1 Status and Trends

1.1 Road accidents in Germany

The number of road accidents has stagnated for the last 10 years – between 2.2 and 2.4 million road accidents. There were slight increases in single years such as 2004, 2007, or 2010, but as well slight decreases in 2002 or 2010. On the long run, there is a slight increase since 2000 by 0.5 percent in 2011 and the forecast for 2012 once again indicates a further increase in accident figures (2011: 2.36 million road accidents).

The number of road accidents with personal injury has decreased by 20 % since 2000, resulting in 306,266 road accidents with personal injury in 2011. For 2012 a further decrease of almost 1.4 % to approximately 302,000 injury accidents is expected.

Casualty figures have also decreased, 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 396,374 in 2011. For 2012 a reduction of approximately 1 % compared to 2011 has been predicted – to about 392,500 casualties in 2012.

Since 2000, the number of severe injuries has been reduced by nearly 33 % to 68,985 seriously injured road users in 2011 and the number of slight injuries has been reduced by nearly 20 % to 323,380 slightly injured road users. Fatalities have decreased by 47 % from 7,503 fatalities in 2000 to 4,009 fatalities in 2011. A reduction to approximately 3,750 fatalities has been predicted for 2012.

Despite this positive development on the long term, the year 2011 was the first time since the unification in 1991, that the number of fatalities has increased by altogether nearly 10 %. Also the number of injury crashes increased by 6 %. While other factors play an important role for the long term development of fatality and crash figures, this short-term increase results mainly from different and extreme weather conditions. E.g. in 2010 January and December were characterized by very wintery conditions, resulting in extremely low fatality figures. On the contrary the spring time as well as the December in 2011 was unusually warm and dry, resulting in an increase of traffic, mainly recreational. As a result, fatality figures are unusually high for these months of 2011.

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 2010 amounted to approximately 30.44 billion Euro.

Furthermore, personal injuries amounted to 12.36 billion Euro. Costs of about 18.07 billion Euro were caused by damage to goods.

The costs per person add up to 1.02 billion Euro for a fatality, 114,020 Euro for a severely injured person and 4,458 Euro for a slightly injured person.

1.3 Vehicle population and road performance

Germany, with its 81.8 million inhabitants, is the Europes country with the highest population and plays
an important role for transit traffic. The number of passenger cars in Germany was 42.3 million on 01/01/2011. Traffic frequencies on federal motorways (approx. 12,800 km) in 2010 came up to an average of 46,300 vehicles per 24 hours (AADT).

The AADT number of heavy vehicles on federal motorways (busses and trucks with a permitted total weight of more than 3.5 t) in 2010 was 6,900 vehicles. Figure 2 and 3 show the situation in 2010.

The total driving performance of all vehicles in 2010 preliminary was about 704.8 billion vehicles/km, of which already/only more than 30% took place on federal motorways.

1.4 Electromobility

eMAP (electromobility – scenario based Market potential, Assessment and Policy options)

In the light of climate change and local environmental problems stemming from nitrogen oxide emissions and particulate matters most of the developed countries discovered a pressing need to prepare for a post-petrol future in the transport sector. Electric driven vehicles offer a potentially solution provided that the whole production chain does not emit too much greenhouse gas. Therefore, a global rise in research, trialling and deployment of innovative vehicle systems has been initiated.

As part of the European research initiative ERA-NET PLUS Electromobility' the Federal Highway Research Institute (BASt) is leading a consortium consisting of six partners from three different countries (Poland, Finland, Germany) in order to address research questions regarding the usage patterns, deployment pathways, economic impacts and relevant stakeholders in the field of electric vehicles.

The project eMAP (electromobility – scenario based Market potential, Assessment and Policy options), which started in July 2012 and will last 33 months, concentrates on the analysis and assessment of the market deployment of electric vehicles and its socio-economic impacts.

In this process feasible deployment paths of electric vehicles will be investigated for the time horizon until 2025-2030. This will be done in a scenario based market model which specifies consumer demand and market supply of electromobility.

The socio-economic impact of the deployment of electromobility on greenhouse gas and local emissions,
transport costs, energy supply safety, and technological change in industry and economy will be evaluated given the different scenarios. Political supporting actions and strategies of electric vehicles will be identified and their impact on the deployment path will be analyzed and evaluated. In the end, recommendations for optimized political strategies will be derived.

1.5 Alternative power train technologies: market penetration and consequences

Reliable quantitative data of the development of vehicles with alternative power train technologies are necessary for anticipatory work in the field of road safety. Therefore in 2010, the Federal Highway Research Institute initiated the observation and analysis of the development of vehicles with alternative power train technologies (e.g. hybrids, electric and fuel cell vehicles) in Germany. The development of the vehicle market and the detailed observation of the accident involvement of such vehicles form the centre of the research. The main goal is to identify possible consequences on road safety.

Objectives of the study:
- tracking of the factual implementation of the technological development in marketable products,
- early and detailed knowledge about the market development of the technological development in vehicles,
- contemporary identification of undesirable developments with regard to road safety.

Table 1 shows the stock of passenger cars, subdivided by different power train technologies. The number of hybrid passenger cars has been increasing on a constant rate of approximately +30% per year, while the number of passenger cars powered by gas remained static since 2007. The number of electrically powered passenger cars was almost non-existent in 2007, but has shown an enormous increase until 2011.

Table 2 shows the involvement of passenger vehicles in accidents with personal injuries according to their power train technology. In 2011, 370,632 passenger cars were involved in accidents with personal injury. Among the passenger cars with information about their power train technology, cars powered by petrol have the highest share (69%) of all passenger cars involved in accidents. 353 hybrid vehicles have been involved in accidents, which amounts to a share of 0.1% of all vehicles involved in accidents. In the year 2011, 17

<table>
<thead>
<tr>
<th>Tab. 1: Stock of type-approved vehicles</th>
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<tbody>
<tr>
<td><strong>Motor fuel code/power source</strong> ¹</td>
</tr>
<tr>
<td>petrol</td>
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<tr>
<td>petrol</td>
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<tr>
<td>271.154</td>
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<td>254.185</td>
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<tr>
<td>244.841</td>
</tr>
<tr>
<td>227.537</td>
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<td>242.896</td>
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</table>

¹until 2010: different motor fuels corresponding to the catalogue of type-approved passenger vehicles since 2011 added by the Federal Motor Transport Authority

Tab.2: Passenger cars in accidents with personal injury, subdivided by power train technology
passenger cars with pure electric power train were involved in accidents with personal injury.

It has to be noted that the type of passenger cars (and especially its power train technology) can only be identified when they are type-approved and consequently classified in the statistics of the Federal Motor Transport Authority. For the time being this is only the case for a minority of vehicles with alternative power train technologies. Nevertheless, a substantial increase of type-approved vehicles is expected in the near future and will give more opportunities for the analysis of the stock and accident involvement of vehicles with alternative power train technologies.

More information about currently available vehicles with alternative power train technologies or detailed information about the accident occurrence of vehicles with alternative power train technologies can be found in the annual report to this study (“Alternative Antriebstechnologien: Marktdurchdringung und Konsequenzen”).

2 Research

2.1 Electromobility

2.1.1 Safety of electric vehicles

The successful integration of electrically driven vehicles into Europe’s future transport system will depend on clear and transparent functional and safety requirements for the vehicles and their subsystems. These requirements are critical for all stakeholders in the transport system: the road user must have confidence that vehicles are safe to operate and the road owner must know if new vehicle types have new requirements for the road infrastructure.

A consortium of Swedish and German partners is working on the European project EVERSAFE (Everyday Safety for Electric Vehicles) founded by ERA-NET Plus Electromobility+ program. The overall objective of the project EVERSAFE is to provide safety requirements for electrically propelled vehicles to support the previously mentioned stakeholders in their decisions. This is achieved mainly by investigating safety issues of second generation vehicles with electric drive systems, which means that not only fully electric vehicles are in focus, but all kinds of electric vehicles, including hybrid electric vehicles, fuel-cell electric vehicles and plug-in hybrid electric vehicles are investigated. All these vehicles are referred to as Electric Vehicles (EV) in general.

Safety issues are categorized into two groups; active and passive safety and each addresses relevant aspects of vehicle safety of electric vehicles. This approach is complemented by a user evaluation of safety related aspects, since user acceptance is crucial for future market penetration. Through this exercise, the consortium can identify both perceived and real safety issues that must be addressed to facilitate consumer acceptance of the vehicles. In this context recommendations for requirements for the design of future electric vehicles can be made and will be made available to all relevant stakeholders.

2.1.2 Driving dynamics of electric propelled vehicles

A major challenge within the electrification of the power train is the concern regarding the battery in terms of capacity, charge, package and safety. Furthermore it’s necessary in hybrid vehicles to define the operating strategy of electric motor (EM) and internal combustion engine (ICE) or the brake systems in terms of recuperation. Especially this aspect has implications on driving dynamics of vehicles which are not known in this kind in existing conventional propelled vehicles.

For that reason a research project is analyzing the fundamental differences between conventional and alternative drive concepts in terms of driving dynamics. A full vehicle simulation model represents various drive concepts with wheel-specific drive or braking torque. Questions arise with respect to different torque characteristics of EM and ICE, changes within the chassis or the package due to electrification as well as the recuperation. Further on critical scenarios are defined, which are then mapped in the total vehicle simulation. The effect of various recuperation strategies are carried out on two sample cars (front-wheel drive concept, rear-wheel drive concept) and are analyzed in terms of stability and driver’s perception. A critical driving situation in daily operation of a vehicle is "braking in a turn". Here, an unsteady state braking maneuver is superimposed to steady state cornering with different parameters: curve radius, lateral acceleration and coefficient of adhesion. Additionally two other maneuver are analyzed with respect to recuperation: The sudden ramp steer input within a straightforward braking and braking on one-sided slippery track surface when driving straight-ahead. Based on the results it is shown that the possibility of recuperation of hybrid and electric vehicles can have a significant impact on vehicle dynamics, especially when combined longitudinal and transverse forces.

2.1.3 New requirements for the periodic technical inspection (PTI) of electric and hybrid vehicles

The periodic technical inspection of vehicles shall ensure that they retain their level of safety throughout the life of the vehicle. For the future, however it is
expected that the number of electric and hybrid vehicles will increase. This results in completely new aspects for the roadworthiness tests. In addition to the mechanical safety comes the electrical and functional safety. The safety systems in the vehicle will be designed different for electric vehicles than for conventional vehicles. The existing test requirements and procedures may no longer fit. The same applies to electrical energy storage.

Finding the defects should be ensured. These include, for example, defects in the high-voltage system and its isolation, defects in other systems to protect against electric shock, defects in the battery system (fire risk, risk of leakage of hazardous substances), etc. For these reasons should be identified in the ongoing project, which points are relevant for the periodical technical inspection of electric and hybrid vehicles. Based on this up to 5000 vehicles in use are examined in a field study by FSD (central body for PTI in Germany) on behalf of BASt. The analysis of the field study allows the identification of additional and possibly unnecessary checkpoints for electric and hybrid vehicles.

2.2 Forward looking safety systems

Forward-looking active safety and primary safety systems are emerging into the vehicle market. While last ESV’s status report stated that these systems will provide potential, it is now commonly agreed that there definitely is potential to lower the risk in road accidents (with the risk being the product of exposure and severity). The consumer test organization Euro NCAP will start testing automatic emergency brake systems (AEB) that address rear-end collisions of passenger cars from next year on, and they have announced to test AEB for pedestrians by 2016. In addition, a UN ECE regulation for AEB for heavy commercial vehicles will be implemented from 2015 on. Another regulation for AEB for medium size commercial vehicles of category M2 and N2 is currently under development and will be implemented from 2016 on.

In Europe the research project ASSESS (Assessment of Integrated Vehicle Safety Systems for improved vehicle safety), which is funded in the 7th R&D framework programme by the European Commission aimed at developing harmonised and standardised assessment procedures and related tools for frontal pre-crash sensing systems. Procedures were also developed for driver behaviour evaluation, pre-crash system performance evaluation, crash performance evaluation and socio economic assessment. ASSESS activities ended in December 2012. As result a relevant set of test and assessment methods applicable to a wide range of integrated vehicle safety systems was developed.

For the development of harmonised test procedures for integrated safety systems all German car manufacturers and two major Japanese manufacturers, the Federal Highway Research Institute (BASl) and the German Insurance Association have got together under chairmanship of DEKRA in the consortium "vehicle frontal safety systems" (vFSS). Based on real accident data test and assessment procedures for pedestrian protection systems and systems for the avoidance and mitigation of rear-end collisions are developed.

Another group that was very active in developing test methods for passenger car rear-end pre-crash testing is the AEB group, composed of vehicle manufacturers, suppliers and various insurance research bodies. And finally, German Automobile Association provided input based on its own test procedure.

All these projects worked together in the European-wide so-called Harmonisation Platform that delivered the input to Euro NCAP in a condensed form.

The final test protocol therefore is a combination of the most significant aspects of all those initiatives. For instance, the AEB-groups’ stepwise increasing test speeds had been selected, part of the Forward Collision Warning test is from the ASSESS project, as well as the aspect of belt pre-tensioning systems. The surrogate target system and accompanying propulsion system had been taken from a development by the ADAC.

Current fields of research are the requirements for an appropriate pedestrian dummy (e.g. should it have articulated arms and legs) and propulsion system as well as the accident scenarios that need to be tested. Since passenger car rear-end collisions will be addressed by consumer testing from next year (and by regulatory testing in the case of commercial vehicles also soon), the focus for improving traffic safety now moves towards the automatic prevention of pedestrian accidents.

Nearly all ASSESS project members gathered again in the ASPECSS project (Assessment methodologies for forward looking integrated pedestrian and further extension to cyclists safety systems), which focuses on forward looking safety systems that are designed to address pedestrian and cyclist accidents. Again, the aim is to deliver harmonised test procedures as input for further regulatory and consumer rating activities. All other initiatives named above continue to perform research in pedestrian accidents and countermeasures. Currently under discussion are propulsion systems as well as the accident scenarios that need to be tested. The above mentioned projects show that at a lot of national and world wide activities are around the specification of active and integrated safety systems. Now it is a matter of bundling these activities and of using the chance of an early world-wide exchange about the potential benefit of advanced forward looking and in case of an imminent crash braking safety systems, no matter if it is an accident between two cars or between a car and a vulnerable road user. This includes an agreement of the definition of test procedures for these systems. BASl serves as the link.
between European and American research initiatives due to its cooperation agreement with NHTSA signed back in 2010.

During the several months of negotiations in the working group of the European Council, the proposal was discussed by the Member States of the EU. The cost-benefit analysis of the Commission (based on AUTOFORE) aims to reduce the time intervals of the roadworthiness test for older vehicles and the extension to other types of vehicles and were doubt drawn by independent cost-benefit considerations of the Danish Ministry of Transport and the BAS (Federal Highway Research Institute on behalf of the German Ministry of Transport). The compromise paper of the Presidency, resulting as a consequence of the discussion in the working group of the European Council, gives Member States more responsibility under the proposed directive to act. The next step is the reading in the European Parliament.

2.4 Cooperative systems – integration of existing systems

During the past years, stand-alone solutions deployed either on the infrastructure side (mostly for purposes of traffic management) or based on in-vehicle equipment (mostly for purposes of driver assistance) have already delivered significant benefits in terms of improved road safety, reduced and more reliable journey times and less environmental pollution. The technological progress in Information and Communication Technologies (ICT) in recent years makes it possible and increasingly affordable to establish a vehicle-infrastructure network on the roads (Cooperative ITS, C-ITS) and - in doing so - explore potential benefits untapped before. C-ITS is designed to make use of hybrid communication concept, involving ITS G 5 (WLAN-IEEE 802.11p) and different generations of cellular communication (3G, 4G).

Many stakeholders have to commit themselves to the deployment of C-ITS. Road authorities and operators have recently prepared the ground for positioning of public authorities as a vital actor in this field. BASt is very active in facilitating C-ITS deployment. BASt drives the development of a roles and responsibilities standard in the context of C-ITS based on architectures for cooperative systems (CEN/ISO TS 17427, expected spring 2013) as an important contribution to fulfilling the European Commission’s Mandate M/453 towards the European standardisation organisations. BASt has also initiated the establishment of an integrated view (including C-ITS) on the value chain for traffic and traveler information. Moreover, BASt is engaged in the Cooperative Systems Task Force of the EasyWay programme, analysing the strengths and weaknesses, opportunities and threats associated with different functional schemes for priority C-ITS services from a road operator’s point of view.

Road authorities and operators as well as the automotive industry are core actors of Cooperative ITS deployment. The umbrella organisations CEDR, ASECA, POLIS and Car2Car Communication
Consortium have formed the Amsterdam Group, a voluntary cooperation platform working towards large scale deployment of Cooperative ITS on European roads from 2015 onwards. In summer 2012, the umbrella organisations have signed a Letter of Intent recommending to their members to engage themselves in deployment of Cooperative ITS. Front runner Member States including The Netherlands, Germany and Austria currently discuss with the automotive industry day one-applications to be deployed within a transnational corridor of motorways and high level roads.

2.5 Safety related traffic information

The “ITS Directive”¹ of the European Commission has defined Priority Actions for the development and use of specifications and standards in the upcoming years. One of these priorities is the definition of “data and procedures for the provision, where possible, of road safety related minimum universal traffic information free of charge to users”, which was finished in the end of 2012.

The specification – which will become an EU regulation – identifies a standardized list of safety related traffic events (in categories) which should be communicated to ITS users free of charge. Furthermore it requires the compatibility and the integration of the messages into ITS services for real-time traffic. The following list of categories of safety related information is included in the specification:

- Temporary slippery road
- Animal/people/obstacles/debris on the road
- Unprotected accident area
- Short term roadworks
- Reduced visibility
- Ghost driver
- Unmanaged blockage of a road
- Extreme weather conditions
- Unexpected end of queue

Within the next time, the following tasks have to be managed by the European Commission and the member states:

- Europe-wide implementation of the specification
- Installation of a national organisational structure
- Define a set of quality criteria for this message categories of safety related traffic information and identification of the national quality level

2.6 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:BAN² which started in 2012 running for a four-years-term until April 2016. The project is funded by the Federal Ministry of Economics and Technology. UR:BAN focuses 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 covers the evaluation and prediction of vulnerable road users’ (pedestrians and cyclists) behaviour and movements. With regard to the complexity of urban traffic UR:BAN aims 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 is involved here with legal expertise since the legal implications of the functions developed in UR:BAN – such as functions performing automated swerving manoeuvres in critical traffic situations – have to be identified and examined. Moreover, UR:BAN focuses on economic and energy efficient driving by means of intelligent infrastructure and networking with intelligent vehicles enhancing future driver assistance systems with regard to traffic management.

Furthermore, UR:BAN takes the human being into account by incorporating adaptive support into the design of vehicle controls and displays. BASt is involved in the examination of the aspect of controllability of new driver assistance systems with psychological and legal expertise.

2.7 Automated Driving

The report of the BASt-Expert Group “Legal consequences of an increase in vehicle automation” was released in 2012.

Therein five degrees of continuous vehicle automation have been defined according to the needs of legal assessment. The definitions take their starting point at the level of driver-only, over assistance, partial automation, high automation and full automation. The definitions take the driver’s point of view and describe duties vehicle automation technology would expect the driver to accomplish in case of the respective degree. These definitions have attracted attention at international level.

The legal evaluation according to German law and legislation has lead to the conclusion that the distinctive feature to be considered legally, according

1 Directive 2010/40/EU of the European Parliament and of the Council of 7 July 2010 on the framework for the deployment of Intelligent Transport Systems in the field of road transport and for interfaces with other modes of transport

2 www.urban-online.org
to the different automation degrees defined, is the attention of a driver required at the respective level. It has shown that the degree of permanently monitored partial automation, which still requires the driver to permanently pay attention to other traffic and remain in a position to react immediately upon any kind of upcoming situation, will remain in line with today’s legal system in Germany (and is comparable with the legal consequences of Driver Assistance Systems today).

The decisive rise in automation is encountered legally at the transition from partial to high automation, the latter of which has been defined to technically allow the driver to detract attention from the driving task and engage otherwise. The use of high automation would lead to a conflict between assumptions underlying today’s road traffic regulations, today’s road traffic liabilities and even manufacturers would run a substantial risk according to today’s product liability regime: In case of accidents whilst highly automated driving, and given causation can neither be assigned to an erroneous intervention of the driver nor to improper driving of another road user (and according to the distribution of the burden of proof), the manufacturer would be liable for these damages.

Important fields of research for future vehicle automation have also been identified. The most important and comprehensive being Human-Machine-Interaction in order to understand more closely human abilities to cope with automated processes in driving

2.8 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 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 next to the field of view and the robustness of the system, aspects as its functionality at day and night as well as under varying weather conditions should be object to scientific investigation. Concerning human machine interaction, it has to be considered, that the perception of velocities and distances of approaching vehicles might be different for CMS as compared to conventional rear-view mirrors and potential influences of factors as the position of the display or drivers’ age should be taken into account. In order to shed light on these and further open issues, BASt is currently conducting a study that will cover the use of CMS and controlled conditions as well in real traffic. The first part of the study will focus on passenger cars, while in a second step the empirical investigation will be extended to heavy goods vehicles, where the potentials as well as the limitations of CMS might differ considerably. Results are expected in early 2014 and are planned to be communicated within the relevant standardization and regulation committees.

2.9 Freight transport

2.9.1 ‘Freight Transport and Logistics Action Plan’ and trial with longer trucks

In the context of the predicted increase in freight transport, the Ministry of Transport Building and Urban Development published in 2010 a ‘Freight Transport and Logistics Action Plan’. For road freight transport the aim is to increase the productivity and decrease the environmental impact. New technologies and an increased use of combined transport are the main topics. One proposed measure is the introduction of longer but not heavier articulated trucks in a field trial in Germany. The truck combination length may be increased up to 25.25 m (to load 3 instead of 2 swap bodies or containers) while the gross vehicle weight stays at 40 t or 44 t in combined transport respectively. A road network, where these longer trucks may be operated in the Federal States, was published by the German Ministry of Transport, Building and Urban Development. However, this road network is not definite. New stretches are being integrated after approval by the responsible Federal States.

Figure 7: Truck of 25.25 m length

Five new longer truck combinations are allowed in the trial:

1. Elongated tractor-semi-trailer combination (+1.30 m)
2. Tractor-semi-trailer and additionally a center axle trailer
3. Truck, (steerable) dolly and semitrailer
4. B-double
5. Truck and trailer with max. length of 12 m each

All new longer truck combinations must be capable for combined transport and maneuver the so called ‘BO-Kraftkreis’ (external circle diameter of 12.50 m and internal circle diameter of 5.30 m). All longer truck
combinations must be equipped with driver assist systems of the latest development state, such as ABS, LDW, ESP, EBS and, what is really new, on board WIM on each axle except steering axle. Special demands for the driver performance are fixed in the exemption regulation as well as a general prohibition of overtaking for those combinations. Prohibited is the transport of dangerous goods, fluids in big tanks, live stock, and swinging loads on trailer-ceilings for safety reasons.

The trial runs for five years. The Federal Highway Research Institute (BASt) is commissioned by the German Ministry of Transport, Building and Urban Development to evaluate the trial with the longer truck combinations. It will be interesting to see, which of the new truck combinations will be chosen by the truck operators and how they behave in practice. A lot of practical questions, like driving behavior, influence on traffic flow, fuel consumption and CO₂ emission and logistics’ questions have been examined which have to be studied in the time frame of this trial.

Initial experiences are that so far nearly two thirds of the combinations in the trial are trucks with (steerable) dolly and semitrailer. However, all five possible longer truck combinations are in use. They carry a wide range of different goods like food, household appliances and serve as courier, express and parcel services or automobile supplier. As an average the longer truck combinations drive a tour of about 500 km. Most of them operate as a shuttle or point-to-point transport.

2.9.2 Advanced Emergency Braking Systems (AEBS) for heavy duty vehicles

Beginning 1st of November 2013 new types of heavy duty vehicles of more than 8 tons and and new types of buses of more than 5 tons must be equipped with Advanced Emergency Braking Systems (AEBS). The systems have to be designed in a way to warn the driver in time if there is an imminent danger of a rear end collision. If the driver does not react, an emergency braking has to be initiated automatically. It is expected that the systems contribute to reduce accident figures as well as material and personal damage since these accidents are often accompanied with a high severity due to the high mass of the vehicles involved. The mandatory fitment is stipulated by the regulation (EC) No. 661/2009 of the European Parliament and of the Council concerning type-approval requirements for the general safety of motor vehicles. However, requirements for lighter trucks and buses do not exist yet. They are elaborated at present by an informal group of experts on UNECE-level. For the light vehicle categories it has to be considered that these vehicles are more agile with regard to steering manoeuvres so that warning and emergency braking actions will have to be started later, meaning closer to the expected collision, in order to allow the driver to master the situation himself by a lateral movement. On the other hand this inevitably leads to less amounts of speed reduction in the emergency braking phase than for the heavier vehicles.

2.10 „BioRID TEG, dummy harmonization“

For several years, work is in progress with regard to develop an improved regulatory dynamic test procedure for head restraints with the aim of mitigation of neck injuries. The dynamic test option in the current GTR No. 7 on head restraints foresees the use of a Hybrid III dummy using the test pulse as described in FMVSS 202a. According to several studies like those from EEVC, the Hybrid III is lacking biofidelity under rear impact conditions and is not humanlike enough for seat or head restraint testing. In consumer test programs like Euro NCAP or IIHS, the BioRID is used for many years for the dynamic assessment of seat performance under rear impact conditions. However, several concerns have been raised about the repeatability and reproducibility of the BioRID. As the anthropometric test device (ATD) is the crucial factor in a dynamic test a suitable dummy needs to be defined for use in regulation. Several studies have shown that out of the available dummies (Hybrid III, THOR, RID3D, BioRID) the BioRID seems to be the potentially best suitable dummy for low speed rear impact seat testing.

Within the framework of the Informal Working Group on a GTR No. 7 on head restraints phase 2 a BioRID Technical Evaluation Group (TEG) has been given the task to improve the BioRID and to develop the necessary specifications and documentation for regulatory purposes. The BioRID TEG started its work in January 2010 and most of the meetings are hold as WebEx meetings with some joint face to face meetings with the GTR No. 7 group. The BioRID TEG is chaired by BASt. The TEG has made significant progress and quite a lot of issues have been discussed, investigated further and addressed in the meantime e.g. by technical bulletins released by the dummy manufacturer (Humanetics). A drawing package is now available on the UNECE website as well as a new draft certification procedure; a built level check list has been published as well as a PADI (Procedures for Assembly, Disassembly and Inspection). Work is ongoing with the aim of reducing the response corridors during certification and refining the certification procedure. The improvements developed and proposed by the TEG and the new certification procedure are used by Euro NCAP and IIHS, too. The aim is a worldwide harmonized BioRID for testing under rear impact conditions for regulatory purposes as well as consumer testing. A really challenging task of the GTR No. 7 group and the BioRID TEG will be the development of validated injury or seat performance criteria addressing the risk of cervical spine distortions.
There are also activities around the world with regard to the improvement or further development of frontal impact test procedures under regulatory aspects as well as in consumer test programs. The currently used Hybrid III family which was basically developed in the 70th has several limitations. Having in mind the demographic impact and the findings by European projects like THORAX and COVER, an improved test tool seems to be needed e.g. for a better prediction of the thoracic injury risk. The THOR dummy has a good potential for worldwide harmonization on a frontal impact dummy.

**Advanced dummy technology for assessment of thoracic injury risk**

Analyses of recent accident data show that thoracic injuries are forming the largest portion of severe injuries in motor vehicle collisions. The evaluation of the injury risk to the thorax in frontal motor vehicle accidents is based in current test procedures on the chest deflection measurements in the dummy Hybrid III. Several studies have shown the limited biofidelity of this dummy. Furthermore the chest deflection is only measured in one single point of the chest.

BASt is involved in various research activities to address this problem.

A multi-point chest deflection measurement device called RibEye available for the dummy Hybrid III is currently being investigated. With this measurement device it is possible to measure the chest deflection at multiple points of the chest. BASt is investigating if an improved assessment of vehicle safety can be achieved with this kind of advanced measurement system.

The RibEye is also available for the side impact WorldSID dummy (Figure 8), which might also have potential for improved assessment of thoracic injury risk in side impact. This will also be evaluated by BASt in future studies.

BASt is also involved in the project THORAX (Thoracic injury assessment for improved vehicle safety) funded by the European commission. The aim of the project is to better understand the mechanism of thoracic injury in frontal impact. For this purpose accident data was analyzed to find the most relevant types of thoracic injury. The two injuries of highest importance were found to be rib fractures and lung injuries. Shoulder injuries and sternum fracture were identified to be of secondary importance.

The research findings of the project were implemented in an updated design of a dummy thorax, which was integrated in the THOR dummy (Figure 9). Within the project injury risk curves based on multi-point deflection measurement and strain gage data will be developed.

BASt was involved in a test series with the updated THOR dummy to build up a data base of test for biofidelity assessment and injury criteria development. Within a further test extensive series at BASt the sensitivity of the new dummy thorax to different restraint system parameters was investigated. The THORAX-project finished April 2013.

After that BASt continues to evaluate the THOR dummy in internal research projects. To support the further evaluation and harmonization of this dummy support, BASt is acquiring an updated version of THOR for internal research projects, and to make it available to other interested parties within Germany and Europe for further testing.
2.11 Frontal Impact and Compatibility

Vehicle safety has been improved in Europe with the introduction of legislative ECE-R 94 and consumer testing Euro NCAP. Stronger occupant compartments and improved occupant restraint systems are evident in the higher assessments awarded in the Euro NCAP testing programme. However, in current passive safety tests the role of the collision partner is not considered explicitly.

Previous research supports the conclusion that vehicle-to-vehicle crash performance is worse than single vehicle-to-barrier test performance, even when the collision partner is an identical vehicle model. This unfortunate fact means that new safety features do not perform as well as expected in real world conditions. This behaviour is a function of the incompatibility encountered in the vehicle fleet today.

Latest accident research shows that in particular deceleration induced injuries were more and more prominent while injuries due to intrusion are getting less.

In previous years frontal impact and compatibility has been analysed worldwide for years but no final assessment approach was defined which motivates a need to further pursue compatibility research to improve the outcome of a significant proportion of EU road casualties.

France made in 2007 a proposal to amend ECE Regulation No. 94 and to introduce the PDB (Progressive Deformable Barrier) but the GRSP Informal Working Group of Frontal Impacts (IWG FI) could not find an agreement between the parties.

The IWG FI is working and trying to set up a new proposal which includes in the first step the introduction of an additional full width test. Germany has made a proposal at the UN ECE on the steps forward and the requirements that shall be covered by the frontal impact regulation including the geometric alignment of vehicles’ front structures.

Figure 10: Car-to-car test

In the seventh framework programme the compatibility project, called FIMCAR (Frontal Impact and Compatibility Assessment Research), has established an assessment approach for frontal impact, integrating self and partner protection. The FIMCAR consortium consisted of 18 partners which include the important research organizations from Europe as well as seven different car manufactures. Japanese institutes are not an official partner; however an extensive collaboration is ongoing. Harmonization activities included also interaction with GRSP IWG FI and EEVC WG 15. The project lasted from September 2009 to October 2012.

Figure 11: Small family car in a full-width test with deformable barrier (FWDB) at 50 km/h

The goals of the FIMCAR project were to answer the remaining open questions identified in earlier projects (such as understanding of the advantages and disadvantages of force based metrics and barrier deformation based metrics, confirmation of specific compatibility issues such as structural interaction, investigation of force matching) and to finalise the frontal impact test procedures required to assess compatibility. The identified real world safety issues were used to develop a list of compatibility characteristics. This analysis resulted in the combination of the Full Width Deformable Barrier test (FWDB) with compatibility metrics and the existing Offset Deformable Barrier (ODB) as described in UNECE Regulation 94 with additional cabin integrity requirement as being proposed as the FIMCAR assessment approach.

The proposed frontal impact assessment approach addresses many of the issues identified by the FIMCAR consortium but not all frontal impact and compatibility issues could be addressed.

Further internal research projects have recently started with the aim to investigate the performance of the restraint systems in different impact conditions. Therefore a survey will be conducted to estimate the benefit of an additional restraint test. In addition, the influence on the passenger loading will be analyzed with different dummy sizes, dummy types as well as the change of seating positions and impact velocities.
CASPER

BASt participated in the European project CASPER (Child Advanced Safety Project for European Roads, 2009-2012). The aim of CASPER was the development of a full understanding of the circumstances of the transport of children and the requirements for the protection of children in vehicles, to enable an improvement in the use of child restraint systems (CRS) and improved opportunities for the development of CRS. The project took into account the aspects of safety as well as sociological aspects. Field data (accident data analysis, studies on use and misuse of child restraint systems, sociological studies) as well as the analysis of existing technical and practical solutions under relevant factors were the basis for the development and improvement of tools that can be used for the approval and development of child restraint systems. Also results were achieved in the area of simulation (Child Dummy FEM, child human body FEM; virtual environment of a test procedure).

Proposals for test procedures were made, taking into account the highest priorities. CASPER supported the work of the UNECE / GRSP informal group "Child Safety".

BASt is also involved in the work of the UNECE/GRSP Informal Group “Child Safety”. The Group deals with a new regulation for CRS. A step by step approach is implemented. The Phase 1 dealt with ISOFix Integral “Universal” CRS, so called “i-size”. The new regulation includes side impact testing, an updated test bench and the use of the Q-dummies. The weight group system has changed to a standing height based system which is easier to understand by users. Up to an age of 15 month an “i-size” CRS has to be rearward facing. The new regulation gives the possibility to have universal rearward facing CRS with ISOFix anchorages. Actual the group works on phase 2, the implementation of CRS with ISOFix type of connectors, were the child is secured by the vehicle 3-point belt. After finalization of phase two, the group will work on other CRS types in a third phase.

The Euro NCAP Child Safety Working Group developed a new child protection protocol with the aim to clearly improve consumer information. It shall motivate the CRS industry to develop well performing CRS for smaller children and the vehicle manufacturer to develop robust interfaces that can accommodate a board variety of child restraint systems available on the European market. The CRS assessment is separated from the car assessment for smaller children by the use of existing CRS consumer ratings to identify “best performing child seats”, available on the European market. A list of seats, good/ best performing in consumer tests, has been identified for the use in the vehicle assessment. The chosen CRS cover all age groups and installation methods. They are used for the CRS-car interface compatibility assessment. In parallel, from 2013 on, the child dummies of the P-Series in the
dynamic testing are replaced by the dummies of the Q-series of the same age group. The Euro NCAP Child Safety working group is now continuing its work to replace the dummies representing smaller children by dummies representing older children in the dynamic test. It will be a clear challenge to the vehicle manufacturer to work on the protection of larger children respectively small adults on rear seats. The Euro NCAP assessment should re-focus on CRS-car interface compatibility, vehicle based assessment and front/side impact dynamic results of older children.

2.13 FlexPLI

A new, biofidelic test tool called FlexPLI (Flexible Pedestrian Legform Impactor) for pedestrian lower legform to bumper tests has been developed from the year 2000 on by the Japanese Automobile Research Institute (JARI). The FlexPLI has more humanlike properties in the tibia and the knee area than the EEVC Pedestrian Legform Impactor that is currently used for type approval tests according to the European Regulations (EC) No. 78/2009 and (EC) No. 631/2009 as well as within the Euro NCAP programme. Seven strain gauges along the entire femur and tibia and four string potentiometers in the knee area enable the acquisition of the femur and tibia bending moments and the knee ligament elongations in order to more precisely predict the risk of femur and tibia bone fractures and knee ligament ruptures in the event of a collision of a pedestrian with a motor vehicle (figure 15).

Figure 15: FlexPLI to bumper test.

Due to the lack of an upper body mass the risk of femur injuries still cannot be assessed appropriately, thus the acquisition of the corresponding bending moments is done, for the time being, for monitoring purposes only. The German Federal Highway Research Institute (BASt) is investigating the effects and applicability of an upper body mass developed within the FP6 project APROSYS (Advanced Protection Systems) with the aim of an improved assessment of femur injuries towards a better evaluation of the protection potential of especially vehicles with high bonnet leading edges or flat frontends.

Figure 16: Virtual testing with baseline FlexPLI, FlexPLI-UBM and THUMS

The FlexPLI is aimed at being introduced within the second phase of the Global Technical Regulation No. 9 (GTR9). After finalization of the work of a technical evaluation group (Flex-TEG) under the umbrella of GRSP in 2010, a new informal group under the chairmanship of Germany (IG GTR9-PH2) has been established at the end of the year 2011. The current schedule foresees the submission of a final draft regulation including phase 2 to GRSP before the end of 2013. Final goal is the introduction of the FlexPLI for type approval testing within the new UN Regulation on pedestrian safety No. 127 from the year 2017 onwards.

Within Euro NCAP, the FlexPLI will be introduced in 2014 along with a homogeneous assessment of the bumper test zone using a grid and more stringent limits. As a medium term goal BASt is working on replacing the bonnet leading edge test with the upper legform and the bumper test with the lower legform by a combined test using the FlexPLI with upper body mass.

Figure 17: Replacement of upper legform and lower legform by FlexPLI-UBM.
2.14 GIDAS – a blueprint for worldwide In-Depth Road Accident Investigations

2.14.1 The GIDAS Project

BASt started investigating road accidents on the spot already in the early 70s. In order to have a more widespread investigation area and increase the number of accident units under investigation, BASt and FAT (The Research Association of Automotive Technology) initiated and launched a common accident investigation project in 1999 – the GIDAS project (German In-Depth Accident Study).

Since that time more than 23,000 accidents have been reported to the system, each one carrying information on more than 2,500 parameters. The GIDAS survey turned out to be a very efficient tool for rule makers as well as for automobile manufacturers. This is very much related to the fact, that the GIDAS data collection follows a statistical sampling scheme. This ensures that the data collected is a representative mapping of the real world. Consequently GIDAS is ideally suited to be used for cost benefit estimations or injury risk assessment.

2.14.2 Other x-IDAS projects

The basic methodology of the GIDAS project is of interest for other countries to build up own In-Depth investigations. BASt started co-operations in order to assist those countries. In 2010 a memorandum of understanding has been signed with Korea, in early 2011 with the Czech Republic and in mid 2011 a contract was signed with the CATARC authorities in China. Although each country needs to design such accident surveys to their own needs it is appreciable that comparable study designs, data collection techniques and reconstruction methods do exist.

Figure 18: Signature of the CATARC-BASt cooperation contract in Beijing in 2011

The Czech Republic and China have already started their In-Depth accident surveys and are by now producing high quality accident data records. It will be of particular interest in the near future to run some first parallel analysis on the current –idas surveys. This shall result in a much better comparison of countries safety priorities than it has been available in the past.

2.14.3 The iGLAD Initiative – making existing In-Depth data comparable

BASt is participating in another project which is trying to gain more insight into the safety diversity aspects worldwide. The iGLAD initiative (Initiative for Global Harmonization of Accident Data) is meant to be an attempt to make direct comparisons between countries possible. This is achieved by bringing together existing In-Depth road accident data sources. The problem of unified data was already identified quite a while ago, and numerous bi-lateral initiatives, regional working groups and task forces are attempting to find solutions. The drawback is that no truly international and global approach has yet been taken to find a globally harmonized and ultimately standardized approach to accident data.

Today the GIDAS consortium, in compliance with ACEA and FIA, supports the alternative to build a universally accepted common data subset built on top of already existing In-Depth projects. Setting up a suitable business model, data providers and data users can be brought together and the data can be made usable for an interested community of experts. Participants shall be confronted with a win-win situation and no further external funding shall be necessary.

2.15 Druid – Driving under the influence of drugs, alcohol and medicines

The use of psychoactive substances such as alcohol, drugs and medicines is a major cause of many traffic accidents in Europe.

2006 the European Commission launched, within its 6th Research Framework Programme, the integrated project DRUID (Driving under the Influence of Drugs, Alcohol and Medicines) aiming to assess the real scope of the driving under influence (DUI) problem and to develop appropriate countermeasures. The project had a total budget of 24 Mio. € (of which 19 Mio. € were EU contribution) and was implemented by a consortium of 37 partners from 17 EU Member States and Norway. DRUID Coordinator was the Federal Highway Research Institute (BASt, Germany).

The project was divided in seven Work Packages (WPs) to cover the whole area of research. In addition, Working Groups for special issues were established, e.g. for toxicological issues. All DRUID-participants collaborated very closely on a bilateral basis as well as within Work Packages. The range of disciplines within DRUID was widespread - physicians, pharmacologists, psychologists, toxicologists, methodologists, police officers were involved. An important part of the collaboration was knowledge and technology transfer. It was ensured, that all involved partners could work in compliance with unified standards for toxicological laboratories. In some countries, the appropriate equipment had to be installed and the staff had to be trained accordingly.
The project was completed in October 2011. The results of the project received a very good recognition of the scientific community; the European Commission evaluated the project as "good to excellent” for its outstanding scientific work, the rich gain of knowledge and the exploitable results and recommendations.

Some of the key findings from DRUID are:

- Epidemiological studies showed that alcohol is still the most dangerous psychoactive substance used by drivers in Europe. The biggest risk of being seriously injured or dying in a traffic accident arises from high blood alcohol levels or from alcohol–drug and drug–drug combinations. Blood or oral fluid samples collected from 50,000 drivers revealed that alcohol was present in 3.48 %, illicit drugs in 1.90 %, medicines in 1.36 %, drug–drug combinations in 0.39 % and alcohol–drug combinations in 0.37 %.

- Of the 13 oral fluid devices evaluated for practicability and their analytical accuracy only three devices were evaluated positively. Cost-benefit analysis showed that increased drug driving enforcement based on roadside saliva screening is potentially beneficial – especially for countries with lower baseline enforcement level. Yet, if the drink driving enforcement will be decreased for the sake of increasing the drugged driving enforcement, the net benefit for road safety will decrease.

- Psychoactive medicines on the EU market were classified into four categories depending on their influence on fitness to drive, and it was demonstrated that a pictogram on the package indicating the risk when driving was effective in changing patient behaviour. It was also shown that a software package could assist pharmacists in giving advice to patients when dispensing such medicines.

All 50 reports of the project (several thousand pages in total) are available for downloading on the DRUID website (www.druid-project.eu).

The DRUID consortium was established aiming to involve as much key European players in the domain of road safety research as possible. Besides, all relevant agencies over the world have been constantly informed on project results. DRUID partners reported on their activities bilaterally, as well as using international platforms like ICADTS/ TIAFT, TRA, Fit-to-Drive Congresses, etc. Relevant institutions have been involved in the process (e.g. EMA in the development of a classification system for medicines). These measures ensure an adequate dissemination of DRUID generated knowledge.

DRUID partners informed their national governments on DRUID achievements. As a result, many European countries have recently started to work on new national regulations taking into account DRUID findings. Among others, legal limits for some psychoactive substances (THC, Metamfetamine or Cocaine) based on DRUID results are under discussion in some countries and have already been introduced in Norway and Portugal.

Figure 19: DRUID – Driving under the influence of drugs alcohol and medicines

2.16 Smoke and toxicity in bus fires

Bus fires occur frequently but are usually not accompanied with severely injured persons. In most of the cases the fire starts in the engine compartment and does not affect any passengers because they can leave the bus in time. However single accidents, in which the fire enters the passenger compartment, resulted in a high number of fatalities. More dangerous than the fire itself is the toxicity of smoke gases due to burning interior parts made of plastic materials.

Therefore BASt initiated a research project with regard to the fire safety performance of buses including smoke development and its toxicity. The study was elaborated by BAM (Bundesanstalt für Materialforschung und -prüfung, Federal Institute for Materials Research and Testing, Germany) and was finished beginning of the year 2013. A lot of burning behaviour tests were carried out with small specimen of bus interior material, with complete seats and using whole buses in order to examine possibilities to further increase bus fire safety and to determine how far it is possible to transfer and adapt existing rail requirements to buses. Some of the outcome of the experiments is already incorporated into international legislation. Especially ECE Regulations No. 107 and 118 cover bus fire safety performance. E.g. fire detection systems in the engine compartment and smoke detection systems in separate interior compartments which turned out to be very useful are already required. Also testing of certain properties of insulation materials to repel fuel or lubricant as well as testing vertical burning rates for vertically mounted parts is specified in the ECE Regulations.
The most important results of the work concern smoke development and toxicity of smoke gas components which are still not covered by legislation. As demonstrated in the experiments, in case of a fire the air in a passenger compartment of a bus is quickly filled with large amounts of opaque smoke that impair visibility. Requirements limiting smoke density and toxic smoke gas concentrations would help to increase the time of escape for passengers in case of a bus fire so that they are not exposed to the toxic components that are produced when bus parts are burning. It is not sufficient to limit all components together by a weighted sum as in the current rail standard since single gases might be lethal although the sum limit is not exceeded. It is rather recommended to limit concentrations for each single component.

The study further recommends that besides smoke also the heat release of burning parts and the ignitability should be limited in order to avoid ignition of adjacent parts and thus minimise fire propagation. Also the concept to use fire suppression systems in the engine compartment should be pursued further.

Figure 20: Smoke spread test in the passenger compartment of a bus (source: BAM)