

GOVERNMENT STATUS REPORT, 2017

FEDERAL REPUBLIC OF GERMANY

Christian Theis, Head of division automotive engineering
Federal Ministry of Transport and Digital Infrastructure
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1. STATUS AND TRENDS

1.1. Road accidents in Germany

The total number of police registered road accidents has stagnated for the last 10 years – between 2.2 and 2.5 million road accidents. There were slight increases in single years such as 2007, 2010 or 2015, but as well slight decreases in 2002 or 2011. On the long run, there is an increase since 2000 by 7 % in 2015. The forecast for 2016 also indicates an increase in accident figures by roundabout 3 % (2015: 2.52 million road accidents).

The number of road accidents with personal injury has decreased by 20 % since 2000, resulting in 305,659 road accidents with personal injury in 2015. This number has increased in the last two years by about 5 % and for 2016 again a slight increase of almost 0.3 % to approximately 306,500 injury accidents is expected.

Casualty figures have also decreased since 2000, with lower reductions for slight injuries and higher reductions for severe injuries and fatalities. The total number of casualties has decreased by more than 22 % from 511,577 in 2000 to 396,891 in 2015. The increased number of injury accidents in the last two years led also to an increased number of casualties of approximately 5 % compared to 2013. In 2016 an increase to about 398,000 casualties is expected.

Since 2000, the number of severe injuries has been reduced by nearly 34 % to 67,706 seriously injured road users in 2015 and the number of slight injuries has been reduced by nearly 19 % to 325,726 slightly injured road users. Fatalities have decreased by 54 % from 7,503 fatalities in 2000 to 3,459 fatalities in 2015. After the increase of the number of fatalities in the last two years in 2016 a decrease to approximately 3,240 fatalities has been predicted.

In contrast to the positive development on the long term, the year 2015 showed an increase of the number of fatalities the second year in a row. And also for the number of injury crashes and casualties the year 2015 was the second year with an increase of accident figures.

The forecast for 2016 shows a stagnating or even increasing number of accidents but a decrease in fatality figures by about 6 %. While many factors concerning e.g. safety behavior or vehicle and infrastructure safety play an important role for the long term development of fatality and crash figures, short-term increases result mainly from changes in mobility and traffic behavior due to different and extreme weather conditions. The years 2014 and 2015 were characterized by an early and mild spring, resulting in high accident and fatality figures concerning mainly motorized and non-motorized two-wheelers. The decrease in 2016 is accordingly mainly due to reductions of the fatality numbers for two-wheelers.

1.2. Socio-economic costs due to road traffic accidents in Germany

The Federal Highway Research Institute (BAST) calculates the costs of road accidents on an annual basis. The costs of road traffic accidents to Germany's national economy include personal injuries and damage to goods.

The calculated costs include direct costs (e.g. for medical treatment, vehicle repair/replacement), indirect costs (for police services, the legal system, insurance administration, replacement of employees), lost potential growth (including the shadow economy), lost added value of housework and voluntary work, humanitarian costs, costs of monetised travel time losses due to accidents on motorways. Using the developed calculation model an analysis of very severe injuries and the effect of underreporting on total accident costs could be accomplished.

The calculated total accident costs for 2015 amounted to approximately 34.44 billion Euro.

Furthermore, personal injuries amounted to 14.31 billion Euro. Costs of about 20.12 billion Euro were caused by damage to goods.

The costs per person add up to 1.192 million Euro for a fatality, 123,510 Euro for a severely injured person and 5,139 Euro for a slightly injured person.

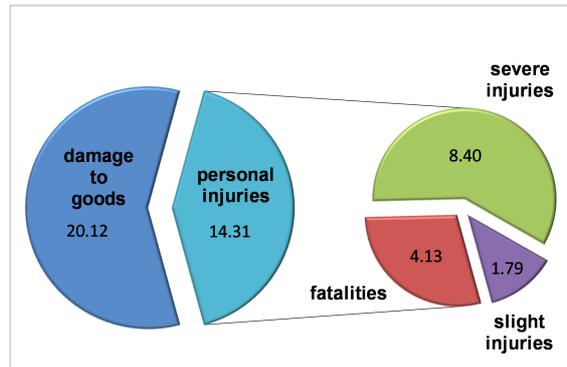


Figure 1: Costs due to road traffic accidents in 2015 (billion Euro)

1.3. German Road Safety Programme

The German Road Safety Program was launched in autumn 2011 and will be running for ten years until 2020. The principal aim of the program is to enable safe, ecologically sensitive and sustainable mobility for all road users in Germany. It comprises a wide range of road safety measures addressing road users, vehicles and the road infrastructure.

The program addresses new challenges (e.g. demographic change and mobility of elderly) and aims at safeguarding the efficiency of the road network. At the same time, it reflects recent technological developments in vehicles such as driver assistance systems, cooperative vehicle systems or new engine concepts. In these latter areas, the main focus lies on ensuring that the development of vehicle technology induces safety gains rather than safety risks. Activities also focus on rural roads and on reducing not only the number of fatalities, but also the number of serious injuries.

For the first time, a quantitative target of -40% for fatalities by the year 2020 was set. The target was defined on the basis of scientific research regarding the expected development of road safety until the year 2020 (R. Maier et al., 2012 a). The monitoring and assessment of road safety measures and the development towards the target is done by the Road Accident Prevention Report, which is prepared every two years and submitted to the German Bundestag. In 2015, a Midterm Report has been launched and published, taking stock of the first half of the road safety program. After the increase of fatality numbers in 2014 and 2015 the number of fatally injured traffic participants has been reduced only by 13.7 % since 2011. To achieve the reduction of 40 % by 2020 further efforts in the next years are necessary. As key issues the accidents of pedestrians and cyclists inside urban areas as well as accidents of cars and motorcycles on rural roads were identified.

2. RESEARCH

2.1. Finished projects

2.1.1. EU Twinning Project - Support to the Ministry of Infrastructure of Ukraine in Strengthening of Safety Standards of Commercial Road Transport

While the accident and mortality rates in the EU tend to decrease, road safety performance in Ukraine remains very low by international standards. The mortality rates from road traffic injuries are among the highest in Europe, standing at 21.5 deaths per 100,000 populations compared to 13.5 averages in WHO European Region.

To help the Ministry of Infrastructure of Ukraine (MoI) in improving the situation, the EU - in consultation with the MoI - considered "institutional twinning" with a Member State (MS) of the EU as the most relevant way to provide assistance in the framework of the EU-Ukraine cooperation. It should accelerate the capacity building of the MoI in benefitting from EU experience and practices, specifically relating to road traffic safety management systems, qualification of directors and managers of road transport companies and drivers, certification of vehicles and their components and accident investigation.

In cooperation with Polish and Lithuanian partners, the German Federal Office for Goods Transport (BAG) and the German Federal Highway Research Institute (BAST) have been involved in the twinning.

BAST took the lead in Twinning Component D, supporting the implementation of technical investigations of accidents. This included assistance in establishing a legal framework, technical education of Ukrainian experts and the preparation of detailed procedures.

It must be noted, that the new draft Law of Ukraine "On Road Transport" includes article 75, according to which road traffic accidents involving vehicles of road operators – physical or legal entities engaged in transport of passengers and goods - are subject to technical investigation. Technical investigations shall be carried out without interference in the work of bodies, the procedural investigation activities of which are foreseen in the legislation.

In particular BAST experts have been conducting analysis of existing legislation and already developed draft legislation in Ukraine in the field of investigation of accidents resulting in heavy consequences. BAST have been providing recommendations on duties and responsibilities of the Ministry of Infrastructure and other stakeholders during the technical investigation. Best EU/international practice has been introduced by means of a stakeholder workshop. BAST has been elaborating detailed procedures for the technical investigations and conducted training workshops for Ukrainian experts from the MoI. To the end a study tour to Germany has been organized, demonstrating also the GIDAS investigation to the Ukrainian partners.



Figure 2: Workshop on the implementation of technical accident investigations in Ukraine, Kiev

2.1.2. Study on winter tyres

Winter tyre use for passenger cars is mandatory in Germany if there is snow or ice on the road. Commercial vehicles are required to have tyres with winter characteristics only fitted to their driven axles, and no specific limits for tyre wear and age are set for any vehicles' winter tyres.

Since wear and age of tyres might have a considerable effect on their friction coefficients, BAST has been asked to perform an extensive study on winterly road surfaces to identify reasonable limits. In general, passenger car tyre properties decrease substantially with profile depths below 4 mm, but not with age. This effect had not been found with commercial vehicle tyres.

It seems that a situational requirement to fit belt chains to driven axles could improve the climbing ability of commercial vehicles in specific situations. Since a large amount of traffic jams on German highways in winterly conditions is due to trucks being stuck, this could in fact improve winterly traffic flow.

2.1.3. Study on Camera-Monitor-Systems

Within the automotive context camera monitor systems (CMS) can be used to present views of the traffic situation behind the vehicle to the driver via a monitor mounted inside the cabin. This offers the opportunity to replace classical outside and inside rear-view mirrors and therefore to implement new design concepts, aerodynamically optimized vehicle shapes and to reduce the width of the vehicle. Further, the use of a CMS offers the potential to implement functionalities like warnings or situation-adaptive fields of view that are not feasible with conventional rear-view mirrors. Despite these potential advantages, it is important to consider the possible technical constraints of this technology and its effect on driver perception and behavior. On the technical side and besides the field of view and the robustness of the system, aspects like functionality at day and night as well as under varying weather conditions have been object to a scientific investigation conducted by BAST. Concerning human machine interaction the perception of velocities and distances of approaching vehicles have been considered as they might be different for CMS as compared to conventional rear-view mirrors. Potential influencing factors like the position of the display or drivers' age have been taken into account. Within the BAST study CMS have been tested under controlled conditions as well as in real traffic for passenger cars and heavy goods vehicles.

In general, it was shown that it is possible to display the indirect rear view sufficiently for the driver, both for cars and trucks, using CMS which meet specific quality criteria. Depending on the design, it is even possible to receive more information about the rear space from a CMS than with mirror systems. It was also shown that the change from mirrors to CMS requires a certain period of familiarization. However, this period is relatively short and does not necessarily result in safety-critical situations.

In June 2016 the corresponding UN Regulation No. 46 "Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regard to the installation of these devices" entered into force.

As some characteristics regarding the human machine interaction need to be clarified BAST carries out a continuative study (see 2.2.3 HMI aspects of Camera-Monitor-Systems)

2.1.4. Urban Space: User oriented assistance systems and network management

Together with 30 partners including automobile and electronics manufacturers, suppliers, communication technology and software companies as well as research institutes and cities BAST has joined the national project UR:BAN¹ which started in 2012 running for a four-years-term until April 2016. The project has been funded by the Federal Ministry of Economic Affairs and Energy. UR:BAN focused on the development of advanced driver assistance and traffic management systems for cities and pays special attention to the human being in all aspects of mobility and traffic.

UR:BAN also covered the evaluation and prediction of vulnerable road users (pedestrians and cyclists) behavior and movements. With regard to the complexity of urban traffic UR:BAN aimed at supporting the driver in performing maneuvers such as driving in narrow or obstructed streets, resolving conflicts with opposing traffic and performing lane changes. By means of novel panoramic sensing and prediction capabilities collisions can be avoided by automatic braking and/or swerving. BAST was also involved here with legal expertise since the legal implications of the functions developed in UR:BAN needed cross-evaluation. Furthermore an experimental psychological study was carried out.

The study aimed to analyze drivers' ability to control the intervention of an emergency steering assistant in a real driving scenario. A false activation of a system-initiated steering torque overlay occurred at a time when the

¹ www.urban-online.org

driver's attention was distracted from the primary driving task by operating a visually and cognitively demanding secondary task. Subjective assessment showed more critical ratings of controllability under distraction than without distraction. There was no significant effect of distraction on lateral acceleration during drivers' oversteering the malfunction of the system. However, the lane keeping performance of the drivers indicated a significantly higher lateral deflection shortly after the malfunction in case the drivers were distracted.

2.2. Ongoing research

2.2.1. Turning Assist Systems For Trucks

Accidents between right turning trucks and straight riding cyclists often show massive consequences. Accident severity is much higher than in other accidents. The situation is critical especially due to the fact that, in spite of the mirrors that are mandatory for ensuring the field of view for the truck drivers, cyclists in some situations cannot be seen or are not seen by the driver. Either the cyclist is overlooked or is in a blind spot area that results from the turning manoeuvre of the truck and its articulation if it is a truck trailer or truck semitrailer combination.

At present driver assistance systems are discussed that can support the driver in the turning situation by giving a warning when cyclists are riding parallel to the truck just before or in the turning manoeuvre. Such systems would generally bear a high potential to avoid accidents of right turning trucks and cyclists no matter if they ride on the road or on a parallel bicycle path.

BASt therefore carried out a research project in order to develop a testing method and elaborate requirements for turning assist systems for trucks. In-depth accident data was evaluated. These findings served to determine characteristic parameters (e.g. boundary conditions, trajectories of truck and cyclist, speeds during the critical situation, impact points). Based on these parameters and technical feasibility by current sensor and actuator technology, representative test scenarios and pass/fail-criteria were defined.

The feasibility of the test procedure, taking into account available test tools and test effort, has shown that readily available test tools with slight modifications are appropriate to simulate a bicyclist travelling close to a truck. All the information (accidentology, verification test results etc.) has been brought into the UN ECE working group on general safety, and finally, the regulation development process has been started by Germany submitting a proposal as a working document for the April, 2017 session of UN ECE's GRSG.

2.2.2. PROSPECT

Several vehicles that are currently on the market feature automatic emergency braking (AEB) systems either as standard or optional fitment. Assessment procedures for these systems are under development or already available. Their expected positive effect on accident figures is taken into account in consumer testing.

However, current systems suffer from a few limitations. Their intervention in critical driving situations occurs shortly before this event - at a time when the vehicle driver has almost no chance to avoid the accident by itself. As a consequence, this late reaction time makes it difficult for the AEB system to avoid (e.g. vehicle comes to a full stop just in front of the threat), in particular in high speed scenarios and scenarios with obscured pedestrians. If the braking intervention would start too early, there would be plenty of false activations in regular traffic, even in perfectly normal situations - which is not acceptable for traffic flow, from a safety perspective, and last but not least for the driver. Also, current systems only have access to vehicle braking systems. There's no automatic steering system in production (some prototypes are available).

Proactive safety systems especially for pedestrians and cyclists can be more effective, if they tune their intervention timing better to the traffic situation and driver fatigue, and if they use steering intervention additionally to braking intervention.

This is where the PROSPECT (Proactive Safety for Pedestrians and Cyclists) project comes in: PROSPECT does develop advanced Human-Machine Interfaces (HMI) as well as advanced vehicle control strategies for combined steering and braking. The advanced HMI does monitor the driver's directional attention and for instance intervene earlier in cases where the threat is out of the driver's focus. The control systems make use of a tremendously increased radial sensor range to find the optimal combination of steering and braking, and advanced sensor interpretation systems allow to better judge the intention of pedestrians along the vehicle route with respect to their direction of movement.

To estimate the benefit for these new functions, advanced testing and validation methods need to be developed. Current validation of automatic brake systems is carried out on a test track, without irritating objects, road clutter, road signs or lines; thus, in rather artificial surroundings. PROSPECT does not only introduce novel realistic surrogate targets, but also performs testing in realistic surroundings including other moved objects, infrastructural facilities, clutter and the like.

Final output of PROSPECT are be three vehicle demonstrators, to be tested in detail using state-of-the art surrogate targets for pedestrians and newly developed surrogate targets for bicycles and their riders.

2.2.3. HMI aspects of Camera-Monitor-Systems

Since June 2016 conventional outside and inside rear-view mirrors can be replaced by Camera-Monitor-Systems to present views of the traffic situation behind the vehicle to the driver. At that time the corresponding UN Regulation No. 46 "Uniform provisions concerning the approval of devices for indirect vision and of motor vehicles with regard to the installation of these devices" entered into force (see 2.1.3 Study on Camera-Monitor-Systems)

Based on the previous study and UN Regulation No. 46 BAST has started a follow-up project which focuses on specific human machine interaction aspects. On the one hand, different display positions (peripheral, central in front of the driver and in the center of the vehicle – according to height variations in accordance with UN-R 46) should be investigated in terms of perceptual speed, discrimination possibilities and human's (direct) view. On the other hand, the effect of merged presentations of backward information on human's perception should be explored. Besides that, the project focuses on human's perception of distances and velocities at high differential velocities in a real driving scenario. This project will finish end of 2018.

2.2.4. Accessibility in long distance buses

In order to deregulate passenger transport, German long-distance bus operators are now allowed to compete against one another and against rail transport. To meet the requirements of all passenger groups in the light of inclusion, their buses will have to e.g. provide two wheelchair spaces by 2020 (by 2016 for newly registered vehicles) and fulfill UNECE-R 107. These requirements build not only towards the German wide aspiration to reduce accessibility barriers, but also towards the goal to avoid barriers systematically in the future. So far, it is not clear if other specifications for equipment going beyond those accessibility requirements in long-distance buses are needed to ensure an appropriate degree of accessibility. For that purpose BAST initiated a first research project carried out by Human Factors Consult, Berlin. After having defined accessibility in this context, the main goal of the research project was to derive recommendations for measures to be taken when designing and building accessible long distance buses as a basis for international discussion on harmonised regulations. The project therefore included two subordinate tasks: first to gather stakeholder requirements and define accessibility which was both done using questionnaires and workshops and second to compose recommendations for respective measures. Different kinds and degrees of disabilities were regarded. The measures focused on the vehicle itself, the operation of the long-distance buses and on operation personnel. Road infrastructure issues were demonstrated using examples for best practice. Deriving measures took also into account the state of the art technology for barrier free access and examples coming from the rail sector. In the end also costs, feasibility (technical limits) and practicability were considered when assessing the measures proposed.

Based on the first research project a second one develops a hand book "Accessibility in long distance buses service" carried out by STUVA, Köln. This document shall act as an easily comprehensible, concise brochure with examples of "best practice" and it is intended to promote and support the implementation of accessibility in practice by the actors. The handbook does not only include accessibility measures for the vehicles required by the German law (section 42 of PBefG), but also includes infrastructure and operation. The final report serves as a basis for the preparation of the hand book. As a research report, it goes far beyond the scope of the hand book. Despite the relatively young remote bus market, there are already positive examples in the three areas of vehicles, infrastructure and operation. The developments are still at the beginning. The handbook is expected to contribute a rapid dissemination of constructive, practice-oriented solutions, thus improving the accessibility of long-distance bus services in a sustainable manner, taking into account the interests of the different actors.

2.2.5. Safety of children in cars

After the entry into force of Phase 1 of the new regulation UN R129 for child restraint systems (CRS) dealing with ISOFix Integral "Universal" CRS ("i-Size"), BAST published a brochure "Kindersicherheit im Auto" to explain the new regulation (also available for download in English "Child Safety in Cars") and give an overview on the use of child restraint systems. This booklet was the basis for the UNECE brochure "UN Regulation No 129 – Increasing the safety of children in vehicles – For policymakers and concerned citizens"



Figure 3: Brochures to explain UN Regulation 129

BAST further supported the work of UNECE/GRSP Informal Group “Child Safety” dealing with Phase 2 of UN Regulation 129 to include child restraint systems for older children, boosters with backrest, into the regulation. For these CRSs, where the child is secured by the vehicle belt, also a stature based system depending on the standing height of the child is used. For children up to 135cm standing height the CRS can be universal, which means, that it will fit on an i-Size labeled vehicle seat. Phase 2 was agreed by WP 29 and will enter into force soon. Boosters without backrest remain in the UN Regulation 44. The UNECE/GRSP Informal Group “Child Safety” therefore developed changes for the UN R44 so that future homologations for boosters without backrest will only be allowed as group 3 CRS (from 22 kg) with a labeling that does not allow the usage below 125cm. The Informal Group “Child Safety” is now working on the third phase of UN Regulation 129 to implement integral CRSs connected to the car by using the vehicle belt system.

Euro NCAP developed a new protocol which includes the Q6 and the Q10 dummies as rear seat occupants in dynamic ODB and side impact tests. The idea behind is to improve the protection of rear seat occupants especially taller children but also small adults. In addition the CRS-car interface compatibility assessment protocol and the protocol for the vehicle based assessment were changed with regard to i-Size products to support the possibility to use CRS homologated according to the UN Regulation 129 in new vehicles.

2.2.6. Appropriate helmets for S-Pedelecs

Pedal electric bicycles have gained in importance on German streets. With the relatively new category of faster Pedelecs so-called Speed-Pedelecs or S-Pedelecs, the boundaries between bicycles and mopeds become blurred. With the legal equality between S-Pedelecs and mopeds the legal provisions for the use of helmets have to be reconsidered. While the moped is entirely powered by its engine, the engine of an S-Pedelec only assists the rider. Therefore riders of S-Pedelecs have to apply themselves physically which results in different needs regarding the weight and ventilation properties of helmets. To allow riders of S-Pedelecs to comply with the helmet laws without the constraint to use conventional motorcycle helmets, a new helmet category has to be admitted. BAST will define reasonable properties for helmets intended for the use by S-Pedelec riders. With the analysis of GIDAS accident cases and other databases, the most critical accident situations of S-Pedelec riders will be identified. The state of research regarding head injuries and possible countermeasures as well as the requirements of helmet standards other than the UNECE-R 22 and the EN 1078 will be considered. The gathered knowledge will result in requirements for helmets to adequately protect the riders of S-Pedelecs without compromising the opportunities to implement sufficient ventilation and weight reduction.

2.2.7. Active Bonnets

A Euro NCAP technical working group tasked with the update of the pedestrian test and assessment procedures finalized its activities in the year 2015. However, initiated by BAST, the topic of testing and assessment of active systems of passive vehicle safety was discussed again during the course of 2016. Deployable bonnets are expected to provide a certain clearance between the inner panel of the bonnet and the underlying structure in order to sufficiently protect pedestrians in case of a head impact during a collision with a motor vehicle. This is done within Euro NCAP by a direct comparison of the deflection of the undeployed with the deflection of the deployed bonnet on the one hand and by establishing a total clearance requirement under consideration of the package on the other hand.

In the meanwhile, a Task Force Deployable Systems under the umbrella of the UN/ECE agreement of 1998 and sponsored by the Republic of Korea has been settled. Aim is to implement legal requirements for deployable systems within GTR9 on Pedestrian safety. While the group's overall target will include, but is not limited to ensuring the activated passive vehicle safety system being in the intended position prior to head impact of a pedestrian, BAST is furthermore aiming at the implementation of prerequisites simulating real world accident situations to ensure the system working as intended in real life, as e.g. a minimum under bonnet clearance as depicted in Figure 4.

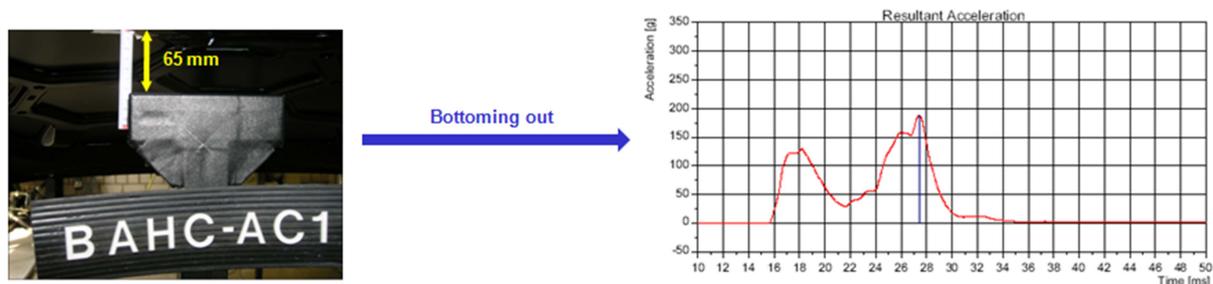


Figure 4: Under bonnet clearance leading to bottoming out of headform impactor in pedestrian component test

2.2.8. SENIORS

As the demographic change leads to an aging society and obesity is becoming more prevalent, the SENIORS (“Safety ENhanced Innovations for Older Road users”) project aims to improve the safe mobility of the elderly, and persons who are overweight, using an integrated approach that covers the main modes of transport as well as the specific requirements of this vulnerable road user group. BAST coordinates this research project funded by the European Commission within the Horizon2020 program (Grant Agreement No. 636136) which has started in June 2015 and aims to finish in May 2018. More information can be found on www.seniors-project.eu.

SENIORS primarily investigates and assesses the injury reduction in road traffic crashes that can be achieved through innovative and appropriate passive vehicle safety tools as well as safety systems. The goal is to reduce, in the near future, the numbers of fatally and seriously injured older road users for both major road user groups: car occupants and external road users (pedestrians, cyclists, e-bike riders). Hereby, the project covers research topics such as crash, hospital and behavioural data analysis, biomechanics, the development of test tools, procedures, and assessments. Further, to gain required data, tests with volunteers and with post-mortem human subjects are carried out, crash and impactor tests are conducted and numerical human body model simulations are performed. BAST is deeply involved in nearly all of these technical activities.

2.2.9. Human Body Modeling

Finite-Element Human Body Models (HBMs) have considerably gained in importance as complementary tool to dummy models. The models are not only capable of representing humans of different sizes and ages. They can also be used for simulating complex accident scenarios, e.g. in impacts involving more than one vehicle or occurring under a complex loading direction, or simulating pre- and in-crash scenarios simultaneously. Furthermore, they have the potential to become method of choice when evaluating new seating or interior configurations expected for highly automated cars.

For this reason BAST is supporting the consortium THUMS User Community (TUC). TUC is a project coordinated by University of Munich (LMU) in cooperation with partners from the automotive industry. Aim of this project is to develop standardized validation and application procedures as well as agreed methods for the evaluation of crash simulation results based on a harmonized HBM version.

BAST thereby considerably contributes to the development of agreed validation procedures. A substantial validation is fundamental to establish credibility in HBMs and to qualify the models to be used for the optimization of safety systems in cars. However, standardized methods for a user-independent objective validation are missing. Therefore, a validation repository is developed within the TUC project and made publicly accessible aiming to provide standardized validation protocols to the HBM community. The repository should include the simulation models of the validation environments, validation parameters in terms of response corridors and a detailed protocol of how to use the data for the application of any HBM.

Within the EU funded project SENIORS (dealing with the safety of older road users), BAST makes use of HBMs to improve vehicle safety. In one part of the project focusing on car occupant safety, BAST is working together with other project partners on a novel methodology to develop improved dummy-based thoracic criteria by paired HBM and dummy simulations.

Another part of SENIORS focuses on external road users in which an improved legform impactor with upper body mass, a head impactor with neck mass and a thorax injury prediction tool are envisaged to be developed also greatly with the support of HBM simulations. Corresponding HBM and impactor simulations were conducted against several actual vehicles and rigs, representing different frontends (Sedan, SUV, Sportscar, MPV), see Figure 5. Based on this work transfer functions and impactor prototypes will be developed.

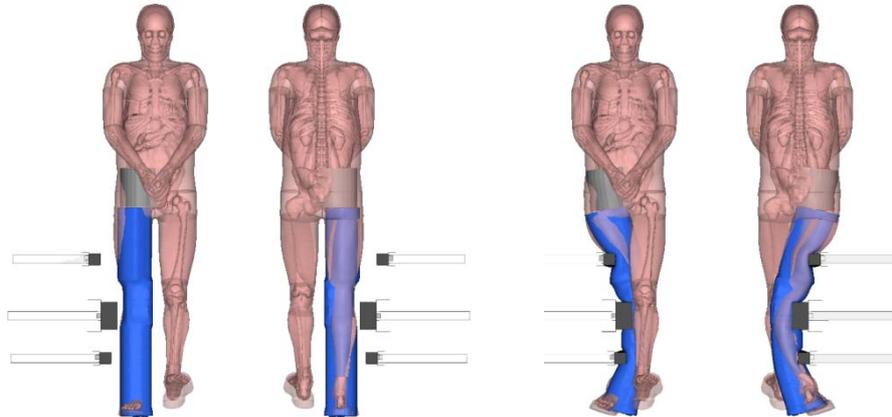


Figure 5: HBM and impactor simulations vs generic test rig

2.2.10. EEVC Task Force TEFIRE (THOR Evaluation for Frontal Impact Regulation)

At ESV 2015 in Gothenburg, the European Enhanced Vehicle-safety Committee (EEVC) announced that it had formed a new Task Force (TEFIRE) to provide advice to the EEVC Steering Committee regarding the applicability of THOR-M in UN frontal impact crash safety legislation. Main objective of TEFIRE was to provide advice on several issues regarding the THOR-M including:

- Repeatability and reproducibility (R&R)
- Handling, durability and qualification procedures
- Seating procedures

As some of these topics were also of interest to Euro NCAP in relation to its planned introduction of the THOR dummy in 2020 the two organizations agreed to join their resources to evaluate the dummy. During the last two years BAST actively supported all activities within TEFIRE group. Based on a workshop held at BAST in October 2015, as well as other member's experience with testing and the seating procedures, comments and recommendation regarding the THOR-M were summarized.

Significant improvements have been made to the THOR-M dummy, particularly regarding durability, which is now very good. Based on the findings of the group further improvement regarding certification requirements are needed to reduce variability between dummies. It was found that current data is based on dummies that have a range of performance in certification tests, which increases variability. This needs to be addressed in further testing.

Despite this, repeatability is considered to be Excellent or Good based on sled tests conducted by BAST and other TEFIRE members. Some remaining concerns regarding reproducibility, particularly for the thorax should be further addressed. However, evaluation of the reproducibility of the injury metrics indicated that the metrics are less variable than the individual measurements.



Figure 6: Investigation of repeatability and reproducibility of the dummy THOR-M in sled tests

2.2.11. GIDAS – new requirements to address new vehicle technology

In summer 1999, a joint effort between FAT (Research Association of Automotive Technology) and BAST (Federal Highway Research Institute) started the German In-Depth Accident Study (GIDAS) which is one of the largest in-depth accident data collections, recording more than 3,000 parameters per crash. Since then vehicles, objectives in road traffic policies and consequently research questions have changed. While the enhancement of passive vehicle safety has been the main objective during the start of GIDAS, requirements to modern field data collections change to gathering crucial information about pre-crash maneuvers and vehicle equipment with respect to crash avoidance technologies.

In modern vehicles, driver assistance functions are increasingly supporting the driver in complex or dangerous situations by applying preventive strategies. These strategies include warnings, enhanced braking assistance, and automatic interventions to increase road safety. A key challenge is to quantitatively assess the safety performance in terms of reduction or mitigation of traffic crashes, as these real-life effects are key considerations for all stakeholders involved in the planning of future mobility. Crash re-simulation and stochastic traffic simulation provide large opportunities to predict these effects. Both approaches require widely recognized models and reliable simulation. Hence, in order to agree on validity and reproducibility, the overall method, from the combined use of heterogeneous data sources in modeling to simulation metrics must be transparent.

Virtual “what-if” re-simulation based on reconstructed crash trajectories may show if a system had affected particular crashes on a case-by-case basis. However, reconstruction relies on limited traces and does not cover the complete traffic situation. But stochastic traffic simulation based on accident data can model how conflicts emerge and how to avoid or mitigate them. The GIDAS consortium is part of an initiative, which will provide a free access, functional framework for a reliable effectiveness analysis. This will necessarily allow incorporating additional data sources and results from other evaluation methods to the GIDAS accident data: e. g. track tests or driving simulator experiments.

For future validation and verification, ex-post statistical analysis is still to be considered after a system is introduced into the mass market.

2.2.12. Estimation of the number of seriously injured road traffic casualties in Germany

Since 2015 the EC has been asking the member states of the EU to report on the number of seriously injured road traffic casualties, MAIS 3+. In Germany this number is determined by two different methodological approaches. The first approach is based on data from the German In-Depth Accident Study (GIDAS). The second approach is based on hospital data from the German TraumaRegister DGU[®] (TR-DGU).

GIDAS data were used in order to learn which types of accident scenarios show a rather high (or low) probability for hospitalized MAIS 3+ road traffic casualty. Applying a *decision tree* method 17 accident scenarios with characteristic high or low probabilities for MAIS 3+ casualties have been identified.

Extrapolating the results to the National German Road Accident Statistics, a total number of 15,442 seriously injured road traffic victims (MAIS 3+) has been calculated for the year 2015. This correlates to 22.8 % of all hospitalized casualties (67,706). For 2014 a number of 15,392 MAIS 3+ victims has been computed.

The second approach, used as a plausibility check on the GIDAS based estimate, uses data from Intensive Care departments of Trauma centers and takes into account severe injuries (ISS16+) and some correction factors. This approach results in a number of 15,838 seriously injured MAIS 3+ for the year 2015, which is quite in line with the prediction based on GIDAS data.

Further investigation of the group of seriously injured MAIS 3+ casualties shall highlight specific risk groups of road users and derive countermeasures at a national and at EU level.

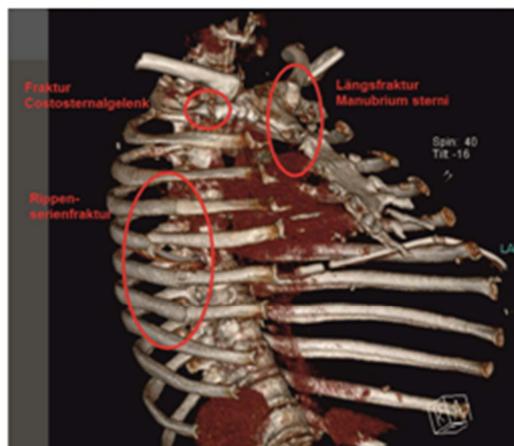


Figure 7: Multiple rib fracture is one of the most frequent AIS 3 injuries in road traffic, leading to seriously injured casualties

2.2.13. Heavy Goods vehicles with extended length

Unlike other European countries, Germany did not allow heavy goods vehicles longer than 18.75 m (truck-trailer) respectively 16.5 m (tractor-semitrailer). Since for some applications additional space is needed, BAST did conduct a field trail on heavy goods vehicles with extended length but without increased gross weight (the maximum vehicle combination gross weight stays at 40 tons) in the timeframe 2012 to 2016. After successfully completing this trail, four of the five different vehicle combination types have been approved for regular traffic on a set of designated roadways and if these vehicles do fulfil specific technical requirements like e.g. electronic brake system, air suspension, rear-view camera etc.

Automotive engineering questions in the field trail were e.g. whether those longer trucks would require other (longer) braking distances, which was confirmed to not be the case, and whether current vehicle stability control systems are able to stabilize those vehicles in certain critical driving situations.

Currently, the only remaining question is whether combinations consisting of a tractor-semitrailer and an additional centre-axle-trailer are controllable in critical situations due to their high number of articulations. This question will be answered by an extensive set of driving experiments over summer 2017.

2.2.14. Automatic Emergency Braking for Heavy Goods Vehicles

Automatic braking systems for heavy goods vehicles are mandatory across the European Union. While the requirements for pre-accident speed reduction on a moving target with 68km/h reduction from 80 km/h are quite demanding, the required speed reduction towards a stationary target is not so strict (13 or 28 km/h from 80 km/h, depending on truck type). One major weakness of the AEBS regulation is the possibility for drivers to switch those systems off (required for rare conditions where the AEBS sensors cannot interpret the environment and thus might act inappropriately) without requiring a mechanism to re-activate the AEBS at a time when the need to switch off has disappeared, the other weakness is that vehicle deceleration is limited during the mandatory warning phase.

BAST is carrying out a research project to investigate how an automatic re-engagement of those systems could be handled and if an adaption of the speed reduction requirements to the current state of the art might be appropriate. Furthermore the possibility to resign the switch off function completely will be determined. Results are expected by late 2018, it is planned to use the results for an international discussion on UN ECE level about an adjustment of UN Regulation 131.

2.2.15. Requirements and Tests for Automatically Commanded Steering Functions (ACSF)

Except for corrective steering functions automatic steering is up to now only allowed at speeds up to 10 km/h according to UN Regulation No. 79. Progress in automotive engineering with regard to driver assistance systems and automation of driving tasks is that far that it would be technically feasible to realise automatically commanded steering functions also at higher vehicle speeds. Besides improvements in terms of comfort these automated systems are expected to contribute to road traffic safety as well. However, this safety potential will only be exhausted if automated steering systems are properly designed. Especially possible new risks due to automated steering have to be addressed and reduced to a minimum.

For these reasons work is currently ongoing on UNECE level with the aim to amend the regulation dealing with provisions concerning the approval of steering equipment. It is the aim to revise requirements for automatically commanded steering functions (ACSF) so that they can be approved also for higher speeds if certain performance requirements are fulfilled. Reasonable system specifications from an analysis of relevant driving situations with an automated steering system have to be derived to cover normal driving, sudden unexpected critical events, transition to manual driving, driver availability and manoeuvres to reach a state of minimal risk. Furthermore there is the need for the development of test procedures for automated steering to be implemented in international regulations. This holds for system functionality tests like automatic lane keeping or automatic lane change as well as for tests addressing transition situations in which the system has to hand over steering to the driver or addressing emergency situations in which the system has to react instead of the driver.

2.2.16. Research program road safety

The Federal Highway Research Institute (BASt) has the task to carry out purposeful planning and coordination of research in the area of road safety and to examine traffic safety improvements.

For this reason BASt elaborates an annual research program, which addresses specific and anticipated safety deficits in road traffic in order to provide scientifically sound information as a base for advice and support of the Federal Ministry of Transport and Digital Infrastructure (BMVI).

The midterm report of the German Road Safety Program has identified as key issues the accidents of pedestrians and cyclists inside urban areas as well as accidents of cars and motorcycles on rural roads were.

Therefore BASt has compiled the clustered research program road safety (Sicherheitsforschungsprogramm, SiFo) 2016 with two focus points:

One key dimension will address road safety of bicycles in particular on inner-city roads. The second part will perform an in-depth analyze of motorcycle safety with focus of Landstraßen, rural roads.

Safety of pedestrian in urban areas will be evaluated in the 2017 research program road safety.

2.2.17. aFAS

The project „aFAS“ (Driverless Safeguarding Vehicle for Highway Shoulder Roadworks“) aims at the driverless operation of a safeguarding vehicle in order to reduce the risks for workers driving these vehicles today. The project has just delivered midterm review and put on a demonstration to take stock of its work until September 2016 at BASt. So far, the demonstration vehicle has proved capable of following the mobile roadworks automatically on testing grounds (designed to be the hard shoulder of a German motorway). The vehicle presently still requires a driver for safety-reasons. During automated operation, the speed will be limited to 10 kph (~6 mph) which is the average speed required for the performance of roadworks by the vehicle in front (cleaning, grass cuttings etc.). The safeguarding vehicle is intended to be driven manually up to the place of work where the automation is activated so that no driver is needed within the domain (driverless). Both vehicles are connected via Wifi for the sake of driving-mode activation but the safeguarding vehicle relies fully on the sensor system for safety.

The development of the safety concept for driverless use on public roads is the most challenging part. It must be ensured that the automated, driverless vehicle will not leave the hard shoulder and head into the traffic passing by (most critical scenario). This key aspect is implemented by means of a sensor system able to detect the road marking reliably and by activating a second “safety path” (braking the vehicle to immediate standstill - the minimal risk or safe state).The standard ISO 26262 is being considered as guideline and reference for this work. BASt is also involved in the identification of the standards’ legal limitations.



Figure 8: Interim presentation at BAST, September 2016, © BAST

2.2.18. Ko-HAF

In 2015 a new research project concerning cooperative, highly automated driving (Ko-HAF) has started. BAST has joined into a national consortium with automobile and electronics manufacturers, suppliers, communication technology and software companies, research institutes and road administration. The project aims at the development of cooperative, highly automated driving on motorways, i.e. for high speed ranges on well constructed road infrastructure. This includes a significant improvement of forecasts for environmental detection in addition to the automation of the longitudinal and lateral control of vehicles.

The driver can not be taken entirely out of the loop during highly automated driving. Therefore, the readmission of the driving task by the human within a certain lead time will be researched in Ko-HAF as well. Several test vehicles will be constructed for testing and demonstration of highly automated driving under normal conditions and in case of system failure. The new vehicle operation will take place on test tracks and on public roads.

Key activities of BAST – in an academic part – are the definition and specification of relevant data on traffic and road conditions to be stored in the back end, the evaluation of usability of external data for the use cases of highly automated driving, the design of data exchange with third parties and the evaluation of data protection issues.

In a first practical part, BAST conducted a driving test to classify the effect of driver's vigilance in a semi-automated drive when permanent monitoring of an automated driving function is necessary over long time intervals. Participants were driven in a 'Wizard of Oz' vehicle, meanwhile fatigue measurements were performed by using psycho-physiological data, e.g. EEG (electroencephalography) as well as behavioral data. The experiment also focused on the influence of small automation failures regarding driver's vigilance. The effectiveness of possible countermeasures will be investigated in a second step.

2.2.19. PEGASUS

PEGASUS (project for the establishment of generally accepted quality criteria, tools and methods as well as scenarios and situations for the release of highly-automated driving functions) develops tools and procedures for the testing and homologation of automated vehicles. The 17 project partners from science and industry fields define hereby a state-of-the-art technology for the safeguarding of highly-automated driving and demonstrate the development in a practical manner, using the example application of the highway chauffeur, which takes over the highly-automated driving on the highway. With this project, key gaps in the field of testing will be

concluded at mid-year 2019, up to the release of highly-automated driving functions. The objective is to develop a procedure for the testing of automated driving functions, in order to facilitate the rapid implementation of automated driving into practice.

BASt is an associated partner of PEGASUS and contributes to the "Evaluation of automation risks of a highly-automated driving function". The aim of the evaluation is the identification of automation risks which arise from the interaction between a highly automated vehicle and the driver. In a first field study performed on highways, factors of the traffic surrounding the automated vehicle (e. g. traffic density) are identified and their effects on the takeover capability of the driver are examined. The driving tests are intended to reveal possible safety risks during transitions and allow an initial assessment concerning the impact of the traffic situation. In a second step, an advanced application scenario will be defined and also investigated in the field. Both empirical studies use the BASt 'Wizard of Oz' vehicle which is able to simulate the considered automated driving functions.

2.2.20. CODECS

The deployment preparation of Cooperative Intelligent Transport Systems (C-ITS) involves many stakeholders, including the automotive industry, National Road Authorities and road operators (including their suppliers), automobile clubs and organisations promoting ITS as a tool to safer, smarter and more environmental friendly mobility. COoperative ITS DEployment Coordination Support is a Horizon 2020 support action (36 months, 05/2015 – 04/2018) which intends to facilitate the C-ITS deployment coordination activities on European scale (EC C-ITS Platform, Amsterdam Group). Focus areas of CODECS are coordination of initial deployment initiatives incl. profiling of standards for applications with infrastructure involvement (I2V/V2I), cross-industry alignment of deployment roadmaps and strategy coordination between core actors in C-ITS deployment. Now having reached halftime of its operation, CODECS has turned out to be a productive node in the C-ITS community. Further to regular congress participation (ITS European/World Congress, Smart City World Expo) more than ten workshops have been organised by CODECS with an average attendance of 40 experts.

2.2.21. International Cooperation

BASt holds several bilateral agreements with various governmental institutions around the world. Most of these Memoranda of understanding (MoU) are related to the research field "Vehicle engineering" and more specifically to the areas of the "Active and passive vehicle safety" as well as "In-Depth Crash investigation".

The main purpose of these co-operations is to discuss actual scientific road safety related topics with experts from the different parts of the world to strengthen common interests, to learn from each other and to reinforce harmonisation processes.

To name a few, BASt holds a MoU for motor vehicle safety research with NHTSA (United States of America) since 2010, a MoU on cooperation to advance knowledge in the field of road traffic with KOTSA (Republic of Korea) since 2010 and a MoU in the field of safety and environment of road traffic with NTSEL (Japan) since 2014. Recently, BASt has agreed on a MoU with the Chinese National Institute of Standardization (CNIS) of the People's Republic of China in 2016.

All co-operations are based on close communication and exchange of information towards the defined topics which also include bilateral meetings, joint symposia and even the exchange of research employees if found beneficial.

2.3. Perspective

As the finished studies show, vehicle safety research is an international issue. Therefore BAST participated in applying for calls of the European framework research programme “Horizon 2020”. In addition national projects complement the work addressing specific research topics. BAST was successful with regard to the projects mentioned below.

2.3.1. C-Roads Germany

The European Commission has published its C-ITS strategy (COM (2016) 766) in November 2016 which heavily builds on the results of the C-ITS Platform (first phase). C-Roads, as a family of deployment pilots for C-ITS services, is seen from this perspective as the most important, infrastructure related, element of practical pre-deployment throughout the EU. The pilots (C-Roads Austria, Belgium, Czech Republic, France, Germany, Slovenia and INTERCOR involving in addition UK and Netherlands) complement the already existing deployment initiatives of the C-ITS Corridor (NL, DE, AT), SCOOP@F and NordicWay (FI, SE, DK, NO). Together they mobilize approx. 150 Mn EUR of infrastructure investment in C-ITS services, an amount potentially to be nearly doubled from the CEF Call 2016 resulting in additional C-Roads national pilots. The investments complements the huge efforts of the automotive industry incl. their suppliers to kick start mass market deployment of C-ITS services in the vehicle fleet by 2019. C-Roads has been officially launched in Brussels in December 2016 (see Figure 9). C-Roads Germany ties together the pilots in Hesse (Rhine Main region) and Lower Saxony (around Braunschweig and Wolfsburg). It is a 10 Mn pilot running until 2020 with the overarching goal of providing interoperable, safety and efficiency targeting C-ITS services. The BAST roles are devoted to the national technical coordination of C-Roads Germany and the provision of coordinated expert input into the various expert groups (addressing issues to be solved for deployment, i.e. organizational issues, security, service harmonization, infrastructure communication, evaluation and assessment of the pilots) of the C-Roads Platform. BAST also supports the Federal Ministry of Transport and Digital Infrastructure in the Steering Committee representation.



Figure 9: Official launch of C-Roads by EU Commissioner Bulc on 12th December 2016 in Brussels ©EC.

2.3.2. 2.3.1 L3Pilot

BAST will participate in the EU project L3Pilot, which starts in 2017. The L3Pilot project aims to test and study the viability of automated driving as a safe and efficient means of transportation, explore and promote new service concepts to provide inclusive mobility. The following scientific and technological objectives are to be addressed: a) Create a standardised Europe-wide piloting environment for automated driving, b) Coordinate activities across the piloting community to acquire the required data, c) Pilot, test and evaluate automated driving functions and connected automation, and d) Innovate and promote AD for wider awareness and market introduction. BAST will contribute to a study on long-term user acceptance of automated driving and to the assessment of impacts of automated driving on road safety.