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ICTCT

INTERNATIONAL COOPERATION ON THEORIES AND CONCEPTS IN TRAFFIC SAFETY

THE USE OF TRAFFIC CONFLICTS' TECHNIQUE AND RELATED METHODS FOR THE EVALUATION OF NEW TECHNOLOGIES IN ROAD TRAFFIC WITH RESPECT TO SAFETY AND SUSTAINABILITY

PROCEEDINGS OF THE 5th WORKSHOP OF ICTCT IN HELSINKI & TALLINN, OCTOBER 1992

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5th Workshop of ICTCT

*I*nternational *C*ooperation on *T*heories and *C*oncepts in *T*raffic Safety

Helsinki, FINLAND & Tallinn, ESTONIA

October 28th-30th 1992

A. INTRODUCTION

For the main part of the 5th workshop ICTCT has kindly been invited by Dago ANTOV, head of the engineering-bureau STRATUM in Tallinn, Estonia. After the first part of the workshop in the afternoon in Helsinki, all participants went by ferry-boat to Tallinn.

Only a short time ago it has not been so easy to go to Estonia for people from the Western countries. So the editors of this report thaught it could be interesting to get some information about the town of Tallinn and STRATUM as well.

TALLINN: SOME INFORMATION AND IMPRESSIONS

The official information brochure about Tallinn starts as follows:

May we claim Tallinn to be the most beautiful city in the world? Why not. If you were asked to name the most beautiful language you'll reply it's your mother tongue. Equally, Tallinn is doubtlessly the most beautiful city in the opinion of those who regard her as their home.

TERVIST, the Tallinners will greet you and invite you to get closer acquainted with their city.

By spinning a globe or studying maps you'll find out that Tallinn lies at 59°26 North latitude and 24°46 East longitude. Along the meridian the distance from Tallinn to the North Pole is 3,330 km, to the Arctic Circle 788 km, and to the equator 6,672 km. The distances to the nearest capital cities and ports, as a bird flies, are:

82 km to Helsinki, 380 km to Stockholm
280 km to Riga, 860 km to Moscow,
320 km to Leningrad, 1,015 km to Berlin.

Standing on the slope of Toompea (= hill in the town of TALLINN) at a height of nearly fifty metres you will get a good view of the gabled roofs, the church spires reaching up into the sky, the entire Old Town with its narrow streets full of nooks and crannies. Nearly each house in the Old Town possesses historical value. Tallinn is also the only North European city to have retained to such a great extent her mediaeval appearance. The Old Town is surrounded by a green belt of parks and avenues laid out on the bastions, filled-up moats and ruins of the war.

And here something interesting for traffic experts:

The entrance of vehicles into the Old Town must be paid for, and at certain hours some streets are entirely at the disposal of pedestrians.

A last important information about a famous Estonian tradition:

The largest numbers of people gather in the Song Festival Grounds every five years - about thirty thousand singers and 200 thousand listeners. The first all-Estonian Song Festival was held in 1869 with the participation of only male choirs and brass bands. Nowadays the festivals have expanded to such an extent that the Song Festival Grounds cannot well hold all the performers and listeners.

INSENERIBÜROO ***STRATUM*** (*STRATUM* ENGINEERING)

STRATUM was stablished at 1988 in Tallinn as a small enterprise by the request of the Road and Traffic Laboratory of Tallinn Technical University and Transportation Department of Tallinn Muncipality.

STRATUM Engineering is a consulting bureau dealing mainly with traffic and transportation management, traffic engineering, traffic studies and road design, traffic safety and public transport.

STRATUM employes 6-7 workhands and for special projects a number of persons (mainly professors and students from TTU) are employed.

During four years activities *STRATUM* has mostly carried out projects at the mentioned areas of speciality for the City of Tallinn.

Some examples of main studies 1988-1992:

* Traffic-actuated traffic lights in Tallinn (using EB Traffic management equipment).
* Database studies of traffic and traffic-lights
* Traffic counting in Tallinn
* Traffic safety database study
* Public transport studies and design for Tartu and Tallinn
* Tallinn Old Town traffic toll system, study and design
* Traffic study for ports of Tallinn through city
* Urban cycling network design for Tallinn
* Traffic modeling and engineering on street network in Tallinn
* Development of the street network and bridges in Pärnu, Estonia (using TRIPS traffic simulation software)
* Introducing parking fee system in the city centre in Tallinn
* Tallinn public transport reorganization (in cooperation with TMS, Sweden).

STRATUM Engineering was participating at VOLVO traffic safety award competition at 1990, and was also represented at the traffic conferences in Brighton, London, Karlsruhe, Paris, and at the PC Software exhibition in St.Petersburg.

STRATUM Engineering has good connections with traffic researchers and consultants in Estonia, Latvia, Lithuania and Russia. There are also connections with researchers and consultants in Finland, Sweden, Great Britain, France etc.

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B. WORKSHOP - CONTRIBUTIONS

1. BRIDGES BETWEEN POLICY AND RESEARCH

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1.1 INTRODUCTION

ICTCT - or to give it its full name, International Co-operation on Theories and Concepts in Traffic Safety - seems to have found its way. After an initial period when conflict observation methods dominated the road safety issue, attention has now shifted to the broader aspects of tranport policy. This is clear from the organisations`s current programme, which includes the following:

- research contributions to the formulation of sustainable transport systems, including road safety aspects;

- raising matters such as the usefulness of conflict observation as a diagnostic and evaluation technique in the short term for existing and proposed infrastructural measures;

- the use of other methods of evaluating road safety measures, such as questionnaires, interviews and accident analyses.

Obviously, this new approach from ICTCT fits in better with the wider issues of transport policy. For this reason, I am delighted that you have asked me to talk about the Netherlands` transport policy in relation to the concepts of a sustainable society and a sustainable safe transport system.

1.2 EUROPEAN PROBLEMS

Traffic has almost doubled in Western Europe over the last twenty years. Traffic jams are now the rule rather than the exception. Petrol consumption has gone up by a third, and diesel consumption has doubled. Air pollution has incrased - smog is with us again - and more and more people have to put up with the constant din of traffic.

At the very least this undermines the quality of our society - at worst it costs lives.

The forecasts are not good either. If we do nothing about it in The Netherlands, there will be 70% more traffic by the year 2010. The United Kingdom expects 80 to 140% traffic growth over the next thirty years. And in the Paris region, the next quarter century will see 21 million daily journeys increase to 28 million.

The rise in world trade, steady economic growth, the single European market, Eastern Europe throwing open its borders - all these mean more private cars and more commercial vehicles on Europe`s limited road network.

Yet little progress has been made in tackling the growth in mobility and the traffic congestion it generates. I doubt if any European country would claim to have found a long-term solution to the traffic problem. True, advances in traffic management have improved road capacity and helped keep traffic moving, but this approach has its limits. It is only a matter of time before traffic management technolgy starts failing to keep pace with traffic growth.

In terms of road safety this is a calamity. Every year, 50 thousand people die on Europe`s roads and more than 1 1/2 million are injured. The annual cost of this slaughter has been put at 250 000 billion guilders - more than the gross national product of Ireland, Portugal or Denmark.

Death and injury on the roads has to be seen as a major public health issue. Consider these statistics:

- one in three deaths in the age group 5-25 years is the result of a road accident;
- road accidents account for more lost years of life than heart and arterial diseases, and nearly as many as those lost to cancer;
- one in ten people injured in a road accident will suffer some degree of long term trauma;
- more than half of rehabilitated disabled people received their injuries in road accidents.

These figures are in stark contrast to safety records on other forms of transport. Rail or air travel is 100 to 200 times safer per kilometre than the private car. In all other areas of our lives where technology plays a part - from health and safety at work to protection from natural disasters - we design precautions against probalities of death many times (sometimes thousands of times) lower than those we take for granted on the roads.

1.3 DUTCH PROBLEMS

Good access to the principal Dutch mainports - Rotterdam Harbor and Schiphol Airport - is vital to their competitive position, and to the Dutch economy as a whole. Road transport is therefore a cause of great concern. Its quality and cost can make or break the Netherlands` claim to be the gateway to Europe; transport is one of the first things firms look at when they are thinking of opening an office or factory.

Road traffic has grown much faster than anyone could have predicted. Motorway tailbacks now threaten to strangle our economic centres. Congestion (especialy in the Randstad) has become commonplace, as the road haulage industry expands even faster than private car use.

In spite of increasing expenditure on road safety, the decline in road accidents is slowing down. The law of diminishing returns is telling us that we have to find new ways to solve the problem.

1.4 TRANSPORT STRATEGY

Although The Netherlands is only a small country, the Dutch have plenty of ideas when it comes to changing current thinking about transport - you only have to look at the concept of the Woonerf in The Netherlands. Given our geography and location relative to the rest of Europe, it is in the Netherlands` interest to find solutions to European transport problems. This also means striking a balance between individual freedom, mobility and the quality of life, one aspect of which is road safety.

The yardstick for the Netherland here is the concept of the "sustainable society". The sustainable society provides for the needs of the present generation without damaging the ability of future generations to provide for theirs.
This presupposes a transport system that is not going to bequeath a legacy of environmental problems to future generations.

And that calls for some courageous political decisions. It means setting limits on the adverse effects of traffic, while simultaneously guaranteeing efficient transport. This delicate balancing act can only be maintained if we modify mobility patterns and adopt stringent traffic management. Accordingly, The Netherlands has opted for the followeing approach up to the year 2010:

Step 1 - Tackling the sources.
Vehicles will have to be as clean, as economical, as safe and as quiet as possible.
Limits must be set on road building and car access to urban areas and areas of natural beauty. The measures being taken include promoting catalytic converters for private cars and cleaner and quieter engines for lorries and buses; making road surfaces quieter;
enforcing speed limits more strictly and designationg more 30 kph zones in cities and villages; providing better urban and regional public transport; and replacing roads with cycle tracks in scenic areas.

Step 2 - Planning for mobility.
The number of kilometeres driven by private motorists and businesses has to be reduced. Planning measures must stem the current trend of commuting ever greater distances. Public transport has to be good and private car travel has to be more expensive.
Among the measures being developed here are: incentives for new businesses to locate close to public transport; experiments with teleworking; road tax surcharges in the rush hour to encourage private drivers to live closer to work or use public transport; less free parking in urban areas and at the workplace; urban renewal plans that discourage cars and promote alternatives; mandatory transportation plans for companies with more than 5 000 employees; and new legislation on the carriage of dangerous goods.

Step 3 - Improving the alternatives.
Measures here include better public transport and passenger information; better infrastructural provisions for cyclists, including cycle lock-ups; promotion of carpooling; more comfortable and more frequent rail services; and shorter journey times on public transport.

Step 4 - Selective access by road.

New roads will only be built where necessary to maintain the Netherlands` strong position in the distribution industry. In congested areas, special lanes are being provided for commercial vehicles, people who car-pool, and buses. Other measures include dynamic traffic management for main roads; electronic route guidance systems; more rampmetering; and allowing buses to use the hard shoulder.

Step 5 - Strengthening the institutional framework.
We have to do more too in relates areas - publicity campaigns, administrative measures, finance, enforcement and research. The Netherland government is working with interested parties to develop a marketing plan, to achieve better enforcement rates for traffic violations, and to evaluate more accurately the measures being taken.

The important point here is that this is proactive policy, anticipating rather than responding to transport developments. The objectives of the strategies and measures set out in the resulting Netherlands transport policy should be achieved by the year 2010.

1.5 ROAD SAFETY

Dutch policy is to reduce private car use, and this will help improve road safety. The aim is to increase the number of journeys people make by public transport or bicycle rather than by car. These preferred forms of transport have therefore to be safe.

The concept of the sustainable society embraces road safety too. It is simply not acceptable for us to bequeath our massive rate of road deaths and injuries to the next generation. We have to try to build roads which reduce the risk of accidents - or at least the most serious accidents.

This requires a whole new approach. Reducing accident rates and creating conditions to eliminate the most serious accidents is not feasible with our present road traffic systems. Sustainable road traffic - in the sense of safe road traffic - can only be achieved by applying the same kinds of standards we apply to other technical systems - nuclear power, oil refineries, air and rail transport for instance. The premise here is that road safety - or rather the lack of it - is a variable which we can change, not a constant fact of life.

The road user is central to any notion of sustainable road traffic. Toad traffic, therefore, needs a road infrastructure designed to take account of human fallibility, and vehicles to simplify the road user`s task and to offer maximum protection. Road users need to be better trained, better informed and, where necessary, more strictly controlled.

In operational terms, these general ideas about safety and sustainability translate into three principles:

- Prevent unintentional road use, i.e. journeys that are not strictly necessary by road transport or by that particular roadtype.

- Eliminate potentially dangerous conflicts between different categories of road user by keeping apart traffic of different speed, weight and direction.

- Improve traffic predictability and driving behaviour by removing uncertainty on the part of the road user.

What, then, would our sustainable safe road system look like? In the first place, every road would be assigned a particular function and be designed for maximum safety for that function. We envisage three functional categories: roads carrying fast through traffic performing a flow function; a link function to allow vehicles to reach given areas; and a function for staying and giving access to roadside destinations while ensuring that the street remains a safe place for pedestrians and bicyclists.

Road design must conform to the function assigned, with mixed-function road being eliminated altogether.

Each function would preferably be characterised by a distinctive design, so that there could be no confusion in the minds of road users. This could only work if the number of road categories based on function and safety criteria were strictly limited. Access points for each of the different categories would also need to be immediately identifiable by drivers, by having road markings and signs unique to that road category. Distinguished speed limits would also apply to each category.

These principles are comparatively easy to apply at either end of the road category spectrum - on the motorway or in the 30 kph residential areas. It is the bits in between that are the problem - the urban arterial roads of 50 kph and the 80 kph roads outside built-up areas. Here, numerous discontinuities mean greater accident risks and here all kinds of traffic use the same road space at a whole range of different speeds.

In vehicle design too, improvements are needed not just in passive safety (reducing the effects of an accident) but mainly in active safety (devices to warn the driver and improve his ability to take avoiding action).

Clearly, road must be designed to foster safer behaviour on the part of road users. But road users are people, and this is the crux of the road safety issue. Road users must be trained properly, whether they are pedestrians, cyclists, motorcyclists or drivers. There will always be a need to educate different road users.

The Dutch Institute for Road Safety Research SWOV states that the number of road deaths can be reduced considerably by the year 2010. This falls short of the ideal if we adopt a policy of sustainable safety. We could have safe roads in 30 years by adding the new safety features to the normal road building and maintenance programme. According to SWOV, this would bring road deaths down to 10% and injuries to 20% of their present figures, assuming a 35% growth in traffic between 1986 and 2010.

Another prerequisite for our sustainable safe road system is that the public supports it, not just the politicians. This means co-operation between different levels of administration and the whole range of interest groups. The Minister of Transport took a lead here recently in June when she accepted the jointly formulated recommendations of the country`s research institutes concerning the approach to a sustainables and safe road traffic system.

The striking thing here is that in The Netherlands it is the research world that is shaping the new sustainable transport policy (albeit at the behest of the Ministry), rather than outline policy coming from government first and the details being filled in later. If nothing else, this demonstrates closer links between policy-makers and researchers, that have always had something of a love-hate relationship in the past.

Research and experimental work is producing the policy, and specific measures then appear in regional transport plans. The Netherlands has recently been divided into 26 Transport Regions, geographical units with common transport characteristics. In an organisational sense, the regions serve as the forum for government and industry to work together on an integrated regional traffic and transport policy. Regions draw up their own transport plans, designed to curb car use, promote the alternatives and still achieve the greatest degree of accessibility. Plans therefore cover the most appropriate forms of public transport, transportationplans for companies, road improvements, carpoolfacilities, parking policy, cycling facilities, and provisions for road freight.

Obviously for ICTCT, looking at road accident prevention, research into the traffic processes involved is going to be more fruitful than a study of road accidents themselves. Analyses of accident black-spots - a retroactive approach which smacks of treating the symptoms, not the disease - is becoming much less popular. Conversely, studies of traffic behaviour in a spatial environment now carry more weight. In The Netherlands, policymakers and researchers now give special weight to the new research into subjects like patterns of mobility, town planning, road design and telematics in relation to their effects on traffic behaviour.

1.6 TRANSPORT POLICY OBJECTIVES

But in The Netherlands, we do not just think in terms of long-term policies and strategies. We have already gone as far as setting a number of detailled targets for the years 1995 and 2010. For full details of these, I refer you to our Transport Structure Plan 1992 Action Book, but the most important are the following:

- Reducing to 35% the 72% growth in car traffic predicted for 1986-2010;
- 20% reduction in the 1986 level of NOx exissions from private and commercial vehicles by 1995, and 75% reduction by 2010; NOx is a major cause of acid rain.
- 20% reduction of CO2 emissions per vehicle kilometre by the year 2010; CO2 is a major cause of the greenhouse effect.
- Vehicle noise standards will be tightened by at least five decibels.
- Road deaths should be reduced by 15% by 1995 (based on 1986 figures) and by 50% by 2010. Targets for reductions in the number of road injuries are 10% and 40% by the same dates.
- Regulations for the carriage of dangerous substances will be maintained at least at current levels.
- From 1995, all major new residential developments must have high quality public transport. From 1992, planning regulations already require new businesses to locate close to public transport.
- From 1995, new regulations will restrict the number of parking spaces available at work from 10 to 40 spaces per 100 employees, depending on the location.
- Urban redevelopment schemes will seek to discourage the motor car with measures like 30 kph zones, roundabouts and speed reduction devices (in this area, ICTCT can apply its

diagnosis and avaluation techniques).
- Pricing structures will favour public transport at the expense of the private car.
- Main roads from the principal ports will only have a 2% probability of a traffic jam in 2010, and other trunk roads a 5% probability.
- Cities will have short, safe and attractive cycle routes; a complete public transport "product" incorporating the bicycle is being developed. (This is also an area of concern for ICTCT).
- The Netherlands is working towards a European-level structure plan.

1.7 POLICY EVALUATION

The Netherlands governments is committed to policy impact reporting. All the government departments involved are expected to describe their policy targets in quantifiable terms, so that progress can be measured. Differences between actual and targeted performance can then be used to modify the measures being taken.

So we do not stop at good intentions - we have a monitoring system as well. After all, we need to know what is happening in transport and why. For instance, are there external factors affecting a particular observed development, or is it the result of measures we have taken?

Better information increases policy effectiveness, and for this we are collecting ever more data on people and vehicles. But our analysis is still not sophisticated enough always to be able to say whether we have achieved a particular goal with a particular policy. This is one area where ICTCT might benefit from developing a methodology for assigning measured impacts to given policy measures. Ideas from ICTCT in this area are always welcome.

1.8 CONCLUDING REMARKS

To conclude, our vision of the transport systems of the future is slowly taking shape. Road safety is already an integral part of this thinking, and is a central policy issue at the Ministry of Transport.

Much of the new policy is already being put into practice, or is being prepared. Objectives and tasks are constantly being updated as plans are implemented, but always on the lines of the Transport Structure Plan.

ICTCT can make a contribution here with its expertise, especially in deagnostics and evaluation. I believe as well that ICTCT could broaden the scope of its work, as governments become more willing to have their policies evaluated, as it is the case in The Netherlands.

It is still true to say that, as a rule, too little use is made of expert knowledge when we draw up policy plans. The question then is how to arrange for all the expertise held by ICTCT partners to be made available to people planning transport at naional, regional and local government level. ICTCT can support us with research contributions for the formulations of a sustainable safe transport system.

The Netherlands would like to start work now on a European transport plan, using the experience it has gained with the concepts of a sustainable society and sustainable safe transport. But a single country cannot tackle that; Europe-wide support is essential.

The Earth Summit in Rio de Janeiro failed to get the rich countries to agree to sustainable use of raw materials and less environmental pollution. In European transport policy, we hope to go further than Rio. Too ambitious? I do not think so.

REFERENCES

MINISTRY OF TRANSPORT 1992, Bicycle Master Plan. Bicycles First; Structured Scheme for Traffic and Transport, The Hague

MINISTRY OF TRANSPORT, PUBLIC WORKS & WATER MANAGEMENT 1991, Long Term Policy for Road Safety, The Hague, The Netherlands

MINISTERIE VAN VERKEER EN WATERSTAAT 1992, SVV Aktieboek 1992; Verkeer en vervoer in een duurzame samenleving. Den Haag

MINISTERIE VAN VERKEER EN WATERSTAAT 1992, Beleidseffectmeting Verkeer en Vervoer; prototype beleidseffectrapportage 1991, Den Haag

SECOND CHAMBER OF THE STATES-GENERAL 1990, Second Transport Structure Plan; transport in a sustainable society, Part D: Government Decision, Session 1989-1990, 20922, nos. 15-16, The Hague, The Netherlands

SWOV 1992, Naar Een Duurzaam Veilig Wegverkeer: Nationale verkeersveiligheidsverken voor de jaren 1990/2010, Leidschendam

2. INTERNATIONAL CO-OPERATION ON EXCHANGING DATA AND KNOWLEDGE FOR ROAD SAFETY MANAGEMENT

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SUMMARY

One of the most important problems of road transportation is road safety.

The present computation technology, Geographic Information Systems (GIS) and Expert Systems (ES) have become suitable to handle large-scale transportation problems.

For traffic safety ESs more accident data are necessary, which requires international co-operation. The standards for the treatment have also to be internationally similar, because the traffic itself is also becoming more international.

In this paper, a Road Safety Management System (RSMS) is drafted on the basis of an ES and a high-performance GIS as an integrator. It could also integrate other ESs in the transportation domain, becoming in its extended form a 'total' Transport Management System. Due to the GIS, the system could integrate or communicate with the data of other domains which have influence on the traffic itself, or on the evaluation of traffic circumstances. The user interface will be created according to the general professional skills, providing the wide-range suitability of the system.

To create the RSMS, international collaboration is proposed to exchange data and knowledge and to use the most advanced technologies.

This paper is based on the booklet, which have been circulated to institutes and experts all over the world in the second half of '92. After the processing the returned questionnaires (which were attached to the booklet) the author will give further information about the recent results of the project, drafted here.

2.1 INTRODUCTION

Today the satisfaction of the basic travel demand is no longer a problem in the developed countries. The improvement in the level of service causes difficulties, because the present transportation demand on the road network is higher than at any other time.

If we look at the evolution of transportation we will see that road traffic is dynamically increasing, while rail and waterway traffic stagnate. This shows that the desired changes (e.g. in modal split) will be slow, and besides the above mentioned management, we must also focus on the improvement of road traffic.

Although experts continuously work in this field, the results seem to be only relative:

In spite of the increasing car ownership and road traffic performances the number of accidents and the amount of losses (human and material) stagnate, or decrease slightly in the last two years. Nevertheless in the European Community every year around 55,000 people are killed on the roads, 1.7 million are injured, and 150,000 permanently handicapped. The financial cost of this is estimated to be more than 50 billion ECU per year; the social cost in human misery and suffering cannot be measured.[(2)]

Many factors play a role in accidents. To improve safety conditions these factors must be modified, and consequently, their particularities have to be analyzed.

In most countries all the accidents are reported and collected in a national database. These are usually very detailed and contain both the accident data themselves, and the local conditions.

The road and traffic conditions belong to the factors involved in accidents. By analyzing these data, searching for connections between them and accidents, it becomes clear that even though we find the number of accidents to be very high, in many cases it is not high enough to obtain a significant correlation.

Although conflicts technique could be useful for analyzing the traffic safety conditions of given network elements, it is not a solution, when a wider range of accident data is required. This is possible only with the availability of accident databases of different countries, by international exchange of information.

This data exchange could help to create Expert Systems (ES) which are internationally applicable. This is very important, because an increasing proportion of the traffic generated is crossborder, so part of the problems have become international. In practice, this means that in the not too distant future a complete and internationally co-ordinated Transport Management System (TMS) is necessary, which is flexible enough to integrate national characteristics.

The internationally distributed Data and Knowledge Bases, their exchange, a Road Safety Expert System, a transport oriented GIS - these will be the parts of a Road Safety Management System (RSMS), which could be the basis of a "total" Transportation Management System.

2.2 EXPERT SYSTEMS - TRANSPORT MANAGEMENT SYSTEM

As a final and future goal we have mentioned the Transport Management System. Firstly, let us see what a TMS is in reality, and what kind of activities have to be integrated into it.

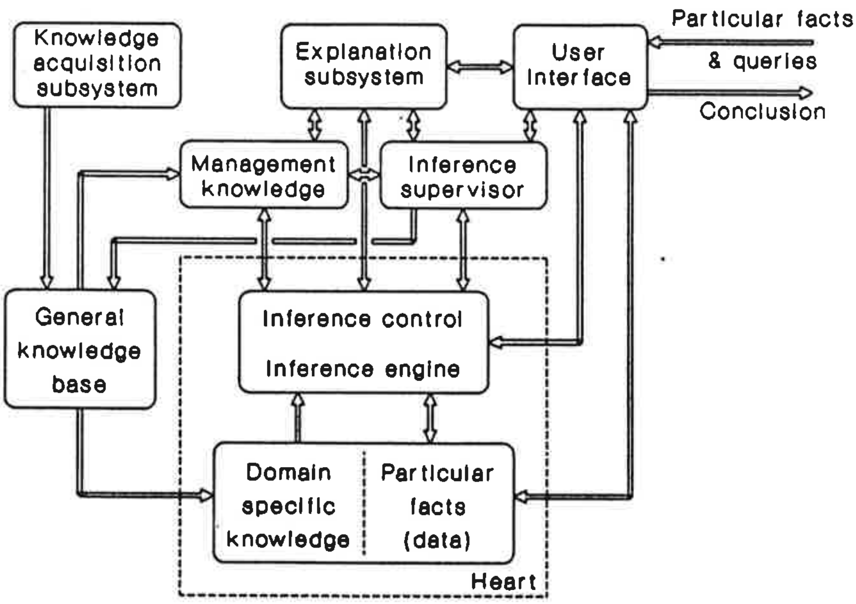
Transport management is the process of controlling and co-ordinating a comprehensive set of activities in order to achieve the optimal balance of the interest of different classes of road (transport network) users, taking into consideration different transport modes. The general target of the optimization is to make the best possible use of resources available, to maximize the benefit to society.

This "total" Transport Management System consists of several subsystems, such as:

- Pavement Management
- Transport Information Management
- Safety Management
- Trip Management
- Environment Management
- Forecasting Systems, etc.

The expertise of these fields is combined to expert systems (ES), which are practically the utilized and exchangeable forms of knowledge. In the TMS every subsystem is represented by an expert system.

In the case of the TMS the several subsystems are represented by their own knowledge base, an ES, but the inference procedure could be controlled by the same algorithm. The results in one domain have influence on the others. For this feedback another co-ordinator routine is required to supervise it, define the order of the procedures, activate the necessary knowledge; so controlling the communication between the several parts of the system. In the knowledge base there has to be a 'domain-independent' part, too (management knowledge), which represents the expertise on the interrelationships between the integrated domains. The draft of this 'multi-expertise' management system is shown in Figure 1.



2.3 ROAD SAFETY MANAGEMENT SYSTEM

In an accident four main factors play a role:

- human factors,
- vehicle design,
- environmental factors (weather ...),
- road and traffic characteristics.

The crucial role of 'human factor' in traffic safety can be reduced by creating circumstances which in themselves induce the drivers to drive more safely. Besides keeping to the general design standards (visibility, etc.), this is the role of the traffic engineers, and the road and traffic characteristics in traffic safety.

In the last decade much effort has been made to find closer connections between accidents and road and traffic characteristics. Many accidents (and conflicts) data have been collected and analyzed from several points of view. As a result, there exist some Expert Systems created by several different institutions around the world. (5)

2.3.1 The necessity of GIS

It is evident that a transportation system could not exist without a graphic tool. The only question is, what kind of graphic tool is necessary; is a CAD (Computer Aided Design) system enough, or is a GIS (Geographic Information System) required?

The definitions of the two types of software do not cover every aspect of the systems. But the difference is clear that GIS is mainly an analytic tool, and CAD is chiefly developed for graphic visualization. Nevertheless the evolution of CAD systems shows that in some aspects they approach GISs. This means that an advanced CAD system with an additional data processing system can work like a GIS, but with certain restrictions coming from the original characteristics of CAD systems.

Generally speaking a GIS is required, when frequent and extended analysis of the data is necessary, and geographic information is used.(6,7)

The solution in GIS is more effective, and it gives wide perspectives. The claim is getting stronger for combining more or all spatial information into one identification system, where both the location of every facility and the interrelationships between different domains could be clarified.

The advantages of an entire system are evident, where all the information relating to geographical locations are combined. In our case this means that e.g. for our "network-oriented subsystem" the environmental data could be derived from an "area-oriented spatial subsystem" which also serves the forestry, agricultural, geological, etc. purposes.

Taking into consideration the arguments for and against, the needle of the scales tilts definitely to the side of GIS. This means that for the flexibility and efficient use of TMS a GIS has to be integrated.

Beside the arguments of the present, we have to have a look into the future. There are some more arguments for GIS.

2.3.2 Future of GIS

People working in the forefront of computation development, see quick (r)evolution of Information Technology (IT) and GIS itself (10-13); some important examples:

- Large use of Expert Systems (as previously described).
- Effective (relational) Distributed Database system, where the user anywhere in the system will have information anywhere on the network without having to know anything about where that information physically resides, how it is structured or how it is maintained. These require a better performance of IT networks.
- Instead of the present specialized software, the actual trend (e.g. within IBM) is to develop one GIS software covering the various application types.
- The concept of GIS database will disappear, and instead of the actual two databases (a proprietary and specialized one for the management of geographic data, and a standard one for the management of alphanumeric data) only one database will remain in future.
- Fully Distributed Database support will become a strong need. This demand has already appeared, but it is not yet reality, because several critical components of the technology are simply not yet available.

2.4 PRESENT SITUATION

2.4.1 Database

As it has been mentioned, TMS requires an entire database. Besides the methodological difficulties, the creation of the database generally causes the problems. In spite of the fact that first we focus on traffic safety, for providing the consistency we have to prepare the database for every operation. For this reason we need all data belonging to one domain in the same structure. The lack of harmonization will cause many problems in the future data exchange.

In the transportation field the necessity of computer databases appeared many years ago. They were created for given purposes, and were getting more detailed and entire in parallel with the evolution of computation (analysis and graphics).

At the determination of the necessary content of the database we have to consider the need of the other fields of road safety (education, vehicle design, assistance of injured etc.). Taking into account the extent of the database required, and the fact that there are existing digital databases, we have to use them instead of creating a new one.

2.4.2 Knowledge base

In the transportation field there are many calculating, analyzing, simulating and decision preparing methods based on computing. The simple ones deal with one aspect only (travel time, air pollution, capacity of junctions etc.). There are combined ones for pavement management and cost-benefit analyses, or complex ones like multi-modal forecasting methods, completed sometimes with multi-criteria analysis, also taking environmental effects and imponderabilia into consideration.

Expert Systems have appeared in the second half of the '80s, solving mainly deterministic problems (Traffic signal design (14), Trip generation (15), and more (4) in the transportation field). After more experience with Expert Systems, professionals also turned to probabilistic occurrences (16-18).

Although there are only a few results and experiences with these Expert Systems, these could be the basis of the TMS system to be developed.

2.4.3 GIS

Almost all software, designed for transportation purposes, contains graphic routines for visualizing the network and the results of the analysis. Some of these programs were developed before the spreading of GIS packages. The majority of these graphic software packages were written for a specific purpose, others use generally distributed graphic tools, like CAD systems.

Nowadays the competition for the dominance in transportation GIS is getting sharper. The giants of the computer industry developed their own GIS software with the necessary hardware supply. At this moment there are no direct relationships between these products (SICAD [Siemens], GPG [IBM], ArcInfo [ESRI], etc.), although there is an aspiration to standardize the data input. However the result of this cannot be expected in the short term, so the most suitable system has to be chosen very carefully, because this decision has far-reaching consequences and the system must operate over a long period of time (19,20).

2.4.4 Data and knowledge exchange

The development of RSMS (and TMS) needs two types of data exchange.

In the phase of development the data and knowledge communication occurs between independent systems and organizations. The media used can be varied, ranging from the direct discussion through magnetic and optical disks to the on-line connection. Of course to realize this, some harmonization and co-ordination (a committee, a workplan etc.) is required.

In the operational phase there will be two types of communication. On the one hand the system has to be maintained regularly. For this purpose the same data are required just as in the development phase, but no knowledge, because the new rules are derived by the data acquisition subsystem. The data will come from independent sources, outside the user's system, but the communication has to be organised on a higher level than before. It could work with regular monitoring, and later as a remote access distributed database.

On the other hand RSMS or TMS operates inside the user's own system, and it also requires data and knowledge communication.

Comparing the demands to the present possibilities, it is clear that all the requirements cannot be fulfilled at the beginning. There will be some problem with the data and knowledge communication in the development phase, caused by the need of harmonization, and critical parts of the distributed database technology are not yet available. This means that at the beginning the data transfer has to be solved in a traditional way. Later on both the TMS (on the basis of RSMS) and the data communication have to be developed in parallelism, according to the new results in the computing and database-management field.

2.4.5 Networking on a large scale

Data and knowledge (including graphics) can be exchanged by communication on a large scale. Therefore we have to set up rules and formats. In the system to be developed we also have to provide us with inter-process communication possibilities, as follows:

Message passing - Processes communicate by exchanging messages. No additional formal structure on message exchange is imposed by the communication system, but the applications themselves adopt a protocol for understanding the messages.

Remote operations - Adds structure to communication among processes by viewing interchanges as a client invoking (remote) operations on a server.

Remote procedure call - Uses the subroutine or procedure call as the metaphor for exchanges between processes. The metaphor of procedure call can be extended in many different ways to incorporate synchronization and other properties in a single mechanism.

2.5 REALIZATION OF THE PROGRAM

The scope of the necessary activities is very wide. This means that co-operation of experts and institutions is required. In the team there have to be experts (or expert groups) on traffic safety ES, data teleprocessing, GIS, transportation management.

The Research Unit for Traffic Engineering and Infrastructure Planning, KU Leuven, has experience in traffic safety, and is involved in a Transport Management System using GIS. With this background, while looking for co-operation, the start of the project is possible with the problem identification, finding the bottlenecks, defining the detailed schedule of the project. Neither the completion of these, nor the beginning of the subsequent phases are possible without having the team of collaborators. When the team is together, these steps could be completed in a short term.

Having the detailed schedule, it will be possible to determine the exact costs and duration of the project.

It is very important to check, whether the circumstances are really suitable to develop the system, as it is drafted. Examining the different requirements, there are two essential parts, which are not available yet, and have to be developed independently from this project:

distributed database technology, and the complete, high-capacity international communication network. Looking at the trend of the development of these, by the operational phase of the Safety Management System both of them will be available.

2.6 WORKING WITH THE SYSTEM, OUTPUTS

Although it is evident from the previous chapters, we try to demonstrate by some examples, how will be the work of the system and what will be the outputs at different stages.

2.6.1 General Transport Management System

The Safety Management System, to be developed in the first step, will be an essential part also of the general management system. It can give answers for wide scale of queries, as e.g. identifying the blackspots in a given area, calculating the safest route between two points of the network, or, due to the ES built in, it can give solution proposals to defined traffic safety problems.

There are many other aspects of transportation besides traffic safety.
On the one hand the evaluation of a network or an investment needs other characteristics. Persisting with the example above, a safety improvement may influence air pollution and noise, mainly in urban areas. In this case the system has to search for the common optimum on subsequent iterative steps, comparing the different modes of solution. The influence of the change of traffic load on the road maintenance cycle could also be taken into account.

There are even more complicated tasks, when e.g. two or more means of transport are involved. Let us suppose that the problem above has to be solved in an urban area, where many kinds of public transport (underground, bus, trolley-bus, tram) compete with car traffic, and in the modal split the parking circumstances also have to be taken into consideration.

These problems could also be solved in the traditional way: using the personal knowledge of the expert, aided by the single-purpose software tools (simulation, calculation, evaluation packages). However this takes much longer and the result depends upon the skill and intuition of the expert.

When only the traffic safety Expert System will be implemented, complex problems, such as those mentioned, could be similarly solved in the traditional way, having the advantage of the comprehensive database, the advanced GIS, and of course the Expert System, created just for safety problems.

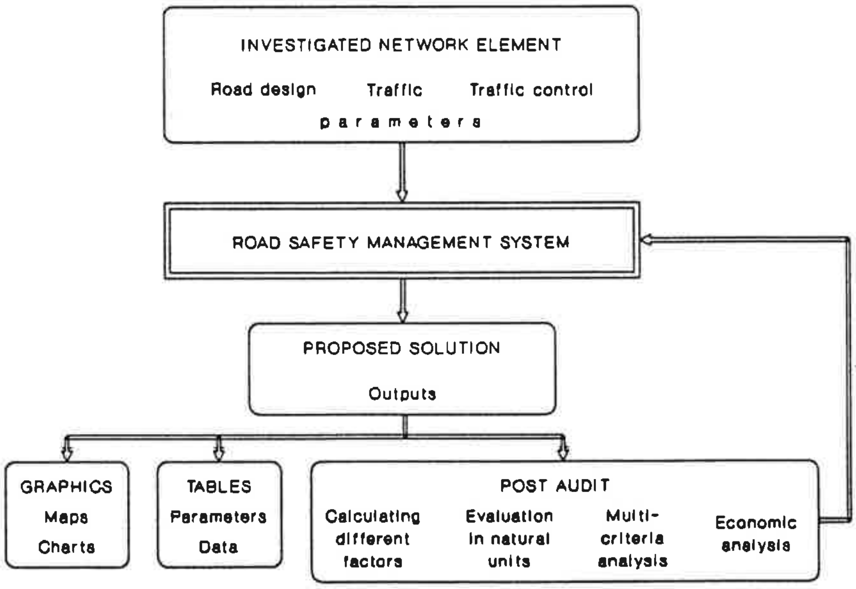
While improving the system and implementing more ESs representing different domains of transportation, the part of the solution which only needs assistance but works independently, is getting bigger. At the same time the duration of the procedure decreasing dramatically in comparison with the traditional solution.

2.6.2 Outputs

The TMS and RSMS must be suitable for solving some simple problems like reporting, mapping, making statistics, etc. The results of these operations are the reports, the maps and the statistics themselves; first on the screen, then in an edited form on a hardcopy device.

The outputs of the more complicated problems depend on the tools implemented. Consider e.g. a safety improvement of a junction, the result could be drafted in text, the changes could be explained in tables, or detailed on a map. The users decide the level of detail required according to their purposes and the type and scale of the problems.

It is certain that on the one hand the system has to provide maximum flexibility to the user in choosing the medium of the result, and on the other hand all the texts, tables and maps are necessary for presenting the results of a complex problem. The outputs have also to be suitable for a 'post audit', with a feedback to update the system itself. (Figure 2)



2.7 CONCLUSIONS

After satisfying the overwhelming majority of the transportation demand, the burning issues in the transportation field are safety and environmental protection. The loss of human life caused by accidents are very high each year. At the present level of technique a solution is necessary:

- where the guidelines and the main tendencies are internationally harmonized,
- which uses all available knowledge,
- which is computerized, and
- easy to use with a basic level of professional skill.

These requirements could be fulfilled by a Road Safety Management System (RSMS) based on a Traffic Safety Expert System. The visualization and the spatial data processing on the one hand, the connection to other spatial models and databases on the other hand require a Geographic Information System.

To solve more comprehensive transportation problems other ESs are also necessary. These have to be integrated into the same Management System. In this regard the first step of the RSMS has to be prepared for this future integration. This general "frame" is the Transport Management System (TMS), and in its future extended form it will be a "global" TMS. Considering both the software (ESs, data teleprocessing, management, GIS) and the hardware circumstances, the situation is suitable for the realization of the system. For the development, international co-operation on data and knowledge exchange on transport safety ESs, GIS and transportation management is required.

Since the system will integrate all available data and knowledge, and will have an iterative control feedback, its use will result in the most effective solutions firstly in road traffic safety, and later for every other transportation problem. Using the same knowledge base to solve similar traffic safety problems in different countries will be an important step for the future standardization.

Taking into account the improvement of the transportation circumstances and the reduction of losses, the efforts of developing the system will be recovered many times over.

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REFERENCES

ZHANG Z. 1991, Road Transport M.I.S.; Present and development thesis, K.U. Leuven (1)

COMMISSION OF THE EUROPEAN COMMUNITIES 1991, R+D in Advanced Road Transport Telematics in Europe. DRIVE '91, DRI202 (2)

NATIONAAL INSTITUUT VOOR DE STATISTIEK 1992, Statistieken van Binnenlandse Handel en Vervoer Nr 1 Januari 1992, ISSN 0773-4263 (3)

CURTIS G.1989, Business Information Systems: Analysis, Design and Practice, Addison-Wesley Publishing Company, ISBN 0-201-17523-1 (4)

INSTITUUT VOOR RUIMTELIJKE ORGANISATIE TNO 1988, Expertsystemen in verkeer en vervoer, Delft, 88/VVG/331 (5)

GUPTILL S.C.(ed) 1988, A Process for Evaluating Geographic Information Systems, Technology Exchange Working Group - Technical Report 1, Federal Interagency Coordinating Committee on Digital Cartography (6)

VAN EERD J. 1992, Wanneer GIS, wanneer CAD?; Verkeerskunde, 1 Spijkers R.C.1992, AutoCAD als Geografisch Informatie Systeem; Verkeerskunde, 2 (7)

MINISTERIE VAN VERKEER EN WATERSTAAT 1991, Een verslag van de prototyping minigis verkeer Direktoraat-Generaal Rijkswaterstaat, Dienst Verkeerskunde, Rotterdam (8)

IBM Corporation 1991, USA, GIS in the 21st century, conference paper, 1st IBM European GFIS Users Conference, Antwerp, Belgium (9)

CONRADY J. 1991, Anticipating the Future of GIS Systems, conference paper, 1st IBM European GFIS Users Conference, Antwerp, Belgium (10)

SAVAGE J. 1991, Distributed relational database systems will benefit GIS users, conference paper, 1st IBM European GFIS Users Conference, Antwerp, Belgium (11)

VAN DE PUTTE M. 1991, GIS Trends and Directions, IBM Belgium (12)

BIRKINSHAW D.E., KIRBY H.R. & MONTGOMERY F.O. 1988, Traffic signal design using an expert system shell, Institute of Transport Studies, University of Leeds (13)

HAZEL G.MCI. & BELL S.C. 1988, A trip generation database for large retail stores and its development into an expert system, JMP consultants and the Transportation Engineering Research Unit of Napier College, Edinburgh, U.K. (14)

RAMACHE A. & BELL M.G.H. 1988, The location of roadside objects: an expert system to assess the safety aspect, Department of Civil Engineering, University of Newcastle upon Tyne (15)

THEOBALD M. & HEYDECKER B.G. 1988, Understanding road accidents - a rule induction approach, Transport Studies Group, University College London (16)

WU J. & HEYDECKER B.G. 1991, The use of expert systems in road accident remedial work Transport Studies Group, University College London (17)

FLETCHER D. 1989, Modelling GIS Transportation Networks, Wisconsin Department of Transportation, Madison. (18)

ARNOLD D.B., DAY R.A., DUCE D.A., FUHRHOP C., GALLOP J.G., MAYBURY R. & SUTCLIFFE D.C. (Eds.) 1990, Graphics and Communication, Proceedings of an International Workshop Breuberg, FRG, October 15-17, Springer-Verlag, 1991; ISBN 0-387-54001-6 (19)

CARSON G.S. 1990, Graphics, Networking and Distributed Computing proceeding, in Arnold et al. (20)

MORTELMANS J.F. 1990, Towards Standards for Combining Database, Knowledge Base and Communication Technologies in the Field of Road Transport Management proceeding, in Arnold et al. (21)

MORTELMANS J.F. & ALBERT G. 1991, A Case Study for Founding a Transport Management System Using GIS-Facilities, conference paper, Annual Transportation Convention, Pretoria (22)

LANCASHIRE HIGHWAY COUNTRY COUNCIL AND DORIC COMPUTER SYSTEMs 1989, Lancashire Highway Information System; U.K. (23)

HUYSE L. 1991, Het gebruik van een GIS systeem voor de wegebbouw en infrastructuur-planning thesis, K.U. Leuven (24)

MORTELMANS J.F., HAELTERMAN K. & VANSTRAELEN G. 1992, Geographic Information Systems seminar paper, Zilina 16.3.92 - 22.3.92, K.U. Leuven (25)

MORTELMANS J.F. 1988, Standardization of traffic and transportation information systems conference paper, Roads and Traffic 2000, Berlin (26)

LAU M.Y.-K, MAY A.D., SMITH R.N. & HUANG H.F. 1990, An Integrated System for Traffic Safety and Accident Analysis conference paper, Eleventh International Symposium on Transportation and Traffic Theory; Yokohama, Japan (27)

MORTELMANS J.F. 1990, Managerial Aspects of Worldwide Co-operation on Road Safety conference paper, International Road Safety Conference, Singapore (28)

MORTELMANS J.F., ALBERT G. & HAELTERMAN K. 1992, Cooperation on Exchanging Data and Knowledge for Road Safety Management, Research Unit for Traffic Engineering, K.U. Leuven (29)

MORTELMANS J.F. 1991, Optimal Use of Knowledge and Data for Road Safety Management International Conference on Traffic Safety, New Delhi (30)

3. HOW TO EDUCATE OUR DECISION-MAKERS: A CHALLENGE FOR RESEARCHERS

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3.1 INTRODUCTION

Traffic safety, as a research area, is classified within "applied sciences", at least by those who consider it as a science at all. This means, or rather should mean, both that research is designed and carried out to provide some answers for practical use, and that results obtained are taken into consideration and reasonably applied by professionals in the field.
In actual facts, relationships between traffic safety decision-makers and researchers have often been uneasy, and a real partnership with clear roles to play for each party has seldom been reached. There may be several reasons to this:

a) Just as everybody else, decision-makers are road-users, whichever means of conveyance they usually adopt; just as everybody else, they have their own opinions on traffic, accidents, and how these occur; assuming responsibility for accident prevention makes them both judge and party, and in their case, individual opinions tend to extend into professional views; it is therefore not surprising that decision-makers do not feel the need for objective information and research findings as much as could be expected.

b) This is further compounded by the fact that trends towards greater democracy and participation of the citizens in public affairs are now developing (at least in Western European countries); decision-makers have to give a more and more attentive ear to the demands and opinions of the road-users, who are not professionals and do not usually possess all the relevant data, but nevertheless become competitors for the researchers in providing a background for policy-making.

c) A kind of rivalry sometimes also develops between decision-makers and researchers: Traffic safety choices generally involve some compromise between rational safety planning based on objective findings, subjective ideas of how things work, and interests other than accident prevention and life saving; according to the respective weights put on each of these motivations, decision-makers tend to form their own theories on the identification of priorities and the best modes of action; these theories are obviously likely to contradict those formed by researchers on (hopefully) purely objective grounds. To avoid an implied criticism of current safety action, there have even been cases when decision-makers have tried to silence researchers, an easy thing to do when they hold most of the funding for research !

d) When the rivalry becomes acute, researchers get to be considered (wrongly) as too far away from practical interests to be of any use: the validity of their work and findings is thus questioned, and when decision-makers feel the need for specific safety training, researchers may not even be callea upon to contribute.

e) From a more down-to-earth point of view, decision-makers relatively often change posts, and therefore fields of action: there are always newcomers in traffic safety and the old-timers do not get time to train them before being moved to other responsibilities; as a result, there is no memory of the practitioners, no real accumulation of experience and know-how, no continuity of knowledge.

It would be unrealistic however to tie all the reasons for the current misunderstanding between research and field practice to the decision-makers or the administrative systems of which they are parts. Researchers, either following their own personal drive or under the influence of the (sometimes restrictive) rules of the research community, are themselves often accused of not listening enough to the needs expressed by decision-makers, keeping their results under a shape hardly usable by practitioners, or refusing to set a foot in the real world of traffic safety professionals in order to get a bath of pragmatism.

This picture, while not entirely untrue, is somewhat caricatural, especially as researchers are not always free of their movements and cannot be systematically blamed for an isolation they have not wanted. But although most traffic safety researchers are at least trying to keep in touch, there is indeed a need for better communication between them and their decision-makers, if research is to have any practical outcome. Why this has not yet been achieved and how to change course with a better chance of success is the topic of the following discussion.

3.2 THE TRADITIONAL SCENE

The relationships between decision-makers and researchers, as usually seen by researchers, are based on a simplified and rather naive model inherited from an old "operations research" approach (Fig. 1):

a) The decision-maker is considered as a well-organized person who can, while dealing with one particular subject, ignore all others, including personal concerns; in our case, the decision-maker keeps only in mind traffic safety objectives and current projects which may have a direct (or perhaps even an indirect) effect on them; he is open and ready to receive any relevant information that may ease his choice of a course of action and improve its effectiveness in reducing accidents.

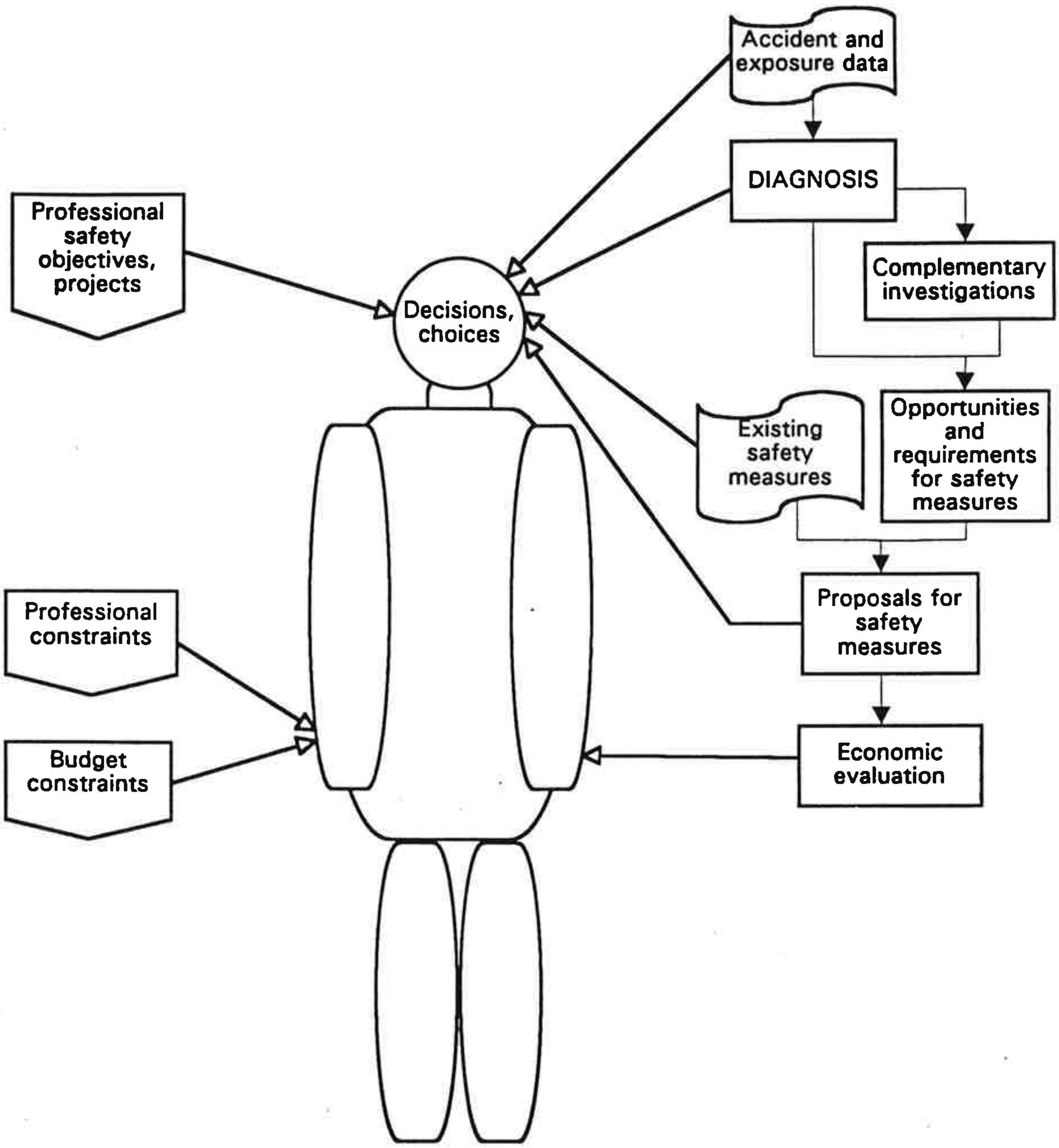
b) The decision-maker, however, works under constraints: a budget which always turns out to be too small for proposed safety projects to get fully implemented, and professio nal surroundings which are not always helpful (lack of multi-disciplinary communica tion, insufficient qualified manpower, limited time available for traffic safety work, etc.); such constraints may be considered as fixed and unalterable, or, more realistically, as partly flexible and likely to be alleviated, given proper effort and justification.

c) The decision-maker is well-meaning and logically-minded: given proper information, he will try to optimize his choice of a strategy towards accident-reduction, making the best use under constraints of the opportunities and the means available.

d) The decision-maker is aware that he needs a strong basis of information to justify his actions, and has set up a direct line to professionals and researchers who have the knowledge and can be provided with the means to prepare such information.

Figure 1

THE DECISION-MAKER
as seen by the researcher



e) In front of a decision-maker with such goodwill and talents, there has to be a researcher willing to apply his abilities to practical safety work. The part he will have to play is only technical: to help define the information needed for safety planning, including, first raw data, then different stages of analysis in relation to the needs anticipated at successive levels of the decision-making pattern, to select the relevant items from the pool of knowledge accumulated through research experience, to work out the analyses and provide the results under a usable format.

In order to perform his task properly, the researcher must have some idea, based on experience, of what is needed to design safety policies. If the decision-maker is new in the field (or open to discussion), the researcher may even be able to push forward some methods and a logical process to take into account as much objective information as possible into the safety planning procedure. His task can be examined in more details under this prospect:

- The first tool needed by the decision-maker is reliable accident and exposure data that will enable him to assess the global safety situation and to frame the most important problems to solve. In most industrialized countries, a data collection system has long been set up, but there is still scope for substantial improvement (under-reporting of particular types of accidents, lack of exposure data); in developing countries, data bases seldom exist and under-reporting is almost a general problem.

Researchers may consider it as a first step in their relationships to decision-makers to help them set up a data collection system, improve it, and, if necessary, contribute an analysis based on up-to-date statistical methods.

- Finding out the most urgent safety problems is not enough to solve them. A thorough diagnosis aimed at understanding the complex accident causation patterns will provide more precise directions for action, on the basis of detailed accident data, possibly complemented with traffic conflict data and behavioural observations. Additional investigations and surveys, of the roads, the vehicles or the road users, can be designed to answer some particular questions arising from the diagnosis, analyse the feasibility of particular types of measures, and prepare a framework for education and information measures. Adequate methodologies are needed to ensure validity of the findings. It is clear that, even provided with relevant data, a decision-maker will neither have the time, nor the necessary (multi-disciplinary) skills to perform these analyses and investigations; researchers have the skills, if not always the time, and should at least design and coordinate diagnostic studies, using every opportunity to train practitioners to perform the different forms of data collection and treatment involved.

- If the constraints on decision-making are considered as flexible, objective findings may be useful to help alleviate them. An economic valuation of the cost of accidents, based on accident data and complementary investigations (in hospitals, with insurance companies, with road transport professionals, etc.), should provide a starting point for the decision-maker to claim a larger traffic safety budget. An institutional analysis of the structure needed to implement a multi-disciplinary programme of measures and of the existing administrative organisation should help promote necessary changes. In this area, it is not only the need for specialized skills and for time that points out to the researcher as the best study designer and coordinator: it is also essential that the decision-maker, himself a part of the administrative system he is trying to improve, can show the proposals he is pushing forward as coming from objective outsiders.

- When it comes to the selection and design of safety measures, the task is really in the hands of the decision-maker and his teams of professionals. However, the step between the diagnosis and the design of a safety programme is not an easy one to take. Here again, the researcher can contribute by gathering research and evaluation results concerning relevant safety measures already experimented in the field, and possibly proposing principles for new safety measures, taylored to the particular problems and conditions of application examined in the diagnosis.

- As soon as safety measures have been applied, some evaluation should be interesting, both from the decision-maker's viewpoint (to promote his efforts if the results are positive, to improve the situation if they are not) and from the researcher's (to add to his pool of knowledge, to improve his methodologies). Sound evaluation requires specific skills and should be carried out by someone who has not taken any part in the decision-making process and the implementation. It is a final task for researchers, although maybe not those responsible for the earlier proposals.

If this simplified model were to work, and researchers to be regularly called upon by decision-makers, it would suggest that a large number of researchers should take part in the process on an alternative basis, in order to be able to keep carrying out new or further research rather than being confined to the application side of it. Researchers should also design training programmes for professionals, who would be able to gradually take over at least part of the information gathering and interpreting tasks. Over time, the most important research tasks would thus become coordination of studies, improvement of methodologies, and up-dating of the training programmes. We are in a "cooperative-type model", which, after a starting period, leads to a situation where the respective parts of the decision-maker and the researcher are well defined, with trained safety professionals as an intermediate element.

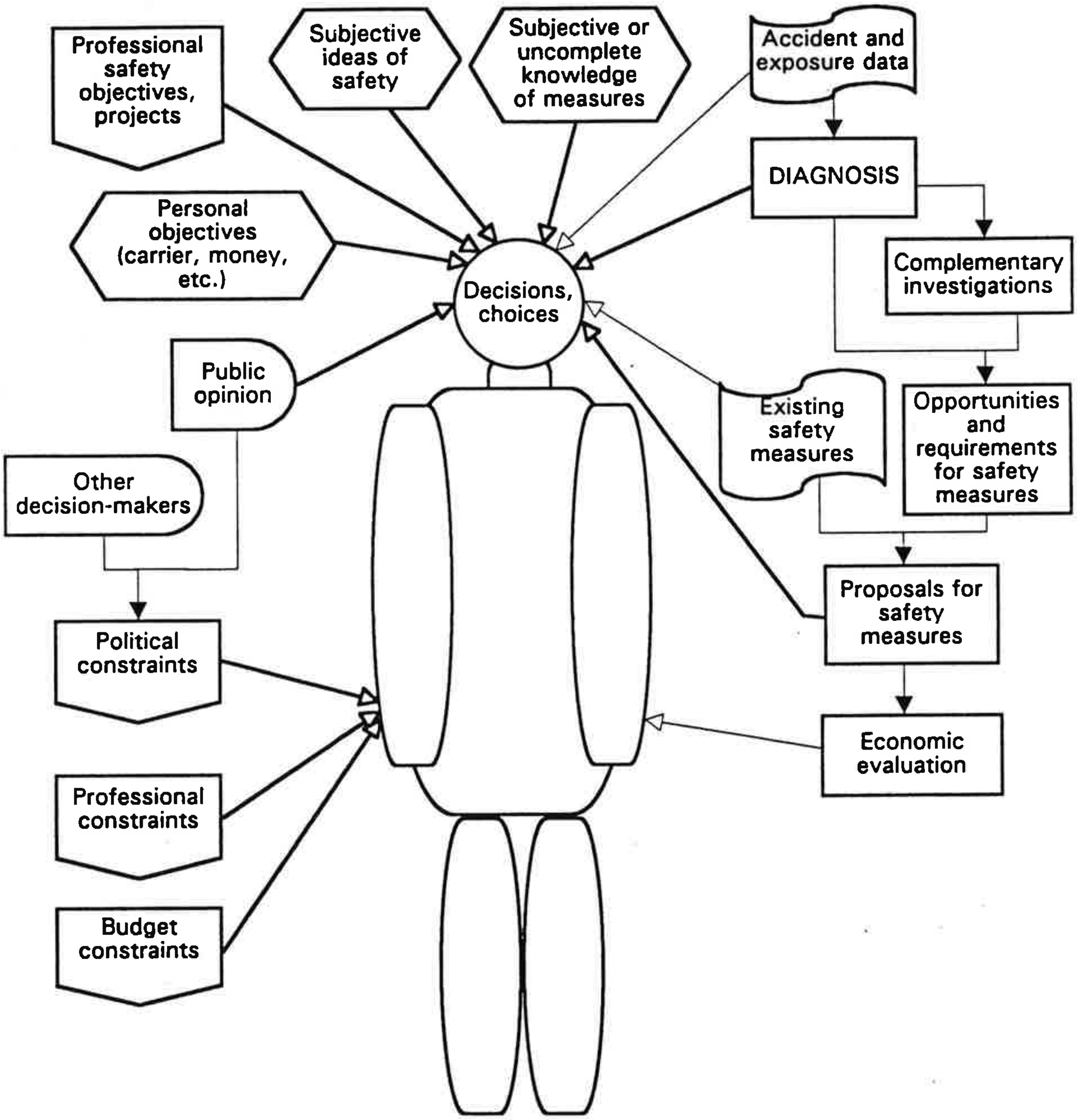
Unfortunately, attempts at testing such a model, both in European and in developing countries, have showed that it could work to some limited extend, but that difficulties arose both when reaching the programme design stage and when trying to establish long-term relationships between researchers and their partners. A new approach is therefore needed, introducing some external influences into the model.

3.3 A MORE REALISTIC VIEW OF THE SCENE

In this second model derived from the simplified one, the decision-maker is seen as a more complex character (Fig. 2):

Figure 2

A more realistic view of THE DECISION-MAKER



a) The decision-maker has still in mind traffic safety improvement as a prominent professional objective, but he cannot entirely get rid of other concerns. One of them may be his own personal goals, such as career, money, etc.; these goals may influence his motivation for accident-prevention (is it valuable for him to put efforts into this field ? can it help him get promoted ?) or even his decisions and choices (is anybody who can be useful to his carreer going to disapprove of some particular proposal for action ?). Personal goals can also create a need for promoting his own efforts in accident-prevention, addressing fellow decision-makers or even the public itself; campaigns for personal enhancement may, if costly, compete with proper preventive action, but may also to some extend help improve the general image of traffic safety work.

b) The decision-maker will work under more constraints than previously acknowledged. One of them is the political constraint, usually relayed by other decision-makers at a higher level; but in a democratic system, public opinion can also directly influence politics and decision-making, as road-users are the citizens who vote, and moreover may express themselves rather loudly when unsatisfied (see for instance lorry drivers' demonstrations) and even demand a culprit for an ill-accepted safety measures. While budgetary and organisational constraints could be hoped to be somewhat flexible given proper justification, political constraints are unstable, but rather difficult to influence through scientific arguments !

c) Being themselves road-users, decision-makers have formed their own subjective ideas of accidents and why they occur. Also, if they have been in the traffic safety field for a while, they will have some overview of the possible countermeasures, although perhaps not a complete one (unless based on intensive international exchange and review of experience) and not an entirely objective one (if criteria for success or failure of measures and conditions of application are not clearly explicited). The less "memory" of traffic safety work at the decision-making level, the more based on limited personal experience the knowledge will be. But whatever the quality of ideas and knowledge in the head of the decision-maker, he will be less convinced of the need for researchers to contribute to the information gathering process than in the simplified model: researchers may have to fight to keep a voice.

d) Being submitted to complex constraints, some of them entirely external to traffic safety concerns, and dealing with both subjective and scientifically obtained information, the decision-maker cannot be expected to be entirely rational, nor to provide the final solution through any optimizing process; similarly, his goodwill may be somewhat decreased by personal considerations; however, he has to be assumed to retain some goodwill and some rationality, and to take some account of objective findings (otherwise, there would be no point in the researcher trying to help in the policy-making process !). The amount of scientific reasoning and the part played by objective information must also be considered flexible, with possible increase in relation to the relevancy and the convincing qualities of the findings provided by the researcher.

The different levels of information that the researcher should provide as a background for decision-making remain the same as in the first model, but his overall task is more difficult:

- Raw data on the accident situation as well as findings from the diagnosis pointing out to the main accident generating processes may be in contradiction with the personal ideas of the decision-maker or opinions currently held in the public; when there is no data base available, the decision-maker may not see an immediate use for one. If the researcher is interested in seeing real priorities tackled first, he has to become a militant to obtain to set up a data collection, push forward his results... and keep in the field.

- The researcher does not just draw a diagnosis, he needs first to convince the decision-maker that it will be a help and a source of ideas rather than just a constraining framework for action, in order to get the necessary funds to perform the study; then he will have, not only to provide results, but to present them in an attractive way and actually promote them to ensure they are duly taken into consideration. The researcher has to double into a "communicator".

- If the researcher makes proposals for safety action or institutional organisation, they will (normally) be based on the findings of the diagnosis and, normally, on an extensive and objective knowledge of the effects of existing measures; the proposals may be in contradiction with some ideas the decision-maker may have formed on the basis of his own knowledge, as well as with other proposals coming out for example from political constraints. The final choice will be the decision-maker's, but here again, the researcher can try his convincing powers, with the aim, not to reach an optimal solution, but simply to keep objective information in the circuit as far as possible.

- Fighting for his own career and unsure of the final success of the programme he has been designing, the decision-maker may not be so keen on getting a real evaluation under way; logically, the more rational the approach, the more confident he should be that an accident reduction will actually be obtained through the measures planned, and the more interested he should be in funding an evaluation that may later be used to promote his efforts. Similarly, the researcher will be more interested in evaluating the effects of safety measures well taylo red to the priority problems and their causation processes, than measures not so well targeted that would not have much relation to the part himself has played. So, there may or may not be an evaluation, but if the researcher feels it could be useful, he certainly will have to fight for it !

In this model, a "semi-cooperative-type" one, there is still some measure of mutual trust between the decision-maker and the researcher. But the latter must accept the irrational and the political elements in the planning process while preserving the scientific one: he has to keep defending his territory, pushing forward his ideas, proving his viewpoint, claiming for funds, and requesting return information for his own knowledge, with only his experience and his convincing powers to help. This requires a much stronger involvement than in the first model, and one which has only partly to do with scientific work and a lot with personal motivation and diplomatic abilities. There is also a measure of risk in it:

- There is no guarantee that results useful for the progress of research can be obtained (save from an observation of the decision-making process), which may be a problem for a researcher's own career;

- There is always a possibility that the dialogue between the researcher and the decision-maker breaks over some litigious point: it may then prove long and difficult to re-establish contact and rebuild mutual trust;

- The researcher may be blamed both by the decision-maker and by his fellow researchers if the safety programme for which he has done some work finally fails to reduce accidents or raises a political or a public storm.

Under this model, is it not understandable that not too many researchers want to get involved in safety action ? Unfortunately, without a strong willingness of researchers to apply their knowledge for practical use, it is unlikely that decision-makers will call on them for more than tasks of limited scope.

As in the first model, researchers could still train safety professionnals to take over some of the objective safety work. The content of the training should then extend to include communication methods and institutional observation on top of diagnosis and evaluation methodologies. But the professional risks could be the same for the dedicated professional (even more so as they could find themselves out of work in case of a litigation). It may also be doubted that decision-makers would leave professional safety training entirely in the hands of researchers, under the suspiscion that they might generate a group of untamed contradictors...

3.4 A MORE PESSIMISTIC VIEW FOR RESEARCHERS

The model described above may still be too mild when testing it against reality, as two main possible constraints have not yet been explicited:

a) The existence of powerful lobbies that exert pressure on the decision-maker to oppose particular kinds of safety measures. Some, as the transporters' lobby, may be considered as belonging to the public, although they are organised parts of it and therefore much more efficient than any ordinary group of road-users in pushing forward their own opinions and demands. Others, as the car manufacturers' or the public works entrepreneurs' lobbies, are economic actors who work directly through political channels under the threat of closing down jobs. Both types of lobbies are likely to be deaf to any scientific demonstration of the adverse effects of plans they are trying to promote or of the safety gains to expect from a measure they consider as having negative effects on their activities.

b) At least in industrialized countries, the need for long term transport planning, both in urban areas and for inter-urban or international communications, is more and more acknowledged, and may conflict in budget and means with programmes aimed at improving traffic safety in the existing transport system. Traffic safety should really be taken into account at an early stage of the transport planning process in order to avoid creating new accident problems in the future. But even when there is a will at high level to do so, traffic safety only becomes a secondary objective after more important ones related to economics and to mobility. Safety researchers may have even more difficulties getting their say than where specific safety programmes are concerned; moreover, they will have to move from a corrective approach (reducing accidents in the current situation) to a prospective approach (avoiding future accidents when designing the new mobility system), which calls for a wider view and new avenues for research.

To provide some weight against lobbies, what can researchers do? Probably nothing just by themselves. It has been said that the only way to promote traffic safety was to generate a supportive lobby within the public: researchers could help by directly providing the public with adequately framed information on accidents and the best known ways to avoid them (or the worse ways to create them), using media with a larger audience or readership than the usual scientific journals. But are safety researchers always allowed to address the public directly ?

As to the second constraint, the part to be played by traffic safety researchers is more difficult to define as we do not have yet enough examples to work from. Clearly, the researcher should be even more pushing than in the previous model, as he would have both to promote safety policies in the short and medium term and the introduction of safety criteria in transport planning, as well as get prepared for the latter task.

3.5 CONCLUSIONS

On the road safety stage, the part of the researcher is ill-defined, which calls for improvisation and attracts protests whichever approach he chooses: keeping to the theoretical and experimental grounds or trying to apply his experience to real-size problems.

The status of the road-safety researcher is unclear, for decision-makers as well as for the research community itself:

- Do researchers detain the truth because their results are objective and obtained on the basis of sound methodologies? or has the knowledge they build really no bearing on the practical world?

- Should they teach what they know to professionals in the field? or should the professionals be taught only what is actually promoted by the decision-makers in order to keep to the "official" line?

- Should the researchers be provided with better means to promote their findings? should they try and advise at all stages of transport planning? or should they keep to the research community and work in a closed circuit until called upon?

- When called upon, should they answer any demand? or should they first reframe it according to their own experience and knowledge?

- Are the researchers expected to be "militants"? Are they even allowed to be militants? Are they allowed to inform the public directly in order to build up support for safety work?

In the present situation, a lot of the research carried out ends up in a cupboard and is wasted. A lot of the research that should be useful for decision-makers (particularly evaluation research) is not funded. Meanwhile, decision-makers are still seen to launch themselves blindly in some new kind of action without any reasonable assurance that it will reduce accidents or victims, thus wasting scarce resources and spoiling the image of traffic safety work.

The situation varies from country to country, which shows that there is scope from improvement. There is a need for the research community to debate and agree upon the role of traffic safety researchers. There is a need for discussions with the decision-makers to get the status of researchers recognized. There is a need for the researchers themselves to consider traffic safety in the broader framework of transport planning and to gather their knowledge into a usable form.

In order to progress, and long before training safety professionals to sound working methodologies, it is essential that we educate our decision-makers in order to establish better communication and mutual interest...

4. A FRAMEWORK FOR THE PREDICTION OF THE ROAD-SAFETY EFFECTS OF NEW TECHNOLOGY

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ABSTRACT

This paper describes a framework for the prediction of the net safety effects to be obtained by the introduction of safety directed devices in the road traffic system.
The framework comprises four interacting components:

(1) The 'engineering estimate' of a device's expected safety effect.
(2) The use rate of the device.
(3) Behavioral adaptation by the user.
(4) The functions relating user behavior to accident probability and severity.

Definitions of these components are given, and initial assessments are given of what quantitative evidence is available to base reliable predictions on. The paper concludes with an inventory of research activities that should lead to the implementation of the framework.

4.1 INTRODUCTION

This paper describes a framework for the prediction of the net safety effects to be obtained by the introduction of safety-directed devices in the road traffic system. Net effects in this approach are seen as originating from the interaction of four different components, and reliable predictions can follow if reliable quantitative information on each of the components is available.

Expected safety effects of new technology are presently derived from what is probably best described as the combination of more or less quantitative, empirically obtained evidence with expert judgement (e.g., Neumann, 1991). The latter seems particularly predominant when it comes to the assessment of what probably should be considered to be the core element determining net safety effects, which is the reaction of users - in the form of behavioral changes - to the availability of new forms of assistance.

The motivation for introducing the present framework is our conviction that a sufficiently large knowledge base now exists in traffic safety science to begin to fill the different relevant components, including induced behavioral changes, with the required quantitative information. Before actually undertaking to do so, however, the format of the required knowledge needs to be defined, and this is what we will do in the present paper.

4.2 COMPONENTS OF THE FRAMEWORK

There are four critical components which, together with their interrelations, comprise the framework to be developed, and which should be specified. These are:

(1) The so-called 'engineering estimate' of a device's expected safety effect, that is the accident reduction to be achieved if 100% of the relevant population had the device and if that population showed no behavioral adaptation whatsoever to the new situation, i.e., *with* the device.
(2) The degree of penetration, or use rate, of the device in the relevant population.
(3) The behavioral mechanisms underlying a road user's response to changes in his task environment brought about by, e.g., the implementation of safety-directed technology.
(4) The functional relationships linking parameters of (driver) behavior to resultant accident probability and severity.

This paper is not intended to derive the specifications for these components themselves, but rather to sketch the *format* of specifications, that is how they must look like and what kind of knowledge needs to be assembled before they can actually be put together.

4.3 THE ENGINEERING ESTIMATE

The basic notion in making an engineering estimate is that expected safety benefits are given as an extrapolation or an implication of a rather straightforward engineering calculation. By doing so, physical changes to the system are considered without initially addressing possible induced user change. For example, if design changes to some roadside device would be calculated by engineering methods to reduce the probability of a driver death on impact by 10%, then the engineering estimate is that a 10% reduction in driver deaths from collisions with the modified device will occur.

The most common way to obtain an engineering estimate is indeed from accident data. A device that, according to accident statistics, causes x % of deaths is expected to yield a safety return of x % upon its removal. Alternatively, if the absence of a device would lead to y % of all deaths, then the implementation of that device would be expected to reduce deaths by those same y %.

In other cases an engineering estimate can be made on the basis of laboratory results, e.g., for hardware devices tested under crash conditions representative of those occurring in reality. In still other cases the engineering estimate can be no more than the expectation of a beneficial safety effect, or an order of magnitude thereof.

The prediction of safety effects can never be better than the engineering estimate permits. That is, each and every safety measure needs an estimate of its effect *per se* when its implementation is being considered, and against which the effect that is ultimately realized must be evaluated. The ideal therefore is that there be extremely little uncertainty in the engineering estimate. We are aware that this ideal will not be achieved in a long time, so that we will most often have to resort to relatively crude estimates of a measure's effectiveness.

4.4 USE RATES

In order to be able to assess a device's effectiveness we must know which part of the relevant population is affected, i.e., how large the device's degree of penetration, or use rate, is.

For safety-directed measures which for their effectiveness rely on the acceptance of the population there is the complicating and complex issue of selective recruitment, meaning that the use rate *per se* as well as the effect that is achieved are affected by self-selective processes in the population. The hypothesis is that those who opt for some safety device differ from those who do not in respects that are essential to its effectiveness, the particular assumption being that those the least inclined to accept a safety measure would profit the most from it (Evans, 1985). Useful quantitative expressions describing the implications of self-selective processes for driving behavior as well as for resultant accident involvement rates have been derived by Evans (1987a,b).

An important issue, preceding the incorporation of self-selective behavioral effects in quantitative form, is what it is that makes some people opt for a safety measure and some not. This is an aspect that is not captured in Evans' expressions, but that must eventually be considered in order to make quantitative predictions of expected use rates.

4.5 THE AVAILABILITY OF A BEHAVIORAL MODEL

People respond and adapt to changes in their environment. There is no reason why they should not do so after the environment has been changed by safety-directed technology. A sensible behavioral model should incorporate this fact either explicitly or as a consequence of its internal build-up.

What is it that people change in their behavior? There is no need to assume that *risk*, however defined, is the variable directly controlled by people taking part in traffic. Instead, an accepted risk level may be no more than a more or less epiphenomenal by-product of decision making balancing several positive and negative factors (utilities) associated with a trip.

Models that permit the quantitative derivation of risk levels maintained by traffic participants as a result of a more general decision making process, and that can incorporate the effects of safety measures, are rare. Risk homeostasis theory (RHT) as developed by Wilde (e.g., 1982, 1988) is the primordial theory in this respect. However, RHT does not contain the critical quantitative expressions that link the relevant variables. O'Neill's model (1977) is an important step in that direction, since it contains quantitative expressions for the choice of at least one parameter (speed) a driver will select which has straightforward implications for accepted risk levels. Janssen and Tenkink (1988) have followed up O'Neill's work with somewhat more detailed considerations.

We expect that models that consider utility considerations as central can capture the essence of behavioral adaptation, that is, the replacement of one form of behavior by another because there is some extra utility to be gained, the consequence being that the reduction in risk offered is to some degree absorbed into improved mobility.

One implication of these models that should be mentioned here is that they could actually imply that mobility, in terms of VMT, could rise as a consequence of having a device that offers more safety per km driven. Thus, while VMT is usually seen as an independent input factor affecting road safety the position is defendable that it is at least partially the other way round. Other higher-order aspects of behavior that will likely be affected, and that will have to be modeled at some stage if realistic safety effects are to be estimated, are in modal split (changes from one mode of transportation to another) and in route choice, given that one already has decided to reach a certain destination by motor vehicle.

4.6 THE RELATION BETWEEN BEHAVIOR AND SAFETY

One more element remains to be specified within the framework, which is the nature of the functions that link parameters of driver behavior to resultant accident probability and severity.

This relationship is more or less known for driving speed, and for its variability (e.g., Nilsson, 1984; Koornstra, 1990). Quantitative knowledge also exists for car-following headways (e.g., Evans & Wasielewski, 1983), though not in a complete functional form. Considerably less is known in quantitative form about interactions between traffic participants and consequent accident risk.

If there is one thing we need in traffic safety science it is the determination of more of these functions and the validation of those that we already have some knowledge of. Nevertheless, there *is* a quantitative basis of knowledge that covers both the free flow situation (where speed is at the driver's discretion) and the restricted flow condition where almost your only choice is how closely to follow your leading vehicle.

4.7 TOP DOWN AND BOTTOM UP THROUGH THE FRAMEWORK

The framework as it has been presented here is not unidirectional in the sense that a certain piece of technology should be available first, after which its effects can be followed through to the very end by applying the theoretical machinery. It is equally possible to start in the middle and work both ways, i.e., to the beginning as well as to the end. For example, questions can be answered like whether it is more worthwhile to design a device that is assumed to take away the top end of free speed distributions or one that is assumed to reduce very short headways under restricted flow conditions. Answering a question like this requires the entire framework, i.e., the production of an engineering estimate (presumably derived from accident statistics), a prediction of the type and levels of behavioral adaptation that will occur for each separate device, as well as the use of the known functions relating parameters of driving behavior to accident risk.

4.8 DISCUSSION AND RECOMMENDATIONS

In this paper we have identified and described the components of a framework that we will believe are necessary and sufficient in permitting us to predict the net effects of the introduction of safety-directed devices in the road traffic system. We have also indicated initial assessments of the type and the amount of knowledge already available for application within the framework.

It is clear that gaps in knowledge still exist, in particular in trying to get a reliable hold on engineering estimates and on the use rates to be expected. However, it is also clear that there is sufficient knowledge in relevant areas waiting to be applied and integrated in order to replace, refine, or at least complement existing methodology for assessing expected safety effects.

The programmatic effort that would be required to explore the implications of what we have said would comprise the following:

(1) The detailed quantitative specification of the separate elements of the predictive framework and of their interrelations.
(2) The validation of the approach by its application to road-safety measures that were already introduced in the past, i.e., of which empirical results in terms of net safety effects are available.
(3) The application of the approach to available new technology that may have a bearing on road safety, where the input is provided by the developments taking place within the European 'PROMETHEUS' and 'DRIVE' programs, as well as within the American 'IVHS' program.
(4) The 'bottom-up' application of the approach, that is, the identification of what would be the most promising areas for developing technology from a safety point of view, given what knowledge we have about, e.g., behavioral adaptation and behavior-safety relations.

It is our intention to proceed along these lines, presenting results as they become available to the 'PRO-SAFE' Group within the PROMETHEUS program.

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REFERENCES

EVANS L. 1985, Human behavior feedback and traffic safety, Human Factors 27, 555-576

EVANS L.1987a, Belted and unbelted driver accident involvement rates compared, Journal of Safety Research 18, 57-64

EVANS L.1987b, Estimating fatality reductions from increased safety belt use. Risk Analysis 7, 49-57

EVANS L. & WASIELEWSKI P. 1983, Risky driving related to driver and vehicle characteristics. Accident Analysis & Prevention 15, 121-136

JANSSEN W.H. & TENKINK E. 1988, Considerations on speed selection and risk homeostasis in driving. Accident Analysis & Prevention 20, 137-142

KOORNSTRA M.J. 1990, Analyse van veiligheidseffecten van veranderingen in snelheden: een mathematisch-theoretische analyse, Institute of Road Safety Research SWOV, Leidschendam

NEUMANN L.1991, The contributions of PRO-GEN to the Common European Demonstrators. Contribution to Munich Workshop, October 1991

NILSSON G.1984, Speeds, accident rates and personal injury consequences for different road types. Linköping: VTI, Report No. 277

O'NEILL B. 1977, A decision-theory model of danger compensation. Accident Analysis & Prevention 9, 157-165

WILDE G.J.S. 1982, The theory of risk homeostasis: Implications for safety and health. Risk Analysis 2, 109-258

WILDE G.J.S. 1988, Risk homeostasis theory: Propositions, deductions and discussion of recent commentaries. Ergonomics 31, 441-468

5. TRAFFIC CONFLICTS AS INDICATORS OF PEDESTRIAN SAFETY IN A *DRIVE* PROJECT

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5.1 THE PYRAMID OF TRAFFIC EVENTS AND THE ACCIDENT - CONFLICT RELATIONSHIP

Interactions between road users can be described by different elementary events, from undisturbed passage through encounters and conflicts of different seriousness to accidents. The probability and by that the frequency of the different kind of events is different. Simplified the relations it can be presented as the well known pyramid (Hydén, 1987).

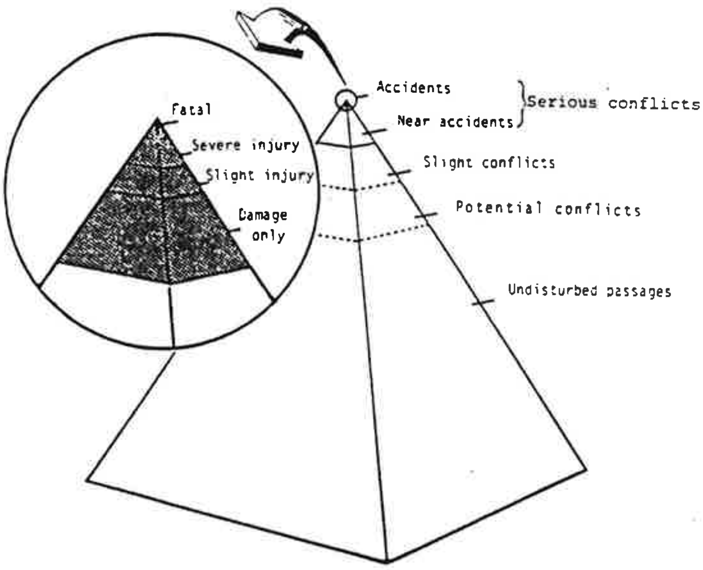


Figure 1. The relation between the different types of elementary events in traffic

Serious traffic conflicts which are the closest to accidents are usually observed in order to define the dangerousness of a place or traffic situation. The most important and the most debated aspect in this respect is how much do traffic conflicts correlate with accidents both as far as the number and type of serious traffic conflicts and accidents are concerned.

While several statistical studies supported arguments for and against the traffic conflict techniques as a tool to predict accidents, the most important theoretical contribution to the topic of the validity of indirect safety measures came from Hauer and Gårder (1986). Defining the safety of an entity (e.g. intersection) they introduce the term "expected number of accidents" occurring on the entity per unit of time. According to them, not the number of future accidents but the expected number of accidents should be predicted by any predictive tool (e.g. by the traffic conflicts techniques). "The number of accidents to occur in the future can no more be predicted than can the roll of a die. The proper question to ask is: how good is the TCT in estimating the expected number of accidents?" They state that a technique is valid if it produces unbiased estimates and if the variance of those estimates is deemed to be "satisfactory". This means that a method should not be classified as simply valid or not valid. It's a matter of degree and what one considers to be a satisfactory variance of the estimate.

The main result of a study carried out at 115 intersections, using 7 years accident data in Sweden (Hydén et al. 1978) was, that at low accident frequencies, up to a couple of accidents a year and intersection, it turned out to be more preferable to use conflicts instead of accidents when estimating the expected number of accidents. Using conflicts proved to give smaller variance than accidents did. The product validity of the traffic conflicts technique seems, therefore, to be satisfactory.

The other indicator of validity, process validity, means to what extent conflicts may be used for defining the process that leads to accidents, i.e. to what extent are conflicts and accidents describing the same process in the pre-crash phase. Hydén's studies (1987) have shown that there is a high degree of similarity between serious conflicts and accidents regarding the type of evasive manoeuvre, the category of road user executing the evasive manoeuvre, speed at the moment when the evasive action started, etc.

5.2 RELATIONSHIP BETWEEN CONFLICTS AND COMMON TRAFFIC BEHAVIOUR

If both product- and process validity of serious traffic conflicts seem to be satisfactory, one can move further down on the pyramid where 'common' traffic events, i.e. conflict-free encounters or common traffic behaviour can be found and ask how much can those elementary events be used as indirect safety measures. The quality of those events is supposed to be in close connection with the safety outcome, i.e. traffic conflicts and accidents. That notion is supported not only by the common sense but also by the results of accident analyses which show that the vast majority of accidents are caused by some mistaken human behaviour.

Human behaviour in traffic, and especially driver behaviour is one of the central topics of traffic safety research, and there exist a lot of theoretical models describing and analyzing the correct and erroneous traffic behaviour. These models are based partly on different psychological theories of human behaviour, motivation, learning, etc., partly on a more empirical base, i.e. traffic accident analysis. Accidents are, however, non-observable events. This is exactly what made indirect safety measures basically necessary.

Traffic conflicts and common traffic behaviour, which are two different levels on the aforementioned pyramid, are both events that are relatively easy to observe and study empirically. There is plenty of literature registering traffic conflicts as well as registering and analyzing different aspects of traffic behaviour (Chaloupka, 1990, Draskóczy, 1990). There is, however, practically no study - at least regarding pedestrians - which would be based on the simultaneous observation of traffic behaviour and conflicts, i.e. traffic behaviour in traffic conflicts and in conflict-free encounters. Traffic conflict studies usually are based on the observation of all kind of conflicts occurring within the area of observation - the majority of which is usually car-car conflicts. Behavioural observations can be carried out from the roadside as well as in-car, using pre-defined lists of variables as well as video-registration and ad hoc variables emerging from the situation observed.

The characteristics of our study are that traffic conflicts and pedestrian behaviour are observed at the same time, and behavioural characteristics of encounters leading to a traffic conflict and that of conflict-free encounters are compared.

5.3 VULNERABLE ROAD USERS WITHIN *DRIVE*

Vulnerable road users are in general quite neglected as far as their traffic safety is concerned. This is even more true for projects like PROMETHEUS and DRIVE which are concerned with advanced technology applied in the road network and within cars. Our present DRIVE project on vulnerable road users (V2005 - Vulnerable Road User Traffic Observation and Optimization - VRU-TOO) is the only project on vulnerable road users in DRIVE II and is a continuation of a DRIVE I project (V1031 - An Intelligent Traffic System for Vulnerable Road Users). Its aim is to enhance the safety and comfort of vulnerable road users (first of all pedestrians) and integrates both pilot project work and further research.

The project consists of three main parts:

* a relatively small scale pilot project carried out in England, Greece and Portugal, by installing intelligent pedestrian crossing facilities in urban environments, using localized signal control to reduce delay and increase safety for pedestrians,

* a behavioural study and formulation of behavioural rules for a pedestrian behavioural model, and

* computer modelling activity which contains an application of the pedestrian model (VULCAN) in Greece and Portugal, and the development of a more behaviourally intelligent version of VULCAN.

5.4 DATA COLLECTION ON PEDESTRIAN BEHAVIOUR PRECEDING CONFLICTS AND CONFLICT-FREE ENCOUNTERS

The behavioural studies are carried out by a team headed by TRC University of Groningen and consisting ITS, University of Leeds, University of Porto and Coimbra in Portugal and us. Its aim is to define and quantify behavioural variables that are related to the safety of pedestrians. Those quantified behaviour-safety relationships will serve as a basis for the safety model and for the development of tools to evaluate the safety effects of the pilot projects.

Conflicts and pedestrian behaviour are observed in urban intersections in Britain, The Netherlands, Portugal and Sweden. Observations are carried out in each country in one signalized and one non-signalized intersection, the characteristics of which are as similar as possible (Euro-intersection). The difficulties of the comparative study started when we defined the so-called Euro-intersections as a crossing of two urban roads, two-way driving direction with one driving lane per direction, with zebra crossing at each leg without refuge, priority of one of the roads regulated by 'give way' signs, major road width 7-11 meters, no parking on the driving lane and no cycle lanes. We expected relatively high vehicle (300-600 vehicles/hour both directions together on the major road) and pedestrian flows and relatively low bicycle flows. It seemed to be the most common type of intersection in every country, but it turned out that it was almost impossible to find it in practice. There were always smaller deviations (one-way road, turning lane, refuge, different kinds of pedestrian crossings, different kinds of traffic lights, etc.) We had to find compromises to fulfil the common demands.

Events which are analyzed by using the same variables are serious traffic conflicts and conflict-free encounters between pedestrians and motorized traffic. Conflicts are defined and observed according the Swedish traffic conflict technique. An encounter between a pedestrian and a motorized vehicle is defined as follows: At least one of the traffic participants obviously adapts his behaviour to the other by changing speed or swerving to give way or to avoid a conflict. According to this definition, a pedestrian can have more than one encounter while crossing the road.

The crossing behaviour is described in three stages:

* approaching phase: starting at a distance of 3 meters away from the point where the pedestrian leaves the kerb and ending at the kerb,
* first half crossing phase: staring at the point where the pedestrian leaves the kerb and ending at the middle of the road,
* second half crossing phase: starting at the middle of the road and ending at the point where the pedestrian reaches the opposite kerb.

For each of these phases the following variables are scored:

Independent variables:

* Course: walking tempo, tempo changes, stopping, waiting

* Visual orientation - head movements

* Safety margins - rejected/accepted

* Traffic variables: type of encounter, speed and type of approaching vehicle, phase of pedestrian traffic light, evasive action of the driver

* Use of the zebra

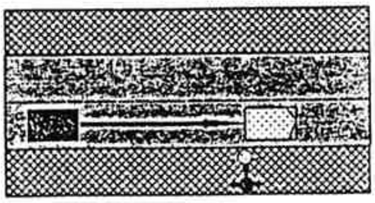
The different types of encounters distinguished can be seen in Figure 2.

Dependent variables

* The main variable is the existence and seriousness of a conflict

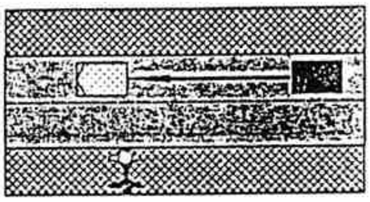
* Additional variables: country, date, day, time of the day, weather conditions, personal variables of the pedestrian (age, sex). social variables (social group size, secondary characteristics of the pedestrian).

Encounter type A:



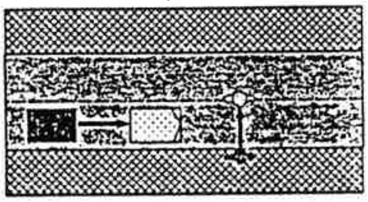
The pedestrian stops or slows down at the curb for a vehicle coming from the left; the vehicle crosses in front of the pedestrian

Encounter type B:



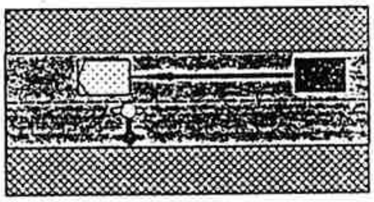
The pedestrian stops or solws down at the curb for a vehicle coming from the right; the vehicle crosses in front of the pedestrian

Encounter type C:



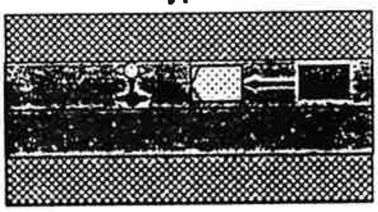
The pedestrian, leaving the curb, crosses in front of a vehicle coming from the left; the vehicle decelerates or swerves around and passes behind the pedestrian

Encounter type D:



The pedestrian, walking on the first half of the road, stops or slows down for a vehicle coming from the right; the vehicle crosses in front of the pedestrian

Encounter type E:



The pedestrian, entering the second half of the road, crosses in front of a vehicle coming from the right; the vehicle decelerates or swerves around and passes behind the pedestrian

Figure 2. Encounter types

Our original plan was to collect 100 conflicts between pedestrians and motorized vehicles at each location and compare them with 100 randomly selected encounters without conflict during the same period and at the same location. The first periods of observation revealed, however, that conflicts between pedestrians and cars are so seldom, especially at signalized intersections, both in Britain, the Netherlands and Sweden that to collect 100 serious car-pedestrian conflicts would take more time than we can afford. It was, therefore, decided that 50 hours of conflict observation and video-recording per location is the necessary and sufficient amount of observation, whatever is the number of serious conflicts during that period. It seems now, that the number of conflicts reaches the originally planned level only in Portugal.

We are at present in the last phase of the data collection period, therefore real conclusions can not yet be drawn from the observations. Some preliminary, more general results can, however, be already drawn:

1. Our research being carried out within DRIVE by an international research team - outside ICTCT - reveals that there is a readiness to move from a strictly accident-based approach of traffic safety toward a wider base, taking different levels of the pyramid of encounters into account and considering serious traffic conflicts as indicators of traffic safety.

2. The Traffic Conflicts Techniques based on human observation on the spot were developed first of all for busy urban intersections. There is, however, a need for such a technique also in situations where traffic conflicts are less frequent - even if still much more frequent than accidents. Such situations can be road sections, or interactions of specific road users, as our case was. Long-range video-recording and image-processing might be a promising direction of development to design a method which is efficient in such situations.

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REFERENCES

CHALOUPKA CH. 1990, How to identify risks by observing human behaviour and interaction, ICTCT, Vienna

DRASKÓCZY M., HYDÉN CH. & RISSER R. 1989, Formulation of safety objectives. DRIVE Project V1040 report. University of Lund, Dept of Traffic Planning and Engineering, Bulletin 85

DRASKÓCZY M. 1990, Traffic conflict and behaviour studies, DRIVE Project V1062 - Multilayered Safety Objectives, University of Lund, Dept of Traffic Planning and Engineering

HAUER E. & GÅRDER P. 1986, Research into the validity of the traffic conflicts technique, Accid. Anal. & Prevention Vol 18, pp 471-481

HIMANEN V. & KULMALA R. 1988, An application of logit models in analyzing the behaviour of pedestrians and car drivers on pedestrian crossings. Accid. Anal. & Prevention Vol 20, pp. 187-197

HYDÉN CH. 1987, The development of a method for traffic safety evaluation: The Swedish Traffic Conflicts Technique. University of Lund, Dept of Traffic Planning and Engineering, Bulletin 70

HYDÉN CH.,GÅRDER P. & LINDERHOLM L. 1978, Samband mellan olycksrisk och olika förklaringsvariabler, University of Lund, Dept of Traffic Planning and Engineering, Bulletin 27 (Relation between accident risks and different explaining variables)

6. THE EFFECTS OF SPEED LIMITERS OF HEAVY VEHICLES - A TRAFFIC SIMULATION STUDY

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6.1 BACKGROUND

The EC Commission proposed in 1990 that heavy vehicles operating in the EC countries should be equipped with speed limiters. The maximum speed for lorries should be 80 km/h. and for buses and coaches 100 km/h. The actual adjustment speed should not exceed this value with more than 5 km/h. In 1991, the ministers of Transport, however, agreed on principle about the speed limiters but decided to increase the maximum speed for lorries to 85 km/h (Finnish EC delegation 1991).

The Finnish Ministry of Transport and Communications wanted to find out the effects of the proposed speed limiters on traffic flow, and especially on travel speeds, traffic safety and the operating costs of traffic. The ministry commissioned VTT to carry out the study. The study was mainly based on the EC Commission's proposal, and the significance of the 1991 modifications had to be evaluated after the actual completion of the study.

In 1990, the total vehicle mileage of Finnish public roads was 28 000 million vehicle kilometres. Of these 7900 were driven on roads with a marked 80 km/h speed limit, 8700 on 100 km/h roads, and 710 on 120 km/h roads (Beilinson et al 1992). In Finland, we have a speed limit of 120 km/h on motorways only. Traffic on roads with lower speed limits will probably not be affected by the speed limiters. The composition of traffic on the roads with a speed limit between 80 and 120 km/h is the following:

Cars	80 %
Lorries	10 %
Buses	2 %
Vans and others	8 %

We realised at once that this study can not be carried out with traditional analytical methods, as the changing the maximum speeds of lorries with a speed limiter cause complicated effects on the behaviour of other vehicles travelling in the same flow too. Thus we decided to carry out the study as a simulation study.

6.2 SIMULATION

The Swedish Road and Traffic Institute VTI has developed a simulation model for two-lane roads in the course of the last twenty years. We have calibrated together with VTI the simulation model in Finnish conditions before, and it has been applied in Finland at a number of occasions with satisfactory results. We thus judged that we could rely on the results of the simulation model to a sufficient degree.

The VTI simulation model need the following input data:

- road geometry
- sight distances to both directions at all points
- speed limits
- free speeds (in order to obtain the target speed for every vehicle)
- composition and volume of traffic

We decided to "build" two roads for the simulation. One was a typical 80 km/h road with a width of 9 m, and two 600 m sight distance maximums. The sight distance was more than 300 m for 60 % of the road length, and more than 460 m for 28 % of the length. The other one was a typical 100 km/h road with a width of 9 m, and one 1000 m sight distance maximum. The sight distance was more than 300 m for 70 % of the road length, and more than 460 m for 54 % of the length.

The free speed distribution for the roads were obtained from the automatic traffic measurement stations of the Finnish National Roads Administration on straight 9 m wide road sections at periods of low traffic volume.

The mean and standard deviation of free speeds were (measurements):

	Speed limit	Mean speed	Standard deviation
Cars and vans	80	87.0	11.0
	100	95.0	11,5
Buses 100 km h	80	85.0	10.9
	100	89.7	6,6
Lorries, no trailer	80	83.0	7,2
& buses	100	84,0	7,7
Lorries, trailer	80	83.0	6,1
	100	84,0	6,5

We assumed that the speeds of only the last two groups are affected by the speed limiters, and only those speeds above the threshold value, which is 85 km/h according to the EC proposal and 90 km/h according to the final agreement. The speeds above the threshold value were changed to follow a normal distribution of expected value of 82,5 km/h (87,5 km/h according to the final agreement) and a standard deviation of 1,0 km/h. The percentage of speeds changed to follow this distribution were:

	Speed limit	% vehicles over threshold value of 85 km/h	90 km/h
Lorries, no trailer	80	53.3 %	26,7 %
& buses	100	58,2 %	32,6 %
Lorries, trailer	80	54,0 %	23,0 %
	100	60,0 %	30,0 %

The traffic flows to be simulated were 0, 450 and 1000 vehicles per hour. The flow of 0 vehicles per hour means simulation of free vehicles only, i.e., vehicles which do not encounter other vehicles and the speeds of which depend on their target speed and road geometry only. The flow of 450 vehicles per hour is a typical workingday flow. 75 % of all mileage on roads with a 80 km/h speed limit is driven at flows below 450 veh./h. The flows of 1000 vehicles per hour are encountered on busy roads during Friday and Sunday evenings.

The flows were chosen on the basis of VTTs earlier experiences, as with this values we can quite well interpolate and in some cases also extrapolate the effects for the whole flow range.

The simulated road sections were 10 km long.

6.3 RESULTS OF THE SIMULATION

The simulation model produces the following output data:

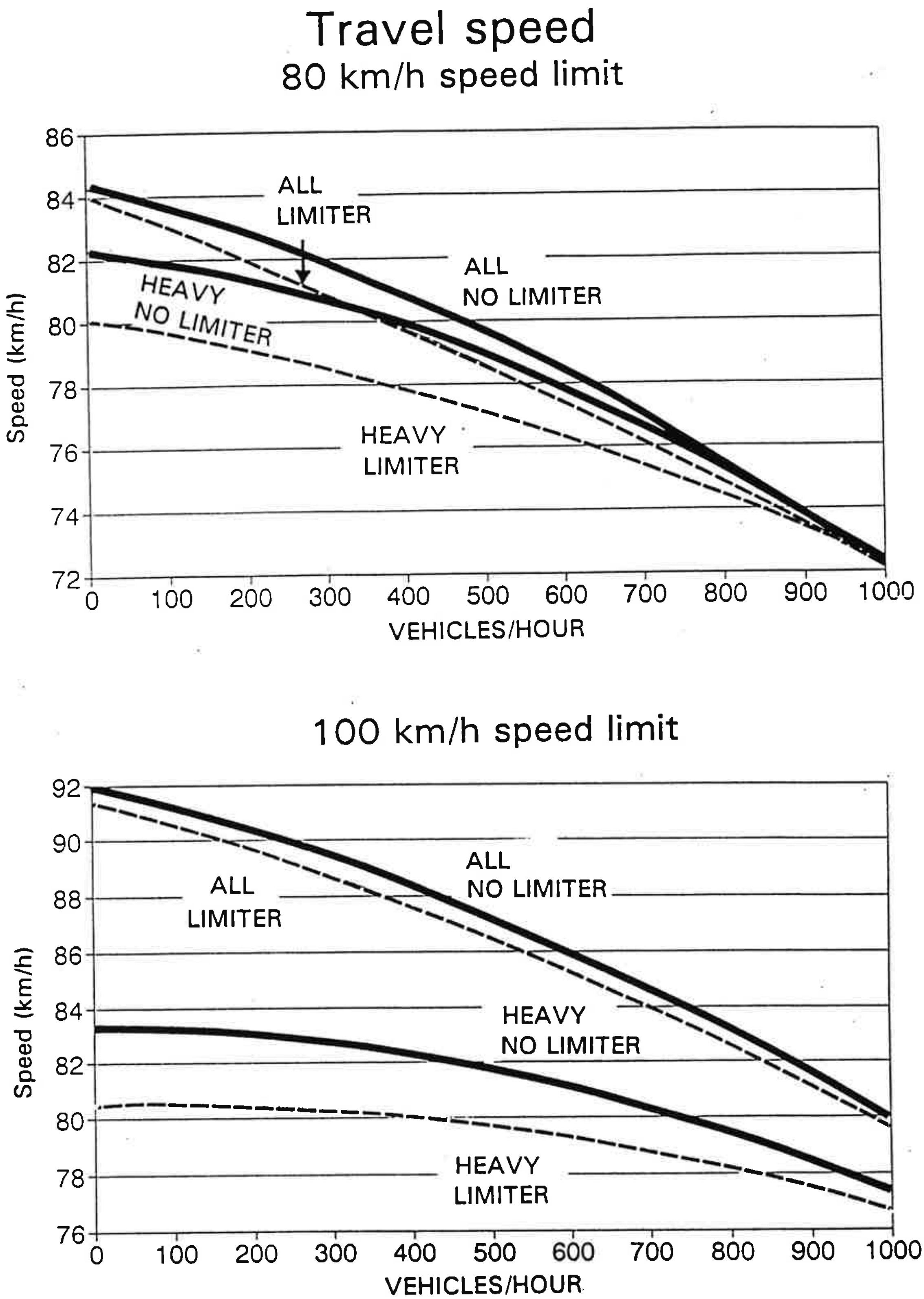
- travel speeds and their distribution
- fuel consumption
- overtakings
- time driven in platoons

The effects of the speed limiter on the average travel speeds are shown in Table1 and Figure 1.

Table 1. The change in average travel speeds (km/h) caused by the speed limiter of heavy vehicles in different flow conditions.

Vehicle type hourly flow	Speed limit on road 80 km/h	100 km/h
Heavy vehicles		
Free flow	- 2.2	- 2.9
450 veh/h	- 1.9	- 2.1
1000 veh/h	0	- 0.7
Cars and vans		
Free flow	0	0
450 veh/h	- 0.9	- 0.5
1000 veh/h	- 0.1	- 0.4
All vehicles		
Free flow	- 0.3	- 0.6
450 veh/h	- 1.0	- 0.7
1000 veh/h	- 0.1	- 0.4

Figure 1. The effects of the speed limiter on the average travel speeds of heavy and all vehicles for different hourly traffic volumes.



The changes are naturally generally larger for heavy vehicles than for cars. The speed decrease of lorries is largest for free vehicles, and very small for flows of 1000 vehicles/hour. At high flows, the traffic density starts to decrease speeds in any case and thus the speed limiters have less effect. For cars and vans, the effects are nonexistent for free vehicles, and quite small for high flows. The largest speed decreases for cars and vans occur at medium flows.

The effects on the standard deviation of speed are shown in Table 2.

Table 2. The change in the standard deviation of travel speeds (km/h) caused by the speed limiter of heavy vehicles in different flow conditions.

Vehicle type hourly flow	Speed limit on road	
	80 km/h	100 km/h
Heavy vehicles		
Free flow	- 1.6	- 2.3
450 veh/h	- 0.8	- 1.7
1000 veh/h	- 0.4	- 0.5
Cars and vans		
Free flow	0	0
450 veh/h	+0.2	- 0.1
1000 veh/h	0	- 0.2
All vehicles		
Free flow	0	+ 0.2
450 veh/h	+0.2	- 0.1
1000 veh/h	- 0.1	- 0.3

The effects are the greatest for free heavy vehicles. Otherwise, the effects on the standard deviation of speeds are quite small.

According to the simulations, the speed limiters would decrease the fuel consumption of heavy vehicles by ca. 4 % on 80 km/h roads, and by 5 % on 100 km/h roads. The limiters would have very little effect on the fuel consumption of cars and vans.

The overtakings would decrease by 3 overtakings/km and hour on 80 km/h roads, and by 0,5 overtakings on 100 km/h roads. The number of overtakings, where a car overtakes a heavy vehicle, would increase while overtakings of any other type would decrease.

Cars and vans would spend 1 - 2 % more of their time in platoons after the implementation of a speed limiter, whereas the heavy vehicles would spend 0 - 2 % less of their travel time in platoons.

6.4 SAFETY EFFECTS

We divided the safety effects into two categories: primary and secondary effects. The primary effects would result from the effects on accidents involving heavy vehicles. The secondary effects are due to the overall changes in traffic flow caused by the speed limiter.

According to Nilsson (1984), the primary effects are approximately proportional to the change in the kinetic energy of the vehicles involved in accidents. The changes in kinetic energy, and thus the effect on the accidents involving heavy vehicles, are shown in Table 3.

Table 3. The change in the kinetic energy of heavy vehicles caused by the speed limiter of heavy vehicles in different flow conditions i.e. the primary safety effect.

Hourly flow	Speed limit on road 80 km/h	100 km/h
Free flow	- 5 %	- 7 %
450 veh/h	- 4 %	- 5 %
1000 veh/h	- 0 %	- 1 %
Average	- 4.5 %	- 6 %

When the effects are converted into annual accident victims, the primary effects would mean an annual saving of 3 dead and 13 injured persons on the Finnish road network.

For the calculation of the secondary effects, we decided to use the general relationships between speed changes and accident changes obtained from the extensive speed limit study carried out by Salusjärvi (1980). The changes in the standard deviation of speed were so small that we estimated the safety effects on the basis of the changes in average travel speeds (Table 1). The resulting safety effects are shown in Table 4.

Table 4. The change in the number of accidents caused by the speed limiter of heavy vehicles in different flow conditions i.e. the secondary safety effect.

Hourly flow	Speed limit on road 80 km/h	100 km/h
Free flow	- 1 %	- 3 %
450 veh/h	- 4 %	- 3 %
1000 veh/h	- 0 %	- 2 %
Average	- 2.5 %	- 3 %

When the secondary effects are converted into annual accident victims, the speed limiters would cause an annual saving of 9 dead and 96 injured persons on the Finnish road network. The secondary effects are thus much larger than the primary effects. In all, the speed limiters would have decreased the annual number of fatalities by 12 persons, and the number of injured by 109 persons, if they had been in all heavy vehicles in 1991.

The speed limiters adjusted to the higher value of 85 + 5 km/h (lorries), would have safety effects that are ca. one third of those above i.e. about 4 dead and 36 injured persons.

6.5 COST EFFECTS

The installation of speed limiters in all heavy vehicles is an extensive investment. This is why we also estimated the monetary benefits due to their implementation. As usually, three different cost categories of vehicle, time, and accident costs were taken into account. The unit cost values generally used in cost-benefit analyses for Finnish road projects were applied in our calculations.

The total cost effects would now be:

Vehicle costs	- 9 million FIM / year
Time costs	+ 137 "
Accident costs	- 109 "
Sum of above	+ 19 million FIM / year

Instead of net benefits, the operating costs of road traffic would increase by 19 million FIM on an annual basis. When we made new estimations based on the final EC agreement of 85 + 5 km/h speed limiters for lorries, the cost effects were:

Vehicle costs	- 3 million FIM / year
Time costs	+ 47 "
Accident costs	- 40 "
Sum of above	+ 4 million FIM / year

It should be noted, however, that the environmental effects are not included in the cost estimations. The speed limiter would decrease exhaust emissions, noise and vibration. If the environmental effects were taken into account, the speed limiters would probably decrease the operating costs of road traffic.

6.6 CONCLUSION

The compulsory speed limiters for heavy vehicles will improve traffic safety by decreasing the number of fatalities and injuries caused by road accidents. In cost terms, the accident savings are offset by the time cost increases due to slightly lowered speeds.

It is quite bold to draw conclusions about the safety effects of the speed limiter on the basis of a few simulations on two "typical" roads. The results are not accurate but they probably give a reliable estimate of the general magnitude and direction of the changes, which the speed limiters will cause in the traffic system.

REFERENCES

BEILINSON L., KULMALA R., MÄKELÄ K. & SALUSJÄRVI M. 1992, Raskaan liikenteen nopeudenrajoittimien vaikutukset, Liikennesimulointitutkimus (Effects of heavy vehicle speed limiters. A traffic simulation study), Technical Research Centre of Finland, Road, Traffic and Geotechnical Laboratory, Research Report 69. 38 p. + app. 5 p.

FINNISH EC DELEGATION 1991, Minutes from the meeting of the EC council of the ministers of Transport 16.-17.12.1991 in Brussels. Unpublished memorandum EEC-1502. 9 p. + app. 4 p.

KARLSSON A. 1991, Simulations on two Finnish road sections for studying the effects of speed limiters for heavy vehicles. Statens väg- och trafikinstitut (VTI). Unpublished

NILSSON G. 1984, Hastigheter, olycksrisker och personskadekonsekvenser i olika vägmiljöer. Linköping. Statens väg- och trafikinstitut, Rapport 277. 21 p.

SALUSJÄRVI M., The speed limit experiments on public roads in Finland. 126 p. + app. 7 p.

7. THE SPEED LIMITER IN THE CAR FOR SAFER TRAFFIC AND BETTER SOCIAL CLIMATE IN THE CITIES

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7.1. INTRODUCTION

In all the countries of the western part of Europe one big traffic-safety problem is created by the fact that car drivers do not comply to the speed limits set by the authorities. This problem seems to be fairly independent of the type of limit itself, and it has to be seen independently from the theoretical discussion about which speed limits are adequate for different circumstances from a traffic safety perspective.

The importance of speed from a safety point of view is accepted by a large part of the researchers in the field. Empirical evidence is showing very clearly that a reduction of speeds (e.g. by a reduction of the speed limit) does produce a very significant drop of accidents, the more severe types the greater is the reduction. There is, however, also indications that a reduction of speeds create a better social climate in general. A study on the effect of car drivers' behaviour versus pedestrians - when speeds were forced down by mini-round abouts at major intersections - showed that there was a significant increase of car drivers that stopped and let pedestrians pass at zebra crossings. Interviews with users also indicated that the 'climate' had been improved (HYDÉN, ODELID & VARHELYI, 1992).

Thus, there seems to be a big consensus regarding the need for countermeasures that can deal with the speed problem in an efficient way. Of course the main target should be speed adaptation, i.e. most important would be to see to it that car drivers actually adapted their speed to the prevailing conditions at every moment. An important first step, however, is to establish an understanding and compliance with the present speed limits. Even though rigid, they still represent societal demands regarding proper speeds in different environments.

Efforts to achieve better compliance with speed limits have so far not been very successful. A lot of methods have been tried: new types of road design, humps and other types of hindrances plus law enforcement were and still are the ones most often used, as well as arguments for better compliance to speed regulations in the frame of traffic safety campaigns. Some of these methods are partly very efficient - e.g. speed humps - but they are only locally efficient, at the same time as they are attributed as being much too expensive to install in all places where they theoretically are needed. Some others of these methods are inefficient, or their efficiency is very difficult to be proved in a short term - e.g. safety campaigns.

At our Department we have tried to look at the problem from another angle: So far, very little has been done regarding "the most natural" thing to do, namely "to control the process" directly at the source, i.e. in the vehicle. We have, therefore, initiated a project about a **speed limiter - SL**. Theoretically, the concept is that every change of existing speed limit is represented by a sender emitting impulses, and each vehicle is equipped with a receiver able to understand these impulses and automatically limiting the vehicle's maximum speed to the speed limit in question

- we call this system for automatic and obligatory, i.e. the system is not possible to manipulate and works all the time.

It must be stressed from the beginning that we, at this stage, are focussing on built-up areas primarily, with speed limits from 30 km/h up to 70 km/h. It is also important at this stage to stress our opinion that the system has to be mandatory, i.e. that eventually it has to be in operation all the time and for everybody: Only a guarantee that a significant majority of car drivers will be complying with speed rules will provide for attitudes towards such a speed reducing measure like the SL that allow a smooth introduction and provide for a real improvement just because of that. Voluntary use would - according to our opinion - not change speed behaviour significantly. Why should it?

7.2 DEMAND FOR EVALUATION OF EFFECTS - GENERAL

The main problem for testing such an automatic and obligatory system can be identified by now already: Such a system does not exist and it will be very difficult - and take some time - to provide for conditions simulating an automatic and obligatory speed limiting system even only in limited areas. Thus, our evaluation task has had to be limited in scope. This does not mean, however, that the task is 'unnecessary' or less important. On the contrary, the less we know about a concept the more important it is to start an evaluation process as early as possible. Evaluation of traffic engineering measures has to a very high extent been lacking in this long-term, 'slow-moving' process of evaluation. It seems as if the more drastic and comprehensive a measure is the less has been done to start a comprehensive evaluation process at an early stage. The introduction of seat-belts in cars is a good example. The only type of evaluation that started at an early stage was crash-tests and biomechanical modelling, etc, in order to find out the reduction of severity of casualties once in a crash. Pre-crash evaluation was not done at an early stage, thus creating a lot of hypothetical discussions at later stages about possible behavioural adaptation processes and similar problems that may reduce the effect of the measure.

Of course the task, even regarding evaluation of seat-belts, is not an easy one. But still, a theoretical preparation, linked with 'as intelligent' empirical studies as possible, had put both researchers and decision makers in a much more attractive position.

There is of course a great safety potential in a concept like the SL. Therefore it is of greatest importance to start an evaluation process as early as ever possible. Decision makers need a sophisticated base for their decisions. Demands to introduce an SL into road traffic will be put into effect only if it is absolutely certain that the advantages, from a safety and environmental viewpoint, will outweigh the disadvantages. So it is important to make an overall appraisal of the extent to which the SL can influence the traffic system, both positively and negatively.

7.3 INITIAL WORK

The Department started a project about an SL in 1986. In phase 1 of the project we carried out a literature study where the basic hypotheses about SL's possible impact on car driver behaviour have been guided by experts' interpretations of existing knowledge regarding car drivers' motives and actions (HYDÉN & ALMQVIST, 1987). More detailed formulations of hypotheses were to be decided on in the following phases of the project. The next phase was formed around Round Table Discussions (RTD), an open form of discussion that can be used to broaden knowledge of a subject not yet discussed widely.

Concerning psychological aspects, the RTDs made clear that the question of acceptance, not explicitly included in the hypotheses named earlier, has to be given priority (see ALMQVIST, HYDÉN & RISSER, 1990). Moreover, it became more and more obvious to us which aspects of technical reliability and functioning smoothness that should be considered thoroughfully: Precision, manoeuvrability, adjustability, comfort, and hamper resistance.

In phase 3 - Self-observation studies - one car was equipped with an SL bought from Germany which met our specifications on technical reliability and functioning smoothness. Of course, it has to be manually turned on, for the time being. Personnel employed at our Department in Lund drove this car. By performing these studies the total list of hypotheses resulting from project phases 1 and 2 were to undergo a first testing, in order to be more well defined, completed, and operationalized.

These initial hypotheses are both concerned with the individual drivers' acceptance of the SL, respectively their reactions to it, and with the effects on an aggregated level (safety, noise, air-pollution). As a main result of phases 1-3 of our research work those hypotheses were verbalized and operationalized more in detail that deal with a situation where only few cars are equipped

7.4 FIELD TEST

7.4.1 Layout

In phase 4, 75 test drivers have been recruited. They have been driving the equipped car, with and without the SL activated, while their behaviour has been recorded simultaneously. The driving period was preceded by interviews to characterize attitudes regarding driving, traffic safety, traffic safety measures, etcetera. The idea was to choose drivers with different attitudes towards traffic safety issues, especially towards the importance of speeds, and measures to reduce speeds. After the test driving new interviews were conducted, focusing on reactions to the SL and changes in driver attitudes.

The observations were carried out by two observers in the vehicle. They used a modified version of the "Wiener Fahrprobe" with one "free observer" sitting on the passenger side in front and one observer sitting in the rear doing systematic observations of behaviour on each part of the test route (RISSER 1985). The "free observer" gave a general characteristic of the driver's driving style. In addition he recorded serious conflicts based on the Swedish conflict technique (HYDÉN 1987).

Additionally, time consumption, speeds, accelerations, and decelerations were recorded automatically with help of a datalog.

7.4.2 Restrictions

Being able to carry out 'real field tests' with 'real drivers' of course increases the possibilities to draw reliable conclusions regarding how an SL-system would work in real life. Still there is a long way to go before the field tests are representative of a situation with an automatic and obligatory SL-system:

* there is only our car equipped to-day, thus the test drivers will meet no other driver that is equipped.

* the test drivers do only have a limited experience with the SL. (They tested the system for 15 minutes before the test started).

* the test rides could not include 'normal' restrictions such as "being in a hurry", "becoming upset because of another driver's behaviour" (two observers were going together with the driver in the car), etc.

In spite of these restrictions a comprehensive evaluation is of course still "worthwhile". The point is that the aims of the study have to be limited. No definite answers on how people will react and behave in a "SL-system" (where every car is equipped and it works automatic and obligatory) can be expected at this stage. But answers to the question "is there a potential that is big enough to motivate further testing in a larger scale?" must be possible to achieve. This limited aim is credible enough and is just an adaptation to the limited possibilities that exist at his stage. But - as said before - this is what should be the normal procedure when developing new systems for safer traffic. Without this stepwise procedure the development has gone too far before any relevant feed-back is given in the developmental process.

7.5 RESULTS - EXAMPLES

7.5.1 Behavioural studies

Below one example from the continuous speed measuring is showed (Figure 1).

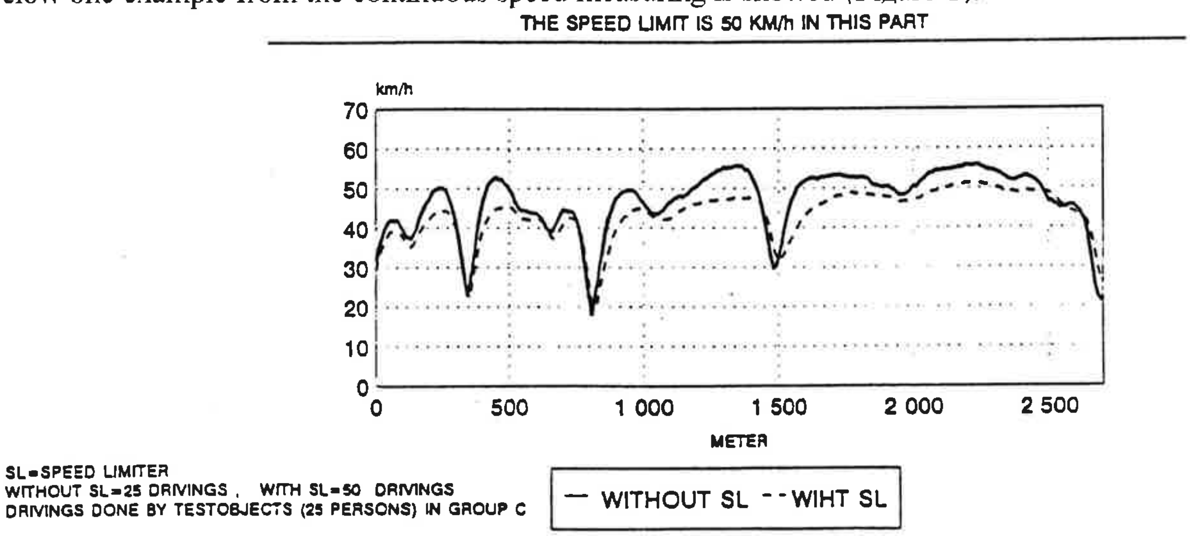

Figure 1: Average speeds on section 1-2

In figure 2 the portion of "improper behaviour" (i.e. driving against green-yellow or red) at traffic signals is shown, as one example from the behavioural studies.

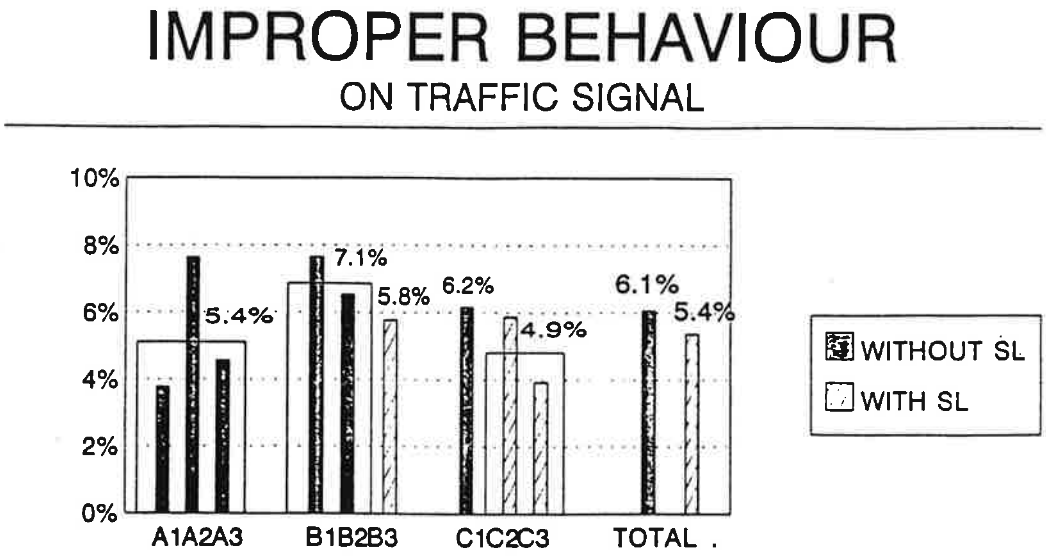

Figure 2: *Portion of incorrect behaviours at traffic signals*

Figure 3 shows the Portion of incorrect behaviours when the drivers were interacting with other drivers (i.e., when drivers were not slowing down or stopping when perceived by the observer as necessary, or the driver does not show his intentions for the other driver in a proper way).

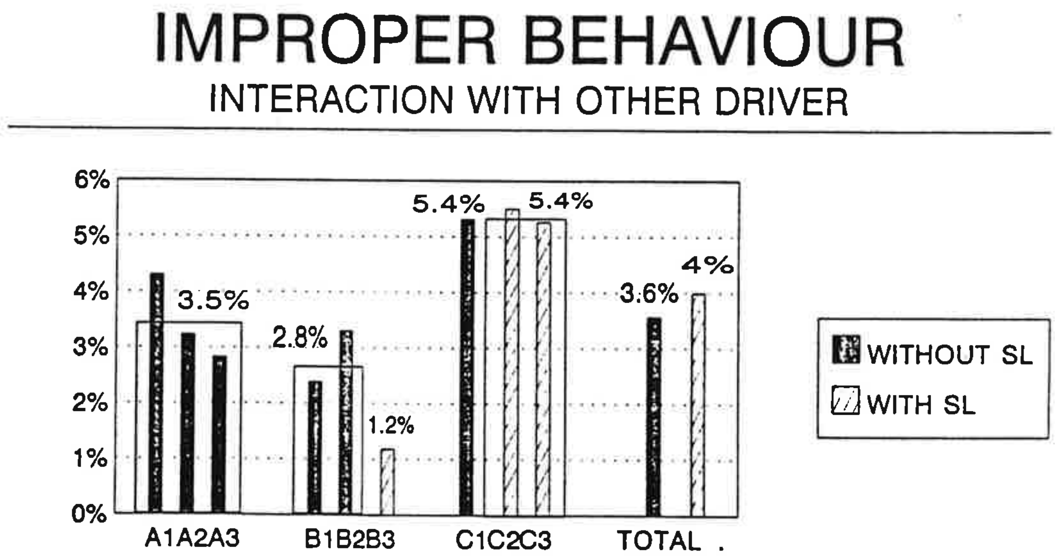

Figure 3: Portion of incorrect interacting behaviour of car drivers versus other drivers

7.5.2 Interviews

Results are presented both in general terms and specifically focused on testing the various hypotheses that are formulated. Below some examples only of the various types of results will be presented, while in the next section the main conclusions from the study will be presented.

Question: How did you like the SL-function?

Value content	Proportion of all answers (%)
Positive/neutral	68
Negative	23
Both positive an negative	9
Total	100

The positive/neutral answers were most often short and general:

- It works well
- It is ok with an SL
- Ok, nothing strange

A fairly common comment was that you got used to it after a while. The negative answers were dealing with unpleasant feelings, hinder, "staggered" driving and a "strange" feeling e.g. when one wanted to accelerate.

Question: How did you appreciate driving with an SL - was it stressing or was it rather relaxing?

Value content	Proportion of all answers (%)
Positive	38
Negative	22
Both positive and negative	21
Neither positive nor negative	19
Total	100

The positive answers were interpreted as expressions of changes when the SL was tested:

- More relaxing
- Relaxing. Not necessary to look at the speedometer.
- Relaxing. Definitely positive.

Negative answers were interpreted as negative changes, most often without explanations:

- Stressing
- Annoying
- Stressing when you cannot influence your speed.

Question: Imagine that all cars were equipped with an SL - and it worked obligatory; how would traffic work regarding car drivers?

Value content	Prop. of all answers (%)	
	Without SL	With SL
Only positive	30	56
Only negative	37	22
Both positive and negative	33	22
Total	100	100

After a test ride with the SL almost twice as many were only positive!

Most of the answers were fairly general, e.g.:

- Very good
- Would be good, increased safety
- Will be negative, degenerating

7.6 SUMMARY OF RESULTS AND CONCLUSIONS

The speed measurements showed expected changes of speeds between intersections, e.g. that speeds were reduced most on roads with the highest before-speeds. Average speeds decreased on average by 4.5 %. Regarding micro behaviour it was found that from a distance of 20 to 50 meters in advance of intersections until entering the intersections, the speeds of vehicles that were turning at the intersections were 1.6 km/h to 3.7 km/h higher of drivers with SL than drivers without. When leaving intersections the acceleration was lower with SL.

Time consumption increased on average by 33 seconds on the whole route (18 km), corresponding to a 2% increase. The emission of NO_x decreased by 5% and CO decreased by 1.4%, while fuel consumption was unchanged.

The in-car observations showed a decrease of the number of incorrect behaviours at traffic signals when driving with the SL and also a decrease of the number of incorrect behaviours regarding distance to vehicles in front.

Incorrect behaviour when interacting with other road users, however, did increase slightly when driving with SL, not statistically significant though. At the same time the number of serious conflicts was significantly lower when driving with SL, 17 without SL and 0 with. The reason for what initially could be seen as a discrepancy between the results of the interactions and the serious conflicts is fitting with our hypotheses about driving in mixed traffic with the SL: Incorrect interaction may occur when the lower speed of the vehicle gives, e.g., a pedestrian the idea that he may start crossing because the driver will let him pass. His own speed may, however, not (initially at least) change the driver's willingness to let the pedestrian pass. At the same time, the lower speed may increase his preparedness, and potential, of avoiding serious conflicts.

The interview results showed that most drivers seemed to adapt very quickly. In more than half of the answers there were no indication of limitations caused by the SL while in 40% of the answers there were remarks about the SL being a 'disturbance'.

Regarding the drivers view on expected effects in an 'SL-system' (where all cars were equipped and the SL worked automatically and obligatory) about one third of the respondents were positive, while the rest were either negative or 'neutral' (giving both positive and negative indications). Interesting, however, was that the share of positive answers were almost twice as high when drivers had tried the SL.

Regarding the hypotheses that were formulated in the earlier phases of the project one can conclude that hypotheses about a future 'SL-system' could only partly be commented based on the results from this study. Some major comments:

* One hypothesis predicts "less stress and annoyance" with SL. The majority of the drivers seemed to agree on this, at least not being influenced by the SL. Some drivers, however, claimed that they would have to plan their travelling more carefully, i.e. allocate more time for the trip. Seven out of 25 drivers in one of the groups claimed this. As the actual time increasement is very small this primarily indicates a dissatisfaction with the risk of having to use more time, even though small.

* Regarding the drivers' view on the effects of an SL-system on the interaction with other road users, one third of the answers regarding interaction with other car drivers was positive only while two thirds of the answers regarding interaction with vulnerable road users were positive only. The answers could be interpreted as if the drivers meant that traffic would be 'less competitive'.

* Regarding "disturbances in the normal driving behaviour" more than half of the drivers thought it was frustrating not being able to accelerate.

To conclude: The studies seemed to give a fairly good view on how drivers would react and behave on an SL. There seemed to be no major changes of behaviour in a negative way, e.g. there were only very small tendencies to some kind of risk compensating behaviour (somewhat higher speeds at the last part of the entry to intersections). The conflict studies did not either support the idea of increased risks. On the contrary, the number of conflicts dropped to zero in our test-rides. Even though small numbers, this was one clear positive indication from a safety point of view.

The study showed that it was very worth-while carrying out a study of this kind, at this early stage. It did sufficiently support the concept as such and produced strong arguments for a larger, long-term study of the SL. This study will produce a perfect basis for that new study, both from a methodological point of view and from the point of view that the results gave clear indications for the design of the new study as it showed what aspects in driving that might create problems from a safety point of view. More focus should be put in studying these aspects in order to make predictions of changes more reliable.

It seems, however, already clear that there is a great safety potential in the concept. It seems also clear that the introduction of SL in a large scale would not produce any major disbenefits or any 'new hazards' of such a magnitude that it would endanger the benefits. This is at least true for urban conditions.

REFERENCES

ALMQVIST S., HYDÉN CH. & RISSER R. 1990. A speed limiter in a car: Phase 2, Hypotheses concerning effects on driver behaviour and interaction

HYDÉN CH., ALMQVIST S., 1987. Förarbestämt förhandsval av fordonets maximihastighet, Litteraturöversikt och problemanalys, Institutionen för Trafikteknik, LTH, Lund, Sweden

HYDÉN CH., ODELID C., VARHELYI A., 1992, Effekten av generell hastighetsdämpning i tätort, Resultat av ett storskaligt försök i Växjö (The effects of general speed reduction in urban areas. The results of a large-scale experiment in the city of Växjö), Institutionen för Trafikteknik, LTH, Lund, Sweden

HYDÉN CH. 1987. The development of a method for traffic safety evaluation: The Swedish Traffic Conflicts Technique. Bulletin 70. Institutionen för Trafikteknik, LTH, Lund, Sweden

RISSER R. 1985. Behaviour in traffic conflict situations. Accident Analysis & Prevention, 17, 2

8. VARYING SPEED LIMITS BASED ON WEATHER CONDITIONS

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When developing speed limits there has been discussion about the inflexibility of the conventional speed limits when the conditions (weather, traffic amount) on the road are changing. The Finnish National Road Administration started 1989 to test varying the speed limits based on the weather conditions especially during the winter time.

The testing place is situated in the south-eastern part of Finland on the motor traffic way that partly runs near the coast. The comparison place is situated on the same road. Because the testing place is situated so near the coast the weather conditions differ from time to time very much from the weather conditions near it. The speed limit is normally 100 km/h. It is decreased to 80 km/h if (one or more) of the following reasons are valid:

1. There is snow, ice or slush on the surface of the road (road is slippery).
2. It is snowing heavily (sight is poor).
3. It is raining hard (danger of aqua planing and poor sight).
4. The damp road surface is unsalted and the surface temperature decreases under 0 degrees Celsius (road is slippery).
5. The damp road surface has been salted and the temperature reaches the estimated freezing point (road is slippery).
6. There is thick fog (sight is poor).
7. The wind speed is over 15 m/s (it is difficult to handle the vehicle).

Varying the speed limit very often has been avoided. The speed limit should stay the same for at least an hour.

The equipment at the testing place is a weather and road surface detector system, a micro computer situated in the maintenance area office and two varying speed limit signs. The signs are based on fibre optics.

The testing of the varying speed limit was started on January the 29th of 1990. During that winter (it was very warm and the connections between the weather detector system and the micro computer were not working properly) there was only one morning when the speeds were measured. It was snowing and the average speed was 84 km/h, which is more than 10 km/h slower than the normal average speed of the road (96 km/h). The fastest speeds decreased most.

The speeds of the comparison place were however about the same as in the testing place although the speed limit was 100 km/h in the comparison place.

During the second winter before decreasing the speed limit the head of the maintenance area office usually checked personally the weather and road surface conditions of the testing place. When snowing the speeds decreased almost the same way in the testing place as in the comparison place. In figure 1 there are the average speeds per hour of the testing place (the upper line) and comparison place 1 (the lower line) for Saturday, February the 23rd 1991. It was snowing heavily. The speeds started to decrease already before the speed limit was decreased to 80 km/h. The speeds also started to increase when the weather became better (before the speed limit was increased to 100 km/h). The average speeds of the comparison place 1 (speed limit 80 km/h) acted the same way as the average speeds of the testing place.

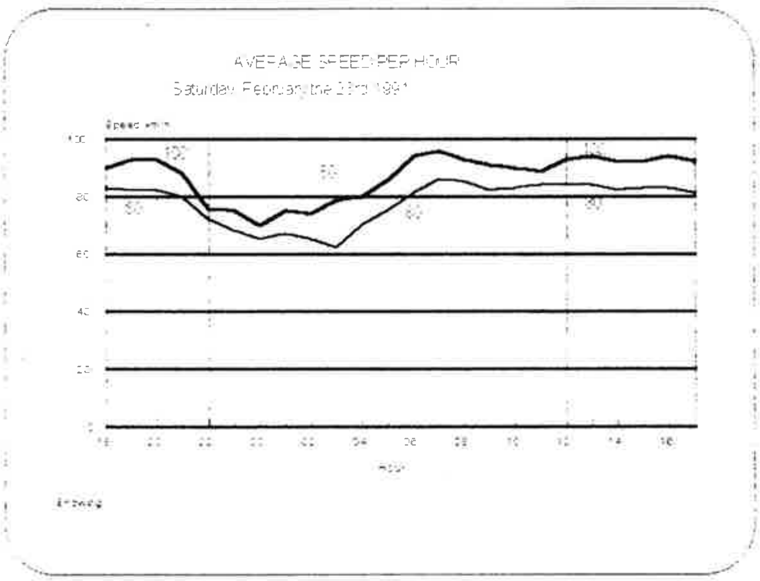

Figure 1. The average speeds per hour of the testing place and the comparison place 1 on Saturday, February the 23rd 1991 when it was snowing.

In figure 2 there are the average speeds per hour of the testing place (thick line) and the comparison place 2 (thin line) on Thursday, January the 3rd. Also then it was snowing. The speed limit of the comparison place 2 was 100 km/h. Again the speeds started to decrease before the speed limit was decreased and the speeds increased again before the increasing of the speed limit. The speeds of the testing place and the comparison place acted the same way. It seems that drivers adjust their speed according to weather conditions not according to speed limit.

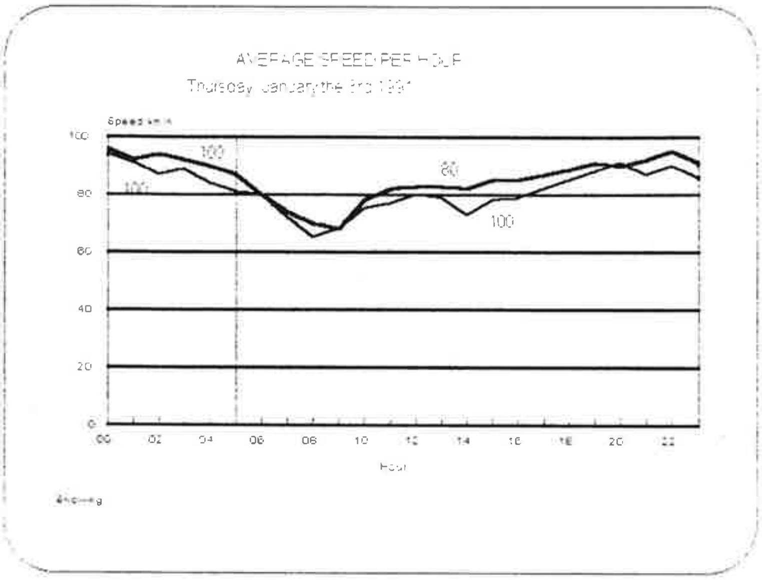

Figure 2. The average speeds per hour of the testing place and the comparison place 2 on Thursday, January the 3rd 1991 when it was snowing.

Because of the weather conditions the average speed could also decrease clearly under the decreased speed limit. for example in fog near 60 km/h. In figure 3 there are the average speeds per hour of testing place (thick line) and comparison place 1 (thin line) for Monday, March the 4th 1991 when it was very foggy. The fog began late in the evening. The average speeds of the testing place decreased clearly before the speed limit was decreased. For one hour the average speed of the testing place was under 60 km/h. Then the speeds increased again long before the speed limit was increased. The average speed of the comparison place 1 acted about the same although the changes were not so big.

When the weather was getting better the effect of the speed limit on the speeds was quite small. The average speed increased already during the 80 km/h speed limit to over 90 km/h. Normally when the speed limit is 100 km/h the average speed is 96 km/h. The effect of the speed limit sign is therefore estimated to about 5 km/h.

During the first summer the varying speed limit signs were damaged by a thunder storm. After that surge protection was added to both signs.

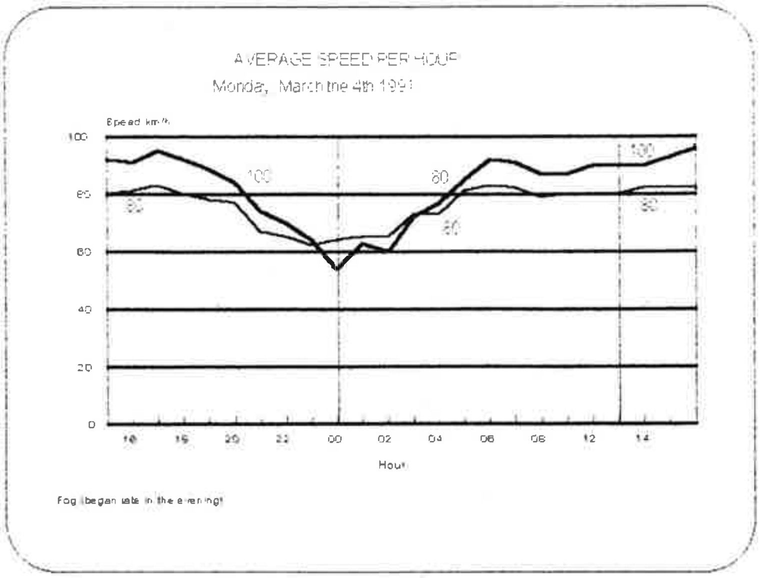

Figure 3. The average speeds per hour of the testing place and the comparison place 1 on Monday, March the 4th 1991 when it was foggy.

The use of varying speed limits during the first two testing winters was less than was planned. The reasons for that were for example warm winters, time that was needed to polish the programs and the faults in the connections. It also takes time to get acquainted with the use of the computer and the programs.

The effect of decreased speed limits was quite small. Because the sign that was used didn't look like the conventional speed limit sign it probably wasn't always understood as a limit. Therefore more information about varying speed limit signs should be available. When the weather was very bad the speeds decreased naturally significantly under the decreased speed limit.

The use of an automatic system can be considered. Then the weather and road surface detector system would give the decrease command directly to the signs. For full automation fog detectors must be added to the system.

The building of a varying speed limit system is expensive compared with the gained benefits. The expansion of the system that is directed only by the weather doesn't seem to be advisable. Later when traffic volume and speed data from the automatic traffic stations can also be used in the adjustment of the speed limit, the varying speed limits can be a sensible solution on the main roads where there are traffic jams.

The weather data could be informed directly to the road users by very simple means. That solution would be cheaper and could easily be expanded for all weather and road surface detector systems.

9. TEST SITE WEST SWEDEN - *ARENA*

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9.1 INTRODUCTION

The Swedish RTI-program, for the time period 1991-94, has a strong direction towards developing and field tests of the RTI-functions/systems included in the program.

The test site named ARENA, with SNRA (Swedish National Road Administration) as leading institution form the base for the program and the field trials. The intention is that the test site should work as an open laboratory for experimenting and evaluation of different RTI-functions and their integration.

The organization of the Swedish RTI-program is running with a program board at the top level consisting of the main sponsors:
- NUTEK; the Swedish National Board for Industrial and Technical Development,
- TFB; the Swedish Transport Reasearch Board,
- SNRA: Swedish National Road Administration
- Televerket; Swedish Telecom
- SAAB
- VOLVO

The aim of the Swedish RTI-program is:

- to demonstrate how the road infrastructure could be improved by use of RTI, and show the benefits for transport economy, road safety and environment.

- to give Swedish actors the opportunities to be in front when implementing of RTI-technolgy is prepared,

- to stimulate product development in minor companies in electronic and supplier industry,

- to cooperate with international partners for wider knowledge, larger markets and shared costs.

The structure of the Swedish RTI-program with the differnt areas of interest is illustrated by the following figure:

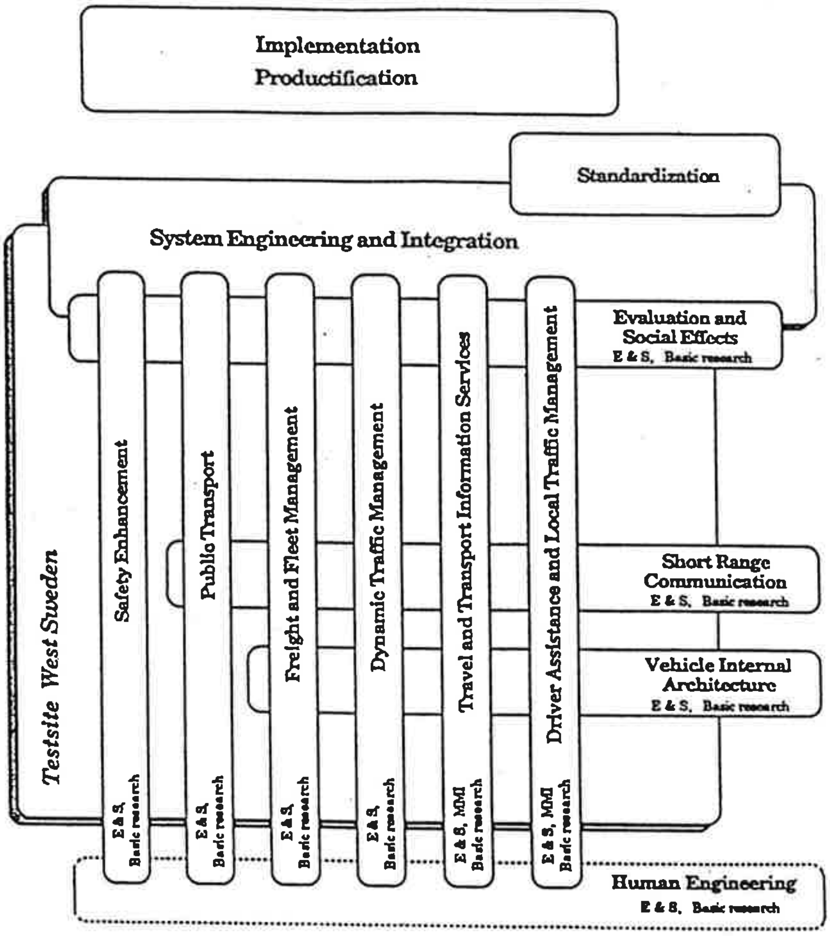

Figure 1: Structure of the Swedish RTI-program 1991-94.

9.2 *ARENA* - TEST SITE WEST SWEDEN

ARENA - Test site West Sweden, is created by the SNRA in the region of Gothenburg. It is a platform for developing and field trials of RTI-functions by cooperation between authorities, industry and other organizations.

The activities are divided in five areas: traffic management, route guidance, traffic safety, production support and economic evaluation.

9.2.1 Aspen Track

Referring to tube DALTM in figure 1, Driver Assitance and Local Traffic Management, in the RTI-program, I am going to present the project "Aspen Track" concerning transmission of road side information to the vehicle.

The partners in this particular project are the City council of Gothenburg, SNRA, Catella Generics, Saab, Volvo and Department of Traffic Planning and Engineering at Lund Institute of Technology, University of Lund.

The aim of this project is to improve the road safety by warning systems in the car in critical situations. To develop, test and evaluate different systems for information of the driver about hazarduos situations.

Along a apprx. 33 km long route in the neighbourhood east of Gothenburg transponders were installed.

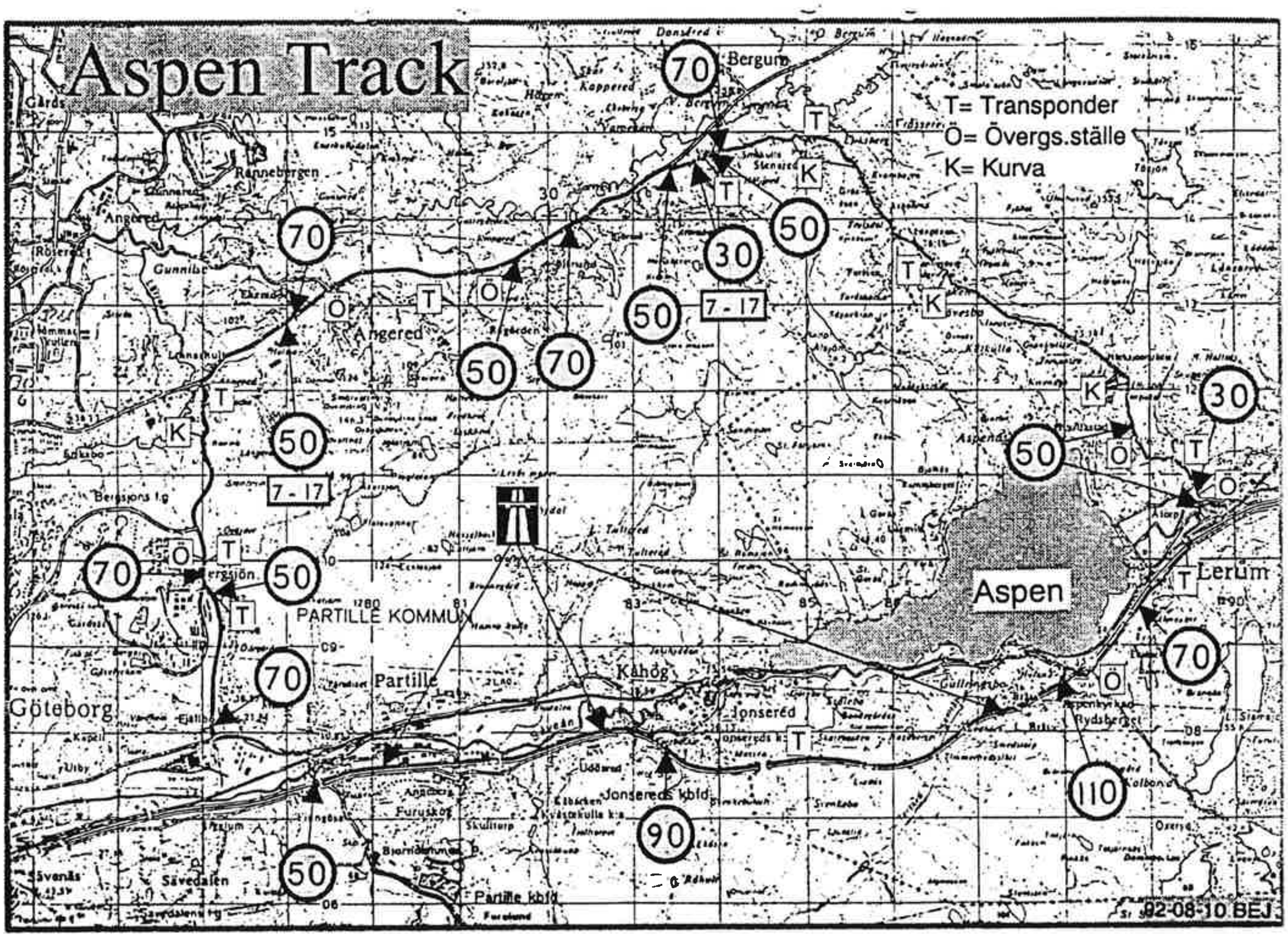

Figure 2: The test route "Aspen Track" with signs and transponder locations.

Via microwaves, using the Compose-system with the frequency 17 GHz, road side information are transmitted to corresponding transponder receivers on the vehicle.

The transmitted information consists of the following:

* Actual speed limits,
* Warnings of pedestrian crossings, and speed recommendation for the particular sites,
* Warnings of dangerous curves, and dito speed recommendation,
* Warning of road work ("Road UP! Men at Work!").

The information to the driver was presented graphically on a display at the dashboard.

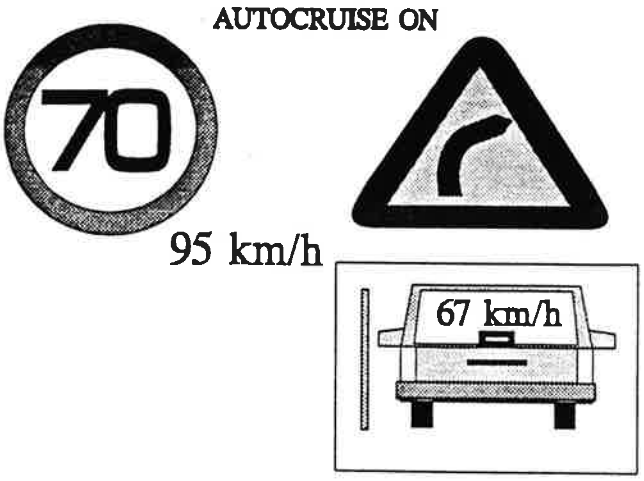

Figure 3: The display design in the Volvo test car.

9.2.2 Procedure

16 persons with different sex and ages, were hired for participation as test drivers in the project. Two equipped cars were used, one Saab and one Volvo. The equipment was the same as the AICC, (Autonomous Intelligent Cruise Control), developed within the Prometheus work (CED 5).

The test drivers started with a ride along the test route with an unequipped car in order to show their "normal driving behaviour". Every ride took about 40 minutes.

The test rides with equipment were carried out a month later. Every test person had to do two test rides. During the first one - called the "informative" - the information signs or messages are visualized for the driver, but the driver can choose if he wants to follow the information or not. The second test-mode was the "assisting or intervening" one. In this case the speed was automatically reduced by the ICC-function to the recommended level at each site as it was decided in advance: either the legal speed limit or a lower one, depending of the situation (e.g. sharp curve, a cross walk, etcetera). At the same time the speed was constantly kept at the legal speed limit on other parts of the route.

The examination methods consist of:

* **Speed logging**, continously carried out for all test rides.

A datalogg was installed in the test cars for registration of time and distance. From the collected data it is possible to calculate speed, accelerations, retardations and stops.

* **Standardized behavioural observations**

A record form was prepared in advance for the observations concerning:

- speed behaviour related to the legal speed limit and for specific situations,
- distance keeping to to vehicle ahead,
- side distance when passing bicyclists or other turnovers
- errors concerning late speed adaption, braking, lane changes, yield obligation, traffic light obedience, use of direction indicators, miscellaneous....
- interactions/conflicts with other road users.

* **Interviews after every test ride**

The interviews aimed to find out the test drivers expectations about the RTI-equipment before they were introduced. Later on after practice and limited experience of the RTI-function the test drivers answering questions about their opinions and experiences of the additional RTI-functions.

* **Work load test** (initiated and analyzed by VTI, Road Research Institute).

9.3 RESULTS

There are still preliminary results available.

9.3.1 Speed logging

From the reference rides, violations against the legal speed limits are frequent at most of the parts along the route.
By using transmitted road side information the speed adaptation can be improved. It is essential to stress that in the informative mode the speed information only is interpreted as a guidance. When using the intervening mode there do not exist any violations to the speed limits, but the speed adaptation at some locations was not acceptable. This was because of the ICC-function that "force" the driver to drive with legal maximum speed as long as possible. Particulary in urban areas or before sharp bends this can be very unsafe.

9.3.2 Behavioural observations

The behavioural observations show results in the same direction.
Behaviour at locations with low intensity of external distraction, like the ride on the motorway and on the rural roads with good standard, results in very few remarks. Only some critical

rear-end situations when the test vehicle is approaching with the choosed speed and the driver is adjusting the speed to late have been registered.

Critical remarks became more frequent at parts of the route in urban areas, were unprotected road users and interactions with other road users have to be considered.
Even at those locations with diffuclt curves critical remarks because of late adjustment of the speed are frequent.

9.3.3 Interviews

The expectation for assisting functions like the one we have used in this project is very high among the test drivers.

The informative mode, which only gives information and recommandations, was accepted as a help for reminding of what rules, in particular: speed limit, were to be respected.
By using the intervening mode with assistance of the ICC-function the test drivers were less free to influence the speed choice. Nevertheless they were very understanding for this new type of driving task. Only one of the test persons (1/15) took a direct negative attitude towards the function. The rest of the group accepted this way of assistance more or less. Arguments often used were calmness, simplicity,legality.
A lot of other useful comments came out from the interviews, in particular that drivers felt comfortable with the assistance in certain situations like at unknown roads where the conditions are unfamiliar, but they also felt unsatisfied with the speed keeping function in certain other situations like towards sharp bends and in urban areas.

9.4 CONCLUSION

The preliminary conclusions are based on the fact that three different methods of evaluation, speed logging, behavioural observations and interviews, point in the same direction.
However, it should be stressed that the project has been carried out with very limited resources. Only a small and very homogenous test group could be studied, new unfamiliar functions with unknown reliability were tested and the tests were carried out in a very limited time.

These were our main conclusions under the prevailing conditions:

* It is possible to influence the speed adaption by using this kind of RTI-equipment which transmitts road side information to the vehicle.

* If the speed adaption can be improved at some critical locations like in urban areas the general road safety could be improved, as well.

* Our test results indicate various "effects" depending of road- standard or/and type.

* A high degree of acceptance of the new RTI-function was registered within the test group.

* Some minor but important changes of the function design will probably improve the possibilities to influence the traffic safety effects.

REFERENCES

ALMQVIST S. TOWLIAT M. 1993, Aspen Track, Estimation of traffic safety benefits by using transmitted road side information to the vehicle. Lund

VÄGVERKET 1992, ARENA - Test site West Sweden, Göteborg

TFB 1992, Informationsteknologi i vägtrafiken, Nr 15, Stockholm

10. EVALUATION OF DRIVER WORKLOAD DURING A SIMULATED AND AN ACTUAL DRIVING TASK

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10.1. INTRODUCTION

It is relatively easy to quantify driver-vehicle performance. It is possible, for example, to measure speed, acceleration, course deviations, control movements. This is made even easier when dealing with a driving simulator. On the other hand, however, little is known of the driver himself, of the difficulties he undergoes, fatigue, the risk he perceives etc.

Very early, interest was focused on the physiological measurements which could differentiate driver status: alertness, muscular tone, cardiac or respiratory rhythm, or even electro-dermal skin resistance. These measurements are, however, difficult to interpret as they can be affected by a large number of factors which can seldom be controlled.

Since the early 50s, work has been directed towards the measuring of "mental effort", also known as the mental load or workload. Seemingly simple, this is in fact an extremely complex concept, which differs from "attention" and on which no agreement has yet been reached. There is no place here to discuss the concept of load, which has been done in the reports this paper refers to.

This research is aimed at developing a method that could be used on a driving simulator or in an instrumented vehicle as well, and that would permit to measure any performance impairment or driver's workload increase. Such a method would be particularly valuable to monitor driving aids effects.

10.2 PRIMARY MEASURES

They are used to describe driver-vehicle performance, without imposing any specific restrictions on the subject.

The following are currently used :

- speed
- longitudinal and transversal acceleration
- yaw, yaw speed,
- position in relation to the side of the road (or the central white line)
- "time-to-line crossing" (TLC), which is the time a vehicle would take to leave the roadway if the actual controls (steering wheel angle, speed) were maintained in the same position. This concept has been developed by Godthelp, Milgram and Blaauw (1984) at the TNO
- steering wheel angle, steering-wheel rotation speed.

In general, however, use is made of other cues calculated using raw data. Literature contains essentially:

- Steering Reversal Rate or SRR (McLean and Hoffmann, 1975), which is the number of times per time unit when the rotation direction of the wheel is inverted, taking into account a range of several degrees to eliminate micro-oscillations.

- Spectral analyses of wheel angle, which are more complicated to carry out but which provide more detailed information, i.e. the movement variance distribution according to frequency (McLean and Hoffmann, 1971). These analyses use Fourier transforms, breaking down a phenomenon into a sine-cosine superposition.

In 1979, Hicks and Wierwille published results obtained on a simulator showing that from 5 measures (including 1 secondary task and 1 physiological measure), the SRR was most sensitive to load, which in this instance was a moderate or strong side wind. McLean and Hoffmann, (1971) analysed frequency spectrums and showed that there are usually two peaks, one at approximately 0.10-0.30 Hz, and the other at about 0.35-0.60 Hz. Referring to Weir and McRuer, (1968), they assumed that this corresponded to two control modes, one based on course or yaw (the highest frequency), the other on lateral placement error (shift in relation to the side of the road). There is also an excellent link between the high frequency energy spectrum and the SRR, which justified the use of the latter when seeking a cue which is relatively simple to calculate.

Nevertheless, McLean and Hoffmann (1975) showed that wheel activity was more likely to reflect the task difficulty and the demands for accuracy that the subjects had set themselves, than an absolute performance level. In fact, depending on the experimental conditions, an increase in load can either increase wheel activity (the subject wishes to maintain the same tracking accuracy), or lower it (the subject is satisfied with a less accurate adjustment to meet other demands).

Care should therefore be taken when handling these cues. They should be used in well-controlled experimental conditions and in relation to other performance and load indicators.

10.3. PHYSIOLOGICAL MEASURES

The most widely used measurements are probably pulse rate and sinus arrhythmia. Reference can be made to Meshkati (1988) who reviews the extensive work, sometimes contradictory, which exists in this field. One of the problems raised by pulse rate is that it may produce a great many indicators. The main indicators are:

- the average frequency (HR), expressed as an average number of pulsations per minute, or more often as an average of the intervals between beats (IBI),
- variability (HRV) or sinus arrhythmia. Egelund (1982), referring to Opmeer (1973), indicates that there are at least 26 ways of calculating this. Those most often used are either the average difference between two successive beats, or the standard deviation of the period between beats,
- spectral analyses of the cardiac signal.

The mean frequency is sensitive to fatigue, but also to occasional events which may not be task-related. It is generally considered that this is not a good indicator, although some surveys, performed in stable environments and involving little physical effort, have been able to show positive results (Wierwille and Connor, 1983).

Several authors have shown that the variability in cardiac rhythm decreases as the load increases (Blitz et al., 1970; Boyce, 1974). But results are contradictory depending on the experimental conditions and the methods used to calculate variability.

It would seem that the best results are obtained by performing a spectral analysis of the inter-beat time interval. According to Sayers (1973), and Egelund (1982), cardiac frequency would indeed seems to be connected to three mechanisms:

- respiratory rhythm,
- blood pressure,
- thermal regulation.

This recurs in the spectral analyses, as blood pressure is linked to the cardiac frequency component located between 0.05 and 0.15 Hz. It is this component which would appear to be linked to the workload (Hyndman and Gregory, 1975, Egelund, 1982, Cohen-Shmuelly et al., 1990). The drop in the energy spectrum in this region appears to be a heavy load indicator.

10.4. SECONDARY MEASURES

The qualities sought in the secondary task are as follows:

- There should be no structural interference with the primary task.

For example, the same sensorial procedure should not be called upon to perform two different things simultaneously (looking in two opposite directions at the same time, performing two manual tasks..).

- If reference is made to the multiple resource model, the secondary task must compete for the use of resources shared with the primary task.

If not, processings could be performed in parallel and the measurement would not be as sensitive. If reference is made to the single channel mode, the choice of task is less important as all the processings are said to be sequential.

- The difficulty of the secondary task must be adapted to that of the primary task, so that the maximum score cannot be obtained simultaneously for both tasks.

Indeed, should there be a residual capacity this could be used, as the subject desires to compensate should the primary task become more difficult, without this resulting in changes in secondary task performance.

- Finally, the measure should be as sensitive and as accurate as possible, whilst remaining non-intrusive.

We can find a lot of secondary tasks in the literature, even if we consider only those which have been used concurrently with a driving or a flying task. On the road, tapping tasks have been extensively used (Michon, 1966, Michaut, 1968, Neboit & Laya 1982...).

On simulators, batteries of secondary tasks are often applied successively in the same conditions, in order to study their relationship with difficulty, and their co-variance with performance measurements. Wierwille and Connor (1983), Casali and Wierwille (1983, 1984), Wierwille, Rahami and Casali (1985) continue to use these methods. The advantage of these studies is that they are systematic (up to 20 load measures studied in the same context).

Wierwille et al (1977), Wierwille and Gutmann (1978), Hicks and Wierwille (1979), have shown that the primary measures and subjective scales provide a clear differentiation between the levels of difficulty which occur when driving (a moderate or strong side wind), whereas the secondary tasks and physiological measures do not show any significant difference. It should however be noted that this result is hardly surprising. Disturbances which affect trajectory control are bound to lead to changes in movement and position, but will make little demand on cognitive resources, which are reflected in many of the secondary measures used.

It could be assumed that the results would be reversed should the type of difficulties introduced arise from traffic, manoeuvres to be performed or navigational problems to be solved. We also find some validation studies, which aim at comparing real and simulation situations. The load is then one of the comparison criteria and is often measured using subjective scales. Blaauw (1982) for example, perceived that both beginners and experienced drivers thought driving was more difficult on a fixed-base simulator than on a track (which is to be expected if the task is more difficult).

This type of research is currently being carried out at the TNO (Harms, 1991). Riemersma et al. (1990) used the Daimler-Benz simulator. They compared decreases in speed obtained in real situations after modifying approaches to built-up areas with those obtained on a simulator. They found that the modifications really did produce the expected decreases in speed, but that speed levels were slightly higher on the simulator than they were in a real situation.

The research work presented below consists of two parts:

- a simulator study, in which different measurements were made in controlled conditions, in order to detect the best indicators adapted to our goals,
- a field experiment, (or more exactly the pre-test of it), in order to validate the method.

10.5. CHOOSING A SECONDARY TASK (SIMULATOR STUDY)

10.5.1 Principle and method

This experiment consisted in putting drivers at the wheel of a rustic simulator, and recording the various dependent variables simultaneously (primary and physiological measures) or successively (secondary tasks). The simulated route, lasting approximately 10 minutes, contained varying levels of difficulty, linked to specifications such as visibility distance (simulation of fog), alignment. The route was covered as many times as there were secondary

tasks, and more than once without any secondary task so as to determine the effects of intrusion.
The aim was to determine which measures best reflected the variations in difficulty of the driving task presented to the subjects. The methodology used was fairly similar to that used by Wierwille and Gutmann in 1978.

10.5.2. Apparatus

It consisted of a vehicle mock-up, the controls of which being connected to a numeric image generator, namely the INRETS GSI, based on a Silicon Graphics station. The image frequency was about 15 Hz, and there was no movement restitution.

10.5.3. Subjects

16 subjects were selected, for the most part members of the INRETS staff, and with varying degrees of experience. For this first experiment, little importance was given to the individual characteristics of the subjects, insomuch as no assumption was made as to the part played by variables such as sex or experience on the mental load.

10.5.4. Circuit

The circuit covered 9800 meters, consisting of 14 sections, straight or winding, of varying widths (300, 500 and 700 meters), and with different visibility distances. To achieve this fog of varying density was simulated. It should be noted that this fog was simulated only very sketchily, and was indicated only by a change of colour and contrasts and that the mantle effect produced by fog did not increase in relation to depth. The effect, even if not realistic, nonetheless considerably impeded the driver. It was assumed that this impediment would be in proportion to the thickness of the simulated fog.

Note that to compensate for possible sequence effects, the sections were not put together in the same order for all the subjects.

10.5.5. Physiological measures

Cardiac beats were recorded using portable equipment designed for sportsmen. This was a Baumann BHL 5000 cardiac rhythm recorder, which recorded the time intervals between successive beats in milliseconds. It consisted of a belt fitted with three electrodes to be placed directly on the chest, and a recording unit the size of a cigarette packet connected by a wire to the belt. At the end of each sequence, the data were then transferred from the unit to a PC, using software provided with the device.

It was then easily possible to calculate cardiac frequency, and the variability cues (standard-deviation or average deviation between successive beats). We expect to perform more complex processing, such as spectral analyses of the cardiac signal, at a later date.

10.5.6. Primary measures

Using this generator it was easy to record the following parameters:

- speed (S)
- Steering-wheel angle (SA)
- yaw angle (YA)
- distance in relation to the median line (MLD)

Another indicator was calculated in real time:

- Time to Line Crossing (TLC), calculated in real time, which is at each moment, the time the vehicle would take to leave the road if the driver maintained the same status for the various controls. It is therefore the available time margin during which it is possible not to react. The data were stored on Unix files managed by one of the INRETS network hosts.

- The Steering-wheel reversal rate (SRR) was calculated a posteriori.

10.5.7. Secondary measures

- Reaction time

This is the simple reaction time to an audible signal. The signal and the response were given verbally, using a headset fitted with a microphone, the entire unit being linked to a portable PC 386, sequenced at 33 MHz. The audible signal lasted for approximately 0.5 seconds and the random interval between the two signals varied between 1.9 and 3.1 seconds

- Offset discrimination and high and low sounds (OBA).

Using the same equipment, high (1400 Hz), or low (440 Hz) sounds were presented to the subject in a random order at a rate of one signal every 2.5 seconds. The interval between the two sounds was therefore approximately 10 tones. The subject was asked to respond by offsetting his response i.e. he was asked to indicate if the signal before last was high or low. For example, for the following sequence the subject should have answered:

signal	high	low	low	low	high	low	high	high	
response		high	low	low	low	high	low	high	high

Verbal responses were recorded on the PC through a digitising card. This task called upon short term memory.

- Reading numbers on a screen (shadowing)

A 14" monochrome screen was placed at eye level but to the right of the control panel. The 2 figure random numbers appeared, one number every 1.5 seconds. Each figure was 3 cm high and 1.5 wide. The place on which they appeared on the screen was also random. As the subject had to turn his eyes away from the road to read these figures, this was probably more a load or visual availability measure than an actual mental load measure. Note that it was initially planned to use a tapping task (producing regular intervals), but technical difficulties linked to recording responses forced us to abandon this task. The following were then calculated:

- average and standard deviation for reaction times (more the 3 tasks).
- error or omission % (for the OBA).
- % of figures read (for reading on screen).

10.6. PROCEDURE AND INSTRUCTIONS

Each subject was first fitted with a cardiac beat recorder. He was then installed at the wheel of the simulator. He then drove for a minimum of 15 minutes to familiarise himself with the circuit, as because of a considerable "transport delay" course control required an adaptation time. He then performed the 4 circuits at his own speed.

For the first (cardiac recording only) he was simply asked to drive normally, remaining if possible in the centre of his lane.

Each of the three other circuits started by familiarising him with the secondary task, performed first when the vehicle was stationary, then when maximum performance was acquired with a moving vehicle. When the subject was ready, he was instructed to perform the secondary tasks as well as he can, but without impairing the driving task. The order of passage of the different circuits was counterbalanced to avoid sequence effects. There was a pause between the circuits. The same procedure was then replicated with speed monitored by the system at 90 km/h.

10.6.1. Independent variables

- There were three thicknesses of fog, which produce 4 levels of visibility, the first level being the no-fog reference (visi1 to visi4).
- two alignment conditions (straight and winding).
- four successive circuits, i.e. 1 per secondary task procedure (cardio, reaction, OBA, screen).
- two speed procedures (unrestricted and imposed).

10.6.2. Dependent variables

- primary measures (S, MLD, SRR, TLC, SA, YA),
- physiological measures (intervals between successive cardiac beats),
- secondary measures (performance in the three secondary tasks, calculated in 3 different ways: mean reaction time, standard deviation, % of errors).

10.7. RESULTS

10.7.1. Effect of experimental factors on performance

A two-fold assumption was made:

- that difficulty increased as visibility decreased.
- that the difficulty would be greater on bends than on straight stretches.

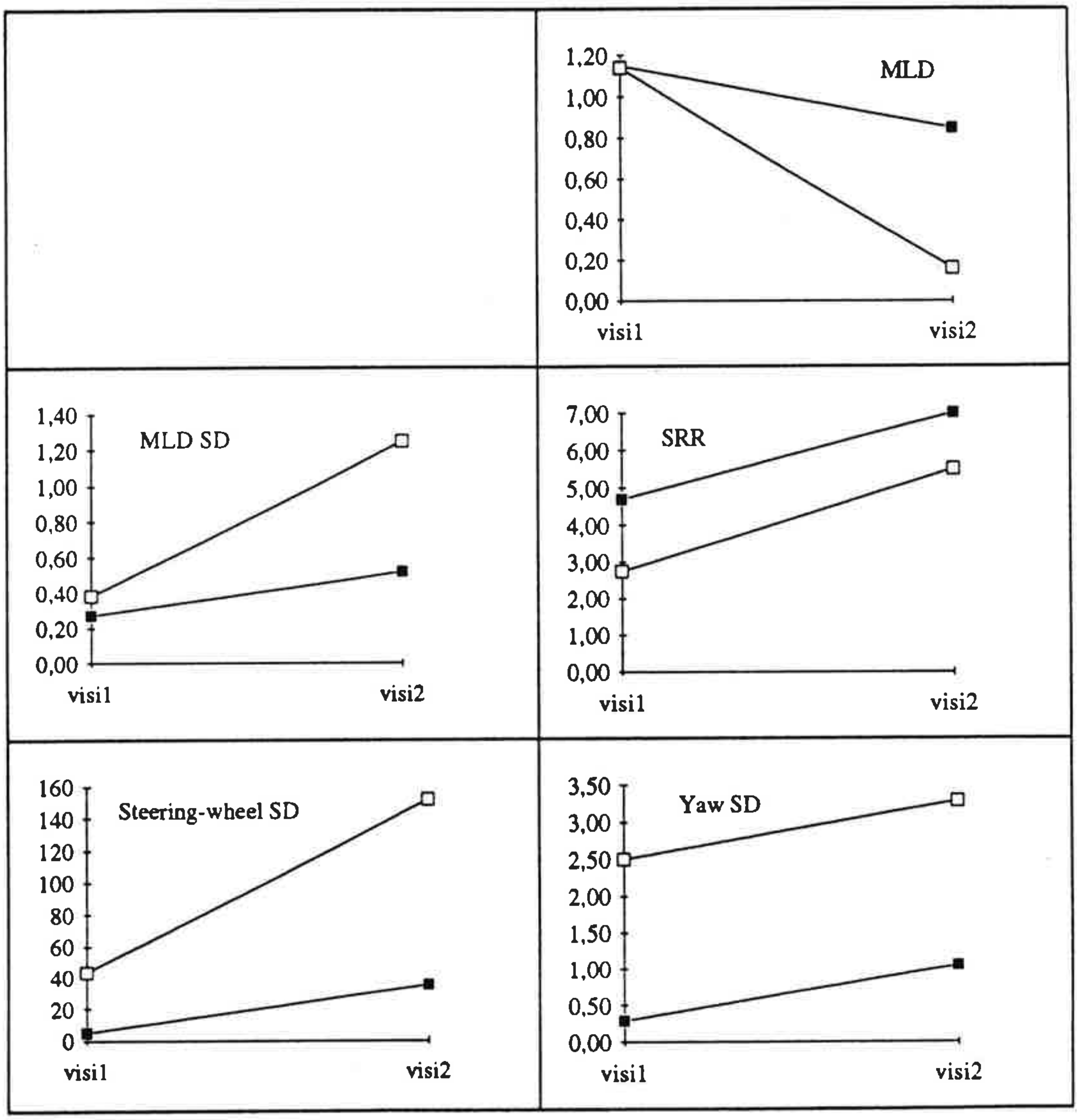
Before examining the results of the secondary tasks, we therefore studied the reference measurements, i.e. those during which only cardiac beats were recorded.

This measure was considered to be a priori non intrusive, i.e. no influence on performance. We will show results only for runs executed at imposed speed. There were several justifications for this imposed speed :

- It is known that there is an accuracy-speed relationship, as subjects tend to reduce speed when the difficulty increases.
- This simulator was too rudimentary to allow for a precise speed adjustment as there was no feedback with regard to acceleration, restored efforts to the steering-wheel and gas pedal, and as there is no lateral vision.

To make the results clearer, we will present only comparisons between visi1 (no fog) and visi2 (fog), because the simulation of fog was not good enough to ensure the linearity of the perceptual effect.

Figure 1: Effect of visibility and road curvature on performance measurements



A clear differentiation can be seen between visi1 and visi2 (factor 1). and between straight and winding (factor 2).

The significance of the difference was controlled using variance analyses performed with SAS or Systat. The Anova model was used with repeated measures. the successive sections (combination of the 2 factors) being the repetitions. The statistic F and the associated probability (1 dl) were computed and show significant differences :

- for factor 1 for every indicator,
- for factor 2 for every indicator except SRR,
- for interactions except for SRR and Yaw SD.

10.7.2. Secondary tasks sensitivity

A measure is likely to be sensitive if we can observe:

- an increase or decrease in relation to visibility.
- a differentiation between a straight and a curved alignment.

10.7.3. Cardiac rhythm

No significant effect was found concerning this indicator.

10.7.4 Reading numbers on the screen

Only the percentage of omitted responses would seem really to differentiate visi1 and visi2. for the two types of alignment (significant at a threshold of 3% for each of the two factors). However, the standard deviation does not provide any interpretable result.

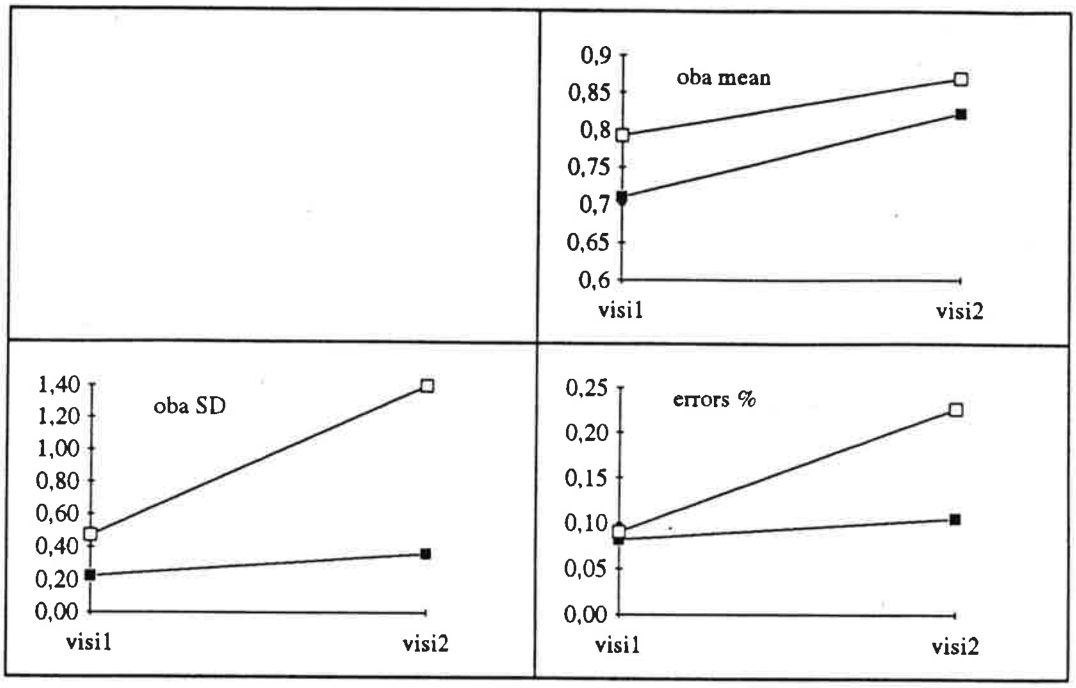
10.7.5. Simple reaction time

This measure does not provide any significant result.

10.7.6. OBA

Performance to this secondary task is presented in the charts below. These results consist of mean reaction time (RT) to the signals, standard deviation of RT, % of errors.

Figure 2: Mean reaction time, standard deviation and % of errors to the OBA task, while driving at an imposed speed of 90 km h.



For this task, the standard deviation and the % of errors differentiate visi1 and visi2, on straight stretches and on bends. An interaction effect can also be noted. As this is the task which produced the best results, the following tables show the results of the variance analyses.

The Anova results show significant differences on RT (SD) and errors % :

	df	mean square	F Snedecor	sign. level
visibility	1	4.537	3.596	.007
road profile	1	6.639	4.806	.045
interaction	1	2.506	4.477	.051

Table 1 : Effect of the factors on reaction time (RT) standard deviation.

	df	mean square	F Snedecor	sign. level
visibility	1	0.102	3.673	.075
road profile	1	0.065	4.253	.057
interaction	1	0.052	3.234	.092

Table 2 : Effect of the factors on the percentage of false responses (% errors).

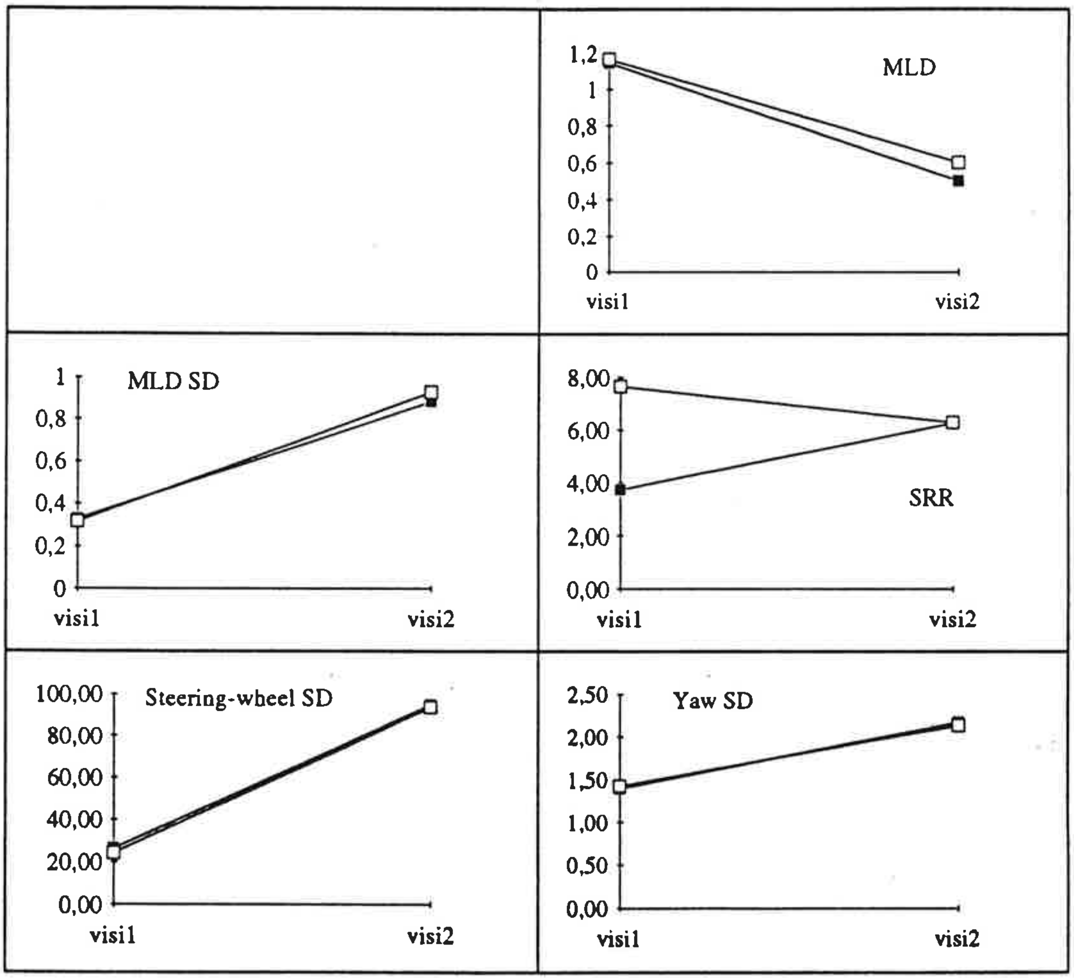
On both these criteria, standard deviation for reaction time and the number of errors, we can observe a significant effect of visibility and road profile factors, together with an interaction effect. This secondary task would seem therefore to be an acceptable workload measurement tool in a given driving situation, on condition it does not impair driving, which will be examined in the paragraph dealing with intrusion.

From this chapter it can be concluded that the OBA task produced the best results.

10.7.7. Intrusion of secondary measures on performance

We will examine the effects for OBA only, the only secondary task sensitive enough to be used. The effect of intrusion will be measured by comparing performance with and without the secondary task (in this instance OBA versus the reference measurement, i.e. cardio).

Figure 3 : performance modifications produced by the secondary task (intrusion)



It can be seen that there is no major difference between cardio and OBA, except for SRR. The similarity of these curves is even remarkable. F and the probabilities linked to the different comparisons were computed, including visibility 3 and 4. No significant difference was found, except for SRR ($p = .016$).

To conclude this first experiment results, we can therefore say that the OBA task proved to be relatively simple and barely intrusive. This is why it was chosen to be validated in a real situation.

10.8. ON-THE-ROAD VALIDATION STUDY (SECOND EXPERIMENT)

The second part of this research work consists in a field experiment, using the same methods as those used on the driving simulator : The aim was to try to validate the results obtained on the simulator.

10.8.1. Apparatus

We instrumented a car with different sensors, video camera, and PC computer, in order to collect the following parameters:

- speed,
- distance,
- steering-wheel angle,
- pulse rate,
- response to the secondary task.

We used exclusively the "OBA" task. The visual field was recorded by a video camera synchronised with the computer.

10.8.2. Subjects

In order to test the vehicle and the method, in this first step we used only 5 drivers. They were trained to the oba task in the laboratory. After that, each of them drove the vehicle on a journey of about 90 minutes, in the neighbourhood of Paris. Actually, they performed three runs, in order to eliminate practice effects. Only the third one was recorded.

10.8.3. Circuit

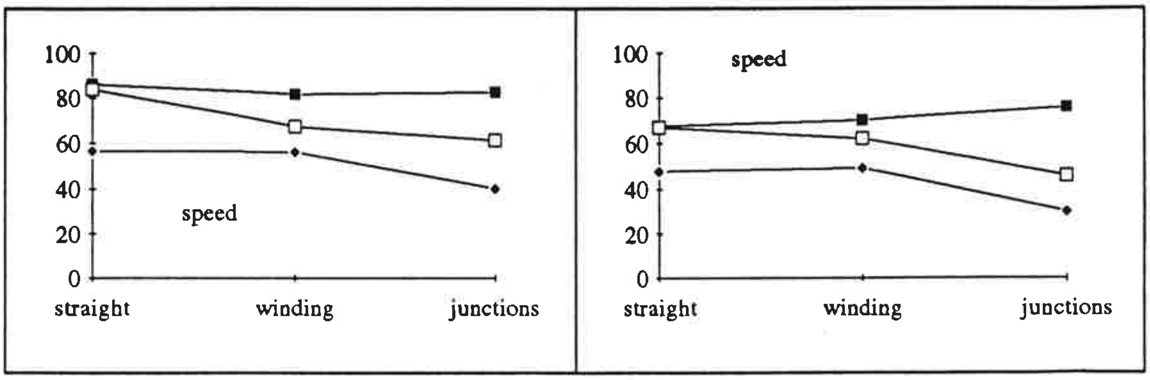
This journey combined different locations, (motorway, two-lane roads, villages), different road characteristics (straight, bends, junctions), and different traffic conditions (low and high). The combination of these variables gave 18 possibilities, unequally represented among the drivers, according to traffic conditions. With a greater number of drivers, this method will make it possible to use Anova with repeated measures <3*3*2>, to test the factors' effects.

10.9. RESULTS

10.9.1. Sensitivity

At the moment, we will only show tendencies on charts. It is obvious that no statistical differences will show up with only 5 people, with regard to the relatively small expected effects.

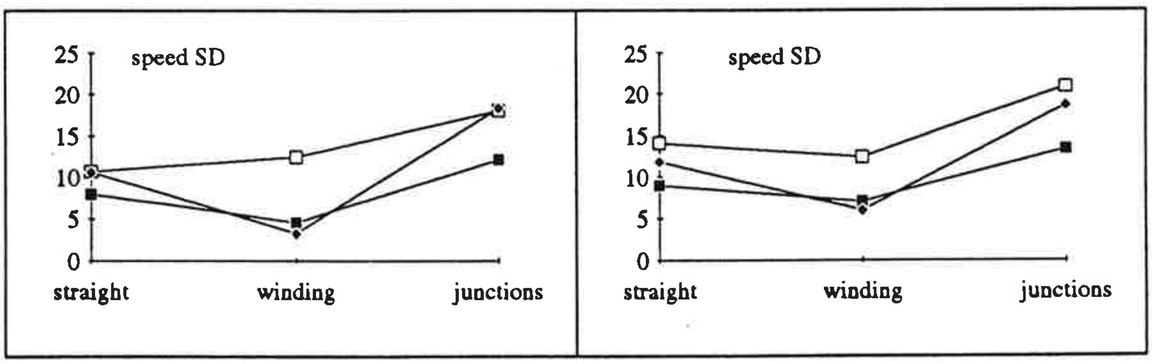
Legend applicable to all the following charts



low traffic heavy traffic

Figure 4 : Speed according to location and road characteristics

It can be seen that speed is of course lower when traffic is heavy. On two-lane roads and in villages, speed is lower than on straight stretches.

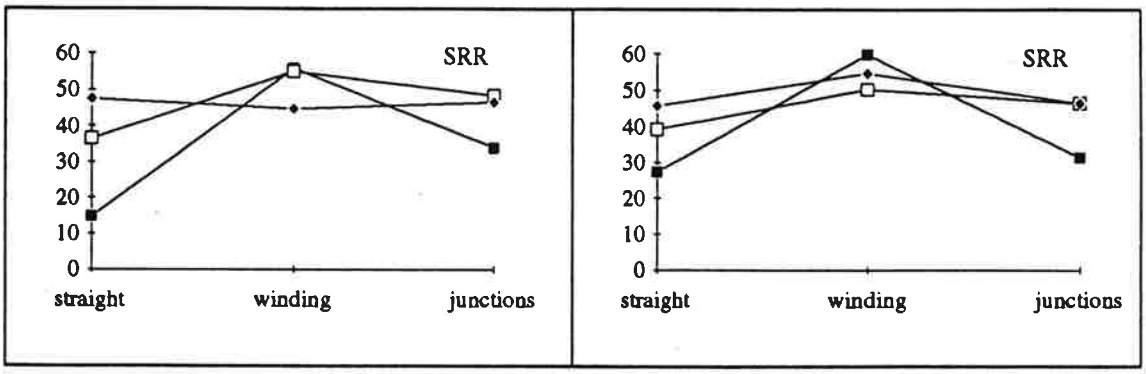


low traffic heavy traffic

Figure 5 : Standard deviation of speed according to location and road characteristics

On two-lane roads and in built-up areas, bends and junctions lower standard deviations. This is not the case on motorways, where there is no strong physical constraint (great radii).

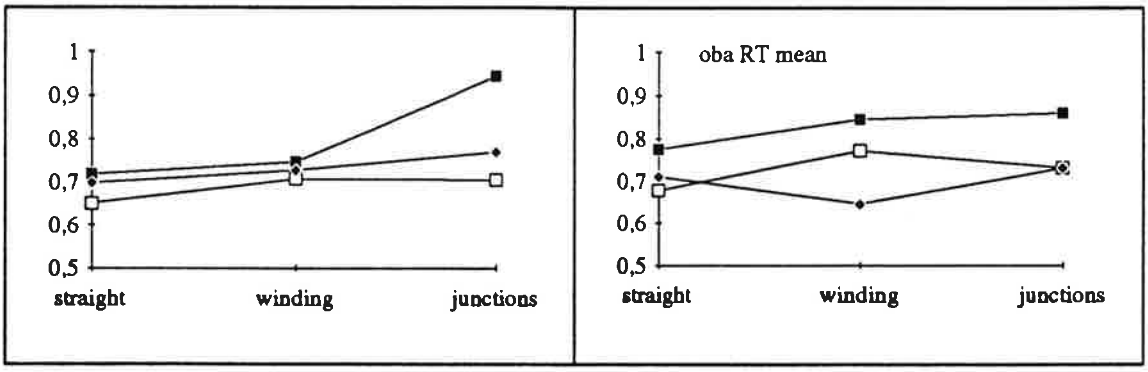
Dispersion is always higher at intersections, because this class includes intersections with different priority status, some of them requiring to slow down, some others not.



low traffic heavy traffic

Figure 6 : SRR according to location and road characteristics

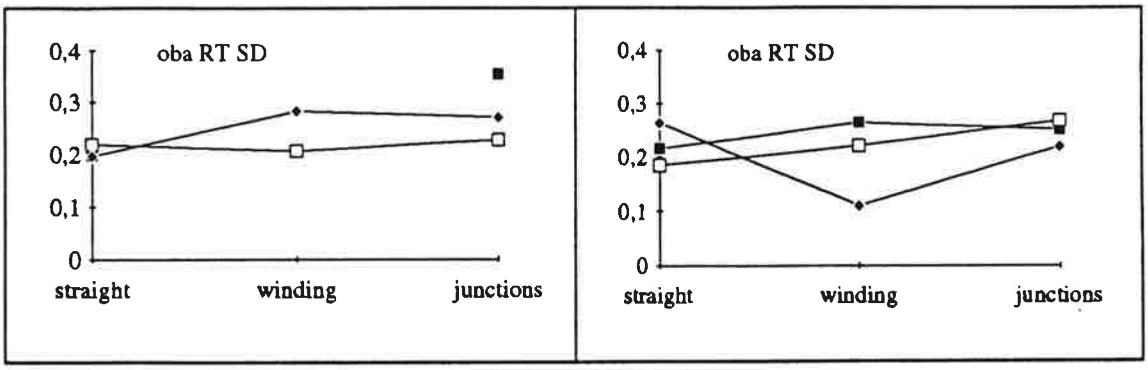
Curves and intersections tend to make this indicator more even, whereas on straight sections the different types of road can be distinguished.



low traffic heavy traffic

Figure 7 : mean reaction time to the secondary task according to location and road characteristics

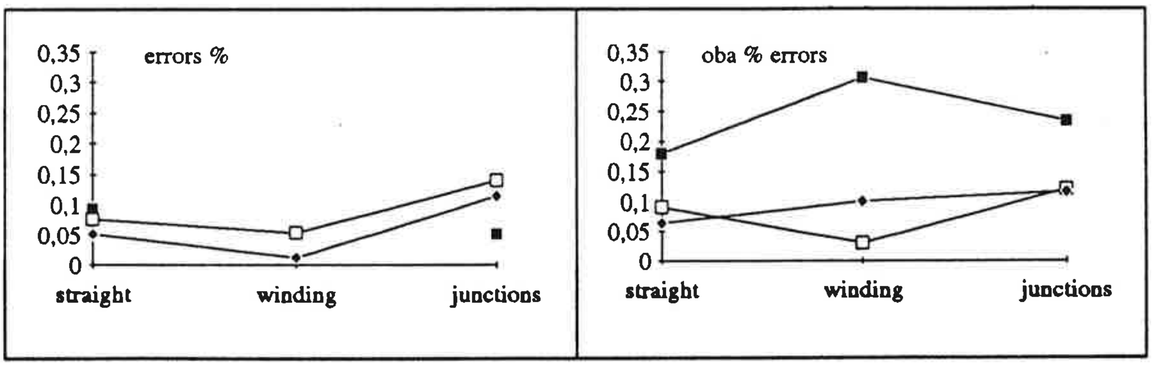
There is no obvious variation of the mean reaction time according to the considered variables.



low traffic heavy traffic

Figure 8 : Standard deviation of reaction time according to location and road characteristics

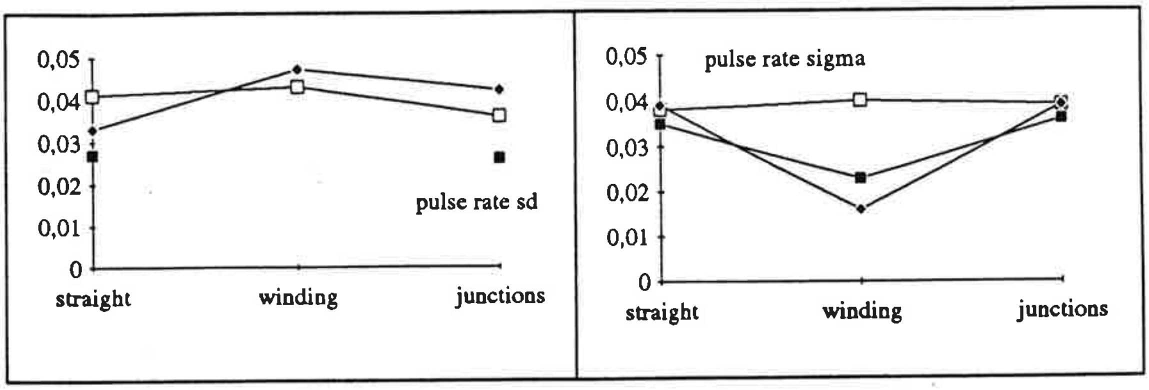
The standard deviation. which is supposed to be the best indicator, does not show any significant tendency.



low traffic heavy traffic

Figure 9 : Error percentage to the secondary task according to location and road characteristics

It can be noticed that this percentage is higher at intersections, and when traffic is heavy, particularly on motorways, where, next to Paris, driving conditions are particularly severe.



low traffic heavy traffic

Figure 10 : Pulse rate standard deviation according to location and road characteristics.

We can see that none of the indicators provides a clear differentiation between the experimental conditions.

The trouble with this "factorial approach", is that in a same cell we sum up different sections of road, different curves and different intersections. In other words, each cell is a mixture, and this cancel all possible diachronic effects.

This is why we attempted more simple treatments, consisting in comparing only two consistent sections, the first one considered as "easy", and the second as "difficult", although it is impossible to describe the difficulty in the same terms as previously. As a whole, difficult means more traffic, alignment more winding, more time spent in built-up area.

	easy	difficult	signif.
RT (m)	0.620	0.724	.20
RT (s)	0.204	0.254	.38
% errors	3.9	5.6	.13

Table 3 : Performance to the secondary task, on easy and difficult stretches of road (results concerning only 4 drivers).

We cannot reach the significance thresholds with only 4 subjects, but we can see that all the tendencies are compatible with the assumptions made. This result is fairly encouraging.

10.9.2. Intrusion effects

During the experiment, we didn't notice any modification in the drivers' behaviour when performing the secondary task. Nevertheless, we investigated this point by comparing primary measures without and with the oba task on two sections. Unfortunately, we failed finding strictly comparable stretches of road. It must be said that the road with oba was minor than the one without, and that it was a little more winding. This will impair the conclusions. This work will have to be done over on the same road, one run without and one run with. This will be done next year. At the moment, results are as follows :

	without oba	with oba	probability
speed (m)	85.04	75.01	.008
speed (s)	15.28	17.74	.146
S-W angle (s)	7.31	12.46	.045
SRR	30.99	46.48	.003

Table 4 : Comparison of driver behaviour on two stretches of road, as comparable as we could find, one without and one with the secondary task (results on 4 drivers only).

It can be seen that without OBA speeds are higher, with a lower SD, that steering-wheel angle SD and SRR are lower. These results seem to indicate an intrusion effect, which was not demonstrated on the driving simulator. This point deserves further experiments, under good statistical conditions.

10.10. CONCLUSION

The inherent difficulty in this type of experiment is that it is extremely difficult to control the effects of learning. Despite a relatively lengthy familiarisation period, which gave the subjects the impression they were in control of the driving situation and the double task, it is probable that they modified their performance throughout the experiment. These learning effects were in part neutralised on an experimental level, which counterbalanced the sequence effects.

This initial research work on the driving workload has yielded encouraging results. We have been able to show that the task used was sensitive, and that these results were easy to record using the calculation facilities at our disposal. As with the vehicle-driver performance parameters, data analysis makes it possible to clearly differentiate the levels of difficulty introduced on the simulator. The problems which remain are comparisons with the actual driving task, in traffic. It can be assumed that the resources called upon by decision-making during actual manoeuvres will differ from those used in the tracking task, even complex, on a simulator. The adequacy of our secondary task has therefore still to be validated. It has a disadvantage when compared with tapping, in that it is performed at a set rhythm. It will therefore be necessary to seek the optimal value for this rhythm, which was in this instance a signal every 2.5 seconds. This will perhaps be a little too fast in a real situation. On the other hand, the considerable advantage of this task is that it is very difficult to automatise by the driver, unlike tapping. This is its advantage, particularly when dealing with the study of more complex tasks, e.g. which make use of screens or keyboards when driving.

With only 5 drivers in actual driving conditions, we failed to validate the results obtained on the driving simulator, which is perfectly normal. Nevertheless, the results proved to be encouraging, and permit to tune up the method. Of course new field experiments will follow, with an improved instrumented car, a new circuit, and above all more subjects. A positive aspect is that the data processing chain is now in place, and that it will allow us to get results very fast after resuming the data collection. A negative aspect is that the reliability of the instrumented car is not good enough to start right away a new experiment, and this is what we are working on at the moment. If we consider both experiments, we think that our method with some improvements will be a good tool in both aspects :

- assessing driving difficulties in various situations, and conditions (including use of driving aids),
- comparing driving simulator with real world driving.

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REFERENCES

AASMAN J., MULDER G. & MULDER L. 1987, Operator effort and the measurement of heart-rate variability, Human Factors, 29(2), 161-170

ACKERMAN P.L., SCHNEIDER W. & WICKENS C.D. 1984, Deciding the existence of a time-sharing ability: a combined methodological and theoretical approach, Human Factors, 26(1),71-82

BLAAUW G.J. 1982, Driving experience and task demands in simulator and instrumented car: a validation study, Human Factors, 24 (4), 473-486

BLITZ P.S., HOOGSTRATEN J. & MUDROITER G. 1970, Mental load, heart rate and heart rate variability, Psychol. Forsch. 33, 277-288

BOYCE P.R. 1974, Sinus arrhythmia as a measure of mental load, Ergonomics, vol 17, n02, 177-183

BRAUNE R. & WIKENS C. 1986, Time-sharing revisited : test of a componential model for the assessment of individual differences, Ergonomics, Vol 29, No 11, 1399-1414

BROADBENT 1971, Decision and stress, Academic Press, London, New York, 522 p

BROWN, I.D. 1962, Measuring the "spare mental capacity" of car drivers by a subsidiary auditory task.Ergonomics, vol 5, 247-250

CASALI J.G. & WIERWILLE W. 1984, On the measurement of pilot perceptual workload : a comparison of assessment techniques addressing sensitivity and intrusion issues, Ergonomics, Vol 27, No 10, pp 1033-1050

CASALI J.G. & WIERWILLE W.W. 1983, A Comparison of Rating Scale, Secondary-Task, Physiological, and Primary-Task workload Estimation Techniques in a Simulated Flight Task Emphasizing Communication Load, Human Factors, 25 (6), 623-641

COHEN-SHMUELLY H., COHEN A., GLUSMAN G. & CASSUTO Y. 1991, Prediction of mental fatigue by use of electrophysiological signals in Designing for Everyone , ed Y. Quiinnec & F. Daniellou, Proceedings of the 11th congress pf the International Ergonomics Association, 451-453

DERRICK W.L. 1988, Dimensions of operator workload, Human Factors, 30 (1), 95-110

EGELUND N. 1982, Spectral analysis of heart variability as an indicator of driver fatigue, Ergonomics, vol 25, n07, 663-672

GLADSTONES W.H., REGAN M.A. & LEE R.B. 1989. Division of Attention : The Single-Channel Hypothesis Revisited. The quarterly journal of experimental psychology, 41A (1), 1-17
GODTHELP H., MILGRAM P. & BLAAUW G.J. 1984. The development of a time-related measure to describe driving strategy. Human Factors, 26(3). 257-268
HARMS L. 1991, Experimental studies of variations in cognitive load and driving speed in traffic and in driving simulation, In Vision in Vehicles- III. A.G. Gale et al. (eds), Elsevier Science Publishers, B.V. (North Holland), 71-78
HICKS T.G. & WIERWILLE W.W. 1979, Comparison of five mental workload assessment procedures in a moving-base driving simulator, Human Factors, 21(2), 129-143
HYNDMAN B.W. & GREGORY J.R. 1975, Spectral analysis of sinus arrhytmia during tal oading.Ergonomics, vol 18, n03, 255-270
ISREAL J.B., WICKENS C.D., CHESNEY G.L. & DONCHIN E. 1980, The event-related ain potential as an index of display-monitoring workload, Human Factors, 22(2),
JENNINGS A.E. & CHILES W.D. 1977, An investigation of time-sharing ability as a factor in complex performance, Human Factors, 19 (6), 535-547
KAHNEMAN D. 1973, Attention and effort.- Englewood Clifes, New Jersey, Prentice Hall
KALSBEEK J.W.H. 1964, On the measurement of deterioration in performance caused by distraction stress.Ergonomics, 187-195
KRAMER A.F., SIREVAAG E.J., BRAUNE R. 1987, A psychophysiological assessment of operator workload during simulated flight missions, Human Factors, 29 (2), 145-160
KRAMER A.F., WICKENS C.D., DONCHIN E. 1983, An analysis of the processing requirements of a complex perceptual-motor task, Human Factors, 25 (6), 597-621
LEPLAT J., PAILHOUS J. 1969, The analysis and evaluation of mental work, In W.T. Singleton et al. (Eds), Measurement of man at work, Taylor & Francis, London
MALATERRE G. 1992 (available at the end of 1992)
MALATERRE G., CAVALLO V., GAURIAT P., LENOIR F., MARTINEZ S., PERROT C. 1992, Evaluation de la charge de travail du conducteur au cours d'une tâche de conduite simulie. Rapport de convention INRETS-DSCR 91 41024 01 224 75 01
MCLEAN J.R., HOFFMANN E.R. 1971, Analysis of drivers' control movements, Human Factors, 13(5), 407-418
MCLEAN J.R., HOFFMANN E.R. 1975, Steering reversals as a measure of driver performance and steering task difficulty, Human Factors, 17 (3), 248-256
MESHKATI N. 1988, Heart rate variability and mental workload assessment.In Human Mental Workload, P.A Handcock and N. Meshkati eds, Elsevier, 101-115
MICHAUT G. 1968, Conduite automobile et charge mentale, Cahier d'etudes ONSER No 18
MICHON J.A. 1966, Tapping regularity as a measure of perceptual motor load, Ergonomics, 9, 401-412
NEBOIT M.& LAYA O. 1982, Charge de travail en conduite automobile, Rapport ONSER, 78p
NOY Y. ex 1990, Selective attention with auxiliary automobile displays, Proceedings of the Human Factors Society, 34th annual meeting, 1533-1537
O'DONNELL R.D & EGGEMEIER F.T. 1986, Workload assessment methodology, In Boff, Kaufman & Thomas, Handbook of Perception and Human Performance, vol 2, chap 42, 1-49, Wiley (ed), New-York
OGDEN G.D., LEVINE J, EISNER E.J. 1979, Measurement of workload by secondary tasks, Human Factors, 21 (5), 529-548
OPMEER C.H.J.M. 1973, The information content of successive RR-Interval times in the ECG. Preliminary results using Factor Analysis and Frequency Analysis. Ergonomics, 16(1), 85-97

RASMUSSEN J. 1977, Reflections on the concept of operator workload, In Moray, NATO conf. series, series III : Human Factors, Plenum Press, New York, 29-40
RIEMERSMA J.B.J., VAN DER HORST A.R.A., HOEKSTRA W., OTTEN N. 1990, Traffic Engineering and Control, July-August, 416-420
SAYERS B. 1973, Analysis of heart rate variability, Ergonomics, 16(1), 17-32
SHNEIDER W, SHIFFRIN 1977, Controlled and automatic human information processing : detection, search and attention, Psychological Review, vol 84, n02, 127-190
SPERANDIO J.C. 1972, Charge de travail et régulation des processus opératoire, Le Travail Humain, Tome 35, n0 1, 85-98
SPERANDIO J.C. 1977, La régulation des modes opératoires en fonction de la charge de travail chez les contrôlleurs de trafic aérien, Le Travail Humain, tome 40, n0 2, 249-256
STERNBERG S. 1969, The discovery of processing stages : extension of Dinder's method, Acta Psychologica, 30, 276-315
SVERKO B. JERNEIC Z. & KULENOVIC A. 1983, A contribution to the investigation of time sharing ability, Ergonomics, Vol 26, No 2, 151-160
SZEKELY J. 1975, L'évaluation de la charge mentale dans le cadre de l'étude et de l'aminagement des conditions de travail, Rapport INRS, 4 Janvier
THINK PascalTM 1991, SYMANTEC Corporation 1988-1990
WEIR D.H., MCRUER D.T. 1968, A theory for driver steering control of motor vehicles, Highway Research Record, 247, 7-28
WELFORD A.T. 1978, Mental workload as a function of demand, capacity, strategy and skill, Ergonomics, vol 21, n03, 151-167
WETHEREL A. 1981, The efficacy of some auditory-vocal subsidiary tasks as measures of the mental load on male and female drivers, Ergonomics, vol 24, n03, 197-214
WICKENS C.D. 1984, Processing resources in attention, In R. Parasuraman et R. Davies (Eds), Varieties of Attention, Academic Press, New York, 63-101
WICKENS C.D., SANDRY D.L.& VIDULICH M. 1983, Compatibility and resource competition between modalities of input, central processing, and output, Human Factors, 25 (2), 227-248
WIERWILLE W.W. 1979, Physiological measures of aircrew mental workload, Human Factors, 21(5), 575-593
WIERWILLE W.W., CONNOR S.A. 1983, Evaluation on 20 workload measures using a psychomotor task in a moving-base aircraft simulator, Human Factors, 25 (1), 1-16
WIERWILLE W.W., GUTMANN J.C. 1978, Comparison of primary and secondary task measures as a function of simulated vehicle dynamics and driving conditions, Human Factors, 20 (2), pp233-244
WIERWILLE W.W., GUTMANN J.C., HICKS T.G., MUTO W.H. 1977, Secondary task measurement of workload as a function of simulated vehicle dynamics and driving condition, Human Factors, 19(6), 557-565
WIERWILLE W.W., RAHIMI M.& CASALI J.G. 1985, Evaluation of 16 measures of mental workload using a simulated flight task emphasizing mediational activity, Human Factors, 27 (5), 489-502
WILKINSON L. 1989, SYSTAT : The system for statistics. Evanston, IL SYSTAT, Inc.
WISNER A. 1969, Using physiological and psychological variables during low physical loaded work, Symposium on physiological and psychological criteria, Amsterdam, 15-18 Sept
YEH Y.Y. & WICKENS C.D. 1988, Dissociation of performance and subjective measures of workload, Human Factors, 30 (1), 111-120.

11. WHAT CAN WE LEARN FROM DRIVER BEHAVIOR AND ACCIDENTS IN ORDER TO DISCUSS THE RELEVANCE OF NEW TECHNOLOGIES

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SUMMARY

DRIVE and *PROMETHEUS*, two current European projects, are focussed essentially on problems relating to the design and integration of driving aids. This paper will firstly provide an overall outline for the analysis of driving situations and driver activity. The conclusions of three studies intended to evaluate driving aids and which reveal several aid-related difficulties will then be examined. Finally, using the results of accident analysis in the specific situation of controlled intersections, we will discuss the difficulties and questions raised when designing new driving aid devices.

11.1. INTRODUCTION

Drive and Prometheus, two current European projects, are focussed on problems relating to the design and integration of driving aids. In our opinion, the first stage of aid design is to obtain information on the essential features of the task and its malfunctions. This design must then be based on a detailed definition of aid requirements, using an analysis of driving situations and driver activity. We will first present a general framework with which to analyse the driving task and driver activity, together with a preliminary definition of driving aids. The conclusions of driving aid evaluations will then be briefly examined, so as to pinpoint certain aid-related difficulties. We will then develop, for purposes of example, the main results of accident analysis in a specific road situation, controlled intersections. This will then be used as a basis of discussion in dealing with the problems raised when designing new driving aid devices.

11.2 DRIVING TASK AND DRIVER ASSISTANCE : A GENERAL FRAMEWORK

11.2.1 Aspects of the driving task

Research in this field has led to the identification of certain characteristics associated with the driving task that may serve as a general framework to analyse activity and examine the problems raised by the designing of new driver assistance modes.

Driving 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 and Bötticher, 1988]. Furthermore, it is relatively unstructured [Saad, 1975] 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. It is also unstructured in that all the road situations that can be encountered by the driver are extremely varied (in view of the many possible combinations of infrastructure, traffic and atmospheric conditions). The information required for journey management is essentially informal information [Neboit, op.cit.]. Finally, in view of present day driving instruction, it can be said that drivers learn to drive "by experience" [Groeger and Grande, 1991].

11.2.2. A driver activity analysis framework

The way drivers adapt through experience demonstrates their capacity to find heuristic solutions to the dynamic problems they are faced with in managing their journeys. Errors, incidents and accidents demonstrate the limits of that adaptation, the determining factors of which need to be analysed. Driver activity models have been widely developed and used in the field of road safety to analyse these adaptation mechanisms as well as human failure in accident occurrence [Schlensinger, 1972; Fell, 1976, Neboit, 1977, Michon, 1985; Malaterre, 1990; Van Elslande et Luber, 1991]. These are functional models, which formalise the different psychological activities brought into play when driving, the mechanisms by which the driver adapts to his environment and manages the various tasks to be performed when driving.

These models usually consider:

- Information acquisition and processing leading to a diagnosis of the situation.
- On the basis of this diagnosis, alternative action is suggested and, depending on the driver's own criteria, a procedure is chosen to control the situation.
- Implementation, which consists of putting into effect the actions defined according to the selected procedure.

Cognitive models stress the fact that all these briefly listed processes interact closely and are functionally linked to the knowledge acquired through experience and stored in the memory (the sum of organised knowledge of the system, its structure, road situation dynamics together with strategies for processing the information and rules of action). They emphasise the active nature of the driver environment interaction and the important role that representations may play when adapting to dynamic driving situations. In the field of cognitive psychology, the notion of representation refers to the idea of an internal model developed by the subject to deal with complex situations [Norman, 1983]. The symbolic structures that 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 and 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 the 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 [Saad. 1991].
In view of this, ergonomic research for road environment planning and/or driving aid design calls for a joint analysis of the characteristics of road situations and of the driver activity mechanisms.

11.2.3 Driver assistance

In the framework defined above, this assistance can be generally described as an activity structuration aid or, more precisely, as a reliable way of directing the driver (both in space and in time) towards the relevant aspects of road situations that he must consider, if safety and driving are to be effective.

The activity can be assisted by adapting the road network characteristics, and developing building and planning standards so as to improve road "legibility" for the user [Fleury, 1990].

It may also be assisted by designing new driving aid systems. This line of action serves, in some ways, to mediate the interaction between the driver and his environment (infrastructure, traffic, vehicle, other users) by formalising a new source of information, aid devices. One can consider, with Bisseret et al [1980], this device as an interface between the designer and the user. Design problems then stem from the compatibility or not between the choice of the designer (filtering and coding information pertaining to the activity), and what the driver needs to achieve his objectives.

11.2. 4 Driving aid devices

The development of Drive and Prometheus. emphasises an increased need for an integrated approach when analysing these problems. This approach is indispensable, given the number of different aids considered in these projects. The purpose of these aids is to improve the performance of several sub-tasks such as speed control, controlling inter-vehicle distances, overtaking, crossing intersections, identifying and following a route, etc... [for further information on this refer to Fontaine et al. 1989; Lassarre. 1989; Fleury, 1990; Malaterre and Fontaine, 1992].

The concept of an "intelligent co-pilot" which helps the driver to manage all these varied sub-tasks raises the all-important theoretical and methodological problems encountered when analysing the task and formalising driver activity. It also emphasises the need for empirical data on which these formalisations can be based. To assign an "intelligent" function [Michon et al 1990] to these devices, implies that they are adaptable, i.e. they take the specific aspects of the different road situations into account as well as the driver activity characteristics.

11.3. EVALUATING DRIVING AID DEVICES IN ACTUAL DRIVING SITUATIONS

We will now give a short description of the results of three driving aid evaluation studies: two speed control devices and an anti-collision radar device [Malaterre and Saad, 1984; 1986]. These devices are already out-dated, as they appeared in the early 80s. As a result of the technical progress made over the past few years, it is clear that a number of defects that were noted at that time could easily be remedied. Other aspects, however, concern, on a more basic

level, the essential dimensions of driver activity that should always be taken into consideration. These are the points that will be dealt with in this paper.
These evaluations carried out in actual driving situations and involving experienced drivers (within the complex interactions that are to be found on the road) showed the difficulties and limitations of an a priori or unduly normative definition of aid requirements. In particular, they revealed significant discrepancies between designer and user objectives, that actually restricted the integration of "aids" in their activity and their acceptance. These discrepancies extend to both the priorities given by the devices to certain controls and the parameters of the situation being considered. Each of the devices studied favoured one of the "formal demands" of the driving task (respecting speed limits, maintaining "safe" inter-vehicle headways), prioritising them and fixing a threshold regardless of the diversity of situations and tasks that appeared to have a determining effect on driver controls. The problem encountered is the filtering and validation of the information provided by the devices in relation to driver objectives, the task being performed, all the information he acquires directly concerning the situation and the processing thereof. A greater number of parameters are taken into account by the drivers when characterising a given situation and assessing its "critical" nature, than are selected by the aid systems. Furthermore, drivers are more likely to base their decisions on whether or not to undertake a control action on a diagnostic of the possible evolution of the situation in hand, than on its instantaneous characteristics.

The problems encountered can therefore be seen in terms of compatibility between the choices made by the designers, and the needs of the user to reach his objectives, and are a reflection of the discrepancies that are often noted between the "prescribed task" and the "actual task", as differentiated by Leplat and Hoc [1983].

These briefly summarised results raise the question of the psychological relevance of the choices made with regard to driver aids. They emphasise how difficult it is for the driver to integrate and co-ordinate the different items of information when driving (information taken directly from the "situation", usually informal, and "formal" information provided by the devices). This is an indication of the major problems encountered when defining a function able to provide assistance, viz the circumstantial and temporal management of the information to be supplied to the driver in the dynamic driving process [Saad and Malaterre, 1989].

11.4. ANALYSIS OF DRIVER ERRORS IN ACCIDENTS AT CONTROLLED TRAFFIC JUNCTIONS

Accident analysis (and in particular driver "error" analysis) provides a useful indication when identifying aid problems. It is a way of revealing the underlying accident occurrence mechanisms and can be used to identify driving situations that, from a safety standpoint, are particularly critical [e.g. Malaterre and Fontaine, 1992; Van Elslande and Nachtergaele, 1992].

This section of the paper will present an example of an accident analysis at controlled traffic junctions. The situation being studied is relatively complex: it takes place in an urban context and involves essentially multiple interactions between different user and space categories (pedestrians, two-wheelers, light vehicles,...). Traffic control at junctions manages the interactions between road users in space and in time. The formal rule, set up by this regulation, relies on a simple and univocal principle. In practice, driver activities appear to be more complex than expected according to formal regulations [Hauer et al, 1988; Joergensen, 1988; Prashker and Mahalel, 1989; Robertson, 1991].

To obtain a better understanding of the processes involved in accident occurrence at controlled traffic junction, the results of four safety studies were re-examined. These studies came from different sources : Municipal Engineering Departments, The Ministry of Transport or studies carried out by INRETS [Ferrandez et al, 1981; Ferrandez et al, 1982; Fleury, 1983; Fleury et al, 1989]. They had different operational objectives: designing safe infrastructure, setting up information campaigns, in-depth accident analysis and overall safety diagnosis. We will try to categorize types of driver errors according to the mechanisms involved (perceptual or decisional) and to the spatio-temporal conditions of their production.

Before presenting the results of this analysis, we will indicate how the road situation being studied was characterised and describe the analysis schema on which this was based.

11.4.1. Intersection characterisation

The intersection is a place where traffic flows meet, and is, for the driver, an area of potential interaction with one or several other users [Saad et al., 1990]. Junction control defines the conditions in which this interaction takes place, by controlling the movements of the different users in time. For intersections controlled by traffic signals, this is done by phasing lights, thus regulating the timing and duration of the traffic flow. In movement dynamics, the intersection therefore represents a *change in the driving situation*, requiring the driver to adapt to regulatory and/or functional demands that differ from the preceding driving situation. An intersection approach area will be defined as a *transitional zone* in which this adjustment must be made. In this area, the available cues enable the driver to infer the type of control, the type of possible interaction and the regulating action to be carried out. Thus, before reaching a signal-controlled junction, it is possible, in the absence of advance signposting, to define this zone as the area in which the traffic signals and their colour are visible.

11.4.2 A scheme for accident analysis

Different research work carried out in the field of road safety does indeed indicate that the detection and processing of changes in situation is a particularly critical aspect of driving and should be analysed in greater detail [Rumar, 1991; Saad, 1989].

These changes in situation may, for the driver, be more or less predictable or expected, depending on whether or not he has available, as he progresses, the information needed to detect and identify them. The processing of these changes depends on a variety of factors such as the type of change (functional or statutory), the range, duration, temporal constraints and the specific driver criteria which direct his choice of regulating action to be applied to the different cases.

The following scheme is suggested as a guideline for accident analysis [Fleury et Saad, 1992].

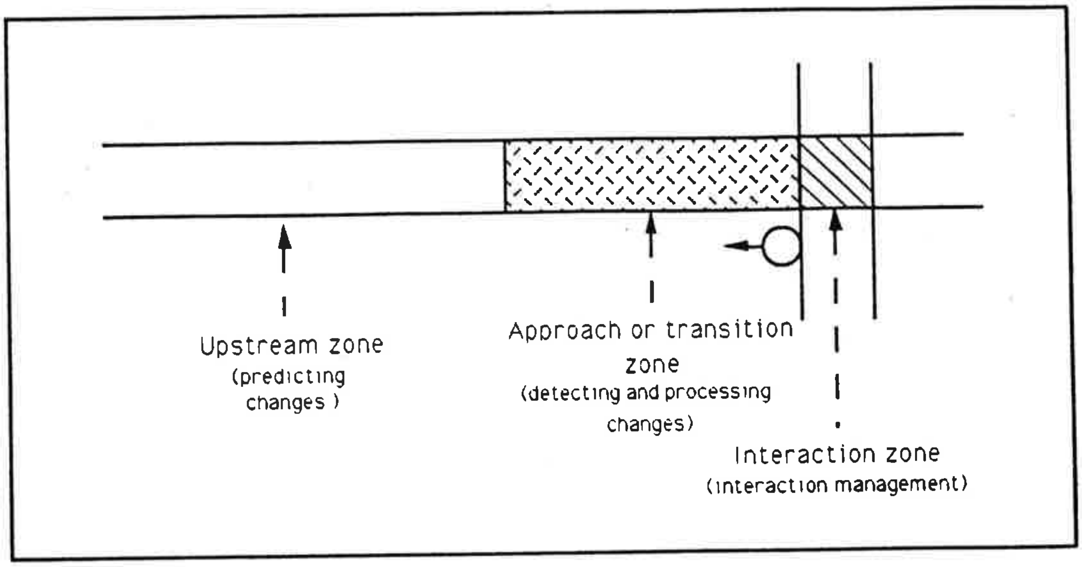

Figure 1: Interaction, approach and upstream zones

In this scheme, certain cognitive mechanisms were deliberately emphasized, as we think they represent the key stages when driving in this type of situation. It tries to take into account the dynamic nature of driving, and the temporal constraints which may influence driver activity. When analysing accidents, we were thus led to consider not only factors linked to the junction itself, but also those found before and on approaching the junction. This scheme formalises the questions that have directed our analysis:

- Could the driver predict the change in situation that the junction is supposed to represent ?
- Has the driver detected this change and how has he processed it ?
- How has interaction with other users at the junction been managed ?

11.5 MAIN RESULTS

On the basis of the schema described above, we have classified the malfunctions in three main categories depending on whether the problem encountered by the driver is related to situation change prediction, to the detection and the processing of this change when approaching the junction, or finally, to interaction management (actual or potential) at the junction itself.

11.5.1 Predicting a change in situation

The cases encountered involve coherency problems between certain types of roads and traffic signals, which is thus relatively unpredictable. For the driver, this results in either failure to detect, or delayed detection of a change in the driving situation.

Driving involves moving along different types of road. For the driver, this is a two-fold problem while driving: he must first recognise the next section, then predict that this section will be equipped with traffic signals. The recognition of a type of road depends on the type of area (open country, urban or semi-urban), the characteristics of the road and the immediate environment, together with the level and type of traffic and road usage. The network structuration is generally such that a certain type of road can only lead on to a limited number of other types of road. The characteristics of the road being used is therefore relevant when predicting equipment - in this case traffic signals - on the following road section. Traffic signals are installed essentially on urban through-roads. It is rare to find traffic signals in the open country, or on motorway type roads, where users expect to have right of way..

Some problems of prediction are to be found, particularly when the section linkage is not predictable during the drive.

Examples :

- There is often a safety problem when pedestrians leave a pedestrian precinct and move directly onto highly-trafficked roads.

- When entering a built-up area there are problems when changing from one type of prediction to another, and the first traffic signal is often difficult to negotiate.

- Another type of problem arises depending on the type of control, on a main road, eg "green waves". The user recognises a sequence of controlled junctions that enable traffic to flow freely. However, a green wave does not necessarily ensure that the driver will be able to continue without stopping, but he may not expect the signal to change to red (or may possibly refuse to stop) which modifies his strategy on this axis. This situation is more likely to be encountered when the traffic signals are close together. A good example of this is when lights are installed at junctions located at both ends of the same bridge.

11.5.2. Detection and processing of changes in situation

There is no problem of coherency between traffic signal control and the section of road the driver is travelling along or is approaching, but the user may not detect the junction or not see the signal. Several types of malfunction can be identified:

- *Detection of a junction*

A junction may not be perceived, as the relevant cues are not sufficiently obvious. In towns, a junction can be identified by a break in the alignment of the facades, indicating a side road and pavements running along it. It is also shown by markings on the road surface, perpendicular to the direction in which users are travelling. This applies particularly to two pedestrian crossings, one on entering and another on leaving a junction. Other cues may become relevant when travelling along a street. Thus, in a well-equipped area (systematic installation of posts equipped with traffic signals at junctions), a junction may not be detected if it is not as well equipped as the junctions through which the driver has previously driven.

- Detection of the signals

Some accidents occur when the signal is not sufficiently visible. This is just as likely to be due to masking (sign, vegetation, parked vehicle), as to insufficient light, a signal barely visible in the urban environment...

- Driver information search strategy

The information search strategy may not be adapted to detecting traffic signals. This is the case when the driving task is concentrated on interaction with other users on a link road. Two types of accidents fall into this category :

- Suddenly stopping some distance before the signal, in a line of traffic on a link road.
- A moped overtaking a line of stationary traffic is surprised by a user turning at a junction.

This lack of search for information also occurs in certain specific cases; when the street is familiar and when a traffic signal controls vehicles moving onto the public highway (fire station, hospital...). As the signal has always been a flashing amber light, the driver will no longer search for specific information, as this usually has no influence on the driving task.

11.5.3 Processing information at the junction itself and managing interactions with other users

The malfunctions dealt with in this context are not related to detection problems when approaching a junction. These have been clearly identified as such, and the signalling status on the branch road in already known. These problems arise more from the processing of information at the junction itself, and more specifically the management of interactions (actual or potential) with other users.

These malfunctions can be grouped under two main headings:

- The problems encountered by users stem from poor focalisation when acquiring information as they cross the junction, or incorrect positioning in the centre of the junction when performing turning manoeuvres, in the face of oncoming traffic. These problems are found particularly at main junctions with a large non-equipped central area. Other problems are linked to evaluating the speed of an oncoming vehicle (particularly motorcycles) ; once again when performing turning manoeuvres.

- The second heading groups together the problems that arise when users do not take into account the formal rule which is intended to manage interactions between different users by controlling the order in which they cross the junction. This often applies to pedestrians or 2-wheelers that take advantage of their small size and relative mobility to adapt to this specific situation. These users seem to consider that traffic signals apply more to motorists than to themselves, and so frequently fail to take the formal rule into account. The strategies they use are based on traffic rather than on signal status. This also applies to drivers of light vehicles who allow themselves to deviate somewhat from the rule and, using their knowledge of the signal sequence, continue to cross or anticipate moving off, taking a chance on the way others will behave. This applies particularly when lights are just changing. It is worth noting that in interviews carried out as part of the In-depth Accident Study [Ferrandez et al. 1986], there was a clear difference in driver attitudes towards crossing on a red light, depending on whether this occurred at the beginning or at the end of the sequence. In the latter situation, although they are anticipating the green light, users do not feel they are breaking the rules, and justify their behaviour on the basis that the signal for oncoming drivers is red. It can therefore be seen that under certain conditions, drivers show a certain laxity with regard to the prescribed task, by loosely interpreting the formal rule and taking into account cues other than those intended to help them carry out this task, such as signal status and/or vehicles stopping on side roads. This laxity is based on a knowledge of the signal sequence (full red light), as drivers think they can cross the junction before users on the side roads move off and, paradoxically, expect that other users will respect the formal rule.

11.6. DISCUSSION

The road situation under consideration was deliberately selected as being one of the most complex. It has been presented here as an example, to illustrate the difficulties encountered when designing relevant aid devices, in view of the questions raised in analysing a specific situation and driver activity in this same situation.

This complexity is seen in the diversity of the malfunctions identified, which affect user information processing when driving and which differ in several ways (non exhaustive). To take them into account may raise several different types of assistance problems:

- depending on the spatio-temporal dimensions in which they occur: some information would have been required well before the intersection, other information is lacking at the intersection itself or at its immediate approach.

- depending on the type of "human failure" identified: in certain cases these failures are linked to a lack of information (present or not, looked for or not,...) or processing difficulties, others are linked to an unexpected or inconsistent usage (in terms of the prescribed task) of available information. In other words, some may be classified as "errors" (or unintentional behaviour) and others as "violations" (deliberate behaviour), as differentiated by Reason et al (1990).

- depending on the type of interaction involved: interaction with the road infrastructure (whether detecting an intersection, its layout or yet again a specific situational factor, traffic light status), interaction with other users (whether evaluating their movement dynamics or predictions, or expectations as to their intentions and behaviour).

- depending on whether these malfunctions concern the performance of a specific sub-task or the management of different sub-tasks during the driving task.

It is obviously not possible, within the scope of this paper, to discuss these different driver assistance dimensions and implications in greater depth. It should, however, be noted that, when dealing with aid design, the dimensions dealt with in this paper lead to the following questions:

- When should assistance be provided for it to be relevant to temporal constraints ?
- What should the role of this assistance be: preventing errors and/or preventing violations ?
- At what level should assistance be provided: a road "reading" aid, an aid for inter-user interaction management, and how to link together these different levels which, during driving, are often closely interconnected ?
- Should it encourage the performance of specific sub-tasks and/or assist the organisation and management of all tasks when driving?

These questions are all-important, not only in terms of technical feasibility but also seen from what one might call an assistance "philosophy", which is expressed in the choice and weighting of criteria such as safety, mobility, the extent of freedom given to the driver, etc... Some of these questions have already been considered and discussed [e.g. Malaterre, 1990; Malaterre and Fontaine, 1992; Van Elslande and Nachtergaele, 1992]. Here, we will indicate only some of the methodological aspects used to identify assistance requirements based on accident analysis studies, and discuss a significant problem which arose when evaluating driving aids, i.e. the circumstantial management of the information to be transmitted to the user.

It should firstly be emphasised that the assistance needs that could be deduced from this analysis obviously reflect the model that was chosen, which helped when classifying the malfunctions. The model selected stressed certain cognitive mechanisms that we assume play a determining role when driving. This led us to consider, when examining the situation, not only intersection characteristics and the events that occurred there, but also prior characteristics and events (1) .

Only to list the step by step correspondance between the malfunctions identified in the accidents, and "aid requirements" would be, in our opinion, an overly simplistic approach. To be able to identify malfunctions when predicting or detecting a change of situation does not necessarily mean that all changes in situation require internal assistance.

As an example, Mazet [1991] has shown that drivers structure examples of intersections into categories, according to "family likeness", and that examples of these categories are not all the same, but are distributed according to a typicality continuum. In other words, certain intersections are more easily "recognisable", and therefore more quickly detected insomuch as they show perceptive and functional characteristics "typical" of their category, that cannot be found at other intersections. Driver "information needs" to detect a given intersection will not, of course, be the same for every intersection. They will vary according to the specific characteristics of each intersection and its approaches. This is where the main difficultiy lies in designing driving aids: that of the selectivity of the information to be transmitted to the users [Mazet and Saad,1990], if undue redundancy is to be avoided (in relation to the actual information to be found in the environment and user knowledge).

Evaluating aids in actual driving situations has shown that drivers filter and validate the information provided by the devices being considered, in relation to their objectives, the on-going or projected tasks and all the information that they have acquired directly about the situation. It would seem at present difficult to design aids which take into account driver objectives or intentions and the procedures they use to organise tasks when driving. Similarly, it should be assumed that direct information about the environment will continue (it will be a long time, perhaps never, before a vehicle will be piloted automatically). The question of the information to be transmitted through aids can, therefore, appear to be justified in terms of its complementarity to the information already available, the way this information is processed by the driver and the difficulties observed in this respect. This assistance could therefore be the taking over of specific processing, known to be difficult to perform in certain conditions (e.g. evaluating certain dynamic parameters).

It could also help to extend the spatio-temporal field of driver control [Leplat,1985] by providing him with access to information he does not have at the present time, as it is outside his "possible field of control" (distance, masking, visibility) or, yet again, by providing information on certain events with which he is unable to deal, because of their somewhat unpredictable, infrequent or "atypical" nature.

This assumes selectivity, flexibility and a choice of priority in the information to be transmitted to users and involves close links with road network "design logic" and planning [Fleury and Dubois,1991], together with knowledge of user information processing procedures or, more generally, "user logic" (whether mental representations used for control purposes or control strategies applied when managing different driving situations, [Mazet op.cit., Saad et al op.cit., Mazet and Saad op.cit., Saad,1992]**(2)**

11.7. CONCLUSION

The questions raised with regard to the potential development of new technologies are complex. Their processing demands a mobilisation and a more detailed knowledge of driver activity as it is performed at the present time with a view to identifying possible "needs". It also involves predicting the effects these devices will have on this activity, once they become part of the driving task. This prediction is all the most difficult because, at the present, the specifications of these devices are far from being clearly defined.

Using a categorization of the malfunctions identified by the analysis of accidents in a given road situation, traffic light controlled intersections, our aim was to illustrate the difficulties found when designing appropriate aids with regard to the questions raised, and provide suggestions as to ways in which this work could evolve.

To be effective aid design cannot dispense with a prior analysis of the mechanisms applied by drivers when managing their journey. This is, for the most part, the analysis of the different driving situations and the activities used by drivers to control them which will, in our opinion, make it possible to reach an optimal balance between means and needs **(3)** .

The psychological analysis of human error, the focal point of driver assistance philosophy, assumes that knowledge of the activity mechanisms which governs their production is available. In view of this, it would seem essential to consider accident and driver activity analyses as complementary approaches, which should be closely associated [Leplat,1985]. The in-depth analysis of road situation characteristics which, as already indicated, are extremely diverse should help to prepare the study and evaluation of incorporating these new devices into the complexity of the interactions involved in actual driving situations.

(2) - This is no way prejudges the use the driver will make of it and the consequences in terms of safety. It has already been seen that, in certain cases, the problems encountered were linked not to a lack of information about the situation, but incorrect use of the available information (either remembered or in the environment). There may therefore be a contradiction between the aid system objectives and safety imperatives.

(3) - It is obvious that no matter what degree of precision is used to study the present situation, it is extremely difficult to predict both qualitatively and quantatively the modifications in activity that these devices will produce. Only the follow-up and iterative evaluation of the effects of incorporating these aids into the driving task will make the detection and possible consideration of any adverse effects possible.

REFERENCES

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

BISSERET A., BOUTIN P, MICHARD A. 1980, Eléments introductifs à l'ergonomie des systémes Hommes-Machines. Informatique et Sciences Humaines, 44, 13-34

FALZON P. 1989, ergonomie cognitive du dialogue. Presse Universitaire de Grenoble.

FELL J.C. 1976, A motor vehicle accident causal system. Human Factors, 18, 1, 85-94

FERRANDEZ F., FLEURY D. & MALATERRE G. 1986, L'étude détaillée d 'accidents: une nouvelle orientation de la sécurite´routiére, Recherche Transport Sécurité, no 9-10

FERRANDEZ F., FLEURY D., BUATOIS & JOURDAN JL. 1981, Etude du non-respect de la signalisation lumineuse - préparation d'un dossier de consultation en vue d'une campagne d'information.Rapport ONSER.

FERRANDEZ F., FLEURY D. & LEPESANT C. 1982, Etude de la sécurité sur un axe dangereux en zone urbaine. Cahier d´étude de l'O.N.S.E.R no 55

FLEURY D 1983, Synthése d'analyse de quelques dossiers d'accidents survenus aux feux tricolores. Rapport ONSER

FLEURY D., FLINE C. & PEYTAVIN J.F. 1989, Méthodologie du diagnostic d'insécurité pour aider a la conception de la politique de Sécurité Routiére d'un département: application au cas de l'Eure et Loir. Rapport Final d'activité. Convention d'étude D.S.C.R./INRETS 1988 Théme no6

FLEURY D.1990, La prise en compte des activités dans la conception des véhicules et des infrastructures routiéres. In J. Leplat et G. de Terssac (Eds),"Facteur humain de la fiabilité" , OCTARES, pp 311-329

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

FLEURY D. & SAAD F. 1992, Driver behaviour and accidents at controlled traffic junctions. International Conference of Road Safety in Europe (FERSI), Berlin, 30 september-2 October, 1992 (To be published)

FONTAINE H., MALATERRE G. & VAN ELSLANDE P. 1989, Evaluation de l'efficacité potentielle des aides à la conduite. Rapport INRETS., No23

GROEGER J.A. & GRANDE G.E. 1991, Too little too soon: limitations on training and the need for continuing drivert support. In Y. Queinnec & F. Daniellou (Eds.), Designing for everyone, Proceedings of the 11th congress of the International Ergonomics Association (Vol. II). London: Taylor & Francis Ltd.

HAUER E., NG J. C. N., LOVELL J. AND MORRIS CN. 1988, Estimation of safety at signalized intersections (with discussion and closure). Transportation research record Washington DC. Serial 1988-01-01 n¡1185 p48-61

JOERGENSEN N.O. 1988, Risky behaviour at traffic signals : a traffic engineer's view. Ergonomics , 31, 657-661

LASSARRE S. 1989, Le véhicule futur et les aides à la conduite. Recherche Transports Sécurité, 23, 57-60.

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

LEPLAT J. 1985, Erreur humaine, fiabilité humaine dans le travail. Armand Colin, Collection U. Paris.

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

MALATERRE G. & SAAD F. 1984, Contribution â l'analyse du contrôle de la vitesse par le conducteur: Évaluation de deux limiteurs - Cahiers d'études ONSER., No 62

MALATERRE, G. & SAAD, F. 1986, Les aides à la conduite; définitions et évaluation. Exemple du radar anti-collision. Le Travail Humain, 49, 4.333-346

MALATERRE, G. 1990, Error analysis and in-depth accident studies. Ergonomics, 33, 10-11, 1403-1421

MALATERRE, G. & FONTAINE, H. 1992, Les aides à la conduite : quels enjeux pour la sécurité. Recherche Transports Sécurité, 35, 43-54

MAZET, C., DUBOIS, D., FLEURY, D. 1987, Catégorisation et interprétation de scénes visuelles: le cas de l'environnement urbain et routier. Psychologie Franéaise, Numéro spécial sur l'environnement, 85-96

MAZET, C. 1991, Perception et action dans la catégorisation. Le cas de l'environnement urbain et routier. Thése pour le doctorat d'université. Université Paris V- EPHE, Laboratoire d'ergonomie physiologique et cognitive

MAZET, C. & SAAD, F. 1990, Contribution de l'ergonomie cognitive aux changements technologiques dans le domaine de la conduite automobile. Sixième Congrès International de l'Association de Psychologie du Travail de Langue Francaise. Université Libre de Bruxelles, Belgique, 14-16 Mai 1990

MICHON, J.A. 1985, A critical view of driver behavior models : What do we know, what should we do ? In L. Evans & R.C.Schwing (Eds) ,Human behavior and traffic safety, Plenum Press, New York.

MICHON, J.A., SMILEY, A. & AASMAN, J. 1990, Errors and driver support system. Ergonomics, 33, 10/11, 1215-1229

NEBOIT, M. 1977, l'analyse psychologique des tâches et la définition des objectifs de la formation. In C. Blanchard & M. Neboit Cahier d'Etude ONSER, No56

NEBOIT, M. 1982, L' exploration visuelle du conducteur: rôle de l'apprentissage et de l'expérience de la conduite. Cahier d'Etudes ONSER, N¡ 56

NORMAN, D.A 1983, Some observations on mental models.- In: Gentner, D.,Stevens, A.L., Mental models. 7-14, Hillsdale, New Jersey, London

PRASHKER J.N., MAHALEL D. 1989, The relationship between an option space and driver's indecision at signalized intersection approaches. Transportation research. vol 23B n¡6 p.401-413 Pergamon press Oxford UK

ROBERTSON S. 1991, Driver behaviour at traffic signals. Proceedings of a seminar at Nottingham University 26-27 Sept. TRRL. UK P99-107

REASON, J.T., MANSTEAD, A.S.R., STRADLING, S.G., BAXTER, J.S. & CAMPBELL, K.1990, Errors and violations on the road: a real distinction ? Ergonomics, 33, 10 and 11, 1315-1332

SAAD, F. 1975, Structuration de la tache et activités perceptives dans la conduite automobile. Document interne ONSER

SAAD, F. 1989, Risk-taking or danger misperception Revue-Transport -Sécurité, English issue, No 4

SAAD, F. & MALATERRE, G. 1989, Evaluation et conception d'aides à la conduite automobile. Aspects théorique et méthodologique. Actes du congrès de la SELF

SAAD, F., DELHOMME, P. & VAN ELSLANDE, P. 1990, Driver's speed regulation when negotiating intersections. In Masaki Koshi (ed), Transportation and Traffic Theory, Elsevier

SAAD, F. & MAZET, C. 1991, Analysis of road situations and drivers' activity in a perspective of cognitive ergonomics. In Y. Queinnec & F. Daniellou (Eds.), Designing for everyone, Proceedings of the 11th congress of the International Ergonomics Association (Vol. II). London: Taylor & Francis Ltd.

SAAD, F. 1991, In-depth analysis of interactions between drivers and the road environment: contribution of on-board observations and subsequent verbal reports.In Proceedings of the 4th Workshop of ICTCT, University of Lund, Bulletin 110.

SAAD, F. 1992, Conduite en file : Représentations des situations critiques selon l'exp□rience des conducteurs. Rapport Final de convention INRETS-ISIS.

SCHLESINGER 1972, Human factors in driver training and education. In T.W. Forbes (Ed),.Human factors in highway traffic safety research

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

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.No 23

VAN ELSLANDE, P. & LUBER, F. 1991, The driving situation - errors of interpretation, outline of a formalization. In Y. Queinnec & F. Daniellou (Eds.), Designing for everyone, Proceedings of the 11th congress of the International Ergonomics Association (Vol. II). London: Taylor & Francis Ltd.

VAN ELSLANDE, P. & NACHTERGAELE, C. 1992, Aides à la conduite et fonctionnement du conducteur en situation - L'accident de la route comme révélateur des limitations potentielles à la prise en compte des aides informatives. Rapport INRETS.No 149

12. FUTURE SAFETY GAINS AND SAFETY PROBLEMS CONNECTED TO NEW TECHNOLOGIES

A STUDY BASED ON EXPERT INTERVIEWS IN THE FRAME OF *PROMETHEUS*

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12.1 INTRODUCTION

PROMETHEUS is a EUREKA project were European car industry and scientists from universities as well as other scientific institutions are working together. The main targets of this project are

- making traffic more safe.
- harmonize traffic flow,
- increase the efficiency of travel and transport management.

The study presented here is a part of a bigger project in the frame of a PROMETHEUS project the author and Ralf Risser were involved in.

12.1.1. PRO-SAFE, The Safety group within PROMETHEUS

Our part in this project is the participation in a group called PRO-SAFE, the safety-group, consisting of engineers, and social scientists. One of the main activities of the group till now was to assess the different technical and electronical systems, which are produced by industry and which are in no case more than prototypes by now, with respect to their safety impacts and to their possible negative side-effects.

We also were involved in the creation of the socalled *Traffic-Safety-Checklist* which is now computerised. The idea of the checklist is to motivate scientists e.g. engineers who try to create a special technical system to think about different possible outcomes and side-effects of the product under discussion. This means that producers of new technologies should also think about e.g. unprotected roadusers and the influence of their product on behaviour of all road users, on life-quality etc..

12.1.2 Traffic is a social system

We think that an important contribution to the work of the safety group of us as social scientists is to make the others aware of the fact that traffic is mainly a social system. In this system behaviour of all road users is to be taken into consideration. Behaviour cannot be programmed like some technical systems.

An example for the importance of a social scientist being involved in discussions about future traffic is the fact that a group of engineers working out such scenarios of future traffic to start with did not consider pedestrians and cyclists. The role of the social scientist, among others, is to detect and deal with problems deriving from the fact that the needs of certain groups are not considered adequately.

12.1.3. New technologies - new behaviour?

Another part of our work especially for the Austrian sponsors was to find out which tasks and problems road users of future traffic will have to solve and if they will have to learn new behaviour in order to be able to participate in traffic correctly and safe.

For example, there will be different levels of intervention in driving activities by different vehicle equipment:

- information warning
- recommendation
- mandatory order
- automatic intervention
- automated driving

Some of the new technologies will strongly interfere with the activities of the drivers. E.g., if braking will be done by the system to keep distance in certain situations, nobody knows till now, how drivers will react to this and if and how they will accept this interference by the machine.

12.2. INTERVIEWS WITH TRAFFIC SAFETY EXPERTS AND ENGINEERS FROM INDUSTRY

Regarding these coming possible changes in the traffic system it seemed interesting for us to know about the opinion of traffic safety experts on the one hand and engineers from industry on the other hand. We wanted to know

- if there were different points of view regarding the efficiency and the safety gains of new technologies
- how both groups assess the role of engineers in relation to social scientists in the frame of designing new technical systems
- if engineers show relevant lack of interest regarding social psychological aspects of traffic behaviour.

So we interviewed members of the safety group (=safety experts) and some engineers from car and supplier industry.

Why these two groups?

Members of the safety-group are experts coming from different scientific areas (engineers, social-scientists, economists, physicians etc.). They are involved in safety projects since many years. They have been meeting each other for several times since the founding of the PRO-SAFE group and therefore used to work interdisciplinarily.

The engineers from industry are involved in mainly technical problems which are sometimes only scarcely related to general safety ideas. Most of them work together with other engineers but seldom with social-scientist or persons from other scientific disciplines.

12.3. TOPICS OF THE INTERVIEW AND MAIN RESULTS

The questions of the interview concentrated on various topics.
The whole questionnaire will be added in the appendix of this contribution.

a) The importance of the role safety plays in the frame of one's own work

Although both groups know the difference between objective and subjective safety, in both groups accidents are looked at as the most important criterion for unsafety. Only two members of PRO-SAFE mention that an unsafe feeling of road-users can be regarded as a hint for unsafe traffic.

b) The point of view about

- *the role of engineers regarding traffic safety work*
- *their responsibility regarding the outcome of engineer's products (liability regarding products)*
- *communication and possible problems with other scientific disciplines (e.g. social scientists)*

Both groups think that the "voice" of the engineer is not taken into account by the public or media as it should be. Two examples: Both groups are of the opinion that journalists for example only hear what they want to hear. Manuals are not read by users correctly, mostly they are not read at all, so as a matter of fact, technical systems sometimes are used incorrectly.

The group of engineers of industry is more longing for information exchange with other disciplines (social scientists and juridical people) than the members of PRO-SAFE. This is not astonishing because the safety group already consists of representants of different scientific groups.

With respect to questions concerning responsibility of the engineer regarding his products the opinion differs in very much both groups: We received such different statements os, e.g.,

- there is no responsibility at all
- the product should be as safe as possible but how to use it is a matter of the driver´s responsibility
- there is total responsibility of the producer of technical systems

Concerning possible consequences of technical systems, there exists a very new Austrian study that shows the opinion of about 400 engineers of different engineering areas of them think that they are not responsible at all for their work and that science is free. But the study also says that the more engineers were not only working scientifically but of applied technology critically about their work and the more they thought that they had to consider possible unintended side-effects of their work.

c) *The awareness about the fact that traffic is a system consisting of the interfering components man-machine-environment*

Regarding this topic knowledge and consciousness about the importance of this point differ very much between both groups.

Engineers from industry seem to know that there are some interfering system components but the components machine and environment are dominant. Traffic is not seen as a social system. Not so within the PRO-SAFE group. They don´t look at traffic reality heavely in a "technical" kind of way, although the group consists also of engineers.

d) *The knowledge about other safety criteria than accidents*

The group of the engineers of industry stated that they were very much interested in all kinds of safety criteria other than accidents. But they did not know where to get informations. Their bosses did not support them at all in this respect. Therefore there has been rather few possibility for them till now to order literature or to participate at congresses dealing with all kinds of problrms connected to transport.

In PRO-SAFE, other safety criteria than accidents are well known: traffic conflicts, violations, errors, etc. However, aspects of life-quality as possible criteria are not so much taken into account.

e) *The necessity of providing for special aids for participation in traffic (including pedestrians, cyclists, all other non-car drivers)*

In both groups there exist similar opinions about this. First of all, engineers from industry rather than members of PRO-SAFE think that it is technically possible to provide for help for unprotected road users. Moreover, they think that those technical inventions should be rejected which make it necessary to find special safety- and information-outfits for the unprotected road users.

f) *Knowledge and awareness of the importance of some tendencies of human behaviour when dealing with technical products like compensatory behaviour delegation of responsibility, behaviour transfer, imitation.*

Concerning different behaviour adaptation tendencies (risk compensation etc.), it could be found out that *risk compensation* was very well known by both groups. They think that it is a relevant factor of influence for road users behaviour which should be taken into account when producing technical systems.

Delegation of responsibility was seen as an important fact by the members of industry but not so much by the members of the safety group.

Concerning *ambiguity of signals* some members of both groups had not thought about it, and some others did not think about it as a relevant matter of safety work.

Both groups have similar opinions about the problem of *imitation* in traffic. They think of it as a problem only of a special group of people namely young males.

Although members of both groups know about these problems, engineers from industry till now did not think about possibilities how to warn consumers and inform them about the fact that their behaviour could be influenced by the technical system. They meant that also in the future this would be a rather unrealistic demand: Managers from car- industry and people who would sell the products lateron would not tell the public about possible side-effects. They are afraid of a rejection of the products by the consumers as a consequence of such information.

g) *The point of view concerning socialisation effects in traffic and concerning "accident proneness"*

Regarding possible socialisation effects both groups have very similar opinions:

Some of them think that there exists something like a national driving style. Some think that driving behaviour is a matter of different driving experience and not at matter of nationality.

In practice, critical behaviour is seen as being most typical for certain groups of drivers. According to their point of view, accidents are mostly found

- in the group of young males, people with lack of experience or who want to show off
- in the group of the elderly people
- and special professional drivers (freight or taxis drivers) because of their exposure

Members of the industry name some other "types" of drivers they think cause problems

- people who are aggressive
- on the contrary people who are very freightened
- and others who are stressed and/or very much in hurry.

Of course, this categorisation does not at all contradict the concept of socialisation. Aggressive behaviour, stress etc. are most certainly products of both social and individual influences.

12.4. CONCLUSION

The interviews showed that the discussion about social-psychological matters within PRO-SAFE so far has lead to the result that there exists a somewhat more complex sight of traffic than in the group of engineers of industry. Traffic is seen as a social system where human properties are taken more into account.

The interdisciplinary work in PRO-SAFE seem to be fruitful for the understanding of each other. Still, engineers in PRO-SAFE tend to try to solve traffic-problems by technical means and not by social-scientific ones like, e.g., information-strategies, feedback and tutoring, public relation work, etc.

This means that social-scientific knowledge has already found the entrance into the traffic safety world, the necessity of more discussion about it seems clear to us.

ICTCT could be a platform for discussion. It seems to be necessary to find a common language to understand each other. Being able to make ourselves understood in our group is a good precondition to make ourselves understood in public, by politicians and opinion leaders.

ACKNOWLEDGEMENTS

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REFERENCES

RISSER R. & CHALOUPKA CH. 1993, Prometheus und Sozialwissenschaften, Sozialwissenschaftliche Grundlagenarbeit im Bereich "Sicherheit" im Rahmen des EUREKA-Programmes PROMETHEUS; Forschungsbericht P8634-SOZ, FACTUM Eigenverlag, Wien

APPENDIX

a) Questions concerning traffic safety in general and the importance of the role safety plays in the frame of one's own work

- What is meant by "traffic-safety", according to your opinion?

- Do you know the difference between objective and subjectiv traffic-safety?

- Which role does safety play in the frame of your work?

- As an expert which possibilities do you see to improve traffic-safety in the frame of PROMETHEUS (or in the frame of your work)?

- Are products of your institution/company systematically analysed with respect to safety (if the products are results of research: are they evaluated?)?

- What do you think is necessary to make traffic safety work
  - a) of your institution
  - b) in general

  more efficient regarding machine, man, environment (the ideas can be utopical) - from a

  a) technical,
  b) legislative,
  c) executive point of view

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b) Questions concerning

- **the role of engineers regarding traffic safety work**
- **their responsibility regarding the outcome of their products (liability regarding products)**
- **communication (problems) with other disciplines e.g. social scientists**

- Do you think that in public (in media, in discussions with politicians etc.) the ideas of engineers/technicians connected to traffic are considered adequately?

- Do you feel need of more information exchange with experts (scientists) from other disciplines?

- If exchange allready exists, do you have the feeling that the cooperation is difficult somehow? If yes, in which sense?

- What should be changed?

- Do you think that there is responsibility from the engineers' side with respect to how the products he created are used "in the field"?
  - If yes: Where do you think are the limits of this responsibility?
  - How is this responsibility reflected or how should it be reflected, respectively?

c) Questions concerning the awareness that traffic is a system consisting of man-machine-environment

- Traffic is a system that consists of many components which influence each other (man-machine-environment) - To which degree are such system-aspects taken into account by yourself when working (e.g. do you think of <u>how</u> new products will be used in practice and to which degree this can have consequences for other road-users (e.g. pedestrians, non-equipped drivers)?

d) Questions concerning the knowledge of other safety criteria than accidents - including life-quality

* Do you feel need of special information (about accident-data, taffic conflict analyses, critical incidents, errors, behaviour-analyses, etc.) that could help you to integrate safety aspects more systematically into the products you create?

- Do concepts like "traffic-conflicts" or "behaviour/interaction" normally play a role in your work?

- When thinking about traffic-safety, do life-quality aspects play any role?

- In your opinion are there contradictions between life-quality and traffic-safety aspects?

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e) Questions concerning the necessity of providing for special help with regard to new technologies (including pedestrians, cyclists, other non-car drivers)

- Concerning the implementation of new technologies/RTI-systems in traffic in the next future: Do you think that road users will need more help for (e.g., do they have to learn new behaviour patterns, do they need new types of instructions, or feedback)?

- Who should provide for such help (e.g. driving-schools, legislation, producers, traffic-safety institutions)?

- How can it be made sure that such an equipment will be accepted, or bought and that this kind of equipment will be used in the way it was planned to be used?

f) **Questions concerning the knowledge and awareness of the importance of behaviour tendencies when dealing with technical products**

- Do you know the expression "**risk-compensation**" - what does it mean?

    - Do you have any spontaneous ideas, what could be done to avoid behaviour modification that "eats up" traffic safety?

- What does the expression "**delegation of responsibility**" mean?

    - Which new technologies could create problems in this regard?
    - What could be done to avoid them?

- In traffic we often are confronted with the problem of the "**ambiguity of signals**" - what does it mean?

    - What could be done to avoid negative effects deriving from the ambiguity of signals?

- Do you know the expression "**behaviour transfer**" - what does it mean?

    - Do you have any idea, how to tackle the problem of behaviour transfer?

- Which role does "**imitation**" play in traffic?

    - Do you think that there are people who are especially affected by imitation - both in the active and in the passive role?

    - What role could imitation play with respect to traffic safety ?

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g) **Questions about the point of view about socialisation effects in traffic**

- In your opinion, which factors influence people so that they become "typical" cardrivers (Mr. or Mrs. Austria, Sweden etc.)?

- Are there in your opinion people who create more problems in traffic than others or that are involved in accidents more than others. Do you think that there exists something like "accident-proneness"?

13. VIDEO RECORDING OF TRAFFIC ACCIDENTS

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ABSTRACT

The video recording of real-life traffic accidents in Helsinki concerns two controlled junctions in the city centre. The actual research material of this study consists of eighteen (18) accidents recorded on video tape. Ten of these are pedestrian accidents and eight are motor vehicle accidents.

Perhaps the most important lesson that can be learned from video-accidents is the central significance of so-called free vehicles. In general, neither pedestrians nor other crossing traffic collide with vehicles in queue.

The special importance of free vehicles is quite decisive when the advantanges and disadvantanges of speed control in busy city centre traffic are compared. The reduction of the highest speeds effects just those free, most dangerous vehicles, whereas the effects on travel times for the majority in queues are very small.

On the basis of the video-recorded pedestrian accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of a pedestrian death on Kaivokatu to almost one third. Travel times would be lengthened by only a few percent.

13.1 INTRODUCTION

In Finland, traffic safety has been studied much less on urban streets than on rural highways, even though urban traffic is often decisively more dangerous. The number of injurious accidents per driven kilometre on Helsinki's most dangerous business street (Kaivokatu) is about one hundred times higher when compared with the safest motorways (Fig.1).

The reason for inadequate studies in safety in urban traffic is partly due to the administrative division of research resources. However, research in an urban traffic environment is also more complex when compared with the less complicated conditions in rural traffic. In urban conditions, the separation of individual factors from the totality is somewhat difficult.

In this respect, the video recording of accidents is shown to be productive. As far as is known, such a system has not been used before.

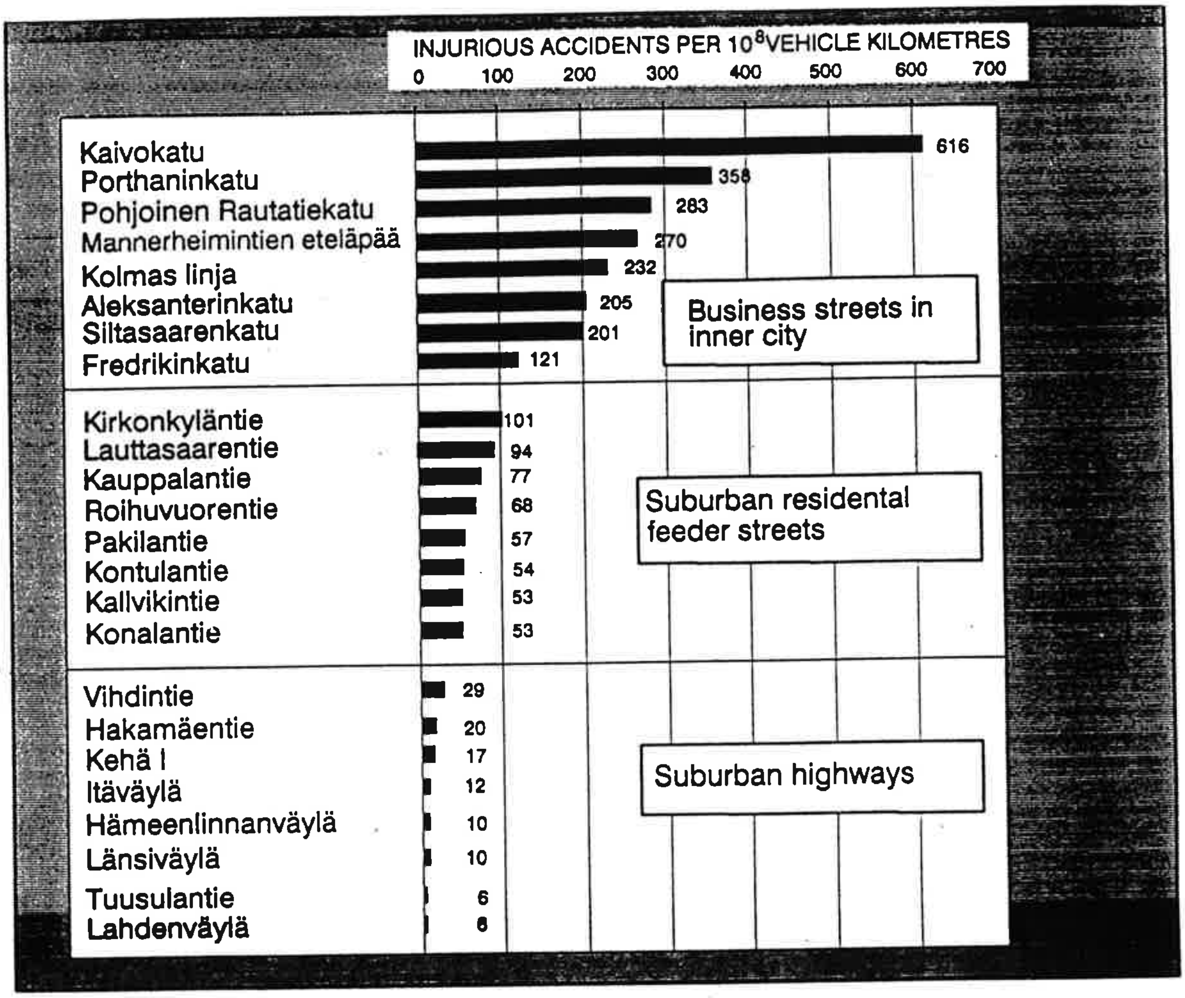


Figure 1: Injurious accidents per driven kilometre for various carriageways in Helsinki.

13.2 RESEARCH METHODOLOGY

13.2.1 Junctions under study

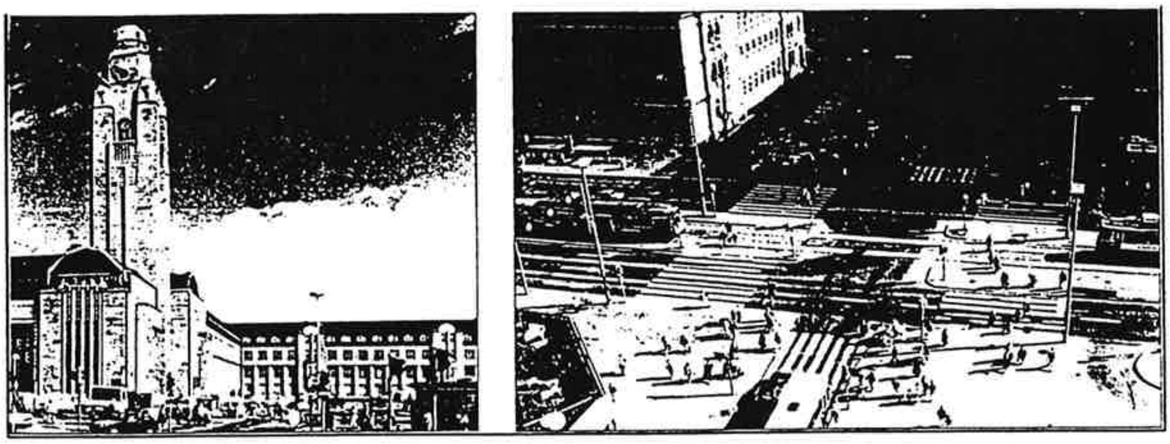
The video recording concerns two intersections in the centre of Helsinki:

- Kaivokatu/Keskuskatu
- Kaivokatu/Mannerheimintie/Simonkatu

In February 1991, a video camera was installed on the clock tower of Helsinki's central railway station to film traffic at the junction of Kaivokatu and Keskuskatu. The camera is connected to a continuously-running video recorder which automatically rewinds and records on top of the previous recording. Consequently, a record of events of the last three hours is always available on tape.

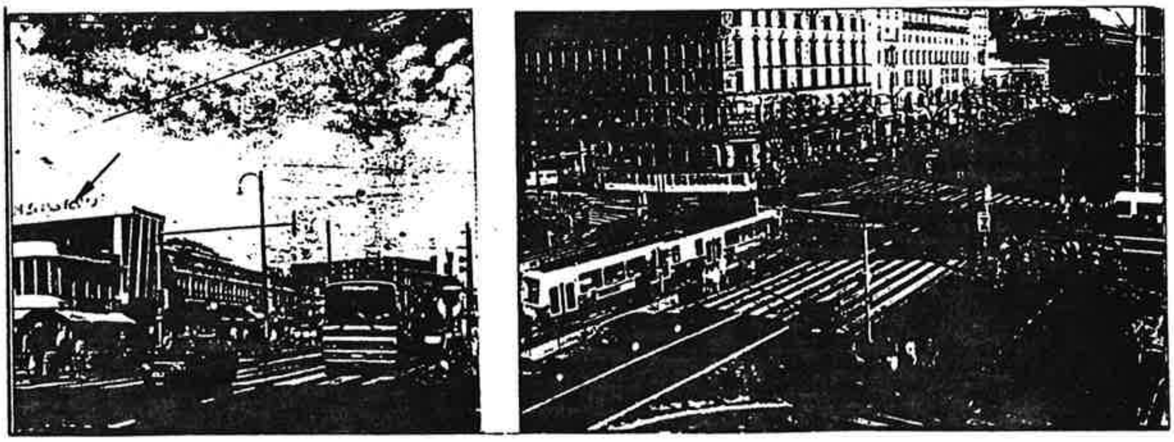
The recorder is located in police premises at the central railway station where a 24-hour duty roster is maintained. When the alarm centre is informed of an accident at the junction in question, they contact the railway station police who then retrieve the tape, replace it with a new one, and deliver the accident tape to the Traffic Planning Division.

Figure 2: Camera and field of view on Kaivokatu



Since November 1991, a similar recording system has been operating at the junction of Kaivokatu, Mannerheimintie and Simonkatu. The recorder is located in the control centre of the Helsinki Traffic Authority and the camera on the roof of the building.

Figure 3: Camera and field of view on Mannerheimintie

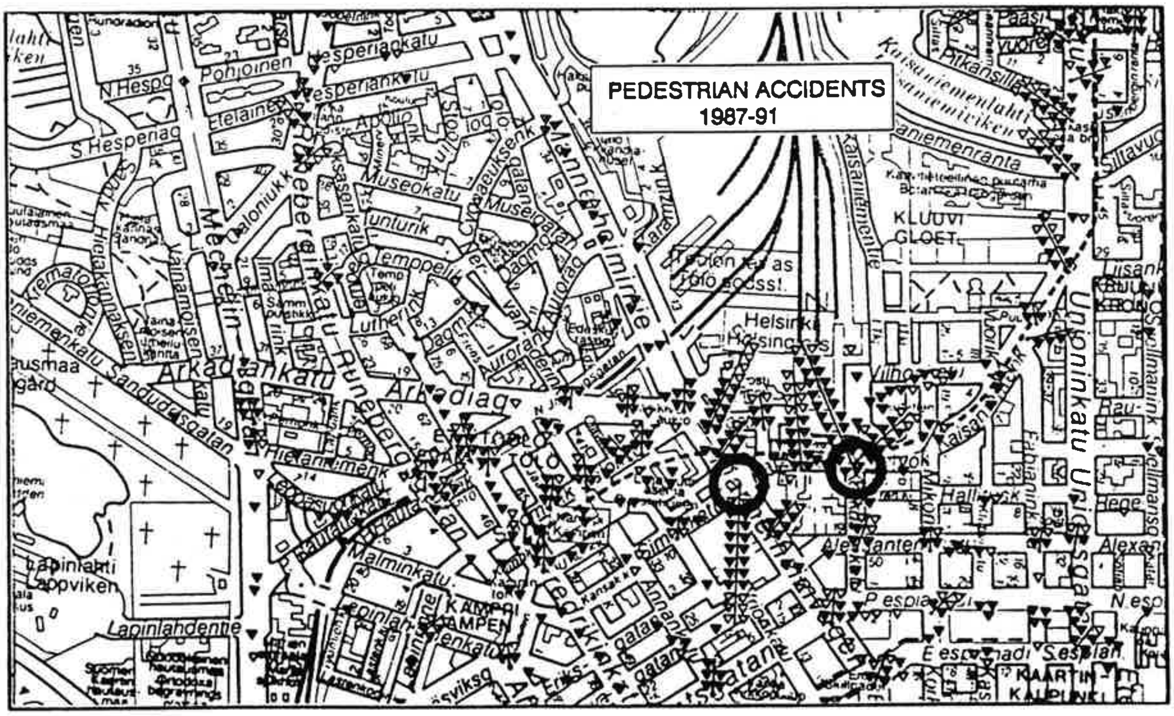


The junctions in question were selected as points of study for two reasons. Firstly, at both points the video recorder can be kept on premises which are close to the camera and which are manned round-the-clock. In addition, for many years both junctions have been among Helsinki's worst pedestrian accident black spots.

Table 1: Some data for the junctions under study

	Kaivokatu/Keskuskatu	Mannerheimintie/Simonkatu
Traffic volume (veh/day)	32 500	35 000
Share of crossing traffic	16 %	38 %
Speed limit change 1.3.1992	50 - 40 km/h	50 - 40 km/h
Pedestrian crossings (ped/day)	50 000	80 000
Pedestrian accidents 1986-90	29	25
All accidents 1986-90	81	97

Figure 4: Junctions under study



13.2.2 Research material

The actual research material of this study consists of eighteen (18) traffic accidents recorded on video tape up to 1.9.1992. Ten of these are pedestrian accidents and eight are motor vehicle accidents.

Of the eighteen accidents under review, 15 occured at the junction of Kaivokatu/Keskuskatu and 3 at the junction of Kaivokatu/Mannerheimintie/Simonkatu.

According to police reports, 33 accidents and 13 injurious accidents occurred at the junctions in question during the time of recording (see table 2). Consequently, about half of all accidents and close to 80 % of the injurious accidents were captured on videotape.

Some of the unrecorded accidents were reported to the police not until a long time after the actual accident event. Other shortcomings are due to unknown interruptions in information transfer.

Due to the central location of the two junctions under study, the portion of pedestrian accidents that occur at night and which involve the consumption of alcohol is greater in the video-accidents than in the accidents in the whole inner city on average.

Table 2: Accident types in the video-research material and in all police reported accidents (the latter ones in parentheses).

	Injurious accidents	Damage-only accidents	Totals
Pedestrian accidents	10 (12)	- (3)	10 (15)
Rear-end collisions	- (1)	3 (6)	3 (7)
Crossing accidents	- (-)	2 (4)	2 (4)
Other accidents	- (-)	3 (7)	3 (7)
Totals	10 (13)	8 (20)	18 (33)

The course of events of the video-accidents can be followed from the tapes at intervals of 0.02 seconds. Vehicle speeds are measured with the aid of a scale made by computer graphics and copied onto the accident tapes. The records of police interrogations have also been available.

Details of the video-recorded pedestrian accidents are shown in appendices 1-10. Accidents involving motor vehicles only are shown in figure 9.

13.2.3 Reference traffic

One of the strong points in favour of this method of research is the possibility to compare the behaviour of the accident vehicles to the normal traffic flow under the same conditions.

The characteristics of reference traffic are acquired from the video tapes by measuring the speed and the position in the traffic flow of 30 vehicles travelling in the same lane prior to each accident.

13.3 RESULTS

13.3.1 Free vehicles

Traffic flow is considered to be free, if vehicles do not effect each other's driving speed to any noteworthy degree. In this study, a vehicle is defined as free if the time interval to the previous vehicle in the same lane is more than 3 seconds.

As expected, in the three rear-end collisions vehicles in queue were involved. In **all** other 15 accidents only free vehicles were involved, though only 40 % of the reference traffic consists of free vehicles. This difference between collision vehicles and other traffic is statistically very significant and means that free vehicles mainly determine the safety level of the junctions in question.

Neither pedestrians nor other crossing traffic generally collide with vehicles in queue.

13.3.2 Pedestrian accidents

Pedestrian behaviour

All ten video-recorded pedestrian accidents occurred at the zebra crossings of the junctions (see Appendicies 1-10). The traffic signals were fully operational in each accident.

In eight cases, the vehicle was driving straight and in two cases the vehicle was turning. In both of the accidents with turning vehicles (see Appendicies 8 and 9), a green light showed for both the pedestrians and the vehicles. The vehicles had a duty to give way.

In all eight accidents involving vehicles which were driving straight through, the pedestrian crossed against a red light. In five cases the pedestrian was under the influence of alcohol.

It is not possible to establish, for example, the head movements of the pedestrians on video tape. However, on the basis of the pedestrians' other behaviour and records of police interrogations, it is probable that those pedestrians who walked or ran against a red light made no appraisal whatsoever of approaching traffic. The question was thus not one of conscious risk taking and of failure in estimating one's own actions or the actions of the vehicles.

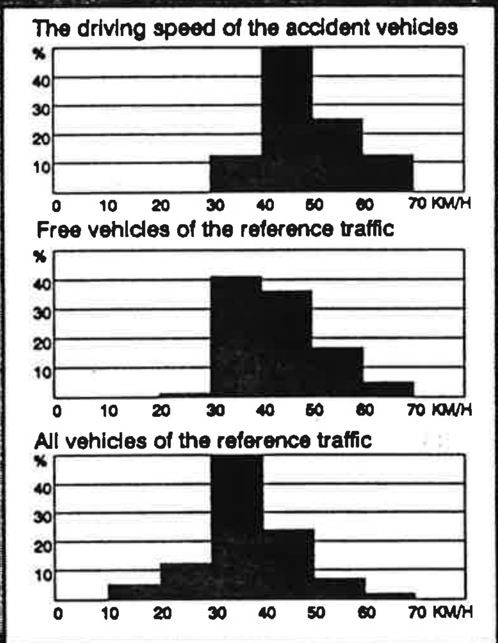
13.3.2 Speeds of collision vehicles

Figure 5 shows the driving speeds (before the accident event) of the eight collision vehicles which drove straight. For reference traffic, the average speed at the point of collision is shown for all vehicles and for free vehicles.

The speed for collision vehicles was on average 47 km/h, i.e. 9 km/h faster than the average speeds for all reference traffic. With the exception of one accident, the speed of the collision vehicles was also higher than the average speed of free vehicles in the reference traffic.

Figure 5: Speeds for accident vehicles (driving straight) and for reference traffic.

APPENDIX	Driving speed of the accident vehicles	Average speed of reference traffic	
		Free vehicles	All vehicles
1	50	45	42
2	40	36	24
3	62	48	47
4	48	39	39
5	50	46	32
6	53	43	39
7	33	43	42
10	43	40	37
AVERAGE	47	43	38



If it is desired to estimate the influence of the driving speed on the probability of a pedestrian accident, a comparison between the speed of the collision vehicles and the speeds of all reference traffic is not correct. The accident risk for a vehicle obviously depends more on its position in the traffic flow (free/not free) than on its speed. For that reason, comparisons must be made with free vehicle speeds.

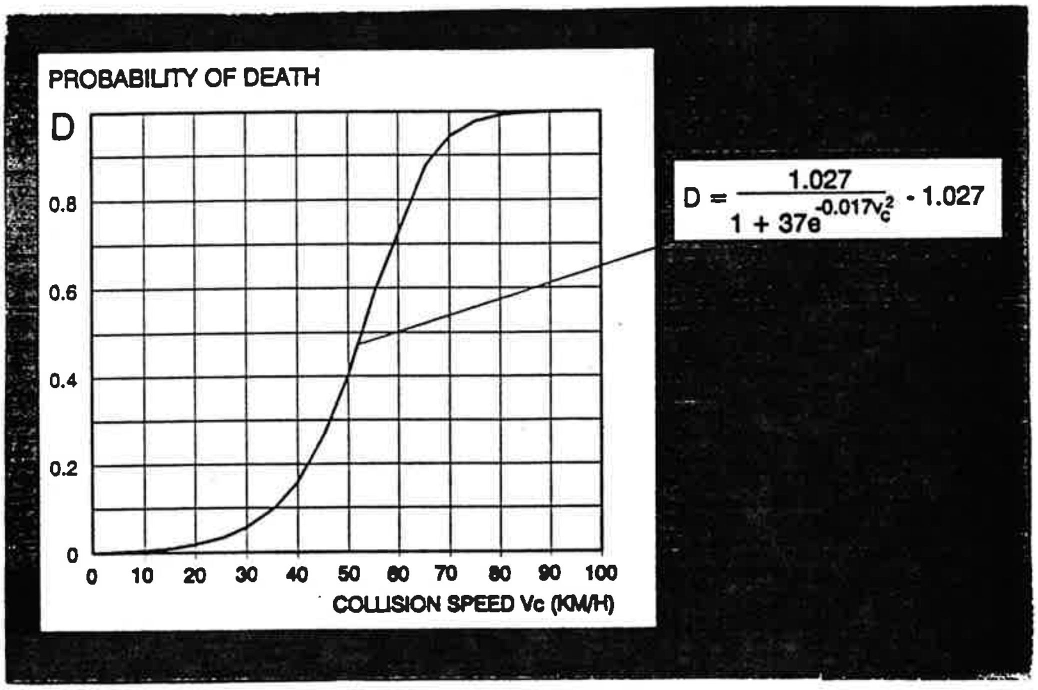
Almost 40 % of the collision vehicles and a good 20 % of the free vehicles in the reference traffic were driving at speeds over 50 km/h. From this it could be calculated that the probability to become involved in a pedestrian accident at a speed over 50 km/h has been more than double when compared with a speed under 50 km/h. It should be noted, however, that for this kind of comparison 8 accidents is statistically a very modest number.

13.3.3 The effect of speed changes on safety

For many reasons, an increase in driving speed increases the probability of a pedestrian accident. A much more important safety factor is, however, the influence of driving speed on collision speed and, through it, on the severity of the accident.

The interdependence between the collision speed and the severity of the accident (probability of death) in car/pedestrian accidents is shown in figure 6[1].

Figure 6: The influence of the collision speed on the severity of a car/pedestrian accident.



Changes in the probability of death can be thought of as a rough indicator of changes in the overall safety of pedestrians. There are three reasons for this:

- The reduction of fatalities is generally considered to be a fundamental objective of traffic safety work

- The cost of a traffic fatality is estimated to be 50 times higher when compared with the average injury[2)]

- In principle, the changes of collision speed have a similar kind of S-shaped influence on the probability of a severe injury as on the probability of death.

1) Pasanen E. 1992 Driving Speeds and Pedestrian Safety A Mathematical Model Helsinki, University of Technology, Transportation Engineering, Publication 77, Otaniemi 1992.
2) An estimate of the Finnish Road Administration.

In March 1992 a 40 km/h speed limit was introduced on most of the residental and business streets in the inner city of Helsinki.

Figure 7 shows the measured driving speed and collision speed as well as the corresponding probability of death in each pedestrian video-accident. The table also shows the estimated collision speed and the corresponding probability of death had the driving speed not been higher than 40 km/h. The estimates have been made assuming a driver's brake reaction time of one second (see Appendix 11).

Figure 7: The theoretical effect of a maximum speed of 40 km/h on the video-recorded pedestrian accidents.

APPENDIX	Accident vehicles			Max. speed 40 km/h		
	V	Vc	D	V	Vc	D
1	50	37	0.12	40	10	0.00
2	40	40	0.16	40	40	0.16
3	62	50	0.39	40	0	0.00
4	48	33	0.08	40	14	0.01
5	50	31	0.06	40	0	0.00
6	53	53	0.50	40	40	0.16
7	33	33	0.08	33	33	0.08
8	18	18	0.02	18	18	0.02
9	30	30	0.06	30	30	0.06
10	43	36	0.10	40	29	0.06
AVERAGE PROBABILITY OF DEATH			0.157	→		0.055

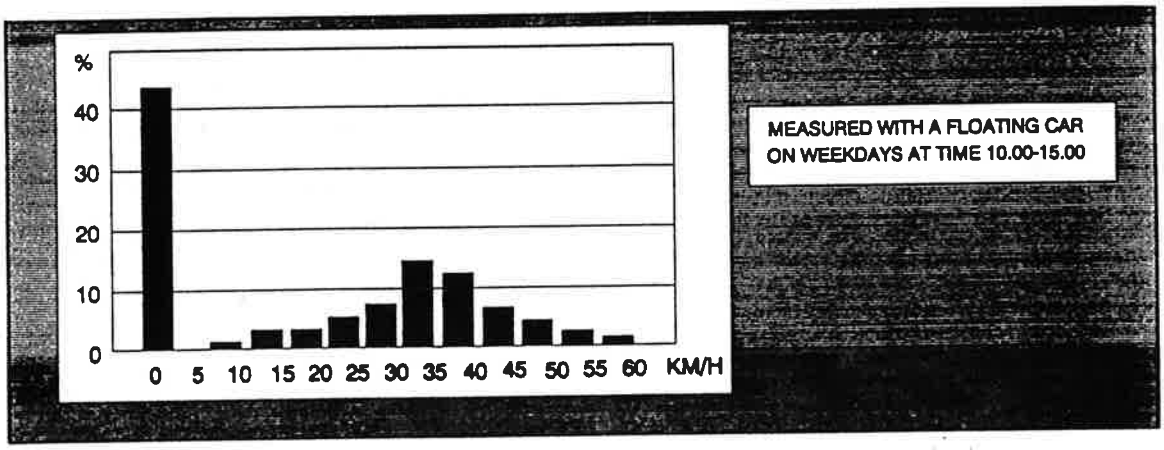
V = DRIVING SPEED
Vc = COLLISION SPEED
D = PROBABILITY OF DEATH

Figure 7 shows, that of the ten pedestrian accidents two would have been totally avoided (collision speed=0), if none of the vehicles had been driving faster than 40 km/h. The average probability of death would have been reduced from 0.157 to 0.055, i.e. to almost one third. This evaluation, however, includes the possibility for error influenced by vehicle type and point of collision.

There is one tram and one scooter included among the vehicles in the pedestrian video-accidents. However, figure 6 is based on accidents between cars and pedestrians. Furthermore, in figure 6 the background material comprises only direct front collisions, when the point of collision in the video-accidents was often the vehicle's front corner.

On the basis of the video-recorded accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of death of a pedestrian on Kaivokatu to almost one third. This estimate includes many factors of uncertainty. It is nevertheless a result worthy of attention, when it has been established that travel times would be lengthened by only a few percent (see Figure 8).

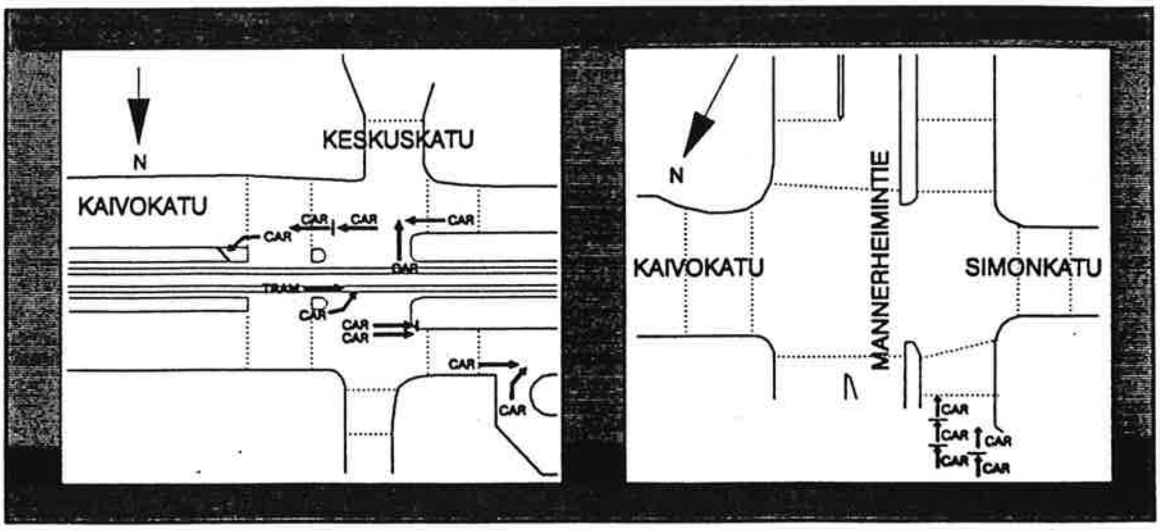
Figure 8: Travel speeds (share of total travel time) on Kaivokatu.



13.3.3 Accidents between motor vehicles

Figure 9 shows video-accidents between motor vehicles. Because of the diversity of accident types and the poor sampling fraction of these accidents (see Table 2), no specific analyses are made. However, it can be mentioned that, with the exception of rear-end collisions, in all the other accidents only so-called free vehicles were involved.

Figure 9: Video-recorded motor vehicle accidents at the junctions of Kaivokatu/Keskuskatu (6 accidents) and Kaivokatu/Mannerheimintie/Simonkatu (2 accidents).



13.4 CONCLUSIONS

13.4.1 Free vehicles, a decisive safety factor in city centre traffic

Perhaps the most important lesson that can be learned from video-recorded accidents is the central significance of the so-called free vehicles, i.e. vehicles not in queue. In general, neither pedestrians nor other crossing traffic collide with vehicles in queue. This is in itself natural, since a continuous flow of traffic in the field of vision is undoubtedly a more efficient warning signal than any sign or regulation. However, the significance of free vehicles is not apparent from conventional accident reports of police or of investigative teams.

When the influence of various factors on traffic safety is studied, the number of accidents is traditionally compared to the vehicle mileage. Results have often been unclear and even conflicting. One reason for this may be that the traffic volume and the number of free vehicles are different things.

For example, if we were to study the influence of darkness on the risk of accidents, we could easily go astray if we did not bear in mind that at night the share of free vehicles is usually much greater than during the day.

The special importance of free vehicles is quite decisive when the advantages and disadvantages of speed control in busy city centre traffic are compared. The reduction of highest speeds effects just those free, most dangerous vehicles, whereas the effects on travel times for the majority in queues is rather small.

13.4.2 Pedestrian behaviour

In pedestrian accidents, a pedestrian rarely tries to cross a street consciously between a short gap and fails through the miscalculation of his own or some other person's performance.

Pedestrians who cross a street are, for various reasons, sometimes momentarily in such a state or situation where they do not think at all of approaching vehicles. An accident occurs if the vehicle happens to be on the 'right' spot, travelling at the 'right' speed.

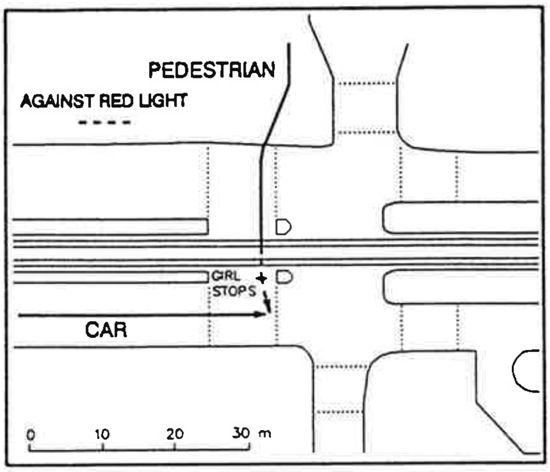
This offers a pessimistic outlook on the possibility to reduce pedestrian accidents by improving pedestrian behaviour. If even the threat of loss of life does not prevent the pedestrian from behaving quite thoughtlessly, how can education or the threat of a fine become a more effective deterrent?

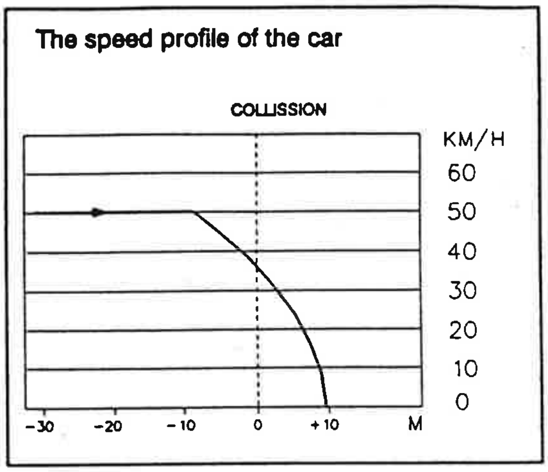
13.4.3 Speed kills

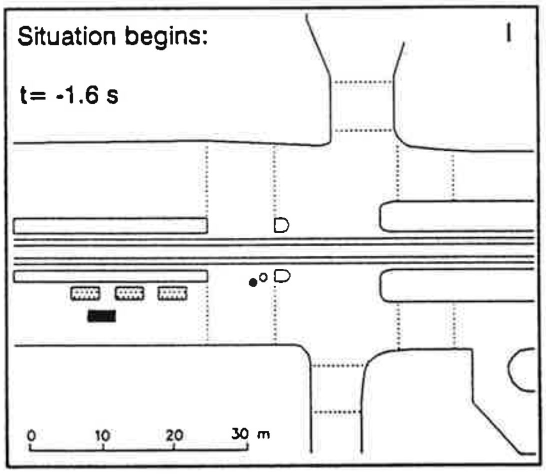
On the basis of the video-recorded accidents, it is estimated that a strict adherence to the new 40 km/h speed limit would reduce the probability of death of a pedestrian on Kaivokatu to almost one third. This estimate includes many factors of uncertainty. It is nevertheless a result worthy of attention, when it has been established that travel times would be lengthened by only a few percent.

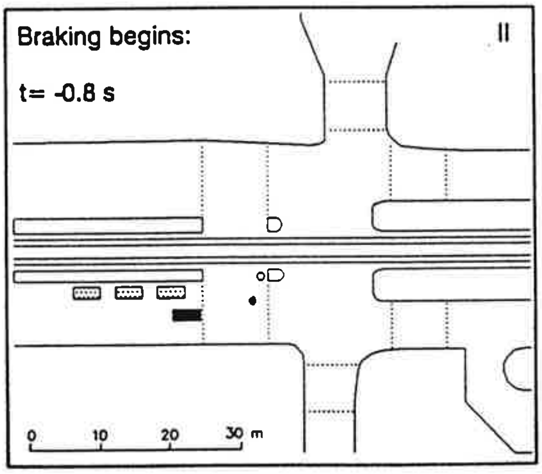
Appendix 1

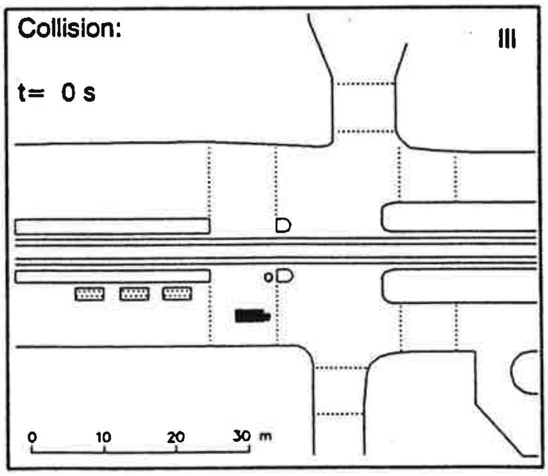
PEDESTRIAN CAR Wednesday 13.2.1991 at time 14.13
Two 14-year-old girls crossed the Kaivokatu pedestrian crossing and stopped at the central reserve when the pedestrian signal turned to red. Suddenly, one of the girls ran across the street against the red signal. A car proceeding along Kaivokatu just managed to begin to brake but collided with the girl, who then struck the bonnet and windscreen and was knocked forward ahead of the car. The girl suffered only minor physical injuries.

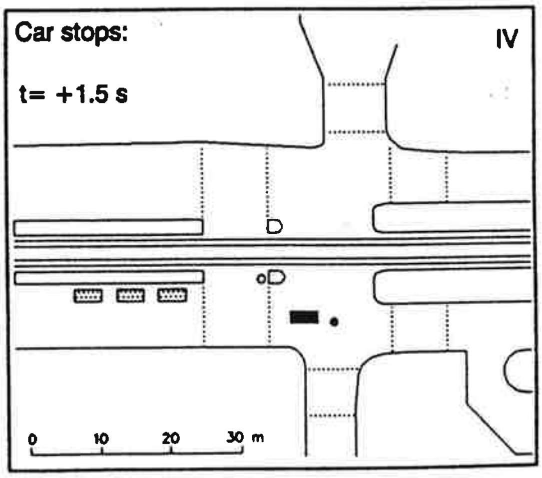






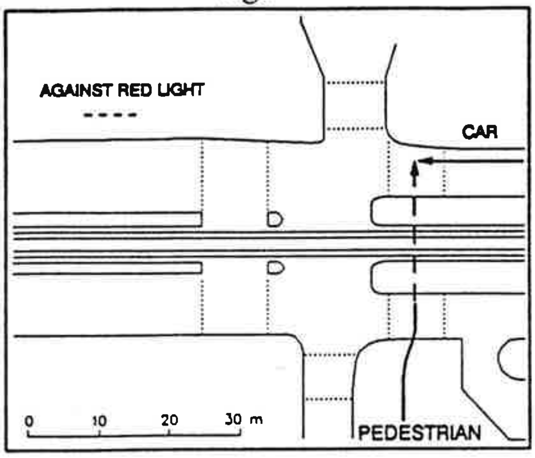


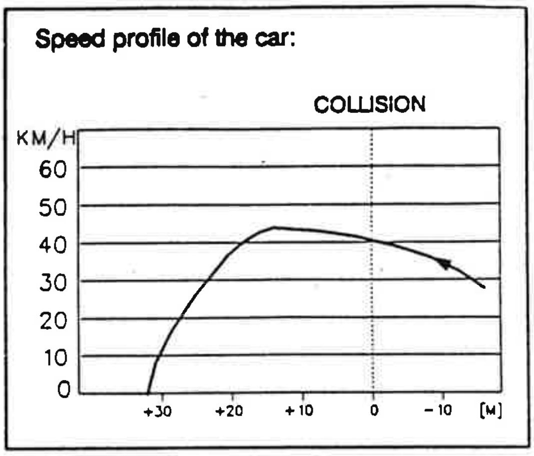


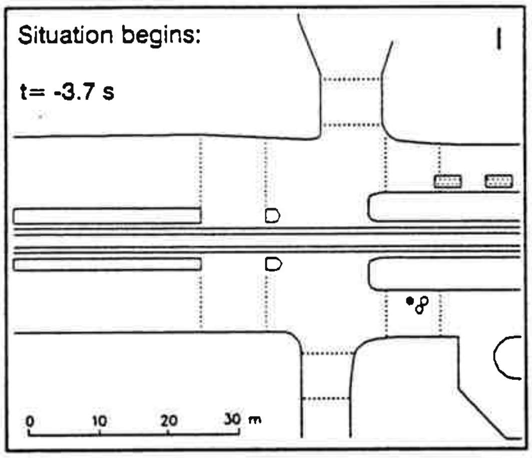


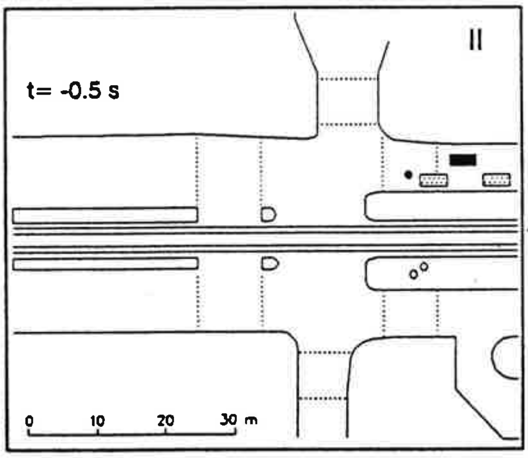
Appendix 2

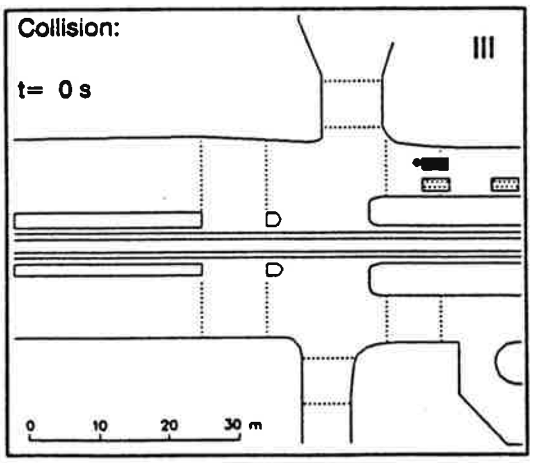
PEDESTRIAN/CAR Tuesday 12.3.1991 at time 00.12
A young man with his friends was crossing the first carriageway of Kaivokatu on the way from one restaurant to another. When the pedestrian signal changed to red, he began to run to get across the second carriageway before a stationary car starts off. A cab in the adjacent lane came from beyond the stationary car and collided with the pedestrian who was thrown via the cab`s right front corner onto the sidewalk. The pedestrian fractured his hand and suffered slight bruises to his face and legs.

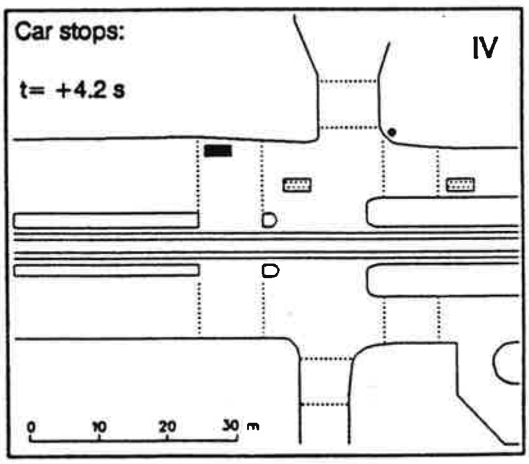






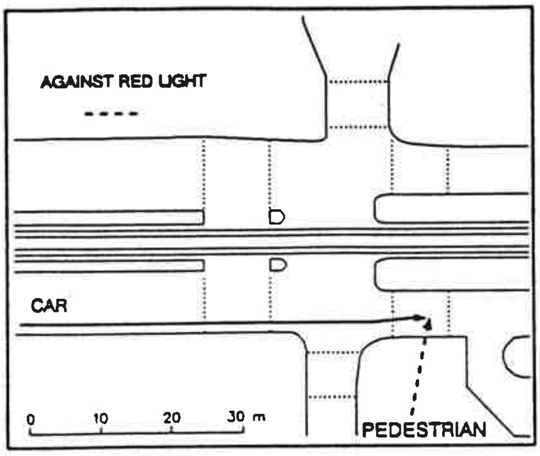


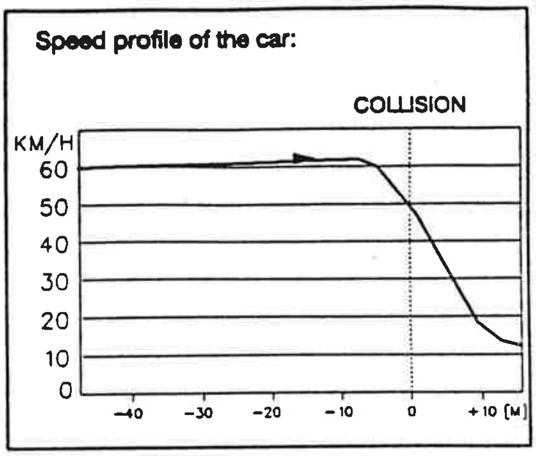


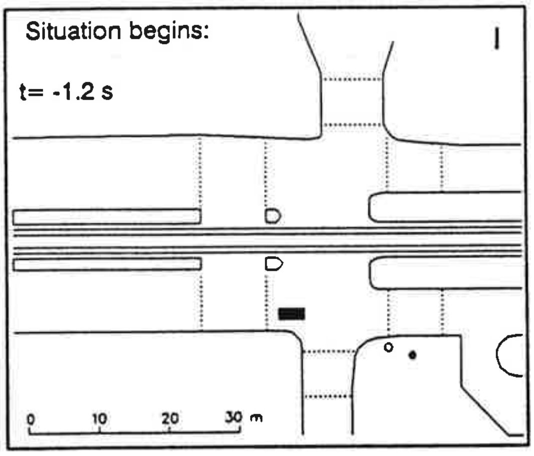


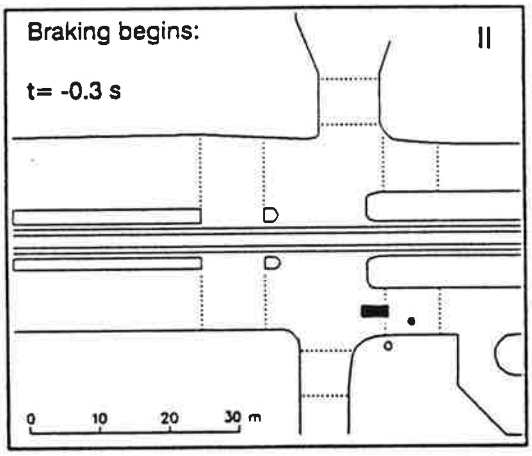
Appendix 3

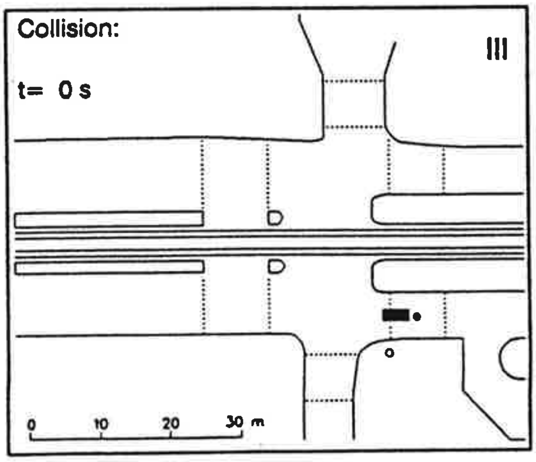
PEDESTRIAN/CAR Wednesday 17.4.1991 at time 00.17
A 15-year-old girl runs after her friends, who are waiting at the Kaivokatu tram stop. A few meters before the zebra crossing she accelerates and runs against a red signal into the path of a cab approaching from the left. The girl was under the influence of alcohol. The driver tried to swerve to the left and managed to begin to brake just before colliding. The cab`s windscreen was broken in the collision but the girl survived with slight injuries.

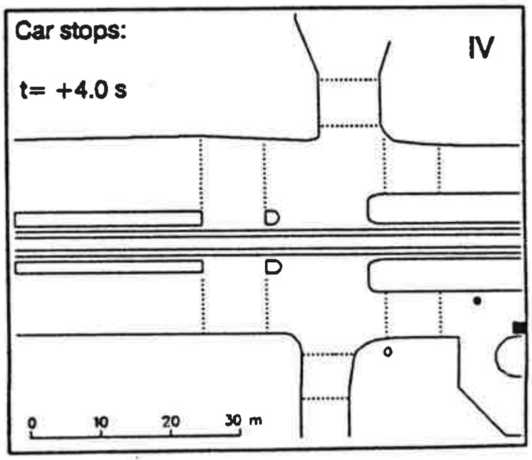






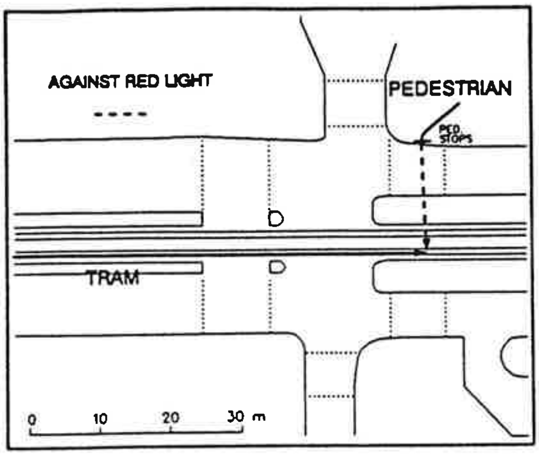


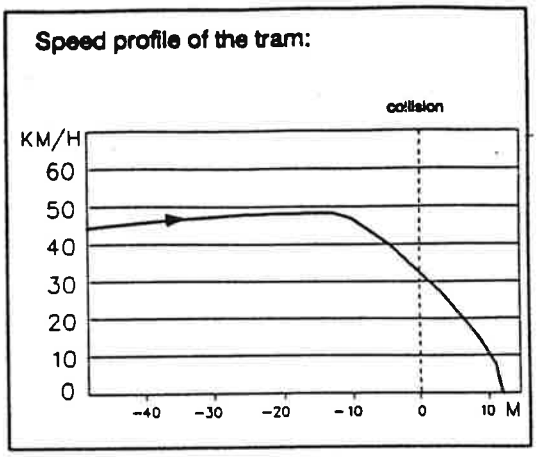


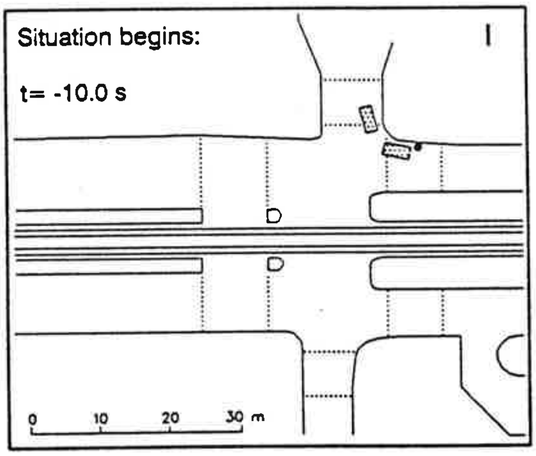


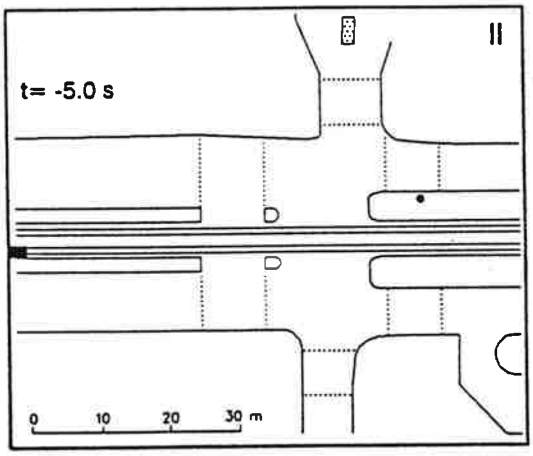
Appendix 4

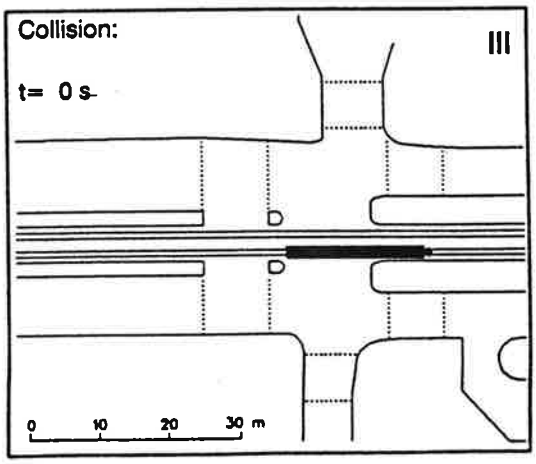
PEDESTRIAN/TRAM Wednesday 26.5.1991 at time 00.28
A young man begins to cross Kaivokatu against the red signal. He walks steadily across the carriageway and straight on in front of a tram. He suffers fatal head injuries after striking the front of the tram. The driver gives a warning signal before he starts to brake.

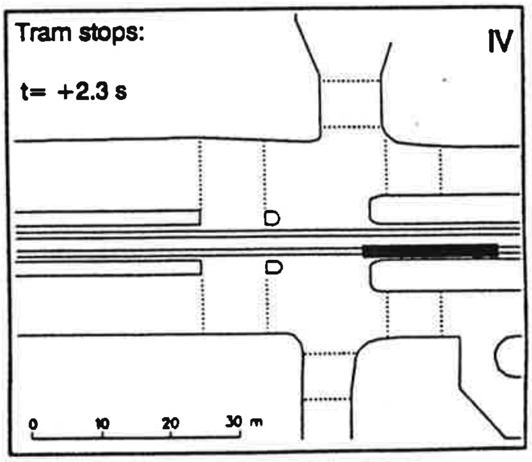






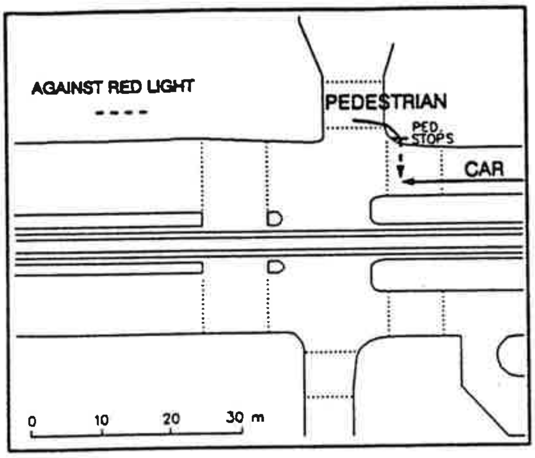


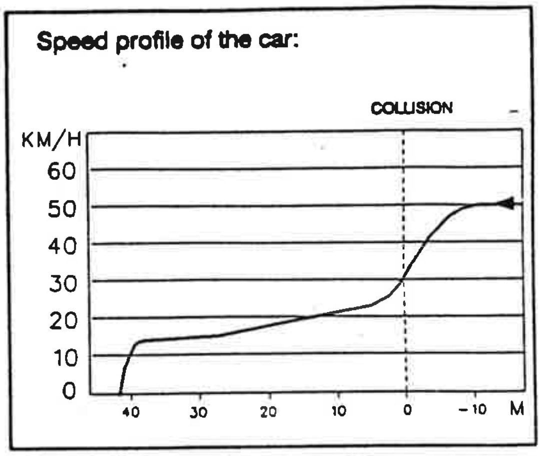


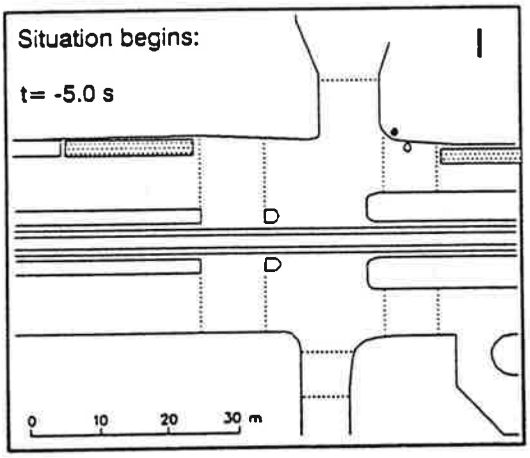


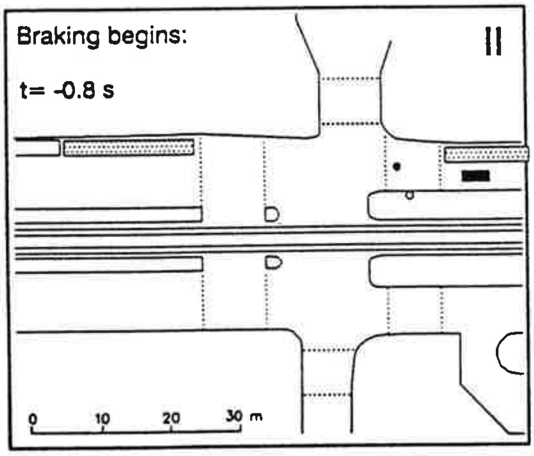
Appendix 5

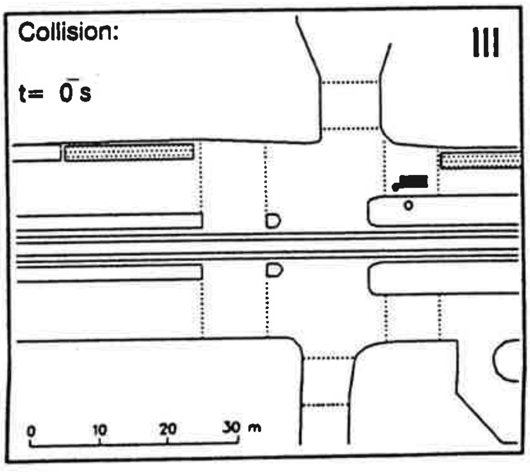
PEDESTRIAN/CAR Saturday 1.6.1991 at time 12.31
An ariculated bus stopped at the crossing on a green signal phase so as not to block the junction beyond the crossing. A middle-aged pedestrian proceeded to cross against the red light followed by a 75-year-old lady who had been waiting for a green signal. The Lady did not notice the car approaching from behind the bus. The car driver tried to swerve to the right. The left corner of the car struck the pedestrian, who suffered fractures to her wrist and ribs.

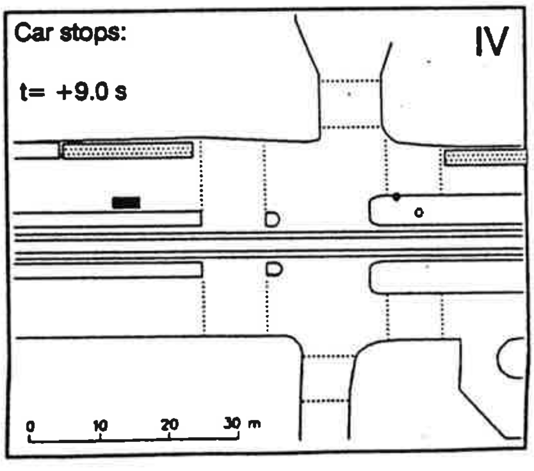






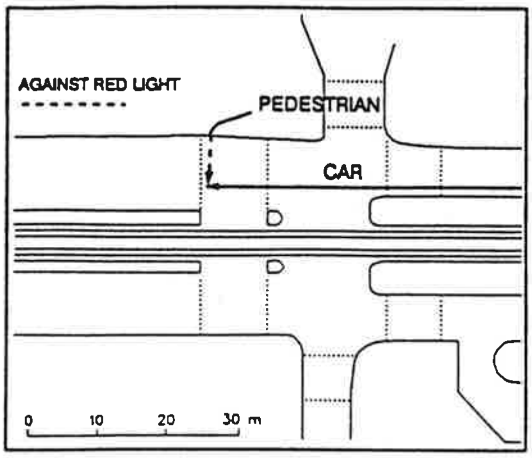


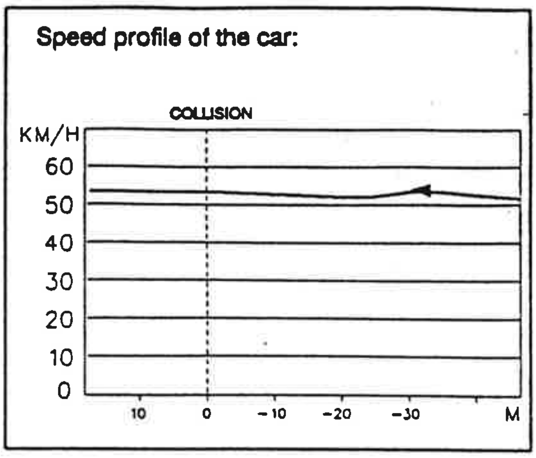


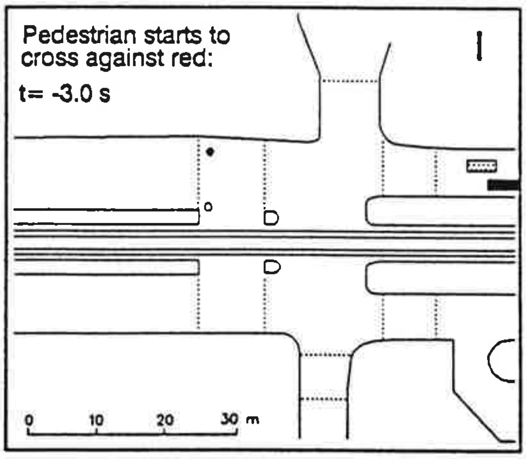


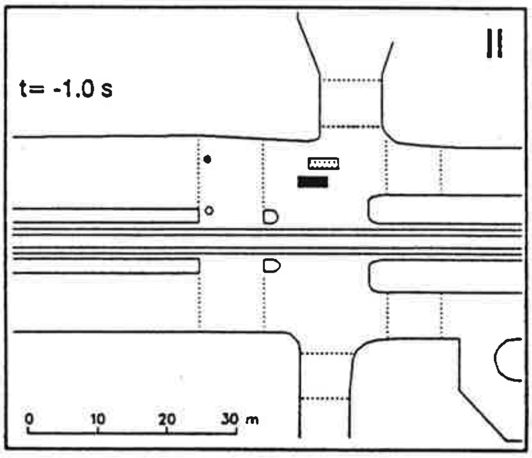
Appendix 6

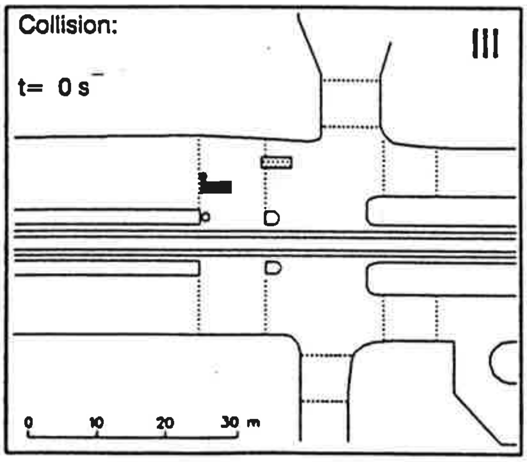
PEDESTRIAN/CAR Thursday 27.2.1992 at time 00.38
A 33-year-old pedestrian followed his girlfriend and was crossing Kaivokatu against a red light. At the mid-point of the crossing he began to run and collided with the front bumper of an approaching car. The driver did not immediately react to the collision. The pedestrian suffered a serious leg fracture with mild bruises to the shoulder and head. The pedestrian was under the influence of alcohol.

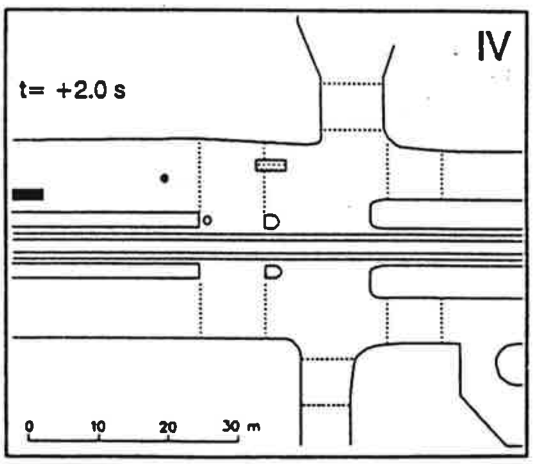






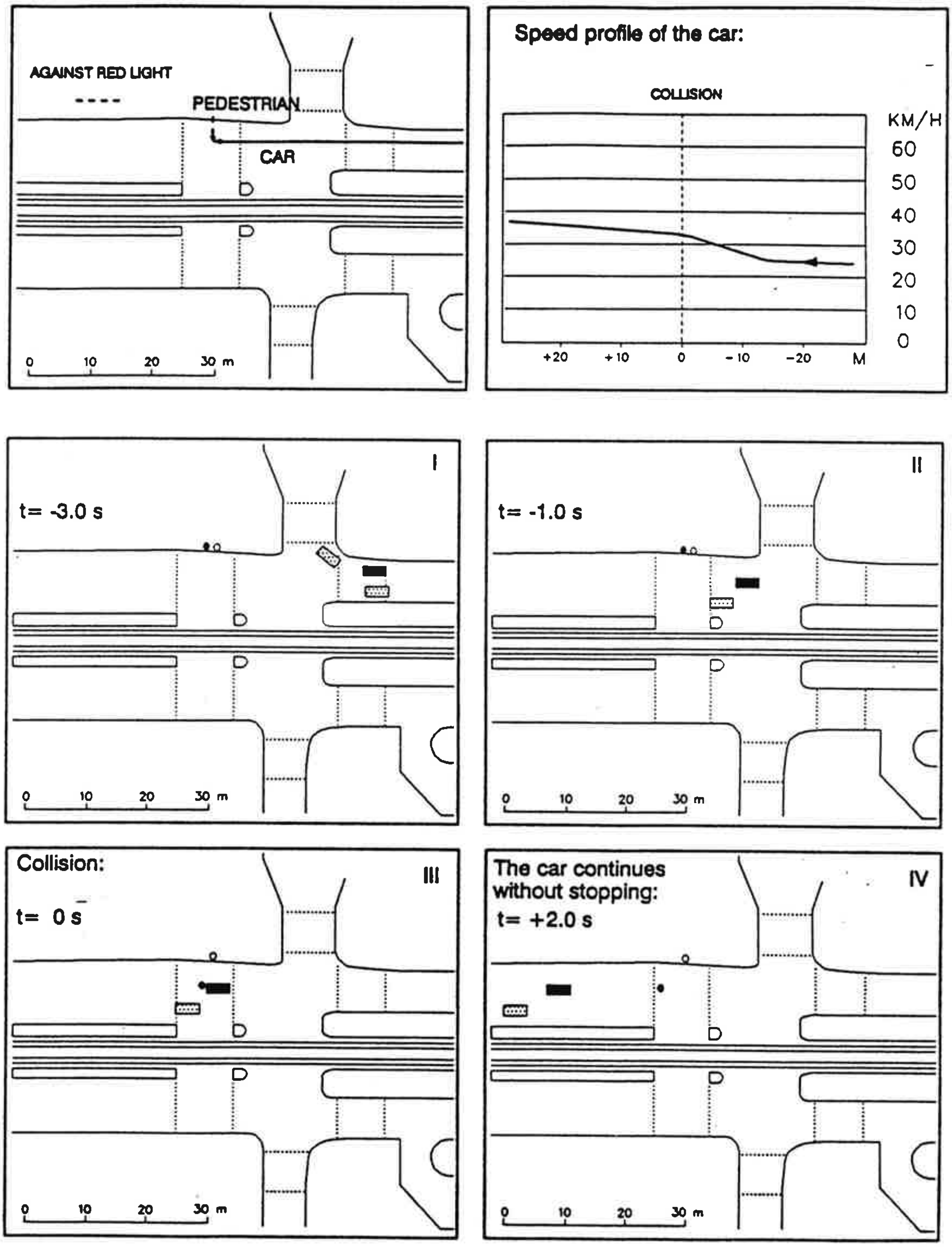






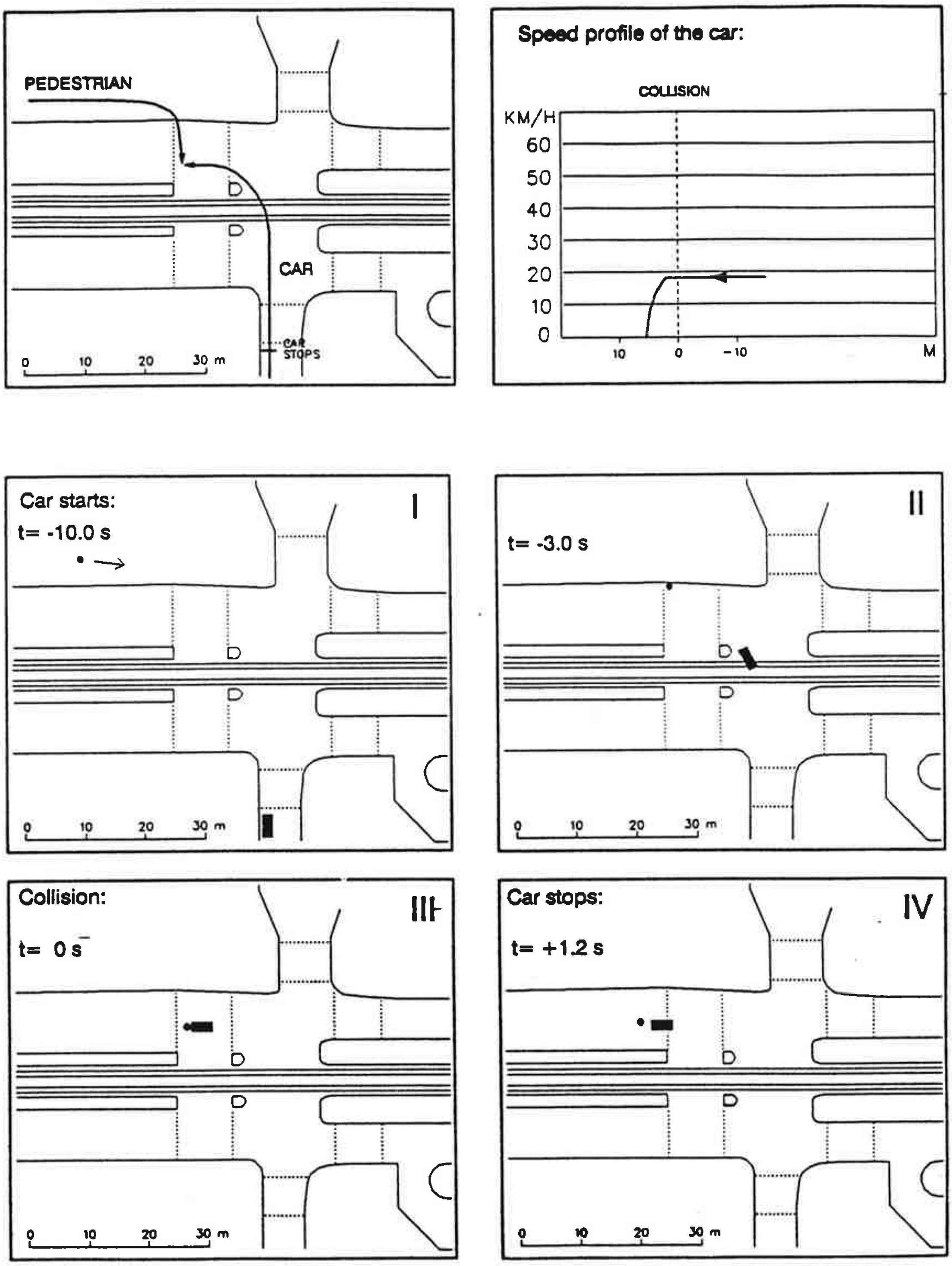
Appendix 7

PEDESTRIAN/CAR Friday 24.7.1992 at time 01.42
A 25-year-old pedestrian, who is under the influence of alcohol, is standing on the sidewalk but suddenly runs against a red light in front of an approaching car. In the collision he loses consciousness and suffers a slight concussion of the brain. The collision car proceeded without stopping.



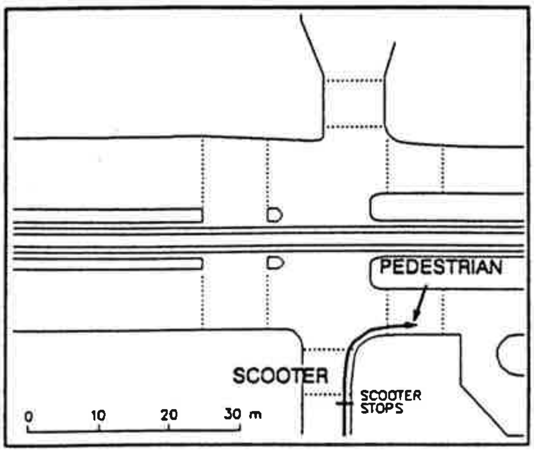
Appendix 8

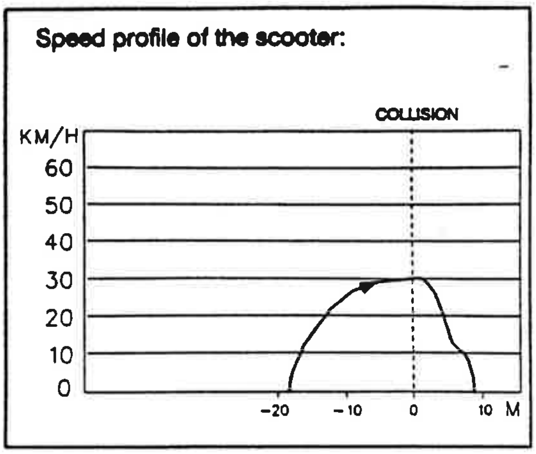
PEDESTRIAN/CAR Monday 5.8.1991 at time 11.48
A cab proceeded to turn left from Keskuskatu to Kaivokatu. At the same time a pedestrian was crossing the Kaivokatu pedestrian crossing with the green light. For some reason the cab driver did not react to the pedestrian before the collision. The pedestrian was thrown forward onto the street via the car's bonnet and windscreen.

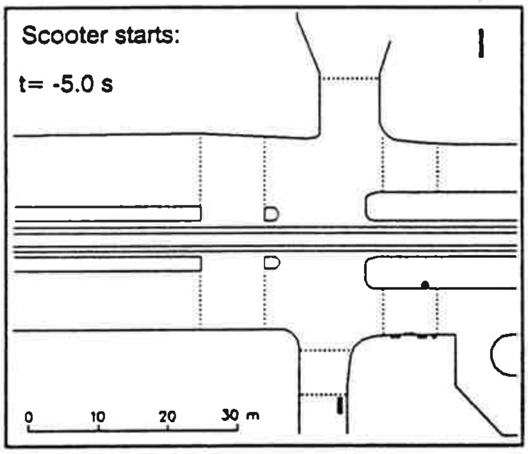


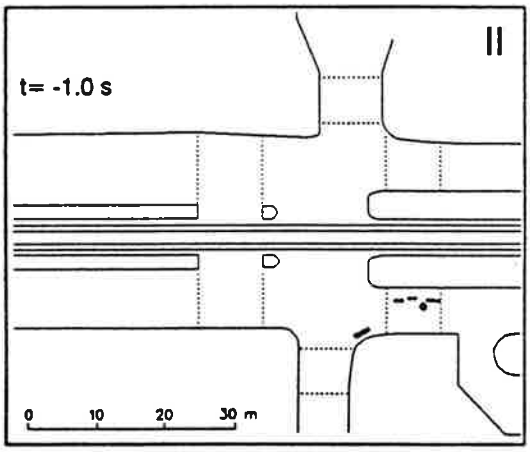
Appendix 9

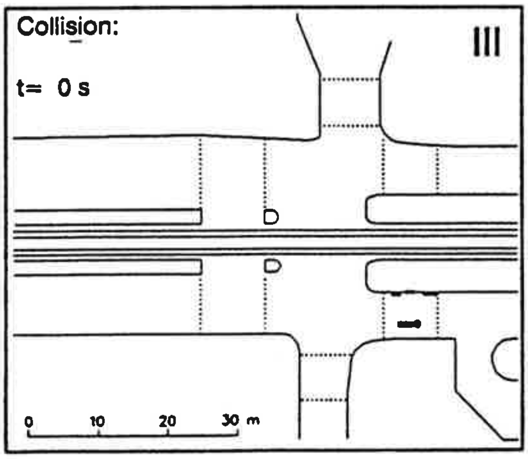
PEDESTRIAN/MOTOR SCOOTER Saturday 23.5.1992 at time 00.09
When the traffic lights changed to green, a scooter proceeded from Keskuskatu to turn right onto Kaivokatu. At the same time, serveral pedestrians proceeded to cross Kaivokatu with the green light in the direction of the railway station. The driver did not notice a crossing pedestrian from the opposite direction in time. The pedestrian collided with the scooter's windshield and suffered torn ligaments in her knee. The driver and the pedestrian had consumed some alcohol.

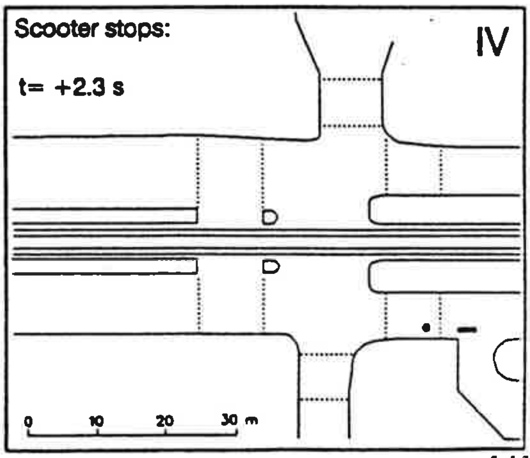






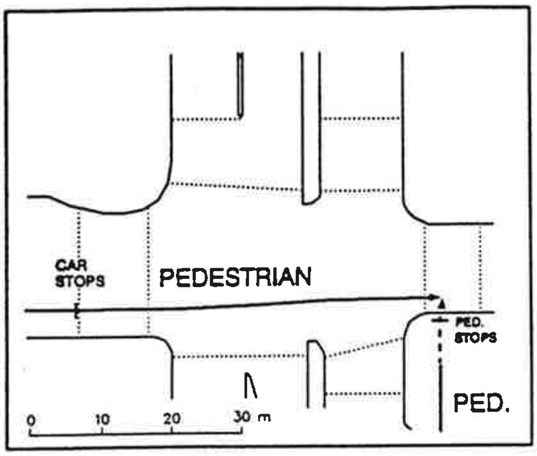


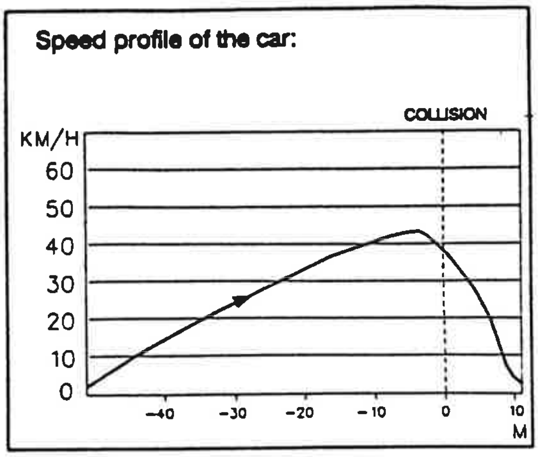


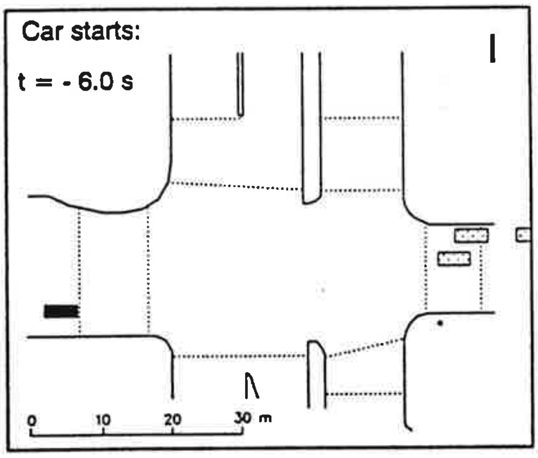


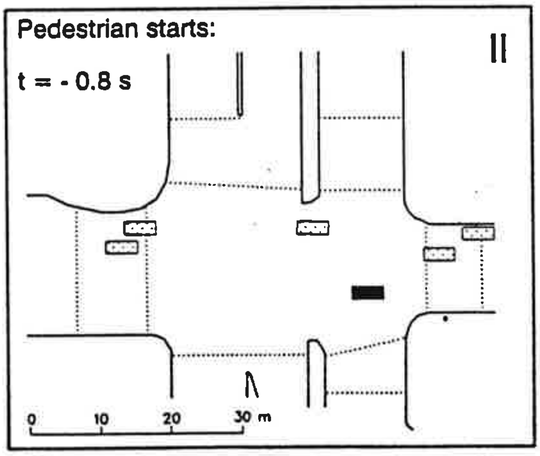
Appendix 10

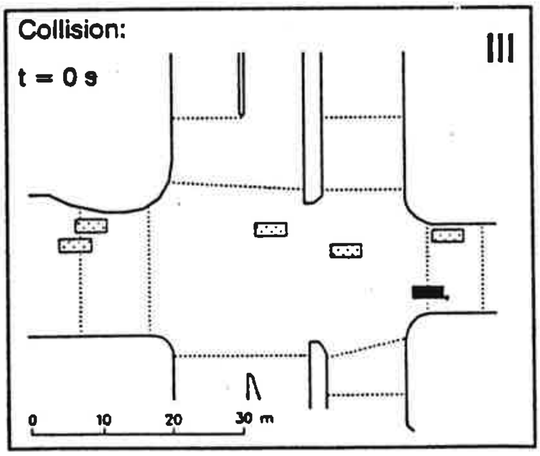
PEDESTRIAN/CAR Friday 13.12.1991 at time 23.21
An 18-year-old man was walking on the Mannerheimintie sidewalk towards the Simonkatu crossing where he stopped at the red light. When the traffic flow from the right ended, he suddenly run across the street and was struck by a cab, which came from the left.

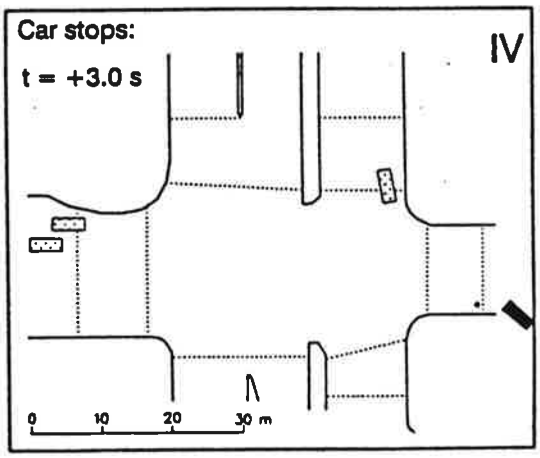






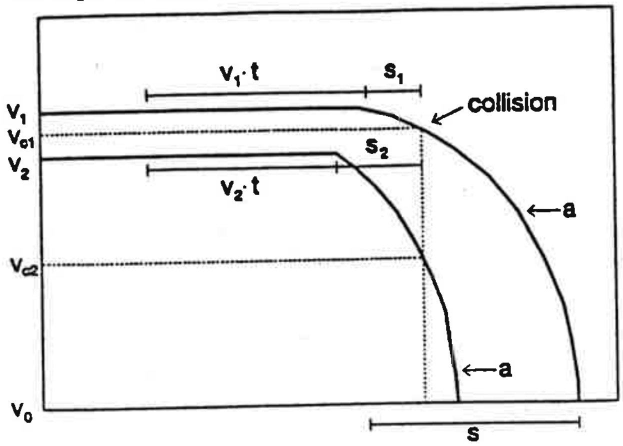






Appendix 11

The collision speed and the probability of death if the max. driving speed would have been 40km/h in the pedestrian video-accidents..



v_1 = driving speed (m/s)
v_{c1} = collision speed (m/s)
v_2 = 40 km/h = 11.1 m/s
v_{c2} = collision speed, if max. driving speed is 40 km/h
a = vehicle deceleration when braking (m/s²)
s = braking distance (m)
t = reaction time of the driver (1 s)

V1, Vo, S and S1 are measurend from video-tapes.

$a = (v_1^2 - v_0^2)/(2s)$ $\quad$ $s_2 = s_1 + (v_1 - v_2)t$ $\quad$ $v_{c2} = \sqrt{v_2^2 - 2as_2}$ $\quad$ $D_2 = \dfrac{1.027}{1 + 37e^{-0.017v_{c2}^2}} - 1.027$

	Accident vehicles							If max speed 40 km/h		
	V1	V0	S	S1	a	Vc1	D1	V2	Vc2	D2
APP 1	50	0	18	8	5.4	37	0.12	40	10	0.00
APP 2	40	-	-	-	-	40	0.16	40	40	0.16
APP 3	62	30	14	6.5	8.1	50	0.39	40	0	0
APP 4	48	0	25	13	3.6	33	0.08	40	14	0.01
APP 5	50	25	12	10	6.0	31	0.06	40	0	0
APP 6	53	-	-	-	-	53	0.50	40	40	0.16
APP 7	36	-	-	-	-	36	0.10	36	36	0.10
APP 8	18	-	-	-	-	18	0.02	18	18	0.02
APP 9	30	-	-	-	-	30	0.06	30	30	0.06
APP 10	43	20	10	4	5.6	36	0.10	40	29	0.06

V = DRIVING SPEED (KM/H)
Vc = COLLISION SPEED (KM/H)
D = PROBABILITY OF DEATH

14. CARDIO-VASCULAR DISEASES AND TRAFFIC SAFETY

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To guarantee safety in traffic is an urgent problem indeed, and its eventual solution is most likely dependent on optimal functioning of "Driver - Vehicle - Environment" system.

In our republic, as well as in Russia as a whole, traffic accidents are unfortunately frequent, taking away many lives and leading to rather considerable economic losses.

Frequencies expressed in absolute figures characterizing traffic accidents (TA) show the number of those injured and killed, besides there are indices of casualties and fatalities in children - the total of TA, those inred and killed from 1986 to 1992 - the total numbers in adults and children reach 250 000 injured and 45 - 50 000 killed annually on the highways of Tussia resulting in 3 billion roubles.

We report growth of TA in Kabardino-Balkarian republic from 1986 to 1992, 996 up to 1335, the number of killes 191 to 286, injured 1104 to 1335. Recordings have been made comprising 130 TA with children in the result of which about 30 Teenagers were killed and 120 were injured. Unfortunately, our data leave little hope for any decrease of TA, confirming the topicality of some effective prophylactic measures.

About 70-90% of the total TA occur through the fault of the traffic drivers (TD). Drivers' fitness and safety in work depend primarily on their personal psychophysiological features, state of their health, drinking habits and use of some medicine drugs.

Within National programmes for the recent 10 years we carried out epidemiological researches of 4500 workers of urban transport enterprises and of more than 1300 workers of rural enterprises.

Among other risk factors arterial hypertension (AH) was found in 22.6% of cases. It is worthy of noticing that in men having AH only 34% of the total were aware of the disease. Of those aware, only 7.1% got some medical care, and only 0.9% received full medical service. Another risk factor of coronary heart disease (CHD) - use or abuse of alcohol - observed in 87.6%, smoking in 74%, psychoemotional overstrain 75.4%, lack of exercise 36%, and excessive mass of weight 19%.

To reveal the spread of CHD and its main risk factors we made the first attempt in Russia in following up 1343 TD aged 20-59. In 370 TD (random choice) levels of Plasma total cholesterol (TC), trglycerides (TG) and lipoproteins of high density (HDL) were determined. The whole investigation was based on the results of some previous researches.

CHD (all its forms) determined with Rose questionnaire and ECG were found in 7.1% of the total. Metabolism disturbances in drivers were observed rather often. Thus, hypercholesterolaemia (TC no less than 250 mg/dL) was found in 15.8% in younger age, and 34.8% in older one; hyperglyceriadaemia (TG no less than 200 mg/dL) - 7.9 and 19.9%, respectively. Levels of antiatherogenous HDL (35 mg/dL and less than that) were found in 8.4 and 9.2% of younger and older men, correspondingly.

Psychophysiological follow-up of TD having CHD, AH and cardiac arrhythmia displayed a notable decrease of their performing fitness and consequently of their reliability. Thus, we observed low rates of visual reaction speed (in sec.) in the test group when compared with the control group (healthy drivers) - respectively, 0.820 ± 0.04 and 0.776 ± 0.13 (p 0.01); indices of moving object monitoring (in mm.) were worse in the test group (6.91 ± 1.08) than those in the control group (6.12 ± 0.34). The situation was the same with the complex reaction (in sec.) - (0.246 ± 0.01 and 0.210 ± 0.01). These discrepances proved statistically relevant (p 0.05). Our data confirm actual dependence of TA on cardio-vascular diseases. Besides, the analyses of medical records of 204 TD whose faults led to TA, showed the dependence of TA rates on the presence of cardio-vascular diseases.

The data obtained so far allow us to warn against a highrise of AH, DHC and their risk factors in TD of Russia. Presence of cardio-vascular diseases deteriorates psychophysiological fitness, TA being frequenter hitherto. These data may prove somehow important and useful in dealing with questions of occupational fitness and selection, medical care of TC, determination of prophylactiv measures against TA and for the improvement of traffic safety.

REFERENCES

GLUSCHKO O.V., KLJUYEV N.V. 1982, Work and Health of Vehicle Drivers, Moscow Transport, p.161.

RETIYEV V.M. 1979, Occupational Hygiene in Urban Traffic Drivers, Moscow, p. 184

VAISMAN A.I. 1988, Occupational Hygiene in Vehicle Drivers, Moscow, p. 191

15. DRIVERS` EMOTIONAL REACTIONS IN CONFLICT SITUATIONS ON ROADS

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The reliability of the driver who is the principal element of the "Driver/Automobile/Traffic Environment" system, is to a considerable degree dependent on his emotional state. Functional changes which are of primary importance in ensuring car driving safety, turn out to be more or less widespread in various emotional states.

As it was demonstrated before, the value of the driver`s emotional tension depends on the amount and character of information he receives, his responsibility for the life and health of traffic participants and material values preservation, and his individual peculiarities.

The present paper describes drivers` emotional reactions in various conflict situations.

Taking into consideration the fact that the notion "Conflict Situations" has a host of definitions in modern literature, we preferred while stating the results of our research, to describe situations under study in a more specific manner. In particular, as far back as 1972, we put forward the term "situations similar to emergency ones", hard braking, abrupt steering wheel rotation or a combination of hard braking and abrupt steering wheel rotation being their characteristic features.

Subsequently, there was introduced the term "Complex Situations" which was interpreted as:

1) leaving the traffic flow
2) entering the traffic flow
3) passing controlled crossroads
4) non-complicated passing of non-controlled crossroads
5) complicated passing of non-controlled crossroads
6) overtaking

To evaluate drivers` state in the above mentioned situations, a continuous electrocardiogram and galvanic skin reaction (alteration of galvanic skin resistance) registration was conductet. The research results are given in the table.

The electrocardiogram results in situations similar to emergency ones, are of special interest. In these cases, the frequency of heart contractions mounted to 140 beatings per minute, the electrocardiogram voltage decreased, the T-marker flattened and the ST segment fell below the isoline. It shoulb be noted that virtually all drivers experienced an increase of heart contraction frequency after mounting the automobile. In the course of the entire period of driving in the conditions of a large city, it was higher than before driving.

In a number of cases, in situations similar to emergency ones we observed the slowing of heart contractions in the beginning of a situation with their subsequent abrupt quickening. The slowing was accompanied by the "sinking heart" behavioral reaction and a subsequent series of energetic actions to liquidate the menace of accident. The emotional state of some drivers led to an abrupt deterioration of the ability to handle the situation which is a very complex activity; the drivers` behavior got disorganized, the acquied habits - inhibited, the drivers got fussy and the reaction to irritants was inadequate, etc.

Thus, the excessive significance and density of received information predetermine the development of strongly pronounced emotional reactions leading to a high probability of traffic accidents.

At the same time, evaluating drivers` emotional reactions one cannot but note a positive aspect of this phenomenon. A moderate emotional tension is important to adapt the driver to the traffic environment. It ensures integration of various systems of his organism for safe car driving.

When moving in the traffic flow along highways, particularly in the night, the driver is frequently registered to suffer "information famine" which gives birth to undesirable consequences. The monotonous receipt of insignificant irritants appears to be a weak subliminal stimulus to actuate a stereotype of more complex situations. This paves way to a specific state of monotony with further possible passing into somnolence and sleep. The considerable weakening of functional capacities to receive and decipher information as well as the ability to drive a car on the basis of sensormotoric reactions when the driver keeps awake, is a specific feature of monotony. Typical drivers` reports on such state are:

- "I suddenly realized I didn`t remember to have passed several kilometers", or
- " was driving a car as usual and all of a sudden I saw an obstacle before the car (another transportation means, a passenger, etc.)".

A number of authors share the view that such states deliver 9-30 % of all traffic accidents and up to 50 % of all Traffic Code violations.

In this connection, the importance to optimize information loads on the driver and particularly traffic information, turns obvious. C.Tetard (1985) has grouped traffic information into very important (one that conditions a possible traffic accident), secondary (relevant to the driver but not connected with accident rate) and useless. We believe that to group this or that information as useless is often difficult because the seemingly insignificant information referred to at first sight, may prove to be indispensable in a monotonous situation. At the same time, we think it necessary to develop the classification into the fourth type of traffic information - harmful. At the present showing, what is meant is not only erroneous information (a traffic sign which has not been removed or noticed in time in connection with the situation changed, etc.), but excessive information over certain portions of road as well without considering the time relevant to the driver to receive and decipher information and to work out a decision at the speed set up over a certain portion of road.

The problem of developing and realizing a set of measures to optimize functional states of the driver in terms of traffic safety is far beyond the limits of this paper. It is worth mentioning that optimization of information loads is one of the numerous ways of its achievement. Particularly with that aim, the authors of this paper have developed theoretical and practical grounds of psychophysiological rehabilitation, rational labour and rest, methods and facilities to fight monotony, etc.

Table 1 Frequency of heart contractions (numerator) and GSR (galvanic skin reaction) (denominator) in typical road situations

Type of transportation and number of measurements (n)		Preoperating state	In driver's cab before trip	Road Situations 1	2	3	4	5	6
City Bus Transportation		73.1±0.7 / 21.6±0.3	77.9±1.5 / 22.3±0.2	78.7±0.4 / 22.5±0.1	79.3±0.4 / 22.4±0.1	78.3±0.77 / 22.4±0.2	79.1±1.1 / 22.4±0.2	85.7±1.4 / 24.1±0.3	86.3±1.2 / 24.2±0.3
	n	15	15	532	517	177	105	73	93
City Taxi	Speed 35-40 km/h	74.3±0.9 / 21.7±0.4	79.1±1.7 / 22.8±0.4			78.3±1.1 / 21.9±0.2	78.6±1.1 / 22.1±0.4	83.3±1.59 / 23.8±0.3	84.7±1.2 / 23.8±0.3
	n	23	23			98	52	42	93
	Speed 55-60 km/h					79.9±1.3 / 22.4±0.4	81.1±0.1 / 23.7±0.4	92.6±1.8 / 25.9±0.5	90.8±1.3 / 25.8±0.3
	n					69	64	54	121

16. INTERACTION BETWEEN CYCLISTS AND CAR DRIVERS. WHICH ROLE COULD TECHNOLOGY PLAY?

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16.1. FRAME OF REFERENCE OF OUR RESEARCH

This contribution refers to a study on conflicts between cyclists and car-drivers in commission-of the municipal administration of Vienna. It continues a series on multidisciplinary studies on perception, attitudes and behaviour of cyclists. For the last proceedings of our meeting at Vienna I reported about our analysis of pedestrian-cyclist-interactions (SCHMIDT 1991b). Correcting my announcement from one year ago: these results are published in "Werkstattberichte" by the Department of town planning of the city of Vienna (RISSER et al. 1992).

The topic "interaction between cyclists and other traffic participants" becomes more and more important because of in general still growing environmental impact of our present traffic system. The extensive use of cars in the Western industrialised countries produces as well global as regional and local problems. Substituting as much as possible individual mobility by car with individual mobility by cycle could contribute to the coping with the following global environmental impact:

* energy consumption
* CO_2-concentration
* ozon near the surface

Promotion of cycling could furthermore help to diminish severe regional and local traffic problems like

* accidents
* noise
* congestion
* parking problems
* air pollution.

These traffic related problems make it inevitable necessary, to search for other accepted forms of individual mobility instead of car-use. To visualize in brief what I mean, I shall present you one of my favorite illustrations, which shows the hierarchy of the social and ecological desirability of different modes of traffic participation (SCHMIDT 1988).

Figure 1 Hierarchy of the social and ecological desirability of different modes of traffic participation

1. Walking
2. Cycling
3. Going by train or tram
4. Going by bus
5. Driving a car

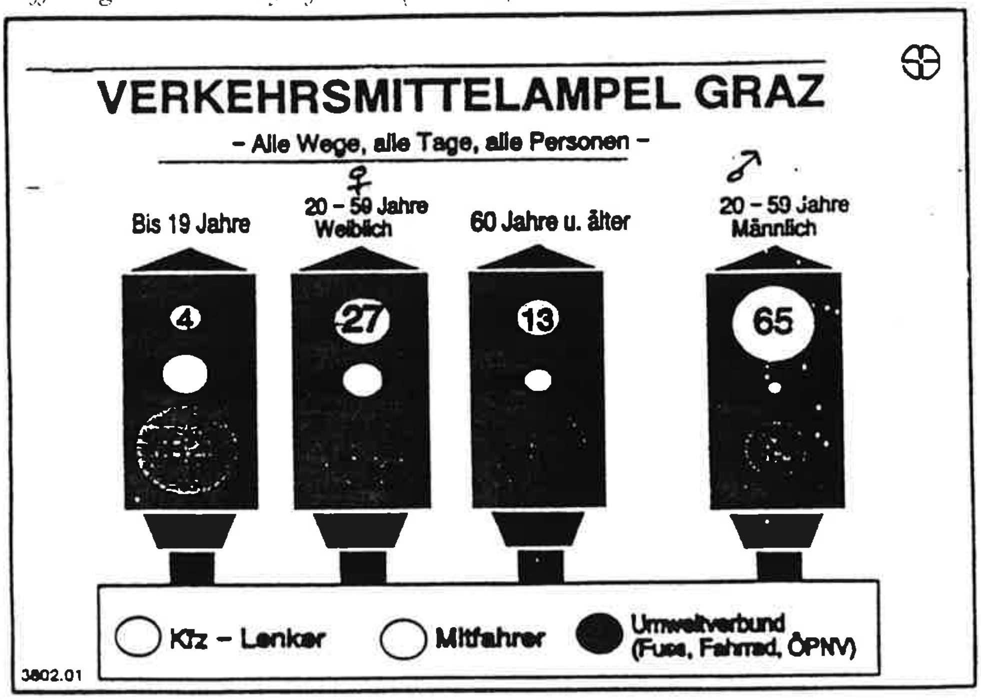
You can observe, that this illustration is manipulated in several respects:

* the only recognizable persons are female
* the car is very tiny compared with mighty pedestrians and cyclists
* pedestrians and cyclists are **above** the car.

But realize, that this illustration is still more fair than the every day manipulation in the opposite direction: here the car is mentioned and not ignored, like it is often done with that mode of traffic participation, which is especially the domain of female road users: walking.

I mentioned sexual differences in modes of traffic participation. The following illustration shows l data for daily mobility, that are more or less typical for different Western European towns. It stems from a study in the Austrian city of Graz.

Figure 2 "Traffic light" in the city of Graz (Austria)



Refering to motives of traffic participation in general and especially for certain target groups it must be taken into account, that especially for the to-day´s main users of private cars, males between twenty and sixty years, independence and enjoyment of the ride are leading motives of traffic participation (SCHMIDT 1991a).

Resuming the results of several studies on the motives of traffic participation the following three categories can be considered as generally important for most target groups and most opportunities:

* independence
* comfort
* time saving

The following motives are in general of secondary importance, but for certain target groups and certain purposes they can dominate the choice of traffic mode:

* costs
* safety
* environmental protection
* enjoyment.

These motives are much more likely to be satisfied by individual modes of traffic transportation than by public transport systems, that are mainly discussed in connection with effects to change the modal split. From a psychological point of view reducing mobility by private cars in our towns without provoking reactance (e.g., the foundation of car-driver-parties) could partly be done by promoting cycling as an every day mode of transportation.

16.2. THE DESIGN OF OUR STUDY ON INTERACTIONS BETWEEN CYCLISTS AND CAR DRIVERS

Refering to the above reflections our purpose was to observe cyclists-driver interactions on different types of roads, which allow fast cycling.

We had three experimental conditions ("technology"):

* mixed traffic with maximum speed of 50 km/h
* mixed traffic with maximum speed of 30 km/h
* cycle-lanes.

The design of our study included the following methods:

* review of the literature, especially on cycle-lanes
* group discussions
* behavioral observation
* traffic-conflict-technique (TCT)
* personal interviews on the traffic sites.

16.3. GROUP DISCUSSIONS ABOUT CYCLIST AND CAR DRIVER INTERACTIONS IN TRAFFIC

Now I want to present some results from the second part of our study, the group discussions about cyclist and car driver interactions in traffic.

We chose this method, because we wanted to explore the subjective perception of the behaviour of the different road user groups. Mainly we were interested in the influence of kind and duration of personal experience in this different role of traffic participation on perception of conflicts and especially on the attribution of certain attitudes guiding the behaviour of the others.

On the following list you can see the typical emotion provoking behaviors mentioned.

Emotion provoking behaviors of cyclists and car drivers

* passing on the right side
* close following
* ignoring traffic rules
* going in front of the cue
* lane changing
* turning right
* turning left

Our hypothesis, that one`s own experience with the role of the other traffic participants leads to fewer conflicts and to less attribution of negative motives to the other group was confirmed especially for the car drivers. If they had personal experience with cycling, they had more understanding and sympathy for cyclists. The attribution of unpleasent motives to car drivers by the cyclists was less dependant from the fact, that the cyclist himself was a car driver sometimes.

Feelings concerning the own mode of traffic participation were explicitly mentioned especially by the cyclists. Both groups mentioned different feelings concerning the interaction with the other group. The following list gives an impression of the mixture of positive and negative feelings in connection with the interaction between cyclists and drivers:

Feelings concerning cyclist-driver interaction

* fear
* anger
* surprise
* triumph
* saving loosing time
* freedom
* independence

* beeng privileged/disadvantaged

One of the important results was, that negative emotions beween these two groups of traffic participants were dominating. There was a lot of misunderstanding of intentions and behavior of the other group, far more than we could find in our former study between pedestrians and cyclists.

We identified different reasons for that:

* the difficulty to communicate with each other
* the higher speeds
* the probability of dangerous accidents
* the missing experience with the other transportation mode.

As a sort of proof for the latter we took the fact, that the highest tolerance for driver behavior as well as for cyclist behavior was expressed by the statements of those members in our group discussions, who practise actually driving as well as cycling.

16.4. BEHAVIOURAL DATA AND INTERVIEWS ON CYCLIST-CAR DRIVER INTERACTION

Meanwhile the third, fourth and fifth part of our study have been finished:

* Conflict observation by following the cyclist similar to the method of BROOKHUIS, CHARGEN & WIERDA, but instead of taking a video we used a phonotape for behavior registration

* Application of the method of traffic conflict observation on certain sites

* Interviewing cyclists and car drivers on the traffic site

At the moment the data are analysed. We have so far no final results.

16.5. CONCLUSIONS

Apart from deatiled results of our own data from the behavioral analysis and the interviews, some general conclusions can be drawn already from the literature study and the group discussions. If we consider the influence of the vehicle used in traffic participation as a variable of technology, we have to bear in mind technology could influence interactions between road users.

Figure 3 Ringing the bell

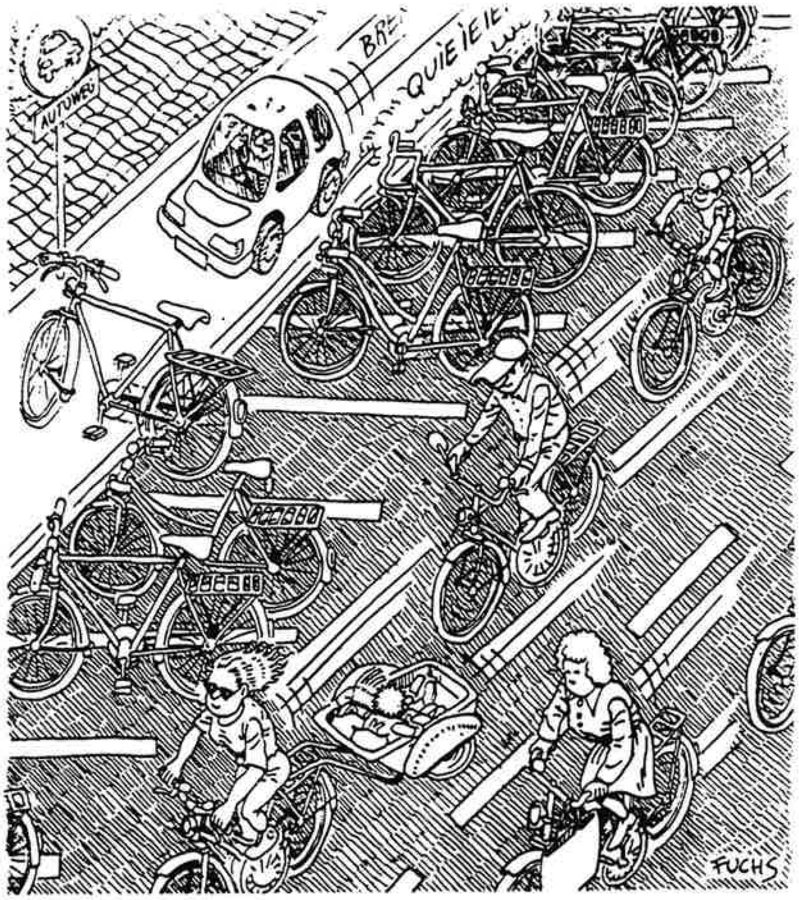
But I rang the bell to warn him!

What you can see on the above illustration is the contrary of what we experience nowadays on our roads: instead of cyclists, here, car drivers are in the helpless position and experience neglection by the more powerful group.

I show this to stress one of our conclusions: a change of perspective is necessary, if we wish to reduce conflicts in traffic. That means not only a better understanding of other road user groups. That should also include thinking about a change of the norms and values regulating our everyday traffic behaviour, traffic organisation and traffic policies.

Although Figure 4 is an utopical vision, it stresses a neccessary step in the right direction: we have to give more place for those we want to promote and reduce place for those, which are - because of their global, regional and local environmental impact - less desired. Road design should give the preference to non-motorized individual mobility one important consequence being better, and thus conflict reducing, visibility of cyclists for the car drivers.

Figure 4 More-lane cycle-traffic



Furthermore one should bear in mind, that despite of the great influence of technology on road user behaviour one should not forget other conditions of actions (e.g. FIETKAU in SCHMIDT 1988). Technology can help providing a desirable infrastructure, and supporting cyclists´feelings of independance, time saving and also enjoyment.

In supplement to this it is necessary to create incentives for changing travel mode, raising public awareness of the indirect and longterm consequences of different modes of traffic participation. People should be reminded of certain values like ecolocical consciousness, love of nature and social responsibility, and invite to experiment with new modes of transportation. We are preparing a project, where we use social scientific know-how to promote social and ecologically desirable modes of traffic participation by stimulating environmental learning in companies (LITTIG & SCHMIDT 1991).

REFERENCES

BROOKHUIS K., v. SCHAGEN J. & WIERDA M. 1988, Analysis of young cyclists traffic behaviour. In ROTHENGATTER, J.A. & DE BRUIN, R.A.(Eds.): Road User Behaviour. Theory and Research. Van Gorcum, Assen, the Netherlands, 218-224

LITTIG B. & SCHMIDT L. 1991, Umweltlernen im Betrieb. Evaluation eines Weiterbildungsprogrammes zur Verkehrsmittelwahl auf dem Arbeitsweg. Unveröffentlichte Projektbeschreibung, Wien

RISSER R., SCHMIDT L., SNIZEK S., HULMAK M. & SCHEIDL M. 1992, Konflikte Fußgänger-Radfahrer am Beispiel Wien. Werkstattberichte Nr. 1, Stadtplanung Wien

SCHMIDT L.1988, Implications of new risk models for the analysis of traffic safety and other traffic related problems. In ROTHENGATTER J.A. & DE BRUIN R.A.(Eds.): Road User Behaviour. Theory and Research. Van Gorcum, Assen, the Netherlands, 127-132

SCHMIDT L.1991a, Indicators for differences in risk-taking and accident risk for female and male road users. Paper presented for the Symposium "Risk taking and Accidents" (G.J.S. Wilde & R. Trimpop) at the Second European Congress of Psychology, Budapest, July 9-13

SCHMIDT L.1991b, Analysis of pedestrian-cyclists-interactions. Experiences with an investigation in Vienna. Paper for the fourth workshop of ICTCT in Vienna, October 1991

17. A STUDY OF THE BEHAVIOUR OF DRIVERS OF ELECTRIC MINICARS

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17.1 INTRODUCTION

In Switzerland there exist many regions where the use of conventional cars is restricted. More restrictions are being discussed. The alpine regions with their natural beauty obviously constantly remind both decision makers and citizens that nature is something that has to be protected. In Switzerland it is maybe more obvious that nature is not something that exists independently of people and their everyday life; we are part of nature, even if we often do not act in agreement with this fact.

Thus, it seems to be the wish to protect nature - nature where people live, come to have holidays, raise their cattle, etc. - rather than a traffic-safety perspective that lead to astonishingly concentrated efforts to promote electric minicars in Switzerland. These vehicles are supposed to be less space-consuming, to cause less noise, and to cause less air pollution than ordinary cars. (Everybody can see that these three aspects are really of vital interest when he/she travels to Austrian alpine valleys: Car traffic has so far not been restricted very much, there, and the results are quite depressing, both from an aesthetical and from a life quality point of view that maybe both aspects are part of the same dimension.)

In 1991 the Institute of Forensic Medicine in Zuerich was asked by the Swiss Government to carry out a series of research projects in order to check feasibility aspects connected to the promotion of electric minicars in today's traffic. One important and heaviliy dicussed question was if electric minicars were "safe" at all - "safe" in the sense of the driver being sufficiently protected in case of an accident. The crash-tests performed in order to answer this question showed that there was no reason to be too pessimistic, as far as the driver's safety was concerned. Additionally, from behaviour adaptation theory the argument was derived that with some probability electric minicars would be driven in a more cautious way. Drivers who do not feel a hundred percent safe would take fewer risks. This would add to the protection of the environment in a broader sense, which could result in advantages for other road users, mainly the vulnerable ones. The Viennese Institute FACTUM was asked by Felix WALZ, the representant of the Institute of Forensic Medicine, to analyse if electric minicars really have the potential of being an even socially well sustainable alternative to the conventional car.
The results of this study that was financed by the **"Schweizerischer Fonds für Verkehrssicherheit"** and the **"Bundesamt für Energiewirtschaft Bern"** will be discussed in the following chapters.

17.2 ROAD TRAFFIC AS A SYSTEM

Traffic safety research has - from a psychological perspective - been practised internationally since many decades. The reduction of accident numbers can be seen as the priority task from the beginning. In a survey about the historical development of traffic psychology, KLEBELSBERG (1988) points out that in the last time the development has slowly "shifted from safety evaluation to system evaluation":

When evaluating safety measures, it is not enough to rely on accident numbers as the only safety criteria. Economy, mobility, comfort, and other aspects have to be considered as well. Safety in traffic is not only relevant for society because of it's implications for physical integrity of people, and because of its potential to reduce societal costs caused by accidents. Subjective sa--fety - i.e., the feeling of being safe or not - is intimately connected to human life quality. Not least, the fear to get involved in a traffic accident could disturb mobility of certain types of road users. Many studies have shown that especially subjects who do not have the possibility to use a car experience fear in traffic, whereas people who frequently drive a car do not report about any felt lack of safety when travelling in their car. It has to be realized that analysis and measures in road traffic must always take place regarding the whole system, and that this system we are talking about is a **social system**.

Recent traffic research quite frequently reflects the fact that studies about the nature of safety can only be really successful and efficient if traffic behaviour is seen in a social context and if the individual person is seen as a homo socialis. Research we did in Austria (CHALOUPKA et al. 1991) led us more and more away from looking at the driver as **one isolated individual under a kind of laboratory conditions**. The description of driver behaviour without considering social-psychological stimuli (i.e., all kind of stimuli that have to do with the overt or mental presence of other road users) is - maybe - fundamental, but it does not reflect traffic reality: The individual car driver does not fulfil tasks similar to solving mathematical equations at his desk, or digesting some food or medicin, or repairing a bycicle (the mere handling of a car is probably much easier than repairing a bycicle): Most of the time, the driver interacts in some way with other road users/with other people.

17.3 WHAT IS A SAFE CAR?

We should bear the arguments above in mind when we aks this question. Problems with traffic in densely inhabited areas are to a high degree related to car traffic: Noise, air pollution, space consumption. In many larger European cities authorities have already started to try to both incite people to use other traffic modes than the private car, and to use the private car in another way than today (less often, less risky, more slowly; see MONHEIM & MONHEIM-DARNDORFER 1991, SACHS 1985, a.o.).

Another option is to change some characteristics of the private cars. In Sweden, experiments are going on in order to test behaviour of drivers of speed limited cars: Speed in inhabited areas is automatically limited to the existing speed limit (PERSSON et al. 1993; ALMQUIST et al. 1991). Also at the University of Lund a scheme was developed for how to analyse the behaviour of drivers of electric minicars (that was preceded by an acceptance study: SCHROEDER 1990). The central hypotheses in both cases: Behaviour of drivers both in speed-limited conventional cars and in electric minicars will be comparably safe.

And in both cases the definition of driving a car safely was related to aspects of the social framework in traffic: The degree of safety is defined by the degree to which car drivers adapt their behaviour to existence and behaviour of other road users, especially as far as unprotected road users are concerned. From this perspective, we expected that electric minicars are **safer than conventional cars.**

When people say that electric minicars are unsafe, they ususally refer to crash-tests, as was already said above: Earlier tests have shown, that in case of accidents drivers are not very safe in minicars. This maybe true, even if this kind of passive safety has improved considerably during the last year (see STRAUSS 1992). What is interesting, however, is that, according to the state of the art **large, strong, and well equipped cars get involved into accidents relatively more often than smaller ones** (PFAFFEROTT 1992). This would allow the hypothesis that drivers behave more cautiously if they do not feel a hundred percent safe in their car, which can obviously be interpreted as some kind of behaviour adaptation (OECD 1990; RISSER R. & CHALOUPKA CH. 1993).

It seems reasonable to analyse the behaviour of drivers, and how they interact with other road users, in order to find out, how different degrees of involvement in accidents can be explained. The central role of interaction in road traffic is underlined by the fact, that around 75% of the accidents in the industrialised countries are accidents between two or more road users.

And as far as interaction with VRUs is concerned, another interesting figure from accident statistics can be presented: **During the last years 25% of all road users killed in Austria per year were pedestrians, in Vienna this percentage was around 60%!** Does this mean that shoes are very unsafe vehicles? Or do pedestrians and cyclists kill themselves by throwing themselves under cars?

17.4 PROS AND CONS CONNECTED TO ELECTRIC MINICARS

If the hypothesis that electric minicars are driven in a more cautious way than conventional cars is right, this is certainly in advantage of the electric minicar, apart from other advantages like being less space-consuming, less noisy, and at first sight, even less air-polluting. However there certainly are some arguments to the disadvantage of electric minicars, as well:

* If cars are developed that are better compatible with the situation in densely inhabited are this might lead to a strong increase of vehicles in such areas, the electric minicar then maybe being the second or third car in the family that is mainly used in the city.

* Energy has to be taken from somewhere. Is it certain that electricity comes from sources that do not cause any environmental problems?

* As the time span of transition from today's traffic to a traffic with a high percentage of electric minicars will certainly be quite long, there is some probability that drivers of minicars will develop some strategies for "survival" that in the long run lead to negative impacts on the traffic climate (e.g., to demonstrate that one is not so weak as it looks) - a little bit like cyclists in cities where cycling is a "new" way of transportation.

The last con just named was central to the study that will be described here. When the Institute of Forensic Medicine at the University of Zurich, till then mainly dealing with the consequences of crashes electric minicars might get involved in, became interested in **active-safety questions** as well, they heard that FACTUM in Vienna had some know-how on how to deal with such questions. It was decided that we should do behaviour observation studies to analyse the traffic-safety aspects connected to the electric minicar.

17.5 A STUDY IN VIENNA AND ZURICH

Work was started with the development of the following **hypotheses about the consequences of the introduction of electric minicars in to-day's traffic**:

a Of obvious reasons speeding will decrease, average speeds when driving electric minicars will be lower

b Phenomena very much connected to higher speeds that reflect impatience and lack of preparedness to cooperate - e.g., pressing by keeping very short distance to the preceeding car - will not occur so often in connection with electric minicars

c Interaction with vulnerable road users (VRUs), e.g., when turning left or right and having to cross the way of VRUs walking/riding straight on, will improve in quality, as the difference in power and size is not so great

d Behaviour at cross roads when not having the right of way will become more cautious, accepted gaps will become longer, as one is more vulnerable

e Insisting on one's right of way will happen more cautiously, as well, of the same reason

However, some **negative behavioural consequences** can be expected, as well: One "is smaller and weaker" and one might be led to"fight back" in case feelings of "not being respected", etc., arise. Moreover, being surrounded by fast vehicles, the tendency to compete could still be kept alive and maybe even grow, possibly leading to negative consequences:

f One of them could be inadequate speed in situations when one actually should drive very slowly (narrow inhabited streets, etc.)

g Overtaking cyclists and moped riders where there is only little space, and similar types of behaviour could become more frequent

h It is also possible that one "forwards" bad treatment one gets from drivers of conventional cars to pedestrians and cyclists

i driving against red and yellow light could become more frequent

17.6 A METHOD FOR EVALUATION

As an evaluation method we used the "Wiener Fahrprobe" (Vienna Driving Test; RISSER 1985; revised version CHALOUPKA et al. 1991, GSTALTER 1990, FASTENMEIER 1990), which was modified considerably, however: The reason is that a SOLEC-Riva car was used (see photo on the next page), where there is only space for the driver and one observer. Behaviour variables the "remaining" observer should register were the following:

- **speeding**
- **short headways**
- **lateral distances** (to pavements, parked cars, cyclists, mopeds)
- behaviour at **pedestrian crossings** (correct, frienldly, dominant)
- **turning left or right** (interaction with oncoming traffic and with VRUs walking/riding straight on
- behaviour in cases where **other road users have the right of way** (correct, submissive, dominant)
- insisting on **one's own right of way**
- character of **lane changes**

These variables are registered on a standardised form that has to be filled in per section.

The Electric Minicar

Other types of behaviour that cannot be specified well in advance are registered freely, i.e., they are described in words. These variables consist mainly of three types:

- **erroneous behaviour** (illegal, dangerous, or both; unclear behaviour that might be misunderstood, or that reflects misunderstanding of others' intentions)
- **communication processes** of all types (independent of their character, and independently of the fact if erroneous or not)
- **traffic conflicts** reflecting imminent danger

17.7 PROCEDURE

The question we wanted to answer as a result of our study was: **Is behaviour when driving electric minicars to be judged as positive or negative compared to driving conventional cars?** In order to answer this question we had 50 persons in Vienna and 10 persons in Zuerich drive on standardised routes in both cities twice: Once with their own car and once with the electric minicar. Half of the test persons drove with the minicar first and vice versa.

In the year 1992 (in June, July and September) 50 persons were observed twice on a standardised route in Vienna, once when driving their own car and once when driving the electric minicar. In October of the same year 10 persons, also once driving with their own car and once with an electric minicar, were observed on a standardised route in Zuerich.

All observations were done by one observer, in eight cases a second observer (a partner in the project) did observations together with the main observer in the subjects' own cars, in order to check inter-rater correlation.

17.8 RESULTS

The results can be divided into two parts: 1) Impressions of the observer and summary of the subjects' comments and 2) Quantified behaviour registrations with the help of the Wiener Fahrprobe.

17.8.1. Impressions and comments

Generally, the observer sustains that driving an electric minicar influences behaviour positively. With the minicar, subjects roll towards crossroads, zebra crossings, and obstacles, rather than driving towards them more quickly and then braking, as is the usual behaviour. Interaction rather changes towards more cooperation and seems to be less dominant with respect to VRUs.

* The first impression is that there are **no striking differences between driving a conventional car and an electric minicar**. Drivers maintained their driving-style, it seemed. When people started driving the minicar they were usually a little bit hesitant and there were some handling problems, to start with, but after 10 to 15 minutes such problems usually vanished, not unexpectedly (see STEINBRECHER 1991; quite usually people commented that "now I got a little bit used to the test car"). The more time went, the more subjects expressed their surprise about the fact that they could follow the traffic so well without being an obstacle.

* Five persons expressed some concern about the fact that they were **pressed by the other car drivers**: This led to the feeling that they had to drive as far to the right of the road as possible, or not to stop at a pedestrian crossing because they were afraid that other cars would hit them from behind. Even on uphill sections of the route the tendency to drive as far to the right as possible was observable.

* In the present study **communication with other car drivers** was a very artificial variable, as communication was obviously enhanced by the fact that the electric minicar raised a lot of interest. One moped-rider started quarrelling because he got surprised by the electric car that had approached him from behind so silently. However, reactions from other road users were very positive generally speaking: Firstly, the minicar is something new and unusual, and secondly the minicar seems to cause a kind of "baby-effect" - everybody is friendly and nice as long as there are not too many of these disturbing creatures around.

* Several subjects said that they **would like to buy such an electric minicar right away**. However, as prices are still very high, this attitude changed quite quickly when the price was named.

17.8.2 Some behaviour changes

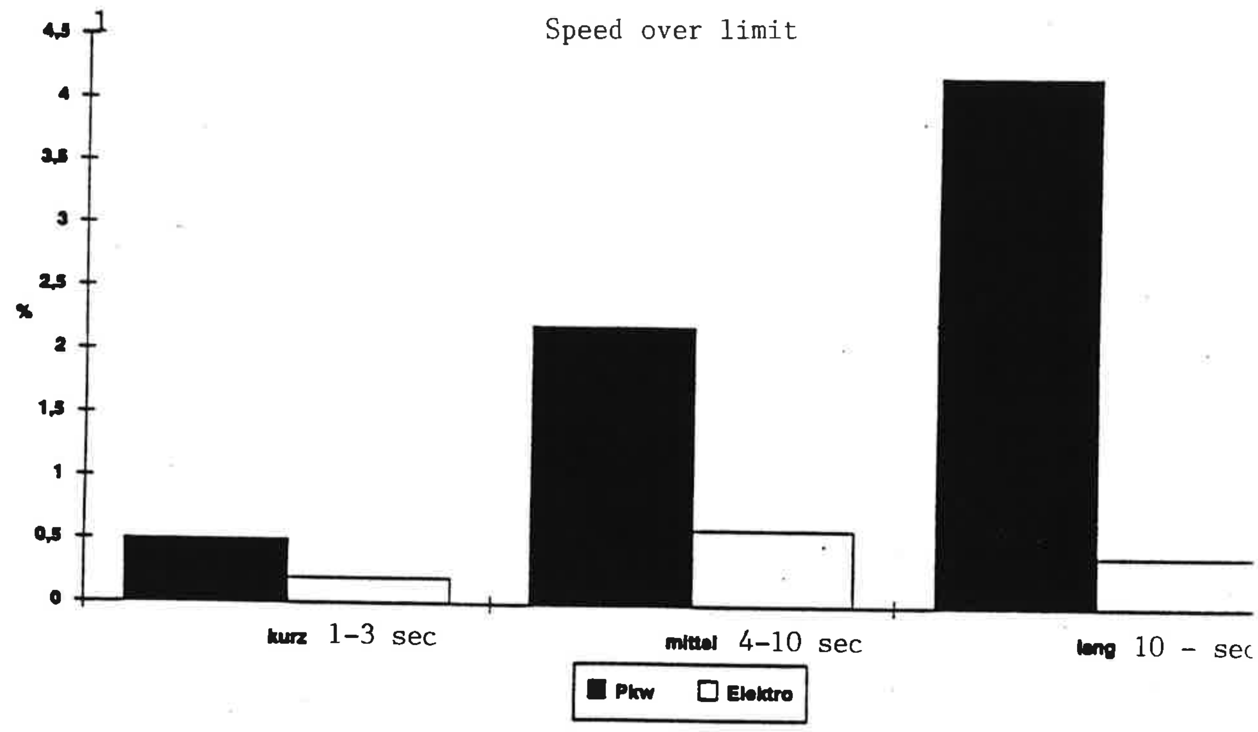
The results of the behaviour observations as related to the hypotheses in chapter 5 were the following:

Hypothesis a: Speeding, especially speeding over a longer time period, was less frequent in the electric minicar (fig 1)

Hypothesis b: This hypothesis is based on the assumption that impatience is reflected by short headways, by driving against red, and similar phenomenons. The behaviour observation showed that short headways became less frequent when driving electric minicars. But at traffic lights subjects driving conventional cars did not behave differently from when driving an electric minicar. It is not quite clear if behaviour of people driving electric minicars reflects less impatience.

Hypothesis c: Interaction and communication with VRUs is better when drivers are driving electric minicars than when they drive their own car. Especially when turning left or right and thereby crossing the way of VRUs walking/ travelling straight on drivers in minicars do not disturb VRUs as often as do drivers in conventional cars (fig 2). In the minicars there is also more preparedness to decelerate and to approach VRUs at a lower speed.

Figure 1


Speed over limit
4,5
4
3,5
3
2,5
%
2
1,5
1
0,5
0
kurz 1-3 sec
mittel 4-10 sec
lang 10 - sec
Pkw
Elektro

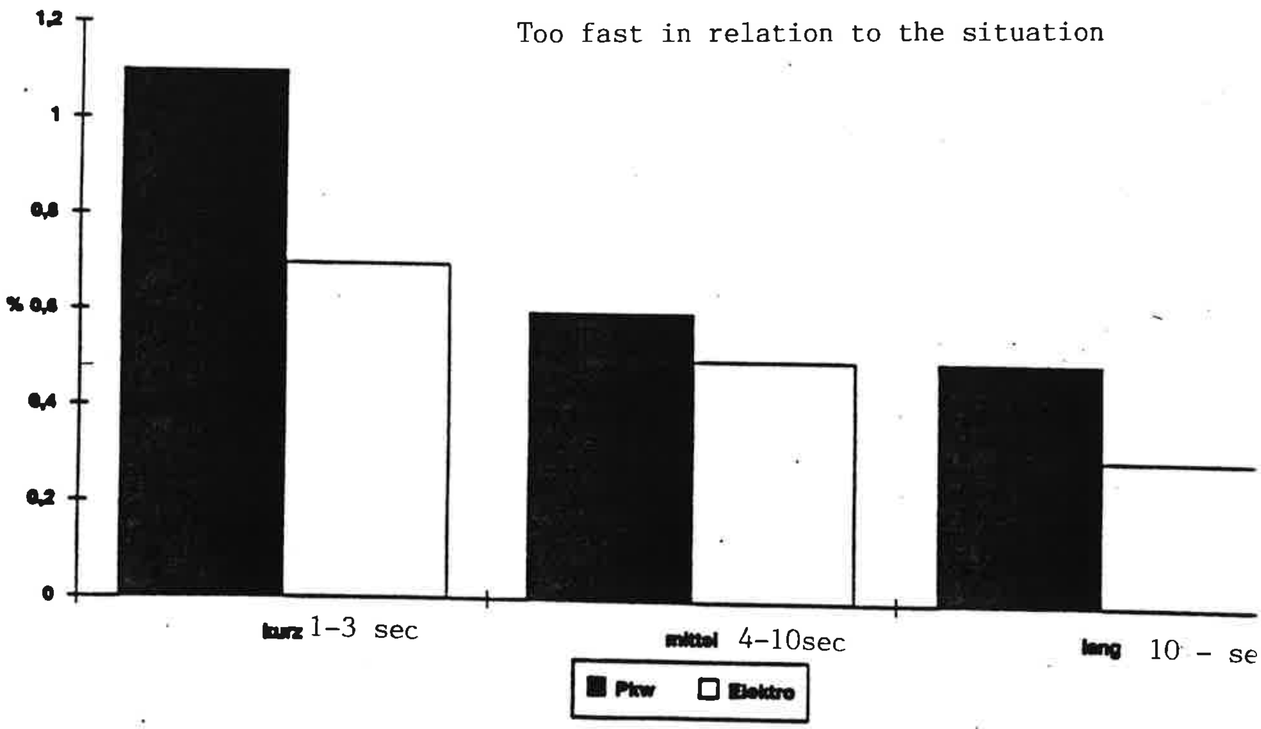
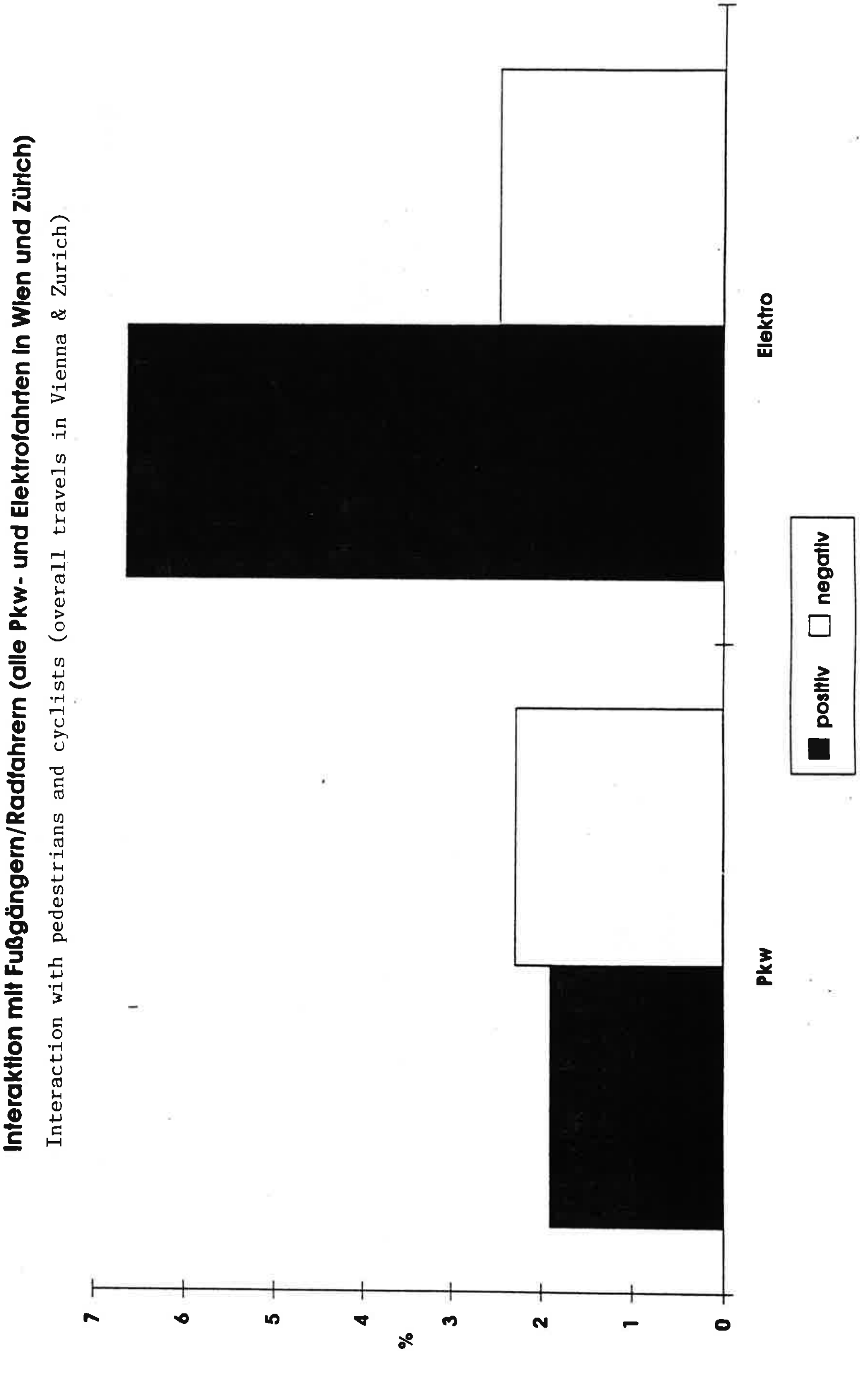

Too fast in relation to the situation
1,2
1
0,8
% 0,6
0,4
0,2
0
kurz 1-3 sec
mittel 4-10sec
lang 10 - se
Pkw
Elektro

Figure 2



Interaktion mit Fußgängern/Radfahrern (alle Pkw- und Elektrofahrten in Wien und Zürich)
Interaction with pedestrians and cyclists (overall travels in Vienna & Zurich)
%
0
1
2
3
4
5
6
7
Pkw
Elektro
positiv
negativ

Hypothesis d: There is no difference between people driving minicars or conventional cars with respect to behaviour in those cases when other car-drivers have the right of way. Infringements and errors happen with the same frequency in both cases.

Hypothesis e: Inadequately insisting on one's own right of way happens as often when driving an electric car as when driving a conventional car.

Hypothesis f: Inferiority feelings supposedly connected to driving of a minicar (smaller size, less power, etc.) according to our expectations could leed to compensatory behaviour. E.g., one could expect non-sufficient speed adaptation in such situations where an adaptation under the speed limit is necessary. However, in this respect there was no difference between subjects driving a conventional car and driving an electric minicar.

Hypotheses g: Another possibility for drivers of electric minicars to compensate is to overtake bycicles and mopeds in situations where there would not be enough space for drivers of conventional cars. We could however not find any differences between minicars and conventional cars.

Hypothesis h: We could not detect any behaviour reflecting the main statement of this hypothesis, that VRUs will "have to pay for the disadvantages drivers of minicars experience" in today's traffic (see hypothesis c).

Hypothesis i: Driving against amber and red happens with the same frequency in the conventional-car mode and in the electric-minicar mode.

To finish with, I want to present a table that to a certain degree reflects subjective safety during the test ride (table 1):

Table 1: Did you feel safe during the test ride?

Feeling of safety	cc Vienna	elm Vienna	cc Zuerich	elm Zuerich
very safe	72%	52%	70%	20%
safe	25%	41%	30%	70%
partly unsafe	0%	7%	0%	10%
unsafe	3%	0%	0%	0%
very unsafe	0%	0%	0%	0% .
	100	100	100	100

cc = conventional car
elm = electric minicar

This table showes that there is good reason to assume that drivers do not feel as safe in electric minicars as they do in their own conventional cars. Of course, it would be interesting to interview some people who have been driving electric minicars for a longer time and who have become used to that, with respect to this question. But this will be part of further projects.

17.9 CONCLUSION

Summing up one can say that drivers behave slightly more safely and socially acceptable (fig 2) in electric minicars than when driving their own conventional car. However, if anybody had expected a more "humble" behaviour in electric minicars, because of the inferiority with respect to power and speed - where "humble" is something positive and means cooperative, patient, etc. - he/she would be disappointed with the results presented here. Driving a car is an activity intimately related to a social field. One feels the impatience of others, is pressed by others, is overtaken by others, experiences advantages of others who drive past fast, and so on. The social environment does not provide for much reinforcement for those who drive slowly, renounce in their right of way, consider other road users' needs, etc. This means that we should not be surprised by the fact that car drivers try to behave like "ordinary" car drivers even when they are sitting in an electric minicar.

REFERENCES

RISSER R., CHALOUPKA CH., LIEDL K. & STOCKINGER M. 1992, Studie über das Fahrverhalten beim Lenken von Leichtmobilen im Auftrag der Universität Zürich, finanziert vom Schweizerischen Fonds für Verkehrssicherheit und vom Bundesamt für Energiewirtschaft, Bern: FACTUM, Wien

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ALMQUIST S., HYDÉN CH. & RISSER R. 1991, The SL - a speed limiter in the car for increased safety and better environment; Paper submitted for TRB- conference, Washington

CHALOUPKA CH., RISSER R. & ROEST F. 1991, Methode zur Identifizierung gefährlichen Verhaltens im Straßenverkehr, Abschlußbericht über ein vom Fonds zur Förderung der Wissenschaftlichen Forschung gefördertes Projekt, Wien

DRASKOCZY M. (Ed.) 1991, International cooperation on theories and concepts in traffic safety, Proceedings of the 3rd Workshop in Cracow 1990, Dept. for Traffic Planning and Engineering, Lund Institute of Technology and ICTCT-Secretariat, Vienna

I C T C T 1990, Theoretical aspects and examples for practical use of traffic conflicts and other interactional safety criteria in several industrial and developing countries, Proceedings of the 2nd Workshop of ICTCT in Munich 1989, Dept. for Traffic Planning and Engineering, Lund Institute of Technology and ICTCT-Secretariat, Vienna

I C T C T 1992, International cooperation on theories and concepts in traffic safety, Proceedings of the 4th Workshop in Vienna 1991, Dept. for Traffic Planning and Engineering, Lund Institute of Technology and ICTCT-Secretariat, Vienna

MONHEIM H. & MONHEIM-DARNDORFER R. 1990, Straßen für alle, Rasch und Röhring Verlag, Hamburg

O E C D 1990, Behavioural adaptations to changes in the road transport system, OECD Expert group, Paris

PERSSON H., TOWLIAT M., ALMQUIST S., RISSER R. & MAGDEBURG M. 1993, Hastighetsbegränsare i bil. Fältstudie av hastigheter, beteenden, konflikter och förarkommentarer vid körning i tätort, Departement for Traffic Planning and Engineering, Lund Institute of Technology

PFAFFEROTT I. 1992, Die Risikospirale. Warum technische Sicherheitsverbesserungen nicht unbedingt zu weniger Unfällen führen, INTRA Psychologie und Gesellschaft 3, Nummer 11

RISSER R. 1985, Behaviour in traffic conflict situations, AAP

RISSER R. & CHALOUPKA CH. 1993, PROMETHEUS und Sozialwissenschaften, Finanziert vom Fonds zur Förderung der Wissenschaftlichen Forschung FWF, Wien

RISSER R., TESKE W., VAUGHAN CH. & BRANDSTÄTTER CH. 1982, Verkehrsverhalten in Konfliktsituationen, Kuratorium für Verkehrssicherheit Wien

SACHS W. 1985, Die Liebe zum Automobil, Rowohlt-Verlag Reinbek bei Hamburg

SCHROEDER M. 1990, Acceptance of Minicars in Sweden. Survey 1990, Lund Institute for Technology, Dept. for Traffic Planning and Engineering

STEINBRECHER J. 1991, Verkehrsteilnehmerverhalten in Abhängigkeit von gestalteter Umwelt. Ergebnisse von fahrerbegleitenden Beobachtungen, in: COHEN A. & HIRSIG R., Fortschritte der Verkehrspsychologie `90, Verlag TÜV Theinland/Deutscher Psychologen Verlag

STRAUSS P. 1992, Crash-Versuche mit Personenwagen und Motorrädern, Schwerpunkt Elektromobile, Diplomarbeit im Studienfach Fahrzeugtechnik an der Fachhochschule München

18. THE PAEDAGOGICAL USE OF TRAFFIC CONFLICT TECHNIQUE

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18.1 INTRODUCTION: TRAFFIC SAFETY EDUCATION IN AUSTRIA

Traffic safety education in Austria starts with the attendence at the kindergarden. The kindergarden teachers are prepared for that task by their education. The focal point of traffic safety education is situated in the area of elementary school, that are the children from 6-10 years, where the traffic safety education is mandatory in all four classes as subject like reading and arithmetic. The lessons are in fact realized in a high degree. This education ends for nearly 80% of the Austrian children by the voluntary cycling examination with the exception of Vienna, the only large city in Austria, where cycling is seldom.

After elementary school the children go to other schools with fan-shaped lessons: while in the elementary school the same teacher gives lessons in all subjects, the children have now in each subject an other teacher. The consequence is, that quite a lot of the teachers push the task to realize traffic safety education towards their coooeaques although according to the principle of teaching traffic safety education each teacher is obliged to enter into traffic safety education in his subject where it fits.

Quite wide-spread is the neglection of traffic safety education in the higher classes of grammer schools (persons from 15-18 years) The reason is, that the traditional kinds of traffic safety education do not fit to that stage of life. It will be regarded as too "childish" by the pupils. But at the same time at that age the participation in motorized traffic starts (Mopeds and small motor-cycles). Motorised road users of this age have an extremely high accident risk. There is therfore a strong need for traffic safety education. However, so far the appropriate means to educate the juveniles at that age for traffic safety were missing.

An advantageous kind of working with these stages of age are the project-lessons, that means that one class is treating a theme self-acting under the supervision of the teacher. The pupiles gain understanding through their own activities and investigation, which are more convincing for them than results reported by the teacher. Here applicable methods are to observe traffic, to count events, to interview traffic participants and to carry out action, always with the background of their own reflections about the observed matters. These activities have provide implicit feed back to the participating pupils, which is operative for traffic safety education.

18.2 TRAFFIC CONFLICT TECHNIQUE IN THE PROJECT-LESSONS

The traffic conflict technique meets exactly the conditions for project-lessons in the higher classes of grammar schools. It needs more intellectual capacity in the sense of learning the technique of observation, but pupils are able to learn it within a short training period. Traffic is for juveniles mostly an interesting matter for young people and therefore they are rather highly motivated to deal with traffic topics. Moreover, in the frame of project work a complete task with a defined beginning and a defined goal is persued. It is easy to judge whether the goal was achieved or not: From the outcome concrete conclusions may be derived. The occupation with the own behaviour will be stimulated by the observation of the other people's behaviour. The pupils are able to act independently and they are taken seriously.

The following routine seems to be adequate for carrying out project work including the application of traffic conflict technique:

1. The goal of the project has to be defined.
2. To establish the working plan and the project design.
3. The class has to make the choice between several methods for their project (Traffic conflicttechnique, behaviour observation etc.)
4. Selection of the observed site and determination of the observer positions.
5. Reading of the features of the observed site and of the traffic flows.
6. Observer training (e.g. in traffic conflict technique.)
7. Realization of traffic conflict observations.
8. Statistical evaluation of the observed traffic conflicts with reference to reported accidents.
9. Graphical presentation of the results.
10. Report with recommendations.
11. Presentation of the project to the public for example:
    "the school public"
    "the parents public"
    "the public of the district"
    "the common public by print and electronic media"

The last point is especially important for the personal identification of the pupils with the result of the project and with their consequences. The interest of the mass-media for the results of such projects is mostly high.

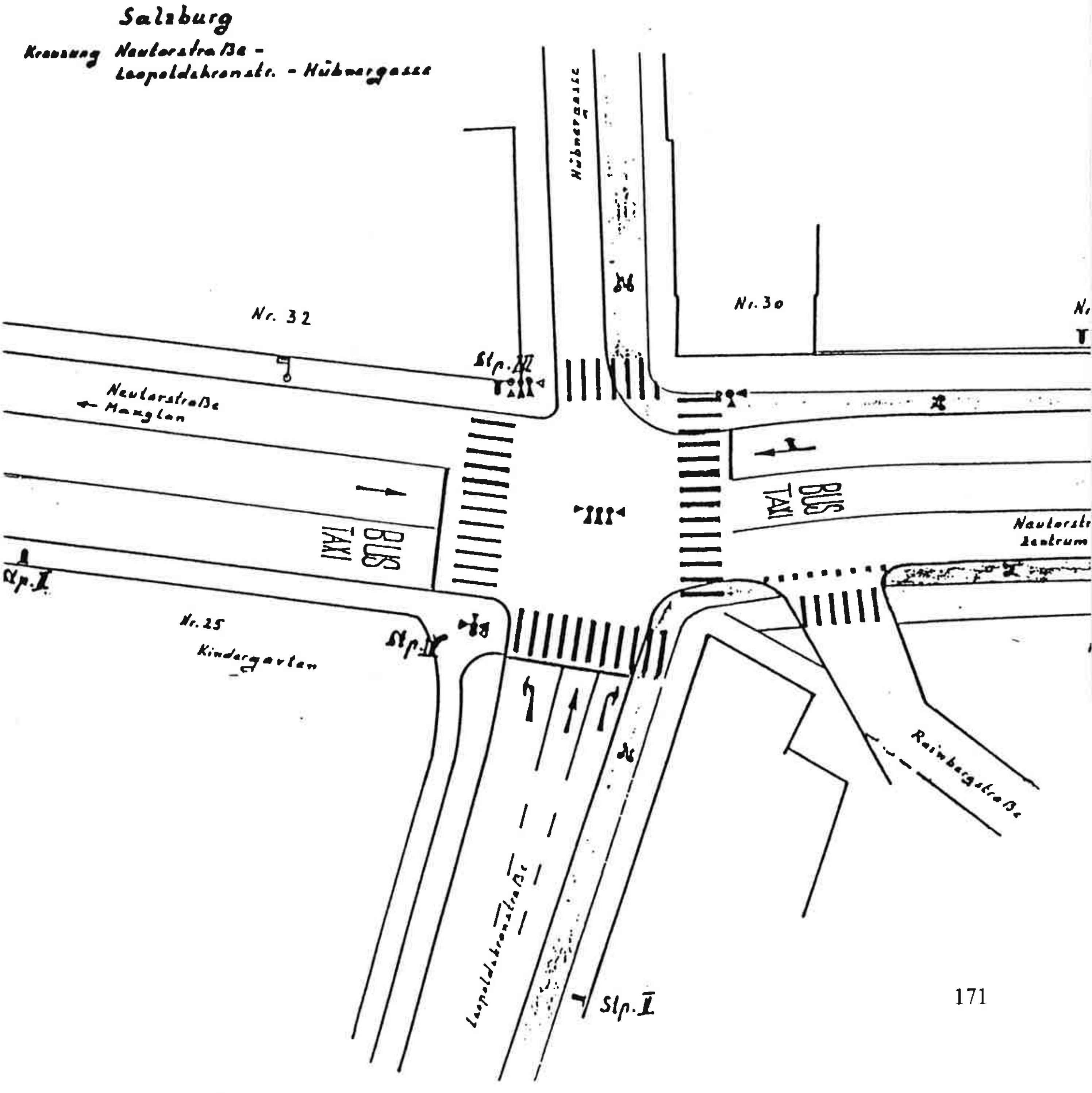
18.3 AN EXAMPLE FOR THE APPLICATION OF TRAFFIC CONFLICT TECHNIQUE IN THE FRAME OF PROJECT WORK

At the Austrian Road Safety Board in Salzburg Walter Tamme (1991) was concerned and engaged with that subject and he has documented four projects of that kind. One of them was a traffic conflict observation in the city of Salzburg.

The project Salzburg 1991

The schoolgirls of the 6th class of the federal secondary school for household and economy had to pass a practical course in the subject of psychology. The teacher applied to the Austrian Road Safety Board for cooperation to carry out the practical course in the field of traffic psychology. The schoolgirls of about 16 years age choose traffic conflict technique as method out of serveral offers and carried out an investigation on the traffic conditions of a highly frequented crossroad in the center of the city of Salzburg. This crossroad was selected from the schoolgirls out of several black spots named to them.

The site is on the one hand part of a street ("Neutorstraße") coming from the airport region in the west of the city of Salzburg going eastward to the center.
On the other hand there is a south-north going street ("Leopoldskronerstraße - Hübnergasse"). Both streets have bus traffic too. The intersection is signalized.



After the choice of the site a working plan was established followed by a theoretical introduction to traffic conflict technique. Susequently the traffic on the intersection has been observed for two days whereby violations by pedestrians and cyclists have been observed as well as problems with traffic signs, that were not well adjusted signalizing to the traffic flow and to other characteristic of the traffic space. From five different observer positions the intersection has been observed and traffic conflicts have been registered.

The following problems were observed:

- The traffic light for pedestrians was neglected for 18 times by pedestrians, whereby conflicts occured with cars. The street on that site is so narrow, that only one car may pass at the same time (one lane and one-way). Therefore even short gaps between the passing cars were accepted by the pedestrians for prohibited crossing. By that traffic conflicts occured between the pedestrians and the cars turning to the right from the "Neutorstraße" into the "Hübnergasse".

- Repeatedly conflicts were observed between line-busses and the other motorized traffic in the direction "Neutor" (east bound) because the busses on that point have to change from the extreme right to the middle lane of the street.

- About one third of the cyclists did not use the cycle path along the "Neutorstraße" because it was not clearly perceptible due to insufficient colouring. In the city of Salzburg cycle paths usually have a red coloured pavement.

- There are often conflicts due to busses stopping in the bus-stop in the "Neutorstraße". The cars following the busses often try to pass the stopping bus, sometimes there is imminent risk of collision with the oncoming traffic.

- The cycle paths repeatedly were used by cars for parking, whereby cyclists were forced to dodge to the street. Both dodging manouvers of the cyclists and cars leaving their illegal parking in some cases caused conflicts with the following traffic. At the end of the conflict observation the results were analysed and recommendations were formulated how to reduce or to abolish the existing problems.

The following recommendations were given:

1. The traffic lights for pedestrians and cyclists should be attached in the level of the eyes, as some of the infringements seemed to be due to the fact that pedestrians has difficulties to keep an eye both on the traffic lights and traffic, as the lights are positioned outside the central field of vision of the pedestrian.

2. To make it more clear that left turning is prohibited from the "Neutorstraße" to "Hübnergasse" when green for traffic going straight on is flashing, a red arrow for left going traffic should appear (=forbidden to turn left).

3. For line busses in the "Neutorstraße" going to the center lane a particular green phase should be installed to avoid the critical interactions between line busses and car traffic going in the same direction.

4. The cycle path in the "Neutorstraße" should be better marked and pedestrian area and

cycle paths should be clearly seperated.

5. On the observed intersection a general green phase for all pedestrians should be installed. Thereby waiting times and law infringements by the pedestrians could be avoided.

6. "Leopoldskronstraße" should be changed from actually three lanes to two lanes in the future. There should be a common lane for traffic going straight on and the one turning to the right.

7. The bus stop in the "Neutorstraße" before the shop row in the direction away from the city should be designed in that kind, that vehicles could pass the stopping bus without getting into troubles with oncoming traffic. Therefore it was regarded necessary to diminish the width of the pedestrian lane for 0,5 meters.

The results of the study and the recommendations were conveyed to the authorities and presented to the public in the frame of a press-conference together with other matters, whereby three schoolgirls reported on their project.

Some weeks ago we had the opportunity to carry out traffic conflict obervations with another group on the same crossing.

The recommendations implemented by the authorities in the meantime proved to be so efficient, that only a few conflicts on that crossing could be observed.

This method seems to us to be a good example that experiences of "hard core" practitioners, namely road users themselves, could play a valuable role in the development and evaluation of new measures, both concerning road and infrastructure design and vehicle equipment.

REFERENCES

RISSER R., ZUZAN W. D., TAMME W., STEINBAUER J. & KABA A. 1991, Handbuch zur Erhebung von Verkehrskonflikten mit Anleitung zur Beobachterschulung, Literas-Verlag, Vienna

TAMME W. 1991, Verkehrskonfliktbeobachtung - Projektarbeit mit Schülern, In: STEINBAUER J. (Hrsg.) 1991, Praktischer Einsatz der Verkehrskonflikttechnik, Kuratorium für Verkehrssicherheit, Vienna

19. MONITORING TRAFFIC BEHAVIOUR IN THE CONTEXT OF AN EVALUATION OF A NATIONAL TRAFFIC POLICE FORCE

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19.1 INTRODUCTION

Until recently, police traffic operations in Israel were coordinated by local and district commanders of the national police force as part of their many other duties. At the district level there were personnel and sub units specializing in traffic related services but there was no national level command, control, and communication structure dedicated to traffic enforcement and other traffic operations

In 1991 a National Traffic Police (NTP) force was established as an operational branch at the national police headquarters in Jerusalem, and all existing traffic units came under its direct command. (The transfer was gradual: first some of the rural districts, then the rest and, finally, the remaining urban districts.)

The NTP introduced an organizational change that put traffic police officers and traffic operations under a separate, nationally coordinated command. In addition, it entailed an increase in resources -- manpower, vehicles and associated enforcement and other equipment. For example, the traffic units in the two districts that have been changed first were nearly doubled in size.

The NTP was empowered and expected to experiment with, and modify strategies and tactics of traffic operations and active enforcement in order to achieve, efficiently, a higher level of traffic safety on Israeli roads.
The Transportation Research Institute is evaluating the total operation of the NTP in order to help improve NTP's functioning and to provide data for those required to determine its success.

The evaluation program was designed to monitor the organizational changes and their impact on NTP functioning and traffic operations; to monitor changes in enforcement activity; to measure changes in traffic or drivers' behaviour and relate them to police actions and; eventually, to asses changes in traffic accidents that might be attributed to the new NTP.

The present report is confined to the monitoring of traffic behaviour during the first phase of the project, when the NTP had jurisdiction over two rural districts, covering about 2500 km. of roads. These roads include all the major, high volume highways in Israel and they accounted for 2600 injury accidents in 1991.

19.2 METHOD OF TRAFFIC BEHAVIOUR MONITORING

19.2.1 Overall approach

The national scope of the NTP and the comprehensive nature of its operation required special methodological considerations with regard to what, where, when, whom, and how to observe and monitor. It was obvious that it would be impossible to monitor every desired driver behaviour (or traffic characteristic) or that the monitoring could be performed at every road and during all times.

Yet the monitored behaviours should represent what happen on the road network much of the time, and indicate whether there are changes in the behaviour over time or locations. As well, it has to be shown that such changes could be attributed to the NTP and that they are, eventually, related to improved safety.

The general approach in designing the monitoring system was to use a large sample of representative road sections and take repeated measures of the set of chosen behaviours. Some behaviours would be automatically collected over longer periods of time while more complex types of behaviours would be manually collected over shorter periods overlapping the automatic records. Knowing the importance of traffic volume in determining most other traffic characteristics it was decided to always record traffic volumes along with other measurements.

The large number of observation sites recognized the large variability in traffic behaviour due to local differences in traffic volume, vehicle mix, roadway characteristics, visibility, weather conditions and a host of other attributes. At the same time an effort was made to reduce the uncontrolled variance by limiting the variety of observation sites and by following a procedure of repeated observations under as similar conditions as practically possible.

19.2.2 The monitored behaviours

The behaviours to be monitored were selected according to the following criteria:

- the behaviour is enforced, (at least in principle), by the police;
- the behaviour is associated, (at least in principle), to safety;
- the behaviour can be reliably monitored and quantified;
- the behaviour can be measured with simple portable equipment;
- the behaviour does not require post- collection analysis (e.g., video interpretation);
- the behaviour can provide sufficient data for statistical analysis and inference.

The traffic behaviours that were selected for monitoring can be divided in two groups:

* Speed and Following Distance, that are measured on road sections;
* Approach Speed on the non priority road, and the Friction Between Turning Vehicles, that are measured at non signalized T junctions.

The interactions between turning vehicles take on three possible Levels of Friction: None, High, and Medium.

19.2.3 Monitoring sites

The sampling, for selecting the observation sites, was done from a list of over 200 road sections. The list was independently compiled by the police prior to the establishment of the NTP. The road network was divided into 10 km to 20 km sections, based on traffic volume, annual accident rate and practical patrolling considerations. At any given time, only some of the sections are actually assigned patrol cars or other enforcement resources.

In the first phase of the monitoring, reported here, 24 road segments were selected from among the road sections with ADTgreater than 5,000 vehicles. In order to provide representation for the various NTP field units, different geographical areas, and different types of roads, the sampling was not random but in clusters to accommodate the above constraints. In each of two NTP districts there were 12 sections, and another 4 in a third, not yet incorporated into the NTP command, police district.

The actual observation site in each road section was selected following on- the- road survey. A non signalized junction with sufficient volume of traffic was located and checked for the monitoring conditions. Traffic behaviour at road sections was monitored on the main road leading to the junction but at a distance far enough to ensure independent behaviour.

The sampling, site selection, and actual observations were carried out independently of any planned or actual police activity at the road sections.

19.2.4 Monitoring procedure

During phase I, data were collected by the same team of observers who visited each site five times, once every other month. Figure 1. shows a typical layout of an observation site.

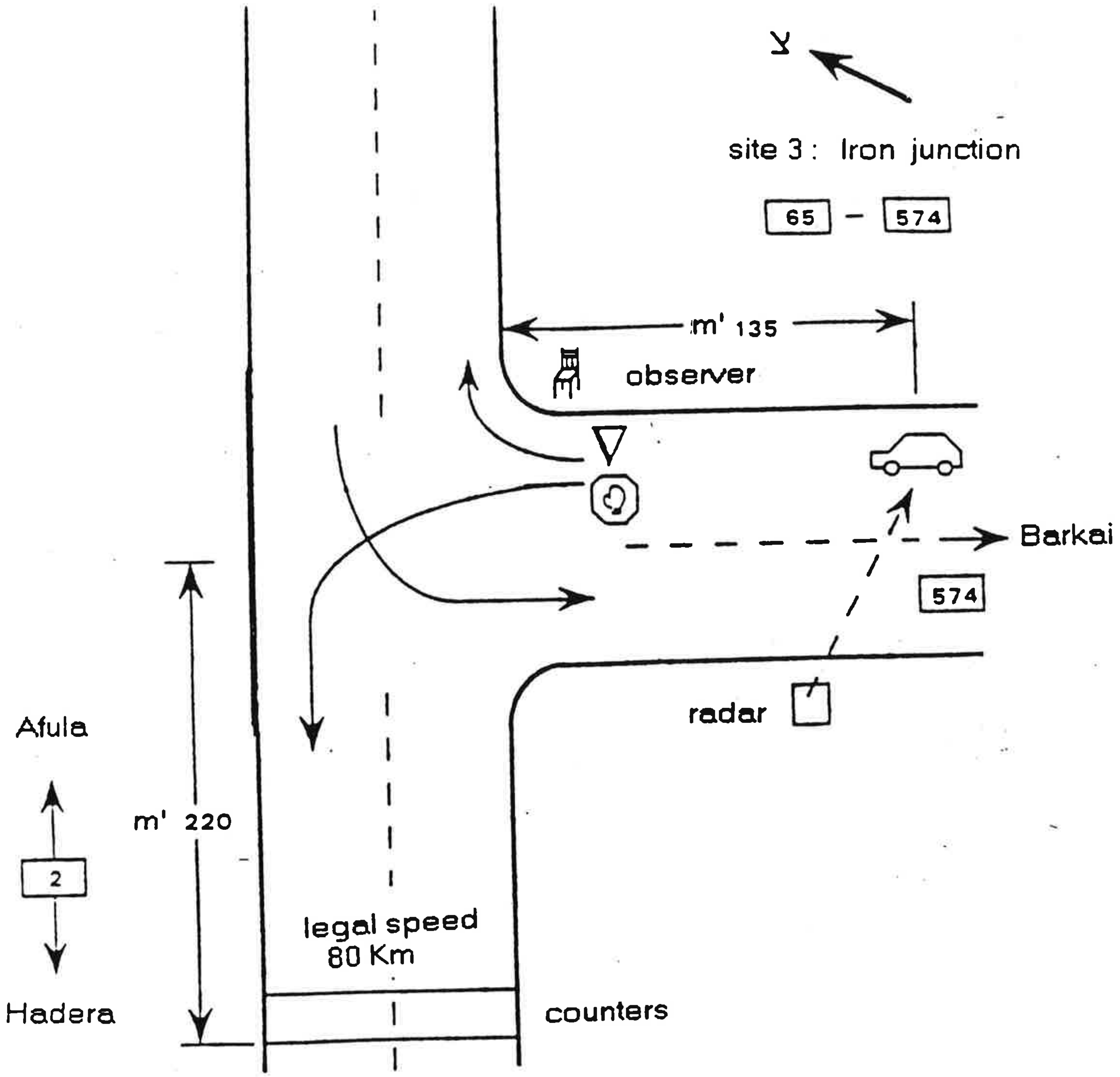
Vehicle volumes, speeds, and following distances on the main road were recorded by electronic Traffic Counters with pneumatic tubes placed 3 m apart. The counters were positioned over 200 m away from the junction, before the beginning of turning lanes or no passing zones. Counters were left for the whole day and, often, overnight and the next day. Data were unloaded into portable computer at the site.

Approach speed on the minor road was measured with a hand operated, portable radar (speed-gun) from inside a parked vehicle. The radar was aimed at a fixed point on the road so that an approaching vehicle would trigger the radar at a specified point from the junction. The point was at a distance where most vehicles begun slowing down slightly. Only free moving vehicles were measured. At least 120 readings per measurement period were taken at each site.

The level of friction at the junction was assessed by an observer positioned at a convenient spot overlooking the junction. The observer used a set of manual counters attached to a clip board to count and classify the turning maneuvers at the junction. Included in the count were all vehicles outgoing the minor road and left turning vehicles form the main road.

Right turning vehicles from the minor road could be in conflict with traffic coming from the left , on the main road: left turning vehicles from the minor road could be in conflict with traffic, in both directions, on the main road; vehicles making a left turn from the main road could be in conflict with oncoming traffic on the main road, with vehicles turning left from the minor road, or with vehicles turning into the minor road from the main road.

Figure 1 Schematic layout of traffic behaviour measures at a junction



Each turning maneuver was classified into one of three categories depending on the amount of friction it generated in traffic at the time of its execution.

Normal friction event included cases when there was no conflicting traffic in the vicinity of the turning vehicle or when each vehicle seemed to act according to priority rules accepted by the other vehicles. There was no indication of last second changes in speed or lane position by either turning or straight going vehicles and no apparent interference with traffic on the main road.

The ***High friction*** category included those obvious cases when the turning event generated emergency reactions, abrupt lane or speed change, by one or more vehicles in the vicinity of the junction in order to prevent a possible collision.

The ***Medium friction*** category was a default category to accept events that were clearly neither of the other two. Preliminary trials suggested that it was best not to define this category in more specific detail.

During field training, examples of the categories helped defining them by way of induction. A minimum of 30 turning maneuvers per direction were observed at each measurement period for a total of over 150 per junction at a time, (turning volumes were not equal.)

The positions of equipment and observers were paint- sprayed and documented in order to assure similar data acquisition conditions in each round of measurements.

19.3 PRELIMINARY RESULTS

19.3.1 Overview of analysis approach

The purpose of the analysis was to detect meaningful changes in the behavioural measures of traffic, from the onset of the NTP project until the last (5th) round of field measurements.
It took the NTP few months to restructure, reorganize, train new officers, acquire new vehicles, develop new operational procedures, and make other adjustments. Therefore, it was expected that the first round of observations represented a base line condition, after which some (hopefully positive) changes would take place as a result of NTP's stronger impact on traffic.

Specifically, the analyses were to find, across five repeated measurement rounds, a trend of change in the following summary measures:

* average speed on main roads;
* % of vehicles moving at speeds higher then the legal speed limit (90 km/h);
* % of following distances smaller than 1 sec or 2 sec;
* average approach speed to a junction, on the minor road;
* % of high and medium friction turning maneuvers at junctions.

In order to relate changes in traffic behaviour to police enforcement, a crude measure of "enforcement level" was obtained for each site. It was based on the mean number of patrolling shifts per week, assigned to the road section, during the month preceding the field measurements.

As noted earlier, traffic volume has a major influence on the momentary values of other traffic characteristics. Therefore, automatic recordings of volumes and speeds were made for many hours and the repeated data for each site were collected under as much similar conditions as possible.

Based on data from all measurement rounds, a "common window of analysis" was identified for each site such that during similar hours of the day, during all measurement rounds, traffic volume was about the same. In most instances, it was a 2.5-3.0 hours afternoon period, just after the noon peek hour and prior to the next evening peak.

The off- peak period is not claimed to represent the whole 24 hours day, but it allows a better comparison of the behavior parameters over time, and during periods of free flowing traffic. It should be noted that at most sites, there was a lot of traffic throughout the day and off- peak volume is just that and not very low volume.

The final element in the analysis concerns the way results from each site and each round of measurements were combined to test the hypotheses about changes in behaviour over time.

Statistical tests were first performed at the single site level. Speed values for five measurement periods were tested in a one way ANOVA for repeated measures. Analysis for contrasts tested for the direction of change (+, 0, -; or pos. n.s, neg). in three comparison periods: 1st to 2-5; 1-2 to 3-5; and 1-3 to 4-5. For example, the 1-2 to 3-5 contrast compared the mean speed during periods 1 and 2 to mean speeds measured during the later periods 3,4,and 5.
The data of the other measures -- % over speed limit, % following distances < 2 sec; % H+M friction at junction -- were cross tabulated according to the different periods compared, and tested with a χ^2 test for significance of the differences.

Even if it the NTP has had a positive effect on all the measures, it is clear that one can not expected to find its impact every time and at each measurement site. Random variation and a host of uncontrolled factors contribute to the measured differences in the data at each single location. However, since every site was just a member of a sample representing a larger population it is necessary to look at the whole sample.

The last step in the analysis consisted of listing all the sites (or a sub- group of sites) and tabulating the direction of change for each comparison period. The list of "+" and "-" was then tested by the Binomial test for the statistical significance of the predominant trend, be it a "+" (positive effect of enforcement), or a "-" (negative effect.) A "0" (n.s , not significant difference) does not count in the calculation and the size of the sample is reduced accordingly.

A priori, there was only very small chance for the NTP to have a discernible impact on traffic behaviour on a national scale. Therefore, the analysis was designed to enhance the possibility of finding any positive effects of enforcement on traffic behaviour (if the effects were indeed there.)

19.3.2 Changes in speed

Table 1 is a summary table of mean speeds on the main road at 17 sites that are on two lane highways. The table also shows the trends of speed change based on the ANOVA and tests for contrasts. The last column reflects an, rather liberal, integration of the three sets of trends. Even so, a Binomial test for the significance of having 9 out of 12 comparisons positive by chance, shows that it is likely at a probability of p = .073 (one-tail.) This outcome may be interpreted as encouraging or discouraging depending on other results and our ability to make sense of the more detailed data. However, examination of the table suggests that the latter may not be easy. The differences between sites are relatively large and quite consistent. The differences between measurement rounds are, usually, less than 5% but not very consistent.

Table 1: Mean speed by site, measurement period, and direction of speed change

Mean speed (km/h) on main road						Direction of speed change			
Site ID	Period 1	Period 2	Period 3	Period 4	Period 5	p1/p2-p5	p1-2/p3-5	p1-3/p4-5	Overall
1	74.85	76.33	76.33	75.36		n.s	n.s	neg	neg
3	79.71	72.99	77.97	80.42	76.85	neg	neg	pos	n.s
4	75.75	74.22	73.69	74.00		pos	pos	pos	pos
5	75.29	71.82	70.26	72.88		n.s	pos	pos	pos
6	78.13	77.79	77.53	76.27	78.78	n.s	n.s	n.s	n.s
7	75.11	76.12	74.23	74.21	74.40	pos	pos	n.s	pos
8	67.08	68.08	65.42	65.17	64.07	pos	pos	pos	pos
9	66.73	67.59	67.49	66.79	68.59	n.s	n.s	n.s	n.s
10	79.58	76.30	77.22	76.56		pos	pos	pos	pos
11	70.50	73.07	66.39	70.89	63.51	pos	pos	pos	pos
12	83.06	79.95	82.36	81.61		n.s	n.s	pos	n.s
15	67.98	73.41	67.74	68.08	69.37	n.s	pos	neg	n,s
16	70.45	70.30	69.05	71.83		neg	n.s	n.s	neg
17	83.65	83.67	86.38	82.75	83.72	pos	n.s	n.s	pos
23	66.22	65.61	65.97	66.15	67.80	neg	n.s	n.s	neg
27	80.49	82.42	81.17	77.60	79.71	pos	pos	n.s	pos
28	78.93	80.28	79.01	74.76	74.90	pos	pos	pos	pos

Approach speeds on the minor roads have changed even less than speeds on the major roads connecting with them. The table of results looks very similar to table 1, only with generally lower speed values. In 25 sites with relevant data, 10 showed decrease in speed over time, 7 showed an increase, and in 8 sites there was no clear change. The Binomial test indicates p = .315 to get such result by chance.

19.3.4 Changes in % speeding and % following too closely

Generally, there was no significant change in the values of these measures across the five periods. Only few of the individual comparisons were significant in the χ^2 test and, consequently, the predominant trend was "no change". The % of vehicles going over 90 km/h (speed limits are 80 or 90) varied from as low as 1% to as high as 35%.

The expectation that this measure will be more sensitive to enforcement effect was not fulfilled. In retrospect, it is not surprising in view of the, inevitable, larger variance in the high tail end of a speed distribution. The mean is actually a more reliable measure.

The % of vehicles following at a distance of 2 sec or less hovered around the 20% value. It was clearly volume dependent; up to 27% at the site with the highest traffic volumes and down to 10% at the lower volume scale.

19.3.5 Changes in level of friction at junctions

Table 2 presents the results of the friction measurements at 25 junctions, during 5 measurement rounds, and the direction of change. The data were aggregated across the three turning manoeuvers. Each entry represents the % events that were at a High and a Medium level friction.

The values range from 1% to 10%. As expected, most of the events were of Medium friction. As with the other measures that refer to a percentage at an upper end of a distribution of behaviour, also here the variability between repeated measurements is high. There is a clear difference between sites, some of which is related to traffic volumes. However, much of the difference in % of friction, between sites, seemed to reflect the nature and quality of the geometric design at the junctions, lane markings, location of bus shelters on the main road, traffic mix, and visibility at all legs of the junction.

At 17 out of 25 junction there was no significant change between periods. Of the 8 sites that showed a relatively consistent trend of change, 7 were in a positive direction, less friction at later periods of measurement (one tailed $p = .035$.)

Table 2: Level of friction at junctions by site, measurement period, and direction of change

	% friction at High -Medium level					Direction of change in level of friction			
Site ID	Period 1	Period 2	Period 3	Period 4	Period 5	p1/p2-p5	p1-2/p3-5	p1-3/p4-5	Overall
1	7.43	10.88	8.96	5.70		n.s	n.s	n.s	n.s
2	8.85	7.32	6.15	7.14	5.00	n.s	n.s	n.s	n.s
3	7.17	9.41	7.47	3.13	4.86	n.s	pos	pos	pos
4	7.90	7.81	4.62	4.90		pos	pos	pos	pos
5	5.50	8.10	5.60	6.88		n.s	n.s	n.s	n.s
6		4.64	2.94	3.54	4.90	n.s	n.s	n.s	n.s
7	7.20	10.48	5.46	5.27	5.78	n.s	pos	pos	pos
8		7.17	5.96	3.65	4.51	n.s	n.s	n.s	n.s
9	6.45	8.44	4.63	5.21	5.00	n.s	n.s	n.s	n.s
10	6.10	7.58	4.79	6.02	6.25	n.s	n.s	n.s	n.s
11	6.16	5.06	4.49	2.73	4.29	n.s	n.s	n.s	n.s
12	6.33	7.04	2.26	4.00		n.s	pos	n.s	pos
14			3.07	4.26	3.09	n.s	n.s	n.s	n.s
15	8.20		5.74	3.77	6.07	pos	pos	pos	pos
16	1.48	5.88	4.02	2.75	1.48	n.s	n.s	n.s	n.s
17	6.96	1.77	1.83	1.46	2.99	pos	n.s	n.s	pos
18	10.00	9.29	8.09	6.70	8.36	n.s	n.s	n.s	n.s
21	8.97	6.72	6.49	5.33	9.37	n.s	n.s	n.s	n.s
22	4.24	4.53	2.80	4.51	5.23	n.s	n.s	n.s	n.s
23		3.14	6.26	6.07	6.46	n.s	neg	neg	neg
24	10.20	8.81	8.05	6.02	8.26	n.s	n.s	n.s	n.s
25	8.51	8.93	8.60	6.85	3.57	n.s	n.s	n.s	n.s
26		6.59	5.78	3.29	3.87	n.s	n.s	n.s	n.s
27		2.13	5.57	4.60	5.26	n.s	n.s	n.s	n.s
28	78.93	4.08	3.75	0.68	2.38	pos	pos	n.s	pos

19.3.6 Did enforcement influence traffic behaviour?

So far, analysis of the results for each measure and across all relevant sites showed no significant changes between periods, with the possible exception of the friction measure. However, it was also shown that there were large differences between sites. Some showed a fairly consistent trend of improvement on all or some of the measures, many showed no change or inconsistent trend, and few showed a negative trend of change. Is there some commonalty between the subgroups of sites that can explain the differences? Table 3 shows an attempt to relate the predominant trend of change at a site to an enforcement variable.

Table 3: Sites, by level of enforcement and direction of change in Traffic Behaviour

Level of Enforcement	Positive change	No change	Negative change	Total
HIGH 14+	5	1	1	7
MEDIUM 11-13	0	5	2	7
LOW > 10	2	2	2	6
TOTAL	7	8	5	20

The 20 sites with data on most of the measures for most of the periods, were classified, according to the trend of change on all the measures, to three categories: positive, no change, and negative.

The same sites were independently classified, on the basis of police operational records, according to the level of enforcement that was assigned to the road section which included the site. The level of enforcement was measured by the mean number of patrolling shifts (typically a single patrol car for a 10- 20 km section, for 8 hr workday) per week during the month just preceding the measurement at a site. The Medium level of enforcement, 11-13 shifts a week, represented the standard enforcement practiced by the police even before the NTP came into being. Lower priority sections were patrolled less frequently.

The NTP tried to boost the enforcement level to more shifts, through permanent increases in resources and by temporarily reallocating forces from some sections to others. In practice, it was possible to increase the level of enforcement over the standard level only at some sections while at others the level remained low.

Table 3 shows the number of sites associated with each level of enforcement and the direction of change that has occurred in the behavioural measures.

The sites that are on roads which were subjected to a relatively high level of enforcement tended to show mainly a positive effect (5 out of 7); sites with the medium, standard enforcement concentrated in the no-change category (also 5 out of 7); and the 6 sites with lower then standard enforcement level split evenly between the three categories of change.

The result is intriguing but must be considered very tentative in view of the small number of cases in the table. The relationship suggests that it may take much more than a low or medium level of enforcement to have a reasonable chance of influencing traffic behaviour, in terms of the measures evaluated in the present study. It is also clear that more attention must be given to **what** police are doing in the process of enforcement and how to increase its impact apart from increasing manpower and vehicles on each road.

19.5 CONCLUSIONS

1. The monitoring system of behavioural measures provides useful information that supports and complements other aspects of the evaluation programme for the NTP.

2. The study demonstrated the importance of using a large number of observation sites in order to draw valid conclusions about the overall effect of a large scale police activity. The variability in traffic behaviour and the large site- specific effects require large samples of sites. On the other hand, the regularty of traffic behaviour at a given site, allows the use of shorter observation intervals.

3. The level of friction at junctions proved to be as useful as other, more traditional behavioural measures. It focuses on junctions, were at least half of the accidents take place, and it generates a lot of data in a short time. It does not depend on special equipment and does not require prolonged training.

4. In the context of an evaluation based on statistical inference from a large sample, measures that reflect the extremes of a distribution of behaviour (such as % of speeding over 90 km/h) may have less discriminating power than modal measures, due to their variability.

5. There is some indication in the data that higher than the usual level of police activity in a generally targeted area, may result in improved traffic behaviour.

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RESUMÈ

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It is typical for ICTCT-workshops that a topic frame is given but that in practice not too many and narrow restrictions for the papers are applied. It is considered most important that as many as possible of the members of ICTCT that come from many different countries with considerable differences in their scientific and professional background participate actively. We want to learn from each other in the broadest sense. At the same time, it has been our experience that even if papers do not fit the central topic too well, the long discussion periods between presentations provide for a pretty good fit and integration of the presentations during the workshop.

In the written proceedings presented here fit and integration of the different papers seems a little more difficult, as the discussion part is missing. Therefore I consider it helpful to finish this report with some personal thoughts about the relationship between the presentations reported here and the general topic of the workshop.

The first chapter gives an interesting overview over new traffic policy.which deals with more than just investigation of accident black spots. In the Netherlands, life quality aspects and the influence of town planning, road design etc. on traffic behaviour are given more importance by policy makers and researchers during the last years.Chapter three deals with the same topic, but is a little more critical about the influence of researchers on traffic policy makers. Chapter two stresses the importance of international cooperation on data exchange in traffic safety and/or road mangement work. Again the different criteria for road safety - more than just accident data - are pointed out. ICTCT can be looked upon as a platform for exchanging knowledge in this respect but also for creating methods to communicate with decision makers who have always to be taken into consideration when the results of research have to be applied to daily life.

The chapters 4 to 7 and 9 to 11 deal especially with new RTI-equipment and methods to evaluate them. All of the studies 4 to 9 have one main item in common, namely speed. Although we know that most of the accidents are caused by inadequate speed, it still seems necessary to collect more evidence concerning this point. Especially chapter 7 points out the important relation between speed and social climate - a relation which is neglected or underestimated by laymen and researchers as well.

When one has found efficient ways to approach authorities (see chapter 3) it is very important to be clear about the types of analyses that should be carried out. Chapters 7 and 10 to 19 reflect quite comprehensively how many different types of variables might be relevant when it is tried to evaluate consequences of the implementation of RTI equipment. Methods for collecting data on different psychological variables are presented in a more or less detailed way in the chapters 4 to 7, 9 to 13 and 17, whereas the Russian colleagues in chapters 14 and 15 stressed the importance of medical aspects. Registration methods vary from a high level of quantification and specification (chapter 10) to types of assessment based on a merely qualitative approach (e.g., chapter 12). Of course, reliability of registration is varying, accordingly. In our case, we have had the luck of being able to include in our workshop the most impressive example for an "on-line" registration method with high - one might even say: optimum - reliability (chapter 13).

In the chapters 16 and 17 the question has been taken up which goals should be reached, or strived for in order to achieve desirable traffic in our societies. Chapter 16 gives a good overview of the criteria for "good-quality" traffic that have been developed in recent German literature dealing with eco-psychological questions related to traffic.

Chapter 18 and 19 indicate that evaluation of new measures and equipment in road traffic could and maybe should - also make use of assistance that can be got by police and by the road users in general - one hesitates to call average road users "laymen", but of course they are in the professional sense. Both the preparation of registration methods for the use by scientific laymen, explanation and discussion of the methods and the results road users themselves get - based on their own analyses are valuable for the traffic safety experts.

And, by the way, why should'nt expectations of non-car drivers concerning consequences of new high-tech equipment in road traffic be of interest? They have not been asked such questions, so far, but I think that chapter 18 shows that it could be worth wile.

APPENDIX

STATE OF THE ART OF THE TRAFFIC CONFLICT TECHNIQUES

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As we have agreed upon it at the last ICTCT general assembly, I started a survey on the state of Traffic Conflicts Techniques (TCT) development and application in the different countries. I sent a questionnaire to the members of ICTCT (34 persons) in February. I thought that the questionnaire might help people to formulate the information about the present state of TCT in their countries and at the same time it will promote it that we get the same kind of information from everybody. I indicated at the same time that I would be thankful for any additional information that people thought to be useful.

Answers came from the following countries and persons: Finland (Risto Kulmala), Israel (David Zaidel and Shalom Hakkert), Austria (Ralf Risser, Christine Chaloupka and Wolf Dietrich Zuzan), the Netherlands (Piet Noordzij), Sweden (Sverker Almqvist, and Åse Svensson), Denmark (Ulla Engel), Lithuania (Raimondas Nasutavicius), Russia (Valerij Yeryomin), Germany (Herbert Gstalter and Wolfgang Fastenmaier), Singapore (Hoong-Chor Chin), Hungary (Magda Draskóczy) and France (Nicole Muhlrad).

The information that could be collected from the questionnaires can be summarized as follows (see the questionnaire in Appendix 1)

1. 'NATIONAL' TRAFFIC CONFLICT TECHNIQUES

It seems that every team which apply traffic conflict technique developed its own method or modified an existing one for its own purposes. The existing different techniques mentioned are as follows:

There is a Swedish Traffic Conflicts Technique, a French one which has a modified version for use in the developing countries, called SBOT. There is an Austrian technique which is similar to the German one and the DOCTOR technique in the Netherlands. There is a Finnish one, a Hungarian TCT which only slightly differs from the Swedish one, the Israeli one, which is a variation of the US method and is used for research purposes. There is a Lithuanian technique for assessing safety of pedestrians on rural roads and a Russian one.

No one reported that he/she uses an imported technique without adapting it to the national situation.

2. THE APPLICATION AREAS OF TCT DURING THE LAST 10 YEARS

The questionnaire gave two main areas of application, namely research and routine safety evaluation. TCT is used in some countries for both purposes, in some countries for only one (usually research), and in Austria the technique is used even for traffic safety education.

The details of the answers are as follows:

	Research:	***Routine safety evaluation***
Austria	unprotected r. users	safety at junctions
	also used as a pedagogical tool with children	
Denmark	-	-
Finland	unprotected r. users safety at junctions	measures at junction new traffic rules
France	safety diagnosis in the Philippines	safety diagnosis in the city of Rennes
Hungary	safety at junctions	-
Israel	pedestrians at intersections behaviour at junctions	-
Lithuania	yes, not specified	-
Netherlands	-	yes, not specified
Russia	student's theses	-
Singapore	expressway merging intersection conflicts	-
Sweden	unprotected r. users	

3. TRAFFIC CONFLICT TECHNIQUE GUIDELINES

There is a guideline (handbook) on the application of Traffic Conflict Technique in Austria, France, Germany, Great Britain, Hungary, in the Netherlands, Sweden, in the USA and an unpublished one in Finland.

4. COURSES FOR CONFLICT OBSERVERS DURING THE LAST TEN YEARS

There were courses for conflict observers in Austria both for research and educational purposes, one course in Finland, there were courses in France both for the city of Rennes and for the local branch of the Ministry of Road and Transport. There were courses for about 50 persons in the Netherlands and at least two courses every year in Sweden.

5. THE ORGANIZATIONS USING TRAFFIC CONFLICT TECHNIQUES

We wanted to find out by this question which organizations are familiar with and use traffic conflict techniques other than the members of ICTCT. The organizations mentioned were as follows: the city of Helsinki and consulting agencies in the Netherlands, Swedish National Road Administration and the City of Göteborg.

One publication in the Australian Road Research (1991) has shown that the traffic conflict technique was applied for safety evaluation of roundabouts in Kuwait also.

6. PUBLICATIONS (AFTER 1983)

We asked the ICTCT members to send us a list of their publications on TCT published after 1983, the year when Joop Kray from SWOV produced a 'Review of Traffic Conflicts Technique Studies'. The updated bibliography can be seen in Appendix 2.

Appendix 1.

Lund, 1992-02-04

Dear Colleague,

As we have agreed upon it at the last ICTCT general assembly, I start a survey on the state of Traffic Conflicts Techniques (TCT) development and application in the different countries. I send you some questions that might help to get similar information from all of you, but I am thankful for any additional information that you think to be useful. It might even help to formulate additional questions.

Here are my questions:

1. Do you have a 'national' traffic conflict technique? Yes No

   If yes, please give references

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   If not, which version of TCT do you use?

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2. During the last 10 years, TCT was used in your country for

   - research (please give references)

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....

   - routine safety evaluation

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3. Do you have a handbook (Guidelines) for TCT in your country?

   Yes No

   If yes, give references

....

....

4. Have you had courses for conflict observers in your country during the last ten years?

   Yes No

If yes, give details

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5. Are there other organisations (or persons) in your country that are familiar with TCT and use it?

Yes No

If yes, give the name
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....
....

6. Joop Kray from SWOV produced a 'Review of Traffic Conflicts Technique Studies' in 1983. Could you give a list of TCT studies published in your country after 1983?

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7. Other information that might be of interest regarding TCT in your country
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8. Do you know about TCT application in countries that have no representative in ICTCT?

Yes No

If yes, give details
....
....
....

TRAFFIC CONFLICTS TECHNIQUES LITERATURE (1983 - 1992)

Collection of papers on Traffic Conflicts Techniques

GraysonG.B. (ed.) 1984. The Malmö Study. A calibration of traffic conflict techniques SWOV Leidschendam

Asmussen E. (ed.) 1984, International Calibration Study of Traffic Conflict Techniques Springer, NATO ASI Series

Proceedings of the Workshop 'Traffic Conflicts and other Intermediate Measures in Safety Evaluation. 1986. Institute for Transport Sciences, Budapest.

Chaloupka Ch., Risser R. (eds.) 1988, Research and discussion on behavioural pre-accident criteria in traffic- and working safety in some industrial countries. Initiation Conference and First Workshop of the International Association ICTCT. University of Lund, Bulletin 81

Theoretical Aspects and Examples for Practical Use of Traffic Conflicts and of other Interactional Safety Criteria in Several Industrial and Developing Countries. Proceedings of the Second Workshop of ICTCT. 1989, Munich. University of Lund, Bulletin 86. 1990

Drasköczy M. (ed.) 1991. International Cooperation on Theories and Concepts in Traffic Safety. Proceedings of the Third Workshop of ICTCT. 1990, Cracow. University of Lund, Bulletin 94

International Cooperation on Theories and Concepts in Traffic Safety. Proceedings of the Fourth Workshop of ICTCT. 1991, Vienna. University of Lund. 1992

Training manuals

The Traffic Conflicts Technique Training Package. Accident Research Unit, University of Nottingham.

Parker M.R., ZegeerJr., Zegeer C.V. 1989, Traffic Conflict Techniques for Safety and Operations - Engineer's Guide. Federal Highway Administration, Washington D.C.

Parker M.R., Zegeer Jr.& ZegeerC.V. 1989, Traffic Conflict Techniques for Safety and Operations - Observer's Guide. Federal Highway Administration, Washington D.C.

Risser R., Zuzan W.D., Tamme W., Steinbauer J., Kaba A. 1991. Handbuch zur Erhebung von Verkehrskonflikten mit Anleitungen zur Beobachterschulung. Kuratorium für Verkehrssicherheit und Literas-Verlag, Wien

Muhlrad N. 1988. Technique des Conflits de Trafic. Manuel de l'utilisateur - Synthese INRETS No 11. 1988. INRETS. Arcueil.France

Erke H.& Gstalter H. 1986.. Handbuch der Verkehrskonflikttechnik (VKT) Unfall- und Sicherheitsforschung Strassenverkehr. Heft 52.

Kraay J.H., van der Horst A.R.A.& Oppe S. 1986, Handleiding voor de conflictobservatietechniek DOCTOR (Dutch Objective Conflict Technique for Operation and Research) SWOV Leidschendam

Utbildningsmanual i konfliktstudier 1983. (Training manual for conflict studies) Statens Vägverk, Borlänge.

Draskóczy M. 1987, Forgalmi konfliktustechnika. (Traffic Conflict Technique) Institute for Transport Sciences, Budapest

Separate papers

Brown G.R.& Cooper P.J. 1986, Safety Evaluation of Intersection Improvements Using Traffic Conflicts. Proceedings of Annual I.T.E. Meeting, Vancouver

Brühning E. et al. 1989, Sicherheit im Ferienreiseverkehr. Bundesanstalt für Strassenwesen. Reihe Unfall- und Sicherheitsforschung Strassenverkehr, Heft 75, Bergisch-Gladbach

Bukasa B., Risser R. 1985, Die Verkehrspsychologischen Verfahren in Rahmen der Fahreignungsdiagnostik. - Kapitel: Die Fahrprobe. Kuratorium für Verkehrssicherheit. Wien.

Chaloupka Ch., Risser R.& Roest F. 1991, Methode zur Identifizierung gefährlicher Verhaltensweisen im Strassenverkehr. Abschlussbericht zu einem FWF-Projekt, Wien

Chaloupka Ch. et al. 1985, Unfall- und Farhverhaltensanalyse ausländischer Kraftfahrer - insbesondere Deutscher - in Österreich. Teilprojekt 2. Kuratorium für Verkehrssicherheit, Wien

Chin H.C. et al. 1988, Traffic safety at merging areas on expressways. Asia-Pacific Conference on Roads, Highways and Bridges, Bangkok

Chin H.C., Chen R.L. 1991, Estimation of accident potential in expressway merging. Third Asia-Pacific Conference on Automotive Technology and Management. Singapore

Chin H.C. et al. 1991, Traffic conflicts in expressway merging. Journal of Transportation Engineers, ASCE Vol 117, No 6

Draskóczy M. 1988, Traffic conflicts techniques. Proceedings of the Second International Course for Transport Management, Budapest

Ekman L. 1988. Fotgängares risker på markerat övergångsställe jämfört med andra korsningspunkter. Bulletin 76. Inst. för Trafikteknik, LTH. Lund

Engel U.1985, Validation of conflicts studies - an international review. Danish Council of Road Safety Research.Technical Report 1/1985

Glauz W.D.& Bauer K.M.1985, Validation of the Traffic Conflict Techniques in the U.S.A. Proceedings of the National Meeting on the Evaluation of Local Traffic Safety Measures. Paris.

Gstalter H. 1986, Der Verkehrskonflikt als Kenngrösse zur Beurteilung von Verkehrsabläufen. Dissert. an der Univ. Braunschweig

Hauer E. 1982, Traffic conflicts and exposure Accident Analysis & Prevention 14,359-364

Hauer E.,Gårder P. 1986, Research into the Validity of Traffic Conflicts Technique. Accident Analysis & Prevention 18, 471-481

Hydén Ch.1987, The development of a method for traffic safety evaluation Bulletin 70. Inst. för Trafikteknik, LTH. Lund

Hydén C.& Draskóczy M. 1989, Identification of hazards, DRIVE Project V1040. Safety Scenario: Identification of Hazards. University of Lund, Bulletin 84

Hydén C. & Draskóczy M. 1991, Traffic conflicts techniques. Proceedings of the Third International Course for Transport Management. Budapest

Jadaan K.S. 1991, An application of traffic conflict techniques for safety evaluation of roundabouts. Australian Road Research, 21(3), September

Kraay J.H. 1984, De conflictmethode; De ontwikkeling van een meetinstrument. R-84-18. SWOV, 17blz.

Kraay J.H. 1985, Subjectieve en objectieve aspecten van de conflictmethode. R-85-50. SWOV, 9 blz.

Kraay J.H.& van der Horst R. 1985, The Trautenfels study: A diagnosis of road safety using the Dutch conflict observation technique DOCTOR. R-85-53. SWOV, 33 pp

Kulmala R.& Pajunen, K. 1985, The effects of the total renewal of Finnish road traffic law on road user behaviour and traffic flow. Technical Research Centre of Finland, Research Report 354

Kulmala R.& Pajunen K. 1985, Conflict studies of unprotected road users in the capital region. Technical Research Centre of Finland, Research Notes 410

Kulmala R.& Pajunen K. 1986, Effects of a varying speed limit. A conflict study at a highway junction. Technical Research Centre of Finland, Research Notes 641

Kulmala R. 1987, The effects of weather conditions on pedestrians' risk taking. Central Organisation for Traffic Safety - Liikenneturva, Research Report 92/1987

Kulmala R. 1989, Safety at channelized junctions. Conflict studies at six highway junctions. Technical Research Centre of Finland, Research Notes 1011

Kulmala R., Auranen T. & Heinonen M. 1990, Driver behaviour at three junctions in an urban area. Technical Research Centre of Finland. Research Notes 1168

Kulmala R. 1991, Effects of urban highway reconstruction in Kauhava. Helsinki. Finnish National Road Administration, FinnRA Reports 27/1991

Kuratorium für Verkehrssicherheit 1992, Praktischer Einsatz der Verkehrskonflikttechnik in Österreich. Wien

Linderholm L. 1987, Signalreglerade korsningars funktion och olycksrisk för oskyddade trafikanter. Bulletin 71. Inst. för Trafikteknik, LTH, Lund

Migletz J. et al.1984, Relationships between traffic conflicts and accidents.Midwest Research Institute, Missouri

Muhlrad N. 1987, Traffic Safety Research for Developing Countries - Methodologies and First Results. - Synthese INRETS No 7. INRETS, Arcueil, France

Oppe S., Kraay J.H. & van der Horst R. 1985, Recente ontwikkelingen van de conflictmethode. R-85-32 SWOV, 20 blz.

Oppe S. 1986, The international calibration of conflicts: an analysis of the results. Institute for Road Safety Research SWOV, Leidschendam

Pajunen K. 1987, The effect of different timing schemes on pedestrian behaviour at signal controlled junctions. Helsinki. Central Organisation for Traffic Safety, Liikenneturva, Research Report 92/1987

Pfundt K., Meewes V. & Maier R. 1986, Einige Bemerkungen zur Verkehrskonflikttechnik.Zeitschr. für Verkehrssicherheit 32,1,39-46.

Risser R. 1985, Behavior in Traffic Conflict Situations. Acc. Anal.& Prev.17,2,179-197

Risser R. & Tamme W. 1988, The Trautenfels Study. Austrian Road Safety Board. Wien

Risser R. et al. 1986, Unfall- und Farhverhaltensanalyse ausländischer Kraftfahrer - insbesondere Deutscher - in Österreich. Teilprojekt 3. Kuratorium für Verkehrssicherheit, Wien

Risser R. & Chaloupka Ch. 1990, Zur Entwicklung eines Instrumentariums zur Identifizierung gefährlicher Verhaltensweisen Zeitschrift für Verkehrssicherheit, 36. Jg, Heft 3, S. 117-123

Risser R. et al. 1990, Konflikte Fussgänger - Radfahrer in Wien. Studie im Auftrag des Magistrates Wien. MA 18, Wien

Schützenhöfer A. 1984, Konflikterhebungen im Rahmen des Verkehrspsychologischen Praktikums der Universität Graz an Kreuzungen mit Ampelanlagen und an ungeregelten Kreuzungen, Kuratorium für Verkehrssicherheit, unpublished

Silyanov V.V., Yeryomin V.M. & Krysin S.P. 1988, Simulation of traffic conflicts during lane changing on urban highways. Proc. of Traffic Safety Centre, Tbilisi

Tamme W. 1991, Die Verkehrskonflikttechnik mit Schulklassen. In: Praktischer Einsatz der Verkehrskonflikttechnik in Österreich. Kuratorium für Verkehrssicherheit, Wien

Yeryomin V.M. & Krbashian V.G. 1984, Traffic flow simulation on cross roads in mountainous relief and traffic safety. Proc. of Moscow Institute of Automobiles and Highways (MIAH) (in Russian)

Yeryomin V.M. et al. 1986, Traffic safety evaluation on two-lane roads by means of traffic flow simulation. Proc. of All Union Highway Research Institute. (in Russian)

Yeryomin V.H.& Dolzhikov A.I. 1987, Traffic conflict techniques in road safety evaluation. Proc. of MIAH. (In Russian)

Yeryomin V.M. 1987, Principles of traffic flow modelling for safety evaluation. Proc. of Tomsk Polytechnic Institute. (in Russian)

Yeryomin V.M.& Tonkonozhenkov O.I. 1989, Simulation of traffic conflicts during overtakings. Proc. of All Union Research Institute (in Russian)

Zaidel D., Elgrishi A.& Katz A. 1985, Pedestrian crossing behaviour and accidents at non-signalized intersections. Transport Research Institute. Report No. 85-86

Zaidel D., Elgrishi A., Eizenman O. 1986, Risk factors of pedestrians crossing arterial streets. Transport Research Institute. Report No 86-104

Zaidel D., Elgrishi A.& Katz A. 1988, The influence of pedestrian held flags on communication between drivers and pedestrians. Transport Research Institute. Report No 88-128