Driver Assistance Technology to Enhance Traffic Safety

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Abstract It is shown in how far driver assistance systems can contribute to enhance the overall traffic safety. Thereby it must be considered as a goal to increase the performance of active safety systems in the scope of an integrated approach, allowing to realize a variety of interactions between the three elements involved in a traffic scenario, say the driver, the vehicle and the driving environment. Focus is pointed on the related technology, the inherent system complexity and aspects of customer acceptance.

1 Introduction

Safety is a basic need of mankind. This entails that aspects of safety are fundamental to the acceptance of any mobility system. In so far safety must be considered as a long term megatopic driving the automotive industry [1]. Safety in the context of automotive engineering [2] addresses two topic clusters: the *active safety* cluster focusing on the avoidance of traffic accidents and the *passive safety* cluster dealing with accident mitigation topics.

Active safety addresses as for example a full variety of chassis systems implemented to enhance the handling and driving characteristics of a vehicle, such as powerful braking and high precision steering systems as well as high stability axle configurations. Typical passive safety features relate as for instance to the crash optimization of the car body structure, collapsing steering columns and the multitude of integrated safety restraint systems, such as seat belts and airbags. The effectiveness of active and passive safety systems is impressively expressed by the statistical results from thoroughful (worldwide) traffic accident recordings and investigations (Figure 1).

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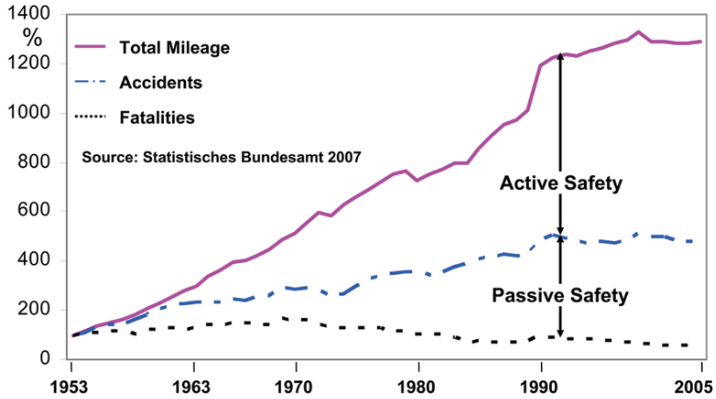

Fig. 1 Traffic accident situation in Germany.

But since we are still far off from a zero traffic accident scenario, the question in how to further reduce the still significant number of traffic accidents must be raised. There is consensus existing among experts that the most promising breakthrough technologies to cope with this topic will be located in the active safety area [3]. In this context great expectations have been attributed to safety relevant driver assistance systems. Indeed a deeper analysis of the situation clearly indicates the many possibilities offered by the driver assistance technology. Driver assistance addresses a full band of applications ranging from information based navigation topics through vehicle guidance and stabilization systems to autonomous driving scenarios.

In the following, focus will be pointed on the safety performance of driver assistance systems related to the different categories addressed. The complexity as well as the potential and risks inherent to the various systems will be discussed as well as their acceptance by “the customer”.

2 The Diversity of Driver Assistance System

Focusing on traffic accidents indicates that there are always three elements involved in an accident scenario: the driver, the vehicle and the driving environment. In the past traffic safety initiatives were concentrating on the safety optimization of these three components independently from one another. By today, it is well understood that only an integrated optimization process, focusing on the optimization of the total system, say addressing simultaneously the optimization of the three elements involved, can lead to a significant further improvement in the traffic accident situation [4]. This indicates that the interaction (connectivity) between driver, vehicle and environment (Figure 2) must be a central part of a promising accident reduction

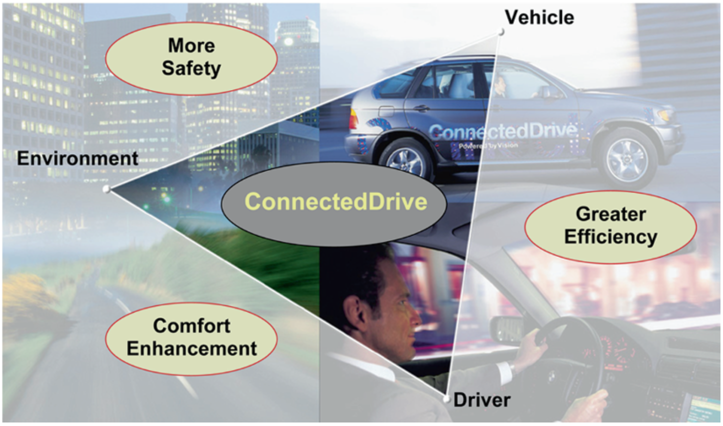

Fig. 2 ConnectedDrive: an integrated approach to active safety enhancement.

Anti-Lock Braking System	ABS	Parking Assistant	PA
Anti-Skid Control System	ASC	Lane Departure Warning	LDW
Dynamic Stability Control	DSC	Lane Change Assistant	LCA
Park Distance Control	PDC	Heading Control	HC
GPS-Navigation	NAVI	Extended Navigation	XNAVI
Active Cruise Control	ACC	Dynamic Performance Control	DPC
Adaptive Head Lights	AHL	Congestion Assistant	COA
Brake Force Display	BFD	Intersection Assistant	IAS
Active Front Steering	AFS	Preventive Pedestrian Protection	PPP
Night Vision	NIVI	Local Danger Warning	DWA
ACC Stop & Go	ACC S&G	Wrong Way Driver Information	WWI
X-Drive	XDR	Emergency Braking	EB
Intelligent Brake Assistant	IBA	Collision Avoidance	CA
Adaptive Drive	ADD	...	

Fig. 3 Driver assistance systems

approach. There is no need to say that this field of interest is directly related to the driver assistance technology.

It can be notified that driver assistance, as it has been introduced since the 70s (Figure 3), was primarily dedicated to the temporary support of the driver in form of the *stabilization of the vehicle* in critical driving situations. Control systems, such as ABS (Antilock-Braking), ASC (Active Stability Control) and DSC (Dynamic Stability Control), being nowadays part of an overall integrated chassis control management system, can be considered as typical technologies in this field. But along the time line a variety of systems were also introduced to assist the driver in the *guidance of the vehicle*. Representatives of that category are ACC (Active Cruise Control) and HC (Heading Control). Moreover it is of importance to consider, in the overall context of driver assistance, so-called information systems which support the driver in the *navigation of the vehicle*. Typical representatives within that category

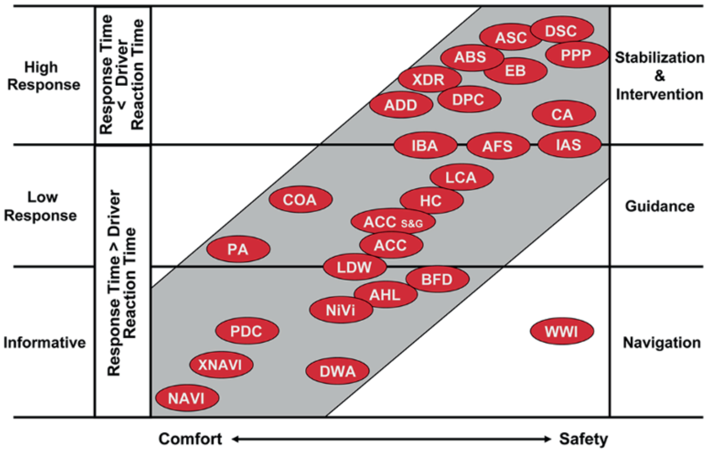

Fig. 4 Driver assistance systems classification.

are GPS navigation systems, actually already flanked by TMC (Traffic Message Channel) traffic jam information capabilities and in the future by additional ad-hoc traffic accident reporting systems making use of a direct wireless communication between vehicles and the traffic infrastructure (Car2X) [5].

The examples addressed indicate the wide range of application of driver assistance. In order to allow a more detailed discussion, it is helpful to cluster the various systems, as is indicated in Figure 4.

The categorization is realized by a distinction between "low response" and "high response" systems. In this context, "low response" means that the driver assistance (control) system action/reaction can be overrun at any time by the driver. Low response systems are related to vehicle navigation and guidance tasks. "High response" systems are characterized by the fact that their control system output, due to the short response time, cannot be overrun by the driver. These systems focus on the stabilization of the vehicle and the autonomous guidance intervention. According to Figure 4, "high response" driver assistance are directly addressing inherent safety critical (driving and traffic) situations.

It is true that the categorization levels of systems are not strictly defined in each case. As for example the distinction between an Active Cruise Control system (ACC) with enhanced braking capabilities and those of an Emergency Braking system (EB) could be rather difficult to define.

3 Active Safety Systems

It can be stated that the introduction of "high response" driver assistance control systems in production vehicles has up to now been restricted to applications allowing

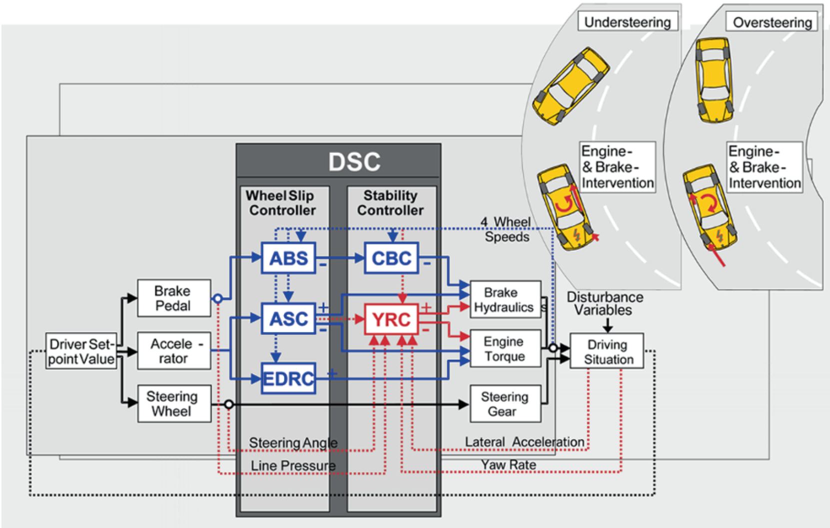

Fig. 5 Block diagram of DSC system.

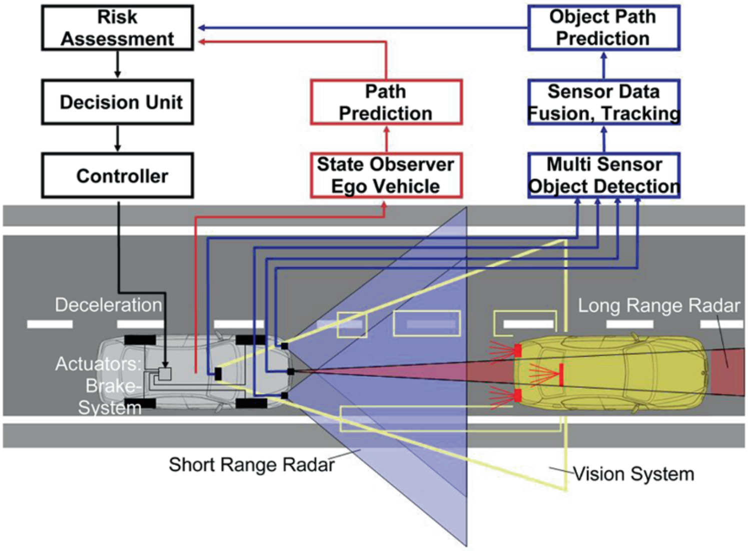

Fig. 6 Emergency brake system.

the required technology to be "completely part of the vehicle". All sensor information and control variables are vehicle fixed! This allows to realize even complex applications, such as dynamic stability control (DSC), as depicted in Figure 5, with an enormous reliability.

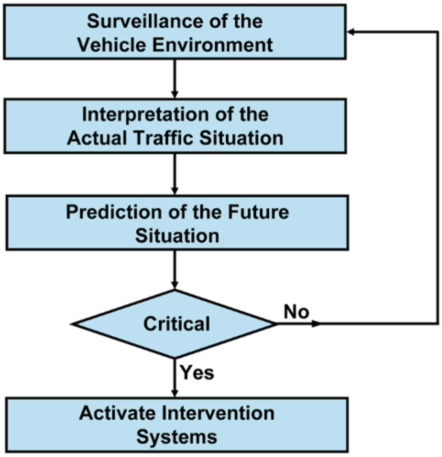

Fig. 7 Decision taking process for autonomous intervention.

This aspect of realibility becomes (by far) more questionable if systems, like autonomous collision avoidance (CA), shown in Figure 6, taking into account the driving environment as a sensorial control system input, are considered. This statement is based on the fact that systems relying on the driving environment information do require, apart from the basic detection via sensors, a clear interpretation of the actual traffic situation around the vehicle (Figure 7). This task might be difficult to solve in the case of real driving situations and it is not realistic to assume that it will be achieved correctly in most situations. Accordingly, there will always be a rest of risk remaining if environmentally sensing high response driver assistance systems were introduced. This remaining risk, which also from a legal point of view (liability) [6] opens a full range of questions, entails that "some more time" will elapse before we will see these systems operational in series production vehicles.

On the other hand there are plenty of realizable new advanced technologies under development which can significantly contribute to reduce the number of (severe) accidents. Analyzing accident cases (Figure 8) indicates that more than 50% of all severe accidents are at least affected by some lack of driver information!

Consequently it must be asked in how far this lack of information can be compensated by the driver assistance technology. In order to provide an additional meaningful information to the driver, the assistance system must acquire relevant data with regard to the traffic scenario "around" the vehicle. As will be shown in the following two examples of application, near and far field data will have to be considered.

Example 1: Lane Change Assistant. The near field perception capabilities of driver assistance research vehicles have been dramatically improved during the past years by the integration of radar, lidar and video systems (Figure 9). This entails that, in case of a lane change maneuver on a highway, the sensor system can easily

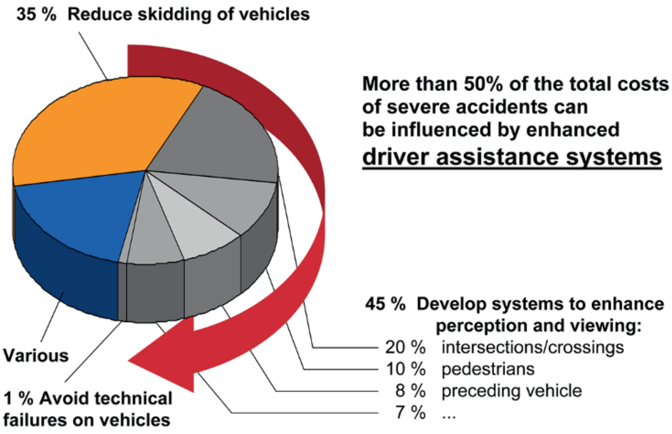

Fig. 8 What do we need to further reduce the total number of severe accidents?.

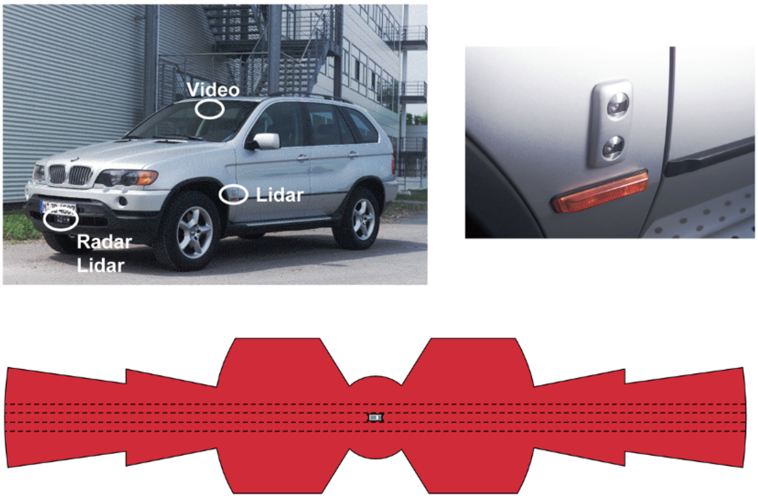

Fig. 9 Vehicle near field perception capabilities.

identify vehicles approaching on the pass lane [7]. The identification is achieved with regard to relative distance and speed data. These data allow us to evaluate if a lane change might be critical. In case the driver intends to perform a lane change, which is normally initiated by the activation of the blinker light and/or a steering wheel input, the assistance system is ready to give a (kinaesthetic, optical, acoustic, etc.) warning if required.

Example 2: Wireless ad-hoc communication. The perception of the far field cannot be realized via the on-board vehicle sensor network. It is however possible to

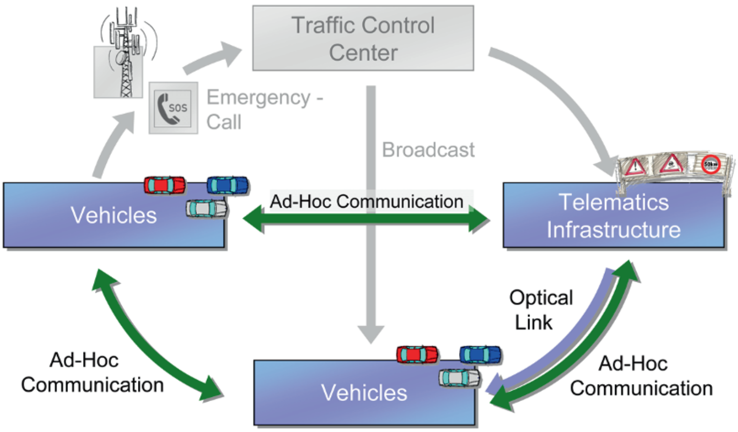

Fig. 10 Direct vehicle to vehicle communication.

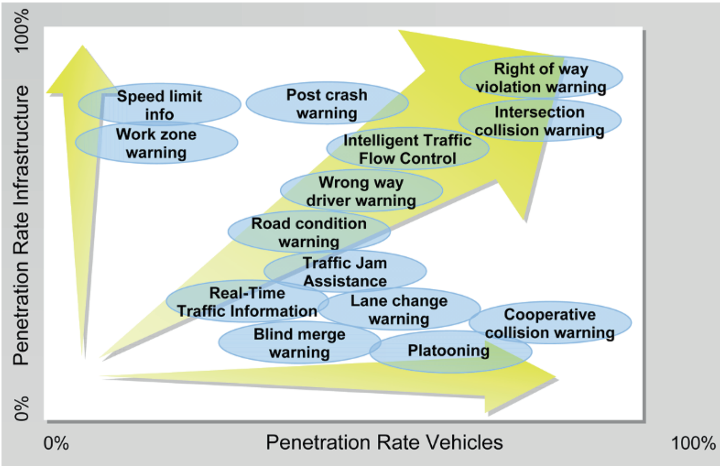

Fig. 11 Applications of ad-hoc connectivity.

provide relevant far field data to the vehicle by means of wireless communication technologies. Imagine that an accident has taken place on a (highway) road. This always entails a critical situation for all following vehicles.

Direct wireless communication (Figure 10) between the vehicles involved in the accident and the approaching vehicles could avoid that the drivers of these vehicles would get surprised when approaching/reaching the accident location.

It has to be mentioned that using (following) vehicles as "wireless hoppers" allows to pass the information along rather long distances.

All in all the wireless ad-hoc communication, with its many applications (Figure 11), must be considered as a highly promising technology in the scope of future accident reducing strategies [8].

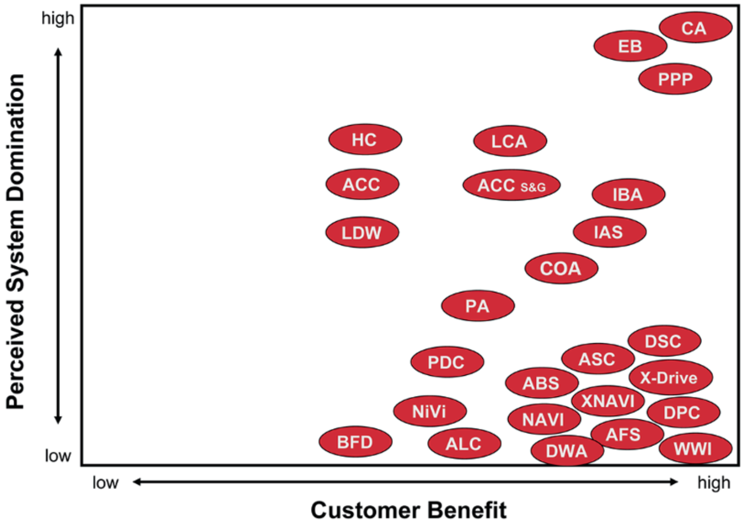

Fig. 12 Benefit/domination relationship of driver assistance systems.

From the topics addressed above it can be concluded that the field of driver assistance does apply to a broad variety of practical applications. With consideration of the actual level of technology available and the legal situation existing, it can be expected that next implementation steps of the technology will not be related to so-called "fast response" systems with an autonomous action. Apart from this futuristic vision, a far more realistic scenario foresees the introduction of a full variety of traffic safety enhancing driver assistance systems related to the levels of vehicle navigation and vehicle guidance [9].

4 Customer Acceptance

Having addressed a priori technical aspects in the previous chapters, focus will now be placed on customer relevant issues. This is of relevance since finally the customer decides about the integration of a driver assistance system (as a special option) into his vehicle. This directly entails that only systems which – from the *customers* view point – do provide a (significant) benefit can be a market success.

Customer research investigations clearly indicate that even if the customer is increasingly sensitive to safety aspects, he is not (yet) accepting safety relevant driver assistance systems which are directly interacting with the guidance of the vehicle. A system domination in this field of driver oriented activities is not accepted! Accordingly, it is of importance to thoroughfully investigate for any driver assistance system the relationship existing between the benefit to the driver and the domination percieved by the driver. In this context it can be foreseen that assistance systems,

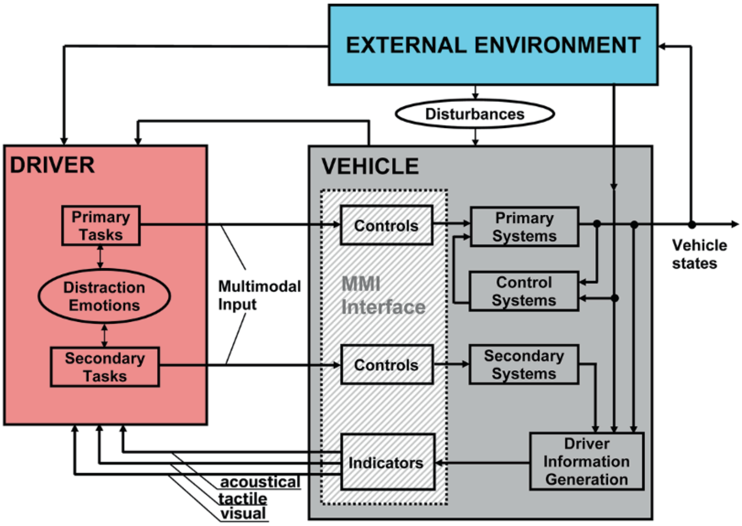

Fig. 13 Interaction between driver, vehicle and environment.

primarily located in the right lower corner of Figure 12, might find the acceptance of the customer and thus become a market success.

A further criterion of customer acceptance is related to the design of the HMI (Human Machine Interface) [10]. The driver expects that driver assistance systems do provide a support to the driving task but do not create an additional workload or distraction. This situation explains why driver assistance systems efficiently operating in the background, such as ABS and DSC, have found a high penetration rate. When driving, the driver must (and he also wants to) fully concentrate on the primary task of driving; occasionally required secondary tasks need to be easily achieved (Figure 13). This entails that it is of primary importance to focus on the easy handling and comprehensible operation of assistance systems. Intensive investigations with regard to these criteria are performed in the automotive industry in the scope of usability and (dynamic) simulator tests [11].

These reflections underline the high importance of HMI investigations in the development and integration process of driver assistance systems [12]. The realization of a real premium HMI functionality is of a vital importance to the system acceptance!

5 Conclusion

An overview of the high potential of driver assistance systems for enhancing driving and traffic safety was given. The key for the realization of efficient systems is related to technologies in the sensor and the traffic/driving situation interpretation fields. A highly reliable technology is required if visionary “high response” autonomous actions in the vehicle guidance are considered. Since this technology is not yet available the next generation of systems will be primarily oriented to functionalities allowing to enhance the traffic safety by “low-response” information and guidance systems. Moreover it was clearly addressed that the overall layout of the HMI interface of driver assistance systems is of a primary importance with regard to the customer acceptance.

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