Current Results Relating the Effectiveness of Advanced Driver Assistance Systems with Increasing Automation

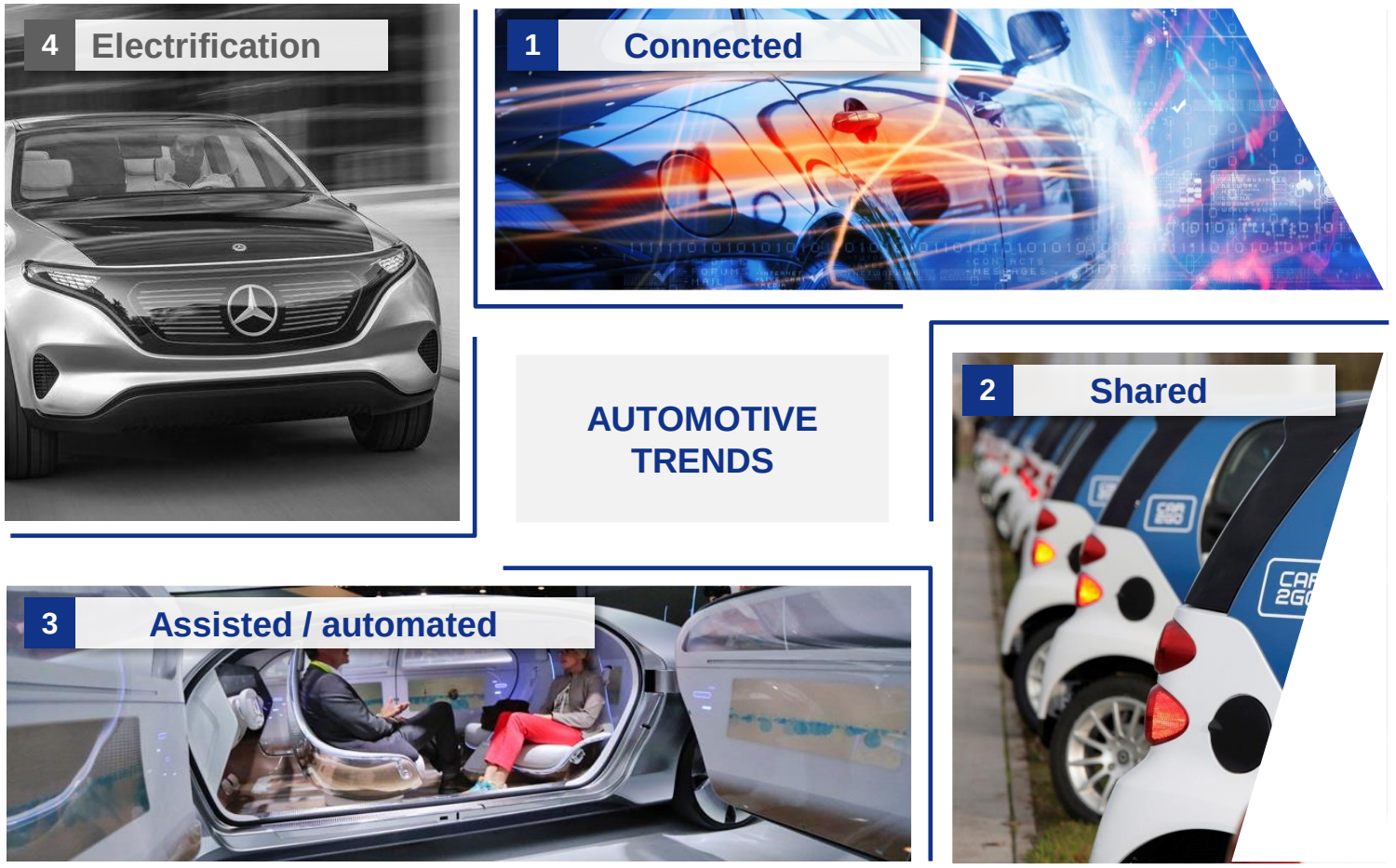
AZT Automotive GmbH
Dr. Johann Gwehenberger
Marcel Borrack
Julian Schatz

April 2017

Source: Bosch

Content

Current Trends and Topics



Quelle: Allianz Global Automotive / AZT / Daimler

Allianz Center for Technology – Overview AZT Accident Research

Cooperation with OEMs and Suppliers

...

Research projects/ field tests/ queries / ADAS tests

- Research projects
- Mobileye field test
- AZT fleet

Market observation relating the development of safety systems

- Driver Assistance Systems
- Automated Driving
- C2x Communication

Scientific cooperation with Universities

- Diploma-, Bachelor-, Master-, Doctor Thesis's

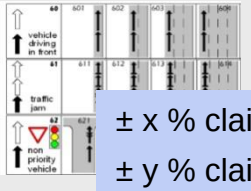
Development of in-depth claim data bases

- TPL claims
- MoD claims

Bodies and labor work

Potential and efficiency analyses of ADAS

- Support for the underwriting
- Risk evaluation

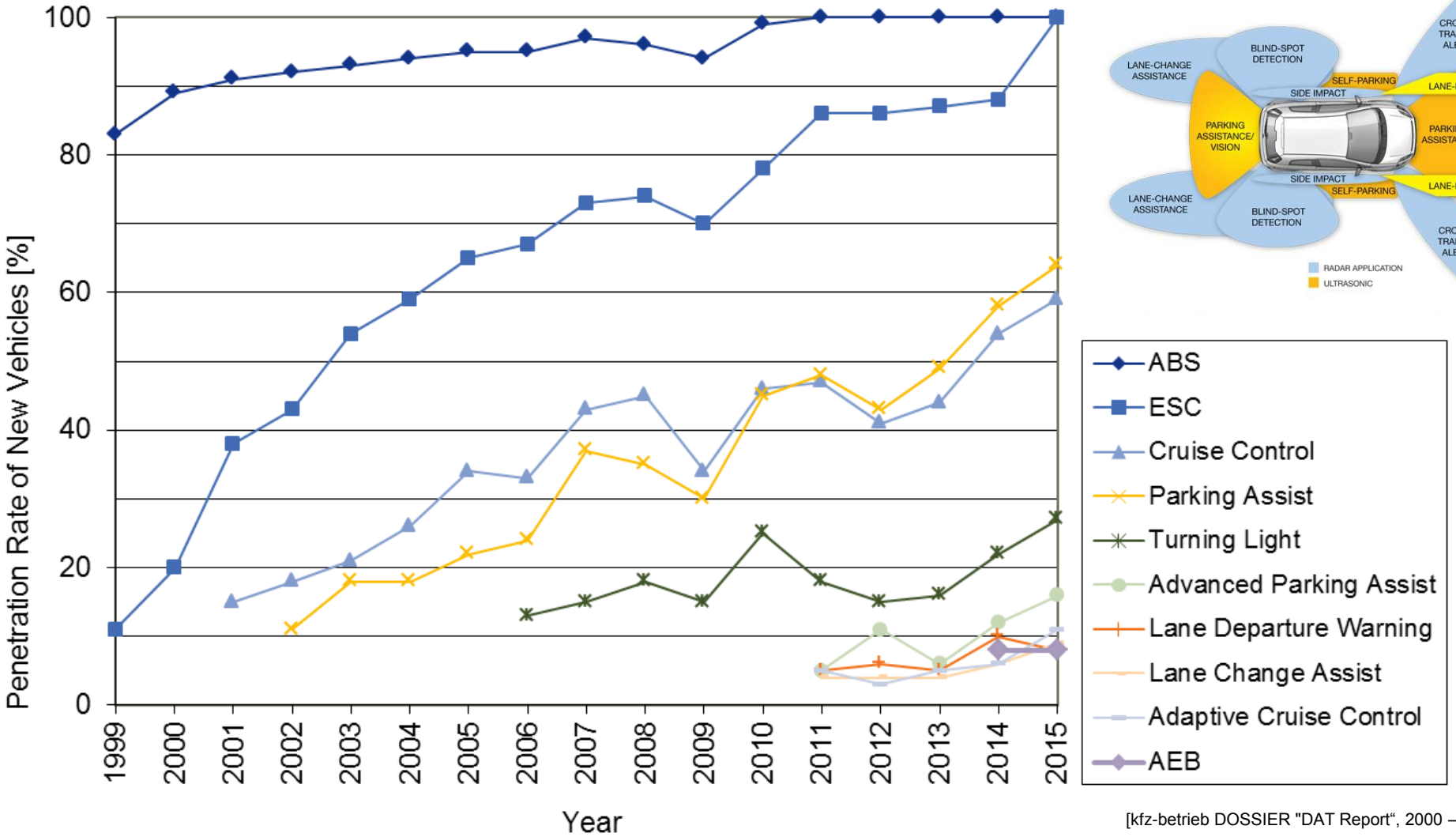


± x % claims
± y % claim costs

Education / presentation / knowledge transfer

- Internal courses for AZ experts
- Consulting of underwriting, claim department, actuaries
- Cooperation with Risk-Management for fleets

Penetration Rate of Driver Assistance Systems
Germany: New Passenger Cars



[kfz-betrieb DOSSIER "DAT Report“, 2000 – 2016]

Availability of ADAS in Current Vehicle Models

OEM	Model	Adaptive Cruise Control	Autonomous Emergency Brake (AEB)	AEB with pedestrian recognition	Lane Departure Warning	Lane Change Assistant	Head-up Display	Traffic Jam Assistant with Steering Assistant	Emergency-Assistant	Crossing Assistant	Reverse-AEB	Reverse Crossing Traffic Assistant
Audi	A3											
	A4									1)		
	A6											
	A8											
	Q5											
BMW	1er											
	Active Tourer											
	3er											
	5er									2)		
	7er											
	x5											
	i3											
Ford	Fiesta											
	Focus											
	Mondeo											
	Edge											
	Kuga											
Honda	Civic											
Infiniti	Q50											
Mercedes-Benz	A-Klasse											
	B-Klasse											
	C-Klasse											
	E-Klasse									2)		
	S-Klasse									2)		

1) for left turn – oncoming traffic
2) crossing traffic

Standard
Optional
Not available

January 2017
Model year 2017

Availability of ADAS in Current Vehicle Models

OEM	Model	Adaptive Cruise Control	Autonomous Emergency Brake (AEB)	AEB with pedestrian recognition	Lane Departure Warning	Lane Change Assistant	Head-up Display	Traffic Jam Assistant with Steering Assistant	Emergency-Assistant	Crossing Assistant	Reverse-AEB	Reverse Crossing Traffic Assistant
Opel	Adam											
	Corsa											
	Astra											
	Insignia											
	Zafira											
Peugeot	308											
	508											
	3008											
Renault	Clio											
	Megane											
	Talisman											
Toyota	Auris											
	Prius											
	Avensis											
Volvo	S90									1)		
	S60											
	XC90									1)		
	V40											
VW	Up											
	Polo											
	Golf											
	Passat											
	Tiguan											
	Touareg											
	Touran											

1) for left turn – oncoming traffic

Standard
Optional
Not available

January 2017
Model year 2017

AZT-Unfallforschung: Marcel Borrack, Dr. Johann Gwehenberger, Jan. 2017

Content

Effectiveness Analysis of ADAS

Both the claims frequency as well as the average claims amount are considered:

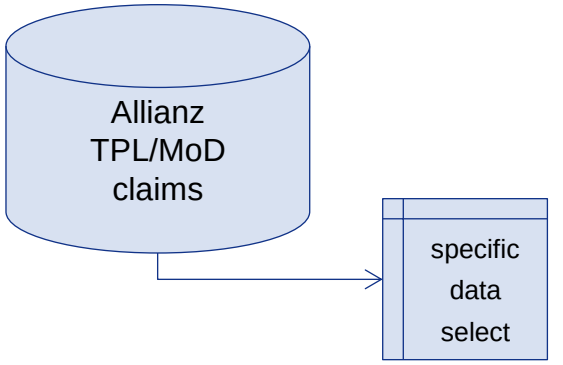
- A decrease in claims frequency is expected from most of the ADAS systems
- The average claims amount can be decreased additionally by e.g. special braking systems, which reduce impact speed and can prevent personal injuries
- A contrario:
  Damage to the ADAS may lead to an increase of the average claims amount itself
  (replacement, repair costs and calibration of the ADAS-sensors)

Effectiveness Analysis of ADAS

General AZT Approach for Ex-ante Analysis

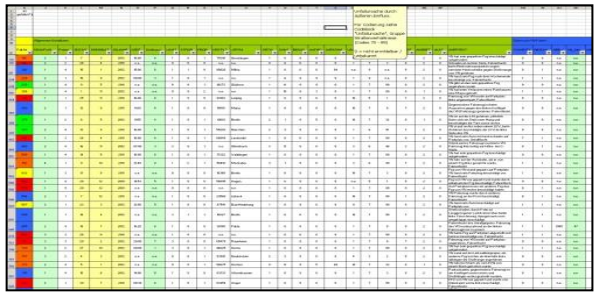
1. Appropriate representative sample of insurance claims data

   e.g. TPL, MoD with digital available parameters like year, VIN, type of claims, claim costs

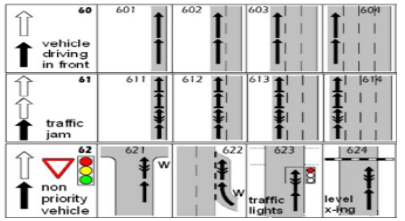


2. Creation of In-depth databases with adequate size and parameters on the basis of claim files (case-by-case study)

   e.g. 1,000 TPL claims with parameters like accident type, vehicle speed, accident location, accident causation



3. Analysis of the In-depth databases regarding ADAS relevance with the help of the specific fields “accident type” and other relevant parameters



4. Prognosis of the effectiveness for a certain ADAS taking into account system limitations, restrictions, repairability, human factor influences like distraction or compensation

± x % claims

± y % claim costs

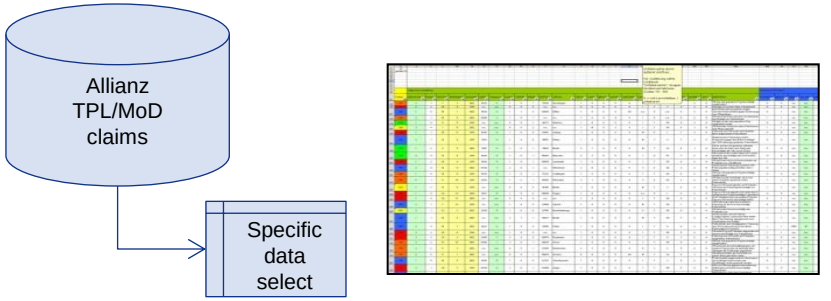
AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,

Effectiveness Analysis of ADAS

General AZT Approach for Ex-post Analysis

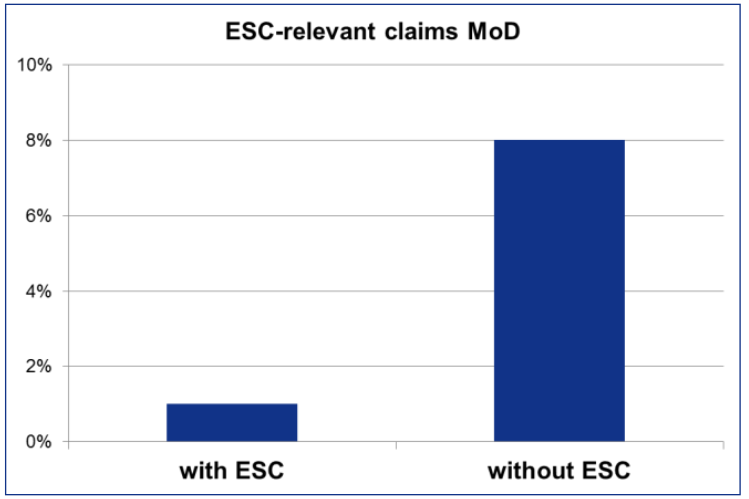
Only possible if ADAS equipment rate is sufficient!

Step 1 and Step 2 similar to Ex-ante Analysis



3. Enrichment of each claim with information about ADAS equipment by
   - VIN request using Audatex
   - VIN transfer from AZT to OEM; ADAS equipment transfer from OEM to AZT

4. Comparison of claims with vehicles equipped and claims with vehicles not equipped with certain ADAS



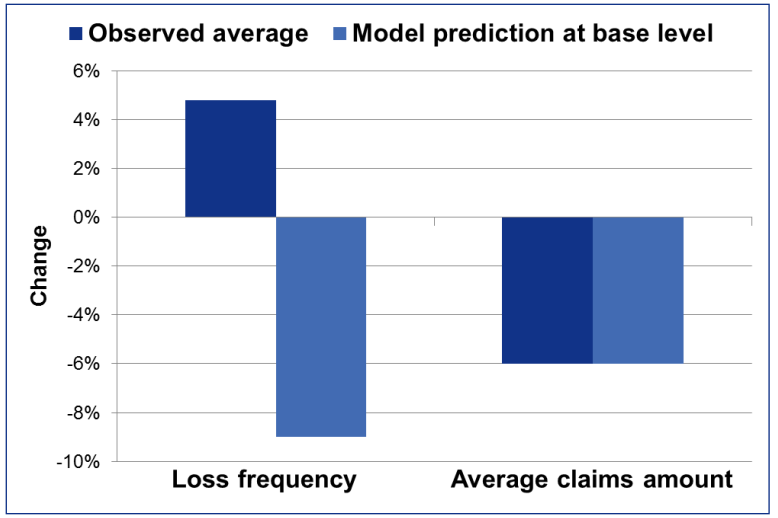
Effectiveness Analysis of ADAS

Multivariate Ex-post-Analysis of the ADAS efficiency on the basis of insured risks

1. Statistical relevant sample of insurance policies with/without ADAS
2. Multivariate Analysis of claim average, claim frequency and claim expectancy including as many rating factors as possible

Considered rating variables:

- Type of vehicle (possible dependence with driver assistance system)
- Type of engine (only little impact on claims frequency)
- No claims bonus (possible influence on choice of vehicle and DAS)
- Age of the youngest driver (classified variable)
- “Social standing” (property owner, own parking space, method of payment)
- Gear mechanism (manual gearbox or automatic transmission)
- Urbanity (according to the registration district classification into major city, small town or rural area)
- Annual mileage
- Type of excess



Results have to be evaluated in the context of the multivariate risk model.

Source: Allianz Germany Actuarial Department/AZT

Content

AZT In-Depth Accident Databases

Insured vehicle is passenger car

TPL Major Claims with Injuries

Third Party Liability major claims with injuries

- Number of claims: 362
- Years: 2002 – 2012
- Cost range of EUR 850,000 to EUR 6,400,000

TPL Claims with Injuries

Third Party Liability claims with injuries

- Number of claims: 833
- Year: 2011
- Random sample, cost range up to EUR 750,000

TPL Claims with Material Damage

Third Party Liability claims with material damage only

- Number of claims: 1000
- Year: 2011
- Random sample, cost range up to EUR 31,000

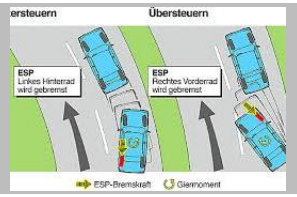
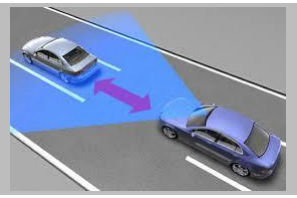
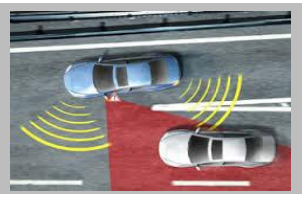
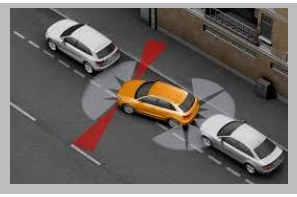
Motor Own Damage Claims

Motor Own Damage claims (only collisions)

- Number of claims: 983
- Year: 2011
- Random sample, cost range up to EUR 35,000

Generic Advanced Driver Assistance Systems

To be investigated relating accident avoidance potential

ESC		Electronic Stability Control
AEB		Autonomous Emergency Braking for Longitudinal Traffic ahead only
AEBpc		Autonomous Emergency Braking for Pedestrians and Cyclists ahead only
LDW/LKA		Lane Departure Warning Lane Keeping Assist
LCA/BLIS		Lane Change Assist Blind Spot Detection
PMA		Parking and Maneuvering Assistant

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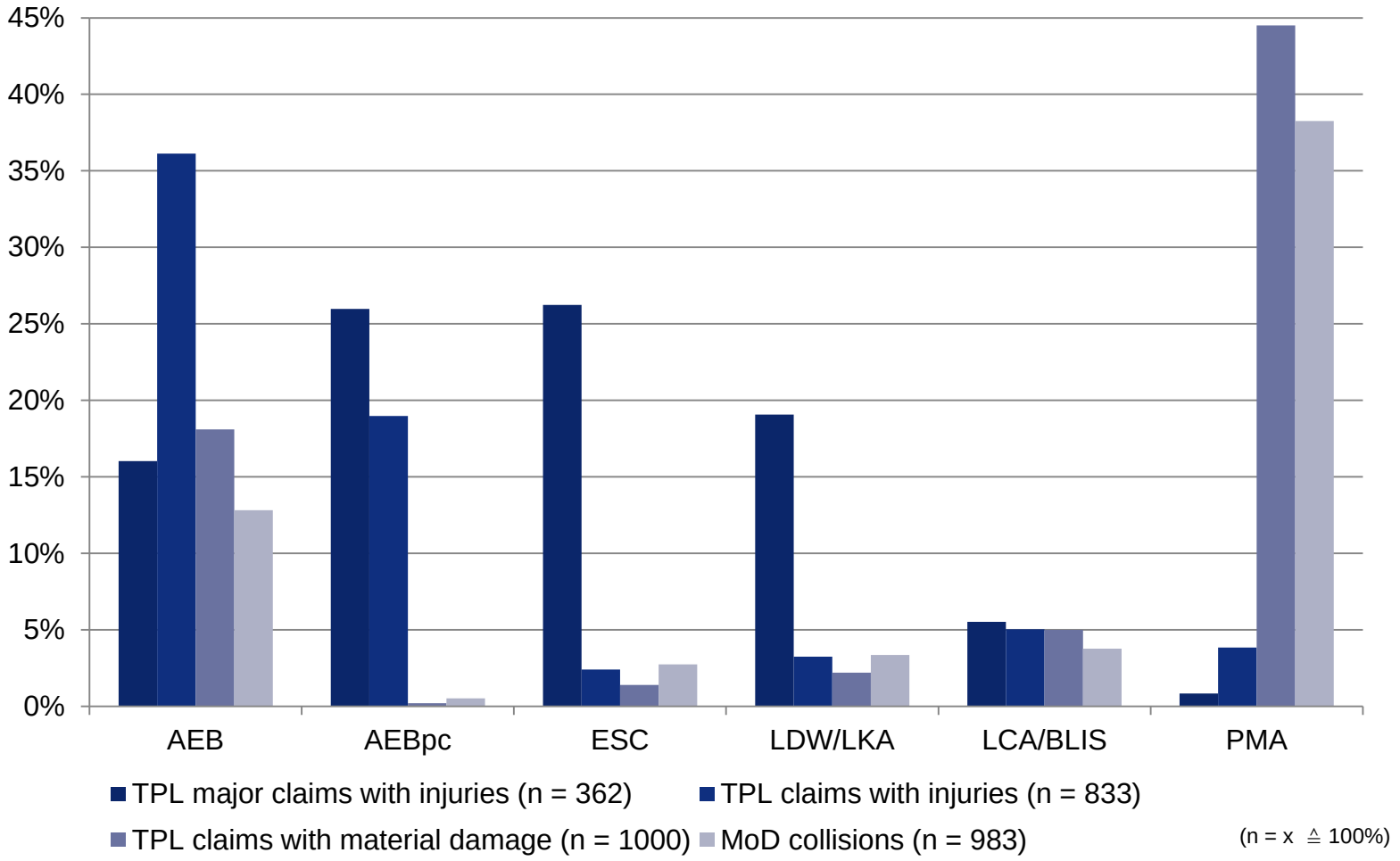
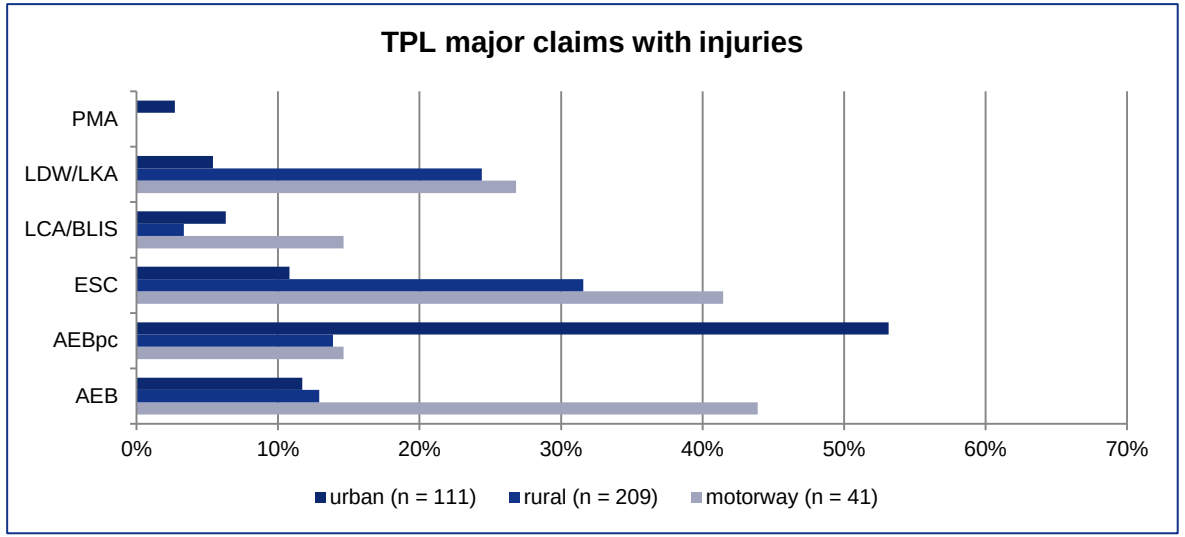
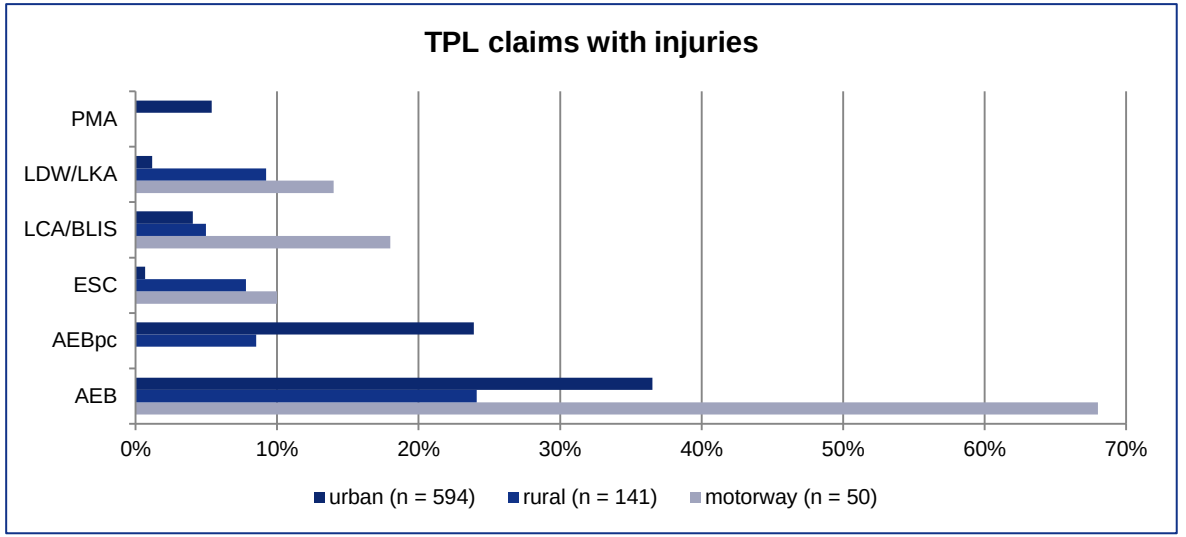
Relevance of ADAS

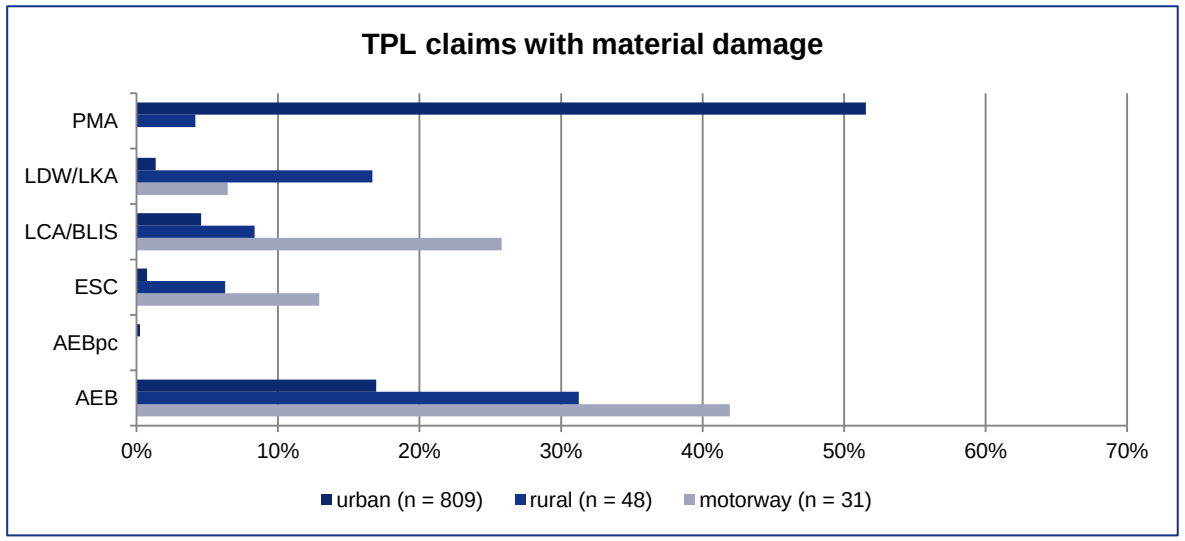
= **theoretical maximum** accident avoidance potential only for a perfect system!

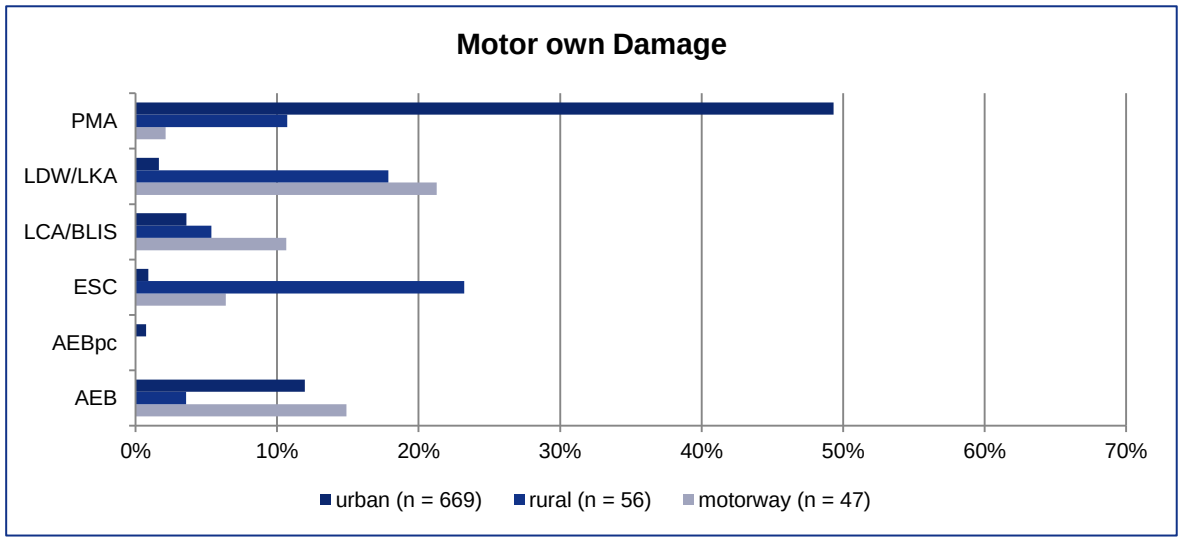


ADAS Relevance Broken Down by Location





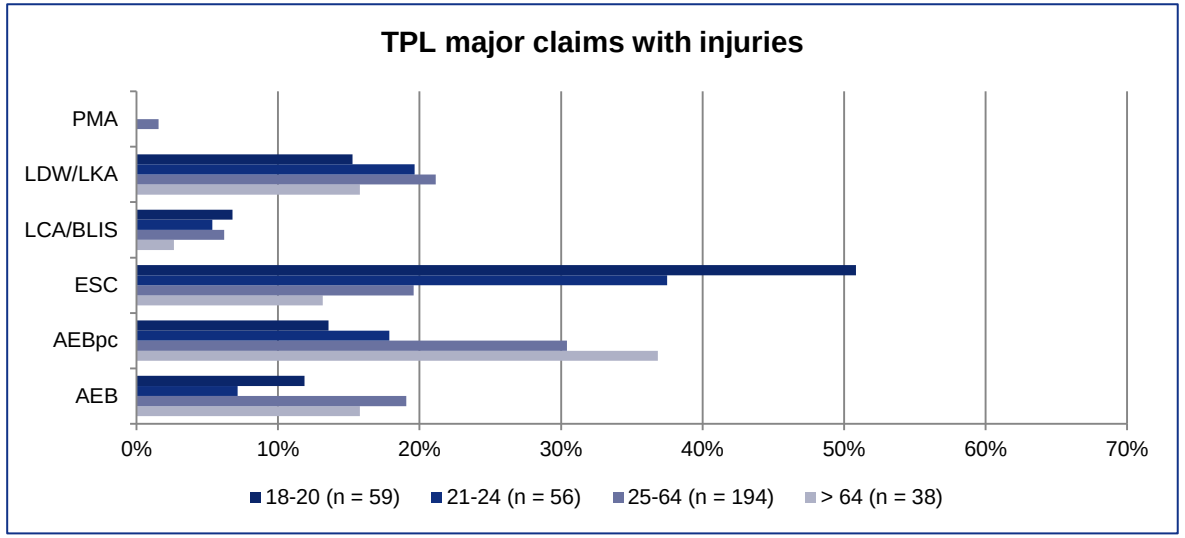


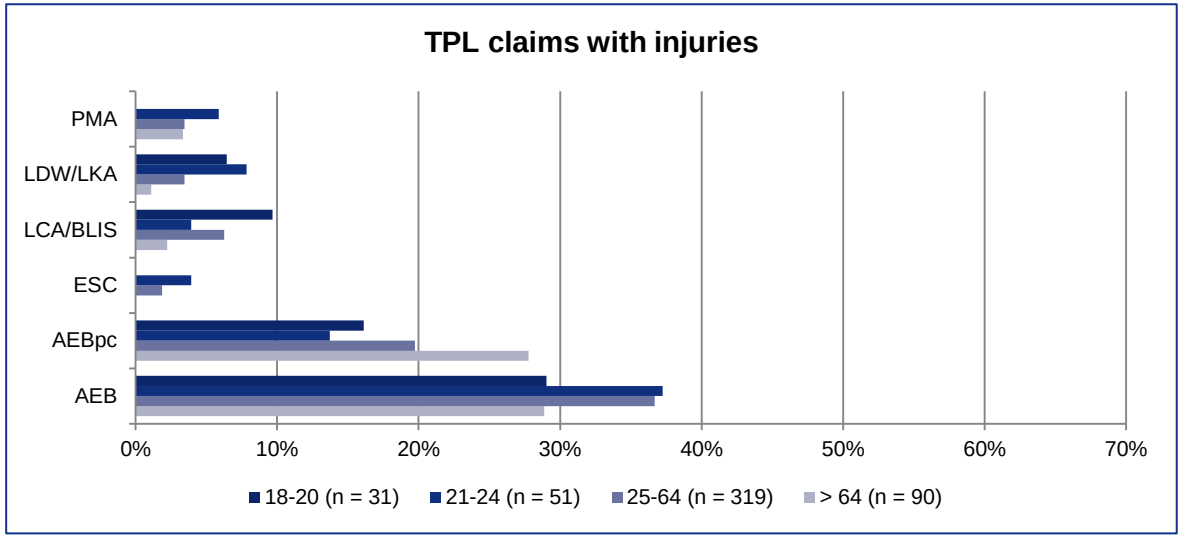


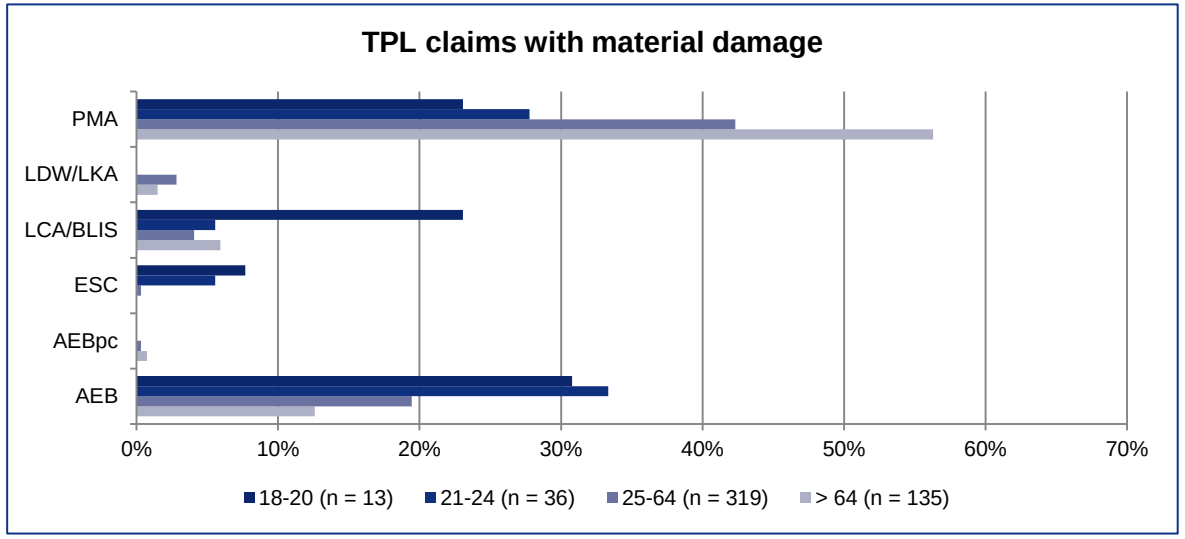
(n = x ≙ 100%)

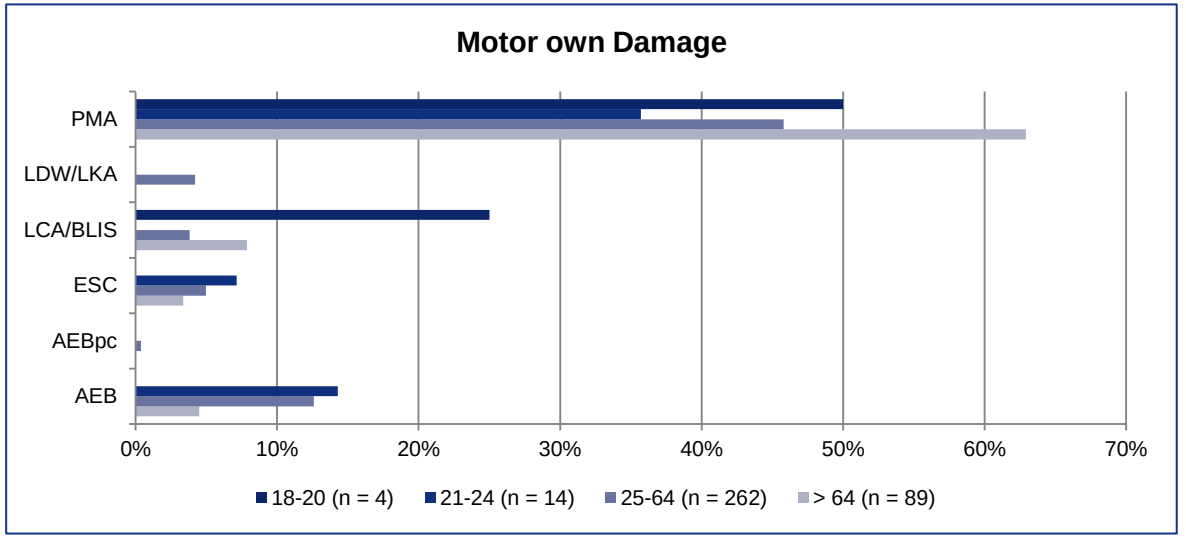
Generally large differences of the ADAS relevance concerning accident location

ADAS Relevance Broken Down by Age of the Driver









(n = x ≙ 100%)

ESC: higher relevance for young drivers; AEBpc: higher relevance for elderly drivers

PMA: higher relevance for elderly drivers in TPL material damage and MoD

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack

AZT/Daimler Research Project Mercedes-Benz B-Class and E-Class

Project Target

Gathering detailed knowledge relating accidents of Mercedes-Benz B-Class and E-Class on the basis of Motor Own Damage claims (MoD)

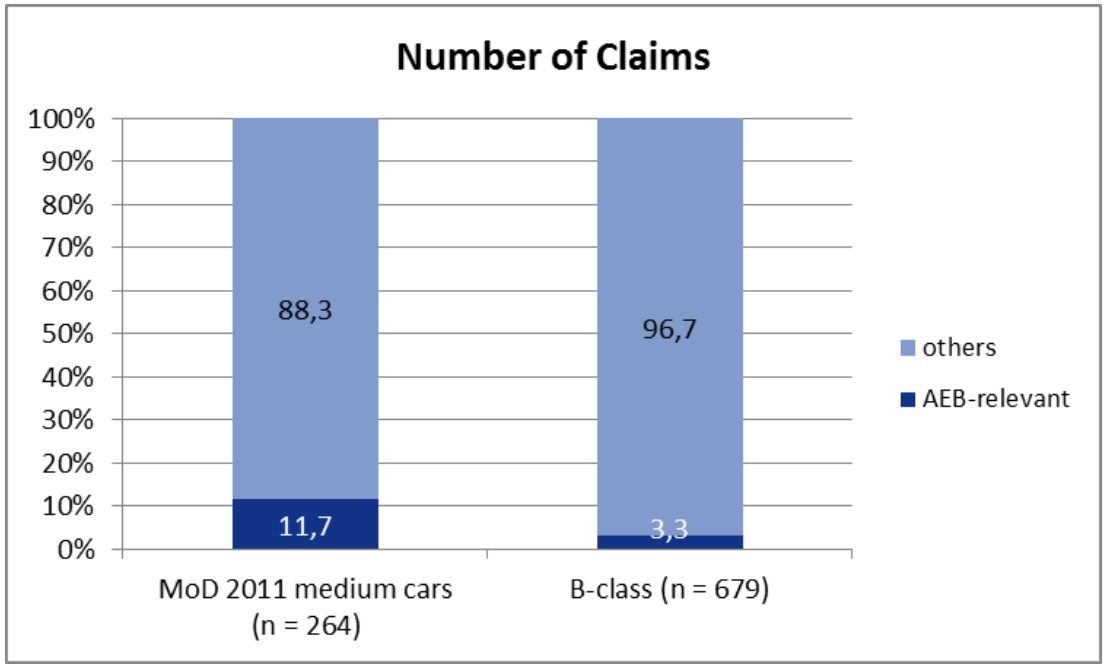
Database and Approach:

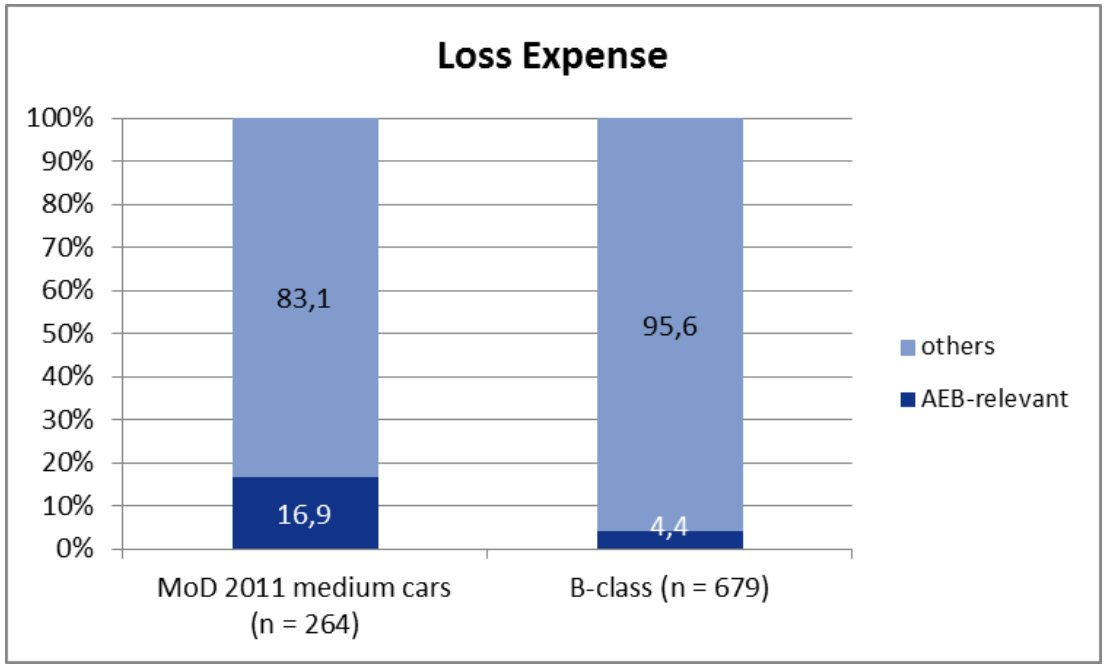
- Random sample of Allianz MoD (only collisions) claims of the years 2012 to 2014 (E-Class 1207, B-Class 970)
- Analysis of ADAS-relevance on the basis of MoD claims (E-Class 854, B-Class 679)

Source: Research Project AZT/Daimler 2015

AEB-Relevance of MoD Collisions in Comparison with Similar Vehicle Types

- MoD 2011: No vehicle equipped with an Forward Collision Warning (FCW)-/AEB-System
- B-Class: FCW is standard fit (Collision Prevention Assist)



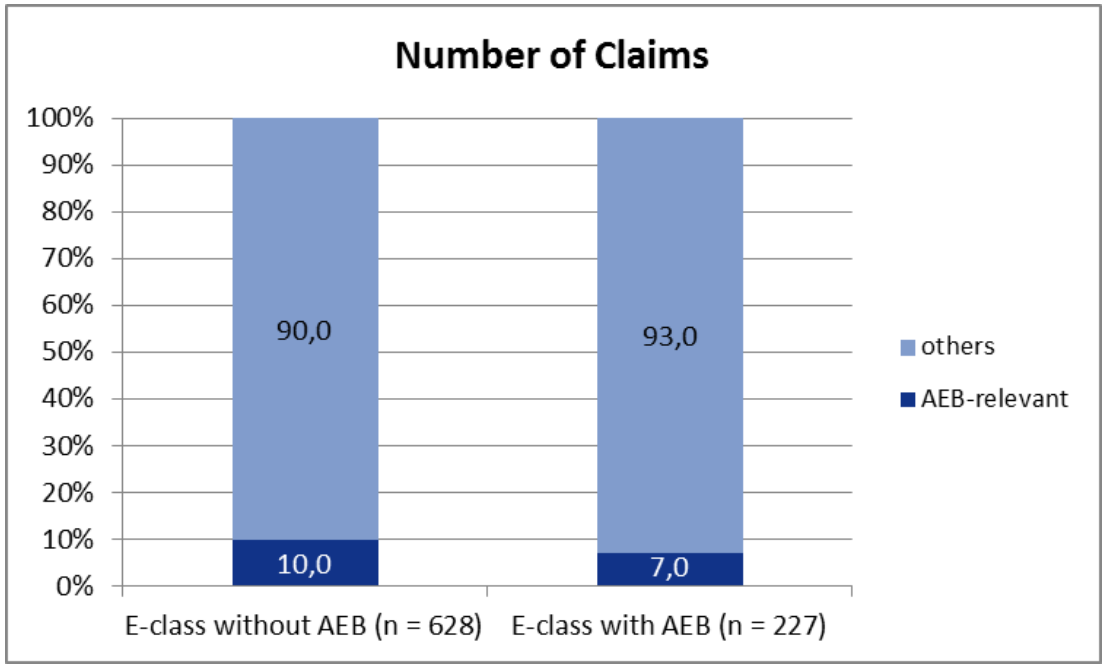


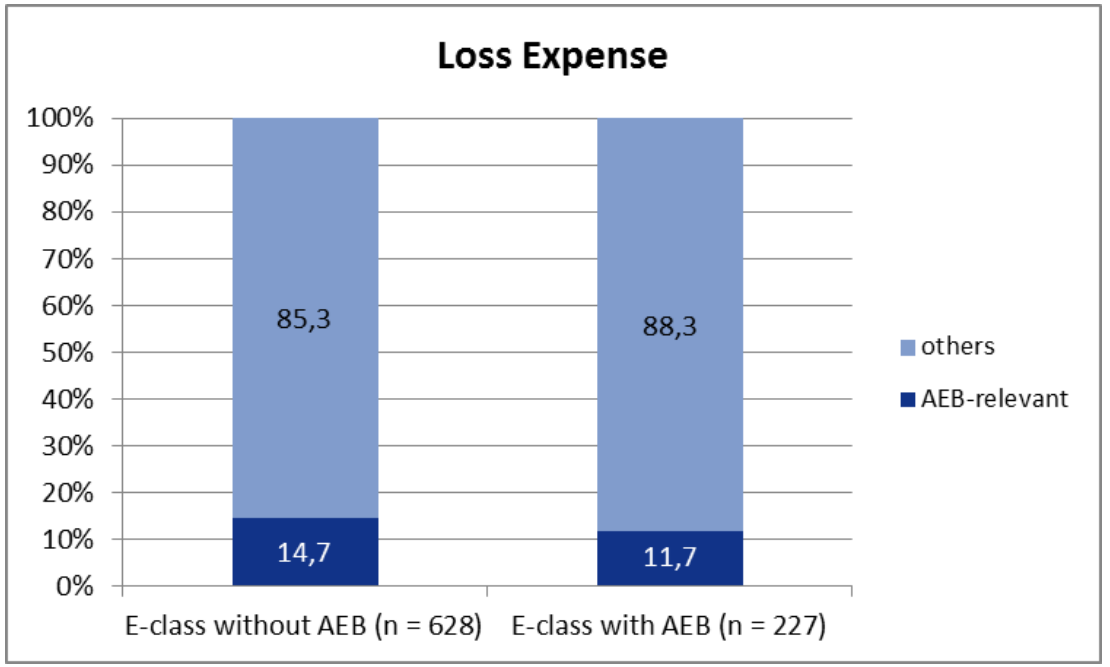
Lower AEB-relevance of B-Class than similar vehicle types ⇨ FCW seems to be effective!

Source: Research Project AZT/Daimler 2015

AEB-Relevance of MoD Collisions of E-Class with/without AEB System

- E-Class: AEB-system is optional equipment





Lower AEB-relevance of E-Class with AEB-System ⇨ AEB seems to be effective!

Source: Research Project AZT/Daimler 2015

AZT/Volvo Research Project Volvo XC60

Project Target

Gathering detailed knowledge relating accidents of Volvo XC60 on the basis of MoD collisions and TPL claims

Database and Approach:

- Random sample of Allianz MoD collisions and TPL claims of the years 2012 to 2015 (Volvo XC60 Type D)
- Analysis of AEB-relevance on the basis of MoD claims (790) TPL claims (829)

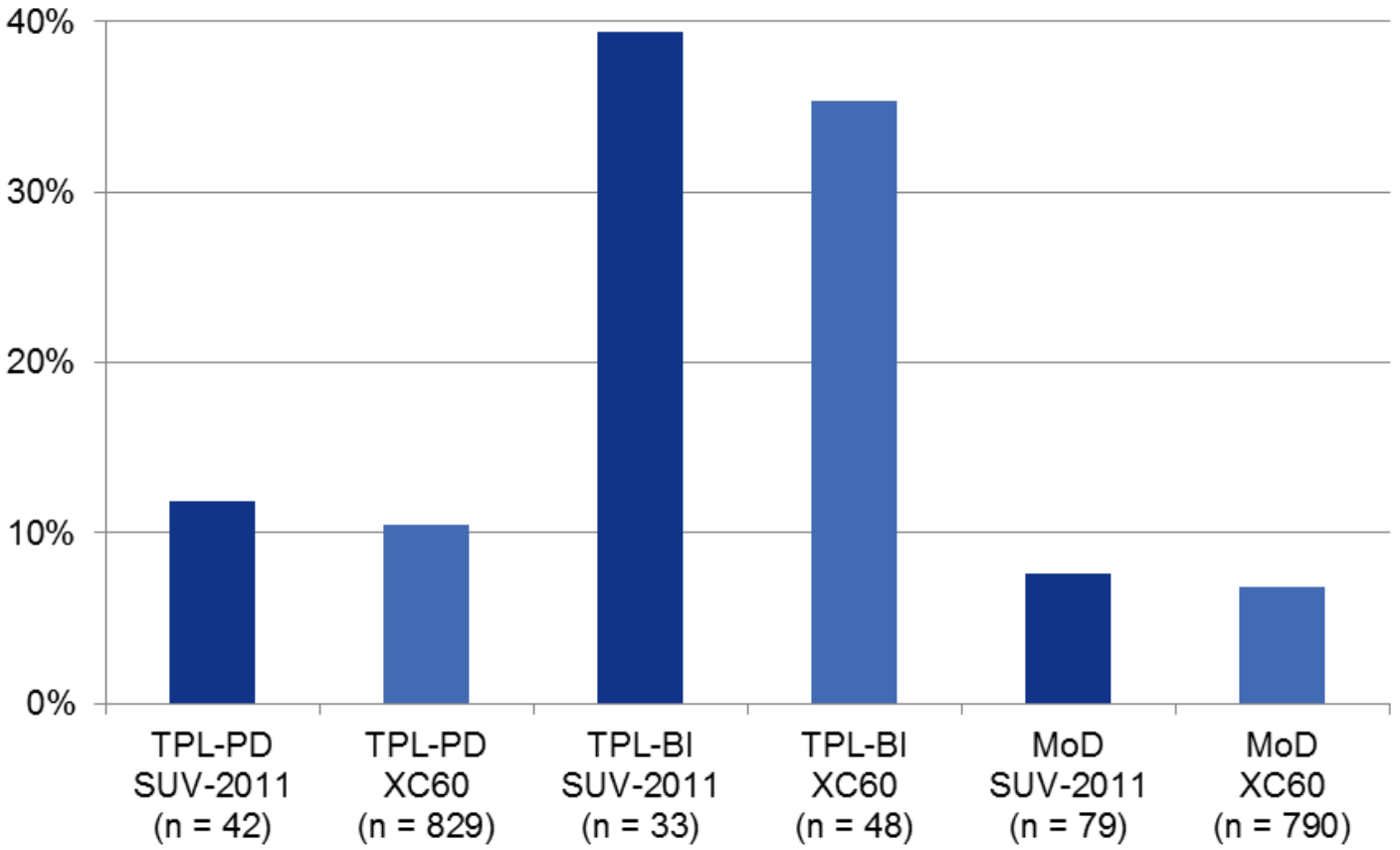
Volvo XC60 Type: D

production period: since 11/2008

Volvo XC60 Type: D Facelift

production period: since 06/2013

Distribution of ADAS Relevance - Volvo XC60 versus other SUVs without AEB

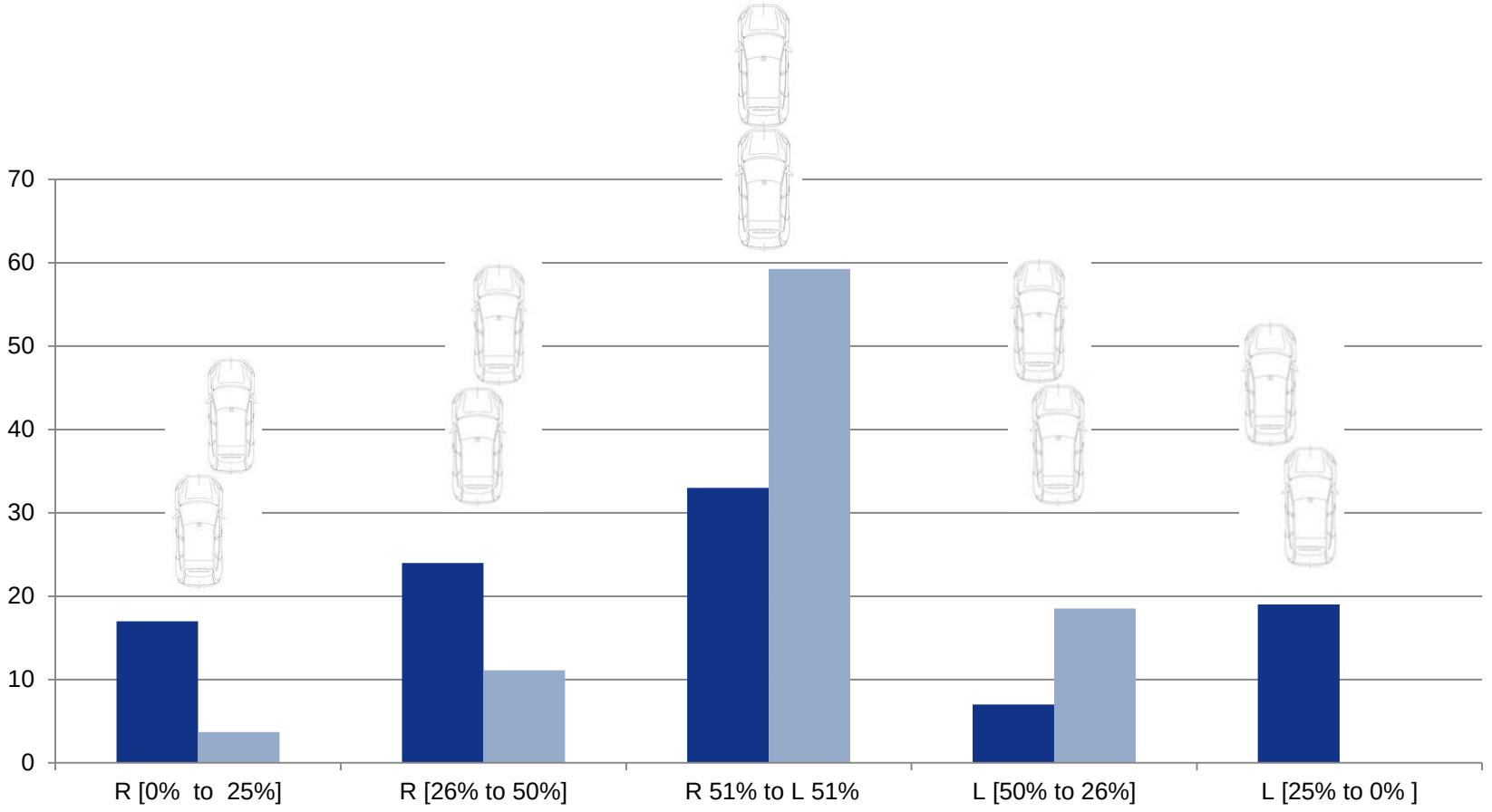


- Volvo City Safety seems to be effective by reducing the frequency of rear end collisions

*TPL-PD: Third party liability with only property damage
TPL-BI: Third party liability with bodily injuries
MoD: Motor own damage

Distribution of Overlap of Rear-End-Collisions

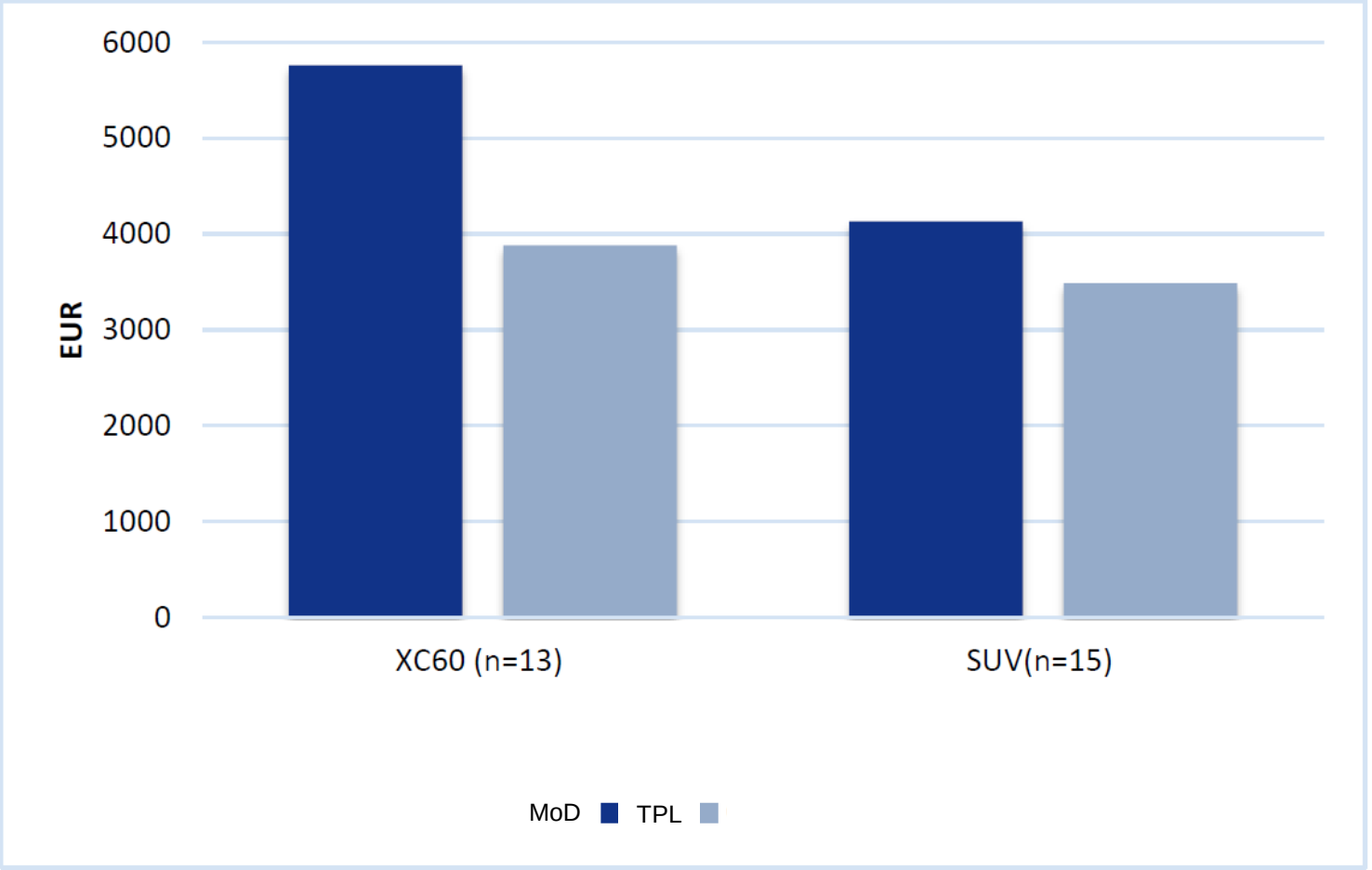
Volvo XC60 versus SUVs without AEB



Volvo XC 60: more rear-end-collisions with overlap lower then 50%

Comparison of Claim Costs in low speed Rear End Collisions

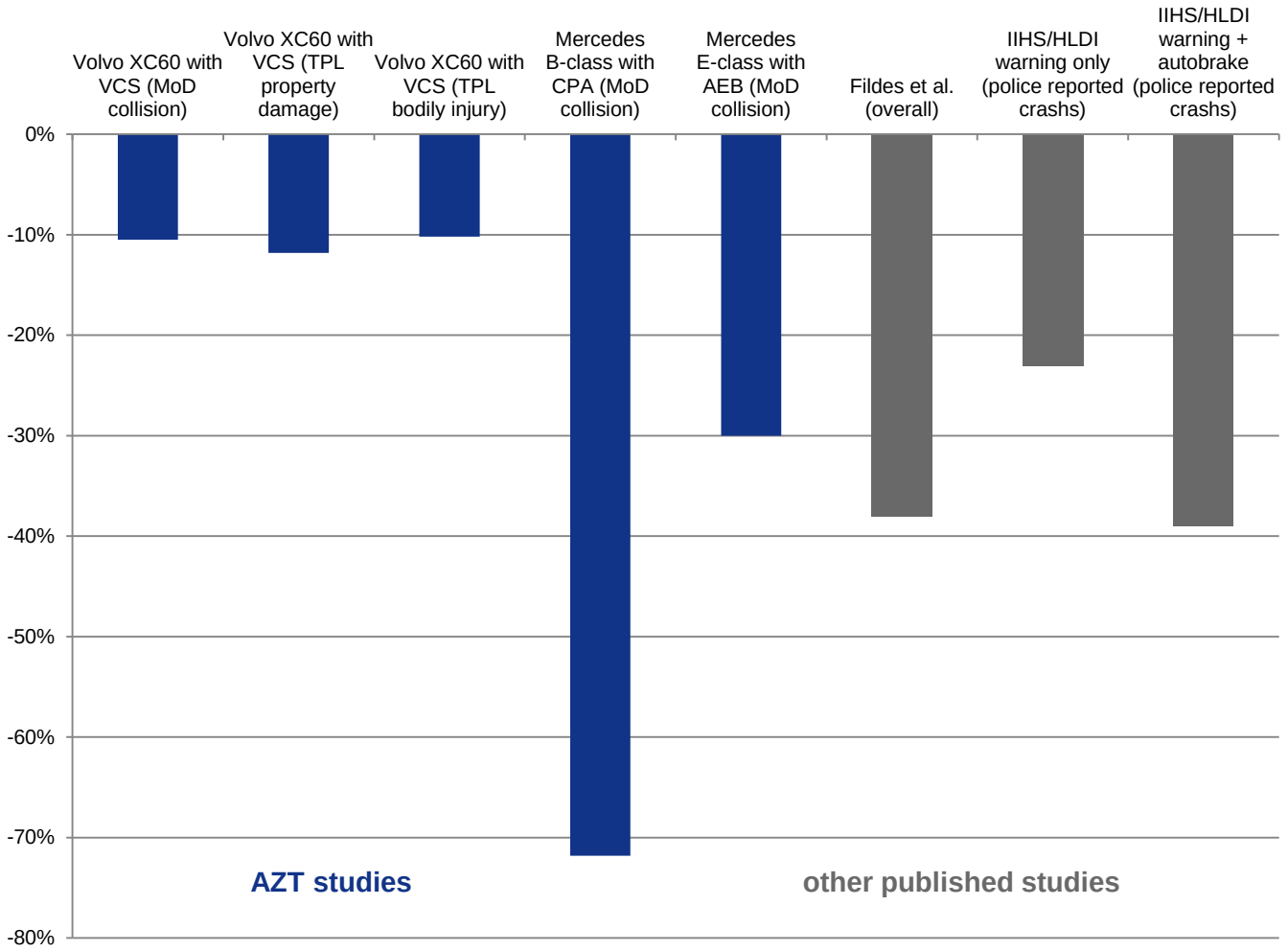
Volvo XC60 versus other SUVs, only claims with MoD and TPL material in parallel



MoD and TPL repair costs of Volvo XC60 are higher because of higher material costs due small overlap

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,

Overview of Efficiency Studies relating the Reduction of Rear-end Collisions due to different Crash Avoidance Systems



Sources:

AZT studies, 2016, 2017

Fildes et al., 2015

IIHS/HLDI, 2016

Abbreviations:

MoD: motor own damage

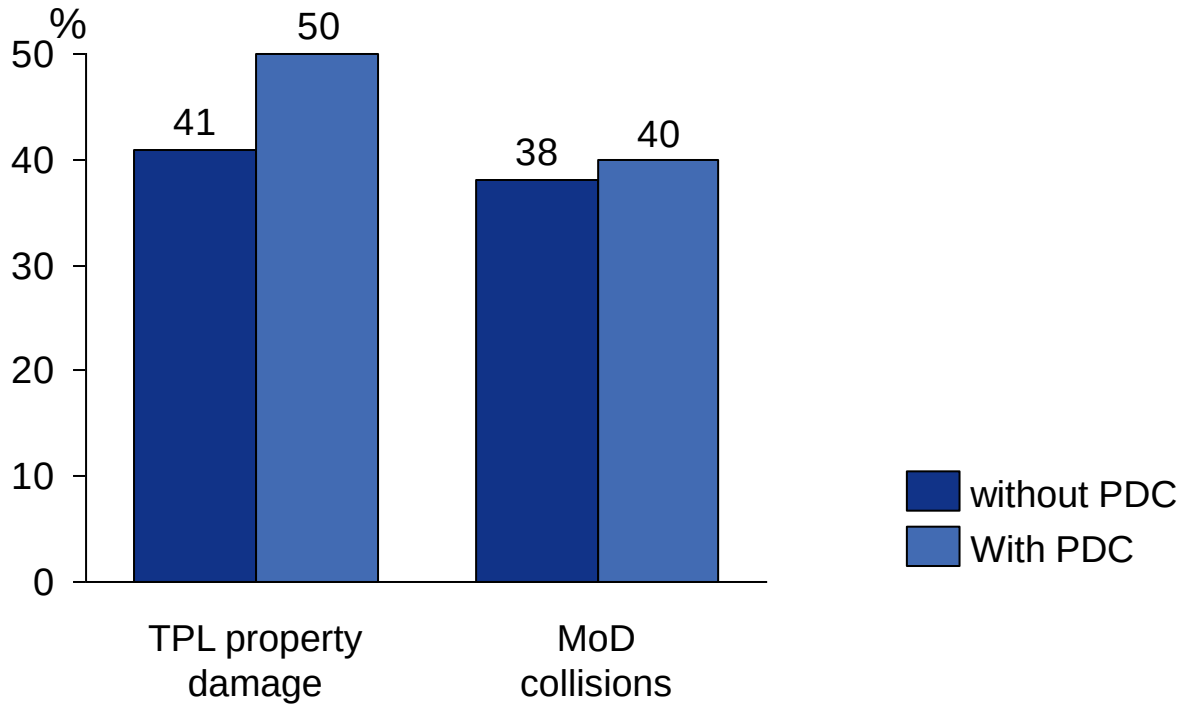
TPL: third party liability

CPA: Mercedes collision prevention system

VCS: Volvo city safety

How effective are Parking and Maneuvering Assistance Systems?

Parking and Maneuvering Accidents with/without PDC



Vehicles with and without PDC have closely the same frequency of parking and maneuvering accidents

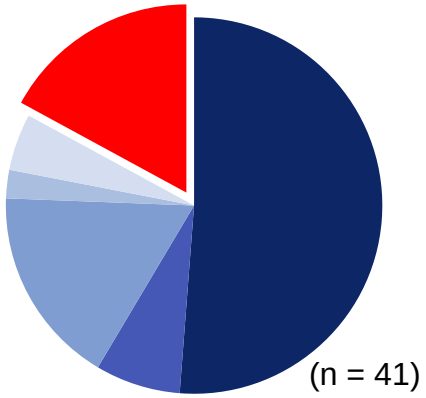
Highly Automated Highway Chauffeur
Which Collisions could be avoided on motorways?

Assumption: In perfect Highway Chauffeur following ADAS are included:

- Autonomous Emergency Brake (AEB)
- Adaptive Cruise Control (ACC)
- Lane Departure Control / Lane Keeping (LDW/LK)
- Blind Spot Detection (BLIS)
- Lane Change Assistant (LCA)
- Electronic Stability Control (ESC)
- Parking and Maneuvering Assistant (PMA)
- Night Vision

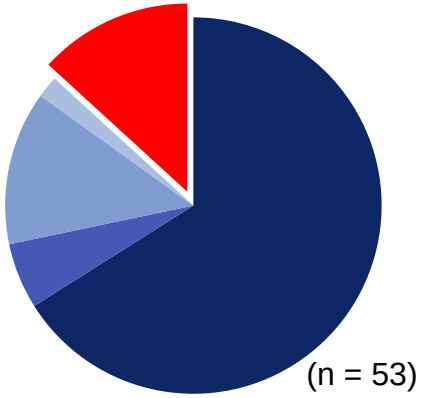
Relevance* of motorway chauffeur on motorway accidents

TPL property damage



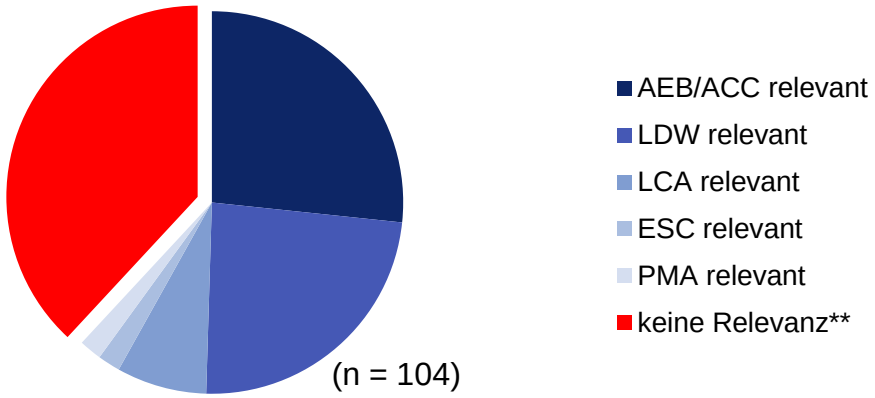
** 3 x moving on standstill vehicle
2 x v > 130 km/h
1 x collision with object (lost load)
1 x aquaplaning

TPL bodily injury



** 5 x v > 130 km/h
1 x influence of alcohol
1 x other vehicle swiped

Motor own Damage collision



** 28 x collision with object (lost load of vehicle in front)
4 x burst tires
3 x v > 130 km/h
3 x aquaplaning
12 x others (e.g. chunks of ice, icy road)

*in accidents with more then one ADAS relevance the prior relevance is taken

source: AZT In-depth databases (DB 2011, DB Audi, DB Volvo 2012-2015)

SAE L3 Autobahn Chauffeur

First conclusions on the basis of small claim numbers

- TPL claims and MoD collisions are less frequent on motorways (< 10%)
- A ratio of two third can be addressed by an SAE L3 Autobahn Chauffeur (if switched on, no misue)
- Additional advantage: components of the Autobahn Chauffeur could also have an positive effect on urban and rural roads

- But: Accidents will still happen because of system limitations:
  - complex traffic situations
  - No anticipation, vehicle are not able (or limited able) to look ahead
  - Intentions of other drivers are not fully recognized (e.g. driver indicator to the right, but turn left)
  - Special dangerous situations are not be recognized (e.g. falling load, sudden situations, aquaplaning)
  - Shift or relocation effects (e.g. distraction, reduced attention and carefulness)

Content

Examples of Current System Limitations of Auto Pilot

Slight Crash Van

Slight Crash in China

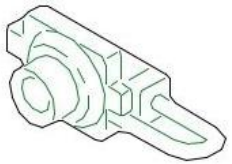
Severe Crash in China

Part Prices of ADAS Sensors and Head Lamps for Different Car Models

Allianz

Long Range Radar

- VW Passat/Golf: 425,- €
- Mercedes CLS/C-Class: 1594,- €
- Honda Civic: 3.386,- €



Mono camera

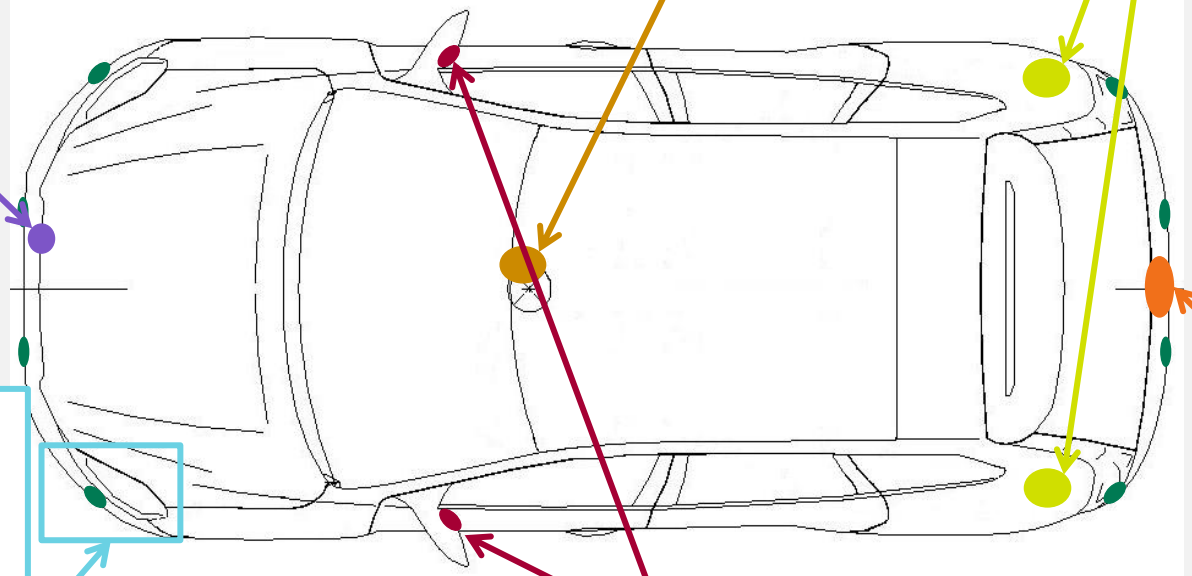
- VW Touran: 414,- €
- Honda Civic: 797,- €

Stereo camera

- Mercedes C-Class: 665,-€
- Mercedes CLS: 788,- €

Short Range Radar

- Mercedes CLS/C-Class: 323,- €
- Volvo XC60: 400,- €
- Honda Civic: 675,- €



Park Distance Control

- Ford C-Max: 20,-€
- Renault Espace: 190,- €

Head Lights

Halogen:
- Opel Astra: 161,-€

LED:
- Audi A4: 1270,- €
- Audi A8: 1850,- €

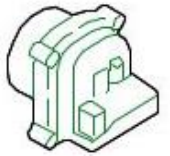
LED-Matrix:
- Opel Astra: 865,-€
- Audi A8: 2440,-€

Xenon:
- Volvo XC60: 377,- €
- Audi A8: 781,- €

Laser:
- BMW i8: 2345,-€
- Audi R8: 5000,-€

Side Camera

- BMW 5er: 231,-€
- Volvo XC60: 395,-€



Rear Camera

- Peugeot 206/306/406: 90,- €
- Honda Civic: 906,- €

Source: audatex; Price rounded without VAT, August 2016

Repair Costs Front Radar Sensors: Example Audi A4 (B9)

- **91 63 19 00: 30 2 Radarsensor aus- u.einbauen**
  - UMFASST
    - 66 04 19 Lüftungsgitter vorn aus- u.eingebaut
- **44 95 01 50: 50 2 Fahrzeug vorn u.hinten prüfen**
  - Schnelleinstieg
  - Verbundarbeit
  - Vorbereitung Assistenzsysteme
- **91 63 05 50: 30 2 Radarsensor prüfen u.einstellen**
  - Schnelleinstieg
  - Vorbereitung Assistenzsysteme
- **91 63 16 50: 90 2 2 Radarsensor einstellen**
- **01 50 00 00: . 2 GFS/Geführte Funktion .**

- Required work: 132 min
- Spare part prices:
  - Front radar sensor right: **986 €**
  - Front radar sensor left: **1,045 €**

Prices: Germany; w/o VAT

Re-adjustment of the adaptive cruise control is required:

- If the rear axle toe setting has been changed.
- If the control unit for ACC has been removed and installed.
- If the front bumper has been removed and installed.
- If the front bumper has been detached or moved.
- If the front bumper is damaged.
- If the vertical misalignment angle is greater than -1.0° to +1.0°.

Special tools and workshop equipment required:

- Vehicle diagnostic tester
- Wheel alignment computer
- Adjusting tool -VAS 272 001-
- Setting device -VAS 6430- or setting device, basic set -VAS 6430/1-
- ACC reflective mirror, Audi -VAS 6430/3-

[erwin.audi.com]

[erwin.volkswagen.de]

[01/2016]

Repair Costs Windscreen: Example Audi A4 (8W)

Windscreen without camera

Spare part price „Standard“ : 287,- €

Working time: 150 min

Windscreen with camera

Spare part price „camera“: 442,- €

Working time: 222 min

- *Windscreen changing … 150 min*
- *camera adjusting incl. preparation ..... 72 min*

Special tools and diagnostic device necessary

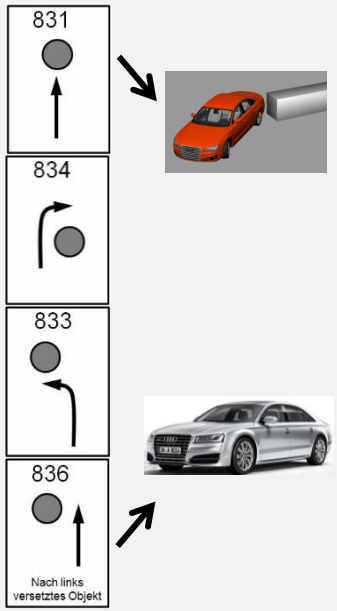
Additional working time with camera:	*+ 72 min (+48%)*
Spare part price with camera	*+ 155 € (+54%)*

[Stand 09/2016]

Monetary Effectiveness Assessment Method – 3 Segments

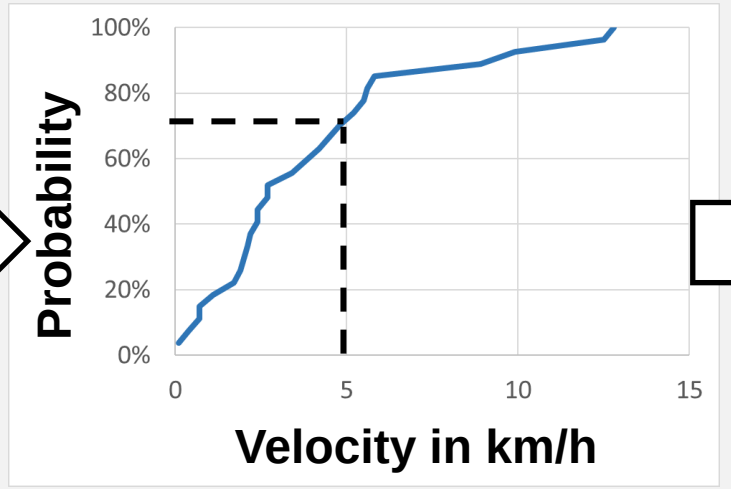
Test Scenarios

In-depth accident database

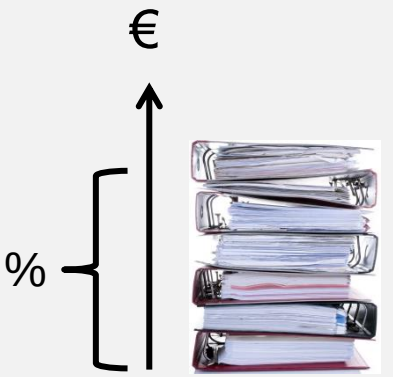


$v_{max,Test}$

Velocity Distribution



Monetary Benefit



% with ADAS

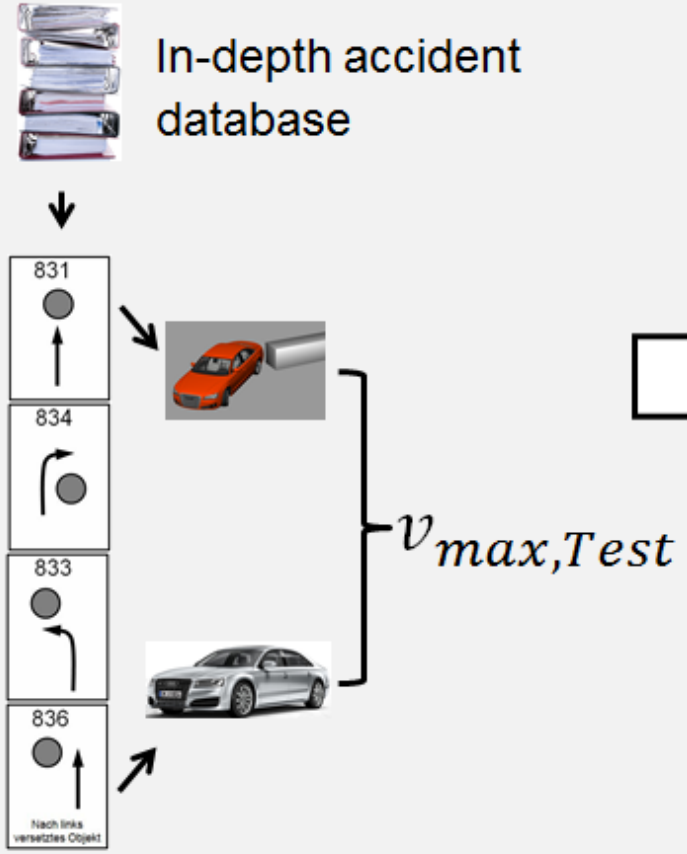
% without ADAS

Schatz und Feig 2017

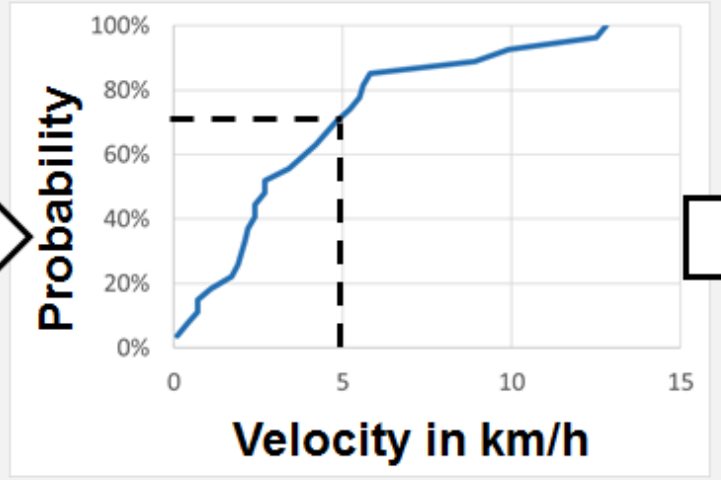
picture sources: pixabay.com, Gschwendtner et al. VKU 2014, PC-Crash, audi.de

Monetary Effectiveness Assessment Method – 3 Segments

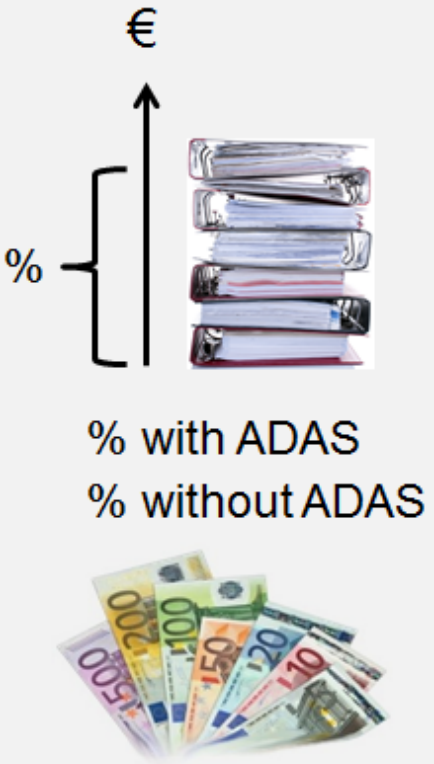
Test Scenarios



Velocity Distribution



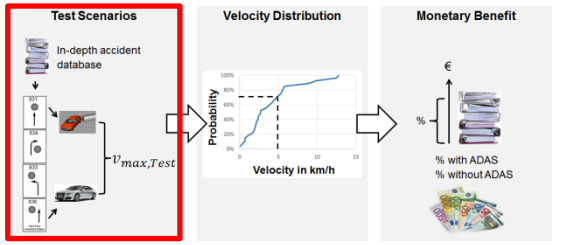
Monetary Benefit



Schatz und Feig 2017

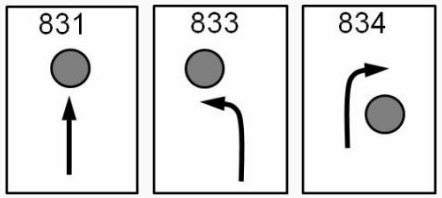
picture sources: pixabay.com, Gschwendtner et al. VKU 2014, PC-Crash, audi.de

Development of Test Scenarios



Real world accidents

Determination of accident kinematics

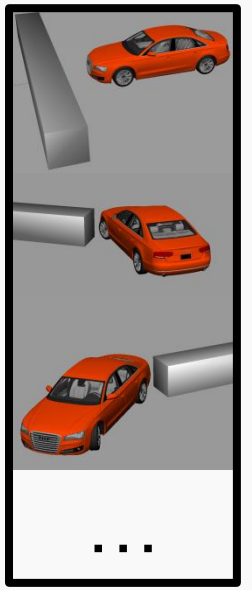


- Type of accident
- Location of damage
- Damaged components

Monetary weighting of individual scenarios

- Frequency
- Claim expenditure

Monetary representative test scenarios for individual ADAS



Driver Assistent System

Determination of the effective field

- Velocity
- Steering angle
- Sensor package
- …

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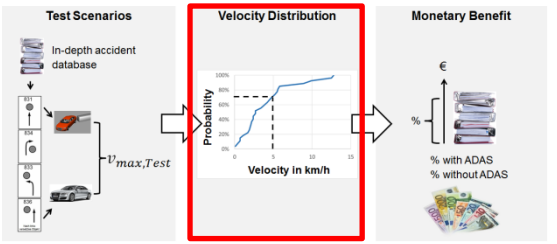
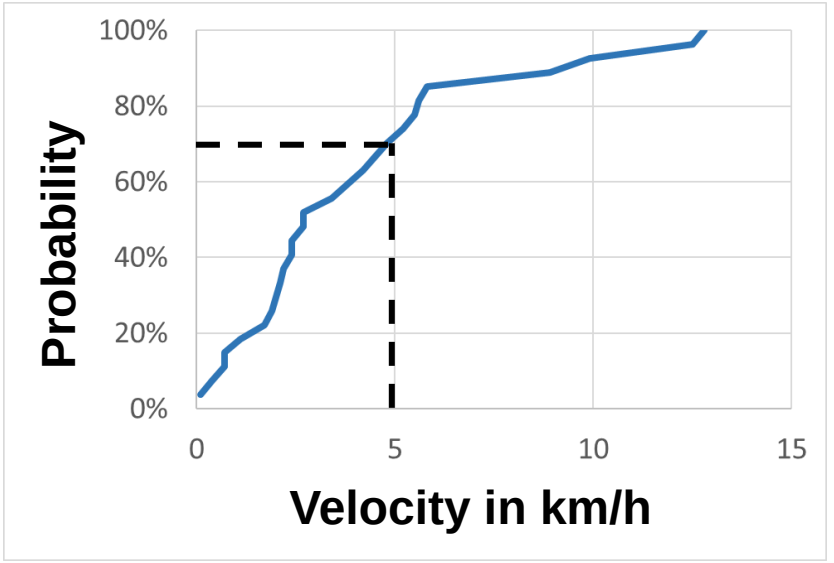
picture sources: pixabay.com, Gschwendtner et al. VKU 2014, PC-Crash, audi.de, audi-mediacenter.com



Velocity Distribution

Velocity when parking and maneuvering

- Naturalistic Driving Study (USA)
- Proband Trial (Germany)



At a velocity of 5 km / h up to 70 % of collisions avoidable

Real Test / Simulation ADAS

- Maximum velocity without collision

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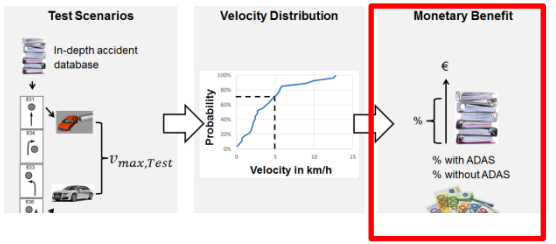
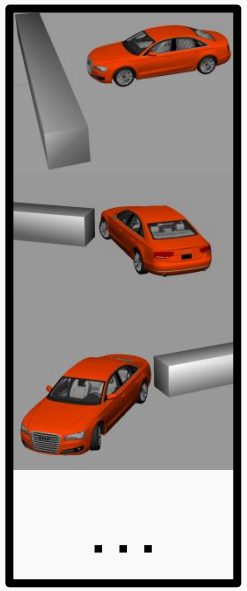
Determination of the Monetary Benefit

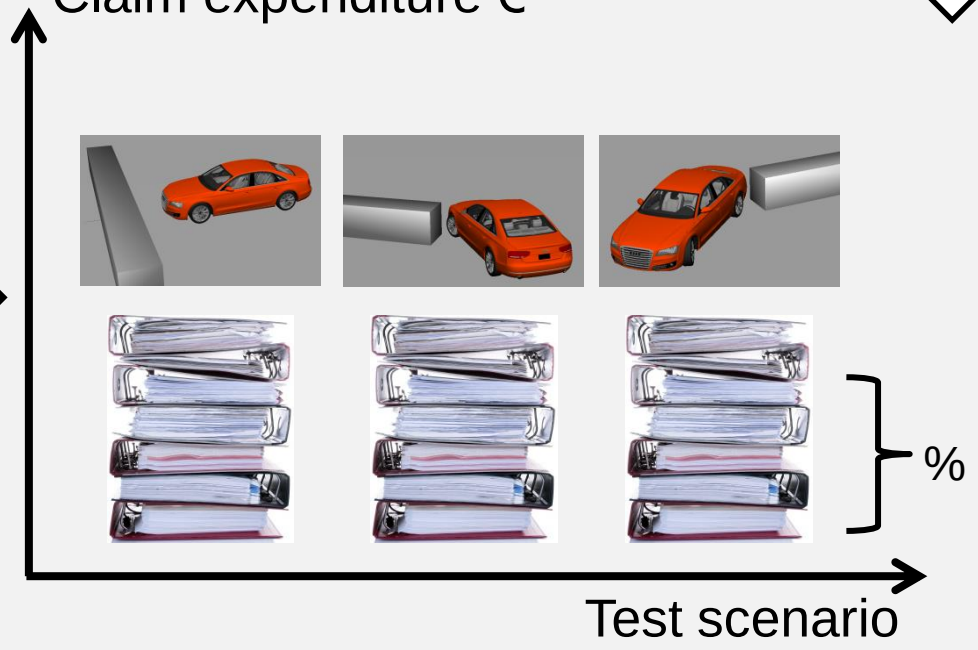


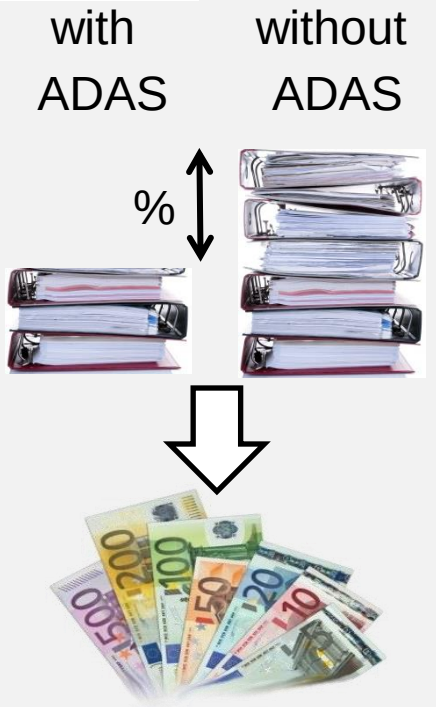
Assignment of test scenarios to damage cases



Sorting depending on claim expenditure and test scenario

Results from ADAS real test
+
velocity distribution





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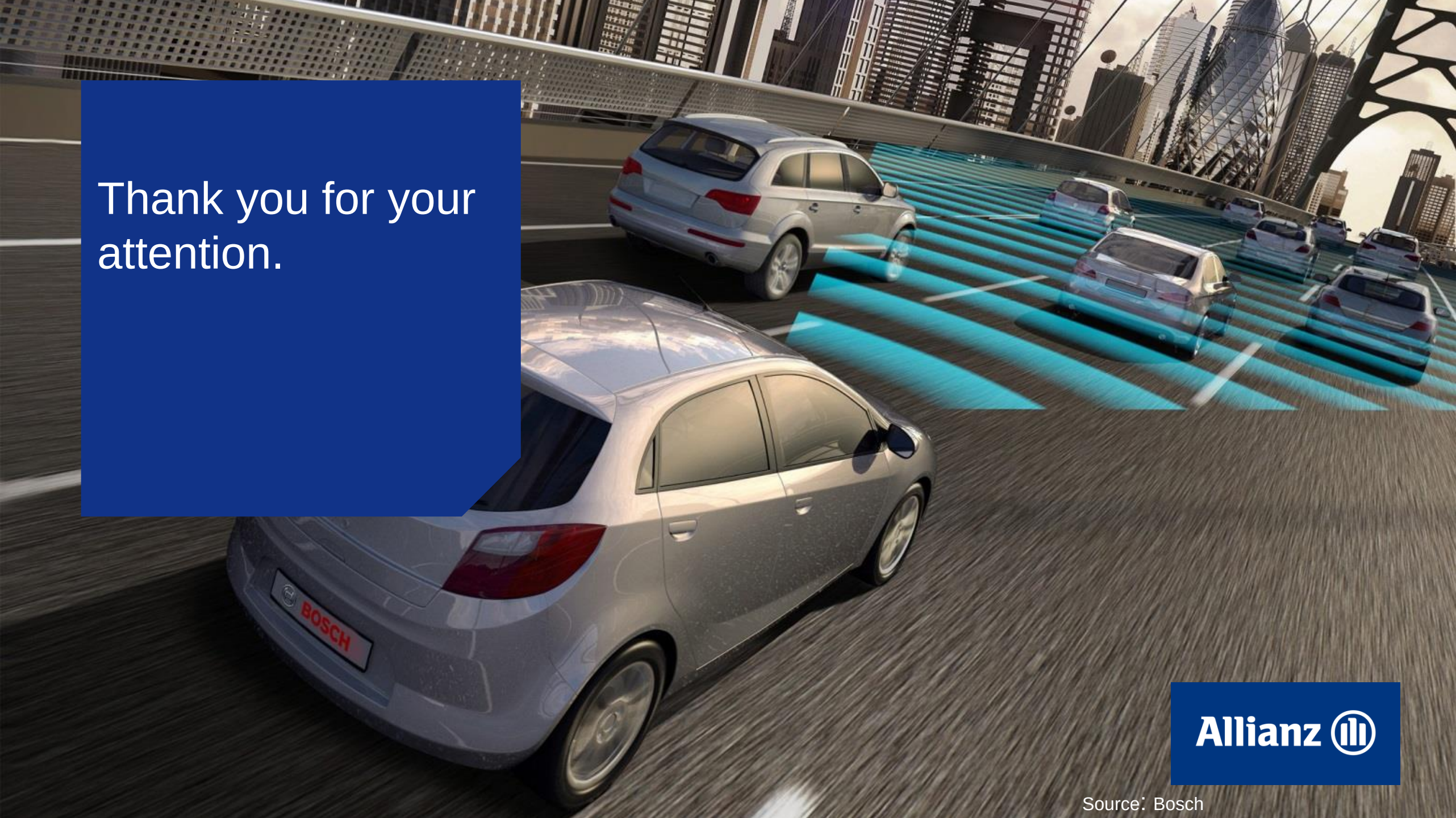
picture sources: pixabay.com, PC-Crash

Conclusions

- New generations of driver assistance systems have the potential to influence insurance claims
- Penetration rates of efficient ADAS are currently low but increasing
- Relevance of ADAS depends on different criteria (e.g. location, driver age, vehicle class)
- Advanced driver assistance systems will lead – in the long term - to a decrease of claim frequency and average claim costs
- …but repair costs of sensors and head lights will be a challenge !!!
- AEB and Parking and Maneuvering Assistants (PMA) have a high insurance claim avoidance potential
- Benefit of current PDC generations is limited concerning loss prevention
- Special insurance products are possible, taking into account efficient driver assistance systems

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,



Thank you for your attention.

Allianz

Source: Bosch