Legal consequences of an increase in vehicle automation

Consolidated final report of the project group

Part 1

including

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Report on the research project F 1100.5409013.01
of the operational programme of the
Federal Highway Research Institute:
Legal consequences of an increase
in vehicle automation

Translation into English language of part 1

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Stabsstelle Presse und Öffentlichkeitsarbeit

Note on accuracy:

The present translation of BASt-Report F83 (Part 1) into English language is intended solely as a convenience to the non-German-reading public. Any discrepancies or differences that may arise in translation of the official German version are likely not accurate. In case of doubt, please refer to the original version in German language.

Kurzfassung – Abstract

Gemeinsamer Schlussbericht der Projektgruppe: Rechtsfolgen zunehmender Fahrzeugautomatisierung

Die BASt-Projektgruppe „Rechtsfolgen zunehmender Fahrzeugautomatisierung“ hat über die heute verfügbaren Fahrerassistenzsysteme hinaus drei verschiedene Automatisierungsgrade identifiziert und begrifflich definiert: Teil-, Hoch- und Vollautomatisierung.

Aus verhaltensrechtlicher Sicht haben sich als wesentliche Unterscheidungsmerkmale verschiedener Automatisierungsgrade die auf das Verkehrsgeschehen fokussierte Aufmerksamkeit des Fahrers und seine ständige Möglichkeit zur Fahrzeugsteuerung herausgestellt. Im Fall der „Teilautomatisierung“ ist die Aufmerksamkeit des Fahrers ständig auf das Verkehrsgeschehen gerichtet und er hat aufgrund der permanent von ihm durchzuführenden Systemüberwachung die Möglichkeit zur Fahrzeugsteuerung, sodass dieser Automatisierungsgrad den aktuellen verhaltensrechtlichen Anforderungen entspricht. Die verhaltensrechtlich geforderte Aufmerksamkeitskonzentration auf das Verkehrsgeschehen und die möglicherweise fehlende Möglichkeit zur Fahrzeugsteuerung stehen jedoch der Nutzung höherer Automatisierungsgrade (Hoch- und Vollautomatisierung) derzeit entgegen. Ihre Nutzung ist gegenwärtig nicht mit dem Verhaltensrecht vereinbar, da der menschliche Fahrzeugführer gegen seine Pflichten verstieße, wenn er sich vollständig auf das System verlassen würde. Soweit ein Automatisierungsgrad zugleich eine freihändige Fahrzeugsteuerung vorsieht, bedürfte es der verhaltenspsychologischen Untersuchung, inwieweit dies den Fahrer in der Ausübung ständiger Vorsicht im Sinne von § 1 Abs. 1 StVO zu beeinträchtigen vermag.

Hinsichtlich der Haftung nach dem Straßenverkehrsgesetz erscheint die Beweislastverteilung im Rahmen von § 18 Abs. 1 S. 2 StVG in den Fällen höherer Automatisierungsgrade (Hoch- und Vollautomatisierung) nicht mehr sachgerecht, soweit dem Fahrer in verhaltensrechtlicher Hinsicht die Ausrichtung seiner Aufmerksamkeit auf andere Tätigkeiten als die konventionelle Fahraufgabe ermöglicht wird. Die Regelungen zur Haftung des Fahrzeughalters bleiben bei allen Automatisierungsgraden weiterhin anwendbar.

In Bezug auf die Produkthaftung zeigt sich im Fall der vollständig fahrerüberwachten Teilautomatisierung die Bedeutung der Systemgrenzen. Produkthaftungsrechtlich gewinnt hier die Einordnung des bestimmungsgemäßen Gebrauchs wesentlich an Bedeutung. Zur Absicherung dieses bestimmungsgemäßen Gebrauchs ist die nachhaltige Beeinflussung der Verkehrserwartung beim Benutzerkreis entscheidend, soweit nicht primär konstruktive Möglichkeiten nach dem Stand von Wissenschaft und Technik zur Verfügung stehen, um unberechtigtes Systemvertrauen auszuschließen. Bei den höheren Automatisierungsgraden, die nicht mehr der Fahrerüberwachung bedürfen (unter der Annahme, ihre Nutzung wäre verhaltensrechtlich möglich), wäre jeder Schaden, der nicht auf ein Fehlverhalten Dritter oder eine Übersteuerung des Fahrers zurückzuführen ist, geeignet, Herstellerhaftung auszulösen. Diesbezüglich spielt die Darlegungs- und Beweislast eine wesentliche Rolle.

Sowohl aufgrund der offenen Fragen in der rechtlichen Bewertung als auch übergreifend zur Verbesserung technischer Ausgangsbedingungen sowie der Gebrauchssicherheit wird von der Projektgruppe weiterer Forschungsbedarf zur Fahrzeugautomatisierung formuliert.

Consolidated final report of the project group: Legal consequences of an increase in vehicle automation

The BASt-project group “Legal consequences of an increase in vehicle automation” has identified, defined and consequently compiled different automation degrees beyond Driver Assistance Systems. These are partial-, high- and full automation.

According to German regulatory law, i.e. the German Road Traffic Code, it has been identified that the distinctive feature of different degrees of automation is the permanent attention of the driver to the task of driving as well as the constant availability of control over the vehicle. Partial automation meets these requirements. The absence of the driver’s concentration to the traffic situation and to execute control is in conflict with the use of higher degrees of vehicle automation (i.e.

high and full automation). Their use is therefore presently not compatible with German law, as the human driver would violate his obligations stipulated in the Road Traffic Code when fully relying on the degree of automation these systems would offer. As far as higher degrees of automation imply hands-free driving, further research in terms of behavioural psychology is required to determine whether this hinders the driver in the execution of permanent caution as required by sec. 1 para. 1 StVO (German Road Traffic Code).

As far as liabilities according to the StVG (German Road Traffic Act) are concerned, the presently reversed burden of proof on the driver within sec. 18 para. 1 S. 2 StVG might no longer be considered adequate in case of higher degrees of automation that allow the driver to draw attention from the task of driving (in case making such use of a system would be permitted by the German Road Traffic Code). The liability of the vehicle "keeper", according to the German Road Traffic Act, would remain applicable to all defined degrees of automation.

In case of partial automation, the use of systems according to their limits is accentuated. The range of use that remains within the intended must be defined closely and unmistakeably. Affecting user expectations properly can immensely help to maintain safe use, in case design-measures that exclude overreliance are not available according to the current state of the art (otherwise such measures would have to be applied primarily). In case of the higher degrees of automation that no longer require the driver's permanent attention (under the presupposition their use would be permitted by the German Road Traffic Code), every accident potentially bears the risk to cause product liability on the side of the manufacturer. Liability of the manufacturer might only be excluded in case of a breach of traffic rules by a third party or in case of overriding/oversteering by the driver. In so far aspects of German procedural law and the burden of proof are of great importance.

The project group has identified the need for further continuative research not only to advance legal assessment but also to improve basic technical conditions for vehicle automation as well as product reliability.

Notes on the structure of this publication

Part 1 of the document reflects the common view of the BASt (Federal Highway Research Institute) project group "Legal consequences of an increase in vehicle automation".

Parts 2, 3 and 4 (not translated) of the document include contents which reflect exclusively the opinions of their respective authors and not necessarily that of the other members of the project group "Legal consequences of an increase in vehicle automation". In part 2 of the document, this applies to the research report on "Basics, technical design and requirements" (BASt research report: FE 88.0006/2009); in part 3 of the document, this applies to the research report "Legal assessment: regulatory law and registration law" (BASt research report: FE/88.0008/2009); and in part 4 of the document this applies to the research report "Product and road traffic liability law" (BASt research report: FE/88.0009/2009).

Part 1

Acknowledgement

The work as well as the herein presented results of the project group "Legal consequences of an increase in vehicle automation" would not have been possible without the dedicated interaction, commitment and expertise of all the members of the project team.

Particular thank is given to all the contractors of the three sub-projects, whose respective work results have been reflected in parts 2, 3 and 4 of the printed and published document. The discussions within the project group started out with the exploration of fundamental ideas, technical designs of vehicle automation and the requirements. This discussion helped to illustrate possible degrees of automation and thus became the starting point for further work. For this comprehensive research, special thank is to Mr Dr. Arne Bartels. The two legal assessment projects have been based on the aforementioned sub-project. For the legal assessment of regulatory and certification law we thank Professor Dr. Clemens Arzt, Ms Jana Eier and Ms Simone Ruth-Schumacher (LL. M.). For the legal assessment of the product and road traffic liability law we thank Mr Wolfgang Vogt, solicitor, for his work.

In addition to the above mentioned authors of those versions which have been marked as parts 2, 3 or 4 of this document, special thank is given to all the other contributors of the project group, who have invested a substantial amount of time on the four face-to-face meetings and have assisted with own contributions. They all contributed with great commitment to the different aspects and have applied their expertise and knowledge in lively discussions, which always led to a fruitful exchange of thoughts, in spite of slight differences in opinion. In this respect, we shall mention Dr. Mihiar Ayoubi, Dr. Lutz Bürkle, Dr. Frank Flemisch, Mr. Dirk Häcker, Mr. Tobias Hesse, Dr. Werner Huber, Dr. Christine Lotz, Prof. Dr. Markus Maurer and Dr. Jürgen Schwarz.

For the Federal Highway Research Institute

Tom Michael Gasser

1 Introduction

The objective of the BASt-project group was an initial assessment of the legal situation in view of increasing vehicle automation on public roads. The legal assessment has been performed according to German law. Subject of consideration has been the compatibility of vehicle automation with applicable law in civil law terms (manufacturer's product liability, operator's liability, driver's liability, insurance company's liability) as well as in terms of public law with special regard to regulatory law (behavioural law).

As a basis for the legal assessment, a detailed technical description was customized to provide practical, though fictional, examples for different levels of automation. This fictional description of different degrees of automation facilitates in-depth legal assessment (the setting of different assumptions is necessary to get a clear picture, which is indispensable; however, it also brings about the restriction that such a consideration remains hypothetical). Therefore, the specific legal assessment is initially solely applicable to the systems described as "scenarios". However, the transferability of the results can be assumed – while generally taking into consideration system-specific designs. The scenarios simultaneously describe the tasks of the driver in varying degrees of automation. Important research issues arise in the area of human monitoring of the systems action, the vehicle in the traffic environment, and the transfer of vehicle control between the "driver" and the system (see research needs, Chapter 8).

The feasibility of a comprehensive automation of vehicles recently did not start to play a role in public perception up to the second "DARPA Grand Challenge" organised by the American Department of Defense in 2005, followed by the "DARPA Urban Challenge" in 2007[1]. DARPA is the American abbreviation for "Defense Advanced Research Projects Agency", which pushes the fast development of machine-driven land vehicles in the interest of military applications. In 2010, over the duration of the BASt-project Group, particular attention was given to press releases on automated vehicles by the Internet Company "Google" in California and, almost simultaneously, the results of the German project "Stadtpilot" (engl. "City Pilot", involving a research vehicle called "Leonie" of the Technical University of Braunschweig = Brunswick). The car "Leonie" drives without driver intervention along the Brunswick city ring road (however, to ensure safety, there is a human driver present, ready to intervene at any time in a case of emergency). Research on the benefits and imaginable future applications of different degrees of automation in road transport have already been taken out for several years, both at national as well as at European level. Just to mention a few recent projects: H-Mode, HAVE-it, Citymobil, SARTRE, Conduct-by-Wire, CyberCars etc. The automation levels, which have been subject of these projects, differ considerably from the prototypical implementation of a full automation (as has been subject of the project "City Pilot").

A scenario of full automation of vehicles fit for public road traffic is currently not in view.[2] However, it is assumed that partial automation which is totally controlled and corrected by the driver can already be accomplished by technological means in series vehicles, provided that the scope is limited to situations with low complexity.[3] Mostly, the introduction within a closed scenario is envisaged, such as a driving situation on motorways[4] or in a parking garage. At the same time, however, reference is made to the dependency of the realisation of vehicle automation on speed, which will be discussed later. Higher levels of automation are technically less complex at lower speeds since standstill (as a rather "safe" – minimal risk – condition is reached in shorter time, e.g. automatic parking systems, etc.).

The relevance of the legal questions of vehicle automation raised below must not be underestimated: A major obstacle and/or the crucial (and co-determining) uncertainty in establishing these systems is

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[1] Compare to the technical implementation of the team on rank 2: Montemerlo, Becker, Bhat, Dahlkamp, Dolgov, Ettinger, Haehnel, Hilden, Hoffmann, Huhnke, Johnston, Klumpp, Langer, Levandowski, Levinson, Marcil, Orenstein, Paefgen, Penny, Petrovskaya, Pflueger, Stanek, Stavens, Vogt, Thrun: "Junior The Stanford Entry in the Urban Challenge", Journal of Field Robotics – Special Issue on the 2007 DARPA Urban Challenge, Part II, archive Volume 25 Issue 9 (Sept. 2008), John Wiley and Sons Ltd. Chichester UK p. 569-597.

[2] The implementation of an – obviously complete – automation is sometimes not expected to happen before the year 2050; compare the presentation by Wolfgang Reinhardt at the eSafety Forum Workshop on the topic "New Priorities for deploying safe, smart and clean road mobility" on 25th Nov. 2010, slide 29.

[3] Bartels: "Roadmap Automatisches Fahren" (Roadmap to Automated Driving), conference proceedings of the AAET 2008, p. 350-364, describing the complexity of various driving situations in detail in a matrix.

[4] Also Bartels: "Roadmap Automatisches Fahren", conference proceedings of the AAET 2008, p. 350-364.

seen in the legal framework of their implementation,[5] which is at this time unclear, not only for Germany or Europe.[6] To pursue this legal question was the task of this BASt project group. From the outset, no comprehensive answer to the legal situation was to be expected; the objective was rather a compilation of the legally relevant aspects and fields of action. Further, the results have been limited by the project group‘s current knowledge in other sciences: Considerable significance is therefore attributed to the performance of the human in monitoring and correcting the automated control systems, which is important for all the levels of automation considered in this study (and already present for existing driver assistance systems). This is clearly reflected in the requirements of this research study, as identified by the project group. Any further assessment of the legal situation will also depend heavily on results of research.

2 Nomenclature and description of vehicle automation

The objective of the project group was to obtain a legal assessment for each degree of automation. To facilitate legal assessment, various scenarios were set up for better understanding.

The allocation of tasks between the driver and the automation system was an essential criterion in the definition of the different automation levels for the purpose of a legal assessment. The project team chose a classification by technical performance, whereby remaining tasks of the driver when using these systems are described. For a better overview of possible driving conditions it seemed reasonable to consider also traditional manual driving ("driver only") and the vehicle driver assistance which is already available in vehicles today ("assisted driving"). However, it is questionable whether driver assistance is to be awarded a special role for legal purposes. There is a difference between driver assistance and partial automation with regard to the degree of automation, as the driver assistance system performs the automated tasks only "within certain limits". Further, assisted driving does not extend beyond the automation of a single task of the driver only, namely automation of longitudinal or lateral control. Therefore, there is a qualitative difference, since in case of assisted driving a control task remains to be actively performed by the driver. A focal point of the project group (see table 2-1) has been to investigate the legal consequences of this technical development.

Another dimension of automated driving is the intended range of speed (see Figure 2-1). In principle, this issue is not legally essential at first glance, but it can play a role in terms of special codification, as provided herein in the form of a technical regulation (see excursus in this chapter to ECE-R 79 with regard to automatic steering functions). However, the speed range has significance in two ways: on the one hand, within the lower part of the speed range, it is imaginable only in exceptional cases that the driver will not have enough time for an oversteering action. On the other hand, the speed is of importance for the realization for technical reasons. Lower speed is closer to a standstill which is identified as a "safe or minimum risk condition of the system". The lower the selected speed of an automated operation, the faster the vehicle can come to a standstill, which is to be classified as relatively 'safe' already on the law of physics – however, dependent on the vehicle environment. Therefore, it can be concluded for all selected scenarios which are located in the highest possible speed range (motorways) that they face relative high requirements for technical implementation. However, as far as complexity is concerned, implementation requirements would have to be classified even higher, e.g. in urban areas.

[5] Hakuli, Bruder, Flemisch, Löper, Rausch, Schreiber, Winner „Kooperative Automation“, in: Winner, Hakuli, Wolf (publisher), „Handbuch Fahrerassistenzsysteme“, p. 647 (651); Weilkes, Bürkle, Rentschler, Scherl in Automatisierungstechnik (at) 53 (2005), p. 4-10.

[6] Beiker, Calo: „Legal Aspects of Autonomous Driving“, Annual Meeting of the Association of Defense Counsel of Northern California and Nevada, p. 227-234 (227), San Francisco, 9/10 Dec 2010.

Nomination and categorisation of automated driving functions (not exhaustive) As of: 6th Sept 2010

Nomenclature	Description of automation degree according to drivers' expectations	Exemplary systems
Driver Only	The driver continuously (throughout the complete trip) accomplishes longitudinal (accelerating/ braking) and lateral (steering) control.	No (driver assistance) system active that intervenes in longitudinal and lateral control.
Assisted	The driver continuously accomplishes either lateral or longitudinal control. The other/ remaining task is – within certain limits - performed by the system. • The driver must monitor the system permanently. • The driver must be prepared to take over complete control over the vehicle at any time.	Adaptive Cruise Control: - Longitudinal control with adaptive distance and speed control, Parking assistance system: - Lateral control is accomplished by the parking assistance (automatic steering into the parking space, the driver accomplishes longitudinal control).
Partial automation	The system takes over the lateral and longitudinal control (for a certain period of time and/ or in specific situations). • The driver must monitor the system permanently. • The driver must be prepared to take over the complete control of the vehicle at any time.	Motorway assistant: - Automatic longitudinal and lateral control - On motorways up to a certain top speed limit - Driver must monitor the actions constantly and respond immediately when prompted to take over
High automation	The system takes over lateral and longitudinal control for a certain period of time in specific situations. • Here, the driver need not monitor the system permanently. • If necessary, the driver will be prompted to take over control, allowing for a sufficient lead time. • All system limits are recognised by the system. The system is not capable of re-establishing the minimal risk condition from every initial state.	Motorway chauffeur: - Automatic longitudinal and lateral control - On motorways up to a certain top speed limit - Driver is not required to monitor the actions constantly. In case prompted to take over, the driver must respond within a certain lead time.
Full automation	The system takes over lateral and longitudinal control completely within the specification of the application. • The driver need not monitor the system. • Before specified limits of the application are reached, the system prompts the driver to take over control, with sufficient lead time. • In absence of driver takeover, the system will return to the minimal risk condition. • All system limits are recognised by the system. The system is capable of returning to the minimal risk condition out of every situation.	Motorway pilot: - Automatic lateral control - On motorways up to a certain top speed limit - Driver is not required to monitor the actions - In case the driver does not respond to a takeover request, the vehicle will brake down to a standstill.

Table 2-1: Definition of various degrees of automation

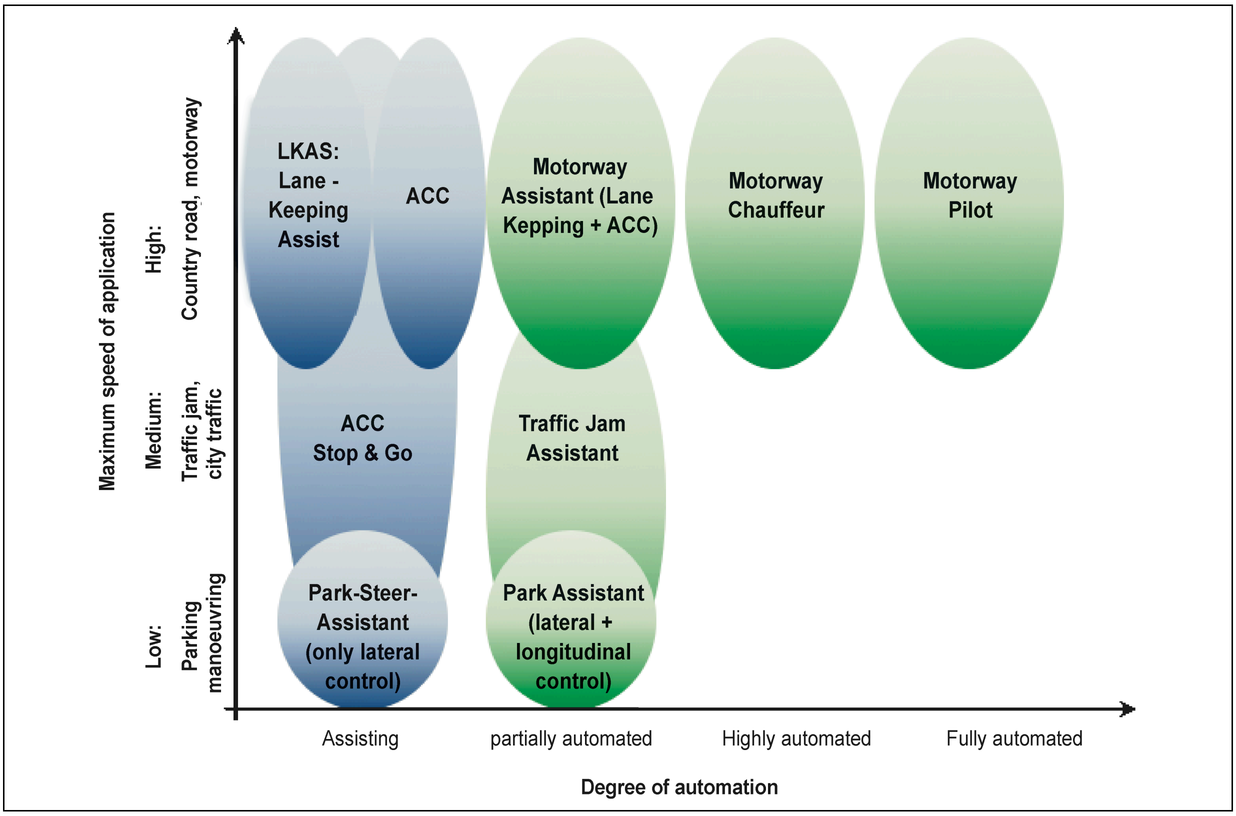

Figure 2-1: Vehicle automation's dependency on speed

Excursion: ECE-R 79: Conditions for the approval of the steering system

In the framework of vehicle type approval (so-called "type approval"), the applicable ECE Regulation No. 79 defines the "Autonomous steering function" - in this respect, more specific than the definitions by the project group - as a “function within a complex electronic control system where actuation of the steering system can result from automatic evaluation of signals [...] to generate continuous control action in order to assist the driver in following a particular path, in low speed manoeuvring or parking operations.”[7]. The partially automated vehicle control discussed in this document will already require a steering function of this kind. According to the existing ECE Regulation No. 79, “the control action shall be automatically disabled if the vehicle speed exceeds the set limit of 10 km/h by more than 20 per cent […].“[8] Thus, according to this regulation, the function in the scenario "Motorway Assistant", classified as partially automated according to the definitions of the BASt Project Group, would be an “automatic steering function” in accordance with ECE R 79 and as such currently not allowed within the speed range of motorways. Prior to the introduction of automated systems, this provision would therefore require amending. A similar change in the rule was already required for the introduction of parking assist systems.

3 Consideration of scenarios

The selected scenarios described in depth in document part 1 shall, on the one hand, serve as a basis for discussion and are for illustrative purposes. At the same time, they provide the necessary substance for an assessment under the applicable law. Although the scenarios are fictional, a first introduction of automatic systems for use on motorways is not unlikely - despite the already presented speed dependency of automation. This is due to the specific boundary conditions on motorways which facilitate automation, i.e.: a uniform setup with only few disturbing influences, the absence of pedestrians and cyclists, cp. section 18 (paragraph 1 Sentence 1) of the German Road Traffic Regulations (StVO), etc. In the interest of a sustainable assessment, any overlap of the scenarios has been consciously avoided. Necessarily, this is accompanied by a loss of closeness to reality, as individual scenarios will feature the realistically expected system safety only with a combination of different automation levels and/or functions. In this respect, the fictional scenarios primarily are means to an end and not a description of a realistic system design.

All three described levels of automation/ scenarios (for partial automation: motorway assistant; for high automation: motorway chauffeur; and for full automation: motorway pilot) describe an application in the same speed range, in order to illustrate the specific differences between those degrees of automation. The scenario of the "emergency stop system" is also used in the same speed range, but represents a special case insofar as it only triggers its function, if the driver loses his or her capacity to act during the trip due to a medical condition. It was decided by the project group to evaluate the legal aspects of this scenario, too.

It shall be noted that many more applications of vehicle automation are imaginable, and each of them will have some technical and possibly also legal particularities. Such systems could not be covered by the project group in detail.

4 Theoretical impact of vehicle automation on the accident situation

It is recognized that the predominant portion of all accidents is caused by human mistake or failure.[9] Only a very small percentage of the of accident constellations is caused by technical defect.[10] Automation might lead to the complete exclusion of the main cause of accidents, which is “human

[7] FEE Automotive Engineering EWG/ECE, Regulations of the Economic Commission for Europe for Motor Vehicles and Trailers (ECE Regulations), loose-leaf text collection with 70th supplement. Lfg, as of: ECE 1 October 2008, ECE-R 79, No. 2.3.4.1.

[8] FEE Automotive Engineering EWG/ECE, Regulations of the Economic Commission for Europe for Motor Vehicles and Trailers (ECE Regulations), loose-leaf text collection with 70th supplement. Lfg, as of: ECE 1 October 2008, ECE-R 79, No. 5.1.6.1.

[9] Weber, S.: Interdisciplinary analysis of interrelations in accident data for the assessment of the potential of driver assistance systems, presentation on 21 June 2010, 9th GUVU Day of Traffic Experts, Cologne.

[10] Cf. footnote 9.

failure"; however, this would be only possible in the design of the comprehensive full automation of any vehicle control, which has currently not even been envisaged.[11]
Unknown factors in case of high and full automation are societal acceptance as well as the risk situation when used on public roads. A significant benefit to society from a reduction in the total number of accidents (as well as their consequences) can, however, be assumed. Figure 4-1 can help to illustrate the assumption made by the project group.

The sketch (Fig. 4-1) illustrates the respective potential of vehicle automation for accident prevention, based on theoretical considerations. It is assumed that certain accident situations cannot be avoided by automation either (shown in blue). However, all in all – starting out from the current number of road accidents (shown blue and green) - it will be possible to avoid a large number of these accidents by automation, because human error will be suppressed in the accident situation. Apart from that, in case of automation there will be (a few) accidents to be expected which will can exclusively be traced back to the automation itself (shown in yellow). This accident potential needs to be added. In comparison, it is to be assumed that the number of accidents avoided by automation will many times exceed the number of those additional accidents due to vehicle automation (the risk of automation).

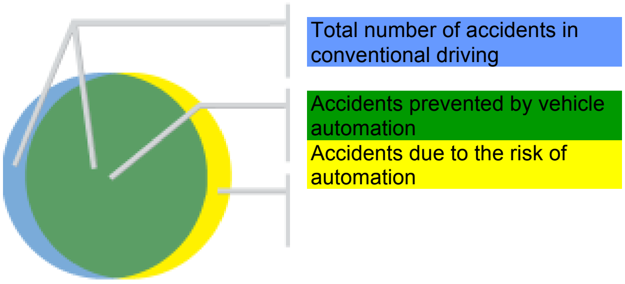

Fig. 4-1: Theoretical potential for accident prevention in vehicle automation (Source: project group)

Consideration must be given to the following, as a foundation for a description of the theoretical potential of accident prevention: From the outset, any potential accident prevention is limited to the application range of the specific system. At the level of individual degrees of automation, the situation for the theoretical potential of accident prevention therefore presents itself in detail as described below.

4.1 Partial automation

When using a system with the automation level "partial automation", the driver must monitor the system continuously and override whenever necessary. This applies in particular when the system reaches its limits within the area of application, in case of system failure and when exiting the area of application. It can be implied that the control of such a system will run error-free – at least to a very high degree. However, system limits of the sensors as well as errors in the context of functional safety requirements are still to be taken into account. A benefit for road safety arises from the extremely low latencies of automatic control systems in comparison with human reaction times. Further benefits result from the prevention of human error in the areas of perception, information processing and the execution of actions within the scope of the automated system. However, for the safe use of the system it is still always required that the driver constantly monitors the system and understands the limits of the system as well as his own abilities well enough to realise when a correction of system control is required. System limits will persist and errors may occur – as explained above. The partially automatic system therefore frees the driver only from the active execution of action – until he regains the necessary active control in driving the vehicle.

4.2 High automation

In case of high automation, accidents are imaginable within the scope of application only to the extent of error on the side of third parties. Further, potential causes of accidents within the scope of

[11] Cf. hereto above, footnote 2.

application may be the rare cases of force majeure and the risk of malfunction due to system defects. Hence, in case of high automation, the leeway for human failure in minimised, because the system has no set system limits within its scope of application and is thus able to prevent accidents within its domain. However, the highly automated system requires that the driving task is returned to the driver beyond the system‘s respective scope of application. This is achieved by allowing for a “sufficient” lead time, so that the driver can always adapt which will increase safety. In particular, the driver is not required to recognise the need for his intervention himself, but the system prompts him to take over when the need arises. Dangers can still occur on the return of the driving task. Since monitoring of the highly automated control was not expected from the driver prior to the return of vehicle control, dangers may reach a different quality than in case of partial automation. This requires further research. Dangers from manual driving (“driver only”) persist beyond the scope of application of highly automated systems.

4.3 Full automation

Possible causes of accidents in case of full automation are likewise force majeure and the risk of malfunction due to system defects. However, human error can be completely excluded as a cause of accident, unless exclusively caused by ill-driving of third party vehicles (and unless the driver himself adversely affects by oversteering the system). As for the return of vehicle control to the driver, further consideration must be given to the fact that the fully automated system is able to automatically return to the safe state; this means that no further dangers arise if the takeover does not happen. Possible risks from manual driving (“driver only”) exist beyond the scope of application of fully automated systems.

5 Feasibility of vehicle automation and motivation

To start with, it is realistic to expect partially automated systems to be launched first, possibly in combination with certain aspects related to higher degrees of automation. However, systems with full automation in public traffic are not yet in sight. From a technical perspective it must be noted that systems with the respective higher level of automation are not conceivable unless preceded by the development stage of partial and high automation: Given finite financial resources and without existing public infrastructure, the technical "leap" would otherwise prove too great to develop products for the complex traffic on public roads today and suited for series manufacturing. However, the systems of higher automation levels build upon each other in terms of sensor technology and environment sensing. Thus the highest and - with regard to road safety - best development stage of automation must be included in the discussion on increasing vehicle automation. Provisionally, it must be assumed that - particularly in systems with the automation level “partial automation” - the essential motivation and sales incentive of such systems on the market will be the benefit of comfort for the driver. From the perspective of society, in particular the impact on road safety is of interest. The crucial research question is the impact in this respect, and it will depend on many factors. Firstly, it is not expected that comfort and the benefits for road safety would exclude each other or even adversely affect each other in case of increasing vehicle automation. An increase of comfort can rather take positive effect on road safety by itself, by reducing the stress on the driver. In this respect, it is to be assumed that the so-called “conditional safety” of the driver would improve.

6 Legal assessment according to public regulatory law (StVO - German Road Traffic Regulations)

The results of the project group from the perspective of the regulatory law (public law) can be summed up in two ways: On the one hand there are legal obligations laid upon the driver regarding vehicle control and attentive road and traffic monitoring. These obligations are presupposed by the road traffic regulations (StVO) and put into concrete terms by individual provisions (for example, in provisions on speed, headway, overtaking, etc.). On the other hand there is the very specific question whether a driver's duty to drive hands-on will persist even in the case of automated two-track vehicles with an automated lateral control.

6.1 Obligation of the driver, according to regulatory law, to control the vehicle and to monitor roadway and traffic attentively

In the wording of the German Road Traffic Code, the obligation of the driver to control the vehicle is explicitly found only in relation to the vehicle's speed. The driver shall not exceed the speed he can control safely (sec. 3 para. 1, sentence 1 German Road Traffic Code (StVO).[12] This concept of control over the vehicle is also found in the Vienna Convention on Road Traffic[13], which facilitates cross-border road transport according to its character as an international treaty. Specifically this is stated in Article 13 paragraph 1 of the Vienna Convention, which also concerns the choice of speed, as well as in Article 8 paragraph 5 of the Convention. Both provisions of the Vienna Convention are to be found among the provisions on regulatory law ("Rules of the Road") addressing the vehicle driver – which makes them comparable to the scope of the German Road Traffic Code (StVO).

In addition to the vehicle control, section 1 StVO, which sums up the governing principles[14] for any behaviour in road traffic (as a catchall element), also includes the requirements of caution and considerateness. These should be noted in the interpretation of all special regulatory requirements and prohibitions addressed to the driver in the following sections of the StVO.[15] Inattentiveness to the roadway or any other neglection of driving tasks,[16] for example literally turning from the task of driving,[17] is considered a violation of these principles.

Also the special rules following systematically in the Road Traffic Code (as far as relevant for the scenarios) reflect duties of the driver: Immediate effect on the scope of the described system functions on motorways is found in the following specific rules on headway (sec. 4 StVO) and overtaking (sec. 5 StVO). They address road users directly[18] – as do the remaining provisions of Chapter I of the German Road Traffic Code. With all that, it is implicitly assumed that the participation in road traffic requires human[19] control. This is characterised as "action or neglection of contrary duty [...] with the aim of participation"[20] influencing a process in road traffic. Up to today, it has been assumed that this can be alone human control, even in case of driver assistance systems with a high degree of support – such as the adaptive cruise control (ACC) this has so far not been put to question: Such driver assistance systems still require the vehicle driver to monitor the surrounding traffic and roadway (as well as they constantly require immediate availability of vehicle control by the driver by means of oversteering if needed), so there is no contradiction to the driver's obligations in terms of regulatory law. This assumption of the factual necessity to permanently monitor roadway and surrounding traffic, as well as to control the vehicle, results from the persisting task of monitoring (lateral or longitudinal control) the driver is required to perform in this mode of automation. Furthermore this level of support provided by the system will not suffice to perform all tasks which are expected from the driver.
With the automation levels discussed and regulations studied so far by the project group, the first thing that stands out is the fact that all automation degrees can be designed to remain oversteerable at any time. This means that they will not prevent the driver from carrying out his duties described in the Road Traffic Code. This applies even more since the constant availability of the option to switch systems off remains available. However, it is necessary to analyse the degree of partial automation on the one hand and high or full automation on the other hand separately:

6.1.1 Partial automation

By definition, partial automation requires the driver to constantly monitor the roadway and surrounding traffic even in case the system is engaged with a corresponding level of automation. The driver is required to constantly stand ready for over-steering possibly required (which means the driver will also

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[12] This was also the judgment of the Federal Court of Justice of 4th Oct. 1966, case number: VI ZR 19/65, in Insurance Law (VersR) 1966, 1156 et seqq.

[13] Approving Act: Federal Gazette II, 1977, 810 et seqq. (the text of the treaty has been reproduced on the following pages of the Federal Gazette in the languages English, French and German). The Vienna Convention on Road Traffic of 8th November 1968 is also available in the contract languages on the UNECE website as amended from time to time: http://live.unece.org/trans/conventn/legalinst.html (accessed on 29th June 2011).

[14] Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 1 StVO, marginal number 5.

[15] Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 1 StVO, marginal number 6.

[16] Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 3 StVO, marginal number 67.

[17] Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 1 StVO, marginal number 7.

[18] Compare the term in: Jagow/Burmann/Heß, Commentary to the Road Traffic Law, section 1 StVO, marginal number 15.

[19] Hereto: Hamburg in the Collection of Road Traffic judgements (Verkehrsrechts-Sammlung, VRS) 36, 449.

[20] Jagow/Burmann/Heß, Commentary to the Road Traffic Law, section 1 StVO, marginal number 16.

need to take corrective action whenever the automated system control exceeds self-perceived personal abilities to control). In that case no contradiction is evident between the partial automation and persisting duties of the driver with regard to vehicle control or with respect to the principles of caution and considerateness from sec. 1 paragraph 1 StVO as well as the more specific regulatory legislation in the following sections of the StVO. Whenever automated system control deviates from the regulatory provisions – for example, by applying a substantially shorter headway than required by sec. 4 StVO – the carefully observing driver has the immediate duty to intervene by oversteering and thus to replace the (poorly performing) system control by own control over the vehicle ("driver only" control). The same is required in case a system would apply a higher speed than the driver believes to be able to control given his personal skills, or a higher speed than allowed in the specific driving or traffic situation or road section. Ultimately, the framework conditions of regulatory law for partial automation remain congruent with those of the driver assistance, and do not contradict regulatory law.

6.1.2 High und full automation

In cases of high or full automation, a degree of automation is reached which, in fact, would allow the driver to deviate from the principle of attentive roadway and traffic monitoring: during these automated phases, the drivers must neither monitor the highly automated nor the fully automated system nor its operation and resulting traffic situations. Monitoring of the system itself is limited to remain prepared for a demand to take over the driving, which is delivered in a suitable way – for example, acoustic or haptical – if required: Here, high automation and full automation differ in particular with regard to the imaginable lead times granted for a takeover, and in the feature that only the fully automated system will fully compensate for the absence of a takeover by the driver.

Excursus: Preliminary considerations

Before examining the regulatory regulations of the German Road Traffic Code in further detail, the following preliminary considerations need to be discussed:

In the following presentation, the regulatory provisions of the Road Traffic Code will be applied to the technology-driven vehicle in order to reveal contradictions under current legislation. This will be done despite of the fact that the addressee[21] of regulatory law is the road user. The traffic participant or road user is defined, objectively and subjectively, by the two characteristic features of behaviour with a relevant impact on the road traffic, say the action or the omission of actions, with the intention to participate (subjective component) in a road traffic event.[22] However, when the vehicle is controlled by a highly or fully automated system, the intention to participate – which is always and permanently present in the case of manual driving ("driver only") - is no longer existent; it is farmore eliminated to a hitherto unknown scale: the driver no longer monitors system control or the roadway and surrounding traffic, which means that in this case no (human) behaviour is significant for the traffic situation (and be it in the form of omission/neglection). In such highly and fully automated phases, the vehicle is in fact controlled by machine. This machine control, which replaces the driver, is able to drive in compliance with the regulatory legal requirements and prohibitions. Furthermore the automatic vehicle control cannot deviate from today's established code of conduct in road traffic since safe driving is required: Although regulatory regulations of the Road Traffic Code are addressed (only) to the human driver, machine control must abide to this code of conduct accordingly, alone to avoid danger. However, this does not mean that the regulatory provisions are binding for the design of machine control. This is not the case. According to applicable law, the only obligation implied would be the driver's duty to oversteer. Rules of Regulatory law would be legally enforceable and binding for machine control only if defined as technical requirements specifying particular objectives. The same result would be achieved in case regulatory law would be applied "accordingly" (which in fact creates technical performance requirements for the machine control – stipulating the end-result to be achieved).

This fundamental contradiction which arises from the nature of the Road Traffic Code as regulatory law can also be found in the individual codified rules of (of the German Road Traffic Code). To which extent this is the case, is considered in part below. Mind that this concerns exclusively the case when – as in the case for high and full automation – the driver would be still able to attentively monitor

[21] König, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 1 StVO, marginal number 5.
[22] Heß, in: Jagow/Burmann/Heß, Commentary to the Road Traffic Law, section 1 StVO, marginal number 16.

roadway lane and other traffic, which is, however, not intended by the envisaged automated driving system.

6.1.2.1 High automation

A benefit of the system that would justify the technical effort required unfolds in a highly automated system only if the driver is no longer required to monitor roadway and the traffic for the duration of the highly automated ride. According to applicable law today (for Germany: StVO), such conduct is legally not foreseen.

Assuming that the observation of the roadway and traffic would not be maintained, the conclusion could be made that there is a lack of driver control: when the driver no longer attentively observes the roadway in front of him and the traffic environment, it can no longer be assumed that he is still immediately capable to drive the vehicle. This eliminates the driver's control of the vehicle (at least temporarily). This follows directly from the underlying concept of the (necessary) action by wilful decision: any action requires some sort of human conduct, according to the basic legal principles of both the civil[23] and the criminal law. This can be achieved by an omission of intervention during automated driving. However, if the driver takes his attention away from observing roadway and traffic for a legally relevant period of time,[24] he can no longer take the driving behaviour of the system into account for a wilful decision, with regard to the specific situation developing on the roadway and in traffic. The will is therefore no longer related to the specific situation. Then, of course, there is also no legally relevant failure of intervention into system control and, subsequently, the human action is nonexistent in this scenario altogether.

Hence, in case of high automation, the regulatory demand for an attentively observing driver and the design of the technical system come apart: the highly automated system will call for a takeover by the driver when needed, to restore his attention to the monitoring of the roadway and the traffic environment; with that, also the vehicle control by the driver would be restored when necessary, in order to ensure traffic safety (provided sufficient lead time is available; duration is subject to research). Assuming regulatory law would allow the omission of roadway and traffic monitoring in case of high automation, it must further be taken into account that safe driving would also depend on the condition that the driver indeed takes up observation of roadway and traffic situation and indeed takes over the vehicle control too (as active action). Drivers' ability to resume control over an automated vehicle is a subject which needs to be researched (to the research needs cp. Chapter 8).

6.1.2.2 Full automation

As for high automation, system benefits justifying the technical effort (again in terms of comfort for the driver) will unfold only if the system allows the driver to cease attentive monitoring of the roadway and traffic for the duration of the fully automated ride. According to currently applicable law (StVO), this is precluded by the applicable provisions of regulatory law which have been discussed above.

If we again assume that the driver would cease attentive observation of roadway and traffic – which is in this respect fully comparable to high automation – there would be a loss of vehicle control by the driver: Targeted human action carried out wilfully and with full awareness is then no longer recognizable. The control of the vehicle runs fully automatically during the fully automated ride.

Again, the requirements of the regulatory law and the actual performance of automated vehicle control fall apart. However, in case of full automation, it does not make any difference in terms of safe driving whether the driver responds to the fully automated system's request to take over vehicle control or not:

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[23] Tortious action is understood as "controllable conduct based on mind control and wilful guidance under the exclusion of physical force or involuntary reflexes due to outside influence". Such action can have the form of an action or an omission. Compare hereto: Sprau, in: Palandt, Commentary to the German Civil Code (BGB commentary) section 823 BGB, marginal number 2.

[24] Compare hereto the rulings on the assumption of gross negligence: Higher Regional Court (Oberlandesgericht) Saarbrücken, decision of 21st Sept. 1973, case number: 3 U 97/72, in: Insurance Law (VersR) 1974, 183 et seqq. (regarding an object – a chewing gum – which fell to the ground inside a vehicle); Higher Regional Court Saarbrücken, decision of 14th Jan. 2004, case number: 12 0 394/02, in: MDR 2004, 874 et seqq. (the driver turned around toward the back of the car in a road bend at night); Higher Regional Court Cologne (Oberlandesgericht Köln), decision of 25th Nov. 1982, case number: 5 U 102/82, in: Insurance Law (VersR) 1983, 575 et seqq. (when the driver turned around toward the back of the car at a driving speed of 120 km/h).

In case the driver does not respond, the system will independently be capable of returning to the safe state (which, as a rule, will imply to bring the vehicle to a standstill at a suitable place). Insofar, current legislation requires much more from the driver than is indeed needed for safe driving in case of full automation.

6.1.3 Special case: emergency stop system

The emergency stop system takes over the control of the vehicle only in case the driver becomes incapable to perform any further action or becomes unconscious (due to a medical condition or when falling asleep). The driver is then no longer able to actively control the vehicle. The driver would be informed when the automated system takes over, and the driver can resume control of the vehicle at any time (in case the driver regains his ability to act). In contrast to the abovementioned partial, high and full automation, the sole purpose of automatic control in this case is to stop the vehicle in a situation classified as an emergency (thereby taking traffic aspects into account). The automatic control will be triggered only if the driver is no longer able to pay attention to the traffic and roadway or to actually control his vehicle. In terms of regulatory law, this constitutes an entirely different situation than in the cases of automation discussed above: while, in those cases, the Road Traffic Code can effectively oblige the driver to act in a certain way, in this case there is no capable addressee from the outset who can be expected to pay attention to the roadway and traffic, or who could be charged for the lack of vehicle control.

In terms of automation degree an emergency stop system can be classified as full automation, because the system is able to establish the risk minimal state by itself and the driver does not need to resume control. However, the emergency stop system represents a unique design given the system's scope of application, which is characterised by the absence of an effective driver. As far as the driver should be aware of the lack in his ability to drive, so if there was a reason to believe he might become unconscious or incapacitated in the course of the journey, it would lack on his fitness for "independent control" within the meaning of section 31 paragraph 1 of the German Road Traffic Licensing Regulations (StVZO).[25] Even a vehicle's keeper is obliged to keep a driver from using the vehicle, in case the driving ability of the driver is at risk as a result of disease, age, or fatigue.[26]

6.2 Driver's duty according to the rules of conduct to steer vehicles with both hands

The StVO includes the express obligation not to drive single-track vehicles hands-free (applicable to cyclists and drivers of motorcycles) (section 23 paragraph 3 sentence 2 StVO). An explicit requirement to steer two-track vehicles with both hands is not apparent in the StVO road traffic regulations. An analogue application of the prohibition of hands-free driving to the drivers of multi-track vehicles is not possible since there is no unintended regulatory gap: the other duties of drivers of single-track as well as multi-track vehicles are regulated in section 23 StVO. In this context, the prohibition of hands-free driving has expressly been restricted to single-track vehicles. Hence, hands-free driving of multi-track vehicles is not prohibited (nor will this be considered an administrative offence in the sense of section 24 of the German Road Traffic Act (StVG)) – unless it coincides with a concrete endangerment according to section 1 paragraph 2 of the German Road Traffic Code (StVO).[27]

The current legal opinion that hands-free driving of multi-track vehicles is a breach of duty has been derived from section 1 paragraph 1 StVO. This perception is based on the assumption that hands-free driving is a violation of the requirement to drive cautiously and considerately (basic principle of the German Road Traffic Code). This legal opinion applies to vehicles existing today and thus to conventional vehicle control by a driver. In conventional vehicle control – as well as in the case of driver assistance – situations are imaginable already at the stabilisation level of the vehicle, which seem to require steering action by the driver, in order to keep the vehicle stable. A driver driving "hands-off" would not appear to be in a position to perform the movements necessary for steering.

[25] Compare Dauer, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 31 StVZO, marginal number 10.

[26] Compare Dauer, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 31 StVZO, marginal number 9.

[27] König, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 23 StVO, marginal number 14, with the note that the breach of duty qualifies as negligence in case it causes any damage.

This leads to the conclusion that hands-free driving of a conventionally controlled vehicle is a consistent breach of driver's duties.

In contrast, in case of semi-automatic driving of a vehicle, it can be assumed that, technically, the system would compensate all adversities due to short-term environmental conditions (road surface, crosswind, etc.) at stabilisation level. Only at the level of vehicle guidance it can be assumed that such a semi-automatic system will reach its limits and may require correction (in terms of steering) by the driver (for example, to avoid obstacles). Technically, the driver would not be required to steer the vehicle with both hands, in order to stabilise the vehicle.

Another duty of the driver is to handle unpredictable obstacles at the level of vehicle guidance (for example to react reasonably on falling cargo or – within certain limitations – to wild animals crossing). The requirement would therefore be that it remains possible for the driver, even after previous hands-free driving, to master these situations in in a way that the requirement of constant caution within the meaning of section 1 paragraph 1 StVO is still met. This requires equally safe reactions to such obstacles as are possible for drivers of vehicles that are driven in a conventional manner from the start (i.e. with two-handed steering). Currently no final decision can be made whether this would be the case. The Project Group therefore sees a research need from the behavioural-psychological aspect, as to the question whether, after previous hands-free driving in semi-automatic systems, unpredictable obstacles can be handled by the driver in a comparable manner (cf. Research needs, Chapter 8.1).

Indeed it depends on the actual traffic situation whether steering with both hands would be required on the vehicle guidance level: the partially automated system is able to keep the vehicle in the lane, but does not respond to misconduct by other road users or unexpected obstacles on the roadway (system limit). Not every traffic situation will be likely to give reason to expect the appearance of such obstacles and disturbances at extremely short notice: in case of sufficient visibility, sufficient track width and low traffic density it can be foreseeable over long distances that an active operation of the driver may not be required at short notice for such reasons. Conversely, particularly difficult traffic situations (such as narrow lanes at construction sites, high traffic density and many others) can make very short-term steering reactions absolutely necessary.

As a result, we can therefore summarize that there is no prohibition of hands-off driving of multi-track vehicles. However, hands-off driving can interfere with the driver's obligation to practise constant caution and can therefore lead to a violation of the provision in section 1 paragraph 1 StVO. This is the rule in conventional driving of vehicles, as well as in case of the driver assistance today. In semi-automatic vehicle control such an infringement is imaginable only at the guidance level (because all disturbances at vehicle stabilisation level are dealt with by the automatic steering function). At vehicle guidance level, an obligation of the driver to steer the vehicle with both hands is to be assumed depending on the actual traffic situation even for partially automated systems whenever the traffic situation requires the driver to control the vehicle. This is notably the case whenever misconduct of other drivers must be expected (for example on narrow lanes, in dense, fast-moving traffic, as well as in case of recognised wrong behaviour of other traffic participants, even if they may still be farther away, etc.). It is still unknown and must be made subject of further behavioural-psychological research, whether, in the remaining situations on vehicle guidance level which may include totally unexpected and unpredictable hazardous situations, the driver will still master any necessary take-over of vehicle control in a suitable manner even in the case of driving hands-off.

7 Legal assessment according to liability law

7.1 Liability of the vehicle keeper

The German Road Traffic Act (StVG) allocates the responsibility for the so-called "operational risk" of an automobile, to the keeper of a vehicle. This operational risk materialises equally from either a driving error of the driver or a technical defect of the vehicle. In this respect, the question could arise to what extent the technical defect may include vehicle control by means of an automatic system. According to the wording of section 7 paragraph 1 StVG, the technical defect of an automatic system would be included in the term "operation" within the meaning of the provision. In the past, it has been assumed with view to driver assistance systems that any damage, which is due to a malfunction of such systems, can be assigned to the operational risk – which is imposed on the vehicle keeper in terms of liability law in section 7 paragraph 1 StVG.[28] This allocation of the operational risk is consequent, since the vehicle keeper continues to bring the risk a “motor vehicle” involves into traffic. The vehicle keeper is therefore generally defined as the one who uses the vehicle for his or her own account, therefore bears the cost, profits of its use[29] and holds the power of disposition, meaning the power to decide for what purposes and at what times the vehicle may be used.[30] This situation does not change by the operation of automatic systems in motor vehicles and therefore can still be used to establisch the liability of the vehicle keeper for the operational risk.

7.2 Liability of the driver

In addition to the keeper of a vehicle, the driver is liable in case of damage, especially according to section 18 StVG (as well as according to section 823 BGB (German Civil Code), which will not be discussed here in further detail). Pursuant to section 18 paragraph 1 sentence 2 StVG, fault of the driver is legally assumed (under civil law) until proof to the contrary is provided. The liability of the driver (section 18 StVG) can be consistently applied in case of partial automation (which requires the monitoring by the driver at all times). In the cases of high or full automation the situation occurs that, in the automated phases which do not require monitoring by the driver, the assumption of fault against the driver is not always appropriate. However, this does not result in a legally unsolvable situation, because the driver still has the option to provide proof of exoneration.

7.2.1 Partial automation

In case of partial automation, it is the duty of the driver to monitor the control exercised by the system on the basis of own (attentive) observation of roadway and traffic. In this context, accidental damage is possible under various conditions: firstly, it can be solely caused by misconduct of third parties. In this case, the driver can exonerate himself from the legal assumption of fault – exactly as in conventional driving (“driver only”) - by providing proof of misconduct on the side of the third party. Accidental damage can, of course, be also due to the driver’s own insufficient monitoring of roadway and traffic and his failure to override the partially automated system. In this case of partial automation, the driver would have indeed committed a breach of his obligations, with the result that an assumption of fault according to section 18 StVG would be justified. In summary, the situation with the use of partially automated systems does not differ from today’s use of driver assistance systems. These require constant monitoring and, if necessary, correction in cases of error at all times.

7.2.2 High and full automation

The situation must be classified differently when highly or fully automated systems are used. These systems do not require the driver’s attentive monitoring of roadway and traffic - assumed this use would be permitted according to regulatory law. Also a constant monitoring of the system is no longer required, apart from the driver’s availability to resume control upon request. The driver who is thus freed of the active vehicle control during the automated phases cannot act with fault from the outset - unless he actively overrides the system or fails to resume vehicle control despite of having been urged to do so. Therefore, the question arises what would still justify the presumption of fault against the driver in accordance with section 18 StVG. Ultimately, the driver is burdened in such a situation with the requirement to provide evidence that the automatic vehicle control was active at the point in time when the accident happened. It is possible that a situation arises in which such proof cannot be presented under civil law. However, this would not result in a legally not resolvable or intolerable situation, particularly not in view of the driver’s co-insurance in the motor vehicle liability insurance. Further, the burden to the driver is not to be classified any higher in this case than in case of conventional driving if fault of a third party cannot be verified under civil law. Just on the contrary, the burden is reduced, because the driver immediately benefits from the use of the highly or fully automated system.

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[28] Berz, Dedy, Granich, in: DAR 2000, 545 (545); Albrecht, in: VD 2006, 143 (146); Albrecht in DAR 2006, 186 (190).
[29] König, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 7 StVG, marginal number 14.
[30] Burmann, in: Jagow/Burmann/Heß, Commentary to the Road Traffic Law, section 7 StVG, marginal number 5.

7.3 Motor vehicle liability insurance

In terms of the motor vehicle liability insurance, the vehicle keeper and the driver are co-insured (in accordance with section 2 cipher 1 and 3) of the German motor vehicle liability insurance regulation (KfzPflVV)). If therefore a damaged third party raises claims against vehicle keepers or drivers, these are covered by the insurance. Pursuant to section 1 of the German Compulsory Insurance Act (Pflichtversicherungsgesetz, PflVG) and to section 115 paragraph 1 sentence 1 and sentence 4 of the German Insurance Contract Act (Versicherungsvertragsgesetz, VVG), the liability insurance company is also obliged directly towards the injured party for damages, and liable to the injured party as joint and several debtor together with the vehicle keeper (and, if applicable, the driver, see above).

Automated driving will not cause any relevant change to the liability principles of the motor vehicle liability insurance, if we assume that the use of automated systems is included in the insurance contract. At the time of the preparation of this report, vehicles with automated systems of partial, high and full automation are regularly considered as "special types of vehicles", which are excluded from regular insurance or insurable only at a surplus premium. It is however to be expected that the use of automated systems in motor vehicles, which will then also be included in the vehicle type approval, will become a coinsured risk, while the now generally accepted range of vehicle liability insurance policies will be retained. This, however, will require that, at the same time, the intended use of highly and fully automated systems will be allowed by regulatory law.

7.4 Product liability of the manufacturer

The manufacturer is responsible for a defective product from the point of view of absolute liability under the Product Liability Act, or from the aspects of fault (due to culpable violation of his legal duty to maintain safety by placing a defective product on the market) pursuant to section 823 paragraph 1 BGB. Both bases for claims have some peculiarities, however, the fault-based liability from section 823 (1) BGB today largely approximates the absolute liability under the Product Liability Act. In view of the claimant's burden of proof, in practice, it is of essential importance for product liability claims to provide evidence that the product was defective and caused the damage. The definition of a 'defect' as assumed by section 823 paragraph 1 BGB and provided in section 3 Product Liability Act (ProdHaftG), is congruent[31] and the central term in this context. For the purpose of the following presentation no further differentiation is therefore required between these bases for claims.

For the determination of the defectiveness in the present context of automated systems, the handling by the driver is of paramount importance, since, in the case of partial and high automation and with the here underlying definitions, the vehicle can be controlled safely only if there is an interaction between driver and system. An essential requirement is that the driver is aware of the performance capability of the system and thus of the system limits, because the monitoring of the system by the driver and his corrective interventions (or the resumption of vehicle control, respectively) are necessary, in case of partially and highly automated systems. Equally important is the driver's own assessment of skills (considering age, health, etc.). While monitoring a partially automated system as well as for the take-over from a highly automated system it is crucial for the driver to detect signs of a necessary override or transition and to operate the vehicle appropriately. Therefore, the expectation of the user with regard to the behaviour of this system is of utmost importance for the proper use of these systems. From point of view of product liability, the instructions of the manufacturer are important, as well as the proper understanding of the recipient. The user manual as well as public statements made for example in credible adverts have a concrete impact on the user expectations which is relevant within product liability law.

Another relevant source of defects, which is upstream of the production process of the individual piece in terms of product liability law, is flawless design of automated systems. It remains unclear which requirements will apply in this case. Particularly in a system which, in collaboration with the driver, shall enable fault-free vehicle control, many questions come up as how to delimit the defect with regard to construction. According to a judgement by the Federal Supreme Court (BGH)[32] on passive

[31] Sprau, in Palandt: BGB commentary (Commentary to the German Civil Code), section 823 BGB, marginal number 166; Wagner, in: MüKo, BGB commentary (Commentary to the German Civil Code), section 3 ProdHaftG, marginal number 3.

[32] "Fehlauslösung von Airbags" (Accidental release of airbags), BGH (Federal Court of Justice), decision of 16th June 2009, case No.: VI ZR 107/08.

safety systems, it is crucial that a product provides the safety which is generally considered necessary in the respective area. In order to avoid danger, a production solution must be applied that is considered fit for use among experts in the respective field. According to the decision of the court, this still significant requirement finds its limit in the reasonability of such measures, depending on the risk level of the product and the economic impact of a safety measure.[33] When assessing this statement in the present context, the relevance of the individual case of a passive safety system must be considered which, if at all, can be influenced only very indirectly by driver's conduct.

However, under the assumption that the findings in the cited judgment were transferable to driver assistance and automated systems, the consequence would be that, with regard to design and construction, significantly lower requirements in terms of safety measures would need to be applied in case of systems exercising longitudinal and/or lateral control of the vehicle if the driver is required to monitor and correct maschine control. In contrast systems no longer requiring permanent monitoring by the driver – such as highly or fully automated systems (provided their use would be permitted to the driver by regulatory law) would be required to meet substantially higher design requirements. This would apply to driver assistance systems and partially automated systems in consequence of their risk-level and since they can be oversteered at any time because permanent monitoring by the driver allows to assume constant availability of the driver as a fallback level. This, however, simultaneously implies the obligation to particularly carefully instruct the driver in this regard, in order to reasonably influence the user's expectations to the system's capabilities and to encourage him to perform any necessary overriding. The safety of the design is therefore closely linked to the instructions provided to the driver.

7.4.1 Delimitation of reasonably foreseeable misuse or abuse[34] of the product (in the case of partial automation)

While in semi-automatic systems the driver must be available as fallback level at any time and immediately, as it is the case already today for driver assistance systems, it is a special feature of partial automation that, although the driver is required to monitor the steering behaviour, he does not need to correct the longitudinal and lateral vehicle control – sometimes over long periods of time, depending on the environment. Thus, if the driver turns away from his duty to monitor the steering, potential significant disadvantages may arise only with a delay. It is to be assumed that the user instructions would strongly warn against such use of partially automated systems.

The scale for determining the defectiveness of a product is, pursuant to section 3 Product Liability Act, the objectively determined legitimate safety expectation. The basis for the determination is the use which can be reasonably expected (cf. section 3 paragraph 1b Product Liability Act). It is recognized by jurisdiction that this must not alone be derived from the instructions enclosed, but must also take the "normal use"[35], the "not entirely unexpected misuse"[36], and exaggerated expectations of the consumer into account. This addresses the distinction between predictable and usual misuse (which lies within the responsibility of the manufacturer) and product abuse (which in the sole responsibility of the user), and admission is made that, in cases of doubt, there always "remains an inevitable degree of uncertainty"[37] when demarcating the terms from each other.

As demarcation criteria are considered: the extent to which improper use of the product must be expected, the extent of damage and the costs of safety measures, which must be accounted for.[38] A

[33] Lenz: "Zur Herstellerhaftung für die Fehlauslösung von Airbags" (About the manufacturer's liability for the accidental release of airbags), in: PHi 2009, 196 (198).

[34] Wagner, in MüKo, BGB commentary, section 3 ProdHaftG, marginal number 21, explains the concepts of "misuse" or "abuse" as follows: "[...] In addition, the provision of section 3 paragraph 1b [Product Liability Act] covers the misuse of a product as its use in contradiction with the intended use, as far as it is predictable or customary. […] The limit is reached in cases of misuse when the user deliberately alienates the product and thus provokes risks that cannot be attributed to the manufacturer, but are solely at the account of the user [...]."
Simplyfying strongly, this means the manufacturer must take "misuse" into account (and shall be liable in this regard), because the user accidentally exceeds system boundaries in the application, which are not clearly obvious for the specific group of users; while "abuse" of the product captures the case where the user (intentionally) disregards system boundaries, which he can be reasonably expected to know upon objective examination.

[35] Sprau, in: Palandt, BGB commentary, section 3 ProdHaftG, marginal number 6.

[36] At the same place, footnote 31.

[37] Wagner, in: MüKo, BGB commentary, section 3 ProdHaftG, marginal number 21.

[38] At the same place, footnote 33.

misuse which is subject to the manufacturer's product liability needs to be considered, if the risks cannot be easily identified by the consumer and can cause large scale damage.[39] Special care is paramount, if a product misleads to a particular type of use for which it is not suitable by design from the outset.[40] However, a lowering of safety standards of a product can be justified in case specific users have established certain precautionary measures.[41]

Therefore, if no technical solutions are available to safeguard partially automated systems against driver's turning away from his driving task, it will be considered crucial to place and present products with partial automation in such a manner that the lower degree of automation (in comparison to high and full automation) becomes apparent, so that their monitoring to ensure safe use can be considered self-evident and a matter of course even by the average driver with low risk recognition capability,[42] and it is an obvious lack of due diligence if he acts otherwise. It will be in particular crucial to exclude the confusion with higher degrees of automation among the users.

7.4.2 Product liability in highly and fully automated systems

The situation in case of highly and fully automated systems must be assessed differently when in automated driving mode. With regard to phases which no longer need to be monitored (again, provided that the use of highly and fully automated systems would be permitted to the driver by regulatory law), the instruction of the user/driver can still have an impact in case vehicle control needs to be returned to the driver (according to the definitions: upon request), however, this impact no longer takes effect immediately. With that, the high demands on the instruction referring to the transition of vehicle control remain the same. At the same time, the system definition itself bounces the demands back to system construction: In the light of the significant risk level which originates from an independent control system on public roads, such highly and fully automated systems need to be designed in such a manner that they are automatically able to deal with all situations that may occur during any period of automated driving.

At the same time, this finding leads to the assumption that any type of damage that occurs during periods of highly or fully automated driving implies a causally underlying product defect, unless the damage is caused exclusively by a third party in the road traffic, and also provided that the cause was not the driver's failure to resume the steering of the vehicle after a "sufficient lead time" and appropriate instruction. This assumption will, of course, only apply if aspects of procedural law are taken into account, in particular the burden of providing evidence of circumstances and the burden of proof in a civil case. A system definition that allows the driver to (temporarily) discontinue attentive monitoring of roadway and traffic as well as monitoring of the system will, according to the current classification according to the product liability law, inevitably lead to the assumption of a product defect, if an accidental damage occurs during a period of automated driving – and this is unaffected by the driver, such as without oversteering.

A different conclusion will be regularly made for damages caused by other road users who acted contrary to road traffic regulations. Despite the obligation to defensive driving (based on the principle of constant caution and considerateness pursuant section 1 paragraph 1 StVO), the confidence principle must be adopted under current law in the interest of free-flowing traffic, which implies that a road user who obeys the road traffic regulations does not need to take into account all possible traffic violations of other road users – unless there have been indicators.[43] If we transfer this regulatory principle to the case of automated control by a highly or fully automated system[44], we will come to the conclusion that a damage can be caused by such a predominant portion of third party's fault that there must not necessarily be a defect in the automated vehicle control. In such cases it will be crucial to establish which situations can still be handled by the automated system and can be proven by the parties according to procedural law.

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39 At the same place, footnote 33.

40 Wagner, in: MüKo, BGB commentary, section 3 ProdHaftG, marginal number 13.

41 Wagner, in: MüKo, BGB commentary, section 3 ProdHaftG, marginal number 10, provides the example of a tractor without roll-over protection, which in certain regions of Europe may have led to precautionary measures on the part of the users (farmers), thus causing a lowering of otherwise necessary safety measures.

42 Wagner uses this term in: MüKo, BGB commentary, section 3 ProdHaftG, marginal number 8.

43 König, in: Hentschel/König/Dauer, Commentary to the Road Traffic Law, section 1 StVO, marginal number 20.

44 Compare the discussion of the problem how duties of conduct can be transferred to a system, above in the excursion of section 6.1.2.

Another important issue arises from the question to what extent highly automated systems can exhibit system limits. The answer to this question again arises from its definition: System boundaries are possible and logical to the extent as they require a transition of control to the driver only after “sufficient lead time”. However, a system limit that requires an immediate return of vehicle control is inconceivable (alone because of the presumption that monitoring is not necessary). System limits are therefore possible only within a very narrow range.

7.4.3 Special case: emergency stop system

In terms of liability law, the emergency stop system has the peculiarity that it takes over driving only at recognised incapacity of the driver. As far as the liability of the vehicle keeper according to section 7 StVG and the motor vehicle liability insurance are affected, it must be assumed that the automatic vehicle control implemented by the emergency stop system belongs to the “operation” of the vehicle, provided the system is licenced for road traffic. This has the effect that damage occurring during automated vehicle control implies liability on the side of the vehicle keeper. This is different in case of the driver: unless it is at least to be expected that a loss of consciousness or inability to act might occur, the driver’s liability for damage during automated control by an emergency stop system is excluded due to lack of fault (the driver must, however, provide proof pursuant to section 18 paragraph 1, sentence 2 StVG).

If the range of application an emergency stop system provides leads to a standstill of a vehicle, preferably on the hard shoulder, but according to the respective traffic situations also on the currently used lane (without a lane change), the enduring operational hazard, especially on highways must in both cases be taken into account: If damage is caused by the stopping or standing vehicle, this belongs to the vehicle keeper’s risk and he must take responsibility in terms of liability law and economically. The motor vehicle liability insurance will regularly insure “vehicle use”. Automatic control of the vehicle does not reflect wilful use of the vehicle, but it is obviously directly induced by the previous use of the vehicle (and insofar comparable to entirely uncontrolled events such as skidding). It is therefore to be assumed that automated control in the event of an emergency stop system should be covered by the scope of the insurance (again, provided the system has been licensed, for example, within vehicle type approval). This is supported by the fact that the emergency stop system only decreases the state of increased operational risk of the vehicle which has previously wilfully been induced by the driver taking up high speed. The operational risk is now decreased in a controlled manner by reducing speed (and if necessary by changing lanes).

With regard to product liability law, the special character of the emergency stop system seems to require a possibly different assessment, as a “special case of full automation”. The emergency stop system takes over the control of the vehicle only in case of an emergency which is characterised by an incapacitated driver for physical reasons. This is, however, a very special situation, as alternative human monitoring of automation is not available. Instructions are unnecessary since the system operates entirely independently – apart from instructions regarding the possibility to resume control/ override the system whenever a driver regains ability to act.

A key point from a perspective upon product liability law is therefore the design of such a system. Guiding principle for an emergency stop system in this respect can therefore not be today’s situation of a physically incapacitated driver and a vehicle without any control. In so far as from today's perspective, every ever so inadequately working emergency stop system might improve road safety in these cases such a design-standard would take a significant, but socially so far only accepted risk as benchmark. It is rather to be expected that such a system will need to comply with the state-of-the-art in science and technology already at the time of initial installation – just as any other product. The decisive guiding principle is therefore the common opinion in the respective field, which is likely to be comprised of what might be considered a deployable solution of such an automated driving system in expert circles at the time of marketing.

Nevertheless, the requirements cannot be set as high as for the highly and fully automated phases discussed above: there, the possibility provided to the driver to wilfully turn away from the driving process (and thus to abandon attentive roadway and traffic monitoring wilfully, with all resulting consequences), implies that such a system cannot have any system limits acting in the short term. In contrast, the use of the emergency stop system creates no additional danger due to an active abandonment of human control over the vehicle, but improves the existing situation caused by the inability of the driver in all possibly imaginable cases. Thus system designs are acceptable which exhibit system limits – as long as the state-of-the-art in science and technology cannot (yet) provide for any better and fully operational solutions. For example, if such an emergency stop system in case of missing lane markings would not be sufficiently enhanced to handle lateral movement of the vehicle by sensing the edges of the road and surrounding traffic and the vehicle would therefore stray from its lane under these environmental conditions, then this would not be considered as critical in terms of product liability law, provided - and this is important – this would be an integral feature of the current state-of-the-art in science and technology that is fully operational and reasonably to be taken into account.

8 Research needs

The work status of the project group in relation to the legal assessment of automated driving is in many ways limited by the state of knowledge accessible to the project group on the research items listed below. The answers to those questions are a precondition for a final legal assessment. The need for research can be classified according to the level of abstraction and degree of automation, as shown below – although this description shall not be regarded as comprehensive.

8.1 Partial automation

In the case of partial automation, there is a need for research on how situational awareness of the driver can be maintained. A closely associated question is whether the ability of the driver can be maintained to resume the full control of the vehicle at any time. One focus is on design of the human-machine interface in in this respect. Further, strategies need to be developed to keep the driver in the control loop, and there is a need for the development of driver monitoring technologies. This work can be supported by legal evaluation of the impact these solutions take on foreseeable misuse and abuse of such products, in order to investigate retroactive effects which might lead to the assumption of fault in construction.

A very specific research question in the field of behavioural psychology lies in the area of hands-free driving in a partially automated vehicle, with regards to the controllability of unexpected situations. What needs to be determined is, specifically, whether in case of partially automated systems that allow hands-off-driving show that the driver can cope with unforeseeable events in a comparably safe way as in conventional driving.

8.2 Partial and high automation

Some comprehensive questions touch both degrees of partial and high automation. They concern the ability of the driver to anticipate forthcoming control of the automatic system. Compatibility of system control and driver expectation is thereby crucial. This is also the key factor for confidence of the driver in a system, and the closely associated reliability of system control. At the same time, this addresses the question of system acceptance. It is in this respect to be clarified whether a generic rating system can be developed (ultimate object, feasibility uncertain). Further, it would be useful to develop a driver model for a model-based detection of the driver’s state.

8.3 High automation

High automation implies own challenges on maintaining a driver’s attention and readiness to resume control. These questions are different from those in the case of partial automation, because in case of full automation it has been specified that the return of control to the driver will only be required after a certain lead time. Therefore, this requires specific technical strategies as well as the exploration of special secondary tasks which will be suitable to ensure the attention of the driver, adequate to high automation. In case of high automation, degradation scenarios of driver attention are an important research issue, because this must be recognized in time. These questions are closely connected with the answer to the question, what period of time is to be considered as a “sufficient lead time” for the takeover of vehicle control in case of high automation. This is an overarching issue which requires also the contemplation from the aspect of behavioural psychology. The transition between machine and conventional control must also be legally assessed in depth and classified on the basis of the specific system design.

8.4 Full automation und emergency stop system

Full automation – as well as the emergency stop system – shows a need for research with regard to the description of “minimal risk conditions” in different situations as well as of appropriate manoeuvres to reach these states. The need for further research in the area of very high automation, which is not to be expected as feasible in the near future, cannot be assessed at present. Full automation still requires considerable technical research.

8.5 Cross-sectional need for research

It is to assume that the legal risk situation as well as social acceptance of high or full automation could currently lead to the prevention of technologies that have the potential to improve road safety. As already shown in picture 4-1, there is the positive effect of accident prevention, but there is also the occurrence of a (few) accidents linked exclusively to automation itself, because there can be no 100% safety. The acceptance of these cases and their legal handling today can potentially prevent the implementation of automation, although the use of automation would clearly result in an overall benefit at the level of society. In the project group, it has been suggested to look into the past discussions which led to the compulsory requirement to wear seat belts, and to examine whether the arguments are transferable to the introduction of automation in legal terms. There is consensus that this issue raises some philosophical questions at the same time and that there is need for collaboration between accident researchers and engineers as well as legal scholars to find answers to these questions.

Questions of licensing law were not subject of the project group’s task. The members of the project group agree that questions of licensing law may potentially arise in case of high automation. However, consensus has been achieved that that, in the first step, the systems always should be designed such that no need for training occurs hence a design should be chosen that allows for intuitive operation. The case of transition of vehicle control back to the driver in case of high automation could potentially require training, but first an attempt to achieve a design that allows handling a takeover intuitively should be made (primarily). This question related to the transition of control in a vehicle with high automation has already been formulated as a research question (section 8.3). An independent need for research in relation to driver licensing law is therefore currently not obvious from the project group’s point of view.

Research is needed into the question, whether infrastructure measures might significantly support the safety effect of automatic driving functions. In most cases, such measures would already improve the availability of driver assistance systems today, or it would be measures which are anyway required to improve traffic efficiency (mobility). Below is a short summary of such measures with their respective significance for vehicle automation:

- Good quality lane markings (in particular: contrast), especially on federal highways (BAB) and well developed multi-lane expressways

  (This measure is already relevant in the case of partial automation and, at the same time, increases the safety of driver assistance systems.)

- Continuous availability of hard shoulders (also called "emergency lanes"), in order to enable automated vehicles to reach a comparatively safe system condition fast.

  (This measure is important for systems above the degree of high automation, but also for the emergency stop system which can be realised comparatively short-term.)

- Continuous equipment of motorways and federal highways (BAB) with game fences.

  (This measure would preclude the danger of animal-vehicle crashes which are most likely uncontrollable at high speeds – even in case of automation. At the same time, these have a safety impact on road transport as a whole, also for conventionally driven vehicles – “driver only”).

- Improve the quality of traffic information (beyond the reliability of the traffic message channel (TMC)), capturing any change in traffic guidance and warning on dangers ahead.

  (Traffic information has a safety effect, if it is highly reliable and available. It is essential for automation levels of high and full automation, but road transport would benefint from the safety-improving effect as a whole, including conventionally driven vehicles – “driver only”).

- Camera monitoring of certain categories of roads (motorways and federal highways) for the purpose of pedestrian detection in compliance with the data protection framework.

  (This measure improves the availability of specific traffic information on the presence of pedestrians on roads with fast traffic. This measure is significant mainly for systems above the degree of high automation.)

- Research and development of a technical solution that enables communication between traffic lights and vehicles with regard to status (car-to-traffic light).

  (This specific measure in the field of vehicle-infrastructure communication is a prerequisite for the implementation of automation in areas with traffic lights. At the same time it would provide a significant benefit for driver assistance functions too.)