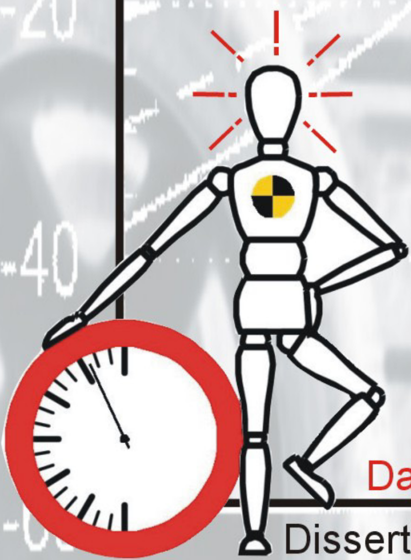
Basic Conditions for the Implementation of Speed Adaptation Technologies in Germany



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Abstract

Inappropriate speed is the most common cause of road traffic accidents world wide. Thus, a necessity for speed management exists. The so-called **SUN**flower states (**S**weden, the **U**nited Kingdom and the **N**etherlands) especially have spent significant effort on traffic safety policies – extremely successful in reducing mean speeds and speed variances using speed management techniques. However, the effect is still not sufficient for the achievement of real traffic safety, and as a result, there is currently a debate about the adoption of technical in-vehicle devices, one of which – called Intelligent Speed Adaptation (ISA) – reduces vehicle speeds. The speed reduction is achieved either by warning the driver that he is speeding, by activating the accelerator pedal with a counterforce, or by reducing the fuel supply to the engine. The three methods of speed reduction are called version 1-3 respectively. There is an EC research project on speed adaptation policies on European roads (PROSPER), which deals with strategic proposals for the implementation of ISA. Selected results from PROSPER are included in this thesis. Two empirical surveys were undertaken in order to provide an overview of the basic conditions (e.g. social, economic and technical aspects) required for an ISA-implementation in Germany. Firstly, a stakeholder analysis and questionnaire using the Delphi-method was undertaken in two rounds. Secondly, a questionnaire-based survey with speed offenders was carried out, also in two rounds. In addition, the author created an expert pool consisting of 23 experts representing the most important fields of science and practice in ISA. The author interviewed most of the experts, either in person or by telephone. 12 experts also produced a detailed publication on their professional point of view of ISA. The two surveys and the professional comments on ISA led to four possible implementation scenarios for ISA in Germany. However, due to the strong political opposition, it is also conceivable that ISA will never be implemented, or that the implementation process will not commence until after 2015 (i.e. outside the aimed period of time). The scenarios are as follows:

- A) Implementation of version 1 by market forces with governmental monetary promotion.
- B) Implementation of version 2 by market forces supported by traffic safety institutions and image-making processes.
- C) Implementation of a modified version 3 by law for speed offenders only, in place of the current practice of withdrawing the driving licence.
- D) Implementation of various versions in Germany as a result of broad implementation of ISA in the SUNflower states.
- X) Non-implementation of ISA, leading to the necessity for alternative speed management measures.

The author prefers scenario B because – ceteris paribus – it seems to be the most likely way to implement the technology. As soon as ISA reaches technical maturity, the implementation process must be accomplished by means of a three step approach.

Marketing and image making -> Margin introduction -> Market penetration

This implementation process for ISA by market forces could effect a percentage of at least 15% of all vehicles equipped with ISA until the year 2015.

Zusammenfassung

Unangepasste Geschwindigkeit ist weltweit die Unfallursache Nummer 1. Geschwindigkeitsmanagement ist daher unabdingbar. Die sogenannten SUNflower Staaten (S,GB,NL) haben sehr wirksame Verkehrssicherheitsprogramme. Erste Erfolge des Geschwindigkeitsmanagements zeichnen sich in diesen Staaten bereits ab. Es konnten Durchschnittsgeschwindigkeiten und Streuungen reduziert werden. Echte Verkehrssicherheit wurde jedoch auch hier noch nicht erreicht. Daher werden andere – teils technische – Maßnahmen diskutiert. Eine Technologie, welche in diesem Zusammenhang oft genannt wird, ist die automatische (intelligente) Geschwindigkeitsbeeinflussung (Abk. ISA). Es gibt drei Arten der Beeinflussung: Version 1 warnt den Fahrer vor einem Tempoverstoß mittels optischer oder akustischer Hinweise, Version 2 gibt einen Gegendruck auf das Gaspedal, Version 3 regelt die Benzinzufuhr zum Motor ab. Das EC-Forschungsprojekt PROSPER hat zum Ziel, strategische Vorgaben für die Einführung der ISA-Technologie zu erarbeiten. Diese Dissertation verarbeitet einige ausgewählte Ergebnisse aus PROSPER. Zwei empirische Untersuchungen wurden im Rahmen dieser Arbeit durchgeführt. Zum einen wurden nach der Delphi-Methode in zwei Runden Interessenvertreter befragt, zum zweiten gab es eine Befragung unter Temposündern, ebenfalls in zwei Runden. Ziel war es, Grundvoraussetzungen (z.B. sozialer, wirtschaftlicher oder technischer Natur) für die Einführung von ISA in Deutschland zu eruieren. Zusätzlich wurde ein „Expertenpool" eingerichtet, bei dem 23 Experten aus unterschiedlichen Institutionen und Fachdisziplinen zu Ihrer fachlichen Einschätzung bezüglich ISA teils telefonisch teils persönlich interviewt wurden. 12 jener Experten fertigten einen schriftlichen Fachbeitrag zu ISA an. Die Resultate aus Befragungen und Expertenpool mündeten in vier unterschiedliche Szenarios, die eine flächendeckende Einführung von ISA in Deutschland beschreiben. Eine starke politische Lobby seitens der Automobilindustrie könnte jedoch dafür sorgen, dass ISA nicht – wie angestrebt – in den nächsten zehn Jahren eingeführt wird. Die Szenarios sehen also folgendermaßen aus:

- A) Einführung von Version 1 über den Markt unter Zuhilfenahme staatlicher Fördermittel.
- B) Einführung von Version 2 über den Markt mit Unterstützung von Verkehrssicherheitskampagnen und intensiver Produktwerbung.
- C) Einführung einer modifizierten Version 3 per Gesetz statt Führerscheinenzug.
- D) Einführung unterschiedliche Versionen in Deutschland aufgrund der flächendeckenden Einführung von ISA in den SUNFlower-Staaten.
- X) Nicht-Einführung – Stattdessen Alternativ- und Flankenmaßnahmen.

Der Autor favorisiert Szenario B, da es unter heutigen Umständen am wahrscheinlichsten umzusetzen ist. Sobald ISA die technische Reife erreicht hat, sollte der Einführungsprozess in drei Schritten durchgeführt werden:

Produktwerbung und –information -> Margeneinführung -> Einführung am Gesamtmarkt

Dieser Einführungsprozess über den Markt könnte dazu führen, dass bis 2015 wenigstens 15% aller Fahrzeuge mit ISA ausgestattet sind.

Table of Contents

Introductive comments: Advice for footnotes and cross-references

The footnotes consist of comments and sources. You will find the full list of the literature used and comments arranged after each footnote number in the appendix. If a [G] is stated in the footnote, this means that the source is only available in German. The full German title is stated in the additional literature list (listed alphabetically by author) in the appendix. Various citations are originally German. The translations were done by the author of this thesis.
The text is divided up into 11 chapters and various subchapters. The author makes use of many cross-references. This is necessary to understand the interdependences between various hypothesises. Cross-references to chapters and subchapters as well as to figures, tables or definitions are included brackets. The term chapter is used generally for all kinds of cross-references to either main chapters or subchapters.

List of abbreviations

The following abbreviations are used throughout the text:

AAP	-Active Accelerator Pedal
ADAS	-Advanced Driver's Assistance Systems
ADC	-Accident Data Collector
EC	-European Commission
EU	-European Union
EuroNCAP	-European New Car Assessment Programme
GALILEO	-European project for space borne positioning system (civil use)
GPS	-Global Positioning System (US- Satellite System originally for military use)
HGV	-Heavy Goods Vehicle
HMI	-Human Machine Interface
imove	-Kaiserslautern University of Technology - Institute for Mobility & Transport
ISA	-Intelligent Speed Adaptation
PROSPER	-Project for Research On Speed adaptation Policies on European Roads
SRA	-Swedish Road Administration
StVO	-German law for road traffic (Straßenverkehrsordnung)
SUNflower	-Countries with high standards of traffic safety
TCS	-Theoretical Collision Speed
V_{85}	-85% of all cars on a particular road section do not drive faster than this speed

Other abbreviations are derived from product names and legal terms. These are explained directly in the text. Abbreviations for numbers, physical values and written language are taken from common British English as stated in the New Oxford Dictionary of English, Oxford 2001.

0 Research on Intelligent Speed Adaptation (ISA)

Foreword

Traffic safety research has a long tradition at the Institute for Mobility & Transport (imove). Thus it took only about two months after I started working at the institute before I first was confronted with a safety question. The question was: “Do you know anything about Intelligent Speed Adaptation?”. I was not sure what that would be, and my previous studies had all dealt with railway planning and technique, so I guessed it had something to do with high speed trains – far from it!

The aim behind the question was to take part in a consortium that was preparing a proposal for a EU-wide project dealing with the implementation of Intelligent Speed Adaptation (short ISA) – a technique which aims to reduce road vehicle speeds to a legal maximum. This consortium (at that time called “SALAMI”) later started the PROSPER project (see below). The empiric work done for PROSPER directly contributed to this thesis.

Due to the fact that speed reduction in Germany means fighting against a strong car industry and driver lobby, we (Professor Hartmut Topp and I) decided to do some research concerning speed-related accidents and how they are presented in the media (see below for further details). Working with the problem of speed-related accidents brought me to the point of view, that the correct cognition of speed and the acceptance of speed limits might have much more effect on traffic safety than any technical solution. Therefore one focus of this thesis lies in the psychological aspects of speeding. I contacted Professor Bernhard Schlag (professor for traffic and transportation psychology and leader of the institute for transport planning and road traffic at the Technical University Dresden). The combination of both projects (i.e. PROSPER and the “sensational accidents” project), together with various further questions, lead to this doctorial thesis. The various questions concerning politics, economy etc. brought the “expert pool” into play. The work with the expert pool is described in chapter 4.1. The idea of interviewing experts from different institutions and sciences in order to get a broad overview of the different conditions and frameworks concerning the implementation of ISA was born.

Many thanks to the participants of the “expert pool”. In addition, I would like to thank a few people, who supported me in finishing this thesis:

First of all I would like to thank Hartmut Topp and Bernhard Schlag for their permanent advice. Thanks also to Marco Schmidt, Thomas Stahl, Torsten Ebel and Christian Böhm, whose diploma thesises directly contributed to this work. Many thanks to Maik Lafrenz for the HMI-design drawing. I would also like to thank the PROSPER colleagues – especially Veerle Beyst, Eric de Kievit and Andras Varhelyi – who supplied me with up-to-date information concerning the ISA field trials in Belgium, the Netherlands and Sweden. Thanks to Harald Reichel from the police department in Ludwigshafen for the continuous contact and help with the questionnaires during speed enforcement actions. Further thanks to Benjamin Condry and Hisham Akkawi for their textual and linguistic corrections of this thesis. I would finally like to thank the numerous student assistants from the two projects.

The project "sensational accidents"

In August 2000, a German bus was involved in a fatal accident in Austria. The related newspaper reports were used as a starting point for a project that ended in 2002. The aim of the project was to determine a relationship between speed, severity of accidents and media interest. Approximately 200 newspaper articles about road traffic accidents (four different local and national German newspapers) were analysed, together with the related accident data sheets. The results were:

1. Inappropriate speed is statistically underestimated
2. Fatal accidents gain more interest from reporters than accidents involving only property damage
3. The role of speed is more concise in the accident data sheets than in the newspaper articles

The results of this project were used as a basis for this on hand thesis. In addition, the project's results lead to the intense contact and co-operation with the police department in Ludwigshafen. The questionnaires during speed measurements (chapter 4.3) were a result of that co-operation.

The PROSPER project

The **P**roject for **R**esearch **O**n **S**peed adaptation **P**olicies on **E**uropean **R**oads – financed by the European Commission – officially started in December 2002. The aim behind the project is to create a framework for a Europe-wide implementation for ISA-technology.

"The Council resolution of June 2000 explicitly identifies advanced assisted driving technology and technology relating to speed IMITA™ devices as important measures for further investigation. Introduction of road speed management based on information technology (i.e. ISA - Intelligent Speed Adaptation) requires international co-operation to overcome technical, legal and policy barriers."[1]

Figure 1: PROSPER logo and advertisement text

The initiation for the project was started by various institutions organising the national ISA field trials in co-ordination with the International Working Group On Speed Control (IWGOSC). Several related works have an influence on the results of the project, one of which is this dissertation.

[1] Source: Official project website www.prosper-eu.nl

Aims of the thesis

This thesis aims to give an overview of the status quo in driving behaviour, speed accidents and the attitudinal aspects of speeding. Furthermore, different points of view towards ISA as a new technology for speed reduction are presented. There are numerous groups and institutions related to the process of ISA introduction and possible necessary flanking measures. These groups are all represented in the surveys (questionnaires and interviews). This analysis ends with a presentation of basic conditions for the implementation of ISA.

Hence, the main aim of the thesis is to provide a guideline and framework for the ISA-implementation process. Thereby all groups involved in the process of implementation have to be taken into account. Due to the fact that ISA exists in many different types and versions, the thesis makes use of four scenarios describing the process.

The final part of the thesis consists of statements towards which groups have to be activated and which effects these groups have on other groups.

At the very end this thesis tries to give an estimation about when ISA-equipped cars might be seen on German roads and – of course – when ISA effects on accident reduction.

Methodology

The following figure gives a brief overview of the four most important steps of methodology used in this thesis.

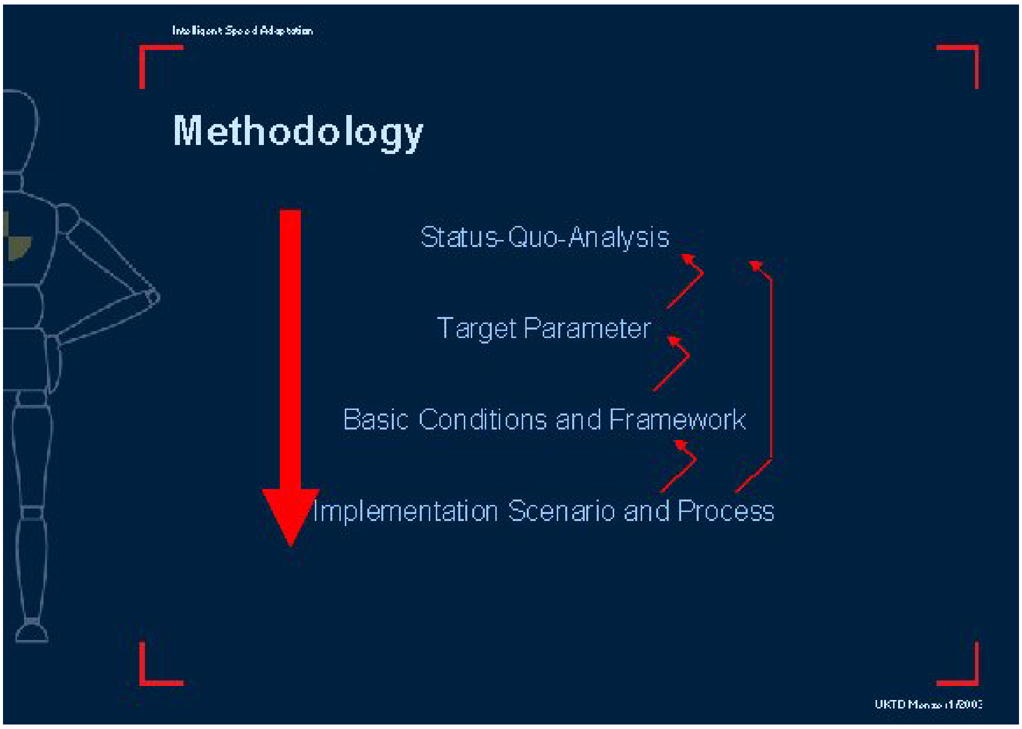

Figure 2: Methodology of the thesis[2]

[2] Source: Menzel, Christoph: Intelligent Speed Adaptation, presentation at the annual meeting of University transportation departments, Aachen/Rolduc September 29th 2003.

The status quo analysis establishes the existing situation concerning speed limits, speeding, attitudinal aspects, aspects of legislation and traffic safety management measures, reflecting literature, statements and results form the various empirical surveys.
Then the second part defines a few target parameters consisting of traffic safety aims and thresholds of knowledge (i.e. research requirements). Thus, the status quo is compared to the conditions for improvements in traffic safety and environmental protection.
This leads to a catalogue of conditions and a framework of measures required to meet the goals set. Finally, the framework is transformed into an ”instruction manual” for the implementation of ISA. In order to start with the description of the status quo, an explanation of what ISA is and does is first required.

Intelligent speed adaptation

The idea of in-vehicle speed adaptation first appeared in 1982 as Swedish and British researchers started to look for solutions against speeding tendencies and speed-related accidents. The statistics of deaths and severe injuries were reduced by the implementation of mandatory seat belt use, but the number of crashes and malpractices were still at a high level. This led to the invention of the speed switch. This was a simple switch inside the car. The aim was to give the driver advice for speed choice on urban roads (50 km/h and 30 km/h). When the system was switched on, a speed limiter was enabled so that an acceleration over the chosen switch position was not possible[3]. The development of the system started in Sweden, the United Kingdom and – surprisingly – Germany. An automation and dynamisation of the system followed in 1997, when the first field trials in Sweden were started.

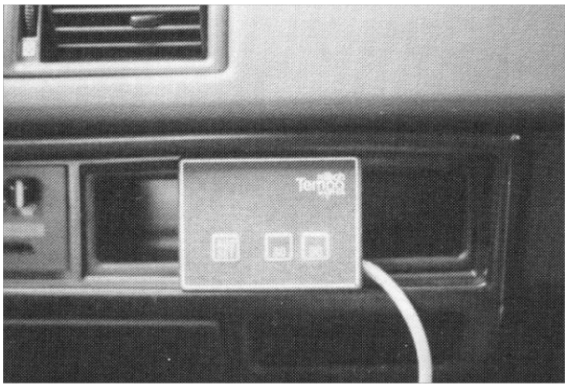

Figure 3: In-vehicle speed switch

Intelligent speed adaptation is a mixture of relatively new technology for road vehicles. Its purpose is to prevent the driver from exceeding a particular legal speed limit. The technology is available in three different basic versions, and the adaptation technique functions through three different channels. Therefore nine different versions of ISA technology exist. In addition, there are several ISA-like or ISA-beneficial ADAS (Advanced Driver’s Assistance Systems), which will be discussed briefly in chapter 3.1. The following table defines the nine different ISA-versions, which are most likely to bring the system to the market. However, the taxonomy of ISA versions includes a lot of other specifications used in the various field trials. These other specifications play no role in the sense of this thesis.

[3] Source: von Winning, Henning: City-package and speed switch[G], in: Verkehr und Technik edition 2/1990, p. 35-40, Bielefeld 1990

Versions:	Open; informative; warning signal	Half-open; haptic throttle; overrulable	Closed; fuel supply intervention, non-overrulable
Static; Data-DVD on the vehicle	**1-A Teleatlas™**	2-A	3-A
Data DVD plus download button	1-B	**2-B BMW™**	3-B
Dynamic; GPS-based	1-C	2-C	3-C

Table 1: ISA-versions [design by the author]

Version 1 informs the driver about current speed limits, either through optical or acoustic signals. This information is distributed through various different channels. Most useful from the traffic safety point of view is an acoustic BEEP-signal warning the driver the very moment he exceeds the speed limit. The signal usually gets louder as the speed increases further above the limit.

Version 2 – the so-called active accelerator pedal AAP (also known as "haptic throttle") – gives a counterforce on the accelerator pedal as soon as the speed limit is reached. The driver can overrule the system by increasing the pressure on the pedal.

Version 3 – also called "dead throttle" – is not overrulable. No further action is possible once the speed limit is reached. This works through an intervention to the fuel supply; although the driver is able to push the accelerator pedal furhter, this has no effect.

A, B and C divides the level of "external intervention". In every case, the car position is checked through satellite navigation tools (either GPS or – more likely in future – GALILEO). The position is counterchecked on a digital road map inside the car. These road maps are available as DVD from various software companies (e.g. Teleatlas™). However, information about legal speed limits is only partly available on these road maps. In addition, the available information is static, and therefore not up-to-date by definition. Thus, the driver has to get the opportunity to download up-to-date information before starting his trip. BMW™ is currently working on such a tool. Dynamic systems make use of up-to-date information from so-called traffic management centrals. The in-vehicle digital road map then is no longer a requirement.

Table 1 is fundamental for understanding ISA in the context of the whole thesis. For the term "acceptability" the behavioural and attitudinal aspects which will lead to a rejection of ISA by drivers must be clarified. The characteristic attributes of the different ISA-versions have different effects on acceptability. So long as ISA can be recognised as assisting – not restricting – the driver, the acceptability of ISA will possibly be higher (Chapter 6.1.5, 7.3 and 7.4.1). Figure 10 page 32 highlights the identification of ISA within the numerous ADAS.

ISA is not yet implemented anywhere, however several field trials have been accomplished since 1997. The most important investigations were made in Sweden, where more than 5000 road vehicles (mostly private cars) are equipped with the different ISA-tools. Further field trials exist in the

Netherlands, in Belgium, France, the United Kingdom, Denmark, Austria and Finland[4], and small projects have started in USA[5], Norway and Canada. Two field trials with a direct interrelation to the PROSPER project exist in Hungary and Spain[4]. Table 1 shows two applications of ISA. Teleatlas™ started equipping their navigation tools with speed limit information in August 2003[6]. BMW™ made extensive research with the active acceleration pedal since 1993 and will equip the 3xx-series from 2005 on[7].

The implementation of so-called "Advanced Driver's Assistance Systems" (ADAS) started in the early 1980s, and since then, several systems have been developed, and some have been implemented. Whether the systems have effected traffic safety, and how big these effects are, is part of the current research. Chapter 3.2 deals with the integration of ISA into the different ADAS. The main focus lies on the question of whether certain ADAS are beneficial for the coordination with ISA. The complete integration of ISA into ADAS tools is mainly a problem of software integration; therefore one further focus lies on the shape and design of the so-called human-machine interface HMI (chapter 7.4.1). It is not sensible to research the benefits of ISA itself. The integration of ISA with measures and techniques relating to traffic safety, environmental protection and relief for drivers must also be taken into consideration. The framework (chapter 7) therefore consists of strategic aspects and comprehensive political ideas and programmes (see chapter 4 for definitions). Before that, acceptability aspects and implementation parameters (chapter 6) have to be determined.

There will be a focus and a synthesis concerning the difference between two main approaches to ISA implementation:

1. implementation by law
2. implementation by market forces

The latter question will be discussed in chapters 5.2, 7.1, 7.2, 8 and 9.2.2 and is of major importance in in relation to the whole project.

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[4] Source: Official website of the dissertation project: www.isa-research.info

[5] Source: Jozwiak, Michelle: Applications of Intelligent Speed Adaptation in speed-sensitive pedestrian areas in the United States, in: Compendium: Papers on Advanced Surface Transportation Systems A&M University Texas p. 138-162, Austin 2000

[6] Source: Teleatlas: Speeding tickets in Europe – a thing of the past, Press release on September 18th 2003

[7] Source: Interview with Dr. Karl Naab of BMW™ on July 24th 2003, Munich

1 Problem: Speed, accidents and attitude

In Germany, around 2.3 m accidents occur every year – 362,060 of those involve fatalities. 6,832 people died in traffic accidents in the year 2002[8]. Although the number of fatalities is decreasing, the number of accidents and injuries remains static but at a high level. The statistical threshold for fatalities from road accidents is set at 30 days after a crash. However, due to the progress in accident rescue systems and intensive care, many accident victims survive crashes for more than 30 days, hence they appear in the statistics as injured. Between 5% and 10% of severely injured suffer life-long from the accident impacts[9]. Thus, no decisive improvement can be observed.

Another phenomenon is that the car industry massively increased crash safety features for people inside the car but not for other road users impacted by a car (pedestrians and cyclists). Figure 4 highlights the classification of the most common vehicle types concerning crash safety for passengers and pedestrians[10].

There is a high level of safety for passengers with newest car products (produced in 2001 and later), however, the pedestrian test rating shows a poor performance. Only one product (Honda Civic 2001) seems to be properly designed for car-human impacts. Honda massively improved the safety characteristics since the 1998 version did not pass the EuroNCAP test.

Nevertheless, the technical equipment for passive car safety is about to reach perfection. The car of tomorrow will have the best possible passive safety features, which will also help to decrease the number of deaths and injuries. However a number of deaths and injuries will remain[11].


Small Family Cars

★ to 31 December 2001
★ from 1 January 2002
✯ Danger of deadly impact

Model	Year	Front and Side Impact Rating	Pedestrian Test Rating
Alfa Romeo 147	2001	★★★☆☆	★★☆☆
Audi A3	2003	★★★★☆	★☆☆☆
Audi A3 1.6	1997	★★★★☆	★★☆☆
Citroen Xsara 1.4i	1998	★★★☆☆	★★☆☆
Daewoo Lanos 1.4SE	1998	★★✯☆☆	★★☆☆
Fiat Brava 1.4 S	1998	★★☆☆☆	★★☆☆
Ford Escort 1.6LX	1999	★★☆☆☆	★★☆☆
Ford Focus 1.6	1999	★★★★☆	★★☆☆
Honda Civic	2001	★★★★☆	★★★☆
Honda Civic 1.4i	1998	★★✯☆☆	★★☆☆
Hyundai Accent 1.3GLS	1998	★✯☆☆☆	★★☆☆
Mercedes A-Class	1999	★★★★☆	
Mitsubishi Lancer GLX	1997	★✯☆☆☆	★★☆☆
Nissan Almera 1.4GX	1999	★✯☆☆☆	★☆☆☆
Nissan Almera Hatch	2001	★★★★☆	★★☆☆
Peugeot 306 1.6GLX	1997	★★★☆☆	★☆☆☆
Peugeot 307	2001	★★★★☆	★★☆☆
Peugeot 307 CC	2003	★★★★☆	★★☆☆
Renault Mégane	2003	★★★★★	★★☆☆
Renault Mégane 1.5RT	1998 and 1999	★★★★☆	★☆☆☆
Suzuki Baleno 1.6GLX	1998	★✯☆☆☆	★★☆☆
Toyota Corolla	2003	★★★★☆	★★☆☆
Toyota Corolla 1.3Sport	1998	★★★☆☆	★★☆☆
Vauxhall Astra 1.6i Envoy	1999	★★★★☆	★☆☆☆
VW Beetle	1999	★★★★☆	★★☆☆
VW Golf	1998	★★★★☆	★★☆☆

Figure 4: Results of the EuroNCAP crash tests

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8 Source: Electronic datasheets of the German federal statistic institute, 2002

9 Source: VCD: Vision Zero – No accident fatalities[G], Master plan brochure, Bonn 2004

10 Source: www.euroncap.com

11 Source: Interview with Bernhard Dicke of the German Association for car industry (VDA) on July 8th 2003 in Frankfurt

Regarding these facts, car traffic is one of the most dangerous aspects in our society. Nevertheless, it seems to be a fact, that almost 7,000 deaths on roads are socially more acceptable than (for example) 280 deaths in railway transport.

Most accidents happen because the driver does not pay attention to specific traffic rules – especially rules concerning vehicle speed. "Inappropriate speed" is the most common reason for traffic accidents. In addition, speed related accidents are insufficiently represented in the statistical evaluation[12].

The general dilemma of road traffic accidents can be derived from the "tragedy of the common"[13]. Every single user of a common good (roads) develops his own concept of maximisation of benefits (driving performance) without taking into account that the benefits for the community (safety) will decrease. It seems that the drivers' attitudes towards speed behaviour are not as much influenced by safety considerations as by the illusions of driving freedom and subjective cognition of time. It is this latter hypothesis on which this thesis is primarily focused. The question behind this hypothesis is: Do drivers accept speed limits? 71% of German drivers do not[14]. The second related question is: Why do they not accept these limits? This then leads to the third (and for this thesis most important) question: What possibilities are there to make people accept the speed limits and make them drive at an appropriate speed, and will they use (or need) technical equipment to do so? Conversely, this means: If (especially German) drivers do not accept legal speed limits, then why should they accept technical solutions to enforce these limits? For each of these questions, an answer must be found in order to cope with the problem of speed-related accidents.

Speed behaviour has a special meaning in Germany as compared to other European countries, since the automobile industry has a very strong lobby; perhaps because Germany is the worldwide number one exporter of "high-performance" cars. Currently, five German car manufacturers produce commercial cars with an power output of (in some cases, far,) more than 330kW, this is a greater number than from any other single country in the world.

In addition, Germany is the only country in the world with no legal speed limit on motorways, merely a "recommended speed limit" of 130 km/h. Being involved in an accident while exceeding this recommended speed limit means a joint guilt and consequences concerning insurance coverage. Nevertheless top speeds of up to 300 km/h have been measured on motorways[8]. Therefore enforcement of legal speed limits seems to be one of the most important tasks for traffic planners and authorities. Accident scientists expect an accident cost rate of approximately 25 billion Euro per year to be saved if speed limits were adhered to [20].

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[12] Source: Menzel, Christoph: The role of Speed in \`sensational´ accidents [G], publications of imove, Green Edition #52, Kaiserslautern 2002

[13] Source: Hardin, Garrett: The tragedy of the commons, in: Science 162/1968 p 1243-1248

[14] Source: Moller, David: How about YOUR ethics?[G], in: Reader's Digest Magazine 6/2003, p 122-129

1.1 Speed limits on German roads

Statistical overview[15]

Road types and speed limits:

Road type	Speed limit (km/h)		
	Private cars	Buses and coaches	Lorries > 7.5 tonnes
Motorways	None [a]	100	80
On a road with 4 or more lanes, with at least 2 lanes intended for each direction of traffic flow. Directions are separated by physical barriers.	Variable [b]	100	80
On a road with 4 or more lanes, with at least 2 lanes intended for each direction of traffic flow. The directions are separated by road markings.	100	80	80
On other public roads	100	80	80
Built-up areas	50	50	50
Roads marked with a traffic sign, indicating 30 km/h [c]	30	30	30
Residential areas, marked with a traffic sign Traffic calmed areas	7	7	Not allowed [d]

[a] "Richtgeschwindigkeit" (recommended speed limit): 130 km/h

[b] no general limit, mostly signs: 120 km/h

[c] mostly "30km/h-Areas"

[d] exceptions: refuse truck/furniture truck only

Table 2: Legal general speed limits

[15] Source: www.destatis.de

Road lengths (km) in 2002 and distances travelled (in billion kilometres) on different road types outside built-up areas in 2000:

Road type	Length		Distance travelled
Motorways	11,800		203.38
Trunk roads	41,200		108.17
Rural roads	86,800		93.85
Minor rural roads	91,000		

Table 3: Road lengths and travelled distances

Type of vehicle	Distances travelled
Total	620.3
Motorcycles	17.7
Passenger cars	511.3
Buses and coaches	3.7
Lorries	75.9
Other vehicles	11.8

Table 4: Distances travelled (in billion kilometres) per type of vehicle in 2001

The distance travelled by road vehicles in Germany is close to the European average. However, the infrastructure, especially length of motorways and other high-class road types is above-average. The German railway network is also very substantial. The market for transport and mobility in Germany is one of the biggest branches of the economy. The infrastructure is almost the most developed in the world. Nevertheless there are enormous problems with congestion and accidents (chapter 1.4).

Speed enforcement

- minor offence: exceeding the speed limit by up to 10 km/h outside built-up areas
- major offences of the first degree: exceeding the speed limit by up to 10 km/h within built-up areas
- major offences of the second degree: exceeding the speed limit by 11 to 15 km/h and more outside built-up areas
- major offences of the third degree: exceeding the speed limit by 11 to 15 km/h and more within built-up areas.

General issues include the requirements for motor vehicle inspection and car insurance.

Germany is the only country worldwide where no general speed limit exists for motorways, however every other road type has a legal speed limit. In addition, several laws deal with speed limits and definitions of appropriate speed. These laws[16] especially concern specific vehicle types (e.g. caravans) and traffic situations (e.g. near zebra crossings).

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[16] Comment: Straßenverkehrs-Ordnung (road traffic manual [StVO]) and Straßenverkehrszulassungs-Ordnung (road traffic homologation manual [StVZO])

1.2 Speed behaviour

In order to give a realistic idea of speeding tendencies, a general statistical overview of mean speeds, highest measured speeds and speed variances on different road types has to be made. The problem is that there is no centralised database for this. There are, however, several local studies dealing with speed levels on different road types and with different speed limits. A general database for speed behaviour on unlimited sections of motorways only exists for the period from 1992 to 1995. Generalised speed measurements were also done before that. However, random samples show that mean speed on German motorways rises by approximately one km/h per year[17]. Nevertheless, differences in speed behaviour can be seen between roads inside built-up areas and those outside (motorways, trunk roads and rural roads). On roads that are mainly designed for links between important places the speeding tendencies without speed management are quite high. Trunk roads and rural roads with wide lanes especially, tempt a driver to exceed the legal speed limit.

Percentage	Motorways	Main roads	Country roads	Urban areas
Germany	18	16	15	7
Austria	19	12	13	7
Belgium	19	15	13	12
Spain	30	16	9	7
Finland	14	14	12	7
France	22	18	13	8
Greece	38	22	19	7
Ireland	18	14	6	4
Italy	23	23	13	11
Netherlands	27	21	12	8
Portugal	48	31	21	15
United-Kingdom	29	19	10	6
Sweden	34	27	12	3
European Union	*24*	*19*	*13*	*8*
Hungary	15	18	15	8
Poland	16	19	17	9
Czech Rep.	17	15	10	6
Slovakia	15	15	12	9
Slovenia	34	19	11	5
Switzerland	23	15	15	2

In the two European SARTRE-projects (1991 and 1996 third round on schedule for 2004/2005)[18], drivers in 21 countries (20 European countries and Israel) were asked about speed behaviour on different road types. Although most divers agreed that "*driving too fast*" is a major cause of accidents, many of the participants stated they would have fun driving fast. Between 14% (Finland) and 48% (Portugal) acknowledged that they would exceed the speed limits on motorways.

Table 5: Results of the SARTRE 2 study[18]

The values are slightly lower for trunk roads but noticeably lower for urban roads, where the difference in the values between the Northern and southern European countries are only marginal. The values for Germany are close to the mean value but have to be relativised because the recommended speed limit on motorways (130 km/h) was not set as a "binding" speed limit.

[17] Source: Kellermann, Gerd: Speed Behaviour on the motorway network in 1992 [G], in: Straße und Autobahn edition 5/1995, p 283-287, Bonn 1995

[18] Source: http://sartre.inrets.fr/english/sartre2E/vitess-en.htm

The study states that, potentially, an international socially accepted norm of approximately 20 km/h above the speed limit outside built-up areas exists. The speed limits on urban roads, however, are – by far – more acceptable for car users all over Europe.

Another European project (MASTER) dealt with speed management methods[19]. The factors affecting speed choice are described as follows:

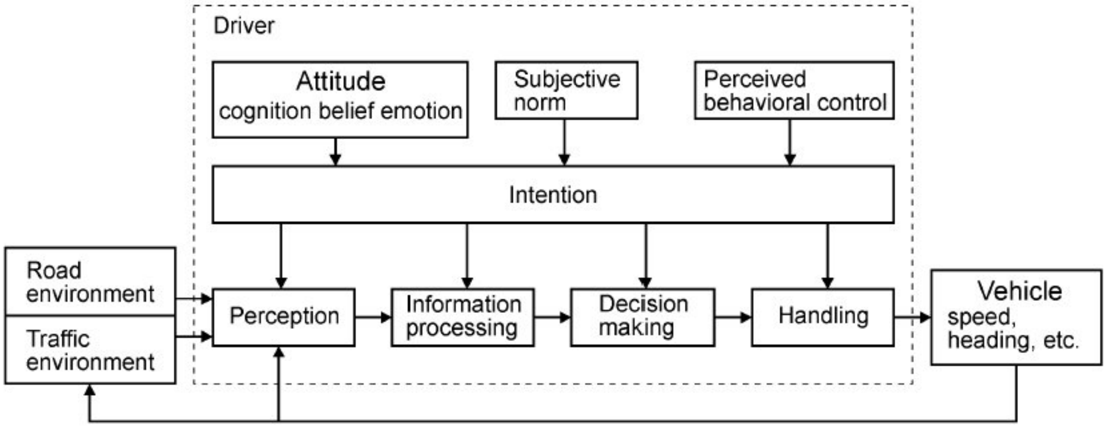

Figure 5: Combined overall behavioural model to indicate factors that influence speed behaviour[19]

Roads outside built-up areas

The tendency for speeding seems to be very low on roads where traffic management or creative planning are in use (e.g. motorways with traffic influencing measures). Both measures belong to speed management methods (Chapter 2 esp. Table 9). On roads of every type, where no speed management method is in use, the percentage of drivers exceeding the legal speed limit lies between 30 and 90 %[20]. Hence, the German national road administration (BASt) started a broad research and measure programme for rural roads. A continuous ban on overtaking supported through foam plastic barriers in the middle of the road will be tested. Both measures come along with intensive surveillance and low speed limits. The implementation of these measures is planned for late 2004[20].

[19] Source: Peltola, Harri et alia [not credited]: MASTER – Managing Speed of Traffic on European Roads, Final Report for Publication, Espoo, 1998

[20] Source: Köppel, Werner/ Meewes, Volker: Speed limiters in motor vehicles – possible effects on speed and traffic safety [G], in: Zeitschrift für Verkehrssicherheit edition 2/2003, p.57-66, Cologne 2003

Roads in built-up-areas

Mean speeds and V_{85} on tangential and radial high capacity roads are higher than on inner-city roads[21]. On some roads, the mean speed is high above the speed limit. In rebuilt 30 km/h areas, mean speed and speed variance are low. This fact also depends on how much pedestrian traffic and especially how much bicycle traffic exist on a certain road section. On some roads, especially high capacity arterial roads, up to 80% of cars exceed the legal speed limit[22]. In spite of being rather uncritical from a traffic safety point of view (bunch driving and low pedestrian/bicycle traffic), the high percentage of speeding cars leads to the necessity of speed management. There is a vicious circle between low pedestrian and bicycle traffic and a high level mean speed because of the deceptive safety of arterial roads. The Norwegian handbook for traffic safety gives a good overview of how to shape arterial roads in order to gain objective and subjective safety and comfort while decreasing mean speed[23] (Chapter 9.2.3 and 7.4.4). On urban roads with broad border utilisation and further traffic safety measures, the speed behaviour is totally different. The mean speed lies far below the speed limit and the number of cars exceeding the limit is often less than 5%[21].

Traffic calmed roads in residential areas are a special case. Due to a court decision, the speed limit is defined as 7 km/h for this specific road type. This is the lowest valid speed limit in Europe. In other countries, the speed limit for traffic-calmed areas is 15 or 20 km/h. Therefore the number of cars exceeding the speed limit in these cases is immense. However, danger of accidents on these roads is relatively low because of very low braking distances. Nevertheless there is a discussion about all-terrain vehicles or pickups using an iron rod in front of the car (also known as “bull-bars” and originally designed for the US-market). In a few cases, this special vehicle type has been involved in accidents with small children. The children died in spite of the relatively low speed of the vehicles (20 km/h) because of the iron rod hitting the children’s head. There is no law for the usage of “bull-bars” but a gentlemen’s agreement was signed by the biggest car manufacturing companies to abandon equipping all-terrain vehicles with them [12].

Speed behaviour also differs between uncritical and sensitive areas. This is based on attitudinal aspects and experiences with these certain situations. Users state that their speed behaviour

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[21] Source: Retzko, Hans-Georg/ Korda, Christian: Effects of various permitted speeds on urban roads[G], Reports of the German Federal Highway Research Institute, Transport Technology, Edition V65, Bergisch Gladbach 1999

[22] Source: Ellinghaus, Dieter/ Steinbrecher, Jürgen: Degradation of Behaviours and Habits? An investigation into the development of traffic habits over the last decades[G], Uniroyal™-Report 25, Cologne/Hanover 2000

[23] Source: Elvik, Rune: Traffic Safety Handbook [Norwegian], Transportøkonomisk institutt, Oslo, 1997

changes massively, when a child is in danger of impact[24,25]. More on that particular question will be presented in chapters 6.1.2 and 6.1.3.

In several surveys, the majority of drivers assess themselves as being cautious. They describe their driving style as being defensive[21,24,25]. Dangerous situations – for most of the drivers – only occur, when a “rowdy driver” or “speeder” is part of the situation. Nevertheless, at least a few drivers describe themselves as offensive. In one questionnaire, the latter were exactly identical to those with the most frequent speeding penalties. Driving behaviour is derived from experience, momentary mood, cognition and additional tasks while driving[24]. This leads to the question of user demands and user requirements on ISA and speed management (chapter 5).

Drivers usually evaluate themselves as “safe” and “careful” (chapters 4.3 and 7.3). There is a huge underestimation of the personal danger (for others) based on the fact that one is speeding[25].

1.3 Psychological aspects of speeding

Speeding – in the sense of this thesis – means driving at a speed level above the legal speed limit. The social integration of car usage brought a subjective feeling of freedom. One decides the route, the time and the speed. The free choice of speed is therefore primarily pragmatic. Regulations and guidelines (i.e. speed limits) are seen as a necessary evil. However, when stress or the will of having fun come into play, the inhibition threshold to speeding falls. Situational aspects (road geometry, traffic density, weather conditions, noise) determine the degree of malfeasance[26].

The choice of speed is on one hand dependent on “physical” conditions like traffic volume, road width, surface and so on. On the other hand, psychological aspects play a role.

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[24] Source: Stahl, Thomas: Intelligent Speed Adaptation – Approach to a guideline for an implementation on German roads[G], Diploma thesis at the Institute for Mobility & Transport of the Kaiserslautern University of Technology, Kaiserslautern 2003

[25] Source: Ebel, Torsten/ Böhm, Christian: Speed vs. Safety – Education, Enforcement, Engineering Possibilities of Adaptation and Control of Speed Choice in order to increase Traffic Safety [G], Diploma thesis at the Institute for Mobility & Transport of the Kaiserslautern University of Technology, Kaiserslautern 2004

[26] Source: Herberg, Klaus-Wolfgang: Speed - a traffic psychological reflection[G], in: Zeitschrift für Verkehrssicherheit edition 4/1983, p. 154-161

The psychological variables defining the driving task are[27]:

1. Trust
2. Situational Awareness
3. Workload
4. "Locus of Control"
5. Perceptual skills
6. Sensation Seeking

The so-called "locus of control" (The question of who is driving the car: Is it the driver or technical device?) especially, plays a role in the sense of this thesis. All of the stated variables are developed by perception, experience, appraisals and attitudes. Some psychological aspects are roughly related to physical conditions for example the definition of an "appropriate" speed on high level arterial roads (chapter 1.2). This leads to a conclusion based on a broad social context. In a social community, two rule types exist. One is the comprehensive body of legislation, the other is a socially accepted norm[28]. The complexity of social interaction leads to the fact that the latter is dependent on how often a situation occurs. Translated to the problem of speeding: "Up to 20 kilometres per hour over the limit is okay". This specific declaration can be observed from the empirical data (chapter 4.3). Nevertheless, driving at a speed level significantly above the legal speed limit is frowned upon. The "20 km/h-criteria" is a threshold for public acceptance of speeding[29].

People are massively influenced by image making and media. TV advertisements do not show real traffic conditions and intend to induce identification between human and car. However, people are influenced more by television shows presenting new cars. The top segment of cars now produce 330KW and more (q.v. introduction to chapter 1). In addition, modern top segment cars look like normal segment cars[30] (e.g. Audi™ RS6, Mercedes™ E55 AMG, Jaguar™ S-Type R). "*The archaic attraction of these cars is dangerous for the belief in the virtues of recommended speed limits'*[30]

Manufacturing cars that reach speeds up to 300 km/h animates at least some people to a speeding behaviour. This hypothesis is stated in various sources[31,32].

[27] Source: Weller, Gert/Schlag, Bernhard: Behavioural Adaptation after the Implementation of A-DAS: Presentation of a Model and Results of an Expert Questionnaire[G], in: Schlag, Bernhard [editor]: Verkehrspsychologie - Mobilität, Sicherheit, Fahrerassistenz, p.351-370, Lengerich, 2004

[28] Source: Interview with Prof. Bernhard Schlag (transport psychologist) on July 28th 2003 in Aachen

[29] Source: Phone Interview with Gerd Lottsiepen of VCD on February 25th 2003

[30] Source: Peters, Wolfgang: The three "muscleteers"[G], newspaper article in Frankfurter Allgemeine Sonntagszeitung July 20th 2003, page V7

[31] Source: Wolf, Winfried: Railways and car delusion[G], Hamburg/Zurich 1992

[32] Source: Monheim, Heiner/ Monheim-Dandorfer, Rita: Roads for everyone[G], Hamburg 1990

The theory behind speed choice depending on road type and situation can be described through two opposite models. One of which is the theory of "risk homeostasis"[33], stating, that one always seeks a certain individual and subjective level of risk, which one can handle. If the situation on the road is recognised as subjectively risk-free, one tends to increase the vehicle speed. However, the theory is insufficient, because the level of risk is individual and dependent on a whole range of circumstances. The "zero-risk-model"[34] relativises that. The driver reduces the level of subjective risk to a minimum (to zero), but only the subjective risk is taken into account, so that objectively risky situations do not lead to a lower level of speed, hence the problem is only the lack of identification of risky situations[35]. Both theories help to understand both speeding at a high level and the choice of inappropriate speed in certain situations (e.g. near junctions).

Risky and fast driving leads to an intense stimulation and cortical excitation. The most important process in this context is the so-called sensation-seeking. Accidents are – in most cases – caused by an unfavourable combination of situational and personal factors and conditions. Motivational factors play a role besides cognitive and technical skills among these personal factors. The most important motivational factor is the readiness for risks. Readiness for risks closely correlates with sensation seeking. Psychologists define readiness for risks as an attitude, whereas sensation seeking is defined as a psycho-biological determined trait[36]. The theory of sensation seeking[37] states that (especially young) people are looking for an ego boost while speeding. It is mentioned that every person needs a certain emotional agitation called optimum agitation level. If the subjective level of agitation is lower than the optimum, one tends to get bored. Then normally the sensation seeking process begins. The sensation can be a cinema movie, a sexual act or a ride on a roller coaster but also a speed flush. If the subjective level of agitation is higher than the optimum, one tends to get scared. The mean optimum agitation level is higher for young men than for young women and decreases with age and experience. This explains the high number of young people speeding. Sensation seeking in combination with a lack of driving experience (especially in borderline situations) leads to the high percentage of young (mostly male) people being involved in fatal accidents. In addition, the driving licence is often the most important symbol for freedom and independence for post-adolescents and young adults. This independence often comes with not being

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[33] Source: Taylor, Donald: Driver's galvanic skin response and the risk of accident, in: Ergonomics edition 7/1964, p 439-451, Leicester 1964

[34] Source: Summala, Heikki/ Näätänen, Risto: Perception of highway traffic signs and motivation, in: Journal of safety research edition 6/1974, p.150-154 Orlando 1974

[35] Source: Otten, Norbert/ Schroiff, Hans-Willi: Enquiry of determinants for the choice of speed – part 2. Trait of routes and choice of speed [G], Research reports of the German federal road administration 169, Bergisch Gladbach 1988

[36] Source: Herzberg, Philipp Yorck/ Schlag, Bernhard: Sensation seeking and behaviour in road traffic [G], in: Roth, Marcus/Hammelstein, Philipp: Sensation Seeking, p.162-182, Göttingen 2003

[37] Source: Hippius, Kerstin/ Joswig, Uta: Sensation seeking and risk disposition of vehicle drivers [G], in: Schlag, Bernhard [editor]: Empiric transport psychology, p 92-110, Dresden 1999

insightful concerning one's own mistakes while driving. A broad social consensus exists for correct choice of speed in "sensitive zones" (e.g. near kindergartens – chapter 6.1.3).
The key to the choice of appropriate speed lies in the correct cognition of a permanent risk as well as risky situations. Therefore the driver has to be aware of the results of his acting decisions. If the expected result is estimated negatively, the driver will adapt speed and steering to the certain situation.
The SEU-model[38] (subjectively expected utility) says:
"*The perception of an objective risk […] is not an alternative response to a certain situation (realised/not realised), but results in a continuum of possible estimations of the relationship between the subjective probabilities of the results of different alternative acts. The decision for or against an alternative act is influenced by the evaluation of the single results of acting. This is the basis in order to pre-estimate the particular choice of alternative acts: One will choose an alternative act, of which the product of the subjective expectance and the subjective value is maximum.* "[38 p.90]
Anticipation of risk therefore can only be reached through experience and durable learning. Learning effects lead to a more attentive driving style and a more reasonable choice of speed especially for traffic offenders[39]. Michael Formann[39] designed special driving safety training scenarios making use of controlled failure processes. Drivers are confronted with critical situations which would lead to a crash in every day traffic. The trainees learn how to prevent crashes through anticipating a situation and choosing an appropriate speed. Additionally, correct responses to specific crash situations – in order to minimise negative crash consequences – are part of the training programme.
This all indicates a lack of traffic safety education. Aspects of acceptability for speed limits and ISA can hardly be influenced without making use of broad educational measures (chapter 2).
Another problem is the existence of so-called extreme drivers. It is stated that only 2% of all drivers tend to be acting aggressively in car traffic[40]. But the effect on other road users is tremendous. Extreme drivers do not consider themselves to be offenders. They think they are a victim of the police and the arbitrariness of the other road users. The Swiss psychologist Klaus Meyer developed a pilot programme for extreme speeding offenders in Zurich[41]. Until 2003 130 participants (mostly young men) took part in the programme which started in the year 2000. In 20 group sessions plus one discussion session afterwards, the people learn to be aware of their offending role and the dangerous aspects of their actions. Klaus Meyer states that speeding has effects analogue to drugs and therefore may become an addiction[41]. Other literature states speeding and car-misuse as a compensation for sexual frustration, a valve for aggressions and a modern kind for

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[38] Source: Klebelsberg, Dieter: Traffic psychology [G], Berlin/Heidelberg/New York 1982

[39] Source: Phone interview with Michael Formann, expert for medical and psychological analysis of traffic offenders on August 13th 2003

[40] Source: Interview with Leander Oswald of TÜV™ on August 19th 2003 in Kaiserslautern

[41] Source: Television news clip from Swiss television SFDRS broadcasted on November 24th, 2003 available on the internet http://www.sfdrs.ch/system/frames/news/10vor10/index.php

hunting – while staying in one's own cave of habitation[31]. Figure 6 shows user's opinions, at which speed above the legal limit "speeding" begins [24,25].

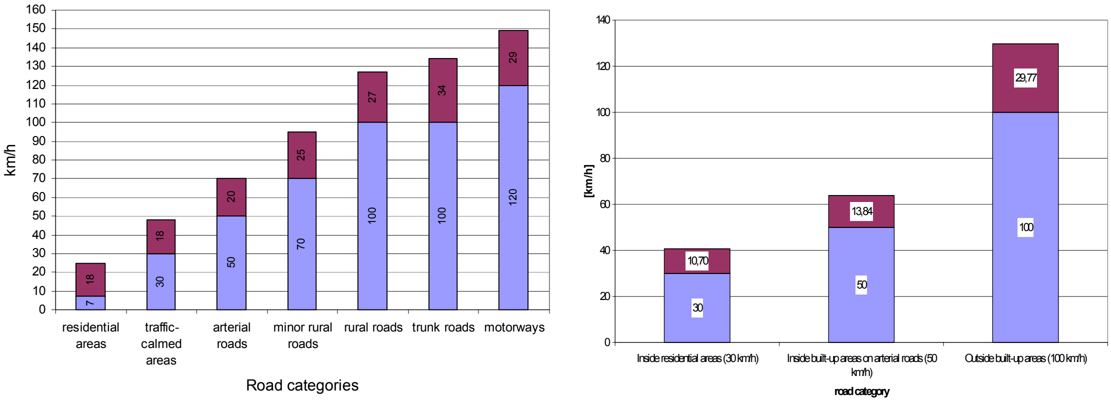

Figure 6: Speed limits and tolerated offences

On rural and trunk roads, where speeding has worst effects, the acceptance of speed limits is lowest. Hence, the highest potential to gain acceptance of speed limits and therefore to reduce accidents and accident effects is to redesign this particular road type. Infrastructural redesign, however, is very expensive compared to vehicle-based measures (i.e. ISA). A sensible solution for that problem can only consist of a measure-mix (q.v. chapter 4 subsection "Definitions and background").

1.4 Speed-related accidents in Germany

Every year, approximately 20% of all accidents occur because of inappropriate speed. On motorways, it is nearly half of all accidents. Most accidents with injuries or deaths occur within built-up areas. However, in these cases mostly pedestrians and bicycle riders are impacted. Approximately 30% of accidents with injuries or deaths occur on rural roads and trunk roads. In these latter cases, normally only drivers and passengers are impacted. Again, this shows the necessity for speed management on rural roads (chapter 1.2 and 2).

Per 1,000 speed accidents, 390 people are injured and 39 people are killed. Only accidents caused by drivers under the influence of alcohol have a worse effect [12]. The total number of accidents is decreasing, but is still high. Comparing accidents throughout a year, it can be determined that more accidents happen in summertime than in wintertime. This fact relates on one hand to the traffic volume, but on the other hand to more careful driving in winter. The latter especially concerns accidents with motorbikes[42]. Table 6 highlights the number of accidents/fatalities per month between 01/2000 and 07/2003.

[42] Comment/Source: In 2001, 62 people died per 1 billion km on motorbikes, whereas 8 people died per billion km by car. This is factor 8. [German Federal Statistical Office]

Rank	Month	Number of fatalities	Month	Number of accidents
1.	08/2001	706	11/2001	221597
2.	07/2001	701	12/2001	216513
3.	05/2000	694	10/2002	212900
4.	06/2000	692	12/2000	211900
5.	06/2003	684	05/2000	211000
6.	09/2000	676	10/2001	209328
7.	08/2000	673	11/2000	208800
8.	06/2002	665	11/2002	207600
9.	09/2002	662	05/2001	204300
10.	12/2000	654	10/2000	203800
11.	07/2002	652	09/2001	198400
12.	05/2001	649	03/2000	197700
13.	05/2002	641	09/2000	196200
14.	10/2001	637	05/2003	195400
15.	10/2000	635	03/2001	195000
43.	02/2003	376	02/2003	168400

Table 6: Chart of accidents/fatalities 2000-2003

The statistical role of speed in accidents however is not yet clear. This is due to the fact that the evaluation of accidents is done slightly perfunctory [12,20]. About 40% of severe accidents are in a grey zone between definite speed-relation and definite non-speed-relation[12]. But in fact, speed and accidents can be put together in two ways. One is the consideration of accident severity – derived from the simple physical relationship between speed and (crash) energy. Inertia and deformation are responsible for the disposition and grade of human injuries. The other is the likeliness of accidental occurrences depending on the level of speeding, together with research on reaction times and braking distances. Several studies deal with the relationship between speed and accidents – unitary judgment: direct dangerous correlation [12,19,20 - each referring to primary sources] (Figure 7). Figure 8 points out that speed variance is also very important for forecasting the number and severity of accidents.

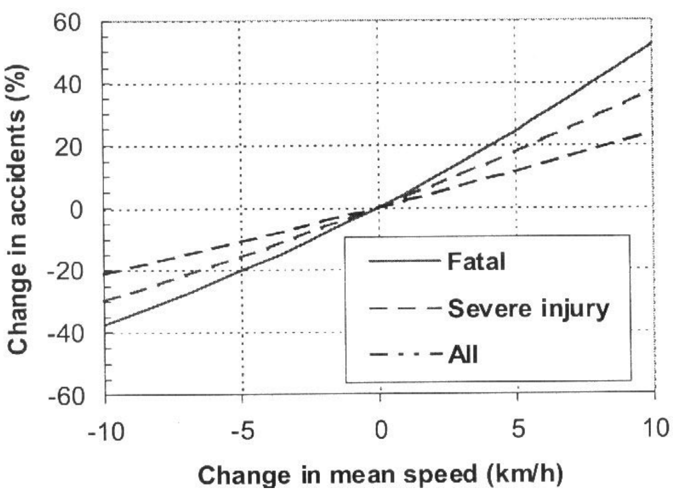

Figure 7: Relationship between mean speed and accidents[19]

The curve is very abstract. The exact mathematic formula for the relationship depends on where the statistic is valid. There are differences concerning road category, traffic volume, the level of motorisation (so-called “Smeed”-status) [51] of the country and local frameworks.

Figure 7: Relationship between mean speed and accidents[19]

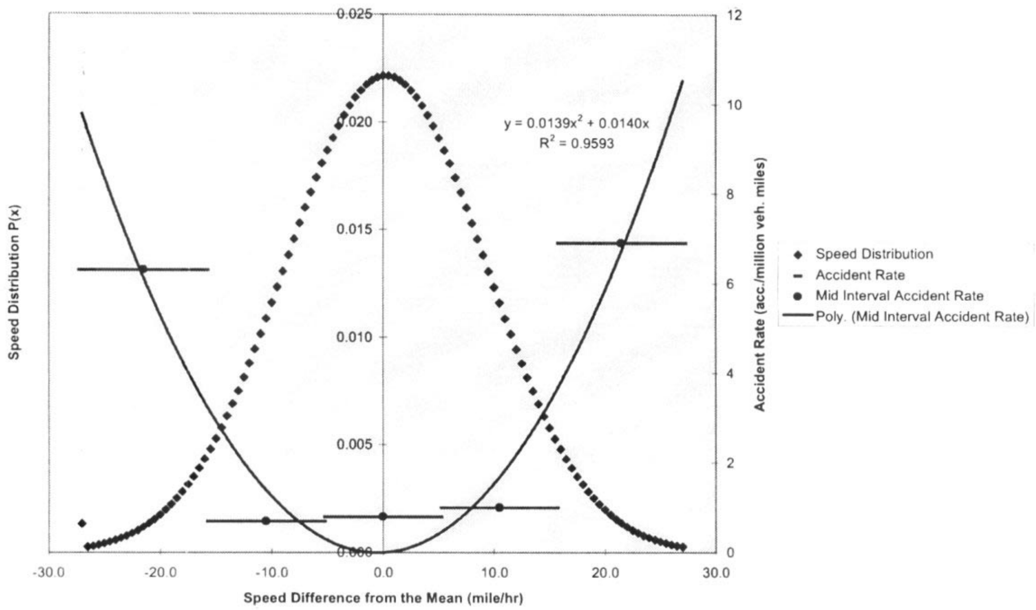

Figure 8: Relationship between speed variance and accidents[43]

The massive effect of the speed variance lies in the human lack of perception concerning speed level differences. The higher the difference between highest and lowest driven speeds on a road is, the more dangerous this road appears.

Most single-vehicle accidents happen on rural roads, especially on narrow avenues with trees on both sides. This is due to the fact that even the smallest mistakes within steering manoeuvres at high speeds lead to a lane departure. Together with bad surface conditions or cornering changes, accidents are a consequence. The severity of single-vehicle accidents on rural roads is higher than on other road categories. The severity of vehicle-vehicle accidents depends on the speed difference and the surroundings at the accident location. A head-on collision – for example – has the highest value of speed difference. Derived from that, the severity and danger of vehicle-vehicle crashes on rural roads – especially narrow ones – is the highest. Thus, the need for speed management is the highest on rural roads.

[43] Source: Carsten, Oliver/ Parkes, Andrew: External Vehicle Speed Control, Implementation Scenarios, Deliverable D6, Leeds 1999

1.5 Speed-related ecological problems

Speed related accidents and their negative effects on the community are only part of the overall problem. There are also ecological effects of accidents such as disposal of the wrecks and local immissions of harmful substances including fuel, oil or antifreezes in windscreen washing waters[44]. In extreme cases when trucks with hazardous material are involved, people may die of toxication, explosions or fire caused by the leaking of dangerous substances[12].

But there are also direct effects of high speed driving on biotopes and on the environment. The consumption of fuel and the deterioration as well as the abrasion of tyres are directly linked to the vehicle speed. The latter has effects on the environmental impact through heavy metals – especially cadmium. Another aspect is the disruption of the characteristic landscape by trunk roads with high traffic volumes and the related effect of landscape separation. This effect is due to the required road width which is derived by the road's design speed. Thus, indirectly, the driven vehicle speeds effect landscape separation[45].

The disruption of landscape not only effects animal migration and coherent ecological habitats. There are effects on population and biodiversity of small animals like toads and rodents. The higher the speed on the road is, the more animals are impacted. However there is no direct interdependence between speeding and the effects landscape disruption. Therefore most ecological problems connected to road design are due to road traffic itself. The estimated effect of ISA would be marginal.

A special problem concerning traffic safety on rural roads is the design of avenues with trees. Most fatal accidents on rural roads occur on this specific road type, which is very common in northern Germany. The historical design of those roads together with the ecological function of the trees lead to the suggestion not to cut the trees but to reduce vehicle speeds. Design elements like reflectors and specially designed crash barriers contribute to a decrease in the number of accidents and fatalities on this particular road type.

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[44] Source: Interview with Kai Tobias professor for ecological planning Kaiserslautern University of Technology on May 6th 2003 in Kaiserslautern

[45] Source: Tobias, Kai: Effects of car/truck speeds in road traffic on the natural balance [G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 77-88 Kaiserslautern 2004

1.6 International comparison

Traffic safety politics, speed behaviour and automobile usage in Germany are unusual in an international context since Germany is the only country worldwide without a legal speed limit on motorways. Sometimes it is stated that the inventor of the automobile was a German, so that German people love their cars more than others. This is surely not the proper explanation for the close relationship between people and the cars (chapter 1.3) but may be one further aspect.

However, Germany does not take part in the international accident database named "care". The political traffic safety programme for Germany – unlike most EU countries – does not include targets for specific reductions in accident rates – neither for fatalities nor for total incident numbers. "*The European way is not the German way*"[46] is the political declaration concerning field trials and implementation of ISA cars in Germany. German automobile manufacturers produce more than 5 million cars per year. This is the highest value in Western Europe. Among the cars produced is – by far – the highest percentage of high-power cars world wide. About 50% of new German cars are able to run faster than 190 km/h[47]. But is the role of Germany in the international context really so special?

Sweden – followed by UK and the Netherlands (the Sunflower states[48]) is the international leader in ISA research, planning and implementation. However, Germany – and German companies –lead in research and development of ADAS.

Table 7 shows that Germany – compared with other industrialised countries – has low death rates from road traffic accidents. However, the rates for injuries are relatively high – as mentioned in the introduction on page 8. This is due to a massive improvement in passive car safety on one hand as well as complementary and ultra-modern accident rescue system on the other. Experiences in accident rescue methods and techniques have influences on developments in automotive engineering (e.g. the automatic emergency button – view chapter 3.1 section "Integration of ISA with other ADAS"). The German automotive industry has developed the up-to-date technique in this context. The German government is very keen on harmonising the international development of transportation laws and planning concepts. One can observe that ISA and speed management is no longer disregarded in public discussions but the process has just begun. Concerning public ISA field trials, none has been carried out in Germany yet, but political institutions are discussing preferences and

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[46] Source: Phone Interview with Roland Niggestich from the German ministry for transportation, construction and housing on February 24th 2003

[47] Source: German Federal Motor Transport Authority, 2001

[48] Comment: SUN in Sunflower stands for Sweden, United Kingdom and Netherlands. The term was first mentioned in 2002 at the European ITS congress Lyon referring to the international comparison of countries with low-level accident data and large political programmes for traffic safety done by several institutions since 2001.

possibilities of the different ISA versions[49]. BMW™ performed their field trials with professional drivers[7]. The coordination and information exchange of the Europe-wide field trials on ISA is one of the aims of the PROSPER project (Again, the Swedish Road Administration and two other Swedish project partners act as the project coordinators and main contributors for information).

Dead per 100,000 inhabitants		
1.	Greece	19.3
2.	South Korea	17.1
3.	USA	14.8
4.	Belgium	14.5
5.	Slovenia	14.0
6.	France	13.8
7.	Czech Republic	13.0
8.	Austria	11.9
9.	Slovak Republic	11.4
10.	Ireland	10.7
11.	Canada	9.5
12.	Germany	8,5
13.	Finland	8,4
14.	Denmark	8,1
15.	Japan	7,9
16.	Switzerland	7,6
17.	Netherlands	6,2
18.	Sweden	6,2
19.	Norway	6,1
20.	United Kingdom	6,1

Accidents with injuries/fatalities per 1 m vehicle-km		
1.	Japan	1.20
2.	South Korea	0.95
3.	Slovenia	0.77
4.	Czech Republic	0.63
5.	Germany	0.61
6.	Slovak Republic	0.59
7.	Austria	0.57
8.	Belgium	0.54
9.	United Kingdom	0.52
10.	Canada	0.51
11.	USA	0.46
12.	Switzerland	0.40
13.	Netherlands	0.34
14.	Greece	0.30
15.	Norway	0.25
16.	Sweden	0.23
17.	France	0,21
18.	Ireland	0,18
19.	Denmark	0,15
20.	Finland	0,14

Table 7: International comparison of traffic accident rates[50]

This table shows how Germany's accident data benchmarks against the low-motorised countries – referring to "Smeed's law" (orange)[51] and against the so-called "SUNflower states" (green) [48]. The level of accidents and deaths is still too high for a high-motorised country. Strategy packages (Definition 6) – from a political point of view – therefore may contain the international benchmarking process in order to gather the "Sunflower" status within a short period of time (e.g. 10 years). The European Charter for traffic safety is supposed to be a good guideline for international equalisation of infrastructural measures and enforcement[9]. The traffic safety programme called "Vision Zero"

[49] Source: Short response letter from Eduard Oswald, chairman of the transportation committee of the German parliament [Bundestag]

[50] Source: International Road Traffic and Accident Database (OECD), 2001

[51] Comment: Smeed's law was developed before 1950 and shows how industrialisation, motorisation and accident fatalities correlate. The number of accidents per inhabitant is rather high in times of low motorisation. The more cars are in service the less deaths occur. However, the number of deaths in high-motorised countries is still on a high level.

plays a role in concerns of international traffic safety policies. Sweden, Austria and Switzerland make use of this vision. A Swedish medic had the idea to gain safe traffic without dead or severely injured[52]. Most European countries use derivates of the “Vision Zero” campaign. In Germany only DaimlerChrysler™ makes use of it. The “vision of accident-free driving” as an advertising maxim – in a way – extends the idea of “Vision Zero”. Nevertheless the strongest influence on traffic safety and adherence to traffic rules such as speed limits is a massive and consequent manner of punishment. The following table shows an Europe-wide comparison of monetary fines for speeding[53].

Chart	Country	Fine (€)
1.	Norway	240
2.	Belgium	200
3.	Poland	170
4.	United Kingdom	160
5.	Switzerland	150
6.	Sweden	150
7.	Italy	135
8.	Finland	100
9.	France	100
10.	Spain	80
11.	Greece	70
12.	Ireland	60
13.	Luxembourg	50
14.	Netherlands	50
15.	Portugal	50
16.	Denmark	50
17.	Austria	30
18.	Germany	30
19.	Czech Republic	15
20.	Estonia	5

In some countries (e.g. the Netherlands, Switzerland or Denmark) the minimum fines are much lower than the maximum fines. Depending on the road category the fine can be double or more than the amount stated in the table. Taking the local economic status into account Germany is the cheapest country for speeding offences.

Table 8: Lowest amount of fines for exceeding the legal speed limit by 20 km/h

52 Source: Rauh, Wolfgang: Safe and mobile – road traffic without fatalities[G], Edition VCÖ Wissenschaft, Vienna 2000

53 Source: www.bussgeld-online.de

2 Speed management

Managing speed means making use of measures and concepts for homogenisation of speed variances and lowering mean speed levels in car traffic generally. The term was introduced by a general European study dealing with aims of traffic safety and with the problem of speeding[19]:

"*Speed management is a concept consisting of diverse single measures, which have to be anchored by law and which directly or indirectly have to affect the speed behaviour of motorised road users on a definite part of the general road network in a positive way.*"[54]

Definition 1: Speed management

The economic effects of single measures (Definition 7 page 36) are described by accident cost rates. Especially "hard" measures such as paving, 30 km/h-zones and consequent speed control tend to reduce accident costs by approximately 60%[20]. Thus speed management is the general framework for the reduction of the negative aspects of speeding (chapter 1.4, 1.5). The necessity for making use of speed management in order to change the general situation in a significant way is high, but it seems that most German political programmes for traffic safety still do not make use of complete speed management. The "traffic safety programme" of the German government refers to specific problems (e.g. young drivers) and proposes a few measures known to be effective in traffic safety (e.g. traffic influencing systems). However, it states neither a specific aim, like Vision Zero, nor does it define specific strategies such as speed management[55].

Speed management as an element of traffic safety

Working with traffic safety concepts means making use of a mixture of methods and measures. Thereby, international best practices (e.g. SectionSpeedControl™[56]) have to be taken into consideration. SectionSpeedControl™ measures the time between two beacons and derives the mean speed for the particular road section (length > 1km). The system is much more effective than local speed cameras. However, only by the co-ordination of individual tasks may sustainable consequences be gained. This means that everyone working in the field of traffic safety must fully understand the relationship of their work to that of others in the field. This is therefore a political problem. Schmidt [54] gives a good overview of reasonable methods. These methods as a whole can be resumed as speed management. The "12-measure-plan" is derived from these methods[57]:

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[54] Source: Schmidt, Marco: A concept for speed management on German highways [G], Diploma thesis at the transportation department of the University, Kaiserslautern 2001

[55] Source: http://www.bmvbw.de/Anlage2568/Verkehrssicherheits-programm.pdf [G]

[56] Source: Franke, Bernd: Unrecognised and effective: SectionSpeedControl[G], in ITS Magazine (Siemens) edition 3/2004, p. 6, Munich 2004

[57] Source: Menzel, Christoph: Traffic safety through speed management – reasons and effects[G], in: Zeitschrift für Verkehrssicherheit edition 4/2002, p 161-164, Cologne 2002

Concerning measure 1: The described statistical fault evolves from the fact that the accident data sheets have to be sent to the federal statistics institutes within a certain time limit – usually two weeks. In most cases the accident evaluators need more time to find out the real cause of the accident. Thus `inappropriate speed in combination with exceeding the speed limit´ is statistically underrepresented[12].

Measure		Juridical and political consequences
1)	Correction of the statistical fault relating to accident causes. This requires a quality management procedure for filling in the accident data sheets and reforming statistical research.	Changes in § 4 pt. 1 of the law for statistical evaluation of traffic accidents and diverse local laws (Only administrative effects). Quality management can be certified as described in DIN ISO 9001.
2)	Involvement of media in traffic safety concepts. This means reporting “accusingly”, while it must be taken into account that personal feelings should not be hurt. The editorial offices have to make use of their pedagogical flair.	E.g. Changes in the statutes of media control institutes of the federal states. Perhaps a gentlemen’s agreement about accusing but fair reporting
3)	Speed limits at major road works on motorways have to be set at a low level (e.g. 60 km/h). This has to be enforced through police control actions. The situation at road works is often very complex and one to which drivers are often unaccustomed, especially in combination with bad weather or changes of lanes. Most of the accidents on motorways occur at sections with road works [8]	No law change necessary. There must be changes to the administration of road works and police enforcement.
4)	There must be controls and enforcements for HGVs. It is known that haulage companies sometimes manipulate the tachometer. Furthermore, HGVs are more dangerous in traffic than cars even at the same speed. This is due to the higher weight, and sometimes, extremely dangerous cargo.	Deregulation of administrative procedures. Intensivation of options for police enforcement.

These measures can be implemented without major effort. A political consensus can be found quickly. The costs for the measures are low.

5)	The perception of speed and the associated danger has to be made easier. “Normal” speed limits (30 km/h and 50 km/h) can be found as red marks on the speedometer. There is no mark at 130 km/h, which is the voluntary legal speed limit. Installing a “speeding” signal (acoustic or optical, better haptic) may have an effect.	Changes of various standards, product licenses. Change in the law for road traffic authorisation
	This measure is dependent on the good will of car manufacturers. However, it will not take long to equip new vehicles with this kind of “communicating speedometer”. Even older cars can be easily equipped afterwards during the periodical technical check. The costs for the material must be very low so that the garages can offer the installation cost-free.	
6)	Implementation of a general speed limit at 130 km/h.	Abolishment of the German law for the voluntary speed limit of 130 km/h. Change of laws concerning speed limits and speed offences. Consequences for judgements. Politically motivated complaints at the highest court of justice are very likely.
7)	Implementation of higher fines and lower tolerances for enforcement measures. The punishments have to be higher than a certain threshold of pain. This means suspending the driver’s license for longer periods, and increasing fines to a very high level like in Denmark and Sweden. Another possibility could be to criminalise very aggressive speeding. It must be made clear that there is an element of crime associated with violating speed limits by a certain margin. §315c StGB (German law for crime and punishment) deals with “dangerous behaviour in traffic”. This normally depends on a particular situation. The judges should take into account that speeding means immanent danger.	This has consequences for the prescriptions of fines and punishment. But most of all judges have to make use of the laws in a more offensive way. This could be made clear through political pamphlets from the juristic alliances (e.g. in Germany: VDJ, RAV, REFV, DJB)

8)	Speed control by using web cams (on motorways only) or SectionSpeedControl™ (on both motorways and rural roads). This technology is fully developed, so that the number of expensive police controls could be minimised. Nevertheless there will be a problem concerning data confidentiality and product liability for this kind of speed measurements. SectionSpeedControl™ is in use on a Dutch four-lane motorway section since spring 2004 [56].	This measure has to be proven by the German federal institute for data confidentiality. This could have effects on various laws. Political opponents may bring out a complaint to the highest German court.
9)	There is a very high acceptance of dynamic traffic management systems (TMS) on motorways. The area-wide application of this technical measure is associated with high costs. The installation will take a long time. The government is planning to double the current length of motorways equipped with a TMS. Due to the high costs of the changeover this will take at least ten years. The implementation of dynamic traffic management systems on rural roads must also be taken into account.	No juridical effects. Political discussions will be started concerning the financing problem.
10)	Implementation of ISA or ISA-like systems.	The implementation of adaptive systems is dependent on an all-embracing framework of laws, prescriptions and technical standards. It is likely that a new law will be released concerning product liability separate from the Vienna convention.
11)	Drivers must accept that driving above the speed limit (even if it is only a few km/h) is dangerous. Hence education and advertising for drivers are required. This will take a long time to modify. It must begin with schools, and end with regular tests of knowledge of rules in road traffic. This can only have an effect if all institutions and disciplines dealing with traffic safety work together.	The German ministry of education, the ministry of transport and the ministry of the interior have to create a collective political pamphlet. Diverse laws are affected.

12)	Changes in the educational plan for driving schools. Implementation of a graded driving license.	The main effect relates to law for driving licenses, but there will also be effects on some certain other prescriptions.

Table 9: 12 measures of speed management

The last measures will have a massive long-time effect. Nevertheless each of them will be associated with controversial political discussions concerning financing and juridical effects..
This list of 12 measures includes various educational aspects. These aspects are very important for the acceptance of speed limits, technical measures and police enforcement. Therefore there has to be a 13th measure, which must be the interaction between the 12 other measures.

3 Advanced driver's assistance systems (ADAS)

Driver's Assistance Systems aim to support self-dependent driving. In the 1990s, car electronics – including ADAS – overtook the mechanical attributes of a car in terms of the importance to driving performance and the steering aspects[58]. The systems can be divided into adaptive and informative versions. Adaptive ADAS are directly related to traffic safety (e.g. ESP or ACC), while informative systems only aim to comfort or to inform (e.g. Navigation-tools). Figure 10 (page 32) gives an overview of ADAS systems and the categorisation of ISA. Indeed, more important is the difference between systems that interfere only within a short period of time or even suddenly, and those systems that interfere constantly and preventively. The traffic safety effects of the existing ADAS are enormous. The potential savings of ABS and ESP alone are 3600 motorbike accidents and 9500 car accidents per year. Lots of those accidents – especially motorbike accidents – would have severe consequences (i.e. deaths and injuries). However, many system failures caused by both new and "matured" ADAS reduce the optimism for the benefits of ADAS[59].

The software for single ADAS can be upgraded. For example: With most of the navigation systems it is possible to download dynamic information about traffic jams or road works. The integration of ISA into navigation tools is relatively straightforward (chapter 3.2). BMW™ is doing this for their application of ISA – called ACC (module speed)[7]. Static information about speed limits is available for nearly 90% of the German road network.

Figure 9 highlights the interaction between the human being, the road and the vehicle. ADAS are tools to help the driver both understand the vehicle and anticipate the consequences of his actions (chapter 1.3). However, they are not able to compensate for severe mistakes or create a complete overview of difficult or risky situations concerning road design and surroundings. Technical research on ADAS therefore mainly concerns the so-called human-machine-interface (HMI) in order to make the technical access as easy and "self-explaining" as possible (chapter 7.4.1).

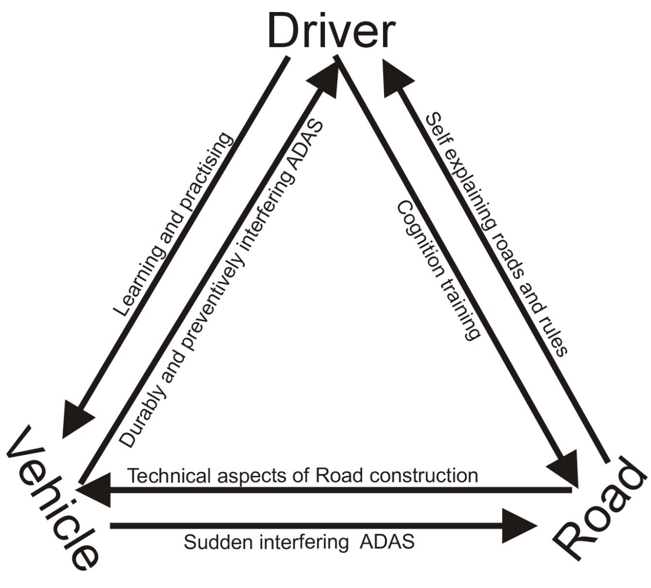

Figure 9: Traffic safety triangle [design by the author]

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[58] Source: Menzel, Christoph: Traffic safety through driver's assistance systems[G], in: Internationales Verkehrswesen edition 10/2004 p 446-449

[59] Source: Mayer, Hans: The last word has to be on the Driver[G], newspaper article in Frankfurter Allgemeine Zeitung May 25th 2004, p.T4

3.1 Is ISA an ADAS?

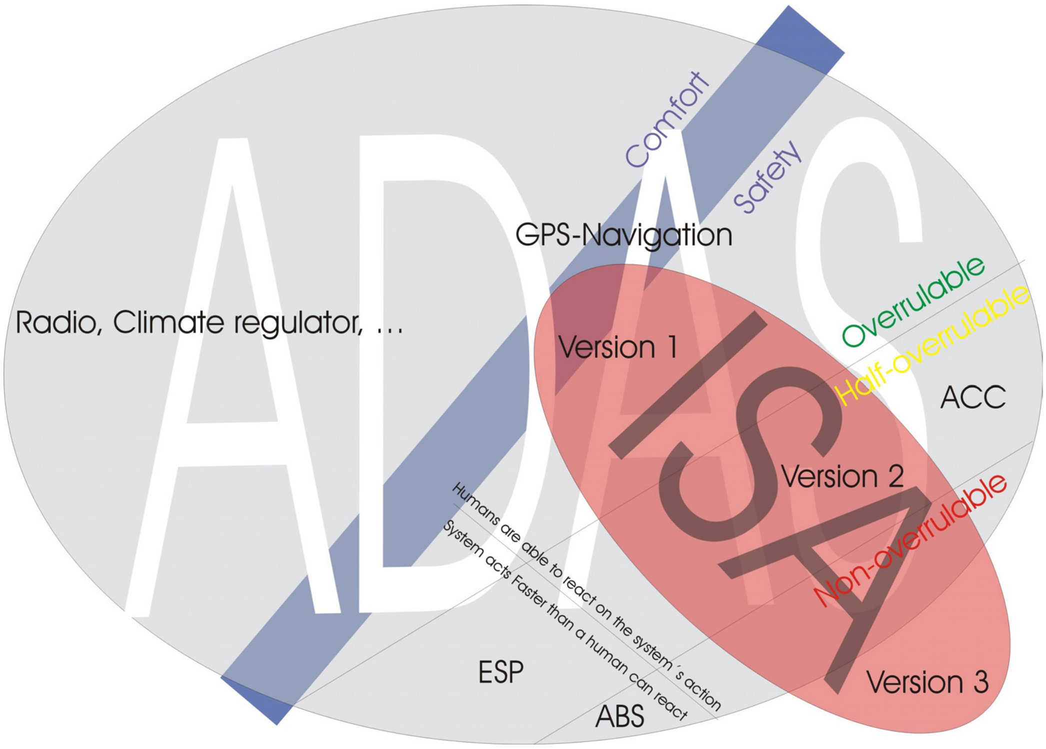

Figure 10: ADAS and ISA-systems [design by the author]

Figure 10 shows the three basic ISA-versions in comparison with the collectivity of ADAS. Many ADAS just aim to increase the comfort status inside the car during trips. Modern navigation systems are equipped with internet and mobile phone functions. In relation to this thesis, only the safety systems are of interest, especially those with an influence on braking and accelerating operation (e.g. ABS and ACC). The possibility of overruling or switching off the particular system is very important for the task of "assisting" a driver. A human being is able to react within 100ms for non-complex actions like pushing down a certain acquainted button; for more complex actions like braking, the reaction time is approximately one second[60]. Due to the fact that – thinking in physical dimensions – this is a rather long period of time, ABS and ESP applications act immediately without advance information being given to the driver. Therefore, one has to distinguish between "immediate" systems, created for borderline cases like overmodulation in curves (ESP), and "preparing" systems, created for anticipating risky situations (ACC, ISA 1 and 2). The figure shows ISA Version 3 as being placed outside the ADAS collectivity. This is part of the international discussion taking into account that product liability and self determination of a driver plays a major role in concerns of traffic safety.

[60] Source: Kempinski, Wolfgang: Interactive visualisation system with automatic Design for control centres of electrical networks [G], dissertation at the University of Duisburg, Department of electrical engineering, Duisburg 1999

3.2 Integration of ISA with other ADAS

Making use of technical solutions with the aim of increasing traffic safety means combining different systems or system parts by the laws of ergonomics and interface management. From a technical point of view, ISA is designed as a GPS application which is able to be integrated into each navigation system. Synergetic effects may be achieved with nearly every traffic safety tool. The problem is that the complete systems should not become too complicated, otherwise “information overload” and overexposure may result. Every assistance system has to be “self-explaining”. The most common active – meaning adaptive or informative – safety systems, compatible with ISA are as follows:

Legend Low/bad ★ Medium/normal ★★ High/good ★★★	**Safety relevance**	**Conduciveness for ISA**	**Compatibility**	**Market penetration**	**Cost/performance ratio**
Adaptive Cruise Control (ACC)	★½	★★½	★★★	★	½
Traffic jam assistant	★★	★	★★★	★	★½
Electronic Stability Programme (ESP)	★★½	★	★★★	★★½	★★½
Antilock Brake System (ABS) + Electronic brake force allocation (EBV)	★★½	★	★★★	★★★	★★★
Cornering Brake Control (CBC)	★★	★	★★★	★★	★★
Braking Assistant (BA)	★★½	★	★★★	★★½	★★½
Dynamic navigation	★	★★½	★★★	★★	★½
Automatic emergency call (ANR)	★★	★	★★★	★	★★★
Head Up Display	★★	★★½	★★★	½	½
Lane Departure Warning (LDW) and Heading Control (HDC)	★★	★	★★★	½	★
Concentration assistant	★★½	★	★★★	-	-[61]
Bend Lighting and Cornering Light	★½	★	★★★	★	★½

Table 10: Evaluation of ADAS[24]

[61] Comment: A rating of cost/performance at the concentration assistant is not possible yet, because the system still is in the development phase.

Remembering the traffic safety triangle (Figure 9) ADAS can be integrated into a simple model for perception and interaction between driver, vehicle and the environment.

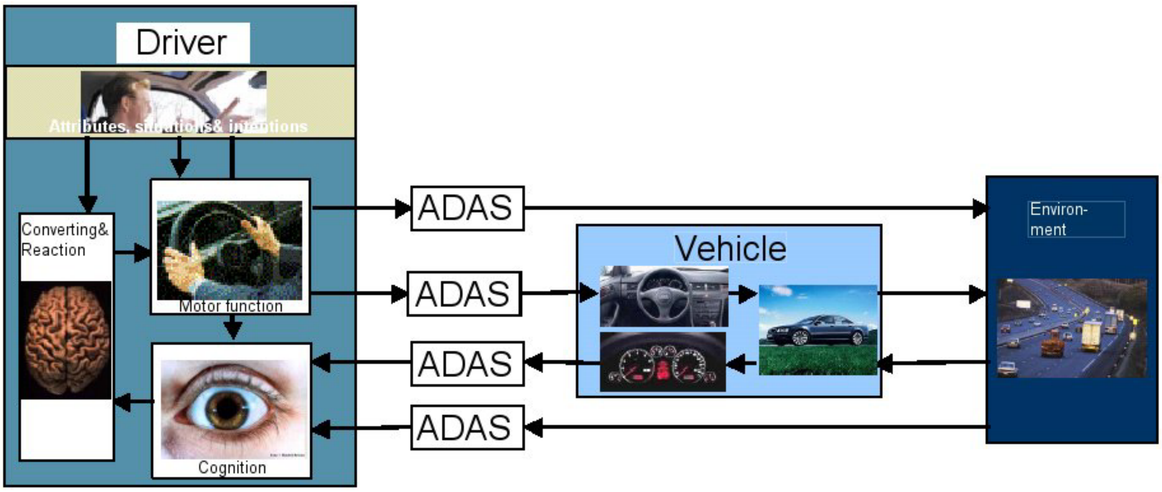

Figure 11: Perception model and placements for ADAS[62]

ADAS have most effect when the driver does not have to concentrate on the system itself but on the road situation. In this case it makes sense to create an open platform, on which every ADAS (including ISA) runs. The driver then has only one interactive display. Compatible technical solutions exist for all parts of the hardware – starting from the on-board-computer and ending with the HMI. Future ADAS requirements therefore only consist of software compatibility and continuous technical support (e.g. auto-upgrade functions).

Apart from technical problems during implementation, there may be effects on driving behaviour due to habituation effects. Drivers may tend to rely completely on the system's support qualities and could therefore make wrong decisions when a habitual situation differs. The latter problem will be discussed in chapter 7.3 and 7.4.

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[62] Source: Vollrath, Mark/ Lemmer, Karsten: Cognition of Driver´s Assistence Systems[G], in GZVB (editor): Automatisierungs- und Assistenzsysteme für Transportmittel, Workshop reader #4, p.93-106, Brunswick 2003

4 Methodology: Acceptance and strategies

It is first necessary to define a few terms. It has to be made clear that `acceptance´, `acceptability´ and `strategy´ have a certain meaning within this study. Furthermore, the terms `strategy package´ and `measure-mix´ will be used. These two terms have also to be defined.
`Acceptance´ and `acceptability´ will be used in chapters 6.1 and 6.2 for defining the basic conditions for ISA-implementation. `Strategy´ and `measure´ will be used in chapters 8, 9 and 10 for the description and background of the different scenarios.

Definitions and background

Acceptance: *"The action of consenting to receive or to undertake something offered"*[63] Acceptance in the sense of this thesis means – on one hand – the willingness of car drivers to use ISA-equipped cars. This basically includes certain types of car drivers with a positive attitude towards the technology. Nevertheless, within the scenarios (chapter 8) a guide to acceptance for all drivers – including the opponents - will be presented. On the other hand it means the willingness of the car industry to equip new or used cars with ISA modules.

Definition 2: Acceptance

Acceptability: Derived from acceptable "*able to be agreed on, suitable, adequate, satisfactory*"[63] Unlike "acceptance" meaning the act of consent, acceptability has to be reached before acceptance is gained. Therefore this is the more appropriate term for this thesis. The aim is to establish a certain level of public acceptability for speed limits and technical measures of traffic safety.

Definition 3: Acceptability

From chapter 6.1.1 to 6.1.3 the acceptability of the legal speed limits will be discussed. Willingness to adhere to the speed limits is indispensable for the acceptability of enforcing the speed limit through technical adaptation or at least by means of automatic reminders. Acceptability is therefore important for single measures apart from ISA.
(Psychological) reactance: Negative experiences with a system lead to a rejection of the system. Especially when a driver sets high expectations of the system's performance, a failure or lack of comfort related to the system leads to a strong attitudinal rejection. The personal feeling of freedom is affected. This effect is called (psychological) reactance[64]

Definition 4: (Psychological) Reactance

[63] Source: Hanks, Patrick/ Persall, Judy: New Oxford Dictionary of English, Oxford 2001
[64] Source: Brehm, Jack: A Theory of Psychological Reactance, Academic Press, New York 1966

Strategy: *“A plan of action or policy designed to achieve a major or overall aim“*[63]. Strategy in the sense of this thesis means the preliminary planning of single measures or a measure-mix. Different aims (e.g. traffic safety or economic benefits of car drivers) may require different strategies. Competitive measures cannot be merged into one strategy. A strategy always makes use of a least one single measure but usually more than one.

Definition 5: Strategy in the sense of this thesis

The definition of strategy is not sufficient to describe what has to be done for the purpose of the implementation of ISA. Therefore the term “strategy package” has to be introduced.

Strategy package: This means bringing about a consensus as a consolidation of different programmatic approaches and strategies for traffic safety considering ISA-technology. The intention is to implement and evaluate different strategies concurrently. This leads to a cost-benefit analysis and a verification of synergetic effects in order to combine all in to **one** common strategy package. In fact, competitive strategies may decelerate this process.

Definition 6: Strategy package

The differentiation of strategy and strategy package has another purpose: Specific effects of single measures have to be related to the linked strategies. The change of certain individual measures in a strategy may dictate the effectiveness of the whole strategy package. This means, if one or two strategies consisting of competitive measures are put together, this cannot have a proper effect and is therefore not a strategy package.

Single measure: *“A plan or course of action taken to achieve a particular purpose*“[63]. Single measures in the sense of this thesis are settled in the three traffic safety fields – the so called `Three E´s (i.e. Education, Engineering, Enforcement). Single measures are used in strategies or strategy packages.

Definition 7: Single measure

The use of single measures directly concerns the implementation of ISA. ISA itself is a single measure from the field of engineering. However, it is not able to function as a stand-alone measure. Therefore other measures have to be taken. Those are flanking and balancing measures (e.g. changes in law or assurance tariffs). As a matter of fact, measures concerning tariffs or taxes extend the “Three E”s to “Four E”s. The fourth “E” stands for `Economic aspects´.

Measure combination / Measure-Mix: A combination of measures exists if more than one single measure is necessary in order to fulfil an implementation strategy. The single measures then have to be co-ordinated. The related strategy will only succeed, if the effects of the measures are complementary and synergetic.

Definition 8: Measure-mix

Making use of more than one single measure does not automatically mean that it is about a measure-mix. The co-ordination and control of the intended effects is thus indispensable. Normally more than one actor is involved in traffic safety management. This means, that an independent controlling instance has to be nominated for co-ordination.

It is important to know, which groups play a role in the decision processes concerning traffic safety. Their attitudes towards ISA are of interest, as well as their acceptance of (speed) limits, technical innovations and surveillance. The design of the surveys and the conclusions are based on the attribution of the different statements. The following figure gives a short overview of the attribution process. Depending of the related importance, most of the groups mentioned are represented in the expert pool (chapter 4.1).

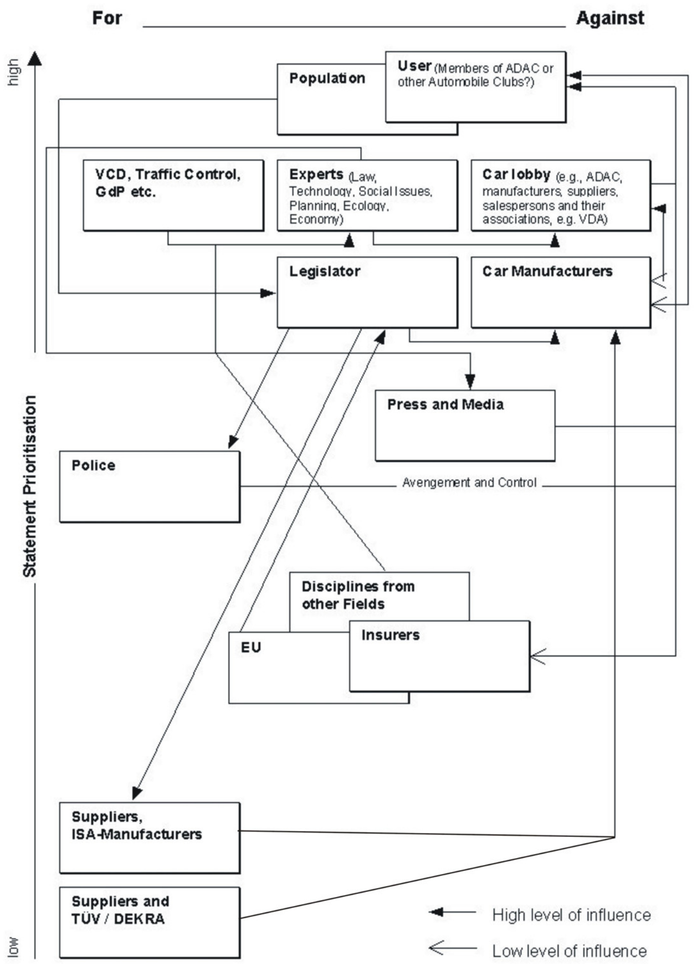

Figure 12: Groups involved in the ISA implementation process [design by the author]

It has to be made clear, that the "users" (or better, "road users") are part of the population and could be for AND against ISA depending on the situation. For example the same person has a different point of view when he or she is a pedestrian compared to when he or she is a driver[28,29,39]. The implementation of ISA therefore depends on how aware people are of the danger of speed. This question will be treated in chapter 9.2.

4.1 Expert pool

The expert pool for this study consists of 23 scientists (socio-psychological, medical, ecological and economic), practitioners, international project partners from the PROSPER consortium, representatives from two different pressure groups, from the car industry and politics. Each person has a certain interest connected to ISA. **Experts in bold letters** have written a publication for the Green edition #63 "Intelligent Speed Adaptation – expert statements", which was partly edited by the author. *Experts in italics* were interviewed face-to-face or by telephone by the author. Some of the experts were in regular contact with the author after the interview. "No demand" means that the experts wrote a publication without being interviewed beforehand.

Institution/Science	Name	Publication	Interview/attendance	likely recommendation	neutral	likely denial
Sociology	**Mrs. Spellerberg**	yes	face-to-face	■		
Behaviour research	**Mr. Erke**	yes	no demand	■		
Psychology	*Mr. Schlag*	no	durable contact	■		
Ecology	**Mr. Tobias**	yes	durable contact	■		
Political economics	*Mr. Feser*	no	face-to-face	■		
Marketing	**Mr. Müller-Merbach**	yes	face-to-face		■	
Traffic education	*Mr. Formann*	no	telephonical		■	
Accident research	*Mr. Köppel*	no	telephonical	■		
International transportation expert	**Mr. Varhelyi**	yes	durable contact	■		
International transportation expert	*Mr. Carsten*	no	durable contact	■		
Police (trade union)	**Mr. Marker**	yes	telephonical	■		
Legislature	**Mr. Kaufmann**	yes	no demand		■	
Law (practical)	**Mr. Feldges**	yes	no demand		■	
Law (scientist)	*Mrs. Gesmann-Nuissl*	no	face-to-face			■
Pressure group VCÖ	*Mr. Rauh*	no	telephonical	■		
Pressure group ADAC	*Mr. Stock*	no	telephonical			■
Technical inspection and supply TÜV	*Mr. L. Oswald*	no	face-to-face			■
Car hiring companies BAV	*Mr. Langmann-Keller*	no	face-to-face			■
Car manufacturer VDA	*Mr. Dicke*	no	face-to-face			■
Car manufacturer DaimlerChrysler	*Mr. Nicolai*	no	telephonical			■
Car manufacturer BMW	**Mr. Huß**	yes	face-to-face (with Mr. Naab/Bujnoch/Scholten)		■	
Media	*Mr. Link*	no	telephonical		■	

Table 11: Expert pool

Human factor scientists: The focus of this thesis lies in acceptability aspects and human points of view. The social and psychological background of behaviour in one of the most frequent every day situations – traffic – is very important understand, in order to learn about the consequences and effects of different measures concerning traffic regulation and law treatment. Further aspects concerning cognitive abilities, accident effects and HMI requirements are of interest.

Global cause-effect scientists: Aims of speed management are closely related to their economic effectiveness. Research has to be done on costs and benefits of measures – especially ISA. Negative effects of speeding consist of a lack of traffic safety as well as social and ecological impacts. The prevention or compensation of negative effects and the main and side effects of the different strategies, measures etc. have to be shown.

Traffic safety practitioners: Infrastructural and educational traffic safety measures are a result of empirical research and trials. Speed management is a measure-mix. Synergies and effectiveness of the different methods therefore have to be checked.

ISA experts from SUNflower states: ISA research and traffic safety strategies are most heavily promoted by planners from the Sunflower states. Experiences with different programmes and acceptability is important for knowledge transfer into the German implementation strategy.

Legislative and executive representatives: The main argument against ISA is the problem of liability. Drivers liability stands in a contrast to product liability. The solution to this problem as well as the legal aspects of ISA implementation have to be found out.

Pressure group representatives: Like in every political discussion, lobbyism plays a major role. Pressure groups like automobile clubs and traffic safety clubs each have a certain interest. Political statements of these groups have a high importance because of the broad public attention paid to them.

Representatives from car industry and related institutions: The automotive industry has to be convinced of the economic benefits of ISA. Their basic attitude towards ISA and ISA-beneficial ADAS decides how far the way to implementation is.

Media and public relation: Media (TV, radio and newspapers) distribute information on accidents, car traffic and new automotive technology. Although most of the broadcasting and newspaper companies (state-run and private) agree in being politically neutral (at least this is stated on the front page), valuing statements and “sensationalism”[12] appear very often. As a consequence, a lack of sophisticated exposure to traffic safety exists. However, some editors of traffic-related TV broadcasts and newspaper articles emphasise their motivation to being neutral and safety-conscious.

Working with the expert pool started as follows:

Firstly, every expert within the pool was interviewed either personally or by phone. The only exceptions were those experts directly related to the PROSPER project (Chapters 0, 1.6 and 4.2). The second step was a collection of written statements by each of the ISA experts from the point of view of the institution they represented. These statements are collected into an anthology, published in green edition of imove. In parallel the website “www.isa-research.info“ was created as a portal for information and discussions concerning ISA. Every expert was connected to that website, but the feedback on the discussion forum was very low. The platform was nevertheless used for downloading up-to-date information on the project. The results of these two steps, the evaluation of the stakeholder survey (chapter 4.2) and the feedback from the website lead into the different scenarios (Chapter 8).

Most of the interviewed experts had a positive or neutral opinion towards ISA versions 1 and 2. The only exception was the representative from the German Association for car industry (VDA), who generally refused the technology. Version 3 was stated as the only proper solution for a noticeable reduction of speed-related accidents. However, the danger of accidents because of a system failure, as well as negative effects of reactance and habituation were stated. The benefits of ISA would be a reduction of accidents, ecological problems and an increase of traffic homogenisation and social interactions. Potential economic benefits are seen for the car manufacturers, their suppliers, car fleet owners and local authorities. The results of the interviews and the statements were directly interlaced into the synthesis and framework of this thesis (chapters 5,6 and 7). The dates and interview partners as well as the expert statements used from the green edition can be found in the table of sources.

4.2 Stakeholder survey

"*The purpose of this task is to obtain more detailed opinions on speed management and ISA from interested stakeholders: what are the main arguments for and against different ISA applications and deployment scenarios? What kind of implementation scenario is preferred? Is there a correlation between the stakeholder groups and the chosen scenarios?*"[65]

Two questionnaires were managed as a DELPHI-survey among five groups of determined stakeholders (political, governmental, scientists, pressure groups, commercial companies). A policy DELPHI survey is interactive and anonymous. It is based on a written questionnaire where feedback and comments play a big role. The survey was arranged in Germany, the UK, Sweden, the Netherlands, Hungary, Spain and Belgium. The co-ordination was done by Langzaamverkeer in Belgium. The author organised the German part of the survey.

First questionnaire

The first DELPHI round started in March 2003 with a so-called stakeholder analysis, in which every possible institution out of the five groups were first detected, then contacted. In total of 741 (Germany: 128) stakeholders were contacted of which 307 (45) answered. Figure 13 shows the participation by group.

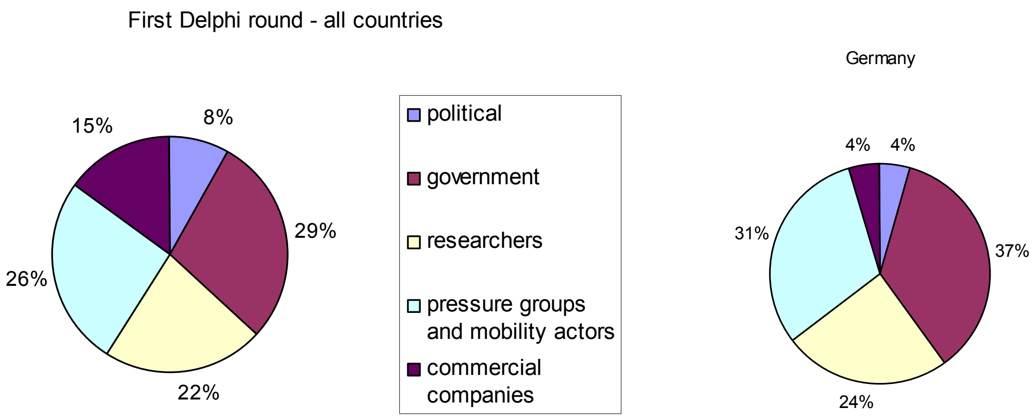

Figure 13: Participation on the first DELPHI-round

The low rate of politicians participating is due to the fact that the political parties often have no particular representative for transport issues. One can see a big difference between the participation from commercial companies. In the Netherlands 24% of 58 in total were representatives of com-

[65] Comment: Cited from the framework for work package 2.1 of the PROSPER-project

mercial companies. The low rate for Germany is due to the fact that many representatives of commercial companies – especially in the automotive branch – refused to answer because of their workload. Note: Three of the contact persons declined to take part because of a possible "*loyalty conflict"* with their supervisors or companies. All of them were representatives of car manufacturing companies. The aim of the first round was to find out tendencies and attitudes towards ISA and its implementation. Most of the questions concerned the benefits and effects of ISA. The results of the first round lead to the verbalisation of six scenarios. The scenarios are described below.

Results of the first questionnaire[66]

The stakeholders were asked how ISA contributes to policy objectives concerning traffic safety, reduction of environmental impacts and traffic homogenisation. More than 93% of all stakeholders agreed that ISA is beneficial for the reduction of deaths and injuries through car accidents. 77.7% agreed that ISA is able to reduce the environmental impact. And surprisingly, far more than 50% of the stakeholders agreed that ISA could increase road capacity and the driving comfort. However, German stakeholders – unlike the European average – did not agree to the latter two hypothesises. Road safety (97%) and environmental protection (80%) are the most commonly stated reasons for implementation of ISA. This goes along with the presumed effects of ISA. The presumed reactions of drivers on the system would be:

- Counteracting
- Frustration
- Misbehaviour apart from speeding (short distances and risky overtaking).

However, from the stakeholders' point of view, the system does not cause additional workload.
Target groups for ISA are professional drivers (22%), speed offenders (31%) and novice drivers (21%). Nevertheless, the stakeholders agreed with the hypothesis that ISA should be targeted at all drivers (79%). The question of the vehicle type to be likely equipped with ISA yielded a similar result. 77% of the stakeholders stated that all vehicles should be equipped if ISA is implemented. Freight transport and buses (together 45%) were also stated.
The implementation should be done for all road types (57%), at least for roads within built-up areas (38%) but less important is the implementation on motorways (19%).
The stakeholders were asked what barriers could hinder the implementation of ISA. The drivers' acceptance, partly derived from the perception of infringement of personal freedom as well as the problem with liability were most commonly stated. Other reasons, like prices, image making process and technical issues were understood as being manageable.

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[66] Source: Beyst, Veerle: PROPSER – Final Report on Stakeholder Analysis, External Deliverable D1, Gent 2004

Second questionnaire

In the second questionnaire the participants of the first round were confronted with six implementation scenarios developed by the Belgian project partner, taking the results of the first round into account. Each of the scenarios got a name for further evaluation. These names are stated as bold words. The scenarios are as follows:

Scenario 1 is developed from the point of view of **equity** for everybody. In this scenario a half-open ISA system is a standard device in every car and as such it is mandatory. Dynamic speed information from all road types is available from a central server in a traffic management centre. The speed limits will change according to traffic conditions (congestion, accident), weather (heavy rain, darkness, snow, ice, fog) and spatial characteristics (residential areas, schools, junctions, dangerous curves).

In **scenario 2**, ISA will be used as a **punishment** for speed offenders and drivers who caused a severe accident due to excessive speed. A closed ISA system will be installed in the driver's vehicle temporarily (for example a year) and speed data and mileage will be logged while driving this vehicle. The police (or the court of justice) evaluate the use of the system after the period of punishment. Other drivers can voluntarily use an ISA system and get a reduction in insurance fee and road taxes.

In **scenario 3**, ISA will be used as an **educational** tool. All persons learning to drive will have to use a half-open ISA system that is installed in the vehicles of the driving school. They will also have to install the same system on their own practice vehicle at home. The government owns the systems and provides them at a low price to the learners. When they pass their driving test and have their driving licence, they will still use the ISA system in their own vehicle for a year. Other drivers can voluntarily use an ISA system and get a reduction in insurance fee and road taxes.

In **scenario 4**, professional drivers will use ISA. **Professional drivers** have a major responsibility for the (dangerous) goods or the passengers they transport. Besides, these drivers are a high-risk group due to their long presence in traffic and their exposure to accidents. The ISA works on all road types. Other drivers can voluntarily use an ISA system and get a reduction in insurance fee and road taxes.

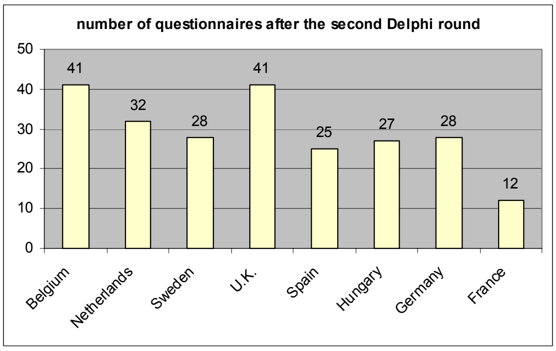
Scenario 5 focuses on **conflict** situations. ISA will be installed on all vehicles and will be used on road types where vulnerable road users are present. There will be an evolution in the spatial application of ISA. In a first phase it will be used in the most vulnerable areas where children play and people walk and cycle. Then the use of ISA will be extended to 50 km/h roads and urban roads. In a second phase ISA will be used on all road types. There is an opt-out function that will only work on roads of a higher category (rural roads).

In **scenario 6**, ISA is part of a major telematics platform in the car. On the platform different services are available to increase the customer's **comfort**: Intelligent Speed Adaptation (warning or intervening), route guidance and navigation, adaptive cruise control, traffic information service, collision warning and avoidance, lane departure warning, emergency call (when pushing a button, the emergency services are informed directly when an accident happens and vehicle data will be send to the emergency services) etc. The driver can choose to use one or several services and all necessary data will be downloaded from a central server in a traffic management centre. No incentives will be given for the use of these services.

The stakeholders additionally had the chance to create their own scenarios or at least give comments on the six scenarios presented.
The stated scenarios (developed by Veerle Beyst) are taken into account for the development of the author's implementation scenarios in chapter 8, but not for the "non-implementation"-scenario. The latter takes the compensating measure-mix into consideration.
In addition, the participants were asked about the environmental and economic benefits of ISA. That was just a feedback for the answers of the first round.

Results of the second questionnaire

The stakeholders of the first round were confronted with the scenarios. However, some of the participants of the first round refused to participate twice. A few persons forgot to fill in the second questionnaire before the expiry date of the survey.



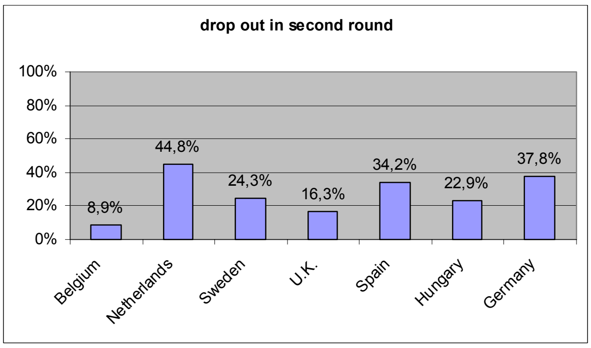


Figure 14: Participation on the second round

The participation and dropout were nearly the same throughout Europe, so that it indicates no significant change of consideration per country. France did not take part on the second round.
Figure 15 highlights the composition of the stakeholder groups. The percentage of participation per group is almost the same as in the first round (Figure 13). There is no significant change in the general attitudes towards ISA.

Figure 15: Stakeholder groups in the second round

The first question of the questionnaire concerned environmental effects of ISA. The stakeholders had the chance to agree or disagree on various statements. Most of the stakeholders (77%) agreed that ISA will lead to a decrease in emissions of harmful exhaust gases. However, even more stakeholders (81%) disagreed that ISA would be the most effective measure to gain that effect. Thus, traffic safety is the first and only reason to implement ISA. Nevertheless, beneficial side effects on environmental protection should be mentioned when presenting ISA on the market.

In the second part of the questionnaire, the stakeholders had to evaluate the presented scenarios from different point of view. They also had the chance to create and evaluate their own scenario. The scenarios were evaluated as follows:

Item	**Scenario with highest mean score**
Contribution to safety	Scenario 1
Contribution to the environment	Scenario 1
Contribution to a reduction in congestion	Scenario 1
Technical feasibility	Scenario 4
Juridical feasibility	No significant difference between scenario 3, 4 and 6
Public acceptance	Scenario 6
Political acceptance	Scenario 6

Table 12: Overview per item of the scenario that scored best

Scenario	Item with the highest mean score
Scenario 1	Safety
Scenario 2	Safety
Scenario 3	No significant difference between public acceptance, political acceptance and safety
Scenario 4	No significant difference between technical feasibility and safety
Scenario 5	Safety
Scenario 6	Public and political acceptance

Table 13: Overview per scenario of the item with the most positive evaluation

Scenario 1 was the preferred scenario for nearly all participants except for those in Hungary. The German results were similar to those of other countries. The only exception was the very positive evaluation of scenario 4 (professional drivers), which was the highest in Europe. Figure 16 highlights the preferred scenario per country.

Equity = scenario 1; Punishment = scenario 2; Education = scenario 3; Responsible professional drivers = scenario 4; Conflict = scenario 5; Comfort = scenario 6

A few of the stakeholders chose their own scenario (= own scenario) or did not state any preference (= none).

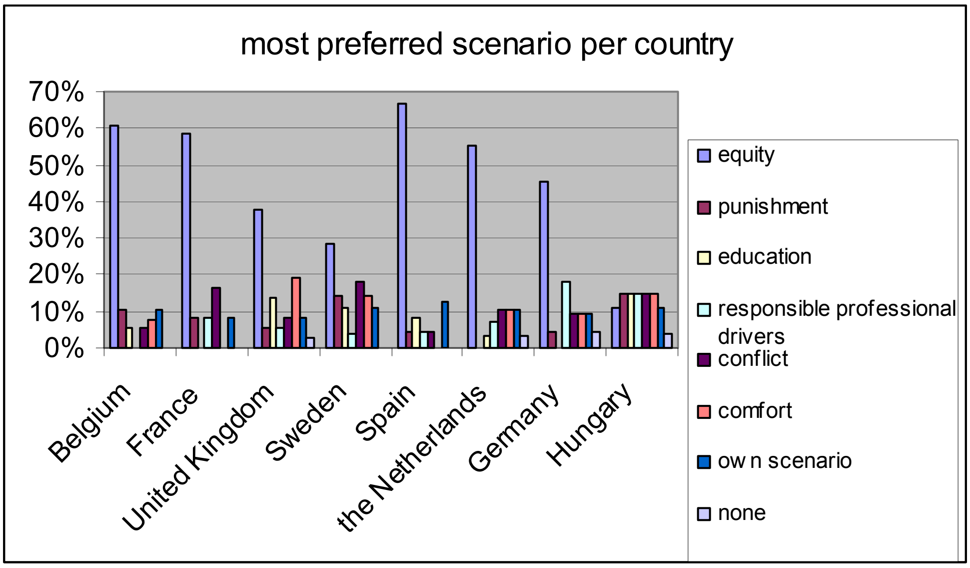


Figure 16: Most preferred scenario per country

These results lead to the conclusion that implementation of ISA should be done through market channels with support from various changes in the law. The mandatory use of ISA is the basic condition for noticeable effects, mainly on traffic safety, but also on environmental protection. This could only be realised if the equipment with ISA is technically feasible and no other problems (e.g. product liability) thwart the process. Nevertheless, ISA is seen as part of a new technology for cars.

This means that the equipment of new cars with modern ADAS and the related telematics platform might automatically include ISA. Retrofitting might be a major problem concerning technical feasibility. The estimated time period for implementation of ISA (result from the first round) is therefore rather high. The introduction of the open systems (i.e. version 1) will start in 2006, mandatory use of the closed system will start in 2015 at the earliest (Table 14).

	Belgium	U.K.	Sweden	Spain	Netherlands	Germany	Hungary	Total
	Mean	Mean	Mean	Mean	Mean	Mean	Mean	Mean
closed installed in new vehicles	2032	2013	2016	2010	2011	.	2014	2015
half-open installed in new vehicles	2008	2011	2009	2007	2009	.	2011	2009
open installed in new vehicles	2007	2010	2007	2006	2008	.	2009	2008
closed mandatory in all vehicles	2036	2019	2022	2011	2015	.	2019	2020
half-open mandatory in all vehicles	2030	2018	2016	2010	2013	.	2015	2017
open mandatory in all vehicles	2034	2015	2014	2010	2011	.	2012	2016
closed voluntary in all vehicles	2030	2016	2015	2008	2013	.	2018	2017
half-open voluntary in all vehicles	2007	2014	2009	2007	2009	.	2015	2010
open voluntary in all vehicles	2006	2009	2007	2006	2008	.	2010	2008
installation new vehicles (Germany)	.	.	.	.	.	2008	.	
mandatory use (Germany)	.	.	.	.	.	2013	.	
voluntary use (Germany)	.	.	.	.	.	2010	.	

Table 14: Mean year of introduction of ISA

4.3 Questionnaire during speed enforcement actions

The survey was carried out by imove supported by the police department of Ludwigshafen. The study area was located in eastern Rhineland-Palatinate. The questionnaires were accomplished in May and June 2003 on ten days[25]. The enforcement actions were made during the morning and the early afternoon. After the end of the control and penalty action done by policemen, two student assistants of imove approached the offenders' cars and asked whether the person was willing to take part in the questionnaire. The interview took approximately 10-15 minutes and was designed as multiple choice questionnaire plus documented comments. 57 persons (46 male 11 female) took part on the first round. Every attendant was asked if he or she was willing to take part in a second round after a period of 6 months; 44 persons agreed and 13 persons declined. In November and December 2003 a second questionnaire was carried out among the people from the first round. This time the questionnaire was designed as a phone interview. 31 persons took part in the second round. 13 persons could not be contacted.

The average age of the participants was 46 years. The number of young participants was very low due to the fact that the questionnaires were all accomplished during the morning/early afternoon, when young divers usually are in school or at their training post. Most of the participants were alone in their car. 65% of the persons were member of an automobile club.

Data concerning engine power of the participants' cars was also collected. The average engine power was 81 kW (110 hp). A few of the participants also took part in the reaction test in the "traffic safety mobile". The participants described the policemen as polite and the whole action as useful and instructive concerning the objective danger of speeding. The statistical overview of the attendants' speed limit exceeding (i.e. driven speed minus legal speed limit) is shown in Figure 17.

Minimal exceeding = lowest measured value of exceeding; average exceeding = overall average value; maximal exceeding = highest measured value of exceeding.

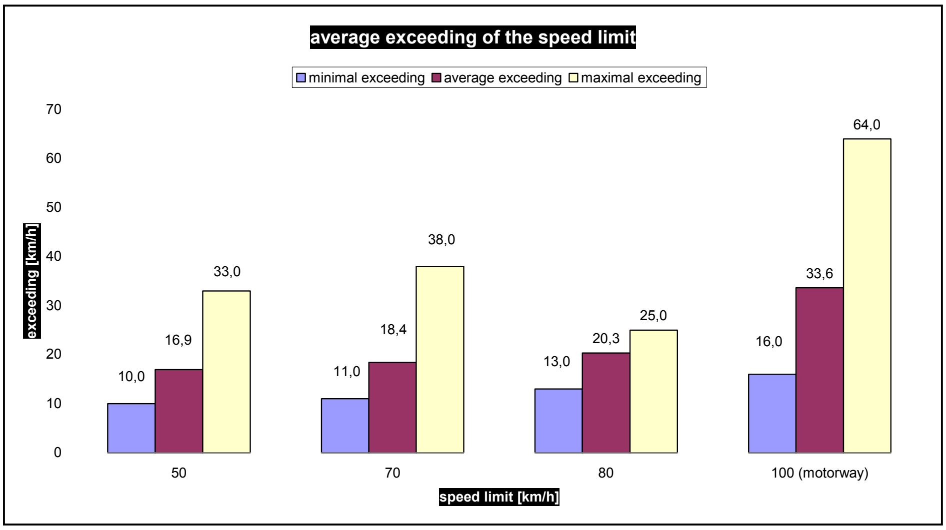


Figure 17: Average exceeding of the speed limits

The persons were asked how they would define “speeding” (Figure 18) and what degree of exceeding speed limits would be tolerable (Figure 6 page 19). The results show that a speed of 20 km/h above the speed limit is considered tolerable (chapter 1.3).

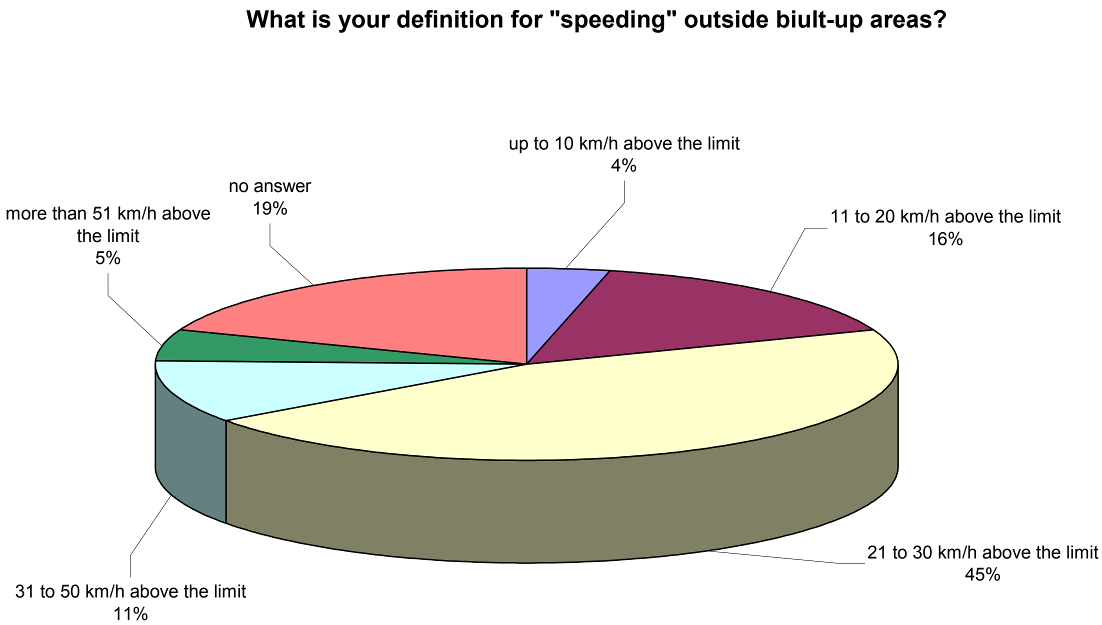


Figure 18: Definition of "speeding"

In the second questionnaire, the participants were asked about “tolerable” exceeding of speed limits.

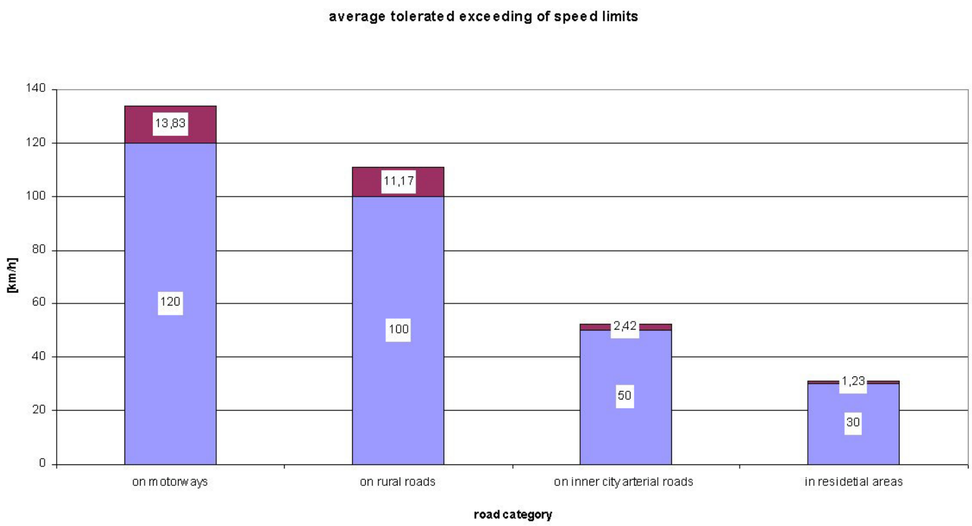


Figure 19: Average tolerated exceeding of speed limits

The results show a different point of view. The tolerances for exceeding are by far lower than the speeding thresholds. Nevertheless the participants’ own behaviour showed “intolerable” excesses (Figure 17).

The participants were also asked how they would qualify their own driving abilities. Most of the drivers defined themselves as very good or good drivers. The values decreased in the second questionnaire (Figure 20).

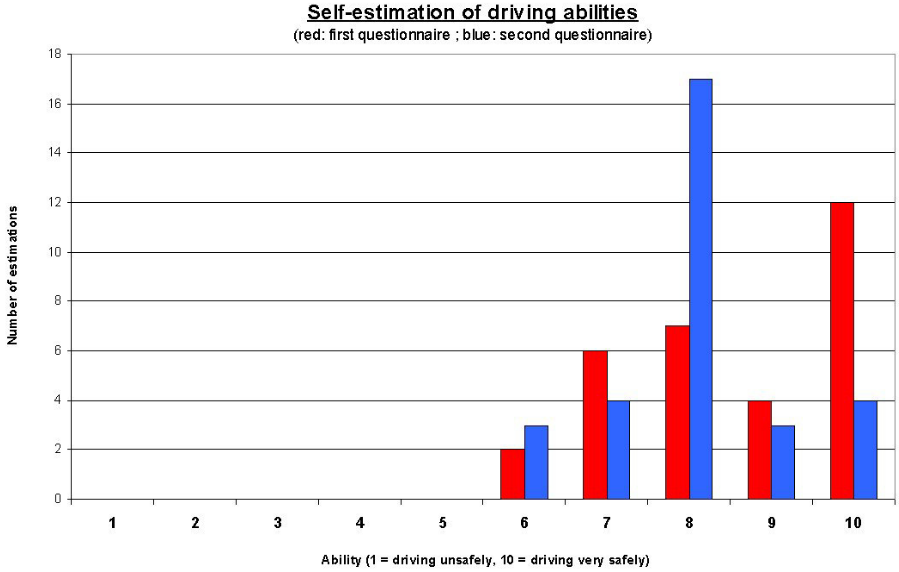


Figure 20: Self-estimation of driving abilities

The most important question was whether the participants comprehend their speed choice as misbehaviour and if they are aware of the danger related to driving at a high speed. The participants were confronted with the "theoretical collision speed" and the related likeliness of killing a pedestrian.

The theoretical collision speed takes into account that a driver has to make an emergency brake application in front of an obstacle (e.g. a pedestrian) starting from two different cases of driven speeds. Case 1: The driver obeys to the speed limit. The vehicle will come to a standstill in front of the obstacle. Case 2: The driven speed is above the speed limit. The vehicle will hit the obstacle with a certain speed. This is the "theoretical collision speed".

Definition 9: Theoretical collision speed

The participants had to guess the theoretical collision speed in the case of their own excess of speed. None of the participants was able to explain the theoretical collision speed. Everyone underestimated the value by far. Even in the second round – remembering the explanation – the participants underestimated the values. Afterwards, the participants were confronted with the value of likeliness of killing a pedestrian at the theoretical collision speed.

The values are as follows:

(Minimum/maximum = derived by the lowest/highest measured exceeding etc.):

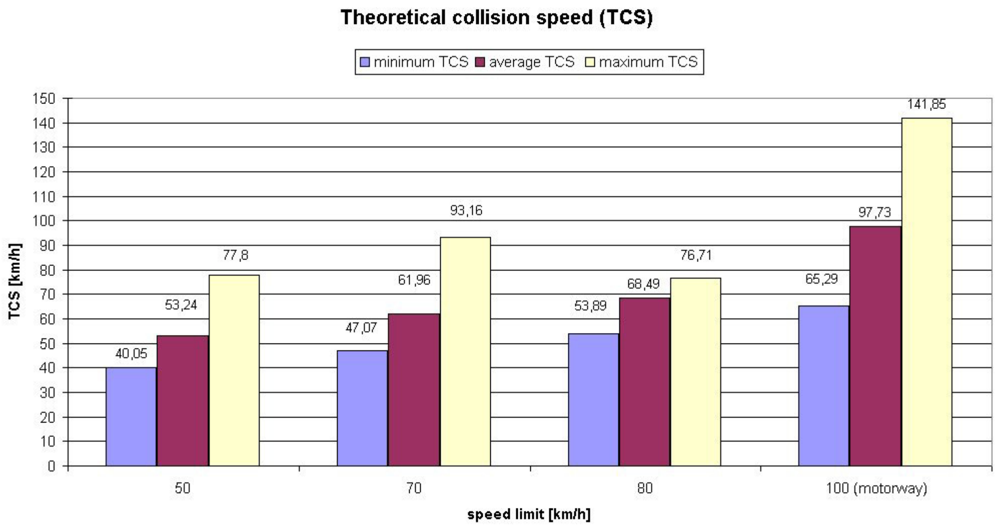


Figure 21: Theoretical collision speed

The drivers first had to estimate the TCS values and then were confronted with the calculated value. After that they were confronted with the calculated likeliness of killing a pedestrian. In both cases the drivers were visibly astonished.

(Minimum/maximum = derived by the lowest/highest measured exceeding etc.)

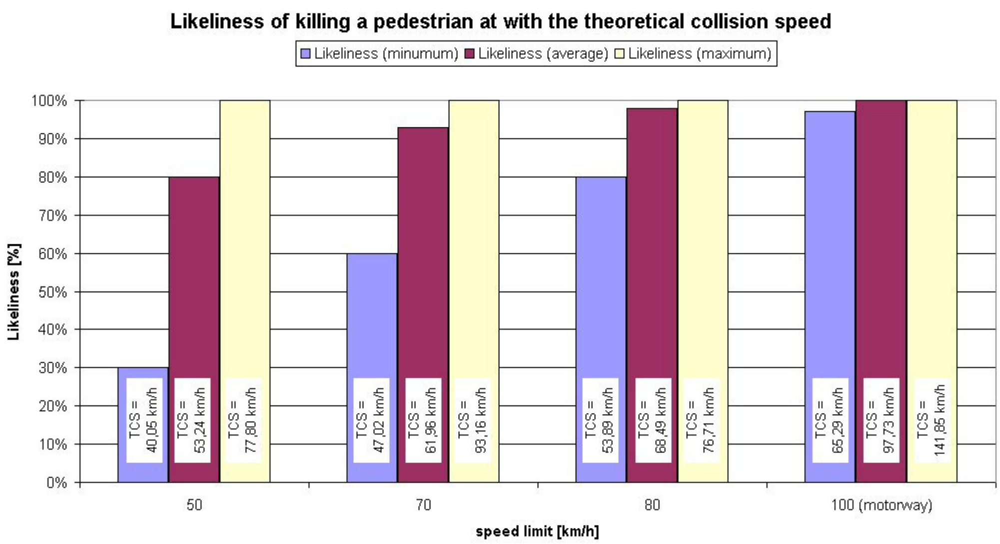


Figure 22: Likeliness of killing a pedestrian

4.3.1 Attitude towards ISA

The participants were asked about their attitude towards ISA-systems. None had heard about the technology before. The evaluation of the three versions is based on the explanation through the student assistants. The acceptability of ISA is derived from the estimated level of constraint (Figure 23). The results comply with those of a small size questionnaire among students (Figure 24).

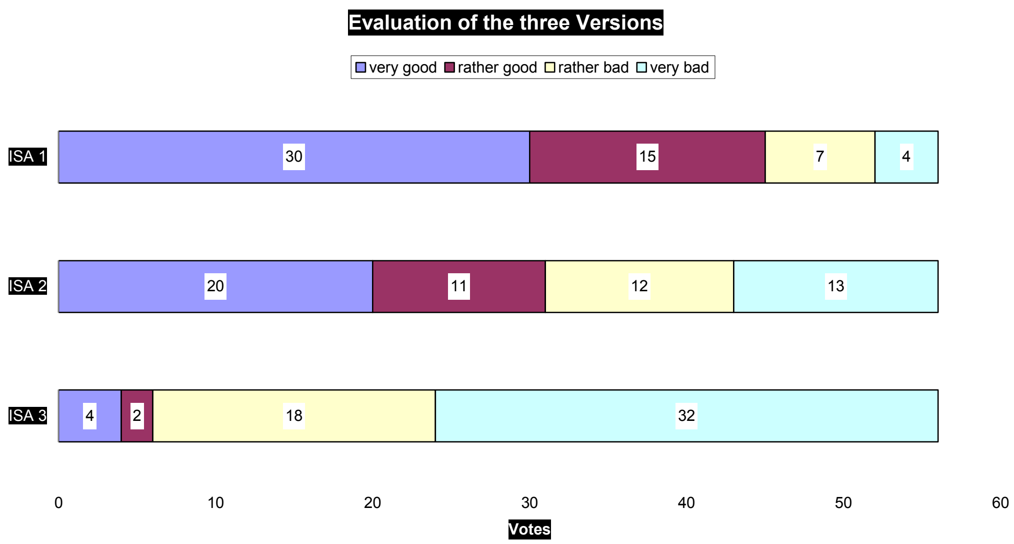


Figure 23: Subjective evaluation of ISA[25]

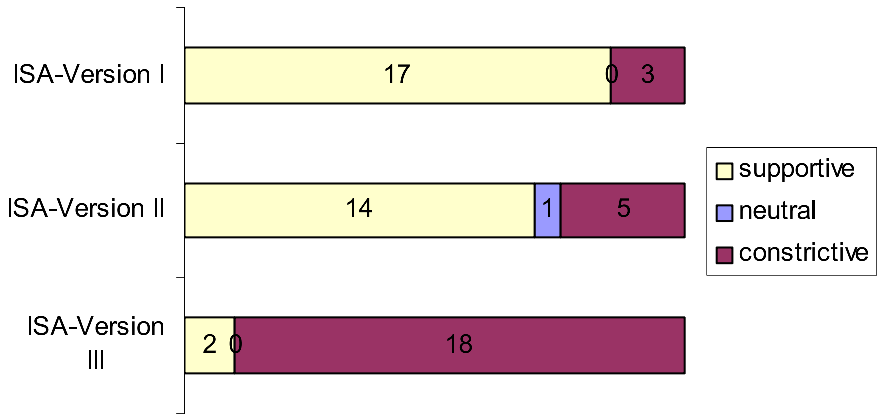


Figure 24: Subjective evaluation of ISA – personal benefits[24]

The acceptance of ISA Version 1 and 2 is rather high in all questionnaires. These results correlate with the pre-trial results of the Swedish[78] and British[43] surveys. So the basis concerning acceptability of ISA technology is the same. Nevertheless, a field trial in Germany would be sensible in order to confront the public with the technology itself in practice.

In the second round, the participants were asked if they would accept an ISA-system in their car. Most of the participants accepted ISA. However, the level of constraint plays the biggest role in the decision of which ISA system would be preferred.

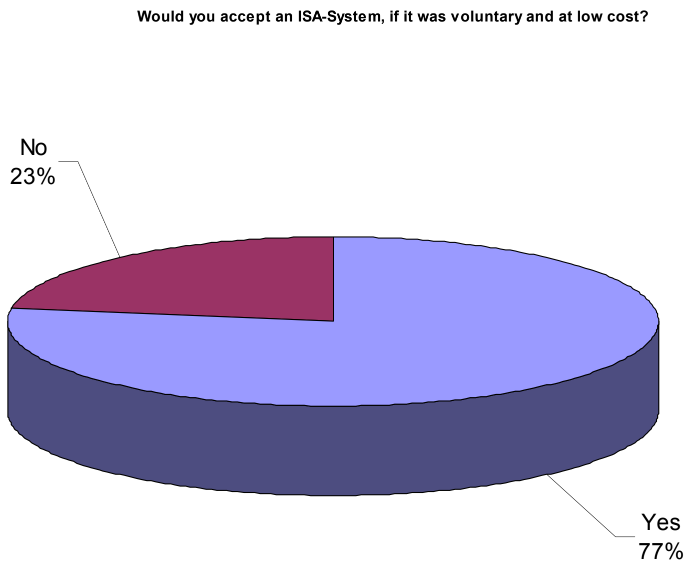


Figure 25:Acceptability of ISA[25]

Finally, the participants were asked which version they would prefer if they were forced (e.g. by law), and if they would keep the speed limits when using the system. Again, Version 1 was preferred. However, some of the participants stated that if ISA was implemented by law, the third version would be the most sensible one.

	Which ISA version would you prefer, if you were forced to choose?					
	Version 1		Version 2		Version 3	
Amount	18		8		5	
Proportion	58%		26%		16%	
	Would you keep the speed limit with the chosen ISA system?					
	Yes	No	Yes	No	Yes	No
Amount	9	9	3	5	5	0
Proportion	50%	50%	37,5%	62,5%	100%	0%

Table 15: Evaluation of ISA if implemented by law

4.3.2 Conclusion

The results of the survey are the basis for the estimation of acceptance (chapters 6.1 and 7.3). It is of importance for the implementation strategy and the choice of flanking measures (chapters 7.1, 8 and 9.2.3). However, the results of the survey have to be relativised. 12 of the 31 participants of the second round stated they would “always” accept speed limits. 11 accept them when a reason is stated on the road sign. Nevertheless, every single attendant exceeded the speed limit (some of them by far). This contradiction can be explained through conscience conflicts when talking about traffic danger and fatal accidents. The awareness of oneself being a danger for others is normally latent. Thus, confronted with the particular situation, people will rather answer from an ethical point of view than to express their honest opinion. However, the acceptance of the enforcement measure itself and the educational background concerning the danger related to speeding was really high. The methodology of stopping the people directly and confronting them with their misbehaviour has large effects on acceptability for surveillance. In spite of single answers being derived from a subjective ethical duty, the attitudinal aspects towards ISA and enforcement actions, as well as the described lack of awareness, can be taken most seriously.

5 Evaluation of user demands

Car users are influenced by three main attributes while driving: 1. The main aim of driving, which can be as simple as “coming home after work” or rather complicated like “just cruising in order to reflect on something”. 2. The subjective cognition of comfort and entertainment, where speeding thrills could play a role. 3. The subjective cognition of safety, which could be totally different to the objective danger connected with the driving manoeuvres. Further attributes depend on the exact physical and psychological situation of the driver. E.g. businessmen tend to “work” while driving (e.g. making phone calls), housewives tend to plan their next steps between their house, the supermarket and so on. Thus, trip purpose and speed behaviour are correlated. In addition, several attitudinal aspects of drivers can be abstracted as driver types (chapter 5.1). There are also differences in driving behaviour (chapter 1.2) and attitude (chapter 1.3) when passengers are in the car. The influence of passengers on the driver depends on their age, their gender and their relationship to the driver[67].

The exact user demands on driving performance and infrastructural supply can therefore be derived from the following attributes:

- ⇨ Trip purpose and daytime
- ⇨ Road category
- ⇨ Driver type and passenger attributes
- ⇨ Automobile attributes

Instruments of traffic safety like ISA and the self-explaining roads have to take this into account.

5.1 Types of road users

Everyone with a certain aim related to a road is a road user. This includes all transport systems (cars and motorbikes, trucks, public transport, bicycles and pedestrians) and all uses at the road side (street cafés, market places, residential zones, parks). Every road user has a certain attitude to his behaviour and the actions of the other road users. However, it is the behaviour of vehicle users and their attitude which is of interest in this context. In chapter 1.3 the psychological framework of speeding is described.

Not every driver speeds, and those speeding do not do so in the same way, so a differentiated point of view towards speeding has to be found. On one hand the driver himself has to be characterised, while on the other hand the transaction between the driver and the environment have to be characterised. Thus the effects of misbehaviour have to be shown by road type and situation. German local authorities and police departments do one-year evaluations of accident occurrence. This results in statistical accident maps in order to check where, when, and for which reasons accidents occur. In road situations with high speed traffic interactions (e.g. rural road crossings) the danger of accidents is very high. These situations are called “black spots” (localities with high accident or conflict rates). Since the late eighties the traffic safety policy has aimed to defuse the related dan-

[67] Source: Silcock, David/Smith, Kim/Knox, Duncan/Beuret, Kristine: What Limits Speed? Factors that affect how fast we drive, Interim Report, London, 1999

ger through speed limits and redesign. But still approximately 1/3 of all injury accidents occur at black spots[8], which means that these objectively critical situations are not recognised properly by the driver.

5.1.1 Behavioural segmentation

A study divides drivers into six categories, named after the outstanding characteristics of attitude and driving behaviour[68]:

1. “Functional” (19% of all drivers)- often exceed speed limits by 10 km/h
2. “Anxious” (17%)- never exceed speed limits but show unpredictable reactions to driving manoeuvres of others
3. “Composed” (16%)- often exceed speed limits by 20 km/h but take care to observe of “sensible” local speed limits
4. “Careful” (16%)- exceed speed limits rarely
5. “Speeding” (15%)- see driving as sport, exceed speed limits as far as possible. In addition, “speeding” people define and perceive “borderline situations” differently to the objective average.
6. “Frustrated” (17%)- have the same attitude as the “speeding” category, but not the equipment (i.e. a high performance automobile). “Frustrated” drivers are aggressive and cramped.

The misbehaviour of the driver types “speeding” and “frustrated” is relevant for all road categories. The misbehaviour of all others, especially the “composed” and the “functional” drivers is of special interest concerning trunk roads and rural roads. On these road types, the lowest acceptance of speed limits and the highest number of accidents coincide (as stated in chapter 1.2 and 1.4). Rural roads are the most dangerous roads concerning complexity of local situations and severity of accidents (chapter 1.4). There is a broad lack of awareness concerning the cause-effect-relationship between the objective situational danger combined with high speeds and the likeliness and severity of accidents. This lack can be observed throughout all driver types[25].

ISA advertisement will not be the right way to deal with this problem. Hence, large scale educational measures, and the involvement of the media in the process will have much more effect (chapter 2 Table 9). Road users have different points of view depending on whether they are drivers or other road users (chapter 4 Figure 12). The knowledge and cognition of the desires and actions of other road users would influence decisions for driving manoeuvres. However, in reality is different: Attitudinal aspects towards driving interactions – especially attitudes related to the perceived driver (stereo)types – undermine mutual considerateness[21].

The latter hypothesis is particularly valid for the “anxious” and the “frustrated” driver categories, because their point of view is dangerously influenced by misapprehension.

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[68] Source: Adelt, Peter/ Grimmer, Werner/ Stephan, Ekkehard: Types of drivers on German roads[G], Bremerhaven 1999

5.1.2 Social segmentation

Potential ISA-users can be divided up into various subgroups (Figure 26). Every step of segmentation requires differentiated arguments towards ISA. For example: private drivers are likely to be-more interested in the safety performance of ISA, whereas professional drivers might be more interested in the functionality of a system. The aim is to persuade at least a few persons out of the most adequate user groups to use an ISA system.

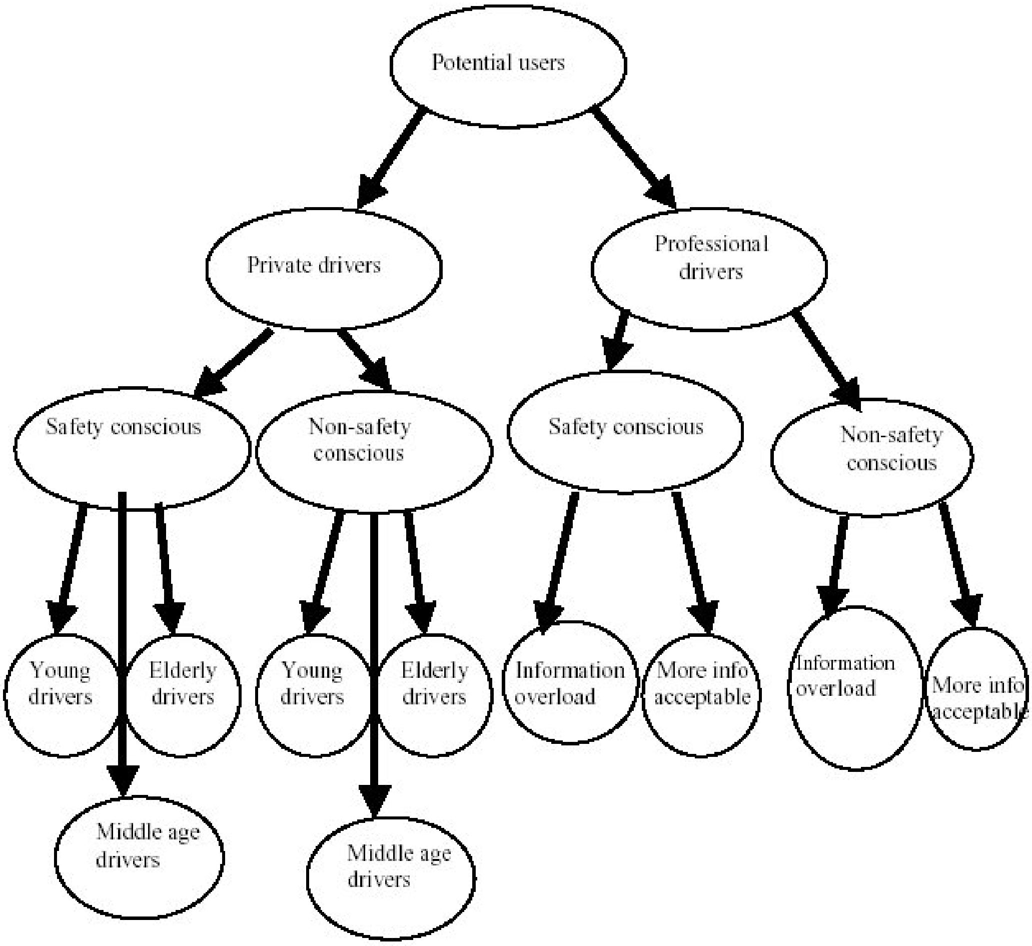

Figure 26: Segmentation of potential ISA-users[72]

The first persons who are persuaded to use ISA are called "early adopters". They report their experiences to others, so that "slow adopters" find interest in the technology[72].
Early adopters are attracted by the novelty and the utility of a product. They are therefore open to innovative technical features. Conservative people can be convinced by the utility of a product, as long as it is proven and they recognise a utility for their own purposes.

5.2 Speed management and marketing methods

Innovations in vehicle electronics – such as ADAS – are presumed to be the most important motivator for the automotive industry within the next decade[69]. Modern ADAS – especially comfort systems – have an avant-garde image. The subjective safety of cars is part of nearly every advertisement for cars (across all manufacturers). Nevertheless, active safety systems such as ACC or LDW are (status 2004) only mentioned in DaimlerChrysler™ advertisements (Vision of accident-free driving – chapter 1.6). DaimlerChrysler™ started a very offensive advertising strategy towards ADAS and traffic safety. However, the effects of that strategy are not clear. E.g. the sales of the ACC-system are less than 1 per cent of all cars sold[70].

Speed management (chapter 2 Definition 1) makes use of different marketing methods like advertising, educational information using various media (TV, radio, newspapers, flyers) and personal/virtual communication, e.g. forums, trade fairs, internet. However, one has to differentiate between the players. Figure 12 on page 37 shows the different players and their effects on each other. One possible approach to a speed management marketing would be to create a contact platform. The traffic safety forum in Rhineland-Palatinate is a pioneer trial for a co-ordinated traffic safety work platform[71]. imove is a member of this forum (q.v. chapter 0 section "Methodology"). Figure 27 gives an overview of a initial structure of a traffic safety forum.

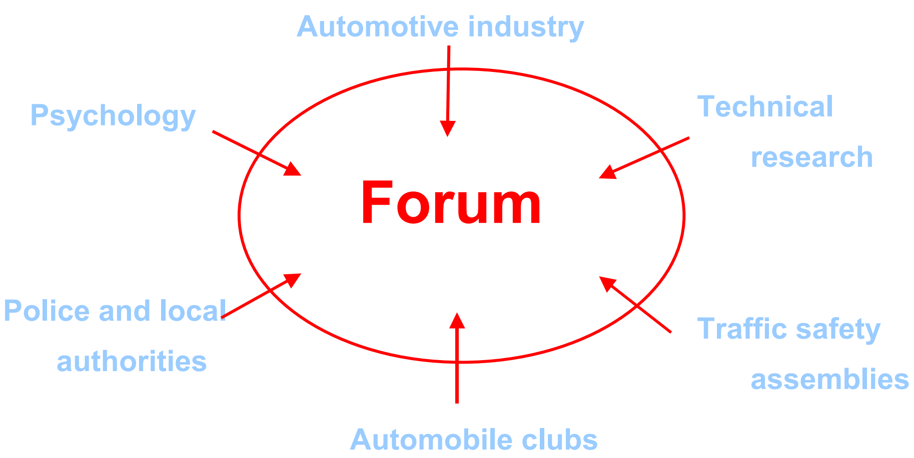

Figure 27: Optimal start configuration for a traffic safety forum [design by the author]

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[69] Source: Müller-Merbach, Heiner: Economic aspects of automatic speed control for road vehicles[G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 143-153 Kaiserslautern 2004

[70] Source: Phone interview with Joaquin Nicolai from the department of research and technology DaimlerChrysler™ AG Berlin on July 15th 2003/Octobre 30th 2003

[71] Source: www.verkehrssicherheit-rlp.de

Concerning ISA implementation, as mentioned before, two possible approaches are conceivable:

1. implementation by law
2. implementation by market forces

Most likely will be a mixture of both. However, the approaches and flanking measures will be different. It would be helpful if the marketing approach was managed by a forum (Figure 27) or a network. Figure 28 shows a guideline and activity chain of how an actor bond of players (derived from Figure 12 and Figure 27) could work[72]. The activity chain itself starts at the road administrator, because "*it can be located in a central position since it has some relationships with most of the actors involved in the project*."[72]

Due to the fact that the survey behind the cited thesis [72] was carried out in Sweden in co-operation with the Swedish Road Administration SRA, who is a project partner in the PROSPER-project (q.v. chapter 0 section "The PROSPER project") and therefore interested in the implementation of ISA, the transference of the actor bonds chain to Germany has to be verified.

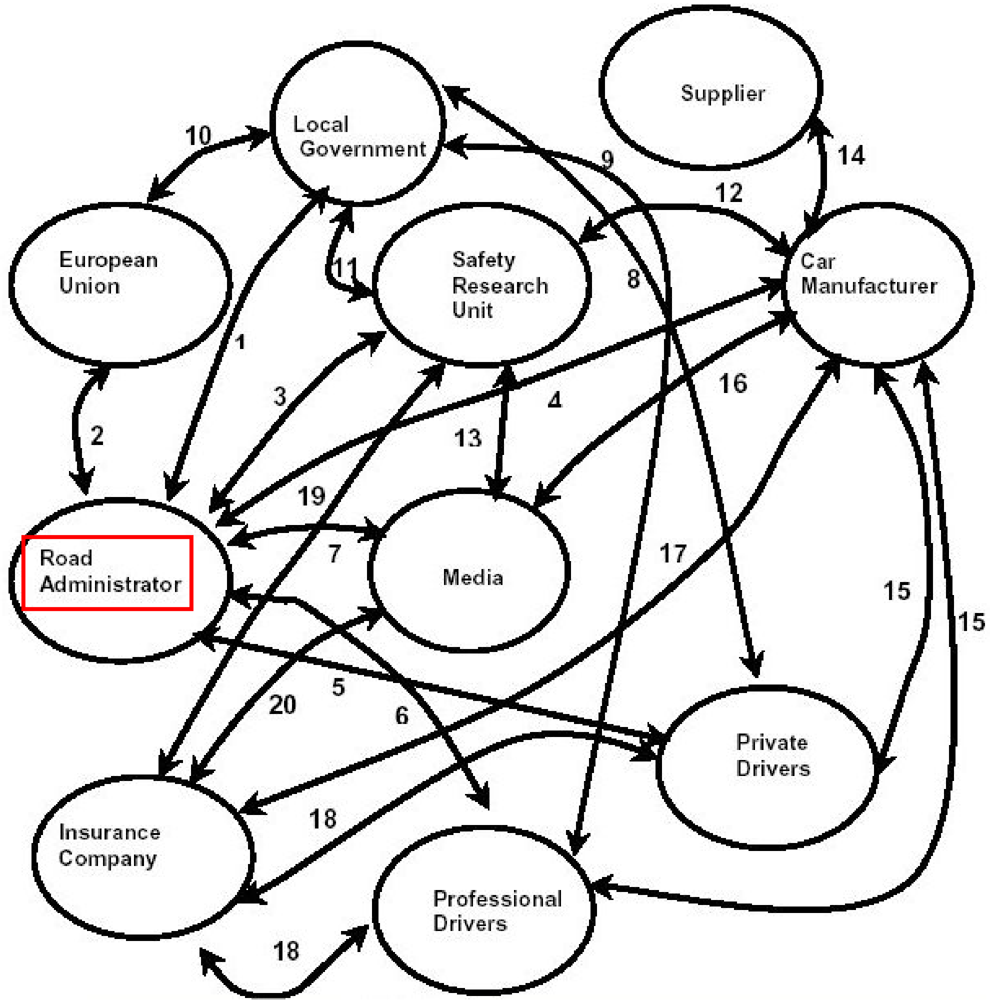

Figure 28: Actor bonds in the ISA-network[72]

[72] Source: Knauseder, Ingeborg/Rose, Betrand: Potential Marketing Approaches for ISA, master thesis at the Technical University Chalmers in co-operation with the Swedish national road administration, Gothenburg, 2001

The chain of actions as described in Figure 28 – applied for Sweden and translated for Germany – works as follows:

1) The road administration is interested in the implementation of traffic safety devices. It introduces ISA for their own car fleet. Road administrations usually are departments of countrywide ministries. Hence, the ministries – in return – activate the road administrations through financing traffic safety research programmes.
2) The SRA as well as most other national road administration have contact with EC/EU or are involved in EC or EU-projects.
3) In most countries the road administration themselves have research units. In addition, they finance projects for external researches. ISA research has played a role in Sweden since 1997. The German road administration just recently started research on ISA[73].
4) The close contact between the road administration and the car manufacturers only exists in Sweden. In Germany, the contact usually functions through representatives of the various assemblies (e.g. VDA).
5) The contact of road administrations and private drivers functions through information brochures or trade fair performances. Otherwise the local authorities start various educative campaigns including local events.
6) The road administrations are in close contact with all kinds of traffic assemblies as well as big companies with their own car fleets. Through this channel, segments of professional drivers could be informed about ISA.
7) The road administration as well as the transportation ministry both have press and media departments. This includes public broadcasting and technical publications for professionals.
8) Local governments as well as local police departments have the opportunity to use direct contact with drivers (e.g. during surveillance actions).
9) The same is valid for professional drivers. Local traffic safety forums might also include assemblies for professional drivers (e.g. taxi driver assembly).
10) The EU (sometimes) finances local projects as well as traffic safety competitions. Apart from the local effects of these projects, the advertising effect is high.
11) Local projects usually are evaluated by research units. Such evaluations often are transformed into guidelines. (this thesis might be taken as an example for this interaction)
12) The contact between research institutions and car manufacturers functions through workshops as well as cooperative research projects. In Germany there are several examples for such interactive projects.

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[73] Source: Seeck, Andre/ Gelau, Christhard: Driver Assistance Systems – with due regard to Intelligent Speed Management, in: Driving Safely in Europe, Reader of the 5th BASt/ADAC-Symposium Octobre 7th/8th 2003 in Wiesbaden

13) Research reports play a role in both professional publications and public media (e.g. local newspapers).
14) Supply companies are the driving forces concerning car electronic systems. The car manufactures and the suppliers.
15) Car manufactures directly (e.g. through test driving performances) or indirectly (e.g. through advertisements) influence all kinds of drivers. As long as at least one car manufacturer is interested in selling ISA-equipped cars, the public relations towards ISA will be achieved implicitly.
16) Several specific magazines deal with car performance and traffic safety concerns. These magazines (e.g. the TV show “Rasthaus“ [105]) have influence on car manufacturing companies. Conversely, car manufacturers usually present most new products and actions in various media.
17) Car manufacturers and insurance companies have durable contact concerning technical issues as well as life cycle cost calculations and quality management. In most cases the car manufacturing company itself has a subsidiary financing/insurance company.
18) Insurance companies sometimes give discounts on insurance tariffs. This might lead at least a few private drivers to buy ISA-equipped cars.
19) Statistical results from traffic safety research and driver statistics have to be evaluated in order to know how the ISA implementation process works.
20) The research and usage results then have to be published. The next process is then to prove the effects.

The German national road administration started research and promotion activity in ISA (The road administration calls the technology ISM – intelligent speed management, including ISA version 1 and 2 but not version 3) in 2003. The contact with car manufacturers, the automobile clubs, media and research institutes concerning speed management already exists [73].

ISA-affine car market segments

In order to know which market segments are feasible for an ISA-implementation, one first has to do market research on the public image of ISA. However, it is very likely, that ISA has a the image of being beneficial for traffic safety and that it supports obeying rules. Due to the fact that the SUN-flower-states do the largest promotion for ISA, there is a political dimension in the image, too. Every victim of an accident is politically frowned upon, that is why Vision Zero was integrated into the political programmes of Sweden, Switzerland and Austria (chapter 1.6). As a consequence, driving at an appropriate speed is “politically correct”. These three parts of the ISA image are useful in order to persuade progressive-thinking people like students, young academic families as well as “young” mobile retirees (chapter 5.1.2) to buy ISA-equipped cars.

Thus, special vehicle types can be attributed to these adequate user groups. If implementation by market forces was started, most probably the first ISA-equipped cars would be:

1. Small inner city vehicles
2. Family vans
3. Mid-range (estate) vehicles

BMW™ wants to equip the 3XX-series (3. type) with ISA-version 2-B [7]. The target groups need broad multimedia information supported by demonstration events at car dealer sites.

Another possible implementation by market forces would concern professional drivers (e.g. from cargo companies) or salesmen. This would bring other vehicle types into play:

4. Small lorries (so-called “sprinters”)
5. Top-range company cars

The target group (professional drivers) will be informed indirectly. Marketing output has to be distributed to the companies. 11% of new cars from German manufacturers (7% of all new cars) are sold to car hire companies. Due to the fact that hire cars are often involved in accidents, in which the responsibility of the driver is hard to prove, car hire companies consider equipping their cars with so-called accident data collectors (ADC). The combination with ISA version 1 would be sensible in this context[74].

Further market segments would be:

6. Car Sharing vehicles
7. Governmental vehicles/vehicles from local authorities/police cars
8. Special vehicles (e.g. crane vehicles))

[74] Source: Interview with Klaus Langmann-Keller of the German National Assembly of car hire companies (BAV) on June 23rd 2003 in Düsseldorf

Incentives.

Incentives as part of an implementation strategy can be understood as “flanking” measures. As for the implementation of ISA, there could be legal incentives or market incentives. The possibilities for legal incentives are broad, because different authorities might dispense incentives (in case of buying an ISA-equipped car). Governmental approaches could be:

1. Reduction of the purchase tax
2. Reduction of the fuel tax/”eco”-tax
3. Reduction of the vehicle tax
4. Increase of commuter subsidy
5. Reduction of penalty points at the traffic offence registry

Local approaches could be:

6. Reduction of registration fees
7. Reduction of maintenance fees
8. Reduction of fees for safety training or psychological tests
9. Special car parks for ISA-equipped professional cars

Governmental approaches could also consist of indirect incentives such as monetary promotion for assurance companies who reduce the insurance rates for ISA-equipped cars. Legal incentives necessarily have to be related to harsh penalties for speeding offences especially if an ISA-equipped car is involved.

From a business-economic point of view, car dealers, insurance companies or garages might make use of incentives in order to force market penetration with ISA-equipped cars. Market incentives could include:

10. Associated car equipment
11. Reduction of leasing rates
12. Reduction of insurance rates
13. Reduction of maintenance costs
14. “Safety points” analogue to “Bonus points”

Public relations, media and police contact during the surveys

During the projects research results were constantly published on www.isa-research.info. In addition, the author made various presentations and publications concerning the project results. Apart from that, the local newspaper in southern Rhineland-Palatinate “Rheinpfalz” published a special report about speeding on 17th July 2003.

During the whole project there was extensive contact with the local police and the Ministry of the Interior of Rhineland-Palatinate. The department for traffic of the police headquarters in Kaiserslautern and Ludwigshafen were closely related to the studies, took part on traffic safety events and had durable contact to print media. The focus for the representatives from the police was on the educational effects of control actions. The feedback on the danger of speeding done by the controlling officer, the information about crash situations and the principles of effects dependent to the choice of speed play a role in the evaluations (chapters 4.3, 6.1 and 9.2.3).

5.3 Driver's demands on ADAS

Drivers can be divided up into 6 groups (chapter 5.1.1). Each group has a certain attitude towards "helping hands" in their car. The "careful" and "anxious" are predestined for ADAS-packages. The "functional" and the "composed" will choose certain ADAS and reject others.

The specification of the ADAS used is individual. The "frustrated" driver makes use of sudden interfering ADAS in order to make sure that he can make it through borderline situations. The "speeding" driver will make use of sudden interfering ADAS in complex road situations with a high amount of car interactions, but will switch them off as soon as he is alone on the road. Porsche design their advertisements directly on the demands of "speeding". The "switch off" function for every single ADAS is stated. The aim behind this is described as "the experience of real driving feeling"[75].

The main aim of ADAS is to help the driver handle critical and laborious situations. This includes either dynamic manoeuvres (e.g. concerning cornering ability) or general driving decisions (e.g. the best way to go). The basic conditions for using the systems depend on common attitudes towards driving and automobile features, i.e. comfort, subjective safety and easy comprehension and handling. One further condition is the avoidance of the driver's subjective feeling of being restricted. The driver has to be the "professor", the system has to be the "assistant"[76].

"Speeding" and "frustrated" drivers in particular will immediately try to switch off any system as soon as he or she feels he or she is being restricted. Nevertheless, the "careful", "composed" and "functional", too, might switch off a restricting system because of a subjective tendency towards sovereignty concerning the driving task. This means that ISA version 3 might not be accepted by at least 83% of all drivers. The questionnaires concerning acceptability of the different ISA versions showed similar results (chapter 4.3 and 6.1.5).

The attitudinal aspects of different driver groups influence the car requirements (concerning new cars or technical upgrades). The general equipment of different vehicle types with ADAS therefore depends on the most common driving situations and conditions (i.e. used road type, driving style and purpose, time of day, etc.).

The driver's cognition of critical driving situations and the reactions to them all have an influence on how ADAS are used. Further on economic aspects play a role. ADAS – especially most modern comfort attributes – usually are so-called "special features" of high class cars and therefore a kind of status symbol. Most of the automobile manufacturers equip their high class series with the most innovative technology. The other car series, too, get the equipment but later.

This has something to do with the theory of economic product cycle [69]. Expensive technical innovations – part of which comfort attributes in cars are – are related to a reputation of being avant-garde. Today, the diversity of car types is due to the very individual expectations of equipment and performance. The most important technical issues are – as mentioned previously [58] – related to

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[75] Source: Leaflet available at licensed Porsche car dealers

[76] Source: Erke, Heiner: Intelligent Speed Adaptation – Speed Regulation and Driving Behaviour, in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 31-43 Kaiserslautern 2004

car electronics. Thus, user demands only affect the combinations of the ADAS offered, the engine power and the car deviations.

In addition to the attitudinal aspects towards ADAS, there are a few psychological and medical requirements for the shape, functionality and design of ADAS. The latter are described in chapter 7.3 and 7.4, where the human machine interface (HMI) is focussed on.

6 Acceptance, acceptability and implementation parameter

Hypothesis: An ISA penetration rate of 15% of all vehicles will lead to noticeable effects on speed reduction. A penetration rate of more than 50% would be able to significantly reduce accident rates[77].

According to Figure 7 and Figure 8 (page 20), a reduction in number and severity of accidents should be the further consequence. Such penetration rates can only be gained if ISA is acceptable for a sufficient number of road users.

According to the definitions of acceptance and acceptability (Definition 2/Definition 3 page 35), it has to be proven, that the interdependent measures "speed limit enforcement" and "ISA" have a certain basic acceptability, so that – even if the broad majority of people are against an implementation at present time – a high level implementation (i.e. more than 50% of all vehicles equipped with ISA) could be reached within the next two decades.

This chapter therefore deals with the demands of different groups. The user criteria is derived from the demands on ADAS (chapter 5.3) the user surveys[24,25] (chapter 4.3) and the documented user experience from the large scale field trials in Sweden[78]. The criteria for other groups as well as the technical, juridical and economic criteria are derived from the expert pool (chapter 4.1) and the stakeholder survey (chapter 4.2).

6.1 Criteria of acceptance for users

The term "users" means people making use of a road in order to obtain a certain goal. Every road user is a human being with certain traffic-related attitudinal and physical attributes. The most interesting group in relation to this discussion is the automobile user group. The road users of public transport, the cyclists and pedestrians will usually accept any measure which reduces speed levels and the objective/subjective danger of crashes. Hence the focus lies on vehicle users (HGV and cars). First of all, the acceptance and acceptability of laws and regulation has to be proven. This is usually the case. Following this, acceptance and acceptability of legal speed limits have to be proven. This is more complicated. Thus, different situations have to be contemplated (chapters 6.1.1, 6.1.2 and 6.1.3).

Finally, the acceptability of ISA – presented as a technical solution for speed-related accidents – has to be proven. Taking into account that ISA has different modes and shapes (Table 1) every single version has to be considered (chapter 6.1.5).

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[77] Comment: One of the tasks of the PROSPER project is to prove through simulation, that these numbers are correct. That part of the project has not been started before this thesis has been accomplished.

[78] Source: Hjälmdahl, Magnus/Varhelyi, Andras: History and status of ISA in Sweden, in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 91-102 Kaiserslautern 2004

The psychological criteria for acceptance are based on attitudes and reactions. This can be represented in a flowchart (Figure 29). The exact reaction may differ from time to time. A major problem in relation to this topic is reactance [38] and the effect of system malfunctions in early phases of application. An estimation of the latter problem is impossible. ISA has to be implemented in Germany before, this can be determined. The results from surveys in other countries are yet insufficient for a prediction of effects in Germany. This is due to the fact that none of the surveys does yet provide sufficient information about long term effects.

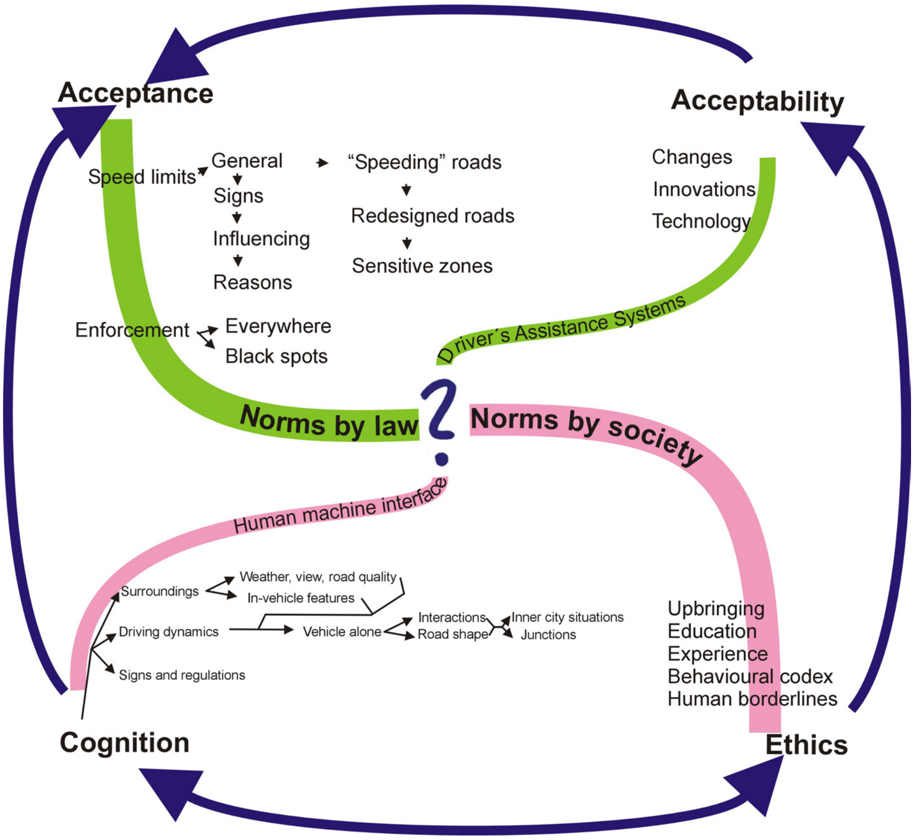

Figure 29: Circular flow of acceptability, acceptance and the psychological background of speed choice [design by the author]

The four stated main terms acceptance, acceptability, ethics and cognition influence the driver's behaviour and attitude. Norms by law – if accepted – lead to objectively correct behaviour. ADAS – if acceptable and used – support objectively correct behaviour. The driver's decisions are partly derived from objective criteria and partly from subjective criteria. Such criteria are "socially accepted" norms like "20 km/h above the speed limit is okay" (chapter 4.3) and situational cognitions. Due to the fact that a driver makes hundreds of decisions during a trip, one cannot clarify for certain which norms and aspects effect a specific speed behaviour (hence the question mark). However, all four terms have interdependencies, so that external influences like education or optimised HMI-devices might lead to correct behaviour even if a decision is derived by subjective criteria.

One important piece of information from the flowchart is that acceptance can only be proven for existing matters (in this case: existing speed management measures). Acceptability for changes (e.g. of law) and innovations or new technology (in this case: ISA) can only be proven through experience (in this case: large-scale field trials and how test drivers report on trips with ISA). The following statements regarding acceptability are therefore derived mostly from the results of the expert pool survey. Statements from the users towards acceptability (chapter 4.3.1) have to be strictly relativised due to the fact that ethical suggestions influence statements concerning speeding. “Real behaviour” might be completely different (chapter 4.3.2).

6.1.1 General acceptance of speed limits

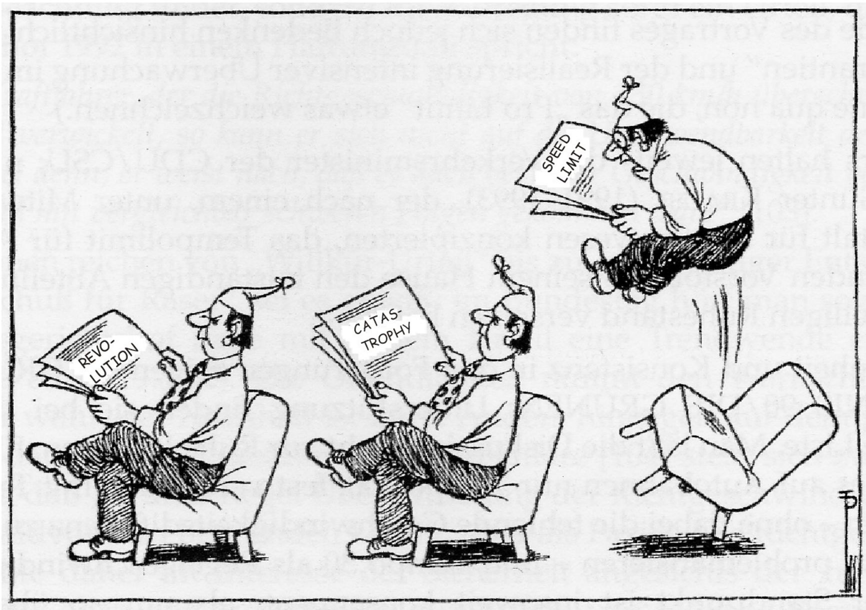

Figure 30: How Germans react on bad news [caricature by Peter Leger]

Human beings are egoistic concerning road usage. When driving, the speed has to be as high as possible, whereas others driving fast – especially near their own house – are considered as “rowdy” drivers. This is partly influenced by the high power of up-to-date vehicles which are able to reach speeds of up to 250 km/h and more[79]. No public road on earth is designed for such high level speeds. In addition, speeding drivers have the feeling of being screwed by the authorities when they get speeding tickets.

The benefits of speed limits in order to prevent crashes – especially fatalities – are accepted. This consideration is derived from education and knowledge. Nevertheless users tend to evaluate speed limits differently while driving. Here situational considerations affect actions, as stated in the SEU-model (chapter 1.3 [38]).

Hence, general speed limits – especially on high capacity roads, such as trunk roads and motorways - are not accepted [24,25,28], but local speed limits with a related explanation (e.g. the dan-

[79] Source: Schidhuber, Friedrich: “Want a little more?” – Speed behaviour on our Roads, in: Speed – accident reason #1 protocols form the 28th session of the Austrian traffic safety council KfV, Vienna 2000

ger of rear-end collisions) are accepted. Adherence and acceptance of speed limits in medium-sized cities are higher than in large cities[21]. This fact might be explained by the geography of medium-sized cities. The structure of the inner city roads is very urban and monocentric, so the amount of pedestrians and bicycle users is high. The acceptance of a general speed limit on motorways is the lowest compared with the other road categories. This might be due to the fact that most drivers misunderstand the recommended speed limit (Table 2) on German motorways. "Recommendation" is considered equal to "advice", and not as "default". Empirical studies [17,21] affirm very high speed levels on rural roads, trunk roads and motorways. This leads to the following hypothesis: The lack of acceptance of speed limits on rural roads and trunk roads has consequences on speed behaviour within built-up areas. The latter fact is due to the situational cognition of speed. The cognition (particularly visual perception) of road elements depends on the speed driven. In urban areas, the speed level is low and the attention is directed to the road side (pedestrians and bicycle users). The field of vision is wide and short. The field of vision becomes narrower and further ahead with higher speeds. However, the change of visual perception functions differently when slowing down (e.g. when leaving a motorway section) [38]. In the first moments the visual field of the driver is calibrated to higher speeds. Thus, even 70 km/h in built-up areas (meaning 20 km/h over the limit) seems like a standstill for the driver[80].

The second consequence is the high level of crash severity. The low number of accidents on motorways (taking the traffic performance into account) is due to the fact that automobile users are normally the only type of road users on these road categories.

Exceeding the speed limit by only "a few" km/h for the driver means no offence against the law[25]. The degree of the malfeasance is "cheap"; the social norm is defined by "inconspicuous" behaviour[76]. In addition, speed behaviour shows other road users the "intentions" of the driver[76]. In extreme cases (driver type "speeding" – chapter 5.1.1), the act of exceeding speed limits is used as a "tool" for showing other road users how competent and agile one can be[76].

The so-called "tragedy of the common"[13] concerning speed behaviour might be broken "*by making the consequences of the behaviour visible for the individual*"[81]. Thus a direct confrontation with the related danger will have an effect. Many participants in the user questionnaires (chapter 4.3) stated that enforcement measures are acceptable when an educative conversation between police officers and the "caught" driver takes place. This is also relevant for a "traffic sign reminder" and the informative ISA system. Warning the driver causes attention to the danger of speeding. The way of warning the driver through the system has therefore to avoid reactance (chapter 7.3.3) on the system.

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[80] Source: Kaba, Alexander: Speed Limits – Acceptance and Signalisation[G], in: Geschwindigkeit – Unfallursache Nr. 1, protocols form the 28th session of the Austrian traffic safety council KfV, Vienna 2000

[81] Source: Schlag, Bernhard/ Schade, Jens: Acceptability of Transport Pricing Strategies - an Introduction, in: Schlag, Bernhard/Schade, Jens [editors]: Acceptability of Transport Pricing Strategies p.1-9 ELSEVIER, Oxford 2003

6.1.2 Acceptance of speed limits at subjectively uncritical segments of the road network

The cognition of dangerous situations depends on estimation and experience (chapter 1.3). Therefore, various parts of the road network, especially wide ones with long distances between junctions are not seen as being critical from a driver's point of view. Hence, the (theoretical) acceptance of, and (real) adherence to speed limits are very low. Awareness of the associated danger does not exist for most drivers (chapter 5.1.1).

The objective danger of these road segments (arterial roads in cities, broad rural roads and trunk roads) lies in the severity of accidents (due to high vehicle speeds) and in the fact that unexpected situations may cause incorrect decisions due to a lack of experience. The geometry and design of roads, especially concerning the road width and the arrangement of lanes, has to be appropriate to the legal speed limit. Thus, roads of the same geometry will have the same speed limits. Experiences with the same geometry of road may effect the general speed behaviour. Roads of the described design in combination with various attributes (comparable road signs, technical equipment, traffic volume and density) are the basis for "self-explaining" roads (chapter 7.4.4). Acceptance of speed limits will more likely be gained if self-explaining roads are implemented. Due to the fact that infrastructural measures have to be organised and accomplished by local authorities – i.e. "by law" – the planning period will be rather long for the whole measure (Chapter 9.2.3).

Speed choice is derived from local and situational attributes[21,76]. The higher the number of local attributes is, the lower the driven speed will be. However, the driver should neither be overloaded with attributes (information overload leads to failures) nor should the attributes build visibility barriers (danger of pedestrian impacts).

The results for tolerated speeding (chapter 4.3) and speed behaviour (chapter 1.2), especially on roads outside built-up areas, lead to the conclusion that keeping these road categories clear from any kind of roadside attributes may be the wrong decision for planners. Better measures would be: The installation of warning signals and the promotion of bicycle usage either on separate lanes or on marked lanes (chapters 9.2.3, 9.2 and 10).

Road signs should be equipped with additional signs showing a "reason"[25] for the limit or an "instruction"[80] concerning speed choice. Such additional signs could mention an accident black spot or a dangerous road structure. The instructions could include stringent attention to movements on both sides of the road or the exhortation to keep clear from the lane boundaries.

6.1.3 Acceptance of speed limits at so-called \`sensitive zones´

Sensitive zones are areas where the likeliness of the presence of vulnerable road users is very high. Roads in the vicinity of kindergartens, schools and residential homes for the elderly are sensitive zones. Arterial roads crossing pedestrian zones , too can be described as sensitive areas.

Nowadays, speed behaviour in sensitive zones is relatively uncritical. This is due to the aided adoption of educational and engineering measures since the late 1970s:

- Installation of warning signs
- Lane narrowings
- Lane separation at pedestrian crossings
- Cobbled pavings at pedestrian crossings
- Redesign of road network (e.g. one-way streets)
- Radio and TV information (e.g. on the first day after school vacations)
- Special lessons at driving schools

Accidents in sensitive zones play no significant role, because the drivers expect small children to jump in front of their car. Nevertheless, accidents with small children are still a big problem in cities. The increasing amount of accidents with children in residential areas and on arterial roads is due to the fact that leisure activities are carried out throughout the city and nearly the whole day long[82]. Thus, redesign of roads, junctions and crossings has to be done in all areas of a city. The aim behind redesign should be the easy cognition of possible dangers and the mutual attention of road users… in other words: The self-explaining road (chapter 7.4.4).

6.1.4 Usability and acceptance of ADAS

Depending on the user group and attitudinal aspects, every ADAS has a certain basic amount of acceptability (chapter 5.3). Then, while using the system, various parameters influence the final level of acceptance for an ADAS. These parameters can be subsumed as usability aspects. The usability of comfort, so-called "infotainment" and safety-systems has effects on driving behaviour and the general psychological constitution of the driver. Safety systems have on one hand to be ergonomic and sensibly integrated into the fittings (chapter 7.4.1). On the other hand the systems have to be controllable and failsafe. The route to acceptance of a system or technology is therefore the integration of usability, feasibility and promotion of the ADAS. Apart from political and sociological influences (chapter 9.1), user perception of the quality and usability of ISA will lead to acceptance of the technology itself. Figure 31 shows the conceptual interdependence between usability and product acceptance.

[82] Comment: These are the first results of a survey concerning accidents with children. The project partners are imove, the local police department, the local authorities and various pressure groups. The survey will be accomplished in 2005.

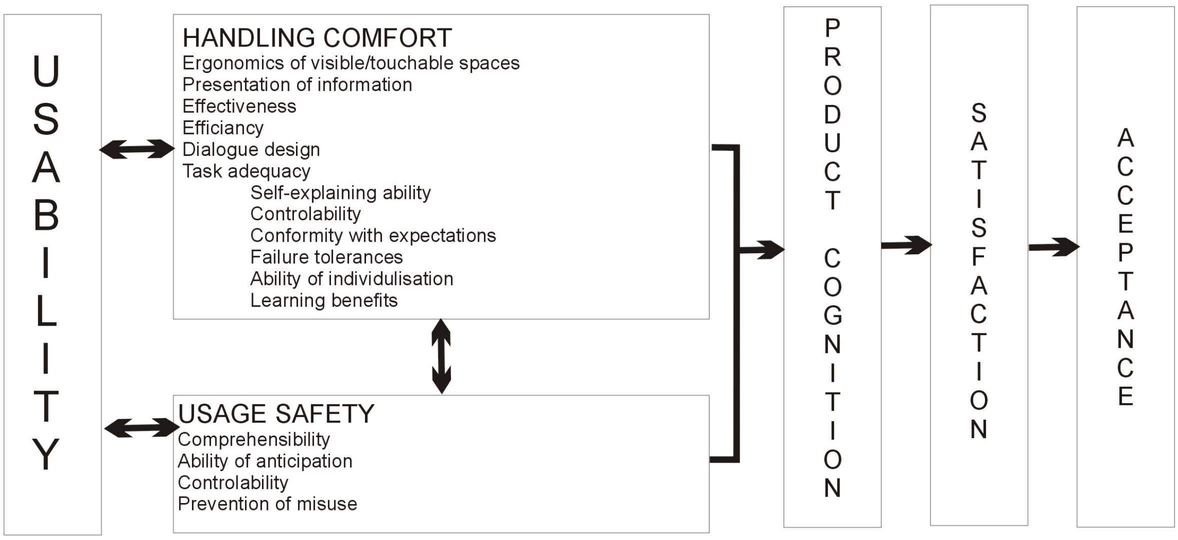

Figure 31: Conceptual interdependence between usability and product acceptance[83]

6.1.5 Acceptability of ISA

The acceptability of ISA (as well as the acceptability of enforcement actions) is directly influenced by the lack of acceptance of the speed limits themselves (Figure 29 page 66). Nevertheless, the various system versions may have benefits for the driver apart from the adherence to speed limits. The effect of incentives has to be taken into account especially.

ISA-Version 1 (open informative system)

The stated acceptability for version 1 in the questionnaire is very high (Figure 23 and Figure 24 page 51). This version reminds the driver constantly of the speed limit and switches whenever the limit changes. Especially during long distance trips, drivers tend to forget about looking at road signs. Thus version 1 is an effective reminder. It also helps the driver to orient himself in complex road sections in inner cities, where concentration might be on the traffic not on the road signs. The combination of ISA version 1 with a traffic sign reminder or a parking guidance system would make sense. The acceptability of the system will be high as long as it does not "restrict" one's own feeling of freedom concerning speed choice -> non-acceptance. In addition, the driver should not have the feeling that the system would "disturb" the driving performance (e.g. through a warning tone) -> reactance. The effectiveness of the system in concerns of traffic safety is therefore questionable. Drivers will accept version 1 when the safety relevance of ISA-systems are pointed out. Due to the fact that version 1 is already available (Table 1 page 6), an implementation by law would not make sense.

[83] Source: Becker, Stefan: Usability and Product Acceptance[G], in: Ebel, Bernhard/Hofer, Markus/Al-Sibai, Jumana: Automotive Management, p.250-270, Heidelberg 2004

The acceptability of the open version was very high in the EVSC project[43], as well as in all other field trials[84]. Drivers who had the choice between the first and the second version preferred the second after experience with both. However, every informing system will have the effect of drivers getting used to it. The adherence to the speed limits with the system after a while might be lower than with a more restrictive system[39].

ISA-Version 2 (half-open adaptive but overrulable system)

The so-called haptic throttle is accepted by the users (chapter 4.3.1) and positively evaluated by the experts (chapter 4.1). The results of questionnaires with test drivers in previous field trials with version 1 (with BEEP-signal or seat vibration) and version 2 (active accelerator pedal AAP) were that the acceptance of both were rather high. Version 1 was more acceptable than version 2. In the most recent Swedish field trials the test drivers favoured version 2 over version 1. That was because of the better performance of the AAP and reactance to the “BEEP”-signal after long-term driving. The AAP cannot be recognised by passengers, so the drivers stated less stress and frustration. The highest effect on frustration was the subjective feeling of being a “brake for others”. The motivation for using both version 1 and 2 was highest on inner-city roads. The necessity of ISA for those roads was very often stated in the questionnaires (before AND after the trials) [78]. However, people rejecting version 2 before driving with an AAP-equipped car were more frustrated and felt a stronger aversion against the system after having tested the system[85].

In the Netherlands, the AAP is also tested in a high-modern driving simulator at TNO human factors in Soesterburg. The test persons were confronted with two different counter pressure versions of the AAP. The acceptance for both was high. However the lower counter pressure was preferred especially by female test persons[86]. The fact that BMW™ wants to equip mid-range cars with the AAP leads to the hypothesis that the broad implementation of ISA version 2 by market forces will be the most likely implementation scenario (chapter 8.2). The effect of the AAP on adherence to speed limits is much higher than with version 1[78]. The technical attributes of the AAP are innovative and may also motivate equipment suppliers to adopt the related hard- and software (chapter 6.2.2).

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[84] Source: Carsten, Oliver: The European Working Group On Speed Control, in: IEE Automotive & Road Transport Systems Professional Network: Intelligent Speed Adaptation – ISA in Europe, Workshop reader from December 9th 2003 in London

[85] Source: Kaufmann, Clemes/Risser, Ralf: The Effects of the Usage of an active gas pedal AAP in a Field Trial in Lund[G], in: Zeitschrift für Verkehrssicherheit edition 4/2003, p.184-190 Cologne 2003

[86] Source: Hogema, Jeroen/Rook, Arno: WP3 Driving simulator experiments, presentation of interim progress report for PROSPER WP3 at the PROSPER consortium meeting on December 10th 2003 in London

ISA-Version 3 (closed, non-overrulable adaptive system)

"The ADAC basically appreciates the assistance of car drivers through sensible new technologies via aid, information and driver's assistance systems. However, the ADAC strictly refuses attempts to decelerate a car driver automatically and compulsorily to a certain speed." [87]

The ADAC is the third biggest automobile club worldwide (14.8 m members). Even more people read their monthly magazine, so that the political statements have a significant effect on public attitudes. However, the stated aversion towards ISA only concerns version 3-C (Table 1 page 6). The official statement towards versions 1 and 2 will likely be different[88]. The ADAC is in close contact with the national road administration, the safety institutions and the automotive industry concerning the so-called "Intelligent Speed Management" including versions 1 and 2.

The various questionnaires and expert statements confirm a broad lack of acceptability for version 3. One reason is the subjective feeling of freedom being reduced by the automatic adaptation of speed. One other main reason is the juridical liability problem. No one wants to be responsible for an accident when the system fails. The pre-trial questionnaires in Sweden and the Netherlands had the same results. However, attitudes towards the dead throttle slightly changed in the post-trial questionnaires. Long-term experience with the system had a positive effect on the acceptance[89].

The experts supporting ISA implementation gave the following statements towards version 3: The EU-wide aim of reducing the number of accidents and injuries noticeably[29] as well as the aim of reducing social stress[90], negative environmental effects[45] lead to the necessity to implement version 3 by law[20]. The lack of acceptability has to be balanced through incentives like tax reductions[91].

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[87] Source: www.adac.de/verkehrsexperten

[88] Source: Phone interview with Ralf Stock of ADAC on March 19th 2003

[89] Source: de Kievit, Erik: A safer city – are drivers willing to contribute?, in: IEE Automotive & Road Transport Systems Professional Network: Intelligent Speed Adaptation – ISA in Europe, Workshop reader from December 9th 2003 in London

[90] Source: Spellerberg, Annette: „The nervous frictions are amplified through the rapid speed" – The speeding phenomenon from a city-sociological point of view[G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 13-28 Kaiserslautern 2004

[91] Source: Marker, Hans-Jürgen: Comments on ISA[G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 105-110 Kaiserslautern 2004

6.2 Criteria of ISA-acceptability for offerers

Providers of technology are, on one hand, the automotive industry (OEM + suppliers), the maintenance and inspection institutions, the providers of the basic system telematics and service companies with large car fleets for either public (e.g. taxis) or commercial (e.g. travelling salesmen) use. ISA will only be accepted if an economic benefit is related to its distribution. This means that either costs have to be reduced (e.g. through bounties or tax reductions) or proceeds have to be augmented (e.g. through additional sales of ISA-equipped cars).

6.2.1 Car manufacturers

The German car manufacturers sell the largest number of "high-performance" cars (i.e. cars with a power output of more than 125KW – categorised by the German federal administration for road vehicles and homologation KBA) worldwide. This might be one reason for their broad rejection of the ISA technology. The refusal concerns all versions of ISA. The AAP product by BMW™ is planned for introduction in 2005[7]. However, it is not clear how strict the AAP will be in its functions. The number of cars equipped with version 2 will initially be very low. Usually, most new cars from a series are not equipped with an innovative technology. For example, in 2003 less than 1% of the newly built Mercedes™ S-class were equipped with ACC[70].

The representatives of BMW™[7], DaimlerChrysler™[70] and the VDA[11] put forward the argument that the driver should always be in charge of the driving manoeuvres. The likeliness that a driver makes a momentous mistake is very low (0.0000001%). This is derived from the fact that a driver makes 12 decisions per kilometre, a light accident occurs every 150,000 km, a fatal accident occurs every 90 m km. No technology on earth has a similar reliability[92]. Nevertheless, many people are affected because of this small lack of reliability.

One other argument of the automobile industry is the problem with product liability. This question will be treated in chapters 7.5.2 and 7.5.3.

ADAS are able to reduce the number and severity of accidents. Since 1999, DaimlerChrysler™ has equipped every new car with ESP. The number of accidents where new DaimlerChrysler™ cars were involved has decreased by 15% since then[93].

The integration of ISA into other ADAS is partly awkward but not impossible. The good will of single car manufacturers to take part in research projects on ISA (e.g. Renault™, Peugeot™ and

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[92] Source: Huß, Christoph: The Introduction of Driver Assistance Systems from the Viewpoint of the Automotive Industry - Can "Intelligent Speed Adaptation" contribute to improve traffic safety?[G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 113-119 Kaiserslautern 2004

[93] Source: Breitling, Thomas: Accident-free road traffic – a Vision? – Contributions from a Car Manufacturer[G], in: ADAC: Unfallfreier Straßenverkehr – eine Vision?, Workshop reader from June 27th 2003 in Hamburg

Citroën™ attend the current French field trial called LAVIA[94]) leads to the hypothesis that implementation is considered likely in the long term.

A simple reason for the German automobile industry to reject the technology could also be the so-called "Not-Invented-Here-Syndrome". Economic scientists found that inventions from external individuals or institutions will not be implemented as long as the industry does not see the necessity. One example for this kind of company policy is the diesel soot filter. The German car manufacturers refused to equip their cars with soot filters so long as there was no demand. The increasing public awareness for environmental problems, especially in France, lead Peugeot™ to equip their cars with the soot filter supported by a large advertisement campaign and trade fair performances. As a consequence, organisations for consumer protection in Germany clamoured for the product. Now, every car manufacturer offers cars equipped with diesel soot filters[69].

Accordingly, the ISA implementation by market forces will only work as long as there is a lobby with an interest in buying ISA-equipped cars.

6.2.2 Component suppliers

The group of component suppliers consists of manufacturing companies for mechanical or electronic car equipment as well as companies for ADAS software engineering except for navigation tools. Companies programming navigation software are subsumed in the group of providers (chapter 6.2.4).

A supplier often sells a specific technology or single modules. Most of the companies focus on producing a few individual elements. A few large companies (e.g. BOSCH™ , Continental™) have segments, departments or joint ventures. The difficult economic conditions for representatives of the medium-sized business lead to the necessity for conservative risk management. The range of products should neither be too small nor too large. Hence, production of innovative technology comes into play if state-aided monetary promotion is granted.

Concerning ISA, many elements are innovative: The design and electronic steering of the AAP, the steering software, the operating system, the basic hardware, the HMI and the internal redundancy units. In Sweden, the production of ISA tools was (and is) part of a political programme for traffic safety and technical research. Thus, today IMITA™ is the only producer of ISA-technology worldwide[95].

Due to the likelihood of for ISA-version 2 being accepted, basic conditions for at least a few companies exist. However, the necessity of a lobby for the technology – especially in Germany – is obvious. Similar to the example of diesel soot filters, a sort of "precursor" company has to be found (chapters 7.2.4 and 9.2.2).

Broad implementation, however, needs long-term preparation. Due to the fact that most of the ADAS are software-based solutions, the primary focus of technical equipment must be based on standardised hardware solutions. The software packages require certain structures (i.e. a car-PC).

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[94] Source: Official website of the project: www.projet-lavia.com

[95] Source: Official website of the company: www.imita.se

Various companies have developed car-PCs (e.g. DELTA™[96]). The electronic systems need a more reliable and effective power supply[97] (i.e. the 42V in-vehicle power network or the hybrid 12V/42V in-vehicle power network). The future automobile might be an "infotainment"-mobile with high-performance safety devices including ISA[58]. Thus, suppliers should take the technology into account.

6.2.3 Regulatory institutions (TÜV™, DEKRA™)

The task for the regulatory institutions is the compulsory regular maintenance check, homologation and technical support for every motorised vehicle on public roads. In particular, the relevant safety elements of a car (i.e. brakes, indicators, lights, crash-safe structural elements of the chassis) must function correctly.

Today, electronic steering equipment is responsible for the most functions and the driving performance. ADAS are part of the standardised equipment of every new car produced since the mid-1990s. Therefore the regulatory institutions have a significant interest in functionality of safety devices.

In addition, TÜV™ undertakes technical research and takes part in traffic safety campaigns[40]. Hence, ISA is of interest. However, the juridical problem with product liability is also relevant for them. Regulatory institutions usually have a broad disclaimer concerning the compulsory regular maintenance check. If a car is involved in an accident because of a malfunction of a component that passed the check recently, or was installed by the institution, the driver is still liable for the accidental damage. This is because a driver is obliged by law to make sure that the vehicle is working properly at all times.

The implementation of ISA is sensible as long as the regulatory institutions have the technical knowledge and adequate equipment for checking the system. The implementation by law has to be combined with the regulation of maintenance cycles. The implementation by market forces should include an agreement with the manufacturers to distribute information about the system properties. The latter statement is valid for all ADAS.

ISA would be synergetic for other devices. It would be a sensible add-on for a compulsory accident data collector (ADC). The ADC is under discussion as a measure for reducing accidents involving young drivers. In addition, field trials with learners take ADAS and the related effects into account.

6.2.4 Providers

Providers – in the main – have two different tasks: The first is the collection and conditioning of data for the digital roadmaps. This includes geographical, touristic, technical and administrative data of roads, cities and regional areas. The second task is the hardware and software engineer-

[96] Source: Official website of the company: www.delta-pc.de

[97] Source: Leohold, Jürgen: The Electric Infrastructure for Future Driver's Assistance Systems [G], in: GZVB (editor): Automatisierungs- und Assistenzsysteme für Transportmittel, Workshop reader #5, p.221-245, Brunswick 2004

ing, as well as the technical support. In other words, providers are in charge of collection and distribution of pre-, on- and post-trip information.

The largest providers are Teleatlas™ and Navtech™ who have a joint venture with all German automobile manufacturers. The collection of speed limit data is done constantly and Europe-wide. Nearly 90% of the speed limits on the German road network are listed[6].

In the DELPHI-survey (chapter 4.2), two representatives of providers (Navtech™ and Geacarta™) answered the questionnaires. Both agreed on the necessity of ISA-implementation, especially version 2. The beneficial effects of ISA for environment and traffic safety were stated.

Providers have an economic interest in ISA because of the broad requirements for digital road maps. However, the product liability problem is also valid for the providers. An implementation by market forces of version 2-B or 2-C would make most sense.

6.2.5 Companies with large car fleets

The request for implementation ISA version 1 or 2 for professional drivers is one of the results of the DELPHI-survey (chapter 4.2). In Germany, many large companies have their own car and HGV fleets. In a small scale phone interview session, three large companies (MAN™ and Siemens™ Mannheim, BASF™ Ludwigshafen) in the Rhine-Neckar-Region in Southwest Germany were asked about the size of their car fleet, how the car fleet is organised, and how potential accidents are handled. In addition, a small amount of internet research was done concerning car fleet management based on telematics. The phone interviews and internet research took place between 5th and 16th of June 2004 and were done by three student assistants of the author.

The results are as follows:

The large companies have (in some cases, far) more than 1000 company vehicles. The distribution of cars and HGV depends on experience and importance of the selected driver. The car fleet management (i.e. buying, selling, maintenance and distribution) is done by internal departments. In the case of Siemens, a major part of the company car fleet are leasing cars (so-called white fleet). The selected driver leases a car and the company pays for it. The rest of the car fleet management is done by an internal department. In case of an accident, the driver himself is responsible for the organisation on location. Afterwards an internal department inherits the case.

Car fleet management is sometimes done through external companies. These make use of up-to-date navigation technologies. A few insurance companies in Germany authorise such companies with the complete car fleet and accident management.

The high number of company cars in Germany, the centralised and modern car fleet management methods and the innovative usage of telematics lead to the hypothesis, that here – as well – is a possible market for selling ISA in combination with the accident data collector.

6.2.6 Car hire companies

Today, 380,000 vehicles in Germany are hire cars. Due to the fact that most of the cars are new vehicles, the car hire companies have a significant influence on the car manufacturers.

Version 2 would be acceptable for these companies and the innovative character of the technology would be interesting for a certain group of customers. In addition, the technology would avoid at least a few accidents and many speeding tickets. Due to the fact that speeding tickets are sent to the car owner (i.e. the company), there is a large administrative effort for distribution of the tickets to the customers. Furthermore, the companies have major problems when a hired car is involved in an accident of which the question of guilt is not solved. The monetary effort for court proceedings is high. Speeding plays a major role in these concerns. Therefore ISA would make sense as long as the driver is responsible for the speed driven. The best would be the combination of ISA with the ADC[24,74].

The implementation of ISA version 2 in hire cars is taken into account in the scenarios in chapter 8.

6.2.7 Public transport, taxi and car sharing companies

One of the results of the stakeholder survey (chapter 4.2) was that equipping public buses with ISA would make no sense. The arguments are: Urban public transport systems are slower than the car traffic anyway. Buses exceed speed limits extremely seldom. The potential for frustration from ISA for bus drivers is higher than for car drivers because they have to take care of the passengers. This rejection of ISA is valid for all three versions. These statements were from both stakeholders supporting the technology and stakeholders rejecting the technology. One of the stakeholders was a representative of the German assembly of public transport companies (VDV), who was resolutely opposed to the technology.

Today, 53,000 normal taxis, 22,842 private hire taxis and 3,902 variably used cars exist in Germany. Hence, the potential benefits (in terms of advertisement) of ISA-implementation would be high. However, the same lack of acceptance as for public transport companies is valid for taxi companies. One representative of taxi companies took part on both the stakeholder survey (chapter 4.2) and a project-related phone interview [24]. He was also generally opposed to the technology.

The observation that public transport companies including taxis completely oppose ISA is a German phenomenon. In the field trials in Belgium, Sweden and Finland both taxis and buses are equipped with ISA systems[1]. In addition, in Finland some of the taxis are equipped with a black box recording speed data. If a driver exceeds speed limits, he gets a dissuasion. In extreme cases, he loses his job[98].

Concerning the field trials in Belgium and Finland, the acceptance for ISA within the group of bus and taxi drivers is not very high. However, the persons in charge of the companies show broad acceptance of all ISA versions. This is derived from company policies and public mentality. Safety plays a role in everyday life. In Germany, the transportation time from A to B has to be as short as possible. Safety deficiencies are tolerable[24].

CarSharing companies are a potential customer for ISA technology. The image of being “alternative” and “beneficial for the environment” has an advertisement effect on intellectual users. The first

[98] Source: Peltola, Harri: Presentation of the interim results of an ISA survey in Finland at the meeting of the European Working Group On Speed Control (EWGOSC) on December 8th 2003 in London

commercial German CarSharing company started work in 1988. In 2002, 90 CarSharing organisations had 2,070 cars and more than 55,000 customers[99].

[99] Source: Huwer, Ulrike: Shaping Combined Mobility: The Interface Public Transport – CarSharing[G], publications of imove, Green Edition #55, Kaiserslautern 2003

7 Political, economic and social conditions concerning implementation of ISA in Germany

A basic analysis of the conditions and key issues from different points of view is indispensable for an implementation of ISA. For the first part of this analysis there will be no statement about strategy or strategy packages (q.v. Definition 5 and Definition 6). The aim of this chapter is to provide an overview of the status quo in Germany. Measures and effects will be described. This is meant as a preparation for the scenarios in chapter 8.

7.1 Political conditions

The political conditions consist of four fundamental parts:

1. Research promotion (e.g. for field trials)
2. Public acceptability (chapter 6.1)
3. Company policies (chapter 6.2)
4. Economic promotion (e.g. for medium-sized businesses)

Today, several European safety research initiatives (e.g. e-safety, INVENT) promote various projects (e.g. PROSPER, SpeedAlert)[100]. In Germany, research on ISA has just started. A few small scale research projects, but no field trials, are planned. The latest results of PROSPER and the Austrian RONCALLI-project[101] may have consequences on the willingness of the German transport ministry to promote an ISA field trial in Germany.

Public acceptability needs pressure groups postulating ISA. Thus, lobby assemblies and political subgroups are responsible for including ISA in their political programmes. Due to the fact that the latest Vision Zero initiatives are stated in a few political publications, the forced promotion of ISA would require no further effort. One of the first pressure groups postulating ISA is the German police trade union (GdP). The necessity of measures against speed-related accidents is stated and the benefits of ISA are reinforced[91].

Company policies are derived from economic motivations. Thus, selling ISA has to provide the opportunity to earn money and many companies will manufacture the technology. Small companies from the car electronics and IT-sector in particular might be interested in selling AAP-equipment, software solutions and car PC platforms. Initial efforts from new small-sized companies should be monetarily promoted. Telematics companies like Navtech™ could be involved in public private partnership programmes. The documentation and revising of local speed limits and the programming could be carried out by the company with governmental support. The verification of speed limits (and in special cases the cancellation) must be done by governmental institutions.

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[100] Source: Jääskäläinen, Juhani: Status of the European e-Safety Initiative, in: GZVB (editor): Automatisierungs- und Assistenzsysteme für Transportmittel, Workshop reader #5, p.1-20, Brunswick 2004

[101] Source: Official website of the project: www.roncalli-telematics.com

Insurance companies decreased prices for car policies after the implementation of ABS in the mid-eighties. However, many accidents occurred because of people testing the system's thresholds [39,74]. Therefore the companies will be very careful about giving discounts for technological innovations. Nevertheless, promoting insurance companies if they decrease the prices for car policies would make sense.

7.1.1 Involved political fields

The major tasks in traffic safety policies have to be accomplished by the transportation ministries (i.e. the overall transportation ministry for Germany and the 16 ministries of the "Bundesländer") and their subordinate institutions (e.g. the German federal road administration "BASt").

However, the ministries for education and culture, and the ministries of the interior, and of course their subordinate institutions have to be included in the process of decision making for strategy packages and the related measure mixes. The traffic safety forum in Rhineland-Palatinate run by all three ministries also includes most private institutions dealing with traffic safety manners.

One of the tasks will be the evaluation of the various governmental promotion budgets. The next task would be the evaluation of possible companies and institutions (both research and distribution of ISA) to be subsidised.

The educational part of the tasks includes teaching driving with ISA-equipped cars. Driving instructors and the specific teaching cars have to be included in the ISA field trials. Experiences of both instructors and learners with ISA have to be documented and taken into account for the implementation[91].

The procedure for defining measure mixes includes the police and the related enforcement. The matters of surveillance have to include both speed measurements and technical parameters of the in-car safety devices (i.e. intervening ADAS including ISA).

The ministries for justice, too, have to be involved in the process. Some laws have to be changed or revised (chapter 2). Enforcement includes judgements (e.g. §315c StGB). The stated paragraph of the German law for crime and punishment deals with endangering in traffic. When a driver does not obey to a certain traffic rule and – as a consequence – endangers other road users, this is a serious offence. If the proof is given, that the misbehaviour was deliberate, the driver might be very severely punished. Thus, if ISA was implemented, speeding with an ISA-equipped car – in most cases – means speeding on purpose. In other words: Not using ISA in spite of having the car equipped with it means speeding is deliberate. If this is done with other road users around this means that endangering lives is also deliberate.

7.1.2 Specific conditions for transport politics

It has to be made clear that the driver is always responsible for his actions. This includes all steering manoeuvres, speed choice, braking and in-vehicle actions (e.g. usage of ADAS). This has to be proven through positive research results on speed behaviour with the various system versions. The positive effects of ISA (e.g. homogenisation of traffic, decrease of accidents, noise reduction) have to exceed the negative effects (e.g. driver's frustration) by far[102].

Administrative conditions include the homologation of the system (chapter 7.5.3) and the related possibilities of checking the system (chapter 6.2.3). The experiences with ISA and the system's attributes must play a role for internal police education. Characteristics of speeding with or without ISA could play a role for speed-related accidents. The additional equipment of cars with accident data collectors (ADC) plays a major role in these issues[29,74,91].

7.2 Economic conditions

Implementation of ISA will play no role in company policies as long as there is no related chance to earn money by selling the system (chapter 7.1). Therefore the companies will have to prove that there is a market for ADAS and platform solutions including ISA. In addition, governmental incentives like tax reductions or monetary promotion might motivate at least a few companies to include ISA in their product range. This might lead to either selling the systems to the automobile manufacturers or selling the systems directly to the customer (e.g. for re-equipment).

7.2.1 Economic status quo of the car industry in Germany

The automotive industry is the largest economic sector in Germany. In spite of only 945 companies (2.36% of all manufacturing companies) the sector includes approximately 855,000 employees (13.33% of employees in manufacturing industry). The turnover per year is approximately 257,875 m€ (19.10%). The investments amount 11,572 m€ (20.94%). The export quota is 59.6%. Hence, most of the vehicles are sold to foreign countries. Apart from North America, most vehicles are sold to the neighbouring EU countries. Thus, German cars play a significant role in the SUNflower states as well. The implementation of ISA in foreign countries might have effects on the German market. This effect is taken into account in the scenarios in chapter 8.

The quota of internal labour is rather small in comparison to other branches. This means that the suppliers play a very significant role in the whole business. This might have effects on the company policies of the Original Equipment Manufacturers (OEM). An ISA implementation by market forces is likely to be started by the small supplier companies. This effect, too, is taken into account in the scenarios in chapter 8.

[102] Source: Kaufmann, Lothar: Intelligent Speed Adaptation – Position Paper of the Ministry of Economy, Transportation, Agriculture and Viticulture[G], in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 157-160 Kaiserslautern 2004

7.2.2 Lobbyism in Germany

Lobbyism has had a great tradition in Germany since World War 2. In spite of part-time political standstill cause by harsh protests from professional assemblies, clubs or a citizens' initiatives, lobbyism is one of the supporting pillars of democracy. Traffic policies are usually discussed emotionally, because every citizen has a personal relationship to road (and car) usage. The automobile is part of social status[28].

Every country with a powerful car industry has a large political lobby. Approximately 40 m car owners and 855,000 employees in the automotive industry have a major interest in the benefits of being mobile with a car. Thus, political decisions and laws against the interests of the car lobby will be very problematic. Objective arguments are affected mostly by two main misunderstandings:

1. Road traffic is a free good for everyone. The government has to make sure that free road use is possible at any time and any place. Negative effects of road traffic have to be paid for by society.
2. Speed choice is an individual form of freedom. Speed limits are an orientation parameter. Enforcement is only necessary for those who exaggerate.

One of the leading advertising slogans of the last 30 years was: “Free driving for free citizens” (“Freie Fahrt für Freie Bürger”). Efforts to increase traffic safety (and decrease environmental effects) started in the early 1970s when 20,000 people per year were dying in road traffic accidents and the oil crisis affected the freedom of car usage.

Does the car user lobby (most of all represented by the ADAC) and the car industry lobby (most of all represented by the VDA) have common attitudes towards incision of free road use and free speed choice?

Attitudes concerning traffic safety devices changed massively. In spite of a broad rejection of ISA version 3, the ADAC, as well as various representatives from the car manufacturers, have a differentiated opinion towards versions 1 and 2 [7,70,88]. The opponents of the so-called car lobby are represented by the transport clubs. The transport club Germany (VCD) supports the idea of Vision Zero and speed limit enforcement, but rejects ISA version 3 [9,29]. The lobbyism in Germany is very different to that in Austria. Due to the fact that the car industry in Austria plays almost no role, the transport clubs have a bigger influence on political decisions. The transport club Austria (VCÖ) therefore has a great influence on German traffic safety initiatives. The fact that VCÖ has approximately the same number of members as VCD (in a country with 10 times fewer inhabitants) gives an idea of the political status of the club. The scientific publications of VCÖ often deal with environmental effects of traffic and accident prevention. Austria adopted Vision Zero in the political programme of the state after an initiative from VCÖ. However, VCÖ is slightly sceptical about the benefits of ISA, suggesting that another version of ISA should be considered - a version that produces an optical signal outside the vehicle, so that the other road users see that a car is speeding[103]. The idea behind this has a psychological background; a human being is not able to estimate speed differences correctly[28].

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[103] Source: Phone interview with Wolfgang Rauh of VCÖ on September 3rd 2003

7.2.3 Social and economic effects of speeding

Speeding has positive psychological effects on the speeding driver because of the so-called speed-flash. All other road users are negatively affected by the speeding. Social stress, hectic conditions and anxiety on inner city roads play a role in everyday life in cities[90]. Road user interactions often lead to aggressive behaviour as well as to traffic jams. The social stress and time loss can be measured using social costs. The economic effects of traffic jams, accidents and misbehaviour during driving interactions can only be described virtually through time-costs[104]. In addition, speeding indirectly causes economic costs because of the ecological effects[45].

The monetary social costs of traffic and speeding – in most cases – are paid by society (taxes, time-costs, health care) – not to mention the non-monetary social costs (e.g. suffering, stress). The idea of internalisation of social costs after the costs-by-cause-principle brought the eco-tax into play. As stated in chapter 7.2.2, the implicitness of low prices for road use comes with the free choice of speed.

7.2.4 Marketing-mix

Selling ISA means searching for potential customer groups. The concept has to take into account that single user types might totally reject the systems, while others might be completely convinced of the system's benefits.

An approach to marketing would be to follow the AIDA-strategy (Attention – Interest – Desire – Action)[69].

1. *Attention*: First of all the system has to be presented at automobile shows (e.g. in Geneva or in Frankfurt) and trade fairs for the automotive and IT-industry. The presentations have to be supported by media reports (positive and negative) newspaper articles and neutral reports on television. In Germany, a few magazines and TV broadcasts publish reports for "mobility" customers mainly with the aim of improving traffic safety and consumer protection[105].
2. *Interest*: The driver groups "functional", "composed" and "careful" might be early adopters of ISA (chapters 5.1.1 and 5.1.2). This can be brought forward to special customer types such as "intellectual", "conservation-conscious" and "young family", who are the first target groups for advertisements and test driving events.
3. *Desire*: If the early adopters accept the system and start word-of-mouth recommendation, the early adopter groups get larger and other user groups might pay attention to the product.
4. *Action*: The implementation of ISA would make sense for specific vehicle types: Family vans, mid-range estate cars, small city cars and mid-range "cult" cars (e.g. VW New Bee-

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[104] Source: Interview with Prof. Hans-Dieter Feser (social economist) on September 4th 2003 in Kaiserslautern

[105] Source: Phone interview with Thorsten Link, anchorman of the TV show "Rasthaus" from Southwest German Broadcasting Company (SWR) on September 5th 2003

tle™, Renault Avantime™) combined with a safety image campaign. The system should be included in a complete software package. The extra charge for the package should not be higher than 100€ (chapter 4.2).

A very important task for the ISA-related marketing is the identification with the product. Identification starts with a certain product image and a well known trade mark. Thus, companies with a safety image (e.g. Volvo™ or DaimlerChrysler™) have better chances of selling the system than companies with an image related to motor sports (e.g. Porsche™).

Design plays a role in the image of a trade mark[106]. In the last ten years, so-called concept cars were brought to the market in order to gain interest in a new product image (e.g. Renault Vel-Satis™, Mégane™ and Avantime™). The aspect of design is mainly valid for the car itself (appearance, external equipment) and also for the inner parts of the car (dashboard and interactive console, technical equipment).

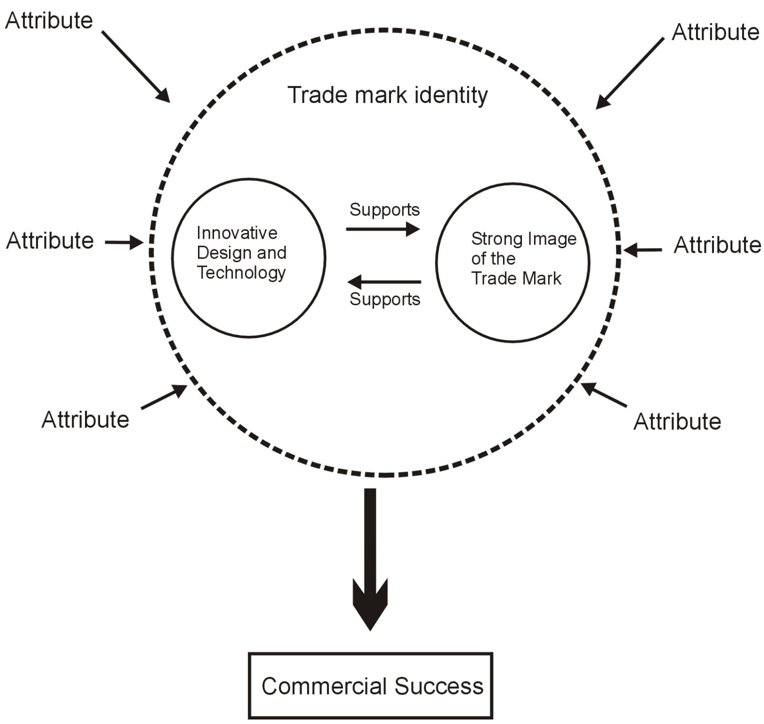

Figure 32: Flowchart of design, technology and trade mark image[106]

If design and image are acceptable to a customer, an integrated ISA will be evaluated as a comfort feature and not as a lack of driving performance. Hence, ISA needs an image campaign either related to a car manufacturer with a strong safety image (e.g. DaimlerChrysler™) or a large supply company selling ADAS-packages (e.g. Bosch™, Continental™). This campaign will not be started unless at least a small group of potential customers can be identified. Here, again, the traffic safety lobbies come into play.

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[106] Source: Bonzanigo, Carlo: The Importance of Design for Creating a Trade Mark Image[G], in: Ebel, Bernhard/Hofer, Markus/Al-Sibai, Jumana: Automotive Management, p.633-642, Heidelberg 2004

7.3 Social and psychological conditions

The psychological aspects of speeding are described in chapter 1.3 and the matters of acceptability are summarised in chapter 6.1. Thus, optimisation of cognition (driven speed, speed limits and danger for other road users) and increase in acceptance of traffic safety measures have to be reached. This is mainly an educational problem for schools, driving schools and enforcement actions. However the car and the in-car safety devices have to fulfil a few conditions[76,83,106]:

1. Usability (self-explaining, not complex)
2. Updates and upgrades (data, design, equipment)
3. “Professor-Assistant”-Relationship

The effects of habituation and reactance have to be taken into account when creating a product strategy. However, the results of the field trials in Sweden, Great Britain and the Netherlands are insufficient to make a final statement about these effects, whereas another effect has to be taken seriously: People who strictly did not accept the system before the field trials felt more strongly opposed while using the system.

7.3.1 Driver, vehicle and road

One of the main aims of ADAS is the optimisation of interactions between the driver and the vehicle. The functions have to be as easy as possible, and the functionality of the different systems has to include all possible driving manoeuvres (chapters 3.2 and 5.3).

The planning tasks are – on the engineering side – a feasible construction of HMI (driver-vehicle), reliable and fail-safe ADAS (vehicle-road) and the design and construction of self-explaining roads (driver-road). On the educational side, the tasks are: cognition training of dangerous situations relating to road structures and situational aspects. Attitudinal aspects concerning road usage are a general problem. The planning task is to start political programmes for stronger public awareness.

The aim of decreasing human failures while driving tasks is supported by increasing driving experience for all drivers. In driving practice seminars, the participants are confronted with inevitable conflict situations, which in real road traffic would lead to a crash. The experience with the situation helps to decrease negative crash effects and avoid post-crash misbehaviour. The practice seminars include cognition training[39]. The necessity for safety training is stated in both questionnaires and expert statements (chapters 4.1 and 4.2). Another measure for increasing traffic safety by experience would be the introduction of quality management for driving schools[40].

7.3.2 Identification, regimentation and feeling of freedom

The image making process of car manufacturers leads to a strong association between the driver and his vehicle. This is also a result of the high cost of new cars. The status of a car is comparable to the importance of a house. Sometimes, people see their car as a member of their family. Cars are equipped with toys, stickers and other symbols of personal identification.

This close relationship causes the emotional misunderstandings (chapter 7.2.2). The car – as well as the house – is a place where one is independent and on his own. It is one’s own decision, where to go, which road to take and at which speed. Every regimentation of these three major decisions

leads to a subjective lack of freedom. A certain amount of regimentation is accepted as long as the general feeling – i.e. the feeling that the aim behind the trip (chapter 5) is going to be accomplished within the estimated time schedule – is not restricted.
The planning task is to increase acceptability of speed limits. This could be done by the installation of additional explicatory road signs related to the speed limit signs (e.g. “danger of rear-end collisions” or “dangerous road section”). Furthermore, the driver has to have the chance to try out the system. Experience will decrease the level of rejection. The feeling of freedom should not be affected.
If the system is supported by a large marketing strategy and image campaign, the user might accept the system as part of the car. It would be best if the composition of ADAS is as individual as possible (e.g. the console design or the digital voice of the integrated ISA and navigation tool). The personal software package leads to a strong identification with the system. Automation of basic driving manoeuvres is another task, especially regarding today’s age structure development. Old people need more support through ADAS and more structural support including educational aspects and – again – self explaining road design. The visions of future vehicles however tend to a drive-by-wire performance[107]. The car manufacturers are working hard on fail-safe drive-by-wire systems[108].

7.3.3 Reactance and rejection

Reactance (Definition 4) is derived by attitudinal aspects and strengthened by negative experiences. In the case of ISA, the reaction would be deliberate speeding, or permanently switching off the system. The user groups “speeding” and “frustrated” are most likely to reject the system. Reactance is likely for the “composed” and “functional” group. The international field trials do not differ by user type, so that a general psychological evaluation of the field trials has to be undertaken before definite measures can be decided.

7.4 Technical conditions

From a technical point of view, ISA is already a complete feasible system. The functionality is high. From time to time a minor system failure occurred in the field trials[78]. However, the system is far from implementation. The technical conditions for ISA depend on the integration of the system into the technical modules of the vehicle and with the other ADAS. Table 10 on page 33 shows that many existing ADAS are not beneficial for ISA.
Another problem is the design of the HMI (chapter 7.4.1). Both input and output has to be optimised for the user. In the case of ISA, the most feasible and usable version has to be found.

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[107] Source: Strassmann, Burkhard: In the Arms of the Female Autopilot[G], newspaper article in: Die Zeit April 27th 2000 p.35

[108] Source: Spiegelberg, Gernot/Maisch, Ansgar/Sulzmann, Armin: Intelligent Vehicle Concepts on Drive-by-Wire Basis – Steps of Implementation in the EU-projects PEIT and SPARC[G], in: GZVB (editor): Automatisierungs- und Assistenzsysteme für Transportmittel, Workshop reader #5, p.162-180, Brunswick 2004

The whole process of developing ISA is closely related to the technical progress of digital road maps including speed limits and the exact positioning of the car. The European satellite programme, GALILEO, will bring an accuracy of less than one meter. On some major roads speed limits differ between lanes. This would be a problem with commercial GPS, where the accuracy (appr. 5m) at the time is more than the lane width. Nevertheless, the technical problems with reliable digital road maps and vehicle positioning systems have to be solved before the implementation of ISA can be started.

7.4.1 HMI and Cognition of ADAS

"The mistakes of the human driver normally occur due to failures in reception and processing of information. It is possible and necessary to transmit relevant information in an optimised way through innovative systems."[109]

Modern ADAS are very complex. In particular, the combination of the various sudden interfering and durably interfering ADAS (Figure 10 page 32) is not easy to understand. There is a necessity for usability of the complete package of ADAS (Figure 31 page 71). It has to be made clear that only one controller (e.g. a console) is responsible for running and communication of the ADAS. The HMI is therefore divided up into two communication channels. The human-machine channel translates commands and information from the driver to the machine kernel. The machine-human-channel gives out information and advice to the driver.

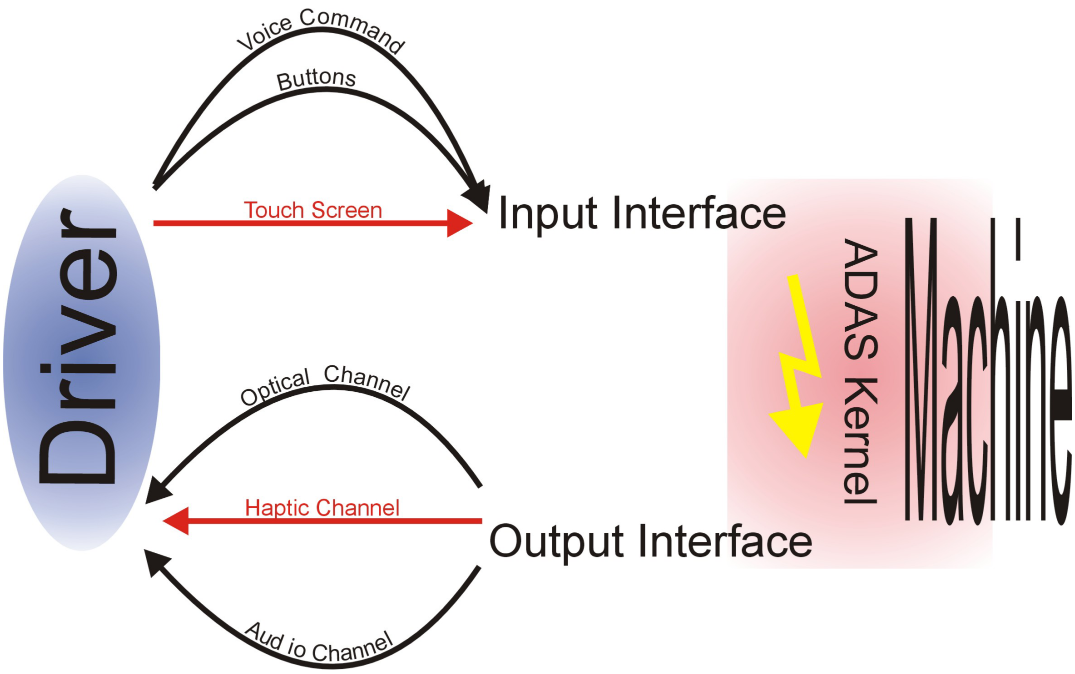

Figure 33: Communication channels between driver and machine [design by the author]

The best overview of all functions and a specified menu can be achieved on a broad, flat touchscreen in the middle of the instrument panel. Information output can be provided through optical

[109] Source: Mann, Mathias: Design of a driver-optimised Human-machine-interface – the example of lane departure warning systems[G], in: GZVB (editor): Automatisierungs- und Assistenzsysteme für Transportmittel, Workshop reader #5, p.81-108, Brunswick 2004

instruments. Possible instruments are a touchscreen, a separate screen or a head-up display (HUD), which displays the information virtually at the bottom of the windscreen. The haptic channel should only be used if a driving manoeuvre is recommended. This could be a turning moment on the steering wheel (e.g. in case of a lane departure warning) or a counter pressure on the pedals (e.g. in case of the AAP).

Communication channel driver-machine

The usage of ADAS – especially concerning comfort or information – is a secondary task which has to be accomplished in addition to the primary driving task. The time for the task should always be much less than 2 seconds. The distraction from the primary task has an influence on driving safety. 25% of all accidents occur because of a short term visual distraction[110]. Complex visual information especially leads to a long distraction of the eye focus. The secondary task can be accomplished safely if the HMI meets the following conditions [110]:

1. visibility
2. distinguishability
3. interpretability

If the task is too complex there is a necessity for partitioning, so that the primary task and the secondary task can be accomplished at the same time. This leads to a fourth requirement of the HMI:

4. chunkability

This means that the HMI has to be optimised for the individual driver preferences basic and the psychological skills (chapter 1.3).

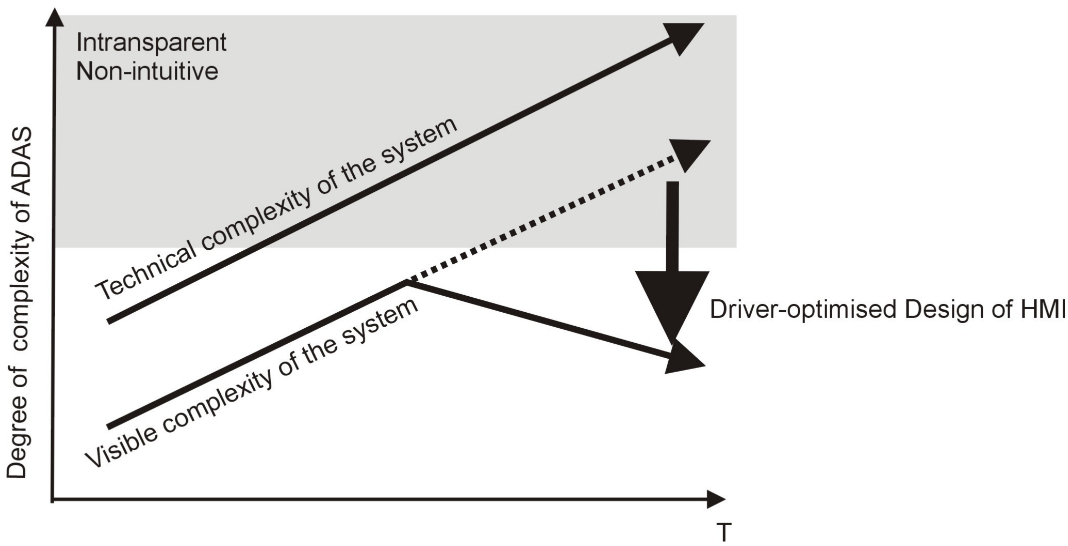

Figure 34: Necessity of driver-optimised design for the HMI[109]

[110] Source: Krems, Josef/Keinath, Andreas/Baumann, Martin/Jahn, Georg: The Occlusion Method – A Simple and Valid Method for Evaluation of Visual Strain for Secondary Tasks[G], in: Schlag, Bernhard [editor]: Verkehrspsychologie - Mobilität, Sicherheit, Fahrerassistenz, p.335-350, Lengerich, 2004

The technical conditions for a driver-optimised HMI-design are not part of this thesis. However, the preferred method would be a haptic signal for the output and an interactive touchscreen for the input.

Communication channel machine-driver

The fastest and most sensible reaction on a driving advice can be reached through haptic signals. *"Concerning car driving, which claims visually, it is recommendable to make use of acoustic or – in combination – of kinaesthetic and haptic signals in order to support the driving task. The optical channel should not be overloaded through additional information."*[111]

The signal of the system's advice has to be clear and directly interpretable. Most ADAS make use of optical or audio signals. Yet no car is equipped with haptic output tools. Nevertheless, both steering and acceleration/deceleration manoeuvres can be safely influenced by haptic signals. The following figure shows the advantages of task-specific haptic signals.

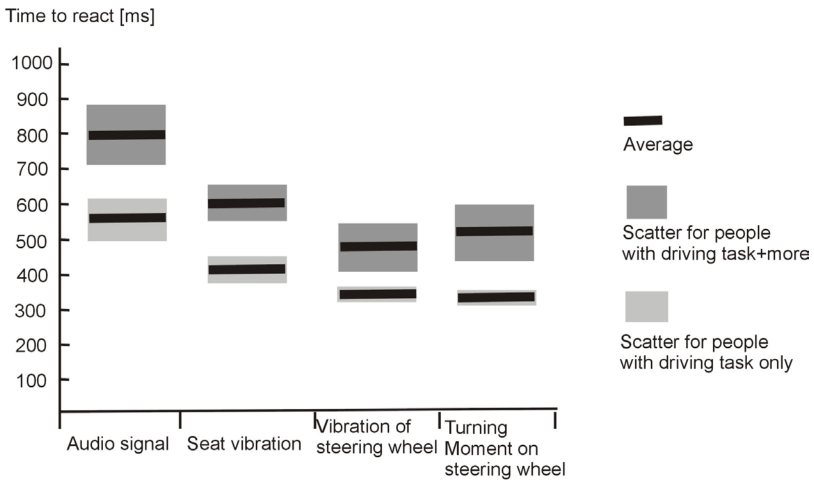

Figure 35: Time to react on various signal types while driving with or without additional tasks[109]

These results lead to the conclusion that ISA version 2 (AAP) meets the technical solutions for a safe and durable usage of ISA. In addition, the effects of reactance are presumably higher for audio systems as well as optical information. Again, the AAP seems to be the best option for the system's implementation. The check-up of the HMI and the system integration should be done by experts under consideration of existing checklist methods for the evaluation of HM-interactive systems in vehicles[112].

[111] Source: Schlag, Bernhard/Heger, Ralf: Approaches to a Psychologically Funded Road Design[G], in: Schlag, Bernhard [editor]: Verkehrspsychologie - Mobilität, Sicherheit, Fahrerassistenz, p.11-28, Lengerich, 2004

[112] Source: Nirschl, Günther/Blum, Ernst Josef: HMI-Checklist – Method and Tool for the Evaluation of Human-Machine-Systems in Vehicles[G], in: Informations- und Assistenzsysteme im Auto benutzergerecht gestalten, Berichte der Bundesanstalt für Straßenwesen edition Mensch und Sicherheit M116, Bergisch Gladbach 2000

Design and Integration into the Instrument Panel

Figure 36 shows how an ADAS-console could fit into the dashboard and which channels are active. Behind the touchscreen, a car PC is installed. Radio and music can be downloaded via internet (a CD player is placed at the bottom of the instrument panel). Comfort ADAS can be permanently switched on and off. Safety devices can only be put on a temporary standby. The desktop design is simple and adapted to the actual task.

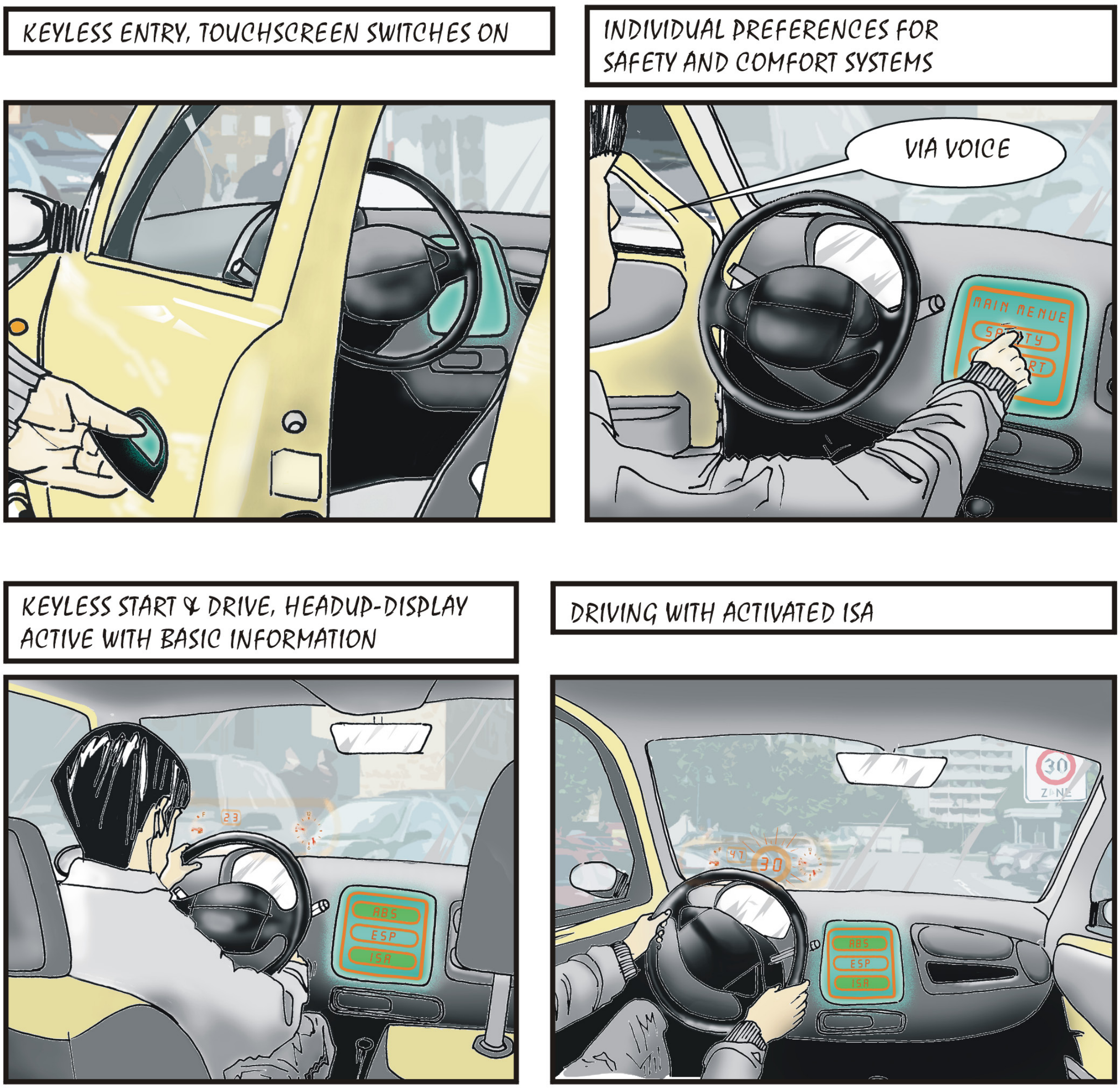

Figure 36: Proposal for the design and functionality of the in-car HMI [design by Maik Lafrenz]

7.4.2 Software solutions and hardware requirements

The automobile of tomorrow will be equipped with a car PC. Every available ADAS (and those of the future) is a software solution. The planning task for the software engineers is now to create a simple compatible operating system for all innovative ADAS. This could be the ADAS kernel (Figure 33 page 88). The technical attributes of the haptic HMI-tools in the steering wheel and the pedals are up-to-date mechatronic elements. The industrial solutions for all technical requirements exist at the present time. Merely the combination of mechatronic elements controlled by a software-based operating system and based on a standard PC hardware is not yet reality.

7.4.3 Database and updates

Concerning ISA, an up-to-date database including speed limits, road categories and dynamic traffic control facilities is necessary. Unfortunately, there is no general database for local speed limits. The administration of speed limits is done by local authorities. The documentation of road signs is done independently[113]. Road works and the related speed limits – especially if the works location is moving (a common method for motorways) – are often installed without informing the local authorities. In most cases, the database is not electronic. Thus, the speed limits have to be constantly checked by employees of the providing companies driving along the road network. The existing electronic information in the system that Teleatlas™ sells Europe-wide includes approximately 90% of the durable existing legal speed limits by road sign or related to the road category. However, no responsibility is taken for the correctness of this information[6].
The reliability of the data collected and the methods of documentation are the largest problem concerning the implementation of ISA in Germany. In other countries (e.g. Finland), the database is complete and reliable. Regarding the large German road network, the lack of reliable information will be a limiting factor for the implementation of ISA. The systems therefore should first be implemented in urban areas, where the diversity of speed limits is uncritical. A network-wide implementation depends on the quality and quantity of the available road network information.

7.4.4 Self-explaining road

Self explaining roads aim to reach safe behaviour through design and attributes without further intervention (e.g. through road signs)[111]. The traffic safety triangle (Figure 9 page 31) shows the fields of interaction between driver, vehicle and road. Figure 37 highlights the necessity of engineering measures to optimise the interaction between driver and road:

[113] Comment: The author contacted national, regional and local road administrations in order to find out the speed limits on motorways. A few limited sections and the free sections (i.e. sections, where the recommended speed limit is valid) are documented. The documentation of the speed limits differs in each of the 16 Bundesländer. Creating a general database is one of the tasks the German National Road Administration (BASt) wants to accomplish until 2006.

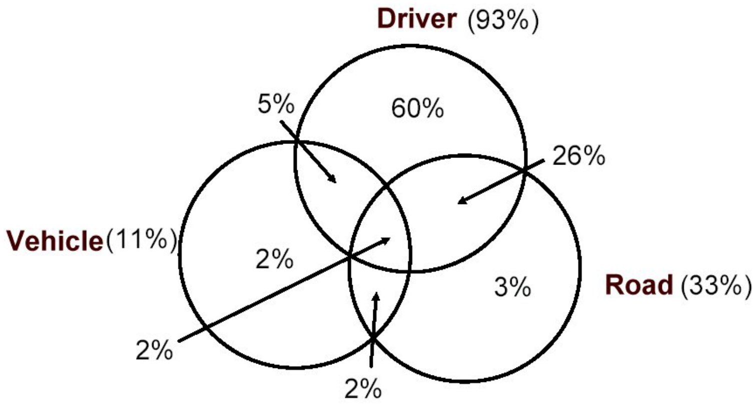

Figure 37: Accident triangle[114]

The speed driven depends on the perceived speeds of the vehicle being driven and the speeds of other road users. High speeds and – as a consequence – speeding, usually occur on roads with a new surface, on tree-lined avenues and on motorways, where the high speeds lead to a behavioural adaptation within three minutes. The perception of speed is completely different in change-over situations from motorways to urban roads (compared with the other way round)[114]. Thus, aspects of road design have to be taken into account in order to decrease driven speeds and speed-related accidents. However, road redesign is always related to large capital investment. Therefore, the economic and ecological aspects of road redesign have to be phased out. Hypothesis: In most cases, vehicle-based measures (e.g. ESP and ISA) have a better cost-benefit ratios and cause less ecological impact. Supportive measures of enforcement (e.g. SectionSpeedControl™ [56]) could also reduce the requirement for self-explaining road design elements.

The (re-)design with high quality surfaces of high capacity roads such as trunk roads - which have the highest amount of speed-related accidents (chapter 1.4), and inner city arterial roads which have the highest amount of speed offences (chapter 1.2), is not as problematic as the avoidance of trees on avenues. Tree-lined avenues have to be treated differently. Admittedly, the negative effect on speed choice on tree-lined avenues caused by the so-called tunnel effect, is less significant than the other stated effects. Continuous speed measurement on such roads could be beneficial.

The main aspects of safety beneficial road design derived from psychological attributes are cognition of speed, visual aspects (e.g. overtaking distances) and infrastructural measures influencing steering manoeuvres.

Various road attributes (e.g. dips) cause delusions concerning correct speed choice and overtaking manoeuvres. The avoidance of those elements (e.g. by landfill) however is expensive and – as a consequence - unconvertible.

The concept of the self-explaining road makes use of certain elements of design. One aim is the avoidance of information overload. Therefore the self-explaining road makes use of regular cues

[114] Source: Kämpfe, Bettina/Weller, Gert/Schlag, Bernhard: The Influence of different Road Designs on Perpetration of Driving Mistakes[G], in: Schlag, Bernhard [editor]: Verkehrspsychologie - Mobilität, Sicherheit, Fahrerassistenz, p.29-46, Lengerich, 2004

and prompts that do not overload the optical input channel but are clear and directly interpretable (e.g. narrowings, reflectors on trees or static road separations).

The highest amount of (severe) accidents can, on one hand, be found on roads that are very challenging because of a complex alignment (e.g. in mountains), because drivers – consciously or subconsciously – see the road as a chance to check out subjective driving abilities – with sometimes fatal effects. On the other hand, wide trunk roads with a high percentage of straight sections have the effect that a driver is less concentrated on the primary driving task and reacts slowly on unanticipated incidents – again with sometimes fatal effects. In Germany, many trunk roads fit into either the first (e.g. B48 near Kaiserslautern) or the second category (e.g. B214 near Brunswick). Thus the driving task has to be challenging, but not significantly so. Elements of road design might help to keep a safe balance between the extremes.

The lane departure in combination with high speeds leads to the most dangerous conflict situations on roads. Car-car-accidents in oncoming traffic have fatal effects (this is simply derivable from the physical axiom of inertia). Sensible design elements for that problem are rumble strips or lane separations.

The problem of high speeds in changeover situations from high-capacity roads to inner-city roads might be reduced through anticipating measures like coarse surfaces, narrowings or illuminated warning signals. Nowadays, roundabouts or lane direction shifts are used for the entrance situation to a built-up area. Concerning inner city roads, optimised relationships have to be reached between the road width and the height of the buildings or elements at the side of the road, as well as optimised relationships between spaces for pedestrians, bicycle users and car lanes. Design elements like trees, artwork and lane direction shifts are synergetic.

7.5 Juridical conditions

The Implementation of ISA, the integrated car PC and the ADAS-kernel needs a preparation phase, in which the juridical context has to be made clear. All car electronic systems need a homologation. Thus, comprehensive tests with the system have to be made. This is another reason for the necessity of an ISA field trial in Germany.

The framework of laws concerning technical solutions for traffic safety consists of the liability law, the road traffic law (StVO) and the road traffic homologation law (StVZO) supported by several guidelines (e.g. for telematics).

7.5.1 Product liability

The strongest argument against ISA (brought up by the car manufacturers) is the problem concerning product liability. Who is responsible if the system fails and the car is involved in an accident? In which cases is the driver liable, in which cases the car manufacturer, in which cases the supplier or the provider?

The normal case in road traffic is that the driver is responsible for an accident, either through driving misbehaviour or because of a lack of accuracy concerning car maintenance. In the case where a failure of technical equipment is (partly) responsible for a crash, it has to be determined whether the crash would have been avoidable if the system was functioning correctly. Or in other words, did the driver have the chance to overrule the system in order to avoid the conflict that led to the crash? The driver/keeper liability became manifest in the Vienna convention on road traffic from 1968. The German government refers to the Vienna convention concerning non-overrulable systems like ISA version 3[115].

ADAS can be divided up into three groups. The first group consists of informative or warning systems. ISA version 1 belongs to this group. Due to the advisory characteristics of these ADAS, the driver is 100% responsible for his actions. Product liability does not come into play, even if the system completely fails. However the driver has to be introduced to the systems' attributes. He must get the chance to learn how the systems act. This task has to be accomplished by instructive notes and reminders (e.g. stickers)[116].

The second group of ADAS are intervening but overrulable systems. ISA version 2 belongs to this group. Here, the same statement as for the first group is valid. However, advertisement and instructions concerning the product have to be clearer and warnings concerning possible failures have to be pointed out as strongly as possible. If the system is distributed as a safety device, the product liability is stronger than for comfort systems[116].

The third group are non-overrulable systems. This includes sudden interfering ADAS (Figure 9 Page 31) as well as ISA version 3. Here – as well – the first question is: How did the driver use the system? In extreme cases, deliberate misuse plays a role. When the first cars were equipped with ABS in the early 1980s, many drivers misused the system for extreme driving and braking manoeuvres. This had effects on the accident statistics[74]. Product liability comes into play when an accident occurs that could not be avoided even by an "ideal" driver. However the consequent risk management of the companies will lead to a total rejection of ISA version 3 as well as all other non-overrulable ADAS. ABS, ESP and ASR are examples for sudden interfering ADAS. Usually, the driver can switch off the system at any time. There are no cases known in which an unavoidable accident occurred only because of a failing ADAS. Usually the system failure is only one link in a chain of "unfortunate circumstances".

The liability is valid for the complete car (if it was not rearranged or equipped with additional tools or attributes), single parts of the equipment and software. The car manufacturer is able to take suppliers or providers into recourse, if it is proven that the failure was not caused by the original equipment manufacturer (OEM). Two different laws are taken into account for product liability concerns. The first is derived from the citizen law (BGB) and gives the OEM the possibility of exculpation (i.e. the complete recourse can be on a supplier/provider). The second is derived from an EU-guideline, and is called product liability law (ProdHG). Here the OEM is always partly responsible for the whole system and the related attributes.

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[115] Source: Feldges, Joachim/Brandenburg, Klaus: Legal Aspects of ISA Technologies, in: Topp, Hartmut [editor]: Intelligent Speed Adaptation - Expertenstatements [G/English], publications of imove, Green Edition #63, p 123-139 Kaiserslautern 2004

[116] Source: Feldges, Joachim/Kanz, Christine: Liability Aspects of Driver's Asistance Systems[G], in: Zeitschrift für Automobilwirtschaft edition 3/2002 p.38-41, Bamberg 2002

Disclaimer

In order to prevent charges concerning product liability, the manufacturers, suppliers and providers have to give out comprehensive information and warning material. This information usually includes a disclaimer. The customer signs – while buying the product – a contract, in which he takes the complete responsibility for driving actions with or without ADAS in function.

This means that the driver has to become familiar with the product and its performance before he uses it in every day traffic. He has to be aware of possible system failures and has to know how to react in order to avoid conflicts, if a system failure does occur. The disclaimer can be included in the general trade conditions, so that a costumer knows about the regulation prior to making a purchase contract[117].

7.5.2 Traffic legislation

The implementation of ISA will surely have positive consequences on traffic legislation. On one hand, depending on the car fleet penetration, some road signs may become obsolete. This is especially valid for reminder signs (in cases where there is a long section with the same speed limit) or speed humps. On the other hand, matters of enforcement might be optimised. The combined implementation of ISA and the ADC would be particularly sensible[74]. This would have the additional effect that the statistical analysis of accidents could be done easily (Table 9 page 30).

The effects of ISA on laws will be slightly small compared with the effects on everyday road traffic in reality. The lack of adherence to legal rules affects nearly all paragraphs of the German traffic law (StVO) [24]. §1 StVO states that a driver has to drive moderately and always carefully. Driving behaviour has always to be considerate to other road users. This is more utopistic than Vision Zero ever could be. Moreover, the enforcement of the basic rules of the traffic law is almost impossible, due to the fact that the burden of proof is one of the principles for jurisprudence in democratic nations. Inconsiderate behaviour and tangible endangerment cannot be proven easily.

Solutions for this problem would be better scope of enforcement for the police as well as a redefinition of “tangible endangerments” or in other words thresholds for “abstract endangerments”[12]. In penology, hazarding the consequences of an action means: no reduction of the penalty.

An example for clarification: A driver passes through a built up area with residents at a speed of 100 km/h (speed limit 50 km/h). Due to the fact that in that particular moment none of the residents is on the street, no tangible endangerment can be proven. Nevertheless the driver knew about the danger he is causing because of his high speed. Is the driver hazarding the consequences of his action? Is this therefore an endangerment?

Traffic law and the related enforcement have to take into account that a certain amount of misbehaviour is a constant human factor, therefore there are certain levels of exceeding associated with concrete situations. Road signs and safety devices should always be instructive, so that misbehaviour could not occur unintentionally[80]. This – in turn – is conductive to the proof of inconsiderate behaviour.

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[117] Source: Interview with Dagmar Gesmann-Nuissl of the Institute for Civil Law at the Kaiserslautern University of Technology on October 15th 2003 in Kaiserslautern

7.5.3 Homologation and authorisation

Every ADAS needs a homologation. The patent office surveys the legislative introduction of a new high technology product. The system must also have an operating license (this concerns equipment for vehicles and running the system) as well as an EEC type approval (concerning manufacturing and installation)[115]. Concerning law support, it has to be made clear that no simpler or cheaper measure can have the same effects as the proposed system[115].

The Federal administration for telecommunication “Regulierungsbehörde für Telekommunikation und Post” is responsible for the authorisation of the telematics background of the systems. To install an ISA system in an existing car one needs a homologation by an official institute for technical inspections (e.g. TÜV™).

Police and inspection institutions have to be able to check whether a system is working properly or not. The introduction of measurement tools is therefore implicit. Due to the fact that ISA is based on existing electronic components and compatible software systems, the authorisation should be no problem.

The additional equipment for ADC or other tools (e.g. toll control systems) is based on various additive rules. ISA is impacted indirectly if the authorisation of the ADAS kernel or other integrative systems has to be verified.

8 Implementation scenarios

The four implementation scenarios (chapters 8.1, 8.2, 8.3 and 8.4) as well as the non-implementation scenario (chapter 8.5) are all developed from the various results of the national and international surveys (chapters 4.2 and 4.3) and the expert pool (chapter 4.1). The scenarios concern an implementation in Germany, and therefore only make partial use of the stated scenarios of the stakeholder survey (chapter 4.2). The main aim behind the scenarios is to give an overview of the most likely methods of ISA-implementation, as well as the strategic background of associated measures. It is important that the implementation in each case will be accomplished within a comparatively short period of time (i.e. five years). This means, that the up-to-date technology (2004) is introduced in the first two years and the car fleet penetration follows in the next three years. Hence, the methods described lead to complete implementation in 2010 at the latest. Subsequent implementation will likely make use of a redesigned and modernised technology, so that even if scenario X becomes reality, an implementation before 2020 (as stated by various stakeholders in chapter 4.2) might occur. Implementation in the sense of this thesis means that the German vehicle fleet penetration with ISA (one or more versions) reaches at least 15%. This is derived from the hypothesis which states that if more than every tenth car is equipped with ISA, there is an effect on traffic harmonisation and a lowering of the mean speed and speed variance as a whole (q.v. introductive text of chapter 6).
The preferred scenario (chapter 9) is derived from the author’s opinion on the highest likelihood of implementation and the stated experience (evaluating expert statements and used literature) with recent implementations of traffic safety devices.
Each implementation scenario takes into account that the pure implementation of ISA will not have a sustainable effect. The measure has to be supported by various additional measures – especially concerning educational aspects.

8.1 Scenario A: Version 1 – implementation by market forces with governmental monetary promotion

Version 1 has already been introduced. Teleatlas sells a DVD (compatible with most navigation systems) which (according to the advertisement brochure) includes nearly 90% of all speed limits in Europe[6]. However, “implementation” means more than introduction and the related advertisement of the system. At least a certain percentage of German cars should be equipped with the technology. Moreover, the public should be well enough informed about the system and its performance. This is not yet the case.
However, there are several possibilities for increasing the number of cars equipped. Governmental monetary promotion for providers (eventually also other than Teleatlas) producing the system as well as the broad neutral presentation of the system and its benefits in mass media (i.e. through independent reporting in TV and newspapers) would help to gain more customers for the product.

Success by market forces is directly derived from public knowledge of the system's performance. Navigation tools including traffic safety devices are very innovative, and therefore have the chance to attract early adopters (chapter 5.2).

The product can be implemented on two ways: One is the serial equipment of new cars with integrated telematics platforms including navigation tools and ISA 1. The other is the retrofitting of the system. The latter includes continuous functional upgrades whereas in the first case merely updates are necessary.

8.2 Scenario B: Version 2 – implementation by market forces supported by traffic safety institutions and image-making processes

One form of version 2 is planned for introduction by BMW™ in the near future. Due to the fact that the 3XX-series has a broad clientele, the introduction will have a larger effect than the stated introduction of version 1 from Teleatlas (scenario A). Nevertheless it will not gain sufficient interest for a long-term effect, so that an implementation needs to make use of further channels. The AAP-technology would be of interest for suppliers to produce. Small scale monetary promotion would make sense. However, the initiative for broad implementation comes from traffic safety institutions and other pressure groups. In the 1970s, political lobbyism in the sense of traffic safety lead to the implementation of seat belts, and finally to the legislative covenant for seat belt usage. Concerning ISA, the same route is possible. Even the ADAC sees benefits in speed management and ADAS-equipment. ISA (often called differently in political programmes) plays a role in this context. As long as it is made clear that the driver who intentionally wants to speed is able to do so even if the system is running, the car user lobby will partly accept the technology, or at least will have a neutral opinion.

The latest political standpoints from the transportation clubs in Germany and Austria (VCD and VCÖ) indirectly state ISA version 1 and 2 as possible solutions for the problems of speed-related accidents. This point of view should necessarily be strengthened. As a consequence, a specific pamphlet on ISA should be published. Due to the fact that only version 3 was evaluated, the ADAC, too, has to relocate and extend the published standpoint towards ISA[87,88].

The connected public awareness of the benefits of ISA will lead to a desire to buy the product. It is very important that the negative image ("Zwangsbremse" = restraint; driver is enforced to brake) related to the term "ISA" – derived from the fact, that it formerly meant version 3 – should play no role. The easiest method to circumvent this is to give the product a new – more popular – name. "AAP" or "speed assistant" are sensible alternatives. The politics and measures of image making are closely described in chapters 7.2.4 and 9.2.2.

The innovations concerning ADAS equipment include a complete reorganisation of vehicle power supply and hardware/software requirements. The car of tomorrow is a multimedia-mobile with high-performance safety devices. The image making process therefore will not only aim at implementation of ISA but to implementation of complete software packages (chapters 6.2.2and 7.4.2). After the introduction of the AAP, the further task will be the continuous upgrade of the related database, the complementary software and the operating system (i.e. the ADAS kernel). The technical problems related to the digital road maps could be circumvented if the system – firstly – is only in function on urban roads and at particular black spots or "black-spot areas" such as rural roads noted for being dangerous.

8.3 Scenario C: Modified version 3 – implementation by law for speed offenders instead of cancellation of the driving licence

Due to the fact that liability problems are likely to lead to a total rejection of version 3, this scenario deals with an overrulable system. Version 3 – making use of the dead throttle – has to have an emergency button in order to overrule the system, so that every potentially critical situation (e.g. a system failure) can be safely handled. However, every time the system is switched off has to be recorded by a data collector. The comprehensive implementation of ISA version 3 with a data collector could be done through a large scale enforcement field trial. Speeding drivers who – because of their misbehaviour – normally would have to dispense with their driving license, could get the choice of equipping their car with ISA-version 3 for a certain period of time (obviously longer than the cancellation of the driving license).

The system software might make use of the dead throttle for the penalty time and then switch to the haptic throttle. Consequently, the evaluation of the data collectors requires legislation. The traffic safety assemblies, the regulatory institutions, local authorities and governmental representatives should get the responsibility for such a project with the aim of a later implementation of ISA as a complete system.

8.4 Scenario D: Various versions – broad implementation in SUNflower states have effects on German car market and traffic laws

Presently, Sweden has the highest number of ISA-equipped cars in various field trials. Finland was the first country with a nationwide digital roadmap including all speed limits. Great Britain has large ISA-field trials as well as broad enforcement measures. The Netherlands and Belgium have a very good traffic organisation structure. The results of the ISA-field trials concerning acceptance and performance of the system are promising. Hence, these countries are most likely to be the first where ISA will be implemented. The governmental support for the system and the strong traffic safety lobbies help to reform the particular traffic laws.

Depending on which version has the best cost-benefit-ratio (presumably version 2)[118], the implementation will have effects on supply companies in the countries mentioned. Due to the fact that the automotive industry is internationalised, the experiences in selling the systems will have effects on the German market.

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[118] Comment: The cost-benefit analysis for ISA is part of the PROSPER project – scheduled for 2005

The national traffic laws in France and the SUNflower states – now – have comparatively low influence on EU-law or related guidelines. However, the latest White paper states that a massive decrease (50%) in deaths and injuries through traffic accidents is aspired by 2010[119]. If the EU is seriously interested in reaching this goal, a traffic safety strategy consisting of a consequent measure-mix has to be introduced in every single member state immediately. This has to be supported by an EU-directive towards ISA equipment and usage. To start the process for such a directive is one of the aims of the PROSPER project. The high level of driven speeds – the most common reason for accidents – has to be reduced markedly. This could include a test introduction of various ISA versions as well as further field trials – including one in Germany.

8.5 Scenario X: Non-implementation and redundancy

Due to the fact that the political opposition to ISA is very strong in Germany, implementation of ISA version 3 is almost impossible. The existing problems concerning data collection and product liability will be the strongest arguments against version 1 and 2. The benefits of a system which cannot be run properly (in addition to the psychological problems of subjective restraint and reactance) are questionable.

The non-implementation has to be taken into account. The question is: Can the proposed benefits be gained through easier and cheaper measures than ISA? This includes (ISA-beneficial) supporting measures towards road design (chapter 7.4.4) as well as the stated speed management measures (chapter 2).

Hence, the effect of non-implementation will be a long-term covenant for governmental institutions to introduce strategy packages towards speed management without ISA. This does not exclude private companies. Speed surveillance, road design and driver safety training could easily be done by private companies under governmental control. The financing model of public-private-partnership (PPP) is a proper method to preserve social, political and economic interests in traffic safety. The communication base for such models is the stated forum (chapter 5.2 Figure 27 page 57).

The scenario does not mean that ISA will never be implemented in Germany. A redesign of the system and the strengthened integration into ADAS as well as a long-term image-making process modules might lead to an implementation at a later date (after 2010). This includes a rearrangement of the framework conditions until then. Attitudinal aspects might change as well as technical requirements for cars. For example, the general tendencies towards social obsolescence will definitely lead to a change in customer demands on car design and equipment.

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[119] Source: Official website of the European Union and European Commission: http://europa.eu.int/comm/energy_transport/en/lb_en.html

9 Scenario evaluation and requirements for ISA implementation

The implementation of ISA in Germany – at the moment – seems to be almost impossible. The political opposition from the automobile industry, the data collection problem and the potential problems with product liability lead to the hypothesis that an implementation of ISA in Germany will not take place within the next 5 years. Hence, scenario X is the most likely one. However, politics sometimes suddenly change as soon as political lobbies support certain projects.
Hence, the preferred scenario is the one, that – from the author's point of view – will most likely become reality. This is partly derived from the results of the different surveys and partly based on the author's personal opinion of what is sensible in concerns of ISA introduction and support.

Preferred scenario

The preferred scenario is scenario B (chapter 8.2). The implementation by market forces meets the demands of both industry and politics. The anticipated effect on traffic safety of version 2 is not as high as that from version 3 (described in scenario C chapter 8.3), however, version 2 – unlike version 3, even in the modified form – has a positive effect on image making. Traffic safety and comfortable usage might be an argument in favour of selling this system. Every kind of implementation by law is associated with rejection by drivers. The results of the stakeholder survey support scenario B. The scenarios 1 (equity and AAP) and 6 (telematics platform) used in the second round of the stakeholder survey of the PROSPER project (chapter 4.2) scored best in the questionnaire (Table 12 and Table 13 page 44). These two scenarios are interlaced into scenario B of this thesis.
In scenario A (chapter 8.1), the effect on traffic safety is insufficient, which corresponds to the results of the Swedish field trials[78]. The car fleet penetration percentage of cars equipped with dynamic navigation systems including speed data (i.e. ISA version 1) might be higher than that for cars equipped with the AAP (ISA version 2). However the technical (e.g. through additional ADAS modules) and political support (e.g. through pressure groups) for version 1 will not be as strong as for version 2. In addition, the political support might stop as soon as the implantation of the system is done. Whereas the implementation of the AAP might lead to new requirements concerning technical solutions in cars and for the infrastructure.
The necessity for self-explaining roads as stated in scenario X (chapter 8.5) is independent from any strategic suggestion towards ISA. Speed Adaptation technologies only help to avoid speed-related accidents as long as the speeding is not deliberate. The self-explaining road aims to avoid any kind of accident derived by unconscious misbehaviour of a driver.
The effects of an implementation of version 1, 2 or 3 in one of the SUNflower states might have less effect on German policies than implementation by market forces. This is due to the fact that Germany sometimes plays the role of a loner in car traffic concerns (chapter 1.6). The ISA field trials and the related optimism are seen very critically [59].

9.1 Ceteris paribus-conditions and global political evaluation

Ceteris paribus: "*With other conditions remaining the same*"[63]. Global effects, political measures (e.g. concerning monetary promotion or environmental protection), economic changes or changes in law might all be beneficial or harmful on the task of ISA implementation. Such effects are unpredictable for the point of view of this thesis. Therefore only a change in the stated conditions (for the various represented sciences and institutions) is to be discussed in this chapter.

Definition 10: Ceteris paribus

The political status quo concerning traffic safety includes several programmes in which speed management plays a role. ISA itself is mentioned directly or indirectly in these programmes. In addition, traffic calming and reduction is stated as an important aim for environmental protection. However, no political programme really enforces speed management – let alone ISA.
The political status quo concerning economy is slightly different. Due to the fact that the financial situation of the Federal Republic of Germany at the current time (2004) is very precarious, political programmes for promotion of innovative technology and new business are partly blocked. The same problem concerns promotion of traffic safety research.
The political status quo in Germany is not beneficial for a fast implementation of ISA. In addition, Germany has massive problems with road administration, speed data (for research tasks), accident data (for research tasks and identification of black spots) and road sign management (especially temporary limitations during road works). This is due to the fact that road administration is done mostly by local authorities or the federal states (Bundesländer). ISA equipment relies on speed limit data and digital road maps. Today, no up-to-date digital road map which includes speed limits is available. However, several institutions show massive interest in editing such a map and effort has already begun to collect data through researching administrative directives. In addition, various companies (e.g. ADAC) collect data by sending out employees to drive on every major road in Germany. The speed limits and other directives (e.g. restricted overtaking) on these major roads (motorways and trunk roads) are recorded and documented.
Changes in traffic law concerning enforcement, liability or a general speed limit are very unlikely. Merely surveillance and control of motorised traffic might be fortified. The German police has to deal with tasks derived from the introduction of tolls for HGV and crime prevention programmes. Therefore broad measures promoting mutual support of crime and traffic police were introduced. The surveillance groups are equipped with most modern devices. The police has a strong interest in speed management and ADAS implementation[120].
The police and the traffic safety researchers seem to be the driving forces for speed management in Germany. A strong user lobby in favour of speed management does not yet exist in Germany[29]. However, the research activity and publications of the Austrian transport club (VCÖ)

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[120] Source: Koslowski, Uwe: Integrative Traffic Safety Projects[G], in: Internationales Seminar – Verkehr ohne Grenzen, March 30th- April 1st 2004 in Münster-Hiltrup, Workshop reader, Münster 2004

have a noticeable influence on strategic German measure plans [103]. This means potentially that projects in Austria like Roncalli could have an influence on the ISA implementation process in Germany. This would be according to scenario D (chapter 8.4).

The ceteris paribus concerning user perception and acceptance is derived from a close relationship between the German car owners and the feeling of freedom. Regulations concerning speed and right of way are very often disobeyed. Misbehaviour usually occurs whenever the subjective perception of a situation does not come with the related social norms for such situations. Wide lanes, low pedestrian or bicycle traffic and long range of sight lead to speeding behaviour. The driver does not expect dangerous situations, the experience with subjectively comparable situations on similar roads (especially roads with higher speed limits) lead to (partly extreme) cases of the speed limit being exceeded. Sudden changes in the situation therefore have severe effects. Due to the fact that a driver is not familiar with such dangerous situations, the likeliness of an incorrect driving decision is rather high. Consequences from that behaviour are conflicts and, ultimately, accidents.

However, as long as drivers are not aware of themselves being in danger while speeding as well as the related danger for other road users, such misbehaviour will not have an influence on the social norm concerning speed choice. The acceptance of speed limits in Germany is very low for most road categories. Merely “sensitive zones” and areas with high levels of non-motorised traffic lead to high adherence to speed limits. The lack of acceptance of speed limits affects the acceptability of ISA. Restrictive ISA-systems would only be accepted for built-up areas (excluding arterial roads). However, informative systems might strengthen the awareness of speed limits. The effect could be, that the drivers still exceed the speed limit, but to a lower extent. The negative effect of getting used to a 100% informative system would be long-term disobeying of most speed limits. The AAP seems to be more effective in these concerns. In addition, the AAP scored better in the evaluation from test drivers in the large scale Swedish field trials[78]. The AAP is less annoying and has direct influence on speed choice (chapter 7.4.1).

The implementation strategy for ISA has urgently to take into account that supporting measures towards acceptability (e.g. marketing processes) and policy making (e.g. political postulations from pressure groups) have to be realised. The strategy must also evaluate the influence of different groups on the process of implementation. Chapter 9.2 describes the necessary parameters for the implementation strategy. The strategy is derived from the preferred scenario B (chapter 8.2) and the supporting measures from scenario X (chapter 8.5).

9.2 Principles of implementation

Due to the fact that the preferred scenario states the implementation by market forces, the user (i.e. the private and professional car driver) plays the largest role. The lack of acceptance for ISA therefore is the largest barrier in the implementation process. However, ISA version 2 was acceptable for both users who are not familiar with the technology (chapter 4.3) and the test drivers in field trials and simulator tests[1,43,78,86]. Figure 38 highlights the introduction of ISA from the user’s point of view.

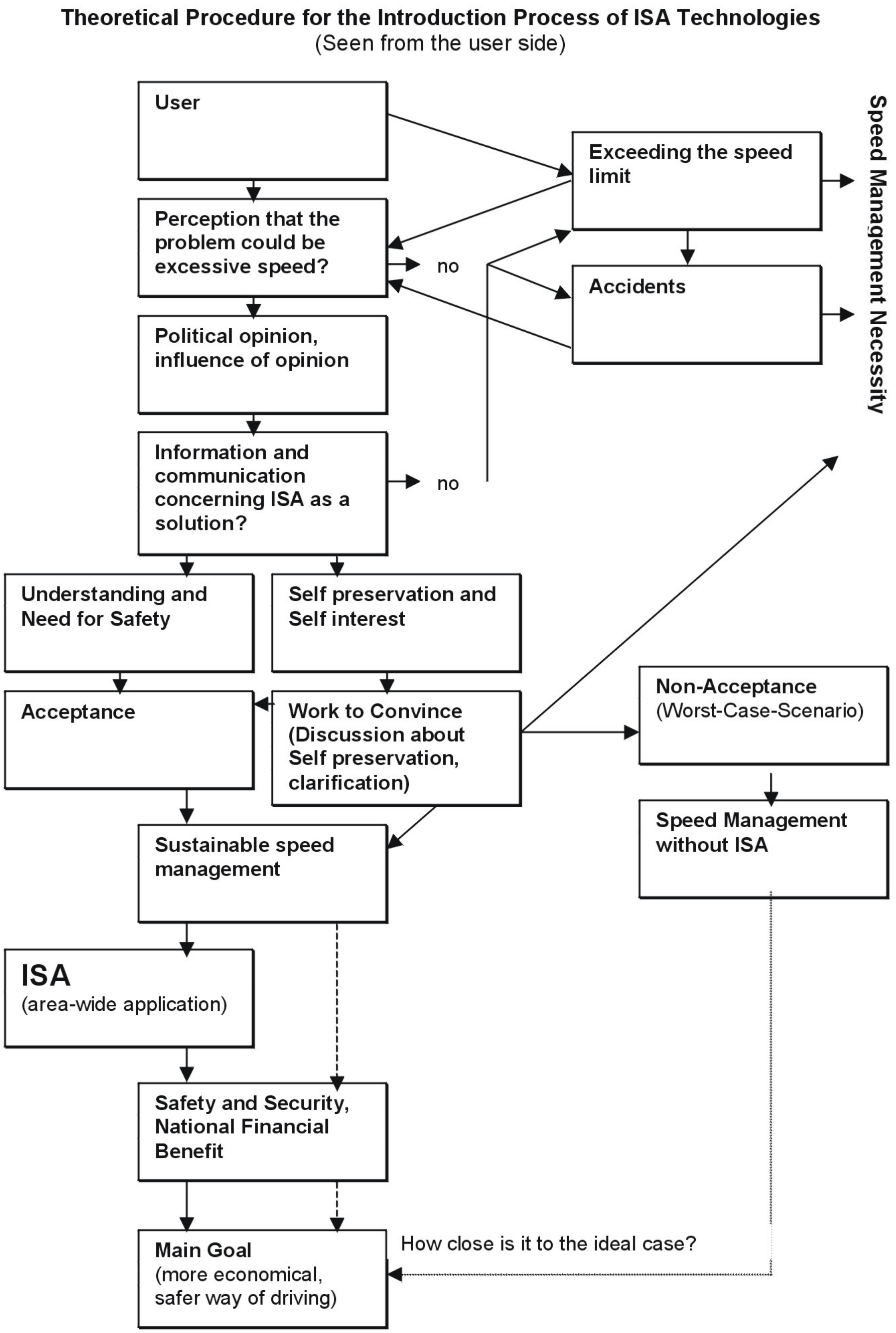

Figure 38: Theoretical procedure for the introduction of ISA [design by the author]

The user is influenced by other groups (Figure 12 page 37) and the political, economic and social status quo (ceteris paribus q.v. Definition 10). The process is partly mirrored in the five scenarios, whereas scenario X (chapter 8.5) would be the worst case scenario.
Concerning implementation by market forces, first of all it has to be made clear that at least a few companies are interested in producing ISA cars or equipment. Due to the fact that the main argument from the car manufacturers against ISA is the product liability problem, the strategy has to highlight those aspects of legislation that support ISA (chapter 9.2.1). The second step is then a concerted marketing strategy (chapter 9.2.2). The framework for the implementation process is then the planning procedure including supporting measures and redundancies (chapter 9.2.3). Finally, the completed strategy has to be arranged and put into a time schedule (chapter 10).

9.2.1 Aspects of legislation

The AAP is a half-open system. The driver decides which speed he wants to choose. The informative feedback of the legal speed limit through the head-up display supports his decisions. Nevertheless, he has to be aware of potential system failures and incorrect data concerning the speed limit. Hence, there has to be a written disclaimer and verbal instructions before an AAP-equipped car is sold. The retrofitting is much easier. The instruction manual should include indications of potential failures or incorrect data. Purposeful misuse of the system, too, must necessarily be included in the disclaimer.
Further legislative requirements are homologation of the system itself and ISA-equipped cars. Similarly, the usage of ADAS (including ISA) has to play a role in driving education at normal schools and driving schools.
The police and the regulatory institutions have at least to be informed about the system infrastructure and electronic devices, which might be done through administrative advice or guidelines. A manifestation of ISA in the traffic law should be a long-term goal of the implementation strategy. This could be supported by a European directive as stated in scenario D (chapter 8.4).
Supporting legislative aspects mostly concern road administration and public private partnerships. The methods concerning changes in law for such measures cannot be described within this thesis. Again, concerning ISA-implementation ceteris paribus is assumed.

9.2.2 Marketing plus x

The marketing strategy is based on three major tasks. The first task is to gain interest of small or medium sized technology companies for including ISA into their ADAS platforms and sell it as a feature. The second task is to convince some pressure groups of the benefits of ISA in order to create a public demand for the technology. The third task is to convince – for example – insurance companies and car hire companies to give incentives for ISA-equipped cars. These three tasks together should be able to initiate the introduction process of ISA on the German automobile market. The strategy – at first – does not require any legislative measures.
The companies potentially selling ISA or ISA components must of course first identify the relevant customer groups (chapter 5.2). They must then check whether governmental monetary promotion could be applied to the production of ISA, digital roadmaps or the related ADAS platform.

The public relations should then make use of all kinds of media. The innovative technique should be presented at trade fairs for automobile technology (e.g. IAA Frankfurt) as well as trade fairs for computer technology (e.g. Cebit Hanover).
However, engagement of single companies – even if supported by governmental monetary promotion – is not enough for a broad knowledge of the system. There have to be pressure groups with a real interest in both implementing and using the system. This would lead to a phase of early adopters as described in chapter 5.2. Positive experience with the system would be the best advertisement. A market, half forced by pressure groups, half by private companies should make changes in law slightly easier.
The implementation of ADAS on a compatible layer, making use of high performance HMI and high accuracy telematics systems, makes ISA an easy-to-use add-on (chapter 7.4.2). This, too, is a marketing aspect. The more ADAS get to be placed on the market, the less ISA is of importance in the selling strategy. The liability problem should easily be solved if ISA is sold as a simple add-on for ADAS platforms. The characteristics of the system will change fast from “safety device” to “comfort device” (chapter 7.5.1).
Another beneficial marketing approach is the potential plan to include ISA and other active safety devices into the EuroNCAP evaluation procedure. EuroNCAP is the most well known institution for car safety tests[10] and is therefore a reliable source for customers planning to buy a new car. At the time there is no official plan to include ISA into this procedure. The PROSPER project started contacting the persons in charge of the EuroNCAP consortium in order to enforce the introduction of an ISA test routine for the procedure[121].
The two basic tasks of the marketing strategy are directly included in the general framework (chapter 10). The strategy should be started as soon as possible.

[121] Comment: The PROSPER consortium is in close contact with persons from Euro NCAP. Hence, the likeliness of an introduction of ISA into the test is rather high. The new chairman of Euro NCAP is the Swedish professor Claes Tingvall, whose name is closely related to Vision Zero. Tingvall was planned to be included in the expert pool. He refused to write a publication for workload reasons but stated a positive attitude towards ISA.

9.2.3 Planning procedure, system proving and redundancy

The traffic planning part for the implementation of ISA consists of two tasks. The first – and surely easier – task is the documentation and evaluation of the field trials, the choice of the most promising version and the technical and advisory support during the introduction process. Finally, it has to be proven that the system really reaches its goals (i.e. decrease of accidents and accidental effects, decrease of emissions and road traffic homogenisation). This task mainly affects those in charge of the national ISA surveys (i.e. researchers and governmental representatives) but also all other institutions related to the ISA implementation process (i.e. the selling companies, the providers and the regulatory institutions).

The second part is the control and enforcement of supporting measures. The speed management strategy is of most interest. Hence, the 12-measure plan – of which ISA is one measure – has to be promoted (chapter 2). Infrastructural measures like traffic influencing systems and the road equipment for self-explanation (chapter 7.4.4) are necessary supporting measures to increase both adherence to and acceptance of speed limits. Targeted surveillance and rigorous enforcement are then the second step. The acceptance of enforcement measures is high as long as there is an educational background (chapter 4.3.2).

Educational improvement and technical issues supporting the self explaining road have the aim of building a redundancy towards smoother and safer driving. In case the implementation of ISA fails (scenario X chapter 8.5), the engineering and educational measures from the speed management plan are most important to deploy. Whether the redundancy measures are able to backup the desirable effects of ISA is, however, doubtful. In fact, the status quo of deaths and injuries and compared to former values as well as the tendency towards reducing the numbers are promising. Nevertheless, further success cannot be reached through an improved rescue system and passive in-vehicle safety devices. These improvements are results from research and innovations of the 1980s and 1990s. Now the innovations of the first decade in the 21st century have to be introduced. These are the ADAS – one of which: ISA.

10 Conclusion: General framework for ISA

The strategy for the implementation of ISA version 2 (according to the preferred scenario B) has to take into account that every group involved in the process (q.v. Figure 12 page 37) needs special input and motivations.

Step zero: Technical Maturity of ISA version 2

Before any introduction to the open market can be achieved, the reliability of ISA equipment has to be proven. This includes the functionality of the system itself as well as the basic technical resources and – most important – the availability of digital road maps with at least 90% of all speed limits. Otherwise the automobile manufacturers have no interest in selling the system [7]. Furthermore, there is a necessity for a complete disclaimer for the missing limits.

The further steps have to be done by the various groups. Some groups are starting groups (impulse) and other groups are target groups (effects). In the second phase of implementation, the former target groups become starting groups. As soon as there are noticeable secondary effects, the implementation process is accomplished. The third step then is the enforced car fleet penetration.

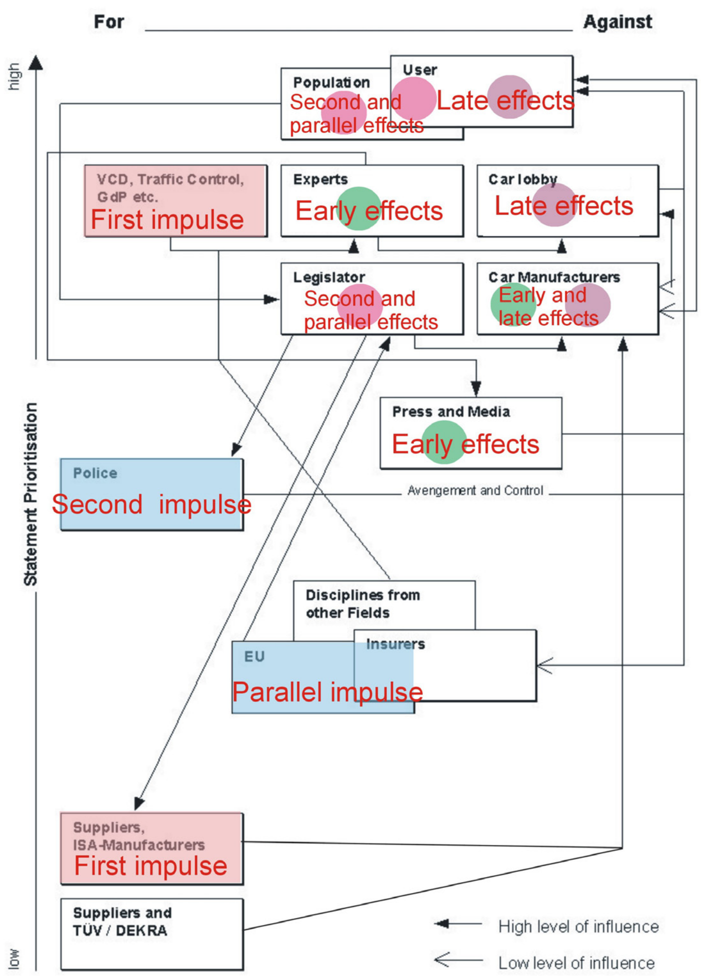

Figure 39: Impulses and effects from/on concerned groups [design by the author]

First Step: Marketing and Image Making Process

The strategy first activates the pro-ISA groups – especially suppliers manufacturing ISA, and various pressure groups. Police and media get information about ISA itself, and the positive results of the field trials, in order to start an image making process. This activates experts and starts a public discussion. Vulnerable road users (as part of the public) might be most interested in the introduction of ISA and therefore start political postulations towards ISA. The knowledge of the technology, its aims and benefits have to increase.
The EU and EC will – in parallel – start a pro-ISA image campaign derived from the PROSPER project. This, too, activates experts, car lobbies and media. Early adopters could use retrofitting systems (AAP on a conventional navigation device). Members of the pressure groups (e.g. VCD), but also CarSharing customers and representative celebrities and politicians, should have ISA-equipped cars with the system in full function.

Second step: Margin introduction

The introduction of ISA makes most sense for new cars. Hence, the suppliers have to ensure that at least some of the car manufacturers equip vehicle types from particular margin series with ISA. Such vehicle types could be family vans, small city cars and small lorries etc. (q.v. chapter 5.2 section "ISA-affine car market segments"). According to Figure 26 page 56, early adopters motivate other groups to test ISA. This leads to secondary adopters, and finally to a sufficient car fleet penetration due to market forces.

Third step: Market penetration

The adoption of ISA systems will start to have an impact on the car lobby and anti-ISA groups. Secondary impulses from EU/EC on government might then have the effect that ISA is at least included in political programmes and better, into law (e.g. through European directives and national action plans). This would be the proper way to go for a 100% car fleet penetration by the year 2030 and this might have positive effects on a potential introduction of mandatory systems (e.g. version 3).

Check of effects

The implementation of ISA with supporting measures concerning road design and enforcement should have noticeable effects within a short period of time. The number of speed related accidents should decrease. In particular, the number of accidents at black spots and specific dangerous road segments (trunk roads and rural roads) should be reduced. As long as the speed limit data for road works is available for ISA cars, there should also be effects on the number of accidents at these locations.
More than 60% of the German network of motorways have no definite speed limit yet. An increasing percentage of motorways is equipped with dynamic traffic management systems. This leads to the conclusion that ISA might not have noticeable effects on the number accidents on motorways. Motorways already are very safe roads. Nevertheless, if an accident occurs on a motorway, the

severity of this accident is often very high. Thus, ISA might have effects on reducing fatalities and injuries on motorways.

These effects should occur within the first two years of implementation (vehicle fleet penetration ≥ 15%). Mean speed and speed variance on all road types should be regularly measured. Here, too, noticeable effects should occur within a short period of time. The homogenisation of traffic is the best way to gain avoidance of congestion. Figure 40 sums up the process of implementation.

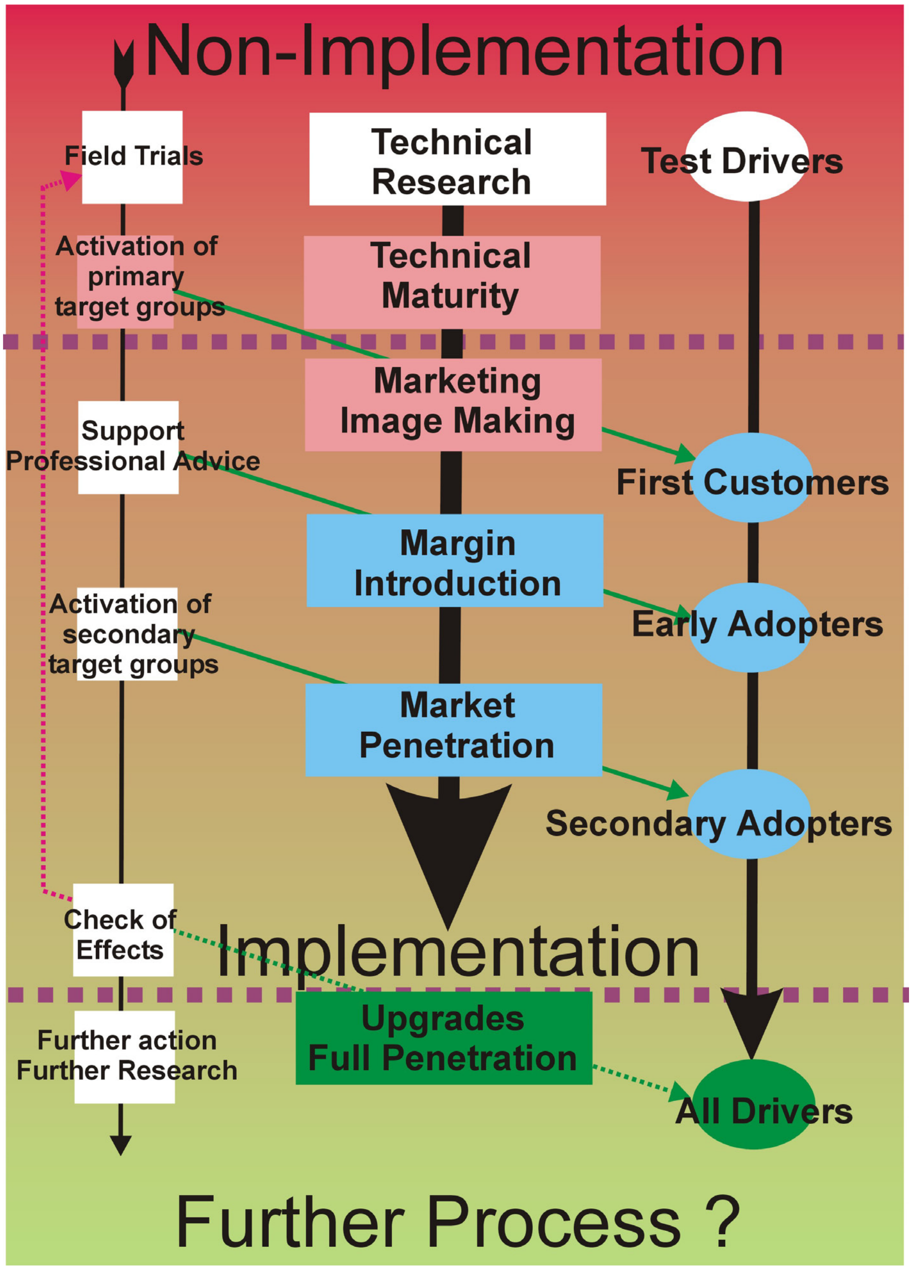

Figure 40: Implementation process [design by the author]

11 Perspective: The ADAS-module “speed“ will be available in 20XX

If ISA is placed on the market, it will unlikely be known as such. This is largely due to the bad reputation of ISA version 3 in German policy, which leads to the hypothesis, that perhaps ADAS-module “speed”, “speed assistant” or “intelligent accelerator pedal” might be sensible future names for the technology.

Initial applications of ISA are already available[6]. However, the introduction of version 2 based on reliable digital road maps will take at least five years. The technical maturity of ISA has not yet been reached. However, right now, the first important target groups must be activated so that the first public ISA-equipped cars (excluding field trials) should be on the road before 2010. The fact that BMW™ plans to equip the 3XX series with AAP before this[7] is beneficial for this purpose. The implementation plan states a targeted vehicle fleet penetration of 15%. It will take another five years until sufficient ISA-equipped new cars are sold. Activities from car hire companies and companies with car fleet management systems could noticeably accelerate this process. This all leads to the hypothesis that in the best case, a positive effect of ISA could be gained by 2015. This does not correlate to the EU white paper stating a reduction of injuries and deaths from road traffic of 50% by 2010. This plan – from the point of view of the author – can not succeed without pushing for ISA. The promising results of the various field trials in Sweden and the Netherlands, the plan of the German government to gain “SUNflower”-status as soon as possible, and the fact that at least some of the German pressure groups took notice of ISA raise the hope that the implementation process might be faster than estimated.

Otherwise, the lack of acceptance for speed limits, the lack of public awareness, the strong rejection of ISA from the German automobile industry, and the emotional discussion on drivers’ freedoms might decelerate the implementation process – in the worst case – to a standstill.

Final comments: Methodological, calculative and textual faults of the thesis

The four different questionnaires that were accomplished for this thesis were all done from a planning and engineering point of view. Thus, some questions might lead to wrong conclusions. Especially attitudinal aspects are partly derived from a "political correctness" of the participants whereas the "honest" answers could be opposite.

All long-term predictions are speculative. Even the large scale ISA field trials in Sweden cannot give sufficient information about what happens when drivers get used to the technology. Another significant problem is that there is no simple "ISA". The ISA taxonomy of this thesis includes 9 versions. In reality, lots of other ISA or ISA-like systems exist – in completely different phases of development.

The preferred scenario (implementation of the AAP) can only mirror the author's point of view which would be the most promising system, supported by tendencies from the results of the various surveys. Nevertheless, the available information from the research so far is not sufficient to underline this hypothesis.

Further calculative and textual faults might arise from the various sources. The expert statements published in the green edition of imove partly mirror subjective opinions of the various experts. Due to the fact that the author conducted seven telephone interviews and nine face-to-face interviews with experts, of which the author's handwritten minutes and memory were taken as a source, there might be faults in the stated sources. All statements from interviews were done to the best of the author's knowledge.

List of figures

List of tables

List of definitions

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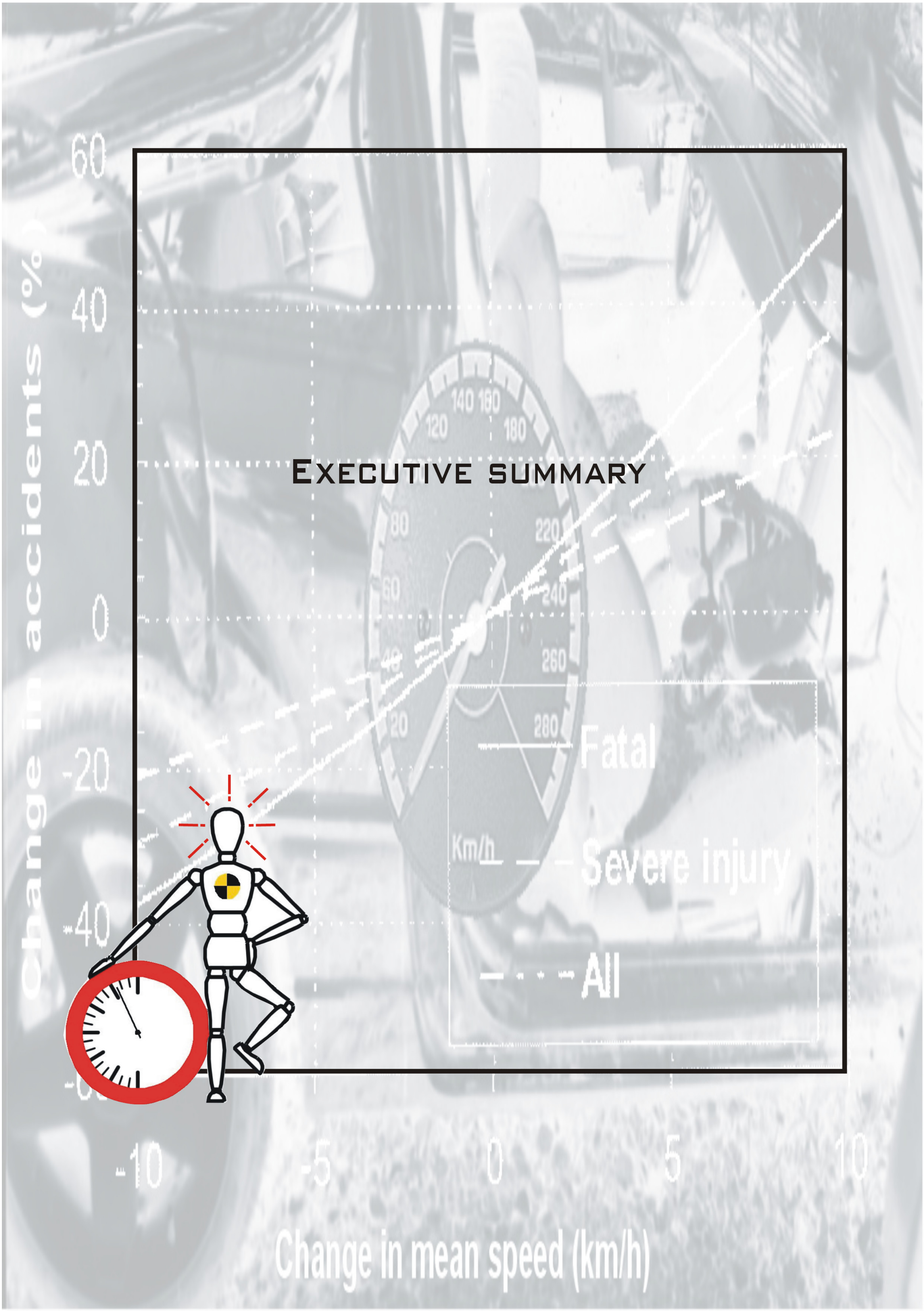
Executive summary



Basic conditions for the implementation of speed adaptation technologies in Germany

Research background

At present, the European Commission (EC) promotes research projects on the so-called Advanced Driver's Assistance Systems (ADAS) and their benefits on traffic safety, environmental protection and the reduction of social costs. One of these ADAS is called Intelligent Speed Adaptation (ISA). ISA aims to reduce speeds driven to the legal limits, because most of the severe traffic accidents (i.e. accidents with deaths or injuries) are a result of an inappropriate choice of speed. The EC-project PROSPER deals with ISA. The aim behind PROSPER is to create a framework for a Europe-wide implementation of ISA-technology.

"The Council resolution of June 2000 explicitly identifies advanced assisted driving technology and technology relating to speed IMITA™ devices as important measures for further investigation. Introduction of road speed management based on information technology (i.e. ISA - Intelligent Speed Adaptation) requires international co-operation to overcome technical, legal and policy barriers."
[cited from the official website of the project www.prosper-eu.nl]

PROSPER logo and advertisement text

What is Intelligent Speed Adaptation?

Intelligent speed adaptation is a mixture of relatively new technology for road vehicles. It's purpose is to prevent the driver from exceeding a particular legal speed limit. The technology is available in three different basic versions and the adaptation technique functions through three different channels. Therefore nine different versions of ISA technology exist.

Versions:	Open; informative; warning signal	Half-open; haptic throttle; overrulable	Closed; fuel supply intervention, non-overrulable
Static; Data-DVD on the vehicle	**1-A Teleatlas™**	2-A	3-A
Data DVD plus download button	1-B	**2-B BMW™**	3-B
Dynamic; GPS-based	1-C	2-C	3-C

The nine versions of ISA

Version 1 informs the driver about current speed limits, either through optical or acoustic signals. This information is distributed through various different channels. Most useful from the traffic safety point of view is an acoustic BEEP-signal warning the driver the very moment he is exceeding the speed limit. The signal usually gets louder, the higher the level of excess is.

Version 2 – the so-called active accelerator pedal AAP (also known as “haptic throttle”) – gives a counterforce on the accelerator pedal as soon as the speed limit is reached. The driver can overrule the system by increasing the pressure on the pedal.
Version 3 – also called “dead throttle” – is not overrulable. As soon as the speed limit is reached, no further acceleration is possible. This is done by fuel supply intervention. The driver is able to further push the accelerator pedal, but without effect.
A, B and C divides the level of “external intervention”. In every case, the car position is checked through satellite navigation tools (either GPS or – more likely in future – GALILEO). The position is counterchecked on a digital road map inside the car.
Inappropriate speed is derived from misbehaviour of the driver – knowingly and unknowingly. Thus, the reasons for the wrong choice of speed and the various situational aspects of “speeding” have to be pointed out in order to implement counter measures. Such measures are all part of the so-called three “e” of traffic safety: Education, Enforcement, Engineering. Three-“e”-measures which aim to reduce speeds driven can be subsumed with the term “speed management”.
The “12-measure-plan” is one potential strategy for speed management in Germany:

1. Reform of the statistical accident analysis
2. Concepts for public relations and education concerning accidents
3. Enforcement and surveillance (particularly at road work sections)
4. Strengthened enforcement of cargo traffic
5. Educative optimisation of speed cognition
6. General maximum speed limit
7. Aggravated punishment for severe offences against speed limits
8. Surveillance by webcam-technology or SectionSpeedControl™
9. Promotion of dynamic traffic management systems
10. Implementation of Intelligent Speed Adaptation (ISA) and Accident Data Collectors (ADC)
11. Promotion of public awareness for the problems of speeding
12. Modernised and optimised education and teaching at driving schools

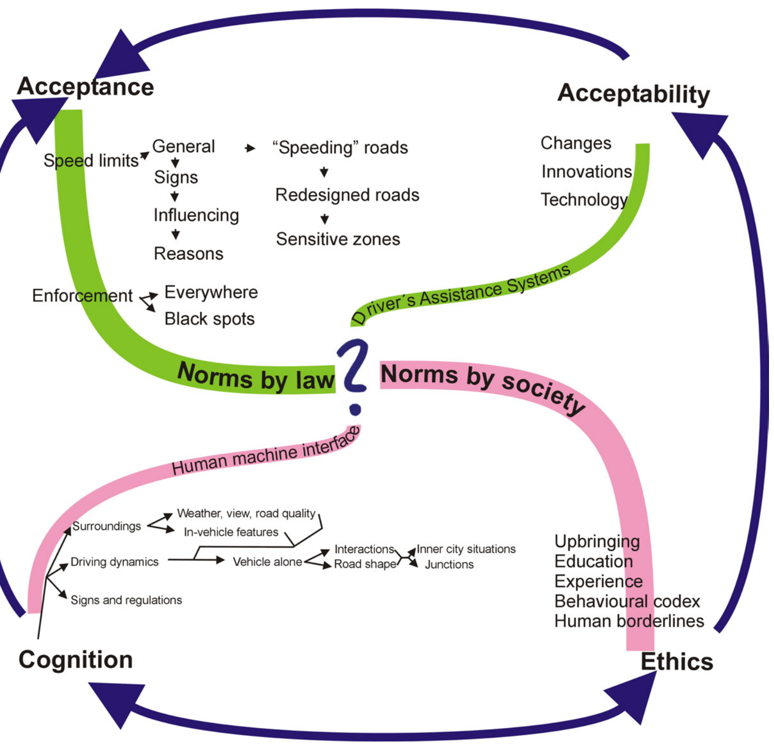
Questionnaires and interviews

This study focuses on strategies for the implementation of ISA embedded in the context of speed management measures. Therefore, the basic conditions for the implementation of ISA have to be established.
Two empirical surveys were undertaken in order to provide an overview of such basic conditions (e.g. social, economic and technical aspects). Firstly, a stakeholder analysis and questionnaire using the Delphi-method was undertaken in two rounds. Secondly, a questionnaire-based survey with speed offenders was carried out, also in two rounds. In addition, the author created an expert pool consisting of 23 experts representing the most important fields of science and practice in ISA. The author interviewed most of the experts, either in person or by telephone. 12 experts also produced a detailed publication on their professional point of view of ISA.

Basic conditions

The two surveys and the professional comments on ISA led to following results:

- ⇨ The implementation of ISA has indispensably to be supported by additional speed management measures. This means that it is necessary for the "12-measure-plan" to be implemented.
- ⇨ Political lobbyists from the car industry oppose implementation of ISA. Political lobbyism is one of the most important traditions of democracy. Implementation strategies for ISA therefore must take into consideration that political opponents compromise beforehand.
- ⇨ ISA-affinitive car market segments exist. The introduction of ISA is most sensibly achieved through market forces. Market research usually leads to the identification of potential customer groups for the ISA product. Such customer groups are called "early adopters" who by word-of-mouth promotion attract secondary adopters.
- ⇨ Behavioural aspects of speeding are derived from psychological values (cognition, education). The identification of the reasons for incorrect speed decisions is almost impossible. The following figure shows the flow chart of the parameters influencing driving decisions (here: the choice of speeds driven). The behaviour itself then differs from decision to decision. A prediction for those decisions is impossible. Hence the question mark.



Circular flow of acceptability, acceptance and the psychological background of speed choice

- ⇨ Rejection of ISA is derived from rejection of legal speed limits. Speed limits are accepted in certain situations (e.g. on urban roads with significant non-motorised traffic volumes). The existing speed limits on urban arterial roads and – moreover – on wide rural roads mostly are not accepted. Measures for enforcing the speed limit consequently are not acceptable.

- ⇨ ISA is acceptable as long as the driver is able to switch off the system. The driver intends to be the “professor” of the car. ADAS can only be the “assistant”. A “professor” will never accept a decision made by his “assistant” without having the option to overrule that decision.
- ⇨ ISA can technically be integrated into a pool of ADAS. The car of the future is based mainly on software technologies. Electronic devices – thus ADAS – play the most important role concerning innovations in the car market. The task for the automobile industry for the next decade lies in the integration of any ADAS into an open operating system. ISA might then be just one of countless programmes running during a trip.
- ⇨ ISA systems need high-resolution up-to-date digital road maps including speed limit data. At present, none of the available digital road maps has sufficient information about speed limits. However, several EC-projects deal with the task of digital road mapping. The future plan for integrated navigation tools includes such information.
- ⇨ ISA needs a juridical disclaimer. No electronic device is free from technical errors. The Vienna convention of 1968 states that the responsibility for each driving task lies with the driver. This means that every electronic device – of course including ISA – has to be overrulable. The product liability aspects lead to the necessity for a disclaimer.

Implementation scenarios

In this study, the author created four possible implementation scenarios for ISA. However, due to the strong political opposition, it is also conceivable that ISA will never be implemented, or that the implementation process will not commence until 2015 (= scenario X):

A) Implementation of version 1 by market forces with governmental subventions.

B) Implementation of version 2 by market forces supported by traffic safety institutions and image-making processes.

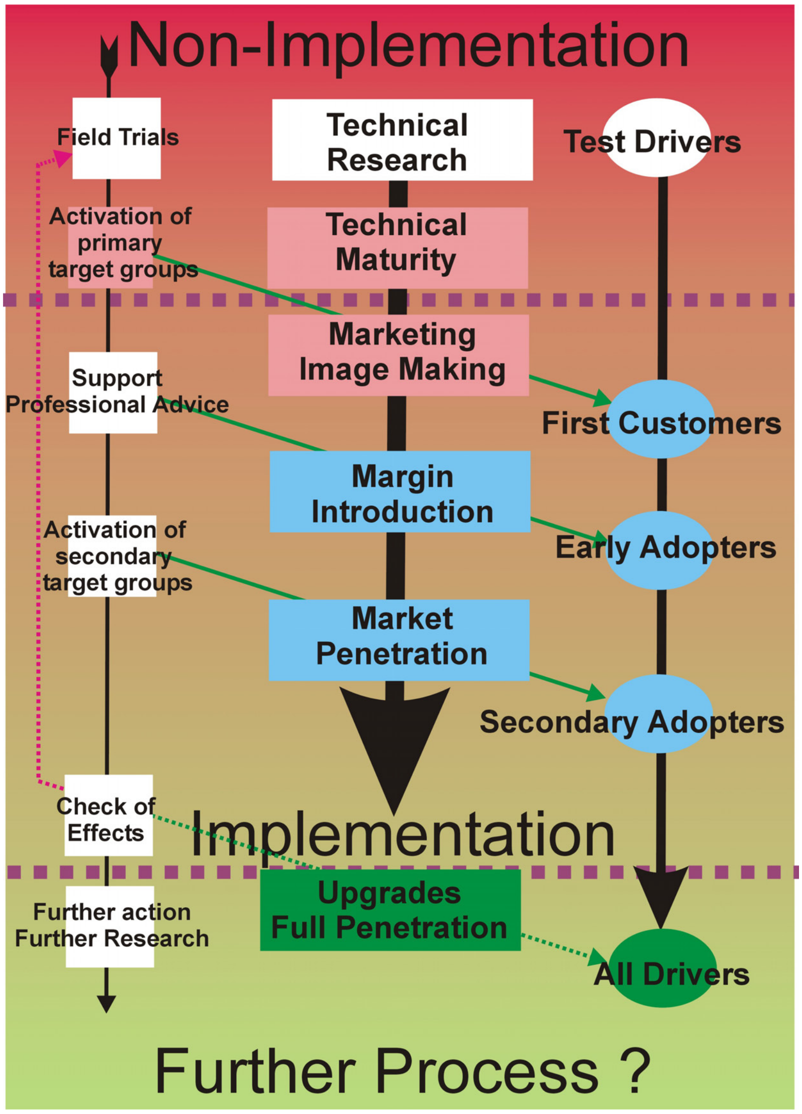
C) Implementation of a modified version 3 by law for speed offenders only - in place of the current practice of withdrawing the driving licence.

D) Implementation of various versions in Germany as a result of broad implementation of ISA in the SUNflower states.

X) Non-implementation of ISA, leading to the necessity for alternative speed management measures.

Conclusion

The author prefers scenario B because – ceteris paribus – it seems to be the most likely way to implement the technology. As soon as ISA reaches technical maturity, the implementation process must be accomplished by means of a three-step approach. The following figure describes this process.



ISA implementation process

Large scale field trials are currently in progress, and technical research on ISA includes network modelling, behavioural aspects, supporting measures of speed management and – finally – strategies for the introduction of the technology. The technical maturity of ISA is directly dependent on the existence of high-resolution up-to-date digital road maps, without which the implementation process cannot commence.