BOSCH

From	Our Reference	Tel	Fax	Schwieberdingen
CR/AEV1	Thomas Lich	0711/811-34831	0711/811-1720	26/3/2012

Report Number
CR/AEV 12/003

R&D Report: **Final Report**

Security Class: Internal   Export control relevant: No

Title: AEV-064: Annual Report 2011 – Details Accident Research

Abstract

1. Issues (situation, motivation and tasks)

AEV-064 represents the CR-Scouting activity with focus on accident research and crash simulation. The main idea of the project is to support the benefit oriented system development for active and passive safety along with the vision of injury (accident) free driving.

Key topics are:

- Benefit analyses and requirements of vehicle safety systems
- Risk analyses for future vehicle safety systems
- Input to focus roadmaps for safety systems
- Information about world wide road accidents and road safety activities
- Identify new systems in terms of accident mitigation and accident avoidance with new methods
- Know how build-up in the fields of crash and occupant simulation, human modeling, vehicle
- structures and occupant protection as base for future innovation
- Commission work (FAT-AK3 and 27, GIDAS, IRTAD)

2. Results

Based on the last years we can see that there is a high need of well-founded and latest information about the worldwide accident situation and the benefit estimation of new safety functions within our Bosch group. The present report contains detailed information of all studies in the field of accident research carried out in 2011.

3. Conclusions and Consequences

Since the project covers a broad variety of topics no final conclusion is given here. Please refer to the single short abstracts included in this report or the according presentations.

Document approval			
	Org.-Unit	**Name**	**Signature**
Author(s):	CR/AEV1	Lisa Sulzberger, Nils Kickler, Thomas Lich, Thomas Schlender, Jörg Mönnich	electronic release (FEBER)
Responsible person:	CR/AEV1	Thomas Lich	electronic release (FEBER)
Reviewer:	CR/AEV1	Andreas Georgi	electronic release (FEBER)
Releasing person:	CR/AEV	Christian Danz	electronic release (FEBER)

		External release of cover sheet:	No
Enclosure(s):	No	**External release of enclosure(s):**	No

Corporate Research

BOSCH

From	Our Reference	Tel	Fax	Schwieberdingen
CR/AEV1	Thomas Lich	0711/811-34831	0711/811-1720	26/3/2012

Report Number
CR/AEV 12/003

R&D Report: **Final Report**

Security Class: Internal Export control relevant: No

Title: AEV-064: Annual Report 2011 – Details Accident Research

Initial mailing list

Recipients: CR/AE1, CR/AEV, CR/AEV1

Cc:

Key Words
Traffic safety, accident research, crash simulation, occupant simulation, benefit estimation / analysis, active and passive safety, driver assistance systems, accident situation world wide including Asia, real world accident scenarios, accidents with injuries and property damage only, crash signals, injury criteria, occupant safety, safety of small and light weight vehicles

Underlying documents	**please link documents**		
Document number	**Title**	**Date**	**Responsible person**
CR/AEV 12/002	AEV-064: Annual Report 2011 – Overview Accident Research and Crash Simulation	26.03.2012	Gian Antonio D'Addetta, Thomas Lich
CR/AEV 12/004	AEV-064: Annual Report 2011 – Details Crash and Occupant Simulation	26.03.2012	Gian Antonio D'Addetta

More information:
https://inside.bosch.com/alias/cr/ufo

BOSCH

Annual Report 2011

CR/AEV

Accident Research

AEV-064

For internal use only!
Further use and reproduction only after consulting CR/AEV1.

BOSCH

From	Our Reference	Tel	Fax	Schwieberdingen
CR/AEV1	Project staff AEV064	0711/811-34831	0711/811-1720	11.01.2012

Report

Issue 2011

Topic **Annual Report of Scouting Activity "Accident Research (AEV064)**

Chapter

Table of Contents 01

BOSCH

From	Our Reference	Tel	Fax	Schwieberdingen
CR/AEV1	Project staff AEV064	0711/811-34831	0711/811-1720	17.01.2012 No. 1/2012

Report

Topic **Annual Report of Scouting Activity "Accident Research and Crash Simulation" (AEV064)**

Abstracts of Investigated Topics in Accident Research in 2011

Person in charge: Andreas Georgi, Thomas Lich, Jörg Mönnich, Thomas Schlender, Lisa Sulzberger, Girikumar K (India)

Chapter 04 – General Information to Accidents Situation Worldwide

Based on the last years we can see there is a high need on well-founded and latest information about the worldwide accident situation within our Bosch group. To meet all requirements we updated our standard accident research statistics arranged in different slides. The range of the presentations varies from the worldwide accident situation to different initiatives for advanced traffic safety where Bosch has its principal markets. Further on a chronological order of the accident situation or information about the major accident set-ups is supported.
The current link gives access to the continuously updated presentations for all Bosch employees and can be downloaded for distribution. We would be pleased if a reference to our department can be given in your presentations.

Bosch Accident Research@inside.portal: https://inside.bosch.com/alias/cr/ufo

Studies Accident Research

Chapter 05 – Benefit estimation about the effect of automatic braking systems in rear-end crashes

Nils Kickler, Thomas Lich

Scope

Estimation of the effect of automatic braking in rear-end crashes in dependence of the vehicle speed and the achievable speed reduction. For the functional assignment AEB-L has to be considered in the analysis.

Procedure

The distribution of vehicle travelling- and impact-speeds were examined within the field of effect for rear-end crash avoidance systems. For the relevant speed 60kph was selected as initial speed and dependencies were evaluated. Descriptive analysis was done for the selected accidents.

Results and Conclusion

About 2/3 of all rear-end crashes with casualties in Germany occur at speeds below 60 kph. A system active up to a travelling speed of 60 kph and decreasing the relative velocity at impact by up to 25 kph could prevent 1/3 rd being 4% of all casualty accidents in Germany.

Chapter 06 – Estimation about the effect of cross traffic alert rear on accidents

Thomas Schlender

Scope

Providing information about relevant accident situations for cross traffic alert rear (CTR) functions.

Procedure

Analysis is based on accidents with casualties from GIDAS (2001-2009) and on accidents with property damage only from AZT (2004 and 2007).
Accidents fulfilling the following criteria are analyzed:

- at least one car, van or transporter is involved
- car is driving backwards
- collision opponent moves lateral to backing vehicle

Results and Conclusion

Share of relevant accidents for cross traffic alert rear assistance functions:

Accidents with casualties (GIDAS):	<1%
Accidents with property damage only (AZT):	3%

Chapter 07 – Field of effect estimation for narrow point assistance systems

Thomas Schlender

Scope

Providing information about use-cases for narrow road assistance functions.

Procedure

Analysis is based on accidents with casualties from GIDAS (2001-2009) and accidents with property damage only from AZT (2004 and 2007).

Accidents involving at least one car, van or transporter are selected and analyzed subdivided in

a) "Accidents at road works on streets with constructional division"
b) "Accidents on rural streets without constructional division" and
c) "Accidents in urban area".

Result

About 0.8% of all accidents with casualties in Germany caused by a passenger car, van or transporter are due to narrow points or leaving lane.
About 3% of all insurance reported accidents with property damage only in Germany caused by a passenger car are due to narrow points.

Relevant cases for narrow road assistance functions:

	GIDAS	AZT
a) road works (constructional division)	<0.1%	<0.1%
b) rural streets	0.2%	1.2%
c) urban area	0.6%	1.8%

Chapter 08 – Potential estimation of motorcycle eCall in Germany

Thomas Lich

Scope

Aim of this analysis is the identification of the potential for an eCall system for powered two wheeler.

Procedure

Analysis is based on evaluation of GIDAS database (2001-2010). Each accident within GIDAS includes time of report and time of arrival of the rescue team on the spot. This time difference is evaluated and the current situation is shown for the German accident situation. Comparing against severity and time difference further results can be obtained in order to verify the needs of an eCall system.

Results and Conclusion

For the analysis 497 weighted accidents w/ casualties in Germany involving PTW available. In 87% of this the ambulance arrived 20 min. after report. All fatal accidents were reached within this time frame. Highest "use case" is seen on accidents where death occurred at the spot, which occurred in 33% of all fatal accidents. Highest benefit assumed for accident scenarios in rural area of single vehicle accidents at night time which have a share of 1% of all accidents w/ casualties with PTW.

Chapter 09 – Benefit Estimation of motorcycle ABS in USA

Thomas Lich

Scope

Estimation of field of effect and benefit from a powered two wheeler ABS for the United States on accidents w/ casualties involving powered two wheeler

Procedure

Analysis is based on a transfer of results out of a study from GER using GIDAS (2001-2004) database to US using GES (2009) data-base. 216 accidents w/ casualties involving powered two wheeler were reclassified according to the GES accident type. After that the share of ABS relevance was recalculated on the GES data. The ABS accident avoidance potential was also shared for the avoided accidents on the GES data.

Results and Conclusion

60% of all accidents w/ casualties involving powered two wheeler are relevant for a PTW ABS. 36% out of this are accidents where the powered two wheeler went off the road or hits an object followed by collision against another vehicle (19%). The accident avoidance potential for a PTW ABS in the US is estimated to 35% by transfer to US. Therefore high potential is seen for powered two wheeler safety systems in the US.

Chapter 10 – Benefit Estimation of LDW/LKS in USA

Nils Kickler, Jörg Mönnich

Scope

Reevaluation of three systems for the prevention of unintended lane departure, taking into account different accident situations in Germany and USA

Procedure

Analysis of accidents with casualties in Germany and USA to determine the field of effect. Transfer the method (same parameter) from German Database GIDAS[1)] to US Database GES[2)] Using the results from a previous study for determine the system efficiency in Germany and transfer to USA.

Results and Conclusion

The share of lane departure accidents within all casualty accidents of cars, trucks and busses is similar in Germany and the United States. The field of effect[3)] for LDW/LKS/ASC is in summary only slightly larger in the USA (6%) as compared to Germany (5%).

Chapter 11 – Estimation about the effect of speed limiters for trucks in USA

Thomas Schlender

Scope

Providing information about the possible effect of using speed limiters for trucks in the USA.

Procedure

Literature research for facts and studies regarding the effect of using speed limiters for trucks in the USA.

Results and Conclusion

- GES data are not suitable to estimate the influence of speed limiters for trucks, therefore literature research was done.
- U.K.: Crash involvement rate for speed-limited heavy trucks fell about 26%.
- Current usage of speed limiters within the USA:
- "...the percentage of fleets that use the ECM speed limiter functionality appears to be approximately 65% across the industry." [8]
- Tampering of speed limiters for trucks was identified as a significant problem in all countries, measures against are relatively expensive.
- Speed limiters could become mandatory in the USA because of the NHTSA rulemaking process in 2012. (Docket No. NHTSA-2007-26851)

Conclusion:

“To summarise, it is clear that the known effects of speed limitation devices are generally very positive for drivers, for companies, for society and for the environment. The negative aspects are small and avoidable ... “ [source: EUR-Lex, Report from the Commission to the European Parliament]

Chapter 12 – Status Accident Research Activities in Asia

Thomas Lich, Jörg Mönnich, Girikumar K, Andreas Georgi

Scope

The highest market growth in automotive market is seen in China and India currently. In order to evaluate their needs for vehicle safety accident data has to be taken into account. Due to this the activities to receive valuable accident data in the Eastern countries have to be increased. In addition to this it is also necessary to come up with benefit estimations of existing systems like ESC, PEBS etc. in the more developed Eastern countries like Japan or Korea and to ensure access to existing data sources.

Procedure

To expand our activities in the Eastern countries – selected Institutes / Universities as well as Governmental organizations are contacted. Starting in 2009 with Japan with our activities on near miss accident data from Naturalistic driving studies we could establish a new valuable data source in South Korea in order to enhance our knowledge of the pre-crash phase. In addition to that several programs were setup in China and India together with OEM to setup an In-depth-Accident investigation. By sharing knowledge based in the field of data collection and study evaluations an in kind is given in order to receive full access to the data.

Results

In China the cooperation with CATARC (China Automotive Technology and Research Center) is ongoing continuously in order to evaluate the benefit of the ESC system. Further on the CIDAS project started in July 2011 with collection In-Depth Accident data in 6 cities. Currently there are about 80 cases available. Reconstruction and severity information only partly available. In Japan full access to event driver recorder data is now available and cooperation with the Tokyo University in order to analyze the behavior of pedestrians in near miss accidents was setup. Due to high costs of In-depth-accident data the current activities are on hold. Besides that our activities in 2009/2010 resulted in a study on powered two wheelers with Honda and possible access to In-depth-accident data from Thailand.

In India a consortium was setup for In Depth Accident data collection. Up to now there are 100 cases available. Partly cases are reconstructed and severity information has to be collected additionally. In order to improve data quality from the on-spot scene GIDAS similar methods were transferred and established.

In Korea together with the Korean Transport Institute a study was started where Bosch exclusively received 4000 video documented taxi accidents around Incheon area. RB and KOTI started a study till June 2012 on the benefit estimation of PEBS in Korea based on the video documented data supported by KOTI.

Chapter 13 – Further results about car accidents of elderly drivers

Nils Kickler, Jörg Mönnich

Scope

Declines in certain driving related abilities, as caused by ageing, favor the occurrence of specific accident situations. In the current study, the principal goal was to compare property damage accidents between elderly and younger drivers. Further, existing concepts to address problems of elderly drivers were summarized.

Procedure

Data from a German insurance company (Allianz) and from the US national highway transport safety agency (NHTSA) were grouped according to different criteria. The group distribution was compared between drivers aged above and below 65 years, having caused the accident. Based on patents and applications from the United States Patent and Trademark Office (USPTO) general approaches to address problems of elderly drivers were summarized. Further, initiatives of different universities and organizations were highlighted.

Results and Conclusion

Low speed property damage accidents (parking & maneuvering) occur more often to elderly drivers than to younger ones. In general, elderly drivers show increased problems while turning and driving backwards whereas younger drivers are more often involved in rear-end crashes. So far, only few concepts for assistance systems addressing the specific needs of elderly drivers were found.

Chapter 14 – Worldwide overview about alcohol related accidents

Girikumar K, Jörg Mönnich

Scope

The current study is aimed to give an overview on global status on road traffic accidents related to alcohol

Procedure

Analysis is based on various reports - Global status report on road safety, IRTAD annual reports etc. The data are consolidated and presented, major fatalities involving alcohol related crashes and BAC limits and laws of each countries and fatalities related alcohol crashes are discussed in this report to give the glimpse on global problem – ‘Road traffic accidents related to alcohol‘

Results and Conclusion

The falling trend in number of fatal accidents and increase/constant share of alcohol related accidents clearly shows that ‘Road traffic accidents related to alcohol‘ is a global problem
Potential for innovation is possible in this area, which can be later products for BOSCH

Chapter 15 – Analysis about accidents at intersections in Germany

Lisa Sulzberger

Scope

Information about situations relevant for intersection assistance and parameters interesting for function development is provided.

Procedure

Analysis is based on accidents with casualties from GIDAS (2001-2008). Accidents at intersections involving at least one car, van or transporter are selected. Accidents at intersections are analyzed subdivided in “collision w/oncoming traffic during left-turn” and “situations caused by ignoring traffic control”. Distributions about different parameters are provided for these accidents.

Results and Conclusion

17% of all accidents with casualties are relevant for intersection assistance systems (5% collision w/oncoming traffic during left-turn, 12% situations caused by ignoring traffic control).
Most of the accidents relevant for intersection assistance take place inside urban areas at intersections which are ruled by sign. Intersection are mainly big (road width >10m). Nearly 2/3 of the causers do not react before crash, the opponents react a bit more often before crash.

EXCURSUS: Injury severity of car occupants in intersection accidents in Germany

Scope

For ISO26262 severity classification estimations about the injury severities of car, van or transporter occupants in accidents at intersections is needed.

Procedure

The analysis is based on accidents with casualties from GIDAS (2001-2011). Accidents are selected in which at least one car, van or transporter has a crash at a junction, crossing, roundabout or property exit. Additionally the crash must be with another vehicle moving ahead or waiting, moving laterally in the same direction, with an oncoming or with another vehicle which turns into or crosses a road. For these accidents the occurring injury severities (AIS level) of car, van or transporter occupants are provided subdivided in the accident site.

Results

One third of all accidents with casualties in Germany involving at least one car, van or transporter happen at intersections and vehicles collide with each other in relevant configurations. About one fifth of the accidents at intersection and relevant crash configuration happen in rural areas. The rest takes place in urban areas. The distribution about the injury severities shows that more than three quarters of the car, van and transporter occupants are injured in rural areas. In urban less than half of the occupans are injured. High injury severities of car, van or transporter occupants in relevant intersections accidents are very rare in urban areas (less than 1% >AIS3). In rural areas this share is bigger: about 2%.

Chapter 16 – Overview about traffic jam related accidents in Germany

Jörg Mönnich

Scope

Collection of fundamental information about traffic jam related accidents. Determination of several characteristics like time, location, severity and vehicle involvement in traffic jam related accidents.

Procedure

Analysis of accidents (based on GIDAS Database 2001-2011) with casualties in Germany to determine the field of effect. The accidents were based on the description of accident and the accident type is determined partly by case analysis.

Results and Conclusion

Approximately 11,000 accidents with causalities (3.7% of all accidents with casualties) per year in Germany are traffic jam related. Around 72 % of these accidents occur in non-urban areas and in nearly 2/3 of all traffic jam related accidents the oncoming traffic is separated constructionally.

Report

Topic Annual Report of Scouting Activity "Accident Research and Crash Simulation" (AEV064)

Abstracts of Investigated Topics in

Accident Research in 2011

Chapter 17 – Concept for determining confidence intervals in GIDAS (German In-Depth Accident Study)

Lisa Sulzberger

Scope

Providing a concept for determining the confidence of results based on accident data analysis from GIDAS. A statement about confidence of the results is interesting because GIDAS is a sample of all accidents injuries in Germany (headword: sampling errors).

Procedure

The sample design which is used for data capture in GIDAS is considered. Literature and internet investigations about methods are conducted which can be used to estimate variances / standard errors for data obtained in complex sample designs. Besides methods which are used in US accident databases to determine confidence intervals are considered. Based on this information a proposal is drawn up.

Results and Conclusion

A concept for determining confidence of results is provided. In the next steps this concept should be reviewed by an external expert. The proposal can be applied to the GIDAS data and by considering an example it should be tested how good the results fit to reality.

Chapter 18 – Status of EU-Project “ASSESSment of Vehicle Safety Systems”

Lisa Sulzberger

Scope

In this FP7-EC-project a relevant set of test and assessment methods applicable to a wide range of integrated vehicle safety systems should be developed.

Procedure

The project started in July 2009 and will last 3.5 years. It is subdivided in 7 work packages. Different procedure will be developed for driver behaviour evaluation, pre-crash system performance evaluation, crash performance evaluation and socio economic assessment. The proposed set of test and assessment methods will be evaluated on the basis of actual safety systems currently offered to the market. It is planned to evaluate the developed test and assessment methods by applying them to the “BAS (Braking Assistant) Plus” of Daimler and to

the "Advanced PCA (Pre-Crash Assistant)" of Toyota. It is planned to use the developed test procedures as basis for additional legislative measures on EU-level or consumer tests.
Bosch is mainly involved in the first work package in which test scenarios will be defined based on accident data analyses. Besides Mr. Kropf (CC/NE2) is a member of the supervisory board. The participation makes it possible to monitor the activities in all work packages of the project and to intervene if necessary.

Results

Based on accident data test scenarios are defined. Assessment criteria for assessing HMI, pre-crash and crash are identified and will be verified. The results based on applying the criteria for the three specified groups will be compiled in one tool which will provide a comprehensive assessment of a safety system. A first version of the tool is available but additional refinement steps are expected.

For estimating the socio-economic benefit an assessment method is designed which will be developed further during the next months. Additionally aspects concerning liabilities and legal issues are considered.

In order to analyze behavioural aspects a story book for a test simulation area is developed. Studies with test persons are conducted. The evaluation and documentation of the results from these studies will be completed in the beginning of 2012.

Besides laboratories and a target vehicle are prepared. Further exemplary tests will be conducted during next months.

References

For more information please see on http://www.assess-project.eu. The deliverables with detailed information about the results gathered in the different work packages can be downloaded on http://www.assess-project.eu/site/en/documents.php.

Small Studies Accident Research

Chapter 19 – Pedestrian Accidents in Japan

Thomas Lich

Scope

Pedestrian accidents account to a share of 9% in Japan. A more significant number are fatal accidents which have a share of 34%. Therefore pedestrian accidents are in focus. Therefore it is of high interest how the accident situations look like. A small inquiry was setup to analyze the official accident statistics considering accidents involving pedestrians.

Procedure

Official statistics out of 2007 were analyzed in more detail and official available information was gathered. In addition to official statistics a master theses on incident data at the Tokyo University was setup to analyze the pedestrian behaviour in 2009. The results of the master thesis are not included in this annual report. If more information required please ask.

Results

As a result within 73159 accidents involving pedestrians a share of 58% are collisions against the pedestrian while crossing the road. Further a share of 15% are collisions while the pedestrian was on the roadway either facing forward or backward. Outcomes from the master thesis results show a similar behaviour for incident data.

Chapter 20 – Comparison of pedestrian accidents in USA and Germany

Thomas Schlender

Scope

Comparison of pedestrian accidents in USA and Germany.

Procedure

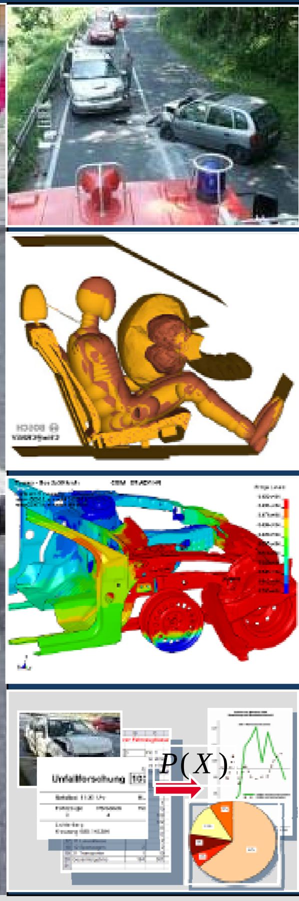
Analysis is based on accidents with casualties from GES(2009) and GIDAS (2001-2009)
Accidents fulfilling the following criteria are analyzed:

- only accidents with causalities
- all accidents involving cars and pedestrians
- vehicle not backing
- no driverless vehicle

Results

In sum it can be seen that the distributions of the analyzed variables do not show a completely different behaviour between Germany and USA.
The different distribution of accident types is on the one hand caused by different coding rules in Germany and USA, on the other hand it can be seen that the different infrastructure and pedestrian behavior has an influence - e.g. road construction at intersections differs between Germany and USA.

Overview of Accident Research in 2011



Accident Research CR/AEV1

BOSCH

AEV-064 Ufo - Overview

Staff Objectives

CR/AEV1 **Andreas Georgi**	**AEV-064 Accident Research** & Crash Simulation

Accident Research (Ufo) HC 4.5

Lisa Sulzberger
Team leader, accident analyses and studies, benefit and risk analyses, prediction model / statistical methods, EU project: ASSESS, representative GIDAS expert groups

Thomas Lich
Area of responsibility: Asian representative; RASSI[1], accident analyses and studies, benefit and risk analyses, powered two-wheeler safety, representative IRTAD

Jörg Mönnich
accident reconstruction, representative GIDAS expert groups, accident analyses and studies, benefit and risk analyses for C2X functions, ögP "simTD"

Thomas Schlender
accident analyses and studies, benefit and risk analyses, representative ADAC

Functional assignment:

Girikumar K (RBEI/ESA3)
accident analyses and studies India, representative RASSI[1]

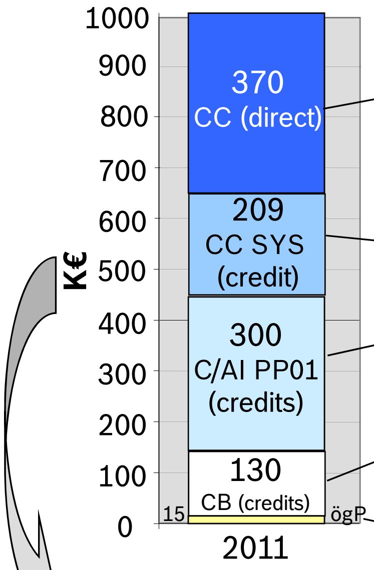
1) Road Accident Sampling System India

BOSCH

Update Accident Research (Ufo)

- **Staff Ufo** within AEV-064
  - Status 2011: 4.5 staff members (constant)
- **Cooperation / sub-contracting**
  - VDA FAT AK3: RB is Partner in GIDAS consortium **[status: running]**
  - EU: Participation in EU funded project ASSESS **[status: running]**
  - China Automotive Traffic Research Centre (CATARC):
    - Support of ESC effectiveness study for China **[status: running]**
    - RB is Partner in CIDAS consortium **[status: running]**
  - China – Tongji University Shanghai: Consortium partner in accident data collection project **[status: terminated]**
  - Japan: Study on pedestrian behaviour using incident drive recorder data with Tokyo University **[status: terminated]**
  - Korean Transport Institute (KOTI): Study on pre-crash behavior based on data from event drive recorder (incl. video) **[status: running]**
  - India: First crash investigation project setup in Coimbatore with JP Research, RB is Partner in RASSI consortium **[status: running]**

Accident Research (Ufo): Status Topics 2011



No.	Topics 2011	exp. status (end of 2011)
1	project management (total 600h)	running on plan
2	small studies (total 650h)	running on plan
3	ESP effectiveness study China (support data analysis/education)	running on plan
4	support marketing activities / political items	running on plan
5	extension of Asian databases (e.g. Brazil (ESP study), Russia)	cancelled
6	short-term inquiries from CC board	running on plan
7	Overview to field of effect and benefit of CC VMS functions, incl. property damage only and	completed
8	analysis to accidents at crossings/intersections	completed
9	analysis to narrow street assist incl. road works (field of effect, rough benefit)	completed
10	estimation of the effect of pre-crash sensors in side crashes	completed
11	estimation of the effect of cross traffic alert rear in all accidents	completed
12	transfer of the benefit of LDW/LKS to USA	completed
13	analysis to traffic jam assist (main focus: ASIL S classification)	completed
14	analysis of pre-crash behavior based on data from a event data recorder (video included)	partially worked on
15	continuation of analysis to motorcycle front wheel ABS - Honda study, update USA	completed
16	first analysis to accident situation in China based on in-depth and official data	running on plan
17	Built-up of know how in China and India (1 employee each) - Main Tasks: Built-up databases similar to GIDAS, be part of accident research community, own analyses	running on plan cancelled
18	commission work GIDAS, FAT-AK3, IRTAD (Ground work)	running on plan
19	support of analyses to ISO 26262 aspects	cancelled
20	development of a concept for extrapolating GIDAS data to EU countries	running on plan
21	education of JP Research concerning accident reconstruction in India	running on plan
22	continuation of analysis to accidents with elderly people	completed
23	analysis to alcohol related accidents - situation in EU, India, China, Russia	completed
24	analysis to far side collisions	completed
25	analysis to potential for motorcycle eCall	completed
26	estimation of the effect of speed limiters for trucks in the US	completed
27	analysis of pre-crash behavior based on data from a event data recorder (focus data preparation)	partially worked on
28	continuation of analysis of pedestrian behavior in accident situation/ near miss (J)	running on plan
29	education of the new employees from India and China in Si	running on plan
30	education of JP Research employees concerning accident reconstruction in India	running on plan
31	update of standard slides	running on plan
32	analysis to the effect of extended AEB-L	completed
33	analysis to deformation behavior of longitudinal member considering impact speed	completed
34	development of a concept for calculation of standard errors for accident estimates	running on plan
35	EU project ASSESS	running on plan

finished in 2011
to be continued in 2012
cancelled/partially worked on

<u>in sum this corresponds to:</u>
5.5employees* = 7370h
260K€ material costs**

<u>but 2011 in reality:</u>
4.5employees* = 6030h
1employee in IN (by mat. costs)

→ no/partial work on future, long-term topics like video analysis, forecast, CN staff

→ Main topics instructed from CC and C/AI running on plan or finished

→ But termination/reduction of future, long-term topics due to employee situation

* Based on 35 working hours per week and employee, AEV hourly rate 103€
** Material costs contain costs for data base access e.g. GIDAS, activities in Asia (1employee in India, China each), software etc.

Bosch Accident Research

– Standard slides / Overview –

Bosch Accident Research @ inside.portal:
https://inside.bosch.com/alias/cr/ufo

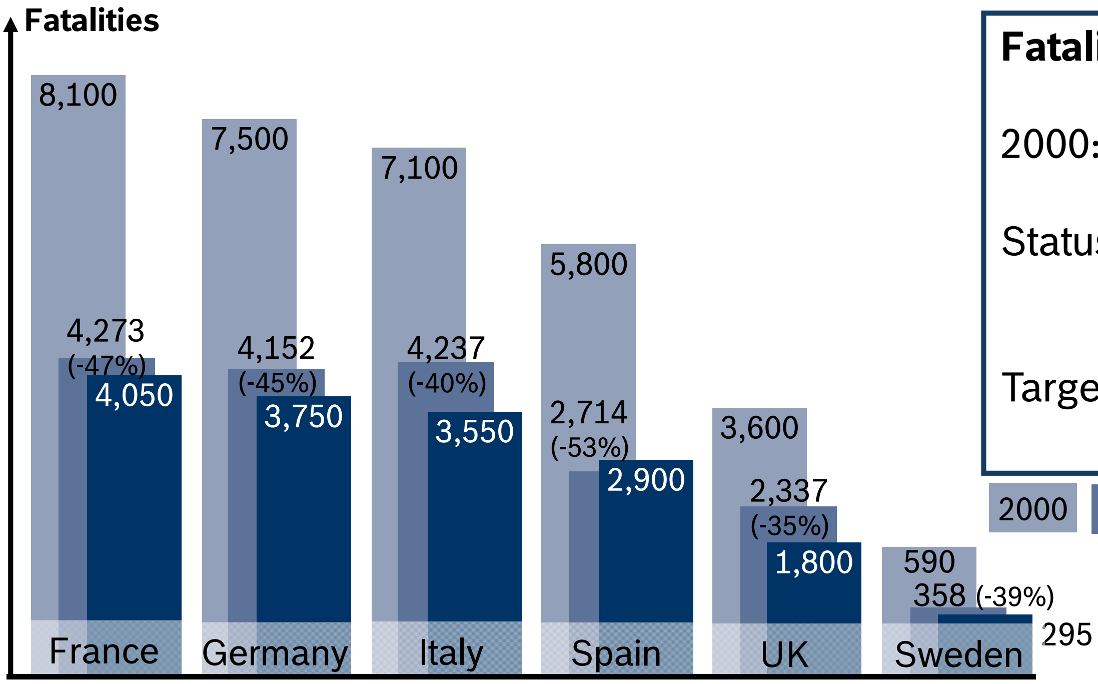
Accident research CR / AEV1

BOSCH

Initiatives in road safety – Europe

25 000 LIVES TO SAVE European Road Safety Charter

Vision: accident-free driving; status 2009



Fatalities EU 25:

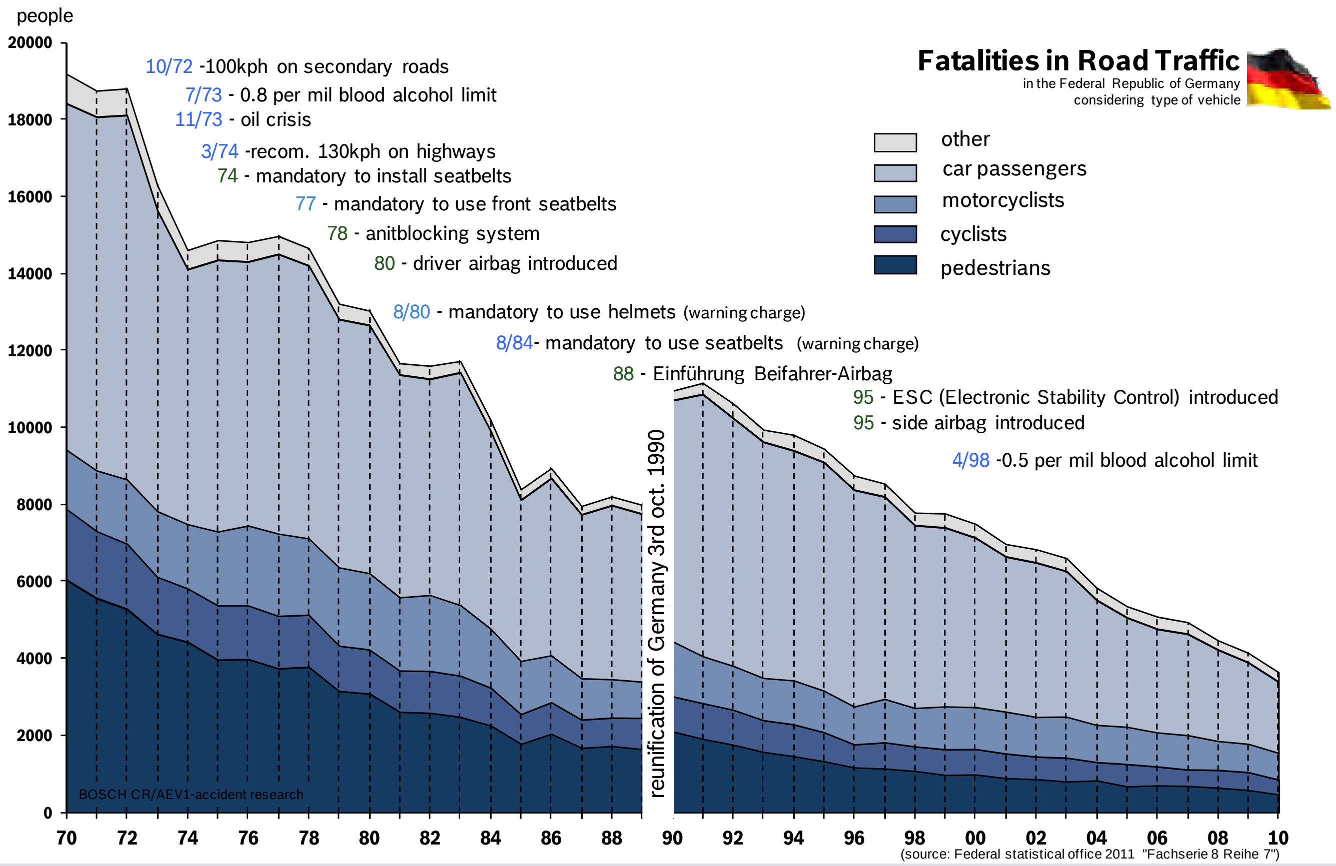
2000: 52,000

Status 2009: 31,120 **(-40%)**

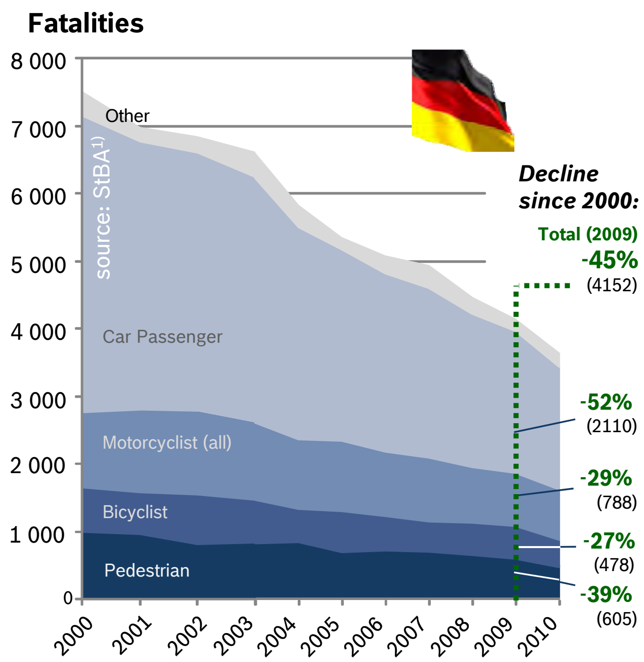
Target 2010: 26,000 **(-50%)**

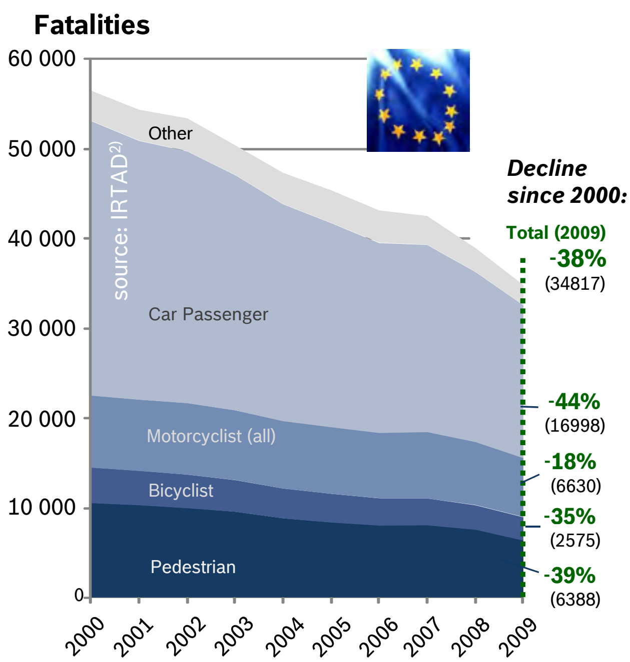
Sources: International Road Traffic and Accident Database IRTAD; CARE database road safety evolution in the EU, 2011 (http://ec.europa.eu/transport/road_safety/specialist/statistics/care_reports_graphics/index_en.htm)

BOSCH



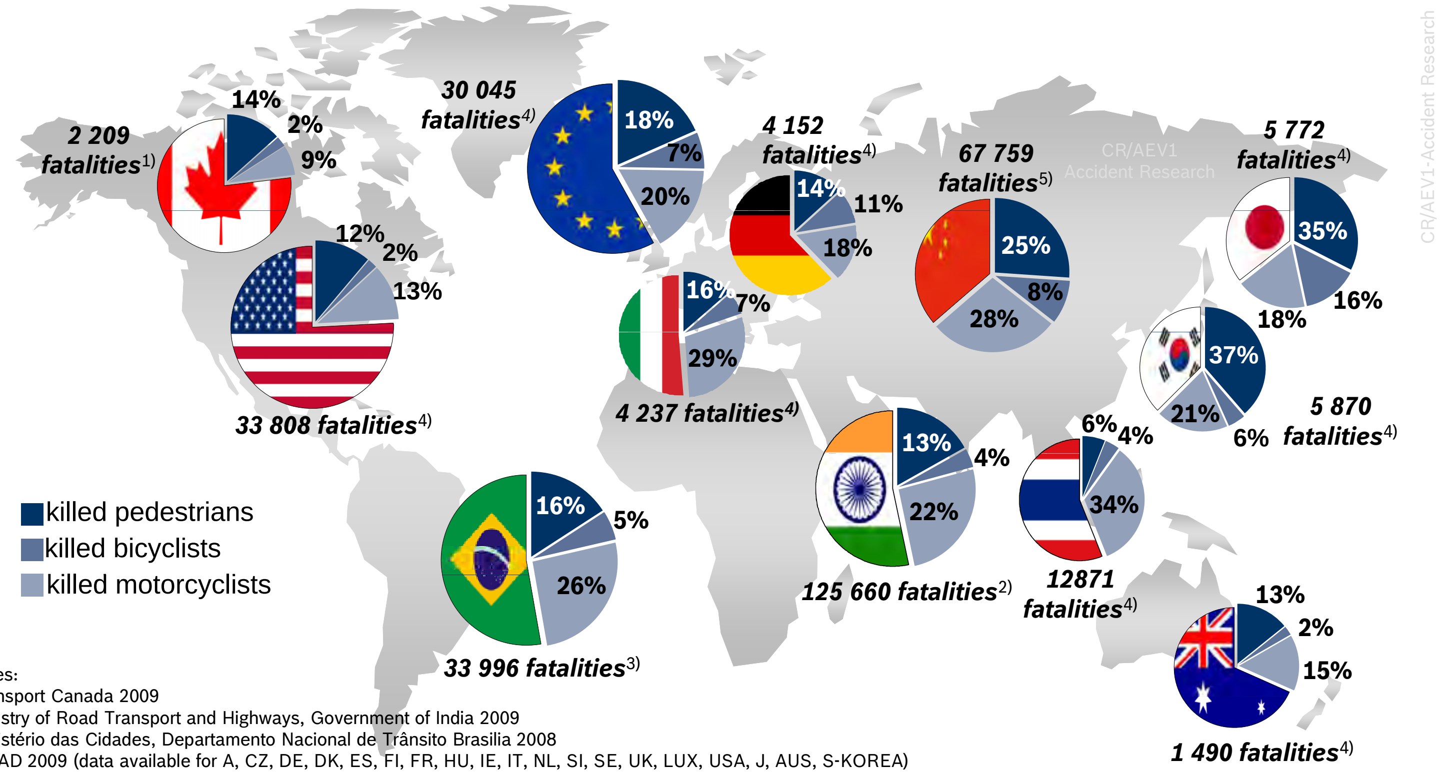
Fatality distribution in Germany / EU27 since 2000





1) StBA: Fachserie 8 Reihe 7 Yearbook 2010, Data from 2000 to 2003 approximated with IRTAD2)
2) IRTAD: Road Safety Annual Report 2010 (Data for year 2010 not available); CARE (EU road accidents database)

Fatalities in road traffic 2009 – share of vulnerable road users (VRU)

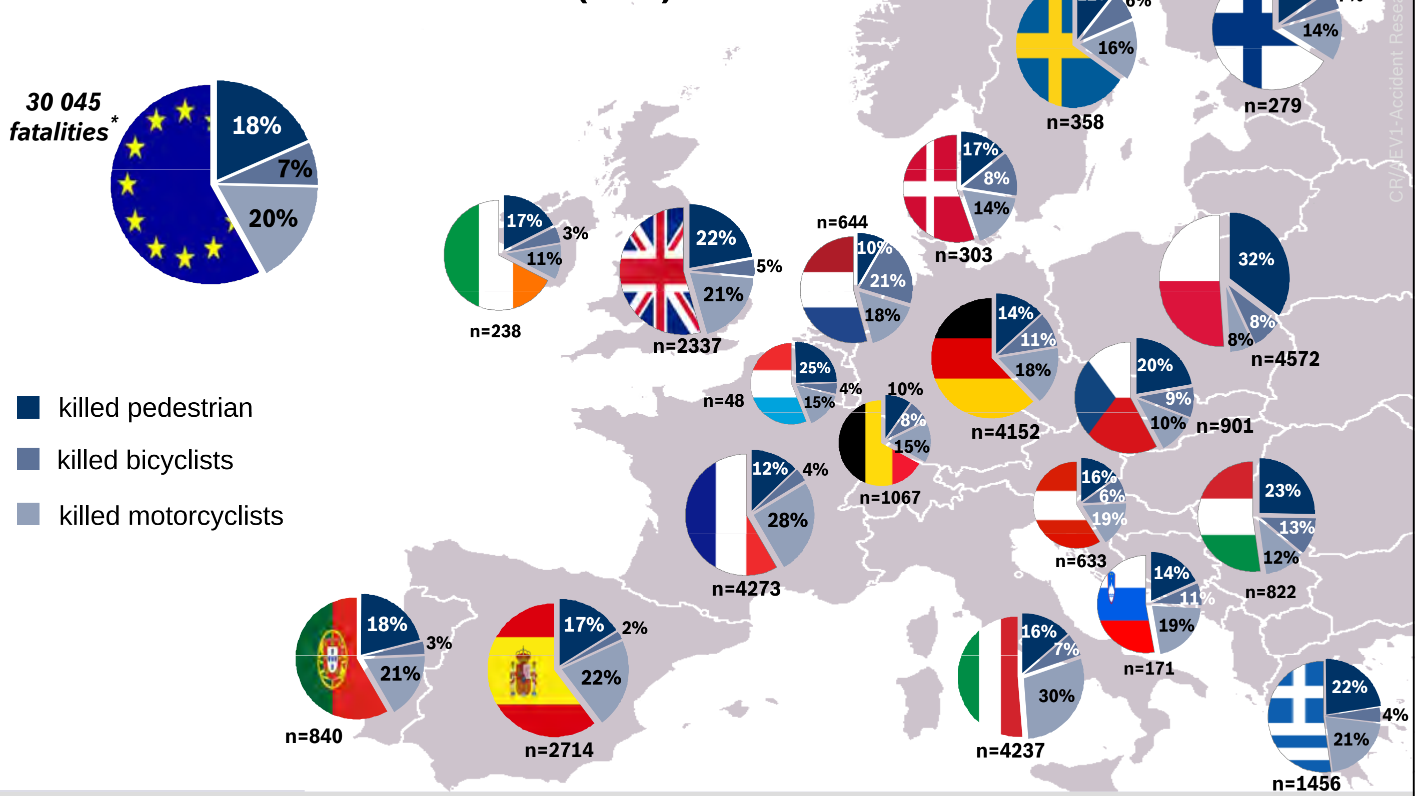


Sources:
1) Transport Canada 2009
2) Ministry of Road Transport and Highways, Government of India 2009
3) Ministério das Cidades, Departamento Nacional de Trânsito Brasilia 2008
4) IRTAD 2009 (data available for A, CZ, DE, DK, ES, FI, FR, HU, IE, IT, NL, SI, SE, UK, LUX, USA, J, AUS, S-KOREA)
5) Traffic Accidents China, Official yearbook 2009
6) Royal Thai Police, Traffic Accident National Highways 2005, extrapolated data (biased) based on 2005, known numbers from 2006: 12 691 fatalities

Standard Slide Accident Research RB - CR/AEV1 008UFO Chapter 04

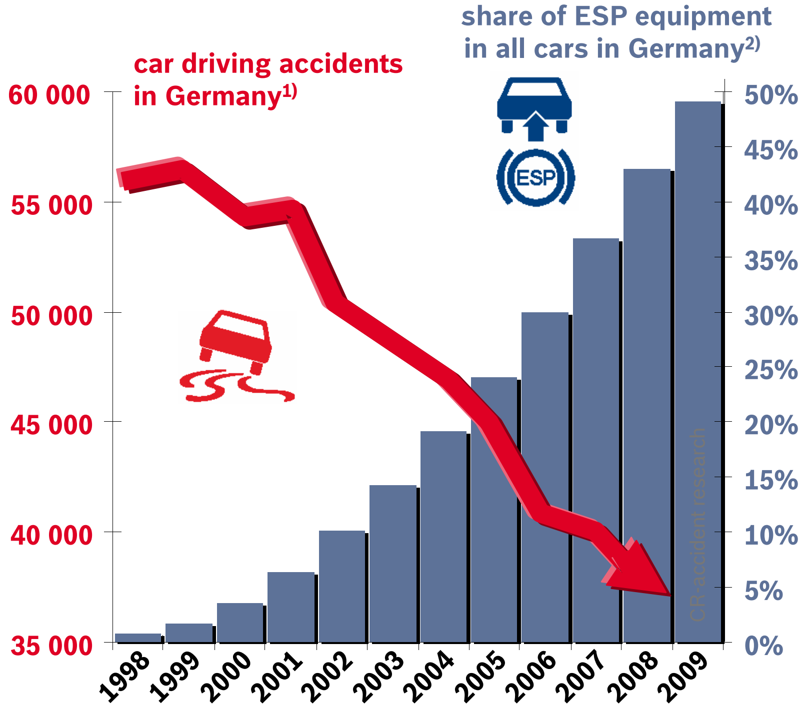
Fatalities in road traffic 2009 - Europe

Share of vulnerable road users (VRU)



* IRTAD 2009 data available for A, BE (2007), CZ, DK, FIN, F, D, GR, H, IRL, I, L, NL, PL, P, SLO, E, S, UK

Trend of driving accidents in Germany



➔ Skidding precedes approximately each second driving accident

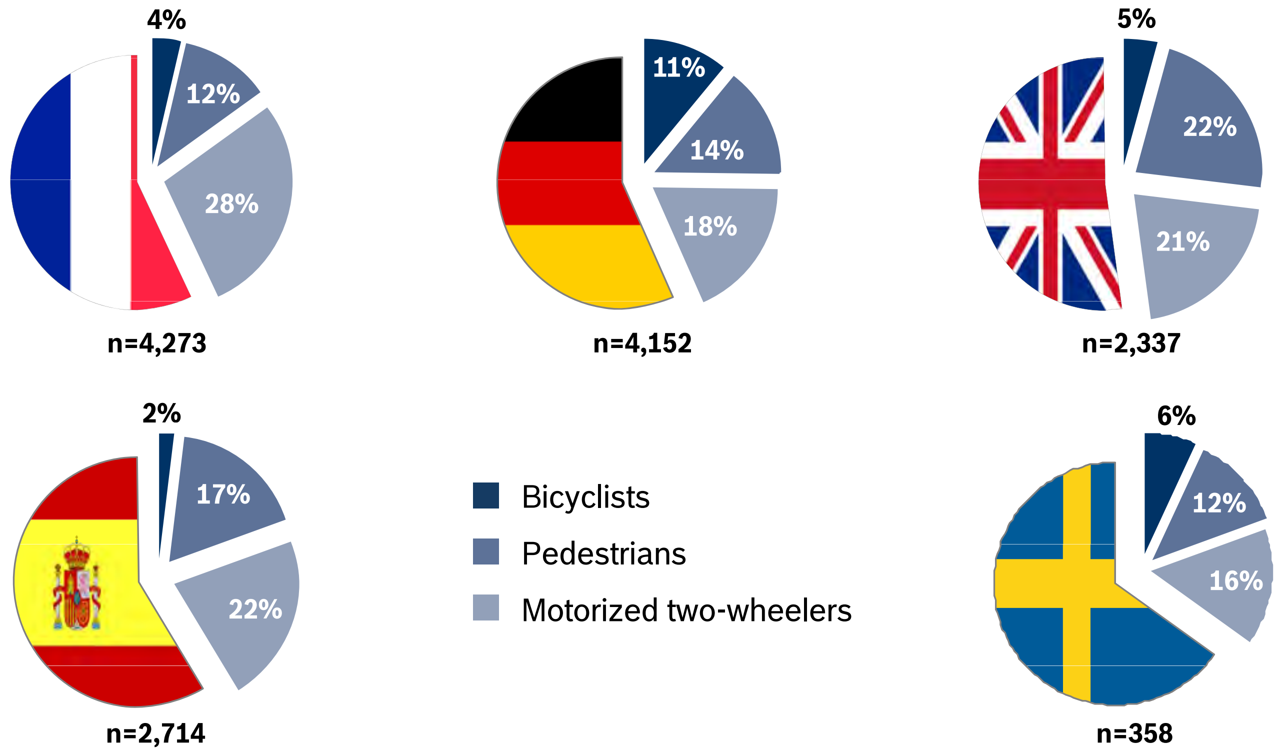
➔ ESP® avoids 80% of skidding situations in accidents

- **ESP® makes a large contribution to the reduction of car driving accidents!**

sources: [1] Federal Statistical Office Germany: special study (accidents with personal injury)
[2] Institute for Transport Economics of Cologne: study “Cost-benefit-analysis of ESP“

BOSCH

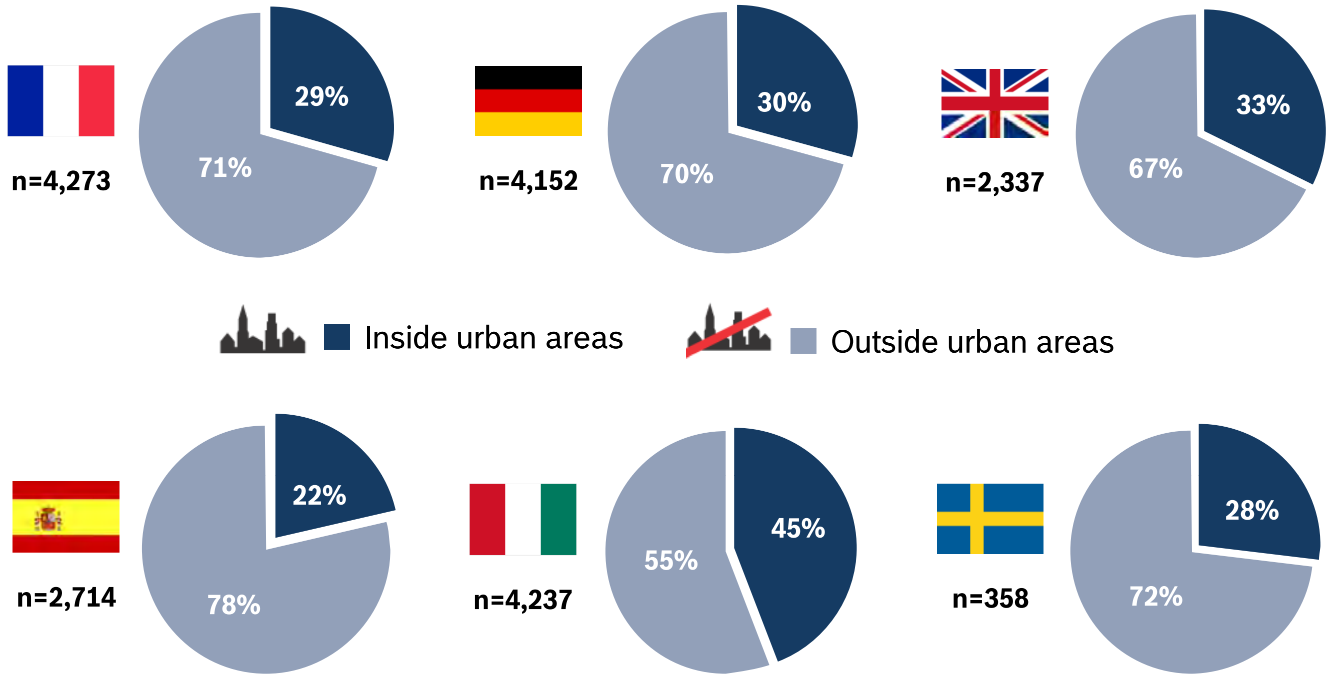
Vulnerable road users - fatalities 2009



Source: International Road Traffic and Accident Database IRTAD

BOSCH

Fatalities by scene of accident 2009

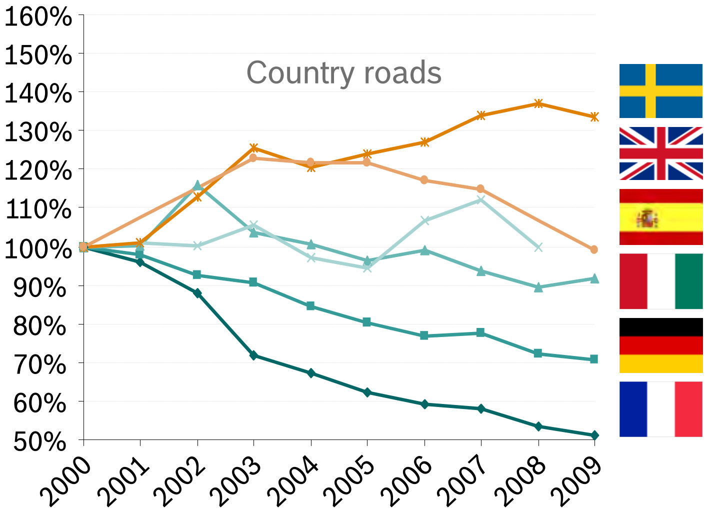


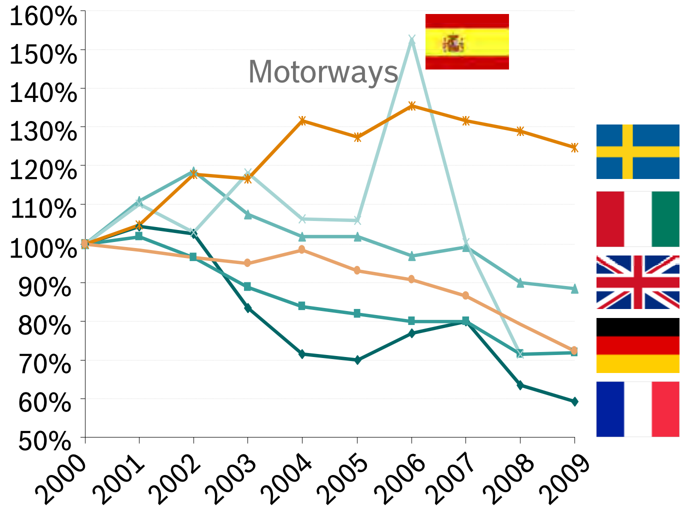
Source: International Road Traffic and Accident Database IRTAD

Injury accidents outside urban areas

Outside urban area

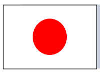
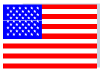
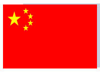
YEAR 2000	France	Germany	Italy	Spain	Sweden	UK*
Country roads	33,248	111,901	43,115	41,599	5,632	56,343
Motorways	7,401	25,578	13,788	3,121	1,128	9,368





source: International Road Traffic and Accident Database IRTAD
* no data available for 2001, 2002 and 2008 in the UK

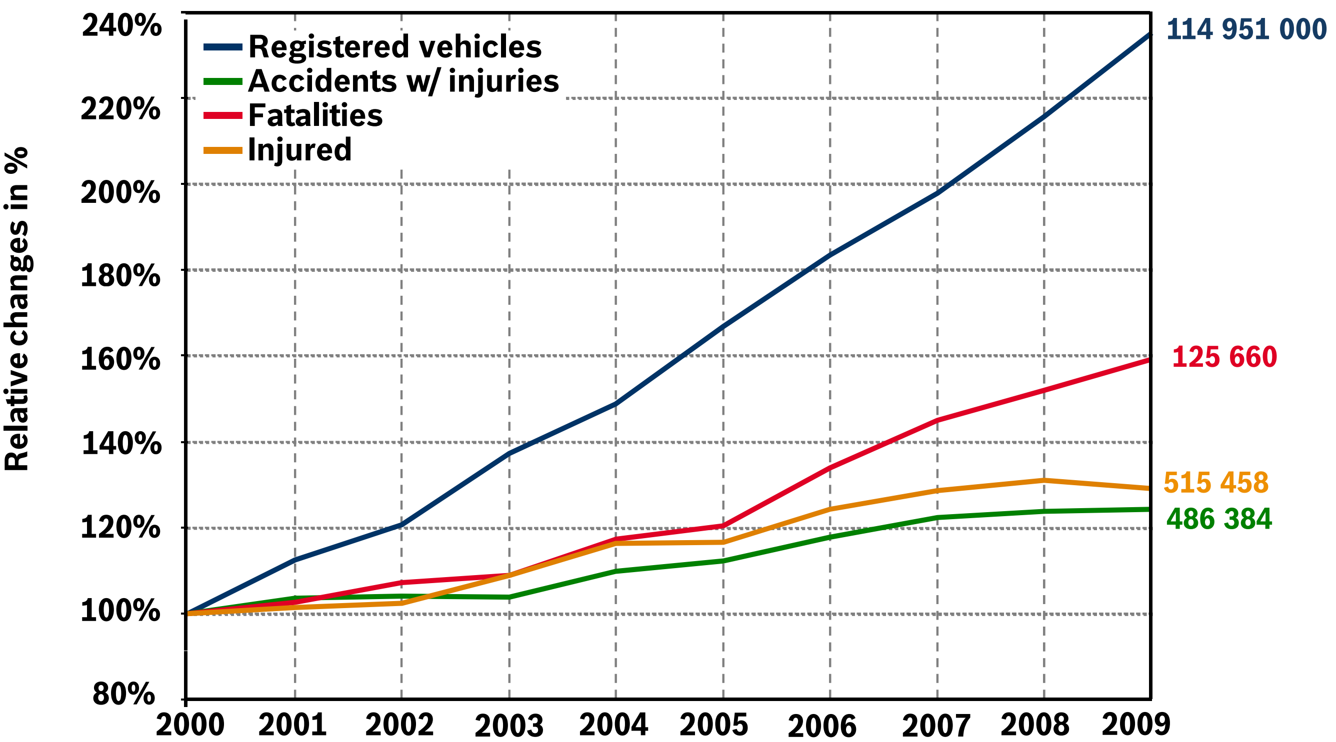
Road safety in 2009 – a public health issue

	Registered motor vehicles [Mio]	**Road accidents involving injuries** [Mio]	**Fatalities**	**Fatality risk per vehicle**
			(fatalities within 30 days after accident)	
	91.2* (* 2007)	0.74	**5,772**	**1 : 18,600**
	301.7* (* 2008)	1.19	**34,817**	**1 : 8,700**
	258.9	1.55	**33,808**	**1 : 7,700**
	19.1	0.23	**5,838**	**1 : 3,300**
	169.9 (* 2008)	0.24	**67759**	**1 : 2,500**
	54.5* (* 2008)	0.43* (* 2008)	**33,996*** (* 2008)	**1 : 1,600**
	38.3 (* 2008)	0.22 (* 2008)	**39,936**** (* 2008)	**1 : 1,000**
	114.9	0.48	**125,660**	**1 : 914**

** fatalities within 7 days after accident

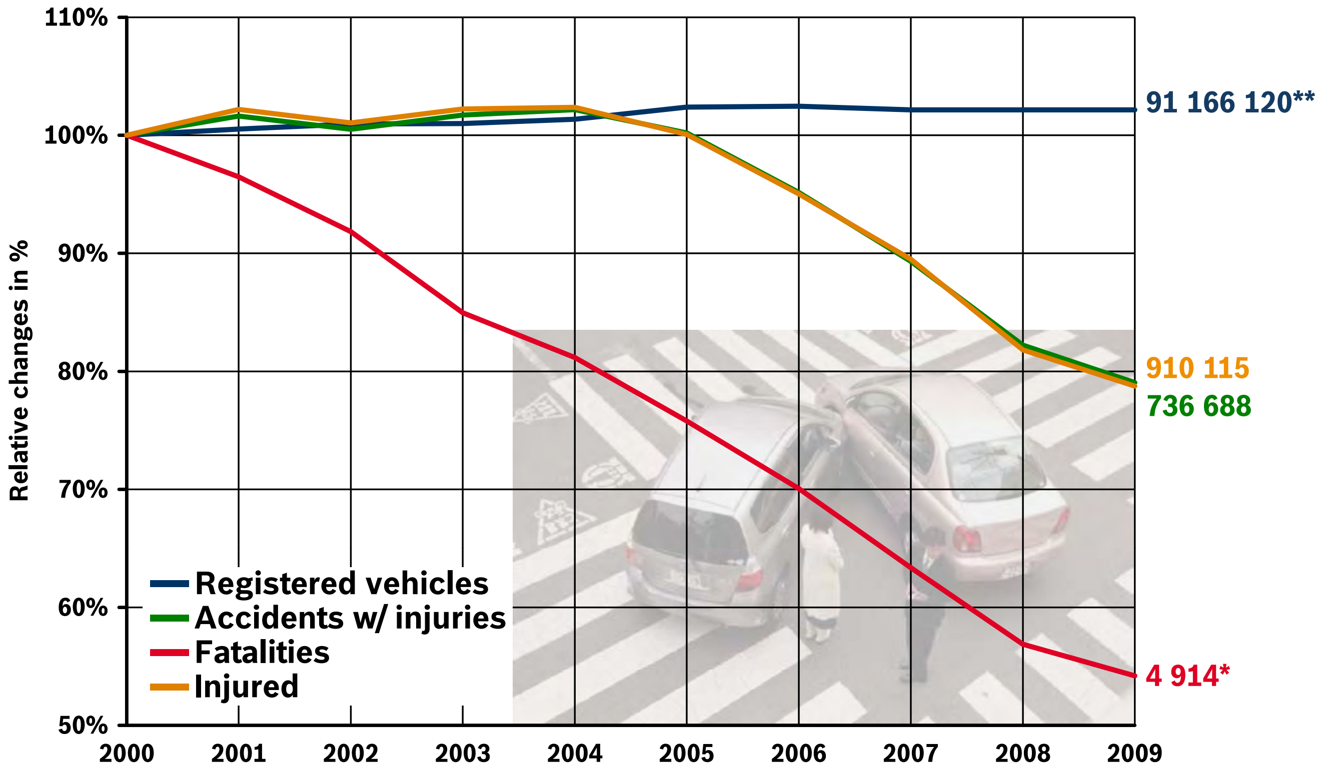
Sources: IATSS Yearbook 2009, CARE 2009 (EU27), NHTSA Traffic Safety Facts 2009, Road Traffic Safety Authority Korea 2009, Yearbook 2009 Traffic Accidents China, DENATRAN 2008, Ministry of home affairs of the Russian Federation, Yearbook 2008 Autostat Russia, RAMI Annual Report 2009, Ministry of Home Affairs, Govt. of India, Ministry of Road Transport & Highways

Road Traffic Accidents India



Source: Ministry of Road Transport & Highway, Govt. of India 2009

Road Traffic Accidents Japan



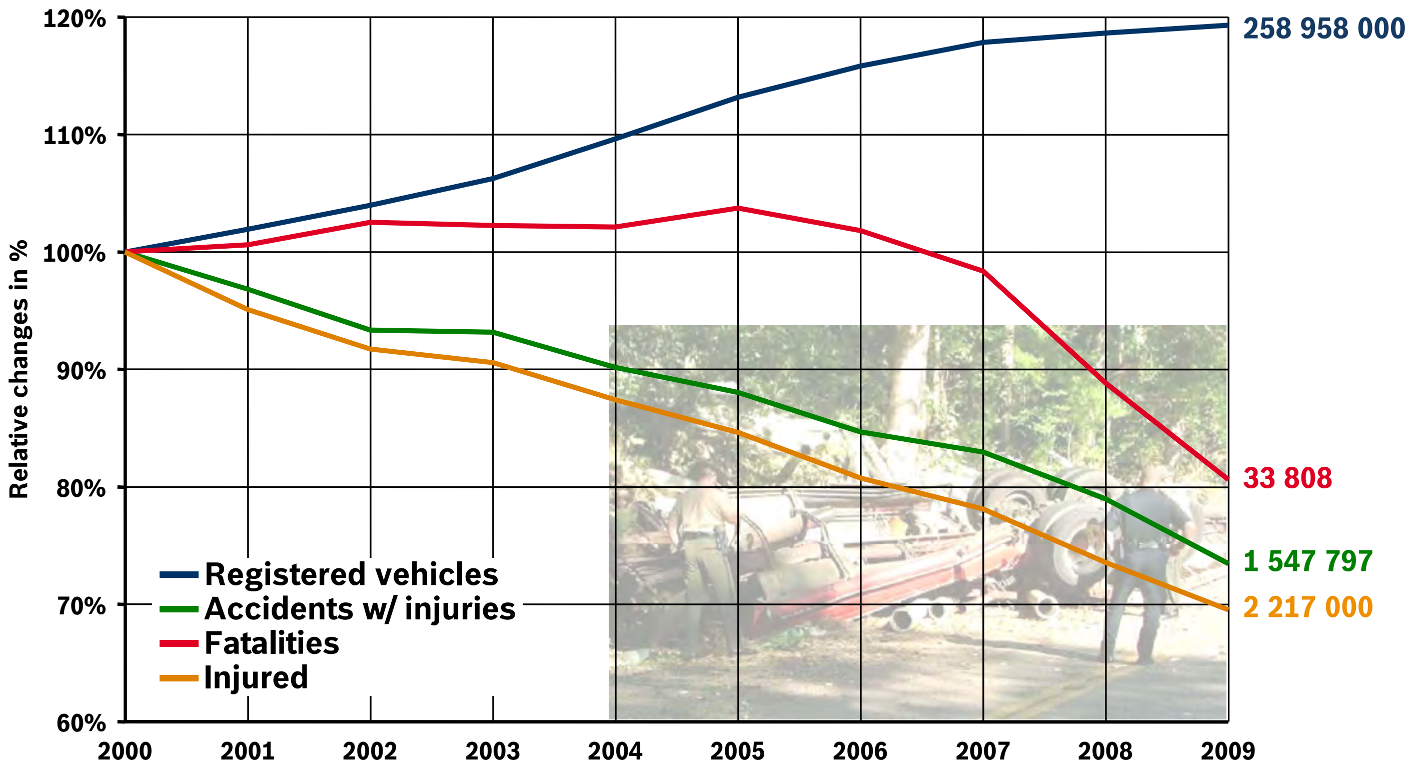
Source: Statistics 2009, Road accidents Japan

* Fatality within 24 hours – 5772 fatalities within 30 days after accident in 2009

** 2007

BOSCH

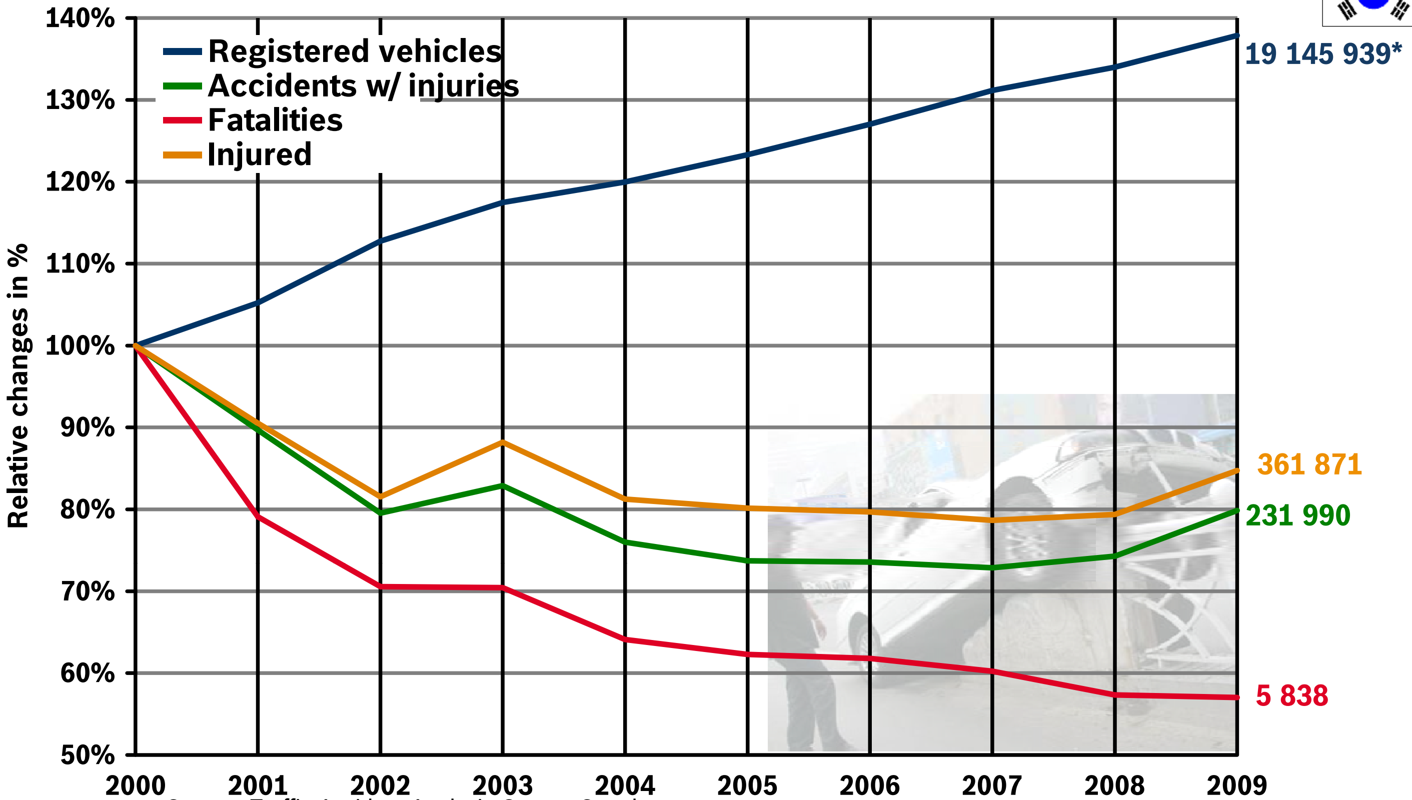
Road Traffic Accidents USA



Source: Traffic safety facts 2009

BOSCH

Road Traffic Accidents Korea



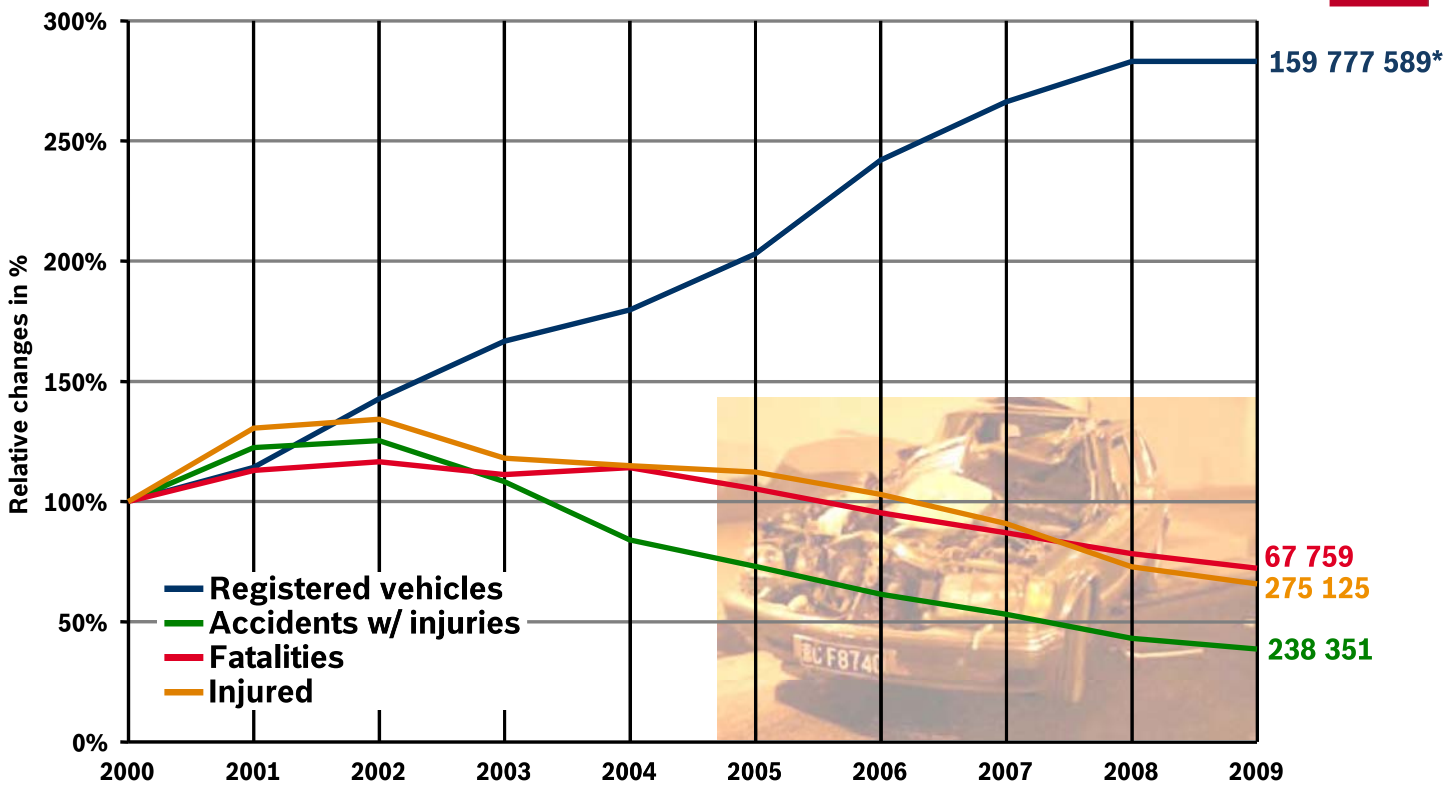
Source: Traffic Accident Analysis Center, Seoul

* excluding construction equipment and agricultural machinery

BOSCH

Standard Slide Accident Research RB - CR/AEV1 003UFO Chapter 04

Road Traffic Accidents China

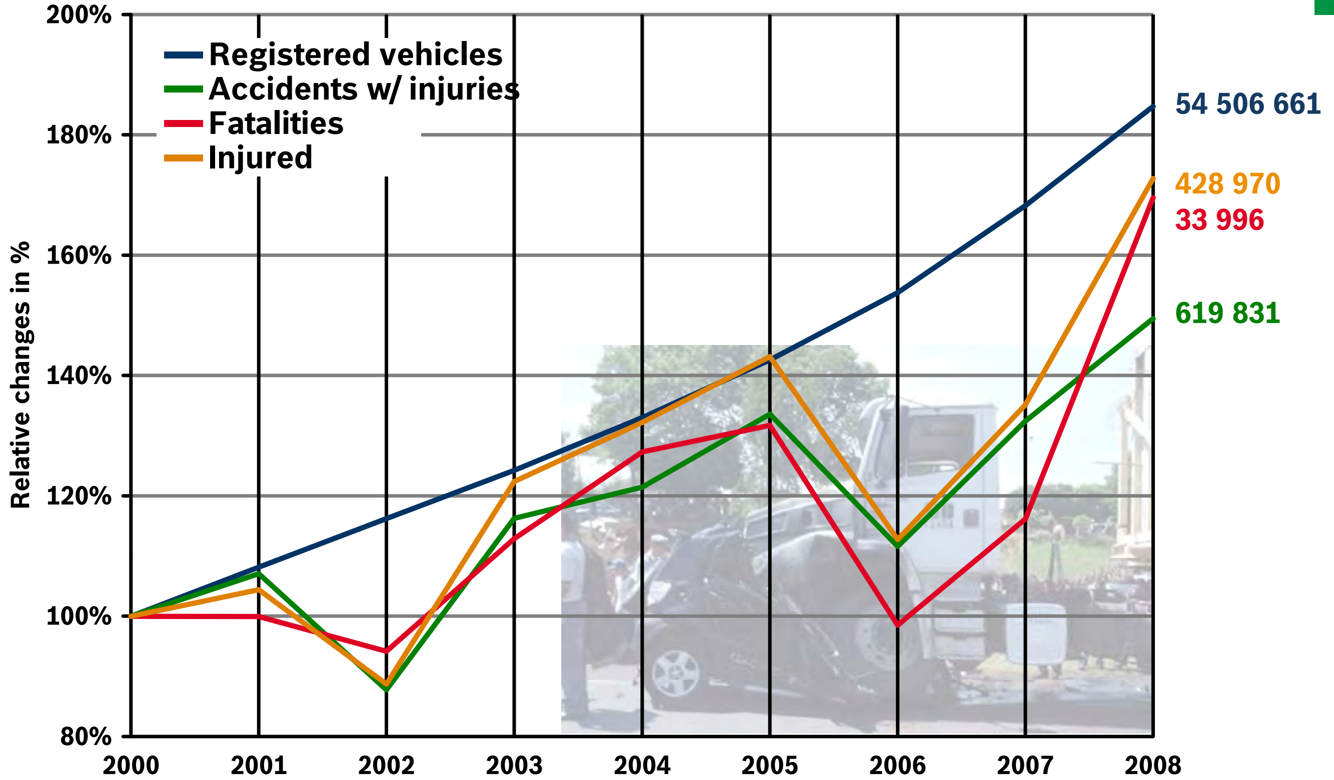


Source: Road accident Statistics China, Yearbook 2009

* Registered vehicles in 2008

BOSCH

Road Traffic Accidents Brazil



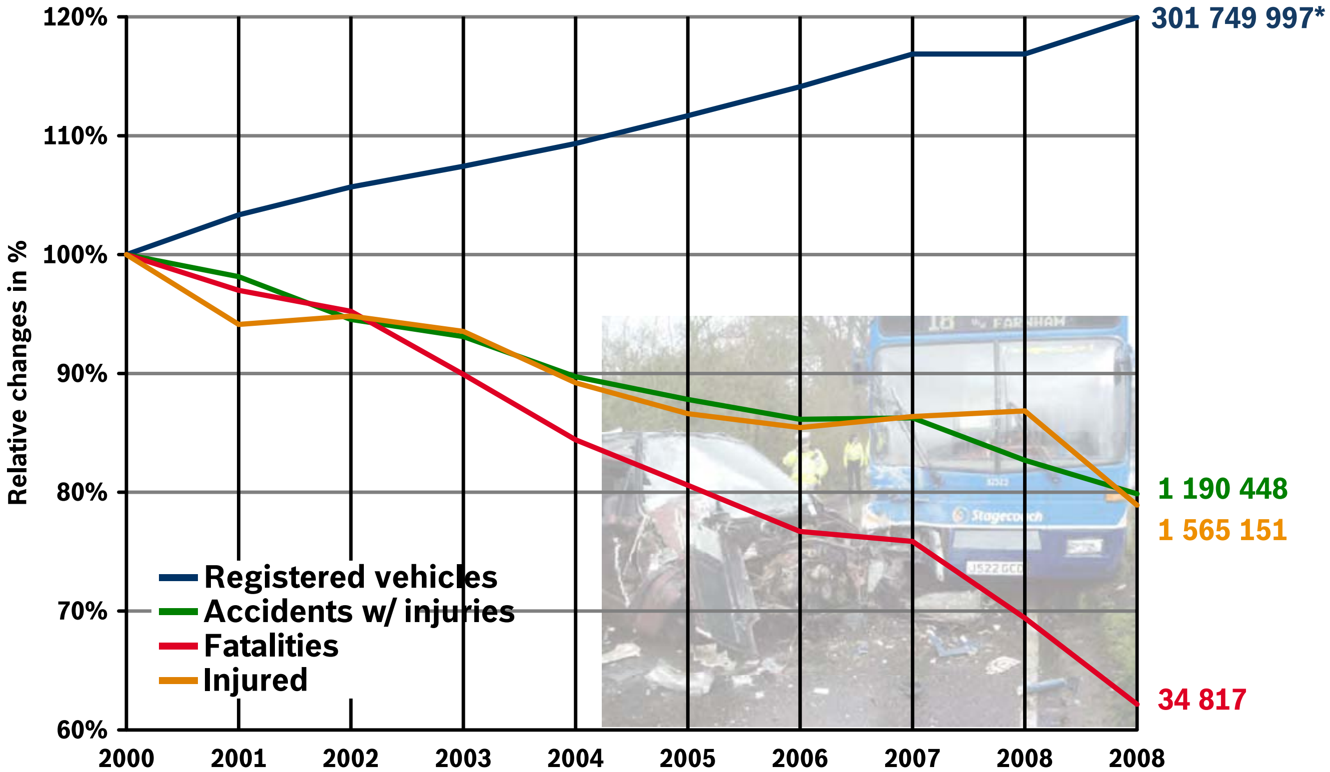
Source: Anuário estatísticodo DENATRAN* - RENAEST 2008, Brazil

* DENATRAN only offers the number of victims at time and location of the accident taken by the police

BOSCH

Standard Slide Accident Research RB - CR/AEV1 003UFO Chapter 04

Road Traffic Accidents EU27



Source: CARE (EU27 road accident database), UN Economic Commissions for Europe and national statistics

* Registered vehicles in 2008

CR/AEV1-Lich | 05/01/2012 | AEV064 annual report 2011 | © Robert Bosch GmbH 2012. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Accident figures 2009

	Resident population [Mio]	Registered motor vehicles [Mio]	Accidents with casualties [Mio]	Fatal Accidents*	Share of Fatal accidents (in casualty accidents)	Fatalities*
	82.0	51.8	0.31	**3,867**	**1.25 %**	**4,152**
	307.0	257.0**	1.55	**30,797**	**1.99 %**	**33,808**
	127.1	91.2***	0.74	**5,537**	**0.75 %**	**5,772**

sources: StBA, GIDAS, NHTSA, IRTAD, NPA Japan, Year 2009

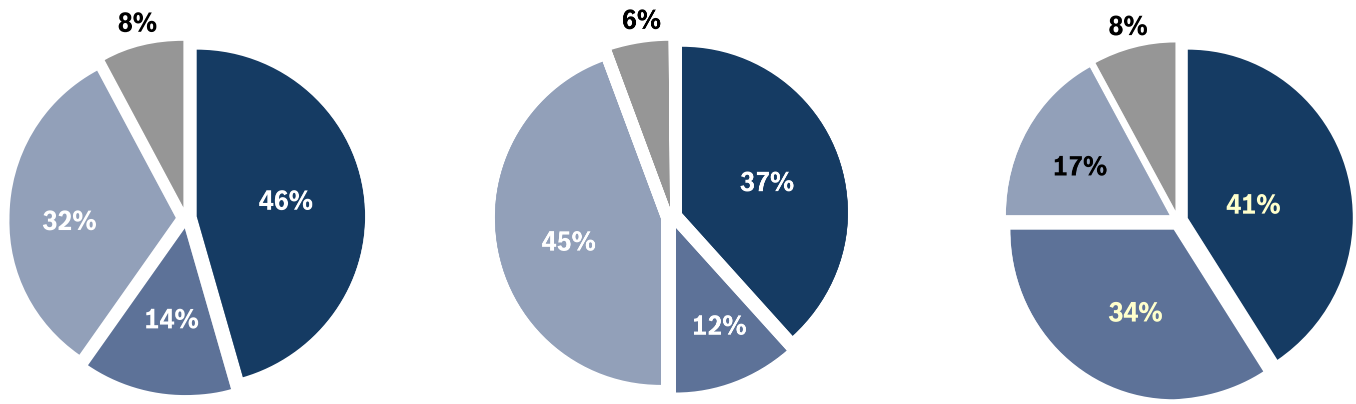
* for fatalities that occur within 30 days (for Japan: extrapolated from data of fatalities who occur within 24 hours)
** 2008 *** 2007

Fatal accidents divided in main categories

n = 3,867 accidents with fatalities

n = 30,797 accidents with fatalities [1]

n = 4,773 accidents with fatalities [2]



main categories:

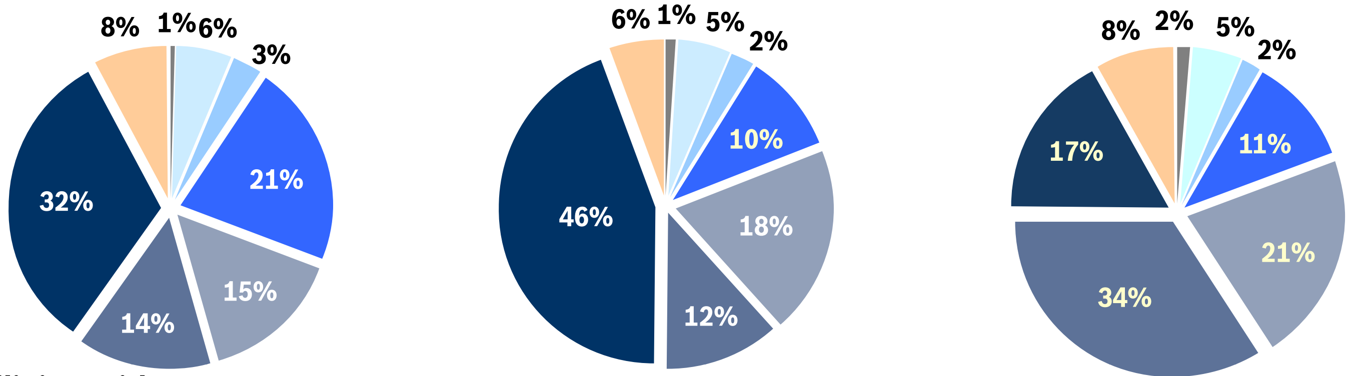
- **vehicle - vehicle**
- **vehicle - pedestrian**
- **vehicle - fixed object (off road)**
- **others (object on road, animal...)**

sources: StBA, GIDAS, NHTSA, NPA Japan, Year 2009

[1] USA: Vehicle to Bicycle - accidents in category „Others“
[2] Japan: Accidents without automobile involvement in category "Others", only fatalities who occur within 24 hours

Fatal accidents by kinds of accidents

Germany	USA [1]	Japan [2]
n = 3,867 accidents with fatalities	**n = 30,797** accidents with fatalities	**n = 4,773** accidents with fatalities



collision with …

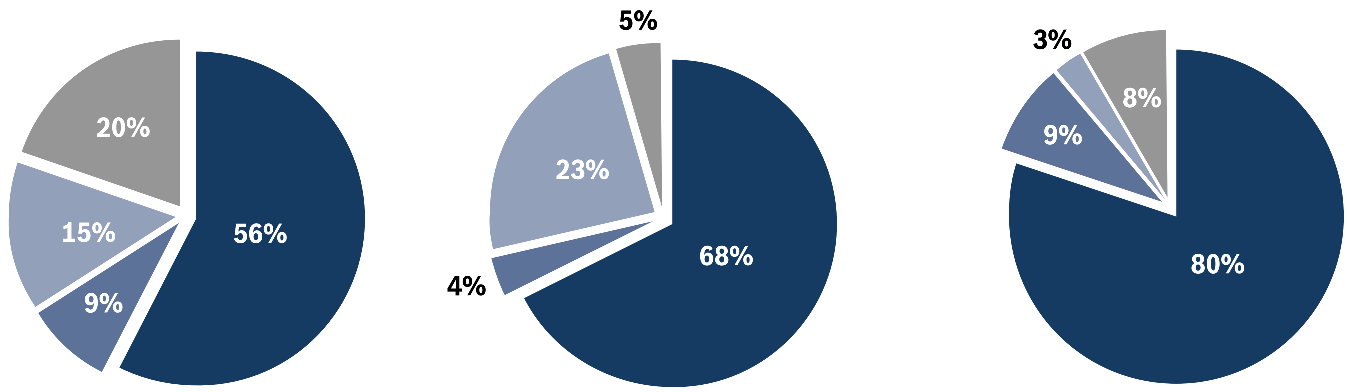
- **parked vehicle**
- **vehicle moving ahead or waiting**
- **vehicle moving laterally in same direction**
- **oncoming vehicle**
- **vehicle which turns into or crosses a road**
- **pedestrian**
- **fixed Object or vehicle leaving carriageway**
- **Accident of another kind** (unknown, not fixed object, animal ...)

sources: StBA, GIDAS, NHTSA, NPA Japan, Year 2009

[1] USA: Vehicle to Bicycle - accidents in category „Others“
[2] Japan: Accidents without automobile involvement in category “Others”, only fatalities who occur within 24 hours

Accidents with casualties divided in main categories

Germany	USA [1]	Japan [2]
n = 310,806 accidents with casualties	**n = 1,548,297** accidents with casualties	**n = 737,474** accidents with casualties



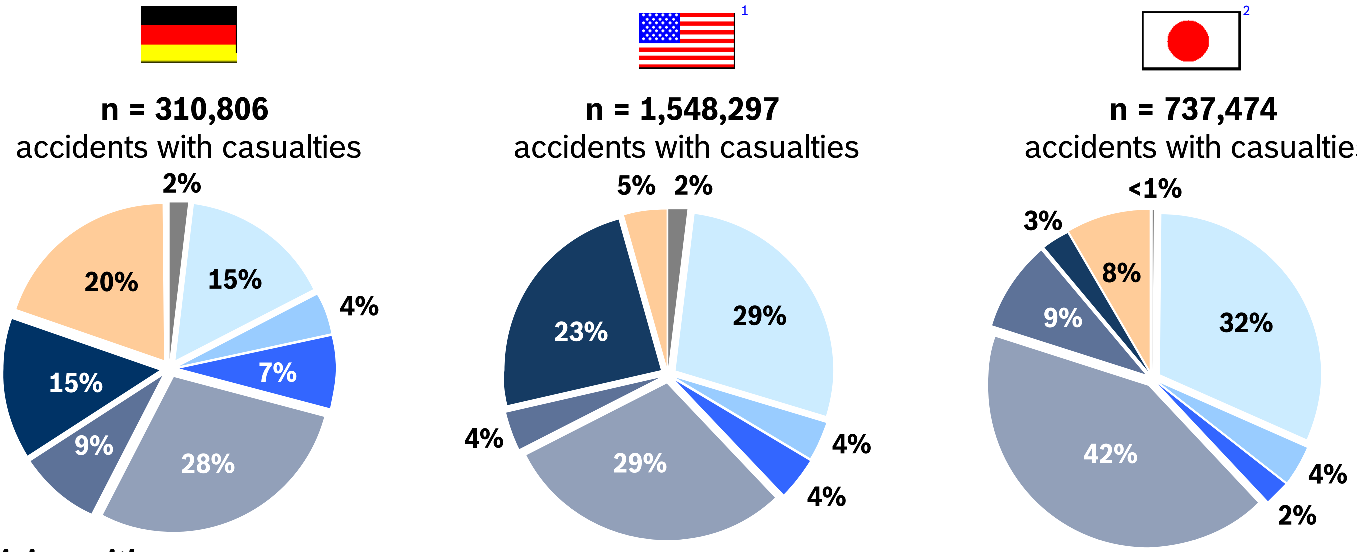
main categories:

- **vehicle - vehicle**
- **vehicle - pedestrian**
- **vehicle - fixed object (off road)**
- **others (object on road, animal...)**

sources: StBA, GIDAS, NHTSA, NPA Japan, Year 2009

[1] USA: Vehicle to Bicycle - accidents in category „Others“
[2] Japan: Accidents without automobile involvement in category “Others”

Accidents with casualties by kinds of accidents



collision with ...

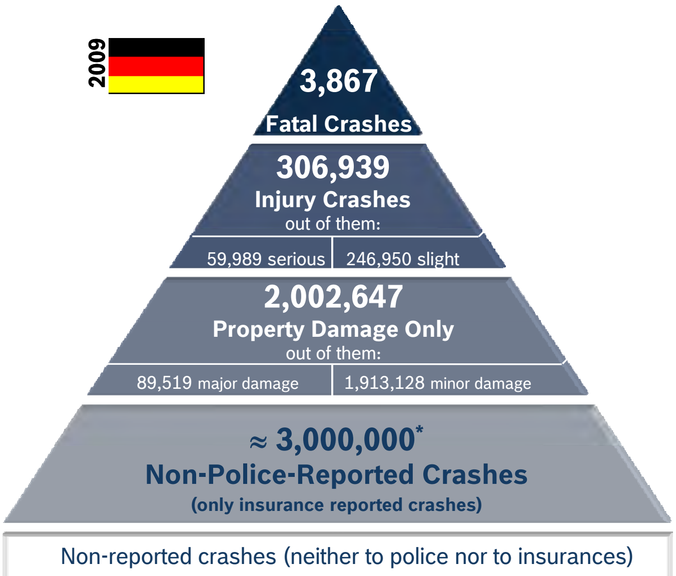
- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)

sources: StBA, GIDAS, NHTSA, NPA Japan, Year 2009

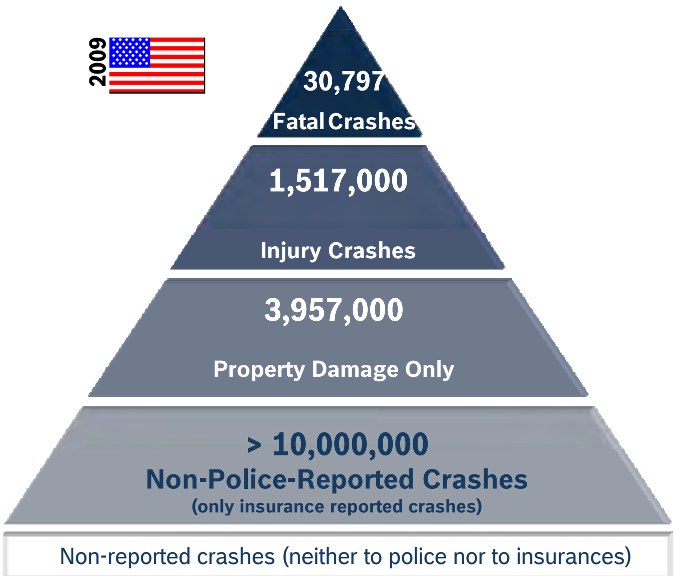
[1] USA: Vehicle to Bicycle - accidents in category „Others“
[2] Japan: Accidents without automobile involvement in category “Others”

BOSCH

Accident figures Germany – USA (2009)



sources: Federal Statistical Office, Germany
* GDV-yearbook (estimation)

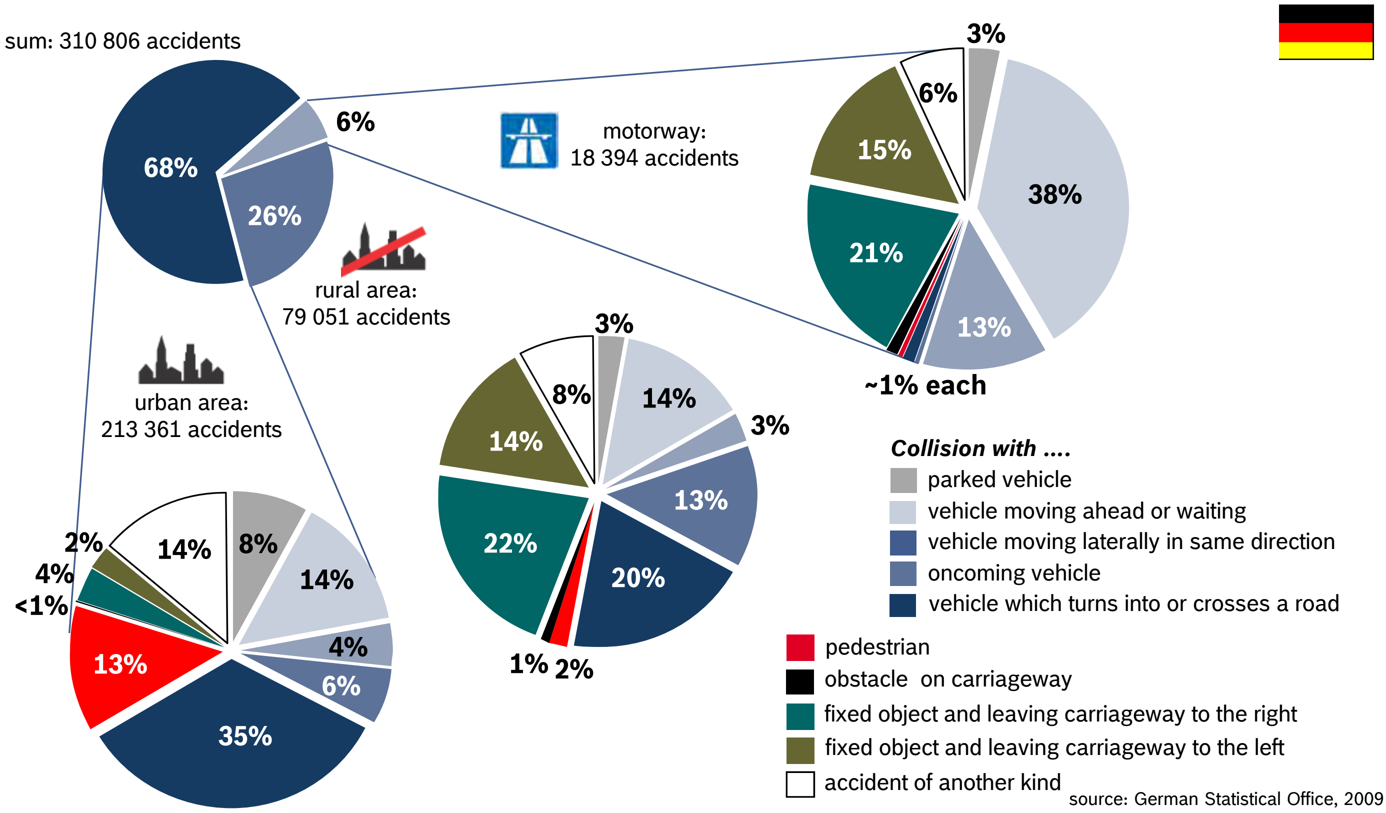


sources: NHTSA / NCSA

- ➔ approx. 5.3 million reported crashes in Germany
- ➔ approx. 16.0 million reported crashes in USA

BOSCH

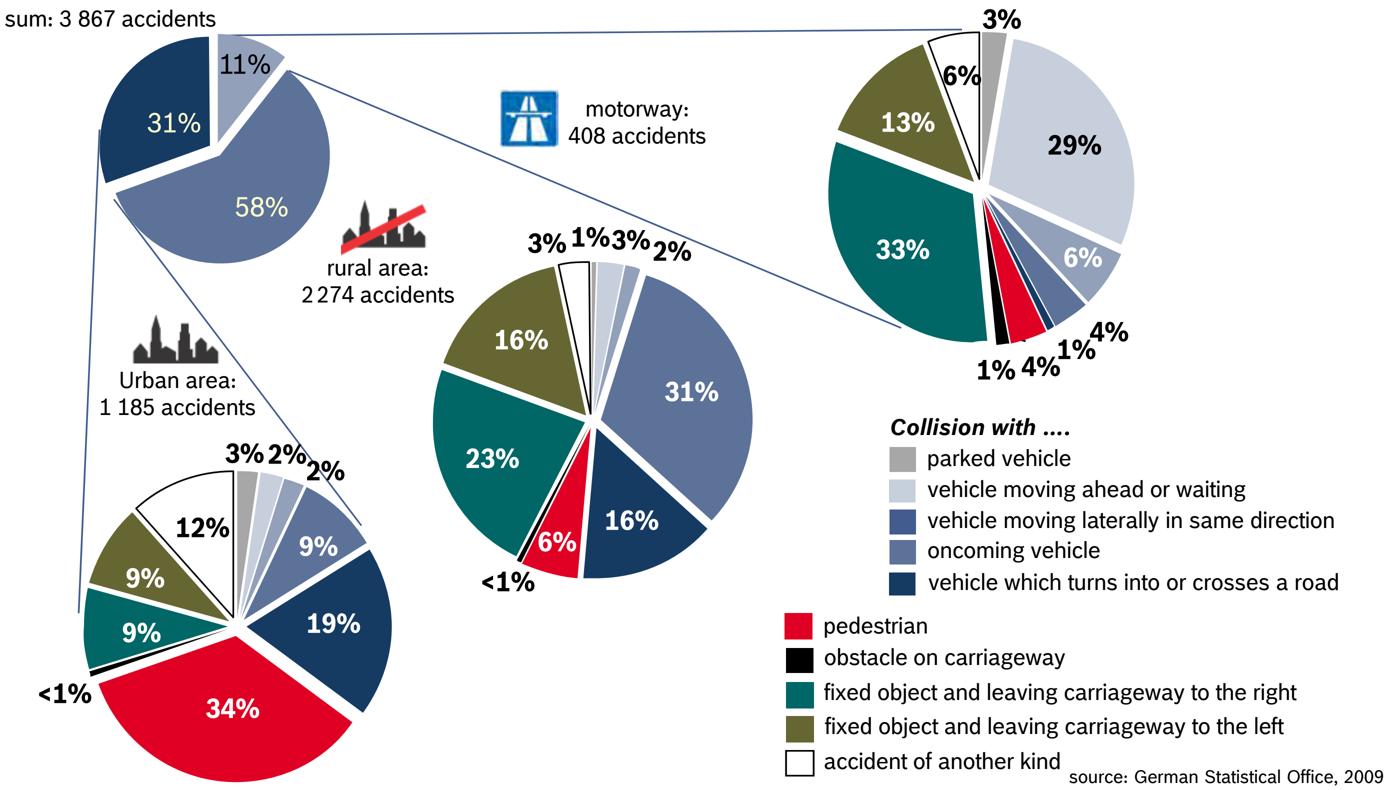
Accidents with casualties by kinds of accident



source: German Statistical Office, 2009

BOSCH

Fatal accidents by kinds of accident

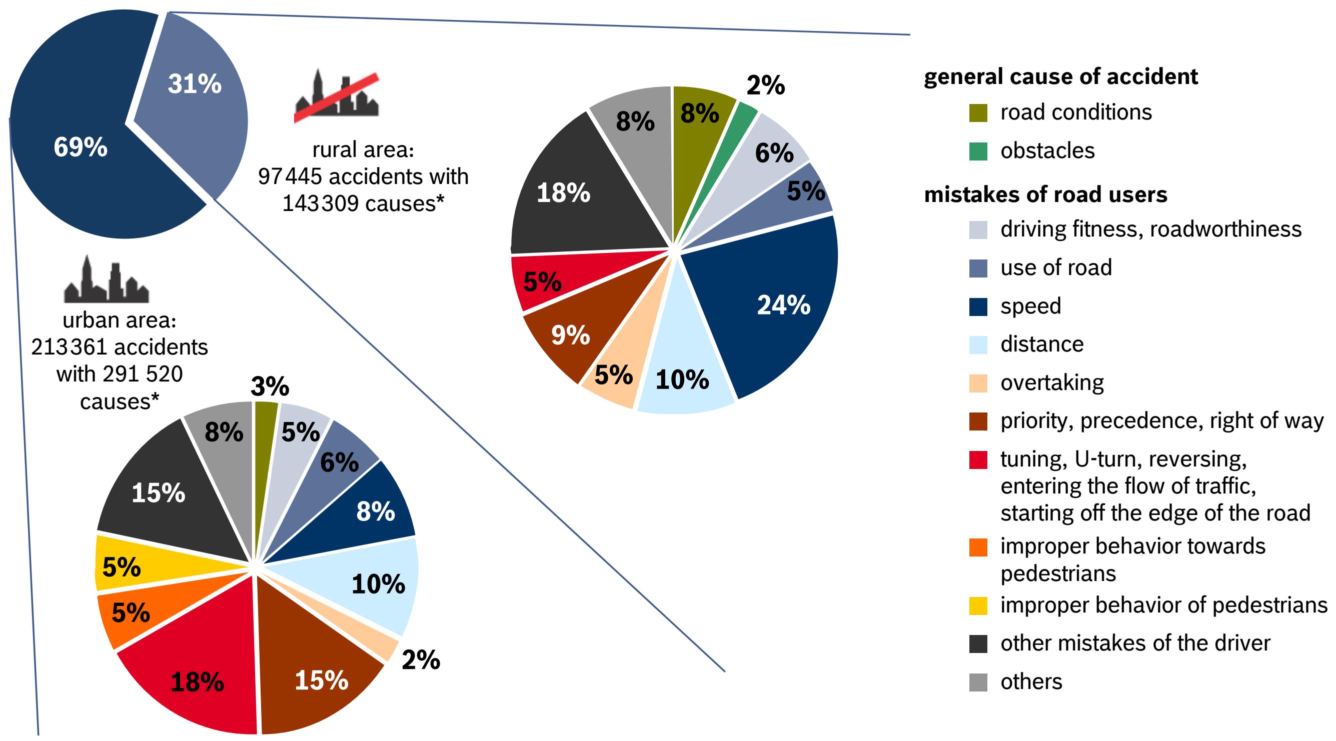


source: German Statistical Office, 2009

BOSCH

Causes for road accidents with injured in Germany

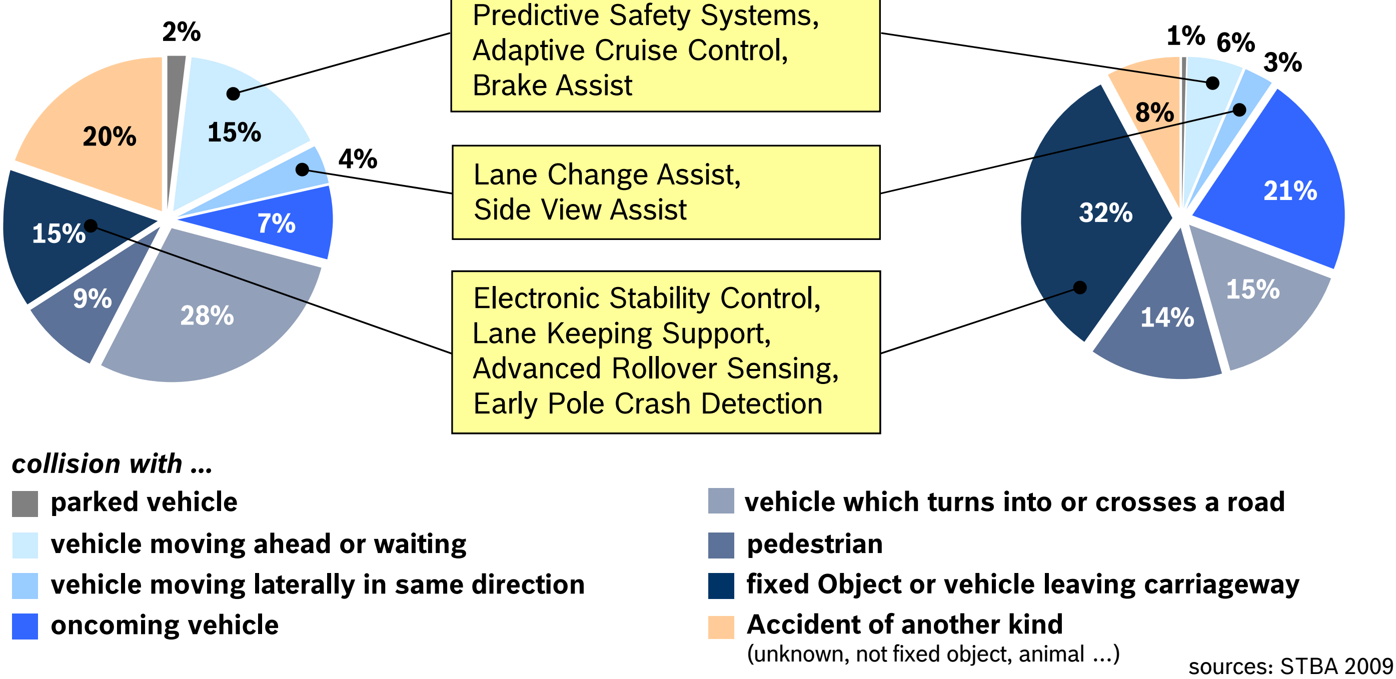
Analysis is based on 310 806 accidents in 2009



source: German Statistical Office, 2009

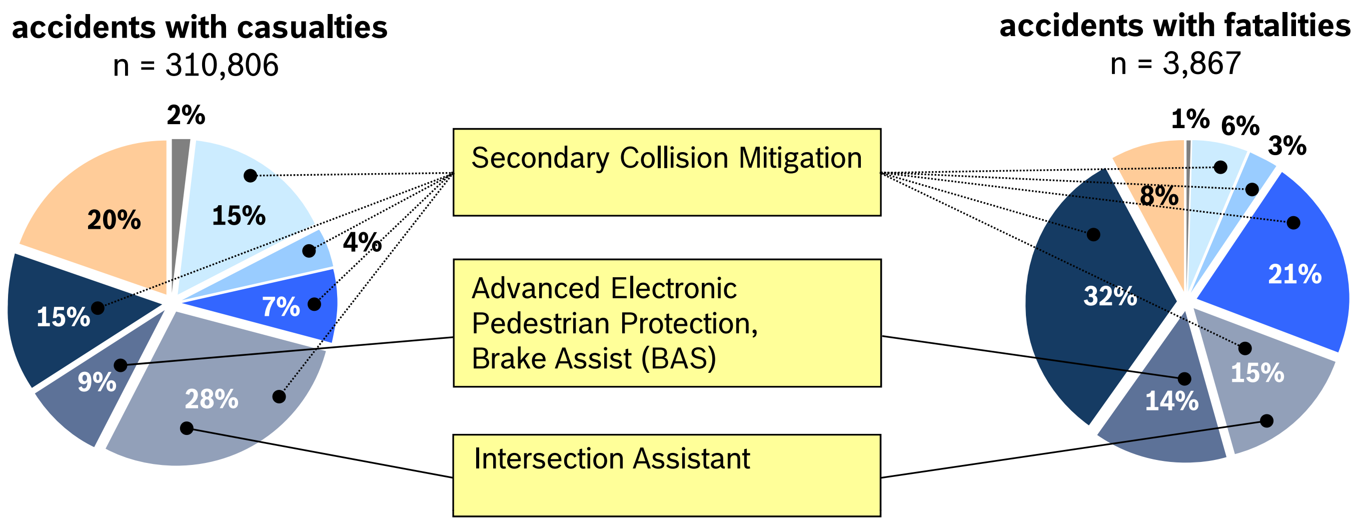
* In the diagram the distribution of causes for accidents is visualized. For each accident up to 8 causes can be recorded.

Scope of safety functions in Germany (1/2)



sources: STBA 2009

Scope of safety functions in Germany (2/2)



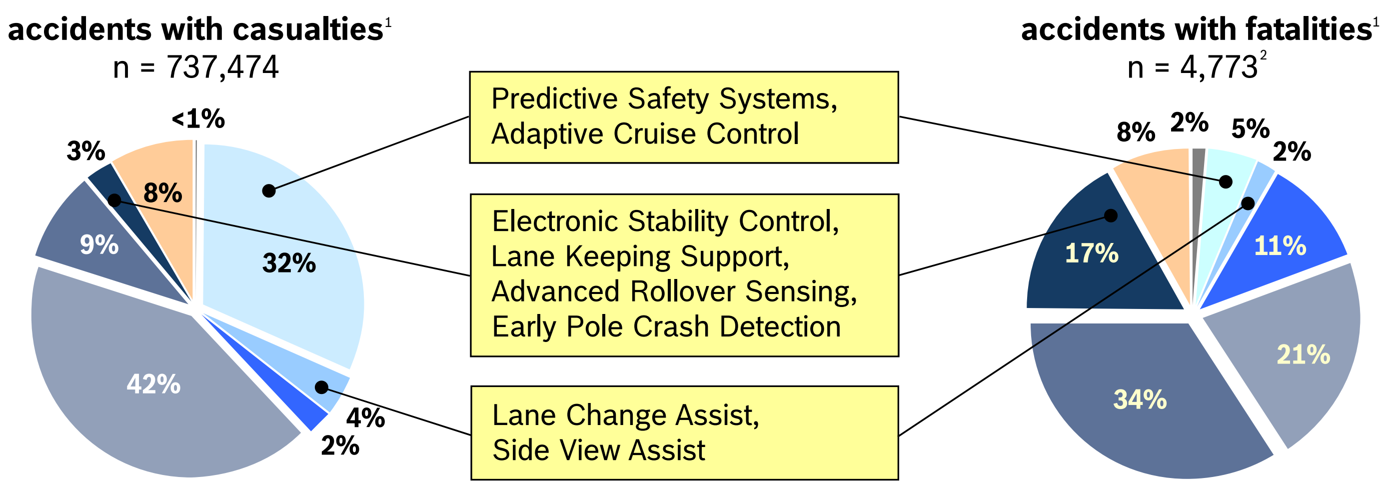
collision with ...

- **parked vehicle**
- **vehicle moving ahead or waiting**
- **vehicle moving laterally in same direction**
- **oncoming vehicle**
- **vehicle which turns into or crosses a road**
- **pedestrian**
- **fixed Object or vehicle leaving carriageway**
- **Accident of another kind** (unknown, not fixed object, animal ...)

sources: STBA 2009

BOSCH

Scope of safety functions in Japan (1/2)



collision with ...

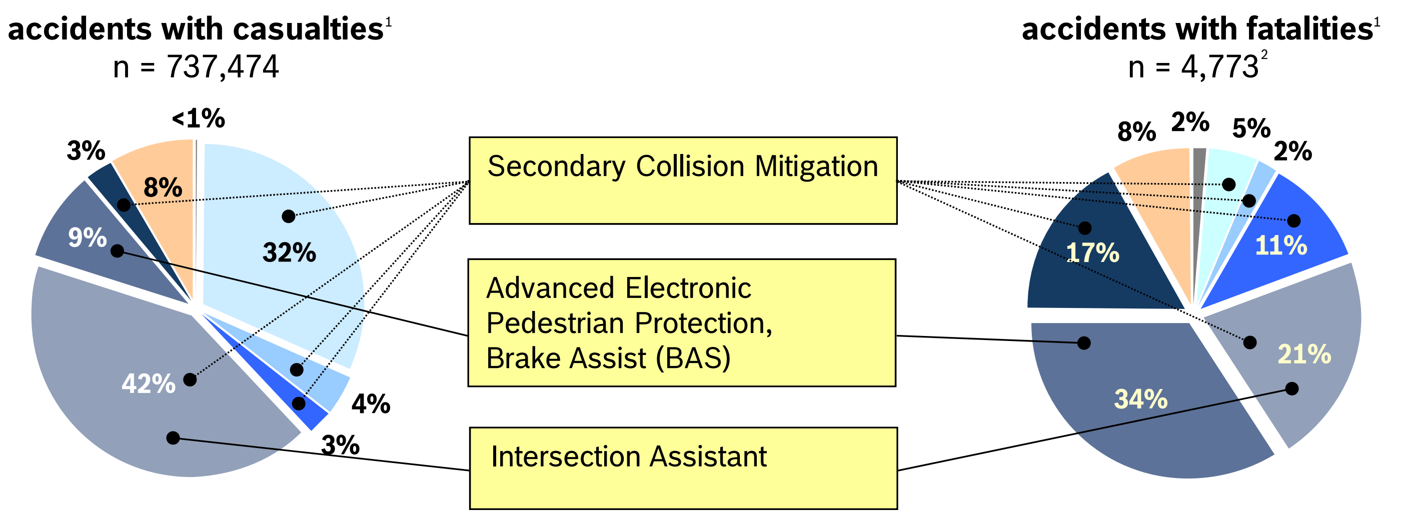
- **parked vehicle**
- **vehicle moving ahead or waiting**
- **vehicle moving laterally in same direction**
- **oncoming vehicle**
- **vehicle which turns into or crosses a road**
- **pedestrian**
- **fixed Object or vehicle leaving carriageway**
- **Accident of another kind** (unknown, not fixed object, animal ...)

sources: IATSS 2009

[1] accidents without automobile involvement in category "Others"
[2] only fatalities that occur within 24 hours

BOSCH

Scope of safety functions in Japan (2/2)



collision with ...

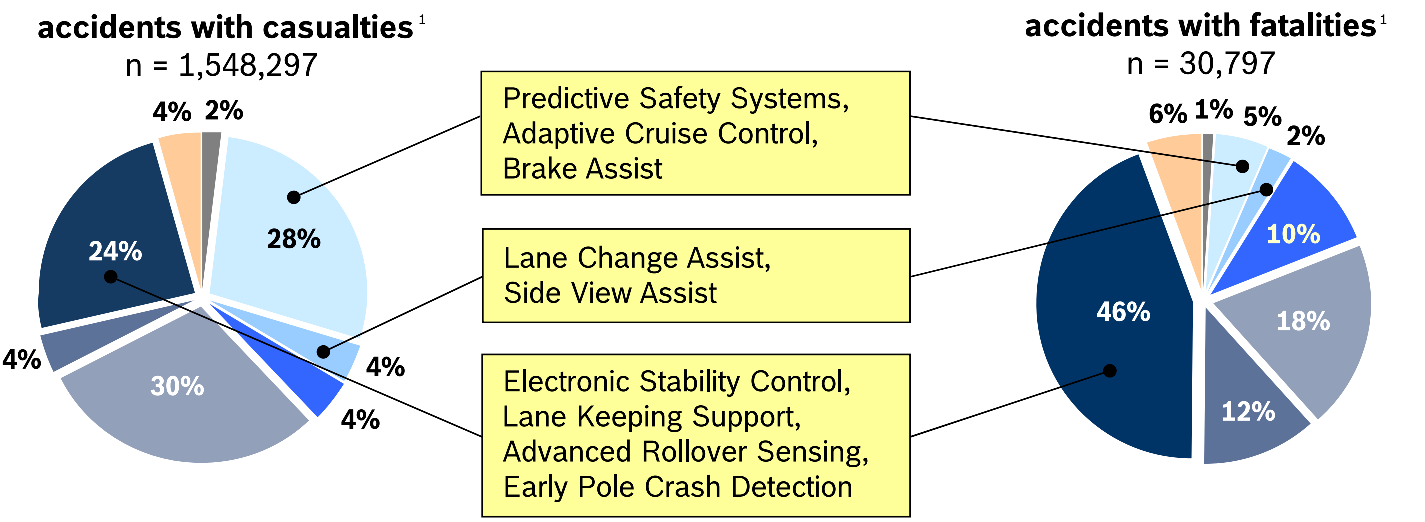
- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)

sources: IATSS 2009

[1] accidents without automobile involvement in category "Others"
[2] only fatalities that occur within 24 hours

BOSCH

Scope of safety functions in USA (1/2)



collision with ...

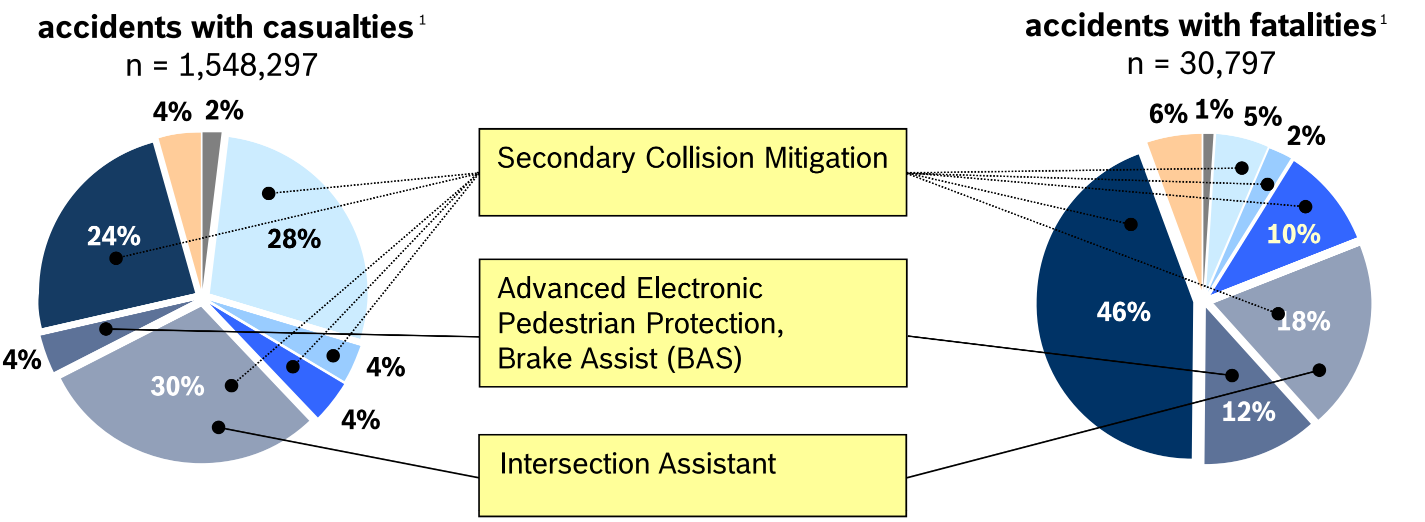
- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)

sources: NHTSA/NCSA 2009

[1] Vehicle to Bicycle - accidents in category „Others"

BOSCH

Scope of safety functions in USA (2/2)



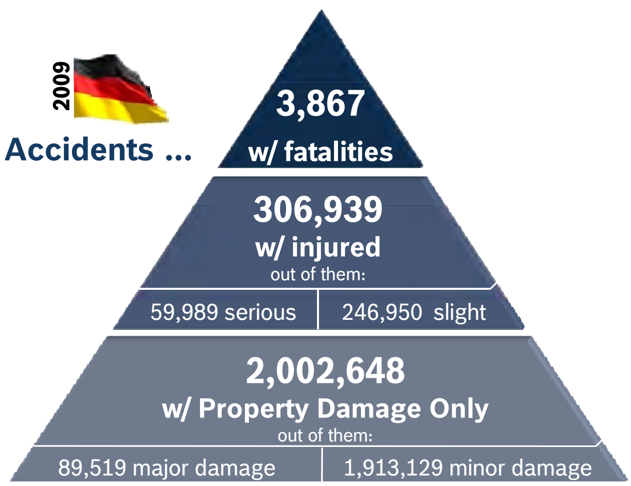
collision with ...

- **parked vehicle**
- **vehicle moving ahead or waiting**
- **vehicle moving laterally in same direction**
- **oncoming vehicle**
- **vehicle which turns into or crosses a road**
- **pedestrian**
- **fixed Object or vehicle leaving carriageway**
- **Accident of another kind** (unknown, not fixed object, animal ...)

sources: NHTSA/NCSA 2009

[1] Vehicle to Bicycle - accidents in category „Others“

Socio-economic costs of German police reported road traffic accidents (2009)



Source: Federal Statistical Office, Germany – Volume 8, Part 7 Accidents in 2009

Socio-economic costs due to accidents ...

4.50 bn. €	**w/ fatalities**	
13.20 bn. €	**w/ injured**	out of them:
	8.63 bn. € serious	4.57 bn. € slight
12.53 bn. €	**w/ Property Damage Only**	out of them:
	1.73 bn. € major damage	10.80 bn. € minor damage

Source: BASt, Scientific information StBA info 04/11; GIDAS 2001-2010

➔ approx. 2.31 million police reported crashes in 2009 for Germany

➔ approx. 30.23 billion Euro socio-economic costs due to road traffic accidents

Automatic Emergency Braking

– Benefit analysis of rear-end collision avoidance and mitigation systems –

Accident research
CR / AEV1

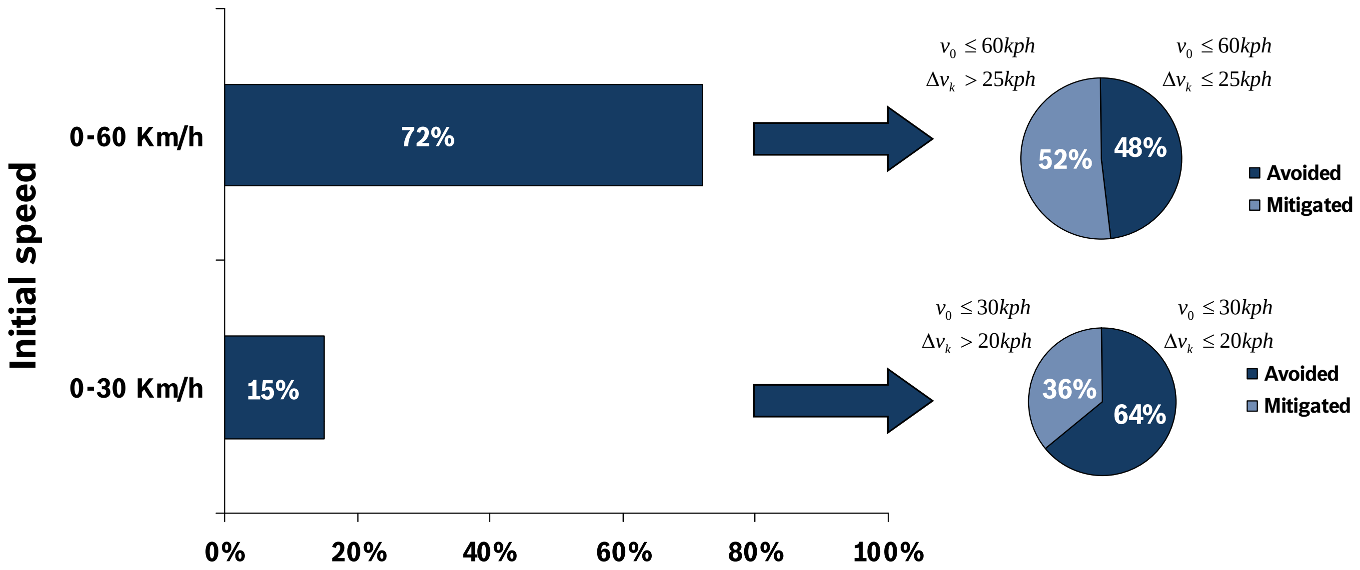
Automatic Emergency Braking

Aim of this study: Estimation of the effect of automatic braking in rear-end crashes in dependence of the vehicle speed and the achievable speed reduction

Method: The distribution of vehicle travelling- and impact-speeds were examined within the field of effect for rear-end crash avoidance systems

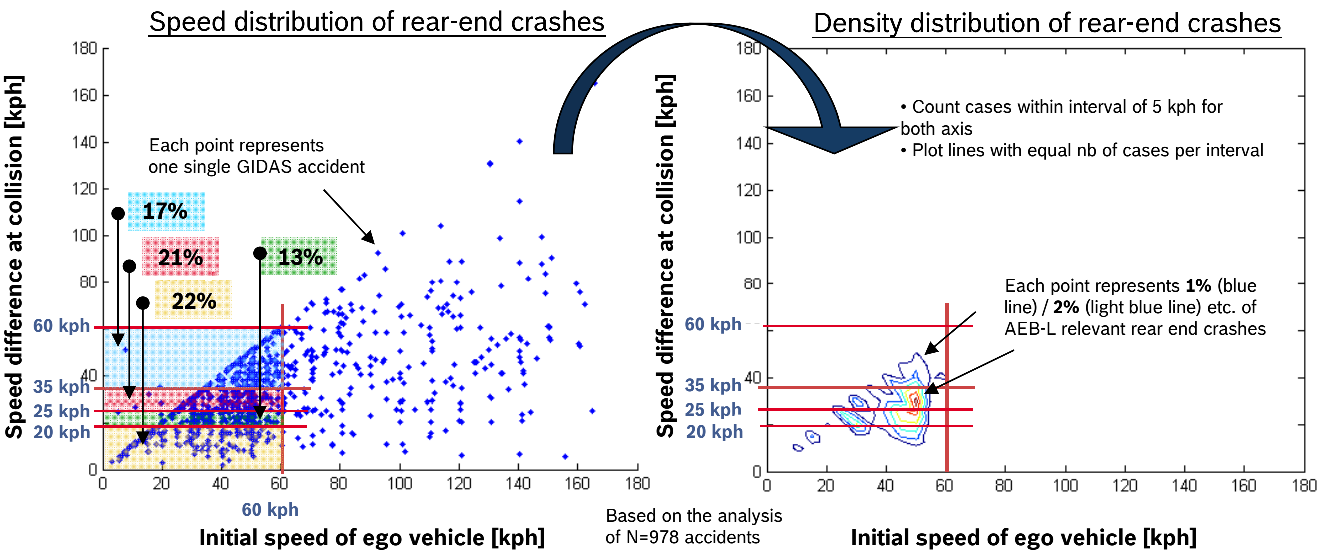
Result: About 2/3 of all rear-end crashes with casualties in Germany occur at speeds below 60 kph. A system active up to a travelling speed of 60 kph and decreasing the relative velocity at impact by up to 25 kph could prevent 1/3 rd being 4% of all casualty accidents in Germany

Distribution of rear-end accidents with personal damage by speed



Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

AEB-L - Selection according to speed distribution

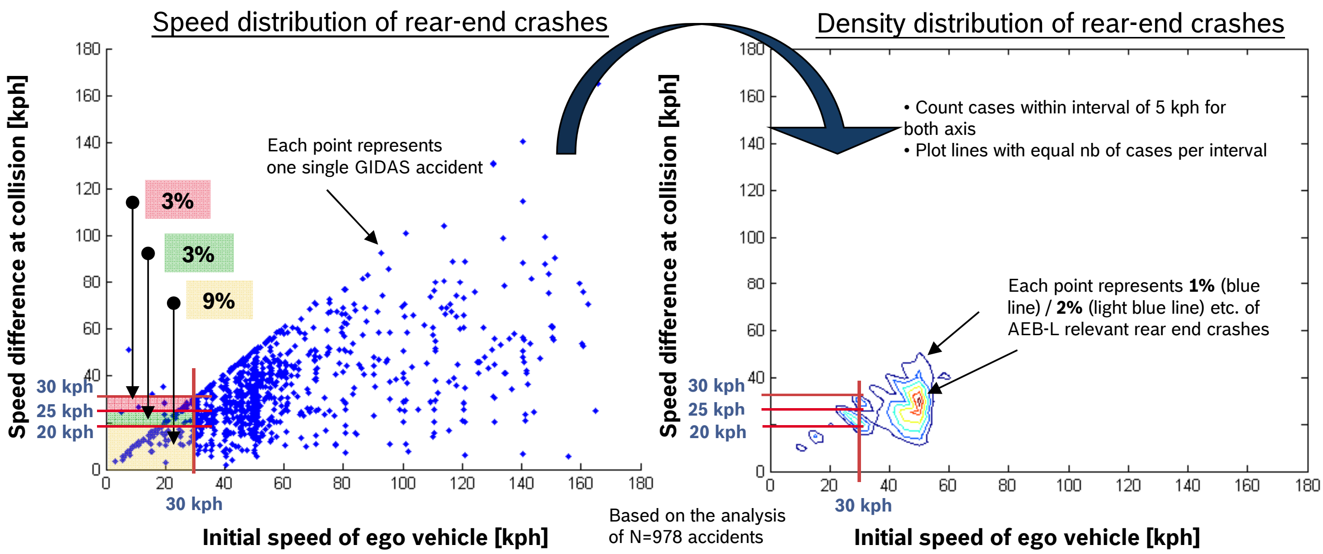


- AEB-L activated up to an ego speed of 60 kph and reducing the vehicle speed by up to 25 kph could prevent[3] about 35% of all rear-end crashes[1] with casualties[2] (cases within green + yellow square)
- Reducing the relative speed by up to 35 kph a further of 21% accidents would become preventable i.e. 56% of all AEB-L relevant crashes (cases within red + green + yellow square)
- Reducing the relative speed by up to 60 kph would lead to prevention of another 17% of AEB-L relevant accidents i.e. 73% of accidents within the field of effect (blue + red + green + yellow square)

1) AEB-L relevant crashes: Rear-end crashes of a car with another vehicle
2) Data source: German in depth accident study (GIDAS) 2001-2010
3) Result assumes similar driver reaction with and without system

Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

AEB-L - Selection according to speed distribution



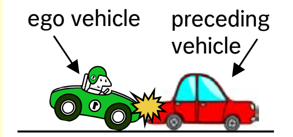
- AEB-L activated up to an ego speed of 30 kph and reducing the vehicle speed by up to 20 kph could prevent[3] about 9% of all rear-end crashes[1] with casualties[2] (cases within yellow square)
- Reducing the relative speed by up to 25 kph a further of 3% accidents would become preventable i.e. 12% of all AEB-L relevant crashes (cases within green + yellow square)
- Reducing the relative speed by up to 30 kph would lead to prevention of another 3% of AEB-L relevant accidents i.e. 15% of accidents within the field of effect (red + green + yellow square)

1) AEB-L relevant crashes: Rear-end crashes of a car with another vehicle
2) Data source: German in depth accident study (GIDAS) 2001-2010
3) Result assumes similar driver reaction with and without system

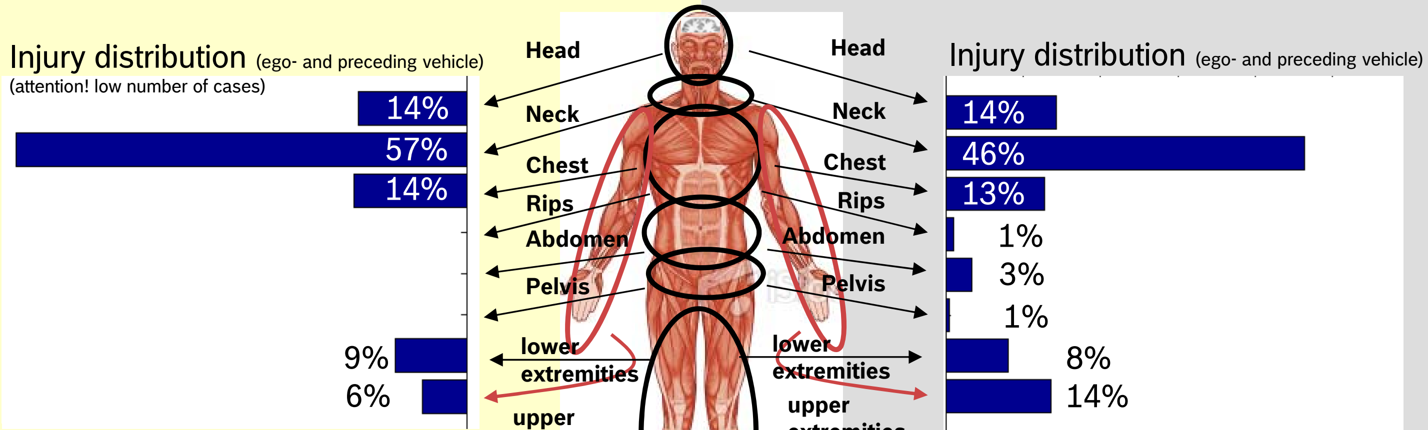
Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

AEB-L - Distribution of injuries in accidents involving two vehicles

Initial speed of ego vehicle ≤ 30 kph



Initial speed of ego vehicle > 30 kph AND ≤ 60 kph



Based on the evaluation of 15 injuries in 13 accidents

On average 1.2 injuries per accident of two vehicles

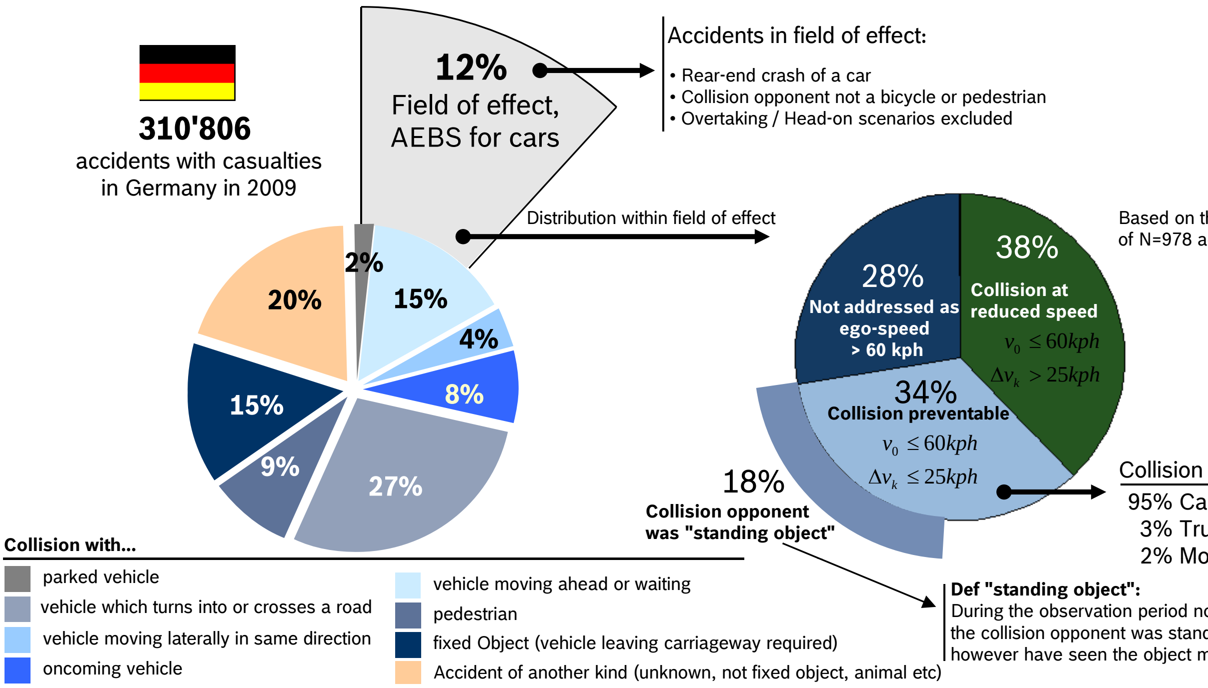
Based on the evaluation of 153 injuries in 92 accidents

On average 1.7 injuries per accident involving two vehicles

- Neck injuries (ex. whiplash) present a higher share in rear-end crashes occurring at lower speeds (≤30kph) as compared to rear-end crashes at higher speeds (> 30 kph AND ≤ 60 kph)
- At higher speeds, injuries of the upper extremities (ex. arms) and abdomen present a higher share

Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

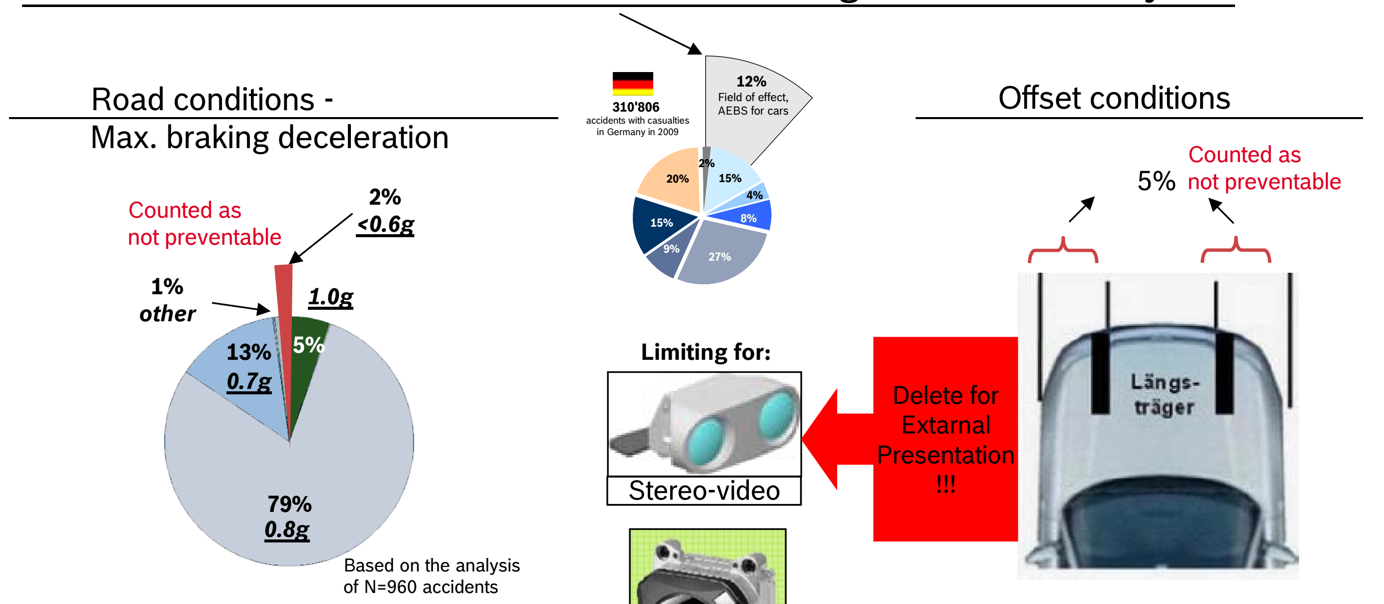
AEB-L - Field of effect and accident prevention



- AEB-L could prevent about 4% of all casualty accidents in Germany (i.e. 34% within the field of effect of 12%)
- In nearly 5% the injury severity can be lowered as the impact occurs at reduced speed (i.e. 38% of field of effect of 12%)

Definitions: v_0 - speed of the ego-vehicle before braking occurred in the accident, Δv_k - relative speed of vehicles at time of collision
Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

Distributions within the field of effect reducing AEB-L efficiency



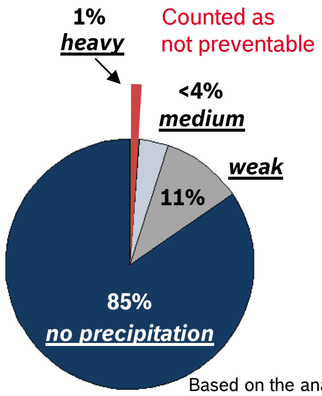
- In 2% of all AEB-L relevant cases, road conditions allowed only for a braking deceleration below 0.6 g
-> Exclude cases with slippery roads

- In 5% of all AEB-L relevant cases, the collision occurred at low offset
-> Cases with low offset collision excluded

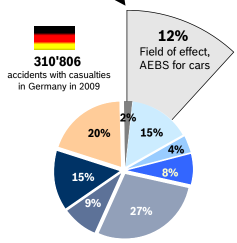
Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

Distributions within the field of effect reducing AEB-L efficiency

Weather conditions - Precipitation

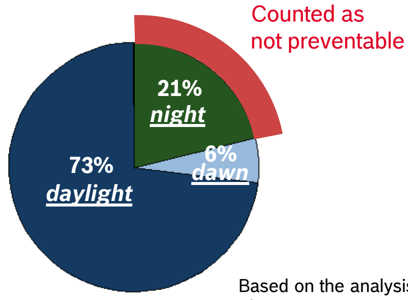


Based on the analysis of N=960 accidents



Limiting for:

Daylight conditions

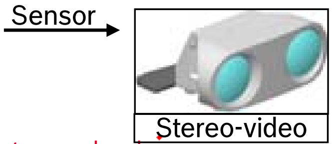


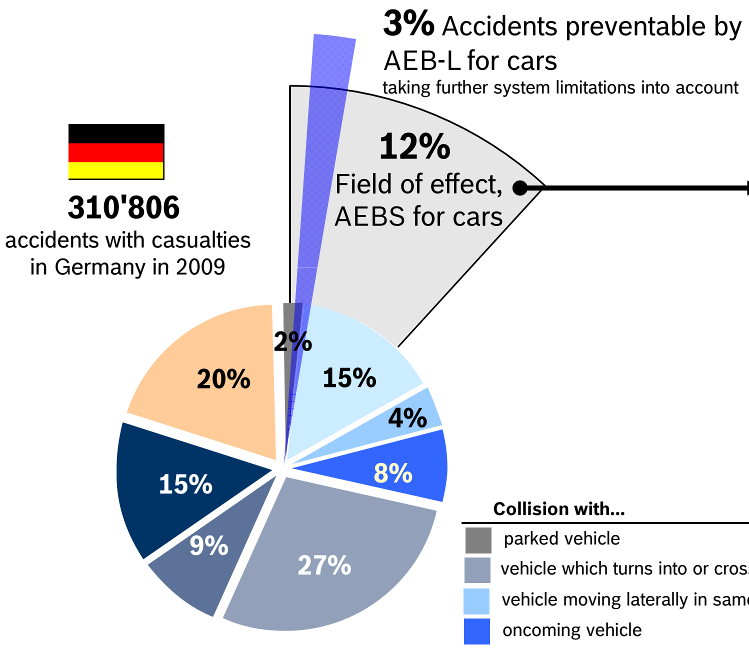
Based on the analysis of N=960 accidents

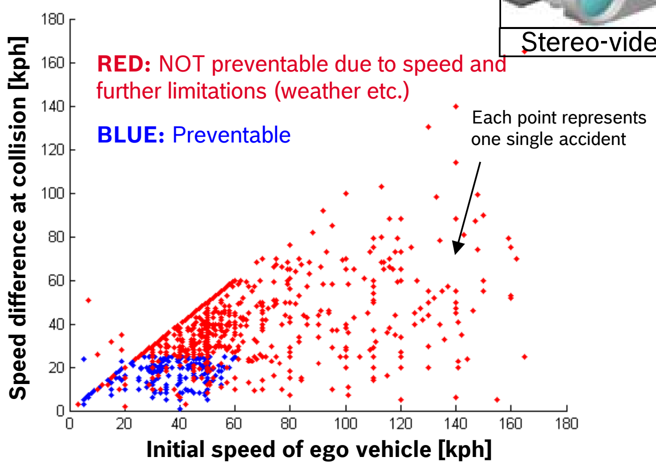
- About 1% of all AEB-L relevant cases occurred during heavy precipitation (rain, snow, hail etc) -> Exclude cases during bad weather

- About 21% of all AEB-L relevant accidents occurred during a night-drive -> Night cases excluded from AEB-L field of effect

Extended AEB-L - Field of effect and accident prevention taking further system limiting factors (road conditions etc.) into account







Based on the analysis of N=978 accidents

Collision with...

- parked vehicle
- vehicle which turns into or crosses a road
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle moving ahead or waiting
- pedestrian
- fixed Object (vehicle leaving carriageway required)
- Accident of another kind (unknown, not fixed object, animal etc)

- Of all AEB-L relevant accidents with casualties, about 27% could be prevented, taking speed and further limitations (weather etc.) into account
- AEB-L therefore could therefore prevent about 3% within all accidents with casualties in Germany

Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

Distribution of rear-end crashes ≤ 60 km/h

2’002’647
Police-reported accidents
with **property damage** only
in Germany in 2009

↓ **22%**

440‘600
Rear-end accidents

↓ ***90% (estimated, ratio unknown)***

396'500 ***(estimated)***
Rear-end accidents with
Initial vehicle speed ≤ 60 kph
(94% of all rear-end accidents)

310'806
Police-reported accidents
with **casualties**
in Germany in 2009

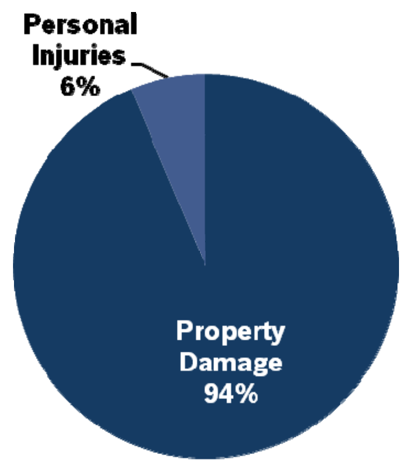
↓ **12%**

37‘300
Rear-end accidents

↓ **72%**

26‘900
Rear-end accidents with
Initial vehicle speed ≤ 60 kph
(6% of all rear-end accidents)

Speeds up to 60 Km/h



Total 423'400 accidents

Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties.

Distribution of rear-end crashes ≤ 30 km/h

2’002’647
Police-reported accidents
with **property damage** only
in Germany in 2009

↓ **22%**

440‘600
Rear-end accidents

↓ **50%**

220‘300
Rear-end accidents with
Initial vehicle speed ≤ 30 kph
(98% of all rear-end accidents)

310'806
Police-reported accidents
with **casualties**
in Germany in 2009

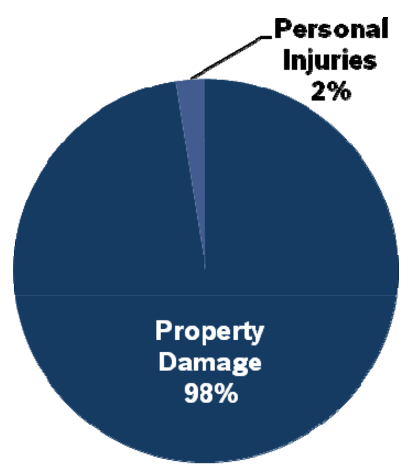
↓ **12%**

37‘300
Rear-end accidents

↓ **15%**

5‘600
Rear-end accidents with
Initial vehicle speed ≤ 30 kph
(2% of all rear-end accidents)

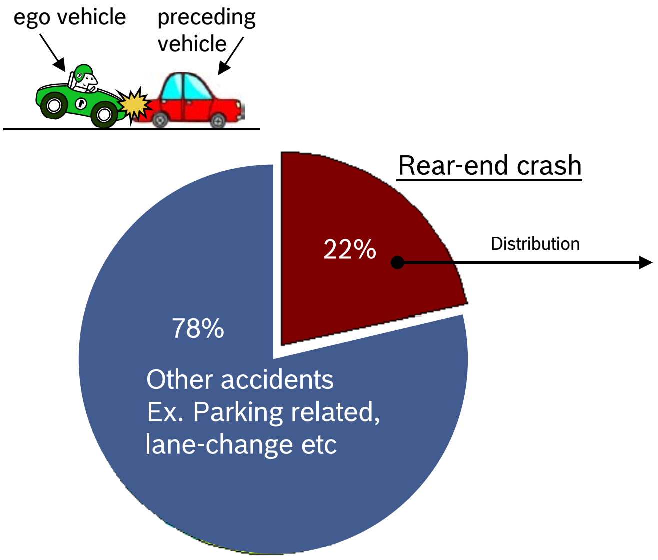
Speeds up to 30 Km/h



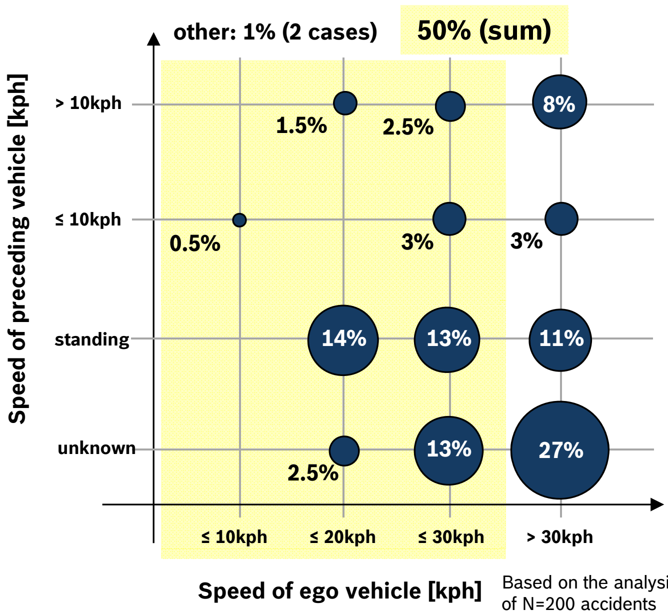
Total 225'900 accidents

Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties.

Rear-end crashes with property damage only - Speed distribution



Based on the analysis of N=1057 accidents reported to full-coverage insurance



Based on the analysis of N=200 accidents reported to full-coverage insurance

- About half of all rear-end collisions without casualties (property damage only) occur with 30 kph or below (evaluated on 200 accidents reported to full-coverage insurance (German "Vollkasko")
- Further accidents addressed by rear-end collision avoidance systems might be present in parking related accidents and accidents with frontal damage in general

Data sources: "Allianz Zentrum für Technik (AZT)" database containing accidents with property damage only

Summary

Casualty accidents Germany (2009)	100%	310'800
Rear-end crashes of cars	12%	37'300
Accidents with $v_0 \leq 60$ kph	9% (i.e. 72% of rear-end crashes)	28'000
Accidents with $v_0 \leq 60$ kph and $\Delta v_k \leq 25$ kph	4% (i.e. 34% of rear-end crashes)	12'400
Accidents preventable taking system limitations into account (weather, road conditions etc)	3% (i.e. 27% of rear-end crashes)	9'300

All numbers rounded

AEB-L as evaluated in the current study could prevent up to 9'300 casualty accidents in Germany per year

*) Definitions: v_0 - speed of the ego-vehicle before braking occurred in the accident, Δv_k - relative speed of vehicles at time of collision
Data sources: GIDAS weighted, reconstructed accidents (2001-2010) and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.

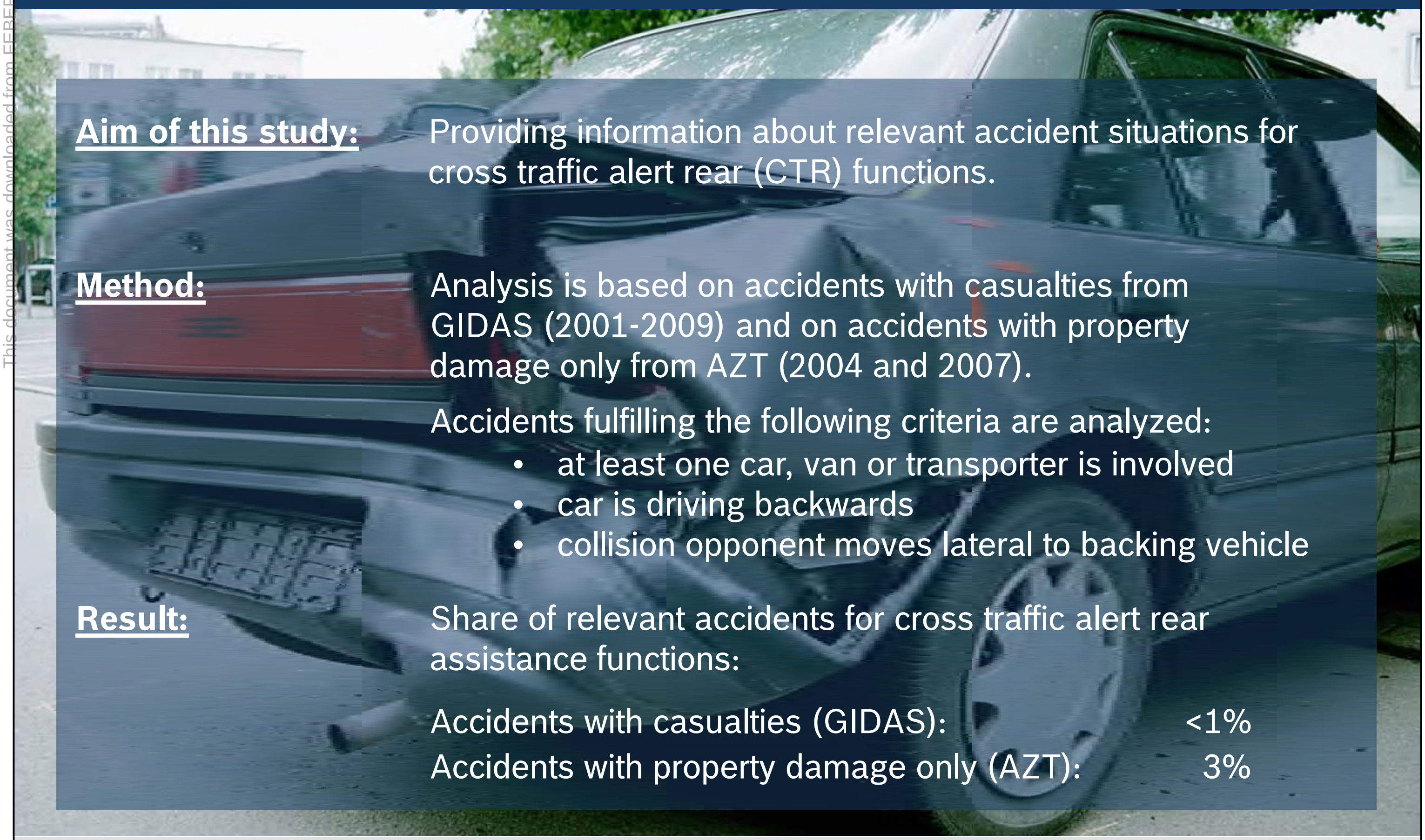
Cross traffic alert rear

– Additional information for function development –

Accident research
CR / AEV1

BOSCH

Cross traffic alert rear



Aim of this study: Providing information about relevant accident situations for cross traffic alert rear (CTR) functions.

Method: Analysis is based on accidents with casualties from GIDAS (2001-2009) and on accidents with property damage only from AZT (2004 and 2007).

Accidents fulfilling the following criteria are analyzed:

- at least one car, van or transporter is involved
- car is driving backwards
- collision opponent moves lateral to backing vehicle

Result: Share of relevant accidents for cross traffic alert rear assistance functions:

Accidents with casualties (GIDAS):	<1%
Accidents with property damage only (AZT):	3%

BOSCH

Selection of relevant situations in accidents with casualties[1)]

accidents	vehicles	selection criteria	share of acc.
14 398 *(14 496)*	24 451 *(24 414)*	Accidents with casualties and necessary information available	**100%**
12 322 *(12 351)*	18 422 *(17 782)*	Accidents with casualties, information available and involving passenger cars, vans or transporters	**86%**
280 *(191)*	283 *(193)*	Car drives backwards *(for distribution of accident types see appendix)*	**2%**
78*+97** *(57*+59**)*	175 *(116)*	Accidents with cross traffic rear *(based on single case analysis and accident type – for details see slide 4)*	**1%**

Relevant accidents for a cross-traffic-alert-rear system separated by type of opponent

Motorized vehicle	Bicycle	Pedestrian**	
33 *(26)*	42 *(29)*	97 *(59)*	**0.3%***

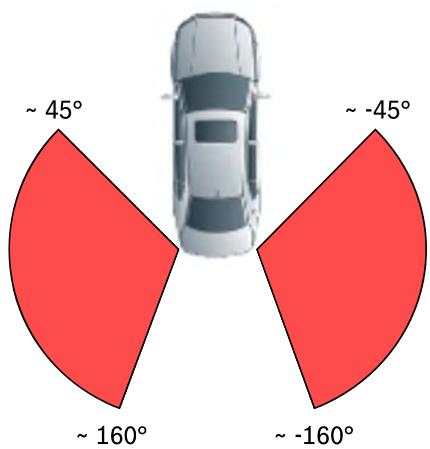
→ ***If opponent is a vehicle, less than 1% of accidents with casualties in Germany are relevant for cross traffic alert rear assistance functions.***

[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
*) w/o pedestrians **) pedestrian, currently not addressed by CTR

Further criteria for system relevance

- Collision opponent moves - at least partially - lateral to ego.
- Collision opponent moves within relevant angular range (appr. 45°-160°).
- If ego car starts driving backwards, collision opponent may not be located directly behind ego.

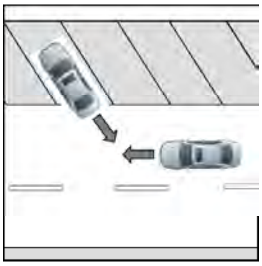
  Reason:
  In this case collision opponent is not detectable for sensor concept of CTR, furthermore it is relevant for PDC (Park Distance Control).



- Type of accident (see appendix) has not necessarily to be one of the relevant types if criteria above are fulfilled.

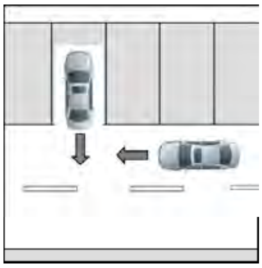
Main scenarios for CTR - opponent: motorized vehicle[1)]

➔ To enable a more detailed classification than possible with current types of accidents (UTYP), the following scenarios were created:



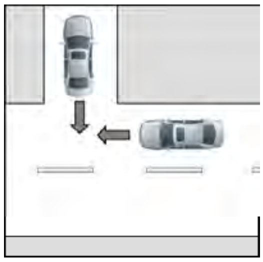
Veh_Type 1

Backing up car leaves diagonal parking space



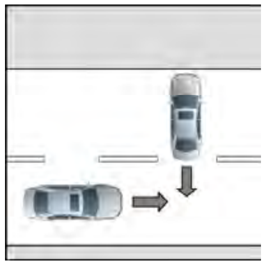
Veh_Type 2

Backing up car leaves orthogonal parking space



Veh_Type 3

Backing up car leaves minor road or driveway



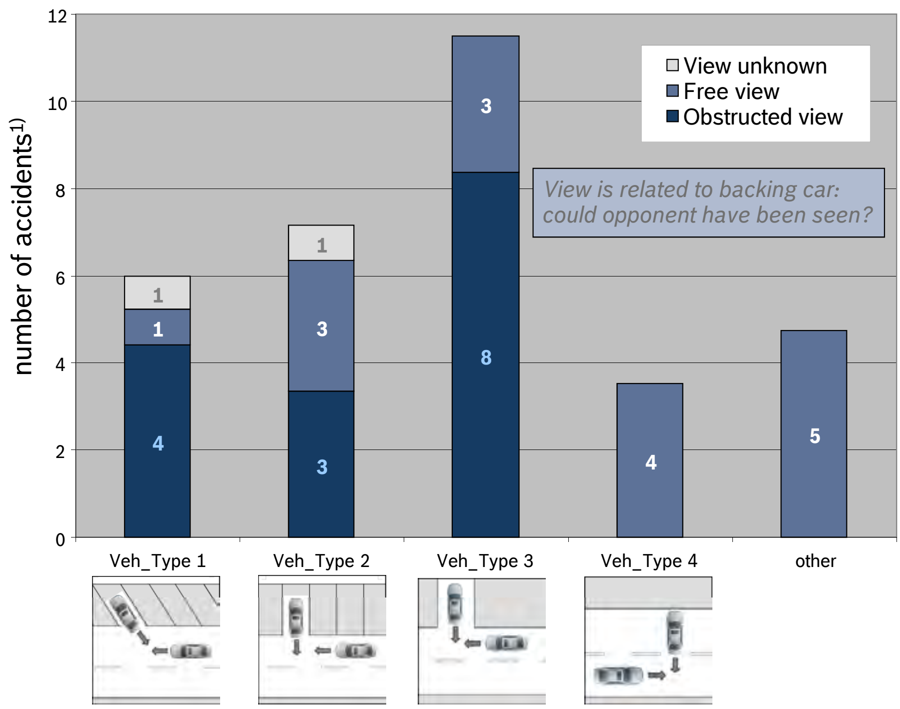
Veh_Type 4

Backing up car orthogonal on road (e.g. turning)

[1)] motorized vehicle could be a passenger car, truck, motorbike etc.

BOSCH

Opponent: motorized vehicle – frequency of main scenarios



➔ in most of the relevant accidents the opponent approaches to the backing car from the right

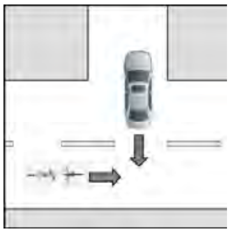
[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

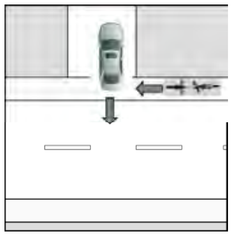
BOSCH

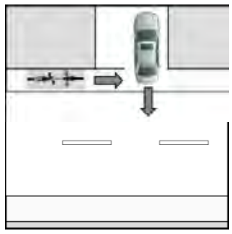
Main scenarios for CTR - opponent: bicycle

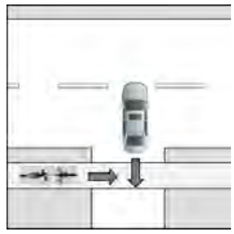
➔ To enable a more detailed classification than possible with current types of accidents (UTYP), the following scenarios were created:

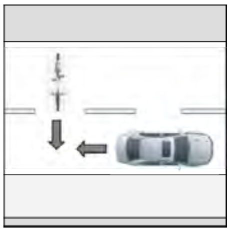

Bike_Type 1

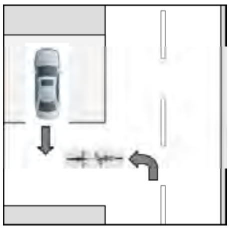

Bike_Type 2


Bike_Type 3


Bike_Type 4


Bike_Type 5


Bike_Type 6

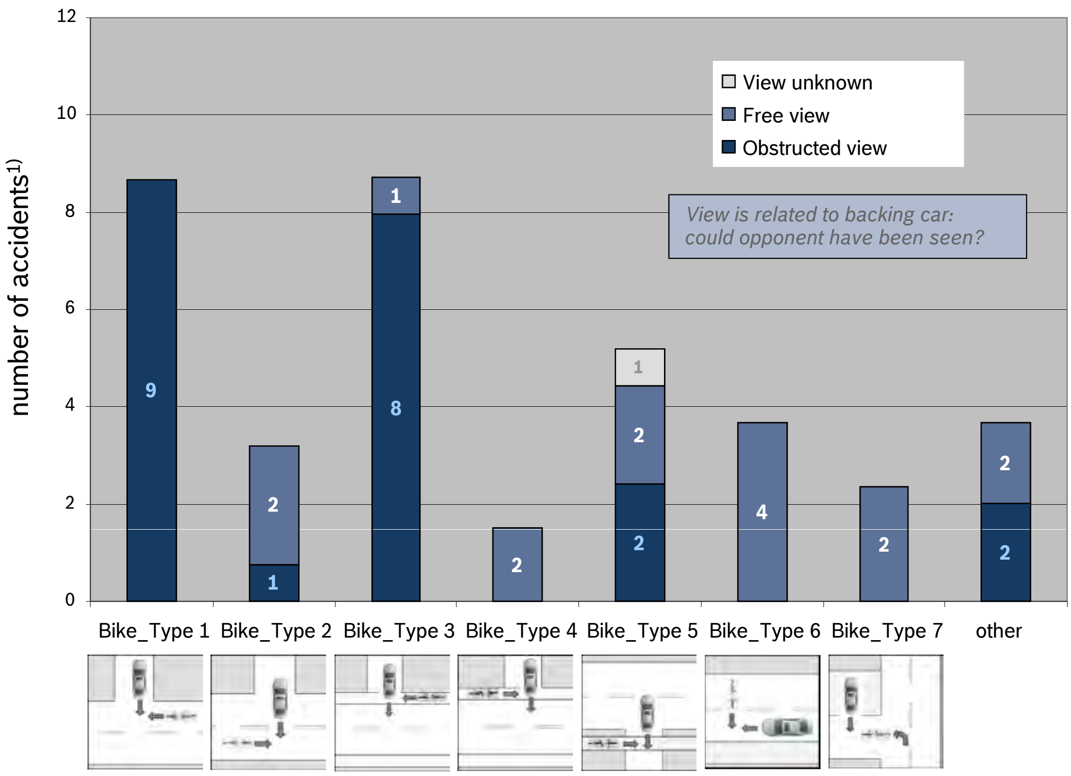

Bike_Type 7

1. Backing up car leaves minor road or driveway, bicycle approaches on road from the right
2. Backing up car leaves minor road or driveway, bicycle approaches on road from the left
3. Backing up car leaves minor road or driveway, bicycle approaches on sidewalk or cycle path from the right
4. Backing up car leaves minor road or driveway, bicycle approaches on sidewalk or cycle path from the left
5. Backing up car crosses sidewalk or cycle path starting from main road
6. Backing up car drives against direction of traffic at main road
7. Backing up car leaves parking space into minor road, bicycle turns into minor road

Cross traffic alert rear

Chapter 06

Opponent: bicycle– frequency of main scenarios



[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Property damage only1) - FCI2) cases with detailed data

accidents	vehicles	selection criteria	share of accidents
3 987 *(3 986)*	6 475 *(6 558)*	Accidents with property damage only and involving passenger cars	100%
1 385 *(1 354)*	1 827 *(1 804)*	Only cases with fully comprehensive insurance and detailed data available (pictures of damage & expert's report, see slide 11)	35% set to **100%**
226 *(271)*	229 *(275)*	Car drives backward	**16%**
21 *(17)*	21 *(17)*	Relevant accident types only (UTYP=571, 572, 579, 714, 715)	**1.3%**
10 *(9)*	10 *(9)*	Collision opponent was moving (GEGNER_BEW=2,3)	**0.7%**

All opponents are motorized vehicles.

→ *Less than 1% of accidents with property damage only and detailed data available are relevant for cross traffic alert rear assistance functions.*

1) Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics
2) FCI ... fully comprehensive insurance

BOSCH

Cross traffic alert rear

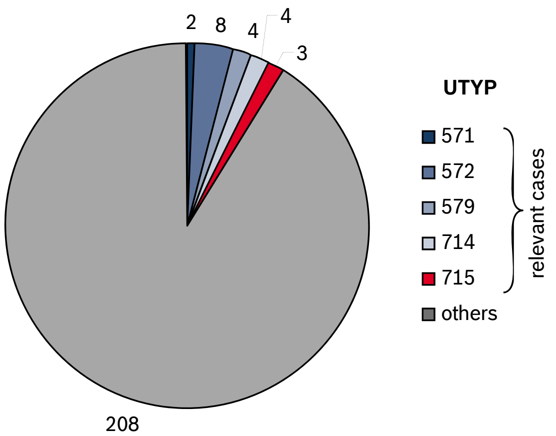
Chapter 06

Property damage only1) - FCI2) cases with detailed data

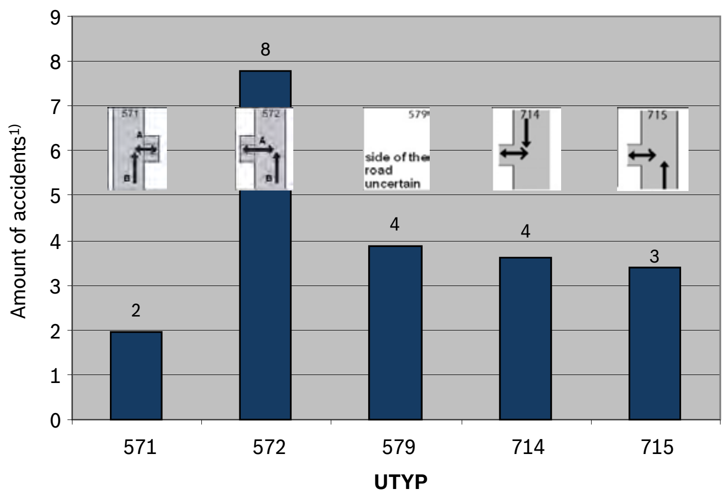
Distribution of accident types:

→ Out of 226 accidents with backing car, 21 have a relevant accident type.

→ For 10 of these cases collision opponent was moving (see slide 11).



Distribution of types of accidents (UTYP) within cases with backing car - total 226 (*271*).



Distribution of relevant types of accidents (UTYP) within cases with backing car - total 21 (*17*).

1) Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics
2) FCI ... fully comprehensive insurance

Internal | CR/AEV1 - Schlender | 05/01/2012 | AEV064 annual report 2011 | © Robert Bosch GmbH 2012. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Prop. damage only[1] - transfer to cases w/o detailed data

- ➔ Detailed data (pictures of damage, moving state of opponent, expert's report) only for a part of *fully comprehensive insurance* cases available.
- ➔ Therefore separated treatment of cases without detailed data is necessary.

18 *(15)*	Relevant accident types only (UTYP=571, 572, 579, 714, 715)	set to 100%
10 *(9)*	Collision opponent was moving (GEGNER_BEW=2,3)	60%

- ➔ In 60% of the relevant accident types for *fully comprehensive insurance* cases with detailed data available the collision opponent was moving.
- ➔ Assumption: ratio of moving / not moving opponent is the same for cases without detailed data (no pictures available).

[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Property damage only[1] – cases w/o detailed data

accidents	vehicles	selection criteria	share of accidents
3 987 *(3 986)*	6 475 *(6 558)*	Accidents with property damage only and involving passenger cars	100%
2 602 *(2 632)*	4 042 *(4 158)*	Only cases without detailed data (no pictures available).	65% **set to 100%**
726 *(841)*	733 *(851)*	Car drives backward	**28%**
179 *(131)*	180 *(133)*	Relevant accident types only (UTYP=571, 572, 579, 714, 715)	**7%** 60% **4%**

Derived from cases with detailed data available: in 60% of the relevant accident types the collision opponent was moving, this corresponds to **107** accidents within the AZT-database.

➔ *Therefore **4%** of accidents with property damage only and <u>detailed data not available</u> are relevant for cross traffic alert rear assistance functions.*

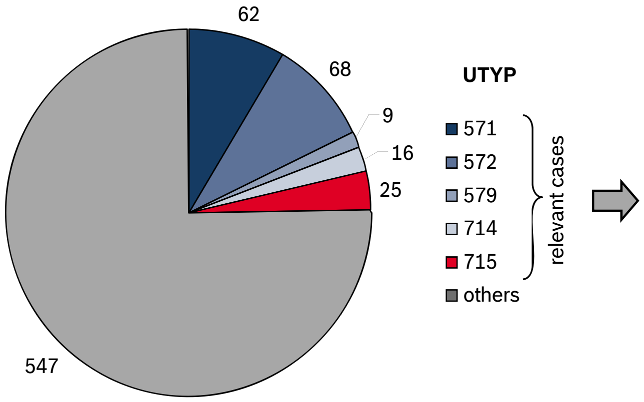
All opponents are motorized vehicles.

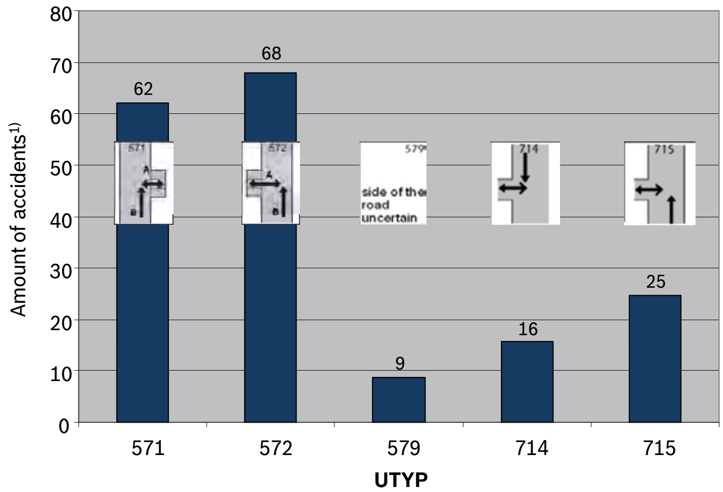
[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Property damage only[1)] – cases w/o detailed data

Distribution of accident types:

- ➔ Out of 726 accidents with backing car, 179 have a relevant accident type.
- ➔ For 107[2)] of these cases collision opponent was moving (see previous slide).





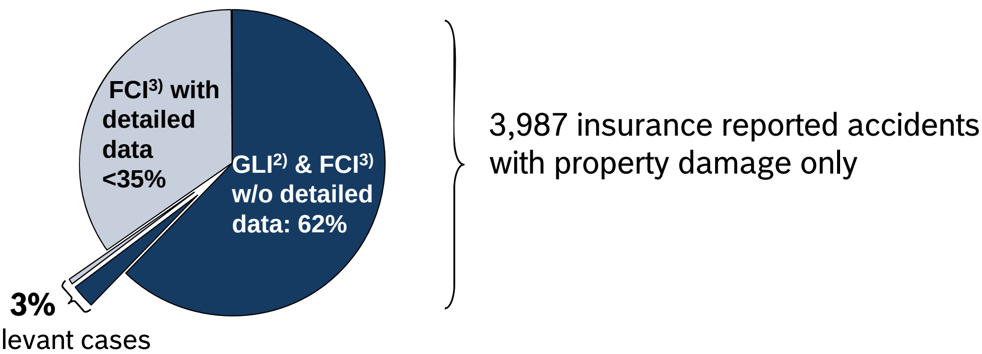
Distribution of types of accidents (UTYP) within cases with backing car - total 726 (*841*).

Distribution of relevant types of accidents (UTYP) within cases with backing car - total 179 (*131*).

[1)] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics
[2)] Derived from cases with detailed data available, see previous slide

Property damage only[1)] – Result

- ➔ Reason for smaller share of relevant accidents within cases with detailed data:
  - ➔ If the expected amount of damage exceeds a threshold (depends on estimation of insurance), an expert's reports will be created.
  - ➔ Therefore expert's reports only available for *fully comprehensive insurance* cases with an increased amount of damage.

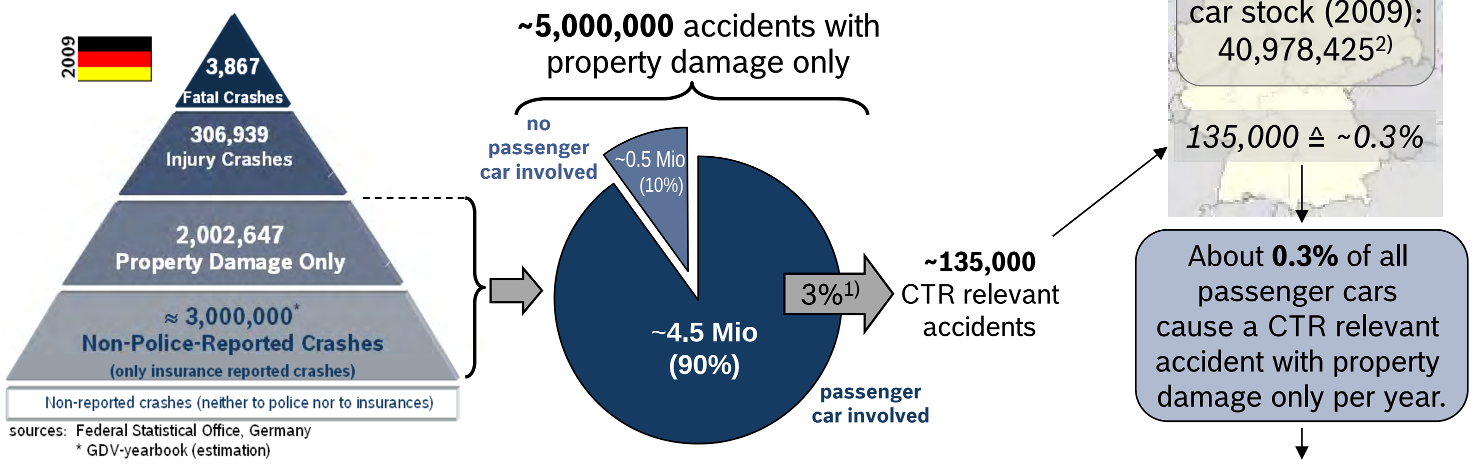


➔ ***Result: 3% of insurance reported accidents with property damage only in Germany are relevant for cross traffic alert rear assistance functions.***

[1)] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics
[2)] GLI ... general liability insurance [3)] FCI ... fully comprehensive insurance

Probability of causing a CTR relevant accident

- AZT data contain only cases with at least one passenger car involved.
- Rate of passenger car involvement for accidents with property damage only is estimated with ~90%.



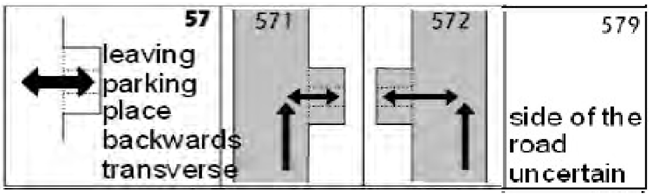
- ***Result:** Within the average life cycle of ~12 years[3] of passenger cars in Germany the probability to cause a CTR relevant accident with property damage only is about 4%.*

[1] relevant for CTR (out of Bosch-AZT study): 3% of accidents with property damage only and at least one passenger car involved (see slide 14)
[2] Source: Destatis [3] Source: KBA

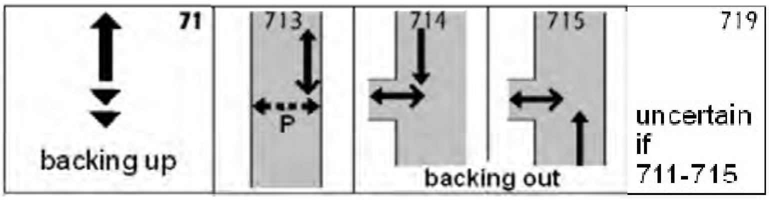
Appendix

Appendix - Relevant types of accidents

Type 57
Conflict between vehicle leaving a transverse parking space backwards and a vehicle of the moving traffic.



Type 71
Accident while backing up or rolling back. Unless manoeuvring to park

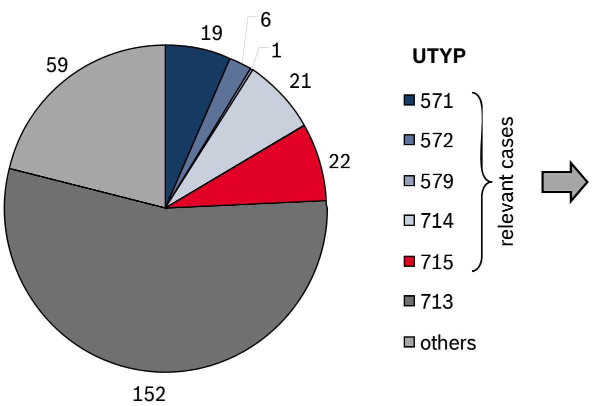


Cross traffic alert rear

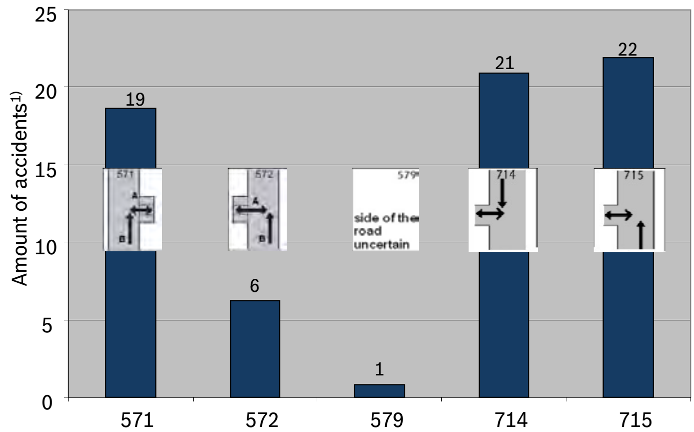
Chapter 06

Appendix - Accident type distribution of accidents with casualties[1)]

- This slide enables a comparison to accident type distribution of property damage only.
- Not all GIDAS cases with relevant type of accident are selected – because further criteria were not always fulfilled (see slide 4).
- Out of 280 accidents with backing car, 69 have a relevant accident type[2)3)].



Distribution of types of accidents (UTYP) within cases with backing car - total 280 (*191*).



Distribution of relevant types of accidents (UTYP) within cases with backing car - total 69 (*53*).

[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
[2)] for relevant types of accidents see appendix [3)] w/o pedestrians

Accidents at narrow points

– Additional information for function development –

**Accident research
CR / AEV1**

Accidents at narrow points

Aim of this study: Providing information about use-cases for narrow road assistance functions.

Method: Analysis is based on accidents with casualties from GIDAS (2001-2009) and accidents with property damage only from AZT (2004 and 2007).

Accidents involving at least one car, van or transporter are selected and analyzed subdivided in

a) "Accidents at road works on streets with constructional division"
b) "Accidents on rural streets without constructional division" and
c) "Accidents in urban area".

Result: Relevant cases for narrow road assistance functions:

	GIDAS	AZT
a) road works (construct. div.)	**<0.1%**	**<0.1%**
b) rural streets	**0.2%**	**1.2%**
c) urban area	**0.6%**	**1.8%**

Distribution of accidents with casualties[1)]

14 398 *(14 496)* — Accidents with casualties and necessary information available

↓

12 755 *(12 809)* — Accidents with casualties, information available and involving passenger cars, vans or transporters, trucks or buses

a) Streets with constructional division	b) Rural streets without constructional division	c) Urban streets	Overlap of a)-b) or a)-c)[2)]
1 783 *(1 387)*	2 888 *(2 113)*	7 978 *(9 217)*	106 *(92)*

3 (2) accidents[1)] could be addressed by narrow road assistance[3)], this corresponds to 0.2% of accidents at streets with constructional division.

25 (*18*) accidents[1)] could be addressed by narrow road assistance[3)], this corresponds to 0.9% of accidents in rural area.

34 (*36*) accidents[1)] could be addressed by narrow road assistance[3)], this corresponds to 0.4% of accidents in urban area.

[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
[2)] e.g. due to different kind of street divisions at crossings (1st motorist at street of cat. a) 2nd motorist on street of cat. b))
[3)] for criteria and explanations see next slides

Selection of relevant situations with casualties[1)]

accidents	vehicles	selection criteria	share of accidents
14 398 *(14 496)*	24 451 *(24 414)*	Accidents with casualties and vehicle involvement	**100%**
12 755 *(12 809)*	19 823 *(19 071)*	Accidents with casualties and involving passenger cars, vans or transporters, trucks or buses	**89%**
1 599 *(1 477)*	2 365 *(2 188)*	Types of accidents relevant for narrow points *(see appendix)*	**10%**
1 493 *(1 386)*	2 220 *(2 061)*	Street not covered with snow	**10%**

...continued on next slides

[1)] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Selection of relevant situations with casualties[1) – at road works

...continued from slide 4

accidents	vehicles	selection criteria	share of accidents
1 493 *(1 386)*	2 220 *(2 061)*	Street not covered with snow	10%
339 *(284)*	541 *(455)*	Street with constructional division	**2.4%**
330 *(273)*	508 *(423)*	Initial speed > 50km/h or unknown	**2.3%**
80 *(62)*	98 *(78)*	Narrow lane (< 3.30m)	**0.5%**
3 *(2)*	*3* *(2)*	Relevant accidents for a narrow road assistance system on streets with constructional division *(based on single case analysis – for details see slide „Further criteria for system relevance“)*	**<0.1%**

[1) Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Selection of relevant situations with casualties[1) - rural area

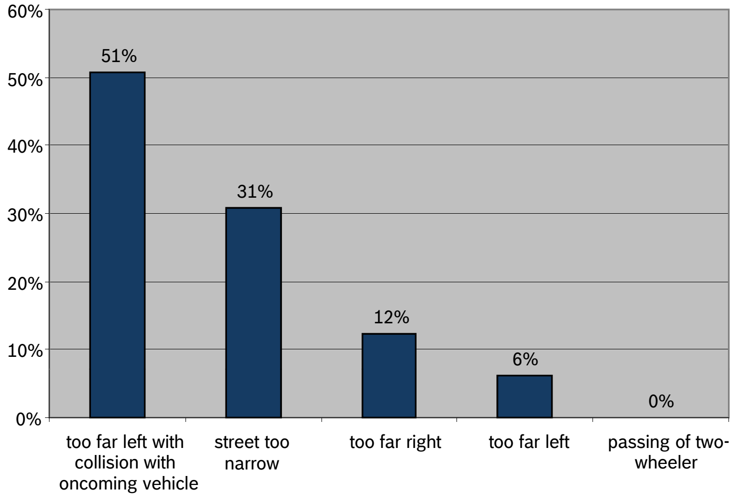
...continued from slide 4

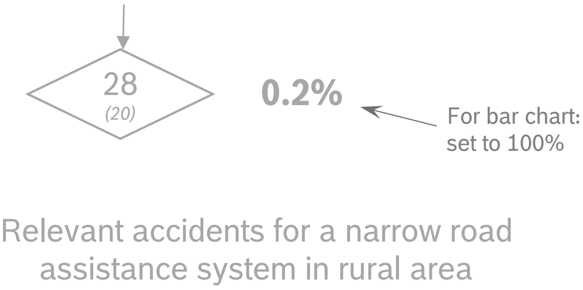
accidents	vehicles	selection criteria	share of accidents
1 493 *(1 386)*	2 220 *(2 061)*	Street not covered with snow	10%
501 *(431)*	675 *(583)*	Rural street without constructional division	**3.5%**
302 *(253)*	392 *(335)*	Initial speed < 70km/h or unknown	**2.1%**
80 *(64)*	*82* *(65)*	Narrow lane (< 2.50m)	**0.6%**
28 *(20)*	*35* *(25)*	Relevant accidents for a narrow road assistance system in rural area *(based on single case analysis – for details see slide „Further criteria for system relevance“)*	**0.2%**

[1) Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Detailed results of accidents with casualties[1] – rural area

Distribution of accident situations within relevant accidents for a narrow point assistance system in rural area:





This corresponds to 1.0% of accidents in rural area (see slide 3)

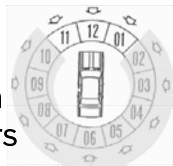
→ in 85% of above accidents an oncoming vehicle was involved or has contributed

[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Selection of relevant situations with casualties[1] - urban area

...continued from slide 4

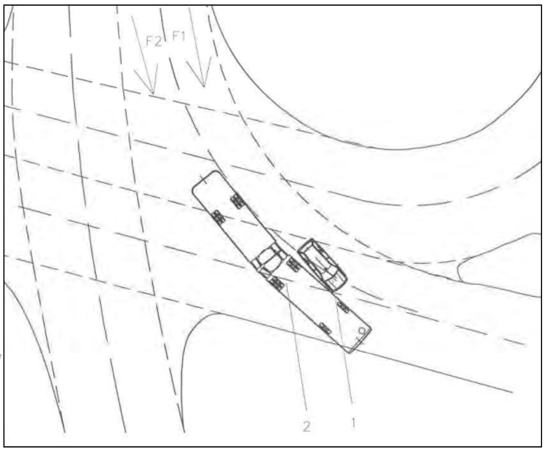
accidents	vehicles	selection criteria	share of accidents
1 493 *(1 386)*	2 220 *(2 061)*	Street not covered with snow	10%
590 *(624)*	*873 (919)*	Urban street	**4.1%**
470 *(505)*	686 *(730)*	Initial speed < 70km/h or unknown	**3.3%**
269 *(280)*	*333 (344)*	Impact direction: head-on *(11, 12 or 1 o'clock)*, location of damage at front at outer sectors only (not only in the middle and not the whole front)	**1.9%**
88 *(92)*	*119 (124)*	Relevant cases for a narrow road assistance system in urban area *(based on single case analysis – for details see slide „Further criteria for system relevance")*	**0.6%**



[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Additional selection criteria[1] – urban area

In very few relevant cases impact direction corresponds not to the selection criteria mentioned above:



- If ego approaches lateral to long vehicles (articulated buses, trams, trucks) - especially in curves - and a part of the long vehicle is within aperture angle of a frontal orientated sensor system.

- Relevant cases:

...continued from slide 4

1 493 (1 386) ↔ 2 220 (2 061) — Street not covered with snow

590 (624) ↔ *873* (919) — Urban street

470 (505) ↔ 686 (730) — Initial speed < 70km/h or unknown

2 (2)

+

...continued from slide 8

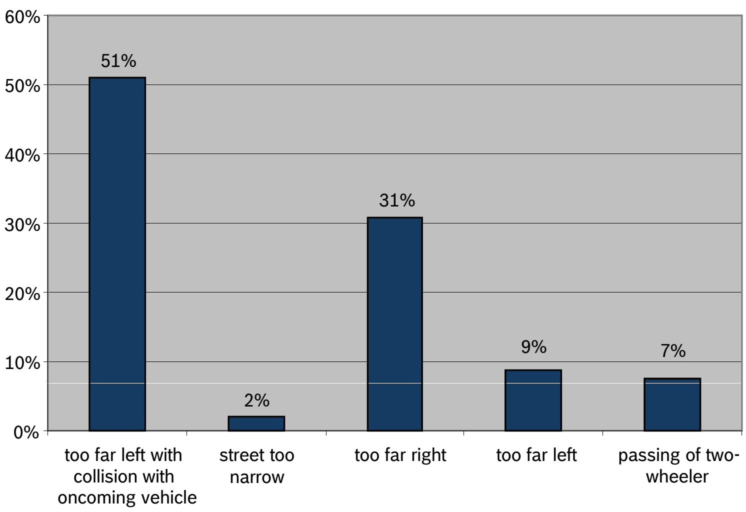
Therefore all relevant cases for a narrow road assistance system in urban area results in:

90 (94) ↔ *121* (126)

[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Detailed results of accidents with casualties[1] – urban area

Distribution of accident situations within relevant accidents for a narrow point assistance system in urban area:



90 (94)

0.6%

For bar chart: set to 100%

Relevant accidents for a narrow road assistance system in urban area

This corresponds to 1.1% of accidents in urban area (see slide 3)

- in 58% of above accidents an oncoming vehicle was involved or has contributed

[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Criteria for system relevance in single case analysis (GIDAS)

- Leaving lane if accident is not addressed by an existing LDW/LKS system:
  - v0 < 60km/h or
  - no or insufficient road marking
- Especially in urban area “dynamical” narrow points are considered, e.g.
  - narrow point because of oncoming traffic
  - ego does not drive far enough to the right (in spite of sufficient space)
- Only intersections with clear visible road marking.
- No influence of driving dynamics, e.g.
  - no skidding before leaving the lane
  - not too high speed in a curve (related to radius)
- In single case analysis only passenger cars, vans and transporter were considered as target vehicle for narrow road assistant.

[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics

Results for accidents with casualties[1]

accidents[1]	vehicles	selection criteria	share of accidents
121 *(116)*	*159* *(153)*	Relevant cases for a narrow road assistance system	**0.8%**

➔ About 0.8% of all accidents with casualties in Germany caused by a passenger car, van or transporter are due to narrow points[2] or leaving lane[3].

- **<0.1% at road works** (on roads with constructional division)
- **0.2% on rural roads**
- **0.6% on urban roads**

[1] Source: GIDAS 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
[2] Especially in urban area “dynamical” narrow points are considered:
e.g. narrow point because of oncoming traffic, ego does not drive far enough to the right (in spite of sufficient space)
[3] Leaving lane if accident is not addressed by an existing LDW/LKS system (v0 < 60km/h or no or insufficient road marking)

Distribution of accidents with property damage only[1)]

3 987 *(3 986)* — Accidents with property damage only

↓

3 987 *(3 986)* — Accidents with property damage only and involving passenger cars

333 *(183)*	923 *(700)*	2 731 *(3 103)*
		
a) Streets with constructional division	b) Rural streets, no constructional division	c) Urban streets
1 (*2*) accident[1)] could be addressed, this corresponds to 0.3% of accidents at streets with constructional division.	29 (*34*) accidents[1)] could be addressed, this corresponds to 3.7% of accidents in rural area.	30 (*29*) accidents[1)] could be addressed, this corresponds to 1.1% of accidents in urban area.

[1)] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Selection of relevant situations - property damage only[1)]

accidents	vehicles	selection criteria	share of accidents
3 987 *(3 986)*	6 830 *(6 934)*	Accidents with property damage only	**100%**
3 987 *(3 986)*	6 475 *(6 558)*	Accidents with property damage only and involving passenger cars	**100%**
397 *(429)*	595 *(612)*	Relevant types of accidents *(see appendix)*	**10%**

...continued on next slides

[1)] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Accidents at narrow points

Chapter 07

Selection of relevant situations - property damage only[1] at road works

...continued from slide 14

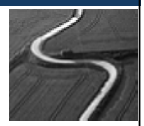
accidents	vehicles	selection criteria	share of accidents
397 *(429)*	595 *(612)*	Relevant types of accidents *(see appendix)*	10%
1 *(2)*	*1* *(2)*	Road works on highways	<0.1%
1 *(2)*	*1* *(2)*	Street not covered with snow	<0.1%
1 *(2)*	*1* *(2)*	Relevant accidents for a narrow road assistance system at road works *(based on single case analysis, check of accident description)*	<0.1%

[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Accidents at narrow points

Chapter 07

Selection of relevant situations - property damage only[1] - rural area



...continued from slide 14

accidents	vehicles	selection criteria	share of accidents
397 *(429)*	595 *(612)*	Relevant types of accidents *(see appendix)*	10%
133 *(169)*	171 *(213)*	Rural streets (site: out of town)	3.3%
84 *(105)*	114 *(139)*	Relevant causes of accidents *(see appendix)*	2.1%
84 *(105)*	*114* *(139)*	Street not covered with snow	2.1%
47 *(59)*	*64* *(77)*	Relevant cases for a narrow road assistance system in rural area *(based on single case analysis, check of accident description)*	1.2%

[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

Accidents at narrow points

Chapter 07

Selection of relevant situations - property damage only[1] - urban area

...continued from slide 14

accidents	vehicles	selection criteria	share of accidents
397 *(429)*	595 *(612)*	Relevant types of accidents *(see appendix)*	10%
237 *(216)*	343 *(306)*	Urban streets	**6%**
167 *(159)*	242 *(223)*	Relevant causes of accidents *(see appendix)*	**4.2%**
165 *(157)*	240 *(221)*	Street not covered with snow	**4.1%**
72 *(74)*	92 *(102)*	Relevant cases for a narrow road assistance system in urban area *(based on single case analysis, check of accident description, including narrow points at parking areas)*	**1.8%**

[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

BOSCH

Accidents at narrow points

Chapter 07

Result for accidents with property damage only (AZT)[1]

- ➔ **About 3% of all insurance reported accidents[1] with property damage only in Germany caused by a passenger car are due to narrow points.**
  - ➢ **<0.1% at road works on highways**
  - ➢ **1.2% on rural roads**
  - ➢ **1.8% on urban roads**
- ➔ **Extrapolated this corresponds to appr. 150.000 accidents in Germany.**

Constraints of AZT data

No ensured / detailed information about:

- ➔ Accident location or vehicle damage (no pictures)
- ➔ Constructional division of lanes
- ➔ Skidding before leaving the lane
- ➔ Width of lane
- ➔ Initial speed (rough division into classes, often unknown)

[1] Source: AZT 2004 and 2007; weighted data by accident type and location; absolute number in italics

BOSCH

Proposal for design of a narrow road assist

- In most of accidents with casualties at narrow points[1] an oncoming vehicle was involved or has contributed to the accident[2].
- If oncoming vehicle is too far within lane of ego the following measures will be able to reduce accident severity or avoid that kinds of accidents:
  - no LDW/LKS intervention (avoidance of driver irritation/restraint)
  - assistance for driving as far right as possible (maybe at border line)
  - assistance for driving outside the lane – at shoulder
  - deceleration

Advantages:

- avoidance of driver irritation/restraint during evade
- using the full road width
- using the full passable width
- reduction accident severity, better controllability of car

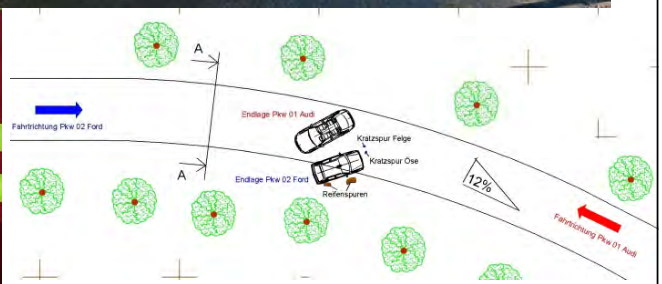
[1] A narrow point is not necessarily due to road construction, it may arise due to oncoming vehicle too far within lane of ego.
[2] See slide 7 and 9

Accidents at narrow points

Chapter 07

Example 1 – assistance for driving as far right as possible [1]

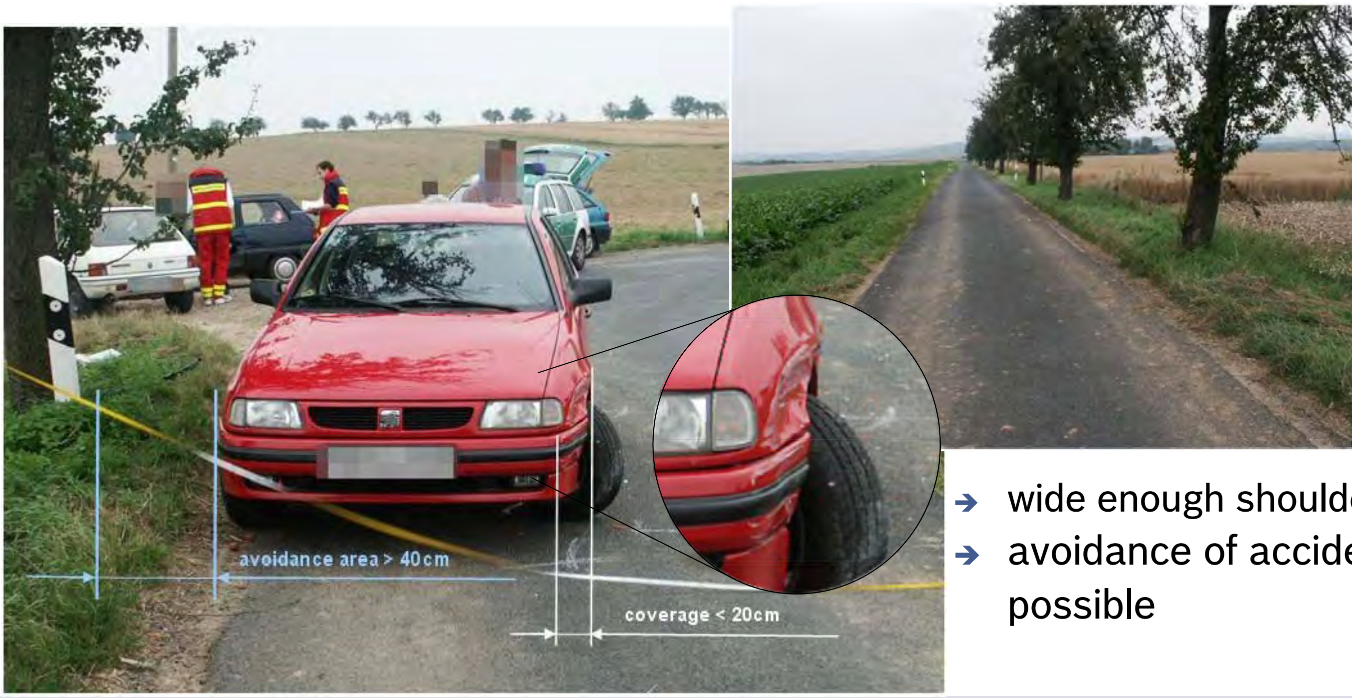
- narrow road, but wide enough for 2 passenger cars
- silver coloured car was too far left
- avoidance of accident possible



[1] Source: GIDAS 2001-2009

Example 2 - assistance for driving outside the lane - at shoulder[1)]

- narrow road, shoulder: even meadow for more than 40cm outside the lane
- there was a collision with low coverage of less than 20cm



- wide enough shoulder
- avoidance of accident possible

[1)] Source: GIDAS 2001-2009

Appendix

Appendix – Relevant types of accidents

Type 13
At a swaying road

Type 14
On a straight road

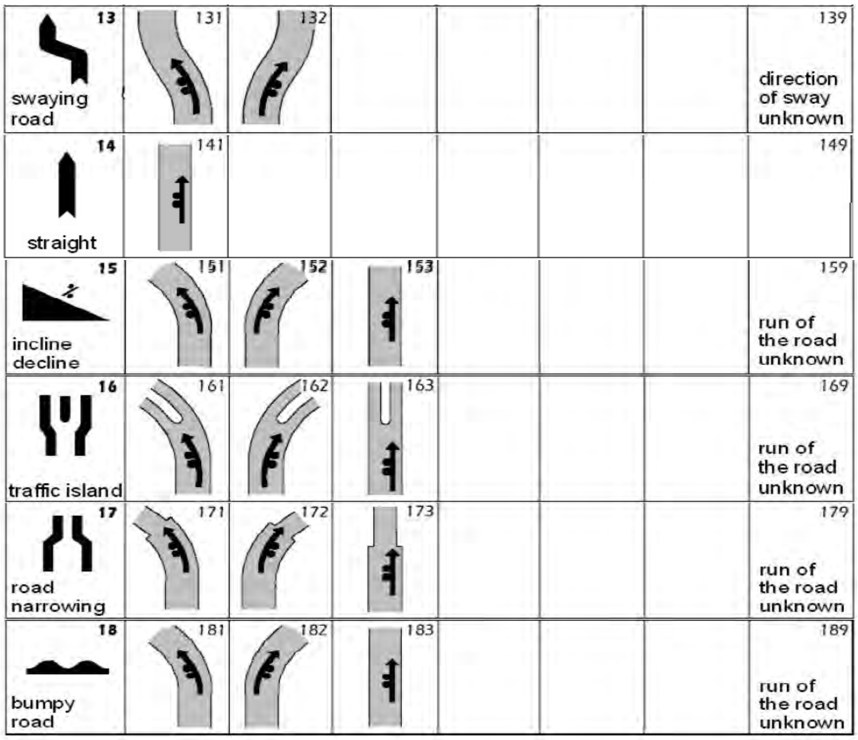
Type 15
…gradient

Type 16
…traffic island

Type 17
… road narrowing

Type 18
… uneven road

Type 19
… other driving accidents



Other driving accidents 199

BOSCH

Accidents at narrow points
Chapter 07

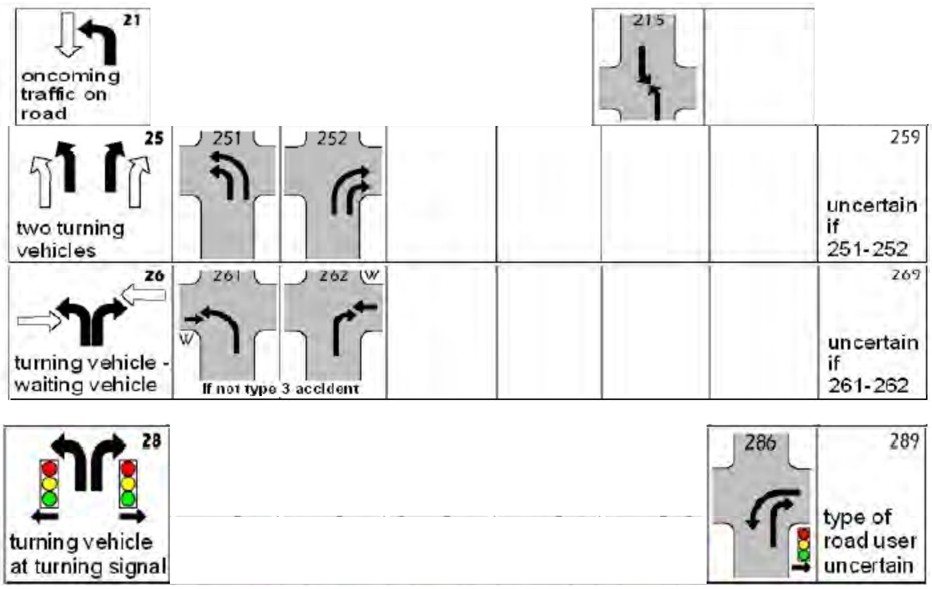
Appendix – Relevant types of accidents

Type 21
Conflict between a vehicle turning off to the left and oncoming traffic

Type 25
Conflict between two turning off vehicles, moving along side in the same direction.

Type 26
Conflict between a turning off vehicle and a vehicle without priority, waiting at the headed road of the turning veh.

Type 28
Conflict between a turning off veh. and another rd user coming from the same or the opposite direction when the turning traffic is regul. by traffic lights.



BOSCH

Appendix – Relevant types of accidents

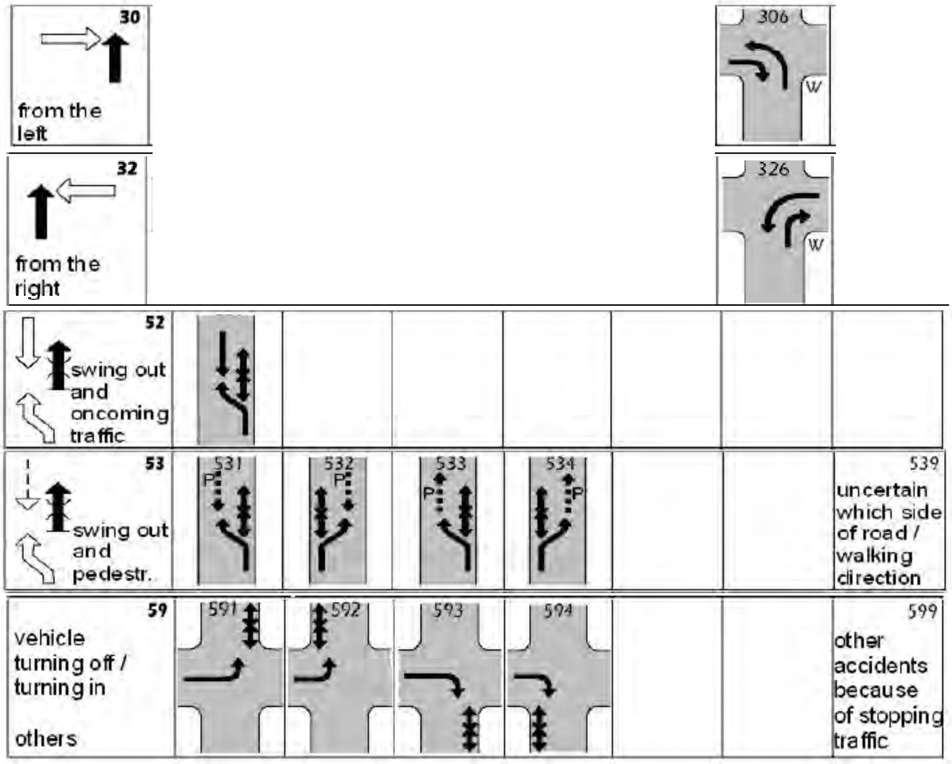
Type 30
Conflict between a non priority vehicle and a priority vehicle coming from the left, which is not overtaking.

Type 32
Conflict between a non priority vehicle and a priority vehicle coming from the right, which is not overtaking.

Type 52
Conflict between a vehicle swinging out to avoid a parking vehicle and an oncoming vehicle.

Type 53
Conflict between a vehicle swinging out to avoid a parking vehicle and a pedestrian.

Type 59
Conflict between a turning vehicle and a parking vehicle which is located at the headed path – as well as other accidents with parking vehicles.



BOSCH

Accidents at narrow points
Chapter 07

Appendix – Relevant types of accidents

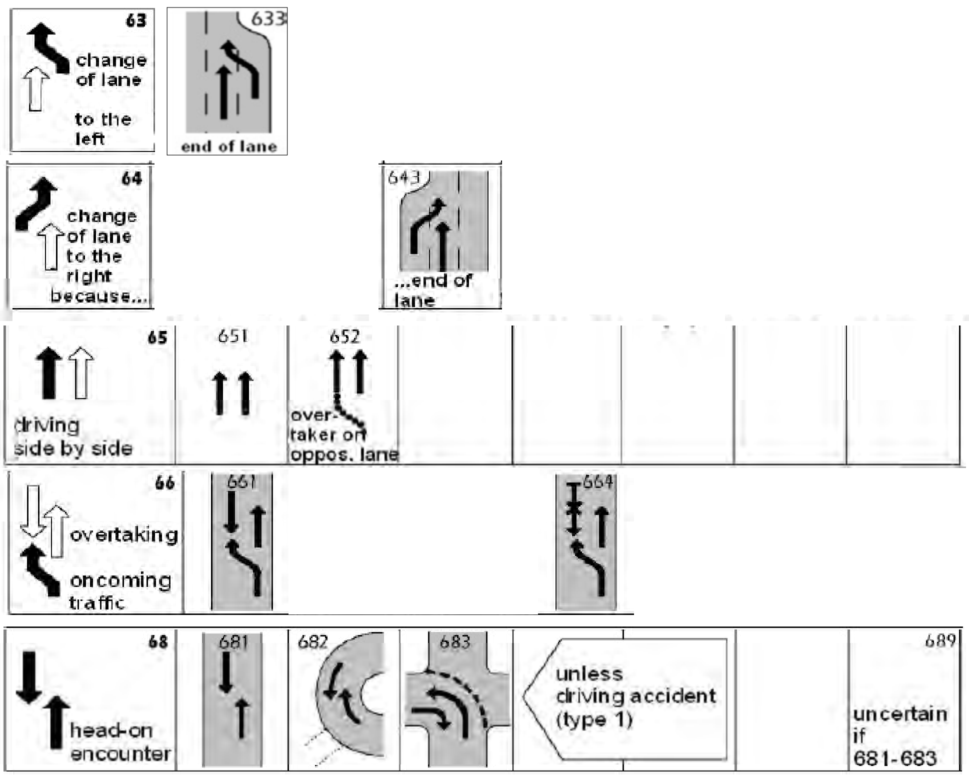
Type 63
Conflict between a vehicle which is changing lanes to the left and a following vehicle on the lane alongside.

Type 64
Conflict between a vehicle which is changing lanes to the right and a following vehicle on the lane alongside.

Type 65
Conflict between two vehicles, side by side, going in the same direction.

Type 66
Conflict between an overtaking vehicle and a vehicle from oncoming traffic, a pedestrian or a parking vehicle.

Type 68
Conflict between two head-on encountering vehicles.



BOSCH

Appendix – Causes of accidents (AZT)

No.	Denomination of cause
	Driving fitness
01	Influence of alcohol
02	Influence of other intoxicating substances (e.g. drugs, narcotics)
03	Overfatigue
04	Other physical or mental faults
	Improper driving
	Use of the road
10	Use of wrong carriageway (or lane) or unlawful use of other parts of the road
11	Violation of the rule of driving on the right side
	Speed
	Unadapted speed
12	and exceeding at the same time the speed limit
13	in other cases
	Distance
14	Insufficient safety distance (Other causes leading to a traffic accident should be allocated to the respective positions, such as speed, overfatigue, etc.)
15	Abrupt braking without compelling reason by the vehicle in front
	Overtaking
16	Unlawful right-hand overtaking
17	Overtaking in spite of oncoming traffic
18	Overtaking in spite of unclear traffic situation
19	Overtaking in spite of insufficient visibility
20	Overtaking without observing the rear traffic and/or without timely and clearly indicating the intention to swerve out
21	Mistake made when returning to right lane
22	Other mistakes made when overtaking (e.g. without sufficient lateral distance; at pedestrian crossings, (cf. pos. 38, 39)
23	Mistakes made when being overtaken
	Driving past
24	Failure to observe the priority of oncoming cars when driving past stationary vehicles, barriers or obstacles (§ 6) (except pos. 32)
25	Failure to observe the rear traffic when driving past stationary vehicles, barriers or obstacles and/or without timely and clearly indicating the intention to swerve out
	Driving side by side
26	Incorrectly changing the lane when driving side by side or failure to observe the "zip method" (merging of two queues with alternate priority of the respective cars (§ 7) (except pos. 20, 25)
	Priority, precedence
27	Failure to observe the rule "right has priority over left"
28	Failure to observe the traffic signs regulating the priority (§ 8) (except pos. 29)
29	Failure to observe the priority of the passing traffic on motorways or motor vehicle roads (§ 18, para. 3)
30	Failure to observe the priority by vehicles coming from dirt roads
31	Failure to observe the traffic control by policemen or traffic lights (except pos. 39)
32	Failure to observe the priority of oncoming vehicles (traffic sign No. 208 of Road Traffic Regulations)
33	Failure to observe the priority of rail vehicles at railway crossings
	Turning, U-turn, reversing, entering the flow of traffic, starting off the edge of the road
35	Mistakes made when turning (§ 9) (except pos. 33, 40)
36	Mistakes made when making U-turn or reversing
37	Mistakes made when entering the flow of traffic (e.g. from premises, from another part of the road or when starting off the edge of the road)
	Improper behaviour towards pedestrians
38	at pedestrian crossings
39	at central islands
40	when turning
41	at stops (also at school busses stopping with the warning flasher device flashing)
42	at other places
	Stationary vehicles, safety measures
43	Unlawful stopping or parking
44	Insufficient safety measures in the case of vehicles stopping or broken down and accident sites or with regard to school busses with children getting on or off the bus
45	Behaviour contrary to traffic regulations when getting on or off a vehicle, loading or unloading
46	**Failure to observe lighting regulations (except pos. 50)**
	Load, number of passengers
47	Overload, maximum number of passengers exceeded
48	Insufficient safety measures with regard to load or vehicle accessories
49	Other mistakes made by driver
	Technical or maintenance faults
50	Lighting
51	Tyres
52	Brakes
53	Steering mechanism
54	Towing equipment
55	Other faults
	Improper behaviour of pedestrians
	Improper behaviour when crossing the carriageway
60	at places where the pedestrian traffic was controlled by policemen or traffic lights
61	on pedestrian crossings without control by policemen or traffic lights
62	near junctions, traffic lights or pedestrian crossings with heavy traffic
	at other places:
63	by suddenly emerging from behind obstacles obstructing the visibility
64	without paying attention to the traffic
65	by other improper behaviour
66	Failure to use footway
67	Failure to use proper side of the road
68	Playing on or near carriageway
69	**Other improper behaviour of pedestrians**
	Road surface conditions
	Slippery carriageway
70	Impurity through oil leakage
71	Other impurities caused by road users
72	Snow, ice
73	Rain
74	Other influences (among others, leaves, loam washed up)
	Road condition
75	Grooves in connection with rain, snow or ice
76	Other road condition
77	**Irregular condition of traffic signs or installations**
78	**Insufficient road lighting**
79	**Insufficiently secured railway crossings**
	Influence of the weather
	Obstruction of visibility by:
80	Fog
81	Heavy rain, hail, flurry of snow and the like
82	Dazzling sunshine
83	**Side wind**
84	**Storm or other weather influences**
	Obstacles
85	Road construction site on carriageway not or not sufficiently secured
86	Wild animals on the carriageway
87	Other animal on the carriageway
88	Other obstacle on the carriageway (except pos. 43, 44)
89	Other causes (list and briefly describe)

= types of accidents relevant for narrow street assist

Potential of *eCall* system

– For powered two wheeler in Germany –

Accident research
CR / AEV1

Potential of eCall system for powered two wheeler

Aim of this study: Identification of the potential for an eCall system for powered two wheeler (ff. PTW) by analyzing accident with casualties in Germany.

Method: Analysis is based on evaluation of GIDAS database (2001-2010). Each accident includes time of report and time of arrival of the rescue team on the spot. This time difference is evaluated and the current situation is shown for the German accident situation. Comparing against severity and time difference further results can be obtained in order to verify the needs of an eCall system.

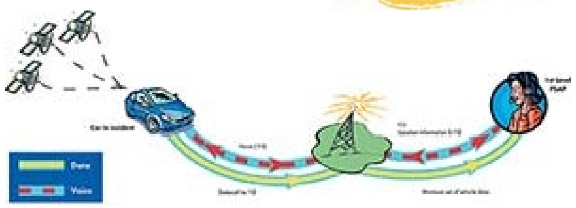
Result: For the analysis 497 weighted accidents w/ casualties in Germany involving PTW available. In 87% of those the ambulance arrived 20 min. after report.
All fatal accidents were reached within this time frame. Highest "use" is seen in accidents where death occurred at the spot in 33% of all fatal accidents.
Highest benefit is assumed for accident scenarios in rural area of single vehicle accidents at night time which have a share of 1% of all accidents w/ casualties involving PTW.

GIDAS #1020196

Definition of an eCall system[1]

What is eCall?

eCall is an electronic "in vehicle" safety system that can automatically call emergency services if an accident happened.



How does eCall work?

The system informs rescue workers of your exact whereabouts, and apparently the ambulance and the fire brigade will be on their way in minutes. It is being touted that the system will work anywhere in Europe, even if you cannot speak the local language.

What does eCall do?

- eCall informs the emergency rescue services that a collision has happened.
- It does not prevent accidents, it does not get the emergency services to the scene any quicker after the eCall system is activated
- It allows communication with the vehicle operator (if possible) to assess what has occurred, what is required and to determine exact location (including all problems that GSM/GPS systems have).

[1] Source: www.righttoride.eu/?page_id=3504

Motivation for PTW eCall[1]

News 08/2011: Fatal single PTW accident

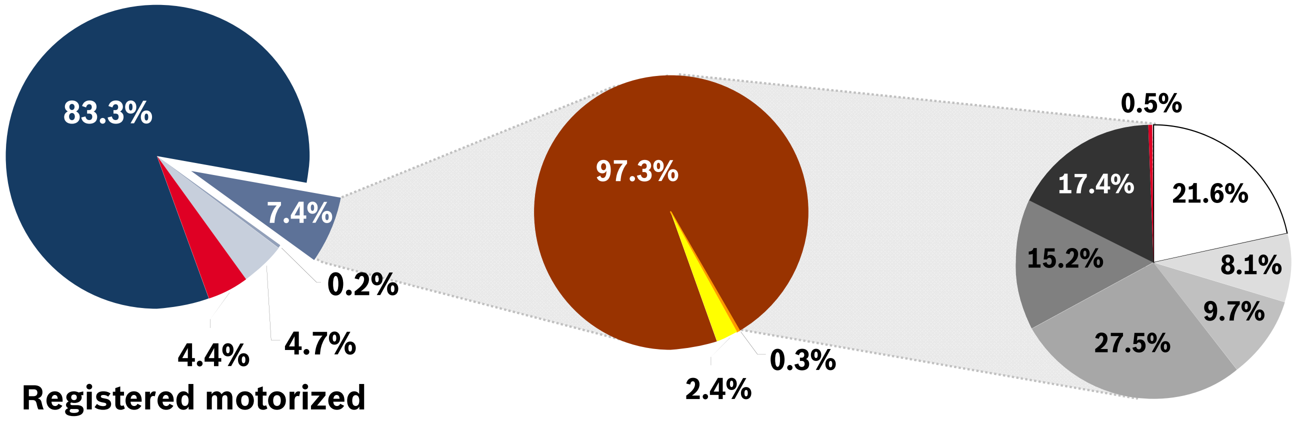
A 47y old PTW rider had a fatal accident during night time on a rural road nearby Friedrichsdorf in Germany. He left the carriageway to the right followed by a multiple rollover. The rider was thrown away and his dead body was found about 5m near the street lying in long grass. He was found after several hours on Sunday morning by a car driver who recognized the motorcycle.

How could eCall support?

If the motorcycle was equipped with an eCall system, the accident would have been recognized by an electronic control unit, e.g. PTW ABS. So first – the accident would have been reported right after the accident. The closest first aid rescue team would have been informed – so quick response is given. Due to GPS – riders location would have been known, so less time for search would have been needed and possibly life would have been saved.

[1] Source: www.hronline.de; Accident report 21.08.2011

Status quo: Registered powered two-wheeler in Germany 2009[1]



Registered motorized vehicles in Germany 2009
Total number of registered vehicles 49 602 623
- Passenger cars
- Trucks
- Powered cycles
- All others
- Bus

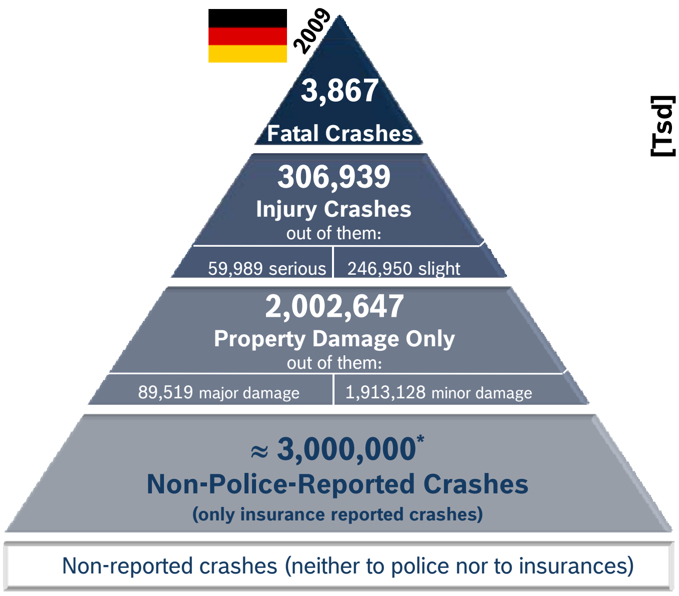
Powered cycles
Total number 3 650 111
- Powered two-wheelers
- Trikes
- Quads

Powered two-wheelers
- up to 125ccm
- 125-250ccm
- 250-500ccm
- 500-750ccm
- 750-1000ccm
- >1000ccm
- others

➔ **More than 3.5 millions (~7%) registered vehicles in Germany are powered two wheelers [ff. PTW]**

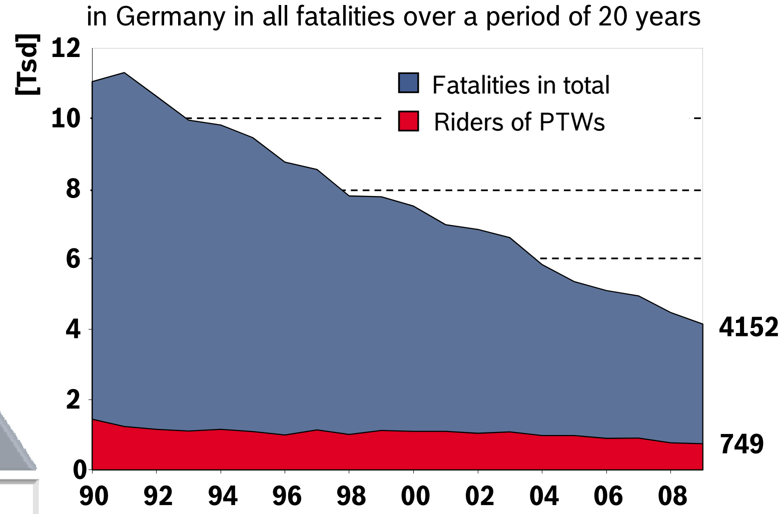
[1] Source: Kraftfahrtbundesamt 2010 – www.kba.de

Accident situation in Germany in 2009



sources: Federal Statistical Office, Germany
* GDV-yearbook (estimation)

Share of fatally injured riders of powered two wheelers in Germany in all fatalities over a period of 20 years



sources: Federal Statistical Office, Germany

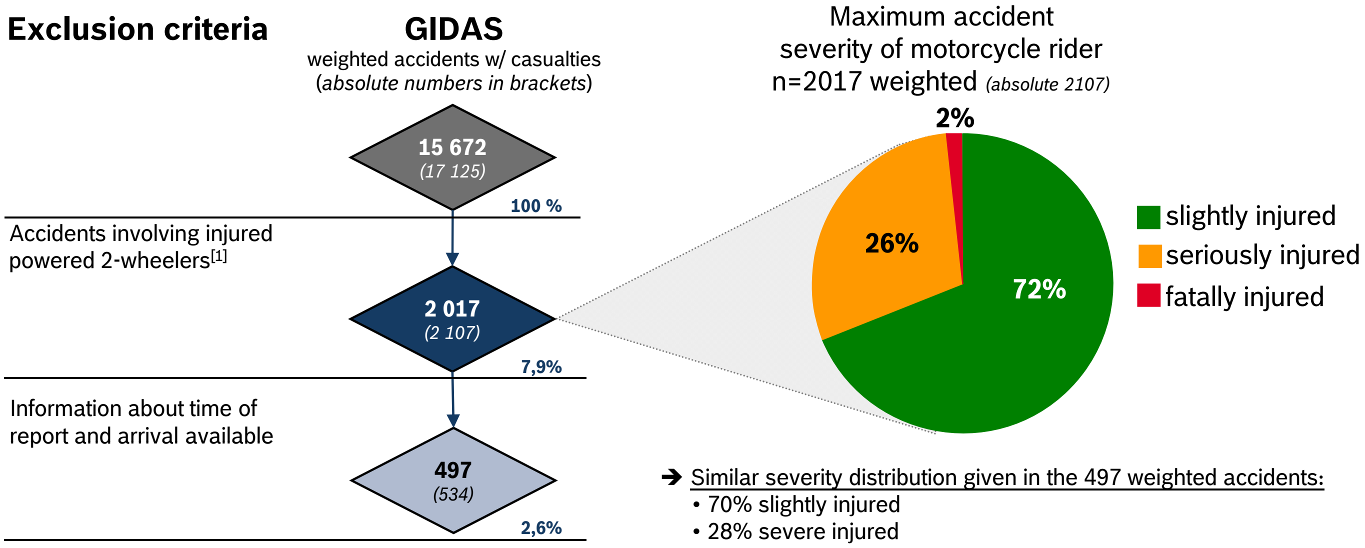
➔ **approx. 5 million reported crashes in Germany**

➔ **18% of all fatalities in Germany are riders of powered two wheelers**

[1] Powered two wheeler:= motorcycles and mopeds

Selection of relevant accidents for eCall analyses using GIDAS (2001-2009)[1]

→ Total: 15 672 weighted & representative accidents w/ casualties including 28 277 vehicles[1]



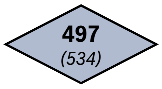
→ Similar severity distribution given in the 497 weighted accidents:
- 70% slightly injured
- 28% severe injured
- 2% fatal injured

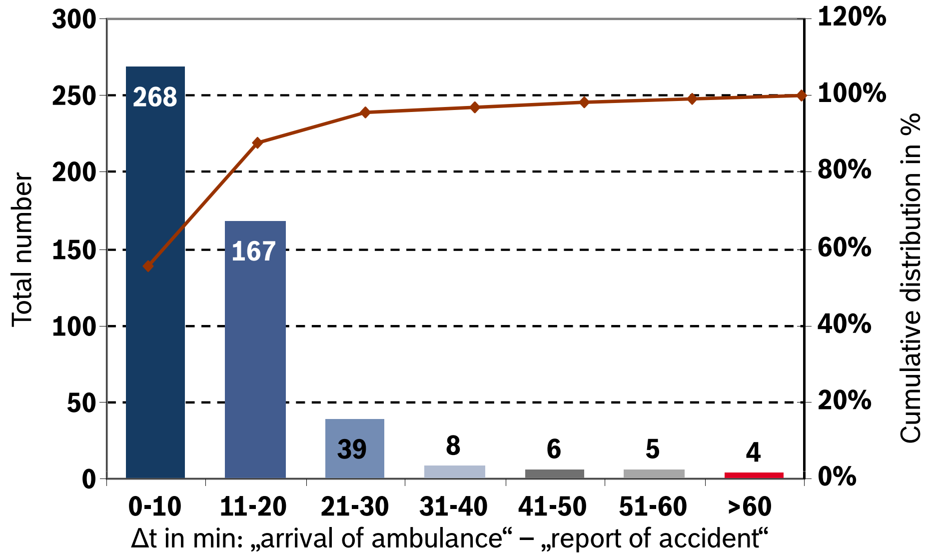
→ **497 (weighted) accidents available for the analysis on PTW eCall system**
→ **About ~2% of all accidents involving PTW are fatal accidents**

[1] Source: GIDAS database (2001-2009) weighted data according to location, severity and accident type, absolute numbers in brackets

Time difference between report and arrival

Frequency and cumulative distribution of accidents classified
In time difference between report and arrival of ambulance (n=497)

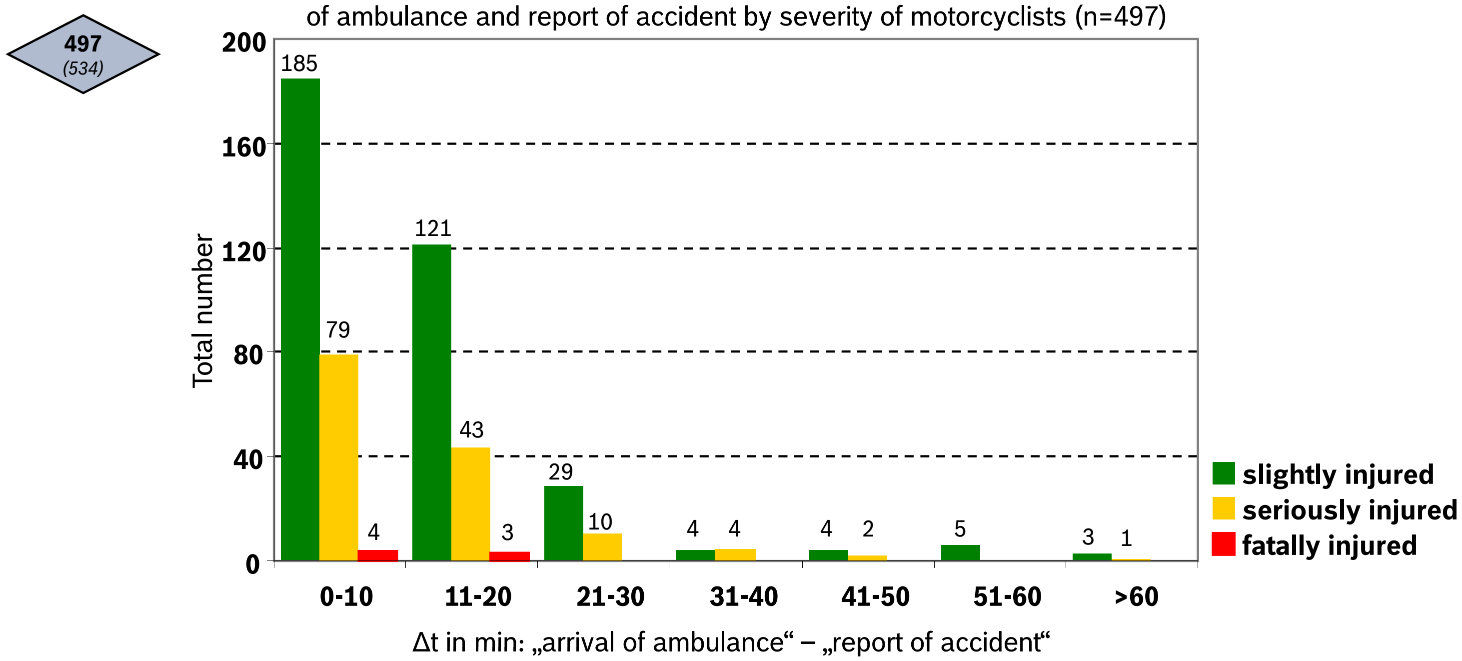




→ **In 87% of all accidents involving PTW the ambulance arrived 20 minutes or less after the report → Identification of arrival time in fatal accidents (see next slide)**

Time difference between arrival & report against severity

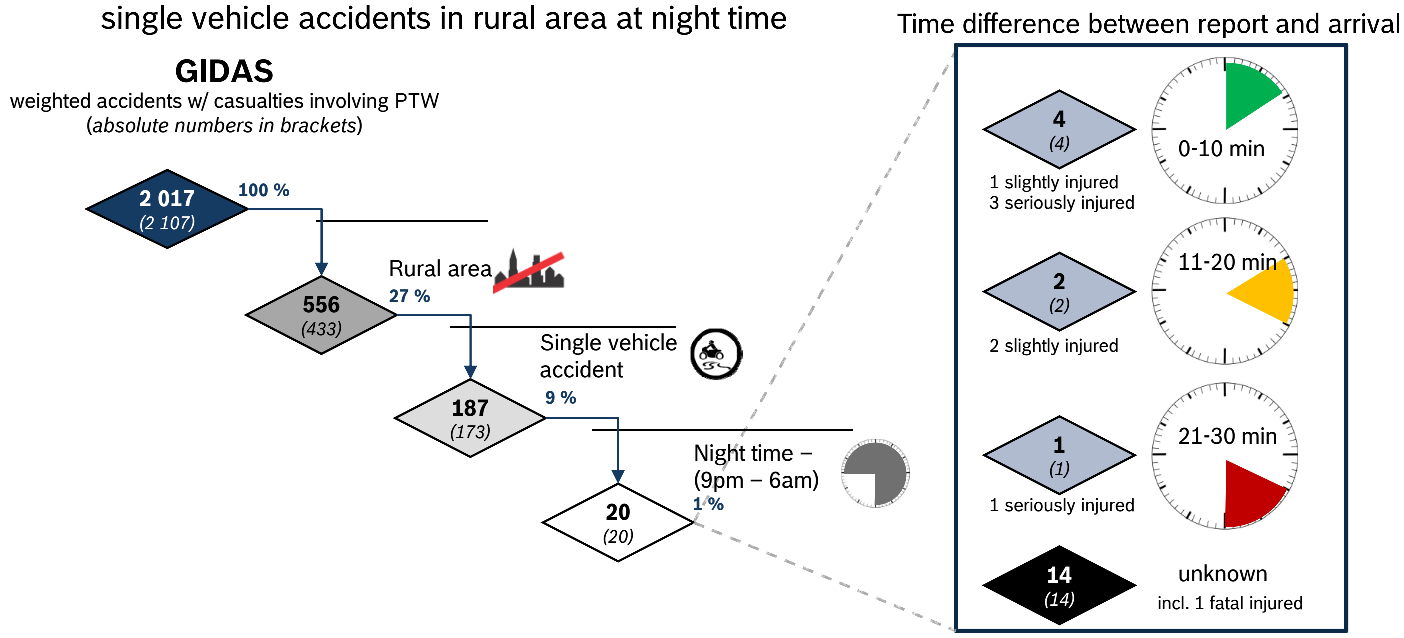
Frequency distribution of accidents against difference between arrival of ambulance and report of accident by severity of motorcyclists (n=497)



➔ **Considering fatal and severe accidents w/ casualties involving PTW only, a share of about 12% were reached after a timeslot of 20 minutes after reporting**

Frequency of selected eCall relevant accident scenarios

➔ Highest benefit expected for the accident scenario:
single vehicle accidents in rural area at night time

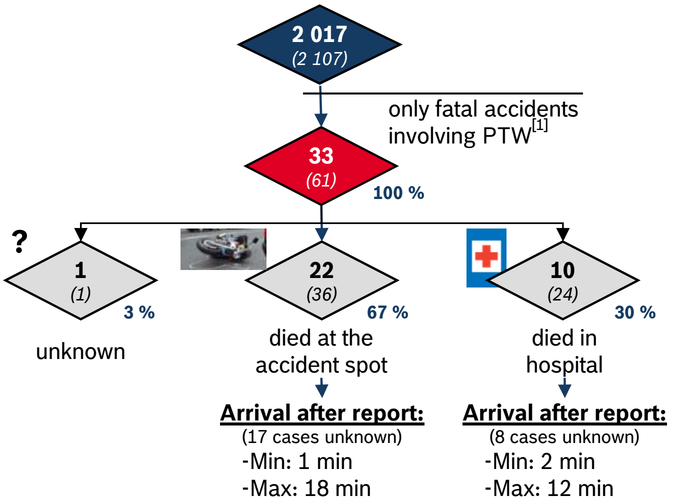


➔ **About 1% of all accidents w/ casualties involving PTW are single vehicle accidents in rural area during night time**

[1] Source: GIDAS database (2001-2009) weighted data according to location, severity and accident type, absolute numbers in brackets

Rough estimation of PTW eCall benefit

GIDAS
weighted accidents w/ casualties involving PTW
(*absolute numbers in brackets*)



- Assumption: Benefit from eCall was estimated by the possibility of survival (using approach similar to SBD [McClure & Graham 2006] study[2])
  - 30% of fatalities diagnosed at hospital
  - 67% died at the accident spot on their injuries
  - "Golden Hour" formula states a 1min response time improvement leads to a 2% reduction of preventable fatalities.
    - One minute time saved or gain result in a maximum reduction of preventable case fatalities or 67%*2% = **1.3% of all PTW fatalities in Germany**

- **Highest "use" for an eCall system is seen on accidents**
  - **where death occurred at the accident spot (67% of all fatal accidents)**
  - **in single vehicle accidents with late or non reporting**
- **eCall PTW benefit is estimated to reduce about 1% of all PTW fatalities in Germany**

[1] Source: GIDAS (2001-2009) weighted data according to location, severity and accident type, absolute numbers in brackets
[2] Approach used in ACEM Public Consultations DEPLOYMENT OF IN-VEHICLE EMERGENCY CALL-eCALL-EUROPE

Summary

- eCall system for PTW not available yet!
- PTW eCall system would be beneficial for single vehicle accidents (mainly rural area) with late or non reporting
- In Germany this is a share of about 1% of all accidents w/ casualties involving PTW
- In 88% the ambulance arrived within 20 minutes after reporting
- In about 67% of all fatal accidents involving PTW death occurred at the spot
- Estimates results in about 1% fatality reduction of PTW riders with an eCall system (rough calculation, no single case analyses)
- eCall can help to reduce PTW fatalities on single accidents but has less significant impact compared to a PTW ABS

GIDAS #1020196

Transfer of study results on motorcycle ABS from Germany to the United States

Source: www.motorcycle-accidents.com

BOSCH

Transfer of PTW ABS study results from GER to US

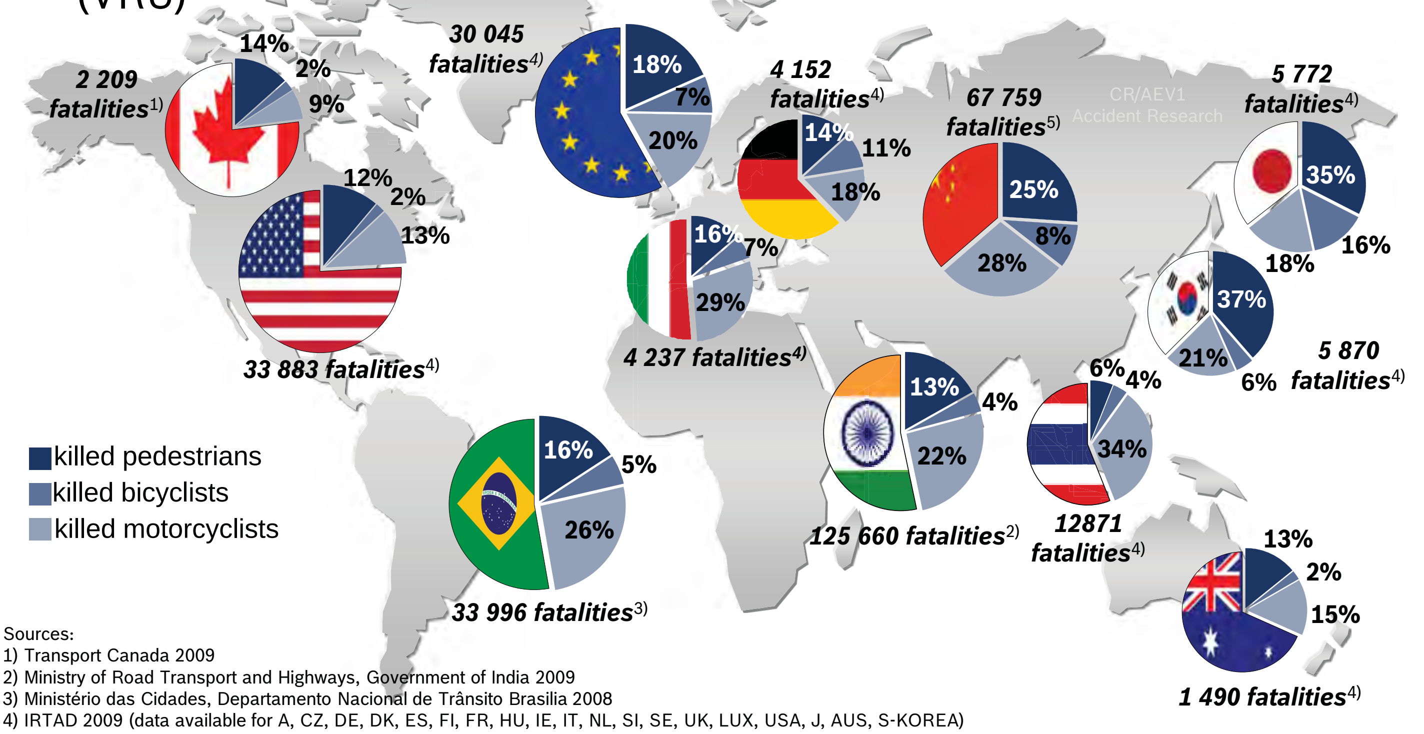
Aim of this study: Estimation of field of effect and benefit from a powered two wheeler anti-lock braking system (PTW ABS) for the United States on accidents w/ casualties involving powered two wheeler.

Method: Analysis is based on a transfer of results out of a study from GER using GIDAS (2001-2004) database to US using GES (2009) data-base. 216 accidents w/ casualties involving powered two wheeler were reclassified according to the GES accident type. After that the share of ABS relevance was recalculated on the GES data. The ABS accident avoidance potential was also shared for the avoided accidents on the GES data.

Result: 60% of all accidents w/ casualties involving powered two wheeler are relevant for a PTW ABS. 36% out of this are accidents where the powered two wheeler went off the road or hits an object followed by a share of 19% collide against another vehicle. The accident avoidance potential for a PTW ABS in the US is estimated to 35%.

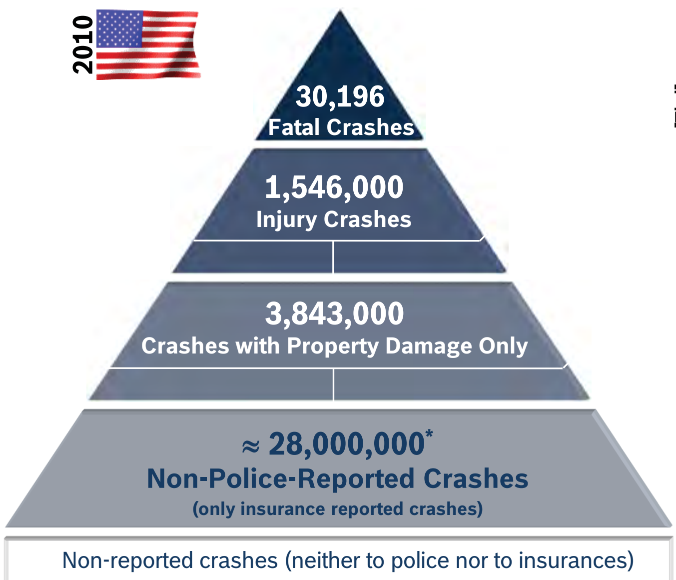
BOSCH

Fatalities in road traffic 2009 – share of vulnerable road users (VRU)



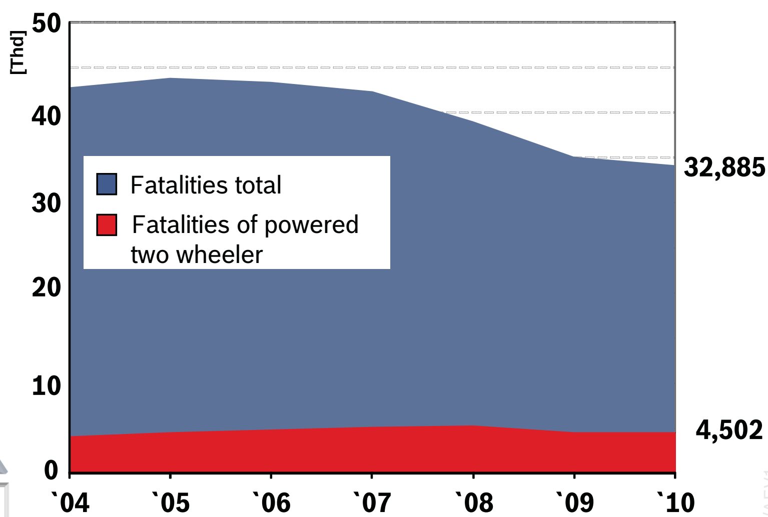
Sources:
1) Transport Canada 2009
2) Ministry of Road Transport and Highways, Government of India 2009
3) Ministério das Cidades, Departamento Nacional de Trânsito Brasilia 2008
4) IRTAD 2009 (data available for A, CZ, DE, DK, ES, FI, FR, HU, IE, IT, NL, SI, SE, UK, LUX, USA, J, AUS, S-KOREA)
5) Traffic Accidents China, Official yearbook 2009
6) Royal Thai Police, Traffic Accident National Highways 2005, extrapolated data (biased) based on 2005, known numbers from 2006: 12 691 fatalities

Accident situation in US in 2010



sources: Traffic safety Facts 2010, US
*Economic impact of Motor vehicle crashes 2000, DOT HS 809 446

Share of fatal injured powered two wheeler in US

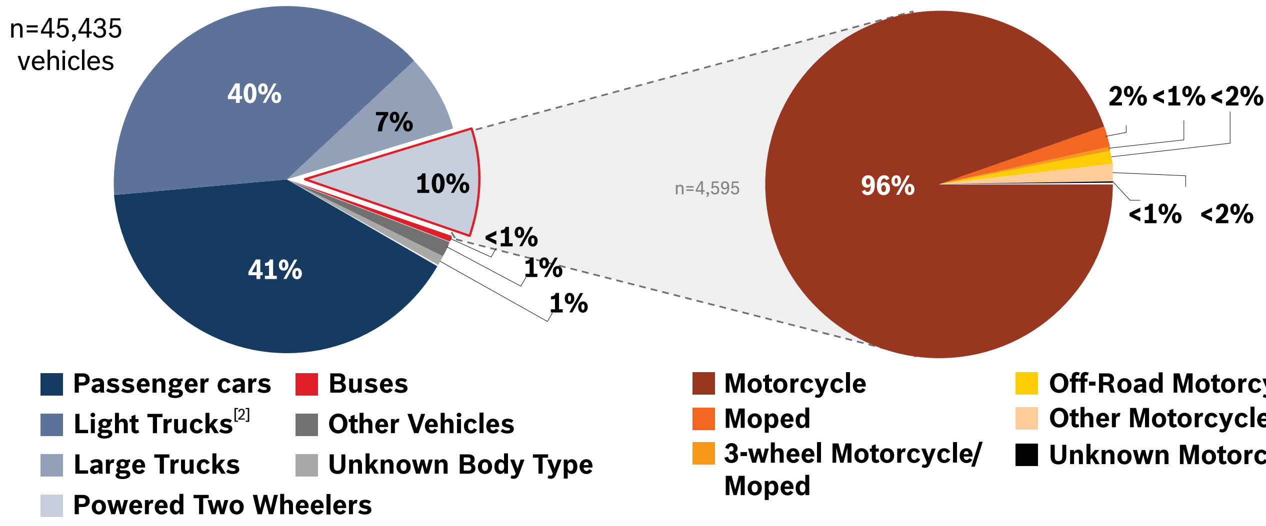


sources: Traffic Safety Facts 2010, US

- ➔ approx. 33 million reported crashes in US
- ➔ 14% of all fatalities in US are riders of powered two wheeler[1]

[1] Powered two wheeler:= motorcycles and mopeds

Vehicles involved in fatal crashes by body type



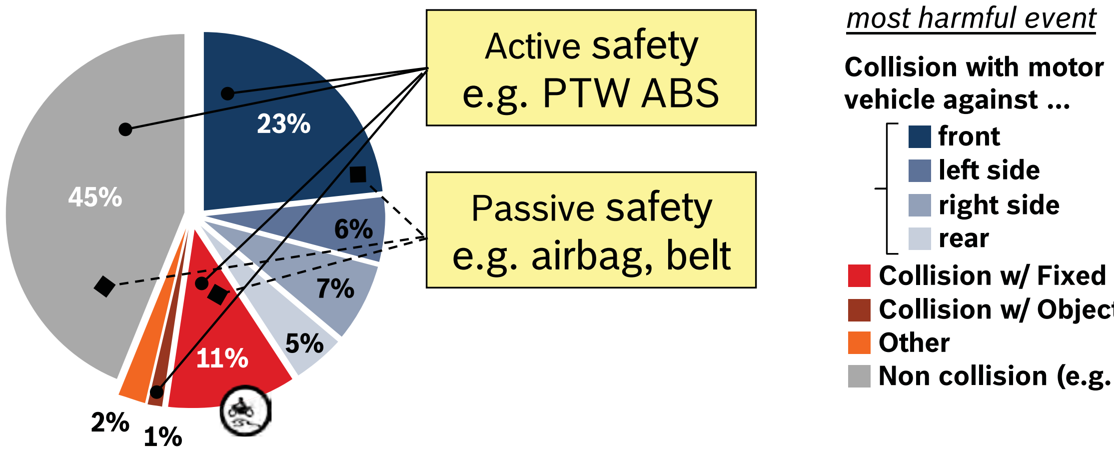
- Approx. 257 million vehicles are registered in US (2008), out of this of 3% are PTW[1]
- A share of 0.02% are involved in fatal crashes
- 10% of all vehicles involved in fatal crashes are powered two wheelers
- Out of this a share of 96% is a motorcycle

→ About ~3% of all registered vehicles in US are powered two wheelers.
→ Safety technologies for powered two wheelers should be considered in the US.

[1] Powered two wheeler:= motorcycles and mopeds
sources: Traffic Safety Facts 2009, US
[2] Light Trucks:= includes pickups, van, utility vehicles, tractors – gross weight rating of less or equal than 10,000 pounds (~4,54t)

Scope of safety technologies for PTW[1]

powered two wheelers involved in crashes w/ casualties by most harmful event
n=88,595



→ Safety technologies for powered two wheelers should be considered either active safety e.g. PTW ABS or passive safety systems e.g. airbag, belt.

[1] Powered two wheeler:= motorcycles and mopeds
sources: Traffic Safety Facts 2009, US

Motorcycle ABS: Effect and Benefit Studies

Bosch, 2007
- ABS field of effect (GER): 60%
  of all powered two-wheeler accidents involving injuries and fatalities
- Reduction of accidents with injuries and fatalities -26%
  (14.000 p.a., incl. < 250cc, base GER 2004)
- Reduction in collision speed -31%

BASt (Federal Highway Research Institute), 2008
- ABS effectiveness[3] (incl. < 250cc) in accidents with downfall only:
  Accidents -2.4%
  Fatalities -12.1%
  Serious injuries -11.7%

TRL (Transport Research Laboratory), 2009
- Cost/benefit ratio for accident avoidance[6] 1€ : 4,2 to 5,6€
- Avoided/mitigated fatalities between 2011-2021[5] Up to 5,999

Continental / DEKRA, 2009
- Reduction of accidents involving severe and fatal injuries (> 125cc):
  ABS only front wheel braked -23%
  ABS front wheel braked, rear wheel braked delayed -33%
  ABS both wheels braked simultaneously -53%

Vägverket[3,4] **(Swedish Road Administration)**, 2009
- ABS effectiveness (> 125cc):
  Fatal crashes -30%
  All accidents with personal injuries -38%
  On severe and fatal accidents -48%
  On severe and fatal accidents at intersections at least -42%

Allianz (AZT), 2005
- ABS field of effect (GER): 50%
  of severe accidents involving all PTW[2] (>250cc)
- Reduction of severe accidents with injuries and fatalities between -8% to -17%
- ABS effectiveness for fatalities -10%

NHTSA (National Highway Traffic Safety Administration), 2006
Stopping distance reduction
- Average (dry+wet surface) -5%
- Loaded bike (dry) -7%
- Rear foot pedal (dry) -17%
- Both brakes (wet) -11%
- Loaded, both brakes (wet) -16%

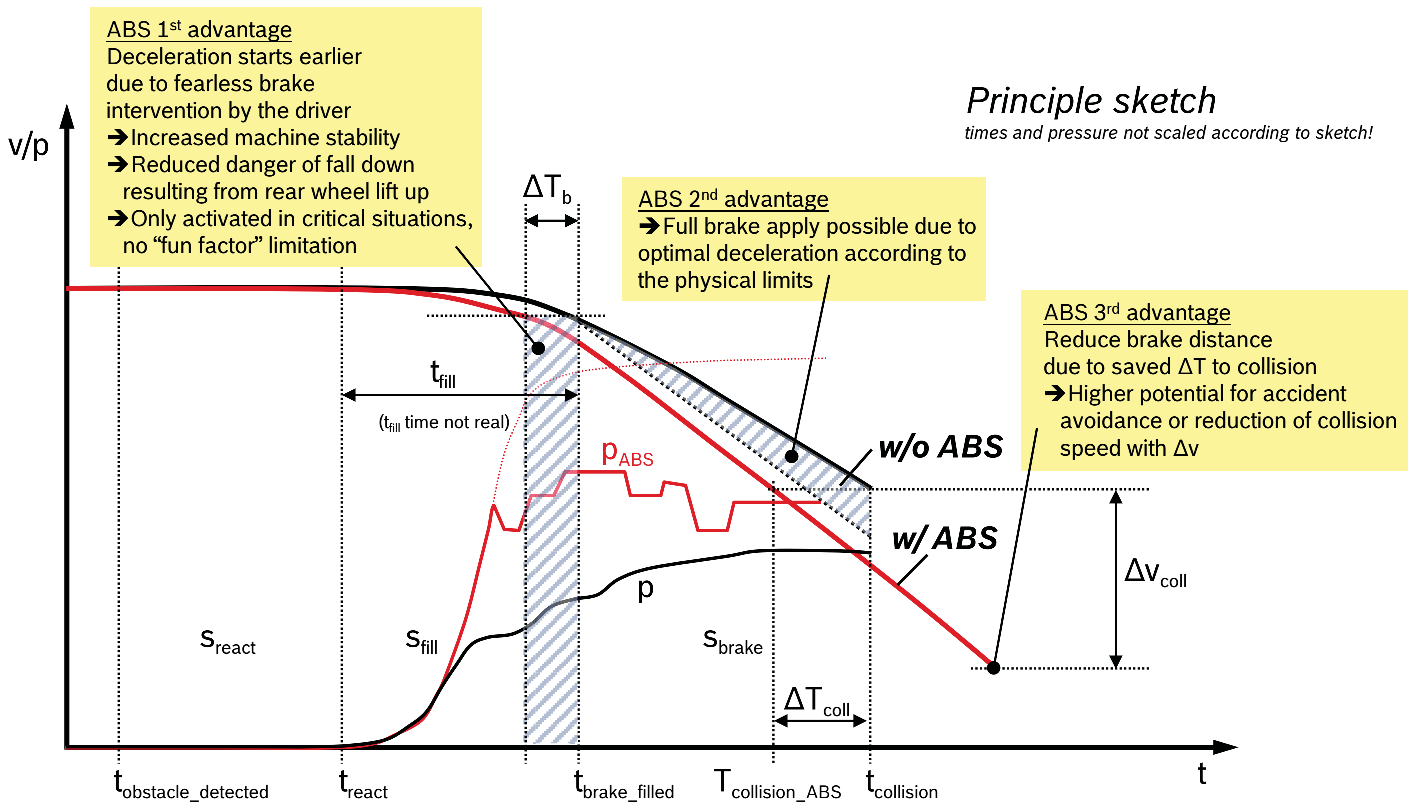
HLDI (Highway Loss Data Institute), 2009
- Reduction of claim frequency -22%
  for motorcycles equipped with ABS

IIHS (Insurance Institute for Highway Safety), 2011
- ABS effectiveness[1] (>250 cc): -37%
  of fatal crash involvement of ABS equipped motorcycles compared to non equipped ABS motorcycles

Studies are based on different approaches and databases

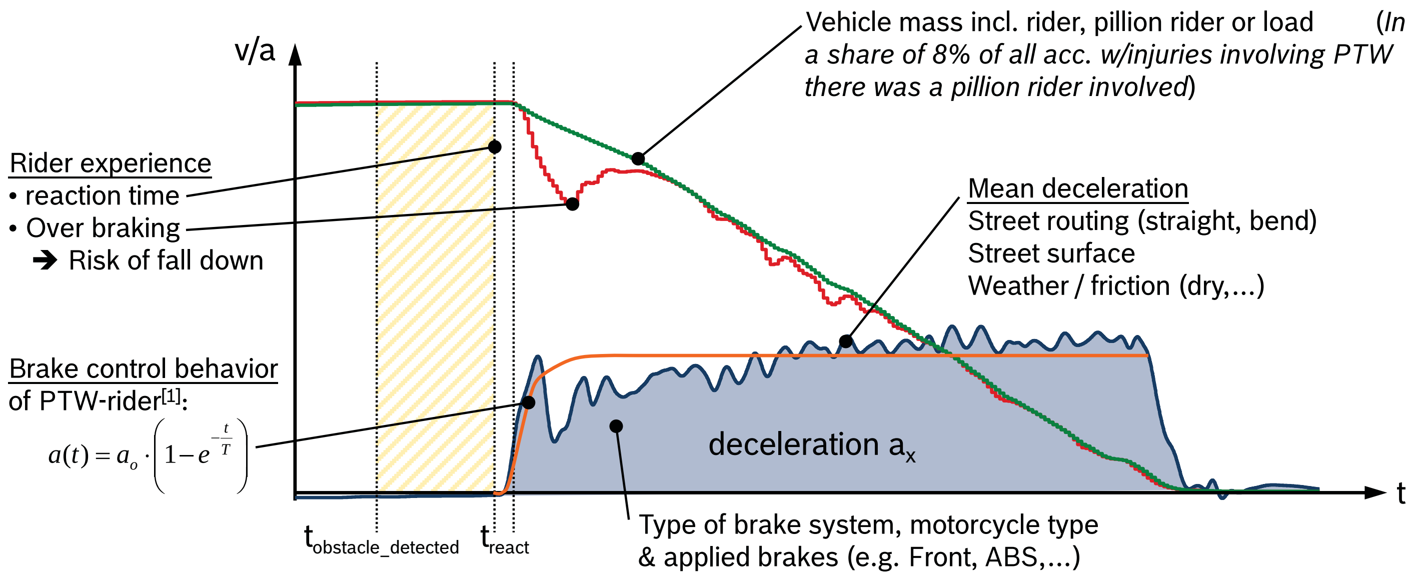
1) Statistical data given by HLDI, effectiveness supported by IIHS study based on minor sample size and per 10,000 registered vehicles
2) Powered Two-Wheeler
3) Study doesn't consider potentials in reduced injury severity by ABS
4) Study in cooperation with Vectura
5) Mandatory ABS on newly registered motorcycles >50cc, Long term 2011-2021, underlying 18% ABS effectiveness
6) Mandatory ABS on newly registered motorcycles >50cc, Long term 2011-2021, compared to "do nothing" scenario

Motorcycle Anti-lock braking system (ABS)-Background



PTW ABS benefit analysis method – Overview I/II

➔ Total achieved deceleration of a powered two-wheeler depends on different parameters:



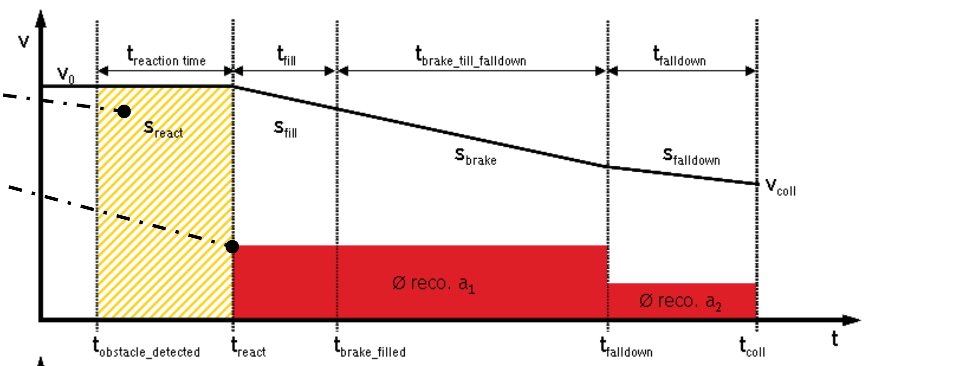
➔ Considered parameters in the study: motorcycle type, street rooting, surface & friction, fall-down, vehicle mass.

[1] Model of deceleration behavior according to "Unfallrekonstruktion 2", Hrgsgb. W. Hugemann
a_0:=Max. deceleration, t:=time since brake intervention; T:=Time to reach deceleration level; typ.values: 0,15s 0,3s (rider experience)

PTW ABS benefit analysis method – Overview II/II

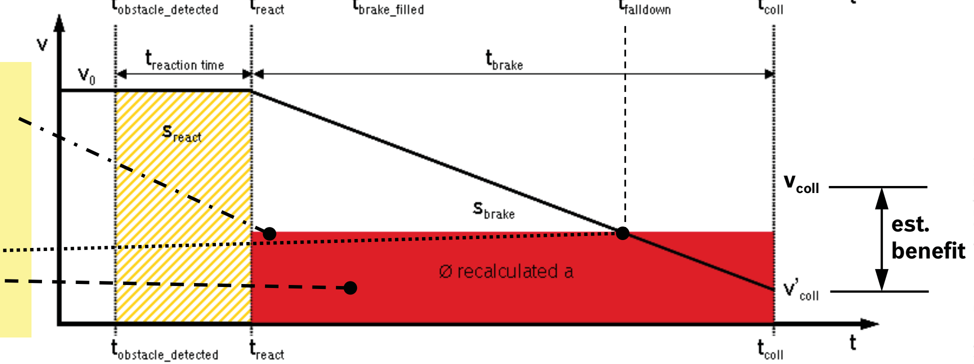
Reconstruction in GIDAS

- Driver reaction time not included in reconstructed distance
- Brake system fill time included in reconstructed distance



Conditions used for PTW ABS study

- Max. of achievable mean deceleration depending on type of PTW
- Street conditions taken into account
- No fall down due to ABS brake
- Street trajectory neglected, i.e. curve



Note: Driver reaction not considered in the recalculation of the new collision velocity in general

PTW ABS benefit analysis method - Formulas

- ➔ Approach by recalculation of new braking distance s’ and collision speed v'_{coll}.
- ➔ Calculation according to:

$$s' = \frac{v'^2_{coll} - v^2_0}{2 \cdot a'_{total}} \rightarrow \text{assuming } v'_{coll} = 0 \text{ for accident avoidance} \rightarrow s' = \frac{-v^2_0}{2 \cdot a'_{total}}$$

$$\rightarrow \Delta s = s_{reco1} - s'$$

$$\rightarrow \Delta s > 0 \text{ accident avoided } / \Delta s < 0 \text{ accident not avoided}$$

$$\rightarrow v'_{coll} = \sqrt{v_0^2 - 2 \cdot a'_{total} \cdot s_{total}}$$

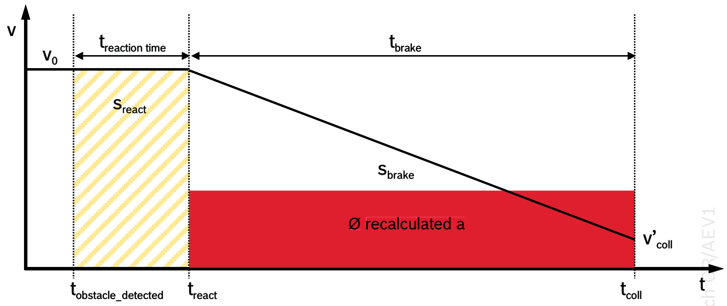
where as

$$a'_{total} = f(\mu, \text{street surface}) \cdot f(\text{PTW}_{type})$$

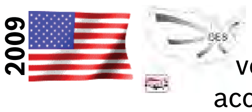
$$s'_{total} = \underbrace{s_{fill} + s_{brake}} + (s_{fall\,down}) = s_{reco_1} + (s_{fall\,down})$$

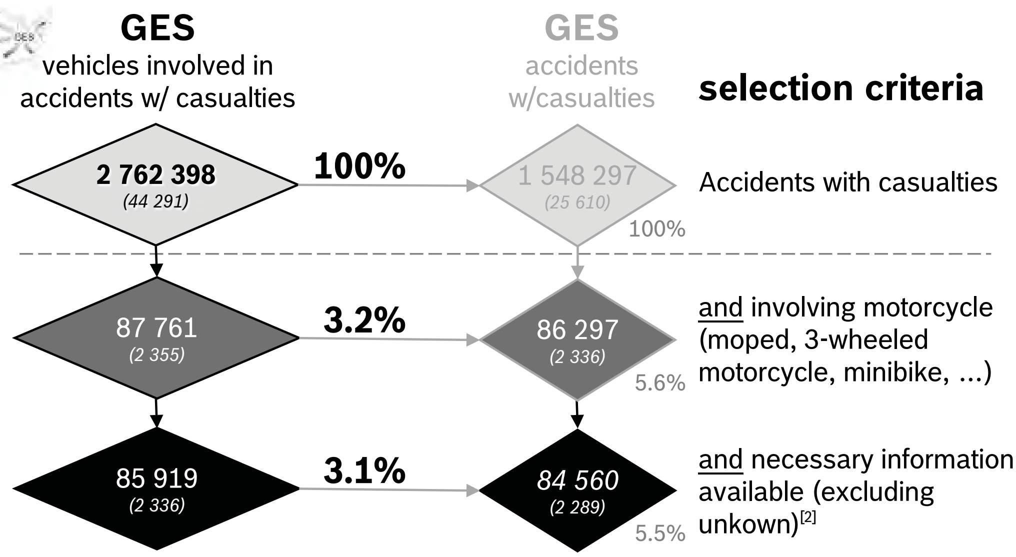
from accident reconstruction

$$v_o, v_{coll}, s_{reco1}, s_{fall\,down}, \mu, \text{street surface}, \text{PTW}_{type}$$



Representativeness GES 2009[1] for PTW study





- ➔ **GES database is representative for US concerning powered two wheeler involvement in accidents w/ casualties.**
- ➔ **About 5.6% of all accidents w/ casualties in the US a powered two wheeler is involved.**

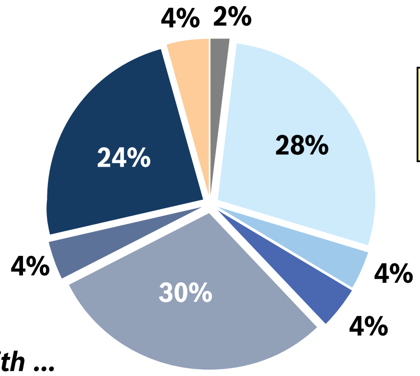
[1] General Estimates System, 2009; weighted data, absolute numbers in italics
[2] accident is excluded if necessary information for at least one vehicle is not available or unknown

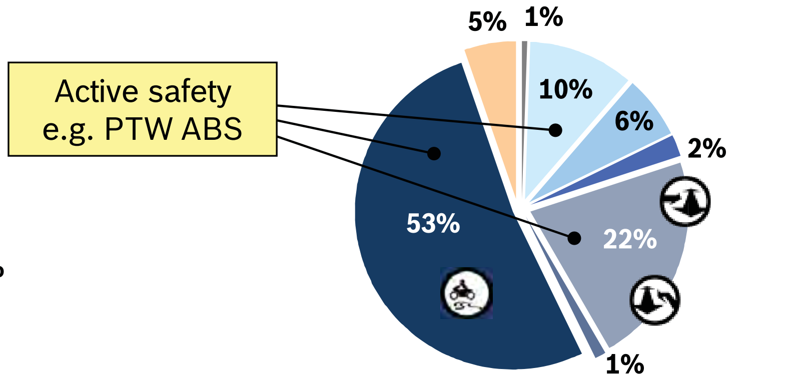
Accidents w/ casualties by kind of accident in US

2009

all accidents with casualties[1]
n = 1,548,297

accidents with casualties involving motorcycles[1,2]
n = 86,297 *(2 336)*





collision with …

- **parked vehicle**
- **vehicle moving ahead or waiting**
- **vehicle moving laterally in same direction**
- **oncoming vehicle**
- **vehicle which turns into or crosses a road**
- **pedestrian**
- **fixed Object or vehicle leaving carriageway**
- **Accident of another kind** (unknown, not fixed object, animal …)

→ **Half of all accidents in the US involving motorcycles are motorcycles leave carriageway or collides with a fixed object.**

[1] Vehicle to Bicycle - accidents in category „Others" sources: Traffic Safety Facts 2009, US, GES 2009, FARS 2009

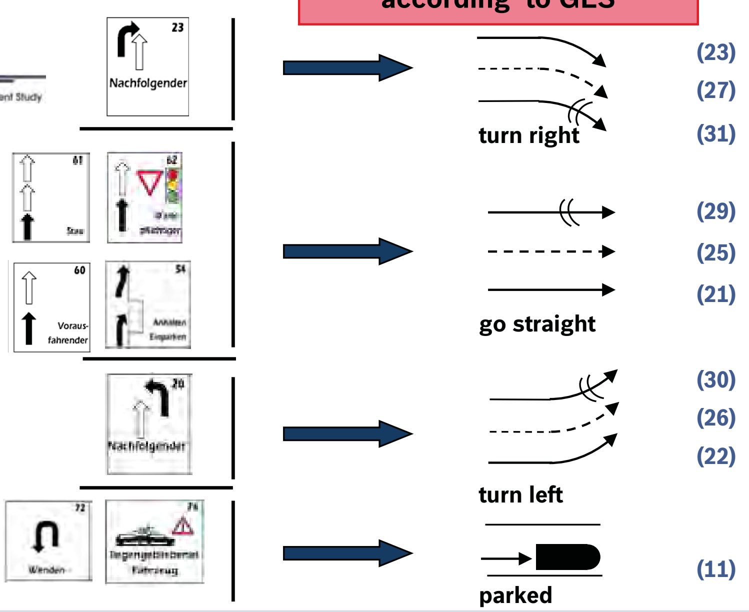
[2] Vehicle to Bicycle - accidents in category „Others" sources: General Estimates System, 2009; weighted data absolute numbers in italics

New accident variable defined: TYPE_ACC

Year 2001-04
GIDAS German In-Depth Accident Study

In GIDAS, an accident is described by one variable (UTYP)

Recoding to new TYPE_ACC according to GES



New variable TYPE_ACC

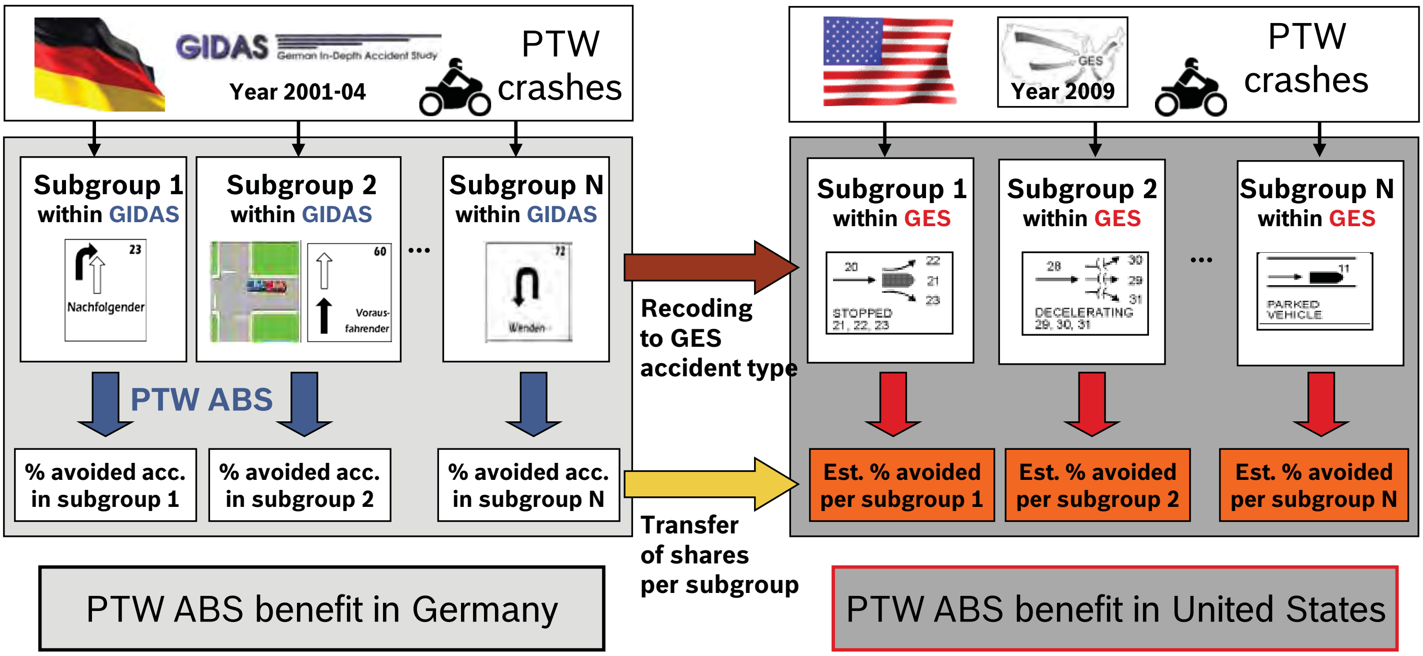
Separate UTYP into:

- **decelerating**
- **slower**
- **stopped**

according to further data from GIDAS

→ **Recoding of accidents from GIDAS to accident type according to GES.**
→ **Results of study for PTW ABS afterwards transferable from GER to US.**
→ **Estimating field of effect and benefit for PTW ABS possible.**

Mapping of PTW ABS benefit from Germany to US



→ **Premise:** **Assuming same prevention potential for same accident type.**

→ **Transfer of results from Germany to United States via comparison of accident type.**

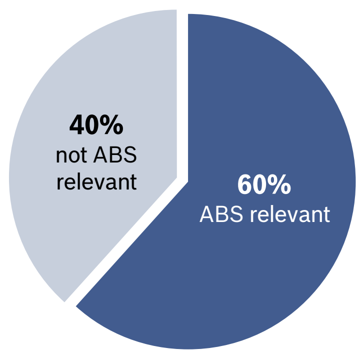
Transferred field of effect for PTW-ABS[1]

→ **Field of effect (ff. FoE)**: Accidents whereas PTW-ABS intervention would avoid or mitigate the accident by fall-down prevention

→ **Relevant accident configuration:**
- No maximum deceleration of PTW
- Blocked rear wheel
- Fall-down due to over braking of either front- or rear wheel
- Motorcycle rider forced fall-down

→ **Relevant parameter for ABS effectiveness:**
- Street characteristics considered (e.g. low or high-mu)
- PTW-type considered in brake performance (brake system)

→ **Approach:**
- Comparison of real accident against full ABS-braked PTW under ideal conditions and course stable trajectory



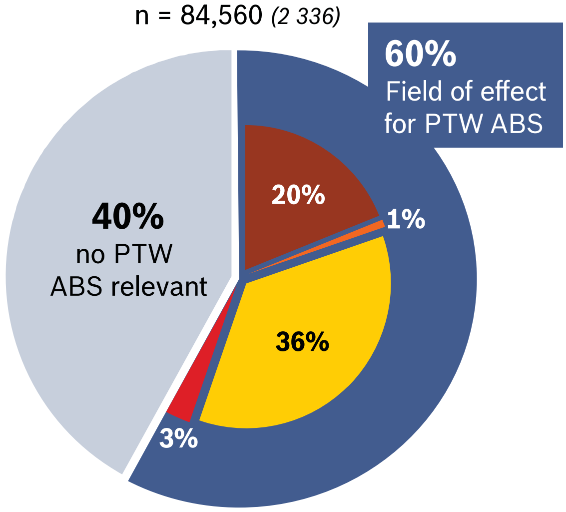
Estimated field of effect on 84,560 representative accidents (2,336 total) involving PTW in US using study results from German analysis[1]

→ **It is estimated that in a share of ~60% of all PTW accidents w/ casualties in US an ABS intervention would have been influenced the accident positively!**

[1] Source: GES database 2009 and GIDAS database (2001-2009) Analysis based on transferred results from 216 representing accidents in Germany (total 232 GIDAS accidents) to 84560 representative accidents in US (total 2289 GES accidents); total number in brackets

Transferred field of effect for PTW-ABS[1]

Field of effect for PTW ABS on accidents w/ casualties involving motorcycles in US
n = 84,560 *(2 336)*



PTW ABS relevant accidents involving motorcycles by main categories:
- **Vehicle - Vehicle**
- **Vehicle - Pedestrian**
- **Vehicle - fixed Object (Rollover, off road)**
- **Others (Object on road, animal…)**

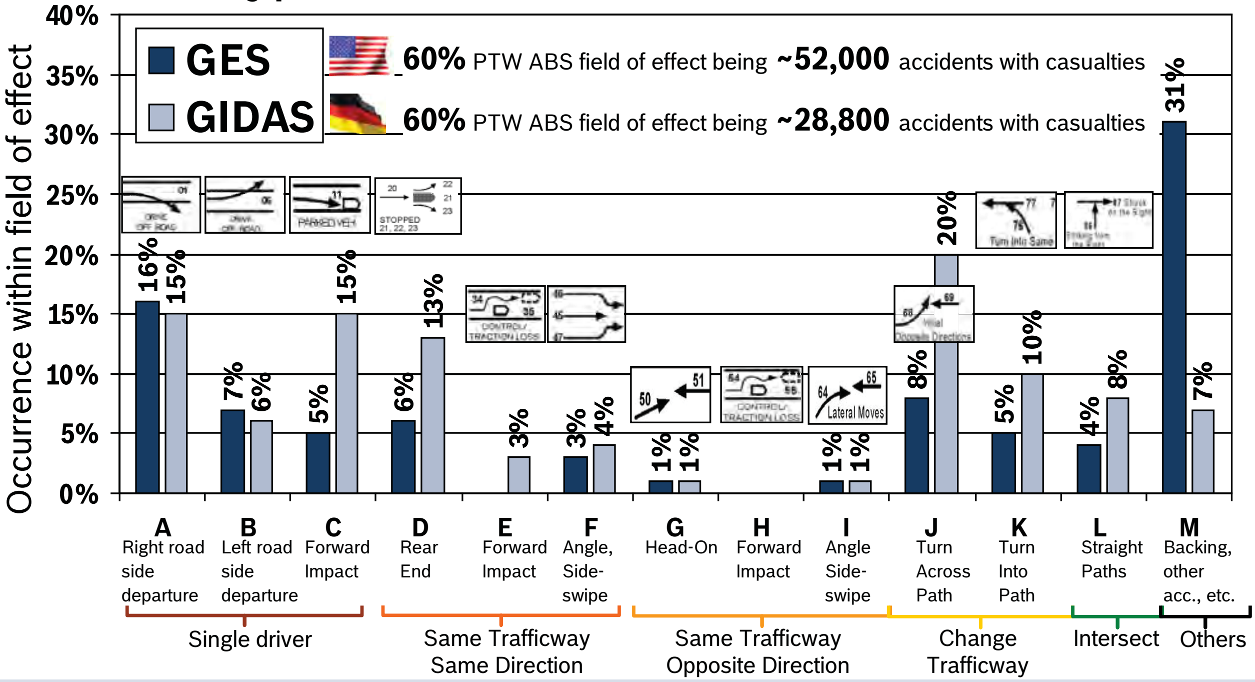
- **Non PTW ABS relevant accidents**

Estimated field of effect on 84,560 representative accidents (2,336 total) involving PTW in US using study results from German analysis[1]

→ **Field of effect a PTW ABS in the US is estimated to ~60% of all accident w/ casualties involving a PTW.**
→ **In 36% the motorcycle collide against a fixed object or went off the carriageway.**

[1] Source: GES database 2009 and GIDAS database (2001-2009) Analysis based on transferred results from 216 representing accidents in Germany (total 232 GIDAS accidents) to 84560 representative accidents in US (total 2289 GES accidents); total number in brackets

Accident types in the field of effect for PTW ABS[1]

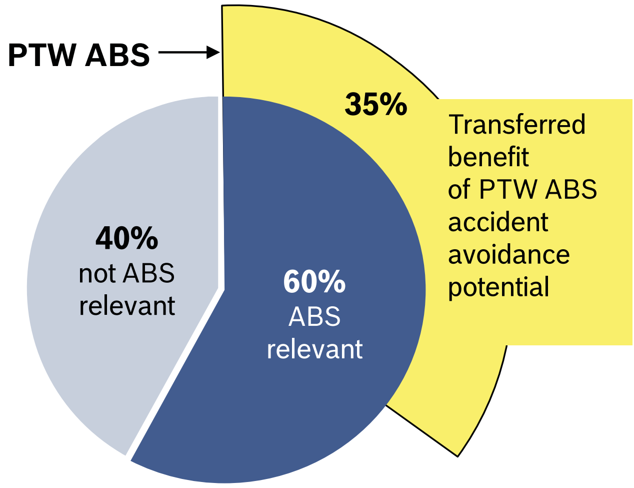


→ **In the majority of all categories similar distribution is see except J and M.**
→ **Accidents classified in M are mainly single vehicle accidents w/ rollover and PTW ABS relevant accidents due to braking maneuver prior to a rollover or fall-down.**

[1] Source: GES database 2009 and GIDAS database (2001-2009) Analysis based on transferred results from 220 representing accidents in Germany (total 232 GIDAS accidents) to 86297 representative accidents in US (total 2336 GES accidents)

Transferred benefit for PTW-ABS in the US[1]

Estimated benefit within field of effect for PTW ABS on accidents w/ casualties involving motorcycles in US
n = 84,560 *(2 336)*



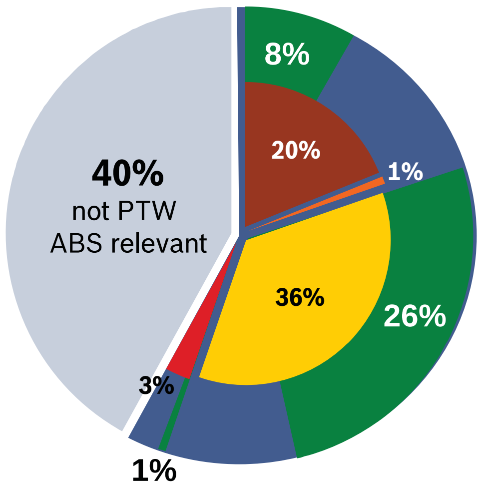
- **Transferred field of effect for PTW ABS[1]:** A share of 60% of all accidents with injuries involving PTW could be addressed by a PTW ABS in the US.
- **Estimated benefit for a PTW ABS in the US[1]:** It is estimated that a share of 35% of all accidents with injuries involving PTW could have been avoided by a ABS in the US. The avoidance potential for a PTW ABS was transferred from GER to US by using results out of the benefit study for PTW ABS (see page 14/15).

Estimated field of effect and benefit on 84,560 representative accidents (2,336 total) involving PTW in US using study results from German analysis[1]

[1] Source: GES database 2009 and GIDAS database (2001-2009) Analysis based on transferred results from 216 representing accidents in Germany (total 232 GIDAS accidents) to 84560 representative accidents in US (total 2289 GES accidents); total number in brackets

Transferred benefit for PTW-ABS in the US[1]

Estimated benefit within field of effect for PTW ABS on accidents w/ casualties involving motorcycles in US
n = 84,560 *(2 336)*



60%
Transferred field of effect for PTW ABS

35%
Transferred benefit of PTW ABS accident avoidance potential

PTW ABS relevant accidents involving motorcycles by main categories:
- **Vehicle - Vehicle**
- **Vehicle - Pedestrian**
- **Vehicle - fixed Object (Rollover, off road)**
- **Others (Object on road, animal…)**
- **Non PTW ABS relevant accidents**

Estimated field of effect and benefit on 84,560 representative accidents (2,336 total) involving PTW in US using study results from German analysis[1]

- **It is estimated that a share of 35% of all accidents w/ casualties involving. motorcycles in the US would have been avoided by a PTW ABS.**
- **The highest avoidance potential is seen in PTW accidents against fixed objects.**

[1] Source: GES database 2009 and GIDAS database (2001-2009) Analysis based on transferred results from 216 representing accidents in Germany (total 232 GIDAS accidents) to 84560 representative accidents in US (total 2289 GES accidents); total number in brackets

Summary

- About ~3% of all registered vehicles are powered two wheelers
- 4502 fatalities are motorcyclists, this is a share of 14% within all fatalities in US, thereof 4,198 are rider and 304 are pillion rider of the PTW[1]
- 90,000 motorcyclists injured in PTW crashes, this is a share of 4% within all injured in US[1]
- In half of all accidents involving PTW, the PTW leaves carriageway or collide with a fixed object
- Study based on the transfer of benefit estimation results from Germany to US
- Field of effect for PTW ABS in US is estimated with 60%
- In sum the distribution about the accident types is similar for GER and US
- Accident avoidance potential for PTW ABS is estimated to 35% within all accidents w/ casualties involving PTW

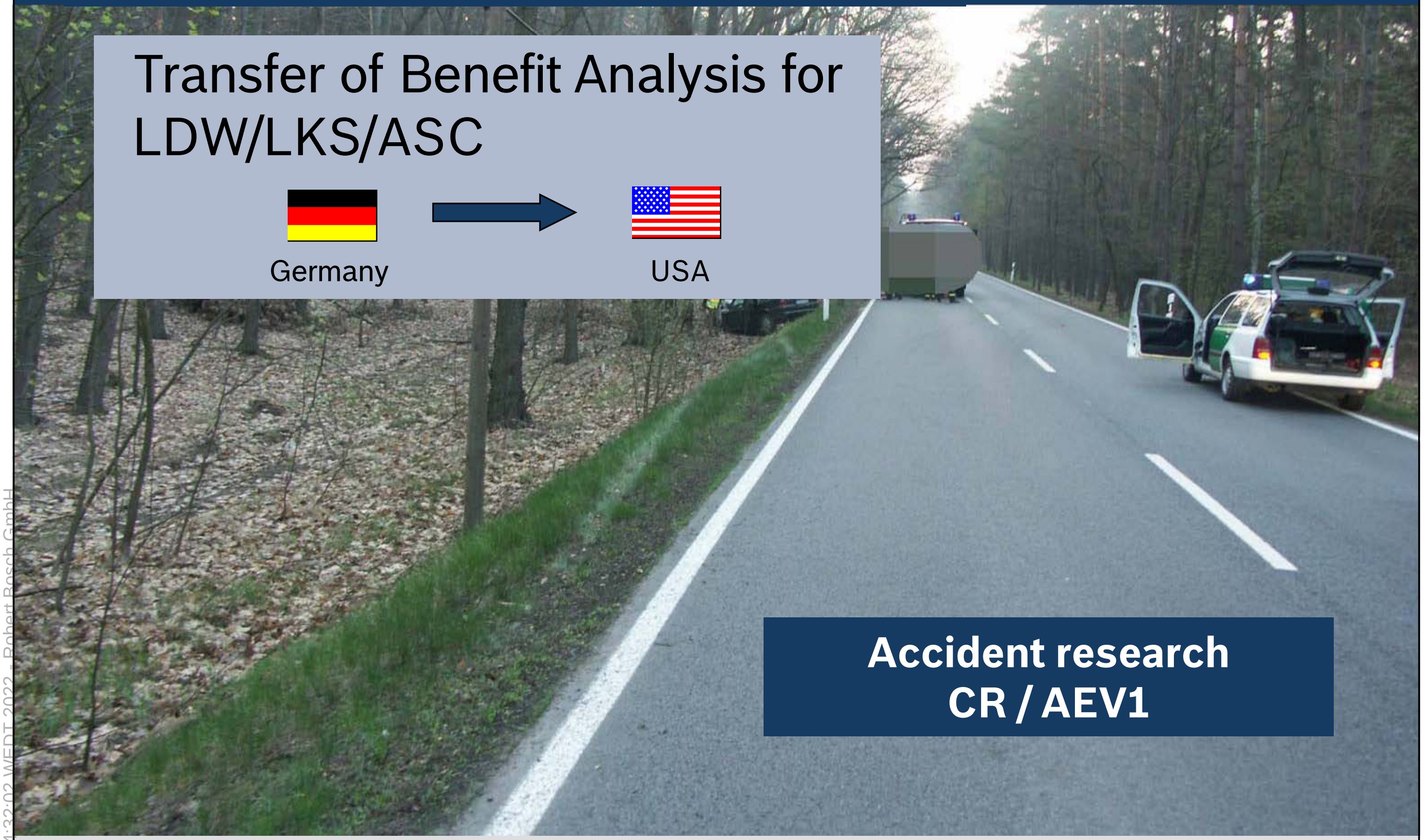
Conclusion:

- **High accident avoidance potential for PTW ABS in the US !**
- **Safety technologies for PTW should be considered in future.**

[1] Traffic safety Facts 2010, US *Economic impact of Motor vehicle crashes 2000, DOT HS 809 446

Transfer of Benefit Analysis for LDW/LKS/ASC

Germany → USA



Accident research
CR / AEV1

BOSCH

Transfer of benefit analysis LDW/LKS/AC GER to US

Aim of this study: Reevaluation of three systems for the prevention of unintended lane departure, taking into account different accident situations in Germany and USA
(i.e. automatic lane keeping by ASC and further small modifications)

Method: Analysis of accidents with casualties in Germany and USA to determine the field of effect. Transfer the method (same parameter) from German Database GIDAS[1] to US Database GES[2] Using the results from a previous study for determine the system efficiency in Germany and transfer to USA.

Results: The share of lane departure accidents within all casualty accidents of cars, trucks and busses is similar in Germany and the United States. The field of effect[3] for LDW/LKS/ASC is in summary only slightly larger in the USA (6%) as compared to Germany (5%).

1) Source: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties.
2) USA: NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties
3) Accidents with casualties

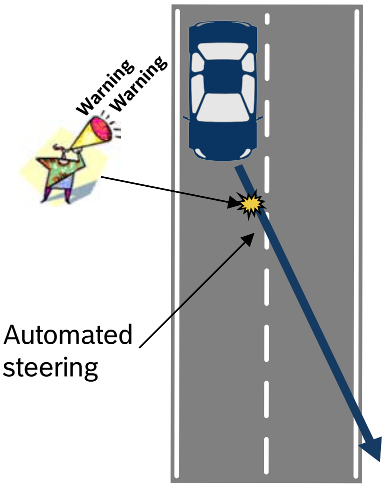
BOSCH

Introduction

Reevaluation of three systems for the prevention of unintended lane departure, taking into account different accident situations in Germany and USA
(i.e. automatic lane keeping by ASC and further small modifications)

LDW – lane departure warning
Warning the driver about 0.2 sec before lane crossing, the driver needs to adjust the vehicle's trajectory

ASC - automatic steering control
LKS - lane keeping system
Keeping the vehicle on the driving lane without driver interaction



Analysis mandated by CC, where LDW, ASC and LKS systems are currently under development

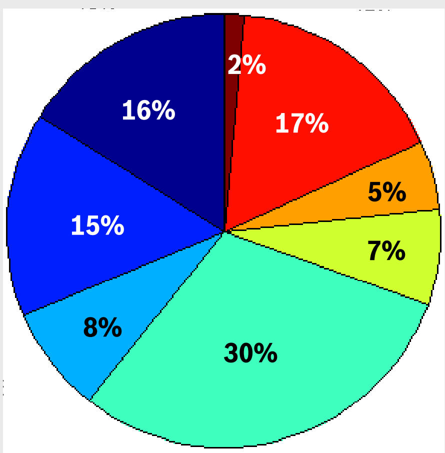
Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

BOSCH

Germany
data sample: GIDAS (2001-06)

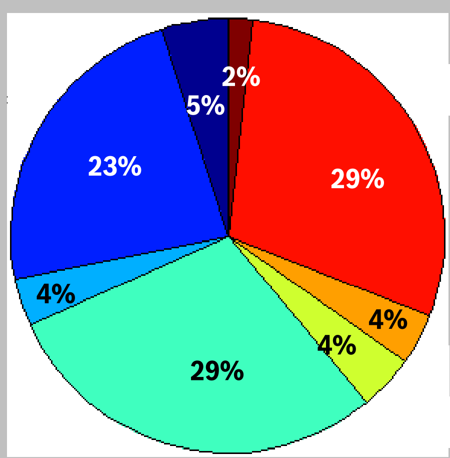
USA
data sample: GES (2009)

310'806 — 2009 Accidents with casualties — 1'540'300



n = 8'060

Collision with ...
- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)



n = 25'610

Transition to road users
(several road users per accident)

Transition to road users
(several road users per accident)

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

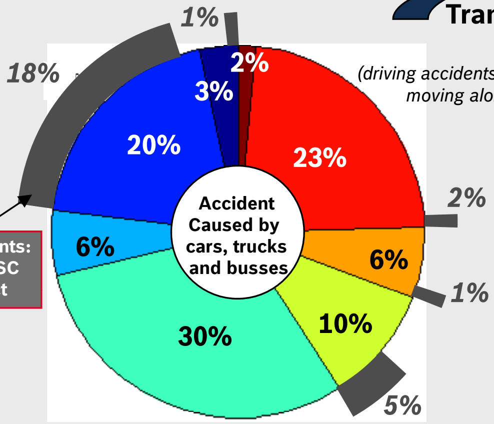
BOSCH

Transfer of benefit analysis LDW/LKS/AC GER to US

Germany		USA
Transition to road users (several road users per accident)		Transition to road users (several road users per accident)
times 1.8 i.e. on average 1.8 road users per accident)		times 1.8 i.e. on average 1.8 road users per accident)
558'101	Road users in accidents	2'762'400
77% of upper level: 428'534	Cars, trucks and busses in accidents	2'665'600: 96% of upper level
58% of upper level: 249'956	Cars, trucks and busses causing an accidents	1'473'400: 55% of upper level

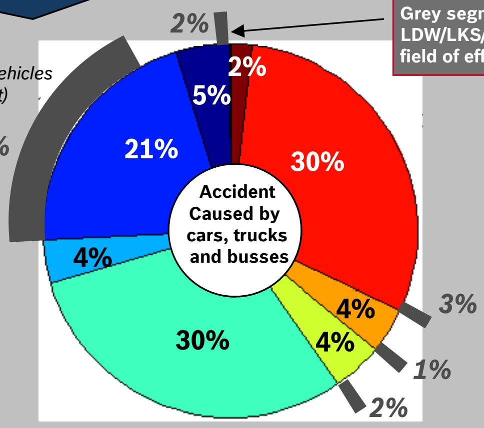
Transfer of lane departure related accidents

(driving accidents, some types from accidents between vehicles moving along in carriageway or from other accident)



Collision with ...

- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)



n = 6'492 | n = 23'338

27% of upper level: 67'488 | 397'818: 27% of upper level

Driver behavior principal cause | Driver behavior principal cause

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

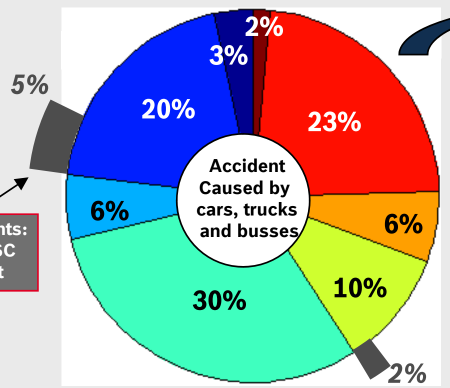
BOSCH

Transfer of benefit analysis LDW/LKS/ASC GER to US

Transfer of benefit analysis LDW/LKS/AC GER to US

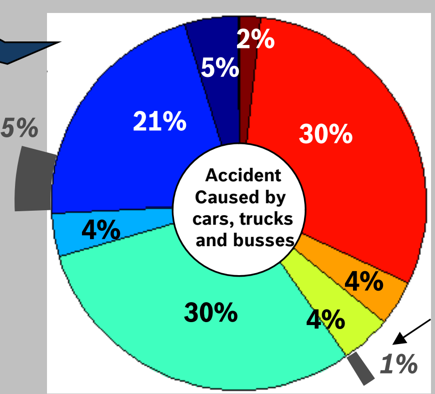
Germany		USA
98% of upper level: 66'274	Driver behavior / characteristic is principal accident cause *(ex. exclude vehicle damages)*	No selection within GES (only in part possible with GES)
28% of upper level: 18'594	Exclude driving errors *(ex. speeding, ignoring safety distance, ignoring right of way)*	
99% of upper level: 18'320	Only forward moving vehicles	
97% of upper level: 17'733	Road surface not covered by snow or ice	
94% of upper level: 16'754	Keep only vehicles with clear lane departure	88'404

Transfer of lane departure related accidents



Collision with ...

- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)



n = 6'492 | n = 23'338

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

BOSCH

Transfer of benefit analysis LDW/LKS/AC GER to US

Chapter 10

Germany
data sample: GIDAS (2001-06)

USA
data sample: GES (2009)

2009
Accidents with casualties

	Germany		USA
Accidents with casualties (2009)	**310'806**		**1'540'300**
Field of effect	**16'754**		**88'404**
Percentage of all accidents with casualties addressed by LDW/LKS/ASC	5%		6%
Transfer of system efficiency	**LKS/ASC** can prevent about 26% of these cases	→	**LKS/ASC** can prevent about 26% of these cases
Accidents with casualties preventable by LKS/ASC	**4'351**		**22'958**
Percentage preventable of all accidents with casualties	1.4%		1.5%

- Lane departure not intended, no driving errors, no other external reasons
- Take into account street conditions needed for system functioning

- **LKS / ASC could prevent about 1.4% of all accidents with casualties in Germany and 1.5% in the USA**

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

Transfer of benefit analysis LDW/LKS/AC GER to US

Chapter 10

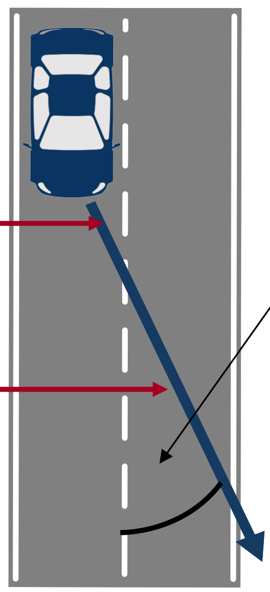
Evaluation of LDW efficiency in Germany – Procedure

A warning is issued when the vehicle is about to cross the white line within 0.2 s and is at a distance below 0.4 m to the white line

1)

If, at the end of the driver reaction time, the vehicle is still on paved subsoil, the case is counted as prevented, else as not prevented

2)



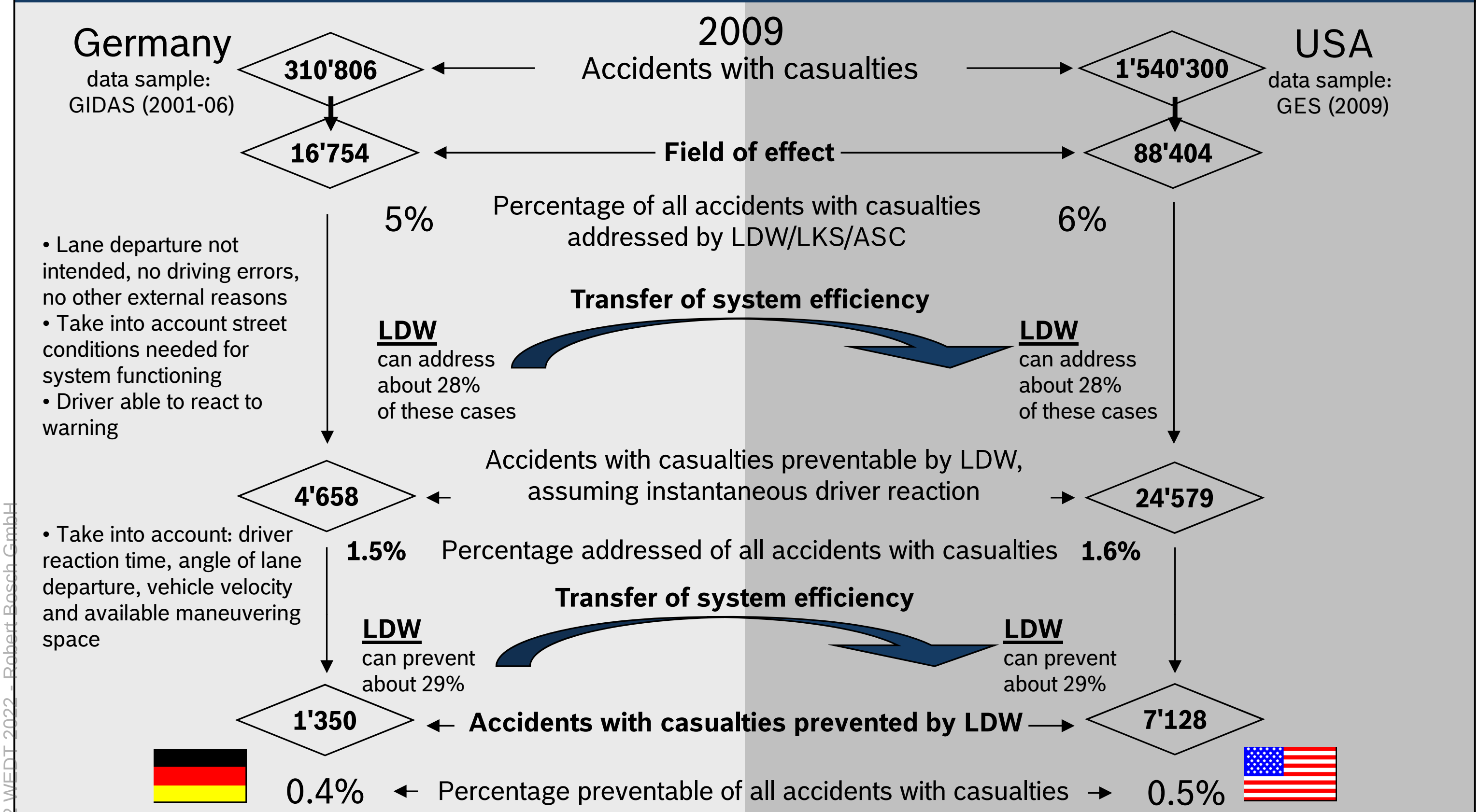
Angle of carriageway departure [deg]

This evaluation was only performed for accidents which have occurred on a straight road

Each accident was evaluated several times, assuming for each evaluation a fixed driver reaction time and a fixed angle of carriageway departure. The total ratio of accidents preventable by LDW was then calculated by weighting the result of this single evaluation with the relative occurrence of the used reaction time and used angle of carriageway departure.

Transfer of benefit analysis LDW/LKS/AC GER to US

Chapter 10



• **LDW could prevent about 0.4% of all accidents with casualties in Germany and 0.5% in the USA**

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

Transfer of benefit analysis LDW/LKS/AC GER to US

Chapter 10

Summary

	Germany 2009		USA 2009	
Accidents with casualties	310'806	100%	1'540'300	100%
Field of effect LDW / LKS / ASC	16'754	5%	88'404	6%
Accidents prevented by LKS / ASC	4'351	1.4%	22'958	1.5%
Accidents prevented by LDW	1'350	0.4%	7'128	0.5%

Prevention of lane departure might not necessarily prevent the accident, for example in the case of an obstacle on the driving lane

- **The share of lane departure accidents within all casualty accidents of cars, trucks and busses is similar in Germany and the United States**
- **The field of effect for LDW/LKS/ASC is in summary only slightly larger in the USA as compared to Germany**

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310‘806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

Transfer of benefit analysis LDW/LKS/AC GER to US

	Germany 2009 casualty accidents		USA 2009 casualty accidents		USA 2002-06 yearly average casualty and property damage accidents	
Traffic accidents	310'806	100%	1'54[illegible]	100%	6'107'000	100%
Field of effect LDW	16'754	5%	88'404	6%	241'000 p. 45ff	3.9%
Accidents prevented by LDW	1'350	0.4%	7'128	0.5%	57'000 p. 150	1%
	(results this work)		(results this work)		(Gordon T et al*, DOT HS 811 405 2010)	

Transfer of benefit analysis LDW/LKS/AC GER to US

Prevention of lane departure might not necessarily prevent the accident, for example in the case of an obstacle on the driving lane

• Results for LDW field of effect and efficiency in casualty accidents are similar to a recent study published by the US NHTSA, evaluating casualty and property damage accidents

*) Advanced crash avoidance technologies (ACAT) program, final report for the Volvo-Ford UMTRI project: Safety impact methodology for lane departure warning - Method development and estimation of benefits

Germany: GIDAS weighted, reconstructed accidents (2001-2006), n=8060 and Federal Statistical Office data for Germany (2009), 310'806 accidents with casualties. **USA:** NHTSA General estimates system 2009, n=25'610 of 1'540'300 accidents with casualties

BOSCH

Speed limiters for trucks (USA)

– Additional information for function development –

Accident research
CR / AEV1

BOSCH

Speed limiters for trucks - USA

Aim of this study: Providing information about the possible effect of using speed limiters for trucks in the USA.

Method: Literature research for facts and studies regarding the effect of using speed limiters for trucks in the USA.

Result:

- Approximately 65% of US truck fleets have activated speed limiters for their trucks since a couple of years.
- Speed limiters for trucks could become mandatory in the USA earliest in 2012.
- In the U.K., crash involvement rate for heavy trucks with speed limiter equipped fell about 26%.
- Australia noted a decrease in the number of collisions since introduction of mandatory speed limiters.

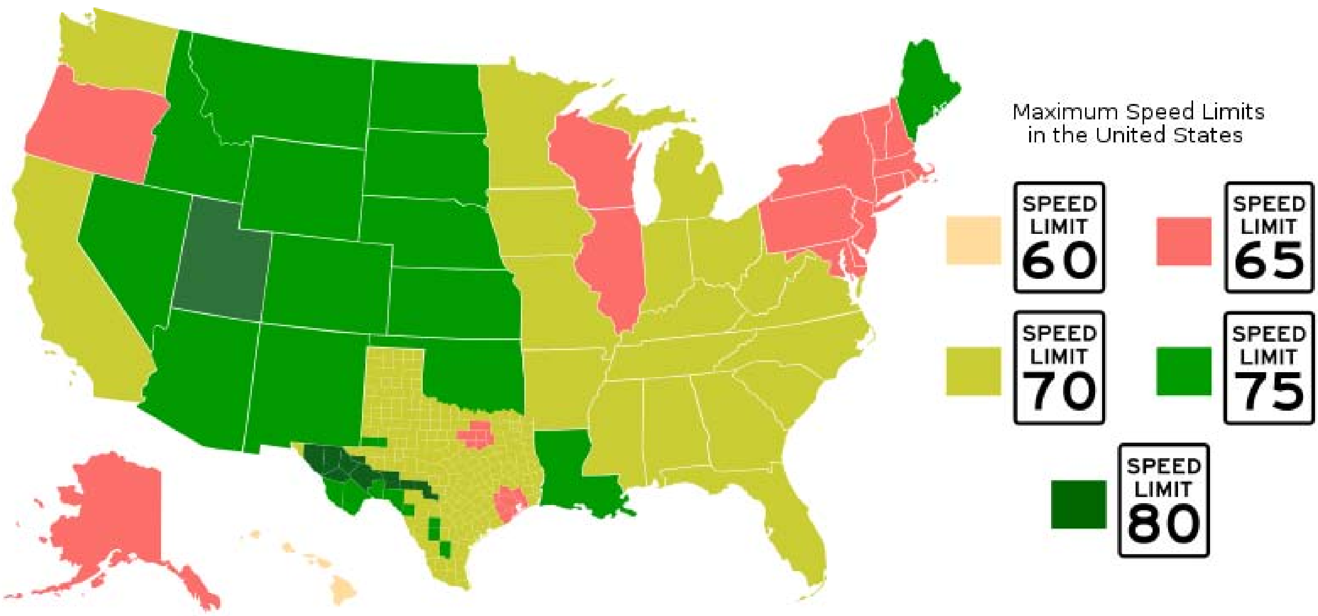
BOSCH

Content

- Speed limits by law - distinctions between the states
- Limitations of GES[1] data
- Facts & statistical data regarding truck accidents
- Facts from literature research – available data
- Facts from literature research – results from different studies
- The pros and cons of truck speed limiters
- Information about legal situation
- Current usage of speed limiters in North America
- Tampering of speed limiters

[1] GES: General Estimates System

Speed limits by law - distinctions between the states (1/4)



Source:
http://en.wikipedia.org/wiki/Speed_limits_in_the_United_States

Texas: A statute effective June 17, 2011, authorizes 85-mph speed limits in Texas, although the new law requires traffic and engineering studies before the higher limit takes effect.

Speed limits by law - distinctions between the states (2/4)

- There is no common speed limit for trucks in USA.
- Sometimes there are special truck speed limit signs.
- In most states there is no generic speed limit for trucks.
- If present, the most common generic speed limits for trucks on interstates are 55, 60 or 65mph.
  (e.g. Arkansas, California, Indiana, Michigan, Oregon, Tennessee)[1)]
- In some states there is a distinction between Interstates and non-Interstate freeways.
- In some states there is a lower speed limit at night *(e.g. Montana, Texas)*[1)].
- There were many changes in the law within the last years,
  e.g. "Texas formerly had a 60 mph ... day / 55 mph ... night truck speed limit. This speed limit did not apply to buses or to trucks transporting United States Postal Service mail. This was partly repealed in 1999 and fully repealed in 2011." [1)]

[1)] Source: http://en.wikipedia.org/wiki/Speed_limits_in_the_United_States

Speed limits by law - distinctions between the states (3/4)

State or territory	Freeway (rural)	Freeway (trucks)	Freeway (urban)	Divided (rural)	Undivided (rural)	County (rural)	Residential divided (urban)	Residential undivided (urban)	School zone
Alabama	70		60	65	55	35–45	25	25	15
Alaska	65		65	65	65	50	25		20
American Samoa	–	–	–	–	25–30	–		15	
Arizona	75		65	65	65	65	25		15
Arkansas	70	65	65	60–65	55				
California	70	55	55-65	65	55–65	55–65	25		25
Colorado	65-75		55–65	65	65	35–55	25–35		20–25
Connecticut	65		45-55	55	55	45	25-40		20
Delaware	65		50-55	55	50		25-35		20
Washington, D.C.	-	-	50	-	-	-	25		15
Florida	70		55-65	65	60	55-60	30		10-20
Georgia	70		55-65	65	55	-	30	25-45	
Guam	-	-	-	35-45	35-45	-			
Hawaii	55-60		50	45	45	45			
Idaho	75	65	65	65	65	50-65			20
Illinois	65		55-65	65	55	55	30		20
Indiana	70	65	50-65	60	55	55	20-30		20-25
Iowa	70		55-65	65	55	45	25		20
Kansas	75		65	65-70	65	55	30		20
Kentucky	70-75		50-55	55	55	55	25-35		25-45
Louisiana	70-75		60	65	55	45	25		20-45
Maine	65-75		55	55	55	50			
Maryland	65		55-65	55	50-55				15-25
Massachusetts	65		55	55	55		30		20
Michigan	70	60	55-70	55-65	55	55	25		25
Minnesota	70		45-60	55-65	55-60	55	30		
Mississippi	70		60-70	65	55		25		
Missouri	70		45-65	55-70	55-65	55	25		20

[1)] Source: http://en.wikipedia.org/wiki/Speed_limits_in_the_United_States

Speed limits by law - distinctions between the states (4/4)

State or territory	Freeway (rural)	Freeway (trucks)	Freeway (urban)	Divided (rural)	Undivided (rural)	County (rural)	Residential divided (urban)	Residential undivided (urban)	School zone
Montana	75	65	65	70	55-70	55-70	25		15
Nebraska	75		60	65	55-65	50-55	25		25
Nevada	75		60-65	65-70	55-70	55-70	25		15, 25
New Hampshire	65		55	55	55	35	30		20
New Jersey	65		55	55	45-55	30-50	25		15-35
New Mexico	75		65-75	65-70	55-65	25-55	25-30		15-20
New York	65		50-55	55	55	55	30		
North Carolina	70		60-65	55-60	55		20-35	20-35	20-35
North Dakota	75		55-75	70	40-65	40-55	30-55	20-45	15-25
Ohio	65-70		55-65	55-65	55	55	25-35		20
Oklahoma	70-75		55-65	60-70	55-65	45	25		25
Oregon	65	55	50-60	55	55	55	25		20
Pennsylvania	65		55-65	55	55	35-45	25-35	20-35	15
Puerto Rico	60-65	50-55			45-55	-	25-35		15-25
Rhode Island	65		55	55	50	-	25		20
South Carolina	70		60	60	55	-	30		
South Dakota	75		55-65	65-70	45-65	35-55	25-45		15-25
Tennessee	70		55-70	65-70	55	35-45	20-45		15-20
Texas	70-80		55-65	70-75	70-75	30-60	30		15-55
Virgin Islands	-	-	-	55	35	-	20		
Utah	75-80		65	65	65		25-35		20
Vermont	65		55	55	50	50			
Virginia	65-70		55-65	55-60	55		25		15-35
Washington	70	60	60	65	65	50-55	25-50		20-25
West Virginia	70		60-65	65	55	55	25-55		15 or 35
Wisconsin	65		55-65	55-65	55-65	55	25-35		15
Wyoming	75		65	65	65				

[1] Source: http://en.wikipedia.org/wiki/Speed_limits_in_the_United_States

Limitations of GES[1] data

GES data were not used because of the following limitations:

- No coding of speed limit for trucks which was valid at scene of accident.
- No coding of US state where the accident takes place - so there is even no possibility to assign the corresponding speed limit for states without separate speed limit for trucks.
- Initial speed based on data from Police Accident Report (PAR), usually estimated by police officer.

Conclusion:
- GES data are not suitable to estimate the influence of speed limiters for trucks.

Proceeding:
- Literature research about studies and facts regarding speed limiters for trucks.

[1] GES: General Estimates System

Facts & statistical data regarding truck accidents

- "... light vehicles are extremely vulnerable when they interact with trucks because trucks often weigh 20 to 30 times as much as light vehicles (Insurance Institute for Highway Safety 2002)…" [8]
- "… trucks require 20% to 40% more stopping distance than do light vehicles (Heavy Truck Safety Study 1987)." [8]
- "… 97 percent of the occupants that are killed in crashes between heavy trucks and passenger vehicles are passenger vehicle occupants." [7]
- "Large trucks account for 3% of all registered vehicles, 8% of total vehicle miles traveled, 8% of all vehicles involved in fatal crashes, and 4% of all vehicles involved in injury and property-damage-only crashes. One out of eight traffic fatalities in 2006 resulted from a collision involving a large truck (2006 Traffic Safety Facts)." [8]

Sources: see reference list at the end of presentation

BOSCH

Facts from literature research – available data

- "Best available data comes from the U.K., which showed a 26% decrease in heavy truck accidents since the legislation was enacted in 1992." [3]
- "The most definitive results on the effectiveness of speed limiters comes from the United Kingdom, which showed that the **crash involvement rate for speed-limited heavy trucks fell 26%** between 1993 (when mandated) and 2005. U.K. authorities noted that other contributing factors may have influenced the decline, but concluded that **speed limiters at least played a significant role**." [8]
- "Australia implemented speed limiter legislation to address rising traffic fatalities involving heavy trucks and has noted a decrease in the number of collisions since its implementation." [3]

Sources: see reference list at the end of presentation

BOSCH

Facts from literature research – results from different studies

There is no study for North America which shows the influence of speed limiters for trucks relative to accident involvement:

- 2007: "McDonald and Brewster ... found it difficult to meaningfully compare fleet safety data before and after speed limiter installation owing to the low number of respondents (56 carriers) that provided objective safety data (in terms of vehicle miles traveled per million miles for pre- and postlimiter installation). Owing to the lack of data for these survey items, it was not possible to make strong claims about safety outcomes for carriers after the implementation of speed governors." [8]
- 2008: "The lack of before and after data severely limits the ability of the Study Team to draw objective conclusions regarding the overall safety effectiveness of speed limiters." [8]
- 2011: "...there is no definitive research showing crash effects associated with posting lower (differential) speed limits for large trucks." [11]

Sources: see reference list at the end of presentation

Facts from literature research – results from different studies

2008 Canada - Transport Canada "ASSESSMENT OF A HEAVY TRUCK SPEED LIMITER REQUIREMENT IN CANADA" (TP14808E):

Results of method 1 (microscopic traffic simulation model):

- "The introduction of speed limiters set at 105 km/h increases safety." [3]
- "The maximum safety gains were obtained when the maximum control speed was set at 90 km/h for uncongested traffic volumes." [3]
- if close to capacity limit of the lane: "... more vehicle interactions take place and this leads to a reduction in safety especially for those segments with increased merging and lane-change activity [...] In these instances the introduction of truck speed limiters can actually reduce the level of safety when compared to the non limiter case." [3]

Results of method 2 (case study):

- "The QEW[1] case study application confirms the findings obtained from the sensitivity analysis of different traffic scenarios and speed control strategies." [3]

[1] Queensway Express Way (a straight Canadian freeway section along the Queensway Express Way)

...continued on next slide

Sources: see reference list at the end of presentation

Facts from literature research – results from different studies

...continued from previous slide

2008 Canada - Transport Canada “ASSESSMENT OF A HEAVY TRUCK SPEED LIMITER REQUIREMENT IN CANADA” (TP14808E):

Conclusion:

Kind of effect (positive or negative) of speed limiters for trucks finally depends on:

- ➔ how close is the traffic volume to the capacity limit of the lane
- ➔ if straight freeway segments or segments with increased merging and lane-change activity
- ➔ the speed limiter compliance rate

2004 FHWA:

“The Safety Impacts of ***Differential Speed Limits*** on Rural Interstate Highways”:

- ➔ Strong limitation: “It was not possible to obtain speeds by vehicle type (passenger cars and truck).” [1]
- ➔ “Overall, the study was not able to isolate or measure the effect of USL/DSL[1)] changes.” [1]

Sources: see reference list at the end of presentation

Facts from literature research – results from different studies

2004 Norway - Elvik, R., P. Christensen, and A. Amundsen, Speed and Road Accidents :

- ➔ “Similarly, a rigorous meta-analysis conducted by Elvik et al. (2004) included **97 different studies** with a total of 460 estimates of the relationship between changes in speed and changes in the frequency of crashes or associated injuries and fatalities. Using the Power Model, this study assessed the relationship between speed and road safety. The study concluded there was a relationship between speed and the number of crashes and the severity of crashes. The data suggest that speed is likely to be the single most important determinant in the frequency of traffic fatalities; a 10% reduction in the mean speed of traffic is likely to reduce fatal traffic crashes by 34% and have a greater impact on traffic fatalities than a 10% increase in traffic volume. *These data include all vehicles and are not specific to large trucks.*” [8]

Sources: see reference list at the end of presentation

Facts from literature research – results from different studies

2008 TRB[1)] - Safety Impacts of Speed Limiter Device Installations on Commercial Trucks and Buses:

- "There is adequate literature on the role of large-truck speed in terms of crash severity, but less empirical data relating to the use of speed limiters to meaningful reductions in total crashes because the percentage of crashes that occur above 65 mph is relatively small. However, the statistical impact could increase over time, as indicated by Insurance Institute for Highway Safety data showing that the number of trucks traveling over the 75 mph speed limit rose from 8% to 14% during the period from 1996 to 2006." [8]

2001 EU - Report from the Commission to the European Parliament:

- "To summarise, it is clear that the known effects of speed limitation devices are generally very positive for drivers, for companies, for society and for the environment. The negative aspects are small and avoidable: if all the speed limitation devices [for trucks] were set accurately to the same speed, there would be less need for overtaking ..." [8][10]

1) TRB...Transportation Research Board

Sources: see reference list at the end of presentation

BOSCH

The pros and cons of truck speed limiters

Pro:

- "Slower truck speeds allow passenger vehicle ... to pass trucks more easily." [11]
- Speed limiters "may reduce overall crash risk", but it is more likely that they "lessen the severity of a crash". [8]
- "Impact force during a vehicle crash varies with the square of the vehicle speed; therefore, even small increases in speed have large and lethal effects on the force at impact (Roads and Traffic Authority 2005)." [8]
- "... speed is likely to be the single most important determinant in the frequency of traffic fatalities; a 10% reduction in the mean speed of traffic is likely to reduce fatal traffic crashes by 34% ... "[1)] [8]
- Lower fuel consumption
- Lower maintenance costs (tires, brakes, ...)
- Increased road safety (fewer casualties)[2)] [10]
- Lower insurance premiums as a consequence of less accidents.[2)] [10]

1) These data include all vehicles and are not specific to large trucks.
2) Valid for Europe.

Sources: see reference list at the end of presentation

BOSCH

The pros and cons of truck speed limiters

Contra:

- Overtaking another vehicle takes longer.
- Potential safety hazard from increased delta of speeds between truck and car.
  - *This is the usual concern of opposers of speed limiters.*
  - "Vehicles traveling the same speed have fewer interactions and make fewer lane changing and decelerating maneuvers in response to other vehicles." [8] => possible higher crash risk due to differential speed
- "Differences in the set speed in Canada and the United States could lead to a competitive advantage for one country." (if there are different set speeds, the pre set limit has to be modified if crossing the border) [8]
- Inability to accelerate in risky traffic scenarios (*but: "... fewer than 2% of crashes and conflicts use acceleration as an evasive action"* [8])

Sources: see reference list at the end of presentation

Information about legal situation

Proposed rules in USA:

- 2006: "In separate petitions in 2006, the American Trucking Associations and Road Safe America [and a group of nine motor carriers] asked NHTSA[1)] to consider requiring limiters set at 68 mph in heavy trucks." [5]
- 2007: These two petitions are addressed in a single federal rulemaking activity (Docket No. NHTSA-2007-26851). [7]
- 2012: "The National Highway Traffic Safety Administration plans to initiate the rulemaking process on this issue with a Notice of Proposed Rulemaking in 2012. The determination of whether to issue a rule will be made in the course of the rulemaking proceeding, in accordance with statutory criteria." [7]

... in other countries / regions:

- "Australia and the European Union (EU) have legislated the use of heavy truck speed limiters since the early 1990s." [3]
- "Canadian provinces Ontario and Quebec also have speed limiter laws" [4], "... which took effect in January 2009" [6]

1) National Highway Traffic Safety Administration

Sources: see reference list at the end of presentation

Current usage of speed limiters in North America

- Especially (large) truck fleets activate speed limiters for their trucks.
- "A Canadian assessment of heavy-duty truck speed limiters estimated that 60 percent of heavy truck fleets in North America use speed limiters." [6]
- USA: "...the percentage of fleets that use the ECM speed limiter functionality appears to be approximately **65%** across the industry." [8]
- Main reasons for using speed limiters: fuel economy and safety

Sources: see reference list at the end of presentation

Tampering of speed limiters

- Tampering was identified as a significant problem in all countries:
  - “Australian officials estimated a **10-30%** speed limiter tampering rate...” [3]
  - “... data from Sweden suggested that **40%** of heavy trucks were exceeding their maximum allowable speed.” [3]
- “It is important to note that a heavy truck’s speed limiter setting itself does not control the vehicle’s top speed. Other variables, such as the tire-rolling radius and rear axle gear ratio, are essential for the ECM to calculate an accurate top speed. The customer specifies these variables when the truck is ordered and the ECM cannot be calibrated until final assembly. Both truck and engine manufacturers believe that the speed limiter setting should be a customer-configurable feature and pre-programming a particular setting is unrealistic and ignores the realities of customized production for the global market.” [3]
- ***Cost of measures against tampering:***
  “Truck Manufacturers Association (TMA) ... estimates a one-time cost of **$35 to $50 million** would be required to develop ECMs with tamper-resistant speed limiters and a one-time cost of **$150 million to $200 million** to develop ECMs with tamper-proof speed limiters.” [7]

Sources: see reference list at the end of presentation

Summary

- GES data are not suitable to estimate the influence of speed limiters for trucks, therefore literature research was done.
- U.K.: Crash involvement rate for speed-limited heavy trucks fell about 26%.
- Current usage of speed limiters within the USA:
  - "...the percentage of fleets that use the ECM speed limiter functionality appears to be approximately 65% across the industry." [8]
- Tampering of speed limiters for trucks was identified as a significant problem in all countries, measures against are relatively expensive.
- **Speed limiters could become mandatory in the USA because of the NHTSA rulemaking process in 2012.** *(Docket No. NHTSA-2007-26851)*

Conclusion:

"To summarise, it is clear that the known effects of speed limitation devices are generally very positive for drivers, for companies, for society and for the environment. The negative aspects are small and avoidable ... " [8][10]

Sources: see reference list at the end of presentation

Speed limiters for trucks - USA
Chapter 11

Reference List

No.	Literatur	Composer	Country
1.	2004 FHWA Effect of differential speed limit for trucks	FHWA	USA
2.	Safety Implications of Mandated Truck Speed Limiters on Canadian Highways (TP14807 E)	Transport Canada (TC)	Canada
3.	2008 - ASSESSMENT OF A HEAVY TRUCK SPEED LIMITER REQUIREMENT IN CANADA - Safety Implications of Mandating Speed Limiters (TP14808E)	Transport Canada (TC)	Canada
4.	2011-03 How would mandatory speed limiters on trucks affect highway safety?	Truckinginfo	USA
5.	2011-04 NHTSA Clears Path for Speed-Limiter Proposal	Truckinginfo	USA
6.	2008-08 Final Rulemaking to Establish Greenhouse Gas Emissions Standards and Fuel Efficiency Standards for Medium- and Heavy-Duty Engines and Vehicles	NHTSA U.S. Environmental Protection Agency (EPA)	USA
7.	2010-12_Federal-Register	NHTSA U.S. Government Printing Office (GPO)	USA
8.	2008 Safety Impacts of Speed Limiter Device Installations on Commercial Trucks and Buses	TRANSPORTATION RESEARCH BOARD (TRB)	USA
9.	2008-03 An International Study on Heavy Truck Speed Limiters (TP14810)	Transport Canada (TC)	Canada
10.	2001 Report from the Commission to the European Parliament		EU
11.	2011-05_IIHS_Q&A_ Speed and speed limits	IIHS	USA

Status Accident Research

– in Asian countries –

Accident research CR / AEV1

BOSCH

Available data sources – worldwide & planned extension

In-depth data
- -manifold detailed data to individual accidents
- -represents a small subset of all accidents

Detailed official data
- -detailed data to all police reported accidents
- -individual analysis possible

Official reports
- -information/statistics to all police reported accidents
- -slightly detailed

Incident data
- - Near miss incident and accident data from driving studies
- - mainly video & event recorder data

→ Extension of detailed knowledge regarding traffic accidents in Asian countries necessary

→ Access to naturalistic driving or event driver recorded data

BOSCH

Activities Japan – Focus near miss database

Access to event drive recorder data:

1) <u>Near-miss incident and accident data – JSAE*:</u>

→ Presentation on derived benefit of PEBS for Japanese market on FastZero 2011 conference in Tokyo – transfer method for FoE/benefit accepted

→ Member in 2nd phase project on EDR including driver video

2) <u>Study with Tokyo University (>15.000 cases available)</u>

→ Identification of typical pedestrian behavior in accident situations based on JSAE* data finished

→ Results transferred for CC-development

Cooperation's

→ Honda powered two wheeler still ongoing but pending status

Aim for 2012

→ Analysis of 2DData for driver characteristics

→ Important information on pedestrian characteristics evaluated

→ Analysis of driver behavior in critical driving situations & during accidents possible

* JSAE: Japan Society of Automotive Engineering
** JARI: Japan Automotive Research Institute

Activities Korea

Access to event drive recorder data:

1) <u>Korean Transport Institute (KOTI):</u>

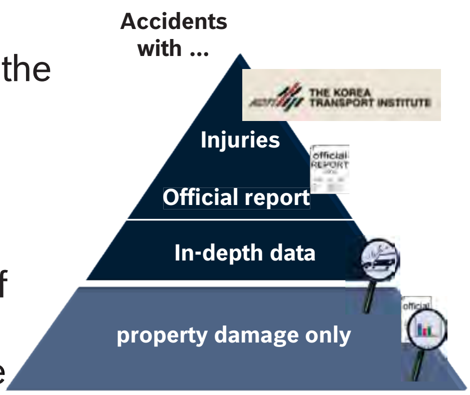
→ Project in cooperation with taxi companies financed by the government in order to educate taxi driver since 2006

→ Up to 39.000 taxis equipped w/ event drive recorder & camera[1]

→ 1y pilot study for PEBS evaluation started in June 2011

→ 4.000 datasets exclusively available for RB, recoding of accidents type and kind of accident finished

→ No other OEM/supplier has these kind of data available currently



Aim for 2012

→ Finish of study on rear end crashes till July 2012

→ Continuing relationship w/ possible next study on pedestrian accidents w/ possibly further access to more data

→ KOTI-data contains important information for analyzing pre-crash-phase in general

→ Human behavior prior to accidents can be evaluated and support future product development e.g. pedestrian or driver reaction prior to collision

Activities China

Access to official accident data with injuries:

1) ESC effectiveness study with CATARC
- → Collection of 40,000 police reported accidents
- → Database and analysis of ESC will be finished 1st q. in 2012
- → Data access for RB promised by CATARC

Access to in-depth accident data with injuries:

1) Membership in Consortium at Tongji-University Shanghai
- → RB terminated membership in 2011 due to less benefit

2) Cooperation with CATARC
- → Setup of project similar to GIDAS (several cities) but only w/ 400 cases p.a.
- → Collected data easier accepted by government but high support of police needed
- → Access to severity information limited and not open as in Germany

Aim for 2012
- → Setup of database with in-depth data and support of CATARC
- → Improvement of data quality and representativeness

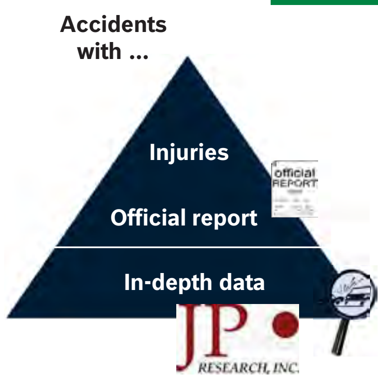
- → Setup of in-depth data collection in China very time consuming
- → Similar to GIDAS: More detailed studies expected to be available 2y after start of CIDAS project (start in 6/2011)

CATARC: China Automotive Technology & Research Center

Activities India

Access to in-depth accident data with injuries:

Cooperation between Bosch and JP Research
- → Setup of similar project according to GIDAS, consortium partners (Daimler, Toyota, Nissan)
- → Access to 100 accidents (including pilot study data)
- → Support and training in in-depth data collection and reconstruction
- → Expansion towards other cities (Karnataka, Gujarat)
- → First step to police reported data for data representativeness
- → Setup of contact to hospitals in order to get access to injury information



Aim for 2012
- → Continuing to improve representativeness and data quality
- → Expansion of in-depth data collection to other cities
- → Collection of in total >200 in-depth accidents till May 2012

- → Analysis of accident situation in India will take more time than expected.
- → Fundamental results available in 2-3 year up from start of RASSI project in 5/11

Car accidents of elderly drivers

Accident research
CR / AEV1

Car accidents of elderly drivers

Aim of this study: Declines in certain driving related abilities, as caused by ageing, favor the occurrence of specific accident situations. In the current study, the principal goal was to compare property damage accidents between elderly and younger drivers. Further, existing concepts to address problems of elderly drivers were summarized.

Method: Data from a German insurance company (Allianz) and from the US national highway transport safety agency (NHTSA) were grouped according to different criteria. The group distribution was compared between drivers aged above and below 65 years, having caused the accident. Based on patents and applications from the United States Patent and Trademark Office (USPTO) general approaches to address problems of elderly drivers were summarized. Further, initiatives of different universities and organizations were highlighted.

Result: Low speed property damage accidents (parking & maneuvering) occur more often to elderly drivers than to younger ones. In general, elderly drivers show increased problems while turning and driving backwards whereas younger drivers are more often involved in rear-end crashes. So far, only few concepts for assistance systems addressing the specific needs of elderly drivers were found.

Structure and content of this study

[1] Declined abilities, crash risk and self regulation of elderly drivers
Changes as part of the ageing process lead to reductions in specific driving capacities. These reductions may lead in consequence to an increased crash risk or behavioral adaptations
Slide 4: "Declined abilities, crash risk and self regulation of elderly drivers"

Reasons for different accidents of elderly and younger drivers

[2] Behavioral adaptations of elderly drivers
Differences in car use need to be taken into account when comparing accident data between elderly and younger drivers. Information systems could be devised to support self regulation
Slide 5: "Accidents of elderly drivers – Driver self regulation"

Casualty accidents; country comparison

[3] Casualty accidents in GER and the US
Differences between elderly and younger drivers are comparable in both countries. Elderly drivers cause more crossing accidents (reduced field of view, neck rotation, cf slide 4) while younger drivers cause more skidding/lane departure and rear-end accidents (travelling speed reduction of elderly drivers, cf slide 5).
Slide 6: "Casualty damage accidents in Germany and the United States"
Slide 7: "Casualty accidents of elderly and younger drivers in Germany"
Slide 8: "Casualty accidents of elderly and younger drivers in the United States"

Property damage accidents; country comparison

[4] Property damage accidents elderly vs. young in the US
For all ages, property damage accidents are more often collisions with a parked/stopped vehicle and side-sweep collisions and less often carriageway departure / crossing accidents as compared to accidents with casualties. Elderly drivers however cause more side-sweep collisions and crossing accidents than younger drivers (reduced field of view, neck rotation, cf slide 4) and less rear-end crashes and carriageway departures (travel speed reduction, cf slide 5). At low speed (all vehicles ≤17 mph) backward driving presents special problems
Slide 12: "Casualty/property damage accidents of elderly and young in the US"
Slide 13: "Casualty and property damage accidents in the United States"
Slide 14: "Property damage accidents of elderly and younger drivers in the US"
Slide 15: "Property damage accidents of elderly and younger drivers in the US"

[5] Property damage accidents elderly vs. young in Germany
Elderly drivers cause more low speed accidents (≤30 kph), especially while maneuvering or leaving & entering a parking site and more carriageway departures (same as casualty accidents, cf. [3]). Especially the right vehicle side seems difficult to survey for elderly drivers. LSV functions could be especially appreciated by elderly drivers and take their constitution into account.
Slide 9: "Property damage accidents of elderly and younger drivers"
Slide 10: "Damaged vehicle areas during parking & maneuvering"
Slide 11: "Efficiency of three systems targeting parking & maneuvering"

System survey

[6] System propositions and public initiatives
Systems devised for elderly drivers mainly target visual impairment, for example during night driving. Recent patent applications make use of the integration of different data-sources, for example using a smartphone. Public initiatives as the "Blind driver challenge" might stimulate the development of systems useful as well for elderly drivers.

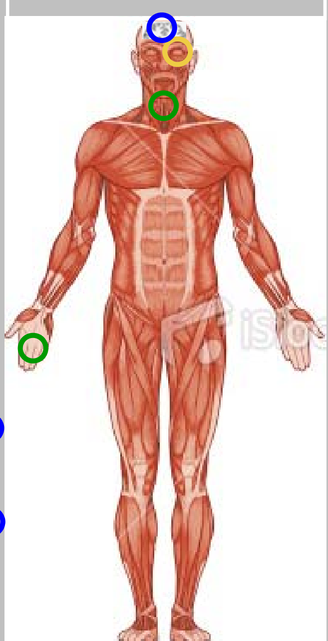
Slide 16: "Proposals in the scientific literature"
Slide 17: "Patents "
Slide 18: "MIT AgeLab Aware Vehicle Project"
Slide 19: "Blind Driver Challenge"

BOSCH

Declined abilities, crash risk and self-regulation of elderly drivers

•Note: "Increased crash risk" is for the moment not differentiated between (i) observed in test (ex. driving simulator) and ii) observed in accident surveys.
•A risk evidenced in test (i) may be compensated by
•behavioral adaptations and not lead to an increase
•in real-world accidents (ii)

- Cognitive decline
- Visual apparatus decline
- Motoric decline



Outcome	Ability
• **2x increased crash risk***	• Concentration — Reduced selective attention, attention switching (divided attention)
	• Memory — Reduced transition from short term to long term memory, reduced short term memory capacity and access speed
• Self-reported avoidance of driving in unfamiliar areas (39%) (relation plausible, not shown)	• Spatial orientation — Reduced spatial representation of objects, reduced mental rotation
• **2x increased crash risk***	• Head rotation — Reduction about 64° -> 56°
• **2x increased crash risk***	• Flexibility — Decreased finger/joint flexibility
• **2x increased crash risk***	• Field of view — Useable field of view reduced to 33% at ~75 yrs
• **Increased crash risk***	• Field dependence — Reduced ability to extract information from background
• Self-reported avoidance of driving at high traffic times (relation plausible, not shown)	• Motion perception — More motion is needed to become visible
• **Increased crash risk***	• Reaction time — Increased duration to take decision and react (choice reaction time)

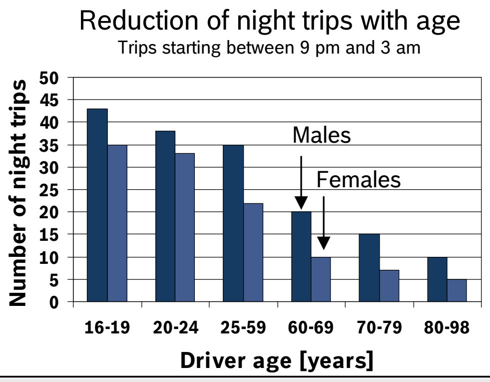
Ability	Outcome
• Light intensity — Reduced light sensitivity, eye retina receives 1/3 rd of intensity at 80 years compared to 21 year old	• Self-reported slower driving, more often in company, avoiding left turns (relation plausible, not shown)
• Glare — Increased glare recovery time, 2s at 15 yrs, 9s at 65 yrs; Reduced glare compensation, 77 yrs old needs ~55 times increased light intensity compared to 10 yrs old directly after glare	• Self-reported avoidance of night driving (8%-80%) (relation plausible, not shown)
• Eye movability — Up-down eye movability halved at 77 yrs	
• Contrast — Reduced contrast sensitivity	• **Self-reported driving problems**
• Spatial detail — Reduced perception of spatial detail at distance, about 60% at 20 yrs compared to 80 yrs	• Running signal traffic violation is increased in age group >65 yrs (relation plausible, not shown)
• Object tracking — Reduced eye pursuit movements, reduction of track velocity by factor three	
• 3D vision — Reduced stereopsis i.e. 3D information from stereo vision	

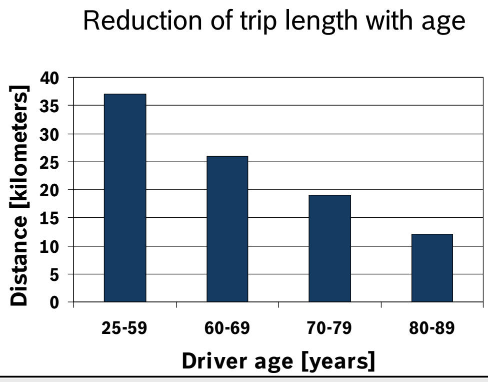
• Decline in abilities needed for driving leads to an increase in specific crash-risks and a selective reduction in traffic participation (self-regulation)

Eby DW, Univ. of Michigan, Transport Research Institute, GM/US DOT project (UMTRI-98-24) (1998)
Eby DW, Univ. of Michigan, M-CASTL Synthesis Report, Vol. 1, (M-CASTL-2008-01) (2008)
Anstey KJ et al, Clinical Psychology Review 25:45-65 (2005) Bougler B, Univ. of California Berkeley, PATH research report (2005)

BOSCH

Accidents of elderly drivers – Driver self regulation





Further adaptations in driving behavior

- Reduction of winter driving (50% reduction of driving activity)
- Avoidance of slippery roads (45% of 70 year old drivers)
- Avoidance of demanding traffic (urban/highway, 12% over 70 years)
- Increased gap to preceding vehicles (1.2s; 20 years vs. 1.4s; 65 years)
- Increased traffic gaps at crossing
- Increased distance to traffic flow at crossing

System ideas: Support self regulation (i.e. make self regulation more convenient)

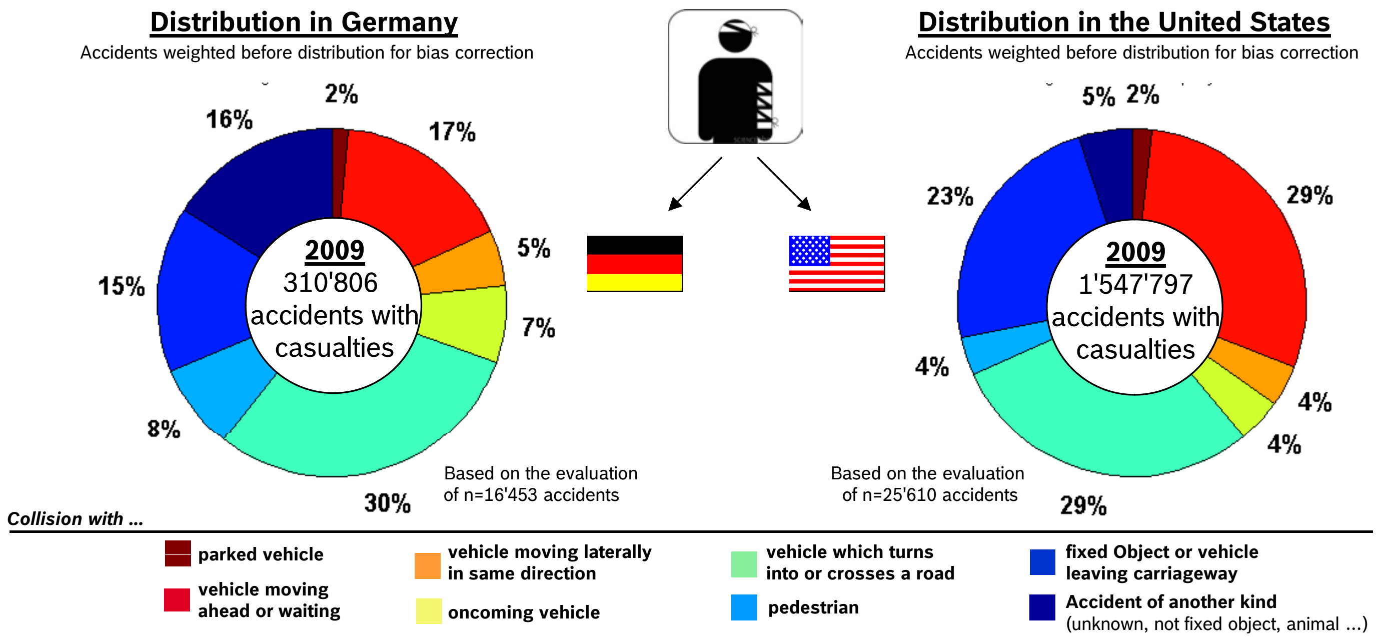
- Combined route planning and scheduling (Advice system planning needed trips throughout the day while taking into account avoidance of specific situations)
- Improved insight into crossroads (Camera system allowing crossroad observance without need to approach the intersection)
- Safe speed and distance (System advising on the distance to keep to preceding and/or lateral traffic participants while considering demands on average speed)

• Elderly drivers are aware of a part of their deficits and adapt their driving accordingly ('self regulation')
• Driver assistance systems could make self regulation more convenient by providing appropriate information
• Self regulation needs to be taken into account when comparing accident database facts between elderly and younger drivers

Results reproduced from:
Smiley A. Adaptive strategies of older drivers. Transportation in an Aging Society: A decade of experience . 2004.

BOSCH

Casualty damage accidents in Germany and in the United States



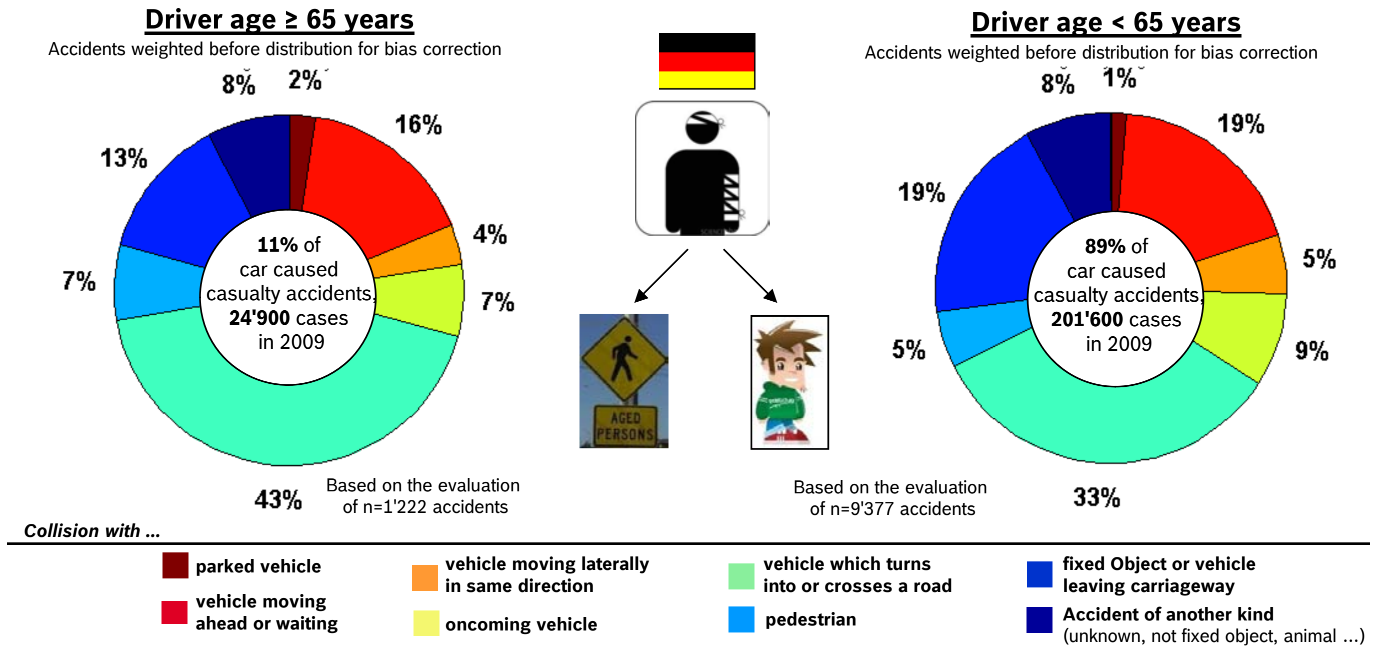
• Accidents involving pedestrians or a vehicle moving ahead or waiting (i.e. rear end crashes) occur more often in the United States than in Germany
• In this categorization, "accidents of another kind" are more frequent in Germany than in the United States. For Germany, this category includes numerous accidents not caused by a motor vehicle

Database: German in depth accident study (GIDAS) 2001-2009, representative sample of accidents with personal injury in Germany
NHTSA General estimates system (2009), sample of US accidents

BOSCH

Casualty accidents of elderly and younger drivers in Germany

Accidents caused by a car - 73% of all casualty accidents i.e. 226'500 accidents in 2009



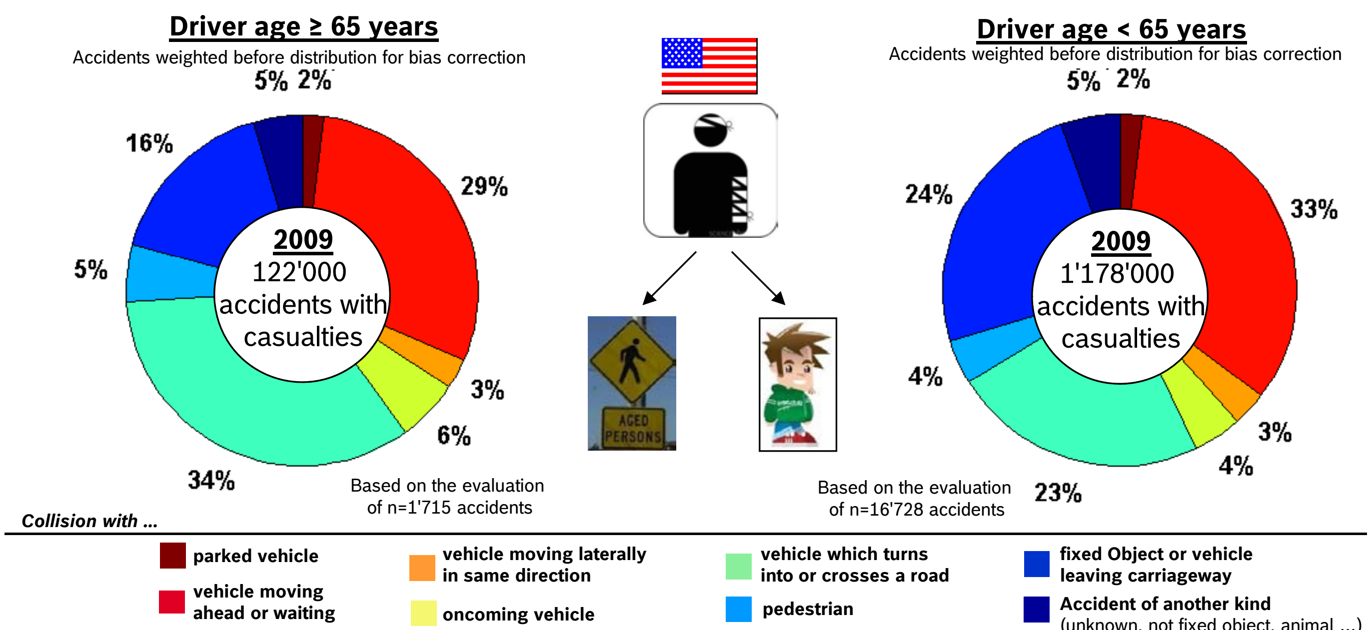
- Crossing accidents present a higher share of elderly drivers' casualty accidents (43%) compared to younger drivers (33%)
- Elderly drivers are less involved in carriageway departure accidents (13%) than younger drivers (19%), probably because of slower driving speeds, reducing the risk of skidding

Database: German in depth accident study (GIDAS) 2001-2009, representative sample of accidents with personal injury in Germany

BOSCH

Casualty accidents of elderly and younger drivers in the United States

Accidents involving not more than two vehicles, caused by a car or light truck (i.e. "pick-up" truck)
i.e. 84% of all casualty accidents or about 1'300'000 cases in 2009*



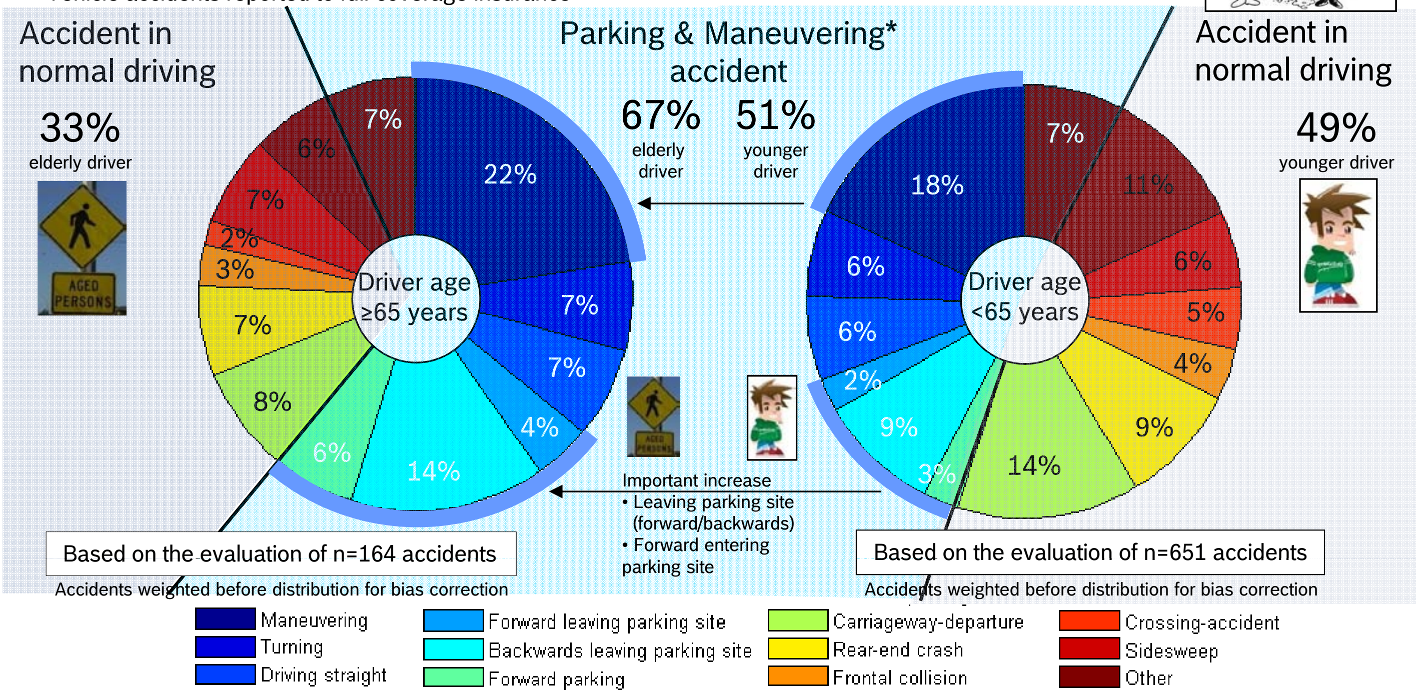
- Crossing accidents occur more often to elderly drivers when causing a casualty accident (34%) than to younger drivers (23%)
- Elderly drivers are less involved in carriageway departure accidents (16%) than younger drivers (24%), probably because of slower driving speeds, reducing the risk of skidding

Database: NHTSA General estimates system (2009), sample of US accidents
*) About 90% of all casualty accidents involve not more than two vehicles. In about 93% of these cases, the at fault vehicle was a car or light truck

BOSCH

Property damage accidents of elderly and younger drivers

Vehicle accidents reported to full coverage insurance



Note: Most vehicles of elderly and younger drivers (85% for both age groups) were not equipped with a parking assistance

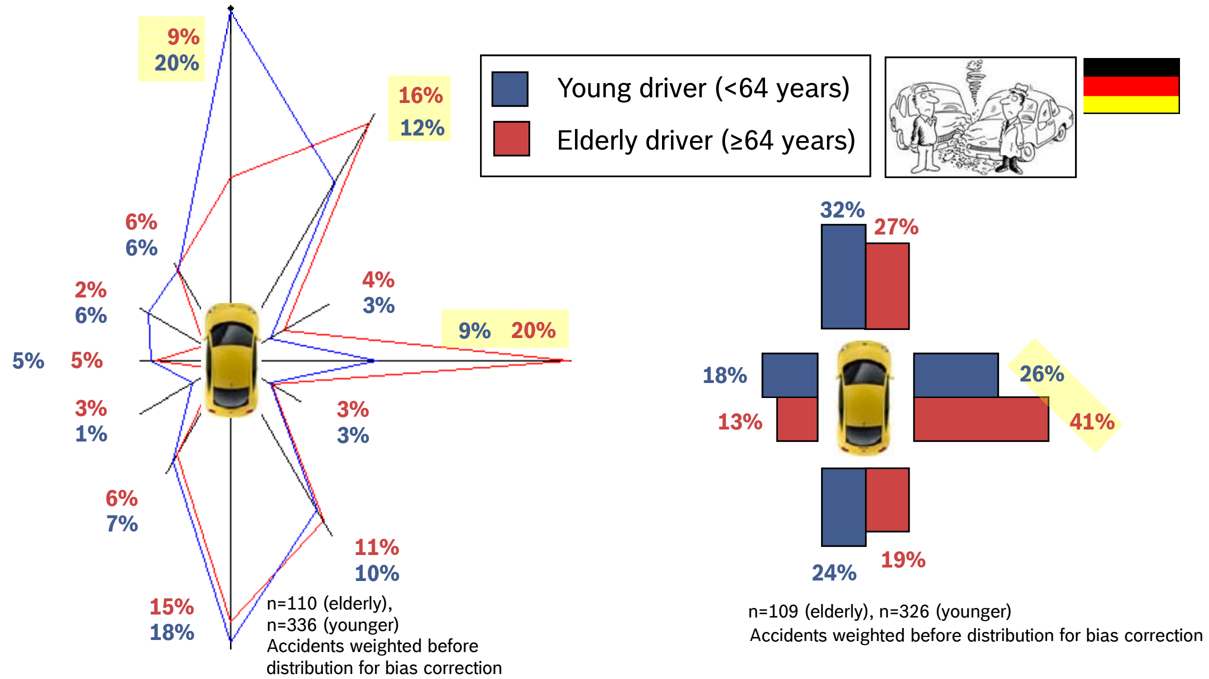
- Elderly drivers (≥65 yrs) show more parking & maneuvering property damage accidents than younger drivers (< 65 yrs)
- Entering and leaving a parking site, especially backwards, is more problematic for elderly than for younger drivers

*)Def. Parking & Maneuvering: Speed <30 kph (also for collision opponent), leaving parking position or coming to hold (ex. in front of traffic light or for another reason), entering car into parking site.
Database: Allianz Zentrum für Technik (2004, 2007), sample of German property damage accidents

BOSCH

Damaged vehicle areas during parking & maneuvering*

Vehicle accidents reported to full coverage insurance



- Elderly drivers present higher damage rates on their right vehicle side during parking & maneuvering than younger drivers
- Parking & maneuvering systems could possibly provide simple assistance by improving visibility of the right vehicle side

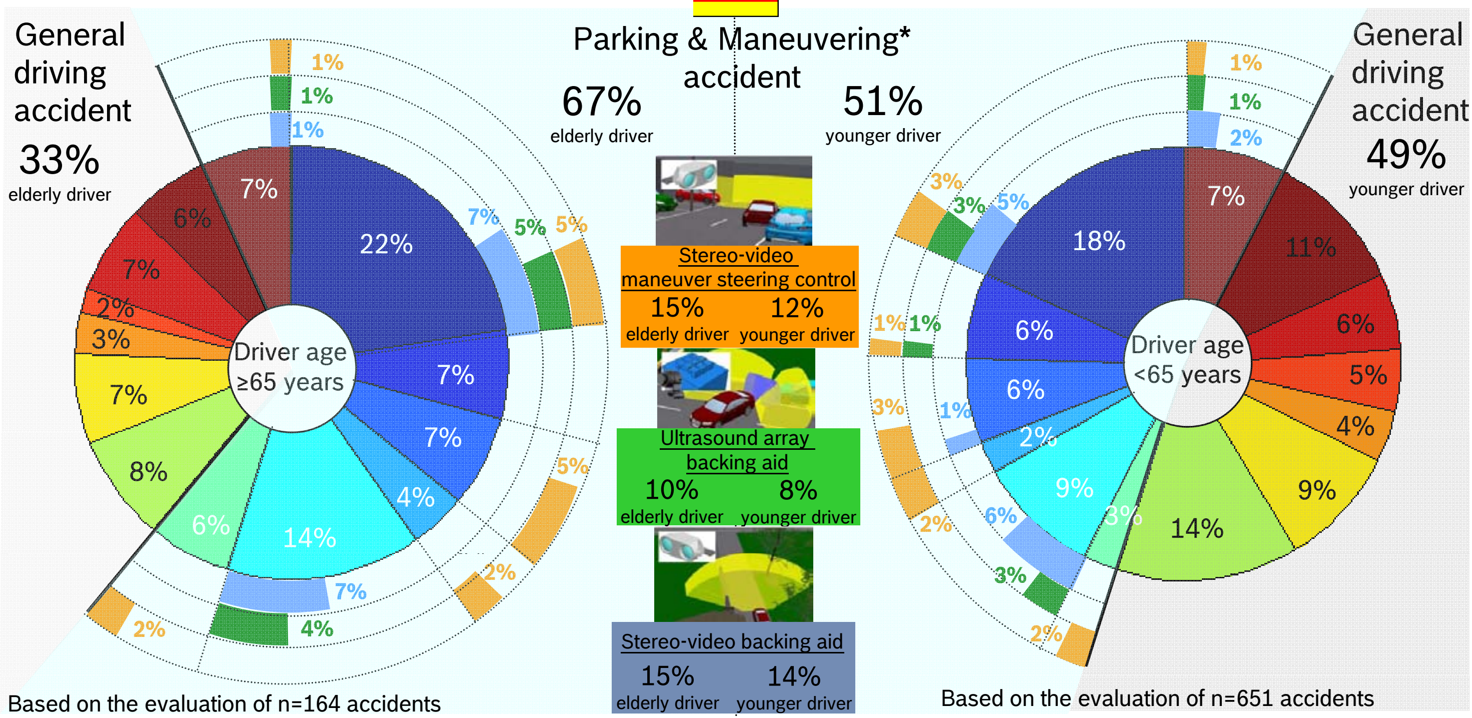
*)Def. Parking & Maneuvering: Speed <30 kph (also for collision opponent), leaving parking position or coming to hold (ex. in front of traffic light or for another reason), entering car into parking site.
Database: Allianz Zentrum für Technik (2004, 2007), sample of German property damage accidents

BOSCH

Efficiency of three systems targeting parking & maneuvering*

Accidents weighted before distribution for bias correction

Attention: Small number of cases in function field of effect for elderly drivers



Database: Allianz Zentrum für Technik (2004, 2007), sample of German property damage accidents

Maneuvering	Forward leaving parking site	Carriageway-departure	Crossing-accident
Turning	Backwards leaving parking site	Rear-end crash	Sidesweep
Driving straight	Forward parking	Frontal collision	Other

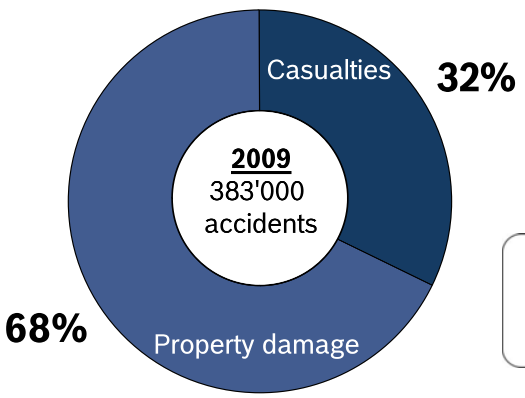
*)Def. Parking & Maneuvering: Speed <30 kph (also for collision opponent), leaving parking position or coming to hold (ex. in front of traffic light or for another reason), entering car into parking site. Systems under development within the project PJ-LSV (Low speed value); AZT Database, vehicle accidents reported to full coverage insurance.

Casualty and property damage accidents of elderly and younger drivers in the United States

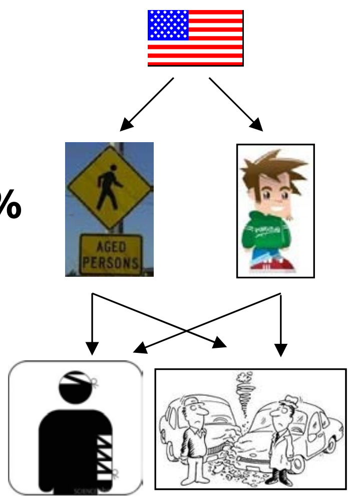
Accidents involving not more than two vehicles, caused by a car or light truck (i.e. "pick-up" truck) i.e. 87% of all police reported property damage accidents or 4'782'000 accidents in 2009

Driver age ≥ 65 years

Accidents weighted before distribution for bias correction

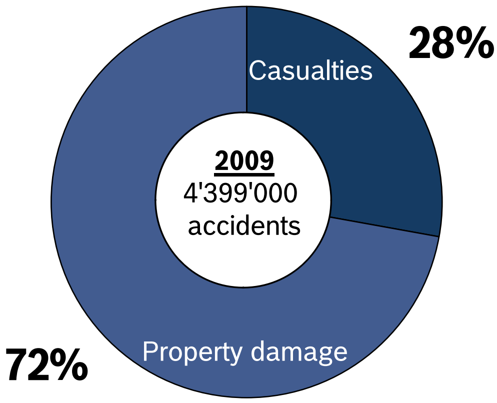


Based on the evaluation of n=2'844 accidents



Driver age < 65 years

Accidents weighted before distribution for bias correction



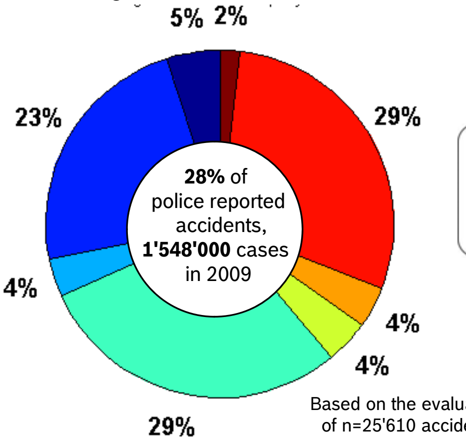
Based on the evaluation of n=29'582 accidents

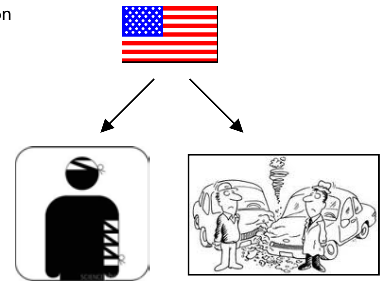
- Elderly drivers present only a slightly higher share of casualty accidents than younger drivers in the US
- Possible interpretation: In spite of higher frailty and deficits in managing dangerous situations (crossroads), elderly drivers efficiently adapt their driving behavior, keeping their casualty accident risk comparable to younger drivers

Database: NHTSA General estimates system (2009), sample of US accidents

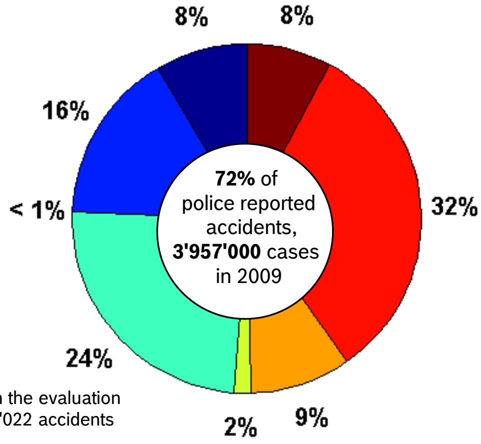
Casualty and property damage accidents in the United States

Distribution of casualty accidents
Accidents weighted before distribution for bias correction





Distribution of property damage accidents
Accidents weighted before distribution for bias correction



Based on the evaluation of n=25'610 accidents

Based on the evaluation of n=19'022 accidents

Collision with ...

- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)

• Lateral collisions (orange) and collisions involving a parked vehicle (dark red) are mostly property damage accidents whereas collisions with a pedestrian (light blue) and carriageway departure (blue) are mostly casualty accidents

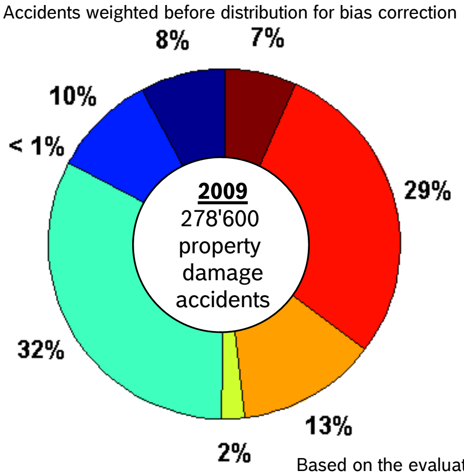
Database: NHTSA General estimates system (2009), sample of US accidents

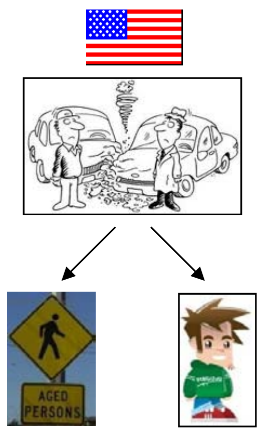
BOSCH

Property damage accidents of elderly and younger drivers in the United States

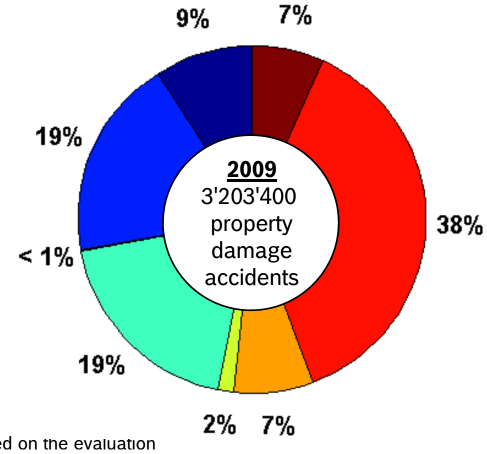
Accidents involving not more than two vehicles, caused by a car or light truck (i.e. "pick-up" truck) i.e. 88% of all police reported property damage accidents or 3'482'000 accidents in 2009

Driver age ≥ 65 years
Accidents weighted before distribution for bias correction





Driver age < 65 years
Accidents weighted before distribution for bias correction



Based on the evaluation of n=1'045 accidents

Based on the evaluation of n=12'938 accidents

Collision with ...

- parked vehicle
- vehicle moving ahead or waiting
- vehicle moving laterally in same direction
- oncoming vehicle
- vehicle which turns into or crosses a road
- pedestrian
- fixed Object or vehicle leaving carriageway
- Accident of another kind (unknown, not fixed object, animal ...)

• Crossing situations (green) are more important in property damage accidents of elderly drivers than in those of younger drivers
• Carriageway departure accidents (blue, including skidding) occur more often to younger than to elderly drivers

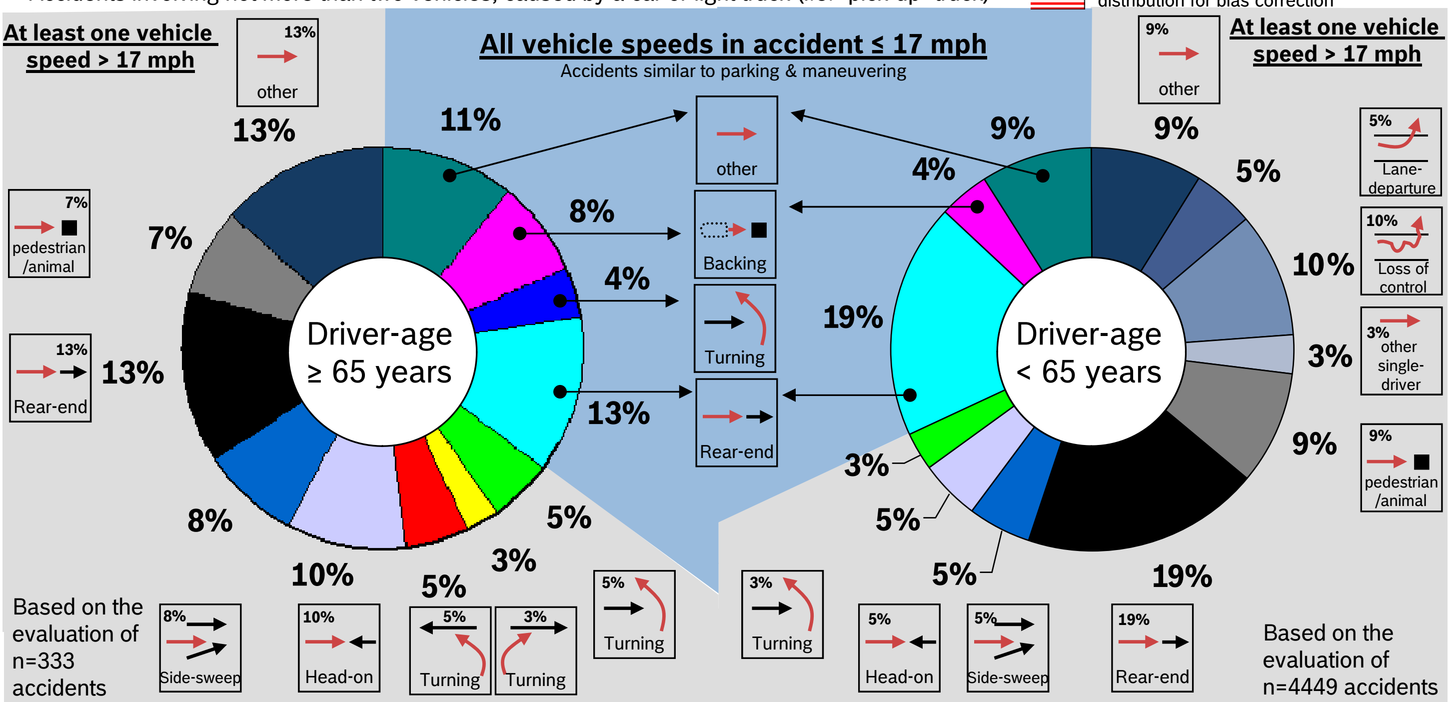
Database: NHTSA General estimates system (2009), sample of US accidents
*) About 96% of all property damage accidents involve not more than two vehicles. In about 92% of these cases, the at fault vehicle was a car or light truck

BOSCH

Property damage accidents of elderly and younger drivers in the United States

Accidents involving not more than two vehicles, caused by a car or light truck (i.e. "pick-up" truck)

Accidents weighted before distribution for bias correction



- **Low speed accidents (≤17 mph) occur in general at the same rate for elderly and younger drivers. However, elderly drivers present a higher share of accidents while backing (8%) and turning (4%) than younger drivers. Because of different data sampling, this result is not comparable with the aforementioned German analysis**
- **At speeds above 17 mph, elderly drivers present higher rates in turning accidents and situations leading to head on collisions, whereas younger drivers are more often implied in single driver accidents as lane departure or loss of control.**

Database: NHTSA General estimates system (2009), sample of US accidents

Assistance systems for elderly drivers – Proposals in the scientific literature

Ability decline of elderly driver taken into account	Suggested technical solution
• Increased glare sensitivity • Reduced eye movability	• Automatic rear-view mirror adjustment
• Disrupted accommodation capacity	• Head-up display
• Reduced contrast sensitivity	• Enhanced dashboard visibility (larger characters, increased contrast)
• Reduced head rotation	• Wide angle mirrors • Backing aid detecting pedestrians, obstacles
• Reduced light sensitivity	• Adaptive lights illuminating forward closing in objects • Night vision
• Further or combination of several disabilities	• Adaptive cruise control

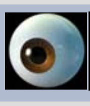
Literature

- Pike J. Reducing injuries and fatalities to older drivers - Vehicle concepts. Transportation in an Aging Society: A decade of experience . 2004.
- Caird JK. In-vehicle intelligent transportation systems: Safety and mobility of older drivers. Transportation in an Aging Society: A decade of experience . 2004.
- Koppa R. Automotive adaptive equipment and vehicle modifications. Transportation in an Aging Society: A decade of experience . 2004.
- Shaheen SA, Niemeier DA. Integrating vehicle design and human factors: Minimizing elderly driving constraints. Transportation Research Part C 9, 155-174. 2001.
- Shaw L, Polgar JM, Vrkljan B, Jacobson J. Seniors' perceptions of vehicle safety risks and needs. American Journal of Occupational Therapy 64, 215-224. 2010.

- No precise proposition for an assistance system targeting the needs of elderly drivers could be found in the scientific literature (journal papers, conference proceedings)

Assistance systems for elderly drivers – Patents

(Patents/Applications mentioning a use for older drivers as application)

Motivation		System proposal
 **Increased glare sensitivity** Increased glare recovery time, 2s at 15 yrs, 9s at 65 yrs. Reduced glare compensation, 77 yrs old needs ~55 times increased light intensity compared to 10 yrs old directly after glare to become visible.	**Avoidance of night driving** (8%-80% of persons in survey)	**Selective windshield darkening [1, 2]** • Driver head (and eye) imaging, localized windshield darkening using (i) LCD technology or (ii) UV-sensitive windshields and localized UV-irradiation • Switchable darkening ('Smartglass') of a general trajectory described by headlights on the windshield
  **Reduced field of view** **Reduced head rotation**	**Increased accident risk in specific situations**	**Non-visual directional warning [3, 4]** • Use directed (3D) sound or haptic indications via driver seat as driver alert
 **Different reasons**	**Avoidance of** • High travelling speed (75kph at 30 yrs, 70kph at 70 yrs) • Left turns • High traffic density, highways • Unfamiliar areas • Inclement weather, darkness **Increased accident risk in specific situations**	**Personalized advice / warning for safe car usage [5, 6, 7]** especially using smartphone accessible data • Advice on route planning (way and scheduling) and vehicle driving (velocity, gaps to other vehicles braking). Personalization via integration of smartphone local data (acceleration, gps-position, video data, driver specific data as health status, driving history) and web-data (weather, road conditions, traffic status, accident statistics, road width)
	Avoidance of • High travelling speed **Increased reaction time**	**Personalized configuration of electronic vehicle systems [8, 9]** • Adapt link between steering-wheel, brake and gas pedal to wheels, brakes and engine to adapt to increased reaction time and decreased reaction strength of an elderly driver

Cited patents and patent applications (USPTO)
[1] "Vehicle imaging system" US Pat App US 2010/0020170 A1; Jan 28, 2010
[2] "Vehicle glare reducing system" US Pat App US 2010/0161177 A1; Jun 24, 2010
[3] "Collision avoidance system" US Pat App US 2005/0258977 A1; Nov 24, 2005
[4] "Vehicle collision warning system" US Patent Nb 5'979'586; Nov 9, 1999
[5] "Vehicle over speed indicator" US Pat App US 2007/0213883 A1; Sep 13, 2007
[6] "Safest transportation routing" US Pat App US 2010/0036599 A1; Feb 11, 2010
[7] "System and method for integrating smartphone technology into a safety management platform to improve driver safety" US Pat App US 2011/0077028 A1; Mar 31, 2011
[8] "Vehicle control system adjustable in accordance with driver's age and characteristic" US Patent Nb 5'172'785; Dec 22, 1992
[9] "Car performance addition service providing system, acquiring system, method, and storage medium" US Pat App 2003/0171859 A1; Sep 11, 2003)

• System ideas found by patent search mostly target deficits in elderly driver's vision or self regulation

Assistance systems for elderly drivers – MIT AgeLab "Aware Vehicle project"

Project goal:

• Measurement of the current driver capacity to manage the vehicle (measures of general awareness, stress-level, mood etc.) exploring numerous parameters (ECG, EEG, facial recognition, gaze concentration and direction, respiration, seat position, skin conductance, steering wheel movement, wheel grip position and pressure etc)

• Give feedback to the driver about his current capacities to trigger self-regulation. As elderly drivers are known to restrict their driving according to their capacities, the system is presented as additional/ new information source for elderly drivers

• In dependence of driver state, increase alert level or reduce stress to keep the driver in a state of optimal performance, between "overload" and fatigue

• Possibly support the driver via information management (ex. delaying incoming phone-calls, prioritize information depending on driver performance)

Results:

• Set-up of a test vehicle in cooperation with US DOT UTC*, AARP* and Ford Motor Company

• No clear results or concepts published, neither for driver performance measurement nor for feedback to driver, assistance or stress level management (calm / alert)

Literature:

• Coughlin JF, Reimer B, and Mehler B, Driver Wellness, Safety & the Development of an AwareCar 2009
• Reimer B, Coughlin JF, Mehler B. Development of a driver aware vehicle for monitoring, managing & motivating enhanced older operator behavior. 2009
• Lavie T, Meyer J, Bengler K, Coughlin J. The Evaluation of In-Vehicle Adaptive Systems. 2005

• Currently no presentation of information directly useable for system development
• Suggestion to regularly follow this activity as target coincides with RB goal to develop driver assistance systems for an ageing population

*)US DOT UTC: United States department of transportation university transportation center,
AARP: American Association of Retired Persons,

Assistance systems for elderly drivers – Blind driver challenge

Project goal:

• Initiative of the "National Federation of the Blind*"
Stated goal: *"The "challenge" is not the development of an autonomous car that drives a blind person around; the "challenge" is to develop a nonvisual interface for a car that can convey real-time information about driving conditions to the blind so that we can use our own capacity to think and react to interpret these data and maneuver a car safely"*

• The technology developed to measure relevant vehicle information and communication via non-visual pathways could as well serve in assistance systems for elderly drivers, as decline in vision is a major feature of aging

Results:

• Only one academic institution participating so far: Virginia Tech University, Robotics & Mechanisms Laboratory, Dr. D. Hong
• Public demonstration of a vehicle driven by a blind on the Daytona International Speedway in January 2011
• Information about the need to steer, accelerate or brake are communicated via vibrating gloves or vests, no further insight into technical details provided
• Stated future goal is to communicate information about surrounding (e.g. obstacle location) instead of, as presently, driving commands (e.g. "steer left")

Literature:

- Blind Driver Challenge: http://www.blinddriverchallenge.org
- Robotics & Mechanisms Laboratory: http://www.romela.org/main/Blind_Driver_Challenge
- National Federation of the Blind: http://www.nfb.org

• Currently no publication directly useable results
• Suggestion to regularly follow this activity as target coincides with RB goal to develop driver assistance systems for an ageing population

*) National Federation of the Blind (NFB): US national organization, 50'000 members in the United States

Summary

• Parking & maneuvering is especially difficult for elderly drivers, probably due to lacking surround view. Especially the right hand vehicle side seems difficult to observe. "Birdview" camera systems or similar could offer adapted solutions.
• Turning and backing are specific problems of elderly drivers whereas younger drivers are more often involved in driving accidents
• Few concepts of driver assistance systems addressing the specific needs of elderly drivers exist so far

Outlook and Perspectives

• Definition of vision aid systems (night and surround view) for elderly drivers

• Examination of information integration for individualized advice on safe driving

• Evaluation of accidents related to age specific illnesses which increase the crash risk **(diabetes, sleep apnea syndrome)**

• Account for HMI demands of elderly drivers in driver assistance systems under development, especially for "parking and maneuvering". Possibly further competence build-up and offer of advice for different RB development projects

• Innovation workshop including elderly drivers, possibly in cooperation with CR/AEY

Bosch Accident Research
Alcohol related road traffic accidents

RBEI/ESA & CR/AEV1

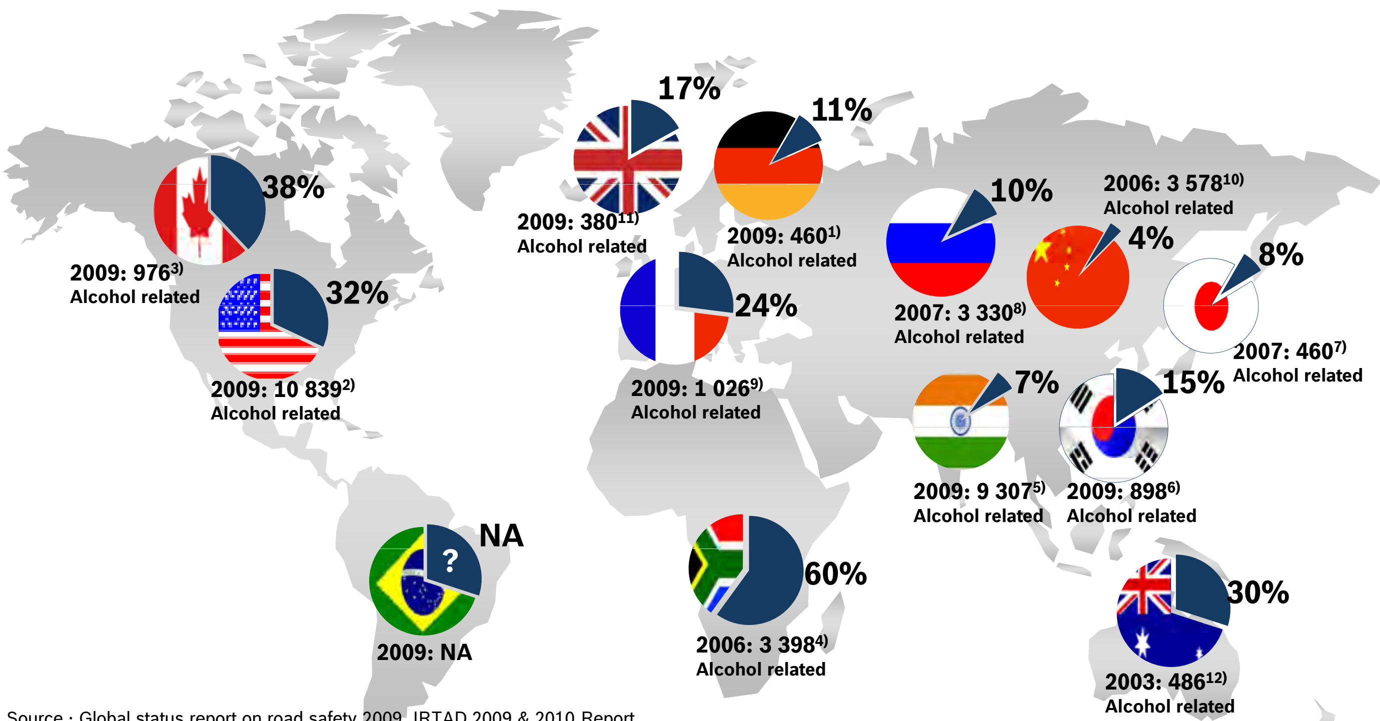
Source: Chennai Traffic police India - Photography: Don't drink and drive by sharadhaksar

Aim of this study: The current study is aimed to give an overview on global status on road traffic accidents related to alcohol.

Method: Analysis is based on various reports -Global status report on road safety, IRTAD annual reports etc. The data are consolidated and presented, major fatalities involving alcohol related crashes and BAC limits and laws of each countries and fatalities related alcohol crashes are discussed in this report to give the glimpse on global problem – *'Road traffic accidents related to alcohol'*.

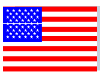
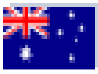
Result: The falling trend in number of fatal accidents and increase/constant share of alcohol related accidents clearly shows that 'Road traffic accidents related to alcohol' is a global problem. High correlation is seen between BAC-limits and accidents involving alcohol. For future traffic safety alcohol as root cause has to be taken into account.

Road traffic fatalities involving alcohol



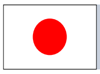
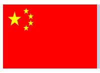
Source : Global status report on road safety 2009, IRTAD 2009 & 2010 Report
1) German Federal Statistic, Fachserie 8 Reihe 7 (UJ44)), 2)FARS 1998-2009,3) Alcohol-crash problem in Canada: 2009, Canadian Council of Motor Transport Administrators,4) Department of Transport. Road Traffic Accident Deaths in South Africa, 2001–2006,5)TRW 2009 India Report,6) Road traffic Accidents in Korea 2009 Report ,7) Japan - Road accident statistics 2007,8) 2007, The Road Safety Department of the Ministry of Internal Affairs.,9) 2006, Observatoire national interministériel de sécurité routière (ONISR).IRTAD 2009 report ,10) Traffic accidents, Yearbook 2008, China - 2006, Police data.,11) Reported Road Casualties in Great Britain - 2008: Department of Transport, 12) Department of Infrastructure, Transport, Regional Development and Local Government Australia, fact sheet 2008.

Road traffic fatalities involving alcohol

	% Road traffic fatalities involving alcohol		Drink & Drive law	Police check	Adult	Youngster
					Blood alcohol content limits in g/dl	
	60%	2006 **3 398**	Yes	Yes	0.05	0.05
	38%	2009 **976**	Yes	Yes	0.08	0.00-0.04
	32%	2009 **10 839**	Yes[1)]	Yes[1)]	0.08	0.00-0.02
	30%	2003 **486**	Yes[1)]	Yes[1)]	0.05	0.00-0.02
	24%	2009 **1 026**	Yes	Yes	0.05	0.05
	17%	2009 **380**	Yes	No	0.08	0.08
	15%	2009 **898**	Yes	Yes	0.05	0.05
	11%	2009 **460**	Yes	Yes	0.05	0.00

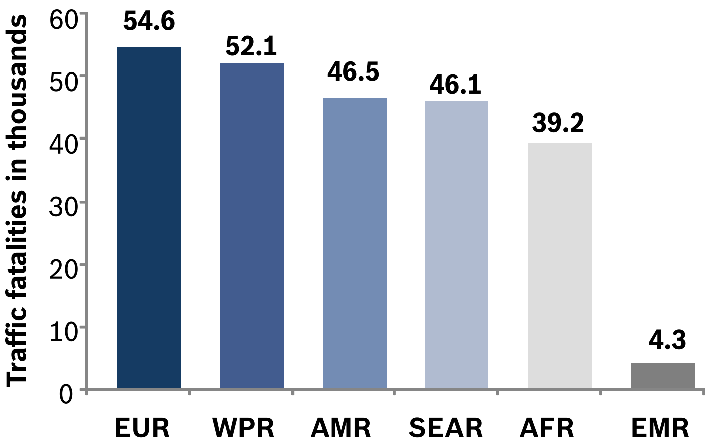
Sources: Global status report on road safety 2009,
No national BAC limit, but all states and the district of Colombia have a BAC limit of 0.08 for general population & 0.02 or less for young/novice drivers & Australia: No national BAC limit

Road traffic fatalities involving alcohol

	Road traffic deaths involving alcohol		Drink & Drive law	Police check	Adult	Youngster
					Blood alcohol content limits in g/dl	
	10%	2007 **3 330**	Yes	Yes	0.03	0.03
	8%	2007 **460**	Yes	Yes	0.03	0.03
	7%[1)]	2009 **9 307**	Yes	Yes	0.03	0.03
	4%	2006 **3 578**	Yes	Yes	0.02	0.02
	NA		Yes	Yes	0.02	0.02

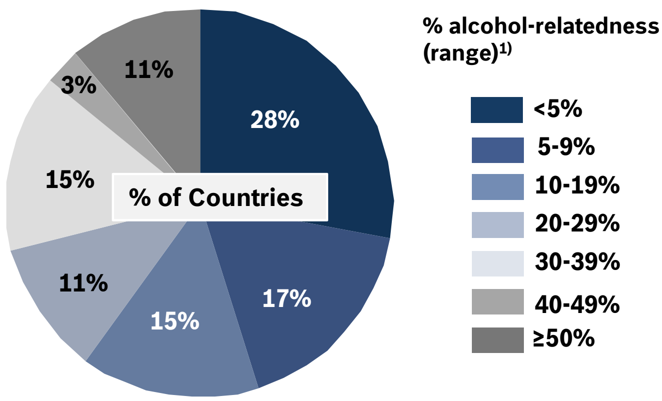
Sources: Global status report on road safety 2009 ,
1) Ministry of surface and road transportation – Transport Research wing Report India 2009 Report

Global alcohol related crashes w/fatalities



Road traffic accidents deaths due to alcohol[2)]

EUR ... Europe
WPR ... Western Pacific
AMR ... American
SEAR ... South East Asia
AFR ... Africa
EMR ... Eastern Mediterranean

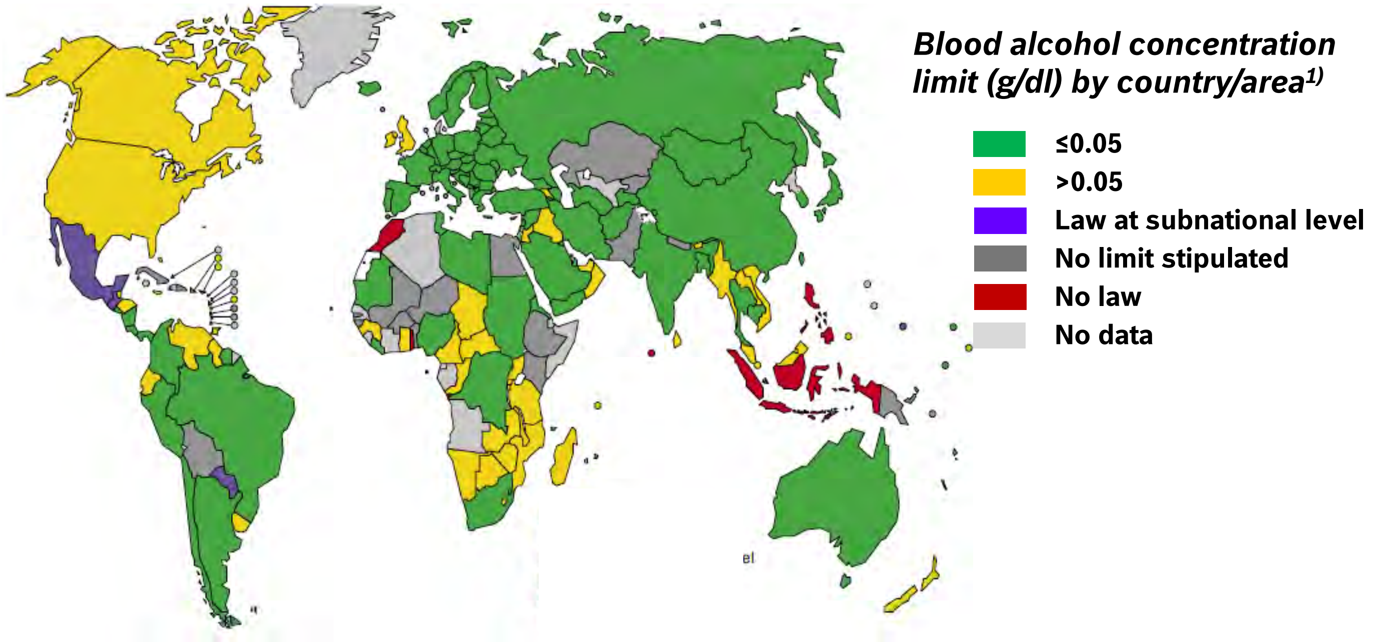


Proportion of alcohol-related fatal crashes in 93 countries[3)]

3) In 90 countries this estimate was based on official data, the source of which is noted in the country profiles. In 3 countries the proportion given is the opinion of the consensus group.

1) Sources: Global status report on road safety 2009
2) Alcohol and Injuries Emergency Department Studies in an International Perspective – WHO 2009 Report (2002 Data)

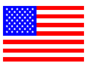
Blood alcohol concentration limits by country for vehicle drivers

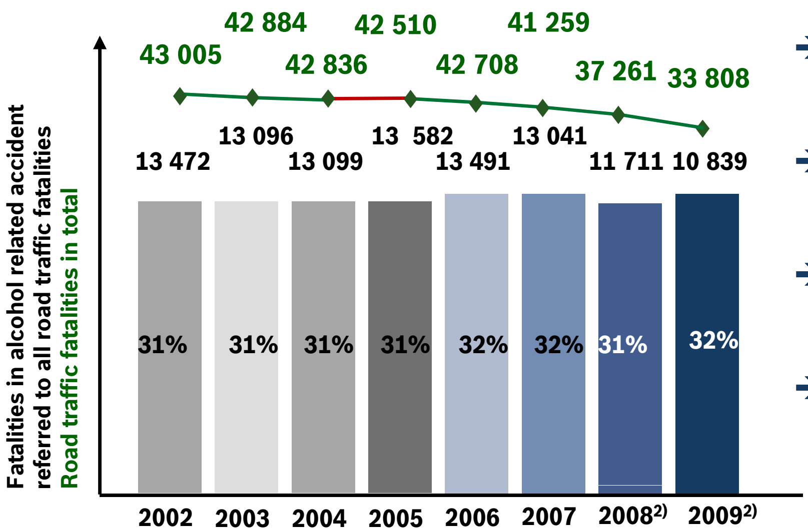


➔ The majority of all countries have a blood alcohol concentration limit ≤ 0.05 g/dl (5‰)

1) Sources: Global status report on road safety 2009

USA





Over the 10 years from 1998 to 2007[1) ...

➔ Driving under the influence increased arrests for women increased by 30%

➔ Driving under the influence increased arrests for men decreased by 7.5%

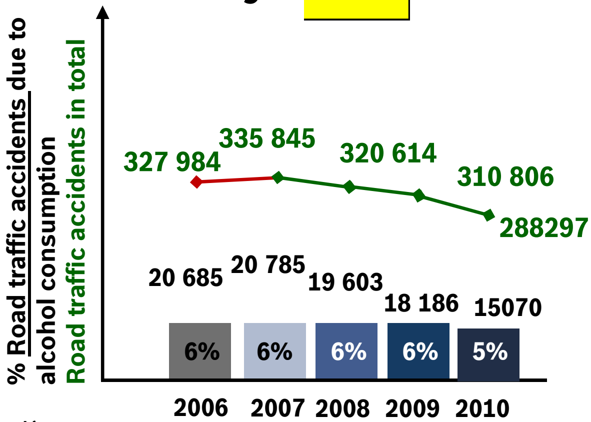
➔ Overall, about 2,000 fatalities a year involve an impaired female driver

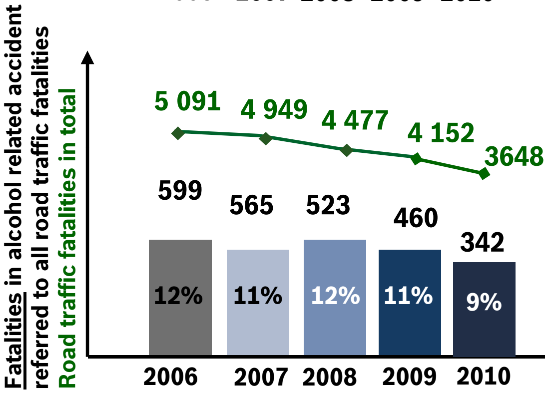
➔ In fatal crashes in 2008, a higher percentage of motorcycle riders had a BAC of 0.08 or higher than any other type of motor vehicle driver in fatal crashes

➔ Alcohol related fatalities is decreasing in number in comparison with the total fatalities but the percentage change in alcohol related fatalities over the decade is almost constant

1) Sources: Global status report on road safety 2009,
2) USA : FARS 1998-2009, Traffic safety facts 2009, BAC Limit +0.08+

Germany



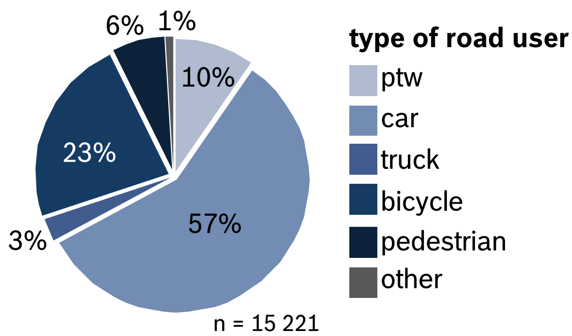


- 2009 data, 20% in cases involving car drivers under the influence of alcohol in the 25-34 age group
- After introduction of the law (August 2007) showed an overall drop of -9% in the first 12 month, compared to the 12 months before
- The number of novice drivers with a BAC level of 0.03% or over was reduced by 15%
- The total number of fatalities and the total number of alcohol related fatalities is decreasing and the percentage change in alcohol related fatalities is almost constant (2006 - 2009)

1) Source: German Federal Statistic, Fachserie 8 Reihe 7 (UJ44)

Germany by Type of Road User (2010)[1)]

alcoholized parties involved in accidents with casualties



type of road user	involved in accidents with casualties		
	total	alcoholized	share
ptw[2)]	*43898*	1480	3.4%
car	*354919*	8734	2.5%
truck	*36568*	416	1.1%
bicycle	*71103*	3489	4.9%
pedestrians	*32145*	975	3.0%

- The biggest groups of registered alcoholized road users involved in accidents with casualties are the drivers of cars (57%) and the bicycle riders (23%).
- Nearly 5% (highest share) of all in accidents with casualties involved bicycle-rider are alcoholized.
- The second largest share is the group rider of powered two wheelers with 3.4% of all in accident with casualties involved riders of powered two wheelers.

1) Source: German Federal Statistic, Fachserie 8 Reihe 7 (UJ44)
2) ptw ... powered two wheeler

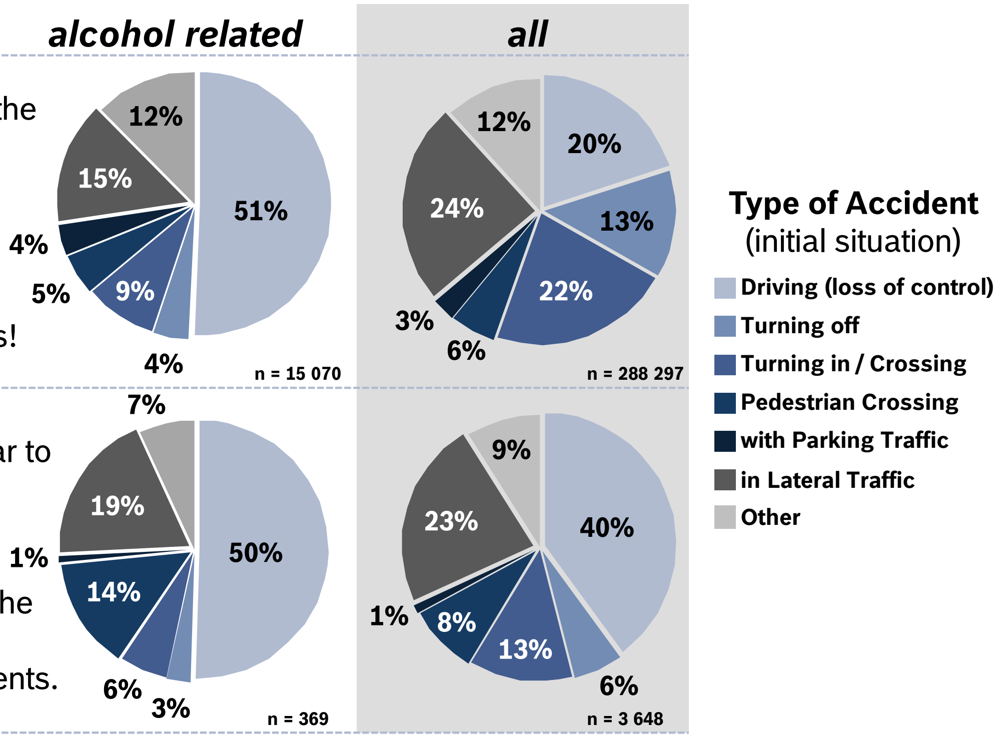
Germany by Type of Accident (2010)[1)]

accidents with casualties

Big difference in the distribution of all accidents with casualties. More than 50% are "loss of control"-accidents!

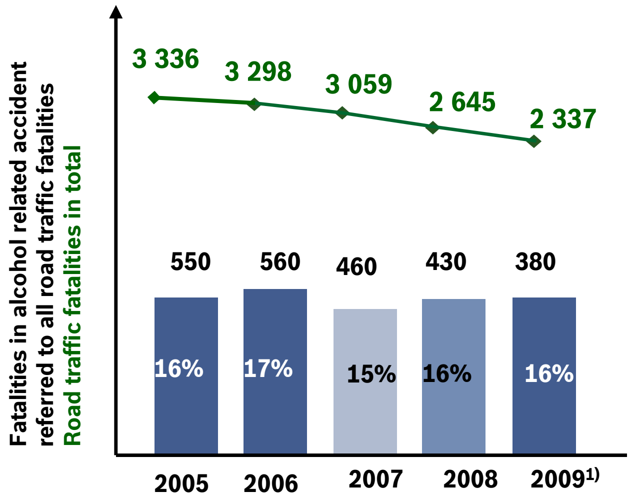
fatalities in accidents

Distribution similar to the distribution of accidents with injuries but also big difference in the distribution of all fatalities in accidents.

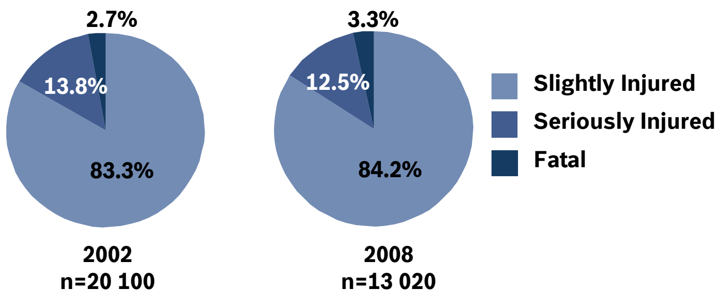


1) Source: German Federal Statistic, Fachserie 8 Reihe 7 (UJ44)

United Kingdom



Total casualties involving alcohol related accidents[2)]

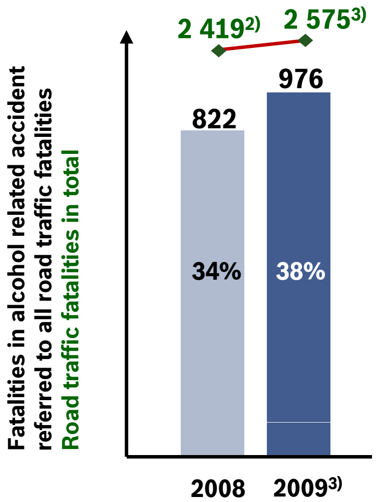


➔ The share of fatalities involving alcohol related accidents is increasing with the fall in number of total casualties involving alcohol related accidents (2002 & 2008)

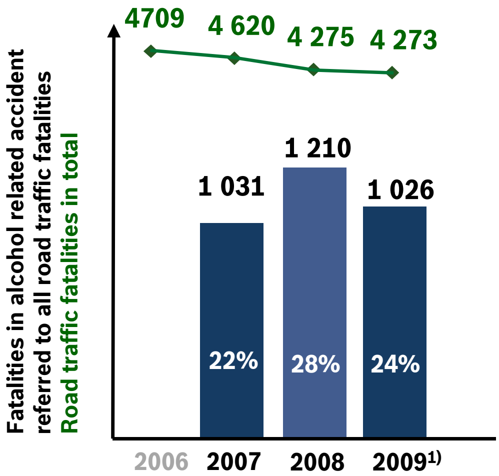
- ➔ The trend shows the total number of fatalities is decreasing and the trend of the share of alcohol related fatalities constant
- ➔ On average, 3,000 people are killed or seriously injured each year in drink-drive collisions [4)]
- ➔ Nearly one in six of all deaths on the road involve drivers who are over the legal alcohol limit[4)]
- ➔ Drinking and driving occurs across a wide range of age groups but particularly among young men aged 17-29
- ➔ On average, there are 200 - 300 road deaths each year associated with blood alcohol levels between 10 - 80mg%[5)]

1)Sources: IRTAD ANNUAL REPORT 2008 & 2009,
2)Reported Road Casualties in Great Britain - 2008: Department of Transport 3.) STATS19
4) Drink Driving Facts UK 5)Nigel Hawkes - Road casualty statistics: up a cul de sac; www.straightstatistics.org

Canada



France



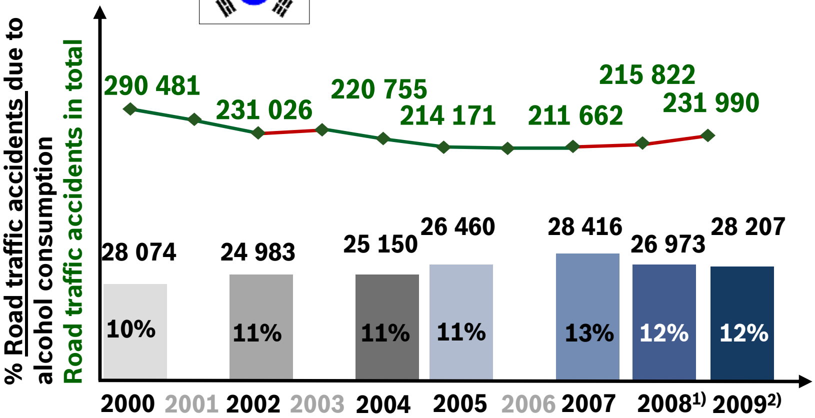
In alcohol related accidents…

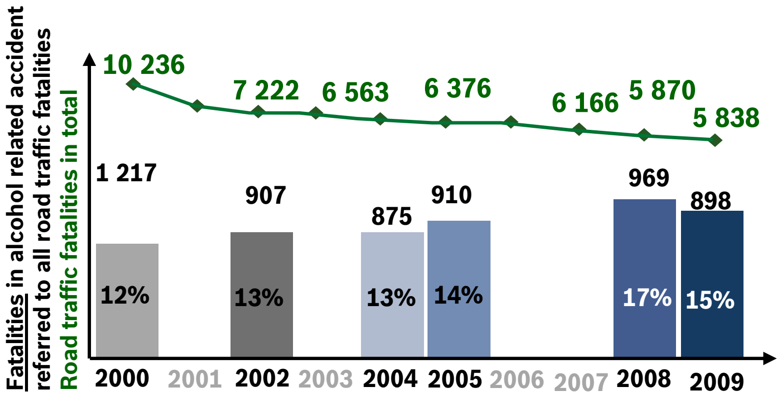
- ➔ In 2006, Nearly 50 % of cases involving fatally injured drivers are in the 25-45 age group[1)]
- ➔ In 2008, more than 45% in cases involving fatally injured drivers are in the 16-45 age group
- ➔ 59% fatally injured drivers are caused by single-vehicle crashes

- ➔ Drink-driving is the first cause of fatalities in France
- ➔ The year 2007 confirms the potential consequences of driving under the influence of alcohol 1 031 deaths and 4 790 injured were hospitalized due to the influence of alcohol[2)]
- ➔ Fatal accidents are more commonly caused by people under the age of 44 [4)]

1)Sources: GLOBAL STATUS REPORT ON ROAD 2009 2)Sources: IRTAD ANNUAL REPORT 2008 & 2009,
3)ALCOHOL-CRASH PROBLEM IN CANADA: 2009, Canadian Council of Motor Transport Administrators
4)WORLD WIDE BREWING ALLIANCE Drinking and Driving Report , 8th edition

Korea

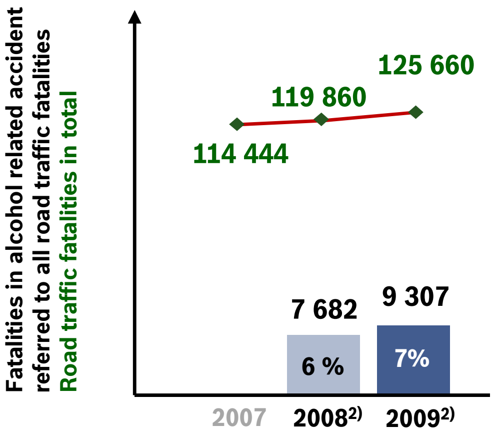




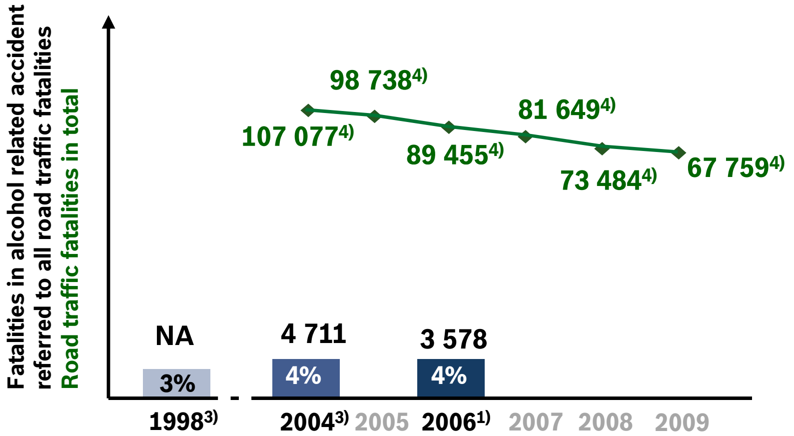
- ➔ The total number of accidents involving alcohol is increasing with the increase in number of total accidents (2007 - 2009)
- ➔ The trend shows the total number of fatal accidents is decreasing but alcohol related fatal accidents is increasing (2000-2009)
- ➔ Driving under the influence of alcohol increased by 9.6% from 2008 to 2009
  (from 26 973 to 28 207 crashes)[1]
- ➔ Fatalities under the influence has been reduced compared to (2008) by 7.3% (from 969 to 898 fatalities)[1)]
- ➔ The group of drivers over the age of 41 years showed a tendency of increased drinking-related accidents during this period[2)]

1)Sources: GLOBAL STATUS REPORT ON ROAD SAFETY 2009
2) Road traffic Accidents in Korea 2009 Report , *IATSS Research Vol.32 No.2, 2008*

India



China



- ➔ Alcohol related fatalities is increasing in number along with the total fatalities
- ➔ Intake of alcohol / drugs by drivers resulted in 27 152 road accidents and 9 307 fatalities
- ➔ As percent share of total accidents and deaths due to "drivers' fault", intake of alcohol/drugs accounted for 7.1% and 10.3% respectively

- ➔ Alcohol related fatalities is decreasing in number in comparison with the decrease in total fatalities with constant percentage share
- ➔ Other Study: A total of 267 severe car accidents were registered in the two cities. 400 drivers involved, 97 were considered to be drinking and driving, which is 25%. 95 were alcohol related, which represents 35.2 percent of the total[5)]

1)Sources: GLOBAL STATUS REPORT ON ROAD
2)TRANSPORT RESEARCH WING MINISTRY OF ROAD TRANSPORT AND HIGHWAYS Report 2008 & 2009
3)WORLD WIDE BREWING ALLIANCE Drinking and Driving Report , 8th edition 4)Traffic accidents, official Yearbook 2008
5) GRSI (Global Road Safety Initiative report by Ann Yuan GRSI coordinator China

Conclusions

- ➔ In North America the share of alcohol related fatalities is 32% with decrease in alcohol related fatalities
- ➔ In Europe, the share of alcohol related fatalities is different (Germany with 11%, UK with 15% and France with 24% share of alcohol related fatalities)
- ➔ In emerging markets (India with 7% share and increasing trend, China with 4% share with decrease in trend of alcohol related fatalities) the possible reason could be of underreporting of alcohol related accidents
- ➔ The countries with relatively high BAC limit as per law, has high percentage share in fatalities related to alcohol related crashes
- ➔ The global trend clearly shows decline in the total number of traffic fatalities (expect India and Canada) but the percentage share of alcohol related fatalities is increasing or constant in many countries, from this study it is evident that 'Road traffic accidents related to alcohol' is a global problem

Accidents at Intersections

– Additional information for function development –

Accident research
CR / AEV1

BOSCH

Accidents at intersections

Aim of this study: Supply of information about situations relevant for intersection assistance and parameters interesting for function development

Method: Analysis is based on accidents with casualties from GIDAS (2001-2008). Accidents at intersections involving at least one car, van or transporter are selected. Accidents at intersections are analyzed subdivided in “collision w/oncoming traffic during left-turn” and “situations caused by ignoring traffic control”. Distributions about different parameters are provided for these accidents.

Result: 17% of all accidents with casualties are relevant for intersection assistance systems (5% collision w/oncoming traffic during left-turn, 12% situations caused by ignoring traffic control).
Most of the accidents relevant for intersection assistance take place inside urban areas at intersections which are ruled by sign. Intersection are mainly big (road width >10m). Nearly 2/3 of the causers do not react before crash, the opponents react a bit more often before crash.

Internal | CR/AEV1-Sulzberger | 01/04/2012 | © Robert Bosch GmbH 2012. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Selection of accidents at intersections

accidents	vehicles	selection criteria	share of accidents
13 899 *(14 046)*	24 451 *(24 414)*	Accidents[1] with casualties and necessary information available[2]	**100%**
11 830 *(11 852)*	17 426 *(16 779)*	Accidents w/ casualties, information available[2] and involving passenger cars, vans or transporters	**85%**
4 688 *(5 337)*	6 638 *(7 286)*	Turning off, turning in or crossing accidents (type 2 or 3) selected by applying Accident Classification System[3] from GDV	**34%**
3 942 *(4 405)*	3 942 *(4 405)*	Turning off, turning in or crossing accidents (type 2 or 3) caused by passenger cars, vans or transporters	**28%**

→About 28% of all accidents with casualties in Germany are turning off, turning in or crossing accidents caused by a car, van or transporter!

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
2) accident is excluded if necessary information (vehicle kind, accident type and causer) for all involved vehicles is not available or unknown
3) for more information about accident types please refer to slide in appendix

BOSCH

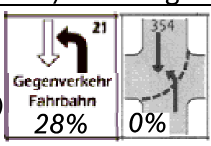
Detailed look at turning off, turning in or crossing accidents[1] caused by cars, vans or transporters

3 942 *(4 405)* set to **100%**

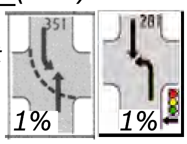
- *relevant[2]* (left turn (a); traffic control (b)): **2 398** *(2 577)* — **61%**, set to *100%*
- *not relevant[2]*: 1 484 *(1 750)* — **38%**, set to *100%*
  - *rear-end crashes*
  - *crashes caused by mistakes in lateral guidance or in finding the lane* — *26%*
  - *impacts with pedestrians or cyclists from cycle paths* — *74%*
- *relevance[2] unknown*: 60 *(78)* — **1%**, *2-digit type not known*

(a) collision w/oncoming traffic during left-turn (30%)

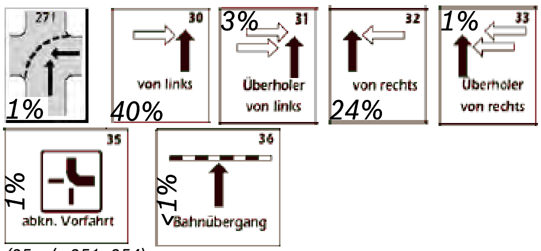
(a1) vehicle turning to the left does not have the right of way (28%)



(a2) vehicle turning to the left has the right of way (2%)



(b) situations caused by ignoring traffic control (70%)



(35 w/o 351, 354)

→About 60% of intersection accidents caused by cars, vans or transporters are collisions w/oncoming traffic during left-turn or "traffic control-situations"

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type; absolute number in italics
2) classification concerning relevance because of intended functions, for more information about accident types please refer to slide in appendix

BOSCH

Analysis of relevant accidents[1)] for function development

1) Traffic control

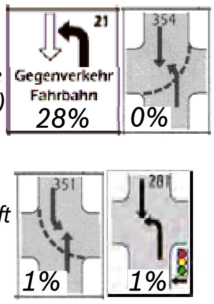
2 398
(2 577)

(a) collision w/oncoming traffic during left-turn (30%)

(b) situations caused by ignoring traffic control (70%)

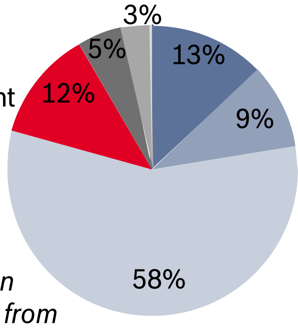
(a1) vehicle turning to the left does not have the right of way (28%)

(a2) vehicle turning to the left has the right of way (2%)



based on 722 weighted accidents
(absolute number: 768 accidents)

- traffic lights
- priority to the right
- give way
- stop
- vehicle from property
- others *(pedestrian crossing, vehicle from playstreet,…)*



based on 1676 weighted accidents
(absolute number: 1809 accidents)

→In most collisions w/oncoming traffic during left-turn the vehicle turning to the left does not have the right of way

→About 70% of the "classic" intersection accidents happen at intersections directed by signs (stop/give way)

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type

2) Accident Site

2 398
(2 577)

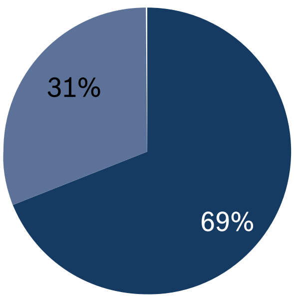
(a) collision w/oncoming traffic during left-turn

(a1) left turning-vehicle does not have the right of way (28%)

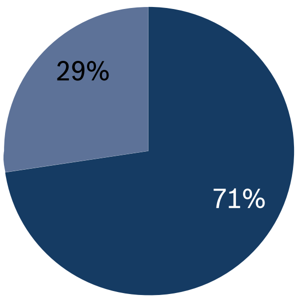
(a2) left turning-vehicle has the right of way (2%)

(b) situations caused by ignoring traffic control (70%)

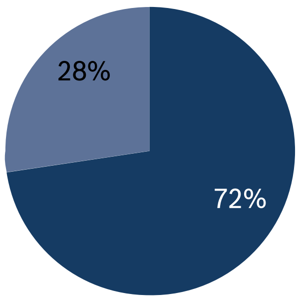
- urban area
- rural area



based on 670 weighted accidents[1)]
(absolute number: 714 accidents)



based on 52 weighted accidents[1)]
(absolute number: 54 accidents)



based on 1676 weighted accidents[1)]
(absolute number: 1809 accidents)

→For all types of relevant intersection situations the share of accidents happening in urban areas takes more than ⅔

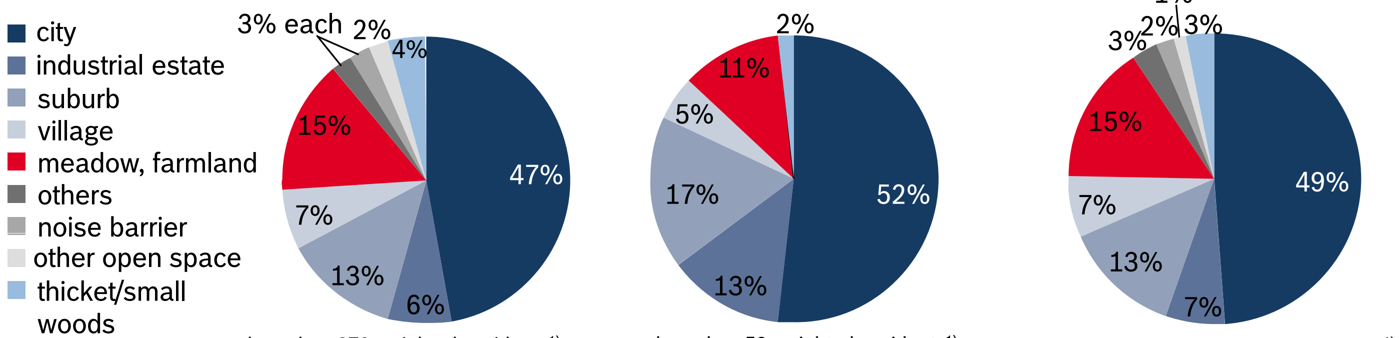
1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type

3) Environment

2 398
(2 577)

(a) collision w/oncoming traffic during left-turn

(a1) left turning-vehicle does not have the right of way (28%) | *(a2) left turning-vehicle has the right of way (2%)* | *(b) situations caused by ignoring traffic control (70%)*



based on 670 weighted accidents[1)]
(absolute number: 714 accidents)

based on 52 weighted accidents[1)]
(absolute number: 54 accidents)

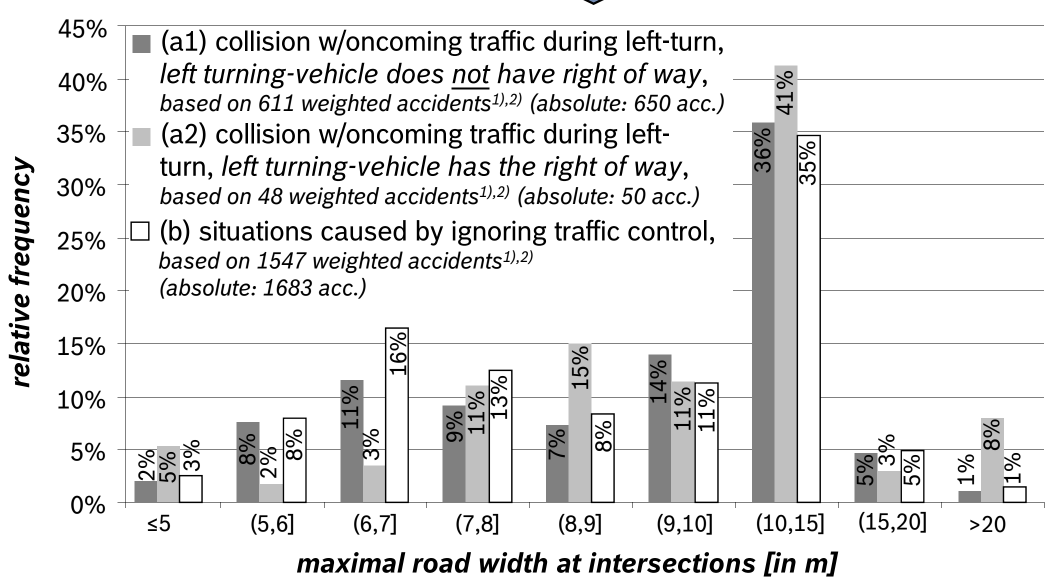
based on 1676 weighted accidents[1)]
(absolute number: 1809 accidents)

→The distribution about the environment is almost the same for (a1) & (b) accidents, for (a2) it is different probably caused by small numbers
→About 75% of the relevant accidents happen in built-up areas

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type

4) Road width

2 398
(2 577)



→The relative frequencies about the road width are similar for collisions w/oncoming traffic during left-turn and for "classic" intersection situations
→More than 40% of the situations each happen on roads wider than 10m

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type
2) for the rest of the accidents the road width is not known

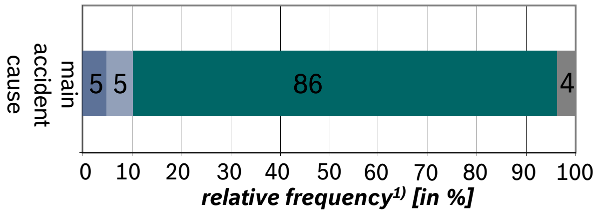
5) Detailed look at accidents with cause for accident causing vehicle "turning off, turning, reversing" or "right of way"

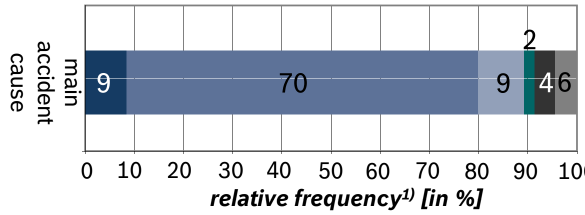
2 398 *(2 577)*

(a) collision w/oncoming traffic during left-turn[2] (30%) | (b) situations caused by ignoring traffic control (70%)

accidents caused by cars, vans or transporters with known initial and collision speed: **722** *(768)* | **1 676** *(1 809)*

accidents with main cause, 1st, 2nd, 3rd or 4th cause of accident causing car, van or transporter: "turning off, turning, reversing" or "right of way": 96% **695** *(741)* | **1 618** *(1 757)* 97%





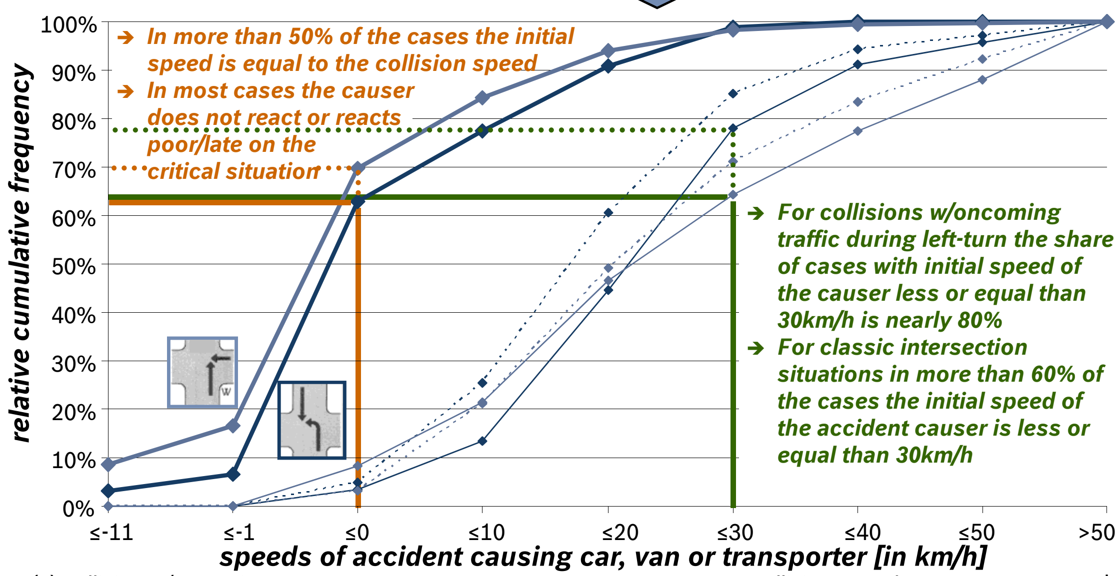
- disregarding the traffic regulation: priority to the right
- disregarding the direction of traffic regulation by traffic lights or police officers
- disregarding the traffic regulation signs (give way)
- mistake during turning[3]
- failure during joining the flowing traffic
- rest (summed up), e.g.

→Intersection situation (a) is mainly caused by mistakes during turning and situation (b) by disregarding the traffic regulation signs (give way)

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type
2) joint consideration of (a1) & (a2)
3) mistake during turning includes situation in which the right of way of the oncoming traffic is ignored by the left turning vehicle, cp. appendix

6) Speeds of accident causing car, van or transporter

2 398 *(2 577)*



In both situations:
→ the initial & collision speed of the accident causer is often equal (>60%)

- (a) collision w/oncoming traffic during left-turn, joint consideration of (a1) & (a2)
- (b) situations caused by ignoring traffic control

— initial speed
(a) 633 weigh. acc.[1),2)] (abs.: 676)
(b) 1447 weigh. acc. [1),2)] (abs.: 1543)

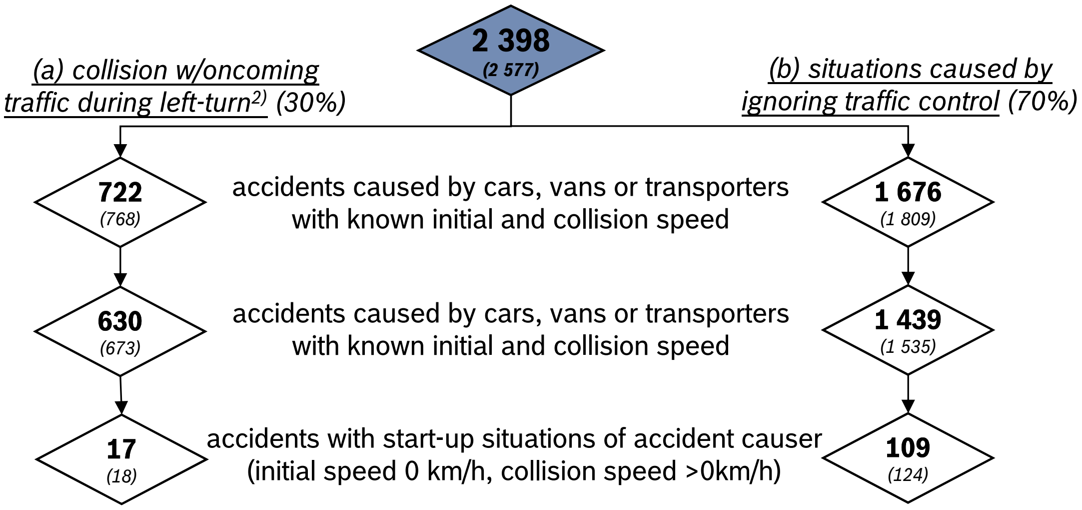
- - - collision speed
(a) 690 weigh. acc. [1),2)] (abs.: 732)
(b) 1612 weigh. acc. [1),2)] (abs.:1738)

— delta of speeds*
(a) 630 weigh. acc.[1),2)] (abs.: 673)
(b) 1439 weigh. acc.[1),2)] (abs.: 1535)

*initial speed - collision speed; this not necessarily the maximal delta in this period of time
Example: The car stands still (initial speed =0 km/h), accelerates, starts decelerating when the driver realizes the opponent and decelerates until colliding with a specified speed. The maximal speed is achieved directly before the deceleration starts, but this information is not documented.

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data
2) For the rest of the accidents the speeds are not known

7) "Start up-situations" of accident causer



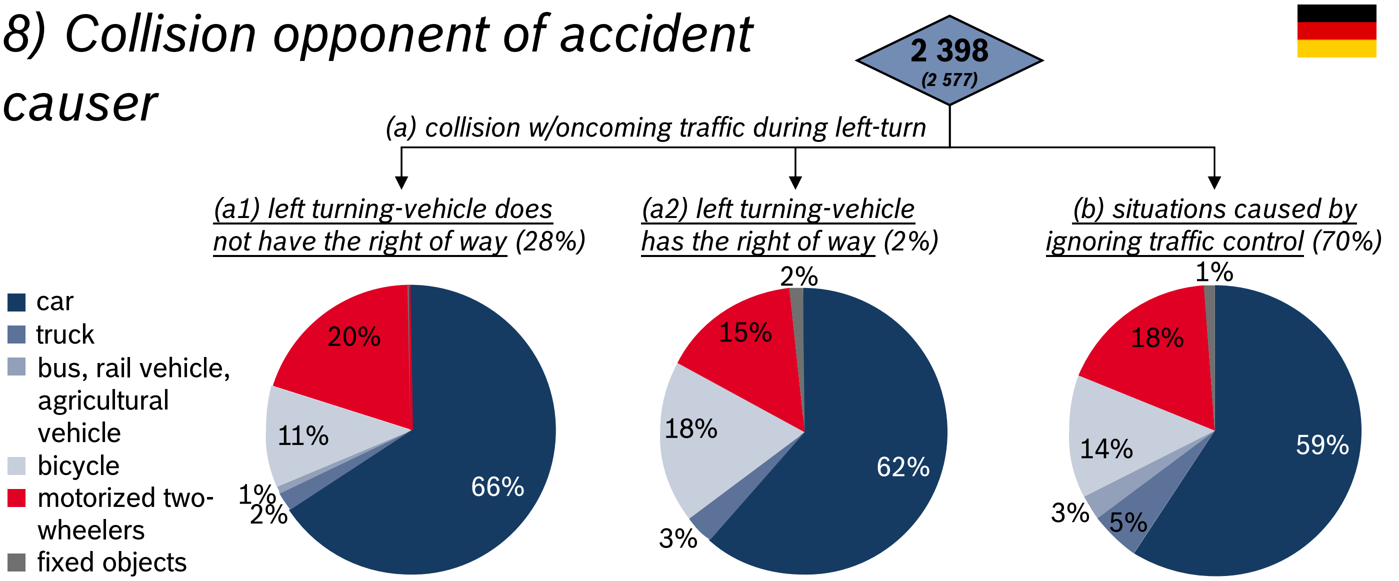
→In ~2% of the relevant collision w/ oncoming traffic during left-turn the accident causing car, van or transporter stands still before and accelerates by the crash

→In ~7% of the relevant "classic" intersection situations the accident causing car, van or transporter stands still before and accelerates by the crash

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type
2) joint consideration of (a1) & (a2)

BOSCH

8) Collision opponent of accident causer



based on 670 weighted accidents[1)]
(absolute number: 714 accidents)

based on 52 weighted accidents[1)]
(absolute number: 54 accidents)

based on 1676 weighted accidents[1)]
(absolute number: 1809 accidents)

→The distribution about the collision opponents are similar for (a1), (a2) & (b)
→In nearly 2/3 of the situations the opponent is another car and in nearly 1/5 the opponent is a powered two-wheeler

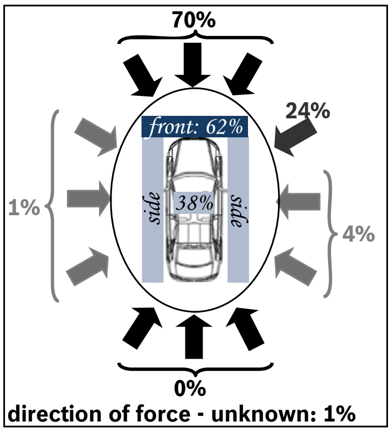
1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type

BOSCH

9) Main damaged vehicle part & direction of force in initial collision of accident causer

2 398
(2 577)

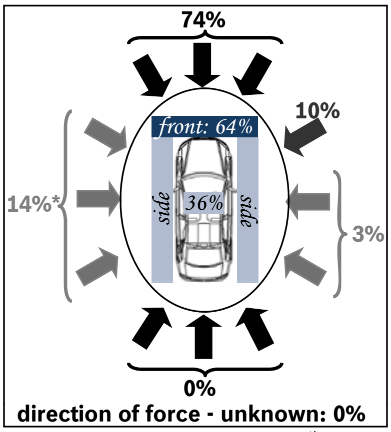
(a1) left turning-vehicle does not have right of way (28%)



based on 670 weighted accidents[1)]
(absolute number: 714 accidents)

- ➔ **Mainly front is damaged**
- ➔ **The direction of force is: in more than 70% from front, in more than one fifth from 2 o'clock**

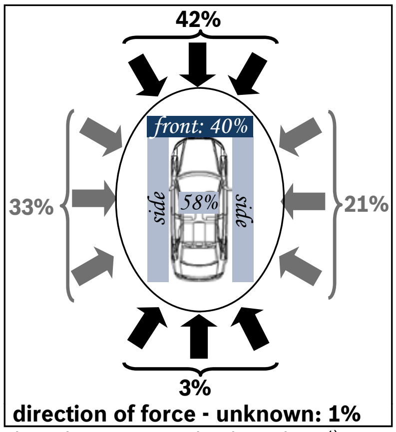
(a2) left turning-vehicle has right of way (2%)



based on 52 weighted accidents[1)]
(absolute number: 54 accidents)

- ➔ **Mainly front is damaged**
- ➔ **The direction of force is: in more than 70% from front, in more than 10% from 9 o'clock**

(b) situations caused by ignoring traffic control (70%)



based on 1676 weighted accidents[1)]
(absolute number: 1809 accidents)

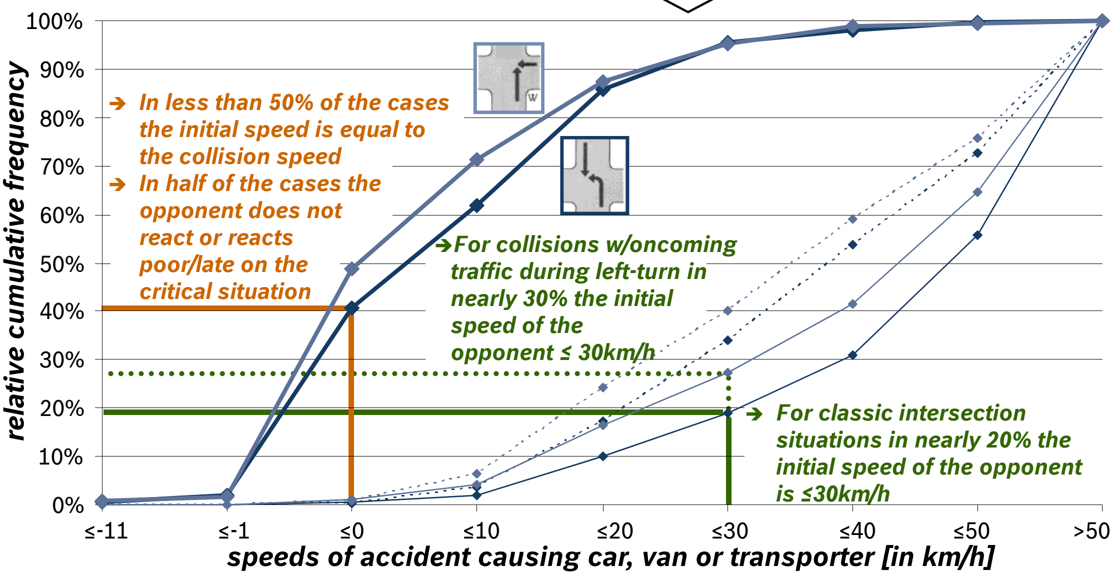
- ➔ **Mainly side is damaged**
- ➔ **The direction of force is: in more than half from side, in more than 40% from front**

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type
* The causer is the vehicle which turns to the left, e.g. on a traffic light controlled crossing the causer can be a person who ignores the red light for driving straight and crashes into a vehicle which turns to the left, cp. accident type sketches on slide 4

10) Speeds of 1st opponent of accident causing car, van or transporter

2 398
(2 577)

2 378
(2 560)
accident causer's opponent is a vehicle



- ➔ **Compared to the causer the initial speed of the opponent and the share of cases in which the driver does not react or reacts late is smaller**

◆ (a) collision w/oncoming traffic during left-turn, joint consideration of (a1) & (a2)
◆ (b) situations caused by ignoring traffic control

— initial speed
(a) 638 weigh. acc.[1),2)] (abs.: 672)
(b) 1420 weigh. acc. [1),2)] (abs.: 1532)

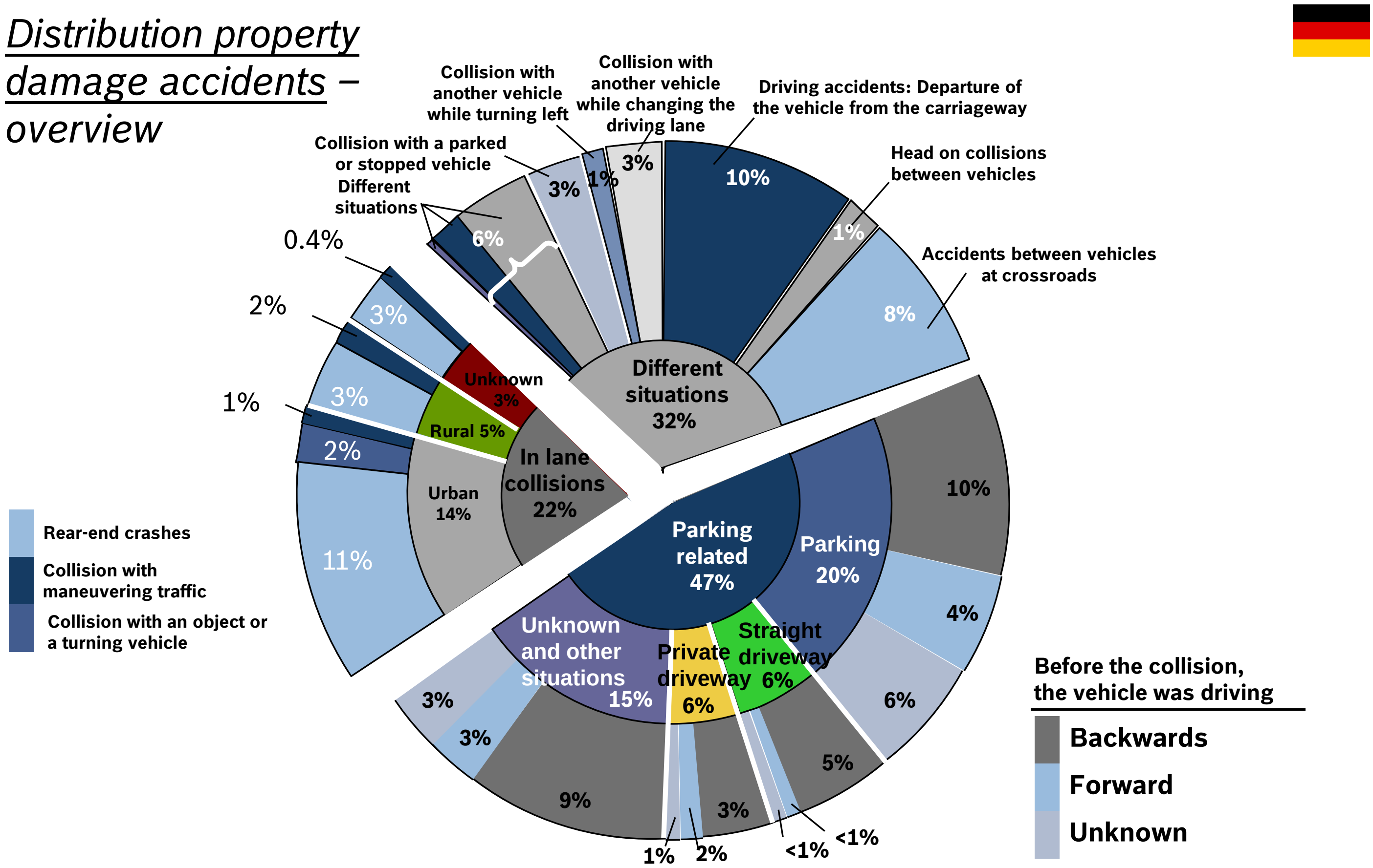
- - - collision speed
(a) 683 weigh. acc. [1),2)] (abs.: 723)
(b) 1580 weigh. acc. [1),2)] (abs.:1713)

▬ delta of speeds*
(a) 630 weigh. acc.[1),2)] (abs.: 664)
(b) 1408 weigh. acc.[1),2)] (abs.: 1519)

*initial speed - collision speed; this not necessarily the maximal delta in this period of time
Example: The car stands still (initial speed =0 km/h), accelerates, starts decelerating when the driver realizes the opponent and decelerates until colliding with a specified speed. The maximal speed is achieved directly before the deceleration starts, but this information is not documented.

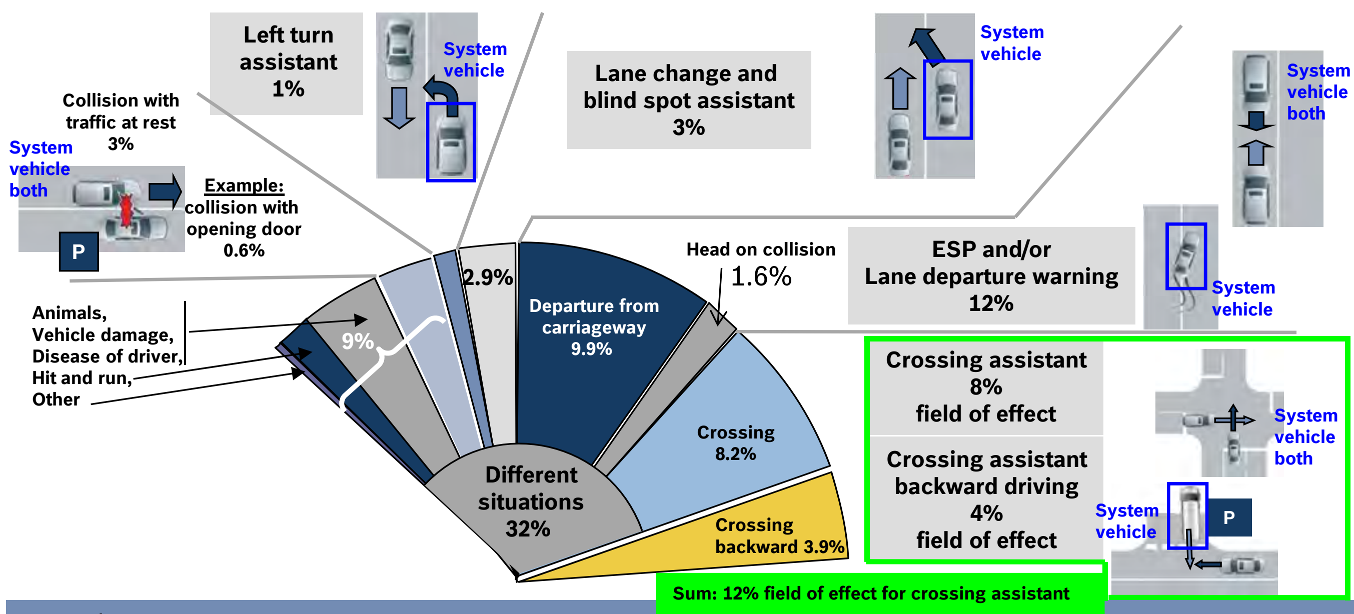
1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data
2) For the rest of the accidents the speeds are not known

Distribution property damage accidents – overview



Source: Allianz Zentrum für Technik, 3985 accidents (2004, 2007)

Distribution property damage accidents - relevance of assistance systems



- ESP/ Lane departure warning could address 12% of property damage accidents
- A system for crossing situations could address 12% of all property damages
- Assistance in crossroad situations could address 8% of property damage accidents
- A system assisting while leaving a parking slot backwards and crossing could address 4% of property damages

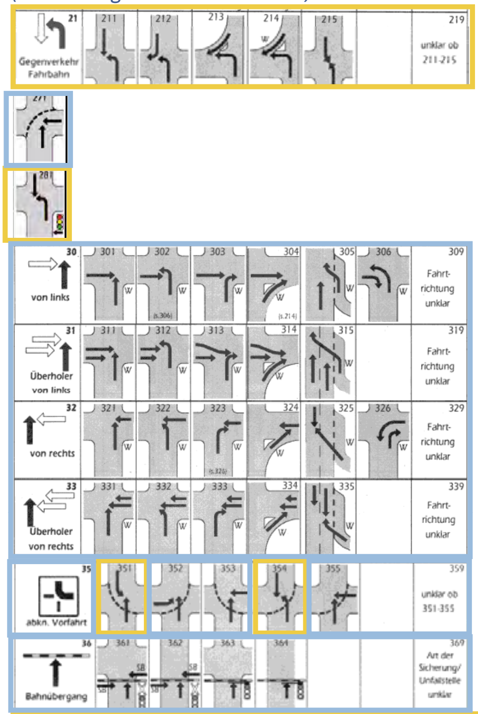
Source: Allianz Zentrum für Technik, 3985 accidents (2004, 2007)

Accidents at intersections

Sketches to GDV accident type definitions describing turning off, turning in or crossing accidents

relevant

(contributing factor: traffic control)

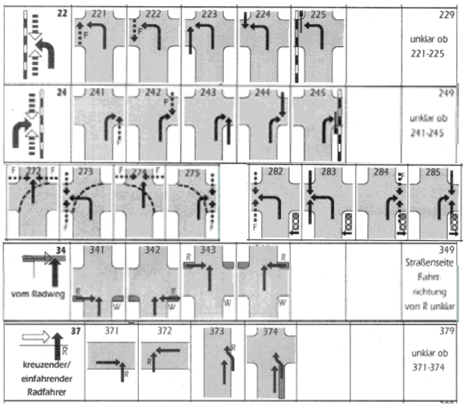


a) collision w/oncoming traffic during left-turn + 351, 354

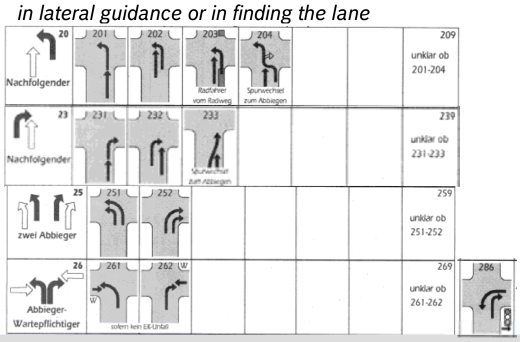
b) situations caused by ignoring traffic control (35 w/o 351, 354)

not relevant

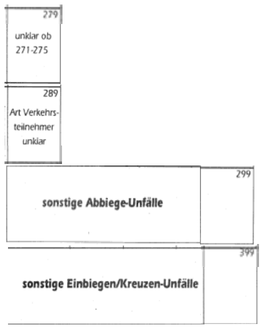
- *impacts with pedestrians or with cyclists from cycle paths*



- *rear-end crashes or crashes caused by mistakes in lateral guidance or in finding the lane*



relevance unknown

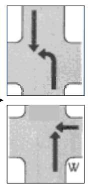


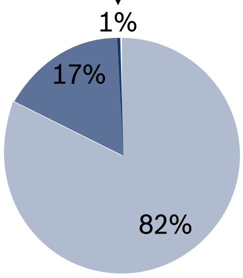
Accidents at intersections

Severity of relevant accidents for function development compared with the distribution in all accidents

accidents[1] with collisions w/oncoming traffic during left-turn (a) or with situations caused by ignoring traffic control (b)

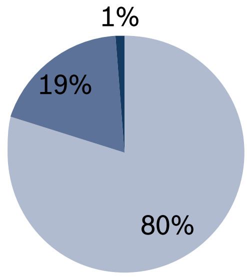
2 398 *(2 577)*





all accidents[2] with casualties

310 806



accidents involving...
- fatally injured persons
- seriously injured persons
- slightly injured persons

→Accidents at intersections relevant for function development do not differ clearly concerning the injury severity!

1) German In-Depth Accident Study, 2001-2009; reconstructed, weighted data by accident severity, location and type
2) Statistisches Bundesamt, Fachserie Verkehr 2009

Accidents at intersections

List of accident causes[1)]

No.	Denomination of cause
	Driving fitness
01	Influence of alcohol
02	Influence of other intoxicating substances (e.g. drugs, narcotics)
03	Overfatigue
04	Other physical or mental faults
	Improper driving
	Use of the road
10	Use of wrong carriageway (or lane) or unlawful use of other parts of the road
11	Violation of the rule of driving on the right side
	Speed
	Unadapted speed
12	and exceeding at the same time the speed limit
13	in other cases
	Distance
14	Insufficient safety distance (Other causes leading to a traffic accident should be allocated to the respective positions, such as speed, overfatigue, etc.)
15	Abrupt braking without compelling reason by the vehicle in front
	Overtaking
16	Unlawful right-hand overtaking
17	Overtaking in spite of oncoming traffic
18	Overtaking in spite of unclear traffic situation
19	Overtaking in spite of insufficient visibility
20	Overtaking without observing the rear traffic and/or without timely and clearly indicating the intention to swerve out
21	Mistake made when returning to right lane
22	Other mistakes made when overtaking (e.g. without sufficient lateral distance; at pedestrian crossings, (cf. pos. 38, 39)
23	Mistakes made when being overtaken
	Driving past
24	Failure to observe the priority of oncoming cars when driving past stationary vehicles, barriers or obstacles (§ 6) (except pos. 32)
25	Failure to observe the rear traffic when driving past stationary vehicles, barriers or obstacles and/or without timely and clearly indicating the intention to swerve out
	Driving side by side
26	Incorrectly changing the lane when driving side by side or failure to observe the "zip method" (merging of two queues with alternate priority of the respective cars (§ 7) (except pos. 20, 25)
	Priority, precedence
27	Failure to observe the rule "right has priority over left"
28	Failure to observe the traffic signs regulating the priority (§ 8) (except pos. 29)
29	Failure to observe the priority of the passing traffic on motorways or motor vehicle roads (§ 18, para. 3)
30	Failure to observe the priority by vehicles coming from dirt roads
31	Failure to observe the traffic control by policemen or traffic lights (except pos. 39)
32	Failure to observe the priority of oncoming vehicles (traffic sign No. 208 of Road Traffic Regulations)
33	Failure to observe the priority of rail vehicles at railway crossings
	Turning, U-turn, reversing, entering the flow of traffic, starting off the edge of the road
35	Mistakes made when turning (§ 9) (except pos. 33, 40)
36	Mistakes made when making U-turn or reversing
37	Mistakes made when entering the flow of traffic (e.g. from premises, from another part of the road or when starting off the edge of the road)
	Improper behaviour towards pedestrians
38	at pedestrian crossings
39	at central islands
40	when turning
41	at stops (also at school busses stopping with the warning flasher device flashing)
42	at other places
	Stationary vehicles, safety measures
43	Unlawful stopping or parking
44	Insufficient safety measures in the case of vehicles stopping or broken down and accident sites or with regard to school busses with children getting on or off the bus
45	Behaviour contrary to traffic regulations when getting on or off a vehicle, loading or unloading
46	**Failure to observe lighting regulations (except pos. 50)**
	Load, number of passengers
47	Overload, maximum number of passengers exceeded
48	Insufficient safety measures with regard to load or vehicle accessories
49	**Other mistakes made by driver**
	Technical or maintenance faults
50	Lighting
51	Tyres
52	Brakes
53	Steering mechanism
54	Towing equipment
55	Other faults
	Improper behaviour of pedestrians
	Improper behaviour when crossing the carriageway
60	at places where the pedestrian traffic was controlled by policemen or traffic lights
61	on pedestrian crossings without control by policemen or traffic lights
62	near junctions, traffic lights or pedestrian crossings with heavy traffic
	at other places:
63	by suddenly emerging from behind obstacles obstructing the visibility
64	without paying attention to the traffic
65	by other improper behaviour
66	**Failure to use footway**
67	**Failure to use proper side of the road**
68	**Playing on or near carriageway**
69	**Other improper behaviour of pedestrians**
	Road surface conditions
	Slippery carriageway
70	Impurity through oil leakage
71	Other impurities caused by road users
72	Snow, ice
73	Rain
74	Other influences (among others, leaves, loam washed up)
	Road condition
75	Grooves in connection with rain, snow or ice
76	Other road condition
77	**Irregular condition of traffic signs or installations**
78	**Insufficient road lighting**
79	**Insufficiently secured railway crossings**
	Influence of the weather
	Obstruction of visibility by:
80	Fog
81	Heavy rain, hail, flurry of snow and the like
82	Dazzling sunshine
83	**Side wind**
84	**Storm or other weather influences**
	Obstacles
85	Road construction site on carriageway not or not sufficiently secured
86	Wild animals on the carriageway
87	Other animal on the carriageway
88	Other obstacle on the carriageway (except pos. 43, 44)
89	**Other causes** (list and briefly describe)

1) Statistisches Bundesamt, Fachserie Verkehr 2009

Excursus: Injury severity of car occupants in intersection accidents

Accident research
CR / AEV1

Selection of relevant accidents at intersections

accidents weighted number *(absolute number)*	selection criteria	share related to all accidents
18 091 *(18 135)*	Accidents[1) with casualties and necessary information available[2)	**100%**
15 185 *(15 392)*	and involving passenger cars, vans or transporters	**84%**
7 185 *(8 119)*	and at junctions, crossings, roundabouts or property exits	**40%**
6 057 *(7 027)*	and collision with another ... a) *...vehicle moving ahead or waiting*, b) *...vehicle moving laterally in the same direction*, c) *...oncoming vehicle* or d) *...vehicle which turns into or crosses a road*	**33%**

➔ One third of all accidents with casualties in Germany involving a car, van or transporter, happen at intersections and vehicles collide with each other in a suitable configuration!

1) German In-Depth Accident Study, 2001-2011; complete cases, weighted data by accident severity, location and kind;
2) accident is excluded if necessary information (vehicle kind, location) for all involved vehicles is not available or unknown

BOSCH

Accidents at intersections: distribution of max. occurring injury severity of car occupants subdivided in accident site

Accidents[1) with casualties at intersections involving cars, vans or transporters colliding with another vehicle: **6 057** *(7 027)*

share related to all accidents: 33%

Subdivision in accident site

- rural: **1 228** *(708)* — **20%**
- urban: **4 829** *(6 319)* — **80%**

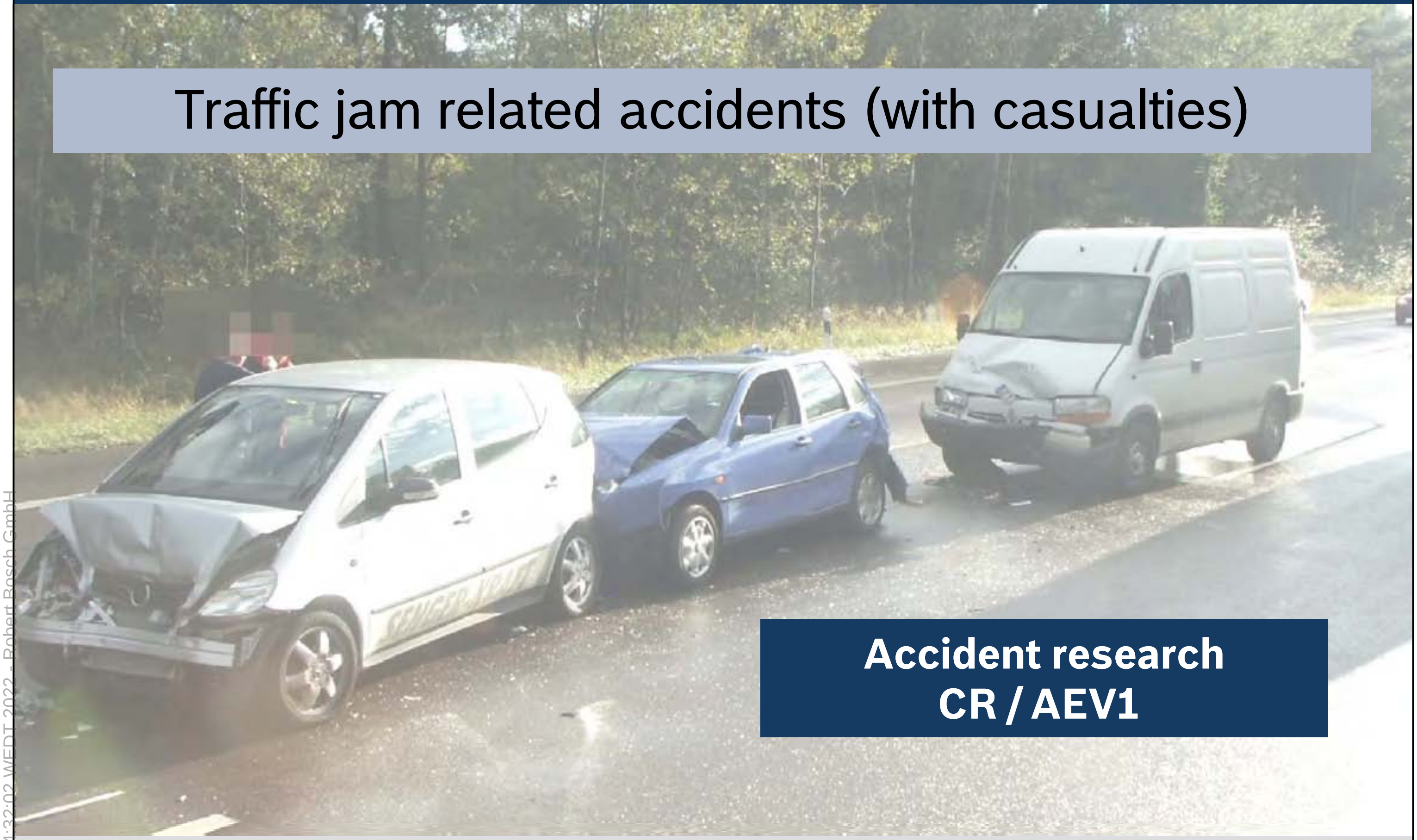
Distribution about maximal occurring injury severity on AIS-level of car occupants in accident

	AIS 0	AIS 1	AIS 2	AIS 3	AIS 4	AIS 5	AIS 6	unknown
rural	23% 282 *(167)*	54% 667 *(350)*	14% 175 *(120)*	2% 19 *(14)*	1% 10 *(8)*	1% 6 *(6)*	<1% 3 *(2)*	5% 66 *(41)*
urban	57% 2745 *(3745)*	36% 1751 *(2069)*	4% 192 *(299)*	<1% 17 *(33)*	<1% 2 *(4)*	<1% 3 *(7)*	0% 0 *(0)*	2% 119 *(162)*

1) German In-Depth Accident Study, 2001-2011; complete cases, weighted data by accident severity, location and kind;
absolute number in italics

BOSCH

Traffic jam related accidents (with casualties)



**Accident research
CR / AEV1**

BOSCH

Aim of this study: Collection of fundamental information about traffic jam related accidents.
Determination of several characteristics like time, location, severity and vehicle involvement in traffic jam related accidents.

Method: Analysis of accidents[1) with casualties in Germany to determine the field of effect. The accidents were based on the description of accident and the accident type is determined partly by case analysis.

Results: Approximately 11,000 accidents with causalities (3.7% of all accidents with casualties) per year in Germany are traffic jam related. Around 72 % of these accidents occur in non-urban areas and in nearly 2/3 of all traffic jam related accidents the oncoming traffic is separated constructionally.

1) Source: GIDAS 2001-2011, weighted data for Germany

Internal | CR/AEV1 - Mönnich | 2011/10/20 | AEV064 annual report 2011 | © Robert Bosch GmbH 2012. All rights reserved, also regarding any disposal, exploitation, reproduction, editing, distribution, as well as in the event of applications for industrial property rights.

BOSCH

Selection of relevant situations

accidents[1)]	share of all accidents / share of traffic jam related accidents	selection criteria
19 533 *(18 188)*	100 %	Accidents with casualties and vehicle involvement
5 134 *(3 874)*	26.3 %	Accidents in longitudinal traffic or U-turns *(overview about relevant accident types see appendix)*
728 *(499)*	3.7 % / 100 %	Traffic jam relevant situation *(single case analysis: criteria see appendix)*
96 *(69)*	0.5 % / 13%	Accident **in** traffic jam
632 *(430)*	3.2 % / 87 %	Accident **at the end of** traffic jam

Approximately 11,000 (3.7%) traffic jam related accidents with causalities per year in Germany.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Location of accident

accidents[1)]	share of all accidents / share of traffic jam related accidents	selection criteria
728 *(499)*	3.7 % / 100 %	Traffic jam relevant situation *(single case analysis: criteria see appendix)*
204 *(164)*	1.0 % / 28 %	urban area
200 *(123)*	1.0 % / 27 %	rural area
324 *(212)*	1.7 % / 45 %	on motorways

Around 72 % of traffic jam related accidents with causalities in Germany occur in non-urban areas.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Light conditions

accidents[1]	share of all accidents / share of traffic jam related accidents	selection criteria
728 *(499)*	**3.7 %** / 100 %	Traffic jam relevant situation *(single case analysis: criteria see appendix)*
596 *(411)*	**3.0 %** / 82%	at daylight
65 *(44)*	**0.3 %** / 9 %	in the darkness
67 *(44)*	**0.3 %** / 9 %	at sunrise or sunset

Around 82 % of traffic jam related accidents with causalities in Germany occur at daylight.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

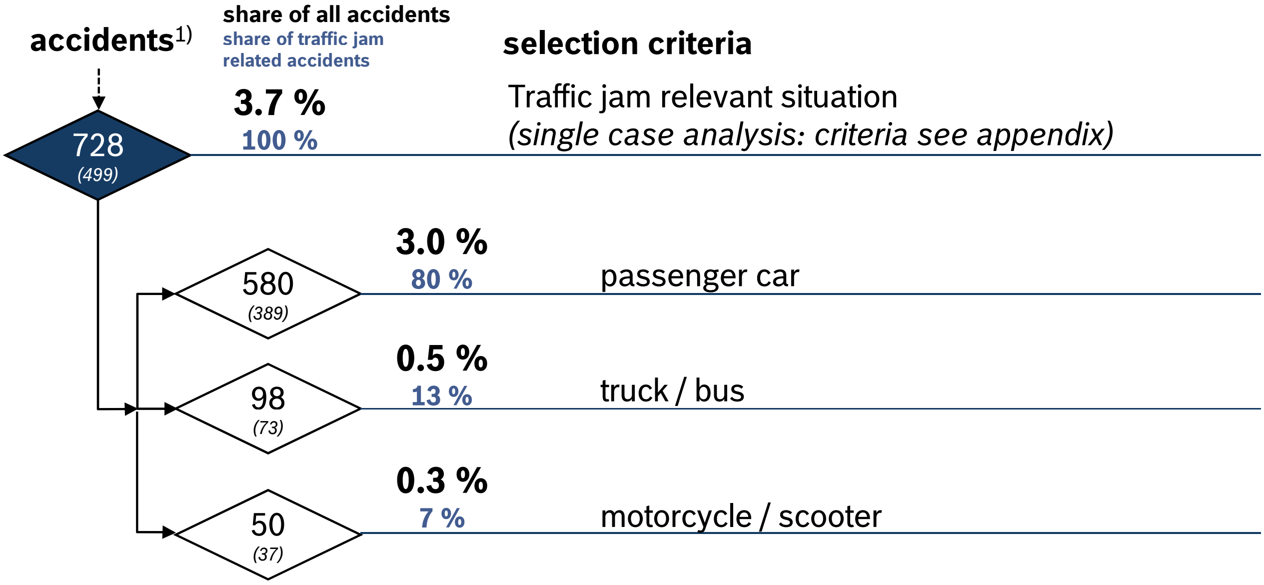
Injury Severity

accidents[1]	share of all accidents / share of traffic jam related accidents	selection criteria
728 *(499)*	**3.7 %** / 100 %	Traffic jam relevant situation *(single case analysis: criteria see appendix)*
626 *(378)*	**3.2 %** / 86%	with max. slightly injured persons
96 *(111)*	**0.5 %** / 13 %	with max. seriously injured persons
6 *(9)*	**<0.1 %** / 1 %	with fatalities

In around 86 % of all traffic jam related accidents only slight injuries occur in all accidents with causalities in Germany.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Type of accident causing vehicle

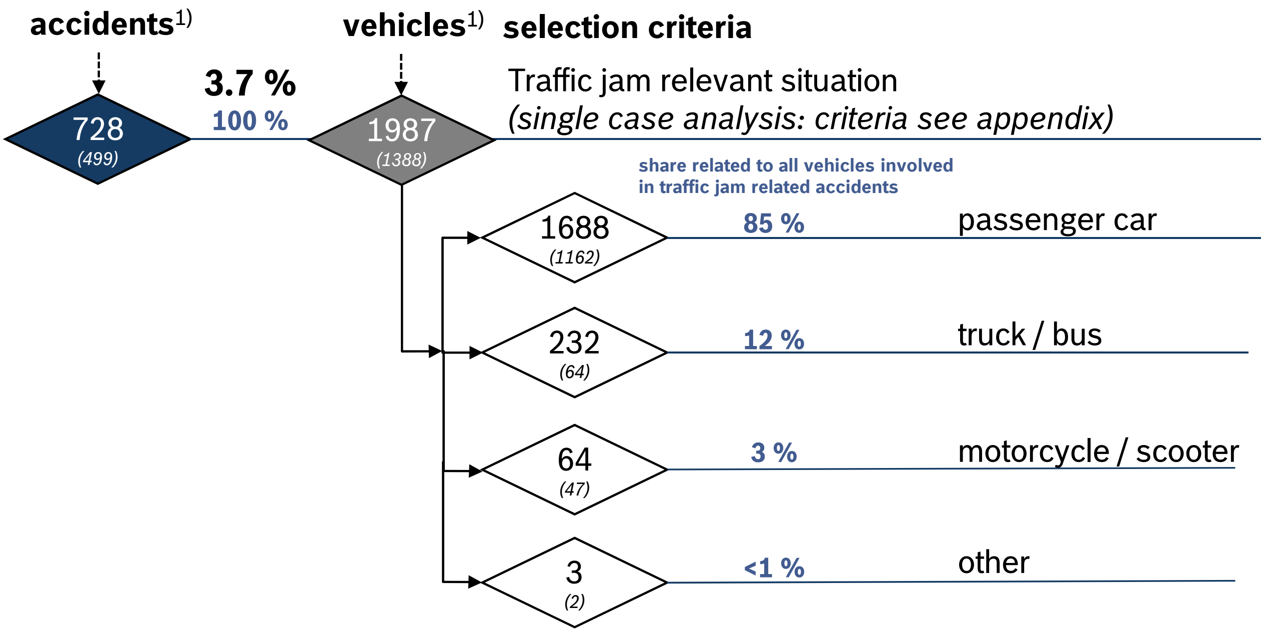


80 % of traffic jam related accidents are caused by a passenger car.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Traffic jam related accidents (with casualties) Chapter 16

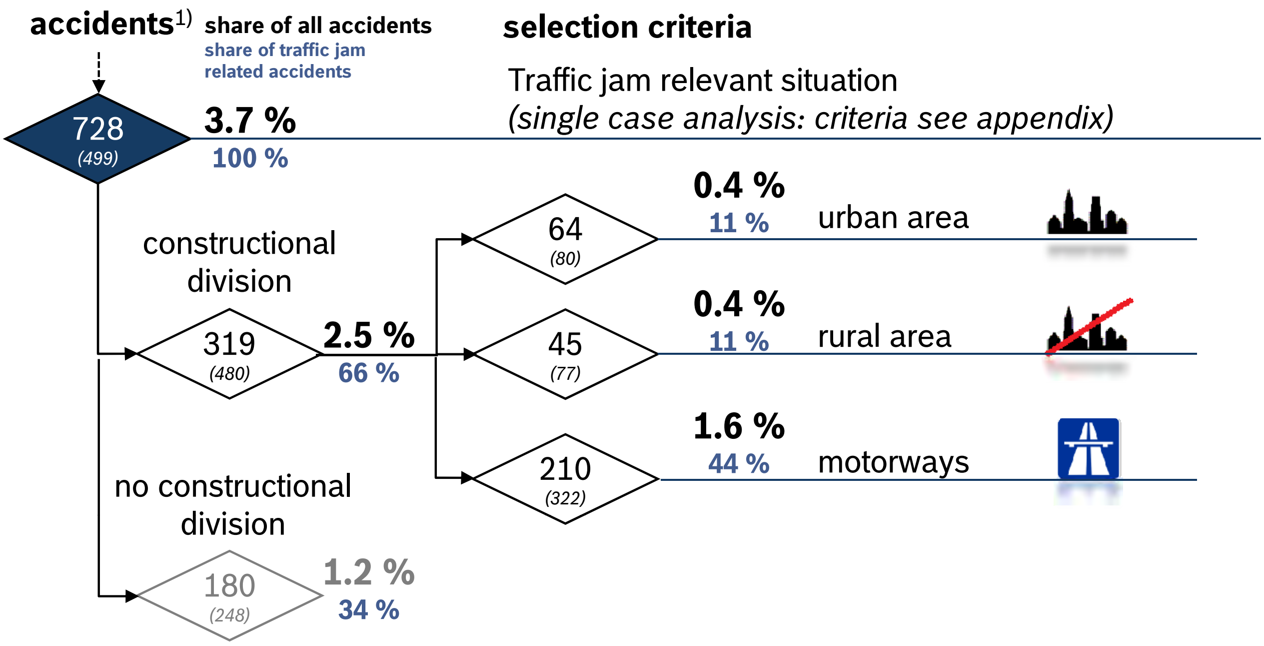
Types of involved vehicles



Around 85 % of all in traffic jam related accidents involved vehicles are passenger cars.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Constructional division to oncoming traffic

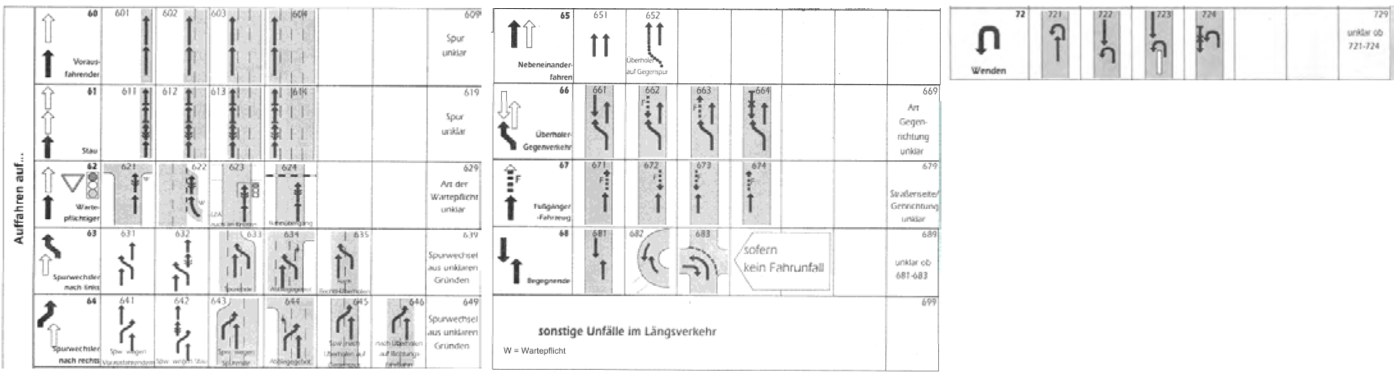


In nearly 2/3 of all traffic jam related accidents the oncoming traffic is separated constructionally.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Appendix

Type of accident in longitudinal traffic or U-turns

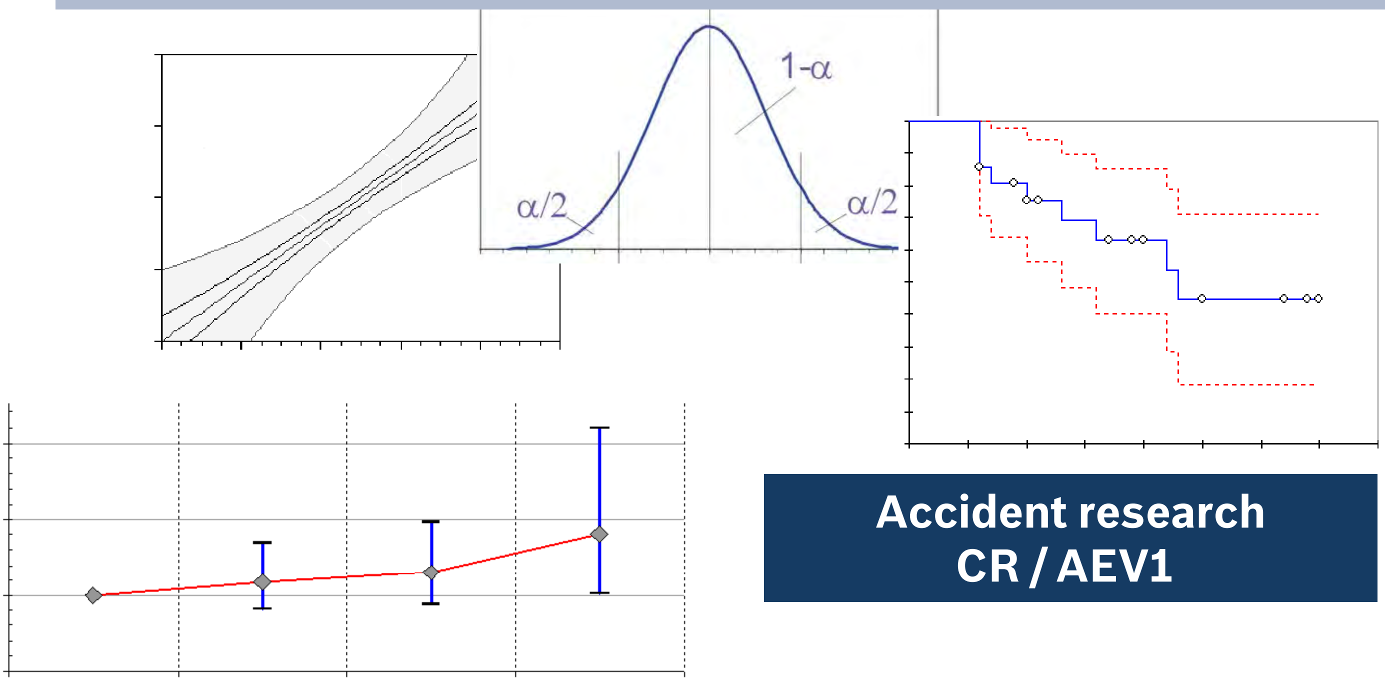


Relevant traffic jam situations determined in single case analysis:
- Vehicle driving in a traffic jam or vehicle approaching the end of traffic jam
- Accident does not occur in the waiting area of traffic lights

Used information:
-Description of accident, traffic level, reconstructed speed, accident pictures.

1) Source: GIDAS 2001-2011, weighted data for Germany, total number of corresponding GIDAS cases in italics

Concept for determining Confidence Intervals in GIDAS[1)]



Accident research CR / AEV1

1) German In-Depth Accident Study

Aim of this study: Providing a concept for determining the confidence of results based on accident data analysis from GIDAS[1)]. A statement about confidence of the results is interesting because GIDAS is a sample of all accidents injuries in Germany (headword: sampling errors).

Method: The sample design which is used for data capture in GIDAS is considered. Literature and internet investigations about methods are conducted which can be used to estimate variances / standard errors for data obtained in complex sample designs. Besides methods which are used in US accident databases to determine confidence intervals are taken into account. Based on these information a proposal is drawn up.

Result: A concept for determining confidence of results is provided. In the next steps this concept should be reviewed by an external expert. The proposal can be applied to the GIDAS data and by considering an example it should be tested how good the results fit to reality.

1) German In-Depth Accident Study

Content

1) German In-Depth Accident Study

BOSCH

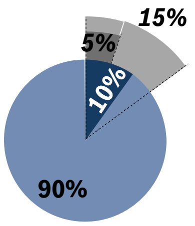
Motivation – why do we need confidence intervals?

A confidence interval shows how much an estimate (determined based on analyzing sampling data) varies. This is needed for conclusions about reality.

E.g. a wide interval for given confidence level indicates either that the sample is small or the investigated phenomenon is so variable that a confidence interval with an acceptable width can be achieved by an unrealistic big sample size.

Examples in the area of accident research:

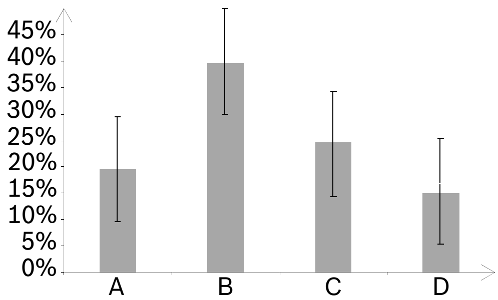
Accidents relevant for a system



- share of accidents relevant for system (point estimate)
- share of accidents not relevant for system (point estimate)
- *share of accidents relevant for system (CI lower border)*
- *share of accidents relevant for system (CI upper border)*

The point estimate of 10% has a confidence interval of [5%;15%]
➔Expected real value between 5% and 15%!

Relative frequency of different scenarios



Estimates show clear distribution about frequencies
➔But considering confidence intervals leads to the conclusion that in reality shape could be different.

BOSCH

Content

➔ Motivation – why do we need confidence intervals?

➔ Necessity of considering complex sample design

➔ Sample design in GIDAS[1)]

➔ Procedure used to estimate confidence intervals in US accident database

➔ Methods for sample error estimation considering complex sample designs: *Taylor series linearization and replication methods*

➔ Proposal for estimating confidence intervals in GIDAS

➔ Summary and Outlook

1) German In-Depth Accident Study

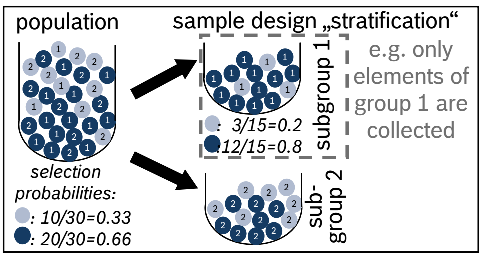
Necessity of considering complex sample designs

Why is it necessary to consider complex sample design[1)] for...

a) statistical estimates?

In complex survey designs (≠simple random sampling) selection probabilities could differ for sample elements from those in the population

➔Different probabilities are compensated by weighting factors



➔**Correction of biased estimates**

b) sample error / confidence interval (CI) estimations?

Independence of elements not necessarily given in complex survey designs

➔Assuming independence of sampling variables needed for calculating sample error estimations with standard procedures *(using this assumption though it is not given, could lead to too small estimated sample errors even if point estimates are corrected with a weighting factor, estimated sample errors/CI - will be wrong)*

➔**For not under-/overestimating sample error (and CI) complex sample design must be considered in the calculation procedure for error estimation**

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts

Content

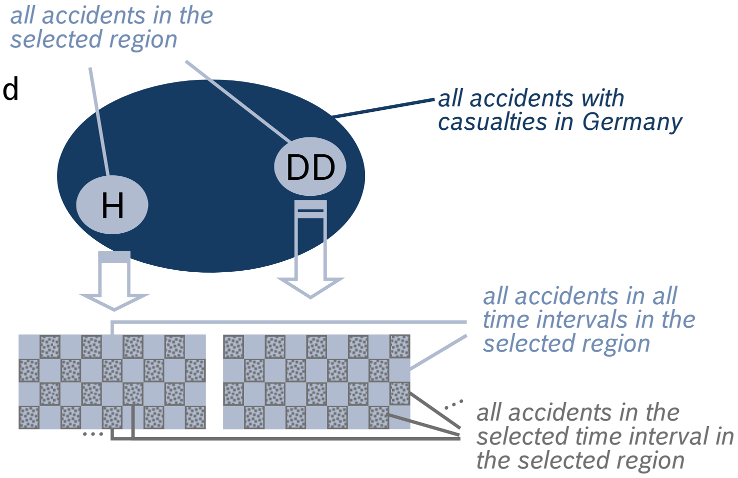
- ➔ Motivation – why do we need confidence intervals?
- ➔ Necessity of considering complex sample design
- ➔ Sample design in GIDAS[1)]
- ➔ Procedure used to estimate confidence intervals in US accident database
- ➔ Methods for sample error estimation considering complex sample designs: *Taylor series linearization and replication methods*
- ➔ Proposal for estimating confidence intervals in GIDAS
- ➔ Summary and Outlook

1) German In-Depth Accident Study

Sample design GIDAS[1)]–procedure for surveying accidents[2)]

PSU or 1st cluster: region

1st stage:
Accidents happening in the area around Hannover and Dresden are selected from all accidents with casualties in Germany.



2nd cluster: time interval

2nd stage:
Accidents happening in selected time intervals are chosen within the selected regions

random selection from 2nd stage clusters

Last step:
Random selection[3)] of *m* accidents out of all *M* accidents (▒) with casualties within each time interval in the selected regions. But the selection rates differ for varying time intervals.

➔ Sample design in GIDAS is complex

1) German In-Depth Accident Study
2) source: "Statistische Methoden zur Auswertung der Erhebungen am Unfallort, Forschungsbericht der BASt, H. Hautzinger
3) random selection should be guaranteed by collecting the latest reported accident

Sample design in GIDAS[1] – resulting requirements[2]

Complex sample design in GIDAS

Demand for adapted extrapolation method for point estimate determination

In a suitable extrapolation/weighting procedure the selection rates are needed in order to multiply with reciprocal of the selection rate. But in GIDAS the selection rates differ in the clusters.

➔ Varying selection rates considered by "post-stratification" in current applied weighting procedure for GIDAS (method described on next slide).

➔ **Aim:** Improvement of the precision of sample parameter estimates

Considering complex sample design in quantifying sampling errors *(usage of standard procedure from sample theory impossible)*

Suitable method for sampling error estimation must be found/developed considering the special sampling procedure in GIDAS.

➔ Methods for estimating sample errors considering a complex sample design are listed on the next slides

➔ Proposal for a concept with which sample error in GIDAS can be estimated is provided on slide 21ff.

1) German In-Depth Accident Study
2) source: "Statistische Methoden zur Auswertung der Erhebungen am Unfallort, Forschungsbericht der BASt, H. Hautzinger

Sample design in GIDAS[1] – post-stratification to compensate different selection rates[2]

Initial situation

All accidents with casualties in GER divided concerning criteria A in strata I, II, III

All accidents in the GIDAS sample divided concerning criteria A in strata I, II, III

➔ GIDAS sample is biased related to all accidents w/casualties

Correction by post-stratification

1) Determination of shares which each strata holds in all accidents, e.g. share for "I"≈ 0.4

2) Determination of shares which each strata holds in sample, e.g. share for "I"≈ 0.3

3) Calculating factors with which the shares of the strata from all accidents can be transferred to those in the sample, e.g. for "I"≈ 1.3

Weighted *data in the GIDAS sample divided concerning criteria A in strata I, II, III*

Characteristics of post-stratification

- Post-stratification will improve precision of parameter estimate if criteria are used for stratification strongly correlated with the parameter of interest
- Assumption:
  Parameters not considered in post-stratification do not have any influence on the selection of cases, e.g. if criteria "region" is not considered in post-stratification it is assumed that the regions do not have any influence on the selection of cases concerning the values of parameters which will be analyzed.

➔ Post-stratification with suitable criteria can improve precision of parameter estimates!

1) German In-Depth Accident Study
2) source: "Statistische Methoden zur Auswertung der Erhebungen am Unfallort, Forschungsbericht der BASt, H. Hautzinger

Content

- ➔ Motivation – why do we need confidence intervals?
- ➔ Necessity of considering complex sample design
- ➔ Sample design in GIDAS[1)]
- ➔ Procedure used to estimate confidence intervals in US accident database
- ➔ Methods for sample error estimation considering complex sample designs: *Taylor series linearization and replication methods*
- ➔ Proposal for estimating confidence intervals in GIDAS
- ➔ Summary and Outlook

1) German In-Depth Accident Study

Procedure used to estimate confidence intervals in US accident database[1)]

Aim

General statement about reliability of different estimates based on analyzing accident data from NASS GES (independent of considered parameter). In other words the sampling error should be commonly estimated for the whole data.

Procedure

1) ***Determining sampling error/variance estimates for selected parameters***
Because of complex sample design of NHTSA GES data, estimates of sampling errors (variance) for selected estimates are determined with Taylor Series Linearization (before 1990 with Balanced Repeated Replication Method).

2) ***Creating generalized variance models***
A common approach should be used in order to display the sampling error in a more common form. Generalized variance models (for crash, vehicle and person) are created by using the estimates of variance from step 1 as dependant variable and the estimate as the independent variable. With regression techniques the models are found.

1) source: "National Accident Sampling System General Estimate System Technical Note, 1988 to 1990" - DOT HS 807 796 NHTSA Technical Report, December 1991

Content

- ➔ Motivation – why do we need confidence intervals?
- ➔ Necessity of considering complex sample design
- ➔ Sample design in GIDAS[1)]
- ➔ Procedure used to estimate confidence intervals in US accident database
- ➔ Methods for sample error estimation considering complex sample designs: *Taylor series linearization and replication methods*
- ➔ Proposal for estimating confidence intervals in GIDAS
- ➔ Summary and Outlook

1) German In-Depth Accident Study

Methods for sample error/variance estimation considering complex sample designs

a) Taylor series linearization

b) Replication methods:

1) Balanced Repeated Replication,
2) Jackknife Repeated Replication method,
3) Bootstrapping,
4) Random group method[1)]

- ➔ Methods are briefly described on the following slides
- ➔ Taylor series linearization and replication approaches do not produce identical estimates, but empirical investigations have shown that for many statistics the approximations are very similar

1) Not considered in the following because it is not commonly used and no information about available Software could be found

a) Taylor series linearization[1)]

Description	A non-linear estimate (e.g. mean) is approximated with the 1st order (linear) element of a Taylor series expansion. The precision of the approximated linear estimate is determined with standard variance estimation methods. This variance is used as an approximation for the variance of the real estimate. The variance estimation depends only on the first stage of sampling. Hence only the cluster/ stratum of the first step of sampling survey design must be known. $V(\theta) \cong V[\sum w_i \sum (\frac{\partial f}{\partial y_i}) y_{ij}]$ $V(\theta) = f(y) = \hat{Y}_i = \sum w_i y_{ij},\ i = 1,2,\dots,n,\quad j = 1,2,\dots c$ ...approximate of variance; w_i ...*weighting factor for each observation i*; c ...*number of variables*; n ...*number of observations*. For complex survey designs (e.g. containing clusters, PSU's or strata) the approximation formula is applied to the (PSU) totals within each stratum. The variance of the population is a weighted combination of the variances for each strata/cluster.
Assumption	Terms of higher order than 1 (linear part) in Taylor series can be neglected. Additionally it is assumed that 1st stage of sampling is sampling with replacement, although this is often not given in practice.
Advantages	Any functional statistic (e.g. totals, regression coefficients, mean, proportions) can be approximated by this method. Efficient approximation method (little computing time).
Disadvantages	Method cannot be used for nonfunctional statistics (e.g. percentiles). For each statistic an extra formula (which can be complex) needs be derived for the estimate and sample error / variance estimation.
Suitable SW	SAS, SUDAAN, STATA, Epi-Info, PC-CARP, CENVAR, IVEware
Example	Method is applied for estimating sampling errors in NASS GES data from 1990 on.
Requirements	Information about the complex survey design must be available. This means variables with the information about the strata / cluster must be known, besides weighting variables must be known. If the information about strata / cluster are wrong or not available the Taylor series linearization procedure will provide wrong approximations about the variances and confidence intervals. In other words this method can be only used if the real sample design is known and can be expressed by the suitable variables in the estimation method.

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts

Concept for determining GIDAS confidence intervals Chapter 17

b) Replication methods

Applying this methods repeated subsamples are taken from the whole data.
For each replicate (subsample) weighted survey estimates are calculated.
The variance is calculated as a function of the deviations of the replicate estimates.

First the full sample and the weight variable is used to calculate the point estimate (e.g. mean) for the whole population.

Second many different subsamples (e.g. *k* replicates) are taken. Each subsample should reflect the sampling plan and weighting procedure of the whole sample. The weight variables are built separately for each replicate sample.

Then the estimate formula is applied to each replicate. *K* point estimates are calculated. Based on the *k* replicate estimates, an estimated variance of the point estimate for the whole sample is calculated.

$$\hat{V}ar\left(\hat{\theta}\right) = c \sum_{r=1}^{k} (\hat{\theta}_r - \hat{\theta}_0)^2$$

k...*number of replicates*

$\hat{\theta}_1, \hat{\theta}_2, \dots, \hat{\theta}_k$ ...*estimate of a parameter* θ *for replicates*

$\hat{\theta}_0$...*estimate of a parameter* θ *for full sample*

c...*constant (depends on replication method)*

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts

b1) Replication method 1:Balanced repeated replication (BRR)

Description	A replicate is generated by dividing each sampling into two primary sampling units. For each stratum one of the two PSUs is randomly selected. The selected PSU should represent the whole stratum. The original weight in the selected PSUs are doubled. $\hat{V}ar\left(\hat{\theta}\right)=\frac{\sum_{r=1}^{k}(\hat{\theta}_r-\hat{\theta}_0)^2}{k}$ *k…total number of replicates* $\hat{\theta}_1,\hat{\theta}_2,\ldots,\hat{\theta}_k$ *…estimate of a parameter θ for each replicate* $\hat{\theta}_0$ *…estimate of a parameter θ for full sample*
Advantages	Very flexible because basic estimation methods are used independent from the statistic which should be estimated. The variance formula is an approximation for the whole sample not depending on the statistic to be estimated. Application to estimators which cannot be expressed in terms of formulas (e.g. median) and to estimators which can be expressed by formulas (e.g. mean). Estimators can be approximated with BRR w/o analytical formula. Method can be applied to general sample designs like stratified multistage sampling.
Disadvantages	Computer-intensive, in basic form applicable to sample designs with big number of strata in which each stratum can be divided into exactly two Primary Sampling Units (PSUs)
Suitable SW	SAS, SUDAAN, WesVar, IVEware
Method application	Very commonly used replication method, e.g. used for estimating 95%-CI in NASS-GES 1988 and before (change to Taylor series linearization because of unavailable Software)
Data preparation	Weight variables for the whole sample and additional weight variables for the replicates are needed.

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts. DOT HS 807 796 NHTSA Technical Report

b2) Replication method 2: Jackknife repeated replication method (JRR) – non-parametric procedure

Description	A special form of the jackknife method is the "delete-1-method". In this form generally a PSU or cluster in a considered stratum is deleted in order to generate a replicate. This replicate is weighted in a new form (so called replicate weights) so that the whole sample is represented and hence conclusions about the whole population are possible. This process is repeated for each stratum independently. The formula for the jackknife variance estimator is: $\hat{V}ar\left(\hat{\theta}\right)=\sum_{r=1}^{k}\alpha_r(\hat{\theta}_r-\hat{\theta})^2$ *k …total number of replicates* α_r*…jackknife coefficient (for each replicate r)* $\hat{\theta}$ *…estimate of parameter θ based on whole sample* $\hat{\theta}_r$*…estimate of parameter θ for full sample obtained from r-th replicate*
Advantages	Method can be applied to any sample design. Application to estimators which cannot be expressed in terms of formulas (e.g. median) and to estimators which can be expressed by formulas (e.g. mean). Estimators can be approximated with JRR w/o analytical formula.
Disadvantages	Computer-intensive
Suitable SW	SAS, SUDAAN, WesVar, IVEware
Method application	Very commonly used replication method

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts

b3) Replication method 3: Bootstrapping

Description	A replicate is created by re-sampling the PSU's in the observed data in order to obtain replicates of the same size and structure as in the sample design. Method is closely related to BRR and JRR. $Var(\hat{\theta}) = \frac{1}{k}\sum_{r=1}^{k}(\hat{\theta}_r - \hat{\theta}_0)^2$ *k…number of replicates (needs to be bigger than 200)* $\hat{\theta}_1, \hat{\theta}_2, \ldots, \hat{\theta}_k$ *…estimate of a parameter* θ *for replicates* $\hat{\theta}_0$ *…estimate of a parameter* θ *for full sample*
Advantages	Application to estimators that cannot be expressed in terms of formulas, estimators can be approximated with Bootstrapping w/o analytical formula
Disadvantages	Large number of replicates is needed. Results from bootstrapping may vary for different users and for different tries of one user (difference to BRR and JRR: these methods provide the same results for different users and for different tries).
Suitable SW	---
Method application	Less commonly used replication method

1) sources: "Estimation of sampling errors for complex survey data", Ibrahim S. Yansaneh, "Household Sample Surveys in Developing and Transition Countries, Chapter XXI", Donna Brogan, "Analysis of Complex Sample Survey Data Using the SURVEYMEANS and SURVEYREG Procedures and Macro Coding" Patricia A. Berglund, "New SAS Procedures for Analysis of Sample Survey Data", Anthony An & Donna Watts, "Try, Try Again: Replication-Based Variance Estimation Methods for Survey Data Analysis in SAS 9.2", Pushpal K Mukhopadhyay, Anthony B. An, Randall D. Tobias, Donna L. Watts

Content

1) German In-Depth Accident Study

Proposal for estimating confidence intervals in GIDAS[1)](1/3)

Applying the **basic procedure from the method used in US accident database**

➔**1st step:**
Determining sampling error/variance estimates for selected parameters (selection of suitable method: Taylor series linearization or replication method).

➔**2nd step:**
Creating generalized variance models with sampling error/variance estimates from 1st step.

1) German In-Depth Accident Study
2) No cluster/Primary Sampling Unit because the observations (accidents) are classified in strata

BOSCH

Proposal for estimating confidence intervals in GIDAS[1)](2/3)

1st step: Determining sampling error/variance estimates

Taylor series linearization

- Requires knowledge and application of real survey design
- Real design from GIDAS (cp. slide 8) cannot be described in sample error estimation method because necessary accident related information about the selected regions (Hannover, Dresden) are not available because of data protection provisions

➔***Not applicable***

Replication method (balanced repeated or jackknife replication)

- Determination of sample errors of with post-stratification (cp. slide 10) "corrected" point estimates by using selected criteria as strata
- Applied design in post-stratification: 1 stage stratification[2)]

➔***Application of jackknife replication because the necessary two primary sampling units in each stratum for balanced repeated replication are not given.***

➔Approach: Estimating sampling error/variances in GIDAS with "Jackknife" method!

1) German In-Depth Accident Study
2) No cluster/Primary Sampling Unit because the observations (accidents) are classified in strata

BOSCH

Proposal for estimating confidence intervals in GIDAS[1)] (3/3)

2nd step: Creating generalized variance models

As described in the procedure used to estimate confidence intervals in US accident database[2)] a generalized variance model should be created. The regression model can be built by using the estimated sampling error for selected parameters (e.g. location, cause of accident, time of day,...) as dependant variables and the point estimates for the selected parameters as independent variables.

➔ Approach: Generating a regression models with sampling error/ variances for selected parameters as dependant variables and the point estimates as independent variables

1) German In-Depth Accident Study
2) No cluster/Primary Sampling Unit because the observations (accidents) are classified in strata

BOSCH

Content

➔ Motivation – why do we need confidence intervals?

➔ Necessity of considering complex sample design

➔ Sample design in GIDAS[1)]

➔ Procedure used to estimate confidence intervals in US accident database

➔ Methods for sample error estimation considering complex sample designs: *Taylor series linearization and replication methods*

➔ Proposal for estimating confidence intervals in GIDAS

➔ Summary and Outlook

1) German In-Depth Accident Study

BOSCH

Summary and Outlook

1) A proposal suitable for estimating confidence intervals in GIDAS following concept from US accident database is made:

   ➔ *Generation of a common regression model to estimate confidence intervals in GIDAS by using sampling error/variance estimations[1] and point estimates for selected parameters.*

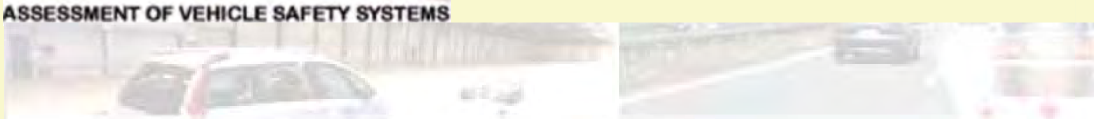
2) The proposed concept should be validated by an external expert

3) If the concept is confirmed from theoretical point of view it will be useful to check whether the concept is practicable. This can be done by using real data about the whole accident (e.g. accident type, severity and location as strata – analyzing accident kind, time or cause). Results from estimation can be compared with real data from official statistics[2]

4) In a next step parameters providing information about vehicles, collisions or persons can be used to check practicability.

1) Determination with "jackknife"-replication method
2) e.g. Federal Statistical Office – "Fachserie 8 Reihe 7"

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS



Status of EU-Project "ASSESSment of Vehicle Safety Systems"

1. Introduction and Status of the Whole Project in November 2011

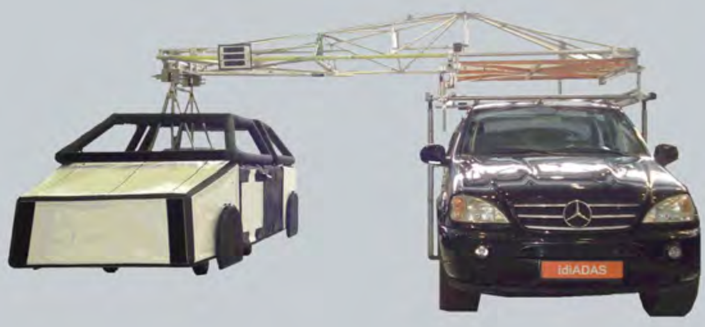
2. Status in November 2011 of WP1: Integrated Assessment

BOSCH

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Assessment of Integrated Vehicle Safety Systems

INTRODUCTION AND STATUS NOV 2011

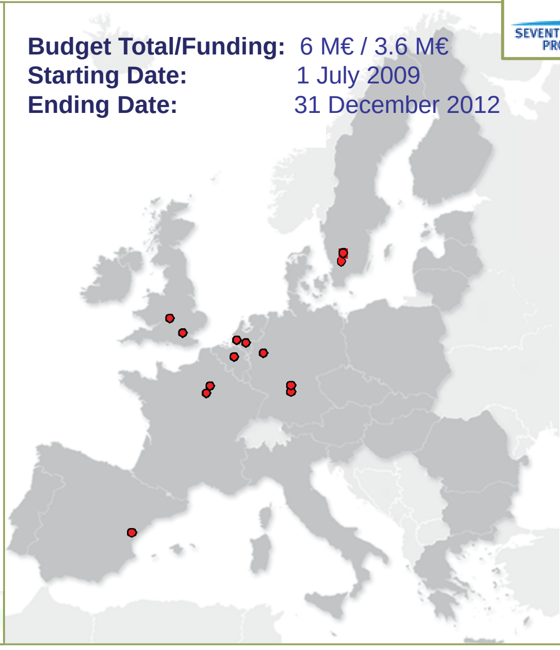


Assessment of Integrated Vehicle Safety Systems

SEVENTH FRAMEWORK PROGRAMME

DAIMLER
BOSCH
eesar
TRL
TOYOTA
UNIRESEARCH
CHALMERS
TNO
Applus IDIADA
HUMANETICS
University of Cologne
bast Federal Highway Research Institute
TRW
TU Graz
PSA PEUGEOT CITROËN

Budget Total/Funding: 6 M€ / 3.6 M€
Starting Date: 1 July 2009
Ending Date: 31 December 2012

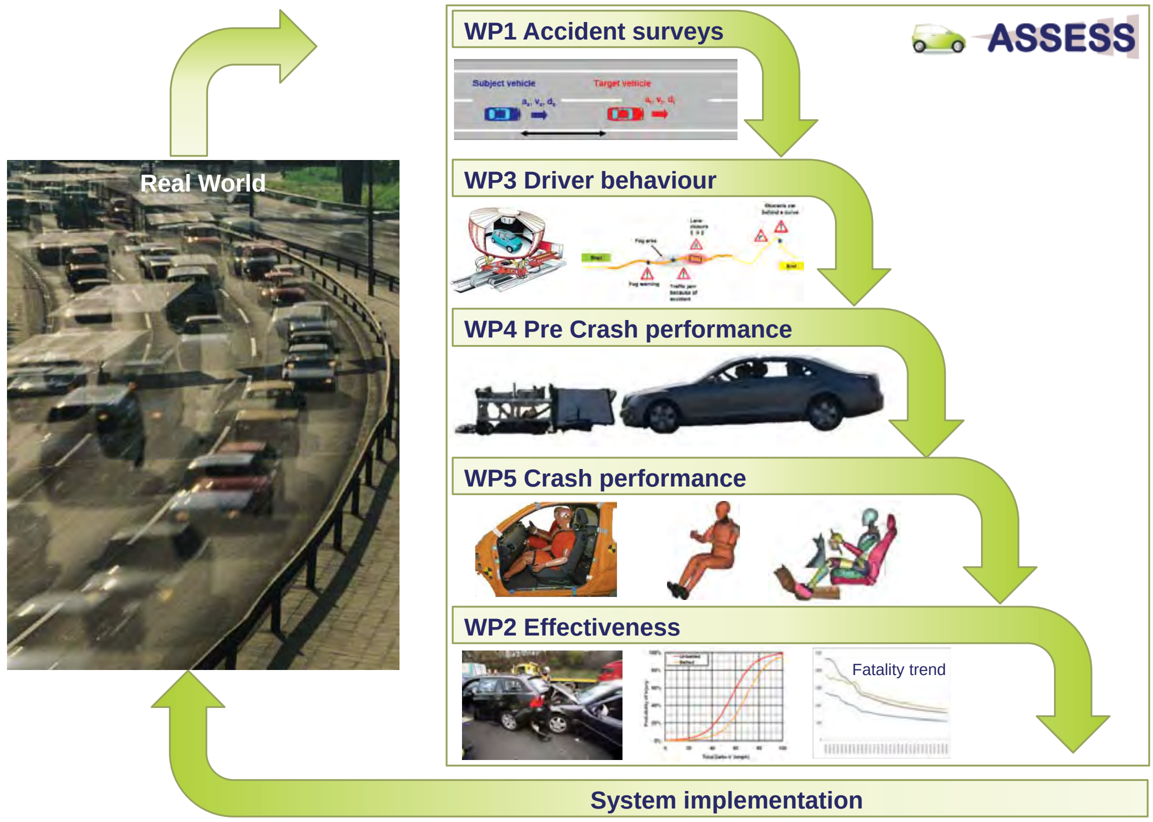


ASSESS ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Rationale and Objectives

- Integrated vehicle safety systems have a high potential to improve vehicle safety
- Various systems offered at the market or close to introduction
- Test and evaluation procedures needed to enable widespread introduction
- Main objective ASSESS is to develop harmonised assessment procedures and related tools for integrated safety systems
  - Driver behaviour evaluation
  - Pre-crash system performance evaluation
  - Crash performance evaluation
  - Socio economic assessment

APPROACH



ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Project Structure and Status

WP1: Definition of targets and final verification
- Test scenario definition
- Assessment criteria
- Validation
- Documentation

WP2: Socio economic evaluation and legal aspects
- Assessment method
- Socio-economic impact assessment
- Liabilities
- Legal issues

WP3: Evaluation of behavioural aspects
- Preparation of experimental design
- Experimental studies
- Evaluation

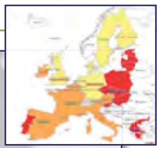
WP4: Pre-crash evaluation
- Define test and assessment methods
- Prepare laboratories
- Testing
- Evaluation

WP5 Crash evaluation
- Defining baseline specifications
- Develop Test and simulation strategies
- Evaluation

finished
in progress
not started

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Test Scenarios



Ranking of accident scenarios

- High level scenario characterization
- Weight factors based on injury costs
- Excluding first impacts with pedestrians

Accident scenario	Germany n=1,399,353		France n=440,024		Austria n=615,497		Sweden n=137,936		Weighted average**	
	freq	rank	freq	rank	freq	rank	freq	rank	freq	rank
Type 1a: Driving accident - single vehicle	19%	3	31%	2	24%	3	29%	2	24%	3
Type 2&3: Accidents with turning vehicle(s) or crossing paths in junction	32%	2	23%	3	26%	2	24%	3	28%	2
Type 4: Accidents involving pedestrians	8%	4	12%	4	12%	4	9%	4	10%	4
Type 5: Accidents with parked vehicles	2%	6	1%	6	1%	6	1%	6	1%	6
Type 1b, 6a & 6b: Accidents in longitudinal traffic with multiple vehicles invloved*	33%	1	32%	1	35%	1	31%	1	33%	1
Type 7: Other accident - single or multiple vehicle(s)	7%	5	1%	5	2%	5	7%	5	4%	5

WP1 / WP4 Workshop

No. Acc. type	Collision Type	Frequency considering injury costs
	Rear	12%
	Rear	6%
	Rear	4%
	Cut-in	4%
	Junction	18%
	Junction	12%
	Junction	9%
	Front	11%
	Front	4%

4 base scenarios

20 base scenarios
excl. variations related to driver behaviour

A. Rear-end scenarios

- Manoeuvre A1A slower lead vehicle / urban scenario 1
- Manoeuvre A1B slower lead vehicle / urban scenario 2
- Manoeuvre A1C slower lead vehicle / motorway scenario
- Manoeuvre A2A decelerating lead vehicle/ urban, normal driving scenario
- Manoeuvre A2B decelerating lead vehicle / urban, emergency braking lead vehicle
- Manoeuvre A2C decelerating lead vehicle / motorway, normal driving scenario
- Manoeuvre A2D decelerating lead vehicle / motorway, emergency braking lead vehicle
- Manoeuvre A3A stopped lead vehicle / urban scenario 1
- Manoeuvre A3B stopped lead vehicle / urban scenario 2
- Manoeuvre A3C stopped lead vehicle / motorway traffic jam scenario

B. Intersection scenarios (B)

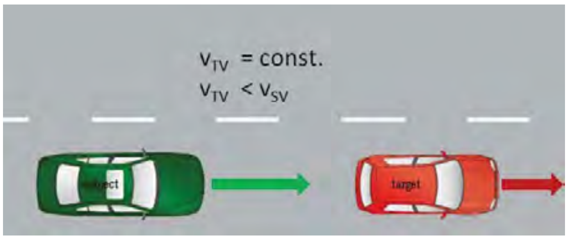
- Manoeuvre B1A urban scenario 1, open view

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Details: Rear-end test scenario specifications

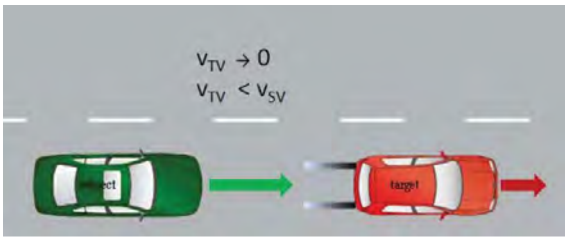
A1: Slower lead vehicle

The lead vehicle (TV) is moving at constant slower speed than the subject vehicle (speeds in km/h).
A1A: $50_{SV}/10_{TV}$ – no offset
A1B: $50_{SV}/10_{TV}$ – 50% offset
A1C: $100_{SV}/20_{TV}$ – no offset



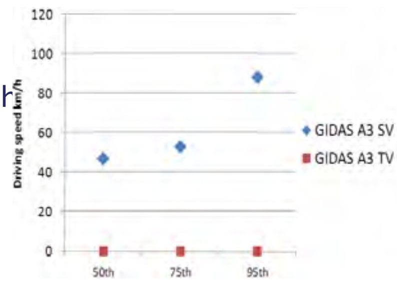
A2: Decelerating lead vehicle

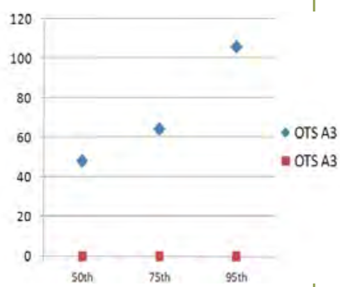
The lead vehicle (TV) is decelerating until stopped (speeds in km/h).
A2A: $50_{SV}/50_{TV}$ – TV normal driving
A2B: $50_{SV}/50_{TV}$ – TV emergency braking
A2C: $80_{SV}/80_{TV}$ – TV normal driving
A2D: $80_{SV}/80_{TV}$ – TV emergency braking



A3: Stopped lead vehicle

The lead vehicle (TV) is stopped (speeds in km/h).
A1A: $50_{SV}/0_{TV}$ – no offset
A1B: $50_{SV}/0_{TV}$ – 50% offset
A1C: $80_{SV}/0_{TV}$ – no offset



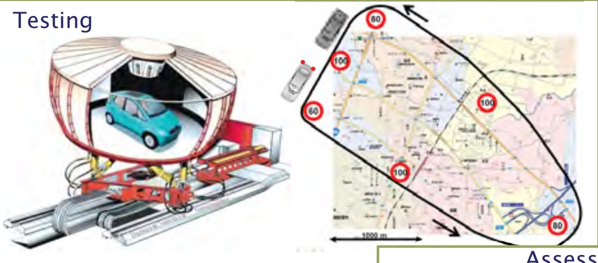


All scenarios x 3: no, slow and fast driver reactions

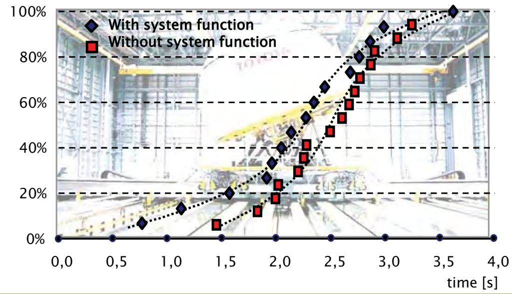
Driver Behavior Evaluation

Simulator and test track tests

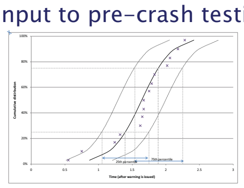
Testing



Assessment driver behaviour:
KPI – Reaction time from leading vehicle starts braking



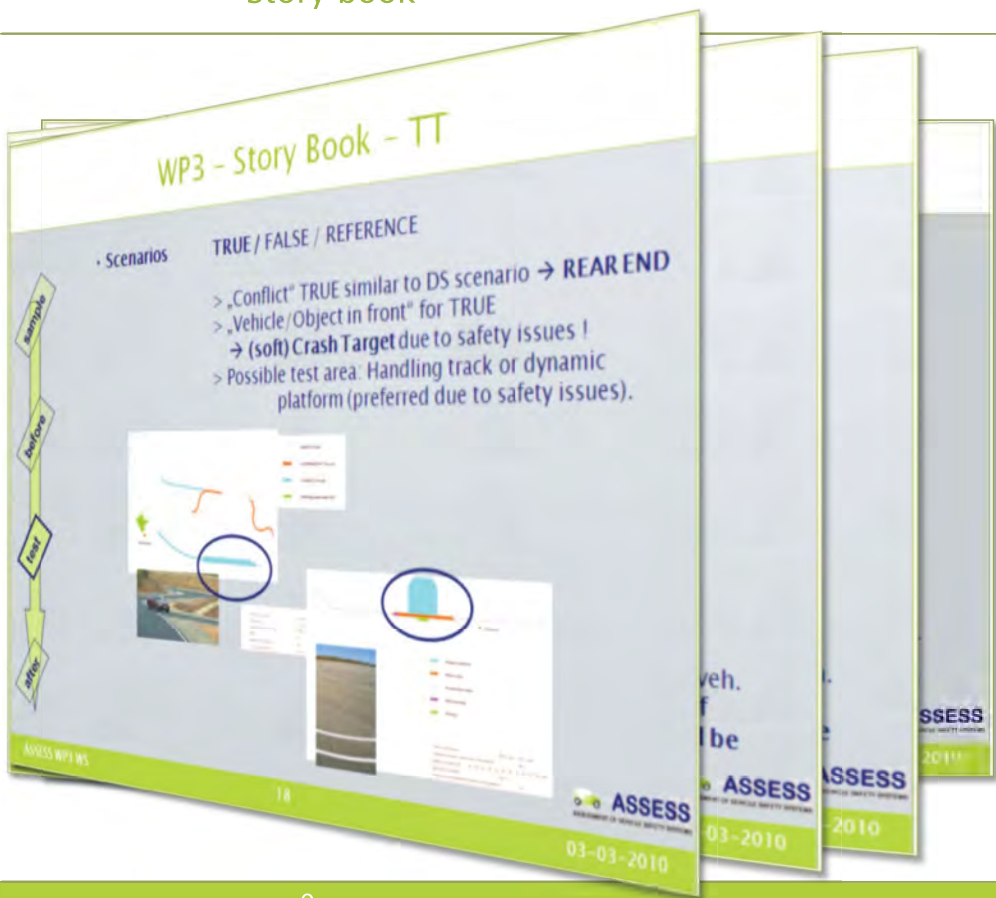
Input to pre-crash testing: driver reaction model



–Slow reaction after warning
–Fast reaction after warning

Driver Behavior Evaluation

Story book



Pre Crash Evaluation

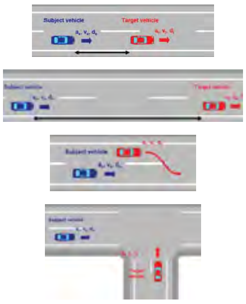
Laboratory diversities

State of Art

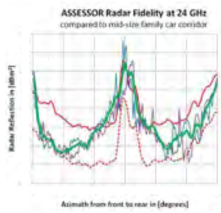
"newcomer"

VEHIL: Relative motions

Test targets developed and installed on tracks to run scenarios



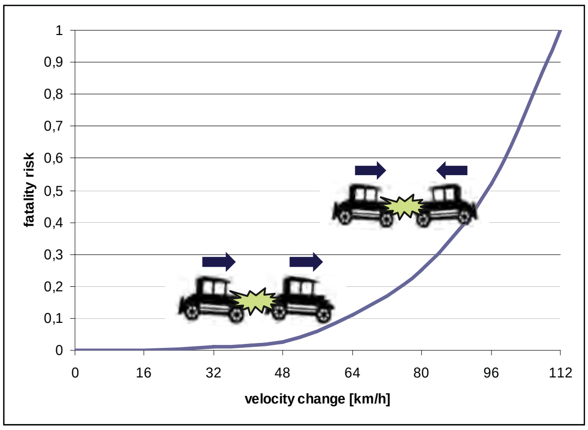
Target Object

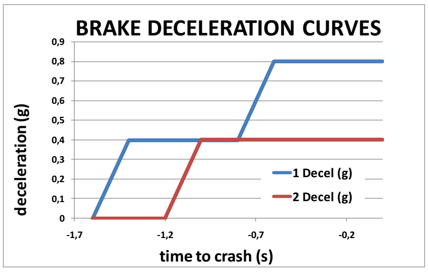


Crash Evaluation

Provide tools and methods to efficiently evaluate injury risks (dummy values) under

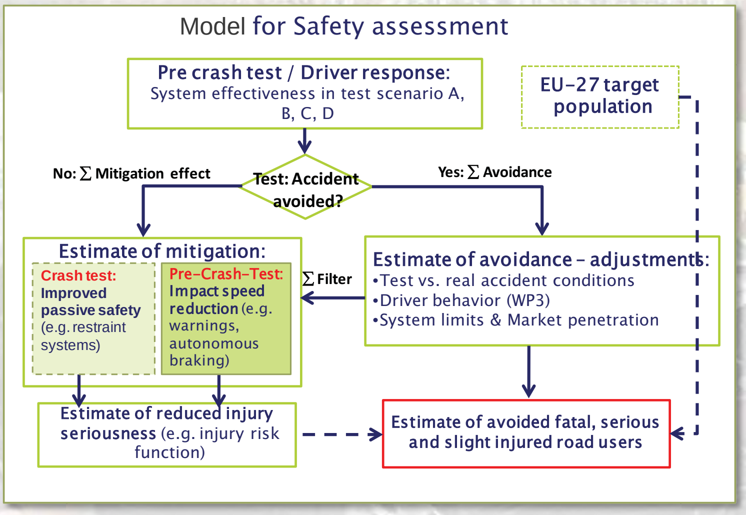
- Changed impact speed
- Pre-activation of restraints

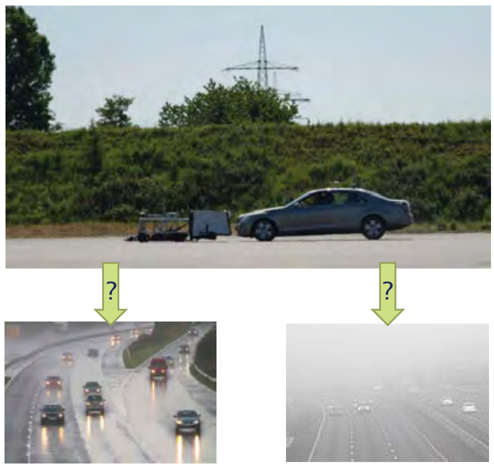




ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Socio Economic Assessment





- Safety impact assessment based on empirical data:
  - Pre-crash and crash testing (ASSESS)
  - EU-wide naturalistic field tests (e.g. euroFOT)
- Analysis for 2020 – 2030 time horizon

Integrated Assessment

One rear-end scenario with sufficient number of subjects

Scenario A1x

Scenario A2x

Scenario A3x

Definition of injury risk vs deltaV

Improved driver reaction

Decrease impact speed

Decrease of injury risk

Integrated assessment

Summary

- The ASSESS project is running for ~2 years
- Basis for all testing activities defined in year 1
  - Methodology for socio-economic assessment
  - "Story book" for simulator and track tests into driver behaviour
  - Test matrix and tools for pre crash evaluation
  - Overview of issues and possible solutions for efficient evaluation of crash performance
- Testing and data analysis started in year 2
  - Driver behavioural aspects completed
  - Pre-crash testing ongoing (expected to finish Jan 2012)
  - Crash evaluation started (expected to finish Mid 2012)
  - Socio-economic assessment ongoing
    - First evaluation Mid 2011
    - Final evaluation using all test data End 2012
- Next steps
  - Evaluation of test procedures 2012
  - Definition and evaluation of KPI's and methodology for system assessment

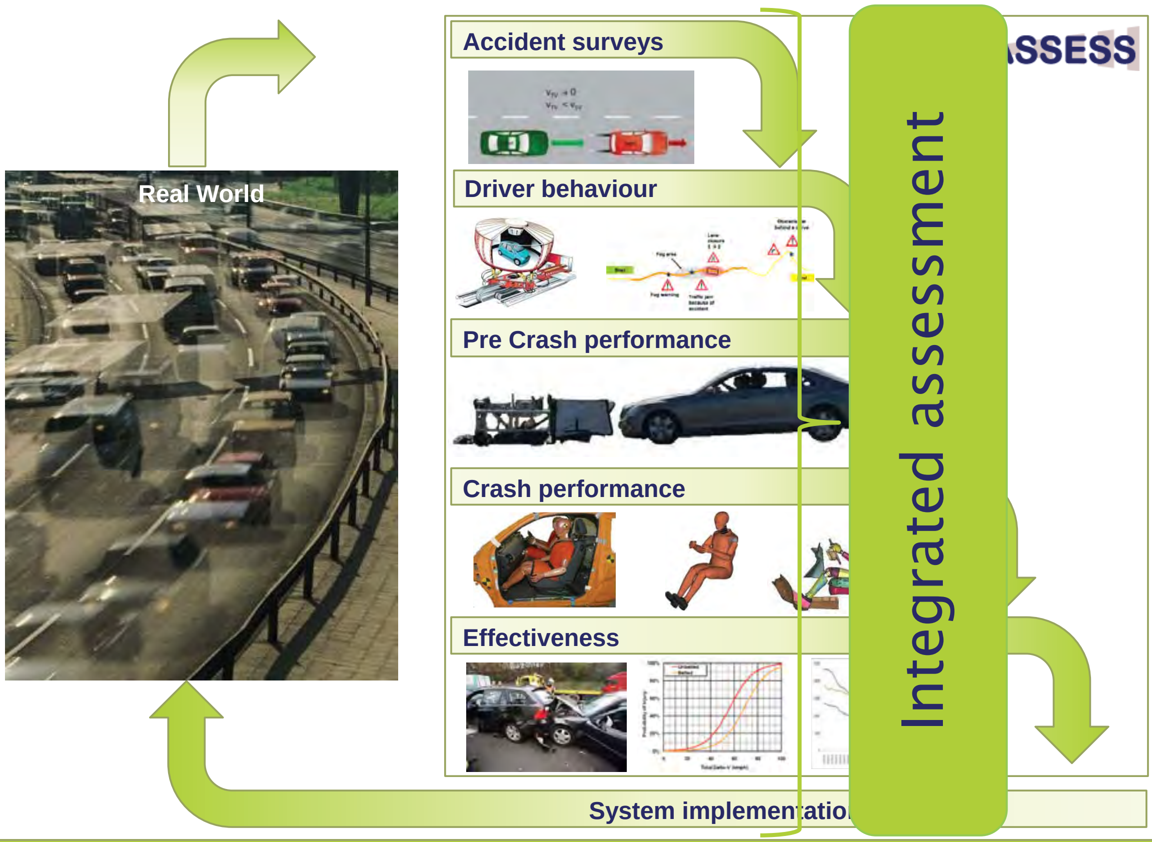
www.assess-project.eu

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Status Workpackage 1: Intergrated Assessment

Status: November 2011

APPROACH



ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Aim of Integrated Assessment

- Develop **methodology to assess system performance** during pre-crash and crash phases with a **focus on a technical assessment** of system performance* by measuring:

  - Driver behaviour performance
  - Pre-Crash performance
  - Crash performance

*not socio economic benefit

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

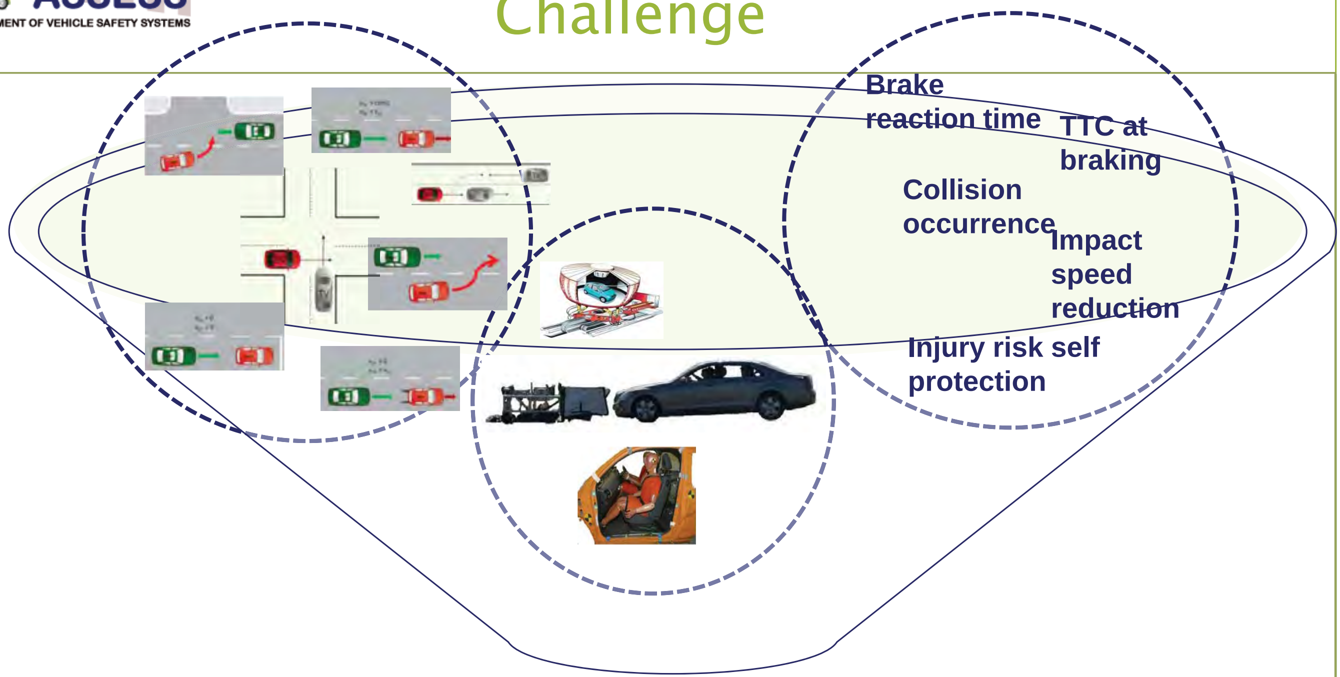
Methodology

- Identify Key Performance Indicators (KPI)
  - HMI assessment
  - Pre-crash assessment
  - Crash assessment
- Combining results from the test phases

- Scenario weight
- Defining assessment criteria, thresholds
  - Results from testing

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Challenge



Integrated assessment

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Details: Key performance indicators

HMI assessment

- Brake reaction time (only A2)
- Time To Collision at Braking

Pre-crash assessment

- Collision occurrence
- Impact speed reduction

- Monitoring KPI´s
  - Warning initiation (type, TTC at first warning onset)
  - Driver assisting action (type, TTC at action onset, triggering action)
  - Autonomous action (type, TTC at activation onset)
  - Passive safety feature (type, TTC at activation onset)
  - Acceleration
  - Speed
  - Brake Force

Crash assessment

- injury risk head
- injury risk neck
- injury risk chest
- injury risk knee, femur, pelvis
- injury risk lower leg, foot and ankle

ASSESS
ASSESSMENT OF VEHICLE SAFETY SYSTEMS

Integrated Assessment

One rear-end scenario with sufficient number of subjects

Scenario A1x

Scenario A2x

Scenario A3x

Definition of injury risk vs deltaV

Key Performance indicators

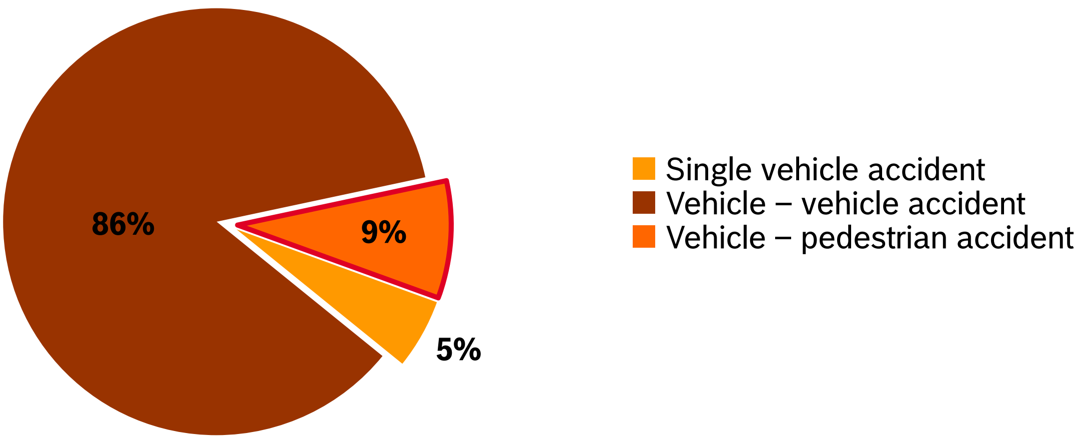
Integrated assessment

Pedestrian accidents in Japan

(use for stereo video systems)

Accidents by road user type

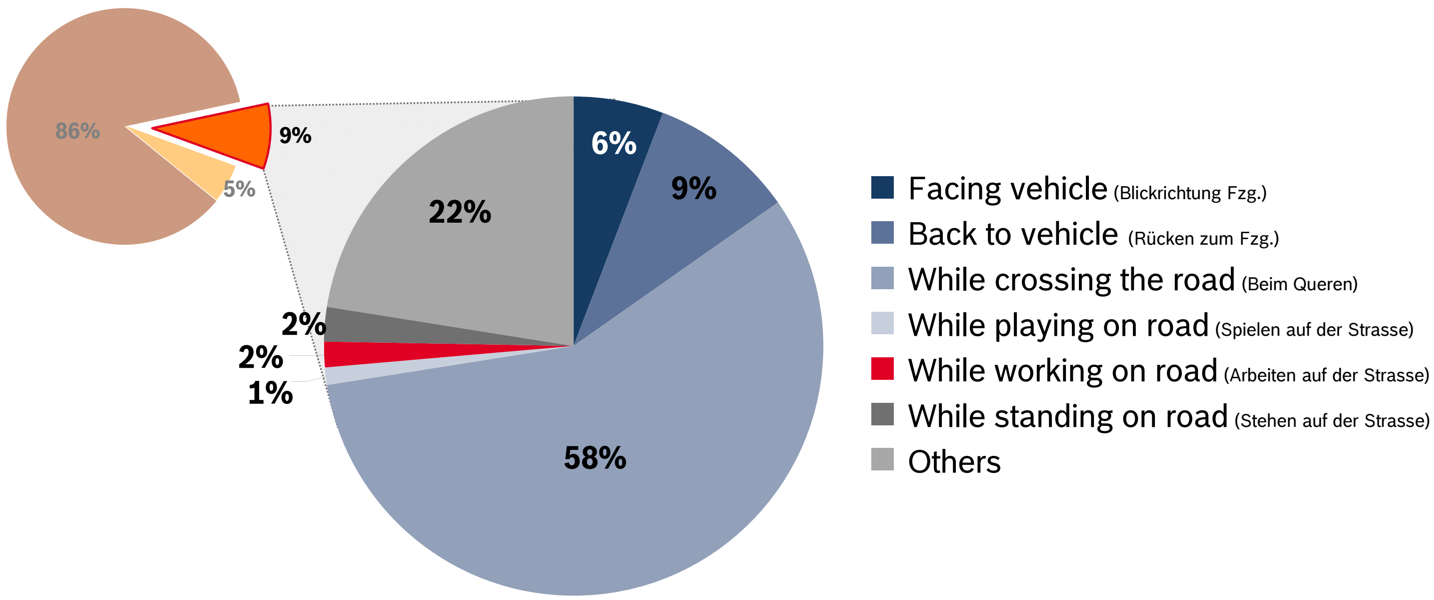
- Total 832454 accidents with casualties[1]
- Including 73159 accidents with primary collision between vehicle and pedestrian (9%)



[1] Source: Annual report Road accident statistics Japan 2007

Pedestrian accidents by type of accident 1/3

→ 73159 accidents with primary collision between vehicle and pedestrian (9%) [1]

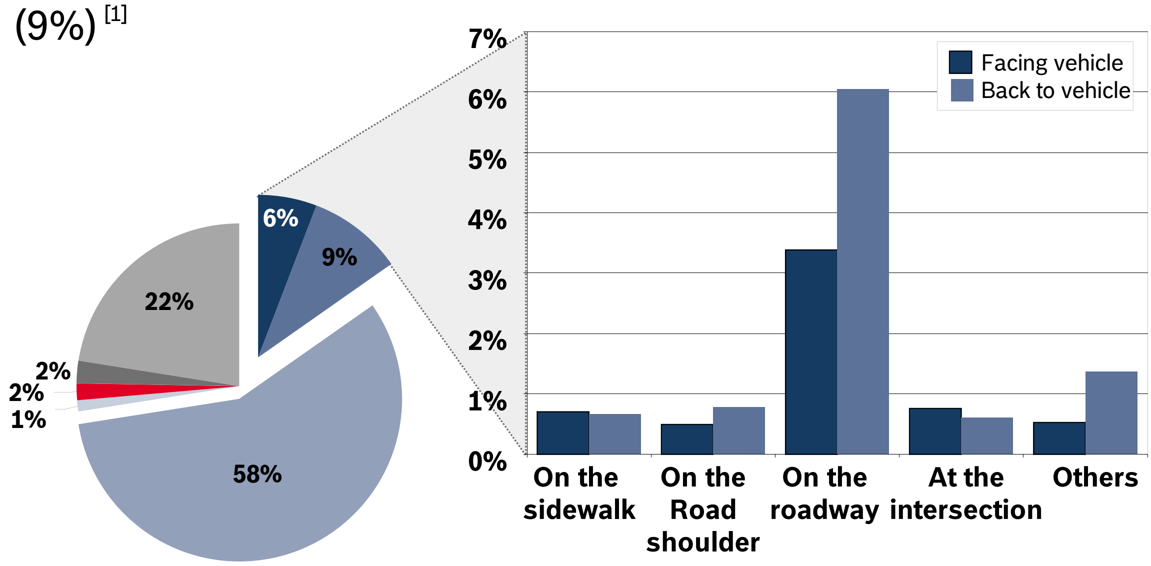


[1] Source: Annual report Road accident statistics Japan 2007

Pedestrian accidents in Japan
Chapter 19

Pedestrian accidents by type of accident 2/3

→ 73159 accidents with primary collision between vehicle and pedestrian (9%) [1]



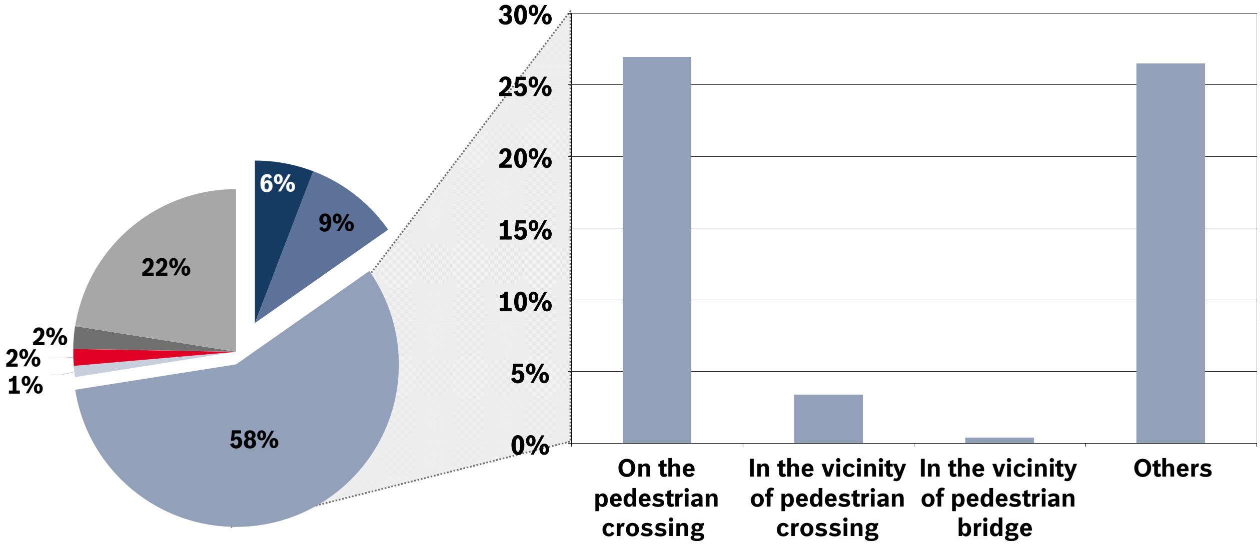
→ A share of 15% are accidents while pedestrian was either facing forward or backward on the roadway.

[1] Source: Annual report Road accident statistics Japan 2007

Intern | CR/AEV1-Lich | 06.07.2010 | AEV064 annual report 2011 | © Robert Bosch GmbH 2012. Alle Rechte vorbehalten, auch bzgl. jeder Verfügung, Verwertung, Reproduktion, Bearbeitung, Weitergabe sowie für den Fall von Schutzrechtsanmeldungen.

Pedestrian accidents by type of accident 3/3

- 73159 accidents with primary collision between vehicle and pedestrian (9%) [1]
- A share of 58% are accidents while pedestrian was crossing the road …



[1] Source: Annual report Road accident statistics Japan 2007

Pedestrian safety

– USA in comparison to Germany –

Accident research
CR / AEV1

Pedestrian Safety USA in comparison to Germany

Accident research
CR / AEV1

Aim of this study:

Comparison of pedestrian accidents in USA and Germany.

Method:

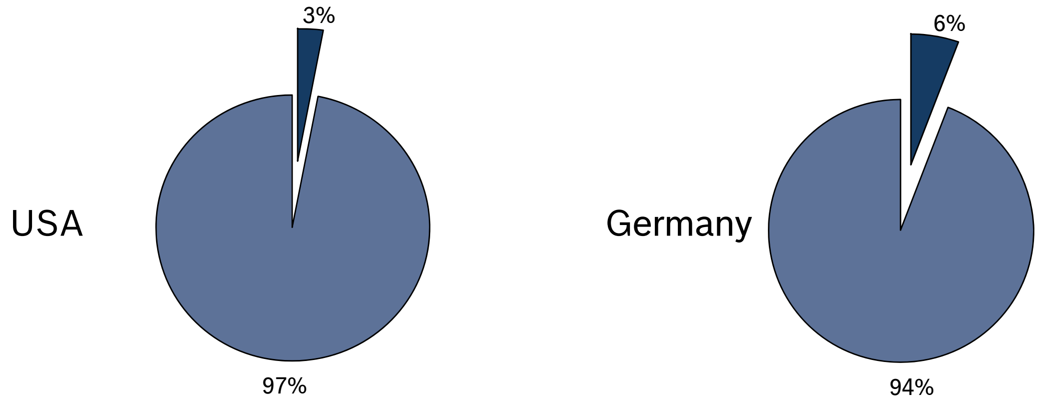
Analysis is based on accidents with casualties from GES(2009) and GIDAS (2001-2009)
Accidents fulfilling the following criteria are analyzed:

- accidents with casualities
- accidents involving cars and pedestrians
- vehicle not backing
- no driverless vehicle

Result:

In sum it can be seen that the distributions of the analyzed variables do not show a completely different behaviour between Germany and USA.
The different distribution of the accident type is on the one hand caused by different coding rules of databases in Germany and USA. On the other hand it can be seen that the different infrastructure and pedestrian behaviour has an influence - e.g. road construction at intersections differs between Germany and USA.

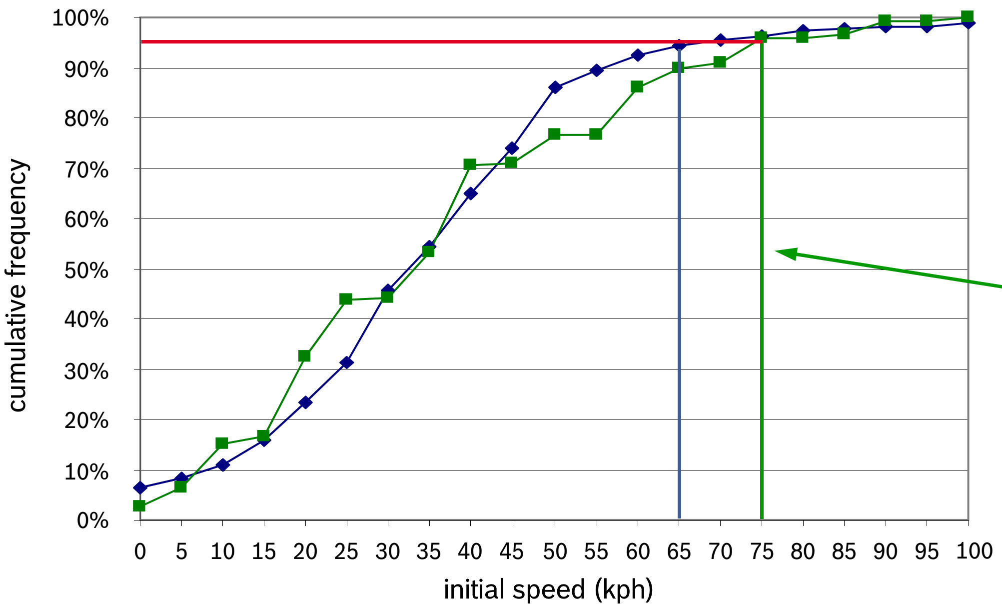
Accidents involving pedestrians



- ➔ USA: about 1.5 Mio accidents with casualties in 2009[1]
  - the rate of accidents involving pedestrians and passenger cars / light trucks (<4.6 to) - not backing, not driverless - is about 3%
- ➔ Germany[2]: about 311,000 accidents with casualties in 2009
  - the corresponding rate is about 6%

[1] source: weighted data from GES 2009, absolute number: 25,610 accidents
[2] source: weighted data from GIDAS 2001-2009, absolute number: 14,496 accidents

Distribution of initial speed in pedestrian accidents



In more than 95% of accidents involving passenger cars and pedestrians in USA the initial speed[1] is ≤75 kph

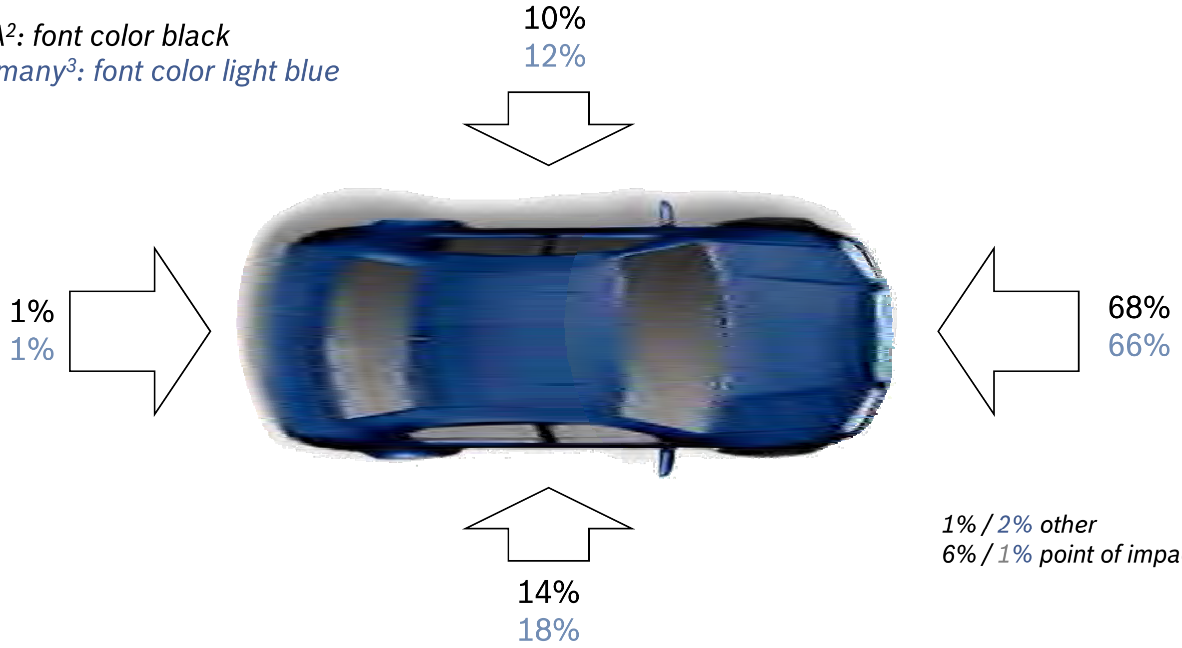
corresponding in Germany[2]: ≤65 kph

- ➔ Initial speed distribution in USA is similar to the distribution in Germany but in USA speed is usually estimated by police officer (see footnote).

[1] source: weighted data from GES 2009, based on data out of Police Accident Report (PAR) - usually estimated by police officer, absolute number: 429 accidents
[2] source: weighted data from GIDAS 2001-2009, based on in-depth reconstructed data, absolute number: 1,089 accidents

Distribution of first collision point at car[1]

USA[2]: font color black
Germany[3]: font color light blue

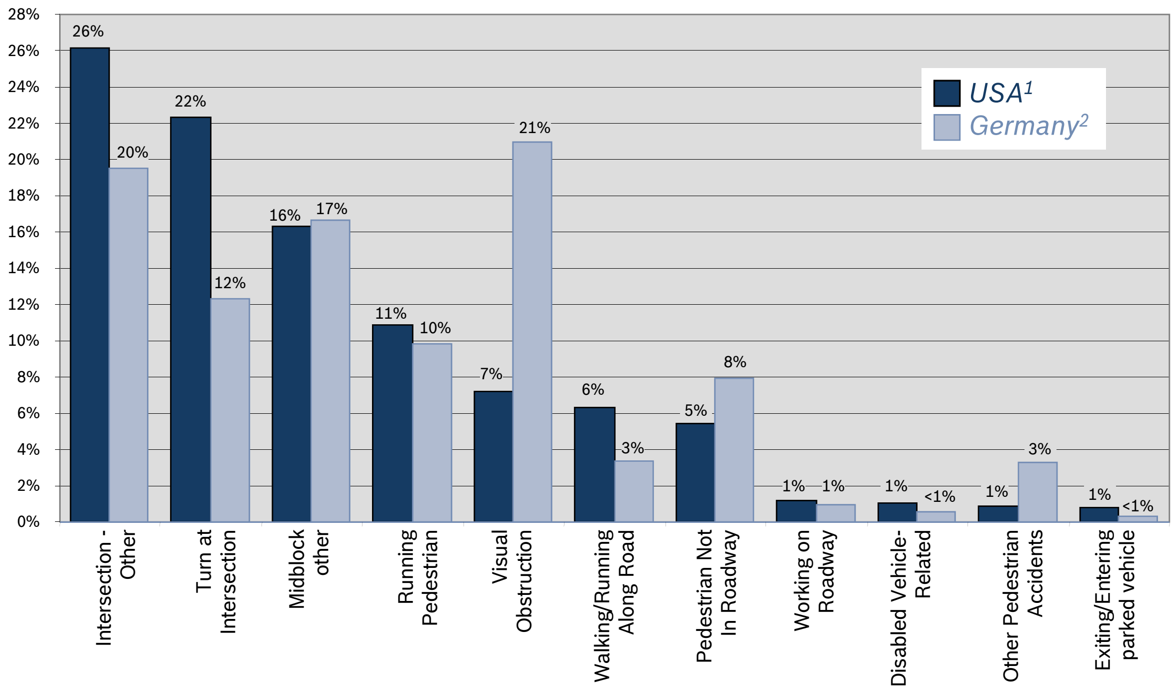


1% / 2% other
6% / 1% point of impact unknown

➔ Distribution of first collision point differs slightly between USA[2] and Germany[3].

[1]) premise: vehicle not backing, not driverless
[2]) source: weighted data from GES 2009, absolute number: 1,464 accidents
[3]) source: weighted data from GIDAS 2001-2009, absolute number: 1,330 accidents

Accident situation (type of accident)



only types with occurrence ≥ 1% within GES or GIDAS

➔ Different frequencies of accident types - especially in "Turn at Intersection" and "Visual Obstruction", might be caused by different coding rules in GES and GIDAS.

[1]) source: weighted data from GES 2009, absolute number: 1,464 accidents
[2]) source: weighted data from GIDAS 2001-2009, absolute number: 1,330 accidents

Summary

- Based on the distribution of analyzed variables it can be concluded:
  - No significant difference in initial speed distribution.
    => Attention: values are based on different kind of data inquiry[1].
  - The share of first collision point at the right hand side is slightly increased in USA compared to Germany.
  - Different frequencies of accident types - especially in “Turn at Intersection” and “Visual Obstruction”, might be caused by different coding rules in GES and GIDAS.
- In sum it can be seen that the distributions of the analyzed variables do not show a completely different behavior. The different distribution of accident types is on the one hand caused by different coding rules in Germany and USA, on the other hand it can be seen that the different infrastructure and pedestrian behavior has an influence - e.g. road construction at intersections differs between Germany and USA.
- For a transfer of the results from Germany to USA these constraints must be taken into account.

[1] initial speed:
in GES based on data out of Police Accident Report (PAR), usually estimated by police officer
in GIDAS based on in-depth reconstructed data

Appendix – Used accident types in GES

Disabled Vehicle-Related	If the person is struck is related to a disabled vehicle.
Intersection - Driver Violation	If the person is struck by a driver who is proceeding straight ahead and the report indicates that the driver committed one or more of the following violations: careless driving, failed to yield right-of-way, signal/sign violation, speeding/too fast for conditions, DWI/DUI.
Intersection - Other	If the crash occurs at an intersection but is not covered by any of the above or there is insufficient information to code any of the above
Midblock other	If the crash occurs midblock
Ped. Walks Into Veh. - At Intersection	Person is walking, not running, and strikes the vehicle.
Pedestrian Not In Roadway	If the person is struck when not in/near a roadway (e.g., in parking lot, driveway, private road, gas station, alley, sidewalk, yard, garage, ball field).
Running Pedestrian	If the person is running
Turn at Intersection	If the person and vehicle collided while the vehicle is in the process of turning/merging, is preparing to turn/merge or just completes a turning/merging maneuver
Visual Obstruction	the motorist's view of the person is blocked until an instant before impact
Walking/Running Along Road	If the person is walking or running along a road The person is not on the sidewalk but could have been walking on the shoulder or in the roadway.
Working on Roadway	If the person (e.g., police/emergency personnel, flagman, traffic guard or member of a roadway/construction maintenance crew) is struck while working on, in, over or under the roadway.

Appendix – Used accident types mapped to GIDAS

- In GIDAS there are different accident types than in GES.
  - Therefore a mapping was necessary:
    - categories "Intersection - Driver Violation", "Pedestrian Walks Into Vehicle - At Intersection" and "Multiple Threat - At Intersection" are mapped to "Intersection - Other". Therefore these categories do not appear at bar chart.
- In some GIDAS cases more than one GES pedestrian accident type could be assigned.
  - Therefore a prioritization is necessary, e.g.:
    - "Running Pedestrian" has the highest priority and overrules any other possible accident types (due to coding rules in GES – see page 278 of 2008_GES_coding_manual).
    - "Visual Obstruction" has the second highest priority and overrules other types with less information depth (e.g.: "Pedestrian Walks Into Vehicle - At Intersection", "Intersection - Driver Violation").