INTELLIGENT TRANSPORT SYSTEMS TODAY: A EUROPEAN PERSPECTIVE

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Abstract
This paper discusses current European research in the area Intelligent Transport Systems (ITS) impact assessment and seeks to determine the future potential of such systems particularly as it pertains to road safety. The study focuses on investigating the anticipated impact of ITS using both previously undertaken research and expert opinions. Several European studies on the impact of intelligent transport systems on road safety are presented, their findings are analyzed and the issues to be considered and be dealt with in the future are obtained. Furthermore, preliminary results from a large Delphi study on the issues regarding the impacts of system use on road safety are also presented and discussed. The results of this paper can assist in defining future needs and expectations from ITS on a European-wide level.

1. INTRODUCTION

Intelligent transport systems (ITS) is a quite recent field in science and as such it demonstrates rapid development (Peirce, Lappin, 2003). ITS are being developed by various parties including system developers, car manufacturers and scientists worldwide (HUMANIST, 2004). The contribution of various groups including engineers, psychologists, ergonomists and lawyers is also apparent. The importance of the development of intelligent transport systems lies mainly on the fact that their contribution in many of today's problems, which have resulted from the mobility growth, is anticipated to be substantial.

Generally the invention of the car and other means of transport has enhanced our everyday life, but their development and resulting growth in mobility has been followed by negative consequences. More specifically, road safety, traffic and environmental conditions are affected by that growth, for which conventional measures seem to be ineffective. Intelligent transport systems seem to be a promising direction towards providing an efficient solution for the reduction of those side-effects of mobility growth, thus setting new standards.

Intelligent transport systems start as an idea, are built as a prototype at a laboratory and their development proceeds to being a fully developed system.

They are then evaluated before being introduced into the market, which is the final stage of their "development". This whole process involves two main actions: system development and testing, both being of equal importance. One of the main questions answered by the testing of a system is its impact on a number of parameters. The first section of the present paper presents a number of studies on specific intelligent transport systems through which possible methodologies used for testing ITS, research findings and gaps in knowledge are identified. There is a vast number of studies on the impact of intelligent transport systems worldwide. Different studies present different and sometimes contradicting results and conclusions. Hence, the overall picture of what the exact impact of intelligent transport systems is and what to expect from their usage is not always clear.

The cost of the implementation of intelligent transport systems is definable and is quite high, whereas their benefits are abstract. Hence, the procedure of systems evaluation and application seems to be a rather slow one. After all this research, the question remains: "Are intelligent transport systems a promising means to the future?". In order to provide an answer to this question a Delphi study is conducted with a group of experts investigating parameters related to the impact of intelligent transport systems. The objective of the study is not to find the absolute truth on the issues presented in the questionnaire, but to record and discuss the views of the people who are responsible for the research, implementation or use of such systems and to identify the gaps in knowledge and needs for further research. In the second section of the paper preliminary results of a Delphi study are presented and discussed.

2. STUDIES ON THE IMPACT OF INTELLIGENT TRANSPORT SYSTEMS

2.1 Estimation of the Impact of Intelligent Transport Systems

Once a system is developed the next step is to evaluate it, by estimating its impact. There is a great variety of types of studies for the investigation of the impact of intelligent transport systems. The most important and commonly used ones are: studies in real traffic, test track studies, simulator studies, laboratory tests, traffic simulation and questionnaire studies. The researcher chooses the most appropriate one for each case balancing the needs, cost, implementation risk, necessary implementation scenarios and the validity of each method. Furthermore, there is a number of parameters which indicate the impact of the use of intelligent transport systems on road safety. The main parameters are accident rates, specific accident related parameters such as speed, headways and specific physiological measures. Once more the choice of parameters is a balance of feasibility, validity and availability.

2.2 Studies on the Impact of Intelligent Transport Systems

This section deals with the estimated impact of a number of intelligent transport systems, through the presentation of specific mainly Europepan studies. The objective is to present the different methodologies that are being used as well as to identify certain limitations of the investigations.

Várhelyi *et. al.* (2002) investigated the use of intelligent speed adaptation using a wide range of methods and measures. The trial took place in Sweden in the city of Lund, had a duration of 5-11 months, and for the trial 284 vehicles were equipped with the investigated system. Amongst the methods used were surveys and interviews with users but also non-users, in-vehicle observations, speed, travel time and emissions measurement and estimation and accident data observation. All of these variables were measured and estimated both before and after the trial. Three important elements of the study were that possible interactions with non-users were investigated, the long duration of the trial and also the use of accident data. However, the accident study that took place revealed that it was not possible to identify any general change of the accident trend in Lund, and hence the use of the 284 ISA-vehicles did not have an impact on road safety in Lund for the duration of the trial. An important and probably the most valid measure of the impact of intelligent transport systems on road safety would be accident statistics. The main problem is that such statistics can only be of relevance in the case of high penetration rates of the systems and for very long periods of time. This means that systems must be forwarded to the market before being assessed by this method. However, a good start towards this direction since some systems are already into the market (navigation systems) would be to update the national accident data collection forms in order to incorporate features involving intelligent transport systems.

Alkim and Korse (2003) investigated the behavioural effects of the use of lane departure warning systems. They tested three systems with different properties equipped on 35 heavy goods vehicles and a bus. All three systems provided an audio warning when the road markings were crossed and no intention of a lane change was indicated. Using as a measure of the impact on road safety the number of warnings over time, the amplitude and duration of crossings, the investigated impact was not clear as these did not decrease over time. This indicates that there is no behavioural change from the use of the systems. However, if penetration rates were high and the duration of the experiment was long, using accident statistics it could be possible to identify the impact on road safety not as a result of behavioural change, but as a result of system compensation. Such studies however are not that feasible to take place, yet.

Muzet *et. al.* (2004) assessed the use of steering grip sensor measurement as a parameter to predict driver drowsiness. One intelligent transport system that is being developed is the fatigue or drowsiness warning system. This system mainly applies to the professional drivers, especially heavy goods vehicles drivers who drive for long distances both during day and night. The way the system operates is to provide warnings haptic, audio or visual when drowsiness is detected. Hence, an important feature of the system is to be able to detect drowsiness efficiently in order to avoid situations where the driver feels drowsy and this is not identified by the system, but also not to detect non-existent drowsiness and produce false alarms. The method that was used was a driver simulator and the steering grip sensor signals measurement was tested against objective sleepiness score (electrical brain activity, electrical eye activity and video recordings of the driver's face) and subjective score (Karolinska Sleepiness Scale). Although significant correlations were found between the investigated measure and the objective and subjective scores, differences were observed that resulted from the individual driver characteristics. The incorporation of different driver and user characteristics into simulation models, traffic or behavioural ones, is still an issue that causes concern for the research of the impact of intelligent transport systems.

The impact of the use of information systems with the use of a traffic simulator was investigated for a mountainous area with adverse weather conditions (Boyle, Mannering 2004). The systems used were an in-vehicle information system (IVIS) and variable message signs (VMS), and the simulator scenarios implemented specific weather (fog) and incident conditions (slow moving snowplows at one of the directions). The parameter used for the system assessment was the vehicle speed throughout the trip, which can be directly linked to road safety. The results of the study are illustrated in Table 1.

Table 1. Mean speed (km/h) with the use of advanced traveller assistance systems (Boyle, Mannering 2004)

Condition	No Fog		Fog	
	No Snowplows	Snowplows	No Snowplows	Snowplows
None	97,7	91,1	86,2	83,7
IVIS	98,1	92,7	82,7	79,0
VMS	97,2	90,1	82,1	77,8
Both	87,5	76,2	74,5	70,4

Although there are differences in the mean speeds, most of them were not proven to be statistically significant. The results indicated a tendency of drivers to react more to VMS rather than IVIS and also to slow down with increasing information. What was also noted is that drivers generally decreased their speed with the information of fog or snowplows but then increased their speed further downstream of the incident as a compensation of the upstream speed reduction. This observation points out the importance of choosing the correct parameters and mainly the location and duration of their measurement for the assessment of such systems.

The effect of the use of adaptive cruise control (ACC) and intelligent speed adaptation (ISA) using three different traffic simulation packages (SISTM, SIMONE and HUTSIM) in different sites was investigated (Yannis *et al,* 2002) in the framework of EU co-funded project ADVISORS. The models used were traffic simulation models with different characteristics. Several scenarios were tested using a range of different road network and traffic conditions characteristics and also system penetration rates. The parameters for assessing the impact were traffic parameters that are linked to road safety. Some of the results of the study are presented in Table 2, where "+" indicates positive impact on road safety, "0" no impact and "-" negative impact.

Table 2. Impact of ACC and ISA (Yannis *et al,* 2002)

1* -> SISTM, 2* -> SIMONE, 3* -> HUTSIM	ACC – SAFETY IMPACT			ISA – SAFETY IMPACT		
	1*	2*	3*	1*	2*	3*
Av. Speed	+	0	-	-	+	+
Headway	+	0		-	0	
Time to collision	+	+		+	+,-	
Lane Change Rate	-			+		

There are several conclusions that can be drawn from the results of Table 2. One general conclusion is that the overall impact on road safety resulting from the use of these two specific systems seems to be positive. Another interesting observation is that different models and investigated scenarios produce different results. Hence, the use of a specific model and range of scenarios could indicate that the impact on road safety is positive, whereas the use of a different model and range of scenarios could indicate the exact opposite. Additionally, for the same model and scenario different investigated variables also produce different conclusions on the impact of system use (Spyropoulou, 2005).

3. DELPHI STUDY

3.1 General Elements of a Delphi Study

Within the framework of the European project HUMANIST (HUMAN centred design for Information Society Technologies) a Delphi study is currently underway. The aim of the study is a better understanding of the relevant parameters of the impact of specific intelligent transport systems mainly on road safety. The Delphi study is a method from which the opinions of experts are recorded through a structured and specific way. It has proven to be a popular tool for identifying and prioritising issues (Okoli, Pawlowski, 2004) and has been used as such in varied research fields including the field of transportation (Mulder *et al*, 1996) and intelligent transport systems (Marchau, van der Heijden, 1998). The main objective of a Delphi study is to reach consensus amongst participants on the investigated issues (Sackman, 1975). Reaching consensus is not always the objective, and other methods of performing a Delphi study by developing a set of alternative future scenarios have also been introduced (Kendal *et al*, 1992, Tapio, 2002).

In this case, the study is conducted with the use of a questionnaire. Hence the procedure is as follows: a questionnaire is sent to experts, who fill it in and send it back. The results are then being processed; and a slight redesign of questionnaire might also take place as a result of the answers or comments of participants. The questionnaire is sent again to each participant along with his/her previous answers and the results of the survey (average answers). Participants are asked to fill-in the questionnaire again and send it back. The same procedure is repeated and usually stops when there is group consensus or else when respondents do not change their answers between rounds. In the case of answers out of the average range respondents are asked to justify their view.

The important elements of the study are the questionnaire itself and the group of experts to whom it is addressed. The questionnaire should be designed carefully in a structured way and the questions should be such so that the conductors of the Delphi study can extract answers to the specific investigated topics. Additionally, the questions should be designed in such a way as to be comprehensive and clear, without creating confusion to the participants. Furthermore, the questionnaire should not be long because the drop-out rate between rounds is usually quite high (Jillson, 1975). Experts should be chosen carefully taking into account their expertise on the investigated topics. It is desirable to have a sample group with varied and distinct characteristics in order to avoid biased results.

3.2 Questionnaire Design

(a) Choice of Investigated Systems

For the design of the Delphi study several specific issues had to be considered. The first issue involved the systems that would be chosen for investigation. An obvious property of the systems is that they had to be such that positive impact is anticipated from their use. Since the study involves safety impact the chosen systems are expected improve road safety.

Generally, the main reason for performing a Delphi study is to provide answers to questions that have not been answered efficiently by research. Hence, the systems chosen had to be “new” systems or else systems for which there is no sufficient evidence on their impact. Another point is that Delphi study also gives an indication of the opinions that experts have, hence it would be interesting to be able to compare the knowledge and views of experts on the “new” systems with those on more established ones. For this reason the systems chosen were the following: Anti-Lock Braking System (ABS), Intelligent Speed Adaptation (ISA), Enhanced Navigation, Lateral Control Warning and Intersection Warning.

These five systems are quite different to each other in terms of their operation and this was an additional parameter for their choice. More specifically on the chosen systems, the anti-lock braking system is a system quite widely used currently. It is designed to stabilize the vehicle; to keep a car maneuverable when braking strongly. Even though this system comprises part of standard equipment nowadays, the number of studies on its impact is not great. Additionally, there are still disagreements on its effect mostly because of users' lack of knowledge on ABS operation and risk compensation.

Intelligent speed adaptation is a range of speed control applications, from external speed recommendations to automatic speed reduction (limitation) function, integrated within traffic control systems. An important number of studies has been undertaken on the impact of intelligent speed adaptation, and this system is developed in a rather efficient stage compared to the other investigated systems (except of course for ABS).

Enhanced navigation systems are consisted by in-vehicle navigation systems combined with real-time information systems. Navigation function will provide location and route guidance input to the driver. It can also have capability to recommend optimal routing based on driver preferences. Enhanced navigation systems may integrate real-time traffic conditions to the calculation of optimal routes. Other included features could be the integration of other ADA systems, for example that may adjust the driving speed if the road conditions are changing. Navigation systems are used in several countries either in the form of vehicle equipment or in the form of nomadic devices. Enhanced navigation systems have not yet been developed greatly, and their impact on road system has yet to be investigated.

Lateral control systems assist the driver to keep the vehicle almost in the center of the lane using on-board vision systems or dedicated lane markings such as magnetic nails or magnetic tapes. The warning could be audio, visual or haptic. Those systems are not yet forwarded to the market and the number of studies on their impact is low.

Last, intersection warning systems enhance driver awareness of the traffic situation at the intersection by providing timely and easily understood warnings of vehicles entering the intersection. Intersection warning systems have not been forwarded yet at the market and are at a quite early stage of development and testing.

(b) Questionnaire structure

The second main issue involves the questions themselves. The study should mainly provide evidence on issues related to the impact of the systems on road safety. Additionally, it would be desirable to include issues of general interest on the systems. The questionnaire itself is divided into four sections. The first section involves general questions on the examined systems such as the type of anticipated impact (road safety, network conditions etc) or the future anticipated penetration rates. These questions give an indication of whether the systems should and hence expected to be further developed and introduced into the market. The second section of the questionnaire involves more specific questions on the examined systems and is focused on issues related to road safety. Questions included in this part describe the expected impact of the systems in terms of its duration (short term or long term effects), the side effects of the systems, the parameters that should be indicators of the impact of the system usage on road safety. The third section of the questionnaire involves general conclusive questions and comments such as user categories that are appropriate for each system or system cost. The final section records participants characteristics.

3.3 Presentation of Preliminary Results

The results presented in this paper concern the first round of the Delphi study, which is still underway. Additionally, the results involve only part (33 respondents) of the final sample of the first round of the study and only participants who work in Europe.

(a) Respondents profile

The respondents profile varied significantly in terms of profession, professional background etc. This variation is desirable since it reduces biased results. An important parameter of the respondents profile is their professional background. Different professional backgrounds indicate a different way of approaching research on the systems, where different aspects of them are important. The profile of the respondents in terms of their professional background is illustrated in Figure 1.

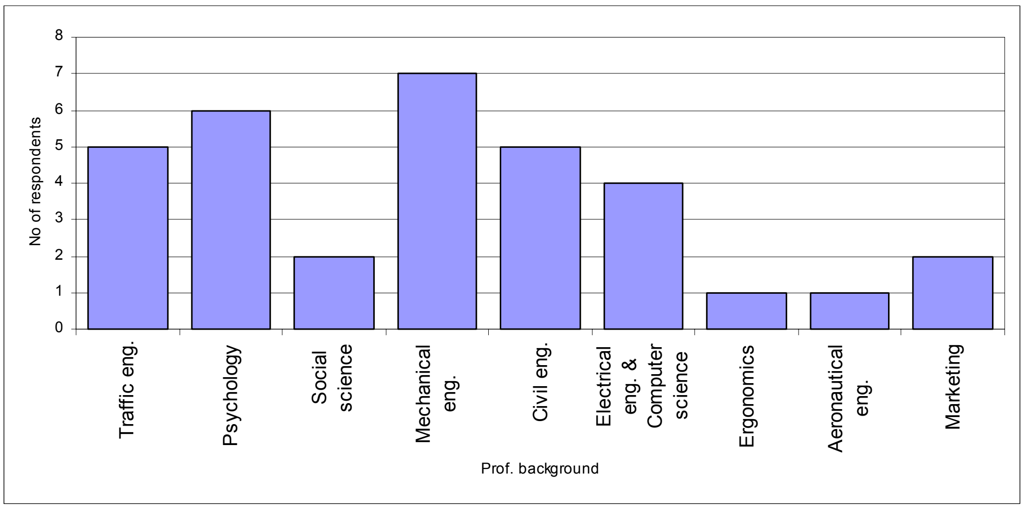

Figure 1. Professional background of the respondents

The profile of the respondents varies significantly. The majority of respondents has an engineering background, with 67% of the respondents comprising this category. Additionally, 6 respondents, 18% of the sample, have a background in psychology. The respondents' profiles also include social science, ergonomics and marketing. Another important characteristic of the respondents involves their expertise on the systems. This expertise is illustrated in two dimensions. The first dimension involves the respondents' knowledge on the systems, hence the way they are involved with them in terms of research. The second dimension describes their experience on the systems, and hence the type of usage of the system. The expertise of the respondents, which is recorded for each of the investigated systems separately, is illustrated in Table 3.

Table 3. Respondents' experience on the investigated systems

Experience/Systems	ISA	ABS	Intersection Warning	Enhanced Navigation	Lateral Warning
Specialist/Expert	2	3	4	5	4
Knowledge Resulting from minor research	8	8	6	15	8
Knowledge Resulting from reading technical literature	24	19	18	18	21
No knowledge	1	5	5	0	3
Personal experience (system user)	6	21	2	14	2
Laboratory experience (use it only in tests)	9	5	9	11	10
No experience	19	9	21	9	20

Once again the profile of respondents varies in terms of their knowledge and experience on the systems. The majority of respondents has gained their expertise on systems from technical literature rather than testing with the exception of the enhanced navigation system for which a significant number of respondents has performed minor research. In terms of the experience on systems, as expected, the majority of respondents is a user of the Anti-lock braking systems as this is part of standard vehicle equipment nowadays. There is no experience recorded for the majority of the respondents on the intelligent speed adaptation, intersection warning and lateral warning systems since these are the least developed ones.

(b) Importance of systems

The view of the respondents on the importance of the systems in terms of the anticipated impact is depicted from two questions the first involves the impact of system use on five issues which are road safety, traffic conditions, environmental conditions, driver comfort and user integration into the road system. The systems were rated for each of these issues from highly negative to highly positive. The total score of the systems is illustrated in Figure 2.

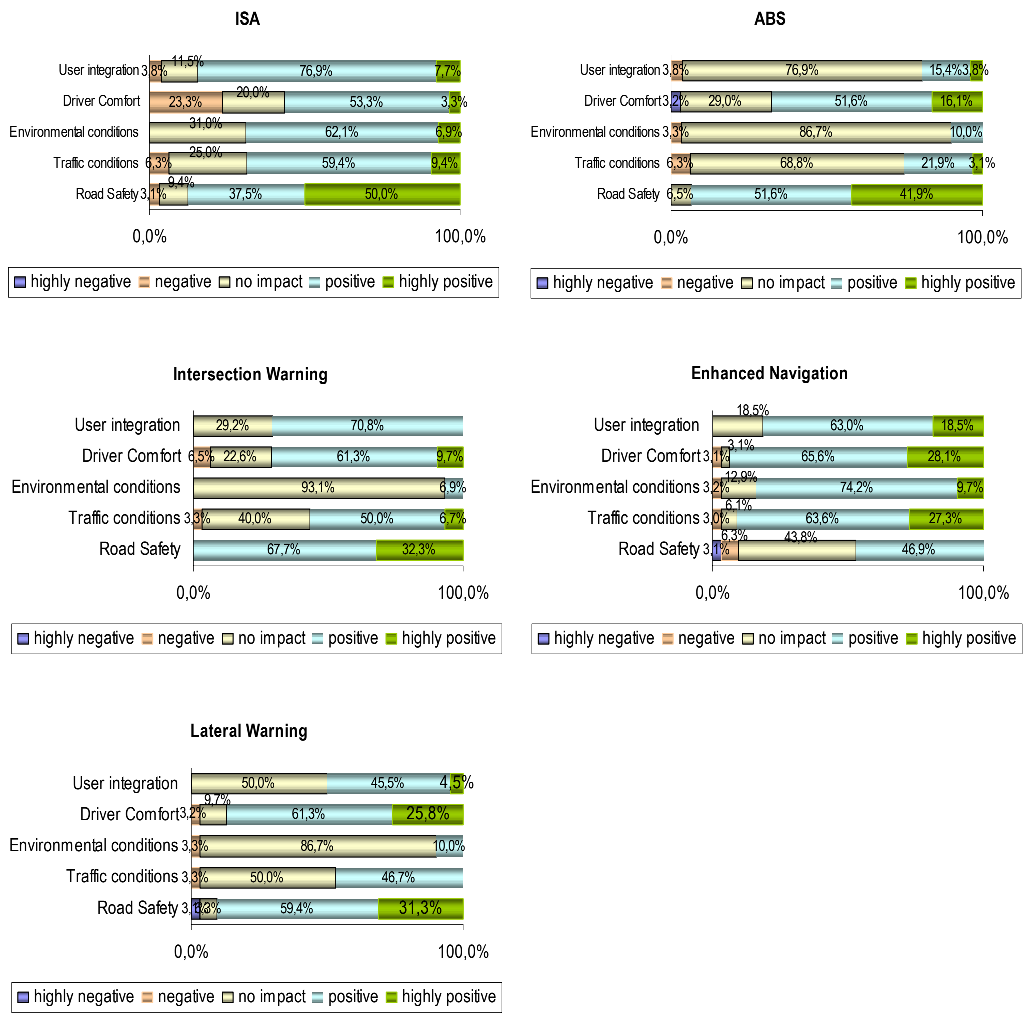

Figure 2. Impact of systems on specific parameters

An important conclusion is that all five systems are expected to improve road safety, with ABS and the intelligent speed adaptation system being the most promising in that direction. Additionally, all systems score differently in each of the impact categories. For example the most promising in terms of road safety is the intelligent speed adaptation system whereas in terms of improving traffic conditions the most promising one is the enhanced navigation system. Furthermore, most systems score also low (ie between negative impact and no impact) in some of the impact categories. The intelligent speed adaptation system is the only one for which one parameter (driver comfort) is expected to be affected negatively by a significant number of experts.

Another question involved the rating of the systems in total. Participants were asked to put the five systems in an order of preference (with the most preferable system scoring 1 and the least 5), and the results of this question are illustrated in Figure 3.

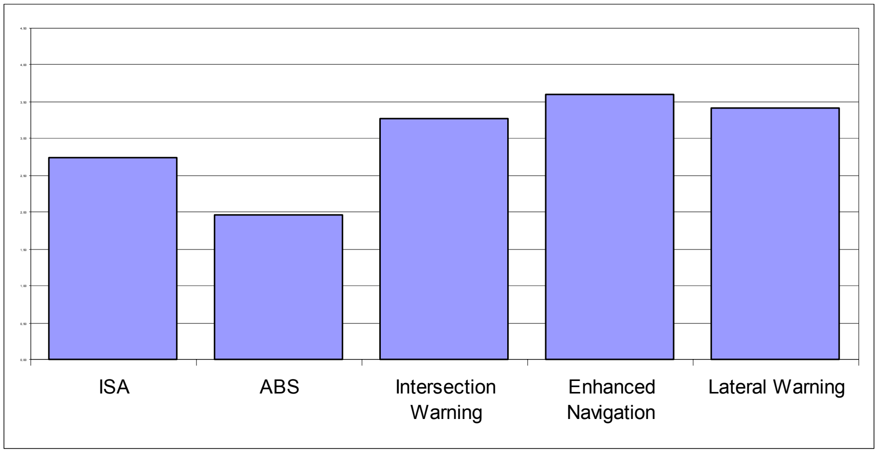

Figure 3. Placement of systems in an order of importance

The total rating of the systems indicates that the most preferable system between the respondents is the ABS and the least is the enhanced navigation one. This conclusion proves to be compatible with the picture that is described through the impact results as illustrated in Figure 2. It seems that for the total rating respondents perceive the impact on road safety as the most important factor. There is a range of parameters for the total ranking of the systems such as development level, system reliability and user acceptability issues. A study that took place indicated that drivers are not very willing to have ISA - at least without any trial. More specifically, in Sweden, they have found that experience of the even mandatory ISA makes drivers more positive towards using them (Mankkinen *et al.*, 2001).

Another question that illustrated the preference of the respondents on the examined systems and also the level of their development involves whether those systems should be part of standard vehicle equipment. The results of this question are illustrated in Table 4.

Table 4. Systems that you consider to be part of standard vehicle equipment

Development/Systems	ISA	ABS	Intersection Warning	Enhanced Navigation	Lateral Warning
In their current level of development	6	32	1	12	3
Following a few more impact studies	11	1	7	10	10
With some further development	9	1	24	9	18

The results indicate that there is a significant number of experts 20% (the participants who did not give a positive answer to this question) who do not think that intelligent speed adaptation should be part of standard vehicle equipment, whereas only a small percentage 3% (1 respondent) for intersection warning and 6% (2 respondents) for enhanced navigation and lateral control believe that those systems should not be part of standard vehicle equipment. This percentage for ISA (20%) which does not agree with the total ratings of the system could reflect speculation on the user acceptability rates. Results of a Finnish survey (Penttinen, 2003) indicated the preference of users on incident and real-time information systems. Although intelligent speed adaptation was one of the examined systems, it scored much lower on user preferences. According to the respondents' answers, although the anti-lock braking system is already part of the standard vehicle equipment (in most vehicles) 2 respondents indicate that more research needs to be done on those systems. The least developed and tested system according to the respondents views is the intersection warning one, with the lateral warning system following.

(c) Gaps in knowledge

The questionnaire provides conclusions on certain aspects around the impact of the systems, on the preferences of the experts but also on our knowledge on the investigated systems. A question that indicates the direction of future research involves the types of studies that should take place for the further testing of the systems. In order to extract such conclusions two questions were asked. The first described the appropriateness of the studies and the possible answers were "not relevant", "slightly relevant", "relevant" and "important", and the results are illustrated in Table 5.

Table 5. Appropriate types of studies for each system

	Real traffic	Test track	Simulator	Laboratory	Questionnaire
ISA	√	√	-	**x**	-
ABS	√	√	-	**x**	**x**
Intersection Warning	√	√	√	**x**	**x**
Enhanced Navigation	√	-	**x**	**x**	√
Lateral Control	√	√	-	**x**	**x**

Generally, real traffic studies are appropriate for the estimation of the impact of the use of the examined intelligent transport systems whereas laboratory studies are not as relevant. Simulator studies also scored quite high for the intersection warning systems. Finally, for the investigation of enhanced navigation systems questionnaire studies also scored quite high.

The second question involved the amount of evidence that is available for each type of study. The answers to this question are illustrated in Figure 4, only for the types of studies that were rated as relevant from the respondents.

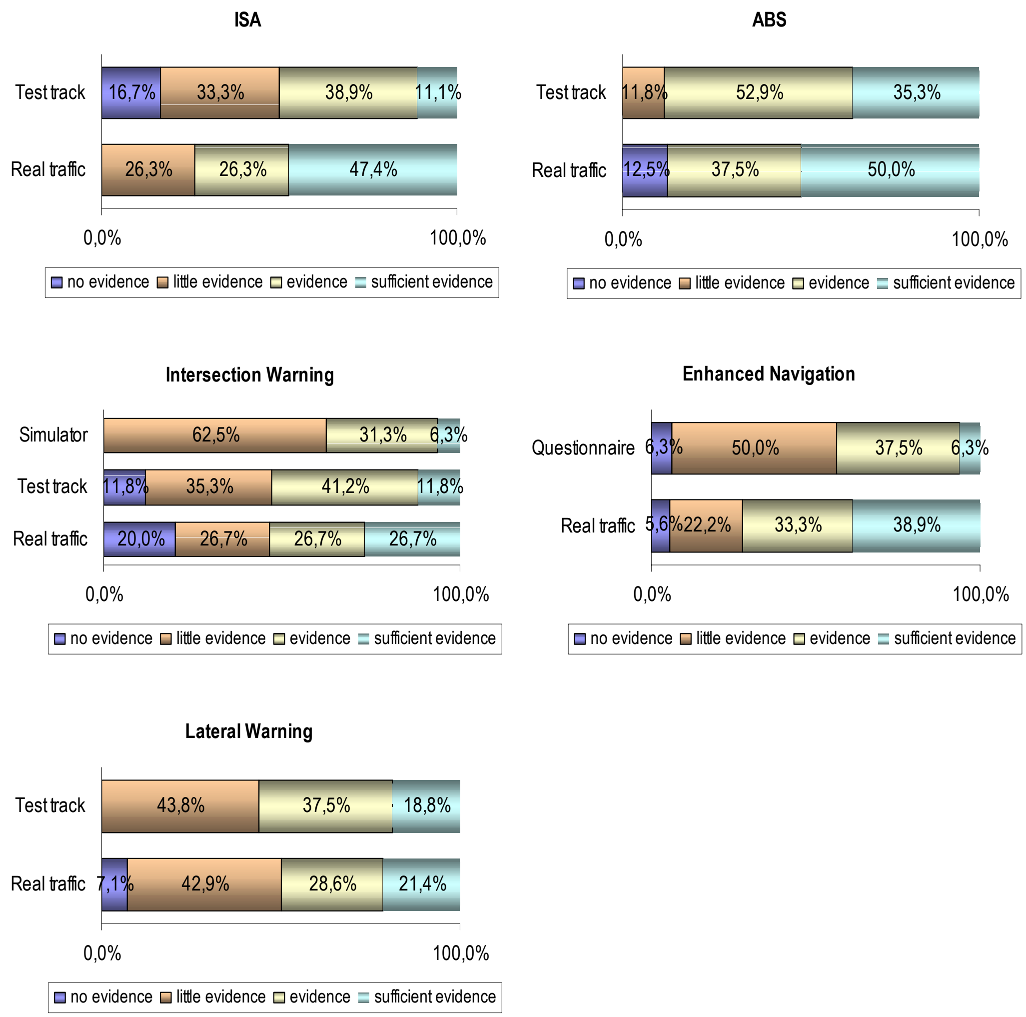

Figure 4. Evidence that is available on the impact of the examined systems

The results indicate that for the investigation of the impact on road safety the majority of respondents believe that there is sufficient amount of evidence for the use of ABS and also a good amount of evidence for ISA, mainly for real traffic studies. However, further research should take place for the other three systems, intersection warning, enhanced navigation and lateral warning.

Another way of identifying adequacy and gaps in knowledge is to calculate the number of the “no opinion” responses in each of the questions. A rough counting indicated that in terms of questions that involved the impact the relationship between the penetration rates and the anticipated impact has not been identified. Additionally, a significant number of experts had no opinion on a question describing the side effects of the systems. There seems to be adequate knowledge on the type of studies that is appropriate for each system. An interesting result is that in contrast with the other systems there is not sufficient knowledge on the amount of evidence that is available from each type of examined study for the anti-lock braking system.

4. DISCUSSION

Within this research the impact of intelligent transport systems on road safety through a European perspective is being discussed . To achieve this objective two main actions took place. First, several studies, mainly European, which investigated the impact of the use of intelligent transport systems on road safety were presented. Second, the opinions of experts in the field on the impact of intelligent transport systems were presented and discussed.

More specifically, through the presentation of studies on the use of intelligent transport systems, the wide range of methodologies and measures that are used for estimating the investigated impact were presented. More specifically, real traffic studies are generally preferred for testing specific systems (such as ISA, ACC, warning systems), whereas simulator studies are preferable when testing advanced traveller assistance systems, and test track studies are used in order to avoid risky situations. Simulation studies are mainly used when several scenarios involving penetration rates, and hence large scale implementation of the systems, want to be tested. Additionally, questionnaire surveys also take place to record the users' opinion on the use and impact of the system.

The measures used include accident related parameters (such as speed, headways etc) and effort is being made for investigating accident data, in a preliminary level. Additionally, subjective measures such as user opinions and ratings are also used.

The findings of the studies, which were also described in the first section of the paper, indicated the anticipated impact from the use of intelligent transport systems, as it is recorded in recent research. Several intelligent transport systems are anticipated to improve road safety and there are many questions for which research in the field has or is able to provide efficient answers. However, there are still issues that remain unsolved and for which further research has to be made. Some of the issues that were identified from the research presented are the difficulty of modelling the individual characteristics and hence behaviour of the users and the lack of recording long-term effects on users. Additionally, the validity of the traffic models that are currently used and the design of appropriate simulation scenarios were issues that need to be further discussed. Another shortcoming in current research is the difficulty of linking directly the impact of the systems with accident risk, which if possible would provide a clear indication of the impact of system use on road safety.

In the second section of the paper the preliminary results of a Delphi study were presented and discussed. Questionnaires were answered by experts in the field of intelligent transport systems, whose job location is in Europe. The questionnaire was designed in such a way as to focus on the impact of intelligent transport systems on road safety, record experts' opinions on issues for which research has been made and also raise some of the questions that were discussed in the first section. Five specific systems were investigated; namely intelligent speed adaptation, anti-lock braking system, intersection warning, enhanced navigation and the lateral warning system.

The results indicated that the majority of experts anticipate that the use of the examined systems will improve road safety. Other types of impact were also discussed: traffic and environmental conditions, driver comfort and user integration. Different systems scored differently in the each of the categories. Intelligent speed adaptation and the anti-lock braking system were the most preferable systems amongst the study participants. However, there was a significant number of respondents who did not think that the intelligent speed adaptation system should be part of standard vehicle equipment, probably reflecting questions on the user acceptability rates of the system.

The need on specific research on each system was also recorded by indicating the amount of available evidence from specific types of studies. The answers of the participants indicated that there is sufficient evidence for the use of the anti-lock braking system and a good amount of evidence on ISA, but also revealed the need for research on the impact of the use of the other three investigated systems.

Lack in knowledge on the impact of system use on road safety was also recorded by measuring the “no opinion” answers provided by the respondents. The questions involving the relationship between the system penetration rate and the impact of the system use and also the side-effects of the system were those that scored highest in this respect manifesting the need for further research in those areas.

Intelligent transport systems have the potential to improve road safety and provide solutions to deal with the consequences of mobility growth. Research on issues related to the impact of intelligent transport systems is funded and conducted using various methodologies. However, some issues still remain unsolved and future research should be directed towards providing answers to them.

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