Evaluation of In-vehicle safety devices - literature survey

Berthold Färber

Brigitte Färber

Michael Popp

Universität der Bundeswehr München

Institut für Arbeitswissenschaft

EU-Projekt 7.2/14 GADGET

BASt-FP 86.005/1998/U3

für die Bundesanstalt für Straßenwesen

November 1998

Contents

Evaluation of In-vehicle safety devices

Abstract

The aim of the study is to give an overview over the currently existing evaluation studies about the following In-vehicle safety devices:

- Car dynamics, including ABS, traction control (ASR), electronic stability program (ESP) and Heading control,
- Distance keeping / Autonomous (adaptive) cruise control (ACC),
- Collision avoidance.
- Alcohol and drug control,
- Driver alertness monitoring,
- Vision enhancement,
- Pedestrian monitoring /Blind corner monitoring,
- Route information systems.

Each system is evaluated under four aspects:
technical description, interaction concept, expected effects for traffic safety and behavioural studies.
The technology analysis shows the importance of a detailed technical description as integral part of a behavioural evaluation study. Under identical names and abbreviations (e.g. ACC) systems with quite different lay-outs and functionality are subsumed. It is sure that different lay-outs and system parameters can influence the results of behavioural analyses in a significant way.
The interaction concept covers the question, whether the system is activated by the user or operates automatically and self-paced.
The prediction of effects on traffic safety is based on global or detailed accident analyses and on expert evaluations.
Behavioural oriented evaluation studies could be found for ABS, ACC and collision avoidance systems. A few studies are published for driver alertness and some for route information systems. For the other systems evaluation studies with respect to driver's behaviour are rare or not existing. Especially long-term studies or investigations about motivational effects or changeover of risk behaviour couldn't be found.

The report finally presents a description of an ideal research and development process. This process starts with the identification of deficits and problems of drivers, followed by an analysis of the reasons behind the actual behavioural problems (e.g. handling deficits or motivation deficits). On the basis of the parameters identified in these first two steps, not only the design and technical test-procedures, but, also the appropriate evaluation and product marketing must be performed.

EU-Projekt 7.2/14 GADGET
BASt-FP 86.005/1998/U3

Evaluation of In-vehicle safety devices – literature survey

1 Introduction

Traffic density increases and consequently risk potential for each driver rises. Also the amount of information which could be transferred to the driver grows. Up to now it is not clear or sure, whether much information is helpful to the driver.
Currently two main streams to solve these problems are discussed:
- Telematic systems,
- transfer of traffic to public transport.

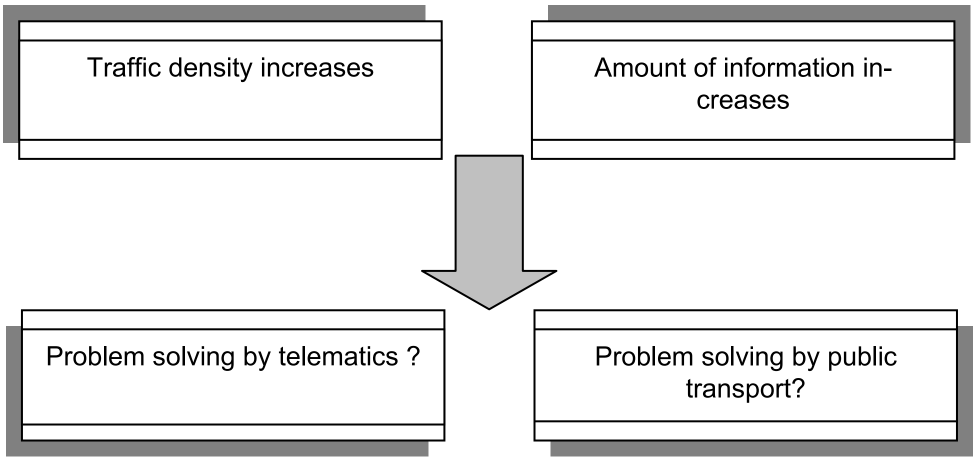

Fig. 1: Overview

Telematics, a combination of tele-communication and informatics, covers a wide range of systems, from complex and interrelated systems like traffic management on the one side, till simple stand-alone systems like reversing aids on the other. Telematics seems to be a subject, difficult to define with a fuzzy set of systems. As WEYD states: „La télématique routière ... Elle ressemble à un grand laboratoire où seraient menées d' innombrables expériences, souvent pragmatiques, parfois empiriques, dans des domaines de pointe, dont on ne maîtrise pas encore toutes les combinaisons." (1996, p. 27).
Even if the definition is not precise and the effects of telematic systems are discussed controversially, there is no doubt about the market potential of telematics. HILGENDORF (see IV, 1997e, p. 519) postulates a market with a turnover of more than 100 million DM per year.

Active safety devices can be seen to some extent as subset of telematic systems. Even it is intended not to need or use tele-communication for the operating of the systems,

some of them would work with higher performance with additional information from other cars or an information centre. The restriction to on-board systems without the need of any infrastructure is merely influenced by financial and political than by technological reasons.
But, as a matter of fact, autonomous, In-vehicle safety devices are developed and will further be developed. As for the whole group of telematic systems the potential benefit must be evaluated.

Data base for the study:
Basis for the current study was a literature survey, based on several sources:

- A former literature study on 'telematics and traffic safety' (BASt project, FÄRBER & FÄRBER, in press),
- the relevant journals on traffic safety and ergonomics,
- project and laboratory reports,
- conference proceedings, like ITS conference reports
- a literature search in 4 data banks:
  Motor Industry Research Assoc., Nuneaton, UK (MIRA),
  Nat. Tech. Info Service, Springfield VA, USA (NTIS),
  Engineering Index Inc., Hoboken NJ, USA (IEEE),
  Forecast International, Newtown CT, USA,
- Search with different search machines in world wide web.

Because telematics is a rapidly developing field, the danger of any report about the actual status of telematic systems and also evaluation studies is to be obsolete after a short period of time. Thus, also studies currently being under work are reported, giving the reader the opportunity to inform about the outcome of the studies in the next time.

Goal of the study:
Within the framework of GADGED the goal of the present study is,
to find out, where evaluation deficits for In-vehicle safety devices exist, in order to develop evaluation criteria in a further study. The detailed description of the technology is a precondition to analyse the possible impacts of such systems as well as the value of the behavioural studies.
As first step the relevant systems are analysed with respect to technology and available evaluation studies.
Finally a research guideline is proposed for the development of In-vehicle safety devices and the selection of appropriate evaluation procedures.
The authors are well aware of the fact that a meta-analysis of the existing evaluation literature would also have been a sensible approach. A meta-analysis allows an evaluation and combination of different studies with respect to their methodological preciseness, number of subjects, number of variables controlled, etc. A weighted combination of the single studies (according to the above mentioned criteria) comes to a single value, representing for example 'expected effect on traffic safety'. However, as will be clear from the report, the evaluation studies differ so much and the systems analysed are by no means technical identical (even if the have the same name) that a meta-analysis is currently not sensible.

2 List of the analysed systems

Analysed are systems, which can be classified under the heading „In-vehicle safety devices", i.e. systems installed in vehicles to increase car and/or traffic safety. Not covered are passive safety devices only moderating the consequences of an accident.
In accordance with this definition the following systems are analysed with respect to :

- Technology,
- interaction concept (warning or intervention system),
- expected influences on traffic safety, not minding whether this is based on individual behaviour or the change of the whole traffic system
- performed evaluation studies.

List of the systems:

1. Car dynamics
   Anti-block systems (ABS)
   Traction control systems (ASR)
   Electronic stability program (ESP) and Adhesion monitoring
   Heading control systems (HCS)
2. Distance keeping - Adaptive Cruise Control
3. Collision avoidance
4. Reversing aids / Parking aids
5. Alcohol and drug control
6. Driver alertness monitoring
7. Vision enhancement
8. Pedestrian monitoring / Blind corner monitoring
9. Route information systems.

3 Analysis of the systems

This chapter analysis the above listed In-vehicle safety devices with respect to:
- Technology,
- interaction concept (system-paced, initiated by the driver or on demand of the driver),
- expected effects on traffic safety,
- evaluation studies, if available.

Regarding the expected effects on traffic safety, there are five aspects to consider:

1. The system offers a possible increase of safety to the driver, due to better information.

2. Traffic safety can decrease, if the system requires a high mental load of the driver: Mental load is high, if there is a need for an intensive dialogue, if the informational content is high, if the driver is ‘forced’ to answer the system, if the driver cannot interrupt communication.

3. Traffic safety can decrease, if the system causes a high sensory distraction of the driver. This happens, if the system, for example, demands long and often glances or the driver gets distracted from driving, because he has to handle the system one- or both-handed.

4. A very crucial aspect is safety in the situational context. Here traffic safety of all traffic participants is to consider, not only the safety of the driver and the vehicle. Speeding in turns, for example, not only endangers the driver and his car, but also following or approaching cars and pedestrians.

5. After all, traffic safety can decrease, when the driver gets an unjustified feeling of safety, because of the In-vehicle safety devices, making him drive more risky.

The expected effects on traffic safety in chapter 3.1 to 3.9 are based on the rating of 23 experts, working on traffic safety. The rating was done on a 5-point rating scale on the above cited aspects 1 - 4 (FÄRBER & FÄRBER, in press).
Aspect 5 was not evaluated by the experts because the knowledge concerning this aspect is extremely weak. The evaluation of aspect 5 would only have been a ‘very personal sight’ of the experts.
If available, accident statistics and other theoretical analyses concerning the expected effects on traffic safety, were mentioned.

3.1 Car dynamics

3.1.1 General description

Systems to improve longitudinal or lateral control are in the stadium of implementation or right before that status. How far these systems provide a risk reduction or a higher risk (cf. risk homeostasis theory, WILDE, 1978) is currently an open question.

3.1.2 Car dynamics – interaction concept

Systems under development, implementation or market penetration act either self-paced and automatically by reducing engine power or changing shock absorber characteristics, or by warning the driver by haptic-kinaesthetic signal on the gas pedal or steering wheel.

Examples form literature for self-paced car dynamics systems:
ABS and ASR (GIES, 1991), active roll stabilisation from Bosch (SCHÖTTLE et al., 1996), the acoustic friction sensor from BMW and Porsche, the stability program ESP from Mercedes-Benz. General descriptions on car dynamics are given by HAMBERGER et al.(1996 a, b), a system for speed regulation for BMW is explained by MOSER (1996).

Examples from literature for warnings:
Driver assistance systems (REICHART, 1996; STANTON, 1995), a warning system for lane-keeping from Mitsubishi (JEDA, 1996) or a lane keeping assistant (AI, 1996 a; BRAESS & REICHART, 1995 b).

3.1.3 Car dynamics – expected effects

Concerning car dynamics, we can report expected effects on
- car dynamics, working automatically and
- warnings, concerning car dynamics.

According to experts' evaluation (compare aspects 1 - 4 in chapter 3) automatic influence of car dynamics
- offers a small amount of information,
- the mental load of the driver is expected to be medium,
- also sensory distraction of the driver is expected to have a medium level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

Warnings concerning car dynamics, after experts' evaluation,
- offer a high amount of information,
- the mental load of the driver is expected to be medium,
- sensory distraction of the driver is expected to reach a high level and

- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

In particular the following systems are discussed under the general heading driving dynamics: Anti-block systems, traction control, electronic stability program and heading control. Even systems for distance control, often called Autonomous or Adapative Cruise Control systems (ACC), belong to the same group of active safety devices, these systems are treated separately. They origin from a different starting point, the cruise control integrating distance information.

3.1.4 Anti-block system (ABS)

Anti-block systems are known under different names like ABV, ABS, and ABS plus.
They improve the qualities of the car during braking especially on surfaces with different friction parameters on different wheels. These differences are called μ-split.

ABS is the first realisation of a whole family of friction control and improvement systems, followed by traction control (ASR) and electronic stability program (ESP). The basic technical aspects of friction control are shown in figure 2.

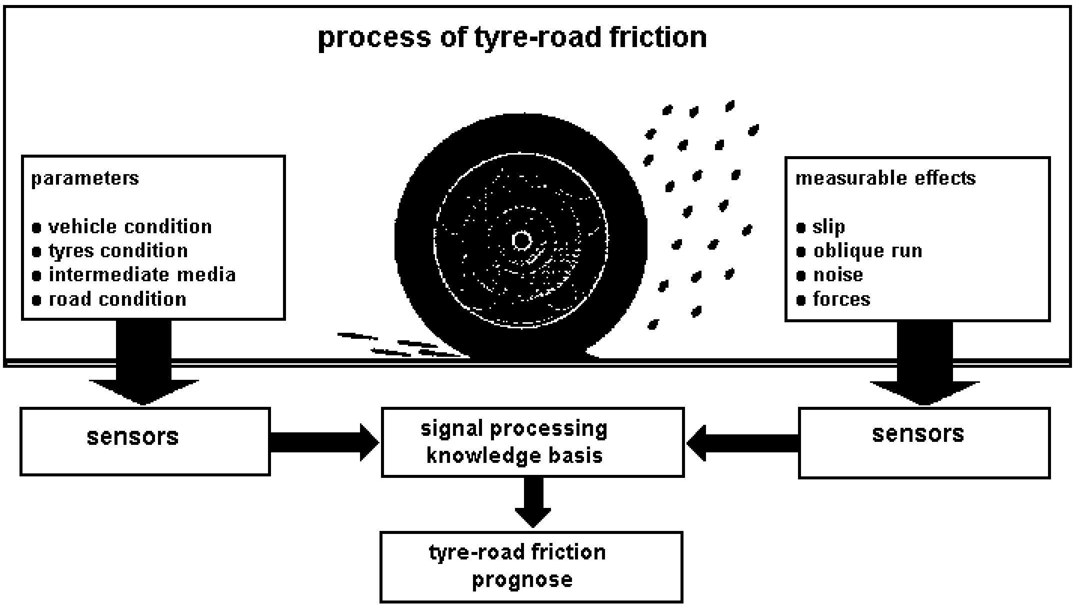

Fig. 2: Basic aspects of tyre-road friction monitoring (compare: BRAESS & REICHART, 1995).

3.1.4.1 ABS - interaction concept

Anti-block systems are only active as long the driver presses the braking pedal. Further, a hard braking action is necessary. The feedback is a moderate pulsation of the braking pedal and a sound in some (especially older) cars.

3.1.4.2 Technology of ABS

ABS (Bosch):
This system is designed to prevent blocking the wheels of a vehicle during hard braking manoeuvres to guarantee maximal deceleration rate as well as the possibility to steer while braking.

Components:
The system consists of optoelectronic wheel revolution sensors, additionally valves in the braking circuit, and a processing and control unit.

Principle of operation:
The rotation velocity of each wheel is measured. If the driver presses the braking pedal, a control unit modulates individually the pressure for the brake cylinder of each wheel in accordance with its revolving speed. The modulation principle is to prevent each wheel from blocking as well as maintaining a maximum deceleration rate. ABS is activated whenever the engine runs. There is no possibility to switch off the system. The anti-lock-system unit tests proper functioning itself together with a test of the whole braking system whenever the engine starts, and continuously during driving. Failures of the system are displayed to the driver. If this occurs he is still able to brake conventionally without the anti-lock feature.

ABS plus (ITT-Automotive):
This system is designed to maintain a maximum of deceleration while braking, the possibility to steer while braking and takes different driving situations into account.

Components:
The system consists of optoelectronic wheel rotation sensors, a double brake pressure booster with pressure sensors, steering angle, yaw angle and lateral acceleration sensors, a processing and control unit, additional valves in the braking circuit, and motor management control electronic.

Principle of operation:
The rotation velocity of each wheel is measured. Additionally the processing unit monitors the dynamic state of the vehicle continuously. With its advanced signal analysis the system tries to detect whether the vehicle drives in a curve and/or is changing its state of load and reaches therefore the limits of adhesion of each individual wheel. The thresholds of the ABS controller are modulated on the basis of this signal analysis dynamically. When the driver brakes, the control unit not only raises or lowers the pressure for the brake cylinder of each wheel in accordance with the adhesion of that wheel, but ABS plus influences the motor management to get additional deceleration if necessary. The asymmetric distribution of pressure between the front wheels compensate the yaw momentum and therefore allows the driver to change direction during emergency

brakes. The rising of the ABS threshold at the outward wheel in a curve reduces the braking distance additionally. If the driver brakes during lane changing or zigzag courses, the system is able to anticipate these manoeuvres using pattern recognition and compensates driver's actions that would bring the vehicle into an unstable condition without the system. Goal of the advanced technique of ABS plus is:

- first the maintaining of a maximum of deceleration (given a certain pressure of the driver on the braking pedal), and
- second to put or hold the vehicle in a stable driving condition.

ABS plus is activated whenever the engine runs. There is no possibility to switch off the system. The ABS plus controller unit tests the proper functioning of itself and the whole braking system whenever the engine starts, and during driving continuously. Failures of the system are displayed to the driver. If this happens he is able to brake down conventionally, but the blocking of wheels isn't prevented and the ability of steering to avoid collisions while braking is reduced (FENNEL, 1998).

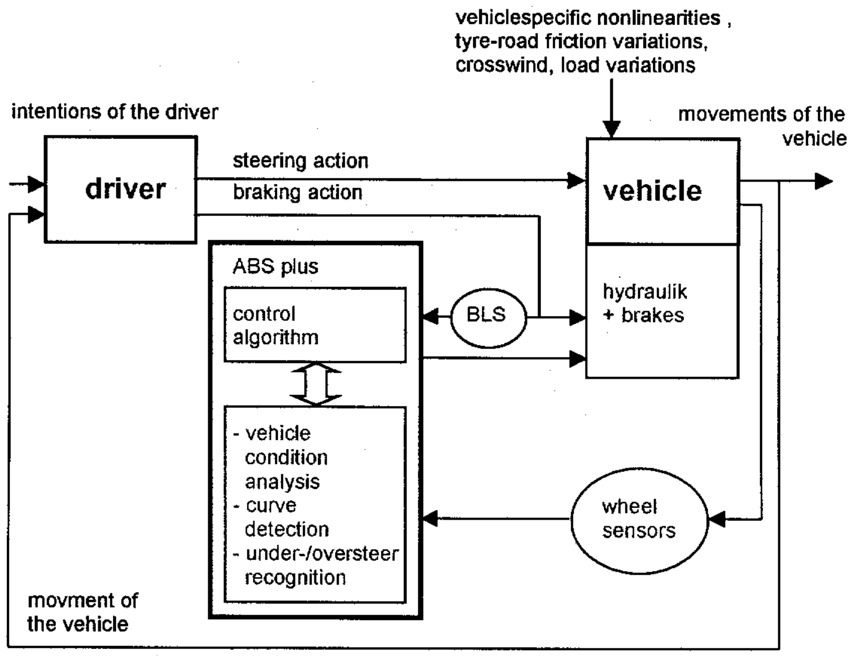

Fig. 3: ABS plus control circuit.

3.1.4.3 Anti-block systems - expected effects

GIES (1991) analysed on the basis of accident statistics, in which circumstances anti-lock systems could be of any effect: they will be effective within all driving manoeuvres causing normally the blocking of one or more than one wheels. Drivers are not very keen to handle this complex regulation of side slippery and simultaneous braking (e.g. in a curve with changing friction of the ground). With an anti-lock system the manoeuvrability and stability of the car is improved.

In 40 % of the accidents an anti-lock system would have been effective. The author guesses that in 15 % of the observed accidents an anti-lock system would have been reducing accident consequences or preventing the accident.
In detail: In 24 % of the cases under investigation the driver tried a combined steering and braking manoeuvre without being able to avoid the accident. Here an ABS would have been helpful. But, one prerequisite would have been the correct reaction of the driver, i.e. he had be familiar with the system. Furthermore, space for an evasive action would have been necessary, a condition which is often not given in urban areas.
For accidents with pedestrians the percentage of blocking brakes is 68 %. The projection for ABS comes to a reduction of accidents to 5,8 %.
For curve driving accidents, in coherence with a preceding braking manoeuvre, the manoeuvrability would have been guaranteed in 6,6 % of all cases.
On wet road surfaces together with higher speeds, a reduction of accidents of 3,4 % for cars with ABS is expected (GIES, 1991, p.185 ff).

3.1.4.4 Anti-block systems - evaluation studies

Statistical data analysis, EVANS (1998):

EVANS (1998) examined statistical data comparing General Motors passenger vehicles having ABS as standard equipment (1992 models) and without ABS (1991 models). “After correcting for model year effects not linked to ABS, the following associations between ABS and crash risk were found by averaging the data from five states” in the USA:

- “a 10 ± 3 % lower crash risk on wet roads than on dry roads,
- a 22 ± 11 % lower risk for a pedestrian crash (assuming no change for non-pedestrian crashes),
- a 39 ± 16 % increase in rollover crash risk (assuming no change in risk for non-rollover crashes).

... It was found that for wet roads ABS reduced the risk of crashing into a lead vehicle by 32 ± 8 %, but increases the risk of being struck in the rear by 30 ± 14 %.” (EVANS, 1998).

ABS study, COLLARD (1998):

COLLARD (1998) reports results of ABS studies: many of them “demonstrated measurable reductions in multiple-vehicle collisions, the decrease in many cases was offset by an apparent increase in single-vehicle collisions for ABS-fitted vehicles, resulting in estimations of the net benefit of ABS of approximately zero.” (COLLARD, 1998).

ABS field experiment, ROMPE et al. (1987):

ROMPE, WALLRICH & SCHINDLER (1987) report a study with 77 drivers having no experience with ABS who had to perform 5 different driving manoeuvres with and without ABS. GIES (1991) summarises the results as follows: “Especially effective was ABS for a μ-split braking manoeuvre. Drivers were able to manage the situation more often by the factor 6,27. For braking in a curve, neglecting the curvature, the standard vehicle left the road more often by the factor 2,7 – 2,75. No statistical significant advantages could be found for the manoeuvres get out of the way and straight braking .Even if the drivers knew that the collision with a suddenly appearing obstacle could be mastered only by braking and simultaneous steering, most reacted only by braking. Steering manoeuvres which could solely not be successful, were tried quite seldom.” (GIES, 1991, p. 143)

ABS field experiment, ASCHENBRENNER et al.:

The question, whether the knowledge about the safety gain of an ABS influences speed and distance behaviour is very important for the evaluation of such devices. Especially because this knowledge is incomplete, e.g. ‘ABS reduces braking distances’, the driver will have a wrong expectation. This assumption is supported by ASCHENBRENNER, BIEHL & WURM, (cited after GIES, 1991), who found a more risky and offensive driving behaviour with ABS. Questions on the effects of ABS are answered by the drivers with too high expectations and an overestimation of the advantages. Very often shorter braking distances, disregarding road surface conditions, are named. Also better lateral control , even for situations without braking, are supposed by the subjects.

Test track performance evaluation of ABS, FLICK & FORKENBROCK (1998):

FLICK & FORKENBROCK (1998) report that a number of statistical analyses of crash databases have shown that the introduction of ABS does **not** appear to have reduced the number of automobile crashes for certain situations. While it appears that involvement in multi-vehicle crashes on wet roads have been reduced with ABS, these reductions were offset by an increase in the frequency of single-vehicle, run-off-road crashes (rollovers or impacts with fixed objects). Because causes are unknown the authors conducted tests using current ABS systems on a wide range of road surface conditions and maneuvers. The surface conditions include as wide range of real-world conditions as possible, including high and low coefficient surfaces, off road surfaces, transitions across surfaces, and rough road surfaces. With this test FLICK & FORKENBROCK want to identify possible correlation with the types of crashes noted in the crash studies.

Questionnaire of NHTSA concerning ABS (1998, current):

The National Highway Traffic Safety Administration (USA) is sending out a questionnaire by WWW. 34 questions concerning relevant parameters of persons (e.g. driving experience), car equipment (ABS), functioning of ABS, personal experience with ABS and if the subject wishes more information about ABS.
Data collecting is still running, first results should be available until the end of 1998.

3.1.5 Traction control systems (ASR, ETS)

3.1.5.1 General description

Traction control systems are designed to maintain a maximum of friction between tyres and road surface, regardless of the road condition. In this sense, these systems are dynamically adapting evolutions of the well known differential gear box systems of conventional cars.

3.1.5.2 Traction control - interaction concept

Traction control systems are self-paced systems which cannot be influenced by the driver.

3.1.5.3 Technology of traction control systems

Components:
As basis of the traction control system the revolving speed sensors of each wheel of the ABS are taken. A control unit to compare the rotation speeds, an actuator system to act on the motor management and/or power distribution between wheels to reduce power for wheels individually, and a feedback device to inform the driver whenever the system is in action.

Principle of operation:
While the differential gear box looks only for rotation differences between the two wheels at the propeller shaft, the traction control system takes into account all four wheels. It calculates the friction conditions for each wheel with a high sampling rate. Whenever the rotation speed of one wheel indicates lost of friction, the power management and power distribution system reduces the power for this wheel without influencing the other wheels. Goal is to maintain a maximum of friction of the whole vehicle. Whenever the system starts to control the friction automatically, an indicator lamp informs the driver that he has reached the physical borders of friction between wheels and road. This should help the driver to get aware of the situation and/or to learn to avoid such situations in the future. (BRAESS & REICHART, 1995).

3.1.5.4 Traction control systems - expected effects

‘AST is designed to improve stability and manoeuvrability in driving situations characterised by high acceleration and high lateral forces. On the basis of accident statistics GIES (1991) supposes an influence of ASR in 5.5% of all accidents - but only if drivers haven’t entered the curve too fast. These 5.5 % can be divided as follows:

- In 5.1 % ASR could be effective on snowy or icy roads, uphill or downhill.
- ASR is especially helpful for light rear-wheel driven vehicles, tending to unstable manoeuvring conditions due to high power engines. 0.4% of accidents could be avoided for this group of vehicles with ASR (GIES, 1991, S. 187 ff).

ASR is more and more implemented in buses. During wintertime traction control can doubtless improve handling qualities of buses. Severe bus accidents are mostly caused by other factors like too long working hours of the drivers and other traffic participants (c.f. FÄRBER et al., 1995).

3.1.5.5 Traction control systems - evaluation studies

No evaluation studies are available.

3.1.6 Electronic stability program (ESP) and Adhesion monitoring system

3.1.6.1 General description

ESP systems are the next step in the evolution of systems to prevent unexpected driving conditions, regardless of bad road conditions and/or inadequate driver actions. ABS systems show their potential only in the case of emergency braking or braking with different friction for each tyre (μ-split). ASR/ET system concentrate on the friction of the wheels but manipulate only the power transmission to each axle in critical friction conditions. The new developed ESP systems will control the yaw and roll behaviour of the car to stabilise the course of the vehicle in critical driving situations without any active input of the driver.

3.1.6.2 ESP and AMS - interaction concept

ESP acts self-paced and can normally not be switched of by the driver(exception AUDI).AMS is a warning system without any direct influence on car or car dynamics.

3.1.6.3 Technology of ESP and AMS

ESP (ITT Automotive / Audi):
This system is designed to combine ABS, ETS and ASR into one system which controls the whole driving dynamics of a car.

Components:
The system consists of sensors for individual wheel rotation speed, additional sensors to measure slip, yaw, oblique run of wheels, lateral and longitudinal acceleration and forces, a steering angle sensor, and sensors recording the pressure of the braking power booster and the force the driver puts onto the braking pedal. A processing and control unit to process the sensor signals, and an actuator system to vary the braking forces for each wheel individually, a braking controller and a controller to manipulate the motor management, an indicator to inform the driver whenever the system is in action.

Principle of operation:
On the basis of the sensor signals of the ABS and the additional sensor data, the processing unit develops a complete picture of the dynamic state of the vehicle in time and the driver’s intentions with respect to steering angle, driven speed and braking pressure.

A very quick operating model - based comparison process - decides which action is necessary to stabilise the movement of the vehicle. The controller uses a single lane model of drive dynamics and calculates a target yaw rate. This target signal is used to calculate target values for the motor management and the braking system. Both target values superimpose the otherwise calculated ABS and ASR target values. The control actions are performed for each wheel individually. An indicator informs the driver whenever the system is in action (FENNEL, 1998).

The AUDI system differs from the ITT system mainly in the interaction concept. It can be switched off, but reactivates whenever the driver brakes. A flashing indicator informs the driver that the system is in action (MANN, 1997).

Adhesion monitoring system AMS (Porsche):
The adhesion monitoring system of Porsche is a totally different approach. The system doesn't influence any vehicle parameters to prevent dangerous driving situations. Instead of that the actual driving dynamics situation is displayed, leaving the responsibility to decide and to act at the driver.

Components:
Sensors to measure wheel rotating speed, yaw variation speed, steering angle, lateral acceleration. Acoustic sensors to estimate the amount of water on the road, and oblique run sensor to detect ice on the road. A processing unit and a display to show the driver his actual state.

Principle of operation:
The sensors are comparable with that of the ESP systems. Also the processing and knowledge basis are similar. In addition to ESP systems the AMS measures the road condition to detect danger of aquaplaning with acoustic sensors. An oblique run angle measuring device is responsible for ice detection. It is known, that the thickness of a water film on the road correlates with the sound level in the wheel casings. Ice on the road surface influences the dynamic behaviour of the oblique run angle.

In contradiction to the other developers of driving dynamic assistant systems, Porsche's system is not designed to act automatically. The system only displays the dynamic state of the wheel adhesion together with the borders of safe driving (adhesion potential) with respect to driving dynamics in a 2-dimensional space (longitudinal and lateral acceleration). The display is designed to help the driver to identify the source of the problem. The adequate reaction to reestablish a stable condition is up to him (WINTERHAGEN, 1995).

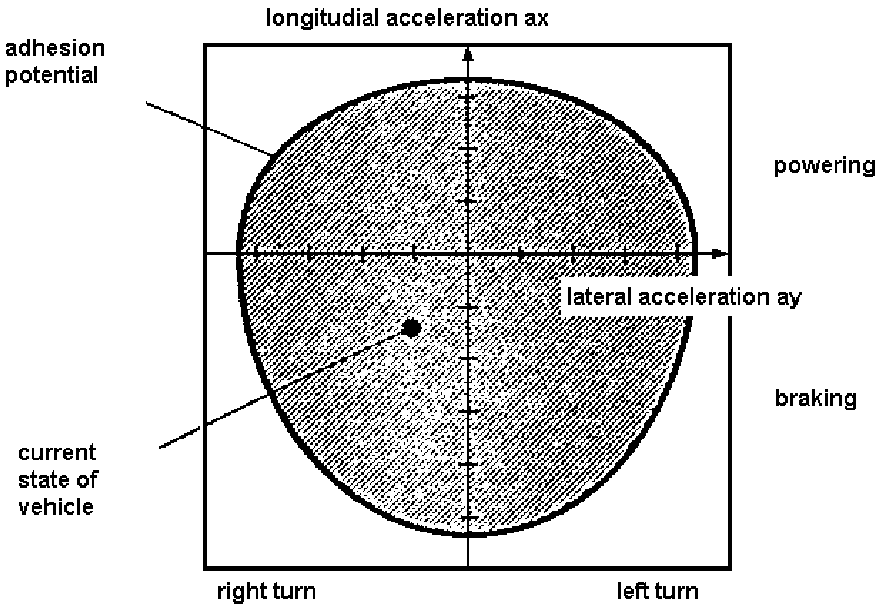

Fig. 4: Adhesion potential display (compare: WINTERHAGEN, 1995).

3.1.6.4 ESP and AMS - expected effects

ESP became popular in conjunction with the elk-test of the A- Mercedes. The value of this test is controversial amongst experts. ESP seems to be a necessary feature for a completely new generation of cars, characterised by short wheelbase in relation to the height of the car. The high centre of gravity of these vehicles can be compensated by electronic means. Further effects for traffic safety are currently not known.

3.1.6.5 ESP and AMS - evaluation studies

No evaluation studies are available.

3.1.7 Heading control systems (HCS)

3.1.7.1 General description

The development of lane keeping systems or of systems assisting the driver in lane keeping follows different directions. The main differences between the systems concern the sensors and feature detection devices as well as differences in car-driver interaction.

3.1.7.2 Heading control systems – interaction concept

Heading control systems are designed as warning as well as intervention systems. Warnings are presented in principal in all sensory modalities: optical, acoustical and haptic. Automatic interventions bringing the driver back to the ‘right’ way lack often information about driver’s intentions or the surrounding traffic.

3.1.7.3 Technology of heading control systems

HCS (BMW):
The "Fahrerassistenzsystem" of BMW uses a classic feature detection approach to evaluate driver's deviation from the best course in the lane. If an important deviation is detected the system tries to bring the driver back to the centre of the lane applying additional steering wheel forces in the appropriate steering direction.

Components:
A video camera with a feature detecting unit, a processing unit, a steering wheel actuator.

Principle of operation:
A video camera is mounted on the inside rear-view mirror to monitor the traffic lane and vehicles ahead. A feature detector unit analyses parts of each frame (method: "area of interest") and is able to recognise the lane bordering lines. Thus the unit is able to calculate the relative position of the vehicle in the lane. The position is continuously compared to the hypothetical position of an ideal ride. If the driver leaves this ideal course, the control unit adds a momentum onto the steering wheel to force the driver back in the right direction. If the driver releases the steering wheel, the system is automatically switched off.

The steering wheel forces are more seen in the sense of a warning. Therefore, the driver can override the system under all circumstances.

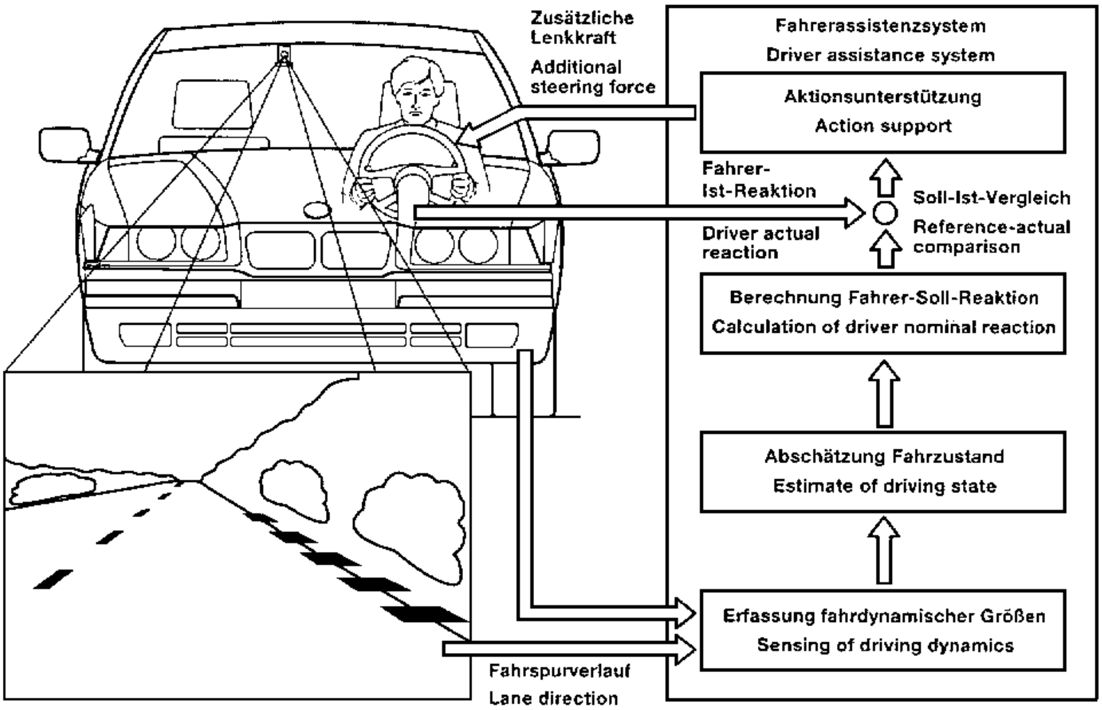

Fig. 5:Principle of BMW's Heading control (from: BRAESS & REICHART, 1995)

HCS (Mitsubishi):
MITSUBISHI has been working on three different systems to keep the driver in the lane. The first approach is similar to the BMW approach. The second approach uses only lateral acceleration and reduces motor power if too high accelerations are detected. This is a solution in between a HCS and an ESP system (see above). The third approach is not a strictly in-vehicle solution but uses external sources of information to decide whether speed and acceleration of the vehicle are inadequate.

Components (HCS, 1st):
A lane detection camera, a steering angle sensor, vehicle speed sensor, yaw velocity sensor, a turn signal switch monitor, and a buzzer for warning sounds.

Principle of operation (HCS, 1st):
The system monitors lane guidelines with a video camera and warns the driver by an acoustic signal if he deviates from the lane.

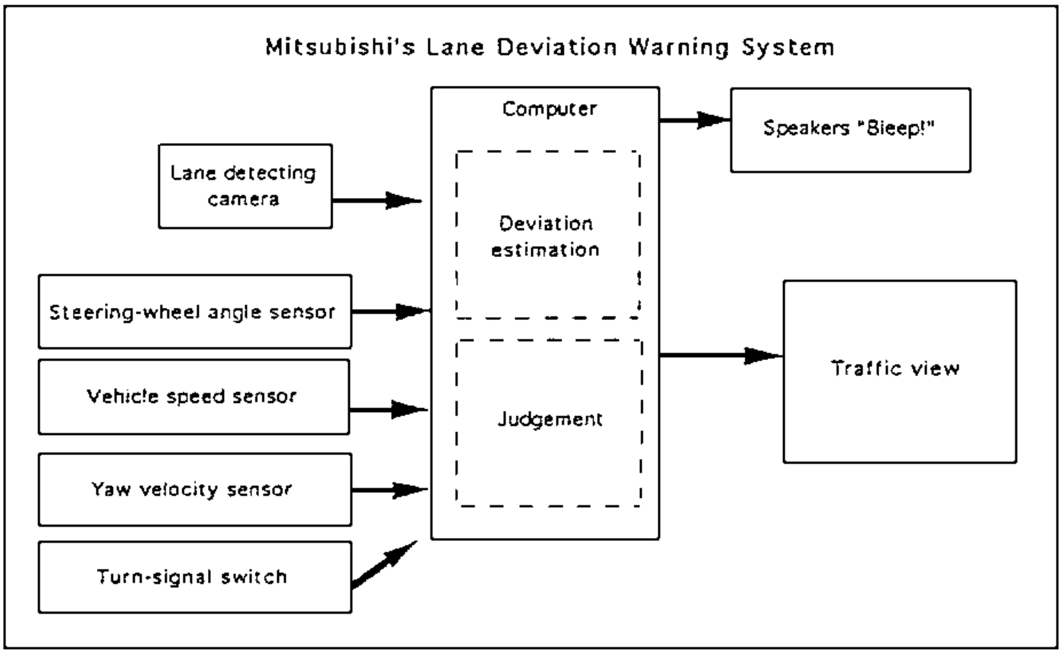

Fig. 6: Mitsubishi's lane deviation warning system architecture (1) (from: JEDA, 1996, p.27).

The principles of lane detection and detection of significant, dangerous deviations from the lane are not specified. The warning philosophy is - in short - inadequate. The warning beep of the lane deviation device has no informational contents! (JEDA, 1996).

Components (HCS, 2nd):
A not specified sensor for lateral accelerations, a device which is able to reduce the motor power.

Principle of operation (HCS, 2nd):
This system, similar to heading control, uses Fuzzy-Logic to prevent wrong handling of the car. If the system detects a dangerous lateral acceleration, the motor power is reduced. It is not possible to evaluate this system because no details of operation, acceleration thresholds or displays for driver's information are specified (ATZ, 1993).

Components (HCS, 3rd):
A system of external beacons transmitting radius of curves and corners to the car, vehicle speed sensor, accelerometer, steering wheel angle sensor, a not specified warning device, and an actuator system to brake the vehicle automatically.

Principle of operation (HCS, 3rd):
The system receives information concerning the radius of approaching corners and curves from roadside beacons and warns the driver, if the car is running too fast. If the driver ignores the warning, the system automatically reduces vehicle's speed. It is not

possible to evaluate this system because of the missing details on operation, warning signals, and operational thresholds (JEDA, 1996).

HCS (research):
This vehicular steering system named ‘cooperative co-pilot’ is developed to assist the driver to keep vehicle in the lane safely.

Components:
A not specified device to recognise the road curvature and width ahead, sensors for lateral acceleration and steering angle, other not specified vehicle motion variables, a computing and decision unit, an actuator to correct the steering actions of the driver.

Principle of operation:
The design concept is a steering control system with the driver and co-pilot operating at the same time. The developed co-pilot can monitor driver's control actions and correct them if necessary. The co-pilot can generate the bounds of feasible steering angle by a special designed controller, and it can determine whether the appropriate steering correction should be applied. The previewed road curvatures are utilised and shaped as control references by a developed guidance law to reduce vehicular lateral acceleration. Vehicle motion variables and road width are also employed for generating suitable zone of steering angle.

3.1.7.4 Heading control systems - expected effects

Theoretically heading control systems should have a serious effect on traffic safety. Single accidents due to lateral control errors – associated with too high speed – are a problem especially for rural areas. Systems really helpful to the driver are going into the direction of automated driving. The current development status of the systems allows no serious estimation of the effects.

3.1.7.5 Heading control systems - evaluation studies

No evaluation studies were available.

3.2 Distance keeping – Adaptive cruise control

3.2.1 General description

The aim of distance keeping systems is the regulation of a safety distance to a leading car. Mostly systems for automatic cruise control are augmented with this feature. They are known under the name ACC (Adaptive Cruise Control), AICC (Autonomous Intelligent Cruise Control) or ADR (Automatic Distance Regulation). The main difference between distance keeping and collision avoidance is the lacking ability of ACC-systems of adequately reacting to stationary objects. They cover different safety problems, behaviour patterns and expectations of drivers. Therefore a distinction between the two systems is commonly accepted.

Examples from literature: AICC or ACC (AI, 1996a; CHALOUPKA et al., 1998; DORISSEN & HÖVER, 1996; HIPP & JUNG, 1997; REICHART & HUBER, 1998; WINTERHAGEN, 1995; WÖRDENWEBER et al., 1996), ADR (HAMBERGER et al., 1996a, b), Manoeuvring (GODTHELP et al., 1993).

3.2.2 Distance keeping – interaction concept

Systems for distance keeping are in principal driver activated or de-activated. If they are activated they operate automatically regulating longitudinal control. Activation is currently performed with a button, deactivation can also be done with a switch but is in any case performed by pressing the braking pedal. For liability reasons the driver gets a visual feedback when the system is in operation.

3.2.3 Distance keeping – technology

Autonomous intelligent cruise control systems (AICCS):

AICC systems base on the cruise control systems taking the distance to vehicles ahead into account

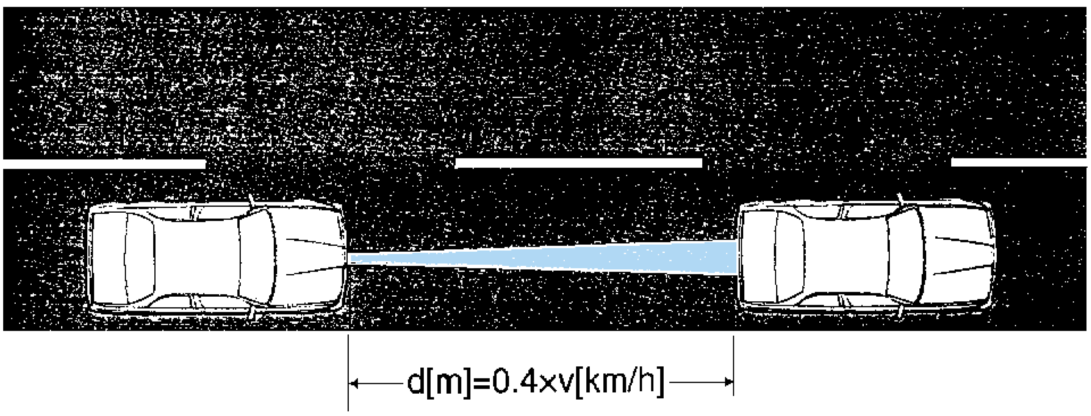

Fig. 7: AICC definition (from: DORISSEN & HÖVER, 1996, p. 397).

Given a pre-set target speed the car will hold this speed but also adopt to lower speeds of leading vehicles according to traffic conditions. The systems varies in the sensors used, and in their viewing field. Radar sensors working in the milli- or microwave band, using the Doppler effect for maximal field of view in depth and wide, are able to detect targets even in curves not being affected by bad weather conditions. Laser emitting / receiving devices for maximal precision of measurement are small and easy to build in, but suffer from bad weather conditions like the human vision. The crucial point of all systems is the generation of a reliable image of the real world on the basis of non-visual information. For example radar can detect sharp edges at a far distance, but these are only edges and no images. They can be reflected from a tree, a bridge, a road sign or anything else. Laser is more precise, but only for small distances and good weather conditions. Without knowledge of the world and good models it is impossible to decide, what kind of obstacle is in the path of the car. To cover dynamic situations it is furthermore necessary to have knowledge on the history of the objects ahead. For example, a car coming from the overtaking lane into my lane can have a smaller distance because it is normally accelerating.
Beside their knowledge base the systems vary in their warning philosophy, and the extend to which decelerations of the car are performed automatically.

AICC (MAN):
This system reflects most of the properties of European AICC systems. The observation range is restricted to the lane before the car small parts of adjacent lanes. The maximal deceleration in the automatic braking mode is moderate.

Components:
A radar sensor, a detection unit, a steering wheel angle sensor, a speed sensor, a pursuing unit, a central strategic unit with actuators affecting the motor management, the retarder, and the brakes, and a display and control unit to communicate with the driver.

Principle of operation:
The radar sensor in the front of the vehicle measures distance and azimuth of reflecting objets in front of the truck. The following detection unit combines the signals to distinct objects, calculates the quality of the object recognition and their distance. These data, the steering angle and the driven speed are input data of the pursuing unit. On the basis of the current course, the steering angle and the speed driven, this unit guesses the course of the lane ahead. This guess is used to determine the relevant proceeding vehicle from all sensory objects. Position, distance and relative speed of this vehicle is transferred to the central strategic unit. This unit is able to classify the situation into one out of a set of typical traffic situations (i.e. approach to a slower vehicle, lane change of another vehicle to the own lane, leaving of another vehicle of the own lane, etc).The traffic situation chosen determines the sort of action the strategic unit performs. The strategic unit is able to control fuel injection, brakes and the retarder. Because of a false alarm rate >0 to irrelevant stationary objects (e.g. trees along the roadside, a tin on the road) the maximal deceleration is limited to 2.5 m/s^2 for safety reasons. Hard unexpected and meaningless braking manoeuvres would endanger other traffic participants.

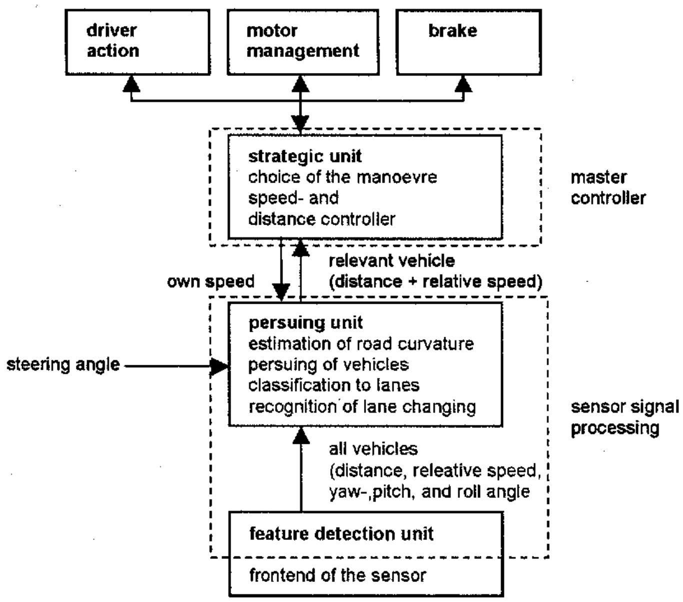

Fig. 8: ACC system architecture from MAN (compare: HIPP & JUNG, 1997, p. 405).

The driver can choose the desired speed. Feedback about this speed is shown on the AICC display in the dashboard. If the system detects a vehicle in the same lane ahead, it displays an icon and starts to control the distance automatically. In accordance with the traffic situation cluster, recognised from the strategic unit, the system uses different control strategies and time lags (HIPP & JUNG, 1997).

AICC (BMW):
The system of BMW uses a broader detection area and is able to operate in two modes. In the driver assistance mode, the system influences the driver to maintain the appropriate distance to the vehicle ahead by means of an active gas pedal, in the automatic mode, the vehicle maintains the appropriate distance itself by manipulating the speed of the vehicle.

Components:
A laser distance measurement system to observe the lane ahead as well as the adjacent lateral lanes, sensors for speed, road conditions, and visibility, an input device for the desired speed, a controller unit, an ACC display unit, additional LEDs in the speedometer, an active gas pedal, and systems to manipulate the speed via motor management and brakes.

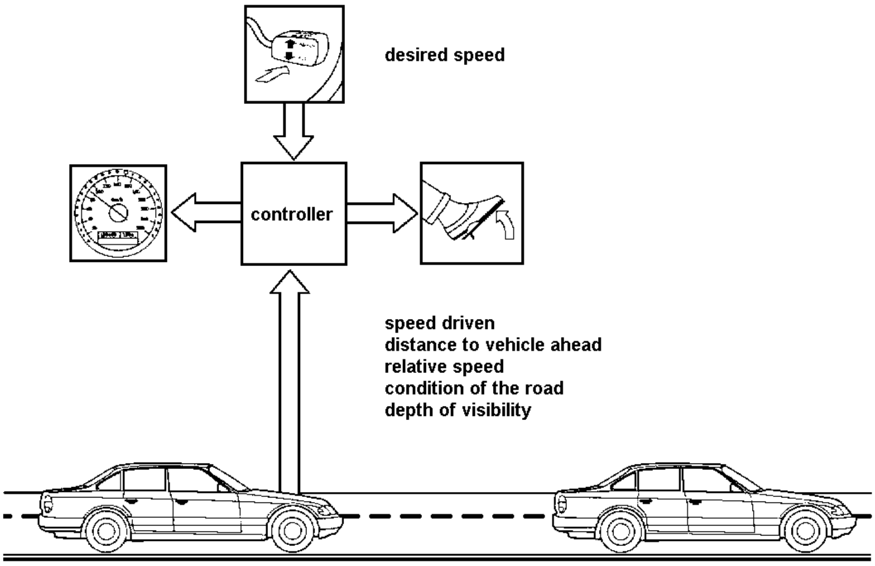

Fig. 9: Adaptive intelligent cruise control (assistant mode) of BMW
(from: BRAESS & REICHART, 1995b)

Principle of operation:
The triple laser sensor system measures the distance and relative speed of the vehicles ahead. The sensor system is able to detect not only the next vehicle ahead in each lane but vehicles in front of them too. The control unit calculates from these data a dynamic picture of the whole traffic scene in front of the car. From the relative movements of the traffic around the car, hypotheses about the intentions of these moving objects, the driven speed, the condition of the road, the visibility depth, and the desired speed the system decides to accelerate, decelerate or hold speed
In the assistant mode, the system influences the driving speed via the active gas pedal. In automatic mode, the system controls the speed itself via the motor management, the gear driven and at least via automatic braking actions. In both modes, the driver is able to override the vehicle actions at any time. The system is activated by the driver. It is switched off by a control, any braking action of the driver, or if the speed falls below 50 km/h. The driver can determine the time lag (distance to the vehicle ahead) in three steps. (See: AI, 1996a; BRAESS & REICHART, 1995 a+b).

AICC (Hella):
This system uses the laser technology and different warning/action modes on the output side.

Components:
Infrared pulse laser sensor (LIDAR), a speed sensor, controller unit, warning display, and an automatic motor management and braking device.

Principle of operation:
The operation principle of the Hella system is similar to the others mentioned above.
The system acts in different modes whenever the actual speed has to be reduced. In the comfort mode, speed reductions are performed in influencing the motor manage-

ment and the gear box. In automatic braking mode, the system acts on the motor management and gear box too. Additionally automatic braking is supplied in several possible modes:

- automatic braking of the system,
- automatic braking only when the driver touches the brake pedal,
- braking force controlled by the system,
- braking forces of the driver and the system are added,
- braking force of the driver is added only to the braking force of the system when the driver brakes harder than the system does.

(see: AI, 1996a; DORISSEN & HÖVER, 1996)

AICC (CTE, Bosch, Mercedes Benz):
Celsius Tech Electronics (CTE), Bosch and Mercedes Benz developed similar systems on the basis of radar distance sensors (see above, AICC system MAN). The systems differ slightly in their controller strategies and the properties of the MMI.

Components:
Millimetre wave radar sensor with 130 m range. a feature extraction and pursuing unit, steering angle and speed sensors, a strategic unit with the possibility to influence the motor management, the gear box, and the brakes, displays and control units to interface with the driver.

Principle of operation:
These three AICC systems work on the basis of a millimetre wave radar for autonomous cruise control and collision warning/avoidance. The systems are designed to work on multiple line motorways, motorways and main roads. They only operate above a certain speed. The principle of signal processing is described elsewhere (above, AICC system MAN). The Mercedes Benz system ("Abstandsregel-Tempomat") is described in more detail because it will come to market in autumn 1998. The system uses a model-based neural distance controller, which directly gives control signals to throttle and brake. The neural network itself consists of a simple multi-layer feed forward perception network. A special training method is used where the neural network is trained on detailed nonlinear longitudinal vehicle model by minimising a cost function. Only a few simulated driving manoeuvres are necessary to train the controller. Practical road tests show, that the model-based neural distance controller can be used for intelligent autonomous cruise control as well as for distance control in stop & go-traffic. All systems control the driving speed in affecting the motor management, gear box and automatic braking up to a certain limit of deceleration. Only the system of Mercedes Benz supplies the driver with additional warning messages, if the distance reduction exceeds a critical speed. All systems show their current state, target speed and the detection of vehicles ahead on a display. The controls for the driver are comparable to the former cruise control handle. (AI, 1996a; ERIKSSON & AS-BENGT, 1997; FRITZ, 1996).

AICC (Porsche):
This system differs from the others described above, having no facility of automatic braking.

Components:
Sensors and processing units of this system are comparable to the Hella system (see above).

Principle of operation:
The distance to preceding cars or obstacles in the lane ahead is measured by means of optical sensors (infrared band) from Leica. The calculated distance is compared with the target distance, computed from the speed driven. If the actual distance becomes smaller than the target distance, the throttle valve position is influenced. Porsche does not plan any automatic actions on the brakes (WINTERHAGEN, 1995).

3.2.4 Distance keeping – expected effects

Distance keeping, according to the expert's evaluation,
- offers a medium amount of information,
- the mental load of the driver is expected to be low,
- also sensory distraction of the driver is expected to be low and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be positive (FÄRBER & FÄRBER, 1998).

HIPP & JUNG (1997) postulate that systems assisting the driver to keep safety distances to leading vehicles would help to avoid or at least moderate accidents, caused by too short distances. On the basis of the accident statistics shown this would be for 9% of accidents with person injury. Taking into account also freight traffic, the percentage would increase to 15,6%.

"On the basis of the GDV (German Insurance Association) large scale accident material an assessment has been made which part of car crashes with personal injury could be influenced by driver assistant systems." (LANGWIEDER, FROST & BACH, 1998, p. 2). The statistics, used by the authors, comprise a total of more than 7000 rear-end accidents - all of them involving personal injury.

The safety benefits of the ACC system are estimated as follows:
"Assuming that it is not possible to detect stationary objects, that speed exceed 40 km/h, that **all cars** (100 %) are equipped with an ACC system, that the system functions properly, first generation ACC systems would influence the outcome of approximately 40 % of all car rear-end accidents on country roads and 60 % on the autobahn."
But "in view of the fact that in the foreseeable future only a small number of vehicles will be equipped with the ACC system (only newly registered cars) and bearing in mind that there is only a limited possibility of avoiding rear-end collisions, it can justifiably said that the practical impact of first generation of ACC systems will be lower by a factor of 10. This would then mean that the first generation ACC system will influence the outcome of less than 2 % of all autobahn accidents and less than 0.3 % of all accidents occurring on country roads."
These percentages are very low, although the safety benefits to persons involved in accidents and potential material damage must not be overlooked. If 10 % of all cars were equipped and the above mentioned assumptions are applicable, then the safety benefits

(per year) would still amount to about 2,300 persons involved in accidents and approximately 80 million DM.” (LANGWIEDER, FROST & BACH, 1998, p.18 f).

3.2.5 Distance keeping – evaluation studies

Investigation of AICC by TÜV-Rheinland, presented by DORISSEN & HÖVER (1996):

TÜV - Rheinland made a series of field studies in real traffic situations. The parameters, to describe behaviour were: longitudinal dynamics of vehicles, video clips of driving situations and the corresponding opinion of the drivers.
The conclusion, drawn by DORRISSEN & HÖVER is, that drivers are capable to handle the system safely. It is also expected that, with an AICC, the comfort of driving is increasing and the influence on the traffic security is positive.
The acceptance of the system and further developments are strongly related to the available sensors for distance measuring (p. 405).

Results in detail (p. 402 f):
The article reports only subjective results, the description is descriptive.
An AICC driving test performed with 30 subjects without braking interference by the system showed that the acceleration, conducted by the speed controller was rated ‘pleasant’ and ‘sufficient’. Following another car was rated ‘pleasant’, ‘relaxing’ and ‘comfortable’. The overall rating of the system was ‘secure’ respectively ‘very secure’.
The essential critics:

- While approaching targets, they (the targets) are recognised and detected too late, especially light vehicles like motorbikes.
- Loss of target or false detection of targets in curves.
- Problems of targets detection at lane borders (p. 404).

Many subjects had a positive opinion about the system and would like to have it in their next car. However this depends on the price and the expected kilometres they drive on highways.

Tests on AICC, CHALOUPKA et al. (1998):

CHALOUPKA et al. (1998) report about 94 driving tests with AICC. They performed standard and free observations of the driving behaviour and of the people involved in the traffic situation.
The authors draw the conclusion, that behaviour observation alone cannot show clearly why people behave in particular ways, because motivation behind the observable behaviour is not known (p. 112).

Results in detail (p. 75 f):

- Drivers with AICC vehicles do not overtake more often, but they change lanes to keep their lanes ahead clear.
- They cooperate less with others.
- When driving with AICC, less security and less braking actions are observed when pedestrians are involved.

- Speed is more homogeneous, but in some situations, where speed should be reduced, a faster speed is kept.
- Distance keeping is improved resulting in less braking actions to hold the right distance.

Making distinctions about the road type (p. 77), one conclude, that in slow city traffic and on highways, less critical situations related to distance keeping and speed occur. However the probability for critical events, related to lane change, interaction with other traffic participants at crossings and in situations concerning right of way increases.
The analysis of the questionnaire data shows (p. 85 f):
- 50% of the subjects think that the AICC makes sense,
- the reaction of the system is rated as ‘too late’ by a great number of subjects,
- the reactions of the system are not predictable: sometimes an expected reaction never occurs,
- wrong reactions of the system, for example in curves and with other vehicles in the adjacent lane,
- nearly 50% of the subjects lose some ‘joy of driving’ because of the system. 15 to 25% get nervous because of the feedback system,
- 50% say, that the feedback system withdraws driver’s attention from the traffic situation for a short time (a critical point in the light of traffic safety),
- more than two thirds would like to have that system in their cars,
- nearly half of the subjects want to have the option to switch off the system,
- 43-46% want the system only if it works perfectly secure,
- two thirds of the subjects think they drive more slowly as usual,
- also two thirds think the system does not interfere with their lane change behaviour (this statement does not correlate with the observed data!).

Unwelcome effects of the system, named by the subjects, are (p. 100):
- you rely on being warned in case of danger,
- you unlearn particular capabilities, which could cause problems in case of a system malfunction,
- warning signals can confuse and overload the driver,
- driving gets more boring and makes more tired. The driver loses attention.

The authors summarise the following behaviour changes (p. 121):
- positive: important adaptation of security distances to leading vehicles,
- positive: speed regulation,
- positive: speed harmonisation,
- negative: longer safety distances provoke other drivers to fill that gap, which causes more conflicts related to lane changing,
- negative: problems to continue driving (for example: if you are mentally poled to the car in front),
- negative: problems interacting with „ weaker“ traffic participants (especially when using the lowest automation level).

ACC driving simulator study, NILSSON (1996):

In a simulator experiment driving with ACC was studied during exposure to 'critical' traffic situations, which focused on functional limitations of the ACC concept. The comparison between ACC and unsupported driving showed the following results:

- "approaching a stationary queue lead to more collisions among ACC users than among unsupported drivers, possibly because of too large expectations leading to too late and abrupt interventions.
- A car pulling out in front of the driver, lead to identical and immediate reactions by unsupported and ACC supported drivers. All ACC drivers reacted (braked) before warnings were presented, possibly because of overlearned behaviour.
- Cars ahead braking hard lead to strong but less immediate driver actions with larger variability. No difference was revealed between unsupported and ACC supported drivers. Nine of the ten ACC users waited to take over control until the warning was received.
- The collisions among ACC drivers could neither be explained by increased driver workload nor by decreased level of driver alertness.
- The ACC was well accepted in spite of its" "limited capability to handle certain situations." NILSSON, 1996, p. 1259, 1254).

Video data analysis, ROBINSON, INMAN & KOZIOL (1998):

ROBINSON, INMAN & KOZIOL (1998) obtained naturalistic driving data from 10 vehicles equipped with an Intelligent Cruise Control system and data acquisition systems. The primary purpose of the video analysis tool was to assist in the determination of a set of driving scenarios, close calls, and driver reaction times. Other required data used to determine potential safety benefits were range (to preceding vehicle) and range rate. At the moment only preliminary results emanating from the video analysis are available.

Video data analysis for ACC within MOTIV, FÄRBER et al., current:

Within the MOTIV project a video analysis of driver behaviour on urban main roads and motorways is currently performed. The results of this behaviour observation will be used for the design and definition of minimal capabilities of such systems as well as for the definition of test criteria. The data analysis is nearly done. The results will be available in autumn 1998.

Acceptance of distance warning and distance keeping systems, survey,
GRIMMER, ADELT & STEPHAN (1995):

The survey by GRIMMER, ADELT & STEPHAN (1995) is not a behavioural evaluation study. With scenarios the authors tried of give an impression to the subjects, how distance warning and distance keeping systems are working, and tried to examine in this way their acceptance of the systems.
Three quarters of the 1,074 test persons rate the systems to be 'good', if they work technically perfect. The same number has doubt about the reliability of the system. 69%

would agree to test such a system, more than a half of the subjects can imagine to get used to the system. 48% think they would use the system very seldom, if their car would be equipped. Especially remarkable is that 86% demand the switch off option as an important feature. Reasons for this demand could be, that nearly 50% feel unsafe while driving. 60% felt like giving away control and 45% fear to lose fun of driving, using such a system (GRIMMER, ADELT & STEPHAN, 1995, p. 43 f)

3.2.6 ACC technology and evaluation studies - concluding remarks

The varying results of the behavioural studies and the detailed description of technology of ACC systems throws some light on the problem of evaluating in-vehicle safety devices. As can be seen from the description of technology, one safety device is not like the other – even the use similar technology and the same name. The concrete layout defines to a great extent the potential benefits and the restrictions of the system. Consequently, evaluation studies can come to quite different results. A minor change of sensor technology, underlying ‘intelligence’ or MMI can dramatically influence impact on traffic safety. That means, evaluation studies must exactly define the system parameters of the system under investigation. It means furthermore that the results of different evaluations are difficult to compare, unless this system description is considered.

3.3 Collision avoidance

3.3.1 General description

Collision warning and avoidance systems try to detect obstacles (cars or static obstacles) with the aid of CCD cameras, microwave radar or laser radar (e.g. Fiat, Jaguar,, Lucas, Matra, Mazda, Mitsubishi, Nissan, Renault, Rover, Toyota, Volvo), or with a piezoceramic device (Polaroid), or they want to detect the distance to all sides (Delco). Eventually they brake automatically.
Japanese manufacturers develop and test these kind of systems (JEDA, 1996; ATZ, 1996; SPREITZER, 1996) in test-vehicles. German car manufacturers and suppliers have been more reserved, partly based on the experiences of the PROMETHEUS project. To react adequately in all possible situations, extremely long time lags are necessary associated with the probability of many false alarms. A new approach, using multiple sensors, including computer vision, mechanically-scanned microwave radar, and sensor fusion to improve the sensor integrity and hence reduce the rate of false-alarms has been started with the AC-ASSIST project (CLARKE, ~1997). For Europe and America concept cars and experiments are published (HALLER et al., 1995; JANSSEN & NILSSON, 1993; JANSSEN & HUGH, 1994; SHINAR, 1995, SHINAR et al., 1997; WEBER et al., 1994; ZIMMERMAN, 1993).

3.3.2 Collision avoidance - interaction concept

Two systems can be differentiated: warning and interrupt systems. While German and American manufacturers prefer warning systems, Japanese manufacturers favour an automatic braking intervention, if the driver does not react to an optical or acoustical warning of an obstacle.

3.3.3 Technology of self initiated Collision avoidance systems (CAS):

Collision avoidance systems can theoretically be seen as high-end ACC-systems, combined with features of parking assistant. But, according to the principle of operation, CA systems (with one exception) look only for obstacles ahead of the car disregarding intentions of the driver or other traffic participants. This isolated ‘view of the world’ is one weakness of these systems.

CAS (Mazda, Mitsubishi, Nissan, Toyota):
The manufacturers call their developments "automatic braking systems". But in reality, all four systems are obstacle detection, warning, and sometimes automatic braking devices.

Components:
A CCD camera, a milliwave radar system, a feature detecting unit, a processing unit, several warning displays (auditive, visual), and an automatic braking system.

Principle of operation:
This automatic braking system uses CCD cameras mounted on the inside rear-mirror to monitor the traffic lane and vehicles ahead. If the system spots an obstacle, milliwave

radar mounted on the front of the vehicle determines its distance from the vehicle. If it judges the situation to be dangerous, the system issues audible and visual warnings, and tells the driver to take evasive action. If the driver does not respond, the system automatically applies the brakes to avert or at least reduces the severity of a collision.
No detailed information is presented in which way obstacles are really detected, neither decision criteria to decide whether a given situation is dangerous or not are explained (JEDA, 1996).

CAS (research):
A more advanced system, integrating ACC features is vaguely described by KEIJIi (1996). But, on the basis of the information given, it is not possible to classify or analyse the system in a more precise way.

Components:
A not specified "stereo image sensor", other components are not mentioned or explained.

Principle of operation:
A safety vehicle using an obstacle detection system with a stereo image sensor has been developed. The matching method adopted for this stereo system is the small area based matching to yield a distance distribution image. The road shape and solids are estimated from the distance distribution image. The safety vehicle has three functions for the 'avoidance stage' proposed in the advances safety vehicle concept as follows: (1) a collision alarm system, (2) an automatic collision avoidance system, (3) lane keeping alarm system (KEIJI, 1996).

3.3.4 Technology of driver initiated Collision avoidance systems (Mercedes Benz)

The „Bremsassistent“ calculates the braking forces which are necessary and sufficient to avoid collisions with other vehicles or obstacles ahead. The system is able to brake automatically, but begins its action only when the driver himself has initiated the braking manoeuvre.

Components:
Sensor systems to detect obstacles or vehicles ahead in the path, a detecting and pursuing unit, braking controller unit, sensors to detect braking actions of the driver.

Principle of operation:
The ‘Bremsassistent’ calculates distances to obstacles or vehicles ahead continuously. Together with the driven speed and the road conditions it is able to calculate the appropriate braking forces to avoid collisions. The system does not act automatically but needs an initiative action of the driver. At this moment the system increases braking forces up to the calculated level, disregarding the braking forces of the driver.

Add-on system to driver initiated CAS (research):
This system can be seen as collision avoidance system in a wider sense. It is designed to perform emergency braking actions more effective.

Components:
Four laser sensors near gas and braking pedal, a processing unit, an automatic braking device.

Principle of operation:
The „Reflex Control System“ uses four sensors to observe movements of the driver's right foot. If he takes his foot away from the gas pedal rapidly and moves it towards the braking pedal, the system decides that the driver intends to start an emergency stop. Whenever this happens, the systems performs an emergency braking manoeuvre. If the driver’s foot has reached the braking pedal to start the braking himself, the automatic braking stops. If his foot doesn't reach the braking pedal, the automatic braking is cancelled within 500 ms.
The system is planed to be integrated in the "Bremsassistent System" of Mercedes Benz (MÜLLER, 1997).

3.3.5 Collision avoidance - expected effects

Concerning collision avoidance, we can report expected effects on
- car initiated collision avoidance and
- collision warning.

According to experts’ opinion car initiated interventions to prevent collisions
- provide a small amount of information,
- the mental load of the driver is expected to be medium,
- also sensory distraction of the driver is expected to have a medium level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

Collision warning, after the experts’ evaluation,
- offers a medium amount of information,
- the mental load of the driver is expected to be medium,
- sensory distraction of the driver is expected to reach a high level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

MALATERRE & FONTAINE (1993) estimate the percentage of users who have at least one need covered by an anticollision device with 38 % (inside and outside built up areas). But they note that this percentage provides an imperfect appraisal of the effectiveness of aids as it considers neither the number nor the severity of avoidable accidents (p. 19).

PEREL (1998) is going to examine recent research findings related to older driver safety problems and driving capabilities that are relevant to the design of collision avoidance technologies. LING SUEN & MITCHELL (1998) think, that collision warning systems will increase safety of elderly and disabled drivers.

PARASURAMAN, HANCOCK & OLOFINBOBA (o.J.) stress the importance of the credibility of a collision warning system: „Imperfect detection conflates the false alarm rate and experience with other technologies confirms operator aversion to false warnings. Although sensitive alarm systems with high detection rates and low false alarm rates have been developed, the posterior probability of a collision given an alarm can be quite low because of the low base rate of collision events."(p. 1).
"...Consistently true alarm response occurs only when the a priori probability of a signal is relatively high. There is no guarantee that this will be the case in many real systems. More generally, these results suggest that designers of collision-warning systems must take into account both the decision-threshold at which these systems are set and the priori probabilities of the collision types, if these are known. ... Decision thresholds for collision-warning systems must be set not just for high hit and low false alarm rates, but for relatively high values of posterior true alarm probabilities as well." (p. 10).
"As a result, only a small proportion of alarms will represent true collision scenarios. These and other factors can conspire to reduce alarm effectiveness in collision-warning systems." (p. 1).

3.3.6 Collision avoidance – evaluation studies

Investigation on three displays for collision warning, DINGUS et al. (1997b):

Three different displays for collision warning are tested.

- A car symbol, becoming bigger in relation to the distance to the leading car, starting to blink at a critical distance with a frequency of 4 Hz;
- A stack of nine bars which are illuminated more and more, depending on the decreasing distance of the leading car; changing their colour (from green to orange and red) and finally blinking at a distance less than 0.9 seconds.
- Two quadrilateral warning fields, one orange/yellow, one red, illuminated according to the distance to the leading car.

The test track is 40 km long. Compared to the baseline measurement the distance with the blinking car increases of 0.2 seconds. The other two displays are of no effect.
In a further experiment the effects of false alarms are investigated: Older drivers, keeping generally more headways are not influenced by false alarms. Younger drivers are not effected by a false alarm rate up to 30 %; they hold the longest headways at a false alarm rate of 31 – 60 % (DINGUS, McGEHEE, MANAKKAL, JAHNS, CARNEY, HANKEY, 1997b).

Collision warning study, VARALDA et al. (1995):

"The ... study was conducted in a simulator. The driving task was car following on a three-lane motorway. The visibility condition was either clear sight or heavy fog. During driving the subjects were visually warned for collision as well as for obstructions ahead. Two MMI solutions were studied: one with a single display for integrated presentation of the two types of warnings, and another where separate displays at different locations on the dashboard were used for the presentation of two types of warnings. A control condition without support system was included as reference.

In the car following task, and hence focusing on collision warning, both MMI solutions lead to longer headways in seconds (average 5.6 s) and longer distances in metres (average 93 m) compared to driving without support system (averages 3.7 s and 63 m) when the sight was clear. On the other hand, especially one of the MMI conditions presenting warnings to the drivers resulted in larger headway and relative speed variability, than the control condition. The proportion of the driving time when the drivers kept closer to the preceding car than a set safety margin was also reduced (from 39 % to 11 %).
In the obstacle avoidance task, and hence focusing on medium range warnings, the lane change performance differed between the conditions when the support systems were used, and the reference condition when they were not. Both MMI solutions lead to earlier initiations of obstacle avoidance manoeuvres (average 5.0 s, 59 m before the obstacle) and less abrupt steering manoeuvres (average 12 °/s) compared to unsupported driving (averages 4.4 s, 49 m, 22 °/s, respectively).

Driving performance certainly differed between the two visibility conditions. In the fog the distance to preceding vehicles (both in metres and in seconds) were shorter, and the variability in driving was less. The initiation of obstacle avoidance manoeuvres was earlier and the steering less abrupt in fog compared to in clear sight. No interaction effects were obtained between the independent factors visibility and MMI, meaning that the visibility effects were not influenced by MMI solution.
The driving performance was not found to be influenced by MMI solution. Thus, integration of the two different types of warnings on a single display had neither positive nor negative effects on driving performance. In the condition with separated displays, warnings presented in the central field of view could not be proven to be more positive than warnings presented more peripherally from a driving performance point of view." (HALLER, BECKER, GERBINO, HOFMANN, MORELLO, NILSSON & VARALDA, 1995, p. 2.2).

Collision avoidance support study, JANSSEN & THOMAS (1994):

A simulator experiment is reported that compares "three collision avoidance systems (CAS) on car-following performance and overall driving behavior and adverse (fog and darkness) as well as normal visibility conditions." 24 male "subjects received CAS-support while following preceding vehicles at pre-specified distances and speed differentials" (JANSSEN & THOMAS, 1994, p. 179).

"There were no significant interactions between CAS and visibility conditions, which should be considered to be the core result of the experiment. ... A CAS can indeed bring down the amount of close following, as well as the average overall driving speed. The only system that does both of these is the '4sTTC + Added Counterforce' CAS. For this system there is also the suggestion that the vehicle is not in the left lane so often, which is indicative of a certain disinclination to perform overtaking manoeuvres. The braking distance HUD did not result in any beneficial effect on behaviour at all." (p. 181).

In short: "Beneficial effects on driving behavior were most consistently associated across visibility conditions with the CAS that used a 4s time-to-collision criterion followed by an action on the vehicle's accelerator (i.e., an increased counterforce on the pedal). This included a reduction in the amount of short following headways as well as an overall reduction in average driving speed. Other systems appeared to suffer from compensatory effects, the inclination to drive somewhat more carelessly because the support is available." (p. 179).

Collision avoidance - field experiment, TÜV Rheinland (~1998):

A new function, which may be used in isolation or in combination with ACC, is called AC-ASSIST. It should warn the driver if a stationary or significantly slower obstacle is detected. If he does not take control of the situation, emergency brake intervention will commence. A field experiment on a test track takes place in autumn 1998, responsible for this experiment is TÜV-Rheinland. The results are not available at the moment (see announcement AC-ASSIST paper).

3.4 Reversing aids / Parking aids

3.4.1 General description

Parking aids are devices, related to collision warning, but technically less sophisticated. They are constructed for the detection of static obstacles at low speeds. They should assist the driver in narrow parking slots.

3.4.2 Parking aids – interaction concept

The parking aid is either activated by the reverse gear (i.e. system-paced) or on demand of the driver. Systems using cameras inform the driver (e.g. AYALA et al., 1995) while systems using ultrasonic technology only present a warning signal (e.g. ATZ, 1990; HB, 1995; STAHL & HÖTZEL, 1996).

3.4.3 Parking aids – technology

Parkpilot, Parktronic System (PTS):

Parking aids use different sensor techniques to measure distances to obstacles in the path of the vehicle. Most developers concentrate on the detection of obstacles behind the car, only one system looks for obstacles in the front, too. The systems differ in their way how to display the distance information to the driver. Better systems display it in the area of the rear window of the car, when the car moves back. Other systems provide very detailed display information with video and/or graphical representation of the surrounding.

PTS (Bosch):
This system uses distance information and displays it, according to one of three distance classes, to the driver.

Components:
There is no information about sensors and processing unit available. The report describes only a display unit in form of a traffic sign, and an auditory warning.

Principle of operation:
The operating range covers 160 – 30 cm. The MMI consists of a display, mounted on the rear parcel shelf of the car, plus an auditory warning. The display panel shows a set of different coloured lights, similar to a set of traffic lights. When the reverse gear is engaged, a continuous green light shows the system to be in operation. The pre-warning area begins at a distance of 160 cm and is indicated by a green flashing light. As the distance between the car and the object closes, the display changes to yellow, than red and, when the obstacle is 30 cm away, to flashing red (AYALA, BARHAM & OXLEY, 1995).

PTS (Mercedes Benz):
This system detects obstacles not only behind, but also in the front of the vehicle. The distance to objects is displayed optically; additional warning sounds are generated, if necessary.

Components:
Ultrasonic distance sensors, capacitive sensors, a processing unit, warning displays in the left and middle part of the dashboard and additionally in the rear upper part of the vehicle cabin.

Principle of operation:
The ultrasonic parking system for the E-class of Mercedes-Benz helps the driver to estimate distances to obstacles, in areas around the car, which are invisible for the driver. Further, it is possible to optimise the use of cramped parking spaces and detect obstacles (also pedestrians) in time. Beside the ultrasonic sensor a capacitive sensor system redundantly and completely observes the area of interest. To achieve correct measures at very close distances the capacitive sensor system is recalibrated (based on ultrasonically measured distances), while approaching an obstacle. If obstacles are detected in the protection area, warning displays in the left and middle part of the dashboard and additionally in the rear upper part of the vehicle cabin show the driver available space to continue his parking manoeuvre. At a distance smaller than 30 cm the optical display becomes red and additionally an interrupted warning sound is generated. If the distance undergoes 20 cm, the sound becomes continuously.

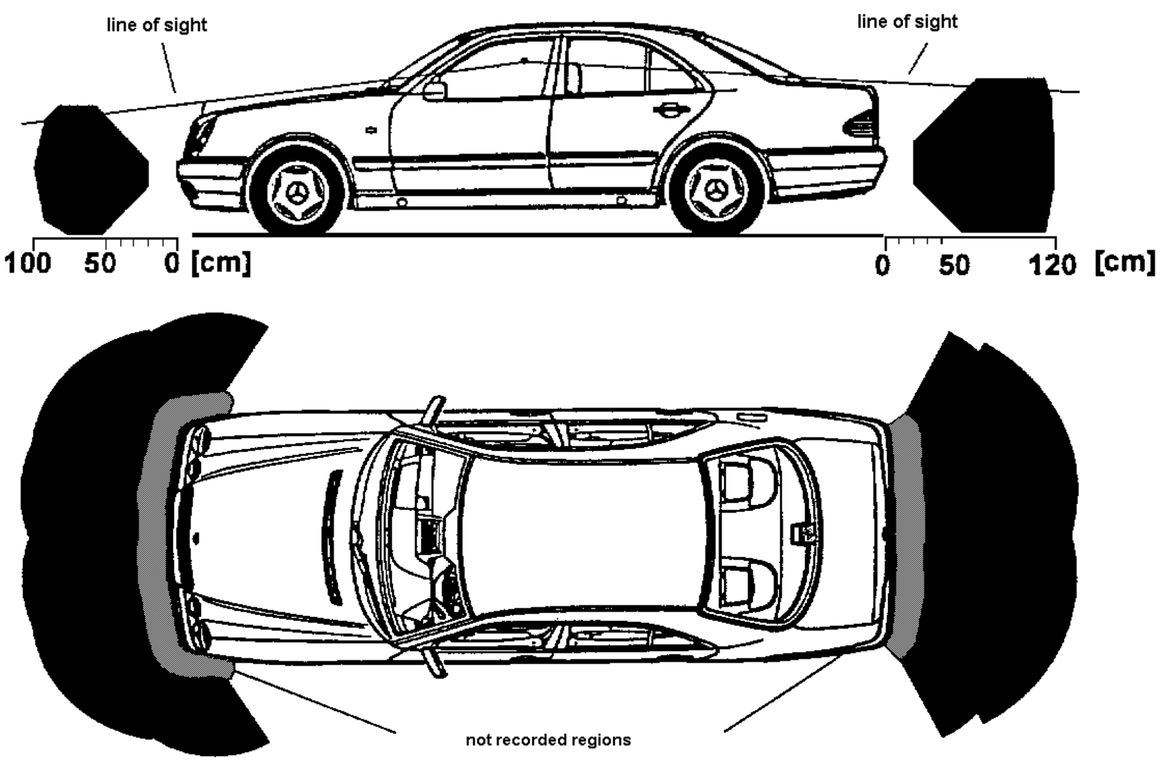

Fig. 10: Vertical and horizontal protection areas of the MB parking system;
top) vertical protection area,
bottom) horizontal protection area (see: STAHL & HÖTZEL, 1996).

Mercedes-Benz plans the development of a system which can detect parking slots along the roadside large enough for the car driven. If the driver is looking for a parking slot and the space between two cars is wide enough, he will be informed by speech output. Furthermore, semiautomatic parking aids on the basis of the system (STAHL & HÖTZEL, 1996) are under investigation.

PTS (GEC Marconi Avionics):
The system measures distances between the rear end of the car and obstacles behind it. The distances of objects is displayed on top of the dashboard in form of a symbolic distance measure.

Components:
A laser sensor centrally mounted on the rear bumper, a processing unit, and a display with coloured LEDs installed on the top of the dashboard.

Principle of operation:
This reversing aid uses the scanned output of a laser diode. The sensor unit is centrally mounted on the rear bumper of the vehicle with a viewing angel of +/-85° in azimuth and from 0° to +20° up to +60° elevation. The maximum range of the system is 3 m, with a minimum range of 10 cm. A simple MMI based on a LED type display with colours corresponding to different distance ranges is installed on top of the car's dashboard. Details of the distance measurement or the values of the distance ranges are not explained. (AYALA, BARHAM & OXLEY, 1995).

PTS (Yazaki):
This system uses techniques and algorithms known from telerobotics to scan the area behind a vehicle, analyse the data and display the results of the analysis to the driver. The user can switch between a symbolic representation including real distances of the objects recognised and a video-view. This system is the only one which is able to detect wholes or gutters in the road behind the car.

Components:
A laser projector installed on the upper rear part of the car, a CCD camera installed side by side to the laser, a frame memory, a data processing unit, a steering angle sensor, a buzzer, and a video monitor.

Principle of operation:
Input data of a video camera are temporarily stored in the frame memory and processed by the data processing unit, to generate a three-dimensional position of an obstacle or gutter. The data processing unit also anticipates the path of the car from steering angle sensor signals and warns the driver about the danger of collision via a buzzer and the display.
To avoid injuries of persons eyes, passing behind the car and looking in the direction of the laser beamer by chance, the pulses are restricted in time to only 40 ms. Additionally an ultrasonic proximity sensor was installed next to the laser projector. Once an object within a distance of 40 cm is detected from the laser projector, the laser is stopped and a warning is given to the driver.
On the display unit the observation area is indicated in top and side view so as to include the car body to help the driver gauge the detection result more easily. The obser-

vation area is divided in 25 cm meshes, and the height of a light spot within a mesh which takes the highest or lowest value in a three-dimensional position measurement is displayed as the height of the mesh. If there is any obstacle in the anticipated path of the car, the message ‘Obstacle on route!’ is displayed and the driver is warned by a buzzing sound.
The system can show the area behind the car in a natural view, the system shows a picture like from a rear view mirror. In this case, the video picture is displayed with left and right inverted and with superimposures that indicate the distance and width of the car (SASAKI, ISHIKAWA, OTSUKA & NAKAJIAMA, 1994).

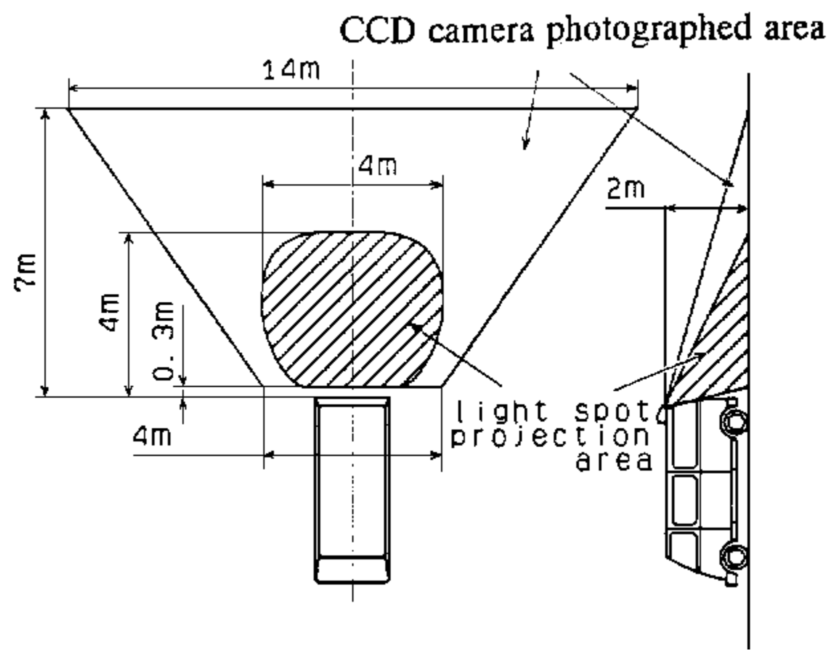

Fig. 11: Light spot projection area and CCD camera photographed area
(see: SASAKI, ISHIKAWA, OTSUKA & NAKAJIAMA, 1994)

3.4.4 Parking aids – expected effects

Positive effects can occur for trucks or buses, to avoid accidents caused by overlooking children behind the truck while reversing.

Concerning parking aids, we can report expected effects on
- information systems and
- warning signals.

According to experts’ evaluation parking information
- offers a high increase of information,
- the mental load of the driver is low,
- sensory distraction of the driver is expected to be medium and

- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium, too (FÄRBER & FÄRBER, 1998).

STAHL & HÖTZEL (1996) are expecting, that the parking aid will help the driver to recognise persons (e.g. children) or obstacles (e.g. flowerpot) and to use the parking space in an optimal way.

3.4.5 Parking aids - evaluation studies

Reversing aids study, AYALA, BARHAM & OXLEY (1995):

AYALA, BARHAM & OXLEY (1995) tested two reversing aids, a dashboard-mounted system by GEC-Marconi Avionics and Bosch's Parkpilot, consisted of a display mounted on the rear parcel shelf of the car plus an auditory warning. Over 100 current drivers aged 65 to 86 took part in the experiment.
"The trials showed quite clearly that both reversing aids helped subjects to park far closer to target objects. In the GEC trial, without the device, only 58 per cent of the sample stopped within one metre of the post or crowd barrier, but this figure increased to 95 per cent when the aid was in use. There was no evidence, however, of the aids having an impact on positioning, nor did they appear to affect the number of collisions that subjects had during trials. In fact, for both systems, for the first manoeuvre of the trial, 23 per cent and 42 percent (with GEC's and Bosch's reversing aid respectively), made contact with the two metre post when using a reversing aid, whilst only a small percentage (11 and 17 per cent, respectively) hit the post when the device was not in use. The number of collisions declined rapidly for subsequent manoeuvres with the aid, suggesting a learning process." (p. 573).
"The fact that subjects tended to take longer over manoeuvres and make more changes of glance direction when using the reversing aid further supports the hypothesis that the device increases the complexity of the driving task and thus the visual and mental workload of the driver. Finally, the results of an after-trial questionnaire showed that the large majority of the sample found both systems easy or very easy to understand, to use and to perform all the reversing manoeuvres included in the trials. Although two thirds of the sample said that the audible feature on the Bosch Parkpilot was useful, 18 per cent did not hear it. The main aspect subjects were impressed by from both devices was the information they received as to the distance to obstacles whilst they reversed. Improvements were product-specific; whilst the main improvement suggested for the GEC device was to provide an audible warning, for the Bosch aid it was to provide subjects with side detection." (AYALA, BARHAM & OXLEY, 1995, p. 574).

3.5 Alcohol and drug control

3.5.1 General description

When a breath alcohol ignition interlock device in the vehicle is installed, prior to starting, the driver is required to provide a breath sample by blowing into the device. If the alcohol content of the breath sample exceeds a pre-set limit, the starter will be locked out and the vehicle cannot be driven. Once the vehicle is in motion, the driver is required to provide additional breath samples at random intervals.
In the USA, drivers who lost their license because of driving drunk, get the license back if they agree to drive only with their car fitted with an alcohol control unit. These units are recommended for driving youngsters too.

Three versions are available:
- alcohol ignition interlock device, ordered by Court mandate,
- systems to protect young drivers making the mistake to drink and drive,
- systems for commercial or corporate fleets (SENS-O-LOCK, 1998).

3.5.2 Alcohol control – interaction concept

The interaction is system-paced, i.e. the test starts, when the driver turns the ignition key. But, the general activation of the system can be willingly or mandatory be the government or the company.

3.5.3 Alcohol control - technology

ACS (Asi):
SENS-O-LOCK is a breath alcohol analyser which is designed to for personal use in cars. It prevents car driving with a significant B.A.C. (blood alcohol concentration).

Components:
The system consists of a car control unit and a central processing unit, a data recorder mounted under the dashboard, and a hand held sensor mounted within easy reach of the driver.

Principle of operation:
The SENS-O-LOCK system requires that a breath sample is given before the car can be started. From that sample, the B.A.C. (blood alcohol concentration) is measured / calculated. If a safe breath is provided, SENS-O-LOCK will allow the driver to start the vehicle. Once the car is on the road, a rolling re-test is conducted at a random time interval to assure that the driver doesn't drink while driving. If a re-test will fail, first the message: "Pleas stop the vehicle!" is heard. After a sufficient time to do so, the light will flash and the horn will beep continuously until the vehicle is pulled off the road and the engine is turned off. The system will never stall or kill the engine.
The unit has a user friendly design with voice instructions. The system contains a digital memory chip which records all operations that the vehicle and driver undergo. Activities recorded are: PASS, FAIL, B.A.C. levels, results of rolling re-tests, attempts to circum-

vent or tamper with the system, battery disconnection, as well as the date and time of each ‘event’. The system is able to store 3,350 separate events.

3.5.4 Alcohol control - expected effects

Currently, no expert evaluation is available for the system. But it is well known that drinking and driving is a severe problem in most countries. Even a rough estimation of possible effects on traffic safety needs knowledge about the following parameters:

- Are there any possibilities to overrule the system?
- Would people accept such a system on a voluntary basis to prevent themselves of drunken driving?
- What is the impact of rolling re-tests at random intervals during driving on traffic safety?
- What governmental regulations are planned and can politically be realised?

3.5.5 Alcohol and drug control – evaluation studies

These systems are just going to market. No evaluation studies could be found.

3.6 Driver alertness monitoring

3.6.1. General description

The idea, to measure driver’s state and apply countermeasures if the driver is drowsy, is quite old. Currently research on drowsiness is going on e.g. in Japan (JEDA, 1996), USA and Canada (DFAS project, ~ 1996). While the DFAS-study recommends to inform drivers, that “sleep is the principal countermeasure to fatigue”, we found different proposals, like to pour out fragrance (e.g. Mitsubishi, Nissan), stop and go of radio music in the rhythm of 30 s (Mazda), voice warning (Honda), optical, acoustical or haptic warnings (Toyota).
From a scientific point of view, currently no valid measurement of drowsiness is possible.

3.6.2 Driver alertness monitoring - interaction concept

The driver alertness monitor works only system-paced.

3.6.3 Driver alertness monitoring - technology

Driver alertness monitoring systems (DAMS):

Two classes of methods are used to monitor the driver's state of drowsiness, methods which analyse the stability of the driver’s steering actions (lane-related measures), and methods which use physiological parameters to estimate the condition of the driver (physiological measures). Whenever the performance, observed with one or both methods, falls below a certain threshold, the driver is supposed to be drowsy and a series of countermeasures are activated.

DAMS (Mitsubishi, Honda):
These systems works with lane related measures. The centre of the lane is compared continuously with the lane keeping actions of the driver. If his performance falls below a criterion value, some actions are started to let the driver stop the ride or to rise his alertness.

Components:
Mitsubishi: A lane detection camera, sensors for steering wheel angle and vehicle velocity, a processing und judgement unit, audio warning, haptic and olfactory displays, as well as an automatic braking system.
Honda: Yaw and speed sensors, a navigation device providing lane position data, a processing unit, and a speech output unit.

Principle of operation:
Mitsubishi: The drowsiness warning system monitors the centre lane of the road with a CCD camera, and monitors the steering angle and vehicle speed.
If the system determines that the driver is drowsy, it issues a warning through the car‘s audio system, which advises the driver to go to a rest. It also vibrates the driver’s seat and the steering wheel, and pours out a fragrance through the vehicle’s ventilation sys-

tem. It is planed to add an automatic brake function if the driver does not respond to the alerting signals. The lane detecting and lane keeping quality criteria are not specified in detail.
Honda: This system detects driver drowsiness using navigation technology that calculates driving position based on data from a yaw rate sensor and a vehicle speed sensor. The sensor, installed in a navigation system, detects the vehicle's deviation from ideal path when driver's alertness level falls and sends an voice warning to the driver. No precise information is given which navigation data and devices are used in detail. The lane keeping criterion is not specified. (JEDA, 1996)

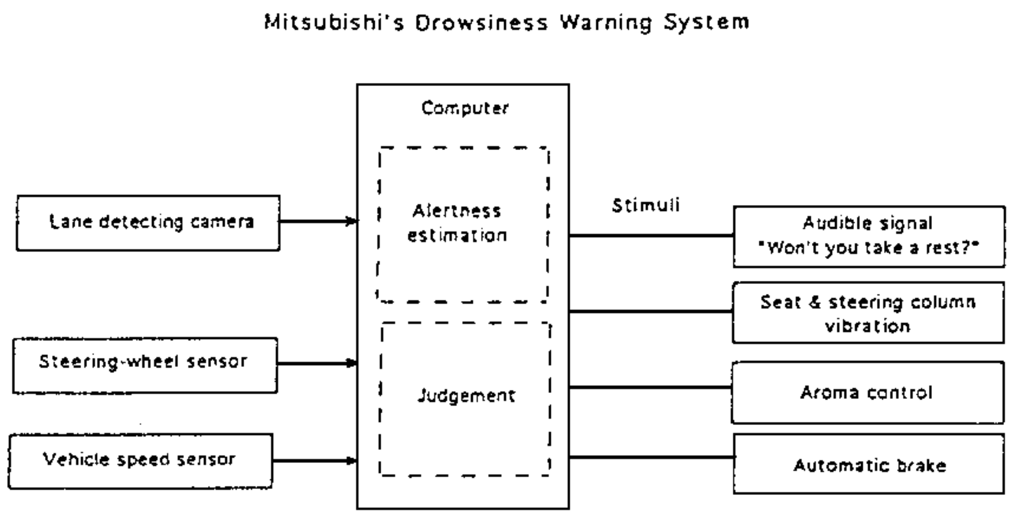

Fig. 12: Mitsubishi's drowsiness warning system (JEDA, 1996).

DAMS (Nissan, Siemens):
Both systems use only physiological parameters to detect drowsiness of the driver.

Components:
Nissan: A video camera to record the driver's eyes and line of sight, a feature extracting unit, a judgement unit, audio warning and olfactory displays.
Siemens: A video camera, an image and signal processing system that monitors the eye lid movement, several display units like a synthetic voice, a buzzer or alarm, flashing dome lights, a vibrating steering wheel or gradual bumping of the brakes.

Principle of operation:
Nissan: This system uses the monitor camera located in the instrument panel to detect driver drowsiness. The camera focuses on the driver's facial expressions and the feature extracting unit estimates how much the driver has his eyes opened. The system gives a warning sound if it detects drowsiness or if the driver has taken his eyes off the road. The air-conditioner also sends a fragrance into the cabin to refresh the driver.
Siemens' drowsiness detection system links a video camera to an image and signal processing system that monitors the eye lid movement of the occupant. The system gathers signals from the driver and compares it to his average blink rate. An algorithm determines from these data whether the drowsiness threshold has been exceeded. Be-

fore an occupant falls asleep, the system recognises measurable performance decrements with associated psychophysiological signs, such as a substantial change in blink rate. This behavioural change allows the system to send a waking-up signal to the driver. Warning devices presently being tested include a synthetic voice, a buzzer or alarm, flashing dome lights, a vibrating steering wheel or gradual bumping of the brakes. These warning signs should alert drivers being in danger to fall asleep preventing possible accidents caused by drowsiness. (JEDA, 1996).

DAMS (Toyota):
This system uses a combination of physiological and lane-related measurements.

Components:
A steering wheel angle sensor, a sensor for driver's heart rate, a not specified judgement unit , visual and auditive displays on the dashboard, a vibrating seat, and automatic brakes.

Principle of operation:
The system uses steering angle and driver pulse as parameters to monitor if the driver is drowsy. The steering sensor located in the steering wheel and a pulse sensor attached to the driver's wrist detect early signs of drowsiness. If the sensors determine that alertness is declining, it triggers alarms (visual and auditive) on the dashboard display which advises the driver to take a break. If driver's alertness level declines even further, the system vibrates the seat. If there is no response, the system will activate electronically controlled brakes to automatically stop the vehicle. No detailed information is given about the relation between heart rate and drowsiness, or steering wheel angle variation (absolutely or relatively) and driver condition. (JEDA, 1996).

3.6.4 Driver alertness monitoring - expected effects

According to experts' evaluation driver alertness monitoring
- offers a small amount of information,
- the mental load of the driver is expected to be medium,
- also sensory distraction of the driver is expected to have a medium level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be small (FÄRBER & FÄRBER, 1998).

3.6.5 Driver alertness monitoring - evaluation studies

Fatigue warning systems study, VINCENT, NOY & LAING (1998):

The purpose of the study of VINCENT, NOY & LAING "was to determine if behavioral adaptation occurs following exposure to the effects of a fatigue warning system (FWS). Drivers were asked to complete two overnight driving sessions (pretest and posttest), one week apart, with an instrumented vehicle on a closed track. Drivers were informed that they could pause anytime they felt the need for a break. A 15 minute break was imposed when drivers hit one of 35 cones placed at regular intervals along the track.

Thirty-two drivers were randomly allocated to one of two groups: a fatigue warning system (FWS) group and a control group. The FWS group was exposed to the fatigue system during the posttest. An observer activated a tone whenever drivers met specific fatigue criteria. Drivers in the control group did not receive any tones during completion of the drives.
Results indicate that breaks are not very effective in reducing objective and subjective fatigue. There is some preliminary evidence that behavioral adaptation to the FWS did occur. Subjective and objective fatigue levels, prior to a break, were higher for FWS drivers during the posttest. Break frequency and duration were unaffected by the presence of the FWS. Recognition of the impact of behavioral adaptation mitigating the effects of safety systems is only beginning to emerge. This study extends earlier work on behavioral adaptation to IST." (VINCENT, NOY & LAING, 1998).

Driver Fatigue and Alertness Study (DFAS), WYLIE et al (1996):

This study employed a between-subject design involving four driving schedule conditions. Measures were taken of 80 commercial motor vehicle drivers' physiology, alertness, and performance during driving and of their physiology during off-duty sleep. The database covers more than 200,000 miles of driving, 4,000 hours of video data and 9,000 hours of physiological recordings.
"The strongest and most consistent factor influencing driver fatigue and alertness in this study was time of day. Drowsiness, as observed in video recordings of driver's face, was markedly greater during night than during daytime driving. Peak drowsiness occurred during the 8 hours from late evening until dawn." (p.6). "Hours of driving (time-on-task) was not a strong or consistent predictor of observed fatigue. ... Lane tracking performance was better in the 10-hour than the 13-hour conditions. ... In the surrogate tests, cognitive performance (via Code Substitution) was better in the 10-hour conditions. Vigilance and reaction time (via Simple Response Vigilance Test) were better in the 13-hour conditions. ... Hand-eye coordination (via Critical Tracking Test) did not show condition-related variation. ... There was little correlation between Stanford Sleepiness Scale self-ratings and objective performance test scores. However, self-ratings of fatigue level on Stanford Sleepiness Scale correlated positively with time-on-task, indicating that driver may have the feeling of increasing fatigue with increasing time-on-task even if there are no strong performance changes." (p.7).
Large individual differences among drivers were found. For example, 36 % of the drivers were never judged drowsy in the video records, 49 % were judged drowsy 10 or fewer times, and 15 % were judged drowsy more than 10 times. In this last group the number of drowsy episodes ranged from 12 to 40, with an average of 22 episodes during their 4-5 day participation period (p.9). No significant relationships were found between driver age and fatigue (p.10).
The authors resume, that "there is no quick fix and no single solution to the fatigue problem. Sleep is the principle countermeasure to fatigue. All drivers need to ensure that they obtain adequate sleep. Drivers must also be afforded the opportunity to obtain adequate sleep." (U.S. Department of Transportation et al., ~1996).

Driver status / performance monitoring research, WIERWILLE et al. (1996):

WIERWILLE, LEWIN & FAIRBANKS (1996) developed different algorithms to detect driver drowsiness. But the revised algorithms, too, showed lower correlation between dependent drowsiness measures and independent performance-related measures than expected after specification. However, classification accuracy improved when a criterion of ‘drowsiness or performance’ was used, with performance assessed directly from a lane-related measure.

Evaluation of a drowsy driver detection system, RAU (1998):

RAU (1998) reports a NHTSA-program to develop drowsiness detection models and algorithms based on field data. The project has started in 1996 and is still in work.

3.7. Vision enhancement

3.7.1 General description

Manufacturers work on different technologies to improve lighting of the road. Examples are: automatic light distribution regulation, automatic dip of headlights (e.g. LIDAR sensors of Hella, see WÖRDENWEBER et al., 1996) UV lights, infra red lights with an infrared camera (BRAESS & REICHART, 1995b; BARHAM et al., 1995, BARHAM, 1997), light adaptation for different road geometry using digital road maps (see HAMBERGER et al. 1996 a, b).
All these attempts try to improve driver's sight under adverse weather and sight conditions.
A rain sensor which is situated on the inside of the windscreen can evaluate different weather conditions, like heavy rain or mist and regulate the speed at which the windscreen wipers operate (HB, 1995).

3.7.2 Vision enhancement - interaction concept

Systems are designed to work sensor-triggered after a principal activation by the driver.

3.7.3 Vision enhancement - technology

Two main approaches exist to enhance vision at night time or under bad weather conditions. The one (active VES) uses additional sensors, information sources like digital maps and special installations to concentrate the headlights on that part of the road ahead, which is of significant interest for the driver. In addition to that adaptation, intelligent in-car systems can adapt the light distribution depending on speed and steering angle.
The second (passive VES) uses non-visible sources of illumination of the road, which have a broader or deeper range ahead. Special sensors receive the reflected emissions and transform them into visible light. The additional image of the road ahead is then displayed to the driver.

VES (Honda, Toyota):
These active VES vary the headlight intensity and the distribution of the headlight beam in curves. Goal is quick obstacle detection (Honda), or the achievement a bright view of the lane ahead (Toyota).

Components:
Honda: A sensor system to measure steering angle, vehicle speed, position of the turn signal switch, information from the navigation system and actuators to move headlight reflectors.
Toyota: A system of millimetre wave radar emitter/sensors and CCD cameras, a series of additional sensors and actuators.

Principle of operation:
The principle of operation of Honda's system is not specified in detail. Toyota's system uses millimetre wave radar and CCD cameras to monitor the lanes ahead of the vehicle

for oncoming traffic or vehicles to be overtaken. The system then automatically adjusts headlight intensity not to blind other drivers. This system provides the driver with the brightest possible view of the road ahead. It also detects curves and adjusts the light distribution in the curve. (JEDA, 1996).

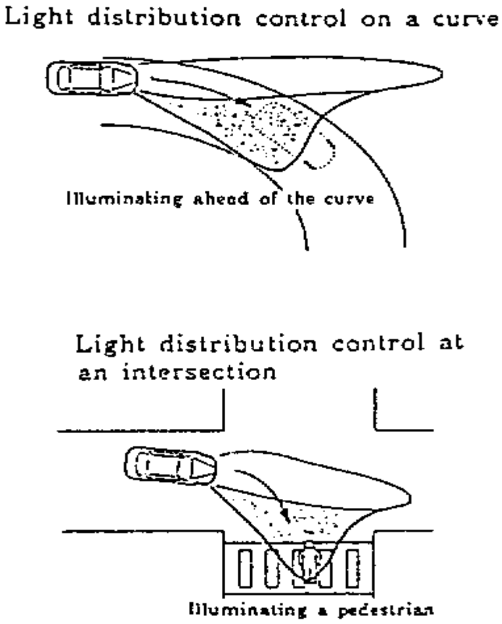

Fig. 13: Light distribution of Honda's active headlight (from: JEDA, 1996, p. 30).

VES (Jaguar):
This passive VES lights the road in front of the car with special infrared light sources and receives the reflected emissions with a camera. The image is transferred into visible light and projected via head-up display (HUD) device onto the windscreen of the vehicle, overlaying the normal view.

Components:
Two infrared headlamps, a CCD camera (monochrome, DSPCAM, Texas Instruments), and a HUD unit.

Principle of operation:
The system uses a monochrome CCD camera operating over a waveband of 400 to 1200 nm. Special infrared headlamps besides the conventional headlamps were used to illuminate the scene with infrared light with a main beam pattern. The energy from these head lamps is invisible for the human eye, but the sensor is able to form an image using this energy. The output of the camera is connected to a head-up display unit mounted in the dashboard. The HUD produces a collimated image to be projected into the windshield. The image is configured to overlay the driver's normal view of the road scene, 25 m in front of the driver. The additional image doesn't cover the whole windshield, but only a window in the central area of vision (see: AYALA, BARHAM & OXLEY, 1995; RUBAS, 1996).

3.7.4 Vision enhancement - expected effects

According to experts' evaluation the improvement of the outside vision
- offers a high amount of information,
- the mental load of the driver is expected to be low,
- also sensory distraction of the driver is expected to have a medium level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be positive (FÄRBER & FÄRBER, 1998).

Based on accident statistics WÖRDENWEBER, LACHMAYER & WITT (1996) expect that car illumination reduce one of the main risks of night accidents. The authors state that in 1993 49.6 % of fatalities occur at night rides, while the mileage during night-time is only 20 - 25%. Factors influencing night-time accidents are, beside sight conditions, drowsiness and alcohol. Fatal accidents occur mainly on rural roads and motorways. But, no exact prediction how sight improvement during night-time could affect traffic safety can be made (WÖRDENWEBER, LACHMAYER & WITT, 1996).

BRAESS & REICHART (1995b) come to a different evaluation They expect a gain of comfort by vision enhancement means for bad sight conditions (night-time and fog). The expected safety gain is comparable low due to higher speeds with these assistant systems.

LING SUEN & MITCHELL (1998) think that night vision enhancement will increase safety of elderly and disabled drivers.

3.7.5 Vision enhancement - evaluation studies

Survey on acceptance, GRIMMER, ADELT & STEPHAN (1995):

GRIMMER, ADELT & STEPHAN (1995) did a survey on acceptance of vision enhancement systems using scenario technique. 1,074 subjects took part in the investigation. The statement: 'if it would operate reliable, I find such a system very good' was answered by
- 44% - 'I fully agree',
- 35% - 'I partly agree'.

73 % of the persons have doubts about the technical reliability of the system. 70% were willing to test the system, 56% could imagine to adopt to it.

Near infrared night vision system, BARHAM, OXLEY & AYALA (1995):

A night vision system, developed by Jaguar, uses near infrared technology. To provide the driver with an enhanced image of the scene ahead in conditions of reduced visibility a head-up display is used. An experiment at the perimeter track of an airfield, using 30 drivers aged 65 or older, showed the following results: "... with the head-up display, dummies dressed to simulate pedestrians could be identified from a moving car at distances that were on average 50 metres greater then when the system was not in use. ...

In spite of the system's success in increasing volunteers' visual range at night, there were several people who experienced difficulty when using the head-up display." (BARHAM, OXLEY & AYALA, 1995, p. 26f).
On the Vision in Vehicles Conference in 1997 a demonstration of the further development to the image displayed and to the nature of the user interface with the system was announced by BARHAM. On this conference only standing pictures were shown, therefore there was no possibility to proof adequacy and performance of the system. Especially the goodness of fit of the two images is an important problem - the real driving scene outside the car and the synthetic scene generated by the infrared system must be congruent, otherwise there could be more negative influence on the driver's perception than the expected positive potential of the system.

Vision enhancement system in fog - simulator study, NILSSON & ALM (1996):

A study was conducted in the VTI driving simulator with 24 experienced drivers in a between-subject design with three visibility conditions: a clear sight condition with 480 m sight distance, a fog condition (50 m sight), and a fog plus vision enhancement system condition (50 m sight plus VES). The VES "generated" a copy of the simulator's video picture, in clear sight version, black and white, 17 x 12 cm in size, positioned directly on the bonnet of the car, in the drivers' central line of view, approximately 1.4 m in front of their eyes.
The mean speed levels were 61 km/h in the fog condition, 91 km/h in the fog plus VES condition, and 105 km/h in the normal sight condition. These differences are significant. Subjects drove closer to the centre line of the road in the fog condition, their variation in lateral position was smallest. Most variation in lateral position was found in the VES condition. This variation indicates, that drivers, who used VES "seem to have larger problems than the other drivers to keep a steady course." (NILSSON & ALM, 1996, p. 269). The control of lateral manoeuvres, looking at the monitor while overtaking a van, seems to be quite difficult, too. "Most drivers moved their eyes between the VES monitor and the real road." (p. 269).
When a red square appeared 400 m in front of the car, subjects should brake as fast as possible. Reaction time was 0,82 s in the normal sight condition and 1.07 s in the VES condition, reaction distance was 25 m and 28 m (not statistically significant). In the fog condition reaction time and distance, of course, were much longer (23.14 s, 385 m), because the subjects sight was only 50 m. Workload, measured by subjects' rating, only showed significant effects of visibility for the factors 'mental demand' and 'physical demand', but not for 'time pressure', 'performance' 'effort', and 'frustration level'. 'Mental demand', as well as 'physical demand' was rated highest for driving in fog, lower for VES supported driving in fog, and lowest for driving in clear sight.
The authors conclude, that "it seems both possible and acceptable to use a small representation of the traffic environment, in order to support drivers in poor visibility. Further studies are necessary concerning long-term effects, MMI aspects, and effects of varying driver strategies for information acquisition." (p. 270).

3.8 Pedestrian monitoring / Blind corner monitoring

3.8.1 General description

Especially Japanese manufacturers follow the idea, to detect pedestrians during night-time and to solve the blind corner problem. Research is purely technology driven, making no comments to user-centred information presentation. (JEDA, 1996).

3.8.2 Pedestrian / blind corner monitoring - interaction concept

The systems are activated on driver's request, then operating automatically.

3.8.3 Pedestrian / blind corner monitoring - technology

Pedestrian monitoring systems (PMS):

Pedestrian monitoring systems are designed to detect pedestrians (or simple obstacles) close to the vehicle or in the path of it. The different developers use different sensor techniques, and different scan areas to look for obstacles or pedestrians.

PMS (Nissan):
This system detects pedestrians in front of the vehicle and shows the direction of the pedestrian.

Components:
A infrared sensor, (a feature detecting unit,) and a display.

Principle of operation:
The front scene of the vehicle is observed with a sensor for sources of infrared rays. The viewing angle and the detection range of the sensor are not specified. The rough direction of pedestrians is displayed at the top part of the instrument panel. It is not specified whether there is a processing unit to extract relevant information to display or if the display shows all sources of infrared signals leaving it to the drivers responsibility to perform the extraction (JEDA, 1996).

Blind corner monitoring system (BCMS):

Blind corner monitoring systems are designed to inform and/or warn the driver whenever an obstacle enters the predicted path of the vehicle outside the driver's direct visual field. Different developers use different definitions of ‚blind corner'. Therefore different solutions for operation principles, sensor type, position and displays exist.

BCMS (Toyota):
This system is designed to provide the driver with a look to the left and right into streets at intersections. Additionally the system provides a rear view.

Components:
Two CCD cameras mounted on either side of the front bumper, and a dash-mounted display, two CCD cameras for the rear view projecting their output on the windshield and the back glass.

Principle of operation:
The two front cameras display their view to the left and to the right in a display on the dashboard. Whether the driver has to switch the image from left to right, or if the both views are displayed side by side, isn't explained.
The output of the camera on the left front is projected onto the windshield. The output of the rear camera is projected onto the back glass. (JEDA, 1996).

BCMS (Mazda, Mitsubishi):
This system is designed to provide the driver with a rear view like the view to the left, middle, and right rear view mirrors.

Components:
Three CCD cameras mounted on the left and right front door, one camera on the top of the rear lift gate, and three LCD displays in the upper area of the instrument panel.

Principle of operation:
The three cameras substitute the three conventional rear view mirrors. The three displays in the upper area of the instrument panel show the camera's view so that the driver can check both sides and the rear of the car with minimum eye movements (JEDA, 1996).

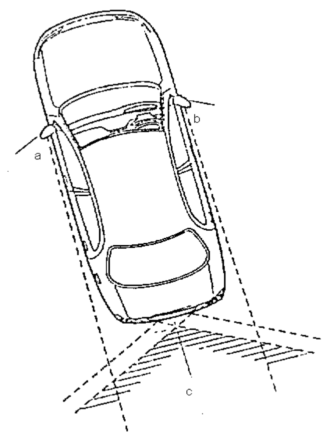

Fig. 14: Top view of Mazda's BMC vehicle; a) left, b) right, c) rear camera.

BCMS (Mitsubishi):
This system is designed to monitor the lanes aside and behind the car, to warn the driver if he attempts to change lanes without checking.

Components:
A side-rear stereo camera, a side-passive beam sensor (front), a side passive beam sensor (rear), a rear stereo camera, a vehicle speed sensor, a steering angle sensor, a yaw velocity sensor, and a turn signal switch, a processing unit, and a not specified warning display.

Principle of operation:
The system calculates target distances from the sensor and video signals. The principle of pattern recognition or feature extraction is not explained. The system is designed to warn the driver about vehicles approaching from the rear, and it warns the approaching vehicle simultaneously by projecting a warning message. It informs the driver about the distance of the two vehicles, if he attempts to change lanes. The form of the warning information and the type of display is not explained (JEDA, 1996).

BCMS:
This system detects moving obstacles in the blind corners of stationary vehicles.

Components:
A Doppler microwave radar sensor, a display unit.

Principle of operation:
The system uses Doppler microwave radar to detect moving objects directly in front or to the right of the vehicle. The system supplements regular school bus or vehicle mirrors. It operates only while the vehicle is stationary. The precise principle of operation, the extraction of significant signals from noise, and the form the moving objects displayed are not specified (JOHNSTON, MAZZAE & GARROTT, 1996).

3.8.4 Pedestrian / blind corner monitoring - expected effects

According to experts' evaluation pedestrian monitoring or blind corner monitoring
- offers a high amount of information,
- the mental load of the driver is expected to be medium,
- also sensory distraction of the driver is expected to be high and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

3.8.5 Pedestrian / blind corner monitoring - evaluation studies

Pedestrian detection system, JOHNSTON, MAZZAE & GARROTT (1996):

The authors developed two systems to detect moving pedestrians either directly in front of or to the right of the bus. System A turned off as soon as the bus moved 6 - 12 inches. The display showed an icon of the school bus, turned straight forward.
System B turned off when the door was closed and no moving objects were present in the area of coverage. The display also showed an icon, but the front of the bus was looking to the right.
The systems were installed at two school buses which were operated on eight consecutive days for a total of 16 runs with different drivers, eight with each system.
The sensors of both systems operated reliable. There were no false alarms generated during laboratory testing, but during the operational testing there was one case with system A, in which the system failed to detect children, one false alarm and several false alarms with system B.
Seven out of eight drivers reported using system A to make a decision about whether or not to start the bus, and in the other test condition six out of eight drivers preferred system B. Information from the system was considered in 90 % (A) or 74 % (B) of situations. Drivers reported using their mirrors somewhat more often than before. The visual warnings seemed to be neither distracting nor annoying. The auditory warning for system A was rated to be acceptable, but not so for system B. "Drivers responded favourably when questioned about the utility and potential safety of pedestrian detection systems." (p. 9). The presence of the systems did increase the associated level of safety.

Drivers answered to turn on always system A, if available, and most of the time system B.
The authors conclude, that over all systems do a good job of informing the driver as to when there is a moving object in front or along the right side of the bus (JOHNSTON, MAZZAE & GARROTT, 1996).

3.9 Route information systems

3.9.1 General description

Information concerning the route shall assist the driver. This information is directly transferred to the vehicle from a central or distributed information centre. Typical examples are: traffic information, info concerning route and road conditions, free parking slots or service stations. The main question for this kind of information is, how it is requested by and displayed to the driver. If this is done not too often and user-friendly, not overloading a sensory channel needed for observation of traffic scenes, the additional information can improve safety. Traffic safety can also be improved, when these systems help to transfer traffic to other transportation means. Under the keyword intermodality many attempts are discussed to ease the change from one transportation system (car) to others (public transport) to reduce for example traffic density. Reduction of motor traffic reduces the probability of accidents.

Data transfer into the vehicle disregarding specific description of the information transferred is published by the following manufacturers: ARDIS (MELE, 1993), DeTeMobil (KREMER & MERTENS, 1995; MERTENS, 1996), Grundig (AI, 1996 b), IBM, Intel, Microsoft (SZ, 1998) and authors like KELLER (1995), PLOSS & TSCHOCHNER (1997).

Traffic regulation is analysed by ANDRESEN et al. (1993), traffic flow cover publications by ANGERMÜLLER et al. (1996), CHASSANG et al. (1996), FAU (1994), GERNER (1996), IV (1997g), KRAUSE (1996), SCHLICHTER & REICHART (1998), SCHMIDT R. (1996), THOMAS (1995), for route information see: EMMIS (1994), IV (1997g), traffic management systems: BOLTZE et al. (1997), parking management: CHEVREUIL (1994), IV (1997a), KONHÄUSER (1996), KROSTITZ & KÖTHNER (1993), KRUX (1998), service stations: FKT (1995), meteorological data: WEYD (1994), information connecting private and public transport: HELLÅKER et al. (1993), hazardous goods transport: ISERMANN & MÜLLER-KÄSTNER (1996).

Of course data transfer is also possible and useful from cars on the road to an information centre, for example concerning road conditions (WINTERHAGEN, 1995).

3.9.2 Route information systems - interaction concept

After principal switch on by the user the system can be activated automatically or on driver’s request.

3.9.3 Route information systems - technology

Several technical standards have developed until now for the transfer of information between cars and information centres. On first sight the kind of data transfer has little to do with the driver-vehicle interaction and thus with traffic safety. But, the technology of data transfer, the service providers and the devices in the car define the kind of information that will be transferred. For example, GSM technology is currently closely linked to mobile phones and the services offered by telecommunication providers.

RTS/TMC:
Digital radio receiver working in the VHF band using the radio data package protocol / traffic message channel. Relevant traffic information is transmitted to the vehicles travelling in the region where the transmitting station is located. This information is displayed to the driver via a visual display and/or voice output. If the vehicle is equipped with a navigation or positioning system, the messages could be filtered according to the actual position and destination of the trip.

GSM:
Mobile network (cellular) telephone functions allow the transmission of data parallel to voice messages or instead of them. The system is able to transfer packed data up to 9.6 kb/s. Short message service (SMS) with messages of sizes less than 160 characters can be transferred in both directions, point to point, parallel to speech connection. In SMS point to multipoint = cell broadcast mode, packets of information within the speech data can be transmitted with 400 bits/s to all mobile units within a cell.

Pager:
Operating at the same band with identical transfer rates as GSM, a pager is only able to receive messages and display them (visually) to the driver in form of short text strings.

IR beacons and other roadside information devices:
These systems are capable to transmit relevant information to the vehicle and the driver. If the transmitted information is static, systems are comparable to conventional road signs. But, given the appropriate infrastructure, they are able to transmit information which changes with varying traffic, roads, or travel conditions. Their data could be transmitted to the driver in a direct way - through the visual channel - or indirect via different receiving devices in the car. These devices transform and store the information. They can display the message on demand or operate automatically. The vehicle itself can transmit data, concerning relevant parameters of the ride of general interest (i.e. speed driven) via these installations to traffic management centres.

GPS:
The satellite based global positioning system provides only data concerning the position parameters of a set of satellites. These data are extremely useful to calculate the actual position of a vehicle. Traffic, road, or travel information cannot be obtained from these signals.

3.9.4 Route information systems - expected effects

Concerning route information systems, we can report expected effects on
- information, automatically displayed to the driver and
- information, demanded by the driver.

According to experts' evaluation information, automatically displayed to the driver
- offers a high amount of information,
- the mental load of the driver is expected to be high,
- as well as sensory distraction.

- The impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be small (FÄRBER & FÄRBER, 1998).

The same kind of information, on active demand of the driver, is rated to be better in two aspects:
- the information content is high,
- the mental load of the driver is expected to be medium,
- sensory distraction of the driver is expected to reach a high level and
- the impact on traffic safety, seen in a situational context and taking into account the traffic safety of all traffic participants, is expected to be medium (FÄRBER & FÄRBER, 1998).

ANGERMÜLLER et al. (1996) report the results of a market study showing high importance (4.5 on a scale from 0 to 5) for traffic information from a user's point of view. As especially important information concerning traffic jams, detour recommendations and free roads are treated. Of minor importance speed, duration and prediction of tailbacks was named by the subjects. General information services reached only a value of 2.25 in this study (ANGERMÜLLER, TILGNER, GABLER & REISCH (1996).

3.9.5 Route information systems - evaluation studies

A report of KRAUSE (1996) concerns the introduction of the warn- and information-system COMPANION in the north of Munich. On a highway section with high accident rates drivers are warned by blinking posts, to indicate tailbacks, accidents etc. By means of the scenario 'puncture of a truck on the hard shoulder', slower speeds were observed for the condition 'blinking posts'. The mean speed reduction was of 25 - 30 km/h, at a speed platform of 130 - 150 km/h. The amount of critical time-lags on the overtaking lane went down from 27 % to 15 % (SCHLICHTER & REICHART, 1998).

HELLÅKER et al. (1993) describe that PROMISE, a system where data processing equipment of transport operators and value added service providers operate seamlessly with telecom infrastructures and end user terminals, is implemented in Gothenburg, Sweden. The services that are planned to be available are: parking occupation overview, parking availability, parking reservation, parking event information, road traffic information, weather situation, weather outlook and some data for public transport (HELLÅKER, PALMGREN & TURUNEN, 1993).

GERNER (1996) reports on a planned field test in Nordrhein-Westfalen, Germany. The aim of the study is to gather Floating Car Data (FCD), to measure traffic flow of each driver for other drivers. Each vehicle equipped swims like a cork in the traffic stream. Many of these Floating cars should give an actual and realistic image of current traffic conditions. Under the acronym VERDI it is performed with about 1000 cars under realistic conditions (WWW, 1998e; LARIMA, 1997). No results are currently available.

KRUX (1998) speaks about a planned experiment in real traffic with an information system, called ‘Cologne Parkinfo’. “Aim of the project is to transmit information into the vehicle. In a first step it is planned to transmit the number of free parking facilities and the trend of occupancy of each multi-storey car park into individual routing guidance systems of the vehicles and to guarantee the guidance to the free parking facilities. Additional a concept for the reservation of free parking facility will be developed and tested.” (KRUX, 1998, p. 60f).

4 Evaluation in the framework of an ideal research and development (R&D) process

The development, evaluation and introduction of active safety devices should follow a defined schedule, here called ideal R&D (research and development) process. An analysis of this ideal process can give valuable insights in the current status and deficits of evaluation studies. The process of research, development, evaluation and implementation should comprise 5 steps:

1. Identification of deficits and problems of drivers
2. Definition of underlying reasons for this behaviour
3. Design of the system
4. Test and evaluation
5. Production and marketing

4.1 Identification of deficits and problems

The starting point for the decision whether an active safety device may be helpful or not, is the identification of traffic safety problems or behavioural deficits of drivers. Hints for these deficits or problems can be obtained mainly from three sources:

- Accident rates,
- critical behaviour,
- unwanted behaviour.

What can we learn from accident analysis?
Accident rates analysing data about frequency and severity of accidents, related to specific groups of drivers or cars, give clear hints where the increase of traffic safety is valuable. But, as will be shown, even the data are very reliable (due to the great number of cases analysed), their validity remains a problem.
An extract of the German road accidents statistics (1996) will demonstrate the difficulties: In 19.8% speed was not appropriate, which means it was too high. 11.5% of all accidents of cars / busses / trucks are caused by too small safety distances. Only 0.5% of the accidents go ahead with overstrain. In 14% the 'give right' rule was misjudged. Finally, in about 5% drivers showed wrong behaviour towards pedestrians.

Which conclusions could be drawn?
First, speed and distance keeping is the major causation for accidents. Hence, assistant systems for speed and distance keeping would influence traffic safety in a significant manner. Second, from a statistical point of view drowsy drivers are no severe problem for traffic safety (0.5% of accidents are explained by drowsiness). Nevertheless, driver monitoring systems are under research and development all over the world (see chap. 3.6).
The very precise calculation based on accidents has one weak point: Accident analysis doesn't say much about the underlying reasons for the accidents. According to FELL (cited after GIES, 1991), traffic accidents are caused in 46 % by perception errors, in 40 % by decision errors and only in 9% by performance errors. That means, accidents can have many sources and therefore different countermeasures.

First consequences from these two examples are:
First, as the example 'drowsy drivers' shows, development of active safety devices is - at least partly - independent from accident frequency.
Second, accident analysis gives only hints where the development of active safety devices is useful from a statistical point of view. It doesn't say much about the underlying reasons for accidents.

Observation of critical behaviour:
Accident analysis has another weakness, namely that accidents are (fortunately) rare events. To cope this problem, the observation of critical incidents (ZIMOLONG et al. 1977) is used as database for the identification of risky situations. These data about traffic conflicts widen the insight into accidents, because they take into account actions of drivers also in the pre-crash phase.

Unwanted behaviour:
Unwanted behaviour may result in critical behaviour, but must not. For example a drowsy driver can come into a critical situation where immediate reaction is necessary and fail because of his prolonged reaction time. The data about unwanted / illegal behaviour stem partly from accident analysis, partly from investigations of the police. For example the proportion of drivers with alcohol is obtained testing all drivers' blood alcohol concentration during night-time in a defined area.

4.2 Definition of underlying reasons

The definition of the underlying reasons for a specific behaviour is the crucial point for design, evaluation as well as for marketing of a driver assistance system. Coming back to the above mentioned examples this can be made more clear.

Many reasons can be responsible for the acceptance of too short distances or too high speeds. It could be a problem of perception, motivation or action. If short headways are caused by perception deficits, better feedback would be the appropriate solution. If they are caused by motivation deficits, technical means must reinforce the driver when he holds greater distances to a leading car, or legal regulations must enforce longer headways. If the problem occurs because of action deficits, the active safety device should assist the driver on the handling / control level (see RASMUSSEN, 1986).
The same consideration can be applied for the example 'drowsiness'. One question is of course, how many drowsy drivers are on the road and involved in an accident. The major question for the development of countermeasures is: Why do they behave in such a way? Don't they realise to be drowsy, or do they, and only want to reach their destination taking into account a calculated risk? Again, the answering of these kinds of questions is of central importance for the layout and test of the driver assistance system.

4.3 Design of the system

The design and construction phase of the system is first of all up to technicians who guarantee high technical reliability under all working conditions.
Integral part of the design phase must be the question of user deficits and needs, i.e. the behavioural level, where the assistance system should help the driver. Another item which separates effective from ineffective solutions is the man-machine-interface (MMI). A principally good system can lose its effectiveness with a bad MMI. Bad MMI solutions can on one hand influence traffic safety directly by distracting the driver. A typical example is a navigation system with the display of a road map. Reading times are doubtless too long for using while driving. Not perfect MMI solutions can indirectly influence safety by annoying the driver or making him a fool.
For example the voice output: 'Please let off your handbrake.' is not accepted by users, because it disgraces them. The minor change: 'Please check your handbrake.' lets the problem of disgrace disappear.

4.4 Test and evaluation

Test procedures must of course cover technical reliability under varying conditions. Parallel to the technical evaluation behavioural evaluation is necessary. For many existing In-vehicle safety systems evaluation studies have been performed (see chap. 3). But, are they sufficient, exhaustive or at least adequate? To our opinion evaluation studies are only valuable, when they cope with the following questions:

- What behavioural aspects are touched by the assistant system and which parts of it are evaluated by the study. For example, distance keeping is a problem of perception and motivation. Thus, ACC evaluations have to be done not only under the ideal conditions of an experiment, where subjects behave co-operative, but also under 'realistic' conditions like time-pressure etc.
- The second aspect, closely linked to the selection of the appropriate behavioural cluster, is the definition of relevant test-items. This statement sounds trivial to a researcher, but, as studies in the past demonstrate, it is by no means. For example, many experiments have been done to decide, whether analogue or digital speedometers are better. Mostly the task of the subjects was, to read a speed from the speedometer and tell it to the experimenter. The answering times for digital speedometers were always faster than for analogue ones. This is a trivial result, because it is of course faster to read a number (for example 52 km/h) and to pronounce it, compared to the task of transforming a pointer into a number and then pronounce it. If one changes the subject's task slightly, asking: 'Are you driving within the permitted speed limit?', and he is again driving around 50 km/h, results change and favour the analogue instrument.
- Behaviour of drivers cannot be seen as isolated phenomenon. Traffic and traffic safety is a highly interactive matter. Evaluation studies must therefore the interaction aspect into account.
- What concrete MMI-solution and technology is used in the system analysed? In chapter 3 several examples for different technologies, having different capabilities and advantages / disadvantages are described. Many of them use the same name, for example ACC, but they are by no means the same. It is important for evaluation studies to hold technology and MMI aspects constant or to vary them systematically.

- Finally, a crucial point for evaluation are long-term effects. Behaviour adaptation to new technological systems can have positive or negative effects. For example, glance frequencies to route guidance displays are reduced as a function of experience (FÄRBER, 1995). On the other hand longer use of ACC- or vision enhancement systems can lead to unjustified expectancies and influence traffic safety negatively in the long run.

4.5 Production and marketing

Why marketing is an important factor within an ideal R&D process? The main problem of marketing is to excite attention of potential customers on the one hand and not to provoke unrealistic expectations. An old, but still interesting example is the introduction of ABS. ABS was first introduced as a system to reduce braking distances. This is partly true within the limits of physics. The main advantage of ABS is the maintenance of manoeuvrability while braking on surfaces with μ-split. As a consequence of the marketing strategy: 'ABS reduces braking distances.' - wrong expectations were evoked at the customers and accidents were caused.
Good and realistic experimental evaluation studies should therefore instruct subjects in a way similar to the marketing strategy. Doing this, expectations about the system and behaviour will be as realistic as possible.

4.6 Final conclusion

If one accepts the description of the ideal R&D process as guideline for the development and evaluation of In-vehicle safety devices, and compares it to the evaluation studies in chapter 3 a discrepancy is obvious. What is urgently needed is a clear framework for the existing In-vehicle safety devices, and devices planned for the future with respect to the correct evaluation procedures.

5. References

AC-ASSIST (~1997): Anti-Collision Autonomous Support and Safety Intervention System. In: http: // www. trentel.org./transport/research/projects/ac-assist.html.

Adam Opel AG, Audi AG, BMW AG, Daimler Benz AG, Ford-Werke AG, Dr. Ing. H.c. F. Porsche AG, Volkswagen AG (Hrsg.) (1995): Verkehrsmanagement - Eine Bestandsaufnahme. München.

AI (1996a): Fahrzeug denkt mit. In: Automobil Industrie, 5, 1996, S. 76.

AI (1996b): Höhere Mächte. In: Automobil Industrie, 5, 1996, S. 80.

Allenbach Roland & Müller Walter (1998): Das Unfallgeschehen im Jahr 2010. In: Zeitschrift für Verkehrssicherheit, 44, 1998, 2, S. 60 - 66.

Ammermann Ursula (Hrsg.) (1992): Kooperatives Verkehrsmanagement - High-Tech-Träume oder echte Chance für den Stadtverkehr? Münchner Forum, Berichte und Protokolle Nr. 108. München.

Anders P. & Petzold B. (1996): Konkurrenz der Serviceanbieter. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 397 - 404. Düsseldorf: VDI-Verlag.

Andresen Steinar, Andersen Bente G. & Svidén Ove (1993): An intelligent co-pilot, RTI as value added services to GMS. In: Proceedings of the IEEE-IEE, Vehicle Navigation and Information Systems Conference. Ottawa Ontario, pp. 41 - 44.

Angermüller H., Tilgner R., Gabler D. & Reisch M. (1996): Ein multifunktionales Verkehrstelematik-Produkt des Mannesmann-Konzerns - Neue Fahrerinformation und Dienstleistung. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 457 - 473. Düsseldorf: VDI-Verlag.

Anner Rudolf (1990): Telematik und Güterverkehr. In: Straße und Verkehr, 76, 1990, Nr. 6, S. 321 - 325.

Appel H. & Granzeier W. (1993): Automobilkonzepte für den Individualverkehr von morgen - Einführungsbedingungen für Stadtwagen. In: Automobiltechnische Zeitschrift. 95, 1993, 1, S. 8 - 16.

Aschenbrenner K., Biehl B. & Wurm G.: Felduntersuchung zur Risikokompensation am Beispiel des ABS. Forschungsbericht BASt, FP 8323.

Ashby M.C. & Parkes A.M. (1993): Interface design for navigation and guidance. In: Parkes A.M. & Franzen S. (Eds.): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

ATZ (1990): Ultraschall-Parkhilfe. In: ATZ Automobiltechnische Zeitschrift, Nr. 92, 1990, 2, S. 89.

ATZ (1993c): Mitsubishi entwickelt Automobil-Steuerung mit Fuzzy-Logic. In: ATZ Automobiltechnische Zeitschrift, 95, 1993, 2, S. 54.

ATZ (1993d): Fahrersitz für Nutzfahrzeuge. In: ATZ Automobiltechnische Zeitschrift, 95, 1993, 5, S. 228.

ATZ (1995): Navigationssystem für vorhandene Displays. Satellitennaviagtion. In: ATZ Automobiltechnische Zeitschrift, 97, 1995, 3.

ATZ (1996): Ultraschall-Abstandssensoren für den Fahrzeugeinsatz. In: ATZ Automobiltechnische Zeitschrift, 98, 1996, 6, S. 327.

Ayala B., Barham P. & Oxley P. (1995): Advanced transport telematics (ATT) and elderly drivers: benefits and safety implications. In: Nwagboso C.O. (1995): Road Vehicle Automation II. Toward Systems Integration. Proceedings of the 2nd Internation Conference on Road Vehicle Automation. 11th - 13th Sept. 1995. Chichester etc.: John Wiley & Sons.

Azuma Shigetoshi, Nishida Kunio & Hori Shinichi (1994): The future of in-vehicle navigation systems. In: VNIS'94, Vehicle Navigation & Information Systems Conference Proceedings. Yokohama, Japan, pp. 537 - 542.

Baedeker C. & Wolf W. (1987): Influence of saccades on manual reactions - a reaction time and VEP study. In: Vision Research, Vol. 27, No. 4, pp. 609 - 619, 1987.

Barham Philip (1997): Jaguar cars‘ near infrared night vision system - results of further research. In: Vision in Vehicles 7, Programme & Abstracts, p. 10, 14 - 17 Sept. 1997, World Trade Centre Marseilles, France.

Barham P., Oxley P. & Ayala B. (1995): Evaluation of the human factors implications of Jaguar’s first prototype near infrared night vision system. In: Vision in Vehicles 6, Programme & Abstracts, p. 26 f., 13 - 16 Sept. 1995, University of Derby, UK.

Baum Herbert (1996): Ökonomische Bewertung der Verkehrstelematik. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 139 -154. Heidelberg: Von Decker-Verlag.

Beißner U. (1997): Informationssysteme im ÖPV. In: Internationales Verkehrswesen, (49), 1 - 2, 1997, S. 57 - 58.

Benedyk R. & Minister S. (1998): Applying the BeSafe method to product safety evaluation. In: Applied Ergonomics, Vol. 29, No. 1, 1998, pp. 5 - 13.

Berger Roland (1996): Lokale Kommunikation mit Baken. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 69 - 76. Heidelberg: Von Decker-Verlag.

Bernotat R. (1970): Operation function in vehicle control. Anthropotechnik in der Fahrzeugführung. Ergonomics, 13, pp. 353 - 377.

Bitterberg U. (1997): Ohne „Cargo Rail Net“ kein „Cargo Net(zwerk)“?. In: Internationales Verkehrswesen, (49), 11, 1997, S. 574 - 575.

Boltze M., Kienzler K., Ludwig R. & Stöveken P. (1997): Leit - Informationssysteme für den Verkehr in Hessen. In: Straßenverkehrstechnik, 10, 1997, S. 475 - 479.

Bony Bruno & Rengnet Jacques (1994): L’ évolution de l’ information routière. In: Revue générale des routes, No. 721, Sept. 1996, p. 35 - 36.

Braess H.-H. (1993): „Nichts steigt so schnell wie Ansprüche“ - Gedanken zur weiteren Entwicklung des Personenwagens. In: Automobiltechnische Zeitschrift, 95, 1993, 9, S. 452 - 458.

Braess Hans-Hermann & Reichart Günter (1995a): Prometheus: Vision des „intelligenten Automobils“ auf „intelligenter Straße“? - Versuch einer kritischen Würdigung - Teil 1. In: ATZ Automobiltechnische Zeitschrift, 97, 1995, 4, S. 200 - 205.

Braess Hans-Hermann & Reichart Günter (1995b): Prometheus: Vision des „intelligenten Automobils“ auf „intelligenter Straße“? - Versuch einer kritischen Würdigung - Teil 2. In: ATZ Automobiltechnische Zeitschrift, 97, 1995, 6, S. 330 -343.

Brauckmann M., Schwarzinger M., Zielke T. & Von Seelen W. (1995): Hinderniserkennung mit Computer Vision. In: Nagel H.-H. (Hrsg.): Sichtsystemgestützte Fahrzeugführung und Fahrer-Fahrzeug-Wechselwirkung, Band 2. S. 844 - 891. Sankt Augustin: Infix.

Brunnhuber G. (1997): Verkehrstelematik - wie geht es weiter? In: Internationales Verkehrswesen, 3, 1997, S. 96 - 97.

Bubb H. (1985): Arbeitsplatz Fahrer - eine ergonomische Studie. Automobil-Industrie, 3, S. 265 - 275.

Bubb H. & Schmidtke H. (1981): Analyse der Systemstruktur. In: Schmidtke, H. (Hrsg.): Lehrbuch der Ergonomie, München: Hanser. S. 263 - 285.

Burdeau Michel (1994): Les routes intelligentes seront-elles européennes? In: Revue générale des routes, No. 721, Sept. 1996, p. 18 - 19.

Burgener E. C. (1993): A personal transit arrival time receiver. In: Proceedings of the IEEE - IEE, Vehicle Navigation and Informations Systems Conference. Ottawa, Ontario. pp. 54 - 55.

Buchholz Joachim (1996): Erfassung der verkehrlichen Infrastruktur. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 93 - 103. Heidelberg: Von Decker-Verlag.

Bundesministerium für Verkehr - StB (Hrsg.) (1994a): Informationen zum Versuchsfeld A555, Autobahntechnologien. Mit Telematik zu einer Autobahn der Zukunft. BMV-StB 13, Autobahn-Tech. Nr. 1/94

Bundesministerium für Verkehr - StB (Hrsg.) (1994b): Informationen zum Versuchsfeld A555, Autobahntechnologien. Teilnehmende Firmen und ihre Systeme. BMV-StB 13, Autobahn-Tech. Nr. 2/94

Bundesministerium für Verkehr - StV (1996): Vereinbarung zu Leitlinien für die Gestaltung und Installation von Informations- und Kommunikationssystemen in Kraftfahrzeugen. Entwurf vom 22.10.1996. Bonn.

Camus Jean-Pierre (1994): La télématique appliquée aux transports routières - une approche comparée des Etats-Unis, du Japon et de l' Europe. In: Revue générale des routes, No. 721, Sept. 1996, p. 20 - 22.

Camus J.-P. (1997): L'interopérabilité des systèmes de télépéage en Europe. In: Revue générale des routes, No. 751, Mai 1997, p. 21 - 25.

Canzler Weert (1993): Das Auto von morgen: Haben alternative Konzepte eine Chance? In: Wechselwirkung, Nr. 63, Okt. 1993.

Cat Michel (1994): Trafic info, un nouveau panneau à message variable. In: Revue générale des routes, No. 721, Sept. 1996, p. 51 - 54.

Catling Ian & Keller Hartmut (1996): Munich COMFORT in TABASCO - Cooperative Management for urban and regional transport. München.

Chaloupka C., Risser R., Antoniades A., Lehner U. & Praschl M. (1998): Auswirkungen neuer Technologien in Fahrzeug auf das Fahrverhalten. Berichte der Bundesanstalt für Straßenwesen, Mensch und Sicherheit, Heft M 84. Bergisch Gladbach: Wirtschaftsverlag NW.

Chassang Robert, Pagny Roger & Sarignac Alain (1996): Les systèmes d'information routinière embarquée. In: Revue générale des routes, No. 746, Déc. 1996, p. 80 - 81.

Chevreuil Martial (1994): L' information routière: une évolution vers la gestion coopérative du trafic. In: Revue générale des routes, No. 721, Sept. 1996, p. 31 - 34.

Chuan H. J., Liang C. W., Kuang-Horng S. & Edge-Chu Y. (1998): Cooperative copilot with active steering assistance for vehicle lane keeping. In: International Journal of Vehicle Design, 19, 1, pp. 87 - 107.

Churan J. & Derkum H. (1997): Wahrnehmung von Verkehrszeichen. In: Straßenverkehrstechnik, 2, 1997, S. 90 - 91.

Clarke Nigel (~1997): AC-ASSIST - (Antikollisions-, autonomes Hilfs- und Sicherheits-, Interventionssystem, ausgearbeitet im Rahmen der Telematics Applications Programme. Paper.

Code of Practice, siehe: Statement of Principles (1998).

Collard D. (1998): Anti-lock brakes and single-vehicle collisions. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-O-09.

Cremer M. & Reimers S. (1998): Ein gekoppelter Simulator für ÖPNV und Individualverkehr zur on-line Prädiktion von Reisezeiten in Großstädten. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 201 - 215. Düsseldorf: VDI-Verlag.

Dahmen-Zimmer K. & Zimmer A. (1997): Situationsbezogene Sicherheitskenngrößen im Straßenverkehr. Berichte der Bundesanstalt für Straßenwesen, Mensch und Sicherheit, Heft M 78. Bergisch Gladbach.

Daimon Tatsuru, Masuno Tomoki & Kawashima Hironao (1994): Drivers's characteristics and peripheral vehicles displaying system. In: Vehicle Navigation & Information Systems Conference Proceedings. Yokohama, Japan, pp. 39 - 44.

Daviet Bruno (1994): La neutralisation automatique de voie (NAV). In: Revue générale des routes, No. 721, Sept. 1996, p. 48 - 50.

Deutscher Bundestag, Pressezentrum (Hrsg.) (1996a): Verkehr: SPD: Auch Telematik wirkt keine Wunder. In: Deutscher Bundestag - WIB, Heft 6, 20.3.96, zit. nach http://www.bundestag.de. wib96.htm/

Deutscher Bundestag, Pressezentrum (Hrsg.) (1996b): Verkehr: Union: Mit Hilfe der Telematik Individualverkehr beschleunigen. In: Deutscher Bundestag - WIB, Heft 19, 13.11.96, zit. nach http://www. bundestag.de.wib96.htm/

Deutscher Bundestag, Pressezentrum (Hrsg.) (1997): Verkehr: Bedeutung der Telematik umstritten. In: Deutscher Bundestag - WIB, Heft 6, 26.3.97, zit. nach http://www.bundestag.de.wib97.htm/

DFAS (~1996): see: U.S. Department of Transportation.

Dicke Bernhard (1996): Die Informationsgesellschaft macht mobil. In: Internationales Verkehrswesen, Special „Verkehrs-Telematik“, 48, 1996, Nr.3, S. 16 - 18.

Dickmanns E.D. & Wünsche H.-J. (in press): Dynamic vision for perception and control of motion. In: Jähne B.: Computer vision and applications. New York: Academic Press.

Dingus T.A., Hulse M.C., Mollenhauer M.A., Fleischman R.N., McGehee D.V. & Manakkal N. (1997a): Effects of age, system experience, and navigation technique on driving with an advanced traveler information system. In: Human Factors, 1997, 39 (2), pp. 177 - 199.

Dingus T.A., McGehee D.V., Manakkal N., Jahns S.K. Carne C. & Hankey J.M. (1997b): Human factors field evaluation of automotive headway maintenance / collision warning devices. In: Human Factors, 1997, 39 (2), pp. 216 - 229.

Dooling D. (1996): Transportation. In: IEEE Spectrum, January 1996, pp. 82 - 86.

Dorißen H.T. & Höver N. (1996): Autonome Intelligente Geschwindigkeitsregelung (AICC) - Ein Beitrag zur Steigerung des Komforts und der aktiven Fahrsicherheit. In: ATZ Automobiltechnische Zeitschrift, 98, 1996, Nr. 7/8, S. 396 - 405.

Duncan C.I. & Auzins J. (1996): Electronics integration and architecture for cost savings and increased functionality. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, 12./13.9.1996. Electronic systems for vehicles / VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, pp. 733 -753. Düsseldorf: VDI-Verlag.

Durand-Raucher Yves (1994): L’ information, un outil de changement des comportements. In: Revue générale des routes, No. 721, Sept. 1996, p. 37 - 39.

Durand-Raucher Yves (1996): Sirius - Prototype des systèmes de gestion de trafic et d’ information aux usagers. In: Revue générale des routes, No. 746, Déc. 1996, p. 75.

Ehlers K. (1996): Forum „Bordnetzarchitektur“ - seine Motivation und seine Ziele. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 203 - 218. Düsseldorf: VDI-Verlag.

Ehrenstein W. & Müller-Limmroth W. (1984): Physiologische Grundlagen der Anforderungen im Straßenverkehr. In: Wagner H.-J. (Hrsg.): Verkehrsmedizin, S. 71 - 86. Berlin: Springer.

Elke D. (1996): Vernetzungskonzept für Mobile-Media-Anwendungen im Kfz. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 351 - 371. Düsseldorf: VDI-Verlag.

EMMIS - Evaluation of Man-Machine Interface by Simulation Techniques DRIVE II PROJECT V 2006 (1994): Device standards and extension of regulations for ATT input and dialogue devices. Authors: Bubb P., De Angeli A., Ferrante A., Gerbino W., Haller R., Jacomussi P., Toffetti A. & Varalda G.

Enkelmann W., Blum E.-J., Fehrenbach H., Heinze N., Krüger W. Nagel H.-H., Rössle S. & Tölle W. (1995): Erarbeitung eines maschinellen Kopiloten zur Unterstützung des Fahrers im Übergangsbereich zwischen Autobahn und Innenstadt. In: Nagel H.-H. (Hrsg.): Sichtsystemgestützte Fahrzeugführung und Fahrer-Fahrzeug-Wechselwirkung, Band 2. S. 679 - 794. Sankt Augustin: Infix.

Enquête-Kommission „Schutz der Erdatmosphäre“ des Deutschen Bundestages (Hrsg.) (1994): Mobilität und Klima. Wege zu einer klimaverträglichen Verkehrspolitik. Bonn: Economica Verlag.

Eriksson Lars H. & As Bengt Olof (1997): Automotive radar for adaptive cruise control and collision warning / avoidance. In: IEE Conference Publication No. 449 1997, pp. 16 -20.

Esch J. (1996): Prolog to Autonomous Vehicles. In: Proceedings of the IEEE, Vol. 84, No. 8, August 1996, pp. 1145 - 1146.

Evans L. (1998): Antilock brake systems and risk of different types of crashes in traffic. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-O-12.

Färber Berthold (1987): Geteilte Aufmerksamkeit. Grundlagen und Anwendung im motorisierten Straßenverkehr. Band 20 der Reihe Mensch-Fahrzeug-Umwelt. Köln: TÜV-Verlag.

Färber Berthold (1990): Mehr Instrumente, mehr Sicherheit? In: Elektronik im Kraftfahrzeug: Tagung der VDI-Ges. Fahrzeugtechnik. VDI Berichte Nr. 819, 1990, S. 1 - 18. Düsseldorf: VDI-Verlag.

Färber Berthold (1993a): Determining information needs of the driver. In: Parkes A.M. & Franzen S. (Eds.) (1993): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

Färber Berthold (1995): The evolution of in-car navigation systems and their relevance for traffic safety. In: Vision in Vehicles 6, Programme & Abstracts, p. 29, 13 - 16 Sept. 1995, University of Derby, UK.

Färber Berthold & Färber Brigitte (1993b): Kategorisierung von Fahrerinformationssystemen unter Berücksichtigung der Sinneskanäle des Menschen (DISSIC). PROMETHEUS-Projekt. Teilbericht 1: Entwicklung und Test eines Expertensystems zum Informationsmanagement. München, Juni 1993.
Teilbericht 2: Kinästhetische Rückmeldung per Fahrersitz. München, Dez. 1993.

Färber Berthold & Färber Brigitte (in press): Telematik-Systeme und Verkehrssicherheit.. Berichte der Bundesanstalt für Straßenwesen - Mensch und Sicherheit, Heft M**.

Färber Berthold, Heinrich Hanns Ch., Hundhausen Gerd, Hütter Gerhard, Kamm Heiner, Mörl Gunther & Winkler Wolfgang (1995): Sicherheit im Reisbus. Berichte der Bundesanstalt für Straßenwesen, Mensch und Sicherheit, Heft M 40, Bergisch Gladbach: Wirtschaftsverlag NW.

Färber Brigitte, Färber Berthold, Hipp E. & Jung Ch. (1992): Die Bedeutung kinästhetischer Informationen für die Fahrzeugführung. In: Das Mensch-Maschine-System im Verkehr: Tagung der VDI-Ges. Fahrzeugtechnik, 19./20.3.92 in Berlin. VDI Berichte Nr. 948, 1992, S. 35 - 41. Düsseldorf: VDI-Verlag.

Färber Brigitte, Färber Berthold & Meier-Arendt Guido (in press): Speech control systems for handling of route guidance, radio and thelephone in cars: results of a field experiment. In: Gale A. G. et al. (Eds.): Vision in Vehicles, Proceedings of the conference on vision in vehicles, Marseilles, France, 14-17 sept., 1997, Elsevier.

Fastenmeier W. (1993): Verkehrstechnische und verhaltensbezogene Merkmale von Fahrstrecken - Entwicklung und Erprobung einer Typologie von Straßenverkehrssituationen. Dissertation an der Technischen Universität München.

Fau Didier (1994): Pleiades: présentation et premier bilan. In: Revue générale des routes, No. 721, Sept. 1996, p. 61 - 63.

Fennel H. (1998): ABS plus und EPS - ein Konzept zur Beherrschung der Fahrdynamik. In: ATZ, Automobiltechnische Zeitschrift, 100, 4, pp. 302 - 308.

Fer B. (1997): Observation du comportement des automobilistes sur les autoroutes de liaison. In: Revue générale des routes, No. 757, Déc. 1997, p. 30 - 33.

Fischer A.-H. (1997): Verkehrsmanagement - was ist machbar, was ist wünschenswert? In: Straßenverkehrstechnik, 3, 1997, S. 115 - 123.

FKT - Projektgruppe (1995): Fahrzeuginterne Informations- und Warnsysteme, Sonderausschuß Insassenraum und Sichtfeld: Empfehlung und Handlungsbedarf zu fahrzeuginternen Informations- & Warnsystemen im Kraftfahrzeug. Statusbericht Oktober 1995.

Flick M. & Forkenbrock (1998): Test track performance evaluation of current production ABS. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-P - 18.

Franken M. (1997): Berlin will deutsche Telematik-Hauptstadt werden. In: VDI-Nachrichten, 17.10.97, zit. nach /http:// www.vdi-nachrichten.de

Frederiksen N. (1972): Toward a taxonomy of situations. American Psychologist, 27, pp. 114 - 123.

Free State of Bavaria, State Capital of Munich, et al. (Publ.) (1996): Munich COMFORT - Cooperative transport management for Munich and its surrounding area.

Freund E., Judaschke, U. & Lammen B. (1995): Koordinierter, kollisionsfreier Betrieb von automatischen Fahrzeugen. In: Nagel H.-H. (Hrsg.): Sichtsystemgestützte Fahrzeugführung und Fahrer-Fahrzeug-Wechselwirkung, Band 2. S. 455 - 552. Sankt Augustin: Infix.

Fritz Hans (1996): Model based neural distance control for autonomous road vehicles. In : IEEE Intelligent Vehicles Symposium, Proceedings 1996, IEEE, Piscataway, NJ, USA, 96 TH 8230, pp. 29 -34.

Galsterer H. (1980): Die Analyse verschiedener Verkehrssituationen als Basis zur Beanspruchungsmessung. In: Graf Hoyos C. (Hrsg.): Belastung und Beanspruchung am Steuer eines Kraftfahrzeuges - Untersuchungen mit Meßfahrzeugen. Bericht der BASt, Bereich Unfallforschung, Köln, S. 120 - 133.

Geiger D., Gundel N., Schult R., Thyes H. & Zimmermann W. (1997): MobIN Baden-Württemberg - die Weiterentwicklung urbaner Verkehrsinformationssysteme. In: Straßenverkehrstechnik, 5, 1997, S. 217 - 223.

Gelau C., Baumann M., Keinath A., Bengler K. & Krems J.F. (1998): Validierung eines Verfahrens zur Bewertung von Informationsdarstellungen in Fahrzeugen. In: Lachnit H., Jacobs A. & Rösler F. (Hrsg.): Experimentelle Psychologie. Abstracts der 40. Tagung experimentell arbeitender Psychologen, 6. - 9.4.1998, Marburg. S. 88. Lengerich: Pabst Science Publishers.

Gerner Helmut (1996): Zusatzdienste mit Mobilfunk. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 61 - 68. Heidelberg: Von Decker-Verlag.

Gibson J.J. (1950): The perception of the visual world, Cambridge, Mass.

Gibson J.J. & Crooks L.E. (1938): A theoretical field-analysis of automobil driving. American Journal of Psychology, 5, pp. 453 - 471.

Gies Stefan (1991): Die Sicherheitsrelevanz neuer Fahrhilfen in Kraftfahrzeugen. Bericht zum Forschungsbericht 8716 der Bundesanstalt für Straßenwesen. Bergisch Gladbach.

Godthelp Hans, Färber Berthold, Groeger John & Labiale Guy (1993): Driving: task and environment. In: Michon John A. (Ed.): Generic intelligent driver support. A comprehensive report on GIDS. pp. 19 - 32. London, Washington DC: Taylor & Francis.

Graham K.E. & Christoher A.R. (1997): Visual accomodation and virtual images: Do attentional factors mediate the interacting effects of perceived distance, mental workload, and stimulus presentation modality? In: Human Factors, 1997, 39 (3), pp. 374 - 381.

Graham R. & Mitchell V.A. (1994): An experimental study into the ability of drivers to assimilate and retain in-vehicle traffic information. In: Vehicle Navigation & Information Systems Conference Proceedings. Yokohama, Japan, pp. 463 - 472.

Grimmer W., Adelt P. J. & Stephan E. R. (1995): Die Akzeptanz von Navigations- und Verkehrsführungssystemen der Zukunft: eine AXA-Direkt-Verkehrsstudie. Bonn: Deutscher Psychologen Verlag.

Grund Egon (1995): Telematik oder Code-Karte? In: Straßenverkehrstechnik, 39, 1995, Nr. 6, S. 253 - 259.

Haase R. (1997): Mobilitätssicherung mit geringem Energieverbrauch. In: Internationales Verkehrswesen, (49), 9, 1997, S. 467 - 468.

Hacker W. & Richter P. (1980): Psychische Fehlbeanspruchung: Psychische Ermüdung, Monotonie, Sättigung und Streß. In: Hacker W. (Hrsg.): Spezielle Arbeits- und Ingenieurspsychologie in Einzeldarstellungen. Berlin: VEB Deutscher Verlag der Wissenschaften.

Haefner Klaus & Marte Gert (1994): Der schlanke Verkehr: Handbuch für einen umweltfreundlichen und effizienten Transport von Personen und Gütern. Berlin: Erich Schmidt-Verlag.

Haller, R. & Becker, S. & Gerbino W. & Hofmann O. & Morello E. & Nilsson L. & Varalda G. (1995): Final Assessment of MMI Evaluation Methods. DRIVE II Projekt, EMMIS (Evalutation of Man Machine Interfaces by Simulation Techniques). Deliverable No. 12., Commision of the European Communities.

Hamberger W. & Willumeit H.-P. (1996a): Navigationssysteme als Datenbasis für ein adaptives Antriebsmanagement. In: ATZ Automobiltechnische Zeitschrift, 98, 1996, 4, S. 218 - 222.

Hamberger W., Willumeit H.-P. & Struck G. (1996b): Navigationsgeräte als Datenbasis für Fahrerassistenzsysteme. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 381 - 395. Düsseldorf: VDI-Verlag.

Hancock P.A. & Caird J.K. (1992): Intelligent Vehicle Highway Systems: Problems and Promises (Part 1). In: HFS, Human Factors Society, Bulletin, Vol. 35, Nu. 10, Oct. 1992, pp. 1 - 4.

Hancock P.A. (1996b): Effects of control order, augmented feedback, input device and practice on tracking performance and perceived workload. In: Ergonomics, 1996, Vol. 39, No. 9, pp. 1146 - 1162.

Haub M. & Tilgner R. & Hahlganß G. (1994): Fahrerinformation und Verkehrstelematik - Ein ganzheitliches Zukunftskonzept des Mannesmann-Konzerns. In: VDI-Berichte Nr. 1152, 1994, S. 565 - 574.

HB (1995): Autoelektronik / Sensoren an Bord - Regentropfen schalten die Wischer ein. In: HB - Handelsblatt, Nr. 117, 21.6.1995, S. 28.

Hellåker Jan, Palmgren Christer & Turunen Seppo (1993): Real-time traveller information - in everyone's pocket?! - a pilot test using hand-portable GSM terminals. In: Proceedings of the IEEE-IEE, Vehicle Navigation and Informations Systems Conference. Ottawa Ontario, pp. 49 - 52.

Hesse Jan (1995): Opportunistische Multiagentenplanung - eine Emulationsumgebung für die Systemevaluation im innerstädtischen Straßenverkehr. In: Nagel H.-H. (Hrsg.): Sichtsystemgestützte Fahrzeugführung und Fahrer-Fahrzeug-Wechselwirkung, Band 2.S. 795 - 844. Sankt Augustin: Infix.

Hildebrandt J., Seidel B. & Trost D. (1997): Möglichkeiten und Grenzen der Vernetzung in ausgewählten Beispielräumen. In: Internationales Verkehrswesen, (49), 6, 1997, S. 294 - 299.

Hipp E. & Jung Ch. (1997): Intelligente Fahrerunterstützung: Der Abstandsgeregelte Tempomat. In: Internationales Verkehrswesen, 49, 7 - 8, 1997, S. 403 - 407.

Höß A., Mächtig T., Peckamnn D., Evers H., Vieweg S., Sellar D., Liebig E., Ilg J. & Dörrhofer C. (1996): BIDIS - Verkehrstelematik ohne stationäre Infrastruktur. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Ges. Fahrzeug- und Verkehrs-technik. VDI Berichte Nr. 1287, S. 475 - 494. Düsseldorf: VDI-Verlag.

Hoffman Steve & Stewart Charles (1993): Text-based routing: an affordable way ahead? In: Proceedings of the IEEE-IEE, Vehicle Navigation and Informations Systems Conference. Ottawa Ontario, pp. 45 - 48.

Graf Hoyos C. & Kastner M. (1986): Belastung und Beanspruchung von Kraftfahrern. Hrsg. Bundesanstalt für Straßenwesen, Bereich Unfallforschung, in der Reihe Unfall- und Sicherheitsforschung, Straßenverkehr, Heft 59, Bergisch Gladbach.

Huguenin, R.D. (1985): Zur Problematik der Theorienbildung in der Verkehrspsychologie.
In: Häcker H. (Hrsg.): Fortschritte der Verkehrspsychologie (1), Köln: Verlag TÜV Rheinland.

Isermann Heinz & Müller-Kästner Kai H. (1996): Einsatzmöglichkeiten des Internet am Beispiel der Gefahrgutlogistik. In: Internationales Verkehrswesen, Special „Verkehrs-Telematik“, 48, 1996, Nr.3, S. 20 - 25.

IV (1996a): Kosmodat: Günstige Telematik-Alternative. In: IV Internationales Verkehrswesen, Special „Verkehrs-Telematik“, 48, 1996, Nr. 3, S. 19.

IV (1996b): Telematik-Konzept für die Eisenbahn. In: IV Internationales Verkehrswesen, Special „Verkehrs-Telematik“, 48, 1996, Nr. 3, S. 26 - 27.

IV (1997a): Cologne Parkinfo: Verkehrsmanagement für freie Parkplätze. In: IV Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 391 - 392.

IV (1997b): Per Scheckkarte ins Hochregal. In: IV Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 393.

IV (1997c): Automatisches Parkhaus in Würzburg. In: IV Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 394.

IV (1997d): 4. Weltkongreß für Verkehrstelematik in Berlin. In: IV Internationales Verkehrswesen, (49), 10, 1997, S. 513 - 514.

IV (1997e): Verkehrstelematik verspricht europaweite Umsätze in dreistelliger Millionenhöhe. In: IV Internationales Verkehrswesen, (49), 10, 1997, S. 518.

IV (1997f): COMPANION bewährt sich seit einem Jahr in der Praxis. In: IV Internationales Verkehrswesen, (49), 10, 1997, S. 529.

IV (1997g): Feinspezifikation für die Realisierung des automatisierten Verkehrswarndienstes auf Basis RDS / TMC. In: IV Internationales Verkehrswesen, (49), 11, 1997, S. 577 - 578.

Jackel Birgit (1998): Telematik als neue Informationstechnik im Straßenverkehrs. In : Zeitschrift für Verkehrssicherheit, 44, 1998, 2.

James B. & Leroy S. (1997): Un exemple de déploiment de l'IST en Europe: L' information routière à Paris. In: Revue générale des routes, No. 757, Dèc. 1997, p. 10 - 13.

Janssen W. & Nilsson L. (1993): Behavioural effects of driver support. In: Parkes A.M. & Franzen S. (Eds.): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

Janssen Wiel & Hugh Thomas (1994): In-vehicle collision avoidance support under adverse visibility conditions 1. In: Proceedings of the International Ergonomics Association, IEA '94, Vol. 4: Ergonomie et design. pp. 179 - 181, Toronto, Canada.

JEDA, Japan Entwicklertreffen Deutscher Automobilindustrie (1996): Man-Machine Interface, July 1996.

Jenk H. (1997): Der beschwerliche Weg zu einer umweltverträglichen Mobilität. In: Schweizerische Technische Zeitschrift, 2, 1997, S. 14 - 19.

Johnston S.A., Mazzae E.N. & Garrott W.R. (1996): An evaluation of electronic pedestrian detection systems for school buses. In: SAE International Congress and Exposition, Detroit, Michigan USA, SAE-Paper No 960518.

Käppler W.D. (1980): Fahrverhalten bei freier Sicht und bei Sichtbehinderung durch Nebel. Bericht Nr. 48 des Forschungsinstituts für Antropotechnik, Meckenheim.

Kassakian J.G., Wolf H.-C., Miller J. M. & Hurton C.J. (1996b): Automotive electrical systems circa 2005. In: IEEE Spectrum, August 1996, pp. 22 - 27.

Kastner M. & Guillot G. (1980): Beanspruchung von Kraftfahrern im kontrollierten Feld. Forschungsbericht an die Bundesanstalt für Straßenwesen. FP 7707/2, Teil II, Aachen.

Kazuyuki Sasakj, Ishikawa Naoto, Otsuka Tatsumi & Nakajima Masato (1994): 3-D image location surveillance system for the automative rear-view. In: VNIS'94. Vehicle Navigation & Information Systems Conference Proceedings. Yokohama, Japan, pp. 27 - 32.

Keiji S. (1996): Drive assist system using stereo image recognition. In: IEEE Intelligent Vehicles Symposium, Proceedings, 1996, pp. 230 - 235.

Keinath H. (1997): Digitale Betriebsfunksysteme für den Öffentlichen Personennahverkehr (ÖPNV). In: Internationales Verkehrswesen, (49), 10, 1997, S. 525 - 528.

Keller Hartmut (1995): Einführung von Verkehrstelematiksystemen am Beispiel des Kooperativen Verkehrsmanagements München. In: Straßenverkehrstechnik, 39, 1995, Nr. 8, S. 373 - 378.

Keller H., Huber W., Bolte F., Philipps P. & Riegelhuth G. (1998): Validierung von Intelligenten Verkehrssystemen in Deutschland im europäischen Kontext. In: Straßenverkehrstechnik, 4, 1998, S. 169 - 177.

KFT (1994): Parkboy II, parking aid. In: KFT, 1994, 3, p. 56.

Kirlik A. (1993): Modeling strategic behavior in human-automation interaction: Why an „aid" can (and should) go unused. In: Human Factors, 1993, 35 (2), pp. 221-241.

Kirson A.M. (1995): A compact driver interface for navigation and route guidance. In: IEEE, 1995, pp. 61 - 66.

Kishi H. & Sugiura S. (1993): Human Factors Consideration for Voice Route Guidance. SAE-Paper No. 930553.

Klebelsberg D. (1965): Analyse des Verkehrsverhaltens. In: Graf Hoyos C. (Hrsg.): Psychologie des Straßenverkehrs. Bern: Huber, S. 15 - 65.

Kloock F. (1997): Auf dem Weg zur „Gläsernen Spedition". Sendungsverfolgung über das Internet. In: Internationales Verkehrswesen, (49), 12, 1997, S. 664 - 666.

Knoll P.M. & Vollmer R. (1994): Car Information, Communication and Entertainment System - Advances and New Developments. SAE-Technical Paper Series, No. 941040. SAE, The Engineering Society For Advancing Mobility Land Sea Air and Space, International. International Congress & Exposition, Detroit, Michigan, February 28 - March 3, 1994.

König, Rainer (1993): Informatisierung des Verkehrs. In: Wechselwirkungen, Nr. 63, 1993, Oktober, S.15 - 18.

König Rainer (1995): Gestaltungskriterien für Telematik-Systeme. In: Straßenverkehrstechnik, 39, 1995, Nr. 2, S. 61 - 67.

Konhäuser Walter (1996): GSM-Weiterentwicklungen und Anwendungen im Verkehr. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 175 - 191. Heidelberg: Von Decker-Verlag.

Krause Günter (1996): Neues Telematiksystem COMPANION im Feldtest. In: Internationales Verkehrswesen, Special „Verkehrs-Telematik", 48, 1996, Nr.3, S. 14 - 15.

Kremer Werner & Mertens Reinhold (1995): Verkehrstelematik in GSM. In: Müller G. & Hohlweg G. (Hrsg.): Telematik im Straßenverkehr - Initiativen und Gestaltungskonzepte. S. 195 - 207. Berlin, Heidelberg: Springer-Verlag.

Krostitz Boris & Köthner Dietmar (1993): Die „intelligente Straße" - auch mit High-Tech auf dem ökologischen Irrweg. Bund für Umwelt und Naturschutz Deutschland, LV Baden-Württemberg e.V., Freiburg.

Krüger Manfred (1996): „Transpo-Track" steuert Transportketten der Kooperation Cargo Line. In: Internationales Verkehrswesen, Special „Verkehrs-Telematik", 48, 1996, Nr.3, S. 6 - 9.

Krull-Lamothe Anneliese (1996): Verkehrs-Telematik soll Infrastruktur einsparen. In: Internationales Verkehrswesen, 48, 1996, Nr. 7 & 8, S. 44 - 46.

Krux W. (1998): Cologne Parkinfo - Ein Beitrag zur stadtverträglichen Verkehrsabwicklung. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 57 -64. Düsseldorf: VDI-Verlag.

Küting H.J. (1976): Belastung und Beanspruchung des Kraftfahrers. Literaturübersicht zum Stand der Forschung 'Stress im Kraftfahrzeug', Forschungsprojekt 7401 i.A der BASt, Bereich Unfallforschung, Köln.

Kunz Josef (1997): Wirtschaftsforum Verkehrstelematik - Ein Ansatz öffentlich-privater Partnerschaft. In: Straßenverkehrstechnik, 3, 1997, S. 112 - 114.

Kurogo Hisamitsu, Takada Kunimichi & Akiyama Hisao (1995): Concept of a parking guidance system and its effects in the Shinjuku area - configuration, performance, and future improvement of system. In: Vehicle Navigation and Information Systems Conference Proceedings. 6^{th} International VNIS. Pacific Rim TansTech Conference, Seattle, Washington, USA. pp. 67 - 74.

Lamboley Christian (1996): Affichage des temps de parcours sur le périphérique de Paris. In: Revue générale des routes, No. 746, Déc. 1996, p. 79 - 80.

Langwieder K., Frost U. & Bach E. (1998): The requirements for driver assistance systems and their effects on real-life accidents. Paper, presented at: National Highway Traffic Safety Administration, NHTSA, ESV-Conference, 1 - 4 June 1998, Windsor, Canada.

Larima Pirjo (1997): Verdi-Feldversuch, Zwischenbericht 04/97. Düsseldorf: Mannesmann Autocom.

Laue U. (1998): Kombinierter Verkehr unter den Aspekten von Verkehrskosten und Verkehrsqualität. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 151 - 157. Düsseldorf: VDI-Verlag.

Laurens Bernard (1994): Les développements du télépéage en Europe. In: Revue générale des routes, No. 721, Sept. 1996, p. 42 - 44.

Leutzbach W. (1997): „Der Wurm muß dem Fisch schmecken“ - Gedanken zur Technik für den Verkehr von morgen. In: Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 375 - 379.

Linde Rüdiger (1996): Telematik im Verkehr - die Sicht der Nutzer. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 155 - 160. Heidelberg: Von Decker-Verlag.

Linde R. (1997): Telematik im Verkehr - die Sicht der Nutzer. In: http://www.mediamit.de.htm/

Ling Suen S. & Mitchell C. (1998): Application of intelligent transport systems to enhance vehicle safety for elderly and disabled travellers. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-O-03.

Löcker G. (1998). Strukturwandel im ÖPNV - Vom herkömmlichen Linienverkehr zum Mobilitätsmanagement. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 259 - 267. Düsseldorf: VDI-Verlag.

Lublow R. & Van Bonn B. (1997): Telematikanwendungen im Sammelgutumschlag. In: Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 371 - 375.

Maes Willy (1995): Europäische Perspektiven für die Entwicklung und Einführung von Telematik-Systemen für den Verkehr. In: Straßenverkehrstechnik, 39, 1995, Nr. 2, S. 53 - 56.

Maillant Hubert (1996): Migrazur - Une solution pour une autoroute atypique. In: Revue générale des routes, No. 746, Déc. 1996, p. 76.

Malaterre Gilles & Fontaine Hélène (1993): The potential safety impacts of driving aids. In: Recherche transports sécurité english issue, No. 9, Dec. 1993, pp. 15 - 25.

Malbrunot Francois (1994): Naissance d’un système européen. In: Revue générale des routes, No. 721, Sept. 1996, p. 45 - 47.

Manigel J. (1995): Bahnführung eines Straßenfahrzeugs durch Computervision. In: Nagel H.-H. (Hrsg.): Sichtsystemgestützte Fahrzeugführung und Fahrer-Fahrzeug-Wechselwirkung, Band 2. S. 553 - 678. Sankt Augustin: Infix.

Mann E. (1997): Schutzengel fährt mit. In: Gute Fahrt, 1997, 1, S. 14 - 17.

Martin-Lamellelt C. & Dejeammes M. (1995): The processing of complex guidance symbols by elderly drivers: a simulator-based study and an evaluation of the CARMINAT guidance system by the European Community DRIVE-EDDIT Projekt. In: Vehicle Navigation and Information Systems Conference Proceedings. 6th International VNIS, Seattle, Washington, USA, pp. 110 - 117.

Mauch S. P. (1996): Verkehr als effizientes Ordnungsprinzip? In: STZ Schweizerische Technische Zeitschrift, 1, 1996, S. 20 - 24.

McKnight A.J. & Adams B.B. (1970 a/b): Driver education task Analysis. Volume I: Task description. Volume II: Task analysis methods. Human Resources Research Organisation, Alexandria, Virginia. Prepared for U.S. Department of Transportation, National Highway Traffic Safety Administartion, (Contract No. FH-11-7336), Washington, D.C.

Mele Jim (1993): Converting trucks to mobile offices - wireless data communications. In: Fleet owner, 1993, pp. 47 - 50.

Mertens Reinhold (1996): Flächendeckender GSM-Mobilfunk mit integrierter Telematikinfrastruktur sichert bedarfsgerechte Lösungen im Verkehrsbereich. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 57 - 60. Heidelberg: V. Decker-Verlag.

Meyrowitz A.L., Blidberg D.R. & Michelson R.C. (1996): Autonomous Vehicles. In: Proceedings of the IEEE, Vol. 84, No. 8, August 1996, pp. 1147 - 1164.

Michael U. (1996): Konzepte für die Instrumentierung - Flexibilität wird zur Pflicht. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 787 - 797. Düsseldorf: VDI-Verlag.

Miller R.J. & Penningroth S. (1997): The effects of response format and other variables on comparison of digital and dial displays. In: Human Factors, 1997, 39 (3), pp. 417 - 424.

Morawietz E. (1998): Informationen gezielt senden. In: Automobil Industrie, 3, 1998, S, 74.

Mortsiefer H.J. (1997): Telematik im Verkehr. In: http://www.mediamit. de.htm/

Moser O. (1996): Energieversorgung 2002 - Verbraucher im elektrischen Bordnetz. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 319 - 327. Düsseldorf: VDI-Verlag.

Müller A. (1997): IST-Weltkongreß in Berlin: Europa hat die Vorreiterrolle in der Telematik. In: Internationales Verkehrswesen, (49), 12, 1997, S. 659 - 661.

Müller G. & Hohlweg G. (1995): Telematik im Straßenverkehr - Initiativen und Gestaltungskonzepte. Berlin, Heidelberg: Springer-Verlag.

Müller Rolf (1997): Sensordaten und Systemelektronik machen das Bremsen effektiver. In: VDI-Nachrichten, Nr. 6, 7. Feb. 1997, S. 25.

Müller-Römer F. (1997a): Multimedia - mobil mit DAB. Teil 1. In: Radio - Fernsehen - Elektronik. 7, 1997, S. 24 - 28.

Müller-Römer F. (1997b): Multimedia - mobil mit DAB. Teil 2. In: Radio - Fernsehen - Elektronik. 8, 1997, S. 32 - 34.

Muir Bonnie M. & Moray Neville (1996): Trust in automation. Part II. Experimental studies of trust and human intervention in a process control simulation. In: Ergonomics, Vol. 39, No. 3, pp. 429 - 460.

Nelson J. Richard, Spitzer Frank & Stewart Scott (1993): Experiences gained in implementing an economical, universal motorist information system. In: Proceedings of the IEEE-IEE, Vehicle Navigation and Informations Systems Conference. Ottawa Ontario, pp. 67 - 71.

Neumann O. (1996): Theorien der Aufmerksamkeit. In: Neumann O. & Sanders A.F. (Hrsg.): Aufmerksamkeit. Göttingen: Hogrefe. S. 559 - 643.

Neumann Odmar & Sanders Andries F. (Hrsg.) (1996): Enzyklopädie der Psychologie - Aufmerksamkeit. Göttingen, Bern, Toronto, Seattle: Hogrefe, Verlag für Psychologie.

NHTSA - National Highway Traffic Safety Administration (lfd): Automotive antilock brake system survey. In: http : // www - nrd. nhtsa. dot. gov/vrtc / absweb. htm.

Nilsson Lena (1996): Safety effects of adaptive cruise controls in critical traffic situations. VTI särtryck No. 265. Swedish National Road and Transport Research Institute, Linköping, Sweden.

Nilsson Lena & Alm Håkan (1996): Effects of a vision enhancement system on drivers' ability to drive safely in fog. VTI särtryck No. 264. Swedish National Road and Transport Research Institute, Linköping, Sweden.

Nirschl Günther (1990): Verfahren zur integrierten Gestaltung und Bewertung von Mensch-Maschine-Dialogen im Kraftfahrzeug, basierend auf einem Entwicklermodell des Fahrerwissens. VDI-Verlag, Reihe 10: Informatik / Kommunikationstechnik Nr. 142. Düsseldorf: VDI-Verlag.

Nouvier Jaques & Morello Steve (1994): Melyssa ... ou la route intelligente au quotidien. In: Revue générale des routes, No. 721, Sept. 1996, p. 55 - 57.

Obert Georg (1996): Verkehrsinformationen mit RDS/TMC. In: Internationales Verkehrswesen, Special „Verkehrs-Telematik", 48, 1996, Nr. 3, S. 10 - 11.

Oldenburg B. (1997): „City Transport '97" und UITP-Kongreß mit Besucherrekord. In: Internationales Verkehrswesen, (49), 7 - 8, 1997, S. 398 - 399.

Parasuraman R., Hancock, P.A. & Olofinboba, O. (o.J.): Alarm Effectiveness in Driver-Centered Collision-Warning Systems (Internes Paper, ca. 1994).

Parkes A. M. & Franzen S. (Eds.) (1993): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

Parsons H. M. (1996): A visionary project for drivers. In: Ergonomic in Design. Jan. 1996, pp. 11 - 14.

Percié du Sert Paul (1994): Information aux usagers sur les autoroutes urbaines. In: Revue générale des routes, No. 721, Sept. 1996, p. 40 - 41.

Perel M. (1998): Helping older drivers benefit from collision avoidance technologies. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-O -11.

Piersma E.H. (1993): Adaptive interfaces and support systems in future vehicles. In: Parkes A.M. & Franzen S. (Eds.): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

Plän H.P. (1998): Große Schritte in der Fahrgastinformation - Wie der Nahverkehr der DB AG die Telematik für den Kunden nutzt. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 253 - 258. Düsseldorf: VDI-Verlag.

Ploss G. & Tschochner G. (1997): Aufbau von Verkehrsinformationszentralen - Pilotprojekt BAYERNINFO. In: Straßenverkehrstechnik, 5, 1997, S. 213 - 216.

Popp M. (1996): Spracheingabesysteme für den Einsatz im Kraftfahrzeug. DGLR-Bericht 96-02 der 38. Fachausschußsitzung Antropotechnik der Deutschen Gesellschaft für Luft- und Raumfahrt, „Interaktive Informationssysteme in Fahrzeugen und Leitstellen“, 07.96, Braunschweig.

Popp M. & Färber B. (1997c): Integrated multifunctional optical displays and mental machine models. In: Gale A.G. (Ed.) „Vision in Vehicles VI“, Derby, UK (in press).

Proskawetz K.-O. & Evers H.-H. (1998): Systemübersicht und Status - Telematikorientiertes Verkehrsmanagement zur EXPO 2000. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 283 - 294. Düsseldorf: VDI-Verlag.

Rademacher F.J. (1996): Multimediadienste im Fahrzeug. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 207 - 219. Heidelberg: Von Decker-Verlag.

Rasmussen J. (1986): Information processing and human machine interaction. New York: Elsevier.

Rau P. (1998): A prototype drowsy driver detection and warning system for commercial vehicle drivers. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-P-30.

Raulin Patrice (1996): Le projet Coraly. In: Revue générale des routes, No. 746, Déc. 1996, p. 74.

Reichart Günther (1996): Einsatz der Telekommunikation für fahrerunterstützende Systeme. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 193 - 206. Heidelberg: Von Decker-Verlag.

Reichart G. & Huber W. (1998): Forschungsprogramm MoTiV - Status und weitere Perspektiven. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 181 - 190. Düsseldorf: VDI-Verlag.

Retzko Hans-Georg (1996): Telematik - eine neue Herausforderung für die städtische und regionale Verkehrsplanung? In: Internationales Verkehrswesen, 48, 1996, Nr. 3, S. 52 - 56.

RFE (1997a): Digital im Auto: Car-HiFi und Telematik. In: RFE Radio - Fernsehen - Elektronik. 11, 1997, S. 16 - 18.

RFE (1997b): Autoradio und mehr. In: RFE Radio - Fernsehen - Elektronik. 10, 1997, S. 30.

Ritzer Michael (1995): Experimentelle Ermittlung der Aufmerksamkeitszuwendung zum Bordcomputer für verschiedene Funktionen. Diplomarbeit an der TU-München.

Robinson M., Inman V. & Koziol J. (1998): Application of a video data analysis tool for the safety evaluation of an intelligent cruise control system. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-P-29.

Rockwell, T.H. (1972): Skills, judgement, and information acquisition in driving. In: Forbes, T.W. (Ed.): Human factors in highway traffic safety research. New York: Wiley.

Rompe K., Wallrich M. & Schindler A. (1987): Advantages of an anti wheel lock system (ABS) for the average driver in difficult driving situations. Paper, presented at the 11th International Technical Conference on Experimental Safety Vehicle, Washington.

Ronzheimer M. (1997): Verkehrstechnik / Telematik-Kongreß in Berlin eröffnet. In: http://www .vineta.com/BerliNews/ messages/297.htm/

Rubas Christine (1996): Frontscheibe als Display zeigt auch, was im Dunkeln liegt. In: VDI-Nachrichten, Nr. 14, April 96, S. 20.

Rumar, Kåre (1985): The role of perceptual and cognitive filters in observed behaviour. In: Evans, L. & Schwing, R.C. (Eds.): Human behaviour and traffic safety, London: Plenum Press, pp. 151 - 170.

Rumar Kåre (1990): The basic driver error: late detection. In: Ergonomics, Vol. 33, No. 10/11, 1990, pp. 1281 - 1290.

S (1997): Chaos an der Grenze. In: (S) Der Spiegel, Nr. 46, 1997, S. 16.

Sasaki K., Ishikawa N., Otsuka T. & Nakajiama M. (1994): 3-D image location surveillance system for the automotive rear-view. In: IEEE Vehicle Navigation and Information Systems Conference Proceedings, 1994, pp. 27 - 32.

Schallaböck Karl Otto (1993): Weniger ist oft mehr: Technik im Verkehr. In: Wechselwirkung, Nr. 63, Okt. 1993, S. 10 - 14.

Schlichter H. G. & Reichart G. (1998): Kooperatives Verkehrsmanagement für Ballungsräume. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 95 - 101. Düsseldorf: VDI-Verlag.

Schmidt E. (1996a): Informationsfluß verflüssigt den Individualverkehr. In: VDI Nachrichten, Nr. 14, April 1996, S. 20.

Schmidt E. & Maier R. (1996b): Technologie-Trends geprägt durch die neuen Bordnetzkonzepte. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 337 - 350. Düsseldorf: VDI-Verlag.

Schmidt Rolf (1996): Mikrowellenbaken in Mehrwegausbreitungsumgebung. In: ATZ Automobiltechnische Zeitschrift, 98, 1996, 1, S. 44 - 50.

Schneider Herbert (1996): Standards in Telematik. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 105 - 121. Heidelberg: Von Decker-Verlag.

Schneidereit G., Daduna J.R. & Voß St. (1998): Informationsdistribution über Netzdienste am Beispiel des Öffentlichen Personenverkehrs. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 217 - 235. Düsseldorf: VDI-Verlag.

Schöttle R., Schramm D. & Schenk J. (1996): Zukünftige Energiebordnetze im Kraftfahrzeug. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 295 - 318. Düsseldorf: VDI-Verlag.

Schulze R. (1996): Digitales Radio liefert störungsfreie Fernsehbilder. In: VDI Nachrichten, Nr. 8, Februar 1996, S. 28.

Schwarz O. & Bock E. (1998): Effiziente Preise im Personenverkehr - Überlegungen für einen intermodalen Ansatz und eine empirische Untersuchung für den motorisierten Individualverkehr. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 35 - 56. Düsseldorf: VDI-Verlag.

Seidel B. & Twele H. (1998): Minimalisierung von Zugangshürden zum Verkehrssystem Eisenbahn. In: VDI Berichte 1372. VDI-Gesellschaft Fahrzeug- und Verkehrstechnik - Gesamtverkehrsforum 1998. Tagung Braunschweig 5. und 6. März 1998. S. 237 - 252. Düsseldorf: VDI-Verlag.

Selbitz H. (1997): Intermodale Fahrplanauskunft: Die Datenintegration ist Voraussetzung. In: Internationales Verkehrswesen, (49), 10, 1997, S. 523 - 525.

Sens-o-lock (1998): Designed for safety, engineered for life. In: http: // www.asil.com/sensolock.html.

Shekhar S., Yang T.A. & Hancock P.A. (1993): An intelligent highway information management system. In: Microcomputers in Civil Engineering, 1993, 8, pp. 175 - 198.

Shinar David (1995): Field evaluation of an advance brake warning system. Short note. In: Human Factors, 1995, 37 (4), pp. 746 - 751.

Shinar D., Rothenberg E. & Cohen T. (1997): Crash reduction with an advanced brake warning system: a digital simulation. In: Human Factors, 1997, 39 (2), pp. 296 - 302.

Shinkle K. (1998): A GPS HOW-TO: conducting highway surveys the nysdot way. In: GPS-World, February 1998, pp. 34 - 40.

Sidaway Ben, Fairweather Malcolm, Sekiya Hiro & McNitt-Gray Jill (1996): Time-to-collision estimation in a simulated driving task. In: Human Factors, 1996, 38 (1), pp. 101 - 113.

Siegle Gert (Hrsg.) (1996a): Telematik im Verkehr. Referate des Kongresses des Münchner Kreises vom 14. Und 15. Februar 1996. Heidelberg: Von Decker-Verlag.

Siegle, G. (1996b): Multimedia-Verbindung in bewegte Kraftfahrzeuge. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 373 - 380. Düsseldorf: VDI-Verlag, 1996

Sodeikat H. (1997): Neue Wege zur Erhaltung unserer Mobilität. In: Internationales Verkehrswesen, (49), 10, 1997, S. 515 - 516.

Spiller Kurt & Fornefeld M. (1996): Telematik an Autobahnen - Einbeziehung der Tank- und Rastanlagen in Telematik-Infrastrukturen und -dienste. In: Straßenverkehrstechnik, 1996, Nr. 12, S. 607 - 608.

Spitzner Meike (1993): Ökologische Verkehrswende. Ansätze zur strukturellen Verkehrsvermeidung. In: Wechselwirkung, Nr. 63, Okt. 1993, S. 5 - 9.

Spreitzer William M. (1996): IST in the United States and Japan. In: Siegle Gert (Hrsg.): Telematik im Verkehr. S. 123 - 130. Heidelberg: Von Decker-Verlag.

Stahl W. & Hötzel J. (1996): Parktronic-System (PTS), aktueller Stand und Ausblick. In: Elektronik im Kraftfahrzeug: Tagung Baden-Baden, VDI-Gesellschaft Fahrzeug- und Verkehrstechnik. VDI Berichte Nr. 1287, S. 443 - 456. Düsseldorf: VDI-Verlag.

Stanton N. (1995): Back to the future: analysing driver performance with potential IVHS. In: Nwagboso C.O. (1995): Road vehicle automation II. Toward systems integration. Proceedings of the 2nd International Conference on Road Vehicle Automation. 11th - 13th Sept. 1995. Chichester etc.: John Wiley & Sons.

Stappert Karl-Heinz (1995): Feldversuch Autobahntechnologie auf der A555 zwischen Bonn und Köln. In: Müller G. & Hohlweg G.: Telematik im Straßenverkehr - Initiativen und Gestaltungskonzepte. S. 168 - 183. Berlin, Heidelberg: Springer-Verlag.

Statement of Principles (formerly known as Code of Practice) (1998): Produced by the human machine interface expert task force, draft version II, 30.3.1998. Brussels.

Steierwald Marcus (1996): Thematische Ansätze einer Technikfolgenabschätzung (T.A.) der räumlichen Wirkungen. In: Internationales Verkehrswesen, 48, 1996, Nr. 7 & 8, S. 12 - 16.

Steiner A. (1985): Modellbildung und experimentelle Überprüfung eines Klassifikationssystems für Straßenverkehrssituationen. Diplomarbeit, Psychologisches Institut der Universität Tübingen.

Summala H., Nieminen T. & Punto M. (1996): Maintaining lane position with periperal vision during in-vehicle tasks. In: Human Factors, 1996, 38 (3), pp. 442 - 451.

Svidén O. (1993): MMI scenarios for the future road service informatics. In: Parkes A.M. & Franzen S. (Eds.) (1993): Driving future vehicles. London, Washington DC: Taylor & Francis.

Swets J.A. (1992): The science of choosing the right decision threshold in high-stakes diagnostics. In: American Psychologist, Vol. 47, No. 4, 1992, pp. 522 - 532.

SZ (1998): Der mit dem Rücksitz spricht. In: SZ Süddeutsche Zeitung Nr. 57, 10.3.1998, S. XII.

TE (1994): Dental selling infra-red parking aid. In: TE, Transport Engineer, 1994, 5, p. 78.

Teltschik H. (1997): Lösungsbausteine für die Zukunft von Mensch und Mobilität sind gefragt. In: Internationales Verkehrswesen, (49), 10, 1997, S. 517.

Teubel U. (1997): Verteilungswirkungen von Straßennutzungsgebühren in einem städtischen Ballungsraum. In: Internationales Verkehrswesen, (49), 3, 1997, S. 97 -103.

Thomas Josef (1995): Das Telematik-Systemangebot der Industrie. In: Straßenverkehrstechnik, 39, 1995, Nr. 4, S. 149 - 154.

Topp Hartmut (1995a): Verkehrsmanagement durch Telematik. In: Straßenverkehrstechnik, 39, 1995, Nr. 6, S. 261 - 266.

Topp Hartmut (1995b): Grenzen und Chancen von Verkehrsmanagement. In: Müller G. & Hohlweg G. (Hrsg.): Telematik im Straßenverkehr - Initiativen und Gestaltungskonzepte. S. 259 - 272. Berlin, Heidelberg: Springer-Verlag.

UPI, Umwelt- und Prognose-Institut Heidelberg e.V. (1993): Scheinlösungen im Verkehrsbereich. Kontraproduktive und ineffiziente Konzepte der Verkehrsplanung und Verkehrspolitik. UPI-Bericht Nr. 23, 4. erw. Auflage, Heidelberg, Sept. 1993.

U.S. Department of Transportation, Transport Canada & Trucking Research Institute (~1996): Commercial motor vehicle driver fatigue and alertness study - executive summary. In: http://home.att.net/~NataH/fatigue.htm

Van Winsum Wim (1996): Speed choice and steering behavior in curve driving. In: Human Factors, 1996, 38 (3), pp. 434 - 441.

VDI-N (1996a): Optischer Sensor erkennt Beifahrer. In: VDI Nachrichten, Nr. 14, April 1996, S. 21.

VDI-N (1996b): Elektronischer Chauffeur im Test. In: VDI Nachrichten, Nr. 14, April 1996, S. 21.

Verwey W.B. (1993): How can we prevent overload of the driver? In: Parkes A.M. & Franzen S. (Eds.): Driving Future Vehicles. London, Washington DC: Taylor & Francis.

Verwey W. B. (1996): Evaluating safety effects of in-vehicle information systems (IVIS). TNO-report TM-96-C068. TNO Human Factors Research Institute, Soesterberg, The Netherlands.

Vexiau Thierry (1996): La télématique routière. In: Revue générale des routes, No. 746, Déc. 1996, p. 73.

Vieveen Jan W. & Joanknecht Jan W. (1993): Telematics and dangerous goods in the Netherlands, telematics for road transport; the TGS project. In: Proceedings of the IEEE-IEE, Vehicle Navigation and Informations Systems Conference. Ottawa Ontario, pp. 653 - 656.

Vikas Athanasios, Presser Stephan, Wöhler Andreas & Willumeit Hans-Peter (1995): Optimierung und Auslegung von Fuzzy-Control-Strukturen mit Hilfe der Evolutionsstrategie - Ein Beitrag zu aktiven Fahrwerken. In: ATZ Automobiltechnische Zeitschrift, 97, 1995, 1, S. 54 - 61.

Villanueva Maria B. G., Sotoyama Midori, Jonai Hiroshi, Takeuchi Yasuhiro & Saito Susumu (1996): Adjustments of posture and viewing parameters of the eye to changes in the screen height of the visual display terminal. In: Ergonomics, 1996, Vol. 39, No. 7, pp. 933 - 945.

Vincent A., Noy I. & Laing A. (1998): Behavioral adaptation to fatigue warning systems. In: Abstracts of the 16th ESV Conference of the NHTSA, Windsor, Canada, June 1-4, 1998. http: // www-nrd.nhtsa.dot.gov/esv/esvweb2.htp, 98-S2-P-21.

Volkswagen AG (1996): Infotainment Car - Individuelle Fahrzeitgestaltung (Prospekt).

Vollmer R. & Knoll P. (o.J.): Fahrerinformationssysteme - Konzepte für den Weltmarkt. (Internes Paper).

Von Benda Helga, Graf Hoyos Carl & Schaible-Rapp Agnes (1983): Klassifikation und Gefährlichkeit von Straßenverkehrssituationen. Bericht zum Forschungsprojekt 7320 der BASt, Bereich Unfallforschung (Band 89), Bergisch Gladbach.

Walbridge Edward W. (1995): Real time ridesharing using wireless pocket phones to access the ride matching computer. In: Vehicle Navigation and Information Systems Conference Proceedings. 6th International VNIS, Seattle, Washington, USA, pp. 486 - 492.

Wang C.-L., Bhat P. B. & Prasanna V.K. (1996): High-performance computing for vision. In: Proceedings of the IEEE, Vol. 84, No. 7, July 1996, pp. 931 - 946.

Ward N.J. & Hirst S. (1998): Exploratory investigation of display information attributes of reverse / parking aids. In: International Journal of Vehicle Design, 1998, 19, 1 pp. 41 - 49.

Ward Nicholas J., Parkes Andrew & Crone Peter R. (1995): Effect of background scene complexibility and field dependance on the legibility of head-up displays for automotive applications. In: Human Factors, 1995, 37 (4), pp. 735 - 745.

Weber William J., Mullins Carolyn A., Schumacher Robert W. & Wright David D. (1994): A systems approach to the development of an integrated crash avoidance vehicle. In: VNIS'94, Vehicle Navigation & Information Systems Conference Proceedings. Yokohama, Japan, pp. 431 - 434.

Werner W. (1997): Entwicklung eines hochpräzisen DGPS / DGLONASS Navitationssystems im Zentimeterbereich: Grundlagen, Algorithmen und Software. In: Ortung und Navigation, Zeitschrift der Deutschen Gesellschaft für Ortung und Navigation e.V., 2, 1997, S. 149 - 169.

Weyd Jérôme (1994): Télématique routière et normalisation. In: Revue générale des routes, No. 721, Sept. 1996, p. 23 - 27.

Wierwille W. W., Lewin M. & Fairbanks R. (1996): Research on vehicle-based driver status / performance monitoring. Abstract of the final report of DOT HS - 808 640. Virginia Polytechnic Inst. and State Univ., Blacksburg, Vehicle Analysis and Simulation Lab.

Wierwille Walter W. & Tijerina Louis (1995): Eine Analyse von Unfallberichten als ein Mittel zur Bestimmung von Problemen, die durch die Verteilung der visuellen Belastung innerhalb des Fahrzeugs verursacht werden. In: Zeitschrift für Verkehrssicherheit, 41, 1995, 4, S. 164 -168.

Wilde G. J. S. (1978): Theorie der Risikokompensation der Unfallverursachung und praktische Folgen für die Unfallverhütung. In: Hefte zur Unfallheilkunde, 130, 1978, S. 134 - 156.

Winterhagen Johannes (1995): Kraftschlußüberwachung und Abstandsregelung. In: ATZ Automobiltechnische Zeitschrift, 97, 1995, 1, S. 22 -23.

Wördenweber B., Lachmayer R. & Witt U. (1996): Intelligente Frontbeleuchtung. In: ATZ Automobiltechnische Zeitschrift, 98, 1996, 10, S. 546 - 551.

www (1998a): LogiBall Projekte. In: http://www.logiball.de/ projekte.htm/

www (1998b): Telematik im Verkehr. Projekt RBL/GPS: Dynamische Fahrgastinformation und Anschlußsicherung ÖPNV. In: http://www.hessen-media.de.htm/

www (1998c): Telematik im Verkehr. Projekt Online Baustellen-Informationsservice. In: http: //www.hessen-media.de.htm/

www (1998d): PASSO, Pannen- und Notrufdienste. In: http:// www.passo.de.htm/

www (1998e): Mannesmann Annual Report 1996: Research and development. In: http: // www. mannesmann.de/english/fakten/1996/forschung.htm/

Wylie, et al. (+1996): see: U.S. Department of Transportation (~1996).

Zackor Heinz (1995): Leitstrategien für Telematik-Anwendungen im Straßenverkehr. In: Straßenverkehrstechnik, 39, 1995, Nr. 2, S. 57 - 60.

Zackor H. (1997): Mobilitätssicherung durch Verkehrssystem-Management. In: Straßenverkehrstechnik 9, 1997, S. 109 - 111.

Zängl W. (1995): Der Telematik-Trick. Elektronische Autobahngebühren, Verkehrsleitsysteme und andere Milliardengeschäfte. München: Raben-Verlag.

Zimmerman, T.A. (1993): IVHS and TRW's Participation. (Internes Paper)

Zimmermann Peter (1996): Kombinierte Nutzung von Verkehrsmitteln. In: Siegle Gert (Hrsg.): Telematik im Verkehr. Münchner Kreis. S. 77 - 84. Heidelberg: Von Decker-Verlag.

Zimolong B., Schwerdtfeger W. & Erke H. (1977): Erhebung von Verkehrskonflikten an Knotenzufahrten. In: Zeitschrift für Verkehrssicherheit, 23, S. 51 - 58.

Zumkeller D. (1997): Sind Telekommunikation und Verkehr voneinander abhängig? Ein integrierter Raumüberwindungskontext. In: Internationales Verkehrswesen, (49), 1 - 2, 1997, S.16 - 21.