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
AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,
Current Trends and Topics

AUTOMOTIVE TRENDS

1. Connected

2. Shared

3. Assisted / automated

4. Electrification

Quelle: Allianz Global Automotive / AZT / Daimler
### Cooperation with OEMs and Suppliers
- Volkswagen
- Bosch
- Bmw
- Volvo
- Ford
- Continental
- Audi
- Opel

### 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
- Supports for the underwriting
- Risk evaluation

### Potential and efficiency analyses of ADAS
- ± 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

[Graph showing the penetration rate of various driver assistance systems in Germany from 1999 to 2015. The systems include ABS, ESC, Cruise Control, Parking Assist, Turning Light, Advanced Parking Assist, Lane Departure Warning, Lane Change Assist, and Adaptive Cruise Control.]

## Availability of ADAS in Current Vehicle Models

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

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

Januar 2017
Model year 2017

AZT-Unfallforschung: Marcel Borrack, Dr. Johann Gwehenberger, Jan. 2017
## Availability of ADAS in Current Vehicle Models

<table>
<thead>
<tr>
<th>OEM</th>
<th>Model</th>
<th>Adaptive Cruise Control</th>
<th>Autonomous Emergency Brake (AEB)</th>
<th>AEB with pedestrian recognition</th>
<th>Lane Departure Warning</th>
<th>Lane Change Assistant</th>
<th>Head-up Display</th>
<th>Traffic Jam Assistant with Steering Assistant</th>
<th>Emergency Assistant</th>
<th>Crossing Assistant</th>
<th>Reverse-AEB</th>
<th>Reverse Crossing Traffic Assistant</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3008</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>Prius</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td></td>
<td>Avensis</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
</tr>
<tr>
<td>Volvo</td>
<td>S90</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>S60</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
<tr>
<td></td>
<td>XC90</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Green</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
<td>Red</td>
</tr>
</tbody>
</table>

1) for left turn – oncoming traffic

---

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

January 2017

Model year 2017

---

Standard
Optional
Not available
Content

1 AZT-Accident Research
   - Objectives
   - Motivation

2 Analysis Methods
   - Ex-ante Efficiency Analysis
   - Ex-post Efficiency Analysis
   - Multivariate Analysis by Actuaries

3 Recent Results on ADAS Relevance and Efficiency

4 Challenges

5 Conclusions
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
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
1 AZT-Accident Research
   - Objectives
   - Motivation

2 Analysis Methods
   - Ex-ante Efficiency Analysis
   - Ex-post Efficiency Analysis
   - Multivariate Analysis by Actuaries

3 Recent Results on ADAS Relevance and Efficiency

4 Challenges

5 Conclusions
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

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,
## Generic Advanced Driver Assistance Systems

To be investigated relating accident avoidance potential

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESC</td>
<td>Electronic Stability Control</td>
</tr>
<tr>
<td>AEB</td>
<td>Autonomous Emergency Braking for Longitudinal Traffic ahead only</td>
</tr>
<tr>
<td>AEB&lt;sub&gt;pc&lt;/sub&gt;</td>
<td>Autonomous Emergency Braking for Pedestrians and Cyclists ahead only</td>
</tr>
</tbody>
</table>
| LDW/LKA | Lane Departure Warning  
|         | Lane Keeping Assist |
| LCA/BLIS | Lane Change Assist  
|         | Blind Spot Detection |
| PMA    | Parking and Maneuvering Assistant |

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack
Relevance of ADAS

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

TPL major claims with injuries (n = 362)
TPL claims with injuries (n = 833)
TPL claims with material damage (n = 1000)
MoD collisions (n = 983)

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack
ADAS Relevance Broken Down by Location

Generally large differences of the ADAS relevance concerning accident location

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack
ADAS Relevance Broken Down by Age of the Driver

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)
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
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

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,
How effective are Parking and Maneuvering Assistance Systems?

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

- MoD collisions:
  - Without PDC: 41%
  - With PDC: 38%

- TPL property damage:
  - Without PDC: 50%
  - With PDC: 40%
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)
- Parking and Maneuvering Assistant (PMA)
- Electronic Stability Control (ESC)
- 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

(\(n = 41\))

TPL bodily injury

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

(\(n = 53\))

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)

(\(n = 104\))

*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)
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 misuse)
- Additional advantage: components of the Autobahn Chauffeur could also have a 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

1  AZT-Accident Research
   - Objectives
   - Motivation

2  Analysis Methods
   - Ex-ante Efficiency Analysis
   - Ex-post Efficiency Analysis
   - Multivariate Analysis by Actuaries

3  Recent Results on ADAS Relevance and Efficiency

4  Challenges and future AZT-Accident Research Approach

5  Conclusions
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

**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,- €
- 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)

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

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 $-1.0^\circ$ to $+1.0^\circ$.

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-

Prices: Germany; w/o VAT

AZT Accident Research: Dr. Johann Gwehenberger, Marcel Borrack,
**Repair Costs Windscreen: Example Audi A4 (8W)**

**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

<table>
<thead>
<tr>
<th>Additional working time with camera:</th>
<th>+ 72 min (+48%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spare part price with camera</td>
<td>+ 155 € (+54%)</td>
</tr>
</tbody>
</table>
Monetary Effectiveness Assessment Method – 3 Segments

Test Scenarios

- In-depth accident database

$ v_{\text{max,Test}} $

Velocity Distribution

- Probability
- Velocity in km/h

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

- In-depth accident database

Velocity Distribution

- $v_{max,Test}$

Monetary Benefit

- €
  - % with ADAS
  - % without ADAS

Schatz und Feig 2017

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

Real world accidents

Allianz

Driver Assistent System

Determination of accident kinematics

- Type of accident
- Location of damage
- Damaged components

Monetary weighting of individual scenarios

- Frequency
- Claim expenditure

Determination of the effective field

- Velocity
- Steering angle
- Sensor package
- ...

Monetary representative test scenarios for individual ADAS

Schatz und Feig 2017

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)

Real Test / Simulation ADAS

- Maximum velocity without collision

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

Schatz und Feig 2017
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

Claim expenditure €

Test scenario

with ADAS

without ADAS

%
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.
Thank you for your attention.