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What drives the Acceptability of Intelligent Speed Assistance (ISA)?

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To have knowledge about the acceptability of Intelligent Transport systems (ITS) is most beneficial for the development of supported implementation strategies. So far, different theories and methods, also stemming from other domains, have been used to define and conceptualize the notion of acceptability. In a previous paper, we developed a theoretical concept to define acceptability of ISA based on different theories and methods used in ITS & ISA research. In the current paper we aim to find out which predefined indicators are relevant to define the acceptability of ISA. Background factors, contextual issues and ISA-device related factors are used as indicators to predict the level of acceptability. Structural Equation Modelling (SEM) is used to define the direct and indirect effects.

Keywords: Intelligent Transport Systems, Public Support, Acceptance

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1. Introduction

In December 2008, the European Commission (2008) took a major step towards the deployment and use of Intelligent Transport Systems (ITS). In the Action Plan on ITS, the EC suggested a number of targeted measures and a proposal for a Directive laying down the framework for their implementation. The main policy objective is to come to cleaner, safer, more (energy) efficient and more secure transport and mobility. The Action Plan stated that better use should be made of the newest active safety systems, such as Advanced Driver Assistance Systems (ADAS), with proven benefits in terms of in-vehicle safety for the vehicle occupants and other road users (including vulnerable road users).

One of the most promising ADAS, aiming at reducing inappropriate speed, is Intelligent Speed Assistance (ISA). ISA is an intelligent in-vehicle device that warns the driver about speeding, discourages the driver to speed, and/or prevents the driver from exceeding the speed limit (Brookhuis & De Waard, 1999). ISA-devices can be categorized into different types (Morsink et al., 2006) depending on how intervening (or permissive) they are. An informative or advisory system displays the speed to inform and remind the driver of the changes in speed levels. A warning or open system cautions the driver if the posted speed limit at a given location is exceeded; the driver may then decides whether to ignore or comply with this information. An intervening, supportive or half-open system gives a force feedback through the gas pedal at the moment the driver exceeds the speed limit (active accelerator pedal). However, it is still feasible for the driver to overrule the counter-pressure initiated by the accelerator pedal. A mandatory, automatic control or closed system will fully prevent the driver from exceeding the limit; hence, the driver cannot overrule the system.

Since the early 1980s the effects of ISA have increasingly been studied through different methodologies and data collection techniques, varying from traffic simulation, driving simulators, instrumented vehicles up to field trials (Carsten, 2002; Morsink et al., 2006). Generally, ISA shows positive effects on driving speed and speed violations (Agerholm et al., 2008; Driscoll et al., 2007; Regan et al., 2006; Varhelyi et al., 2004; Vlassenroot et al., 2007). The magnitude of the effects mainly depend on how intervening the systems are set. A restrictive ISA seems more effective in reducing speed and speeding than an advisory ISA. Tate and Carsten (2008) conducted a study based on their field trials in the UK to predict the safety-impacts of ISA. Possible policies for ISA implementation were examined, investigating how these policies might affect the overall safety benefits. Two alternative policies were examined: a market driven policy in which drivers choose to adopt ISA and an authority driven policy with more encouragement of ISA adoption. The analysis indicated that over a 60-year period from 2010 to 2070, the market driven policy is expected to reduce fatal accidents by 10%, serious injury accidents by 6%, and slight injury accidents by 3%. The authority driven implementation policy is expected to reduce fatal accidents by 26%; serious injury accidents by 21%; and slight injury accidents by 12%.

With respect to ISA implementation, it is essential to know whether the general public will accept the system or not. Brookhuis and De Waard (1999) stated that the user-acceptance of the system strongly depends on the mode of the used feedback. Morsink et al. (2006) describe an "acceptance versus effectiveness" paradox: the more effective ISA is on road safety (e.g. restricting ISA), the less accepted it is by the users. It is recognized that acceptance, acceptability, and public support are very important for ISA implementation. Consensus about the definition of acceptance and acceptability and how these should be measured is, however, still lacking (Adell, 2007; Regan et al., 2006; Vlassenroot et al., 2006). It is stated that in many trials and studies on ISA, acceptability research has been approached differently. The use of different methods in ISA studies lead to a main criticism that the results are inconsistent: a criticism that could be used as a 'show-stopper' in the development of implementation strategies. Also, most ISA studies focused only on a few determinants of acceptability. A relevant distinction can be made between user acceptance and potential acceptability. E.g. Schade and Schlag (2003) described acceptance as the respondents' attitudes, including their behavioural responses, after the introduction of a measure, and acceptability as the prospective judgement before such future introduction. In this case, the respondents will not have experienced any of the measures or devices in practice, which makes acceptability a construction of attitudes. In the present study the focus will be on the acceptability of ISA.

A main goal in our (overall) research is to find out which factors are mainly used to define acceptability and which of these factors could predict acceptability the best.

Previously an in-depth analysis was conducted on different user acceptance models, acceptability theories and researches that was used in the field of ISA and ITS. This analysis resulted in 14 factors or indicators that could possibly influence acceptability the most. For a more in-depth discussion we refer to Vlassenroot et al. (2010). These 14 found factors could be categorized in three main groups:

- Indicators related with the characteristics of the device (device specific factors).
- Indicators related to the context wherein ISA is used (speeding & traffic safety). These indicators can influence the specific factors and acceptability.
- The third group are more general issues like personal information (age, gender, education) and driving information (mileage, experience, accident involvement). These background factors will influence the contextual and device specific indicators.

The next step in our research was to measure these factors, which has been done in 2009 in a large-scale survey among Belgian and Dutch car-drivers (Vlassenroot et al., 2011). This paper will focus on how the 14 found indicators would directly and indirectly influence the level of acceptability by using a structural equation modelling (SEM) approach. Section 2 describes the method. The results on the direct and total effects are given in section 3. In section 4 the results are discussed in the context of ISA implementation policies.

2. Method

2.1 The conceptual model

In a previous in-depth study on the factors that influence the acceptability on ISA (Vlassenroot et al., 2010), the following conceptual model was constructed (see Figure 1).

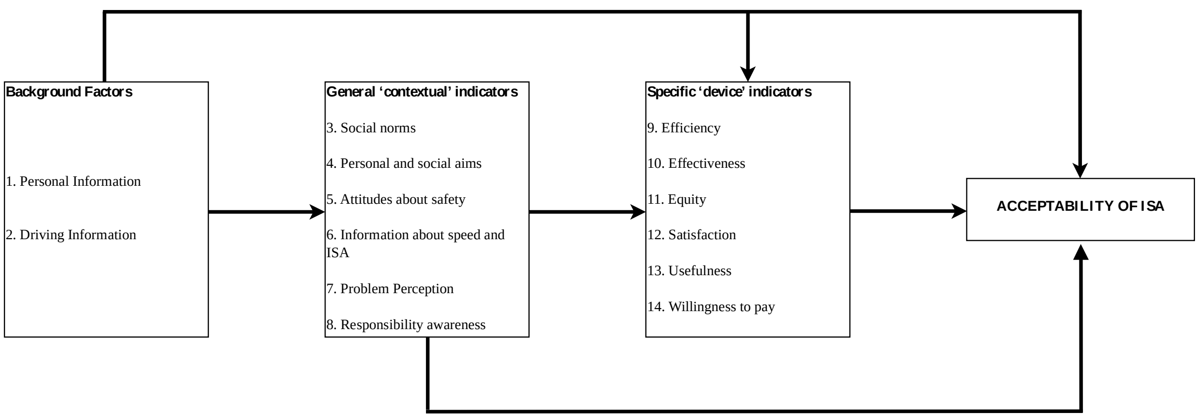

Figure 1. Hypothetical model of the found indicators that define acceptability

In Figure 1, the three main blocks are described that would influence acceptability. The background factors and the general contextual indicators would determine the specific device factors while the general indicators are only influenced by the background factors. It can be stated that these 14 factors may either directly or indirectly affect the acceptability of ISA and so they would influence each other as well. In the next paragraphs, the causal order between the factors is described; including the relationships between every factor would make Figure 1 too complicated and incomprehensive. More detailed information of the issues included in the factors is also given in Annex 1. A casual order is assumed, going from the highest ranked item (1) to the lowest (15). This ranking is based on our previous developed theory that is described in Vlassenroot et al. (2010). All selected variables are assumed to directly or indirectly influence ISA acceptability.

The personal information factors (*age, gender, family situation and education*) are considered to be exogenous variables in the model, hence, not influenced by any other variables. The driving information factors (*type of car. i.e. company car, private vehicle etc., accident involvement, mileage and driving experience*) are the next variables in causal rank order, only influenced by the socio-demographic variables. Both of these factors (personal and driving information) may affect any other remaining variable in the model: for example, gender and age are noted as relevant determinants in the performance of speeding behaviour; i.e. speed is associated with young male drivers (Shinar et al., 2001).

The third factor, *social norms* related to speed and speeding behaviour, may influence every contextual and device specific factor in the model. In many models and theories (like theory of planned behaviour (Azjen, 2002), technology acceptance model (Davis et al., 1989)), it is stated that peers or co-workers will influence the attitudes and behaviour of individuals. Silcock et al. (2000) noted that immediate peer pressure is an important factor in speeding for some groups. The choice to speed or not can depend on the *personal and social aims* of people when driving. This fourth variable refers to the dilemma between social or personal aims and benefits (Schade & Schlag, 2003) to consider speeding or not: the hypothesis is that people who want to drive as fast as possible according to their own preferences could be less aware of the *speeding problem* and other issues that causes accidents. *Attitudes on safety* will be measured by defining which issues could causes accidents: most of the time, people will also compare the speeding problem in relation with other road safety issues (Corbett, 2001), like intoxication, experience or infrastructure. Therefore the *attitudes concerning road safety* could influence the level of *problem awareness* but also the *information and knowledge* about the consequences of excessive speed. The factor *information and knowledge* refers to the assumption that people who are better informed are possible more aware of the problem and the alternatives to tackle it. One of the main context variables is the *problem perception:* in many trials (Vlassenroot et al., 2010) it was noted that the acceptability of ISA would depend on the *awareness that speeding is a problem*. The last context indicator is *responsibility awareness* (Schade & Schlag, 2003): if the individual is considered at least partly responsible to solve the problem, a higher acceptability may occur. But if he/she only indicated that the external parties (governments) are considered the problem owners, a negative affect can occur in the acceptability of ISA.

All the context factors could possibly influence the device specific indicators. The determination of the order of the device specific indicators was rather difficult because most of these variables were not investigated in one and the same model. Some theories and approaches used in ISA trials formed the base to determine the causal order (Adell, 2007; Agerholm, 2008; Biding & Lind, 2002; Driscoll, 2007; Harms et al., 2007; Regan et al., 2006; Varhelyi, 2004; Vlassenroot et al., 2007).

Efficiency of ISA related to other speed management systems (e.g. speed cameras, police enforcement) can be considered as a 'gate' between the context factors and the device specific factors: it is assumed that people would compare the suggested new solution to counter the problem (speeding) with other existing measures. Defining the efficiency already implies how the respondents would recognise that speeding is a problem, also compared with other road safety issues; concern who is responsible to solve the problem; have information about the solutions; compare these instruments related to their own or social aims and; would possibly be influenced by their peers. If ISA is rated efficient compared to the other measures a next step can be to define how effective ISA is rated by the potential drivers: *effectiveness* is first related to other ITS devices that supports the driver: it is assumed that the effectiveness and acceptability of ISA will depend on how the effectiveness of other ITS is rated (Regan et al., 2006). Secondly the effectiveness of ISA is defined by rating the effectiveness of ISA to maintain the speed in different speed zones (Agerholm, 2008; Biding & Lind, 2002). Thirdly some secondary effects are given like ISA can reduce speeding tickets, ISA is better for the environment. A causal order is assumed between the effectiveness factors going from ITS *effectiveness* to ISA *effectiveness* to *secondary effects* of ISA. These 3 items could possibly influence the other device specific factors and the acceptability of ISA. The third device specific factor is equity: *Equity* refers to perceived justice and integrity (Schade & Schlag, 2003). The respondents were asked to indicate when they would (*penetration level*) use a certain type of ISA and *for whom* a certain type of ISA would be the most beneficial. The assumption is made that the level of penetration would also influence for whom the system should be beneficial. Both of these factors are assumed to be influenced by the efficiency and the effectiveness parameters. The fourth and fifth device specific factors are *satisfaction*, i.e. when a certain ISA would be used, and usefulness of ISA to support the drivers' behaviour. *Usefulness* and *satisfaction* are two parameters from the method of Van der Laan et al. (1997) and considered to be important variables to determine the level of acceptability: the technique consists of nine rating-scale items. These items are mapped on two scales, the one denoting the usefulness of the system, and the other satisfaction. *Satisfaction* will be mainly influenced by *effectiveness* and combined with *effectiveness* define the level of *usefulness*. The final parameter in our model is the *willingness to pay for a certain system* that is influenced by all the parameters. *Willingness to pay* is a frequent used predictor to define the acceptability of ISA in trials (Biding & Lind, 2002).

To determine *the acceptability* of ISA by the drivers, the respondents had to indicate which system they preferred on a 5-point scale going from no ISA, informative, warning, supportive to restrictive.

2.2 Constructing the survey

In a first phase, a web-survey was constructed using the open source program Limesurvey and distributed among a few colleagues to test it. The questions were categorized into questions about: (1) personality characteristics or background information (2) questions about problem recognition related to traffic accidents, speed and speeding (3) questions about the use of the new technology (ISA) to counter speed and speeding.

Using their comments, especially about user-friendliness, a pilot test-survey was conducted and distributed by mail and the popular network-website 'Facebook'. Based on the answers of these respondents some modifications were made to improve the survey and some first data were processed to find out whether the questions would cover the described determinants of acceptability.

In a second phase only the questions that were relevant to define the indicators were used. Around 60 questions were found to be relevant. A new version of the survey was made, based on these questions. A reduction to 36 main questions was made based on stakeholders (in the field of transport psychology) values and user-friendliness.

Finally the definitive web-survey was put online at the end of September 2009. The web-address of the survey was published by the Flemish and Dutch car-users organisations. In Flanders an email newsletter was sent to the VAB members. In the Netherlands, the link to the survey was first announced on the ANWB website. Because of the low response rate in the Netherlands an additional email newsletter was sent, only to the subset of 'active members. It is also possible to subscribe (for free) to different kind of newsletters of ANWB products and services. Active members are members that pay a fee to ANWB for several kinds of services.

In total 6370 individuals (see Table 1) responded to the web-survey in Belgium and 1158 persons in the Netherlands. Of these 7528 respondents 5599 responses of car drivers were considered useful for further analysis.

Most respondents were male (79%), because most VAB and ANWB members are male. Only 2% of the respondents were younger than 25 years, while 27% were between 25 and 45 years, and 71% of the respondents were older than 45 years.

Table 1. Gender, age and education of the respondents

	Belgian (Flemish)	Owner of drivers' license* (2007)	Z-test	Dutch	Owner of drivers' license** (2008)	Z-test	All Resp.
Response							
Response (N)	6370	7621		1158	10321996		7528
N (withheld)	4641	7621		958	10321996		5599
Gender (in %)							
Male	77.3	53.6	P<0.01	89.4	53	P<0.01	79.4
Female	22.6	46.4	P<0.01	10.6	47	P<0.01	20.6
Age (in %)							
17-24	1.4	10.0	P<0.01	2.5	7.9	P<0.01	1.6
25-34	9.0	15.6	P<0.01	6.5	17.7	P<0.01	8.6
35-44	19.0	18.9	n.s.	13.7	20.9	P<0.01	18.1
45-54	30.0	18.3	P<0.01	25.0	21.8	P<0.05	29.1
55-64	26.9	14.9	P<0.01	34.4	16.9	P<0.01	28.2
65 +	13.4	22.2	P<0.01	17.8	14.8	P<0.01	14.1
Education (in %)							
Higher education	58.2	28.5	P<0.01	53.9	-	-	57.4
Secondary education	39.2	54.5	P<0.01	44.9	-	-	40.2
Primary education	1.8	15.4	P<0.01	0.8	-	-	1.7
No education	0.7	1.6	P<0.01	0.3	-	-	0.6

A Z-test was used and indicated that our sample of responses differs significant from drivers' license owners in Belgium and the Netherlands. Only for the Belgian drivers between the ages of 35 and 44 our sample would be representative. For the respondents in the Netherlands it was possible to compare with the national figures (SWOV, 2010) In Belgium it was only possible to compare with the results collected from a large-scale travel behaviour survey (Vlaamse Gewest, 2010). Compared with the population of drivers' license owners in Belgian and the Netherlands, drivers younger than the age of 34 are underrepresented and the age group 45 – 64 is overrepresented. More male and elder drivers have participated. Although our sample was not representative for the whole population of drivers' license owners in the Netherlands and Flanders, both motorist organisations indicated that our results were relevant compared to their member-databases, although exact data of every parameter (e.g. education level) was not available. This can partly be explained by the fact that predominantly elderly people have a membership of the motorist organisations. In the sample, one out of two drivers had a "higher education" (university). This was expected since using a web-survey specifically stimulates people with a higher education to participate. 49% of the drivers have no children living at home. Our research goal is mainly to define how the different acceptability predictors are related to each other instead of to determine the acceptability of a certain population.

2.3 Data analyses

Annex 1 specifies the topics asked in the survey, the range of the response scales and sub-questions. Five-point scales have been used as a response format for most questions. Some elements were further described in the survey, which can be found in the most right column. Instead of the name of a certain ITS or ISA system, a description of its functionality was presented to the respondents.

It was assumed that every indicator is defined by the set of sub-questions. Factor analysis was applied to examine the structure and the dimensionality of the responses. Also the Cronbach's alpha was calculated to determine the reliability of a summed scale (see Table 2).

Not all the items of the different indicators loaded on a single factor like *problem perception, ISA effectiveness* and *equity*. The reliability of some indicators was improved by dropping one of the selected items. The variable *intoxication of speed or alcohol* as cause of an accident to define the *attitudes about safety* was left out. Compared to the other variables to define the *attitudes* this one seemed to be of a different order. This was also the only variable that loaded high on a second factor. On *the effectiveness of ITS*, the item of *black box* was left out which increased the reliability: most of the other systems that were described in the survey would interact when driving, while the black box is only a monitoring system. This could explain why *black box* loaded on a second factor. The reliability of *efficiency* was improved by leaving *campaigns* out. It is assumed that for drivers the efficiency of campaigns is difficult to predict. Also campaigns are not a 'hard measures' to reduce speeding compared with the other presented items to the respondents. On *information about ISA* the items regarding the *information about the trials in Ghent or Tilburg* was left out. We assumed that this was too long ago to remember for the respondents.

Regarding the *problem awareness*, a main distinction could be made between *low speed zones* like home zones, 30 kph area and urban area, and *higher speed zones*, like outside urban area and highways. In our model we allowed these items to correlate.

The scale to define acceptability consists of 5 items between no intervening systems to high intervening systems (closed ISA). Therefore it can be assumed that the acceptability of high intervening types of ISA has been measured in this model.

Cronbach's alphas of the intended scales were above .70, except for *responsibility awareness* and e*fficiency*. It was concluded that the reliability of these scales was reasonable (e.g. Molin and Brookhuis. 2007). The scale scores were constructed by summing the scores on the constituting indicator variables, equally weighing each variable.

Structural equation modelling (SEM) was used for the data-analyses. SEM is a modelling approach enabling simultaneous estimation of a series of linked regression equations. SEM can handle a large number of endogenous and exogenous variables, as well as latent (unobserved) variables specified as linear combinations (weighted averages) of the observed variables (Golob, 2003). SEM contains a family of advanced modelling approaches, among which is path modelling (e.g. Molin & Brookhuis. 2007; Van Acker et al. 2007; Ullman, 2007).

Table 2. Cronbach's alpha & explained variances (%)

Indicators	% variance explained	Cronbach's alpha
Attitudes about safety	50%	.748
Problem perception		
Speed and speeding in high speed zones	75%	.884
Speed and speeding in low speed zones	65%	.884
Responsibility awareness	66%	.692
Social Norms	58%	.794
Personal & social aims	57%	.844
Information about ISA	59%	.776
Efficiency	49%	.694
ITS Effectiveness	69%	.836
ISA Effectiveness		
ISA speed effectiveness	78%	.931
ISA secondary effects	72%	.868
Equity		
Equity for different groups of drivers	66%	.908
Equity depending on penetration level	59%	.760
Affordability	55%	.725
Usefulness	64%	.860
Satisfaction	72%	.870

3. The estimated Model

An initial model was estimated based on the causal order presented in Figure 1. Initially, all possible paths were drawn from factors earlier in the causal order towards all factors later in the causal order. The exogenous variables were allowed to correlate and the two variables related to speeding. The model was estimated with the program AMOS 7.

Only the variables of which the effects were found significant ($p < 0.05$) were further used in the model. Paths that were not significant were left out the model, which lead to a total number of 139 distinct parameters in our final model to be estimated (df = 186). The probability level is .091 and Chi-square is 212, 27. The goodness of fit (GFT) is 0.99. The probability level and the GFT indicate a good overall fit of the model. Another indication, especially when a large amount of data or cases are used, to define the model fit is the ratio between the chi-square and the degrees of freedom: if the figure is lower than 2 a good fit of the model is indicated (Wijnen et al., 2002). In our estimated model the ratio is 1.141, which also indicates an acceptable fit.

3.1 Direct effects

The estimated standardised direct effects are presented in Table 3. The effects are briefly discussed with respect to the plausibility of the significant relationships. The strength of the relationships between the variables is given between brackets. Only the most remarkable effects are described. Not every class related to age, having children, car use and mileage were kept in the model because they had no significant influence on the other variables. The different levels of education seemed to have no significant influence.

This model explains 56% of the variance in acceptability. *Acceptability of ISA* is directly influenced by *effectiveness of ISA on speed* (.37), *equity on ISA equipment for different groups* (.31). *Usefulness* (.13) and *equity of ISA depending on level of penetration* (.11): drivers who find ISA effective and useful will accept ISA more. Also the lower the penetration level has to be before installing ISA and if more intervening types of ISA are chosen for the different groups, the higher the acceptability is. Remarkably is that the *willingness to pay* has a very small direct effect (.02) on the acceptability. Drivers who like *higher speed limits and speeding* will accept ISA less (-.09 in high speed zones; -.08 in low speed zones). Respondents who rather choose *social aims* (.04) in driving and drivers who use the *car as main transport mode to work* (.07) are more willing to accept ISA. *Drivers between 25 and 45 years old* (-.04) will less prefer ISA.

Willingness to pay is directly influenced by *equity related to the level of penetration* (.49) and to *ISA equipment for different groups of drivers* (.10): Drivers who like to pay for ISA will already do this at a low penetration level and if they are convinced that ISA is beneficial for all types of drivers.

Usefulness is directly influenced by *satisfaction* (.68) and *personal & social aims* (.14). *Satisfaction* will increase by the influence of *personal & social* aims (.12) and *equity on penetration level* (.19).

Both *equity* variables are highly influenced by the *effectiveness of ISA on speed* (.32 and .38). *Personal and social aims* (.13), *information about ISA* (.10) and *effectiveness of ITS* will also influence the *equity related to the ISA penetration level*.

The *effectiveness of ISA* on speed is influenced by *efficiency* (.14), *effectiveness of ITS* (.34) and *personal and social aims* (.16). Drivers who valuated social aims highly, are aware that ISA can be efficient to reduce speeding related to other measures, think that ITS or ADAS can be effective in driving, and will find ISA more effective. The *effectiveness of ISA on secondary effects* (like reducing speeding tickets etc.) will depend on how *effective ISA is rated to reduce speeding* (.44) and the *equity related to the group of drivers* (.20).

The valuation of *efficiency* will decrease by both *age groups* (-.11 and -.16) but increase if they *have children younger than 12 years old*. *Personal & social aims* (.10), *responsibility awareness* (.14) and the *effectiveness of ITS* (.19) will also influence efficiency.

Attitudes on safety (.15) and *responsibility awareness* (.13) will directly influence the *effectiveness of ITS*. Drivers, who are convinced that the proposed items could cause an accident, found ITS more effective. *Female drivers* (-.09) and *drivers between 25 and 45* (-.08) years old are less convinced of the *ITS effectiveness.*

Female drivers have less *knowledge of ISA* (-.13). *Mileage 1* (.12) and the *attitudes on safety* (.09) influence *the knowledge on ISA.*

Young drivers (<25 years; -.11) and *drivers who like to speed in high speed zones* (-.10) have less *responsibility awareness*. *Personal & social aims* (.18) and *attitudes on safety* (.22) will increase *responsibility awareness.*

Speeding in both zones is influenced by *personal & social aims* (-.24 and -.21). Respondents who valuate personal aims higher are more likely to speed.

Drivers younger than 25 years are less influenced by the (-.12) or the risks certain driving behaviour can have on road safety.

Personal & social aims are directly influenced by *social norms* (.19) and *the age group 25 to 45 years* (.13). Social norms are influenced by both age groups (.15 and .13) that were significant relevant in the model.

Table 3. Direct standardized effects

	Gender	Age < 25y	Age between 25-45y	Having children <12y	Mileage < 25 000 km	Mileage <45 000 km	Having Company car	Car as transport mode to work	Social Norms	Personal & Social Aims	Attitudes on Safety	Speeding in High speed zones	Speeding in low speed zones	Responsibility Awareness	Information & Knowledge about ISA	Effectiveness of ITS	Efficiency	Effectiveness of ISA on speed	Equity on level of ISA penetration	Satisfaction	Equity on equipment of groups	Usefulness	Effectiveness of ISA on secondary effects	Willingness to pay
Background factors																								
Age between 25-45y	.14*																							
Having children <12y	.07*		.47*																					
Mileage < 25 000 km	-0.23		0.08	0.04																				
Mileage < 45 000 km	-0.17		0.08																					
Having Company car					0.25	0.16																		
Car as transport mode to work	-0.05				-0.16	-0.09	-0.10																	
Context indicators																								
Social Norms	-0.10	0.15	0.13					-0.05																
Personal & Social Aims	-0.07	0.05	0.13			0.12		-0.07	0.19															
Attitudes on Safety	0.07	-0.12	-0.08							0.09														
Speeding in High speed zones	-0.09					0.04				-0.24			.68*											
Speeding in low speed zones		0.05		-0.05						-0.21		.68*												
Responsibility Awareness		-0.09								0.18	0.22	-0.10												
Information & Knowledge about ISA	-0.13				0.12			-0.06			0.09													
Device specific indicators																								
Effectiveness of ITS	-0.09		-0.08							0.08	0.15			0.13										
Efficiency	0.07	-0.11	-0.16	0.10	-0.06				0.06	0.10				0.14	-0.09	0.19								
Effectiveness of ISA on speed								0.05	0.06	0.16		-0.05		0.05		0.24	0.14							
Equity on level of ISA penetration			-0.05				0.08			0.13	-0.05				0.10	0.18	0.07	0.32						
Satisfaction										0.12				0.05					0.19					
Equity on equipment of groups		-0.05	-0.05		-0.06						0.07			0.04		0.05	0.06	0.58	0.09					
Usefulness			0.05							0.14									0.06	0.68				
Effectiveness of ISA on secondary effects												-0.09	0.06				0.07	0.44	0.08		0.20			
Willingness to pay			-0.06		-0.04									0.07		0.09			0.49		0.10	0.05		
Acceptability of ISA			-0.04					0.07		0.04		-0.09	-0.08					0.37	0.11		0.31	0.13	0.04	0.02

* Correlations

Table 4. Total Standardized effects

	Gender	Age < 25y	Age between 25-45y	Having children <12y	Mileage < 25 000 km	Mileage <45 000 km	Having Company car	Car as transport mode to work	Social Norms	Personal & Social Aims	Attitudes on Safety	Speeding in High speed zones	Speeding in low speed zones	Responsibility Awareness	Information & Knowledge about ISA	Effectiveness of ITS	Efficiency	Effectiveness of ISA on speed	Equity on level of ISA penetration	Satisfaction	Equity on equipment of groups	Usefulness	Effectiveness of ISA on secondary effects	Willingness to pay
Background factors																								
Age between 25-45y	.14*																							
Having children <12y	.07*		.47*																					
Mileage < 25 000 km	-0.21		0.10	0.04																				
Mileage < 45 000 km	-0.16		0.08																					
Having Company car	-0.08		0.04	0.01	0.25	0.16																		
Car as transport mode to work	0.00		-0.03	-0.01	-0.19	-0.11	-0.10																	
Context indicators																								
Social Norms	-0.08	0.15	0.13		0.01	0.01	0.01	-0.05																
Personal & Social Aims	-0.08	0.08	0.17	0.00	0.02	0.13	0.01	-0.08	0.19															
Attitudes on Safety	0.07	-0.12	-0.10		0.00	-0.01	0.00	0.01	-0.02	0.09														
Speeding in High speed zones	-0.12	0.02	0.04		0.00	0.07	0.00	-0.02	0.05	-0.24			.68*											
Speeding in low speed zones	-0.02	0.07	0.01	-0.05	0.00	0.03	0.00	-0.02	0.04	-0.21		.68*												
Responsibility Awareness	0.04	-0.13	-0.05		0.00	-0.03	0.00	0.02	-0.04	0.22	0.22	-0.10												
Information & Knowledge about ISA	-0.15	-0.01	0.01	0.01	0.13	0.01	0.01	-0.06	0.00	0.01	0.09													
Device specific indicators																								
Effectiveness of ITS	-0.08	-0.04	-0.11		0.00	-0.02	0.00	0.01	-0.02	0.12	0.18	-0.01		0.13										
Efficiency	0.08	-0.13	-0.15	0.09	-0.07	-0.02	0.00	0.01	0.03	0.15	0.06	-0.02		0.17	-0.09	0.19								
Effectiveness of ISA on speed	0.01	-0.04	-0.08	0.01	-0.02	-0.04	-0.01	0.07	0.02	0.24	0.06	-0.06		0.11	-0.01	0.27	0.14							
Equity on level of ISA penetration	-0.03	-0.04	-0.12	0.01	0.02	-0.02	0.08	0.03	-0.02	0.24	0.01	-0.02		0.07	0.09	0.28	0.12	0.32						
Satisfaction	0.01	-0.02	-0.05	0.00	0.00	-0.02	0.01	0.02	-0.03	0.18	0.02	-0.01		0.07	0.02	0.05	0.02	0.06	0.19					
Equity on equipment of groups	0.02	-0.10	-0.13	0.01	-0.07	-0.03	0.00	0.05	0.01	0.19	0.12	-0.05		0.13	-0.01	0.24	0.15	0.61	0.09					
Usefulness	0.00	-0.01	0.03	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.01	-0.01		0.05	0.02	0.05	0.02	0.06	0.19	0.68				
Effectiveness of ISA on secondary effects	0.02	-0.05	-0.08	0.01	-0.03	-0.03	0.00	0.04	0.01	0.18	0.06	-0.13	0.06	0.09	-0.01	0.20	0.17	0.59	0.10		0.20			
Willingness to pay	-0.02	-0.04	-0.15	0.01	-0.04	-0.02	0.04	0.02	-0.01	0.16	0.05	-0.02		0.13	0.05	0.25	0.07	0.22	0.51	0.03	0.10	0.05		
Acceptability of ISA	0.01	-0.05	-0.14	0.01	-0.04	-0.04	0.00	0.11	0.00	0.23	0.07	-0.14	-.08	0.09	0.00	0.21	0.12	0.62	0.12	0.09	0.32	0.13	0.04	0.02

* Correlations

3.2 Total effects

The total effects are given in Table 4. A brief description of the most relevant findings is given.

Finding *ISA effective to reduce speeding* (.62) will have a very high influence on the *acceptability of ISA*. This was also expected. Also being convinced that other *ITS systems are effective* (.21) will highly influence acceptability. In this way we can assume that drivers who are convinced that technology can help to support their driving behaviour will accept ISA better. Also being convinced that ISA is *beneficial for most of the groups of certain type of drivers (equity)* (.32) will increase the acceptability. The lower the *ISA penetration level* has to be the higher (.12) the acceptability can become. Believing that ISA can be *useful* and *satisfying* will increase the level of acceptability. These two items were already proven as relative good predictors of ITS and ISA acceptance (Varhelyi et al., 2004; Vlassenroot et al, 2007). *Satisfaction* (.68) will highly influence *usefulness*. Drivers who *like to speed in high-speed zone*s (-.14) (as part of the factor problem awareness) will less accept ISA. Rating ISA *efficient* (.12) related to other speed reducing measures will also increase the acceptability. Drivers between the age of *25 and 45 years* (-.14) will accept ISA less. A higher value for *social aims* (.23) will increase the acceptability. While in many trials *willingness to pay* has been stated as a good predictor for acceptance, this was not found in our model. Also the *secondary effects of ISA* will not have a high influence on the level of acceptability.

Drivers who are not influenced by the *equity level of penetration of ISA* are more *satisfied* (.19) and will rate ISA more *useful* (.19). Also these drivers are highly *willing to pay* for ISA (.51). *Effectiveness of ISA* (between .22 and .59) on speed and speeding seems to be a good predictor for all of the system related indicators except for usefulness and satisfaction. *Efficiency* (between .07 and .17) will also influence all the other system related indicators, except usefulness and *satisfaction*. The same can be found for the total effects on *effectiveness of ITS*.

A high valuation of the *responsibility* of the different actors to counter speed will influence the *efficiency* of ISA (.17) related to other measures. Being aware of responsibility can also lead to find ITS and ISA more *effective* (.11 and .13) and a higher willingness to pay (.13). People who *like to speed* will *accept* ISA (-.14 in high speed zones and -.08 in low speed zones) less and will find it less effective (-.06 and -.13). Being convinced that certain driving behaviour and contextual issues (items from the *attitudes on safety*) can cause accidents could lead to a higher *responsibility awareness* (.22), higher valuation on the *effectiveness of ITS* (.18) and finding ISA *beneficial for different groups of drivers* (.12) (as part of the factor *equity*). Personal and social aims would have a high influence (higher than .10) on many of the variables (except on usefulness and knowledge about ISA). *Social norms* will mostly influence personal and *social aims* (.19).

Going by *car to work* can also increase the *acceptability* of ISA (.11). *Mileage* will decrease the use of a car as *transport to work* (-.11 and -.19): people who drive less than 25000 km on yearly base will use the car less as transport mode to work. *Having children* would mainly influence the *efficiency of ISA* (.09) but would slightly lead to *speeding in low speed zones* (-.05).

Two age groups were kept in the model as the only groups that have significant influence on the other variables. *Drivers between 25 and 45 years* will less *accept ISA* (-.14). This is also the group with the most children younger than 12 years old (.47). Social norms (.13) and personal & social aims (.17) will be highly effect by this age group of drivers. Age between 25 and 45 will have mainly a negative effect on most of the 'device specific indicators' (between -.08 and -.15). *Younger drivers* (<25 years) are less convinced that certain behaviour or accidents could cause accidents (*attitudes on safety: -.12*); these drivers will also valuate *responsibility awareness* (-.13) and *efficiency* (-.13) lower. *Female* drivers will less speed in *high-speed zones* (-.15) and are less *informed about ISA* (-.15).

4. Discussion and conclusion

In this paper, a model has been estimated, by using SEM, to find out which predefined indicators would be relevant to define the acceptability of ISA. Background factors, contextual issues, and ISA-device related factors were used as indicators to predict the level of acceptability. The factors that were used in the model were based on the methods used in past ISA trials, acceptance and acceptability theories and models.

The effectiveness of ISA (1), equity (2), effectiveness of ITS (3) and personal and social aims (4), were the four variables that had the largest total effect on the acceptability of ISA. Effectiveness was found a relevant predictor for acceptance in many trials (Morsink et al, 2006). The model showed that the willingness of drivers to adopt ISA increases if they experience the system in practice: if people are convinced that ISA will assist to maintain the legal speed in different speed zones, the acceptance will be higher (Van der Pas et al., 2008). Hence, trials seem a good way to demonstrate the effectiveness of ISA. However, trials typically do not allow many people to try out ISA. Therefore, communication strategies that focus on the ISA-effectiveness would be helpful to convince people about the benefits of using such a system.

Often when new driver support technologies are introduced – especially when it could restrict certain freedom in driving – a majority of the population is reluctant when it comes to 'buy or use' the system. In the Ghent ISA trial (Vlassenroot et al., 2007) it was noted that most of the drivers were convinced of the effectiveness and were highly in favour of the supportive system but they stated that they would only use ISA further when more or certain groups of drivers would (also) use the system (equity on level of penetration). In the development of implementation strategies this is a very important issue. Therefore policymakers should be aware that if they would introduce certain types of ISA, the penetration level should be sufficient from the start to convince others to accept ISA. Promoting ISA by certain groups of drivers, for instance professional drivers (bus-, taxi-, van-, truck-drivers) or younger drivers, may be helpful to introduce certain systems (equity related to the equipment of certain groups).

In some studies (see Morsink et al., 2006; Marchau et al., 2010) the willingness to pay was reported to be a good predictor for acceptability. However, in the present study the effect of willingness to pay was very low or even absent; hence it may be assumed that better indicators are put in the model than the willingness to pay.

With respect to context indicators, 'personal and social aims' seemed to be the variable with the highest influence on acceptability. Drivers, who rate social aims above personal aims with respect to speed and speeding, will accept ISA more. Personal and social aims had also a high influence on most of the device specific indicators. Furthermore, drivers who speed for their personal benefit were found to rather speed more often.

Drivers who speed in high-speed zones would also be less inclined to accept ISA. This is in line with previous findings (e.g. Jamson et al., 2006), frequent speeders would support ISA less; those drivers who would benefit most of ISA would be less likely to use it. This is an important finding when considering the strategies for implementing ISA. Some studies (e.g. Morsink et al., 2006) indicated that to increase the acceptability, implementation strategies and campaigns could focus on other benefits of ISA (like reducing speeding tickets, emissions etc.). According to our study these secondary effects have rather small effects to increase acceptability. Drivers who like to speed would even care less for these secondary benefits of ISA.

The youngest group of drivers (<25 years old) would influence responsibility awareness negatively. These younger drivers are also less convinced that certain behaviour or circumstances could cause accidents. Many studies indicated that young drivers overestimate their own driving skills, drive faster and are less aware of accident causes (Shinar et al., 2001). For the implementation of ISA – although there is no direct relationship between younger age and acceptability – a different strategy is needed to convince this group of drivers. Awareness campaigns and communication should be deployed during their education, however, road safety education and training stops during secondary school or higher education (OECD, 2006).

Drivers between 25 and 45 years old would also be less inclined to accept ISA, mainly considered out of indirect effects in the estimated model. This group of drivers may be labelled as one of the most active groups of drivers. Another aspect is that both of the significant found age groups were influenced by social norms. This may be very important in implementation strategies. For instance, role models could be used in ISA driving. This strategy was also used in the Belgian trial to gain more publicity and attention. The positive image and the improved information communication of ISA as a possible measure in road-safety have led to several voted resolutions in the Belgian federal parliament and senate (Vlassenroot et al. 2007).

Our study had some limitations as well. The groups of respondents were not representative compared to the average drivers' license owners in Belgium and the Netherlands. However, the involvement of two major motor vehicle organizations and the participation of their members, indicates that a relevant group of drivers has been covered in this survey. It may be presumed that these groups of respondents are more auto-minded than average. Motor organizations will largely defend the positions and opinions of their members. Therefore these organizations can be highly influential in future policy actions.

Additionally, some of the chosen topics to define the indicators could be improved, especially to determine responsibility awareness and efficiency. Also the scale that was used for acceptability of ISA could be better: the range from no intervening to complete intervening could possibly be interpreted in such a way that in our research the acceptability of restrictive ISA is determined. Future research should make a better distinction between the acceptability of the different systems.

One of the main ambitions was to come to a more simplified model to define acceptability with respect to ADAS. However, taking into account a large variety of different indicators left this model yet rather complex. This may be a striking indication that defining acceptance and/or acceptability is rather complex. Many different items would directly or indirectly influence acceptability, which is important for the development of implementation strategies: increasing the support of ISA has to be established at different levels.

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Annex. Topics in the survey for the different indicators

Content Indicator/question	Scale	Specified for
Gender	Male/female	
Age	<25 years; 26 – 45 years; 46 – 65 years; >65 years	
Having children	No children; < 12 years old; <18y. >12y.; <18 years	
Education	No education, primary, secondary, higher education	
Mileage	<25 000 km/y: 25001-45000; >45000	
Company car	Yes/No	
Car use	Transport to work/transport for work/transport shopping/transport leisure	
Attitudes about safety	1-5 Low to high influence	
Less driving experience		
Inappropriate speed		
Other less exper. drivers		
Bad weather conditions		
Mobile phone use		
Bad infrastructure		
Risk seeking behaviour		
Fatigue		
No distance keeping		
Problem Perception		
Attitudes on own speeding behaviour	1-5 never speeding to always	For every speed zone
Mistakenly speeding	Range from posted speed limit until 50 kph above	For every speed zone
Irresponsible speeding	Range from posted speed limit until 50 kph above	For every speed zone
Best posted speed limit	Range from posted speed limit until 50 kph above	For every speed zone
Responsibility awareness	1-5 no responsibility to high	
Road administrators		
Police		
You (Yourself)		
Other drivers		
Politicians		
Social norms	1-5 maintain speed to drive faster	
To impress others		
To get along with drivers		
If they push to drive faster		
If I have pass. of same age		
If I have passengers		*Speed zones
To compete w. traffic flow		Home zones (20 kph)
Per. & soc. aims		30 kph area
Normal conditions	1-5 slow down to drive faster	Urban area (50 kph)
During the night		Out urb. area (70-90 kph)
In a hurry		Highways (120 kph)
Knowing the road		
Alone on the road		
No control		
You can endanger others		**ISA system
Inf. on ISA	1-5 no information to well informed	Informative ISA
Speed informative systems		Warning ISA
Speed warning systems		Supportive ISA
Haptic throttle		Restrictive ISA

Continued Annex. Topics in the survey for the different indicators

Information about ISA		
Speed warning in GPS		
Speed Alert		
Efficiency	1-5 no to high efficiency	
Speed camera's		
Police control		
Infrastructure measures		
ISA		
ITS Effectiveness	1-5 not to high effective	
FDW		
ACC		
Collision Warning systems		
Seat belt rem.: Type 1		
Seat belt rem.: Type 2		
Alcohol-warning		
Alcohol-lock		
ISA Effectiveness	1-5 not to high effective	Every speed zone and ISA**
Reduce fuel consumption	1-5 no to high effective	For every ISA system
To reduce emissions		
To increase traffic safety		
To reduce speeding tickets		
Equity for different type drivers (1)		
Young drivers	1-5 not beneficial to high beneficial	For every system
Elder drivers	1-5 not beneficial to high beneficial	
Vans	1-5 not beneficial to high beneficial	
Trucks	1-5 not beneficial to high beneficial	
Motorcyclist	1-5 not beneficial to high beneficial	
Bus drivers	1-5 not beneficial to high beneficial	
Taxi drivers	1-5 not beneficial to high beneficial	
Problem drivers	1-5 not beneficial to high beneficial	
Equity depending on penetration level	1-5 from high level of penetration to low level	For every ISA system
Willingness to pay	1-5 from no willingness to pay to high willingness	For every ISA system
Usefulness		
Useful	1-5 not useful to useful	For every ISA system
Good	1-5 bad to good	For every ISA system
Effective	1-5 not effective to effective	For every ISA system
Assisting	1-5 not assisting to assisting	For every ISA system
Alertness	1-5 less alertness to high alertness	For every ISA system
Satisfaction		
Pleasant	1-5 not pleasant to pleasant	For every ISA system
Nice	1-5 not nice to nice	For every ISA system
Likeable	1-5 unlikeable to likeable	For every ISA system
Desirable	1-5 undesirable to desirable	For every ISA system
Acceptability	1-5 from no ISA to high intervening ISA	