Proceedings of ROAD SAFETY AND TRAFFIC ENVIRONMENT IN EUROPE in Gothenburg, Sweden, September 26-28, 1990
- Vulnerable Road Users
- Future Traffic and Road Traffic Informatics (RTI)
- Environment
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Proceedings of ROAD SAFETY AND TRAFFIC ENVIRONMENT IN EUROPE in Gothenburg, Sweden, September 26-28, 1990

Abstract (background, aims, methods, results) max 200 words:

Papers presented at the seminar were as follows: Riding a Moped: Acquisition of Basic Skills and Mental Effort (Wierda, M); Intelligent Traffic System for Vulnerable Road Users (Carsten, O and Tight, M); Traffic Related Knowledge, Attitudes and Risk Perception in Dutch Secondary School Children; Consequences for Traffic Education (Brinks, J); Lifestyle, Leisurestyle and Traffic Behaviour of Young Drivers (Schulze, H); Test Site West Sweden - Learning RTI and Demonstrating Its Usefulness (Sjoeberg, L-E); Future Traffic and RTI - Status Report of The Federal Republic of Germany (Behrendt, J); Evaluation of the Perspectives of Driving Aids Based on Short Range Transmission Links between Ground and Vehicles and between Vehicles (David, Y and Hane, B); RTI - Current Global Projects (Karlsson, T); Total Environmental Impact of the Car (Jansson, U); Traffic and the Environment. Measures to Reduce Pollution Caused by Traffic (Ahrens, G-A and Becker, K); Status Report from the Netherlands (Pulles, M P J and Moll, H C).
PREFACE

The Swedish Road and Traffic Research Institute (VTI) and the Bundesanstalt für Strassenwesen (BASt), Federal Republic of Germany, were jointly organizing this international conference. The objective was to review and examine some specific road safety issues and the increasing environment problems in road traffic in different countries.

The following areas, within the field of Road Safety and Environment, were presented
- vehicles
- city planning
- speed
- vulnerable road users
- future traffic and RTI
- environment
- campaigns and publicity
- information and enforcement

Linköping October 1990

Kenneth Asp

Proceedings of ROAD SAFETY AND TRAFFIC ENVIRONMENT IN EUROPE in Gothenburg, Sweden, September 26-28, 1990:

VTI RAPPORT 362A
- Opening
- Vehicles

VTI RAPPORT 363A
- City Planning
- Speed

VTI RAPPORT 364A
- Vulnerable Road Users
- Future Traffic and RTI
- Environment

VTI RAPPORT 365A
- Campaigns and Publicity
- Information and Enforcement
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**VULNERABLE ROAD USERS**

**Riding a Moped: Acquisition of Basic Skills and Mental Effort**
Marcel Wierda, Traffic Research Centre, the Netherlands

**Intelligent Traffic System for Vulnerable Road Users**
Oliver Carsten and Miles Tight, Institute for Transport Studies, United Kingdom

**Traffic Related Knowledge, Attitudes and Risk Perception in Dutch Secondary School Children; Consequences for Traffic Education**
Jan Brinks, Traffic Research Centre, The Netherlands

**Lifestyle, Leisurestyle and Traffic Behaviour of Young Drivers**
Horst Schulze, BASf, Federal Republic of Germany

**FUTURE TRAFFIC AND ROAD TRAFFIC INFORMATICS (RTI)**

**Test Site West Sweden - Learning RTI and Demonstrating Its Usefulness**
Lars-Erik Sjöberg, Swedish National Road Administration, Sweden

VTI RAPPORT 364A
Future Traffic and RTI
Status Report of The Federal Republic of Germany
Jürgen Behrendt, BASt, Federal Republic of Germany

Evaluation of the Perspectives of Driving Aids Based on Short Range Transmission Links between Ground and Vehicles and between Vehicles
Yves David, INRETS CRESTA, France and B Hane, IM, Sweden

RTI - Current Global Projects
Tage Karlsson, Volvo DRIVE-SECFO, Belgium

ENVIRONMENT

Total Environmental Impact of the Car
Ulf Jansson, Volvo Car Corporation, Sweden

Traffic and the Environment
Measures to Reduce Pollution Caused by Traffic

Status Report from the Netherlands
M P J Pulles and H C Moll, Centre for Energy and Environmental Studies, the Netherlands
ROAD SAFETY AND TRAFFIC ENVIRONMENT IN EUROPE

Gothenburg, Sweden

September 26-28, 1990

WEDNESDAY SEPTEMBER 26

OPENING

9.30 - 11.30

Chairman: Mrs Monica Sundström, Director General, Swedish Road and Traffic Research Institute (VTI), Sweden

Opening Speeches
Mrs Gunnel Färm, Deputy Minister of Transport and Communications, Sweden
Prof Dr Heinrich Praxenthaler, President, Federal Highway Research Institute (BASt), Federal Republic of Germany
Mrs Monica Sundström, Director General, Swedish Road and Traffic Research Institute (VTI), Sweden

Motorization and Trends in Road Traffic
Prof Dr-Ing Karl-Heinz Lenz, Federal Highway Research Institute (BASt), Federal Republic of Germany

Traffic and Environment - What is the Problem?
Mr Börje Thunberg, Research Director, Swedish Road and Traffic Research Institute (VTI), Sweden

Traffic Safety facing Year 2000: Challenge for the Automotive Industry
Mr Jan Crister Persson, Vice President Engineering, Volvo Car Corporation, Sweden
WEDNESDAY SEPTEMBER 26

VEHICLES

13.00 - 16.30

Chairman: Prof Dr-Ing Karl-Heinz Lenz, Federal Highway Research Institute (BASt), Federal Republic of Germany

The Use of Simulation to Improve Vehicle Design
Mr François Badin, Institut National de Recherche sur les Transports et leur Sécurité (INRETS), France

Vehicle Development and Road Safety
Dr Christa Michalik, Austrian Road Safety Board, Institute of Traffic Education, Austria

The Role of the Motor Vehicle in Traffic Engineering of the Future
Dr Joachim Schmidt, Deutsche Automobilgesellschaft mbH (DAUG), Federal Republic of Germany

Automotive Crash Safety Engineering - Time for a New Approach?
Mr Hugo Mellander, Volvo Car Corporation, Sweden

The Daimler-Benz Driving Simulator - Research for Road Safety and Traffic Environment
Dipl Inf Volkhard Schill and Mr Joachim Stritzke, Daimler-Benz, Federal Republic of Germany

The VTI Driving Simulator
Prof Staffan Nordmark, Swedish Road and Traffic Research Institute (VTI), Sweden

Protection Effects of Child Restraints - Experiences from Accidents and Sled Tests with Carry-Cots
Dipl-Ing K-P Glaeser, Federal Highway Research Institute (BASt), Federal Republic of Germany
WEDNESDAY SEPTEMBER 26

CITY PLANNING

13.00 - 16.30

Chairman: Prof Niels O Jørgensen, Technical University of Denmark, Denmark

Traffic Management by Design in One Family Housing Areas
Architect Jens Bjørneboe, Norwegian Building Research Institute (Norges Byggforskningsinstitutt), Norway

Pedestrian Safety and Delay at Crossing Facilities in the United Kingdom
Dr J G Hunt, University of Wales College of Cardiff, United Kingdom

The Safety of Cycling Children. Effect of the Street Environment
Dr Lars Leden, Technical Research Centre of Finland, Finland

Analysis of Traffic Safety regarding Public and Individual Transport
Prof Dr-Ing Uwe Köhler, University of Kassel, Federal Republic of Germany

Urban Traffic Network - A Spatial Approach
Prof Dr S Olof Gunnarsson, Chalmers University of Technology, Sweden

Comparison of Road Safety in Different Cities
Dozent Dr sc techn H-J Neumann, Transport University (Hochschule für Verkehrswesen), German Democratic Republic
THURSDAY SEPTEMBER 27

SPEED

9.30 - 13.00

Chairman: Mr Gunnar Carlsson, Research Director, Swedish Road and Traffic Research Institute (VTI), Sweden

Effects of Speed Reducing Measures in Danish Residential Areas
Ms Ulla Engel, Senior Research Scientist, Danish Council of Road Safety Research, Denmark

A Case Study Evaluating Traffic Warning Devices with Respect to Operating Speeds and Accident Rates
Prof Dr-Ing Rüdiger Lamm, University of Karlsruhe, Federal Republic of Germany

Area Wide Traffic Calming Measures and Their Effects on Traffic Safety in Residential Areas
Prof Dr-Ing Werner Brilon, Ruhr-University Bochum, Federal Republic of Germany

Statistical Distribution of Speeds on German Motorways
Dr Dirk Heidemann, Federal Highway Research Institute (BASt), Federal Republic of Germany

Drivers' Attitudes and Beliefs towards Speed Limits and Speeding on Dutch Motorways
Dr Ton Rooijers, Traffic Research Centre (VSC), The Netherlands

FUTURE TRAFFIC AND ROAD TRAFFIC INFORMATICS (RTI)

(WORKSHOP)

14.00 - 17.30

Chairman: Prof Kåre Rumar, Swedish Road and Traffic Research Institute (VTI), Sweden

Test Site West Sweden: Learning RTI and Demonstrating Its Usefulness
Mr Lars-Erik Sjöberg, National Swedish Road Administration, Sweden

Future Traffic and RTI. Status report of the Federal Republic of Germany
Dr Ing Jürgen Behrendt, Leitender Regierungsdirektor, Federal Highway Research Institute (BASt), Federal Republic of Germany

Evaluation of the Perspectives of Driving Aids based on Short Range Transmission Links between Ground and Vehicles and between Vehicles
Mr Yves David, INRETS-CRESTA, France

RTI - Current Global Projects
Mr Tage Karlsson, Director, Volvo DRIVE-SECFO, Belgium

VTI RAPPORT 364A
THURSDAY SEPTEMBER 27

VULNERABLE ROAD USERS

9.30 - 13.00

Chairman: Prof Dr S Olof Gunnarsson, Chalmers University of Technology, Sweden

Riding a Moped: Acquisition of Basic Skills and Mental Effort
Dr Marcel Wierda, Traffic Research Centre (VSC), The Netherlands

An Intelligent Traffic System for Vulnerable Road Users
Mr Oliver Carsten, Senior Research Fellow, Institute for Transport Studies, United Kingdom

Traffic Related Knowledge, Attitudes and Risk Perception in Dutch Secondary School Children; Consequences for Traffic Education
Dr Jan Brinks, Traffic Research Centre (VSC), The Netherlands

Lifestyle, Leisurestyle and Traffic Behaviour of Young Drivers
Dr Horst Schulze, Federal Highway Research Institute (BASt), Federal Republic of Germany

ENVIRONMENT (WORKSHOP)

14.00 - 17.30

Chairman: Mr Göran Friberg, Director, Swedish Environmental Protection Board (SNV), Sweden

Total Environmental Impact of the Car
Mr Ulf Jansson, Volvo Car Corporation, Sweden

Environment. Status report of the Federal Republic of Germany
Dr Klaus Becker, Federal Environmental Agency (Umweltbundesamt), Federal Republic of Germany

Status report from the Netherlands
Dr M P J Pulles, Center for Energy and Environmental Studies (IVEM), The Netherlands
FRIDAY SEPTEMBER 28

CAMPAIGNS AND PUBLICITY

8.30 - 12.30

Chairman: Prof Dr Günter Kroj, Federal Highway Research Institute (BASt), Federal Republic of Germany

National Road Safety Politics - A Contradictory and Suppressed Field of Decision Making
Ms Karin Køltzow, Research Officer, Institute of Transport Economics (TØI), Norway

Motorway Driving Speed Reduction and the Associated Public Information Campaigns in the Netherlands
Dr Peter Liedekerken, Ministry of Transport and Public Works, The Netherlands

Campaigns against Drunken Driving among Young Drivers
Mr Per Studsholt, Section Eng, Danish Society of Engineers (Nordjyllands Amt), Denmark

The Effectiveness of the 1988 Police National Motorway Safety Campaign
Ms Nicola Christie, Transport and Road Research Laboratory (TRRL), United Kingdom

Improvement of Traffic Safety by Local Public Relations Campaigns
Dipl-Ing Klaus Schlabbach, Town Planning Authority Darmstadt (Bauderzernat Stadtplanungsamt), Federal Republic of Germany

A Comedy on TV to Promote Traffic Safety
Dr R D Wittink, Institute for Road Safety Research (SWOV) and Dr W J A Nelissen, Research & Marketing, The Netherlands

Road Safety as Business - Vision or Reality? The Brazilian Example
Mr J Pedro Correa, Volvo do Brasil, Brazil
FRIDAY SEPTEMBER 28

INFORMATION AND ENFORCEMENT

8.30 - 12.30

Chairman: Prof Dr Karl-Heinz Lenz, Federal Highway Research Institute (BASt), Federal Republic of Germany

A New Way of Broadcasts for Motorists
Mr Walter Melchers, Der Innenminister des Landes NRW, Federal Republic of Germany

Automatic Monitoring and Enforcement of Traffic Highway Violations
Mr Nicholas Ayland, Castle Rock Consultants, United Kingdom

Can Road Traffic Law Enforcement Permanently Reduce the Number of Accidents?
Mr Torkel Bjørnskau and Mr Rune Elvik, Research Officer, Institute of Transport Economics (TØI), Norway

A Vehicle Accident Data Recorder
Dr William Fincham, Queen Mary and Westfield College, United Kingdom

Enforcement: The Scope for Automotive Detection and Information Systems
Dr Talib Rothengatter, Traffic Research Center (VSC), The Netherlands
List of participants Road Safety and Traffic Environment in Europe September 26-28, 1990

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Riding a Moped: Acquisition of Basic Skills and Mental Effort

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Riding a moped: acquisition of basic skills and mental effort

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Riding a moped is becoming more and more dangerous in the Netherlands. Development of educational programs, as one of the possible countermeasures, needs an empirical foundation for several reasons. The most important reason is that we need a behavioural, psychological model of the moped rider. With an empirical based model educational goals may be determined, we should be able to predict the outcome of learning processes and we should be able to evaluate a specific educational effort in terms of effectiveness. The study to be presented is one of a series meant to enable the formulation of such a model.

The main question in the experiment was whether moped riders with different riding experience vary in required mental effort to control a moped. Participating subjects had either no experience at all, had three months or at least twelve months of experience. The task consisted of riding a moped and performing on a reaction time task simultaneously. In this secondary task subjects had to react selectively to an auditory stimulus which appeared randomly in one of the ears with intervals between 2 and 5 seconds. Both speed and complexity of manoeuvre were independent variables. Dependent variables were variance in speed and handlebar angle, reaction time (RT), misses and false alarms. The results can be characterized by the Power Law of Practice, especially the RT and errors in the reaction time task.

The effects of mental overload due to controlling a moped will be discussed in relation to other determinants of behaviour, such as knowledge and motivation, as a preliminary attempt to formulate a behavioural model of the moped driver.
RIDING A MOPED: ACQUISITION OF BASIC SKILLS AND MENTAL EFFORT
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1. INTRODUCTION

The actual appearance of the moped rider in Europe differs throughout the constituent countries. Variables involved are, amongst others, the minimum age of the rider, a mandatory riding instruction, wearing a helmet, the displacement (power) of the engine, minimum and maximum speed and, last but not least, the legal status (OECD, 1978). In Holland the moped is defined as a cycle with an auxiliary motor, and has to give way to all road-users approaching from the left on an unregulated intersection. This is in strong contrast with the Federal Republic of Germany, one of the direct neighbours of Holland, where the moped rider has priority in the same situation. This difference may in the near turn out to be a major problem for the safety of both moped riders, and cyclists, since the only physical barrier, the border, will be removed as a consequence of establishing a United Europe.

Despite the major differences between countries, a number of similarities do exist among the moped riders of Europe. The most important one is age. Obviously the moped is most popular amongst youngsters from 14 up to 20 years, in particular from 15 to 18 years. Since the experiment to be discussed in this chapter concerns aspects of the learning of the basic skills of riding a moped, the generalizability of the results is dependent upon the resemblance of the group of moped riders who participated in the experiment and the target group of moped riders throughout Europe. It is hoped that the generalizability is optimized by carefully selecting the age distribution of the participating subjects, since this variable unites most moped riders.

Considering accident rates it appears that riding a moped in the Netherlands is becoming increasingly hazardous. The development of educational programs as one of the possible countermeasures, requires an empirical foundation preferably in the framework of a behavioural, psychological model of the moped rider. With such an empirically based model, educational goals may be determined, predictions can be made about the outcome of learning processes and educational programs can be evaluated in terms of effectiveness. The study to be presented is one of a series designed for the formulation of such a model.

2. MENTAL EFFORT DUE TO VEHICLE CONTROL

The main objective of this experiment was to investigate whether moped riders with different riding experience vary in mental effort required to control a moped. It is known that the mental effort required for the task of controlling a bicycle is minimized after 7 years of experience (Wierda, Brookhuis, 1990). Since the study reported here and the mentioned experiment on mental effort used in cycling share a number of features, it will be discussed to some detail.

The progress in learning bicycle-control is curved following a power law function, a function which is commonly found with perceptual-motor skills (Newell and Rosenbloom, 1981). The learning mechanism can be qualified as automatization (Shiffrin and Schneider, 1977), a process in which the subject starts with declarative knowledge (he can 'declare' or verbalize the information he is using to accomplish a task) about the task. Only by consciously paying attention to the task can this information be put to work. After a number of trials, or repetitions of the task, behavioural chunks are formed which do not contain any declarative knowledge, nor is attention necessary for these chunks to be executed: behaviour has become automatized. This mechanism of learning can be used in modelling the novice road user (Wierda, 1987), and in principle for all types of transport mode, provided the model is implemented in a production-rule system (Anderson, 1983, Newell, 1990). The question may be raised why the learning curves of controlling a bicycle and moped might be different, since the vehicles are, to a certain extent, similar. A number of reasons can be mentioned. Firstly, the moped and bicycle may be legally quite comparable, but in practise the differences in appearance and the necessary abilities to control the moped and bike may be very large. Secondly, in studying the 'natural' novice cyclist one is bound to restrict the age range from 6 to 8 years since
that is the age that a person learns to ride a bicycle. The result is that the learning curve incorporates two factors: a general developmental effect and an effect of the specific experience with the bicycle. Since the average age of the novice moped rider is approximately 15 years old we may not find the general developmental effect. The third and last to be mentioned reason is that the automated behaviour for the control over a bicycle may be transformed/generialized to the new task of controlling a moped. This generalization might be beneficial, especially on the control level of the task, i.e. balancing, steering etcetera, but may also be counterproductive, in this case particularly the manoeuvre level of the riding-task (see Michon, 1985). On this level the cyclist and moped rider has to estimate time gaps between crossing road users, apply traffic rules and communicate with other road users. It is not inconceivable that novice moped riders use, unjustly and unwisely, scheme's and behavioural procedures that were adequate while they were pedal cyclists but may now that they are moped riders turn out to be dangerous (Wierda, Van Schagen and Brookhuis, 1989).

To measure the cognitive load required to control a moped, a secondary cognitive task had to be performed by the subject while riding on his moped. The concurrency of the task implies that the subject has to allocate his cognitive resources selectively if the total demand becomes larger than the actual available resources (Kahnemann, 1973). In many so called dual tasks a subject can intentionally give a higher priority to one of the tasks. In this task, however, the subject feels a strong urge to allocate at least a minimum of attention (resources) to the riding task since the penalty for errors is high, i.e. falling of the moped. It should also be clear, however, that performance on the tasks will have to be taken into account when assessing the resources needed to control the moped.

3. METHOD

All subjects were paid volunteers. They either had no experience at all (novice), three months (mediocre) or at least twelve months of actual riding experience (experts). Each group had 10 subjects and within each group the subjects were balanced for sex (50/50%) and educational level (low:middle:high/5:3:2). This composition is considered representative for the "moped riding Dutchman" (CBS, 1987)

The experimental site had a normal infrastructure but was closed for other traffic. As the primary task the subjects had to ride a rectangle anticlockwise, the long sides being 168 meters long and the short sides only 29 meters. Only data collected from the long side were used in the analysis. In half of the conditions they had to slalom around 7 cones, placed 15 meters apart on the long side of the rectangle. The subjects had to ride with three different speeds: 20, 30 and 37.5 km/hour. The subject could maintain the right speed by attending a small light mounted in the helmet which could have three colours, red: you are going at least 2.5 km/hour too fast, green: correct speed, orange: your speed is at least 2.5 km/hour too slow. This visual feedback could be adjusted for the three experimental speeds. All subjects were able to maintain a proper speed.

In the secondary task (see above) the subjects had to react selectively to an auditory stimulus which appeared at random in one of the ears with intervals of between 2 and 5 seconds. Subjects had to react only to beeps in the left ear by pressing a button with the right thumb. The time uncertainty of the stimulus was introduced for two reasons. Firstly for the ecological validity: most events in normal traffic have also a time uncertainty. Secondly, it is known that time uncertainty increases the difficulty of the task (Mulder, 1983).

As independent variables the following factors were used: experience of the subject (3 levels), speed (3 levels) and complexity of the manoeuvre (2 levels). Dependent variables were variance in speed and handlebar angle in the primary task, and reaction time (RT) (time elapsed between the presentation of a beep and the button press), misses (there was a beep but no reaction) and false alarms (there was button press without a valid beep) in the secondary task.
4. RESULTS

The results on the secondary and primary task must be considered with respect to each other. In the following paragraphs the effects on the dependent variables will be discussed successively. The evaluation of the total performance of a subject group can only be made with respect to all dependent variables together.

All the group differences are tested statistically using the method of multivariate analysis of variance.

4.1 The primary task: moped control

The variables with respect to the control over the moped show that subjects tend to ride too fast if they are instructed to ride at 20 km/hour on a straight road. The experts show this effect quite strongly. However, if the subjects are instructed to slalom around the cones, all subjects tend to slow down if they have to ride at 37.5 km/hour (F(18,1) = 15.14 p < .001). Bear in mind that the subjects are allowed to change their speed only minimally. The standard deviation in riding speed shows that variance in speed increases in conditions in which a higher riding speed is required (F(36,2) = 36.5 p < .001). Averages increase from 0.8 km/hour variance to 1.0 km/hour: the increase is only small. There is no significant effect of experience on this variable.

If we look at the degree of sway, measured in de standard deviation steering angle (see figure 1), it appears that there is no effect of experience whatsoever. There is however an effect of riding speed, and surprisingly, such that a higher speed reduces the degree of sway. This finding is significant (F(36,2) = 42.2 p < .001).

![Graph showing the standard deviation of the steering angle of three groups of subjects, see the legend, in relation to riding speed while riding on a straight road.](image)

Figure 1: The standard deviation of the steering angle of three groups of subjects, see the legend, in relation to riding speed while riding on a straight road.

Taken as a whole we can conclude that the level of experience is not noticeable in the moped-control-variables. If there is an effect of limited cognitive resources at all, then the subjects make a strong trade-off between the primary and secondary task such that the primary task does not suffer at all from the limitation in resources. This trade-off is rational: if you miss a beep in the secondary task nothing happens, if you sway to much you'll fall, a very unpleasant experience. This explanation implies that possible effects of a limited amount of available cognitive resources will have a full impact on the secondary task. Since limitations on the
amount of available resources are predicted, the effect on the variables in the secondary task should be considerable.

4.2 The secondary task

In order to compensate for differences between subjects in the auditory detection task, the subjects were asked to do the task for a few minutes without doing anything else. The resulting baseline values are subtracted from the values of variables in all other conditions on a subject by subject basis.

All subjects slow down in their reactions to the beeps in the left ear if they have to ride on a straight road with an average of 200 msec. Two aspects in the data are notable. Firstly, the expert moped riders slow down just as the beginners, indicating that even experts have to allocate some resources, i.e. must pay same attention, to the vehicle control task. However easy the task may seem for experts, simply riding with a constant speed on a straight road does take mental effort. Secondly, the effect does not increase with speed, either with the beginners, or the experts.

During slalomming, see figure 2, the beginners obviously experience great difficulty in keeping up with the task demands in the 37.5 km/hour condition. They take almost 600 msec more to react to a beep than when they are standing still beside the moped.

Figure 2: Increase in averaged reaction time to the auditory detection task for the three experience groups dependent on riding speed. The data is from conditions in which the subjects slalom around cones.

The main effect of speed and slalomming are significant (F(36,2) = 4.05 p < .02 and F(18,1) = 6.55 p < .02). The main effect of riding speed on RT can partly be explained by the strong increase in RT from the beginners. Notice however, that the subjects with some experience and even the experts slow down.

The RT on a detection task must always be considered in combination with the number of errors, i.e. false alarms and misses. It is conceivable that a subject decides to be very fast with as a result low RT’s but high numbers of errors. These trade-off effects do not menace the results as long as the effects are differential to the experimental groups. From figures 3 and 4 can be seen that again the novice moped riders perform worst, and therefore the conclusions count a fortiori.
A reaction time task with a binary choice yields two types of error: false alarms and misses. The types may be combined. This is not done here since the numbers of false alarms and misses are quite comparable and therefore a reference to only one type of error, the misses, can give an idea of the error distribution.

Figure 3 and 4 reveal a clear difference between road types: the effect of slaloming is large. For the beginners the extra manoeuvre results in an increase of 30% misses. The main effect of the slalom manipulation results in a significant increase in misses (F(18,1) = 14.5 p < .001) and in false alarms (F(18,1) = 8.2 p < .01). Riding with a higher speed makes the secondary task more difficult, the number of misses increases (F(36,2) = 5.7 p < .01) as does the number of false alarms (F(36,2) = 3.8 p < .03). The effect of speed on the number of errors is most pronounced during slaloming: the interaction between speed en slaloming is significant (F(18,2) = 4.85 p < .02). The linear trend (t = .286 p < .01) indicates that mainly the novices and the subjects with some experience are unable to accomplish the secondary task.

The general picture is that none of the subjects make many errors during straight riding. During the slalom, the subjects also perform well in the slowest condition. With 30 km/hour the beginners cannot compensate any more for the mental pressure and begin to make a considerable number of errors. In the 37.5 km/hour condition, the group with some experience also begins to show these effects. The beginners are in a state of mental overload and their performance is bad at this speed.

Figures 3 and 4: The percentage misses on the auditory detection task per experience group and riding speed. Figure 3 (upper) represents data while riding straight, figure 4 (lower) shows data while slaloming.
4.3 Conclusions

The moped control variables (variance in steering angle, speed and variance in speed) were measured in order to be able to check for alternating trade-offs between the primary and secondary task. The steering angle variable may make us believe that subjects tend to steer better when they ride with higher speeds, inspect figure 1. An alternative and plausible explanation for the observed stability at higher speeds are the mechanical forces in the wheels. The centrifugal forces in a wheel increase with the velocity of rotation (riding speed). The higher this force, the stronger the wheel tends to straighten up. Leufen and Müller (1986) demonstrate that a motorbike with a velocity of 50 km/hour will never fall. This explanation reveals a warning: higher speed results in a greater stability, a situation in which the moped will resist all forces exercised on the wheels and handlebar. In other words the rider cannot steer the moped by moving the handlebar alone but needs to use his bodyweight to move the centre of gravity. This implies that new abilities have to be learned by the novice moped rider.

The effects of riding speed and the slalom manipulation on the secondary task are large. The beginners, and to a lesser extent the subjects with some experience, suffer from a mental overload: they are not capable of reacting to a simple tone in the left ear: in the worst case, performance on the secondary task drops to chance level: 50% of errors are made. The riding speed is relatively low in this situation: 37.5 km/hour while on the average moped riders employ higher speeds (Wierda, Van Schagen and Brookhuis, 1989). Many of the observed speeding moped riders could be classified as 'subjects with some experience', a finding which may indicate high riding speeds as one of the factors causing high accident involvement.

On the basis of the results one may conclude that a learning curve which predicts the quality of the task performance will show a strong learning effect in the first months of experience. The incremental effect decreases asymptotically. Probably after 6 months of riding experience no further substantially learning effect takes place, at which point the riding task has become automatized. The task does, however, still require some attention, even in this later stage of learning.

5. DISCUSSION

On the basis of the results of these experiment one might conclude that a practical training of the basic skills to control the moped would be beneficial for the safety of the moped rider. We have at least some hints to suggest that beginners in traffic compensate for their suboptimal abilities (see for instance Vilardo and Anderson, 1969). When implementing a training course we need to be sure that the trainee moped rider does not become too self-confident and stops to compensate for his suboptimal abilities. This warning needs to be emphasized for two reasons. Firstly, we now know that even after 3 months of experience the perceptual motor skills have not been fully automatized. A training course with a few hours practical training can only be the very first step. Secondly, the main group of beginner moped riders is 16 to 17 years of age. At this age the potentials of perceptual-motor skills are great, but it is also the age at which youngsters underestimate danger, overestimate their own capabilities and even 'may be out to seek danger' (Conger, 1977).

There are therefore more factors besides the perceptual-motor skills that influence traffic behaviour. Van Schagen, Kuiken and Brookhuis (1986) identify three factors: motivational variables, knowledge about rules and signs and skills. To understand the effect of a training of the basic skills we need a unified theory of the moped rider in which causal relations exist which can predict the effect of increasingly better skills on, for example, motivational variables.

We must conclude that the training of basic skills will have a positive effect on these skills. However, the main point of the training-course must be a theoretical part in which the relationship between perception of one own's abilities and the strategy to compensate for suboptimal skills in normal traffic is explained. Training in actual riding should be an extra to the theoretical part. The training should incorporate all manoeuvres which are typical for the moped and necessary for a defensive riding strategy such as steering by body movement and braking. The point being that the moped rider needs to ride defensively for at least three
months, with or without training. In short, a riders license must not and cannot ever be a replacement for eyes, ears and a defensive riding strategy.

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LITERATURE

An Intelligent Traffic System for Vulnerable Road Users

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An Intelligent Traffic System for Vulnerable Road Users

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This work, funded by the EC under the DRIVE programme, is intended to help create a traffic system that meets the needs of vulnerable road users (namely pedestrians and cyclists) both in terms of travel and safety. The creation of a system that meets the needs of vulnerable road users (VRUs) will be achieved on two levels.

1. The project will develop a model of the traffic system that incorporates VRUs as an integral part. This model will build on existing models of the traffic system and will incorporate information on VRU route choice criteria. Outputs from the model will include predictions on both travel (flows) and safety (conflicts and accidents) and will provide planners and other users with the ability to create networks that meet VRU needs.

2. The project will evaluate a number of RTI applications in signalling and junction control, in order to ascertain what benefits can be obtained by such local measures. The information obtained from vehicle and VRU detection devices will be used in an attempt to reduce VRU delay times and thus to increase their relative importance in the transportation system.

In the latter stages of the project, the two levels will be linked by feeding back into a relevant sub-model the results of the localized experiments. These real-world demonstration studies will also serve to test the reliability of this sub-model as a prediction tool. Simulations will also be run to assess the effects on vehicular traffic of larger-scale interventions to favour VRUs.

This paper presents a discussion of the overall project design, outlining the major elements of the work. It discusses progress in the first year of the three-year project. These include a comparison of problems for pedestrians and cyclists in the three countries involved (Britain, The Netherlands and Sweden), a review of previous work on pedestrian and cyclist route choice criteria, and early decisions on the focus of the modelling and experimental work. Implications of these for subsequent work on the project will be discussed.
AN INTELLIGENT TRAFFIC SYSTEM FOR VULNERABLE ROAD USERS

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1 BACKGROUND

This paper presents the work to date on a three-year DRIVE project that began at the start of 1989. The aim of the project is to help create a traffic system that meets the needs of vulnerable road users (namely pedestrians and cyclists) both in terms of travel and safety. The project started with the notion that pedestrians and cyclists are an important part of the traffic system — in some locations even the dominant part — but that their needs are currently catered for inadequately. Furthermore, there are indications at present that the development of new, advanced traffic systems may have further detrimental effects on pedestrians and cyclists. Most current developments are exclusively directed at the improvement of the efficiency and safety of motorized traffic and tend to neglect the position of vulnerable road users (VRUs). As a result such systems may have negative safety and mobility effects for vulnerable road users which can seriously impair the positive effects on the traffic system as a whole.

The project is attempting to achieve the creation of a system that meets the needs of vulnerable road users on two levels. Firstly, the project is developing a set of models of VRU traffic behaviour for use by planners, urban authorities, and road traffic engineers. The ultimate aim of the modelling work is help meet the needs of vulnerable road users in terms of journey desires by offering them preferred routes and then protecting them on those routes, rather than by sacrificing their preferred routes to assist motorized travel and reduce conflicts between vulnerable road users and motor vehicles. Secondly, the project is evaluating some RTI applications in signalling and junction control (in particular the use of microwave detection devices linked to traffic signals), in order to ascertain what benefits can be obtained for vulnerable road users by such measures. In the latter stages of the project, the two levels will be linked by feeding back into a relevant sub-model the results of the localized experiments. These real-world demonstration studies will also serve to test the reliability of this sub-model as a prediction tool.

A system that considers the needs of vulnerable road users as well as the needs of motorized traffic is not pure fiction: it may well correspond to the realistic state of affairs in many central cities. Furthermore, if such a system had only a small impact on traffic flows and network capacity outside central cities, it might well be worth adopting there, in the interest of encouraging pedestrian and bicycle trips and of reducing accidents for vulnerable road users.

2 TECHNICAL APPROACH

The principal task of the project is to prepare a traffic model that represents vulnerable road users. In addition to performing network assignment (i.e. the prediction of flows), the project will attempt to translate the information on the flows and behaviour of various classes of road user into predictions of "unsafety". This will provide to planners and others an indication of the safety effects of
alternative schemes. The model requires information on motor-vehicle, cyclist and pedestrian flows, on origin-destination (O-D) matrices for VRUs, on VRU route choice criteria, and on VRU behaviour in encounters with other traffic modes. To calibrate the model, data on behavioural response to modifications in the network will be of significant importance, particularly as here there may be some considerable variations between countries. The project scheme (depicted in Figure 1) incorporates the necessary elements to achieve these requirements.

Because of limitations in existing data on vulnerable road user flows and on the behaviour of pedestrians and cyclists, a substantial data collection effort was required. It is important not to create a fictitious or "simulated" model, but one that corresponds to the realities of travel behaviour. To achieve a wide spread of behaviours (e.g. whether turning vehicles habitually yield to pedestrians, whether cyclists frequently jump lights, or how willing pedestrians are to jaywalk) and environments, data collection has been carried out in one urban area in each of three European countries, namely Bradford in Britain, Groningen in the Netherlands and Växjö in Sweden. The first of the sites is in a comparatively large metropolitan area, while the other two are in medium-sized cities. An even larger variety of urban areas and the inclusion of more countries is, of course, theoretically desirable, but practical limits on project size and available time have prevented this. It is hoped that the release of sub-models for wider use in DRIVE will provide the capability for evaluating their robustness in other environments.

It is clearly necessary to establish at the outset the scale on which any model is intended to operate. For this project, the key issue is the interaction between pedestrians, cyclists and cars, both on a network-wide route choice level and on a signalised junction level. The decision was made, early in the project, to focus on a level that was more extensive than a single junction, but considerably less extensive than the whole VRU network. The project has termed this level the "meso" level to distinguish it from the micro level of individual decision on when to cross and the macro level of overall route choice between origin and destination. Specifically, the modelling work has focused on the same-sized area that is being studied for the project's experimental work, namely the three-junction network depicted in Figure 2. The pedestrian model will, however, of necessity also include aspects of micro behaviour.

Existing traffic models cannot very easily be adapted to simulated VRU behaviour. In particular, the whole notion of limits on network capacity (congestion) does not apply in most VRU situations. It follows that the pedestrian and cyclist models being constructed are stand-alone models with pedestrian and cyclist behaviour as the central focus, although the models do use various techniques and concepts drawn from SATURN (Van Vliet, 1982).

The inputs to the pedestrian and cyclist meso models will be:

1. Demand in the form of O-D matrices.
2. Supply, i.e. a representation of the physical network.
3. Route choice criteria.

The pedestrian model will also have a micro component to take into account individual delay at a specified crossing point. Cyclist route choice will not be
Figure 1: Overall Project Scheme
Figure 2: The Three-Junction System

E = Entry Points
S = Shops

Pedestrian Network

Cyclist Network

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considered in the cyclist meso model, although data has been collected on this for future modelling needs. The cyclist model will, however, take into account cyclist queuing and lane choice behaviour. The output from these sub-models will be statistics describing local area pedestrian, cyclist and car interactive behaviour. Such output can be compared with data on the likelihood, given various circumstances, of meeting with a vehicle in crossing (pedestrian) or passing a junction (cyclist), in order that an assessment of safety can be made.

The selection of the site for the small-scale experiments in RTI applications has been completed in each city. The first set of experiments to examine the feasibility of installing pedestrian detectors linked to existing signals to reduce pedestrian delay have been carried out in Bradford and the results are expected shortly. The larger-scale experiments in the third year of the project will include the enhancing of existing signals with "intelligent" features (pedestrian and cyclist detection, vehicle gap detection, etc.), the alteration of signal timings to favour vulnerable road users, the linking of signals to correspond to vulnerable road user flows, plus other possible measures. The behaviour at the experimental sites can be compared to the behaviour at similar sites which did not receive specific treatment. These studies will serve both to evaluate the consequences of introducing RTI measures and to test the accuracy of the model as a predictive tool.

3 WORK COMPLETED

This section summarizes some of the main pieces of work completed so far, but exclude a more detailed discussion of the modelling work because of the constraints of space. The work discussed includes a comparison of safety and mobility problems for VRUs in the three countries, a critical review of previous studies on pedestrian and cyclist route choice criteria, and a large data collection effort on overall VRU route choice criteria and on VRU behaviour in the locations being studied.

3.1 Comparison of Safety and Mobility in the Three Countries

This part of the project produced a report (Tight and Carsten, 1989) which aimed to provide a review of those safety and mobility issues that are related to the RTI measures envisaged by the project rather than a general comparison of the safety and mobility problems faced by VRUs in the three countries. The report was split into two sections, firstly comparing safety and mobility at a national level, and secondly making similar comparisons at the local (city) level.

COMPARISON AT THE NATIONAL LEVEL. The three countries involved in these comparisons differ in a number of ways. Of the three, Britain has the highest population with 54.5 million people in 1981, followed by the Netherlands with about 14.5 million in 1987, and lastly Sweden with about 8.4 million people in 1987. However, in terms of size Sweden is very much the largest country (449,793 km²), followed by Britain (229,523 km²), and finally the Netherlands (40,883 km²). Hence, the density of population in Sweden is considerably lower than in either of the other countries. There are also many other differences between the countries, including differences in culture, differences in the law as
it relates to road users, and differences in the infrastructure and facilities provided for road users.

In terms of safety, it was shown that in each of the three countries VRU casualties make up about one-third of all casualties. However, the split between cyclists and pedestrians differs considerably. In Britain, about two-thirds of the VRU casualties are pedestrians, compared to the Netherlands where only about a quarter of the VRU casualties are pedestrians. Sweden falls somewhere between the two with roughly even proportions of VRU casualties being pedestrians and cyclists. In all three countries, most pedestrian and cyclist accidents occur on urban roads, though the proportion in Britain is slightly higher than for either Sweden or the Netherlands. In terms of age, the Netherlands has a very high proportion of pedestrian casualties in the age group 0–9 years compared to the other countries, particularly Sweden. Both the Netherlands and Britain have about twice the proportion of child pedestrian casualties (0–14 years) as Sweden. Conversely there is a much higher proportion of adult pedestrian casualties (20+) in Sweden than in either of the other two countries. In Britain, 51.3% of pedal cycle casualties are under the age of 20 years, compared to only 39.5% in the Netherlands and 33.5% in Sweden. However, in the Netherlands 17.9% of pedal cycle casualties are 60 years and over compared to only 5.6% in Britain. This may point to there being very few adult pedal cyclists in Britain compared to the Netherlands, perhaps due to some extent to topographical differences between the two countries. Finally, a much higher proportion of pedestrian casualties in the Netherlands occur on crossing facilities than in Britain (no comparable statistics were available for Sweden).

In terms of mobility, the Dutch on average make more trips per day than either the British or the Swedes. In terms of pedal cycle trips the average Swede makes nearly five times as many trips per day as the average British person. However, the average Dutch person makes nearly fourteen times as many pedal cycle trips per day as the average person in Britain. This trend is reversed somewhat in the case of pedestrians, with the British making more such trips than either the Dutch or the Swedish, though the differences in pedestrian trips are by no means as great as the differences in pedal cycle trips. More VRU trips in total are made in the Netherlands than in Britain or in Sweden.

The Swedes and Dutch travel further than the British as VRUs. This means that the average trip length of people in Sweden is somewhat longer than in either of the other countries, perhaps reflecting the much lower densities of population in Sweden than in Britain and the Netherlands. In terms of pedal cycle travel, the Dutch travel just under four times as far on average as the Swedish, and just over seventeen times as far on average as the British. In terms of the average distance per pedal cycle trip, the Dutch travel slightly further than either the British or the Swedish (3.3 km compared to 2.6 and 2.5 km respectively). The average distance travelled by pedestrians in Britain is slightly higher than in both the Netherlands and Sweden. However, in terms of the average distance travelled per pedestrian journey, the situation is remarkably similar in the three countries (1.1, 1.2 and 1.4 km in Britain, Sweden and the Netherlands respectively).

By combining the safety and mobility data it was possible to produce various measures of accident risk to both pedestrians and cyclists for each of the three
countries. Figure 3 shows the risk of becoming a VRU casualty per head of population for each of the three countries. It can be seen that using this measure Sweden seems to be the safest country for VRUs, having about half the rate of casualties as the Netherlands and about one-third the rate of Britain. For pedestrians, Britain has about four times the rate of casualties per 100,000 population as both the Netherlands and Sweden. However, for cyclists Sweden is the safest country using this rate, whilst the situation in the Netherlands seems particularly dangerous. Figure 4 shows the rate of pedestrian casualties per million kilometres walked by pedestrians and the rate of cyclist casualties per million kilometres cycled. This shows that in Sweden and the Netherlands the risk for pedestrians is very similar, while in Britain the risk is about three times as high. For pedal cyclists the rates for the Netherlands and Sweden are again largely similar with the Netherlands only slightly lower than Sweden, but the rate for Britain is more than ten times as high as that for the Netherlands.

COMPARISON AT THE LOCAL LEVEL. In both Växjö and Groningen cyclist casualties (though not fatalities) exceed pedestrian injuries, whereas in Bradford pedestrian casualties far exceed cyclist casualties. Figure 5 shows the rate of pedestrian and cyclist casualties per 100,000 population for each of the three cities. Växjö and Groningen stand out as having far better safety records for pedestrians than Bradford. The rate of cyclist casualties per 100,000 population is 28.6 for Bradford, 39.1 for Växjö and 140.0 for Groningen. Figure 6 shows the rate of pedestrian and cyclist casualties per million kilometres travelled for each of the three cities. This shows that using this measure Växjö and Groningen appear to be about equally safe for VRUs in terms of distance travelled, but Bradford has a substantially greater problem.

In Bradford and Groningen two-thirds of pedestrian casualties occur in accidents away from junctions, whereas in Växjö two-thirds of pedestrian casualties occur in junction accidents. Three-quarters of pedal cycle casualties in Bradford occur in accidents away from junctions, but in Groningen and even more so in Växjö most pedal cycle casualties occur in accidents at junctions. In terms of age, almost half (48%) of pedestrian casualties in Bradford are under 15. The comparable figure for Växjö is 9% and for Groningen 22%. Both Växjö and, to a lesser extent, Groningen have a relatively high proportion of pedestrian casualties among those aged 60 and above. As regards cyclists, Bradford once again has a problem with the very young: 37% of cyclist injuries in Bradford are incurred by riders aged under 15, compared to 14% in Växjö and 13% in Groningen. Finally, in terms of time of occurrence it is shown that a greater proportion of pedestrian accidents in Bradford occur at weekends than in either of the other two cities.

The conclusion from the evaluation of VRU safety and mobility was that there are in fact three types of situation where the implementation of RTI measures of the type envisaged by this project could prove to have a beneficial effect upon the safety and/or mobility of vulnerable road users. These are:

1. Situations where pedestrian or bicycle flows are high and many accidents occur;
2. Situations where pedestrian or bicycle flows are high and the risk of an accident is high;
Figure 4
VRU Casualties per Million Kilometres

[Diagram showing VRU casualties per million kilometres for GB, S, and NL, with categories for Pedestrians (solid black) and Cyclists (hatched)]
Figure 5
VRU Casualties per 100,000 Population

Bradford

Växjö

Groningen

Pedestrians

Cyclists

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Figure 6
VRU Casualties per Million Kilometres

Bradford vaxjd Groningen
- Pedestrians m Cyclists

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3. Situations where pedestrian or bicycle flows are not high because of trip suppression caused by real or apparent high vehicular flow.

3.2 Literature Review on Pedestrian and Cyclist Route Choice Criteria

A report was produced which reviewed previous studies on VRU route choice criteria and assessed the implications of these for future work on the project, in particular the data collection and modelling (Hopkinson, Carsten and Tight, 1989). The report came to a number of conclusions both about overall methodological issues and about pedestrian and cyclist route choice criteria.

On the broader methodological issues, the report concluded that previous work was generally inadequate and that VRU route choice had not been covered in a holistic, integrated manner. For example, most of the studies reviewed had a rather narrow focus, either in terms of the environment in which they were carried out or in terms of the factors they examined. In terms of environment, the focus of most pedestrian studies had been the Central Business District and in terms of factors, research has often asked participants what is the most important factor, and has thus failed to catch the potentially complex interplay of factors. In addition the report pointed out that research has not adequately distinguished between the trip planning or strategic level of route choice on the one hand, and the operational or tactical level on the other hand. At the strategic level, the route plan is established. Below the strategic level is the tactical level. Here the origin of the pedestrian trip might be altered because of parking problems encountered as a motorist prior to starting the pedestrian trip, and the intended route between origin and destination might be altered because of problems encountered (e.g. traffic conditions) or because a diversion is made to an alternative attraction (such as a cafe). In the tactical decision process, a different set of criteria from those used at the strategic level may be operating.

The studies surveyed on pedestrian route choice revealed that it can be modelled successfully, albeit in a limited environment. This leads to the conclusion that route choice can also be modelled in a broader context. They also revealed a number of the criteria that, consistently across studies, motivate route choice. Here distance and/or time emerges as paramount, although there has been some confusion in many studies about what respondents are referring to when they indicate that they prefer the “shortest” route. The possibility remains that, behind the urge to minimise distance and time, the underlying factor is the desire to minimise effort, i.e. labour input. Finally, it is clear that criteria vary considerably with trip purpose and that some criteria, such as the weather, which are difficult to capture in a limited range of trips, may nevertheless have important implications for modal choice and route choice.

In terms of cyclist route choice, distance/time again emerged as the most crucial factor, while other factors included the quality of the road surface, gradient, safety and weather. However the studies reviewed had a number of problems. In particular, they only dealt with limited study areas and a limited set of trips. A number of the studies had very little empirical basis for their findings and only sought to identify what a cyclist would do in a hypothetical situation. Many
studies focused on a limited range of criteria, and hence failed to fully explore the true interrelationships between the many criteria used by cyclists in determining their route choice.

3.3 Route Choice Criteria Studies

Work here has been carried out to collect data on the travel characteristics of pedestrians and cyclists: origin-destination, routes, trip purpose, etc. Two separate deliverables have been produced:

1. A report of an interview study to describe the actual travel characteristics of pedestrians within the modelled areas (typically consisting of a stretch of road with three junctions) in each of the three participating countries and of pedal cyclists in the modelled areas in the Netherlands and Sweden (in the British situation, pedal cyclist travel is too limited to make the application of a cyclist model and, hence, of data collection on cyclist travel useful).

2. A report on an experimental study of the route choice criteria of pedestrians and pedal cyclists. The results describe the relative importance of route characteristics in route choice and will enable a model to predict the preferred routes of pedestrians and pedal cyclists.

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Nevertheless, a number of tentative general conclusions can be drawn. The majority of both pedestrian and pedal cyclist trips are made for more than one purpose. Several activities tend to be combined, for example shopping on the way home from work, shopping after a visit to the doctor, and so on. Pedestrians often use public or private pre-transport to cover the distance between the outer residential areas and the commercial city centre. Age and gender differences in trip purpose, route choice motive and type of origin/destination are mostly of minor importance. The differences that were found varied by location. There are some indications that route choice motivation depends on trip purpose, in that minimizing distance is the most important motive for shopping trips, whereas minimizing time is the most important motive on official trips (such as going to school, work or other time-based appointments). The results are, however, not conclusive which is probably caused by the fact that time and distance are highly related in both pedestrian and pedal cyclist trips.

*Pedestrian and Pedal Cyclist Route Choice Criteria* (Westerdijk, 1990) reports on a structured, computer assisted interview, based on the Multi Attribute Utility Technique (MAUT). This was carried out to reveal the relative importance of various route characteristics (attributes) in choosing one's route from origin to destination. In the Netherlands and Sweden, both pedal cyclists and pedestrians (of six age/gender categories) participated in the study. They were asked to judge and compare the attributes of a number of alternative routes for a familiar journey within an urban network. In Great Britain, only pedestrians participated. Here, they went through the interview twice: once for a good weather condition and once for a bad weather condition.

The relevant attributes of routes were obtained from the literature review discussed in section 3.2 and reformulated to fulfil the requirement of mutual independence in this methodology. The eight attributes on which the alternative routes had to be judged were almost the same for pedestrians and pedal cyclists:

- distance
- number of crossings with pedestrian lights (traffic lights)
- number of crossings without pedestrian lights (traffic lights)
- pleasantness
- attractions
- quality of the pavement (road surface)
- traffic safety
- gradient

Time and effort, which had been found to be important attributes in other studies, were excluded from this set, because they largely depend on distance, number of crossings and gradient. In the Netherlands gradient was left out for obvious reasons.

The study resulted in a very large amount of relevant data on the reasons that pedestrians and pedal cyclists choose certain routes and avoid others. In general, it can be concluded that for pedestrians distance and pleasantness (e.g. shops, trees, other people walking around) were the most important route characteristics. For pedal cyclists these same attributes and traffic safety were the most important ones. There are only marginal differences in the relative importance of route
characteristics for different age groups and for men and women: the distance factor tends to become less important with increasing age and is less important for women than for men. From the British data it can be concluded that in bad weather conditions people judge the routes on different criteria than in good weather conditions. Distance, quality of the pavement or road surface and gradient are rated as more important during bad weather, whereas pleasantness and attractions are rated as more important during good weather. On the average, the cross-cultural differences in route choice criteria were negligible.

The practical consequences of this study are at least twofold. First of all, the data can be used to predict the routes people will choose (e.g. for a macro assignment model), given a origin-destination matrix and given the objective characteristics of the infrastructure. It appeared that 65 percent of the preferred routes of pedestrians and 62 percent of the preferred routes of pedal cyclists are objectively the shortest (in distance) routes. The correlation between the preferred route and distance is 56 percent for pedestrians and 58 percent for pedal cyclists. Adding the attribute pleasantness for the pedestrians and pleasantness and traffic safety for the pedal cyclists, the correlation between preferred route and the mentioned attributes increases to 70 percent and 71 percent respectively. More studies will be needed to objectify the subjective concepts of pleasantness and traffic safety, i.e. to find a reliable method of rating particular routes for pleasantness and safety.

The second practical application is related to the first one. The applied methodology makes it possible to compare the relative importance of each of the attributes, i.e. if a route improves on one attribute, how much may a route decrease on another attribute to remain an equally attractive alternative. The results indicate that both pedestrians and pedal cyclists are prepared to take a longer route if this route is considered as being more pleasant. Of course the acceptable increase in length is limited, but it clearly shows, that by making safe routes more attractive, people can be encouraged to choose a particular route, even though it is longer. The consequences for traffic planning (e.g. in the case of footbridges or subways) are obvious.

### 3.4 Database Construction

Here two types of activities have been performed. On the one hand there is the collection and storage of data on car flow, pedal cyclist flow and pedestrian flow within the three experimental areas and on the other hand there is a review of the traffic behaviour of pedestrians and pedal cyclists in so far as it affects both safety and delay: red light violation, gap acceptance and rule compliance. The report consists of contributions from different partners in the project and contains both theoretical considerations about the required type of data and databases and the results of the literature and observation studies on traffic behaviour.

_A Database for a Pedestrian and Pedal Cyclist Traffic Model_ (van Schagen, 1990b) discusses how a pedestrian and pedal cyclist micro/meso model that produces output in terms of internal flows and safety requires, in principal, three sets of data:
1. Location-specific information about the network (road layout, flows, origin-destination, traffic light cycle times and other facilities, and location-specific travel characteristics etc.), stored in a location-specific database.

2. Data on generally relevant pedestrian and pedal cyclist traffic behaviour, stored in a knowledge base.

3. Data required for conflict and accident predictions, stored in a safety base.

In each of the three experimental areas detailed data on pedestrian, pedal cyclist and motorized vehicle flow was collected to fill in part of the location-specific database. A special software programme was developed to ensure that data were entered in an identical format that could be read by the model. Origin-destination data, collected from the interviews conducted in the three locations, was also entered in this way.

Information on the traffic behaviour of pedestrians and pedal cyclists, to fill in the knowledge base, was collected from studies of the literature and small-scale observation studies carried out in the three areas. These studies concentrated on red light violation and gap acceptance by VRUs and on the rule compliance of road traffic towards VRUs. In Great Britain, pedestrian crossing strategies within pelican crossing zones were also studied. In later work these behavioural data will be integrated into the model structure.

The results showed that many pedestrians and pedal cyclists decrease delay time by violating the red light. Women as well as children and the elderly are more inclined to wait for green than other groups. The actual violation rate is highly dependent on locational characteristics, such as road traffic flow, road width etc. Gaps (i.e. the time between the moment a pedestrian (or pedal cyclist) leaves a conflict point and the time road traffic reaches this conflict point) were studied in all three situations. In general, accepted gaps are smaller in off-peak periods than in peak periods and women tend to accept smaller gaps than men. Gaps accepted in the second lane are smaller than in the first lane. Priority rules favouring pedestrians and pedal cyclists differ in each situation. A global overview shows that vulnerable road users experience delay rather often, because other traffic does not yield when supposed to. The crossing strategies within pelican zones, observed in the British situation, appear to deviate often from the normative strategy. Many pedestrians used the pelican itself only partly or not at all. Best use of the pelican was made by women and children under 12 years old.

The safety base will not be filled within the immediate future. A dynamic estimate of the conflict/accident rate, taking into account behaviour-safety relationships and relationships between physical characteristics of the network and safety is not feasible. At the moment, little empirical data on these relationships is available and such data is not easily obtainable. The model's estimate of safety will be based mainly on traffic flow data, which is available in the location-specific database.
4 FUTURE WORK

In the second half of 1990 the model will be "filled", i.e. it will be given knowledge of the important behavioural relationships that have either been observed or have been gathered from the literature. At this point the model will become a real tool for the evaluation of the effects of infrastructural changes and we hope that it will achieve widespread use.

Early in 1991 we will begin our full-scale experiments, using the detectors in all three countries. Simultaneously, the model will be run in simulation mode as a test of its ability to predict. In the final stage of the project the simulation output will be compared with the experimental results, and any necessary modification to the model carried out.

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6 REFERENCES


Traffic Related Knowledge, Attitudes and Risk Perception in Dutch Secondary School Children
Consequences for Traffic Education

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Traffic related knowledge, attitudes and risk perception in Dutch secondary school children; consequences for traffic education

In the Netherlands many cyclists of 12 up to 16 years of age are involved in accidents or near accidents. Various studies of basic cycling skills and functional abilities required for safe cycling behaviour indicate that these skills and abilities are for the most part adequately mastered. So, other factors that contribute to (un-)safe cycling behaviour must explain the high accident involvement. From a cognitive point of view the knowledge of traffic rules and signs, the knowledge of (normative) rules governing complex manoeuvres and also processing environmental information and linking this information to the proper actions are supposed to contribute to accident involvement. Besides, attitudinal and motivational issues (including risk acceptance) are pointed out as important factors in accident involvement, particularly in the age group concerned. Our understanding of the way these factors link to accident involvement is increasing. However, little is known about 'the state of the nation' on these factors in the age group concerned.

In the framework of an evaluation research project concerning the implementation of traffic educational materials we extensively investigated the initial situation of 12 - 16 year old children with regard to most of the factors mentioned above. The investigation shows that there are severe deficiencies with regard to the knowledge of priority rules particularly when right of way is not indicated by signs or road marks. Also the knowledge of (normative) rules governing complex manoeuvres (such as turning left at an intersection) is inadequate. The same goes for anticipating risks and reacting to these anticipated risks in a safe manner. With regard to attitudinal issues it is found that attitudes toward safe traffic behaviour hold out but faint hopes. Furthermore, various specific attitudes seem to form a sort of conglomerate. In adults (i.e. teachers) the attitude toward the benefits of traffic rules and the attitude with regard to violations in specific situations appears to be unrelated. This might mean that whereas adults judge their actions on an occasion by occasion base guided by 'expert knowledge', 12 - 16 year old children still lack this cognitive skill.

The various findings will be presented in some detail and their interrelations will be pointed out. Finally the consequences these findings have for traffic educational objectives and programmes will be discussed.

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VTI RAPPORT 364A
TRAFFIC RELATED KNOWLEDGE, ATTITUDES AND RISK PERCEPTION IN DUTCH SECONDARY SCHOOL CHILDREN; CONSEQUENCES FOR TRAFFIC EDUCATION
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1. INTRODUCTION

In the Netherlands many bicyclists of 12 up to 16 years of age are involved in accidents or near accidents (or near misses, if you prefer). Studies of basic cycling skills and functional abilities required for safe cycling behaviour indicate that these skills and abilities are for the most part adequately mastered (see: Van Schagen, 1984). This suggests that countermeasures have to be based on other factors contributing to (un-)safe cycling behaviour. With respect to the type of countermeasure traffic safety education is a preferable alternative to 'enforcement' or 'engineering' (Van Schagen, Wierda and Brookhuis, 1989). However, this does not answer the question which factors have to be addressed by traffic safety education.

The primary objective of traffic safety education is, of course, safe traffic behaviour. To pursue safe traffic behaviour, the behaviour in question can be trained or the required behaviour (change) can be pursued by attaining secondary or enabling objectives with respect to knowledge, cognitive processes and attitudes (Van Schagen, Rothengatter and Brookhuis, 1987). Possible topics with respect to the educational objectives are indicated by analyzing accident data and comparing actual with required (safe) traffic behaviour (Rothengatter, Brookhuis and van Schagen, 1987). The relevance of these topics is indicated by the initial situation of the age group concerned with respect to the educational objectives. In this paper the topics that have to be included in traffic safety education programmes for the lower grades (1-3) of secondary schools will be explored, accounting for the initial situation with regard to educational objectives.

Firstly, a few comments will be made on factors contributing to accident involvement in the age group concerned. Subsequently, a short digression is made on a basic educational goal structure and topics indicated by empirical data. In this digression cognitive processes underlying actual traffic behaviour and attitudes toward safe traffic behaviour play a role in linking data to possible topics. Empirical results regarding the initial situation with respect to the topics indicated will be presented in section 4, the central section of this paper. Attention will be payed to the level of knowledge of traffic rules and signs, the level of knowledge of (normative) rules governing complex manoeuvres, anticipating risks and reacting to anticipated risks. In addition, certain attitudinal issues will be addressed. Finally the educational consequences will be discussed in some detail in terms of topics that have to be included in traffic safety education programmes. In addition, comments will be made on methodical issues.

2. ACCIDENT INVOLVEMENT

The majority of Dutch children in the lower grades of secondary schools go to school by bicycle, as can be seen from figure 1. Cycling also figures as the common mode of transportation on other trips (Brinks, 1989).

In 1988 32 Dutch children from 10 up to 15 years of age were killed in traffic (24 as bicyclist), while another 2747 were injured (1891 as bicyclist), according to data based on police records (CBS, 1989). However, the number of injured children is expected to be at least four times greater (Van Montfoort, Van Galen and Harris, 1988).
Many accidents in which the children are involved concern manoeuvres at intersections, that is, crossing an intersection or turning left at an intersection. In addition, many children are reported to be involved in accidents while riding ahead (rear end collisions or flank collisions) (Van Schagen, Brookhuis and Kuiken, 1985; Miedema en Van der Molen, 1984). According to accident analyses and expert opinions (see: Brinks, 1987a) the accidents at intersections must, at least partly, be contributed to attentional or perceptual problems, risk acceptance (accepting small time gaps or failing to decelerate) or inadequate decisions on right of way. As far as accidents while riding ahead are concerned, attentional or perceptual problems, faulty choice of location on the road or course deviations are suggested as contributing factors. In addition it is believed that the phenomenon of cycling in groups plays an important role, at least in the Netherlands.

It should be noted that the age group concerned, in particular pupils in the first grade of secondary schools, experience a quantitative as well as a qualitative leap in traffic participation. The pupils spend more time in traffic; initially because of the school trips they make and later on also because of additional trips. In addition, the trips they make shift from the direct vicinity of their homes to trips in more complex traffic environments with which the pupils hardly have any experience.

Taking into account that most pupils are not free to choose whether they do or do not travel (to school) by bicycle this poses a serious policy problem with regard to traffic safety. As was stated in the introduction, this problem should be addressed by traffic safety education, primarily aiming at adequate or safe behaviour patterns. The factors contributing to accident involvement can be related to inadequate behaviour (e.g. course deviations). Most of the contributing factors, however, relate to decisions resulting in inadequate behaviour patterns, as will be argued in the next section.

3. TRAFFIC EDUCATIONAL OBJECTIVES

In order to display adequate or safe traffic behaviour patterns children have to master a repertoire of basic cycling skills and abilities as well as some basic knowledge on traffic par-
Compulsory traffic safety education in elementary schools addresses these 'basics'. By the time children enter secondary schools the 'basics' have been mastered (Van Schagen, 1984). Although, an exception probably should be made with regard to anticipating latent risks (Brinks, 1987a; Van Schagen, 1984) and visual search strategies (Kuiken and Brookhuis, 1986).

Having mastered the basics, however, the pupils are only half way in qualifying as expert cyclists. To qualify as an expert, additional experience in traffic, additional knowledge and additional cognitive skills or abilities are required as well as a proper state of mind (attitude or motivation) as is depicted in the goal structure of figure 2 (from van Schagen e.a., 1987).

**Figure 2: Goal structure with respect to traffic safety education**

Traffic safety education in secondary schools faces the task of teaching the additional knowledge, enhancing the cognitive processes and addressing attitudes facilitating safe traffic behaviour. This means a shift in focus with respect to traffic safety education in elementary schools. The 'basics' have been mastered and, according to Van Schagen and Rothengatter (1986), training behaviour patterns per se (a primary objective) is not effective when required manoeuvres become more complex, as is the case when children enter secondary school. Hence, traffic safety education in secondary schools focuses mainly on attaining secondary objectives. What has to be taught, in terms of topics with respect to these objectives, is indicated by the findings touched upon in the preceding section. However, simply translating these findings into educational programme modules may lead to incoherent or even inconsistent programmes. What is needed is a model capable of describing traffic behaviour.

In recent years cognitive process models describing cognitive processes resulting in actual traffic behaviour are advocated (Michon, 1986). With respect to bicyclists the model of Anderson (1983) is supposed to be applicable (Rothengatter e.a., 1987). Central to this model are so called production rules. The general paradigm for a production rule is: IF (condition) THEN (action). For example, IF (traffic is light is red) THEN (brake).

Novices in a traffic role (e.g. cycling children) are still in the process of acquiring (new) simple production rules and integrating them into more or less complex sets of rules, so called production systems. Experts, on the other hand, rely heavily on existing production systems. Becoming an expert starts with memorising simple production rules and then consciously practising these meaning, accounting for relatively slow cognitive processing. Repeated prac-
tice leads to integrating simple rules into production systems enveloping sequences of rules that are 'triggered' automatically, meaning relative fast processing.

The production rule model suggests at least two problem areas with respect to the age group concerned (Rothengatter e.a., 1987). These areas cover many of the factors that contribute to accident involvement. Firstly, children may lack the basic knowledge (production rules) that enables them to make accurate decisions on right of way or to perform complex manoeuvres. Secondly, the interpretation processes matching a perceived situation with appropriate productions (e.g. actions) are still relatively slow. This may lead to mental overload problems reflected into the attentional and perceptual problems already mentioned.

With regard to the possible lack of knowledge two questions are relevant. Firstly, what do pupils have to know? And, secondly, what do pupils actually know? Taking into account the factors contributing to accident involvement, the pupils have to acquire knowledge with respect to:

- traffic rules and signs related to specific traffic environments (e.g. priority rules),
- rules governing complex manoeuvres (e.g. turning left)
- traffic hazards and risky situations in relation to risk scenarios (see also: Van Schagen e.a., 1989).

According to the production rule model the knowledge has to include behavioural consequences. What the pupils actually know on these topics is presented in the next section.

Concerning the relatively slow cognitive processing it is not clear whether specific cognitive skills or abilities can be trained or whether increasing experience by training or even maturation should do the job. At this moment increasing experience by training is advocated (Wierda, Van den Burg and Tromp, 1989). Hence, concerning cognitive processes no specific topics are indicated.

Accurate knowledge and fast cognitive processing do not guarantee adequate or safe traffic behaviour. In addition to inaccurate or lacking knowledge and relatively slow cognitive processing, the traffic behaviour of secondary school pupils rather resembles playing than purposeful behaviour (Rothengatter e.a., 1987). Besides, the findings of Maring and Van Schagen (1990) indicate that secondary school pupils and young adults are less motivated to comply to rules than other groups of bicyclists. One might suppose that motivational issues may contribute to attentional and perceptual problems or the decisions on right of way. Motivational issues or 'a proper state of mind' are addressed in the area of attitude objectives. Various (specific) attitudes might contribute to actual traffic behaviour of the age group concerned. For example using the results of Koch (1980) with respect to moped riders. However, it is not clear whether specific attitudes can be addressed, and if so, which attitudes have to be addressed. In the next section and the discussion we hope to answer this question in some detail.

4. THE INITIAL SITUATION

In the framework of an evaluation research project concerning the implementation of traffic educational materials, the initial situation with respect to the majority of the topics just mentioned was investigated (Brinks, 1989). The findings reported in this paragraph are based on the first assessment of the initial situation and on preliminary research with regard to the feasibility of the measuring devices. Both investigations concern pupils in the lower grades of secondary schools. In addition, parts of the preliminary research also concern teachers. Attention will be payed to knowledge of (priority) rules and traffic signs that are of particular importance to bicyclists, to knowledge of rules governing complex manoeuvres, to risk perception and anticipation and to attitudinal issues.
4.1. KNOWLEDGE OF RULES AND SIGNS

The knowledge 12 to 16 year old pupils have of priority rules and traffic signs was investigated using a test that consisted of thirty slides of traffic situations. The children had to indicate if the behaviour that was shown was right or wrong or if the target cyclist should stop at an intersection. The pupils had about 5-7 seconds to answer after the question was orally posed.

The average number of items answered correctly indicates a barely sufficient level of knowledge. If the test is to be considered as an educational test, about twenty items should be answered correctly to pass. In fact an average score of 19.5 was found. The average score covaries with grade and type of education as can be seen in table 1. A higher grade means a higher average score as does a higher type of education.

<table>
<thead>
<tr>
<th></th>
<th>lower vocational education</th>
<th>advanced elementary education</th>
<th>higher general education</th>
</tr>
</thead>
<tbody>
<tr>
<td>grade 1</td>
<td>17.1</td>
<td>18.1</td>
<td>19.8</td>
</tr>
<tr>
<td>grade 2</td>
<td>18.2</td>
<td>18.9</td>
<td>23.3</td>
</tr>
<tr>
<td>grade 3</td>
<td>18.8</td>
<td>19.8</td>
<td>22.5</td>
</tr>
</tbody>
</table>

The composition of the test gives us some insight into traffic situations that are accountable for the relatively low scores.

The test consisted of five subtests. One subtest consisted of items on traffic signs and correct location on the road. As can be seen from figure 3, the proportion of right answers barely exceeds the guessing level. The other four subtests make up a two by two table, set up by the type of priority rules (indicated by signs or road marks versus no physical indication) and the number of other road users (one versus two road users approaching). As can be seen from figure 3, the proportion of correct answers -accounting for guessing- is lowest when there are no physical indications on right of way and, in addition, the number of other road users approaching is two. In this case the average proportion of correct answers is at guessing level. Furthermore, the proportion of correct answers appears overall to be smaller when right of way is not physically indicated compared with situations in which right of way is indicated by signs and road marks.

![Figure 3: Proportion of right answers on subtests of the slides test.](image-url)
The relatively low proportion of correct answers to some subtests appears not only to be related to knowledge of traffic rules as such. Given ample time to answer, by presenting photographs and written questions while the answering time was not restricted, comparable pupils scored much better (Maring e.a., 1990), but still not as good as adults. The main problem, therefore, seems to be processing information in order to make a decision on right of way rather than knowing priority rules. In other words: the relevant productions appear to be present but are either slowly 'activated' or recognition of the right of way situation takes too much time. Hence, the fairly general held belief in the Netherlands that children leaving elementary school 'know' the priority rules is not fully discarded. At the same time, however, it must be concluded that pupils lack the experience to put these rules into practice in the time constrained situations that are characteristic of real traffic situations. In addition, some lack of knowledge remains with respect to situations in which the right way is not indicated by signs or road marks.

### 4.2. RULES GOVERNING COMPLEX MANOEUVRES

Manoeuvres can be looked upon as sequences of overt perceptual and behavioural acts or steps. In order to investigate the extent to which these sequential steps (and the rules they imply) are available to pupils we presented four traffic situations (overtaking a parked car, turning left at an intersection, crossing an intersection and departing from a bicycle path). Using photographs as a point of reference the pupils in the second grade (about 14 years of age) had to mention the overt steps that stage the manoeuvre in question. The observed answers were for the most part not incorrect but failed, however, with respect to mentioning all the critical steps in some detail. This can be seen in table 2 where the proportions of critical steps mentioned are presented.

<table>
<thead>
<tr>
<th></th>
<th>overtaking</th>
<th>turning left</th>
<th>crossing</th>
<th>departing</th>
</tr>
</thead>
<tbody>
<tr>
<td>two critical steps mentioned</td>
<td>.01</td>
<td>.18</td>
<td>.05</td>
<td>not relevant</td>
</tr>
<tr>
<td>one critical step mentioned</td>
<td>.27</td>
<td>.33</td>
<td>.26</td>
<td>.40</td>
</tr>
<tr>
<td>no critical steps mentioned</td>
<td>.73</td>
<td>.49</td>
<td>.69</td>
<td>.61</td>
</tr>
</tbody>
</table>

One might argue that these manoeuvres are to a certain degree automated, which makes it difficult to recover the individual steps in a sequence, especially when the children have no hint of what steps were available to them. However, even when the steps of interest are indicated to the children in advance, little improvement was observed (Brinks, forthcoming). It must, therefore, be concluded that the pupils in the lower grades of secondary schools are not very familiar with the rules governing complex manoeuvres. The level of knowledge concerning manoeuvring appears not to be related to the level of knowledge on (priority) rules and signs.

### 4.3. RISK PERCEPTION AND ANTICIPATION

The same traffic situations that were used to investigate the knowledge on rules governing manoeuvres were also used to investigate risk anticipation. The pupils (second grade) were asked to indicate hazards they perceived in the presented traffic situations as well as the steps that should be taken to counter these hazards. As with the answers to the questions about manoeuvring, the answers tended to be global. The hazards that were reported are for the most part at the level of 'having an accident' without the accident being specified. Much the same is true for the steps to counter specific hazards. The majority of answers emphasize 'paying due attention' or 'paying more attention' as countermeasure. In both cases the mi-
nority of pupils mentioned situation specific hazards or countermeasures as can be seen in table 3.

Table 3: Proportion of specific answers to the questions about risk and steps to be taken to counter them

<table>
<thead>
<tr>
<th></th>
<th>overtaking</th>
<th>turning left</th>
<th>crossing</th>
<th>departing</th>
</tr>
</thead>
<tbody>
<tr>
<td>specific risks</td>
<td>.48</td>
<td>.38</td>
<td>.33</td>
<td>.10</td>
</tr>
<tr>
<td>mentioned specific</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>countermeasures</td>
<td>.37</td>
<td>.36</td>
<td>.22</td>
<td>.36</td>
</tr>
<tr>
<td>mentioned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It appears that most of the pupils cannot imagine specific risk scenario's that end up in accidents and, thus, have no specific defensive strategies at hand to counter specific hazards.

The pupils in the first grade also answered questions on risky situations. These situations (eight in total) were chosen on the basis of accident data and expert opinions (Brinks, 1987a) on the specific hazards in risky situations. Using photographs as examples of a number of risky traffic situations, the pupils had to rate the frequency of encountering such a situation (exposure), the perceived risk level of a situation and the extent to which they consider themselves to have mastered a proper course of action (coping) given a situation. Surprisingly, the perceived risk level is not related to exposure nor to coping, taking into account all the relevant situations. Coping and exposure do covary, however. Pupils who indicate a greater degree of exposure tend to believe with greater strength that they have mastered appropriate courses of actions ($r = .38$). However, taking into account the level of knowledge on manoeuvring, one is tempted to question the safety of the mastered courses of actions.

4.4. ATTITUDES

The development process of measuring devices in the framework of the evaluation of traffic educational materials originally aimed at measuring three specific attitudes, namely:

- the attitude towards rule compliance,
- the attitude towards safety of one's own cycling behaviour,
- the attitude towards considering the safety of others (Brinks, 1987b).

Factor analysis of the individual statements, however, did not validate the existence of these attitudes. In contrast, two related attitudes were found. Firstly, the attitude towards the benefits of traffic rules and consideration for other traffic participants, to which shall be referred as 'the attitude toward rules'. Secondly, the attitude towards rule violations and playing in traffic, that is subsequently referred to as 'the attitude toward violations'. In addition, a third attitude, that towards the safety of cycling in groups was distinguishable.

Two significant findings should be noted. The attitude scores on the three attitudes scales steadily decline over grades. Hence, the higher the grade, the less traffic safety is emphasized (see figure 4). In addition, the three attitudes intercorrelate rather highly (between $r = .40$ and $r = .60$) indicating a sort of conglomerate in which the individual attitudes are hardly distinguishable.

These findings are in line with the findings from a survey on knowledge and attitudes held among cyclists of a wider age range (Maring e.a., 1990). From the same survey it was concluded that the attitudes (toward benefits of and intrinsic pleasure in complying to rules) were stronger related in the age groups 11-14 and 15-18 than in the group of 19 up to 65 years of age (the 'expert' group). Our own results show a similar pattern as far as the attitudes toward rules and toward violations are concerned. Attitude scores based on statements that are not age related show a rather strong relation ($r = .40$) in pupils whilst the relation in teachers is effectively absent ($r = .00$) (Brinks, 1987b). In general, the attitudes of teachers or cyclists between 19 and 60 years of age emphasize traffic safety to a greater degree.
The attitudes do not relate to knowledge of (priority) rules and signs. The attitude toward violations does, however, relate to the knowledge of rules governing complex manoeuvres. Pupils who put a greater emphasis on traffic safety tend to have a higher level of knowledge concerning these rules. It is not clear, however, whether the attitude level 'causes' the level of knowledge concerning rules governing complex manoeuvres or whether the relation is the other way around.

5. DISCUSSION; CONSEQUENCES FOR TRAFFIC EDUCATION

As was to be expected, the basic knowledge of pupils in the lower grades of secondary education was found to be inaccurate with respect to safe traffic behaviour. It was found that the pupils lacked knowledge concerning traffic signs and road marks (in particular with regard to choice of location on the road) and also concerning priority rules. In addition, knowledge with respect to rules governing complex manoeuvres appears to be absent in most pupils, as is knowledge concerning scenario's or scripts with respect to hazardous traffic situations. Nevertheless, the pupils gain increasing confidence with respect to their own ways of coping with various traffic situations as exposure increases. With regard to attitudes, it must to be concluded that secondary school pupils have less favourable attitudes toward traffic safety relative to more experienced bicyclists. Furthermore, specific attitudes, in particular the attitudes towards 'rules' and towards 'violations', are still strongly related.

The findings with respect to what secondary school pupils know offer some clear indications concerning the topics that have to be included in traffic safety education programmes. In terms of basic knowledge the following topics have to be included:

- signs and marks indicating position on the road,
- priority rules in situations in which the right of way is not physically indicated,
- rules governing complex manoeuvres,
- traffic hazards and risky situations in terms of risk scenario's.
Indications with respect to attitudinal issues that have to be included in traffic safety education programmes are not clear. It was not possible to clearly identify specific attitudes as is the case with age groups above the age we are concerned with. Considering the developmental stage secondary school pupils are in, they may still lack the traffic experience to have formed specific attitudes concerning traffic safety. Assuming that specific attitudes (e.g. towards 'rules' and towards 'violations') are formed on the basis of experience, this might mean that, whereas, experts are able to judge their actions on an occasion by occasion base guided by 'expert knowledge', secondary school pupils still lack this cognitive skill and the accompanying attitude. With respect to the lower grades of secondary schools we are, therefore, compelled to follow Van Schagen ca. (1989). They recommend that the educational efforts with regard to attitudes should initially focus on increasing insight in the traffic system and clarifying the purpose and benefits of the rules that are taught.

In sum, it must be concluded that we were able to indicate traffic safety topics with respect to the area of knowledge objectives. With respect to speeding up cognitive processing and addressing attitudes the (increasing) experience of secondary school pupils seems to play an important role. Dealing with experience in terms of education, however, is rather a matter of method than of substance. Hence, the paper will be concluded with a few remarks on methods.

The matter of experience and the methods to be used to increase experience is not only relevant to cognitive processes and attitudes. In an evaluation study of two instructional methods on cycling behaviour (Van Schagen and Rothengatter, 1988) it was found, for example, that theoretical lessons concerning priority rules did increase knowledge, but this knowledge was not put into practice. It was supposed that children had adopted their own informal set of rules on giving way. This phenomenon probably not only occurs in decisions on right of way but also in manoeuvring in (hazardous) situations. Pupils in the age group concerned were for instance found to use other (more primitive) visual search strategies in approaching intersections then experts did (Kuiken e.a., 1986).

These findings mean that traffic safety education does not only have to deal with actual or future experiences but also with past experiences. This suggests at least two (tentative) methodical principles concerning traffic safety education.

1. Traffic safety education in secondary schools must, at least initially, focus on what pupils do and how and why they do it. The best moment to begin is when they enter secondary school and first encounter new and more complex traffic situations. At that time existing informal rules and strategies are still relatively fresh. Hence, it may still be possible to uncover them and to begin to install formal or 'expert' rules or strategies enabling the pupils to deal more adequately (and safely) with the new situations. The first results with respect to the evaluation of effects of various traffic educational materials indicate that materials using this approach also have favourable effects with regard to the general attitude towards traffic safety (Brinks, 1988).

2. Traffic safety education should offer sufficient opportunity to practice the acquired knowledge in order to speed up cognitive processing and form favourable attitudes. While practising, however, there has to be some form of feedback with respect to what has been done wrong and why it was wrong. In the majority of secondary schools, however, there will be no opportunity to train in real traffic situations, whereas the school yard does not seem to be a proper place to train more complex traffic tasks. Hence, other methods preserving the dynamic features of real traffic situations and offering opportunities for feedback have to be used. Audio visual materials (such as video films) or computer simulation of cycling behaviour may be fruitful (Van Schagen e.a, 1989). Recently a computer program simulating manoeuvres while approaching an intersection and making decision on right of way has been developed. The pupil gets feedback on how he does from a cognitive point of view (Wierda e.a., 1989). Momentarily the program is being evaluated in global terms.
The clearly indicated topics in the area of knowledge and the methodical principles to deal
with past, present and future traffic experiences with respect to traffic safety education offer
a promising starting point. However, many problems have still to be solved.
Three important problem areas are:
— the exact kind of relationship between knowledge, cognitive processes and attitudes or
motivation,
— the development processes with respect to attitude formation,
— the way differences between types of school and between grades must be handled.

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Lifestyle, Leisurestyle and Traffic Behaviour of Young Drivers

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Abstract

Young Drivers Leisure-Related Nighttime Accidents ("Disco Accidents")

This analysis was aimed at investigating the factors decisively involved in the occurrence and serious consequences of "disco accidents". The information gathered is to be used for development of measures leading to the reduction of these types of accidents. The data for the analysis is based on a three-month nationwide study of all accidents involving casualties, which took place on the way to, from, or on the way between discos.

During the three-month study, 216 disco accidents were registered. Sixty-four young people were killed and 484 were seriously injured. 61 percent of the drivers involved in the accidents had blood alcohol contents that were too high. The percentage of drivers under the influence of alcohol was significantly higher in congested urban areas than in rural areas. Accumulation of these accidents were identified in left hand curves with large curve radii. In these curves vehicles overloading in connection with a lack of knowledge about the physics of driving on the part of the young drivers accounted for 20 percent of the accidents. Among other factors, the serious consequences of disco accidents can be attributed to the high percentage of unfastened seatbelts - particularly in the back seat.

From a socialpsychological point of view the study shows that young drivers' accident proneness is correlated with their membership of definite leisure- and lifestyle groups. Some factors that constitute leisure - and lifestyle might have a negative effect on driving style and accordingly on accident proneness. According, future concepts of traffic safety campaigns should develop differential messages directed at young drivers.
LIFESTYLE, LEISURESTYLE AND TRAFFIC BEHAVIOUR OF YOUNG DRIVERS

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Federal Highway Research Institut

1. INTRODUCTION

The technological and structural change has shown evident effects on the mobility of the young generation:
- Many areas of life (schools, education and work places) have increasingly disappeared from the residential areas. They cannot be reached on foot and often not even (or with difficulties) by public transport.
- For young drivers the leisure and fun functions of the car are in the foreground. The availability of a car and the "ability to drive" thus mark the standing of young drivers within their peer group.
- As well as other areas of life, many leisure places have also disappeared from residential areas or have been established far from the centre. Firms marketing leisure activities, count on the mobility of their customers and provide for large catchment areas.

The favoured out-door leisure locations (e.g. milk bars, cinema, dancing halls, swimming pools, sportsgrounds, etc.) of the past decades could be reached on foot or comparatively small efforts invested in getting there. Nowadays the leisure locations preferred are mostly outside of the centre (cinema palaces, discos, fitness centres, surfing possibilities, skateboard grounds, etc.). Consequently young people are often involved in accidents on their way to or from these leisure places.
2. DISCO ACCIDENTS

Among the weekend-activities of young people, the visit of a disco has been the most favourite since quite some time. For a direct access to the data on the accidents associated with visits to discos, the Federal Highway Research Institute (BASt) undertook a study of all disco accidents involving at least one injured person during the three winter months of 1987/88. The starting point of this accident analysis were the accident records of the police. During the three-month study, 216 disco accidents were recorded. Sixty-four young people were killed and 484 were seriously injured. 61% of the drivers involved in the accidents had blood alcohol concentrations that were too high (more than 30 mg / 100 ml). 31% of the drivers even had blood alcohol concentrations of 130 mg / 100 ml and more which correspond to an absolute inability of driving according to the Penal Code. The percentage of drivers under the influence of alcohol was significantly higher in congested urban areas than in rural areas. An accumulation of these accidents was identified in left hand curves with large curve radii. In these curves, overloaded cars in connection with a lack of knowledge about the physics of driving on the part of the young drivers accounted for 20% of the accidents. Particularly on rural roads, but on wide, well-designed urban roads as well, young people drive relatively fast at night, nearly at critical speed levels, as far as these wide left hand curves are concerned. If there are then four, five or even six people in the car, it will be thrown off course, swerve to the right, the right-hand wheels will get onto the soft shoulder causing the car to skid. Among other factors, the serious consequences of disco
accidents can be attributed to the high percentage of unfastened seatbelts - particularly on the rear seat.

2.1 Resumé of the study

Although the basic conditions are comparable, the risk of an accident on the way to or from a disco is not the same for all young drivers. The analysis has shown that the inability of separating drinking from driving is primarily a problem of male drivers, the degree of intoxication becoming higher with age. Among the people who caused the accidents and who were completely unable to drive, the percentage of female drivers was only 8%.

The disproportionately high participation (45%) of groups working in the metal, building and military fields and their high rate of intoxication further points to a highly profession-related readiness to take risks.

From a sociopsychological point of view, the study showed that young drivers' accident proneness is correlated with their membership in leisure and lifestyle groups. Some factors playing an important role in one's leisure and lifestyle might have a negative effect on the style of driving and accordingly on accident proneness.

3. LIFESTYLE, LEISURESTYLE AND TRAFFIC BEHAVIOUR

With the objective of a closer insight into the causes of the accident risks of young drivers, BASt conducted an analysis, in 1989, of the relationship of young people to life- and leisure style groups and the accident risk connected therewith.
3.1 Method of analysis

From November 1988 until January 1989, a representative interview survey of 18 - 24 year-olds was carried out in the Federal Republic of Germany. 1024 persons were questioned and 79 % of them were in the possession of a class-3-driving licence (pass. car).

Data from the following fields were collected:
1. Life and leisure style elements
   - leisure activities
   - music interests
   - film interests
   - symbolic self-expression by clothing
   - affinity towards groups of the youth culture and alternative forms of culture.

2. Traffic-related attitudes and behaviours
   - Extramotives
   - annual travel in terms of veh.-kms.
   - frequency of accidents.

3. Habits concerning alcohol
   - frequency of drinking
   - quantity of drinking.

4. Sociodemography

3.1.1 Evaluation

The membership of the 742 licence owners of the sample of leisure and lifestyle groups was investigated by multivariate statistical analysis. During a further step of analysis, traffic-related attitudes and behaviour, drinking habits and sociodemographical characteristics of the clusters were looked into.
3.2 Results

The cluster-analysis of leisure and lifestyle elements led to 7 groups. The discriminant analysis of the goodness of classification showed that 85% of the subjects had been classified correctly. The large number of different types of young people alone showed how wrong it would be to regard all 18-24 year-olds as a homogeneous group. A study of the dangerous extramotives, such as thrill-seeking, self-expression, showing-off or letting off steam and other factors linked with increased risks, revealed that only 30% of the target group had to be regarded as a high risk group which, in turn, had to be broken down into 3 groups representing different style elements (types of juveniles). These will be described in the following: Action, Fan and Nonconforming (Nonconformist) Type.

3.2.1 The "action type"

This cluster represents 16% of the target group. It differs from all the other clusters by its high amount of outdoor leisure activities, especially visiting pubs, bistros and discos. Killing time by driving a car is also of great importance. The action type favours all kinds of action films (detective, western and adventure movies). He vehemently rejects highly sophisticated subjects like news and critical social films as well as soap operas, serials, etc.

As regards music, he mostly likes rock and punk. Jazz and classical music are not his favourites. By means of clothing and appearance, he tries giving the impression of being cool, sexy and knowing what's what, a message resembling a commercial.
He shows a high affinity to football and disco fans as well as rockers, punks and skins. He does not like so much environmental activists and groups belonging to the peace movement.

His being attracted by action films and his rejecting all forms of entertainment that requires to come to terms with intellectual contents, characterizes the action type as a personality whose thinking and acting is determined more by emotional than by rational factors.
3.2.2 The fan type

9 % of the target group belong to this group. It is a soccer and disco fan cluster. Except for riding around by car or time-killing in any form, there is not any leisure activity he derives pleasure from. Being together with the family or hiking is rejected outright. Like the action type he prefers action films. Coming to terms with any more intellectual subjects is of no interest to him.

3.2.3 The "nonconforming type"

With 6 %, this type represents the smallest cluster of the target group. The members of this group reject sports of any kind, club memberships, family get-togethers and hiking. They rather tend to favour riding around by car or time-killing. The nonconforming type is more or less a modern variety of the rocker. From all groups, he shows the highest affinity for rock and punk music and heavy metal. At the same time he is more open-minded and is receptive to more serious forms of music and films. Compared to the other style groups, he shows the highest affinity to punks, rockers and skins. In his opinion, environmental activists and pacifists are quite all right, but he strongly dislikes football and disco fans. No other group has such a negative judgement of its fashion conscious peers as the nonconformist does.

3.2.4 Group-specific driving records

Compared to other age groups, the annual travel (veh.-kms) of the group aged 18 - 24 years is
relatively high. Differentiated by style groups, the analysis however shows that the amount of travel varies with the membership of style groups. The highest annual amount of travel is produced by the nonconforming type with an average of 20,000 km per year. That is nearly twice as high as the travel in group five (the indoor type). Also group four (fan type) distinguishes itself by an annual travel which is clearly above average.

3.2.5 Group-specific drinking habits

The action, fan and nonconforming types are the young drivers where with whom drinking during leisure time is more frequent than in any other group. More than 50% of the members of these groups reported to consume alcoholic beverages several times a week. For these groups, drinking often also means drinking large amounts of alcohol. Compared with other groups, the quantities of alcohol they consume (pure alcohol in ccm) both on weekdays (about 100 ccm) and during the weekend (about 150 ccm) are quite above-average.

All three groups are known to drive a lot and a great deal of their driving is done at nighttime due to the leisure time activities they favour. At these times, they often consume large quantities of alcohol. Increasing the already high amount of alcohol on weekdays by an additional 50% over the weekend, these groups are associated with an especially high Saturday-night accident risk.

3.2.6 Group-specific motivational aspects

Driving a car fulfils a great many functions for young people. Besides the primary motive of getting from A to B, driving a car often satisfies further
so-called extra motives (see NääTänEN & Summula 1976), which become obvious in traffic-related attitudes and behaviours.

The group-specific analysis of these extra-motives revealed above-average means (based on the degree of affirmation received) for the action, fan and nonconforming types with respect to risky motives. According to the Scheffe-test, the actual means obtained for the action- and fan type groups significantly differ from the rest of the groups.

To estimate the group-specific accident risk, the relative number of accidents based on the amount of travel, was taken as an indicator. Due to the large number of groups versus the small number of accidents, the results of the analysis are not significant in statistical terms. Nevertheless, the results are highly plausible, because the interaction of high exposure, frequent and high consumption of alcohol, acting-out of self-asserting, showing-off, self-testing and thrill-seeking tendencies while driving a car, are by themselves combined with a high accident risk.

3.2.7 Sociodemographic characteristics

Male adolescents dominate within the particularly high-risk style groups with a percentage of 70 to 80%. More than half of the members of these groups belong to the lower educational level (primary school).

Between 30 and 40% of the adolescents forming these groups belong to markedly masculine professions, like the metal industry and building trades. This result also validates the result of the disco accident analysis according to which the percentage of young people belonging to these professions is three times as high among those having caused disco accidents as
the percentage of young people in these professions in the population of the Federal Republic of Germany.
4. SUMMARY AND CONCLUSIONS

The analysis of disco accidents has proved that young drivers' accidents are not only strongly related to their leisure behaviour, but can largely also be explained by their leisure behaviour. As young drivers are not a uniform group with relatively homogeneous patterns of behaviour, but an aggregate of very different groups with their own behavioural codes, a global assessment juveniles with respect to their accident risks does not make much sense. A differentiation by leisure and lifestyle groups might result in a better insight into the risks associated with special groups. Within the youth culture, the leisure and lifestyle groups could be subdivided by fashion, music and film preferences, leisure interests, drinking and consumption habits, affinity to groups of the youth culture and alternative cultural forms and by their forms of self-expression. The study points to a strong relationship between membership of leisure and lifestyle groups and traffic related attitudes and behavioural patterns. With their share of 30 % in the target group, the action, fan and nonconformist types turned out to be particularly high-risk groups. But the remaining groups also show risks of a style group-specific nature which can be explained by their still being in the midst of a learning process which is far from having ended. The differentiated description of style groups based both on their specific safety risks and their sociological and psychological characteristics, provides the possibility of considerably improving the effectiveness of the countermeasures to be taken.

To sum up we can thus conclude that it is necessary for future concepts of safety campaigns to concentrate on the development of messages especially
addressing the various particular groups of young drivers involved.
Test Site West Sweden
Learning RTI and Demonstrating Its Usefulness

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"Test Site West Sweden: Learning RTI and Demonstrating Its Usefulness":

Abstract

The Swedish National Road Administration (SNRA) is responsible for the main part — including thoroughfares in cities — of public roads in Sweden.

The interest from SNRA in Road Transport Informatics (RTI) goes back at least ten years, both in practise for improving the productivity of road maintenance and road services (especially winter road services) and in principle for developing new services to road users as well as improving the performance of the road transport system.

It is the belief of SNRA that a more "intelligent" road must be entered in order to handle future road traffic. In fact a new technological "style" is required of future road traffic, making it more functional as well as environmentally sustainable. An important factor in this context is RTI.

The introduction of new technology in a business requires the renewal of the knowledge base. The latter does not fall from heaven and can not be planned forth in a straightforward manner. On the contrary, it must be acquired from continual experimentation (and accompanying failures). From this standpoint Test Site West Sweden, with the City of Gothenburg as focal point, was established early this year.

The purpose of Test Site West Sweden is fourfold:

- to acquire new technological know-how, especially with regard to RTI
- to find out how new technology works in different applications
to create a systems environment in order that functions and products can be tested in a realistic context, and that different actors are stimulated to engagement and co-operation.

to demonstrate by pilot projects how new technology - in a new setting for the design of an integrated road traffic environment (IRTE) - can advance the performance of the road transport system.

SNRA is in charge of the test area. There is a small steering committee with the principal actors in the test area as members. The National Transport Research Board is an adjunct member. By Government decree an inter-ministry reference group has been established to follow RTI developments in Sweden.

By the summer 1990 work is gaining momentum in three project areas:

1. Road maintenance & service production (Production support)

2. Road user support services, especially for specialized vehicle fleets, which will be the motor for RTI developments (Road user support)

3. Road traffic management

A special program on the evaluation of behavioural effects on road traffic, environmental impacts as well as socio-economic effects of IRTE/RTI developments is also being planned.

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1. BACKGROUND

There has been a surge in the development of road traffic in Sweden during the 1980's. The pace of road infrastructure investments is on the other hand sluggish since a long time, and as a consequence the gap between movable and fixed capital in the road transport system is rapidly widening. This imbalance - a general phenomenon in the industrialized world - is of a growing concern.

It is safe to say that the growth of road traffic is becoming too large in view of system deficiencies in the road transport system. It has not until quite recently been realized fully neither the demand for road infrastructure nor the environment impact that mass automobility entails.

On the other hand the automobile is becoming an indispensable part of society. As road infrastructure is lagging behind, the need for accessibility and speed is gradually outpacing the driver’s physiological and psychological abilities. As there has always been a balance in favour of the transport benefits of the automobile over the quality of the road traffic environment, road transport manifests itself increasingly to the detriment of the environment in many respects.

However, the road traffic problem can, literally speaking, be seen as fertile soil for the growth of new technology, particularly informatics. There is an attracting potential for a new technological "style" to road traffic, based on an increasing share of value added in the road transport system on design, quality and information.

The key word here is not information, however important it is, but design. There is a great need for advancing the design principles of the road transport system. To-day oldfashioned ideas hamper a constructive development of road transport. However, new technological opportunities open our minds. It is interesting to note
how negative effects of road traffic hitherto played down — in part by lack of feasible solutions — are now becoming matter-of-fact problems in view of the possible capabilities of RTI.

2. DESIGNING THE FUTURE ROAD TRANSPORT SYSTEM

Road building as a panacea for improving road transport is no longer seriously contended by lack of finance, space, and environment concerns. Piecemeal traffic & environment management measures to contain the worst negative effects of growing road traffic are in the long run not viable. The intentions are praiseworthy, but the measures taken together are likely to only superficially ameliorate the problems. Road building and traffic management will of course be necessary, but then as an integral part of a more "intelligent" approach.

In Sweden road capacity is — with few exceptions as yet — not a major problem. At the periphery of Europe, with low population density, and a long winter, transport efficiency and comfort are more important issues for Sweden. There is also great concern for traffic safety and the impact of road traffic on human settlement and nature.

A principal feature of Swedish transport policy is that increasing transport needs should be met, but with significant improvements of environment impacts, use of energy and natural resources, and traffic safety. Such a policy involves a considerable challenge to the transport sector. In the short term little can be effected, and for the long term success of the policy radical solutions must be sought.

The Swedish National Road Administration (SNRA) has prepared a report "Miljövänligare vägar och trafik" (1990; in Swedish), commissioned by the Swedish Government, suggesting the outlines of a program for a more radical approach to the problems, especially environment impacts, of road traffic. Key terms in the report are system, design, experiment and demonstration. It is concluded that a system outlook on transportation is gaining acceptance. Different transport means are being seen as complementary. Road vehicles, road infrastructure and the environment are also being seen in one context.

The european ventures Prometheus and Drive are seen as two expressions of a change in bearings.
In Sweden, industry and the national road authority to-day sit at the same table taking, within the framework of RTI-developments, a more comprehensive look at the road transport system.

The possibilities inherent in RTI are judged as considerable. But in order to realize these, there must be a political will to design the road transport system and its interaction with the environment. For that purpose the design principles for road traffic must be advanced. Basic for the long-term prospect is also to seek new forms for education, research and development in the fields of traffic planning and engineering. It is proposed that an interdisciplinary centre for the design of the road traffic system and its environment is created.

The report concludes that it is on the whole important to experiment with and to demonstrate new technology and advanced design concepts, in order to obtain knowledge about new possibilities as well as enlarge the awareness of the need for change. Only then can a strategy for the future development of the road transport system be fully adequate. As a matter of fact the road transport system must be raised to a higher technological level.

3. TEST SITE WEST SWEDEN

The SNRA is responsible for the lion part – including thoroughfares in cities – of public roads in Sweden. The Swedish road budget is, as mentioned earlier, meager in view of the transport demand. This fact puts heavy pressure on the SNRA to increase productivity and to seek new ways to make good use of the roads.

The interest from the SNRA in RTI goes back many years both in practise for raising the productivity of road maintenance & services (especially winter road services) and in principle for developing new services to road users as well as improving the performance of the road transport system. The SNRA partakes in both the PROMETHEUS project and the DRIVE programme.

The introduction of new technology in a business requires a new knowledge base. The latter does not come easily and cannot be planned forth. On the contrary, it must be acquired from continual experimentation (with accompanying failures). When moving from principle to practise you will also need a laboratory as well as a testing ground. For that purpose Test Site West Sweden (TSWS) was established early in 1990.
The test area comprises the larger Gothenburg region including the City, suburban and rural parts, as well as important roads for connecting Oslo (E6), Malmo/Copenhagen (E6), and Stockholm/Helsinki (E3). The Swedish auto industry is also located in the area.

The purpose of TSWS is fourfold, namely

- to acquire new technological know-how, especially with regard to RTI
- to find out how new technology works in different applications (laboratory tests)
- to create a systems environment in order that products, functions and systems can be tested in a realistic context, and that interested parties are stimulated to engagement and cooperation (field tests)
- to demonstrate by field tests and pilot projects how new technology - in a new setting for the design of an integrated road traffic environment (IRTE) - can advance the performance of the road transport system

The SNRA is in charge of the test area. There is a small steering committee with the principal actors in the test area as members. Members other than the SNRA are, for the time being, Saab-Scania AB, AB Volvo, and the Swedish Transport Research Board. By Government decree an inter-ministry reference group has been established to follow RTI developments in Sweden.

New technology requires new competence. The SNRA is anxious to have highly qualified persons for key work tasks in TSWS. Via the engagement in PROMETHEUS and DRIVE a network of researchers and experts has formed, which will also be at the support of the test area.

From the summer 1990 work at TSWS is gaining momentum in three projects areas, namely

- Road maintenance & service production (Production support)
- Road user support services, especially for specialized vehicle fleets, which will be the motor for early RTI applications (Road user support)
Road traffic management

The first project descriptions have been prepared. An urgent matter for all projects areas is to establish a base structure for a production and traffic information & management centre. This includes installation of basic equipment for catching, transferring and receiving data as well as communicating traffic information.

The main projects in TSWS adopted at the time of writing (September 1990) are the following:

- Reference model for future production management centrals (especially winter road services)
- Road and traffic information via RDS/TMC
- Interactive route guidance via GSM (DRIVE project SOCRATES)
- Automatic Vehicle Location (AVL), e.g. via Global Positioning System (GPS), as a basis for vehicle fleet management
- Park & Ride
- Basic traffic analysis of the test area
- Traffic signal systems development, including green wave and advanced cruise control of vehicles
- Basic judicial aspects on RTI implementations
- Macro Simulation and Evaluation of RTI (in co-operation with DRIVE/SECFO) — evaluation of behavioural effects on road traffic, environmental impacts, and socio-economic effects of RTI implementations

4. SUMMING-UP

There are some recent writings on the road transport problematique and RTI that are full of implications as to advanced design principles. It suffices to mention a report that must be accorded special weight, namely "The Challenge of Advanced Transport Telematics" (June 1990) by the DRIVE Strategic Consultative Committee.
It is likely that a long-term strategy for the development of the road transport system is emerging. It involves new technology and advanced design principles. Accordingly a new knowledge base is required. It will not come easily, as said before, but has to be conquered. In this process awareness of the road transport problematique will grow, and the full implications of RTI for designing the road transport system will be revealed.

By establishing Test Site West Sweden, the SNRA decided to learn by practise in order to be able to demonstrate, gradually, the usefulness of RTI.
Future Traffic and RTI
Status Report of the Federal Republic of Germany

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The great demand for capacity that is placed upon the road system by further volume increases can only be satisfied to a very limited degree by road expansion and the construction of new roads. In addition to new transport models, making a smoother and environmentally more acceptable transport operation possible through a greater degree of integration of the various modes of transport, great significance will also be attached to RTI systems. The expectation is that future traffic guidance and information systems will be able to increase the efficiency of important transport connections on the road by up to 30% in the medium term. This expectation is based upon the existence of a comprehensive system of up-to-the-minute information on traffic delays, expected journey times and alternative routes which will enable an individual journey to be planned before it is embarked upon. Suitable traffic guidance systems will ensure that the road network's available capacity is subjected to systematic, controlled exploitation. Roadside (collective) traffic guidance by means of a system of traffic lights and variable traffic signs will be supplemented by individual vehicle piloting using in-car information and guidance. Infrastructure-supported systems do not only permit a traffic-dependent system of origin-destination guidance. They will also be able to give up-to-the-minute warnings of fog, black ice, aquaplaning, accidents, etc.

In urban centres, a traffic management system will assume responsibility for an overall traffic guidance system in which public transport, the emergency services, fleets of taxis and other important traffic functions are integrated. The available public transport and commercial and private traffic capacities will be managed, for instance, from the point of view of air pollution and with regard to some important functions of a city, including that of being a place people care to live in.

Future in-car guidance systems will be supported by a roadside infrastructure in order that they are able to operate at their most effective level. The systems and their technical components must be standardized at European level at least in terms of their transmission
interfaces. Various research and development programmes, for example, DRIVE and PROMETHEUS, are being conducted on an all-Europe basis. Based upon the status quo and upon fundamental research work, larger-scale field trials are to provide information concerning the application possibilities of future systems.

In the Federal Republic of Germany, a guidance and information system was developed which is based upon communication between the roadside and individual vehicles by means of infra-red transmission. A comprehensive field trial, designated LISB, is being conducted in Berlin. Via beacons positioned at road junctions, vehicles receive information which enables them to choose best routes for themselves without having to reveal their individual destination or route to the system. In return, they anonymously supply on-line journey times between the junctions fitted with beacons to the system control centre. From this, information which is important for the whole system of on-line guidance in the city can be obtained. The results of the field trial are expected to be available by 1991. LISB is being installed in modified form in London under the designation AUTOGUIDE. A European industrial standard has been developed for the infra-red transmission interfaces.

In North-Rhine Westphalia, preparations are currently underway for a field trial using RDS-TMC (Traffic Message Channel). The purpose of this is to test in practice the digital transmission of standardized, encoded radio traffic messages on FM channels. The involvement of large numbers of official bodies means that the field trial requires considerable efforts from an organizational point of view.

The development of an integrated management system is being started in a number of cities including, for example, the area of Munich. Here, in addition to new organizational models, new RTI techniques are to be tested and introduced on a step-by-step basis.
1. FUTURE TRAFFIC

Traffic on the roads over wide areas of Europe is threatened with total collapse. The indications for this are ever more frequent, ever longer breakdowns in traffic, starting at the bottlenecks of important traffic connections and extending outwards, including across national borders, which has been a regular occurrence for some time now. Precise analyses of the precariousness of the situation are available, a whole series of prognoses points to the extent of the additional stresses and strains which we will have to expect over the next twenty years. From experience, the only grounds for criticizing them are that, given unrestricted development, they will probably be understating the case. However, the most recent prognoses are suffering the same fate as did the cry of Cassandra: it is best to pretend that something awful doesn't exist, not to grasp its consequences, even when it is visibly in the offing.

The excessive strain, which in the main is the result of the rates of increase in road traffic, is concentrated in the densely populated countries of Europe and in the large industrial conurbations. The problems are being intensified by traffic geography. Significant traffic turntables are forming, and, of course, there are natural obstacles which have to be overcome. Here, in an ecologically sensitive area, the destructive effects of great avalanches of traffic are becoming evident. But, so, too, is the correlation in which the functioning of our highly developed society, with a high level of individual mobility and an economy based on the division of labour, is dependent upon the existence of an efficient infrastructure. When one of the supporting legs of the bridge over the Inn valley near Kufstein collapsed earlier this summer, making the bridge unpassable, this led to long tailbacks and far-reaching diversions of traffic affecting at least three European countries.

Problems arising out of modern road traffic have long since ceased to be restricted to questions of efficiency and safety. Rather, traffic has become an environmental factor of the first order. However, this is an area dealt with in another contribution to this conference.
Against the background of a transport system which is already overburdened, the political changes in Central and Eastern Europe and the internal market economy without borders in the Western half of the continent represent a serious challenge to all forms of transport, but particularly to road transport. The opening up of the economic systems in the East and the process of their adaptation will go hand in hand with high rates of increases in the ownership of cars, high rates of mobility and high levels of transport movements. In the countries concerned, this development will be faced with a road and rail network which is totally unprepared to cope. Soon, here, too, on account of the greater degree of flexibility which it offers, the main burden will fall upon the road system. Experts in the field of transport are viewing this scenario with some trepidation. After all, it is well-known that the economic changes in the East will only be possible with the assistance of an efficient infrastructure. It is not one of the themes of this presentation to look at this problem in any further detail.

A turntable of international traffic is developing in Central Europe. In the very near future, East - West links will have to be built to partner the North - South connections which already exist. The high level of domestic traffic, which will increase sharply as a result of the economic reconstruction of East Germany, will have to share the available traffic space with international transit traffic which is increasing at a considerable rate. On the one hand, a greater degree of liberalization in respect of the transport markets is a declared objective of the European politicians in Brussels - but on the other, these objectives are faced not only with problems relating to capacity, but also with considerable problems of an environmental and a social nature. During the course of several transport conferences which took place this summer, almost everyone shared the point of view that it is necessary to seek out new ways and means:

1. The railways and the roads as transport systems must work hand in glove with each other. It will not suffice if the railways simply pursue a policy of making offer after offer. This way, despite the most strenuous efforts and considerable financial expenditure, the proportion of the so-called Road-Rail-Road integrated freight traffic does not achieve a level exceeding 5% of the total throughput in ton-km. New systems of control will probably have to be introduced if the annual rates of increase are to be coped with or a major proportion of transit traffic is to be shifted onto the railways. Simply abandoning the roads to their
fate of becoming utterly congested with cars will get nobody anywhere.

2. Both for the expansion and the management of the roads, new financial models are coming under consideration. Many transport economists are studying models in which the taxes directly related to road traffic are replaced by a system of tolls. Here, the thinking is that anyone using a transport system should pay for it directly. In this respect, it is intended that socially acceptable components will have a role to play. Infrastructure and management should be separated from each other to a much greater degree. Critics of such models, who as a rule use terms such as "taxing roads" and "medieval" as the basis of their argumentation, are accused of not knowing the difference - and challenged to propose effective alternatives of their own.

3. There are great hopes being placed in new technologies which are introduced into the field of traffic guidance techniques. At the same time, somewhat confused evaluations of their possible use are being made: it is a case of hoping for the best. The only point which has at least been partly proven concerns the important and far-reaching consequences that the use of logistics might have in the field of freight transport, but all the possibilities have by no means been exhausted. However, it is also a matter of considering for whom it is that logistics is working. Just-in-time methods of transportation as a modern form of storage on the open road might well be efficient. What is at dispute is the consequences for road traffic.

2. RTI--ROAD TRAFFIC INFORMATICS

I shall now discuss some technical systems for the future control of road transport. In this connection, the following points are important:

- Optimizing available road capacity and making traffic flows efficient.
- Ensuring that traffic flows with a high degree of safety.
- And also that it does so as economically as possible and with as little damage to the environment as possible.

All national and international research programmes have devoted themselves to these main objectives. As examples of such programmes, I refer to PROMETHEUS, part of the EUREKA programme, which is more vehicle-related, and DRIVE, from the research programme of the
European Community, which is more concerned with infrastructure. There are no longer any barriers between EFTA and the European Community in the field of research.

RTI is the magic word: Road Traffic Informatics. What this means is the utilization of modern electronics, information and communication technology for the purpose of traffic guidance in the broadest sense of the term. When Europe is united, it is intended that road users should be better informed about traffic on the roads, that intelligent vehicles should be communicating with roadside infrastructures and that the technologies involved should be standardized and integrated into an overall traffic management system. This should incorporate private transport as well as freight transport. A plethora of research projects is studying individual topics, coordination, questions concerning standardization, implementation strategies, etc. It has become common to attach eye-catching acronyms to programmes and projects:

- RACE, ESPRIT, DRIVE, IMPACT are examples of European Community programmes.
- DEMETER, CARMINAT, EUROPOLIS, PROMETHEUS are examples of EUREKA programmes.
- EURONETT, ICAROS, SECFO, PUSSYCATS, ODIN AND CHRISTIANE are examples of DRIVE projects.

These terms mean nothing without explanation, and only cognescenti can use them with any degree of safety. Anyone having to concern himself with any of these should secure a copy of the relevant original papers.

If you consider the gradual evolution of traffic guidance technology, keeping in mind first and foremost the objectives which go hand in hand with it, then it is possible to adopt a more understanding approach to RTI projects:

A. SYSTEMS WHICH KEEP THE DRIVER INFORMED
   Traffic radio messages: road conditions, weather conditions, journey times.

B. SYSTEMS WHICH KEEP THE DRIVER INFORMED AND GUIDE HIM ON AN INDIVIDUAL BASIS
   Autarchic navigation, where appropriate with electronic mapping
   Infrastructure-based and traffic-dependent guidance, advanced car park booking, etc.
   Public transport connections, guidance to park and ride facilities
Demand management, road pricing and automatic debiting.

C SYSTEMS WHICH KEEP THE DRIVER INFORMED, GUIDE HIM INDIVIDUALLY AND LOOK AFTER HIS SAFETY
   Intelligent manoeuvring: automatic distance-keeping, prevention of accidents when overtaking, at junctions, etc.

D SYSTEMS WHICH ASSUME COMPLETE RESPONSIBILITY FOR MAKING THE JOURNEY
   Surrender of responsibility to technology, automatic vehicle guidance, the formation of traffic convoys, etc.

Research is being conducted into subjects at all four of these levels: functions are being tested in practice by means of pilot trials and prototypes. Depending upon the respective point of view – be it that of industry, the user, government authorities – the progress which is achievable is evaluated differently at every level. The user has still hardly been questioned yet. To some degree, the person at the centre of events is still being left out in the cold.

The new techniques are concentrating upon influencing the individual driver. Information and signals are transmitted to the individual vehicle where they are conveyed to the driver or the vehicle by a suitable means. In this connection, it must not be overlooked that for the time being conventional means of traffic guidance do not become superfluous, nor are they excluded. These conventional means are roadside traffic signs and direction signing, and also dynamic traffic-relevant guidance by means of variable message signs. The reason for this is that roadside traffic signs alone have a legal basis, and failure to comply with them can lead to prosecution. Drivers must at least have 100% clear vision. This is the basis of conventional traffic guidance with roadside or overhead signs and signals. We also use the term collective traffic guidance to refer to this in order to distinguish it from individual traffic guidance by means of the new in-car communication techniques.

It is not yet possible to foresee to what extent new, individual guidance techniques will be used or the impact that they will have on the market. Neither is it possible to foresee whether any, and if so, which, components will be introduced on a European-wide and, if necessary, compulsory basis. Questions concerning the state's responsibility for safety, questions concerning the extent of its sovereign functions, questions relating to data protection, and also those relating to legal liability and other legal aspects
have not yet been dealt with in depth by all the European countries involved. At the current moment in time, it is being assumed that vehicles equipped with new individual guidance techniques and those not so equipped will be driving on the roads side by side and one in front of the other. The entire guidance strategy and the technical development of the roads have to proceed accordingly.

3. DEVELOPMENTS IN THE FEDERAL REPUBLIC OF GERMANY

I should now like to discuss some of the concrete developments in the Federal Republic of Germany.

It is no longer possible in every case to distinguish the purely German activities from the developments in Europe as a whole. Nevertheless, there are still some activities in priority areas which originated in Germany.

The gradual development of a future guidance and information system takes its starting point from the basis of conventional techniques, and from here it is designed to be upgrade-compatible with new techniques. Here, the Federal Ministry of Transport envisages the following development structure:

1. Equipping the major roads with a traffic detection system (currently usually induction loops), supplemented by sensors for the evaluation of weather influences (fog, ice, if possible, aquaplaning, etc.).

2. Expansion of "collective traffic guidance" by means of roadside installations equipped with variable message signs (speeds, warnings, traffic diversions, etc.).

3. Improvement of radio traffic warnings by means of automatic text generation and a reduction in the transmission times.

4. Introduction of a traffic message channel (TMC) in the digital Radio Data System (RDS) for future radio traffic messages.

5. Development of an individual traffic guidance and information system with infrastructure support. The system disposes over information concerning journey times between intersections within the whole network. In addition to traffic guidance, other functions are also to be expanded.
6. Options for the introduction of in-car guidance systems, from the PROMETHEUS programme, for example (automatic distance-keeping, etc.).

The term "Intelligent Road" was coined as a means of conveying the overall objective to the public at large.

Various steps and techniques are being developed side by side. All the stages mentioned are at the development or trial stage. From an administrative point of view, the following guidelines must be adhered to:

- The infrastructure must be restricted to the absolute minimum. Where at all possible, the intelligence of the systems should for the most part be transferred to the vehicles.

- In the case of the infrastructure, which has a longer service life, it is necessary that it can be used over a long period of time, and, if need be, for several, successively progressive systems.

- It is necessary that the systems can be used uniformly throughout Europe, at least in the case of traffic signs, manner of traffic announcements and nature of the in-car optical display units.

- This requires demanding and difficult levels of harmonization and standardization. Although individual technical components do not have to be identical, they do at least have to meet minimum requirements in terms of transmission interfaces, and they must perform the same functions.

- The optical displays must appear in such a form as to make them immediately comprehensible to the driver without distracting him from the key functions of driving. The audible channel should also be used.

- Hitherto, traffic guidance in Germany has been regarded as a sovereign responsibility of the state. Thus, it is incumbent upon the state to create a management system through which large quantities of data, including all peripheral factors, are collected from the traffic within the road network, converted into up-to-date and comprehensive directions and instructions for the benefit of the driver, and conveyed to the relevant components in the system. The system output can only be as good as the system input allows. This fact entails considerable obligations for those managing the system.
New developments are leading to new considerations concerning to what extent a proportion of the responsibilities for traffic guidance can be relinquished into the hands of a private company - as is to happen in England.

3.1 RDS-TMC

RDS stands for Radio Data System, and consists of the digital transmission of information alongside the analogous transmission through radio channels.

Preparations are currently underway for a RDS field trial. From a transmission point of view, the technical requirements for a static RDS, with which individual signals for transmitter identifiers, type of radio programme, etc. can be transmitted, have been met. A static RDS has already been introduced, or is in the process of being introduced, in several European countries. Trials are now to be carried out on a dynamic RDS. This transmits up-to-date traffic messages on a Traffic Message Channel (TMC) which can be received in vehicles. One such trial is to be carried out in the federal state of North-Rhine Westphalia, in collaboration with the local radio station, WDR, the radio equipment industry and the authorities responsible for traffic control. In this connection, cross-border cooperation with Holland and an enlargement of the scheme into an international research project is the ultimate aim. As the rate of transmission is technically limited, the traffic messages are coded using what have become international standards. They are decoded in the vehicle upon reception and translated into a special language (artificial language). The messages can be decoded into several languages, an important factor in the European context. Through information inputted by the driver concerning the route he intends to take, selective message-receiving should be possible, that is, from the plethora of information transmitted, the driver only receives that which is of relevance to him. However, considerable expense will be incurred on the necessary in-car equipment.

3.2 Autarchic Navigation Systems

In recent years, a number of autarchic systems have been developed to the stage where they are marketable. "Travel Pilot", is a German example of such a system. It originated in the research programme EVA and represents the first stage of a system which has still to undergo further development. Travel Pilot works in conjunction with map-matching, that is, it operates on the principle of navigational correction. A display
unit presents the driver with a road network from which he can zoom-select a section. His travel position is always indicated by an arrow pointing upwards, and in the case of a change of direction, the network "pivots", as it were, around the car. The road network of the Federal Republic of Germany, including the urban networks, has been recorded onto compact disc. A deliberate decision was taken to omit network restrictions, hindrances, etc. from the recording.

It is possible to develop Travel Pilot in such a manner that external influence in the form of infrastructure support becomes possible: the road network, for instance, could be updated by means of RDS codes, and certain roads declared unpassable, etc. A second navigational system, City Pilot, is supplied by a different company, but this operates without map-matching.

I do not wish to deny the fact that from the point of view of administration we have a critical attitude towards the display of both maps and sections of networks on maps in moving vehicles. The reason for this critical attitude is that we believe that the majority of drivers are incapable of coping with such route guidance in conditions of heavy traffic. It would seem to us that questions concerning comprehensibility, legibility, adapting the human eye to displays of different degrees of illumination, the size of the display units, etc. have still to be solved. Otherwise, development at the moment is being left to the workings of market forces, but intervention will ensue in the event that unsuitable display systems emerge which are a danger to road safety.

A further question concerns our evaluation of autarchic destination guidance systems in comparison with systems supported by an infrastructure. There is concern in many urban centres that the system could direct traffic searching for the best route into traffic-restricted sidestreets. It might well be possible to solve this problem at the stage where the road network is first recorded. What is insoluble, however, is the problem created by the dearth of up-to-date information relative to specific traffic conditions within the network. This is the reason that, in the longer term, systems supported by an infrastructure are gaining preference.
3.3 Infrastructure-supported route guidance system, LISB

Only an infrastructure-supported route guidance system can attain maximum efficiency. For this, we rely upon an inexpensive infrastructure with infra-red transmission between roadside beacons and the vehicle on the road. Infra-red transmission was used in the early 1980s in pilot projects concerning bus priority at traffic lights.

The operational testing of a new guidance system was carried out by means of a large-scale field trial in Berlin. The abbreviation LISB stands for Lead (guide) and Information System Berlin. This is a twenty million DM project, 50% of which is being financed by participating industry. The remaining 50% is being financed by the Federal Ministry for Research and the City of Berlin. The experimental phase will be completed this year. As the literature contains a detailed report on the field trial, I can restrict myself here to just a few of its aspects.

The idea behind the guidance system:

The idea behind the system is that vehicles equipped with autarchic navigation can make contact with the urban guidance system at strategically important points in the road network via beacons installed at the roadside. This guidance system consists of each beacon offering best, that is to say, quickest, routes to a total of 900 destination areas. The destination areas are hierarchical in structure, that is, should a vehicle simply be in transit en route to a destination further away, they combine into larger areas. Within the destination area itself, there are three or four exit points from the guidance system. From any one exit point it is usually not more than 100 metres to the final destination, which the driver then reaches using autarchic navigation once again (cf. Fig. 1)*.

At the commencement of his journey, the driver inputs his destination in the form of x and y coordinates into his navigation system. He can also do this using destination codes based on the address book principle. He is autarchically guided, that is, compass-directed, until he reaches the first beacon. Here, the in-car navigational computer, which alone knows which destination has been entered, selects the best route. The vehicle is guided from this beacon along the route by means of detailed guidance information until the next beacon is reached, where the procedure is repeated (cf. Fig. 1).

* All Figs. are found in the Annex.
Thus, the respective best routes are selected anonymously by the in-car equipment itself. The LISB control centre, which calculates current best routes for all traffic correlations every five minutes, and transmits this information to the beacons, is aware of neither the destinations nor the routes of the individual vehicles. This means that data protection problems are excluded right from the start (cf. Fig. 1).

However, in order that traffic-dependent best routes can be calculated in the first place, the system receives - anonymously - data concerning journey times from the individual vehicles. This happens as follows: the vehicle automatically transmits the journey time that has elapsed since the last beacon was passed to the next beacon in front; the amount of time spent idle at traffic lights is also transmitted in this way. This means that the guidance control centre has at its disposal a matrix of continually up-to-date journey times between the individual beacon positions, and from this it can calculate revised best routes to the destination areas at regular intervals. By means of an analysis of daily and weekly volume cycles off-line, permanent trends can be determined. This means that approximate best routes dependent upon the hour of the day and the day of the week already exist. It is only necessary to subject them to precise on-line readjustment in order to update them. This learning effect is highly efficient. The information that the system receives also constitutes valuable data bases for the collective control of traffic. This might include, for example, the control of traffic signals.

Network and vehicle equipment:

The field trial encompasses approximately a quarter of West Berlin's road network of an overall length of 3000 km. Guidance recommendations are only given within a defined network of main roads. In this network, 230 of the some 1,200 traffic signals are equipped with infra-red beacons. In addition, there are ten such beacons located along the urban motorways. By mounting the beacons on the signal posts and using the existing cables from the centrally-controlled traffic signal installation for the purpose of transmitting data to and from the beacons, considerable cost savings could be made.

It was possible to equip 700 vehicles for participation in the field trial. This represents less than 1% of all the cars in West Berlin. It proved difficult, and in some cases impossible, to obtain sufficiently representative journey times for the whole network from
the number of vehicles on the road at any one time. This had the consequence that the best routes as indicated by the time cycles could only partially be subjected to on-line updating (cf. Fig. 2).

For in-car indication, a display unit was developed which provided easily comprehensible information using simple directional symbols. The driver is always aware of how far he is being guided, autarchically or with the aid of the beacons, within the road network. In addition, the most important pieces of information are conveyed audibly, using artificial language. This proves helpful, particularly in difficult traffic conditions (cf. Figs. 3 and 4).

Evaluation:

The field trial LISB is currently being evaluated. It will provide a plethora of technical and organizational knowledge. Extending beyond private transport, LISB is intended to create the foundations for a comprehensive traffic management system, also encompassing bus traffic. Special tests were carried out for the fleet of taxis. With the support of the European Community, a special field trial (TRANS-LISB) is currently being carried out in order to ascertain whether or not the system will also be of benefit for dynamic route planning in the case of goods distribution.

There are two trains of thought in particular which I should like to single out in advance:

Communication between the vehicle and the road using a system of infra-red beacons has proved a success. It is the intention to employ it in other areas. It will also be used on the motorway network, though initially on a trial basis. The transmission interface between the beacon and the vehicle has been further developed into an industrial standard independent of any one company which other countries will also be using. In London, a guidance system is being developed under the designation AUTOGUIDE which is using this infra-red transmission technique. Transmission is now also to be standardized at the European level at CENELEC. For once, it would appear that practical development has overtaken European research. However, as far as the competition of other means of transmission, such as a mobile telephone network (cellular radio system) is concerned, a decision on the final design of a future transmission system for the whole of Europe still has to be arrived at.

As my second point, I should like to emphasize an aspect concerned with traffic technology:
Hitherto, collating details of traffic information as the basis of any attempt at controlling traffic has simply been a matter of the passive collection of data, for which in the main induction loops were used. From this, it was not possible to derive any information concerning journey times, or, at best, such information could only be deduced very indirectly and imprecisely. In the future, car drivers will place individual data at the disposal of the system. It will be possible to evaluate this directly in accordance with the density of traffic and journey times between different points in the network. This will mean that there has been a breakthrough in the quality of the data base for the control of traffic. At an easily affordable cost, it will be possible to make the journey time, reliable estimations of which will also be made on-line and in short-time prognosis, the most important decision-making criterion both for the guidance of individual and collective traffic within the network and for the individual driver before the commencement of his journey. It will be possible to plan your journey thoroughly, both while on the road and while at home. It will be possible to postpone your journey due to the current situation on the roads, or to choose to travel by another means of transport. Information concerning journey times will be available from the urban network in the same way as it will be available from the non-urban network. It will be of great importance for the individual driver as well as for commercial traffic in so far as it will make a contribution to the more efficient use of the road network even in the absence of an active traffic guidance system.

3.4 Cooperative Traffic Management, Munich

The introduction of new RTI systems presupposes close levels of cooperation between all the offices in any one region responsible for all aspects of traffic and traffic control. In fact, the current state of the system makes this essential. A regional model is being developed for the area of Munich.

Cooperation between government and local authority offices, public transport authorities, the university, the Bavarian radio station, the automobile clubs and industry has established itself under the term "Cooperative Traffic Management, Munich". One of the leading spokesmen is BMW, deriving from its involvement with the PROMETHEUS research programme.

The scheme came into being as a result of the serious problems which are looming in respect of transport connections to the city from the new international airport in the north of Munich when the airport becomes operational. The subject then became less specific and
came to incorporate the management of all transport in the area. It might be possible to draw comparisons here with the "traffic field trial Gothenburg/Western Sweden".

The objectives of the Munich management team are:

- a re-evaluation of mobility
- an assessment of the demand for transport
- better use of public transport
- reducing environmental pollution, in particular CO₂
- improving the safety deficit
- organizing transport and transport space
- reducing traffic volumes at peak times.

The first stage of the process is the single-minded coordination of existing modes of transport and institutions. This should also include the optimization of conventional techniques, such as park and ride facilities, the control of traffic signals and the control of alternative routes, etc., and the integration of the central operation and control centre of the public transport sector into the management system.

During the second stage, an increased number of individual RTI guidance techniques are to be implemented, particularly individual traffic guidance and information and the automatic detection of breakdowns and accidents and such like. The problems concerning the integration of the new airport into the transport system will soon provide the model with the opportunity of proving its worth.

4. PROSPECTS

RTI techniques will offer traffic management and passenger information many possibilities for improvement. They will also represent the basis of an integrated traffic guidance system, that is, a system which encompasses social and environmental factors. Technical matters relating to the provision of public information in respect of the availability of public transport facilities must be developed more intensively. To what degree new techniques will be successful is dependent, on the one hand, upon cooperation between governments and industry in respect of standardization: only standardized components can become the building bricks of future guidance systems. On the other hand, however, it is dependent upon whether or not those who operate the system will be in the position to develop a professional organization for the management of future traffic guidance systems. In
the final analysis, it is probably the consumer, the one who uses the system, who will have the final say. He will only pay for the installation of components in his car if he can see that he personally derives sufficient benefit for the price he is paying. Thus, important as the technology itself is, the organization of the technology will be an even more important factor.

Even so, RTI technologies will not be able to solve the traffic problems which are awaiting us. But they will be able to help to alleviate them. If an improvement in performance of between 5% and a maximum of 10% in the control of non-urban traffic can be achieved today using conventional methods of traffic guidance, then the effects of future systems will be more highly rated. An improvement in the movement of traffic ranging from between 20% and 30% should be possible through more intelligent use of the roads. But this will not suffice as a substitute for the expansion of the road systems. In the urban centres, the technique of traffic guidance can only be one among several components in overcoming traffic problems and retaining the urban function. Far-reaching and integral guidance mechanisms must be developed in these cases.

I should like to finish by sounding a note of horror: Road Pricing - RTI techniques will also overcome this technical problem with ease.
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Fig. 1: Destination Zones
Fig. 2: LISB Components
Fig. 3: Display Figures

Fig. 4: Display Unit

VTI RAPPORT 364A
Evaluation of the Perspectives of Driving Aids
Based on Short Range Transmission Links between
Ground and Vehicles and between Vehicles

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EVALUATION OF THE PERSPECTIVES OF DRIVING AIDS BASED ON SHORT RANGE TRANSMISSION LINKS BETWEEN GROUND AND VEHICLES OR BETWEEN VEHICLES

In the context of a DRIVE project bearing on the development of short range microwave links for road traffic informatics (RTI) functions, an analysis of the requirements concerning these links has been made.

This analysis has led to a more extensive reflexion on the interest and feasibility of the electronic aids involving these links.

The object of the paper is to present the main results of this work.

After a short presentation of the main electronic aids which have been considered, the authors examine the adequation of the links with regard to different criteria like the required range and directivity, the sensitivity to propagation disturbances, the requirements in matter of safety and of vehicle positioning.

It results from this analysis that the aids which are designed to substitute fully to the driver’s direct perception or to remedy to deficiencies of this perception raise safety problems which are difficult to solve. With some exceptions, the aids involving road-vehicle links are relatively easy to implement, the aids based on vehicle to vehicle communication raise more difficulties, and except for anticollision aids and intelligent cruise control along a lane, their perspectives of development are very low even in a long future.
EVALUATION OF THE PERSPECTIVES OF DRIVING AIDS
BASED ON SHORT RANGE TRANSMISSION LINKS BETWEEN
GROUND AND VEHICLES AND BETWEEN VEHICLES

Y. DAVID - INRETS CRESTA, FRANCE
B. HANE - IM, SWEDEN

The European research programs PROMETHEUS and DRIVE have ambitious perspectives of development of electronic aids for road traffic which are generally based on communication links between road and vehicles or between vehicles.

Independently of the technical developments involved in these programs, a number of researches are conducted on the interest and on the actual possibilities of application of these aids.

These researches have been mainly based up to now (1), (2), (3), (4), (5)

- either on ergonomic considerations on the influence of such aids on the driving task
- or on cost-benefit considerations supported by a detailed analysis of accident data and of the potential impact of the different aids which are envisaged on the most frequent categories of accidents.

In the study which we intend to present hereunder, and which has been conducted in the frame of 2 DRIVE projects (7), (8), we have used a more technical approach, consisting in an evaluation of the feasibility of the equipments, particularly of the transmission links which are required for the realization of the aids under consideration.

After a short presentation of the aids which have been envisaged in these DRIVE projects, we describe the different criteria which have been used to assess the technical feasibility of these aids. Then, starting from these criteria, we try to evaluate the actual perspectives of development of these aids.

Considering that medium to long range links like RDS or the GSM cellular mobile radiotelephone are already in operation, we address here only to the aids based on short range (<500 m) links.
1 - ELECTRONIC AIDS TO BE CONSIDERED

An important activity of the DRIVE and PROMETHEUS programs consists in the establishment of an exhaustive list of all the electronic aids which may be developed in the future for the road traffic (6).

In our study, we were mainly interested by the aids which could involve short range road -vehicle or vehicle- links based on the following supports:

- microwaves
- infrared
- radiating cables

We decided to class these aids into 3 categories, corresponding to an increasing complexity of the required links:

- road → vehicle one way
- road ← vehicle two ways
- vehicle to vehicle one or two ways.

We arrived to the list of Fig. 1, which corresponds to the main aids generally considered in PROMETHEUS and DRIVE.

2 - CRITERIA FOR THE ASSESSMENT OF THE AIDS UNDER CONSIDERATION

To appreciate the suitability of the possible transmission links for the different aids listed in §1, it appeared desirable to establish a list of relevant criteria to support this assessment. After some reflexions, the following list was proposed:

- required coverage of the links
- confinement of the transmitted signals
- cost and ease of installation
- sensitivity to disturbances
- frequency allocation problems
- safety aspects of the function and of the link
- requirements for an on-board positioning system.

The definition of these criteria as well as the reasons why they have been selected are detailed hereunder:
Fig. 1 - List of RTI functions involving communications links

<table>
<thead>
<tr>
<th>- Road to vehicle links - one way:</th>
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<tbody>
<tr>
<td>1 - Radio-retransmissions in tunnels</td>
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<td>2 - Retransmission of radiotelephone in tunnels</td>
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<tr>
<td>3 - Traffic information and guidance</td>
</tr>
<tr>
<td>4 - Anticollision at intersections</td>
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<tr>
<td>5 - Traffic light state repetition</td>
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<td>6 - Traffic signs repetition</td>
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<td>7 - Parking management</td>
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<th>- Road to vehicle links - 2 ways</th>
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<tr>
<td>8 - Assistance to bus operations</td>
</tr>
<tr>
<td>9 - Bus priority schemes</td>
</tr>
<tr>
<td>10 - Traffic data collection using car transmission</td>
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<tr>
<td>11 - Automatic debiting</td>
</tr>
<tr>
<td>12 - Communications in tunnels with service and emergency vehicles</td>
</tr>
<tr>
<td>13 - Aids to distressed vehicles</td>
</tr>
<tr>
<td>14 - Fleet management</td>
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</tbody>
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<table>
<thead>
<tr>
<th>- Vehicle to vehicle links</th>
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</thead>
<tbody>
<tr>
<td>15 - Emergency warning systems</td>
</tr>
<tr>
<td>16 - Assistance to column driving</td>
</tr>
<tr>
<td>17 - Overtaking and passing aids</td>
</tr>
<tr>
<td>18 - Emergency vehicles signalling</td>
</tr>
<tr>
<td>19 - Automatic driving</td>
</tr>
<tr>
<td>20 - Conviviality link</td>
</tr>
</tbody>
</table>
2.1. - Coverage

This criterium represents the length of roads to be covered by the link.

The reasons for considering this criterium are:

. for microwaves or infrared signals, which propagate along a straight line, the range may be limited by curves or hill-tops;

. for radiating cables, this criterium is directly associated to the cost of the ground equipment.

2.2. - Confinement

This criterium is representative of the directivity of the link and of the possibility of strictly limiting the propagation domain of a transmitted signal, either in the road to vehicle direction, or in the vehicle to road direction.

A good confinement may first of all alleviate the difficulties for obtaining frequency allocations. It is moreover necessary to avoid the propagation of a message in non concerned zones, which could be a source of disturbance and of inefficiency for the system.

2.3. - Cost and ease of installation

These criteria do not require particular comments.

2.4. - Sensitivity to disturbances

The main disturbances which may affect the links under consideration are:

- the masking effects due to other vehicles or to the road environment. Microwaves and infrared signals which propagate along straight lines are particularly sensitive to these effects;

- the "multipath" effects due to the fact that, in a complex road environment, signals may propagate between an origin and a distinction either directly along a straight line or indirectly through successive reflexions on the surrounding obstacles. The combination in the receiver of all the signals arriving through these different paths produce interference effects and important amplitude fluctuations in the resulting signal.

2.5. - Frequency allocation

This criterium characterizes the degree of difficulty for obtaining a frequency channel for the realization of the link.

This criterium is particularly important as:
- the frequency spectrum is already fully allocated in a number of European Countries up to about 60 GHz. Consequently for any new application, it is necessary either to check that this application may be compatible with those using the same channel, or to move existing applications towards another channel, which may take a long time.

- the different frequency channels in the microwave spectrum are generally not allocated to the same users in two different countries, which makes the possibility of obtaining a common frequency throughout Europe for a given application very problematic.

- The bands which are the most suitable for road applications, either for radio or radiating cable links (1-1000 MHz) or for microwave links (1 to 10 GHz) are among the most overloaded, and it is practically impossible to obtain a frequency channel below 3 GHz.

2.6. - Safety aspects

A number of functions listed in Fig.1 do not present safety features: this is namely the case of road information (with perhaps some limited exception), road guidance or fleet management.

The other functions may be ordered into 2 classes according to the safety level which they require:

- level 1: the function influences the traffic safety, but does not totally substitute to the driver who keeps the possibility of assessing the situation. The following functions may be ranged in this class:
  
  . traffic light or traffic signs repetition
  
  . aids to distressed vehicles
  
  . emergency warning systems
  
  . assistance to column driving

- level 2: the functions in this class substitute totally to the driver's view, and any failure in the corresponding equipment may lead to severe accidents. This is namely the case of the following functions:

  . anticollision at intersections
  
  . overtaking and passing aids which involve either the surveillance of the so called "blind zone" at the rear of the vehicle, or the detection on the left lane, in front of the vehicle, of obstacles which may be masked by the distance or by curves.

The equipments in this class must be realized and maintained with a great care, and respect safety failure rates of the same order as those which are required for instance in railways.
2.7. - Positioning

This criterium defines if for the fulfillment of the function, the communication link has to be associated with an on board location system, for lateral and/or longitudinal positioning.

In general, road to vehicle short range links do not require specific positioning equipment on board, the limitation of the coverage area creating physical limits which allow to confine or discriminate the zone where a particular message is transmitted.

In vehicle to vehicle communication systems, the link does not allow by itself the relative positioning and mutual identification which are generally necessary for vehicles which exchange a message.

For instance, for a function like column driving assistance, a relative longitudinal positioning system is required. For a function concerning the assistance to multilane manoeuvres to be efficient, a longitudinal as well as lateral positioning system is required for all cars.

2.8. - General considerations on these criteria

The different aids listed in Fig. 1 have been examined relatively to these criteria, taking into account the following complementary considerations:

2.8.1. - It seems firstly highly unrealistic to assume that, even in the long term, all cars should be constrained to be equipped with longitudinal or lateral positioning equipments, and it is equally improbable that a majority of drivers adopt such equipments on a voluntary basis.

Furthermore a lateral positioning system requires either very complex image processing systems on board, or the cooperation of the infrastructure, which should involve for instance inductive cables or magnetic paintings for marking the lanes, and the national road administrations seem far from being ready to engage such investments.

2.8.2. - The safety requirements for the level 2 mentioned in the § 2.6 do not seem compatible with the conditions of production, of operation and of maintenance of private cars.

They involve important precautions in the design and realization stages of a car, and redundancy measures which would result in prohibitive increases of the cost of the cars.

Furthermore the detection of some particular failures, like a frequency shift or a signal amplitude weakening in a transmitter, may require a permanent cooperation between the vehicles and the infrastructure, like in automated guided transports.

2.8.3. - It seems equally excluded that the implementation of such equipments becomes compulsory even in the long term.
3 - ASSESSMENT OF THE ENVISAGED AIDS RELATIVELY TO THE CRITERIA

Starting from all these criteria and considerations, it appeared that the aids listed in Fig. 1 could be classed into 4 categories according their feasibility.

3.1. - Category 1: Already existing and feasible

3 functions based on radiating cables:

- radio retransmission in tunnels
- radiotelephone retransmission in tunnels
- communication with service and emergency vehicles in tunnels.

1 function based on beacon-type transmitter/receivers:

- bus priority at traffic lights (which does not require a common standard frequency throughout Europe).

3.2. - Category 2: Technically feasible but raising some difficulties concerning frequency allocations

- road based traffic information and road guidance
- traffic sign repetition
- traffic lights repetition
- traffic data collection
- parking management
- automatic tolling
- assistance to column driving
- emergency vehicles signalling.

3.3. - Category 3: Functions with low feasibility characteristics and low perspectives of development

- anticollision at intersections
- emergency warning systems
- passing and overtaking aids
- automatic driving

It is worthwhile to explain why these four functions, which could significantly influence the driving conditions as well as road safety appear almost impossible to be realized.
3.3.1. - Anticollision at intersections

Critical criteria:

- frequency allocation
- coverage
- safety

It should be recalled that the objective of this function is to inform drivers that a possible conflict may arise with crossing vehicles. Such protection is rather relevant on open country roads, not equipped with traffic lights or Stop signs.

Two solutions may be envisaged for such a function:

- a cooperative system in which the vehicles have the possibility of declaring their presence by sending signals in front of them, these signals being able to propagate into the crossing roads.

Such a system is hardly feasible for at least two reasons: first of all it requires that all vehicles be equipped with safely designed longitudinal positioning systems; secondly there is no hope to find an available channel in the frequency bands (< 1 GHz) which can diffract in the transversal branches of an intersection, and anyhow it would be impossible in these bands to control the range of the transmitted signals and to avoid the risk for a car to receive irrelevant signals. It should be consequently necessary to work at higher frequency bands (perhaps over 60 GHz), but these frequencies propagate along straight lines, and would require the implementation of relay transmitter/receivers at the intersections, with severe safety constraints.

- a non cooperative system in which the approaching vehicles are detected through appropriate sensors in each branch of the intersection, and in which signals are elaborated from the informations given by these sensors and transmitted towards the interested vehicles by a fixed transmission equipment.

In this case, the links do not raise important technical difficulties; however it seems difficult to find appropriate detectors which could track over a distance of about 200 to 300 m all the vehicles approaching on each branch of an intersection with the high safety level required for such an application.

3.3.2. - Emergency warning systems

Critical criteria:

- frequency allocation
- coverage
This function aims at the avoidance of secondary collisions after a first incident or accident.

It is based on an alarm transmitter which is put into action by a crash detector, or eventually manually, on board the accidented car, and which sends a specific signal towards the on-coming vehicles.

The great difficulty raised by this function is that it is particularly useful for the detection of masked obstacles, behind curves or hill-tops.

As it has been already underlined, the frequencies which may be available are in the high part of the spectrum (perhaps over 60 GHz) and propagate only along straight lines: it should be consequently necessary to equip all these masked zones of relay transmitter/receivers, but there is very little probability that the road administrations accept to invest in such relay equipments.

3.3.3. - Passing and overtaking aids

Critical criteria:

- frequency allocations
- safety
- positioning requirements

A number of reasons make the perspectives of development of these aids very problematic:

- very restrictive safety requirements
- need for lateral and longitudinal positioning equipments
- necessity of equipping all vehicles

3.3.4. - Automatic driving

The same constraints and the same conclusions apply to automatic driving systems.

3.4. - Category 4: Technically feasible functions, but with higher range links

During this analysis it appeared that 4 functions for which the use of radiating cable or microwave links has been initially considered as possible could better be based on higher range links:

- assistance to bus operation (radio VHF)
- aids to distressed vehicles (radiotelephone)
- fleet management (radiotelephone, satellits)
"conviviality" links (CB, radiotelephone).

4 - CONCLUSION

It results from this research that the functions involving short range links between road and vehicles are generally technically feasible, with the main exception of the collision prevention at intersections. An important restriction is however associated with the difficulty of obtaining the allocation of a common European frequency band for these functions.

The aids based on vehicle-vehicle short range links raise generally more difficulties either for safety reasons, or because they require on board positioning equipments. Two aids only in this category appear as technically feasible: assistance to column driving, and emergency vehicles signalling.

Naturally this analysis of a purely technical nature does not preclude other investigations, based on ergonomic or economic considerations.

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RTI – Current Global Projects

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ABSTRACT for
RTI Current Global Projects
at the International Conference on
ROAD SAFETY AND TRAFFIC ENVIRONMENT IN EUROPE
in GOTHENBURG on September 26 - 27, 1990

The presentation labelled: "RTI - Current Global Projects" will give a brief presentation of the comprehensive projects in Europe, US and Japan:

EUROPE

PROMETHEUS
DRIVE
EUREKA TRANSPORT RELATED PROJECTS

USA

MOBILITY 2000
ELECTRANS

JAPAN

AMTICS
RACS

Similarities and differences in objectives and approach will be treated.

Common related opportunities and problems will be touched upon:

* Driving forces behind the research efforts
* Key Policy Issues, like Privacy, Liability, Financing
* Standardisation and International cooperation
* RTI investments and implementation relations to the general road investment levels
* The importance of Man Machine Interfaces and Tuition
* RTI from the points of view of living patterns and citybuilding

The presentation will end with a personal evaluation of the expected progress of the Global RTI Projects

Best regards

Tage Karlsson
1. BRIEF HISTORY

The Automated Highway and the use of Information Technology for the improvement of the Road Traffic were subjects of much discussion and research in the US already in the early sixties. General Motors was a leading force. These early investigations were maybe launched at too early a stage, however, and the idea of the merger of the Road Traffic with, what we today call, Road Transport Informatics was abandoned. This is said to be the reason, why the US has been quite late in the recent starts of cooperative research efforts in these fields.

In 1973 the Japanese Ministry of International Trade and Industry, MITI, launched research in the Comprehensive Automobile Traffic Control System, CACS for short. CACS was a forerunner to the present day projects in Japan, Europe and US in making use of and testing sophisticated information devices in vehicles and on the road side. There are several bus transport companies in Japan, more than 25, that have installed location systems derived from the CACS project.

In Europe there were some minor efforts to look into the RTI areas, but no real cooperative research activity was considered, until the European Automotive Industry launched the PROMETHEUS research program in 1986, based on initial discussions within the German industry during 1985.

In Japan and the US, RTI products have been presented to the market by individual companies, without having been preceded by large cooperative research programs. The ETAK navigation device is one American example and the several satellite communication systems, combined with LORAN C positioning systems, sold mainly to truck transport operators, is another one.

Bosch of Germany has from the ETAK developed the Travel Pilot, which now is being marketed in Germany. Philips is also developing the CARIN (Car Information and Navigation System), which is expected to be marketed within a couple of years.

In the London area the Trafficmaster is sold for use on the M25 motorway and eventually other routes. It gives traffic information.

The Transtrack, using meteoric bursts as a means of communication reflectors and Loran C for positioning, is also an interesting private RTI initiative launched in the US.

There are several companies in the US developing products and preparing for the day, when enough GPS satellites will be in place to offer 24 hour positioning. If these satellite positioning devices will be available at a reasonable cost, they will most likely replace the positioning by means of Loran C. GPNS is a British Navigation system under development making use of the GPS satellites.

Most Japanese manufacturers of cars have been and are offering navigational devices in different degrees of sophistication.

Both in the US and Japan mobile two-way radio systems offering positioning, navigation and communication have been marketed for quite some time. Motorola introduced earlier this year the Coverage Plus system, which claims satellite capability at less cost. This RTI product will in the future offer telefax -facsimile- as well.
The Nordic countries in Europe have been forerunners in the use of mobile telephones. The early success of the cellular telephones in Scandinavia, and later in the entire Europe, serves as a good illustration to the need of a Global, or anyway a Pan European, approach to the preparation and implementation of Road Transport Telematics. The Nordic mobile telephones are not compatible and usable in the rest of Europe, with some exceptions, which they could have been, if there had been an early concerted Pan European effort. This is being remedied now, however, when the new GSM-based mobile telephones will be introduced in Europe in the early nineties.

Another European example, of an individual company developing RTI solutions, is the Siemens Aliscout, which is being tested in Berlin and in a somewhat modified version in London. By means of infrared communication with road side posts the driver gets route guidance and some other information from a central computer, that handles the traffic management of the city area.

2. GLOBAL RTI PROJECTS

A Global RTI Project is supposed to mean a research program with a wide participation from companies, authorities and research institutions.

The brief history and samples given above indicate, that it is possible to arrive to public acceptance and commercial success within some limited area of RTI products, without those products being derived from, or based in, a global project.

There are advantages in such a development. The time to start the project and develop the product is shorter.

The research is being done much quicker, when the contact areas are smaller and the consensus needed is restricted to one company hierarchy only. If the product planning has been done in a skilled manner, the pioneering company can reap great economical results from its bravery.

With the exception of autonomous navigational devices, radio and satellite communication, which rely on already installed or planned systems, most RTI products require, however, an extensive cooperation from, and modification of, the infrastructure, to be able to function. In the case of vehicle to vehicle communication it is necessary, that the means of communication between the vehicles are compatible. Digital maps should be made in a common pattern, the messages conveyed ought to be understood in different languages. To gather and distribute the information, there has to be road side posts and data bases. The means of communication between the vehicles and the road side must be uniform in neighbouring countries or, preferably, on a world wide scale. If identification of vehicles and automatic debiting will be included in the future systems, it is not possible to have different systems for that in the different countries.

These examples may be enough to illustrate the need of effective cooperation between the various actors: the vehicle manufacturers, the makers of the electronic components, the authorities, including the road holders and the telecommunication organisations, the law makers and the standardisation bodies. The problems are growing into such magnitudes, that just keeping track of them is a task in itself, not to mention the amounts of actual research work needed. This stresses the necessity of having competent research institutions involved.
The need for new standards and laws has been presented by big European industrial companies, as a reason not to develop RTI products, until these uniformation measures are in place. In the very dispersed multiparty consensus process, which leads to standardisation of a product, system or method, it is seldom the pioneering product, that ends up becoming the standard. The pioneer is therefore not getting any benefit out of being first. That being the case, he rather refrains from the honour of the leadership position.

The analyses made indicate, that the adoption of the quickly developing Information Technology would be of great help in alleviating the ever more pronounced problems of the Road Traffic. In Japan, US and Western Europe there are in sum more than 100.000 people killed in Road Traffic Accidents every year, congestions cause inefficiencies in the economy, irritation and serious air pollution. It is felt, that the investments in road infrastructures could be more efficiently utilised, if the RTI functions were brought into use.

These reasons have stimulated, or maybe forced, the formation of large cooperative RTI projects and research programs in the three most important areas of the world: USA, Japan and Western Europe.

3. CURRENT RTI PROJECTS IN USA

The near completion of the 70.000 km Interstate Highway System, which was started during the Eisenhower administration in the fifties, has given rise to an extensive debate in the US regarding the future transport system. Increasing congestions, particularly in the South Western corner of the US, lacking maintenance and no enlargement of the present infrastructure have aggravated the problems.

The evolution of the RTI projects in Europe and Japan, in combination with the recent progress of micro electronics and information technology, have stimulated the US authorities, universities and industries to reconsider the negative results from the sixties.

During 1990 has been presented the National Transport Policy, which lines out the needs to maintain and expand a healthy transport system, to improve safety, environment and quality of life as well as advance the US transport technology.

The transformation of the new transport policy into action programs is planned to include a National Highway System, three to four times the length of the present Interstate Highway System. This National Highway System will make up some 4 - 5 percent of the total public mileage in the US, but it will carry 35 - 40 % of the total traffic.

The National Highway System is intended to make use of the best available "smart car/smart highway" technology in order to achieve the objectives for efficiency, safety and quality of life.

Daring entrepreneurs have from the advent of the technical possibilities been developing smaller RTI projects and products in the US. The last few years have, however, also in the US seen the evolution of large scale interstate and federally supported projects aiming towards the utilization of RTI products for the improvement of Road Traffic.

The Los Angeles area suffers the worst congestional problems in the US and therefore it is logical, that the first comprehensive projects have started in California.
Berkeley University established within their Institute of Transportation Studies the Programme on Advanced Technology for Highway, PATH, organised in four thematic groups: Navigation, Simulation, Control and Software. Part of the work on Navigation is the Pathfinder navigation and driver information system. Anti-collision radar, magnetic lateral control and platoon driving are included in the program.

Most of the PATH Programme has been included in the Smart Corridor Demonstration Project along the Santa Monica Freeway in Los Angeles. Additional Motorist Information systems and Traffic Management are included as well in the Smart Corridor Project. The California projects enjoy financial contributions from as well state and federal sources as from private industry.

After Berkeley other Universities have engaged in RTI research with the help of federal and state money. Private industry, state and federal authorities began to take a deeper interest in the RTI research and possibilities.

The need of a national coordination emerged and to this end Mobility 2000 was formed; a voluntary informal coalition of industry, university and federal, state and local government participants, who were convinced, that the new RTI technologies will make highways more productive and vehicles safer and more efficient.

Mobility 2000 has established an American terminology for RTI and has been very active in proposing a research agenda for the US.

What we in Europe call RTI, RTT and ATT is in US named IVHS standing for Intelligent Vehicle Highway Systems. IVHS is grouped in four elements:

- Advance Transportation Management Systems,
- Advanced Driver Information Systems,
- Automated Vehicle Control Systems,
- Commercial Vehicles Operation.

Mobility 2000 has stimulated and led a very comprehensive cooperative work in analysing the potential IVHS benefits, in setting tentative milestones, estimated the needed funding for Research and Development as well as Investment Requirements.

The improvements in Safety because of the IVHS, introduced according to the tentative milestones, would by year 2010 save 11000 lives annually and 40 times as many traffic injuries at a total value of 22 B USD. Great savings in travel time and fuel consumption are forecasted, as well as a considerable reduction of air pollution. The capacity of freeways is predicted to double except for the High Occupancy Vehicle Lanes, which are expected to triple their capacity.

The aggregate funding for the Research and Development work has by Mobility 2000 been calculated to 1.4 B USD up to year 2010. More than 80% is intended to be spent before the turn of the century. The field operational tests will require another 3.1 B USD in the same period, but there some 40% will be used after year 2000.

The investments in IVHS infrastructures will require additional 30 B USD up to year 2010.

The equipments in the vehicles are not included in these figures, but are estimated to cost an average 1000 USD per fully equipped vehicle. If all vehicles are fully equipped, this means another 12 B USD per year.
Assuming a linear growth from 0 USD in 1990 to 12 B in 2010, the total costs for the IVHS equipment in vehicles, during the 20 year period 1990 - 2010, would come to 126 B USD. The total investment for IVHS will thus come to 160 B USD over the 20-year period. Despite these tremendous sums, they represent only 0.16 % of the GNP of the US and will be passed by far by the values of the benefits envisioned. This may be compared with the 17.5 % of the GNP, which represent the total cost of transport in the US.

The US Department of Transportation has taken a great interest and part in the endeavours of Mobility 2000. In March this year the DOT recommended the US Congress to create a coordinated program to advance IVHS. In May at a National IVHS Leadership Conference in Florida, hosted by the DOT, General Motors and the Highway Users Foundation, it was proposed to form a new Electronic Highway Transportation Association of America (ELECTRANS), to guide the development and coordination of IVHS activities.

No commitments, as to the federal funding of the IVHS research activities, seems to have been made, but the general expectations are, that there will be allocated some 100 M USD per year.

Considering the experience of already marketed IVHS products in the US, the high level of knowledge in informatics and computer sciences and the US experience in large scale projects -like Interstate Highway System and Space Programs- it is very likely, that the IVHS development in the US quickly will recover the lead, that Europe and Japan has gained because of their earlier starts in cooperative research programs in the areas of IVHS (or RTI).

4. CURRENT RTI PROJECTS IN JAPAN

Without any comparison Japan has the most experience in cooperative research programs in the areas of RTI. And it is not only research, that has been done. Several field tests, with quite high number of vehicles involved, have been performed and the automotive companies have not hesitated in using the Japanese market as an additional test site for their RTI products.

In addition to the initial CACS project, there has been launched a number of other projects with high number of participants in every one. One conclusion from CACS was, that some form of coordinating body would be needed to utilize the results from the CACS experiences. The JSK is the answer to these demands.

JSK, which is said to mean Association of Electronic Technology for Automobile Traffic and Driving, was formed under the MITI in order to promote pre-competitive research and development. JSK has 40 members and is supported by member fees and the Japan Motorcycle Organization.

The results of JSK are projects like ARIES (Automobiles Roadside-transceiver Information for Extensive Services), IVS (Intelligent Vehicle System), PVS (Personal Vehicle System), Gyri-Cator, Navicom and Driveguide and, probably, all the automotive projects. Some of the projects were made in cooperation with the Mechanical Social Systems Foundation.

CACS was an interactive route guidance system indicating the recommended choice of road by arrows in front of the driver.

The evaluation of CACS revealed, that Japanese drivers were not satisfied by not having the total overview of the map, in which they were driving, if you allow.
Hence the JSK work gave birth to the RACS (Road Automobile Communication System) and AMTICS (Advanced Mobile Traffic and Communication System) projects, which both use a digital map stored aboard the vehicle in a CD-ROM disk.

It is interesting to note, that the development from CACS to RACS and AMTICS has been brought about by a multitude of cooperative efforts, in some cases competitive:

<table>
<thead>
<tr>
<th>MITI, Ministry of International Trade and Industry</th>
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<tbody>
<tr>
<td>JSK, Association of Electronic Technology for Automobile Traffic and Driving, 40 members</td>
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<tr>
<td>ARIES</td>
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<td>AMTICS</td>
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<td>RACS</td>
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<td>MSSF, Mechanical Social Systems Foundation</td>
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<td>IVS, Intelligent Vehicle Systems</td>
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<td>PVS, Personal Vehicle Systems</td>
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<tr>
<th>Japanese National Police Agency</th>
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<tr>
<td>JTMTA, Japan Traffic Management Technology Association, 50 members</td>
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<tr>
<td>AMTICS, Advanced Mobile Traffic Information and Communication System</td>
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<tr>
<td>AMTICS Implementation Council, 60 members</td>
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<tr>
<th>Ministry of Construction</th>
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<tr>
<td>JACIC, Japan Construction Information Centre</td>
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<tr>
<td>HIDO, 310 members</td>
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<tr>
<td>Japan Digital Road Map Association</td>
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<tr>
<td>RACS, Road Automobile Communication System, 25 members</td>
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<tr>
<td>Next Generation Road Traffic Systems Committee</td>
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<tr>
<th>Ministry of Post and Telecommunications</th>
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<tr>
<td>Teleterminal Japan City Media Corporation</td>
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<tr>
<th>Car Manufacturers</th>
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<tr>
<td>Gyro-Cator</td>
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<td>Navicom</td>
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<td>Driveguide</td>
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<th>Ministry of Post and Telecommunication+</th>
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<td>Ministry of Construction+</td>
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<td>Japanese National Police Agency</td>
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<tr>
<th>Ministry of Post and Telecommunication+</th>
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<tr>
<td>VICS, Vehicle Information Communication System (RACS+AMTICS)</td>
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</table>
The in vehicle equipment in AMTICS and RACS are more or less the same: CD-ROM stored Digital Map, Screen display of the map and messages, Map matching capacity, Communication capacity for traffic information, services, telefax etc., Vehicle identification and Positioning. The differences between RACS and AMTICS are the communication links and the sources of information and central contact. AMTICS was originally intended to be used in the city areas and RACS in between the cities. The very logical conclusion has been to merge the two projects into one, which is named VICS, Vehicle Information Communication Systems. When the tests and analyses of RACS and AMTICS will be concluded in the fall of 1990, the VICS will be specified and the organization to run it will be set up.

The initial work for VICS has been started by the Ministry of Construction, which is responsible for the roads in Japan. The preparatory Committee, called "Next Generation Road Traffic Systems Research Committee", has listed the following research subjects:

1. Road condition detecting systems,
2. Lane guidance systems,
3. Obstacle detecting system,
4. Road traffic management, information system,
5. Automatic toll collection system,
6. Headway control system,
7. Collision avoidance system,
8. High speed automatized cruising system.

With all the research made, tests realized and experience gained, combined with the great market interest and authority support for this kind of products in Japan, it may be reasonable to assume, that one fully integrated and competent, but modular, RTI system will be available in Japan within five years.

5. CURRENT RTI PROJECTS IN EUROPE

There are two global frameworks of RTI projects in Europe: DRIVE and the Eureka Transport Related Projects. Within the latter ones PROMETHEUS is the biggest and most important project. PROMETHEUS' comprehensiveness, objectives and management are so extensive, that it may be rather more appropriate to consider PROMETHEUS as one of three major European research programs: DRIVE, EUREKA and PROMETHEUS.

EUREKA is a regulatory framework, according to which the European governments approve multi-country research programs and allocate financial contributions country by country.

Beside PROMETHEUS, EUREKA has nine important Transport related RTI projects with members from several European countries and companies:

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<tr>
<th>TRANSPOLIS</th>
<th>Goods transport services</th>
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<tr>
<td>CARMINAT</td>
<td>Navigation and Information</td>
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<tr>
<td>EUROPOLIS</td>
<td>Traffic and fleet management</td>
</tr>
<tr>
<td>ERTIS</td>
<td>Information and communication with drivers</td>
</tr>
<tr>
<td>TELE-ATLAS</td>
<td>Topographic and traffic data bases</td>
</tr>
<tr>
<td>DEMETER</td>
<td>Standards for digital maps</td>
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<tr>
<td>LOGIMAX</td>
<td>Information Network for Logistics</td>
</tr>
<tr>
<td>ROADCOM</td>
<td>En route data communication</td>
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<tr>
<td>ATIS</td>
<td>Tourist information</td>
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</table>
PROMETHEUS (Program for a European Traffic with Highest Efficiency and Unprecedented Safety) started, like most of the other EUREKA projects, in 1986. The European automotive industry in West Germany, France, Great Britain, Italy and Sweden was the initiator. After a definition year the real research work started in 1988 in cooperation with European universities, government authorities and automotive suppliers.

The PROMETHEUS research work is directed towards 23 defined functions, which are grouped under the headings of:

- IMPROVED DRIVER INFORMATION
- ACTIVE DRIVER SUPPORT
- COOPERATIVE DRIVING
- TRAFFIC/FLEET MANAGEMENT

It is interesting to note, that the groupings are not very different from those of the American IVHS.

In order to bring the research nearer the realization phase, PROMETHEUS has agreed upon ten Common European Demonstrators, i.e. vehicles in which some defined functions are to be installed and tested.

DRIVE (Dedicated Road Infrastructure for Vehicle safety in Europe) is run under Directorate General XIII of the European Commission (Directorate General for Telecommunications, Information Industries and Innovation).

There are 73 sub-projects in the DRIVE research programme distributed in six main areas:

- TRAFFIC CONTROL
- ROAD SAFETY AND BEHAVIOURAL ASPECTS
- ENVIRONMENTAL CONTROL STRATEGIES
- COMMUNICATION STRATEGIES
- ADVANCED PUBLIC TRANSPORT AND FREIGHT MANAGEMENT SYSTEMS
- SYSTEMS ENGINEERING AND EVALUATION TECHNIQUES

PROMETHEUS and DRIVE overlap some, but only to such an extent that it stimulates good cooperation. DRIVE is more directed towards the infrastructure and PROMETHEUS more towards the vehicles.

Each DRIVE project is being run by a consortium of some 5 - 6 members: industrial companies, universities and/or authorities. The members in the consortia come from most of the West European countries.

DRIVE is only a three year programme. In order to secure a continuation of the research work and later implementation, a successive program is now being discussed and it may be approved towards the end of this year. The next DRIVE program will emphasize test sites and pilot projects.

RACE and ESPRIT are sister programs to DRIVE within DG XIII of the Commission. They include some transport related RTI projects. Particularly there are some 13 projects within ESPRIT, that have direct relation with transport.

IMPACT, SPRINT and TEDIS are other transport related projects within DG XIII, to some extent dealing with electronic data and communication.

Other Directorates but DG XIII have as well started research programs, which touch upon RTI items.

DG III, Directorate General Internal Market and Industrial affairs, has proposed the Transeuropean Networks for interoperability with particular emphasis on transport, energy, telecommunication and training.
DG XVI, Directorate General on Regional Policy, is together with DG XIII enlisting European cities, that want to cooperate in the testing of Traffic Management concepts. Some 30 cities are involved this far.

COST, European Cooperation in the field of Scientific and Technological research, which is a wider concept than the Common Market, runs some projects, which may be classified under the RTI global label:

- Antennae in the 1990's,
- The GSM mobile telephone system,
- Road Meteorology and Maintenance Conditions,
- Logistics of Freight Transport,
- Express Parcels Services in Europe,
- Transport of Dangerous Materials.

6. IMPLEMENTATION OF RTI RESEARCH RESULTS

From the long listing above it may be clear, that there is no lack of research projects and project proposals in the RTI area.

Research may in itself be valuable, because it helps to develop scientists and it widens the general area of knowledge. Still, if the research does not result in the implementation of practical products, it will, after some time, be judged as having less value.

The great number of projects under the auspices of different overseers make it a great task for the limited number of researchers, that can be allocated to work in these fields, just to keep track of, what is going on. The implementation has to be realized by either existing industrial companies or by new entrepreneurs. The researchers are not always the best implementation agents. It adds to the problem, that most RTI products ought to be implemented as pan-continental solutions.

Considering the engagement of the Japanese ministries and the industrial partners in the Japanese projects, it seems, that the distance between research and implementation is quite short in Japan. The same may be said for the Department of Transport engagement together with universities and industries in the American ELECTRANS.

There are activities underway in the EC Commission to cover this gap between research and implementation by organizing some form of public-private Pan European joint enterprise, that will have as its task to plan and stimulate a gradual implementation of researched RTI items.

If such a group will be formed, it will have a challenging task to evaluate and put priorities on the most promising technical solutions. It will have to stimulate standardization and to harmonize introduction plans in Europe, West and East, involving vehicle and equipment industries as well as authorities responsible for roads and telecommunications.

However challenging and laborsome these technical and planning components of the work of this intended coordination group may be, they are quite straight forward and simple in comparison with the political obstacles, that have to be overcome as well.

The political problems are of two kinds; financing and public opinion, but still related to each others.

In the democracies the public opinion is of magnanimous importance, particularly those parts of it, that play a role in the elections. In between the elections the opinions are formed and spread via debates and the publicity media. But the public opinion also votes in the market place by preferring or refusing to buy items offered.
Sometimes these three means of reading the public opinion—elections, publicity and purchases—do not agree, or anyway make the impression of not agreeing. Such discrepancy may cause confusion and policies, that are not the best.

It seems, that the road traffic is subject to such confusing signals and, as a result from that, inadequate policies. The market forces make the road traffic and the number of vehicles to grow in line with the general economic development. Within some 25–30 years the number of vehicles will have doubled in Europe. Within some 20 years Europe will reach the relative vehicle population of 750 vehicles per 1000 inhabitants, that US has already now. Living, leisure, shopping, work and location of industries and distribution centres are all geared to the use of the automotive vehicles for the transport of goods and people.

The growth of the automotive mobility has caused the commonly known problems of environment, safety, discomfort and inefficiencies because of congestions and delays as well as the gradual depletion of petroleum energy. Strong public forces have mobilized and their efforts have resulted in remedy-ing legislation, technical development and more awareness about the negative effects.

The public opinions expressed seem to have been taken so seriously by the political decision makers in almost all West European countries, that they have reduced the investments in road infrastructures from 1.2 % of the accumulated GNP:s in 1975 to about 0.6 % ten–fifteen years later. In some of the European countries the allocations to the roads have been reduced so far, that the capital value of the road infrastructure is actually decreasing.

It seems, that the reduction of road investments, despite the growing automotive population, is an example of inadequate policies, resulting from the misinterpretation of the diverging public signals from the opinions in the media and in the market place.

It is important for the implementation of the RTI equipments, that there is an awareness about the need of more investments in the roads. The RTI equipments may bring many improvements, but they cannot substitute adequate investments in the infrastructures. It could be said, however, that use of RTI equipments and methods deserve a prioritized position, when more investments in road infrastructures are considered.

The initial RTI products, which have been sold in the US and Japan, had, of course, to be autonomous, i.e. independent of the infrastructure, since no adaptations of the road side could have been done prior to the introductions of those products. The big gains in efficiency, safety and environment protection will be harvested, when there is a good match between the on board equipment and the road infrastructure. Still, the driver can enjoy many benefits and comfort from his RTI equipment, even when it is autonomous or only relying on the contact with the regular telecommunication networks.

He can find his way, he can be in touch with the office, the home and the rest of the world, he may know all about the workings of his vehicle and its road holding, he does not have to bother about thieves and the information presented to him makes him a better driver.

These, from the road side autonomous, RTI functions offer large areas of product development and stimulating competition between the manufacturers, for the benefit of the consumers and to give them sound reasons to discriminate among the products offered.
The way, in which the information is presented and the ergonomic arrangements of displays and controls, will be very important for a good tuitional effect. These alluring improvements ought to be of great interest to this conference on Road Safety and Traffic Environment.

Systems, debiting for the road services in an automatic way, will bring a much more fair relation between the actual use of the road and the cost than the present clumsy annual road and fuel taxes. Differentiated pricing will then help to spread the traffic more, both geographically and over the hours of the day, thus alleviating the congestional problems. Introducing the market economy in the allocation of the use of the road opens also up the possibilities of new, private, sources of financial resources for the investment in the road infrastructures.

In connection with the automatic debiting it has been pointed out, that the identification of the vehicles may endanger the personal integrity and privacy. The risks need not be much greater than for the widespread use of credit cards however. Investigations and discussions are under way regarding this delicate subject. In the end it may be necessary to offer one alternative way of anonymous automatic payment, which is possible.

The electronic equipment, to be installed in the vehicles and on the roadside, will be subject to difficult physical conditions. The many pieces of software, that will govern the communications, have to be compatible. Errors during micro-seconds may cause great damages and losses. This emphasizes the problems of who is responsible.

The basic laws and directives concerning liability for defective products seem to be in place in most European countries, but there are no prejudicial court cases of those regulations, as far as this type of products is concerned, as yet.

The common opinion for the moment is, however, that liability problems should not be a serious deterrent to the introduction of RTI equipments.

7. CONCLUSION

There is a fascinating development of RTI products under way in the entire Western World. Many of the topical projects are pre-competitive and cooperative. Later there will be more competition between manufacturers and countries.

Some widely supported and respected organization will still be needed to secure the coordination of implementation and compatibility of RTI products, systems and methods in Europe.

The outcome of the competitive process will be RTI products, which offer safer and cleaner traffic, more comfort, unlimited access to information and efficient, continuous instructions for making better drivers.

There will be a fair distribution of the costs for the, hoped to be, sufficient infrastructures.

For offering the consumers the benefits of this development, there will be produced great values of the new products, thus creating employment and a basis for further technical progress.

The awareness, that the competitive process will create winners and losers in this new key product area, will further stimulate industrial efforts, all for the gain of the common consumer.

Tage Karlsson
Total Environmental Impact of the Car

Ulf Jansson
Msc
Volvo Car Corporation
Sweden
TOTAL ENVIRONMENTAL IMPACT OF THE CAR

When talking about the environmental effect of the automobile, it is necessary to take the entire life-span of the car into consideration, i.e. from production to scrapping.

The car designer plays a key role in this respect.

When we build a car, we lay the foundation for effects on the environment in the future. The choice of materials and system solutions influence a car during its entire lifetime. Negative effects during production and operation can be avoided as well as unnecessary discharges during maintenance and scrapping by using sound construction techniques.

We have been working in the field of the environment and how our production plants affect it for many years. We buy more and more complete components from suppliers and they need to clearly understand our environmental goals, too.

Emission reduction is the most important aspect of a car's environmental impact. We have worked on this for many years and were the first to introduce the lambda sond and three-way catalytic converter in 1976.

Our emission reduction systems have gradually been refined since then; and we are working with alternative fuels and energy sources, e.g. methanol and electricity.

Noise while in use and using products which are hazardous to the environment are other important issues.

Our garages and dealers link us to the customer. How a car is taken care of at garages and dealers and how waste and other items are disposed of are vitally important.

Last but not least, a proper traffic-planning system which gives information to the driver by means of displays inside or outside of the car will help make planning more efficient and reduce the burden on the environment.

Finally, there is a negative impact on the environment when a car is scrapped. We need to work on both short and long-term goals in order to improve the current intolerable situation.
TOTAL ENVIRONMENTAL IMPACT OF THE CAR
Ulf Jansson, Msc

Volvo Car Corporation

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Volvo has chosen base its activities on this overall picture.

Picture 1

We have been working in the field of the environment and how our production plants affect it for many years. We buy more and more complete components from suppliers and they need to clearly understand our environmental goals, too.

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To illustrate our work in reducing the negative impact of the car, I would like to describe the Volvo Environmental Concept Car which was on display in Geneva this year. It should be regarded as a first step in an evolutionary development process; it will be followed by other similar studies in the future.

This is not the first environment-friendly concept car that we have put on exhibit. The Light Component Project (LCP) in 1983 was based on a total energy efficiency.
In the car, a 745 GL, we have chosen to show:

The engine in the Environmental Concept Car is a further development of the M85-engine that was completed in the autumn of 1989. M85 stands for a ratio 85 per cent methanol and 15 per cent petrol.

The newly-developed engine can be run on almost any mixture of methanol and petrol. A sensor determines the quality of the fuel and adjusts the engine's automatic control system as required. Thanks to this mixture of methanol and petrol, it is possible to cut in half the amount of carbon monoxide and hydrocarbons released today. There is a good possibility that the engine can be developed even further so that it will meet the expected requirements in California in the year 2007; a goal that the world's car manufacturers are working towards today.

Also on display, as part of the Environmental Concept Car, is the electrically-heated catalytic converter which substantially reduces the exhaust problem. In the first two minutes of driving (e.g., for about twenty minutes), 80 to 90 per cent of all the exhaust discharges take place when the engine and catalytic converter are cold.

Use of the electrically-heated catalytic converter reduces the starting time for the catalytic converter as well as CO and HC emissions during the first minutes of driving by 50 per cent. The advantages are considerable, especially in urban areas which is where most of the cold starts normally occur.

The discharge of organic solvents is a problem at our production plants.

A general reduction in the use of solvents is underway by changing to water-based paints and materials with a higher degree of dryness.

All our metallic colours will be water-based in our new paint shop in 1991.

A completely solvent-free undercarriage protection designed for application when hot was introduced at the beginning of the year. It is known as the Hot Melt method and it has reduced the discharge of hydrocarbons at four Volvo plants were reduced by 550 tonnes annually; three of the plants are in Sweden and one is in Canada.

To enable us to reduce the discharge of solvents even more, we are also working on solid water-based paints.

An increase in the use of powder paint is also an interesting possibility.
Chlorofluorocarbons, commonly known as CFC or freons, are damaging the earth’s protective ozone layer. They are used as a cooling agent in air conditioners and in the manufacture of plastic foam items.

Volvo is actively working towards the elimination of CFC material. The Environmental Concept Car is entirely free of CFC. In the case of production cars, however, 1993 is a realistic target date for the complete elimination of CFC. The cooling agent which is most likely to be used in the future is called R134a. It is a chlorine-free material which is considered to be completely harmless to the ozone layer. Volvo expects to begin introducing R134a as early as 1991. Full production is expected in 1993.

CFC was previously used in the manufacture of polyurethane foam items, which are mainly used inside the car, e.g. in steering-wheels, dashboards and seat fillings, as an expanding and releasing agent.

More and more plastic items are being manufactured without CFC, e.g. foam in armrests and seat fillings. Volvo’s suppliers have already reduced their use of CFC by 60 per cent because of these and other measures. In the case of soft foam plastics, CFC has been entirely eliminated. In the case of hard plastics, the use of CFC is going to be reduced 90 per cent by 1991 and be replaced entirely by 1993 at the latest.

It also important to consider the driver and passenger environment while driving.

Because of this, there is an item in our Environment Concept Car which significantly improves the inner environment of the car, namely an air-intake filter. This filter works together with a sensor. The sensor controls the air intake and prevents exhaust fumes from the outside from being sucked into the car’s interior.

The interior filter is still only a research and development project which will have to be thoroughly evaluated before thinking about production.

The negative consequences of scrapping must be taken into consideration more than ever before.

Today, scrapping is done by fragmentation. Therefore, it is possible to recycle metal material while other things, i.e. plastics, rubber, paper, glass etc., are left behind; at present, this is equal to 30 per cent of a car’s scrapping weight. The environmentally-hazardous materials which remain will sooner or later find their way into the ecological system.

Our primary task is to quickly eliminate materials which are detrimental to the environment.

The current Volvo 700-series is virtually free of cadmium and Volvo 240 is also well below the established limits as defined by the law at present. We are also working to find alternatives for the mercury used in switches.
Brake linings, clutch plates and all gaskets in petrol engines are completely free of asbestos. In Volvo's engine plant in Skövde, all the yellow-chromed engine parts have been replaced by a more environment-friendly process. This, however, has been done mainly to improve the working environment.

In addition, we have established a standard for marking plastic components. By doing so, the quality of plastic in each component can be identified when the car is scrapped. This paves the way for environmentally-sound methods of destruction in the future.

In the long term, we are working on a construction guide which will help our designers create products that are environment friendly. A first draft will be finished sometime later this year.

We are also working on a set of scrapping instructions that will be used in the near future.

The solutions I have been describing have either been developed or are expected to be developed in the next few years. As I said earlier, this car should be seen as one step in a continual process of development. The Environmental Concept Car will be followed by others in the future.

The environment is going to be increasingly important in the future. We must strive to improve and reduce the impact of our products on the environment. In conclusion, we must become better at publicizing our work in the environmental field as well as our results in this area in order to gain the confidence of the public.
FREE FROM CADMIUM, MERCURY, ASBESTOS AND YELLOW CHROME PLATED COMPONENTS

MARKED PLASTIC COMPONENTS

Volvo Car Corporation
Traffic and the Environment
Measures to Reduce Pollution Caused by Traffic

G-A Ahrens
Federal Environment Agency
Federal Republic of Germany

and

Klaus Becker
Dr
Federal Environment Agency
Federal Republic of Germany
Abstract

Traffic is one of the main sources of environmental pollution in terms of air pollution, noise, and land consumption.

Due to tightened environmental standards and using new technologies, ever more environmentally compatible vehicles and transport infrastructure have been designed and implemented. The reductions thus achieved, however, have often been offset by increases in the amount of traffic. Even though the potential for reducing pollution through the use of technical measures has not yet been fully exploited, it is already becoming clear that it will not be possible to achieve the necessary reductions in traffic-related pollution levels everywhere by technical means alone.

In view of the increase in the volume of traffic and kilometers driven, traffic-related hazards to human health and the environment are expected to remain at excessively high levels, unless further measures are taken in traffic and environmental policy. This holds true for both the Federal Republic of Germany and the whole of Europe.

Signs of global dangers of an alarming magnitude have become apparent, necessitating a further-reaching, drastic reduction in pollution levels. Excepting questions of traffic safety, the most important factors making rapid action imperative are considered to include:
(1) Damage to forests

(NO\textsubscript{X}, HC emissions: elevated ozone levels, acidic and nitrogen inputs as well as accumulation of pollutants in soil and water bodies);

(2) climatic changes, greenhouse effect

(CO\textsubscript{2} emissions, energy consumption: world-wide climatic changes, sea level rises, shift in vegetation zones);

(3) air pollution and noise levels in excess of existing limit and guide values due to traffic, occurring sporadically in densely populated areas and posing a hazard to human health

(NO\textsubscript{2}, particulate and CO concentrations, elevated ozone concentrations especially on the periphery of conurbations, carcinogenic substances, risk of heart and circulatory diseases due to constant exposure to high noise levels);

(4) economic losses, due also to traffic noise
(as a result of the above-mentioned damages as well as real-estate depreciation);

(5) loss/dissection of biotopes.

The increase in traffic and the additional damage and hazards resulting therefrom make it necessary, in light of the legal obligations of hazard prevention and precautionary environmental protection, to set definite priorities in environmental and traffic policy and take action in the following sectors:

(1) Further reductions in vehicle emissions - particularly of heavy-duty vehicles - as well as reductions in energy consumption and CO\textsubscript{2} emissions by making full use of all justifiable vehicle-targeted technical options;

(2) reductions through traffic-control measures;

(3) traffic-infrastructure planning in accordance with the principles of the Federal Nature Conservation Act and only following comprehensive environmental impact assessment which is to include, in particular, an assessment of demand assumptions;

(4) funding as well as development and implementation of measures to reduce traffic-related pollution in a joint effort of the interdisciplinary authorities involved.
One of the urgent tasks in environmental and traffic policy is to establish initially a programme "environment and traffic in the Federal Republic of Germany" in order to define specific goals for the reduction of traffic-related pollution and draw up plans for measures to be taken. Preparatory to this, it would be necessary to perform scenario analyses to assess the environmental effects of future developments in traffic, to develop the fundamentals of a policy integrating regional-planning, traffic and environmental considerations including environmental impact assessment, and to work out recommendations for actions to be taken within the framework of such a policy.

Important elements of this work include:

(1) Review and processing of the relevant environment- and traffic-related data and information, investigations to obtain data where missing;

(2) development of a set of instruments to predictively assess the effects of possible traffic- and environmental-policy measures (scenario analyses);

(3) vehicle-targeted technical measures to reduce traffic-related pollution, approval and monitoring of vehicles, fuels and fuel additives, incentives for the purchase and operation of low-pollutant cars;

(4) exemplary development and initiation of measures for traffic-volume control as well as for an environmentally compatible management of traffic and planning of traffic infrastructure;

(5) other tasks, such as management of the waste and residues arising in traffic, transport of dangerous goods, effects research.

If not preceded or accompanied by the appropriate scientific investigations, the implementation of the necessary measures would lack important prerequisites. Traffic-control measures, in particular, are an area still requiring further investigation.
Traffic and the Environment
Measures to reduce pollution caused by traffic
G.-A. Ahrens, K. Becker
Federal Environment Agency, Bismarckplatz 1, D-1000
Berlin 33

1. INTRODUCTION

Traffic is one of the major causes of environmental pollution:

- Pollution of the air by compounds such as CO\textsubscript{2}, NO\textsubscript{2}, and volatile organic substances which harm vegetation and the climate is caused to a great extent by traffic. Emissions of heavy metals and persistent organic substances contribute to the accumulation of pollutants in soil and water. In densely-populated areas emissions from traffic are the major cause of forms of environmental pollution which can be detrimental to human health. Carcinogenic substances (including diesel soot and benzene) are of particular significance in this respect.

- Traffic is also the major cause of noise pollution. People living close to main roads are exposed to a higher risk of illness. Devaluation of buildings and land near busy roads causes severe losses to the economy.

- The proportion of roads with impermeable surfaces has risen in the last 30 years by some 30%. The proportion of land within settled areas used for transport is at present approximately 40%. The consequences of land consumption include loss of vegetation, increase of impermeable land, carving up expanses of land with the accompanying loss of habitats and other disturbance to the balance of nature, as well as optical pollution in both urban and rural areas.

Whilst distinct reductions of emissions from industrial plants and power plants have been achieved, traffic is increasing in the Federal Republic of Germany to such an extent that it is becoming a major environmental problem.
New technology combined with more stringent environmental legislation has led to the use of more environmentally friendly vehicles and traffic systems. However, the effect of the reduction resulting from this is often cancelled out by the increased volume of traffic. The potential of technology for reducing pollution has not yet been fully exhausted but it has already become obvious that technical solutions alone will not suffice to bring about the necessary reduction in pollution caused by traffic.

To date attention has focused on technological means of reducing emissions and pollution levels in the environment. Environmental policy in the future must go beyond this and incorporate "non-technical traffic-related" approaches to the problem.

2. PRESENT SITUATION

2.1 Environmental pollution caused by traffic

In 1987 traffic accounted for approximately 25% of total end energy consumption. In terms of emissions, the figures were 62% for NO\textsubscript{x}, 75% for CO, 53% for HC, 30% for soot particles and 20% for CO\textsubscript{2}. These values are primarily a result of road traffic, which

(1) accounts at present for 82% of passenger transport and 58% of freight transport in the Federal Republic of Germany at present and is on a rising trend;

(2) and whose specific energy consumption and emission rates are significantly higher than those of rail and waterway traffic.

The emissions of pollutants from the transport modes rail and inland shipping are comparatively low. Levels of emissions from air traffic, apart from in the vicinity of airports and flight paths to airports, are also minimal at present. Nevertheless, due to the sudden sharp rise in air traffic and the emissions of pollutants at high altitudes, they are becoming increasingly relevant in terms of the environment. In terms of noise pollution, however, air and rail traffic are very significant.
The following paper on the present situation of the most important traffic-related forms of pollution and probable future trends will concentrate on road traffic as the major culprit.

2.1.1 Traffic trends

All traffic volume prognoses to date, including the recently published one, have been based on the assumption of degressive trends. These assumptions have rapidly been overtaken by reality. For example, the mileage assumptions for cars in the year 2000, used for calculating emissions in the 4th Report on Environmental Standards, which were based on prognoses made in 1985, had already become reality by 1987. In April 1990 the DIW (Deutsches Institut für Wirtschaftsforschung – German Institute for Economic Research) published a new prognosis for car trends up to the year 2010. Table 1 summarises the fundamental information contained in this report, which has taken into account future trends in East/West traffic.

Table 1: Trends in car data
(Source: DIW weekly report no. 14/90)

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<th>Unit</th>
<th>1979</th>
<th>1982</th>
<th>1987</th>
<th>2010</th>
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<tr>
<td>Vehicle stock¹)</td>
<td>Millions</td>
<td>18.9</td>
<td>24.1</td>
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<tr>
<td>Total mileage</td>
<td>Bill. km</td>
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<td>Average mileage</td>
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<tr>
<td>Average distance per trip</td>
<td>km</td>
<td>16.0</td>
<td>17.1</td>
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<tr>
<td>No. of passengers transported</td>
<td>Millions</td>
<td>25,973</td>
<td>26,665</td>
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<tr>
<td>Passenger kilometres</td>
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<td>Car trips</td>
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<td>19.096</td>
<td>20.536</td>
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¹) Cars and estate cars
Source: Federal vehicle licensing office, calculations by the DIW

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The modal split trend in the last 20 years (fig. 1) shows that the overall increase in traffic was accounted for entirely by road and air traffic. This trend will continue in the future unless counter-measures are taken. It puts an increasingly one-sided strain on the transport infrastructure with the familiar overload and congestion situation on motorways and urban roads.

As far as freight transport is concerned economic growth and structural change have been accompanied by an overproportional increase in road freight transport (fig. 1). The Single European Market and new East-West relations will generate additional transport streams.

The stock of commercial vehicles, which produce higher emissions of pollutants and noise than other forms of road and rail traffic, will continue to increase. The volume of long-distance freight transported by road has almost tripled in the last 20 years (1967: 34 billion tkm; 1988: 106 billion tkm - fig. 1). The annual rates of increase are at present around 4 %. In this period the proportion of goods transported by road increased from 37 % to 55.4 % - most of this at the expense of rail transport.

The mileage of the lorry fleet (commercial vehicles over 3.5 tonnes gross weight) will probably increase from 26.7 billion km in 1985 to around 40 billion km in the year 2000. The introduction of the Single European Market could have the effect of increasing the already existing growth dynamics.
Figure 1: Trends in transport volume in passenger and tonne kilometres
2.1.2 **Air pollution**

There is a general consensus that substances emitted from motor traffic pollute the air and can endanger the environment and human health. Attention should be drawn in this context to carcinogenic substances but also to nitrogen oxide and hydrocarbons, which are a major factor in the "new forest damage", particularly as they are precursors to oxidants such as ozone. Ozone also impairs the growth of agricultural crops and in times of high radiation during the summer months is also harmful to human health. The substance of highest environmental relevance is CO₂ which affects the climate. The traffic-related emissions of CO₂ are increasing each year.

Table 2 shows the emissions calculated for the years 1985 - 1989, 1998 and 2005 for the pollutants CO, HC, NOₓ, soot particles, lead, SO₂, and CO₂ and the fuel consumption calculated. For the purposes of comparison emissions from stationary sources (power stations, industry, households and small consumers) have been given alongside the emissions from traffic.

In the case of hydrocarbon emissions from cars with spark-ignition engines a differentiation has been made between exhaust emissions from the engine, evaporation from the tank and fuel system and emissions which occur during the distribution of fuel. The category "soot particles from stationary sources" contains only particulate emissions from combustion processes. The particle volumes from spark-ignition engines which are more than an order of magnitude lower have not been included due to a lack of measured data. The lead emissions from spark-ignition engines run on leaded fuel are given here as metallic lead. The CO₂ levels have been calculated from the fuel consumption figures.

The category "other forms of traffic" includes:

- civil and military air traffic
- shipping on inland waters
- rail traffic with diesel traction
- agriculture and forestry traffic
- military traffic (excluding air traffic)
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1) Rail Traffic with electro-traction included under stationary sources

Table 2: Air pollution and CO₂ emissions in the Federal Republic of Germany (rail traffic with electro-traction included under stationary sources)
Absolute values in 1,000 tonnes, CO₂ in million tonnes (as of: July 1990)

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The results presented here show a sharp decrease of some 50 % in emissions of CO and HC from traffic in the period between 1987 and 1998. This is a result of the legislation on technical means of reducing emissions (including closed-loop three-way catalytic converters in cars) introduced at this time which had a positive effect despite the sharp increase in traffic.

The reductions in nitrogen oxides and soot particles forecast are not so satisfactory. From 1987 to 1998 there was an overall drop in nitrogen oxide emissions of 32 %. However, the decrease in the traffic sector was only 24 % as compared to almost 50 % from stationary sources. The reason for this is the increase in NO\textsubscript{x} emissions from commercial vehicles between 1987 and 1998 which, according to this prognosis, should not have reached the 1987 value until the year 2005. The increase in emissions of NO\textsubscript{x} from commercial vehicles - caused by the fact that the expected sharp increase in traffic was not compensated by a reduction in pollutants comparable to that achieved for cars - is only partially compensated by a decrease in emissions from cars (closed-loop three-way catalytic converters) of approximately 50 %. It is striking that commercial vehicles are the greatest source of NO\textsubscript{x} in and after the year 2000.

The situation with soot particles presents a similar picture, although stationary combustion processes are the main culprit here. Nevertheless, despite the introduction of more stringent limit values, a decrease in particle emissions from commercial vehicles with diesel engines cannot be expected until the next century.

In view of the additional dangers posed by the anthropogenic greenhouse effect, the trend in CO\textsubscript{2} emissions which can be deduced from this prognosis must be seen as unsatisfactory. The sharp increase in traffic coupled with the small decrease in specific consumption which can be expected from the current situation will play a decisive role in the further increase in CO\textsubscript{2} emissions. As no technical means of reducing these emissions exist, a reduction can only be achieved by measures which affect the traffic directly. In the sector of commercial traffic the highest increase in CO\textsubscript{2} emissions calculated on the basis of this prognosis is 30 %. Here the sharp increase in
mileage, amongst other things as a result of the Single European Market, will take its toll. One of the main possibilities for bringing about a reduction in this area is to reduce traffic volumes, as the engines in today's commercial vehicles are already very economical in consumption and any further reductions in consumption would clash with NOₓ reduction technology.

2.1.3 Traffic noise

Traffic noise is perceived by the general public as a major form of environmental pollution. More than 60% of the entire population and 73% of city dwellers are disturbed by traffic noise. Although some motor vehicles, trains and aircraft have become quieter and the central government alone spent some 1.8 billion deutschmarks on noise abatement along major trunk roads in the Federal Republic of Germany, disturbance from traffic noise has increased as has the size of areas affected by noise. The main reasons for this are:

- higher traffic volumes
- new roads and transport facilities
- limited possibility for use and limited effect of passive noise abatement schemes.

Surveys carried out along roads badly affected by traffic noise (more than 65 dB (A) in the daytime) have shown that noise increases the risk of cardiac and circulatory disease. Almost 8 million citizens in the Federal Republic of Germany are exposed to levels of this kind.

17 million citizens in cities are exposed at night to exterior noise levels of more than 50 dB (A) and can only sleep peacefully with their windows closed. More than 20,000 km², i.e. 10% of the total surface area of the Federal Republic of Germany, next to roads outside towns and cities are exposed by levels exceeding 60 dB (A) which means that undisturbed recreation in these areas is impossible. This area increased by 30% between 1973 and 1985.

VTI RAPPORT 364A
Calculations of future trends in traffic noise show that due to the expected increase in traffic volume only the use of distinctly quieter cars and commercial vehicles can bring about any significant relief to the population.

2.1.4 Land consumption

The area of impermeable road surfaces has increased in the Federal Republic of Germany in the last thirty years by some 30%. The Federal Statistics Office puts the figure for the year 1985 (having included all areas - central reservations on roads, wasteland etc.) at 1.21 million hectares for roads, tracks, squares and other space used for traffic and arrives at a figure of 4.90% of the total surface area and 40% of the 3 million hectares of built-up area. Land consumption means loss of land available for vegetation, increase in impermeable land surface, carving up of countryside with the concomitant loss of habitats and further disturbance of the balance of nature as well as optical pollution in both towns and countryside.

2.1.5 Further forms of pollution

A number of other forms of pollution are caused by traffic. Without going into detail they are:

- Use of resources for automobile manufacture
- Waste management problems posed by scrap cars
- Soil and water pollution (e.g. from material which has worn off tyres and road surfaces by abrasion)
- Vibrations
- Damage from salt
- Changes to the topography and to the appearance of towns and the countryside
- Risks posed by accidents (transport and storage of dangerous materials).

Losses and inconvenience to the public brought about by almost 8,000 traffic fatalities per year and more than 400,000 casualties (1987) and losses to the economy
(costs of accidents according to calculations by the Federal Highways Office totalled 49 billion deutschmarks in 1986) have not been included here.

3. MEASURES

It is obvious that further measures to counteract the pollution of the environment by traffic are absolutely essential. In setting priorities the well-known axioms of environmental policy:

\[
\text{Avoidance before reduction at source} \\
\text{Reduction at source before passive protection technology}
\]

should be adhered to.

In addition to the introduction of technology in vehicles to reduce emissions and levels of pollution in the environment measures which influence the traffic are now gaining in importance.

As it is still the case that in the short term technological measures produce faster results which are easier to calculate than anything undertaken in the field of urban planning or transport planning they are still being favoured. However, as the possibilities for technological modifications to vehicles are gradually being exhausted, the traffic-related measures which tend to take effect in the medium or long term, are gaining significance.

3.1 Vehicle technology

In reducing levels of pollutants and noise in the environment the following approaches should be adopted both on a national and European level:

- Continued reduction due to improved vehicle technology and better quality fuel

- Reduction due to environmentally friendly driving behaviour (accompanied by appropriate vehicle technology, monitoring technology, driver education, road traffic management, traffic and transport planning)
Reduction due to maintenance and prevention of subsequent tampering with the vehicle

- Noise reduction by appropriate design of tyres and road surfaces

Since motor vehicles are the major source of pollutants priority must be given to measures relating to road traffic. In doing so, however, emissions from aircraft, diesel locomotives and ships which must also be reduced, should not be neglected.

To reduce noise pollution it is vital that measures be taken for road, air and rail traffic.

3.1.1 Reduction of emissions of pollutants from motor vehicles and of fuel consumption

The following vehicle design measures to reduce energy consumption and emissions of pollutants are the most important approaches which must be adopted within the EEC:

- Translation of the basic policy decisions taken by the EEC environment ministers into formal resolutions (EEC Directives) to ensure that limit values are laid down as soon as possible requiring closed-loop catalytic converters in all vehicles with spark-ignition engines regardless of engine displacement.

- Measures to monitor emission behaviour of in-service vehicles with the aim of ensuring low emissions of pollutants throughout the lifetime of the vehicle.

- Setting/updating limit values for diesel vehicles, with the principal aim of reducing particulate emissions and NO\textsubscript{x}. A reduction in emissions from commercial vehicles is of high priority in view of the increasing share of NO\textsubscript{x} and particulate pollution.

- Adopting limit values and regulations for lightweight trucks similar to those applicable to cars.
- Measures to reduce emissions of hydrocarbons including evaporative and fuelling losses.

- As a necessary complementary measure to engineering design the quality of fuels must be improved by the introduction of fuel standards (reduction in the benzene content in petrol, improved quality of diesel fuel).

- For the effective reduction of fuel consumption and consequently of CO₂ emissions legislation must be introduced pertaining to the fuel consumption of individual vehicles and of the fleet. These regulations should be continually tightened up.

The following measures can be implemented on a national level until all that is technically possible has been laid down as a standard requirement in the EEC. Until this is achieved they can be used to prepare for the implementation of further reaching EEC directives.

- Incentives for all new spark-ignition cars and estate cars and light trucks to be fitted with closed-loop three-way catalytic converters and retrofitting of as many existing vehicles as possible with catalytic converters by introducing:
  - financial incentives and tax relief schemes
  - obligations on the manufacturer
  - advantages for the user
  - advertising and public information campaigns

- Incentives for the development and increased use of vehicles with low fuel consumption by:
  - increasing taxes at the petrol pump
  - introducing a "CO₂ tax"
  - replacing road tax for motor vehicles by an exhaust emission tax varying according to emission levels

- Encouragement of driving behaviour which produces low fuel consumption and low emissions by:
  - appropriately designed and equipped vehicles
  - public information and education
- Extension of the existing periodic inspections of exhaust emissions to all motor vehicles (trucks, diesel cars and cars with catalytic converters)

3.1.2 **Reduction of traffic noise**

Measures to reduce traffic noise are necessary for air and rail traffic as well as road traffic.

To reduce road traffic noise the EEC limit values for cars, trucks and buses must be made more stringent as the regulations which came into force for cars on 1.10.1988 and for trucks and buses on 1.10.1989 do not make full use of the technical possibilities for reducing noise from vehicles. It is essential that limit values be tightened up particularly for trucks. The values set down as the national definition for low-noise vehicles in Annex XXI to the Motor Vehicle Licensing Act could be taken as limit values.

The following measures could be implemented on a national level to reduce noise from road traffic.

- Promotion of low-noise vehicles of all categories by introducing schemes such as user advantages, labelling of low-noise vehicles, recommendations by automobile associations, purchase guidelines

- Roadside checks particularly of motorcycles

- Passive noise abatement schemes

- Reduction in road/tyre noise

Due to the international nature of air traffic any measures to reduce aircraft noise at source can only be implemented through international agreements. They are essential since passive measures are only effective in localised areas.

Examples of measures for reducing aircraft noise which could be implemented on a national level are:

- Encouraging the use of low-noise aeroplanes by introducing user incentives
Further optimisation of landing and take-off procedures to incorporate environmental considerations

Extension of the requirement for passive noise abatement schemes to cover buildings near airports.

Noise pollution from rail traffic is quite high at present. The problem is particularly severe at nighttime, the period when freight is usually transported and when noise levels from road traffic — usually the dominant noise source — are only slightly higher than those from rail traffic. In order to reduce these levels in the near future, intensive measures are needed for the existing rail transport system (carriages, locomotives, routes, passive noise abatement measures) as well as planning and design measures for new routes. This will gain in importance as more attempts are made to shift transport services from the road to rail. When developing new rail transport facilities the fact that noise increases out of all proportion to speed should be taken into account.

3.2 Traffic-related measures

The reductions required cannot be achieved using vehicle technology alone. The measures listed below which influence traffic can bring about significant additional reductions - both in noise levels, air pollution and other forms of environmental pollution. There are two distinct categories of measure:

- Those which influence traffic volume and
- Those which promote environmentally friendly traffic management

Measures by urban and regional planners which take a preventive approach to environmental protection can have an important influence on traffic volume. In view of the continuing trend towards population migration out of the city, increase in leisure activities and the increase in economic processes in which the labour force is not bound to any particular place, these measures cannot be very effective in reducing overall emission levels in the short term. They do, however,
counteract tendencies which generate traffic and thus contribute in the longer term to traffic avoidance and thus to restriction of environmental pollution.

The main way of reducing emissions in the short and medium term is to implement measures which bring about changes in transport modes. Calculations of the reduction of air pollutants from traffic which can be achieved by modal split changes of realistic magnitude have shown that these kinds of measures can utilise a reduction potential up to the year 2000 which can compensate to a large extent for the increased pollution generated by rising traffic volume.

The following schemes and strategies can be introduced to encourage people to use environment-friendly modes of transport such as bicycles, public transport, or their own feet:

- Fees or taxes on transport systems based on the polluter-pays-principle
- Tax and investment incentives to influence the choice of transport mode and the occupation rates of vehicles
- Management of parking, reducing parking space and restriction of access for cars
- Improvements in the organisation and services offered by the German Federal Railways and local public transport companies
- Planning and promotion of systems to coordinate and combine different means of transport.

Even if these measures to influence traffic volumes are implemented comprehensively and effectively, road traffic will continue to be one of the major forms of nuisance. Any traffic which cannot be avoided must therefore be dealt with by traffic and transport planning policies and organisational approaches which are as environmentally friendly as possible. The most important of these are measures to promote smoother traffic flow and reduce the speed of road traffic.

Measures relating to private motor traffic which can be implemented relatively quickly and cheaply include:
- Environmental traffic management schemes
- Monitoring of traffic and of individual vehicles
- Coordinated traffic lights
- Measures to influence traffic behaviour
- Avoidance of traffic circling in search of parking space

Other measures relate to environmentally friendly organisation of (local) freight transport and other management strategies to increase the effectiveness and attractiveness of the green modes of transport and above all measures to link up different modes of transport in a way which can benefit the environment.

Examples of measures which can make public transport more attractive include:

- Measures to reduce journey times by eliminating sources of hold-ups
- Better operations management
- Improved information for passengers and better marketing
- Different use models tailored to particular places and times of day

Non-motorised traffic can be made more attractive by improving pedestrian and bicycle schemes such as:

- Establishing large-scale, self-contained cycle path and footpath networks
- "Traffic calming" schemes
- Setting up parking facilities for bicycles
- Surveillance of foot paths and cycle paths to prevent parking offences
- Revoking right of way regulations for cars (e.g. at traffic lights)
- Allowing bicycles to go along one-way streets in the "wrong" direction
- Specially signposted routes for pedestrians and cyclists

Each system of transport has an area where it is most effective. The aim of all measures should be to optimise each system not in isolation but in a way that it contributes to a high-quality, environmentally friendly overall system. In order to attain an environmentally friendly system of routes and transport chains the first priority must be to create intersections between them or improve the functioning of existing ones. The main areas for concern are:

- Coordination of private cars and public transport
- Link between bicycle traffic and public transport
- Linking of modes of transport for freight

There are no generally valid ways of implementing town planning schemes to influence traffic volume nor the possibilities mentioned above for more environment-friendly traffic management. Local authorities must develop their own concepts tailored to local conditions. This requires close co-operation between all departments involved.
4. SUMMARY

Traffic is the main cause of environmental pollution in terms of air pollution, noise and land consumption.

New forms of technology and increasingly stringent environmental regulations have meant that vehicles and transport facilities which are more environmentally benign have been built and put into service. The increase in traffic, however, has offset the benefits of this. The potential for reducing pollution by technological means has not yet been exhausted but it is already evident that technical solutions alone cannot achieve the required reduction in environmental pollution caused by traffic.

The increase in traffic with the concomitant additional damage and risks means that clear priorities must be set and measures implemented in the field of environmental and transportation planning based on the mandatory obligations to avert danger and take a preventive approach to environmental protection. Measures are required in the following areas:

(1) Further reduction in emissions from vehicles - particularly from commercial vehicles - along with reduction in energy consumption and CO$_2$ emissions by exhausting all feasible technological vehicle modifications

(2) Reductions through measures which influence traffic

(3) Transport infrastructure planning which is based on the Federal Conservation Act and preceded by a comprehensive environmental impact study which focuses above all on the question of whether the planned scheme is really necessary.

(4) Financing and inter-department development and implementation of measures to reduce the harmful effects of traffic on the environment

The measures required can only be implemented successfully if appropriate scientific studies are carried out before and during their implementation. There is a marked deficit in the area of traffic-related measures.
Status Report from the Netherlands

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and

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The Netherlands
This paper will present some data on the environmental impact of road traffic in The Netherlands.

Road density in The Netherlands is one of the highest in the world and amounts about 2.8 km of road per km² [1]. These roads are used by about 135 cars per km², travelling on the average about 15000 km per annum each. In addition to this private transport system The Netherlands have a high quality public transport system consisting of 2900 km of railways and many buses and streetcars [2].

The high population density in the western part of the country together with the intensive economic activities cause large traffic jams each day. Nevertheless the use of cars in The Netherlands now increases by about 5 % annually. The Dutch government decided to decrease the growth rate to such an extend that by the year 2010 the car density stabilizes at about 170 cars.km⁻² [3].

This paper discusses the environmental problems connected with the use of private cars in the Netherlands and the policy of the Dutch local and central authorities to deal with these problems. The following aspects will be discussed:
- primary and secondary air pollution due to use of cars;
- environmental noise;
- use of natural and city space for parking and driving cars;
- life cycle of automobiles and the embodied materials from construction to demolition.
Some conflicting scenarios concerning long term development of transportation systems will be discussed.

Finally this paper will deal with some aspects of choosing behaviour of people between use of public or private transport systems. It will be argued that measures based on changing relative costs of using both systems.

1. INTRODUCTION

Like in many other developed countries, the number of cars present in the Netherlands increased to an enormous extent since the early sixties. Since all these cars are bought to be used by their owners, a simultaneous increase of the space used by roads occurred. The number of cars and the length of road per inhabitant are in the Netherlands comparable to those in other Western-European countries. As a consequence of the high population density in the country, road density now is one of the highest in the world and amounts about 2.8 km of road per km² [1]. These roads are used by about 135 cars per km², travelling on the average about 15000 km per annum each. In addition to this private transport system The Netherlands have a high quality public transport system consisting of 2900 km of railways and many buses and streetcars [2][3].

The high population density in the western part of the country together with the intensive economic activities cause large traffic jams each day. Nevertheless the use of cars in The
Netherlands now increases by about 5% annually. The Dutch government decided to decrease the growth rate to such an extend that by the year 2010 the car density stabilizes at about 170 cars.km⁻² [4]. Figure 1 presents some of these data graphically.

The environmental movement in the Netherlands has developed an alternative scenario [5], aimed at a drastic decrease of mobility, reducing the number of cars in 2010 to about 20% of the number expected by the government (dashed lines and open symbols in Figure 1).

This paper first describes the environmental problems of road traffic in the Netherlands (section 2). Section 3 deals with the measures to influence mobility.

<table>
<thead>
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<th>Table A</th>
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2. ENVIRONMENTAL PROBLEMS

2.1 Primary and secondary air pollution due to the use of cars

The main sources of air pollution in the Netherlands (taken from the national emission inventory [6]) are indicated in Table A. Road traffic is the largest contributor to the carbon monoxide, nitrogen oxides and hydrocarbon emissions. Nitrogen oxides together with sulphur dioxide are major compounds involved in the acidification problem. Road traffic therefore attributes significantly to the acidification of soil and lakes.

Emissions during recent years [2, 3] are represented in Figure 2. Despite the steady increase of the intensity of road traffic, emissions of air pollutants stabilize or even decrease somewhat since the 1970's. This is due to the improved efficiency of car engines (carbon monoxide, hydrocarbons) and to regulations concerning emissions of engines (nitrogen...
emission (million kg per annum)

Figure 2 Changes in emissions of air pollutants from road traffic since 1960 (Source [2, 3]).

Figure 3 present the spatial distribution of emissions of carbon monoxide and nitrogen oxides. With the exception of heavily industrialized regions (Rotterdam/Rijnmond area and IJmuiden) and near electricity generating plants the emissions of these compounds by road traffic are much higher than those by industry. These figures also show that the highest emissions occur in the western part of the country.

Figure 3 Carbon monoxide (left) and nitrogen oxide (right) emissions due to road traffic (left, closed bars) and industry (right, open bars) in 1983 per square of 20 x 20 km² [6].

Nitrogen oxides and hydrocarbons are precursors of photochemical smog. When these compounds are present in the atmo-
Figure 4 Formation of ozone during the day in summer. The plots give averaged ozone concentrations at different hours. Data from [?]

sphere and the intensity of sunlight is high enough, complex chemical reactions take place, resulting in the formation of oxidizing molecules. Ozone is one of these oxidizing substances. Figure 4 (from [7]) shows the formation of ozone during the day and its disappearance during the night. Photochemical smog of this oxidizing type now is formed each summer as soon as the weather is nice and reaches concentrations which are rather bothersome for people with lung diseases.

From Figure 2 it is concluded that the emissions of air pollutants due to road traffic have stabilized or even decreased since the 70's, despite the continuing growth of the road traffic system. The official scenario's expect to continue this trend. This will be achieved by introducing more severe emission standards: increase of the energy efficiency of cars, use of three way catalysts and unleaded fuels.

2.2 Annoyance

A second environmental problem caused by road traffic is annoyance caused by noise and malodour.

Environmental noise
Apart from noise by neighbours, road traffic is the most important source of environment noise ([8], Figure 5). About half of the Dutch people report being annoyed by noise from road traffic. No drastic changes in this number are expected in the future. Additional measures indicated by the dotted bars for 2010 are aimed at a reduction of the use of private transport
and an increase of the use of public transport systems. It is assumed that the use of private cars in 2010 is equal to that in 1985 [8] in this case. When these additional measures will be implemented, noise annoyance by road traffic will be reduced to about 30% of the population.

Odour
A second source of annoyance associated with road traffic is annoyance by stench. The odours stem both from the exhaust gasses and from the evaporation of gasolines from fuel tanks and filling stations. In 1985 about 20% of the dwellings in the Netherlands is exposed to some kind of malodour. In about 7% of the houses odour annoyance is attributed to road traffic [8]. It is expected that in 2010 still about 16% of the dwellings will be exposed to stench. The malodour caused by
traffic will occur in again about 7 % of the dwellings. With additional measures, such as a more stringent standards on the emission of (reactive) hydrocarbons might reduce this number to about 5 % [8].

2.3 Use of natural and city space for parking and driving cars

The space needed by 5 million cars, present in the Netherlands in 1990 and each about 5 m long and 2 m wide, is about 50 km², representing 0.15 % of the total available land area in the Netherlands. This does not seem to be to large a problem. However cars need space to be used. In 1985 the space available to traffic was about 1300 km² or 3.6 % of the total area [2, 3]. Assuming an averaged lane width of about 4 m, the 5 million cars will be on the average 65 m apart (both parked and used). This indeed means a very crowded system. A figure to illustrate the intensity of road traffic in another way is obtained by realizing that 5 million cars, travelling 15,000 km per annum each on about 100,000 km of road, mean an averaged flux of 80 cars per hour.

The infrastructure available for road traffic in the Netherlands now consists of about 100,000 km of road and increased with about 40 % as compared to 1965 (Figure 7). About half of these roads are situated within cities and other builted areas. The number of cars increased in the same time span with 280 %. A regression between length of road and number of cars shows that every additional car has lead to an increase of the length of road of about 8.4 m.

2.4 Energy use

As advertisements promise the specific energy use for driving cars must have been reduced from about 10 km per litre in the
60's to about 15 km per litre now or even better. The actual developments in (direct) energy use by cars are given in Figure 8. The increase in energy use in the early 70's has been reversed due to the energy crisis. A significant reduction of energy use however has not taken place. This might have different reasons:

a) the present cars on the average are larger and faster than those of the 60's and 70's. Energy use per kilometre increases at higher weight and higher speeds.

b) Cars are much more sophisticated: they are equipped with many features to improve the safety and comfort for driver and passengers. Many of these features are required to meet regulations. Every additional feature however increases the energy need of the car.

c) The roads have been improved both in available length and in quality and, which allowed people to indeed use the higher power of their cars.

Figure 8 shows that the official expectations are that energy efficiency of cars will improve in the future.

2.5 Life cycle of automobiles and the embodied materials from construction to demolition.

Apart from the use of cars environmental problems also stem from the construction and the demolition of cars. This section will qualitatively deal with these problems. A quantitative description using a life cycle model will be published in [9].

The life cycle of a car is schematically given in Figure 9. In this scheme a car is conceived of as a device constructed from a number of materials: iron, zinc, aluminium, a number of other
metals in (micro)alloys, plastics and so on. Air pollution occurs in the surroundings of the primary production plants (the smelters) where raw materials are produced from ore and from recycled material.

The environmental problems of using the car have been discussed in section 2.1. After a number of years, a car will be discarded and dismantled. Part of the materials are recycled into the metal smelters, either directly or after shredding. Part of the materials however are not recycled but leak into the environment.

Since 1975 much effort has been invested in lowering the energy use in driving cars. This has been primarily done by decreasing the weight of automobiles: iron has been replaced by aluminium and plastics. In Figure 10 (data from [10]) it is shown that the use of aluminium and plastics has grown faster than the use of iron and steel in German cars. This replacement of iron and steel has also increased the lifetime of cars. Corrosion of the remaining iron parts has been further postponed by using zinced steel. In recent years electronic regulating devices are mounted in the newer models, both to improve the specifications of the car and because the addition of exhaust gas cleaning equipment requires a more precise functioning of the engine. The result is that a car develops into a device with a more complex composition. Separation of this mixture of materials also becomes more complicated. As a result of these developments the recycling of materials used in cars is becoming harder and harder. It is very difficult and very energy intensive to separate the different metals used in a car. It is virtually impossible to separate metals like zinc, chromium, vanadium and niobium from the bulk of metals. The
aluminium alloys can only be reused in certain applications.

The limited possibilities for recycling of materials embodied in cars thus yields two environmental problems:

a) partly irreversible use of the worlds limited resources of metals and energy; and

b) a certain fraction of the used car cannot be fed back into the system and has to be dumped. This fraction consists of a mixture of metals, oily products, paint, plastics and so on which might give rise to severe pollution of soil and ground waters below the waste dump.

In the Netherlands now about 455,000 (750.10^6 kg) cars are discarded each year [2, 3]. About 450.10^6 kg material is now recycled. To dump the remainder about 4.5 km^2 of car dumps are in operation.

3. MOBILITY BY PRIVATE OR PUBLIC TRANSPORT

3.1 The governments view: decreasing the use of cars

Above it was stated that the Dutch government plans to reduce the growth of road traffic to such an extend that the system will stabilize around 2010. Figure 1 shows that these plans aim not so much at the stabilization of the number of cars owned by people, but at stabilization of mobility by car at a level of about 6000 car*km/person/annum. This means that people still will be allowed to buy cars and that policy must be aimed at decreasing the use of these cars. So, if the number of cars still increases in 2010, as is suggested by Figure 1, each car should be used less and less to keep mobility by car constant.
Since the growth of total mobility (private plus public transport systems) is assumed to be more or less a law of human nature, the Dutch government thus aims at a shift of the choice each person makes between using his own car or a public transport system. This choice must be made each time he wants to go from one place to another.

There are different ways the government tries to influence this choosing behaviour especially with respect to the daily travel between the home and the working place:

a) tax measures aimed at increasing the costs of the daily trip from home to work by private car and decreasing (or not increasing) the costs of public transport.

b) influencing the costs of car use by means of automatic toll systems in highways and by a shift from taxes on purchasing automobiles towards taxes on fuels.

c) new locations for houses and working places will be located near high quality public transport facilities; at the same time the facilities for parking and using private cars in cities and business locations will be decreased.

With these measurements the official plans assume that, if choosing private transport is made less attractive as compared to public transport, a number of people will change behaviour and leave their cars parked in stead of using them. It is our opinion that this assumption is rather naive. It is hard to believe that people will spend about $10000 to buy a car and not use such a precious possession whenever they can. Moreover, history shows that substantial increases in fuel costs have not influenced the growth of the road traffic system to a great extend. Private transport continued to grow faster than the public transport systems. In Figure 1 the effects of the energy crises of 1973 and 1980 can hardly be recognized although the first crisis caused fuel prizes to double within a few months. The assumption that people used their cars regardless of the (direct) costs associated with this use is at least as probable. Apparently other reasons are important in choosing behaviour than costs.

3.2 The environmentalists view: decreasing the number of cars

The low mobility scenario of the Dutch environmental movement [5] chooses a different approach. This scenario has been based on the necessity of meeting environmental standards and goals. To achieve this goal mobility has to be drastically decreased. This scenario aims at a drastic reduction of the number of private cars present in the Netherlands. The use of the remaining cars is comparable to the use in the 1960's and 1970's (Figure 1). A very large part of all movements of people in this scenario has to be performed by using other means that private cars: public transport, bicycle and walking. The
scenario assumes that the number of movements equals that of the 'official' scenario, but that the distances covered by these movements decrease. The total time each person spends in travelling stays constant. It is concluded that such a system is technically and economically conceivable [5].

Although no indication is given about the implementation of the low mobility scenario, other than that the government has to make rather drastic decisions, this scenario has a few advantages above to the official one:

a) environmental pollution due to road traffic decreases to a level which meets environmental standards.

b) the scenario does not suppose that people still will buy cars but not use them whenever they please.

A draw back of this scenario of course is that it requires a rather drastic change in policy in a direction which is not popular. People like to have and to use cars. It might be a collective interest to decrease the use of private transportation, it certainly is not conceived of as in the interest of every individual. It is far from certain that in a democratic system politicians will be prepared to choose drastically for the collective interest of a sustainable future with a good environmental quality. Politicians want to be reelected after 4 years.

[2] Centraal Bureau voor de Statistiek (1990), Algemene Milieustatistiek (General Statistical Data concerning the Environment; In Dutch), CBS, Den Haag; and earlier publications in this series.
[3] Centraal Bureau voor de Statistiek (1986), Luchtverontreinigingsemisssies door wegverkeer (Emissions of air pollutants by road traffic; In Dutch), CBS, Den Haag; and earlier publications in this series.
