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Acceptability of Intelligent Speed Adaptation (ISA)

Conceptual framework and first results

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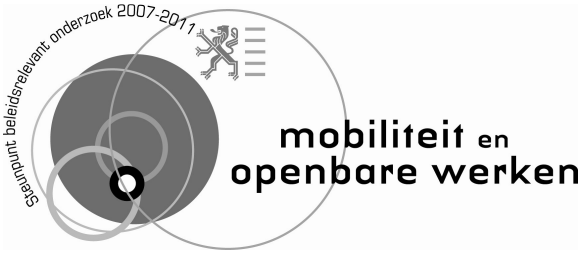

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Samenvatting

Acceptatie (draagvlak) voor Intelligente Snelheidsaanpassing (ISA): Conceptueel kader en eerste resultaten

Een belangrijke succesfactor bij de implementatie van nieuwe voertuigtechnologieën ligt in het begrijpen hoe de potentiële gebruikers deze toepassingen zullen ervaren.

Hoewel wordt erkend dat aanvaarding, draagvlak of de aanvaardbaarheid belangrijk is, ontbreekt het toch nog steeds aan een duidelijke afbakening van de begrippen en een meetmethode. In dit rapport wordt het concept beschreven voor de begrippen aanvaarding en aanvaardbaarheid aan de hand van bestaande theorieën en uitgevoerd onderzoek rond ISA.

Door analyse van de verschillende theorieën en methoden die worden gebruikt in ISA proeven kwamen we bij de 14 meest potentiële indicatoren die de aanvaardbaarheid kunnen beïnvloeden.

In ons onderzoek stelden we de vraag of er aanvaardbaarheid van ISA is door het publiek? 6370 personen in regio Vlaanderen en 1158 personen in Nederland hebben gereageerd op een web-enquête. De respondenten achten vooral hun eigen rijgedrag als de grootste invloed op ongevallen in plaats van omgevingsfactoren, zoals infrastructuur of zelfs andere chauffeurs. Sterker nog, de respondenten geven aan dat ITS ten goede zou kunnen komen om hun rijgedrag te ondersteunen.

95% van de respondenten zijn voorstander van één of andere vorm van ISA. Zeven op de tien bestuurders geeft de voorkeur aan een informatief of waarschuwend systeem.

Drie van de tien bestuurders willen nog verder gaan en kiezen voor een ondersteunende of zelfs een beperkende ISA. Voor deze laatste systemen blijkt wel de penetratiegraad van zeer groot belang.

English summary

Abstract

A key success factor in the future implementation of new in-vehicle technologies is in understanding how users will experience and respond to these devices. Although it is recognized that acceptance, acceptability and/or support is important, consistency in the definition of acceptability, and how it can be measured, is absent. In this report we conceptualize acceptance as the attitudes towards a new device after its introduction and acceptability as the attitudes to it before its introduction. It is our goal to describe and conceptualize the most common and relevant socio-psychological factors that can influence acceptance and acceptability of Intelligent Speed Adaptation (ISA). Several trials with different types of ISA have shown that ISA can be an efficient and effective way to reduce speed and speeding.

By analysing the different theories and methods used in ISA trials we arrived at the 14 most potential indicators that could influence the definition of acceptability and acceptance.

In our research we asked the question will there be acceptability of ISA by the public? 6370 individuals responded in Belgium (Flanders region) and 1158 persons in The Netherlands on a web-survey. In our survey the respondents indicated that their own driving behaviour is of great influence on accidents and traffic safety, instead of environmental issues like infrastructure or even other drivers. Even more, the respondents indicated that ITS could be beneficial to support their driving behaviour. It was noted that there is a high market potential for Advanced Driving Assistance Systems (ADAS).

95% of the respondents are in favour of ISA. Seven out of then drivers want to have an informative or warning system. Three out of ten drivers wanted to go even further and choose to have a supportive or even a restricting type of ISA. Drivers would only choose for more restricting systems if the penetration level is high enough.

Content

1. INTRODUCTION

In their white paper "European Transport Policies for 2010: Time to Decide", the European Commission stated that the main challenges for sustainable mobility include a reduction of congestion, an increase in traffic safety (a 50% reduction in fatalities in 2010 compared with 2000), an increase in energy efficiency, and a reduction of dependence on fossil fuels (European Commission, 2001). The use of new transport technologies (also known as Intelligent Transport Systems or ITS) may play a significant role in achieving these policy goals. Many ITS applications in the field of traffic management and travel information that are already on the market have proved their effectiveness. These systems support transport system users, traffic managers, and fleet operators with traffic and travel information. However, to achieve the stated EC transport policy goals, the implementation of more advanced ITS applications is required, with active intervention in vehicle driving tasks. This category of ITS device is also known as the Advanced Driving Assistance Systems (ADAS) that partially take over driving tasks such as distance keeping, lane keeping, overtaking, and so on. Many research initiatives on different ADAS technologies are being conducted at international, national, and regional level. While most studies focus on the technological feasibility of ADAS and its intended impacts, an important question as to whether these new technologies will be accepted and used remains unanswered.

ADAS vary from relatively simple systems that provide drivers with basic information to relatively complex systems that take over parts of the drivers' tasks to achieve 'good' driving behaviour (Brookhuis & De Waard, 2005). The need to understand how users experience and respond – or not – to the support of ADAS is important for determining how drivers' needs can be integrated into the development and implementation of ADAS. In general, understanding potential users' points of view has been roughly noted as acceptance or acceptability. Although several studies have examined acceptance and/or acceptability of ADAS there is little consistency on what is understood by acceptance or acceptability and, equally important, how these factors can be measured (cf. Molin & Brookhuis, 2007). The present paper aims to define acceptance and acceptability, and to determine which indicators should be considered relevant for their measurement. We will focus on Intelligent Speed Adaptation (ISA). ISA is a traffic safety device that warns the driver about speeding, discourages the driver from speeding, or prevents the driver from exceeding the speed limit (Brookhuis & De Waard, 1999), and hence, can be considered an ADAS application.

The aim of this research is first to define acceptance and acceptability, i.e. to develop a theoretical framework that concurs with our conceptualization. We introduce our definitions of acceptance and acceptability, and give a brief overview of current theories and methods used in ISA trials. Based on these theories and methods we then define similarities between the items or model concepts that lead to the selected indicators. Besides that our theory is relevant to define acceptance and acceptability we will focus on acceptability This framework forms the basis for constructing a survey to discover which indicators can be considered relevant to define acceptability. Finally the descriptive results are given based on the survey of Belgian and Dutch car-drivers on acceptability. This report describes the results of phase 3 (developing a procedure, method and survey) and phase 4 (executing the survey) of the project 8.2 (The relationship between velocity and environmental impact, speed management, traffic management).

2. DEFINING ACCEPTANCE AND ACCEPTABILITY IN ITS AND ISA RESEARCH

2.1 What is acceptance and acceptability?

Acceptance, acceptability, social acceptance, public support, social support, etc. are all terms frequently used to describe a similar phenomenon, how potential users will react and act if a certain measure or device is implemented. The interest in defining acceptance or acceptability lies in the precondition that the effectiveness and success of a measure will increase if there is public/social support for it. Under favourable conditions a positive assessment leads to an increased willingness to accept a measure and even to support it actively (Nelissen & Bartels, 1998; Goldenbeld, 2002). Although it is recognized that acceptance, acceptability, and support are important, a clear definition of what acceptance and acceptability are and precisely how they should be measured is still absent (Adell, 2008a; Regan et al., 2006; Vlassenroot, 2006).

To a certain extent the terms acceptance and support are strongly related. Goldenbeld (2002), however, introduces an important nuance between both concepts. The basic idea is that even if acceptance exists, it would not necessarily lead to the support of a measure.

In the field of ITS, Ausserer and Risser (2005) define acceptance as a phenomenon that reflects to what extent potential users are willing to use a certain system. Hence, acceptance is linked closely to usage, and acceptance will depend on how user needs are integrated into the development of the system. Nielsen (cited in Young et al., 2003) described acceptability as related to the question of whether the system is good enough to satisfy all the needs and requirements of the users and other potential stakeholders. More generally, in Rogers' (2003) diffusion of innovations, acceptability research is defined as the investigation of perceived attributes of an ideal innovation in order to guide research and development to create such an innovation. Van der Laan et al. (1997) distinguished between user acceptance and social acceptance. User acceptance is directed more towards evaluation of the ergonomics of the system while social acceptance is a more indirect evaluation of consequences of the system.

In another distinction between acceptance and acceptability, 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 attitude. In our research, we are more interested in defining the social aspects that could lead to public acceptability. Our research target group will not have experienced driving with ISA. Therefore, the term acceptability should be preferred, whereas in the literature this difference is not always found.

The lack of a theory and definition regarding acceptance has resulted in a large number of different attempts to measure ITS acceptance, often with quite different results (Adell, 2008a, Carsten, 2001). Some existing theories were used to measure these within the acceptance and acceptability research of ITS. In the next sections we describe some of the 'general' user acceptance models, acceptability theories, and research into ISA.

2.2 User acceptance models and theories

One of the most frequently used frameworks to define acceptance is the Theory of Planned Behaviour (TPB). Based on the Theory of Reasoned Action (Ajzen, 2002), the TPB assumes that behavioural intentions, and therefore behaviour, may be predicted by three components (Van Acker et al., 2007, 2010): attitudes towards the behaviour, which are individuals' evaluation of performing a particular behaviour; subjective norms, which describe the perception of other people's beliefs; and perceived behavioural control, which refers to people's perception of their own capability.

TPB has been used successfully to predict behaviour in a wide variety of applied research settings within different domains, including several studies dealing with driving behaviour and traffic safety, such as the effects of drinking and driving (Aberg, 1993; Parker et al., 1992a), driving violations (Parker et al., 1992b), and speeding and speed behaviour (Elliot et al., 2005; Haglund et al., 2000). Warner and Aberg (2006) specifically used the TPB related to the use of ISA. Comparing self-reported speeding of test drivers within an ISA trial with logged data explained 28% of the variance in logged speeding. In their study, Warner and Aberg (2006) noted that perceived behavioural control did not add significantly to the prediction of drivers' logged speed.

Another successful model is the Technology Acceptance Model (TAM) (Davis et al., 1989). TAM was designed to predict information technology acceptance and usage on the job. TAM assumes that perceived usefulness and perceived ease of use determine an individual's intention to use a system, while it is this intention that serves as a mediator of actual system use. TAM has been used – in the field of ITS – in the prediction of electronic toll collection (Chen et al., 2007).

Van der Laan et al. (1997) published a simple method to define acceptance. Acceptance is measured by direct attitudes towards a system and provides a system evaluation in two dimensions. 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.

Venkatesh et al. (2003) noted that there are several theories and models of user acceptance of information technology, which presents researchers with difficulties in choosing the proper model. Venkatesh et al. (2003) found different underlying basic concepts in acceptance models by means of a detailed description and analysis of different models such as TPB, the motivational model, TAM, innovation diffusion theory, and combined models. Based on these theories, they constructed a unified model they named the Unified Theory of Acceptance and Use of Technology (UTAUT). In the UTAUT, four constructs play a significant role as direct determinants of user acceptance: (i) performance expectancy – the degree to which an individual believes that using the system would help him or her to attain gains in job performance; (ii) effort expectancy – the degree of convenience with the use of the system; (iii) social influence – the importance of other people's beliefs when an individual uses the system; and (iv) facilitating conditions – how an individual believes that an organizational and technical infrastructure exists to support use of the system. The supposed key moderators within this framework are gender, age, voluntariness of use, and experience. Although in several models, 'attitude towards use', 'intrinsic motivations', or 'attitude towards behaviour' are the most significant determinants of intention, these are not mentioned in the UTAUT. Venkatesh et al. (2003) presumed that attitudes towards using the technology would not have a significant influence.

Stern (2000) developed the value–belief–norm (VBN) theory to examine which factors are related to acceptability of energy policies. Stern and colleagues proposed the VBN theory of environmentalism to explain environmental behaviour, including the acceptability of public policies. They proposed that environmental behaviour results from personal norms, that is, a feeling of moral obligation to act pro-environmentally. These personal norms are activated by beliefs that environmental conditions threaten the individual values (awareness of consequences) and beliefs that the individual can adopt

to reduce this threat (ascription of responsibility). VBN theory (Steg et al., 2005) proposes that these beliefs are dependent on general beliefs on human–environment relations and on relatively stable value orientations. VBN theory was successful in explaining various environmental behaviours, among which consumer behaviour, environmental citizenship, willingness to sacrifice, and willingness to reduce car use (Stern et al., 1999; Nordlund & Garvill, 2003).

Schlag and Teubel (1997) defined the following essential issues determining acceptability about traffic measures: problem perception, important aims, mobility-related social norms, knowledge about options, perceived effectiveness and efficiency of the proposed measures, equity (personal outcome expectation), attribution of responsibility, and socio-economic factors.

2.3 Acceptance measurements in ISA trials

In our approach we want to describe the most common and relevant socio-psychological factors that influence acceptance and acceptability of ITS and that actively interact with vehicle driving tasks. We will focus on ISA. ISA can be categorized within different types, depending upon how interventionist (or permissive) they are (Morsink et al., 2006).

Table 1. Overview of different types of ISA (Morsink et al., 2006)

Level of Support	Type of feedback	Definition
Informing (open)	Visual	The speed limit is displayed and the driver is reminded of changes in the speed limit.
Warning (open)	Visual/auditory	The system warns the driver when exceeding the posted speed limit at a given location. The driver decides whether to use or ignore the information or warning.
Assisting (half-open)	Haptic throttle	The driver gets a force feedback through the gas pedal if he/she tries to exceed the speed limit. Overruling of the system is still possible
Restricting (closed)	Dead throttle	The speed of the vehicle is automatically limited and the driver can not overrule the system.

In most ISA studies, acceptance and acceptability refer to the opinions, attitudes, and values of the users relative to the experience they had when driving with the system (Brookhuis & De Waard, 1999; Comte et al., 2000; Vlassenroot et al., 2007; Young & Regan, 2007). In these studies, acceptance is measured by comparing behavioural changes when driving without ISA before using the device and driving with ISA and finally driving without ISA after the test period (Adell et al., 2008b; Biding & Lind, 2002;

Hjalmdahl & Varhelyi, 2004; Katteler, 2005). Brookhuis and De Waard (1999) defined these behavioural changes as the level of adaptation instead of acceptance. Adaptations are those behaviours that may occur following the introduction of changes to the road-vehicle user (Dragutinovic et al., 2005). Therefore, adaptation will better describe the behavioural outcomes (and changes) when drivers have experienced the device, while acceptance will be more related to the attitudes, norms, and beliefs that may influence adaptation. Goldenbeld (2002) has noted that opinion and attitude studies are the most widely adopted research methods for measuring acceptability and acceptance of road safety measures.

Based on recent ISA field trials in different countries, certain directions for defining acceptance can be found. Although the main research set-ups and methods used were different in most trials, some common ground is evident.

In a large-scale ISA trial in Sweden, different types of ISA were tested voluntarily by 10,000 drivers between 1999 and 2002 (Biding & Lind, 2002). In these trials, acceptance was measured by relating attitudes to traffic safety and speed with experience of the tested ISA, willingness to pay, performance when using ISA, and the Van der Laan scale.

In the Dutch ISA trial (Ministerie van Verkeer en Waterstaat: Adviesdienst Verkeer en Vervoer, 2001) a mandatory (closed) system was tested, implying that the drivers could not violate the speed limit. The acceptance aspect focused primarily on the influence of ISA on drivers' tasks (e.g. driving behaviour inside and outside the limited areas), technical functions of ISA, and ergonomic issues.

In the Australian trial (Regan et al., 2006), the acceptance study was based on the model of Davis and Nielsen (cited in Young et al., 2007). The five main constructs were usefulness (users perceive the system to serve a purpose), effectiveness (users believe that the system does what it is designed to achieve), usability (the ease of use of the system), affordability (willingness to pay), and social acceptability (broader scale that users may take into account in assessing whether ISA is acceptable). The scope of research in the Australian trial involved other ITS devices such distance-keeping warning.

In 2001, a new trial started in the UK, called ISA-UK (Carsten et al., 2008). In four field trials conducted in different parts of the UK, 80 private and professional test drivers drove 20 vehicles that had a system installed over a period of six months (during the first and last month the system was not activated). The system made it impossible for the test drivers to exceed the speed limits without using kick-down or pressing an emergency button. Predicting speeding behaviour and drivers' attitudes was assessed by using TPB related to speeding in three scenarios: speeding on a motorway, urban 40 mph road, and residential 30 mph road. The impact of ISA on acceptance was rated using dimensions of usefulness and satisfaction.

In 2004 an ISA experiment with 20 vehicles was conducted near Versailles, France (Pianelli et al., 2007). A survey was carried out to study the drivers' acceptance of the system and to define both their attitudes and social representations of speed and ISA. This means that the behaviour of individuals and groups is directly determined by the responses they show for an objective or to the situation in which they find themselves. Social representations guide relationships, communications, and social practices.

In a Belgian trial (Vlassenroot et al., 2007), drivers drove with an active accelerator pedal, implying that the drivers received feedback through a push-back of the accelerator if they sped. The concept of acceptance was based on a framework designed to define public opinions on speed measures and ISA. This framework denotes how people view mobility and transportation in relation to road safety, especially with respect to speed, speeding, and speeding restrictions. Based on this framework, basic attitudes to road safety, speed, and speeding, and recognition of speed as a problem in society and attitudes about road safety and policy could be measured, distinguishing between different socio-demographic backgrounds of transport users. Further aspects were the voluntary use of the system outside the test area, willingness to pay, and the scaling of the use of ISA on satisfaction and usefulness (Van der Laan et al., 1997).

A Danish trial (Harms et al., 2007) used an open ISA system, based only on information about speeding, in combination with other incentives when driving safely (e.g. lower insurance premiums). This trial focused on the influence of background factors such as age and driving experience, questions related to driving style, attitudes to safe driving, driving speed and speed limits, and to risky traffic behaviour. The respondents were also asked to judge a number of frequently used ISA features, and to anticipate effects of driving with ISA.

Molin and Brookhuis (2007) defined problem awareness, car drivers' beliefs about the selected policy instruments, and car drivers' personal characteristics as the main variables that would influence ISA acceptability. De Mol et al. (2001) based ISA acceptability measurement on the attitudes and opinions given by individuals, which stand for the general public. Within this concept several layers with mutual relations were defined, with the socio-demographic issues and the individual transportation habits as the 'basic' factors for the creation of public support. The basic attitudes denote how people perceive mobility and transportation, in particular the perception of speed in relation to motorized vehicles. Public support is also determined by 'being a (problem) issue in society', because, if there is no social indication that a problem about the relationship between road safety, speed, and speeding is perceived, there will be no change in future acceptance. Some of the abstract norms and values are made concrete in issues concerning how people think about road-safety measures. At this level a 'real' discussion on possible acceptance should occur. Within the SARTRE (Social Attitudes to Road Traffic Risk in Europe) project (Drevet, 2004) some questions related to how people noticed speed and speeding, and were brought into relation with willingness to use a speed-limiting device. Some of the aspects used in acceptance research and in acceptability research are mutual.

As a reminder, we will define acceptance as the reaction (beliefs and attitudes) of individuals, based on their behavioural reactions after the introduction of a measure or device. Acceptability describes the prospective judgement of measures to be introduced in the future. In our further research we will focus on acceptability instead of acceptance.

3. CONCEPTUALIZATION OF THE MODEL

The previous sections described how methods and theories are used to distil the most relevant determinants that could influence acceptance and acceptability. In these theories and methods we tried to find which items were related to each other. Venkatesh et al. (2003) did a similar exercise to build their UTAUT model.

In Figure 1 a distinction is made between general indicators (related to the context awareness of the system) and system-specific indicators (directly related to the characteristics of the device). The 14 indicators are considered to be the most relevant that can or will influence acceptance/acceptability. In our theoretical approach we gave every indicator the same weight. These general and specific indications will influence each other and the level of acceptance and acceptability. We give a brief description of every indicator.

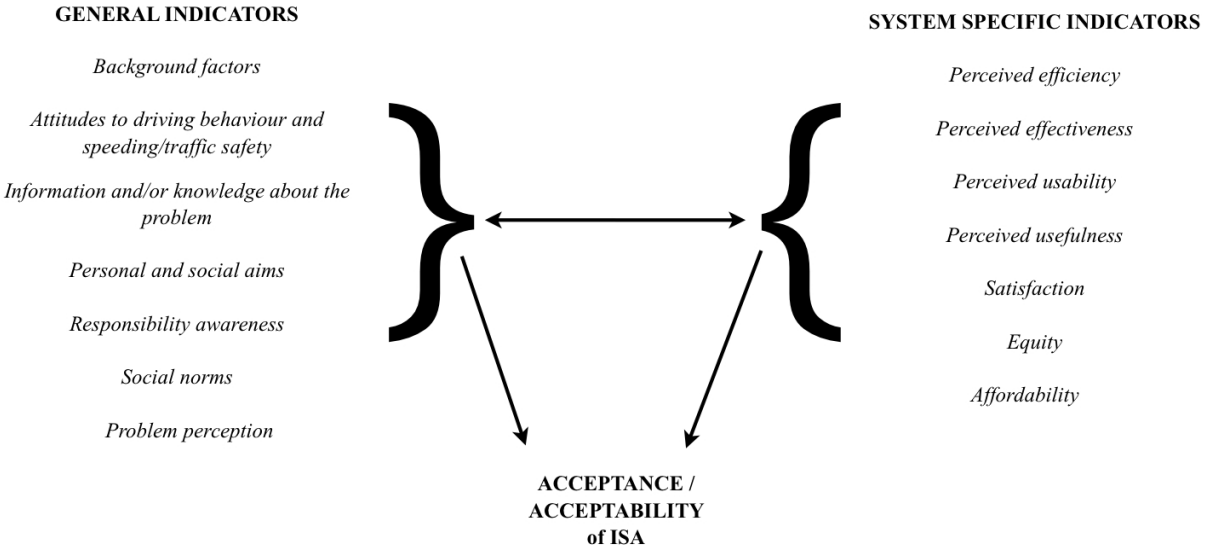

Figure 1. General and system specific indicators that can influence acceptance or acceptability

3.1 General indicators

3.1.1 Individual factors

Gender, age, level of education, and (income) employment are considered to influence how people think about speed and speeding and therefore on the use of ISA. Gender and age are considered as relevant determinants within the performance of speeding behaviour. Speed is more associated with young drivers (Ingram et al., 2001; Parker et al., 1992a; Stradling et al., 2000), and more specifically, with young male drivers (Stradling et al., 2003). Although male drivers are more likely to speed, some studies noted that a difference between sexes could not be found. Shinar et al. (2001) analysed the proportion of licensed drivers that reported that they drive within the speed limits. They noted that age, education, income, and gender are relevant factors in speeding behaviour. Shinar et al. (2001) observed that drivers who were more educated and had a higher income (related to employment) were more likely to report that they sped than the less educated and poorer respondents.

3.1.2 Attitudes to driving behaviour and speeding/traffic safety

Travel behaviour, driving style and the choice of vehicle are also related to speeding behaviour. Silcock et al. (2000) noted that people admitted to driving faster in more powerful and comfortable cars. Moreover, Steg et al. (2001) conducted a study to clarify the importance of symbolic-affective as opposed to instrumental-reasoned motives for car use. These motives for car use can have an impact on why individuals drive too fast, or whether they would or would not accept ISA. Stradling et al. (2003) examined the demographic and driving characteristics of speeding, violating, and thrill-seeking drivers. They concluded that in England drivers who speed, who violate other rules of the road, and who seek excitement when driving, pose greater risks to themselves and to other road users. Stradling et al. (2003) also found two population groups whose driving behaviour put themselves and other road users at risk. The first group was young and mostly, but not exclusively, male drivers. The second group was drivers from high-income households, living out of town, driving larger-engine cars for high annual mileage as part of their work. Crash involvement has been noted as a possible influence on speed and speeding behaviour. In relation to defining the acceptance and acceptability of ISA, the influence of travel behaviour, car use, vehicle choice, and driving style should be considered relevant indicators.

3.1.3 Personal and social aims

Schade and Schlag (2003) describe personal and social aims as the dilemma between social or personal aims and benefits. They assume that a higher valuation of common social aims will be positively related to acceptability. Clearly, people who want to drive as fast as possible will have a lower acceptability and acceptance of ISA. Another issue is the effect of speeding measures on individual freedom. Policies or devices that seriously affect individual freedom will be less acceptable (De Groot & Steg, 2006).

3.1.4 Social norms

Perceived social norms and perceived social pressure refer to the (assumed) opinions of their peers multiplied by the importance of the others' opinions for the individual. In other words, social norms refer to an individual's assumptions about whether peers would think that he or she should accept the device (Ajzen, 2002; Schade & Schlag, 2003). It is assumed that peers, e.g. co-workers or specific other road users, will influence the attitudes and behaviour of individuals

3.1.5 Problem perception

The extent to which speeding is perceived as a problem is a necessary indication in defining acceptance and acceptability. There is common agreement that high problem awareness will lead to increased willingness to accept solutions for the perceived problems (Schade & Schlag, 2003; Steg et al., 1997; Eriksson et al. 2006; Goldenbeld, 2002; Molin & Brookhuis, 2007; De Mol et al., 2001).

3.1.6 Responsibility awareness

This concept is based on the norm activation theory (Schwartz, 1977) and environmental travel demand management studies (Eriksson, 2006; De Groot & Steg, 2006; Stern, 2000). Responsibility awareness explains how an individual stands in respect to the issue of whether it is the government (others/extrinsic) or the individual (own/intrinsic) that is deemed to be responsible. It is assumed that environment-preserving behaviour becomes more likely if individuals perceive the damaging consequences of their own

actions on the environment and others, and at the same time ascribe the responsibility for the consequences to themselves (Schade & Schlag, 2003).

3.1.7 Information and knowledge about the problem

The level of acceptability can depend on how well-informed the respondents are about the problem and about any new device that is to be introduced to solve the problem (Schlag & Schade, 2003; Steg et al., 1995). The hypothesis may be that the more that people are informed, the higher the acceptance/acceptability will be. However, better knowledge about a problem can also lead to less acceptance/acceptability for a specific solution caused by, for instance, awareness of alternatives to solve the problem.

3.2 Device-specific indicators

Device-specific beliefs are directly related to the characteristics of the system. Seven indicators could have the potential to define acceptance or acceptability and how user needs are integrated into the system. As noted, ISA acceptance is related to drivers' attitudes and behaviour about speed and speeding. Therefore, the previously noted concepts of general beliefs must be taken into consideration and will influence specific beliefs for defining acceptability of ISA.

3.2.1 Perceived efficiency

Perceived efficiency indicates the possible benefits users expect of a concrete measure (or device) as compared with other measures.

3.2.2 Perceived effectiveness

Effectiveness refers to the system's functioning according to its design specifications, or in the manner it was intended to function (Young et al., 2003). In most ISA trials, this was found through an evaluation of the technical/ergonomic issues. The main question in these trials remained whether the system assisted the driver to maintain the proper speed. The level of effectiveness can depend on how interventionist a system is or was. For instance, an advisory system can be considered as less effective than a system that prevents the driver from exceeding the speed limit.

3.2.3 Perceived usability

Perceived usability is the ability to use the system successfully and with minimal effort. Usability is also an indication for how users understand how the system works. User friendliness can be associated with usability: the users will expect a service that does not distract or overload them with information and (difficult) tasks (Landwehr et al., 2005).

3.2.4 Perceived usefulness

Perceived usefulness is related to how the system supports the drivers' tasks and driving behaviour. Usefulness is, in a certain way, different from effectiveness. A potential user can find ISA effective in general but not for his own driving behaviour. Young et al. (2003) define usefulness as the degree to which a person believes that using a particular system will enhance his or her performance.

3.2.5 Satisfaction

Satisfaction is one of two factors derived form the items within the ITS acceptance scale that Van der Laan et al. (1997) developed to study user acceptance.

3.2.6 Equity

In general, equity refers to the distribution of costs and benefits among affected parties. However, from a psychological viewpoint, perceived justice, integrity, privacy, etc., are basic requirements for acceptability. This may differ from the objective costs and benefits, but equity is an important indicator influencing personal perceptions (Schade & Schlag, 2003). The integrity of driver information, privacy, and loss of certain freedom in driving can be an issue for willingness to use ISA.

3.2.7 Affordability

It may be assumed that socio-economic status will affect acceptance and acceptability, as users will consider ISA as a symbol of status ('having ISA as a new gadget or feature'), or they will want to be among the early adopters (Rogers, 2003). On the other hand, affordability will depend on the individual's budget and/or public/private funding. It is to be expected that low-income groups will be more opposed to ISA. In many trials acceptance was defined by willingness to pay for ISA (Vlassenroot et al., 2007; Biding & Lind, 2002; Hjalmdahl, 2004). The willingness to pay will depend on income, but in many trials it is assumed that the more people are willing to pay, the higher the acceptance and acceptability will be. Incentives such as lower road taxes and lower insurance fees can stimulate the acceptance or acceptability of ISA (Lahrmann et al., 2007; Schuitema & Steg, 2008).

4. RESEARCH METHODOLOGY

In the previous section we described the most relevant indicators that could influence acceptance and acceptability based on previous research and methods. In this section we want to render our conceptual framework operational. To this end, we developed and tested a first survey.

Based on the literature about acceptance and acceptability theories and models, different factors and some 250 possible questions from past surveys – some questions had multiple sub-questions – were found. These questions were categorized into questions about (i) personality characteristics, (ii) problem recognition related to speed and speeding, (iii) the use and integration of the actual methods to counter speeding, and (iv) the use of the new technology (ISA) to counter speed and speeding. These clusters made it possible to identify similar questions and to redefine some questions. The above-mentioned 14 indicators were also positioned in these clusters.

In the second phase only questions relevant to defining the indicators were withheld: about 60 questions were deemed relevant. A first survey was made, based on these questions. Some of the questions were redefined and only the most relevant questions were taken into account. The number of main questions was reduced to 36, most of which consisted of different items (sub-questions) that had to be rated (besides some identification questions) on a 5-point Likert-scale. To reduce the number of items that the respondents had to fill in, in questions relating to car choice and responsibility awareness, respondents were asked to rank the items from most important to least important.

A Web survey was assembled using the open source program 'Limesurvey' and sent first to colleagues for testing. Using their comments, especially about user friendliness, a pilot test survey was made and circulated by mail and the popular networking site Facebook. The goal was to reach 150 respondents. Based on the answers of these respondents some modifications were made to improve the survey and some of the early responses were processed to find out if the questions would cover the described indicators (main variables).

Finally the definitive Web survey was published online. The goal was to have at least 1000 respondents in Belgium (Dutch-speaking part) and 1000 respondents in The Netherlands. The Web address of the survey was distributed by the Flemish and Dutch motoring organizations. In Flanders a motoring organization sent an email newsletter to their members, in the Netherlands, the link to the survey was announced on motoring organization's website.

5. PRIMARY DESCRIPTIVE RESULTS

5.1 Background Information

5.1.1 Individual Factors

In total 6370 individuals responded on the web-survey in Belgium (Flanders region) and 1158 persons in the Netherlands. Of these 7528 respondents 5599 responses of car drivers were further used in the analyses, 1929 surveys were incomplete. The majority of respondents were male (79%, female 21%). 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. A majority in our survey belonged to the category older drivers, i.e. 42% was older than 60 years. This can be explained by the fact that predominantly elderly people have a membership of the car-users organisations. One out of two drivers had a "higher education". This was expected since using a web-survey specifically stimulates people with a higher education to participate.

5.1.2 Driving and Travel Behaviour

Over 90% of the respondents drove in their own vehicle, 13% of the respondents had a company vehicle (some of the respondents had more than one vehicle). About 30% of the respondents drove up to 10 000 km/year, 48% between 10 000 and 25 000 km/year and 22% more than 25 000 km/year. No less than 76% of the drivers had been involved in an accident; of these 77% had only small damages, 18% had an accident with mildly injured people, 4% with severely injured people and 1% were involved in an accident with one or more casualties. In total 51% reported to use the car to go to work or school, 73% use their vehicle for shopping and 74% use a car in their spare time.

5.1.3 Information about ISA

0ne out of two drivers had heard about systems that can give a warning or information about the posted speed limits. Over 60% of the respondents were aware that speed limit advice can be found in navigation systems; 14% knew what ISA was and 20% was familiar with the term speed alert systems. Only 5% of the respondents knew about the trials conducted in Ghent (B) or in Tilburg (NL).

5.2 General Indicators

In our concept we distinguish indicators related to the context wherein the system will be used. As main general indicators we consider (1) problem perception and recognition, (2) social or personal aims and (3) responsibility awareness to influence the acceptability of ISA.

5.2.1 Problem perception

The respondents were asked to value to what extent the given traffic offenses would have an impact on traffic accidents (table 2).

Table 2. The influence of traffic offences on accidents

	No Influence				**High influence**
	1	**2**	**3**	**4**	**5**
Driving under influence of alcohol or drugs	0,1	0,5	2,9	7,6	88,8
Little driving experience	0,3	5,5	24,8	36,6	32,7
Inappropriate speed	0,5	3,5	11	27,9	57,2
Other, less experienced drivers	0,5	7,2	28,1	37,1	27,2
Bad weather conditions	0,2	5,7	29,8	38,4	25,9
Mobile phone use (without using a car-kit)	0,9	5,8	18,3	31,5	43,6
Bad infrastructure	0,7	10,7	30,5	34,1	24,1
Taking risks	0,1	0,9	7	27,5	64,5
Fatigue	0,1	0,8	10,4	39,3	49,5
Insufficient distance keeping	0,3	1,8	11,4	35,8	50,7

According to the respondents, 'driving under influence' is the number one cause of an accident (89% said it has a high influence), followed by 'taking risks' (65%), 'inappropriate speed' (57%), 'no distance keeping' (51%) and 'fatigue' (50%). Most of the drivers would explain the cause of an accident in their own behaviour instead of other (environmental) influences like bad weather (26%), bad infrastructure (24%) or other drivers (27%).

The drivers were asked how often they would drive faster in different speed areas. One out of two drivers indicated that 'sometimes' they would drive faster, 30% drives regularly too fast outside urban area and on highways, while 22% would drive faster in 30 km/h areas, and only 10% drive faster in urban area. The respondents had to indicate the best and safest speed for the different areas as well. Related to this question they had to indicate when a speeding offense is made which maximum speed would be tolerable ("mistake") and which speed should be considered as irresponsible and as a huge crime (table 3).

Table 3. Responses on safest speed, tolerable and irresponsible speeding offenses

Speed zone (official limit)	Safest indicated speed (median in kph)	Tolerable speeding offense (median in kph)	Irresponsible speeding offense (median in kph)
Home zone (20 kph)	30	30	50
30 area (30 kph)	30	40	60
Urban area (50 kph)	50	60	80
Outside urban area (80 or 90 kph)	90	100	120
Highway (120 kph)	130	130	160

Except for residential areas and highways, the drivers indicated the legal posted limit as the best and safest speed. Most of the drivers stated that driving about 10 kph more than the posted limit is tolerable. Driving more than 30 kph too fast in residential, 30 kph and urban areas, and more than 40 kph too fast outside urban areas and highways were noted as irresponsible offenses. These are rather high margins, the respondents are relatively tolerable about the driven speed to be concerned as an irresponsible speeding offense, although they indicated that they would not speed very often.

5.2.2 Personal and social aims

The respondents were given some descriptions of situations in which they could choose to maintain the speed, drive slower or drive faster. One out of two drivers will slow down if they think that they could endanger other road users, in the other situations they would maintain the speed or drive faster. Two out of three respondents will drive faster in the situation of being in a hurry for an appointment and in the situation if there is nobody else on the road. One out of two drivers would speed during the night, 44% will drive too fast if the roads are familiar and they know the way. Finally, 41% would speed if they are certain that there is no or little speed control, 58% would maintain the speed in this situation.

5.2.3 Responsibility awareness

The respondents had to indicate how much responsibility (from no responsibility to high responsibility on a 5-point scale) each different actor has, and whether these actor(s) had to do something about the problem of speeding. 81% indicated that they are responsible themselves as drivers. 77% stated that the police are responsible to counter speeding, 63% puts the responsibility on the politicians and 54% on the road authorities.

5.3 Device Specific Indicators

Indicators that were marked as relevant to define how people think about ISA were perceived efficiency, perceived effectiveness, perceived usefulness and satisfaction, equity and willingness to pay.

5.3.1 Perceived efficiency

The perceived efficiency indicates the possible benefits users expect of a concrete measure (or device) as compared to other measures.

According to the respondents, they believed that the best measures against speeding are police controls (81%) and speed cameras (78%), followed by the use of technology in the vehicle (69%). Speed bumps (48% noted as effective) and road safety campaigns (15% noted as effective) were not believed to be very effective.

The drivers recognized that technology could help to reduce speed offenses or even help to maintain the speed. In table 4 the results are given of the evaluation of efficiency for the drivers on different ITS systems. Instead of the name of a certain ITS system the description on what the device could do was given to the respondents. It is noted that the drivers are certainly interested in different kinds of ITS systems. The alcohol-lock is found the most efficient (45%), followed by the alcohol-warning systems (38%) and the collision warning systems (37%). If the scores on 4 and 5 are combined, at least 40% of the respondents prefer a certain system: 62% is in favour of a collision warning system: 59% for the alcohol-lock. Even the black box (described to the respondents as a system that could monitor different aspects of the driving behaviour) is found efficient for 43% of the drivers.

Table 4. Valuation of efficiency of different ITS by respondents

	Not efficient				**Very efficient**
	1	**2**	**3**	**4**	**5**
Following Distance Warning (FDW)	18,7	11,7	19,8	24,3	25,5
Adaptive Cruise Control (ACC)	22,4	14,1	18,2	20,6	24,7
Collision Warning systems	10,3	9,3	18,3	25,0	37,1
Seat belt reminder: Car would not start if the driver does not wear the seat belt	24,8	10,3	15,5	17,5	31,9
Seat belt reminder: Car would not start if everybody in the car is not wearing seat belt	25,1	11,7	16,5	18,1	28,6
Alcohol-warning: Gives only a warning-signal when intoxicated	20,5	8,6	14,8	18,1	38,0
Alcohol-lock	21,7	8,2	11,3	13,9	45,0
Black box: Monitoring of different driving aspects	27,1	11,6	18,0	19,9	23,4

The respondents were also asked in a second question which ISA-system they preferred. Only the description of the system was given, for instance, a system that would give information about the speed limit. In this sense 30% was in favour of an informative system, 38% preferred a warning system, 12% a supportive system (active accelerator pedal) and 15% a closed. Only 5% indicated that they did not want any ISA, whereas 27% of the drivers indicated that they would rather choose to have an interfering type of ISA than just to have a warning or information.

5.3.2 Perceived effectiveness

The drivers were asked to indicate which system would be the most effective in different speed zones and for different reasons.

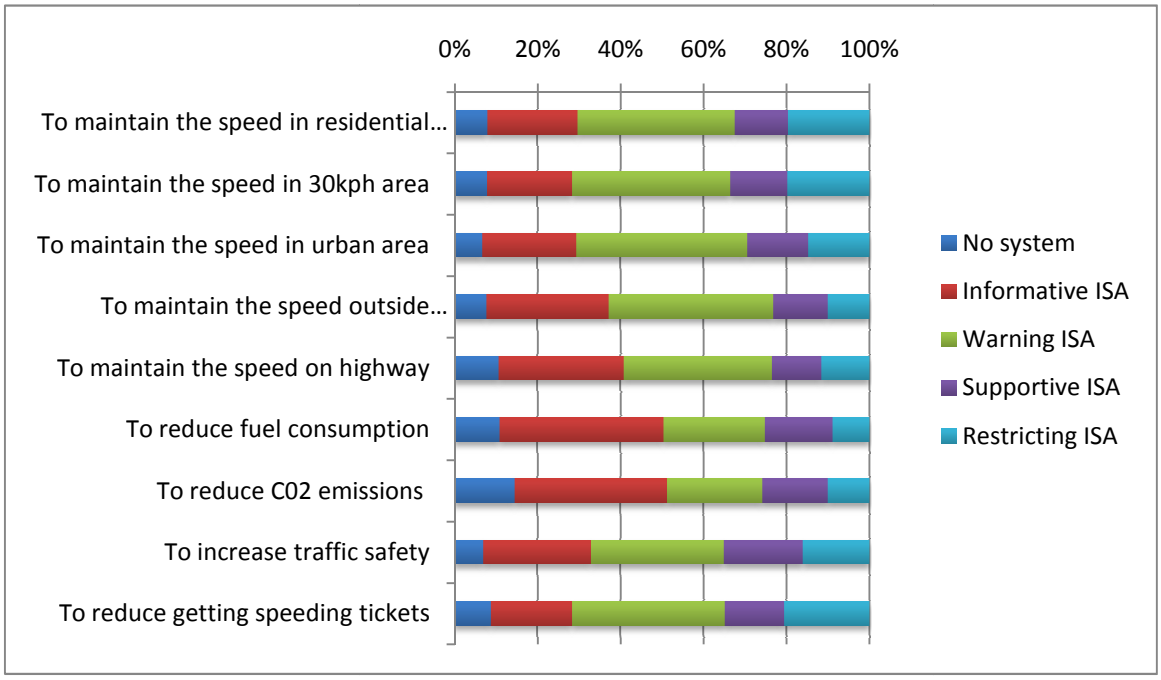

Figure 2. Valuation on effectiveness of different types of ISA in different speed area

Warning ISA has been considered as the most effective in all speed zones (38% in residential and 30 kph area, 41% in urban area, 40% outside urban area, and 36% on highways). The higher the speed zone, the less restrictive system was chosen. In low speed zones, the restricting ISA had a somewhat better support (20% in residential and 30 kph zones). The respondents indicated that an informative system would be the most sufficient to reduce fuel consumption (40%) and C02 emissions (43%). A warning system would increase safety the best (32%) and would help most to reduce getting speeding tickets (37%).

The drivers preferred a warning ISA most –which was also noted in a previous question -, although studies indicated that the more restrictive a system is, the better it would be for traffic safety and for the environment. The respondents would choose those systems that still give a certain feeling of freedom, but would be beneficial for their own driving behaviour as well.

5.3.3 Perceived usefulness and satisfaction (Van der Laan – scale)

The ITS acceptance scale of Van der Laan et al. was developed to study user acceptance. Acceptance is measured by direct attitudes towards a system and provides a system evaluation in two dimensions. The technique consists of nine rating-scale items, each a 5-point Likert scale. These items are mapped on two subscales, a scale denoting the usefulness of the system, and a scale designating satisfaction.

In figure 3, the respondents' opinions on usefulness and satisfaction has been scaled. The respondents could only evaluate the system from which they choose in a previously asked question, for example, who chose to have a closed ISA could only scale the 9 items on satisfaction and usefulness about a closed system.

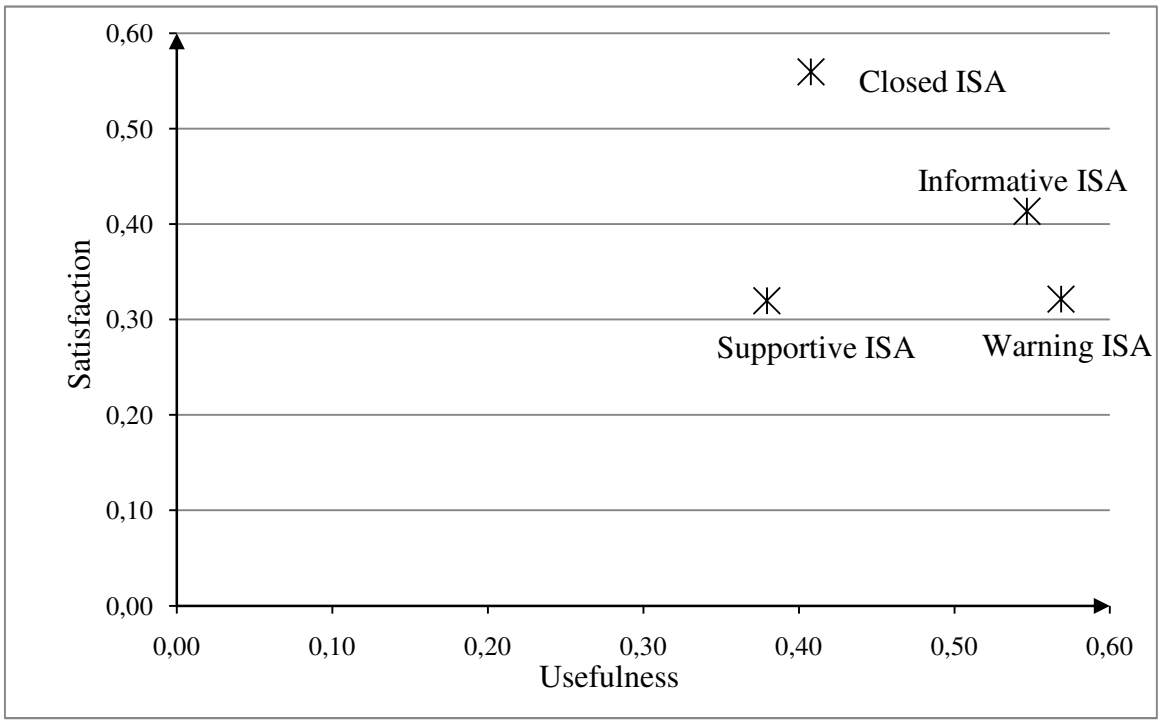

Figure 3. Drivers' opinion of ISA scaled on usefulness and satisfaction

All four systems were evaluated as positive. Drivers who chose to have closed ISA find it more satisfying. Respondents on warning ISA find it more useful. The supportive system has been evaluated as less satisfying and useful related to the other systems. It is assumed that it would be more difficult to evaluate a supportive system because it is far more difficult to imagine how it would work, or how it would feel. For the other three systems it is easier to imagine how they would work. Also the less intervening the systems are, the more useful they were evaluated. Morsink et al. (2006) described this as the 'acceptance versus effectiveness' paradox: the more effective ISA is on road safety (e.g. restricting ISA), the less accepted it will be by the users.

5.3.4 *Equity*

Equity was measured by asking the questions when they would install a certain ISA system and for whom a certain system would be the best.

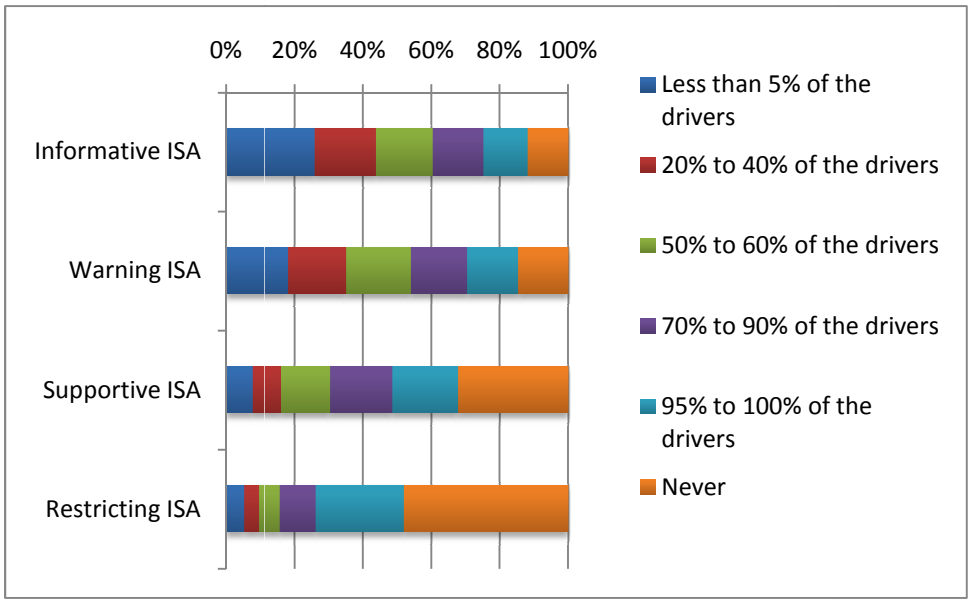

Figure 4. Level of penetration that would influence the drivers' choice on a certain ISA system

The drivers were asked to indicate how many people (in percentage) should have a certain device before they would decide to install a specific type of ISA. One out of four drivers would install informative ISA if only 5% of the population would have this kind of system, while half of the drivers indicated that they would rather not choose to have restrictive ISA. It is noted that the more intervening a system is, the higher the penetration level has to be before a driver would choose to have it.

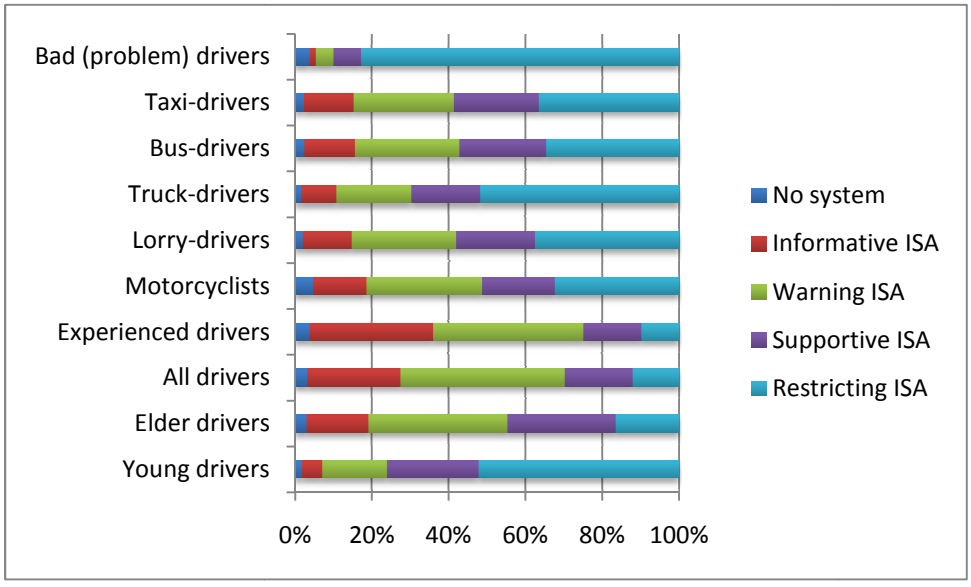

Figure 5. Indication of for which drivers a certain type of ISA would be the most beneficial.

Eight out of ten drivers indicated that frequent speeders or problem drivers should be using restrictive ISA. At least one out of two respondents stated that professional drivers

should use intervening systems like supportive and restrictive ISA. This also gives a certain indication about the safety and 'speeding' image of these professional drivers. Also young drivers should be equipped with more intervening systems, 52% are in favour of restrictive ISA. It should also be noted that 97% stated that ISA is beneficial for all drivers, i.e. 24% informative ISA, 42% warning ISA, 18% supportive ISA and 12% restrictive ISA).

5.3.5 Willingness to pay

The four different ISA types were explained to the respondents. The respondents could indicate under which financial condition they would buy a certain system.

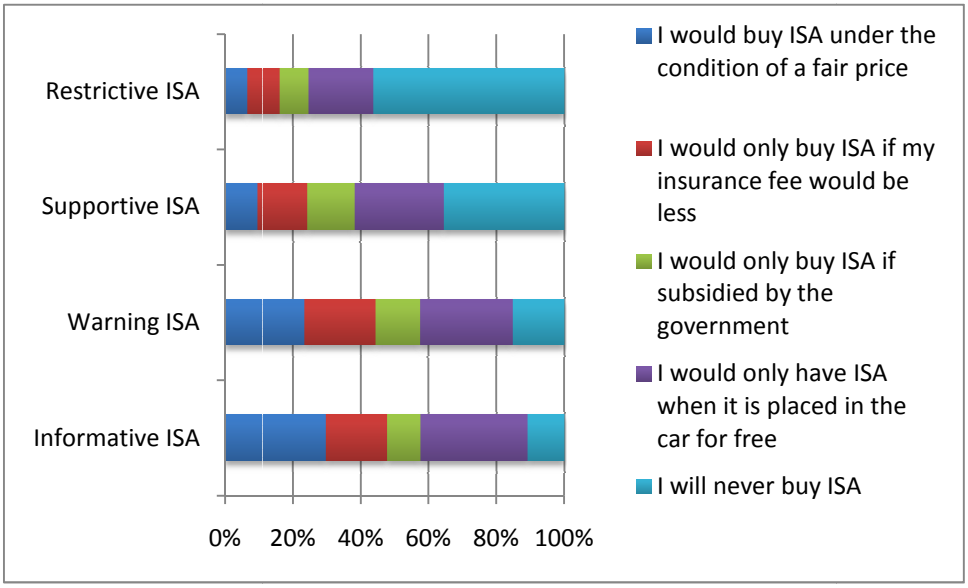

Figure 6. Willingness to pay for different ISA-types

For almost every type of ISA a certain specific strategy could be used. Although free placement is preferred for every system, most respondents are willing to pay for informative (30%) or warning ISA (24%) if the price is fair. Supportive ISA still got some high resistance (36%) but a smaller insurance fee (15%) and subsidies (14%) could convince people to install it. The best strategy for a restrictive type of ISA would be free placement (19%), but still one out of two drivers would not want to have it.

6. CONCLUSION AND DISCUSSION

It is recognized that knowledge concerning the level of acceptance or acceptability of a measure is important for future implementation of in-vehicle technologies. Ironically, a clear definition of what acceptance and acceptability are or how they should be measured is still lacking. In this paper we aimed to improve on this lack of knowledge. We made a distinction between acceptance and acceptability based on time and experience of the individual, whereby acceptance entails beliefs and attitudes, based on their behavioural reactions after the introduction of a measure. Acceptability describes the prospective judgement, based on attitudes and beliefs about a measure, without experience, to be introduced in the future.

New vehicle technologies such as ISA are difficult to implement. Therefore there is a need to understand which factor or indicator would influence future drivers' acceptability or acceptance. Based on different socio-psychological theories and methods used in ISA trials we found 14 relevant indicators that we divided into general indicators (related to persons' psyches, social values and norms at that time, and so on) and device-specific indications (factors that are directly related to the device itself).

Driving under influence, taking risks and inappropriate speed are considered to be the top three causes of an accident. In our questionnaire the respondents indicated that their own driving behaviour is of great influence on accidents and traffic safety, instead of environmental issues like infrastructure or even other drivers. Related to this it was noted that our respondents were in favour of certain ITS devices like the alcohol-lock, collision warning systems and active cruise control; even four out of ten drivers were in favour of a black box. This indicates that there can be a high market potential for Advanced Driving Assistance Systems (ADAS).

Three out of five respondents are aware that speed limit information can be found in navigation systems. Outside urban area and on highways the drivers would speed regularly. Even in 30 km/h areas it was noted that 20% of the drivers would speed more often. Although they would speed in these areas, the actual posted speed limits in all the speed areas were found to be the safest, except for highways where the limit could be higher. Driving 10 kph above the speed limit has been indicated as tolerable, driving faster than 20 kph was noted to be irresponsible. This means that our respondents are tolerant on higher speeds, although they won't speed that often and stated that the present speed limits are good.

Most of the respondents (95%) are in favour of ISA. Seven out of ten of these drivers want to have an informative or warning system, three out of ten wanted to go even further and choose to have a supportive or even a restricting type of ISA. Warning ISA was evaluated the most useful while restricting ISA was found the most satisfying. The respondents indicated that warning ISA would be the most effective. It is noted that the more restrictive a system is, the better it is for road safety. It is assumed that the respondents decided to have a system that would be helpful enough to maintain the speed but that would not restrict their 'freedom or driving experience'.

Drivers would only choose more restricting systems if the penetration level is high enough, although with a penetration rate of 95%, only one out of two would like to have restrictive ISA. Therefore it is needed to stimulate drivers to get ISA. Supportive ISA would only be successful if it was placed for free in the car. It was also noted that the respondents indicated that professional drivers should use ISA. Restrictive ISA is indicated to be the best. This could mean that professional drivers like truck and lorry drivers have a rather bad image if it comes to excessive speed.

This research showed that ISA is acceptable for most of the drivers but give also a good indication that for the different systems, different implementation strategies are needed. The more intervening a system becomes, the more stimulating actions (like subsidies or

even free placement) are needed. Besides the affordability or willingness to pay it was noted that equity could be a relevant factor in the acceptability or support of ISA. It was stated that more intervening ISA was preferred for professional drivers. If it comes to the implementation of ISA, this can be a good strategy to first equip company-vehicles before private-owned vehicles. Also the penetration level of certain types is very important for the potential users and should be taken into consideration when developing deployment strategies.

In the second phase of our research analysis, following the large-scale survey, the data will be processed to define how indicators relate to each other and how they fit the model. This model will be used to define how far implementation strategies should be taken to encourage higher acceptability and future acceptance of ISA.

One of the key issues is how the public will react if ITS is implemented. The understanding of the defined indications that will influence acceptability and acceptance may support decision-makers in developing an appropriate implementation strategy. Through the construction of this framework, we want to provide decision-makers with methods and procedures that are easy to use and understand, based on well-accepted socio-psychological models.

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