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PROCEEDINGS OF THE 4th WORKSHOP OF ICTCT

in Vienna, November 1991

ICTCT-Secretariat
Danhausergasse 6/8
A-1040 Vienna, Austria

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from a road-user behaviour and interaction perspective?
What should be done?

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P R E F A C E

The topics related to traffic safety are peculiar in many respects: They embrace quite a considerable number of safety-factors which, ultimately, would have to be connected with a considerable number of scientific disciplines, as communication theory, sociology, social psychology, the psychology and biology of perception, drug medicine, economics, traffic law, car and road construction technology, electronics and, of course, the methodology of data gathering, observation and statistical analysis. The papers of this volume give a feeling of the multitude of aspects and points of departure for studying traffic safety. But there is another peculiarity of the traffic-safety-area: It relates to a type of human communication which exists for a relatively short time in view of the centuries of history of civilisation, namely to the communication between persons driving with eventually high speed and with short distances between each other. To observe the other car's speed and movements and to expect reactions of the others to one's own speed and movements is a relatively new form of interaction, at least involving the high speeds as they are used on roads. One of the pioneers in studying the "technologically mediated" communication was H. POPITZ by his work with co-authors of 1964 "Technik und Industriearbeit", analysing this phenomeneon in industrial work. Later, the same consideration was applied to traffic. In this volume, this type of communication is dealt with in the papers of CHALOUPKA, FLEURY and KULMALA.

There is a further peculiarity to the traffic-safety-area. It cannot simply be reduced to technological conditions and to perception and reaction processes. As human beings are involved, a specific property of humans comes into the picture: homo sapiens is the only living being we know, which is able of the so-called "meta-mapping", which means that we are able not only to create an image of our environment within our brain, but also of observing and describing this mapping process itself; that means to go to a meta-level of consideration. For traffic-safety it follows that the driver is able to create an image of his own traffic behaviour, related to a single traffic situation as well as to long-lasting specific patterns of active and reactive behaviour. In the paper of SAAD, this human capacity of meta-mapping plays a central role within the methodology as the driver is confronted with a video-tape of her/his own driving. But also to accept or to evaluate risk means to use this human faculty. Risk evaluation was treated in papers of RISSER and ROTTER.

From the foregoing considerations, it should be obvious that the field of traffic safety research is a relatively new one. That means that an expansion of topics as well as of the methodology can be expected. It seems appropriate therefore to dwell in the framework of this introduction also on possible and desirable future developments:

A difficult question is, what parameters should be influenced in order to get the greatest possible improvement of traffic safety; should we concentrate on the interactive system of the ongoing traffic movements, or should we study how the driver is acquiring through the long process of "traffic socialization" her/his characteristic traffic and traffic-conflict behaviour? The driving lessons are certainly not the only environment within wich traffic behaviour is learned. But obviously, research on "traffic socialisation" will be, as a rule, more expensive than many other types of resaerch, as, e.g. it might necessitate to use panels and would need much more time. Still it might help us to influence traffic safety at a crucial point, namely at the psychological disposition of the drivers.

In view of the enormously rapid development of the information technology, it is quite necessary to study its impact on driving behaviour. Two studies of German authors, FASTENMEIER and GSTALTER, are devoted to this subject. The power of this technology is growing from month to month. Therefore, in the future, this field of research will certainly expand within traffic safety research.

If asked to characterise the field of traffic safety research, I would describe it as a field of great responsibility, but also of grat fascination by the multitude of its methods and liaisons among scientific disciplines.

Robert H. REICHARDT

CONTENTS

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SOME PERSONAL THOUGHTS ABOUT RISK AND SAFETY IN TRAFFIC

SUMMARY

Main topics of the following contribution are:

- The characteristics of the traffic system
- The aims of the person when travelling
- Risk on a societal and personal level
- The process of accident occurence (its stochastic quality)
- Behavioural modification as a consequence of a system change
- What can be done?

1. INTRODUCTION

Modern road traffic is a system in which millions of cars move and meet with a speed difference of 100-200 km per hour, separated by only a few meters from each other. Moreover, those machines of big mass and power are not at all strictly separated from the human living areas and from those members of the community, namely pedestrians, playing children, etc. who actually do not take part in road traffic. On the one hand, our modern life is very much interwoven with car traffic, on the other, traffic means one of the major everyday risks of accident injury or death on a societal level. Traffic safety researchers and experts have the task to study this negative side effect of the system and eliminate or at least decrease accident risks. As road traffic is a technical system built in order to fulfill human needs and controlled (on several levels) by human beings, contributions from both technical and human sciences are needed in order to optimise its way of functioning.

Technical development is based on a mechanistic - deterministic model of the universe and, in fact, that is the most common scientific paradigm within all branches of sciences, including psychology. There is, therefore, an expectation towards representatives of human sciences to present a mechanistic - deterministic model of human beings as users of technical systems, in our case as traffic participants. This model then could be combined with the model of the traffic system and serve to predict its unwanted side effects and show possible ways of eliminating them. It is true that some elements of the human behaviour can be predicted more or less exactly within the frame of such models, but not human behaviour in general. The old deterministic model of the universe is questioned recently even by some natural sciences. Psychology has never been able to build a wide ranging general model of human behaviour or psychological functioning on a mechanistic - deterministic base.

What can we, psychologists, do then without a well proven paradigm of human behaviour in a world of technics that needs some knowledge and prediction of human behaviour?

2. THE CONCEPT OF PERSONAL KNOWLEDGE

Michael POLANYI's concept of 'personal knowledge' (POLANYI, 1958) gave me an insight of a possible contribution to the solving of the problem mentioned above. POLANYI rejects the statement of scientific detachment and states that all knowing is personal knowing - participation through indwelling. A meaningful model of the universe or of human beings can not be set by integrating more and more factual knowledge into a detached mechanistic model. Personal, tacit assessments and evaluations are required at every step in the acquisition of knowledge, even scientific knowledge. He states: "I regard knowing as an active comprehension of the things known, an action that requires skill. Skillful knowing and doing is performed by subordinating a set of particulars, as clues or tools, to the shaping of a skilful achievement, whether practical or theoretical. We may then be said to become 'subsidiary aware' of these particulars within our 'focal awareness' of the coherent entity that we achieve. Clues and tools are things used as such and not observed in themselves." In this system "there are three centers of tacit knowledge: first the subsidiary particulars; second, the focal target; and third the knower who links the first to the second. We can then say that the knower integrates the subsidiaries to a focal target."

In the case of a psychologist working as traffic safety expert, subsidiaries are both his or her direct experiences regarding human beings in- and outside traffic situations and all theories and psychological knowledge that he or she has accumulated through studies and work in his profession. All those are available in a subsidiary way when traffic safety problems are in the focus of his awareness.

3. SOME PERSONAL STATEMENTS ABOUT HUMAN BEINGS AS TRAFFIC PARTICIPANTS

Tacit knowledge - exactly because its tacit components, the subsidiaries, are essentially unspecifiable - is always richer than what can be expressed by words. It can, however, be tried to be outlined as a personal knowledge, a personal integration of cognitive and sensory experiences focused on an object. As POLANYI said: "Such integration cannot be replaced by any explicit mechanical procedure. In the first place, even though one can paraphrase the cognitive content of an integration, the sensory quality which conveys this content cannot be made explicit. It can only be lived, can only be dwelt in." A cognitive integration of personal knowledge can, however, be formulated, even if it cannot necessarily be proved by formal logical methods.

I try to formulate some statements about human beings as traffic participants that mean a basic personal knowledge for me when I concentrate on traffic safety problems.

3.1 Unsafety in traffic is caused by **us** not by **them**

It is an old hypothesis in traffic safety that a specific group of people is 'accident prone', i.e. is responsible for a disproportionately high number of traffic accidents. Statistical studies have shown that there is a low probability that the hypothesis is true, and accident proneness as explanation of accidents can not be found very often recently in the scientific literature. Still it seems that the majority of the traffic experts share the common illusion of the community of traffic participants, i.e. that 'accidents happen with others not with me'. The illusion originates from a basic characteristics of traffic accidents, i.e. that accidents are very rare from an individual's point of view. Even if road traffic is one of the major everyday risks on a societal level, the average driver in the highly developed countries would have to drive for several thousand years before he gets killed or he kills another person (RUMAR 1988).

The common illusion mentioned above has serious consequences for road user behaviour in general. It means that people make decisions during driving without the feeling that they are taking risk, when in fact their decision is risky. An observation made by SUMMALA (SUMMALA et al. 1988) revealed plausibly that traffic safety experts, as drivers, behave in a similar way. The driving speeds of Finnish road safety experts were measured when they were approaching a hotel where a national meeting on road safety was arranged. This time the topic of the meeting was speed and safety. The results have shown that experts' speeds were clearly faster than those of other traffic participants - including those who had travelled approximately similar distances during their trip. SUMMALA's conclusion from the observation is that the knowledge of safe driving does not guarantee safe driving.

I would like to stress another conclusion that can be drawn from SUMMALA's observation, namely that traffic safety experts share the illusion of the common driver that unsafety is caused by others. It does not only mean that they expose themselves to risks in a similar way as the general population. It means also that, when they focus on traffic safety problems, they have in their minds a tacit knowledge of 'others' who behave in an unsafe way and cause unsafety in traffic. By so doing they lose all the tacit knowledge in their professional work which might have been provided by their everyday experiences as drivers or other kind of traffic participants who are endangered by their own common behaviour in traffic.

To accept the fact that our common behaviour has elements of risk which might lead to accidents in case of some coincidence of factors, could be a similar shift of thinking as was the one initiated by FREUD in psychopathology when he revealed that the difference between pathologic and normal psychologic functioning is only quantitative not qualitative in nature.

3.2 Risk in itself is generally not attractive for people

It is a basic observation on the traffic safety field that modifications of the traffic environment, which were meant to improve safety, had very often less than expected safety effect. The theory of risk homeostasis offered an explanation for the experts saying that the temporal accident rate, i.e. per time unit of aggregate road user exposure, was the output of a closed-loop control process in which the population target level of risk operated as the one and only reference input. The accident rate was defined as a sum of the cross-products of the frequency of accidents and their severity (WILDE 1985). Although risk homeostasis theory refers first of all to an aggregate level, the theory is mentioned very often as an explanation of behaviour on the individual level also. WILDE's model assumes that the level of accepted subjective risk is a more or less stable personal parameter, but does not suggest, as many traffic safety experts imply when they use the expression 'risk compensation', that people seek after keeping a definite risk level quite independent of the gains that they achieve by it.

Risk is an essential part of human life on many different levels. Risk is usually the price of some gain against which it is weighted. A child must risk falling down if he wants to learn to walk. Success can be attained usually by risking also failure in many different areas of human experience. This is true also for traffic. Risk taking cannot be understood by itself, there is always some gain behind the risk and that should be understood if one wants to understand and influence behaviour, in this case road user behaviour.

3.3 Accidents are very often really 'accidents'

The English word 'accident' expresses something about the common understanding of the causation of those unwanted events that happen 'by accident'. The expert approach is usually to analyse accident processes and find out what 'caused' them, what was the preceding event, error, etc. that lead to the accident and without which the accident would not happen. The problems of such an analysis in case of traffic accidents are well known, and the difficulty lies not only in the fact that accidents cannot be directly observed and therefore our information about them is always incomplete. According to my understanding, the problem lies deeper than that. It is impossible to divide traffic actions into two well separated groups: defective ones which cause accidents and error-free ones which exclude accidents. The traffic system, with all kinds of traffic participants, is too complex and it is extremely difficult to define a solid limit between correct and incorrect behaviour. There are, of course, clearly incorrect, erroneous and dangerous actions, but the majority of actions, though safe enough in most of the situations, might be risky or even dangerous in some of them which occur very infrequently. That means also that a driver behaviour which would be prepared to diminish accident probability to almost zero (e.g. would be even prepared to avoid running over a drunkard who is laying on the motorway at night) would cost too much both for the driver and for the society. Generally accepted driver behaviour which people learn by their own experiences and by imitating each other, contains elements which might contribute to accidents 'by accident' if the situation and the partner's action produce an unexpected constellation. The legal process, when an accident happens, tries to fine a 'causing agent' and by that a 'cause'. The question of 'cause' from the researcher's point of view is not so simple.

REFERENCES

POLANYI M. 1958, Personal Knowledge, Towards a Post-Critical Philosophy, Routhledge & Kegan, London

RUMAR K. 1988, Collective risk but individual safety, Ergonomics, 1988, 31, 507-518

SUMMALA H. et al. 1988, Liikenneturvallisuusasiantuntijat ajavat kovaa (Road safety experts drive fast), Reports 15:1988, University of Helsinki, Traffic Research Unit

WILDE G.J.S. et al. 1985, Risk homeostasis in an experimental context, In: EWANS-SCHWING (eds.), Human Behaviour and Traffic Safety, Plenum Press, New York

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RECOGNITION OF DRIVING SITUATIONS AND ROAD LEGIBILITY

SUMMARY

The road user in traffic faces many conflict situations which are problems he has to solve. The process involved is then generally based on the recognition of the precise situation thanks to a pattern of clues which lead to the activation of an ad-hoc procedures of resolution. Incoherence in the traffic system - considered as a whole - can therefore lead to difficulties in recognition and sometimes misunderstandings.

In-depth accident investigations show importance of these dysfunctions, especially because driving is performed in a very high level of time constraint: an accident occures in a few seconds which is a very short time for adequate recognition and for choosing the right action by the driver.

Improving road safety necessitates being alert to those cognitive processes and the structuration of knowledge on roads in the driver's head, whose integration makes possible a better "legibility" of the space the driver is moving in.

1. INTRODUCTION

What are the main reasons for risk? To this question the workshop is trying to answer, I do not think we will be able to find very new answers, because for so many years, so much research has been done and so many papers written about road safety. However, and because we have nowadays a lot of experience and knowledge behind us, I will try to look at this precise question not really through the concept of risk but more precisely in the idea of prevention, in other words, in the way of designing a system with a better level of safety.

In this way I am not avoiding the topic of the workshop but on the contrary focusing on Ralf RISSER's recommendations in his invitation when he writes: "Imagine you have to tell authorities what they really should do to make traffic safer".

As a civil engineer I am interested in the designing of roads. When I work with people locally responsible for the road networks, I talk to people who are used to improving them through accident investigation and through a good common sense - these words are not derogative for me -. In Aeronautics industry this is called the three F approach : "fly - fix - fly". Build an aircraft and fly it. If it crashes, investigate that accident, find the causal factors, fix them, and fly again. Road accidents are more spread out, less spectacular and severe, even if globally they lead to a higher risk. Even so, with different procedures of investigation road improvement is made with a similar retrospective or backward-looking goal and conceptual framework.

However we can learn, through the experience gained that way, that unsafety comes from dysfunctions which result generally from a lack of consistency in the traffic system. Therefore integrated safety can be improved while looking at this system at different levels of analysis and paying attention to the consistency of the decisions and actions, taken at each of these levels.

2. SAFETY OF THE TRAFFIC SYSTEM

Looking at road network as a whole is not an obvious task even for a researcher. It is however much more easy to develop that point of view locally - in a town, a Departement - that for designing a National safety policy. This is one of the reasons for the governments to develop incentive programs like the "minus 10%" type operating in France, Holland, Austria.

National safety problems can be seen as the sum of what takes place at a local level; thus, the list of blackspots in France is the sum of those observed in each "département" (French administrative area).

From this standpoint, local activities serve as a relay for national policy which, without them, would not in many cases become a reality. It therefore reproduces what is implemented on a national level: information campaigns, the application of road building and planning norms....

Because of taking into account risk calculation instead of processes and interactions analysis, measures planned on a national level are often based on monocausal road unsafety analysis. Thus, alcohol-related measures are not linked with measures directed towards the technical control of vehicles. However, on a local, and therefore less remote level, it is easier to consider a smaller-scale reality in a more "systemic" way. Viewed from this angle it becomes possible to incorporate geographical components, the spatial distributionof activity, town planning, population movements, road network history, into a more in-depth insecurity analysis.

This analysis is based on the commonly accepted idea that the driver is regulating a system (so called elementary) comprising three components: man, vehicle and environment. By referring to a system such as this, it is possible to stress the interaction between the different components, i.e.:

- collecting and processing information,
- driver's actions on the vehicle,
- dynamic behavior of the car on the road.

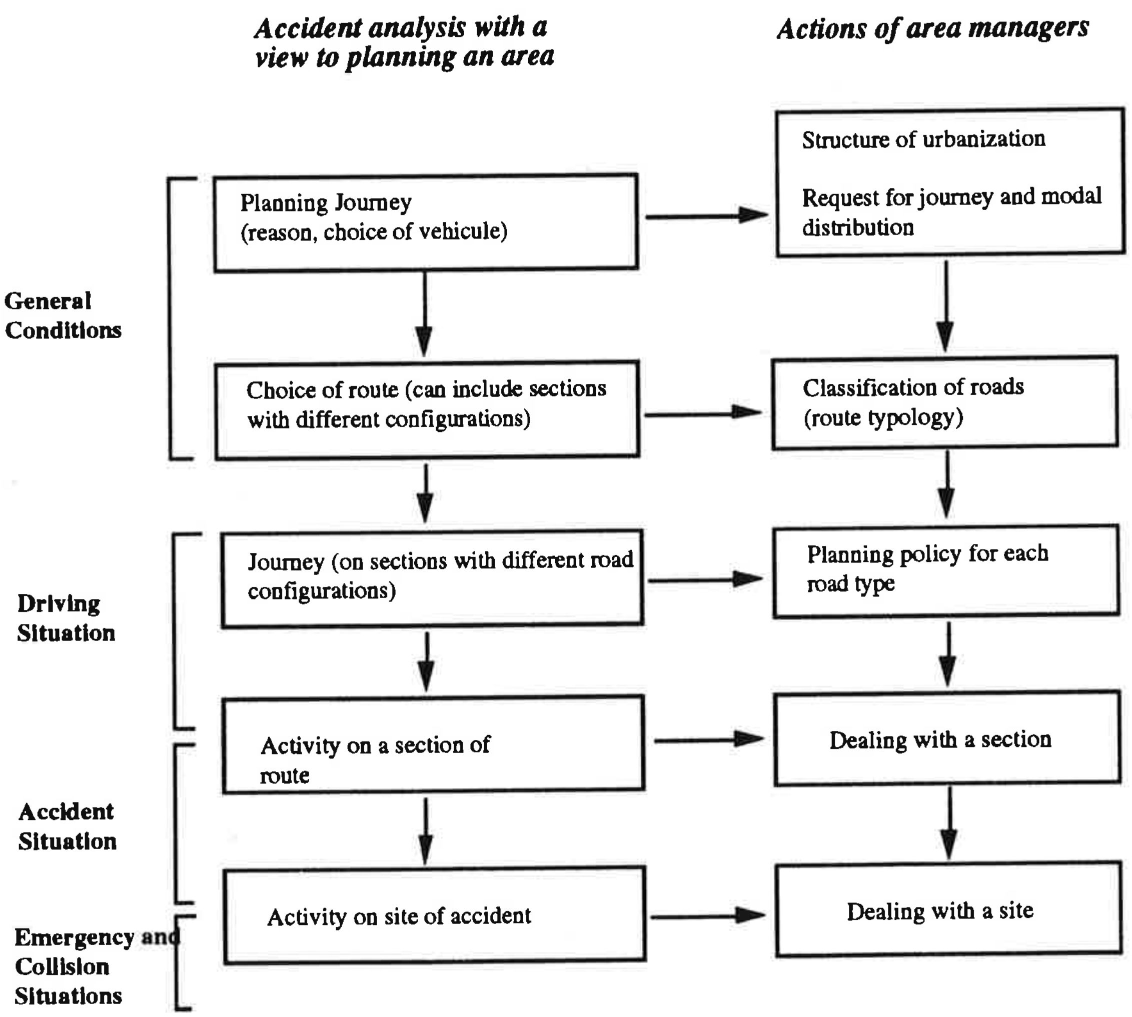
It is important to analyze these mechanisms so as to understand the accident sequence and to explain the origin of the malfunction(s).

The accident-factors, related to the components are therefore independent from the occurrence of this specific accident. It is possible - and in my opinion it is part of the definition of the word "factor" - to have an action on them in order to prevent these unsafety conditions from reappearing.

There is a great wealth of literature dealing with analysis models, giving preference in one way or another to functional sequences such as: information acquisition, processing, decision, action. This type of model can be said to be functional as it is focussed on the description of the relevant mechanisms and is aimed at understanding the malfunctions.

Another type of model is built up using the description of the different events as they occur (phase model). This description is based firstly on the kinematic reconstruction of the accident, so as to observe, at each instant, the speed coordinates for each vehicle, analyze each successive event and reveal the causal logic behind the way these different phases are linked together (see figure 1).

Figure 1: Conclusions drawn from accident analysis with a view to local measures



During the In-depth Accident Investigation "EDA" which took place at Salon-de-Provence in 1980, a phase model such as this was used to describe the accident as a succession of situations: General Journey Conditions, Driving, Accident (encounter), Emergency and Collision Situations.

It is obvious that these aspects should be complementary. If accident analysis based on a functional model can be used to determine the relevant mechanisms and the malfunctions, a phase model can be of use in "staging" the drivers/pedestrians throughout the sequence. It is therefore possible to go as far back as possible when analyzing the unsafety determinants, and apply measures well before this unsafety occurs. More precisely, accident-factors such as home location, urban planification can be investigated whereas the in-depth investigations only refering to a functional model cannot think of them as relevant for safety analysis.

These models refer therefore to the analysis of a traffic system in different hierarchically-linked levels (see figure 1), which is an operational formalization for both the analysis and the measures taken. Thus, the analysis of accidents using a phase model can reveal the extent of urban systems and the distribution of activity centers. Vehicle choice and usage are also affected by physical and geographical constraints, the hierarchy of the existing road network and public transport facilities. The processing of infrastructures, in physical and statutory terms, can also explain the behavior observed.

Asmussen some time ago presented such a parallel between the phase model of the transport and traffic process and the consequences of this model for collective control. It was therefore possible to draw a parallel between the driver's regulation of the elementary system and the one made by the managers of the traffic system, what Asmussen called the micro-regulation and the macro-regulation. An important way to reach safety goals and for a safety program to be successful, is for the government decision-maker to take the wishes of individuals into account.

3. ROAD LEGIBILITY

Coming back to road and environment improvement, great attention is nowadays taken to the meaning of the space the driver is moving in. Road legibility is in connection with the physical characteristics of the road operating into the cognitive processes involved in the driving task.

As it is possible to see different levels in the analysis of an accident and the same parallel levels in the regulation of the whole traffic system, different levels of space legibility can be recognized. These different levels are generally studied separately. Roughly, the first level refers to the legibility of the city (see Lynch). Our present researches bear on the two other levels of representations which refer to other kinds of road legibility. More precisely, the hypothesis is investigated that the representations of road sections and of traffic situations are structured into classes corresponding to different patterns of characteristics and procedures. The second hypothesis is the dependency of the representations of traffic problems upon the representations of the environment at the higher level.

Many technical improvement of roads and streets can be seen as a change in the section legibility, which lead the driver to an other interpretation of the space he is moving in. These kinds of operation first took place in town, changing a road into a street; they are nowadays more generally used.

4. TIME CONSTRAINT

The road user in traffic faces many conflict situations which are problems he has to solve. The process involved is then generally based on the recognition of the precise situation thanks to a pattern of clues which lead to the activation of an ad-hoc procedure of resolution.

In-depth accident investigations show the importance of dysfunctions in these processes, especially because driving is performed in a very high level of time constraint: an accident occurs in a few seconds which is a very short time for adequate recognition and for choosing the right action by the driver.

In most cases, an accident can be seen as the result of a lack of coherence in urban development, the road and overall planning which produce a discrepancy between driver activity and the situation actually encountered. This lack of coherence can lead to difficulties in recognition and sometime misunderstandings and therefore prevents the driver from anticipating what is going to happen. A general principle for improving safety could be to improve overall traffic system coherence, not only from a technical point of view but also as a social space.

Going farther in the analysis of the road system management shows that many lacks of coherence come from history, from land ownership and from a lack of pluridisciplinary work when different jobs are involved. But it also comes from the fact that technical actions take years to be implemented. The idea of setting a charter seems to be a safety tool useful as a guarantee to assure the coherence of the laying out of a public space during time.

5. RESEARCH PROGRAM ON ROAD LEGIBILITY

As a conclusion I would like to present briefly the cooperative programme on road legibility developed since four years by INRETS, the National Center for Scientific Research (D. DUBOIS) and other research centers in France. The starting point of this programme was the implicit hypothesis regarding the categorization of the urban and rural environment resulting from accident analysis, which had become an argument for the evaluation of the relevance of the theoretical framework elaborated on simple objects, applied to these complex environments.

Thus the questions to be investigated were the following:

- What is the cognitive categorial knowledge of the "common driver"? What is the hierarchical cognitive organization of the environment elaborated through the driving behavior?
- What sets of properties of the environment appear to be relevant for the categorial organization and finally what clues (or patterns of clues) of the environment are associated as predictors of different types of problems or patterns of behavior?
- What categories of the environment can be identified at the "basic level", adjusted to driving behavior?
- Can "typical" representations be identified for the different categories of environments?

5.1. Study 1

A pilot study has been carried out to explore the semantic content of a set of words referring to the urban and road environment in order to accede to the representations associated to these verbal inductors. Subjects were presented with words such as"city", "urban area", "village"... belonging to 3 types of environment (urban environment, roads and streets, intersections). Then, they were asked to "activate" an image of the object or scene the word referred to, and finally, to name the properties of the object they "see in their mind".

5.2. Study 2

The second experiment follows the same line of arguments as the previous study but goes one step closer to the "real" ecological situation of driving, by using photographs of urban scenes, instead of words. Furthermore these analogical representations of the "real world" are processed through a non verbal method of investigation of categorial knowledge: a classification task.
Subjects were thus required to classify sets of photographs showing approaches to intersections and their contextual road section, according to two different instructions. The first one stressed the morphological properties of the environment as a classifying feature, whereas the second one focused the subject's activity on the behavioral adjustment he would have had within the scene.

5.3. Study 3

The same set of slides as previously used in study 2 was implemented on a laser-video disk and subjects were required to react as fast as possible when they had identified a scene which induced a modification of their driving behavior, and then to point out directly on the TV screen (with a light pen) what property of the picture led them to the decision. The identification time was recorded and considered as an indicator of the legibility of the environment: the more legible it is, the faster the identification and the decision is.

5.4. Study 4

This study can be viewed as a revision of study 2, regarding the methods used but the questions concerned another set of photographs related to road sections discarding punctual environment events such as intersections, curves and also the traffic. This selection refers to the question of the categorization of sections as the critical level for the generation of provisional frames and scenarios (in contrast with intersections which could be viewed as the level of problem identification and solving). The instructions required the subjects to estimate the "potential problems" they could meet and to classify the photographs according to this criterion. Nowadays 4 experimentations have been made with different sets of photographs in urban and rural areas.

5.5. Study 5

A new regulation in December 1990 reduced the speed limit in towns from 60 to 50 km/h. There were also introduced 30 km/h speed limit zones in certain areas, and also a maximum 70 km/h speed on certain road sections. An experimentation was set up to examine how categories of urban roads, according to these 3 speed limits would be divided into subcategories for driving activity. This experimentation consisted in having experienced subjects class pictures of urban sites, and in questioning traffic engineers on the speed limits in these sites. By using hypotheses of psychology, the results make clear the criteria the subjects used in structuring their representations as well as the order they used in taking into account pertinent clues.

5.6. Study 6

Drawings are much easier representations to deal with than photographs because it is possible to build different scenes according to any combination of characteristics. Different sets of drawings have therefore been made and experiments done according to the same procedure as experiments 4. It was discovered that moving the drawing from simplicity to complexity, lead to a change in the treatment from analytic to family resemblance. Further developments are prepared, to study inter-personal differences, and especially the influence of experience on the structuration of the knowledge. Video disk presentations should be emphasized as it allows the study of the coherence between the type of section which has already been specified by other experiments, the different kinds of conflict situations and the equipments which help the drivers to solve them. This system is also convenient for studying the dynamic sequential process involving these recognition and decision tasks.

REFERENCES

ASMUSSEN E. 1984, in OCDE programmes intégrés de sécurité routière, Chapitre III. Paris

BAKER J.S., FRICKE L.B. 1986, The Traffic Accident Investigation Manual. Northwestern University Traffic Institute

BARTHELEMY J.P., DUBOIS D., FLEURY D., TENIN A. 1990, Categorization of situations from photographs and drawings : typicality, family resemblance or analytic processing? European Cognitive Psychology Society Conference, Como, Italy.

DUBOIS D. 1986, La compréhension de phrases : la représentation sémantique et processus. Thèse de Doctorat d'Etat. Université de Paris VIII.

DUBOIS D. 1991, Sémantique et Cognition, Ed. du CNRS, Paris

DUBOIS D., FLEURY D., MAZET C. 1991, Représentations catégorielles : perception et/ou action ? Publication atelier PIRTTEM "Représentations pour l'action"

FLEURY D. 1990, Accident analysis methods and research prospects, IATSS Research Vol. 14 n°1

FLEURY D. 1991, Catégorisation de scènes routières et sécurité, de l'analyse des accidents aux représentations typiques, Soumis pour publication à Intellectica

FLEURY D., DUBOIS D. 1991, Catégorisation mentale et sécurité des réseau, 6ème Conférence internationale sur les comportements de déplacements Quebec Mai 22-24

FLEURY D., DUBOIS D., FLINE C., PEYTAVIN J.F. 1991, Catégorisation mentale et sécurité des réseaux. Rapport INRETS n°146

FLEURY D., FLINE C., PEYTAVIN J.F. 1991, Modulation de la vitesse en ville et catégories de voies urbaine, Expérimentations sur les représentations de sites routiers, Rapport INRETS n°144

FLEURY D., MAZET C., DUBOIS D. 1987, Road Safety Analysis and categorization of urban environment, 2nd International Conference on road Safety, Groningen, Hollande, Septembre

HENDRICK K., BENNER L. 1987, Investigating Accidents with STEP. Occupational Safety and Health, Marcel Dekker, New York

HOC 1986, Psychologie cognitive de la planification, Grenoble, Presse Universitaire de Grenoble

LYNCH K. 1976, L'image de la cité DUNOD. 222P.

MAZET C., DUBOIS D., FLEURY D. 1987, Catégorisation et interprétation de scènes visuelles: le cas de l'environnement urbain et routier, Psychologie Française, Numéro spécial : la psychologie de l'environnement en France

MEDIN D., WATTENMAKER W., HAMPSON S. 1987, Family Ressemblance, Conceptual Cohesiveness, and Category Construction, Cognitive Psychologie 19,242-279

RIEMERSMA J. B. J. 1987, An empirical study of subjective road categorization, Traffic Behaviour Research Group Institute for Perception, TNO

ROSCH E., LLOYD B.B. 1978, Cognition and Categorization, Hillsdale, New Jersey, Lawrence Erlbaum

SAAD F., DELHOMME P., VAN ESLANDE P. 1991, Drivers speed regulation when negotiating intersections, in: Elsevier Science Publishing Co, Inc. Transportation and traffic Theory, Editor Masaki Koshi

SCHANK R., ABELSON R. 1977, Scripts, Plans, Goals and Understanding, Hillsdale, (N.J.), Lawrence Erlbaum

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DRIVING TASKS AND NEW INFORMATION TECHNOLOGIES

SUMMARY

In the framework of the development and evaluation of new information technologies in vehicles, the driver maintains the central component of the traffic system. In this context, it will be most important to recognize and describe processes necessary for a safe and effective conduct of the driving task. In traffic research, however, systematic approaches to the analysis of the driving task are rare.

Therefore, the important approaches are shortly reviewed and evaluated with regard to certain criteria. At last, they are summarized and assessed in a conclusive manner, including proposals for further research activities.

1. INTRODUCTION

In the framework of the development and evaluation of new information technologies in vehicles, the driver maintains the central component of the traffic system. Quite independently from what new developments are going to modify his task it will be most important to recognize and describe the processes necessary for a safe and effective conduct of the driving task - that means, to perform some kind of task analysis.

Therefore, task analysis is a concept of central importance to the design and evaluation of all components constituting a man-machine system (or driver-vehicle system). This (self-)evident fact has led to numerous theoretical approaches and methodological procedures for task analysis in work psychology and ergonomics. In traffic research, however, systematic approaches to the analysis of the driving task are rare. Especially today, where new technologies can be used to redesign the task of car driving, this shortcoming is quite regrettable. The aim of a study, we had done by order of DRIVE Central Office, was to analyze and evaluate existing studies and methods for driver task analysis to assist in recognizing the gaps of knowledge that should be closed by further research. The main part of our report documents various approaches to driving task analysis. Obviously it is not possible to give a detailed presentation of all evaluated approaches. Therefore, each author/approach is shortly described in key-words; major concern will be put on evaluative aspects and possible conclusions.

2. DRIVING TASK ANALYSIS PROCEDURES

The order of presentation is according to a distinction introduced by HACKMAN (1970). He classified four types of task analysis approaches:

1. Task -qua - task
2. Task as behaviour requirement
3. Task as behaviour description
4. Task as ability requirement

First, studies are listed that follow the "task-qua-task" concept, i.e. focus on the objective task properties and the physical nature of the task. Only two approaches could be adjoined to this concept:

v.BENDA (1977):	classification system of traffic situations
EICHENAUER et al (1981):	road characteristics

Most of the reviewed approaches are associated with the second concept: task as behaviour requirement. The question is raised, which behaviours should be emitted, given the task. First, procedures closely connected with the task-qua-task aspects are described:

GALSTERER (1978):	measurement of task complexity of traffic situations
FASTENMEIER (1988, 1989):	taxonomies of traffic situations and task complexity, combination with observation methods.

Several approaches that have been developed for driver education purposes are following:

McKNIGHT et al (1970):	detailed behaviour requirement lists
BARRETT et al (1973):	emergency situations for driver education
JENSCH et al (1978):	prototypical situations for driver education.

The chapter ends with approaches that structure the driving task hierarchically or by means of production rules:

ALLEN et al (1971):	hierarchical modelling of the driving task and derivation of driver information needs
SCHRAAGEN (1989):	normative task analysis for navigation in unfamiliar cities
HALE/MICHON:	driver behaviour as production rules systems.

The third group of studies is connected with the description of overt driver behaviour: what are drivers really doing when they accomplish their task? Several studies (in an exemplary manner) could be compiled in this descriptive category:

KLEBELSBERG (1970):	characteristics of driver behaviour and driving style
TRÄNKLE (1980):	driver behaviour on motorways
QUENAULT (1969):	observation procedure for overt driver behaviour

C.T.: conflict and error counting methods.

We were not going to deal with the "task as ability requirement" concept, because individual differences in driving ability are of minor interest in the present context.

Each of the documented approaches is shortly evaluated in relation to its utility for further driving task analysis work.

As most of the work reviewed showed a lack of cognitive task analysis, a chapter with an overview on psychological models of the driver as an information processor was added. These concepts try to describe and explain cognitive and motivational processes involved in accomplishing the driving task. Internal representations of critical situations, redefinitions of the task, perceived risks, rules, knowledge, etc., are topics of those driver models.

3. EVALUATION OF THE PRESENTED APPROACHES

This chapter summarizes the information about the methods presented in the previous chapter. It is organized into a matrix giving some evaluation criteria as rows and the main task analytic approaches as columns. The evaluations do not try to evaluate the respective methods per se, but concentrate on their usefulness for task analysis in real traffic. It follows a short explanation of every criterion variable to further the understanding of the table and some comments to avoid possible misunderstandings.

3.1. Original purpose

What was the original aim that led to the development of the methods? It can clearly be seen, that task analysis per se has nearly never been the motive for the development of the procedures. In most cases, the original purpose was either to construct a tool for some kind of applied research (e.g. on stress and strain, driver fatigue, information needs) or to derive curricula for driver education.

Is the method derived from a model of the driving task or some other theoretical framework or is it a more or less arbitrary agglomeration of items? Some authors really modelled the traffic system elements as a source of their gathering details of task elements (e.g. McKNIGHT), others used theories of cognitive psychology (e.g. HALE et al. explicitly relate to ANDERSON's theory) or SCHRAAGEN on various theoretical approaches from cognitive science; the kind of theoretical background is indicated by a few words in the respective matrix cells. It may surprise that the work of ALLEN et al. is scored "no theoretical background", because these authors developed a brilliant conception of the driving task. But the order of succession was vice versa: They first collected their data and analyzed the driving task. The model of the driving task was developed later on to structure the different subtasks they had found in the task analysis.

3.2. Empirical evidence

This row characterizes the approaches according to the kind of empirical evidence: was data gathered in field studies or from laboratory experiments? The result shows that many approaches have never been assessed by empirical means.

3.3. Degree of elaboration

This variable does not need to be explained in detail. We added it to the list because of the huge differences between the methods (the number of basic items or categories varies from 7 to 1700)

3.4. Extensiveness of training needed to apply the method

Some approaches can be applied quite easily with a minimum of training in the tools. Others, especially those techniques that rely on more than one human observer in field studies afford a lot of work in training observers, checking their inter-rater-reliability etc. Some methods could not be scaled on this dimension, because the main result of that work was something different from a method (see e.g. the approaches with driver education improvements on the mind).

3.5. Application utility

This variable tries to evaluate the scope of the approach: Some methods are clearly restricted in the application area (e.g. TRÄNKLE only collected items with regard to motorway driving), some methods are very general and can be used for many different kinds of work with no or only minor modifications.

What elements of the method can be of value for further research on traffic task analysis? Some of the reviewed approaches are very extensive and have undergone a lot of working steps that are not directly related to driver task analysis. We therefore specify that elements in this category that seem to be of more importance for further research on task analysis. If "none" is coded, our - of course subjective - opinion is that these studies are not suited as a base for further developments in task analysis. Please remember that this assessment has nothing to do with the overall value of these studies, but only refers to our specific perspective with regard to further driving task analysis utility.

3.6. Results useful for task analysis

This category is strongly related to the preceding one. It gives the main results of all approaches and some quantitative information for a better assessment of the scope of the approaches.

The approaches with an explicit relationship between the elements of the traffic environment and the typical tasks that have to be performed just there, seem to be of value for further activities to us (e.g. v.BENDA; GALSTERER; FASTENMEIER). The work of

McKNIGHT et al. is given a positive judgment for its extensiveness as a catalogue of tasks. Its completeness makes it well suited to be a source for more cognitive models. The conceptual framework of the ALLEN et al. studies is going to maintain its value in structuring tasks on different hierarchical levels. Also the postulated processing characteristics related to the model will be an accepted standard in the future. This evaluation is based more on the theoretical model of the driving task than on the task analysis procedure proposed by the authors. The hierarchical model has been of great heuristic value in the sense that it stimulated further work and gave central ideas that could be used or generalized by other researchers. This is an outstanding characteristic if this approach that put it apart from the others. SCHRAAGEN's normative task analysis is valuable because it applies to a subtask of driving that is severely underrepresented in task analysis until now: the navigation domain. The approach adopted by some authors (e.g. MICHON; HALE) to use production rules to describe the driving task seems to be interesting. But probably, its usefulness will be restricted to the guidance level of driving.

Table 1: Evaluation matrix

Criteria / Approaches	von Benda (1977)	Eichenauer et al. (1981)	Galsterer (1978)	Fastenmeier (1988, 1989)	Mc Knight & Adams (197o)	Barrett et al. (1973)	Jensch et al. (1978)	Allen et al. (1971)	Schraagen (1989)	Hale et al. (199o)	Klebelsberg (197o)	Tränkle (198o)	Quenault (1969)	Conflict Techniques
original purpose	scaling of dangerous traffic situations	description of optical input of drivers	research on stress and strain	derivation of driver's information needs	development of objectives and curricula for driver education	to identify critical situations for driver education	development of objectives and curricula for driver education	to derive driver information needs	normative task description	task analysis	description of driver behaviour	fatigue research	to identify types of drivers	safety measurement
theoretical background	significance of traffic situations in traffic system context	no theoretical background	significance of traffic situations in traffic system context	significance of traffic situations in traffic system context	based on traffic system components	no theoretical background	no theoretical background	no theoretical background	based on spatial knowledge representation approaches	models traffic behaviour as production rules	no theoretical background	no theoretical background	no theoretical background	no theoretical background
empirical evidence	data gathered in lab. experiments	no empirical evidence	data from field studies	data from field studies	no empirical evidence	no empirical evidence	no empirical evidence	data from field studies	no empirical evidence	no empirical evidence	data from field studies	data from field studies	data from field studies	data from field studies
degree of elaboration	high	low	high	high	extremely high	low	high	high	medium	extremely high	medium	low	medium	high
extensiveness of training needed to use the method	high	low	high	extremely high	./.	./.	./.	medium	./.	?	medium	low	medium	extremely high
application utility	many applications possible	restricted to the dexcription of road characteristics	many applications possible	many applications possible	data base for further research & to develop driver education programs	restricted to driver education program development	restricted to driver education program development	many applications possible	restricted to navigation in unfamiliar cities	many applications possible	restricted to the description of driving styles	restricted to the description of driver behaviour on motorways	restricted to the assessment of individual differences in driver behaviour	many applications possible
what elements can be used as tools for further research on traffic task analysis?	classification system for traffic situations	none	behavioral requirements analysis procedure	combination of traffic taxonomies with observation methods	list of behaviour requirements	none	none	driver behaviour model; lists of driver infromation needs	normative task analysis	idea to describe driver behaviour as production rules	none	none	none	observation methods
results useful for task analysis	12 elements, 14 coding units, 9 categories to classify traffic situations; description of routes for 5 trip purposes	15 characteristics of driving situations	measurement of task complexity in 72 traffic situations	taxonomy about task complexity for 116 different traffic situations; catalogue of traffic situations for representative trip purposes	17oo behaviour requirements in 45 major tasks	8 critical driving manoeuvres	7 prototypical driving tasts	1o tables of driver information needs; hierarchical model of the driving task	normative task analysis (verbal description of items)	not yet finished	4o observed driver behaviours grouped to 7 driving style factors	4 clusters of driver behaviour variables	16 items for driver behaviour observation; 3 factors of conduct	many different observation procedures for traffic behaviour

4. SYNTHESIS AND CRITIQUE OF THE FIELD

In the preceeding chapter the various task analysis procedures had been compared and comprehensively assessed by means of some criteria. In this chapter we try to proceed in assessing the task analysis approaches in a conclusive manner. First, this will be done by means of a matrix: the rows of this matrix represent the hierarchical structure of the driving task according to the hierarchical three-level model of the driving task. This approach has been choosen because it is the model that both has been proven to be heuristically fruitful and which is acknowledged by many scientific disciplines dealing with traffic safety problems. Nevertheless, it has to be added that a hierarchical modelling of the driving task should not be overestimated so far as it still is more a conceptual framework for the description than for the explanation of driving tasks and driver behaviour. The rows of the matrix are distinguished as follows:

- Navigation 1 (pre-trip phase)
- Navigation 2 (direction-finding)
- Guidance
- Control

The columns of the matrix include various components of drivers' information-processing. They are structured according to well-known models of human information-processing, differentiating into components such as perception, cognition and action:

Perception: sensing and identifying
Cognition: interpreting and judging
Action: executing control

One cell of this matrix remains "empty": per definitionem cognitive processes can not be analyzed on the control level where highly overlearned automatized skills dominate behaviour.

By means of this matrix we try to present a conclusive overview in order to demonstrate
- the topics the various task analyses have dealt with
- which aspects of the driving task are sufficiently compiled
- on which topics research is scarce.

The names of the authors which represent a specific driving task analysis approach are categorized according to the rows and columns of the following matrix.

Table 2: Taxonomy of driving task analysis approaches

	Perception:	Cognition:		Action:
	sensing & identifying	interpreting & judging	decision-making	executing control
N1	McKnight et al Allen et al Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon
N2	McKnight et al Allen et al Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon	McKnight Allen Schraagen Hale/Michon
G	v.Benda Galsterer Fastenmeier McKnight (Jensch) Allen Hale/Michon	v.Benda Galsterer Fastenmeier McKnight (Jensch) Allen Hale/Michon	Galsterer Fastenmeier McKnight Allen Hale/Michon	v.Benda Barrett Galsterer Tränkle Fastenmeier C.T. McKnight Quenault Jensch Eichenauer Allen Klebelsberg Hale/Michon
C	Galsterer Fastenmeier McKnight Allen Hale/Michon			Barrett McKnight Klebelsberg C.T. Tränkle Hale/Michon Quenault Jensch Galsterer Allen Fastenmeier

Abbreviations:
N1= Navigation level1; N2= Navigation level2; G= Guidance level; C= Control level.

Regarding this matrix for its own one could have the impression that the approaches listed above seem to have dealt sufficiently with all relevant aspects of driving task analysis. So far, this matrix reveals a blurred image of the subject. This is, because many attempts are both of restricted value for the purpose of a systematic task analysis - as evaluated above in each case - and include in some cases just singular aspects of the driving task.

For instance, the task analysis procedures by HALE/MICHON and JENSCH et al are put in parenthesis. This is on account of the fact that JENSCH' et al approach was to derive curricula for driver education purposes; their crucial point is clearly in investigating the "overt behaviour" of drivers and their actions, respectively. Perceptual and cognitive processes in driver behaviour are to some extent taken into consideration - this is the reason why JENSCH is listed in the matrix - however, these processes are dealt with in a rather peripheral, arbitrary and abstract manner, i.e. there is no systematic inquiry of perceptual and cognitive processes at all.

The disadvantage of the production rules' idea (see HALE and MICHON) is - apart from objections mentioned in chapter 2 - that it is, so far, a more or less theoretical approach. Taking for granted that it is indeed an universal approach, all processes that are represented by the cells of the matrix could be thoroughly analyzed by means of this technique. However, as far as we know, there is still a discussion how it could be applied to real traffic; thus, it still seems to be a work that needs to be done.

Regarding each level of the driving task in detail, the following comments have to be made: The control level seems to be the only field of research that has been studied extensively. This holds true both for the approaches, presented in this report, and for the linear control models concentrating in modelling within one task, e.g. steering and cornering skills.

As far as the "middle ground" is concerned (guidance level) many useful results are available at present although a systematic linking of larger driver-vehicle interface design features to expected task behaviour is surprisingly lacking (compare HALE et al 1990). Furthermore, a remarkable fact is that many approaches on the guidance level concentrate on the "action" side of driving. Only few procedures take adequate notice of underlying processes such as perception, cognition, anticipation, etc. According to these basic topics only the research done by ALLEN et al and FASTENMEIER turns out to be useful; McKNIGHT's approach is of restricted value in this context and although the production rules' idea is based on an explicit theory from cognitive psychology experience is still lacking with this approach.

The main shortcomings of task analysis procedures seem to exist on the navigation level: HALE/MICHON are listed rather for theoretical than for practical reasons. SCHRAAGEN's attempt is by its nature normative in its approach and restricted to driving in unfamiliar areas; it has to be validated by an empirical or experimental study. Although McKNIGHT et al extensively analyzed many relevant driving task components, the number of items concerning navigation tasks is strictly limited; thus, the usefulness of this approach for the navigation tasks has to be questionned. The same holds true for ALLEN et al: they also use very few items for the analysis of what they call macroperformance tasks. Especially as far as the implementation of electronical in-car navigation systems is concerned task analysis should concentrate more on cognitive styles and cognitive mapping of drivers and related topics. The importance of these processes for both evaluating navigation systems and establishing design criteria has been summarized recently in DRIVE-reports (e.g. VAN WINSUM et al 1990; GSTALTER & FASTENMEIER 1991).

What we should also bear in mind is the following: the discussion in this report about various driving task analyses made evident that a relevant number of these approaches ranges back to the early 1970's. So far, the question arises if research done in 1970 can be transferred to road traffic problems in the 1990's without any reservation especially under the premise of introducing new technologies in vehicles. In our opinion this has to be taken into consideration as far as the results of these analyses are concerned: in any case, the "older" procedures are in need to be updated. Less detriment has to be made for the task analysis techniques themselves.

Another shortcoming of task analysis relates in general to that kinds of approaches which appear to have remained closely to their origins, i.e. task analysis for driver training purposes. Their "atomistic" view indeed seems to be useful for the purpose of deriving detailed and elaborate curricula for driver training and driver education by extensively analyzing all kinds of task components. However, the value of these procedures has to be questionned as far as the design of new driver-vehicle interfaces is concerned.

Another remarkable fact is, in general, a lack of a precise description, definition and integration of environmental objectives, i.e. explicitly situational variables such as traffic and driving situations. Thus, with the exception of FASTENMEIER who integrated the task-qua-task and the behaviour-requirement approaches by v.BENDA and GALSTERER, in most task analysis procedures

- situational variables aren't clearly defined or are just "mentioned" in general
- situational variables usually aren't varied systematically.

This seems so much the more a surprising statement as already twenty years ago task analysis research claimed the urgent need of a taxonomy of situations in order to describe and control the interactions between driver and situational characteristics (e.g. HACKMAN 1970; FREDERIKSEN 1972; MAREK & STEN 1977; recently HOYOS & KASTNER 1986).

Summarizing the discussion about the task-as-behaviour-description approaches it shows up that they are of limited value for general task analysis purposes. They concentrate both on car-handling and drivers' overt behaviour without regard to underlying cognitive processes.

The most promising procedures are comprised in the task-as-behaviour-requirement approach, especially when they are linked with task-qua-task aspects. However, a systematic error-modelling should be added to these approaches, i.e. they also should consider tasks which arise when the driver-vehicle-road system is operating abnormally (or single components of this system, respectively).

Indeed, this lack of both the error-modelling and a comprehensive driver errors' taxonomy applies to task analysis research in general. Such a taxonomy neither exists in relation

- to driving performance in general
- to single parameters of drivers' information-processing.

Of course, this doesn't claim that research has neglected driver errors so far: what is missing is a systematic approach! Many attempts of error classification have been made in fact especially in work sites (e.g. LEPLAT & RASMUSSEN 1982; REASON 1985; etc.) but a transmission of approaches from work psychology and related topics to road traffic is still missing.

Most error counting methods in road traffic stem from a Conflict Technique background, because it is proposed that the same types of errors are also causes of traffic conflicts. One attempt of systematically counting errors by in-car observation has been presented by RISSER & BRANDSTÄTTER (1985). Modified versions of this method by other authors have been applied for various purposes: evaluation of an in-car navigation system (GSTALTER 1991) and analysis of driver information deficiencies (FASTENMEIER 1991).

An approach to overcome some of the deficiencies, mentioned above, could be indeed a combination of error counting methods with behaviour requirement approaches which explicitly take regard of situational variables. In this context, one basic assumption is the concept of a safety-continuum. If one considers traffic safety to be a variable varying between correct behaviour (i.e. behaviour according to a defined standard) and traffic conflicts and/or - in a further step - accidents, then errors in the behaviour of road users should be found somewhere in between those two extremes. Within the following succession: standard behaviour - errors in driving behaviour - traffic conflicts - accidents, the frequency of events is decreasing, the dangerousness of events increasing. For instance, the probability of two traffic participants to be involved in a traffic conflict is limited to a certain degree; on the other hand, a conflict will only possibly lead to a collision. So, when trying to identify types of behaviour which lead to traffic conflicts or to accidents one would expect an accident to have been preceded by dangerous or erroneous behaviour. Thus, one will have to distinguish between different types of errors, i.e. considering both the legality and the degree of danger coincident to any certain behaviour as two very important aspects. Those aspects of traffic safety reducing behaviour should be analyzed together with their relationship to traffic conflicts, accidents and behavioural requirements. In this context, a number of questions have to be answered:

- how to determine the logical and numerical relationship between errors and conflicts?
- how to define the term "error" itself? how to observe and record the difference between errors, slips, mistakes, faulty actions and traffic violations?
- how to proceed in developing a taxonomy of driver errors which is closely related to traffic situations: take a driving task analysis from the behaviour requirement approach and define errors as deviations of "ideal" and required behaviour?

Both the process of task analysis and the development of a task analysis methodology can be very time-consuming. According to this statement there are two main strategies for further research in general, being dependent on cost-benefit considerations: first, all task analysis procedures which have been evaluated as appropriate tool for further applications could be adopted for all problems arising under the premise of developing and implementing new driver-vehicle interface design features. There is indeed a pool of procedures which can cope with problems such as changing driving tasks due to the introduction of RTI-systems, changes in task allocation, etc.

Nevertheless, one could argue that there is a need of a task analysis methodology to be developed fundamentally for road traffic purposes. Especially as far as the drivers' cognitive processes are concerned, this report made evident that very few approaches take adequate notice of this basic topic. Thus, one possible proceeding is to take a model of human information-processing as a conceptual framework and/or tool of analysis both in order to exactly defining all steps and phases of information-processing and by regarding all components of the driver-vehicle-environment system to finally derive the tasks that have to be accomplished by the driver.

Another aspect should be mentioned at last: So far, driving task analyses of course had been confined to "driving" itself. But as far as future conceptualizations such as cooperative road infrastructure management are concerned, new and other aspects of the driving task will become important. Supposing that such concepts will be realized in the near future it should be obvious that the existing characteristics of the driving task will change. In this case adequate task analysis procedures are still lacking.

REFERENCES

FASTENMEIER W. & GSTALTER H. 1991, Review on studies and research work about driving task analysis, Study realized by order of DRIVE Central Office, CEC, München, diagnose & Transfer, Institut für Angewandte Psychologie

GSTALTER H. & FASTENMEIER W. 1991, Components of test routes for evaluation of in-car navigation systems, DRIVE-Project 1017 (BERTIE), Report No. 69, München, Forschungsgruppe München

HACKMAN J.R. 1970, Tasks and task performance in researxh on stress, In: McGrath J.E. (Ed.), social and psychological factors in stress, New York, Holt, 202-237

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QUALITY PROBLEMS IN CONNECTION WITH FIELD OBSERVATIONS AND REGISTRATIONS

SUMMARY

In the introduction of the following paper the difference between objective risk and what road users experience as risky is pointed out. This depends among others things on the social isolation of car drivers, and on the lack of possibility to learn practically about relationships between objective and subjective risks.

The main part of the presentation deals with the "test criteria" validity, reliability and objectivity of both accident analyses and behaviour observations (more specially: traffic-conflict registrations). There is some evidence that on a local or individual level the diagnostic and prognostic quality of "the criteria variables" (i.e. accidents) with respect to validity, reliability and objectivity is lower than the one of predictor variables: This is especially valid for severe traffic conflicts.

To finish with, the locus-of-control problem, very often connected to behaviour observation, its relevance for field studies in traffic, and ways to overcome it, are mentioned.

1. OBJECTIVE VS. SUBJECTIVE RISK

One can define risk in several different ways. One can to a certain degree quantify it by giving certain figures reflecting the probability of an accident or any other negative outcome. So the term "probability" - in connection with the term "risk" - refers to **unwanted consequences** of all types, that events of all types could have.

A more subjective way to approach the concept of "risk" is to relate it to human experience, where "experience" is meant in mainly two senses:

- o One **experiences** risk in those cases where certain events trigger more or less autonomous physical reactions, accompanied by the expectation - or even the fear - that something might happen. This process of experiencing risk is not an analytical cognitive process from the beginning; at first - i.e., when confronted with certain stimuli the first time(s) (e.g., as a child, or as a beginner, etc.) - it is more comparable to an unconditioned natural reflex, triggered, e.g., by loud noises, by fast or unexpected movements, etc.

- o Experience, in it's other meaning, is the precondition for a more elaborated association of the probability of negative/ unwanted consequences to certain events: One learns that certain events, or constellations, etc., are dangerous. After some time of learning ("experience"), these events trigger reactions similar to reflexes, as well - in this case the reflexes are conditioned ones, however. A negative outcome can be of mere emotional character, without any physical aspects. Severe traffic conflicts (near accidents) can have such an effect.

2. STATISTICAL HAZARDS RELATED TO BEHAVIOUR AND EXPERIENCE

KLEBELSBERG has pointed out the importance of differentiating between what he called objective and subjective risk already in the 70s. I do not want to repeat KLEBELSBERG's concept once again, here (for a comprehensive overview, see KLEBELSBERG 1982); but of course, it is a very natural hypothesis that people normally take only those risks which they think are under good control. So if so many people take so many objective risks in road traffic - which they obviously do, otherwise there would not be approximately 40000 injury accidents only in Austria every year - it is a good guess that they do not know they do.

The situation is such that experts point out other risks (and experts think: objectively) than road users - especially car drivers - experience (subjectively). He/she who has studied **accident files** of good quality long enough, or he/she who has **observed traffic in the field** long enough, has an idea of the many unexpected things that can happen. So, e.g., a speed that is looked upon by the driver as being harmless, can result as totally inadequate in reality.

- This is an important aspect I want to underline: Quite many types of behaviour and interaction (**b/i**) are dangerous, statistically speaking. It is only that road users, in terms of learning psychology, never get the chance to learn to associate certain types of b/i to negative outcomes.

How do we know? As said just above, studying of good accident files, but especially observation of b/i in the field (e.g. CHALOUPKA et al. 1991 as a very recent example), gives one the strong impression that there is a wide gap between the statistical risk in a b/i, and the way road users experience the hazard connected to precisely this b/i, when they set it themselves.

3. ASSESSMENT OF RISK BASED ON ACCIDENT FILES

However, accident files are very often not of good quality; e.g., they are often very incomplete or even nonchalantly done with respect to b/i that preceded and/or accompanied the accident. This we should consider when we now during the following two days listen to reflections based on the studies of accident files telling us which types of b/i are hazardous.

The problems connected to accident data as a basis for analysis of which types of risk certain types of b/i reflect can be summarised in the same way as the problems connected to psychological tests usually are: Namely in terms of validity, reliability, and inter-rater objectivity.

3.1 Validity

Speed, or short headways, or other types of b/i cause problems, statistically speaking. However, the reliability of accident data in many cases is very bad on a primary leve: The information about which b/i aspects led to accidents is often missing, unclear, or misleading. Still there is enough evidence that inadequate speed (in most cases speed above the speed limit), risky overtaking manoeuvres, short headways, and right-of-way problems (especially between car drivers and unprotected road users) are the types of b/i most often to be observed in connection with accidents. We will certainly get some more information about these aspects during our workshop.

Anyway, statements about the relation between certain types of b/i and accident risk are at least theoretically possible if one uses the whole national traffic system, or sub systems as large as possible as bases for the identification of relationships between b/i and accident outcome.

But what if you want to assess local or individual safety by use of accidents as criteria? Accident data are not valid themselves in local or individual cases: E.g., the prediction of accident numbers based on accident registrations in the past is probably working worse than the prediction based on severe traffic conflicts, as Per GÅRDER (1986) has shown us.

3.2 Reliability

As said before: The interpretation of accident files with respect to what happened, when the accident happened, is most often very difficult, allowing several possibilities of assessment, which represents both a reliability and an inter-rater objectivity problem. This could be overcome by standardising both the labelling of registered accidents and the interpretations of file data better. But strangely enough this problem that seems so easy to be solved has not been solved yet.

Another strange reliablity problem connected to accident data is that many accidents - even injury accidents, and even fatal ones - are not officially registered, at all. However, this does not really disturb the establishing of overall relationships between certain types of b/i and accident outcome.

For safety (or risk) assessment on the local or individual level the first type of reliability problems I mentioned, together with the low validity of accident events that results from the statistical characteristics of accident events is much more disturbing than the generally bad reliability of accident registration on national levels.

4. ASSESSMENT OF RISK BASED ON OBSERVATION OF B/I IN THE FIELD

How about those aspects of b/i connected to risk one learns about with the help of field studies? There are of course the same types of problems as with the use of accident files that have to be overcome:

4.1 Validity

The question is often put: How do you know whether a b/i is dangerous, hazardous, risky, or whatever you could call it, when you cannot relate it to an ultimate criterion? Maybe speeding, or short headways, or other types of b/i cause problems, statistically speaking. But how can you decide whether they cause problems in the individual case? We simply have to accept, that most of the time they probably don't. There is no deterministic relation. The whole system, or sub-systems as large as possible have to be used as bases for the identification of relationships between b/i and accident outcome, reflecting the validity of the registration of b/i and their interpretation.

4.2 Reliability

Are the same events always registered in the same way? That, we know, depends very much on the definition of items that have to be registered. The registration of speed can be done quite reliably, if one prepaires his studies well. The registration of more complex b/i (right-of-way situations, etc.) is less reliable in the sense, that observers easily miss relevant details of the whole event. The reason for such mistakes can be on the situational side (too high complexity of an event) or bad accessibility for the human senses (assessment of head-ways).

It can also be on the observer's side: If an observer is tired, or badly trained, or biased with respect to his/her own habits as a road user (e.g., driving habits, the observer's usual mode choice), etc.

4.3 Inter-rater objectivity

Different observers should register the same events in the same way. Bad reliability in the sense that the events to be registered are not well accessible, or not well defined, reduces inter-rater objectivity sharply, of course. One has to consider, though, that even a very simple and clear definition has to be internalised well by an observer, in order to be applied well in the field. That means that a good training of observers is necessary in any case.

4.4 The locus of control

Another important aspect is the locus of control: We are inclined to explain our own behaviour in terms of situational factors, whereas the behaviour of other people is more often explained in terms of their presupposed intentions and dispositions. As observers we do not know, which situational aspects the actor is aware of or considering, respectively.

The driver - or actor - on the other hand is in a situation to believe that he/she can react to all possible hazards he/she can think of. Maybe he/she can, but the question is if he/she can do that in time.

Both the non-expert passanger **and the expert observer** are very much interested in registering all important things that happen in order to be able to react in time on the level at their disposal: The non-expert passanger maybe wants to tell the driver that he wants to leave the car, to drive more slowly, to be careful, to watch out, etc.

Of course, observers e.g., if they carry out observations from observed subject's cars, do not want to be steered too much by anxiety. Moreover, they do not want to leave the car. The solution as a rule is to do observations out of observed subjects' cars with driving teachers in not identifiable driving-school cars.

In connection with the locus-of-control aspect the usual argument has to be added: Longer experience with observation, of course preceded by a good training, helps catching those cues telling one what the driver/actor is aware of. Moreover, an observer has to learn which cues are more and which are less vital. Some cues an observer should absolutely not miss. Training and experience can help a great deal in this respect, as well.

But one will soon find out that certain questions can only be answered if one uses verbal data, as well. I.e., one has to talk with observed subjects after the test rides, if possible basing on video registrations of certain events that have to be discussed.

REFERENCES

CHALOUPKA CH., RISSER R. & ROEST 1991, Methode zur Identifizierung von Verhaltensweisen, die auf erhöhte Unfallgefährdung hinweisen, FACTUM, Wien

GÅRDER P. 1986, Theory for strong validation, in: KTI, Traffic conflicts and other intermediate measures in safety evaluation, Institute for Transport Sciences, Budapest

KLEBELSBERG D. 1982, Verkehrspsychologie, Springer-Verlag, Berlin, Heidelberg, New York

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SAFETY IMPACTS OF IN-CAR NAVIGATION SYSTEMS

SUMMARY

In-car navigation systems constitute one of the most prominent groups of road traffic informatics developments, some systems are already on the market. To evaluate the safety related influences of these systems on driver behaviour empirical research is needed. In a study funded by BMW and DRIVE the authors were to answer the question which kind of test route would be appropriate for such research work. Here, some of the more principal lines of reasoning leading to the proposal of test route characteristics are presented.

At first, we list the possible effects, that navigation systems can have on driver behaviour and try to explain these effects within some theoretical framework.

Problems of mental load, visual distraction, overreliance, deskilling, interactions with unprotected road-users and system misuse are discussed.

The next paragraph discusses various parameters of drivers and the road environment that possibly moderate the outcome of a study for each of the effects listed above. The most important variables are the degree of driving experience, the driver's spatial abilities and their amount of local knowledge about the road network.

Some general conclusions from the discussion for test route selection are summarized.

1. SAFETY RELATED CHANGES IN DRIVER BEHAVIOUR DUE TO NAVIGATION SYSTEMS

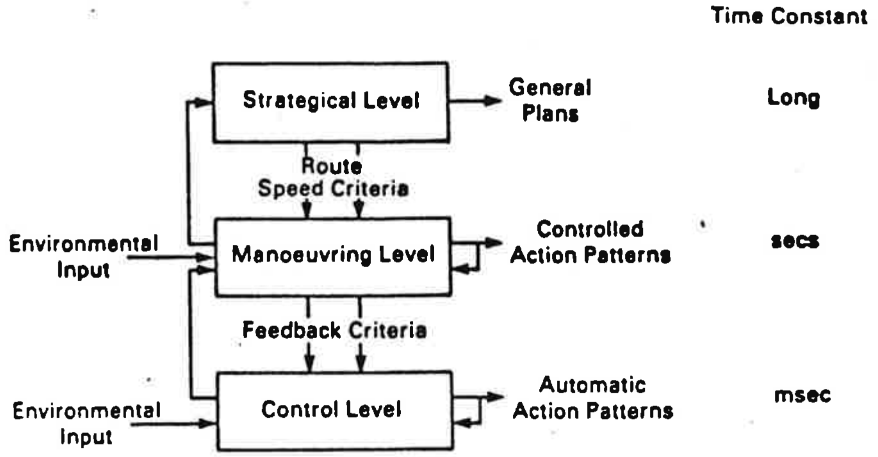
The development of NS has been motivated by a lot of possible positive effects concerning economical, ecological and safety aspects. We shall focus our attention in the following analysis on those effects of NS that are directly safety related. Of course, there are also indirect effects on safety, e.g. if the NS shortens the routes in time or space and thus changes the driving exposition.

This chapter tries to give a short description of possible effects of NS on driver behaviour at various levels of the driving task.

Two classes of models with different backgrounds and purposes have become useful -and therefore common- in distinguishing between different driving tasks and respective driver information processing activities. One class is in the tradition of the attempt to model driver behaviour as a hierarchical task (JOHANNSEN 1976, JANSSEN 1979), the other has been developed by RASMUSSEN (1983) in the context of supervisory control tasks. Recently, several authors have attempted to combine these models (e.g. PARKES 1989, RUMAR 1990, HALE et al 1990).

We shall use some of the concepts of these frameworks in the next chapters to describe the safety related aspects of driver behaviour which are likely to occur in the context of NS. We therefore give a brief description of the model.

Figure 1: Hierarchical structure of the road user task (after JANSSEN 1979)



The driving process is modelled as a hierarchical task structure. Performance is differentiated at three levels. On the strategic level the driver makes trip-specific decisions. He sets goals like definition of trip destination, subgoals about what routes to take etc, i.e. he is planning his trip. Performance at this level is therefore directly related to the navigation task. If the navigation task is not automatized (like on daily used roads for the same purpose), it affords conscious processing at a knowledge-based level.

The general plans from the strategic level have to be transformed into controlled patterns of action. Behaviour at this manoeuvring level is mainly rule-based, i.e. it follows learned "if-then" rules. The driver e.g. decides to overtake and retrieves the necessary information about the actions for that manoeuvre from long-term memory. Finally, on the control level of driving, strongly automatized action patterns dominate behaviour. Actions on that level are quick, efficient and can be taken without great subjective effort. They are called skills and they don't afford conscious attentional control by the driver. For an experienced driver, examples of skills are using the steering wheel, clutch, brake etc.

1.1 Mental load

Mental load has become a key concept in psychology and human factors research in the last decades. GSTALTER & FASTENMEIER (1987) have summarized the main theoretical assumptions and implications of the construct recently in an attempt to evaluate different stress-measurement techniques in the PROMETHEUS-context. We therefore restrict our presentation here to aspects of mental load that are of key importance for the construction and evaluation of NS.

The notion of mental load in connection with NS is twofold: Some authors predict a decrease in the drivers mental load, because less attention on the driver's side would be needed for navigation purposes, others fear an overload induced by the presentation of navigation information in highly demanding traffic situations.

How can a navigation system reduce mental workload?

Navigation, mainly consisting of route planning and route following is a knowledge-based activity located at the strategic level of the model in Figure 1. This kind of information processing is serial, slow and error-prone. Everything processed in this mode has to pass the bottleneck of conscious awareness. This kind of information processing is therefore extremely time- and resource-consuming. If a NS can substitute elements on the strategic level it has the potential to reduce the driver's mental load. This is, e.g., the case, if drivers don't have to activate their knowledge about the road network (their "cognitive maps") to decide between possible alternative ways during the trip.

Another way to decrease mental load can be achieved by a shift from knowledge-based to rule-based behaviour, i.e. from the strategic to the manoeuvring level. If a NS tells or shows the driver to turn left at the next junction, the decision is taken over by the system and the task left over to the driver -prepare for the manoeuvres for the turning off- is a rule-based (or partly even sensorimotor) activity.

Still another possibility of reducing mental load by the system can result from an easier perception and/or interpretation of useful navigation information via the NS compared to driving without the system (e.g. seeking and reading sign boards, street names etc versus having this information on the in-car display).

As the model of the driving task in figure 1 is a hierarchical one, you could suppose spare mental capacity on a higher level to be of use in terms of more attentional resources on the lower levels.

It is important to note that all potential benefits described above only apply to cases, where the driver really has to manage a knowledge-based navigation task. No effect on the driver's mental load can be expected on well-known routes between sources and destinations like workplace and home. Here the navigation task is automatized and subconsciously controlled.

But intelligent systems (e.g. LISB), which can supply the driver with recommendations based on real-time information about disturbances in traffic flow like jams or accidents can of course indirectly lower the driver's mental load by guiding him/her on routes with an easier driving task to perform.

Of course, all advantages listed above are only advantages in the sense that they can be achieved by an optimal design of the NS. PARKES (1989) and ZIMMER (1990) give detailed information about the requirements connected with the planning and construction of RTI systems. If the design of the system or the system-interface is bad, the system can become counterproductive. It can disturb and distract the driver, it can give the wrong kind of information and/or at a wrong point in time, or it can display information that is hard to understand etc. In total, badly designed systems can produce an <u>increase</u> in mental load.

It follows that NS should be carefully designed and in any case their effects should be empirically tested, nevertheless.

What is the relationship between mental load and safety?

It is often (more or less implicitly) assumed that an increase in strain or mental workload automatically impairs human performance. This is obviously wrong as long as the driver can cope with the situation by using greater mental effort. VERWEY & JANSSEN (1988) mention this point and refer to the distinction between "data-limited" and "resource-limited" conditions (NORMAN & BOBROW 1975): " In resource-limited conditions (i.e. in task conditions where the operator has no spare capacity), human performance is fully determined by the demands of the task and mental load decrement will immediately result in performance increment. In data-limited conditions, however, (i.e. if spare capacity is available) performance corresponds less to mental load, because humans can use spare capacity to compensate for extra task demands."

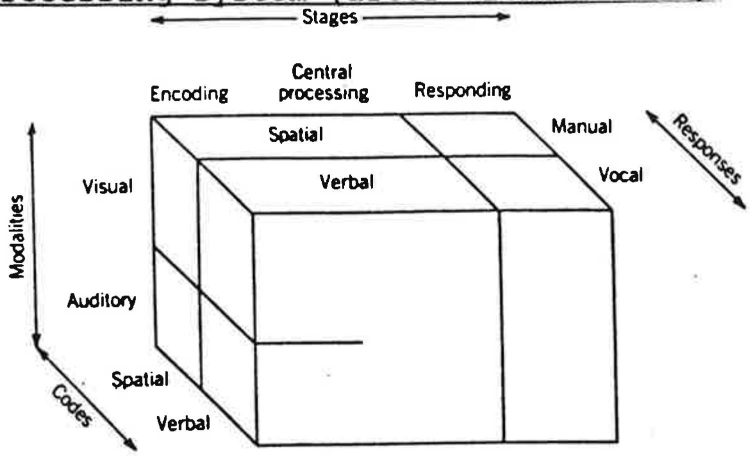
Another argument against a simple relationship between traffic safety and driver's mental load is the fact that traffic participation is -at least in many situations- a self-paced task. Drivers therefore have coping strategies (like reducing speed) to compensate for higher levels of mental load. That drivers really behave in a way to hold task demands on a constant level ("strain homeostasis") has been shown in a number of investigations (GSTALTER 1985, HOYOS & KASTNER 1986, VAN WINSUM 1987).

For the topic under discussion here it follows that safety-related changes in mental load due to NS should be studied under conditions near the resource limits.

<u>1.2. Multiple resources</u>

In the discussion above we have treated "resources" as a single, homogenous source of attentional capacity. This concept of attention as a flexible, time-sharing processing resource of limited capacity has been introduced by KAHNEMANN (1973). This has been shown to be too simple to explain certain phenomena of time-sharing performance (WICKENS 1984, 1987, FÄRBER 1987). Not only the level of task demand, but <u>task structure</u> became the object of research. A multiple-resource model was developed by WICKENS (1987) that conceived of resources as separate energy supply systems to different information processing structures. WICKENS (1987) modelled the human resource structure in a three-dimensional space.

Figure 2: A model of the multiple resources within the human processing system (after WICKENS 1987).



Obviously, this notion has important consequences for the design of information systems, if their interaction with drivers should result in data-limited structures. VERWEY & JANSSEN (1988, p.16) draw detailed inferences from the multiple-resource model for navigation system design, especially with regard to the question of when auditory or visual information presentation should be preferred. They conclude:

> "...it can be expected that the presentation of simple visual navigation information is less intrusive than auditory information, but at the same time more interfering with visual demands of the driving tasks. Predictions concerning the optimal presentation modality are therefore hard to make. Self-paced information, however, may induce integration of information intake with other driving tasks. Because the visual modality is better suited for self-paced information, visual route guidance information presentation may show more practice effects than auditory and, eventually, this may lead to an advantage for visual information."

How can overload influence safety?

According to RUMAR (1986) under normal driving conditions (data-limited case) the order of importance of information is the following: Highest priority for information about the road (control level), medium priority for information about the interaction with other vehicles (manoeuvring level) and lowest priority for navigation information (strategic level). But what happens if a driver cannot avoid a state of mental overload? VERWEY & JANSSEN assume that drivers are capable of ignoring less critical driving tasks (in terms of safety) to cope with overload conditions:

> "... differences in mental load as a result of navigation are expected to exhibit themselves in tasks like driving speed, stopping time, navigational errors and mirror usage. No effects are expected on the occurrence of c ritical incidents." (VERWEY & JANSSEN 1988, p. 17)

This is an optimistic point of view. It could also be argued (as has been done e.g. by PARKES 1989), that drivers under overload conditions are liable to changes in the normal prioritisation of information. If navigational information is given priority over important aspects of the roadway ahead, critical situations will occur. This kind of prioritization of the navigation task can be strengthened by so-called "command-effects" induced by a navigation system.

Conclusions

The current theoretical state of the art is insufficient. At the moment, NS can only be evaluated empirically. Investigations should be carried out under resource-limited conditions.

1.3. Visual distraction

The driving task puts a heavy load on the visual channel; most of the information intake and feedback is visually controlled. Each distraction of the driver's view therefore is a potential danger because relevant visual information from the roadway can get lost during the scanning of an in-car display. This obvious fact has been recognised early and led to research about the amount of distraction induced by visual displays. Various techniques have been developed to measure and quantify visual distraction. ROCKWELL (1988) has introduced the notion of "visual cost". The most important parameter is the time, the driver is diverted from the front view. It can be split into glance frequency and glance duration. A high glance frequency can be a hint for bad memorability of the information presented at in-car displays, glance duration can be used to evaluate the ease of information extraction from the display. For more details on how to quantify "visual cost" using "visual matrices" see ROCKWELL (1988) and FAIRCLOUGH & PARKES (1990).

WIERWILLE et al (1988) and WIERWILLE et al (1989) could not find evidence for the intrusion of displays as navigation aids. They concluded that drivers are able to adapt their visual scan patterns appropriately. Although in the WIERWILLE et al (1989) study the level of visual demand imposed by the driving task was varied as well as the amount of traffic volume, we conclude that his subjects still drove in a state of "data-limited" processing (compare the discussion in the previous chapter).

PARKES (1989) and especially FAIRCLOUGH & PARKES (1990) have compared the distribution of visual attention in a field study. An in-car navigation device was tested against a map condition and compared to a control condition (no navigation component).

The following table summarizes the results.

Table 1: Distribution of visual attention over the forward view for both conditions (n=10) compared to a control (n=24)

.	Control	Map	Computer
Rear view mirror	2.3	1.7	2.3
Roadway	92	67.2	76.1
Navigation device	---	22.1	12.1
Dashboard	1.5	0.2	0.3
TOTAL	95.8%	91.2%	90.8%

In the control condition, 92 % of the driver's visual attention was allocated to the roadway ahead. This number decreased considerably for the drivers with the navigation aid ("computer"), but even more in the map group (76% and 67%, respectively). For a detailed analysis see FAIRCLOUGH & PARKES (1990).

Sometimes it is argued that "auditory costs" should be considered in an analogous way by systems that make use of accoustic information presentation. These systems could disturb or even startle the driver by giving sudden unexpected messages. Moreover, noise from the traffic environment can be masked and the perception of the motor noise of the own vehicle distorted. Although these effects may occur, we don't treat "auditory costs" here as a special chapter or effect, because we don't see a direct relationship between the occurrence of these effects and specific traffic situations. If a system gives accoustic messages to the driver, the driver's reaction to the message should be observed; but the inclusion of specific traffic situations to test for these effects seems unnecessary to us.

It is important to note that the difference between driving in a well-known area (i.e. driving without a real navigation task involved) is very much easier than driving in strange environments. The difference in the visual distribution cited above therefore cannot be interpreted in the sense that the navigation device impairs traffic safety compared to "normal" conditions in strange environments (which are better approximated by the map condition). The am ount of increased task complexity and thus reduced traffic safety induced by the search task has been demonstrated lately by ENGELS & DELLEN (1989) in a study comparing the accident risk of native and foreign drivers. Foreign drivers were significantly overrepresented in the causation of those accidents which happened in a traffic situation involving an orientation component (e.g. in junctions, approaches to junctions, lane-changing), whereas other accident causes (e.g. speeds too high, headways too short) showed an equal distribution of accident causation proportion of foreigners and native drivers.

GALSTERER & GSTALTER (1990) could also show on the basis of error-data that a related sample of drivers had more safety-related problems in unknown parts of Berlin compared to their trips in well known parts of the road network.

In another study GALSTERER et al (1990) observed a significant increase in lane-exceedences by drivers with the LISB- navigation system compared to trips without an electronic device. They attributed the effect at least in part to visual distraction factors.

In total, a glimpse on the literature about the safety-related consequences of visual distraction by the use of navigation displays seems to sample confusing or even contradictory pieces of evidence. But reasoning about why and how visual distraction can influence safety leads back to the notion of mental workload discussed in some detail in the previous chapter. If we perceive the requirement of scanning a display as a classical dual task, adding mental workload to the primary task of driving, we would arrive at the same inference like that in Chapter 1.1: If the joint mental load of primary and secondary task (both competing for the same kind of attentional resources!) reaches the level of resource-limited processing, driver performance is likely to deteriorate, possibly explainable in terms of a shift in RUMAR's prioritisation of information from different relevant sources.

In other words, in its consequences we might view hazards through visual distraction as a special case of the general mental load topic or as a cause of reaching an overload level of information processing. Thus, if we take into consideration all other variables influencing drivers mental load, we come to more conclusive results about the hazards induced by visual distraction through NS. In this context the varying results of experimental studies on the topic become more comprehensible.

Conclusion

Visual distraction through the use of in-car navigation systems can be potentially dangerous. If, therefore, a given NS is suspected to divert the driver's view too often or for a too long time span from the roadway ahead, this assumption has to be tested empirically.

1.4. Overreliance

Overreliance on technical systems, sometimes referred to as "overconfidence" means too much trust into the system. A typical case might be as follows. The driver has made a destination input into the navigation system in an unknown traffic environment. When he looks at the display later on, he sees that his destination is at a right angle to the left of his car's position and he approaches a junction. That arrangement may influence him to try to turn left at the intersection. If his reliance on the system is very strong he may attempt to turn left, even if it is prohibited at that junction. This effect is sometimes referred to as a "command-effect". The tendency to "obey" the system's message will be strengthened by the "confirming bias" people have: we always try to obtain information which justifies our actions and tend to ignore contradictory evidence (see e.g. MICHON et al 1990, REASON 1990).

Overreliance will probably vary with the experience a driver has in using the system and with the driver's knowledge about the system's performance and failures. Probably, system "intelligence" will also influence the liability of the driver to command-effects.

Conclusion

For the present discussion it is important to note that in a study of a NS the routes chosen should include features, where overreliance-effects can show up.

1.5 Deterioration of skills

Deskilling is often mentioned as a peril of automation. It means that a human operator, whose task (or parts of it) have been taken over by machines looses his/her skill because of lack of practice. If - in an emergency situation- the operator has to go back to manual control, various factors work in favour of ineffective control. BAINBRIDGE (1983, p. 775):

> "... a formerly experienced operator who has been monitoring an automated process may now be an in experienced one. If he takes over, he may set the process into oscillation. He may have to wait for feedback, rather than controling by open-loop, and it will be difficult for him to interpret whether the feedback shows that there is something wrong with the system or more simply that he has misjudged his control action. He will need to make actions to counteract his ineffective control, which will add to his workload."

Deterioration of skills has sometimes been found in pilots who had used autopilot-systems for longer time-periods (DREYFUS & DREYFUS 1986), as well as in the case of supervisory control tasks in power plants (SHARIT et al 1987, SHERIDAN 1987).

In our opinion, no skills of the driver are substituted by current NS. But as RASMUSSEN (198 6, p.113) points out:

> "An important point is that it is not the behavioural patterns of the higher levels that are becoming automated skills. Automated time-space behavioural patterns are developing while they are controlled and supervised by the higher level activities, which will eventually deteriorate, and their basis as knowledge and rules may deteriorate."

What kind of knowledge could deteriorate through long-term use of NS? To answer this question one needs to know how drivers navigate in unknown environments, i.e. what kinds of knowledge they acquire and use. There is a lack of experimental studies in this respect. SCHRAAGEN (1989) has recently reviewed the concepts from cognitive science that could be fruitful for this topic. He proposes three types of spatial knowledge, organised hierarchically: landmark and sensorimotor knowledge, procedural or route knowledge and surveyk nowledge. In principle, features of all three types of knowledge could deteriorate through long-term use of NS. Will map-reading ability decrease? Does NS-use diminish driver's knowledge about traffic signs?

These questions can only be answered by long-term studies.

Conclusion

Although often mentioned in the context of in-car NS, it is not quite clear what skills can deteriorate on the driver's side. Moreover, possible skill deterioration would probably take its time. Therefore, we don't see a necessity of regarding deskilling as a permanent danger involved in the introduction of NS.

1.6. Problems with pedestrians and cyclists

This is no real aspect of its own: Paying less attention to unprotected road-users by drivers using NS is a function or consequence of more general aspects like "mental load" or "visual distraction". It is nevertheless treated in an extra paragraph here because of its great accident potential and expected accident severity. ZIMMER (1990) lists "perciving of unprotected road-users" under the heading "possible negative effects of driving aids", but he doesn't comment on it. RISSER et al (1982). and GALSTERER & GSTALTER (1990), and CHALOUPKA et al. (1991) could demonstrate less careful driving with respect to unprotected road-users and worse information acquisition by drivers that had orientation problems.

Conclusion

Because of the relationship between driver orientation and safety of pedestrians and cyclists, test routes should always contain areas with unprotected traffic participants, when a NS is under study.

1.7. System misuse

New systems can often be misused in the sense that it is fun to play with them, to explore their possibilities etc. This is of particular importance if a driver plays with a NS during driving. But we are not going to establish "system misuse" in our list of effects of NS on behaviour, because of two main reasons. At first, even if playing with the system can be observed in a study it can be assumed that this kind of behaviour will not last for long. Moreover, this kind of system misuse doesn't seem to be site-specific, i.e. we wouldn't expect it to show up at certain kinds of roads.

Another kind of "misuse" is wrong interaction with the NS. This is an important aspect as well. Display and dialogue design should be carefully managed in the sense that errors in interaction with the NS are minimized. Proposals and requirements for good interface design can be taken from a large number of guidelines and design rules or even standards.

2. RELEVANT CHARACTERISTICS OF DRIVERS AND THE ROAD ENVIRONMENT

In the following paragraphs, we shortly discuss critical variables of the driver, road environment and format of a display, which will considerably moderate the amount of strain induced by visual distraction.

2.1. Driving experience and driving skill

Like all skill acquisition processes, learning to drive a car to a considerable extent consists of substituting knowledge-based behaviour by rules and rule-based behaviour shifts with growing experience to the level of automatic skill-based behaviour. Experienced drivers therefore have much mo re spare mental capacity that can be used to talk, listen to the radio, etc. compared to beginners. Different strategies of eye movements between beginners and experienced drivers have already been shown by MOURANT & ROCKWELL (1970). Experienced drivers combine various skills into more holistic strategies. This kind of skill integration favours experienced drivers in the task of including additional information requirements -like looking at a display- over beginners. This fact is possibly limited to the case of self-paced information.

It follows that a careful examination of the driver's experience should take place in attempts to evaluate visual distraction by NS.

2.2. Map reading ability

The spatial ability of drivers varies to a large extent. People with low spatial ability are going to have great problems reading a map but also problems of orientation with the "help" of displays using spatial representations of the road environment (like e.g. Travel-Pilot). This will certainly strongly effect the glance duration and thereby modify the extent to which visual distraction from the front view will be found in a study.

Several investigations have shown that approximately 40 % of the adult population have considerable problems in map reading. Especially in the case of experimental studies with small numbers of subjects, map-reading ability has to be taken into account as an important moderator variable affecting the degree of visual dis-traction by NS.

2.3. Complexity of the driving task

Mental load will easier reach resource-limits of the driver the more complex a driving task is. Complexity differs between static characteristics of the road environment (e.g. different types of roads and junctions), the manoeuvres required (e.g. turning off versus straight ahead) and the time-variable parameters (e.g. traffic flow). The more complex the primary task of driving, the less spare capacity will be left. Task demand for this reason has to be controlled in experiments assessing the safety impacts of NS.

2.4. Knowledge of the road network

The same logic applies to the degree of knowledge a driver has about an environment. This can be confounded with the purpuse of the trip (e.g. routes driven for professional reasons will tend to be better known than ravely used routes for recreational purposes).

2.5. Modality and format of the display

A number of studies has compared visual against auditory information given by NS. A detailed discussion of the advantages and drawbacks of both input modalities can be found in VERWEY & JANSSEN (1988). Some systems combine both input channels (e.g. LISB). The driver is alerted by an auditory signal when a message is displayed on the monitor. Oversimplified, auditory information seems to be better suited for drivers not used to electronic route guidance. With practice the visual modality may have advantages because it allows for better skill integration.

Modality effects have to be seperated from differences caused by stimulus properties of the display. The level of pacing, the coding of information, hardware characteristics and the overall design of the interface clearly have great influences on how much a NS can interfere with the visual attention required by the driving task. General statements of the principles that should guide the design of the interface can be found in ZIMMER (1990).

3. CONCLUSIONS

There is a lot of possible effects that a navigation system can have on the safe conduct of a car. Even if a system is carefully designed according to the task at hand and to the design guidelines concerning the man-machine interface, this does not guarantee safety. New systems therefore always will have to be tested empirically.

For positive and negative effects of the system oppearing during test drives it is proposed to choose a combination of test route characteristics and subjects that achieve a performance near resource-limited conditions. Because some driver variables, mainly driving experience, spatial abilities and the degree of local knowledge about the test area influence mental load of the driver heaviliy, for experienced drivers the complexity of the traffic sites should be very high, whereas for novices and elderly, foreigners or people with low spatial abilities average driving conditions will suffice.

Detailed instructions how to proceed in optimising the test route complexity for given samples of subjects are given in our research report (GSTALTER & FASTENMEIER 1991).

Once the difficulty of the overall test route has been selected the researcher should refer to a list of special traffic situations that allow for a testing of visual distraction and overreliance effects.

Because of the great vulnerability of pedestrians and cyclists a safety evaluation should also include areas with sufficient numbers of unprotected road users.

All the necessary details for these subtasks can be found in GSTALTER & FASTENMEIER (1991).

4. PUTTING THINGS TOGETHER: EFFECTS OF NAVIGATION SYSTEMS ON DIFFERENT GROUPS OF DRIVERS

Chapter 1 has reviewed several possible influences NS can have on driver behaviour, Chapter 2 has argued that certain characteristics of drivers might moderate these effects. Chapters 1 and 4 try to combine the information from both chapters.

Chapter 5 finally will give detailled information on how a test route should be constructed to achieve high or medium complexity.

Drivers handicapped by inexperience, low spatial ability and each of prior knowledge about the road network they have to navigate through are going to reach resource-limited information processing structures quite early. We therefore propose test routes with normal complexity and average traffic flow. The greater the driving experience, the better the drivers spatial abilities and the better the local knowledge of the test area, the more spare mental capacity these kind of drivers' will have. For effects of the NS on these drivers to emerge, the researcher should choose difficult traffic situations to allow for resouce-limited conditions. Besides this general choice rule for the route's degree of complexity, special traffic sites or situations should be incorporated if "Visual cost", "Overreliance" or "Pedestrians and cyclists" as effects can be assumed to occur because of the characteristics of the system under study. The next chapter will discuss, what situations should be included for what effects.

4.1.Mental load

As stated above, medium route complexity should be chosen, if the test drivers are novice or elderly drivers, if they have little orientation abilities or if they do not know the test areas. The contrary applies for experienced drivers, high spatial ability people and drivers with much local knowledge. They will only reach resource-limited conditions in difficult traffic situations. Of course, the distinctions taken between the drivers' variables are very rough. Moreover, subjects will probably seldom combine all good or all bad characteristics to represent "best case" or "worst case" groups of test drivers.
With respect to mental load we propose to establish a route in a city because of its higher complexity over rural traffic situations and its greater economy in gathering relevant data on driving behaviour.

4.2. Visual cost

Visual costs of the use of NS are likely to occur in urban traffic conditions. But there is reason to believe that effects on drivers visual distraction can manifest themselves on rural streets as well. Whereas route-following is easy on motorways it may be quite a difficult task on rural streets with many curves, bad visibility or slopes. The course of the road cannot be anticipated as easy as on a motorway and thus affords more visual conrol of the roadway ahead. Distraction caused by the visual demands of reading an in-car display therefore could show observable effects on driver behaviour.

4.3. Overreliance

Overreliance effects can be studied in certain traffic sites which are listed in chapter 5. If a NS is suspected to facilitate overreliance effects, these situations should be incorporated into test routes with medium complexity for novice and elderly drivers, foreign drivers or subjects with low spatial ability. Traffic situations with overconfidence effects can be imagined on all kind of roads. If a researcher therefore has enough resources he is advised to check for these effects on rural and urban - roads. Even experienced drivers can be liable to overreliance for reasons other than high mental load. It may therefore not be necessary to confront them with high complexity conditions, unless they are judged to posess high spatial abilities. If drivers hold good general knowledge of the road environment but not a complete representation of all details (like the occurrence of one-way streets, the prohibition of turning manoeuvrers at certain junctions etc) they may be liable to overreliance effects under high complexity conditions. If they perfectly know the routes, e.g. because they are part of a daily routine, no overreliance effects are likely to emerge. We would therefore not propose to include special overreliance situations for these drivers.

4.4. Pedestrians and cyclists

A possible danger to unprotected road-users through NS use can never be excluded (exception: on motorways). Test routes should therefore always be composed in a way to ascertain the occurrence of pedestrians and bicyclists along parts of the track. That does not mean, that the route should be constructed to include large residential areas, but to allow for encounters with pedestrians on crosswalks etc. The advice to pay special attention to problems with unprotected road users is independent of driver characteristics.

5. TASK ELEMENTS FOR SPECIAL EFFECTS

This chapter lists certain traffic situations that should be included in test routes, if the NS under study can be suspected to be liable to divert the driver's visual attention, to produce overreliance, or may lead to hazardeous situations for unprotected road users. These situations should be included for both high and medium complexity test routes and should be involved in greater numbers then a representative route would allow for.

Visual distraction

Visual distraction can be dangerous and can have observable effects where the expectation of the driver is not in sufficient accordance with traffic reality in the near future. Driving behaviour -like most human behaviour- is strongly governed by continuity phenomena (NÄÄTÄNEN & SUMMALA 1976): In the absence of contradictory cues drivers anticipate the traffic environment to "behave" in a consistent, predictable way. That argument holds true for street characteristics (a motorway is supposed to continue as a motorway beyond a curve, a street going up a hill straight ahead is expected to lead straight ahead down the other side of the hill, etc.) as well as behaviour of other traffic participants (e.g., "common movement illusion", constant speeds and directions). Visual distraction therefore can become dangerous in situations where the diversion from the front view can lead the driver to miss visual cues from the road environment that signalize deviations from the continous and "normally", expected traffic situations. Typical observations that can often be traced back to visual distraction are lane exceedences, especially when the route guidance deviates from usual standards. Other disturbances caused by visual distraction could be late or erroneous decisions and control actions.

Include for rural areas:
- narrow roads
- roads with curves and slopes
- curves with unusual radius and bad visibility
- narrowing roads
- junctions with unusual geometry and their approaches

Include for urban areas:
- work sites
- lane closures
- set-off carriageways

Overreliance

Overreliance in the sense that a driver strictly accepts all system proposals can lead to insufficient route selection if the system is not really good. But in most cases this will only lead to loss of time or comfort, create anger, etc. More interesting for our topic is the case where a system proposes a behaviour that can be dangerous (or is prohibited) or seems to do so. If a system gives a spatial representation of the road environment and indicates car position and travel destination (as Travel pilot for instance does), include situations, where the nearest way to the destination is not the best to reach it. Of special interest are cases where the nearest route is

- a one-way street in the wrong direction
- is prohibited or only for residents
- can only be reached by a prohibited manoeuvre

Overreliance can probably also manifest itself in sudden manoeuvres meant to prepare for system proposals; e.g., a sudden lane-change without proper preparation (looking into a mirror, signalizing the intention to other road users) if the system advises the drivers to turn off at the next junction. Therefore, include multi-lane approaches to all kinds of junctions. Overconfidence can also occur in situations where system proposals contradict alternative evidence from sign-boards (both in urban and rural areas).

Include parts of motorways near parking lots, access points, service areas.

<u>Pedestrians and cyclists</u>

In urban areas:

- Include C4,C5,C6,C7
- Include pedestrian crossings on C1 to C7,
  if possible:
- Include C1 to C7 with cyclists but without bicycle crossings or bicycle ways;
  if possible:
- Include K1 to K4 with pedestrian crossings, especially with car turning right (left in UK)

in rural areas:

- Include narrow, complex local traffic guidance.

SUMMARY

How to proceed in constructing a test route for a given NS:

Given a certain NS, what are the most suited test routes to check the systems influence on driver behaviour with regard to safety effects? The following procedure, ordered into different steps, shows how this report can help to construct a suited source and destination for an experimental evaluation.

Step 1: Find the group of drivers the system is intended for

Step 2: Find the best suited degree of complexity of the test route

Step 3: Find the typical elements of a route with the given degree of complexity from Chapter 5.1.

Step 4: By referring to Chapter 2, are visual distraction or overreliance possible effects of the system you are going to study?

Step 5: If you found one or more special effects in the previous step, turn to Chapter 5 to find the traffic situations these special effects can occur in, and include these situations in your route.

Step 6: Find a real course that approximately fulfills the demands of Steps 3 and 5

Step 7: If you have some degrees of freedom left, try to define start and destination of the test trip to shift the route towards representativeness. Use the information from Chapter 5 and the appendix.

Remarks: If the group of drivers the system is to support is underspecified, prefer worst case conditions, e.g. select novice and/or elderly drivers as subjects. This is because positive as well as negative effects of the system on driver performance will show up more clearly with these drivers.

If you don't want to explore a general purpose navigation system but a system with a very specific application, say an address finding system for taxi drivers, then you should draw a representative sample of taxi drivers, define the events you want to observe as safety indices and accompany the taxi drivers for a certain time interval on the job. The narrower the application idea of the system is, and the better specified the target group of potential users is, the more is the question of what test route to select can be answered.

REFERENCES

AVIOLO B.J., KROECK K.G. & PANEK P.E. (1985). Individual differences in information-processing ability as a predictor of motor vehicle accidents. Human Factors 27, 577- 587

BAINBRIDGE L. 1983, Ironies of Automation. Automatica, 19, 775-779

BARRET G.V., ALEXANDER R.A., FORBES, J.B. 1977, Analysis of performance measurement and training requirements for driving decision-making in emergency situations. JSAS Catalogue of Selected Documents in Psychology, 7, 126

v.BENDA H. 1983, Die Häufigkeit von Verkehrssituationen. FP 7320/2 im Auftrag der Bundesanstalt für Straßenwesen, München: Lehrstuhl für Psychologie, Technische Universität

BERGUM J.E. & BERGUM B.O. 1982, Driver skills, field-dependance, suspectability to illusions, and self-perception, Proceedings of the Human Factors Society - 26th Annual Meeting, 238

BEYREUTHER G. & LAIDEBEUR A. (1989). RTI, State of the Art Review. Drive Project V 1017 (BERTIE), Report No. 28

BEYREUTHER G., CANO, L., LAIDEBEUR A., PETER G. 1990, Introducing RTI and training process. Drive Project V1017(BERTIE), Report No.51

CHALOUPKA C., RISSER R. und ROEST F. 1991, Methode zur Identifizierung von Verhaltenscharakteristiken, die auf erhöhte Unfallgefährdung hinweisen, unpublished final report, Factum, Vienna

DREYFUS H. & DREYFUS S. 1986, Mind over machine. New York, Free Press

ENGELS K. & DELLEN R. 1989, Der Einfluß von Suchfahrten auf das Unfallverursachungsrisiko. Zeitschrift für Verkehrssicherheit 35, 93-100

FÄRBER B. 1987, Geteilte Aufmerksamkeit, Köln: Verlag TÜV Rheinland

FASTENMEIER W. 1988, Verhaltensanforderungen und Informationsverarbeitung beim Führen von Kraftfahrzeugen. Teil I: Ein Katalog von Verkehrssituationen für repräsentative Fahrtypen. Teil II: Entwicklung einer Verkehrssituations-taxonomie und Konstruktion einer repräsentativen Versuchs-strecke. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität.

FASTENMEIER W. 1989, Ermittlung des Informationsbedarfs verschiedener Fahrergruppen in definierten Verkehrssituationen. Teil I: Anforderungsanalyse von Verkehrssituationen und Untersuchungsmethodik. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität

FASTENMEIER W. 1990, Ermittlung des Informationsbedarfs verschiedener Fahrergruppen in definierten Verkehrssituationen, Teil II u. III: Versuchsreihe I bis III - Erfahrene, unerfahrene und ältere Fahrer. Ergebnisse im Überblick. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität

GALSTERER H., FASTENMEIER W. & GSTALTER H. 1990,

Sicherheitsaspekte von LISB - Fahrten auf Routinestrecken, Forschungsbericht im Auftrag der BMW AG München, Verkehrsforschung, München: Forschungsgruppe München
GALSTERER H. & GSTALTER H. 1990, Sicherheitsaspekte von LISB auf unbekannten Strecken (Suchfahrten). Forschungsbericht im Auftrag der BMW AG München, Verkehrsforschung. München: Forschungsgruppe München
GOODENOUGH D.R. 1976, A review of individual differences in field dependance as a factor in auto safety. Human Factors 18, 53-62. GSTALTER H. 1985, Workload and stress in driving. In: Proceedings, 9 th Congress of the International Ergonomics Association, BROWN I. (Ed.). London, Taylor and Francis, 994-996
GSTALTER H. 1985, Workload and stress in driving, In: Proceedings, 9th congress of the International Ergonomics Association, BROWN I. (Ed.), London, Taylor & Francis, 994-996
GSTALTER H. & FASTENMEIER W. 1987, Recognition of driving conditions of drivers. Final Report, Prometheus WP 31 138
HALE A.R., STOOP J. & HOMMELS J. 1990, Human error models as predictors of accident scenarios for designes in road transport systems. Ergonomics, 33, 1377-1388
HAUTZINGER H. & TASSAUX B. 1989, Verkehrsmobilität und Unfallrisiko in der Bundesrepublik Deutschland, Ergebnisbericht, Forschungsbericht 195 der Bundesanstalt für Straßenwesen, Bereich Unfallforschung. Bergisch-Gladbach: BAST
HOYOS C.Graf 1990, Psychologische Unfall- und Sicherheitsforschung, Stuttgart: Kohlhammer.
HOYOS C.GRAF & KASTNER M. 1986, Belastung und Beanspruchung von Kraftfahrern, Unfall- und Sicherheitsforschung Straßenverkehr, Heft 59, Bergisch-Gladbach: Bundesanstalt für Straßenwesen JANSSEN W.G. 1979, Routeplanning en geleiding, Een literatuur-studie, Report IZF C-13. Soesterberg: Institute for Perception, TNO.
JOHANNSEN G. 1976, Preview of man-vehicle control session. In: SHERIDAN T.B. & JOHANNSEN G. (Ed.): Monitoring Behaviour and Supervisory Control. New York: Plenum Press
KAHNEMANN D. 1973, Attention and effort. Englewood Cliffs, New York, Prentice Hall
KLEBELSBERG D. 1982, Verkehrspsychologie, Springer-Verlag, Berlin, Heidelberg, New York
KORTELING J.E. 1988, Information processing of elderly traffic participants, TNO-Report IZF 1988-9. Soesterberg
KOSZLOWSKI L.T. & BRYANT K.J. 1977, Sense of direction, spatial orientation, and cognitive maps, Journal of Experimental Psychology, 3, 4, 590-598
LOO R. 1979, Role of primary personality factors in the perception of traffic signs and driver violation and accidents, Accident Analysis & Prevention 11, 125-127
MARBURGER E.A., KLÖCKNER J.H., STÖCKER U. (1988). Abschätzung der möglichen unfallreduzierenden Wirkungen ausgewählter PROMETHEUS-Funktionen, Forschungsbericht für die PRO-GENERAL SAFETY GROUP, Bergisch-Gladbach, Bundesanstalt für Straßenwesen
MAUKISCH H. 1990, Die alternden Autofahrer: Das Problem der Zukunft? In: W.R. NICKEL (Bd.-Hrsg.), Fahrverhalten und Verkehrsumwelt, Psychologische Analysen im interdisziplinären

Feld, 223- 256, Köln, TÜV Rheinland (Mensch-Fahrzeug-Umwelt, Bd. 25)
MICHON J.A. SMILEY A. & AASMAN J. 1990, Errors and driver support systems, Ergonomics, Vol. 33, 10-11, 1215-1230
MOURANT R.R. & ROCKWELL T.H. 1970, Mapping eye-movement patterns to the visual scene in driving, An explanatory study, Human Factors, 12, 81-87
MOURANT R.R. & ROCKWELL T.H. 1972, Strategies of visual search by novice and experienced drivers, Human Factors, 14, 325-335.
MOURANT R.R. & DONOHUE R.J. 1977, Acquisition of indirect information by novice, experienced and mature drivers, Journal of Safety Research, 9, 39-44
NÄÄTÄNEN R. & SUMMALA H. 1976, Road user behaviour and traffic accidnets, Amsterdam, North HollandGÅRDER P. 1986, Theory for strong validation, in: KTI, Traffic conflicts and other intermediate measures in safety evaluation, Institute for Transport Sciences, Budapest
NORMAN D.A. & BOBROW D. 1975, On data-limited and resource-limited processing, Journal of cognitive psychology, 7, 44-60. NOULIN 1987, Méthodes psychologiques, In: CAZAMIAN P., Traité d'ergonomie, Editions Octares, Entreprises
OECD 1986, Guidelines for improving the safety of elderly road users, Paris: OECD
PARKES A. 1989, Changes in driving behaviour due to two models of route guidance information presentation: a multi-level-approach, Drive Project V 1017 (BERTIE), Report No. 21.
RASMUSSEN J. 1986, Information processing and human-machine interaction, Amsterdam, Elsevir
REASON J. 1990, Human Error, Cambridge University Press.
RISSER R., TESKE W., VAUGHAN C. & BRANDSTÄTTER C. 1984, Verkehrsverhalten in Konfliktsituationen, Studie im Auftrag des Jubiläumsfonds der Österreichischen Nationalbank, Wien, Kuratorium für Verkehrssicherheit
ROCKWELL T.H. 1988, Spare visual capacity in driving- revisited, In: Vision in Vehicles II (GALE A.G. et al., Eds.), p. 317-324
ROSCH E., LLOYD B.B. 1978, Cognition and Categorization, Hillsdale, New Jersey, Lawrence Erlbaum
RUMAR, K. 1988, Collective risk but individual safety, Ergonomics, 1988, 31, 507-518
RUMAR K. 1986, In-vehicle information systems, In: DORGHAM M.A. (Ed.), Proceedings of the International Association for Vehicle Design, 33-42
RUMAR R. 1990, The basic driver error: late detection, Ergonomics, 33, 1281-1290
SCHLAG B. 1989, Ältere Autofahrer - ein Problem mit Zukunft? Zeitschrift für Gerontologie, 19, 410-418.
SCHRAAGEN J.M.C. 1989, Navigation in unfamiliar cities: a review of the literature and a theoretical framework. IZF 1989-36, TNO Institute of Perception
SHARIT J., CHANG T.C. & SALVENDY G. 1987, Technical and human aspects of computer-aided manufactoring, In: SALVENDY G. (Ed.): Handbook of Human Factors, 1694-1723
SHERIDAN T.B. 1987, Supervisory Control, In: SALVENDY G. (Ed.): Handbook of Human Factors, 1243-1268
SHOPTAUGH C.F. & WHITAKER L.A. 1984, Verbal response times up to directional traffic signs embedded in photographic street scenes, Human Factors, 26, 235-244

STREETER L.A., VITELLO D. & WONSIEWICZ S. 1985, How to tell people where to go: Comparing navigational aids. International Journal of Man-Machine Studies, 22, 549-562

STREETER L.A. & VITELLO D. 1986, A profile of drivers' map-reading abilities, Human Factors, 28, 223-239

THORNDYKE P.W. & STASZ C. 1980, Individual differences in procedures for knowledge acquisition from maps, International Journal of Man-Machine-Interaction, 12,137-175

VAN WINSUM W. 1987, De mentale belasting van het navigeeren in het verkeer, Groningen: Verkeerskundig Studie Centrum, Report VK 87-30

VERWEY W.B. & JANSSEN W.H. 1988, Route following and driving performance with in-car route guidance systems, IZF-Report C-14, Soesterberg, Institut for Perception TNO

WICKENS C.D. 1984, Engineering psychology and human performance, Columbus, Charles Merrill

WICKENS C.D. 1987, Information processing, decision making, and cognition, In G. SALVENDY (Ed.): Handbook of human factors, New York, Wiley, 72-107

WIERWILLE W.W., AUTIN J.F., DINGUS T.A. & HULSE M.C. 1988, Visual attention demand of an in-car navigation display system, Proceedings of Vision in Vehicles Conference, Nottingham 1987

WIERWILLE W.W., HULSE M., FISCHER J.T. & DINGUS T. 1989, Visual adaption of the driver to high-demand driving situations while navigating with an in-car navigation system, Abstract from Vision in Vehicles III Conference, Aachen, 1989

ZIMMER A. 1990, Driver information needs. Drive Project V 1017 (BERTIE), Report No. 25.

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RISK IN THE HUNGARIAN ROAD NETWORK
(The Violators are Victims, too)

1. INTRODUCTION

The Hungarian politicians and the public, too, should be extremely concerned by the inacceptable and increasing number of lives lost in road accidents and by the increasing number of injuries caused in accidents, as well as the heavy toll in terms of human suffering and effects detrimental to the economy arising from the lack of safety in the road network.

They should be particularly disturbed by the trend lately recorded in Hungary, which shows that the situation has deteriorated markedly since 1986. It is obvious, that the road safety policies need to be given fresh impetus which has to call for determined efforts by the Government, a contribution from the various agencies active in this connection in society, and greater awareness on the part of all road users. It must be reaffirmed that the official road safety policy will give clear-cut priority to measures designed to reduce road casualties significantly, and on a lasting basis.

2. AN OVERVIEW OF THE PRESENT SAFETY SITUATION

A total of over 2,400 people were killed in 1990 in road accidents in Hungary. The total number of persons killed and injured in road accidents was almost 40,000.

In 1990 the number of road traffic accidents showed a 14 per cent increase compared to the previous year, and the number of fatal accidents showed an almost 13 per cent increase. The number of fatalities increased by 13 per cent as well, but the number of all persons killed and injured increased by 15 per cent.

The number of persons killed per 100 injury accidents was 8, which means that the severity of accidents is very high.

Since 1982 the severity of accidents has been showing an upward trend, and all of the road accident data have been showing a significant deterioration since 1987, indicating a recent tragical crisis in the road safety situation of the country. The following reasons as principal factors contributing to road accidents are mentioned by experts:

- decreasing quality of service in the road network due to deteriorating pavement conditions and the lack of an extensive motorway system
- unacceptable technical features of the vehicle fleet and maintenance capabilities and
- aggressive attitude of the road users, especially the car drivers

Table 1

	1987	1988	1989	1990
Number of fatalities	1450	1562	1943	2185
Number of accidents (involving personal injury)	19,848	21,313	24,371	27,801
Persons killed per 100 acccidents	7.3	7.3	7.9	7.9

The human factors are the source of the vast majority of road accidents, 80 per cent of the injury accidents were directly caused by the motor vehicle drivers.

The most frequent types of erroneous human behaviour were the following:

- Excessive speed (28 percent of all the accidents caused by drivers)
- improper maneuvers (25 per cent)
- disobeying the yield rules (22 per cent)
- disobeying the rules regarding overtaking (7 per cent)
- lack of attention (13 per cent)

All of these causes played an increasing role in the last year compared to the previous years. The increase was between 10 and 26 per cent. In the last year 15 per cent of the injury accidents were caused by road users under influence of alcohol. The percentage of these accidents has increased significantly within the total number of injury accidents.

In addition, the proportion of cases when the guilty driver of a motor vehicle tries to escape leaving the site of the accident without helping the injured victim or victims has increased by about 70 per cent in the last year.

3. OFFENDERS AND VICTIMS

While the drivers of motor vehicles caused 87 per cent of the road accidents, they were mostly the victims as well. 48 per cent of all of the persons killed or injured in road accidents were drivers of a vehicle.

Both the number of drivers (causing accidents and being injured as well) and their proportion within the total number of persons (causing accidents and being injured in accidents together) have shown a dramatically increasing trend in the last years. 36 per cent of drivers causing accidents was 19 - 30 years old, and 22 per cent was 31 - 40 years old.

Regarding the driving experiences the data show that 26 per cent of drivers causing accidents had more than 10 years long driving experience.

Looking at the data concerning persons killed and injured we can realize the significant increase in the number and proportion of the killed and injured drivers. There has been more than 50 percent increase since 1986 in the drivers' group and almost 60 percent increase in the passengers' group.

The conclusion is that passenger car drivers being relatively young and experienced in driving, cause most of the accidents, and probably most of the hazardous situations. This group is probably the most frustrated part of the society recently. This risky group of drivers should be the target of activity that focuses on changing road users' behavior. There are frustrating periods of societies and frustrated groups of each society.

All of the facts mentioned before which contribute to road accidents clearly show the predominant role played by human behavior of the motor vehicle drivers. Such behavior is connected to the public image of the car ownership and car use, and may be strongly influenced by other social-economic factors.

The political and economic changes in the country during the last years for the significant part of the society lead to the impression that all of the rules and regulations of the "old system" were worth nothing. Now we are experiencing a time when there are no rules, just freedom, and the society in general has not reached the level of maturity to accept in everyday life the well known basic rule: that the boundaries of individual freedom lie where it infringes on the rights of others. The public must be aware that in certain fields, notably in the field of road traffic, these boundaries must be traced by regulations.

Moreover the public must learn again to obey these regulations in order to leave the recent suicidal attitude and avoid as much premature death of road users as possible.

Accordingly particular priority must be given to influencing those human factors that can lead to accidents by accomplishing the following tasks:

- to conduct more detailed studies and surveys so as to have a reliable basis for assessing which human factors are basically involved in road accidents within recent circumstances;
- to review, and if necessary change the domestic regulations, penalties and requirements in order to filter the chronic traffic violators;
- to establish a more effective driver education, go beyond the mechanics of vehicle operation, develop hazard perception, risk evaluation and decision making; discover their own limitation in information processing an decision making;
- to pay attention to post education, of active drivers with individual approach;
- to organize safety campaigns targeting: modification of human attitude and behavior, improve driving behavior in general;
- to arrange an adequate level of traffic supervision.

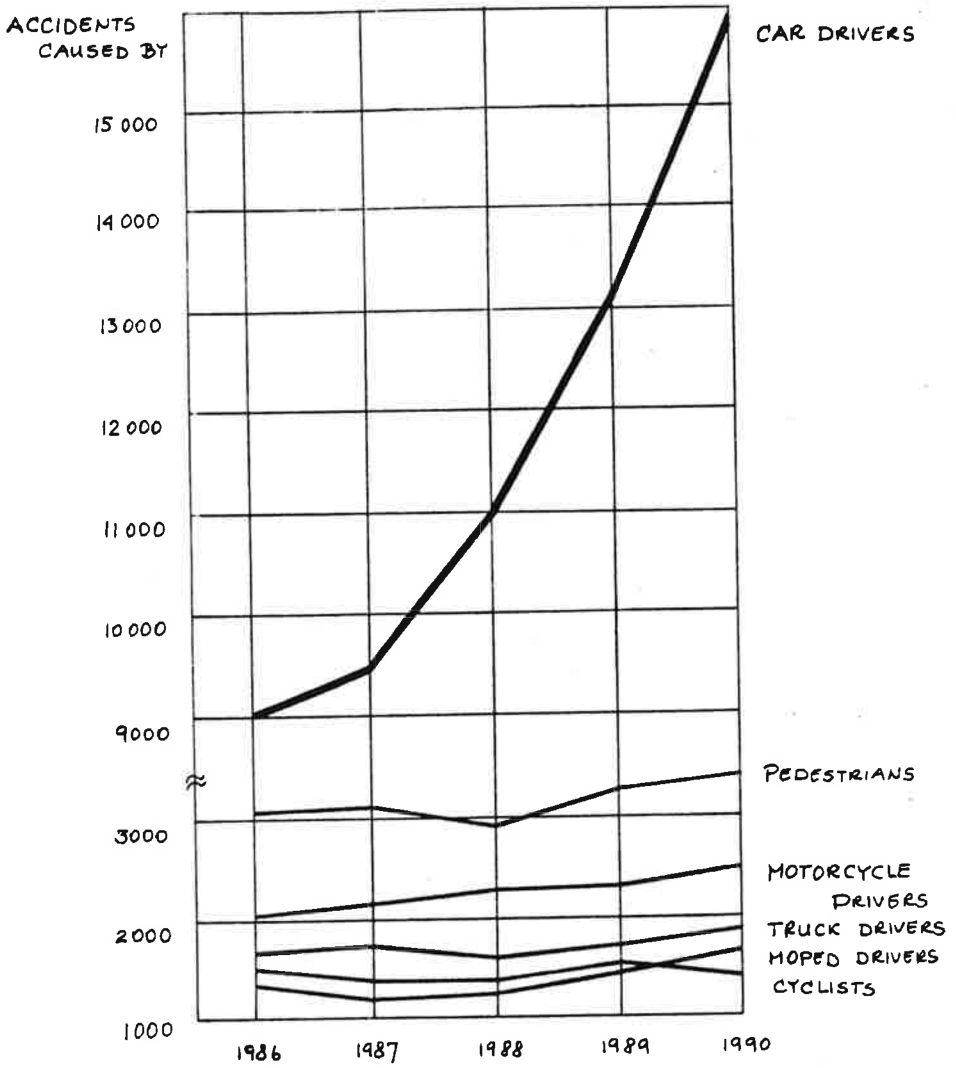

FIGURE 1

NUMBER OF ROAD ACCIDENTS

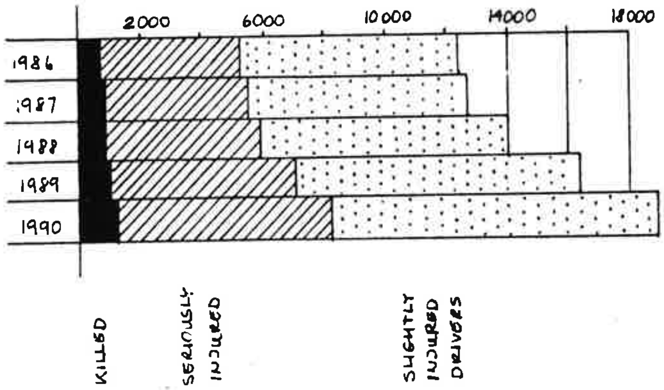

FIGURE 3

DRIVERS KILLED AND INJURED IN ROAD TRAFFIC ACCIDENTS

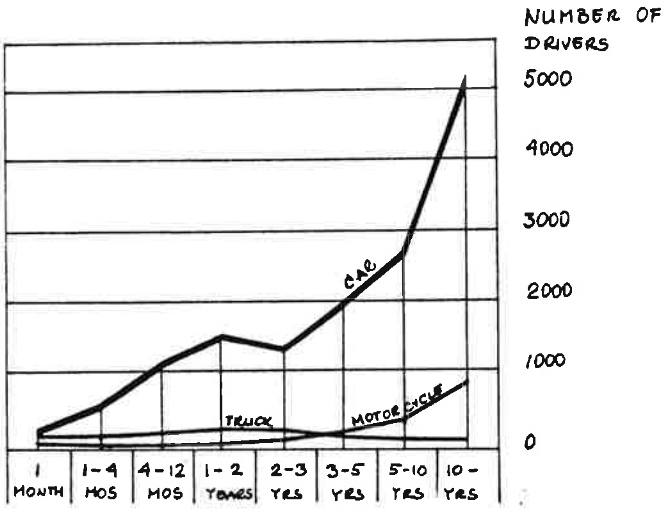

FIGURE 2

EXPERIENCE OF DRIVERS CAUSING ACCIDENTS

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IN-DEPTH ANALYSIS OF INTERACTIONS BETWEEN DRIVERS AND THE ROAD ENVIRONMENT - CONTRIBUTION OF ON-BOARD OBSERVATIONS AND SUBSEQUENT VERBAL REPORTS

SUMMARY

In-depth analyses of road situations and drivers' activity make an important contribution to improving driving conditions, whether in terms of the design of the road environment or the development and evaluation of driving aids. In this paper we will start by presenting an avenue of research that emphasises the analysis of the cognitive aspects of the regulation of driving. It will enable us to specify the interaction levels involved in the driving task. We will then describe a methodology for the analysis of driver behaviour in real driving conditions, involving techniques for the controlled observation of behaviour during the journey combined with subsequent verbalization techniques. The merits of such an approach will be discussed and examined on the basis of an analysis of driver activity in two particular road situations: crossing intersections and car-following.

1. INTRODUCTION

The different questions treated in the field of applied research emanate from complex situations, which in turn have to be taken into account to validate research findings and recommendations. The problems associated with driving cars, and more generally with road safety, represent a perfect example of that complexity, whose characteristics and implications for research have to be examined. As psychologists involved in research from an ergonomic perspective, one of the approaches we consider most useful is to analyse road situations and driver activity with the aim of identifying the conditions likely to facilitate the user's adaptation to the traffic system. From that perspective, it is necessary to identify and examine the situational demands to which drivers have to adapt while driving, as well as to analyse drivers' activity by describing their behaviour and explaining the psychological mechanisms underlying the management of their interaction with the road environment.

That approach is classic in ergonomic psychology and is based on analyses both of the prescribed task and of the effective task, according to the distinction used by LEPLAT and HOC (1983), which can be described as follows:

- The prescribed task is the task conceived by the designer of the system. It pre-exists the activity that it is designed to influence and determine to a greater or lesser extent. Analysing the task will thus consist of explaining the objectives that are to be achieved by the subject within the system, and the demands and constraints that he has to take into account.

- The effective task is what the subject actually does. It corresponds to the goals and conditions he effectively takes into account. The identification of that task thus calls for a study of the activity. Analysing the activity will then consist of showing how the subject reacts to the demands of the task, the goals he actually sets himself, the information he selects from the environment, the way he processes it and the responses he formulates.

The systematic study of driver behaviour in real driving conditions makes, in our view, a useful contribution for such analyses. Such an approach is characterised by the fact that it focuses on an analysis of behaviour and its determinants within the framework of the complex interactions that operate in real situations on the ground. It raises numerous theoretical and methodological problems that merit further investigation. It calls for advances as regards not only the theoretical models underlying the selection, organisation and analysis of behavioural and situational data but also the research techniques and methods utilised. It is thus based on an in-depth examination of models of the driving task and models of driver behaviour and the development of complementary techniques enabling several indicators of behaviour to be measured in order to confirm the hypotheses formulated about the psychological mechanisms that underly driving behaviour.

2. A CONCEPTUAL FRAMEWORK FOR THE ANALYSIS OF ROAD SITUATIONS AND DRIVING ACTIVITY

Research in this area has led to the identification of certain characteristics associated with the driving task that may serve as a general framework for analysing the activity. Driving a car is generally defined as a complex task of a dynamic nature, which is subject to temporal constraints, requires the driver to adapt continuously to the different and changing road situations he encounters, and involves the coordination and execution of various sub-tasks (ALLEN et al. 1971; NEBOIT 1982; VAN DER MOLEN & BÖTTICHER 1988). Furthermore, it is relatively unstructured, in the sense that the formal task (such as it is shaped by the rules of the highway code) only partially defines the conditions and procedures for carrying out that process of adaptation (SAAD 1975).

Drivers' adaptation with experience demonstrates their capacity to find heuristic solutions to the dynamic problems they are faced with in managing their journeys. That adaptation may be conceived as resulting from a structuring of the task, through the acquisition and organisation of knowledge about the structure of the road system, about the (formal and informal) rules governing its use and interactions with other road users, and about the dynamics of driving situations, as well as through the development of strategies for processing the information and rules of action.

Errors, incidents and accidents demonstrate the limits of that adaptation, whose determining factors need to be analysed. Many behavioural studies have shown that the operator's activity does not always correspond to the specifications of the prescribed (or formal) task. For instance, considerable disparities have often been found between the formal demands as regards speed control (SAAD & MALATERRE 1982) or adherence to safety margins (SUMNER & BAGULEY 1978; POSTANS & WILSON 1983; EVANS & WASIELEWSKI 1982).

Some research shows that drivers take time to become aware of conflicts with other users and display a certain inertia or rigidity in the regulating actions they execute in different types of road situation, such as crossing intersections (MONSEUR & MALATERRE 1969; GIRARD 1987). Factors connected with the features of the road environment (disparity between the structural characteristics of an intersection and the regulations governing it - MONSEUR & MALATERRE op. cit.) and factors related to driver characteristics (familiarity with a given situation - LOVEGROVE 1978) have been identified as the cause of these problems. Lastly, accident studies have highlighted the problems connected with the temporal constraints associated with the occurrence of accidents and have stressed the importance of predictive activity when driving (FERRANDEZ et al. 1986; MALATERRE 1987; FLEURY et al. 1988). The disparities between drivers' predictions and expectations and the events that actually occur during their journeys seem to be a result of processing errors and the late detection of critical situations, reducing the available margin for resolving them.

These different research studies are a good illustration of the differences that can exist between the prescribed task and the effective task in driving a car, and they raise the question of analysing the factors that might explain them. One of the main problems they pose relates to the driver's detection of and response to changes in the road situation. In effect, it appears that drivers do not treat some changes in situation as such, or do so too late in terms of safety requirements. Detecting changes in situations thus seems to constitute a critical aspect of driving (SAAD 1988).

The questions raised by this type of analysis dealing with the interaction between the driver and the road environment can be defined as follows:

- What in the driver's view constitutes a change in the road situation necessitating an immediate or anticipatory regulating action?

- To what extent does the road environment facilitate the detection and anticipation of changes in the road situation?

These changes of situation may be linked to, among other things:

- Changes in the road infrastructure: for example, a main road that passes through an urban area, a bend after a straight section of road, or an intersection.

- Changes connected to the traffic or the behaviour of other users: a roaduser arriving at or crossing an intersection, for instance, or a driver slowing down in the same lane.

For the driver, these changes of situation may be more or less predictable, more or less expected, depending on whether or not he has the knowledge and the information needed to detect and identify them during the course of his journey. The way he deals with these changes may be a function of various factors, such as the nature of the change (whether functional or regulatory), its extent, its duration and the driver's own criteria determining his choice of regulating action to be taken in the different cases.

Briefly summarised, these elements characterising the task and the nature of certain malfunctions point to an avenue of research that puts the emphasis on an analysis of the cognitive aspects of driving and the purpose of which is to analyse the knowledge and representations that drivers have of various road situations, the conditions and mechanisms of their activation while driving, and the regulating strategies associated with them.

In the field of cognitive psychology, the notion of representation refers to the idea of an internal model developed by the subject for dealing with complex situations (NORMAN 1983). The symbolic structures which enable the subject to deal with such situations result from a construction based on an analysis of the situational data and the retrieval of stored knowledge, as well as on inferential mechanisms (SENACH & FALZON 1985, FALZON 1989). These representations serve as a guide for the planning and control of the activity. They thus play an important "functional" role (LEPLAT 1985), in particular by enabling the subject to anticipate the result of his own actions and to make predictions about the evolution of situations in which he finds himself. The effectiveness of these representations depends on their homomorphisms with "reality".

In that respect, the driver's behaviour in a particular situation is regarded as a function of the information available at a given moment (both information actually present in the road environment and information stored in the driver's memory, acquired with experience), of its processing and of the decision-making criteria underlying the regulating action he takes. From an ergonomic perspective, the search for ways of reducing the frequency of the disparities mentioned above calls for a joint analysis both of the environmental factors likely to play a role in their occurrence and of the characteristics of the driver's activity.

3. A METHODOLOGY FOR THE ANALYSIS OF DRIVER BEHAVIOUR IN REAL DRIVING SITUATIONS: ON-BOARD OBSERVATION AND SUBSEQUENT VERBALISATION

The study of the activity in real driving situations seems to us to be an appropriate approach if one wants to identify the "effective task(s)", which is to say analyse what drivers really do in different road situations. To our knowledge, while much experimental work has been conducted in controlled situations (on circuits or in the laboratory) to analyse the different skills required for the driving task, little work has considered the application of these skills in the broader context of the global driving task. Much research has been based on external observations of behaviour (from a fixed observation point). That was the case, for instance, of the study into headways adopted in car-following. They enabled the critical nature of the headways adopted by drivers in that type of traffic to be highlighted. This type of approach makes it possible to evaluate the frequency with which such behaviour occurs and the effect of different variables to be estimated at a global level. On the other hand, it provides little information about the frequency with which a given driver is or is not involved in these critical situations, in what circumstances and for how long. Similarly, the mechanisms by which the driver controls his driving and the regulating actions he carries out cannot be studied in depth. To that end, it is necessary to develop complementary methodologies, such as observations of the driver's behaviour during a journey made from within the vehicle itself. This type of research technique, based on the use of broader functional units of analysis, should also make it possible to analyse how the driver organises and controls the various sub-tasks involved in driving, how he weights them and takes account of the different demands associated with driving in the context of the complex interactions at work in real situations.

A methodology was devised for making controlled observations of driver behaviour in real driving situations along specific routes, which were chosen on the basis of the type of task to be studied and the hypotheses to be tested. To complement those observations, in-depth interviews were conducted with the drivers in order to determine their objectives and strategies, their knowledge, and their representations of the driving situations studied. This methodology should make for greater control over the situational variables and a more detailed analysis of drivers' behaviour.

3.1 An instrumented car for the observation of driver behaviour

An instrumented car was designed in the psychology laboratory at INRETS in order to measure the following indicators:

- time (enabling the observations to be dated),
- distance (enabling the observations to be situated in a spatial context),
- the speed practised by the driver,
- the use of the brake.

A video recording of the visual scene encountered along the route was made simultaneously and the four indicators mentioned above were projected on the video screen. This observation technique, combining a video recording of the driving scene with the simultaneous recording of different indicators, produces a more sophisticated analysis of behaviour in real driving situations. It results in a more detailed characterisation of road events occurring during the journey and a more accurate analysis of the regulations executed by the driver. In addition, the recordings constitute a data bank that can be used for further research, enabling the levels of analysis to be further refined if need be, or the number of situations studied to be increased.

3.2. Assisted verbalization techniques

The purpose of these interviews was to complement the analysis of observed behaviour by seeking in particular to identify the knowledge and representations that drivers have of the situations studied and to find out what rules they apply in managing those situations. The interview carried out after the experimental drive is primarily based on subsequent verbalization techniques (BAINBRIDGE 1979; LEPLAT & HOC 1981).

Immediately after his journey was completed, the subject was interviewed at length. The interview took place in a room, and the video recording of the subject's journey was shown on a television screen, serving as a basis for the conduct of the interview. The driver was asked to comment on his driving, especially when carrying out certain manoeuvres, with the aim of recreating the sequence of events. The recording helps the driver to recall his behaviour and the events that took place while he was driving, and enables him to make more accurate comments about his behaviour, especially as regards the environmental conditions which influenced him and the "rules of action" that came into play in the various situations he encountered.

The methodology used is thus based on two techniques for investigating driver activity: the observation and measurement of behaviour in particular road situations and the questioning of drivers after their journey. Hence, it entails an analysis both of "spontaneous traces" - those resulting from the subject's activity in ordinary situations - and "provoked traces" - those induced by the researcher seeking to obtain information about that activity which the subject does not provide spontaneously (LEPLAT 1982). The complementarity of these research techniques has to be stressed. "The interview enables us to make sense of the observed behaviour, to obtain information about unobservable processes, and to hear a personal account of the situation. Observation gives access to behaviour that cannot be put into words, as well as illustrating, explaining and putting into perspective what drivers say about their activity" (NOULIN 1987). The intrinsic validity of these methods, and hence the data they enable us to obtain, and their respective contributions to the analysis of the phenomena concerned nevertheless remain to be examined attentively (CUNY 1979; BAINBRIDGE op.cit, LEPLAT op.cit).

4. IN-DEPTH ANALYSIS OF INTERACTIONS BETWEEN DRIVERS AND THE ROAD ENVIRONMENT IN TWO ROAD SITUATIONS

This methodology was used for carrying out two recent research studies, one dealing with the negotiation of intersections (SAAD et al. 1990) and another involving a detailed analysis of driver behaviour when driving along a motorway (SAAD & KHOUDOUR 1991). For the purposes of illustrating our approach, we will explain some of the dimensions taken into account in these analyses and their interest for understanding the way drivers behave in the situations concerned.

4.1. Analysis of drivers' representations of changes in situation and strategies when crossing intersections

The intersection can be regarded as a transitional zone along the road where the driver may have to adjust his speed so as to comply with regulatory or functional requirements. More specifically, we would define it as a zone of potential interaction with one or more other road users. Our research was aimed at finding out how, in the dynamics of driving, do drivers treat changes in the situation that intersections are supposed to represent? We are interested here in the effective regulations practised by the drivers and the identification of the conditions of that regulation.

The methodology used entailed making observations from within the instrumented car (described above) during an actual drive on the public highway. In addition, in-depth interviews were conducted with each subject after the journey using two types of aid (presentation of the video recording of their journey and slides of different scenarios of interaction with other users at the junctions studied). All the subjects were required to pass through five intersections, four of which were on a main highway with central islands at each intersection and the other on a secondary road with no island. At all the intersections concerned, there were road signs giving the subjects priority over other users. Two groups of drivers took part in the experiment: 12 experienced motorists and 10 novices.

We analysed the adjustments in speed executed by the drivers at the five intersections concerned. For the purposes of this analysis we selected only those situations where the subject's progress was not hampered by the presence of longitudinal traffic on the same lane. We singled out, on the one hand, the regulating actions made when there was no traffic and, on the other hand, those made when traffic was visible on the lateral branches of the intersection and likely to interfere with the subject's trajectory. We compared average speeds at the approach to the intersection (400 m from the centre) and on arrival at the intersection (50 m from the centre).

The results revealed variations in speed regulation at the different intersections. The strategy adopted in each case appeared to be a function of the driver's appreciation of the characteristics of the road infrastructure and the traffic situation.

In the absence of traffic at the crossroads, it emerged that on the same road, the main highway, drivers modified their speed significantly in the approach to only two of the four intersections studied. That speed regulation is linked to infrastructure characteristics which, in the driver's view, in some way mark a discontinuity in relation to the previous driving situation (extent of the road installations and visibility over the whole intersection or a change in the conditions of his progress in approaching the intersection). In the other cases, the cues present at the intersection are not sufficient to prompt a reduction in speed, attesting to the treatment of the intersection as a zone of transition in the journey. Our findings confirm the idea put forward by MONSEUR & MARCHADIER (1971) that it would be desirable for road design either to highlight the intersection visually or to incorporate structural constraints that clearly identify it as a transitional zone.

The presence of traffic at the intersection has an influence on the regulating actions taken: when that was the case, there was a significant modification of speed at the four intersections. The presence of another road user at the crossroads is thus apparently an element contributing to the representation of a change in the situation calling for some regulating action. This indicates, moreover, that although they have priority, drivers take account of their interaction with other road users approaching the intersection from another direction. Adjusting their speed constitutes a way for drivers to put themselves on the alert and enable them to determine the circumstances of that interaction. These findings concur with those of previous studies (MONSEUR & MARCHADIER op.cit.; CHRISSIKOPOULOS et al. 1983) using different methods (roadside observation of unalerted drivers).

Analysing the interviews enables the conditions of that regulation to be ascertained. It illustrates the diversity of cues taken into account by the driver in his assessment of the situation: localisation of the other road user at the intersection, relative proximity, speed of approach of the other user, and so on. That analysis reveals the importance of the assumptions made by the driver as regards the behaviour of other users. They contribute to his assessment of whether the interaction is of a critical nature or not. Depending on the outcome of that assessment, several types of possible regulating action are mentioned: paying closer attention to the behaviour of one or several other users at the intersection, establishing some communication with those road users in the event of protracted uncertainty over their intentions, and finally, reducing speed. Depending on how the situation evolves, the driver may execute one of these regulating actions or a combination of them. In-depth accident analysis relating to this type of road situation (VAN ELSLANDE & MALATERRE 1987; FLEURY et al. 1988) has shed light on the difficulties sometimes encountered by the driver with the right of way in processing these parameters and interpreting the behaviour of the user on the other arm of the intersection. Our findings suggest that the design of driving aids for this type of situation should take account of the dynamic and interactive nature of the management of the interaction.

Lastly, it has to be pointed out that there appeared to be no significant difference between experienced drivers and novices as regards their negotiation of the intersections on the main highway. An examination of their speeds shows that novices generally drive through intersections as fast as experienced drivers, which could prove prejudicial to their safety in view of their capacity to detect and resolve conflicts.

The results obtained at the fifth intersection located on a secondary road essentially reveal the effect of driving experience: the experienced drivers modified their speed significantly at the intersection while the novices did not. These differences seem to be linked to the difficulties of detecting the intersection in the approach to it (an effect of perceptive continuity) and to the representation of the relative status of the two roads. It may be assumed that the representation of the status of the road on which the intersection is located is an important element in determining the regulating actions that are taken. Finally, it is important to emphasise that the degree of skill seems to be more apparent in the execution of some tasks than of others.

In conclusion, the differences observed in the performance of the same formal task - crossing an intersection when one has priority - have to be stressed. These findings highlight the multiplicity of the mechanisms that may explain the adjustments of speed effected by drivers and hence the means that could be used to exert an influence on those adjustments. Such analyses contribute to identifying categories of driving problems and hence the approach to be adopted in the design of the road system and the development of driving aids (SAAD & MAZET 1991):

- Firstly, there is the problem of singling out infrastructure characteristics likely to facilitate the identification of road situations and the detection of changes in the situation, which can be grouped under the general heading of **"readability of the road"**.

- A second set of problems relates to the management of the interaction between road users, in a given space, reflected by the cues and modes of communication likely to facilitate the dynamic management of that interaction.

4.2. Detailed analysis of environmental conditions and drivers adaptation in car-following on a motorway

In this type of road situation the driver's adaptation is crucially dependent on his control of his interaction with other users that could interfere with his driving and on the maintenance of "safety margins" that are sufficient to enable him to deal with possible incidents. That margin takes the form in particular of the headway he leaves between himself and the vehicle in front. Our research was aimed at finding out how the car driver manages this type of road situation and how he regulates his speed and controls his distances vis-à-vis other vehicles applying strategies that need to be identified. This point is particularly interesting from a psychological point of view. In effect, driving in these conditions is only possible if the motorist makes assumptions about the behaviour of other drivers, in particular about whether they will adhere to the "average" behaviour of the other vehicles in the same lane without stopping, braking suddenly or changing lane for no apparent reason. Understanding the way this "stock" of assumptions is built up with experience and how they are activated when driving is crucial for deciding what measures need to be taken to improve road safety.

As we stressed above, little research has been carried out using on-board observation of driver behaviour. The most important work in this field was done by FULLER (1980, 1981, and 1986) using a sample of drivers of heavy goods vehicles engaged in a particular type of driving activity, namely driving in convoy (which requires the driver to follow behind another vehicle for a long period of time). He demonstrated that the headways adopted by the drivers varied according to the type of car-following situation (stable following, before overtaking or after braking, or a slower user catching up). Few analyses of car drivers' behaviour have been made using this methodology. A previous qualitative analysis (CARRÉ & SAAD 1981) showed the merits of such an approach, illustrating the role played by drivers' familiarity with the route as regards not only the headways adopted during the journey but also the more general strategies of lane use enabling drivers to manage their interaction with other drivers and escape from the constraints of car-following situations. We thus conducted a new study using the methodology described earlier, allowing greater control over the situational variables and a more detailed analysis of drivers' strategies.

The route chosen for the experiment was a stretch of urban motorway in the Paris region, covering an overall distance of 11 km. This type of motorway is a complex network comprising a lot of junctions (slip-roads) and points where drivers have to choose which direction to take. There is generally a high volume of traffic, often resulting in car-following situations. Two groups of male drivers took part in the experiment - one of four experienced drivers and one of three novices.

Our work had an important methodological objective: it was designed not only to describe the behaviour of drivers in this type of situation (in terms of the headway they maintain with the vehicle in front, the speeds at which they travel, the lanes they use, and the manoeuvres they carry out) but also to identify the cues likely to best describe the road situations encountered during the journey.

4.2.1. Characterisation of the surrounding traffic and other road users' behaviour

We sought in particular to monitor the surrounding traffic conditions during the journey. Our view is that, while the regulations made by the driver depend on the immediate interaction with the vehicle in front, they are also a function of traffic conditions both in adjacent lanes and further ahead. Indicators on a scale of 1 to 5 were used to describe the traffic situation in each lane (from 0 = no traffic in sight to 5 = lanes saturated). From that, an overall traffic indicator could then be calculated (average local traffic).

The manoeuvres carried out by other drivers are also recorded when they have a direct influence on the subject's driving, which is to say when they occur immediately in front of him and in relation to the lane in which he is travelling. We distinguished between the following cases:

- insertion of another road user in front of the subject
- road user in front leaving the lane
- braking by vehicle in front
- insertion and braking in front
- vehicle in front but no manoeuvre

Lastly, the speed of the surrounding traffic in relation to the subject and the occupation of the adjacent lanes are also gauged by observing whether the subject is overtaken or not by another vehicle.

4.2.2. Characterisation of the infrastructure

Similarly, it is important to take account of the characteristics of the infrastructure, which may have an influence on the strategies adopted: avoiding other road users close to motorway access roads and the choice of lane in zones where directions are marked, for example. We characterised several types of zone as follows:

- entry zones, where there is the possibility of interference from other vehicles entering the motorway;
- directional zones, where the driver has to choose between alternative directions;
- bifurcation zones, which follow zones where a direction has to be chosen;
- insertion zones, where the subject enters the motorway via a sliproad or as a result of the merger of two motorways;
- and lastly, "straight" stretches of road which are comparatively "stable".

Behaviour indicators and indicators characterising road situations were thus recorded on a continuous basis at intervals of 100 metres, resulting in 110 points of measurement for each subject. This form of sampling provides a good summary of the behaviour of the subject during the test drive to the extent that it enables in particular all his changes of lane to be recorded. Furthermore, it enables these actions to be localised relative to the road infrastructure in a manner that is homogeneous for all the subjects.

Hence, we sought to develop a methodology providing for a detailed analysis to be made of the driving situations encountered during the journey and for drivers' behaviour to be monitored and recorded.

As a first step, we made a global analysis of the situations and behaviour patterns using correspondence analysis in order to examine the relevance of the indicators selected to describe the driving conditions encountered during the journey and, secondly, to obtain an overview of drivers' practices and the variables likely to explain them. On the basis of these analyses, we were able to characterise both drivers' behaviour and, most importantly, the environmental conditions likely to explain it. In particular, we were able to highlight the existence of a certain hierarchy amongst the constraints weighing on drivers' activity (immediate interaction with the vehicle in front, degree of constraint associated with the surrounding traffic, structure and characteristics of the infrastructure). The level of driving experience seems to be an important factor in the behavioural adaptation to various constraints, whether in terms of the frequency with which drivers are involved in critical situations (situations in which the margins observed are short, i.e. 40 metres or less), their choice of lane or the speed they adopt. This global analysis enabled us to identify general tendencies which will be used in the continuation of this research. They focus attention on a number of "critical" driving situations from the point of view of the margins adopted by drivers, defined by a combination of traffic conditions and infrastructure characteristics. They lead us to formulate hypotheses about the strategies underlying these practices. The subsequent analysis of the interviews conducted with the subjects will enable us to shed further light on this point. We will seek in particular to verify and support these hypotheses.

It has to be pointed out that this global analysis of driver behaviour could not take account of an important dimension of driving activity, namely its sequential aspects. In the next phase of this research, we will have to analyse in greater detail how drivers shift from one situation to another while driving (for example, how they go from a car-following to a less constrained situation), and under what conditions. It is possibly in terms of the driver's control over these transitions and the types of regulating action he takes (change of speed and/or lane) that experience will prove to play the most decisive role. Lastly, this more sophisticated analysis of observation data should also enable the temporal aspects of risk-taking to be explored, which entails identifying the circumstances in which critical safety margins are adopted and for how long.

5. CONCLUSION

The studies we have presented here represent the first part of a programme of in-depth research into drivers' activity in various road situations. It illustrates an analytical approach in the context of the real environment, which is designed to identify the main determinants of behaviour in particular situations. It is aimed at highlighting the characteristics of drivers' activity using complementary indicators: the observation and measurement of behaviour and verbal reports, which yield data whose analysis and comparison should confirm the hypotheses formulated about the psychological mechanisms underlying driving behaviour.

This type of study carried out in the field requires considerable resources for the prior analysis of road situations, the organisation and conduct of the research, the structuring and exploitation of the data and, lastly, the synthesis of the findings obtained from using two research techniques. Despite the attendant constraints and difficulties, in our view this type of approach makes a useful contribution to analysing drivers' behaviour. It has to be regarded as complementary to other research techniques, such as external observation of behaviour, experimentation and simulation. The interest of this approach is that it attempts to analyse drivers' actual practices in the complexity of real driving situations. That knowledge is particularly important when it comes to improving the ergonomics of the road system, whether in terms of the design of the road environment or the development and evaluation of driving aids. A detailed analysis of the role played by the characteristics of the road environment in the regulations executed by the driver should contribute to identifying solutions as regards road design. This knowledge of drivers' actual practices in performing certain tasks also enables us to tackle the problem of the introduction of new driving aids and the possible changes they may engender in drivers' behaviour.

In the long term, this type of approach aimed at studying driver behaviour in a complex, realistic task, and in particular at identifying the "rules of action" and the "conditions" for applying them in specific driving situations, should eventually contribute to the development of models of driver activity in the form of "production rules" (NEWELL & SIMON 1972) or "scripts" (ABELSON 1981), as suggested by JOHANNSEN & ROUSE (1979). This kind of research should provide the empirical data needed for that kind of formalization.

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REFERENCES

ABELSON R.P. 1981, Psychological status of the script concept, American psychologist, 36, 7, 715-729

ALLEN T.H., LUNENFELD H. & ALEXANDER G.J. 1971, Driver information needs, H.R.R, 36, 102-115

BAINBRIDGE L. 1979, Verbal reports as evidence of the process operator's knowledge, Int. J. Man-machine studies, 11, 411-436

CARRÉ J.R. & SAAD F. 1981, Etude dans une perspective de sécurité sur le comportement des conducteurs et la circulation en file sur autoroute urbaine, Rapport ONSER

CHRISSIKOPOULOS V., DARZENTAS J. & McDOWELL M.R.C. 1983, Decelaration of major-road vehicles approaching a T-Junction, Traffic Engineering & Control, 433-436

CUNY X. 1979, Differents levels of analysing process control tasks, Ergonomics, 22, 4, 415-425

EVANS L. & WASIELEWSKI P. 1982, Do accident-involved drivers exhibit riskier everyday driving behaviour? Accident Analysis and Prevention, 14, 1, 57-64

FALZONE P. 1989, Ergonomie cognitive du dialogue, Presse Universitaire de Grenoble

FERRANDEZ F., FLEURY D. & MALATERRE G. 1986, L'étude détaillée d'accidents: une nouvelle orientation de la sécurité routière, Recherche Transport Sécurité, 9-10, 17-20

FLEURY D., FERRANDEZ F. & LEPESANT C. 1988, Analyse typologique des manoeuvres d'urgence en intersection, Rapport INRETS N° 62

FULLER R.G.C 1980, Time headway in different vehicle-following manoeuvres, Perceptual and Motor Skills, 50, 1057-1058

FULLER R.G.C 1981, Determinants of time headway adopted by truck drivers, Ergonomics, 24, 6, 463-474

FULLER R.G.C 1986, Unsafe following: a possible cause, Cinquième congrès international de l'ATEC

GIRARD Y. 1987, Les comportements en intersection à travers l'analyse des accidents, In: F.SAAD (ed.), L'analyse des comportements et le système de circulation routière, Actes INRETS

JOHANNSEN G. & ROUSE W.B. 1979, Mathematical concepts for modeling human behaviour in complex Man-Machine systems, Human Factors, 21, 6, 733-747

LEPLAT J. 1982, Perspectives méthodologiques pour l'étude des activités mentales, Le travail humain, 45, 2, 347-356

LEPLAT J. 1985, Les représentations fonctionnelles dans le travail. Psychologie Française, 30, 3-4, 269-275

LEPLAT J. & HOC J.M. 1981, Subsequent verbalization in the study of cognitive processes, Ergonomics, 24, 10, 743-755

LEPLAT J. & HOC J.M. 1983, Tâche et activité dans l'analyse psychologique des situations, Cahiers de psychologie cognitive, 3, 1, 49-63

LOVEGROVE S.A. 1978, Approach speed at uncontrolled intersections with restricted sight distances, Journal of Applied Psychology, 63, 5, 635-642

MALATERRE G. 1987, Les activités sous contraintes de temps: le cas des manoeuvres d'urgence en conduite automobile, Thèse de 3° cycle

MONSEUR M. & MALATERRE G. 1969, Prise de décision des conducteurs aux carrefours, Le Travail Humain, 32, 3-4, 217-238

MONSEUR M. & MARCHADIER B. 1971, Franchissement des intersections

et prise de risque, Une méthode d'analyse de la situation de conduite aux carrefours, Le Travail Humain, 34, 1, 81-98
NEBOIT M. 1982, L'exploration visuelle du conducteur : rôle de l'apprentissage et de l'expérience. Cahier d'Etudes ONSER, N°56
NEWELL A. & SIMON H. 1972, Human problem solving, Printice-Hall, Inc.Englewood Cliffs, N.J.
NORMAN D.A. 1983, Some observations on mental models, In: GENTNER D., STEVENS A.L., Mental models, 7-14, Hillsdale, New Jersey, London
NOULIN 1987, Méthodes psychologiques, In: CAZAMIAN P., Traité d'ergonomie, Editions Octares, Entreprises
POSTANS R.L. & WILSON W.T. 1983, Close-following on the motorway, Ergonomics, 26, 4, 317-327
SAAD F. 1975, Structuration de la tâche et activités perceptives dans la conduite automobile, Document interne ONSER
SAAD F. & MALATERRE G. 1982, Régulation de la vitesse, aide au contrôle de la vitesse, Synthèse, Rapport ONSER
SAAD F. 1989, Risk-taking or danger misperception Revue-Transport -Sécurité, English issue, N° 4
SAAD F., DELHOMME P. & VAN ELSLANDE P. 1990, Driver's speed regulation when negotiating intersections, In: KOSHI M. (ed.), Transportation and Traffic Theory, Elsevier
SAAD F. & KHOUDOUR L. 1991, In-Depth analysis of driver behaviour in car-following: Methodological aspects and global behaviour analysis, PTRC, 19Th Summer Annual Meeting, Traffic management and road safety, Proceedings of seminar K
SAAD F. & MAZET C. 1991, Analysis of road situations and drivers' activity in a perspective of cognitive ergonomics, In: QUEINNEC Y. & F. DANIELLOU (eds.), Designing for everyone, Proceedings of the 11th congress of the International Ergonomics Association (Vol. II), London: Taylor & Francis Ltd.
SENACH B. & FALZON P. 1985, Représentations opératives, cognitives et circonstancielles, Colloque de la SFP., Dialogue entre Recherche et Pratique pour la Psychologie du Travail, Paris, 8-9 Mars.
SUMNER R. & BAGULEY C. 1978, Close following behaviour at two sites on rural two lane motorways, TRRL LR 859, 7 p.
VAN DER MOLEN H.H. & BÖTTICHER A.M.T. 1988, A hierarchical risk model for traffic participants, Ergonomics, 31, 4, 537-556
VAN ELSLANDE P. & MALATERRE G. 1987, Les aides à la conduite, analyse des besoins en assistance des conducteurs, Rapport INRETS, N° 23

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MALFUNCTION OF COMMUNICATION AND BAD TRAFFIC CLIMATE - A SOURCE OF SOCIAL CONFLICTS LEADING TO TRAFFIC CONFLICTS

SUMMARY

A project is presented whose target was, to find out hints for risk for traffic-conflicts and in the long run for accidents, which can be found in the interaction and the behaviour of cardrivers.

A special observation method was used where the observers were sitting in the same car as the observed person. One of the working-hypothesis was, that there exist a lot of communication possibilities by using car movements or other signs by the cardriver.

Two main results are discussed and interpreted.

1. INTRODUCTION

Two years ago at the ICTCT-workshop in Munich a project just starting then was presented. The title was: "A Method to Identify Dangerous Behaviour in Traffic".

Target of this project was, to find out which hints for the risk for traffic-conflicts and in the long run for accidents we can find in the behaviour and in the interaction of cardrivers by using a special observation method. With this method the observer, sitting in the same car as the observed person, was instructed to register specially defined behaviour of the observed person and of the traffic participants around him/her.

"Specially defined" behaviour it is said because there was not so much concentration on the usual handling tasks but more on the characteristics of interaction and communication between the driver and the other road users.

Before the field study was started it was tried to find out which information can be exchanged between road users. Normally it is seen to be very difficult to explain one's actions or to tell about one's plans when driving a car.

2. COMMUNICATION IN TRAFFIC

The hypothesis was established that there are a lot of communication possibilities by using car movements, or other signs which were used by motor-vehicle-drivers either knowing about the effects of their behaviour or which were "unconciously" used without knowing about the possible effects for the other road users. E.g. driving with too little distance behind another car can cause a feeling of being pressed by the driver in front. This may or may not be intended by the driver following. As an other example one can imagine a driver being in the middle of a complicated intersection with an overflow of information who tries to cross just before a pedestrian without perceiving him, who than feels endangered.

Some signs being used in traffic:

Coming from the driver personally: e.g. waving the hand, nodding or shaking the head, looking into the mirrow

Signs coming "from the car": braking (sometimes very short, which means "keep more distance"), blinking (e.g. lorry-drivers sometimes use the left indicator to signalize to a car, which wants to overtake, that this is not possible now), driving very close to the other resp. pressing the other to tell him, that he should go on faster, driving to a crossing very fast and braking in the last moment which makes road users on the priority road give up their right of way etc.

All of these movements and signs can be related to different emotional meanings. The reactions following certain types of road user's behaviour have to be interpreted basing on hypothesis on how these types of behaviour are perceived.

We tried to register if the actions resp. reactions of the observed persons were intended or not: It had to be found out, if for example person A wanted to signalize to person B that he should renounce on his right of way on purpose, or if this was not intended so.

3. SOME RESULTS OF THE FIELD-STUDY

Two important aspects concerning the perception of other road users' behaviour could be found out:

a) Car drivers often do not realize that a lot of information coming from their car might be potentially important information for the others

   E.g., driving with rather high speed to a cebra-crossing where pedestrians were almost starting to cross the street makes that pedestrians stop going on further or start going very fast or running.

b) Such "informations" obviously have strong emotional effects which in the further run lead to - emotional - reactions such as "passive resestance" of pedestrians (e.g. walking more slowly on purpose).

Very often it seems that motor-vehicle drivers do not at all realize that pedestrians or bicylists are present although it was daylight, the perspective was open (no curve or trees etc.), no other important processes were disturbing the driver's concentration. etc.

4. INTERPRETATION

The interpretation and generalisation of the two aspects mentioned above is:

o Car drivers often do not expect the presence of other traffic participants (in that sense: "What should not be there, cannot be there").

o an overfloaw of information coming from the traffic situation, is often the consequence of the fact that they drive with too high speed. With "too high" an inadequate speed with respect to situational cues is meant and although one might expect the observed persons to decelerate, they don't.

o) It seems as if many motor-vehicle drivers are not conscious about the importance of using signs such as blinking or waving the hand in order to inform pedestrians or cyclists. It is as if they had the hypothesis that only other motor-vehicle drivers were eager to get informations about ones actions and plans.

These aspects reflect a bad traffic climate between different road user groups and does not support cooperative behviour in traffic.

To minimise risk in traffic it seems that traffic safety experts have to give cues to car drivers to remind them of the existence of other road user groups and to provide for rigorous reductions of speed in mixed traffic areas, e.g. by rebuilding streets, so that the necessity to slow down can easily be understand (see "readability" in the paper of SAAD above).

REFERENCES

CHALOUPKA CH., RISSER R. & ROEST F. 1991, Methode zur Identifizierung von Verhaltenscharakteristiken, die auf erhöhte Unfallgefährdung hinweisen, Unpublished Research report, FACTUM, Vienna

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RISK PERCEPTION IN DRIVERS WITH DIFFERENT DRIVING LICENCES

SUMMARY

The problem of the risk in driver's profession is on the one hand a clear fact as a result of participation in traffic but on the other hand that problem appears seldom in public discussion. It is sure, that some risk must be accepted by every road user in the moment, when they enter the road. A certain amount of risk is simply the part of road users' status.

The perception and acceptance of risk could be tied with many factors, such as: age, sex and experience of drivers. It is possible to formulate the hypothesis about relation between the level of risk and the kind of vehicle which has been driven, the category of driving licences, etc.

To study that problem, the Transport Psychology Unit of Jagiellonian University together with the Traffic Research Group of Institute of Psychology of the University of Uppsala has prepared the special form of questionnaire consisting of 126 questions. The group of subjects consisted of 448 Polish drivers with different cathegories of driving licences.

The level of Risk Acceptance Factor (RAF) for owners of different driving licence is significantly different. RAF is tied with the practice of risk behaviour on the road.

We used two following measures: The Scale of Declaired Risk and the Scale of Undertaken Risk. The result of our research has shown two important trends. The highest level of RAF we observed in the group of lorry drivers (category C). Quite lower but near average RAF was characteristic for the group of car drivers (category B). The lowest RAF was typical for the group of bus drivers (category D). We could not find a clear tendency in the group of motorcyclists (category A) and drivers of heavy lorries with trailers (category E).

1. INTRODUCTION

Problems tied with risk taking on the road belong to the group of problems which are very important from the point of view of traffic safety. Practically risk must be taken by everybody who wants to become a road user. Very often two kinds of risk are mentioned: objective risk which is a direct result of the situation on the road, and the subjective risk which is tied with the individual attributes of road user (NÄÄTÄNEN & SUMMALA 1976). The level of the subjective risk influences directly driver's behaviour in dangerous situations. Undoubtly the risk is related in bigger part with the character of personality (BENA, HOSKOVEC & STIKAR 1968). But the risk is also tied with other factors. From a technical point of view we can fix several factors of risk minimalization. Engineering parameters of the road (the width, the shape of the road, the kind of its surface, the environment etc.) could increase or reduce the level of risk. The technical parameters of vehicles play a similar role (KLEBELSBERG 1969). The kind of driven vehicle is a very important thing. It is usually tied with the category of driving licence in accordance with international regulations. In reality, the category of driving licence contains components such as age and experience. Therefore, it could be a general determinant of risk.

For that reason we can formulate the general hypothesis:

> The level of accepted risk and the level of risk taken is connected to the category of driving licence.

2. METHOD

In our research we used the special questionnaire whcih has been prepared together by the Traffic Psychology Group of University of Uppsala (Sweden) and Transport Psychology Unit of Jagiellonian University in Cracow (Poland). The questionnaire contains 126 questions. In the bigger part they allowed to measure the Risk Acceptance Factor (RAF). The respondents had to give answers on 6-degrees scales:

1	2	3	4	5	6
never	very seldom	rather seldom	sometimes	often	very often

In the last part of the questionnaire we asked for data about the number of kilometers driven by respondents, their places of living, possibilites of using a car, evaluation of their own quality of driving and frequency of errors made by themselves. Very important were such data as: age, sex, education and the type of vehicle. The subject had to inform us about his/her accidents in the last time. The questionnaire was anonymous.

3. SUBJECTS

In our investigation 445 persons (72 females and 373 males) took part. 100 of them lived in villages, but others in the city. The range of age was 18 - 65 years. The group of 143 respondents have had basic education, the group of 212 respondents had a middle education and 90 persons had high education. The research took place in May 1990 in Cracow District.

4. RESULTS

The analysis of the results shows several groups of drivers with different degrees of accepted risk and risk-taking. The category of the driving licence is a basic criterion of that differentiation. As shown in Figure 1, the safest group are bus drivers (cat. D) and international truck-transport drivers (cat. E). They present the relatively low level of RAF (1,87). The RAF level = 0-6; the level "0" means very low risk taking and risk acceptance in traffic acitvity; the level "6" means full risk and complete ignoration of traffic safety.

The most dangerous group of drivers are lorry drivers (cat. C) with a RAF level of 3,67 and car drivers (cat. B) with a RAF level of 3,34. In the group of motorcyclists we could not find a clear trend in the RAF level.

It is clear, that the category of driving licence as the feature of one of the elements of the system - DRIVER-ROAD-CAR - cannot be dependent on the variable describing the system. It can be a parameter only. In this sense it describes the system. Table 1 shows the power of influence of driving licence category on the differentiation in RAF area.

Table 1 Multiple correlation of some variables tied with the risk

.	A	B	C	D	E.
A	-	0,197	0,062	0,421	0,238
B	0,197	-	-0,045	0,503	0,147
C	0,062	-0,045	-	0,611	-0,018
D	0,421	0,503	0,611	-	0,627
E	0,238	0,147	0,018	0,627	-

A...Experience
B...Kind of vehicle
C...Taking part in accident
D...Category of driving licence
E...Number of driven kilometers per year

We can see that kind of category of driving licence cannot be identified with other variables such as: experience, number of driven kilometers etc. The category of driving licence is the main factor creating RAF level.

Additionally we compare the values of two scales of risk: accepted and taken (Fig.2).

The level of taken risk bases on a level of self-criticism of drivers. We are very surprised because of big differences between the risk accepted and risk taken characterizing the different groups of drivers. We could observe that if the level of accepted risk is extremely high the level of taken risk is very low. This relation is characteristic for bus drivers (cat.D) and truck-drivers of cat. E.

On the contrary, car and lorry drivers (cat.B and C) are in reality very dangerous road users, but in their opinion they are driving very gentle and safe.

These two important relations urge us to find another additional variable which describes the measure of risk more precisely. Such a variable exceeds the system "Driver-Vehicle-Road" and it has psycho-social character. We could define it as "playing the social role of drivers". The role needs a special demand and special expectation of society. It is tied with a system of social orders and law regulations. It is clear, that a scale of demands and expectations of society directed to bus and international truck are diffrent from drivers those directed to lorry and cardrivers. The danger of kinds of vehicles is very similar but the social role of drivers are different.

Fig.1 Relationship between undertaken risk and the cathegory of driving licence

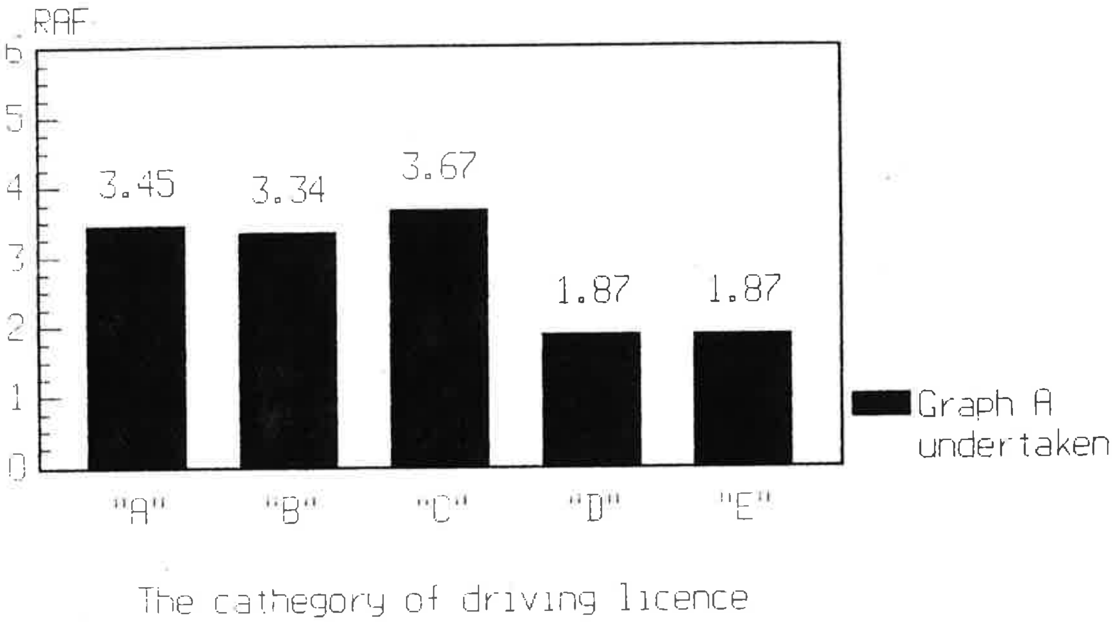
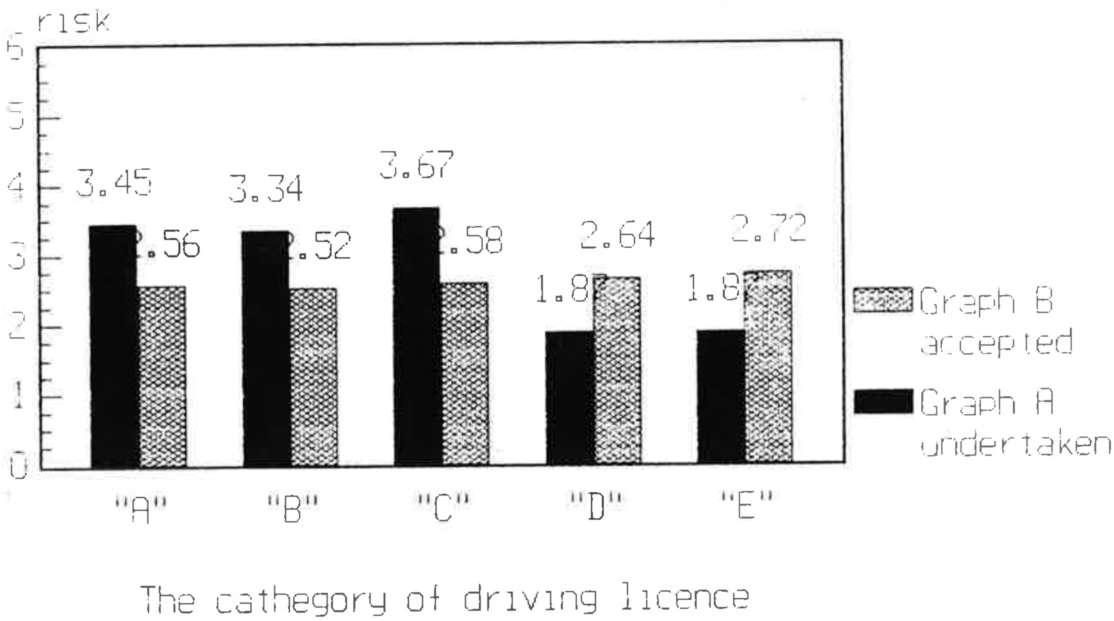


Fig.2 Relationship between the different cathegory of driving licence and accepted risk and undertaken risk



REFERENCES

BENA E., HOSKOVEC I. & STIKAR I. 1968, Psychologie a fyziologie ridice, Praha

KLEBELSBERG D. 1969, Risikoverhalten als Persönlichkeitsmerkmal, Stuttgart

NÄÄTÄNEN R. & SUMMALA H. 1976, Road user behaviour and traffic accidnets, Amsterdam, North Holland

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SUBJECTIVE SAFETY AS A BASIS FOR THE USER BEHAVIOUR IN ROAD TRAFFIC AND PUBLIC TRANSPORT

ABSTRACT

Subjective safety is a more or less emotional, more or less detailed result of the comparison of transportation motives and risks. The transportation motives can be specified in terms of destination, time, cost, comfort etc. in a direct way and in an indirect way in terms of personal and social integrity, safety of personal property etc. The corresponding risks cover the whole range from being late or catching a cold to violence and accidents.

This concept was applied in a study of the users of public transport and of parking facilities in Hannover. The results reconfirmed the theoretical approach and showed ways how to improve the objective conditions contibuting to subjective safety.

Long version did not arrive in time

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ANALYSIS OF PEDESTRIAN-CYCLIST-INTERACTIONS EXPERIENCES WITH AN INVESTIGATION IN VIENNA

SUMMARY

By example of our experiences in a study on conflicts between pedestrians and cyclists in commission of the municipal administration of Vienna (RISSER, SCHMIDT, SNIZEK, HULMAK & SCHEIDL 1990) I shall present you some reflections on and some results of the application of traffic conflict techniques for the interaction between pedestrians and cyclists.

For those, who are especially interested in further details of our study, it shall be mentioned, that it will be published in 1992 in the publication series "Fahrrad und Umwelt" from the ARGUS, the austrian cyclists representation.

1. WHY INVESTIGATE PEDESTRIAN-CYCLIST-CONFLICTS?

In connection with growing environmental problems, e.g. energy consumption, global climate change, ozon hole, and cities respectively landscapes, which can stand no longer the consequences of an uncontrolled growing private motorized traffic, the different modes of traffic participation are discussed with respect to their social and ecological compatibility. An evaluation according to these criteria aims at giving pedestrians the highest priority, followed by cyclists, puplic transportation in train, trams and buses. Driving private cars receives the last position in this hierarchy of social and ecological desirability (see in more detail SCHMIDT 1988, 1989).

From a psychological point of view these two modes of non motorized individual mobility have a further advantage: they can satisfy important motives of choice of travel mode, which are especially relevant for automobilists: independancy and joy of movement. Therefore walking and cycling are capable to guarantee individual mobility in future in towns which need to prevent private car movements in their inner districts.

2. SPECIAL CONDITIONS OF THIS TARGET GROUPS WITH RESPECT TO THE USE OF TRAFFIC CONFLICT TECHNIQUES

The application of the traffic conflicts' technique, which has originally been developped and elaborated for the observation of automobile interactions, implies special characteristics and problems, if one wants to observe the following special conditions:

- o Pedestrians and cyclists move with lower speeds than car. That means one has a better opportunity to observe the development of conflicts

- o Pedestrians and cyclists are less limited in their movement directions than cars are. Locations of potential conflict areas are more difficult to preview. That means more time is necessary for preteste.
- o The interaction between pedestrians and cyclists is more perceived as a social interaction than that between cars. (On the contrary to the car traffic, where one talks about the "BMW", "Mercedes", "Mazda", "Golf GTI" itc., that made a dangerous overtaking maneuver, one speaks of the "cyclist on the racing cycle", "mountain biker"). The other traffic participant is more looked at as a person, than as a vehicle if he uses a cycle instead of a car.
  Because of the lower speeds and because they are not hidden in a "steel cave" cyclists and pedestrians can perceive each other as persons with special gestures, mimics and other nonverbal communication signals.
- o Due to the social relationship and the directness of meeting each other the interactions between pedestrians and cyclists have a stronger emotional touch. That means, traffic climate can still be influenced in a safety threatening way without any traffic conflicts being observable. Therefore additional interviews with the observed traffic participants to explore their subjective perception of the situation are especially important.

3. OUR INVESTIGATION METHODS

The investigation consisted of the following methods:

- group discussions
- behavioural observations including traffic conflict techniques elements
- personal interviews in traffic situations

In my present contribution I shall refer especially to our behavioural observations. Some of our experiences are included in an recently published Austrian Handbook on Traffic Conflict Techiques (RISSER et al. 1991).

We developped an observation scheme, which included the description of the behaviour of the interacting pedestrians and cyclists.

We distinguished:

- interpersonal/social conflicts
- mistakes /
- traffic conflicts (according to the definition in ASMUSSEN 1984)

Apart from the direct personal observation we used video tapes for the behavioral analysis. Each of our assistants was trained both as an observer and as an interviewer. Partly he had one of these tasks, partly the other. We payed attention, that everybody taking part in data collection knew both roles of traffic participation by his own experience, to be sure, that their observations and interviewing was as valid as possible.

Our assistants got a comprehensive instruction:

- they took part in pretests on the traffic sites in question
- they had to be very familiar with the oberservation categories and the questionnaires.

4. RESULTS

- o Pedestrians are very much adapted to a passive, "suffering" role, they do not complain as much as the cyclists
- o There are great differences in frequencies and seriousness of traffic conflicts depending on the construction of the traffic site
- o The following criteria support the genesis of conflicts between pedestrians and cyclist:

  - narrow footpath
  - narrow cycle track
  - high speed of cyclists
  - bad visability of the other traffic participant
  - considerable age differences between cyclist and pedestrian

  only few conflicts were very dangerous. Danger will become more serious, if several of these criteria are combined

- o The most servere observed conflicts were those between cyclists and cars.

5. CONCLUSIONS

Guideline for a future-orientated traffic planning should be the promotion of the "original" modes of individual traffic partcipation: the promotion of walking and cycling.

Because of its optimal social and ecological compatibility walking should have highest priority. That means, the safety and fluency of pedestrian movements should be the leading goal (see EGER & RETZKO 1986).

The dividing of traffic space, but also the organization of traffic lights and the formulation of traffic rules should guarantee, that the most important motives for traffic-mode choice like independence, comfort, time saving, but also safety will be best for walking and cycling, not for driving a car.

Cyclists have different claims concerning speed and subjective safety, which for instance are connected to experience in traffic (REITER et al. 1987). Planning for cyclists should take care of the fact, that "fast" cyclists want to use the road, even when there exists a separate cycle track.

Cycle tracks marked direcly on the road or combined lanes for busses, taxis and cyclists can help to avoid a lot of conflicts, accidents and other urban traffic problems, if they are carefully implanted (see e.g. ANGENENDT 1989).

REFERENCES

ANGENENDT W. 1989, Sichere Gestaltung markierter Wege für Fahrradfahrer, Band 2. Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

ASMUSSEN E. 1984, nternational Calibration Study of Traffic-Conflict Techniques, Springer Verlag Berlin, Heidelberg, New York

EGER R.& TETZKO H.-G. 1986, Führung des Radverkehrs im Innerortsbereich, Teil 6: Gemeinsame Verkehrsflächen für Fußgänger und Radfahrer, Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

I C T C T 1990, Theoretical Aspects and Examples for Practical Use of Traffic Conflicts and of Other Interactional Safety Criteria in Several Industrial and Developing Countries, Lund Technical Highschool, Institute for Traffic Technique, Bulletin 86, Lund, Sweden

REITER H., SCHMIDT L. & SNIZEK S. 1987, Bewertung von Radverkehrsanlagen durch Radfahrer, Untersuchung im Auftrag der Stadt Wien, MA 18 Stadtstrukturplanung, Wien

RISSER R., SCHMIDT L., SNIZEK S. & HULMAK M. 1990, Konflikte Fußgänger-Radfahrer in Wien, Untersuchung im Auftrag der Stadt Wien, MA 18 Stadtstrukturplanung, Wien

RISSER R., ZUZAN W.D., TAMME W., STEINBAUER J. & KABA A. 1991, Handbuch zu Erhebung von Verkehrskonflikten mit Anleitungen zur Beobachterschulung, Lebensraum Verkehr, Kleine Fachbuchreihe des Kuratoriums für Verkehrssicherheit, Band 28, Wien

SCHMIDT L. 1988, Verantwortliches Handeln im Straßenverkehr, Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

SCHMIDT L. 1989, The significance of accepted risk and responsible action for goals and methods in psychological traffic research, Paper presented at the first European Congress of Psychology, Amsterdam

SCHMIDT L. 1990, Regelwidriges Verhalten von Radfahrern in Beziehung zu Radfahrer-Fußänger-Konflikt, Vortrag für Arbeitskreis 2 "Unfälle - Unfallursachen, Analyse und Beobachtung", In: ARGUS (ed.): Velo-Secur 1990, Sicherheit rund ums Radfahren, Reihe Fahrrad und Umwelt, Band 1

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EXAMPLES FOR THE APPLICATION OF TRAFFIC CONFLICT TECHNIQUE FOR THE ANALYSIS OF BLACK SPOTS

1. INTRODUCTION

In 1984 in the western part of Austria an extensive accident inquest was carried out with the aim to detect the specific risks of holiday traffic. 12 black spots were determined. Six of them rested untreated whereas on six other sites remedial measures were taken. In the sense of a before - after - design the efficiency of the taken measures should be analysed. The six untreated sites should show, wether there had been a change in accident - resp. traffic conflict occurence by change of traffic conditions, or not.

The observed period comprised in the "before"-study the time space from June to September 1984 and in the "after"-study time space from June to September 1985. The "afterwards" inquest 1985 were carried out on the same week-days and within the same periods of the month of the summer-month June and July as the year before.

2. MEASURES AT THE BLACK SPOTS

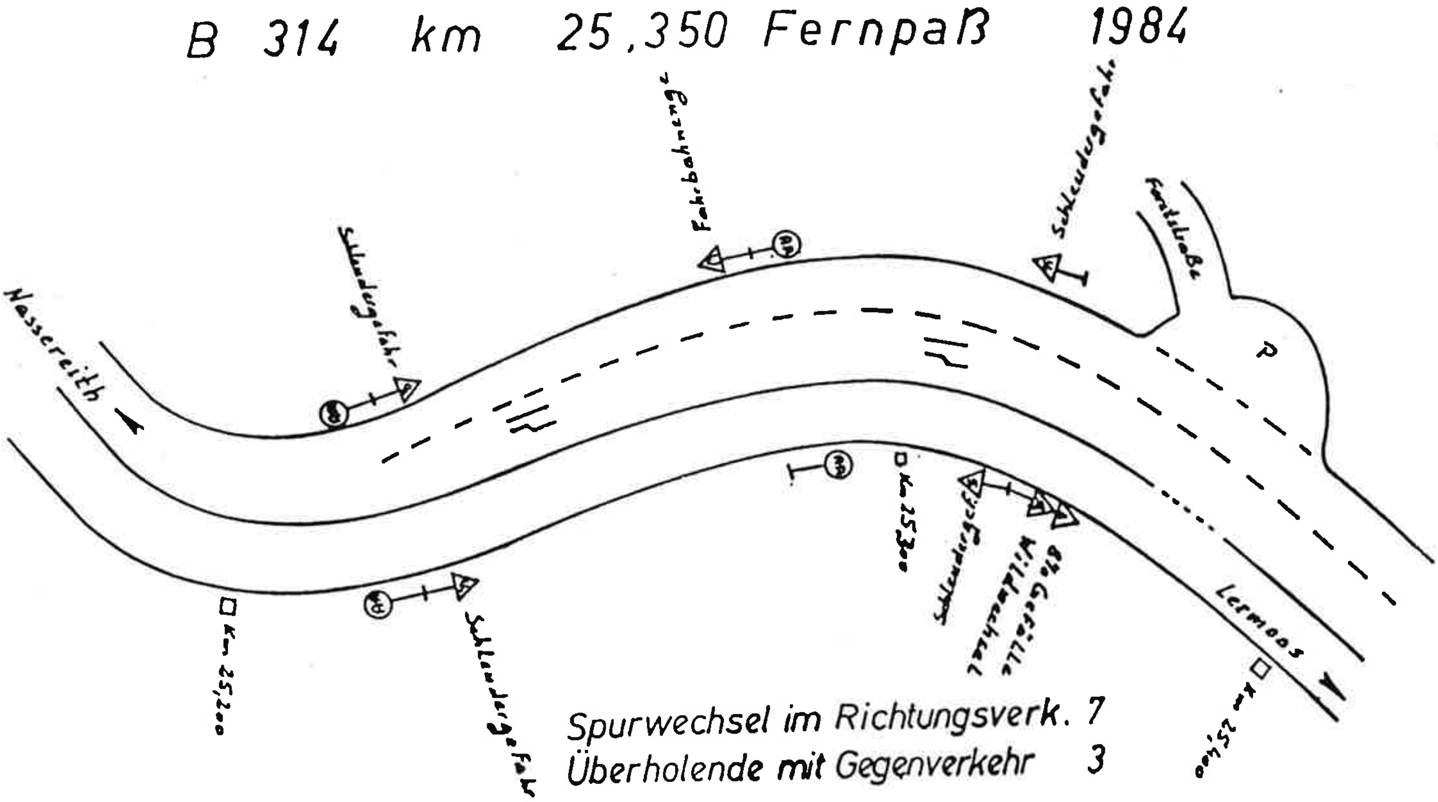
The following variables were observed:

- the quantity of traffic conflicts
- the quantity of accidents with personal injury
- the quantity of vehicles per hour
- the mean of driven speeds.

2.1. Black spot on the Fernpaß - Federal Highway B 314 at Km 25,3

On this spot the Fernpaß - Federal Highway rises coming from Lehrmoos and going in the direction of Nassereith, whereat the lane narrows in a left curve. On the end of the narrowing there is a right curve.

Graph 1



On this spot the following improvements were strived for:

- reduction of severe lane changing conflicts
  and
- decrease of overtaking conflicts as most dangerous events on that spot.

By these measures should be achieved, that the drivers attention should be called earlier as yet and supplied by pavement paintings to the lane narrowing. It should be proved, whether the quantity of rear and conflicts outside of the directly observed area rised.

The following measures were suggested to the authority and were in fact realized:

- o Announcement of the lane narrowing in the direction "Fernpaß" by the traffic sign "lane narrowing" on both sides.
- o Change of the prohibition line in the area of lane narrowing (improve perception resp. adaptation of the line trace)
- o The traffic sign "prohibition of overtaking" in the driving direction of "Fernpaß" was set approximatly 100m earlier.

<u>Observed change in the traffic conditions:</u>

In the observation period there were registered 8 lane changing conflicts, two overtaking conflicts and two rear end conflicts. In the before period 1984 45 lane changing conflicts, 26 overtaking conflicts and 13 rear end conflicts were observed. Severe conflicts and near-accidents ceased entirely. According to the observers estimate the traffic flow was better in the observed area as well as outside. Rear end problems were conspicuous. The expectation of a reduction of severe lane changing and overtaking conflicts had been fulfilled although the traffic frequency increased by a third compaired with the previous year.

Table 1: Conflict occurence 1984/1985 on Fernpaß at Km 25.3

type of conflicts	1984 A	1984 S	1985 A	1985 S
right turn conflicts	3	0	0	0
lane changing conflicts	45	7	8*	0*
overtaking conflicts	26	3	2*	0*
rear end conflicts	13	0	2*	0
all conflicts together	87	10	12*	0*

Within the table the letter "A" stands for "all conflicts" and "S" stands for "severe conflicts". The figures marked with asterisc (*) stand for significant changes compaired with the preceeding investigation represented in confidence intervals on the basis of a Poisson-distribution (Alpha is smaller or equal 5%).

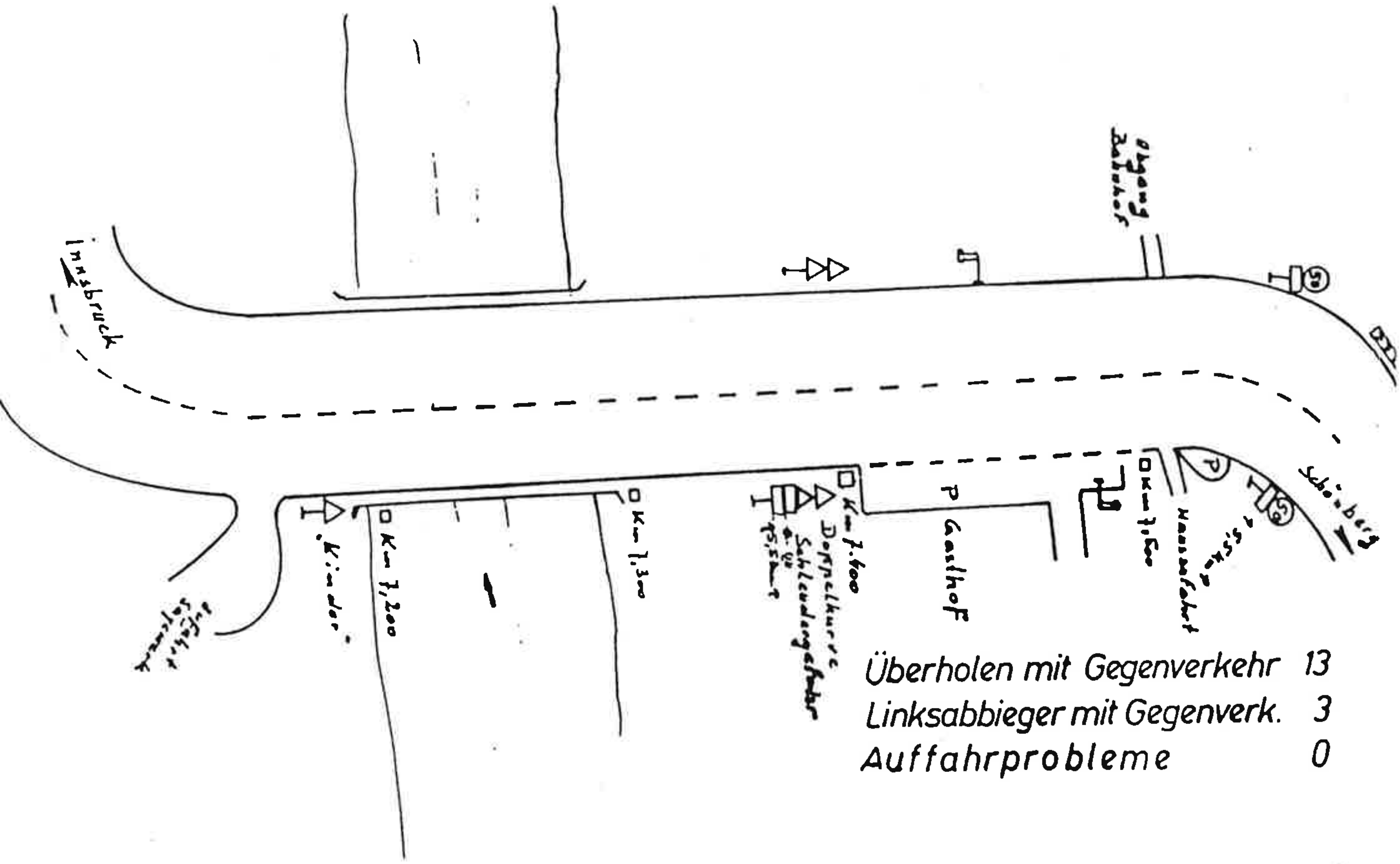
On the observed spot on the Fernpaß the mean speed in 1985 was 59 km/h opposite to 64 km/h the year before. Considering the already low mean speed that is a considerable decline which could be attributed to the changed optical design of the road space. But there was no variation of the 85%-speed, which was 68 km/h in 1984 and 69 km/h in 1985. It seems, that drivers choosing consciously high speed are less influenced in their speeding behaviour by the measures as taken at this place.

1.2. The "Brenner"-Federal Highway B 182 at km 7.4 near Mutters "Stefansbrücke"

Coming on from Innsbruck the "Brenner"-Federal Highway rises in the direction of "Brenner"-pass. After a sharp left curve the Federal Highway crosses over a bridge the Sill-river. A guest-house with parking place is situated on the right handside. After the guest-house follows a sharp right curve.

Graph 2

1984 B 182 km 7,40 Mutters Stephansbrücke



The main goal in the Stefansbrücke-area was to reduce the amount of severe overtaking problems especially for overtaking manoeuvers in the curves. That should be achieved by better optical design of the road space.

The following measures were selected in order to solve the problem:

- painting the prohibition-lines in both curves
- fixing leading planks on the outside curve in the uphill going right curve.

Change in the traffic conditions:

On this spot overtaking- and lane-changing-conflicts represented the main problems 1984. Both kinds of conflicts have diminished considerably 1985 compared with the previous year.
Nevertheless now as before there occured severe overtaking conflicts although the amount dropped to about one third compaired with the previous year. The goal to eliminate entirely the critical driving manoeuvers could not be achieved, but an improvement of the situation could be noticed. The high amount of near accidents caused by carrying out left-turn manoeuvers to the guest house parking place was nearly constant. They were not influenced by the measures taken.

Table 2: Conflict events 1984/1985 at Stefansbrücke (B 182) at Km 7.4

kind of conflict	1984		1985	
	A	S	A	S
right turn conflicts	6	0	0*	0
left turn conflicts	3	3	4	2
lane changing conflicts	27	0	4*	0
overtaking conflicts	30	13	4*	4*
rear end conflicts	3	0	3	2
all conflicts together	69	16	15	8

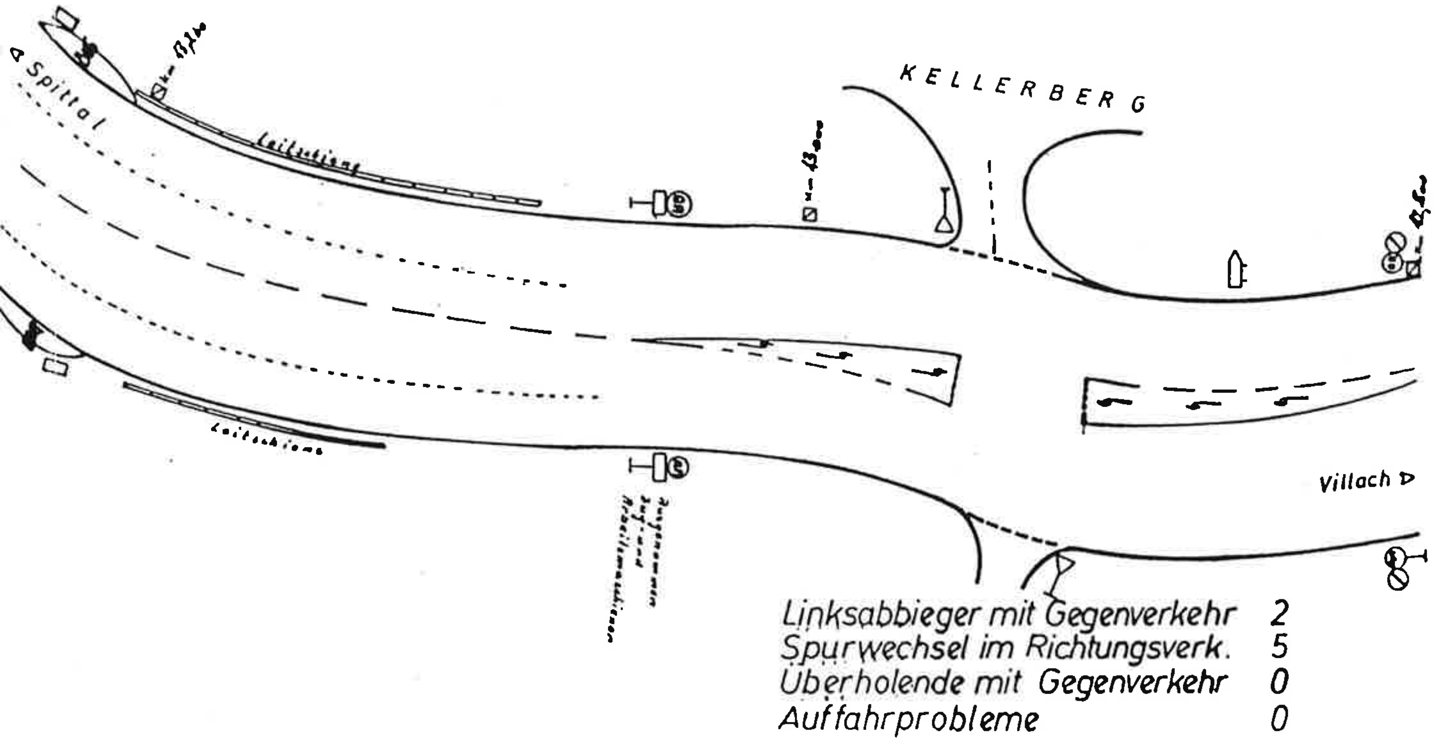
Unexpected was the occurence of severe rear end conflicts after the setting of the measures and that one time in connection with an unexpected right turn manoeuver an another time in connection with an overtaking manoeuver that had to be stopped. The amount of near-accidents could be halfed by setting the measures. The mean speed did not change compared with the previous year (62 km/h in both years). The 85% speed dropped from 97 km/h in the year 1984 to 69 km/h in the year 1985, what could well be a consequence of the taken measures.

1.3. "Drautal"-Federal Highway B 100 at km 13.0 in the area "Kellerberg"

The "Drautal"-Federal Highway was on that spot coming from Spittal and leading in the direction Villach supplied with four lanes and narrowed in the Kellerberg area from four to two lanes. In the middle between the two lanes a special line up-lane for left turning manoeuvers was established.

Graph 3

B 100 km 13,00 Kellerberg 1984



The following effects should be achieved on this crossing between the B 100 and the entrance to the village of Kellerberg:

- decrease of the amount of severe lane changing conflicts directly in the crossing area
- absence of severe left turning conflicts
- reduction of overtaking conflicts

Analogous to the proceedings on the Fernpaß it should be achieved thereby to call the driver attention to the lane narrowing resp. to the crossing area.

The taken measures:

- o Additional pavement painting of three arrows directing to the right (in the direction "Villach").
- o Setting up of three traffic sign "lane narrowing" on the left road side (in the direction "Villach") as supplement to the pavement paintings between the right directing arrows.
- o Setting up of additional traffic signs "lane narrowing" with symbolic representation of the "zip"-principle and the inscription "Let traffic from the other lane get into your lane".
- o Pavement painting of a prohibition area of 100 m length in the middle of the street to mark clearly the lane narrowing from two to one lane in the direction "Villach" (km 13.1 to km 13.0). By that measure the line-up lane for left turning manoeuvers should be made safer.

Changes in the traffic conditions:

On that spot an impressing reduction of the number of traffic conflicts could be achieved. Only two kinds of traffic conflicts could be observed after the implementation of the measures, namely overtaking and rear end conflicts.

Table 3: Conflict occurence 1984/1985 on the B 100 highway in Kellerberg at km 13.0

	1984		1985	
	A	S	A	S
Type of conflict				
right angle conflicts	19	0	0*	0
left turner conflicts	2	2	0	0
right turner conflicts	4	0	0	0
lane changing conflicts	62	5	0*	0*
overtaking conflicts	19	0	2*	1
rear end conflicts	46	0	2*	1
all conflicts together	152	7	4*	2

The result is not as satisfactory as it may seem at the first sight: The amount of severe conflicts indeed was reduced to a quarter. However for the first time a severe overtaking conflict with four vehicles involved occured. That might have the reason in the fact that an announcement refering to the chance of overtaking might have been misunderstood by some drivers. The announcement was set up shortly before the Kellerberg crossing in the direction to Villach. So the crossing has been regarded by these drivers as chance for overtaking. Therefore the table has been transfered to another place after our analyses in 1985.

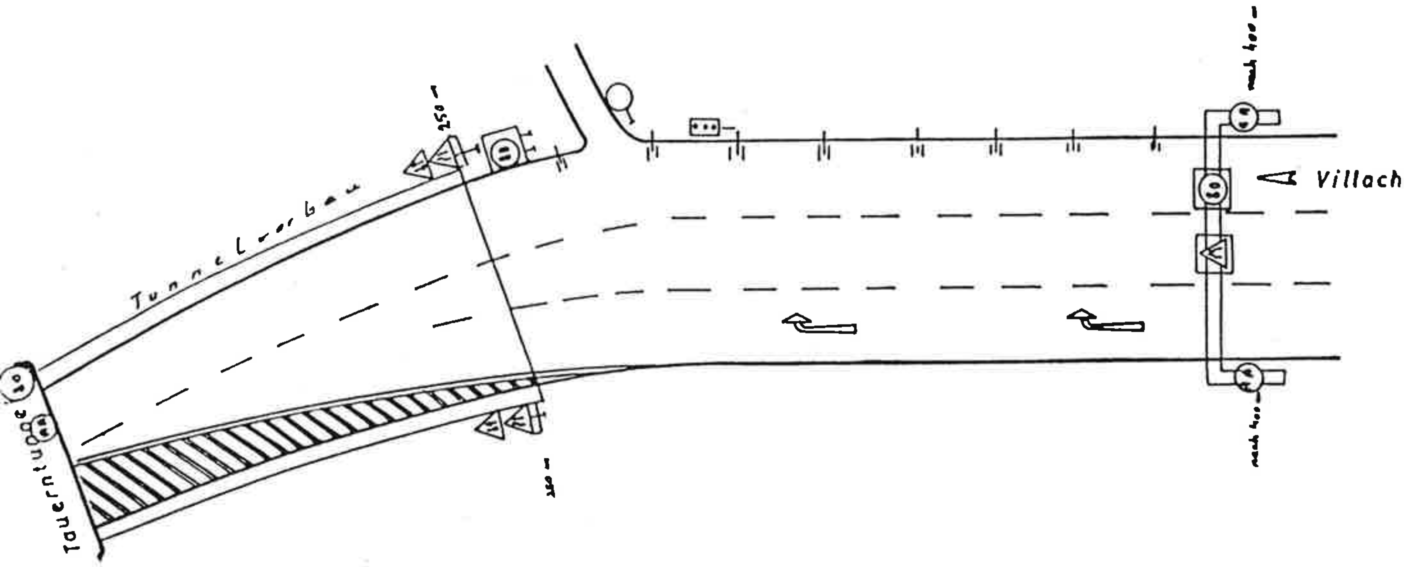
On that spot a considerable increase of traffic frequency had to be handled: The density of traffic rose from 650 vehicles per hour in 1984 to 901 vehicles in 1985. This increase gives evidence that the results have to be judged quite positive. To the mean speed of 78 km/h in 1984 stands opposite a mean speed of 76 km/h in 1985. The 85% speed declined from 91 km/h in 1984 to 88 km/h in 1985. The speeding behaviour could obviously not be influenced by the reorganisation of the Kellerberg crossing. The main effect for the reduction of the number of traffic conflicts was indeed due to the better orientation and the announcement of a critical situation.

1.4. "Tauernautobahn" (Tauern freeway) A 10 at km 80.6, area before the tunnel entrance

Coming from Salzburg the "Tauernautobahn" ascents in the direction of the entrance of the "Tauern-tunnel". On the uphill going section there are three lanes in that direction which are narrowing before the tunnel to one lane.

Graph 4

A 10 km 80,600 Flachau 1984



Spurwechsel im Richtungsverk. 10

The main danger on that spot were the severe lane changing conflicts on the narrowing from three to one lane. The mixing section of the middle and the right lane were overlapping. Additional lane changing manoeuvers were often set in the last moment before the entrance of the tunnel. Therefore the pavement painting should be changed in that sense, that the both merging areas should be seperated, so that lane changing manoeuvers should take place earlier and step by step.

<u>The implemented measures:</u>

- o Begin for the narrowing of the three lane at km 80.5 (before: 80.7)
- o Application of four oblique right showing pavement painted arrows on the third (left) lane over a stretch of 210 m, to divert the drivers from the third lane to the second lane in time.
- o The first and the second lane were separated by a prohibition line from km 80.5 to km 80.8, so that the two traffic flows could not merge earlier than in the area immidiatly before the tunnel.
- o The traffic signs "lane narrowing on the left side" and "oncoming traffic" with the additional table "250 m" were transfered from the begin of the tunnel front building 54 m

into the front building and were set up in an inside illuminated design.

- o Over the two lanes in the direction "South" an announcement table was put with a symbolic representation of the "zip"-principle and the inscripition "Let them get into the lane" and additional the speed limit "80 km/h" was announced by an inside illuminated traffic sign.
- o At km 81.0 on both sides the traffic sign "Overtaking prohibited" was put, which was beamed on by a light emitter.
- o From km 81.0 to 81.1 at the beginning of the one lane traffic through the "Tauern-tunnel" in the direction "South" three reflecting guard rails were set up.

Changes in the traffic conditions:

If one takes as a measure for the achievement of the goals the decrease of the total amount of traffic conflicts from 1984 to 1985 the changes in the design of the road space were efficient. The number of near-accidents declined considerable compaired to the previous year.

Table 4: Conflict occurence 1984/1985 on the A 10 freeway at Flachau at km 80.6

	1984		1985	
	A	S	A	S
Type of conflict				
lane changing conflicts	97	10	10*	2
rear end conflicts	14	0	6*	0
all conflicts together	111	10	16*	2*

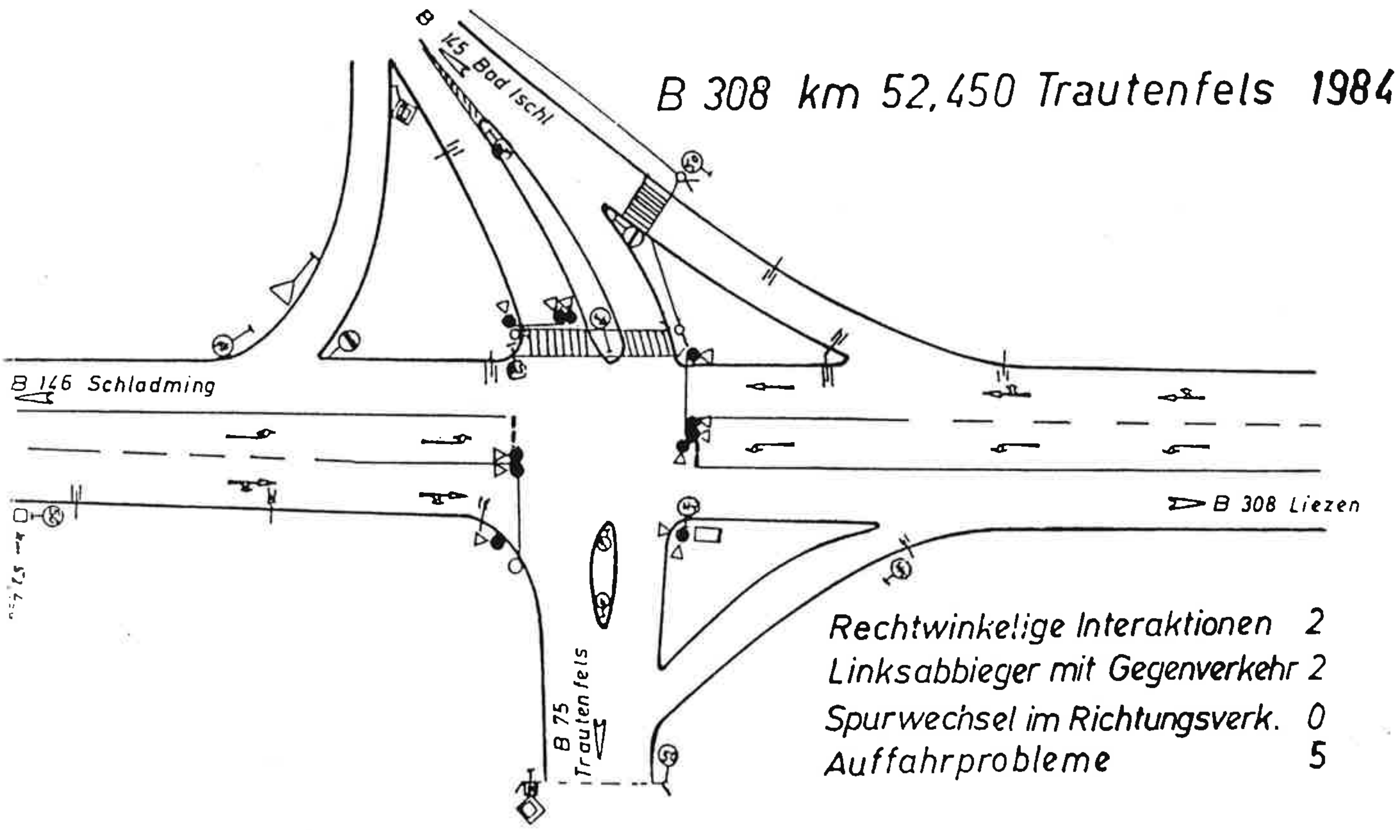
It is nevertheless important to point out that a reduction of traffic quantity of 33% from 600 vehicles per hour in 1984 to 451 vehicles per hour 1985 happend. Despite the decline of traffic quantity the mean speed on that observation spot decreased from 74 km/h in 1984 to 69 km/h in 1985. The 85% speed did not change, however. It was 87 km/h in 1984 and 86 km/h 1985.

The reduction of the traffic quantity apparently did not effect the driven speed. Obviously that result is partly attributable to the implemented measures.

1.5. Ennstal-Federal Highway B 308 at km 53.6 close to the village of Trautenfels

The "Ennstal"-Federal Highway B 308 crosses coming from the town Schladming and going in the direction of the town Liezen close to the village of Trautenfels the "Salzkammergut"-Federal Highway B 145, which is going from Trautenfels north to the town Bad Ischl. On the opposite side of the crossing a local road is going south to the village Irdning. This crossing is protected by a speed limit of 50 km/h as well as by a traffic light. The Ennstal-Federal Highway is widened to three lanes in that area. Exits and entrances to the main road are arranged fan-shaped.

Graph 5



In that sector of the highway problems with left turners and rear end conflicts are frequent. Turning off vehicles as well as vehicles approaching the changing traffic light sometimes reduce their speed in the crossing area abruptly. Left turning vehicles take advantage of very short gaps in the oncoming traffic for turning left. Therefore the hypothesis was formulated that the problems occuring in that sector and being typical for crossings regulated by traffic lights would decrease, when the drivers would be prepared in time and sufficiently to the presence of the traffic light. By that preparation they would be able to adapt driven speed and attention to the situation.

<u>Implemented measures:</u>

- Announcement of the control by traffic light already 300 m resp. 400 m before the crossing on both sides of the road in each driving direction by a traffic sign in the dimension of 250 cm hight.
- The announcement of the traffic light 300 m resp. 400 m before the crossing was equipped with an intermittent light in the yellow field of the symbolic represented traffic light.

- o Improvement of the traffic signaling by setting up bigger signposts on both sides of the road in each direction.
- o A speed limit of 70 km/h in each case 100 m before the crossing on both sides of the road and for each driving direction.

Changes in the traffic conditions:

The number of all conflicts observed on the Trautenfels crossing decreased only sightly in comparison with the previous year. The goal could not be reached concerning the left turn conflicts because their amount rose in comparison to the year before. 1985 there were more right angle conflicts too (six in comparison to four in the previous year). Lane changing problems decreased, but in 1985 for the first time two severe conflicts of this type were observed.

Table 5: Conflict occurence 1984/1985 on the B 308 Federal Highway at km 53.6 close to Trautenfels

	1984		1985	
	A	S	A	S
Type of conflict				
right angle conflicts	4	2	6	2
left turning conflicts	10	2	16	2
lane changing conflicts	7	0	2	2
rear end conflicts	9	5	2*	0*
all conflicts together	30	9	26	6

In comparison to the previous year indeed an increase of the traffic frequency from 217 to 268 vehicles per hour was noticed, but that fact cannot explain the unsatisfactory result. On the other observed spots an essential reduction of the number of traffic conflicts was observed in spite of an increase in traffic frequency.

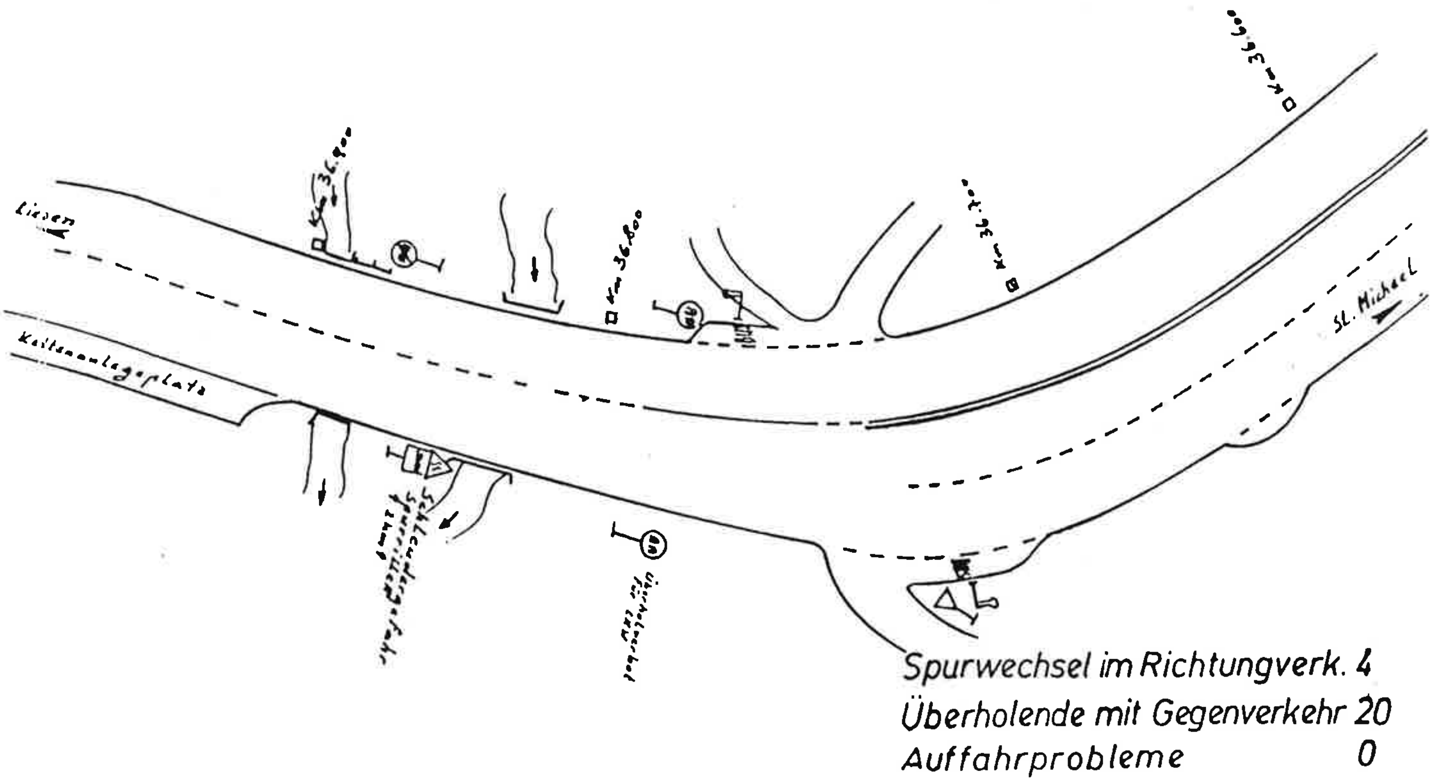
In the year 1984 a mean speed of 59 km/h was measured in Trautenfels (speed limit of 50 km/h). This mean speed rose in 1985 even to 60 km/h. The 85% speed was 1984 at 68 km/h and increased 1985 to 70 km/h.

A satisfactory improvement of the situation could altogether not be achieved by the implemented measures. An essential improvement can only be expected by substantial reorganisation of the intersection.

1.6. Schoberpaß-Federal Highway B 113 at km 36.9 close to the village of Treglwang

The Schoberpaß-Federal Highway goes from Liezen in the direction St.Michael uphill and widens in the observed area from two to three lanes, because uphill an additional lane for slow going lorries is designed. The black spot is situated several hundred meters before the widening to three lanes. Coming from Liezen there is a wide right curve followed by a straight on part of the road for several hundred meters. Uphill a slight left curve links up within which the road is widening to three lanes.

Graph 6 B 113 km 36,90 Schoberpaß 1984



Characteristic for this spot are the many severe overtaking conflicts. Some severe lane changing conflicts were also recorded, but their importance is secondary in view of the outstanding problems with overtalking. Drivers going in the direction St.Michael often get problems, if they want to overtake between the km 36.9 and 36.8. More than half of the drivers involved in conflicts at that spot were involved in conflict exactly in that area. These conflicts are unnecessary because the highway several hundred meters later is equied with two lanes in that direction and an overtaking is then possible without danger. By that reason it was necessary to call the drivers attention to the chance of overtaking several hundred meters later to detain them from a premature and therefore dangerous overtaking manoeuvers.

Implemented measures:

- o For the direction St.Michael the coming chance for overtaking between km 36.9 and 35.1 was announced by a traffic sign. Thereby overtaking manoeuvers should be excluded in the dangerous area with two lanes before the overtaking chance.
- o Between km 36.7 and km 36.9 in addition to this a prohibition line was painted on the pavement to exclude overtaking manoeuvers in that area.

Changes in the traffic conditions:

Altogether a clear reduction of the number of traffic conflicts resulted in this area. The number of lane changing conflicts decreased distinctly. Nevertheless the same number of vehicles got into severe lane changing conflicts as in the previous year. Referred to the total number of traffic conflicts the diminuation was more marked for overtaking conflicts accompanied by a remarkable decrease of near-accidents. The number of rear end conflicts decreased too, but in 1985 for the first time two severe conflicts of that type had to be registered. The achieved improvement on that spot was especially remarkable as the traffic frequency rose from 288 vehicles per hour in 1984 to 423 vehicles per hour in 1985.

The mean speed in the year 1984 was 78 km/h on that spot. It declined in 1985 to 73 km/h. The 85%-speed was 101 km/h in 1984 and sank in 1985 to 97 km/h. This slight reduction of the driven speed might be a side-effect of the implemented measures. On the other hand, the speed reduction might be attributed to the increased traffic frequency.

1.7. The accident developement on modified and non-modified spots

In 1984 12 black spots in the transit-road-network with increased accident occurence were selected to study by traffic conflict observation the behaviour of the different nationalities traversing Austria. Six of these spots were selected to demonstrate the chance of improvement of traffic safety by simple measures.

Table 7: Accidents with personal injury on modified and non-modified accident accumulation spots

modified spots	10 km before area	observed spot	area 10 km subseqent
1984	83	10	101
1985	76	7	89
non-modified spots			
1984	94	18	233
1985	106	18	207

The total observation time for the inquest of the accident occurence was 732 days on modified spots just as on non-modified black spots.

Table 8: Observed traffic conflicts on modified and non-modified spots

Severity of conflicts	1984	1985
all conflicts	563	109
severe conflicts	76	32

The observation time was 3 1/2 days for modified spots just as on non-modified spots. The comparison of accident data with traffic conflict data demonstrates that the accident data on the observed spots show only a small amount and therefore only an insufficient efficiency control is possible (BAST 1989). The number of traffic conflicts responded quite more sensitive to the implemented measures: An accident recording time of 732 day stands against a traffic conflict observation time of 3 1/2 days. Traffic conflict observation by that fact is not only a more efficient research method but also saving time and costs.

REFERENCES

BAST (Ed.) 1989, Sicherheit im Ferienreiseverkehr (Ausländischer Kraftfahrer - insbesondere Deutsche - in Österreich), Unfall- und Sicherheitsforschung Straßenverkehr, Heft 75

BAUMANN M., BRÜHNING E., CHALOUPKA CH., HÖFNER K. J., KUDLICZA P., LUKASCHEK H., SÖMEN D., TAMME W. & ZUZAN W.D. 1983, Unfall - und Fahrverhaltensanalyse ausländischer Kraftfahrer - insbesondere deutscher - in Österreich (State of the Art Report), Kuratorium für Verkehrssicherheit, Wien

CHALOUPKA CH., RISSER R., ZUZAN W.D. & LUKASCHEK H. 1985, Summary of part 2 of the project: Unfall - und Fahrverhaltensanalyse ausländischer Kraftfahrer - insbesondere deutscher - in Österreich, Kuratorium für Verkehrssicherheit, Wien

RISSER R., CHALOUPKA CH., ZUZAN W.D. & LUKASCHEK H. 1986, Summary of part 3 of the project: Unfall - und Fahrverhaltensanalyse ausländischer Kraftfahrer - insbesondere deutscher - in Österreich, Kuratorium für Verkehrssicherheit, Wien

ZUZAN W. D., LUKASCHEK H.& CHALOUPKA CH. 1984, Summary of part 1 of the project: Unfall - und Fahrverhaltensanalyse ausländischer Kraftfahrer - insbesondere deutscher - in Österreich, Kuratorium für Verkehrssicherheit, Wien

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B I C Y C L I S T   S A F E T Y   A T   J U N C T I O N S

SUMMARY

The use of bicycle has become more and more popular in Finland during the last ten years. This has caused an increase in the number of accidents involving bicyclists despite the fact that separate routes and pathes for bicyclists have been constructed.

Most of these accidents occur in urban or suburban areas, and at junctions. The most common accident type is one where the bicyclist is driving along a pedestrian-bicycle path beside the major road, and collides with a car approaching from the left-side minor road and intending to turn at the junction. These junctions often have poor sight conditions.

According to our accident analyses, conflict studies, and behavioural studies, most of the drivers turning right from the minor road concentrate their attention to the main road motor vehicle traffic approaching from the left, and neglect to look out for the bicylist traffic possibly approaching from the right.

The bicyclists, however, sometimes interpret the behaviour of the car drivers (slowing down or stopping) as an intention of giving way to bicyclists, and drive on.

Minor engineering measures such as warning markings, elevated crossings, and humps were implemanted at eight junctions in Helsinki for the purpose of making the car drivers to pay more attention to the bicycle traffic. Preliminary results of the behavioural studies are presented.

1. INTRODUCTION

During the past ten years cycling has greatly increased in Finland. This in turn has meant a construction of more and more bicycle or bicycle/pedestrian paths, but also an increasing number of injury accidents involving bicyclists. More than a half of all police-reported bicycle accidents in Finland occur on pedestrian/bicycle crossings at junctions.

The situation is similar in all Nordic countries, and that is why a Nordic study CYKLKORS concentrated on bicycle accidents at junctions (NTR 1989). The idea of the study was to use a common methodology based on a thorough accident analysis complemented with relevant behavioural studies. The accidents were analysed within the frame-work applied by the accident investigation teams in Sweden and Finland (Salusjärvi 1989, TRK 1978).

The method deals with the function of the human information processing system described by mechanical, perceptual, and cognitive filters, through which the information is passed. The method includes interviews of the persons involved in accidents in addition to the analysis of the police reports.

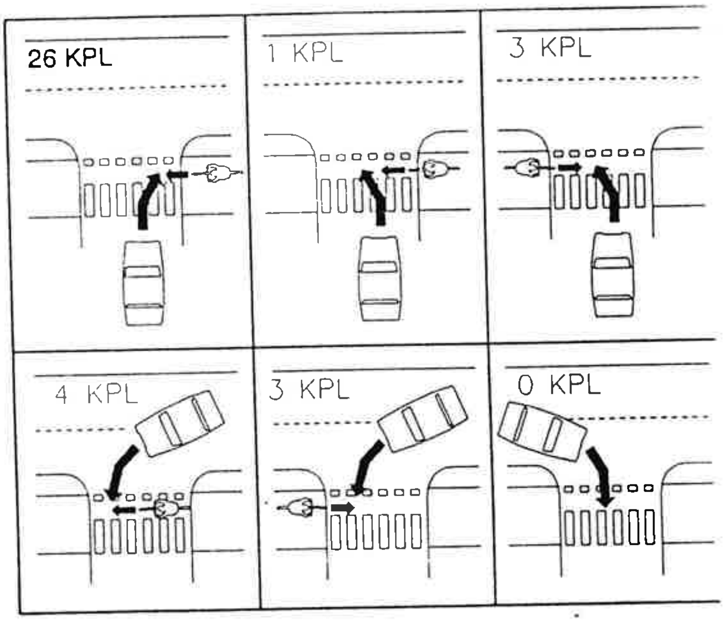
One purpose of the Nordic study was to test the method as a diagnostic tool in order to come up with inexpensive engineering measures for improving bicyclist safety.

The junctions and safety problems in each of the participating countries (Denmark, Finland, Norway and Sweden) were chosen individually by the country. In the City of Helsinki, an experiment for decreasing the number of bicycle accidents was being started at the same time (PASANEN 1990). We deemed this as a good application for the Nordic method.

Figure 1 shows the type distribution of police-reported accidents on pedestrian/bicycle crossings in Helsinki for one year.

Ca. 70 % of the accidents involved a car turning right, which ran into a cyclist on a pedestrian/bicycle crossing before entering the junction. The cyclist was in these acci-dents always approaching from the right-hand side of the car.

Figure 1. Police-reported bicycle accidents on 25 pedestrian/bicycle crossings without signal control, in all 37 accidents (PASANEN 1990).



2. THE JUNCTION

The Nordic study was primarily a pilot study for trying out the methodology, and so the monetary resources restricted us to study only one junction. We had to choose a junction with as many bicycle accidents as possible, and we furthermore required that these accidents should have occurred within the last year. Otherwise the interviews would probably not be of any use. (In fact, persons involved in an accident should be inter-viewed within hours of the accident so that their memory would still give an unbiased description of the occurrence.)

The junction best meeting our requirements was that of Mestarintie and Mäkitorpantie in a suburb of Helsinki. The measure description diagram of Figure 3 (see Chapter 5) shows the layout of the junction. The junction is a T-junction with Mestarintie as the street ending at the junction. No priority or yield signs exist i.e. vehicles have to give way to other vehicles approaching the junction from the right. This also means that right turning vehicles from Mestarintie should give way to cyclists coming from the right. A pedestrian/bicycle path exists on both sides of the straight going street of Mäkitorpantie. Mäkitorpantie has a quite steep incline on the right-hand side arm (seen from Mestarintie). This means that bicyclist approaching the junction from the right (seen from Mestarintie) are driving downhill i.e. with considerable speeds.

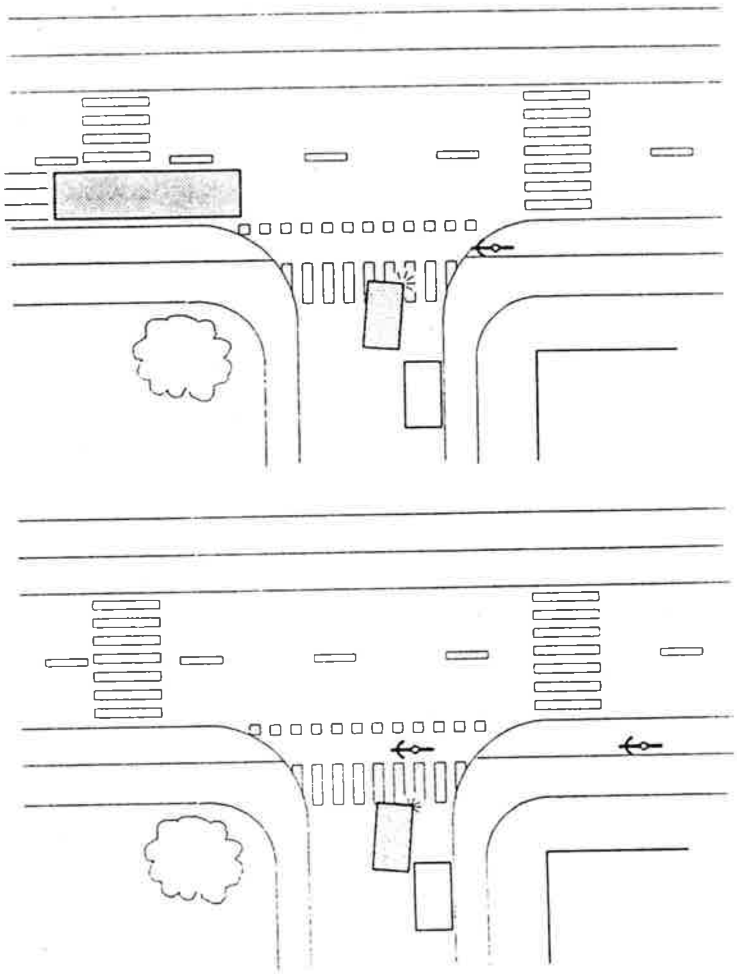
The junction is surrounded by blocks of flats, one of the very close to the right-hand corner of the junction. This obstructs the vision of car drivers from Mestarintie very severely so that it is impossible to see to the right at distances of more than 10 - 15 metres before the junction. The safe way to negotiate this junction from Mestarintie would be to always stop in front of the pedestrian/bicycle crossing, look there to both right and left, and then proceed when other traffic enables that.

Junctions of this type are numerous in Helsinki, and the City of Helsinki chose five other junctions as targets for other engineering measures. These were studied separately by the University of Helsinki and the City of Helsinki (Pasanen 1991). The preliminary results of those studies are discussed later.

3. ACCIDENT ANALYSIS

Two traffic accidents involving a bicyclist had occurred at the junction of Mäkitorpantie and Mestarintie within a year preceding the beginning of the study. These accidents are shown in Figure 2.

Figure 2. The analysed accidents at the study junction



Both of the accidents were of the before mentioned type involving a car turning right from Mestarintie, and a bicyclist coming from the right of the car. The car drivers should have given way to the bicyclists, and in both cases the bicyclists thought that this would be the case due to the car braking. This was a faulty conclusion as the car drivers told us at the interviews that they had braked because of other road users. In the other case that road user was a bus on Mäkitorpantie, and in the other case another bicyclist driv-ing a short distance in front of the cyclist involved in the accident. In the accident involving the bus as the disturbing factor, the bicyclist ran into the side of the car on the crossing.

The car drivers told at the interviews that they had not seen the bicyclist at all before the collision as they were mainly concerned with motor vehicle traffic on Mäkitorpantie. The bicyclists were apparently driving at a considerable speed.

Both bicyclists suffered minor injuries due to the accident.

4. BEHAVIOURAL STUDIES

On the basis of the accident analysis, we decided to perform behavioural studies at the junction. We studied the following factors:

- stopping place (cars from Mestarintie) -
- observation making of car drivers from Mestarintie (looking sideways by turning their head)
- bicycle speeds when approaching the crossing
- traffic conflicts

In addition, we counted the traffic in the various flows.

The studies were made in the morning (7.30 - 9.00) and afternoon (15.30 - 17.00) during two working days. In all this meant six hours of observations. During an average hour, ca. 20 cyclists and 20 pedestrians crossed Mestarintie on the pedestrian/bicycle crossing. 90 motor vehicles entered the junction from Mestarintie. 60 of those turned right, and 30 left. 380 motor vehicles drove straight through the junction on Mäkitorpan-tie during an average hour.

Table 1 shows the stopping behaviour of cars from Mestarintie.

92 % of the car drivers from Mestarintie do not stop at all, and only 3 % stop safely in front of the crossing. For left-turning vehicles the figures are just slightly better. 3 % of the drivers stopping on the crossing and 23 % of those stopping in front of it stopped because of giving way to a cyclist or pedestrian. The others stopped because of other motor vehicles.

Table 1. The stopping place of cars entering the study junction from Mestarintie.

CAR TURNING	No stop	On crossing	In front of crossing	Number of cases
RIGHT	92 %	4 %	3 %	406
LEFT	75 %	20 %	4 %	210

Tables 2 and 3 show where the car drivers looked when entering the junction.

Table 2. The car drivers' observation making by turning head when cars entering the study junction from Mestarintie. Only vehicles turning right.

LOOKING	STOPPING PLACE		
	No stop	On crossing	In front of crossing
Left in front	71 %	78 %	42 %
Left on crossing	1 %	-	-
Left & Right in front	21 %	6 %	50 %
Left in front, Right cross.	7 %	17 %	8 %
Left cross., Right in front	0 %	-	-
Number of cases	366	18	12

Table 3. The car drivers' observation making by turning head when cars entering the study junction from Mestarintie. Only vehicles turning left.

LOOKING	STOPPING PLACE		
	No stop	On crossing	In front of crossing
Left in front	1 %	-	-
Left on crossing	-	2 %	-
Left & Right in front	76 %	55 %	100 %
Left in front, Right cross.	22 %	43 %	-
Left cross., Right in front	1 %	-	-
Number of cases	156	42	9

71 % of all drivers from Mestarintie turning right omit to look to the right when enter-ing the junction. The situation is somewhat better for those stopping in front of the crossing (42 %). Drivers of vehicles turning left look to the right almost always, but often on the crossing.

It should be noted that turning head to the right does not necessarily mean looking to the right or observing a bicycle approaching from that direction. It is quite clear from tables 2 and 3 that car drivers are mainly aware of other motor vehicles approaching the junction and forming some sort of a threat to them. Bicyclists do apparently not rank highly among factors to be considered when negotiating an urban junction with such short sight distances. We observed five conflicts at the junction during the six hours of observation. Three of the conflicts occurred on the pedestrian/bicycle crossing, and they all involved a bicyclist driving downhill and a car from Mestarintie. The other two conflicts were between two cars at the junction itself.

The average speed of bicyclists just before the crossing was quite high, 16.9 km/h. For bicyclist that did not have to stop or considerably slow down due to vehicle traffic, the mean speed was 17.9 km/h.

The results from the studies at the five other junctions were very similar to ours.

5. THE MEASURE

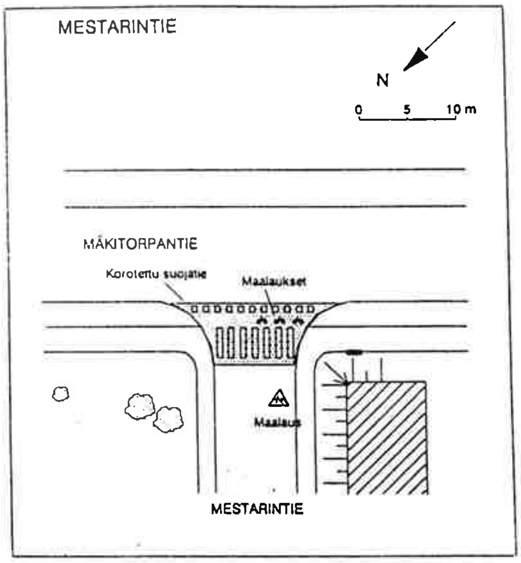
The safety problem was quite obvious as was its remedy: we should somehow have to make the car drivers to stop before the pedestrian/bicycle crossing and make them aware of possibly approaching bicyclists. The measure that would produce such an effect, however, was not at all obvious. The following measures were considered:

- elevated pedestrian crossing
- relocation of crossing closer to the junction
- bicyclist warning markings on crossing and in front of it
- stop sign in front of crossing
- short but effective hump in front of crossing
- special colouring of the bicycle part of the crossing

Together with the City of Helsinki, we chose to have an elevated pedestrian/bicycle crossing with bicyclist warning markings both in front of the crossing and on the crossing itself. The measure is shown in Figure 3.

Most of the other measures were applied to the group of five junctions studied at the same time.

Figure 3. Description of the measure.



6. EFFECTS OF THE MEASURE

The behavioural studies were renewed ca. 3 months after the measure was implemented. The results concerning the stopping of vehicles from Mestarintie are shown in Table 4.

Table 4. The stopping place of cars entering the study junction from Mestarintie

CAR TURNING Before/After	No stop	On crossing	In front of crossing	Number of cases
RIGHT, before	92 %	4 %	3 %	406
after	86 %	6 %	7 %	324
LEFT, before	75 %	20 %	4 %	210
after	58 %	30 %	12 %	207

After the measure, 86 % of the car drivers turning right from Mestarintie do not stop at all, and only 7 % stop safely in front of the crossing. For left-turning vehicles the figures are slightly better, but only 12 % of them stop in front of the crossing. The measure has improved the situation, but not very much. Closer examination of the crossing showed that the elevation on the crossing was too shallow in order to affect the speeds and stopping behaviour of the car drivers.

6 % (3 % at the before studies) of the drivers stopping on the crossing and 42 % (23 %) of those stopping in front of it stopped because of giving way to a cyclist or pedestrian. This also indicates that the elevated crossing with warning markings has somewhat improved the situation for unprotected road users, although the hourly bicycle volumes had increased, too (from 20 to ca. 40 bicyclist/hour).

Tables 5 and 6 show where the car drivers looked when entering the junction.

Table 5. The car drivers' observation making by turning head when cars entering the study junction from Mestarintie. Only vehicles turning right.

Looking, where?	Before	After
Left in front	70 %	50 %
Left on crossing	1 %	2 %
Left & Right in front	21 %	34 %
Left in front, Right crossing	7 %	14 %
Left cross., Right in front	0 %	-
Number of cases	396	324

Table 6. The car drivers' observation making by turning head when cars entering the study junction from Mestarintie. Only vehicles turning left.

Looking, where?	Before	After
Left in front	1 %	2 %
Left on crossing	0 %	-
Left & Right in front	72 %	57 %
Left in front, Right crossing	26 %	38 %
Left cross., Right in front	0 %	1 %
Left & Right on crossing	-	1 %
Number of cases	207	210

The effect on looking seems to be positive for the car drivers turning right. Before the measure 21 % of them looked both ways in front of the crossing, whereas the percentage after the measure was 34 %. Still ca. half of the drivers do not look right at all before entering the junction even after the measure. For the part of left turning vehicles, the situation has become worse. The percentage of drivers looking both ways in front of the crossing has decreased from 72 % to 57 %. Perhaps drivers sometimes first fix their interest on the elevated crossing, and after having cleared the elevation start to look out for motor vehicle traffic from the right. The percentage of left turners stopping on the crossing had also increased from 20 % to 30 %, which seems to support the assumption. Vehicle volumes on the main road were of the same magnitude as in the before studies.

The number of conflicts involving bicyclists on the pedestrian/bicycle crossing was after the measure also three as in the before studies.

Bicycle speeds had increased due to the smoother passage of the crossing caused by the elevation. The mean speed of undisturbed bicyclists in the studied direction (downhill) was in the after studies 19.6 km/h, when it had been 17.9 km/h in the before studies. The highest speed recorded was as high as 37 km/h.

7. CONCLUSIONS

The measure studied was an elevated pedestrian/bicycle crossing with bicycle warning markings. The measure caused the car drivers to behave in a safer manner. They stopped more frequently in front of the crossing, and also looked more frequently to the right before entering the junction.

Even though the result was positive, it was totally inadequate. Ca. a half of car drivers turning right at the junction do not look to the right at all before entering the junction. In case of these drivers, only the cyclist can do something to avoid a potential accident whenever a car and a bicycle are approaching the crossing at the same time. This is the case even though the traffic code requires the car driver to give way also to cyclists approaching from the right.

The fact that the improvement was so disappointingly small is undoubtedly caused by the poor implementation of the measure. The elevation is much too shallow in order to affect speeds and to make drivers stop. Sharp humps and stop signs caused the mean speeds of vehicles in front of the crossing to decrease to 6 km/h at the junctions studied by the City of Helsinki. The stop sign and the sharp hump were the most efficient measures tried in the other five junctions, but even they could not improve the situation enough (PASANEN 1991).

The car driver's way of negotiating such a junction is apparently subconscious and a result of years of driving experience. Inexpensive engineering measures can not alter that kind of behaviour in a sufficient manner. Most of the drivers also seem only to care about their own safety and comfort, and neglecting to consider the lethal hazard that they with their vehicles cause to the unprotected and unthreatening road users.

One problem is connected to the low bicycle flows. If a bicycle comes from the right 15 times in an hour, i.e. once every four minutes, many of the drivers could pass the junc-tion tens of times without ever encountering a bicyclist coming from that direction. Because of this it is very hard for car drivers to anticipate such an event.

Three approaches exist for the improvement of such junctions. One approach would be to make bicycle paths one-way only so that bicyclists would enter the crossings from the left-hand side of the drivers. In our junction this would mean that the bicyclist driving downhill would use the bicycle path on the other side of the road. For most junctions this solution would mean construction of a bicycle path on the other side of the street, too. Thus it is not an inexpensive solution, and neither is signal control, which would probably solve most of the problems. Both of these engineering solutions are unthinkable for locations with as low vehicle and bicycle volumes as most of the problem junctions.

The third approach would be to concentrate on driver education and training for the purpose of making the drivers to anticipate the appearance of bicyclists at junctions, also from the right-hand side. In training for such a well defined situation, the use of the traffic conflict technique would presumably be very valuable.

A fourth approach of changing the priorities so that the bicyclist should give way to motor vehicles at junctions has also been proposed. We rejected it as it would certainly bring about more problems than remedies.

REFERENCES

NTR 1989, Cykelulykker i kryds (Cyclist accidents at intersections), Et metodestudium, Lyngby, Nordisk Trafiksikkerheds Råd, Rapport 51. 40 p.

PASANEN E. 1990, Kokeilujärjestelyt pyöräilijöiden suojatieonnettomuuksien vähentämi-seksi (Experimental designs for decreasing bicycle accidents on pedestrian crossings), Helsinki, Helsinki City Planning Office, unpublished memorandum 27.12.1990. 3 p.

PASANEN E. 1991, Oikealle kääntyvän autoilijan ja oikealta tulevan pyöräilijän ongelma (The problem of right turning vehicles and cyclist coming from right), Helsinki, Helsinki City Planning office, unpublished memorandum, 9 p.

SALUSJÄRVI M. 1989, Road accident investigation teams, Developing the on-the-spot, in depth, case-study methodology, Espoo, Technical Research Centre of Finland, VTT Research Report 617. 125 p.

TRK 1978, TRK:s haverikommission (TRK Multidisciplinary Accident Investigation Project), Redogörelse för en försöksverksamhet, Stockholm, Försäkringsbranschens Trafiksäkerhetskommité - TRK (The Insurance Road Safety Committee), Rapport nr 1. 323 p.

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EFFECTS OF ROAD CHARACTERISTICS ON SPEED

ABSTRACT

Since 1988 the TNO Institute for Perception conducts a research programme on determinants of drivers'speed and the relationship between speed and road characteristis, commisioned by the Transportation and Engineering Division of the Dutch Ministry of Transport, Rijkswaterstaat.

In this presentation the results of a literature review on relevant determinats of drivers' speed will be discussed, followed by recent results of experimental research with respect to speed choice under the influence of several factors - such as sight distance, road width, and curve characteristics -, and its implication for speed reducing measures on 80 km/h roads.

Long version did not arrive in time.

Nicole MUHLRAD

INRETS, DERA
Paris, France

ACCIDENTS IN DEVELOPING COUNTRIES: REQUIREMENTS FOR IDENTIFYING PROBLEMS AND SOLVING THEM

ABSTRACT

Traffic safety information and knowledge transfer to developing countries is not an easy task as little is known yet about accident causation processes and their determinants in a context of fast growing travel demand and mixed traffic.

Thorough diagnoses are needed, which requires a minimum amount of data and observation tools, with some adaptions to fit each country's particular situation. Interactions between accident factors identified in the diagnosis usually point out to complex safety action, requiring specific decision-making and research structures.

The following figures shall give an impression about the special demands on the research work in developing countries.

To start with there is an overview about the different situation in road-safety management in France in relation to a developing country like e.g. Ivory Coast (figure 1)

Figure 2 shows general problems in developing countries from a traffic safety point of view.

In figures 3 and 4 you can find different starting points using "blackbox" or "glassbox"-approaches to traffic safety.

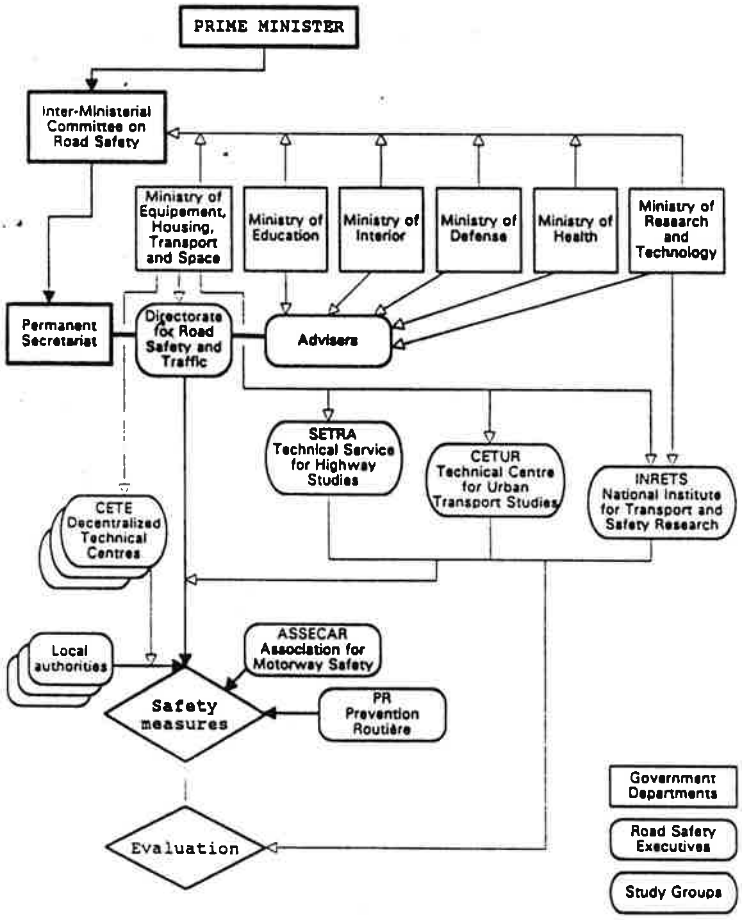
Figure 5 shows the procedure for integrated safety mangement.

Figures 6 to 8 give an impression about the general way from safety diagnosis to programme design.

Excessive speed is looked upon as being one main cause for pedestrian accidents. Figure 9 gives an overview of several factors functioning as a background for excessive speed.

F I G U R E 1

ROAD SAFETY ORGANIZATION IN FRANCE



CÔTE D'IVOIRE IVORY COAST

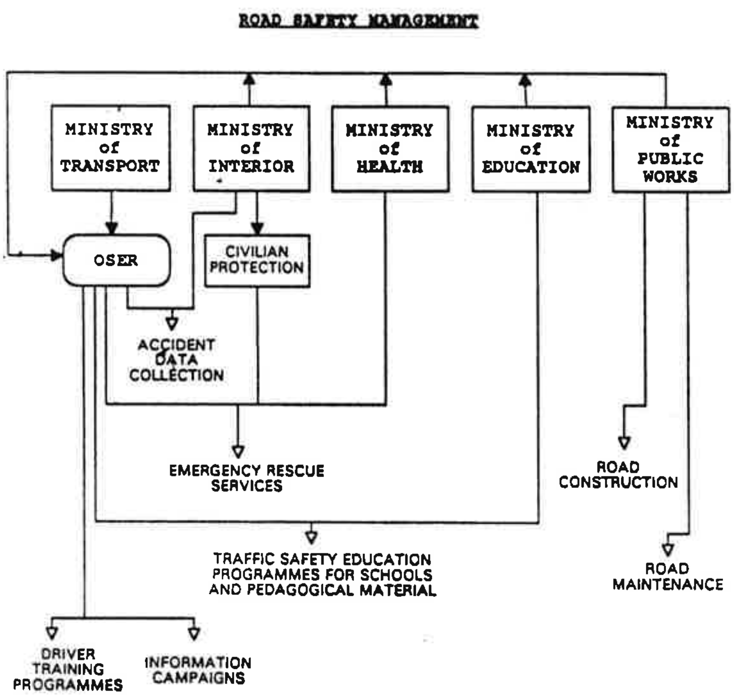
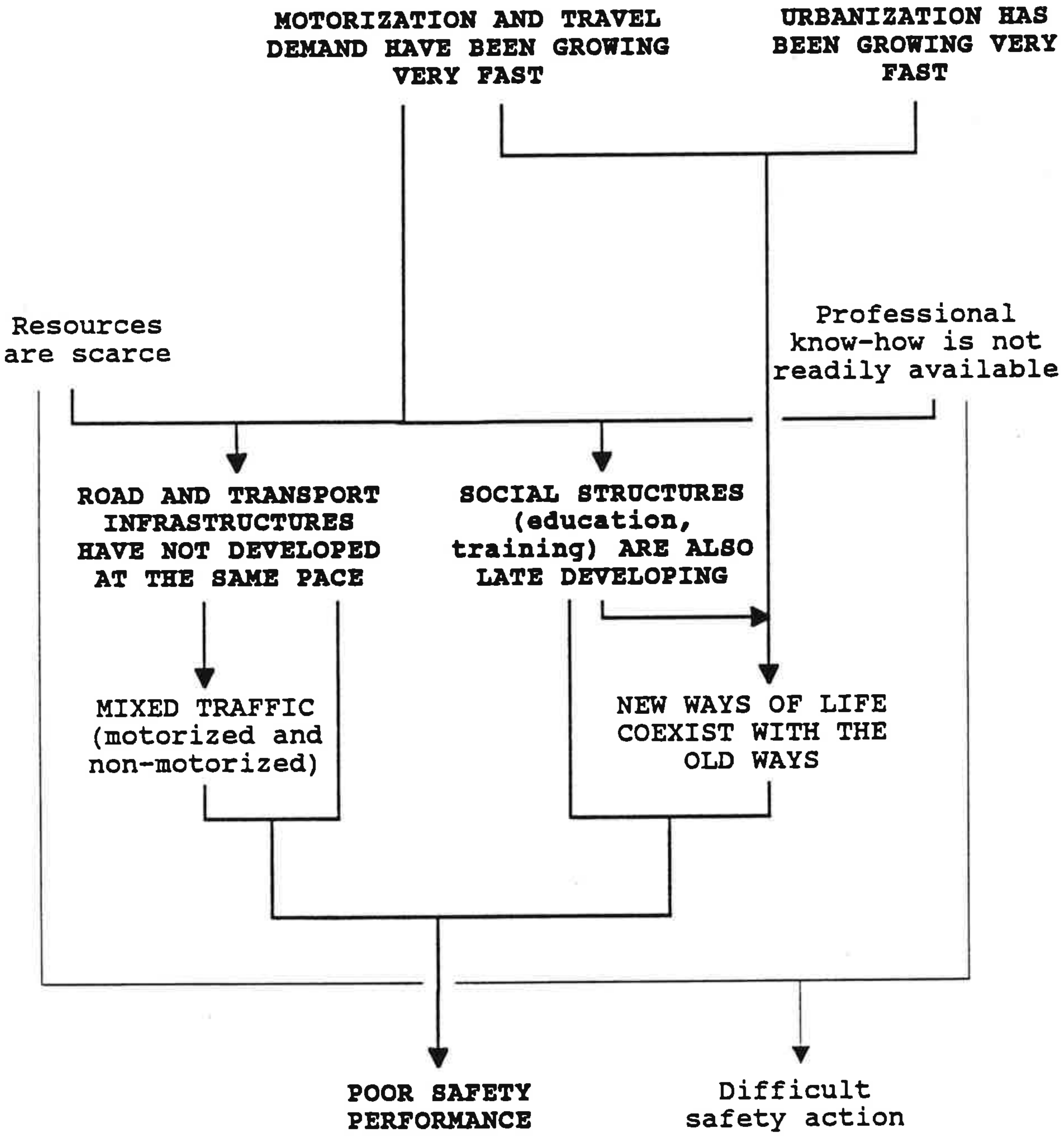


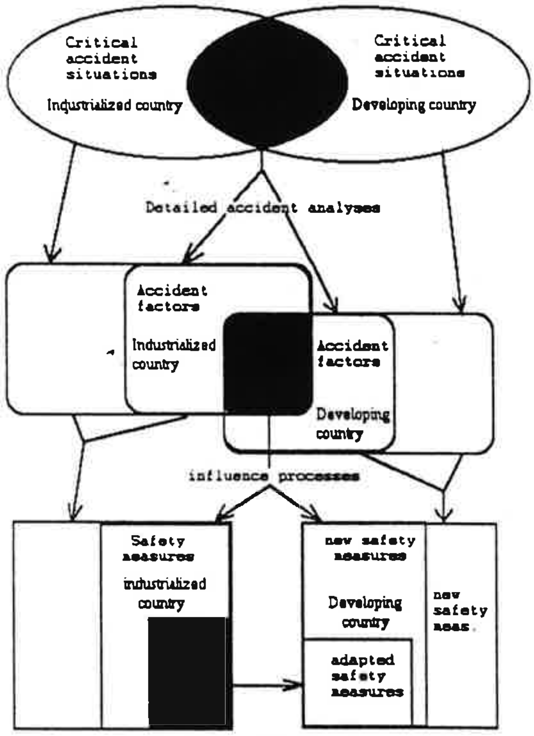
FIGURE 2

DEVELOPING COUNTRIES FROM A TRAFFIC SAFETY VIEWPOINT



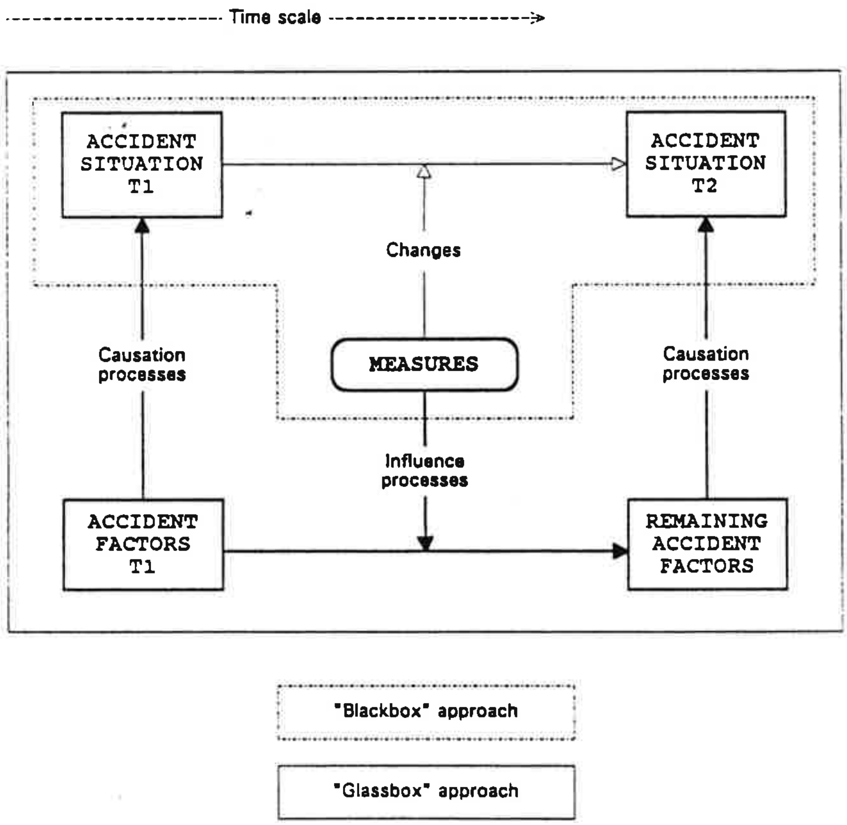
F I G U R E 3

GLASSBOX APPROACH TO INFORMATION AND TECHNOLOGY TRANSFER



F I G U R E 4

"BLACKBOX" AND "GLASSBOX" APPROACHES TO TRAFFIC SAFETY



F I G U R E   5

PROCEDURE FOR INTEGRATED SAFETY MANAGEMENT

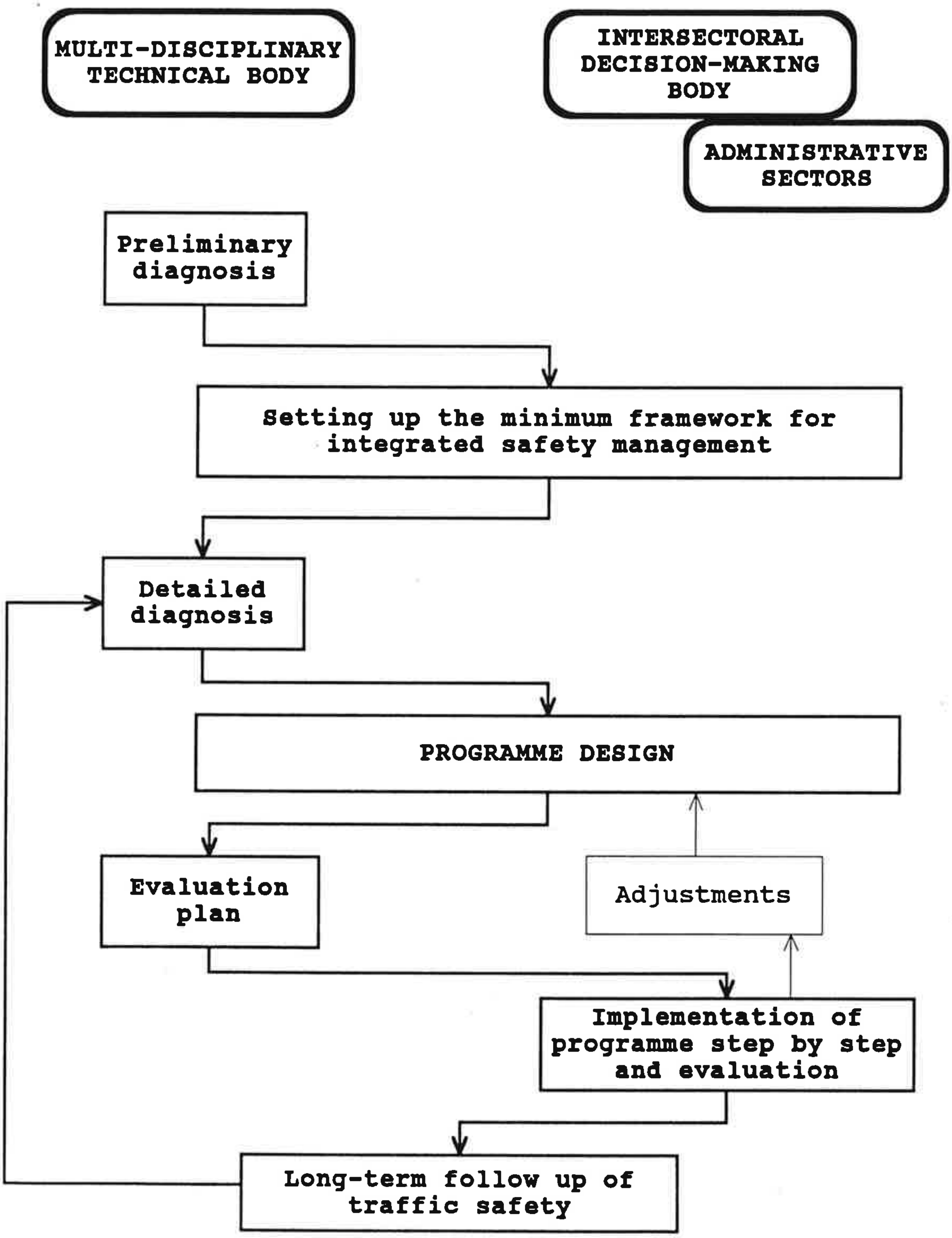


FIGURE 6

EXTENDED SAFETY DIAGNOSIS

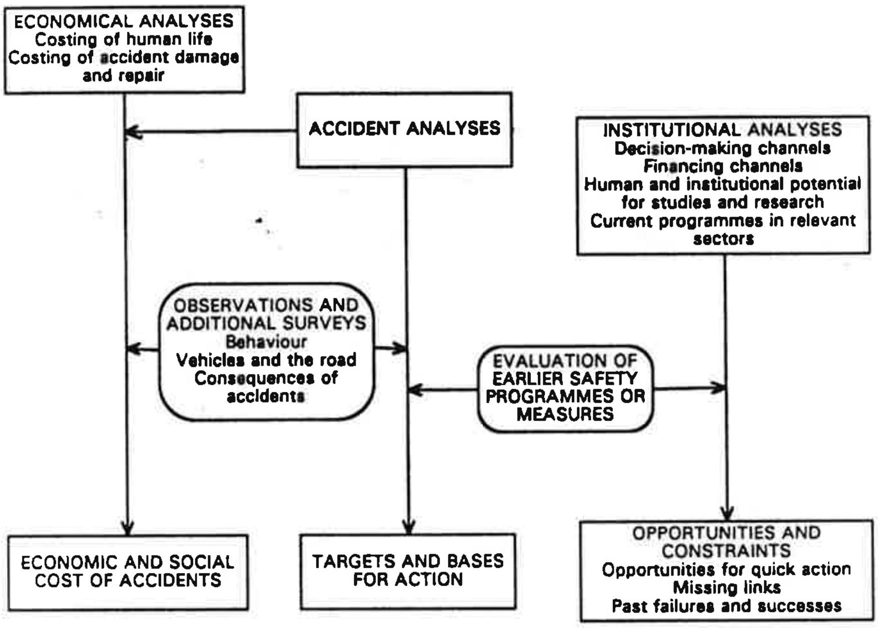


FIGURE 7

ACCIDENT ANALYSES

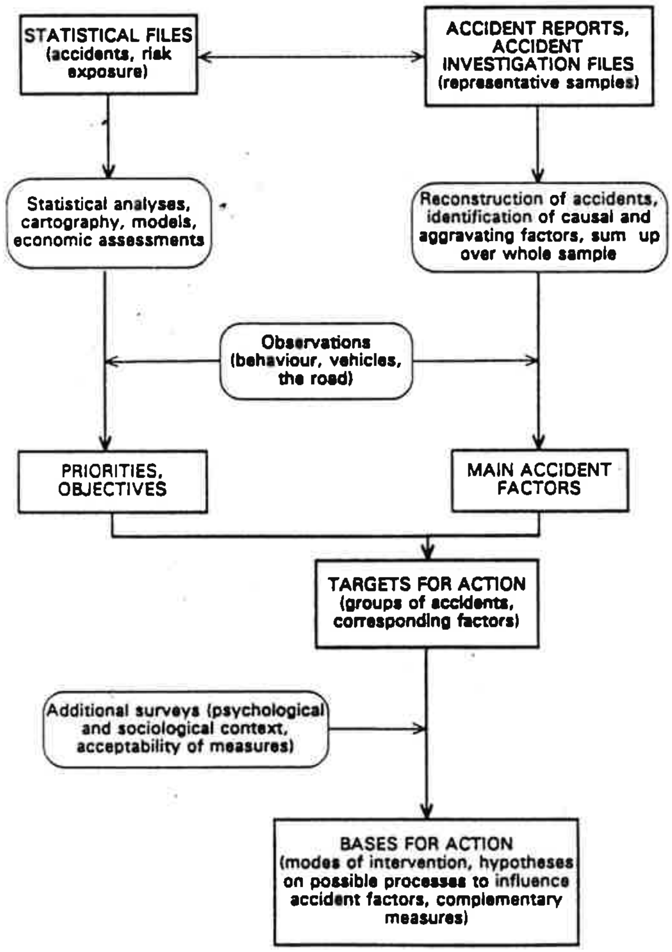


FIGURE 8

FROM SAFETY DIAGNOSIS TO PROGRAMME DESIGN

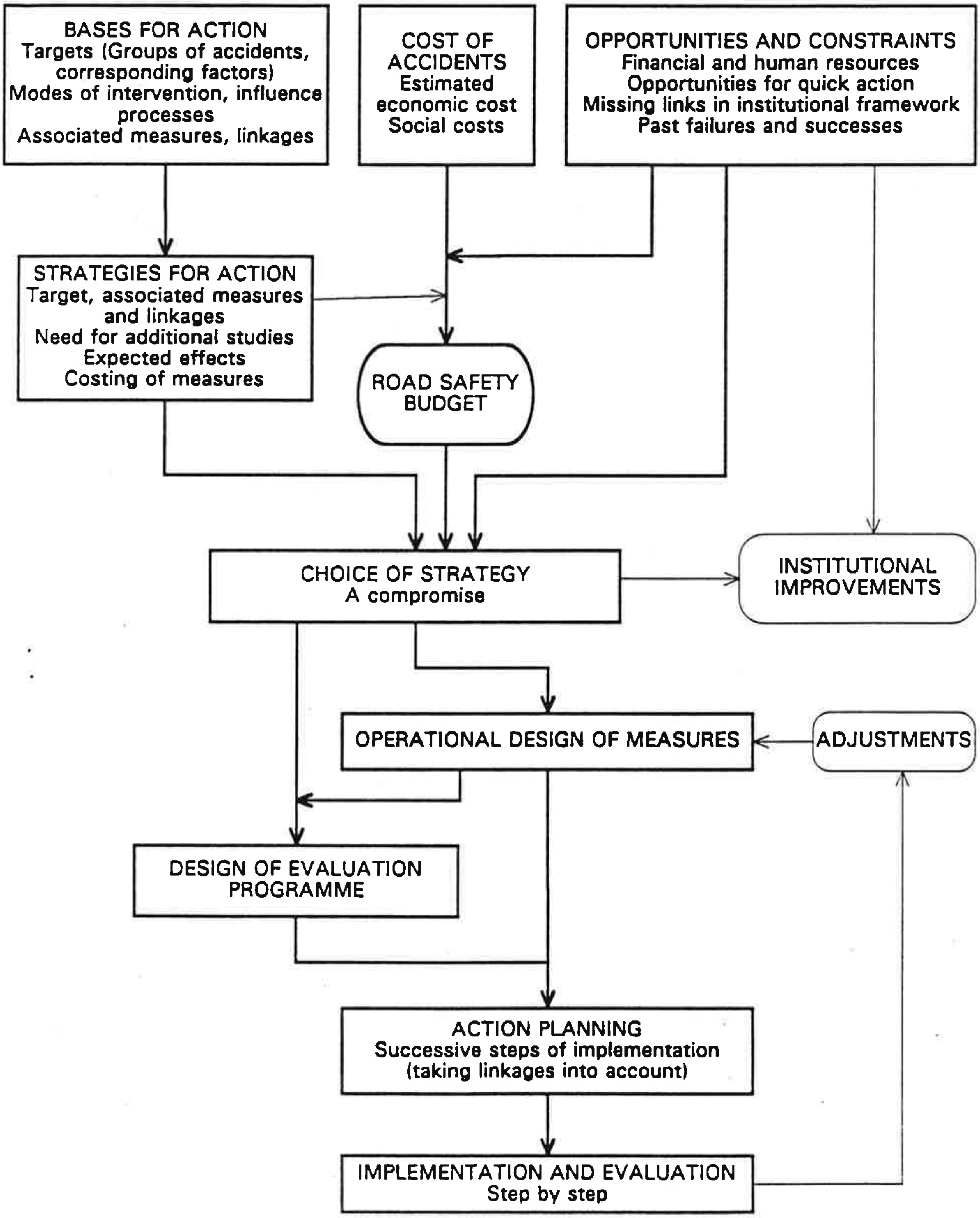
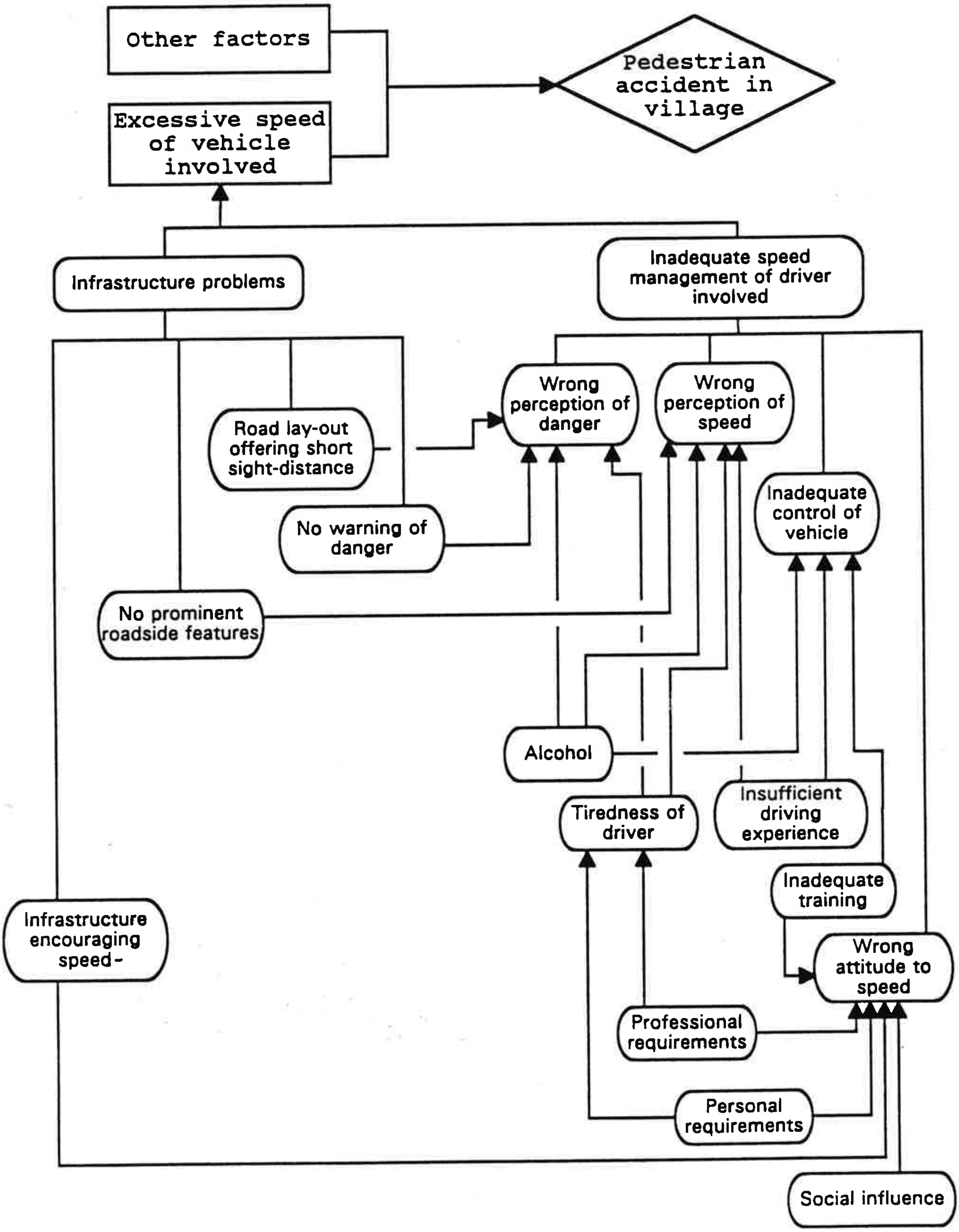


FIGURE 9

ACCIDENT FACTORS



FINAL COMMENTS TO ACCIDENT-OBSERVATIONS AND -SURVEYS IN GENERAL

Being engaged in accident research work it seems to be importent to focus on the following aspects:

o Understanding the accident problem and generating processes

- Traffic conflict data collection and analysis
- Measurement and analyses of risk exposure (traffic volumes and mix, mobility patterns, etc.)
- Investigation of critical road features
- Observation of critical behaviour
- Survey of vehicle state of repair

o Influencing accident factors and processes

- Analyses of the determinants of behaviour: attitude and opinion surveys
- Survey of road-users' perception of current or previous safety measures and programmes
- Investigation of acceptability for the public of particular safety measures

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ACCIDENT INFORMATION SYSTEM IN AN INDIAN CITY: CASE STUDY DELHI

SYNOPSIS

Rising accident trends have been engaging the attention of all concerned agencies. Though the occurance of the accidents is attributed to manifold reasons, the quality of information prohibits in-depth analysis for drawing up meaningful programmes for accident prevention. It is observed that, irrespective of the high vehicle ownership, the developed nations have been able to approach the problem of accidents in a systematic manner by developing a variety of information systems with the use of the information technology, and has shown considerable efficiency in prevention and elimination of certain types of accidents. However, in India no serious efforts have been made until now to understand the problem of accidents and injuries. The anxiety for improving road safety has not brought down the rising trends and thus left the problem unabated. While there is less or literally no impact of the recent information technologies in this potential area of information management, this Paper critically analyses the prevailing manual systems with the hope that in future, with able political leadership, the country will see an entire transition process towards "New Information Order".

1. INTRODUCTION

Though technological innovation has added enjoyment to the life of man, it also has exposed the humanity to adverse effects. All countries are suffering from the by-products of high motorisation in the form of road accident toll which is killing and maiming, that has reached a proportion unequalled by war and other man made calamities. Reports of world health situation have regularly stressed the scale of road traffic accidents with about 10 million persons injured and 250 000 persons killed every year throughout the world (WHO 1979). The innovations to make driving a safer activity have not eliminated traffic fatalities and driving is not as safe as it should be. Trying to scare drivers into safer actions by comparing statistics on war and road death rates has not worked either (Bauman 1975).

In India, the road traffic accidents pose a great challenge to all those who are concerned with their reduction since comparative figures with many countries do not present a complimentary situation to them. Irrespective of the high vehicle ownership of 1 motor vehicle for 2 persons in United States of America (USA) and for 3 persons in Japan against 1 motor vehicle for 268 persons in India, the fatality rate was observed to be 64.9 per 10 000 motor vehicles, whereas it was 4.7 in U.S.A., 2.9 in Japan and varied between 5 and 15 in most of the European countries. The accident risk to which we are exposed on roads is increasing. In the year 1981, about 150 000 accidents were reported on the 1.5 million km of road network of India. About 10 per cent of the vehicles are involved in road accidents, killing 25 000 persons and injuring more than 100 000 persons. It means that every four minutes, one accident occurs killing or injuring one person in average on Indian roads (IRF 1971, SRINIVASAN 1985).

These accident risks are extremely high on urban roads. On these roads, that represent only six per cent of the total road network of the country, about 75 per cent of the accidents occur of which 40 per cent are reported from four big cities namely Bombay, Calcutta, Delhi and Madras alone.

2. ACCIDENTS AND THEIR PREVENTION

During recent years, scientists have turned the word "crash" to the term accident in reference to traffic collisions. Their belief is that traffic collisions are caused occurances rather than incidents involving chance alone. The occurance of the accident is attributed to manifold reasons. The problem of accident is a multidimensional one, involving a system that comprises man, machine and environment and all the complex relationships that are possible between these variables. There are always a number of causes which fit together like the links of a chain to create the final situation. Most of the circumstances of accidents can be discovered and, once discovered, can be controlled. The important circumstances can be isolated through analysis which makes the accident prevention possible. Whole series of accidents have common circumstances and by concentrating on the elimination of these circumstances, it is possible to reduce, or in some cases even eliminate completely a particular type of accident.

Today, from the experiences of the developed world, we know much about traffic and accidents and some people think that accidents have been prevented and are being prevented up to appreciable levels. In India, however, no serious effort has been made until now to understand the problem of accidents and injuries. The reliable information concerning injuries and accidents is difficult to obtain. Although in recent years, the ever increasing accidents on roads have been drawing attention of all concerned agencies, the accident problem is unabated. This may be attributed to the quality of information available which prohibits in-depth analysis for drawing up meaningful programmes, to take the problem of accidents. This needs urgent attention and perhaps the first useful step in this direction would be to strengthen accident collection and recording and to develop an efficient "Road Accident Information System".

3. ACCIDENT INFORMATION HANDLING AND INFORMATION TECHNOLOGIES

3.1 Experiences Abroad

With the emergence of fast computers and supportive technologies, both the scale of information systems and their efficiency changed in the developed world. As a result, it is possible to have varied and detailed policy options. This is a good precondition to bring government's full intelligence to bear on resolving the central problems of society.

The review of literature on accident information handling in the developed world suggests that concerted efforts were made with emphasis on improving traffic accident recording systems and dissemination of information according to user needs. For example, the Presidential Committee of USA for traffic safety (1961) laid emphasis on establishing or improving the existing system, and have suggested that the system must incorporate a service agency, covering the areas of collection of basic records, data, extraction, compilation and supply the needed information to all users and not only to one favoured department. In order to assist in forwarding dissemination and exchange of knowledge relating to the cause and prevention of accidents, a "National Accident Prevention Centre" was founded in the House of Representatives of the USA (1963). As a result, there were several automated information systems designed at Federal and at State Levels. Various reports suggest that this had considerable impact on reduction of accidents, fatalities and severity of accidents (HRB 1979).

3.2 Indian Experiences

In India, the anxiety for improving road safety has been reflected by proposals for establishment of a "National Road Safety Council" at the Centre and State level. District and City level Councils are to act as arms to coordinate working of various departments involved in road safety. This has been under consideration of the Union Ministry of Transport for a considerable time. In the absence of a central agency for information handling, the scattered numerous sources are encouraged to give out incomplete information and inadequate results. The collection by parallel agencies have also resulted in misreporting. A comparative analysis (Table 1) of the statistics by two Union Ministries namely the Ministry of Home Affairs and the Ministry of Transport in 1977 brings out that the difference between two sets of figures was large (25 per cent in total). The situation is particularly serious in the context of metropolitian cities like Bombay, Kanpur, Ahmedabad and Hyderabad, where the reporting differed by 35 to 99 per cent. When we are at a point where the accident problem has to be tackled systematically, as there is no simple answer to the problem, the figures confirm the fact that the existing system in the country for recording such data are inherently defective.

Table 1 Comparison of accident statistics disseminated by two government agencies in India 1977

Number of persons killed in accidents

Name of State/City	Ministry of Transport*	Ministry of Home Affairs	Comparision with Ministry of Transport figures =100
Calcutta	358	358	100.00
Bombay	660	822	124.50
Delhi	694	571	82.20
Madras	199	210	105.50
Bangalore	247	257	104.00
Ahmedabad	149	51	34.20
Hyderabad	210	4	1.90
Kanpur	73	96	131.50
Total 22 States	18247	14242	74.00
Total 9 Union Teritories	891	848	95.20
Total	20138	15090	74.90

* Ministry of Transport (1982)
\+ Ministry of Home Affairs (1979)

Today, accident records and data are scarce and difficult to obtain even by agencies involved in research, planning and management. Researchers find that whatever the quality of data availability may be, the time spent on compilation and gathering of basic information is eating up a large part of the time for research efforts. Thus in accident research in the country, there is too much duplication of effort, and one is often unaware of information available elsewhere. Though various institutions are collecting accident data, the information derived is often not made available to others. These valuable data are recorded, but are scattered, fragmented and neither adequately indexed nor properly identified with respect to where they can be found. The present manual system is unable to provide the needed efficiency in information storage, retrievel and dissemination.

4. METROPOLITAN EXPERIENCE

In metropolitan cities, the facilities and the environment for systematic approach are available and because of localised nature of administration, better systems of reporting should prevail. The present paper reviews the existing systems for accident information by a case study, to underline the strengths and weaknesses, the impact of information technologies and to suggest suitable measures for strengthening the system.

Case study selection

Amongst four big cities in India, i.e. Bombay, Calcutta, Delhi and Madras, traffic volume has been increasing at an alarming rate since the last two decades (Table 2). In Delhi, between 1961 and 1981, the number of vehicles has increased from 51 000 to 499 000 vehicles, an increase of 800 per cent against 18 per cent increase of population. In addition, there were about 700 000 cycles, about 16 000 slow moving vehicles (RAJESH 1982) and a few thousand motor vehicles from other states which come to Delhi every day. This results in heavy volumes of traffic of heterogeneous composition on the road network in Delhi.

Table 2 Distribution of population and vehicles in four metropolitan cities of India

	Population (million)			Vehicles (million)		
	1961	1971	1981	1961	1971	1981
City						
Calcutta	5.74	7.03	9.16	0.038	0.104	0.152
Bombay	4.15	5.97	8.20	0.067	0.177	0.265
Dehli	4.77	4.30	5.62	0.051	0.217	0.499
Madras	1.73	2.47	4.27	0.021	0.048	0.079
Total	14.39	19.77	27.26	0.177	0.546	0.945

This increased number of vehicles on the roads has also resulted in an increase in the number of road accidents, Table 3 shows that the fatalities went on increasing steeply from 98 persons killed in 1956 to 694 in 1980. The severity of accidents is also observed to be very high in Delhi compared to other cities which has been revealed in 172 deaths per 1 000 accidents whereas this figure stood at 60 in Madras, 40 in Calcutta and 30 in Bombay. On the above grounds of increase in vehicles and high severity of accidents, Delhi has been selected for discussion.

Table 3 Accident situation in Delhi

Year	Population (million)	Vehicles (million)	Total Accidents	Casualties		Victims
				Killed	Injured	per 1000 Accidents
1956	2.12	0.02	1127	98	731	730
1960	2.64	0.05	4814	163	1760	390
1964	3.16	0.08	8006	283	3193	430
1968	3.75	0.14	7893	400	3316	470
1972	4.50	0.25	5143	503	3301	730
1976	5.00	0.10	3840	587	3730	1120
1980	5.70	0.50	4032	694	3974	1130

5. EXISTING INFORMATION SYSTEM IN DELHI

5.1. Institutions involved

In Delhi, the following agencies are interested in accident data

(a) The prime responsibility for collection rests with Delhi Police. They collect information on day-to-day occurance through on-the spot surveys.

(b) Delhi Transport Corporation (D.T.C.) being the single agency for providing public transport facilities with their objectives of providing a safer traffic, collect the information on accidents, as and when their buses are involved, by on the spot surveys, for their internal purposes.

(c) When the victim is brought to the emergency hospital, the medico-legal case forms are filled with the coding of severity when the person arrived. Besides, medical history and progress reports are maintained for monitoring and for planning purposes.

(d) As and when an insured vehicle is involved in an accident, the accident damages are claimed and the surveyors of insurance companies assess the actual damage. These data are maintained by the Tariff Advisory Committee for revising the premium on policies.

(e) As a communication media the Newspaper agency collects the daily number of accident photographs and information regarding typical accidents. The number of fatal accidents and a short history on cause are disseminated daily.

Though many institutions hold records, most of them are not very accurate and largely dependent upon the primary information provided by the police, the victim or the local evidence. This review of sources of information suggests that as at present, Delhi Police is the major agency for a comprehensive collection of data and should, therefore, be the nodal agency for collection of accident information.

5.2. Data Collection Methods

From the time of accident to the final compensation level, the necessary data are collected, according to the responsibilities and requirements, in predesigned proformas. The following types of information are collected.

(a) First Information Report (FIR) and Research Forms of Indian Roads Congress (IRC) are filled by Delhi Police. FIR format contains Date, Hour of Occurance, Witness, Address, Steps taken, delay in recording, time and date of dispatch from police station. This format is intended to note all law violations and to record immediately addresses of offenders and witnesses. There are no special formats suggested for accidents. This FIR is to be supported by a charge-sheet which covers the accident spot and sitution report by the investigation officer who has seen the accident site. The photographs of very serious accidents are also included. But the measurements of skid markds etc. are often found missing in the reports.

(b) The IRC research forms collected by the Delhi Traffic Police contain location, record link, classification of accidents, roadway characteristics, details of the driver and the victims involved. These records are filled only for fatal accidents. This record will be helpful in identifying the areas and road sections having frequent severe accident occurances.

(c) The medico-legal forms filled in the Emergency Hospitals contain the name, place, date, police station, age, sex, address, nature of injury and the state in which the victim has been brought to the hospital. It is observed that these lengthy forms discourage the doctor to fill them in, most often in the case of slight injury accident. These records are not monitored but can be used for provision of suitable health facilities to the accident victims.

5.3. Manpower Capacities

While collecting the information, we need to consider capacities of the manpower involved in collection. The general outlook of the personnel involved is found to be different in many cases as would be revealed below.

(a) The FIR form is filled by a sub-inspector of police. The minimum education level is intermediate school and he has other responsibilities like attending to criminal law cases.

(b) The investigation reports completed by the investigation officer are concluded without any scientific arguments in identification of the cause of the accident.

(c) Research forms are filled by the Traffic Inspector who is responsible for speed checks, licence checks, patrolling and VIP security. As there is no special training given for investigation of road accidents, the forms are not understood well and are hardly ever filled in completely, thus it is also observed that Research forms are filled by intuition without an in-depth investigation effort.

(d) It is observed that the Investigation Officer is not provided with transportation facilities for the follow up action, which inhibits collection of useful information for identification of actual causes of accidents. The outlook of police in filling FIR forms is to prosecute a person involved in an accident which results in a biased report. In the present system of overloaded responsibilities, low qualification levels, and mechanical nature of work, it is impossible to expect reliable information without any special training or senior officers supervision, and without proper incentives (Bawa 1979).

(e) Medico legal case reports are filled by a casualty medical officer with the qualification of medicine and surgery. We can expect reliable and efficient information collection, if forms are redesigned to suit the requirements.

5.4. Quality and Quantity

With the existing system of manpower capacities and the facilities available, it is found that the quality of information which is equired for understanding of causes and effects of accidents is poor. It is seen that:

(a) The road accident casualties reported in hospitals and police records show a considerable under reporting and misreporting by the police. In Delhi, there are 95 per cent discrepancies found between police and hospital records (Rajesh 1982). Amongst which 40 per cent of fatal accidents, 86 per cent of seriously injured and 100 per cent slightly injured are under-reported. The accidents occurring in the sample week are estimated to be 2 600 whereas 1 100 accidents are reported in hospitals and 66 accidents in police records. These discrepancies are shown in Table 4.

Table 4 Accidents in hospital and police records (sample week)

Report	Accidents	Persons			
		Fatal	Seriously Injured	Slightly Injured	Non-injury
Hospital	1100	20	426	883	-
Police	67	12	61	-	1
Under reporting (%)	45	40	86	100	-

(b) The evaluation of the quality of information reviewed on the basis of completeness and accuracy of filled forms, reveals that only 29 per cent of the information is made available in the present collection (Rajesh 1982).

6. CRITICAL ANALYSIS OF THE EXISTING ACCIDENT INFORMATION SYSTEM

6.1. Input

The prevailing accident information system in Delhi is coordinated by the accident research cell of Delhi Police which receives the number of accidents, injuries and fatalities and the roadway and traffic characteristics data collected in the Research Proformas. Often these Research Proformas are filled by traffic inspectors after 2 days and the resulting information gaps are filled by intuition. The evaluation of the filled forms shows that the present proforma is lengthy and the technical terminologies are not completely understood by the traffic police. In addition to the collection of day-to-day accident data, welfare organisations and public also provide information to traffic police regarding potentially accident prone spots near their areas of residence. In the present system, accident information can reach the headquaters earliest after one day. Daily/Weekly/Fortnightly diaries, Research proforma for fatal accidents and the traffic violation reports are the only records as INPUT in the preesent system.

6.2. Recording and Storage

The data collected by traffic inspectors and the information reaching Delhi Police through daily/weekly/fortnightly diaries are recorded and stored in the Accident Research Cell (ARC). The daily and weekly diaries are coded in a temporary file and are updated through the fortnightly diaries. It is observed that some accidents which have been reported in daily diaries are not reflected in fortnightly diaries. In the number of casualties, there is a certain amounts of discrespasncies. The fortnightly diaries are recorded in the accident index register with a master index according to the date of occurrance. There is no register maintained for all victims reported. The fatal accidents and their brief history are recorded in the brief history register. Information regarding roads is recorded in a predesigned proforma "Roadwise Data Form".

The forms that have been filled by Traffic Inspectors for all fatal accidents are kept in files and coded in the index register. The accused drivers' particulars are maintained in a manual register for further action.

Existing recording of locations is found incomplete. While recording the accident, the investigator fixes the spot by landmarks, intersection code, lamp post number and major structures. The locations are based on street maps. Locations that are at long distances from landmarks and on open roads are however difficult to identify. It is also observed that there is no direction of traffic movement at the accident site. As no measurements or estimated distances are given from the landmark, this results in vague and incomplete data.

The present storage of collected information is done manually. the brief history of fatal accidents, the data on the drivers accused for fatal accidents, the accident index and roadwise data forms are at present stored in registers. As there is no recording of victims, the information linkage is not possible. Though, useful data are collected, not all are stored because of the limitations on manual systems. As there is no exactly known location for storage, there is no inquiry from local agencies to identify the accident prone location for safety improvements programmes.

6.3. Dissemination Practices

Monthly review-of-crime reports (including traffic accident data) and yearly reports on road accidents and enforcement are the two publications disseminated by Delhi Police. Monthly reviews include total prosecutions, cash realised and activities of road safety cells by Police stations and traffic Police management activities.

This monthly review will be published in the following month whereas the yearly report on road accidents will be published by the sixth month of the following year. The yearly report includes past trends of accidents by time and day of accident, road-wise accidents and comparative figures of three-year accidents.

In each monthly and yearly summary, there is often a sub-classification of motor vehicle accidents by Police, which is essentially meaningless for users. Both in monthly and yearly disseminations, the location, place and road factor tabulation are not present. In case of motorcycle fatalities, there is no indicator whether the victim wore any helmet at the time of the accident. Type and speed of the vehicles involved in accident are not mentioned either. Information about defective brakes, light and other machanical failures is completely missing. Timewise classification of accidents is not useful, as this is not cross-classified with the regulatory measures initiated by police. Percentage comparison is missing.

The portion of childred killed and injured is not thoroughly sub-classified. The time tabulation is of little value when published. Distribution of accidents by day of week and time of day is well known and varies but slightly from month to month and from year to year. There is little value in repeating it every month. The terminology used to classify day and night accidents is not accurate. All the tabulations evaluated and summarised in yearly reports leave the reader with the task of interpretation of the data. The tables found in monthly/yearly accident summaries consist entirely of observed frequencies of accidents. The percentages are more informative for the readers than the observed frequencies. A comparative table affords an opportunity to test the changes from year to year. Mileage rates are useful rather than numbers of vehicles as they only present the total exposure. It is therefore concluded that the present dissemination which provides repetitive summaries months after months is not meeting the user requirements.

6.4. Objective Evaluation

The evaluation of the present dissemination in the light of needed information (Table 5) reveals that except for the law enforcement agency, the information is inadequate for all other user groups. The present system is not useful for further action on road maintenance as the exact locations of accidents are not identified.

Table 5 **EVALUATION OF PRESENT DISSEMINATION IN VIEW OF USER NEEDS**

Accident Prevention	Cause of Accident Deaths & Severity Injury		When, Where Critical (Immediate measures)		Suggest Preventive Actions		Measure effect or effort		Determine negligence or fault		Evaluation
User Groups	Needed	Present	Needed	Present	Needed	Present	Needed	Present	Needed	Present	
1	2	3	4	5	6	7	8	9	10	11	12
LAW ENFORCEMENT											
Police			x	O	x	N	x	N	x	I	N
Courts									x	N	N
SAFETY EDUCATION											
Road Users	x	I	x	I	x	I					I
Non-road Users	x	I	x	N	x	N					N
School Education System	x	N			x	N					N
PUBLIC INFORMATION											
Parliament					x	N	x	N	x	N	N
Public-TV etc.	x	I	x	N	x	I					I
DRIVER LICENCING											
Examination					x	N	x	N	x	N	N
Education	x	N	x	N	x	N	x	N			N
Improvement							x	N			N
Cancellation									x	N	N
ENGINEERING											
Traffic Engg.			x	I	x	N	x	N	x	N	N
Street Lighting			x	N	x	N	x	N	x	N	N
Geometric Design			x	N	x	N	x	N	x	N	N
Control Devices			x	N	x	N	x	N	x	N	N
Signs			x	N	x	N	x	N	x	N	N
EMERGENCY SERVICES											
Ambulance	x	N			x	N	x	N			N
Police	x	N	x	N			x	N			N
Hospitals	x	N			x	N	x	N			N
COMMUNICATION											
Telephone			x	N			x	N			N
Wireless			x	N							N
VEHICLE											
Design					x	N	x	N			N
Inspection	x						x	N	x	N	N
Cancel Permit					x	N	x	N	x	N	N
FINANCIAL RESPONSIBILITY											
Short Term	x	N	x	N	x	N					N
Long Term	x	N			x	N	x	N			N

x = User Needs O = Satisfactory I = Inadequate N = Not Satisfactory

The summaries and tabulations are informative in nature, but do not add any knowledge to causes and effects of accidents for drawing up any meaningful action programme. A critical analysis of the existing information system is shown in table 6.

Table 6 **CRITICAL ANALYSIS OF EXISTING ACCIDENT INFORMATION SYSTEM**

Components	Particulars	Content	Method	Merits	Demerits
1	2	3	4	5	6
Input	- Daily/Weekly/ Fortnightly diaries - Research proforma for fatal accidents - Traffic violation reports	- No. of accidents persons injured filled - Roadways traffic characteristics - Vehicles, persons involved	-Predesigned profroma for diaries - A-I form by IRC - Reports on prosecutions	- Accident information can reach the Admn. earliest by one day - Updation of accident by fortnight	- Collecting acc. information for research purposes are by intuition -The proforma is lengthy, technical terminologies are not completely understood
Recording	- Temp. files for diaries - Index register for reported accidents	- FIR No./Police Station classification - Brief history for fatal accidents	- Manual register - Predesigned register	- Manual operation reduces cost - Redundant data can be avoided	- Not all particulars can be recorded - Incomplete and inaccurate records
Storage	- File for research proforma - Acc. index register - Roadwise data forms - History register for fatal accidents - Accused drivers' involved in fatal accidents-records further actions	- Index No., location persons killed/ injured - Roadwise accidents - Accused drivers' particulars	- Manual storage - Predesigned forms for roadwise data - No format for brief history and drivers' records	- Master indexing of all accidents reported will be useful for retreval purposes	- Unnecessary piling of data will occupy space - Efficiency in preserving records cannot be assured - No system for exact road location makes the record meaningless
Analysis	- Summarisation - Categorisation	- Day, time, P.S.. veh. involved, roadwise accident summary	- Manual analysis	- Summaries and categories can be useful for comprisons	- Manual processing avoids usage of statistical techniques for cross-tabulation
Retrieval	-For review of accident situation by DCP (T)/Lt. Governor. - Inquiry from Parliament	- Police District-wise accidents - Accidents by certain Vehicles	- Manual retrieval - Statement of accidents by month - Identification of Index No.	- Will summarise specific accidents for better interpretations	- Manual retrieval limits accurancy, speed and completeness of needed information
Dissemination	- Crime report monthly review by traffic police -Yearly report on road accidents and enforcement	- Total prosecutions-cash realized-activities of road safety cell-acc. by P.S. Circles-Traffic Police management activities - Past trends/time, day of accident - Comparative figures of three year accidents - Roadwise accidents	- Monthly review is published by the next month - Yearly report is published by six months	- The summaries can be helpful for comparing trends - Informative	- Tabulation of repetitive data do not provide any increased knowledge on cause and effects - The disseminations are not presented in view of user needs

7. SUMMARY AND CONCLUSIONS

Rising accident trends in India have been engaging the attention of all concerned agencies. Though the occurrence of the accidents is attributed to manifold reasons, the quality of information prohibits indepth analysis for drawing up meaningful programmes for accident prevention. This problem needs urgent attention and perhaps, the first useful step in this direction would be to evolve an Accident Information System.

The review suggests that a wide variety of Information Systems have been developed in developed countries. In india control, management and regulation of traffic and in particular the maintenance of law and order rests solely upon the police. It is desirable that the accident information system be organised to serve all athe agencies having accident prevention responsibilities, and that it is centralised under a single responsible institution.

Delhi, the third largest city in India which is growing at a faster rate than any other large metropolis in the country has been selected for assessing the weakness of the prevailing accident information system in metropolitan areas. For the control of crime and law and order situation, Delhi suburban area is subdivided into six Police districts; sixty four police stations are located widely over Delhi for these purposes. For traffic management and regulatory purposes, the city is subdivided into sixteen circles manned by traffic inspectors and supported by base support staff comprising zonal officers/traffic constables at the lower levels. In the event of accident occurrence, the accident information is transmitted to either the police control room/Station House Officer/ traffic control room/Traffic Inspectors/constable at the lowest level.

The First Information Report (FIR) is the major accident record which includes broad information pertaining to an accident. Follow up action brings out its severity supported by witness report. This is transmitted daily to the Accident Research Cell (ARC) which at present coordinates the information system. The ARC is collecting factual information in the prescribed proforma for Research purposes on the request of Indian Roads Congress. The Accident Research Cell documents this information in predesigned formats and stores it in manual registers for dissemination. Detailed investigation of accidents is taken on the strength of research forms filled by traffic inspectors for an indepth study of fatal accidents. In the First Information Reports collection of technical information of first hand is lacking. The Research proformas are filled by Traffic Inspectors normally after two days, and information gaps are filled up by intution.

Numerous agencies such as transport corporations, insurance agencies, ambulance services and the emergency hospitals also collect information and maintain records of accidents. However, most of these accident records are not very accurate and largely depend upon the primary information provided by the police, the victim, or the local evidence. The review of source of information suggests that at present Delhi Police is the major agency for a comprehensive collection of data on accidents and should, therefore, be the nodal agency for collection of information.

The review of completeness and accuracy of the accident forms filled by Police revealed that most of the columns remain unfilled and some columns are misunderstood. The collision diagramme which provides the environment data on accident occurrence is missing completely. However the evaluation of usefulness of collected information of 25 samples of filled forms by scalogram technique revealed that only 29 per cent of the reliable information has been obtained by the present system of collection.

The extent to which the reportable accidents either in hospitals or in police records are estimated to be one-third of the total accidents. About 94 per cent of the victims are underreported in police records than at hospital records.

Collection of accident information and the location procedures adpoted to locate the accident spot are based on road names, without any actually estimated distances from the landmark, which results in vague and incomplete data. Traffic engineers have great problems in traffic safety work as they are far removed from the data collection phase.

In the present information system, as accident records involve the analysis of large volumes of data, lack of special training and skilled manpower forbids the use of statistical techniques for anlysis of the record. The storage of information by manual methods is found to be inefficient and it reduces the capacity of storing of more needed information. This manual storage limits the retrieval of needed information from local agencies. The retrieval of the information regarding vehicles involved or accused drivers or dangerous locations is difficult with the existing manual storage.

The interpretations of categorised summary statisticss are found missing completely. The location tabulation has no research utility in the present system. The sub-classification of accidents by police distircts and stations is essentially meaningless for the users. The evaluation of the present dissemination in the light of user needs reveals that it is inadequate for operational and regulatory purposes. The periodicity of publication on monthly and yearly basis is found to be inadequate to cope with the urgency of information needs.

It is concluded that the present information diessemination is not adding knowledge to the causes and effects of accidents in India. The prevailing accident information system does not meet the requirements of providing needed information to the users in understanding the magnitude of the problem, the effectiveness of attempted counteer measures, and for the developing of useful accident prevention programmes.

REFERENCES

BAUMAN R. 1975, The absurd statistic, in: The California Highway, Patrolman 39, No. 4 : p 27

HRB 1979, Development of Improvement Methods for Reduction of Traffic Accidents, Highway Research Board, U.S.A.

IRF 1971, World Road Statistics 1966-70, International Road Federation, Washington D.C., U.S.A.

MINISTRY OF HOME AFFAIRS 1979, Accidental Deaths and Suicides in India, 1977, Bureau of Police Research and Development, Government of India

MINISTRY OF TRANSPORT 1981, Motor Vehicle Accident Statistics in India 1970-1980, Transport Research Division, Government of India

RAJESH T. 1982, Accident Information System in Metropolitan Cities of India, unpublished Thesis Dissertation, School of Planning and Architecture, New Delhi

SRINIVASAN N.S. 1985, Road Safety in Urban Areas, Proceedings of Metropolitan Transport in India Seminar, The Times Research Foundation, New Delhi

THE HOUSE OF REPRESENTATIVES 1963, National Accident Prevention Centre, Washington D.C., U.S.A.

THE PRESIDENT COMMITTEE 1961, Highway Safety Action Programme, Committee on Road Safety Washington D.C., U.S.A.

WESTIN A.F. 1971, Information Technology in a Democracy, Harvard University Press

WHO 1979, Road Traffic Accident Statistics, EURO Report and Studies 19, World Health Organisation, Copenhagen

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EVALUATING THE RISK OF SKIDDING FROM CONFLICT STUDIES

SUMMARY

Being situated near Equator, the island-republic of Singapore experiences hot climatic conditions with frequent spells of rain. These characteristics cause the road pavements to have alternating periods of dry and wet surfaces. To avoid skidding on the road pavements and the possibility of an accident, drivers normally maneouvre their vehicles with greater care while travelling on the wet pavements. They are often advised to drive with caution but it is difficult to determine specifically and quantitatively what is involved in "driving with caution".

This paper describes how traffic conflict studies can be used to examine the issue of skidding on the roadway and to apply the results to analyze the impact of wet pavements on road safety. To illustrate this, conflict data from an on-ramp merging into an expressway were used. The quantitative measure used to describe conflicts was the minimum deceleration required to avoid collision. For each pair of observed vehicles in the merging process, the value of this conflict measure was computed over a number of intervals so that a nearly continuous evaluation of the conflict measure was possible. The value corresponding to the most severe instant of conflict was regarded as a measure of the severity of the conflict in each merging encounter.

From the severity values determined, a mathematical distribution of conflict severity was then derived. With this it was possible to derive the probability of a near-collision once the threshold for near-collision was specified. The threshold chosen for the study was the limiting deceleration of vehicles just before skidding and this was assumed to follow a normal distribution.

The probability of near-collision is affected by the threshold distributed chosen. If the behaviour of drivers travelling on wet surfaces remains the same as on dry surfaces, then the increase in risk level on wet days can be evaluated. It is also possible to study the influence of changes in driver behaviour expressed in terms of reduction in speeds on the probability of near-collision.

1. INTRODUCTION

One of the major causes of accidents on the road is the low skid resistance of the pavement surface. A site with low skid resistance is particularly hazardous during wet-weather conditions. Although not all accidents occurring on wet roads result from skidding, there is evidence (WAMBOLD et al 1986) that the accident rates are higher during wet periods than dry periods.

This paper examines the risk of skidding, not from the point of view of accident occurrence but from the likely increase in traffic conflict potential. This approach requires a definition of conflict which is suitable for indicating the risk of skidding. Furthermore, the risk of skidding is evaluated in probabilistic terms based on a modelled distribution of conflict occurrence rather than direct measurement of conflict counts. The problem is considered for the case of merging traffic and in particular for an expressway situation.

2. DEFINITION OF CONFLICT

Consider a merging situation on the expressway in which a vehicle on the expressway is in potential conflict with a vehicle merging into the expressway from the on-ramp. Suppose that at a given time t, the offending (merging) vehicle is at position $x_m(t)$ downstream from the ramp nose of the expressway and the conflicted (expressway) vehicle is at position $x_e(t)$. If $x_m(t)$ is measured with reference to the rear bumper of the merging vehicle and $x_e(t)$ is measured with reference to the front bumper of the expressway vehicle, then there will be a clear spacing between the vehicles Δx which will vary with time during the entire period of merging interaction, i.e,

$$\Delta x(t) = x_m(t) - x_e(t)$$

No collision has occurred as long as $\Delta x(t)$ remains positive throughout the merging process.

Denote the speeds of the expressway and merging vehicles at this time as $v_e(t)$ and $v_m(t)$ respectively. Provided that $v_e(t) > v_m(t)$, there is a likelihood of a collision should the speed and path of the vehicles remain unchanged with time. Under such a condition the collision will occur after a time interval τ given by

$$\tau = \frac{\Delta x(t)}{v_e(t) - v_m(t)}$$

This time duration is also known as the time measured to collision or time to collision. However the collision can be avoided, if among other things, the expressway vehicle will reduce its speed to that of the merging vehicle within a time 2τ. This will require an average deceleration, α such that

$$\alpha = [v_e(t) - v_m(t)] \,/\, 2\tau$$

Therefore at any time t, the conflicted vehicle must apply a deceleration $\alpha(t)$ to avoid a collision if the offending merging vehicle does not alter its speed and if both vehicles remain in the same path of motion. Generalising this to include cases in which $v_e(t) \leq v_m(t)$ for which non-positive deceleration will result and when collisions are inadmissible, we may adopt a measure of conflict between the vehicles as the average deceleration to avoid collision which can be written as

$$\alpha(t) = \frac{|v_e(t) - v_m(t)|\,[v_e(t) - v_m(t)]}{2\,\Delta x(t)}$$

If one were to trace the vehicles throughout the entire duration of the merge, it is possible to obtain varying values of $\alpha(t)$ at different instants of the merging process. The series of values obtained are necessarily correlated. If a particular merging process constitute a conflict event, then we can define the severity of that conflict as the maximum recorded value of the average deceleration to avoid collision i.e.,

$$s = \max_{t \in T} \{\alpha(t)\}$$

where s is the severity of the conflict in the merge and T the duration of the merging process.

If sufficient samples of vehicle merging can be obtained, a distribution of s may be derived. Since the non-positive values of s are not important for the purpose of describing conflict severity, it may be sufficient to derive a distribution function $F_S(s)$ defined only in the positive domain of s.

Consider now the reaction of the driver of the following vehicle in the midst of a conflict. Should the driver respond, at the most critical instant of conflict as defined above, by decreasing his speed to avoid a collision, a minimum deceleration of s must be applied for at least the duration of the time to collision, τ. Skidding will occur if such a deceleration exceeds the limiting deceleration s^* governed by the coefficient of friction for braking μ_b between the pavement surface and the tyres, i.e.

$$s^* = \mu_b g$$

where g is the gravitational constant. It follows then that it is possible to interpret the risk of skidding as the probability of occurrence of conflicts at which s exceeds s^*.

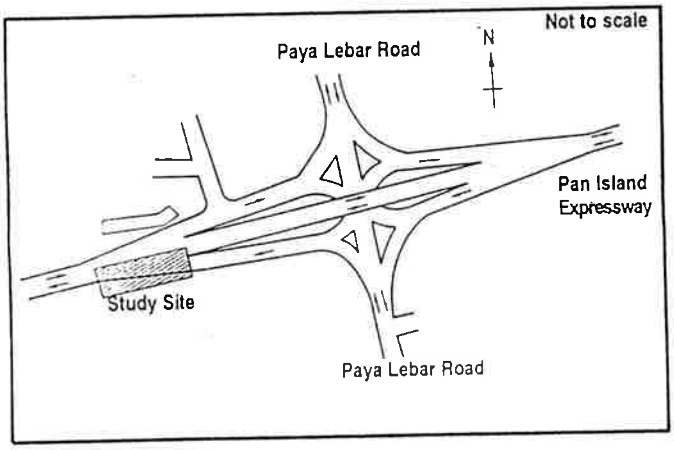
The coefficient of braking friction depends on not only the conditions of the road surface but also the type and condition of the tyres of the vehicles. If μ_b follows a particular statistical distribution so that we may express the probability density function of s* as h(s*), the risk of skidding can then be expressed as

$$p_s = (1 - p_0) \int_{s=0}^{\infty} (1 - F_s(s))\, h(s)\, ds$$

where p_0 is the probability in which $v_e(t) \leq v_m(t)$ for all t.

3. COLLECTION OF CONFLICT DATA

To understand the conflict behaviour of merging, traffic maneouvres at the merging area of the Paya Lebar on-ramp in Singapore were observed (see Figure 1).



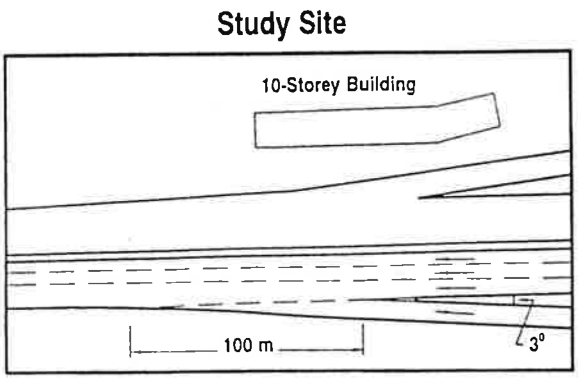


Figure 1: Study Site

The space-time information of vehicles on the on-ramp and the near-side lane of the expressway were obtained over eight separate periods corresponding to different flow conditions. This represents a total of about 1600 merging events. The process of data gathering and data extraction using video and computer equipment is described elsewhere (CHIN et al 1991). From the space-time data, the kinematics of the vehicles throughout the merging process were derived from which the average deceleration to avoid collision α at various instances of the merge is computed for each pair of vehicles involved. Figure 2 shows the variation of α throughout the merging area for some typical cases of merge. Notice that as in most cases observed, the most severe instant of conflict occurs in the beginning section of the merging area.

For each merge event, the maximum value of α, i.e., s is located and fitted to a theoretical distribution. The function for $F_S(s)$ that best fit the data was found to be the WEIBULL distribution, a maximal value function of the form

$$F_s(s) = 1 - e^{-(s/w)^k}$$

where k and w are the shape and scale factors. Using all the merge events observed, p_0 was found to be 0.2422 and the best fitted Weibull distribution has a shape and scale factor of 0.6286 and 0.1818 respectively (see Figure 3).

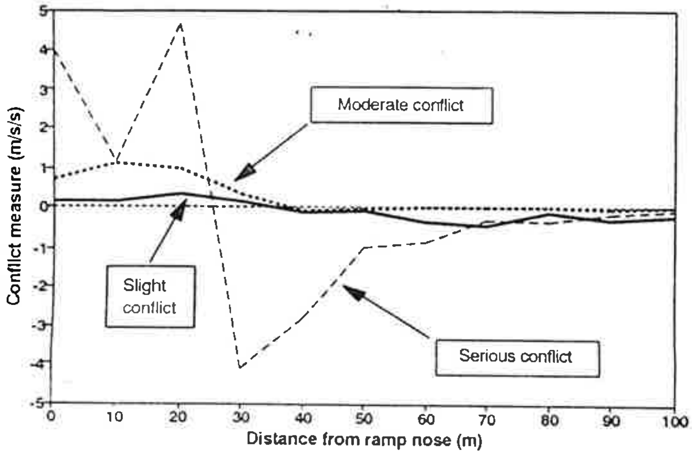


Figure 2: Variation of conflict (average deceleration to avoid collision)

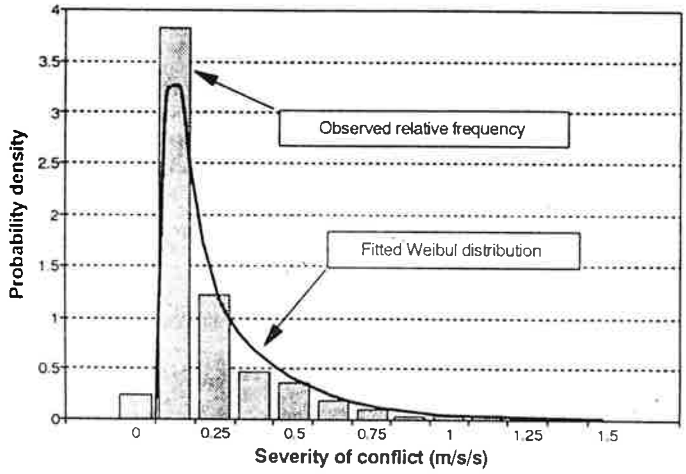


Figure 3: Distribution of severity of conflict

4. RISK OF SKIDDING

To obtain the skid resistance of the pavement, a British Pendulum Tester was employed. The test gives the skid resistance in terms of the British Pendulum Number (BPN) which can be taken to represent the skid friction at low speed. From the in-situ measurements, it was found that the BPN obtained on the dry surface has a mean of 65.2 and a standard deviation of 6.2. Based on the exponential model of skid variation (SHAH et al 1978) and a measured average speed of expressway vehicles of 49.3 km/hr, the coefficient of braking friction for the pavement surface investigated works out to be 0.52 with a standard deviation of 0.05.

Making use of these information, and assuming that μ_b is normally distributed, $h(s^*)$ has a mean of 5.1 m/s^2 and a standard deviation of 0.49 m/s^2. The risk of skidding as defined earlier can be determined for the data set of 1600 merging events. The probability of skidding, based on all the observed merging events was 0.000254 or about 2.5 in ten thousand merges. It must be noted that this does not represent the expected or actual number of skids but rather the potential number of skids.

5. APPLICATIONS

When the pavement surfaces are wet and have been subjected to polishing action of the traffic, the coefficient of friction between the tyres and the pavement will drop. Based on skid studies done in Singapore (RAMASWAMY et al 1988), the BPN may vary from 80 for very good conditions to below 40 for wet polished conditions. This range of BPN translate to a corresponding range of μ_b of 0.32 to 0.64. The change in the level of risk with reference to the existing condition is shown in Figure 4.

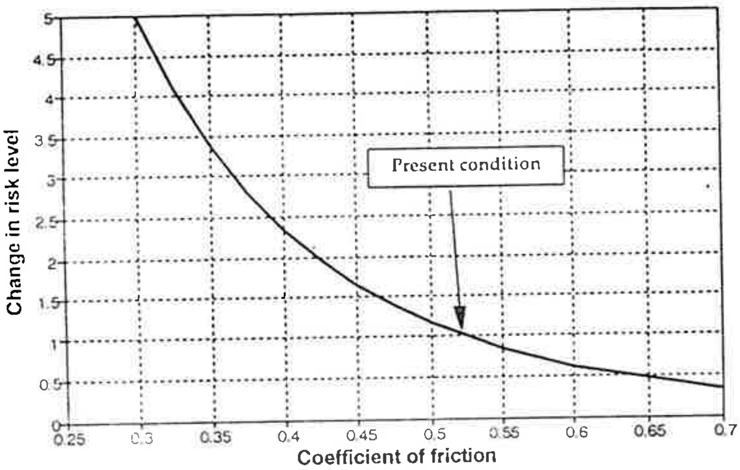


Figure 4: Predicted change in risk level

On average the risk of skidding doubles for every drop of 0.1 in the coefficient of braking friction. In the life of a pavement, the coefficient of friction will degenerate with increasing traffic usage until a new surface dressing is applied. During this period, it is unlikely, however, that the drivers will respond to such changes especially when the pavement surface remains visually similar. When the surfaces are wet the coefficient of friction will be lower thereby increasing the risk of skidding. However, the magnitude of this increase in risk is debatable since drivers may alter their behaviour to account for the increased risk potential.

6. CONCLUDING REMARKS

The procedure developed in this paper illustrates how the risk of skidding can be examined using conflict studies. The numerical values presented here are obviously specific to the location investigated and therefore certain findings may not be generalized. Nonetheless, it is important to note that since the risk of skidding is dependent on the coefficient of friction of the surface and that this is decreasing on average, the level of risk, at least from the point of view of skidding is unlikely to remain constant even if traffic factors remain invariant.

The prediction of risk level during wet weather conditions is particularly interesting. At present, this can only be done in this method by assuming the drivers behave in the same way as on a dry surface. Currently, work is underway to examine wet-weather risk level which takes into account possible responses of the drivers.

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REFERENCES

CHIN H.C., QUEK S.T. and CHEU R.L. 1991, Traffic conflicts in expressway merging, Journal of Transportation, American Society of Civil Engineers, Vol 117, No. 6, New York, pp. 633-643

RAMASWAMY S.D., FWA T.F. and TANABORIBOON Y. 1988, Skidding aspects of highway and airfield pavements, Journal of the Institution of Engineers (Singapore), Vol 28, No. 1, Singapore, pp. 59-67

SHAH V.R. and HENRY J.J. 1978, The determination of skid resistance - speed behaviour and side force coefficients of pavements, Transportation Research Record, No. 666, Transportation Research Board, Washington, D.C., pp. 13-18

WAMBOLD J.C., HENRY J.J. and HEGMON R.R. 1986, Skid resistance of wet-weather accident sites, The Tire Pavement Interface, American Society of Testing and Materials, STP 929, Philadelphia, pp. 47-60

T O T A L L I S T O F R E F E R E N C E S

ABELSON R.P. 1981, Psychological status of the script concept, American psychologist, 36, 7, 715-729

ANGENENDT W. 1989, Sichere Gestaltung markierter Wege für Fahrradfahrer, Band 2. Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

ALLEN T.H., LUNENFELD H. & ALEXANDER G.J. 1971, Driver information needs, H.R.R, 36, 102-115

ALLEN et al 1971, hierarchical modelling of the driving task and derivation of driver information needs

ASMUSSEN E. 1984, in OCDE programmes intégrés de sécurité routière, Chapitre III. Paris

ASMUSSEN E. 1984, international Calibration Study of Traffic-Conflict Techniques, Springer Verlag Berlin, Heidelber, New York

AVIOLO B.J., KROECK K.G. & PANEK P.E. (1985). Individual differences in information-processing ability as a predictor of motor vehicle accidents. Human Factors 27, 577- 587

BAINBRIDGE L. 1979, Verbal reports as evidence of the process operator's knowledge, Int. J. Man-machine studies, 11, 411-436

BAINBRIDGE L. 1983, Ironies of Automation. Automatica, 19, 775-779

BAKER J.S., FRICKE L.B. 1986, The Traffic Accident Investigation Manual. Northwestern University Traffic Institute

BARRETT et al 1973, emergency situations for driver education

BARRET G.V., ALEXANDER R.A., FORBES, J.B. 1977, Analysis of performance measurement and training requirements for driving decision-making in emergency situations. JSAS Catalogue of Selected Documents in Psychology, 7, 126

BARTHELEMY J.P., DUBOIS D., FLEURY D., TENIN A. 1990, Categorization of situations from photographs and drawings : typicality, family resemblance or analytic processing? European Cognitive Psychology Society Conference, Como, Italy.

BAUMAN R. 1975, The absurd statistic, in: The California Highway, Patrolman 39, No. 4 : p 27

BENA E., HOSKOVEC I. & STIKAR I. 1968, Psychologie a fyziologie ridice, Praha v.BENDA H. 1983, Die Häufigkeit von Verkehrssituationen. FP 7320/2 im Auftrag der Bundesanstalt für Straßenwesen, München: Lehrstuhl für Psychologie, Technische Universität

v.BENDA H. 1977, classification system of traffic situations

BERGUM J.E. & BERGUM B.O. 1982, Driver skills, field-dependance, suspectability to illusions, and self-perception, Proceedings of the Human Factors Society - 26th Annual Meeting, 238

BEYREUTHER G. & LAIDEBEUR A. (1989). RTI, State of the Art Review. Drive Project V 1017 (BERTIE), Report No. 28

BEYREUTHER G., CANO, L., LAIDEBEUR A., PETER G. 1990, Introducing RTI and training process. Drive Project V1017(BERTIE), Report No.51

CARRÉ J.R. & SAAD F. 1981, Etude dans une perspective de sécurité sur le comportement des conducteurs et la circulation en file sur autoroute urbaine, Rapport ONSER

CHALOUPKA CH., RISSER R. & ROEST F. 1991, Methode zur Identifizierung von Verhaltenscharakteristiken, die auf erhöhte Unfallgefährdung hinweisen, unpublished Final-research-report, FACTUM, Vienna

CHIN H.C., QUEK S.T. and CHEU R.L. 1991, Traffic conflicts in expressway merging, Journal of Transportation, American Society of Civil Engineers, Vol 117, No. 6, New York, pp. 633-643

CHRISSIKOPOULOS V., DARZENTAS J. & McDOWELL M.R.C. 1983, Decelaration of major-road vehicles approaching a T-Junction, Traffic Engineering & Control, 433-436

CUNY X. 1979, Differents levels of analysing process control tasks, Ergonomics, 22, 4, 415-425

DREYFUS H. & DREYFUS S. 1986, Mind over machine. New York, Free Press.

DUBOIS D. 1986, La compréhension de phrases : la représentation sémantique et processus. Thèse de Doctorat d'Etat. Université de Paris VIII.

DUBOIS D. 1991, Sémantique et Cognition, Ed. du CNRS, Paris

DUBOIS D., FLEURY D., MAZET C. 1991, Représentations catégorielles : perception et/ou action ? Publication atelier PIRTTEM "Représentations pour l'action"

EGER R.& TETZKO H.-G. 1986, Führung des Radverkehrs im Innerortsbereich, Teil 6: Gemeinsame Verkehrsflächen für Fußgänger und Radfahrer, Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

EICHENAUER 1981, road characteristics

ENGELS K. & DELLEN R. 1989, Der Einfluß von Suchfahrten auf das Unfallverursachungsrisiko. Zeitschrift für Verkehrssicherheit 35, 93-100

EVANS L. & WASIELEWSKI P. 1982, Do accident-involved drivers exhibit riskier everyday driving behaviour? Accident Analysis and Prevention, 14, 1, 57-64

FALZONE P. 1989, Ergonomie cognitive du dialogue, Presse Universitaire de Grenoble

FAIRCLOUGH S. & PARKES A.M. 1990, Drivers visual behaviour and In-vehicle information, Drive Project V 1017 (BERTIE), Report No. 29.

FÄRBER B. 1987, Geteilte Aufmerksamkeit, Köln: Verlag TÜV Rheinland

FASTENMEIER W. 1988, Verhaltensanforderungen und Informationsverarbeitung beim Führen von Kraftfahrzeugen. Teil I: Ein Katalog von Verkehrssituationen für repräsentative Fahrtypen. Teil II: Entwicklung einer Verkehrssituations-taxonomie und Konstruktion einer repräsentativen Versuchs-strecke. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität.

FASTENMEIER W. 1989, Ermittlung des Informationsbedarfs verschiedener Fahrergruppen in definierten Verkehrssituati-onen. Teil I: Anforderungsanalyse von Verkehrssituationen und Untersuchungsmethodik. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität

FASTENMEIER W. 1990, Ermittlung des Informationsbedarfs verschiedener Fahrergruppen in definierten Verkehrssituati-onen, Teil II u. III: Versuchsreihe I bis III - Erfahrene, unerfahrene und ältere Fahrer. Ergebnisse im Überblick. Forschungsbericht im Auftrag der BMW AG München, E-W 13, im Rahmen des EUREKA-Projektes PROMETHEUS. München: Lehrstuhl für Psychologie, Technische Universität

FERRANDEZ F., FLEURY D. & MALATERRE G. 1986, L'étude détaillée d'accidents: une nouvelle orientation de la sécurité routière, Recherche Transport Sécurité, 9-10, 17-20

FLEURY D. 1990, Accident analysis methods and research prospects, IATSS Research Vol. 14 n°1

FLEURY D. 1991, Catégorisation de scènes routières et sécurité, de l'analyse des accidents aux représentations typiques, Soumis pour publication à Intellectica

FLEURY D., DUBOIS D. 1991, Catégorisation mentale et sécurité des réseau, 6ème Conférence internationale sur les comportements de déplacements Quebec Mai 22-24

FLEURY D., DUBOIS D., FLINE C., PEYTAVIN J.F. 1991, Catégorisation mentale et sécurité des réseaux. Rapport INRETS n°146

FLEURY D., FLINE C., PEYTAVIN J.F. 1991, Modulation de la vitesse en ville et catégories de voies urbaine, Expérimentations sur les représentations de sites routiers, Rapport INRETS n°144

FLEURY D., MAZET C., DUBOIS D. 1987, Road Safety Analysis and categorization of urban environment, 2nd International Conference on road Safety, Groningen, Hollande, Septembre

FLEURY D., FERRANDEZ F. & LEPESANT C. 1988, Analyse typologique des manoeuvres d'urgence en intersection, Rapport INRETS N° 62

FULLER R.G.C 1980, Time headway in different vehicle-following manoeuvres, Perceptual and Motor Skills, 50, 1057-1058

FULLER R.G.C 1981, Determinants of time headway adopted by truck drivers, Ergonomics, 24, 6, 463-474

FULLER R.G.C 1986, Unsafe following: a possible cause, Cinquième congrès international de l'ATEC

GALSTERER H., FASTENMEIER W. & GSTALTER H. 1990, Sicherheitsaspekte von LISB - Fahrten auf Routinestrecken, Forschungsbericht im Auftrag der BMW AG München, Verkehrsforschung, München: Forschungsgruppe München

GALSTERER H. & GSTALTER H. 1990, Sicherheitsaspekte von LISB auf unbekannten Strecken (Suchfahrten). Forschungsbericht im Auftrag der BMW AG München, Verkehrsforschung. München: Forschungsgruppe München

GALSTERER 1978, measurement of task complexity of traffic situations FASTENMEIER 1988, 1989, taxonomies of traffic situations and task complexity, combination with observation methods.

GIRARD Y. 1987, Les comportements en intersection à travers l'analyse des accidents, In: F.SAAD (ed.), L'analyse des comportements et le système de circulation routière, Actes INRETS

GOODENOUGH D.R. 1976, A review of individual differences in field dependance as a factor in auto safety. Human Factors 18, 53-62. GSTALTER H. 1985, Workload and stress in driving. In: Proceedings, 9 th Congress of the International Ergonomics Association, BROWN I. (Ed.). London, Taylor and Francis, 994-996

GSTALTER H. 1985, Workload and stress in driving, In: Proceedings, 9th congress of the International Ergonomics Association, BROWN I. (Ed.), London, Taylor & Francis, 994-996

GSTALTER H. & FASTENMEIER W. 1987, Recognition of driving conditions of drivers. Final Report, Prometheus WP 31 138

HALE A.R., STOOP J. & HOMMELS J. 1990, Human error models as predictors of accident scenarios for designes in road transport systems. Ergonomics, 33, 1377-1388

HAUTZINGER H. & TASSAUX B. 1989, Verkehrsmobilität und Unfallrisiko in der Bundesrepublik Deutschland, Ergebnisbericht, Forschungsbericht 195 der Bundesanstalt für Straßenwesen, Bereich Unfallforschung. Bergisch-Gladbach: BAST

HENDRICK K., BENNER L. 1987, Investigating Accidents with STEP. Occupational Safety and Health, Marcel Dekker, New York

HOC J. M. 1986, Psychologie cognitive de la planification, Grenoble, Presse Universitaire de Grenoble

HOYOS C.Graf 1990, Psychologische Unfall- und Sicherheitsforschung, Stuttgart: Kohlhammer

HOYOS C.GRAF & KASTNER M. 1986, Belastung und Beanspruchung von Kraftfahrern, Unfall- und Sicherheitsforschung Straßenverkehr, Heft 59, Bergisch-Gladbach: Bundesanstalt für Straßenwesen JANSSEN W.G. 1979, Routeplanning en geleiding, Een literatuur-studie, Report IZF C-13. Soesterberg: Institute for Perception, TNO.

HRB 1979, Development of Improvement Methods for Reduction of Traffic Accidents, Highway Research Board, U.S.A.

I C T C T 1990, Theoretical Aspects and Examples for Practical Use of Traffic Conflicts and of Other Interactional Safety Criteria in Several Industrial and Developing Countries, Lund Technical Highschool, Institute for Traffic Technique, Bulletin 86, Lund, Sweden

IRF 1971, World Road Statistics 1966-70, International Road Federation, Washington D.C., U.S.A.

JENSCH et al 1978, prototypical situations for driver education

JOHANNSEN G. 1976, Preview of man-vehicle control session. In: SHERIDAN T.B. & JOHANNSEN G. (Ed.): Monitoring Behaviour and Supervisory Control. New York: Plenum Press

JOHANNSEN G. & ROUSE W.B. 1979, Mathematical concepts for modeling human behaviour in complex Man-Machine systems, Human Factors, 21, 6, 733-747

KAHNEMANN D. 1973, Attention and effort. Englewood Cliffs, New York, Prentice Hall

KLEBELSBERG D. 1969, Risikoverhalten als Persönlichkeitsmerkmal, Stuttgart

KLEBELSBERG D. 1982, Verkehrspsychologie, Springer-Verlag, Berlin, Heidelberg, New York

KLEBELSBERG 1970, characteristics of driver behaviour and driving style

KORTELING J.E. 1988, Information processing of elderly traffic participants, TNO-Report IZF 1988-9. Soesterberg

KOSZLOWSKI L.T. & BRYANT K.J. 1977, Sense of direction, spatial orientation, and cognitive maps, Journal of Experimental Psychology, 3, 4, 590-598

LEPLAT J. 1982, Perspectives méthodologiques pour l'étude des activités mentales, Le travail humain, 45, 2, 347-356

LEPLAT J. 1985, Les représentations fonctionnelles dans le travail. Psychologie Française, 30, 3-4, 269-275

LEPLAT J. & HOC J.M. 1981, Subsequent verbalization in the study of cognitive processes, Ergonomics, 24, 10, 743-755

LEPLAT J. & HOC J.M. 1983, Tâche et activité dans l'analyse psychologique des situations, Cahiers de psychologie cognitive, 3, 1, 49-63

LOO R. 1979, Role of primary personality factors in the perception of traffic signs and driver violation and accidents, Accident Analysis & Prevention 11, 125-127

LOVEGROVE S.A. 1978, Approach speed at uncontrolled intersections with restricted sight distances, Journal of Applied Psychology, 63, 5, 635-642

LYNCH K. 1976, L'image de la cité DUNOD. 222P.

MALATERRE G. 1987, Les activités sous contraintes de temps: le cas des manoeuvres d'urgence en conduite automobile, Thèse de 3° cycle

MARBURGER E.A., KLÖCKNER J.H., StÖCKER U. (1988). Abschätzung der möglichen unfallreduzierenden Wirkungen ausgewählter PROMETHEUS-Funktionen, Forschungsbericht für die PRO-GENERAL SAFETY GROUP, Bergisch-Gladbach, Bundesanstalt für Straßenwesen

MAUKISCH H. 1990, Die alternden Autofahrer: Das Problem der Zukunft? In: W.R. NICKEL (Bd.-Hrsg.), Fahrverhalten und Verkehrsumwelt, Psychologische Analysen im interdisziplinären Feld, 223- 256, Köln, TÜV Rheinland (Mensch-Fahrzeug-Umwelt, Bd. 25)

MAZET C., DUBOIS D., FLEURY D. 1987, Catégorisation et interprétation de scènes visuelles: le cas de l'environnement urbain et routier, Psychologie Française, Numéro spécial : la psychologie de l'environnement en France

McKNIGHT et al 1970, detailed behaviour requirement lists

MEDIN D., WATTENMAKER W., HAMPSON S. 1987, Family Ressemblance, Conceptual Cohesiveness, and Category Construction, Cognitive Psychologie 19,242-279

MICHON J.A. SMILEY A. & AASMAN J. 1990, Errors and driver support systems, Ergonomics, Vol. 33, 10-11, 1215-1230

MINISTRY OF HOME AFFAIRS 1979, Accidental Deaths and Suicides in India, 1977, Bureau of Police Research and Development, Government of India

MINISTRY OF TRANSPORT 1981, Motor Vehicle Accident Statistics in India 1970-1980, Transport Research Division, Government of India

MONSEUR M. & MALATERRE G. 1969, Prise de décision des conducteurs aux carrefours, Le Travail Humain, 32, 3-4, 217-238

MONSEUR M. & MARCHADIER B. 1971, Franchissement des intersections et prise de risque, Une méthode d'analyse de la situation de conduite aux carrefours, Le Travail Humain, 34, 1, 81-98

MOURANT R.R. & ROCKWELL T.H. 1970, Mapping eye-movement patterns to the visual scene in driving, An explanatory study, Human Factors, 12, 81-87

MOURANT R.R. & ROCKWELL T.H. 1972, Strategies of visual search by novice and experienced drivers, Human Factors, 14, 325-335.

MOURANT R.R. & DONOHUE R.J. 1977, Acquisition of indirect information by novice, experienced and mature drivers, Journal of Safety Research, 9, 39-44

NÄÄTÄNEN R. & SUMMALA H. 1976, Road user behaviour and traffic accidnets, Amsterdam, North HollandGÅRDER P. 1986, Theory for strong validation, in: KTI, Traffic conflicts and other intermediate measures in safety evaluation, Institute for Transport Sciences, Budapest

NEBOIT M. 1982, L'exploration visuelle du conducteur : rôle de l'apprentissage et de l'expérience. Cahier d'Etudes ONSER, N°56

NEWELL A. & SIMON H. 1972, Human problem solving, Printice-Hall, Inc.Englewood Cliffs, N.J.

NORMAN D.A. 1983, Some observations on mental models, In: GENTNER D., STEVENS A.L., Mental models, 7-14, Hillsdale, New Jersey, London

NORMAN D.A. & BOBROW D. 1975, On data-limited and resource-limited processing, Journal of cognitive psychology, 7, 44-60. OECD 1986, Guidelines for improving the safety of elderly road users, Paris: OECD

NOULIN 1987, Méthodes psychologiques, In: CAZAMIAN P., Traité d'ergonomie, Editions Octares, Entreprises

OECD 1986, Guidelines for improving the safety of elderly road users, Paris: OECD

PARKES A. 1989, Changes in driving behaviour due to two models of route guidance information presentation: a multi-level-approach, Drive Project V 1017 (BERTIE), Report No. 21.

PASANEN E. 1990, Kokeilujärjestelyt pyöräilijöiden suojatieonnettomuuksien vähentämi-seksi (Experimental designs for decreasing bicycle accidents on pedestrian crossings), Helsinki, Helsinki City Planning Office, unpublished memorandum 27.12.1990. 3 p.

PASANEN E. 1991, Oikealle kääntyvän autoilijan ja oikealta tulevan pyöräilijän ongelma (The problem of right turning vehicles and cyclist coming from right), Helsinki, Helsinki City Planning office, unpublished memorandum, 9 p.

POLANYI M. (1958), Personal Knowledge, Towards a Post-Critical Philosophy, Routhledge & Kegan, London

POSTANS R.L. & WILSON W.T. 1983, Close-following on the motorway, Ergonomics, 26, 4, 317-327

QUENAULT 1969, observation procedure for overt driver behaviour

RAJESH T. 1982, Accident Information System in Metropolitan Cities of India, unpublished Thesis Dissertation, School of Planning and Architecture, New Delhi

RAMASWAMY S.D., FWA T.F. and TANABORIBOON Y. 1988, Skidding aspects of highway and airfield pavements, Journal of the Institution of Engineers (Singapore), Vol 28, No. 1, Singapore, pp. 59-67

RASMUSSEN J. 1983, Skills, Rules, Knowledge: Signals, Signs and Symbols and other distinctions in Human Performance Models. IEEE Transactions: Systems, Man & Cybernetics, SMC-13, 257-267

RASMUSSEN J. 1986, Information processing and human-machine interaction, Amsterdam, Elsevir

REASON J. 1990, Human Error, Cambridge University Press.

REITER H., SCHMIDT L. & SNIZEK S. 1987, Bewertung von Radverkehrsanlagen durch Radfahrer, Untersuchung im Auftrag der Stadt Wien, MA 18 Stadtstrukturplanung, Wien

RIEMERSMA J. B. J. 1987, An empirical study of subjective road categorization, Traffic Behaviour Research Group Institute for Perception, TNO

RISSER R., SCHMIDT L., SNIZEK S. & HULMAK M. 1990, Konflikte Fußgänger-Radfahrer in Wien, Untersuchung im Auftrag der Stadt Wien, MA 18 Stadtstrukturplanung, Wien

RISSER R., ZUZAN W.D., TAMME W., STEINBAUER J. & KABA A. 1991, Handbuch zu Erhebung von Verkehrskonflikten mit Anleitungen zur Beobachterschulung, Lebensraum Verkehr, Kleine Fachbuchreihe des Kuratoriums für Verkehrssicherheit, Band 28, Wien

RISSER R., TESKE W., VAUGHAN C. & BRANDSTÄTTER C. 1984, Verkehrsverhalten in Konfliktsituationen, Studie im Auftrag des Jubiläumsfonds der Österreichischen Nationalbank, Wien, Kuratorium für Verkehrssicherheit

ROCKWELL T.H. 1988, Spare visual capacity in driving- revisited, In: Vision in Vehicles II (GALE A.G. et al., Eds.), p. 317-324

ROSCH E., LLOYD B.B. 1978, Cognition and Categorization, Hillsdale, New Jersey, Lawrence Erlbaum

RUMAR, K. 1988, Collective risk but individual safety, Ergonomics, 1988, 31, 507-518

RUMAR K. 1986, In-vehicle information systems, In: DORGHAM M.A. (Ed.), Proceedings of the International Association for Vehicle Design, 33-42

RUMAR R. 1990, The basic driver error: late detection, Ergonomics, 33, 1281-1290

SAAD F. 1975, Structuration de la tâche et activités perceptives dans la conduite automobile, Document interne ONSER

SAAD F. & MALATERRE G. 1982, Régulation de la vitesse, aide au contrôle de la vitesse, Synthèse, Rapport ONSER

SAAD F. 1989, Risk-taking or danger misperception Revue-Transport -Sécurité, English issue, N° 4

SAAD F., DELHOMME P. & VAN ELSLANDE P. 1990, Driver's speed regulation when negotiating intersections, In: KOSHI M. (ed.), Transportation and Traffic Theory, Elsevier

SAAD F. & KHOUDOUR L. 1991, In-Depth analysis of driver behaviour in car-following: Methodological aspects and global behaviour analysis, PTRC, 19Th Summer Annual Meeting, Traffic management and road safety, Proceedings of seminar K

SAAD F. & MAZET C. 1991, Analysis of road situations and drivers' activity in a perspective of cognitive ergonomics, In: QUEINNEC Y. & F. DANIELLOU (eds.), Designing for everyone, Proceedings of the 11th congress of the International Ergonomics Association (Vol. II), London: Taylor & Francis Ltd.

SAAD F., DELHOMME P., VAN ESLANDE P. 1991, Drivers speed regulation when negotiating intersections, in: Elsevier Science Publishing Co, Inc. Transportation and traffic Theory, Editor Masaki Koshi

SALUSJÄRVI M. 1989, Road accident investigation teams, Developing the on-the-spot, in depth, case-study methodology, Espoo, Technical Research Centre of Finland, VTT Research Report 617. 125 p.

SCHANK R., ABELSON R. 1977, Scripts, Plans, Goals and Understanding, Hillsdale, (N.J.), Lawrence Erlbaum

SCHLAG B. 1989, Ältere Autofahrer - ein Problem mit Zukunft? Zeitschrift für Gerontologie, 19, 410-418.

SCHMIDT L. 1988, Verantwortliches Handeln im Straßenverkehr, Forschungsbericht der Bundesanstalt für Straßenwesen, Bereich Unfallforschung, Bergisch Gladbach

SCHMIDT L. 1989, The significance of accepted risk and responsible action for goals and methods in psychological traffic research, Paper presented at the first European Congress of Psychology, Amsterdam

SCHMIDT L. 1990, Regelwidriges Verhalten von Radfahrern in Beziehung zu Radfahrer-Fußänger-Konflikt, Vortrag für Arbeitskreis 2 "Unfälle - Unfallursachen, Analyse und Beobachtung", In: ARGUS (ed.): Velo-Secur 1990, Sicherheit rund ums Radfahren, Reihe Fahrrad und Umwelt, Band 1

SCHRAAGEN J.M.C. 1989, Normative task analysis for navigation in unfamiliar cities

SCHRAAGEN J.M.C. 1989, Navigation in unfamiliar cities: a review of the literature and a theoretical framework. IZF 1989-36, TNO Institute of Perception

SENACH B. & FALZON P. 1985, Représentations opératives, cognitives et circonstancielles, Colloque de la SFP., Dialogue entre Recherche et Pratique pour la Psychologie du Travail, Paris, 8-9 Mars.

SHAH V.R. and HENRY J.J. 1978, The determination of skid resistance - speed behaviour and side force coefficients of pavements, Transportation Research Record, No. 666, Transportation Research Board, Washington, D.C., pp. 13-18

SHARIT J., CHANG T.C. & SALVENDY G. 1987, Technical and human aspects of computer-aided manufactoring, In: SALVENDY G. (Ed.): Handbook of Human Factors, 1694-1723

SHERIDAN T.B. 1987, Supervisory Control, In: SALVENDY G. (Ed.): Handbook of Human Factors, 1243-1268

SHOPTAUGH C.F. & WHITAKER L.A. 1984, Verbal response times up to directional traffic signs embedded in photographic street scenes, Human Factors, 26, 235-244

SRINIVASAN N.S. 1985, Road Safety in Urban Areas, Proceedings of Metropolitan Transport in India Seminar, The Times Research Foundation, New Delhi

STREETER L.A., VITELLO D. & WONSIEWICZ S. 1985, How to tell people where to go: Comparing navigational aids. International Journal of Man-Machine Studies, 22, 549-562

STREETER L.A. & VITELLO D. 1986, A profile of drivers' map-reading abilities, Human Factors, 28, 223-239

SUMMALA, H. et al. (1988) Liikenneturvallisuusasiantuntijat ajavat kovaa (Road safety experts drive fast), Reports 15:1988, University of Helsinki, Traffic Research Unit

SUMNER R. & BAGULEY C. 1978, Close following behaviour at two sites on rural two lane motorways, TRRL LR 859, 7 p.

THE HOUSE OF REPRESENTATIVES 1963, National Accident Prevention Centre, Washington D.C., U.S.A.

THE PRESIDENT COMMITTEE 1961, Highway Safety Action Programme, Committee on Road Safety Washington D.C., U.S.A.

THORNDYKE P.W. & STASZ C. 1980, Individual differences in procedures for knowledge acquisition from maps, International Journal of Man-Machine-Interaction, 12,137-175

TRÄNKLE 1980, driver behaviour on motorways

TRK 1978, TRK:s haverikommission (TRK Multidisciplinary Accident Investigation Project), Redogörelse för en försöksverksamhet, Stockholm, Försäkringsbranschens Trafiksäkerhetskommité - TRK (The Insurance Road Safety Committee), Rapport nr 1. 323 p.

VAN ELSLANDE P. & MALATERRE G. 1987, Les aides à la conduite, analyse des besoins en assistance des conducteurs, Rapport INRETS, N° 23

VAN DER MOLEN H.H. & BÖTTICHER A.M.T. 1988, A hierarchical risk model for traffic participants, Ergonomics, 31, 4, 537-556

VAN WINSUM W. 1987, De mentale belasting van het navigeeren in het verkeer, Groningen: Verkeerskundig Studie Centrum, Report VK 87-30

VERWEY W.B. & JANSSEN W.H. 1988, Route following and driving performance with in-car route guidance systems, IZF-Report C-14, Soesterberg, Institut for Perception TNO

WAMBOLD J.C., HENRY J.J. and HEGMON R.R. 1986, Skid resistance of wet-weather accident sites, The Tire Pavement Interface, American Society of Testing and Materials, NTR 1989, Cykelulykker i kryds (Cyclist accidents at intersections), Et metodestudium, Lyngby, Nordisk Trafiksikkerheds Råd, Rapport 51. 40 p.

WESTIN A.F. 1971, Information Technology in a Democracy, Harvard University Press

WHO 1979, Road Traffic Accident Statistics, EURO Report and Studies 19, World Health Organisation, Copenhagen

WICKENS C.D. 1984, Engineering psychology and human performance, Columbus, Charles Merrill

WICKENS C.D. 1987, Information processing, decision making, and cognition, In G. SALVENDY (Ed.): Handbook of human factors, New York, Wiley, 72-107

WIERWILLE W.W., AUTIN J.F., DINGUS T.A. & HULSE M.C. 1988, Visual attention demand of an in-car navigation display system, Proceedings of Vision in Vehicles Conference, Nottingham 1987

WIERWILLE W.W., HULSE M., FISCHER J.T. & DINGUS T. 1989, Visual adaption of the driver to high-demand driving situations while navigating with an in-car navigation system, Abstract from Vision in Vehicles III Conference, Aachen, 1989

WILDE, G.J.S. et al. (1985) Risk homeostasis in an experimental context, In: EWANS-SCHWING (eds) Human Behaviour and Traffic Safety, Plenum Pr. New York

ZIMMER A. 1990, Driver information needs. Drive Project V 1017 (BERTIE), Report No. 25.

A N N E X

It is a great pleasure for ICTCT to congratulate ICTCT's chairman, Christer HYDÉN and his colleagues from the Traffic Safety Group in Lund Technical University for winning the 1991 VOLVO Traffic Safety Award for their work with the traffic conflict tecnique:

Here is Christer HYDÉN's speach, helt at the price ceremony at Aalborg, 1991:

> Executive Vice President of Volvo, dear jury members of the award, including its secretary Professor Olof Gunnarsson, Ladies and Gentlemen!
>
> Let me first of all tell you how honored I am, being awarded the Volvo-price. So, thank you very much, members of the jury, and of course thank you Volvo.
>
> On behalf of all my colleagues in the Traffic Safety Group at the Department (most of them sitting here...) I can assure you that we are all very happy to-day. For many of us the Traffic Conflicts Technique is becoming more and more of a life-long commitment. Even though it is far from the only thing we are working with it has a great importance and influence on a great deal of our research. We have by now gone through all the different stages and problems a researcher can face: including for instance definition problems, statistical problems, "computer errors", cold feet (both metaphorically and literally), disappointing results. Just to mention some... And, not to forget, struggling for research funds. So, thank you, the Transport Research Board and its predecessor, the Transport Research Delegation, back home in Sweden, for the long-term and devoteful support of this part of our research.
>
> But, problems like those mentioned also tend to create a counter situation. So also with us: We have really had many happy, joyful and encouraging moments. And lot of enthusiasm. I never forget when some of us - a long time ago...- tried to climb l`Arc de Triomphe in Paris from the exterior, just to be able to do some video-recordings from one of the most fascinating places for encounters and conflicts that we had seen.
>
> I do not want to finish this short speech without mentioning ICTCT, the International Cooperation on Theories and Concepts in Traffic safety. It has members from all over the world. The Department of Traffic Planning and Engineering is one of them, but almost all persons and organisations that are working with the Conflicts Technique are members. They have all been working hard with the technique and the promotion of it. So, this is a great day for ICTCT as well.
>
> People sometimes ask us how it is possible to go on with this kind of research? Do we never give up? The answer is fairly easy to give! No, we do not give up! Thanks a lot to the Traffic Conflicts Technique we have got such a deep insight into traffic safety problems that we have got obsessed by the

idea that we must do something to contribute to an increase of living quality in traffic. The traffic system was quite too much suffering to justify the claim that we are providing a transportation system with adequate living standards.

One big problem, however, is "to sell" this kind of "underst-anding". As individuals we most often give very low priority to traffic safety issues. Something that we as researchers feel strongly. The public is without any interest until the day you do some experimenting on "their roads". Then people react heavily. We do obviously not want to experience any changes to our well established habits, especially not in traffic.

In light of this I am therefore particularly happy for the price because it gives us new opportunities to promote the Conflict Technique both in connection with empirical traffic safety research and in connection with general information to the public regarding "the true picture" of hazards, danger, threats and risks in traffic. Conflicts fill a gap between behaviour and accidents. Displayed - for instance on video - serious conflicts represent an excellent communication tool to people regarding what constitutes unsafe behaviour. My definite opinion is that conflicts should be used much more at driving schools, on TV, in ordinary schools, etc. This price gives us a unique opportunity, that our research funds never allow us.

I want to thank the Volvo Car Corporation for the initiative to establish a traffic safety award, not aiming at promoting work in the passive safety area but in the active safety area. I am proud of this price and I sincerely hope that our communication with Volvo will benefit from it. The car industry represents one of the most important actors in the traffic safety area. It is, therefore, important that our understanding of the character of the safety problems in traffic are as similar as possible. There I think the price and the Conflict Technique will be of good help to an improved communication regarding these matters.

Having this opportunity I also want to mention our boss, Professor Gösta Lindhagen. He has been the head of our Department since the beginning of the seventies. He has all the time supported our struggling for research funds and our work in general. It is a neccessary prerequisite to have an open-minded head that without hesitation is prepared to support you both when the road goes upward and when it goes downward. Thank you Gösta Lindhagen!

I also want to express our thanks to the other colleagues at the Department. Their everlasting demands and support keep everybody in a good shape intellectually.

Finally I want to mention my family. I am very glad also on their behalf. Now they can finally appreciate the fact that there is a great external support for our conflict work.

Conflicts; a word they did not even want to hear sometimes, for obvious reasons.

I am sure that this last part is valid for the families of my colleagues as well.

Finally I hope that you all thanks to this event as individual road users will have your eyes opened a bit for the concept of conflicts. The general safety goal for the individual - to minimize his involvment in serious conflicts (instead of accidents) - is well worth trying.

I wish you good luck in doing so.