ITS Evaluation and Assessment Issues: EC Discussion paper.*

INTRODUCTION

In the proposals for assessment and validation work to underpin the projects which form part of the transport telematics stream of the EU Fourth Framework Programme [1] five broad categories of assessment have been defined[2]. These are:

- **technical assessment,** concerned with the technical performance of the system;
- **user acceptance assessment,** concerned with users' attitudes to and perceptions of the application under review;
- **impact assessment,** in terms of safety, environmental conditions, or transport efficiency;
- **socio-economic evaluation,** of a fairly conventional kind: either cost-benefit analysis or multi-criteria analysis;
- **financial assessment,** where the telematics application might impinge, positively or negatively, on the capital or operating costs of a transport service.

GENERAL APPROACH TO RTT / ITS EVALUATION & ASSESSMENT

The European Commission has placed a strong emphasis on the importance of evaluation and assessment within the 4th R & D Framework Programme. DGXIII, is the Directorate within the European Commission responsible for research into telematics. Towards the end of the 3rd Framework Programme, the CORD project produced advice on the evaluation of applications in each of the key application areas. These were written by key evaluation experts organised into Task Forces by ERTICO. Within the 4th Framework Programme, DGXIII has taken this process a stage further to ensure a more consistent approach to evaluation and assessment. Activities on validation quality were included in the support action project CONVERGE.

Demonstration projects within the Telematics Applications Programme are required to follow a five phase approach. The phases are:-

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* This is an edited version of a paper by John Miles, Director, Ankerbold International Ltd. and Ken Perrett, Senior Project Manager, Transport Research Laboratory, published in Traffic Engineering and Control, March 1997.

- Analysis of user requirements
- Definition of functional specifications
- Building a demonstrator
- Validation of the demonstrator in two stages
  - Verification
  - Demonstration
- Exploitation Plan

All of the demonstration projects within the Transport Sector of the Telematics Applications Programme were required to prepare a Validation Plan within six months of the start of the project. CONVERGE-VQ, as the Validation Quality activity is known within CONVERGE, produced a guidebook for assessment[3] and a checklist[4] to be followed by all projects in preparing these plans.

The guidebook and checklist provide Evaluation Managers within each project with a systematic approach to the planning of the evaluation tasks. These two documents were presented at the first Concertation Meeting in March 1996 and subsequently discussed with all the Project Evaluation Managers at a workshop held in Brussels in June 1996. The 54 demonstration projects are grouped into application areas as shown in Table II, each with support fi-om an evaluation expert assigned by CONVERGE-VQ.

The Guidebook and Checklist have been followed by all the projects, leading to a highly consistent approach not previously achieved within the earlier Telematics Prograrnmes. The plans covered the following for the verification and demonstration phases of each application:-

- Description of the application
- Objectives for the application
- Assessment objectives
- Expected impacts on different user groups
- Selection of assessment category
- Selection of indicators
- Measurement plans
  - Definition of indicators
  - Choice of the reference case
  - Selection of measurement method
  - Control conditions
  - Statistical considerations (e.g. choice and size of sample)
  - Confidence levels
  - Definition of success

– Confirmation of the integrity of measurement

The Draft Validation Plans were subjected to a formal review by the nominated evaluation expert within CONVERGE-VQ. The review involved consideration of 72 aspects of each plan. Feedback reports were produced for each project, containing comments directed towards both the Evaluation manager and for the Project Officer within DGXIII. In some cases projects were asked to re-submit the Draft Validation Plans by the Project Officer.

The CONVERGE-VQ evaluation experts have produced a report to DGXIII based on the experience gained from the review process'. The following key points are drawn from the conclusions of that report:-

Preparation of the Draft Validation Plans

Projects were commended on their efforts in preparing Draft Validation Plans. These have provided a greatly improved basis for planning evaluation activities within the current programme compared with the previous programmes. Project Officers and those reviewing the progress of the projects have a more consistent information base than would otherwise be available.

Remaining uncertainties

Many of the projects are complex, involving many combinations of validation sites and applications. It is clear that some of the necessary decisions regarding deployment have still not been made and this has created uncertainties in the evaluation process. Consequently, many Draft Validation Plans still have missing elements. The most significant of these missing elements is in the area of the large demonstrations where it has not yet been possible to optimise the opportunities for comparative assessment across sites. Much of this work will need to be incorporated into the Final Validation Plan. Projects are generally aware of the areas which are missing and are committed to the completion of the full Validation Plans.

European Added Value

It has always been the intention of the Telematics Applications Programme that projects should be encouraged to identify opportunities for collaborative work demonstrating Added European Value through joint application development and through comparative assessment. Most projects have focused on the applications being developed within the project. The process of preparing Draft Validation Plans should facilitate the process of identifying opportunities for development and assessment between projects.

CONCLUSIONS

This paper has summarised the role and importance of systematic assessment and evaluation when considering investment in Road Transport Telematics. The CONVERGE project recommends the use of five broad evaluation themes detailed above, to which we can add a sixth market assessment - to give the commercial perspective.

The method of project financing, whether through private finance, public funding or self-financing revenue streams, will certainly influence the coverage and content of the assessment. Central to this is a comprehensive assessment of the major risks involved in an RTT / ITS project, whether of a technical, organisational, regulatory or market kind. In all cases there will be a need for reliable forecasts of key performance indicators against which to judge project viability, social and economic impact and - last but by no means least - value for money. Evaluation and assessment has therefore a central part to play in the decision making process for new investment in telematics applications.

The European Commission is working towards consistency of approach across the whole telematics programme and this will greatly assist closer working together of those concerned with evaluation and, hopefully, more robust results for the decision makers and those involved in the planning and design of RTT / ITS schemes.

Further research is needed on the response of companies and individuals to better knowledge in real-time of current and forecast road network conditions in order that the true value of reliable information can be properly built into the evaluation. There is great public policy interest too in the use of telematics for travel demand management. Research can help to show how travel users respond and the effectiveness and acceptability of enforcement. The results from the evaluation of the 54 European telematics demonstration projects are eagerly awaited.

Finally, the evaluation methodology required for the assessment of telematics applications must include more of the intangible costs e.g. pollution, congestion, journey comfort, confidence, and reliability. Disaggregate models are being developed to deal with some of these aspects, but most are not yet available for general use. Further work is needed on these areas is required to reach consensus on the approach.

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Table I Principal Decision Makers for the main groups of RTT / ITS Applications.

RTT / ITS Application area	**Principal decision makers**
Inter-urban traffic management and control	Government, highway authorities; private sector concession-holders.
Electronic tolling: motorways etc.	Government and highway authorities; private bridge and tunnel operators
Urban traffic management and control	Local authorities with national government support
Urban road pricing (congestion charges)	Local authorities with national government support
Enforcement and electronic vehicle identification	Police, highway authorities; other enforcement agencies
Speed, journey time and other traffic monitoring	Highway authorities,
Automatic speed control systems	Motor vehicle manufacturers with national governments and highway authorities
Bus passenger information systems	Large bus operators and collective transport authorities
Smart card ticketing	Large bus operators and collective transport authorities
Driver information, navigation and guidance, including VMS, RDS-TMC	Independent service providers, broadcasters, individual vehicle owners, fleet owners and operators, highway authorities & local authorities, collective transport authorities
Freight and fleet management applications	Vehicle fleet operators, operators of large freight interchanges such as ports, airports, channel tunnel terminals.
Vehicle-based applications	Motor manufacturers, vehicle owners with government and local authority control of highway infrastructure requirements
Applications for vulnerable road users	Government, local authorities and motor manufacturers,

Table II Validation projects within the European Transport Telematics Applications Programme2

Application Area	No of projects
Telematics Applications for travellers	3
Telematics for Freight	3
Road Traffic Management and Modelling	4
Vehicle Control and Driver Assistance	4
Demonstrations of Integrated Telematics Applications	11
Public Transport	4
Railway Transport Telematics	3
Multi-modal payment systems and short range communications	4
Maritime: water-borne Transport Telematics	6
Air Transport Telematics	12
Total	54

Traffic Management Systems and Information Services

The TEN - Transport Projects: prospects for ITS implementation in Europe

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European Commission - Directorate General for Transport

Introduction

An efficient transport infrastructure is one of the preconditions for the free movement in the vast internal market formed by the European Union with its population of some 370 million people spread amongst 15 Member States. Demand for mobility will continue to increase over the years and will double between now and year 2010. Over the last two or three decades, traffic has been growing constantly at a rate been in the range of 2 to 3 % per annum. with much faster rates on the road network sector which attracts 88% of goods transport and 72% of passenger transport.

Public authorities in charge of Transport policy are facing to considerable traffic and attendant environmental problems (annual cost of road traffic congestion is around 100 billion ECU / $ 130 in Europe), as well as constant increasing awareness of safety and comfort. As they do not want to conclude that transport infrastructure in the Community is not up to the task of ensuring sustainable mobility. the Member States have to formulate new strategies to face these problems

A number of decisions approved by the European institutions have raised at various occasions the implementation of Intelligent Transport Systems (ITS) services as an important contribution to make in the achievement of the goals of the European Union's common transport policy. The major goals are to enhance the safety, efficiency and environmental compatibility of transport in order to achieve sustainable mobility.

The Tram-European Transport Networks

To day Europe has more a transport patchwork than a network built in a age where countries did not look very far beyond their national borders for trade and travel. But now the European Union is involved in a major effort to remove the barriers between the Member States and to put together an *integrated transport network* across Europe (roads, railways, waterways, ports, airports) which meets the demand for fast, reliable and safe connections.

Since lrst November 1993 (Treaty of the European Union) the Community is committed to the establishment of a European Transport network *by promotion of interconnection and integration of interoperable* national networks.

The research and development carried out in national and Community programs has led to the demonstration of advanced telematics applications (telematics is the combination of telecommunications and informatics or information technologies), and some of these applications are now considered mature enough for large-scale implementation. Their new potential has encouraged the EU to incorporate and deploy ITS tools, *such* as *traffic* management and *information services,* directly to the trans-European Transport and its components, thus contributing to the smooth and safe flow of traffic. Their development will also enable European industry to create a common market for ITS and the distribution of advanced transport services. Finally, the evolution towards an "information society" is also opening up new opportunities and considerable prospects for several sectors including ITS.

The degree to which traffic management and traffic information services have been developed so far varies greatly within the Union, both according to the mode of transport (air, road, rail or water) and whether it has a local, national or international dimension. Therefore, the European Union can provide the vital impetus for the establishment of traffic management and information services by giving them a European perspective and encouraging the integration of existing systems.

Prospects for ITS implementation

The trans-European road network, composed of 70,000 km of motorways and highways. is a prime focus for the development of ITS infrastructure and services on the main European routes . This has been identified from both the Trans-European Network for Transport (TEN-T) guidelines adopted in July 1996 by the European Union and the implementation projects supported financially through the TEN-T program.

the TEN-Transport guidelines

They serve as a *general reference framework* to encourage the Member States, and where appropriate. the Community in carrying out *projects of common interest* the purpose of which is to ensure cohesion. interconnection and interoperability of the trans-European transport network. These guidelines combine the use of the various transport modes according to their comparative advantages to create a truly multimodal transport system and make clear that ITS is an integral part of the network.

Similar guidelines for the trans-European telecommunications network are likely to be adopted soon. These are important not just because telecommunications and information networks are conduits for ITS applications, but because the Information Society opens up new opportunities for our citizens, including access to applications such as teleconferencing and teleworking which can reduce travel demand.

For road traffic management, the guidelines stress the overall objective of continuity of services based on active co-operation between traffic management systems at European, national, regional and local levels, and on the technical interoperability of telematics infrastructure and devices.

The priorities identified by the guidelines are initiatives for:

- development of traffic data collection
- monitoring of road and weather conditions
- management of traffic through Traffic Control Centers and Traffic Information Centers
- implementation of traffic information services

the TELTEN2 initiative

The implementation of ITS applications will be at the national, regional and local level and the subsidiary principle will be applied. However the creation of a coherent and interoperable trans-European transport network needs the definition at European level of standards and common recommendations which allow the Member States to ensure their implementation activities within a European perspective.

TELTEN2 has developed these recommendations to ensure minimum quality and continuity of ITS services, interoperability of systems and compatibility of equipment for :

the implementation of the backbone of ITS applications in terms of monitoring, organizations and data exchange;

and the first mature traffic management and user information services of Variable Message Signs (VMS) and RDS-TMC traffic information services.

TELTEN2 has also elaborated a common language and understanding amongst the sector actors in the field of Traffic management and information services issues and has shown how these services can meet requirements of a high level of services for the Trans-European Road Network.

The first outcome of this strategic initiative is that these recommendations will serve as a reference for setting-up and evaluate TEN-T projects .

Funding

Policy and planning in road traffic management are primarily the responsibility of national. regional and local public authorities and transport operators. However, the European Union can support investment in traffic management provided this is related to the TEN-T guidelines.

The EU has provided financial support to co-ordinate the implementation of traffic management systems and services and to stimulate investment. This support is necessary for several reasons:

1. ITS is a new area for which funding mechanisms still have to be created at national, regional and local levels;
2. for many applications, public sector investment opens the door for more added-value services offered by the private sector;
3. real-world implementation can fulfill an important role by corroborating R&D results and can lead to wide-scale implementation.

In the TEN-T budget, the financial resource in the Mullet-annual Indicative Program (MIP) for supporting Road Traffic Management and Information Services (RTMIS) is around 125 Million Ecu from 1995 to 1999. More than 36 Million Ecu have already been allocated for feasibility studies and projects in 1995 and 1996. The following figure shows the overall TEN-Transport indicative budget for financial support (1995- 1999).

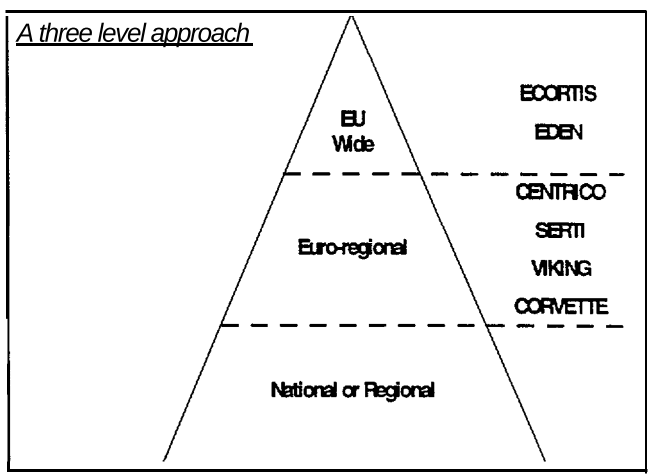
	Ten-T allocation	Scenario as input to discussions with Financial Assistance Committee				
	decision 95	96	97	98	99	1995-99
Total for 14 priority projects	181,5	210	268	324	366	1350
Traffic management	**45**	**54**	**67**	**82**	**92**	**340**
Other important projects	13	16	17	24	38	108
TEN transport beget line	240	280	352	430	496	1798

Fig. 1 - TEN-Transport indicative budget for financial support (19951999)

Overview of the TEN-Transport projects

There are three types of TEN-T projects:

- Europe-wide projects focus on the provision of pan-European services through the implementation of ITS applications;
- Euro-regional projects focus on cross-border co-operation by implementing continuous and interoperable services in neighboring transborder areas;
- National, regional and local projects include all other initiatives for which EU support has been granted because they are considered of common interest.



Applications covered by the TEN-T projects

The TEN-T are aimed at implementation and answer the to following questions:

- what specific services will be offered to the users?
- on which parts of the network?
- what will be their impact and how will these services be implemented technically, financially and organizationally?
- What level of coordination between Member States do we need ?

The following table give a list of the ITS services which will be provided through the TEN-Transport projects:

Monitoring	Knowing what happens to manage traffic and inform users
Organizations	Co-ordination and responsibilities to make ITS applications work
Data exchange	What happens in neighboring regions that affects the trips of road users
Variable Message Signs (VMS) for traffic management	Controlling traffic flows for timely and safe travel
Radio Data System - Traffic Message Channel (RDS-TMC) information services	Traffic information in the drivers' language throughout Europe
Automatic Toll Collection (ATC)	Paying tolls without stopping throughout Europe
Pre-trip information	What drivers should expect on the road when leaving home

The Euro-Regional projects

The Euro-regional projects represent a multi-annual platform for the implementation of ITS services. They are focused on cross-border co-operation by implementing continuous and interoperale services in neighboring transborder areas. There are four Euro-regional projects which coordinate the implementation of traffic management ans user information services on the TERN, covering a large part of Europe:

- CENTRIC0 which covers the centrally located countries in Europe (B, L, F, D, NL)
- SERTI which covers the south region of Europe (F, D, I, E)
- VIKING which covers the northern Europe (DK, FIN, D, N, S)
- CORVETTE which covers the Alpine area (A, D, I)

Conclusion

The EU projects on the trans-European road network are important as key stages in the implementation of intelligent transport systems in Europe. The institutional aspects and the coordination of activities between the Member States are determinant factors to guaranty the success of ITS implementation, this is the reason why the Commission thinks that the Euro-regional projects are progressing with a substantial degree of success.

Acknowledgments

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Road Transport Telematics (RTT) in Europe

URBAN AND INTER-URBAN SYSTEMS AND SERVICES

An overview of the European Commission Research Programme

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Abstract

This paper summarises European research into telematics for road transport in three main areas: urban applications, inter-urban applications and advanced vehicle control systems. Coverage of the current projects under the Fourth European Framework Programme (4FP) is described alongside key results from the earlier DRIVE I and DRIVE II programmes.

The urban work includes new methods for traffic operation and control, techniques for demand management, dynamic travel and traffic information and support for collective transport services. In the inter-urban domain the paper stresses the importance of traffic monitoring and surveillance, traffic control strategies and strategic organisation and management issues.

A brief description of European activities concerning advanced vehicle control systems is included, drawing on results from the PROMETHEUS programme, DRIVE II and 4FP coverage.

1. Introduction

The eleven months since the 1995 World Congress in Yokohama have seen the successful completion of the remaining work on the European Commission’s (EC) programme on Advanced Transport Telematics (known as DRIVE II) and the start-up of new projects funded under the European Union (EU) Fourth research and development Framework Programme (4FP).

The new programme is known as the Transport Telematics Applications Programme and is concerned with the entire telematics chain, from data capture and processing to transmission and reception. The aim, amongst other things, is to consolidate the research into Road Transport Telematics (RTT) done in DRIVE I and II. Moreover, in accordance with the aims of the EU Corm-non Transport Policy to apply the principle of sustainable development to the transport sector, the new programme also lays stress on the development of combined and integrated multi-modal transport services for both passengers and freight. The use of telematics in support of inter-operability between road and the other transport modes therefore assumes greater significance in 4FP than before.

Many of the ideas which spawned the development of RTT and which were included in the DRIVE I programme (1989 - 1991) proceeded to a validation and demonstration phase in DRIVE II (1992 - 1995) and are now ready for commercial exploitation. This paper describes a number of examples. But in other cases validation and full-scale demonstration of the concepts are still required, first to see that the application satisfies user requirements and is properly specified in relation to the desired functions, and secondly to evaluate cost-effectiveness, user-friendliness and the impact on the user environment. Many of the 4FP projects are at this stage. Key objectives of the current EC-funded research are therefore:

- To demonstrate European Road Transport Telematics Systems and Services, in particular to do so for traffic management and (value-added) information services
- To ensure interoperability of RTT Services considering the realisation of EU Transport Policy aims, and to support a Common Market for European industry.

The focus of this paper is therefore on urban and inter-urban RTT systems and services in the Transport Telematics Fourth Framework Programme, with frequent references to the basic technologies and methods from the previous DRIVE I and DRIVE II programmes. Coverage is divided between a number of topics, starting with basic data collection and forecasting methods, moving on to consider those telematic applications being developed for the urban and inter-urban road transport sectors. Finally there is coverage of EC research on advanced vehicle control systems which will support the next generation of RTT applications, including the advanced safety vehicle and the automated or semi-automated highway.

2. Basic Data Collection and Forecasting Methods

2.1 Traffic Data Collection

Traffic data collection technologies are needed for almost all further basic methods in the field of traffic control and management. In urban areas data collection is mainly done by inductive loops, in a few cases by using microwave, infrared, and image processing techniques to measure and to detect traffic flows, speeds, queues, accidents and traffic composition. Traffic data is normally gathered finally in an urban traffic control (UTC) system and is to be provided either to further prediction, modelling or other methods. or for control and information purposes to other systems.

Besides the conventional traffic data collection, technologies using special vehicle equipment and a radio communication link in order to collect floating-car data (e.g. link travel times), are increasingly being considered for enhancing traffic data bases in both urban and interurban areas.

Such “probe vehicle” technologies are based on either an infra-red communication link (e.g. in the earlier EUROSCOUT project in Berlin), or on a GSM communication link (as in some interurban projects, e.g. in the DRIVE II project RHAPIT project and the 4FP project ENTERPRICE, but also in the urban project CAPITALS when Berlin joins. probably in late 1996).

2.2 Automatic Incident Detection

Automatic incident detection methods have been tested already in many European projects but mainly within interurban areas. One of the most promising contributions to motorway traffic management has been in vehicle detection technology utilising computer vision analysis techniques. The new detection systems, combined with new algorithms have a high detection rate (>93%) combined with low false alarm rates (<8%), and have proved to be a very effective tool for traffic control centre operators.

In urban sites, inductive loops, CCTV, radar and video image processing techniques are used in 4FP projects. Such methods are integrated in traffic control centres combined with signal control and/or VMS control and information display. DRIVE II projects which had in particular addressed automatic incident detection in urban areas were e.g. MELYSSA, ARTIS and SCOPE.

2.3 Short-term Forecasting

Short-term forecasting methods in urban systems and services are used in parking guidance systems, signal control systems (e.g. in the context with origin-destination estimation models for urban networks), for information purposes (e.g. via VMS. travel pre-information but still not yet tested very much). Short-term or even long-term forecasting models are increasingly applied in motorway control and information centres e.g. for advising on strategic route choice for long distance travellers, using VMS.

2.4 Traffic Modelling

Traffic models are applied in the urban context mainly in signal control systems, automatic incident detection and management, public transport and demand management schemes. Within previous EU projects such models were enhanced and tested, e.g.. as a functionality of the on-line signal control methods SCOOT, MOTION and UTOPIA, or also within several simulation models supporting control and also assessment of telematics systems and services.

2.5 Future developments

A specific objective for 4FP projects is to further develop and validate an integrated approach to incident detection and management and integrate this into overall network management using in particular the technologies of computer vision, high performance computing and multi-media data capture.

3. Urban Road Transport

European Research into advanced Road Transport Telematics in DRIVE II already included many urban applications, using and integrating models, basic functionality's and methods developed in DRIVE I or in national programmes. Various projects concentrated mainly on prototype operation with some field trials to indicate and demonstrate the benefit of such applications (refer to various project and programme publications).

In the Transport Sector of the current Fourth Framework Programme (4FP) many DRIVE II projects have continued - mostly integrating new partner cities and new application areas - in order to further enhance and improve the developments and to demonstrate these in field trials. The verification and demonstration phases are regarded as important steps towards regular operation, or towards market introduction of the services so far as end users (e.g.. travellers) are concerned.

There are several 4FP projects in the urban area which address systems and services being applied and demonstrated within application areas such as:

Traffic operation and control and demand management
Traffic and travel information
Collective transport (e.g.. public transport) services.

All large European urban demonstrator projects include several applications and systems which are partly wide-spread over the field of urban transport activities and it is difficult to assign them uniquely to one or other application area. Therefore, a more thematic structure will be followed to introduce the main elements.

3.1 Traffic Operation and Control and Demand Management

Traffic Management in urban areas had been the subject in many DRIVE II projects and is followed in the new 4FP projects with an emphasis on demonstration. The applications can be allocated to three sabres: the contribution of traffic information to traffic control. signal control with integrated incident management, and travel demand management.

3.1.1 Traffic Information via VMS and Parking Control/Information Systems

This subgroup of RTT applications are aimed at providing traffic information to support drivers in making the appropriate route and destination choice. Within DRIVE II projects. the acceptance of VMS systems in urban areas has already been successfully tested (Amsterdam, Cologne, Paris). An interest result was that 80% of drivers using the urban ring road in Paris (the Boulevard Peripherique), preferred to be told about travel time rather than queue length.

VMS has been installed on city approach roads to provide information concerning parking and/or park-and-ride (P+R) has also been also very effective, leading to a considerable increase in park-and-ride users. Parking guidance and information systems have been developed and tested which provide real-time and accurate information on car park occupancies in urban areas.

Demonstrations of traffic and parking information disseminated via VMS systems will be provided in 4FP projects such as:

AUSIAS (Valencia, Spain): Information via road panels informing drivers about city parking and the P+R availability, Dynamic information system for users

TABASCO (Glasgow, Munich, Amsterdam): VMS information systems for P+R usage

EUROSCOPE (Cologne, Southampton, Rotterdam, Strasbourg): Dynamic parking information on the approaches to and within inner cities.

3.1.2 Traffic Control using Signal (Network) Control and VMS Systems (also Integrated with Incident Management)

Applications of this subgroup are aiming at controlling and guiding drivers in the urban road network. Such applications are mainly signal control systems which include intelligent models based on real-time data collection. Very often, computer models for incident and congestion detection and management, and public transport priority are integrated in such control systems.

VMS systems are also used not only for information purposes but for supporting the guidance of road users as well.

In DRIVE II, urban traffic control (UTC) systems formed the core of many projects. They included new strategies for improved control and new functionalities e.g.. dynamic origin-destination estimation integrated to UTC systems such as SCOOT (UK), UTOPIA/SPORT (Italy), PRODYN (France) and MOTION (Germany). Tests and measurements indicated a successful operation so that almost all of these control methods will be included in 4FP projects for further enhancements.

Similar comments apply to the field of incident detection and management. Several tools have been tested in DRIVE II projects (e.g.. in HERMES, MELYSSA) based on e.g.. extended Kalman filtering techniques or a revised version of the California incident detection algorithm and others.

Traffic signal control is addressed in many 4FP projects e.g.. in:

COSMOS (London, Piraeus, Turin): Implementation and demonstration of the dynamic signal network control systems SCOOT, MOTION and UTOPIA. Enhanced functionalities are to be tested and evaluated.

EUROSCOPE: The SCOOT system including bus priority will be tested in Southampton, the MOTION system (refer to COSMOS) will be extended in the Cologne test site, and in Strasbourg a public transport signal priority system will be demonstrated.

QUARTET PLUS (Toulouse): The urban traffic control system will be enhanced by an expert system for congestion management (CLAIRE).

AUSIAS (Valencia): Real-time dynamic network control (including bus priority) selecting optional signal plans is under preparation to be demonstrated.

TABASCO (Glasgow, Munich, Lyon): The local UTC systems will be improved by integration of several control systems, partly also by integration with inter-urban traffic control.

VMS based traffic control (partly integrated in signal control) will be implemented and evaluated e.g.. in:

CAPITALS (Brussels, Madrid): Integration of UTC (and motorway control at Madrid) and incident management with a VMS system.

EUROSCOPE (Piraeus): The VMS system with guidance advice towards the port will be integrated with the UTC system (implementing the MOTION model).

Integration of UTC with urban incident management will take place in several projects e.g.. in:

AUSIAS (Valencia): EUROSCOPE (Cologne, Rotterdam, Strasbourg), QUARTET PLUS (Toulouse) and CAPITALS wazzu (Brussels).

3.1.3 Travel Demand Management via Access control and Parking Management

Travel demand management measures are often associated with tolling systems (these will be addressed in another paper).

Access control using an integrated electronic payment system for parking and public transport will be implemented and tested in e.g.:

CAPITALS (Rome, Madrid, and a feasibility study for Brussels): The Rome combined approach on access control for the historical city centre could be assumed to be the largest test. Madrid will integrate parking supply information and adaptive pricing for parking.

CONCERT (Barcelona, Marseille, Bologna, Thessaloniki, Hannover, Bristol. Trondheim, Dublin): This project is focusing on all kinds of multiservicing. pricing and multimedia information applications to favour public modes of travel instead of car use.

3.2 Travel and Traffic Information

By their nature travel and traffic information systems and services address users both in urban and inter-urban areas. Urban features demand specific elements in system design and operation.

Substantial progress has been achieved in DRIVE II. Travel and traffic information systems have been widely tested in pilot projects basing on available communication infrastructure. The technology and experience is now available to approach the enhancement and European interoperability of such systems. VMS and the Radio Data System (RDS) for broadcasting traffic information have been tested and there are already well developed systems that have shown their benefit for traffic control and information. Progress has been made in agreeing compatible protocols (e.g.. ALERT C for RDS-TMC or the EDIFACT protocol integrating the structures of ATT ALERT and STRADA data dictionaries). Pre-standards for geographic data and location referencing have been achieved as well.

3.2.1 Pre-trip and On-trip Travel Information via VMS, RDS-TMC, GSM, Beacon Technologies

Although travel and traffic information systems and services so far are currently more common in interurban areas and on motorways, some 4FP projects have started to integrate such services in urban areas, in particular in corridors interlinking regions and major city conurbations.

EUROSCOPE will investigate RDS-TMC services for parking information (Cologne), for a region and the city (Rotterdam), or on ferries (Piraeus).

TABASCO, QUARTET PLUS and EUROSCOPE will use VMS technologies widely to inform travellers on trip on their way also in urban areas.

On-trip information services using in-vehicle equipment for drivers and communication links such as GSM or infra-red will be considered under inter-urban systems.

3.2.2. Traveller Information Services using Fixed Terminals, Personal Traveller Assistants (PTA) or On-line-Services

Such information services will be set up in many European projects, or at least the information base will be provided to encourage private or public/private service providers to start business with related services. All information services have to be based on an information platform, e.g.. a traffic information centre, which can be run either by regional (interurban) bodies (mostly authorities), or partly in connection with urban information or control centres but also sometimes as a stand alone urban information centre.

Cities regard such traffic information centres mostly as an additional system level which can be built onto existing traffic control systems which have operated for many years.

Database development and the interlinking with existing urban data resources are the main issues in some projects. For example:

CAPITALS (Paris, Rome, Madrid, Brussels and Berlin when joining, probably in late 96): Urban and motorway traffic control and information centres will be linked (Brussels, Paris, Madrid) and a traffic information platform will be set up. Rome will support the “Easy City” concept. Berlin will link via GSM into a privately operated information service centre, mainly to integrate so-called floating-car data.

Some projects are setting up on-line information services (e.g.. INTERNET services), e.g.. QUARTET PLUS, TABASCO, and ENTERPRICE in the Frankfurt urban area.

3.3 Collective Transport Services

Collective transport services are used in the field of public transport - either addressing the information of the passenger pre-trip or on-trip, or dealing with the improvement of public transport (vehicle) operation.

3.3.1 *Pre-trip and On-trip Information using Trip Planning Information, Real-time Public Transport and Enquiry Office Services*

Efficient management of information to the end users/passengers is critical to the achievement of the telematics systems in the public transport area. There are many aspects which have been already addressed within DRIVE II projects (e.g.. in EUROBUS . PHOEBUS, QUARTET, GAUDI, LLAMD or SCOPE) and in some task forces (e.g.. HARPIST, CARTRIDGE, SATIN). Although travel choices and demand management has not been measured, the key expected benefits from information management are an improved integration of systems which increases the overall efficiency of the public transport operators in many of their tasks.

Such information services are very often combined with other kinds of traveller information although information to public transport users can be regarded as the most common one, e.g.. in the following 4FP projects:

TABASCO (Glasgow, Munich) will provide public transport passenger information on-street, as will:

EUROSCOPE (Southampton, Strasbourg) which will be presenting on-board real-time information in passenger trains or trams and buses.

Further projects in this area (i.e. providing passenger information at bus stops) are SAMPO, CONCERT and QUARTET PLUS.

3.3.2 *Collective Transportation Management including Public Transport, Vehicle Priority and Vehicle Scheduling and Control Systems*

Public Transport vehicle priority and vehicle scheduling and control systems have a long history in European cities. Implementation in some places is already well advanced.

In previous DRIVE II projects, public transport vehicle priority has been integrated in some urban signal control schemes using special bus transponders and inductive loops and/or the vehicle location by radio communications. In particular in the PROMPT project, savings in bus delay and journey times have been measured in London, Turin and Gothenburg.

Also, an improvement in service regularity could be obtained which is particularly important when setting up vehicle scheduling and control systems. Such systems are normally integrated with passenger information systems. This has been successfully achieved in field trials at e.g.. Southampton (SCOPE), Munich (LLAMD), Birmingham (QUARTET) and Brussels (PHOEBUS).

Urban traffic control systems as SCOOT, PRODYN, SPOT, CELTIC, UTOPIA and MOTION which are enhanced or developed in European projects, include special features for public transport priority treatment and they are now in operation and ready for demonstration in many 4FP projects.

4. Inter-urban Road Transport

Research and development in the inter-urban domain is directed towards improving the traffic management and control techniques that increasingly are being adopted by the network managers and traffic controllers for Europe's inter-urban motorways and major highways. The operational objectives have been defined by the EU Motorway Working Group[1] as follows:

- keeping the highway available and safe;
- ensuring the smooth operation of traffic flow; and
- assisting drivers and providing travel services.

In the European context, distances between urban conurbations are relatively short and inter-urban traffic management cannot be totally divorced from related urban and peri-urban management, or from services provided independently of location. Therefore R & D efforts in DRIVE I and II, and continuing into the Fourth Framework Programme (4FP) have been directed towards the achievement of a future Integrated Road Transport Environment (lRTE) in Europe.

4.1 Inter-urban Traffic Management

A major emphasis of research into Road Transport Telematics is to develop improved traffic control techniques as part of an integrated approach involving both monitoring and strategic (especially data exchange) aspects. Both individually and taken together these projects provided a firm view of the issues confronting wide-scale implementation of Advanced Transport Telematics. Much research activity has focused on the effective use of different types of detectors, data transmission systems and information carriers for a variety of purposes: network control, emergency management, flow monitoring and weather related traffic management. An example would be the current 4FP project VADE MECUM which is a feasibility study from Nijmengen to Cork, with applications in information services and network management.

4.1.1 Monitoring and surveillance

Activity on this topic has been concerned primarily with the development and validation of promising techniques, some developed within DRIVE I and II, and bringing them to a state of readiness for commercial exploitation and for adoption by network owners and operators.

In the DRIVE II projects GERDIEN, PLEIDES and RHABIT a range of data sources - inductive loops, acoustic, video images, beacons, floating cars, piezo-sensors (for weigh-in-motion) and meteorological sensors - were considered from a number of practical viewpoints.

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[1]Motorway Working Group. Action Magic: Traffic Management on the Trans-European Road Network. Final Report, Brussels, European Commission DG VII, July 1994.

The product of this research has been the development of a set of tools for network monitoring and congestion detection, travel time measurement and origin-destination data. Under 4FP this work is continuing.

4.1.2 Network Control Strategies Using VMS

Variable Message Signs are, and will probably remain for some time, one of the essential means for delivering information and indications to drivers on inter-urban highways. They can be used for control purposes (speed control, motorway entrance or exit closure. guidance by means of variable directional signs or route advice) as well as for information delivery (comfort and safety). But until now there has been no common agreement on:

- the effectiveness of VMS use;
- VMS messages and strategies, and
- VMS impact on driver behaviour.

European R & D projects are addressing these issues in various operational contexts. notably:

- use of VMS for warning, information and guidance applications;
- different technical and management strategies supporting the switching of VMS:
- alternative legends and message formats; and
- driver reaction and response to VMS.

One major contribution has been the application of real time VMS control strategy selection and traffic prediction information based on a range of more than 12 models developed in the DRIVE II programme to reflect different operating environments. Using these models as part of a re-routing strategy has been shown to reduce traffic delays by up to 20%. It has been estimated that reducing delays by 20% would reduce CO by up to l0%, HC by 5% and NOx by 5%. Development of modelling and re-routing strategies is continuing, for example the project INFOTEN is concerned with traffic information and traffic management on motorway corridors, using Munich-Insbruck-Verona as a validation corridor.

4.1.3. Driver Information

There are three principal information carriers with potential for immediate exploitation on a pan-European basis: GSM digital cell-phones, the Radio Data System-Traffic Message Channel (RDS-TMC) and the Variable Message Signs (VMS) described above. In-depth evaluation of both technical and organisation aspects of all three systems features in a number of projects introduced under this heading. For example, FORCE deals with RDS-TMC applications in 10 countries of the EU. There are also links to the Trans European Transport Networks project ECORTIS.

The CLEOPATRA project deals with modelling to support route guidance including VMS and RDS-TMC, and will be working in 10 city regions across the EU. Finally ENTERPRICE deals with the development of mobility and traffic information centres and includes traffic management among its applications.

4.1.4 Incident Management and emergency call systems

The development of a pan-European GSM system has the potential to enhance the effectiveness of emergency call systems and of incident rescue and management, for example an incident involving vehicles carrying dangerous goods. Trials in Germany have utilising the satellite Global Positioning system and digital road map together with GSM for data transmission of the emergency telegram. A reduction in the response time (43%) of emergency vehicles has been measured using these systems with an increase in survival rate (between 7 and 12 %) and a potential reduction in the long term severity of any injury incurred.

The current project IN-RESPONSE deals with incident management and response including incident detection, incident verification with multi-media communications and decision support. It includes test sites at Oslo, Valencia, Eurodelta, Thessaloniki, Munich and Paris.

4.1.5 Flow monitoring

The speed at which a queue can form against the flow of traffic, even in moderate traffic flows, is a major problem for the network operator when trying to prevent a major incident. The only known effective solution is to use an automatic system that will be responsive to changing situations and activate VMS to warn drivers of the situation in a timely and effective way. A special task force was established to examine the work undertaken by 10 of the DRIVE II projects addressing this issue and a comprehensive report has been produced indicating the benefits of using a number of the technological developments, particularly in the area of video analysis.

4.1.6 Weather related traffic management

In the DRIVE II project ROSES a comprehensive weather monitoring station was developed and implemented using a range of new weather monitoring detectors together with in-vehicle systems used to warn drivers of changes in road conditions. In the MELYSSA project VMS was used extensively to present information relating to weather: speed and / or text displaying fog / ice etc. Most of the results have been achieved by implementing speed control. Up to a 10% reduction in vehicle speed was obtained in France. In Germany, the number of accidents decreased by more than 30% with a concomitant reduction of more than 40% in the number of people killed or injured. The most significant decrease was observed for foggy days: more than 85%. During rainy periods, a decrease of 33% was observed.

4.2 Strategic Issues.

The major field trials of Road Transport Telematics enables the two Pan-European concepts of inter-operability and subsidiarity to be validated in principle. Specific issues are:

European inter-operability of basic services for traffic information,

the subsidiarity associated with different organisations being responsible for data collection,

the preparation of traffic messages in each country, and

the adoption of common protocols across Europe for mobile receiver equipment.

Three of the major DRIVE II projects - MELYSSA, PLEIADES and RHABIT - facilitated comparison of the main technologies for delivering in-vehicle driver information. The work covered standardisation (of messages and geographic data files), user value and the legal.

commercial and political issues related to ground equipment, data ownership, information dissemination, etc.

In the current programme most of the major RTT demonstrators continue to address these issues. For example DACCORD is concerned with integrated and co-ordinated control of inter-urban motorway corridors, with an emphasis on system architecture. Another project, HANNIBAL, deals with the management of the corridor Paris, Lyon, Frejus, Turin. Milan. Trieste, concentrating mainly on the management of the Alps crossing, and including congestion detection and data exchange as in the research.

4.2.1 Data Exchange

The transfer of information between TICS and TCCs has been addressed by a number of projects and task forces, each focusing on a specific area in the information chain. Various coding systems (GSM, RDS, GDF) and data dictionary formats (ALERT-STRADA) have been established and now need to be validated.

The EDIFACT standard was used for travel and traffic information interchange purposes. This has enabled a language independent facsimile form to be established in combination with cross-border procedures required to address the need for vital unambiguous exchange of information at critical times.

4.2.2 System Architecture

Work within the DRIVE II programme - particularly in QUARTET and GERDIEN -has increased the awareness of the need for an architecture framework. Open system architectures for traffic management have been developed by the ERTICO SATIN Task Force to provide a stable foundation for the integration of individual systems during many generations of computer technology development.

Under 4FP the CONVERGE project provides the horizontal co-ordination of system architecture development across the entire Transport Telematics Applications Programme. covering all transport modes. Projects will be expected to evaluate their systems against eight different dimensions: performance, flexibility, safety & reliability, security, usability. maintainability, cost effectiveness and manageability.

CONVERGE will identify good practice and common requirements amongst all the projects and will work to form a consensus around the European requirements for RTT systems. Through the Trans-European Network project TELTEN[2] a start has been made on developing a framework within which the results of research can be deployed and advanced traffic management and information systems implemented.

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[2] TELTEN: Telematics for the Trans-European Road Network

5. Advanced Vehicle Control Systems

Various examples of Advanced Vehicle Control Systems are the subject of R&D activities in Europe at the moment and are designed assist drivers in their tasks, thereby increasing driving comfort and safety.

Safety is of paramount importance given the ‘terrible toll resulting from accidents on European roads each year - 47,000 deaths and 1.7 million injured people, 150,000 being left permanently handicapped. The associated economic cost is estimated at 50 billion ECU (about US $64 billion)

Advanced vehicle safety systems have therefore an important place in European research activities. Improved traffic flow and pollution reduction are also anticipated as a result of the deployment of these systems.

5.1 Main Applications

A number of applications have been and are currently the object of Europe-wide R&D activities the most significant related to driver monitoring and driver assistance/support and automated driving. They cover both autonomous systems and infrastructure based or linked systems and are an essential part of the overall concept of the “intelligent vehicle”.

5.1.1 Driver monitoring

Driver impairment covers a wide range of situations from fatigue, inattention, sleepiness. alcohol usage and inability to cope with heavy workload situation to sudden health-related problems. Monitoring of the driver state allows for the detection of problems in driver performance from any of these causes.

These mainly monitoring systems can be coupled to driver support and emergency handling control systems which can either warn the driver or operate in a semi-automatic or fully automatic way (as in the case of emergency stop). Driver monitoring may also be used as part of an enforcement system in which the car is stopped and the driver prevented from continuing to drive as a result of the detection of persisting inattention/sleepiness or high levels of alcohol. Besides reducing the number of accidents and improving the quality of driver’s performance, such systems can also avoid secondary accidents by warning the surrounding traffic and by making an emergency call to a centre.

5.1.2 Driver assistance/support

Driver assistance and support systems include a number of systems such as Autonomous Cruise Control, Automated Stop & Go, Collision Avoidance and Autonomous Lane Keeping, all of which can support the driver in his or her normal driving tasks, warn them, or even control the vehicle in the case of potentially dangerous situations or driver impairment. These applications may work in warning/advisory, semi-automatic or automatic mode and can have a major impact on driver/traffic safety, driver comfort and economic aspects.

Electronic links with the road infrastructure (through communications beacons for instance) combine the vehicle functions with traffic management policies (e.g. dynamic speed recommendations or limitations to optimise traffic flow).

5.1.3 *Automated Driving*

Automated driving includes the more advanced driving concepts of totally automated motorway driving. Special applications concerning truck/freight services are the electronic tow-bar and automated platooning in which a leading vehicle (with a driver) controls one or more driverless trailing lorries/trucks in a totally automated way.

5.2 Past and current activities

Since 1986, the automobile industry together with the electronics and automotive supply industries and research institutes have co-operated first within the European wide the **PROMETHEUS**[3]initiative - a pre-competitive research initiative, later within the EU's DRIVE II programme and the Fourth Framework Programme/Telematics Applications Programme (4FP).

5.2.1 PROMETHEUS and DRIVE II

Within PROMETHEUS various technologies and applications were investigated related to safe driving and cooperative driving: vision enhancement, friction monitoring and vehicle dynamics, lane keeping support, visibility range monitoring, driver status monitoring, collision avoidance, cooperative driving, autonomous intelligent cruise control and automatic emergency call.

Such collaboration was also present in the **DRIVE II** programme through various projects dealing with driver monitoring and tutoring, driver information enhancement and dialogue management and co-driver/driver assistance applications. A number of methodologies and guidelines were produced as a result of this research especially on the relations between the Human-Machine Interface and driver performance.

To mention just two of the projects : in the ARIADNE project a model was developed. which allows for the prioritisation and timing of messages presented to the driver on the basis of his or her momentary performance. The HOPES project produced methodologies for prospective and retrospective evaluation of HMI and traffic safety impacts.

Results from the **DRIVE II** projects showed the potential benefits that could be obtained from the deployment of vehicle control systems. The use of Accident Data Recorders resulted in a reduction of 41% in accident recurrence and lower accident severity. The deployment of driver monitoring systems decreased the number of observed overspeeding cases in equipped commercial vehicles. The availability of vision enhancement systems would encourage 60-70% of elderly people questioned to drive more at night. Real-life testing (albeit limited) with collision avoidance systems show an increase of average Headway Time (HT). Simulator and track test results with Intelligent

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[3] PROMETHEUS: Programme for a European Traffic with Highest Efficiency and Unprecedented Safety

Cruise Control Systems (ICC) showed safety improvement as a result of reduction in average vehicle speed and an increase of average Headway Time.

The use of emergency call systems has also shown dramatic benefits: a reduction in the response time (43%) of emergency vehicles and an increase in survival rate (7-12%) and reduction in the long term severity of any injury incurred.

5.2.2 Current (4FP) Activities

Within the **Telematics Applications Programme** (4FP, 1995-1998) a number of projects have been launched that built on the results from both PROMETHEUS and DRIVE II.

The SAVE project is developing a driver monitoring system that will warn the driver if an abnormal situation is encountered such as fatigue/sleepiness or inattention. It will also inform the surrounding traffic in case an emergency situation occurs and has the capability of establishing a call to an emergency centre.

In case of driver impairment, the system will be able to automatically drive the car to the roadside and stop it.

The project AC-ASSIST will develop an intelligent in-car system that warns the driver of the car of a potential collision situation (along the longitudinal axis of the vehicle) enabling the driver to take corrective action. Optionally the system may automatically act on the brakes and throttle on the car if the situation becomes critical to the point where the driver would not have time to react. The anti-collision warning part of the system will be tested on real life road conditions. Human-Machine interface (HMI) issues will be carefully studied in order to optimise user-friendliness, efficiency and safety issues. The specific needs of special categories of drivers - such as the elderly and disabled drivers - will be taken into account as well.

The UDC (Urban Drive Control) project links traffic management policies by road authorities in urban areas to speed control of cars. Dynamic speed recommendations. are sent via beacons to the car. In the basic mode these recommendations are passed on to the driver. In an enhanced mode, the system uses these recommendations to control the car by trying to maintain a certain speed subject to safe distance keeping to the car in front.

UDC will therefore it will combine autonomous cruise control functions with traffic management and is expected to significantly improve traffic flow in the with obvious impacts on travel times. energy consumption, noise, comfort and safety. This system will be tested in the city of Turin, Italy.

The PROMOTE-CHAUFFEUR project investigates and develops a system based on automated driving concepts. In this case an electronic ‘tow-bar’ system will be developed in which a leading truck will control the ‘trailer truck’ in a total automatic way by means of electronic communications between the two vehicles and full truck control systems. Extensions of this system (involving a platoon of trucks) will also be investigated. This system is expected to allow the increase of traffic freight and allow goods to be transported further in a normal working day. It is foreseen to undergo trials on a motorway under normal traffic conditions.

5.3 Product Development Issues

In all these projects, user requirements and user acceptance are being carefully investigated through the involvement of potential users of such systems, because final product design and indeed the marketability of such systems depend on it.

There are a number of potential barriers linked to legal and liability aspects which may hinder the testing, certification and deployment of advanced vehicle control systems. For instance due to the very complex nature of the systems deterministic testing is difficult and a probabilistic/statistical approach will have to be used. This will have to be taken into account when establishing the certification/authorisation procedures and in clarifying the liabilities of the involved parties - manufacturer, system provider , owner/user so as to minimise and identify the liability and legal risks associated with the market introduction of the new systems.

A common European-wide approach will have to be considered. The existing legal and regulatory situation in different EU Members States is now starting to be investigated as a joint project activity. The findings may well result at a later stage in the establishment of European guidelines reflecting a common set of safety related requirements for the testing and commercialisation of advanced vehicle control systems.

6. Conclusions

The results of the research work described in this paper will be utilised in the years to come through commercial exploitation by the industrial partners who have been directly associated with the projects. But the results will also be utilised in support of transport policy initiatives, such as the European Commission proposals for a Citizens' Network[4] - a flexible and accessible public transport network - and the initiative to establish the Trans-European Road Network (TERN). The TERN is based on linking together the strategic international routes that are formed from the national networks of inter-urban highways. The high level group representing the heads of state of the EU governments [5] recognised the importance of traffic management services for this network. Most of the inter-urban RTT applications described here can be applied to achieve more effective network operations and improved conditions for drivers. An example is the moves to establish a pan-European language independent RDS-TMC driver information service which can complement VMS. Similarly for the conurbations, RTT will contribute to transport policy goals across the three key areas of safety efficiency and the environment.

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[4] Citizens' Network: a consultation document. European Commission, Brussels & Luxembourg , 1996

[5] Christophersen Report: Trans-European Networks. European Commission, Brussels & Luxembourg, 1995

Acknowledgements

The authors wish to acknowledge the many contributory sources for this paper, in particular the reports prepared by the Chairmen and Rapporteurs of the working groups and task forces within DRIVE II and the Fourth Framework Programme.

Disclaimer: The opinions expressed in this paper are those of the authors and do not necessarily represent the views of the European Commission.

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ITS/TRANSPORT TELEMATICS IMPACT ASSESSMENT

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ABSTRACT .

The EU DRIVE II programme (1992-1994) has supported a wide range of transport telematic applications in projects throughout Europe. Whilst a key emphasis has been on the promotion of interoperable systems/system elements, the many demonstrations have produced results which take forward our understanding of the potential impacts of telematics. This paper gives an overview of some of those key results.

Users of *travel and traffic information* systems found them to be worthwhile generally, and were prepared to pay for services. The benefits perceived by the individuals could also be translated into network benefits, although issues relating to ownership of, and access to, information remain.

Traffic management, operations and control applications have built on the substantial systems already developed in Europe. New incident detection, network monitoring and integrated strategies/systems have shown to produce substantial savings in time and hence costs. Technology to support vulnerable road users has also been shown to be worthwhile.

Technologies and systems for the on-line management of *public transport* with support from priority and passenger information systems has been applied and shown worthwhile benefits. However. resulting longer term changes in modal split are not yet able to be demonstrated, except in specific situations such as park and ride.

The growing applications of *automatic debiting and demand management* techniques has demonstrated the effectiveness of the technology and the potential environmental and other benefits in a series of specific circumstances.

calculated The use of more advanced communications means (Mobile Data and Satellite Communications) led to significant savings in travel time, dispatch time and travelled distance and increased the range of services that can be offered to the customers.

Substantial economic and other benefits have been demonstrated resulting from the application of telematics technology in the area of *driver assistance and cooperative driving,* largely to provide driver monitoring and support.

INTRODUCTION

Research and Development in the area of transport telematics has been supported since 1989 in the 2nd and 3rd European Framework Programmes, commonly referred to as DRIVE I (1989-91) and DRIVE II (1992-1994). This paper describes the main socio economic impacts of DRIVE II which were reported mainly during 1995. It is based largely on a review undertaken for the EU by the authors and others. but comments and interpretations remain the responsibility of the authors. Clearly, in a paper of this length. only an overview can be presented, with more detailed background and results being available in the many papers produced by the Project participants.

The results may be presented in a variety of ways, by domain, by type of impact or by project. In this paper the six domains used to coordinate DRIVE II have been used. These were:-

- Travel and traffic information
- Traffic management, operations and control
- Public transport
- Automatic debiting and demand management
- Freight and fleet management
- Driver assistance and co-operative driving

TRAVEL AND TRAFFIC INFORMATION

At a pre-trip level these include portable on line interactive services using standard digital mobile networks. Developments in network monitoring and integrated transport data bases have supported the provision of information systems and services. Static terminals have been installed to provide public access to core databases of traveller information, to particularly encourage consideration of modes other than care. In general, public access terminals were welcomed by the survey respondents: most found them easy to use (92% of those using the terminals found the information very adequate and 72% very accurate). The Munich and Rhine Corridor Trial found RDS-TMC services were used in about 70% of trips for pre-trip information. There was also evidence of a substantial increase in peoples' knowledge about public transport services after using the terminals. 60% of the users were influenced by the information provided. 40% changed their departure time, 30% changed the departure date and 20% used an alternative route. Advice given by the road operator leads to a spreading use of the road network especially during 5 x rush-hours. There was, however, no significant change to other transport modes when the first choice corresponded to the road.

A range of in-car systems for on-trip information have evolved during the programme with various traffic information, navigation and dynamic route guidance functions. Users generally rated relevance. accuracy, timeliness, credibility and comprehensibility as being average to good, although only a small number of equipped vehicles were available. However, the more extensive RDS-TMC tests showed very positive results with the majority of drivers finding the information useful and the service satisfactory and easy to use (70-92% in different field trials). More than half the users would be willing to purchase a system (100 ECU). An important feature contributing to the added value was the possibility of being able to request information when needed, to select messages, and to repeat messages. The RDS-TMC messages about relevant congestion led to changes in route choice (20-24%) and a simulation study estimated that total travel time could be decreased by 3-9% by using a RDS-TMC service. Also, 30% of test drivers at one site claimed that RDS-TMC led them to reduce speed when approaching an incident, before the queue was visible.

The use of variable message signs (VMS) to provide network information has been successful. Typically, in Scotland, a 20% reduction in delays likely to occur following an incident on the Forth Road Bridge may be expected using VMS with other of people savings of 5 to 10 minutes when problems occur on other parts of the network. A large majority (82% of these interviewed by questionnaire) of people who use the route regularly indicated that they would follow VMS information even if it was in conflict with other sources.

Drivers have seen substantial benefits in terms of reduction in delay (20% on interurban routes), and high levels of satisfaction have been found amongst drivers with two thirds following advice. Trials utilising the 350 VMS around the Peripherique in Paris established that 80% of drivers preferred to be informed about travel time rather than queue length. VMS used as part of a weather traffic management system resulted in a 10% speed reduction and up to 30% less accidents in rainy conditions and 85% reduction on foggy days. It was found that the use of pictograms improved the comprehension of messages for foreign drivers, and enhanced its perception.

Dynamic route guidance trials have not been sufficient to enable full impact assessments and evaluation has centred on technical performance of systems and driver response, using a common questionnaire, logbooks and some data from other studies. In general, more than half the drivers agreed that the systems could be beneficial with a smaller proportion following the advice (20% or more). Perceived benefits included greater security and a reduction in stress as well as travel time reduction. Half the drivers were willing to pay 750 ECU or more for route guidance equipment. Most would pay between 180 and 350 ECU per year for a corresponding dynamic traffic information service. Modelling has shown significant network benefits with only low proportions of guided drivers (e.g. 6% reduction in travel time with a penetration rate of 20% and 100% compliance).

TRAFFIC MANAGEMENT, OPERATIONS AND CONTROL

(i) Incident and Emergency Management: The use of computer vision analysis techniques for incident and emergency management has resulted in high detection rates (>93%) and low false alarm rates (<8%). The transfer of information between TICS and TCCs has been progressed by a number of projects and task forces, each focusing on a specific area in the information chain.

(ii) Emergency Calls: A number of initiatives have been developed to address public safety and facilitate the means of calling for assistance. range from trials of vehicles fitted with impact sensors which automatically trigger a radio signal in the event of a major accident which is automaticallq located by GPS.

A reduction in the response time (43%) of emergency vehicles has been measured on systems fitted to vehicles carrying dangerous goods. Using these systems has increased survival rates (between 7 and 12%) and a potential reduction in the long term severity of any injury incurred.

(iii) Motorway Traffic Control: Modelling has shown that a re-routing strategy can reduce traffic delays by up to 20%, CO by up to 10%, HC by 5% and NOx by 5%. The need for an architecture framework and open system architectures for traffic management has been highlighted.

(iv) Urban/motorway Traffic Control, Integration: VMS installed on the motorway providing information concerning parking or park and ride schemes have been very effective with an 80% increase in park and ride users. In Paris, control strategies using ramp metering and 350 VMS on the entire Peripherique and the Boulevard des Marechaux increased the mean speed by 21%, 16% and 19% for the motorway, parallel network and total corridor respectively. Similar results were obtained in Amsterdam when ramp metering produced a reduction in delay by 19% for all traffic on the ramps.

(v) Traffic Control for Pedestrians: Trials of new microwave detection of pedestrians with new control strategies have achieved improvements for pedestrian safety with a decrease in red light violations and the number of pedestrian-vehicle encounters. The main benefits of this technology related to an increase in comfort and safety for pedestrians, with benefits to particular pedestrian groups, such as the elderly and the disabled.

(vi) Weather Related Traffic Management: A weather monitoring station has been developed and implemented using a range of new weather monitoring detectors together with in-vehicle systems used to warn drivers of changes in road conditions. These have led to speed reduction (<10%) and accident reduction (>30%). Speed control was most effective.

(vii) Urban Traffic Control: Achievements in DRIVE II have included new UTC systems/strategies and new integrated functions such as public transport priority, variable message signing. Automatic Incident Detection and new facilities for pedestrians. Advanced UTC systems such as SCOOT and UTOPIA have been proven to be cost effective in reducing vehicle delays. In DRIVE II. evaluation of PRODYN and the new MOTION system have indicated typical reductions in travel time of 10% with associated savings in fuel consumption and emissions. Pollution control in one city incorporating UTC and VMS has achieved predicted reductions in emissions of some 26-30% (CO. NOx, HC) in the controlled area in two instances of severe pollution.

PUBLIC TRANSPORT

(i) Information Management: DRIVE II projects and Task Forces have addressed the issues which are expected to provide benefits from improved integration of systems.

(ii) Vehicle Scheduling and Control Systems (VSCS): In DRIVE II, projects have focused on providing higher order services, including (i) location through satellite-based GPS (Global Positioning System), (ii) location for passenger information and public transport priority systems and (iii) integration with new Demand Responsive Transport Systems. No impacts of VSCS have been assessed in DRIVE II projects, although impacts of applications supported by Automatic Vehicle Monitoring are summarised in the following sections.

(iii) Public Transport Priority: The implementation of public transport priority in advanced Urban Traffic Control (UTC) systems has been an important telematics application in DRIVE II, supported by a range of vehicle detection/location technologies, including bus transponders with inductive road loops, bus tags with roadside beacons and AVM radio technologies. Projects have produced consistently favourable results. Delay savings for buses and trams at signals due to priority averaged some 50% across all assessments (up to 97% in one application) with negligible impacts on private traffic. Other quantified operational benefits recorded included (i) reduced variability in PT journey times and delays (up to 29%), (ii) improved regularity of PT services (11%), (iii) savings in fuel consumption and emissions (4%-6% in simulation studies in Gothenburg, using enhanced UTC with PT priority) and (iv) some evidence of increased PT patronage. Economic cost-benefit analyses undertaken for four systems/strategies indicated very favourable rates of return, with payback periods varying from 3-16 months.

(iv) Passenger Information: Passenger response to the usefulness of at-stop real-time information has been positive (57-90%). 18%-64% of passengers perceived reduced waiting times, even though punctuality did not generally improve. Users have reported a very high acceptance of information provided by public access enquiry terminals, with some evidence of increased public transport usage resulting. An application of travel centre enquiry support reported increased mobility (10%) and increased public transport usage (8%) based on the results of interviews. For both in-home terminals and/or portable personal units surveys have revealed a strong potential for the product.

(vi) Demand Responsive Transport (DRT): The use of VSCS in one DRT project has highlighted benefits to the operator, including driver time saving of 30-60 minutes per day, and potential benefits for the community through increased mobility and reduced access time for users.

AUTOMATIC DEBITING AND DEMAND MANAGEMENT

(i) Automatic Toll Collection: The average time saving with fully deployed Automatic Toll Collection is expected to be over 40h/year for the average motorway commuter. Safety of private and commercial vehicles is also expected to be improved as a result of extensive deployment of automatic tolling on motorways due to the elimination of traffic channelling at toll plazas as well as of possible queues; this result should also improve the air quality and reduce the energy consumption of the average motorway commuter by about 5%. By replacing one out of five manual toll gates with a mono-lane enforcement system (in combination with a multi-lane tolling gantry) it has been that the passage time of the equipped cars could be reduced from 156 s to 45 s. irrespective of the traffic increase. Assuming a progressive increase of subscriber market penetration for cars from 5% in 95-97 to 25% in 2004-06, even non equipped vehicles would also benefit of a 30% reduction in the toll gate passing time due to the reduced demand in the manual lanes. An assessment of both the vehicle operating costs and the economic value of travel time saving indicated a payback period for the infrastructure operator of 6 years. Also, road maintenance costs could be significantly reduced by discouraging the overloading of Heavy Goods Vehicles through the use of automatic weighing for toll collection.

In Trondheim, Norway, the toll ring which operates as a cordon around the central area with 12 entry points is used successfully with 76,000 subscribers having AVI tags in their cars. Tolls must be paid entering the cordon during business hours, and over 85% of the locally registered vehicle stock now use the equipment successfully for payment of the tolls. There has been a These 10% reduction of crossing of the cordon during toll hours with trips redistributed in time and spatial patterns in response to the toll system. Public transport usage has increased by 8% for the whole city area. Surveys concerning user response have also found that citizens had less awareness of road pricing than of any other demand management measures and questioned its effectiveness in influencing modal choice and travel behaviour. In Trondheim, the attitude towards road pricing showed that 46% of respondents have negative opinions and 37% have positive opinions. People inside the existing toll ring area are more positive towards road pricing than those outside. Modelling of the travel impacts of Road Pricing based on user response studies in Gothenburg. showed that the implementation of a road toll over a defined area of the city would result in a 1.9% decrease in trips by car for work, and a 6% decrease in car trips in the area for shopping.

(ii) Access Control: An average 18% reduction in travel time inside the Barcelona special events zone was identified following access control. Surveys also indicated a 15% increase in both on-street parking availability and in on-street space usage resulting from a shift of parking from the inside to the border zone, with a 20% perceived reduction in congestion problems, The citizens' perception of the quality of information provided by the public authorities on the pilot implementation of Access Control systems was rated good by 89% of people surveyed. In Barcelona, residents of the special events zone were 70% in favour and 24% against the measures implemented.

The non-stop access control application in Bologna showed a 55% reduction of the total recorded entry volume, with major re-assignment to the Inner Ring Road. Within the Access Control trials. pollution monitoring showed a 50% reduction of emission in the central area. In terms of financial return on investment (excluding intangible benefits) it was estimated that the pay-back period should be between 2 and 5 years depending on the actual violation rate. In Bologna, where the payment card had only been used for the bus service, a survey indicated that 75% of the users were in favour of an extension to a multiservice operation. The same city-wide survey on the acceptance of non-stop access control measures showed a rather close 40/37% split between for/against options.

(iii) Parking Control: In Munich the use of Variable Message Signs to advise motorists approaching the city of a new Park and Ride facility resulted in a modal shift that reduced the use of private car by 1.6 million km/year for that site (a reduction of fuel consumption of at least 200,000 litres/year). From surveys made during the trials, 16% of the respondents attributed their decision to the availability of VMS information about parking space availability; over 26% of the parking facility users on weekdays and 46% of the users on special event days stated they would have otherwise used the car for the entire trip to the city centre. A cost-benefit analysis indicated that the provision of VMS for parking access information and guidance can only be commercially viable for sites of 500 spaces or more. A similar system in Cologne more than doubled the use of the Park and Ride facility with 33% of users doing so directly because of the information; many of the cars would otherwise have proceeded to the city centre.

(iv) Integrated Payment: Trials of the use of smart cards for integrated payment applications have shown very high levels of user satisfaction (70-90%). Also, high user satisfaction was reported by the parking operator in a multi application trial in Dublin.

FREIGHT AND FLEET MANAGEMENT

On the basis of the average trials results, Freight and Fleet management functions should provide savings in travel time close to 5% (trials range 0-16.5%) and savings in dispatch time above 12% (trials range from -4.2 to 35.2%). Travelled distance should accordingly be reduced by over 6% (trials range 0.3-21.3%). As a result of EDI use , data have become more reliable and transport order cycle time has been reduced. Both drivers and dispatchers feel comfortable in using the new Fleet Management equipment. since it reduces stress, enriches work and let drivers feel more secure. It also increases the range of services that can be offered to customers.

Experience with Inmarsat-C satellite communications, used on 32 vehicles at 5 companies, indicated an estimated saving of 2% mileage in international transport with a payback period of 4-8 years. Other results showed that up to 37.5% of the currently wasted time (waiting time, pick-up time. delay time) could be saved using Mobile Data Communications for freight and fleet management functions and that. with the use of Transport Telematics, the number of delayed arrivals decreased by 35%. The systems used in the IFMS trials were expected to lead to a payback period of 3.4 years.

Cost estimations have shown that, in average, the use of Mobile Data Communications for Fleet Management applications would lead to a marginal increase of transport cost per vehicle and km in the amount of only 1ECU/l000 km.

As a result of freight and fleet management functions, an average reduction of fuel consumption of 2,350 litres per vehicle and year was measured, resulting approximately in a 4.4% fuel reduction based on average 150,000 km /year travelled distance and 351/l00km specific fuel consumption.

For Inter-modal Tracking and Tracing applications trials showed that the average waiting time for vehicles of the transport fleets was reduced by up to 20%, whilst, for the combined mode, the pick-up and waiting time for switching from road to rail was reduced by hours. Savings in distance travelled could lead, on a European scale, to a fatal accident reduction of 150 per year.

DRIVER ASSISTANCE AND CO-OPERATIVE DRIVING

(i) Driver Monitoring: The use of an Accident Data recorder on commercial vehicles for driver monitoring purposes resulted in statistically significant reduction in accident occurrence (41%) and beneficial reduction in accident costs due to lower accident severity. The average user response also indicated that the implementation of a driver monitoring function has a slightly negative impact on driver comfort but has shown a positive assessment of its contribution to a better safety. UK trials on driver monitoring showed a downtrend in the number of observed "overspeeds" per 1000 km by the fleets of equipped commercial vehicles, also leading to a likely reduction of fuel consumption and related emissions; at the fleet level, a reduction of the commercial vehicles operating costs was observed as a result of reduced accident related damages and repair cost /km decreased up to 40%; a reduction of consumption and wear out costs (fuel, tyres and other vehicle components) was also observed, often leading to a recovery of the equipment cost within one year.

(ii) Cooperative Driving: The use of Collision Warning functions resulted in an increased average time headway. Tests on a driving simulator have showed that Intelligent Cruise Control systems use may improve safety as a result of a reduction in average vehicle speed (5% for the informative mode) and of an increase of average time headway (30% for the informative mode). Track tests on ICC systems have indicated an average time headway increase in the car following scenario of between 5 and 10% (from low to high speed), a modification of the Headway Time distribution (which showed a reduction at low frequency and an increase at medium frequencies) and an increase up to 35% of the average time-to-collision for the approaching phase (under stationary speed conditions). There was an improvement in speed harmonisation (especially at higher speeds) resulting in improved safety conditions due to the lower relative speeds. Tests on a driver simulator indicated that informative-only Intelligent Cruise Control systems contributed less to driver comfort than ICC systems operating in the automatic mode.

(iii) Driver Support: The majority of the elderly drivers who have tested route guidance support systems indicated that they would increase their propensity to travel. Vision enhancement aids allowed drivers to see/identify pedestrians and road features at a greater distance in night driving. leading to reduction of potential collisions with vulnerable road users. The availability of vision enhancement would allow 60-70% of elderly people to drive more at night.

Driver support and collision avoidance systems have so far found a higher level of acceptance from people that would otherwise suffer some limitation in their ability or willingness to drive (disabled people in general and elderly drivers with respect to congested or unknown areas and limited visibility conditions). However, in dense fog conditions, collision avoidance systems, though subjected to limited real-life testing, would found acceptance, if a very low rate of false alarms could be achieved.

CONCLUSIONS

The substantial research, development and application of transport telematics in DRIVE II has resulted in common understandings of the impacts, benefits and opportunities. Whilst much is still to be achieved, the outcomes have provided a sound basis for the 4th Framework activities in which generally more comprehensive applications of technology are taking place.

REFERENCES

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IMPACT ON	TRAVELLERS											MANAGERS AND OPERATORS										SOCIETY			
GROUP OF:	ON PRIVATE VEHICLE						ON PUBLIC TRANSPORT				ON COMBINATION OF MODES	OF FREIGHT AND FLEET					OF INFRASTRUCTURE					ENVIRONMENT			SOCIO ECONOMIC
IMPACT INDICATORS / APPLICATIONS & SERVICES	travel time	travel time variance	vehicle operating cost	comfort	safety	other	travel time	trip reliability	convenience	security		travel time	travel time variance	cost	service quality	safety	cost savings	capacity	number of users	accidents / conflicts	service quality	air quality	noise quality	energy consumption	
Travel & Traffic Information																									
Pre-trip travel information		+																	+		+				
On-trip information																									
On vehicle	+	+			-																				
Roadside	+		+	+	+												+	+			+	+		+	
Traveler service information																									
Route guidance	(+)	+	+	(+)	+/-	+/-											-			+/-		+/-		+/-	
Ride matching reservations	+																								
Traffic Management, Operations and Control																									
Incident & emergency management																	+		+	+					
Emergency calls				+	+										+	+	+			+					
Urban traffic control	(+)	+	+			+/-	+	+									-	+		?		+		+	+
Motorway traffic control	+	+	+	+	+							+	+	+		+	+	+	+	+	+				
Urban/motorway traffic contr. integr	+	+		+								+					+	+							
Vulnerable road users facilities	-				+												-			(+)					
Weather and road monitoring				+	+										+	+				+					
Public Transport																									
Information management																									
Vehicle scheduling & control																									
Public transport priority	-		-				(+)	(+)									-					+		+	(+)
Passenger information								+	(+)	+							-				+				
Demand responsive systems																									
Automatic Debiting & Demand Management																									
Integrated payment				+					(+)		(+)						(+)								
Automatic toll collection	(+)		+	+								(+)		+			+	+		+	+				
Road pricing				+/-							+											+		+	
Access Control											+											(+)		(+)	
Parking management	+		+	+							+						+								
Enforcement																	+								
Freight & Fleet Management																									
Freight management														(+)	(+)										
Fleet management													+	(+)	+	+									
Intermodal tracking & tracing														+	+										
Hazardous goods monitoring																(+)							+		
Freight terminals operations															+										
Integrated logistics																									
Administrative tasks															+										
Driver Assistance/Vehicle Control																									
Driver monitoring				-	+																				
Driver support				+	+																				
Cooperative driving																									
Collision avoidance				+	+																				
Intelligent cruise control				+	+/-																				

Table 1 Operational Impact Matrix