Finnra

Finnra's Traffic Management Research Programme

Summary of publications 1993-1997

Finnra Reports

20/1998

Helsinki 1998

Finnish National Road Administration
Traffic Services

Finnra Reports
20/1998

Finnra's Traffic Management Research Programme

Summary of publications 1993-1997

Finnish National
Road Administration

Helsinki 1998

ISBN 951-726-429-1
ISSN 0788-3722
TIEL 3200511E

Oy Edita Ab
Helsinki 1998

This Publication is available from:
Finnra, Library
Telefax int +358 204 44 2652

Finnish National Road Administration
Traffic Services
Opastinsilta 12 A
P.O. Box 33
FIN-00521 Helsinki, Finland

Finnra's Traffic Management Research Programme. Summary of publications 1993-1997. Finnra reports 20/1998. TIEL 3200511E, ISBN 951-726-429-1, ISSN 0788-3722. Finnish National Road Administration, Helsinki 1998.

Key words traffic management, traffic control, traffic and traveller information, demand management, transport telematics, intelligent transport systems

ABSTRACT

This report contains summaries of reports published under Finnra's Traffic Management Research Programme during 1993-1997. In Finnra, traffic management is defined to cover traffic control, traffic and traveller information and short-term demand management functions. The emphasis of the programme is on intelligent transport systems, i.e transport telematics based traffic management services.

Chapter 1 contains general studies:

- The future of road transport telematics in the Nordic countries, 1993
- Preparations for "DRIVE III", 1994
- Road Transport Telematics – techniques, effects and assessment, 1995
- Telematics of road transports, 1995
- Energy consumption and emissions of motor vehicles in urban traffic, 1994
- Traffic management in the Helsinki Metropolitan Area. A preliminary study, 1994
- The impacts of road traffic congestion and their costs in the Helsinki metropolitan area, 1994
- Traffic flow on low-speed two-lane roads in Finland, 1996
- Effects of weather on driving speeds, 1995
- Traffic management applications toolbox, 1997
- Finnra's strategy for traffic management, 1997
- Finnra's VIKING programme, 1997
- Road transport telematics terminology, 1997

Chapter 2 summarises studies on data collection:

- Preliminary study on possibility to detect the tire/road friction level onboard, 1994
- Traffic monitoring and incident detection, 1995
- Road traffic monitoring preliminary study, 1996
- An integrated monitoring station. General functional requirements, 1996

Chapter 3 contains studies on traffic centres and information systems:

- The tasks and the functions of the traffic management centre in Finnra Uusimaa Region, 1996
- The traffic management centre of Finnra Uusimaa region: Reference groups and principles for data exchange, 1997
- Description of a logical service database, 1997

Chapter 4 focuses on traffic information:

- Finnra driver information services. Development study, 1993.
- Finnra's guidelines for road-user information, 1994

- Perception of traffic conditions and traffic information - a road user survey on two lane roads, 1996
- Drivers' information needs, 1996
- Finnra's concept for Travellers' points of information, 1996
- Assessment of Finnra's traffic information services – survey questionnaires and instructions, 1997-98

Chapter 5 includes studies on traffic control:

- Comprehension of variable message signs for road conditions, 1993
- The effect of a speed display on driving speed, 1993
- Effects of display units indicating driving speed and safety distance between vehicles, 1995
- Behavioural effects of slippery road variable warning signs in Turku region in winter 1993-1994, 1995
- The effect of variable road condition warning signs, 1996
- The influence of route guidance system on highway 4 between Järvenpää and Mäntsälä, 1995
- Kotka-Hamina weather-controlled road. Project report, 1995
- Weather-controlled road and investment calculations, 1995
- Socio-economic profitability of weather-controlled road, 1995
- Evaluation of the lane control system on Kalla bridges in Kuopio, 1995
- Safety evaluation of incident warning systems. Integration of results. HOPES project, 1995
- Guidelines for the use of variable message signs in Finnra, 1996
- Effects of technology of variable speed limit signs on speed behaviour and recall of signs, 1996
- Effects of the weather controlled traffic management system in the motorway section between Kotka and Hamina, 1997
- The socio-economic profitability of the Kotka-Hamina weather-controlled road, 1997
- Driver responses to variable road condition signs, 1997

Chapter 6 on demand management contains the summaries of the following studies:

- Lane arrangements for High Occupancy vehicles, 1994
- Study on the German "Statt-auto"-concept, 1995
- Plan for park-and-ride in the Helsinki region, 1994
- Sudies on park-and-ride in the Helsinki region, 1996
- Demonstration of - Adept 2 project, 1997-98

And finally, Chapter 7 summarises studies on methods for assessment of the effects of road transport telematics:

- Transport telematics – techniques, effects, assessment, 1995
- Guidelines for Assessment of Transport Telematics Applications in Inter-Urban Traffic Management and Information, 1994
- Simulation as a tool in assessment of transport telematics, 1997

FOREWORD

This report contains summaries of reports published under Finnra's Traffic Management Research Programme during 1993-1997. Some of the studies were carried out in co-operation with other organisations (such as the Ministry of Transport and Communications, Helsinki Area Metropolitan Council, Nordic Road Association, etc).

Finnra´s Traffic Management Research Programme was initiated in 1993 for the years 1993-1996. Traffic management was defined to cover traffic control, traffic and traveller information and short-term demand management functions. The emphasis of the programme was on intelligent transport systems, i.e transport telematics based traffic management services. The objectives of the programme were to

- assess the suitability and effects of different traffic management applications in Finnish circumstances
- estimate how widely the Finnish transport problems can be settled with traffic management
- make traffic management know as a new tool for road and traffic operators.

After 1996, the Traffic Management Research Programme has been continued on a year-to-year basis.

In 1996, Finnra initiated a three-year (1996-1998) large-scale field trial and demonstration on the road E18: Road transport telematics – E18 test area. The results of the E18 demonstration project will be reported separately in early 1999. However, this publication contains summaries of some reports produced by the E18 test area in already in 1996-1997.

This publication also contains information on some traffic management pilot projects carried out by Finnra's regions outside the Traffic Management Research Programme.

Several studies described here and realised after Finland joining the European Union in 1995, have been granted European Union financial aid in the field of Trans-European Networks – Transport (TENT-T) or under the 3rd or 4th Framework Programme.

In Helsinki in April 1998,

Finnish National Road Administration
Central Administration, Traffic Services

CONTENTS

1 GENERAL

1.1 The future of road transport telematics in the Nordic countries (1994)

Nordic Road Associations Committee 53 "Traffic information systems" conducted in 1993 a Delphi study on the future needs and possibilities of RTI (Road Transport Informatics) in Nordic countries (Denmark, Finland, Norway and Sweden. The third round of that study was a seminar in Helsinki on October 28th and 29th, 1993.

The conditions in Nordic countries differ from those in Central Europe with regard to e.g. traffic volume, trip length and weather conditions. It is not obvious that applications suitable for Nordic conditions will be developed in European research and development.

The objective of this study was to support preparation of RTI-strategies and to work as a tool in bringing forth common Nordic conceptions.

Through the study it was possible to bring together 60 experts' views on the development and effects of RTI-applications. The Delphi methodology proved to be successful.

Experts' views on the development of the applications, their importance in Nordic countries and their major effects were considerably similar. However, it must be noted that most of the participants were experts in traffic control and information systems and they could be somewhat biased in assessing the importance of their own field.

Most of the participants believed in economic growth and increasing traffic volumes. It was believed that traffic safety will improve and emissions will decrease.

The technical development of RTI is rapid. Most applications were thought to be ready for use already within five years. According to the participants every other application will be taken into use in major urban areas in the Nordic countries within ten years. The first to come are information systems, road pricing and fleet management systems.

The participants believed in the use of RTI in solving traffic problems. However, the variation in the answers indicate an uncertainty. RTI was believed to improve traffic safety, alleviate congestion problems, increase driving and travel comfort and make the use of transport fleet more efficient

RTI-applications were in general regarded as good tools. The importance of each application and their relative priority depends on the particular traffic problems. Most applications have effects on many traffic modes and journey types. Effects can also be contradictory.

Liikenteen informaatiotekniikan (RTI) tulevaisuus Pohjoismaissa. Delfoi-tutkimuksen yhteenveto. [The future of road transport telematics in the Nordic countries, a Delphi study]. Pohjoismaiden Tieteknillinen Liitto, Suomen osasto. Sisäinen raportti nro 4/1994. ISBN 951-47-9456-7. Nordic Road Association, Internal report 4/1994, Helsinki 1994.

1.2 Preparations for "DRIVE III" (1994)

When Finland joined the European Economic Space (and later the European Union) it became possible for Finland to participate equally in European research and development programmes together with other EU countries.

In 1993, the Ministry of Transport and Communications, Finnish National Road Administration (Finnra) and Technology Development Centre Finland (TEKES) started to plan Finnish participation in transport telematics EU research and activate research institutes and industry.

A questionnaire was sent to various companies and research institutes in the branch. The companies' interest to participate in EU's research and development projects, their special capabilities and former experiences in development projects were asked.

Finally, Finland's transport telematics strategy in European R&D was sketched based on the answers to the above mentioned questionnaire, experiences in the preceding DRIVE programmes and general traffic, research and industrial objectives. Along with these, key areas of research and development were defined. In addition, recommendations on how to plan, coordinate and finance the participation were given.

DRIVE III -ohjelmaan valmistautuminen. [Preparations for "DRIVE III"]. Liikenneministeriön julkaisuja 23/1994. ISSN 0783-2680. Ministry of Transport and Communications. Helsinki 1994.

1.3 Road transport telematics - techniques, effects and assessment (1995)

Telematics is the part of information technology that consists of both data communications and data processing. The term road transport telematics covers a large number of applications for collecting and processing data about road conditions, traffic and travel, as well as using these data in traffic control, informing travellers, controlling transport fleets and single vehicles. Transport telematics is a means of traffic management, which, in turn, aims at affecting travel demand, modal split, route choice and trip timing, and users' behaviour in a way that improves tranport efficiency, economy and safety and reduces harmful environmental impacts caused by traffic.

This literature study gives an overview of international research programmes like ATT and IVHS, applications of transport telematics, their effects, and assessment methods. The report also includes an English-Finnish glossary of road transport telematics terminology.

Expectations for the positive effects of transport telematics are high but the verified impacts are still quite modest. Currently widely implemented applications of transport telematics include fleet and freight management, automatic debiting and driver information systems. The costs and benefits of these systems cannot, however, still be reliably estimated.

In transport telematics, Finland is focusing on weather related traffic management, radio and cellular network based information services, public transport management, integrated payment systems and logistics applications. The responsible organisations in Finland are the Ministry of Transport and Communications, Technology Development Centre Finland (TEKES), Finnish National Road Administration, municipalities, freight and public transport operators and the police.

The field of transport telematics is rapidly progressing. Thus, at the moment, the Finnish parties should concentrate on clarifying their needs and enhance national, Nordic, and international co-operation. A successful implementation of transport telematic services requires careful preparation, quality control, and well organised research. The effects of the implemented systems should always be assessed and evaluated in order to analyse the impacts, costs and benefits of the applications, so that the future investments can be directed in a sensible way.

Tieliikenteen telematiikka, sen vaikutukset ja vaikutusten arviointi. [Road Transport Telematics – techniques, effects and assessment]. Tielaitoksen selvityksiä 12/1995. TIEL 3200290, ISBN 951-726-036-9, ISSN 0788-3722. Finnish National Road Administration, Helsinki 1995.

1.4 Telematics of road transports (1995)

The objective of the study is to investigate if companies need such information from road maintenance authorities that could be used in freight and fleet management. Freight and fleet management techniques and systems used nowadays and their development are considered in the literature research. Present freight and fleet management of companies, information needs in the future and attitudes towards new management techniques are investigated by an interview-study.

Telematics of road transports, which is used in freight and fleet management, is studied in many research programs all over the world. Telematics is the part of teleinformatics, which utilises both telecommunications and computers. Telematics research programs have moved from basic research and testing of separate management techniques to testing co-operation between systems of companies and authorities. Co-operation would enable effective production and utilisation of traffic information in different organizations. In the near future research will be focused on getting the systems to common use.

Only few Finnish companies use advanced freight and fleet management techniques. Mobile telephones are commonly used in communications between drivers and the management center of the company. However, companies have considered advanced techniques and some companies already utilize positioning, advanced mobile communications and digital maps. Advanced techniques would be useful especially in monitoring and managing of transports of hazardous materials.

To make freight and fleet management more effective, companies need mostly real-time information about accidents and other breakdowns, due to which the road is closed. Companies are also interested in traffic information of the near history, traffic forecasts and real-time information about weather and road conditions. This information can be produced by a system, which is based on positioning and vehicle identification in different points of the road network (transponders, identification tags). Also management systems of companies (positioning, communications and digital maps), which are in co-operation with each other and with a common traffic management center, can produce this information.

Tiekuljetusten telematiikka. [Telematics of road transports]. Tielaitoksen selvityksiä 8/1995. TIEL 3200286,ISBN 951-726-032-6, ISSN 07883722, Finnish National Road Administration. Helsinki 1995.

1.5 Energy consumption and emissions of motor vehicles in urban traffic (1994)

This research has been conducted by the Ministry of Transport and Communications, Finnra, Finnish Petroleum Federation, Neste Oy, Finnmap Oy and Matrex Oy. The research has studied the effects of urban traffic conditions to the energy consumption and exhaust gas emissions of passenger cars. Types of emissions inspected in the research are nitric oxides (NO_2), carbon monoxide (CO), hydrocarbons (HC) and carbon dioxide (C02). Focus of the work is in the gasoline-powered passenger cars, urban traffic and average speeds less than 60 km/h.

The starting material consisted of field and laboratory tests run with passenger cars. Field tests yielded a total of 251 speed observation series or driving cycles. Laboratory tests studied the effects of the state of the motor to emissions and consumption. Data simulation was used when combining the results of the laboratory and field tests.

In the research, fuel consumption and emission models based on vehicle speeds have been prepared, which fit into the presently used traffic planning programmes. Models may be used when comparing the effects of urban traffic projects.

On the basis of the research, the following conclusions can be drawn:

1. Transport efficiency plays a key role in the energy consumption and emissions of ordinary vehicles. Increase of average speed usually decreases the emissions and consumption.
2. Average speed of urban traffic should not be permitted to sink below 20 km/h because then the consumption and emissions start to increase heavily. This applies especially well to the cars without a catalytic converter.
3. When the motor is heavily overcharged, the catalytic converter does not work and a large proportion of the total emission is born within a brief time.

Moottoriajoneuvojen kulutus ja päästöt kaupunkiliikenteessä. [Energy consumption and emissions of motor vehicles in urban traffic]. Liikenneministeriön julkaisuja 42/1994. ISSN 0783-2680. Ministry of Transport and Communications, Helsinki 1994.

1.6 Traffic management in the Helsinki Metropolitan Area. A preliminary study (1994)

Activities concerning traffic management (traffic control and information) on the main road network in the Helsinki Metropolitan Area have until now been modest. For traffic control only fixed road signs and local signal control systems are available. Traffic information given to the road users is very limited and modest. This is due to the fact that no single authority has the whole responsibility for ensuring the smoothness of the traffic flow.

However, everyday travellers in the region would accrue substantial benefit from real-time traffic information: it would be possible to plan the trip in regard to the most suitable means of travel, route, destination and time of travel, taking into account actual conditions such as congestion, accidents and bad weather. The traffic control system could support the given information through a suitable control strategy. Both the road users and the road operators gain from an effective traffic system wherein travel times and environmental impacts decrease and usage of the infrastructure is more effective and efficient.

Traffic management consists of three elements: demand management, traffic information and traffic control. An important task is to manage incidents.

The Finnish National Road Administration started this study in the beginning of 1992. The goals were to obtain more knowledge of the current status and development of RTI (Road Transport Informatics) and on that basis present a proposal for the development of a Traffic Management System for the Main Road Network in the Helsinki Metropolitan Area. During the work much knowledge has been obtained for example concerning the content and progress of the DRIVE program. The ATT (Advanced Transport Telematics) is in a phase of very fast development.

For the Helsinki region the study is proposing an incremental development of traffic information, traffic control and interactivity between these two measures. Existing traffic control and information activities should be gathered into one place, which enables interactive traffic control and information, i.e. traffic management. In the first stage the most important task is the development of regional real-time pre- and intrip traffic information for the road users using RDS/TMC and text-TV.

A monitoring system for traffic and road conditions - incidents, congestion, weather - must be implemented as a basis for real-time traffic information and control. The operators in the Traffic Management Centre may use a CCTV system to ensure that the monitoring system is working accurately before drastic actions are taken. The study proposes a comprehensive development of the traffic management system in the following sectors:
demand management, traffic and road condition monitoring, traffic information, traffic control and the traffic management centre

Helsingin seudun pääväylien liikenteen hallinta. Esiselvitys. [Traffic management in the Helsinki Metropolitan Area. A preliminary study]. Tielaitoksen selvityksiä 6/1994. TIEL 3200217, ISBN 951-47-8779-X, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1994.

1.7 The impacts of road traffic congestion and their costs in the Helsinki metropolitan area (1994)

In the literature part of this study the impacts and the incidence of congestion are examined. Definitions and causes of congestion are also discussed.

Traffic congestion arises when there are more people trying to use a given transportation facility during a specific period than the facility can handle. Vehicles interfere each other's mobility, which causes queues and delays. And because travel time becomes longer, comfort, reliability and efficiency decrease.

Stop and go traffic is characteristic to congestion. That kind of driving includes many accelerations, decelerations and stops. These increase fuel consumption, noise and emissions. The extra fuel consumption causes direct costs. Noise and air pollution influence health, comfort and environment. Congested corridors may also add to the barrier effect in communities.

Congested conditions increase conflicts between vehicles, which increases the amount of accidents. Yet lower speeds diminish severity. Response time by emergency services is greatly increased as congestion impedes rescue service.

All those impacts experienced by individuals and companies finally effect the whole society through reduction in production, deterioration in quality of life, changes in community structure and massive extra costs.

The research part of this study concentrates on the morning and evening peakhour congestion in the Helsinki metropolitan area without the downtown. Congestion in the area mainly originates in overloaded intersections. Capacity of the links is more sufficient than that of the intersections.

To research the impacts of congestion in the area intersections and links are studied separately. An intersection is considered to be congested when queues appear regularly, because vehicles cannot pass the intersection during the first green. A link is congested, when the mean speed fails at least 10 km/h compared to the speed in daytime.

Extra delays in the area caused by congestion are in total 900 000 vehicle-hours per annum. This causes additional delay costs as much as 60 million FIM yearly. The cost of a morning rush-hour congestion delay in the area is 160 000 FIM and the cost of an evening rush-hour congestion delay is 90 000 FIM. In the average 1 0 % of the travel time during peak-hour is delayed by congestion. Ring road I and the intersectionVihdintie - Hameenlinnanväylä - Hakamäentie and the route Turunväylä - Paciuksenkatu - Mannerheimintie are the most problematic in the area. Environmental hazard, extra fuel consumption, impacts on safety and land use are also suffered in the area.

Tieliikenteen ruuhkien vaikutukset ja ruuhkakustannukset pääkaupunkiseudulla. [The Impacts of road traffic congestion and their costs in the Helsinki metropolitan area]. Tielaitoksen selvityksiä 60/1994. TIEL 3200269, ISBN 951-47-9459-1, ISSN 078-3722. Finnish National Road Administration. Helsinki 1994.

1.8 Traffic flow on low-speed two-lane roads in Finland (1996)

This report is a summary of a research work with the purposes to give basic information about traffic flow on two-lane roads with the speed limit 40–60 km/h and to develop field measurement techniques and level-of-service meters for these roads.

The studies were done on six different road sections in the Helsinki region with the AADT 10 000–21 000 veh./day. The field studies were done in October 1994 and in May–June 1995 as well in normal daytime traffic as in morning and evening rush-hour traffic. The field studies consisted of point measurements using traffic analyzers and travel speed studies with the license plate and moving observation car methods. All study methods proved to be suitable for low-speed roads. The results were usable and the methods are complementary to each other. If possible, all methods should be used side by side because any of them cannot fully be replaced with the others.

The one-way flow rates varied between 128 and 1 360 veh./h during the measurements. In the rush-hour traffic the maximum flow rates observed in the main direction were 764–1 360 veh./h. The space mean speeds decreased slowly when the flow increased. The decrease was 1–3 km/h at the locations with the speed limit 60 km/h, 3–7 km/h at the speed limit 50 km/h and 4 km/h at the speed limit 40 km/h, when the one-way flow increased by 1 000 veh./h.

The mean travel speeds were usually a little lower and decreased faster than the space mean speeds when the flow increased. The decrease was 5 km/h on the road sections with the speed limit 40 or 60 km/h and 4–10 km/h on the road sections with the speed limit 50 km/h.

The product of traffic flow and mean travel speed represents the efficiency of traffic. The maximum of the traffic efficiency is reached before the capacity is reached. The maximum one-way traffic efficiencies that could be determined were about 65 000 on the road sections with the speed limit 60 km/h, about 55 000 on the road sections with the speed limit 50 km/h and about 35 000 (veh.*km)/h^2 on the road sections with the speed limit 40 km/h.

The average delays as well as the share of the travel time spent delayed increased with increasing flow. The acceleration noise, which describes the smoothness of traffic flow, decreased with increasing travel speeds. All delay parameters varied a lot and no clearly interdependent relationships could be determined.

At low flow rates the platoon percentages were about 2–10 percentage units higher at the locations with the speed limit 40 km/h than at locations with other speed limits. At higher flow rates the platoon percentages were 3–4 percentage units higher at the speed limit 50 than at 60 km/h. The mean platoon lengths were 0.5–3.5 vehicles shorter at the speed limit 60 km/h and the difference increased when the flow rates increased.

The level-of-service of the road sections in this study was analyzed in three different ways based on the HCM. The calculation method used for urban and suburban arterials, in which the mean travel speed is the main indicator of the level-of-service, seemed to be the most suitable for the low-speed two-lane roads in this study. However, this method should be used only for roads with traffic signals, because the delays caused by the traffic signals have been taken into account when determining the limiting values between different levels-of-service in the HCM. The calculation methods for two-lane rural highways using either the v/c ratio or the Percent Time Delay as the main indicator for the level-of-service gave too low levels-of-service for low-speed two-lane roads, because the methods are mainly developed for roads with higher speed levels.

J Hietanen, Å Enberg: Liikennevirta alemman nopeustason kaksikaistaisilla väylillä. [Traffic Flow on low-speed two-lane roads in Finland]. Tielaitoksen selvityksiä 18/1996. TIEL 3200387, ISBN 951-426-202-7, ISSN 0788-3722. Finnish National Road Adminstration. Helsinki 1996.

1.9 Effects of weather on driving speeds (1995)

Objectives of this study were to find out how changes in weather and light affect driving speeds and to create statistical models for predicting speeds on different types of roads in varying weather and light conditions. Statistical models that were created by using analysis of variance are reported as results of the study. Speeds of three vehicle types; passenger cars, lorries and buses were examined separately. The models give information about effects of different weather and light conditions on speeds. The models can be used for predicting average speeds, standard deviation of speeds and percentages of vehicles that exceed speed limits by at least 10 km/h on selected road-type and in certain weather and light conditions. The characteristics of the road that are used for predicting speeds are following: the type of the road (motorway, semi-motorway or average 2-lane road), the speed limit, the existence of road lighting, and the seasonal, monthly and hourly traffic variations.

The data for this study were obtained from automatic traffic monitoring and road weather systems. The data were collected at 18 sites during the year 1993.

During dry weather in summer and in winter, speeds are usually higher in daylight than in the dark. In summer, changes in weather have minimal effect on speeds of passenger cars. Compared to dry weather, rain reduces average speeds of different vehicle types by 0,5... 4,3 km/h in summer. In winter, the greatest drops in speeds happen in snowy weather. Snowy weather causes a drop of 0,6... 6,7 km/h in average speeds of different vehicle groups. Adverse weather conditions have greater effect on speeds of passenger cars and buses than on speeds of lorries.

In summer, changes in weather have almost no effect on standard deviation of speeds. In winter, standard deviation of speed decreases when the weather becomes snowy, icy or rainy.

In summer, rainy weather, and in winter, snowy weather cause the greatest drop in the percentage of vehicles exceeding speed limits by at least 10 km/h. During dry winter conditions, the percentage of vehicles that exceed speed limits in all vehicle groups is larger in daytime than in the dark. The effect of icy, snowy and rainy weather conditions on the percentage of passenger cars and lorries that exceed speed limits by at least 10 km/h is greater in daytime than it is in the dark.

The results obtained in this study are similar to those of earlier studies carried out by other research institutes. In this report, studies concerning the effects of weather on driving speeds, and other issues closely related to that, are briefly introduced.

K Estlander: Sään ja kelin vaikutukset eri ajoneuvoryhmien nopeuksiin. [Effects of weather on driving speeds]. Tielaitoksen selvityksiä 23/1995. TIEL 3200301, ISBN 951-726-057-1, ISSN 0788-3722. Finnish National Road Adminstration. Helsinki 1995.

1.10 Traffic management applications toolbox (1996/1997)

Traffic management is management of traffic flows by traffic information, traffic control and demand management measures to keep the transport system available, uncongested and safe, in order to minimise pollution and improve transport efficiency and traveller comfort. The goals are met through affecting travel demand, modal split, route choice, trip timing and user's behaviour.

The aim of this publication is to make traffic management known as a new tool for road and traffic operators, to inform about the suitability of different applications, to report about the experiences and lessons learned in Finnra and to harmonise different applications and systems that will be brought into use. The publication concentrates on telematics based systems that are considered to be suitable for Nordic conditions or that are already in use in the Finnish National Road Administration.

Chapter 2 deals with such traffic problems that may be affected through traffic management. With each problem, suggestions for suitable traffic management measures to be used are given.

Chapter 3 gives an overview of traffic management (traffic control, traffic and traveller information and demand management) and the infrastructure behind the actual traffic management applications (road and traffic monitoring systems, data bases, information systems etc.)

Chapter 4 presents traffic management applications. As for traffic control, the applications are variable speed limits (at a single spot, weather based variable speed limit system, speed harmonisation), lane control, ramp metering, local warnings with variable message signs (road conditions, elks, queue warning, road works, swing bridge, traffic signals), route guidance with VMS / variable signing, parking guidance, and VMS based "speedometer check info signs" and safe driving distance information signs. This publication does not deal with traffic signals since several separate reports have been published.

Traffic and traveller information applications presented are informing users about road and weather conditions, road works, traffic status, traffic incidents, routes and timetables as well as alternative travel modes. Demand management applications presented are park and ride, car pooling, road pricing and access control.

In addition to the application description, information is given about the cost and effects of the application as well as about its recommendable way of use.

Chapter 5 contains detailed descriptions of the traffic management applications currently in use in Finnra. The descriptions contain information about the goals and effects of the systems as well as their practical set-up: location, when brought into use, technology applied, investment and maintenance costs, designers, suppliers/deliverers of the system etc.

Telematics based traffic management is a rapidly developing area. Information about the applications and their effects augments continuously. This "toolbox" should thus be stored in electronical format in the intranet pages of Finnra, where it can be updated.

The report has been granted Community financial aid in the field of Trans-European Networks - Transport.

M Karhunen, M Noukka, M Vatanen: Liikenteen hallinnan toimintokortisto. [Traffic management applications toolbox]. Tielaitoksen selvityksiä 2/1997. TIEL 3200449, ISBN 951-726-312-0, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1997.

1.11 Finnra's strategy for traffic management (1996/1997)

The Finnish National Road Administration (Finnra) is responsible for ensuring the efficiency and safety of the road transport system while minimising the environmental impacts. One of Finnra's means is traffic management. In Finnra, traffic management is considered to cover traffic information, traffic control and demand management functions. This strategy deals with transport telematics based traffic management functions.

Finnra is responsible for the provision of real-time safety relevant information of the current and predicted state of the traffic conditions on the road transport system. The variety and quality of the information services varies according to the transport problems on the road link and user requirements. The information services are usually based on telecommunications to the users' own receivers and terminals. Variable message signs are used at exceptional locations only. Finnra may provide real-time access to its databases also to private service providers.

Traffic and demand management systems are implemented at locations, where their implementation is clearly economically feasible for the society.

Transport telematics fulfils Finnra's objectives related to transport system efficiency, safety and environmental impacts. The implementation of the systems shall not increase the risk of road fatalities and injuries or the environmental burden. Specific systems and applications function for the end users in a similar way in the whole road transport system. The objective is to link the transport telematics systems of Finnra to the telematics systems of other transport modes enabling the function of an intermodal transport system.

Finnra is responsible for the monitoring of the state of the road transport system, and the collection and management of the traffic condition data for its road network. Finnra is also responsible for operation of its traffic management and information centres and the data exchange with relevant national and international actors.

The success of traffic management depends on good co-operation between Finnra, municipalities, the police, rescue authorities and various transport service providers.

By the year 2010, various traffic management services are to be implemented in the different parts of the road transport system. The most effective system on the main roads is incident management incorporating information, control and efficient incident recovery. Variable speed limits are implemented and pilot studies on road use fee collection from heavy vehicles are undertaken on crucial main road sections. Finnra provides real-time on-trip and pre-trip information and forecasts on ferry schedules, road weather, traffic flow, incidents, and road works to road users.

On high-class roads, variable speed limits are implemented in addition to in-vehicle telematics systems, of which Finnra supports the intelligent speed adaptation and lane-keeping support systems.

Special traffic management systems are applied in connection to tunnels as well as bridges with problematic weather conditions. Variable message signs are used at special locations in warning about vulnerable road users, slippery road surfaces and elks, etc. Further development of signal control occurs for both individual junctions as well as interconnected systems. On road sections with efficiency and safety problems, traffic management is used instead of or to postpone traditional road projects for the purpose of solving overtaking problems, speed harmonisation or diversion of traffic from congesting sections.

In large urban areas, Finnra participates in remote control of signal systems, park and ride, area fees, and other demand management systems. Finnra is also involved in the implementation of systems promoting the use of public transport and car-pooling, information services at public transport stops and terminals as well as guidance to or from important destinations in urban centres.

In sparsely populated areas, Finnra provides information of the state and progress of road maintenance actions to the public, and supports the implementation of various demand-responsive services. Heavy vehicle route guidance and hazardous goods monitoring services cover the whole country. In addition, Finnra supports the implementation of demand responsive public transport, information and guidance services at terminals, travel and traffic information services, automated traffic enforcement, and various driver assistance systems.

In the near future, the research and development activities of traffic management concentrate on traffic and road weather monitoring, development of traffic management service database and user interface, traffic management centres along with their operational and institutional issues, and the impact and socio-economic evaluation of the various systems. The development activities are mainly linked to radio, GSM and internet based traffic information services, weather related traffic management, and incident management. RDS-TMC will be implemented.

The Finnra regions carry the main responsibility of the implementation of traffic control and demand management systems. The implementations concern traffic and road weather monitoring, traffic management and information centres, traffic management in urban surroundings, variable speed limits, signal control, tunnel and bridge traffic management systems and travellers' points of information.

The transport telematics actions should follow the general operational guidelines defined below:

1. Transport telematics fulfils Finnra's objectives related to transport system efficiency, safety and environmental impacts and supports the integration of the transport system into a multimodal system.
2. The implementation and development of transport telematics services is based on the requirements and acceptance of the users (road authorities, transport operators, road users, etc.)
3. The development of transport telematics systems is performed through controlled pilot studies and experiments, in which the impacts, benefits and costs of the systems are assessed. Systems that have been proven to be beneficial and effective can be introduced as standard Finnra telematics services.

4. Finnra's transport telematics systems and services are interoperable and consistent for the users throughout the country, and interoperable with the Pan-European systems and services.
5. Finnra can provide access to its telematics systems for other actors in order to support the development and implementation of services, which support the fulfilment of Finnra's objectives.
6. Finnra actively contributes to the international development, recommendations, agreements and regulations in the area of traffic management in the EU and other international organisations.

Tielaitoksen liikenteen hallinnan strategia. [Finnra's strategy for traffic management]. TIEL 100018. ISBN 951-726-372-4. Finnish National Road Administration. Helsinki 1997. (Finnish and English version available)

1.12 Finnra's VIKING Programme

The objective of the report was to describe the action of Finnra in the Euro-regional VIKING Project. VIKING harmonises traffic telematics applications and services in Northern Europe, i.e Finland, Sweden, Norway, Denmark and Germany.

The report contains:

- A short description of the background and objectives of the Euro-regional projects
- A description of the organisation and funding of VIKING
- Focal areas of Finnra's projects and the linking of VIKING to other telematics projects of Finnra
- Description of Finnra's VIKING organisation
- Draft schedule of Finnra's VIKING programme and
- List of VIKING projects

P Leviäkangas: Finnra's VIKING Programme. Finnra internal publications 24/1997. TIEL 4000174E. Finnish National Road Administration. Helsinki 1997.

1.13 Road transport telematics terminology

NVF (Nordisk Vegteknisk Forbund, Nordic Road Association), is an organisation of individuals in the Nordic countries with interest and capabilities in the field of road and traffic engineering. Its Committee 53 is engaged in the progress and use if information technology - telematics - in this particular area. Committee 53 commissioned, with the economical support from the National Road Administrations in Finland, Denmark, Norway and Sweden, an expert group to develp a common terminology for the use in the area "road transport telematics".

The intent of the work was to create a basis for Nordic mutual understanding in the area, and to create consensus around what English terms to use in international communication.

The terminology is published in five different versions. In the different Nordic versions of the terminology the terms are defined in English and the Nordic language in question, and translated to all Nordic languages. In addition, an English version (without Nordic terms) has been produced with the purpose of providing an input and feedback to the European and global harmonisation and standardisation work.

Road Transport Telematics Terminology. Nordisk Vegteknisk Forbund (Nordic Road Association), Technical group 53. Report 1/1997. ISSN 0347-2485. Oslo 1997.

Tieliikenteen telematiikka, Pohjoismainen terminologia/ Vägtransport-telematik, Nordisk terminologi. Suomalainen laitos/ Finländsk upplaga. Jaosto/ Utskott 53, raportti/ rapport nro 1/1997. ISSN 0347-2485, ISBN 951-726-379-1. Helsinki 1997.

2 DATA COLLECTION

2.1 Preliminary study on possibility to detect the tire/road friction level onboard (1994)

This report is a state-of-the-art survey on possibility to detect the tire/road friction level onboard. The survey is conducted at Helsinki University of Technology in the Automobile Laboratory for the Finnish Road Administration. The survey has concentrated in technical methods for friction detection, which seem to have potential for realisation. The report is based on literature survey and discussions.

In this project it has become evident that many research institutes are looking for different methods to solve this problem. None of the systems has been developed to commercial level, but many of them, however, are in a level, where their use in field tests could be possible.

Prediction of friction level is possible by optical sensors. Sensors based on reflection can measure thickness of the water layer up to the total water coverage. For the aquaplaning also the thickness of full covering water layer is important. Measurements with sensors vulcanised to the tire indicate, that even in a freely rolling tire the local stress and contact path deformation differ remarkably between high and low friction levels. When the tire comes to contact with the road surface, there will be deformation that can be used as a measure for friction level.

Although a tire sensor seems to have potential for automatic friction detection, there are many aspects that need further development. This sensor technology offers, however, good possibilities direct measurement of friction level. Most important is to develop the sensor to be suitable for serial production tires with steel belts. After this the functionality of the sensor and the effects of parameters can be evaluated in field tests.

In order to find out the connection between tire noise and friction level, microphones near tire/road surface contact have been used. Some approximations of friction level can be made from the noise spectrum but there are far too many other parameters affecting the noise that this method could be reliable. There should be more information about properties of the road surface.

Among the European research laboratories the Universities of Hanover, Darmstadt and Delft seem to be leading units in this field.

According to the survey, there seems to be enough information and technology available for a large scale field-tests in real driving situations. For the Finnish applications also the possibility to detect slipperiness caused by ice, not only water, is important. The capability for ice detection should be carefully examined.

Esiselvitys automaattisesta liukkauden havaitsemisesta liikenteessä. [Preliminary study on possibility to detect the tire/road friction level onboard]. Tielaitoksen selvityksiä 63/1994. TIEL 3200272, ISBN 951-726-009-1, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1994.

2.2 Traffic monitoring and incident detection (1995)

The objective of traffic management is to improve the efficiency and safety of the traffic system and to reduce the negative impacts of traffic on the environment. Traffic management consists of three elements: traffic information, traffic control and demand management. Traffic management is reaching an equal position amongst the traditional road construction and maintenance methods.

The objective of traffic monitoring is to provide reliable information on the traffic situation on the network. Traffic monitoring can be carried out by automatic vehicle detection systems or by human observers. This literature study deals with real-time automatic road traffic monitoring, which serves traffic system management and utilises road transport telematics. Furthermore, automatic road traffic incident detection methods are studied.

The need for traffic monitoring data varies in different parts of the road network. On roads with no recurrent congestion human reports supplemented by automatic monitoring at specific sites with problems are sufficient. On congested roads, e.g. in the Helsinki metropolitan area, automatic monitoring methods are needed.

An automatic traffic monitoring system consists of detectors, roadside processing units, data communication and central data processing. The traffic monitoring system can also include human observations through Closed Circuit Television (CCTV). In the research and development of automatic detection old proven methods are improved and completely new technologies are tested and brought to the market. In this report, the possibilities, requirements, benefits and restrictions of both mature and prototype monitoring methods are presented. Furthermore, experience of use and comparative detection technology tests are presented.

The inductive loop is at the moment the most reliable detector choice. Image processing, microwave and active infrared detection and automatic vehicle identification and location (probe/floating car) are promising alternative technologies.

A traffic incident is defined as an unexpected event that decreases the road capacity and/or reduces the traffic safety level, and that may disturb traffic flow conditions. The aim of Automatic Incident Detection (AID) is to detect the incident as quickly as possible. In AID dedicated algorithms are used to process the traffic monitoring data and to recognise abnormal changes in the traffic flow. The objective of incident management is to minimise the negative effects of incidents. Close co-operation between different authorities and co-ordination of measures in a Traffic Management Centre are needed.

In the development of traffic monitoring it is of greatest importance, through existing monitoring systems and planned pilot tests, to learn more about the nature of traffic flow and the reactions of individuals on traffic information, traffic control and demand management. This is the prerequisite for effective traffic management and the basis for wider use of automatic traffic monitoring systems.

M Johansson: Liikenteen seuranta ja häiriöiden havaitseminen. [Traffic monitoring and incident detection]. Tielaitoksen selvityksiä 52/1995. TIEL 3200329, ISBN 951-726-115-2, ISSN 0788-3722. Finnish National Road Adminstration. Helsinki 1995.

2.3 Road traffic monitoring preliminary study (1996)

The main task of traffic monitoring is to produce real time traffic network state data for traffic management purposes. Traffic management utilises the acquired data to optimise traffic infrastructure use, to minimise incident consequences and to strategic control decisions. Research and traffic engineering acquire also statistical information for their own purposes.

The first part of this preliminary study defines general and technical principles of traffic monitoring, applicable technologies and a monitoring development strategy.

Inductive loops are a familiar technique, reliable and therefore used for automatic monitoring. Speed, volume, density, headway, occupancy and speed variation rapidity are observed at the monitoring points. The same equipment is used to observe some additional parameters for statistical purposes.

Applicable technology survey resulted in the need to specify a new integral monitoring outstation. This outstation could, on top of monitoring purposes, also replace aged LAM (automatic traffic measuring) and weather stations.

The second part of the preliminary study consists of a proposal to initiate the system design work and realise a pilot installation in the Helsinki Metropolitan Area. The pilot enables a comparison of various technologies and collection of user experience for expanding the system. Simultaneously it constitutes a part of the later areal monitoring system.

The main roads in Helsinki Metropolitan Area which will be included in the monitoring system are classified in primary links, secondary links and separately monitored interchanges.

The pilot installation will open the realisation of the Helsinki Metropolitan Area monitoring system. The installation area covers short interconnected sections of the western radial highway, Ring I and main road 1.

The pilot will gradually be expanded towards the goal system. First expansion stage will be a measuring point network that covers the whole intended area. Traffic management can make use of its data. This first stage will later be gradually completed to the goal coverage.

Pilot design comes directly after this preliminary plan. Design of the monitoring system's first stage will be based on the pilot experiences. Completing the first stage will give an overall traffic picture and enable use of the data for traffic information and management purposes.

Liikenteen seurannan esiselvitys. [Road traffic monitoring preliminary study]. Tielaitoksen sisäisiä julkaisuja 24/1996. TIEL 4000141. Finnish National Road Administration. Helsinki 1996.

2.4 An integrated monitoring station. General functional requirements (1996)

Finnish National Road Administration's *Traffic Management Research Programme* has surveyed and defined principles and development of traffic monitoring. Real time traffic data and information about circumstances affecting traffic are a precondition for traffic information and control.

The survey resulted in the need to specify a new general integral monitoring outstation. There are about 200 each of LAM (automatic traffic measuring) and road weather stations already installed and at least the same number will be needed for traffic monitoring purposes.

This memorandum comprises general functional specifications for a real time traffic and traffic circumstances monitoring station.

The new monitoring outstation is a part of a distributed system in which the road side units are connected via an open data transmission platform to various management systems. It is also used as a data transmission unit for earlier LAM and road weather stations, when these are used parallel to the new outstations.

An integral outstation operates, depending on its detector equipment, as a real time traffic monitoring data collection and processing unit, as a traffic counting and classification unit, as a station that collects environmental data, as a road weather station and as a control unit for variable message signs. As a part of a distributed system it is able to draw out individual conclusions based on the data it has collected and transmit regularly and immediately after exceeding set thresholds or in case of malfunction. The station supports various data transmission solutions and also enables transmission of CCTV-system pictures.

The monitoring outstation's modular structure enables site specific configuration and expanding of the station. Modules produced by various suppliers must be interchangeable. This secures a real competition between the suppliers in the situation of constantly developing detection technology.

This memorandum contains a general specification for an integral monitoring outstation. The task should be continued with preparing the station's detailed functional and technical specifications. These could be produced in co-operation with the Swedish National Road Administration who is about to launch a similar project. As a goal for this co-operation could be set to specify a general outstation suitable for northern circumstances and a wide road network with low traffic volumes.

Integroitu havaintoasema. Yleiset toiminnalliset vaatimukset. [An integrated monitoring station. General functional requirements]. Finnish National Road Administration. Unpublished memorandum 1996.

3 TRAFFIC MANAGEMENT CENTRES AND INFORMATION SYSTEMS

3.1 The tasks and the functions of the traffic management centre in Uusimaa region (1996)

The traffic management centre (TMC) was founded in Uusimaa Region in October 1995. It is located in the same room with the regional road weather monitoring centre (RWMC) which has been operating for a couple of years. The aims of the TMC are to improve traffic safety and efficiency and to reduce harmful environmental impacts caused by traffic on the main roads in Uusimaa, especially in Helsinki urban surroundings. The ultimate aim is to participate actively in network traffic control around Helsinki together with other responsible organisations. To be able to develop the TMC further, its tasks and functions have to be defined. That is the objective of this study.

This study gives an overview of the present situation of traffic management in Uusimaa Region. it also presents the framework of traffic management defined by the European Union. This study includes an English-Finnish glossary of road transport telematics terminology.

The recommended functions defined by the Advanced Transport Telematics (DRIVE 11) have been used throughout this study. The functions are organised in ten areas. Not all of them are needed in the TMC of Uusimaa Region. Traffic control, traffic information, travel information and road management and logistics are the areas that should be included in the operation of the TMC. Other areas, such as public transport management and freight and fleet management, can be supported by the TMC. However, the responsibility belongs to other organisations.

The main tasks of the TMC are to monitor and to control traffic and to provide traffic and travel information to drivers. The data collected and disseminated by the TMC and the systems required by the tasks and the functions of the TMC are discussed in this study.

The study was carried out by Finnra Uusimaa region, and it has been granted European Community financial aid in the field of Trans-European Networks - Transport.

M Uusiheimala: Uudenmaan tiepiirin liikenteen hallintakeskuksen tehtävät ja toiminnot. [The tasks and the functions of the traffic management centre in Uusimaa Region]. Tielaitoksen selvityksiä 5/1996. TIEL 3200374, ISBN 951-726-183-7, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1996.

3.2 The traffic management centre of Finnra Uusimaa region: Reference groups and principles for data exchange (1997)

The traffic management centre of Finnra Uusimaa region started its operation in autumn 1995. Already existing traffic management systems were gathered to one place. After that, real-time information services have been developed together with other parties. Traffic monitoring has been enhanced, and testing of one new media, RDS-TMC, has been started. The development of information system is also well on way.

Co-operation helps implementing the services designed for road-users. One of the most important missions of the traffic management centre is informing the road-users about incidents on the road.

This study was the first stage of the TMC development process. The operations model for the traffic management centre was developed, its interest groups were identified and principles for data exchange were discussed.

The interest groups of the TMC include other traffic centres (national traffic information centre, traffic centres of Finnra's other regions, foreign traffic centres), cities, the police, regional emergency centres and rescue authorities, road maintenance management centres, control centres of other modes, other data providers, value added service providers and the media.

As for data exchange, the aim is not to develop a centralised system but a decentralised net in which the monitoring, management and information systems of various parties are exploited. The principles of information exchange defined in this publication are the base for developing the co-operation. The information flow going from one party to another is divided into three classes taking the urgency of the information into account:

1. immediately after the incident
2. after a short delay
3. constantly or when the situation has changed

Techniques for data transmission will be determined later.

The study was carried out by Finnra Uusimaa region, and it was granted European Community financial aid in the field of Trans-European Networks - Transport.

Uudenmaan tiepiirin liikennekeskus: Sidosryhmät ja tiedonvaihdon periaatteet. [The traffic management centre of Finnra Uusimaa region: Reference groups and principles for data exchange]. Tielaitoksen sisäisiä julkaisuja 11/1997. Finnish National Road Administration. Helsinki 1997.

3.3 Description of a logical service database (1996-1997)

In traffic management; traffic control and information, many-sided information about traffic, incidents, weather etc. is needed. Most of the information needed is taken from existing systems like road data bank, road weather system, roadwork data bank and traffic monitoring system.

Information is also exchanged with external parties such as the Meteorological Institute, the police, regional emergency centres, municipalities and foreign traffic management centres.

A logical service database is developed to facilitate the information collection and processing. With the help of service database it is possible to find quickly the data needed, process it and combine information from different databases and form messages for different media. The aim is to handle all this automatically. This calls for clear rules and parameters. Co-operation with external organisations is based on standards that are produced together. This means that the service database is a set of descriptions, rules and standards.

In this publication the service database is illustrated beginning from the description of the contents of the logical service database; the data needed to manage traffic, systems that produce data and the services in different media. Additionally the rules are described roughly. The design of the service database itself will begin in the next stage of the project.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

Loogisen palvelutietokannan kuvaus. [Description of a logical service database]. Tielaitoksen sisäisiä julkaisuja 3/1997. Finnish National Road Administration. Helsinki 1997

4 TRAFFIC INFORMATION

4.1 Finnra´s driver information services. Development study (1993)

The development study

The Finnish National Road Administration (FinnRA), considers it important to be at the service of road traffic and road users in addition to its role in the management, maintenance and development of the road network. Traffic safety and the fluency of traffic are improved by traffic monitoring and by giving information on traffic and road weather conditions. As a consequence, travelling is made more comfortable.
This study examined how well the road users know the present traffic information services and how satisfied they are with them. It also studied the need for development of the present and possible future traffic information services and the road users' attitude towards charging for these services. The results of the study will help FinnRA in creating its information policy towards the road users and in developing its services: the services to be concentrated on and the services to be marketed.

The study looks for concrete operational models in regards to information and equipment the road users will be needing. The results of the study tell us what the road users consider important.

The following aspects of traffic information have been included in the study: information on road works, information on traffic conditions, route planning service, information on road weather conditions and other services offered by Finnra.

The study showed that the road users regard the available information on traffic as important. The road users emphasised especially the importance of the information on traffic congestions and local road weather conditions and the information on the factors slowing down traffic or on the condition of the road sectors under construction.

The majority of the persons involved in the study were of the opinion that the information available to them will influence their behaviour in traffic. Especially information on road works, traffic conditions and road weather conditions were singled out as most important. Road users obtained as much information before setting off on a trip as during the trip. They expressed their willingness to pay for some of the traffic information.

Those road users who use traffic information services form a relatively homogenous group.

The information media involved in this study were: multimedia and road weather monitors, Road Info, TeleSampo (BBS), text TV, road users' telephone service line, speed and temperature display signs on the roads, maps on road works, ferry time tables and radio stations.

The road users specified the information given in radio broadcasts and in the speed and temperature display signs on the roads as the most significant sources of information. However, their opinion was that it is good to be able to receive information through various sources of information, because there are users for all of them.

On the basis of the results of this study, proposals for the development of the separate information sources have been made. In addition, a proposal was made to create e.g. a set of uniform instructions for the development of information monitors.

Telephone interview of professional drivers

In this part of the study, 45 transport companies, public transport (bus) operators and other professional drivers were asked about their current use and future needs of traffic and road conditions information. The interview was carried out by telephone.

According to the study, professional drivers use driving conditions information rather little and they do not see a big need to increase information services. Transport companies are neither very willing to invest money in getting information. In general, professional drivers use their experience and information from other drivers. The interviewees stated, however, that they might use more information if it were available quickly, easily, reliably and at a low price.

The information needs of the transport companies are mainly related to special transports; such as weight limitations, maximum dimensions of the transport, bad state of the secondary road network during frost damage period. Public transport operators were also interested in incidents and roadwork that affect their ability to maintain the time schedule.

Telephone and radio were stated to be the most handy media.

Assessment of the user interface

Finnra has actively developed computer programs to provide road users with driving condition information at services areas. In 1993, the various user interfaces (different data contents, functions and visual appearance) were analysed.

Various defects were discovered: some of the user interfaces were difficult to use since they were originally aimed at professional use and thus lacked the instructions on how to apply the information provided. Also contents of the various services were incoherent and not always up-to-date. Assessment of the user interface demonstrated that the biggest development demand is for making the different programs more homogenous. As a next step it is proposed that detailed rules and standards are developed for user interfaces and also partly for the contents of the services.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus. [Finnra's driver information services. Development study]. Tielaitoksen selvityksiä 88/1993. TIEL 3200215, ISBN 951-47-8774-9, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1993.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus: Tienkäytön ammattilaisten puhelinteemahaastattelu. [Finnra driver information services. Development study. Telephone interview of professional drivers]. Tielaitoksen sisäisiä julkaisuja 54/1993. Finnish National Road Administration. Helsinki 1993.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus: Käyttöliittymäanalyysi. [Finnra driver information services. Development study. Assessment of the user interface]. Tielaitoksen sisäisiä julkaisuja 55/1993. Finnish National Road Administration. Helsinki 1993.

4.2 Finnra's guidelines for road-user information (1994)

In 1994, Finnra's guidelines for the provision of road user information were defined. Road user information is information that a road user gets before or during the trip and which enables him to plan the trip and in prepare for the prevailing driving conditions.

Finnra's central administration co-ordinates the development of the road user information and maintains the national traffic information centre. Regional service is served by Finnra's regions.

Finnra takes responsibility for delivering traffic safety and efficiency related information. The service is intended for large amounts of road users and it uses different mass-media. Service is free of charge for the users.

The most important information services are road conditions and roadwork information as well as information about incidents. Information about incidents is provided by Finnra in co-operation with the police and the Finnish Broadcasting Company.

Personal service for road users' individual needs is provided as far as possible. Personal service is mainly subject to charge.

Road user information is part of the road management and Finnra is responsible for its costs. The services can be financed by money from advertising. Advertisements cannot, however, be included in roadside signing. The services may also be run on commercial basis by an outside company. In such a case, Finnra is entitled to oversee the use of its data.

Road user information is distributed primarily through mass-media such as the Finnish Radio and its local stations, text-TV and newspapers. The map of roadwork is issued every summer. The development of phone services and traveller's points of information is ongoing. Also new service means are examined.

Tienkäyttäjäinformaatio. Tielaitoksen toimintaperiaatteet. [Finnra's guidelines for road-user information]. TIEL 2300009, ISBN 951-47-9097-9. Finnish National Road Administration. Helsinki 1994.

4.3 Perception of traffic conditions and traffic information - a road user survey on two lane roads (1996)

The aim of this study was to clear out how car drivers perceive traffic conditions on two-lane main roads. Potential benefits of real-time traffic information were investigated, too. A road-side interview survey was carried out at service stations on highways no. 1, 4 and 6. 704 car drivers were interviewed for their subjective estimates of the present traffic conditions as well as for their background and trip-centred variables. As a specific aim, the Finnish translation of the European scale free/ heavy/ slow/ queuing/ stationary traffic was tested. The drivers were also asked for their target speed, and whether they could maintain it in the present conditions, and for the driving comfort and irritation caused by traffic. To reveal potentials of radio (and RDS) traffic information the use of radio and the prevailing channel was checked as well as willingness to change route according to traffic information.

A direct willingness-to-pay -method for better fluency was used to estimate the value of congestion and time. The interviews were compared with simultaneous travel and spot speeds from registration plate and loop detector data. The hourly volume varied from 50 to 1500 cars/lane, and traffic demand did not exceed capacity.

The results show that it is possible to define general levels for drivers' conception of traffic conditions by using a threshold method. 50 % of the car drivers said the traffic was 'queuing' when the average headway between vehicles *(local environment of a driver in the flow,* 15 vehicles in front of and 5 vehicles behind) was lower than 4-5 s or when the average spot speed was lower than 90 % of the free flow speed. There were certain differences between the road sections. On highway 1, 50 % of the car drivers considered the traffic condition as 'free" when the average headway in the traffic flow exceeded 7 s. On highway 6 the corresponding limit was 14 s. Journey speed did not explain perceived traffic conditions in a better way than the parameters measured at one spot. 50 % of the car drivers said their driving comfort decreased when the average headway of the traffic flow was smaller than 5 s or when the average spot speed was 8 % lower than free flow speed. The results suggest that the traffic was not irritating because of the growing density but because of the driver and trip related factors and the behaviour of other drivers.

The value of congestion varied from 12 FIM/hour (work trips) to 58 FiM/hour (business trips). The accepted average freeway toll for a 70-80 km road section was 8 FIM. The value of time varied between 30 FiM (for trips shorter than I 00 km) and 90 FiM/hour (for trips over 300 km).

M Kiljunen, H Summala: Ruuhkaisuuden kokeminen ja liikennetilannetiedottaminen. Tienkäyttäjätutkimus kaksikaistaisilla teillä. [Perception of traffic conditions, and traffic information - a road user survey on two lane roads.]. Tielaitoksen selvityksiä 25/1996. TIEL 3200393, ISBN 951-726-214-0, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1996.

4.4 Drivers' information needs (1996)

This study was designed to investigate what kind of information Finnish drivers need and like to receive, which means of communication they prefer and how the information influences them. The data were collected by telephone interviews. Totally, a representative sample of 1,002 Finnish drivers were interviewed. The study has been granted European Community financial aid in the field of Trans-European Networks-Transport.

The most popular sources of information were variable message signs, television, newspaper and radio. Road maps, road work maps, text television, RDS-TMC and information monitors at service stations were also considered important. The drivers showed least interest in Internet, GSM messages, as well as individual telephone service and fax service provided by the road administration.

All information sources were estimated to be more important for infrequent than frequent trips. There were little differences between driver categories (i.e. sex, age, experience and area of residence). Nevertheless, the most experienced drivers wished to receive more on-the-road information (variable message signs, RDS-TMC and GSM-messages). Men were more interested in RDS-TMC and GSM than women. Young drivers were more interested in GSM and CD-ROM-map than the others.

On frequent trips, the proportion of drivers that estimated information to be important or very important varied according to the subject as follows: weather 37%, road constructions 31%, the fluency of traffic, congestions and incidents 40% and routes, travel times and schedules 16%. On rarely made trips, the corresponding proportions were: weather 54%, road constructions 44%, the fluency of traffic 45% and routes, travel times and schedules 27%.

Concerning road and weather conditions the drivers appreciated information on slipperiness, ice, slush and snowfall. Regarding road works, drivers considered important information about alternative routes and the length of road work sections. Information about lowered speed limits and the quality of the pavement in the road work section were also relatively important. With regard to the fluency on traffic flow, drivers considered most important the information of alternative routes and the duration of the delays. Regarding routes, travel times and schedules, information of speed limits and the amount of slow traffic were considered most important.

When asked about the willingness to pay for different services, 36% of the drivers were willing to pay for GSM-messages (traffic information), 57% for prints from information terminals, 52% for calls to service telephone and 52% for RDS-TMC-device. For GSM-messages the drivers were willing to pay FMK 52 a month on average (only drivers who were willing to pay something). The corresponding prices were FIM 11 for a print from information terminals, FMK 3 per minute for calls to service telephone and FIM 960 for RDS-TMC-device (1 FMK ≈ 0.17 ECU).

When asked about the influences of information, drivers estimated that it affected driving behaviour and travel comfort.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

M Penttinen: Autonkuljettajien informaatiotarpeet. [Drivers' information needs]. Tielaitoksen selvityksiä 73/1996. TIEL 3200440, ISBN 951-726-297-3, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1996.

4.5 Finnra's concept for Travellers' points of information (1996)

In 1994, Finnra's guidelines for the provision of road user information were defined. Road user information is information that a road user gets before or during the trip and which enables him to plan the trip and in prepare for the prevailing driving conditions.

Finnra's central administration co-ordinates the development of the road user information and maintains the national traffic information centre. Regional service is served by Finnra's regions.

Finnra takes responsibility for delivering traffic safety and efficiency related information. The service is intended for large amounts of road users and it uses different mass-media. Service is free of charge for the users.

The most important information services are road conditions and roadwork information as well as information about incidents. Information about incidents is provided by Finnra in co-operation with the police and the Finnish Broadcasting Company.

Personal service for road users' individual needs is provided as far as possible. Personal service is mainly subject to charge.

Road user information is part of the road management and Finnra is responsible for its costs. The services can be financed by money from advertising. Advertisements cannot, however, be included in roadside signing.

The services may also be run on commercial basis by an outside company. In such a case, Finnra is entitled to oversee the use of its data.

Road user information is distributed primarily through mass-media such as the Finnish Radio and its local stations, text-TV and newspapers. The map of roadwork is issued every summer. The development of phone services and traveller's points of information is ongoing. Also new service means are examined.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

Liikenteen tiedotuspistekonsepti. [Finnra's concept for Travellers' points of information]. Tielaitoksen sisäisiä julkaisuja 25/1996. Finnish National Road Administration. Helsinki 1996.

4.6 Assessment of Finnra's traffic information services – survey questionnaires and instructions

The Finnish National Road Administration (Finnra) has within the past few years investigated in different ways the satisfaction of their customers and constituent groups. Traffic information services have been one subject of these studies. The most recent study was "Drivers' information needs".

The aim of the assessment framework project was to create methods, questionnaires and instructions to investigate the satisfaction of the customers of Finnra's traffic information services. All the questions were directed to drivers since they can be considered as the main customers of Finnra. The questions were aimed at providing insight for developing traffic information services. In addition, the questionnaires included questions about the usage of existing traffic information, opinions about the information available, the kind of information is needed and the needs to develop the information, if any. The most feasible sources of traffic information were also under interest.

In total 13 different questionnaires and instructions were developed. They consisted of three groups: (1) the most extensive questionnaires suited for national usage, (2) questionnaires suited for regional (iFinnra's regional offices or big cities) usage and (3) for short interviews concerning the traffic information needs in one special case.

The most extensive questionnaires were suited to national studies and are mainly comparable to "Drivers' information needs" (Penttinen, 1996). The questionnaires are suited to telephone interviews with a maximum duration of 30 minutes. Totally six different questionnaires were planned for national purposes, four of those concentrating on a specific information content (i.e. weather, road works, the fluency of traffic or route information) and two investigating more extensively the information needs in wintertime trips or in summertime trips. All these nationwide studies may be repeated every fourth or fifth year.

The second group of questionnaires was designed for regional usage. In total four different questionnaires were developed. Each of the questionnaires concentrates separately either to weather, road works, the fluency of traffic or route information. These questionnaires are to be used by regional road administrations. Studies may be repeated every second or third year or when ever needed because of a special theme in a region.

The third group of questionnaires was designed for short interviews. Two of those are aimed at investigating the needs and usage of traffic information for a special trip and may be used at service areas in special weeks in wintertime (sport vacation trips) and summertime (summer vacation trips). One questionnaire is aimed at investigating the satisfaction of drivers in Finnra's telephone service.

The data collection methods developed will be used in the future to provide multi-level information on the needs to develop or modify the traffic information services in Finland. In addition, the methods may be used in other countries which provide drivers with similar services.
The assessment framework has been granted European Community financial aid in the field of Trans-European Networks-Transport.

M Penttinen, P Rämä, V Harjula: Tielaitoksen liikennetiedotuksen arviointi ja kehittäminen – kyselylomakkeet ja ohjeet [Assessment of Finnra's traffic information services – survey questionnaires and instructions]. Tielaitoksen sisäisiä julkaisuja 4/1998. Finnish National Road Administration, Helsinki 1998.

5 TRAFFIC CONTROL

5.1 Comprehension of variable message signs for road conditions (1993)

This study consists of two different parts: a literature survey and an interview study. The literature survey describes the present situation of information on poor road conditions in Finland and in the other Nordic Countries.

The study is also examining the status of information on poor road conditions based on some previous studies.

The interview study investigated, how different variable message signs (numerical, symbol and verbal messages) for poor road conditions are comprehended. The study also investigated what kind of information on slippery road conditions road users prefer, what they think about variable message signs for poor road conditions and potential in-vehicle displays that would show similar messages. The main part of messages were imaginary variable signs along the roads. One hundred and thirty-one drivers of different ages were interviewed at the service stations in the different parts of Finland.

The studied messages can be roughly distributed into four classes concerning their comprehension and preference. The classes are: (1) comprehensible and preferable messages, (2) comprehensible but less preferable messages, (3) preferable but less comprehensible messages, (4) messages that are both less comprehensible and less preferable.

The most comprehensible and preferable messages were symbolic cautions representing slippery road, slipperiness because of snow or ice, and a verbal/numerical message "ROAD SURFACE" as text and temperature in degrees Centigrade. Following messages were comprehensible but less preferable: symbolic messages representing slipperiness because of rain, crosswind, caution for rain or snowfall, verbal/numerical messages as temperature of air ("AIR"), temperature of road ("ROAD") and a picture of the road (with a message of the temperature). Verbal/numerical messages "HEADWAY" (and recommended minimum value in meters) and "ROAD SURFACE" with the arrow that shows whether the temperature is falling or rising (and the temperature) were preferable but less comprehensible messages. Symbolic messages caution for aquaplaning, caution for icy road surface or snowfall and verbal/numerical messages "FRICTION" (and value), "ICE ?" and "SLIPPERY ?" were both less comprehensible and less preferable.

The implication of this study is that only comprehensible and preferable messages should be used. The use of comprehensible but less preferable messages is also possible, but they must be especially justified. If preferable but less comprehensible messages are used, information of their meaning must be provided in another more effective way. On the other hand it should be examined whether those messages could be showed in more intelligible form. Finally, less comprehensible and less preferable messages are not recommended.

Almost all interviewees would like to have these variable message signs for poor road conditions along the roadside. More than half of interviewees considered information on the local road condition to be more necessary than information on road conditions for long distance. 63 % of interviewees would like to have in-vehicle display that would show similar messages. Furthermore, 95 % of them would also be willing to pay for this device and even 43 % of them 1.000 FIM or more.

E Kosonen: Kelitiedotus ja tienvarressa esitettävien keliviestien ymmärrettävyys. Master's Thesis, Helsinki University of Technology. Espoo 1993.

E Hirvenoja: Comprehension of variable message signs for road conditions. Finnra reports 62/1994. TIEL 3200271E, ISBN 951-726-008-3, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1995.

5.2 The effect of a speed display on driving speed (1993)

A study on how a portable speed indicator board affects driving speeds was carried out at Lahti semi-motorway in 1993. The research was carried out as before-after study, concerning both location and time. The data were collected at several locations using automatic traffic measurement equipment before installing the speed display, at the time the display was working and after the display had been removed. Reference material was collected at main road no. 8, where there is a fixed speed display located north of Pod at automatic traffic monitor site no. 207.

The study showed that the speed display had no effect on driving speeds anywhere else but at the place of the sign. There the reduction in speed was approximately 4.5 km/h, only at times when the display was active. The standard deviation of speed did not vary by the action of the speed display, not even at the place of the sign. Excluding the days of heavy rain from the data did not affect the results. The data collected at traffic monitor site no. 207 showed that the speed display had no long-run effects on levels of speed. It is presumable that reduction in speed near the speed indicator board at Lahti semi-motorway was a result of change in drivers' behaviour caused by the measurement.

During Friday afternoon peak hours generated by outgoing traffic, the display had negative effect on the traffic flow. At lowest, hourly average speed went down to 20 - 30 km/h, while speed limit was 100 km/h. However, as drivers get used to the speed indicator board, ifs disturbing effect will probably decrease.

The speed display can be used for informing road users of actual driving speeds. Since the speed display affects levels of speed only momentarily at the place of the sign, it is unsuitable for controlling driving speeds.

The ways of measuring and displaying speed need to be improved, as well as the speed indicator board's technical properties. The display must be clear and visible in the daytime also. In that way the road users can reliably read the speed information, also during hours of busy traffic.

Nopeusnäyttötaulun vaikutukset liikenteen nopeuksiin. [The effect of a speed display on driving speed]. Tielaitoksen sisäisiä julkaisuja 53/1993. TIEL 4000053. Finnish National Road Administration. Helsinki 1993.

5.3 Effects of display units indicating driving speed and safety distance between vehicles (1995)

A study on the effects of display units on traffic flow was carried out on three locations. The permanent speed indicating display unit on the Main Road 3 in Lastustenmäki in the road section between Valkeakoski and Tampere, was one of the studied units. The two other ones were the safety distance units on the Main Road 1 in Nummi and on the Main Road 6 in Koskenkylä.

As a result of the use of a speed indicating display unit, the driving speeds decreased by approximately 1,5 km/h in its vicinity. At the same time, there was a distinct decrease in the number of vehicles driving very close to the vehicle in front of them: before the display unit was mounted, the share of the vehicles with a driving distance less than 1 second measured in time was 8,3 % and with the display unit in function the percentage was 4,4.

lie effect of safety distance unit on driving speeds was fairly insignificant. The average driving speed on the Main Road 1 in Nummi, where the speed limit is 80 km/h, decreased by 0,8 km/h and on the Main Road 6 in Koskenkylä with the speed limit of 100 km/h, the decrease was 1,6 km/h. The display unit had a clearly favourable effect on the driving distances of vehicles in queue: the distances in time became longer and their distribution more even. When the display unit was placed in a road sector with a good possibility for overtaking, the effect could only be seen in the decrease of the share of the shortest distances (less than 1 second). Other than that, the display unit had no effect on the distribution of driving distances.

The results of the study indicated clearly that neither kind of display unit had any negative effects on traffic. The effects of a safety distance display unit on driving distances were solely positive, if the location of the unit was selected correctly. In road sections, where the drivers have to drive in a queue, the use of a display unit is clearly beneficial: the driving distances increase and their distribution becomes more even.

Nopeudennäyttö- ja turvavälitaulujen vaikutukset liikenteeseen. [Effects of display units indicating driving speed and safety distance between vehicles]. Tielaitoksen selvityksiä 27/1995. TIEL 3200305. Finnish National Road Administration. Helsinki 1995.

5.4 Behavioural effects of slippery road variable message signs in Turku region in winter 1993-1994

The purpose of this study was to investigate how a slippery road VMS (Variable Message Sign) and a headway recommendation VMS affect driver behaviour. The comprehension of these new signs and their functions was also studied.

The slippery road VMS included a slippery road pictogram with a snow flake symbol beneath it and a headway recommendation. The recommendation was assigned to each vehicle and its value depended on vehicle type, speed, and the prevailing road surface condition class. The signs were studied at Eurajoki (highway 8), Kullaa (11) and Koski TL (10). The slippery road VMS was only installed for one driving direction. The was lit by the road weather centre when the road surface condition was classified as possibly slippery. When the centre had confirmed the road to be slippery, the VMS was set on a blinking mode. lie headway VMS in Eurajoki was on also in good road conditions. Data on behaviour was collected with automatic counters based on loop detectors located well before the VMS, ca. 500 m after them, and further after the VMS, in both driving directions. The other direction was used as control data. Data was collected before and after the implementation of the VMS in different road surface conditions.

When the road was slippery the average speeds decreased significantly about 2 - 4 km/h by the slippery road VMS at every other places than at Koski. The speed reductions were usually larger in slippery than in possibly slippery conditions. The speed reductions were more profound in the dark than in daylight. The speed reductions were observed only at the loop detector stations 500 m after the VMS whereas clear speed reductions could not be identified at the next loop detectors situated between 3 and 14 m after the VMS. We could not observe any significant speed reductions in the control direction. The headway VMS decreased the proportion of headways below 1.5 seconds by 28 - 48 % in good, and by 37 - 47 % in slippery road conditions. Ale proportion of headways below 1.5 seconds remained unchanged at Kullaa and Koski TL, where there were no headway VMS signs. The headway VMS also reduced driving speeds by ca. 1 km/h in good road conditions.

The signs were in operation in the spring for ca. 1.5 months before the end of wintery road conditions. Of the 149 drivers interviewed, 70 % understood the slippery road VMS correctly and 23 % understood it partly wrongly. Ca. 40 % stated correctly the meaning of the steady VMS display, and 30 % that of the blinking display. The heading VMS was correctly understood by 48 % (n=131) of the drivers whereas 27 % thought that the VMS showed the measured distance to the car in front.

The slippery road VMS signs reduce driving speeds considerably in adverse conditions. Usually even small decreases in average speeds correlate with accident risk reductions. The effect of the VMS does not last very long, although we could not quantify the length of the effect in distance. We also have no knowledge of the effects in longer use. The headway VMS had the expected effect of reducing the proportion of very short headways, and of decreasing driving speeds, too. The drivers had some problems in comprehending the different operation modes of the slippery road VMS, and the headway recommendation. Even so, the headway VMS still seemed to remind most drivers of the importance of maintaining a sufficiently long headway to the car in front.

P Rämä, R Kulmala, M Heinonen: Muuttuvien kelivaroitusmerkkien vaikutukset liikennekäyttäytymiseen Turun tiepiirissä talvella 1993 - 1994. [Behavioural effects of slippery road variable message signs in Turku region in winter 1993-1994]. Tielaitoksen selvityksiä 36/1995. TIEL 3200313, ISBN 951-726-082-2, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1995.

5.5 The effect of variable road condition warning signs (1996)

The Finnish National Road Administration (FinnRA) launched the experiment of variable road condition warning signs during the winter of 1993-1994. The results showed that the sign warning about slippery road conditions reduced the mean speeds. In addition, the variable safety margin sign extended the headways and reduced mean speeds.

The experiment was continued during the winter of 1994-1995. The signs were tested at four sites: Eurajoki (vt 8), Koski (vt 10), Salo (vt 1) and Koikkala (vt 1). This study was designed to investigate the effects of the variable signs on vehicle speeds and headways, and the persistence and duration of the effect. In addition, the understanding of the sign was studied, and user experiences were noted.

The signs used in the experiment were variable road condition warning signs equipped with an additional snowflake sign or without a snowflake, and a variable safety margin sign of an individual safety margin recommendation between the illustration of two cars. In the middle of the winter, the word .recommendations was added underneath the sign.

Information about driver behaviour was collected using detector loops and an instrumented car. In addition, roadside interviews were made as well as a questionnaire to the personnel of the road condition centre.

The effects of the variable message sign warning about slippery road conditions remained about the same as in previous winter at Eurajoki and Koski. The speed-reducing effect of the sign was about 2 km/h when the sign was blinking, and about 1 km/h when the sign was on continuously. In Sao, the road condition sign did not reduce speeds but the sign decreased the portion of headway's less than 1.5 seconds by 10 percent. At the Koikkala curve, the sign had a statistically significant effect on the driving speeds both in the vicinity of the sign and on the straight section 1200 meters from the sign. The duration of the speed effect of the sign warning about slippery road conditions was about 3 kilometres. The blinking sign affected at least at the distance of 14 km.

The variable safety margin sign decreased the proportion of the drivers in queues with headways of less than 1.5 seconds by 28-38% during good road conditions and by 31-37% during slippery road conditions. The effect was decreased after the addition of the word "recommendation". In addition, the sign decreased the speeds by about 1 km/h.

The purpose of the slippery road warning sign was correctly understood by 80% of the drivers (n=213). The proportion of drivers who understood the variable safety margin sign correctly was 84%, after the addition of the word .recommendation'. 45-50% of the drivers didn't know the meaning of the different ways to use the sign (blinking/continuous).

Both of the signs changed driver behaviour into a safer direction. The slippery road warning sign can be used at locations that are especially prone to slipperiness. The operation of the sign requires that the road conditions are under continuous surveillance. The additional snowflake sign is not necessarily required. The sign should probably only have two modes of operation: it is either lit, warning of slipperiness, or off. The use of the blinking option remains to be considered taking into account the whole traffic control system and the information management processes of drivers. The safety margin sign affected as such both mean speeds and headways. Hence, the sign displaying a safety margin recommendation on the basis of prevailing road surface condition and vehicle speed should be developed further. It is still unclear whether the effects of the signs would increase or decrease if they were used more extensively.

P Rämä, R Kulmala, M Heinonen: Muuttuvien kelivaroitusmerkkien vaikutus ajonopeuksiin, aikaväleihin ja kuljettajien käsityksiin. [The effect of variable road condition warning signs]. Tielaitoksen selvityksiä 1/1996. TIEL 3200370, ISBN 951-726-178-0, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1996.

5.6 The influence of route guidance system on highway 4 between Järvenpää and Mäntsälä (1995)

The route guidance system was installed to the highway 4 to make the traffic more fluent on the road during the peak hours. The route guidance equipment guides the drivers to use an alternate route (main road 140). The field studies were made before and after the installation of the system.

The percentage of the vehicles turning to the alternative route from the Järvenpää junction was very high during the Midsummer peak hours and on Friday in August during the peak hours when people were going to their summer cottages for the weekend. The road also looked very crowded. During the after studies the percentage of the turning vehicles was higher than during the before period. In September on Friday during the peek hours the percentage of the turning vehicles was about the same before and after the installation of the route guidance system. In September during the field studies the road did not look very crowded. Also the drivers were more used to the route guidance than during the earlier field observations.

There were no conflicts or potential conflict situations observed on the main road NR 4 in Järvenpää junction or in southern Mäntsälä junction. After the installation of the route guidance system there was observed some uncertainty in the traffic behaviour (drivers stopped on the road side or came back from the off-turning ramp to the motor way). his was probably due to the short time the system had been in use. The drivers were not yet used to the system.

The drivers were interviewed on the alternative road before the installation of the route guidance system and after it. The percentage of the drivers aged over 40 years, drivers on holiday or leisure time trip, drivers who came from Helsinki, Espoo or Vantaa (capital region) and drivers who were aiming to Lahfi (about 30 km from the place of the interview) or further was higher during the after period than during the before period. With the route guidance system you can effect on the route choice of the drivers who are on holiday or leisure time trip (going to their summer cottages). It seems that they have partly choiced the alternative route. About a fourth of the interviewed drivers told that the reason for their driving the alternative route was the route guidance.

The average speeds of the vehicles driving trough the route guidance system (highway 4 and main road 140) weighted by the traffic volumes (the average speed of the system) were higher during the after period than during the before period. After the installation of the system the vehicles were then able to get faster trough the route guidance site than before.

K Alppivuori, M Anila, K Pajunen: Valtatie 4:n Järvenpää - Mäntsälä - välin muuttuvan reittiopastusjärjestelmän vaikutukset. [The influence of route guidance system on highway 4 between Järvenpää and Mäntsälä]. Tielaitoksen selvityksiä 86/1995. TIEL 3200 361, ISBN 951-726-164-0, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1995.

5.7 Kotka-Hamina weather-controlled road. Project report. (1995).

Kotka-Hamina weather-controlled road is a 14 km long motorway section with 36 variable speed limit sings and five information boards. The variable message sings are controlled on the basis of road and weather conditions. The aim of this experiment is to make traffic more manageable and improve traffic safety.

Data on weather and road condition is collected from two automatic road weather stations. The central unit of road weather system analyses data and gives the speed limit recommendations. The variable speed limit sings and information boards are controlled by their own dedicated equipment that receives the speed limit recommendations from the central unit. According to the situation signs can also be controlled manually.

The speed limits vary between tree, in mid-winter two, different speeds. The road section normally has a speed limit of 120 km/h in summer and 1 00 km/h in winter. In m id-winter speed limits will vary between 80 and 1 00 km/h according to conditions. Boards give pictorial and textual information on weather and road conditions and possibly other information too.

The weather-controlled road was built in association and at the same time with the Otsola-Summa motorway, however the weather-controlled road was in many ways as an independent project. Project was co-operation between several departments of Kaakkois-Suomi Region, also there was participants from other units of Finnish National Road Administration and private companies. The planning of the road weather information system was started at the beginning of the year 1992 and the system was ready in time for the opening ceremonies of the Otsola-Summa motorway at the November 1994. The total investment costs of the road weather information system was 8,3 million Finnish marks and the estimated maintenance costs per year are 350 thousand Finnish marks.

The effects of the road weather information system will be closely studied. The aim is to evaluate the effects of the system on drivers' behaviour, traffic safety and maintenance of roads. The results will be used to make a decision whether the system can be applied to other highways.

The report was written by Finnra Kaakkois-Suomi Region.

Sääohjattu tie Kotka-Hamina. Projektiraportti. [Kotka-Hamina weather-controlled road. Project report.] Finnish National Road Administration. Kaakkois-Suomi Region. Kouvola 1995.

Weather-controlled road and investment calculations. Finnish National Road Administration. Kaakkois-Suomi Region. Kouvola 1995.

5.8 The Socio-economic profitability of weather-controlled road (1995)

The aim of the study was to find out how the sosio-economic profitability of weather-controlled road has to be evaluated. Changes in the sosio-economical costs of traffic can be calculated on bases of the impacts weather-controlled road has on speeds and number of accidents. When the sosio-economical impacts are compared with the investment and maintenance costs, profitability and productivity of the system can be calculated. Sosio-economical calculations are especially useful comparing where road weather systems can be used and what kind of systems should be used.

The evaluation method was used to estimate profitability of the weather-controlled road between Kotka and Hamina at Finnish National Road Administration South-East region. Since the sosio-economical impacts of the system were uncertain, the sensitivity of parameter variations was evaluated.

Message sings changing according to weather lower speeds during bad road conditions, when accident risk is remarkable higher than usually. That makes is possible to save in the accident costs without significant increase in the time costs. The weather-controlled road has only small effects on the other evaluated sosio-economical costs. Based on the estimations done in this research it seems that the Kotka-Hamina weather-controlled road has been sosio-economically profitable investment.

The study was carried out by Finnra Kaakkois-Suomi Region.

J Lähesmaa: Sääohjatun tien yhteiskuntataloudellinen edullisuus. [Socio-economic profitability of weather-controlled road]. Finnish National Road Administration. Kaakkois-Suomi Region. Kouvola 1995.

5.9 Evaluation of the lane control system on Kalla bridges in Kuopio (1995)

The first reversible lane control in Finland was taken to use in Kuopio in 1995. It consists of 70 variable message signs, a pair of booms and traffic lights. The road is a high-level 2-carriageway road (2+2 lanes) with maximum speed of 80 km/h on the bridge and 100 km/h around the bridge. The average daily traffic is 22 500 vehicles.

The lanes of the bridge have to be closed for traffic every now and then because of the maintenance works. During the summer the bridge is opened some 400 times for maritime traffic. In this publication we have observed the effects of the new traffic control system on the traffic flow and the work of the maintenance workers. Also the opinions of the road users have been asked.

The new system has improved traffic flow and made the working conditions of the maintenance workers safer. Variable message signs are obeyed well. The speeds were reduced already from the first sign and the closed lane was not used at all. Before the experiment the speeds were 30 - 50 km/h at the critical place. After the installation of the system they are 15 - 25 km/h.

The working conditions have become safer. The traffic is stopped fully during some maintenance operations. Because of the reduced speeds and stopping down the traffic, the queues are however longer than before the experiment.

The amount of work to control the traffic has reduced greatly. Before the experiment it took 2 - 4 hours to close the bridge. Now it takes only 5 - 10 minutes. The control system is automated and it can be controlled from a remote centre.

Road users consider the variable message signs clear and more attractive than the older ones.

The study was carried out by Finnra Savo-Karjala Region.

Kallansiltojen muuttuvan liikenteenohjauksen vaikutusselvitys. [Evaluation of the lane control system on Kalla bridges in Kuopio]. Finnish National Road Administration. Savo-Karjala Region. Kuopio 1995.

5.10 Safety evaluation of incident warning systems. Integration of results (1995)

The DRIVE II project HOPES carried out an evaluation the purpose of which was to assess the safety impact of incident warning systems (IWS). Three different IWS were to be implemented in the projects V2022 EUROTRIANGLE, V2037 PORTICO and V2040 MELYSSA of the Transport Telematics programme. All of these systems were to be implemented on inter-urban road sections, and usually on motorways. Due to practical problems beyond our control, we could proceed as planned with a before and after study design at one site only, the two-lane road site of PORTICO (IP5).

The evaluation task was divided into the following six main activities: accident review, speed and traffic flows, traffic behaviour, traffic conflicts, simulator study on incident warning messages, and control room operations. All of these activities have reported their main results as separate HOPES deliverables. This report integrates the results of these activities along with results obtained elsewhere.

The accident review showed that a large proportion of accidents at the sites were relevant for the IWS, but there were considerable differences between the accident patterns at each site.

The safety evaluation of the PORTICO light pole system was based on the analysis of traffic flows, speeds, traffic behaviour and conflicts before and after the implementation of the system. The system was usually triggered by speeding cars on the two-lane IP5 road in Portugal. The IWS caused a reduction of driving speeds, especially the highest ones, and thereby stabilised the traffic flow. Most of the disturbances and conflicts were connected to overtaking situations. The number of overtakings and related disturbances had decreased after the implementation of the IWS, but not significantly. The speed changes would indicate a reduction in accident risks, most likely of the magnitude of 10 - 15%.

The flow, speed, disturbance and conflict analyses at two other sites could not be used in the assessment of the safety impact as the IWS systems were not implemented in time. A new promising method was, however, developed in these analyses for analysing the safety of traffic flow on the basis of vehicle by vehicle loop data.

The simulator study investigated the effects of different level of detail in IWS messages. All IWS systems studied made the drivers slow down and speeded up the drivers' response to the incidents. The content and coding of messages affect driver behaviour, especially via the action recommendations displayed. The level of detail in the messages, however, had no effect on the variation of behaviour. There are large individual differences between drivers in reacting to IWS messages. Some drivers will obey a message to a rather high degree, while another group will rely more on their own judgement than on the IWS.

Earlier accident studies have usually shown accident reductions on the IWS equipped motorway sections. The whole range of the effect on the total number of injury accidents was from - 35% to + 9%. The effects are more beneficial on secondary accidents. Very little information exists of the safety effects of radio based IWS systems.

R Kulmala, S Fránzen, B Dryselius: Safety evaluation of incident warning systems. Integration of results. HOPES (Horizontal Project for the Evaluation of Safety), DRIVE II Project V2002, Deliverable 35. 1995.

5.11 Guidelines for the use of variable message signs in Finnra (1996)

Variable message sign is a general name for all devices used along the road the road which can deliver variable information. Traffic lights are not included in variable message signs.

In 1996, Finnra's guidelines for the use of variable message signs were defined. The aim of the guidelines is that the message given by a variable message sign follows the same principles all around the country. Furthermore, it should not be forgotten that the use of variable message signs follows the same rules as the use of conventional traffic signs.

Five lines of action were identified to make the use of variable message signs more coherent in Finnra:

1. We shall report the results of the experiences. A database that contains up-to-date information about the systems in use and under planning will be set up
2. We shall act in accordance with agreed principles. There has to be a well defined reason to use VMS. The VMS systems have been divided to three categories:
   - **Standard solution**. The content and outlooks of the VMS have been defined based on previous experiences. The system can be brought into use without evaluation.
   - **Solution under experiment**. The solution is in use and being evaluated. General rule is that the results of the evaluation should be available and beneficial (-> standard solution) until implementing the system in another location.
   - **New solution**. There are no previous experiences. During the planning phase, cost and benefits will be estimated. If an experiment is considered worthwhile and it is carried out, the system will be carefully assessed.
3. We shall design together with the Ministry of Transport and Communications such variable message signs that differ from those defined at traffic regulations.
4. We shall take care of the operation and maintenance of variable message signs also outside working hours.
5. We shall design the systems based on uniform technical descriptions.

Muuttuvien opasteiden kokeilun ja käytön toimintalinjat Tielaitoksessa. [Guidelines for the use of variable message signs in Finnra]. TIEL 2300010, ISBN 951-726-249-3. Finnish National Road Administration. Helsinki 1996.

5.12 Effects of technology of variable speed limit signs on speed behavior and recall of signs (1996)

This field study was designed to compare effects of two different technologies of variable speed limit signs on (a) speed behaviour and (b) recall of signs. Specifically, the speed limit signs were of fibre optic and electromechanical technology. The experimental site was located on an interurban road, with a fixed speed limit of 80 km/h. Variable speed limit signs of 60 km/h were erected 245 m (fibre optic) and 266 m (electromechanical) before an intersection of a secondary road. The stimulus condition was always changed after one hour to match the lighting and traffic conditions. The speed of about 2,200 cars and vans, as well as 340 trucks and buses was measured by detector loops locating 1,550 and 25 m before the intersection. In addition, 307 drivers were interviewed about 1 km after passing the sign. The main question concerned the content of the variable speed limit sign.

The main results showed that the speed limit sign of fibre optic technology reduced the mean speed of cars and vans travelling in free-flow traffic from 87.7 to 66.3 km/h, while the electromechanical sign reduced the mean speed from 88.4 to 70.4 km/h. The corresponding reductions for trucks and buses were from 84.8 to 65.4 km/h and from 84.0 to 68.6 km/h, respectively. There were no statistically significant differences between initial speeds for signs. However, the differences in speeds after the signs were significant indicating that the sign of fibre optic technology decreased the mean speed of cars and vans 3.4 km/h more than the electromechanical sign. The corresponding reduction for trucks and buses was 4,0 km/h. The results of the driver interviews showed that 91.0% of the drivers recalled the sign when the fibre optic sign was used, but only 71.6% of the drivers recalled the sign when the electromechanical sign was used.

The main implication of this study is that the variable speed limit sign of fibre optic technology is more effective than the electromechanical sign. However, more research is needed to evaluate whether these effects exist if drivers frequently encounter the signs of fibre optic technology, for example. At present variable speed limit signs are used only in a few locations in Finland.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

J Luoma: Muuttuvan nopeusrajoitusmerkin tekniikan vaikutukset ajonopeuksiin ja merkin muistamiseen. [Effects of technology of variable speed limit signs on speed behaviour and recall of signs]. Tielaitoksen selvityksiä 76/1996. TIEL 3200443, ISBN 951-726-302-3, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1996.

5.13 Technical performance of variable message signs in Finnish climate (1995-1996)

In winter 1995-1996, Finnra arranged a test in the Finnish Lapland in order to assess the mechanical durability of variable message signs. In total 10 signs of different manufacturers (prism, electro-mechanical and fibre-optic signs) were tested. Manufacturers of the signs were not given any quality requirements, but they were informed that the weather conditions at the test site were to be hard.

Four (4) out of the ten (10) signs tested got through the test without remarkable damage.

The results of the test will be used in preparing quality requirements for variable message signs. Also European performance requirements are under preparation.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

5.14 Effects of the weather controlled traffic management system in the motorway section between Kotka and Hamina (1994-1997)

This study was designed to investigate the effects of weather controlled speed limits and displays on driver behaviour. Specifically, we collected data on (a) vehicle speeds and headways and (b) driver acceptance. In addition, the system performance and reliability were evaluated.

The system consisted of thirty-six variable speed limit signs and five variable slippery road signs/temperature displays that were installed along the 14 km long motorway section between two Finnish cities (Kotka and Hamina) on Finland's southern coast. Local weather and road surface conditions were monitored automatically from road weather stations, and the information was used for determining appropriate speed limits and controlling variable displays. The maximum speed limit was 120 km/h in summertime and 100 km/h in wintertime. If the road was slippery (because of snow, ice or water), the speed limits were 100 or 80 km/h.

Speed and headway data were obtained from detector loops. In addition, speed profiles along the section were studied by the car following method. The road weather data and status of variable signs were recorded by the weather stations. The road surface judgements based on the road weather station data were compared with the manual observations of the road surface conditions and friction measurements. Finally, road users were interviewed in four road-side surveys.

The main results showed that variable speed limits of the experimental road decreased the mean speed more than adverse road conditions on the control road with fixed speed limits. Specifically, the effect of the change from 100 km/h to 80 km/h decreased the mean speed of the cars travelling in free-flow traffic by 3.4 km/h, in addition to the average decrease in the mean speed by 6.8 km/h caused by adverse road surface conditions. The corresponding effect was 4.8 km/h if there was no rain or the rain was insignificant. The proportion of these conditions was approximately 85 %. These speed effects were 1.7 and 3.0 km/h if the slippery road sign was on. In addition, the reduction of the speed limits on the experimental road decreased the standard deviation of the speed, while the effect was opposite on the control road with fixed speed limits.

The results of the survey showed that 88 - 94 % of the interviewed drivers (n=590) recalled the variable signs. However, only 66 % of the interviewed drivers (n=61) recalled the variable slippery road sign. Furthermore, 81 % of the drivers expressed that the prevailing speed limit was appropriate, and 95 % of the drivers expressed that the variable speed limits were useful.

During the winter 1995 - 1996, the decreased speed limit (80 km/h) was applied for 21 % of the total time. In the summertime, the decreased speed limit of 80 km/h was applied for 3 % of the time and 100 km/h for 20 % of the time. The comparison of current speed limits and manual observations of the weather and road conditions showed that too high speed limits were applied in 26 % of the cases. In contrast, the speed limits were infrequently too low.

It is concluded that the system of weather controlled speed limits and displays improved traffic safety by decreasing mean speeds and distribution of speeds. The effects on mean speeds were not sufficient to make the system socio-economically profitable. The lowering of the speed limits because of poor weather and road conditions was acceptable to the drivers. The evaluation of the system performance showed that the methods to detect slipperiness needs further development.

The study has been granted European Community financial aid in the field of Trans-European Networks-Transport.

P Rämä: Sää- ja kelitietoon perustuvan liikenteen ohjausjärjestelmän vaikutukset Kotka-Hamina moottoritiellä. [Effects of the weather controlled traffic management system in the motorway section between Kotka and Hamina]. Tielaitoksen selvityksiä 1/1997. TIEL 320 0488, ISBN 951-726-311-2, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1997.

5.15 The socio-economic profitability of the Kotka-Hamina weather controlled road (1997)

The purpose of the study was to find out the socio-economic profitability of the Kotka - Hamina weather controlled road. It was also illustrated how the changes in the cost factors affect profitability. Based on this estimates were made about how similar road weather information systems could be made more profitable in the future.

The socio-economic costs of traffic were estimated based on the changes the road weather information system has on average speeds and the numbers of accidents. Variable speed limits controlled according to weather and road conditions lower speeds during bad conditions when the risk of accident is many times higher than in normal conditions. This makes it possible to save in accident costs without significant increase in time costs. The accident costs at the Kotka - Hamina weather controlled road were estimated to decrease about 1, 1 million Finnish marks annually while time costs increase by less than 500 *000* Finnish marks. The weather-control system has only small effects on the other evaluated socio-economic costs.

The productivity and profitability of the system was calculated by comparing the total socio-economic impacts with the investment and maintenance costs. The construction of the weather-control system cost some 8,2 million Finnish marks and the annual maintenance costs are 330 000 marks. The benefit-cost ratio of the investment is 0,5 and the remunerative rate of interest is 4 per cent. The socio-economic savings account for only half of the total costs of the system and the return on investment is poor.

The Kotka - Hamina weather controlled road is an experiment and the costs were not the main concern during the construction. If a similar system would be built now it would be 2,2 million marks less expensive. In addition by using the system on a longer road section, when the fixed costs of construction and maintenance would have relatively smaller share, and by trying wireless communication it would be possible to reduce the costs even more. If these preconditions can be met weather-controlled roads can be a profitable investment to the society.

The study has been granted Community financial aid in the field of Trans-European Networks - Transport (TEN-T).

J Lähesmaa: Kotka-Hamina sääohjatun tien yhteiskuntataloudellisuus. [The socio-economic profitability of the Kotka-Hamina weather-controlled road]. Tielaitoksen selvityksiä 36/1997. TIEL 3200482, ISBN 951-726-368-6, ISSN 0788-3722. Helsinki 1997.

5.16 Driver responses to variable road condition signs (1997)

A recent Finnish study by Rämä, Kulmala, and Heinonen (1996) showed that (a) the variable sign warning about slippery road conditions reduced the mean speed by 1-2 km/h and (b) the variable sign recommending the minimum headway between vehicles decreased the proportion of the drivers following other vehicles with headway of less than 1.5 seconds by 28-38%. However, the signs might have other impacts on driver behaviour in addition to the effects on speed and headway. Consequently, this study was designed to investigate other potential responses to these signs. The data were collected by telephone interviews involving car drivers willing to participate in the telephone interview. The preceding roadside interviews sampled drivers who encountered either of the signs in adverse road surface conditions. Specifically, each roadside interview was conducted while the measured coefficient of friction was between 0.2 and 0.3. Totally, 114 drivers that had encountered the slippery road sign and 111 drivers encountered the minimum headway sign were interviewed. The questions about the slippery road sign concerned the prevailing road conditions (snow fall) and the slippery road conditions that are not easily detectable ('black ice'). The questions about the minimum headway sign only concerned the prevailing 'black ice' conditions.

In both road conditions, the drivers indicated that the slippery road sign influenced particularly driving speed and direction of attention. Specifically, drivers reduced their driving speed in general and particularly in curves, concentrated on own driving more than usually, were attentive, and monitored opposing traffic more than usually. In the 'black ice' conditions, there were more reported responses than in the prevailing road conditions, on average. In addition, testing of the slipperiness by braking was emphasised in these road conditions.

Furthermore, the drivers relatively frequently reported the following responses: improved driving comfort, extended headway, refraining from passings, and different use of controls (steering, brake pedal, or gas pedal). The effects on driving speed and headway correlated positively with many other responses.

The drivers indicated that the minimum headway sign particularly influenced the following distance (monitoring or increasing the distance). In addition, the following effects were indicated relatively frequently: monitoring the vehicle ahead, focusing on own driving, discussion of the meaning of the message, checking of and general reduction of driving speed, and testing of the slipperiness by braking.

The results suggest that these variable message signs have many other impacts than can be measured in terms of speed and headway. The most essential effects deal with the direction of attention to find cues showing potential hazards, testing the slipperiness, and careful passing behaviour. On the other hand, the results suggest that the driving speed and headway are also the most essential variables which many other variables correlate with.

The study has been granted European Community financial aid in the field of Trans-European Networks - Transport.

J Luoma, P Rämä, M Penttinen, V Harjula: Muuttuvien keliopasteiden vaikutukset kuljettajan toimintaan. [Driver responses to variable road condition signs]. Tielaitoksen selvityksiä 22/1997. TIEL 3200469, ISBN 951-726-350-3, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1997.

6 DEMAND MANAGEMENT

6.1 Lane arrangements for High Occupancy Vehicles (1994)

The traffic management research programme supports Finnra's strategic planning through assessing the applicability of traffic management techniques and their impact on traffic system.

In this context, one possible technique is HOV-arrangements. The term HOV stands for *High Occupancy Vehicle,* i.e. a vehicle with at least one traveller in addition to the driver (2+). The functional, technical and economic characteristics of these arrangements are not generally known. This state-of-the-art report is based on North American literature.

Most of the HOV arrangements have been implemented in North American metropolises, on radial and ring motorways. HOV-lanes are designated for use by vehicles fulfilling the occupancy criteria (usually 2+). They are usually separated from the actual roadway.

Some ten years of US experience has been expressed in functional and technical design guidelines for HOV-arrangements. These guidelines correspond to normal, generally accepted traffic and roadway design principles, that are in use also in Finland. Thus, they can be implemented as such in Finnish functional and preliminary technical studies. This report contains guidelines that can be applied to achieve an optimal and user friendly (safety oriented and legible) design.

HOV arrangements are one way to increase the efficiency of moving people, especially for journeys to work, in an area or traffic corridor. In Finland, areas with substantial traffic are few and limited. This, and the technical characteristics of our main road network, limit the possibilities for implementing economically viable HOV-arrangements. In this report, further studies on traffic policy, political and technical conditions are proposed, to give a better basis for further discussions about HOV-arrangements. The studies would concern

- transportation policy aspects in general
- HOV demand and potential
- a technical and economical design for a given corridor.

HOV- ratkaisut. Monimatkustaja-ajoneuvoja palvelevat kaistajärjestelyt. [Lane arrangements for High Occupancy Vehicles]. Tielaitoksen selvityksiä 21/1994. TIEL 3200231, ISBN 951-47-9381-1, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1994.

6.2 Study on the German "Statt-auto"-concept (1995)

"Statt-auto" is a service where a private company lends vehicles to private people. This system enables people to use a private car when needed without buying their own car. People who wish to use Statt-auto join the company by paying an initial fee and yearly/ monthly fees, and pay for the use of the car based on hours and mileage driven.

The concept started in Germany and now there are "Statt-auto" enterprises also in Switzerland, Holland and Austria. Interest has been show for "Statt-auto"-concept in Great-Britain, Spain, France and Finland.

This research consists of a literature survey, a field study made in Cologne in Germany and a marketing survey made in Helsinki region. These surveys were drawn together in a final report.

The aim of this research was not to copy the concept but to build a system designed to the Finnish environment based on the German "Statt-auto"-concept. It is clear that circumstances in Finland and in Germany are different. Also the cultural differences have to be taken into account.

Sijaisautotoiminta. Tutkimus saksalaisen Statt-auto -mallin soveltuvuudesta Suomen olosuhteisiin. [Study on the German "Statt-auto"-concept]. Kansainvälisen kaupan opiskelijayhdistys ry. Helsinki 1995.

6.3 Plan for park-and-ride in the Helsinki region (1994)

This report handles the plan for park-and-ride in the Helsinki-region. The plan was made by Helsinki Metropolitan Area Council in co-operation with Ministry of Transport and Communications, Finnish Railways, Finnra and the cities of Helsinki, Espoo and Vantaa.

The aim of park-and-ride system is to reduce the number of vehicles trying to get to the centre of Helsinki. According to forecasts, the number of vehicles using park-and-ride will equal the number of vehicles on three lanes trying to get to centre of Helsinki in the year 2010.

In this plan, five locations for park-and-ride experiment were proposed.

Information of the level of service of the public transport is believed to have a positive effect on the attractiveness of park-and-ride. Therefore, information will be given through variable message signs by the roadside. Signs will contain information about the service interval of different transport modes.

During the experiment phase the service will be free of charge. Later the charge will be handled with the help of smart card.

Suunnitelma liityntäpysäköintikokeiluksi pääkaupunkiseudulla 1994. [Plan for park-and-ride in the Helsinki region]. Pääkaupunkiseudun julkaisusarja B 1994:2. Helsinki Metropolitan Area Council. Helsinki 1994.

6.4 Studies on park-and-ride in the Helsinki region (1995-1996)

Helsinki Metropolitan Area Council in co-operation with the Ministry of Transport and Communications, Finnish Railways, Finnra and the cities of Helsinki, Espoo and Vantaa introduced park-and-ride in the Helsinki region in 1995.

Park-and-ride was introduced in five locations (Itäkeskus, Mellunmäki, Tuomarinkartano, Leppävaara ja Vantaankoski) in May 1995. The route signing to these locations was improved, partly with the help of variable message signs, and more parking places were constructed. The whole system was marketed in different media. People living outside the Helsinki-region were offered a possibility to buy a 30-day ticket at the same price than those living inside the region.

According to a study made in September 1995 the number of vehicles in the park-and-ride had increased with 9%. At the same time the number of parked vehicles in other parking areas had stayed constant. Most of the park-and-riders were 35-44 years old (38 %) and women (65%).

The reason for using park-and-ride was mainly the parking troubles in the destination zone (43%). The car was needed for some part of the trip for 18% of the people in the survey. The fastest alternative it was for 13% of the people. Comfort and traffic jams were following on the list of reasons for using park-and-ride.

58 % of the people interviewed in the survey used the same transport mode as before the experiment. 11% used private transport and 14% used public transport. 6% were commuters. 9% had changed they origin or destination during the experiment. The most important reason to move to park-and-ride were the new arrangements of park-and-ride (19%).

The improvement wishes were mainly about the timetable information (22%) and commuter connections to stations and bus stops (16%). Additionally was noted that park-and-ride should be free of charge. Parking areas should be in good shape and covered. Route signing and information should work well and the level of service should be high. The pricing should be moderate.

Liityntäpysäköintikokeilun tutkimukset pääkaupunkiseudulla 1995. [Sudies on park-and-ride in the Helsinki region]. Pääkaupunkiseudun julkaisusarja C 1996:2. Helsinki Metropolitan Area Council. Helsinki 1996.

6.5 Demonstration of a traffic demand management toolbox in Helsinki, Leppävaara – the ADEPT 2 project

The ADEPT 2 is a European Union 4th Framework Programme project that demonstrates, validates and evaluates electronic transport payment systems. ADEPT 2 has a total of 18 partners, among which the Finnish Ministry of Transport and Communications, Finnra and the Helsinki Metropolitan Area Council. The co-ordinator of the project is The University of Newcastle upon Tyne in the UK.

During autumn 1997, the ADEPT II test site Helsinki demonstrated a demand management toolbox; a set of telematic transport demand management measures, their interoperability with automatic payment systems and collected feed-back from demonstration participants.

In the demonstration, the park-and-ride system in Leppävaara was completed with telematic demand management tools making use of smart cards and microwave transmission. The demonstrated onboard unit provided traffic information, route guidance and also an opportunity to book and pay for park-and-ride parking. Automatic smart card payment made the modal interchange to public transport a competitive and easy to use option. A road pricing fee was collected automatically, if the driver chose to continue by car to the city centre.

Also a small-scale survey was made regarding the participants' expectations of demand management and on the possible impacts of the demonstrated system.

7 METHODS FOR ASSESSMENT OF THE EFFECTS OF ROAD TRANSPORT TELEMATICS

7.1 Transport telematics – techniques, effects, assessment (1995)

Telematics is the part of information technology that consists of both data communications and data processing. The term road transport telematics covers a large number of applications for collecting and processing data about road conditions, traffic and travel, as well as using these data in traffic control, informing travellers, controlling transport fleets and single vehicles. Transport telematics is a means of traffic management, which, in turn, aims at affecting travel demand, modal split, route choice and trip timing, and users' behaviour in a way that improves the efficiency, economy and safety of the traffic system and reduces harmful environmental impacts caused by traffic.

This literature study gives an overview of international research programmes like ATT and IVHS, applications of transport telematics, their effects, and assessment methods. The report also includes an English-Finnish glossary of road transport telematics terminology.

Expectations for the positive effects of transport telematics are high but the verified impacts are still quite modest. Currently widely implemented applications of transport telematics include fleet and freight management, automatic debiting and driver information systems. The costs and benefits of these systems cannot, however, still be reliably estimated.

In transport telematics, Finland is focusing on weather related traffic management, radio and cellular network based information services, public transport management, integrated payment systems and logistics applications.

The responsible organisations in Finland are the Ministry of Transport and Communications, Technology Development Centre Finland (TEKES), Finnish National Road Administration, municipalities, freight and public transport operators and the police.

The field of transport telematics is rapidly progressing. Thus, at the moment, the Finnish parties should concentrate on clarifying their needs and enhance national, Nordic, and international co-operation. A successful implementation of transport telematic services requires careful preparation, quality control, and well organised research. The effects of the implemented systems should always be assessed and evaluated in order to analyse the impacts, costs and benefits of the applications, so that the future investments can be directed in a sensible way.

Tieliikenteen telematiikka, sen vaikutukset ja vaikutusten arviointi. [Transport telematics – techniques, effects, assessment]. Tielaitoksen selvityksiä 12/1995. TIEL 3200290. Finnish National Road administration. Helsinki 1995.

7.2 Guidelines for assessment of transport telematics applications in inter-urban traffic management & information (1994)

The DRIVE II Programme included a number of projects which were examining the effectiveness of transportation systems applicable to urban areas. There were a diverse range of systems and test sites and most projects had developed evaluation plans which set out the approach and which also reflected local priorities and financial constraints.

In order to reach conclusions on the strategic aims of the Prograrnme, it was necessary to obtain a common understanding on specific evaluation issues in particular:

1. Definitions of the systems being evaluated and the expected impacts of these systems (i.e. the objectives of the assessments)
2. Methods of evaluation and indicators selected for measurement (the design of the field trials)
3. Opportunities for comparative studies between projects within the DRIVE

The evaluation process adopted by each project can be expressed in simple terms as follows:

1. WHAT is being examined (system descriptions and functionality)?
2. WHY are systems tested (objectives, expected impacts)?

3. HOW are evaluations conducted (methods, indicators)?
4. WHERE are tests carried out (location of field trials)?
5. WHEN are measurements taken (time of day, year, duration)?

Establishing the links between the systems implemented. the objectives of these systems and the methods of evaluating the system effects represents the basic requirement of a set of evaluation guidelines. It is also necessary to have a clear understanding of issues and common definitions to ensure consistency in the approach to the assessment of projects

This document gives details of the assessments being undertaken by projects in the Urban Traffic Management and Information (UTMI) Working Group of the ATT Task Force on Evaluation. It identifies the commonalties in system objectives, evaluation methods and indicators, and areas where comparative studies of project results can be carried out.

S Morello, D Maltby: Guidelines for Assessment of Transport Telematics Applications in Inter-Urban Traffic Management and Information. CORD Project V2056 Deliverable No AC07 -Volume 5. European Commission 1994.

7.3 Simulation as a tool in assessment of transport telematics (1996/1997)

Transport telematics offers many methods to affect on transport efficiency and safety on roads. Telematics also supposed to have positive impact on environmental effects of traffic. There is still a lack of empirical experience of effects of many telematic solutions, because they represent new technology and new ideas. Hence, a computer simulation is almost the only useful method to collect systematical data on effects of systems before implementation.

Microscopic processing is becoming more common in every sector of traffic simulation. Microscopic models are behaviourally more realistic than macroscopic models, because they can describe the effects of dynamic phenomena more directly. The weak points of microscopic models are their great requirements to validation and input data and technical requirements to building and usage of a model.

The development work of traffic simulation models and programs has normally been done in universities and research organisations, where they still mostly are used. Traffic simulation programs have typically rather difficult user interface despite of fine traffic technical details. However, programs are becoming easier to use due to development of computing technology and growth of program usage with increase of users. Many traditional programs have been adapted and new programs developed to run using Windows platform. Along with usage also the building of models have been supported by development of interactive editor programs and combination of data systems.

The invention of models shows that the effects of telematics have been tried to assess with many models. An intensive development work is underway, but it has not proceeded far enough, so that there were suitable simulation programs to assess many different telematic solutions. However, the development is quickly leading that way.

On providing the simulation programs, one should concentrate on well validated, integrated programs, that fit the Finnish circumstances. The ministry of transport and communications and the ministry of industry could support the delivery of these programs. HUTSIM represents the Finnish expertise in traffic simulation and its integration, user interface and telematic development are worth supporting. Also demand simulation, weather and road condition simulation, simulation of safety effects and simulation of information systems should be contributed. These very important sectors still need a lot of development work.

The study has been granted European Community financial aid
in the field of Trans-European Networks - Transport.

J Ojala: Simulointi liikenteen telematiikan vaikutusten tutkimus- välineenä. [Simulation as a tool in assessment of transport telematics]. Tielaitoksen selvityksiä 32/1997. TIEL 3200478, ISBN 951-726-363-5, ISSN 0788-3722. Finnish National Road Administration. Helsinki 1997.

8 APPENDIX

8.1 List of publications in the traffic management research programme 1993-1997

Publications of the in the Traffic Management Research Programme

Nopeusnäyttötaulun vaikutukset liikenteen nopeuksiin. [The effect of a speed display on driving speed]. Tielaitoksen sisäisiä julkaisuja 53/1993. TIEL 4000053. Finnish National Road Administration. Helsinki 1993.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus. [Finnra driver information services. Development study]. Tielaitoksen selvityksiä 88/1993. TIEL 3200215. Finnish National Road Administration. Helsinki 1993.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus: Tienkäytön ammattilaisten puhelinteemahaastattelu. [Finnra driver information services. Development study. Telephone interview of professional drivers]. Tielaitoksen sisäisiä julkaisuja 54/1993. Finnish National Road Administration. Helsinki 1993.

Tielaitoksen liikenteen informaatiopalvelujen kehittämistutkimus: Käyttöliittymäanalyysi. [Finnra driver information services. Development study. Assessment of the user interface]. Tielaitoksen sisäisiä julkaisuja 55/1993. Finnish National Road Administration. Helsinki 1993.

Tienkäyttäjäinformaatio. Tielaitoksen toimintaperiaatteet. [Finnra's guidelines for road user information]. TIEL 2300009. Finnish National Road Administration. Helsinki 1994.

Kosonen, Eini: Kelitiedotus ja tienvarressa esitettävien keliviestien ymmärrettävyys. Master's Thesis, Helsinki University of Technology. Espoo 1993.

Hirvenoja Eini: Comprehension of variable message signs for road conditions. Finnra reports 62/1994. TIEL 3200271E. Finnish National Road Administration. Helsinki 1994.

HOV-ratkaisut. Monimatkustaja-ajoneuvoja palvelevat kaistajärjestelyt. [Lane arrangements for High Occupancy Vehicles]. Tielaitoksen selvityksiä 21/1994. TIEL 3200231. Finnish National Road Administration. Helsinki 1994.

Helsingin seudun pääväylien liikenteen hallinta. Esiselvitys. [Traffic management in the Helsinki Metropolitan Area. A preliminary study]. Tielaitoksen selvityksiä 6/1994. TIEL 3200217. Finnish National Road Administration. Helsinki 1994.

Tieliikenteen ruuhkien vaikutukset ja ruuhkakustannukset pääkaupunkiseudulla. [The Impacts of road traffic congestion and their costs in the Helsinki metropolitan area]. Tielaitoksen selvityksiä 60/1994. TIEL 3200269. Finnish National Road Administration. Helsinki 1994.

Esiselvitys automaattisesta liukkauden havaitsemisesta liikenteessä. [Preliminary study on possibility to detect the tire/road friction level onboard].

Tielaitoksen selvityksiä 63/1994. TIEL 3200272. Finnish National Road Administration. Helsinki 1994.

Tiekuljetusten telematiikka. [Telematics of road transports]. Tielaitoksen selvityksiä 8/1995. TIEL 3200286. Finnish National Road Administration. Helsinki 1995.

Tieliikenteen telematiikka, sen vaikutukset ja vaikutusten arviointi. [Road Transport Telematics – techniques, effects and assessment]. Tielaitoksen selvityksiä 12/1995. TIEL 3200290. Finnish National Road Administration. Helsinki 1995.

Estlander, Katja: Sään ja kelin vaikutukset eri ajoneuvoryhmien nopeuksiin. [Effects of weather on driving speeds]. Tielaitoksen selvityksiä 23/1995. TIEL 3200301. Finnish National Road Administration. Helsinki 1995.

Nopeudennäyttö- ja turvavälitaulujen vaikutukset liikenteeseen. [Effects of display units indicating driving speed and safety distance between vehicles]. Tielaitoksen selvityksiä 27/1995. TIEL 3200305. Finnish National Road Administration. Helsinki 1995.

Rämä Pirkko, Kulmala Risto, Heinonen Matti: Muuttuvien kelivaroitusmerkkien vaikutukset liikennekäyttäytymiseen Turun tiepiirissä talvella 1993 - 1994. [Behavioural effects of slippery road variable warning signs in Turku region in winter 1993-1994]. Tielaitoksen selvityksiä 36/1995. TIEL 3200313. Finnish National Road Administration. Helsinki 1995.

Johansson Martin: Liikenteen seuranta ja häiriöiden havaitseminen. [Traffic monitoring and incident detection]. Tielaitoksen selvityksiä 52/1995. TIEL 3200329. Finnish National Road Administration. Helsinki 1995.

Alppivuori Kari, Anila Matti, Pajunen Kirsi: Valtatie 4:n Järvenpää - Mäntsälä -välin muuttuvan reittiopastusjärjestelmän vaikutukset. [The influence of route guidance system on highway 4 between Järvenpää and Mäntsälä]. Tielaitoksen selvityksiä 86/1995. TIEL 3200361. Finnish National Road Administration. Helsinki 1995.

Rämä Pirkko, Kulmala Risto, Heinonen Matti: Muuttuvien kelivaroitusmerkkien vaikutus ajonopeuksiin, aikaväleihin ja kuljettajien käsityksiin. [The effect of variable road condition warning signs]. Tielaitoksen selvityksiä 1/1996. TIEL 3200370. Finnish National Road Administration. Helsinki 1995.

Hietanen Juha, Enberg Åsa: Liikennevirta alemman nopeustason kaksikaistaisilla väylillä. [Traffic Flow on low-speed two-lane roads in Finland].

Tielaitoksen selvityksiä 18/1996. TIEL 3200387. Finnish National Road Administration. Helsinki 1996.

Kiljunen Matti, Summala Heikki: Ruuhkaisuuden kokeminen ja liikennetilannetiedottaminen. Tienkäyttäjätutkimus kaksikaistaisilla teillä. [Perception of traffic conditions, and traffic information - a road user survey on two lane roads]. Tielaitoksen selvityksiä 25/1996. TIEL 3200393. Finnish National Road Administration. Helsinki 1996.

Liikenteen seurannan esiselvitys. [Road traffic monitoring preliminary study]. Tielaitoksen sisäisiä julkaisuja 24/1996. TIEL 4000141. Finnish National Road Administration. Helsinki 1996.

Liikenteen tiedotuspistekonsepti. [Finnra's concept for Travellers' points of information]. Tielaitoksen sisäisiä julkaisuja 25/1996. Finnish National Road Administration. Helsinki 1996.

Muuttuvien opasteiden kokeilun ja käytön toimintalinjat Tielaitoksessa. [Guidelines for the use of variable message signs in Finnra]. TIEL 2300010. Finnish National Road Administration. Helsinki 1996.

Penttinen Merja: Autonkuljettajien informaatiotarpeet. [Drivers' information needs]. Tielaitoksen selvityksiä 73/1996. TIEL 3200440. Finnish National Road Administration. Helsinki 1996.

Luoma Juha: Muuttuvan nopeusrajoitusmerkin tekniikan vaikutukset ajonopeuksiin ja merkin muistamiseen [Effects of technology of variable speed limit signs on speed behaviour and recall of signs]. Tielaitoksen selvityksiä 76/1996. TIEL 3200443. Finnish National Road Administration. Helsinki 1996.

Integroitu havaintoasema. Yleiset toiminnalliset vaatimukset. [An integrated monitoring station. General functional requirements]. Finnish National Road Administration. Unpublished memorandum 1996.

Rämä Pirkko: Sää- ja kelitietoon perustuvan liikenteen ohjausjärjestelmän vaikutukset Kotka-Hamina moottoritiellä [Effects of the weather controlled traffic management system in the motorway section between Kotka and Hamina]. Tielaitoksen selvityksiä 1/1997. TIEL 3200488. Finnish National Road Administration. Helsinki 1997.

Karhunen Mikko, Noukka Mirja, Vatanen Mervi: Liikenteen hallinnan toimintokortisto. [Traffic management applications toolbox]. Tielaitoksen selvityksiä 2/1997. TIEL 3200449. Finnish National Road Administration. Helsinki 1997.

Loogisen palvelutietokannan kuvaus. [Description of a logical service database]. Tielaitoksen sisäisiä julkaisuja 3/1997. Finnish National Road Administration. Helsinki 1997.

Luoma Juha, Rämä Pirkko, Penttinen Merja, Harjula Virpi: Muuttuvien keliopasteiden vaikutukset kuljettajan toimintaan. [Driver responses to variable road condition signs]. Tielaitoksen selvityksiä 22/1997. TIEL 3200469. Finnish National Road Administration. Helsinki 1997.

Ojala Jouni: Simulointi liikenteen telematiikan vaikutusten tutkimusvälineenä. [Simulation as a tool in assessment of transport telematics]. Tielaitoksen selvityksiä 32/1997. TIEL 3200478. Finnish National Road Administration. Helsinki 1997.

Lähesmaa Jukka: Kotka-Hamina sääohjatun tien yhteiskuntataloudellisuus. [The socio-economic profitability of the Kotka-Hamina weather-controlled road]. Tielaitoksen selvityksiä 36/1997. TIEL 3200482. Finnish National Road Administration. Helsinki 1997.

Leviäkangas Pekka: Finnra's VIKING Programme. Finnra Internal Publications 24/1997. TIEL 4000174E. Finnish National Road Administration. Helsinki 1997.

Tielaitoksen liikenteen hallinnan strategia. [Finnra's strategy for traffic management]. TIEL 100018. Finnish National Road Administration. Helsinki 1998.

Penttinen Merja, Rämä Pirkko, Harjula Virpi: Tielaitoksen liikennetiedotuksen arviointi ja kehittäminen – kyselylomakkeet ja ohjeet [Assessment of Finnra's traffic information services – survey questionnaires and instructions]. Tielaitoksen sisäisiä julkaisuja 4/1998. Finnish National Road Administration, Helsinki 1998.

The Traffic Management Research Programme has participated in the following studies:

Liikenteen informaatiotekniikan (RTI) tulevaisuus Pohjoismaissa. Delfoitutkimuksen yhteenveto. [The future of road transport telematics in the Nordic countries]. Pohjoismaiden Tieteknillinen Liitto, Suomen osasto 1994. Sisäinen raportti nro 4/1994. Helsinki 1994.

DRIVE III -ohjelmaan valmistautuminen. [Preparations for "DRIVE III"]. Liikenneministeriön julkaisuja 23/1994. Ministry of Transport and Communications. Helsinki 1994.

Moottoriajoneuvojen kulutus ja päästöt kaupunkiliikenteessä. [Energy consumption and emissions of motor vehicles in urban traffic]. Liikenneministeriön julkaisuja 42/1994. Ministry of Transport and Communications. Helsinki 1994.

Morello S, Maltby D: Guidelines for Assessment of Transport Telematics Applications in Inter-Urban Traffic Management and Information. CORD Project V2056 Deliverable No AC07 -Volume 5. European Commission 1994.

Suunnitelma liityntäpysäköintikokeiluksi pääkaupunkiseudulla 1994. [Plan for park-and-ride in the Helsinki region]. Pääkaupunkiseudun julkaisusarja B 1994:2. Helsinki Metropolitan Area Council. Helsinki 1994.

Liityntäpysäköintikokeilun tutkimukset pääkaupunkiseudulla 1995. [Sudies on park-and-ride in the Helsinki region]. Pääkaupunkiseudun julkaisusarja C 1996:2. Helsinki Metropolitan Area Council. Helsinki 1996.

Sääohjattu tie Kotka-Hamina. Projektiraportti. [Kotka-Hamina weather-controlled road. Project report.] Finnish National Road Administration, Kaakkois-Suomi Region 1995.

Lähesmaa Jukka: Sääohjatun tien yhteiskuntataloudellinen edullisuus. [Socio-economic profitability of weather-controlled road]. Kaakkois-Suomen tiepiiri 11/95. Finnish National Road Administration, Kaakkois-Suomi Region Kouvola 1995.

Weather-controlled road and investment calculations. Finnish National Road Administration. Kaakkois-Suomi Region. Kouvola 1995.

Kallansiltojen muuttuvan liikenteenohjauksen vaikutusselvitys. [Evaluation of the lane control system on Kalla bridges in Kuopio]. Finnish National Road Administration. Savo-Karjala Region. Kuopio 1995.

Sijaisautotoiminta. Tutkimus saksalaisen Statt-auto -mallin soveltuvuudesta Suomen olosuhteisiin. [Study on hhe German "Statt-auto"-concept]. Kansainvälisen kaupan opiskelijayhdistys ry. Helsinki 1995.

Safety evaluation of incident warning systems. Integration of results. HOPES (Horizontal Project for the Evaluation of Safety), DRIVE II Project V2002, Deliverable 35. 1995.

Uusiheimala Mari: Uudenmaan tiepiirin liikenteen hallintakeskuksen tehtävät ja toiminnot. [The tasks and the functions of the traffic management centre in Uusimaa Region]. Tielaitoksen selvityksiä 5/1996. TIEL 3200374. Finnish National Road Administration, Uusimaa Region. Helsinki 1996.

Uudenmaan tiepiirin liikennekeskus: Sidosryhmät ja tiedonvaihdon periaatteet. [The traffic management centre of Finnra Uusimaa region: Reference groups and principles for data exchange]. Tielaitoksen sisäisiä julkaisuja 11/1997. Finnish National Road Administration. Helsinki 1997.

Road transport telematics terminology. Nordic Road Association, Technical Group 53. Report nr 1/1997-GB. Oslo 1997.

Tieliikenteen telematiikka. Pohjoismainen terminologia.[Road transport telematics terminology]. Pohjoismaiden Tieteknillinen Liitto, Jaosto 53. Raportti 1/1997. Nordic Road Association, Technical Group 53. Finnish Edition. Helsinki 1997.

ISBN 951-726-429-1
ISSN 0788-3722
TIEL 3200511E