SOCIO-ECONOMIC IMPACTS
OF TELEMATICS APPLICATIONS IN TRANSPORT

ASSESSMENT OF RESULTS
FROM THE 1992-1994 TRANSPORT TELEMATICS PROJECTS

MAIN DOCUMENT

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This report is based on an evaluation of responses to an impact assessment questionnaire as well as a review of final reports and deliverables of transport telematics projects. The report was prepared for the Commission services by an expert team consisting of Messrs B. Finn, G. Fisher, N. Hounsell, M. McDonald, Y. Stephanedes and M. Traversi.

Special care has been taken to ensure that the information and statements presented in this document are accurate. The European Commission services which coordinated the expert group responsible for the production of this report cannot undertake any responsibility for inaccuracies which may occasionally be traced.

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1. EXECUTIVE SUMMARY

Context

The research activities on Telematics Applications on Transport started in 1989 with the DRIVE exploratory Programme and continued through the period 1992-94 with the Third Framework Programme. Over 60 projects were supported that involved more than 30 cities and 13 major transport corridors and brought many new technologies closer to large scale implementation. The degree of impact of Telematics Applications on safety, efficiency and the environment can effect the policy making process, particularly when having to consider financial issues. This document details the results of an impact analysis of the results from the project activities with commentary concerning the issues being addressed and the impact in other areas.

For the assessment of transport telematics impacts the telematics services and applications were classified into 6 main domains:
-- 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.

Each domain was then further divided as appropriate, resulting in a total of 34 sub-domains.

Three matrix tables are provided in the report to support the search for information. The first table shows the subdomain where impacts were measured/observed by specific transport telematics projects. The second table illustrates the impact indicators relevant to each sub domain, with information on the number of projects providing results for each impact/domain type, thus showing the coverage and likely robustness of overall findings in each case. The third table indicates where positive and, in some cases, negative impacts have been found, highlighting the main impacts by domain.

The core of this document provides a detailed analysis of the impacts from the Telematics Applications Programme that were identified within each domain. After a short description of the issues being addressed, the key results, the measured impacts, other impacts and general benefits obtained by applying telematics are presented, together with relevant comments obtained from project deliverables which are related to problems and limitations, future needs, integration and implementation issues and cross domain implications.

There were many actors in the transportation field covering research, policy and financial issues who were not directly involved in the Programme. It is essential that the benefits to be obtained from the most promising applications are easily identified by the various actors in relation to the key transportation issues. For this reason the transport telematics impacts are also presented by category of main user benefits and features which are most relevant for future exploitation, such as safety, efficiency, environment and energy, cost, socio-economic policy, user response and acceptance.

A summary of the most relevant results and impacts from the various domains is presented next.
Key Results and Impacts

TRAVEL AND TRAFFIC INFORMATION - In general, the public access terminals for Pre-trip Information were welcomed by the survey respondents. Most people found the terminals easy to use. 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 in projects in France and Germany. Advice given by the road operator leads to a spreading use of the road network especially during rush-hours.

For On-trip/On-vehicle Information, only a small number of vehicles could be equipped with on board information systems and the results obtained need to take into account the small driver sample. Those involved rated relevance, accuracy, timeliness, credibility and comprehensibility as being average to good. More than 50% of the drivers complied with the information and 85% indicated a willingness to buy in-vehicle equipment if the price for the extra RDS-TMC facility would not exceed 100 ECU. The majority (70%) of the subjects concluded that the RDS-TMC system proved to be satisfactory, contributing to a decrease in uncertainty of journey time.

For On-trip Roadside Information, results from tests in Scotland indicated a likely 20% reduction in delays following incidents on one of the main routes may be expected using Variable Message Signs (VMS) whilst savings of 5 to 10 minutes could be achieved when problems occur in other parts of the network. Otherwhere 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, as measured in projects in France, Germany, Holland and Italy.

Limited trials on Dynamic Route Guidance did not enable full impact assessments. No trial has had more than 100 equipped vehicles. Evaluation has therefore centered on technical performance of systems and driver response, using a common questionnaire, logbooks and some data from other studies. Answers given by the drivers indicate that the system was capable of changing their driving habits either by leading them to take different roads or by enabling them to drive at different times. On the other hand simulation results indicated a 6% reduction in travel time using a decentralised multi-routing strategy, given a 20% penetration rate and 100% compliance with guidance advice. Advanced simulation models were used to develop DRG strategies and predict the impact of route guidance under large scale implementation by addressing new journey time prediction, new incident management strategies and new techniques for origin and destination estimation.

TRAFFIC MANAGEMENT AND CONTROL - The most promising contribution to Incident and Emergency Management has been in vehicle detection technology utilising computer vision analysis techniques. With a detection rate better than 93% and false alarm rates lower than 8%, the new detection systems, combined with new algorithms, have been used as very effective operator tools that also allow direct visibility of the incidents’nature.

For Emergency Calls a number of initiatives have been developed to address public safety and facilitate the means of calling for assistance. Vehicles within urban areas were fitted with the latest “emergency call system” for rapid assistance in case of accidents. Any incident involving vehicles carrying dangerous goods would implement the emergency call system 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.

A special task force was established to assess the work of projects addressing the use of automatic systems responsive to changing situations by Variable Message Signs activation to warn drivers of specific situations; a comprehensive report has been produced indicating the benefits of using a number of the technological developments, particularly in the area of video analysis. Various models developed to reflect different operating environments were applied to test real time VMS control strategy selection and traffic prediction information. The use of these models as part of a re-routing strategy demonstrated the possibility to reduce traffic delays by up to 20% and thus CO by up to 10%, HC by 5% and NOx by 5%.

Improvements in the Urban/Motorway Traffic Control integration was achieved using VMS in a number of applications. VMS installed on the motorway were used to inform drivers of the option to use park and ride facilities which resulted in an 80% increase in patronage. Control strategies using ramp metering and VMS increased the mean speed between 16 and 21% and resulted in delay reduction up to 19% for all traffic on the ramps.

For Pedestrian Traffic Control, trials of new microwave detection for pedestrians with new control strategies have achieved improvements for pedestrian safety with a decrease in red light violations and in the number of potential pedestrian-vehicle collisions.

Weather monitoring stations using a range of new weather related monitoring detectors were tested together with VMS and in-vehicle systems as part of a weather related Traffic Management application to warn drivers of changes in road conditions or to implement speed control. Reductions in vehicle speed of up to 10% were obtained and accidents decreased by more than 30% and the number of people killed or injured by more than 40%.

Urban Traffic Control Tests of new advanced UTC systems have indicated typical reductions in travel time of 10% with associated savings in fuel consumption and emissions. Pollution control incorporating UTC and VMS has achieved predicted reductions in emissions of some 26-30% (CO, NOx, HC) in the controlled area under severe pollution conditions with traffic entering the central area reduced by 5%. A maximum reduction of 25% in journey time has been estimated for all modes once a complete integration of 10 planned applications interfaced to a common network has been completed.

PUBLIC TRANSPORT - Enhanced information management systems can provide an important supporting framework covering systems architectures, databases, data communications and interfaces for the more efficient implementation of telematics services. The benefits of improved systems integration can also improve the overall efficiency of the public transport operators, leading to a gradual downward movement of system prices.

Vehicle Scheduling and Control Systems and Automatic Vehicle Monitoring systems, provide operational support to public transport operations, through regular real-time location of the vehicle within the system. This allows better management of services through direct intervention and through the provision of data, allowing improved planning and scheduling of services by using vehicle location through satellite-based GPS (Global Positioning System), passenger information, public transport priority systems and integration with new Demand Responsive Transport Systems.
The implementation of Public Transport Priority in advanced Urban Traffic Control systems has been 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. 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 measured operational benefits included up to 25% reductions in PT journey times and delays variability, up to 11% improved regularity of PT services. Simulation studies of enhanced UTC with PT priority use indicated potential savings in fuel consumption/emissions and economic cost-benefit analyses indicated very favourable rates of return, with payback periods varying from 3-16 months.

Passenger Information systems have tested which indicated 57-90% positive passenger response for at-stop real-time information. There was a very high user acceptance of information provided at public access enquiry terminals with some evidence of increased public transport usage resulting. For travel centre enquiry support, one application reported increases in mobility (10%) and in public transport usage (8%) based on results of interviews whilst for in-home terminals, PC access and portable personal units early developments and surveys have shown substantial future market potential.

Preliminary use of Demand Responsive Transport systems, which consist of public transport services having flexible departure times, routes, vehicles, etc., demonstrated the possibility of route and passenger assignment optimisation and of reservation and payment functions management with driver time saving of 30-60 minutes per day and potential benefits such as improved mobility and reduced access time for users.

FREIGHT & FLEET MANAGEMENT - If the results on travelled distance reduction per year experienced on a fleet of 63 commercial vehicles over a 13-month trial are extended to the European context, the use of Mobile Data Communications, Global Positioning Systems and/or Trip Recording equipment, would potentially lead to an average reduction of about 150 fatal accidents per year.

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%). Other results showed that, using Transport Telematics and Mobile Data Communications for F&F management functions up to 37.5% of the currently wasted time (waiting time, pick-up time, delay time) could be saved and the number of delayed arrivals decreased by 35%.

As a result of Freight & 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 150,000 km/year travelled distance and 35 l/100km specific fuel consumption per vehicle.

Cost estimations have shown that, on 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 1 ECU/1000 km. 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.

Trials results from one project indicated that Transport Telematics functions for Freight Management had a capital cost ranging from 3.5 to 25.6 kECU per system and from 2.0 to 11.6 kECU per
vehicle; with reference to an average capital cost of 12.7 and 5.5 kECU per system and vehicle it can be expected a system running cost of about 3.8 kECU/year and a vehicle running cost of about 2.2 kECU/year. On the basis of the corresponding expected benefits, an internal rate of return of about 21% can be assumed which would lead to a payback period of 3.4 years.

For Intermodal 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. Paper work was generally reduced and automated processing of deliveries became possible. It is therefore assumed that the number of administrative personnel could be reduced substantially. The use of Tracking and Tracing systems has also demonstrated a high potential to increase the number of customers served with the same operational resources due to the fact that just-in-time and more efficient operations become possible.

On the basis of the observed reduction of emergency response time and on the estimated high potential for reduction of accidents, accident consequences and environmental damage due to Hazardous Goods Transport incidents should be significantly reduced by the use of related Transport Telematics applications. In general emissions and noise in the field trials corridors were reduced as a result of the monitoring of speed and vehicle conditions; by also monitoring and deviating noisy vehicles from urban/public areas, noise impact was reduced in such areas.

AUTOMATIC DEBITING AND DEMAND MANAGEMENT - For Automatic Toll Collection it is expected that using automatic multilane tolling instead of manual toll gates the average time loss would be reduced by several minutes resulting for the average motorway commuter in an average saving of over 40h/year and a reduction of the energy consumption by about 5%.

On a specific test site, by replacing one out of five manual toll gates with a mono-lane enforcement system (in combination with a multi-lane tolling gantry) the passing 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.

On the other hand, an assessment of both the Vehicle Operating Costs and the economic value of travel time saving indicated an estimated saving per toll passage for equipped vehicles of 0.23 ECU for busses and of 0.13 ECU for heavy freight vehicles. Assuming a commercial cost of 50 ECU and a 5 year lifetime for each on-board unit, the minimum number of passages/year to recover the equipment costs would be 44 for busses and 77 for trucks. In turn as a result of the 60% increase in capacity and the operating cost reduction, the net benefits for the period 1995-2006 would amount to 1.15 MECU. As total costs would reach about 0.64 MECU, the payback period for the infrastructure operator would be of 6 years with an internal rate of return of 33% over the whole 12-year period. In terms of environmental benefits the reduction of noise and emission levels would be equivalent to a saving of 130 kECU (a value close to the total investment cost of the ground equipment) for the same period.

Integration of Toll Collection and Axle-Weight Road Pricing can effectively contribute to improved road and environment protection. The principal benefits are expected to be in the form of environmental improvements through a reduction of noise, emissions and energy consumption as well as of contaminating accidents. The road maintenance costs can be significantly reduced by
discouraging the overloading of Heavy Goods Vehicles through the use of automatic weighing for toll collection. The resulting improvement in the efficiency and capacity of the tolling system and the less frequent maintenance works on road pavement should help increase the infrastructure capacity.

For Access Control, on the basis of journey time surveys, in Barcelona an average 18% reduction of travel time inside the special events zone was identified, whilst, in terms of vehicle traffic flow during working days, in Barcelona the total recorded entry volumes before and after access control implementation showed a 33% reduction for the special event zone and a 78% reduction for the priority zone. The non-stop access control application in Bologna showed a 55% reduction the total recorded entry volume, with major re-assignment to the Inner Ring Road. Within the Access Control trials in Bologna, pollution monitoring data showed a 50% reduction of emission in the central area. In Barcelona, model estimates in the special events area had predicted a 50% reduction of emission inside the zone, while surveyed citizens indicated a perception of reduced air pollution (19%) and reduced noise (20%) within the priority zone. The social acceptance of the access control measures by the citizens was also assessed by means of opinion surveys. In Barcelona 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 about the special events zone (only 3% giving a bad rating). For the priority zone on a 1 to 9 scale residents gave an average 5.8 mark to the quality of information (compared with a 4.1 mark from visitors). Data from the public transport operator indicate for the special events zone a 50% increase in public transport trips city-wide indicating a good attitude towards a modal shift, whilst residents of the special events zone were 70% in favor and 24% against the measures implemented. In the priority zone residents gave to the measures an acceptance rating of 6.1 compared to city-wide rating of 6.0. In Bologna, a city-wide survey on the acceptance of non-stop access control measures showed a rather close 40/37% split between for/against options. In terms of financial return of investment (excluding intangible benefits) it was estimated that in Bologna the pay-back period should be between 2 and 5 years depending on the actual violation rate; the corresponding figure for the Barcelona priority zone application was 4 years.

The modal shift due to the Frottmanin (Munich) Park'n Ride operation, where Variable Message Signs were used to advise motorists approaching the city, is estimated to be able to reduce the use of private car by 1.6 million km/year corresponding to a reduction of fuel consumption of at least 200,000 litres/year. Over 16% of the surveyed respondents attributed their decision to the availability of VMS information about parking space availability. In total 26% of the users on weekdays and 46% of the users on special event days, would have used the car for the entire trip if the Park'n'Ride facility were not available. Usage of the P'n'R facility in Köln more than doubled with 33% of users doing so directly because of the information; many of the cars using the facility would otherwise have proceeded to the city centre.

Post trials user surveys indicated that 91% of the respondents in Dublin found the Electronic Purse a convenient way for paying for Public Transport services; 84% of the Marseille respondents highly regarded the reduction of money and ticket use and were very satisfied with the design of the portable units and the related messages. In Bologna 65-70% of respondents had no problems with the smart card use, nor with the new location-related fare structure. In Bologna, where the 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. Results from Marseille surveys showed that a remote payment device can offer the users a number of advantages: ease and control of gesture, friendly user interface, good security, flexibility of operating modes (speed of communication, on-and off line). The card used was considered adequate in terms of data storage, processing and security capabilities. The integration of payment for parking was included in the multi-application smart card in Dublin,
with many users using the card for other modes as well. High user satisfaction was reported by both
the motorists and the parking operator. Queuing time for exit was significantly reduced for motorists
with smart cards. Impacts on parking behaviour were not measured.

Surveys concerning user response to Road Pricing have found that citizens had less awareness of road
pricing than of any other demand management measures and questioned its effectiveness in
influencing mode choice and travel behaviour. The surveys found that road pricing measures had
very low levels of acceptability with citizens, whereas non-price related issues such as access
restrictions have a high level of acceptability even among motorists. In Trondheim, Norway, where a
toll ring is operating as a cordon around the central area with 12 entry points, Automatic Fee
Collection is used successfully with 76 000 subscribers having AVI (Automatic Vehicle
Identification) 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.

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.

DRIVER ASSISTANCE AND CO-OPERATIVE DRIVING The use of an Accident Data recorder
on commercial vehicles for Driver Monitoring purposes resulted in statistically significant reduction
in accident occurrence (up to a maximum 41% reduction with respect to past historical average of
the number of accidents for a fleet of 130 vehicles) and beneficial reduction in accident costs due to
lower accident severity.

The UK trials on Driver Monitoring showed a downtrend in the number of observed "overspeeds"
per 1000 km by the fleets of equipped commercial vehicles, 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, together with a reduction of consumption and wear out costs (fuel,
tyres and other vehicle components) often leading to a recovery of the equipment cost within one
year. In addition, as a result of reduced accident related damages, repair cost / km decreased up to
40%.

It has also been outlined that, if Driver Monitoring could be more widely used in commercial fleets, a
widespread reduction of accidents severity would lead to a greater reduction of total social costs
from road accidents (including insurance, hospitalisation and other costs); the average user response
has 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.

The assessment of the answers to a questionnaire about the potential change induced by Driver
Support in the driving habits and attitudes of elderly people has shown that reversing aids would only
marginally affect the willingness to drive to places where parking manoeuvres were known to be
difficult, but the availability of vision enhancement means would allow 60-70% of elderly people to
drive more at night. The majority of the elderly drivers who have tested Route Guidance systems for
Driver Support stated that the availability of these systems should impact on their travel behaviour
in a way to lead to a higher likelihood of travelling to unfamiliar places. In terms of socio-economic
aspects, the results of an enhanced ability to drive by Drivers with Special Needs (DSN) indicate the possibility of achieving a better social integration of DSN people through the use of Driver Support systems.

Driver Support and Collision Avoidance systems have also found so far 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, have found widespread good acceptance, assuming that a very low rate of false alarms could be achieved. With reference to the use of Collision Avoidance systems on private vehicles by normal drivers, measurements of the average Headway Time (HT) indicate that the use of Collision Warning functions actually resulted in an increased average HT. Since the answers to a questionnaire on Workload effects resulting from display use have shown no significant variations in workload, an extensive use of collision warning is expected to induce an increase of Headway Time and thus result in safer driving conditions.

Tests on a driving simulator showed that Intelligent Cruise Control (ICC) systems use can improve safety as a result of a reduction in average vehicle speed (5% for the informative mode) and an increase of average Headway Time (30% for the informative mode). Track tests on ICC systems have indicated an average Headway Time increase in the car following scenario 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). Tests on a driver simulator were assessed using a pre-/post-questionnaire in terms of impact on the driving comfort: with respect to the initial baseline value, informative-only ICC systems had a worse average assessment whilst ICC systems operating in the automatic mode were generally assessed as contributing to a better driving comfort.

**Conclusions and Recommendations**

Since during the Transport Telematics programme the evaluation process has often focused on technical performance, results on transport efficiency impacts and user response to systems which have often been experimental, are indicative, based on limited surveys covering limited impacts. In particular there have been few quantitative results concerning road safety, environmental impact and economic/financial performance of systems. These issues will then require a more concerted coverage in the 4th Framework Programme.

To maximise the value of telematics evaluations across Europe, it is necessary to use a common evaluation framework, implement a sound evaluation methodology and implement common information management procedures to maximise information accessibility and transfer. During the 4th Framework there will be good opportunities to improve on each of these aspects.

It is apparent that the evaluations in some studies have been driven more by resource constraints than statistical requirements. This has led to more qualitative and inconclusive results than initially expected, so that firm conclusions are often not then possible. Given limited resources, it is recommended that field trials are designed to produce statistically robust results for a limited number of scenarios and impacts, rather than covering too many scenarios/impacts and achieving only inconclusive results.
Despite these limitations, the conclusions presented in the report can make reference, for each application and for each domain, to a number of promising results with particular attention being given to safety, efficiency, environment, cost-benefit, the state of the art concerning technology and the user acceptance. The following are some of the key results obtained in the various domains.

- RDS-TMC has now become established as a major facility for the dissemination of traffic information.
- Pre-trip travel information systems have been trialled successfully using both portable and permanent systems with a high user acceptance and increases the willingness for the public to use public transport.
- VMS have been used for network re-routing with the use of new strategy control selection models with up to 20% saving in journey time and with more than 82% of the drivers confident that the message presented is both timely and accurate.
- The use of VMS used to reduce delays has also reduced the level of pollution
- New Automatic Incident Detection models have been developed for both urban and inter-urban areas which speed up the response to incidents.
- Automatic emergency crash sensors that can activate the transmission of information relating to the location, type of vehicle and when appropriate the contents to speed up rescue measures have been implemented.
- Video detection systems have been enhanced to provide a cost effective means of detecting congestion / incidents.
- Pedestrian detection systems have been integrated with signal control strategies to provide benefits for the vulnerable road user.
- Park and Ride schemes have had a positive impact on modal shift
- Electronic ticketing has been successfully implemented for public transport fare payment.
- Public transport priority has been integrated with UTC schemes providing benefits for the bus/tram services.
- Automatic Vehicle Location systems have been developed using the latest satellite communication techniques that will assist the freight and fleet operators manage their business easier and more cost effectively.
- Vision enhancement aids allowed drivers to see and identify pedestrians and road features at a greater distance in night driving, leading to reduction of potential collisions with vulnerable road users.

The final recommendations of the report are focussed on the many problems experienced by the projects including the limitations due to restricted time scales, legal and institutional issues and the general integration with the existing infrastructure and cover the following main points.

- Suggestions to overcome the limitations and problems in implementing Transport Telematics that were experienced by the projects.
- Future development needs and requirements that are a key factor in the future implementation programme.
- Opportunities offered by the latest developments in the communications sector
- Monitoring the development of technologies and models and their application
- Establishment of common impact indicators to be used across all projects.
- Improved statistical measurement methodology.
2. INTRODUCTION

The Application of Telematics in Transport (ATT)

The research activities on Telematics Applications in Transport were originally established in the late 1980s, as part of the DRIVE programme, to identify potential improvements in road safety and reductions of congestions on the European road network. An investment of 60 million ECU was made between 1988 and 1991 to co-finance exploratory research in this front.

The Transport Telematics strand of the Programme "Telematics Services in Areas of General Interest" in the context of the Third Framework R&D Programme (1992-94), though concentrating on road transport, has also covered interfaces between road, rail and sea transport. It has invested a further 140 million ECU from the EC budget to co-finance R&D and Pilot Project activities that were completed by end 1994 - mid 1995, with a total investment of over 4000 person years of effort, including the partner's financial expenditures.

The 64 projects supported have involved over 500 industrial, governmental and research partners, have run pilot test sites in over 30 cities and in 13 major transport corridors and succeeded, through a number of real-life integrated tests, in bringing many new technologies closer to large-scale implementations.

In the 4th Framework RTD Programme (1994-1998), Transport Telematics activities cover Research and Demonstration projects in all modes of transport, committing however a major part on Intermodal and road transport. The basic philosophy is to maximise the use of similar telematics tools for all transport modes, thus increasing the possibilities of reducing costs and accelerating implementation.

Telematics research on Transport concentrates on application development and the involvement in the process of different actors including the POLIS city network and the CORRIDOR interurban motorway network. With many partners, multi-national consortia, multi-site projects, and regular 'concertation' meetings, there have been constant opportunities to exchange experiences. Working relationships have been developed from which pan-European standards and commercially viable interoperable applications are emerging. The Programme has supported European standardisation efforts through direct participation or input to the European standardisation bodies CEN TC278/CENELEC and ETSI.

In addition, CORD/CORDEX, the Technical Coordination projects, facilitated the development of consensus and provide guidelines for assessing transport telematic applications. These projects were central to the task of agreeing common specifications and were coordinated out by ERTICO (European Road Transport Telematics Implementation Coordination Organisation), a body which represents the interests of manufacturers, motorway operators, service providers, telecom operators and public administrations and has become the European counterpart of overseas organisations such as ITS America and VERTIS (Japan).
Third Framework Programme (ATT - DRIVE II)

The second research programme on telematics applications in transport took place in the period 1992-94 under the Third Framework RTD Programme and was called the Advanced Transport Telematics (ATT) Programme (often also referred to as DRIVE II). This programme had a structured workplan that continued with development work, but with a far greater emphasis on the integration of elements and the demonstration in real conditions. The ATT programme was designed to form a bridge between the R&D work and actual deployment of transport telematics. This required to implement field trials, to test the impact on users and to provide measured results to assist in policy formation by the authorities and infrastructure owners. In parallel, the twin processes of demonstration and of technical harmonisation had the objective of stimulating suppliers to develop and produce the products required for the emerging market.

The programme concentrated on road-based transport and was structured in seven Areas of Operational Interest which provided a fairly clear definition of the priorities within its workplan.

- Demand Management
- Traveller and Traffic Information
- Integrated Urban Traffic Management
- Integrated Inter-Urban Traffic Management
- Driver Assistance and Co-operative Driving
- Freight and Fleet Management
- Public Transport Management

The ATT programme was supported by a Concertation process designed to facilitate interaction among the projects harmonisation of technical approaches and the development of programme-level outputs. Specific technology domains were targeted as needing priority for harmonisation. "Topic Groups" were established to allow programme-level development of Common Functional Specifications and for the generation of inputs to the relevant standardisation activities. These operated with varying degrees of success in terms of their objectives, but certainly ensured that projects shared information and allowed cross-fertilisation of ideas and specifications. In the later stages of the programme, a series of Task Forces were established in order to draw together the collective developed expertise for technologies and applications which had been the subject of multiple projects. These generally reported during 1995, were too late to feedback into the projects, but provided a starting point for new projects either within or outside the EU RTD remit.

Purpose of document

This report provides a summary of how transport telematics impact on the various applications and services within the seven major areas detailed above. The methodology adopted was initiated by holding a workshop with a number of experts involved with the projects or supporting the Commission's administration (DG XIII-C-6). The initial task was to establish the key applications and services related to six transport telematics domains (Areas 3 & 4 have been combined) and determine the nature of the impact indicators that could be used to assess how effective the results of the research undertaken by the ATT - DRIVE II projects have been in contributing to the application or service. An operational impact matrix has been compiled and is shown in Annex A. Annex B contains descriptions of the 1991-1994 Transport Telematics projects.

An impact assessment questionnaire was prepared and sent to all ATT - DRIVE II project leaders in Summer 1995 to identify the main types of impacts reported by the projects. The results obtained
were then supplemented by information obtained from relevant work packages of the projects relating to one single application/service/impact indicator, in order to determine the overall impact of the research in a more comprehensive manner. Three matrix charts have been produced - shown in Chapter 3 - to indicate which projects have contributed to a particular application or service.

The core of this Main Document contains impact information by Transport Telematics domain. A short description of the issues being addressed is followed by a text of key results, measured impacts, other impacts and general benefits obtained from doing the work. In addition, important comments made in the project deliverables indicating future needs, problems/limitations, integration and cross domain implications, have been included. Furthermore, section 5 provides an overview of the analysis by category of broader user impacts such as safety, efficiency, environment and energy, cost, socio-economic aspects and user response and acceptance. Finally, section 6 contains the conclusions and recommendations for further action.
3. OVERVIEW AND SUMMARY TABLES

The activities of the projects which participated in the Transport Sector of the Telematics Applications Programme, were organised into six main domains:

1. Travel and traffic information
2. Traffic management, operations and control
3. Public transport
4. Automatic debiting and demand management
5. Freight and fleet management
6. Driver assistance and co-operative driving

The impact analysis provided in this report is therefore presented using these domains as the reference framework to show how the individual projects have contributed to each domain as well as how the activities performed in the various domains actually contributed to the different impact results.

To provide a preliminary overview of these contributions and achievements, three summary tables are presented in this section which can provide a reference framework to help obtain access to the information provided in the detailed impact analysis presented in Section 4.

On Table 3.1 the telematics functional domain and sub-domain categories are shown which have been adopted for this impact assessment, reflecting those used in the "Impact Assessment Questionnaire" distributed to participating projects which are shown listed in alphabetical order, with their project numbers. The matrix entries show where each project has reported an important impact which has contributed to the analysis in Section 4. This matrix does not therefore, identify all the areas of activity of each project. For example, some projects involved in horizontal areas such as kernel or management activities, systems developments, communications and standards may not have an entry in the matrix unless they have also been involved in application activities resulting in specific impacts.

On Table 3.2 the number of projects contributing to a specific impact result is shown for the same domains/sub-domains presented in Table 3.1. The impacts presented here are further analysed in Section 5, which provide a description of impacts by vertical columns whilst Section 4 is structured according to horizontal rows of the matrix. Its purpose is to illustrate the different impacts applying to each sub-domain and to indicate the likely robustness of results presented in the following sections; as an example, the numerical values of impacts based on results from a larger number of projects are likely to be more robust than those based on a smaller number or on a single study.

On Table 3.3 the same matrix of Table 3.2 is used to present an indication of the key impacts (circled) and the "direction" of each impact, through a broad interpretation of results presented in Section 4. The direction of the impact can be basically positive (a benefit) or negative (a disbenefit) as well as either positive or negative impact depending on the actual conditions. For example, in-vehicle route guidance may be beneficial to safety because of reduced distance travelled, but disbeneficial if an inappropriate HMI causes distraction. The example of "other" impacts on private traffic for route guidance includes the observation of trip generation because of the new service. Drivers making new trips will have improved mobility (a benefit), but will contribute to increased traffic volumes (a disbenefit). This table should only be viewed as indicative of the prevailing quality of impacts since it cannot be made comprehensive nor can provide information on the actual scale of the benefits/disbenefits.
<table>
<thead>
<tr>
<th>DRIVE II Project</th>
<th>acronym and number -</th>
<th>Telematics domain and sub-domain</th>
</tr>
</thead>
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<td>V2003 COMBICOM</td>
<td>Travel &amp; Traffic Information</td>
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<td>On-trip information:</td>
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<td>Traveler service information</td>
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<td>Route guidance</td>
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<td>Ride matching reservations</td>
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<td></td>
<td>Traffic Management, Operations and Control</td>
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<td></td>
<td>Incident &amp; emergency management</td>
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<td>Emergency calls</td>
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<td></td>
<td>Urban traffic control</td>
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<td></td>
<td>Motorway traffic control</td>
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<td></td>
<td></td>
<td>Urban/motorway traffic control</td>
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<td>Vulnerable road users facilities</td>
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<td></td>
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<td>Weather and road monitoring</td>
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<td>Public Transport</td>
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<td>Information management</td>
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<td>Vehicle scheduling &amp; control</td>
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<td>Public transport priority</td>
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<td>Passenger information</td>
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<td>Demand responsive systems</td>
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<td>Automatic Debiting &amp; Demand Management</td>
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<td>Integrated payment</td>
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<td>Automatic toll collection</td>
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<td>Road pricing</td>
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<td>Access Control</td>
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<td>Parking management</td>
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<td>Enforcement</td>
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<td>Freight &amp; Fleet Management</td>
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<td>Freight management</td>
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<td></td>
<td></td>
<td>Fleet management</td>
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<td></td>
<td></td>
<td>Intermodal tracking &amp; routing</td>
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<tr>
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<td></td>
<td>Hazardous goods monitoring</td>
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<td></td>
<td></td>
<td>Freight terminals operations</td>
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<td></td>
<td></td>
<td>Integrated logistics</td>
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<td></td>
<td>Administrative tasks</td>
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<td></td>
<td>Driver Assistance/Vehicle Control</td>
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<td>Driver monitoring</td>
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<td>Driver support</td>
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<td></td>
<td></td>
<td>Cooperative driving</td>
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<td></td>
<td></td>
<td>Collision avoidance</td>
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<td></td>
<td></td>
<td>Intensive cruise control</td>
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Table 3.1 Matrix of key reported impacts domains for each project
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<thead>
<tr>
<th>Impact on</th>
<th>Travellers</th>
<th>Managers and Operators</th>
<th>Society</th>
</tr>
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<td>group of:</td>
<td>on private vehicle</td>
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<td>on combination of modes</td>
</tr>
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<td>Applications &amp; Services</td>
<td>impact indicators</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>on-trip information</td>
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</tr>
<tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>roadside</td>
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<td></td>
</tr>
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<td></td>
<td>traveler service information</td>
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<td></td>
</tr>
<tr>
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<tr>
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<td>ride matching reservations</td>
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</tr>
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<td>7 4 4 4</td>
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<td>8 5 8 4 10 4 8</td>
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<td>1</td>
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<tr>
<td></td>
<td>vehicle scheduling &amp; control</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>public transport priority</td>
<td>4 2 2 4 4 4 4 4 4 3</td>
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</tr>
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<td>2 4 4 2 5</td>
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<td>demand responsive systems</td>
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</tr>
<tr>
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<td>intermodal tracking &amp; tracing</td>
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<td>hazardous goods monitoring</td>
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<td>freight terminals operations</td>
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<td>cooperative driving</td>
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Table 3.2 Matrix of number of projects contributing impacts results for each sub-domain.
### Table 3.3 Operational Impact Matrix

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<th>IMPACT ON GROUP OF:</th>
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<th>MANAGERS AND OPERATORS</th>
<th>SOCIETY</th>
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<td></td>
<td>ON PRIVATE VEHICLE</td>
<td>ON PUBLIC TRANSPORT</td>
<td>ON COMBINATION OF MODES</td>
</tr>
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<td>IMPACT INDICATORS APPLICATIONS &amp; SERVICES</td>
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<td>travel time variance</td>
<td>vehicle operating cost</td>
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<td>Pre-trip travel information</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>On-trip information</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On vehicle</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Roadside</td>
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<td>+</td>
<td></td>
</tr>
<tr>
<td>Traveler service information</td>
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<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Route guidance</td>
<td>+</td>
<td>+</td>
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</tr>
<tr>
<td>Ride matching reservations</td>
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<td></td>
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</tr>
<tr>
<td>Traffic Management, Operations and Control</td>
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<td></td>
<td></td>
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<tr>
<td>Incident &amp; emergency management</td>
<td></td>
<td>+</td>
<td>+</td>
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<tr>
<td>Emergency calls</td>
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<td>Urban traffic control</td>
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<td>Information management</td>
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<td>Vehicle scheduling &amp; control</td>
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<td>Access Control</td>
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<td>Intermodal tracking &amp; tracing</td>
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<td>Integrated logistics</td>
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<tr>
<td>Intelligent cruise control</td>
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Table 3.3 Operational Impact Matrix
4. DETAILED IMPACT ANALYSIS BY DOMAIN

4.1 TRAVEL & TRAFFIC INFORMATION

Introduction

Travel and Traffic Information is concerned with the issues related to collecting, processing and distributing information. This section focuses on the Area within the Advanced Road Transport Telematics Programme ATT-DRIVE II where end users being travellers using any form of transport are confronted with systems that provide them with information or end users who need information as a managerial tool while carrying out their profession. The information may be of benefit to people before they make a trip, in the course of their journey or in their work. Almost half of the projects in the ATT-DRIVE II programme have an activity which is concerned with travel and traffic information. 7 kernel projects of the programme which are part of this domain are providing standards on developing systems that are essential to consistent application across Europe. 17 projects tested travel and traffic information systems in urban and interurban situations.

The kernel of the domain are 11 projects which have travel and traffic information as a main topic based on communications systems that are available. These projects are making use of traditional visual means of communications (variable message signs) and electronic communication systems (FM-radio, RDS, RDS-TMC) cellular phone (GSM), and short range communication systems (microwave or infrared).

These projects are used to assess the needs, to describe the constraints, to indicate the problems, and to derive a system synthesis with steps for optimization and implementation. The practical problems concerning travel and traffic information from the viewpoint of tourist managers, representatives of automobile clubs, organizers of big events and representatives of fairs, are a valuable supplement to the projects.

Objectives

The following are the general objectives, which are set within the general Transport Telematics objectives.

Safety. Travel and traffic information systems were developed to improve traffic safety, especially through the use of dynamic information and route guidance. Other travel and traffic information systems were to be checked for their effect on traffic safety.

Efficiency. Travellers are to be encouraged to choose between alternative times to travel, modes of travel and routes by providing them with appropriate travel and traffic information.

Environment. Travel and traffic information that allows people to make more efficient and safer use of the transport systems that are available should also help to minimize adverse effects on the environment.

Since these first objectives were defined there has been an important shift in perception. What seemed to be an excessively ambitious almost futuristic vision has, within the time frame of the ATT
Programme, developed into a serious option which is expected to reach the market in the course of the next 5 years.

Those working within the domain of travel and traffic information had to operate within some of the more specific objectives of the DRIVE II Programme, namely:

- Establish a framework which will validate and improve results achieved so far in DRIVE and EUREKA, to assist decision makers in their future actions on implementation.
- Establish common functional specifications and promote standards which meet user needs and provide basis for innovations and competition, concentrating on those which need European coordination and contribute to the completion of the single market.
- Encourage the development of administrative, legal and financial procedures and advice to enable the adoption of ATT systems which are compatible internationally.
- Promote the development of interfaces with other modes of transport, via appropriate information systems, in an architecture which will allow the integration of services by all modes of transport.

4.1.1 PRE-TRIP TRAVEL INFORMATION

Pre-trip information may be required for a number of reasons, for example: planning a journey while at home or office, making changes to routes while travelling on ferries or visiting service areas or at the road side part way through a journey. DRIVE projects involved with pre-trip travel information concerned the use of terminals, both static and portable, to be used by the travelling public and assessing the potential to spread the demand during peak periods.

Interactive public information terminals were installed at service stations, information centres and motorway rest stops as part of the PLEIADES project. RDS-TMC message translation software had been installed in these units (the information can be delivered in 6 different languages and covered the whole of the PLEIADES area.) Two terminals were installed on the UK side of the corridor, one at Dover and the other at the Eurotunnel site. In France, touch screen information terminals were installed on seven different sites. The terminals were capable of determining routes and the corresponding travel time under normal traffic conditions. The terminals were accessed by the public within the range of 1,200 to 2,000 each month. 75% required route plans or real time traffic information.

Portable on line interactive services using standard digital mobile networks, based on real time information have been used successfully to provide a wide range of traveller and public information services including traffic information and hazard warnings; public transport information, and tourist and visitor information. The functional requirements were defined based on the output of the commercial feasibility study. Portable terminals were then built, modified, integrated and tested. At Gothenburg a pager was used with a palmtop computer to provide simple one-way traveller information such as traffic, weather and parking. A GSM adapted palmtop computer, utilising the GSM short message service (SMS), supported more advanced services such as the requesting of detailed trip-planning information. In Birmingham, Class B (two-way) services were provided by a GSM digital portable telephone connected to a laptop PC. A further achievement was the
development of TMC location databases and coding rules, which allowed travel information to be coded prior to transmission.

Five public access terminals were installed in the UK by the QUARTET project to enable members of the public to access the CENTRO database and retrieve information. The screens on these terminals operate using the same software as the enquiry office and Hotline systems, but with a different interface. For the general public a simple, more colourful environment was developed. A number of screens lead the user through their journey details to the optimum route output. A further options function is available and a hard copy can be printed out. Responses are provided in English, French, German and Spanish. Using other simple screens, the traveller can request information on the other 3 terminal functions.

**Enquiry offices, computer and communication systems**

An enhanced computer system was installed at five travel enquiry offices in the UK - the town centre bus stations in Wolverhampton, Coventry and Walsall, Merry Hill Centre in Dudley, and New Street Station in Birmingham. Personal computers linked to the main Public Transport Passenger Information System (PTPIS) network via an Ethernet, Token Ring or ISDN card were implemented as the enquiry office work stations. These enabled enquiry clerks to interrogate the CENTRO databases in response to traveller information requests.

Like the Hotline office (see below) the enquiry office upgraded terminals are driven by either mouse or keyboard, and provide more information than the in-street terminals.

**'Hotline' enquiry office**

The provision of an upgraded system for Centro's "Hotline" telephone enquiry terminals was a key part of the PTPIS project. This was a full implementation of the new system, not simply a field trial. For the terminals, a user interface was designed that would provide as much information as possible on one screen in a user friendly manner. The enquiry terminal software uses a windows application that can be either mouse or keyboard driven depending on operator preferences.

The Hotline terminal provides a range of information including optimum route responses, timetables and service disruptions. The Optimum route enquiry response screen gives a summary of the enquiry and a detailed route breakdown, along with any disruption messages and total journey times. Further options are available for the same journey (e.g. for different traveller criteria) and return journey details are also available.

**In-home terminals**

In-home terminals based on the Minitel system have been available in France and other countries for some years. In the UK, the Keyline company has developed an in-home terminal. The terminal, which is primarily aimed at the home shopping / banking market, also has the capacity to interface with various information services. The CENTRO system was being trialled on this terminal to make public transport information available to users in the West Midlands. As well as timetable and optimum route information, real-time information on bus stop departure times was also available.

**Enquiry offices survey**
A survey was conducted by means of a short questionnaire at two of Centro's Enquiry Offices at Birmingham New Street Station and Wolverhampton Bus Station. The questionnaire was conducted over two days at each site, between 4th and 5th May 1995 at New Street Station and 11th and 12th May 1995 at Wolverhampton. In total, 100 interviews were conducted over this period, 50 at each site.

**Measured impacts**

- 8% of the sample chose to travel by train instead of their previous mode following their visit to the New Street Enquiry Office, and at Wolverhampton 8% of respondents chose to travel by bus instead of car, train or by foot following their visit to the Enquiry Office.
- 10% of respondents would not have made their journey at all if they had not been able to obtain the information they required, while 34% stated that they would have made the journey the same way.
- 92% of respondents found the information provided by the Enquiry Offices to be either adequate or very adequate.
- 76% of respondents found the information provided by the Enquiry Offices to be either accurate or very accurate.
- 72% of respondents had used the Enquiry Office prior to April 1995, when the new system was installed. Of these respondents 38% had noticed an improvement in the quality of information recently provided at the Enquiry Offices.

**In-street/public access terminals**

The public Access and In-Street Terminals Survey was carried out at the Public Access Terminal at New Street Station and the In-Street Terminal in Sutton Coldfield using a short specially designed questionnaire. The questionnaire was conducted between 5th and 9th May at Sutton Coldfield and on 5th May at New Street Station. In total, 100 interviews were carried out, 50 at each site.

**Measured impacts**

- In general, the Public Access and In-Street Terminals were welcomed by the survey respondents. Most people found the terminals easy to use and would use them again. There is evidence of a substantial increase in peoples' knowledge about public transport services after using the machine. Some 16% of respondents thought that using the machine would be likely to result in them making more public transport journeys, but there is little evidence to suggest that the information provided would, by itself, induce people to use public transport rather than the car.

**Other impacts**

- the survey showed a disparity between the opinions of respondents who used the New Street Station Public Access Terminal and those who used the In-Street Terminal at Sutton Coldfield, with users of the latter finding it more easy to use; 6% would consider changing mode after using the terminal at Sutton Coldfield, whereas no-one at New Street stated they would change mode; one third of all respondents at Sutton stated that they would be likely to make more journeys by public transport after using the terminal, whereas no-one at New Street thought that they would.

**Future needs and developments**
The results from the pilot sites suggest commercial operation could be successfully achieved in the future, albeit after improvements have been made in a variety of areas.

- additional services and features;
- improved reliability and access times; and
- improved design to increase user-friendliness and portability

Of the information services provided during the field trials, both traffic information and public transport information should be given high priority in the future, reducing the emphasis on weather information. The results of the Birmingham tests showed that the effect of providing both public and private transport information would be a net shift away from public transport, at least as far as the sample respondents are concerned. It is important that this finding is taken into account when considering which services are most appropriate for the future, particularly if increased use of public transport is to be a goal. The results from the pilot operations have also highlighted several additional information services that subjects require in a commercially operated PROMISE system, including the integration of new transport modes such as ferry and air.

Certain technical recommendations have been identified for improving portable terminal systems performance, particularly of the PROMISE Birmingham system, and include measures to improve response and display times. It is also important, both in Gothenburg and in Birmingham, that developments in the personal communications field are fully taken advantage of in order to provide more functional, portable and user-friendly terminals. Other issues such as design and ergonomics, and reliability of the system, should be addressed as development work progresses.

In addition to these recommendations, further involvement of industrial manufacturers is recommended for the development the portable hardware and standardisation. There is also a need for further standardisation and evaluation of economic and legal issues and for a closer examination of the potential target market for PROMISE. The favourable responses in Birmingham suggest that a market similar to that represented by subjects at this test site may be suitable, but further work is required in this area to ensure the success of the PROMISE system when it is launched.

**Spreading demand**

One of the main objectives of the pre-trip travel information work was to inform and advice end-users in order to achieve spreading demand during peak traffic periods. For this reason, Videotex, Audiotex, PCs and points of information were used. Moreover, links between the main cities London Paris, Lille, Stuttgart, Marseille and Barcelona were established by information operators involved in travel information dissemination and on-line architecture for data exchange as well as information broadcasting was used.

**Measured impacts**

60% of the users were influenced by the information provided.
40% changed their departure time.
30% changed the departure date.
20% used an advised alternative route.
Advice given by road operators leads to a spreading use of the road network especially during rush-hours.
There was no significant change to another transport mode when the first choice corresponded to the road.
Future needs and developments

The duration of the project was too short a duration to undertake a full evaluation.

A traveller, about to use a critical area may not be aware of the potential changing circumstances and the impact any changes introduced by the network operator will have on their journey. Some network status information may be available on the internet but there is no indication of any re-routing that has just been introduced. The processing and dispatching of information should be quicker.

There is a need to undertake work relating to the interaction between network owners, data suppliers, multi-modal services, public travellers, freight/fleet organisations etc. to assess the integrated use of telematic services (monitoring, operation of AID, re-routing) and, the inter-organisational requirements (level of information exchange) when incident and emergency management strategies are to be applied to address the changing circumstances in-order to inform the travelling public preferably before the start of the journey.

4.1.2 ON-TRIP INFORMATION ON-VEHICLE

The ATT programme has seen substantial advances in technology for in vehicle information systems. A diversity of systems have evolved with various traffic information, navigation and dynamic route guidance functions.

The projects in this area aimed at:
- increasing network efficiency
- developing and evaluating an integrated information system
- providing on-board information about the state of the traffic in real time and therefore improving drivers' knowledge of road network conditions
- improving usage of P & R facilities in order to encourage modal shift.

In order to achieve these objectives, a traffic information receiver with graphic display, a dynamic route guidance terminal, a P+R information system as well as RDS-TMC and VMS technologies were used.

One problem was that only a relatively small number of vehicles with on-board information system took part in the project and therefore they may have created a bias in the limited sample of subjects that could be assessed.

Key results and achievements

GEMINI recognised the necessity that messages transmitted via the various media should, as an absolute minimum, never contradict each other. The work focused in particular on the Radio Data System Traffic Message Channel (RDS-TMC) and Variable Message Sign (VMS) Networks. This was achieved through trial sites in Italy and the UK. The main location for the work in Italy was on the 70km test site of the Italian A4 Motorway between Grisignanano and S. Dona di Piave, managed by three motorway companies. For the first time the potential use of RDS-TMC for services other than for mobile road users, the activation of VMS, was tested intensively and its use in varying different road network management scenarios was assessed. In the UK communications to the VMS and to the in-vehicle units was not directly linked. The information flowed from the control centre responsible for setting the VMS, then from there to the TIC (the Automobile Association), to the
broadcaster, and finally on to the in-vehicle unit providing an opportunity to test the whole cycle management of information flow.

The MELYSSA project was to develop, implement and test inter-connections of European traffic control centres, inter connections of urban and inter-urban traffic control centres, dual mode route guidance systems and RDS/TMC for driver information. Modules were designed and installed in Rennes in the TDF research centre and a front end that receives and stores traffic data is received from the TIC based in Lyon. Nine transmitters were fitted with en-coders. The terminals enabled the project to verify that data disseminated by Rennes were transmitted successfully in a specific area of the MELYSSA corridor.

The ICAR project assessed and compared the use of leaky feeders and mode converters methods of extending the GSM voice and data service for vehicular use, inside confined areas such as tunnels. One tunnel in Belgium was to be used for some of the development tests and another in Italy where the use of fibre optic feeder cables were to be tested.

Within LLAMD, three different in-vehicle information systems were tested: a SOCRATES system in the APPLE project (London), a EUROSCOUT and RDS-TMC based IVU in the COMFORT project (Munich). In the London APPLE project, the SOCRATES Dynamic Route Guidance system was linked to the London SCOOT UTC system. For the realisation of the RDS-TMC field trials in Munich COMFORT the results of the BEVEI field trial in NordRhine-Westfalen, Germany, have been applied as far as possible.

Measured impacts

- In Birmingham, Trieste-Brescia, North Rhine-Westphalia, Rhine Corridor and Kent Corridor, on average 70% of the questioned drivers were "satisfied" or even "very satisfied" with the RDS-TMC service.
- In-depth studies in Munich and Rhine Corridor showed that drivers considered RDS-TMC information "useful" or "very useful" in 82% of the trips made.
- The majority (92%) of test drivers in North Rhine-Westphalia and Rhine Corridor support full-scale RDS-TMC implementation in Europe.
- More than 50% of the drivers complied with the information.
- 85% of the test drivers is Rhine Corridor. Trieste Brescia, Birmingham, Kent Corridor and Munich indicated a willingness to buy in-vehicle equipment by the price for the extra RDS-TMC facility should not exceed 100 ECU.
- The majority (70%) of the subjects concluded that the RDS-TMC system proved to be satisfactory, contributing to a decrease in uncertainty of journey time.
- About 77% of test drivers in North Rhine-Westphalia, Rhine Corridor and Munich consider the service "easy" or "very easy" to use.
Other impacts

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Results (GEMINI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevance of information</td>
<td>average - good</td>
</tr>
<tr>
<td>Accuracy of information</td>
<td>average - good</td>
</tr>
<tr>
<td>Timeliness of information</td>
<td>average</td>
</tr>
<tr>
<td>Credibility of information</td>
<td>average - good</td>
</tr>
<tr>
<td>Comprehensibility of information</td>
<td>average - good</td>
</tr>
<tr>
<td>Satisfaction with information</td>
<td>55% of test drivers</td>
</tr>
<tr>
<td>Willingness to change mode</td>
<td>large portion of test drivers (LLAMD)</td>
</tr>
<tr>
<td>Willingness to buy in-vehicle equipment</td>
<td>85% of test drivers</td>
</tr>
<tr>
<td>Additional acceptable cost</td>
<td>RDS-TMC: DM 200</td>
</tr>
<tr>
<td>Safety</td>
<td>significant distraction from driver tasks</td>
</tr>
<tr>
<td>Driver stress</td>
<td>84% of test drivers - reduced (MELYSSA)</td>
</tr>
<tr>
<td>Travel time improvement</td>
<td>positive impression (LLAMD)</td>
</tr>
<tr>
<td>Driver compliance with information</td>
<td>50% of test drivers</td>
</tr>
<tr>
<td>Effectiveness of operator interfaces</td>
<td>average</td>
</tr>
</tbody>
</table>

Further, there was a communication breakdown in shadowed areas (ICAR).

Results on infrastructure were drawn from combination of measurements and estimates:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Results (GEMINI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of process data at TIC</td>
<td>less than 10 minutes</td>
</tr>
<tr>
<td>Percentage transmission errors</td>
<td>not significant</td>
</tr>
<tr>
<td>Integrated information coverage</td>
<td>project objectives achieved</td>
</tr>
<tr>
<td>Effective broadcast capacity</td>
<td>project objectives achieved</td>
</tr>
<tr>
<td>Failure rate of the system</td>
<td>not significant</td>
</tr>
<tr>
<td>RDS-TMC features</td>
<td>accuracy, good timing, reliability (LLAMD)</td>
</tr>
</tbody>
</table>

Overall this work demonstrated that a high quality integrated RDS-TMC and VMS traveller information system feasible in two scenarios at different levels of automated information processing (GEMINI).

Further, CARMINAT system informs about the state of traffic in real time and helps people reduce travel time in congested conditions. As a consequence, users were highly satisfied with the use and usefulness of the system and changes and modifications made to their journeys as a result of having the terminal on board (MELYSSA).

**Future needs and developments**

- Timeless and accuracy of received information must be improved (MELYSSA)
- Technical problems in applying ETSI GSM recommendations to confined areas.
- Problems in defining general rules to establish optimum system architecture (ICAR).
- Further information has to be gained about drivers response to combined information from VMS and radio broadcasts (conventional as well as RDS/TMC).
- Further information has to be gained about the impact of in-vehicle information on network management and control.
• In-vehicle information systems based on two-way communication with beacons along the motorway (for both disseminating data to the vehicles and acquiring data from them) need to be evaluated for addressing issues such as: information delays, most effective link and protocols, data flow rates, multiple communications conflicts, priority rules, ...
• Situations where conflicts would exist between VMS indications and in-vehicle system indications should be examined and evaluated (for information as well as for guidance/advice indications) from both a system and an institutional point of view.

A number of projects contributed to the dissemination of traveller information through static and portable terminals to support both pre-trip and on-trip services and even with a limited number of terminals the public recognition of the potential for having access to terminals was very evident. The assessment of content and usefulness was, however, very limited due to the very small number used. This was not the case with RDS-TMC. A considerable amount of experience obtained within the ATT programme using this facility enabled a collaborative study to be undertaken to analyse the content and general quality of the information distributed. The following is an extract of the conclusions relating to user acceptance and information quality from the CORD project V2056 - Acceptance and Impacts of RDS-TMC Traffic Information.

Conclusions on user acceptance

Conclusions on actual use of RDS/TMC

• The RDS/TMC information system appeared to be used frequently by the majority of the test drivers. This frequent use is a positive indication of the user acceptance.
• RDS/TMC is generally being used as both pre-trip information and on-trip information.
• Divergent practises with the filter functionality have been tested.
  - Where a selection functionality was not provided, the system caused serious information overload.
  - It seems that where only route relevant messages are presented, there is a need for more information.
  - Where filtering choices were left to the driver, the filter functionality has been used in more than half of the trips recorded.
• Actual use of the RDS/TMC information by test-drivers was at a sufficient high level to allow for testing impacts of the use of RDS/TMC.

Conclusion on ease of use

• Ease of use was at a high level in most projects. About three-quarters of test drivers judged positive. Operation convenience was assessed at a low level in one project only.
• Nine of ten test persons quickly mastered the system: they found it easy to operate at the very beginning.
• Legibility of information displayed seems to be at a lower level of quality compared to audibility of spoken messages in particular under specific circumstances like at night or with incoming sunlight.

Conclusions on reliability

• There is a potential for improvement of reliability of information on traffic conditions. Drivers' experiences of the messages received and the traffic problems encountered suggest that the information was more or less frequently not of adequate quality.
As regards to both reliability and accuracy of information, a substantial part of the test drivers perceive these qualities of RDS/TMC positively. However, the number of test drivers with negative views is rather high as well. These divergent views are reflected in the current attitudes towards the general quality of information. About 37% shows a poor level of satisfaction.

Conclusions on timeliness

A substantial part of test drivers appeared to perceive timeless of messages negatively (about 40%). Although this lack of timeless is not inherent to RDS/TMC alone, the perception of the usefulness of the RDS/TMC medium is, among others, dependent on the timely availability of information. Therefore, broad implementation of RDS/TMC should run in parallel to an improvement of the message generation process.

Nevertheless, two field trials could report that about half of the test drivers reported they experienced a more timely availability of messages through RDS/TMC compared to the conventional radio bulletins.

Technical performance test suggest a considerable reduction in information transit time. The mean delay between transmission of a message and receipt by the in-car unit has decreased in a number of field trials.

Conclusions on perceived usefulness

It can be concluded that the RDS/TMC systems tested proved to be satisfactory to the majority (70%) of subjects and moderately acceptable to a group of nearly one-thirds of subjects. Field trials experiences show stability over time.

As far as projects addressed the issue, about half of the test-drivers identified substantial added value to RDS/TMC over the conventional system of radio traffic information.

Most important features contributing to the added value are the possibility to request information when wanted. The possibilities to select messages and to repeat messages were found to be other important features in more than one field trial.

A substantial support for broad implementation of RDS/TMC could be observed (nine of ten test drivers in Bevei and Rhine Corridor).

Conclusion on decrease of uncertainty

RDS/TMC seems to contribute to a decrease of uncertainty in different ways:
- part of the drivers report a reduced uncertainty on arrival time or travel time (about 45% in two projects)
- uncertainty on the relevant broadcasting station on the point in time in the conventional radio traffic information system can be considered to be overrun by RDS/TMC.

Conclusions on willingness to pay

More than half of the drivers who experienced RDS/TMC are willing to buy an RDS/TMC equipment.

The price to be paid for the extra facility should not exceed 100 ECU. The field trials suggest that the additional costs would have to be relatively low to attract a large number of users with a sufficient level of reliability of information as a prerequisite.
Conclusions on information quality

Conclusions on comprehensibility

- Generally, it can be concluded that comprehensibility of RDS/TMC information has not yet reached an optimal standard. Roughly a quarter of the test drivers report to have some problems in this respect.
- No indications are found that comprehensibility of voice is different from comprehensibility of maps. However, available reported data are limited and not fully comparable. Additional research would be required to arrive at more detailed conclusions.

4.1.3 ON-TRIP INFORMATION ROADSIDE

It is vital to be able to communicate with the driver when implementing unscheduled control strategies. These can be for re-routing purpose, or to provide important information concerning safety of the driver. Variable Message Signs (VMS) are currently the only means of presenting information that will be seen by all drivers passing a particular location. Strategies and decision making processes have been designed and evaluated to ensure important information is presented to the driver using roadside information systems that adequately reflect the network conditions and that improved route choice decisions can be made from the information provided.

The EAVES project aimed to provide and to apply methodologies for qualitative, quantitative and economic assessments to improve the effectiveness of Variable Message Signs. The recipients of this kernel project were the Pilot projects. This project contributed to the recommendations for Common Functional Specifications for the operation, location features and strategies of Variable Message Signs systems and their integration with other technologies. It also designed and monitored experiments to evaluate these systems in different Pilot Projects of the programme.

The PORTICO project main objectives for roadside driver information and early warning was to detect incidents and reduce their impact by adopting an early warning system with a short time reaction and a dynamic warning effect by using roadside beacons which, when illuminated, produced light waves to warn drivers. The PORTICO network included two main roads, the IPI/A/E80/E01 from Lisboa-Porto to the IP5/E80 Aveiro-Vilar. The systems were installed at black spots on the road network.

The MELYSSA project brought together national (French) and regional (Baden-Württemberg) administrations and a major French motorway consortium (involving 5 different companies), as well as important industrial companies. The project developed, implemented and tested interconnections of European traffic control centres and new VMS systems for traffic control. Particular emphasis was put on traffic safety improvements by testing alternative techniques (pictograms) and technologies for automatic incident detection.

The QUO VADIS project aimed at increasing our understanding of the behavioural, operational, institutional and technical requirements for the effective implementation of a traffic information system using variable message signs. Two extensive field trials were implemented in two road networks (Scotland; Edinburgh-Perth-Sterling and Denmark; main road network around Aalborg) which offer real and substantial route choice opportunities.
One of the objectives to be undertaken on the ARTIS Corridor La Junquera-Seville was to develop, demonstrate and to assess the use of RDS-TMC message editing terminal for changing information on Variable Message Signs on the M40.

The EUROCOR project developed and implemented (by field trials in Amsterdam and on the Boulevard Peripherique in Paris) on-line control strategies for the effective management of traffic in urban/inter-urban corridors using variable message signs. The motorway control techniques previously developed was extended to the access points and beyond into the feeder network, thus allowing a greater dimension of control, this was exercised through the additional use of variable message signs.

LLAMD is a co-operative Pilot Project between the five cities. Particular attention was given to systems architecture and to the integration of information relating to urban and inter-urban traffic, parking, park-and-ride using VMS.

The SCOPE project covered 4 areas of ATT pilot applications in 3 cities of Cologne (D), Southampton (UK) and Piraeus (GR) utilising VMS. The 4 areas include various pilot applications of Integrated Urban Traffic Management, Travel and Traffic Information, Strategic Information systems, Public Transport, with differing types and importance for each application according to the infrastructure and the existing problems of each of the 3 cities. In Cologne VMS were used to display parking and park and ride information. In Southampton the VMS were used for a number of network management functions and in Piraeus the VMS were used to display information relating to the operation of the port. The project's work is strongly integrated and has ensured a high level of interaction and co-operation between the cities at a political, administrative and technical level.

Two projects outside the ATT programme have been following the work and exchanging views. They are CITRAC from Strathclyde in Scotland (City Traffic Control) and Brescia from Northern Italy (City Network Management).

In Scotland, a 20% reduction in delays likely to occur following an accident on the Forth Road Bridge may be expected using VMS with other savings of 5 to 10 minutes when problems occur on other parts of the network. A large majority (82% by questionnaire) who use the route regularly during the project trials have indicated that they will follow VMS information even if the information is in conflict with other sources. The EAVES project carried out a number of trials on the Amsterdam Ring to assess the response to VMS. Of those interviewed 80% found the information to be correct; 98% understood what the sign meant; 68% thought there was some improvement in driver comfort and 63% reacted to the information. The EUROCOR project used 350 VMS around the Peripherique in Paris and established that 80% of the drivers preferred to be informed about travel time rather than queue lengths.

**Measured impacts**

*Private vehicles*
- User cost-benefit analysis: Network cost saving of between £2,000 and £4,000 per incident in Scotland (observed).
- From cost-benefit analysis, net socio-economic benefit of about £60,000 in Scotland over a 3-month-period was achieved (QUO VADIS).

*Infrastructure*
- Cost of system
<table>
<thead>
<tr>
<th>Cost factor</th>
<th>Amount (LLAMD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>535,000 ECU</td>
</tr>
<tr>
<td>Running cost</td>
<td>25,000 ECU/yr</td>
</tr>
</tbody>
</table>

**Other impacts**

*Private vehicles*
- Estimated network cost saving: 14 kECU/year (LLAMD)
- VMS influence diversion rates at junctions (EAVES observed)
- VMS effects on speed and speed variance varied (EAVES observed)
- Potential queues could be reduced by up to 50% (QUO VADIS observed)
- Several VMS results were drawn from questionnaires:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Results</th>
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<tbody>
<tr>
<td>Conspicuity</td>
<td>slight improvement (MELYSSA)</td>
</tr>
<tr>
<td>Legibility</td>
<td>reduction (MELYSSA)</td>
</tr>
<tr>
<td>Comprehensibility</td>
<td>mixed (MELYSSA) - 97% of test users positive (QUO VADIS)</td>
</tr>
<tr>
<td>Utility</td>
<td>mixed (MELYSSA) - positive (EAVES)</td>
</tr>
<tr>
<td>Accuracy</td>
<td>82% of test users positive (QUO VADIS)</td>
</tr>
<tr>
<td>Comprehensiveness</td>
<td>82% of test users positive (QUO VADIS)</td>
</tr>
</tbody>
</table>

**Combination of modes**

With improved VMS information, willingness to change mode increased (LLAMD)

<table>
<thead>
<tr>
<th>Knowledge rate of VARIO P&amp;R panel users</th>
<th>Quantity of users (SCOPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All users</td>
<td>66%</td>
</tr>
<tr>
<td>Frequent users</td>
<td>94 - 100%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Acceptance by VARIO P&amp;R panel users</th>
<th>Quantity of users (SCOPE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All users</td>
<td>54%</td>
</tr>
<tr>
<td>Frequent users</td>
<td>29%</td>
</tr>
<tr>
<td>Users who go shopping</td>
<td>42%</td>
</tr>
<tr>
<td>Users who go to an educational institution</td>
<td>44%</td>
</tr>
<tr>
<td>Users who go to work</td>
<td>19%</td>
</tr>
</tbody>
</table>

*Freight & Fleets*

Positive impact on system utility (EAVES questionnaire).

*Infrastructure*
- Payback of cost of equipment and operations can be 18 months (EAVES).
- Improved network control (EAVES observed).
• Users are highly satisfied with the information provided (MELYSSA).
• With VMS, up to 20% of traffic delays, which had occurred before the use of the system, could be saved (QUO VADIS observed).
• Increase in use of P&R facilities (SCOPE estimated).

Environment

<table>
<thead>
<tr>
<th>Additional Emission/Energy</th>
<th>Potential Reduction (QUO VADIS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>10%</td>
</tr>
<tr>
<td>NOx</td>
<td>5%</td>
</tr>
<tr>
<td>HC</td>
<td>10%</td>
</tr>
<tr>
<td>Fuel</td>
<td>10%</td>
</tr>
</tbody>
</table>

Benefits

• VMS improve safety, reduce stress for drivers and lead to financial benefits for society (EAVES).
• Increased network efficiency through improved modal split (LLAMD).
• VMS reduce vehicle operating cost and travel time in incident conditions (QUO VADIS).
• Drivers appreciate the provision of good quality information. Industry generally benefits from a new style of fully authorised sign. The system can be applied to any similar city (SCOPE).
• The benefits of the use of VMS in Cologne were better information for drivers, reduction of car traffic into the city center and increase in use of public transport and P&R (SCOPE).

Future needs and developments

• Three years are not sufficient for accident statistics to provide statistically significant results on safety (EAVES).
• Only 'soft' VMS messages have been displayed (MELYSSA).
• Drivers wish to see VMS system expanded (SCOPE).
• VMS for route guidance - with only 3 signs installed, ability to effect a change in driver behaviour is severely limited (SCOPE).
• VMS for car park information - new style signs are restricted to single route and survey respondents commented that a city-wide system would be more beneficial (SCOPE).
• Mobile VMS - only deployed on few occasions to date so exposure has been limited (SCOPE).
• Further knowledge has to be gained about drivers response to VMS. Various differing sets of text messages have been developed for use in VMS systems throughout Europe. The standardisation of the messages themselves is impractical, if only because of the language difficulties. However the current situation is not satisfactory, and it is necessary to make progress in this field. For example, there may be scope to standardise the root meanings of messages and to define the context in which each message might be used. Pictograms can assist understanding, particularly for foreign drivers, but there are relatively few pictograms available compared with the number of messages in use.
• There is a need to establish a balance between the use of pictograms and text for different applications, i.e. traffic management support and rerouting.
• The content and structure of text information for different situations, i.e. informative and instruction, need to be examined.
• Standardisation of the procedures used to generate messages would be beneficial.
• General consistency of VMS indications has to be assured, e.g. there should not be conflicts between messages displayed on strategic level (addressing problems being management at the
level of a wide area network) and messages displayed on local level (addressing problems referring to a local situation).

- Guidelines giving indications as to the optimal location of data collection stations and of VMSs at decision points in a network still need to be produced.

**Variable Message Signs - Pictograms**

**Other impacts**

The objective of this workpackage was to assess the benefits that could be expected by adding a pictogram to an existing text only VMS. Benefits could be in terms of:

- conspicuity of the panel,
- legibility and memorisation: better and quicker capture of information,
- comprehensibility: wider potential target among users, especially foreigners,
- utility.

If comprehension of messages is improved, better driver behaviour with regard to existing traffic conditions and improved traffic safety can be expected.

It was also an opportunity to test a new scrolling technique for pictogram allowing a very high resolution.

A total of 2666 interviews have been obtained, out of which 650 are foreign drivers (for the autumn wave, it was not possible to maintain the proportion of foreigners).

Usually, the VMS perception was good, and it seems that it increased with the pictogram. About 2/3 of the users had a spontaneous recollection of a lighted traffic sign. For spontaneous memorisation, the pictogram slightly improves the VMS perception while for suggested memorisation (among drivers who did not remind the sign spontaneously), the pictogram seems to reduce the VMS perception.

Concerning the spontaneous perception:

- foreigners better perceive the VMS,
- perception did not vary with the type of vehicle,
- the more often the user takes the motorway, the more he is able to perceive the VMS,
- the profession and duration of the driver licence, except for young drivers have no impact,
- men generally perceive the VMS better than women.

As a general conclusion, the results did not entirely match the expectations perhaps because only "soft" messages could be tested: for not well-known pictograms like accident, it seems that the addition of pictogram to text was less efficient for French drivers. However for foreign drivers, the performance was increased.

For well-known pictograms, it seems that a slight improvement was obtained.

**Future needs and developments**
• A balance should be found between the physical features of the pictogram and the text. For "strong messages" (warnings, etc.) the ideal situation could be:
  - conspicuity of the pictogram first (catch the attention of the drivers),
  - then the legibility of the text.
• Some comparison with other experiments have been also conducted by the EAVES project that has produced recommendations for the use of VMS.
• Pictogram only messages are probably not sufficient, but text messages are necessary most of the time. However, a generalisation of the use of pictograms can be an advantage, if some changes are made in the choice of pictograms (use of more well known pictograms) and if redundancy is gathered with the text + pictogram being complementary. Furthermore, information campaigns could be run to make the pictograms known to the users. Time would also serve the apprenticeship of users.
• As a strategic issue for the use of VMS it seems interesting to use pictograms:
  - to reinforce the comprehensibility (the traffic sign must be known) for warning of traffic control messages (quicker capture can be expected)

4.1.4 ROUTE GUIDANCE

The application described in this section refers to in-vehicle systems providing route guidance capabilities, where drivers are guided on an optimum route to their destination. A range of different systems have undergone technical and (limited) field trials in DRIVE II. These include

1. The EUROSCOUT system, with infra-red beacons and two-ways communications with vehicles, providing centrally-computed optimum routes for equipped vehicles, taking account of current and predicted traffic situations. Following the earlier trial of EUROSCOUT in Berlin (LISB), trials in DRIVEII were held in Stuttgart, as one mode of operation in the Dual Mode Route Guidance (DMRG) trials and (ii) in Turin, where the EUROSCOUT technology has been applied with the support of local intelligence (i.e. at each signal controller where a beacon is located) to implement a multirouteing strategy.

2. Dual Mode Route Guidance (DMRG) in STUTTGART, where route recommendations are either calculated on-board in the navigation computer (de-centralised, autonomous route guidance) or, where beacons are encountered, through the EUROSCOUT system.

3. Route guidance using the Pan-European GSM Standard (Global System of Mobile Communications (GSM) linked to in-vehicle equipment containing route guidance functions. Applications were trialled in the Rhein/Main Area (RHAPIT) and in Gothenburg (TANGO) as part of SOCRATES (System of Cellular Radio for Traffic Efficiency and Safety).

4. Autonomous route guidance using CARMINAT, an in-vehicle system capable of decoding RDS-TMC messages. The CARMINAT C3 terminal was tested in the MELYSSA project. Drivers are guided by visual and local indications via a colour screen. In addition to the dead reckoning and map matching functions, the C3 was connected to the GPS module (Global Positioning System). Trials have also been carried out in Paris in the CITIES Project.

Scientific support for the off-line evaluation of Dynamic Route Guidance and control strategies has been provided by the MARGOT subproject of LLAMD. Other impacts of route guidance have been addressed in a number of horizontal projects, particularly:
• HARDIE (V2008) : Human-Machine Interface issues
• EDDIT (V2031) : Issues concerning the Elderly and/or Disabled
• HOPES (V2002) : Safety Impacts

Measured impacts

Dynamic route guidance trials in DRIVE II have not been sufficient to enable full impact assessments. No trial has had more than 100 equipped vehicles. Evaluation has therefore centred on technical performance of systems and driver response, "obtained using a common questionnaire supported by logbooks and other data in some studies.

The DMRG trials in Stuttgart involved test drivers representing a good cross-section of typical first-wave buyers of route guidance.

It was found that:

• 73% agreed that the system could help in guiding the user to unknown destination
• other information sources were used much less frequently by the sample after installation of the system
• more than 80% of trip recommendations made in unknown areas were judged to be 'good'
• more than 60% of trip recommendations made in known areas were judged to be 'satisfactory'
• most of the test sample were satisfied with the man-machine interface
• 48% of the sample indicated that they had made additional trips on unknown routes after installation of the system
• the test sample indicated they were willing to pay an average of 190 Marks a year for the service and 2000 Marks for the equipment

The simulation results for Stuttgart showed that the most significant travel savings for all types of vehicle (equipped and unequipped) would be achieved with a penetration rate of around 50% (assuming a compliance rate of over 70%) and that savings can be dramatic when there is an incident. The Stuttgart simulations showed that at lower penetration rates, the system would save time for equipped drivers only.

The results of the Turin simulations suggest, that there is greater potential for using the system as a traffic management tool than the Stuttgart simulation results would suggest. In the runs for the Turin network and for selected O/Ds the better results for both equipped and unequipped vehicles were obtained with lower penetration rates.

In view of the limitations of the field trial and the differing evidence of the simulation runs, it was concluded from the Stuttgart work that no general statement on the potential impact of the system on traffic as a whole could be made.

The field trials of CARMINAT C3 in MELYSSA involved 6 equipped vehicles used in the Rhône Alpes areas during a five weeks test period during the summer of 1994. Questionnaires, 'black boxes' and data logs were used for evaluation, involving 31 people with C3 terminals. Concerning trip making overall, 5% of drivers declared that they modified their trip planning and 13% declared that they changed their itinerary, subsequently to the information given by CARMINAT. Overall, 20% of informed drivers modified their behaviour. Around 50% of drivers receiving information found it generally relevant, given the stated user requirements:
  - a better itinerary (92%)
- a gain in time (89%)
- more security (87%)
- reduction in stress (84%)
- forecast on trip duration (77%)

It was concluded that the answers given by the drivers indicate that the system was capable of changing their driving habits either by leading them to take roads they do not usually take, or by enabling them to drive at different times. The quality of the system satisfied the drivers and its usefulness has been endorsed.

Common results from route guidance questionnaires have been compiled by CORD (V2056) in a cross project collaborative study. Results covered user requirements, ease in learning and understanding, comparison of different information sources, perceived utility, route quality, change in driver's behaviour and suitable investment. Key results were that:

- 55% of test drivers believed that the systems were useful for travel time reduction (sample size 170).
- 42% of test drivers considered the recommended route better than their own choice.
- 50% of test drivers were willing to buy route guidance equipment at a price above 750 ECU.

For in-vehicle route guidance in Turin, simulation results indicated a 6% reduction in travel time using a decentralised multi-routing strategy, given a penetration rate of 20% and 100% compliance with guidance advice. The MARGOT project used advanced simulation models to develop DRG strategies and predict the impacts of route guidance under larger scale implementation. In particular:

- New journey time prediction methods were developed to provide improved route optimisation for normal and incident conditions.
- New incident management strategies for route guidance aimed at gaining up to 30% in travel time savings due to guidance, depending on incident characteristics.
- New techniques for origin-destination estimation, multi-routing strategies (as required when route guidance implementation exceeds 10-20% of the population) and strategies for integration between guidance and traffic control systems, where substantial positive impacts are predicted.

The evaluated MMI issues in HARDIE centred mainly on the functions, clarity, ease of understanding and timeliness of information, including route guidance. Results concerning in-vehicle units were generally very favourable, although drivers in many trials reported occasions when advice was received too late to respond safely. Average glance times were found to increase with the complexity of the display but were lower than for glances to traditional maps which might otherwise be used for navigation. For elderly drivers, trials in EDDIT of the Bosch Travel pilot, Motorola and Philips Carin Systems showed that systems and displays were generally intelligible and easy to use, with acceptable glance time requirements, although there was some variability according to the display. For this target group route guidance systems could also provide routes to minimise stress and/or accident risk.

The results from HARDIE were not clear-cut in the sense that it can be stated unequivocally that a route guidance system does or does not improve safety. The conclusions were too varied and mixed to permit such an overall statement. However, it was concluded that for driving in unfamiliar situations, the current generation of route guidance systems is a substantial improvement over the
traditional paper map, combined with street signs, etc. Route guidance systems create less visual
distraction and lower levels of workload. Consequently driver performance is enhanced.

For driving in familiar situations, however, it was concluded that route guidance systems can have
rather negative effects, as they act not so much as a support in a difficult task as an interference in an
internalised and automated task, that of driving in familiar territory.

Other impacts

Reductions in travel times and distance travelled due to route guidance would be expected to
produce additional benefits of reductions in vehicle operating costs, pollution and accidents (due to
reduced exposure). Route guidance might also affect trip making. The EDDIT project indicated that
40% of elderly drivers with route guidance would make more trips to unfamiliar places, while 9%
would drive more frequently. Similar results were obtained from the wider sample of users in
Stuttgart. This advantage of increased mobility could have a corresponding social disbenefit in larger
scale systems through increased traffic generation and congestion.

Future needs and requirements

- Each project involved with route guidance has identified substantial further development
requirements before wider implementation is possible. A need is recognised for route guidance
equipment interoperability across Europe (using common communications standards, interfaces
etc.) which could support a diversity of in-vehicle systems and services.

Other Requirements

The provision of efficient route guidance requires the availability of digital road maps:

Digital road maps

Specially processed geographic information is essential for problems related to: location, route
finding, traffic analysis and traffic management. Each of these functions belong to a RTI system in
some way. Therefore compatible concepts for the handling of digital maps need to be found to
ensure multi-usability of data sources for different ATT applications. Such an horizontal task, not
dedicated and restricted to a particular application area, has motivated the work of an European
Digital Road Map project. The main task can be summarized as the harmonization and
standardization of geographic road databases. Within the ATT programme, EDRM2 project has
given support to some ATT pilots/projects using digital road maps. The main goal of EDRM2 was
to establish GDF as the only standard in Europe for the exchange of geographical data.

Impact

- A GDF editing toolbox has been developed. It includes: Data Capturing & Editing Tool and
Attributing & Relationship Tool. Validation checking procedure have been implemented directly
in the toolbox for the import/export of data. This software is available as a product, it requires
Intel-based PC386 with math co-processor and it runs under DOS 5.0 with MicroStation 5.0
from Intergraph. These tools are already used by companies like Bosch, Tele Atlas, Siemens,
Volvo, Daimler Benz, Huber cartography, etc.
- The main activity concerning integration of static and dynamic traffic information was the
development of GDF based kernel TCC to be used in three pilots. These plans have been put into
operation in the so called Inntal Triangle pilot project in southern Germany. In CITIES and STORM, the introduction of a harmonized solution for digital maps in TCCs was successful, because the GDF standard decisively influenced the development of their data models and database structures.

- A very important step for the acceptance and the future of GDF was its incorporation in CEN/C278. Compared to GDF2.0, the Feature, Attribute and Relationship catalogues have been considerably extended. Quality checking procedures of GDF data sets have also been defined, tested with real data and finally included in the standard. The project has also taken care of liaisons to CEN TC287, ISO TC204, IVHS America and others.

**Other impacts**

Development of GDF has given European industries a competitive advantage towards Japanese and American counterparts. This is also illustrated by the fact that GDF has been accepted as the basic input document to the ISO/TC204. Furthermore GDF can be seen as the basis of the development of a real European product which will support the development of an internal market.

**Future needs and development**

- Implementation User Support and Education for Pilots Projects in Europe, has been proposed to the Telematics Applications Programme of the 4th Framework Programme (4FWP). It is proposed to support all 4FWP pilot projects with a need of digital road map data, to promote GDF by educational activities and workshops, to link GDF to other data models (PRA, public transport) and finally to monitor the GDF standard by representing a unique European voice in ISO. If accepted, this new project will reduce overall costs related to digital road maps in the 4FWP pilot projects and will harmonize the use of digital maps throughout the ATT projects.

- Other important issues regarding the usage of GDF in a professional environment remain yet to be solved. These issues are: handling of update information, combination of data sets with different information content, coverage accuracy and coordinate systems.

**4.1.5 RIDE MATCHING RESERVATIONS**

The efficiency of trips made by private car can be increased if some car drivers are willing to share, at least occasionally, and to travel instead as car passengers. This reduces the number of vehicle kilometres travelled. At the same time, breaking the tradition of driving one's own car for every trip may cause people to consider available public transport options. The greatest potential for ride sharing occurs where people have similar not only origins and destinations, but also where the timing of their trips coincide.

Car (and van) pooling has been successfully operated in the USA where there are incentives to employers to organise such schemes at the workplace. In Europe, car sharing exists on an informal basis, especially in rural areas. Despite the American experiences, it is organised car sharing is virtually unknown in Europe.

**Measured impacts**

No actual implementation has been carried out within the ATT program. The CITIES project carried out a feasibility study on car pooling in 1993 and progressed this to a detailed business plan for a
scheme based on unrelated users in the Ile-de-France region. The technologies include means of communication of potential carpooler needs, ride-matching software, and user compensation system. The business plan examined the potential in the South West of the Ile-de-France area and estimated that 3,000 users would participate. Implementation costs of some 1.5 MECU were estimated, most of this being independent of the number of users involved. About 40% of the costs are earmarked to publicity and communication in order to achieve an early critical mass.

The City of Madrid provided a demonstration site to CITIES where they implemented a High Occupancy Vehicle (HOV) lane on the N-6 motorway in 1995. This is common practice in the USA, but not yet in Europe. Cars with two or more occupants are allowed to share the lane with taxis and buses. Surveys indicate that 70% of people have a positive view towards ride-sharing with 40% actually willing to use the HOV lane (two thirds as bus users, one third as car user). Based on the expected travel pattern shifts, a saving of 10-15 minutes on the journey time by car, and 20 minutes on the journey by bus is expected. However, as the lanes are being created by widening the motorway, it is difficult to say how much of the benefit would be due to the ride sharing element.

**Other impacts**

The surveys of the potential users demonstrated that there are three main categories of person who is susceptible to car pooling:

- "Reasonable" people who are willing to weigh up the factors for individual trips
- People who prefer the human contact involved in ride sharing
- People who are cost and money conscious, and wish to reduce travel costs

Loss of privacy, and concerns about sharing with strangers appear to be the most significant concerns, followed by loss of flexibility for the return trip (timing, other purposes).

The increased level of use of the HOV lanes is expected to overcome the "empty lane" syndrome where motorists are tempted to violate a priority facility because they feel it is not being used.

**Benefits**

The business plan for Ile-de-France estimated an internal rate of return of 29%, with a seven year payback. Environmental benefits would be expected through reduced car-use, but the level has not been quantified. Environmental benefits were not considered to be significant motivators for car pooling in either Ile-de-France or Madrid.

**Problems and limitations**

The Ile-de-france system has not yet been implemented, so a demonstration of such a system is clearly needed to quantify the actual impacts. The main potential problems are organisational in the sense of ensuring a guaranteed lift home, and penalising car drivers who fail to provide the planned lift. A variety of means for the potential carpooler to communicate requests to the system is expected, but the ability to communicate back to the carpooler in the event of problems may be an important factor.

Employers are generally positive towards the concept of ride sharing but have some concerns about whether they will end up with extra administration, and the impact on punctuality of their staff.
**Future needs and development**

The key need is to test carpooling and ride sharing of unrelated persons in a variety of environments. The ability to communicate requirements are not a problem. The focus must be on the efficiency of the ride matching software, the ability to handle exceptions, impact on travel patterns, and the sustainability of schemes. In addition, quantification is needed of the impacts on traffic levels and consequent impacts, as well as on public transport usage.
4.2 TRAFFIC MANAGEMENT, OPERATIONS & CONTROL

Introduction

Traffic management refers to the range of techniques used by the operators of motorway and main road networks between cities and within cities to fulfil the main network management objectives of:

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

The transport strategies involve objectives which include consideration of a range of issues such as environment, lifestyle, safety, congestion and finance. These objectives will be set at a political level, albeit with technical advice, and will involve local judgements as to the emphasis to be placed on each issue. Variations in factors such as city size, network structure, public transport and public attitudes will also influence objectives and the techniques to be applied to reach them. However, despite these differences at city and perhaps national level, it is certain that common trends and issues will occur in both the settling of objectives and the techniques used.

Within the above context, the DRIVE activities may be seen as:

(i) providing a technological ENABLING ROLE, to give city managers the opportunities to better achieve their objectives with greater precision and effectiveness than would be possible without the use of ATT techniques and, (ii) the COORDINATION of the technologies and applications, and the dissemination of information so that inter-urban city authorities may become more aware of the opportunities available for comprehensive systems and the integration of system elements.

It is clear that Integrated Urban Traffic Management should be considered in the context of city transport objectives and techniques which include, but are not limited to, those which are ATT derived.

Activities in this domain are through projects which have been developing improved systems for management, control and information of car drives and vulnerable road users in urban areas. The systems have addressed traffic (network) control, trip planning and parking management and emergency management. Essential elements of those systems are that they require extended data collection and transmission techniques, and a management or control centre to process data in order to provide operators with real-time information for decisions as well as for automatic control. The dissemination of messages requires various technologies for home, office, road-site and/or in-vehicle equipment, all of which need to be integrated into a single Urban Traffic Management System. Furthermore integration has also to be envisaged between urban and interurban systems.

The principal techniques available to network managers to enhance the operation of a network are:

(a) traffic control. This includes actions intended to impact directly on traffic efficiency or safety, and includes ramp metering, headway and speed control and lane assignment. These actions may make use of variable signs, signals and perhaps in-vehicle equipment.

(b) driver information. This includes information given to drivers for the purposes of comfort, safety and reassurance. Although the primary objective is to give information, drivers use this information to modify their behaviour and routes. Indeed, the means by which information is
given (VMS, radio, in-vehicle dedicated information/navigation/guidance equipment) are similar to those used for traffic control. The interaction between traffic control and driver information is clearly essential but the level of integration is far from distinct and will have to be taken into consideration when integrating different control strategies.

(c) Emergency action and general assistance. These are techniques used by infrastructure operators to provide rescue and assistance to drivers in the event of accidents, breakdowns, etc. The management of logistics and technical supports is included.

(d) Provision of travel services. These are services provided to the user and related to his travel, whether en-route or before departure, and that he may have to pay for. Typically, trip planning information, tourist information, guidance services complement inter-urban traffic management operationally, legally and institutionally.

Support of the effective utilisation of these techniques relies on two features of mature traffic management systems:

(a) Monitoring and surveillance. This includes all the means that contribute to real-time knowledge of the network traffic status and of what is happening on the network, together with the forecasting of traffic patterns in the short-term. It ranges from traffic data collection to incident detection by all means.

(b) Data transmission and exchange. This refers to the transmission of data of all kinds (voice, digital data; images), using all means (pairs, coax, fibre optics, aerial, etc.), between all sort of points (road-based equipment, clustering facilities, control centres, etc.), for collection or command purposes, by means of any architecture.

In an number of respects, an integrated view has to be taken of both the principal traffic management techniques and the supporting facilities, taking into consideration:

(a) The considerable overlap between the management techniques available to network managers.

(b) That individual data sources may be available in support of a range of applications.

(c) Ultimately, traffic management cannot be regarded as independent from related urban and peri-urban management or from services provided independently of location.

Integration is thus a key consideration from technical, organisational and institutional points of view. For this to be achieved a common understanding and consensus relating to the main objectives has to be reached (consistent with the principle of subsidiary) among all ATT actors in inter-urban traffic management (network operators, service providers, industrials) as to the techniques and strategies to be used. Only then can the best possible service be given to the end customer the driver and to the network manager.

### 4.2.1 INCIDENT AND EMERGENCY MANAGEMENT

Congestion is a normal occurrence for increasing periods of the day in most large urban areas, motorway / motorway interchanges or at intersections in close proximity to busy urban networks. A range of established control and management techniques are available to mitigate the effects. In
congested conditions, the early detection of an incident is particularly important for remedial action to be taken quickly. Automatic Incident Detection (AID) systems have been developed and deployed using video techniques as an integral part of incident and emergency management. The AID process is one of continuous monitoring network conditions and identify normally expected situations against which incidents may be identified. False alarms must be acceptably low and this is a particularly stringent requirement in close proximity to urban areas where congestion can result in significant short term local variations.

AID involves two major elements, a traffic detection system that provides the traffic information necessary for detection, and an incident detection algorithm that interprets the information and ascertains the presence or absence of a capacity reducing incident.

HERMES, based on results previously achieved in the DRIVE I projects (V1047) and MONICA (V1056), aimed at increasing traffic safety and efficiency through improved knowledge of the current state of traffic in a given network by using dynamic on-line Origin/Destination (O/D) estimation and AID, and through the application of control strategies (re-routing and traffic signal control) based on this knowledge. For the O/D-estimation in HERMES the dynamic model, ODYN has been further developed & and modified. The development of the network-models and their calibration was realised for the two test sites in SCOPE-Cologne/Deutz (O/D-estimation for signal control) and Frankfurt Airport (O/D-estimation for variable message signs).

The HERMES work on interurban AID, was the acknowledgement that, to cover the whole spectrum of traffic conditions and road topologies, a single algorithm can scarcely be the optimal solution. A mixture of various AID algorithms in a multimodel approach seemed to be more promising. Therefore various AID algorithms were compared and proper strategies for their use defined.

In cooperation between HERMES and MELYSSA, two algorithms were implemented in the MELYSSA test site in Lyon: one was based on extended Kalman filtering techniques, and the second was a revised version of the well known California 8 algorithm (California #9). Further algorithms under investigation were AID based on stochastic process analysis, double exponential smoothing, and an algorithm used on Dutch motorways.

The objective of another HERMES work package was the development of re-routing rules for motorway networks. For this task an existing simulation tool, SIMONE, was extended. Route diversions can now be investigated along different routes with no limit in number, time and duration, it is further possible to divided a traffic flow somewhere in a network and to merge it somewhere else. A state estimator that calculates the traffic state in a section from measured data of loop detectors has been embedded into an overlaid model, which is also the interface to the re-routing algorithm.

Measured impact

The most promising contribution to incident and emergency management has been in vehicle detection technology developed in DRIVE II utilising computer vision video analysis techniques. A number of projects have trialled video detection techniques and can show the many benefits of having a multi-purpose facility. Evaluation of loop based and video AID systems on the same site
shows that video AID was, in 1993 about 30% more expensive than loop based AID systems. A very reliable detection rate >93% combined with low false alarm rates <8% have established video techniques as a very effective tool for operators to use bringing to their attention a particular problem within about 15 seconds while at the same time providing them with the opportunity to see the nature of the incident. The additional costs have to be weighed against the advantages of having visual monitoring of any situation providing the opportunity to accelerate the decision making process to clear the problem. Reduced maintenance operations and a reduction by up to 80% of the amount of time spent observing monitors, releasing resources to undertake more vital tasks, also needs to be taken into account.

The production of automatic incident detection system specifications for motorways and urban sites.

Other impacts

Video and loop based AID show different capabilities: video is able to detect a large variety of incidents (with and without consequences on traffic). Loops are only able to detect those which cause severe consequences on traffic flow. Both systems, however, show low false alarm rates and frequency.

Non-loop based systems can provide improved service (LLAMD) and are an alternative to loop based systems if highly detailed data are not needed, but an accurate overall assessment of traffic conditions is adequate. Applications in tunnels and bridges, where good results from loops are hard to obtain, are particularly effective. Systems do not provide detailed speed information and may not be suited for travel time estimation (PLEIADES).

The data that could be used by the HERMES project covers the period from 29 April to June 1995. During this time period the video system detected 251 stops, but only 5 "detectable incidents", i.e. incidents that had any major impacts on traffic flow, occurred in the sections where California #9 was implemented and only two where the Kalman based algorithm was installed. California #9 detected two of the five, and Kalman one of the two plus the downstream consequences of one of the incidents in the section equipped with California. The limited number of detectable incidents does not enable firm conclusions to be drawn on the HERMES algorithm detection rate, neither for global performance nor for its sensitivity to parameters. Better conclusions can be drawn on false alarm performance from the 52 days of operation, during which a surprisingly small number of false alarms occurred compared to what is generally experienced with loop based AID systems.

Cross-border interconnection for incident and emergency management

The EURO-TRIANGLE project addressed the Problem of exchanging information across regional and international borders and different transport organisation when responding to incidents and the need to implement traffic management strategies.

In order to design and evaluate the system for cross-border interconnection three situations were taken into account: the Before, the Intermediate and the After situation.

Main result of the analysis of the before situation was that too many messages without relevance for the neighbour region were exchanged. The received messages were not used, especially for dissemination to the drivers due to several reasons:

- A selection according to relevance was too difficult for the receiving operators
- language problems (exchanged to NRW in French and Flemish, exchanged to Belgium in German)
- low knowledge of network and names of locations of the neighbouring regions
- manual input of information on neighbouring regions into databases

According to this knowledge the operational practice of the message exchange was modified in the Intermediate Situation. Fewer, selected messages were transmitted then, but no explicit rules for the selection were applied. A "User Experts Group" was set up to analyse the needs and requirements for message exchange and co-operation in depth.

**Future needs and developments**

- The observation is quite encouraging, but a longer operation time is required for more solid conclusions to be drawn.
- The evaluation of AID algorithms has been completed by off-line analysis on the selected "local" algorithms. The lack of incidents does not allow a complete evaluation of this off-line analysis but does indicate however that, in general, the "section" algorithms appear to work better than the "local" algorithms. This needs to be examined further.
- The use of the floating car concept as a means for detecting congestion and incidents should be further investigated.
- Further step should consist of achieving and validating the integration of the whole range of incident management components into an efficient integrated tool: incident detection, fast warning (to prevent secondary accidents), incident handling (to assist injured people without delay and clear the carriageway), hazardous goods monitoring, alarm management system, driver information and traffic control (to minimise the impact on traffic).

**Measured Impact**

As a result of the work of the "User Experts Group" the project developed.

- rules for selection,
- rules for an agreement process when diversion routes have to be recommended which cross different regions (different responsibilities)
- language independent Fax-forms to be able to include The Netherlands (NIL) in the message exchange and the agreement process,
- a prototype for on-line interconnection using the latest outcomes of the DATEX Task Force (Consolidated Data Dictionary, EDIFACT message TRAVIN) and TMC location coding structure.

**Other impacts**

The procedure using language independent Fax-forms has been used since November 94 (including also the Dutch centre in Driebergen). The on-line system has been in operation since April 95. The exchange of messages between the regions is now restricted to those being relevant and useful.

The exchanged messages are disseminated by the regional broadcasters (WDR, BRF, BRTN, RTB, Radio AC) and thus reach the drivers.
Future needs and developments

- There are a number of initiatives relating to the use of telematics across a number of domains; health, education, administration etc. but there is little evidence in the results of the ATT DRIVE programme that there has been any integration of the services, or reports that show that the appropriate groups have been in discussion to address emergency management services in the transport environment. The key organisations involved should be identified and an assessment made of the potential integration of telematic services and harmonisation of organisational issues.

4.2.2 EMERGENCY CALLS

Emergency call systems (generally call boxes along the road, linked to traffic control centres) are part of the Incident Management system, and are still the most common source of information about incidents. Implementing emergency management procedures in the event of an accident, is dependant on having accurate information on which to make decision. CCTV systems will contribute to the information if the incident occurs within a CCTV controlled area, but if an accident occurs outside the range of CCTV then the operators are very dependant on information from other sources. GSM mobile phones used by the public for emergency calls are already making a significant contribution to the retrieval of accurate location information. The increased use of mobile phones while providing the driver with added comfort should difficulties occur also introduces problems for the network operator trying to handle the multiple response when network problems arise.

Reducing the impact of injury to the public caused by the spillage of hazardous goods, as a consequence of an accident, can have major cost savings for the community in terms of health care and the severity of injury caused by the substance. One way of achieving this is to improve the way information is obtained and distributed to the relevant organisations involved in responding to a particular problem. An automatic system was seen as the most efficient way of addressing this issue. Any accident involving vehicles carrying dangerous goods would contribute to an effective emergency response by using an emergency call system developed in the QUARTET project utilising the satellite Global Positioning System (GPS) and digital road map together with GSM for data transmission of an emergency telegram.

Measured impact

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 reduction in the long term severity of any injury incurred.

Other impacts

An important secondary service of this facility provides a continuous communication capability to primary service.

The Travin EDIFACT message format was successfully implemented for the inter-communication between systems representing Fleet management and Traffic Control Centres. (additional information may be available from the travel and traffic information sector).
Tests with elderly drivers showed that the availability of an in-vehicle alert system would enhance the feeling of personal security of the drivers and could lead to "social" changes in driving behaviour such as willingness to drive on unfamiliar roads, or alone at night.

**Future needs and developments**

- **In-Vehicle Emergency Call Systems** (dedicated systems or GSM mobile phones using the international emergency call number 112) should be developed and assessed, primarily for calling for assistance but also for detecting and reporting incidents.
- Such systems need to be provided with precise automatic location capability for the sake of efficient routing of rescue teams and identification of relevant intervening authorities; consideration should be given to adapting them to Heavy Goods Vehicles monitoring.
- **Ground-based emergency call boxes** on the network will continue for decades to provide the basic emergency call system in use on the TERN; multi-lingual boxes, asking relevant standard questions to drivers in their mother tongue, could be developed, as it is already in use on some motorways. Access to and use of these equipment should be made as easier as possible for elderly and disabled (particularly people with hearing problems).

**4.2.3 URBAN TRAFFIC CONTROL**

- **Urban Traffic Control (UTC)** systems form the core of Integrated Urban Traffic Management (IUTM). Developments in DRIVE II have included new UTC systems, new strategies for improved control and new functionalities integrated to UTC. The advanced traffic responsive UTC systems involved in the DRIVE II projects include SCOOT (UK), UTOPIA/SPOT (Italy) PRODYN (France) and MOTION (Germany). SCOOT is operational in over 120 cities worldwide and its benefits have been well established from previous studies. UTOPIA has been operational in Turin for over a decade and its benefits have also been established there. PRODYN has been developed more recently in Toulouse (France) and were implemented in Brussels in the CITIES project. MOTION is a new traffic control concept developed in the SCOPE and HERMES projects and evaluated initially in Cologne.

**Measured impacts**

MOTION was tested as a group of nine junctions in Cologne, using floating car measurements over 3 days per strategy. Reductions in travel time of up to 20% were recorded with MOTION on selected routes, and up to 10% overall. PRODYN was compared with the centralised fixed time control in Brussels as 25 intersection with travel time data collected from 105 O-D pairs. In general, the comparison showed that, with PRODYN, there was a 10% increase in mean speed a 10% increase in traffic in the zone and a 2% reduction in the number of vehicle hours. Given the increase in traffic volume related to PRODYN, a 19% increase in mean speed due to the control was estimated.

**Other impacts**

Improved UTC systems providing reduced journey time/delays also reduce vehicle operating costs and pollution. However some additional traffic may be generated given the improved travel conditions. Economic performance of MOTION and PRODYN is not reported but would be expected to be favourable, given the delay savings.
Problem and limitation

For MOTION only one of the two parts of the algorithm that was designed for optimising the green waves was realised in the first prototype, measurements showed that those traffic streams which were running against the main routes were less well served than should have been the case. This confirms that, in future systems installations, the full algorithm needs to be used. Another problem that became evident in the field trial was that the number of frame signal plan changes and the method of switching still needs to be optimised in order to minimise disruptions when these changes are necessary. However, in spite of these limitations, the overall performance of the system was so satisfactory that the City of Cologne intends to run MOTION in every day operation for the whole test network once these improvements have been carried out.

Future needs and developments

- Concerning MOTION, whilst not all of the functionalities have been realised so far, it has turned out that MOTION, which has shown its potential in this field trial, is a promising novel system for area signal control. The MOTION system is now said to be in a state which can be described as advanced prototype and is ready for implementation in any European signal control area and any control computer.

Traffic control using knowledge-based systems

The KITS project (V2039) developed knowledge-based intelligent traffic control systems (KBS) to support operators in surveillance and traffic management tasks. KITS was applied in Trondheim, Cologne, Genoa and Madrid, the latter including on-line implementation within ARTIS (V2043). In Madrid, the KITS KBS was used as an additional level in traffic control centres giving a traffic knowledge processing layer on top of available traffic control facilities.

Field trials on 3 roads in Madrid showed that 75% of problems (e.g. incidents) were correctly identified by KITS. The other situation were influenced by detectors being out of services. KITS driven messages were displayed to drivers on 2 days with 10-15% of drivers responding to the messages.

Urban aid

The extensive real-time traffic data provided by advanced UTC systems has found the basis for new Automation Incident Detention Methods. Two systems used and developed further for urban AID in HERMES (V2019) are ASTRID and INGRID. ASTRID is a database system for automatic and continuous monitoring of traffic which has been adapted to operate on-line. This enables information on both the current state of the network and the expected state of the network based on historic data to be accessible for use by other information or incident detection systems.

In the DRIVE I project MONICA, four different methods for detecting incidents using data from UTC systems were developed. In HERMES these two methods have been combined to produce the INGRID system for detecting incidents and the congestion that they cause, and then INGRID and ASTRID were combined to provide on-line journey-time information as well as congestion and incident warnings.

Measured impact
The combined ASTRID/INGRID system was installed in Southampton and integrated with the SCOOT UTC system there (consisting of approximately 450 detectors and 150 links) as part of SCOPE. During the evaluation period between May and November 1994, data was successfully stored on 106 weekdays, providing 540 hours of data. Police records show for this period 17 accidents near SCOOT detectors, and the analysis of the traffic data around each accident shows that of these accidents 6 were severe, none were moderate and 11 were minor.

The evaluation distinguished between four confidence levels from "not confident" to "very confident". All six severe incidents were detected at all four levels with the mean detection time ranging from 4.2 to 9.2 minutes and at 0.093 to 0.003 false alarms per junction per hour.

As a result of the evaluation it was recommended that INGRID sends a message once an incident reaches a "mildly confident" level. In this set up, INGRID would detect all 6 severe incidents with a mean detection time of 6.5 minutes at a false alarm rate of 0.006 false alarms per junction per hour.

Future needs and developments

- INGRID has been developed with the objective of detecting incidents automatically so that the information can be provided to the road user. Further development is needed to provide incident information so that the UTC system could respond to an incident automatically.

Dynamic O-D estimation

The estimation of traffic origin and destination in real time can have substantial benefits for traffic control, as well as for other ATT functions such as route guidance. Advanced UTC systems provide suitable link-based traffic flow date for dynamic O-D estimation.

For the O/D estimation in HERMES the dynamic model ODYN was further developed and modified. The development of the network-models and their calibration was realised for the two test sites in SCOPE-Cologne/Deutz (O/D estimation for signal control) and Frankfurt Airport (O/D estimation for variable message signs).

The validation of algorithms for these sites was carried out on the basis of simulated and then, as far as possible, real data. For the test site at Frankfurt Airport the results of the simulations showed that the majority of the estimated O/D flows were quite close to the observed (or given) values. For the test with real data, the test of the convergence showed that the real and estimated volumes on the single links during the estimation procedure were very close.

Additional plausibility checks (knowledge of the traffic engineers etc.) show that the result obtained appear to be of good quality. In Cologne-Deutz, a second validation stage was carried out with real O/D information (license plate surveys for certain O/D-flow) for a complete day in April 1995. The results confirmed that the algorithm used for the prediction was statistically very well-behaved.

A practical application of OD estimations is also seen in the MOTION UTC systems.

On-line O-D estimation was also carried out in Munich COMFORT using the signal control method BALANCE. O-D streams were estimated with the information from 27 inductive/detectors, with estimation of the OD matrix using a ME algorithm based on dynamic weights. Evaluation showed a high correlation between predicted and observed data (32% root mean squared error). The results of O-D estimation and simulations were reported to show the practicability of the traffic models and the usefulness of the development of re-routing strategies.
Future need and developments

- As short term traffic forecasting is a key building block of all traffic management decisions and systems, although encouraging results have already been obtained, a continuing activity is needed in this difficult field.
- On-line OD estimation, on-line dynamic assignment and driver behaviour modelling (route choice according to information supplied) are an essential part of the network control strategies identification. Two streams of modelling techniques have been identified: behavioural models which explicitly model driver behaviour, and descriptive methods which rely on statistical modelling techniques. For longer term horizons, the behavioural models are considered to offer advantages; for shorter term horizons, where behavioural aspects may not yet become significant, there are indications that statistical modelling techniques may be the best choice. Since no conclusive evidence is available, further work is recommended.
- As desired accuracy and forecasting horizon depend on the application in view; and actual accuracy of models is strongly related to the quality of the measurements, further work is needed to determine the optimum level of traffic data collection required to support a particular model and four different levels of network complexity and applications in view.
- Since model predictions are especially useful during incident conditions and in assessing the effect of control measures, particular attention should be paid to the feedback effect of information on driver behaviour. Due to the difficulty of modelling driver behaviour, a continuous adjustment of prediction based on on-line traffic measurements is recommended.
- The value of information collected from equipped vehicles for forecasts of OD matrices, route choice and travel times should be further evaluated.

Environmental control

UTC strategies can be targeted towards environmental control by, for example, reducing the use of sensitive routes (e.g. by increasing the travel time on these routes) or through gating where traffic is restrained from entering sensitive areas.

In Turin, an Environmental Monitoring Subsystem (EMS) acquire meteorological and environmental data from 12 detection stations recording the levels of 7 main pollutants. Environment monitoring software (ARMONIA) receives traffic-related data and vehicle emission estimates from the UTC subsystem and uses special software to calculate forecasts of air pollution. These forecasts are sent to the Town Supervisor for use in its calculation of reference strategies, implemented by the UTC system and other functions, to protect critical areas of the network.

The "5T" implementation in Turin (QUARTET Project) has a target reduction of 18% in pollutant emissions. From simulation results and field trials in the PRIMAVERA project, it is estimated that the use of integrated traffic control strategies will reduce emissions by 2%-5%, with a further 6% reduction due to town supervisor action targeting pollution reduction.

The APOLLON implementation in Athens in QUARTET was also aimed at environmental traffic control through pollution- sensitive traffic re-routing and environmental area licensing. UTC provided the information on traffic flows and congestion (which contribute to pollution) covering a pilot area of about 30 km².

Measured impact
Two pollution episodes occurred in the Athens field trials in the winter of 1994/95. It was estimated that the number of vehicles entering the centre on these occasions decreased by 5%. Pollution calculations and simulation modelling were used to predict the following impacts.

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Pollution level (ppm) at Kerbside</th>
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<tbody>
<tr>
<td></td>
<td>Inside Controlled Area</td>
</tr>
<tr>
<td></td>
<td>Before</td>
</tr>
<tr>
<td>CO</td>
<td>16.5</td>
</tr>
<tr>
<td>NOX</td>
<td>0.67</td>
</tr>
<tr>
<td>HC</td>
<td>4.69</td>
</tr>
</tbody>
</table>

Pollution reduction in the controlled area was higher than the increase in pollution outside the controlled area.

**Other inputs**

Simulation modelling was used to predict the effect of environmental control on other network performance parameters. It was estimated that, overall total vehicular travel (veh km/h) increased by 2% and average speed reduced by a 7%. This is unsurprising given the objective of this strategy of environmental improvement rather than minimising travel time.

**Integrated Urban Traffic Management**

The development and implementation of Integrated Urban Traffic Management (IUTM) systems have been a key achievement of many city projects. The functionalities and architecture of IUTM has varied between cities. IUTM projects have played a valuable role in extending and refining the tools for the urban environment and our knowledge of when the tools can be applied and the impacts they can be expected to have.

Open System Architectures have been used in the development of a Strategic Information System to ensure that tools are available for implementing Integrated Road Transport Environment (IRTE) Target Architecture for the Urban Systems. Integrated Traffic Monitoring Architecture Systems based on central and local traffic control philosophy have been developed in the programme. The quality of Traffic Data Collection has been enhanced to provide on-line information by adapting detection systems in non-UTC areas and the collection of information from instrumented vehicle fleet. This has been used to develop vehicle monitoring software which estimates traffic conditions, flow and travel time, on urban and motor way roads and forecast traffic status on a short term horizon.

Several project sites have adopted Urban Road Monitoring by utilising the new concept of Strategic Information Systems for integrated network monitoring on-line. One project addressed the specific area of improved information infrastructure through the provision of accurate and timely travel and traffic information on all modes of transport, to all actors in the transport context. Integration with Geographic Information Systems (GIS) has also been achieved.

The developments described above from an essential basis for the IRTE onto which integrated system can be implemented efficiently with enhanced control strategies. A number of projects implemented integrated control strategies. Those dealing with public transport priority and variable message signing are described in other sections of this document. Other applications concerning significant evaluation of impacts included the PRIMAVERA and QUARTET projects.
The objectives of the PRIMAVERA projects was to develop and evaluate integrated strategies that combine queue management, public transport and traffic calming methods on urban arterial roads. A key issue was whether the implementation of combined strategies provides "value-added" to their separate implementation. Trials of integrated strategies for queue management, bus priority and speed advice (using VMS) were centred on Leeds, using SCOOT and SPOT traffic control and on Turin, using SPOT.

Measurement impacts

For Leeds, the bus priority strategies reduced travel times for buses by 6%-16% with a small increase in travel time for private traffic (up to 4%). Bus travel time variability was reduced by 16%-29%. The speed advice signs reduced the proportion of vehicles speeding from 18% to 3%, with average speed reductions of up to 4mph (6km/h) at one site, giving significant predicted safety benefits. For Turin, private traffic journey times were reduced by 11%-28% on the arterial, and 10% for the network as a whole. Numbers of stops on the controlled arterial were reduced by over 30%.

The main public transport service gained a 6% reduction in journey time. Reductions in emissions and fuel consumption of 5% were estimated.

Other impacts

Potential influence on model change due to public transport priority.

In Turin, a complete IRTE has been established with 10 applications interfaced to common network. A main anticipated impact concerns the benefits of integration, which should be greater than the sum of benefits that would be derived from the autonomous operation of the component systems. A 25% reduction in journey time for all modes of transport is the expected impact from complete integration at all three levels of architecture (the Town Supervisor, subsystems and multi-function outstation layer).

4.2.4 MOTORWAY TRAFFIC CONTROL

For motorway traffic control to be applied safely and efficiently the operators can either rely on rapid responsive automatic systems or be aware of the network status at any instant in time and have the tools available that can be used to support the decision making process. Both require extensive surveillance and control models configured to suit the prevailing conditions and the road environment. The established technique used to monitor the road network is to use loop detection systems normally installed in critical sensitive areas where financial justification can be relative easy to support and with access to a communication systems to collect the traffic data. Strategic traffic management techniques, if they are to be effective and to support tactical control mechanisms, require information from the network as a whole, including some local road networks in close proximity to urban areas The early detection of an incident, as a consequence of congestion or accident, is particularly important for remedial action to be taken. The level of monitoring required to achieve this requirement using existing technologies would place considerable demands on financial resources unless the information can be obtained from other sources. New detection, control strategies, ramp metering and decision making processes combined with automatic systems that can be implemented using network models have been at the centre of many DRIVE projects.
The benefits of using AID systems have already been explained in section 2.1 as a means of controlling motorway traffic. Another major contribution to the success of controlling motorway traffic has been the application of real time VMS strategy selection based on models developed in the DRIVE programme (MCONTRAM, SIMRES, METANET, OPERA and AUTOMATIC) utilising the information obtained from the network. Traffic prediction information is another parameter used by the operators working to maintain a stable and trouble free network. This has been addressed by the DRIVE programme and a range of traffic models have been established for traffic forecasting within a time range from 1 to 60 minutes (DYNA, ATHENA, MITHRA, NSMP, KIDS, MUNICH, METANET and SIMRES) with one SIMONE with a time range of 10 hrs.

Accident on motorways, although not as frequent as on other roads, can when they do occur involve a large number of vehicles of different classes and more people. Preventing the primary accident through the application of telematics integrated into the motorway infrastructure is one way the network managers can contribute to the reduction of accidents. Preventative measures include speed control and route information in adverse weather conditions.

The speed at which a queue can form against the normal flow, even in moderate traffic flows, is a major problem for the network operator when trying to prevent a secondary accident. The only know effective solution to is to use automatic incident detection systems. The AID system has to be responsive to rapid changing situations and activate VMS to warn drivers of the situation in a timely and effective way. This was a major issue to be addressed by 10 of the DRIVE projects. The AID Task Force, funded by the commission, has produced a comprehensive report "Guidelines for implementation of automatic incident detection systems". This document details the results obtained from all the projects covering : detection, algorithms, integration with the infrastructure and cost benefit analysis for motorway traffic control.

Measured impact

Ramp metering when applied as part of an integrated urban / motorway control strategy increased the mean speed on the motorway by 21% and in Amsterdam reduced the on ramp delay by 19%.

Other impacts

Measurements carried out to determine the accuracy of the existing VARIA O-D estimator, show good results and simulation showed expected benefits from the re-routing strategy. Motorway flow and efficiency were improved (LLAMD).

Reducing journey time and traffic delays make a positive contribution in improving the air quality. Responding to incidents using ATT strategy models (MCONTRAM, OPERA and VARIA) is one way of reducing the impact on the environment. Achieving up to 20% saving in delays, as demonstrated by the QUO-VADIS project in Scotland, has been estimated to reduce CO by up to 10%, HC by 5% and NOx by 5%.

Operating an efficient network with free flowing traffic conditions will contribute to the more efficient use of energy. Reducing delays by re-routing can save time and, compared with slow moving traffic, can save fuel. It has been calculated that up to a 20% reduction in delay in the Scottish project produced up to 10% saving in energy.

System architecture
The use of telematics is expected to make an important contribution to a more efficient, safer and sustainable transportation system. Both in Europe and in other continents the research and development will continue and result in new products and services. As these products and services continue to emerge on the market, there is a severe risk for incompatible systems and services throughout Europe and a fragmented market.

There is, therefore, a strong need for a framework, which will allow for:

- the integration of existing and future applications;
- cross-border interoperability of applications;
- an open market for products and services.

This framework is referred to as an open systems architecture for traffic management and provides a stable foundation for the integration of individual systems during many generations of computer technology.

The GERDIEN architecture framework for the IRTE comprises a Reference model, a Functional Architecture, an Information Architecture, a Data Communication Architecture and a Physical Architecture. The methodology of the GERDIEN architecture framework was adopted in the SATIN task force and in Topic Group 10.

The first version of an architecture design was made for the domain of IUTM. A kernel part of the framework has been implemented in a real world situation in the vicinity of Rotterdam in the Netherlands. To this aim a number of ATT application have been integrated in an open infrastructure. Key aspects of the infrastructure are transparent data communication protocols for physical integration and a generic data model, based on the GDF standard (for logical integration. The pilot applications comprise Traffic Monitoring (including WIM), Travel time & Congestion Monitoring. Current Capacity estimation and Short Term Forecasting.

**Measured impacts**

- **Infrastructure Development**
  - Design and development of transparent communication protocols for a Roadside-TCC cabling network, based on the TCP/IP protocol suite.
  - Modular, multifunctional Roadside Systems for a collection of peripherals including meteo sensors, beacons, vehicle detectors and weigh-in-motion detectors. The pilot implementations were based on Intel 386/RMX systems.
  - Generic systems for the regional centre based on an implementation of the Gerdien information architecture. The system is based on a GDF road map presentation and open conceptual data scheme for standardised traffic data registration and data exchange. GIS technology has been used, based on the Intergraph Micro station environment.
  - Development of software to allow integration of the Roses (V2045) central monitoring system in the Gerdien framework.

- **Application development**
  - Development of WIM prototype subsystem for interfacing to both existing loop detectors and pilot roadside system.
Development of precipitation detection for interfacing to pilot roadside system.

The Network State Monitoring and Prediction (NSMP) system contains algorithms for on-line monitoring the current and expected network traffic state. It contains algorithms for estimating current roadway capacity, for detecting congestion and estimating travel times and for making short-term forecasts. Software was developed and tested in a separate environment and later on integrated into the GRMS implementation. A dithering technique was developed to semi-automatically select the "best" inputs to the neural networks used for making the forecasts.

The pilot activities have been geared with other development programs in the Dutch Ministry of Transport.

The main achievement is that the GERDIEN project has contributed to an increased awareness of the need of an architecture framework by communicating its results in the area of inter-urban traffic management, in the systems architecture topic group and after that in the SATIN Task Force. At the end of the DRIVE II programme, there is a better common understanding of what a system architecture and is of methodologies that can be used to describe them.

Also, preliminary architecture descriptions have been given for urban and inter-urban traffic management. Architecture is now one of the main issues to be addressed in each project in the Fourth Framework Programme. The importance of an architecture has also been recognised by the Dutch Ministry of Transport, Public Works and Water Management. It is strongly suspected that the GERDIEN project has contributed to raising the importance of architecture in dynamic traffic management.

Other impacts

Usability of the GDF standard
GDF proved to be a usable foundation for the registration and presentation of traffic data in a modular extendible open system.

Costs aspects in the infrastructure
The evaluation on cost aspects in the infrastructure focused on the costs of open multipurpose roadside systems with regard to closed dedicated systems. The evaluation considered costs of ownership during the entire life cycle and also looked into institutional aspects that effect investments in infrastructure. Although no real cost figures on open multipurpose roadside systems were available, there is substantial information that costs for operation and maintenance will be considerably less with open multipurpose systems. A second conclusion is that a lot of practical problems, mainly of an institutional nature, must be solved before a smooth settlement of open infrastructure for traffic management will take place.

Future needs and development

• The models in the Network State Monitoring and Prediction system were tested and calibrated using off-line data recordings. A detailed evaluation of the models was conducted using the results of field observations.

The results for the models for estimating capacity and travel times were promising. The models are a good basis for future deployment. The travel times even showed an excellent fit with travel time observations under congested conditions. The use of neural networks for forecasting traffic is still at a research stage, but has already produced interesting results...
In a wider sense, the models and the Generic Road Management System (GRMS) were evaluated with respect to their behaviour in various situations in which the incoming data is incomplete, and recommendations for improvements were given. Further, the extendibility and flexibility of the GRMS was explored by considering a number of cases, such as traffic smoothing, variable message signs and coordinated ramp metering.

An architecture, the Integrated Road Transport Environment was considered necessary as a stable framework for present and future applications and services in the field of transport telematics. The framework should allow for cross-border interoperability, consistency and for a sound European market.

Before a start can be made with the definition of a system architecture, the importance of traffic management using telematics and of the need for a system architecture must be well-understood by a broad group of users.

• There is a need to demonstrate the co-ordination of different traffic management strategies (i.e. ramp control and speed control in conjunction with AID and weather monitoring, using open system techniques and existing communication systems for the transfer of information and the interaction of the relevant control systems) in order to determine the correct level of interaction between each management system and, if necessary, to resolve conflicts and identify priorities for control purposes.

OD - Control theory

DYNA is a research project in the general applied area of the control of motorway traffic through informatics and regulatory measures. The specific topic of DYNA is the provision of short-term forecasts based on historic and immediate pass data and their use in determining real-time motorway control strategies. The aim is to assist operators in the use of Variable Message Signs (VMS), radio messages or on-board guidance equipment, and to manage traffic light control at entry ramps. DYNA has been developed on real data from a Dutch Pilot Project Site.

One of the major objectives of DYNA was the assembly of a working predictive system for a real motorway network, providing real-time forecasts of traffic conditions over time horizons ranging from one-minute to one-hour ahead of the time of initiating the calculation. DYNA also established a control-theory basis for system use to address the use of predictive systems for the purpose of controlling traffic, rather than merely providing "passive" forecasts of traffic states. The project team set out to explore control strategy development, that is the way in which the predictions would actually be used to define and implement effective traffic control.

The work led to proposals for an extended DYNA system with control strategies, consisting of three major modules:

1) a surveillance system bringing current information from the actual motorway
2) a traffic prediction being the DYNA enhanced forecaster
3) a control strategy generator selecting best control strategies using 1) and 2).

Impacts

The major achievements of DYNA have been:
• to develop two conceptual approaches to real-time forecasting of motorway network traffic conditions
• to extend these to a stage at which practical implementation could take place
• to embed the approaches in generalisable software to allow real-time forecasting to occur for inter-urban networks
• to organise the receipt and processing or real data form a Pilot Project at which suitable data was being collected.
• to test and demonstrate the methodology (and the software) on the real data, in preparation for the end-project evaluation and software report
• to complete a review of the possibilities for the use of the methodology within a control framework
• to test and demonstrate the control aspects on a real example
• to develop extensions of the software and database to allow information to be supplied to Urban Planners from developments of motorway demand
• to review the theory of database creation and management for DYNA system extensions
• to review the theory of route choice behaviour and its relationship to information and learning to extend the DYNA algorithms.

Other impacts

The review and analysis of the problem led to an appreciation that the Behavioural Traffic Model (BTM) and the Statistical Model (STM) presented different control strategy problems and opportunities, actually dealing with different control mechanisms to a large extent. The BTM and its longer-range, behaviourally oriented approach lends itself naturally to strategic studies of route guidance problems, whereas the STM with its very-short-term, more localised focus seems best suited to local control measures, such as ramp metering.

4.2.5 URBAN/MOTORWAY TRAFFIC CONTROL INTEGRATION

The interface between urban and inter-urban networks can be a major stress factor for many drivers - will the exit roads be clear is this the best route for packing, is there an alternative, am I going to be delayed -- are the common questions asked when traffic conditions approach peak flows. Roadside driver information systems (VMS) when used as part of an integrated control system can be effective in reducing driver stress. Centres for integration control have been developed in a number of cities bringing together some or all UTC, parking information and management, public transport operations/information, network monitoring / incident detection and VMS. Ramp metering projects have investigated the impact they have had on the adjacent road network and the integration with other control measures. In Paris, control strategies using ramp metering and 350 VMS on the entire Corridor Peripherique and on the Boulevard des Marechaux, evaluating the impact of each control strategy.

In Amsterdam, a number of access control strategies were applied on the approach to the Coen Tunnel between junctions S101 and 105 of the A10 West motorway. In Glasgow, 2 km of motorway with one metered ramp and a parallel artery with 5 signal controlled intersections were used to develop algorithms for an integrated control strategy (ramp metering, signal control, VMS). The developed algorithms were used for simulation studies using the METACOR simulation tool.

Measured impact
The 6% reduction in journey time (Turin QUARTET).

VMS installed on the motorway providing information concerning parking or park and ride schemes can be very effective as demonstrated in the SCOPE projects when an 80% increase in P & R users occurred.

In Paris, the increase in the mean speed resulting from the control implementation in the field trial was found to be 21%, 16% and 19% for the motorway, parallel network and total corridor respectively.

In Amsterdam, the general results show that ramp metering produced a reduction in delay by 19% for all traffic on the motorway on the ramps.

The overall conclusion from Paris and Amsterdam is that suitable utilisation of control strategies integration between motorway and adjacent network can (i) reduce the extent of recurrent and non-recurrent congestion on motorways (ii) reduce total travel time including waiting time on the ramps (iii) increase the total amount of vehicles served by the motorway (iv) optimise utilisation of the motorway capacity (v) reduce or avoid “rat-running” traffic in the adjacent road network.

Other impacts

The interconnection of existing urban and interurban traffic control centres to achieve coherent overall strategies and co-operative traffic management is a vital requirement if progress is to be made towards an IRTE. The EUROTRIANGLE project has achieved the interconnection of traffic control centres and traffic information centres between 3 regions in Europe: Flanders, Wallonia and NordRhine Wesphalia using the Travin EDIFACT specification as the bases for the interconnections. Efficiency and reliability of the systems adopted were very high. A new organisational structure has also been developed to reduce the level of redundancy in the messages being exchanged across borders making the transfer of information more efficient.

Reduced travel time with a reduction in carbon monoxide emissions (EUROCOR).

Exit and entry points on motorways interfacing with busy secondary roads will often require traffic control measures to be implemented to prevent a queue back onto the main motorway or to control the entry onto the motorway (ramp metering).

ATT video detection techniques are now being applied to monitor and control the flows on the approach to the at grade signals to prevent queuing back onto the motorway, preventing a flow break down and reduced capacity.

System architecture recommendations for information exchange between adjacent Traffic Control systems (e.g. urban and inter-urban), and between UTC and Public Transport operation systems have been established.

Future needs and developments

• Ville de Paris site owner decided to continue control strategy beyond experimentation phase and plans significant VMS increase from 300 currently to 800 in near future. Originally only 9 VMS were planned for the project (EUROCOR).
Cost-benefit analysis result: No cost-benefit analysis has been carried out, although it is clear that the established benefits relating to a reduction in traffic delays will apply.

- Urban and peri-urban systems are often mutually dependent in that drivers can pass from one to the other, depending on traffic conditions and information and control applied. Coordination of strategies used in each system mainly relies on agreement at the transport policy level, but also on the availability of proper tools for designing strategies. In this respect:
  - the level of information to be exchanged has to be better defined
  - operational tools like general OD estimation and coordinated traffic lights/ramp metering/
    VMS control strategies need to be further developed and evaluated in the field
  - A lead strategy (urban or inter-urban) has probably to be defined according to circumstances.
- A continuity of service should be assured to drivers passing from urban to inter-urban systems and conversely. VMS and (especially) in-vehicle systems should provide information on what is happening in the system the driver approaches; this means that a connection between data bases generally managed by different bodies, and, probably, agreed priority ranking of information should be achieved.

4.2.6 TRAFFIC CONTROL FOR PEDESTRIANS

New traffic control systems and strategies developed in DRIVE II have focused primarily on improving the efficiency of vehicle movements. Developments have all been undertaken within the constraints set by the City Authorities concerning the provision of facilities for pedestrians. However, one project in DRIVE II concentrated uniquely on traffic signalling for pedestrians (VRU-TOO, Project V2005), aiming at the reduction of risk and minimisation of delay to vulnerable road cross (pedestrians) with as little inconvenience to motorised traffic as possible.

Trials of new microwave detection for pedestrians and (in some applications) vehicles with new signal control strategies were undertaken in 3 cities of Leeds, Porto and Elefsina in the UK, Portugal and Greece respectively.

Similar applications are also emerging with national funding, such as the PUFFIN (Pedestrian User Friendly Intelligent crossing in the UK). The VRU-TOO trials were applied to fixed time isolated or linked traffic signals and to 5 junctions in total. Evaluation was undertaken from movements of vehicle and pedestrian flows and delay pedestrian behaviour and vehicle-pedestrian conflicts, which can provide a proxy for injury accident rates.

Measured impacts

It was concluded from the project field trials that pedestrian behaviour tends to be highly adaptive to momentary circumstances. Many different strategies are followed when crossing the road and these strategies differ substantially in their likelihood of resulting in an encounter with vehicular traffic and in the likelihood of this encounter turning into a conflict. Moreover, pedestrian behaviour tends to deviate substantially from the normative behaviour. Red light violations are frequent. As a consequence, detailed analysis is required to assess effects of measures that aim to improve pedestrian safety and comfort. Conflict studies on their own provide little or no understanding of the way pedestrians will adapt their behaviour to the changed circumstances. The behavioural studies have revealed that the effects of the pilot project implementations are indeed in the expected direction. The normative behaviour generally improved, there is evidence for a decrease in red light
violations and, at the majority of sites, the number of pedestrian-vehicle encounters decreased. These positive results are only partly confirmed by the results of the conflict observations, but the overall conclusion that some safety gains are made, seems warranted. The results with regard to pedestrian comfort are more straightforward. Overall, the crossing delay was reduced after the implementations, and pedestrians were more often arriving when the pedestrian lights were green and more often able to complete the crossing during the green light stage.

The pedestrian strategies trialed had a small and generally insignificant, impact on vehicle delays.

**General benefits**

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 young, the elderly and the disabled.

**Future needs and developments**

- Given the encouraging finding from VRU-TOO there is a need to further study the technology and strategies in the context of other parallel developments in this field, so that timely exploitation can be achieved.
- The behavioural studies have achieved new insights into how pedestrians behave as they encounter car traffic, showing which pedestrian strategies are most likely to result in a traffic conflict. This work provides the basis for future micro-simulation models which have the potential to predict pedestrian risk with far greater accuracy than traditional meso-level statistical models. Such models would provide a powerful tool for fine-tuning signal systems so that they are truly adapted to pedestrian needs and for ensuring that accident risk is minimised.

**4.2.7 WEATHER RELATED TRAFFIC MANAGEMENT**

Adverse road and weather conditions together with high traffic densities have a significant impact on the safety of road traffic. The complex dangers of rain, snow, hail, wind, fog, frozen roads together with high traffic densities call for an integrated approach of maintaining a good road condition and a proper adaptation of the traffic to the prevailing conditions. The need to inform drivers of the potential changes in driving conditions, particularly in remote areas, is a vital part contribution to making the journey safer. While radio broadcasting has the benefit of keeping drivers informed of the general situation it does not always reflect the actual road conditions at any particular instant in time in local areas. This would require local monitoring and a means of distributing the information to inform the driver on the approach to the critical area. A number of projects have focused on enhancing detection techniques and improving the management and distribution of conventional weather data.

One of the main areas addressed by the ROSES project concerned the direct interaction between the vehicle operation, supported by warning signals, and the driver when adverse weather conditions were detected. This was achieved by combining information between an infrastructure base system and the in-vehicle safety assessment system. The tests have shown, when adverse weather conditions have been detected, that an increase in the accelerator return force, combined with visual warning, was shown to be the correct method of warning the driver which encourages the right reaction at the moment, namely the closing of the throttle and subsequent reduction in speed. In these tests the drivers have emphasised its positive effect in adverse weather conditions, when it is difficult to estimate the friction potential.
The weather related traffic management task undertaken by the MELYSSA project was aimed at studying driver behaviour and reactions when presented with weather related information and advise.

Two test sites were used; one in France with a daily traffic flow of between 15000 and 23000, and the second in Germany with a traffic flow over 50000 per day.

**Measured impact**

**French Site**
N.B. The results indicated below for the French Site correspond to several scenarios; each of them involved more than 500 vehicles. The total amount of vehicles analysed was approximately 200,000.

During clear weather, speed limit displays (130 Km/h) on VMS had a significant impact on the average speed and on the overspeed percentage for the first four VMSs, but this impact was weak after the 4th VMS and did not continue after the 5th VMS.

During light rain, the impact of VMS (speed limit 110) was significant until the 5th VMS. The speed reduction was about 5 to 7 km/h and the percentage of vehicles which exceed the speed limit (110km/h) decreased from 78% to 72% : that is to say, there was an impact of the VMS but it was not sufficient to ensure an acceptable level of adherence to the posted speed limit.

During light rain, the percentage of vehicles exceeding 130km/h (i.e. the speed limit for clear weather) decreased significantly (from 42% to 32% at the first VMS, and from 47% to 35% at the third VMS).

During strong rain, the VMSs had an impact on the speed and the lane assignment (slow lane was used more frequently), but this is more difficult to prove from a statistical point of view because the level of data is insufficient.

**German Site**
Between 1991 and 1993 on the stretch of the A8 concerned, the total number of accidents decreased by more than 30% with a concomitant reduction of more than 40% in the number of people killed or injured. For the global network, a 10% decrease in the number of accidents has been observed during the same period.

The most significant decrease was observed for foggy days : more than 85%. During rainy periods, a decrease of 33% was observed for the A8. A global cost-benefit evaluation has been performed for the A8 Hohenstadt-Ulm.

**Other impacts**

The distance between two adjacent VMSs (4 km) seems too long, since the VMS effect was no longer observed on the points which are located 3.5 km downstream of the VMS.

Operators and managers were satisfied by the easy use of the software and also by the different possibilities given by this tool, the system provided: manual possibilities to intervene in case of roadworks and accidents, and the most important, automatic control of the VMS functionalities. The software was well accepted in terms of automatic and manual use (particularly in the case of roadworks).
Future needs and developments

- More time is required to record the impact the different weather conditions have on the drivers.
- More understanding is needed on the selection of working thresholds which match individual drivers’ performance so as to avoid the unnecessary strain identified in the ROSES project.
- The safety impacts of the interaction between technological support and driver behaviour need to be explored further.
- Weather and weather related road condition monitoring and forecast still remain a difficult exercise because of the instability of involved phenomena, and further investigations are needed (modelling, use of equipped vehicles as detectors).
- Consideration should be given to equipping patrol vehicles with sensors and communication facilities to the weather management centre.
- Weather related traffic management (either using advice or directions) should be further developed and assessed, especially in foggy conditions where there is a great risk of serial collisions; in this respect, integration between weather related traffic management and strategic management (at the scale of the network) is highly desirable.
- Weather information is interesting for a number of activities and could be privatised, relations with traffic management centres should be clarified in this respect.
- Institutional issues need to be addressed concerning the responsibility for signing (relevance, accuracy, timeliness, consistency, conflict of priority with other signs); the level of automation to activate signing systems should also be considered taking these issues into account.
4.3 PUBLIC TRANSPORT

Introduction
There is a growing recognition throughout the member states of the European Union of the need for good-quality public transport to both provide an alternative to private transport in congested urban areas and to reduce the environmental impact of cars. Against this background the main focus of the public transport work has been in DRIVE II

1. The development of common functional specifications for systems and contributions to the development of standards through a forum which has included operators, city authorities, planners and industrial partners.

2. Identification, development and promotion of solutions which improve the attractiveness and efficiency of public transport particularly in relation to:
   a) database development for systems integration and planning, under the general area of 'information management'
   b) vehicle scheduling and control systems
   c) vehicle priority systems
   d) passenger information systems
   e) demand responsive systems

3. An assessment of some of the barriers facing successful implementation and further development of ATT systems for public transport.

4.3.1 INFORMATION MANAGEMENT

The efficient management of information is critical to the achievement of the telematics systems in public transport. This can be seen in the following key aspects:

- Consistent System Architecture for Public Transport operations
- Underpinning data model consistent with the system architecture
- Development of public transport databases for transport operators
- Consistency of the public transport system architecture with that of other transport modes
- Existence of a framework generation, collection, processing and distribution of data
- Assurance of appropriate interfaces and protocols for data exchange
- Availability of required data from sources external to the individual application
- Reliability and consistency of data
- Management of data transmissions and minimisation of communications costs

Most of these aspects have been addressed within the Transport for Telematics program at the level of projects and Task Forces.

Measured impacts

Information management will not result in any direct impacts in terms of traffic patterns, travel choices, or demand management. It is background support which enables the more efficient implementation of the telematics systems.
Other impacts

The TRANSMODEL pan-European data model for public transport management has been developed in the EUROBUS project. Elements have been tested in other projects such as PHOEBUS, QUARTET and GAUDI. The data model has been submitted to CEN TC278 WG3 for adoption as a standard.

The HARPIST Task Force established common functional specifications for datamodels and terminology in passenger information systems. The CARTRIDGE Task Force was established to analyse systems providing information for trip planning or route guidance primarily for car users and which seek to integrate public transport information. Most likely scenarios have been developed and prioritised recommendations have been made for common data structures, data modelling and data messages.

The SATIN Task Force has developed system architectures for an Integrated Road Transport Environment. A system architecture for public transport (and for other domains) has been developed based on work from the various projects in the public transport domain. It has not yet been possible to fully integrate the architectures for the different domains, but they have at this stage been compared and contrasted. This work continues.

Munich (LLAMD project), Birmingham (QUARTET project), and Southampton (SCOPE project) have developed and implemented comprehensive travel and traffic information frameworks for the integration of traffic management systems and public transport systems. This has allowed effective transfer of data between applications for both management and information dissemination purposes.

Benefits

The key expected benefits from information management are improved integration of systems with increases in overall efficiency of the public transport operator; ability to integrate with systems of the traffic authority; standardisation of platforms and interfaces leading to a gradual downward movement of system prices; and greater transferrability of expertise and training tools.

Future needs and developments

- The main needs relate to the adoption of the harmonised program outputs on a broad scale, the identification of areas for improvement in the architecture and datamodels as they are implemented in practice, and the development of training tools to assist operators, researchers and manufacturers in exploiting them. It will be advisable to consider how developments in other IT domains (artificial intelligence, new processing techniques, data storage and retrieval, communications methods, etc.) can be imported from the IT domain into the transport sector.

4.3.2 VEHICLE SCHEDULING AND CONTROL

Vehicle scheduling and control systems (VSCS) or Automatic Vehicle Monitoring (AVM) systems are used to provide operational support to public transport operations. Such systems normally provide continuous real-time location of the vehicle within the system. This data, coupled with the scheduled activities, allows better management of the services both through direct intervention, and through the use of the data for better planning and scheduling of the services. AVM/VSCS have
been in operation in European and American cities for over fifteen years. The field trials focused on providing higher order services and better performance from the systems.

**Measured impacts**

No impacts of the implementation of VSCS on the public transport operation have been recorded.

**Other impacts**

The Hasselt field trial of the PHOEBUS project implemented a public transport database using TRANSMODEL to test the integration of VSCS and DRTS elements. This was achieved successfully, although it took significantly more effort than expected, and the approach can now be followed by other manufacturers and operators.

GPS was utilised successfully in the Hasselt field trial of PHOEBUS and the Bologna field trial of GAUDI and the required location accuracy was achieved. However, in urban areas the level of reception of satellite signals can be insufficient in street with high-buildings, and distance measuring systems may be needed to support the GPS data.

Integration of VSCS with passenger information systems has been achieved successfully in the field trials at Southampton (SCOPE), Munich (LLAMD), Birmingham (QUARTET, and Brussels (PHOEBUS). The VSCS provides the location and predicted arrival times at the various stops to the passenger information systems. Whilst the integration was successful, the systems had varying degrees of success in the accuracy of the arrival time predictions and consequent public confidence.

Integration of VSCS with bus priority systems was achieved in field trials at Southampton (SCOPE), Torino (PROMPT and QUARTET) and Göteborg (PROMPT). This requires higher location accuracy and accurate prediction of arrival times at junctions. The integration was achieved successfully. In the Torino trial (the most advanced of the three) the short-term prediction algorithms were within the required accuracy, but the medium-term predictions require further development.

In order to harmonise the outputs of the different projects, two Task Forces were established in 1995. The VESCOS task force defines the functional architecture for VSCS based on a large number of projects, providing a platform for both new R&TD projects and independent initiatives. The APOS Task Force provides guidelines for the use of GPS.

**Benefits**

The development work on VSCS systems has not directly improved the operational performance of individual systems. However, by providing the platform for the bus priority and passenger information systems, the overall efficiency and attractiveness of the public transport network is improved.

**Further needs and developments**

- Deployment is not dependent on further technological development. The operational effectiveness of VSCS systems could be improved further through the additional of artificial intelligence and/or knowledge-based techniques. Consistency of approach and standardisation of components and interfaces may both reduce system costs and increase potential for integration with other operational systems of the transport operator.
4.3.3 PUBLIC TRANSPORT PRIORITY

The implementation of public transport priority in advanced UTC systems has been an important application of Advanced Transport Telematics in DRIVE II. One project (PROMPT) concentrate uniquely on this application with developments and trials in London, Turin and Gothenburg concerning the SCOOT and UTOPIA/SPORT advanced traffic control systems. Public transport fleets covered buses and towns with public vehicle detection using bus transponders and inductive loops and/or Vehicle location (AVL) using radio communications. Impacts measured in PROMPT are summarised below:

**Measured impact**

For London, bus priority provided 22%-33% savings in bus delay per junction (7%-8% saving in journey times) and a reduction in bus delay variability of 6%-25% per junction with no significant impact on general traffic. For Turin, average tram/bus delay savings per junction of 97% were reported (19% saving in journey time) with an 11% improvement in service regularity and insignificant disbenefits to general traffic. For Gothenburg, the new traffic control system provided a 5%-15% saving in journey time for general traffic whilst maintaining absolute priority for trams.

**Other impacts**

Measured impacts have been incorporated into full social cost-benefits analyses: for London, the total implementation of 200KECU at 10 sites in Camden provided economic benefits of 145 KECU per year, giving a first year return of 72% or 16 months playback period. Benefits were predominantly bus passenger time savings and bus operating cost savings, and excluded potential benefits through modal change. For Turin, annual benefits of 3.2 MECU have been estimated for the installation of UTOPIA/SPOT, with PT-priority on a 5km tram route, against an implementation cost of 0.84 MECU.

These benefits were made up of travel time savings for PT user (43%), regularity savings (1%) and travel time savings for general traffic (56%). An economic evaluation of the AVM system SIS (Service Information System), produced overall annual benefits of the system at full capacity of 3.5 MECU through savings in ground staff, reduced irregularity and increased number of passengers. (For the latter, a 1% variation in speed perceived by PT users, without altering scheduled speed, led to a corresponding change of between 1% and 1.36% in demand.) Operating and maintenance costs were reported as 1.3 MECU.

Simulation modelling of the Gothenburg system indicated savings of 5% in fuel consumption and savings of 4%-5% in emissions of CO₂, NOx and CO.

In addition to PROMPT, four other projects included Public Transport priority applications priority applications (LLAMD, PRIMAVERA, SCOPE and CITIES). These cover the advanced European UTC systems SCOOT (U.K.), UTOPIA (Italy), PRODYN (France) and the newer BALANCE system (Germany). A review of 20 simulation and field trial assessments of PT priority in these projects has indicated 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 25% in London and Toulouse trials), (ii)
improved regularity of PT services (11% in Turin trials), (iii) savings in fuel consumption and emissions (4%-6% in simulation studies in Gothenburg, using enhanced UTC with PT priority) and (iv) limited evidence of increased PT patronage (in Turin and Munich). Economic cost-benefit analyses undertaken for four systems/strategies indicated very favourable rates of return, with payback periods varying from 3-16 months.

General benefits

This application has clear benefits to public transport operations, and can contribute towards a cleaner environment as well as encouraging modal change.

Future needs and developments

- The technology and strategies for public transport priority in UTC are now well established and applicable for implementation more widely across Europe. Further research has been identified as beneficial to improve priority strategies for more complex situations, such as where high public transport flows occur on "conflicting" routes on junctions.
- The Task Force PLATO has also identified the benefits and need for further developments towards greater integration of traffic control and public transport systems, including the sharing of data, infrastructure and/or control strategies. Increased implementation of AVL technologies for fleet management and real-time information offers an important platform for further system integration.

Problems And Limitations

The achievement of greater integration between traffic control and public transport systems will depend partly on organisational issues, including the bodies responsible for the different systems and the practical impacts on deregulation.

4.3.4 PASSENGER INFORMATION

Passenger information systems for public transport has been tested in many of the field trials and other projects within the ATT program. Within the field trials, five different means of dissemination of passenger information have been utilised:

<table>
<thead>
<tr>
<th>Dissemination media</th>
<th>Field trials/projects</th>
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<tbody>
<tr>
<td>At-stop real-time information</td>
<td>Southampton (SCOPE), Brussels (PHOEBUS), Lyon (LLAMD), Birmingham (QUARTET)</td>
</tr>
<tr>
<td>Public access enquiry terminals</td>
<td>Southampton, Piraeus (SCOPE), Madrid, Marseille, Thessaloniki (EUROBUS), Birmingham (QUARTET)</td>
</tr>
<tr>
<td>Travel centre enquiry support</td>
<td>Marseille (EUROBUS), Birmingham (QUARTET)</td>
</tr>
<tr>
<td>In-home terminals or PC access</td>
<td>Munich (LLAMD)</td>
</tr>
<tr>
<td>Portable personal units</td>
<td>Birmingham, Goteborg (PROMISE)</td>
</tr>
</tbody>
</table>

These have generally been implemented successfully to allow demonstration of their impacts. In addition, many cities have implemented real-time passenger information at stops as independent initiatives. These include London, Paris, Barcelona and Brescia.
Generally, the provision of passenger information has been utilised by actual or potential passengers to assist them with planning their trip, or to assist during the trip. Assistance during the trip is particularly needed at stops to advise on the expected arrival time of the next vehicle.

**Measured impacts**

Impacts of at-stop real-time information systems were assessed in a number of projects. The STOPWATCH application in Southampton (SCOPE/ROMANSE) involved equipping 114 buses into the required AVL technology and passenger information at 42 bus stop in a corridor of the city. 81% of users found the at-stop real-time information useful for their journey, and 58% advocated further investment. 3.7% of users stated they would use public transport more as a result, but there has been no measurable increase in usage. No change in punctuality was observed.

Five at-stop displays were implemented in Birmingham (QUARTET). Evaluation indicated that these were well received, giving passengers more flexibility in travel, but there was little evidence of increased public transport usage. Results suggest that this form of information improves the generation of service reliability, without directly leading to increased usage.

In Lyon, the SYMPHONIE real-time passenger information system was implemented at 47 bus stops for one bus route. Acceptance of the implemented real-time bus information was lower than for comparable systems (e.g. STOPWATCH).

This was partly due to the regonomics design and partly due to the power quality of the displayed information.

Public access enquiry terminals were implemented in 6 cities. For example, in Southampton, 10 trip planner terminlas were provided at public access locations. These were used 50-150 times per day, with very high user acceptance of ergonomics and usefulness. From 100 interviews at public access terminals in Birmingham, 16% of respondents said that they would use public transport more, but few would use public transport rather than car just because of the information; more positive responses were received in the suburban area compared to the central station where travel patterns were more constrained.

On-street information terminals were installed in Madrid at 9 city locations covering the entire transport and street network. The system used static timetable information and was upgraded to a GIS digital map as part of the project. Quantative data was collected from the terminals and in the case of Madrid showed 3,820 queries on 3 units with an average enquiry time of 3.5 minutes. A survey of 35 users in 1993 showed that 78% had no problem using the system, 50% found it very easy or easy to use, average difficulty 47% and very difficult by 3%. A further survey among general users found that 82% found the terminals easy to use, 39% had used the terminal before, 77% found the information given to be dependable and 90% indicated that the system improved the image of the public transport operator.

A Travel Centre Enquiry Support Service was a major application in Birmingham (QUARTET), involving 6 travel information centres. From 100 interieurs of users, 10% said they would not have made the journey without the information; 8% used public transport mode instead of other previous preference; 92% consider the information adequate; 76% consider the information to be accurate.
The DEFA system in Munich (Dynamic Electronische Fahrplan) provides on-line access to public transport service databases with a search facility and offering in-home/office PC access. A high acceptance of the system was noted, with users indicating that they would use public transport more as a result.

Portable Personal Unit including public transport information were trialled in Birmingham and Gothenburg. From 46 interviews of 50 users of portable terminals in Birmingham, it was included that these were well received; 47% said they would use public transport more, but 24% of rail users would use car more if traffic information was available. Potential ergonomic improvements were also identified.

Future needs and developments

The following main points are noted:

- Application of Public Transport Passenger Information Systems requires availability of communications systems that are appropriate for the size of database and speed of interrogation (SCOPE).
- Databases must be of high quality in terms of coverage and accuracy (QUARTET), and information must be frequently updated (SCOPE).
- Attention should be placed on defining functional and technical specifications and installing/optimizing software (QUARTET), and potential problems with MMI technology and user acceptance (SCOPE).
- Institutional barriers between authorities and operators need to be addressed (QUARTET), especially where public transport has been deregulated (SCOPE).
- System improvements can be achieved with improved MMI, and multimedia application to instruct public on use of terminal facility (SCOPE).
- Large-scale, long-term trials are needed (QUARTET).

4.3.5 DEMAND RESPONSIVE SYSTEMS

Demand Responsive Transport Systems refer to public transport services which are flexible in some fashion (departure time, route, vehicle type) etc. and which are modified in some way to the current identified needs. Typically they are buses services, but may also be integrated with other local forms of transport such as taxi, inter-urban bus and rail, and some services may be designed for special needs users. Efforts for such services in the past two decades have caused interest, but have generally not been economically viable. The addition of a telematics layer has the potential to allow virtually real-time communication of user needs to the vehicle, optimisation of route and passenger assignment, and management of the reservatin and payment functions.

Measured impacts

Field trials in Hasselt (B) utilised a VSCS system to support demand responsive bus services on six new lines which allowed a certain flexibility on route deviations and stopping points within an otherwise fixed schedule. The automation of the DRTS booking, reservation and control process did not result in any observed increase in usage over the field trial period.

Other impacts

The automated system provided satisfactory handling of bookings, obviating problems of wrong or missed bookings. 80% of users were satisfied with ease of booking. The customer satisfaction with
the interface with the system was partially offset by the quality of the service connections (where interchange was required). This was an operational matter and will be addressed by the operator.

The operators showed high satisfaction with the system. The automatic transfer of service journey data to the driver saves a significant amount of driver time (30 to 60 minutes per day), thus improving efficiency. At the same time, the drivers perceive an improvement in working conditions from this feature.

The integration of the DRTS with the VSCS system proved successful. The GPS system provided lower than expected, but adequate accuracy for the purpose of the DRTS services.

Benefits

Citizens and communities can avail of increased access to public transport systems, and thus regain mobility opportunities. Walk and wait times for potential public transport users can be reduced, whilst it is possible to ensure that appropriate vehicles are allocated where there are special users needs. The operator will have the possibility to increase patronage with small increases in costs, whilst also having the opportunity to increase service efficiency.

Problems and limitations

The reported field trial was of extremely limited scope and duration, with the evaluation focusing on the user interface with the system and the technical functioning.

Future needs and development

- DRTS need to be tested on a larger scale in a wider range of environments.
- On the travel impacts side, the potential for mode shift, integration with other modes, and increase in personal mobility needs to be established.
- Business cases are needed both for the implementation of DRTS, and for the transport telematics layer.
- The effectiveness of the core reservation and allocation software needs to be established as this is critical to the quality of service offered and costs incurred.
- The institutional and operational aspects of multi-operator and multi-mode environments need to be examined.
4.4 FREIGHT AND FLEET MANAGEMENT

Freight Transport received increased importance in the Transport Programme. The projects in this domain had the objective of supporting and sustaining future economic development in Europe by ensuring the most efficient use of the available freight transport system, by improving freight transport reliability, safety and customer services, ensuring better conditions for drivers and dispatchers as well as helping to reduce the unfavourable effects of freight transport on the environment and ease congestion on the roads.

The projects and task forces on "Freight and fleet management" addressed the following specific objectives:

1. Promote the application of Advanced Transport Telematics (ATT) in freight and fleet management activities.
2. Optimise the use of the transport infrastructure for a reduction of environmental impact and increase in traffic safety.
3. Develop an Open System Architecture for Computer-Aided and -Integrated (freight) Transport Systems (OSA-CAIT) within which most potential freight users and applications will be integrated within the shortest time and at a minimum cost.
4. Achieve European concertation in the development of applications.
5. Make common or co-ordinated use of resources in demonstrators or pilot projects.
6. Harmonise evaluation methods and arrive at commonly accepted and comparable results.
7. Generate input to international standardisation procedures and bodies, and finally
8. Share conclusions with other projects in the Advanced Transport Telematic Programme and exchange of experience with similar programmes in the US and Japan.

The topic of the definition of an Open System Architecture for Computer-Aided and Integrated Transport (OSA-CAIT provided an overall framework of the work which addressed four separate subjects:
- Electronic Data Interchange (EDI) of messages for freight transport management applications within fixed networks (stationary EDI)
- Mobile Data Communication (MDC) System (mobile EDI) for fleet management applications
- Tracking and Tracing of goods and vehicles (especially in a combined transport environment)
- Dangerous Goods Monitoring and Control

Each of these subjects were in turn addressed from various points of view mainly centred around five topics:
1. User Requirements and Specifications
2. Further Development of appropriate Integrated System Architectures
3. Design and Implementation of Pilot Systems
4. Evaluation of capabilities and impacts, and
5. Suggestions for common functional specifications and system design.

A clear characteristic of the work was the effort to formulate and promote "integrated" solutions which could be blended together with respect to their inputs and outputs, within the overall urban or interurban IRTE (Integrated Road Transport Environment) that Transport Telematics is promoting in Europe.
4.4.1 FREIGHT MANAGEMENT

The use of Transport Telematics for Freight Management essentially aims at improving the efficiency of freight transport operations by extensive use of telematic tools such as Electronic Data Interchange (EDI) and (to a more limited extent) Mobile Data Communications (MDC). EDI is implemented mainly to increase the productivity of administrative tasks and to reduce the chance of errors and, unlike MDC, EDI is not effective in reducing mileage or other operational impacts. On the other hand EDI is very important because it is one of the telematics systems which enables SME's to conveniently connect to freight services.

The METAFORA project aimed specifically at decreasing indirect costs by developing a certain degree of non-paper administration (i.e. reduction of manpower, requirements for repetitive tasks, administrative overheads, human errors and related complex paperwork involved) while building up a real shipper - operator partnership and improving the customer service level.

To support business expansion and improve transport efficiency along the entire logistical chain, extensive use of EDI between transport operators and shippers was implemented and a suitable combination of MDC and EDI was applied where appropriate.

In METAFORA 6 pilot trials were carried out, with 4 operators exchanging EDIFACT messages with 5 shippers and one ferry company. Messages included the transport order, contract status, ferry booking, ferry confirmation and ferry status. The number of messages exchanged between two parties varied from 72 to 912 over the pilot period, which was a very small percentage of the potential number of messages to be exchanged. Data were collected and analysed over a period of 5-8 months. A new message subset, especially designed for SME operators, was also developed and later applied.

Project IFMS had the main objective of increasing freight transport competitiveness by integrating freight logistics and cargo management within the use of advanced Information and communication technologies for fleet resources and vehicle management. All transport companies involved in the project used a customised tool-sets based on a common IFMS system architecture.

Within EU and EFTA member states, extended field trials took place; IFMS established an EDI pilot in France between a transport company and a shipper, exchanging transport orders and status reports. All messages were according to EDIFACT standards.

The trials aimed at implementing system concepts to real transport operations. A wide scope of transport segments, functions and technologies implemented and more than 270 equipped vehicles led to a sound statistical basis for evaluation. Furthermore, a comparison 'starting point' versus 'state of the art' was made by means of a cost/benefit analysis and a technical analysis as well as a analysis of working conditions.

Project LLAMD, on the other hand, partly aimed at improving freight management efficiency. For this reason, an assessment of the suitability of transport telematics for freight management was carried out in Munich to also assess the potential use of S-Bahn (Metro) for transferring air freight between airport and city. Field trial activity was limited to questionnaires, test studies and a workshop.

Project FAST/TITE was only a feasibility study about the use of transport telematics tools to connect SMEs to freight transport centres: it provided detailed knowledge about SME
requirements on freight transport and a database on related Transport Telematics systems, telematics product providers and transport centre characteristics.

**Measured impacts**

- Concerning the impact on Managers of Freight & Fleets, IFMS has obtained the following results on savings in travel and dispatch times and in travelled distance, which are based on three test scenarios of capital cost per system/vehicle:

<table>
<thead>
<tr>
<th>Category</th>
<th>average</th>
<th>best</th>
<th>worst</th>
</tr>
</thead>
<tbody>
<tr>
<td>Savings in travel time:</td>
<td>4,9%</td>
<td>16,5%</td>
<td>0,0%</td>
</tr>
<tr>
<td>Savings on dispatch   :</td>
<td>12,3%</td>
<td>35,2%</td>
<td>-4,2%</td>
</tr>
<tr>
<td>time:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savings on km:</td>
<td>6,1%</td>
<td>21,3%</td>
<td>0,3%</td>
</tr>
</tbody>
</table>

| System capital cost:   | 12735 ECU | 3515 ECU | 25630 ECU |
| Capital cost per       | 5486 ECU  | 2020 ECU  | 11625 ECU |
| vehicle:               |          |         |          |
| System running cost    | 3828 ECU | 0 ECU   | 11616 ECU |
| per year:              |          |         |          |
| Yearly running cost    | 2246 ECU | 800 ECU  | 6580 ECU |
| per vehicle:           |          |         |          |
| Internal Rate of       | 21,1%    | 63,4%   | 2,4%    |
| Return:                |          |         |          |
| Payback Period in      | 3,4      | 1,3     | 5,7     |
| years:                 |          |         |          |

- In terms of environmental impact IFMS has identified the following data on Emission/Energy reduction per vehicle and year (cost-benefit-analysis):

<table>
<thead>
<tr>
<th>Emission/Energy</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO:</td>
<td>6,076 kg</td>
</tr>
<tr>
<td>NOx:</td>
<td>39 kg</td>
</tr>
<tr>
<td>HC:</td>
<td>31 kg</td>
</tr>
<tr>
<td>Fuel:</td>
<td>1 %</td>
</tr>
</tbody>
</table>

**Other impacts and potential benefits**

According to the LLAMD results from a workshop and the answers to questionnaires, has indicated that 50% of the respondent Managers of freight & fleets considered that Transport Telematics applications in freight management could improve the service quality of their freight operations. As a result of the freight & fleet management trial implementation, 300 annual offences or non-compliances with required driving and resting periods were recorded.
As a result of EDI use in IFMS, the data have become more reliable, and transport order cycle time was reduced. The companies have gone through a learning process which they will be able to use later. Further, EDI, when integrated with the inhouse system, is likely to have a positive payback period; but this depends on a number of factors, such as the type, size and frequency of messages. It was also found that the initial investment costs were relatively high, in contrast to the variable cost, which was low. The variable message costs can be further reduced by combining a number of messages within one connection.

In addition to an improvement of the IT awareness within the company and the company image itself the company METAFORA discovered that, through the building of a real shipper-operator partnership it was possible to achieve a reduction of order-handling process time and of the manpower requirement for any repetitive task to be performed within an integrated EDI situation. More specific benefits were the reduction of human errors, the improvement of transport efficiency along the logistical chain and the increase of customer satisfaction by improving the level of information supply and customer flexibility.

**Problems and limitations**

There were a number of technical problems in using EDI between transport operator and shipper. These were mainly due to bad quality telephone lines, an unreliable X.25 network in some countries and an overheated communication card. However, after initial start-up problems, no serious technical problems were met.

With respect to mobile EDI, the overhead added by the EDIFACT standard caused unacceptably high transmission costs.

The implementation of EDI has been a long and slow process. Difficulties arose in matching timetables between partners, and EDI was a completely new topic for most companies. Since only a limited number of messages was exchanged, the companies did not change their working pattern, and did not integrate EDI in their inhouse system, with one exception. They preferred to work on a stand-alone workstation while often the traditional communication pattern remained in place. As a result EDI did not result in efficiency gains.

**Implementation and integration aspects**

Together with the proof of the use of its system architecture, IFMS has provided a validation of the benefits observed during the field trials; the various new concepts and the prototypes close to marketable products (such as the communication platform and the system toolbox) can provide valuable hints for system suppliers.

**Future needs and developments**

- Both METAFORA and IFMS have shown that there is a need to create further awareness, knowledge and experience on EDI applications by promoting, encouraging and partly financing the "re-engineering" of processes and systems within SME's, encouraging EDI software development for SME's and integrating EDI with other telematics applications.
- It will significantly contribute in encouraging the development of Value Added Networks that will provide actual services to SMEs and promoting the use of EDI applications by the administrations and the various other suppliers of transport services.
A prerequisite for an effective deployment of EDI applications will still be represented by the promotion of EDI standards and, in some countries, by the improvement of the telecommunications infrastructure.

4.4.2 FLEET MANAGEMENT

Fleet Management addresses the need to improve the efficiency of freight transport operations mainly by exploiting the capabilities provided by Mobile Data Communications which provide the enabling technologies for Fleet Management; however, other projects in these domain have also used MDC in their pilots, for example as an element of a Hazardous Goods Monitoring and Control system.

At the start of the projects’ activities only two MDC systems were available with a true European coverage: Inmarsat-C and Euteltracs. Euteltracs already had quite a few users in Europe and even more in the USA, but Inmarsat-C had just started to launch its services. Other MDC-systems did not yet exist (e.g. GSM) or did not have a European coverage (e.g. Mobitex).

A more efficient road freight transport would also result in the derived benefit of reducing its negative effects on the environment.

To allow for a convenient and widespread exchange of information, the use of MDC was achieved though the development of an Open System Architecture for Computer-Aided and -Integrated (freight) Transport Systems (OSA-CAIT).

The METAFORA project aimed at improving customer service and control capabilities of SMEs on their transport operations.

By using Mobile Data Communications (MDC) and Global Positioning Systems (GPS) as well as trip recording equipment, the project aimed at demonstrating the possibility to achieve time savings in communications between planners and drivers and in processing trip data to improve management information, improved control of costs and reduction in empty vehicle running.

The METAFORA pilot trials concerned message exchange under real working conditions between the transport planners and the drivers by five transport operators from four European countries (The Netherlands, Belgium, UK and Greece). During the trial, 32 vehicles were equipped with MDC equipment (Inmarsat-C satcom system) and data recorders (onboard computers), while 31 vehicles only had data recorders. The performance of the two groups of vehicles was monitored for 13 months in the corridors North-western and Southern Europe.

The main objective of project IFMS was the integration of advanced Information and communication technologies into the transport logistics process for a more effective fleet and vehicle management as well as the increase of competitiveness to be achieved through an improvement of resources utilisation.

Within a common communication platform based on an open system architecture, the project has developed a customised tool-sets for transport companies and specific routing/trip planning algorithms to be used in conjunction with digital road maps and Global Positioning System (GPS) equipment.
IFMS implemented and tested under real working conditions 6 different types of MDC (Mobitex, Modacom, Traxys, Inmarsat-C, Euteltracs and GSM) in the aim of implementing system concepts for real transport operations. In total, 9 transport companies from a wide scope of transport segments participated with 107 trucks in pilots within the EU and EFTA member states having a duration from 2 to 8 months, which led to a sound statistical basis for evaluation.

Furthermore, a comparison 'starting point' versus 'state of the art' was made by means of a cost/benefit and a technical analysis as well as an analysis of working conditions.

In addition to its main activities in the domain of Integrated Interurban traffic Management, project MELYSSA also addressed the objective of providing support and improving the management of commercial fleet operations by using specific telematic tools such as the TICOM (PC and software) and STRADA (data dictionary, hardware and software) systems.

In the MELYSSA field trials, all tests were carried out within the Stuttgart-Lyon-Barcelona corridor in a real environment and with real information.

**Measured impacts**

- In terms of impact on fleet Managers, MELYSSA results showed that up to 37.5% of the currently wasted time (waiting time, pick-up time, delay time) could be saved using MDC.

- As a result of combining traffic information with global communication functions, MELYSSA demonstrated an increase of the total annual benefit by up to 2.5%.

- MELYSSA trials showed that, with the use of Transport Telematics, the number of delayed arrivals decreased by 35%.

- METAFORA has shown that, in average, Mobile Data Communications led to a marginal increase of transport cost per vehicle and km in the amount of 0.001 ECU.

- The IFMS pilots, where shorter evaluation periods and less detailed analysis have been applied, showed mileage reductions by 0.3-23.3%, vehicle time reduction by 0-16.5%, reduction of dispatch time by -4.2 to +35.2% and fuel savings of 0-1.4%. As a result payback periods vary between 2.3 and 3.2 years.

It can be concluded that the expected increase in efficiency within the pilots indeed has taken place. For the transport companies payback periods of satcom (based on tangible benefits only) varied from 4.1 to 8.4 years. For the environmental aspects a reduction in mileage on international transport of 2.4% seems to be feasible, leading to a reduction of emissions and accidents.

IFMS has provided the following results on savings in travel and dispatch times and in travelled distance, which are based on three test scenarios of capital cost per system/vehicle:

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</tr>
<tr>
<td>Payback Period in years:</td>
<td>3,4</td>
<td>1,3</td>
<td>5,7</td>
</tr>
</tbody>
</table>

METAFORA has shown the following accident reduction (per year):

<table>
<thead>
<tr>
<th>scenario</th>
<th>less accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum</td>
<td>300</td>
</tr>
<tr>
<td>minimum</td>
<td>3</td>
</tr>
<tr>
<td>average</td>
<td>152</td>
</tr>
</tbody>
</table>

In terms of environmental impact METAFOA has shown the following Emission reductions:

<table>
<thead>
<tr>
<th>scenario</th>
<th>bn tonnes</th>
<th>ppercent</th>
</tr>
</thead>
<tbody>
<tr>
<td>maximum</td>
<td>9900</td>
<td>50,30%</td>
</tr>
<tr>
<td>minimum</td>
<td>93</td>
<td>00,05%</td>
</tr>
<tr>
<td>average</td>
<td>4480</td>
<td>20,40%</td>
</tr>
</tbody>
</table>

As a result of freight & fleet management, fuel consumption per vehicle and year decreased by 2.355 litres (based on 150.000 km per year).

On the other hand IFMS has shown the following Emission reduction per vehicle and year:

<table>
<thead>
<tr>
<th>Emission</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

METAFOA 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 impacts and potential benefits

Both drivers and dispatchers feel comfortable in using the new 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.
The system has increased the operator awareness of the capabilities of new technologies; while providing significant time savings, it also allowed to improve the management of vehicles and fleets, the efficiency of information management and the company competitive position.

The continuous interaction between pilot test and the resulting technological developments led to improvements in the system performance.

The reduction of Transport cost led to a reduction of prices, trip length, emissions and number of accidents.

The success of the project was also demonstrated by the operator requests to equip more vehicles with MDC equipment.

The IFMS project has validated the proposed system architecture and provided valuable hints to the system suppliers; it has also derived concepts and prototypes close to marketable products, such as a communication platform and a system toolbox.

**Problems and limitations**

MELYSSA has experienced delays in the availability of STRADA system.

METAFORA field trials could not run long enough to allow for changes in operational characteristics of the operators to be observed.

The operational requirements of trucks used in the pilot did not allow an immediate repair to the MDC equipment when affected by technical problems.

The project experienced the need for more reliable telecommunications infrastructure, communication services and local technical support.

In the pilots only 88-93% of the text messages and 60% of the position messages were successfully received. The mobile-to-mobile configuration used in England delivered unsatisfactory results. At one stage the Inmarsat-C network did not have enough capacity to cope with the traffic, causing enormous delays in transmission.

In the Athens/Pireaus area the X.25 network caused serious problems.

In general it was felt that many problems would not have occurred if the hardware and software components had been tested more thoroughly by the supplier. Better help from the suppliers would have been beneficial, especially for SME’s.

For the integration of MDC with other applications the importance of a system integrator with the know-how needed to integrate components became evident. A hotline type of helpdesk in case of malfunctioning would have been necessary.

In a Swedish pilot an EDIFACT standard for MDC appeared to generate too much overhead, resulting in high costs and low transmission speed. However the companies in the pilots were in general satisfied with the MDC technical performance.
Most MDC applications worked well as stand-alone application, but several problems occurred when the systems were integrated. At this moment stand-alone applications are 'tied together', bringing high extra costs for adaptation. There is no open architecture yet which facilitates integration of systems.

**Implementation and integration aspects**

The projects have shown that there is a need for further integration of the various MDC applications in the truck and at the homebase, so that information from the truck can be automatically forwarded to the client internal system and vice versa.

**Future needs and developments**

- Functional specifications of the modules have to be described as well as interfaces.
- Configuration and use of hardware and software should require less extensive knowledge of computers, especially for SME's.

### 4.4.3 INTERMODAL TRACKING & TRACING

Transport Telematics applications on Multimodal Tracking and Tracing focussed on the need to improve the operational efficiency of the multimodal (or combined) freight transport system and thus provide a better service to the users: it requires the establishment and integration of proper communication linkages among all actors involved through the development of an open interface environment for the exchange of information.

COMBICOM project addressed this scope by developing an information system able to communicate all relevant operational road/rail information, e.g. the status of Combined Transport (CT) load units (containers, swap-bodies, semi-trailers etc.) at particular points of their journey, to all relevant system participants, including shippers, highway operators, hauliers, freight forwarders, customs, and receivers of goods.

The system, designed to allow the exchange/share of real-time information about future transport, position of load units and warnings to highlight expected transport exceptions to operators, was implemented on the road-rail corridor Rotterdam-Cologne-Verona with the participation of five operators and fifty customers in accordance with the user requirements of the terminal organisations and their clients; it was based on a UNIX distributed system architecture and used embedded automatic identification equipment, tags and EDI readers interfaces.

The pilot implementation was monitored in full operation of multi-consignment transport transactions related to user satisfaction, performance and reliability. Because of the limited number of tagged CT units, the number of units per day (4) amounted to only 1% of the potential (480 per day).

COMBICOM II was a project extension that continued the research and pilot implementation activities of COMBICOM and extended the corridor to Brindisi as well as to inland and deep sea transport; the complete intermodal corridor from Rotterdam to Verona with the extension towards Brindisi was operational from November 1994.

**Measured impacts**
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.

A cost-benefit-analysis showed a profit increase for each transport action of 4.5 to 15 ECU for operators and 20 to 80 ECU for shippers/forwarder.

**Other impacts and potential benefits**

The project activities led to the availability of marketable products such as the COMBICOM Kernel, user interfaces and client modules, the EDI front-end.

Reduced pick-up time for freight vehicles and, in case of delays, better information on expected delay times to freight owners.

In case of misroutings or loading errors, to the benefit of of freight & fleets Managers, "lost" items were usually found immediately.

With reference to the infrastructure costs, the most efficient solution was identified for the price per road/rail-terminal and per unit.

No capacity limits were found for the number of transactions, the transport mode and the day of transaction.

The use of Transport telematics will likely improve the competitive position of combined transport as well as the international cooperation between operators in EU countries.

The Multimodal Tracking and Tracing information will lead to a greater flexibility of the Combined Transport system. The most important benefit on the demand side appears to be the higher quality of transport, while on the supply side the improved opportunities for resource and fleet management are certainly the most important features.

**Problems and limitations**

Any infrastructural project seems to suffers from an 'all or nothing' attack from outsiders.

Extension of coverage (as percentage of traffic covered on the corridor) and wish for an extension to other corridors appear to be conflicting limitations. The project management considers a gradual growth with reasonable early benefits the only way out of this dilemma.

The actual implementation gave rise to more problems than expected due to the novelty of the technology and the slow process of granting the required permissions.

Readers accessed through public networks caused more problems than those connected via private networks. Furthermore the technology of the combi-reader is still under development by the reader supplier.
The developed architecture is adequate but various questions concerning cost/benefits and cost allocation figures need to be solved.

Implementation and integration aspects

A rough estimate of the current MMTT system cost for the German network (50 terminals with 4 readers, 50,000 swap-bodies with 1 tag, 15,000 wagons with 2 tags, software and computers at 50 terminals) is around 5 million ECU and the total investment and operating cost is estimated at about 1.55 DM per consignment.

As a minimum the current system should be upgraded to include integration with the inhouse system (booking and order processing), establishment of a “reader and tag” infrastructure, links with terminal operators and railways.

The user-computer interface also requires some changes/additions to achieve an optimum balance between quick response times and at-a-glance access to as much information as possible.

Future needs and developments

- The users evaluation of the present MMTT system has indicated that current features should be further expanded and innovated to allow for a full exploitation of the system potential by extending the system to other UIRR axes, other intermodal rail operators and other modes in the intermodal chains.
- Users also need information about the units when the trip is not planned with strict estimated departure and arrival times.

4.4.4 HAZARDOUS GOODS MONITORING AND CONTROL

Transport Telematics applications on Hazardous Goods Monitoring and Control focussed on the need to improve the safety features of hazardous/dangerous goods transport, especially on roads, by means of a suitable integrated monitoring and control system. It requires the definition of a common European system for the monitoring and control of Dangerous Goods Transport (DGT) on motorway corridors and of a common set of data exchange messages and communication protocols.

The identification of the most suitable architecture for an information system to monitor hazardous goods shipments within an intermodal transport environment requires the conceptual development of an integrated polycentric system architecture able to provide real-time information about the movements of load-units (containers, swap-bodies, semi-trailers, etc.) on several corridors and regions, using Automatic Vehicle Locating (AVL) equipment.

Several projects have focused on the development and testing of a Hazardous Goods Monitoring and Control (HGMC) system.

HGMC systems, primarily aimed at improving the safety of dangerous goods transport, had to be made cost-effective to become also accepted by the users, i.e. the transport companies. Since many different parties were involved, the HGMC systems adopted an open system architecture.

A common structure could be deduced from the various HGMC systems developed under the Transport Telematics programme. Each HGMC system included at least the following components:
• A kernel component or control centre, equipped with one or more databases which could be either centralized or decentralized. The databases held both static and dynamic information.
• A number of mobile nodes (in-vehicle equipment), collecting information on the vehicle status and transmitting it to the control centre.
• A local component (end-user), consisting of a number of terminals to assist the user in accessing the database and present the information.
• Terrestrial and spatial telecommunication components to link the kernel, mobile and local components.

Test sites included the corridor Dublin-Rotterdam-Athens, the A55 in North Wales and M4 in South Wales, the A99-A8 and A93 in Germany, the A22 in Italy, a highway in Austria, various stretches of road in Spain, the motorway Lisboa - Porto and the highway Aveiro - Vilar Formoso in Portugal.

Project FRAME aimed at optimising the freight and fleet management operations of hazardous goods cargo transport for administration, commercial and other extended users by maximising the system reliability and availability through the utilisation of distributed database with high communication throughput and message accuracy.

Such an approach was chosen to minimise the message delay time and the position and estimation of errors, to satisfy the capacity and security requirements, to facilitate monitoring, statistical data collection and notification of emergency services, to provide chemical data information and messaging capability for authorities and drivers, as well as to enhance the efficiency of operation and of emergency services.

To implement the above functions equipment from several Information & Communication Technologies were used, from satellite (Eutelsat, Inmarsat) to terrestrial communications, intelligent terminals, mobile equipment (Euteltracs, Inmarsat-C, GPS), client/server networking and distributed databases.

FRAME trials were concerned with the evaluation of two distinct activities, firstly with monitoring of hazardous goods through the trial areas and secondly with the response to a staged incident/disaster exercise involving vehicles carrying hazardous goods cargo. Three commercial operators with 100 totally equipped vehicles and one administrative user participated to the trials.

In the Ireland-Rotterdam-Athens corridor, pilot trials involved long range communications for monitoring, management and control with associated aspects.

Sporadic emergency field trials were performed in Wales; North Wales was used as the experimental control area for the FRAME trial exercises. Vehicles were continuously monitored using the existing roadside systems and infrastructure associated with A55. A disaster exercise was staged during October 1993 so that a benchmark of performance could be obtained and results could then be used in assessing the real worthyness of the project.

A pilot system was fully implemented in the South Wales area, concentrating on the M4 corridor, which involved the implementation of three intelligent terminals to enable the local fire, police and ambulance services to monitor and control the movement of appropriately equipped vehicles travelling via the local road networks. This enabled continuous monitoring of vehicles and provided means to evaluate the FRAME system equipment.
FRAME has provided its technology to many other projects, such as ARTIS, CITRA, SAMOVAR. Increased know-how in the development of monitoring, management and control systems for freight and fleet tracking with much potential to market system components - intelligent terminals, mobile terminals, networking and other value-added systems - very shortly.

Project CITRA implemented and tested an international integrated monitoring and control system for hazardous goods transport in a pilot project along the Munich-Verona corridor.

The PORTICO project focussed on the evaluation of EDIFACT-based EDI data exchange to monitor safety characteristics of hazardous goods' road transport using Inmarsat communications, GPS (Global Positioning System) equipment and PC-based traffic control & fleet management system simulators.

PORTICO’s objectives were to define, design and develop a HGMC system to be applied within an administrative/commercial environment. The system should be used for monitoring hazardous goods cargo flows, real-time checking of hazardous goods vehicles and accident management by authorities and fleet/vehicle management. It was also designed to identify the constraints of a pan-European solution and test possible solutions. The resulting prototype HGMC system was tested in a real working environment.

The field trials took place in Portugal, where the position & status of equipped vehicles (GPS + SAT communications) was continuously monitored.

Measured impacts

Messages about status changes in the PORTICO trials were received in about 3 to 6 minutes instead of the hours required under previous conditions.

Various other impact were observed but not quantitatively reported; they are included in the following section.

Other impacts and potential benefits

The hazardous goods monitoring system enabled more cost-effective freight and fleet operations; in the FRAME project, for instance, paper work was reduced and automated processing of deliveries became possible. Therefore the number of administrative personnel could be reduced substantially. The FRAME system has also shown a high potential to increase the number of customer served with the same operational resources due to the fact that just-in-time and efficient operations became possible.

The following results were based on observation studies and answers to questionnaires:

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<tr>
<th>Indicator</th>
<th>Impact</th>
<th>Source</th>
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<tbody>
<tr>
<td>Message and information errors:</td>
<td>minimized</td>
<td>observation</td>
</tr>
<tr>
<td>Error in measuring vehicle position:</td>
<td>minimized</td>
<td>observation</td>
</tr>
<tr>
<td>Unauthorized system access:</td>
<td>minimized</td>
<td>observation</td>
</tr>
<tr>
<td>Man-machine interface effectiveness:</td>
<td>acceptable</td>
<td>questionnaires</td>
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</table>
All pilot trial users responded favourably to the FRAME system, expecting its implementation on a pan-European level to contribute in achieving efficient, harmonised and safe operations.

On the basis of the observed reduction of emergency response time and on the estimated high potential for reduction of accidents, accident consequences and environmental damage due to hazardous goods transport incidents, it is expected that a significant increase of safety can be achieved through the management, monitoring and control of vehicles and resources.

In general emissions and noise were reduced as a result of the monitoring of speed and vehicle conditions; by also monitoring and deviating noisy vehicles from urban/public areas, noise impact was reduced in such areas. Energy consumption was also reduced by reducing empty vehicle km and improving the provision of road assistance.

On the basis of a cost-benefit analysis, the FRAME project demonstrated operational, administrative, environmental and other benefits with minimal investment cost as well as a reduction of access costs for commercial users and government authorities.

**Problems and limitations**

In one pilot the average time interval between sending and receiving messages was on average 32 min compared with the required 15 minutes.

Problems were experienced in another pilot on the connection to a remote database for the retrieval of information.

The map resolution was not always sufficient and the maps did not cover all trips; these problems were solved at a later stage.

In the FRAME project, impact results were limited due to restrained users.

Legal issues among different users and national organisations caused problems and delays until negotiations and agreements could finally be reached.

Taking an intangible profit into consideration, PORTICO operators considered the system cost as too high.

Some project trials experienced problems with deliveries from suppliers.

**Implementation and integration aspects**

Preliminary results show that routine hazardous goods monitoring on its own offers limited benefits, but in combination with fleet management systems might be commercially interesting. In such a case the marginal cost for a HGMC system would be acceptable.

**Future needs and developments**

- It was noted that a vehicle trajectory calculation based on the last position report would be helpful. Similarly the local database should acquire historical trip data for a vehicle or a group of vehicles.
• During the monitoring trials it became clear that the fleet system will need to filter vehicle location and status data, sending to the traffic control centre (TCC) system only alert messages or messages needing direct action by TCC operators.
• For messages from the TCC, the nature of the fleet operator's business determines the value of different information.
• A HGMC system can only be successful if harmonised all over Europe. Therefore, standards must be agreed upon and the system should be open.
• Since HGMC will only represent a cost for transport companies, where possible mobile systems should be included which are already used for commercial purposes by advanced transport companies. This will increase the acceptability of HGMC systems.
• Furthermore, links with other authorities and modes should be intensified.
4.5 AUTOMATIC DEBITING & DEMAND MANAGEMENT

The work on Automatic Debiting and Demand Management was related to the use of Transport Telematics technologies in helping urban authorities and the managers of interurban transport to strike an efficient balance between the traveller's demand and preferences, and the capacity of the road and rail network in accordance with the transport policy of the administration(s) concerned. The application of the policy should utilise the ability to affect user's choice of mode as a function of travel time charge (to the user) and comfort. This in turn implies controlling the use of road space, the provision and pricing of parking, and the complimentary investment in public transport by rail and road. The applications include direct pricing for the use of roads, and will require therefore effective measures for policing and enforcement.

4.5.1 INTEGRATED PAYMENT

The use of smart card as the key payment tool to implement automatic debiting systems is already established in some areas of the European transport system (even in a multi-provider environment) but it is characterised by a lack of standardisation and multiservicing capabilities which is typical of the bank-type magnetic strip credit card.

On the other hand, since it appears that the EU central banks feel that the introduction of an electronic purse as a new payment instrument does not pose insurmountable problems and that, since it could contribute to making payment systems more efficient, they will not unduly hamper its development, though at the national levels the commercial banks certainly do not see such developments in favourable terms.

Even if (unlike credit cards) the most widespread applications of smart cards for debiting or crediting purposes (such as telephone cards) are essentially mono-service it appears that there is a strong need for a fully transparent approach to card development that covers both the transport and banking sectors.

The legal issues surrounding the operation of smart cards containing an electronic purse are many and complex and, whilst it is clear that the right to issue an electronic purse needs to be restricted to credit institutions clear rules are still missing about who could be allowed to disable parts of the card or actually confiscate it as a result of its improper use.

Security aspects and related piracy possibilities (as emerged from the pay-TV as well from the retail sector for the conventional credits cards) indicate the need to provide a suitable security framework to tolling and Integrated Payment services applications in view of the 4 rapidly growing prospects for a rapid growth of smart card use as well as of automatic debiting applications on European motorways.

The main objectives of the projects involved were validating traveller and operator acceptance of Integrated Payment Systems. For the management of mobility demand and identifying the institutional aspects to be resolved for full scale implementation, by using contact-type smart-cards and portable card interface units able to communicate (via IR or microwave links) with televalidating equipment and user/operator surveys specifically designed for the above objectives.
The GAUDI field trials consisted in Dublin in a month experimental use of a multiservice electronic purse; more than 10,000 transactions were completed by 1,000 users on a single bus route, 20 payphones, 1 car park, 1 toll-bridge and 4 POs terminals.

In Marseille, a large number of fare products and PT operators were involved in field trials resulting in more than 55,000 transactions completed in 5 months by 1,000 users on a total of 66 televalidators (25 at metro stations, 16 on buses, 15 at interurban bus/rail links, 2 at P&R, 2 at tunnel and 6 at POs sites). In Bologna 250 users made payments with their smart-card units on 6 bus-lines to implement and test new position-relate PT fare products.

**Measured impacts**

**Combination of modes**

An analysis of pilot systems transactions provided an indication of the amount of multiple service usage: In Dublin out of 980 cards, 46% were used to pay for more than one service and 13% for more than two services. The corresponding figures in Marseilles (for 737 cards) were 46 and 21% (GAUDI).

**Freight and fleets**

In terms of benefits for the operators some indicators have been identified (GAUDI) in the fraction of system transactions using Electronic Purse instead of conventional payments and related fares (71% reloadings referred to 396 cards in Dublin and 31% reloadings referred to 4,873 cards in Marseilles).

Another indicator has been identified for Marseilles in the fraction of use of televalidation (either by IR or microwave): Each user, in case of a problem in completing the transaction remotely, could insert the smart card directly into the validator as for conventional cards.) Operational data indicate 85% IR remote operation and 15% contact operation during the first phase (IR only); during the second phase (IR and microwave) the corresponding indicators are 41% (IR), 32% (microwave) and 27 (contact).

**Public transport**

User surveys (MIRO) indicated that, for the GAUDI trials, 91% of the respondents in Dublin found the electronic purse a convenient way for paying for service, 84% of the Marseilles respondents highly regarded the reduction of money and ticket and were very satisfied with the design of the portable units and the related messages. In Bologna 65-70% of respondents had no problems with the smart card use, nor with the new location-related fare structure.

**Combination of modes**

In Bologna, where the card had only been used for the bus service, a survey indicated that 75% of the users were in favor of an extension to a multiservice operation (MIRO).
Other comments

Results from all sides (but especially Dublin and Marseilles) demonstrate that the marketplace provides a gap of opportunity for an electronic payment product which has the control and flexibility benefits of all pre-paid cards.

- In particular, results from Marseilles show that a remote payment device can offer a number of advantages: Ease and control of gesture, friendly user interface, good security, flexibility of operating modes (speed of communication, on-and off line).

- The card used is adequate in terms of data storage, processing and security capabilities.

- On the reliability of televalidation equipment in Marseilles, operational data indicated an overall 97% reliability (GAUDI). From the MIRO surveys 62% of the respondent were very satisfied. From transaction data smart cards appeared more durable and reliable than magnetic cards.

Future needs and developments

- The legal issues surrounding the operation of smart cards containing an electronic purse are many and complex and, while it is clear that the right to issue an electronic purse needs to be restricted to credit institutions, clear rules are still missing about who could be allowed to disable parts of the card or confiscate it as a result of its improper use.

- Security aspects and related privacy possibilities (as emerged from the pay-TV and the retail sector for conventional credit cards) indicate the need to provide a suitable security framework to tolling and Integrated Payment services applications in view of the rapidly growing prospects for a rapid growth of smart card use as well as of automatic debiting applications on European motorways.

4.5.2 AUTOMATED TOLL COLLECTION

Increase of motorway traffic (either passenger or freight) has resulted in a situation of worsening congestion not just in links with insufficient capacity but also at the main terminal or intermediate barriers of all toll motorways leading to waste of time and fuel and damage to the environment.

The need to find new direct forms of financing further infrastructure developments has also led various free-of-charge motorways into considering the implementation of toll debiting systems. There is therefore a definite need for the developments of effective automatic toll collection systems for either toll-plaza or free-flow applications which should allow every user to freely roam among the motorway networks of the various operators.

Various types of remotely operated toll collection systems have already been implemented in toll-plaza environments which single-lane, 30-50Km/h continuous flow operation.

As the results from autonomous developments by different equipment suppliers, even if all systems originate from the same common approach and basic transaction protocol (VITA), such systems do not provide interoperability of the on-board equipment from different systems.

Furthermore, the single-lane approach does not provide the capability to implement the enforcement of automatic toll collection transactions in a free-flow multi-lane environment which would be
mandatory in all motorway networks that do not already use toll-barriers. A fully interoperable toll debiting system should also be able to handle both open and closed systems as well as charge-account or pre-paid transactions. The increasing emphasis on intermodality would also require to extend payment capability to other transport modes as well as to P&R facilities, thus essentially implying integrated payment capabilities. The related standardisation, legal and institutional issue represent therefore a very complex combination of critical problems to be urgently solved.

In the PORTICO project the field trials consisted in the installation of dynamic and automating weighing equipment on a lane of the Carragado Toll Plaza. Installation of multilane toll collection equipment along a motorway near Florence were implemented by ADS to perform the field trials on real traffic conditions using a 5.8 Ghz enhanced microwave 2-way communication link.

The ADEPT project developed and tested in Jönköping a complete multi-lane automatic tolling system, also based on the use of the 5.8 GHz microwave link, which included full enforcement and classification capabilities using multiple video cameras and real-time video image processing. Within the same ADEPT project, the Jönköping microwave automatic tolling system design was used to implement in Thessaloniki, near the existing toll-site at Malgara, a multi-lane automatic debiting system combined with a mono-lane enforcement system located approximately 300 m downstream of the multi-lane gantry.

Whilst the Jönköping tests were only aimed at a full technical system evaluation on a test track, the Thessaloniki results, having been obtained on a toll-motorway under normal commercial operation, allowed a full socio-economic assessment.

**Private vehicles**

Using multilane tolling instead of manual toll gates, travel time is reduced because it is not necessary to slow down for toll payment, and waiting time during peak hours is eliminated; time variance due to toll collection is expected to become negligible. The average time loss would be reduced from several minutes to 0 resulting in an average saving of over 40h/year for the average motorway commuter. Safety is expected to be improved due to lack of traffic channeling as well as to elimination of possible queues. Fuel consumption for the average motorway commuter could be reduced by 100 litres of petrol per year (ADS).

**Freight and fleets**

Travel time, time variance and safety should improve as for private vehicles (ADS).

From the Thessaloniki test site results, an assessment of both the Vehicle Operating Costs and the economic value of travel time saving led to an estimated saving per toll passage for equipped vehicles of 0.23 ECU for buses and of 0.13 ECU for heavy freight vehicles. Assuming a commercial cost of 50 ECU and a 5 year lifetime for each on-board unit, the minimum number of passages/year to recover the equipment costs would be 44 for buses and 77 for trucks (ADEPT).
Investment of infrastructure and operating costs of manpower should be reduced. The number of transactions per unit time should have a huge improvement (ADS).

The use in Thessaloniki of a multi-lane tolling gantry with mono-lane enforcement in each direction would result in a 60% increase in capacity; the net benefits for the period 1995-2006 were calculated in the amount of 1.15 MECU. As total costs would amount to 0.64 MECU, the payback period for the infrastructure operator would be of 6 years with an internal rate of return of 33% over the whole 12-year period (ADEPT).

The road maintenance costs can be significantly reduced by discouraging the overloading of Heavy Goods Vehicles. The resulting improvement in the efficiency and capacity of the tolling system and the less frequent maintenance works should help increase the infrastructure capacity (PORTICO).

**Environment**

Multilane Automatic Toll Collection Systems will improve the air quality and reduce the energy consumption of the average motorway commuter by about 5% (ADS).

The implementation of a multi-lane tolling/mono-lane enforcement system in Thessaloniki would result in environmental benefits from reduction of noise and emission levels equivalent to 130 kECU (a value close to the total investment cost of the ground equipment) for the period 1995-2006 (ADEPT).

**Problems and limitations**

Lack of specific legislation which can help the implementation of the automatic weighing and tolling approach that has been developed and tested (PORTICO).

**General benefits**

The resulting specifications on Automatic Debiting provide input to the standardisation process; resulting adoption of standards will be beneficial to both users and operators (CASH).

In addition to the cost for the operator and the efficiency/safety benefits for road users, multilane systems should provide equipment industry with new market opportunities (ADS).

In the socio-economic analysis performed for the Thessaloniki test site, it has been estimated that the implementation of a multi lane tolling system would result in safety benefits equivalent to 70 kECU for the period 1995-2006 (ADEPT).

Integration of toll collection and axle-weight road pricing can effectively help road and environment protection. Dynamic Tolling based on automatic weighing in addition to better road protection, improved road safety and comfort, reduced road maintenance cost, and should provide market opportunities for new products (PORTICO).

Positive results form field trials increased operators willingness to further invest in multilane automatic debiting technology.

In addition to the cost reduction for the operator and the efficiency/safety benefits for road users, multilane systems should provide equipment industry with new market opportunities.
Travel time, variance and safety should improve as for private vehicles (ADS).

The resulting specifications on Automatic Debiting provide input to the standardization process; resulting adoption of standards will be beneficial to both users and operators (CASH).

**Future needs and developments**

- Availability and enforcement of standards will be required to assure interoperability. Lack of Agreement between operators in different counties to assure contractual interoperability of the various systems. The consensus forming process in Europe is complex and time consuming (CASH).
- Development of automatic vehicle classification and enforcement subsystems.
- Availability of an adequate frequency bandwidth to support high data rates.
- There are many initiatives in Europe to implement Electronic Toll Collection which can support a wide range of applications from access control to road pricing (ADS).
- State - of - the - art technologies can already support the future implementations of multilane ATC systems. Investment of Infrastructure and operating costs of manpower should be reduced. The number of transactions per unit time should have a huge improvement.
- The road maintenance costs can be significantly reduced by discouraging the overloading of Heavy Goods Vehicles. The resulting improvement in the efficiency and capacity of the tolling system and the less frequent maintenance works should help increase the infrastructure capacity.
- Lack of specific legislation can help the implementation of the automatic weighing and tolling approach that has been developed and tested.
- Specific legislation would be required to implement dynamic tolling based on automatic weighing (PORTICO).

### 4.5.3 ROAD PRICING

Road pricing is the concept of charging road users on the basis of their utilisation of the road resource. Normally it is taken to mean that road space is selectively priced on the basis of criteria such as congestion impact (time of day, section of the network), vehicle type (private car or public transport) and/or user type (resident, commuter, visitor). There is currently no application of this type in Europe. Surrogate measures such as a toll-ring around a central city area have been implemented in Norway and Sweden.

Within the ATT program the projects GAUDI and MIRO have established user responses to toll rings and road pricing. The ADEPT project tested technologies for congestion metering in Cambridge, UK.

**Measured impacts**

In Trondheim (N), a toll ring has been functioning since 1991 as a cordon on the central area with 12 entry points. Automatic fee collection is used successfully where 76 000 subscribers have 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. Projects GAUDI and MIRO have assessed the user response.
From extensive surveys, no evidence has emerged of reduced total car usage. However, there has been a 10% reduction of crossing of the cordon during toll hours. The trips have redistributed in time and spatial patterns in response to the tolls. Public transport usage has increased by 8% for the whole city area. Enforcement is achieved through video camareas and the level of violation of the toll ring is low, and is at a level acceptable to the authorities.

Modelling of the travel impacts of road pricing based on user response studies carried out within GAUDI and MIRO (see below) was carried out for Gothenburg (S) and Trondheim (N). In Gothenburg, the modelling exercise shows 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. Women and car users on lower incomes indicated higher reductions in car use in the area as a result of such a toll.

In Trondheim, the attitude to road pricing shows 46% with negative opinions and 37% with positive opinions. People inside the existing toll ring area are more positive towards road pricing than those outside. Modelling indicated that there would be a 3% reduction in entries to the areas for a NOK 5 toll, and a 4% reduction for a NOK 15 toll.

Other impacts

User response to road pricing has been examined in the MIRO project which measured user perceptions and responses in eight cities from the GAUDI and ADEPT projects. This found that citizens had less awareness of road pricing than of any other demand management measures, and questioned its effectiveness in influencing mode choice and travel behaviour. The survey found that road pricing measures had very low levels of acceptability with citizens, whereas non-price related issues such as access restrictions have a high level of acceptability even among motorists.

Benefits

The principal benefits are expected to be in the form of environmental improvements through reduced noise, emissions, energy consumption and accidents. The city should benefit through increased income, and the public transport operator from additional business. The organisations in the city are expected to benefit through reduction in journey time and travel costs for businesses, although concern is expressed that business might divert elsewhere.

Problems and limitations

No trials have actually been carried out of road pricing in Europe, so neither the travel nor the public impacts have been assessed in the real environment.

Appropriate technologies for communication, payment methods etc. have been tested successfully, but questions remain over the ability to plan, apply and enforce dynamic road pricing over large areas. The issue of price collection from vehicles based outside the controlled remains to be resolved.

Future needs and developments
It is clear that a demonstration of road pricing is required to validate the predicted travel and environmental impacts, to determine both the immediate and medium-term public reaction, and to identify the legal, organisational and institutional issues associated with road pricing.

4.5.4 ACCESS CONTROL

The continuous start increase of private vehicle use in urban areas of all sizes led to worsening levels of traffic congestion in most European city centres with related negative impact in terms of noise and air pollutions.

Local authorities have therefore implemented a number of corrective measures ranging from the establishment of pedestrian areas, street parking limitations, dedicated lanes for public vehicles to the implementation of parking facilities.

A common feature of all these different measures was the need to define suitable space and time criteria for limiting the access of vehicles to specific areas and for implementing effective controls in the enforcement of such restrictions. Although the most obvious approach has been the issuance of access permits to a limited number of users and to implement random checks by direct visual inspections from urban police officers.

Obviously such measures can only be effective if the natural level of violations remains low, otherwise the cost or the effectiveness of the enforcement action become unacceptable. Such a situation led to an increasing interest in the development and testing of automatic means of access control and enforcement to limited access zone which could also lead to more effective dynamic restrictions criteria and open the way to the future implementation of road pricing policies or even automatic speed limiting.

One of the main requirements for an effective access control strategy is to assure that the control procedure itself does not generate outside of the restricted zone more congestions that it would prevent inside.

The resulting implications are related to the actual choice of enforcement means which can take the hard form of removable physical barriers of various kind (real time enforcement) or the soft form of videocamera recording of violating vehicle pictures (administrative type enforcement). Though enforcement is technically considered a separate function which can be shared with other applications (such as automatic debiting), the real time enforcement approach implies the assessment and definition of several critical features which need to be designed in the overall system, together with the basic functions of identifying entitled vehicles (fitness with urban decor, safety implications, need for operator assistance etc.)

The main objective of the work performed by the project GAUDI was the assessment in a pilot demonstration of the social acceptance and travel behaviour resulting from the introduction of access control measures aiming at traffic reduction in specific urban areas. A further objective was the assessment of the related institutional effects from the introduction of smart card services as Telematic infrastructure managed by local traffic authorities for the following traffic management applications

- access control for special events
- non-stop zone access control
- pedestrian priority zone
The introduction of smart card use for the above applications was also seen as a first step towards the implementation of Integrated Payment Services.

The main aspects of the test site applications were the assessment of traffic impact and social acceptance of smart card control, including the experiences with tag distribution and citizen information within the special events access control in Barcelona; the evaluation and certification procedures of a monolane DSRC link within a non-stop access control systems as well as the evaluations of OCR and digital photo technologies for enforcement applications in Bologna and the smart card validations/image-voice management of non-equipped vehicles for the pedestrian priority zone in Barcelona. More than 50,000 travellers were involved as authorised users in the 3 test sites.

**Measured impacts**

**Private vehicles**

Using car following journey time surveys in Barcelona an average 18% reduction of travel time inside the special events zone was identified; for the pedestrian priority zone no travel time changes were observed over routes both inside and outside the zone. Concerning the variance of travel time for a pedestrian priority zone, telephone surveys with residents and visitors have shown that 31% of visitors have anticipated 21% and 13% increase in loading during the two unrestricted entry periods with respect to the 12 hour average. In terms of vehicle traffic flow during working days the total recorded entry volumes before and after access control in Bologna with major re-assignment to the Inner Ring Road was a 78% reduction for the priority zone in Barcelona. In this test site telephone surveys reported that both residents and visitors reduced the manner of car trips per week after the access control implementation (respectively 1 and 3 car trips reduction for week.)

Concerning parking space availability in Barcelona, surveys indicated a 155 increase in on-street availability within the special events zone and a 15% increase in on-street space usage within the zone resulting from a shift of parking from the inside to the border zone with a 20% perceived reduction in problem. In Bologna, pollution monitoring data showed a 50% reduction of emission in the central area. In Barcelona, model estimates in the special events area had predicted a 50% reduction of emission inside the zone, while surveyed citizens indicated a perceptions of reduced air pollution (19%) and reduced noise (20%) within the priority zone.

**Other impacts**

In Barcelona the citizens’ perception of the quality of information provided by the public authorities on the pilot implementation was rated good by 89% of people surveyed about the special events zone (3% bad rating). For the priority zone (on a 1 to 9 scale) residents gave an average 5.8 mark to the quality of information (4.1 visitors).

Data from the public transport operator indicate for the special events zone a 50% increase in public transport trips city-wide. Data from the non-stop access control tests in Bologna provided an indicator by digital photo processing: during daytime successful readings were respectively 75% (automatic only) and 97% (automatic with operator support).

**Combinations of modes**

Telephone surveys to residents and visitors of the Barcelona priority zone indicated a perceived increase in public transport use of non-motorized trips. The same survey showed that the main
benefit provided by the access control scheme was perceived as an improvement of traffic conditions for pedestrians and cyclists.

The social acceptance of the access control measures by the citizens was assessed by means of opinion surveys.

In Barcelona residents of the special events zone were 70% in favor and 24% against the measures implemented. In the priority zone residents gave to the measures an acceptance rating of 6.1 (on 1 to 9 scale; city wide rating was 6.0)

In Bologna, a city wide survey on the acceptance of non-stop access control measures showed a close 40/37% split between for/against options.

In terms of financial return of investment (excluding intangible benefits?) it was estimated that in Bologna the pay-back period should be between 2 and 5 years depending on the actual violation rate; the corresponding figure for the Barcelona priority zone application was 4 years.

**General benefit**

The impact of advanced restrained tools in supporting the achievement of a real sustainable mobility appears superior than the one which can be obtained from conventional technologies.

**Future needs and developments**

- The lack of funds available to local authorities has made the relatively high costs of Telematics technology a problem in the implementation of effective pilot projects. This will pose a conflict with the need for further pilot efforts to demonstrate integration of zone access control with off-street parking and other services requiring occasional access (hotels, vehicle repair shops etc.)
- To reduce legal problems optical character recognition of vehicle number plates should be used for enforcement purpose (in combination with smart-card/transponder units) rather than simple validations of access rights.
- Identification of best design solution for future implementation would require additional system developments and hybrid combinations of existing configurations.
- Access control benefits are largely aimed at pollution/noise reduction; identification of a suitable mechanism to obtain financial support from environmental protection agencies appears of crucial importance. Roadside validation and integrated Payment Service for metro access need integration of the current access approach with smart-card/on-board unit equipment.
- Demonstration of advantages from the integration of zone access control with inside-zone functions and services (off-street parking, repair services etc.) requires further pilot project experiments.

**4.5.5 PARKING CONTROL**

The search for parking in urban areas is considered to have significant disbenefits. It places stress on the user, the search increases the journey time, cost and energy consumption, and the collective of searching traffic in central areas can cause additional congestion. The main relevant objectives in parking management and control are to facilitate reservation of spaces, to inform users of available
spaces, to guide intending parkers to the available spaces, and to assist the payment/access functions. There is considerable overlap with the domains of Travel and Traffic Information and Integrated Payment.

Measured impacts

In Munich (LLAMD project) Variable Message Signs were used to advise motorists approaching the city of the new Park'n'Ride facility at Frottmaning. The mode shift due to the P'n'R is estimated to be able to reduce the use of private car by 1.6 million km. per year for that site, with 16% of the benefit attributable to the VMS information. 26% of the users on weekdays, and 46% of the users on special event days, would have otherwise used the car for the entire trip.

In Cologne (SCOPE project) Variable Message Signs were used on the approach to the city to advise motorists of availability of Park'n'Ride facilities. Usage of the P'n'R facility more than doubled with 33% of users doing so directly because of the information. Many of the cars would otherwise have proceeded to the city centre.

The integration of payment for parking was included in the multi-application smart card in Dublin (GAUDI project), with many users using the card for other modes as well. High user satisfaction was reported by both the motorists and the parking operator. Queuing time for exit was significantly reduced for motorists with smart cards. Impacts on parking behaviour were not measured.

Benefits

The principle benefits are expected to be the reduction in the secondary congestion, pollution and energy consumption associated with searching for parking spaces; reduction in stress for motorists; increased business and occupancy levels for parking operators.

A cost-benefit analysis of the Munich P'n'R site indicated that the provision of VMS is really only commercially viable for P'n'R sites of 500 spaces or greater.

Future needs and developments

- The impact of parking reservation and guidance on reducing search traffic and personal stress to drivers needs to be evaluated through demonstration. Such research should also consider whether motorists are more likely to bring their car into the city when information about parking is made easier.
4.6 DRIVER ASSISTANCE AND CO-OPERATIVE DRIVING

Human performance has been long identified as crucial to the efficiency and safety of the road transport system. To identify problems in the performance of the driver tasks, it is essential to develop models that are capable of providing a dynamic description of such tasks. Problems in the driver task performance may either occur if the driver makes driving errors (due to a state of impairment or to a high level of mental load) or when he/she commits deliberate traffic law violations. The safety implications of such problems are obvious.

The projects in this domain have covered a wide range of applications, technologies and methodologies; the main applications being related to:

- driver monitoring in terms of driver state (i.e. impairment etc.) and of driving performance
- driver tutoring
- driver information enhancement and dialogue management
- co-driver functions in advisory, semi-automatic and automatic modes.

Related technologies cover several horizontal aspects of the programme. In particular, the work concerning communication links and system integration has significant implications for the programme as a whole. The same applies to the safety-relevant activities that are part of the area. These activities address system safety, safety aspects of the human-machine interaction and traffic safety. Another horizontal activity deals with electromagnetic compatibility risks. The general nature of the work carried out by many projects in this area is also evident in the activities concerning methodologies, tools and guidelines, in particular in relation to the safety evaluation and HMI issues.

Though the activities so far performed in the domain of driver assistance have already led to the successful development of several stand-alone systems (e.g. anti-collision radar, driver performance monitoring, driver impairment monitoring, co-driver systems in advisory mode) that are now ready for more exhaustive tests in pilot project trials, there are many important questions still remain unanswered.

Systems such as driver tutoring, co-driver systems in semi-automatic or automatic mode, integrated automatic enforcement and in particular integrated systems combining co-driver functions on tactical and strategic level (which will ultimately provide the most effective cost/benefit figures) will require further and significant R&D activities.

As safety represent the most relevant issue in driver assistance, it must always be taken in due account for all the related applications that, to achieve significant safety benefits, all the activities should have a clear focus on the main goal of minimising the driver possibility to make errors or commit violations (the two main sources of accidents).

In this respect it should always be remembered that the results so far achieved have been mainly obtained under experimental conditions only, often just in driving simulators; long-term trials under real-life conditions are therefore needed to fully assess the actual safety benefits.

Special attention should also be paid to the possible behavioural adaptation that is known to occur when new technological developments are implemented on a large scale.

At the same time it must be acknowledged that the applications so far developed only touch upon the most basic aspects of a support to the driving task. In fact driver errors often occur at a much higher
level (such as wrong interpretation of the received information) and the actual sources of these errors have not yet been investigated.

A more thorough analysis of the driving tasks, using dynamic task modelling techniques which appears to be a prerequisite to more effectively approach such problems, has not even been attempted so far within the Transport Telematics Programme.

About benefits from driver assistance applications, it must also be recognised that safety improvements have a relevant impact on both society and individuals: where new applications provide drivers with improved comfort and safety without any negative impact on their strategic and performance choices, the individual benefits are quite apparent and thus easily accepted. However, in the case of systems such as driver impairment monitoring or law enforcement, their social and legal implications need a careful consideration together with the obvious user acceptance issues and may require the definition of a suitable strategy of incentives.

Since, on the other hand, human error and traffic law violation account for the majority of traffic accidents, the actual performance improvements already achieved and the resulting potential safety benefits should be very carefully estimated.

Therefore, given the aggregate set of potential safety, comfort and mobility benefits and to allow their successful exploitation in a future optimised Transport System, the Driver Assistance and Co-operative Driving systems here described certainly warrant a continued and concerted development and implementation effort which should give priority to the following issues:

- Supporting research is required in relation to topics such as driver modelling, workload assessment, individual differences, behavioural adaptation and road user acceptance to enhance the functionality of stand-alone and integrated systems
- Information presentation, in particular for integrated systems, still remains a separate R&D topic which needs to be properly addressed, even though considerable progress has been achieved within the Transport Telematics Programme. Specific attention should be given to the actual possible differences between in-vehicle and roadside information due to the different strategies of the information suppliers
- The activities that have been carried out in relation to communications requirements indicate that this is a critical task requiring further attention from communications technology specialists, also in consideration of their rapid evolution
- While much attention has been devoted to the safety implications of the systems under development, quantification of the safety impact has not yet been achieved. To this purpose, safety analysis should be integrated in the projects and a comprehensive safety methodology needs to be developed. In particular, the development of safety predicting tools requires further attention.

4.6.1 DRIVER MONITORING

The applications on Driver Assistance and Co-operative Driving are developed with the explicit purpose to aid, assist or support the driver in the performance of the vehicle driving task.

A prerequisite to achieve this aim in an adaptive way is however the capability to monitor and record the driver's behaviour, which requires the development of a range of sensors and communication technologies.
Driver monitoring has been addressed in several ways: in the SAMOVAR project, a system was developed which continuously records vehicle parameters with the purpose of either providing feedback to the driver or providing information in case an accident occurred. A distinction must be made between the Journey Data Recorder (JDR) and the Accident Data Recorder (ADR). Work has concentrated on the ADR development and a considerable number of units have been installed and tested in two vehicle fleets. The accident data that have been collected by means of these units have been analysed to assess the merits of such data when compared to the data collected by traditional means.

Since it was expected that the future presence of JDR units would positively affect the drivers' behaviour and consequently will reduce accident involvement of vehicles fitted with such units, an evaluation plan was defined in the SAMOVAR project to allow the detection of this kind of effects should they have actually occurred. The field trial consisted in tests over a 12 month period on normal roads in NL, UK and Belgium using a fleet of 750 equipped commercial vehicles.

In the DETER project, driver monitoring was used to detect either driver impairment conditions or traffic law violations and alert the driver. In the former case, vehicle parameters related to the driver control actions were used as input to a neural net computer that determines any significant deviation in the driver state implying an impaired condition. Another driver monitoring function was used to detect traffic law violations: it identified the legally required behaviour on the basis of roadside information provided by transducers connected to an adaptive database and performed a comparison with the actual behaviour.

Prototypes of the driver impairment monitor and the traffic violations detection system have been built and tested in a driving simulator and on road.

The system development efforts within the project have also led to the availability of a marketable distance radar.

**Measured impacts**

The use of an Accident Data recorder on commercial vehicles resulted in statistically significant reduction in accident occurrence (up to a maximum 41% reduction with respect to past historical average of the number of accidents for a fleet of 130 vehicles) and beneficial reduction in accident costs due to lower accident severity.

At the fleet level a reduction of the vehicles operating costs was observed. As a result of reduced accident related damages, repair cost / km decreased up to 40%; a reduction of consumption and wear out costs (fuel, tyres and other vehicle components) were observed, often leading to a recovery of the equipment cost within one year.

In terms of environmental impact, the UK trials showed a downtrend in the number of observed "overspeeds" per 1000 miles, leading to a likely reduction of energy consumption.

**Other impacts and potential benefits**
The average user response has indicated that the implementation of a driver monitoring function has a slightly negative impact on driver comfort but has showed a positive assessment of its contribution to a better safety.

In turn the use of an Accident Data Recorder led to an improvement of service quality in commercial fleets because of the reduced vehicle downtime (resulting from the reduction of number and severity of accidents) and the better accuracy of accident analysis data. This would also lead to an expected reduction of legal and administrative costs required by professional accident investigations.

Furthermore, should driver monitoring be more widely used in commercial fleets, a widespread reduction of accidents severity could lead to a greater reduction of total social costs from road accidents (including insurance, hospitalisation and other costs).

**Problems and limitations**

The Accident Data Recorder assessment was influenced by the funding limitations which, by limiting both the number of vehicles to be used in the trials and its duration, influenced the statistical relevance of the results. Furthermore, the operational priorities of fleet managers limited the accessibility to the installed equipment for maintenance and data downloading purposes, with the result of some data losses.

**Implementation and integration aspects**

To allow for an effective in-vehicle monitoring of traffic violations, the main requirement is an extensive deployment of electronic signs, labels or tags to provide information about local limits and constraints.

For the Accident Data Recorder the main requirements for an implementation at the transport system level relate to the definition of relevant specifications and performance characteristics for data recording technology with respect to the various interrelated driver and vehicle functions (driver tutoring, vehicle handling, fuel efficiency, etc.), of the inclusion of the driver feedback process into a future scenario of traffic safety evolution and of a detailed analysis of possible commonalities with other Transport Telematics on-vehicle functions, which could lead to significant integration opportunities.

At the technical/commercial level, the possibility of equipment synergies with other monitoring functions being planned or considered for future vehicles could significantly reduce the direct equipment cost to users.

**Future needs and developments**

- To stimulate wider interest and acceptance of potential vehicle/driver monitoring applications, a broader dissemination and promotion of the benefits already identified should be undertaken. However, any decision about the future deployment of mandatory in-vehicle systems to monitor driver behaviour is a purely political issue; for such a reason it appears that, **unless suitable incentives are identified and adopted**, a future extension of this technology to the passenger car mass market appears unlikely.
- Furthermore, legal issues about the accuracy of data capture must be resolved.
4.6.2 DRIVER SUPPORT

The driver aid, assistance or support functions may either consist in providing additional information (as in vision enhancement), proper feedback, explicit instructions and tutoring recommendations (in particular for novice drivers) or, as in the case of traffic law violations and driver state temporary or partial impairment, in specific warning / enforcement or active support systems. Such systems have as common objective the active improvement of the quality of the driver's performance by preventing and correcting errors and deviant behaviour or by supporting decisions and vehicle controls actuations by suitable aids.

Many of the advanced telematics systems being developed imply the presentation to the driver of new additional information, either in-vehicle or roadside, which may result in an overload of information, particularly for specific driver groups such as elderly people. This requires careful consideration of a number of issues related to information and dialogue management, scheduling and prioritising.

In the ARIADNE project a prototype instructional support system was implemented with the aim of improving the quality and effectiveness of the feedback drivers normally get as a result of their driving performance. The system add to the naturally occurring feedback more evident support actions which should induce a lasting enhancement of the driver's skill. The prototype was evaluated in a driving simulator to determine the most effective types of instructional support messages given by the system and the conditions/situations under which the support should be provided to achieve maximum benefit. Acceptance trials indicated considerable interest for the results obtained from such a system.

Within the EDDIT project, test trials with two different vision enhancement methods (ultra-violet light and near infra-red) were performed with samples of elderly drivers. The systems were tested on closed tracks at night-time. Both systems provided a substantial increase of the distance at which drivers first saw pedestrians and some, through not all, road features. The majority of drivers found the system helpful and easy to use; on the basis of such initial responses, it can be expected that the introduction of such systems could increase the amount of driving that older drivers can safely undertake during the hours of darkness.

The commercial route guidance systems operating in the advisory mode on a strategic level were tested by the EDDIT project with samples of elderly drivers. The key findings were that both systems were found to be easy to use and understand.

The activities of the projects involved in driver support tasks were focused on the needs of special drivers, such as elderly drivers and Drivers with Special Needs (DSN). DSN are people with some limb or visual impairment who could improve their actual driving capabilities thanks to suitable telematic supports.

The TELAID project provided a definition of DSN requirements together with a methodology for the assessment of DSN aids and a supporting database available free on diskettes or on INTERNET. Specific design guidelines and standards for DSN application were also developed and published on a Handbook.

DSN capabilities were tested and assessed on a driving simulator whilst reversing aids and vision enhancement equipment were tested on private test tracks and route guidance systems on public roads.
Measured impacts

The activities on driver support essentially aim at providing qualitative results (improved comfort, less psychological tension and fatigue, friendlier machine interactions) related to the use of private vehicles.

No actually measured impacts where therefore identified.

Other impacts and potential benefits

The enhancement of comfort and safety resulting from the use of telematics aids was in general assessed on the basis of expert opinions and users interviews. Safety assessment was also assessed using driving simulator tests.

Reversing aids enabled elderly drivers to position the car more easily and accurately. As an indicator of potential safety improvement, the number of collisions or near misses was measured in reversing with obstacles in the rear path. From the tests performed it appears that the number of low-speed minor accidents and the chance of collision with children running across the path of a reversing car could be reduced.

The applications tested and the related Human-Machine Interfaces used resulted in relatively small changes in driving safety performance were found as measured by ten criteria for driving safety assessment.

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 user (VRU’s). Customised route guidance can encourage more elderly drivers to safely drive to unfamiliar places and busy areas. However, from the observed driver behaviour with/without route guidance, only minor changes with little statistical significance on safety were identified.

For route guidance support systems, the elderly drivers' views on the effects of having these systems on their travel behaviour were, for the majority, a higher likelihood of travelling to unfamiliar places and, for a small minority, more frequent travelling.

In terms of socio-economic aspects, the results of an enhanced ability to drive by DSN indicates the possibility to achieve a better integration of DSN people within our society.

Furthermore, the assessment of the answers to a questionnaire of the potential change induced in the driving habits and attitudes of elderly people has shown that reversing aids would only marginally affect the willingness to drive to places where parking manoeuvres were known to be difficult, but vision enhancement means would allow 60-70% of elderly people to drive more at night whilst route guidance would substantially increase their propensity to try unfamiliar routes.

On an institutional and political level, the now available database on aids for DSN (TELDAT) can also be used by industry (for car adaptation and related equipment/fittings development) and by authorities (licensing, homologation, financing bodies). Guidelines and Draft Regulation for DSN Aids may also be used by authorities to improve road safety and comfort.

Problems and limitations
Time and resource limitations have restricted tests to a limited number of DSN groups (mainly paraplegic and tetraplegic people) and of telematic aid systems (main vehicle controls, adaptive cruise control, reversing aid). Broader research and tests are therefore needed to cover all the actual DSN needs.

Implementation and integration aspects

Cost appear to be the main obstacle to the implementation of vision enhancement aids and of customised route guidance equipment and systems for elderly drivers. The rigid "design-for-standard-driver" approach does not provide optimal solutions even for normal drivers. Nevertheless, a "design-for-all" approach in developing driver support functions can prevent additional barriers to DSN users while their intrinsic flexibility could help increase the number of successful DSN drivers.

Future needs and developments

- Successful application of reversing aids needs the availability of suitable and visual warning NIR equipment. The area of enhanced vision must be widened.
- Additional research is required on the effects on distance perception and on the issue of reduced attention to peripheral objects.
- Route guidance systems for elderly drivers should use simple programming controls, effective protection of displays from sun glare and more accurate and immediate localisation of the vehicle within the display.
- The main suggestions for system improvements were related to the display position, the need for better protection from glare and concerns over lag time between actual position and displayed position of the vehicle.

4.6.3 CO-OPERATIVE DRIVING - COLLISION AVOIDANCE

Transport Telematics applications in Co-operative Driving, or Co-driver Systems, refer to systems that support the drivers in performing their driving and aim at improving driver comfort or safety. The relevant driving tasks may concern vehicle control and the performance of manoeuvres such as overtaking (operational or tactical tasks) or route choice and navigation (strategic tasks).

Co-driver systems may operate in the advisory mode (as when they merely provide the driver with additional information or specific instructions) or in the semi-automatic mode (when actions are initiated automatically by the system leaving the driver with the option to override them at any time); such an option would not be any longer available in the automatic mode.

These considerations apply to both the subdomains on Co-driver systems addressed in the Impact Analysis, Collision Avoidance and Intelligent Cruise Control (ICC); safety issues are quite relevant on both but, whilst ICC applications, primarily oriented to the drivers comfort and convenience, can also indirectly contribute to the achievement of better traffic harmonisation and efficiency, specific Collision Avoidance applications are primarily intended to provide the drivers with new, advanced preventive safety features aiming at the detection and avoidance of obstacles (i.e. unexpected objects within the vehicle trajectory).

Often ICC systems also include at least a collision warning feature to warn the driver when the car in front shows higher deceleration rates than those automatically handled in the car-following cruise
mode. Since however the various benefits of ICC must be achieved without compromising the overall traffic safety, the same safety considerations and constraints used for Collision Avoidance applications do also apply to the ICC systems addressed in the next section.

In summary, the development and test work that has been carried out on co-driver systems of both types within the Transport Telematics Programme shows that, if a sufficiently high level of HMI operation and dialogue management can be achieved, the systems have a real potential of improving traffic safety and driver comfort. An optimisation of these benefits can be achieved by further systems enhancement (such as improvements of functionality and adaptability to the individual driver characteristics).

Co-driver systems can then actually potentially provide a substantial increase in driver comfort and safety. Critical vehicle control indicators such as speed choice and distance keeping can be substantially improved by specific applications.

With specific reference to Collision Avoidance systems, in ARIADNE an innovative electronically scanned obstacle warning radar was developed. In addition to the range information provided by conventional radars, the system could also determine the lateral position of objects and thus achieve a wide coverage without resorting to the relatively expensive and less reliable mechanical scanning techniques.

The HARDIE project, on the basis of Collision Avoidance prototype systems already available, performed a review of the results from previous research with specific attention to Human-Machine Interface (HMI) specifications for Collision Avoidance Systems and performed on-road trials around Bristol (UK) involving 18 drivers to assess the influence of such systems on driver behaviour and thus provide an experimental base to define guidelines for system design improvements.

Project EMMIS developed evaluation tools for the HMI assessment of Collision Avoidance systems using stand-alone Collision Avoidance and medium range pre-information functions already available. The system allowed their integration in a rapid prototyping environment to allow the evaluation of different innovative solutions in a driving simulator.

The simulator tests were performed using 48 drivers, a combination of different HMI solutions (single and dual display) and 2 visibility conditions to assess driver behaviour with and without collision warning support.

Project EDDIT aimed at improving traffic safety (that is, reducing the number and severity of accidents) by assisting elderly drivers in making safe judgements and decisions on turns across incoming traffic or at a T-junction. The tests were performed, on the basis of pre-trial driver assessment and post-trial surveys, by using a prototype guidance device on a driving simulator and involved 30 drivers (aged 65 or over) performing turning manoeuvres with and without the aid of a simple red/green “gap-acceptance” warning display indicating “safe/not safe” turning conditions for the next gap in simulated incoming traffic.

**Measured impacts**

The objectives of all the project were all related to the assessment of the influence that Collision Avoidance co-driver system have on driver behaviour; the identification of measurable impacts was therefore outside of the project scope.
At the present stage, even the survey results which could lead to a quantitative distribution of responses have shown wide variations at the individual level which prevented any significant analysis in statistical terms.

From the current stage of evaluation and assessment all impacts have therefore been only expressed in qualitative or orientative quantitative (increase/decrease) terms.

Similar conclusions have also been reached by the “Cross-project Collaborative Study” on Collision Avoidance which compared the results so far obtained in terms of “average time headway” parametre, as measured by projects from both the Collision Avoidance and Intelligent Cruise Control sub-domains.

Collision avoidance

Systems are in advanced development that warn drivers when nearby vehicles are too close (Collision Warning, or "CW"). More elaborate systems include Intelligent Cruise Control ("ICC") which maintains a steady speed but warns when coming too close to a leading vehicle, and Autonomous Intelligent Cruise Control ("AICC") which controls both vehicle speed and following distance in critical cases.

Five projects came together in this study, which assessed the safety impacts and users’ acceptance of all three types of collision avoidance system. The following extracts are taken from the full report.

Driver safety

Operating in advisory or warning mode, the tested systems led to an average increase of time-headway between vehicles of about 15%; this should correspond to a lesser risk of collisions.

Comparing the three types of collision avoidance systems - and including non-equipped vehicles - in a speed range of 80-90 km/h, the largest average time-headway was observed for CW, whereas the smallest was observed for AICC. The average time-headway under ICC was comparable to that of non-equipped vehicles.

Because an AICC system intervenes automatically, its shorter time-headways should not correspond to a lower safety level, but should in fact increase highway capacity by allowing smaller time headway between vehicles following each other.

Human-Machine interface aspects

In questionnaire surveys, the test drivers expressed the view that collision avoidance systems should improve traffic safety, and in their experience do not add too much mental load to the driving task.

In general, driving supported by both ICC or CW with visual or acoustic warning was considered by drivers as rather unpleasant, while AICC or CW with tactical warning was evaluated as relatively pleasant.

Other impacts and potential benefits
With reference to the use of private vehicles by normal drivers, measurements of the average Headway Time (HT) indicate that the use of Collision Warning functions resulted in an increased average HT, whilst the answers to a questionnaire on Workload effects resulting from display use have shown no significant variations in workload. Therefore an extensive use of collision warning is expected to induce an increase of Headway Time and thus safer driving conditions.

With reference to the use of private vehicles by elderly drivers, the impact on safety was assessed in terms of the gap time in traffic (measured electronically) under which the driver decides to perform a turning manoeuvre at a junction or an intersection. The use of a Safe/Not Safe indicator allowed shorter gaps to be "accepted" and successfully used by the drivers, but wide variations were observed at the individual level. On the basis of the answers to the post-trial questionnaire, the use of a Safe/Not Safe indicator for turn at junctions should effectively help elderly drivers at nighttime or other poor visibility conditions.

Therefore an extensive use of a turning aid should provide a reduction of the number and severity of accidents at junctions as well as an average reduction of traffic congestion at junctions as drivers could safely use shorter traffic gaps.

The availability of guidelines on the recommended use of HMI design specifications for Collision Avoidance systems should help improving the quality of future equipment design and thus allow greater system interoperability at a pan-European level.

In general, the development and test work that has been carried out on co-driver systems within the Transport Telematics Programme shows that, if a sufficiently high level of HMI operation and dialogue management can be achieved, the systems have a real potential of improving traffic safety and driver comfort.

**Problems and limitations**

At the current stage, the trade-off between on road and driver simulator tests can only provide complementary and not alternative contributions.

In fact the use of a driving simulator, despite its effectiveness and flexibility, introduces the artificial element of "virtuality", therefore requiring additional on-road trials to validate the results.

However, despite its limitations, the driver simulator environment appears a very effective development tool able to perform preliminary comparative impact assessments of driver behaviour with/without the telematic support functions under investigation. On the other hand the on-road trials on Collision Avoidance lacked the flexibility that the use of a driving simulator could have offered. Ideally on-road trials should then be used only to validate a more exhaustive range of simulated tests.

**Implementation and integration aspects**

To make effective use of current achievements it would be necessary to reach a widespread diffusion of project results and guidelines to system designers and standardisation bodies.

Actual system acceptance by drivers should also be verified across a much more representative sample base.
Future needs and developments

- For a more exhaustive evaluation of Collision Warning applications, more realistic simulator scenes should be made available. It seems, on the other hand, that adequate information about safe/not safe turning situations could be more efficiently supported by a roadside system able to identify all the relevant traffic movements in complex junctions and intersections.
- Future highly advanced co-driver systems to properly operate will need a very large knowledge base which requires in turn extensive roadside-vehicle and vehicle-vehicle communications. Further development of key enabling technologies such as sensors, communication technologies and radars are therefore urgently required to allow full exploitation of co-driver systems potential and to optimise their functionality.
- Besides the obvious benefits of the current generation of advisory or semi-automatic "collision avoidance" systems, a real ‘‘anti-collision’’ system able to automatically take over in any emergency situation would be required to avoid the most dangerous accidents.

4.6.4 CO-OPERATIVE DRIVING - INTELLIGENT CRUISE CONTROL

The Intelligent Cruise Control systems developed and/or tested by the projects that were active in this subdomain performed as a minimum the longitudinal control (engine power and brakes) of the vehicle movement on the base of a distance measurement from the preceeding vehicles. Some systems also had lateral control (wheels steering) capability which allowed to also implement Intelligent Manoeuvre Control functions.

Within the project TESCO, several systems were developed or improved, in particular a co-operative driving system derived from a more generic system developed within the Prometheus programme; its original functions were enhanced to ensure that it could meet the requirements of the intensive field tests planned by TESCO in terms of both accuracy and reliability. It included microwave detection technology for vehicle-vehicle communications, infra-red technologies for beacon-vehicle communications, computer-graphic technologies for driving/scenario simulation and computation technologies for real-time applications. In addition, an automatic lateral positioning equipment, based on an antenna detecting the magnetic field generated by a wire positioned in the road surface, was developed and implemented.

Field Trials included 6 days of operational tests on 5 equipped vehicles and over 2 months of endurance tests (280,000 km by 45 different professional drivers) by a fleet of 6 equipped vehicles, using different driving scenarios (mainly car following, approaching and overtaking) and considering different factors such as type of HMI, platoon position, speed range.

In ARIADNE, a co-driver system prototype was implemented. This system included support for headway and speed (tested on both driving simulator and vehicle) through an active gas pedal and steering support through haptic steering feedback (simulator only). This system was implemented in conjunction with a dialogue management system to optimise the presentation of information to the driver.

In the HOPES project, two types of collision warning systems used in ICC systems developed by TESCO and ARIADNE and an Autonomous Intelligent Cruise Control system developed in Prometheus were compared in terms of comfort and safety and analysed for their effects on driver behaviour, performance and workload.
The HARDIE project performed an overall review of Human-Machine Interfaces specifications for Autonomous Intelligent Cruise Control systems followed by experimental improvements of the existing HMI state-of-the-art through in-depth tests on a driving simulator to optimise/improve symbols and pictograms and provide guidelines for the design of future commercial systems; the system assessment was based on driving performance, cognitive workload, error robustness and user acceptance.

Project EMMIS developed evaluation tools for the HMI assessment of stand-alone ICC systems allowing their integration in a rapid prototyping environment and the evaluation of alternative HMI solutions in a driving simulator. Tests were performed using 60 drivers and 6 different HMI configurations (no ICC, Informative or Automatic ICC with and without telephone).

Aiming at the improvement of mobility for people with special needs, project TELAID modified standard in-vehicle controls to develop an Adaptive Cruise Control for disabled people which was and tested on a driving simulator to assess its impact on the workload of Drivers with Special Needs

Measured impacts

In the EMMIS tests on a driving simulator the impact of ICC use on safety was measured in terms of variations in average vehicle speed (5% reduction for the informative mode) and average Headway Time (30% increase for the informative mode); the NASA-TLX workload assessment method was used which indicated a lower workload for the automatic mode.

The impact on comfort was assessed using a pre-/post-questionnaire resulting in a more negative average assessment (with respect to the baseline value) for informative ICC and a more positive assessment for automatic ICC.

Impact on travel time was estimated by TESCO from the measurements of instantaneous flow and density (calculated every 30 seconds of an equipped platoon travel) indicating higher flow for the same density in a car following scenario.

Variance of travel time cannot be assessed since only short-term (30 second) average speed variances were measured which, always for a car following scenario, indicated an improvement in speed harmonisation (especially at higher speeds) and an improvement in safety conditions (lower relative speed).

More direct safety indicators were provided by the average Headway Time variation (increased in the car following scenario between 5 and 10%, from low to high speed), the Headway Time distribution (which showed a reduction at low frequency and an increase at medium frequencies) and by the average time-to-collision (under stationary speed conditions) which, for the approaching phase, increased up to 35%.

Other impacts and potential benefits

The HOPES simulation results showed no significant impact on safety from ICC operation whilst Autonomous Intelligent Cruise Control provided a decrease in speed variability but also in Headway Time thus indicating an increased level of risk. However the results also indicate that the car-following distance varies within the different systems so that beneficial safety effects due to increases in following distance may be achieved with suitable strategies. Active gas pedal control, on the other hand, tend to increase Headway Time and thus to decrease risk.

On the basis of TELAID driver tests on a simulator as well as from an assessment of expert opinion the use of an Adaptive Cruise Control sytem resulted in an enhancement of disabled driver safety.
The EMMIS tests on a driver simulator showed a high acceptance rate for ICC in automatic mode.

Results and related guidelines provide by HARDIE should improve the quality of future HMI designs and assure a better interoperability of future systems.

From TESCO results, it can be estimated that ICC system will result in improved driver safety and better traffic harmonisation, thus leading to a general increase in traffic safety, especially under bad weather conditions.

**Problems and limitations**

When a large number of specific indicators has been used to measure the impact on safety and comfort of different systems, it becomes rather difficult to transfer the results into the reduced set of macroindicators normally used for the impact analysis.

Time and resource limitation have restricted tests to a limited number of groups representing persons with special needs.

Since the HARDIE AICC trials were only performed on a driving simulator the test results could not be validated on the road.

The test results from TESCO were somewhat limited by the sample characteristics (all drivers being male and experienced professionals) and by the fact they were performed in a protected environment.

**Implementation and integration aspects**

The operational experience gained from the TESCO trials has provided better capability for the design and development of reliable and accurate vehicle telematic systems as well as better knowledge of the general issues concerning cooperative driving. It has also contributed to the capability to develop and implement complex real-time software applications and general data handling and processing.

As a result of the EMMIS tests on a driver simulator, the Automatic mode of ICC operation had higher acceptance than the Informative mode and appeared overall safer.

**Future needs and developments**

- Since to allow for use of ICC systems all vehicles and motorways must be equipped, full standardisation is needed and significant liability and legislative problems must be addressed and solved.
5. DETAILED ANALYSIS OF IMPACTS ON MAIN TRANSPORT ISSUES

In the previous section the relevant impacts of the various Transport Telematics applications on the main characteristics of the European Transport System were presented which resulted from the pilot projects and field trials performed during the Third Framework Programme on Research and Technology Demonstration of the European Commission.

For reasons of continuity with the organisational framework used to manage and co-ordinate the activities taking place within over sixty projects as well as to allow a proper visibility of achievements by domain, such a presentation has been structured according to the six main Areas of major Transport Telematics functions.

However, this document is also and mainly intended to provide information about the benefits to be obtained from the most promising Transport Telematics Applications to all the many other important Transport actors who may be not fully familiar or interested in the programme organisational characteristics. For the convenience of these new potential users of the programme’s achievements, the very same results are presented in this section structured according to categories of broader user benefits and issues that are most relevant for future exploitation, such as safety, efficiency, environment and energy, cost, socio-economic policy, user response and acceptance.
5.1 SAFETY

5.1.1 Safety: Travel & Traffic Information

Variable Message Signs, used as part of a traffic management system, resulted in a 10% speed reduction and up to 30% less accidents 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 with over than 85% less accidents.

An improvement of traffic safety may be provided by vehicles fitted with sensors which will automatically trigger a radio signal in the event of an accident; the signal can be also operated manually as a call for help.

Adverse weather roadside or on-board warning systems can also contribute to improving safety by influencing the drivers to slow down when the road friction is reduced.

No direct safety impacts of Dynamic Route Guidance systems have been measured. However, it has been predicted that reductions in distance travelled for guided vehicles would reduce "exposure" to accidents and therefore reduce accident risk/frequency. Driver-specific routeing strategies could also target safety risk minimisation (e.g. conflict minimising routeing for the elderly).

Overall impacts on safety of in-vehicle operation of DRG systems, including Human-Machine Interface issues, are not clear-cut. Distraction from the driving task has been shown to vary with the complexity of the route guidance display, but is less that for traditional maps. Guided drivers unfamiliar with a network should benefit from reduced navigational load whereas RG for familiar drivers may occasionally result in some distraction.

5.1.2 Safety: Traffic Management, Operations & Control

No direct safety impacts of new UTC developments/functions have been reported from the projects in the Transport Telematics programme, although safety is always a key component in design.

Improvements in pedestrian safety at pedestrian crossings can be obtained by using new microwave pedestrian detection technology linked to new signal control strategies. This reduces the number of red-light violations by pedestrians and thus can prevent potential pedestrian-vehicle collisions.

The use of Automatic Incident Detection (AID) systems would effectively contribute to reducing the time necessary to set warning signs and thus prevent secondary accidents.

5.1.3 Safety: Public Transport

On Public Transport Priority applications no measured results are available, although maintenance of safety has been a key criterion in the priority strategy development. Potential safety impacts were highlighted in one project, together with implications for control.

To the extent that transport telematics applications can contribute in making public transport more competitive and acceptable (and thus favour modal shift from private vehicles) it is expected they can also lead to improved road safety.

5.1.4 Safety: Freight and Fleet Management
In Fleet Management applications, the results on travelled distance reduction per year from the use of Mobile Data Communications, Global Positioning Systems and/or Trip Recording equipment experienced on a fleet of 63 commercial vehicles over a 13-month trial, if extended to the European context, would potentially lead to an average reduction of about 150 fatal accidents per year.

In terms of Hazardous Goods Monitoring and Control the only measured impact was related to the significant reduction (from the usual hours to 3-6 minutes) of the time elapsing from the occurrence of a relevant status change in the safety characteristics of the transported dangerous goods and the reception of the corresponding message by the interested accident management authorities.

However, since all pilot trial users responded favourably to the HGM&C systems under trial, it is expected that its implementation on a pan-European level should contribute in achieving safer hazardous goods operations.

In conclusion, through proper management, monitoring and control of vehicles and resources, there is indeed a high potential of increased safety to be achieved, in terms of reduction of emergency response time (as already observed) and in terms of estimated reduction of accidents, consequences and environmental damage due to hazardous transport incidents.

5.1.5 Safety: Automatic Debiting & Demand Management

Safety of private and commercial vehicles is expected to be improved as a result of extensive deployment of automatic tolling on motorways due to the elimination of traffic channeling at toll plazas as well as possible queues.

In the socio-economic analysis performed for the Thessaloniki test site, it has been estimated that the implementation of a multi lane tolling system would result in safety benefits equivalent to 70 kECU for the period 1995-2006.

Implementation of demand management features such as road pricing and access control, if supported by suitable policies on safety enforcement, is likely to contribute to the overall safety as a result of reduced traffic congestion.

5.1.6 Safety: Driver Assistance and Co-Operative Driving

The use of an Accident Data recorder on commercial vehicles for driver monitoring purposes resulted in statistically significant reduction in accident occurrence (up to a maximum 41% reduction with respect to past historical average of the number of accidents for a fleet of 130 vehicles) and beneficial reduction in accident costs due to lower accident severity.

On private vehicles, the average user response has indicated that the implementation of a driver monitoring function has shown a positive assessment of its contribution to a better safety.

The safety assessment of Driver Support equipment and applications was performed on the basis of expert opinions and users interviews as well as test track and driving simulator tests. The use of reversing aids enabled elderly drivers to position the car more easily and accurately. As an indicator of potential safety improvement, the number of collisions or near misses was measured in reversing with obstacles in the rear path. From the tests performed it appears that the number of low-speed
minor accidents and the chance of collision with children running across the path of a reversing car could be reduced.

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 assessment of collision avoidance systems was essentially oriented towards the evaluation of the influence that such co-driver system may have on driver behaviour; the identification of measurable impacts on safety was therefore outside of the projects’ scope.

At the present stage, even the survey results which could lead to a quantitative distribution of responses among type of users have shown wide variations at the individual level which prevented any significant analysis in statistical terms.

With reference to the use of collision avoidance systems on private vehicles by normal drivers, measurements of the average Headway Time (HT) indicate that the use of Collision Warning functions actually resulted in an increased average HT, whilst the answers to a questionnaire on Workload effects resulting from display use have shown no significant variations in workload. Therefore an extensive use of collision warning is expected to induce an increase of Headway Time and thus safer driving conditions.

For private vehicles, the answers to a questionnaire collected after trials on a driving simulator have shown that the use of a Safe/Not Safe indicator controlled by an electronic measurement of the available gap time in traffic to assist the drivers in performing turns at junctions or intersections should effectively help elderly drivers, especially at night time or under poor visibility conditions.

In general, the development and test work that has been carried out on collision avoidance co-driver systems has shown that, if a sufficiently high level of HMI operation and dialogue management can be achieved, the systems have a real potential of improving traffic safety (as well as driver comfort).

In the EMMIS tests on a driving simulator the impact of Intelligent Cruise Control systems use on safety was measured in terms of variations in average vehicle speed (5% reduction for the informative mode) and average Headway Time (30% increase for the informative mode).

On the other hand track tests performed by TESCO on ICC systems have indicated an average Headway Time increase in the car following scenario 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).

Short-term (30 second) average speed variances were measured which, in a car following scenario, indicated an improvement in speed harmonisation (especially at higher speeds) resulting in improved safety conditions due to the lower relative speed.

These results show that, should the systems be extensively deployed with proper emergency handling capabilities and prevention of negative adaptation effects, the use of ICC systems should contribute to the establishment of safer motorway traffic conditions.

The HOPES comparative simulation results, on the other hand, showed no significant impact on safety from ICC operation whilst the use of an Autonomous Intelligent Cruise Control provided a
decrease in speed variability but also in Headway Time thus indicating an increased level of risk. However the results also indicate that the car-following distance varies within the different systems so that beneficial safety effects due to increases in following distance may be achieved with suitable strategies. Active gas pedal control, on the other hand, tend to increase Headway Time and thus to decrease risk.

On the basis of TELAID driver tests on a simulator as well as from an assessment of expert opinion, the use of an Adaptive Cruise Control sytem resulted in an enhancement of disabled driver safety.

From TESCO results, it can be estimated that an extensive use of ICC system should result in improved driver safety and better traffic harmonisation, thus leading to a general increase in traffic safety, especially under bad weather conditions.
5.2 EFFICIENCY

5.2.1 Efficiency: Travel & Traffic Information

According to the field trials and surveys in this domain, pre-trip information obtained by all kind of travellers has influenced 60% of the users; 40% of them changed their departure time, 30% changed the date and 20% used an alternative route.

Among test drivers using RDS-TMC, 55% believed that the systems were useful for travel time reduction and 42% considered the recommended alternative route better than the one of their own choice.

Field trials of in-vehicle Route Guidance systems have been insufficient in scope to assess their impact on network efficiency; the impact assessment has thus been made mainly through simulations and user response surveys.

Evidence from RG simulation studies (for unguided drivers in low penetration scenarios) has indicated journey time savings of typically 4-8%, depending on network, traffic and system characteristics. Highest potential benefits are predicted under incident conditions. As penetration levels rise there is simulation evidence that DRG could contribute to network efficiency through its contribution to improved traffic management.

5.2.2 Efficiency: Traffic Management, Operations & Control

The application of a real-time VMS control strategy selection, based on models developed as part of the Transport Telematics programme and using models for re-routing, led to a reduction of traffic delays by up to 20%.

Control strategies using ramp metering increased the mean speed for the motorways, the parallel network and the total corridor by 21%, 16% and 19% respectively.

Ramp metering reduced delays at on-ramps by 19%.

The transfer of information between Traffic Information Centres and Traffic Control Centres has been improved by establishing language independent facsimile forms.

Traffic responsive Urban Traffic Control (UTC) systems have been demonstrated providing significant efficiency savings over isolated control or fixed time UTC. Benefits for SCOOT (UK) and UTOPIA (Italy) were already established and reported before. From the field trials here considered, impacts of other evaluations involving PRODYN (France) and MOTION (Germany) have demonstrated:
- 10 to 20% increases in mean speed
- up to 20% reduction in travel time (typically 10%)

New UTC-related functions, successfully developed in the Transport Telematics programme, include knowledge-based systems, Automatic Incident Detection, congestion monitoring and dynamic Origin-Destination (O-D) estimation. Each has satisfied its own measure of performance and contributed to improved network efficiency.
For Integrated Urban Traffic Management (IUTM), including UTC, it has been estimated in one project that a 25% reduction in journey time for all modes should be achieved from complete integration of all functions. Examples of integrated UTC, driver information and public transport priority strategies showed savings in:
- private vehicle travel times (ranging from -4% to +28%)
- bus travel times (from 6% to 16%)
- number of stops (about 30%)

5.2.3 Efficiency: Public Transport

On Public Transport Priority applications, field trial/simulation results from one project in 3 cities (concentrating on bus/tram priority in advanced UTC systems) and four other projects with priority applications revealed:
- delay savings due to priority for buses/trams at signals, which averaged around 50% (range 22-97%) across all applications and with generally negligible impacts on private traffic.
- journey time savings for buses/trams of 7-19%.
- reduced variability in PT journey times and delays (up to 25%).
- improved regularity of PT services (11% in one example).

5.2.4 Efficiency: Freight and Fleet Management

On the basis of the average results from IFMS trials, Freight and Fleet management functions should provide (according to an intermediate evolutionary scenario that assumes a given capital cost per system/vehicle) 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, the data have become more reliable, and transport order cycle time was reduced.

METAFORA 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. From the METAFORA experience, it was also discovered that, through the building of a real shipper-operator partnership, it is possible to achieve a significant reduction of order-handling process time. More specific benefits were the reduction of human errors, the improvement of transport efficiency along the whole logistical chain.

MELYSSA 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 F&F management functions and that, with the use of Transport Telematics, the number of delayed arrivals decreased by 35%.

For Intermodal Tracking and Tracing applications COMBICOM II 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.

5.2.5 Efficiency: Automatic Debiting & Demand Management
For Automatic Toll Collection it is expected by ADS that using automatic multilane tolling instead of manual toll gates, travel time will be reduced because it will not be necessary to slow down for toll payment and that waiting time during peak hours can be eliminated; time variance due to toll collection is also expected to become negligible. The average time loss would be reduced from several minutes to nil resulting in an average saving of over 40h/year for the average motorway commuter.

For the Thessaloniki test site, as a result of the expected traffic increase through the year 2006, it has been estimated that, with no modifications to the existing 5 manual toll lanes, the average passing time for cars should increase to 156 seconds from the 90 seconds measured in 1994. By replacing one of the manual gates with the mono-lane ADEPT enforcement system (in combination with the multi-lane tolling gantry) the passing time of the equipped cars would be reduced to 45 seconds 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, non equipped vehicles would also benefit from a reduced passing time increase to 108 seconds (a 48 second or over 30% reduction) due to the reduced demand in the manual lanes.

For Road Pricing, from extensive surveys made by MIRO, no evidence has emerged of reduced total car usage. However, at Trondheim there has been a 10% reduction of crossing of the cordon during toll hours. The trips have been redistributed in time and spatial patterns in response to the tolls. Public transport usage has increased by 8% for the whole city area. With enforcement achieved through video cameras, the number of violations across the toll ring is low, at a level considered acceptable by the authorities. Modelling of the driver behaviour has indicated that there would be a 3% reduction in car entries to the areas for a NKr 5 toll and a 4% reduction for a NKr 15 toll.

For Access Control, on the basis of journey time surveys performed by the MIRO project in Barcelona using the “car following” technique, an average 18% reduction of travel time inside the special events zone was identified; for the pedestrian priority zone no travel time changes were observed over routes both inside and outside the zone.

Concerning the variance of access time distribution for the pedestrian priority zone in Barcelona, telephone surveys with residents and visitors have shown that 31% of the visitors have anticipated the time of entry into the priority zone, whilst measurements of hourly entry volume counts indicated a 21% and a 13% increase in loading during the two unrestricted entry periods with respect to the 12 hour average.

In terms of vehicle traffic flow during working days, the total recorded entry volumes before and after access control implementation showed a 33% reduction for the special event zone in Barcelona, a 55% reduction for the non-stop access control in Bologna, with major re-assignment to the Inner Ring Road, and a 78% reduction for the priority zone in Barcelona. In this test site telephone surveys reported that both residents and visitors reduced the manner of car trips per week after the access control implementation (respectively 1 and 3 car trips reduction per week).

Concerning parking space availability in Barcelona, surveys indicated a 15% increase in both on-street availability within the special events zone and in on-street space usage within the zone resulting from a shift of parking from the inside to the border zone with a 20% perceived reduction in congestion problems. Data from the public transport operator in Barcelona indicated for the special events zone a 50% increase in public transport trips city-wide.
Data from the non-stop access control tests in Bologna provided an indication by digital photo processing effectiveness: during daytime successful readings were respectively 75% (automatic mode only) and 97% (automatic mode with operator support).

For Parking Control, in Munich the use of Variable Message Signs to advise motorists approaching the city of the new Park'n'Ride facility at Frottmaning resulted in mode shift due to the P'n'R availability that could reduce the use of private car by 1.6 million km/year for that site. From surveys made during the LLAMD trials, 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.

In Köln VMS were also used by the SCOPE project on the approach to the city to advise motorists of availability of Park'n'Ride facilities. Usage of the P'n'R facility more than doubled with 33% of users doing so directly because of the information.

The integration of payment for parking was included in the multi-application smart card in Dublin within the GAUDI project, with many users using the card for other modes as well; queuing time for exit by motorists with smart cards was significantly reduced.

5.2.6 Efficiency: Driver Assistance and Cooperative Driving

Impact on travel time of Intelligent Cruise Control systems was estimated by TESCO in a car following scenario from the measurements of instantaneous flow and density (calculated every 30 seconds of an equipped platoon travel) indicating higher traffic flows for the same vehicle density.

For private vehicles, the answers to a questionnaire collected after trials on a driving simulator have shown that the use of a Safe/Not Safe indicator (controlled by an electronic measurement of the available gap time in traffic to assist the drivers in performing turns at junctions or intersections) should effectively help elderly drivers, especially at night time or under poor visibility conditions.
5.3 ENVIRONMENT AND ENERGY

5.3.1 Environment and Energy: Travel & Traffic Information

Effective use of Variable Message Sign selection strategy reduced delays by up to 20% which has been estimated to reduce CO by 10%, HC by 5% and Nox by 5%.

The APOLLON implementation in Athens in QUARTET was also aimed at environmental traffic control through pollution-sensitive traffic re-routing using VMS.

Two pollution episodes occurred in the Athens field trials in the winter of 1994/95. It was estimated that the number of vehicles entering the centre on these occasions decreased by 5%. Pollution calculations and simulation modelling were used to predict the following impacts.

<table>
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<tr>
<th>Pollutant</th>
<th>Pollution level (ppm) at Kerbside</th>
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<tr>
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<td>Inside Controlled Area</td>
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<tr>
<td></td>
<td>Before</td>
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<tr>
<td>CO</td>
<td>16.5</td>
</tr>
<tr>
<td>NOX</td>
<td>0.67</td>
</tr>
<tr>
<td>HC</td>
<td>4.69</td>
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</tbody>
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Pollution reduction in the controlled area was higher than the increase in pollution outside the controlled area.

Reductions in journey time and distance travelled due to improved vehicle routeing, as demonstrated by simulated tests with in-vehicle Route Guidance systems, would lead to a 5% reduction in fuel consumption and emissions as well as to a better protection of environmentally sensitive areas through guidance onto other designated routes.

5.3.2 Environment and Energy: Traffic Management, Operations & Control

Savings of in fuel consumption and emissions (4% - 6% in simulation studies using enhanced Urban Transport Control with Public Transport priority). Further improvements are possible if modal change is achieved.

For new UTC, reduced journey time/delay provides associated reductions in emissions and fuel consumption. Examples of impacts of simulated integrated strategies include 2 -5% predicted reductions in fuel consumption and emissions.

The use of an advanced predictive environmental model integrated with traffic control and having on-line connections to meteorological and pollutant measurement stations and VMS has shown reductions in the controlled area of:
- 29% in kerbside CO ppm
- 30% in kerbside NO\(_x\) ppm
- 26% in kerbside HC ppm;
outside the controlled area, pollutants increased by 13% and total network travel time increased by 2%.
Development of control models aimed at reducing journey time and traffic delays would therefore contribute in reducing pollution.

- Urban environmental monitoring and pollution monitoring equipment: these have been implemented in some cities but don't in themselves produce impacts.
- Integrated control strategies to reduce pollution: Athens is the only example with results, although Turin has reduction target of 2% to 5% through the use of integrated traffic control strategies with a further 6% reduction due to town supervisor action targeting pollution reduction.

5.3.3 Environment and Energy: Public Transport

See previous section

5.3.4 Environment and Energy: Freight and Fleet Management

On the basis of the average results from IFMS trials, Freight Management functions should provide a reduction in travelled distance leading to a reduction of fuel consumption and thus of emissions.

As a result of freight & fleet management functions, METAFORA measured an average reduction of fuel consumption per vehicle and year of 2,350 litres (approximately 4.4% based on 150,000 km per year and 35 l/100km).

Automatically activated emergency call systems based on a telegram system using Global Positioning System and GSM digital cellular techniques have been developed within the Hazardous Goods Monitoring and Control applications which can automatically transmit details of vehicle contents in the event of chemical spill, thus reducing the time required to take action and prevent environment contamination.

On the basis of the observed reduction of emergency response time and on the estimated high potential for reduction of accidents, accident consequences and environmental damage due to hazardous goods transport incidents should be significantly reduced by the use of related Transport Telematics applications. In general emissions and noise in the field trials corridors were reduced as a result of the monitoring of speed and vehicle conditions; by also monitoring and deviating noisy vehicles from urban/public areas, noise impact was reduced in such areas. Energy consumption was also reduced by reducing empty vehicle km and improving the provision of road assistance.

5.3.5 Environment and Energy: Automatic Debiting & Demand Management

Use of Multilane Automatic Toll Collection Systems will improve the air quality and reduce the energy consumption of the average motorway commuter by about 5%.

The implementation of the ADEPT multi-lane tolling/mono-lane enforcement system in Thessaloniki would result in environmental benefits from reduction of noise and emission levels equivalent to 130 kECU (a value close to the total investment cost of the ground equipment) for the period 1995-2006.

Integration of toll collection and axle-weight road pricing can effectively contribute to improved road and environment protection.
Modelling of the travel impacts of road pricing based on user response studies carried out within GAUDI and MIRO was carried out for Gothenburg (S) and Trondheim (N). In Gothenburg, the modelling exercise 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.

The principal benefits are expected to be in the form of environmental improvements through a reduction of noise, emissions and energy consumption as well as of accidents.

Within the Access Control trials in Bologna, pollution monitoring data showed a 50% reduction of emission in the central area. In Barcelona, model estimates in the special events area had predicted a 50% reduction of emission inside the zone, while surveyed citizens indicated a perceptions of reduced air pollution (19%) and reduced noise (20%) within the priority zone.

In Munich Variable Message Signs were used by the LLAMD project to advise motorists approaching the city of the new Park'n'Ride facility at Frottmaning. Over 26% of the 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 with a corresponding increase of emissions. The mode shift due to the Frottmanin P'n'R operation is estimated to be able to reduce the use of private car by 1.6 million km/year.

In Köln VMS were also used by the SCOPE project on the approach to the city to advise motorists of availability of Park'n'Ride facilities. Usage of the P'n'R facility more than doubled with 33% of users doing so directly because of the information. Many of the cars would otherwise have proceeded to the city centre.

The main benefits of Parking Monitoring and Control for P’n’R facilities are then expected to be a reduction in the secondary congestion, pollution and energy consumption associated with searching for parking spaces within the city.

5.3.6 Environment and Energy: Driver Assistance and Co-operative Driving

The UK trials on driver monitoring showed a downtrend in the number of observed “overspeeds” per 1000 miles by the fleets of equipped commercial vehicles, leading to a likely reduction of fuel consumption and related emissions.
5.4  COST

5.4.1  Cost: Travel & Traffic Information

More than half of the drivers who experienced RDS-Traffic Message Channel systems to receive on-trip traffic information indicated they would be willing to buy RDS-TMC equipment. The price they would be willing to pay for the extra facility should not exceed 100 ECU.

5.4.2  Cost: Traffic Management, Operations & Control

Previous evaluations of SCOOT had shown how efficient traffic responsive Urban Traffic Control systems can repay their costs typically within 1 year, when implemented in place of isolated control or fixed time UTC. No new economic evaluations were reported in Transport Telematics programme.

For Automatic Incident Detection systems, implementation costs are very low for detection based systems (mainly software) but higher for video-based systems. Benefits are related to the reliability and speed of detection and to the quality/effectiveness of subsequent incident management strategy.

For dynamic estimation of Origin-Destination parameters using software models, costs are low; however benefits of improved traffic control/routeing have not been yet reported.

For environmental monitoring in UTC systems, costs are highly system specific and economic benefits of reduced pollution cannot be readily calculated.

5.4.3  Cost: Public Transport

One study reported a total implementation cost of bus priority within existing UTC of 200 kECU for 10 junctions, with annual economic benefits (mainly bus delay and operating cost savings) of 145 kECU, giving a first year return of 72%.

A further study indicated costs of new UTC plus tram priority of 850 kECU for a 5 km tram route producing annual benefits of 3200 kECU through travel time savings for tram users (43%), regularity savings (1%) and travel time savings for general traffic (56%).

Economic cost-benefit analysis undertaken for four systems/strategies produced favourable rates of return, with payback periods ranging from 3 to 16 months.

Further economic benefits have been predicted for greater integration of public transport and traffic control systems.

5.4.4  Cost: Freight and Fleet Management

METAFORA project experience with Inmarsat-C satellite communications, based on trials by 32 vehicles from 5 companies indicated, as a result of the estimated saving of mileage in international transport, a payback period of 4 to 8 years.

The systems used in the IFMS trials to perform Freight Management functions had a capital cost ranging from 3.5 to 25.6 kECU per system and from 2.0 to 11.6 kECU per vehicle; with reference to an average capital cost of 12.7 and 5.5 kECU per system and vehicle it can be expected a system
running cost of about 3.8 kECU/year and a vehicle running cost of about 2.2 kECU/year. On the basis of the corresponding expected benefits, an internal rate of return of about 21% can be assumed which would lead to a payback period of 3.4 years.

In general terms, according to the IFMS operators experience, integration of Electronic Data Interchang with the in-house system and depending on a number of factors (such as the type, size and frequency of messages) is likely to have a positive impact on the overall payback period; they have found that the initial investment costs were relatively high, in contrast to the variable cost, which was considered low. The variable cost of messages can be further reduced by combining a number of messages within a single connection.

From METAFOREA experience it was also discovered that, through the building of a real shipper-operator partnership, it is possible to achieve a reduction of the manpower requirements for any repetitive task to be performed within an integrated EDI situation.

METAFOREA has also 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 1 ECU/1000 km.

For the transport companies involved in the field trials, the payback periods of satellite communications systems used to equip the vehicles (based on tangible benefits only) varied from 4.1 to 8.4 years.

For Intermodal Tracking and Tracing applications, a cost-benefit-analysis showed a profit increase for each transport action of 4.5 to 15 ECU for operators and 20 to 80 ECU for shippers/forwarder. With reference to the infrastructure costs, the COMBICOM II project was able to identify the best cost/performance compromise for both the road/rail-terminal and the cargo-units.

The Hazardous Goods Monitoring system enabled more cost-effective freight and fleet operations; in the FRAME project, for instance, paper work was reduced and automated processing of deliveries became possible. Therefore the number of administrative personnel could be reduced substantially. The FRAME system has also shown a high potential to increase the number of customer served with the same operational resources due to the fact that just-in-time and efficient operations became possible.

On the basis of a cost-benefit analysis, the FRAME project demonstrated operational, administrative, environmental and other benefits with minimal investment cost as well as a reduction of access costs for commercial users and government authorities.

5.4.5 Cost: Automatic Debiting & Demand Management

As a result of multilane automatic tolling systems on motorways, investments in infrastructure and operating costs of manpower should be reduced. The number of transactions per unit time should have a huge improvement.

The use in Thessaloniki of the ADEPT multi-lane tolling gantry with mono-lane enforcement in each direction would result in a 60% increase in capacity; the net benefits for the period 1995-2006 were calculated in the amount of 1.15 MECU. As total costs would amount to 0.64 MECU, the payback period for the infrastructure operator would be of 6 years with an internal rate of return of 33% over the whole 12-year period.
The road maintenance costs can be significantly reduced by discouraging the overloading of Heavy Goods Vehicles through the use of automatic weighing for toll collection. The resulting improvement in the efficiency and capacity of the tolling system and the less frequent maintenance works on road pavement should help increase the infrastructure capacity. Dynamic Tolling systems based on automatic weighing in addition to better road protection, improved road safety and comfort should help reducing road maintenance costs and provide market opportunities for new products.

In terms of financial return of investment (excluding intangible benefits) it was estimated that in Bologna the pay-back period for Access Control systems should be between 2 and 5 years depending on the actual violation rate; the corresponding figure for the Barcelona priority zone application was 4 years.

A cost-benefit analysis of the Munich P'n'R site indicated that the provision of VMS for parking access information and guidance can only be commercially viable for P'n'R sites of 500 spaces or more.

5.4.6 Cost: Driver Assistance and Co-operative Driving

At the fleet level, a reduction of the commercial vehicles operating costs was observed: as a result of reduced accident related damages, 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.

In turn the use of an Accident Data Recorder led to an improvement of service quality in commercial fleets because of the reduced vehicle downtime (resulting from the reduction of number and severity of accidents) and the better accuracy of accident analysis data. This would also lead to an expected reduction of legal and administrative costs required for professional accident investigations.
5.5 SOCIO-ECONOMIC POLICY

No significant indication on Socio-economic impacts were available from the projects of the Transport Telematics programme involved in the applications of Travel & Traffic Information, Traffic Management, Operations & Control, Public Transport and Freight & Fleet Management.

5.5.1 Socio-Economic Policy: Automatic Debiting & Demand Management

Dynamic Tolling based on automatic weighing in addition to better road protection, improved road safety and comfort and reduced road maintenance cost should provide market opportunities for new products.

The cities should benefit from the implementation of road pricing applications as a result of increased revenue opportunities whilst the public transport operator should benefit from enlarged patronage. The organisations within the city are expected to benefit from the reduction in journey time and travel costs for businesses, although concern has been expressed that business siting might be diverted elsewhere.

The impact of advanced restraining tools for access control in supporting the achievement of a real sustainable mobility appears far more effective than the one which can be obtained from conventional technologies.

The main benefits of Parking control applications are expected to be the reduction in stress for motorists and the increased business and occupancy levels for parking operators.

5.5.2 Socio-Economic Policy: Driver Assistance and Co-operative Driving

If driver monitoring can be more widely used in commercial fleets, a widespread reduction of accidents severity could lead to a greater reduction of total social costs from road accidents (including insurance, hospitalisation and other costs).

The majority of the elderly drivers who have tested route guidance support systems stated that the availability of these systems should impact on their travel behaviour in a way to lead to a higher likelihood of travelling to unfamiliar places; only a small minority stated that such systems could lead them to a more frequent travelling.

The assessment of the answers to a questionnaire of the potential change induced in the driving habits and attitudes of elderly people has shown that reversing aids would only marginally affect the willingness to drive to places where parking manoeuvres were known to be difficult, but the availability of vision enhancement means would allow 60-70% of elderly people to drive more at night.

In terms of socio-economic aspects, the results of an enhanced ability to drive by Drivers with Special Needs (DSN) indicate the possibility of achieving a better social integration of DSN people. To this aim the results of the TELAID driver tests on a simulator as well as an assessment of expert opinion on the use of Adaptive Cruise Control systems by DSN indicated that such an application would provide a significant enhancement of disabled driver safety.

On an institutional and political level, the now available database on aids for DSN (TELDAT) can also be used by industry (for car adaptation and related equipment/fittings development) and by
authorities (licensing, homologation, financing bodies). Guidelines and Draft Regulation for DSN Aids may also be used by authorities to improve road safety and comfort.

The availability of guidelines on the recommended use of Human-Machine Interface design specifications for Collision Avoidance systems should help improving the quality of future equipment design and thus allow greater system interoperability at a pan-European level.
5.6 USER RESPONSE AND ACCEPTANCE

5.6.1 User Response and Acceptance: Travel & Traffic Information

Key cross-project results from surveys of user response to Dynamic Route Guidance systems include:

- 55% of test drivers believed that the systems were useful for travel time reduction
- 42% of test drivers considered the recommended route better than their own choice
- 50% of test drivers were willing to buy route guidance equipment at a price above 750 ECU.

Other relevant results from individual projects include:

- the usefulness of guidance to unknown destinations (73%)
- the generation of additional trips due to the availability of a RG system, as indicated by 40%-50% of respondents in different surveys. (The impacts of this would be improved mobility/accessibility, but potentially reduced traffic efficiency.)

5.6.2 User Response and Acceptance: Traffic Management, Operations & Control

Positive user response to new/enhanced UTC is reflected in the quantitative measures of improved network efficiency.

5.6.3 User Response and Acceptance: Public Transport

Limited evidence of modal change to public transport due to priority was provided by field trials in two cities. However, more evidence is emerging from other studies. An earlier study found a 1.36% increase in PT demand for a 1% increase in speed perceived by PT users.

5.6.4 User Response and Acceptance: Freight and Fleet Management

According to the LLAMD results from a workshop and the answers to questionnaires, has indicated that 50% of the respondent Managers of freight & fleets considered that Transport Telematics applications in freight management could improve the service quality of their freight operations.

The use of Freight Management functions has led to an increase of customer satisfaction by improving the level of information supply and customer flexibility.

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.

The system has increased the operator awareness of the capabilities of new technologies; while providing significant time savings, it also allowed to improve the management of vehicles and fleets, the efficiency of information management and the company competitive position.

The success of the Fleet Management application was also demonstrated by the operators requests to equip more vehicles with Mobile Data Communication equipment.
5.6.5 User Response and Acceptance: Automatic Debiting & Demand Management

An analysis of pilot systems transactions on Integrated Payment provided an indication of the amount of multiple service usage in the GAUDI project: in Dublin, out of 980 cards, 46% were used to pay for more than one service and 13% for more than two services. The corresponding figures in Marseille (for 737 cards) were 46 and 21%.

In terms of benefits for the Freight & Fleets operators some indicators have been identified in the fraction of system transactions using Electronic Purse instead of conventional payments and related fares (71% reloadings referred to 396 cards in Dublin and 31% reloadings referred to 4,873 cards in Marseille).

Another indicator has been identified for Marseille in the fraction of use of televalidation (either by Infrared or microwave): Each user, in case of a problem in completing the transaction remotely, could insert the smart card directly into the validator as for conventional cards.) Operational data indicate 85% IR remote operation and 15% contact operation during the first phase (IR only); during the second phase (IR and microwave) the corresponding indicators are 41% (IR), 32% (microwave) and 27 (contact).

User surveys performed by MIRO indicated that, for the GAUDI trials, 91% of the respondents in Dublin found the electronic purse a convenient way for paying for Public Transport services, 84% of the Marseille respondents highly regarded the reduction of money and ticket and were very satisfied with the design of the portable units and the related messages. In Bologna 65-70% of respondents had no problems with the smart card use, nor with the new location-related fare structure.

In Bologna, where the card had only been used for the bus service, a survey indicated that 75% of the users were in favor of an extension to a multiservice operation MIRO.

Results from Marseille surveys showed that a remote payment device can offer the users a number of advantages: ease and control of gesture, friendly user interface, good security, flexibility of operating modes (speed of communication, on-and off line). The card used was considered adequate in terms of data storage, processing and security capabilities. On the reliability of televalidation equipment in Marseille, operational data indicated an overall 97% reliability . From the MIRO surveys 62% of the respondent were very satisfied. From transaction data, smart cards appeared more durable and reliable and thus more acceptable to users than magnetic cards.

Customer benefits in terms of travel time savings, reduced time variance and improved safety should lead to good user acceptance of Automatic Toll Debiting systems from both private and commercial users of toll motorways

In Trondheim (N), the toll ring operates as a cordon around the central area with 12 entry points. Automatic fee collection 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.

User response to road pricing has been examined in the MIRO project which measured user perceptions and responses in eight cities from the GAUDI and ADEPT projects. This found that citizens had less awareness of road pricing than of any other demand management measures and questioned its effectiveness in influencing mode choice and travel behaviour. The survey found that
road pricing measures had very low levels of acceptability with citizens, whereas non-price related issues such as access restrictions have a high level of acceptability even among motorists.

A modelling of the travel impacts of road pricing (based on the user response studies carried out within GAUDI and MIRO) was performed for Gothenburg and Trondheim. In Trondheim, the attitude to 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.

The social acceptance of the access control measures by the citizens was also assessed by means of opinion surveys. In Barcelona 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 about the special events zone (only 3% giving a bad rating). For the priority zone (on a 1 to 9 scale) residents gave an average 5.8 mark to the quality of information (compared with a 4.1 mark from visitors).

Data from the public transport operator indicate for the special events zone a 50% increase in public transport trips city-wide indicating a good attitude towards a modal shift.

Telephone surveys to residents and visitors of the Barcelona priority zone indicated a perceived increase in public transport use of non-motorized trips. The same survey showed that the main benefit provided by the access control scheme was perceived as an improvement of traffic conditions for pedestrians and cyclists.

In Barcelona, residents of the special events zone were 70% in favor and 24% against the measures implemented. In the priority zone residents gave to the measures an acceptance rating of 6.1 (on 1 to 9 scale; the city-wide rating was 6.0)

In Bologna, a city-wide survey on the acceptance of non-stop access control measures showed a rather close 40/37% split between for/against options.

In Munich Variable Message Signs were used to advise motorists approaching the city of the new Park'n'Ride facility at Frottmaning. The mode shift due to the P'n'R is estimated to be able to significantly reduce the use of private car: 16% of the respondents attributed their decision to the availability of VMS information about parking space availability. In total 26% of the users on weekdays, and 46% of the users on special event days, would have used the car for the entire trip if the Park'n'Ride facility were not available.

Usage of the P'n'R facility in Cologne more than doubled with 33% of users doing so directly because of the information. Many of the cars would otherwise have proceeded to the city centre.

The integration of payment for parking was included in the multi-application smart card in Dublin (GAUDI project), with many users using the card for other modes as well. High user satisfaction was reported by both the motorists and the parking operator. Queuing time for exit was significantly reduced for motorists with smart cards. Impacts on parking behaviour were not measured.

The main user benefits from parking control applications are expected to be the reduction in the secondary congestion, the reduction in stress for motorists and the increased business and occupancy levels for parking operators.
5.6.6 User Response and Acceptance: Driver Assistance and Co-operative Driving

The average user response has indicated that the implementation of a driver monitoring functions has a slightly negative impact on driver comfort but has shown a positive assessment of its contribution to a better safety.

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 driver 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, have found widespread good acceptance, assuming that a very low rate of false alarms could be achieved.

The EMMIS tests on a driver simulator were assessed using a pre-/post-questionnaire in terms of impact on the driving comfort: with respect to the initial baseline value, informative-only Intelligent Cruise Control systems had a worse average assessment whilst ICC systems operating in the automatic mode were generally assessed as contributing to a better driving comfort.
6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Travel and Traffic Information

RDS-TMC has, within the time scales of the ATT programme, become established as a major facility for the dissemination of traffic information through the whole of Europe. There was a very high percentage of drivers interviewed in a number of project who used the facility concluded that they were very satisfied with the accuracy, timeliness and credibility of the information provided and that on a number of occasions contributed to a decrease in uncertainty of journey time. A number of car manufactures are now incorporating RDS-TMC as a standard feature for promoting the sales of their flag ship products, and more broadcasting organisations are working towards an implementation policy making the long term potential very encouraging. The work and co-operation being achieved through the standards committees addressing the many communication parameters will also ensure a continuing growth in this area.

Pre-trip information concepts have also been matched with the latest technologies using both portable and permanent terminals, particularly in relation to public transport information with more than 60% of the population involved in the trials influenced by the information provided. The work undertaken to address the man machine interface problems is continuing to pay dividends with most of the public finding the terminals easy to use. The technological growth in this area is continuing with manufacturers of mobile telephones looking towards the integration of communication and display as a major feature for the next generation of portable communication terminals. The inevitable link with RDS-TMC will be another means of increasing the public awareness of a whole range of traveller information services.

Roadside information systems that can be adapted to present unfamiliar text or display pictograms to integrate with the permanent roadside route direction signing rely heavily on the use of VMS. The rapid growth in the dot matrix technologies have provided the opportunity to apply the capability of displaying a wider range of text, allowing the network operators to manage their networks more efficiently with up to 20% reduction in delays. The growing confidence of the drivers reflected in the very high percentage ( >80% ) who consider the information presented to be timely and accurate is a reflection on the quality of the network information obtained by the operators but also indicates the need for integration between network surveillance and strategic control. There is also a need to ensure that the information provided by RDS-TMC is compatible with the use of VMS text. The use of VMS at the interface between urban and inter-urban to indicate parking availability and route choice has also been effective.

Route Guidance

Dynamic route guidance trials in DRIVE II have not been sufficient to enable full impact assessments. No trials has had more than 100 equipped vehicles. Evaluation has therefore centred on technical performance of systems and drivers response, using a common questionnaire, logbooks and some data from other studies. It was found by the test drivers that the system could keep in guiding the user to unknown destinations and that the trip recommendations made were judged to be good. There was an increase in the number of additional trips made on unknown routes after installation of the system. The test drivers also indicated that the system was capable of changing their driving habits by using new roads or to drive at different times. A range proposition considered the alternative route better than their own choice. Although only a small number of vehicles were involved the information obtained clearly indicates that the DRG system have a place in the traffic
management tools and further work should be undertaken to integrate DRG with traffic management schemes.

**Ride Matching Reservations**

No actual implementation has been carried out within the ATT program. The CITIES project carried out a feasibility study on car pooling in 1993 and progressed this to a detailed business plan for a scheme based on unrelated users in the Ile-de-France region. The technologies include means of communication of potential car-pooler needs, ride-matching software, and user compensation system. The business plan estimated that 3000 users would participate. The city of Madrid provided a demonstration site to CITIES where they implemented a High Occupancy Vehicle (HOV) lane. The surveys indicated that 70% of people have a positive view towards ride sharing with 40% actually willing to use the HOV lane (two thirds as bus users, one third as car user).

6.2 **Traffic Management Operations and Control**

New vehicle detection systems utilising the latest computer vision analysis techniques, combined with new algorithms to operate automatic Incident detection system have been very effective for network operators and are set to become more cost effective as the capabilities increase and more resources can be saved. Another major break through in automatic systems has been with vehicles fitted with the latest "Emergency call system" activated by sensors which automatically trigger a radio signal that transmits the location of the vehicle, and if a lorry the contents. It has been designed to be operated manually as a call for help and will be a major benefit to those travelling by themselves in isolated locations. Using such a system has reduced the response time by emergency vehicles by 43% which can increase the survival rate from between 7 and 12%.

Responding to the detection of incidents and implementing emergency procedures across regional and national borders will also be enhanced by the results of the DRIVE (II) work in using the EDI and EDIFACT System to transmit valuable information.

The application of real time VMS control strategy selection and traffic prediction has made a contribution in the reduction of delays by 20% on the network. Ramp control has had a similar result in both the delay on the ramps and the main route traffic. VMS installed on the motorway in the close proximity to the urban area providing park and ride availability has had a very significant impact with more than a 80% increase in park and ride users.

Trials of new microwave detection for 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 pedestrian, with benefits to particular pedestrian groups, such as the elderly and the disabled.

A comprehension 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. Most of the results have been achieved by implementing speed control with a very significant decrease in accidents particularly on foggy days.

6.3 **Urban Traffic Control / Public Transport**
The improvement of public transport services is seen by City Authorities across Europe as an important strategy to contribute towards reduced congestion and environmental impact, as well as providing improved accessibility to cities. A range of ATT-related public transport systems have been developed and evaluated in DRIVE II, demonstrating the significant potential that exists for wider deployment.

Efficient information management systems have been demonstrated to provide an important supporting framework covering systems architectures, databases, data communications and interfaces for improved implementation of telematics services. The key benefits indicated from information management are improved integration of systems providing improvements in overall efficiency of the public transport operator, the ability to integrate with systems of the traffic authority and the standardisation of platforms and interfaces. Recommendations for future needs and developments include the identification of areas of improvement in the architecture and data models as they are implemented in practice, and the development of training tools to assist operators, researchers and manufacturers in exploiting them. It is also recommended to consider whether/how developments in other IT domains, such as artificial intelligence, new processing techniques, data storage/retrieval and communications could be usefully imported to this public transport sector.

New Automatic Vehicle Location (AVL) systems are being introduced into many public transport fleets in European cities, using various location technologies, including dead-reckoning, roadside beacons and Global Positioning Systems (GPS) and radio communications between public service vehicles and the AVL centre. AVL can provide real time support for fleet management, passenger information, public transport priority and Vehicle Scheduling and Control Systems (VSCS), as well as substantial data to aid service planning. The benefits of AVL and VSCS in providing a platform for operational improvements have been demonstrated in a number of DRIVE II projects. It is concluded that this important area of ATT development should be consolidated through further work into standardisation and integration of systems as well as developing guidelines for operators to improve operational efficiency using these systems.

Public transport priority within advanced Urban Traffic Control (UTC) systems have been demonstrated in DRIVE II to offer substantial operational and economic benefits. UTC systems are increasingly incorporating public transport priority as an integral function and wider deployment across Europe is now timely. Further work into optimising priority control strategies is identified, particularly for complex junction situations of high and competing bus flows mixed with general traffic. Increased integration of UTC and public transport systems is identified as offering substantial potential benefits of cost savings, through shared infrastructure/data and improved benefits from better control/information. There is a strong recommendation that this work should be pursued at the European level.

Developments of passenger information systems in DRIVE II have included real-time information at bus stops, public access enquiry terminals at key city locations, travel centre enquiry support services and portable personal units. Each application has reported a positive passenger response and details of potential system improvements, although little evidence has yet emerged concerning increased patronage. A number of conclusions have been drawn: For wider applications, comprehensive, accurate and timely databases must be available, and attention should be placed on defining functional and technical specifications. The MMI is particularly important if use is to be maximised and multi-media interfaces could be appropriate. Institutional issues between Authorities and Operators also need further consideration.

Demand Responsive Transport Systems (DRTS) can provide flexibility in public transport (departure time, route, vehicle type, etc.) responding to user needs. Telematics has been shown in DRIVE II to
improve economic viability to allow virtually real-time communication of user needs to the vehicle, optimisation of route and passenger assignment and management of the reservation and payment functions. One application in DRIVE II demonstrated successful integration of DRTS with VSCS. There is sufficient potential for DRTS, including telematics applications to be supported with further research and development initiatives.

To summarise, it is clear that there are a range of public transport applications where increased use of advanced telematics can produce significant benefits for city Authorities, Operators and passengers. Some applications, such as public transport priority and passenger information systems are well established and can now be demonstrated and exploited, with parallel research focusing on system enhancements. Other applications, particularly demand responsive systems, show substantial potential as a cost effective ATT application and more fundamental research, development and evaluation is recommended here. Overall, the DRIVE II projects have shown that ATT has a vital role to play in efficient public transport systems and services.

6.4 Automatic Debiting and Demand Management

The main priority of the Transport Telematics Programme has been so far the development and application of new Transport Telematics tools; the actual novelty of such tools combined with the political sensitivity of their applications has prevented the development of a coherent framework for the evaluation of their performance. In fact, at this stage, no systematic way of comparing performance is available to enable trade-offs between acceptance levels and techno-economic performance.

At the same time, together with the new tools that have been developed, the pilot projects have allowed the creation of a knowledge base which can be used to identify how and when such measures can be utilised and what type of impact they can be expected to have; on the other hand the technical solutions proposed to facilitate multi-lane debiting have already been incorporated in national tolling trials which, though technically successful, resulted in different conclusions about their implementation prospects, due to the actual subsidiarity of the prevailing political situations.

As a first general conclusion of the experience gained so far, it can be stated that further experimentation is required particularly on the impact of packages of applications consisting in properly combined Demand Management measures and of suitable schemes, focused on producing modal shifts towards increasing public transport patronage, which should be combined with appropriate action to enhance the public transport efficiency and convenience.

This leads to the user response aspects which, for the sensitive road pricing issue, provide limited evidence that congestion metering (also referred to as “delay-charging”) may result the most acceptable method from the user’s viewpoint, since it achieves the best congestion reduction per unit charge. This however may not be the most environmentally efficient system and a set of sustainable mobility criteria need to be derived for the evaluation of Transport Telematics based demand management schemes.

Time-of-day changes and re-assignment effects are in fact the principal impacts and the modal shift to public transport only appears more achievable when proper combinations of measures are applied as packages; Transport Telematics based access control appears to have potential as either alternative or first step toward urban road pricing.
The longer-term effects of such measures have yet to be examined and further research is needed to establish the sustainability of expected modal shifts against tendencies for decentralised re-location of activities to avoid road charges. Evidence does appear to suggest that the electronic purse will be a well accepted means of integrated payment for mobility and other services, which should imply that road pricing could become a more acceptable burden if the mobility issue were addressed in the same terms and conditions of all the other services the users accept to pay.

To achieve demand management goals and to achieve an adequate card performance specification, it is recommended that new proposals for implementing smart card payment for public transport use should encompass a wider set of services which also include private mobility services.

From the user’s point of view there is already enough evidence that interoperability across modes requires a single, intelligent payment medium and thus implies an IC smart card-base system that can be both used on board of a private vehicle and carried around by the owner to pay for other services. To ensure the rapid deployment of compatible equipment and facilitate economies of scale in the shortest possible timescale, the development of smart card services for transport applications must be integrated with system specifications being developed in the banking and communications sectors.

This will in turn reduce the system costs and maximise the potential for designing attractive products for integrated mobility services, including an all-purpose electronic purse; current outlooks for contact and contact-less smart card standardisation are particularly promising in this respect and therefore their extensive use in future project demonstrations and programme concertation activities should be considered as one of the top priorities for the successful implementation of any future demand management policy.

Legal and institutional requirements affect the implementation of electronic purse payment schemes, though a positive attitude toward pilot implementations has been expressed by the banking sector. In this respect the transport sector can obtain the greatest potential benefits from an extensive and seamless utilisation of such payment instruments but also has particular demands in terms of card performance and capabilities; it is therefore recommended the provision of all the necessary support for the development of integrated payment systems that cover all modes of transport.

Since the Transport Telematics Programme has focussed upon the interaction between land-based transport modes, but various constraints have mainly limited the project work to road transport, letting rail applications to be considered only in terms of urban integrated payment studies, it is important that future activities address the issue of payment integration with water and air-based transportation.

Given the likely operational interest in IC card payment within passenger and goods handling systems across all modes, it will be important to establish an effective concertation across sectors and across urban and interurban demonstrators in support of the strategic EU objectives concerning modal shift to ecologically efficient modes.

In this respect it must be acknowledged that the very nature of telematics-based measures tends to introduce even more segmentation into the market than currently exists. Whilst most currently applied travel demand models start from the separation of travellers into those who do and do not have a car (and then further subdivide into types of trip activity), the deployment of Transport Telematics measures calls for much more differentiation.
Demand management modelling needs therefore to become much more disaggregated and yet be capable of expansion in ways that make forecasting feasible for the common European market. In this respect the different policies and strategies that are likely to develop for urban an interurban demand management applications seem to suggest that the more direct focus on demand management of urban authorities and operators could be best dealt with separately in a way that could help pushing the key urban interests on aspects such as integrated payment, road pricing for demand management objectives and multimedia traveller information.

The revenue collection issue, which seems to be the prime objective of interurban authorities and operators, could on the other hand be more properly addressed together with the strategic investments required for the implementation of the Trans-European Road and Rail Networks and the motorway tolling requirements within a closer dialogue of all the actors involved in the interurban demand management issues.

6.5 Freight and Fleet Management

All activities of the Transport Telematics Programme in the domain of F&F Management were performed with active involvement of users which led to the possibility of a continuous and careful monitoring of user responses and to the identification of the following issues as main user requirements:

- The Transport Telematics Programme has fulfilled the existing needs of the freight operators but they should be provided more with more flexibility to adapt project objectives to the rapidly changing business environment
- There is a need for further integration of external systems, especially in multimodal and combined transport environments as well as for the integration of internal and external systems within each company
- The Transport Telematics applications need to be evaluated by external experts within the specific operational environment of each company
- Future Transport Telematics applications should take into account the co-ordination problems arising in ports and inland terminals

Since therefore the technical integration of the Transport Telematics technologies and systems within the companies and transport organisations involved in the F&F Management domain is still in a very early stage, there is a lot of work yet to be done in the various sectors and modes.

The new effort needed mainly concerns further research on the overall systems and architectures but additional R&D will also be needed to fill the existing gaps and support the future implementation of soundly tested and fully integrated systems; the most important needs are listed below.

- The various applications in the truck, which include data sensors to monitor fuel, load temperature, engine conditions etc., need to be fully integrated with the on-board processing and communication equipment. Functional specifications and interfaces for the various modules need to be properly defined and specified. In particular the most cost effective solution for the implementation of mobile EDI must be identified depending on the actual mode of operation such as pick-up and delivery or long-range haulage.
- At the home-base end, further integration of internal application programs (like scheduling, distribution and dispatching) with external services must be achieved and the operational impact assessed. In particular the integration of mobile EDI within a global scenario should be achieved
mainly through a formal adoption of common standards and with proper interfacing of software and hardware systems.

- Significant improvements can be made in the user interface features of the existing systems at the truck and home-base ends of the communication links; at the truck end such interfaces need to be more versatile, “intelligent” and easily customised to specific new requirements, such as language differences.

- There is also the important need to achieve integration and proper communication links with the various authorities that are involved with freight transport or with the interfaces between the transport modes (such as customs/declaration services). This area of future improvements is required in almost every current freight transport activity: only the inclusion in the road freight transport telematics infrastructure of all other relevant players, such as authorities and other non-road modes, can ultimately lead to a fully integrated freight transport system.

- The pilot projects operating in urban environment have identified urban distribution as a specific field were further development and integration of telematics systems is needed. Urban distribution, or the so-called city logistics, requires the definition and undertaking of direct concerted actions between public bodies (city and regional administrations) and commercial actors (transport operators, freight forwarders and shippers).

- A full multi-modal approach should be achieved concerning functions like real-time reservation and booking as well as tracking and tracing of goods. In particular, the operational management of multi-modal interchange nodes should be supported by information and communications facilities.

- There is a need to investigate more shipper-oriented applications; the work so far performed has been more focussed on the needs of the transport operators and on the sub-systems they use, but little emphasis was put on the goods’ shippers and their needs. Some of the EDI applications that have been investigated also involve the shippers, but the shipper requirements need to be further investigated to identify how they can be properly accounted for and satisfied by the overall freight management system that is now under development.

- Finally, in view of their economic importance, the specific requirements of the SMEs must be also considered in detail to identify and develop technical solutions adapted to their specific conditions.

The Transport Telematics Programme has therefore effectively contributed in setting up the stage for a sophisticated telematics-based infrastructure able to optimise freight and fleet operation within the European single market. Since however we are still far from the comprehensive, harmonised and fully integrated system of F&F Transport Telematics applications that are needed for the competitiveness of the European economy, the work performed so far can only be seen as the necessary and now well established foundation of the additional effort that will be required to build such a system.

On the other hand, the existence of a large and further expanding market for the Freight and Fleet Management services, coupled with a short term scenario of an extensive restructuring of the basic logistics approach to meet the challenges of the single market and of a rapid, explosive growth in terms of cost/performance and innovation features of the advanced Mobile Communications technologies that are the essential support for the implementation of the related Telematics

### 6.6 Driver Assistance and Co-operative Driving

The actual development of applications in this domain has been concentrated on R&D in the areas of driver performance monitoring, generic dialogue control, driver impairment monitoring, automatic enforcement/tutoring, and co-operative driving. The evaluation work was however extended to a wider range of applications, such as Route Guidance, and has also included systems, such as AICC
(Autonomous ICC), vision enhancement and reversing aids that were developed within other programmes. Furthermore there has been a significant emphasis on the development of HMI (Human-Machine Interface) design capabilities and of evaluation tools and methodologies. These activities should have a relevant impact not just within the area but also on the evaluation activities within the whole Transport Telematics Programme. In its last period, a major effort has been made to enhance the synergy process with the aim of achieving a higher level of coherence in evaluation criteria and an integration of the safety evaluation within the normal development process.

The already tested applications have demonstrated that real and significant gains can be achieved by modifying critical driver behaviours and providing the necessary critical support. Co-driver systems can then actually potentially provide a substantial increase in driver comfort and safety. Critical vehicle control indicators such as speed choice and distance keeping can be substantially improved by specific applications; for other applications, such as driver impairment monitor, the safety benefits, whilst potentially relevant, still need to be further demonstrated.

Since human error and traffic law violation account for the majority of traffic accidents, the actual performance improvements already achieved and the resulting potential safety benefits should be very carefully estimated. However many important questions still remain unanswered: the achievements have been mainly obtained only under experimental conditions, often just in driving simulators; long term trials under real-life conditions are needed to fully assess the actual safety benefits; special attention should also be paid to the behavioural adaptation that is known to occur when new technological developments are implemented on a large scale.

At the same time it must be realised that the applications so far developed only touch upon the most basic aspects of a support to the driving task. Driver errors often occur at a much higher level (such as wrong interpretation of the received information) and the actual sources of these errors have not yet been investigated. A more thorough analysis of the driving task using dynamic task modelling techniques, which appears to be a prerequisite to more effectively approach such problems, has not even been attempted so far within the Transport Telematics Programme.

To operate properly, highly advanced co-driver systems need a very large knowledge base which requires in turn extensive roadside-vehicle and vehicle-vehicle communications. Further development of key enabling technologies such as sensors and radars would therefore be urgently required to allow the development of co-driver systems to their full potential.

Safety benefits affects both society and individuals: where new applications provide drivers with improved comfort and safety without any negative impact on their strategic and performance choices, the individual benefits are quite apparent, whereas, as in the case of systems such as driver impairment monitoring or law enforcement, their social and legal implications need a careful consideration together with the obvious user acceptance issues and may require the definition of a suitable strategy of incentives. On the other hand, given the aggregate set of potential safety, comfort and mobility benefits, the Transport Telematics systems under development certainly warrant a common concerted implementation effort within a future optimised Transport System.

The domain of Driver Assistance and Co-operative Driving is perhaps the one where activities at the R&D level will be carried-on much longer than in any other domain of the Transport Telematics Programme; there are however a few relevant issues which need an urgent and effective continuity with the work done so far, both in terms of completion of the R&D efforts that have already been undertaken and in terms of suitable support for the implementation of the most promising applications.
An outline of such strategic needs, that must be satisfied in the near term to achieve full benefit from to large effort already spent in this area, is summarised below:

- Several stand-alone systems (e.g. anti-collision radar, driver performance monitoring, driver impairment monitoring, co-driver systems in advisory mode) that were developed within the area are now ready for pilot project trials, but for other systems (such as driver tutoring, co-driver systems in semi-automatic or automatic mode, integrated automatic enforcement) and in particular for integrated systems combining co-driver functions on tactical and strategic level, further R&D activities will be required.
- Further development of sensor and communication technologies is required to optimise the functionality of co-driver systems
- Supporting research is required in relation to issues such as driver modelling, workload assessment, individual differences, behavioural adaptation and road user acceptance to enhance the functionality of stand-alone and integrated systems.
- Information presentation, in particular for integrated systems, still remains a separate R&D issue which needs to be properly addressed, even though considerable progress has been achieved within the Transport Telematics Programme. Specific attention should be given to the actual possible differences between in-vehicle and roadside information due to the different strategies of the information suppliers.
- The activities that have been carried out in relation to communications requirements indicate that this is a critical task requiring further attention from communications technology specialists.
- While much attention has been devoted to the safety implications of the systems under development, quantification of the safety impact has not yet been achieved. To this purpose, safety analysis should be integrated in the projects and a comprehensive safety methodology needs to be developed. In particular, the development of safety predicting tools requires further attention.
- To achieve significant safety benefits, all the activities in this area should focus on the main goal of minimising the driver possibility to make errors or commit violations.

6.7 Monitoring the Development of Technologies and Models and Their Application

One of the major products from the DRIVE programme has been the vast number of models covering many aspects from Origin/Destination to strategic and tactical network control. There was 15 models produced by the area 4 projects in DRIVE 11 and there must be many more from the other areas (3 & 7) which would impact on the efficiency and safety of the network. The integration of new ATT technologies is not just a problem of interfacing with the existing infrastructure but how the technologies will be used with all the various models as they develop and are adapted with experience, combined with the need to operate various models on the same section of road. Issues of priority for both efficiency and safety soon become a major issue.

Most models are developed using a specific type of technology and infrastructure with very little indication about the possibilities of using other technologies. Even considering the technology for one model can be very time consuming. The level of complexity in attempting to resolve which combination of models and technologies to use, or when, will be an even greater burden on time and resources for the decision makers responsible for the network operation. One way of increasing the level of confidence for the decision makers to make changes and improvements would be to establish management tools that would allow member states to monitor technological evaluation that is not restricted to one particular type of technology or application that can be used to indicate the potential for up-grade, or to be aware of the implications of using a particular type of technology if a model is to changed or modified.
To take this forward would require an in depth analysis of all the current leading models to determine the data input requirements; accuracy, speed of response and reliability in all operating environments. Establishing the key influencing features (input/output) of using a model could be used to identify corresponding features in other models being used in the same area to assess the suitability of making use of common data systems. The same analysis work can also be used to benefit all MS by determining which models have the potential for integration - partial, only in special circumstances or not advisable on grounds of efficiency or safety. The information obtained could be built into an analysis software packages covering specific areas of application to support an organisation/management procedure. Legal requirements may have to be taken into consideration concerning property rights etc.

The objective would be to provide a mechanism to constantly move towards progressive matching for integration, irrespective of technology and application and the end results would be:

- the establishment of guidelines for organisations to use when considering the deployment of new technologies when applying new control strategies.
- the availability of a specification for the type of software required to be available to monitor the technological evaluation which is capable of reflecting changes in technology and model application enhancement.
- the availability of a specification for software development required to assess the integration of new and existing models.

6.8 Opportunities from Latest Advances in Communication Technologies

The Transport Telematics applications that have been so far developed and tested were certainly all aiming at the achievement of specific and valuable user benefits or at the solution of some critical transport problem through the use of available products or services based on the Information and Communication technologies. Since however the main concern and challenge has been so far the possibility to demonstrate feasibility and effectiveness of technological solutions within the context of research programmes which had financial and organisational support from the public authorities’ specific research and transport policies, not much attention has been given to the marketing features that would be characteristic of each application at the time of its intended deployment.

Future Transport Telematics applications will likely be brought to market only if there is a reasonable expectation of demand by either users, operators or public authorities but the motivations and conditions for their eventual success on the market will widely differ depending on the type of demand they must satisfy in view of the general functional and/or operational features that could most heavily influence the potential success on the market of each “intelligent” application.

In this respect it should be verified to what extent the “intelligent” systems owe this denomination to the capability to implement a more or less sophisticated form of computer-based control/automation of a given “process” (related to either collective transport or individual driving) or if the “intelligence” actually aims at the successful completion of a variety of individual, interactive “transactions” which would correspond to the provision of intelligent services according to specific contractual terms.

This latter type of systems, aiming at the provision of specific information-based services, can be very effectively supported from a variety of communications links, ranging from short-range all the way up to satellite communications; the wide range of terrestrial communications links that is in between takes the form of either broadcasting/connecting networks or direct 2-way channels. The most promising communication platforms are certainly the switching and connecting networks that
already have the largest amount of built-in intelligence and the largest potential for future convergence and graceful upgrading, able to allow mobile networks to largely exceed their current bandwidth limitations.

The different aims to which the use of the intelligent technologies is targetted result in quite different marketing implications for the two groups of intelligent systems considered above: automatic systems will mainly provide significant benefits in operational effectiveness and efficiency but will remain rather transparent to the individual users who will always look for minimum nuisance from any kind of collective constraints to their freedom of choices. Personal-type services, on the other hand, have the capability to provide immediate on-demand actions/solutions to any individual request or problem. Furthermore, since the typology of services is not specific of the transport system, it is reasonable to expect that, by sharing with other non-transport applications the use of the same communication infrastructures, a wider range of better and less expensive services could be more easily and efficiently offered to the transport system users.

From the above considerations it seems that Travel (Traffic) Information and Booking Services, Private Freight and Fleet Management Services and Private Emergency Services are the three areas of Transport Telematics applications which should most benefit from the competitive environment offered by the exploitation of advanced Personal Mobile Communications where the expected further developments of Information and Communication technologies should play a major enabling role.

Digital microelectronics has already had a fundamental enabling role in propelling Information and Communication technologies to their current level through the continuing increase of data and signal processing power and of memory capacity per unit area. The computer sytems power available to the Information Technology applications has also led to the PC revolution and to even more revolutionary changes in telecommunications business, since the possibility of embedding progressively larger amounts of “intelligence” inside the telecommunication networks has also made possible for the telecom companies to offer their customer a much broader range of services than just more reliably switching a large amount of point-to-point connections. This radical change in the telecom business structure has in turn made of computer networking the appropriate framework for a new computer revolution and has triggered at the same time both the full telecom deregulation and its consolidation with the media industry; but, more importantly and perhaps in a less visible way, it has also set the stage for the build-up of the multimedia Intelligent Networks which will represent the essential backbone of the future Information Society.

Within this context and in view of the practical saturation of the single user’s processing requirements, the future increases in processing power will likely be devoted to a quantum leap of improvement in the ease of use and friendliness of the computer human-machine interfaces and will thus open the access to information services and databases to much larger sectors of our Society. For Transport Telematics applications, that are so much involved in the effort to improve mobility, this virtuous circle of technology evolution will shortly offer unprecedented opportunities to support mobile users, anywhere and at anytime, with any information which may be needed to either optimise their travel or transport conditions or to maintain throughout their movements the same ability to access the information they normally have at home or in the office. However, to allow the proper planning of an Transport Telematics deployment strategy able to exploit every opportunity to be offered by the future by I&C Technologies, it will be necessary to become fully aware of the next already well defined steps in the expected evolution of Personal Communication Technologies, which could have hardly be taken into proper account at the time when the current Transport Telematics achievements were originally planned.
Two-way Digital Mobile Communications represents the technology sector that is undergoing the most rapid and revolutionary changes, in view of the fact that their first generation systems were just intended to provide significant improvements in the quality and operation of the existing analogue voice system, but had already so much “intelligence” originally built in the systems that all the following functional expansions and improvements were and can be quickly implemented according to well scheduled plans. The only thing that could not be originally expected was the actual timing of the deregulation process that is so rapidly eliminating the privileges of the public monopolies and opening the way to a very beneficial convergence between the fixed and mobile networks.

In terms of relevance for the successful implementation of the most promising Transport Telematics applications, the assessment of the DMC systems should focus on the implications resulting from the Intelligent Networks approach and on the main aspects of DMC evolution.

For the Intelligent Networks, the driving factor was represented by the increasing demand for special and advanced services from the business sector to the fixed networks operators and the need of the mobile networks operators to cope with increasing network complexity. As soon as the network management problems shifted from the adequate coverage of the area to be served to the capacity of traffic that the network was able to handle, it forced both operators to heavily invest in adding large amount of additional intelligence to the network management capability.

In the digital mobile networks like GSM, this evolution has implied the addition of more intelligent resources (as required to handle the transition from the original single macrocellular architecture towards the multilevel micro- and picocellular structures) to the basic connectivity-oriented intelligence. This evolution has implied the need to distribute the network management function throughout the system, for instance by systematically using intelligent agents which can dynamically run the network on a local level. Distributing the intelligence at the local operational level will enable the network to respond dynamically to local needs and requirements as well as to widely increase its capability and flexibility in the provision of advanced services to the subscribers and thus allow the network to rapidly grow and adapt to changing market needs.

Another unique aspect of the intelligence distributed in the GSM architecture is the presence in the Mobile Station of a smart card represented by the Subscriber Identity Module (SIM): it has already allowed the implementation of a client/server architecture in which the client is represented by an extended SIM card. By embedding in it a message interpreter, the SIM card can be converted in a full-fledged computer on which a variety of value-added personalised services can be downloaded or activated on demand from the service centre. In a deregulated market this approach will enable network operators to easily configure and offer customer-specific services for new market segmentation and product differentiation.

DMC systems and in particular GSM, due to its well established market base and widespread acceptance, appear in a very competitive position to support the implementation of Transport Telematics systems involving mobile users; however, as previously outlined, their main strength appear to be the very promising and robust path of evolution and service enhancement that is already planned. The main specific aspects of this evolution are summarised below.

Multimode/multiband terminals - Though GSM, thanks to the intelligence built in the network, is able to provide a single handset with compatible operation from pico- to macrocells, the existence of other modes of mobile communications (from cordless extensions of fixed lines, such as DECT, to Low Earth Orbiting satellite systems such as Iridium and ) offers various opportunities to integrate on a single handset multiple modes of operation (e.g. DECT plus GSM) with a slight increase of cost and complexity with respect to the most expensive unit. The same result can be obtained for handsets
that can support multiband radio operation (e.g. DCS 1800 plus GSM 900). The internal controller will automate the choice of the available mode that, depending on actual call destination, is most convenient for the user.

Convergence of Fixed/Mobile networks/services and Wireless Access to fixed networks - The advent of Universal Personal Communications has induced a radical evolution of cordless technologies: CT2 and DECT in Europe, PHS in Japan and PCS in the USA provide speech quality indistinguishable from wired telephone, high-speed data services and easy integration with in-door wired systems such as PABXs, but suffer from mobility restriction over small areas and for the lack of the complete network architecture that support the cellular systems. The rapidly progressing deregulation process and the technology evolution of the fixed and mobile network components and services tend to blur the distinction between the two types of networks and make cellular technology the likely ultimate winner of the competition for the last-mile wireless local loop, particularly in rural areas or in urban areas subjected to a rapid evolution.

Future GSM support for high speed data - The data rate from the current circuit switched GSM service (9.6 kb/s) can already be enhanced up to over 30 kb/s by using suitable data compression techniques, but the bottleneck for the enhancement of current data rates lies within the air interface; a significant improvement (up to 96 kb/s) will shortly be achieved through an extension towards a multiple time slot system, which maintain the main system feature as they are and will allow in 1997 the use of multiple independent subchannels for the implementation of the High Speed Circuit Switched Data (HSCSD) service, characterised by flexible connections and user rates. Higher data rates will be possible in 1997-98 with the more advanced General Packet Radio Service (GPRS) which, by using a packet switching rather than a circuit switching approach, will require a radical modification of the GSM system but will provide significant service benefits to users since GPRS will charge on the basis of the amount of transmitted data and not on the connection time.

Third Generation Services - The GSM MoU Association has recently refocussed the vision of the Universal Mobile Telecommunication System and defined new targets for the standardisation work. They aim first at a full integration and transparency to the user of fixed and mobile services, a full extension of the integration, control and portability of all services irrespective of the user access to either home or visited networks, then to the provision extensive wideband services as allowed by spectrum availability with WAN data rate of 144 kb/s and LAN data rate up to 2 Mb/s. As ATM will become the backbone of fixed networks, a mobile ATM version will be developed and deployed to provide seamless and cost effective transport wherever appropriate. Major improvements are expected in the adaptability characteristics of the mobile terminals during each of the three phases: error correction and upgrade provision as well as new service extension should be possible by downloading the software or the service execution logic from the network; by storing the user’s customised service logic on a smart card, it would become accessible from any visited network, either fixed or mobile. All these techniques will require the implementation of extensive built-in security management features. The evolution from the current second generation features will be gradually phased-in from the existing networks by adding new, enhanced capabilities in each planned phase, thus allowing faster implementations and easier re-adjustments to the evolving market and business targets.

In conclusion, as compared to the range of new radio data broadcasting services that are planned for the foreseeable future, the outlook proposed for the Personal Mobile Communications by the operators of the fixed and mobile networks seem to underline a clear no-contest situation: level of intelligence already built in the networks, prospects for a full deregulation and integration of both mobile and fixed networks, quantum leaps in performance, flexibility and cost competitiveness.
should get a significant leverage from the current exploding business situation and thus provide a supporting framework, unmatched in terms of solidity and credibility, for the development of truly effective, successful and long lasting Transport Telematics applications.

6.9 Commonality of Impact Indicators Across Projects

Evaluation in DRIVEII has often focused on technical performance transport efficiency impacts and user response to systems which have often been experimental. Results are then only indicative, based on limited surveys covering limited impacts. In particular there have been very few quantitative results concerning road safety, environmental impact and economic/financial performance of systems. These issues require a more concerted coverage in the 4th Framework Programme.

To maximise the value of telematics evaluations across Europe, it is necessary to use a common evaluation framework, implement a sound evaluation methodology and implement common information management procedures to maximise information accessibility and transfer. The opportunity exists in the 4th Framework to improve on each of these aspects.

6.10 Improved Experimental Design

It is apparent that the evaluations in some studies have been driven more by resource constraints than statistical requirements. This has led to more qualitative and inconclusive results than need have been the case, so that firm conclusions are often not then possible. Given limited resources, it is recommended that field trials are designed to produce statistically robust results for a limited number of scenarios and impacts, rather than covering too many scenarios/impacts and achieving only inconclusive results.
GLOSSARY

ADS Automatic Debiting System
AID Automatic Incident Detection
ATT Advanced Transport Telematics
AVL Automatic Vehicle Location
AVM Automatic Vehicle Monitoring
CARMINAT In-vehicle navigation and information system (France)
DMRG Dual Model Route Guidance
DRG Dynamic Route Guidance
DRIVE Dedicated Road Infrastructure for Vehicle Safety in Europe
DRTS Demand Responsive Transport Systems
ECU European Currency Unit
EDI Electronic Data Interchange
EDIFACT Electronic Data Interchange for Administration, Commerce and Transport
EUREKA European Research Coordination Agency
EUROSCOUT Infra-red beacon based DRG system
GDF Geographic Data File
GIS Geographic Information System
GPS Global Positioning System
GSM Global System for Mobile Communication
HGMC Hazardous Goods Monitoring and Control
HMI Human Machine Interface
HOV High Occupancy Vehicle
ICC Intelligent Cruise Control
IRTE Integrated Road Transport Environment
MDC Mobile Data Communication
MMTT Multimodal Tracking and Tracing
MOTION Traffic responsive UTC system (Germany)
O/D Origin Destination
OSA-CAIT Open System Architecture for Computer-Aided and Integrated (Freight) Transport Systems
P&R Park-and-Ride
PRODYN Traffic responsive UTC system (France)
RDS/TMC Radio Data System/Traffic Message Channel
RTI Road Transport Informatics
SCOOT Traffic responsive UTC system (UK)
SIS Strategic Information System
TCC Traffic Control Centre
TIC Traffic Information Centre
UTC Urban Traffic Control
UTMS Urban Traffic Management System
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tr>
<td>UTOPIA</td>
<td>Traffic responsive UTC system (Italy)</td>
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<tr>
<td>VDS</td>
<td>Variable Direction Sign</td>
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<tr>
<td>VMS</td>
<td>Variable Message Sign</td>
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<tr>
<td>VRU</td>
<td>Vulnerable Road Users</td>
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<tr>
<td>VSCS</td>
<td>Vehicle Scheduling and Control System</td>
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<tr>
<td>WIM</td>
<td>Weigh-in-Motion</td>
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SOURCE OF REFERENCES

The information sources used for compiling this document included:

- Final Reports from the ATT - DRIVE II Transport Telematics projects
- Relevant Project Deliverables, including the cross-project collaborative studies carried out by CORD
- Results from the June 1995 "Impact Assessment Questionnaire" completed by the Projects
- Documents on Achievements & Technical Achievements of the DGXIII ATT Programme
- Other relevant documents concerning telematics evaluation, including advisory work commissioned for the European Parliament.
ANNEX

PROJECT DESCRIPTIONS
AND CONTACT POINTS

The following information provides a short introduction to the projects that have contributed to the European Commission’s programme of Applications of Telematics in Transport - ATT (DRIVE II), carried out as part of the Third Framework Programme for RTD (1992-1994) of the European Union. Every care has been taken to present the correct contact point but it is possible with time that the original project representative may have changed employment. The company who supported the work may be able to help with any information required.

V2001 ASTRA Integrated System of Assistance Service for Travel and Traffic

ASTRA has investigated the feasibility of an interactive integrated system of Assistance Services for travel and traffic, based on dynamic information, reservation, guidance services for travellers. The project also investigated assistance to public transport operators for dynamic scheduling, connection services, advice to shuttle buses including a pilot assessment of a multi-modal advanced booking system for ferries using Helsingor harbour. ASTRA integrates several existing systems for traffic management and information and in particular focuses on the dynamic and real time tools to improve the strategic management of transport applications.

Carl Bro Civil & Transportation
Mr. W.D. Watjen
Tel. +45 42 45 6625
Fax +45 43 43 6898

V2002 HOPES Horizontal Project for the Evaluation of Safety

The project provided a framework for safety assessment and integrates the safety evaluation results produced by different pilot projects of the current programme. The project covers two of the three safety levels identified in DRIVE: Traffic Safety and Man-Machine Interaction. The evaluation work has produced the following outcomes: a preliminary safety analysis, a framework for prospective and retrospective safety analysis. Some of the functions are aimed specifically at the improvement of safety, in accordance with the overall objectives of the Programme.

University of Leeds
Dr. O.M.J. Carsten
Tel. +44 113 2335 348
Fax +44 113 23335 334

V2003 COMBICOM Combined Transport Communication Systems
The project addressed the need of combined transport operators to provide a better service to the client by developing and information system giving up to date information on cargo status. The aim of the project was to develop and to install a road / rail informatics system which can be used to communicate all relevant operational information, e.g. the status of combined traffic units (swap bodies or containers) at particular point of their journey, to all relevant system participants, including shippers, hauliers, freight forwarders, customs, and consignees. The project makes extensive use of EDIFACT messaging.

Professional & Service Development, Cap
Mr. Jan E. Broekman
Tel. +31 30 2526 783
Fax +31 30 2526 857

V2004 ARIADNE  Application of a Real-Time Intelligent Aid for Driving and Navigation Enhancement

The goal of the project was to provide an intelligent driver support system that would offer driver support under a wide range of circumstances, whilst being maximally consistent with the information requirements and performance capabilities of the human driver. The project started with the ambitious development of a generic driver support system, some features of which have already been demonstrated in the previous project GIDS. ARIADNE was to enhance the complexity of the decision environment to which the system aids response, including as one function the development of the sensors and software for a collision avoidance radar and the demonstration of its effectiveness. National institutions and a leading university collaborated with industry.

ATC Warwick University
Mr. R. Mc Murran
Tel. +44 10203 52 47 14
Fax +44 1203 52 47 07

V2005 VRU-TOO  Vulnerable Road User Traffic Observation and Optimisation

This project was targeted at the reduction of risk to pedestrians pioneering work of the previous project VRU. The implementation of advanced detector systems to improve condition for pedestrians at signalised junctions and pedestrian crossings was undertaken in cities in northern and southern Europe. It applied enhanced logical operational control in conjunction with radar equipment used to monitor the presence of people waiting to cross the road, and monitor the presence of people on the crossing. The project carried out the necessary behavioural work to create detailed rules for the safe and unsafe interaction of pedestrians and vehicles. These rules generated independently were used in the behavioural evaluation in the pilot projects.

University of Leeds
Dr. O.M.J. Carstan
**V2006 EMMIS  Evaluation of Man Machine Interface by Simulation Techniques**

The project had the goal to improve the effectiveness of the design phase for the driver interfaces of on-board information systems and to generate and validate evaluation tools for MMI solutions. This project was led by three motor manufacturers in partnership with leading public research institutes. It was to define the conditions for valid proving trials and to apply the simulation system to practical test on MMI prototypes. The results of these tests were then to be compared with real-world experience in so far as this practicable and safe. A panel of drivers and observers were used so as to represent a broad spectrum of aptitudes and abilities. The project consisted of the phases of definition, system development, and application. MMI for the following three applications were to be developed: Navigation and Route Guidance, Collision Avoidance and Intelligent Cruise Control. The adaptation of existing tools for rapid prototyping, driving simulation and driver specific performance evaluation have been defined and implemented.

Centro Ricerche Fiat  
Mr. P. Gay  
Tel. +39 11 9023050  
Fax + 39 11 9023096

**V2007 SAMOVAR  Safety Assessment Monitoring On-Vehicle with Automatic Recording**

This project was a limited study to assess the feasibility of development up to commercial standards of a recorder comprising modules (a) to capture and store information relevant to the course of a journey, and (b) to store recent data which would facilitate analysis of the events immediately preceding and accident. Previous work was carried out under the DRACO project. The objective was to determine the feasibility of an in-vehicle device which records vehicle and driver behaviour with respect to traffic accident and safety issues and to conduct field trials. The flexible structure of the envisaged system was targeted at a wide number of users including fleet operators and emergency services. Special attention was paid to the potential impact of different recording devices on the behaviour of the driver.

Queen Mary and Westfield College  
Dr. W. Fincham  
Tel. +44 171 9755344  
Fax +44 181 9810259

**V2008 HARDIE  Harmonisation of ATT Roadside and Driver Information in Europe**
This project builds on the work in DRIVE on standards for man-machine interaction. The project was to analyse existing requirements in European states and to develop a theoretical framework for the assessment of the in-vehicle man machine interface (MMI). The project would then try to establish a basic performance standard against which to assess possible alternatives, and test a number of these against this benchmark. It proposed recommendations for the presentation of information to drivers based on a range of criteria including safety, clarity, audible and visual means of presentation, harmonisation of text and symbols and compatibility between in-vehicle and external information. A draft design guidelines handbook was prepared and the examination of the feasibility to develop standards to be adopted for in-vehicle presentation.

Transport Research Laboratory  
Mr. J. Smith  
Tel. +44 1344 770 588  
Fax +44 1344 770 643

V2009 DETER Detection, Enforcement & Tutoring for Error Reduction

This project carried forward previous work on these fronts. It assembled and demonstrated equipment to detect transgressions of safe or legal driving practice; to monitor the condition of the driver in relation to fatigue or possible reduced capability due to drugs or alcohol; and to tutor the driver to help him or her to develop and apply enhanced skills. Simulation and on-the-road trials were supplemented by surveys to test public attitudes towards the voluntary and the mandatory use of technologies of this type. The potential contribution to road safety was assessed. The project aimed to develop and test prototypes of on-site, in-vehicle, and integrated monitoring and enforcement systems. Simulator studies and field trials were used to assess their reliability, validity and behavioural effects. Field studies were carried out on an on-site tutoring and enforcement system to assess user acceptance and legal implications and to demonstrate the effects of the implemented system on road user behaviour.

University of Groningen TRC  
Dr. K. A. Brookhuis  
Tel. +31 50 636 772  
Fax +31 50 636 784

V2010 TESCO Test on Cooperative Driving

TESCO objectives were to test co-operative driving functions already identified in Prometheus in the protected environment of a trial track available for good reproduction of motorway traffic. The main attention was devoted to the motorway environment with Intelligent Cruise Control and Intelligent Manoeuvring Control functions. An endurance test of 8 vehicles were performed with more than 600,000 km covered mixing equipped and non-equipped cars. From the test analysis conclusion, suggestions and recommendation were derived regarding the implementation and the introduction of ICC and IMC in the near future.

Centro Studi Sui Sistemi di trasporto
V2011 COMIS  Communication Using Millimetre Wave Systems

COMIS aimed to develop a 60-64 GHz Millimetre wave Monolithic Integrated Circuit (MMMIC) transceiver for automotive use in facilities such as cooperative driving and intelligent cruise control.

The ESPRIT project, CLASSICS handled the technological hardware development of an economic 60-64 GHz MMMIC transceiver and COMIS supplied them with the systems architecture for automotive use in short to medium range communications (up to 400m). Their main consideration was road transport applications which are complementary to services offered over cellular radio systems, such as those already mentioned and co-operative driving.

Daimler Benz Aerospace AG
Dr. Ing. H. J. Fischer
Tel. +49 731 392 5467
Fax +49 731 392 4970

V2012 PROMISE  PROMETHEUS CED 10 - Mobile and Portable Information Systems in Europe

The main objective of this, essentially industrial, consortium was to develop a multi-modal traveller information system, based on the use of a hand-held portable terminal suitable also for use within vehicles. The approach was to develop an open systems architecture, in collaboration with the SOCRATES KERNEL, for the exchange and interconnection of information. The project also investigated the potential for implementing two way communications utilising the GSM and/or modern paging systems such as HERMES to facilitate applications such as ticket reservations as well as park and ride applications.

AB Volvo
Mr. J. Hellaker
Tel. +46 31 772 40 75
Fax +46 31 772 40 70

V2013 SOCRATES KERNEL  System Of Cellular Radio for Traffic Efficiency and Safety

The overall objective was to prepare for a pan-European traffic information and communication system. The main task was to prove the functionality of the systems (Route Guidance et-al) over different cellular sites and media, although optimally the system was to be implemented over the GSM for pan-European use; this was piloted at the Hessen site and studied at the London site pending GSM implementation. The coordination of the SOCRATES projects and the development of their parallel/horizontal tasks was undertaken by the KERNEL. Packet data structures and the more global
common communications media interface architectures are also included in the work of the KERNEL (See SOCRATES pilot projects : LLAMDE; CITIES; and RHAPIT). The work included analysis and development of operational issues, liaison with standardisation bodies including GSM, co-ordination of common technical developments, and establishment of the DRIVE Normalised Transmission (DNT).

De Te Mobil - Bonn
Mr. Bernd Guenther
Tel. +49 228 936 2722
Fax +49 228 936 2709

V2014 ICAR Integrated Confined Areas RTI Communication System

This project recommended methods of extending the GSM voice and data service for vehicular use, inside confined areas such as tunnels. The consortium assessed and compare the use of leaky feeders and mode converters. One tunnel in Belgium was to be used for some of the development tests and another in Italy where the use of fibre optic feeder cables were to be tested.

Inrets Villeneuve D’Ascoq Cresta
Mr. M. Heddebaut
Tel. +33 6362 7050
Fax +33 6362 7013

V2015 INVAID II Evaluation of the INVAID System in Motorways and Urban Pilot Projects

The project aimed to test automatic methods of detecting incidents on motorways and in cities. The system used an innovative combination of both vision related and loop based data to provide a traffic controller operator with a firm indication of the presence of an incident at a location(s) in motorway & urban networks. The application of image processing and computer vision techniques for Automatic Incident Detection was developed in the DRIVE project INVAID.

On Campus Technology S.A.
Mr. S. Guillen
Tel.+34 6362 70 50
Fax +34 6362 70 13

V2016 PRIMAVERA Priority Management for Vehicle Efficiency, Environment and Road Safety on Arterials

The project focused on integrated traffic control on urban arterial corridors, integrating 3 techniques: queue management, public transport priority, and traffic calming. The integration of the techniques was tested by special simulation programmes, while real life trials were performed in urban arterial corridors in the cities of Leeds (UK) and
Turin (I). Integrated strategies for managing queues while at the same time giving priorities to public transport in a traffic calmed environment were being developed and assessed. These strategies include dynamic traffic control measures using real time data and coordinated with existing UTC and surveillance systems. The strategies considered efficiency, environment and safety issues related to the main roads and the intervening residential roads.

University of Leeds
Mr F. O. Montgomery
Tel. +44 113 2335 339
Fax +44 113 2335 334

V2017 EUROCOR  European Urban Corridor Control

The EUROCOR project developed and implemented (by field trials in Amsterdam and on the Boulevard Peripherique in Paris) on-line control strategies for the effective management of traffic in urban corridors, including traffic signals, ramp metering and variable message signs. EUROCOR implemented and extended developments form DRIVE, notably the techniques of the CRISTIANE project (V1035). Flexible corridor modelling and control were being further developed and applied to the two test sites - both integrated urban networks and motorways, but of different character in terms of user requirements, traffic levels and application details. The motorway control techniques previously developed was extended to the access points and beyond into the feeder network, thus allowing a greater dimension of control, this was exercised through the additional use of variable message signs.

Transportation Research Unit Thessaloniki
Mr J. Chrisoulakis
Tel. +30 1825 3777
Fax +30 1825 3780

V2018 QUARTET  Quadrilateral Advanced Research on Telematics for Environment and Transport

The principal aim of the project was to put together the components of the Integrated Road Transport Environment using RTI/ATT technologies in a Pilot Project to verify the benefit of integration and coordination of related RTI/ATT Services. Each of the cities of Athens (A), Birmingham (B), Stuttgart (S) and Torino (T) worked from the basis of a completed major strategic transport policy review recommending a modal shift towards public transport. Lead cities, with involvement from each of the other, tackled the following target architectures : the IRTE Architecture (T) - including the combination of the output from the other cities; Environmental Control (A); Dynamic Route Guidance (S); Emergency Call Systems (S), Public Transport Management and Information Systems (B). Continuation of developments of DRIVE, PROMETHEUS and national programmes was ensured by the participation of major actors from this programme.

Mizar Automazione Spa
Prof. Ing. Vito Mauro
V2019 HERMES  High Efficiency Roads with Rerouting Methods and Traffic Signal Control

The HERMES project aimed at improving the knowledge of the current state of traffic by using dynamic on-line Origin/Destination estimation and Automatic Incident Detection and applying control strategies (rerouting and traffic signal control) based on this knowledge. Test sites used were Cologne (D) and Southampton (UK) for the urban applications and the Rhein/Main corridor (D) and the Lyon (F) corridor for the inter-urban applications. HERMES cooperated closely with several other Transport Telematics projects such as RHAPIT, SCOPE and MELYSSA in order to validate the developed algorithms and strategies.

MVA Consultancy
Mrs. C. Biedelfeldt
Tel. +44 131 5575533
Fax +44 131 5575596

V2020 EAVES  Evaluation and Assessment of Variable European Sign Systems

This project aimed to provide and to apply methodologies for qualitative, quantitative and economic assessments to improve the effectiveness of Variable Message Signs. The recipients of this kernel project were the Pilot projects. Some of them had carried a contract with EAVES to be supported and monitored in their VMS impact assessment and cost benefit analysis. This project also contributed to the recommendations for Common Functional Specifications for the operation, location, features and strategies of Variable Message Signs systems and their integration with other technologies. This project also investigated integration of VMS/RDS-TMC systems on an European scale and with particular regard to driver and operator benefits.

WS Atkins Consultants Ltd
Mr. J.J. Steed
Tel. +44 1372 726 140
Fax +44 1372 740 055

V2021 INTERCHANGE

The main objective of this project was to establish a pan-European Travel Information data network for real time exchange of Travel and Traffic data through national information centres which give service to European travellers well into the future. In order to achieve a larger consensus the project established a liaison structure with external actors to develop common specifications as data dictionary or data exchange formats.
V2022 EUROTRIANGLE  Pilot Application of Advanced Traffic Management in Flanders (B), Wallonia (B) and North Rhine Westphalia (D)

The main application to be examined in the project was the interconnection of control centres and institutional issues. The 1st phase of the project was a technical feasibility study investigating the interconnection and interoperability of 7 applications between the control and information centres of 3 regions in 2 countries. The seven applications studied were: Image processing, Incident handling, Ramp metering, Public Transport Integration, Overall congestion warning, Interconnection of Control Centres and Information handling. The pilot project established integrated traffic control and information systems along the corridors linking three European regions: Flanders (B), Wallonia (B) and Northrhine-Westphalia (D).

TRITEL - Traffic Consulting and Engineering
Ir. R. Tegenbos
Tel. +32 2 675 0949
Fax +32 2 660 4602

V2023 PHOEBUS  Project for Harmonising Operations of the European Bus

The main effort of this project was devoted to the development and implementation (based on the work done under DRIVE in the BARTOC-V1001 and CASSIOPE-V1019 projects) of an integral Vehicle Scheduling and Control System (VSCS) covering all the functions required for Urban, Inter-Urban and Rural Public Transport applications with a possibility of integration with Urban networks. A simplified VSCS based on scenario 1 of BARTOC was demonstrated in a suburb of Madrid. A user information system inside the vehicles and at stops, using RDS radio broadcast as transmission carrier was implemented at full scale in Brussels. Included in the integral VSCS (of Gent) the necessary algorithms were implemented to create virtual networks with variable route and variable schedule lines, for demand responsive bus sub-systems. The necessary passenger and driver information and reservation functions were also be developed. The demand responsive service was implemented in two rural areas and tested in a small urban environment.

Compagnie Generale Automatisme
Mr. A. Gold
Tel. +33 169 88 53 43
Fax +33 169 88 54 40

V2024 CASH  Coordination of ADS for Standardisation and Harmonisation

The project proposed to define the future standards that would be applied to toll collection devices and for, other telematic applications. In very close collaboration
with other projects, like ADEPT, ADS and GAUDI, CASH propose to establish, for
the whole European highway networks, the rules for the future toll collection systems.
CASH as kernel project obtained results directly or indirectly from other projects using
ADS technology (ADEPT, ADS and GAUDI). The main aims of CASH was to
establish Common Functional Specifications (CFS) for Automatic Debiting Systems
(ADS). These CFS were based upon all developments employed until now for which
consensus can be achieved between European operators and manufacturers. A
standard specification technique (MIL-SID-490A) was used as a foundation for the
specification. CASH also coordinated evaluation and reviewed the activities and
results from the different pilot projects realised under the Transport Telematics
framework in this field.

Ministry of Transport and Public Works
Mr. J. P. Lagerweij
Tel. +31 70 351 7043
Fax +31 70 351 7090

V2025 EUROBUS European Reference Data Model for Public Transport
(Transmodel) and Polis Passenger Information Services
(Popins)

To facilitate and to harmonise their methodology and to increase their performances,
the EUROBUS project proposed to examine new tools:
- the first tool concerns the establishment of a complete data base (called
  Transmodel)-. This software tool can be used in the future by any public
  transport company (small or large) in view to manage their own vehicle
  network;
- the second aspect of the study covered the establishment of specifications
  applied to a man-machine interface intended to inform the users of the public
  transport network over all aspects that they can found (schedules, lines,
  timetables, etc).

The objective of this project is twofold:
1. To comply with the need for public transport operators to have at their disposal
   a common reference data model. To be compatible with as many applications as
   possible. Two data-models under development (the "Cassiope" data model developed
   under DRIVE and the "ÖPNV" data model developed by SNV and published by
   "VDV") would be integrated.
2. To experiment a set of advanced computer aids for passenger information in
   the area of public transport. In particular interactive street terminals based on a
   common transport database and a geographical information system (GIS) on public
   transport schedules and road network.

These interactive passenger terminals included an "intelligent" interface (auto
adaptation to user level), digital based maps, tactile screen and state-of-the-art
software (info on transport supply, optimise a journey, make a reservation, etc) A
terminal for automated aids for information desks (e.g. telephone info centre) was also
developed.

Cete Mediterranee
Mr. B. De.Saint Laurent
V2026 ADEPT Automatic debiting and Electronic Payment for Transport

The aim of this pilot project was to develop new devices (smart-cards and tags) taking into account the results obtained by the CASH study and the outcome obtained by the projects SMART and PAMELA in the DRIVE I programme. The ADEPT project also realised field-trials in various European sites through several applications of various types of toll collection systems in urban and inter-urban areas and also for parking payment. The ADEPT project used the results of DRIVE "PAMELA" (V1030), to continue the further development of an integrated system for all kinds of Automatic Debiting applications. The system was built on a 5.8 GHz secure microwave communications link combined with a multi-purpose smart card providing for all the payment needs. Four separate field trials were implemented (Gothenburg, Lisbon, Thessaloniki, Trondheim), one to demonstrate the on-street parking management (booking and guidance) and debiting application, another on non-stop tolling and two sites will be dedicated to multi-lane applications including enforcement. The high capacity of the link to and from the roadside was to be assessed for future applications such as information to drivers, congestion metering and more effective forms of traffic control. The project also develop an in-vehicle monitoring device for the diagnosis of congestion and automatic debiting as and when congestion is experienced.

University of Newcastle-Upon-Tyne
Prof. P. Hills
Tel +44 191 222 6547
Fax +44 191 222 8352

V2027 GAUDI Generalised and Advanced Urban Debiting Innovations

The GAUDI Euro-project associates five major European cities (Barcelona, Bologna, Dublin, Marseille and Trondheim) faced with problems of heavy congestion, difficult access to the city centre, and pollution. The GAUDI cities decided to launch a federated approach to define, experiment, and appraise multiservice urban debiting applications: road pricing, public transport ticketing, parking debiting and zone access systems. The significances of the filed trials - size sampling, commitment of the local transport authorities - makes this Euro-project valuable enough to attract the interest of other large European cities like Berlin, Frankfurt and Paris. The technological solutions (smart cards and transactions at 5.8 GHz) are quite similar to the ones of ADEPT.

Centreservei Zona Franca
Mr. K. Cabrero
Tel. +34 341 4650
Fax +34 341 4163

V2028 ATT-ALERT ATT-Advice and Problem Location for European Road Traffic
The ATT ALERT project promoted and prepared the standardisation of a set of protocols to enhance the capabilities in providing a comprehensive drive information service on several media or bearers: RDS, AMD (AM Data systems), DAB (Digital Audio Broadcast) and DRC (Digital Radio Communication Systems).

The overall objective of ATT-ALERT was to complete and standardise the current RDS-TMC ALERT C protocol in order to enhance its capabilities in providing a comprehensive driver information service. On one side, it aimed to develop essential additions to the existing protocol and pursue standardisation at international level. On the other side, ATT-ALERT will provide for consistent application of the protocol on other media or bearers (DAB, AMD and DRC).

Castle Rock Consultants
Dr. J. Booth
Tel. +44 133 28 14 141
Fax +44 133 28 14 181

V2029 BATT  Behaviour on A.T.T.

The objective of BATT was to evaluate, within the framework of and in conjunction with the ATT programme, the changes in travel behaviour resulting from the introduction of ATT. This was based on before/after comparison of travel behaviour, investigated so as to set the pace for further developments of the material used in DRIVE.

TRENDS (Athens)
Mr. G. Argyrakos
Tel. +30 1211 0227
Fax +30 1228 9943

V2030 MARTA  Monitoring Attitudes towards Road Transport Automation

MARTA concentrates on the impacts of ATT on inter-urban intra-European flows of people, and matching this aspect with the study which one partner carried out for DG VII on freight flows, where modal shares will also be affected by ATT. The project was to draw together evidence from a variety of data sources and models in order to offer the necessary predictions.

TMT  PRAGMA
Mr. F Filippi
Tel. +39 685 46051
Fax +39 684 11858

V2031 EDDIT  Elderly and Disabled Drivers and Information Telematics

This project addressed two main problems. First EDDIT addressed the problems of drivers suffering from the reduction of efficiency in perception and cognitive functions associated generally but not necessarily with ageing. It studied ways of ameliorating these problems, including avoidance of obstacles in low-speed manoeuvring, and
assessed the particular requirements of ATT services if these are to help rather than to endanger the growing number of drivers in this category.

Second, it developed a specific device for the radar detection of obstacles (street furniture, parked vehicles) behind a car so as to facilitate manoeuvring at low speeds by drivers who cannot easily turn their heads and see as well as younger drivers. Note that TELAID (V2032) addresses the problems of the physically handicapped.

Cranfield Institute of Technology
Mr. P. Oxley
Tel. +44 1234 754 121
Fax +44 1234 751 712

V2032 TELAID Telematic Applications for the Integration of Drivers with Special Needs

This project brings together most of the leading European research institutes in this field, together with one manufacturer of control modifications who also represents the European federation of companies in this industry. TELAID examines the particular requirements of drivers suffering from handicaps necessitating the modification of vehicle controls, and involves the participation of companies specialising in equipment of this type. Much of its work consisted of identifying, as a point of reference, how drivers perform with the available "mechanical" modifications. The project was then extend to assess the benefits of telematics; to permit much more thorough trials on a sophisticated driving simulator. Based on surveys and trials, guide-lines and draft standards were proposed. TELAID thus complements EDDIT, which addresses the problems of drivers who can use un-adapted cars. Note that EDDIT (V2031) addresses the special problems of elderly drivers.

Aristotles University of Thessaloniki
Mr. A. Naniopoulos
Tel. +30 31 995 765
Fax +30 31 995 789

V2033 LLAMD London, Lyon, Amsterdam, Munich and Dublin, with Margot Euro-Project

LLAMD was a co-operative Pilot Project involving five cities. Particular attention was given to systems architecture and to the integration of information relating to urban and inter-urban traffic, parking, park-and-ride, urban public transport, cross-city freight movements, and the interaction between route guidance and traffic management. The project included model development and calibration concentrating on the distribution of route recommendations. Accident statistics are the theme of the Dublin component. Experience was compared both by monitoring and social survey techniques, and by predictive modelling in the MARGOT section of the project.

Ian Catling Consultancy
Mr. I. Catling
Tel. +44 1737 55 2225
V2034 FRAME  Freight Management in Europe

FRAME was concerned with freight management with special emphasis on control and monitoring of hazardous goods shipments both on land and maritime crossing. It developed a distributed command control centre based on distributed databases and implemented an intelligent terminal for use in freight network management. Pilot experiments were performed on the channel crossings, the Welsh corridor and the crossing to Ireland. Tests were also included on remote terminal operation between the Netherlands and Greece (perishable goods monitoring).

Brand Consultants
Mr. T. Brand
Tel. +31 053 4777 3806
Fax +31 053 476 2817

V2035 LIAISON BERLIN  Linking Autonomous and Integrated Systems for On-line Network and Demand Management in Berlin.

The project has completed a feasibility study for the development and installation of a demand management system for selected areas of the Berlin city centre, in the framework of an Integrated Network and Information Management System that covers the CBD priority, radial arterials and the motorway ring around Berlin. The project was terminated at the end of the one year feasibility stage.

Contact TTCO for any further information.

V2036 DYNA  A Dynamic Traffic Model for Real-Time Application

The objective of this project was to produce a fully operational dynamic traffic model system for real time applications. The system provided short term forecasts of traffic flows and travel time to traffic operators, plus a dynamic traffic assignment model for application in real time, and a statistical traffic model for real time applications. The model was applied on a real scale in a pilot project in an inter urban motorway network in the Rotterdam area.

Hague Consulting Group
Mr. H. F. Gunn
Tel. +31 70 346 9426
Fax +31 70 346 4420

V2037 PORTICO  Portuguese Road Traffic Innovations on a Corridor
The PORTICO objectives was to be achieved by installing and testing real time warning waves (illuminated) and incident detection algorithms in two selected locations of the PORTICO corridor. The surveillance of hazardous goods was to be provided by efficient monitoring of HGV using mobile communication and Automatic Vehicle Location techniques.

Junta Autonoma de Estradas
Highways Department
Mr. J. S. Marques
Tel. +351 1295 3525
Fax +351 1295 7503

V2038 GEMINI  Generation of Event Messages in the New Integrated Road Transport Environment

To achieve the aim of integration, it is necessary that messages transmitted via the various media should, as an absolute minimum never contradict each other. It is essential that they should be mutually conformative. The key emphasis of GEMINI focused on the demonstration and evaluation of the integrated system in particular on the Radio Data System Traffic Message Channel (RDS-TMC) and Variable Message Sign (VMS) Networks. This was achieved through trials sites in Italy and the UK.

Castle Rock Consultants
Dr. F. Sommerville
Tel. +44 133 28 14 141
Fax +44 133 28 14 181

V2039 KITS  Knowledge-Based Intelligent Traffic Control Systems

The KITS project addressed the development and experimentation of Knowledge-Based models for intelligent traffic control systems applied to urban as well as inter-urban traffic environments. The project aimed at achieving large-scale testing and in-depth assessment of those models by implementing extensive field trials in several European sites: Cologne (D), Trondheim (N), Genova (I) and Madrid (E).

Automa Research & Development
Dr. M. Boero
Tel. +39 10 2092 591
Fax +39 10 203 987

V2040 MELYSSA  Mediterranean - Lyon - Stuttgart Site For ATT

MELYSSA brought together national (French) and regional (Baden-Württemberg) administrations and a major French motorway consortium (involving 5 different companies), as well as important industrial companies. The project developed, implemented and tested inter-connections of European traffic control centres, interconnections of urban and inter-urban traffic control centres, dual mode route guidance systems, RDS/TMC for driver information, new VMS systems for traffic control, static and dynamic databases enabling traffic modelling and forecasting. Particular emphasis
was put on traffic safety improvements by testing alternative techniques and technologies for automatic incident detection. The test site for the Melyssa project was the motorway corridor between Stuttgart (German test site), Lyon (French test site), with its extension to Spain.

Cete Lyon
Eng. J. Nouvier
Tel. +33 4721 43144
Fax +33 4721 43120

V2041  CITRA  System for the Control of Dangerous Goods Transport in International Alpine Corridors

CITRA was an international Alpine Pilot Project through Germany, Austria and Italy which proposed the realisation of an integrated monitoring and control system to optimize hazardous/dangerous goods transport. The project was also organized around a system integration at international level by the interworking of the national traffic control centres.

The main results are the definition of a methodology for Hazardous Goods Monitoring and impact assessment on traffic management, environment and safety.

Strategic Marketing, Italtel SPA
Prof. E. Angeleri
Tel.39 554 20 22 32
Fax +39 554 20 25 21

V2042  QUO VADIS  Queue Obviation by Variable Direction and Information Signs

The QUO VADIS project aimed at increasing the understanding of the behavioural, operational, institutional and technical requirements for the effective implementation of a traffic information system using variable message signs. Two extensive field trials were implemented in two road networks (Scotland and in Denmark) which offer real and substantial route choice opportunities.

Oscar Faber TPA
Mr. S. Tarry
Tel. +44 121 236 6204
Fax +44 121 236 4709

V2043  ARTIS  Advanced Road Transport Informatics in Spain

The main objectives of the ARTIS corridor, La Junquera-Seville, was to demonstrate and to assess the efficiency of Advanced Transport Telematic technologies around five applications: national and international travel and traffic information exchange, knowledge based intelligent traffic control system, automatic incident detection using vision technique, use of RDS-TMC for controlling Variable Message Signs and dangerous goods control operations. External projects collaborated and contributed
directly to ARTIS within the 5 working areas identified by this pilot project (MELYSSA, KITS, INVAID II, GEMINI and FRAME).

On Campus Technology S. A.
Mr. S. Guillen
Tel. +34 6362 7050
Fax +34 6362 7013

V2044 GERDIEN   General European Road Data and Information Exchange Network

The GERDIEN project was an infrastructure orientated aimed at the development of a coherent network for road traffic data collection and exchange, allowing for flexible integration of a variety of Advanced transport Telematics applications at all levels. It covered the major part of the infrastructure required for Dynamic Traffic Management in Inter-urban parts of the Integrated Road Transport Environment. A combination of Advanced Transport Telematics applications was integrated into a common "real world" environment - a motorway section in the Netherlands - and the efficiency of the resulting infrastructure was evaluated.

TNO Institute of Applied Physics
Ing. J. C. Blonk
Tel. +31 152 692 338
Fax +31 152 692 111

V2045 ROSES   Road Safety Enhancement System

This project aimed at the practical implementation of a fully integrated traffic, road condition and weather monitoring and control system to support safety improvements and winter maintenance decisions. This was achieved by the integration of road side systems and vehicle based monitoring and information systems (warning, support, control), weather forecasting, safety margin assessment from different viewpoints and early ice warning strategies. Work was carried out through simulation, in-door testing, controlled environment testing using research vehicles (POSCHE) and two pilot tests in the Netherlands and Wales.

TNO Road Vehicles
Mr. A. P. De Vos
Tel. +31 152 697 402
Fax +31 152 697 314

V2046 ACCEPT ALERT Concerted Cooperation in European Pilots for TMC

The overall objective of this project was to enhance the acceptance and to speed up the implementation and the standardisation of RDS-TMC (Radio Data System - Traffic Message Channel) on a European level based on cross-border and metropolitan field trials. Several issues of international interest were supported such as inter-connection of national traffic information centres and international compatibility of in-car-
receivers. This project dealt with field trials for testing of RDS-TMC as an effective tool for traffic information and control. Three national corridor RDS-TMC projects were linked through ACCEPT: the German BEVEI project and the Dutch Rhine Corridor are RDS-TMC trials for main roads which were interconnected through cross-border traffic information transmission; the Paris - Ile de France project adds the (sub)urban aspects to ACCEPT and used as a test bed for in-car TMC terminal comparison and compatibility.

Robert Bosch GmbH  
Mr. U. Kersken  
Tel. +49 5121 494 901  
Fax +49 5121 494 538  

V2047 PLEIADES  Paris - London Corridor

The PLEIADES project covered an international corridor that linked France, Belgium and UK. Bringing together three national/regional road administrations in UK, F and B as well as EUROTUNNEL. It aimed principally at improving multi-modal travel, traffic information and traffic management on the whole corridor. It developed, demonstrated and linked traffic information centres in England and France that have real-time knowledge of travel conditions on the main routes for cross-channel trips. Moreover, a range of information services was provided and evaluated to disseminate accurate, timely and consistent information and advice to travellers, drivers and freight hauliers both before and during journeys along the corridor.

Atkins Wootton Jeffreys Con.  
Dr. D. J. Jeffery  
Tel. +44 1372 728 222  
Fax +44 1372 740 055  

V2048 METAFORE  A Major European Testing of Actual Freight Operations using RTI on an Axis

The main goal of this project was to set up and evaluate in a real working environment the Road Freight Operations activities that were found to be of priority in the previous DRIVE work. The activities to be tested were: Communication with driver/vehicle and other Mobile Data Communication (MDC) activities, and EDI between shipper/operator combined with MDC. Special emphasis was given to the application of RTI in SME's. Test have been carried out on several alternative routes between North-West Europe and Greece.

Trademco  
Mr. V. Evmolpidis  
Tel. +30 1 7248048  
Fax +30 1 7237415  

V2049 PROMPT  Priority and Informatics in Public Transport
The project focused on the problem of achieving active priority of public transport within systems of dynamic urban traffic control. The field tests were carried out in 3 European cities having dynamic and real time adaptive urban traffic control systems: LONDON (system SCOOT), TURIN (system UTOPIA), and GOTHENBURG. The tests include active priorities of buses, trams and emergency vehicles. Integrated strategies and control systems for public transport were also developed.

Atkins Wootton Jeffreys Con.
Mr. R. Meekums
Tel. +44 1372 728 222
Fax +44 1372 740 055

V2050 SCOPE Applications of ATT in Southampton, Cologne and Piraeus

The projects covered 4 areas of ATT pilot applications in 3 cities of Cologne (D), Southampton (UK), and Piraeus (GR). The 4 areas included various pilot applications of Integrated Urban Traffic Management, Travel and Traffic information, Strategic Information systems, Public Transport, with differing types and importance for each application according to the infrastructure and the existing problems of each of the 3 cities. Local authorities and service operators were active in order to steer transport research and technological developments (including strategic information systems) towards successful pilots and future eventual implementation.

Two projects outside the ATT programme followed the work and exchanged views. They are CITRAC from Strathclyde in Scotland (City Traffic Control), and BRESCIA from Northern Italy (City Network Management).

City of Cologne
Ms S. Mueller
Tel. +49 221 221 1480
Fax +49 221 221 1900

V2051 IFMS Integrated Freight Logistics Fleet & Vehicle Management System

Within the IFMS project an Open System Architecture for Computer Aided and Integrated Transport (OSA-CAIT) was specified, implemented and validated within pilot projects in the areas of controlled logistics on a pan-European scale including urban, interurban and combined transport operations. Based on the pilot experiences, recommendations for functional specifications and standardisation were given and strategies for pan-European implementation derived.

Damler Benz AG
Mr. K. H. Schmeck
Tel. +49 711 172 2409
Fax +49 711 175 1642

V2052 EDRM2 European Digital Road Map 2

The goal of the EDRMII project was to provide the first steps towards availability of digital map data for a defined set of pilot applications within the field of traffic control.
and traffic management and to enable the link with data on real time events. Specific tools for the validation of GDF data sets were developed as a precondition for provision of data, to be available before the installation of the pilot projects. ERDMII supported the Transport Telematics community in the field of data exchange and data transmission. Further standardisation activities are planned for upgrading the GDF standard to include dynamic data. The requirements profile for CD standards was also considered.

Robert Bosch GmbH
Mr. J. C. Pandazis
Tel. +49 5121 494 650
Fax +49 5121 492 520

V2053 ADS Automatic Debiting Systems

The project had the objective of improving traffic flow in the motorway network through European countries by the application of automatic debiting systems. Multilane non-stop payment and multimodal information exchange for advanced booking was the topic of two field trials respectively, in Italy near the Mont Blanc tunnel and the harbour of Brindisi. These automatic tolling and booking systems were accomplished by the use of a radio communication between vehicle and ground, based on a microwave 5.8 GHz link. This project aimed at setting common functional specifications for these financial transactions in order to prepare real pan-European standard on Automatic Debiting Systems.

Autostade
Mr. Armellini
Tel. +39 554 20 22 32
Fax +39 554 20 25 21

V2054 CITIES Cooperation for Integrated Traffic Management and Information Exchange Systems

CITIES studied, developed, and evaluated advanced systems dealing with distribution and broadcasting of transport-related information, route guidance, traffic control and demand management through Pilot Projects in Paris, Brussels and Gothenburg. The project compared the effectiveness and operation of a number of travel and traffic information systems. These techniques and systems include CARMINAT, SOCRATES, PRODYN, Videotext, Minitel, RDS-TA & VMS. A particular emphasis was put on flexible publicly available personal transport including car pooling.

Region de Bruxelles -Capitale
Ing. F. Vanderborght
Tel. +32 2 230 31 80
Fax 32 2 230 31 07

V2055 RHAPIT Rhein/Main Area Project for Integrated Traffic Management
This project will help build confidence in Advanced Transport Telematics by acting as a focal unit for the coordination and promotion of activities in the Transport Telematics programme which are intended to contribute to efficient implementation of the corresponding systems. The results will guide relevant activities to achieve, as far as possible, a consistent technological, socio-economic, sociological, regulatory and legislative assessment of pilot projects in order to contribute to the implementation strategy of Advanced Transport Telematics in Europe. It also played an important role in the preparation of the necessary standards in this field.

Hessisches Landesamt fur Straben und Verkehrswesen
Mr. G. Riegelhuth
Tel. +49 611 366 481
Fax +49 611 366 484

V2057 PASSPORT  Promotion and Assessment of System Safety and
Procurement of Operable and Reliable Road
Transport Telematics

The objective was to demonstrate the feasibility and effectiveness of application of System Safety techniques to assure the safety, operability, reliability and dependability of ATT systems. It produced frameworks for Prospective System Safety Evaluation. For ten projects a Preliminary Safety Analysis (PSA) had been conducted and in two workshops the PASSPORT method of PSA has been taught.

University of Leeds
Mr P. H. Jesty
Tel. +44 113 2335 452
Fax +44 113 2335 468

V2060 MIRO Mobility Impacts, Responses and opinions

The overall objectives of MIRO was to obtain measures of the opinions and key operators concerning their acceptance of, and possible travel behavior response to, a series of scenarios concerning the introduction of innovative ATT based demand management schemes in and around cities throughout Europe, and to indicate the possible impact that next stage implementation of such schemes could have upon prevailing traffic and environment conditions.

Centreservei, Zona Franca
Mr. K. Cabrero
Tel. +34 341 4650
Fax +34 343 14163

V2062 DESPINA Demand Spreading through Pre-trip Information.

‘Demand spreading’ has been identified as one of the essential means of a sound equilibrium of investment which are related to existing infrastructures. It can take several forms, one of which is advising and informing users in pre-trip situations. DESPINA evaluated demand spreading by; (a) providing the appropriate set of tools
and adequate information for effective pre-trip planning, (b) interlinking the relevant databases and provide travel and traffic information and advice at a European level. End users’ degree of acceptance of information and advice was measured in relation with each specific media, and the potential impact on demand spreading was assessed.

Cete de Lyon
Mr. A. Reme
Tel. +33 784 181 25
Fax +33782 640 39

V2063 KITE Kernel Project on Impact of Transport Telematics on the Environment

ATT-based strategies designed to solve traffic problems have the potential to reduce the environmental burden. A set of appropriate tools (e.g. models) and methods, provided through KITE, were used to evaluate both actual and potential benefits. The set of tools and methods developed in KITE will permitted:

- the assessment of potential air pollution impacts of ATT-based strategies prior to costly implementation.
- the determination of the actual impact of limited implementations such as field trials or pilot projects.
- the estimation of air pollution impacts of such implementations if extended to wider urban areas.

The project aimed to provide a set of standardised tools and methods that can be widely applied throughout Europe.

City of Cologne
Mr. P. Sonnabend
Tel. +49 221 221 1479
Fax +49 221 221 1900

V2064 EMCATT ElectroMagnetic Compatibility of Advanced Transport Telematics.

The development of ATT systems enhanced by urban and interurban pilot projects have considerably increased Electromagnetic Compatibility (EMC) risks among the different systems installed in the infrastructure as well as aboard vehicles. A co-ordinated research programme and significant trials in the field of EMC relating to ATT in several of Europe’s primary corridors was undertaken in this project in order to develop EMC test methods and theoretical models, to evaluate a range of information terminals from the EMC point of view, to disseminate relevant information for the standardisation bodies, to advise the pilot projects and to enhance the technical evaluation procedure of the DRIVE 11 pilot projects

Cete De Picardie
Mr. J. M. Hotteau
Tel. +33 20 49 60 93
V2065 GEM  Generic Evaluation Methodology for Integrated Driver Support Applications.

The primary goal of the GEM project was to assess how the provision of integrated driver support systems affects the performance of the driver and to identify the optimal mode of presentation of the information to the driver, in order to ensure their safe utilisation. The objectives was achieved through the development of a Generic Evaluation Methodology to be employed as and when new driver support systems become available. The methodology addresses all of the factors that must be considered when incorporating a new application into a vehicle capabilities and the requirements of the application itself, from both a behavioral analysis and systems integration viewpoint. The project seeks to identify:

- a generic method for evaluating the effects of combining multiple applications.
- criteria for determining what types of application can be combined to the benefit of the driver, and which combinations seem likely to be detrimental.
- whether new Man/Machine Interfacing technologies (e.g. Head Up Displays ) are likely to enhance the potential of existing support systems.

It was anticipated that the results of the project would form the bases of a European Code of Practice on this topic.

Warwick University
Mr. R. Mc Murran
Tel. +44 1203 52 47 14
Fax +44 1203 52 47 07

V2066 MITHOS  Monitoring Inter-modal Transport of Hazardous Goods.

The objectives of MITHOS was to develop specifications and propose the most suitable architecture for an information system to monitor hazardous goods shipments in an Inter-modal transport environment. The project developed, as an introductory step, a definition of the problem and study of the frame of reference related to the inter-modal transport of hazardous goods. The work already covered by some projects was evaluated and completed by surveying both the market situation: producers, consumers, transporters (maritime, road, rail and inter-modal sectors ) and the existing scenarios, legislation, and administrative bodies involved.

OCT  C / Hugo de Montcada
Mr. J. Albors
Tel. +34 362 70 50
Fax +34 362 7013

V2067 FAST / TITE  Facilitated Access for Small and Medium Size (SME) Transport Enterprises to Telematics.

The FAST / TITE project was a feasibility study on SMEs, telematic and freight transport centres. The project covers a precise identification of SME user requirements for ATT systems and functional descriptions of telematics platform
suitable for SMEs A functional description of an overall telematics platform within an open inter-modal transport centre network was elaborated. The project defined a large scale pilot test based on the following objectives:-

· identification of the specific needs and requirements of SMEs in freight transport for implementing appropriate telematics systems, thereby leading to a better control over the full transport chain;
· investigation into the possibilities of facilitating the access of small and medium size transport enterprise to telematics.
· identification of the most suitable existing and emerging ATT systems for SMEs contributing to a telematic platform which comprise integration of EDI chains and RTI systems including road traffic data applications and communications with mobiles;
· design of a technical configuration for the creation of an open inter-modal transport centre network considering physical networks, communication protocols, application programmes and user facilities to support operational needs of SMEs operation.