



NETWORK & TRAFFIC MANAGEMENT



Final AREA REPORT

Project Identification

CODE is a support action responsible for supporting the concertation activities, undertaking outreach activities and co-ordinating the reporting of the key results and achievements within the Transport Sector of the Telematics Applications Programme.

The Consortium is composed of 6 Partners and 6 Subcontractors :

Partners

Name	Role in the project
Atkins Wooton Jeffreys	<i>Project management UTTF/IUTTF organisation Road telematics reporting Vehicle control reporting</i>
CERTU	<i>Technical Co-ordination Traveller Information reporting Public Transport Operation reporting Traveller Intermodality reporting</i>
Keller & Friedrich Verkehrsforschung und Beratung	<i>CARTS preparation</i>
Heusch-Boesefeldt GmbH	<i>Driver Information reporting</i>
Eratosthenes Ltd	<i>Network and Traffic management rep.</i>
Barcelona Tecnologia S.A	<i>Demand management reporting</i>

Subcontracting reporters

Name of expert	Company	Area of reporting
Rodolfo PIEDRA	<i>Personal consultant</i>	<i>AIR Transport</i>
Robert TREMLETT.	<i>Personal consultant.</i>	<i>WATERBORNE Transport</i>
Carlo PENTIMALLI	<i>Lab. Fond. G. Marconi</i>	<i>RAIL Transport</i>
Michael FAIRBANKS	<i>Personal consultant</i>	<i>GNSS</i>
Christian RIESENBERGER	<i>PTV Consult GmbH</i>	<i>Freight intermodality</i>
Robert LIBBRECHT	<i>Personal consultant</i>	<i>Fare collection & Integrated payment Automatic debiting & Tolling</i>



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Authors(s)	Christopher Veinoglou	ERATOSTHENES

Written and edited by the Area reporter :

Christopher Veinoglou
ERATOSTHENES
43 Kallidromiou Str.
GR10681 Athens
Greece
Tel : +301-381-7315 (383-3588)
Fax : +301-380-6245
E-Mail : chvei@eranet.gr

Reviewed by the Area Officer :

DG INFSO - B5
200 rue de la loi - BU 29 2/27
B - 1049 Bruxelles
Tel : +32.2.296.35.42
Fax : +32.2.296.95.48
E-Mail

Issued on behalf of the CODE Project by:

Anna SUNTER
Atkins Wootton Jeffreys
Auchinleck House
Five Ways
UK - Birmingham B15 1DJ
Tel: +44 121 643 9621
Fax: +44 121 643 9688
E-mail: asunter@wsatkins.co.uk



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1. EXECUTIVE SUMMARY

1.1 SCOPE

The area of Network and Traffic Management

The area of Network and Traffic Management is one of the sub-areas of the Road mode. The area mainly addresses the items “services to transport infrastructure owners” (management and control), “services to travelers” (information) and “other services” (emergency services). The content of the area relates to the line of “Telematics for Network Management, Control and Operations” of the TAP work programme of the 4th FP, as well as the line of “Validation of Integrated Telematics Infrastructure and Related Services on Test Sites”.

Users/services

The main problems related to traffic are congestion, incidents, and road closure due to road-works or adverse weather. During normal traffic conditions, problems are mainly related to lack of information for motorists (and other travelers) concerning destinations, routes, parking facilities or special events. The telematics applications in this area are of three main types: traffic control applications, information and guidance applications and emergency action applications. They offer services to users on the levels of infrastructure owners/authorities, operators/service providers and end-users (motorists and other travelers).

The users for the first group of applications (the traffic control group) mainly include the authorities and control centre (UTC and motorway control) operators. Systems and applications in this group offer services which assist these users to better monitor the conditions on the network and to better handle situations as they occur.

The users for the second group of applications (the information and guidance group) include the service providers and operators (traffic control centres, traffic information centres, broadcasters) and the motorists and other travelers (end-users). Systems and applications of this group offer services which allow the service providers and operators to better communicate with motorists and manage their network, and the end-users (motorists and other travelers) to better plan their trips.

The users for the third group of applications (the emergency action group) include the service providers and operators (emergency response authorities, police and fire-departments, traffic control centres, broadcasters, automobile clubs) and the motorists and other travelers (end-users). The systems and applications of this group offer services which allow the operators and service providers to be better informed on emergency situations and to better deploy their units or their management and control measures; they also allow the affected end-users to be assisted in a faster manner, and other non affected traffic to be notified and diverted as necessary.



RTD&D problems

The problems in RTD&D which the area was aimed to address include new techniques and tools for incident management, network management (through signal control, lane and speed control, ramp metering and information-guidance), intersection and local control, linking control centres which jointly monitor or manage the network, enforcement systems (including vehicle classification and identification for violations of speed, signals or urban tolling) and emissions reduction. Furthermore, problems to be addressed within the horizontal line 'validation of integrated telematics infrastructure and services on test-sites' include the user response to and acceptance of telematics applications and services, their impacts on traffic, their impact on safety and the environment, as well as issues related to interoperability and transferability, market potential, and overall European added value.

1.2 MAIN ACHIEVEMENTS

The achievements within the area of network and traffic management include the development and implementation of a series of systems in a number of sites (urban and interurban) and the assessment, to a certain extent, of user reaction and acceptance and the impacts on traffic. Achievements have been made in the three main groups of applications (traffic control, information and guidance, emergency actions), within the level of better understanding the network conditions, and the level of managing and controlling the network.

Understanding the network conditions

Tools and models for observing the network status and detecting incidents and congestion have been developed. In one of these approaches (QUARTET PLUS, Turin), the town supervisor performs the functions of Origin-Destination (O-D) estimation, monitoring and assignment. O-D estimation is carried out on-line every hour for the entire network (for private vehicles and public transport). Average speeds are monitored every 5 minutes for the entire network. Assignment is run every hour for the entire network for private means and public transport, thus detecting congestion. Output is given to the Variable Message Signs (VMS), the UTC and the in-car route guidance units.

The Path Flow Estimator, which is a network state estimation and forecasting method, tested in six cities over the EU (CLEOPATRA), gave results compared to measured flows, within the range of +/-20% for 58% to 81% of the links. The Journey Time Prediction, which is another such tool, showed that short term prediction of journey times in urban areas, is possible to a precision of 10% or less.

In a Traffic Information Centre application (CAPITALS, Berlin), input data from a variety of sources is processed, in order to be disseminated as traffic information, including floating car data, from infra-red beacons and equipped cars.

Traffic predictions for Day+1 and Day+2, which are subsequently used for traffic information provision, have given good results compared to observations (CAPITALS,



Ile de France): 100% of flow forecasts were within a range of +/- 10% of observed values for the interurban network, 94% for the urban network; for the peripheral. Average errors between forecasts and observations were within 6.6% for days with normal traffic conditions. For the requirements of this application, two traffic control centres (the city and the region) were linked and exchanged data with a customised version of Datex Net.

Managing and controlling the network

Results from a dynamic signal control (UTC) demonstration (QUARTET PLUS, Turin, Gothenburg and Toulouse) show benefits for travel times of 17% for private traffic and 15% for public transport. Emissions are estimated to be reduced by 5-6% locally. Furthermore, these dynamic signal control strategies when integrated with information and guidance, show travel time benefits of 20% (and even 21.6% on total trip-duration) for private traffic and 19% for public transport. For the emissions, the benefits were estimated at 18% locally and 8% globally. It was also estimated that there was a modal shift to public transport, due to the information systems, in the order of 2-3% (in Turin and Gothenburg).

In another UTC demonstration (TABASCO, Munich), using the BALANCE system for public transport priority, benefits for public transport and private traffic were shown again. Public transport journey times were estimated to be reduced by 10%, delays for public transport vehicles were reduced by 54%, and delays to passengers by 57%. Furthermore, public transport journey times were more reliable. It was estimated that for a network of 20-30 intersections, the benefit to cost ratio would be in the order of 19:1.

In a test of integrated urban corridor control (TABASCO, Glasgow), the traffic control strategies (IN-TUC) for the urban network adjacent to the motorway, showed a capacity increase for the urban diversion routes of 20% and a capacity decrease for the urban network of 10% (during the afternoon peak hour of 4-5 pm). The integrated strategy of traffic control and VMS re-routing, showed capacity increases of 23% on the urban diversion routes and a capacity decrease on the urban network of 6%.

For the actual control of intersections, the concept of the standard interfacing module and the intersection platform software have been developed, in order to arrive to a new type of vendor independent intersection controller (ESCORT). This will allow the interconnectivity at intersection level, being a first step to open system architectures. This will also allow an open interface and an easy integration of heterogeneous hardware devices and software applications.

From tests of re-routing strategies on interurban networks and on the interface between urban and interurban areas (TABASCO, the Scottish Central Belt and Munich), savings of 25% of vehicle-hours were estimated. With the OPERA system, which supports the development and implementation of re-routing strategies (the Scottish belt) 47% of the motorists stated that they followed the recommendation; with the VARIA system, which supports the development and implementation of re-routing strategies (Munich) 15% of the motorists accepted the recommendations.



From the tests of travel time information provision (CAPITALS, Ile de France), and during extraordinary conditions (the opening ceremony/match of the 1997 World Cup), overall peak hour traffic levels on the network immediately adjacent to the Stadium (A1/A86) were 15% lower than normal. During this World Cup period, drivers on the urban network were notified of delays on the interurban network, and advised through VMS to use an alternative route, with VMS signing continuing on the interurban network. Over 7,000 drivers diverted following this advice, saving over 20 minutes on their journey times to the Stadium.

From the results of a ramp-metering trial (TABASCO, Glasgow) it was found that 59% of the drivers found ramp-metering very helpful or fairly helpful. The system had a positive impact on the capacity of the motorway (increase by 5%) and on the urban diversion routes (increase 13%), a decrease in capacity in the urban network (3%) and an overall positive impact on the total network (increase by 2%) for the afternoon peak (4-5 pm). In the case of an integrated approach, whereby the adjacent urban network is controlled with the IN TUC strategy and the VMS advise on alternative routes, these figures show a further improvement (increase in capacity of the urban diversion route of 6%).

From emergency services tests (IN RESPONSE, Paris) the average time savings per incident were evaluated at 9 minutes. The resulting total annual benefit amounts to 5.1 Meuros: the benefit to cost ratio for travel time savings is 3.3 and for accident costs reduction 0.062.

From the hazard warning tests, (TABASCO Munich), it was found that after the activation of the warning light poles, there was a reduction of speeds between 15 and 25 km/h. More than half the drivers (60%) stayed on their current lane. Vehicle headways of under 1.5 seconds dropped from 15% (without hazard warning) to none. Headways of under 3 seconds dropped from 55% (without) to 39% (with).

1.3 MAIN CONCLUSIONS

The area of network and traffic management has developed and validated applications capable of providing telematics services to the end-users (motorists and other travelers), the service providers (mainly control and/or information centres) and the authorities/infrastructure owners.

The impacts on traffic and user acceptance of the applications tested have been assessed to a certain degree. Impacts on the environment have simply been estimated on the basis of the traffic impacts (in a rather limited manner). New modeling tools for the assessment of impacts on the environment have not emerged. The issue of safety implications has not really been investigated in depth.

In relation to European policies (particularly sustainable mobility and the information society) the work carried out in the area does in fact show that transport telematics can contribute well, especially in terms of improving the efficiency of the road network.



The dimension of the environment and safety clearly require further work; the same applies to intermodality and the demand management approach.

Certain issues of interest to the area concerning the need for further research have already emerged. These include:

- the possible switching between UTC systems (fixed time plan-adaptive systems);
- the automatic implementation of strategies;
- the overall concept of Urban Traffic Management and Regional Control Centres;
- more detailed research into methodologies (including models and algorithms) now that the enabling technologies are becoming available;
- the demonstration of forecasting tools for interurban networks which have become available;
- the further integration of systems.

Topics not covered in depth (or at all), also need research or further research (e.g. control strategies with special focus on the environment, automatic behaviour monitoring tools). Research into impacts and driver response to management strategies (especially route choice in diversion strategies) also needs to be taken further, especially in terms of demonstration. Finally the impacts of the telematics applications and services still need to be demonstrated on a large scale, with focused approaches and for a substantial duration.

2. PRESENTATION

2.1 Context

The Telematics Application Programme, running from 1994 to 1998, is part of the Fourth Framework Programme of Research, Technological Development and Demonstration of the European Union. This programme has been subdivided into 4 domains including 12 sectors grouped as follows:

- * Telematics for services of public interest: **Transport, Administrations**
- * Telematics for knowledge: **Researchers, Libraries, Education and training**
- * Telematics for improving employment and quality of life: **Urban and rural areas, Healthcare, Elderly and disabled, Environment.**
- * Horizontal RTD: **Telematics engineering, Language engineering, Information engineering.**

The Transport sector is the largest in terms of funding resources. It builds on the results of two former research streams: the DRIVE Programme (1989-1991) and the Advanced Transport Telematics programme also known as ATT (1992-1994). The current Transport Sector enlarges the scope of the former DRIVE and ATT programmes, as it copes with all the transport modes and all transport infrastructures and not only with Road transport.

The TAP programme emphasised “user orientation”. Regarding the Transport Sector, the following table shows the categories of services to users by transport mode.

Services to	Infrastructure	ROAD		RAIL		WATERBOURNE		AIR	
		Interurban	Urban	Interurban	Urban	On water	In harbour	In the air	At the airport
travellers	Information	A1	B1	C1	D1	E1	F1	G1	H1
	Payments (1)	A2	B2	C2	D2	E2	F2	G2	H2
	Other services (2)	A3	B3	C3	D3	E3	F3	G3	H3
shippers	Freight intermodality	A4	B4	C4	D4	E4	F4	G4	H4
transport infrastructure owners	Network managt	A5	B5	C5	D5	E5	F5	G5	H5
	Infrastructure fee collection	A6	B6	C6	D6	E6	F6	G6	H6
	Other services (3)	A7	B7	C7	D7	E7	F7	G7	H7
fleet operators	Fleet management	A8	B8	C8	D8	E8	F8	G8	H8
	Other services (4)	A9	B9	C9	D9	E9	F9	G9	H9
vehicle operators	Information (5)	A10	B10	C10	D10	E10	F10	G10	H10
	Assistance	A11	B11	C11	D11	E11	F11	G11	H11
	Other services (6)	A12	B12	C12	D12	E12	F12	G12	H12

Table 1, Grid for area analysis

(1) = Travel fee payments, Other services paid within the journey (telephone, newspapers, food, entertainment, free tax etc.)

(2) = Baggage handling, Emergency calls, Reservation, Booking, Business facilities, Entertainment, Recreation, Disease assistance, etc.

(3) = Infrastructure remote monitoring, remote maintenance, Emergency services, etc.

(4) = vehicle remote monitoring, remote maintenance, etc.

(5) = including weather

(6) = vehicle aboard monitoring, aboard maintenance, etc...

Around 105 projects have been launched within Transport sector of the TAP. To monitor the programme, to analyse its progress as a whole and to report its results, it



has been divided in 6 concertation Areas. Two Areas which were very large (Traveler intermodality and Road transport), have been subdivided in subsets. These areas and sub-areas are the following.

1. Traveller Intermodality
 - 1.1 Traveller Information
 - 1.2 Fare Collection and Integrated Payments
 - 1.3 Public Transport Operations
2. Freight Intermodality
3. Road Transport
 - 3.1 Car driver Information
 - 3.2 Automatic debiting & Tolling
 - 3.3 Network and traffic management
 - 3.4 Vehicle control
4. Air Transport
5. Railway Transport
6. Waterborne Transport

The current document reports the progress, achievements and results of sub-area 3.3 **“Network and Traffic Management”** under the Road Transport mode. The area is one of the sub-areas of the Road mode. It was established at the first Concertation Meeting of the sector and gathers a grouping of projects on a permanent basis, with applications in Network and Traffic Management.

In reference to the "GRID for area analysis" presented in Table 1 above, this area mainly addresses the following items, all under the road mode and in the urban and interurban context: “services to transport infrastructure owners” (A5, B5), “services to travelers” (A1, B1, A10, B10) and “other services” (A7, B7).

The content of the area relates to the line of “Telematics for Network Management, Control and Operations” of the Transport sector work programme of the 4th FP TAP, as well as the line of “Validation of Integrated Telematics Infrastructure and Related

The area is in fact a continuation and a merging of the areas of Integrated Urban Traffic Management and Integrated Interurban Traffic Management of the ATT programme, as it was felt that joint meetings of these two areas produce better results and cooperation.

2.2 Objectives of the report

Projects participating in the area are: DACCORD, EUROSOCPE, HANNIBAL, IN-RESPONSE, VADE MECUM, CAPITALS (and its follow-up CAPITALS PLUS), COSMOS, CLEOPATRA, INFOTEN, ENTERPRICE, QUARTET PLUS, TABASCO, CONCERT, AUSIAS, VERA and ESCORT. All of these have applications in the area of network and traffic management.

Furthermore, the CARISMA project, although, strictly speaking, a horizontal support project and not a project of the area, is concerned with developing advice and guidance



notes on a number of issues related to traffic management and information provision, and is therefore closely linked to the area.

The objective of the area is to support consensus formation, through:

- the exchange of experience;
- the necessary discussion on common practices and approaches;
- the search for common functional specifications and standards/pre-standards;
- the contribution towards the future deployment of pan-European services.

The objective of the area report is to present the key achievements in telematics-aided network and traffic management applications within the Transport sector of the TAP.

The report will present an overview of the users, services and main problems of network and traffic management, the scope of the area in the work programme of Transport sector of the TAP, the telematics applications developed and demonstrated, and the key results currently available, in terms of systems and impacts and user acceptance. The report also reviews the conclusions from the work so far and the perspectives for the future of the area.

The report is based on information available from progress in the area projects: the project deliverables and the discussions and presentations at concertation meetings.

3. SCOPE

3.1 *Scope of traffic management*

The main objectives of traffic management have in the past been defined as:

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

This definition of objectives was adopted by the Area of Integrated Interurban Traffic Management of the ATT programme, but is equally relevant to the urban context. In all cases, the objectives of network and traffic management applications are to help optimize existing infrastructure capacities, link networks and services, improve safety, and reduce the negative effects on the environment.

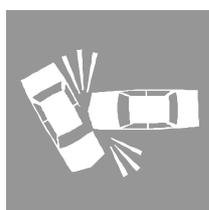
Within the framework of the ATT programme, the applications of utmost importance for Network and Traffic Management in the urban context were seen as including traffic control, trip planning and parking management, and emergency services and management. For the inter-urban context, the principal techniques for network managers were seen as comprising traffic control, driver information, emergency response and general assistance, and provision of travel services.

The following key groups of applications can therefore be seen as common for both the urban and interurban context:

- traffic control (signal control, congestion and incident management, traffic re-routing, ramp metering);
- information services (information and guidance en-route or pre-trip);
- emergency action and assistance (emergency response, health services response, incident management, hazard warning).

3.2 *Main problems*

The main problems which occur on road networks are congestion and incidents, road works or bad weather conditions leading to road-closure. Normal traffic conditions are also burdened with traffic problems, mainly due to the steady increase of traffic volumes, but also caused by lack of information concerning destinations, routes, parking facilities or special events. From the environmental point of view, problems caused by traffic include pollution, noise, vibrations and optical intrusion. Accidents with or without casualties are a problem from the socio-economic point of view, as well as increased journey times for persons and goods, due to congestion.



The fundamental problem which traffic control operators face is the deterioration of the level of service on their network. For most operators, this causes political and social pressure to improve this level of service. For those parts of the network which are privately operated, this could even mean loss of revenue.

In the past, the operators' approach had been mainly focused on maximizing the capacity or throughput of the network, especially for routine traffic or foreseen interruptions. With the gradual emergence of advanced monitoring and adaptive control systems capable of reacting to situations as they occur, operators can tackle problems related to unforeseen situations, such as incidents or congestion, inappropriate route choice on the part of the drivers (especially in the case of incidents or special events), but also other problems, such as environmental problems and accidents or emergency situations.

The main problems faced by traffic management operators therefore, who are the users responsible for facing the traffic problems, can be stated as follows:

- insufficient knowledge of the real time conditions on the network, due to incomplete monitoring infrastructure (sensors and cameras) and low levels of data processing;
- management techniques or tools not advanced enough to cope with a variety of situations;
- insufficient knowledge of potential driver reaction to control and/or information measures and the corresponding impacts on traffic;
- insufficient or inadequate means to communicate with motorists.

3.3 Users

Users in the area of network and traffic management are found at distinct levels: authorities and infrastructure owners, operators and service providers, and end-users. The applications and services provided by traffic management are targeted to users on one or more levels, depending on the nature of the service or application.

- For the traffic control applications group: the key users are urban traffic control centres and motorway control centres.





- For the driver information services group: users are the service providers (the traffic information centres, broadcasters, automobile clubs etc.) and the end-users (motorists and other travelers).

- For the group of applications in the fields of emergency response and general assistance: users are the service providers (emergency operators e.g. ambulance, police, fire-departments, and also motorway control centres, urban traffic control or information centres etc.) and the end-users (motorists and other travelers).



The most important need for the infrastructure owners is the need for applications which will assist them in improving the network and traffic conditions. For the service providers the most important need is for systems and applications that will allow them to perform their management and control operations more effectively and/or to gain more revenues. For the motorists and other travelers, the basic need is for services that will improve their travel conditions.

Some of the findings of the work on user needs are of particular interest, with respect to what the traffic management authorities perceive as their most important problems. From a survey conducted in the UK among UTC operators (by the ROMANSE project in Southampton), in relation to incident management, it was found that the most important issue according to UTC operators was the issue of strategies for managing incidents. The authorities rated highly the need for fairly accurate data on flows, journey times and queues; CCTV was rated as very important equipment for monitoring incidents. The ability to deploy emergency services was also rated very highly in incident management. Furthermore, there was no conflict perceived between the deployment of emergency services and congestion management. Finally, automated strategy systems were seen as providing advice to control centre operators, rather than automatically implementing a strategy.

In another survey among UTC operators (conducted by the COSMOS project), the various approaches among European authorities were identified. In Germany the authorities judged recurrent congestion as a more severe problem than unexpected congestion (e.g. incidents), whereas in the UK it was felt to be the other way. In Germany the feeling was that green waves on the main arterials are a sound practice for managing traffic, whereas in the UK this is not felt so strongly. In the UK there is a tendency for offsets determined automatically by the UTC system. In Germany there is a strong support for absolute public transport priority where the network allows it and even some support for absolute public transport priority in all circumstances. In the UK there is a preference for individual solutions according to the case. As far as re-

routing is concerned, there was a common understanding that it is generally acceptable if the alternative route is not in residential areas.

3.4 Services

As already indicated, the services offered by the applications and the systems of network and traffic management are targeted at the transport infrastructure owners in the road mode and the travelers (mainly in the road mode). These services are offered by operators or service providers, who are in effect also a user group of the services in the area.

The services provided by the traffic control applications group are mainly targeted at authorities/infrastructure owners and service providers. Services offered include traffic monitoring, incident detection, weather conditions monitoring, services which enable operators to better handle situations such as congestion and incidents and even influence driver route choice.

The services offered by the driver information services group are targeted at end-users and service providers. Services offered include en-route traffic information and guidance by use of VMS or on-board vehicle equipment, and pre-trip information. The emphasis of the area is on en-route information services through VMS; in vehicle units for en-route information and pre-trip information services are primarily addressed by the driver information area and the traveler information area (see the corresponding reports for more information on these topics).

The services offered by the emergency action and general assistance applications are targeted at end-users and service providers. Services offered are incident detection and verification, health services response, emergency services response and hazard warning.

3.5 Telematics applications

Applications in network and traffic management are grouped into three main categories: the traffic control group, the information services group and the emergency action and assistance group. These applications are structured on two levels:

- how knowledge of the network conditions is obtained (traffic monitoring, incident detection, forecasting and modeling);
- what this leads to in terms of traffic management applications and strategies (congestion and incident management, guidance and information, integration of guidance with signal control, ramp metering, deployment of emergency services, demand management applications).

The first level is usually implied inherently in all traffic management applications and strategies, since management action can only be taken if the problem or the conditions are known. The second level is the main level where management and control action is taken. The interlinking of control and information centres in order to monitor traffic

conditions across geographic or administrative borders or systems but also to manage and control traffic across them is an application which is found on both levels.

Level 1 knowledge of network conditions		
traffic monitoring, modelling and forecasting, incident detection, links between control and information centres		
Level 2 control-management action		
traffic control group – signal control – congestion and incident management – ramp metering – re-routing	information services group – information and guidance en-route (VMS) in the urban context – information and guidance en-route (VMS) in the interurban context	emergency action and assistance group – emergency response – health services response – incident management – hazard warning
links between control and information centres		

Table 2, levels in traffic management and application groups

The projects participating in the area of network and traffic management fall within the urban and interurban context, and cover multi-site/multi-application approaches and approaches based on single-site/multi-application or multi-site/single-application. The area related applications within these projects are described in Appendix 3. The area projects can be clustered as on the following table, according to their context (urban, inter-urban) and their major applications.

	Urban	Interurban
control-guidance strategies	<ul style="list-style-type: none"> • COSMOS • EUROSCOPE • QUARTET PLUS • CAPITALS • CLEOPATRA • TABASCO • AUSIAS 	<ul style="list-style-type: none"> • IN-RESPONSE • HANNIBAL • INFOTEN • VADE MECUM • ENTERPRICE • HANNIBAL • DACCORD • TABASCO
congestion management	<ul style="list-style-type: none"> • COSMOS • CAPITALS • AUSIAS • QUARTET PLUS 	<ul style="list-style-type: none"> • HANNIBAL • DACCORD
intelligent intersection control	<ul style="list-style-type: none"> • ESCORT 	

incident management	<ul style="list-style-type: none"> • COSMOS • EUROSCOPE 	<ul style="list-style-type: none"> • IN-RESPONSE • ENTERPRICE • HANNIBAL
ramp metering	<ul style="list-style-type: none"> • TABASCO 	<ul style="list-style-type: none"> • DACCORD • IN-RESPONSE
emergency services and hazard warning		<ul style="list-style-type: none"> • IN-RESPONSE • INFOTEN • TABASCO
enforcement and policing	<ul style="list-style-type: none"> • VERA 	<ul style="list-style-type: none"> • VERA
links control-information centres	<ul style="list-style-type: none"> • CAPITALS • EUROSCOPE 	<ul style="list-style-type: none"> • TABASCO • ENTERPRICE • VADE MECUM • HANNIBAL
links urban-interurban information and control centres	<ul style="list-style-type: none"> • CAPITALS 	<ul style="list-style-type: none"> • TABASCO • DACCORD
demand management	<ul style="list-style-type: none"> • CONCERT • CAPITALS 	<ul style="list-style-type: none"> • HANNIBAL

Table 3, Clustering of the Projects

The table shows a slight predominance of interurban applications, although it should be noted that some of these are in fact applications on the interface between interurban and urban areas. The table also shows the high interest of the area projects in the combined control-information/guidance approach, and the interest of the area projects in the links between control and/or information centres.

3.6 Collaborative evaluation

The TAP programme placed particular emphasis on demonstration and evaluation of impacts and user acceptance. For this reason, within the horizontal support activities of the programme, initiatives have been established for coordinating evaluation activities and for collaboration among projects, so that results can be compared and transferred.

The need for coordination has been met by issuing validation guidelines (the CONVERGE project), which have been used by all projects. The need for collaborative evaluation in the area of network and traffic management has been met through a dedicated initiative (the Cross-Project Collaborative evaluation studies), for the topics of Integrated Urban Traffic Control and the Use of VMS in Urban Areas.

Within the Integrated Urban Traffic Control collaborative study, the topics investigated cover:

- integrated strategies;
- public transport priority;
- incident management;
- parking management;

- environmental monitoring;
- traveler information.

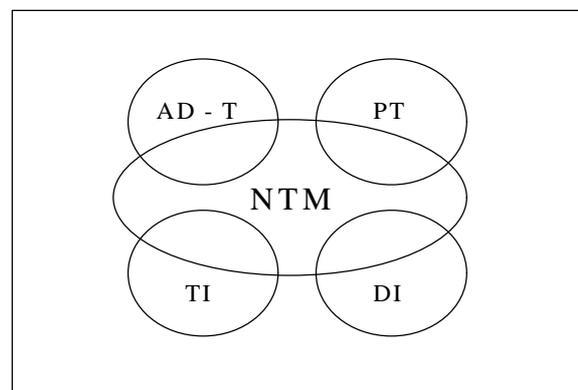
The collaborative study on the Use of VMS in Urban Areas addressed cases where VMS were used in urban areas for:

- advance warning or current information (free-text messages) or information on traffic conditions on particular routes (categorized messages);
- travel time and delay messages on alternative routes;
- congestion/queue length messages;
- variable directions;
- parking guidance and information.

All of these issues, in both collaborative studies are closely related to the applications of particular interest to the area in the urban context (Table 3, above, ‘Clustering of the Projects’). The work carried out in the Cross Project Collaborative Evaluation Studies is reported separately.

3.7 Relationship with other areas

Network and traffic management is linked to the other sub-areas of the road transport mode and also to traveler intermodality.



Since information services are one of the major groups of applications for network and traffic management, it is obvious that the area has a close relation with sub-areas 1.1 (traveler information) and 3.1 (driver information).

The provision of information and/or guidance en-route, via VMS or in-car units is a complementary area between network and traffic management and driver information. Information of such a type, particularly in relation to incidents, can cause drivers to change their route-choice and may help to rearrange traffic on the network. It is therefore an information service for the end-user (the motorist), but also a traffic management service for the traffic control operator. The network and traffic management area is mainly concerned with en-route information using VMS, whereas the in-vehicle units are handled in the driver information area. Almost all the area



projects have demonstrated to some extent the integration of information with traffic control measures, as indicated in Table 3, above, 'Clustering of the Projects'.

The provision of pre-trip information is an area of overlap between network and traffic management and traveler information. Provision of such information can influence the choice of mode, destination, time or route of the motorists/travelers and contribute towards an integrated traffic management approach. It is therefore an information service for the end-user (motorist or other traveler) and also a traffic management service for the traffic control operator. A number of projects of the area have demonstrated the use of pre-trip information as a tool to influence driver behaviour (EUROCOPE, QUARTET PLUS and CAPITALS PLUS in the urban context, and ENTERPRICE, INFOTEN and HANNIBAL in the interurban).

Traffic restraint measures, which have been considered as part of broader demand management strategies and include automatic debiting and tolling or integrated payment systems, represent another complementary area between network and traffic management and automatic debiting and tolling. A number of projects in the area have demonstrated this approach (CONCERT, CAPITALS in the Rome site).

Furthermore, the public transport priority applications of urban traffic control systems have a close relation to the sub-area 1.3, public transport operations, since they allow better journey times or improved reliability of public transport vehicles. A number of projects has also demonstrated this approach (EUROSCOPE, TABASCO, QUARTET PLUS).

Finally, the applications of en-route information which encourage the use of public transport (e.g. in the form of location and availability of Park & Ride schemes) are also areas closely related to the public transport operations sub-area. This approach has been demonstrated in certain of the area projects (EUROSCOPE, TABASCO).

3.8 Part of the scope addressed within the programme

Within the work programme of the Transport sector of the TAP, the area addresses the vertical line of "Telematics for Network Management, Control and Operations" and the horizontal line "Validation of Integrated Telematics Infrastructure and Related Services on Test Sites". The main objectives were to develop and validate telematics systems and services to enable the better use of the road network in normal, congested and emergency situations. Emphasis was on strong user involvement and large scale demonstrations.

The research tasks of the vertical line covered topics such as incident management, network management, intersection and local control, multicentre control, vehicle enforcement and classification systems, behaviour monitoring compliance tools and emissions reduction.

Most of these tasks have been demonstrated in a number of projects, as can be seen in Table 3, 'Clustering of the Projects', above. Work on emissions is mainly through



estimates of emissions reductions from the traffic impacts and not so much through new techniques or models. Work on automatic behaviour monitoring and compliance tools has mainly concentrated on tools for monitoring traffic compliance rather than automatic behaviour monitoring.

For the horizontal line of validation themes, the focus was on user response, interoperability of telematics tools, direct and indirect costs and benefits, additive benefits of integration of telematics services, market potential and technical, administrative, legal and financial arrangements necessary for successful deployment. Particular emphasis was placed on the opportunities offered by the pilot projects already developed within FP3, under the POLIS and the CORRIDOR initiative for the urban and interurban context.

Indeed, the majority of the urban demonstration projects in the area (EUROSCOPE, CAPITALS, QUARTET PLUS, CONCERT and TABASCO), have built upon the achievements of the POLIS initiative in FP3. The POLIS projects in FP3 have reached the stage of a limited field-trial and evaluation. In the current programme, they have enlarged the scope of the field-trial and evaluation to a verification and demonstration/validation stage, with substantial user involvement and comprehensive evaluation, along commonly agreed guidelines (the CONVERGE guidelines).

For the interurban demonstrators, there is a similar trend, whereby projects have built upon achievements of FP3 pilot-projects, and proceeded to demonstrations. These projects include ENTERPRICE, TABASCO (the interurban element), DACCORD and, to a certain extent, IN RESPONSE.

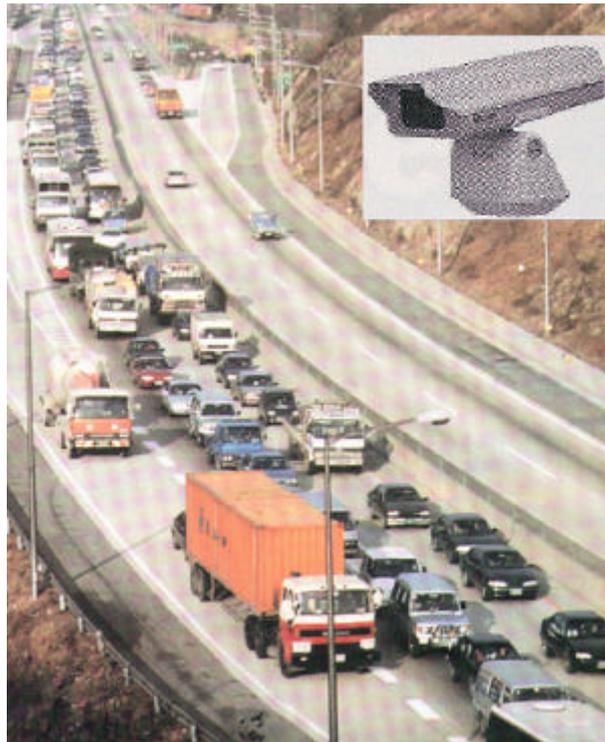
The objectives of the horizontal line have mostly been met through the work in the area. The user response and the impacts of the telematics systems and services have been investigated to a certain extent in the demonstrator projects. The additive benefits of various services have also been investigated and demonstrated, although not really for the non-transport services. Examples of good practice to cope with the administrative, legal and financial arrangements for successful deployment of the services have been identified. Direct and indirect costs and benefits are clearly an area which requires further investigation, as is the market potential.

4. PROGRAMME ACHIEVEMENTS

Achievements as a result of demonstrations have emerged within each project and site, according to their specific objectives. This section describes the systems implemented, the impacts and the user acceptance as they have been measured or estimated in the demonstration stages. The section presents achievements following the 2 levels of 'knowledge of the network conditions' and 'traffic management applications and strategies', with the traffic management applications grouped into the 3 main categories, as indicated in Table 2 in section 3.5, above.

4.1 Knowledge of the network conditions

Sound and timely knowledge of the conditions on the network is necessary for almost all network and traffic management applications, but also for traffic information services. The applications in this area include traffic monitoring, modelling and forecasting and incident detection. This group of applications also includes vehicle identification applications (e.g. via video), for the purposes of enforcement of violations (traffic signals, bus-lane, speeding and tolling charge).



4.1.1 Modeling and forecasting

Systems

Modeling and forecasting are applied for purposes of estimating the current status of traffic (volumes, speeds etc.) or predicting the future status of traffic (short or medium term), using traffic data from sensors on the network.



In the town supervisor approach (the QUARTET PLUS project in the Turin site), the functions of Origin-Destination (O-D) estimation, monitoring and assignment are performed. O-D estimation is carried out on-line every hour for the entire network (for private vehicles and public transport). Average speeds are monitored every 5 minutes for the entire network. Assignment is run every hour for the entire network for private vehicles and public transport, thus detecting congestion. Output is given to the Variable Message Signs (VMS), the UTC and the in-car route guidance units. This approach applies cooperative monitoring, i.e. sharing of data among various operators, so that cooperative control can subsequently be applied.

In another context, traffic predictions for Day+1 and Day+2, which are subsequently used for traffic information provision, have given good results compared to observations (in CAPITALS/Ile de France) - 100% of flow forecasts were within a range of +/- 10% of observed values for the interurban network, 94% for the urban network. For the peripheral, average errors between forecasts and observations were within 6.6% for days with normal traffic conditions.

Another application of day+1 prediction was developed and demonstrated for the requirements of a special event (the 1997 world ski championship, the HANNIBAL project). At the end of the day, a new traffic forecast and a new forecast for traffic control advice is sent to the Co-ordination Centre and the Travel and Traffic Information Centre, so that the appropriate demand management measures can be implemented, and the relevant information provided to travellers. A fully dynamic traffic model (MIDA) was used as the basis for traffic prediction, using traffic data coming from different sources (loop sensors on critical road sections, toll barriers, parking facility occupancy sensors).

In another trial, where traffic monitoring is performed so that it can support the implementation of re-routing strategies (the TABASCO project, the Scottish Central Belt), incidents are reported to the traffic data-base (the NADICS data-base) and their impacts are assessed by a special tool (the SIMRES tool). The system also checks the upstream VMS, the O-D's on the links for significant flows (major destinations), and checks the situation on the diversion route. Forecasts of the situation in 1.5 hours are produced. Itinerary estimation is also performed, using an assignment model (MCONTRM) and a fixed O-D. The system works on a 6 minute cycle. In the Munich site of the project, the AIDA tool for incident detection is used to check the status of the diversion route, before the re-routing strategies are implemented.

The Path Flow Estimator, which is a network state estimation and forecasting method, tested in six cities over the EU (CLEOPATRA), gave results compared to measured flows, within the range of +/-20% for 58% to 81% of the links. The Path Flow Estimator was also tested in a UTC demonstration environment (COSMOS, the Piraeus site) and gave the majority of path flows within a +/-20% range compared to measurements. The Journey Time Prediction, which is another such tool (CLEOPATRA), showed that short term prediction of journey times in urban areas is possible to a precision of 10% or less.



The use of floating car data from equipped cars and infra-red beacons was demonstrated in a Traffic Information Centre (the CAPITALS project, the Berlin site); the data is processed with data from other sources for the requirements of traffic information provision.

Video based traffic condition monitoring applications are being developed and demonstrated for bus-lane violations, speed or red-light violations and toll charge violations (in the VERA project) and for intelligent intersection control (the ESCORT project).

4.1.2 Incident detection

Systems

Incident detection is performed so that the appropriate management measures are implemented (e.g. signal control or re-routing) or in the cases of accidents, so that emergency services can be deployed in time. It is also performed so that the relevant information can be provided as a traffic information service. Incident prediction models offer an important contribution in this domain.

In a test of incident detection for the requirements of emergency services (IN RESPONSE), indicators for the performance of incident detection systems were defined as follows: accuracy within a location of 300 m, detection rate 95% or better, false alarm rate 1% or less, time to detect less than 2 minutes, system unavailability less than 5%. The results obtained in this test, with machine vision (Thessaloniki), showed an accuracy in location of 131 m, a detection rate of 82%, a false alarm rate of 3 out of 1,440 and a time to detection of 1 min; with loops (Paris, the Boulevard Peripherique), the corresponding results were accuracy in location 500 m, detection rate 42%, false alarm rate 0.83% and time to detect 4 min. System availability was 71% (Paris, the Boulevard Peripherique) and 96% (Munich). An on-line incident prediction model is being developed, using traffic data, data on road geometrics and weather data; the model will give probabilities for incidents at specific locations.

Automatic congestion and incident detection functions with data from loops, have been developed and are being tested for the adaptive control systems of SCOOT, UTOPIA and MOTION (the COSMOS project). The MOTION incident detection function was also tested in another scenario (EUROSCOPE, Cologne). The results showed that MOTION overestimated incidents (as well as congestion) when compared to data from video-cameras.

The BEATRICES radar, tested on a motorway (EUROSCOPE/Strasbourg), gave detection rates of 99% and 95% respectively for congestion and incidents; false alarm rates were 1% and 2% respectively. The INGRID algorithm (EUROSCOPE/Southampton) detected all known and reported incidents.

4.2 *Management-control action*

The variety of management applications which have been developed and tested in the area, is shown on table 3 (clustering of the projects). As a general observation, it can be seen, that in most sites, there is a combined approach, where more than one application is developed. This reflects an emerging trend of integrated traffic management.

Within these applications, strategies play a key role for network and traffic management. Strategies are in fact a structured method of applying a management measure or a combination of measures.

The realisation of strategies via telematics technologies which were addressed by the demonstrations of the area are:

- the development of signal control strategies for congestion and incident management;
- the integration of UTC with public transport priority;
- the integration of information and guidance strategies with congestion and incident management (including re-routing);
- the development of information and guidance strategies on urban and interurban networks (re-routing);
- the use of ramp metering and its integration with information and guidance (re-routing);
- the integration of emergency services with incident management;
- the applications related to the management of demand.

4.2.1 *Traffic control group of applications*

4.2.1.1 *Urban traffic control strategies*

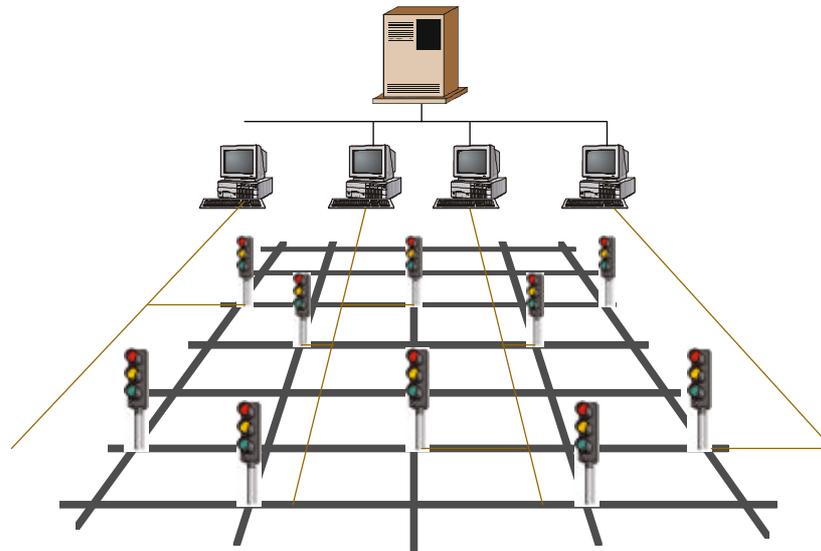
Systems

Signal control strategies in the urban context are applied in order to manage congestion/incidents or to give priority to certain vehicle classes (particularly public transport vehicles). Signal control strategies can be seen as a combination of tactics and tools, addressing a particular situation (according to a review of strategies undertaken by the COSMOS project).

Tactics could include entry gating, free exit, prevention of blocking back and special handling of particular movements. Tools are provided by the possible changes of signal control parameters (cycle length, green split, stages and offsets). A strategy is therefore defined by the selection of a tactic and the relevant selection of signal control parameters. Urban congestion and incident management strategies were developed and tested for the adaptive control systems of SCOOT, UTOPIA and MOTION (the COSMOS project). General strategies for congestion and incident management were

defined for 5 scenarios - for primary and secondary congestion and incidents, for upstream/downstream links and for secondary links.

In the town supervisor approach (the QUARTET PLUS project, the Turin site), congestion management is handled on three levels: the town level (covering the entire network), the sub-systems level (corresponding to sectors) and the outstations level (corresponding to the intersections). Congestion management handles predictable congestion, unpredictable congestion and local congestion; the objective is to maintain the status of user equilibrium. In the global trip management approach (the SGGD, in the Toulouse site of the project), an Artificial Intelligence system is the basis of the strategies. The CLAIRE system is used for congestion management.



For the actual control of intersections the concept of the standard interfacing module and the intersection platform software have been developed, in order to arrive at a new type of vendor independent intersection controller (ESCORT). This will allow the interconnectivity at intersection level, being a first step to open system architectures. This will also allow an open interface and an easy integration of heterogeneous hardware devices and software applications.

Impacts

Results from a dynamic control (UTC) demonstration (in the Turin, Gothenburg and Toulouse sites of QUARTET PLUS) show benefits for travel times of 17% for private traffic and 15% for public transport. Emissions are estimated to be reduced by 5-6% locally. As will be seen in section 3.2.2 the integration of dynamic control with information and guidance yields even higher travel time savings, which reach 19 and 20% for public transport and private traffic respectively.

In another UTC demonstration (TABASCO, Munich), using the BALANCE system for public transport priority, benefits for public transport and private traffic were shown again. Public transport journey times were estimated to be reduced by 10%. Delays for public transport vehicles were reduced by 54% and delays to passengers



were reduced by 57%. Furthermore, public transport journey times were more reliable. It was estimated that for a network of 20-30 intersections, the benefit to cost ratio would be in the order of 19:1.

Results from the SCOOT demonstrator testing gating strategies (COSMOS/London, Kingston) show a reduction of delays by 22% and of congestion by 43%. The UTOPIA results (COSMOS/Turin) indicate a reduction in congestion of 49% (for the whole day). The MOTION results (COSMOS/Piraeus) indicate reductions in travel times of 19.5% on six major routes in the am period, when congestion and incident management functions are added to the basic MOTION system.

The adaptive signal control system SCOOT has also been tested in another context, where it is combined with public transport priority (the EUROSCOPE project, the Southampton site), without however giving statistically significant results.

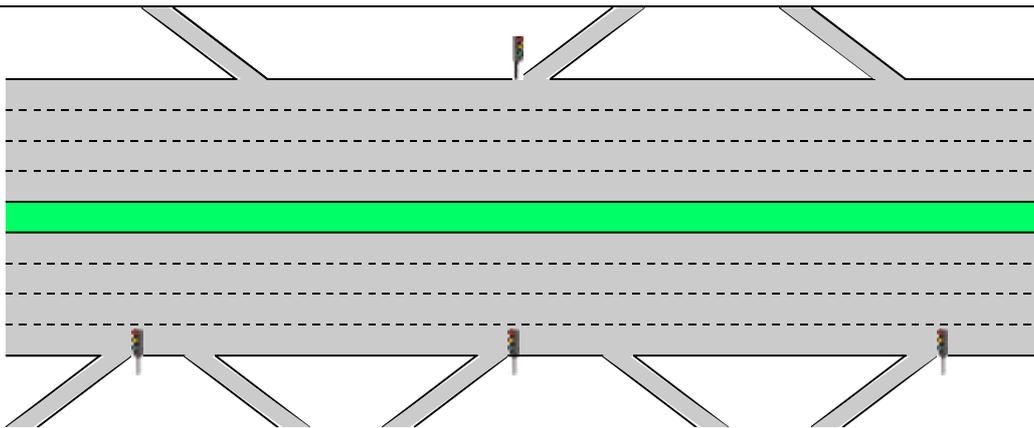
4.2.1.2 Ramp metering

Systems

Ramp-metering strategies are applied in order to control congestion on motorways and ramps mainly in the interurban or the periurban context.

Ramp metering strategies, integrated with traffic information and guidance via VMS, but also with signal control on the adjacent urban network have been developed and tested (the TABASCO project, the Glasgow site). Ramp metering was implemented using the ALINEA control law (aimed to maintain occupancy downstream of the on-ramp at a desired level).

Coordinated ramp metering was also implemented in an interurban network (DACCORD, the Amsterdam region). The system could not be demonstrated in time, because of various technical reasons, but also because of political hesitations (concerning the traffic problems on the urban-interurban interface). The strategies foreseen were based on a Dynamic Traffic Management System for interurban motorway corridors, with an open system architecture. The test site included 5 ramp metering locations with the ALINEA, METALINE and RWS strategies. Mainline metering has also been discussed and simulated. Within this same context, integrated motorway control was also simulated on the Paris network, based on optimal combinations of VMS, ramp-metering and motorway-to-motorway control, and giving results which show very large potential benefits.



Impacts-user acceptance

From the surveys of this

trial it was found that 59% of the drivers found ramp-metering very helpful or fairly helpful. The system had a positive impact on the capacity of the motorway (increase by 5%) and on the urban diversion routes (increase 13%), a decrease in capacity in the urban network (3%) and an overall positive impact on the total network (increase by 2%) for the afternoon peak (4-5 pm). These figures show a further improvement in the case of the integrated approach, with the exception of the adjacent urban network (increase in capacity of the urban diversion route of 6%, decrease in capacity of the urban network of 6%).

4.2.1.3 Managing the demand

Systems

Demand management strictly speaking is not a traffic control application, but rather a policy and a combined approach. The demand management policy relies heavily on traffic and parking restraint in selected areas or on applying special charges for the use of the road network or on providing incentives for a shift from private transport to public transport. All of these have an impact mainly on individual motorised traffic and require suitable management measures or applications.





Traffic restraint measures have been implemented and tested in central urban areas within a demand management framework (the CONCERT project, the Barcelona site, the CAPITALS project, the Rome Site). At the Barcelona site, a section of the city centre is physically restricted by retractable bollards, whereas at the Rome site, a section of the historic centre is physically restricted by 10 gates (400 cars are equipped with the Telepass system). A road 'cordon' pricing scheme was also implemented within a demand management framework (the CONCERT project, the Trondheim site).

For the case of managing traffic demand during special events (e.g. the 1997 winter ski world championship), a combination of restraint measures and a bus shuttle service were demonstrated (the HANNIBAL project, the Sestriere site). A decision support tool was tested stopping vehicles at gates and allowing access into the restricted area of Sestriere. An interface with the tourist and traffic information system was also implemented. General news or event information were presented, together with parking occupancy and travel time on selected O-D paths.

Impacts-user acceptance

In the demonstration of the access control system for the historic city-centre (CAPITALS, Rome), system unavailability was found to be less than 2.2%. From the demonstration it was found that the flows and the modal split were significantly dependent on the access fares policy.

In a road pricing scheme, tested within the framework of a demand management policy (the CONCERT project, the Trondheim site), a sharp differentiation of price was applied to the morning peak, with additional charges for traffic through the city centre. Reductions in traffic ranged between 10% and 17% for the high charging scheme. The increase in traffic was around 4-5% for the no charging scheme. The rather negative user attitude towards road pricing (52%) would change to a rather positive attitude (61%), if road pricing were to be combined with reduced vehicle and fuel taxes.

For the 1997 winter ski world championship, it was estimated that without any traffic management and control measures there would have been about 6,000-7,000 extra vehicles in Sestriere, parked along the roads. Moreover, traffic jams would have been inevitable and queue clearance would have taken 6-8 hours.

In another context (the CONCERT project, the Bristol site), VMS were used to dissuade car usage during times of bad air quality and showed little impact on traffic (less than 1%), confirming the dependence on automobiles for some trip categories.

4.2.2 Traffic information group of applications

Strategies for information and guidance through VMS on urban and interurban networks are applied in order to divert traffic from areas of the network with a particular problem, such as an incident, bad weather or severe congestion, but also in order to give information on destinations, routes, travel time estimates, parking facilities and special events. This information and guidance has impacts on driver route



choice, causes traffic rearrangement on the network and can therefore impact positively on the network. The strategies require sound monitoring techniques and the use of decision support systems, for strategy selection and/or implementation.

4.2.2.1 Strategies in the urban context

Systems

In the Turin town supervisor (QUARTET PLUS), an overall picture of the traffic and transport network status is made available to all sub-systems, the feasible equilibrium point is set, the value of the control variables is set (including the UTC and the VMS) and a decision-support system for long term planning is implemented.

In another context, regarding the interface of the urban-interurban network, an integrated approach has been developed and tested (TABASCO, Glasgow). The system controls the urban network adjacent to the motorway (the M8), provides routing advice through VMS and also controls one ramp to the motorway. The signal control strategy (IN-TUC) is applied on the urban network adjacent to the motorway. The VMS re-routing strategy is applied so that travel times between alternative routes on the motorway and the urban diversion route are equalised.

In a demonstration of UTC systems linked to rerouting tools (the COSMOS project). The SCOOT system was linked to the VAMPIRE rerouting module, which developed rerouting recommendations (London, Kingston). The MAKSIMOS module, developed rerouting recommendations based on traffic estimates from the Path Flow Estimator (MOTION, Piraeus).

In another context (the EUROSCOPE project, Southampton, Piraeus, Rotterdam), the central control rooms receive data from the network, with particular emphasis on incidents (including road-works), on the ferry departures from the port and on the bridge status at river crossings. Re-routing strategies are selected from a library and implemented through the VMS. Modeling tools such as the RGCONTRAM assignment model have been used to assess the impacts of the strategies before implementation.



Impacts-user acceptance

Dynamic control strategies integrated with information and guidance were tested, giving encouraging results (the QUARTET PLUS project). Travel time benefits for private traffic were 20% (and even 21.6% on total trip-duration) and for public transport 19%. For the emissions, the benefits were estimated at 18% locally and 8% globally. These figures show an improvement in relation to the dynamic control only approach (17% for private traffic and 15% for public transport). From the surveys it was found that VMS for parking information were more appreciated than routing VMS. In a survey concerning user attitudes on the various types of information and user interfaces (the Midlands site), the users indicated a high interest in information on congestion, public transport problems, special events and severe weather problems, with preference for broadcasting means. Furthermore, it was estimated that there was a modal shift to public transport, due to the information systems in the order of 2-3% (in Turin and Gothenburg).

In the test of integrated urban corridor control (the TABASCO project, the Glasgow site), the traffic control strategies (IN-TUC) for the urban network adjacent to the motorway, showed a capacity increase for the urban diversion routes of 20% and a capacity decrease for the urban network of 10% (during the afternoon peak hour of 4-5 pm). The integrated strategy of traffic control and VMS re-routing, showed capacity increases of 23% on the urban diversion routes and a capacity decrease on the urban network of 6%. These figures suggest an improvement in impact in the case of the integrated strategy. 40% of the drivers stated that they had changed their route after the VMS recommendations.

In a Park and Ride test, based on advice displayed on VMS (TABASCO, Munich), parking facility usage was increased by 100% during special events. Queue lengths were estimated to decrease by 400 vehicle-hours daily (the Amsterdam site). It was also estimated that 2.4 million veh-km's would be saved annually (2% of the total traffic in the particular part of the network), and that the information system would contribute by 23% to this saving.

In VMS routing strategy tests (CLEOPATRA) modeled results, with the SITRA-B+ and the NEMIS models, indicate travel time savings of up to 3.4% for affected drivers



(Toulouse) and 2.7% (Turin, with a relatively low driver compliance rate of 20%). In VMS information strategy tests (CLEOPATRA, London), modeled results indicate travel time savings of up to 25% for the affected drivers, in the case of immediate messages (as in incidents) and negligible effects for the entire network.

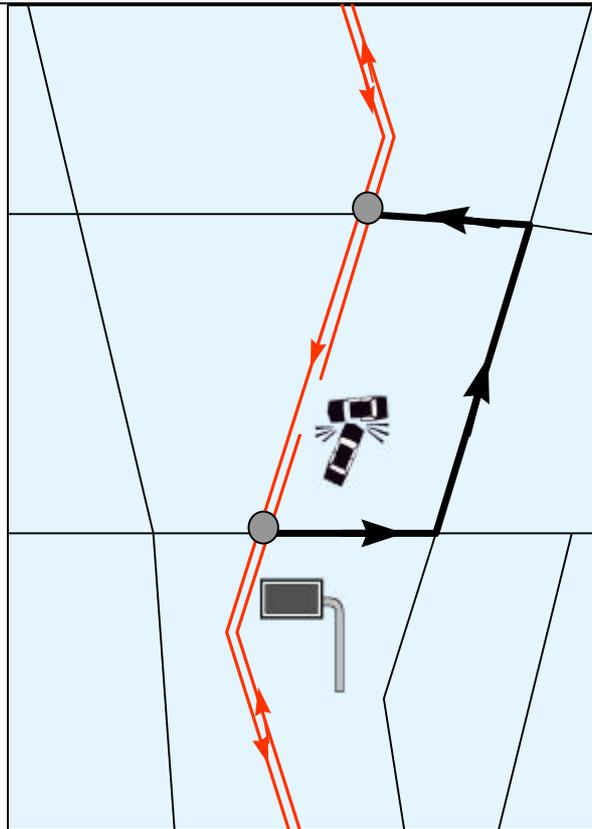
Results from rerouting based on the MAKSIMOS module (COSMOS, Piraeus) indicate reductions in travel time of 16%. This difference is in comparison to the situation where the MOTION UTC operates, with the added congestion and incident management functions. The VAMPIRE rerouting recommendations (COSMOS, London Kingston) show that 3% of the flow past the VMS sign diverted (12.6% of the flow into Kingston).

From the test of information and guidance related to incidents (EUROSCOPE/Southampton) it was found that diversion rates from the incident route to the diversion route ranged between 5.8% and 7.3%; 54% of the drivers were influenced by the information. Tests of information and guidance, related to a large passenger port (EUROSCOPE/Piraeus), showed that 12% of drivers diverted from their intended route. The travel time reduction reached 10% for certain routes. It was found that drivers noticed the port related VMS at higher rates (70%) than the other urban VMS (57%) and they generally stated that they found that the VMS had improved the conditions in the port area (68%).

4.2.2.2 Strategies in the interurban context

Systems

Re-routing in the interurban context is mainly achieved through VMS/VDS (Variable Direction Signs). In-car units or other information media, which can inform the motorists, are also an option, but for the area of network and traffic management, the emphasis is on road-side equipment.



Tests of re-routing strategies on interurban networks and on the interface between urban and interurban areas were carried out with use of decision support tools (the TABASCO project, the Scottish Central Belt site and the Munich site). The OPERA system (in the Scottish site) receives information on incidents, assesses their impacts and selects VMS strategies (the SELECT system). The system works on a 6 minute cycle and composes on-line legends on a rule-basis. The operator can override the system and can also simulate scenarios and test off-line. With the VARIA system (the Munich site), re-routing from the motorway to an arterial is decided if the latter is not burdened by incidents (which are detected by the AIDA tool).

Traffic information strategies were tested on the Paris ring road and an interurban network, offering information via VMS on travel times and congestion and travel times (the CAPITALS project, the Paris site). The system requires the collection and processing of traffic data from a number of control and information centres. Travel time information is updated every 1 minute.

In a traffic information demonstration, across two countries (HANNIBAL, the Alps crossing tunnels of Mont-Blanc and Frejus, between Italy and France), control centres and motorway companies exchange traffic data, using a version of DATEX. The objective is to provide a homogeneous level of information on the motorway corridor between the two countries and to advise on tunnel closure, in cases of adverse weather.



A strategic management shell as one of the sub-systems of the platform 'Mobility and Traffic Information Centre' (the ENTERPRICE and CAPITALS PLUS projects) has also been tested in the interurban context.

Impacts-user acceptance

From tests of re-routing strategies on interurban networks and on the interface between urban and interurban areas (the TABASCO project, the Scottish Central Belt site and the Munich site), savings of 25% of vehicle-hours were estimated. With the OPERA system, 47% of the motorists stated that they followed the recommendation; with the VARIA system, 15% of the motorists accepted the recommendations.

From tests of travel time information provision (the CAPITALS project, the Paris site), and during extraordinary conditions (the opening ceremony/match of the 1997 World Cup), overall peak hour traffic levels on the network immediately adjacent to the Stadium (A1/A86) were 15% lower than normal. During this World Cup period, drivers on the urban network were notified of delays on the interurban network, and advised through VMS to use an alternative route, with VMS signing continuing on the interurban network. Over 7,000 drivers diverted following this advice, saving over 20 minutes on their journey times to the Stadium.

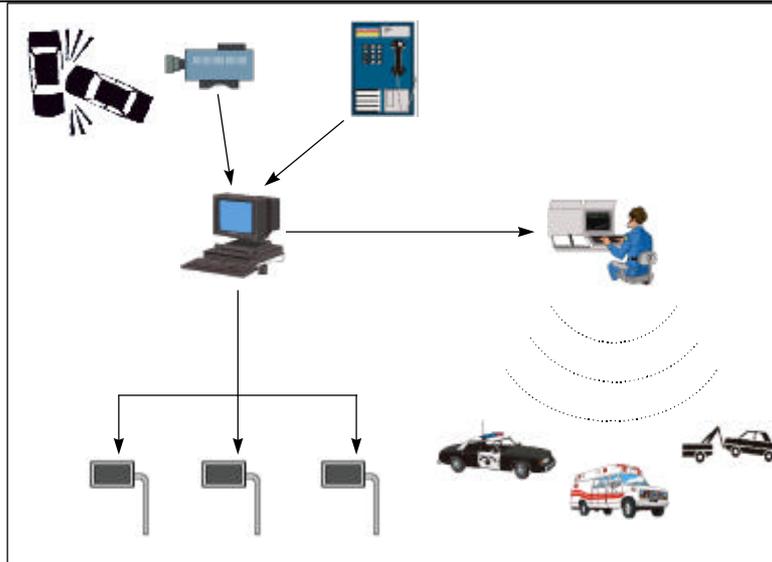
From the test of cross-border information provision (HANNIBAL, the Alps tunnel crossings), according to a large survey among 2,500 drivers, 26% of the users had got information on road and traffic conditions before starting their trip. Some 30% had encountered some form of incident during their trip and, of these, 47% received information concerning this incident (by VMS or radio).

In a speed advice test on a motorway (EUROSCOPE/Strasbourg), traffic flows were found to increase by 5%. 80% of the drivers recognised the speed limit message and 66% felt that traffic conditions were safer.

4.2.3 Emergency services group of applications

Systems

Emergency management includes the functional phases of incident detection, verification, prediction, response as well as health emergency response. Decision support systems and a graphical user interface for the operator at the central control room are recommended options. An interface to the broader context of traffic management, and especially information to motorists and other travelers (e.g. hazard warning) is also necessary. The deployment of emergency services, based on a comprehensive approach of incident detection and verification, and subsequent deployment of the health services and the emergency response services has been tested in a number of sites (the IN RESPONSE project, the sites of Oslo, Paris, Eindhoven, Munich, Valencia and Thessaloniki).



A variety of techniques for incident detection has been tested (including video and radar) on interurban or periurban motorways. The deployment of the emergency response services includes such features as a fast warning system for medical services, with video data transmission (the Paris site). A decision support tool for the operators of emergency services has also been developed, with a model base, a data management system and a Human Machine Interface.

Hazard warning (with BMW's COMPANION system) has been tested on a motorway stretch in Munich, using flashing light poles on the edge of the carriageway (TABASCO and INFOTEN projects).

Impacts-user acceptance

In an emergency services test (IN RESPONSE, Paris) the average time saving per incident was evaluated at 9 min. The resulting annual savings amount to 5.1 Meuros. The estimated annual reduction in HC and CO emissions amounts to 26 tons and 134 tons respectively. The annual benefits from accident reduction are estimated at approximately 100 Keuros. The benefit to cost ratio for the travel time savings is 3.3 and for the accident cost reduction 0.062.

From the hazard warning tests, (TABASCO Munich), it was found that after the activation of the light poles, there was a reduction of speeds between 15 and 25 km/h. More than half the drivers (60%) stayed on their current lane. Vehicle headways of under 1.5 seconds dropped from 15% (without hazard warning) to none. Headways of under 3 seconds dropped from 55% (without) to 39% (with).

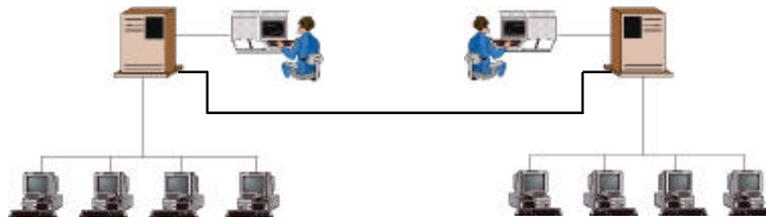
4.2.4 Links between centres

The successful implementation of network and traffic management applications, in certain cases requires tools that can assist control centres in their monitoring or control functions. These include links between control centres and links between control and information centres, allowing traffic data and information to be exchanged, or

strategies to be jointly implemented. The linking of control or information centres is an issue closely related to system architectures, to data exchange formats and standards and to inter-agency cooperation (legal, institutional and organizational aspects).

Control and information centres have been successfully linked in a number of projects, for a variety of purposes:

- in order to harmonize traffic information which is subsequently provided through a number of means and user interfaces (CAPITALS/Paris);
- in order to implement public transport priority (UTC-public transport control centres, the EUROSCOPE project, the Genoa, Southampton and Strasbourg site, the QUARTET PLUS project, the Turin site);
- in order to implement re-routing strategies across borders (the HANNIBAL project, the Alps tunnel crossings);
- in order to implement common strategies on the urban and motorway networks between the UTC and the motorway control centre (the EUROSCOPE project, the Strasbourg site).



The DATEX data dictionary or customized versions of it have been used in order to exchange traffic data (HANNIBAL, CAPITALS/Paris, EUROSCOPE/Strasbourg, TABASCO/the Scottish site). Special bodies and special agreements have been established in order to handle the organisational problems related to such interlinking activities (the SCOTIA public-private partnership in TABASCO, the interchange agreement between French and Italian motorways in HANNIBAL).

Finally, traffic data exchange and interlinking of traffic information centres is a key element for the interurban applications of traffic management and traffic or multimodal information (the INFOTEN project, the ENTERPRICE project).

5. NEXT STEPS

5.1 *Ground covered - Remaining gaps*

From the review of the work which has been undertaken, it can be said that the main emphasis was on the demonstration side, rather than research and the development of new technologies. In fact all the projects of the area were demonstration projects (either directly demonstrating systems and applications or indirectly linked to demonstration projects).

In the domain of traffic monitoring (including modelling and forecasting, and incident detection) applications giving short or medium term predictions or giving the status of traffic on the network and detecting congestion and incidents have been implemented and tested. The use of dedicated sensors (radar and video) has also been demonstrated for purposes of incident detection, and is being demonstrated for enforcement and policing of violations (video). The use of floating car data however has been limited to one site only and constrained to the data collection and analyses only.

In the urban context, dynamic control systems have been demonstrated. The integration of dynamic control with information and guidance (re-routing strategies) has been demonstrated, and the extra benefits from this integration have been shown. The integration of dynamic control with public transport priority has confirmed the benefits for public and private transport. The integration of information and guidance (diversion strategies) with incident management has also been shown. Control strategies with special focus on the environment however have not really been tested.

In the interurban context, information and guidance (diversion) strategies have shown benefits (related to congestion, incident management and adverse weather conditions). Emergency management, especially concerning incident detection and management has been demonstrated in a few sites. Ramp metering (in one site) has also shown benefits, especially when integrated with information and guidance or even with dynamic control of the adjacent (urban) network. Speed control and lane control applications have not been among the applications demonstrated in the area projects. As in the urban context, management strategies with special focus on the environment have not really been tested.

Models and decision support tools for strategy implementation have been enhanced and tested in the urban and interurban context. Links between control centres, using standard exchange formats (DATEX or customized versions of it) have also been tested and organisational arrangements agreed upon.

In a few cases, impacts on traffic and user acceptance have been evaluated. Impacts on the environment have simply been estimated on the basis of traffic impacts (in a rather limited manner). New modelling tools for the assessment of impacts on the environment have not emerged. The issue of safety implications has not really been investigated in depth.



5.2 *Need for further research*

As most of the projects of FP4 are reaching completion, certain issues of interest to the area concerning the needs for further research are already starting to emerge. These include

- the possible switching between UTC systems (fixed time plan-adaptive systems);
- the automatic implementation of strategies;
- the overall concept of Urban Traffic Management and Control and Regional Control Centres;
- more detailed research into methodologies (including models and algorithms) now that the enabling technologies are becoming available;
- the demonstration of forecasting tools for interurban networks which have become available;
- the further integration of systems.

The topics not covered in depth (or at all) according to the previous section 4.1, and section 2.7, also need research or further research (e.g. control strategies with special focus on the environment and automatic behaviour monitoring tools). Research into impacts and driver response to management strategies (especially route choice in diversion strategies) also needs to be taken further, especially in terms of demonstration.



6. CONCLUSIONS

The FP4 is nearing its completion. The Transport sector workplan of the TAP, for the network and traffic management area of the road mode was aimed to cover a number of topics in two lines (one vertical, one horizontal). The emphasis in the work programme was on developing and validating telematics applications which will provide enhanced services to transport users in Europe, through improved efficiency, safety and environmental quality, taking into account European policy objectives. The entire chain was meant to be covered, from data capture and processing, to transmission and reception.

The area of network and traffic management (within the road mode) has indeed developed and validated (or is in the final stages of doing so) applications capable of providing such services to end-users (motorists and other travelers), service providers (mainly control and/or information centres) and infrastructure owners. These applications have been developed in three main groups (control action, information services and emergency management) and on two levels (knowledge of network conditions and management/control action).

For these groups of applications, systems have been built or enhanced in the urban and interurban context, in a variety of situations such as:

- congestion and incidents on urban networks;
- congestion and incidents on motorways (mainly interurban);
- bad weather conditions-road closure;
- emergency situations;
- special events;
- lack of information for end-users.

The impacts and user acceptance of the applications tested have been assessed to a certain extent. The results show improvements for users, especially in the cases of integrated approaches such as instance signal control and guidance, ramp metering and guidance and signal control, signal control and public transport priority.

In relation to the objectives of the research programme relevant to the area, one could say that they have been met to a satisfactory degree. There are of course some topics that have not been covered in depth, and there is still need for further research and development and also for demonstrations (sections 2.7 ,4.1 and 4.2 of this report).

In relation to European policies (particularly sustainable mobility and the information society) work carried out in the area does in fact show that transport telematics can contribute, especially in terms of improving the efficiency of the road network. The dimension of the environment and safety clearly require further work. The same applies to intermodality and the demand management approach.

In relation to the first priority domains of the EU (Council resolution of 28-9-95), the projects of the area, through their research results, are contributing towards the domains of Transport Data Exchange/Information Management and Systems Architecture. In relation to the other applications to be developed as a priority



(Council resolution in the OJ of 11.10.95, and also the TEN-T guidelines) the projects are contributing to On-Trip Information and Guidance and Urban and Inter-urban Traffic Management, Operation and Control, again through their research results, but also through the systems and services that have been developed and are operational. Overall therefore, the area has been successful.



NETWORK & TRAFFIC MANAGEMENT



APPENDICES



Project Identification

CODE is a support action responsible for supporting the concertation activities, undertaking outreach activities and co-ordinating the reporting of the key results and achievements within the Transport Sector of the Telematics Applications Programme.

The Consortium is composed of 6 Partners and 6 Subcontractors:

Partners

Name	Role in the project
Atkins Wooton Jeffreys	<i>Project management UTTF/IUTTF organisation Road telematics reporting Vehicle control reporting</i>
CERTU	<i>Technical Co-ordination Traveller Information reporting Public Transport Operation reporting Traveller Intermodality reporting</i>
Keller & Friedrich Verkehrsforschung und Beratung	<i>CARTS preparation</i>
Heusch-Boesefeldt GmbH	<i>Driver Information reporting</i>
Eratosthenes Ltd	<i>Network and Traffic management rep.</i>
Barcelona Technologia S.A	<i>Demand management reporting</i>

Subcontracting reporters

Name of expert	Company	Area of reporting
Rodolfo PIEDRA	<i>Personal consultant</i>	<i>AIR Transport</i>
Robert TREMLETT.	<i>Personal consultant.</i>	<i>WATERBORNE Transport</i>
Carlo PENTIMALLI	<i>Lab. Fond. G. Marconi</i>	<i>RAIL Transport</i>
Michael FAIRBANKS	<i>Personal consultant</i>	<i>GNSS</i>
Christian RIESENBERGER	<i>PTV Consult GmbH</i>	<i>Freight intermodality</i>
Robert LIBBRECHT	<i>Personal consultant</i>	<i>Fare collection & Integrated payment Automatic debiting & Tolling</i>

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Authors(s)	Christopher Veinoglou	ERATOSTHENES

Written and edited by the Area reporter :

Christopher Veinoglou
ERATOSTHENES
49 Kallidromiou Str.
GR10681 Athens
Greece
Tel : +301-381-7315 (383-3588)
Fax : +301-380-6245
E-Mail : chvei@eranet.gr

Reviewed by the Area Officer :

Antonios Barbas
DG INFSO - B5
200 rue de la loi - BU 29 2/27
B - 1049 Bruxelles
Tel : +32.2.296.35.42
Fax : +32.2.296.95.48
E-Mail: antonios.barbas@cec.eu.int

Issued on behalf of the CODE Project by:

Anna SUNTER
Atkins Wootton Jeffreys
Auchinleck House
Five Ways
UK - Birmingham B15 1DJ
Tel: +44 121 643 9621
Fax: +44 121 643 9688
E-mail: asunter@wsatkins.co.uk



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Appendix 1: Acronyms List

ATT	A dvanced T ransport T elematics
CCTV	C losed C ircuit T ele V ision
CEN	C omité E uropéen de N ormalisation
DRIVE	D edicated R oad I nfrast S tructure for V eh I c L e S afety in E urope
EC	E uropean C ommission
EU	E uropean U nion
FP	F ramework P rogramme
GNSS	G lobal N avigation S atellite S ystem
GPS	G lobal P ositioning S ystem (Satellite)
GSM	G lobal S ystem for M obile T elecommunications
HMI	H uman M achine I nterface
ISO	I nternational S tandards O rganisation
ITS	I ntelligent T ransport S ystems
MOTION	M ethod for the O ptimisation of T raffic S ignals I n O n-line C ontrolled N etworks
O-D	O rig I n- D estination
RDS-TMC	R adio D ata S ystem- T raffic M essage C hannel
RTD&D	R esearch, T echnological D evelopment & D emonstration
RTT	R oad T ransport T elematics
SCOOT	S plit C ycle and O ffset O ptimisation
TAP	T elematics A pplication P rogramme
TERN	T rans E uropean R oad N etwork
TT	T ransport T elematics
UTC	U rban T raffic C ontrol
UTOPIA	U rban T raffic O ptimisation by I ntegrated A utomation
VDS	V ariable D irection S ign
VMS	V ariable M essage S ign
WP	W ork P ackage



Appendix 2: List of Tasks in the FP4 Work Programme

Vertical Line 3, Telematics for Network Management, Operation and Control

All modes

TR3.1 Short-term Management: aiming at the development and validation of telematics systems allowing operators to predict and identify short term problems and take suitable action

TR3.2 Demand Management Systems: aiming at the development and validation of an appropriate mix of tools for demand management (including user charging) in urban and regional environments

TR3.3 Models and Simulation Tools: aiming at the development and validation of on-line simulation tools to support telematics systems for multi-modal traffic

TR3.4 Open Systems Architecture: aiming to create an open systems architecture allowing the various aspects of management, operation and control to act together

TR3.5 GNSS-1: aiming at the development of telematics systems in support of the European contribution to GPS/GLONAS, using INMARSAT III satellites for all modes of transport

TR3.6 GNSS-2: aiming at the development of a technical design for a civil internationally controlled navigation system (GNSS-2), also considering requirements of modes other than air

TR3.7 Passenger Flow Monitoring: aiming at the development and validation of telematics systems to monitor and observe passenger flow systems

Road Specific

TR3.8 Incident Management: aiming at the development and validation of telematics tools to enable integrated approaches to incident management in a range of road network conditions (including machine vision, high performance computing and multimedia)

TR3.9 Network Management: aiming at the design and validation of integrated network management systems, including intelligent network surveillance and control systems and incorporating a framework for handling the many forms of real-time conditions

TR3.10 Intersection and Local Control: aiming at the development and assessment of telematics systems for surveillance and control of local traffic conditions

TR3.11 Multicentre Traffic Management and Control: aiming at the development and validation of telematics systems in an open architecture to enable traffic management and control based on interconnection of multiple centres (urban/interurban, public/private)

TR3.12 Vehicle Classification and Enforcement Systems for Road-Tolling: aiming at the design and testing of the practical reliability of automatic vehicle classification and enforcement systems suitable for multilane automatic debiting and road pricing



TR3.13 Behaviour Monitoring Compliance Tools: aiming at the development and testing of automatic behaviour monitoring, traffic compliance control and enforcement tools, interoperable and compliant to the right of user privacy

TR3.14 Emissions Reduction: aiming at the assessment of the reduction in road transport emissions through the application of telematics technologies. Aiming also to adapt, integrate and validate the use of on-line diagnostic tools as part of an interactive traffic control system

Horizontal Line 6, Validation of Integrated Transport Telematics Infrastructure and Related Applications on Test Sites

Aimed to validate the potential of transport telematics based on services (particularly integrated), to satisfy user requirements in support of the provision of safe, efficient, environmentally sound and sustainable transport, through demonstration projects of an appropriate scale. The validation issues were aimed at considering user response, interoperability of tools, direct and indirect costs and benefits, additive benefits of integration of services (including non-transport services), market potential, and technical, administrative, legal and financial arrangements necessary for successful deployment.



Appendix 3: The Projects and the Sites

CAPITALS (TR 1007) is an urban demonstrator (multi-site, multi application). The project is demonstrating advanced control strategies, traffic management with use of floating car data, long term traffic prediction, links of traffic control with traffic information for harmonization of the information and limited access zones. The sites are Paris, Madrid, Rome, Berlin and Brussels. The project builds upon the achievements of the ATT project CITIES.

QUARTET PLUS (TR 1044) is an urban demonstrator (multi-site, multi-application). The project is demonstrating cooperative monitoring and control strategies, and analysing the transferability of architectures and tools. The sites are Athens, Gothenburg, Stuttgart, Toulouse, Turin and the Midlands authorities in the UK. The project builds upon the achievements of the ATT project QUARTET.

EUROSCOPE (TR 1023) is an urban demonstrator (multi-site, multi application). The project is demonstrating network monitoring, integrated management strategies (with a strong emphasis on VMS guidance and information), incident management, priority measures, links between control and information centres and strategic information systems. The sites are Hampshire/Southampton, Cologne, Piraeus, Rotterdam, Genoa, Strasbourg and Cork. The project builds upon the achievements of the ATT project SCOPE.

TABASCO (TR 1054) is an urban and interurban demonstrator (multi-site, multi-application). The project is demonstrating network control and re-routing, integrated urban and interurban control, and integration of UTC with public transport priority. The project will also be testing the COMPANION incident warning system. The sites are Munich, Glasgow, Edinburgh, London, Amsterdam, Dublin, Belfast and South Yorkshire. The project builds upon the achievements of the ATT projects LLAMD, QUO VADIS and EUROCOR.

CONCERT (TR 1013) is an urban demonstrator (multi-site, multi-application). The project is mainly demonstrating demand management applications. The sites are Barcelona, Bologna, Marseilles, Bristol, Hanover, Thessaloniki and Trondheim. Network and traffic management elements are to be found in the use of VMS for information and re-routing, and bus priority. The project builds upon the achievements of the ATT project GAUDI.

AUSIAS (TR 1006) is an urban demonstrator (single site/multi application). The project is demonstrating dynamic plan generation, traffic modelling, information exchange and information to users. The site is Valencia.



CLEOPATRA (TR 1012) is developing modelling tools for strategies for VMS and in-vehicle re-routing and information. The sites are Turin, Gothenburg, London, Lyon, Stockholm and Toulouse.

COSMOS (TR 1015) is an urban demonstrator. The project is demonstrating congestion and incident management applications, with integration of re-routing and UTC, using the SCOOT, UTOPIA and MOTION control systems. The sites are Turin, London and Piraeus.

HANNIBAL (TR 1028) is an interurban demonstrator (multi-site, multi-application). The project is demonstrating mobility management systems and centres for the world ski championship of Sestriere, and traffic management applications with re-routing for the Alps crossing. The sites are the Lyon-Turin link and the Sestriere region.

INFOTEN (TR 1032) is an interurban demonstrator (multi-site, multi-application). The project is focused on information provision, and the network and traffic management element is mainly through the links between the information and control centres, exchanging data and information. The project will also be testing the COMPANION system. The sites are Bavaria, North Italy, Austria, with links to Switzerland and France. The project includes the INTERMATRIX back-bone and the INFOTEN back-bone, both for traffic and travel information exchange.

ENTERPRICE (TR 1020) is an interurban demonstrator (multi-site, multi-application), mainly focused on information provision. The sites are the Hessen region, the Eurodelta region around Rotterdam, Copenhagen and Switzerland. The network and traffic management element is again through the interlinking of the traffic information and control centres. The project takes advantages of the experience gained through the ATT projects RHAPIT and FRUIT.

DACCORD (TR 1017) is an interurban demonstrator (multi-site, multi-application). The project is demonstrating integrated and Coordinated control for inter-urban motorway corridors and an open system architecture for inter-urban traffic management. The sites are Amsterdam, Paris and the Padua-Venice motorway. The project takes advantage of the experience gained through the ATT projects EUROCOR, DYNA and GERDIEN.

IN-RESPONSE (TR 1030) is an interurban demonstrator (multi-site, multi-application). The project is demonstrating tools and systems for incident detection, prediction, verification and emergency service response, and with different sensor technologies and multimedia telecommunications. The sites are Oslo, Valencia, Eindhoven, Thessaloniki, Munich and Paris.

VADE MECUM (TR 1061) was a feasibility study which ended in 1996. The project examined the future deployment and validation of services in an interurban context. The



site investigated at a feasibility level was the corridor along Ireland, the UK and the Netherlands. Demonstration was not foreseen within the current programme.

VERA (TR 4027) focuses on video enforcement. The objectives include examination of legal and operational issues for the harmonization of video enforcement, the preparation of functional specifications, the preparation and coordination of demonstrations and the dissemination of results to the wider user community. The generic traffic management and control violations for which VERA will examine the use of video enforcement are urban applications (traffic signal, bus lane, speed violations), interurban applications (speed violations) and pricing applications (toll charge violations).

ESCORT (TR 4008) focuses on the development and testing of intelligent intersection control systems. The sites in which this will be done are Valencia, Val de Marne and Milan, in which the same interactive controller will be demonstrated.

**Appendix 4: The Projects and their Contacts**

PROJECT	NAME & CO.	TEL. NO.	EMAIL
AUSIAS	Vincente Sebastian, Electronic Trafic, S.A	+34 96 379 6362	Marques_etra@vlc.servicom.es
CAPITALS	P. Schmitz, Region de Bruxelles Capitale AED Service	+32 2 204 1970	pschmitz@skypro.be
CLEOPATRA	Nick Hounsel, Mizar Automazione Spa	+ 39 11 65 00 411	Nbh@soton.ac.uk
COSMOS	Christiane Bielefeldt, The MVA Consultancy	+44 1620 89 55 25	Chr.bielfeldt@lineone.net
DACCORD	Eric Kroes, Hague Consulting Group, NL	+31 70 34.69 426	epk@hcg.nl
ENTERPRICE	Mr. George Stern	+49.611.366 3443	hlsv-43@t-online.de
ESCORT	Antonio Marques	+34 96 379 63 62	amarques.etra-id@etra.es
EUROSCOPE	Jÿrgen Grotepass, Stadt Kšln	+49 221 221 1485	100433.2635@compuserve.com
FORCE I & II	David Bowerman, ERTICO	+32 2 550 0049	d.bowerman@mail.ertico.com
HANNIBAL	Martial Chevreuil, ISIS	+33 1 30 48 47 70	100730.3112@compuserve.com
INFOTEN	Hans-Joachim Schulz, Heusch/Boesefeldt	+49 89 54 9184 66	Peter.philipps@hh.heuboe.de
IN-RESPONSE	Yorgos J Stephanedes, Transeuropean Consulting Unit of Thessaloniki (TRUTh)	+30 1 825 3777/9	truthsa@athena.compulink.gr
QUARTETPLUS	Vito Mauro, MIZAR Automazione Spa	+39 11 6500 411	100126.56@compuserve.com



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