C O R D

Project V 2056

KEY ACHIEVEMENTS
OF THE ADVANCED TRANSPORT TELEMATICS
RESEARCH AND TECHNOLOGICAL
DEVELOPMENT PROJECTS

Programme: Telematics Systems in Areas of General Interest

Revision 2

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EXECUTIVE SUMMARY

The Advanced Transport Telematics or ATT Programme ended in 1995, having succeeded in stimulating activity at a European scale to develop and validate telematic services for road users. This report is a brief overview of the key achievements of the entire Programme, bringing together information dispersed across many project Reports and other summaries. It is addressed at any reader wanting to know the outcome of the ATT Programme, but especially to decision makers.

While avoiding too much technical detail, this document includes an extensive list of references to the original sources of information. We summarise below the key results in the main ATT application areas.

Thanks to the ATT Programme, Travel and Traffic Information (TTI) has achieved significant results, opening the way to implementation. RDS-TMC is now technically ready to assure a cross-border and interoperable pan-European service. Autonomous navigation systems using a range of technologies are now commercially available.

The trials have determined significant benefits for users of TTI and consequently confidence in market acceptance of the available technologies. In particular, in-vehicle information/guidance systems have found a wide acceptance of potential users willing to pay for services. The results further showed positive impacts of both in-vehicle and roadside (i.e. VMS) TTI applications on transport efficiency under different local conditions.

Several Traffic Management and Control (TMC) applications were tested in urban and extra-urban areas. New technologies have been demonstrated for Adaptive Traffic Control for urban networks, Variable Message Signs for section and network control, Automatic Incident Detection systems, Emergency Call systems, and Ramp Metering. The Projects have shown that the integration of the different aspects of traffic management results in wider opportunities for both industry and operators.

The trials results indicate clear safety benefits of these applications, particularly incident warning and speed control systems which can lead to considerable reduction of accidents or dangerous manoeuvres on motorways. Substantial travel time savings were demonstrated from applications such as intelligent traffic signal control and ramp metering.

Integration of Public Transport (PT) management systems with urban traffic control systems to provide bus priority was tested in several cities and found to attract more passengers and enhance the efficiency of operations. Telematics applications for Park and Ride have proved that patronage of PT can be increased (leading to less car traffic). Passengers strongly welcomed trials of real-time information at bus stops.

Several important advances were made in standards for PT operations, including a data model for the integration of Transport Telematics applications (in PT and other areas as well) and standards for information displays. With cost-benefit analysis showing some very short pay-back periods, the whole area of Public Transport has shown a remarkable success.

Projects successfully tested the integration of GPS (satellite location system), GSM (digital cellular telephony) and Mobile Data Communication in Freight and Fleet Management (FFM). The trials determined the great potential of telematics for FFM in...
improving transport efficiency, increasing safety of hazardous goods transport and bringing considerable economic benefits to operators. Freight operators have adopted Transport Telematics as a means to reduce wasted time, improve deliveries and optimise fleet and resources management. The savings in distance travelled translated to additional environmental and safety benefits. The applications found wide acceptance by freight and fleet managers and customers, with the larger companies perceiving a real improvement in operations.

In the area of **Automatic Debiting and Demand Management (ADDM)**, the ATT Projects have shown that technology for high speed free-flow automatic debiting systems is now available from the shelf, notwithstanding the current debate in many countries on road pricing and toll collection. The smart card proved a viable means for payment of services. On the basis of the trials carried out, the primary benefits of ADDM applications are expected in reduced congestion, less environmental pollution, and in reduction of waiting time at motorway toll gates. However, road pricing proved unpopular amongst the general public as a demand management tool.

**Driver Assistance and Co-operative Driving (DACD)** applications were trialled aimed at improving the relationship driver-vehicle-vehicle-road. The ATT programme provided the means to test in operating but controlled conditions new devices such as anti-collision radar, vision enhancement, cruise control, automatic driving, driver monitoring etc. “Warning” technologies proved more popular than “control” technologies. The trials confirmed high safety benefits and high acceptance of DACD for drivers, in particular amongst the elderly and disabled. In particular, cruise control with automatic distance keeping has great potential to increase motorway capacity by reducing the safe headway between following vehicles (driving in platoon). Driver comfort may be improved, particularly for elderly and disabled drivers, e.g. by vision enhancement for driving in darkness.

To help in implementation, model **System Architectures** have been produced for key applications areas, as well as for urban and inter-urban environments and for the “IRTE” (Integrated Road Transport Environment). A general framework for developing and planning a Transport Telematics **System Architecture** was produced.

The exchange of traffic data in coded language-independent form is a prerequisite for the interconnection of traffic services at European level. **Data Exchange (DATEX)** specifications (including data dictionary, event list, EDIFACT messages) were produced, were submitted for standardisation and are being now implemented by traffic centres throughout Europe.

Design and performance criteria for **HMI (Human-Machine Interface)** for designing and evaluating in-vehicle systems were produced as a reference tool for developers, resulting in guidelines helpful to industry and Public Authorities.

Digital maps are an essential basis for many transport telematics applications. Specifications were developed for **Geographic Data Files (GDF)** opening the way to common solutions for applications like in-car navigation; GDF is now on its way to becoming a global standard. Linking GDF to location referencing used in RDS-TMC has been solved and testing is under way.

The ATT Programme has had enormous impact on **Standardisation** in Europe and even at global level. Many of the advanced work items inside the CEN TC 278 work programme were contributed by the ATT Programme, in areas such as dedicated short-range communications; public transport data model; message list for RDS-TMC traffic...
information; specifications for data exchange; geographic data files. By the end of 1996 42 documents had reached committee stage, and 6 European prestandards and 5 draft prestandards had been published.

Summing up, the key results have brought many ATT applications from R&D towards implementation and the market. The ATT Programme was remarkably effective in creating an awareness of Transport Telematics applications as a vital contribution to solving present and future European transport problems.
KEY ACHIEVEMENTS OF THE ATT PROGRAMME

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1. GENERAL INTRODUCTION

1.1 Looking in retrospect

The goal of the 3rd Framework ATT (Advanced Transport Telematics) Programme was to develop and validate telematics applications to provide enhanced services to transport users through improved efficiency, safety and environmental quality, taking into account European policy objectives. Looking back over the ATT Programme, these objectives have been met. Both the European Parliament and the European Council have recognised that Transport Telematics is a basic tool in the development of road transport, with priorities on telematics infrastructures, data exchange between traffic information/control centres, road information services based on RDS-TMC and technical interoperability.

Several summaries and overviews of the Programme have already been published, including:

- “Index and User Guide to Achievements and End Products of the ATT Programme” [1]
  a CORD deliverable addressed at the technical community. It is a sort of “Yellow Pages” where results reported by projects are classified by topic area, by project and by product type (from reports to fully working commercial systems);
- “Area Reports” [2]
  prepared by the Area groups (corresponding to the 7 application areas of the Programme), summarising and evaluating the results from each Area;
- “Socio-economic Impacts of Telematics Applications in Transport - Assessment of Results” [3]
  an extensive document based on a survey of the reported impacts of the telematics applications developed under the ATT Programme, with recommendations for further activities.

This summary of the “key achievements” fulfils the need for a single concise document in which significant results could be brought together in an overview form.

1.2 The “Key Achievements” of the ATT Programme

The CORD project had the task “to review key deliverables reporting evaluation results” and “to produce an ordered summary of the achievements of the Projects and of the ATT Programme in general, relating to results, impacts and significance as a benefit to the transport telematics actors”. The activity was centred on presenting a global overview of the Programme in a short, easily readable document. The reader is then referred to the underlying specific and technical documents through an extensive list of references.

A “headline” style was adopted, to disseminate results to a wide audience and to provide readers with the necessary guiding elements for developing implementation considerations.
1.3 Definition of a “key achievement”

In this report, “key achievements” are those results obtained in the ATT Programme with a value beyond the Programme itself or individual Projects, either going towards market implementation or being a reference point for future activities in the sector, as for example the definition of a standard.

If we consider the achievements as a “pool”, the actors dealing with Transport Telematics will look at it in different ways (Figure 1-1)

![Figure 1-1 Different views of the ATT Programme](image)

Each group has its own needs and criteria. Public Authorities will look for the assessment of impacts in order to better define their policies. Operators will look for results on the efficiency of the applications they wish to install. The industry will look for product specifications (as standards) that can result in better products and larger markets. End users of the new services need to know their benefits. The reports indicated in [1], [2] and [3] already present outcomes in an orderly way; this deliverable, by linking key achievements with their assessed impacts and benefits, should provide the reader with a more focused overview of the Programme.

Many of the achievements of the ATT Programme were obtained through co-operation by projects or by tailor-made Task Forces: an approach pioneered by the CORD Project. Task Forces became part of the management structure of the Programme. This was already a major result, demonstrating that real progress is obtained at European level by collaboration directed at common goals and focusing on solving clearly defined problems.

1.4 The Process of Innovation

Transport Telematics comprises a wide range of innovative technologies applied in a way to bring positive changes to society. In the process of innovation, the ATT Programme played the essential role of demonstrating (wherever possible on a large
scale) the viability of the technologies in bringing positive solutions to road transport problems. At the European scale, consensus and harmonisation are a pre-requisite and the ATT Programme dedicated considerable efforts in this direction, with significant success. Projects in the Programme were requested to place a significant amount of effort to analyse and, when possible, to measure the impacts (or effects) of the new technologies: this was necessary to provide confidence to industry and public authorities alike to pursue effective implementation. The ATT Programme has confirmed and passed to the implementation world the value of telematics solutions.

1.5 Presentation of the Document

This document is addressed to all areas of the ATT community. It presumes readers’ familiarity with the structure of the ATT Programme and its technologies: as an overview, the document has avoided technical details. An extensive search was made: Final Reports from Projects, Area Reports, Cross-Project Collaborative Studies, Task Forces Reports, Guidelines and CORD Deliverables. Comments were received from Project Officers, Area Chairmen and CORD team members. Every effort has been made to realise a useful reference document. Nevertheless it does not presume to be exhaustive or complete: it is based on the experience gained by the CORD team as support to the management of the Programme.

The document presents key technical achievements obtained in application areas and in horizontal or cross-project activities. A large part is dedicated to a summary of the impacts of TT technologies (on safety, efficiency and environment) and, where available, of their benefits (user acceptance, economic impact). Remarks at the end of each section draw some conclusions on the degree of significance in each area. Finally general conclusions are presented.

To avoid overcrowding the text, references to original documents are made in endnotes. Most of these documents are Final Reports or Overview Reports. For further information on the referenced documents, the reader can contact:

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2. KEY ACHIEVEMENTS OF THE ATT PROGRAMME

2.1 Introduction
Achievements of the ATT Programme came both from the Projects included in the application areas and from those that were taking part in “horizontal” activities, e.g. common to projects in different areas. The ATT Programme was structured into 7 application areas. In the following, and consistently with [3], achievements in Area 3 (Integrated Urban Traffic Management) and Area 4 (Integrated Inter-urban Traffic Management) have been grouped under a more general heading “Traffic Management and Control”.

2.2 Achievements in application areas
The technical achievements are described under these six clusters:

- Travel and Traffic Information (TTI)
- Traffic Management and Control (TMC)
- Public Transport Information and Management (PTIM)
- Freight and Fleet Management (FFM)
- Automatic Debiting and Demand Management (ADDM)
- Driver Assistance and Co-operative Driving (DACD).

2.2.1 Traffic and Travel Information (TTI)
The ATT Programme stressed the relevance of Traffic and Travel Information (18 projects were active in TTI, Area 2 Report [2]), on board vehicles and at the roadside for pre- and on-trip information. The single key achievement in this area is the body of results relating to RDS-TMC (Radio Data System - Traffic Message Channel) [4], which has finally reached the stage of commercial introduction.

1) In-vehicle systems - RDS-TMC
Eleven test sites in seven international projects (ACCEPT, CITIES, GEMINI, LLAMD-Comfort, MELYSSA, PLEIADES, SCOPE-Ports) tested RDS-TMC for information to drivers, in Dual Mode Route Guidance (DMRG) systems, in control centres, and for switching of Variable Message Signs (VMS). Software, hardware and infrastructure components were specifically developed and tested within these trials.

As a result, the key components of the RDS-TMC service [5] are now available for stepping into implementation:

- ALERT C Protocol for the coding of the information to be transmitted via RDS-TMC (now a CEN prENV, TC/278 WG4);
- Location Referencing Rules for the supporting location databases (now a CEN prENV, TC/278 WG7);
- EUROAD Concept for the transmission of traffic information about another country (forwarded to CEN TC/278 WG4 and WG7);
• Event List to ensure compatible exchange and transmission of messages in any country and any language (now a CEN prENV, TC/278 WG4);

In the course of these developments, infrastructure for collecting automatic data, input of manual data, message editing, management and transmission of information via broadcast networks were tested and tuned. These developments make a truly cross-border interoperable RDS-TMC service an imminent reality.

The importance of these achievements even goes beyond RDS-TMC: in effect the Event List, the Location Referencing and Location Referencing rules can be used with other future transmission media that will depend on digitally encoded databases.

2) Other in-vehicle systems

In this particular subject, in-vehicle route guidance systems (both autonomous and dynamic navigation system) were tested operationally in different projects with different technologies. With the concurrent development in digital maps, navigation equipment is now ready for next commercial introduction.

MELYSSA, PLEIADES and CITIES demonstrated the viability of route guidance based on information broadcast using RDS-TMC, while the QUARTET application used active beacons. SOCRATES demonstrated dynamic route guidance via GSM and proved the feasibility of the floating-car method (based on GSM mobile phone system) as an efficient way of collecting traffic data to be subsequently diffused as traffic information. GSM on the other hand was shown to offer opportunities in many other applications (where two-way communications is required) as emergency services (in combination with GPS as localisation system) and parking.

3) Roadside systems - Variable Message Signs

Variable Message Signs can be used either as control or as information devices. Being the signs normally under the responsibility of Traffic Managers they are described in more detail in the section on Traffic Management and Control.

4) Portable systems

Portable terminals for 1- and 2-way data exchange with information centres which can be used both inside and outside vehicles were demonstrated (PROMISE project) as a viable means to reach final users in all circumstances. Common Functional Specifications were developed (LLAMD, SOCRATES, CITIES) relative to multimodal travel information services and prototypes developed.

5) Travel information terminals

Travel information kiosks or terminals were developed and tested, usually in relation to public transport information, in several projects. See sections 2.2.3 and 3.4 for further information.

Conclusions and remarks

Thanks to the ATT Programme, Travel and Traffic Information is going to implementation: it has been a successful area of the Programme. RDS-TMC has reached the technological maturity for a cross-border and interoperable pan-European service. The level of standards in RDS-TMC will assure this technology the leading role in deployment. Using a range of different technologies, navigation systems have shown their market-ready state, particularly autonomous navigation systems: commercial
products are already available. The next step is under way, i.e. very large scale
demonstrations where the organisational and institutional problems are met (and possibly
solved) and commitment on the part of the final investors should be reached.

2.2.2 Traffic Management and Control (TMC)
Traffic management is an area with extensive and long-established operational
experience. In this application area, a large body of reported results are “impacts” and
are described under that section. A great variety of products were tested or created (see
[1]), and key achievements were obtained in Traffic Control (urban and interurban),
Incident Management and Variable Message Signs (see also Area 3 and 4 Reports [2]).

1) Urban Traffic Control
The major achievement in Urban Traffic Control (UTC) has been the demonstration that
close integration of traffic management systems (traffic, public transport, environment,
intermodality, etc.) can increase the efficiency and bring substantial benefits [6]. The
ATT Programme stressed the opportunity of measuring extensively the impacts of
existing and operational systems, testing new control strategies. The Projects CITIES,
SCOPE, GAUDI and QUARTET involved at least 16 European cities [7]. The
integration of traffic control with environmental control is a new issue addressed in
QUARTET and PRIMAVERA. New traffic data collection systems (e.g. video cameras
with image processing) have been developed enhancing measurement of conventional
traffic parameters or measuring new parameters, with a view to the future widespread
application of ATT systems (QUARTET and LLAMD Projects). Efficient algorithms for
traffic forecasts (in the short term) were developed (see Inter-Urban Traffic Control);
RHAPIT proved that measurements of travel times and origin-destination data from
GSM/GPS equipped cars (floating car data) is possible and accurate.

The integration of bus priority schemes in traffic control systems has been a successful
demonstration (PROMPT and LLAMD Projects), best described in the Public Transport
section. SCOPE demonstrated the use of GPS as Automatic Vehicle Location in
integrating bus priority systems in urban network control systems.

Even pedestrians have been integrated in the control systems, enhancing their safety at
intersections (VRU-TOO Project).

Ramp Metering is new in Europe but has shown positive results as in the US. The
EUROCOR Project demonstrated the positive effects on traffic of Ramp Metering in
urban motorways.

2) Inter-Urban Traffic Control
An important achievement in this area has been putting into motion Public Authorities in
order to define their policies towards Traffic Control Centres and Traffic Information
Centres (e.g. EURO-TRIANGLE Project). The MELYSSA Project tested in real
operating conditions complex traffic management strategies involving re-routeing, RDS-
TMC, Variable Message Signs, Automatic Incident Detection (AID): it demonstrated
how many tools are at disposal of traffic managers and how their combination can result
in greater efficiency. Data collection systems based on existing or new techniques were
tested and improved (GERDIEN, PLEIADES and RHAPIT). Short term (15 to 60 min)
traffic forecasting models have been developed in several projects (DYNA, GERDIEN,
LLAMD, QUO VADIS and RHAPIT). Different models solve specific traffic needs [8]
and their relative methods were assessed in a common workshop [9]. A focus on weather and road condition monitoring (ROSES Project [10]) resulted in hardware and software for enhanced detection and assessment techniques, providing improved management of conventional weather data. Software algorithms calculate safety levels and recommended maximum speed in risky weather situations.

In-vehicle emergency call systems were assessed particularly with a view to their accuracy and reliability as indicators of incidents. Commercially available techniques were used, including GSM and DGPS (Differential Global Positioning System) using a GDF (Geographic Data File) base.

3) Incident Management

Within the ATT Programme different kinds of innovative Automatic Incident Detection (AID) technologies and techniques have been developed and tested (EURO-TRIANGLE, HERMES and MELYSSA Projects). They were brought to a state of readiness for commercial exploitation and for adoption by network owners and operators. Considerable steps were taken towards the development of general guidelines and recommendations for the implementation of automatic monitoring of incidents, outcome of the specific AID Task Force [11]. The guidelines reflect the general and latest European experience regarding the whole range of AID applications and provide recommendations for implementing different kinds of AID systems.

As part of the Incident Detection System, in-vehicle emergency call systems were assessed particularly with a view to their accuracy and reliability as indicators of incidents (QUARTET Project). Developments focused on SOCRATES/GSM technologies.

4) Variable Message Signs

Variable Message Signs (VMS) or Dynamic Signing, received special attention as tools for both traffic management and traffic information. Their potential for traffic management has been fully evaluated resulting e.g. in guidelines for a European practice for VMS (EAVES Project [12]). These guidelines include the analysis of strategies, data collection for decision support and operational procedures. The same EAVES Project provided a well-defined methodology for evaluating the impacts of VMS [13]. VMS for weather conditions (essentially fog) warning were also included. The methodology will be helpful on future VMS installations.

QUO VADIS was concerned primarily with the use of variable message signs (VMS) for traffic control (information and guidance) in both inter-urban and urban sites, using an approach based on off-line plans and two dynamic algorithms.

Applications in Cologne (SCOPE) and Munich (LLAMD) used VMS on inbound motorways to inform the driver of park and ride facilities and of the associated availability of a fast metro connection to the city. The effectiveness of the measure in Cologne was reflected in a sharp rise in car park usage since the installation of the VMS sign.

In an urban environment, QUARTET, EUROCOR and PRIMAVERA used VMS for speed control and advice, for congestion and transit time information and in general as integration of traffic management strategies between urban and extra-urban areas.

Conclusions and remarks
Technologies in this Area are mature enough to find widespread application. Adaptive Traffic Control Systems, Variable Message Signs and Emergency Call systems are enhanced by new technologies. The functions rather than technologies are finding a European dimension. To-day, the accent is on control strategies, modelling and algorithms (like AID) adapted to the local problem to be solved. The Projects have shown that the integration of the different aspects of traffic management results in wider opportunities for both industry and operators.

2.2.3 Public Transport Information and Management (PTIM)

Collective transport has been using Telematic Systems for monitoring and control of bus operations since more than a decade. These systems, like Vehicle Scheduling and Control Systems (VSCS), were tailor-made for each application. The ATT Programme has contributed to the development of third-generation modular systems adaptable to different needs of operators [14]. Eleven Projects involving about 30 cities were active (Area 7 Report [15]).

Two achievements have distinctive prominence in this area:

1) Common reference data model

A common reference data model (Transmodel) including a complete Public Transport data dictionary has been developed inside the EUROBUS Project, completed with the work in the HARPIST [16] and CARTRIDGE[17] Task Forces. This model gives Public Transport companies and software suppliers the opportunity to develop compatible and inter-operable information systems, to supply better services and better information to passengers.

The Data Model includes several domains of functionality such as:

- Scheduling
- Automated vehicle monitoring
- Off-line passenger information
- Fare collection
- Personnel disposition
- On-line passenger information
- Link with traffic and road work data
- Management Information Systems and statistics
- Link with Geographic Data File (GDF) standard.

The Transmodel Data Model was submitted to CEN TC 278 WG3 for standardisation (as of November 1996 draft is being circulated for stage 32).

2) Guidelines for information systems

The INPUT (Information System for Public Transport) Task Force had the objective to develop common specifications for the display to the travelling public of information about public transport services. The outcome of this Task Force was a report [18], containing eight proposed standards covering:
1. Screen layout for bus stop displays
2. Waiting time mode of presentation for bus stop display
3. Use of buttons for public access terminal
4. Use of icons for public access terminal
5. Screen layout in public access terminal
6. Languages in public access terminal
7. Use of icons for enquiry office terminal
8. Terminology for enquiry access terminal

The Task Force COMINPUT constituted a continuation of the INPUT Task Force, focusing on the definition of a set of common requirements, concepts, and guidelines for the communication systems and interfaces to be used in public transport passenger information systems. The final report [19] presents three proposals for communication protocols for the transfer of data to the passenger information displays to be placed at stops. The protocols are designed to be used at layer 7 of the OSI model and describe the data to be transmitted in terms of TRANSMODEL definitions. Two protocols are specifically designed for low capacity communication networks such as radio systems. The third protocol, to be used where high capacity communication networks are available, is an application of the TRAINS message as defined in the DATEX specifications.

These proposals, that will contribute both to easy access to transport services and to more comfortable use of these services by international travellers, have been submitted to CEN TC 278 WG3.

Another important achievement has been obtained in priority systems. Priority systems for public transport vehicles at signalised intersections were tested in eight cities [20]: they have been successfully integrated with traffic control systems and produced excellent results (reduction in journey time and wasted time, better regularity of operation) (LLAMD, PROMPT and CITIES Projects). More results are described in the impact section.

Other achievements have been:

- Automatic Vehicle Location (AVL) based on satellite technology (GPS) is a promising technology for Public Transport (APOS Task Force [21] and the Projects SCOPE and GAUDI).

- System Architecture for Vehicle Scheduling and Control Systems (VSCS): The VESCOS (Vehicle Scheduling and Control Systems) has studied the level of development and use of VSCS’s for public transport operations, with particular attention to the functionalities of these systems and the system architecture, and to specify all kinds of interfaces related to these systems. The final report [22] identifies the interfaces to be standardised and defines the characteristics of these interfaces and establishes an overview of requirements for further research and development.

- Demand responsive services in low density areas have been automated and integrated in the VSCS (PHOEBUS Project): the system contains modules for reservation, registration, planning and operations control.
• Fare collection systems based on the use of smart cards have been proven achievable even in the framework of an integrated payment concept, including payment for public transport and other transport related services (GAUDI Project).

Conclusions and remarks

Technological development has reached so far that integration of public transport management systems with urban traffic control systems is no longer a technical problem: the tools are available to the decision making authorities. Given the dispersed market, the adoption of a common framework for the integration of Transport Telematics applications in Public Transport (and to other areas as well) opens enormous opportunities. Results in Public Transport are certainly significant also in statistical terms, as indicated by the number of cities (from medium to large size) that have participated.

The ATT programme has produced sufficient consensus documents ready for being introduced in the standardisation process in order to allow in the coming years for an opening of the market for ATT systems in this domain allowing free competition between European industry. The operators and finally also the end user will take advantage of this situation in the coming years.

2.2.4 Freight and Fleet Management (FFM)

Reliable and cost efficient freight logistics is essential to European economies. The ATT Programme has further contributed to the development of freight and fleet management systems and combined transport systems. The involvement of large and small freight operators assured concrete results in a field constrained by economic factors.

The key achievements of the Projects in this area were connected to the central issue of mobile data communication between managers and drivers on the road:

1) System Architecture

• An Integrated Transport Communication Platform (ITCP, Project IFMS [23]), an open architecture describing the communication functions (on fixed and mobile networks) between core functions (freight/logistics, fleet/resources, vehicle/cargo) and the other systems (localisation, identification, clearance, etc.)

• An open architecture (software-based) providing the integration of different transport modalities, terminals, transactions and filtering of events (Project COMBICOM) [24]

2) Standardisation

• All Projects in the area supported the UN EDIFACT standard, as a clear indication of the route to follow

• Standardisation proposal for Mobile Data Communications (MDC) by merging the Macro Encoded Message (MEM) approach towards a structure following a UN, EDIFACT Standard (Project IFMS)

• Proposal for EDI status messages with planned and real time data for intermodal transport (Project COMBICOM).

Furthermore improved techniques for on-line monitoring and controlling and recommended new regulations were indicated. The FREDI Task Force synthesised the
work on EDI and identified a minimal set of segments and data elements needed for all phases of each transport process, including segments and data elements for situations which deal with Combined Transport and Mobile communication with vehicles on route. The FREDI Task Force consolidated results in an implementation guideline for freight.

As far as the movement of Hazardous Goods is concerned the work done concentrated on the testing of technologies for Hazardous Goods Monitoring and Control (HGMC) and on testing a particular architecture for such a system at a European level (FRAME Project [25]). Special emphasis laid on the development of solutions for data and information flow management.

Automatically activated emergency call systems based on a telegram system using GPS and GSM digital cellular techniques have been developed within the HGMC 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.

The METAFORA Project proposed and issued specifications for an integrated Maritime Information Network System (MARINS) [26]: if realised it will provide transport companies and agents added-value services connected to harbour space reservations, ship schedules, connection to other networks.

The domain of facilitating Intermodal Freight transport Operation involved the creation of what may be the first pan-European Intermodal Information and Communication system (COMBICOM Project).

Conclusions and remarks

The economic constraints of the sector can be at the same time the reason for successful implementation (the system is increasing productivity) or for limited diffusion (large companies only could afford the cost of the system). The technology has proven itself and is largely based on a good telecommunication infrastructure. There is still a large potentiality in combined and multimodal transport.

2.2.5 Automatic Debiting and Demand Management (ADDM)

Various Member States are showing interest in new systems for electronic road pricing either for levying tolls on motorways (e.g. for financing the infrastructure) or as a tool for demand management (e.g. in densely populated areas). This application area has received much attention and some controversy. Promising technical achievements often do not reach implementation because of external factors, such as the political debate on road pricing.

Projects (11 in Area 1, see Area 1 Report [2]) used technologies for electronic payment of transport services, for road-use access or pricing, public transport, car-sharing/parking or other chargeable service. First developments concerned high speed free-flow multilane automatic toll collection systems based on a DSRC (Dedicated Short Range Communication) link at 5.8 GHz: feasibility was demonstrated by the projects ADEPT (Thessaloniki and Gothenburg) and ADS (Florence, Telepass technology). CASH provided the main input for the preparation of the draft prestandard on the application interface for DSRC. Microprocessor "smart cards" were used to provide faster service for the mobile user. The very same road-use application can be used as an efficient demand management tool. The demonstrator projects in this area (ADEPT,
GAUDI and ADS) played a particularly valuable role in extending and refining the tools contained in the ATT demand management tool-box:

- Collective Transport Card-based services for train, metro, bus, P&R, phone
- Private Mobility Card-based services for off-street and on-street parking, non-stop access control, pedestrian priority zones, mono-lane open/closed tolls, multi-lane tolls, congestion metering, and parking booking information.

The Programme contributed to the first (albeit small-scale) deployment of such “integrated payment” technologies in Europe - in many cases a world first.

As for integrated payment, a proposal for standard data elements (containing 26 data types, 237 basic data elements and 18 composite data elements) has been forwarded to CEN TC 224 (prENV 1545). Communication interfaces have received a lot of attention towards the definition of common requirements concerning DSRC, also brought to the attention of CEN TC 278. Technical solutions have been proposed which facilitate multi-lane tolling and these are now incorporated in further national tolling trials, with the CARD-ME Task Force aiming at reaching agreement over Europe on medium and long term strategies for convergence to full interoperability of electronic fee collection.

Not only have the tools been developed but, through demonstrators, a knowledge base is being created which indicates how and when such measures can be utilised and what type of impacts they can be expected to have.

A smart card in integrated payment contains real purchasing power. The work in the GAUDI project highlighted the need to establish by legal contract the roles and undertakings of the different entities (contracts between service providers, between service providers and load agents, between service providers and users, and with the electronic purse provider) that participate in such systems. Ad-hoc meetings between the European Committee for Banking Standards (ECBS) and the ADEPT and CASH projects led to an initial report, outlining service payment issues seen from the respective banking and transportation points of view.

Conclusions and remarks

ADDM is one of the ATT areas arousing high interest. The ATT Projects have shown that the technology for high speed free-flow automatic debiting systems is now available from the shelf. However practical implementation needs more work - the domain of legal and institutional aspects, enforcement and vehicle classification. The current debate in many countries on road pricing (a tax), the position by private companies managing toll motorways on tolls (a service), are representative of the problems to be solved. Enforcement is vital in all applications and Public Authorities and motorway operators are pursuing the issue in the 4th FP. The smart card proved a viable means for payment of services and is becoming widespread.

2.2.6 Driver Assistance and Co-operative Driving (DACD)

These technologies have raised large hopes for improving the safety of drivers and vehicles, either stand-alone or as part of general traffic. At the same time, they need large support from institutional bodies, modification of existing regulations and last but not least drivers’ acceptance or acknowledgement.
Activities in this area took place in a strictly controlled environment. Some important results have been illustrated in an overview report [27]. Collision Warning, Intelligent Cruise Control and Driver Monitoring proved to improve safety conditions without increasing the mental load of the driver.

The 8 projects in the area (Area 5 Report [2]) essentially handled two issues: the driver and the vehicle.

1) Driver

In the SAMOVAR project, a JDR (journey data recorder) and an ADR (accident data recorder) were developed and tested, both for providing feedback to drivers and as information units. While practical conditions made a systematic evaluation difficult to achieve, there are some indications that fitting fleets with this equipment does improve the fleet operators’ safety record.

Within the EDDIT project, trials with vision enhancement methods (ultra-violet light and near infra-red) have shown that they would improve elder drivers’ capability to drive during darkness.

The DETER Project tested a device alerting the driver when committing a traffic violation.

Specific attention was given to Drivers with Special Needs (DSN) and elderly drivers: for DSN an assessment methodology was developed as well as an inventory (TELDAT data base) of requirements (TELAID Project).

2) Vehicle

Intelligent Cruise Control (ICC), Autonomous Intelligent Cruise Control (AICC) and Collision Warning (CW) were the major areas of research. ICC maintains a steady speed and warns when coming too close to the preceding vehicle, AICC controls the vehicle speed and actuates the brake system when coming too close to the preceding vehicle. ARIADNE and HARDIE tested CW technologies. DETER, EMMIS, HARDIE, HOPES and TESCO Projects tested ICC and AICC technologies, inclusive of CW [2].

Human-Machine Interface (HMI) has been recognised as a fundamental problem in these new technologies. Recommendations and guidelines were formulated for information presentation; design of HMI, common experimental approaches to HMI, DSN aids, requirements for harmonisation of multiple application integration and safety analysis and evaluation. A specific Task Force was set up which issued guidelines [35].

Conclusions and remarks

As mentioned, research took place in a strictly controlled environment. However, it is apparent that “warning” technologies are more apt to reach the market sooner than “control” technologies. The need now is to give industry and public authorities alike enough confidence in these technologies to start considering implementation.
2.3 Achievements from horizontal activities

In the ATT Programme, horizontal activities were designed to build upon the experience of several projects and to ensure technical interoperability and region-to-region harmonisation. The active collaboration of many experts coming from many projects making it possible to reach wide consensus on strategic issues. Task Forces were a new way of working, building on the co-ordination efforts of Transport Telematics Fora, Areas and Topic Groups, in an ascending order of problem-focusing.

From these horizontal activities four results emerge as firm points of success:

- Architecture (SATIN Task Force)
- Data Exchange (DATEX Task Force)
- Evaluation (Evaluation Task Force)
- Human-Machine Interface (Topic Group 4)

A fifth important result is classified here, even if coming from a single project, its relevance crossing a high number of Transport Telematics applications:

- Geographic Data File (GDF)

Their success story is based on willingness to solve a common problem and to lay the foundation of future growth. These results are now being exploited in the 4th FP where projects like CONVERGE assure continuation of work.

2.3.1 Achievements on System Architecture

Much of the progress in the development and deployment of Transport Telematics technologies appears to be a direct result of clear focus on the development of well-defined ‘building blocks’ such as driver information, traffic control, route guidance or public transport information systems. Europe is facing the challenge of integrating these ‘building blocks’ into a pan-European approach that would offer some degree of consistency and synergy across applications.

A key achievement in this area was developed by the SATIN (System Architecture and Traffic Control Integration) Task Force including experts from several Projects (QUARTET, GERDIEN, EUROBUS, IFMS, GAUDI, LLAMD and PASSPORT were part of the Task Force while SCOPE, MELYSSA, COMBICOM, METAFORA, ADEPT, PROMISE and SOCRATES also contributed). SATIN produced architectures at three levels [28]:

- application area level including:
  - traffic and travel information
  - urban traffic management
  - inter-urban traffic management
  - public transport
  - freight and fleet management including hazardous goods monitoring
  - automatic debiting system
• urban and inter-urban level
• IRTE (Integrated Road Transport Environment) level including interfaces between application areas

SATIN produced [29]:
• the definition of the system architecture concept;
• the recommendation of a methodology for developing and assessing Transport Telematics architectures;
• the description of architectures for the application areas.

The SATIN developed methodology and architectures are being extensively used in the Fourth Framework Programme and have been forwarded to CEN TC 278 WG13.

System architecture can help in organising the passage from research to implementation, assuring coherence and a global overview of Transport Telematics. The successful result of this Task Force leads to proper interfacing among the applications, providing reference and guidance to implementation.

2.3.2 Achievements in Data Exchange

Travel and Traffic Information, Traffic Management and many other areas of Transport Telematics need an efficient, language-independent, unambiguous way of exchanging data. Traffic data exchange is of paramount importance in the success of Transport Telematics which combines telecommunication and information technologies. With an electronic coded exchange of data, Traffic Centres are able to send real-time road traffic/travel information that can be received and understood by other Traffic Centres: a necessary prerequisite is that all of them should have implemented the same specifications. As a result of the DRIVE I Programme, three competing incompatible systems (STRADA, INTERCHANGE and EURO-TRIANGLE) were handling the issue of data exchange. In the ATT Programme, the CORD-led DATEX Task Force (formed by experts coming from the ACCEPT, ARTIS, ATT-ALERT, EURO-TRIANGLE, INTERCHANGE, MELYSSA and PORTICO Projects) developed a set of detailed technical and functional specifications in order to achieve interoperability between systems [30] and that can be also used as a stand-alone system. The so called DATEX-Net Specifications are available to the transport telematics community [31], and are obtaining wider and wider acceptance amongst the European organisations, making the prospect of a real European data exchange network a forthcoming reality.

DATEX-Net has produced specifications for:
• Traffic and Travel Data Dictionary
• A set of eight EDIFACT messages
• RDS-TMC Geographical Location Referencing

The DATEX-Net is composed of Client-Supplier subsystems with the following interfaces:
• Application Interface
• Operator Interface
• Communication Interface

• Database Interface

With the adoption of DATEX-Net, the worst situations can be handled: cross-border data exchange (e.g. between Countries using different systems), as well as data exchange within Countries (e.g. different actors using incompatible systems). The DATEX-Net results, which have already received acknowledgement for implementation across Europe, have also been forwarded to CEN TC/278 WG8.

Data exchange between fixed points is a prerequisite to real interconnection of Traffic and/or Travel Centres, at the European scale but also at National level. This result is allowing the creation of a real interoperable European base infrastructure and is included both in the large demonstrations of the 4th Framework Programme and in the Euro-regional Projects funded under the Trans-European Networks budget of the EU.

2.3.3 Achievements in Evaluation

Common methods and tools for evaluation ensure the ability to reach conclusions on the strategic aims of the Programme and to ensure that final recommendations have a wider level of acceptance.

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

• definitions of the systems being evaluated and the expected impacts on these systems
• methods of evaluation and indicators selected for measurement
• opportunities for comparative studies between projects within the Programme or with projects which lie outside.

An Evaluation Task Force produced such guidelines [32] that have been accepted in the 3rd Framework Programme and whose approach has been widely adopted in the ensuing 4th Framework Programme.

The framework for evaluation plans indicates guidelines for:

• decision context and assessment objectives
• system/application overview
• evaluation categories and methods
• impacts expected
• indicators to be assessed
• experimental design
• data processing and analysis
• evaluation parameters
Evaluation guidelines have been issued for each area of operational interest; guidelines which provide a framework (common guidelines for assessment of ATT pilots); guidelines to enable the synthesis of results from different projects (guidelines for cross-project collaborative studies [33]); guidelines for data analysis and results presentation; and guidelines and tools which enable the evaluation of safety impacts, user response and HMI (Human-Machine Interface).

Guidelines were issued on Assessment of Transport Telematics Applications [34] in the following areas:

- Public Transport
- Urban Traffic Management and Information
- Freight and Fleet Management
- Hazardous Goods Management and Control
- Inter-Urban Traffic Management and Information
- Driver Assistance and Co-operative Driving
- In-vehicle Information Systems
- Demand Management and Automatic Debiting

The ATT Programme stressed the relevance of a proper assessment of projects’ results and the proper management of such complex programmes requires a strong commitment in evaluating and assessing results.

### 2.3.4 Achievements in HMI (Human-Machine Interface)

Transport Telematics applications in use have to interface with a human being. Topic Group 4 was charged with the identification of the benefits and drawbacks of HMI evaluation methodologies and with the definition of assessment criteria in respect of safety requirements. The Topic Group, comprising the 12 relevant ATT Projects, issued criteria in four broad areas [35]: driver performance analysis, physiological measures, subjective measures and behavioural measures. Results were forwarded to CEN TC 278 WG10.

### 2.3.5 Achievements in Geographic Data File specifications

Digital maps are needed in the following ATT applications, amongst many others:

- Traffic Management
- Vehicle Navigation
- Fleet Management and Hazardous Goods
- Travel Information Services
- Travel Guidance Services

For all these applications geographic information is essential and needs to be provided in an appropriate transfer format. Most (if not all) future ATT pilots will need some kind of a digital road map. Some pilots (inter urban) may not need such an accurate map, but other pilots need the exact location of every street in the pilot region plus its attributes.
(one way street, road class, street name, etc.). The EDRM2 Project (with the members of CEN TC/278 WG7) had as its main goal the establishment of a European standard for the exchange of geographical data [36]. The project succeeded and the current version (v 3.0) of the Geographic Data File (GDF) specification has been submitted to CEN TC 278 and is now a ENV.

All main European digital road producers now comply with the GDF standard and are able to deliver GDF for most of the European sites. The availability of the GDF data editing tools developed in EDRM2 enables the user to manipulate GDF data.

GDF specifies the format for an ASCII file containing geographic data structured in a standardised way. Actually, the underlying data model of GDF fits a wide range of vector-data-based geographic information and is not only restricted as at its early stage to the representation of the road network information but it includes the possibility to describe railways, waterways, land cover and other transport-related features.

Efforts were also dedicated to merging GDF with Location Referencing as used in RDS-TMC. The two systems having different purposes, the merge would have been done one at the expense of the other. A solution was found creating a cross-reference mechanism between the two systems [37]. The interchangeability of digital maps is a must if applications like in-car navigation can have a European dimension. The reaching of a standard in this sector (and recently a way of communicating with Location Referencing) is extremely significant for producers and users.

### 2.4 General remarks on achievements

In summary, it can be said a number of technologies have reached sufficient maturity to face the challenges of the market: RDS-TMC and Navigation in TTI, Bus Priority systems and VMS in Traffic Management, Passenger Information in Public Transport, Automatic Debiting are the more evident examples.

The success of any market depends ultimately on user acceptance, which is the ability of a product or a service to satisfy and meet user needs. Groups of representative users were involved in varying degrees in the ATT Programme: from hundreds of users in trial of TTI or FFM to a few tens of users in DACD, and from tens of cities testing urban TMC to a few specific sites testing ADDM.

CORD’s deliverable proposing a vision of ITS [38] has stated the conditions for success of the technologies in these terms:

“Critical success factors for the implementation of ITS (Intelligent Transport Systems) are mainly related to the desire of the public and private sectors to cooperate. In fact, the public sector should take the lead to act as a catalyst to launch the market, facilitating an increasing role by the private sector. Many ITS services and products cannot be implemented without the involvement of Public Authorities. Despite the commitment of the EU towards ITS, subsidiarity means that real commitment of Member States is vital for the deployment of ITS throughout Europe.”
2.5 Contribution to standardisation

In the preceding, many references were made to standards. Standardisation plays a strategic role in the implementation of Transport Telematics. The European industry is looking at the standardisation process as a way of enlarging the market opportunities. All actors are looking at standardisation as a way of insuring truly interoperable European systems.

An important strategic goal of the ATT Programme has been to link standardisation issues to relevant Projects and Task Forces towards developing substantive contributions. The creation of CEN TC 278 in 1991 at the beginning of the ATT Programme responded to these needs.

Inputs from the ATT Programme to the process of standardisation is without doubt a key achievement. ERTICO and Projects alike have provided recommendations for the creation of Working Groups and Sub-Groups, and the definition of Work Items; they formed consensus on many issues and have, furthermore, provided own resources in many CEN Working Groups.

The Programme contributed to define or to make advancement in standards related to:

- RDS-TMC
- ALERT C and ALERT Plus Protocols
- Traffic and Travel Data Exchange
- System Architecture
- Geographic Data File (GDF)
- Data Model for Public Transport
- Data Elements for Smart Cards
- Information Systems for Public Transport
- Application Interface for DSRC.

A standardisation framework has been provided to TC 278 as a management tool to help the clarification of the process [39]. Co-operation with the international body ISO was also instituted.

A substantial number of documents were sent to standardisation committees as a direct input for development of standards and reports: 42 documents have reached committee stage, six European Prestandards (ENVs) and five Draft Prestandards (prENV) have been published [40]. In conclusion the process of standardisation, through the ATT Programme, has been focused and clarified, with notable effect on the progress of the whole process.

In fact, the work items that are most advanced today in CEN TC 278 are those which received significant input from the ATT Programme.
3. KEY IMPACTS OF ATT APPLICATIONS

3.1 Introduction

This section of the document is dedicated to a summary of the key impacts as measured by the projects in the ATT Programme. New technologies do affect society and their impacts should be examined before decisions on their deployment can be made. The ATT Programme stressed the necessity of this issue and requested Pilot Projects to dedicate time and resources to evaluate and report the significant impacts.

Results are classified according to the same application areas used for technical achievements; consistently with [3], impacts in each area are divided according to:

- safety impacts
- impacts on transport efficiency
- impacts on environment
- user acceptance
- economic impacts

Not all projects have reported impacts in all categories and the measurement methodologies were not uniform. Economic impacts or cost-benefit analysis were very limited. The Task Force on Evaluation has provided a framework for achieving consistent results but the outcome was not clear in every case. Some key achievements are nevertheless clear:

- traffic information services and RDS-TMC in particular have shown a favourable impact
- integrated control management can provide positive solutions in urban and extra-urban areas
- bus priority systems have proven effective
- passenger information services were favourably accepted by users.

Impacts in application areas have already been presented in a complete report [3], in a series of cross-project collaborative studies (co-ordinated by CORD) and in an informative brochure [41]. In the following, reference is made to these synthesis documents, where needed.
3.2 Travel and Traffic Information (TTI)

3.2.1 Safety impacts of TTI applications

1) In-vehicle applications - RDS-TMC

According to the RDS-TMC cross-project study [42], the in-vehicle information system has a high potential to improve traffic safety. Field tests in Germany and the Netherlands found that one-third of drivers receiving RDS-TMC information reduced speed when approaching an announced incident area, before the congestion was visible.

Concerning the Human-Machine Interface (HMI), in-vehicle observations suggested that RDS-TMC messages do not disturb driving behaviour in general. “Glance analysis” found that of the “glances away” from the driving direction, 25% were directed at the in-vehicle RDS-TMC equipment and more than 50% at the back mirrors.

Further, users reported that operating RDS-TMC took more attention than conventional radio, but listening to TMC messages was not more engaging than listening to conventional radio (Figure 3-1).

2) Other in-vehicle applications

In general, distraction from the driving task caused by in-vehicle route guidance varies with the complexity of displays, but is less than that caused by looking at traditional maps. Guided drivers unfamiliar with a network should generally benefit from reduced navigational load whereas route guidance for familiar drivers may occasionally result in some distraction.

In-vehicle observations carried out by HOPES Project in Stuttgart [43] found that the dual mode route guidance (DMRG) system tested increased dangerous lane changes from 6% to 32%, but reduced risky speeds from 33% to 14%. Based on a limited
number of traffic conflicts observed, this study further found that 2 out of 7 conflicts observed with the system switched on happened while drivers were looking at the display. In addition, too short distances to the vehicle ahead were registered significantly more often with the system switched on. The observers’ interpretation is that such too short distances were partly caused or enhanced by the fact that the drivers were interacting with the system.

The HOPES field trials further confirmed the HMI safety potential of DMRG systems [44]:

- mean glance duration to the in-vehicle display was 0.56 sec and to the map 0.89 sec;
- mean maximum glance duration to the display was 2.2 sec and to the map 4.12 sec.

### 3.2.2 TTI impacts on transport efficiency

1) *In-vehicle applications*

According to the RDS-TMC cross-project study report [42], RDS-TMC messages on congestion relevant to drivers in Munich, Kent Corridor and Rhine Corridor led to a change of route in 22% of trips on average. This suggests that RDS-TMC could have a corresponding potential impact on traffic management, by causing drivers to choose alternative routes.

Concerning information provided, the study confirmed a generally better supply of traffic information by RDS-TMC than by conventional traffic radio. In Northrhine-Westphalia, for instance, test drivers were informed in good time by RDS-TMC about 64% of relevant queues, compared to only 39% of relevant queues by conventional traffic radio broadcasts.

Field trials of RDS-TMC within the ACCEPT Project [45] determined an average time gain of about 20 min over the alternative route, and an average detour distance of 13 km.

A simulation study in Northrhine-Westphalia found that total travel time can be decreased by 3%-9% by using RDS-TMC services. Highest potential benefits are predicted under incident conditions.

QUARTET trials on DMRG system [46] found that:

- average travel time was reduced by 33%;
- in 51% of recorded trips drivers did not comply with the route recommendations;
- 96.6% of drivers following the recommended route had a shorter journey;
- 45% of those drivers saved time in their journey, and 38% saved distance as well.

RHAPIT trials [47] found that SOCRATES GSM-based information is able to reduce the proportion of traffic in the centre of cities looking for a free parking space, and in case of integration of P&R and PT information in the system it is supposed to contribute to improvements in the demand of P&R systems. Vehicles equipped with the parking guidance system achieved in 73% of all analysed test rides a distance benefit and in 55% a time benefit.
2) Roadside applications

Both on-street information terminals and VMS (Variable Message Signs) as information devices were tested. According to the field trials and surveys in this domain [48], pre-trip information (on-street information terminal) obtained by all kind of travellers influenced 53% of the users; 30% of them changed their departure time, and 50% used an alternative route.

CITIES field trials in Paris on VMS providing traffic information determined a diversion rate up to 4% [49]. The figure, apparently small, brought however considerable effects in the heavily congested situation.

According to questionnaire surveys within the BATT Project [50] about 72% of drivers declared to have been affected at the same time in their route choice by the VMS information. About 23% changed route regularly and 9% often. Further, about 30% declared doing this at messages of queue lengths up to 2 km, while 50 % declared doing this at messages of a minimum queue length of 2 km.

Investigations within the BATT Project found that on average, the detour distance was up to 2 km in 24% of the cases, 2-5 km in 43% of the cases and more than 5 km in 26% of the cases.

The P&R facility at Fröttmaning in North of Munich is supported by the Variable Message Signs installed on the Motorway A9 and advising drivers in changing travel mode. According to the results achieved within the LLAMD trials, this application has a considerable potential on mode shift in favour of public transport. A reduction of using private car by 1.7 million vehicle-km per year has been estimated for that site. Further, more than 26% of the parking facility users on workdays and 46% on days with special events would have used the car for the entire trip to the city centre (LLAMD survey [51]) before the implementation of this application.

3.2.3 TTI impacts on environment

1) Roadside applications

Very limited measurements were made on the issue but the first tests were encouraging. The QUARTET/APOLLON implementation in Athens 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% [46]. Pollution calculations and simulation modelling were carried out to predict the impacts. Actual measurements showed that pollution reduction in the controlled area was greater than the increase in pollution outside the controlled area.

According to LLAMD (Munich) and SCOPE (Cologne) Projects the main benefits of Parking Monitoring and Control for P&R facilities are expected to be a reduction in the secondary congestion, pollution and energy consumption associated with searching for parking spaces within the city.
3.2.4 User acceptance of TTI applications

1) In-vehicle applications - RDS-TMC

In Birmingham, Trieste-Brescia, Northrhine-Westphalia, Rhine Corridor and Kent Corridor, on average 70% of the questioned drivers were “satisfied” or even “very satisfied” with the RDS-TMC service (Figure 3-2), according to the RDS-TMC cross-project study [42]. In-depth investigations in Munich and Rhine Corridor showed that drivers considered RDS-TMC information “useful” or “very useful” in 82% of the trips made (Figure 3-3). The majority (92%) of test drivers in Northrhine-Westphalia and Rhine Corridor support full-scale RDS-TMC implementation in Europe (Figure 3-4).

![Figure 3-2: How satisfied are you with RDS-TMC services? (RDS-TMC cross-project study)](image)

![Figure 3-3: How useful is RDS-TMC information? (RDS-TMC cross-project study)](image)
Munich and Rhine Corridor trials found RDS-TMC services were used in about 70% of trips for pre-trip information, and in 85% of trips for on-trip information. Where they had the choice to switch it on or off, over half of test drivers switched on the information filter, which allows the driver to select only information relevant to his or her particular journey. About 77% of test drivers in Northrhine-Westphalia, Rhine Corridor and Munich considered the service “easy” or “very easy” to use.

Concerning the acceptable price for RDS-TMC equipment, users from Rhine Corridor, Trieste-Brescia, Birmingham, Kent Corridor and Munich were willing to pay on average 105 ECU more than the price of a standard radio for RDS-TMC features (Figure 3-5).
In terms of comprehensibility of RDS-TMC information, three quarters of test drivers surveyed at Rhine Corridor, Ile de France, North Pas de Calais and Munich considered the information provided was “comprehensive” and “understandable”. Generally, legibility of information displayed is poorer than the audibility of spoken messages, particularly at night or when driving against bright sunlight.

Regarding reliability of RDS-TMC information the majority of test drivers (between 54% and 77%) in Northrhine-Westphalia, Rhine Corridor, Ile de France, Trieste-Brescia and Birmingham considered the information provided was “reliable” or “accurate”.

Further, about 60% of test drivers from Northrhine-Westphalia, Kent Corridor, Trieste-Brescia and Birmingham confirmed that the RDS-TMC information was “timely” for their journey or driving decisions.

2) Other in-vehicle systems

According to the IVRG (in-vehicle route guidance) cross-project study [51], for over 90% of users saving of journey time is the most important requirement of an IVRG system. More than 60% also want IVRG in order to reduce the risk of getting lost.

Most test drivers (about 90%) found it “easy to learn” to operate IVRG equipment. Route recommendations were “easy to understand” for most (83%) test drivers at all test sites (Figure 3-6).
Figure 3-6 How easy were the route recommendations to understand? (IVRG cross-project study)

Compared to conventional direction signs and street maps, IVRG was, following the study report, generally

- more appreciated by drivers in urban areas, and
- less attractive to drivers on motorways.

The majority considered IVRG systems useful to prevent getting lost. Over all test sites, the majority (between 40%-90%) of drivers thought the IVRG system tested increased driving comfort and/or reduced stress.

According to the results from Munich, Rhine-Main area, Ile de France and Stuttgart, 55% of test drivers believed IVRG systems were useful to reduce travel time (Figure 3-7). 42% of test drivers in Rhine-Main area, Ile de France, Lyon and Stuttgart considered the recommended route better than their own choice (Figure 3-8).
Trials in Rhine-Main area, Lyon and Stuttgart found the use of IVRG systems had no influence on drivers’ choice of departure time. However, in Rhine-Main area and Stuttgart between 20% and 44% of drivers changed route following the recommendations of the IVRG system.

Where drivers did not comply with route recommendations, the main reasons quoted include lateness of the information, poor correspondence of the recommended route with the actual network (e.g. prohibited manoeuvres or blocked roads), and recommendations unclear or seen as not useful.

According to results from Rhine-Main area, Ile de France and Lyon, about 80% of drivers wanted to have an IVRG system. Investigations in Rhine-Main area, Lyon and Stuttgart provided evidence of an acceptable price and annual subscription fee for IVRG on-board equipment. The price most would be prepared to pay lies between 750 and 1500 ECU (Figure 3-9). Most subjects would pay between 180 and 350 ECU per year for a corresponding dynamic traffic information service (Figure 3-10). Note that German subjects would accept a higher purchase price and a lower annual subscription fee, while French drivers prefer a lower purchase price and a higher annual subscription fee.

Figure 3-8 How did the recommended route compare with your own route choice? (IVRG cross-project study)
3) Roadside applications

Large-scale CITIES surveys in Paris confirmed high user acceptance of VMS systems implemented there [50]:

- 97% of questioned drivers understood messages completely and 98% considered them easy or quite easy to understand;
- more than 80% of these drivers thought the messages totally or quite reliable. The messages were considered completely accurate by 24% and quite accurate by 49% of
the drivers. However, 14% of the drivers never noticed the messages, and 20% thought the messages not updated in real time;

- more than 90% of the drivers considered messages provided completely or quite useful;

- the majority of the drivers considered the messages being adapted to their needs (84%), allowing them to choose right route (79%), and increasing driving comfort (75%);

but also

- Some drivers are sceptical concerning safety improvement (40%).

### 3.2.5 Economic impacts of TTI applications

According to CITIES socio-economic evaluation results [49], the total estimated benefits of a VMS system providing traffic information may reach FF 550 million a year. Considering the investment cost of FF 680 million and annual operational cost of FF 50 million the system provides very high socio-economic benefits.

### 3.2.6 Conclusions and remarks

A great number of different TTI applications were demonstrated within the ATT Programme. These trials have determined an overall significant benefit of TTI and consequently confidence in market acceptance of the available technologies.

In particular, in-vehicle information/guidance systems have found a wide acceptance of potential users, whose willingness to pay for service is encouraging.

The results further showed positive impacts of both in-vehicle and roadside TTI applications on transport efficiency under different local conditions. The correlation between the penetration rate and the impacts on transport efficiency of the in-vehicle applications needs to be further determined, probably on the basis of simulation studies.

The current in-vehicle information/guidance applications have both positive and negative impacts on traffic safety. On one hand, incident warning functions may help to avoid secondary accidents (e.g. one-third of drivers receiving RDS-TMC information reduced speed when approaching an announced incident area, before the congestion is visible); on the other hand, operating or looking at the on-board display may distract drivers from the driving task, although it is much better than looking at a map. A well designed HMI is therefore a key issue in introducing safe in-vehicle information/guidance applications, and corresponding standards need to be further established and widely adopted.

The available results also give indications of potential environmental and economic benefits of TTI, which need to be further determined in future studies.
3.3 Traffic Management and Control (TMC)

3.3.1 Safety impacts of TMC applications

1) Urban Traffic Control (UTC)

Following VRU-TOO Project report [52], pedestrian detection technology integrated with signal control systems can potentially increase pedestrian safety. Field tests in UK, Greece and Portugal found that such technology reduced serious conflicts by up to 22%.

2) Incident management

In this area substantial progress was made. The use of Automatic Incident Detection (AID) systems would, according to HERMES Project [53], effectively contribute to reducing the time necessary to set warning signs and thus prevent secondary accidents. Measurements carried out in Germany showed that AID with multi-modal approach reduced average detection time considerably in comparison to the conventional system, and on average 145 drivers approaching the incident area were additionally warned in each detected incident case (due to the shorter detection time).

PORTICO/HOPES field trials of a light-pole Incident Warning System (IWS) in Portugal (on the two-lane road IP5) [54] found that the system reduced average vehicle speed by 3 km/h, and the number of overtaking manoeuvres, and thus harmonised traffic flow. The speed change measured represents an estimated decrease of accident rate by 10-15%.

According to QUARTET field trials carried out in Germany [46], systems integrating emergency call systems supported by GPS, digital road maps and GSM can reduce response time of emergency vehicles by 43%, and increase survival rate by 7-12%, and reduce long term severity of any injury incurred.

3) Variable Message Signs

MELYSSA field trials in Germany and France [55] found that Variable Message Signs (VMS) providing speed limit, incident and bad weather warning, etc. led to a 10% decrease in number of accidents for the global network. More encouraging results were determined for German motorways, with a reduction of total accidents by more than 30% and a reduction of accidents with people killed or injured by more than 40%. The most significant VMS safety impacts were observed for foggy days with over 85% less accidents.

These trials also confirmed the positive influence on drivers’ speeds provided by the VMS system: the percentage of vehicles exceeding the speed limit was reduced by more than 10%.

According to a CITIES safety study based on analysis of three years’ accident statistics [49], VMS providing traffic information in Paris had no negative effect on traffic safety.

According to the DETER field trials [56], speed enforcement systems with a feedback VMS (indicating the proportion of non-speeding vehicles) reduced by 50% the vehicles exceeding the speed limit by more than 20 km/h. Further, the measured reduction of 2.72 km/h in average speed on motorways due to the speed enforcement may lead to a 6-8% reduction in injury accidents and more than 10% reduction in the number of fatal accidents.
3.3.2 TMC impacts on transport efficiency

1) Urban Traffic Control

Improvements were essentially measured in urban areas. CITIES trials in Brussels [49] confirmed the following impacts of the PRODYN urban traffic management system:

- a 10% increase in mean journey speed,
- a 10% increase of traffic capacity in the zone equipped, but
- a 2% reduction in number of vehicle-hours within the UTC zone.

According to PRIMAVERA trials in Leeds [57] implementation of advanced UTC systems (SCOOT and SPOT) can lead to a 10% reduction in travel times for buses, when compared to the current state-of-the-art UTC systems, and without significant disruption to cars.

In Turin, the PRIMAVERA trials determined the following improvement based on the adoption of the UTC control strategy devised:

- a reduction of travel time in the network by 10% in the AM peak and 12% in the PM peak,
- a reduction of bus journey time by about 6%,
- a reduction of the number of stops on the arterial of the order by 30%.

VRU-TOO field trials in UK, Greece and Portugal [52] found that dedicated signal control systems supported by pedestrian detection technology reduced waiting time of pedestrians at traffic signals from a mean of 18.5 sec to 17 sec, and increased the proportion of pedestrians arriving at crossings on a green signal from 5% to 9%.

2) Inter-urban Traffic Control

According to EUROCOR trials in the Netherlands [58] ramp metering based on ALINEA strategies reduced by 19% the total delay of traffic on both motorway and on-ramps. The results of EUROCOR trials in Paris further suggested that 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. These trials confirmed that suitable utilisation of ramp metering strategies is capable of:

- reducing the extent of congestion on motorways, reducing total travel time including waiting time on the ramps,
- increasing the total amount of vehicles served by the motorway,
- optimising utilisation of motorway capacity.

Further, at both sites the total travel time was clearly decreased by 20% whereas mean speed and total travel distance increased by 20% and 7% respectively. The congestion area of the morning period diminishes in space and time. Override of control strategy decisions in case of excessive queue lengths avoids interference with surface street traffic.

3) Incident management
MELYSSA field trials in Lyon, France [55] determined an annual time saving of 5400 vehicle-hours on a motorway section of 3.9 km by an automatic incident detection system (AID) based on computer vision technology.

Following simulation studies carried out by the ARTIS project [59] and with the assumption of ideal traffic behaviour and driver responses, AID systems tested can considerably improve incident management, including:

- a decreased duration of recurrent congestion on motorways by 25% to 75%;
- a decrease of congestion caused by unexpected incidents by 5% to 30%;
- a travel time reduction between 20% and 40% in case of recurrent congestion, depending on hypothesis of drivers’ response;

### 3.3.3 TMC impacts on environment

Most of the results were obtained through simulation studies indicating the early stages of this type of assessment. On the basis of QUARTET simulation studies [46] 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 (as implemented in Athens) could lead to reductions in the controlled area of:

- 29% in kerbside CO ppm
- 30% in kerbside NOₓ ppm
- 26% in kerbside HC ppm.

In the two measured episodes, outside the controlled area pollutants increased by 13% and total network travel time increased by 2%.

The same QUARTET simulation studies showed that the system has positive environmental impacts, including a 6% reduction in both pollutant emissions and total fuel consumption.

### 3.3.4 User acceptance of TMC applications

DETER field trials [56] found that speed enforcement systems with a feedback VMS (indicating the proportion of non-speeding vehicles) are acceptable by the majority of drivers (see Figure 3-11).
Questionnaire surveys carried out by MELYSSA Project with 2666 interviews [55] confirmed a high user acceptance of VMS systems as shown in Figure 3-12 with percentage of positive answers amongst all answers. In particular, it was found that:

- foreigners noticed VMS better than French drivers;
- men generally perceived VMS better than women;
- pictograms increased the comprehension for foreign drivers; and
- generally users were very satisfied with the VMS systems tested.

3.3.5 Economic impacts of TMC applications

Incident Management

On the basis of MELYSSA field trials [55] cost and benefits were determined for one direction of a motorway section. The main benefits are expected from:

- reduction of the overall incident duration,
- reduction in the severity of the injuries (each minute gained would spare 1% of the personal safety costs).

MELYSSA produced a cost-benefit comparison between three different technologies for Automatic Incident Detection: detection based on video cameras, on loop detectors and on the combination of video cameras plus loop detectors. Table 3-1 shows the results which can be used as an element in decision making.
Table 3-1 - MELYSSA cost benefit analysis results

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Video AID</th>
<th>Loop plus CCTV AID</th>
<th>Loop AID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incident duration reduction [min]</td>
<td>15</td>
<td>10</td>
<td>5</td>
</tr>
<tr>
<td>Investment cost* [KECU]</td>
<td>121</td>
<td>75</td>
<td>42</td>
</tr>
<tr>
<td>Annual maintenance cost* [KECU]</td>
<td>6.1</td>
<td>8.0</td>
<td>6.4</td>
</tr>
<tr>
<td>Annual traffic benefit* [KECU]</td>
<td>89.5</td>
<td>62.5</td>
<td>32.7</td>
</tr>
<tr>
<td>Annual total benefit* [KECU]</td>
<td>123.8</td>
<td>70.1</td>
<td>36.5</td>
</tr>
<tr>
<td>Pay-off [year]</td>
<td>1.0</td>
<td>1.2</td>
<td>1.4</td>
</tr>
<tr>
<td>Cost** [KECU]</td>
<td>167.8</td>
<td>137.5</td>
<td>91.4</td>
</tr>
<tr>
<td>Benefit** [KECU]</td>
<td>951.7</td>
<td>539.3</td>
<td>280.6</td>
</tr>
<tr>
<td>Benefit/cost ratio**</td>
<td>5.7</td>
<td>3.9</td>
<td>3.4</td>
</tr>
</tbody>
</table>

* all costs/benefits are given for one km in one direction
** results determined for a period of 10 years and with a 6% discount rate

Avoiding secondary accidents through automatic fast warning procedures have not been taken into account here. If fast warning could however reduce the global safety cost by 5%, an additional 25 KECU/km/direction could be saved each year.

According to QUARTET trials [46] costs would equal benefits for implementing the emergency call system tested can be achieved with 1.33 million cars equipped for a scenario of minimum use of the system.

### 3.3.6 Conclusions and remarks

Several Traffic Management and Control (TMC) applications were tested within the ATT Programme, including different automatic incident detection systems, VMS for section and network control and intelligent traffic signal control systems.

As expected, the trials results indicate clear safety benefits of these applications, although these are based on a relatively short period of observation and vary with the applications tested and the specific local conditions. In particular, incident warning and speed control systems may lead to considerable reduction of accidents or dangerous manoeuvres on motorways. A longer-period observation is needed to determine statistically more confident results on safety benefits of these applications.

Further, on the basis of the results achieved, the implementation of these applications can have positive impacts on transport efficiency as well, in both urban and interurban areas. A considerable reduction of travel time may be expected as results of e.g. intelligent traffic signal control or ramp metering applications.
Concerning environmental impacts, there are only limited results available, which however indicate the potential of TMC applications in reducing environmental pollution of traffic.

Again there is a lack of results on economic impacts of TMC applications. MELYSSA project carried out an interesting study comparing the cost-benefit potential of different AID technologies, on the basis of a number of estimated values for different parameters, which may however vary from country to country and have direct influence on the final results.

### 3.4 Public Transport Information and Management (PTIM)

#### 3.4.1 Safety impacts of PTIM applications

Bus priority systems were tested in real operating conditions. The Public Transport Priority (PTP) cross-project study [62] synthesised safety impacts of PTP systems tested within the ATT Programme.

According to PROMPT studies in London [60], possible negative safety impacts of PTP systems were minimised by

- maintaining non-priority stages if demanded, even if that meant some delay in implementing priority,
- not including optional stages (for buses) and
- using maximum green extension timings.

PROMPT/Gothenburg studies found that rapid shifts in stage sequence, using optional stages to minimise PT delays could cause safety problems, particularly for vulnerable road users.

In Munich (LLAMD Project) PT operators reported fewer accidents involving tram vehicles following implementation of the PTP system, although statistically reliable results are not available [61].

#### 3.4.2 PTIM impacts on transport efficiency

The PTP cross-project study [62] determined significant delay savings for Public Transport (PT) vehicles at signalised junctions due to PT priority, averaging some 50% across all participating projects. These savings from active priority strategies are substantially greater than those available using passive priority (e.g. BUS TRANSYT) at traffic signals. These benefits, according to the PTP study, were generally achieved with negligible impact on delays to other traffic, within systems usually allowing user-selection of the level of priority provided.

Further, the PTP cross-project study also established a reduction in the variability in PT journey times and delays (e.g. up to 29 % in London and Toulouse), leading for example to an improved regularity of PT services (e.g. a reduced deviation between actual and nominal headways) of 11 % in Turin.

The Public Transport Passenger Information (PTPI) cross-project study [48] estimated that improved quality of bus stop information systems can attract an extra 5-10% of
passengers to use the bus. However, where the information system indicated delays of 15 minutes and over, 10-26% of users were found to leave the bus stop, taking the opportunity to go to a nearby metro station.

The study further found that of 53% of users who would make use of the information supplied, half said they would change route, and 30% would shift their time of travel. Network impacts proved almost impossible to assess: 97% said they would not change mode, although 16% said they were likely to make more public transport trips.

Field trials of a public transport information system (STOPWATCH) within BATT and ROMANSE Projects found that:-

- use of the bus is increased by 5%;
- there is a large number (from 6.8% to 23.9%) of first time users of the bus route;
- there is also a significant number (18%) of people who use the bus when they have a car available as a driver or as a passenger;
- the perceived quality of the bus services is improved, particularly in terms of its reliability although there are still concerns over the accuracy of the information given;
- levels of satisfaction with the bus service from frequent bus users is high and has increased over the survey period;
- STOPWATCH has allowed a greater flexibility in the travel patterns of bus users, particularly in the way in which they can switch to another route or destination, walk all the way or go to a shop and come back to the stop;
- the impact of STOPWATCH varies between the different socio-economic groups with the young and those in employment being the most positive in their response. Age and employment status are the two most important variables used in the disaggregation.

LLAMD trials in Munich on P&R information [61] confirmed the impacts of this application on mode choice, i.e. shifting of private car to public transport:

- About 26% of P&R users in Fröttmaning on a workday and 46% on days with special events used the car for the whole trip before the implementation of this application.
- Although some P&R users there used only public transport for the whole trip before the system implementation, the P&R information service could reduce traffic by 1.7 million vehicle-kilometres per year.

QUARTET trials [46] found that there is no evidence to suggest that at-stop real-time information display tested led to an increase in bus patronage either as a result of people using the route for the first time or as a result of increased use by regular users. Further, there is evidence to suggest that enhanced public transport information provided by portable terminals could promote a modal shift in favour of public transport. However, 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.

Automated Demand Responsive Systems were evaluated in the PHOEBUS Project (in low density areas) resulting significantly more accurate and comfortable in comparison to the manual handling of customers’ requests.
3.4.3 PTIM impacts on environment

Most trials within the PTP Cross-project study [62] found evidence for reduced fuel consumption, due to fewer vehicle stops. These translate into lower vehicle operating costs and reduced environmental impact. Simulation results from the Gothenburg studies indicate 4%-6% savings in fuel consumption and emissions.

According to LLAMD trials in Munich P&R the information system at one P&R facility could have the following environmental impacts due to changed mode shift and therefore reduction of total traffic:

- reduction of CO-emission: 10 t/year
- reduction of NOx emission: 0.3 t/year
- reduction of HC-emission: 1 t/year.

3.4.4 User acceptance of PTIM applications

A survey with 100 interviews within the QUARTET Project [46] found that most respondents thought public access and in-street terminals easy to use and would use them again; some 16% of respondents thought that using the system 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.

According to QUARTET trials the introduction of at-stop real-time information displays enabled travellers to make better use of their time while waiting for the arrival of the bus, particularly at places where bus frequencies are much lower. Such real-time displays do promote a ‘feel-good’ factor among bus users.

The majority of respondents who took part in a joint QUARTET/PROMISE survey would be prepared to pay for an information service provided by portable terminals, with the best market potential for the information package being a software application for use on a home computer which would also incorporate flight and long distance travel information, information on local events and town plans.

A further QUARTET study suggest that most of 100 interviewed passengers found the information provided at travel enquiry offices to be either adequate or very adequate (92%) and also either accurate or very accurate (76%). Of the 72% of respondents who had used the Enquiry Office prior to system installation, 38% had noticed an improvement in the quality of information.

According to the PTPI Cross-project study [48], 57-90% of users expressed support for bus stop information displays; but users quickly lost confidence where these were unreliable. In London, 89% of users questioned felt that waiting at the bus stop was now more acceptable.

Further, between 18% and 64% of passengers thought waiting time had reduced, even when in fact it was unchanged or had worsened! In London, although 82% of users perceived the displayed information as accurate, only 28% of users would rely on the information in their travel decisions.
From the same study, between 66% and 90% of users questioned had noticed the bus stop displays. In one trial where both technologies were tested, users preferred (powered) LED displays to (passive) LCD displays.

Concerning interactive trip planning terminals, the PTPI Cross-project study found that between 25% and 92% of users wanted more terminals to be installed; more car users than public transport users favoured expansion. There was strongest support for terminals to be located at travel transfer points (stations, etc.). Further, between 61% and 80% of users found the terminals “very easy” to use.

According to LLAMD trials on the Euro-Scout system [61] more than 80% of test drivers quoted that public transport information provided is very helpful, and 45% of these drivers rated the conventional direction signs as a more difficult information source for reaching the desired destination in comparison to Euro-Scout.

LLAMD trials in London found that
- passengers are willing to pay £ 0.26 per trip (53% of average fare) for PT or P&R information;
- PT vehicle arrival time was provided with an accuracy within 1 min in 55%, within 2 min in 80% and within 5 min in 100% of cases; stress and anxiety of passengers were substantially reduced;
- passengers perceive that waiting time was reduced and PT reliability improved.

LLAMD trials in Lyon found that the high rate of regular passengers, high number of riders entering at termini and numerous overlapping lines on long distances limited the interest in an information system at stops. PHOEBUS trials in Belgium found, in one year experiment with a Demand Responsive System, that customers were positive towards the service because of its punctuality and ease of reservation.

### 3.4.5 Economic impacts of PTIM applications

The majority of respondents who took part in a joint QUARTET/PROMISE survey would be prepared to pay for an information service provided by portable terminals, with the best market potential for the information package being a software application for use on a home computer which would also incorporate flight and long distance travel information, information on local events and town plans.

According to a socio-economic evaluation study carried out by PROMPT project [60], the implementation of bus priority within existing UTC costs 200 kECU for 10 junctions in London, and brings annual economic benefits (due to savings in bus delay, operating cost, etc.) of 145 kECU. That means a first year return of 72%.

Following a further PROMPT study, the costs of new UTC with tram priority would be 850 kECU for a 5 km tram route in Turin, which produces substantial annual benefits of 3200 kECU through travel time savings for tram users (43%), regularity savings (1%) and travel time savings for general traffic (56%).

The PTP Cross-project study found that the delay savings combined with vehicle operating cost savings and other secondary benefits translate typically into an economic “pay back period” for PT priority of 3-16 months. In favourable cases, the PT journey time improvement would allow a reduction in the operating fleet to provide a given level...
of service. In Munich, this financial saving would give a pay back period of around 5 years.

According to LLAMD field trials in Munich [62] the P&R information for one P&R facility can lead to the following benefits:

- Reduction of vehicle operating costs: 82 kECU/year
- Additional revenues for the public transport operator: 77 kECU/year

A comparison between the costs (annual depreciation rate over a period of 10 years and running costs) of about 80 KECU/year and the benefits leads to the result that the benefit-cost ratio is more than 1.

According to QUARTET trials [46] it is difficult to justify the high level of investment associated with at-stop real-time information systems without any increase in bus patronage.

3.4.6 Conclusions and remarks

Bus priority systems that can offer shorter journey times and better regularity have a double economic effect in 1) attracting more passengers and 2) enhancing the effectiveness of the operations. The technique has reached maturity and components are readily available.

Public Transport passenger information systems can potentially increase ridership by 5 to 10%, again with an available technology. Park and Ride can also increase the patronage of PT (while decreasing car traffic). Information at bus stops makes the use of PT more attractive but direct benefit to operators has been hard to prove: nevertheless it has been shown to stop the negative trend in transported passengers. The area of Public Transport as a whole has shown a substantial success, and many examples of good practice have been demonstrated in the pilot projects.

3.5 Freight and Fleet Management (FFM)

3.5.1 Safety impacts of FFM applications

1) Freight and fleet management

In FFM, safety impacts were not a direct concern, but were a logical consequence of better fleet management and use of data recorders and Mobile Data Communications (MDC). The calculations based on the results from the IFMS tests would for example for France mean a reduction of 3700 accidents where lorries are involved, 260 fewer fatalities and a benefit for society of 62 million ECU simply by the reduction in fatal accidents [63].

According to field trials in the Netherlands, a wide use of Mobile Data Communications (MDC), Global Positioning Systems (GPS) and/or Trip Recording equipment in Europe would potentially lead to an average reduction of about 150 fatal accidents per year due to travelled distance reduction [64].

2) Hazardous goods monitoring and control (HGMC)
HGMC applications may significantly reduce the time (from hours to 3-6 minutes) to detect an abnormal status of dangerous goods transport. That indicates a high potential for increased safety, in terms of reduction of emergency response time and in terms of reduction of accidents, accident consequences and environmental damage [25].

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

In summary, 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, accident consequences and environmental damage due to hazardous goods transport incidents.

3.5.2 FFM impacts on transport efficiency

Within IFMS trials pilot companies perceived improved efficiency and improved transport services, although the full benefits can only be determined over a longer period of time with the inclusion of more vehicles and customers [63]. The effects of the ATT systems on drivers’ and dispatchers’ working conditions were generally positive. On the basis of the average results from these trials FFM applications could reduce travel time by about 5%, dispatch time by more than 12%, and travelled distance by more than 6%. Further, as a result of EDI use, the data have become more reliable, and transport order cycle time was reduced.

The METAFORA trials established transport time savings, reduced work load of the employees, more communication comfort by using satellite communication equipment [64]. These trials also showed that through the building of a real shipper-operator partnership, it is possible to achieve a significant reduction of order-handling process time.

According to the MELYSSA trials implementation of MDC would reduce the wasted time (waiting time, pick-up time, delay time) by up to 37.5% and the number of delayed arrivals by 35% [55].

The COMBICOM trials [65] showed that the average waiting time for vehicles of the transport fleets was reduced by up to 20% by Intermodal Tracking and Tracing applications, whilst, for the combined mode, the pick-up and waiting time for switching from road to rail was reduced by hours.

3.5.3 FFM impacts on environment

The average IFMS trials results indicated that the lorry-km driven in 1992 on the Germany-Sweden-corridor could have been reduced by ca. 23 million kilometres by using ATT throughout the road freight transport sector [63], leading to a reduction of fuel consumption and thus of emissions.

As a result of FFM functions, METAFORam [64] 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/100 km).

As for HGMC, there is strong confidence of reduced environmental impacts in case of accidents due to much shorter response time.
3.5.4 User acceptance of FFM applications
The LLAMD surveys indicated that 50% of the respondent managers of freight & fleets considered that Transport Telematics for FFM could improve the service quality of their freight operations [61]. Also customers were satisfied with the applications tested due to improved information supply and customer flexibility.

From the opinion of both drivers and dispatchers, the FFM application reduces stress, enriches work and lets drivers feel more secure.

The success of the FFM application was also demonstrated by operators requests to equip more vehicles with MDC equipment.

3.5.5 Economic impacts of FFM applications
The cost-benefit analysis carried out by the IFMS project showed that the pay-back period for the mobile communication systems ranges from 2.3 to 3.2 years (the extreme minimum and maximum results excluded) [23]. The availability of cheaper standard products will further reduce the length of the pay-back periods.

All operators participating in the METAFORA project found new markets or re-discovered old ones, especially in countries with less developed communications infrastructure [64]. Additional return loads were estimated to give benefits from about 800 to 3000 ECU per vehicle per year. Overall, in the long run the operators felt that their competitive position would be improved and the customer service would get better.

According to the METAFORA analysis, the pay back periods for the participating operators would be between 4.1 and 8.4 years with the majority (three out of five pilots) under 5 years. The benefits from using MDC technologies depend on the initial investment cost and the number of equipped vehicles. There seemed to be a threshold of about 10 vehicles, above which the benefits were larger.

The COMBICOM cost-benefit-analysis [65] showed that Intermodal Tracking and Tracing applications would bring a profit increase for each transport action of 4.5 to 15 ECU for operators and 20 to 80 ECU for shippers/forwarder. On the basis of the simulation study carried out by the COMBICOM project the impact of the advance information available to Combined-Transport users was estimated at savings up to 20% of the pick up and delivery costs, or 10% of the overall combined transport price.

3.5.6 Conclusions and remarks
The trials carried out have determined the great potential of telematics for FFM in improving transport efficiency, increasing safety of hazardous goods transport and bringing considerable economic benefits to operators. On the basis of reduced travel distance due to better transport management, additional environmental and safety benefits are also likely. The applications have reasonably found a wide acceptance of freight and fleet managers and customers; on the basis of these trials a wider and timely implementation of telematics technologies for FFM is expected. On the other side, the size of the freight company appears to be relevant in the adoption of the technologies, with larger companies perceiving a real improvement in operations. Cheaper investment and communication costs would attract also the smaller firms.
3.6 Automatic Debiting and Demand Management (ADDM)

3.6.1 Safety impacts of ADDM applications
Available results on safety impacts of ADDM applications are very limited. According to the ADEPT project study at the Thessaloniki test site [66], the implementation of a multi-lane tolling system would have a potential in improving traffic safety equivalent to 70 KECU for the period 1995-2006.

3.6.2 ADDM impacts on transport efficiency
Several trials on automatic toll collection applications indicate a great potential of these applications in improving transport efficiency. According to the analysis of ADEPT project, the passing time at manual gates will increase in the next 10 years to 156 seconds due to increase in traffic volumes. An electronic multilane tolling system would reduce and make constant (i.e. independently of traffic volumes) the average passing time for equipped cars. In the multilane tolling system, including a monolane enforcement system, installed at the Thessaloniki site [67], the average passing time in 2006 would be 45 sec instead of the actual 156 sec (with manual toll), notwithstanding the estimated increase in traffic.

According to a study carried out by the ADS project (Florence field trial), automatic multilane tolling would bring an average time saving of over 40h/year for a motorway commuter [68](due to reduced passing time at toll gate).

Based on results of interviews with bus/truck drivers carried out by the MIRO project in Thessaloniki, the majority of the drivers believe that use of electronic toll collection reduces considerably delays (about 94%) and queues (90%) [71].

MIRO surveys performed in Barcelona on the basis of the “car following” technique determined an average 18% reduction of travel time inside the special events zone, with electronic access control.

Payment for parking was an application 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 to exit the car park by motorists with smart cards was significantly reduced.

3.6.3 ADDM impacts on environment
ADDM applications should have high environmental benefits according to several trials carried out. The multi-lane tolling with a mono-lane enforcement system in Thessaloniki, for instance, would reduce 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 [66].

Within the GAUDI trials [69] pollution monitoring data from Bologna showed a 50% reduction of emissions in the central area due to the Access Control application. Similar results were also gained in Barcelona. Model estimates had predicted a 50% reduction of emissions inside the controlled zone.
3.6.4 User acceptance of ADDM applications

1) Operator acceptance

Based on questionnaire surveys in five trials, the SMARTIE Cross-project Study [70] found that operators have a good understanding of the technology that is or will be available. Most operators would be looking seriously at adopting ITS, including smart card services, before the end of the century.

The operators interviewed were clearly reluctant to implement systems on a large scale until certain barriers were overcome. The need for standards and political considerations together with cost are the main obstacles perceived for the introduction of Automatic Debiting Systems.

Despite - and perhaps because of - their experiences, several operators were unclear about the benefits of introducing smart card technologies and systems. They were in general least sure about the commercial benefits for their own company, and most confident of the benefits linked to winning new customers and gaining new information about their customers’ preferences. Clearly operators want more information: clear data concerning benefits, and guidelines for implementation.

2) End user acceptance

Smart Cards

GAUDI trials in Dublin and Marseilles of multi-service smart cards [69] found that nearly half of holders actually used more than one service. In both trials, 85% of users thought that the system was “better than cash”, while between 66% and 89% found the system “easy to use”.

GAUDI trials of a position-related fare collection system in Bologna confirmed a high user acceptance. Almost 66% of users stated they did not have any problems in using the smart card and an additional 17% reported minor difficulties. Further, 75% of the users were in favour of an extension to a multi-service operation.

Over two thirds of users reported a perfect understanding of the zone-based fare structure, while less than 5% found it unclear. Over 90% of travellers did not have any problems in the identification of the destination zone and a similar percentage did not find it hard to key it in the ticket validator. In descending order of importance, most of those who anticipated problems in keying it in blamed it on the validation time, the size of the keys, the identification of zones, and the fact that vehicles were crowded.

As to the introduction of the smart card as a way to promote public transport use, there is a balance between for (46%), against (33%) and don’t know (21%). Finally, over 90% of users gave high marks to the look of the card.

On the reliability of tele-validation equipment in Marseilles, operational data indicated an overall 97% reliability. From the MIRO surveys [28] 62% of the respondents were very satisfied. From transaction data, smart cards appeared more durable and reliable and thus more acceptable to users than magnetic cards.

Road Pricing

According to questionnaire surveys carried out by the MIRO project in eight European cities, this application found in general a low acceptance by the citizens. In Trondheim, for instance, more than half of questioned drivers felt that the toll ring is unjust, and a
quite a large proportion thought that it was neither just nor unjust [71]. The results further show an increased feeling of unjustness with increased use, and with increased car ownership in the household. The other interesting result is that more people from outside the restricted area (61%) felt negative than those from inside (42%).

Access Control

According to MIRO surveys [71], Zone Access Control measures in Barcelona have been well accepted by the zone residents, obtaining from them a 6.1 score on a 1 to 9 scale. Further, regular vehicle users and traders, who are more directly affected by the measures, do approve the implementation, giving a 5.2 and 6.3 score respectively. Visitors, to whom the access restriction is addressed, gave a 4.6 score on a 1 to 9 scale, with the major part of them giving to the system a score equal to or higher than 5.

These measures further have reduced the number of visitors’ travel by car, increased trips by walking and public transport, and no influence on trips by motorcycle and bicycle. 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.

Park & Ride

According to the trials results [61], the P&R facility at Fröttmaning in North of Munich, supported by the Variable Message Signs installed on the Motorway A9, is well accepted by the car drivers and other users. This application has a considerable potential on mode shift in favour of public transport. A reduction of using private car by 1.6 million km/year has been determined for that site. Further, more than 26% of the parking facility users on weekdays and 46% of the users on special event days would have otherwise used the car for the entire trip to the city centre.

In Dublin, high user satisfaction with a multi-service smart card based payment system was reported by both the motorists and the parking operator [69]. Waiting time for parking exit was significantly reduced.

3.6.5 Economic impacts of ADDM applications

Toll Collection

The socio-economic analysis carried out by ADEPT project found that the multi-lane tolling gantry with mono-lane enforcement in Thessaloniki would bring net benefits of 1.15 MECU to the operator for the period 1995-2006 [66]. With a total costs amounting to 0.64 MECU, the pay back period for the operator would be of 6 years with an internal rate of return of 33% over the whole 12-year period. The application would also bring high benefits to drivers, due to the reduced vehicle operating costs and saving in travel time, with a benefit-cost ratio of 8.3 and an internal rate of return of 47% for the period until 2006.

Access Control

It was estimated that the pay-back period for Access Control systems tested in Bologna should be between 2 and 5 years depending on the actual violation rate; the corresponding figure for the Barcelona zone access control application was 4 years.

Road Pricing
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.

3.6.6 Conclusions and remarks

On the basis of the trials carried out, the primary benefits of ADDM applications are expected in improving living conditions in urban areas, due to reduced congestion, less environmental pollution, etc., and in increasing transport efficiency on motorways through reduction of waiting time at toll gates.

Concerning economic aspects, toll motorway operators may expect a pay back period of six years, and toll motorway users may experience a high benefit-cost ratio (8.3), according to ADEPT trials. Further, for system operators, road pricing and access control are in general economically beneficial as a result increased revenue. Also public transport operators will benefit from these applications due to enlarged patronage.

The results on user acceptance vary with different applications and user groups:

- system operators were reluctant to implement smart card based payment system on a large scale until certain barriers (e.g. standards, political considerations and cost) were overcome, while users are supportive to these applications, particularly multi-service payment based on smart card, due to more comfort during travel;
- Access Control applications have generally found more support by inside residents than by outside visitors;
- road pricing applications have found in general low acceptance by the citizens.

3.7 Driver assistance and co-operative driving (DACD)

3.7.1 Safety impacts of DACD applications

The trials have confirmed a significant potential of DACD applications in increasing safety. The applications will also require necessary modifications in driving habits and in manufacturing of cars. Most of the experiments were performed in closely controlled environments and often in simulated conditions.

1) Driver safety

The tests carried out in different projects have demonstrated significant gains achieved by collision avoidance applications in terms of improving driver behaviour, e.g. in speed choosing and distance keeping, and providing support in critical situations. Further, a potential increase in driver comfort and safety is possible with properly designed HMI.
For some applications, e.g. the driver impairment monitor, the safety benefits are potentially substantial but still need to be demonstrated.

The Collision Avoidance Cross-project Study [72] found that collision avoidance systems in advisory or warning mode led to an average increase of time-headway between vehicles of about 15%; this should correspond to a lesser risk of collisions. Moreover, comparing 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 (Collision Warning), whereas the smallest was observed for AICC (Autonomous Intelligent Cruise Control, with automatic speed and distance control functions). Where the ATT system is related to a safety-critical situation, as with the collision warning device, the wide range of reaction times found indicates such devices need to be set to match individual driver requirements: uniform settings would be at best unhelpful, at worst dangerous.

Because an AICC system intervenes automatically, its shorter time-headway 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. From TESCO results, the average time-headway under ICC (Intelligent Cruise Control, usually with advisory and warning functions and in some cases also with automatic intervention functions) was comparable to that of non-equipped vehicles or showed an increase from 5 to 10%. The same Project 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 [73].

EDDIT trials indicated that in terms of safety of driving, the greatest improvements would arise from use of vision enhancement systems for driving in darkness. With the aid of training in the use of the system, reversing aids would make a modest contribution to safety, particularly in reducing the likelihood of reversing into a person [76].

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 system resulted in an enhancement of disabled driver safety [74].

The SAMOVAR project has indicated how 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 determined 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 [75].

In conclusion, 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 prediction tools requires further attention.

2) Human-Machine Interface aspects

According to Collision Avoidance Cross-project Study questionnaire surveys [72], 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.

Driving simulator tests have shown that the use of a SAFE/NOT SAFE indicator assisting the drivers in performing turns at intersections effectively help elderly drivers, especially during night-time or under poor visibility conditions.

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.

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).

3.7.2 DACD impacts on transport efficiency

Within TESCO experiments an improvement in platoon stability was observed. Vehicles in the platoon have a more homogeneous behaviour with consequently more efficient use of the road [73].

3.7.3 User acceptance of DACD applications

DACD applications have generally found a higher level of acceptance from disabled people in general and elderly drivers. EDDIT trials found a high degree of willingness to use and purchase ATT systems. The average amount elderly drivers would be willing to pay for emergency alert system was between £260 and £270 [76].

The EMMIS tests on a driver simulator found that 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.

3.7.4 Economic impacts of DACD applications

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 (TELAID) 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 [77].

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.

If driver monitoring systems 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.

3.7.5 Conclusions and remarks

The trials carried out have confirmed high safety benefits of DACD to drivers. Collision Avoidance systems with automatic intervention are able to avoid any collision theoretically.

Further, AICC with automatic distance keeping has great potential to increase motorway capacity due to reduced safe headway between vehicles following each other (driving in platoon).

These trials have shown that DACD applications found high acceptance by drivers. In particular, elderly and disabled drivers are willing to use and purchase DACD systems. Concerning HMI, more drivers prefer tactical warning than visual or acoustic warning for CW, ICC and AICC.

3.8 General remarks on impact assessment

Innovation is bringing changes and changes have to be assessed. The assessment of the Projects’ results is an important part of the Programme.

Some issues led to difficulties in achieving fully the hoped-for evaluation results across the Programme:

- In particular, assessment of user acceptance and of impacts were relatively well addressed, if on a limited scale;
- On the contrary, assessment of system costs was generally missing, and assessment of safety impacts and impacts on the environment were limited;
- The reported impacts vary in quantity and dimension. Safety was not considered a focal point [78] partly for the good reason that safety is difficult to measure over a short period.

This confirms that Projects were mainly focused on system performance.

Despite the problems encountered, the assessment activities produced many useful results. Some key points are:

- The assessment in ATT projects of a wide range of transport Telematics applications and trial sites has produced substantial experience in ATT performance and impacts;
• Concertation activities undoubtedly improved the quality of individual project assessment, and created an “evaluation community” where experiences were exchanged and a common approach found;

Projects were willing to collaborate in Programme-level assessment activities that achieved some important syntheses of results, as reported in this document.
4. CONCLUSIONS AND RECOMMENDATIONS

4.1 The ATT Programme on the road to implementation

The ATT Programme has been extensive, testing equipment, software, technologies and applications in different stages of evolution. Projects have brought many important applications of Transport Telematics closer to real market exploitation. As an R&D Programme, it was not intended to solve many of the problems connected with implementation: commitment of financial resources for investment, assumption of risk by leading actors, adaptation of the regulatory framework to new relationships [79]. However, the ATT Programme has brought Transport Telematics to the level of the Trans-European Network for Transport: the first example of a European initiative where transport telematics is one of the unifying elements.

Conclusions and Recommendations concerning the key achievements and assessment results of the ATT Programme have already been provided in the Reports indicated in [1], [2] and [3]. This section indicates some general conclusions on the benefits these achievements have brought to the main actors. Industry, Public Authorities, Operators, Users all were actively engaged in the ATT Projects and, recalling Figure 1-1, what has been the return on their activities?

Industry

The developments of a substantial number of European standards is opening a European market for industry products. Industrial partners in Projects brought a tangible contribution to product definition and enhancement. Traffic and Travel Information has taken the lead in market penetration with RDS-TMC and navigation devices being on the verge of commercial introduction. Communications technologies as GSM or DSRC proved to be efficiently used within ATT, with GSM profiting from the wide installed infrastructure base. Also, advancements in Traffic Management and Control, Public Transport Information and Management, Automatic Debiting and Demand Management, Freight and Fleet Management have opened wide opportunities for new products or enhancements of existing products. Detection and monitoring devices were improved, software, standards for geographic data bases, data exchange protocols, smart cards, localisation equipment were developed. Results in Driver Assistance and Co-operative Driving have given firm ground on which to build a whole new set of devices. The testing of the Transport Telematics applications has shown a high degree of acceptance, even within the limitations of an R&D Programme. Though market definition was not an objective of the Programme, many technologies have shown enough maturity to face market conditions.

Public Authorities

The high number of cities participating in the Programme is a clear indication of where the problems are. If cost-benefit analyses were less common, the impacts of the applications, in terms both of traffic condition improvements and of user acceptance, were measured throughout. Public Authorities now have range of products which have shown their positive societal impacts. Projects active in Public Transport have demonstrated that the negative trend in passenger patronage can be reversed. Developed standards will make the realisation of wider and cheaper systems. Automatic Debiting
and Demand Management, though in some cases a controversial issue, are now tools at the disposal of Public Authorities.

Projects have also been a proving ground for collaboration with the private sector (Public Authorities and private companies were partners in many projects). Projects have underlined how Public Authorities should use their regulatory authority for implementation (this is especially true for Driver Assistance and Co-operative Driving).

**Operators**

Projects laid a great deal of attention on system performance. The measure of the efficiency of Transport Telematics applications was then one of the more successful areas: Traffic Management and Control measured the efficiency of urban control systems, variable message signs, automatic incident detection, emergency services to name a few. Public Transport Information and Management showed the effectiveness of bus priority systems. Automatic Debiting and Demand Management demonstrated the improvements in traffic flow obtained from free-flow toll collection systems, and in traffic congestion from access control. Freight and fleet operators can gain substantial savings by the use of mobile data communications and resources data bases. Public Transport operators now have standards for communication with passengers and inside their own organisations. Projects have shown that information is now the essential link between the operator and its customers.

**Users**

Samples of users were involved in many projects and their reactions measured. The general feeling is that Transport Telematics applications are favourably accepted by drivers. Transport Telematics is part of the general trend towards the Information Society and drivers and passengers need information before and throughout a journey. Users even accept restrictions or controls, such access control or variable speed limits, once understood that they are to their benefit. The ATT Programme has shown that the “service” concept is at the base of user acceptance of application: the user is the customer of a service and is willing to pay for it if he can perceive a benefit through its use. Indications were scarce on willingness or how much to pay, but there were no strong objections to payment of services. The saving of time, the elimination of incertitude on traffic conditions, an increased sense of safety were directly appreciated as strong benefits coming from Transport Telematics. In general, information services received more attention, again as an indication of their market-ready state.

### 4.2 Lessons learned

In the path towards Innovation the Fourth Framework programme is making a further step towards commercial introduction of Transport Telematics applications through large demonstration projects, for example for RDS-TMC. As experience has shown, the clearly focused definition of problems and the creation of Task Forces dedicated to finding solutions has been the most effective approach in the Third Framework Programme. The experience gained in the organisation, management and co-ordination of the ATT Programme Task Forces should not be lost.

The first task of programme co-ordination should be a careful analysis of the needs for concerted action across projects. This will determine the need for cross-project arrangements (e.g. task forces, common work packages, collaborative studies) in order
to produce a specific output, such as a pre-standard, a common specification, a set of guidelines, a cost-benefit analysis.

Arrangements for programme management and co-ordination must be flexible - in timing, resources and ability to respond quickly. In the ATT Programme, the needs for concertation activities such as task forces for evaluation, data exchange, automatic incident detection, and system architecture were not always clear from the outset, and action was taken one or two years after the programme start. In any R&D programme, it must be possible to plan, start up and complete specific actions quickly and at the time when they are most needed.

Clear indications to the projects on coherence of results and on the assessment of their results should be given at the very outset.

Four main points emerge:

a) Guidelines: these were outcomes of Task Forces, Projects, Collaborative Studies and constitute firm points on which to build further consensus: the implementation of guidelines has to be supported and their adaptation made as soon as new requirements emerge.

b) Assessment: a high quality of assessment procedures is required to ascertain the value of Transport Telematics applications as implemented in the “real world”.

c) Standardisation: consensus at R&D level and input from an R&D Programme to CEN is vital for the rapid making of standards.

d) Objective setting: Programme achievements should be identified at the outset of the Programme and should be monitored throughout.

Sharing of data and infrastructure among different applications should be maximised: this will lead to cost reductions, improved efficiency and more benefits to the user. Numerous successful Public-Private partnerships have shown that the combination of regulatory power and managerial skills is beneficial to the world of ITS. The areas of safety and Human-Machine Interface will have a significant role in determining the market acceptance of all applications: there is still more work to be done.

The important fact is to stress and build upon the results which will favour innovation, as a positive change in the domain of transport. In this case, achievements, properly assessed and evaluated, can be the base for successful commercial introduction.
NOTES and REFERENCES


   “Area 3 - Integrated Urban Traffic Management”, A. Lauer, M. MacDonald
   “Area 5 Report Driver Assistance and Co-operative Driving”
   “Achievements of Area 6”
   “Area 7 Public Transport Management and Information”, B. Finn, K. Holmes


[4] To RDS-TMC the EC has dedicated a specific brochure disseminating knowledge and results: “RDS-TMC Developments and Challenges”, EC-DG XIII


[6] An overview of the achievements in urban areas is given by the EC brochure “Transport Telematics in Cities”, EC-DG XIII; the brochure presents also an overview of the User Fora.


[8] The AREA 4 Report lists 15 traffic models (for forecasting, simulation and control) together with a contact person.


   id. “Proposals for the standards for the implementation of information systems on Public Transport services” - CORD Deliverable AC 11 Part 2
[19] Ger van der Peet, Robert Libbrecht, “Proposals for standard communication messages to be used in passenger information systems”, Final COMINPUT report
[22] “VESCOS Task Force” Final report April 1995
[28] Application-dependent architectures are in:
“Interfaces between the IRTE areas” CORD Deliverable AC13 - Part 8, January 1995.

[29] A synthesis of the results is contained in “An Overview of Programme-Level Achievements on System Architecture” J.F. Gaillet, CORD Deliverable D007, July 95. The SATIN Task Force is continuing to operate in the 4th FP.

As part of the architectural efforts an important outcome has been a list of TT functions together with their definition:


[30] The set of the DATEX documents is included in CORD Deliverable AC12, December 1994:

Part 5.2 “Trafi/Travel Dictionary”
Part 2.1 “TRAVIN (Travel & Traffic Situation Information Message)”
Part 3.2 “TRAREQ (Travel & Traffic Information Request Message)”
Part 4.2 “TRAVAK (Travel & Traffic Information Acknowledgement Message)”
Part 6.1 “TRALOC (Travel & Traffic Location Definition Message)”
Part 7.1 “TRADES (Travel & Traffic Description Definition Message)”
Part 8.0 “TRAILS (Travel & Traffic Route Guidance and Planning Message)”
Part 9.0 “TRADIN (Travel & Traffic Means of Transport Reporting Messages)”
Part 10.0 “TRAUNS (Travel & Traffic Information on Timetables (schedules) Message)”

An overview is contained in “Overview of Achievements in the Domain of Interoperable Road TTI Exchange”, G. Trenta, A. Sala, CORD Deliverable AC21 Part 1, April 1996

[31] The latest version of DATEX-Net was released in December 1996, as CORDEX Deliverable AC23:

Part 2 “DATEX-Net Specifications for Interoperability”, Version 1.1
Part 2.1 “Annex 1: Conceptual Data Model”
Part 2.2 “Annex 2: DATEX EDIFACT Messages”
Part 3 “Traffic/Travel Data Dictionary”, Version 3.0


[34] Evaluation Guidelines:


“Guidelines for Assessment of Transport Telematics Applications in Driver Assistance & Co-operative Driving”, Morello, E., CORD Deliverable AC07-Volume 2, Brussels, June 1994


“Guidelines for Assessment of Transport Telematics Applications in Demand Management & Automatic Debiting”, Vierth, I., CORD Deliverable AC07-Volume 1, Brussels, July 1994


[39] The latest version of the framework is in:


[41] “Telematics Applications at Your Service: Benefits and Market Acceptance of Transport Telematics in Road Transport”, EC-DG XIII


[58] “Experiment Results and Comparative Analysis”, EUROCOR Deliverable D11A, June 1995


[69] “Position-Related Fare Collection Field Trials”, GAUDI Deliverable D11, November 1995
[71] “Report on City-Specific Survey Results”, MIRO Deliverable D06.2, June 1995
“Final Report”, TESCO, March 1995
[75] “The Use of Accident Data Recorders and Journey Data Recorders for the Study of Accident Rates”, SAMOVAR, Deliverable D6, May 1995
“Draft Regulations for Aids for DSN”, TELAID Deliverable 8, January 1994
[78] The Guidelines for Assessment include also Guidelines for Safety in the application areas, collecting the experiences of the Projects that considered the issues.
[79] A major issue in implementation is the co-operation between the public and the private sectors; the EC has published a brochure based on a TT Forum that identifies the conditions for successful partnership: “Public Private Collaboration in Travel and Traffic Information”, EC-DG XIII