

# European Transport Networks, Telematics and the Environment

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## 1 Introduction

Our mobile and environmentally unfriendly society shows a clear network configuration. The transition towards a network economy - not only at a local, but also at a global scale - has in combination with world-wide liberalisation trends created the conditions for a globalisation of our economies. This globalisation is already clearly reflected at the European level, where internationalisation has taken a rapid pace in recent years, but is gradually becoming a basic feature of all industrial economies. The emergence of component industries, the creation of new industrial configurations based on out-sourcing and the advanced telecommunication infrastructure have played a critical role in the above mentioned trend. As a result we are witnessing nowadays an extraordinary rise in international transport, supported by modern logistics and telematics. International trade and international mobility

are at present rising at a rate which exceeds the growth of GNP in many countries. While the economic benefits of globalisation trends are to be recognized, it is also evident that the accelerated rate of growth in international transport causes a formidable burden on environmental quality at a world-wide scale, not only in terms of landscape destruction, but also in terms of noise and air pollution.

New information and telecommunication technologies applied to the transport sector, often named "Advanced Transport Telematics" (ATT) have the potential to offer new solutions to these transport problems in Europe. However, the successful exploitation of ATT in European transport markets depends on the technology

*La nostra società, mobile e nemica dell'ambiente, mostra una chiara configurazione a rete, a livello locale ma anche a livello globale. La globalizzazione in un'economia di rete e la liberalizzazione hanno determinato uno straordinario sviluppo dei trasporti (nazionali ed internazionali) con un formidabile deterioramento della qualità ambientale globale e locale. Nuove tecnologie, nuovi criteri di scelta modale, nuovi modelli di trasporto potranno determinare l'andamento futuro dell'impatto ambientale. Tuttavia, anche le nuove tecnologie di informazione e comunicazione applicate al settore dei trasporti (Advanced Transport Telematics - ATT) potranno in un futuro prossimo offrire, per l'Europa, ulteriori soluzioni al problema. Tali tecnologie costituiscono una parte importante nell'evoluzione della rete dei trasporti europea. Dal momento che il mercato delle ATT comprende un largo numero di utilizzatori intermedi, privati e pubblici, nel presente studio si delineano le possibilità di tale mercato, secondo quanto emerge da una serie di interviste ai potenziali utenti le quali mettono alla luce le abitudini e le aspettative degli utilizzatori in merito alla telematica nel trasporto.*

being implemented in a way which meets the defined needs of the different road user groups in order to achieve social acceptance and thereby political approval. It is, therefore, vitally important that decision makers (i.e. those influencing the adoption of ATT) have sufficient information on the needs of (commercial) road users and on the way they perceive ATT options in addressing those needs. The paper contains therefore also some empirical results.

The empirical part of this study consists of an investigation of the potential ATT market among the intermediate user group of road transport authorities/operators. In-depth interviews have been used to gather relevant information on their attitudes and expectations with regard to the potential and the benefits of these modern transport telematics as being a new part of developing transport networks.

The following section starts with some general

considerations regarding the evolution of the European transport network. In Section 3 the main future transport trends are identified and discussed. Subsequently, in Section 4 the role of telematics is discussed as a new integrative part of the transport network. Section 5 summarizes some of the major areas of telematics technologies for inter-urban road management, while Section 6 contains empirical results from a series of in-depth interviews with road managers in the Netherlands. Finally, in Section 7 the main results are summarized.

## 2 The Evolution of the European Transport Network

As mentioned in the introduction, Europe is gradually



but steadily moving towards a network society, characterized by economic integration, political coordination, regional autonomy and mobility of people. Networks connect people and places and are able to generate socio-economic added value through synergy and interaction. Such networks may be physical, immaterial, organisational or club-oriented in nature, exhibiting a wide spectrum of multi-layer configurations e. g. roads, railways, telecommunications, e-mail etc.

New network technology has promoted satellite and fibre optic networks for communications, the reductions in costs of computing and networking have allowed "real time" decisions to be made, and huge data bases are available to assist in the decisions of many businesses. The move to the post-industrial society has revolutionised the ways in which existing networks are used and created opportunities for new forms of communications through city networking, data exchange and research networking (Knowles 1993).

It goes without saying that the construction of network society does not materialize automatically, but requires dedicated efforts from both the public and the private sector. Substantial capital investment is required to construct a high quality network and difficult decisions have to be made if the European dimension is considered as important as the national concerns. Traditionally, most transport infrastructure investment has been carried out by national governments in the public sector, and it is only in the communications sector that the possibility of private capital has been explored. New European agencies (e.g. EBRD and EIB) have been set up to adjudicate on new investments, and possibilities are also being considered of joint venture projects between the private and the public sectors. In the operations of transport and communications markets, many European countries have had different traditions, some based on strong central intervention and others allowing much greater market freedom. Under these different political regimes, networks evolve in different ways. For example, with respect to bus and air transport in a deregulated market the structure moves from a comprehensive network of services with many links to one based on a hub and spoke configuration with longer distances to be travelled, but with more frequent services. There are significant savings to the operator and entry to the market may be difficult.

In the context of regulatory policy on networks the role of governments is of utmost importance. Most decisions on European networks are taken by national governments through well established procedures. As transnational European networks evolve, many decisions will have to be taken by international agencies. This requires that new institutional, organisational and legal frameworks be established. The roles of the different political, legal, financial and planning agencies will have to be resolved, together with an understanding of

how decisions are taken. The implications of decisions taken at one level in the process will have to be accommodated at other levels if integration, equity and efficiency are to be maintained. In addition to the EC political dimension, there are important issues of harmonisation and standardisation in networks, access to information, the organisational culture of networks and institutional and organisational barriers in networks.

Networks generate synergy through (physical and non-physical) spatial interaction. Transportation fulfils a key role in modern societies, not only for road users, but also for many other actors: public authorities, network operators, industry and society at large. In the same vein, transport is assuming a central role in the new European force field. The context and nature of European trade and transport is entering a new era. As a result of globalization and the rapid rise in international interaction and communication, transportation in Europe (both passengers and freight) has grown enormously, especially in recent years.

While the economic benefits of globalisation trends are to be recognized, it is also evident that the accelerated rate of growth in international transport causes a formidable burden on environmental quality at a world-wide scale, not only in terms of landscape destruction, but also in terms of noise and air pollution. However, there is a lack of insight into the complex mechanism of (inter)national trade and transport of people in relation to air pollution and the resulting climate change.

### 3 Future Transport Trends and the Environment

Future transport trends will have impacts on the negative effects of transport. Globally, we may distinguish the following trends: new technologies, future modal choices, future transport patterns (as transport is a derived demand), logistic strategies and mainports. We will indicate the current state of the art with respect to each of these issues and identify how we can enhance our understanding of the effects of the globalising economy on the environment.

#### *New technologies*

New technologies refer to both vehicle and infrastructure technology (e.g., TGV, automated vehicle guidance, mega-airplanes, Maglev) and to information and telecommunication technology. The first one has extensively been studied in a previous NRP study (and is still investigated at TRAIL), but the second one deserves more attention. The availability of especially new telecommunication and information technologies has led to new "transportation" alternatives to many actors within the global economy (e.g., for international business traffic). Both consumers and producers might alter or restructure their respective consumption and production patterns, given the emerging options. Some travel might be substituted by other means of transportation.



However, new travel via so-called "traditional" means might also be generated as a consequence of the impetus that these new technologies provide to economic activity or of information on other attractive places (e.g. international tourism). Therefore, the impact of these new technologies on Co2 emission levels remains rather uncertain. This requires a clear transport technology assessment, where different developments in short and deep sea shipping (e.g. mega container ships), aviation, trucking, railway technology are to be mapped out. Also ISDN and EDI services have to be explored here. There is quite some knowledge on individual elements, but the project would seek to integrate this fragmented knowledge into a more clear and uniform pattern.

The government's role in the diffusion of these technologies is a very interesting and highly relevant topic. There are at least two reasons for the government to play an active role in this area. In the first instance, the existence of all types of external effects might distort the market system from being efficient and might lead to a suboptimal allocation of scarce resources, thereby potentially placing a relatively large burden on the environment. Examples of external effects with respect to new technologies are, for example, the positive network externalities generated by new information services such as the Internet. Here, subsidising the early adopters is a necessary condition to obtain the critical mass needed to let the technology take off. In addition, it can be shown that the introduction of advanced motorist information systems is also likely to generate both positive and negative congestion externalities (see Arnott, DePalma and Lindsey in *American Economic Review* (1993), and Emmerink, Verhoef, Nijkamp and Rietveld in *Journal of Transportation Economics and Policy* (1996)). Second, sub-optimal allocations might be a result of either lack of or too much standardization with respect to these new technologies. On the one hand, lack of standardization might lead to many slightly different new technologies that would prevent the economy from reaping the full benefits of economies of scale associated with implementing these technologies. On the other hand, too much standardization might also hinder the introduction of a new and technologically much more sophisticated system.

### Modal choice

Not only new types of telecommunication lie ahead, also new (public/individual/freight) transportation modes are likely to be introduced in the near future. Not only does this require a reassessment of the usefulness of transport models that attempt to predict the modal choice distribution in practice. At a more strategic level, it should also prompt us to assess the desirability of these new means of transportation in terms of land-use and air pollution and its resulting impacts on the quality of the environment. Particularly, getting to grips with

the interaction between air pollution and land-use, alternative means of transportation, the transport infrastructure and the global economy is a new fascinating research subject. It requires, on the one hand, a better understanding of the social economic aspects of cities and regions, and on the other hand, an improved knowledge of the mechanisms governing the future availability of new technical possibilities. That means, to better understand the deriving forces behind the introduction of future transportation modes, so that some form of government guidance towards more environmentally friendly transportation alternatives is possible. Technology assessment of these forces is then necessary.

### Assessing future transport patterns

The global transport flows concern both people and goods. Future travel patterns by individuals and households are obviously influenced by the above mentioned two issues. In addition, in order to provide an answer to what the impacts of these issues on environmental quality and levels of CO2 emissions might be, one also has to model the future patterns of travel behaviour. In the literature it is often argued that demand for transportation is a so-called derived demand. Demand for mobility originates from the fact that individuals would like to be engaged in particular (economic) activities. Transportation, then, is required to carry out activities at different locations. International research in this area has generally ignored the derived characteristics of travel demand. This is rather surprising, as various government policies directly aim at influencing activity patterns of individuals and economic actors. Only, as a result of changes in these patterns, mobility behaviour might change, and together with this the burden that transportation places on environmental quality and the levels of CO2 emissions.

International commodity flows have thus (partly) a derived demand character. Although more is known about cross-border goods flows, there are still many uncertainties left, e.g. on back-hauling, on combined transport, on tariff structures in intermodal transport, and on the degree of substitutability instigated by the informatics sector.

### Logistic strategies

One of the elements having an important impact on the international flows of goods are the logistical strategies of firms. Important changes in logistical strategies concern shifts from stock-based to order-based systems, reductions of the number of layers in distribution systems implying a reduction in the size of total stocks, exploitation of economies of scale and scope, and the use of information and telecommunication technologies (for example EDI). These changes have led to (and are expected to lead to) an increase in the transport compo-



nent of production, not necessarily implying an increase of the transport cost share, since transport costs have decreased in relative terms

During the past decades the dominant logistical strategies in combination with infrastructure policies have favoured the increase of the market share of rapid transport modes (freight via roads; high value goods via air). Present government policies are aiming at an increase in the share of environmentally friendly transport modes, including combined transport. For a really successful development of combined transport for international transport flows it is essential that efficient multi-modal terminals are constructed which will offer high quality services. This will most probably imply the necessity to further develop large scale marine terminals

#### *Mainports*

In recent years, there is a tendency, both in passenger as well as in goods transport, towards the development of so-called mainports. In these airports and harbours, large and concentrated flows of passengers and goods are handled more or less continuously. On the one hand, this puts strong demands on transportation technology and logistics, whereas on the other hand the environmental burden of transport becomes far more concentrated than usually seen. For a country, developing these mainports means building more infrastructure.

This raises the question whether alternative options are feasible to reap the benefits of housing a mainport without being left with the negative side-effects in terms of land-use (including expansions of road and rail networks) and other environmental impacts. These options may range from using environmentally more benign modes of transport (such as high-speed trains, inland shipping) instead of road and air transport, to extending port handling to incorporate also warehousing and manufacturing (and thereby increasing value added considerably).

It is thus clear from the above arguments that the worldwide increase of international mobility creates many environmental effects impacting also on our climate system. This means that on the basis of various scenarios of (inter)national trade and transport, the possible future options have to be investigated. The transport network will evolve with different transitions in time, and probably the one in the nearest future is the extension of the transport network with telematics systems that may improve the efficiency of the existing transport infrastructure

#### **4 Transport and Telematics**

Road transport started in the realm of engineering but has nowadays become such a complex set of organisations that research and development have to involve

many other disciplines, e.g., economics, management, computer science, geography and policy sciences. Whatever the progress of engineering, in the road transport equipment industry such equipments must be integrated into the technical road transport system and its market. The technical system takes for granted that vehicles, infrastructure and operating techniques will evolve in harmony, as was for instance the case for the TGV in France.

The trend towards globalisation (or at least internationalisation) and the need for more competition at all levels in the new European setting have provoked a profound interest in the functioning of the road transport network in Europe. Traditionally, this interest was instigated by supply side motives, but it is increasingly recognised that new competitive behaviour of firms in Europe requires us to focus much more directly on those actors who co-ordinate, manage and operate flows in this network.

Many improvements too transport efficiency could arise if better information on the state of the network would be available to planners and users. In this respect, Advanced Transport Telematics (ATT) is often advocated as the transport planner's 'secret weapon'. ATT is the application of telecommunications and information technology in the transport field. It can address the functioning of all transport modes as well as the integration of these modes. This effectively opens up the transport market to the large communications sector and also enlarges the opportunities for producers of software and system designers. Systems developed for monitoring and data processing, information dissemination and processing in fields such as defence or the oil industry now become applicable to transport. What remains uncertain in the future policy environment is the size and nature of the market.

ATT has the potential to offer new solutions to the transport problems in Europe. However, the successful exploitation of ATT in European transport markets depends on the technology being implemented in a way which meets the defined needs of the different road user groups in order to achieve social acceptance and thereby political approval. It is, therefore, vitally important in the ongoing programmes of ATT research and development in Europe that decision makers (i.e. those influencing the adoption of ATT) have sufficient information on the needs of (commercial) road users and on the way they perceive ATT options in addressing those needs.

The ATT market comprises a large number of actors from both the public and the private sector. At the demand side, some major potential market sectors can be identified. In addition to private users, there are intermediate or collective users (e.g., road authorities) and commercial users (e.g., the freight sector). In the latter case ATT may play a strategic role by facing the



need of the freight sector to orient itself towards the opportunities offered by the European internal market, which has far-reaching impacts not only on organisations operating in international networks, but also on those operating nationally.

The existence of the road transport market in the true sense of the term is all the more essential, given the diversity of both the demand of travellers, depending on income, trip purpose and physical and geographical conditions, and of the type of goods, depending on their nature, destination, batch size and frequency of delivery. Only a genuine market combining a diversity of products and tariffs can meet this multiplicity of needs.

The major technical and commercial systems will call for all resources of science and organisational and information technologies. Complexity requires to be managed and this will require the creativity of the ATT industry which is investing primarily in the non-material software and which has the ability to transmit the right messages to individual users and logistic operators on the basis of an almost instantaneous knowledge of demand. These logistic operators are set to be the prime users of the future service-integrated numerical networks of the ATT industry and the value-added networks. These will be able to integrate the whole process from production to distribution and thereby fulfil a logistic role which is nothing else than the provision of value-added transport (Giannopoulos et al. 1992).

## 5 ATT Technologies for Inter-urban Road Management

The road authority sector as part of the public sector for ATT. The ATT requirements for inter-urban is an road important market management vary largely. the most important ones are shown in Table 1. The requirements from, Table 1 can be met by a large range of advanced inter-urban ATT applications, already existing and/or in development. Some of the most promising technologies are (EC 1993):

### Automatic debiting systems

A wide range of automatic debiting possibilities, in terms of application area and of charge systems, are open to local and national governments. The application area may be a network of high density motorways, but also an urban quarter might be elected. Charge systems can be rather flexible, e.g. location and time dependent charges. They can be more or less user-friendly, e.g. depending on costs and payment forms. In many systems a combination with automatic vehicle identification is made to calculate the right charge

### Road-side based information systems

Road-side based information systems are systems which make use of fixed road-side based infrastructure. Functions of these systems are general management and traffic control on motorways and the provision of traffic information to drivers. A typical characteristic of road-side based systems is that all drivers can be reached. These applications include inter alia signalling systems and variable message signs. These systems can provide road users information about road status, weather conditions, pollution, incidents, road works, congested conditions, queue lengths, speed compliances etc.

### Navigation and dynamic route guidance

The principle of in-vehicle systems is their functioning on an individual basis. Drivers' behaviour is influenced by the provision of situation-specific information. In-vehicle equipment and (one way or interactive) communication with a central control centre are needed to realize navigation or dynamic route guidance. The application area of information can be small or large, depending on the specific tools and their geographical coverage.

### Travel planning information systems

Reliable (pre-trip) travel information, extended with public transport information, will contribute to a lower demand for traffic. The latter function is especially suited for congested areas where the competitive position of public transport is very good. A compatibility with other policies of stimulating public transport or discouraging the use of cars is then possible.

Policy objective	ATT requirements
Demand management	Sharing of reports of incidents with emergency services and other control centres Monitoring and forecasting traffic demand Provision of information about alternatives, travel times, availability Operating road pricing Giving early warning of potential problems within the road network
Capacity management	Fast response to incidents Provision of effective directional guidance for road users Planning and understanding network behaviour and problems Enhancing and maintaining the capacity of the existing road system Quick response to faults Installing and operating route guidance
Safety management	Operating incident detection, warnings, speed controls Faster emergency services response with traffic control cooperation
Environmental management	Linkage of local pollution forecast to traffic control strategies

Table 1: ATT requirements for inter-urban road management



## 6 Attitudes and Expectations of Road Managers

Public authorities in the area of transport telematics are usually road managers normally associated with departments of national and local governments. These institutions have the responsibility for the performance and guidance of traffic flows on inter-urban road corridors. For many ATT applications, the efficiency of individual trips may be increased, although this will not necessarily result in a greater overall benefit to the transport system in terms of safety, traffic flow efficiency or a better quality of the environment (Emmerink et al 1994).

In investing in and implementing ATT, road authorities start usually from a firm strategic policy basis for transport in their area. These policy objectives are then developed into a number of operational strategies some of which may be applicable and relevant to ATT products. Each strategy has normally various methods of implementation, and ATT methods will have to be compared with alternatives to evaluate the most cost-effective way of achieving the strategy and therefore the policy objective. It turns out that nowadays road authorities need to demonstrate a significant added value of costly ATT investments.

The attitudes and expectations of road managers towards the possibilities of applying these information and telecommunication technologies to their networks have been explored by a series of in-depth interviews, which were held in the Netherlands with key persons of Rijkswaterstaat, which is the national road manager in this country. These interviews were held in June and July 1994 and had a sample size of 5. Respondents were selected both at the central department as well as at some regional subdivisions of Rijkswaterstaat. This selection should ensure that opinions would be included of those who are involved in planning and research (central department), as well as of those involved in the actual implementation of the technologies (regional subdivisions).

The respondents expected that debiting systems would have a relatively high potential to smooth traffic flows in relation to the potential of the provision of traffic information. However, this measure has a weak public support. Especially in the case of advanced automatic debiting systems which trace car trips, privacy aspects are a sensitive matter. The lack of public support is believed to be a serious bottleneck to implementation of debiting systems. Therefore the focus in the interviews was clearly on the provision of various kinds of travel information to motorway users. The attitudes and expectations towards these systems are depicted in the following:

### *Perceived added value from ATT technologies*

Respondents agreed that driver information means that are existing at present are useful to a limited extent but

its quality is certainly not sufficient. For instance, it was mentioned that traffic information provided by various media (radio, TV) is repeatedly not sufficiently updated because the channel from source to driver is too long. The collection of the information is often subjective while different sources may provide conflicting information. These issues make the information in general not very reliable and accurate. Therefore, a significant added value was expected from new user-oriented and improved information systems.

### *Basic requirements*

Some basic requirements were mentioned by the respondents which are seen as absolute conditions for a successful implementation of ATT technology on motorways. These were the development of an open or flexible system architecture according to agreed standards, fully reliable information and a full acceptance by road users. While the first issue relates to the hardware of the technology, the latter two relate to the user side. It is recognised that user acceptance is of critical importance for the further development of ATT technologies. Almost all respondents mentioned the issue that when people are once misled by false information, all belief in such a system will immediately decline.

### *Perceived potential contribution of ATT to traffic pollution, efficiency and safety*

Although it is perceived that the contribution of ATT applications to the achievement of higher traffic efficiency will be limited, it is in general believed that this effect will still be significant. The significance of the impact is supported by the fact that traffic queues usually occur when traffic demand marginally exceeds the road infrastructure capacity. This would mean that even when only a small share of drivers were re-routed, this already could have a large impact on traffic performance. Improvements of traffic flows as estimated by the respondents varied between 3% and 15%.

Opinions on the possible impacts on traffic pollution were more varied and slightly more negative. It was felt that positive impacts on traffic performance would not directly mean that also positive impacts on pollution by cars could be expected. This effect could indeed be negative since ATT policy in fact enlarges usable capacity. By rerouting of vehicles, the total mileage could be enlarged. This effect could neutralize the benefit by reduction of congestion pollution.

ATT has also much potential to improve traffic safety. Some clear examples were mentioned like fog warning systems and signalling systems that were already operational in the Netherlands. Fog warning systems and signalling systems that filter out extreme speeds appear to be quite effective. Furthermore, also the provision of dynamic traffic information to car drivers is regarded to



have a positive contribution to safety, since it may decrease the driver's uncertainty resulting in less distraction from the driver's task. In general the respondents were thus optimistic about the impact of ATT systems on safety.

#### *Expected drawbacks*

The use of ATT technologies brings along also possible (negative) side-effects. The main side-effects of information provision to road users are believed to be the following three. First, drivers may be distracted from the driving task by digesting too much information at one time or by a visual interface. These problems mainly concern in-car systems, and therefore there is more confidence in systems with speech interfaces. Critical is also the size of text displays of variable message sign. Second, in certain cases congestion may be not reduced but transferred to other parts of the motorway network (called 'squeezing a sausage'). Third, another problem is that an undesirable use might take place of secondary roads.

#### *Expected major problem areas in the implementation process*

According to the respondents, major potential bottlenecks which could delay the process of implementation of inter-urban ATT applications will probably not be technological, operational or financing problems. It was indicated that conflicts with local (car unfriendly) policies of large cities could probably cause some delays in this development but could certainly not obstruct the implementation in the long term.

#### *Expected future developments*

In the past five years the development of ATT systems has shown a rapid acceleration. The driving factor behind this has been the growing public census that unlimited expansion of road infrastructure will put serious damage to the environment and will not be sufficient to meet all kinds of traffic problems. However, until the present time the emphasis has mainly been on the development of the technology itself and pilot tests. It is agreed that now is the time for broader implementation of those systems that are fully standardized.

It is expected that within the next five years some existing technologies may be implemented and/or launched on the private market. This is the case for for example VMS systems and the Radio Data System-Traffic Message Channel(RDS-TMC). The introduction of other in-car driver information systems will take place over a longer period (in the next 10-20 years). It is expected that various different systems may exist parallel to each other, given the fact that the end-user market will be segmented. In general it is believed that the actual speed of development of ATT technologies will continue until at least the year of 2000/2010,

although it may show development waves dependent on waves of public interest. In the longer run it is expected that no limits will exist regarding the development of new generations of ATT systems.

In conclusion, from these interviews it became clear that, although the limitations of the application of information and telecommunication technologies in inter-urban road transport management are known, road managers are quite optimistic about the use of these systems, in view of the relative low cost compared to other measures to increase road traffic capacity. This may be an important indication for future adoption rates of these technologies by collective users.

## **7 Conclusions**

Advanced transport telematics technologies have the potential to offer new solutions to the transport problems in Europe. However, a critical success factor of these technologies is the adoption of these technologies by the potential users.

The ATT market comprises a large number of actors from both the public and the private sector. At the demand side, some major potential market sectors can be identified. In addition to individual users, these are collective users. The aim of this paper was to investigate the potential ATT market among road managers as collective users of ATT technologies. The results of a case study in the Netherlands were presented, concerning an investigation of the attitudes and expectations of road managers by means of in-depth interviews.

The road managing representatives were in general optimistic about the success of public inter-urban ATT applications regarding many aspects. It was believed that ATT could significantly contribute to the achievement of higher traffic safety and traffic efficiency. Strong success factors of these ATT applications were believed to be their relative low costs and few drawbacks in relation to other means to improve traffic performance. The importance of some basic requirements were stressed like the development of an open flexible system architecture according to agreed standards and a full acceptance by road users. It was expected that no major potential bottlenecks on either the supply or demand side could stop the process of implementation of these ATT applications. Based on the developments in the past five years, the respondents thought that the actual speed of ATT developments would continue with a similar rate at least until the end of the century. It was expected that in the longer run no limits would exist to the development of newer generations of ATT systems.

A final conclusion to be drawn is that indeed the actual technical development of information and telecommunication technologies applied to road transport is promising. There is optimism about the future implementa-

tion of public systems. It is clear that, as one of the possible future options for the development of the transport system, the ongoing development of information systems applied to transport will need a thorough assessment of the user side.

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