D’ACCORD

Development and Application of Co-ordinated Control of Corridors

Project TR 1017

Telematics Applications Programme
TRANSPORT

Title: User requirements for DTM applications

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Technical Abstract

The deliverable summarises the user-needs concerning Dynamic Traffic Management systems for Interurban Motorways for the three test-sites participating in the project. First the possible ‘users’ of the system are identified, grouped into user-classes, and a working definition of the system’s users common to the three test-sites is extracted. Then the requirements for integrated and co-ordinated control are analysed given the need for integration and coordination. After that, the participating test-sites (in France, Italy, and The Netherlands) are described, and the user-classes are identified in each of the test-sites. Against the background of existing DTM systems, the user’s requirements are solicited and compared. The common elements are identified, and implications for the functional specifications of the respective DTM systems are formulated.

Four main user-classes have been defined: (a) policy makers, (b) network operators, (c) system operators and (d) drivers. At all test-sites the network and system operators were identified as being the most relevant users of DTM-applications. The user requirements for the demonstrator were equal for all test-sites on four points: (a) data checking and monitoring, (b) traveltime estimation and prediction, (c) short-term traffic forecasting and (d) investigation towards integrated and co-ordinated control. Other requirements were motorway-to-motorway control, rampmetering, human machine interfaces and information exchange between traffic control centres.

Executive Summary

This report is a deliverable of the Fourth-Framework project D’ACCORD. This project is aimed to design, implement and validate a practical Dynamic Traffic Management System for integrated and co-ordinated control of inter-urban motorway corridors.

Given the emphasis within the Fourth framework on tangible and applicable results rather than ongoing research, close attention is paid throughout the programme to the needs of the prospective users of the system, and the extent to which the projects address those needs. For the D’ACCORD project, this means the user-needs of Dynamic Traffic Management (DTM) systems.

The aim of this deliverable is first to unambiguously identify the users, second to extract their requirements and expectations of DTM systems (‘user needs’), and to identify the common elements in these user-needs across the three test-sites. The third aim of this deliverable is to identify what the DTM system should be like to satisfy these user needs, and to formulate implications for the functional specifications of the DTM system.

Identification of users

Among the many stake-holders four main categories of users have been identified based on the requirements they impose on a future DTM system:

- **policy makers**: Policy makers are recognised as a user, because they formulate the strategic goals that tools such as DTM’s should help achieve. Policy makers operate at the strategic level.
- **network operators**: Network operators are bodies that translate the general policies formulated for road systems into practical goals, and co-formulate the operational doctrine. Network operators operate at a tactical level.
- **system operators**: System operators are a distinct user-group because their task is to act on and refine the operational doctrine. System operators work at an operational level, and they actually control the DTM system.
• **drivers**: Drivers are the direct users of the motorway network. Their behaviour can be considered egoistic as they are primarily interested in the most efficient journey for themselves. Clearly, drivers translate society’s need for transport into actual, measurable demand. Due however to the fact that the scope of their individual decision-making is severely limited, they are cast in a more passive role than the other users (without downplaying their importance).

**User needs**

The user needs of the *policy makers* tend to simply consist of the requirement that the executive bodies ‘optimise’ certain aspects of the operation of the transport system, such as performance, safety, accessibility, etc. and to minimise disruptive effects, so as to provide maximum benefit and minimum detriment to society as a whole.

The user needs of the *network operators* are to have a tool for facilitating optimum road use, and to effectively deal with disruptions, at reasonable cost to themselves.

The user needs of the *system operators* are to have a tool that allows them a quick and accurate overview of the traffic situation, and preferable allows them foresee developments, and to assess the impact of DTM measures.

The user needs of the *drivers* tend to be simply having the best possible service, and the best possible information when service is suboptimal to be able to reliably schedule or otherwise optimise their use of the road.

**User needs for the demonstrator**

For the demonstrator a number of specific user needs have been identified. The user needs are shown for each of the test-sites separately in the table below. The table clearly shows the common user needs for data checking and monitoring, the need for traveltime estimation and prediction, the need for short-term traffic forecasting and the need for an investigation towards the integrated and co-ordinated control. Additionally a number of site-specific user-needs have been identified.

<table>
<thead>
<tr>
<th>x=outside D’ACCORD, -=not applicable</th>
<th>Amsterdam</th>
<th>Paris</th>
<th>Padua-Venice</th>
</tr>
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<tbody>
<tr>
<td>Data Checking / Traffic Monitoring</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Traveltime Estimation and Prediction</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Short-Term Traffic Forecasting</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Human Machine Interface</td>
<td>x</td>
<td>x</td>
<td>✓</td>
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<tr>
<td>Connection between TCC’s</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Motorway-to-Motorway Control</td>
<td>-</td>
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<td>-</td>
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<td>Rampmetering</td>
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<tr>
<td>Investigation towards Integrated and Co-ordinated Control</td>
<td>✓</td>
<td>✓</td>
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</tbody>
</table>
1. Introduction and Framework

1.1. D’ACCORD framework

The D’ACCORD project participates in the Transport Sector of the Telematics Applications Programme which is carried out for the European Commission - DGXIII.

The main objective of D’ACCORD — Development and Application of Co-ordinated Control of Corridors — is to design, implement and validate a practical Dynamic Traffic Management System (DTMS) for integrated and co-ordinated control of inter-urban motorway corridors. An additional objective is to further develop an open system architecture for inter-urban traffic management.

This deliverable is part of Work Package WP03: User Requirements. This work package forms the first step in the project life-cycle: the Analysis of User Requirements. Work Package WP03 will produce two deliverables. This deliverable (D03.1) will deal with the user requirements for Dynamic Traffic Management Applications, while deliverable D03.2 will deal with the user requirements of System Architecture.

1.2. Objectives

The objective of this work package is — as formulated in the Technical Annex 1 — to assess the needs for Integrated Dynamic Traffic Management.

This work package provides the detailed objectives for the project. It’s aim is to specify what exactly the users want to achieve, how they intend to achieve it and how they are going to assess, at the end of the project, how successful the project has been. This work package provides the key inputs for both the orientation of the application work, the architecture work and the evaluation part at the end of the project.

This deliverable will deal with the user requirements of operators for DTM applications. These DTM applications will have to be fully implemented, applied and evaluated within the three year duration of this project. These applications relate to traffic instruments that are already operational or will be so very soon, and can be integrated and applied in the network management system without delay.

1.3. Structure of the deliverable

The three testsites within D’ACCORD are quite different in many ways. Especially with respect to the users involved at the testsites and their particular roles the differences are such that a general approach was no alternative. For this reason the user requirements have been dealt with separately for each of the testsites.

After this introduction, chapter 2 will present a categorisation and definition of users. For each of the testsites this categorisation may be adapted to suit the specific local situation. In chapter 3 the requirements for integrated and co-ordinated control are analysed given the need for integration and co-ordination. The requirement for integrated and co-ordinated control itself follow from the determination of the individual testsites. In chapter 4, 5 and 6 the user requirements for the individual testsites are determined. In each chapter the current and planned situation is presented, the relevant user groups are identified, short and long term requirements are determined for these groups and the requirements for the demonstrator within D’ACCORD is derived. Finally chapter 7 will present a synthesis of the user requirements for the project as a whole and it will also sketch the relation with the next step in the project life-cycle.
2. USERS OF DYNAMIC TRAFFIC MANAGEMENT APPLICATIONS

In order to determine the functionality of a system, it is necessary to determine what the (future) users of the system expect from it. One of the first steps therefore is to determine who the users are and what their characteristics are. In order to effectively describe the user requirements it is beneficial to categorise the users in groups based on common characteristics. In this chapter a categorisation of users will be presented which will be used for the determination of the user requirements for both the DTM-application as well as the system architectures.

In this chapter first of all a definition of users will be given. The following paragraph will examine useful characteristics on which a categorisation may be based, and finally the categorisation of users will be presented.

2.1. Definition of users

Users are very divers and one could argument that they cannot be captured in one single definition. On the other hand, there is no need to find one single definition, as long as their is an objective comprehension of what a ‘user’ represents.

One way of describing users is:

Users are “the humans on whose behalf the system is developed”

In a broad sense this might include any of the following groups of users:

♦ National Authorities,
♦ Regional Authorities,
♦ Municipal Authorities,
♦ Road owners,
♦ Traffic managers,
♦ Network operators,
♦ Police, emergency services,
♦ Maintenance-crews,
♦ Freight-organisations,
♦ Road-users,
♦ Researchers, etc.

To determine the user requirements separately for all these groups —and those not yet mentioned— would be a major undertaking. However, although these groups of users are all quite different, they also have many characteristics in common.

2.2. Common characteristics

The characteristics —and therefore the user needs— of the groups mentioned in §2.1. substantially overlap. For a useful categorisation of user groups, the common characteristics must therefore be identified that functionally divide user needs for dynamic traffic management applications and system architectures.

Two such characteristics are:

♦ perspective
♦ area-size
For DTM-application and system architectures a difference in perspective can possibly lead to different user needs. Users with a short term perspective are hardly interested in systems that will solve problems in the far future. They want immediate results. Likewise, users with a long term perspective are satisfied when problems are solved in the long run. Next to perspective also the area-size plays a role in differentiating the user needs for DTM application and system architectures. A user that governs a large area naturally has different user needs than the one that is only interested in a small part of it.

Concerning perspective and area-size a classification in four groups will be used:

1. **Policy Makers**
   - long term perspective (years, decades)
   - large area (national)

2. **Network Operators**
   - medium long term perspective (months, years)
   - network-size area (regional)

3. **System Operators**
   - short term perspective (days, weeks)
   - corridors-size area (local)

4. **Drivers**
   - very short term perspective (the moment, a journey)
   - journey-size area (route between the origin and the destination)

**Policy Makers**: These are the Public Authorities (either regional, national or inter-national). The objective of Policy Makers is to provide a cost-effective, safe and efficient transportation system. Their objectives have a long term perspective and will reflect their vision and ambition. The targets set by these users are fairly abstract, such as: 10% less congestion in 2000, 20% less accidents in 1997, etc.

**Network Operators**: These are the managers of a network. The objective of Network Operators is to translate the policies into practical plans and study programs, and thus provide a cost-effective, safe and efficient transportation system. Their objectives have a medium long term perspective. Most of their user needs (towards DTM) will arise from the need to improve the efficiency of the transportation system and thus realise a so called ‘working’ system. The cost-effectiveness and safety will form the boundaries between which the user needs can be realised. In this case user needs will be defined in terms of functionality’s. The standard terms are 'Section Traffic Control', 'Intersection Traffic Control', 'Network Traffic Control' and 'Localised Area Traffic Control'.

**System Operators**: This is the crew that operates a traffic control centre. The objective of the operators is the day-to-day running of a safe and efficient system using the facilities that are provided by the Network Operators. They have a short term perspective. Their main concern is the efficient and safe running of the system/facility and thus to realise a so-called ‘workable’ system. User needs will range from specific functionality’s (ramp meters) to ergonomics (Human Machine Interface).

**Driver**: These are the individual road-users. Each driver has only his/her own personal needs of the moment to consider. This ranges from efficient throughput (smallest travel time) to the road-environment (good pavement) and personal preferences.

One might argument that some users mentioned in § 2.1 do not completely comply with the above categorisation (police, emergency services, freight organisations). The police and the emergency services are grouped under the system operator and the freight organisations are grouped as driver (Road-user). In the determination of user needs for each testsite a further distinction can be made, but for now the 4 groups will suffice.
3. USER REQUIREMENTS FOR CO-ORDINATED CONTROL

This chapter addresses user requirements for co-ordinated control on a general, site-independent level, with particular emphasis on periurban and interurban networks. After clarification of the notion of co-ordinated control in §3.1, the scope of the user requirements analysis for this chapter is outlined in §3.2. The background of evolving general requirements for co-ordinated traffic control are presented in §5.3, while §5.4 is deals with the specific user requirements for each considered user group.

3.1. The Notion of Co-ordinated Traffic Control

3.1.1. Traffic Control Objectives

The first reason for introducing traffic control measures at urban junctions was in order to enable the safe crossing of conflicting traffic streams of vehicles and/or of pedestrians. In the era of mass individual mobility, it became apparent that traffic controllers may also be used to maximise traffic efficiency, initially in the urban network and later also on motorways. With ever increasing traffic demand, additional objectives, including air pollution, noise, and specific operational requirements, had to be taken into account. Typically, the employment of traffic control measures evolves from single, isolated, fixed-time measures towards multiple, co-ordinated, real-time (traffic responsive) control. This evolution is facilitated from parallel continuous achievements in methodological (optimisation, automatic control, artificial intelligence) and technological (communications, computing, information technology) areas that lead to the emerging era of Transport Telematics.

3.1.2. The Traffic Control Loop

A traffic control system may be schematically represented as shown in Figure 3.1, whereby the traffic process may be anything from a single urban junction to a whole traffic network; typical disturbances may include traffic demand, incidents, and weather conditions and may be partially measurable or predictable; measurements are usually occupancies, traffic volumes and mean speeds at specific locations; objectives address safety, efficiency, environmental aspects and specific operational needs; finally control measures may be of the same or different kinds, local or distributed, etc. It is the task of the control strategy to determine the control measures based on real-time and/or historical measurements so as to achieve to a satisfactory degree the control objectives despite the influence of partially unknown and partially measurable or predictable disturbances.

If there is only a single control measure applied to a particular location (e.g. a local ramp metering system), the scheme in Figure 3.1 may be readily used to represent the individual control components. Consider, however, two local ramp metering systems applied to two respective consecutive ramps of a motorway. Figure 3.2 makes clear that both controlled subsystems interact which each other, i.e. the control results of subsystem 1 act as a disturbance on subsystem 2 and vice versa. The situation may become more complicated if we consider a whole motorway axis with many consecutive subsystems or even a whole motorway network. Finally, inclusion of further control measures (like variable speed limits, Variable Message Signs (VMS) providing guidance or information, etc.) acting on the same traffic process as the ramp metering measures (Figure 3.3), leads to a highly complex overall control environment. The complexity arises not only from usually not considered mutual interactions, but also from partly different data requirements, separate data bases and/or communication means, and in some cases also from different involved administrations.
3.1.3. Co-ordinated Control

Historically, control measures were gradually introduced into the urban and/or motorway networks with partially independent or even conflicting objectives. Taking again the example of ramp metering, one may distinguish:

- Local ramp control
- Motorway axis ramp control
- Motorway network ramp control.
Figure 3.3: Multiple control measures

Clearly, the different ramp metering installations should ideally act in co-operation rather than to the detriment of each other. Moreover, different control measures (VMS, variable speed limitations) should act in a way that maximises their synergetic effects and minimises their mutual interference.

It is the declared objective of co-ordinated control to harmonise the action of control measures within a defined traffic entity, so as to maximise the overall control efficiency with regard to the specified overall control objectives. The considered traffic entity in the motorway context may be a motorway stretch, a motorway axis, or a whole motorway network. The considered control measures may be different installations of the same type (e.g. several ramp meters) and/or multiple control measures (e.g. ramp metering, VMS control, variable speed limitation), all acting on the same traffic entity.

3.1.4. Co-ordinated Control within D’ACCORD

D’ACCORD will develop generic, co-ordinated control tools for periurban motorway traffic networks including a number of different control measures (ramp metering, motorway-to-motorway control, VMS, VDS, route guidance, variable speed limits) along with their implementation and demonstration at the project sites.

3.2. Scope of User Requirements

The present chapter 3 addresses user needs related to co-ordinated control of periurban motorway networks on a general, site-independent level. This means that the corresponding investigation is not the outcome of interviews, inquiries, etc., of real users but it rather addresses an abstract periurban motorway network to analyse different user requirements in a deductive rather than in an inductive way. Nevertheless, it was the basic objective of this investigation to identify typical requirements of different user groups, that are representative for most periurban motorway networks around Europe. This investigation is a combined synthesis of views, experiences, and conclusions of all D’ACCORD partners, i.e. of network managers, network operators, researchers, system developers and, last not least, drivers.

In accordance with the rest of this report, the investigation of this chapter explicitly addresses four distinct user groups:

- Policy makers
- Network managers
- Network operators
- Drivers.
In addition, for this particular chapter, the according research and development needs will be explicitly addressed. In fact, co-ordinated control is a medium-term endeavour that did not start with D’ACCORD and will not be completed within the lifetime of D’ACCORD. Progress in this direction is ensured via numerous efforts both within and outside the Transport Telematics Programme. Therefore, when analysing user requirements, it is legitimate to include research and development requirements that will ensure further progress beyond the lifetime of D’ACCORD, and in fact reflect the user requirements of tomorrow.

3.3. General Requirements Background

3.3.1. Features of Control Measures

Most of the control measures to be considered in the RTD and demonstration work within D’ACCORD are not new, neither for the project sites nor on a European level. The main features of each one of these measures are summarised in the following.

Ramp Metering: Ramp metering was first introduced quite massively in the USA European installations are known in France, The Netherlands, United Kingdom, and Germany. The USA applications were reported to mainly aim at improving the merging process and redistributing traffic demand in space and time. Efficient ramp metering strategies (ALINEA, METALINE) were found in previous European projects (CHRISTIANE, EUROCOR) to additionally decrease substantially the total time spent and to slightly increase the total served demand. Although co-ordinated control was not found to substantially improve traffic conditions on an urban motorway axis, generalisation of ramp metering at a network level, along with advanced coordination strategies, is very likely to drastically improve both recurrent and non-recurrent traffic conditions.

Motorway-to-Motorway Control: Motorway-to-motorway control installations were reported to dramatically improve traffic conditions at very busy motorway junctions in the USA, streamlining traffic operations and helping to avoid deadlock conditions. No installations of motorway-to-motorway control are known in Europe. This control measure has an obvious similarity with ramp metering and an overall coordination is very likely to provide an even more powerful tool for combating traffic congestion in urban motorway networks.

Variable Message Signs (VMS): Europe, France and Germany are the countries with the earliest and most comprehensive installations of VMS providing information and/or guidance to drivers. This control measure aims at full exploitation of the network capacity, particularly in presence of non-recurrent congestion. In the last five years, largely thanks to the Transport Telematics Programme, successful application of VMS was reported from virtually all EU countries, though with partly varying declared objectives and utilised messages. Combined application of VMS with other control measures (e.g. ramp metering) to one and the same motorway site was reported only in very few cases (mainly in France). No co-ordinated action of VMS with other control measures, based on common or harmonised objectives and taking into account the mutual interactions, was attempted so far.

Individual Route Guidance: Individual route guidance is likely to become a widespread control measure in the near future. Though its impact is similar to the one of VMS, several particularities arise for this control measure, like, for example, the possibility of high-resolution guidance of traffic substreams with particular destinations, or its commercial character calling for particular consideration of equipped vehicles. A number of both organisational and technological issues have still to be resolved before a full-scale integration of route guidance with other control measures can be envisaged.

Variable Speed Limitation: Variable speed limits aim at homogenising the traffic flow on motorway stretches, and eventually reduce the risk of congestion. Moreover, under certain conditions, a slight increase of traffic throughput has been reported. Most variable speed
limitation installations are known from Germany and The Netherlands. To the best of our knowledge, no combined or co-ordinated application of variable speed limits with any of the aforementioned control measures has been attempted so far.

### 3.1.2. Background Material

Design and application of co-ordinated control for periurban motorways requires availability of a number of skills, experiences, and tools that have been acquired by the project partners through their previous activity, notably within their previous involvement in the DRIVE and DRIVE II projects CHRISTIANE, EUROCOR, DYNA, and GERDIEN. More precisely, available background material may be classified as follows:

- **Integrated modelling tools** have been developed at various levels of modelling detail within the projects CHRISTIANE, DYNA, GERDIEN, and EUROCOR. These models incorporate the combined impact of various control methods on a motorway network, and are a valuable tool for assessment of co-ordinated control strategies of various kinds, as well as for real-time prediction of traffic conditions.

- Preliminary **co-ordinated control** approaches have been developed mainly within the projects EUROCOR and DYNA. They will be further enlarged, tested, and demonstrated at the D’ACCORD sites.

- **Implementation concepts** for co-ordinated control of periurban motorway networks were developed mainly within EUROCOR, as well as by the involved network administrations, and will provide a basis for large-scale demonstrations within D’ACCORD.

- **System architecture** issues were the main concern of the project GERDIEN. They will be further developed in the specific context of co-ordinated control of periurban motorway networks as a valuable frame for the planned demonstrations at the D’ACCORD sites.

### 3.4. Specific Requirements

This section addresses user requirements related to co-ordinated control of periurban motorway networks. The exposition will consider each user group separately and will focus on the added value provided by the coordination of various control measures.

#### 3.4.1. Policy Makers

Policy makers are interested in installing a cost-effective, safe, and efficient transportation system. The construction of periurban motorway networks was a major policy makers decision with a major impact on land use, urbanistic and economic developments. From the transportation point of view, motorways were conceived in the aim of enabling unlimited individual mobility without any of the delays experienced in urban networks due to traffic lights and congestion. However, the exponential increase of car ownership and the high population density in metropolitan areas rendered the initial plans obsolete and call for suitable control measures to combat recurrent and non-recurrent congestion in periurban motorway networks.

A major concern of policy makers is to satisfy (or at least to not dissatisfy) their electorate. This may have a negative impact on some control measures, that may be effective from a traffic engineering point of view, but in some cases may be felt by the drivers as a limitation of their freedom, e.g. ramp metering, variable speed limits, or guidance systems. Moreover, as motorway networks typically extend over a large surface, conflicting interests of different regional representatives may have to be resolved, before a network-wide policy can actually be implemented.

Policy makers are making their decisions taking into account a number of different, partly competing aspects. In order to support their decision making, some figures that assess the
expected impact of according measures should be provided. Regarding co-ordinated motorway network control, it is generally believed that the coordination of different control measures will increase efficiency and safety of traffic flow and reduce environmental pollution. However, no quantitative results, no convincing demonstrations, and no guidelines are available at this stage.

Another issue for policy makers is the transferability of the developed systems, i.e. easy application of successful coordination measures to other sites.

In summary, general requirements of policy makers call for:

- Implementation of co-ordinated control to the extend that it positively influences traffic conditions.
- Serious consideration of the opinion of directly affected users.
- Suitable concertation mechanisms for early resolution of related regional or administrative conflicts.
- Quantification of the expected positive impact of co-ordinated control along with guidelines concerning its development and deployment.
- Transferability of co-ordinated control systems.

### 3.4.2. Network Managers

Network managers translate policies into practical plans within a medium-term perspective. Because transportation policies may in some cases only suggest target levels concerning congestion and mobility, network managers may have to make decisions on the concrete measures to be implemented so that the targets are met without violating their available budget. To facilitate their decision making, network managers need to know, in much more technical and economical detail than policy makers, what is the probable impact of candidate control measures and of their coordination. This implies early assessment, verification, and demonstration of well-defined co-ordinated control systems.

Network managers are moreover interested in various technical and organisational aspects of co-ordinated control measures, such as:

- Maintenance needs: is co-ordinated control likely to increase or decrease the maintenance cost for the according administration?
- Reliability and vulnerability of control installations.
- System architecture: is co-ordinated control feasible with an according extension of the existing control and surveillance infrastructure, or does it require a completely new implementation concept?
- Qualification of operating staff: does co-ordinated control increase the required operational skills? Is it likely to increase or decrease the required number of operators?
- Extensibility: is it possible to easily (i.e. with low development cost) extend the co-ordinated control concepts to other measures and/or to larger network parts?
- Organisational issues: what kind of co-operation with other regional administrations, the police, hospitals, and further institutions is necessary for the implementation of co-ordinated control?
- Flexibility: co-ordinated control should be easily adaptable to modifications of the control goals and should take into account specific constraints regarding the distribution of traffic demand in space and time, the permissible load of particular areas or subnetworks etc.
3.4.3. System Operators

System operators are responsible to run the system on a day-to-day basis. The employment of various control measures in a motorway network increases the possible interactions and mutual interferences and hence the complexity of the operators’ task. Therefore, the system operators have a major interest in the application of co-ordinated control concepts that streamline operations and minimise mutual interferences in an automatic way. Moreover, system operators have a major interest in a harmonisation of the pursued control objectives which is also a prerequisite for the development and application of co-ordinated control. Naturally, the higher efficiency in meeting the control objectives, that is potentially achievable with control coordination, is in the centre of interest of system operators.

On the other hand, the employed co-ordinated control concept should take into account particular requirements of system operators such as:

- An HMI (Human-Machine-Interface) that visualises in an ergonomically efficient and flexible way the current system operation and that enables direct operator intervention when necessary.
- The co-ordinated control should be sufficiently automatic, reliable, and efficient to release the operators from frequent interventions.
- Precise rules should be established that regulate the conditions for operator interventions.
- The decisions of the co-ordinated control system should be sufficiently documented to be understandable to the system operators. This may require operators involvement at an early stage and operators training at the final stage of the co-ordinated control system development.
- The co-ordinated control action should be conceived so as to minimise violations or other kinds of incorrect behaviour of drivers.

3.4.4. Drivers

Drivers are the direct users of the motorway network. It is quite accurate to consider their behaviour as an egoistic one, or, in a game-theoretic terminology, as a competitive behaviour for limited resources against all other drivers. In the case of commuters, this view leads directly to the celebrated user optimum with regard to route choice. Because the user optimum is generally different from the system optimum, drivers may be viewed to compete with the control system also.

Drivers are primarily interested in an efficient (essentially quick) journey for themselves. They may obey to obligatory control measures (e.g. ramp metering or variable speed limitations) if they are sufficiently informed about the necessity of these measures and/or if the immediate reasons for the control measures are apparent to them and/or if the control measures are sufficiently enforced. Nevertheless, some drivers may attempt to circumvent the controlled stretches, e.g. by taking different routes, but this is a predictable behaviour (user optimum) that may be taken into account (and actually be exploited) by sophisticated co-ordinated control strategies.

Under recurrent congestion conditions, drivers are interested in receiving information that will enable them to supposedly optimise their individual route to their destination and will lower their psychological stress (e.g. in case of provided travel time predictions). Under non-recurrent congestion conditions, drivers may be interested in route guidance under the constraint that a possible indicated deviation will not disadvantage them compared with non-followers. Because route guidance measures cannot be enforced, the mentioned constraint represents a constraint for the control strategy that makes the guidance decisions.
Co-ordinated control of multiple measures in a motorway network is aimed at improving traffic conditions and may therefore be primarily understood as a service to the average driver. Nevertheless, if the outlined interests of the individual driver are not taken into account sufficiently, the competing driver behaviour may jeopardise the potential benefits. Hence, the precise objectives and constraints of the co-ordinated control strategy should be carefully chosen so as to reflect the individual driver expectations.

3.4.5. RTD Needs

The development and deployment of co-ordinated control of motorway networks is a longer procedure than the lifetime of D’ACCORD. As outlined in §3.1.2) above, D’ACCORD developments and implementations are based on previous achievements in various respects. The planned demonstrations will clearly mark an advancement compared to the situation of today. Nevertheless, administrative, organisational and methodological limitations do not allow the implementation and demonstration of a fully co-ordinated control strategy in the field. On the other hand, in order to prepare further advancements and future implementations of co-ordinated control, it is necessary to develop the corresponding advanced control strategies at this stage. For this reason, D’ACCORD is prepared to follow a dual path:

To apply co-ordinated control concepts in the project sites as far as the organisational, administrative, methodological and budget constraints allow.

To further develop and demonstrate —via simulation— advanced co-ordinated control strategies to enable future advancements.
4. TESTSITE AMSTERDAM

In this chapter the Amsterdam test-site is described and the user requirements are determined. The work in this chapter is based on communications with the relevant operators and on very recent material dedicated to the preparations of plans for Dynamic Traffic Management in the Amsterdam region.

First an overall description of the test-site is given, with the current and planned measures for traffic management. After that the various types of user are identified, and an account is given of their stated needs, both in the long and the short term.

4.1. Overall description of test-site

The Amsterdam test-site for D’ACCORD is part of the EURODELT-testsite, an initiative of the Netherlands Ministry of Transport, Public works and Water management (RWS). While the EURODELT-testsite covers a wide range of topics, the Amsterdam test-site is focused on motorway traffic.

With respect to road-traffic test-sites, a distinction is made between the passive collection of traffic-information, and dynamic traffic management. The D’ACCORD project concentrates on dynamic traffic management.

4.1.1. Location and network description

The Amsterdam test-site consists of the Amsterdam Orbital Motorway (AOM) and may include certain parts of the regional motorway network. An overview of the Amsterdam test-site is shown in Figure 4.1.

The central feature of the Amsterdam test-site is the Amsterdam Orbital Motorway (the A10). The A10 simultaneously serves local, regional, and inter-regional traffic and acts as a hub for traffic entering and exiting North-Holland. To the North, the A8 motorway feeds into it, carrying a large amount of commuting traffic to Amsterdam. To the Southwest we have the A4 which carries most of the traffic between the North of the country and attractors in the South such as Schiphol Airport, The Hague, and Rotterdam. South of the A10, we have the A9 which forms a bypass for traffic between the Northeast on the one hand and the Centre of the country as well as the region between Amsterdam and The Hague (including Schiphol...
airport) on the other. The A2 connects the A10 to the A9 bypass and connects the A10 with the Centre of the country. Finally, to the Southeast, the A1 connects to the A10, and serves traffic between the North of the “Randstad” and the North and Centre of the country.

The A10 contains two tunnels which effectively divide it into two sections: the “North Ring” and the “Ring West/South/East”.

The network is subject to considerable recurrent congestion, a situation which is expected to continue. Congestion is especially heavy on the North-western and Southern parts of the A10, but less so on the North-eastern part. Due to the network structure, and the current network load, route-choice is a factor of influence on this network, which presents a potential for dynamic traffic management.

Traffic management for this area comes under the Regional Directorate North-Holland of the Directorate-General for Public Works and Water Management, who are responsible for the formulation of the Traffic Management Plan (“Verkeersbeheersingsplan Noord-Holland”) for the regional road network.

4.1.2. Current measures for dynamic traffic management

A number of dynamic traffic management measures have been implemented:

- Motorway Traffic Management (comprising sensors and variable message signs)
- Rampmetering (TDI for Toerit Doseer Installatie)
- park-and ride (P+R) facilities
- dynamic route information panels (DRIP)
- Incident management (IM) (tow trucks held in readiness at strategic points throughout the network)
- a Traffic Control Centre (TCC) in Oostzaan (not shown).

These measures have been implemented individually, but are not, at this stage, incorporated into an integrated system. The current situation is one of ‘Island Automation’. Not all of the dynamic traffic management issues listed above will play an active part in the D’ACCORD project.

4.1.3. Current on-site equipment

The current equipment consists of several systems, which at the moment are only loosely inter-connected. The current on-site equipment is currently controlled from a Traffic Operations Centre. An overview of the existing situation within the Traffic Operations Centre is shown in Figure 4.2 below. The sensors and actuators are shown on the bottom row, the functional units such as DRIP, TDI, detector stations etc. are shown one row up. The Traffic Operations Centre itself is shown on top, with the separate systems installed in it. Each of the systems will now be discussed briefly

The MTM: A data-collection system called the MTM (Motorway Traffic Management) system is currently in place. The system employs inductive-loop detectors every 500 meters. The MTM system is primarily aimed at traffic signalling for various purposes (e.g. road-works warnings, variable speed limit indications) and is closely related to the autonomous Pile-Up Prevention system. Traffic measurements collected by the MTM system are gathered in a central location, where they may be used as input to various model systems.
The MIRA system: The MIRA (Motorway Information in the Region of Amsterdam) system is a data collection system (partly under construction) with inductive loops every 2000 meters. It is built on top of the so-called MONICA (MONItoring CAsco) system. It is expected that a monitoring system with MONICA specifications will be implemented on a national scale.

Variable Message Signs: A number of variable message sign systems are installed on the demonstrator network, which should be distinguished for the sake of adherence to the standard definition of VMS.

Traffic-sign VMS: This type of VMS sign can display a limited repertoire of traffic signs (‘lane free’, ‘lane closed’, ‘speed limit nn’, ‘congestion-warning’) on overhead gantries. It is mainly used to display congestion-warnings (to help prevent accidents from traffic driving headlong into the tail of a sudden congestion), speed-limits (used for traffic calming), and to close lanes (e.g. in case of road-works or accidents). The congestion-warnings are called ‘file beveiliging’ (Pile-up prevention), and they work completely autonomously because of the reaction speed required. Other messages are initiated and controlled by the traffic operator.

Dynamic Route Information Panels: Currently four Dynamic Route Information Panels are operational, which are centrally controlled through a stand-alone computer system (called RIA for Route Information Amsterdam). This system uses MTM monitoring information to calculate queue-lengths on the alternative routes before the tunnels on the East and West side, and displays this information to the traffic entering the A10 Orbital motorway.

Rampmetering systems: Isolated TDI (Rampmetering) systems are installed in several locations on the network. Within the CORA (Co-ordinated Rampmetering) project, tests have been conducted with locally co-ordinated ramp-metering. The test results are not completely unambiguous.

Video cameras: The tunnels are equipped with video camera’s; the video camera’s do not feed into automatic image processing systems, but directly serve the operators.

Park-and-ride facilities (the TESZA system): Park-and-ride facilities are provided by a so-called ‘Transferium’, which is essentially a large parking facility within easy reach of the motorway, and with public-transport facilities. The TESZA system, which consists of variable message signs, is used to indicate the available parking space, and to indicate the route from the motorway to the transferium. In addition to its day-to-day use, the system is regularly used to provide parking space outside the city during special events.
4.1.4. Planned equipment

One of the most important new developments is a new Traffic Management Centre (TMC), which will be located near Velzen (see Figure 4.1). It will replace the previous centres located near the ringroad. In the design of the new centre great emphasis is put upon an open system architecture (following parts of work done in GERDIEN). In general this means that the new system will be modular, have clean and well-defined interfaces and should make use of available standards where possible. For more information on the structure of the TMC, see the deliverable on system architecture (D03.2).

The heart of the new system is the so called Operator Support System (OSS). An overview of the planned architecture is given in Figure 4.3. The OSS itself has no traffic management functions. Currently the traffic management functions are developed in the Central Traffic Management System (CTMS).

The following extensions of the current situation are either planned or under construction:

- a new Traffic Management Centre in the Wijkertunnel near Velzen
- an Operator Support System (OSS)
- extension of the traffic data-collection facilities through the MIRA system
- Central Traffic Management System (CTMS)
- Extension of the DRIP system from 4 to 16 panels. With this extension the need for network wide co-ordination increases.
- Extension of the rampmetering systems. Also here, the need for co-ordination increases.
- Installation of a route-guidance system for Park and Ride facilities in relation with the opening of a Transferium.
- Development of an Incident Management software module.
4.2. Identification of users

The aim of this deliverable is to determine the user needs with respect to dynamic traffic management. In this context we have to note that the division between user classes, as explained in chapter 2, is sometimes blurred because for example the Regional Directorate of North Holland wears two hats so to speak: policy maker and policy implementer.

The introduction of Dynamic Traffic Management follows a policy that is set out by the Ministry of transport, and is refined and implemented by the Regional Directorate of North Holland. In terms of the user groups defined in the main text of this deliverable these constitute the users at the Policy Maker level.

The operational sections of the Regional Directorates belong to the category of Network Operators because they do not make the policies, they implement them. As mentioned above, within the framework of the development of regional dynamic traffic management a new Traffic Control Centre (TCC) will be built in the region. A Traffic Control Centre will feature a traffic manager (as personification of the Network Operator), who has the authority to exert control over traffic flows, and for instance determines whether or not road-works can take place.

The operators of this TCC —in terms of user groups the System Operators— will be direct users of Dynamic Traffic Management instruments.

The individual travellers on the Amsterdam network —the Road Users— are seen as having a somewhat ambivalent position. On the one hand they do not exert direct control on the system, and can be regarded as quantities who’s impact on traffic conditions is to be influenced by dynamic traffic management. On the other hand the entire DTM system is set up to offer them improved road service even if they are indirect rather than direct users of Dynamic Traffic Management.

On balance it was decided not to include them as users of the system in the sense of giving input to the system design since the design requirements of the DTM system stem primarily from the user-requirements of the network and system operators. As long as the resulting system serves the users, they need not be involved in its formulation.

Although it might seem at first glance as if this important category of users is thus excluded from consideration, this is not the case. The road-users’ collective (as opposed to individual)
best interest is represented by the policy makers and the operators through the following policy objective of Dynamic Traffic Management (Netherlands Rijkswaterstaat): “Dynamic Traffic Management consists of influencing the road users, based on the current traffic situation so in such a way that the travel-time for road users is as short and predictable as possible. The way to ensure optimum travel conditions is to maintain optimal functioning of the main road network”. As individual road users cannot be relied upon to be either equipped for, capable of, or interested in optimising anything but their own itinerary, they generally have no direct contribution to make to traffic management other than to be co-operative, sensible, and ‘manageable’.

For these reasons consideration of user-groups for the Amsterdam Testsite can be limited to the following two categories:

♦ Network Operators
♦ System Operators

4.3. Overview of user needs

The user-needs of the user groups identified (Network Operators and System Operators) are best understood in the light of the tasks that have been set for them, more often than not by the policy makers. For this reason we will briefly touch upon the policy objectives, even though these have no direct links with the project as formulated.

The policy objectives (i.e. user-needs of the Policy Makers) which set the environment within which the Dynamic Traffic Management operations of the Network Operator and System Operator take place can be summarised as follows:

- guarantee the availability of the main road network
- increase the reliability of (the service level of) the road network
- promote selective treatment of distinct groups of road users
- increase local throughput of the network of main roads.

Such policy objectives operate at a higher level of abstraction than is addressed in the D’ACCORD project. These policy-objectives are subsequently used by the Network Operators to formulate their own tasks and those of the System Operators. These tasks can be grouped under the term “Dynamic Traffic Management”. Finally the tasks of the Network and System operators induce the user-needs which operate at the abstraction level of the D’ACCORD project, and determine the design and operation of the demonstrator.

The (tentative) ‘escalation ladder’ in Table 4.1 is used as a guide-line to define DTM goals and to select its measures.

In the given range of road conditions the tasks are in general quite similar. However, they will be presented once more together with the measures/instruments that can be used to fulfil the requirements.

Additionally, DTM provides the Operators with tools that permit them to select from a palette of possible DTM policies.
Road conditions | Requirements/objectives derived from the Policy Makers
--- | ---
demand << capacity<br>free-flowing traffic | no specific requirements

demand between 80 and 100% of capacity<br>unstable traffic flow | prevent / delay the onset of congestion

demand > capacity<br>traffic jams | minimise the extent of the congestion and its effects on the system as a whole
- prevent gridlocks
- resolve the congestion(s)

demand >> capacity<br>gridlock | resolve the congestion / gridlock

Accidents | implement measures requested by police to maintaining public safety

Table 4.1: Road conditions and the requirements from a Policy level.

<table>
<thead>
<tr>
<th>objective</th>
<th>Dynamic traffic management tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>prevent / delay the onset of congestion</td>
<td>• homogenisation (traffic calming)&lt;br&gt;• ramp metering&lt;br&gt;• mainline metering&lt;br&gt;• rerouting (to use excess capacity on the network)&lt;br&gt;• general information provision</td>
</tr>
<tr>
<td>prevent gridlocks and resolve congestions</td>
<td>to optimise throughput&lt;br&gt;• ramp metering&lt;br&gt;• mainline metering&lt;br&gt;• rerouting&lt;br&gt;to manage traffic jams&lt;br&gt;• traffic information (travel-times)&lt;br&gt;• upstream warnings of traffic jams&lt;br&gt;• route-information&lt;br&gt;• buffer zones</td>
</tr>
<tr>
<td>resolve gridlocks</td>
<td>• close access to crucial intersections&lt;br&gt;• mainline metering&lt;br&gt;• route-information</td>
</tr>
<tr>
<td>emergencies</td>
<td>• incident management&lt;br&gt;• closure of entire roads&lt;br&gt;• compulsory re-routing</td>
</tr>
</tbody>
</table>

Table 4.2: traffic management goals and measures

An important distinction between the usage of different tools is that some lead to a strict user optimum (promoted by dissemination of information) while other will lead to a system optimum whereby the operators have more freedom to define their goals, and may assign priority to certain traffic flows or traffic users at the expense of others (as is the case with traffic control in urban area’s).

In this context we will distinguish between short-term user needs (time-scale coinciding with the D’ACCORD project) and long-term user-needs (time-scale exceeding that of the D’ACCORD project).
The user-needs for the Network and System Operators can be viewed simply as requests for technical assistance in carrying out the measures and achieving the goals as set out in Table 4.2.

**Requirements from the Network Operator**: Since the Network Operator is supposed to find solutions for the policies made by the Policy Makers, the tools that can be used to provide an answer to the policies form a requirement for the Network Operator. The tools must result in a working system which reaches the objectives set out in the policy.

**Requirements from the System Operator**: In his day-to-day work the System Operator is confronted with available tools. Their requirements are that the tools form a workable system. Their requirements concern safety, user interfaces, etc.

### 4.3.1. Short term user needs

Short-term user-needs are defined as user-needs which are to be addressed entirely within the time-frame of the D’ACCORD project, so that they will constitute part of the ‘environment’ in which the D’ACCORD project is carried out. The corresponding time-frame is from the present to three years from now.

The general nature of these user-needs concerns the implementation of the “Eerste fase Dynamisch Verkeersmanagement” (“First phase of Dynamic Traffic Management”), consisting of reactive traffic management systems.

With respect to the short-term user-needs for Network and System operators, we can identify the following user needs:

- Traffic signalling (e.g. incident detection and warning)
- Incident management
- Congestion management (e.g. rampmetering)
- Dynamic Route Information Panels
- Infrastructural measures
- Traffic information (RDS-TMC)
- Usergroup-specific measures
- Traffic monitoring
- the OSS (Operator Support System): a uniform user interface through which a Traffic Operator can receive data from all sensors and drive all actuators, irrespective of the physical location of the operator.

Except for the requirement of integration, embodied by the OSS, this list of user-needs could in principle be addressed issue by issue, without paying heed to the question of integration. The OSS however focuses the need for concentration of all incoming and outgoing data streams in a single system which on the one hand displays the data in an ergonomic way, and on the other hand serves as a convenient interface through which the actuators can be controlled. A sketch of the OSS is shown in Figure 4.3.

### 4.3.2. Long term user needs

The general nature of the long-term user-needs (which fall partly inside and partly outside the time-frame in which the D’ACCORD project is carried out) concerns the implementation of the “Tweede fase Dynamisch Verkeersmanagement” (“Second phase of Dynamic Traffic Management”), and consists of proactive traffic management systems.

The long-term user-needs comprise the following:
• a fully developed, mature and centralised traffic management system
• operational short-term predictions of traffic conditions and travel-time
• a complete monitoring system for the national motorway network (plus roads of lower categories, where needed)
• an operational incident management system for the entire national motorway network
• a system of DRIP’s covering the entire motorway network
• a system of co-ordinated ramp-metering installations
• integrated and co-ordinated control of DVM-instruments
• a RDS-TMC system with national coverage and dynamic route information
• local measures such as user-group specific lanes

Two elements in this list define a marked difference from the short-term user-needs: the wider area that is controlled (a whole network instead of e.g. a corridor or a tunnel), and the lean towards anticipatory traffic management instead of purely reactive traffic management.

Although the precise added value of predictive control in traffic management is still being assessed (see [Transpute, 1996]), in a number of cases its value appears to justify the cost of implementation:
• for DRIP’s which generate strong response
• travel-time information that generates strong response
• route information panels
• coherent predictions for Traffic Information Centres (for area’s up to 120 Km.)
• Traffic Management Decision Support (simulation of the effects of various control measures before they are implemented)
• area-wide network optimisation

From this list a clear user-need for pro-active traffic management in the form an operational, short-term (15-60 Min.) traffic prediction model can be identified.

4.4. User needs for the demonstrator

In this chapter we will list which user-needs may be addressed in the Amsterdam testsite of the D’ACCORD demonstrator. An anticipatory study of possible work on the D’ACCORD demonstrator at the Amsterdam testsite has been conducted, and has identified the following list of user requirements which can be addressed in the D’ACCORD demonstrator:

• on-line advanced automatic traffic monitoring
• on-line short-term traffic forecasting
• on-line travel-time estimation and prediction
• an investigation into integrated and co-ordinated control (network-level)

Concerning the monitoring estimation and predictions, a schematic diagram of the system aimed to address these user-needs stated is presented in Figure 4.4. In this figure, the traffic estimation system is fed with traffic measurements coming from the left, static data (network data etc.) and current time-dynamic data from above. The output of this module consists of a network-wide estimate of the current traffic situation (middle). Shown on the right is the traffic prediction system, which takes the current estimate as an input, supplemented by the available historic data (historic traffic measurements classified by e.g. type of day) and any
dynamic traffic data that may be relevant during the prediction period (such as traffic controls!). The end-product of the system would be a prediction of the future traffic situation on basis of traffic control measures.

A slight adaptation of the system is shown in Figure 4.5, where the system is given a number of scenario’s upon which to predict future traffic conditions. Such a feature could serve the user-need for decision-support as identified in the long-term user-needs.

**prospective system**

![Diagram of prospective system]

*Figure 4.4: Prospective system*

**scenario system**

![Diagram of scenario system]

*Figure 4.5: Overview of a system to investigate scenario’s on-line.*
5. TESTSITE PARIS

5.1. Overall description of FRANCE test-site

The pilot site in France comprises two main parts:

- *The Ville de Paris site*: the Paris urban area and the express ringroad of Paris namely the Corridor Périphérique (C.P)
- *the motorway network around Paris city* (A1 to A13)

![Network](image)

An overview of the "Ile de France" network is presented in Figure 5.1.

There are two main authorities in charge of traffic management:
1. The Paris City "Ville de Paris" operates the Paris inner urban network and the C.P
2. The SIER "Service Interdépartemental d'Exploitation de la Route" operates the motorway network. The SIER is under the authority of the DREIF "Direction Régional d'Equipement d'Ile de France" administration. The DREIF is under the authority of the Transport Ministry.

5.1.1. Ville de Paris Network Description

The construction of Boulevard Périphérique (BP) took place between 1954 and 1974. The main objective of this work was to improve the traffic conditions on the urban network, which was already saturated during peak hours, and to promote the North-South transit traffic by avoiding the transit through the centre of Paris. Before the Boulevard Périphérique was completed, the only North-South transit lanes were the Boulevard des Maréchaux considered as urban lanes producing nuisance to the residents.

The Corridor Périphérique (CP) consists of two parallel beltways around the city of Paris (see Figure 5.2.), each having a length of some 35 km in each direction, and of the connecting radial streets. The outer motorway belt is the Boulevard Périphérique (BP) including a total of 70 on-ramps and 70 off-ramps in both directions. Some of these ramps are the beginning or end points of corresponding motorways that start from or lead to the city of Paris. The inner,
signal-controlled arterial belt is the Boulevard des Maréchaux (BM). The Corridor Périphérique is a central highway facility of the extended traffic network of Ile-de-France. It carries a variety of traffic types, including daily commuters, holiday traffic, and commercial vehicles, and offers connections from Paris to the suburbs and vice versa, between pairs of Paris locations, and between suburbs. Moreover, the CP is used by a non negligible number of through drivers when changing motorways on their far-distance trip.

CP is managed by the Paris town-hall. Two control centres are dedicated for rapid lanes traffic management and urban traffic management (see Figure 5.2). The first control centre is located in the centre of Paris (LUTECE) and its main function is the urban traffic management (intersections). The second control centre is located at Porte d'Ivry which only manages the traffic on the rapid lanes (Boulevard Périphérique). It is important to note that the Boulevards des Maréchaux management is ensured by the control centre LUTECE and that a data exchange in terms of traffic states is going to be implemented in order to coordinate the control strategies between these two central control rooms.

![Figure 5.2. Corridor Peripherique of Paris](image)

The boulevard Périphérique represents 40% of the Parisian traffic for a network surface equal to 2.5% of the overall motorway and urban network of Paris. Today the Boulevard Périphérique is the only complete ring considered as a motorway in Ile-de-France. Linked up to 6 motorways (A1, A3; A6a, A6B, A13, A86), it supports important national and international traffic; it is the main access to the motorways from Paris and the near suburban area.

The number of vehicles served per day is equal to 1.100.000 vehicles for an average travelled distance of 7 kilometres. The trunks represent about 10% of the number of vehicles. In some areas of the southern part (experimental site), this value is 17%.

The OD matrix distribution is divided on an average basis according to Table 5.1 by considering both origins: Paris and suburban area.

<table>
<thead>
<tr>
<th>Destinations</th>
<th>Origins</th>
<th>Suburban area and far beyond</th>
<th>PARIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suburban area and far beyond</td>
<td>30%</td>
<td>30%</td>
<td></td>
</tr>
<tr>
<td>PARIS</td>
<td>30%</td>
<td>10%</td>
<td></td>
</tr>
</tbody>
</table>

*Table 5.1: O/D Matrix*

The ringway of Paris has been a test bed of the field trials part of DRIVE I and ATT Program respectively CHRISTIANE and EUROCOR. On this site, a number of ramp metering and
VMS strategies have been implemented, tested and evaluated. The traffic problems have been identified and analysed.

### 5.1.1.1. On-site equipment

As mentioned before, the CP consists of the urban arterial (Boulevard des Maréchaux), the urban motorway (ringway of Paris) and the corresponding connection roads. These sites are equipped with loop detectors for measuring traffic volumes, occupancies and speeds. On the ringway part, the density of the measurement stations is high compared to the urban arterial (Boulevard des Maréchaux). As a matter of fact, the number of the measurement stations on the whole of the ringway is equal to 142 (71 by traffic direction : internal and external) as indicated in Figure 10. These installations include:

- loop detectors for traffic volume, occupancy and speed measurements
- the traffic monitoring is accomplished by 100 cameras installed on the Boulevard Périphérique
- emergency call : 166 emergency call units are already installed (one every 500 m) for the incident or accident reporting. All calls are received in the central control room
- mobile police : 10 police cars are dedicated to the on site traffic survey
- variable message signs (VMS) : on the Boulevard Périphérique 300 VMS are installed at the carriageway and the critical intersection around the BP and each on/off ramps. Since 1994 (EUROCOR) all the VMS are currently controlled manually from the central room. These VMS are installed respectively on the BP and the Boulevard des Maréchaux in order to perform the traffic control of the CORRIDOR PERIPHERIQUE.

The central control room is equipped with several computer stations organised around the ETHERNET network. Every computer station is dedicated to one or two applications : for example, the real data collection and the traffic monitoring are performed on one Work station. The traffic monitoring (synoptic) of the Boulevard Périphérique is activated by another computer station. On the other hand, the link between the urban central room at LUTECE and the Boulevard Périphérique at IVRY is performed and currently information exchanges between the two central rooms IVRY and LUTECE especially concerning the traffic conditions on the two parallel routes are running.

At this stage, the real data collected is subdivided between 2 control centres : LUTECE for the urban real data collection and IVRY at Boulevard Périphérique centre for the motorway real data collection. A communication link between the two control centres has been established. The traffic state on the BP can be observed from the control centre LUTECE.

### 5.1.2. SIER Network Description

The SIER motorway network covers 515 km (A1 to A13). The traffic management and control are subdivided into four control centres (North, South, East and West). The level of the congestion in the "Ile de France" network (including the CP) represents 80 % of the total congestion in the overall France motorway network.

Since 1988, DREIF has launched a project called "SIRIUS" (Service d'Information pour un Réseau Intelligible aux USagers) aiming at optimising the traffic conditions on the overall motorway network of the "Ile de France" in terms of traffic control (ramp metering, automatic incident detection, lane assignment etc.) and traffic information/guidance given to the users.

Moreover, in order to alleviate the traffic on the CP of Paris, two other motorway rings around Paris are planned (A86 and La Francilienne). At yet, the A86 ring is achieved until to 2/3 length, the rest is planned to be achieved in 1998. With respect to the Francilienne ring, it is planned to be achieved current 21 century.
5.1.2.1. On-site equipment

The East part of the SIER motorway is fully equipped with loop detectors for measuring traffic volumes, occupancies and speeds. The density of the measurement stations is equivalent to the C.P. This equipment consists of:

- Loop detectors (2500) for traffic volume, occupancy and speed measurements
- Video cameras (370) for traffic monitoring
- Emergency phones (every 1000 m) for incidents or accidents reporting.
- Mobile police: 10 police cars are dedicated to the on site traffic survey
- Variable message signs (VMS; 175) for user information

Each control centre is equipped with several computer stations organised around the ETHERNET network. A communication link using ETHERNET network is implemented between the four control centres. All real data collection is stored in the server located at Créteil centre CRICR (Centre Régional d'Information et de Coordination Routière) for the information diffusion to the users.

5.2. Current measures for France DTM

For the two sites, a DTM comprise an internal and external functions. The internal functions consist to the existing control measures either for the urban, ring way, and motorway networks (SIER). The dynamic traffic management measures can be summarised as follows:

- Real data collection
- Traffic monitoring via cameras and « synoptics »
- Urban intersection control: based on expert system (SAGE) for the urban part (Ville de Paris)
- Information Systems via VMS: queue length and travel time display
- Ramp metering (Motorway and CP of Paris)
- Incident detection (Only for motorway network and the ring way of Paris)

With respect to the external functions, a big effort is dedicated to the data exchange between the all System Operators of Ile de France Network. In particular, a network serveur (server « grossiste ») is build including a communication link between the SIER and the Ville Paris for data exchange in terms of traffic conditions (travel time on the ring way and the motorway, queue length, incident, exceptional events etc.) and traffic data.

5.3. Availability of the network for D’ACCORD

In frame of D’ACCORD Project, the two Traffic Management centres will be available. In particular, the following functions will be addressed:

- Real data system
- Traffic information system via VMS
- Ramp metering

With respect to ramp metering control, additional equipment (signal light or others) will be installed in particular for the main lane control (BP/A6) taking into account an important factor: the safety aspect. More details are given in the §5.4.3: system operators.
5.4. Identification of users

As follows from chapter 2, we can distinguish the following four user categories.

1. Policy makers
2. Network Operators
3. System Operators
4. Drivers

5.4.1. Policy makers:

With respect to the France sites, either DREIF and Ville de Paris, the national authority is the Ministry of Equipment, Lodging, Transport and Tourism. This ministry is in charge of defining the policy to be adopted in mean and long term by all the guardianship administrations for the transportation system already implemented or to be implemented in the future. Important to note in this respect is the intervention of the Ministry of Transport Mr. B. PONS during the last inauguration (February 1996) of the SIRIUS system concerning the travel time display on the Ile de France motorway network (see Pons, 1996)

This intervention can be summarised as follows:

- Research and Development of the new technologies must be concentrated on the "Drivers" requirements and in particular the credibility of the information (individual or collective) provided by the system to the drivers.
- Intelligent transport systems must be developed at national and international level and in particular the participation of the site owners to the EEC programs aiming at:
  - The improvement of environmental conditions in the city.
  - The minimisation of congestion areas at critical sections
  - The improvement of network capacity utilisation which leads to reduction of the overall travel time
  - The improvement of route choice during the peak periods where the users expect traffic problems
  - Even in case where it is not possible for the user to change his route, the information of expected waiting time is an important service

These objectives should be accomplished by the guardianship authorities and in particular the Regional Council of Ile de France and the national RD Programs under the authority of the Ministry of the teaching and researches.

5.4.2. Network Operators

In Ile de France, the "Network Operators" is composed by the Regional Council and the DSCR department (Direction de la sécurité et de la circulation Routière). These two main authorities are in charge of defining the modalities and the founding of the program in transportation systems. The objective of Network Operators is to translate the policies into practical plans and study programs (e.g. SIRIUS), and thus provide a cost-effective, safe and efficient transportation system. The "Network Operators" concerns all the departments of Ile de France also.

Two main Research and Development programs are underway:

- SIRIUS : extension of SIRIUS to the West part of Paris
- CARMINAT and INFLUX system development : these systems are dedicated to on-board traffic information systems.
5.4.3. System Operators:

In D'ACCORD Project, the System Operators includes the SIER and the Ville de Paris authorities. As indicated in §5.1.2, the SIER are in charge of the management of the motorway network while the Ville de Paris is in charge of management of the City of Paris including the intersection Control and the ringroad (C.P) of Paris. The two System Operators participate actively in three Projects of the EEC Program: D'ACCORD, IN RESPONSE, CAPITALS.

With respect to D'ACCORD project four France System Operators requirements have been identified:

1. Real time collected data screening (demonstrator planned)
2. Traffic forecasting for travel time estimation
3. Motorway to motorway control and ramp metering implementation (demonstrator planned)
4. Network Simulation tool: "METACOR" which have been developed in frame of ATT Project EUROCOR

5.4.3.1. Real time collected data screening

In general, this work area constitutes a fundamental aspect for any Traffic Management Centre and in particular for any implemented strategies (control or information of the users). The quality of any implemented control strategy is related on one hand to the approach used for the development of the strategy (e.g. open loop, closed loop etc.), on the other hand to the level of accuracy of the real data collected which can be considered as the main strategy inputs.

The main objectives of this work are the qualification of collected data (in real time): detection of the missing and false traffic data and the reconstitution of these missing data.

With respect to the France System Operators needs, this activity will be conducted in frame of D'ACCORD Project and outside D'ACCORD.

Six steps constitute this work:

a) Problem identifications of the real data systems (VP and SIER): existing real data analysis based on one year sample data (VP) and 3 months (SIER)
b) Identification of the critical nodes (problem frequencies) in the architecture of the real data collection systems
c) Algorithm developments of the false data detection
d) Algorithm developments of reconstitution of missing data
e) Software specification
f) Demonstrator development and verifications

5.4.3.2. Traffic forecasting for travel time estimation

To provide users with information on traffic conditions (queue length and travel time displays) corresponds to the priority of the France System Operators. On the C.P network the travel time display system has been in operation since 1994 and concerns around 350 Variable Message Signs (VMS). This system has been developed in frame of ATT Program EUROCOR.

The developed travel time algorithm is based on the computation of the elementary links and the total travel time corresponds to the addition of the all elementary travel time from the
location of the VMS to the next main destination. Consequently, the algorithm computes the
instantaneously travel time without any traffic condition prediction.

The CP system evaluations have demonstrated that the calculated travel time follows the real
travel times (travel time surveys -floating cars-). The means errors are around 10%. However,
as far as the calculated travel times address a long distance ( > 7 km), the accuracy of
calculated travel time decreases (more than 30%).

Concerning the motorway network (SIER site), the traveltime displays have been put in
operation since February 1996. Compared to the CP, the density of the installed VMS is less
(175 VMS for 300 Km of motorway length). The same algorithm as used on the CP was
implemented on the SIER network. Concerning the evaluation, similar results have been
obtained as for the CP.

The main objectives of this Work Area, are the improvement of the calculated travel time by
introducing the traffic forecasting algorithms. In frame of ATT program "DYNA" and at the
INRETS Program, several algorithms have been developed for traffic forecasting. Among all
existing algorithms, a suitable algorithm will be tested, evaluated and implemented. The
considered test site will be the overall C.P and the same site as in IN REPONSE Project for
the SIER (ring: BP, A4, A3, A86).

5.4.3.3. Ramp metering and motorway to motorway control verifications

The main objectives of this Work Area are to verify in real live the impact of isolated and co-
ordinated ramp metering control and the motorway to motorway control strategy on two test
sites and two System Operators: the Ville de Paris and the SIER. A common requirement has
been identified:

- Improvement of the traffic condition on the ringway of Paris and the connecting
  motorways around Paris

- More specifically, the Internal part of the ringway of Paris is very congested. The high
  congestion levels on the ring way of Paris and A6 motorway are due to the reduction of
  the lane number at the off-ramp Gentilly (from three to two lanes) and to an excessive
  entry volume at the A6 motorway entrance. At 7:00 am, the "congestion head" first
  appears at the A6 entrance, then the congestion spreads upstream until on-ramp Italie, and
  very often up to Porte de Bagnolet, see Figure 5.3.

From previous theoretical investigations (see Papageorgiou et al., 1990) and field trials
conducted within the DRIVE-1 and ATT Program respectively the Project CHRISTIANE
(V1035) (see Haj-Salem, et.al., 1990; 1991; Smulders and Middelham, 1991) and EUROCOR
Project (see Haj Salem et.al 1994), it is well-known that ramp metering is capable of:

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

Moreover, ramp metering has proved to be suitable as a tool for reducing or avoiding rat-
running traffic in the adjacent road network (see Buijn and Middelham, 1990).

On the other hand the role and impact of ramp metering in the corridor context is well
understood (see Haj Salem and al 1994). In fact, a ramp metering system aimed at avoiding or
reducing congestion on motorways has a positive on the adjacent road network traffic:

- On-ramp queues may motivate drivers to use a road link route instead of a motorway path
  which may result in an additional demand for the road subnetwork.
Avoidance or reduction of recurrent congestion on motorways may attract more drivers to use a motorway path which will eventually reduce traffic problems on the road network.

The test site for D’ACCORD experiments corresponds to the southern part of the CP of Paris located between Porte d’Italie and Porte de Sèvres and the A6 motorway. One part of this site (ringway of Paris only), has been used within CHRISTIANE and EUROCÓR to test and compare a number of isolated and co-ordinated ramp metering techniques.

This part of Boulevard Périphérique is saturated almost all day long due to the excessive on-ramp volume from the motorway A6 entrance at Porte d’Orléans, and the reduction of the lane number (from three to two lanes) at the off-ramp Gentilly. Hence, the traffic conditions on this part are very difficult whatever the time of the day. Every day, this congestion spreads until Porte de Bagnolet at peak hours (5 kilometres upstream of Porte d’Italie).

On this site we can distinguish three main components (see Figure 5.4):

1. The CP
2. On-ramp A6 to the BP
3. The Motorway A6
Figure 5.4: SIER and VP test sites
The CP total length of the experimental area is approximately 8 kilometres (see Figures 5.3 & 5.4), including 5 on-ramps (Italies, A6, Orléans, Chatillon and Brançion) and 6 off-ramps (Gentilly, A6, Chatillon, Vanves, Brançion and Plaine). The test site is located in the south part of the Ringway of Paris. The number of lanes on the carriageway is varying from 3 to 2 lanes and (over short distance) from 3 to 4 lanes along some small stretches. Among the 5 on-ramps, three equipped controllable on-ramps are available for implementing ramp metering strategies (Italies, Chatillon and Brançion).

With respect to A6 motorway (see Figure 5.4), the total length of the experimental area is approximately 35 kilometres (only the direction to Paris will be considered) including 7 on-ramps which is controlled today by a fixed time control strategy.

The on-ramp A6 to the BP will constitute a test bed for the motorway to motorway control.

This work will be conducted according to the following six main steps:

1. **Off-line simulation using METACOR**: this step constitute the first one before the implementation phase. METACOR will be applied on the considered network, calibrated and validated using traffic data coming from the two control centre PC_A6 (Arcueil) and CP centre (BERLIER).

2. **feasibility study**: it consists to analyse the several constraint imposed by the owners and in particular the safety aspect which is very related to the topology of the site.

3. **On site equipment**

4. **Experimentation** : Three main scenarios have been identified :
   - actual situation
   - on-ramp metering applied to the BP et A6W
   - on-ramp metering + motorway to motorway control applied on the entrance A6_BP

5. **Evaluation**

Finally, the D'ACCORD pilot site in France includes the Boulevard Périphérique and A6 motorway can be considered as a comprehensive system covering many elements of Road Transport Informatics (RTI). In fact, a number of systems have been developed and implemented within and outside the 4th R&D Program. Within DRIVE I project V1035 : CHRISTIANE, the internal south part of the Boulevard Périphérique has been chosen as a test site where the ramp metering techniques both on isolated and co-ordinated level were implemented, tested and evaluated. Within ATT Programme: "EUROCOR", the overall CP has been considered a test site for traffic information systems using the VMS (travel time display).

### 5.4.3.4. Network Simulation tool: "METACOR"

Modelling of traffic flow on motorway and urban networks is a useful tool for several traffic engineering tasks such as:

- development and evaluation of traffic control strategies
- short-term prediction and surveillance of traffic state in complex networks
- evaluation of the impact of new constructions, comparison of alternatives etc.
- evaluation of the impact of capacity reducing events (e. g. works) or increased demand etc.

According to the specific task, the use of the model may be either off-line or in real time.
The macroscopic approach is important in that it leads to relatively low computational effort and eventually allows for simulation of traffic flow on large scale networks. On the other hand, the macroscopic approach requires adequate modelling of complicated route choice phenomena which are more easily treated in a microscopic scale for the price of excessive computational effort.

METACOR may be used for the description of dynamic traffic phenomena in mixed networks (motorway and urban networks) with arbitrary configuration including several origins and destinations and several connecting paths for each origin-destination-pair. The specific structure of an application network must be specified in well-defined input files. The model requires availability of destination-specific demands at all network origins over the required simulation time horizon. Traffic incidents with arbitrary intensities and durations may be considered via suitable input file specifications. The user may also choose a number of traffic variable histograms from selected network locations (motorway and/or urban) for graphic display after completion of a simulation run. Moreover, a comprehensive coloured graphic display of the whole network or a part of it, that classifies (fluid, dense, congested) and visualises (green, orange, red) traffic conditions during the simulation.

A number of control measures may be considered in the simulation of traffic phenomena in corridors including ramp metering at the motorway entrances, signal control at urban junctions, motorway to motorway control at motorway junctions, driver information and/or guidance via variable message signs at motorways and/or urban roads, and route guidance.

METACOR calculates a number of performance criteria for the motorway part, the urban road part, and the integrated corridor network. These criteria include total travel time, total travel distance, total fuel consumption, total waiting time at on-ramps or other network entrances etc. Availability of uniform performance criteria for the overall corridor network facilitates the study of integrated control strategies involving a number of different control measures.

METACOR may be used for analysis of traffic conditions, for design, testing and comparison of control strategies in urban corridor, and with minor modifications, for real-time short-term prediction of traffic flow. In particular, the model may be used for investigating the impact of individual control measures on the overall corridor network, e.g. the impact of ramp metering on motorway and surface streets. Moreover, the model is suitable for testing integrated control strategies attempting to improve traffic flow performance in the overall corridor by co-operative design of a variety of different control measures.

For the France pilot test site, it is intended to develop and investigate traffic responsive on-ramp metering and motorway to motorway strategies on one hand, and on the other hand traffic responsive integrated control strategies for the overall network including traffic information, traffic forecasting and on-ramp and motorway metering techniques. In this context, a macroscopic traffic flow model METACOR will be used.

### 5.4.4. Drivers:

The "Driver groups" constitutes respectively the principal actors and users simultaneously. Among the four categories of users defined before, the "Drivers" have a central role. All developed and implemented UTC and MTC systems are oriented to the Driver requirements. The "Policy Makers", the "Network Operators" and the "System Operators" follow, more or less, the "Driver requirements" in general for several reasons and in particular the political one.

In order to identify in qualitative and quantitative terms the driver requirements, and in particular the impact of travel time VMS strategy, in 1994 and 1996 questionnaire surveys have been organised respectively by the VP and the SIER. A detailed evaluation of the available questionnaire data leads to the following conclusions:
• It appears that the main requirements of the "Drivers" are the extension of the **traffic information systems** (collective and individual). At home or along their trips, the drivers need more and more information about traffic conditions (travel time, queue lengths, incident events, works, exceptional events etc.). All the traffic control centres and the implemented traffic control systems are non transparent for the Drivers. The only part of the "Iceberg" seen by the Drivers corresponds to information displayed on the VMS.

• The travel time display strategy implemented on the VMS system have the total agreement of the users. For the CP site, 80% of the users prefer the travel time display instant of queue length display. For the SIER, the two types of message were implemented.

• With respect to the safety aspect, it appears that the queue length display strategy is more efficient than the travel time display.
6. TESTSITE PADUA-VENICE

6.1. Overall description of the test-site

The Italian test-site consists of two different environments: the extra-urban and the urban ones. The following sections will describe respectively the different contexts that are considered of interest for the D’ACCORD applications.

6.1.1. The AINE motorway

The test-site regards the A4 (E70) motorway from Brescia to Venezia along 180 km, managed by two different companies of AINE, Spa Autostrada Brescia-Padova and Spa Autostrade di Venezia e Padova.

Two Traffic Control Centres (TCC) are located in Verona and in Mestre (Venezia), and both are interested by the objectives of D’ACCORD regarding the DTM applications and the system architecture, while only the TCC of Verona will be involved in the interconnection and traffic data exchange with the City of Brescia.

The level of traffic for both the two stretches of motorway is very high, with an average of about 200,000 vehicles per day.

Figure 6.1 shows the above mentioned motorway.

Some differences about the infrastructures interesting the D’ACCORD project characterise the two stretches of motorway, because of a partially different approach to the traffic problems of the two companies, more control-oriented between Padova and Venezia, more...
information-oriented between Brescia and Padova; that is due also to the very intensive
density of population along the motorway close to Venezia.

6.1.1.1. The Brescia-Padova motorway

The 146 km from Brescia to Padova are equipped today with 46 traffic detectors (magnetic
loops), that on average are located each four km and each two km in the more critical points.
Furthermore 24 video cameras are installed for monitoring purposes and for automatic
incident detection; and 111 additional video cameras are planned by the end of 1997 at forty
points of control.
All these data are transmitted to Traffic Control Centre of Verona through the proprietary
telecommunication network existing along the motorway and utilising the optic fibers.
From the point of view of the information to the drivers, apart from the radio and video
information distributed by the national traffic information centre of Rome (CCIIS), fed by the
various TCCs, on the Brescia- Padova motorway are installed 24 VMS (alphanumeric
messages) at the entry lanes of the toll stations, 3 VMS (alphanumeric messages and
pictograms) on the access roads for the cities of Verona, Vicenza and Padova, and 6 VMS
along the motorway (alphanumeric messages and pictograms).
Further 22 VMS are under installation along the motorway (one in front of each exit station),
and 7 VMS on the access roads of the main toll stations; the entire operation will be
completed by spring 1997.
The Traffic Control Centre is located close to the Verona South toll station. Its architecture is
based on a local area network (token ring) connecting two main servers (in back-up) and
many front-end processors, one for each application (traffic data collection, video cameras,
VMS, emergency posts, radio system, meteo, TCCs and CCISS link, etc.).

6.1.1.2. The Padova-Venezia motorway (The "Easy Driver" Control System)

This motorway presents the already known Easy Driver system, aimed both to the traffic
monitoring and to the traffic control and information.
Easy-Driver is a Motorway Traffic Control System developed by the Fiat-Auto in
collaboration with the Centro Studi sui Sistemi di Trasporto S.p.A. (CSST) and MIZAR
Automazione S.p.A. and implemented by the Società delle Autostrade di Venezia e Padova
S.p.A. on the stretch of motorway between Padova and Venezia. Easy Driver has been in
operation since July 1992 and it represents the state of the art in scientific research and
technology.
The proposed system of control utilises the most modern and dependable technologies
available in the fields of information relay and communications. The innovative elements
with respect to the national scene consist in the high level of automation of the motorway
flow control strategies and in the capacity for recognising, in real time, the events which
might disrupt the flow and providing an up-to-the-minute response.
The high demand for dependability and automation requires a system organisation which is
robust with respect to malfunctions - i.e., capable of guaranteeing and controlling the
functionality of the system even in the case of single component breakdowns. In addition, a
high degree of flexibility has been guaranteed in order to permit the system to grow in terms
of its physical extension and of adoption of new technologies which may become available
over time, particularly in the field of data collection.
Objectives
The Easy-Driver automatic motorway traffic control system has three main objectives:

- increase in safety, to be achieved both directly and indirectly. Directly, by means of the automatic detection of primary accidents and timely information to the users regarding obstructions and recommended speed, thus reducing the probability that secondary accidents occur as well, in any case the continuous indication of recommended speed has the effect of reducing the probability of primary accidents. Indirectly, by supplying better information to the users on the conditions of use of the motorway and on the weather conditions which the user may encounter during his/her journey.

- improvement in the use of the available flow capacity, assisting both the user (reduction in travel time) and the manager of the motorway infrastructure. This objective can be met by means of the extensive use of automation on one hand and information to the users on the other.

- assistance to day-to-day management, using tools that allow for the easy management of abnormal situations, programmed or otherwise, as for example maintenance work in progress.

The system also envisages the creation of a data bank for planning and scientific research, contributing to an ever better knowledge of traffic-linked phenomena.

Functional breakdown
The system is broken down into two functional levels:

- the central level, responsible for the overall control of the system; it is the "intelligence" of the system and it is capable of calculation and links up all the necessary information;

- the local level, with specific functions; it involves equipment located along the motorway which also has autonomous calculation capability.

The main functions of the central level are:

- automatic processing of the data relating to the characteristics of the traffic flow and the atmospheric conditions;
- automatic processing of the strategies of traffic flow control;
- definition of the recommended speed messages and information for the users;
- management of communications regarding both incoming data and transmission of messages to the users;
- statistical analysis of traffic and system function data;
- operator interface;
- management assistance (e.g., maintenance work).

The main functions of the local level are:

- automatic collection of the characteristic data of the vehicle flow;
- automatic detection of the atmospheric conditions;
- automatic detection of accidents or flow anomalies;
- communications management;
- visualisation of information messages.

The functional breakdown is schematically presented in Figure 6.2.
Architecture

The system architecture is hierarchical (two functional levels) and modular (allows extension without the need to re-design), with a distributed intelligence and a high degree of dependability and automation. A diagram of the system is shown in Figure 6.3.

![Figure 6.2: The functional breakdown of the Easy Driver System.](image)

![Figure 6.3: The architecture of the Easy Driver System.](image)
The system includes:

- a set of central computers; the central system architecture provides for an HP 1000 and an IBM PS2 computer linked together, each with specific functions. In addition a MS-DOS 386 computer performs the function of "data logger" of the basic traffic data.

- a network of microcomputers; the Local Units are made up of MS-DOS industrial PCs installed along the motorway. Three different types of Local Units are envisaged, depending on which mix of functions is implemented (traffic data collection, weather data collection, fog detection, VMS controller). The Local Units are linked to the centre by different data networks using copper cables.

- equipment for collecting traffic data (loop sensors and associated Detector), see Figure 6.4.

- equipment for detecting atmospheric conditions, sensors for temperature, moisture, fog, rain, road surface status, etc.

- equipment for relaying messages to the users, VMS constructed using LED technology. The VMS must display messages which can directly influence the behaviour of the drivers on the motorway, such as recommended speed in the different lanes and how each should be used, as well as more general information on traffic or weather conditions along the motorway. The messages in the first category (recommended speed and lane) are visualised on variable message signs mounted on gantries roughly every 1000 metres.

The informative messages are displayed by means of textual VMSs located both along the motorway or at point of entry.

**System operation**

The data from the network of Local Units (Industrial DOS PC) housed in individual shelters located along the motorway is fed into the central computer (the communication media is copper cables). The microcomputers are polled by the centre with a cycle of less than one minute.

The local microcomputers are capable of acquiring data from the sensors assigned to them (inductive loops for detecting flow characteristics, sensors for detecting weather conditions, etc.), and using their autonomous calculation capability are able to compute the speed and the length of each vehicle passing over the sensor.
Using this very basic data, several tasks are performed by the local microcomputer, in particular:

- It computes the flow, the occupancy and the space mean speed every ten seconds. This data is not used directly as traffic flow characteristics, but an estimation is made of the state of the traffic on the motorway section in terms of speed, flow and density, using a suitable algorithm based on Kalman filtering techniques. This also makes it possible to compensate for the failures of some components of the data collection system.

- It detects the presence of vehicle flow anomalies such as accidents, back-ups, etc., using a "multimodel" approach for AID, making it possible to cover the full extent of traffic situations ranging from low to high flows.

- It computes a classification of vehicles for each lane in terms of speed and vehicle length (the time interval for the classification as well as number and range of classes are defined by the operator).

The above information is then organised into a set of data messages that are transmitted to the centre at each polling cycle or at the specific request from the centre.

The Central system processes the information gathered from the Local Units and by means of appropriate software and specific control algorithms, automatically defines the action to be taken in order to maximise safety and flow capacity along that section of the motorway, elaborating the appropriate messages for the users and sending them to the local microcomputers to which the variable message signs located along the motorway (control signals) or in useful points off the motorway (preventive information) are linked.

The HP1000 computer has the following main functions:

- **Front End**, with the primary task of managing communications between the centre and the Local Units, logging all data exchanged between them;

- **Controller** on which the overall "observation" (in terms of traffic characteristics) of the motorway system is running and Control Strategies are implemented; in particular three main strategies must run to set speed and lane recommendations:
  - the strategy that computes the recommended speed for the optimal exploitation of the available capacity of the motorway, also taking into account the atmospheric conditions (fog and road surface status);
  - the strategy that slows down the traffic when an incident is recognised;
  - the strategy that optimises traffic when there is a bottle-neck due to work in progress area queues on or off ramps.

At the same time the above strategies also define which messages must be sent to all VMS (textual or pictograms) also located off the motorway.

- **Supervisor** with the task of managing priorities, duration, refreshing messages and commands sent to Local Units. It is also in charge of monitoring the operations of all components setting off alarms in the case of malfunction. Moreover it is in charge of storing all data, with different levels of aggregation, relating to traffic, weather conditions, and status of devices.

The IBM/PS2 computer has the following main functions:

- **Monitoring User interface**, with which a synoptic of the motorway and of the equipment installed is presented. By means of a coloured code, the state of the equipment and of the traffic is continuously conveyed to the operators and alarms are set off. Moreover operators can interact with the system to send commands or messages or to ask for information stored in the Data Base.
• **Statistics and reporting**, a set of options making possible to display both in graphical and in numerical form all available data.

• **Variable Messages management**. Since the system collects automatically only data related to the stretch of motorway for which the Motorway Company is responsible, other source of information (police, other Motorway Companies, etc.) that can provide data related to the stretches of nearby motorways must also be processed. To do so the operator can interact with the system in an easy, safe and guided fashion. The operator must only insert into the system information in terms of "events" with some attributes. Events can be selected from a list (closure of an exit-entrance ramp, closure of a stretch of motorway, maintenance in progress, etc.) and for each of them the introduction of attributes is guided by means of the graphic User Interface. The definition of the messages for the VMSs will be made automatically by the system on the basis of rules which take into account current priorities and strategies.

**The system in action: the Padova-Mestre motorway**

The Padova-Mestre motorway passes through one of the most densely populated and economically dynamic areas of Veneto; generally speaking, it has the function of linking the motorway systems of Northwest, Central and Northeast Italy.

It was particularly appropriate for the implementation of a traffic control system for two main reasons:

• traffic intensity, over 60,000 vehicles daily, with an annual increase on the order of 6%;

• the presence of an important terminal barrier at Mestre, which is a critical point in terms of safety and traffic flow.

Easy Driver on the Padova-Mestre has been installed using:

• 10 MS-DOS road side computers on DOLO-MESTRE stretch which have linked:
  • 120 inductive loops
  • 5 fog sensors
  • 2 weather monitoring stations
  • 2 ice surface sensors
  • 10 gantries for VMS providing lane and speed recommendations.

In addition have been installed 56 loop detectors and 10 VMS for textual information located at the nodes along the Padova-Mestre motorway.

Equipment have been installed by ITALTEL-Telesis and SOLARI.

The TCC of Mestre is also linked to CCISS in Rome and to the other motorway TCCs, and in particular to the close TCC of Verona.

**6.1.2. The city of Brescia**

In the following a description of the current situation in terms of existing systems in the fields of urban traffic control and traffic and travel information management is reported.

The scope is to give a clear idea of the existing systems and available data which are present in the urban area of the city of Brescia and which could be of interest and involved in the Bs-Pd-Ve test site, again with the particular aim to manage the relation between urban and motorway systems.
Several technologies are currently running for the control and management of traffic, parking and information systems in the city of Brescia, and all of them can interact with the motorway system in order to satisfy some of the needs coming from the different users group.

The city of Brescia is situated in the North of Italy. It has 200,000 inhabitants, but reaches 400,000 including suburbs and 1 million persons in the whole Province.

Since 1908 the Azienda Servizi Municipalizzati (ASM) is the Municipal Services Board of Brescia, 100% owned and controlled by the City Council.

ASM is in charge of several services, the main of which, more related to the D’ACCORD project, being: urban transport, parking, traffic lights. ASM has 1,800 employees and a gross income of 350 MECU.

The territory covered is an area of about 70 km$^2$, the distribution of the crosses where traffic lights are automatically and centralised controlled, and the traffic flow monitored continuously and in real time.

**Objectives for testing/installing physical measures**

The irregular growth in the requirement for mobility, which has been experienced in the last few years, has caused one of the major problem for road traffic as well as a propelling element for the re-planning of the towns.

The awareness of the fact that mobility and liveability cease to be antithetic conditions when the traffic system as a whole can be managed in a rational and orderly way, has been one of the propelling element within the projects and implementations the Azienda Servizi Municipalizzati of Brescia has carried out in the sector.

For the town of Brescia the challenge appears to be particularly demanding: the control of the traffic, ensuring at the same time a high level of safety for road users, and within an area where, in 70 square kilometres only, 200,000 people live, and in a town submitted each day to peremptory, demanding and often also pressing attack of more than 160,000 private vehicles.

The proliferation of traffic-lights, pedestrian crossings and traffic controlled areas are inadequate measures. A "stupid" traffic-lights installation, i.e. not synchronised with the consecutive ones or not set according to the real state of traffic, further to inducing the car drivers into a state of impatient, does not contribute significant to the implementation of those conditions of smoothness and order that are the prerequisite for a sure improvement in the mobility.

The same applies for a traffic restricted area, should such an area not be duly integrated within the territorial environment, all it does is to shift a little further on the conditions of precariousness.

Generally speaking, the system of urban mobility is extremely complex. It requires the adoption of an integrated traffic policy, in its turn strictly co-ordinated with the management of road conditions.

It is thus a challenge that has to be faced jointly and in full agreement by all actors operating on the territory.

In particular, it is a question of implementing an efficient public service, with routes dedicated as far as possible, capable to satisfy adequately and in terms of quantity and quality, as well as in line with financial requirements, collective mobility demand, and manage to reach in the splitting of transfers between collective and private transportation means, those conditions of balance necessary for ensuring the survival of the latter, avoiding thus chaotic situations or general paralysis.

From this point of view, also the establishment of traffic controlled areas has to be envisaged.
Still from the point of view of a well-balanced development, it is also a question of implementing a proper network of parking-lots to satisfy that parking demand consisting of a different typology and function according to their location, and to operate them in a unitary and co-ordinated manner (motorised in the inner city, central fluid systems, suburban park-and-ride systems).

Finally, for what the traffic control is concerned, it is important to make use of efficient facilities which could guarantee an efficient flow of information between the A4 motorway, passing close to the town, and the urban area, in order to guarantee real time and correct information to the motorway drivers entering the city and similar information to those exiting the urban area directed to A4.

The whole of the interventions to face and solve the complex problem of mobility, a brief mention of which has been made earlier, requires, on one hand, few interventions of infrastructural type, and on the other, the establishment of advanced telematic applications, made available by the technology, and which allow the management of the complexity integrating the various aspects interacting one another.

ASM, in Brescia, has faced the problem in a systemic way, i.e. defining initially a project on a comprehensive system level and then, also with the use of the most updated technologies, informatics and telecommunications, implementing, first individually, and then in a more and more integrated way, a set of sub-systems permitting to monitor and improve the vehicle flow.

The reference model, that can be named "secure city" or "telematic city", on its highest hierarchic level, consists of a network which all of the authorities and organisations interested in the management and planning of the territory can gain access to, for collecting and supplying data and information as well as for integrating services and systems.

In this purely exemplifying scheme, being an open type scheme, different specialised systems (or authorities operating them) are shown, linked to a network acting as a common support for the exchange of data and information between the systems themselves.

Possible control centres, or supervisors, with the task of presiding over the monitoring and management of a series of several functionally interconnected systems, will have to be connected to this network.

**The physical measures**

*The traffic-lights control system*

Since the beginning of the 70's, a traffic control system has been installed - and subsequently extended and strengthened. At present, the system can control nearly all of the urban traffic-lights intersections, and is based on a crossing microcomputer network and a main processor.

The application software installed on the main processor allows to evaluate the evolutionary trend of the vehicle flow (traffic volume and density) as well as transmit timely the relevant instructions to the microcomputer network, so as to adequate the control according to the expected conditions.

This function is based on the traffic data collected constantly through a set of inductive type sensors located under the asphalt and connected via cable to the operating station.

Such data are then stored in a special data base and used for statistic and study purposes as well as for planning measures or interventions in the traffic sector.

The system permits to load and/or change the variable parameters relevant to the local traffic-lights plan, directly from the main processor up to crossing microcomputer, eliminating so the need to carry out on site interventions, should the stored traffic-lights control plan need to be modified. The visual monitoring of the most crucial crossing points is ensured through a set of closed circuit telecameras.
The traffic-lights control system is considered as one of the most important instruments among the many which are part of a more complex traffic control system.

The vehicle flows have to be as far as possible guided and directed, so as to avoid unnecessary routes and thus prevent or, at least, reduce traffic jam situations caused both by accidental and ordinary or planned type facts, of which the road user is not aware.

Therefore, it is a question of managing to supply in some strategic points a set of information concerning the road traffic conditions as well as the state of those facilities especially established for car parking.

*The remote control system for urban bus transportation*

The rationalisation of public transportation service is long since ensured by a remote control system.

The system permits to interrogate the mobile means in order to detect a set of data and information necessary for the control of the service, among which the location of each bus, as well as to collect and process those data needed for the network management, planning, check and adaptation, such as number of passengers transported, number of obliterated bus tickets, etc.

The system can also transmit to special information panels, placed at the main bus stops along the network, information for passengers waiting for the bus on the estimated time before the arrival of the next bus.

The remote control for bus location is discontinuous, as it occurs through special markers installed all along the route of the various bus lines, and the calculation of the estimated waiting time at the different bus stops is processed thanks to a modelling of the time taken for covering a certain route for the various length sections.

This type of system allows the ASM to carry out a twofold function, i.e. collection and supply of information.

*The priority system for urban public transportation service*

An important step towards the implementation of the model mentioned in the preliminary is the system concerning the interconnection of the traffic-lights control system with the bus remote control system, so as to allow on certain conditions a priority right of way for urban buses.

A supervisor is entrusted with this function and collects from the bus control centre all information on those buses running late (bus line, bus number, location, minutes of delay as well as load of passengers).

On the basis of the information received, the supervisor produces a priority list, associating to each bus a coefficient calculated according to the importance of the bus line, delay time and load of passengers, and then transmits such a list to special local microprocessor units.

The latter provides for the identification of those buses notified on the basis of signals from certain proximity coils embedded in the roadway, and generates requests for priority for the traffic-lights regulators, which act directly on the time for green light, within a pre-established span compatible with the overall traffic-lights coordination system.

The function of the priority list processed by the supervisor is that of allowing the local units to select that bus which shall be given priority to in case of a contemporary presence of more than one delay bus approaching the same crossing point.
The user multimedia information project

The aim of this system is to supply useful information for the users of urban transportation service, road users and, more generally, for the citizens.

Some information may be considered as "real time information" and concern special conditions or situations that is important they are supplied as soon as possible; other information instead is the result of an interactive processing.

From the point of view of the facilities used, two main groups may be distinguished: information diffused through the existing polyfunctional systems, such as videotel, and those shown onto specific structures or specially implemented.

The user telematic communication through the videotel network

This project (which is obviously involving all of the utility services) was started in 1989 with an experimental application installed at the Utility users information/cash desk, consisting of an expert system installed on a PC placed at public disposal, capable even of giving all the main information on the bus transportation service, such as:

- bus schedules
- bus tariffs
- conditions for buying bus tickets
- temporary diversion of bus lines
- possible bus service interruption
- etc.

The project has now evolved into a system, where a telematic communication process is controlled by the utility processing centre and connected to the videotel network.

All the information already substantially present in the aforementioned expert system are sent over the videotel network and, moreover, an application capable of supplying in an interactive way the modes for shifting from anyone point of the town to another, indicating also the bus lines of the urban service to be used, is available.

The application supplies:

- the bus line to be used
- the bus stop point where to get on the bus
- the bus stop point where to get off the bus
- the possible transfer line, indicating on/off bus stops, should a passenger transfer be made necessary.

Obviously, also this measure aims at encouraging the use of public transportation means facilitating its use for the citizens.

The telematic communication through specific structures

The bus stop panels

Such panels are connected to the remote control system mentioned before. At present there are about 150 bus stop panels installed, some of them are capable of showing also generic messages, communicated by the control centre via radio or/and cable.

The pages displayed on the little variable message panels inform in real time on the service and give notices of general nature, such as:

- information on bus delay
• bus schedule, on a limited period of time, for each bus line required
• information concerning bus schedules and routes
• various service messages
• information of public utility (e.g. chemist's on duty, etc.).

Large Variable message panels
These panels, a few samples of which are already in place (at the present time 8), constitute a network at the service of road users to inform them mainly on the state of road traffic, such as:
• possible diversion due to "works ahead"
• possible road blocks or slowdowns due to accidents or different causes,
as well as specific information on car-parking vacancy.
The number of VMPs is going to be increased in the next future with other 12 panels, financed by the Lombardia Region.

Information islands
10 of such typically pedestrian access islands or kiosks will be installed in 1996 (under the European project called EUKIOSK, financed by DG III) in locations open to the public and subject to special traffic and, through the management of an interactive dialogue, will supply users with information similar to that available through the videotel network.
The information islands will allow also to carry out certain operations or transactions, especially for what the urban transportation service is concerned, such as the purchase of bus passes, ordinary bus tickets, season-tickets, etc.
Later on, further of course to the information and transactions concerning the other services provided by the ASM, these stations could also be made available for information and transactions pertaining to other Boards/Authorities.

The remote management of car parking-lots
The main target of the system, which is still in course of project, consists of an automated management for the various multiple-use car parking-lots.
By way of such a management it is meant to rationalise the vehicle flow, which will be diverted towards the various town parking-lots, and maybe to manage to let drive through the inner city only those authorised vehicles and those that have previously reserved a car space, preventing them to make vicious detours in search of a free parking space.
The remote control and parking control system will have to allow a screen control, interphone, management of remote control devices (lighting, ventilation, pay-toll, access control), as well as a technical supervision of the structures (carbon monoxide, fire, damages, lack of tickets and/or coins in the machines).
Moreover, the system foresees along the main access roads and thoroughfares for town traffic, the installation of a few guide and signal panels leading those traffic flows interested in parking. Such panels have to inform about the availability of car places inside the various parking-lots, divided as per structure.
Likewise, in proximity of each structure, such panels, named "proximity panels", will have to indicate the status of the specific parking-lot. The aim is to notify in real time the availability of free car parking places, optimise the routes in search of free parking space, reduce traffic and permit the centralised management of several parking-lots. Some of these panels will
have to be installed in connection with centres suitable for booking a car parking place in one of the available parking-lots.

The system has to be able to operate non-stop, day and night, and it does not have to require the presence of personnel in charge of that specific single parking-lot.

**The electronic control for access to traffic controlled areas**

After a short period of experimentation, the ASM provided to install an electronic identification system for their own service vehicle fleet in connection with the utility headquarters carriage entrance/exit.

The system allows, in particular, to identify automatically the vehicle and its driver. The latter is identified through a personal micro-chip identification card that has to be inserted in a special slot on board of vehicle.

This experience will be placed at the Local Government disposal for a possible future use of a similar system for the control of car access to traffic controlled areas in the inner city.

The various access to those areas could for instance be equipped with special electronic portals, capable to identify whether the vehicle driving through is authorised or not and, in case it isn't, a photo will be taken, by means of special telecameras, of the vehicle number-plate, and the relevant data automatically transmitted, via network and digitisation, to the local Municipal Police Station for checks and subsequent application of possible penalties.

A project financed by National organisations is undergoing, for the preparation of a technical/economical feasibility study for the realisation of such a system covering the whole downtown.

Results of this project will be made available at the end of 1996.

### 6.2. Identification of users

In accordance to the definition of the User Groups presented in chapter 2 the following User Groups were defined for the Italian test-site and the specific users identified for each group are described.

One user group has been added, namely the Emergency services people who have an important role in each motorway company and that can contribute in defining the D’ACCORD user needs.

In more detail the following users have been identified:

**Policy Makers:** Regional Authorities, City Councils of the cities closed to the Brescia-Venezia motorway.

**Network Operators:** the group includes both the administrative people of AINE and ASM companies that have mainly long-medium term perspective and people belonging to AINE and ASM companies who have to manage the network translating the policies decided at an upper level into practical plans.

**System Operators:** operators of the TCCs belonging to AINE (TCC of Verona and TCC of Mestre) and to ASM (TCC of Brescia).

**Emergency services:** operators of the emergency services of AINE and ASM.

**Drivers:** road users of the Brescia-Venezia motorway and of the city of Brescia.
6.3. Overview of user needs

In the present section the methodology adopted in determining the user needs is described and general comments about the needs for each group of users are provided.

6.3.1. Methodology adopted in determining the user needs

To determine the user needs different methodologies have been applied depending on the user categories.

Despite the short time available some simple investigations have been made for determining the user needs in some user groups. In particular a list of user objectives has been distributed and people had to fill it up specifying the level of priority which they thought the objective should have been satisfied both within the time scale of the D’ACCORD project and beyond the project itself. The priority has been expressed as a number with the following meaning:

1. high priority
2. medium priority
3. low priority.

The results obtained —and reported later— were used together with other source (like reports of previous studies and results coming from previous investigations) to better determine the user needs.

For determining the user needs of the **Policy Makers** the Italian partners based on the literature and on the experience they gained in co-operating with Italian Local and Regional Administration.

The user needs referring to the **Network Operators** have been defined on the basis mainly of the experience gained from the AINE and ASM participants to the D’ACCORD project. Furthermore a small investigation, of the type described before, has been made between administrative people and more technical staff who is in charge of managing the network.

The **System Operators** needs, as for the previous group of users, have been deducted as a result of an investigation among the operators at the TCCs of Mestre and Verona and on the results obtained from the DRIVE II project GEMINI during the evaluation framework.

Several operators of the **Emergency Services** of the motorway companies were interviewed.

Referring to the **Drivers** the needs have been determined depending on the comments received by the users at the toll stations and at the service centres, considering a quite small amount of interviews (around 30).

6.4. Results obtained

For each category of users some results have been obtained and they will be summarised in the following. With reference to those user groups for which a small investigation has been made, will be reported a table containing a list of the objectives identified for the specific category with the correspondent priorities resulted from the investigation itself.

6.4.1. Policy Makers

Authorities don't make any difference in the situation with or without D’ACCORD: their aims are safety and user satisfaction. In particular Policy Makers have the following objectives:

- improve road safety
- reduce the number of incidents
- reduce environmental pollution
- reduce the global travel time
- decrease congestion
• improve the users satisfaction

6.4.2. Network Operators

The opinion of several managers seems to be the same on the fact that they are interested in everything capable of increasing safety, traffic flow and users satisfaction. In general priorities given in D’ACCORD do not differ too much from those given beyond D’ACCORD, even if it is reasonable to expect that D’ACCORD does not influence directly the reliability of the TCC system and of the detection systems, rather affecting quality and quantity of available information.

Table 6.1 reports the priority given to every objective.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>within the D’ACCORD time scale</td>
<td>beyond the D’ACCORD time scale</td>
</tr>
<tr>
<td>increase the rate of service usage</td>
<td>3</td>
</tr>
<tr>
<td>improve the user satisfaction</td>
<td>2</td>
</tr>
<tr>
<td>make better use of existing road capacity</td>
<td>1</td>
</tr>
<tr>
<td>minimise costs for new equipment</td>
<td>1</td>
</tr>
<tr>
<td>minimise operational costs</td>
<td>1</td>
</tr>
<tr>
<td>minimise maintenance costs</td>
<td>1</td>
</tr>
<tr>
<td>optimise the communication costs</td>
<td>1</td>
</tr>
<tr>
<td>extend the traffic management</td>
<td>1</td>
</tr>
<tr>
<td>provide common management rules to the operators</td>
<td>2</td>
</tr>
<tr>
<td>control the operation of a road system</td>
<td>1</td>
</tr>
<tr>
<td>reduce environmental pollution</td>
<td>3</td>
</tr>
<tr>
<td>reduce the global travel time</td>
<td>2</td>
</tr>
<tr>
<td>improve the traffic distribution</td>
<td>2</td>
</tr>
<tr>
<td>decrease congestion</td>
<td>1</td>
</tr>
<tr>
<td>influence the driver behaviour</td>
<td>2</td>
</tr>
<tr>
<td>improve the quality of information provided to drivers</td>
<td>1</td>
</tr>
<tr>
<td>improve credibility of information to drivers</td>
<td>1</td>
</tr>
<tr>
<td>minimise the information displaying delay</td>
<td>2</td>
</tr>
<tr>
<td>improve reliability of information to system operators</td>
<td>2</td>
</tr>
<tr>
<td>know the traffic state related to neighbourhood</td>
<td>1</td>
</tr>
<tr>
<td>improve the system reliability</td>
<td>3</td>
</tr>
<tr>
<td>improve road safety</td>
<td>1</td>
</tr>
<tr>
<td>detect incidents</td>
<td>3</td>
</tr>
<tr>
<td>prevent incidents</td>
<td>2</td>
</tr>
<tr>
<td>improve the emergency service</td>
<td>3</td>
</tr>
<tr>
<td>assist road users</td>
<td>1</td>
</tr>
<tr>
<td>reduce drivers’ stress</td>
<td>3</td>
</tr>
</tbody>
</table>

Table 6.1: Priorities for Network Operators.

6.4.3. System Operators

The table presented is the result of an investigation among the operators at the TCCs of Mestre and Verona and among the operators of the Brescia urban traffic control centre. To be underlined their quite unanimous convergence about priorities.

The operators have two main objectives in their job:
• operate in the simplest and as quickest as possible way;
• achieve the expected results in safety and assistance.

In fact that is reflected in the answers, see Table 6.2.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>simplify the control and management activities</td>
<td>2 1</td>
</tr>
<tr>
<td>simplify the use of the system</td>
<td>2 1</td>
</tr>
<tr>
<td>simplify the emergency calls management</td>
<td>2 1</td>
</tr>
<tr>
<td>improve credibility of information coming from the system</td>
<td>1 1</td>
</tr>
<tr>
<td>improve quality and quantity of information available</td>
<td>1 1</td>
</tr>
<tr>
<td>improve efficiency of the traffic information centres</td>
<td>1 1</td>
</tr>
<tr>
<td>availability of common management rules</td>
<td>3 2</td>
</tr>
<tr>
<td>reduce time for decision-making process</td>
<td>2 2</td>
</tr>
<tr>
<td>provide cross boundary information (different owners)</td>
<td>2 2</td>
</tr>
<tr>
<td>provide advanced warnings to drivers</td>
<td>1 1</td>
</tr>
<tr>
<td>reduce the delay of incident detection</td>
<td>1 1</td>
</tr>
</tbody>
</table>

Table 6.2: Priorities for System Operators.

6.4.4. Emergency Services

Several operators of the emergency services of the motorway companies were interviewed and safety with the prompt assistance intervention results their main objective, both inside and outside D’ACCORD, see Table 6.3.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>PRIORITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>improve road safety</td>
<td>1 1</td>
</tr>
<tr>
<td>reduce violations</td>
<td>3 2</td>
</tr>
<tr>
<td>simplify the emergency operations</td>
<td>1 1</td>
</tr>
<tr>
<td>reduce the delay in assistance</td>
<td>1 1</td>
</tr>
</tbody>
</table>

Table 6.3: Priorities for Emergency Services.

6.4.5. Drivers

These answers are the average of the comments received by the users at the toll stations and at the service centres, considering a quite small amount of interviews (around 30). Drivers are always strongly interested in receiving timely precise information both on trip and on pre-trip, in receiving timely assistance when needed and overall in safety conditions, see Table 6.4.
### Table 6.4: Priorities for Drivers.

<table>
<thead>
<tr>
<th>OBJECTIVES</th>
<th>PRIORITY</th>
<th>WHEN</th>
</tr>
</thead>
<tbody>
<tr>
<td>reduce travel time</td>
<td>1</td>
<td>within D'ACCORD time scale</td>
</tr>
<tr>
<td>reduce travelled distance</td>
<td>2</td>
<td>beyond D'ACCORD time scale</td>
</tr>
<tr>
<td>reduce fuel consumption</td>
<td>3</td>
<td>beyond D'ACCORD time scale</td>
</tr>
<tr>
<td>receive tourist information for travel planning</td>
<td>2</td>
<td>beyond D'ACCORD time scale</td>
</tr>
<tr>
<td>rely on the pre-trip information provided</td>
<td>1</td>
<td>within D'ACCORD time scale</td>
</tr>
<tr>
<td>rely on the on-trip information provided</td>
<td>1</td>
<td>within D'ACCORD time scale</td>
</tr>
<tr>
<td>reduce driving stress</td>
<td>2</td>
<td>beyond D'ACCORD time scale</td>
</tr>
<tr>
<td>receive a timely emergency service</td>
<td>2</td>
<td>beyond D'ACCORD time scale</td>
</tr>
<tr>
<td>drive in safety condition</td>
<td>1</td>
<td>within D'ACCORD time scale</td>
</tr>
</tbody>
</table>

#### 6.5. User needs for DTM application

Main user requirements can be briefly identified as follows, depending on:

1. **The A4 motorway network and system operators need:**
   1.1. to know real time information concerning the state of the traffic in the main fast-ways and areas close to the motorway exits to the urban area, other than the general state of the traffic in the city.
   1.2. to rely on traffic data coming from the road in order to make right decisions for the traffic control;
   1.3. to use friendly and efficient instruments to perform the traffic control;
   1.4. to receive some predictions concerning the possible changing in the entity of the traffic flow passing on the motorway or exiting the city of Brescia and accessing the motorway. This option will permit to the motorway control operator to react in time in order to prevent possible serious problems on the motorway.

2. **The Brescia urban traffic control operators need to receive real time information concerning the status of the traffic along the A4 motorway.**

3. **The A4 motorway drivers and customers need:**
   3.1. to receive real time information concerning the state of the traffic on the motorway and in the urban area and the eventual presence of traffic jams, congestion or incidents in specific areas, other than some suggestions on the best route and, may be, the best exit to enter the urban area.
   3.2. to obtain access to some other information concerning their trip, like:
      3.2.1. some public transport facilities (which lines to be taken to reach specific points of the city, buses timetable, current bus service situation, generic information on ticketing and public transport subscription),
      3.2.2. some generic information concerning the location of the places of major interest, and the fastest ways to reach them (together with indication of possible park and ride facilities),
      3.2.3. the location and availability of parking areas,
      3.2.4. some tourist information (main architectural, cultural and tourist attractions in Brescia and in the Province),
3.2.5. some practical functionality (like banking facilities, hotel reservation).

These needs can be satisfied through the access to information points or kiosks, located at some motorway service areas or at some exits.

4. The urban drivers exiting the city and approaching the motorway need to receive information concerning the real time traffic situation along the motorway, the presence of queues or accidents, in order to permit them to make possible different route choices.

These messages could be communicated to the drivers through some large variable message panels located on the main roads linking the city and the motorway and also through the use of information kiosks installed over the urban territory; at these kiosks some eventual optional information, coming from the motorway centres, could be given, like weather predictions and generic information concerning ticketing, best routes and payment systems over the motorway network.

### 6.6. User requirements for the demonstrator

On the basis of the determined user needs, the activities planned for building a demonstrator on the Italian test-site consist of the following items:

1. **Data Checking**: the idea is to perform a checking of the data and information coming from the road on the whole Brescia-Venezia motorway in order to understand how good the information sources are and if they are consistent or not. The activity is necessary for any correct implementation of the traffic models.

2. **Travel times forecasting**: basing on an OD prediction model the purpose is to implement a model that can forecast the travel times of the motorway trips. Within the D’ACCORD project the idea is to apply and demonstrate the model just referring to the stretch of the motorway from Padova to Venezia, as the complexity of the model would otherwise be high.

3. **Connection of the TCC’s**: this activity is more related to the architectural aspects of the D’ACCORD project but it should be also important on the side of the DTM applications, in fact on the basis on what has been said before on the travel time forecasting each TCC could use the prediction coming from an other TCC and apply the appropriate strategy to its own stretch of the motorway. The connection has been planned between the two control centres of Verona and Mestre.

4. **Connection city-motorway**: this activity is analogous to the previous one but it involves the city of Brescia and just the stretch of the A4 motorway from Brescia to Padova, in particular the control centre of Brescia will be connected to the TCC in Verona. The aim is to provide information to users exiting from Brescia and entering the motorway and vice versa.

5. **Human Machine Interface**: with the aim of simplifying the control activity of the network operators and more directly of the system ones the idea is to improve the already existing HMI of the Easy Driver system located in the Mestre TCC.

### 6.7. Planned improvements to the existing situation

*The AINE motorway (Brescia-Padova)*

The application software already created is in an improving phase and a significant help is expected by the D’ACCORD project results.

For the D’ACCORD objectives, in particular with regard to the planned connection and traffic data exchange with the TCC of the City of Brescia, new equipment have being introduced directly connected to the mentioned LAN, in accordance with the annexed architectural schema. This installation has been decided in order to support also other
European projects like INFOTEN, and it should allow an easier distribution of information also by means of new tools like fixed information terminals and portable traveller assistants.

*The AINE motorway (Padova-Venezia)*

The actual situation of the Padova-Venezia motorway is going to be improved by extending the existing control to the ring road of Mestre. For that reason the ring road will be equipped for collecting data.

The existing software will be also improved particularly for taking into account travel time forecasting and to improve the Human Machine Interface of the Easy Driver system.

*The city of Brescia*

The autonomous changes at the Brescia test site which establish the added value of the D’ACCORD project are represented by the full test site, which is going to be developed just following the existence of the D’ACCORD project.

Then, all applications, tools, interfaces, physical connections and communications which will be put on the field are all added value coming from the project.

What is existing or is part of different projects are some variable message panels (both on the motorway and in the urban area) and some information kiosks (a part from those directly interesting the exiting points to the city of Brescia).
7. SYNTHESIS AND THE RELATION TO D04.1

After the individual analysis of user needs for the three test sites in chapters 4, 5 and 6 this chapter is meant to bind them together again and to highlight the similarities. First of all, the user groups will be discussed separately and then the common needs for the demonstrator will be presented. Lastly the relation to deliverable D04.1: Functional specifications for DTM applications will be clarified.

7.1. Synthesis of User-Requirements

Policy Makers

Regarding the Policy maker, user-needs at this level are formulated as fairly general policies, and typically include common-sense goals such as:

- minimise congestion, travel-time, incidents, pollution
- maximise the efficiency of road-use

In this respect the user-needs of the Policy makers are very comparable.

Network Operators

The more practical goals, and hence user-needs, of the network operators are basically the same in all three test-sites, but some differences in emphasis can be identified. To some extent this may be due to the fact that of the parties involved many can be categorised under more then one heading; in some instances it is a question of a single organisation wearing different hats. Another consideration is that the Italian and French policy seems to lean more towards providing full information to individual road-users to enable these to optimise their own itinerary than towards direct control. In the Netherlands (at the moment, the TCC not yet being operational) emphasis seems to be towards a system that provides information, but which can take directive measures when the collective user-optimum can be significantly improved by giving priority to distinct groups of users.

The factors underlying this difference in emphasis may well include maturity of operation: the French and Italian TCC’s are already operational, and routinely disseminate information on current traffic conditions, so that the Network and System operators have had more time to solve the technical issues and can now concentrate on optimising existing practice and tackling the more fundamental issues.

In the Netherlands, where traffic control developments have resulted in e.g. autonomous systems for pile-up prevention, operator-assisted traffic control has been concentrated on ‘hot spots’ such as tunnels bridges, and road network in the vicinity. At the moment the first of a nation-wide system of TCC’s is entering commission, so that the user objectives are more focused on technical issues. On the other hand, the network of the TCC in the Amsterdam area seems to be more equipped with ‘hard’ controls than area’s of corresponding TCC’s in France and Italy.

In this context e.g. ramp-metering can be seen as an example of a DTM tool that allows an operator to serve the best interests of the majority of users by regulating access to the motorway system for (i.e. penalising of) prospective users of the motorway, in addition to passive provision of information, or letting the users work out matters on their own.

System Operators

In France emphasis is on information provision and advice rather than on ‘hard’ control measures, so that to be effective, credibility is crucial. This might cause a slight lean towards road-users’ needs.
In Italy tasks of the TCC have been set out, and operation of the DTM is routine. The issues are now: cost-efficiency, cost-savings in the operation of the system, and provision of information by the system to road-users. This leads to emphasis on quality and credibility of information provided to drivers. There is a general feeling that the system must be seen to ‘prove its worth’ to road-users.

In The Netherlands, where the TCC is not yet fully operational, user-needs are focused on the establishment of an Operator Support Tool with a uniform interface and decision-support tools.

**Drivers**

In general the user needs for DTM for drivers (road-users) are considered to be indirect user needs in the sense that their needs are already addressed by the network operators. Specific user needs for drivers should not be forgotten, and especially towards the evaluation the drivers experience and opinion should have high priority. However, for the formulation of user needs to be addressed in D’ACCORD the user needs of the network and system operators are considered more relevant.

**Combined user needs for the demonstrator**

For the demonstrator a number of specific user needs have been identified. The user needs are shown for each of the test-sites separately in the table below. The table clearly shows the common user needs for data checking and monitoring, the need for traveltime estimation and prediction, the need for short-term traffic forecasting and the need for an investigation towards the integrated and co-ordinated control. Additionally a number of site-specific user-needs have been identified.

<table>
<thead>
<tr>
<th>x=outside D’ACCORD, -=not applicable</th>
<th>Amsterdam</th>
<th>Paris</th>
<th>Padua-Venice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Checking / Traffic Monitoring</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Traveltime Estimation and Prediction</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Short-Term Traffic Forecasting</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Human Machine Interface</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Connection between TCC’s</td>
<td>x</td>
<td>x</td>
<td>✓</td>
</tr>
<tr>
<td>Motorway-to-Motorway Control</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Rampmetering</td>
<td>x</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Investigation towards Integrated and Co-ordinated Control</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

*Table 7.1: User needs for the demonstrator at all test sites*
7.2. Relation to D04.1: Functional specifications

In this section we will highlight the connection between the User-requirements and the functional specifications to be drawn up in WP04.

The requirements for a DTM system that have been identified are:

- **monitoring**: the DTM must reliably absorb and digest large amount of data, and make this accessible to the responsible system operators. The user needs an automated system to monitor traffic on a network-wide scale, to automatically assess the accuracy and quality of the incoming flood of measurements, and to reliably warn the system-operators of incidents and congestion.

- **assessment**: the DTM should reliably assess the data and present the operators with a coherent picture, transcending the level of isolated, measurements.

- **decision-support**: the DTM should be able to provide support to the responsible traffic operators to reach their conclusions, and decide what (if any) measures to take; it should also foretell the impact of these measures

- **implementation-support**: once a decision is reached, the DTM should facilitate its implementation.

- **cost-effectiveness**: the DTM be as cost-effective as possible.

The implications for functional specifications are that the system should have monitoring, assessment, and decision-support functions, and provide implementation support for DTM measures. Cost-effectiveness is considered to be closely related to open-systems architecture and modular design.
8. **Keyword List**

User requirements / User needs  
VMS  
DTM  
Policy Makers  
Network Operators  
System Operators  
Drivers / road users  
Co-ordinated Traffic Control  
Rampmetering  
Motorway-to-Motorway control  
EUROCOR  
DYNA  
GERDIEN  
TCC
9. BIBLIOGRAPHY

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9.2 References for the Paris testsite description


### 10. GLOSSARY

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATT</td>
<td>Advanced Transport Telematics</td>
</tr>
<tr>
<td>AVV</td>
<td>Adviesdienst Verkeer en Vervoer (department of the Netherlands Ministry of Transport, Public works and Water Management)</td>
</tr>
<tr>
<td>AOM</td>
<td>Amsterdam Orbital Motorway</td>
</tr>
<tr>
<td>BM</td>
<td>Boulevard des Maréchaux (Paris)</td>
</tr>
<tr>
<td>CORD</td>
<td>Coordination Of Research and Development (DRIVE-II project)</td>
</tr>
<tr>
<td>CONVERGE</td>
<td>Successor of the CORD project in the 4th framework programme</td>
</tr>
<tr>
<td>CORA</td>
<td>CO-ordinated Rampmetering Amsterdam</td>
</tr>
<tr>
<td>CP</td>
<td>Corridor Périphérique (Paris)</td>
</tr>
<tr>
<td>CTMS</td>
<td>Central Traffic Management System</td>
</tr>
<tr>
<td>D'ACCORD</td>
<td>Development and Application of Co-ordinated Control of Corridors</td>
</tr>
<tr>
<td>DYNAX</td>
<td>A Dynamic Traffic Model for Real-Time Applications</td>
</tr>
<tr>
<td>DRIP</td>
<td>Dynamic Route Information Panel</td>
</tr>
<tr>
<td>DTM</td>
<td>Dynamic Traffic Management</td>
</tr>
<tr>
<td>DTMS</td>
<td>Dynamic Traffic Management System</td>
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<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>GERDIEN</td>
<td>General European Road Data Information Exchange Network</td>
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<tr>
<td>HMI</td>
<td>Human Machine Interface</td>
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<tr>
<td>IM</td>
<td>Information Management</td>
</tr>
<tr>
<td>LAN</td>
<td>Local Area Network</td>
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<tr>
<td>METACORE</td>
<td>Network simulation tool</td>
</tr>
<tr>
<td>MIRA</td>
<td>Motorway Information in the Region of Amsterdam</td>
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<tr>
<td>MONICA</td>
<td>MONItoring Casco (Dutch testsite)</td>
</tr>
<tr>
<td>MTM</td>
<td>Motorway Traffic Management</td>
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<tr>
<td>OSS</td>
<td>Operator Support System</td>
</tr>
<tr>
<td>P+R</td>
<td>Park and Ride</td>
</tr>
<tr>
<td>SIER</td>
<td>Service Interdépartemental d’Exploitation de la Route</td>
</tr>
<tr>
<td>SIRIUS</td>
<td>Service d’Information pour un Réseau Intelligible aux USagers</td>
</tr>
<tr>
<td>TCC</td>
<td>Traffic Control Centre</td>
</tr>
<tr>
<td>TDI</td>
<td>Toerit Doseer Installatie (rampmetering installation)</td>
</tr>
<tr>
<td>TIC</td>
<td>Traffic Information Centre</td>
</tr>
<tr>
<td>TMC</td>
<td>Traffic Management Centre</td>
</tr>
<tr>
<td>VMS</td>
<td>Variable Message Signs</td>
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<tr>
<td>VP</td>
<td>Ville de Paris</td>
</tr>
<tr>
<td>WAN</td>
<td>Wide Area Network</td>
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