The role of traffic safety in ITT development

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The declared aim of developing and implementing intelligent transport systems is to improve safety and efficiency of transport and decrease negative environmental impacts. About15 years ago when major co-ordinated efforts started in Europe in the area of road transport informatics the hope of traffic safety experts was that while the primary aim of developments initiated by the car industry and the PROMETHEUS programme would mainly serve the individual customers' interests, a parallel programme financed by the EU (DRIVE) would focus on problems that are important for the broad community. Safety was the number one goal of the first DRIVE programme (1988-1992) having precedence over the goal of achieving increased road transport efficiency. Topics that were financed within that program included basic questions such as the safety objectives for intelligent transport systems or concepts for generic intelligent driver support, etc. The second period of co-ordinated R&D and implementation in the area (DRIVE II) still supported safety evaluation of new technology by financing a so called horizontal project for safety evaluation (HOPES) with the aim of developing traffic safety and MMI evaluation frameworks and screening pilot projects. The importance of safety aspects has been decreased since and the present EU document (European Transport Policy for 2010) speaks about intelligent transport systems as follows: "Their successful development and application could hold the key to solving many of our transportation problems, reducing environmental impact, increasing economic efficiency and saving lives." Also: "Effective Community action on this front will enable more effective planning, helping travellers and freight distributors to avoid delays and congestion and will increase the productivity of transport operators, while reducing the human cost of accidents and pollution." You can see how priorities have changed as far as expected impacts of intelligent transport systems are concerned.

Is road safety really a less serious problem nowadays?

The last report from the European Transport Safety Council states " Involvement in road accidents is one of the three leading causes of death and hospital admission for EU inhabitants (together with cancer and coronary heart diseases), and it is the leading cause of death for EU citizens under 50 years old. Road accidents cause a larger loss of expected life years than any kind of disease in the EU, due to the low mean age (about 32) of road accident victims." (ETSC, 2003) The above mentioned European Transport Policy for 2010 paper says, "...the degree of acceptance of the lack of safety is not always logical. How else can the relative tolerance towards road accidents be explained when every year there are 41 000 deaths on the roads, equivalent to wiping a medium-sized town off the map. Every day the total number of killed on Europe's roads is practically the same as in a medium-haul plane crash." Traffic un-safety is still a very serious problem, but it seems that both individuals and bigger communities are reluctant to face its seriousness.

It seems that the lack of awareness as far as traffic safety problems are concerned is which leads to the lack of demand for intelligent transport technology that directly targets safety problems. The development and implementation of intelligent transport systems is mainly steered by the stated preferences of the market and the push of new technological development, the producers of which hope to find a broad market in road transport, therefore application in practice gives preference mostly to congestion reduction and driver comfort.

Some hypotheses on the safety impacts of intelligent transport systems

The primary indicator of safety, i.e. accident can almost never be used as indicator of the safety effect of an intelligent transport system. It is seldom possible to detect changes in the number of accidents following a small-scale introduction of an intelligent transport sytem, particularly if this effect should be measured over a short period of time. It is even more difficult to address changes in these numbers, if detected, directly to the implementation of the system. It is of primary importance, therefore, to formulate hypotheses on the mechanism of the possible safety impacts so that the right intermediate indicators can be chosen for the evaluation.

There are two main categories of intelligent transport systems from traffic safety point of view: those that have the primary or secondary aim to improve traffic safety and those that have an aim other than safety. As any modification of the traffic system may have, and very frequently does have, impact on the safety of road users, some - positive or negative - impact on safety of the majority of intelligent transport systems can be hypothesised. Usually an intelligent transport system has a number of possible positive and negative effects on safety. This is because effects might differ in relation to road user group, road environment, weather condition etc. The final total impact will thus be the sum of various effects. Both categories of intelligent transport systems have, therefore, to be tested in order to see if they have some side effects that influence safety.

The HOPES project in the second DRIVE Programme has developed a system of generating hypotheses how ITS may have positive or negative impact on road safety. (Draskóczy ed. 1994) The ten areas of possible safety are as follows:

- Direct effects of an in-car system on the user (modification of the driving task),
- Direct effects of a road-side system on the user,
- Indirect, behaviour modifying effects of the system on the user,
- Indirect, behaviour modifying effects of the system on the non-user (imitating effect),
- Modification of interaction between users and non-users (including vulnerable road users),
- Modifying accident consequences (e.g. by improving rescue, etc.),
- Modifying exposure (frequency and/or length of travel),
- Modifying modal choice,
- Modifying route choice,
- Modifying speed choice.

The following analysis will be based on these hypotheses, although they will be covered in a different structure.

Intermediate indicators of safety impacts

- ***Direct safety impact by intelligent speed adaptation***

The number one safety related ITS concept these days is intelligent speed adaptation (ISA). There have been national as well as EU projects in the last decade (MASTER, PROSPER) concentrating on its different forms, expected impacts, its acceptance by the driving community, etc. Speed choice of the drivers in different traffic situations has a tremendous effect on traffic safety, both by influencing the probability of avoiding an accident to occur in a critical traffic situation, and by having influence on the impact of collision and on the outcome of an accident.

The intermediate factors behind the safety impact in this case may be allowing more time for assessing situations for both the equipped and the non-equipped partner. The ISA system does not imply changes in the driving task, but it may lower drivers' workload by taking over some of the task of controlling speed. It is important to make it clear that the locus of responsibility for speed adaptation remains with the driver even if the system does not allow exceeding the speed limit. A possible safety impact that needs to be studied is if speed control systems have behavioural adaptation effects, i.e. what speeds do drivers adopt in non-equipped areas and in situations which need a lower speed than the actual speed limit (turning, giving way, etc.). It also may happen that equipped drivers engage in other negative forms of adaptation, e.g. close following or more aggressive interaction with other vehicles.

- ***Direct safety impact by driver monitoring***

The second area where direct safety impact is expected from intelligent transport systems is the area of driver monitoring. The idea behind these systems is that dangerous driving is the cause of most traffic accidents and therefore monitoring whether drivers adhere to the traffic rules will have a tremendous positive safety impact. These systems are clearly not attracting drivers to buy them but they may be made compulsory for some user groups (tachographs for bus and truck drivers, etc.) or insurance companies may develop an incentive system for those who use them. These systems do not intervene with the driving task in any other way than by monitoring if the driver violates traffic rules. It is a function that is at present allocated to the police and fulfilled by occasional monitoring, using a lot of human resources. Information technology makes it possible that the function be automated and carried out in a much more regular way. Another advantage of an intelligent driver monitoring system is that it can provide immediate feedback to the violating driver. The main expected impact of such a permanent monitoring is to reduce driving errors and violations and improve traffic safety by that.

- ***Secondary safety impacts***

There is a very wide range of intelligent transport systems that do not aim primarily to improve safety but that still have positive or negative safety impacts (sometimes the same system has both positive and negative one) in many different ways. Safety impacts may be generated by the following functions:

- ***Providing drivers with information***

Many new systems that give drivers' information or advice have been developed in order to increase drivers' situation awareness by informing them on factors that are hidden for the naked eye but have influence on the driving task. Factors like that are adverse road surface-, visibility- or traffic conditions in a short distance ahead, state of the vehicle, etc. If drivers get information on these conditions, their situation awareness increases.

- ***Assisting drivers***

One of the basic needs behind implementation of new technology in road transport is to reduce human errors that lead to accidents, and assist drivers in driving functions where machines can function more accurately than human beings. Many systems, especially driver assistance systems *(dynamic vehicle control and collision avoidance systems, speed control system, etc.)* have the potential to prevent human errors, such as errors in distance keeping, lane keeping, selection of appropriate speed, etc. However, driving is a dynamic process in which drivers may use the assistance they get to attain further advantages by e.g. driving faster, taking more risk, and this may produce new sources of error. Moreover, the system intervention itself may be a new source of errors when e.g. different information sources interfere with each other and with the driving task, or systems that are designed to reduce driver workload decrease vigilance in a degree that is already dangerous. It is necessary that human errors created by new systems are carefully analysed in an early phase of system development, and their sources eliminated before introducing the system into the market.

There may be special groups of drivers, first of all elderly drivers who, on the one hand are a primary target group for driver assistance systems *(route guidance systems and other information systems, dynamic vehicle control and collision avoidance systems, speed control systems, etc.)*, on the other hand have special difficulties with learning new ways of driving, and may be prone of special system-created errors. Driver assistance systems have to be tested especially with elderly users, to ensure that their design takes into consideration their special needs and their special shortcomings, too.

A system that advise/guide or give assistance in vehicle control (*navigation and route guidance systems, speed control systems, dynamic vehicle control and collision avoidance systems, etc.)* may decrease driver work load substantially, although mainly in situations which are monotonous even by traditional driving. There is a danger that using these systems drivers will turn their attention to other activities, or their arousal level will be too low, and they will not be able to react efficiently in an unexpected dangerous situation. The situation may be even more difficult if there is some doubt about the locus of control, i.e. for how long is the system taking responsibility for the actions, and when should the driver take over and act. Many systems that assist drivers by substituting some part of the driving task with machines, that are more accurate at measuring e.g. distances, speeds, aim at increasing road capacity by allowing shorter distances between vehicles. If drivers of non-equipped vehicles imitate the behaviour of equipped vehicles, in this case keep similarly short headway, it may cause serious traffic safety problems in the changeover period.

- ***Taking over some control functions***

When tasks that traditionally are performed by humans are automated or at least part of the control is taken over by technology from the human operator, it is always a hot topic, who has the overall responsibility for the error-free functioning of the system. Driving a motor vehicle on a road that is not designated only for motor vehicles, but is a place where different kind of road users move around, is an activity that needs a human operator. It is a firm statement of the car industry and road transport technology providers that the locus of responsibility is going to remain at the drivers, even if sophisticated driver assistance systems offer support to them. If this is the case, it must be made clear for those who buy and apply those systems. Even if the overall responsibility for accident-free driving is on the driver, responsibility has to be shared between the driver and the system provider in case of systems that take over part of the control over the vehicle. The most critical period of semi-automatic driving is the hand-over phase, both from safety and from responsibility point of view.

- ***General behavioural effects of the change***

It is a well known phenomenon that if a change is introduced to the road-vehicle-user system, road users adapt their behaviour to the new situation and this adaptation is not always in line with the intention of the initiators of the change. Introduction of new transport technology aims at improving traffic safety and efficiency, but drivers who use the technology have their own aims, and use the possibilities provided by new technology for fulfilling them.

One possible behaviour adaptation effect on new road transport technology may be the *delegation of responsibility* on systems that take over some control task (distance keeping, lateral control, speed keeping, etc.*)*, and dividing attention between driving and some other tasks or activities, or simply relaxing and not concentrating fully on the driving task. It may be especially attractive to use new technology, e.g. computer and internet connection available for the driver, to carry out some office work while driving, if some driver assistance system takes over part of the driving task. Another dangerous form of behaviour adaptation may be the imitation of the often rather short following distance or relatively high speed of the vehicles that are equipped with systems, such as cruise control or vision enhancement, by drivers of non-equipped vehicles. Also, drivers of vehicles equipped with some driver assistance system may overestimate the assistance they get, and take risks that they would not take without the system.

Communication is a vital element of taking part in traffic as driver. The activity of driving is traditionally based on direct communication between traffic participants e.g. when giving way to one another, and on direct perception of the traffic environment. New technology introduces other channels of communication for the driver, mainly in the form of messages coming from the control centre and received partly from a roadside gantry outside the vehicle, partly from some information source within the vehicle. This development, especially if many information sources are working inside the vehicle *(navigation/route guidance system, speed warning system, RDS/TMC, lateral vehicle control warning, etc.)* may cause that drivers' attention is more and more drawn toward in-car displays, and their communication and co-operation with other road users is weakened.

Systems that provide guidance or give assistance in vehicle control make some traditional driving skills unnecessary, and as those skills will not be practised, some *loss of skills* is probable. The loss of skills does not mean any problem until the driver enters a situation where the system does not function any more (e.g. *cruise control or lateral control does not function, route guidance or collision warning is not provided, etc.)* either because its function depends on some support from the infrastructure that is missing in the given area (e.g. infrastructure based navigation support), or the system fails and the driver has to take over its function. If the skills in question are vital for safe driving, some procedures have to be developed to ensure skill maintenance especially in case of professional drivers.

System failure is an inevitable aspect of technical systems, but the consequences of a failure are dependent on many factors. Road vehicles, however well equipped with new technology, will be for a long time remain under the human command of the driver, therefore if systems can fail gracefully, by warning the operator on failure and revert to a manual mode of functioning, harmful effects of the system failure can be minimised. The consequences of a system failure and the way of handling them are dependent on the level of system intervention into the driving task. If the system's function is to inform or guide the driver *(e.g. traffic-, road-, weather related warnings, warnings on excessive speed, danger of a collision, etc.)*, it is vital that the driver is warned about the non-functioning of the system, so that it is clear that he/she can no more rely on the system's messages or guidance. Driver assistance systems, which take over part of the vehicle control functions need not only warn the driver of system failure, but also have to provide a procedure for taking over control by the driver.

- ***Other safety related effects on the transport system***

Different travel modes and different parts of the road network have different accident risks, therefore, any measure that influences mode choice (traveller information systems, road pricing, area parking strategies) or route choice by diverting traffic to roads of different category (dynamic route information and guidance systems) has influence on traffic safety

Traffic safety, the number of accidents occurring is highly dependent on the frequency and length of travel, exposure. Intelligent transport systems may have a strong impact on exposure in both ways. Systems that influence congestion, the distribution of traffic over the network (e.g. route guidance systems) and the comfort of travel may have an unplanned secondary effect of increasing travel demand, and by that influencing traffic safety.

Conclusions

"Road accidents lead to more than 93% of all passenger transport accident costs each year and are higher than the congestion costs or the costs of environmental pollution, as estimated by the European Commission." (ETSC, 2003) In spite of that, intelligent transport systems under development and implementation do not give high priority to safety as their primary aim. Those systems, however, have impacts on safety – positive or negative – as they have influence on the transport environment in many different ways. It is, therefore, of vital importance that those safety impacts are assessed and taken into consideration at system development.

An overview of the existing and planned intelligent transport systems reveals that the vast majority of them are for motorised traffic, and vulnerable road users' safety is not targeted by them. „Travelling by car is about 1 to 3 (per time) and 7 to 9 (per distance) times safer than by cycling or walking, but car occupants are still 10 (per distance) to 12 (per time) times less safe than bus occupants. If the walking or cycling before and after a train or bus trip comprises more than 15% of the trip distance then it is safer for the individual to travel by car (avoiding the high risk of walking or cycling) than by bus or train. However, cars mainly cause the road traffic death of other car occupants, motorised two-wheelers, cyclists and pedestrians. Therefore, trips by public transport and before and after walking or cycling are collectively safer than car trips." (ETSC, 2003) Vulnerable road users are mainly present in urban traffic, and it seems that ITS can not much contribute to traffic safety in this area by the present information, assistance and control systems. Only some directly safety related systems, i.e. intelligent speed adaptation and driver monitoring systems are promising in this respect.

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