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INTELLIGENT TRANSPORTATION SYSTEMS AND ROAD SAFETY

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The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation on its Working Parties, and representatives of a wide range of national and international organisations with transport safety interests and Parliamentarians of all parties on its Main Council to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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EXECUTIVE SUMMARY

The primary purpose of this review is to provide advice for European policymakers on which Intelligent Transportation Systems (ITS) should be encouraged and developed and which should be discouraged and even prevented from a road safety point of view. The secondary target group is the research community, industrial representatives, road user and other interested organisations. Public as well as private ITS is considered.

The main reason for carrying out this review is to analyse in which ways ITS may contribute to reducing the unacceptably high human and economic toll from road crashes within the EU. In absolute figures over 42,500 people (800 every week) are killed on EU roads and more than 3.5 million persons are injured (including underreporting) each year. Expressed in other ways about 1 in 80 European citizens will end their lives on average 40 years too early and about 1 in 3 European citizens will need hospital treatment during their lifetime due to road crashes. The estimated costs of all these crashes within the EU is over 160 billion euro — around twice the EU budget and close to 1 per cent of GDP — an almost incredible figure.

Intelligent Transportation Systems (ITS) are based on intelligence placed at the roadside and in the vehicle. By means of communication between these systems and road users (primarily drivers), various road safety problems can be solved more easily. These can be societal problems such as speed adaptation as well as individual problems such as a call for help in an emergency. So far ITS has not lived up to its expectations concerning road safety. And it is important to point out that such a positive impact does not come by itself but needs careful analysis, planning and monitoring. The primary questions are “How can the safety of ITS be checked before it comes on the market? What is the appropriate process for such quality control? This is where the European Union has a key role.

Road safety has, until lately, been a mere by-product in ITS development and certainly not a central aspect of design. Today, there is sufficient evidence to suggest that the development and application of ITS should not be left entirely to market forces, as the market does not necessarily select the alternative most beneficial to safety. Manufacturers should be helped with design, development, and implementation issues, in order to re-establish the correct balance between safety and other ITS objectives, and to prevent further uncontrolled development. What might be allowable in the struggle for a common video standard is certainly not acceptable when it comes to saving lives.

It is becoming more and more clear that the introduction of various IT functions will not just change some of our tasks as road users. Widespread implementation of IT functions will completely revolutionise our lives. ITS may radically modify transport systems, particularly the extent to which they may change the role and the behaviour of the driver. It is presently impossible to predict all the ways in which our lives and behaviour as road users will be changed. In fact the response of road users to ITS applications, as they are introduced, is the most critical factor for the safety effects of ITS.

There are two ways to improve road safety by means of ITS: systems that influence safety in a direct way and systems that influence safety in an indirect way. Examples of promising direct systems are, for example, incident detection and warning systems using variable message signs, violation detection and enforcement systems, electronic licences, in-vehicle black boxes (crash recorders), variable speed limits, intelligent speed adaptation. Examples of indirect systems are those that change the exposure or mode of traffic, debiting systems, systems giving priority to public transport.

Another way of analysing the potential safety effects of ITS applications, which is the method used in this report, is to distinguish between three main variables that determine road safety levels in terms of health consequences: exposure in traffic, risk of a crash given the exposure, consequence of the crash. ITS has the potential to improve safety along each one of these three dimensions:

- It is possible and feasible now to influence or even control traffic exposure by means of ITS.
- It will be possible to reduce the probability of crashes, to prevent crashes by means of ITS.
- It will be possible to reduce the injury consequences of crashes by means of ITS.

ITS’ effect on safety through changed exposure.

There are a wide range of ITS applications addressing traffic volume and thus exposure. Practical experience as well as research results show that it is possible to reduce exposure by these means.

Many of these applications will be introduced as a matter of course, as safety objectives go hand in hand with other traffic policy goals such as energy consumption and environment. A number of applications include benefits for drivers in terms of improved information and other services. That will facilitate the introduction of systems such as:

- electronic driver licences
- road pricing schemes
- travel planners
- route guidance
- freight and fleet management

One of the ITS applications described in this report has outstanding potential in terms of crash savings. That is the electronic driver licence, which directly addresses the driver’s authorisation and ability to drive the vehicle.

ITS’ effects on safety through reduced crash risk.

A number of systems exist with high safety potential in reducing crash risk. Some of them are of a very general character:

- intelligent speed adaptation
- electronic driving licence

On motorways, the most safety beneficial systems have the potential to reduce injuries and fatalities by about 10–15 per cent. These systems are:

- motorway control systems
- driver and vehicle monitoring systems
- collision avoidance systems
- incident management
- automated speed enforcement

On other rural roads, current systems with the potential to reduce injuries and deaths by more than 10 per cent are fewer than on motorways, but they are more effective - intelligent speed adaptation has a 30 per cent and automated speed enforcement a 20 per cent injury reduction potential. Collision avoidance systems which work perfectly would, of course, have a very high potential. However, there are considerable problems in designing collision avoidance systems to work perfectly. The ITS systems with the highest safety potential are:

- collision avoidance
- automated speed enforcement
- speed control systems with variable speed limits
- driver and vehicle monitoring systems

In urban areas, systems with most safety potential (injury reduction of 30 per cent when fully implemented) are:

- collision avoidance
- intelligent speed adaptation
- urban traffic control

Much ITS development has so far concentrated on motorways, including the development of safety relevant ITS. The safety problems, however, concentrate in urban areas and on rural roads other than motorways. Hence, the implementation of ITS for the purpose of reducing crash risk should concentrate in urban areas and on rural roads other than motorways. Intelligent speed adaptation is the ITS application with the highest safety potential to reduce injury crashes in the whole road transport system.

ITS' effects on safety through the reduction of injury consequences.

ITS offer sensing and communicating systems that may improve the effectiveness of protective devices such as seat belts and air bags substantially, thereby contributing to the reduction of crash consequences. By means of ITS it will also be possible in the future to design more intelligent restraint systems. At the present level of development the largest safety potential exists in increasing seat belt wearing rates by means of seat belt warning and interlock systems and by means of emergency notification (Mayday) systems.

Implementation of ITS.

In view of the substantial added value of a common approach to legislation and standards for road transport telematics systems, a more co-ordinated approach is needed at a European level. Currently, there are no research-based standards for in-vehicle HMI (Human Machine Interface) and there is an absence of advice concerning compliance in the current guidelines. The future deployment of systems that can benefit safety needs common standards at a European level. Safety systems should not stop working when a car crosses a border. Without common action countries will make different decisions about which architecture to implement for a particular system, with missed opportunities for pan-European benefit. At EU level, there needs to be greater co-ordination between the various Directorates of the Commission. The efforts of different standards organisations which are currently operated by industry and professionals need to be part of a broader European strategy. It is, therefore, recommended that the Commission should establish a European Task Force, reporting via the High Level Group on Telematics to the Council and Parliament, to make an urgent strategic review of the procedures for enacting certification processes and, at a later stage, standards and the need for new standards, particularly in the area of cross-border compatibility and interoperability.

The following recommendations concerning action from the European Union are made:

A. Strategy

1. It is clear from the current situation that the European Union needs to establish a long-term strategy on ITS with a view to road safety. It also needs to develop its role in giving advice to industry with regard to design, development, implementation and evaluation of new products. It is important to ensure that the potential benefits to the community are maximised and that any disadvantages are minimised. The key issue is how such a process should be developed and designed.
2. Priority should be given to the development of ITS that address identified road safety problems, rather than to promoting technologies for their own sake. Other general aims than safety are, of course, legitimate as long as safety is not hampered.
3. The EU should encourage the early European-wide implementation of those ITS which have proven safety benefits.
4. The EU should give priority in long-term development to systems that have a significant potential to improve safety.
5. The EU should ensure that ITS introduced on the market is monitored and evaluated from a safety point of view.

B. Specific Actions

1. The European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems, as presented by the European Commission in 1998, represents an initial, non-mandatory approach to design and installation. The Statement of Principles needs to be made more specific and should define
   - a procedure that should be followed to ensure compliance with these principles;
   - a certification process through which products can be shown to have complied with these principles;
   - an EU certification process for ITS functions which are very critical from a safety point of view.

Steps to move beyond the current knowledge embodied in the Statement of Principles are recommended under (C) below.

2. A mandatory certification procedure to approve ITS applications in terms of system safety should be developed at a European level (reliability issues and the availability of adequate fallback procedures need to be addressed, as a system failure might put the road user in a very dangerous situation). The existing procedures for ensuring system safety should also be adopted at the international standards level, through ISO. Specifically, the need for standardisation and quality assurance of relevant control algorithms and protocols should be addressed.

3. Implementing ITS requires special consideration for safety in the transition phases -which may last several decades- during which car fleets, driver abilities, and ITS functions and interfaces will be very varied. The EU should establish a monitoring system to evaluate the design, development and implementation of ITS and their short, medium, and long-term impacts on traffic safety, that is, the overall safety effect of ITS on the traffic system.

C. Promoting Research

1. The Statement of Principles is only an interim measure. Research needs to be carried out in the EU Fifth Framework Programme to identify the link between levels of performance in HMI and effects on traffic safety. This would allow a research-based set of performance standards for in-vehicle HMI to be developed and proper attention to be given to cognitive ergonomics. The experience obtained with HMI in fields such as aviation should be taken into account.

2. The further development and proper application of evaluation tools for traffic safety should be required in European-funded research and development projects and when ITS are implemented, for example, in the Trans-European Road Network. This would help to ensure that negative effects are minimised and that knowledge on how to maximise safety benefits is increased.

3. Research on promising safety applications, such as Seatbelt Warning and Interlock Systems and Intelligent Speed Adaptation, including the study of alternative systems and the development of implementation strategies, should be carried out in the Fifth Framework Programme.

Today, road transport is by far the most dangerous mode of transport. The strictest safety criteria should be applied in the future, in order to reach the safety levels of, for example, rail transport, where fatalities are considered simply unacceptable. The opportunities offered by ITS should not be wasted!

1 Introduction

In absolute figures over 42,500 persons (800 every week) were killed and, taking into account underreporting, more than 3.5 million persons were injured each year. Expressed in other ways about 1 in 80 European citizens will end their lives on average 40 years too early and about 1 in 3 European citizens will need hospital treatment during their lifetime due to road crashes (CEC, 1998). The estimated costs of all these crashes within the EU is over 160 billion Euros -around twice the EU budget and close to 1 per cent of the GDP- an almost incredible figure (ETSC, 1997).

This review examines ways in which road transport telematics and intelligent transport applications (ITS) can contribute to reducing the unacceptably high human and economic toll from road crashes within the EU. It also addresses the question as to whether (and if so when and where) there is a risk that ITS may reduce safety on our roads. The primary purpose is to inform European policymakers about ITS applications which should be encouraged and promoted and those which should be viewed with caution from a road safety point of view. The secondary target group includes the research community, safety professionals, industrial representatives and road users.

The safety potential and safety impact of probable development of ITS for public and private road transport is defined in the review for the short term (5 years) and longer term (20 years) starting with an historical perspective. What is the present situation? What has happened and what is happening in other parts of the world? What has led to the present situation? What can be done to encourage development along the right track? The two main actors in ITS development are industry and government. However, the needs, the acceptance and the reactions of users are the most critical variables both for the penetration of ITS and for ITS impact on safety.

1.1 Current ITS situation

History

Ideas about using advanced information and communication technology to enhance road traffic in general and road safety, in particular, have been put forward on more than one occasion during the development of road transport. The first wave came in the technologically optimistic fifties, after the Second World War; the second in the seventies when computer development was very intensive. During this time, expectations exceeded the level of technical development of the components and systems. Either the equipment could not carry out what was expected of it, or the costs of achieving what was expected of it, were too high.

It was not until the third telematics wave in the eighties that technological development matched the expectations of vehicle, road and traffic control experts. Intensive research and development programmes started simultaneously in Europe (Prometheus and Drive) and in Japan (AMTICS, RACS). While efforts in the United States started somewhat later, development is now very rapid. Many systems and functions are already commercially available on the market in all three areas mentioned, Japan being ahead in this respect.

Another mismatch which became apparent in the late eighties was the lack of co-operation between private and public, between non-governmental and governmental ITS initiatives. It was better understood that unless the roles of these two main actors were made clear and the respective responsibilities made explicit, there would be a large risk that the initiatives of the private and the public actors would counteract each other from a safety point of view.

During the first two waves the main arguments presented in favour introducing ITS were that ITS would enhance the efficiency of motorised traffic. However, already in the initial phase of the third wave, improving safety was commonly cited as one of the main arguments for research and development on ITS. Very strong safety effects of ITS were predicted. Figures such as a 50 per cent reduction in crashes due to the introduction of ITS were not uncommon and are still used (see 1.3 below). In spite of this, today few safety focused ITS have been developed and are available. Most systems and functions have objectives other than safety.

Current problems

According to many studies, those factors most closely related to safety are exposure, speed, alcohol / drugs and various injury reducing measures (for example, seat belts and helmets). All four factors influence both crash prevention and crash consequences. Consequently some ITS must aim at reducing the impact of these variables. Reducing the volume of motorised traffic (exposure) is also advantageous from an environmental point of view. Another aspect of exposure is the gradually increasing congestion problems on European roads. Road users are kept on the roads (exposed) for unnecessarily long periods. Goods transport is delayed by congestion and damaged in crashes. The economic consequences of these must not be forgotten.

Drinking and driving is a problem that is widely acknowledged. In most countries public condemnation of drunk driving is increasing and the problem is slowly decreasing. However, drinking and driving is still one of the major crash factors in Europe. Speed, however, is still a sacred cow for many people and consequently for policymakers. Speed influences both active and passive safety in an exponential or accelerated way which is one of the reasons why it is such an important variable in road safety work. Research has established beyond any doubt that reduced speed leads to increased safety. Currently, ITS aiming at exposure (for example, debiting systems, traffic management systems, electronic driver licences, and traveller information systems) as well as speed (for example, Intelligent Speed Adaptation – ISA), alcohol (for example, alcohol interlock systems) and injury reducing systems (for example, intelligent air bags, seat belt warning and interlock systems) exist or are being developed.

The size of the various problems and the situations and impacts of the different variables are, of course, different in urban areas, two lane roads and motorways.
Other major road safety problems recognised in most countries are high crash and / or injury rates

- among young and new drivers;
- for unprotected road users (for example, pedestrians, cyclists and motorcyclists);
- for heavy vehicles such as trucks (mainly dangerous for other road users);
- in bad visibility conditions such as darkness and fog;

- in low friction conditions (for example, on ice, snow, heavy rain);
- for tired drivers (the exact size of this problem is not known but it is believed a large part of the single vehicle accidents belong to this category);
- for drivers that are driving a vehicle without being authorised to do so (for example, stolen or without licence or with a withdrawn licence);
- for old drivers (who are increasing proportionally in most European countries).

Factors contributing to the high injury consequences of crashes are

- delayed rescue service (congestion in heavily populated areas and long distances in sparsely populated areas make it increasingly difficult for victims to be treated within a reasonably short time);
- a large number of injury causing constructions of various kinds (for example, lighting columns, interior of the car interior, vehicle crashworthiness).

The two last factors are in contrast to the others mainly passive safety oriented.

It is also important to prevent ITS with primary purposes other than safety from introducing new safety problems. The very rapid and uncontrolled introduction of mobile telephones is a good illustration of this problem (although mobile telephones can also have a positive effect on safety to the extent that they are used to call for help or alert other drivers to potential dangers). Mobile telephones are further discussed in Section 7 together with another potential safety hazard of the same kind namely the introduction of the in-car office (Scrase, 1998).

An additional safety aspect that must not be forgotten is what is normally called system safety, which means that the system should be technically reliable and if it breaks down it should do so in a way which permits the driver to handle the situation without introducing any new hazardous moments. This aspect is very important because systems have a tendency to increase in complexity when various ITS are built into the vehicle. System reliability is decreasing rapidly with increasing system complexity.

Current development

There are a number of safety hypotheses and proposed developments, but few ITS have proved their safety efficiency. There are several systems, which are very promising from a safety point of view such as emergency alerting systems, incident management systems, intelligent alcohol interlock systems, electronic driver's licence and policing systems. There are, however, also a number of systems and functions that have been studied and questioned from safety point of view. The best and most widespread example is probably the mobile telephone (hands-free or not). Other examples of functions belonging to this questioned category are navigation systems and vision enhancement systems.

There are two ways to improve road safety by means of ITS: systems that influence safety in a direct way and systems that influence safety in an indirect way. Examples of promising direct systems are for example incident detection and warning systems using variable message signs, violation detection and enforcement systems, electronic licences, in-vehicle black boxes (crash recorders), variable speed limits and intelligent speed adaptation. Indirect systems are, for example, those that change the exposure or mode of traffic, debiting systems, and systems giving priority to public transport.

It is not enough to develop ITS that might offer safety improvements as a secondary benefit. A number of ITS aimed specifically to enhance safety and reduce fatalities, injuries and crashes must be developed and tested. Systems must influence the major safety variables. There are two main types of safety countermeasures: actions aiming at preventing crashes (often called active safety measures) and actions aiming at reducing the consequences of crashes (often called passive safety measures).

1.2 Future ITS development - a revolution?

It is becoming increasingly clear that the introduction of various IT functions will not just change some of our tasks as road users. Widespread implementation of IT functions will completely revolutionise our lives. ITS may radically modify transport systems, particularly in terms of the extent to which they may change the role and the behaviour of the driver. It is presently impossible to predict all the ways in which our lives will be changed and only our imagination puts limits on that.

ERTICO (the European organisation which aims to promote ITS and carries out contracts particularly to implement ITS) has presented an optimistic vision of the future of ITS (ERTICO, 1997). Shibata (1998) gives a corresponding optimistic view. He claims that one of the major reasons for a successful Japanese road safety work is the implementation of ITS. The main features in the ERTICO vision are

- ITS will contribute significantly to a 50 per cent reduction of road fatalities;
- Survival rates for crash victims will increase by 15 per cent as a result of in-vehicle automatic emergency call systems based on ITS;
- ITS will reduce travel time by 25 per cent;
- ITS will lead to 50 per cent less pollution in city centres due to enhanced urban traffic management;
- Automatic debiting and tolling systems based on ITS will save travellers over 40 hours per year;
- Public transport priority measures based on ITS will reduce delays by 50 per cent;
- Freight and fleet operations will become more efficient cutting costs by 25 per cent.

At present most of the information perceived by the driver comes from outside the vehicle, but this situation may change when information is produced within the vehicle itself. It is becoming less and less direct and increasingly mediated by diagrams, voice etc. When systems can act on the vehicle, they will produce a certain amount of automation, which in time may have a considerable influence on the tasks, and the behaviour of the driver.

ITS will also provide a way of carefully adjusting utilisation costs for road infrastructures, presently financed by tax revenues, and debit these costs to the users.

Intermodality between private driving and various modes of public transport can be developed effectively, particularly by using the relevant information provided to users. Freight transport is gradually being rationalised so that the work of heavy transport drivers can be more easily “controlled” by computers. The concept of the vehicle itself may ultimately be modified when it becomes possible to find an “intelligent” way of sharing the same vehicle and therefore radically reducing the present-day difference between private vehicles and public transport.

Such a move may question the symbolic link between driver and vehicle, an emotional link based on an “investment” in which the freedom to drive or pleasure of speed are of prime importance. ITS will by means of such influence also raise the issue of actual infrastructure design and the management of urban road networks and thus modify their relationship with the town.

This is not an attempt to predict what lies ahead but to consider that ITS may, at some time in the future, create a genuine revolution in road transport. This will require, therefore, not only a detailed analysis of potential impacts on safety, but also policy monitoring with regard to the design, introduction and development of these systems. This monitoring should include an analysis of behaviour-related effects resulting from improved performance and increased comfort. It should also include analysis of the effect of potential loss of skill, conflicts between the individual and the system, difficulties of utilisation for certain segments of the population or any other side effects which are difficult to forecast, but which may influence the level of road safety.

The hope is, of course, that future ITS will live up to initial safety expectations. However, such a positive impact will not come by itself, but will require careful analysis, planning and monitoring. Another prerequisite is that the perceived value of increased safety (safety awareness) among both the public and the decision-makers is increased.

The introduction of ITS has so far been market driven and is likely to continue to be the main force behind ITS. The size of the expected market is enormous (ITS World, 1997). Market forces, however, do not automatically lead to improved safety and it will be necessary to study consumer acceptance of various safety functions before they are introduced (Cairney, 1995 and Steele, 1995). Some aspects of ITS will need to be compulsory in vehicles in order to achieve full safety impact. The cost effectiveness of ITS introduction will also need to be examined.

The fact that it is so hard to predict the safety impact of ITS (see Section 8) is a strong argument for a close and systematic monitoring of the safety effects of ITS following its implementation. Safe implementation, as well as effective monitoring of safety results, requires international co-operation and action.

1.3 Other relevant activities in progress

This review is not intended to duplicate any of the activities carried out in other national or international fora. There are a large number of activities in progress which include:

- The European Commission has just published a Statement of Principles for In-vehicle Information and Communication Systems. Task Force HMI (Human-Machine Interface) 1998.
- There are several national Codes of Practice in the same area for example Germany, UK, Netherlands, Japan.

- The European Commission (DG VII) has a High Level Group on Road Safety interested in the impact of ITS (members from the Member States).
- The European Commission (DG VII and DG XIII) also has a High Level Group on Road Transport Telematics (representatives from the Member States).
- Together these two groups have a special joint subgroup with the task to look specifically at ITS and its safety impacts.
- Within the Fourth Framework Programme there have been several projects of relevance for this study (for example, CODE, GADGET, HINT, MASTER).
- PIARC (Permanent International Association of Road Congresses) has a special committee for Intelligent Transport (C16) and another special committee for Road Safety (C13). These two committees take a common interest in ITS and road safety, especially incident detection and road equipment.
- ISO (International Organisation of Standardisation) has two working groups on standardisation of in-car-information systems (IVIS) and adaptive cruise control systems (ACC).
- ESV (Enhanced Safety of Vehicles) has created a special programme to initiate co-operative research between the automobile manufacturing countries with the purpose of creating an International Harmonised Research Agenda (IHRA). One of six areas is in-vehicle ITS.
- OECD (Organisation for Economic Co-operation and Development) has a special ITS working group.
- ECMT (European Conference of Transport Ministers) has issued recommendations on the safety and ergonomics of in-vehicle ITS.
- USA, Japan and Australia all have their ITS activities organised within their respective ITS Societies.
- There are numerous other national activities carried out to study, produce, promote, co-ordinate, control and standardise various ITS.

The interest in how ITS may or may not contribute to road safety is presently increasing in Europe. A corresponding development is seen in USA (ITS International, 1998) and in Australia (Cairney & Green, 1998).

Most of these groups have one thing in common: they focus on a limited part of the general problem discussed here — how may ITS improve safety and which aspects of ITS should be avoided from safety point of view. Each study or activity contributes to our knowledge about this general problem. However, there is a lack of overview of the situation at international level of the safety potential of ITS and of the potential threats on safety from ITS which this review seeks to address.

1.4 Content of this review

This introductory section presents the background and rationale for this review. Section 2 examines what is meant by ‘safety’ together with ways in which it can be measured and influenced (exposure, crash risk and crash consequence). The various potential safety impacts from ITS on road safety are outlined.

In Section 3 an analysis is made of how the introduction of ITS will influence the task of road users. This is the basis for the general impact of ITS on traffic. Road user behaviour and road user response will be the regulating factor for the effect of ITS on road safety.

Section 4 analyses and discusses the impact of ITS introduction on the use of the car and other modes of road transport. The purpose is to indicate how exposure, one of the major safety relevant variables in road traffic, may be influenced by ITS.

In Section 5 the possible influence of ITS on the probability of a crash (crash risk) is considered. Crash avoidance measures include driver aspects such as monitoring of driver condition, ramp metering and incident detection. The discussion covers rural as well as urban situations.

Section 6 looks at the potential of ITS to reduce the injury consequences of a crash. Crash consequences depend on the injury reducing capacity of in-vehicle and environmental systems and on the effectiveness of the rescue service and the treatment and rehabilitation of the victims.

Section 7 reviews the new concept of the in-vehicle office and considers how this type of IT development may influence safety. In Section 8 the problems of implementation, monitoring and evaluation of ITS are reviewed and discussed from safety point of view. This includes research as well as administrative issues. Section 9 deals with public and society acceptance of various ITS introductions and with the legal aspects of ITS implementation.

Finally, in Section 10 conclusions are made and the key elements of a safety strategy for ITS within the European Union are proposed. Appendix 1 gives the inexperienced reader an introduction to the different types of ITS functions. Appendix 2 lists the legal and administrative instruments available. Appendix 3 is a simple glossary of terms used in this report.

2 Safety and risk in road traffic

This Section discusses the meaning of road safety, how road safety can be measured and the various ways, in which safety may be influenced by ITS. It also touches upon the difficult problem of evaluating the positive and negative safety effects of various ITS, which is treated in depth in Section 8.

2.1 Road safety

Transport safety can be defined in a number of ways, including the official World Health Organisation (WHO) safety definition ‘freedom from unacceptable risk of harm’. Road safety is, however, usually defined in a negative way. Safe road traffic is characterised by the absence of crashes, injuries and fatalities. Crashes are used here instead of accidents because the word accident leads thoughts in the direction of an event that is hard to do something about — “it happened by accident”.

For society and for the individual, the loss of health is the most serious effect of crashes. It leads both to serious personal suffering and to huge societal losses in monetary terms. Therefore, it is essential to state at this early stage that loss of health is the main road safety criterion. Convalescence and health restoration have economic consequences as have vehicle damage and loss of vehicles and goods.

The need for a strategy and action plan on a European level to reduce the very large road casualty problem was recognised only fairly recently. In 1991 a High Level Expert Group presented “European Policy for Road Safety”. The immediate impact of this ambitious and concrete report was, however, limited. In 1997 the European Commission presented “Promoting Road Safety in the European Union: the Programme for 1997–2001”. The same year the need for a targeted strategy was further elaborated on in the ETSC Strategic Road Safety Plan for the European Union (1997).

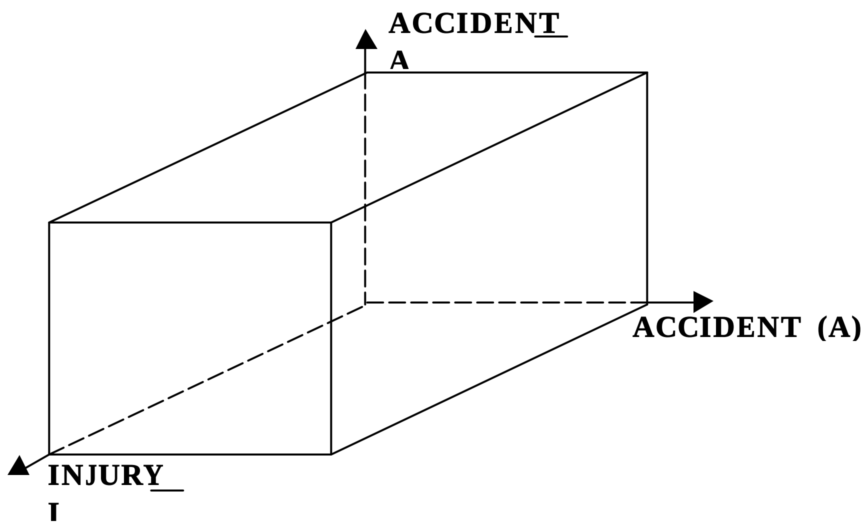
Road safety may be influenced along many separate dimensions and various models have been used in road safety management:

- There are three main variables that decide the road safety level in terms of health consequences: exposure in traffic, risk of a crash given the exposure, consequence of the crash.
- The health consequences of road crashes may be influenced by actions taken before the crash (active safety), during the crash (passive safety), and post crash (rescue, treatment, rehabilitation).
- Most of the crashes are triggered by human errors, sometimes intentional but normally unintentional. There are three basic ways to reduce the human errors: selection of road users (for example, licensing), improving road users (for example, information, education, training, and enforcement), adaptation of road and vehicle engineering solutions to human characteristics and limitations (make it easier to drive, to bicycle, to walk in traffic).

The first mentioned model is the most comprehensive and will be used here. The second does not include exposure as an important safety variable and the third does not include passive safety as an important safety variable. ITS have the potential to improve safety along each one of the three mentioned dimensions (Rumar, 1996):

- It is possible and feasible now to influence and even control traffic exposure by means of ITS.
- It will be possible to reduce the probability of crashes, to prevent crashes by means of ITS.
- It will be possible to reduce the injury consequences of crashes by means of ITS.

Figure 1 **The size of safety problem (number of human injuries and fatalities)**
illustrated as a function of the product of the three variables



2.2 Measurement of road safety

There are, in principle, two ways to measure road safety:

- By direct methods focussing on the safety consequences of road traffic in terms of crashes, injuries, fatalities. Those measures have a comparatively very high validity (except some bias from systematic underreporting) but, unfortunately, these crash-based measures have a fairly low reliability. They measure with low precision and require, therefore, large scale implementation in traffic and long periods of exposure. It is presently hard to reach this situation for ITS which, initially and in most cases, are only implemented in very small scale.
- By indirect methods such as conflicts, exposure, speed, wearing of personal protection and other such measures which have no direct relation to crashes but which have a known relation or correlation with the above mentioned direct road safety measures. With one name these measures are often called performance indicators. These measures have a comparatively high reliability (precision) but a lower or unknown validity (they are not directly measuring crashes).

The consequence of this is that the best way to measure road safety is to use several measures simultaneously. Decision makers, quite rightly, tend to trust direct road safety measures more than indirect road safety measures. This poses problems for ITS because so far, it has rarely been implemented on a large scale in traffic.

Risk is a common concept in road safety. In order to be able to calculate risk it is not enough to have the number of crashes, injuries or fatalities. It is necessary to know the exposure or volume of travel in each separate situation or for each road user group. By dividing the number of fatalities by the exposure, the risk of being killed is obtained. Exposure is often very difficult to obtain, as is illustrated in a new report by ETSC on risk analysis of transport in the EU (ETSC 1999). ITS opens up new possibilities to solve risk calculations based on exposure because exposure may be obtained automatically by various sensing systems, without threatening road user privacy, which are used for other purposes in ITS.

2.3 Influence of ITS on road safety

Draskóczy (1993) and Kulmala (1996) discuss a number of safety relevant areas that may be influenced by the introduction of ITS. Their list may be summarised as follows:

- Direct in-car modification of the driving task by giving information, advice, and assistance or taking over part of the task. This may influence driver attention, mental load, and decision about action (e.g. driver choice of speed).
- Direct influence by roadside systems mainly by giving information and advice. Consequently the impact of this influence is more limited than of in-vehicle systems (e.g. change of route).
- Indirect modification of user behaviour in many, largely unknown ways. The driver will always adapt to the changing situation. This is often called behavioural adaptation and will often not appear immediately after a change but may show up later and it is very hard to predict. Behavioural adaptation may appear in many different ways (for

example, by change of usage of the car, by change of headway in a car following situation, by change of expectation of the behaviour of other road users).

- Indirect modification of non-user behaviour. This type of behavioural adaptation is even harder to study because it is often secondary. Non-equipped drivers may for example change their behaviour by imitating the behaviour of equipped drivers (for example, driving closer or faster than they should, not having the equipment).
- Modification of interaction between users and non-users. ITS will change the communication between equipped road users. This change of communication may influence the traditional communication with non-equipped road users. To a large extent this problem may appear in the interaction between drivers and unprotected road users.
- Modification of road user exposure by, for example, information, recommendation, restrictions, debiting. This is certainly an area where introduction of ITS will have a large impact for example by changing travel pattern, modal choice, route choice, etc.
- Modification of accident consequences by intelligent injury reducing systems in the vehicle, by quick and accurate crash reporting and call for rescue, by reduced rescue time.

Malaterre, Fontaine and van Elslande (1991) approached the problem from the other side, trying to analyse the types of real world crashes that might have been influenced by ITS introduction. They identified 17 driver needs from detecting obstacles to monitoring driver status and checked to which extent 14 ITS could meet these needs in over 3,000 road crashes. Their results indicate that in rural areas the 14 ITS could avoid about 22 per cent of all crashes. In urban areas the corresponding reduction was estimated to 17 per cent. In total, one crash out of three could be avoided by correct use of ITS. The largest potential impacts were estimated for intersection control and loss of vehicle control. According to ETSC (1997) loss of vehicle control is responsible for 18–42 per cent of fatal accidents in many EU countries. This approach is for several reasons more limited than the above analytical approach. It does not fully appreciate the change of traffic and driver behaviour pattern that most probably will follow as a consequence of ITS introduction. It is, however, an interesting complementary approach.

2.4 Safety evaluation of ITS

There are several problems associated with safety evaluation of ITS. As mentioned in subsection 2.2 it is difficult to measure the safety impact of ITS by the traditional methods based on number of crashes or injuries. Other evaluation problems are mentioned in Section 3 where the total change of road user tasks as a consequence of ITS introduction will be analysed and discussed. These evaluation problems are discussed in more detail in Section 8.

However, some conclusions may already be drawn here:

- To a large extent the introduction of ITS will be driven by market forces. As it is extremely difficult to evaluate safety effects of ITS it is imperative that the impact of ITS on road safety is monitored on introduction.
- Therefore, it should be in the interest of the authorities that the ITS that are put on the market have a high probability of improving safety (and environment). This requires that the basic pre-evaluations are made in advance before the system is put on the

market. It is, therefore, a primary responsibility of the EU to take initiatives that will stimulate ITS to improve safety (and environment) and secondly to make sure that some form of safety certification procedure to guarantee safe design and performance of the ITS product is established.

3 ITS and the task of the road user

3.1 Introduction

As mentioned previously, ITS devices of all types modify the driving conditions of a driver and this will usually result in temporary or permanent changes in driving behaviour. Although such changes are often intended, unintended and unwanted behavioural changes will be quite possible. This section reviews some of the mechanisms for such changes, both for behavioural changes in an intended, positive direction and for changes in a negative way. By way of introduction, some of the basic behavioural elements of the driving task are considered in brief.

3.2 The driving task

Human limitations

In order to navigate through traffic a driver must perceive the surrounding scene, process his or her observations and take action, by means of controlling the vehicle, in such a way that the driver's goals will be attained without endangering other road users. There are a number of reasons why these apparently simple tasks can be difficult to accomplish:

- the speed differences in traffic are often considerable, especially on roads with mixed traffic and at-grade intersections, which call for swift reactions;
- there are usually several road users or obstacles to take into account at any given time;
- human beings, though capable of quite complex behaviour, usually are quite slow in executing that behaviour when compared to the swiftness of changes in traffic;
- human resources like attention and energy are limited: these limitations are expressed in the term task load. It is generally accepted that there is a certain range of task load in which control actions can best be performed. Task load below or beyond this range leads to deterioration of control.

If ITS is to improve road safety, a more careful consideration of how road users manage their everyday tasks is necessary. Essentially, the question here is: "how do drivers manage to compensate for their limitations". Understanding the mechanisms of behavioural compensation is the basis for understanding the effects of ITS. However, to employ that understanding to design effective ITS systems, the subsequent question must be "how will drivers make use of improvements to their capacities".

Compensating for driver limitations

In past decades many behavioural theories have been put forward, all of which contain useful components but none can really claim to be complete. One of the later developments: the theories of Situation Awareness (Endsley, 1988, 1995) integrates many previous theories. Summarily stated the mechanisms to compensate the limitations are as follows:

- Instead of reacting to the current situation, drivers largely react to *a predicted situation*, thereby compensating their slowness. This prediction includes both the behaviour of their own vehicle and the behaviour of other road users. Only unpredicted situations lead to purely reactive behaviour, which often causes problems.
- Drivers develop a repertoire of simple models to assess and predict traffic situations. The simplicity allows quick analysis and decisions.
- The simple models also require the observation of only a limited set of characteristics of the surrounding traffic, thus also speeding up perception. Each model in the repertoire is associated with its own characteristics.
- Routines and tasks that must be performed regularly can be automated to such an extent that they do not require conscious attention, thus lowering task load and freeing resources for other tasks.

These compensation mechanisms provide a number of handholds for the estimation of ITS effects but there are also additional behavioural effects that must be considered. These include the longer term adaptation effects that result from prolonged use of ITS, effects on route choice, choice of mode of transportation and the possible effects of different attitudes and beliefs. In the following sections, these considerations underlie the assessment of some of the possible effects of ITS.

3.3 Possible positive safety effects

3.3.1 Effects on Situation Awareness

Systems that support or enhance observation
There are two types of systems:

1. vision enhancement systems that facilitate vision in difficult circumstances (night, rain, fog)
2. systems that focus the perception on critical parameters. These can be systems outside the vehicle like conspicuity enhancement (for example, daytime running lights) or in-vehicle systems like alerting or warning systems (proximity or collision warnings).

Additional positive effects may arise from a general lowering of task load making it easier to keep task load within the optimal range.

Systems that enhance prediction:
So far, systems that support short-term prediction of the behaviour of other road users do not exist. Some ITS devices may contribute indirectly by standardising traffic behaviour but only if virtually everyone uses them. Examples are, in certain conditions, devices that support headway and course keeping and speed management devices. Devices that simplify handling of the own vehicle exist and can improve comprehension and prediction of the behaviour of the vehicle, resulting in more accurate predictions and a general lowering of task load. Systems that support longer-term prediction also exist. Radio Traffic Information systems and signalling systems using Variable Message Signs provide

information that can not be obtained from the immediate vicinity of the driver and therefore extend the predictive range.

Decision and action

An important class of ITS devices is intended to alleviate or take over certain driving tasks. They aim to perform controlling actions more quickly and reliably than could be achieved by a human controller. Examples are speed and headway (distance to the car in front) control, lateral driving support, collision avoidance systems and the Intelligent Speed Adapter. Potentially, those devices increase safety in a number of ways:

- by taking over tedious tasks, thus lowering the task load of the driver and freeing some of the driver's capacity for other traffic tasks;
- by enhancing human skills and limiting the necessary repertoire of routines in different conditions;
- by reacting more swiftly to emergency situations than a driver could, thus enhancing driver performance.

Task load

A variety of ITS applications that simplify part of the driving task will effectively lower the driver's task load. Current understanding is that this will only have a significant positive effect on safety when the original task load is high. This means that such devices will enable the driver to cope safely with more demanding situations than without ITS.

3.3.2 Longer term effects on individual behaviour (learning, adaptation)

By simplifying the driving task, ITS devices can also have positive effects in the long run because:

- necessary driving skills will be simpler and more robust in dealing with different conditions;
- cognitive capacity that can be applied to other important tasks like interaction with other road users is freed;
- the learning process will be simpler and shorter, both for schemata and skills. This may shorten the dangerous period that all learner drivers go through. Also, the change from one type of vehicle to another will involve less or no adaptation.

Given the possibility of certain negative long term behavioural effects, ITS may be modified or extended in such a way that those expected effects are counteracted.

3.4 Possible limiting and negative effects

Although the positive effects that have been described so far are certainly not imaginary, there are certain conditions that may limit the attainable effects. These include:

- the lack of standardisation of ITS functions and interfaces: standardisation allows optimisation of the Human Machine Interface and facilitates the learning process of learner drivers strongly
- the difficulty of having *all* vehicles equipped with a number of basic ITS functions.

As regards the existing situation, it is likely that ITS will not be standardised extensively and will be introduced by market mechanisms so the level of equipment of individual vehicles may vary greatly.

Also, the majority of ITS devices so far are designed primarily with motorway conditions in mind and the consequences for driving on other types of road have not been thoroughly considered. In the following paragraphs the possible negative effects of these, non-optimal conditions will be reviewed.

3.4.1 Effects on Situation Awareness

Observation

Research has shown that some ITS applications like route guidance displays are often neglected when the traffic situation outside is demanding. This adaptation is only possible if the driver can access the information source whenever he/she wants it. If the information source is located outside the vehicle, the driver can only access the information in a limited area and time before the sign is past. This limits the possibilities of the driver to regulate the task load and so produces a higher risk of overload. Furthermore, all information devices may give some detrimental effects because they can arrest attention so that an important event elsewhere is missed.

Prediction

There is a long-term risk involved in progressively automating human tasks, specifically when the automation becomes more and more complex. In this case the user may not fully grasp the workings of the system and arrive at faulty predictions or expectations. This misunderstanding can lead to dangerous situations. It has already led to some (near) accidents in aviation.

Furthermore, ITS systems can change a driver's outwardly observable behaviour and make it different from behaviour that unassisted drivers would display under the same circumstances. This make this modified behaviour difficult to predict which must be considered less safe. This is especially relevant when relatively few drivers utilise ITS so that the modified behaviour is rare and has not yet been learned by the majority of drivers. So, although the ITS may help to improve the safety of a minority of drivers, the overall effect can be a deterioration of safety in this case.

Decision and action

Many of the devices that are intended to take over part of the driving task like Autonomous Cruise Control (ACC), lateral driving support etc. are mostly intended for operation under motorway conditions. As such they have been designed to alleviate the driving task. In urban circumstances, where frequent changes of course and speed are normal, these devices should not operate but if they do are likely to cause serious complications.

Research (Endsley, 1995) also indicates that human controllers who have developed certain manual control skills and are then placed in a supervisory role will perform better than human controllers who have never developed specific skills. This indicates the possibility of a long term deterioration in driver performance and thereby also in road safety. If future generations are trained solely in vehicles with all possible support systems they will not develop the skills associated with “manual control” that are required without support or with failing support.

When support systems become more and more complex, they may present the user with the additional problem of always knowing and understanding what the system is currently doing. The driver that misinterprets the action of a complicated system may end up “fighting” the system, which demands a lot of attention and is potentially very dangerous. There have been examples of such “fights” in recent incidents in highly automated civil aircraft. Another potential problem associated with higher system complexity is that it becomes more difficult for a user to determine accurately whether the systems functionality is deteriorating and has become substandard. Especially gradual deterioration combined with rarely used functions may lead to unpleasant surprises and hence to dangerous situations.

Task load

Task overload is thought likely when several tasks compete for attention so that the driver is unable to process all relevant information and is, therefore, mainly associated with the Human Machine Interface. Since much of the information input goes by way of the visual channel, this channel is considered a prime candidate to produce this overload. The addition of yet another visual task by ITS applications therefore increases the risk of overload.

Underload is defined as the state of reduced vigilance (no specific driving task demands) or deactivation (dozes off). Underload can be brought about primarily by devices that partly take over the driving task, combined with quiet and monotonous traffic conditions. So-called Highway Hypnosis is an example of underload.

3.4.2 Longer term effects on individual behaviour

Human-out-of-the-loop problems

If ITS reduces the operator’s role to supervision instead of active control, the supervisory activities can easily be neglected or omitted entirely, thus freeing capacity for other activities. What can happen then is illustrated by research with driving simulators. For instance, it turns out that drivers readily adapt to the use of anti-collision devices and will completely rely on the device after only a short learning period. If the simulated device is made to fail, more than half of the drivers tested fail to take effective action and crash! (Stanton & Marsden, 1997) Again, these tests have been made under motorway conditions. In urban conditions, with a multitude of moving and stationary obstacles, failure of the automatic device is far more probable. This sort of adaptation could therefore prove even more dangerous in an urban setting.

Counterproductive behavioural adaptation

Counterproductive behavioural adaptation is when drivers start behaving in riskier ways as a result of a perceived increase in safety provided by an ITS device (or any other device). These effects, sometimes described as risk homeostasis, still have not been very well researched and are often speculative but must be taken seriously. Drivers of vehicles equipped with Anti Braking Systems, for example, have shown adaptation to the device and/or by increased speed under adverse conditions. In the balance, ABS therefore has changed the types of accident rather than having decreased the number of accidents.

Indirect long term effects

Indirect effects can be defined as behavioural adaptations on levels or modes of behaviour that are not directly related to the function(s) of ITS devices. Some examples are:

- a general effect of automating difficult or dull parts of the driving task may be, that driving becomes more attractive which will lead to an undesired increase in the use of motor vehicles;
- route and traffic information systems may lead to a redistribution of traffic through areas where high traffic densities are not desired;
- ITS systems that improve the handling characteristics of vehicles may lead to increased use of those vehicles under adverse weather conditions like heavy rain, snow or icing;
- ITS can create time or opportunity for activities that are not related to the driving task. These tasks, for instance the operation of a PC in the car, can distract the driver to such an extent that the activity consumes more than the available extra time.

3.4.3 Effects of multiple ITS devices

If drivers can freely equip their vehicles with more than one ITS application, a number of different problems can arise as a result of lack of co-ordination. These problems include:
- the placement of multiple displays, making the observation task unacceptably more complex;
- simultaneous messages, with all possible mixtures of modes (visual, auditory, tactile) that arrest attention and demands time to sort out;
- conflicting instructions or even conflicting actions.

3.5 Conclusions

ITS devices in traffic applications have the potential to simplify and standardise driving tasks, to support the most powerful aspects of human controlling behaviour and to compensate weaknesses in that behaviour. If we can realise that potential this will without doubt lead to a substantial improvement in general safety. However, there are still some important obstacles before this can be realised. On a general level, there is the problem that the positive effects of ITS depend strongly upon the degree of use: the level of penetration. The solution for this type of problem is closely linked to functional standardisation of ITS.

On a more detailed level we find that the basis of human driving behaviour is often more intelligent and complicated than is outwardly apparent. Current “intelligent” systems often prove to be too simple to provide extensive and reliable support for that behaviour. Substantial research effort will be required to develop functionally adequate ITS that is also technically robust and affordable.

Also, adaptable human nature will probably cause difficulties that can only be foreseen in outline. As a consequence, development of ITS will not be a “single shot” activity but will always require monitoring and adjustment afterwards. In short, there are still considerable scientific, technological and organisational problems to overcome but the benefits will also be substantial. Realising these benefits will require concerted effort by governments and industry.

4 ITS and traffic exposure

4.1 Introduction

Traffic reduction is primarily an environmental objective. The negative impacts of transport such as energy consumption, congestion and pollution are related to the total amount of transport. However, as mentioned previously, exposure is one of the main variables of road safety. Research and experience demonstrate that if total vehicle mileage is reduced, then the number of crashes on average will be reduced.

This section deals with ITS systems affecting the amount or distribution of traffic in terms of routes or transport modes and consequently safety. The strong correlation with the environmental impact is a clear advantage because it means better profitability and stronger political focus on measures to reduce exposure.

There are several ways of reducing total traffic exposure. Basically, any measure reducing the need for transport will contribute to this objective. This includes:

- physical planning
- localisation
- specialisation of industries etc.

On the next level, the demand for transport can be reduced by one or more demand management measures. These include:

- access control
- pricing schemes
- incentives to change travel mode.

Finally, optimising routes and freight movements to minimise the distance travelled will also contribute to a reduction in exposure.

4.2 ITS and the use of the car

Demand management aims at reducing the amount of transport by physical or financial restrictions. The most common ITS measures are access control and electronic road pricing schemes.

An efficient way of reducing traffic in a town centre or similar is to apply an access control scheme where only authorised vehicles are allowed to enter the area. By means of ITS, access control can be automated either by an electronic surveillance system or by a number of barriers requiring a certain electronic code to open. Field trials in Barcelona and Bologna show considerable reductions in traffic volumes and consequently in the impacts of traffic such as air pollution and noise (CEC, 1998) in spite of the fact that powered two wheelers (PTW) have access to the city centres.

Electronic road pricing schemes cover a variety of systems and applications. They may be grouped into three categories: tolls, cordons (toll rings) and distance and time based systems

Toll systems are traditionally used on motorways, tunnels and bridges to make users pay for the infrastructure. In some countries these facilities are privately owned and operated and the tolling system is an integral part of the commercial operation.

The effect on traffic and consequently on safety depends largely on the topography of the surrounding road network. If alternative routes are free of charge, drivers may be tempted to divert to them. In Austria, a study of the potential effects of motorway tolling has been carried out for two different motorway sections based on model calculations (Machata, 1998). The results show an increase in the number of injury accidents between 5.4 and 7.2 per cent depending on the model and the section used. The estimated diversion of traffic from the motorway was between 5 and 20 per cent, depending on the capacity of the secondary road network. This illustrates that from a safety point of view, motorway tolling is not necessarily an advantage as drivers may choose less safe routes.

There is little practical experience with road pricing in urban areas, but existing pricing schemes are based on cordons or toll rings. In Norway, the first toll ring was established in Bergen in 1986. The Oslo Toll Ring has been in operation since 1990 and the main aim is to raise money for infrastructure investments. Different reductions in traffic volume has been reported, ranging from 3–4 per cent (Waersted, 1992) to 5–10 per cent (Tretvik, 1993). The largest reduction took place in the off-peak periods. This tendency is supported by modelling results from Gothenburg, estimating a 1.9 per cent decrease in work trips and a 6 per cent decrease in shopping trips in the case of an urban road pricing scheme (CEC, 1998).

In Stuttgart, a large field trial has been carried out to investigate the impact of variable road pricing charges. The trial included a segment of a cordon around Stuttgart and 400 test drivers. The fee varied between 8 DM and 2 DM in the morning rush hour. The trial showed that 12.5 per cent of the car trips were moved to a cheaper period, 15 per cent changed to a cheaper route and only 5 per cent changed to public transport. Car sharing increased to cover 7 per cent of all trips. The change in destinations was negligible (Mock-Hecker & Schnittger, 1997).

In an ideal road pricing scheme, the fee would vary according to the location (at area or street level), the time of the day, the type of vehicle and the distance driven. This would make it possible to charge, for example, drivers in rush hour traffic in urban areas more than drivers in traffic in rural areas, or drivers using local roads more than drivers using the motorways.

There are no such systems in operation yet and very little ongoing research reported as well. Most motorway tolling systems are based on the distance driven and there are examples of varying fees over the day. Similarly, urban cordon systems may have a time-dependent fee structure. A newly established Danish research programme is focussing on the feasibility and the consequences of an ideal road pricing system but no results are reported yet (Kildebogaard, 1999).

The principle of distance and time based road pricing is supported by the European Commission in its White Paper on Fair Payment for Infrastructure Use (CEC, 1998). The principle is expected to have a considerable impact on traffic volumes and travel behaviour in general. EU has initiated the concerted action CARD-ME to facilitate a common European implementation of electronic fee collection schemes by promoting interoperability between systems (Bourne, 1997).

A modal shift from car to public transport will generally increase traffic safety as the risk level for public transport is lower. However, when comparing the two alternatives, the total trip including walking etc. should be considered (ETSC 1999). There is a wide range of applications that may make public transport more attractive to car drivers:

- passenger information (see also subsection 4.3)
- park-and-ride schemes
- public transport priority schemes (bus and tram)
- other operational improvements of the public transport

Today, these applications will be supported by ITS systems, but a detailed discussion on how to improve public transport in general is considered outside the scope of this report.

A more radical approach is to reduce the need for transport. Communication technology may replace physical transport to a certain extent. Although it is outside the traditional scope of ITS, distance working (tele-working, tele-commuting etc.) should be mentioned. It is often suggested that the use of part time distance working is growing and leading to a reduction in travel but a Danish survey shows that this effect may be compensated to a large extent by distance workers moving further away from their workplace (Transportraadet, 1996). Even if tele-commuting does not change the total exposure, it may affect the departure time and consequently contribute to less rush-our traffic which in turn may reduce the accident risk.

4.3 Travel planning with ITS

The strategic level of travel behaviour includes choice of transport modes and routes, time of trip etc. (section 3.2). It can be affected by ITS applications that mainly provide the traveller with a better basis for decisions in terms of traffic and travel information. In particular, better information about public transport is an important prerequisite to get drivers to change from car to bus or train (CEC, 1993).

In the field of ITS, travel planners have been developed on an off-line basis. The typical solution is based on the Internet giving the answer of how to get from A to B taking various requirements into account. This may be time of arrival, time of departure, travel time, travel cost etc. (an example in Danish can be found on: www.rejseplan.dk).

In future, travel planners based on Personal Digital Assistants (PDA) will be available as a mass product. The PDA's such as the "PalmPilot" are already on the market for personal planning etc. Since they can be carried everywhere, they will permit very dynamic planning procedures. Mounting units for car use are available. Likewise, specific car computers including travel planners and route guidance systems are on the market.

As discussed in section 8.2.2, the Human Machine Interaction of those units and systems is of utmost importance. Unfortunately, separate units mounted or used in the car do not require any form of standardisation or approval and consequently there is a risk of driver distraction while operating these units.

ITS applications supporting car sharing are not common. Certain systems have evolved on a local basis based on the Internet or the Intranet of certain companies. There are many practical and psychological obstacles to overcome before this is accepted as a compromise between individual and public transport.

4.4 Route guidance

A route guidance system guides the driver along the fastest (or shortest) route to his destination. As one of the main driving tasks in an unfamiliar area is to find the way to a destination, a route guidance system can reduce driver stress and release mental capacity to better observe and react in traffic. In theory, the system will also reduce exposure as the amount of unnecessary driving is reduced. The route guidance facility may on the other hand create new trips because drivers feel comfortable going to unknown destinations (CEC, 1998).

Another problem is that route guidance systems do not always consider the relative risk between different routes. An obvious improvement would be to add to the traditional optimisation criteria (the shortest or the fastest route) a new option: the safest route. In theory, this would require a large amount of crash statistics to be added to the digital maps on which the route calculations are based. In practice, however, estimates of the crash risks of certain road types would be a reasonably good approximation.

A common characteristic for route guidance and travel planning systems is that they optimise an individual's trip or route. This does not necessarily correspond with the total optimum from the societal point of view. As an example, short cuts through residential areas are undesirable for many reasons. Society must find ways to prevent these negative effects – either in the navigation system or by physical obstacles.

Route guidance systems range from simple navigation systems based on digital maps to dynamic route guidance systems based on actual traffic information. Several autonomous systems are available on the market and the driver interface ranges from a map with the location of the car and the destination to a display with an arrow showing the driving or turning direction.

The Human Machine Interface is crucial for the safety value of these systems. Systems based on map displays should not be used when driving. It is also important that the route guidance system is of a certain quality: which means that the database is detailed enough to cover the whole trip to a certain address, shop, hotel or parking ground. In urban areas it is crucial that the system includes all one-way streets and turning bans to avoid confusing and dangerous driving situations. Maps must be up-to-date and the location system of the vehicle must be accurate in order to avoid confusing or dangerous driving situations.

A special type of route guidance is parking guidance systems based on variable message signs (VMS) along the streets. These systems have been introduced or are underway in many European cities. The idea of giving information about available parking space is good, but this is an example of an intermediate technology (VMS). The advantage of this solution is that the information is simple and that it is available to everybody. However, it addresses everyone in the same way regardless of the driver's need. An in-car solution based on a request from the driver would be safer, more efficient and more environmentally friendly.

Results concerning route guidance systems are varied and contradictory. Some results indicate that the systems decrease exposure by directing drivers to their destination along the shortest routes and without the need to look for the destination by driving around. Other results indicate that owners of these systems start to make new trips to places that they are not so familiar with, thus increasing exposure. It is also clear that in-car route guidance systems distract the drivers from their normal driving task, but, on the other hand, to a lesser extent than a conventional map (CEC, 1998; Ståhl, Berntman & Petzell, 1997 and Winkler & Nowicki, 1997).

Quantitative analyses show very small crash reductions due to dynamic route guidance systems but a risk for more accidents if route diversions from motorways are frequent (Federal Highway Administration, 1997a; Elvik, Borger Mysen & Vaa, 1997 and Perrett & Stevens, 1996).

4.5 Freight and fleet management

Commercial vehicles account for a large proportion of urban traffic while heavy goods vehicles are more common on European motorways. Collisions involving heavy goods vehicles generally have severe consequences in terms of damages and injuries. There are potential benefits in better management of freight and fleet operations.

The use of Mobile Data Communications, Global Positioning Systems (GPS) and Trip Recording could lead to a substantial reduction in the total distance travelled by commercial vehicles. In terms of hazardous goods monitoring and control, a significant reduction of alert time from the usual hours to a few minutes has been noted (CEC, 1998).

The CHAUFFEUR Tow-Bar system is an electronic coupling of heavy goods vehicles. The leading truck is driven conventionally by a driver while the second one follows automatically (Schultze, 1997). The system can increase the efficiency of heavy goods transport considerably. At the same time it will reduce the exposure as the platoon of trucks may be considered as one (although very long) vehicle. It is difficult to assess the overall safety effect as the new combined vehicle has quite different physical characteristics in terms of length, weight and manoeuvrability. In particular, the system safety of the electronic coupling is of crucial importance. Furthermore, the interaction between CHAUFFEUR equipped platoons and conventional traffic requires extensive studies.

A British desk study indicates that the implementation of freight and fleet management systems is expected to reduce crashes mainly due to less distance travelled (Perrett & Stevens, 1996). The savings in mileage are estimated to be 3 per cent.

A special case of freight and fleet management is what is called “city logistics“, dealing with the optimisation of goods delivery operations in urban areas. The aim is to reduce freight and delivery traffic and to perform the necessary transport operations with more appropriate vehicle types. The effect on the total exposure has not yet been described, and there are contradictory measures in use. One of the attempts is to use smaller and more appropriate vehicles for urban traffic but this will all other things being equal increase the total mileage.

4.6 Selection of road users

The importance of human error in road safety is discussed in section 2.1. One way of reducing human error is to prevent unqualified persons from driving. This may be seen as a way of reducing the exposure, concentrating on a critical segment of drivers. Recent development has made it technically possible to identify at least two types of unqualified drivers before they switch on the engine: drivers without a valid driving licence and intoxicated drivers. Surveillance of drivers while driving is discussed in section 5.

In Sweden, an Electronic Driving Licence has been developed and tested. The driving licence is a smart card containing personal information about the driver, including which vehicle types or even individual vehicles he or she is authorised to drive. The smart card serves as an ignition key, and the vehicle will only start if there is correspondence between the card and the vehicle unit (Goldberg, 1995).

A field trial with 15 vehicles has been carried out with support from the Swedish Road Administration. Myhrberg (1997) concludes that the concept works in practice and that it could have great effect on traffic safety by preventing unauthorised driving and car theft. The users have no problems getting used to the Driving Licence and in general their attitude to the new system is positive. There are, however, many practical issues to be solved before a large-scale introduction can take place.

The system can be extended with an alcohol test based on the alcohol interlock system. In this, the driver must blow into a mouthpiece connected to an alcohol meter. It is only possible to start the car if the test is negative. Combining the two systems, the intelligent driving license could require that a particular driver must perform the test before driving. This could be used for repeat excess alcohol offenders. Other types of ability tests could also be included. Furthermore, certain requirements or limitations to the driver could be included, e.g. maximum speed level for new drivers, restricted driving hours of the day or restricted routes. The concept is very promising and deserves major attention on a European basis.

4.7 Conclusion

There is a wide range of ITS applications addressing traffic volume and thus exposure. Practical experience as well as research results show that it is possible to reduce exposure to some extent by means of these applications. It is, however, doubtful whether all these applications are economically feasible from a safety point of view alone.

Many of these applications will be introduced as a matter of course as the safety objective combines with other traffic policy goals such as reduction in energy consumption, environment protection and improvement of transport efficiency. Finally, a number of applications include benefits for drivers in terms of improved information and other services. In total, this may justify the implementation of a number of “general” applications such as:

- Road pricing schemes
- Travel planners
- Route guidance
- Freight and fleet management

One of the applications described has an outstanding potential in terms of crash savings. This is:

- the electronic driver’s licence that directly addresses the driver’s authorisation and ability to drive the vehicle.

This discussion has shown that for most of the applications affecting exposure very few results are available. To improve decision making, it is therefore recommended that future evaluation schemes on ITS applications should consider any potential effects on traffic exposure.

5 ITS applications and crash risk

5.1 Introduction

This section deals with the ways in which various ITS applications can influence crash risk. Some applications are designed to reduce crash risk by providing support to drivers in a number of ways. Some monitor the state of the driver or the vehicle, and inform the driver of deficiencies detected. Some aim at reducing crash risk by informing and warning drivers of imminent hazards, like following the vehicle in front too closely, or hazards to be expected ahead on their route, or an incident blocking the road. The expectation is that road users utilise this information by adapting their behaviour to account for the hazard and thus avoid a collision. Several applications control traffic behaviour with the help of variable message signs or signals to harmonise traffic flow or to achieve greater separation between road users, in order to reduce the risk of collisions. Yet another group of systems, most still under development, aim to reduce crash risk by taking over control of the driving task and intervening in situations of increased crash risk to eliminate or at least to reduce risk to an acceptable level.

The various ITS systems, which affect crash risk, are discussed below according to ITS function type. The emphasis is on reviewing existing data on the effectiveness of these systems in affecting crash risk.

5.2 Speed Adaptation

The adaptation of driving speed to the prevailing conditions is a primary way of controlling the crash risk of the driver. Different systems exist, ranging from informative to intervening systems.

The informative systems include many variants. Giving individual or collective speed feedback to drivers has proven to be successful, and accident reductions have been observed (Elvik et al., 1997). Advisory speeds can be posted at critical locations such as sharp bends with considerable effects on speeds (Federal Highway Administration, 1997b). Advice on appropriate speed can also be given via in-vehicle systems signalling with light and sound if the driver exceeds the speed limit. Such systems are expected to reduce the number of injury accidents by around 10 per cent (Carsten & Fowkes, 1998).

Influencing vehicle speeds with the help of variable speed limits has been tried especially in connection with weather-related traffic management systems by lowering speed limits in adverse conditions. A variable speed limit system integrated with a fog warning system reduced the number of injury crashess on a German motorway by around 20 per cent (Balz & Zhu, 1994), and a variable speed limit system integrated with a slippery road warning system on a Finnish motorway by around 10 per cent (Rämä, 1997). Both studies reported significant reductions in mean speeds (3 to 9 km/h) in adverse weather conditions, and the latter also a significant decrease in speed variation. A Dutch fog warning system including a text warning ("fog") and dynamic speed limit VMS signs on a motorway, reduced speeds in fog by 8 to 10 km/h, although in extremely dense fog, the system had an adverse effect on speed. This was due to the too high "lowest possible speed limit" display in the VMS (60 km/h). A more uniform speed behaviour was obtained due to the introduction of the system (Hogema, van der Horst & van Nifterick, 1996). Variable speed limits have also been applied in school surroundings, resulting in a 20 per cent crash reduction (Elvik et al., 1997).

The most promising system is Intelligent Speed Adaptation (ISA) or External Vehicle Speed Control (EVSC), which has been estimated to reduce crashes by around 35 per cent as a compulsory and intervening system (Carsten & Fowkes, 1998; Gustafsson, 1997 and Lind, 1997). Várhelyi (1997) has estimated that automatic speed limiting on rural roads would reduce the total number of injury crashes in Sweden by about 10 per cent. ISA in conditions of low friction would decrease the total number of injury crashes by around 12 per cent and ISA in darkness by 12 per cent.

5.3 Collision avoidance

Collision avoidance systems discussed here cover a number of systems ranging from Adaptive Cruise Control to headway adaptation systems and to actual Collision Avoidance Systems. Cruise Control systems reduce driver stress but can also cause safety problems in critical situations, if not properly designed (Gustafsson, 1997). Autonomous Intelligent Cruise Control has been shown to decrease speed variability but also to reduce headways — the latter effect indicates increased accident risks. Active gas pedal control tends to increase headways indicating improved safety (CEC, 1998). A simulator study indicates that Adaptive Cruise Control reduces journey speeds and overtaking, resulting in somewhat increased safety (Gustafsson, 1997).

To ensure safety, cruise control systems should be accompanied by actual collision avoidance systems. Not surprisingly systems which intervene in the driving process have been found to have more positive effects on behaviour in the form, for example, of longer headways than just informative systems. Properly designed collision avoidance systems have the potential to contribute substantial improvements in safety (CEC, 1998 and Lind, 1997). Hiramatsu, Satoh and Matsukawa (1997) have estimated that an automatic collision detection and prevention system would prevent 45 per cent of road fatalities in Japan. Similar estimates are given by Sala, Clarke, Carrea and Mussone (1997) for Anti-Collision Assist (ACA) systems, and by the Federal Highway Administration (1997a) for collision warning systems. Perrett and Stevens, (1996) predict a 80 per cent reduction in fatalities due to anti-collision systems. However, these predictions need to be treated with caution: the technologies required to make collision avoidance feasible are not yet mature; the systems are only relevant to some kinds of crashes; and driver behaviour in vehicles fitted with such systems is not known.

Drivers are usually quite negative about the introduction of intervention systems while systems offering information or recommendations are ranked considerably higher (Carsten & Fowkes, 1998; Gustafsson, 1997 and Várhelyi, 1997).

Roadside systems for headway adaptation have included individual headway feedback (Elvik et al., 1997) and individual dynamic headway recommendation (Rämä, Kulmala & Heinonen, 1996). A small reduction (6 per cent) of crashes has been observed for the former system, whereas the latter resulted in a reduction of very short headways in addition to a minor mean speed decrease.

5.4 Weather information

In addition to speed control, the high accident risks caused by adverse weather conditions can be decreased by providing information, warnings and support to road users, but also by combating weather problems with the help of winter maintenance. A Finnish study (Rämä et al., 1996) showed that slippery road warning VMS decreased mean speeds by around 1–2 km/h when the signs were lit. The system was also shown to affect the direction of attention to find cues showing potential hazards, and to make passing behaviour more careful indicating an even larger positive impact on safety than that due to lower speeds (Luoma, Rämä, Penttinen & Harjula, 1997).

The automatic fog-warning system on the M25 motorway in England displays the “Fog” legend on roadside matrix signals. Efforts to assess of this system showed that the net mean vehicle speed reduction was around 3 km/h, when the signals were switched on as a result of the formation of fog (Cooper & Sawyer, 1993). However there were problems with system unreliability. Collision warning systems are probably beneficial to road safety in the fog (Saroldi, Bertolino & Sidoti, 1997).

The application of ITS can also improve the efficiency of winter maintenance activity on vehicle routes, which in turn leads to an improvement of safety (Federal Highway Administration, 1997b).

5.5 Vision enhancement and vehicle conspicuity

Vision enhancement systems could be beneficial to safety in the dark or in poor visibility. Ultraviolet light, infrared, and laser systems etc. have been promoted (Clowes, 1997 and Nishimura & Nagaya, 1997). Systems assisting car drivers in detecting motorcycles and incorporating this function in various safety warning systems could improve motorcycle safety (Hsu, 1997). Drivers can also be warned of junctions ahead, and the angle of the headlights can be adjusted to help the driver see around turns (O’Shea, 1997).

Rumar (1997) has studied the feasibility of a unified, adaptive vehicle illumination system, including direct and indirect illumination systems, systems for adverse weather and street lighting conditions and daytime running lights. The extent of road safety impact of such a system will rely on how drivers will adapt their behaviour to the increased visibility conditions. Drivers have been found to compensate for the improved vision from certain systems by increasing their speeds as demonstrated, for example, by Kallberg (1991).

Lane keeping assistance and collision avoidance systems with game detection capabilities could reduce run-off-the-road and animal collisions considerably (Federal Highway Administration 1997a). Roadside systems detecting large animals (elks, moose, deer, reindeer etc.) and warning drivers of them via Variable Message Signs (VMS) are under development and testing.

5.6 Lane keeping

Lane keeping support systems are expected to reduce the number of meeting crashes and single run-off-the-road crashes. The vehicle safety system may for example warn drivers who begin to stray from the road (O’Shea, 1997). A road departure avoidance system could halve the risk of single run-off-the-road crashes according to Najm and Burgett (1997). On motorways, the systems have been estimated to reduce the total number of collisions by 1 per cent (Perrett & Stevens, 1996).

5.7 Driver and vehicle monitoring

A number of systems exist for detecting driver impairment caused by drowsiness, illness, or drug abuse, and then informing and warning the drivers or even performing an emergency control function that will stop the vehicle if the driver is no longer capable of driving safely (Coda, Antonello & Peters, 1997; Hancock & Verwey 1997; Lind 1997 and Renner & Mehring 1997). Some systems even attempt to detect whether the driver is devoting less attention to the driving task (Clowes, 1997).

On-board safety monitoring systems in heavy goods vehicles determine the safety status of the vehicle and cargo (Evanco, 1997). Vehicle monitoring senses and collects data on the condition of various vehicle components that could affect safety such as the brakes, tyres, and lights. Cargo monitoring senses unsafe vehicle cargo conditions such as cargo shifts. If unsafe conditions are detected, warnings can be provided to the driver and, subsequently, transmitted to the transport operator and the appropriate enforcement authorities. Automated roadside safety inspections allow electronic access to the safety records of carriers, vehicles, and drivers in order to determine which vehicles should be stopped for an inspection. The inspection process is automated through the use of sensors and diagnostics to establish the integrity of safety related vehicular components. A large-scale introduction of the systems could reduce heavy goods transport related fatalities by perhaps 15 per cent (Evanco, 1997).

The use of a crash data recorder ("black box") on commercial vehicles for driver monitoring purposes resulted in a substantial reduction in crashes as well as decreasing crash severity. Driver monitoring functions on private vehicles have also indicated changes in driver behaviour which indicate improved safety, (CEC, 1998). The introduction of digital tachographs in all heavy vehicles in Europe and elsewhere in the beginning of the next century will bring about improvements in heavy vehicle safety (Miyake, 1997).

Perrett and Stevens (1996) estimate that driver and vehicle monitoring systems could reduce the total number of accidents by 4 per cent. Lind (1997) estimates that with a very high implementation level, a driver monitoring system could reduce injury crashes by 20 per cent.

5.8 Policing and tutoring

One way of helping the road user to adapt his or her behaviour in a safe way to the prevailing road, traffic, and environmental conditions is to give feedback on the behaviour via various policing and tutoring systems. Automated speed and traffic signal compliance enforcement systems are one group of such systems, which have already been implemented. Advanced, in-vehicle tutoring systems are still in the development phase.

Automated speed enforcement systems aim at more efficient speeding detection and feedback than traditional speeding enforcement systems. The systems have been effective in lowering the percentage of speeding drivers and thus the average speeds by around 10 per cent. The overall estimate of the effect of the automated enforcement systems is a 17 per cent decrease in the number of injury crashes (Elvik et al., 1997; Federal Highway Administration 1997a; Malenstein & van Loosbroek 1997; Mäkinen & Rathmayer 1995 and Perrett & Stevens 1996).

Automated traffic signal compliance enforcement systems, red-light cameras, have been found to increase traffic signal compliance considerably. The overall estimate of the effect of these systems is a 12 per cent reduction in the number of injury crashes. The system has decreased especially crossing and rear-end collisions (Elvik et al., 1997).

Drivers should benefit from feedback that informs them of the quality of their driving performance, and thus strengthens appropriate driving procedures. In-vehicle systems giving feedback to the drivers of their speed behaviour in the form of verbal messages or feedback by means of the accelerator pedal have been tested and proved to be effective in reducing the incidence and seriousness of speed errors. Verbal messages were better than accelerator pedal feedback both in terms of effectiveness and workload. Immediate feedback after the error was more effective that prospective (based on driver's own performance the last time he/she was at a similar location as the one close ahead) or accumulated feedback (based on driver's own performance across a number of trips around the test route). It is, however, possible that these systems lose their effectiveness due to the drivers considering the recommended procedures unnecessary or inefficient (Kuiken, 1996).

Driver tutoring can also be based on roadside systems applying VMS integrated with in-vehicle monitoring systems, where driver violations are used as a reference for warning and tutoring (CEC, 1998).

Feedback regarding distance keeping to a car-in-front has been found to have positive effects. The number of drivers following the car in front below one second were significantly reduced in case of tutoring, although drivers have difficulties in estimating inter-vehicle distances expressed in time headway. Explicit recommendations to the driver with respect to the appropriate time headway, for example, by means of a bar that changes colour, is to be preferred (Brookhuis, 1995).

5.9 Incident management

Incident management includes the detection, warning and clearance of incidents. Safety benefits are obtained by avoiding secondary collisions as a result of quicker incident management provided by the introduction of ITS. Crash reduction due to a comprehensive incident management system has been estimated as 28 per cent (Lind, 1997).

Incident warnings are provided by roadside VMS or beacons, and via radio and cellular information services. Studies usually show crash reductions on the IWS (Incident Warning System) equipped motor way sections. The whole range of the effect on the total number of injury crashes is from –35 per cent to + 9 per cent, where the largest reductions may include bias caused by the regression-to-the-mean effect. The effects are more beneficial on secondary collisions (Kulmala, Fránzen & Dryselius, 1995). Very little information exists of the safety effects of radio based IWS systems such as RDS-TMC (Radio Data System–Traffic Message Channel). According to Elvik et al. (1997), rear-end injury collisions have decreased as a result of queue warning systems on motorways whereas the number of rear-end collisions resulting in property damage only have increased.

5.10 Flow control

Safety can be improved not only by just reacting swiftly to incidents but also by preventing them through harmonisation of the traffic flow. This can be accomplished by ramp control (or ramp metering), lane control, route diversion schemes, and in general traffic management. Safety is also expected to be improved as a result of replacement of manual toll collection with automatic tolling on motorways due to the elimination of traffic channelling at toll plazas as well as of the possible queues and unnecessary stops (Bandmann & Finsterer, 1997).

Lane control has little effect on injury crashes (Perrett & Stevens, 1996 and Elvik et al., 1997). Ramp control (control of vehicles entering motorways) is considerably more beneficial to safety, the crash reduction on equipped motorways being up to 10 per cent as such, and more than 15 per cent as a part of an integrated motorway management system (Federal Highway Administration, 1997a; Lind, 1997; Perrett & Stevens, 1996 and Tarry, 1997).

Route diversion schemes are beneficial to safety only when the diversion does not increase exposure (driving distance) too much and does not divert traffic to roads with higher crash risk. Unfortunately, this is very seldom the case. The opposite case is shown by for example Lashermes and Zerguini (1997). Traffic management centres and the introduction of freeway service patrols decrease the number of crashes to some extent (Federal Highway Administration, 1997a).

5.11 Urban traffic control

The primary tool of urban traffic control is signal control, which is applied in the urban network to facilitate the safety and efficiency of road transport in the network. Network control systems vary in their context from one urban area to another, and may include incident management, traffic signal management as well as motorway control functions (Lind, 1997). Signal control aims at reducing crash risk by separating conflicting road user flows in time. The implementation of traffic signals at junctions has been found to decrease the number of injury crashes on average by 15 per cent at T-junctions and by 30 per cent at X-junctions (Elvik et al., 1997). It should be noted that these effects apply to junctions, which have higher than average crash frequencies. Crossing and turning collisions usually decrease the most whereas the number of rear-end collisions often increases after the implementation of signal control.

The crash risk at a signalised junction is related to the magnitude of different traffic flows, and especially turning flows at the junction. Hence, crash risk in an urban network can also be affected by combining signal control to other traffic management measures such as, for example, turn prohibitions to produce optimal routing patterns with regard to safety as well as travel times. The optimisation of network control systems in this way should decrease the crash risk in the network. A modelling study indicated that network optimisation could reduce collisions by 12 to 30 per cent while increasing total travel time by 10 to 15 per cent in a congested network (Maher, Hughes, Smith & Ghali, 1993).

5.12 Vulnerable road users

Very few ITS applications have been designed for vulnerable road users. The notable exception has been specially designed traffic signal systems. These systems include ITS device to detect vulnerable road users waiting to cross and crossing the road or junction (Sayeed, Kehtarnavaz, Rajkotwala, Nakamura & Urbanik, 1996 and Carsten, Timms & Brundell-Freij, 1994). The main objective of these systems has been to improve the safety of vulnerable road users. These systems have been found to reduce red light violations by pedestrians and hence to have a positive effect on safety (Carsten, 1995).

The most positive ITS applications with regard to the safety of vulnerable road users are speed adaptation systems, discussed previously.

A particular function and equipment that might avoid the rare but tragic cases where children are injured and killed when playing under trucks is missing. The technology is there but not the product.

5.13 Conclusions

A number of systems exist with high potential to reduce crash risk. The safety impact of some ITS systems has already been verified in field studies and medium-scaled demonstrations, while in many cases the estimates of the safety potential rely on prospective safety analyses.

For motorway travel, the most safety beneficial systems have the potential to reduce injuries and fatalities by about 10–15 per cent. These systems are:

- motorway control systems
- driver and vehicle monitoring systems
- collision avoidance systems
- incident management
- automated speed enforcement

On other rural roads, current systems with the potential of reducing injuries and fatalities by more than 10 per cent are fewer than on motorways, but they are more effective. Intelligent speed adaptation has a 30 per cent and automated speed enforcement a 20 per cent injury reduction potential. The ITS systems with the highest safety potential are:

- collision avoidance
- automated speed enforcement
- speed control systems with variable speed limits
- driver and vehicle monitoring systems

In urban areas, systems with most safety potential (injury reduction of 30 per cent for full implementation) are:

- intelligent speed adaptation
- urban traffic control

Much ITS development has so far concentrated on motorways, including the development of safety relevant ITS. The safety problems, however, concentrate in urban areas and on rural roads other than motorways. Hence, also the implementation of ITS for the purpose of reducing crash risk should concentrate in urban areas and on rural roads other than motorways. Intelligent speed adaptation is the ITS application with the highest safety potential to reduce injury crashes in the whole road transport system.

6 ITS and the reduction of crash consequences

6.1 Introduction

The reduction of crash consequences is the third main axis of road safety measures, the previous two which have been discussed being reduction of traffic exposure and reducing crash risk.

Reducing crash consequences as a road safety strategy is still in its infancy. It has only been systematically researched and implemented during the last 30 years. It will not lead to a reduction in the number of crashes but the most successful road safety measures from an injury reduction point of view are probably to be found in this category — for example seat belts, car crashworthiness, motorcycle and cycle helmets. One of the main reasons for this success is that the effectiveness of the passive safety measures mentioned are not reduced by behavioural compensation in the same way that most active road safety measures are. However, reducing crash consequences (injury reduction) comprise much more than the aforementioned traditional passive safety measures.

Injury consequences of crashes may be influenced by:

- changing the speed and the course of the inevitable crash (for example, from high speed frontal collision to running off the road at a lower speed);
- reducing the injury consequences of the crash for vehicle occupants (by measures directed at the user, in-vehicle or along the road);
- reducing the injury consequences of crashes outside the vehicle for persons situated outside the vehicle — normally unprotected road users (by measures on the vehicle);
- emergency notification (Mayday systems) thereby reducing the time between crash and treatment;
- fast and satisfactory treatment of the victims (in the ambulance and / or the hospital);
- adequate rehabilitation of the injured victims.

The largest safety impact as a consequence of ITS introduction is foreseen in the second and fourth approaches. ITS at the moment has no influence on the last method mentioned.

6.2 Speed and crash course

By means of ITS the collision speed may be reduced and the course of collision may be changed Thereby, the physical impact of the crash may be less serious. For instance the in-vehicle or between-vehicle ITS may decide that in a situation where a crash for some reason is inevitable it is less dangerous to have two single vehicle crashes at a reduced speed in a forgiving environment than a frontal collision at high speed.

6.3 Occupant protection systems

Intelligent injury reducing systems in the vehicle are expected to have a large safety impact. Seat belts exist in almost 100 per cent of cars in the EU. The wearing rate varies between countries, but even in countries with high wearing rates it is not over 90 per cent and in many EU countries it is much lower. Those not wearing seat belts are over-represented in fatal crashes. The 10–20 per cent of drivers not wearing belts are involved in close to 50 per cent of the fatal crashes. ETSC (1996) has estimated that around 7,000 persons would be saved each year in the EU if the wearing rate reached 95 per cent (the best wearing rate achieved in any European country so far).

The seat belt is the basic injury protection in a car. It cannot be replaced by air bags and other means. Increased belt usage is a key road safety measure that may be reached by more intelligent warning systems when the belts are not used. This is an acceptable and sufficiently effective method if the warning is made aggressive enough according to Swedish studies. If public acceptance is sufficiently high an even better result could be reached by compulsory interlock systems.

Protection systems in the car could also be made more efficient by means of ITS. The wearing of belts and the size and weight of occupants can be estimated by means of sensors and air bag deployment may be tailored thereafter (Andrews, 1995). According to Cullen et al. (1996) intelligent restraints could reduce up to 20 per cent of serious injuries. Another approach is to start the tensioning of the belt in an early stage of the crash (Bernat, 1995). This allows a gradual response of the protection system, which may avoid certain disadvantages.

6.4 Protection of vulnerable road users

In many countries about half of those injured in road traffic are unprotected road users such as pedestrians, cyclists and motorcyclists. Most of these persons are injured in urban traffic situations. Studies have shown (Waltz et al., 1983) that at collision speeds above about 30 km/h the fatality probability of a pedestrian rapidly increases. It is also an illustration of a general safety problem in road traffic. When the variation of the size of the road users (from a heavy truck with trailer to a young pedestrian) is too large, even a modest collision may have very serious injury consequences. This problem is most pronounced in urban traffic. But the same problem exists in rural traffic.

The capacity of a car to limit the injury caused to a pedestrian in a collision has been the focus of an EU research and development programme over the last twenty years. Test procedures which have been developed are used in the present EuroNCAP (New Car Assessment Programme, 1997) international crash testing programme in which the EU takes an active part. Test results indicate that industry has, as yet, made little progress in this area and that legislation is now required. In future, ITS may be able to contribute to reducing injury by sensing the type and position of collision about to happen and the type of vulnerable road user involved. This creates difficult sensor problems. However, if these variables can be sensed then the protection may be tailored in such a way that the injury consequence is minimised.

6.5 Emergency notification (Mayday)

When asked what kind of ITS systems drivers would like to have, one of the most common answers was emergency notification, a Mayday system (Cairney, 1995). There is today an agreement about a common European emergency telephone number. However, there is nothing which corresponds for car emergencies. Due to the satellite-based GPS (Global Positioning System), manual or automatic emergency notification systems in the vehicle will be able to quickly lead the ambulance and police directly to the position of the crash. The emergency system may even automatically tell the rescue team how serious the crash is. It is well known from other studies that the time between the crash and the treatment is crucial for injury outcomes. Mayday systems are available on the market. According to ITS World (1997) there were 22 service providers listed at the time.

There is one problem associated with the automatic Mayday systems which is comparable with today's' problems with burglar alarm systems – they are ignored due to the frequent false alarms. There will be a need for protocols to be drawn up to establish the circumstances under which emergency services will attend Mayday calls. In other words the system safety aspect is crucial also for Mayday systems.

If the rescue team, by means of ITS applications such as automatic or manual emergency notification, may know the seriousness and the character of the crash the probability of effective treatment is increased.

6. 6 Conclusions

The idea of reducing the injury consequences of road traffic crashes by means of various protective vehicle or roadside devices is fairly young in the long history of road safety measures. These measures have, however, in the past been very successful from a safety point of view. Thousands of lives have been saved by devices such as seat belts, helmets, air bags, crash barriers, and collapsible lighting poles.

A general reduction in vehicle speed, which has been mentioned several times in this report, will also have an impact on speed in the moment of collision. This will have a considerable effect in reducing the injury consequences of a crash.

ITS offer sensing and communicating systems that may improve the effectiveness of injury reducing systems substantially, thereby contributing to the reduction of crash consequences. At the present level of development the largest safety potential exists in increasing seat belt wearing rate by means of seat belt warning and interlock systems and by means of emergency notification (Mayday) systems. However, ITS technology is still in its infancy and with future developments other ITS applications may also show considerable potential.

7 'Office-on-wheels'

7.1 Mobile telephones

The introduction of the mobile telephones about 20 years ago was the first step into creating on office in the vehicle. The number of cars equipped with mobile telephones is now rapidly increasing in Europe. Using the mobile telephone may interfere with driving in two ways:

- The handling of the telephone (e.g. to dial a number and to hold the telephone) may interfere with the handling of the car.
- The attention and mental effort needed to keep a conversation going in the telephone may interfere with the attention demands and the mental effort required to interact with other road users in a safe way.

It is, therefore, not surprising that the mobile telephones have been questioned from safety point of view from the public as well as from politicians and researchers. However, in spite of the potential danger and the public concern, mobile telephones have been introduced without any public control or requirements except that they may not be mounted in such a way that they may cause injury in case of a collision. Some countries have in recent years forbidden the use of mobile telephones if they are not "hands free". One of the reasons for not restricting the use mobile telephones more strictly is that they are no doubt positive from a safety point of view in the respect that they are often used to call for help (an early Mayday system) and to warn other road users for unexpected dangers via traffic control centres or traffic radio – RDS, TMC (California Highway Patrol 1987, Alm and Nilsson 1989). Another reason is that enforcement of such a restriction has been very difficult to enforce.

However, research confirms the fact that the manual handling of the mobile telephones has negative effects on driver behaviour. The dialling procedure influences driver capacity to keep the course on the road (Zwahlen et.al. 1988). The distraction and mental load effects have also been studied (Brown et.al. 1969, Alm and Nilsson 1994 and 1995). The results show that driver reaction times are increased by 0.5 – 1.5 seconds when talking in the telephone. One study (Redelmeier and Tibshirani 1997) has studied the relation between use of mobile telephones and crashes. They claim that the crash risk is increased by a factor four when the driver is talking in the telephone. But they also found that almost half of the drivers involved in a crash used the mobile telephone to call for help.

The mobile telephone is an ITS system which has alrwady been already widely implemented. How can the negative effects be reduced without eliminating the positive effects?

- The telephone should be placed on the dashboard as close as possible to driver line of sight.
- The telephone should be "hands free" and it should be possible to dial by voice.
- Drivers should be trained in using the telephone in a safe way.
- The telephone should have a "wait" function for occasions when talking is dangerous.
- The telephone must be integrated into the total ITS equipment meaning that telephone messages should be weighted against other messages.
- Research on mobile telephones should be continued. There are many questions still unsolved.

7.2 The future

The introduction of new information systems into vehicles constitutes a huge potential market for equipment suppliers and car manufacturers. The first wave of research and development was led by car manufacturers and the traditional suppliers of automotive electronic systems, including Bosch, Siemens, Phillips, Motorola, with much of the work taking place in European programmes (DRIVE and PROMETHEUS) or national programmes (for example, the Intelligent Transport Systems programme in the US). More recently, non-traditional suppliers of systems, such as TrafficMaster in the UK have seen the opportunities and have built up a market. In the last year there has been a sudden wave of interest from the giants of the computer electronics field, with Intel developing its "Car PC" and Microsoft promoting its "Auto PC" based on the Windows CE operating environment (ITS International, 1998). Development in this area has been so rapid that there is very little scientific material on it and the Internet provides much of the up-to-date information (for example, Intel, 1998).

7.3 Issues

Companies such as Intel and Microsoft understand that, with hundreds of millions of cars in the world, there is an enormous potential market for their hardware and software. They also perceive that there is a very large market for services that are fundamentally not related to the driving task. Indeed, since drivers may consider that their time spent in driving is wasted and could be spent more productively on other activities, it makes sense for service providers to give drivers the opportunity to access their e-mail, access address books in order to communicate by cellular telephone, and even access the Internet. The interface for all of this would be provided through a device that would fit in the normal DIN slot in the dashboard that is currently used for car radios.

Some visions in this area extend beyond the Office on Wheels concept to the "Home on Wheels". Chrysler has recently show a concept car that would allow a small hand-held computer to be plugged into a docking station in the dashboard (New York Times, 1998) The computer would be used as an interface to provide control over the audio and climate-control systems in the car, to provide weather forecasts, connection to the Internet and to a cellular phone. But in addition it would give users access to devices at their homes, such as control over security systems, lawn sprinklers, lights, etc.

The dangers implicit in such devices are obvious. There are likely to be problems in the interfaces, particularly as regards visual aspects. The small screens implicit in fitting in the DIN slot or in using a hand-held computer mean that there will be severe problems for the driver in viewing the information on the screen, particularly if that information uses a normal (office or home computer) layout. But perhaps even more important is the likely distraction from the driving task caused by engaging in tasks that are not remotely connected with the primary task of driving, but which could be quite demanding in terms of the attention needed to carry them out. Indeed, the danger is that such tasks would in many circumstances become the primary task for the driver, with driving relegated to being a secondary task that would be carried out with any mental capacity not being used for the office- or home-related activities. Driving would be severely endangered by this.

7.4 Conclusions

It is recommended that the provision and use of irrelevant functions by the driver while driving be banned on safety grounds. At most, system and service providers should be allowed to provide an alert message to the driver, indicating that the on-board computer has incoming messages awaiting him or her. The technical means to accomplish the banning of inappropriate messages or functions while driving is obvious: it could be done though the kind of speed sensor which is already present in many vehicles for anti-lock braking (ABS).

8 Safety Evaluation of ITS

8.1 Introduction

Many ITS systems have a direct or indirect impact on safety. In order to ensure that systems are deployed so as to ensure the maximising of the benefit to safety, it is vital to carry out proper safety evaluation of these systems. It is equally important to ensure for any telematics system, even one not aimed at enhancing safety, that any disbenefits to safety are eliminated or minimised.

8.2 Safety aspects of ITS

The safety implications of Intelligent Transport Systems are commonly classified into three areas:

1. System Safety — covering safety problems from hardware design and from software design with particular focus on reliability, the propensity for malfunction and the potential to go into a dangerous and/or unanticipated system mode.

2. Human Machine Interaction (HMI), that is interaction between the user and the system. Key issues are the design of buttons and controls; menus; screen size, brightness and location; means of dialogue between the user and the system; channel for information (auditory or visual), and feedback to the user (auditory or visual). Inappropriate design

can lead to overload (too much effort required) or underload (the user no longer involved in the main task of for example driving) or to distraction from the driving task at inappropriate times.

3. Traffic Safety — this is the overall effect of system use on the safety of the traffic system as a whole. It covers the outcome of System Safety and HMI (that is the potential for problems in either area to lead to accidents). More broadly, it also covers the overall ways in which a particular system might affect road user behaviour so as to alter the interaction between the driver, the vehicle, the road infrastructure and other road users (including vulnerable road users such as pedestrians, cyclists and motorcyclists).

In each of these areas, various procedures and guidelines have been developed in an effort to ensure that safety problems are minimised. Currently these guidelines are voluntary and as a consequence there are issues of how to ensure compliance with recommended practice. In addition, in some areas, because the systems are so new and there is so little experience on their effects, there is a need to develop further the basic knowledge required in order to develop standards to ensure safety.

8.2.1 System Safety

This is perhaps the area in which the procedures are most developed and where there has been the greatest receptiveness in manufacturing industry to adopting the recommended techniques. The procedures were developed primarily by the PASSPORT (MISMA guidelines) and EMCATT projects in DRIVE II and have since been summarised in the CODE and CONVERGE projects in the Telematics Application Programme in Fourth Framework Research Programme. The procedures cover Preliminary Safety Analysis (PSA) which should be carried out when a system concept is being formulated (Hobley et al., 1995a) and Detailed Safety Analysis (DSA), once a design and its components have been specified (Hobley et al., 1995b). In the UK, these procedures have been formally adopted by the motor industry (MISRA, 1994).

However, two major hurdles to the widespread use of these techniques remain:

(1) They have not been formally adopted at the international standards level. There is therefore no ISO standard for system safety in ITS systems.

(2) There is no certification procedure for approving ITS systems for system safety at the national, European or international levels. In terms of enforcement of best practice, therefore, the necessary teeth in the shape of a required certification process are lacking.

8.2.2 Human Machine Interaction

Tools and procedures for HMI evaluation have been developed by a considerable number of projects including BERTIE in DRIVE I and HARDIE, HOPES, EMMIS and GEM in DRIVE II. Perhaps the most significant of these was HARDIE (Harmonisation of ATT Roadside and Driver Information in Europe) which issued a set of design guidelines for information presentation by in-vehicle information systems (Ross, Vaughan, Engert, Peters, Burnett & May, 1995). These guidelines formed the basis for the HARDIE Design

Guidelines Handbook (Ross et al., 1996) and in turn for the UK HMI Safety Checklist for in-vehicle information systems (Quimby, Watts & Pethwick, 1996).

The principle behind these guidelines is to apply a checklist procedure during the design stage of a system. In that sense, they constitute, if enforced, a set of procedural standards for the development of in-vehicle information systems.[1] Such procedures could logically be extended to cover other areas of HMI, for example for vehicle control systems such as Adaptive Cruise Control (ACC). In addition, the UK Checklist has some design recommendations, for example on display location, use of colours and icons in messages, etc. The UK checklist has 79 separate items (questions posed to the designer) with recommended procedures and supporting documentation for addressing each question.

Following the procedures recommended in such checklists would almost certainly produce a better-designed system, but there are a number of significant drawbacks to them:

1. The procedures are quite laborious — often each issue requires a separate test;
2. It cannot be guaranteed that a system that has been produced in accordance with the checklist process meets even a minimum level of safety in actual operation;
3. The procedures have no standing in law so that, as in the case of the System Safety procedures, there is no requirement to follow them and no verification to check that they have been carried out.

Partly as a result of the sheer number of items in the checklist and of their overall complexity, there has been some effort at both national and European levels to reduce them to a set of major principles. As a result we have the UK Code of Practice (Department of Transport, 1994), the German Code of Practice (Wirtschaftsforum Verkehrstelematik, 1996), the ECMT Statement of Principles of Good Practice (ECMT, 1995) and, most recently, the European Statement of Principles on Human Machine Interface from the HMI Expert Task Force (European Commission DGXIII, 1998). The problem with all these codes is that, while it is impossible to quarrel with the basic advice contained in them, they do not go beyond a statement of broad principles on good design and they provide no guidance at all on how the principles are to be achieved. Thus the complete text of the new European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems (European Commission DGXIII, 1998) in the area of information presentation is as follows:

2.3.1 Visually displayed information should be such that the driver can assimilate it with a few glances which are brief enough not to adversely affect driving.

2.3.2 Where available internationally and/or nationally agreed standards related to legibility, audibility, icons, symbols, words, acronyms or abbreviations should be used.

2.3.3 Information relevant to the driving task should be timely and accurate.

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[1] Standards can be broadly classified into three types: design, procedural and performance. In *design standards*, a specific design is specified for example for screen size, letter height or keyboard layout — the standard computer or typewriter keyboard is a typical example. In *procedural standards*, a given set of procedures has to be followed in product development or testing (ISO 9000/9001 is the best-known example). In *performance standards*, a certain level of performance has to be reached by the system (crash testing of new cars is an example).

2.3.4 The system should not present information which may result in potentially hazardous behaviour by the driver or other road users.
2.3.5 The system should not produce uncontrollable sound levels liable to mask warnings from within the vehicle or outside.

This does inform the manufacturer about some major HMI issues, but does nothing to ensure that a system will perform safely. Even if a complete checklist process is followed, there is, as already indicated, no guarantee that a system will be reasonably safe in actual use. Rather the system provider or the public authorities are left with an almost overwhelming amount of data and indicators — on glance durations, glance frequencies, workload, driver physiological performance, usability, etc. It is currently not possible for either the system developer or the authorities to make judgements about whether one design is more or less safe than another, nor whether a system meets a certain minimum level of safety in actual use.

There is therefore an urgent need for research to develop criteria and procedures which would allow HMI to be evaluated on safety performance grounds. This would permit the development and promulgation of standards for ensuring that systems while in actual use meet a certain minimum level of safety. It is recommended that a research task be incorporated into the Fifth Framework Project with the objectives of:

- Identifying the critical indicators in terms of safety;
- Identifying thresholds for safety below which performance is degraded to an unacceptable level;
- Developing a set of performance tests for in-vehicle HMI, focusing initially on in-vehicle information systems, but also studying the feasibility of extending the procedures to other areas of application;
- Identifying scenarios in which those performance tests should be applied;
- Making recommendations on testing equipment and techniques;
- Developing a draft standard for a European certification procedure for testing in-vehicle HMI.

In the meantime and as an interim step, the European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems needs to be given some teeth in the form of :

1. A statement of the procedures that should be followed to ensure compliance, and
2. Promotion by the EU of a certification process by which products can be shown to be in compliance.

8.2.3 Traffic Safety

As in the other two areas of safety, various frameworks and procedures have been developed for the evaluation of the traffic safety effects of ITS systems at various stages of development. The major relevant project here is the HOPES project in DRIVE II, but one set of guidelines were further developed in the FP4 CODE project (Telematics Application Programme).

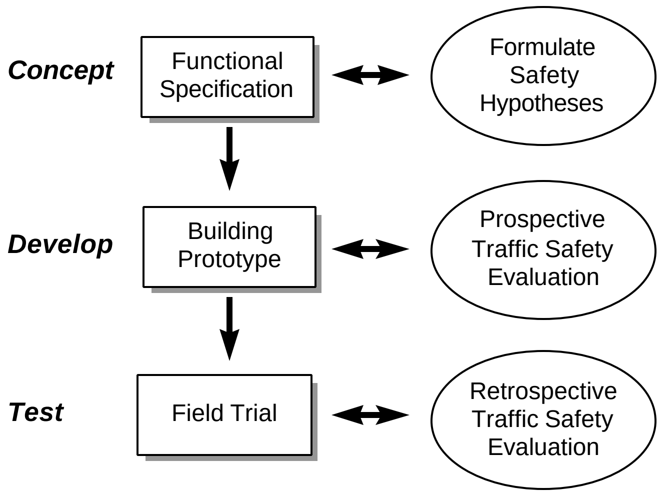

Figure 2: Traffic Safety Evaluation and the System Life Cycle

Figure 2 shows the relationship between the procedures to be followed and the system life cycle. The HOPES Framework for Prospective Traffic Safety Analysis (Carsten, 1993) provides guidance for the concept and development stage. The counterpart Framework for Retrospective Traffic Safety Analysis (Oppe, 1993) provides similar guidance for the testing (validation) stage. The CODE Guidelines on Safety Evaluation of Transport Telematics Systems (Draskóczy, Carsten and Kulmala, 1998) provide guidance on hypothesis formulation and evaluation methods for the later two stages.

However, here too there are a number of important concerns:

1. There are no procedures currently in place at a national or European level to ensure that the current best practice is followed. Even in the Telematics Application Programme itself, the small support activity for traffic safety, which provided advice to projects on relevant traffic safety issues and appropriate evaluation methods was terminated halfway through the programme.
2. The evaluation methods themselves require further development. Crash studies, the traditional measure of a change in road safety, are not appropriate because there are never sufficient vehicles in any trial for the numbers to be reliable indicator of a change in safety. Other techniques such as behavioural observation and conflict studies require further development and validation before they can become fully trustworthy as indicators of traffic safety — in particular the need (1) to observe traffic from the roadside on all types of road and (2) to collect data on driver behaviour in the vehicle tends to exceed the capability of methods developed on the whole for detecting the safety effects of major changes in the road infrastructure.

Thus in traffic safety too, there is a need for new and fundamental research to create a set of reliable tools across the broad spectrum of ITS systems. Currently, it is very difficult or even impossible to come to a conclusion about whether a given system is or is not beneficial to safety. Properly validated evaluation techniques would provide the authorities and the public with reliable conclusions about the safety impacts of systems and so could help to guide investment and public policy decisions. This need should be addressed in the Fifth Framework Programme.

8.3 Designing an evaluation scheme

The need for further development of methods and tools does not mean that, for each of the areas of safety, there is not sufficient knowledge and experience to guide a proper evaluation of each new ITS application that is introduced. There is a large body of expert advice available and recommendations exist on the procedures to be followed. Such evaluation will identify problems before they can result in the injuries or deaths to European road users and will also provide guidance on how problems can be corrected.

There are, however, a number of reasons why ITS applications are quite hard to evaluate from a safety point of view. One very important consideration is the system life cycle, shown in Figure 2. Different evaluation procedures and methodologies are required for the different stages of application development. At the early stages, when evaluating a concept or a prototype, evaluation can often not be carried out in real traffic, since the system has not yet been deployed. Evaluation will then have to be carried out using such methods as laboratory techniques, driving simulator studies, test track studies and simulation modelling. Other complexities stem from the following:

- One of the major advantages of ITS applications is that they interact with other ITS applications. However, this can make evaluation more complex and more difficult.
- Many ITS applications change the driver situation radically. The most obvious examples are the various systems that intervene in vehicle control. This creates a completely new situation, for which the behavioural consequences are very hard to predict.
- The introduction of ITS will split road users into two categories — equipped and non-equipped. Vulnerable road users will most probably belong to the second group. As a result of this modification, the interaction between road users is likely to change considerably
- The penetration of ITS will grow gradually, both in terms of proportion equipped and in terms of number of systems in each vehicle. This will also modify road user behaviour in a way which is very hard to study in an early stage.
- ITS will influence different road user groups in different ways. Compare for example, young users with old users, private users with professional users.
- Just as users do when faced with most other support systems, ITS users may behave one way initially and quite differently when they have become accustomed to the ITS application, including its possibilities and limitations.

One consequence of these issues is that ITS systems have to be evaluated in the context of quite large field trials in the real world, so that rational judgements on purchasing and regulatory decisions by both the public authorities and private individuals can be made. Noy (1998) has proposed a testing procedure which every ITS must go through before it is introduced on the market.

8.4 Conclusions

In terms of in-vehicle HMI, there is a need for research to develop criteria and procedures which would allow HMI to be evaluated on safety performance grounds. This would permit the development and promulgation of standards for ensuring that systems while in actual use meet a certain minimum level of safety. It is recommended that a research task in this area be incorporated into the Fifth Framework Research Programme. As an interim measure, the European Statement of Principles on Human Machine Interface for In-

Vehicle Information and Communication Systems needs to be given some teeth in the form of a statement of the procedures that should be followed to ensure compliance, and promotion by the EU of a certification process by which products can be shown to be in compliance.

In terms of the overall safety evaluation of ITS, it is vital that:

- in the implementation of telematics systems and in future research programmes, sufficient resources should be provided to carry out proper safety evaluation, preferably with the use of expert advice on the most appropriate procedures to follow;
- both national and European authorities require system providers to demonstrate that their systems have been properly evaluated;
- there be coverage in evaluation of all ITS systems that are safety relevant — systems that come in through the back door, for example via the Internet, should not be free of the responsibility to show that they are safe;
- the monitoring of the safety impacts of systems be maintained beyond the initial phase of system introduction, so that the long-term effects of system use can be assessed and in order to increase the reliability of the assessment (short-term assessment often produces results that are not statistically significant).

9 Implementation issues

9.1 Introduction

This Section covers a number of important aspects of the deployment of ITS systems. In such deployment it is important to ensure the support of the general public. Rather obviously, the public will not buy systems that do not have desirable qualities, but acceptance is also vital for the deployment of systems for the benefit of the community as a whole. The legal framework provides both the basis for action by the public authorities and the regulatory environment in which systems are deployed.

9.2 Acceptance of ITS

To be acceptable to both public bodies and private users, ITS applications must be cost-effective, reliable, easy to use and to maintain. For public authorities ITS systems must achieve their objectives in terms of increased efficiency of the transport system, reduction in environmental harm from transport or reduction in the number or severity of crashes. It is important that the first two types of benefit should not be at the expense of an increase in crashes. Private individuals will have many of the same goals in purchasing or using ITS systems — they will want shorter and more comfortable journeys, improved information, new services, etc., but they will not want to sacrifice these benefits by increasing their risk. Almost certainly, systems which are perceived by the public to be hard to use or unsafe will not prove popular in the long run. New technologies have in the past often met with public resistance or even a backlash when safety concerns have arisen. The recent experience with airbags particularly in the United States affords an example: although airbags have been shown to save a considerable number of lives overall, concern about the harm they can do to children in front seats has damaged public acceptance.

It is also important that ITS products, when marketed and sold to the public, come with appropriate consumer information. For simple systems, warnings in the instruction manual may be sufficient — such warnings against misuse while driving are already routinely provided with mobile phones — but, for more complex systems, such advice may have to be built into a training package provided with the product. Providing advice should not, however, absolve the manufacturer or supplier of responsibility for safety. It is not sufficient to say that the user is always responsible for his or her actions as a way of absolving the manufacturer of the consequences of bad design. Good design will seek to prevent misuse in the first place.

9.3 Legal aspects

In law, the European Union has certain special responsibilities, for example, to ensure high level of protection to EU citizens. These responsibilities extend, in theory, to road transport telematics systems for which there is no special body of law. Equally, the obligations and responsibilities of the other actors stem from the general legal framework, rather than from any special law on telematics.

Legal issues arise at a number of levels in the traffic systems. The most important of these are the following:

- traffic law (for example, the obligation to comply with speed limits);
- privacy / data protection (for example, recording license plate numbers for electronic toll collection; speed profile for reconstruction of the course of an accident);
- liability and insurance (for example, product liability, burden of proof in case of losses; insurance coverage for accidents caused by faults in the ITS);
- obligation to implement and/or operate ITS or certain components (for example, a transponder for recognition of a vehicle; an in-vehicle crash recorder);
- standardisation of components (for example, common functional requirements of human-machine interfaces);
- competencies of public and private institutions (for example, for information acquisition and distribution).

A more comprehensive outline of these aspects has been documented by the DRIVE project IMPACT (CEC, 1990). There are, in addition, a number of important actors in the standards area, and in some cases these actors are promulgating standards which are highly relevant to safety.

9.3.1 Actors

The implementation of road transport telematics applications for road safety involves responsibilities and actions by a variety of authorities and agencies. These include:

- The European Union
- Member States
- Regional and local authorities
- Commercial service providers

- Equipment and vehicle manufacturers
- European standardisation bodies
- International standards bodies
- Road user organisations

Concerted legislative action at EU level is necessary to ensure the safety of applications coming onto the market and to maximise the potential of telematics applications to address known safety problems. The aim of this section is to consider the legislative framework for action by the European Union in the area of road transport telematics deployment and to underline the opportunities which exist for concerted action on road safety.

9.3.2 Legal framework for action by the European Union

To date, the emphasis in deployment of road transport telematics applications at EU level has been primarily on the Trans-European Road Network, the implementation of traffic information services based on RDS-TMC and the development of electronic fee collection.

The European Union has wide powers to implement road transport telematics applications for road safety. There are Treaty obligations to provide a high level of protection in the Single Market harmonisation process (Article 100a) and to take action on transport safety whenever it can give added value to what can be achieved by Member States individually (Article 75). European Whole Vehicle Type Approval for cars and motorcycles gives the EU exclusive competence for the agreement of technical standards. Opportunities exist for implementation on road infrastructure on the Trans European Road Network and EU-financed projects.

As the High Level Group on Road Transport Telematics has stated, the European Union has a key role in the implementation of road transport telematics application in Europe by:

- Promotion of research and development activities
- Technical harmonisation of standards and EU legislation
- Co-ordination of activity and dissemination of best practice
- Financial instruments

A Table in the High Level Group on Telematics report outlining the scope for community intervention in this area is reproduced in Appendix 2.

9.3.3 Technical harmonisation

The process for harmonisation of standards and rules in Europe is a complex one, involving interaction with Brussels, Geneva and the wider international community. The main international standards organisations are UN ECE, ISO and CEN, although UN ECE is not as yet much involved in telematics applications. Appendix 2 provides a summary of the relevant work of these various bodies.

The EU can implement technical standards produced by any of these organisations, but has to ensure that a high level of protection is given in the harmonisation process. The principal Commission Directorates involved in this process are Transport (VII), Industry (III), Technology (XXIII) and Consumer Policy (XXIV). In addition, there are the High Level Groups on Road Safety (DGVII) and on Telematics (DGXIII) which comprise senior officials from Member States created at the request of the Council of Ministers.

9.3.4 Vehicle standards

There are in law various legal requirements for manufacturers, owners and operators of vehicles, but the source of these legal requirements varies. In terms of manufacturing, the design of the vehicle (for example, in terms of occupant protection) and vehicle control is covered by EU legislation. The design of some optional equipment, whether fitted by the manufacturer, the dealer, an aftermarket fitter or the customer, may be covered by both EU and national law. Regulations on what can be done with originally fitted equipment, for example, the disabling of devices to control emissions are normally covered by national legislation, while retrofitting of safety systems to older vehicles is covered by both EU and national legislation.

The mere fact that the laws have not been written to take into consideration in-vehicle telematics systems leads to certain inconsistencies. There is no obligation, for example, to ensure that in-vehicle information systems are installed in such a way as not to cause hazard to occupants in the event of a crash, except when they are part of the manufacturer's original equipment. When such systems are fitted to the vehicle after purchase, neither the manufacturer of the device nor the installer has any special obligations in this area beyond the normal obligations of consumer protection.

As mentioned previously, technical standards affecting car construction and use in EU-registered cars are implemented via the Community-wide system of whole vehicle type approval for cars (ECWVTA) which was established by the 92/53/EEC Directive and made mandatory in January 1996.

Type approval is an avenue for the compulsory fitting of systems. Type approval makes manufacturers responsible for compliance with legal requirements on vehicle construction and use of every new vehicle with confirmation by the type approval authority that their interpretation of the regulations has been satisfied. The manufacturer submits a representative sample vehicle to the type approval authority for compliance testing and approval. The system also requires manufacturers to certify 'conformity of production' and to issue a certificate of conformity with each vehicle sold. EU Whole Vehicle Type Approval has been mandatory since January 1996 which means that any vehicle type granted ECWVTA can be sold anywhere in the Community without the need for further inspection or approval 1996. The EU Whole Vehicle Type Approval system is managed by the Commission's Industry Directorate with the assistance of the Committee on Adaptation to Technical Progress which comprises representatives of Member States and an advisory body, the European Motor Vehicles Working Group.

Examples of a road transport telematics application which can now be taken up within this type approval system is the mandatory fitment of in-vehicle data recorders (black boxes) and seat belt warning devices.

9.3.5 Road infrastructure and standards

There are a number of applications which are already developed and ready for deployment and which have been shown, through experience gained from actual implementations, to have a substantial impact in terms of improving traffic safety: They include:

- roadside incident detection and warning systems using Variable Message Signs (VMS);
- weather-related information and warning systems using VMS;
- violation detection and automatic enforcement systems;
- advanced signalised crossings for pedestrians;
- ramp metering, flow control and variable speed limits on motorways.

There are, however, a number of obstacles to the deployment of these systems on a pan-European basis, including on the Trans-European Road Network. One important obstacle is the lack of common standards for such systems in terms of:

- communication (for example, radio frequencies, location coding, coding for data exchange between different organisations and centres);
- information to road users (for example, pictograms on VMS, legal meaning of signs such as speed limits on VMS signs).

The process for reaching agreement on such issues is generally rather laborious and has tended to add long delays to the deployment of new systems.

9.4 Conclusions

In view of the added value of a common approach to legislation and standards for road transport telematics systems, a more co-ordinated approach is needed at a European level. As already noted in section 8.2, there is a lack of research-based standards for in-vehicle HMI and absence of advice on compliance in the current guidelines. The future deployment of systems that can benefit safety need common standards at a European level. Safety systems should not stop working when a car crosses a border. Without common action, countries will make different decisions about which architecture to implement for a particular system, with missed opportunities for pan-European benefit. At the EU level, there needs to be greater co-ordination between the various Directorates-General of the Commission. The efforts of standards groups currently operated by industry and professionals need to be part of a broader European strategy. It is, therefore, recommended that the Commission should establish a European Task Force, reporting via the High Level Group on Telematics to the Council and Parliament, with a goal of making an urgent review of the procedures for enacting standards and the need for new standards, particularly in the area of cross-border compatibility and interoperability.

10 Conclusions and Recommendations

10.1 Introduction

As a consequence of rapid development in the field of Telematics, we are about to witness a revolution in vehicle and transport technology. Intelligent Transport Systems (ITS) are due to be implemented en masse, and these systems have the potential to significantly reduce the currently intolerable number of deaths on European roads. ITS give us the opportunity to solve acute transport problems across all transport modes, especially as traffic demand and the appalling number of deficiencies in current transport systems are still increasing. We are facing the prospect of a "new type of engineering" which can create a transport system that has inherent flexibility and which can adapt to varying situations and specific or individual needs. However, the allocation of parts of the driving task to machines and the implementation of new information and control technologies may also have adverse effects on road safety. These effects may prove substantial, depending on the degree to which driving is "virtualised".

10.2 Society and the market

Road safety has, until lately, been a mere by-product in ITS development and certainly not a central aspect of design. Today, there is sufficient evidence to suggest that the development and application of ITS should not be left entirely to market forces, as the market does not necessarily select the alternative most beneficial to safety. Manufacturers should be helped with design, development, and implementation issues, in order to re-establish the correct balance between safety and other ITS objectives, and to prevent further uncontrolled development. What might be allowable in the struggle for a common video standard is certainly not acceptable when it comes to saving lives.

In a time of deregulation and growing involvement of private organisations in areas which were once the exclusive domain of public authorities, there is a need for objective Technology Assessment of ITS at the early stages. This may sound restrictive and an impediment to industrial creativity, but it should rather be seen as a positive opportunity for ITS. The early detection of adverse effects on road safety will save ITS developers considerable future costs. Technical feasibility is also only one consideration on the road to widespread practical implementation, others being public acceptance, market needs, cost-effectiveness, and the potential to solve actual problems. There is a clear need for more integrated and sustainable development strategies and a transition away from technology-driven approaches towards demand- and user-oriented ones. The 'Office on Wheels' is one example of a development primarily driven by technology; it is very likely to cause safety problems, especially as regards visual interfaces. The major problem for such a development is that the ITS technology changes so fast.

Current ITS are mainly focused on motorway environments, but these are not the source of major safety problems. It would seem reasonable to require ITS to address the well-established problem of crashes on rural and urban roads. Apart from a few notable exceptions, hardly any ITS applications are currently available that enhance the interaction between vehicle drivers and vulnerable road users. Urban junctions (as major high-risk crash sites) are another example of a field yet to be tackled by ITS.

Although a number of promising applications have already been identified, large scale implementation could be a tedious and costly process, and most of the burden will fall on Member States. It will inevitably be necessary to make the installation of certain ITS equipment compulsory beyond a specific date, if transition phases are to be limited. That again raises the issue of legal and market acceptance, as society and individuals often differ in their awareness of safety issues. ITS that can reduce driving times *and* increase safety may be very attractive to drivers, but a system that offers safety benefits alone may not.

10.3 The human factor

There are many unanswered questions regarding the design of Human Machine Interfaces (HMI) and users' tendency to temporarily or permanently adapt their behaviour in response to such automated systems — both in intended and unwanted ways. ITS can bring benefits in areas where human beings perform badly, by enhancing the perception of essential driving parameters, by automating recurrent routines or by keeping the task load within a certain range, where control actions can be performed best. On the other hand, a number of phenomena might limit the benefits of ITS. The effects of risk compensation, that is the tendency to engage in riskier driving as a result of a perceived (ITS-related) safety gain, have not been well researched but must be taken seriously.

The avoidance of those display types and interactions with the system that distract the driver from the primary driving task is of utmost importance. Those ITS interfaces that require the visual attention of the driver can have particularly detrimental impacts on safety. The positive experiences (and findings on usability of HMI) obtained in aviation or other technical fields could provide valuable input to ITS for roads. Still, these experiences and findings will not necessarily be transferable, given the vast number of traffic situations involved and considerable variability in vehicle fleets and driver abilities. One should also ask whether or not automation in driving should be limited, in order to keep the driver "in the loop" and in control of the task load; in the longer term, ITS may lead to a loss of driver expertise and skills, and to a dangerous confidence in automated devices. With automated processes becoming more complex, drivers may more easily misinterpret the system's state and functional performance, and this may also lead to accidents (as has been the experience in aviation). It will be absolutely necessary to continuously monitor the safety impacts of ITS, so that long-term effects can be assessed.

10.4 Improving safety

According to the general safety model applied in this report, ITS have the potential to influence all three major road safety variables; exposure in traffic, crash risk and crash consequences.

Exposure, that is the rate at which road users interact with the transport system, can be influenced at different levels, such as route choice, charging schemes, freight logistics, and suggestion of safer travel modes. The most promising approach in this context, however, is the smart authorisation to drive (electronic driving licence, alcohol interlock systems).

At a given exposure, the risk of becoming involved in a crash can be significantly influenced by ITS. Intelligent Speed Adaptation (ISA) has been identified as one of the most promising ways of reducing crashes (by up to 35 per cent). Other applications have shown — or are expected to have — potential for reducing injuries by up to 20 per cent. These include roadside incident detection and warning systems using Variable Message Signs, automatic enforcement systems, variable speed limits, driver and vehicle monitoring, and Collision Avoidance Systems. Intelligent signal control — together with ISA — will also bring about benefits for vulnerable road users. Additionally, in contrast to many traditional traffic engineering measures, applications such as ISA could provide a very cost-effective means of increasing safety.

Once a crash has occurred, the number or extent of injuries resulting from the crash can be reduced through intelligent protection systems and devices that ensure emergency services are notified immediately and that adequate treatment is given. The most substantial contribution to injury reduction is expected from seatbelt warning devices and interlock systems and Mayday systems.

10.5 Safety evaluation and implementation

There is a need for co-ordinated approaches to legislation and mandatory standards or procedures at a European level to ensure the proper design of new ITS with regard to HMI, System Safety and Traffic Safety (that is the overall safety effect of ITS on the traffic system). The European Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems, as presented by the European Commission in 1998, represents an initial and non-mandatory approach to design and installation. The Statement contains a set of common-sense requirements but cannot guarantee any safety benefits. Hence, the development of safety performance standards is necessary, in order to ensure that systems meet certain safety criteria when these systems are in actual use. In order to provide focus for all those with responsibilities in this area and to ensure effective common action, a joint European effort is required. A first step should be to implement existing standards and further elaborate the need for new standards.

10.6 Recommendations

The recent developments in telematics show that urgent need for the development of a medium and long-term EU strategy that would adequately account for ITS road-safety issues. In particular, the EU needs to develop further its clear role as provider of advice to industry with regard to design, development, implementation and evaluation of new ITS products. It is important to ensure that potential benefits to the community through ITS are maximised and that any disbenefits are minimised. This process would involve all players in the transport sector, from the EU and relevant authorities in the Member States to manufacturers and standardisation bodies.

In view of the above, ETSC recommends the following to the EU:
The EU should encourage the early European-wide implementation of those ITS which offer significant safety benefits — or are very likely to do so. Examples of such applications are: automatic enforcement systems, motorway control systems using Variable Message Signs (including variable speed limits, roadside incident detection, as well as weather-related information and warning systems), driver and vehicle monitoring (for example, via the ‘Black Box’), urban traffic control, and the electronic driving licence. The EU should also identify those applications, one example being the ‘Office on Wheels’, with potential to reduce safety.

1. Intensified research on very promising safety applications, such as seatbelt interlock systems and Intelligent Speed Adaptation, including the study of alternative systems

and the development of implementation strategies, should be carried out in the EU Fifth Framework Research Programme.

2. In its RTD programme, the EU should give priority to the development and evaluation of systems that have the potential to improve safety and to solve actual problems, rather than to promoting technologies for their own sake. In addition, the added value of applications such as electronically-coupled Heavy Goods Vehicles and Automated Highway Lanes should be questioned from the point of view of strategic transport policy.

3. The European Commission's 'Statement of Principles on Human Machine Interface for In-Vehicle Information and Communication Systems' (1998) needs to be made more specific and should define
   - a procedure that should be followed to ensure compliance with these principles, and
   - a certification process through which products can be shown to have complied with these principles.

4. The Statement of Principles is only an interim measure. Research needs to be carried out in to identify the link between levels of performance in HMI and effects on traffic safety. This would allow a research-based set of performance standards for in-vehicle HMI to be developed and proper attention to be given to cognitive ergonomics. The experience obtained with HMI in fields such as aviation should be taken into account.

5. It is recommended that a European Task Force be set up to review on a strategic basis the procedures for implementing existing standards and the need for new standards, particularly in the area of cross-border compatibility and interoperability. This would include a certification procedure to approve ITS applications in terms of system safety. The availability of different fallback levels (which continue to allow safe driving) must also be ensured, as system failures might put road users in very dangerous situations. Specifically, the need for standardisation and quality assurance with regard to relevant control algorithms and protocols should be addressed.

6. Implementing ITS requires special consideration of safety in the transition phases — which may last several decades — during which car fleets, driver abilities, and ITS functions and interfaces will be very varied. The EU should establish a monitoring system to evaluate the design, development and implementation of all safety relevant ITS and their short, medium, and long-term impacts on traffic safety. At the same time, awareness of safety issues needs to be raised, to bridge the current gap between societal and individual views.

7. The further development and proper application of evaluation tools for traffic safety should be required in European-funded research and development projects and when ITS are implemented, for example, in the Trans-European Road Network. This would help to ensure that negative effects are minimised and that knowledge on how to maximise safety benefits is increased.

8. Research results are not properly disseminated at EU level. One of the major aims of the EU research programme should be to make sure that the findings of research projects are made available to all parties involved in research, development and implementation, preferably via the Internet. Currently, the relevant information is dispersed around multiple sites, there is no central document library, and older reports are often not available.

Today, road transport is by far the most dangerous mode of transport. The strictest safety criteria should be applied in the future, in order to reach the safety levels of, for example, rail or airborne transport (where fatalities are considered simply unacceptable). The opportunities offered by ITS should not be wasted!

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Appendices

Appendix 1

ITS Applications

The availability of modern information and communication technologies for road transport allows for various applications which are structured in different ways in Europe, U.S.A., and Japan where most of research and technical development has been done.

The following list gives an incomplete overview of basic technologies for system components at functional level:

- In-vehicle equipment
  - measurement of
    - road surface
    - range of sight
    - road geometry
    - location and speed of neighboured vehicles
  - storage of digital road map
  - data processing, for example, for navigation or distance and speed control
  - transmitter and receiver for communication with external units
  - input / output (driver-vehicle interface)

- Roadside equipment
  - measurement of
    - traffic (volume, speed)
    - environmental conditions (esp. weather)
  - control units
  - data transmission from and to other units
  - display of information for drivers (esp. variable message signs)

- Central devices / control centre
  - system surveillance
  - data storage
  - data processing (open and closed loop operation)
  - links with other information or control centres

- Terminals for private use (at home, office, public places/information kiosks)
  - pre-trip information
  - booking of parking place, seat reservation in public transport

- Communication systems (for communication between vehicles and outside world)
  - beacon based short range communication (infrared, microwave)
  - cellular radio communication (GSM)
  - broadcasting (RDS, DAB)
  - satellite communication

Based on these technologies, the European Community runs a "Telematics Application Programme" (TAP) which covers five application areas:

- Telematics services for travellers
- Telematics services for freight operations
- Telematics for network management, operation and control
- Telematics for fleet operations
- Telematics for vehicle control

It is supplemented by two horizontal sub-programmes:

- Validation of integrated telematics infrastructure and related services on test sites
- Support issues specific to transport telematics

The Americans and the Japanese use the term "ITS user services" and have defined more detailed structures. The American structure of user services is well known and applied all over the world and gives a good idea on the content of ITS applications. It provides 8 groups and 32 single services as follows [ISO–97]:

- Traveller information
  - (1) Pre-trip information
  - (2) On-trip driver information
  - (3) On-trip public transport information
  - (4) Personal information services
  - (5) Route guidance and navigation

- Traffic Management
  - (6) Transportation planning support
  - (7) Traffic control
  - (8) Incident management
  - (9) Demand management
  - (10) Policing / enforcing traffic regulations
  - (11) Infrastructure maintenance management

- Vehicle
  - (12) Vision enhancement
  - (13) Automated vehicle operation
  - (14) Longitudinal collision avoidance
  - (15) Lateral collision avoidance
  - (16) Safety readiness
  - (17) Pre-crash restraint deployment

- Commercial Vehicle
  - (18) Commercial vehicle pre-clearance
  - (19) Commercial vehicle administrative processes
  - (20) Automated roadside safety inspection
  - (21) Commercial vehicle on-board safety monitoring
  - (22) Commercial vehicle fleet management

- Public Transport

(23) Public transport management
(24) Demand responsive transport management
(25) Shared transport management

- Emergency
  (26) Emergency notification and personal security
  (27) Emergency vehicle management
  (28) Hazardous materials and incident notification

- Electronic Payment
  (29) Electronic financial transactions

- Safety
  (30) Public travel security
  (31) Safety enhancement for vulnerable road users
  (32) Intelligent junctions

Appendix 2

COMMUNITY INSTRUMENTS AVAILABLE FOR TRANSPORT TELEMATICS (FROM HIGH LEVEL GROUP ON TELEMATICS REPORT RTT-HLG5/EC/WD25)

Following the provisions of the Treaty, the Community may:

Research and Development:

- Support research development and demonstration activities by setting up a multi-annual framework programme. As such actions on RTD activities for the development of telematic tools and service for transport are covered by Community programmes;
  - Title XV research and technological development (Article 13 f.h.i) of the EC Treaty applies

Technological Harmonisation

- Implement any measures that may prove necessary to ensure the interoperability across national frontiers of telematic applications and to facilitate the functioning of the Internal Market: this includes support to the standardisation work done by the European Standardisation Bodies (CEN:CENELEC/ETSI), which, where necessary, might be complemented by Community legislation and Memos of Understanding ;
  - Title V Common rules on competition, taxation and approximation of laws (Article100a) and Title XII Trans-European network (Article 129c) of the EC Treaty apply.

Co-ordination

- European level concertation and co-ordination of national policies has to be established to set the agenda and priorities for the implementation of Transport Telematics. This will identify where proposals for legal instruments, standards, co-financing and concertation activities, by the community might be necessary. It will also provide a central reference point to provide assistance;
  - Title XII Trans-European network 5Article 129c2) of the Treaty applies.

Financial Support

- Support financial efforts made by the Member States for projects of common interest[2] identified in the guidelines adopted by the EC Treaty. The Community may also contribute, through the structural instruments to the financing of specific projects in Member States in the area of transport and telecommunications which contribute to regional objectives;
  - Title XII Trans-European network (Articles 129) of the EC treaty and Title XIV Economics and social cohesion (Article130a-e) of the Treaty apply.

[2] Council regulation (EC) N2236/95 of 18/09/95 laying down general rules for the granting of Community financial aid in the field of Trans European networks, OJ n° L 228/1 of 23.09.95.

Legislation

- ➾ Adopt legislation which will facilitate the proper functioning of the internal Market through the development and use of transport Telematics;
  - Title III free movement of persons, services and capital (Articles 59-66) and Title V (Article100a) of the Treaty apply.

- ➾ Adopt legislation establishing an Internal Market for Transport Telematics services, networks and equipment;
  - Title III Free movement of persons, services and capital (Article 59-66) of the Treaty applies.

- ➾ Adopt legislation establishing guidelines for Trans-European network which highlight the use of telematics systems in the various modes of transport; Council has agreed on in July 1996 the Guidelines on TEN transport;
  - Title XII Trans-European network (Article 129) of the Treaty applies.

- ➾ Include the appropriate regulatory framework for the development of the Information Society, legal measures appropriate for the development of transport telematics applications and services;
  - Title III Free movement of persons services and capital (Article 59) of the Treaty applies.

- ➾ Promote measures to facilitate the introduction of electronic tolling and actions to increase safety;
  - Title IV Transport (Article 75 and article 129) of the Treaty applies.

Appendix 3

Technical standards organisations

The United Nations Economic Commission for Europe (UN ECE)

International harmonisation of vehicle standards has been taking place in Europe as long ago as 1958 with the establishment of the Geneva Agreement Concerning the Adoption of Uniform Conditions of Approval and Reciprocal Recognition of Approval for Motor Vehicle Equipment and Parts. This Agreement, which provided a framework for a voluntary system of type approval based on United Nation Economic Commission for Europe (ECE) Regulations, was set up originally with the aim of removing barriers to international trade by harmonising technical standards. In April 1998, the European Union became a signatory to this agreement.

ISO International Standards Organisation

The International Organisation for Standardisation (ISO) is a world-wide federation of national standards bodies from 90 countries. The mission of ISO is to promote the development of standardisation and related activities in the world with a view to facilitating the international exchange of goods and services, and to developing co-operation in the spheres of intellectual, scientific, technical and economic activity. ISO's work results in international agreements which are published as voluntary International Standards. .

Under Technical Committee 22 (Road Vehicles), there is a Subcommittee 13 (Ergonomics Applicable to Road Vehicles). This has a Working Group 8 (TICS on-board --MMI), which is deals with standards for HMI in in-vehicle information systems. Technical Committee 204 (Transport Information and Control Systems) has a Working Group 14 (Vehicle/roadway warning and control systems), which deals with standards for Adaptive Cruise Control. Technical Committee 204 also has a WG 13 (Human factors and man machine interface). This is essentially a shadow of an SAE subcommittee, chaired by Ford USA.

CEN

CEN's aims are to draw up voluntary European Standards and promote corresponding conformity of products and services in areas other than electrotechnical and telecommunications. CEN consists of the national standards organisations of the EU and EFTA countries, and of the Czech Republic. Associate members include consumer, industrial and union organisations. CEN is currently working in fields such as: Information Society standardisation; quality, measurement and value analysis; materials; mechanical engineering; building and civil engineering, health and safety at the workplace; Healthcare; and Transport.

CENELEC

CENELEC is the European Committee for Electrotechnical Standardisation. It has been formally recognised as the European Standards Organisation in its field by the European Commission in Directive 83/189 EEC. CENELEC works with 40,000 technical experts from 19 EC and EFTA countries to publish standards for the European market.