

# APPLICATIONS IN TRAFFIC ACCIDENT RESEARCH TO IMPROVE VEHICLE SAFETY

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# Structure

1. Necessity of traffic accident research
2. Application assisted accident investigation
3. Data analyses for research on traffic safety
4. Pre-crash simulation to enhance traffic safety
5. Conclusion

# Applications in Traffic accident research to improve vehicle safety

## Necessity of traffic accident research

### Accident research in the 1920s



Early “accident research” in Dresden



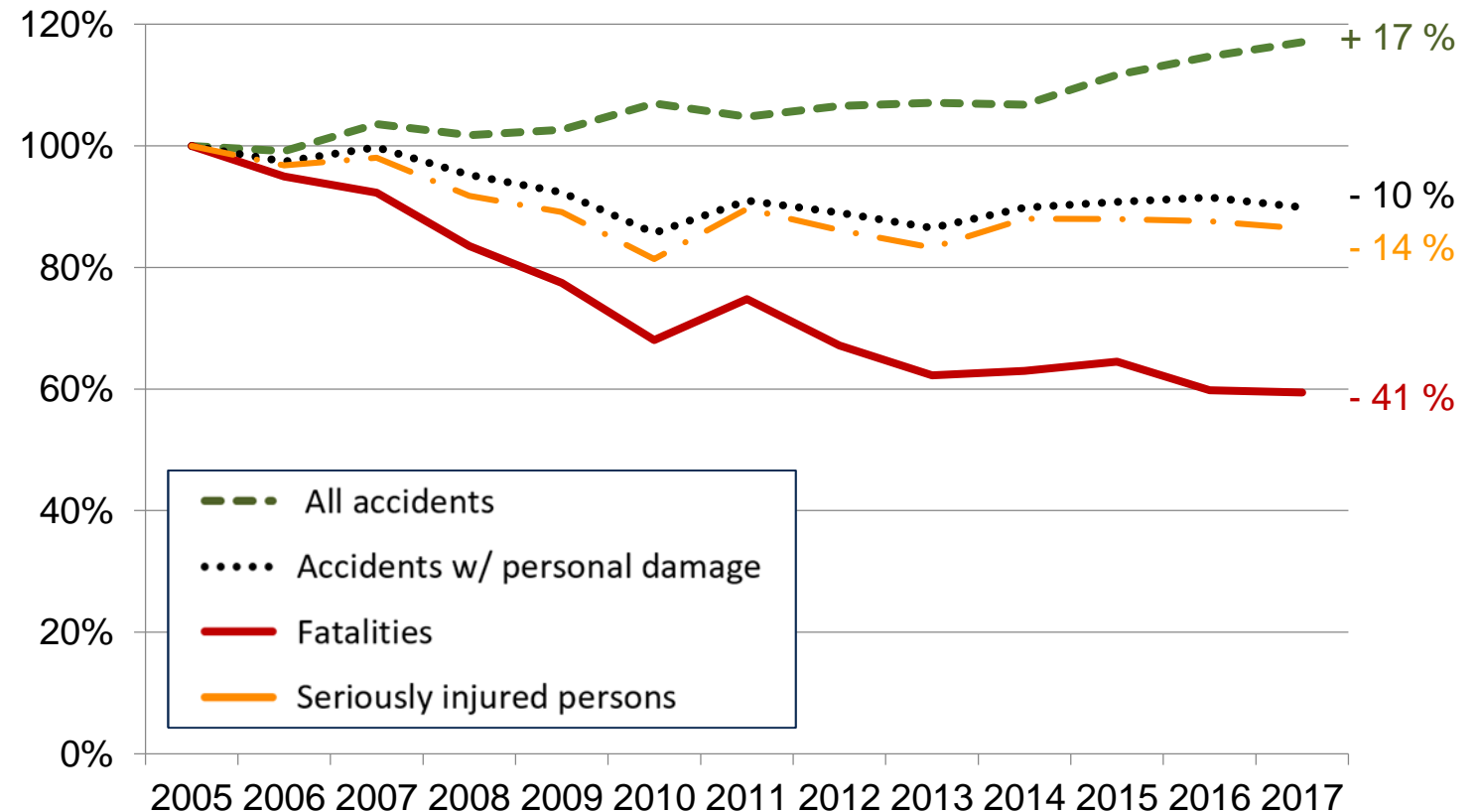
Source: Youtube

# Applications in Traffic accident research to improve vehicle safety

## Necessity of traffic accident research

### Accident scenario in Germany

- Car occupants benefit from active and passive safety
- Numbers of accidents & casualties are stagnating since some years
- In 2017 persons:
  - Fatalities 3,186
  - Seriously injured 66,495
  - Slightly injured 323,659



Source: DESTATIS, Fachserie

# Applications in Traffic accident research to improve vehicle safety

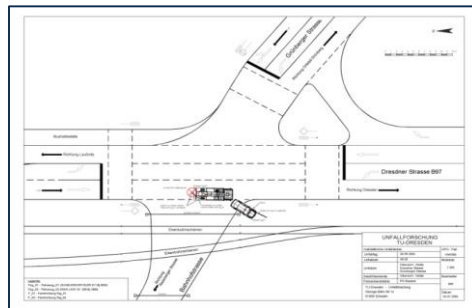
## Necessity of traffic accident research

GIDAS – German In-Depth Accident Study, since 1999

General information



Accident sketch



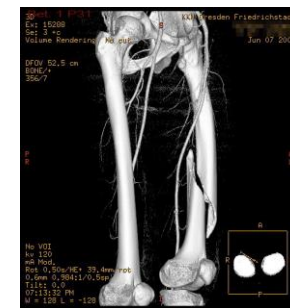
Ø 3.500 single information/accident



Technical investigation



Medical investigation



# Applications in Traffic accident research to improve vehicle safety

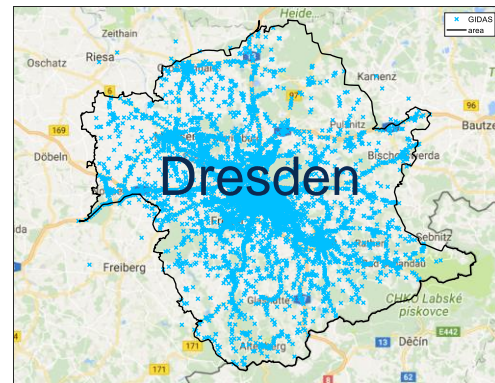
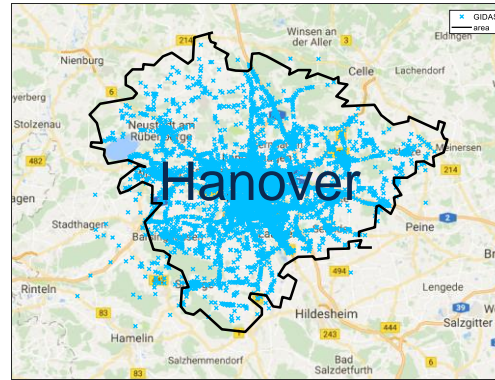
## Necessity of traffic accident research

### Criteria



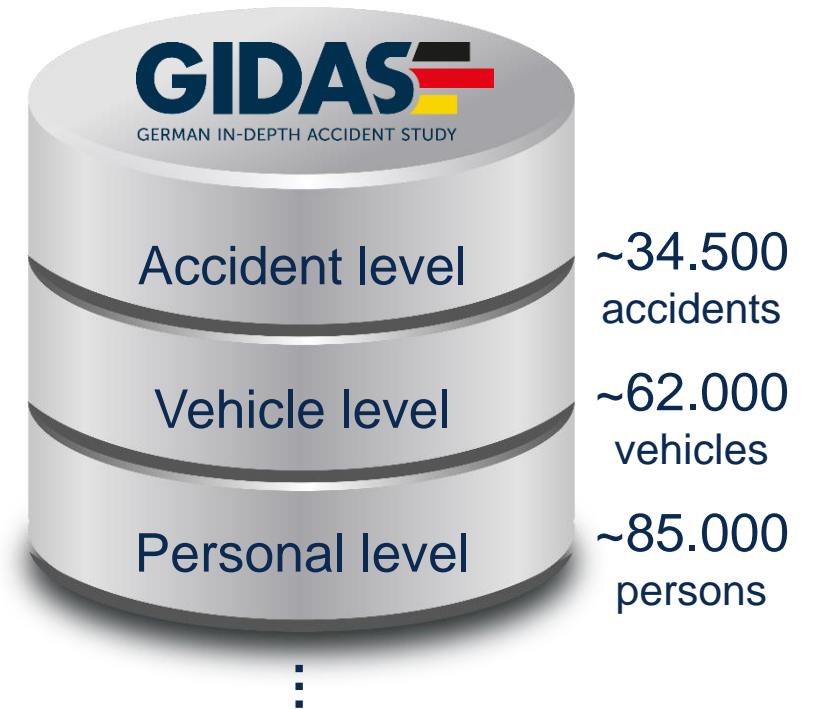
Only accidents with personal damage

### Investigation area



Source: Google Maps & GIDAS

### Database



# Structure

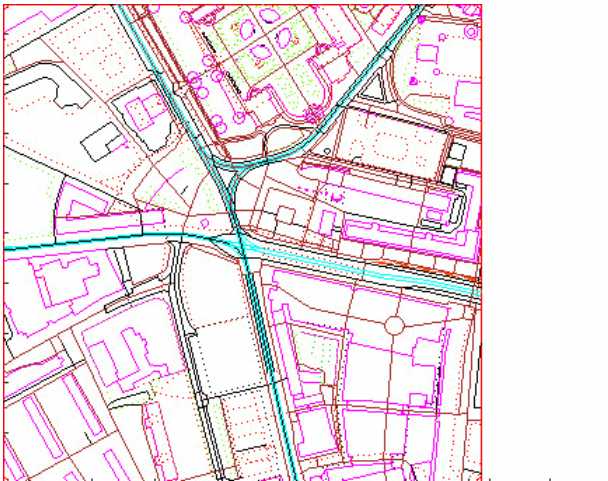
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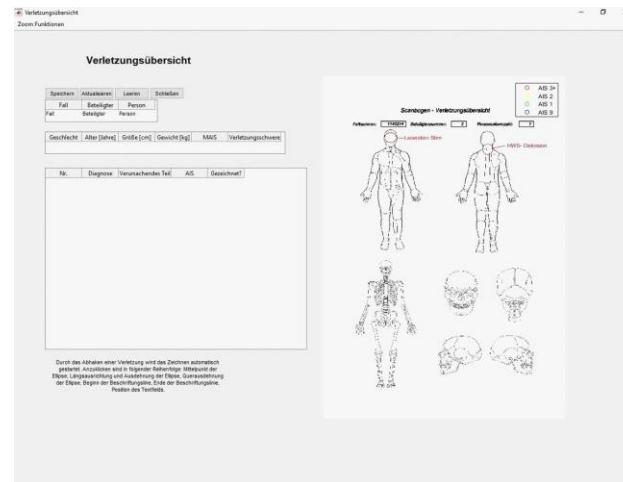
## Application assisted accident investigation

### Some examples

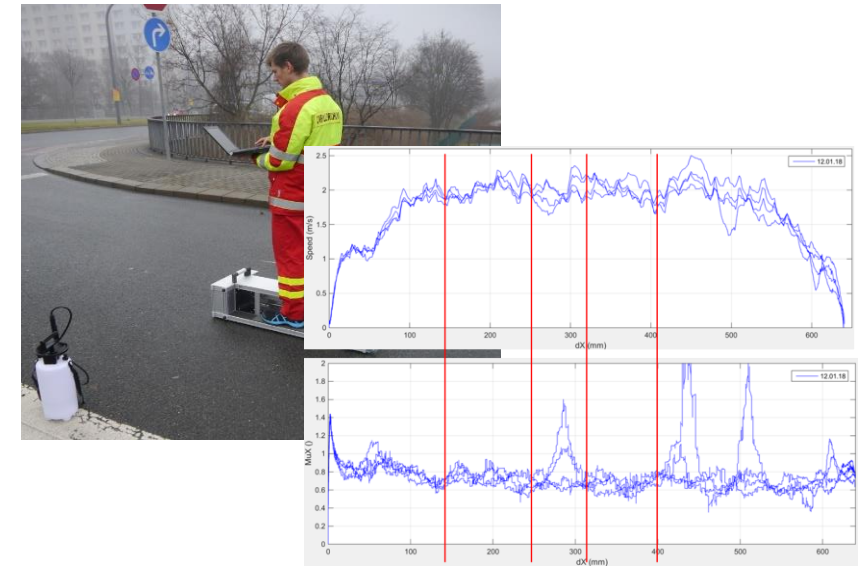
OpenStreetMap (OSM)  
for accident sketch



Coding of injuries



Signal processing  
of measurements





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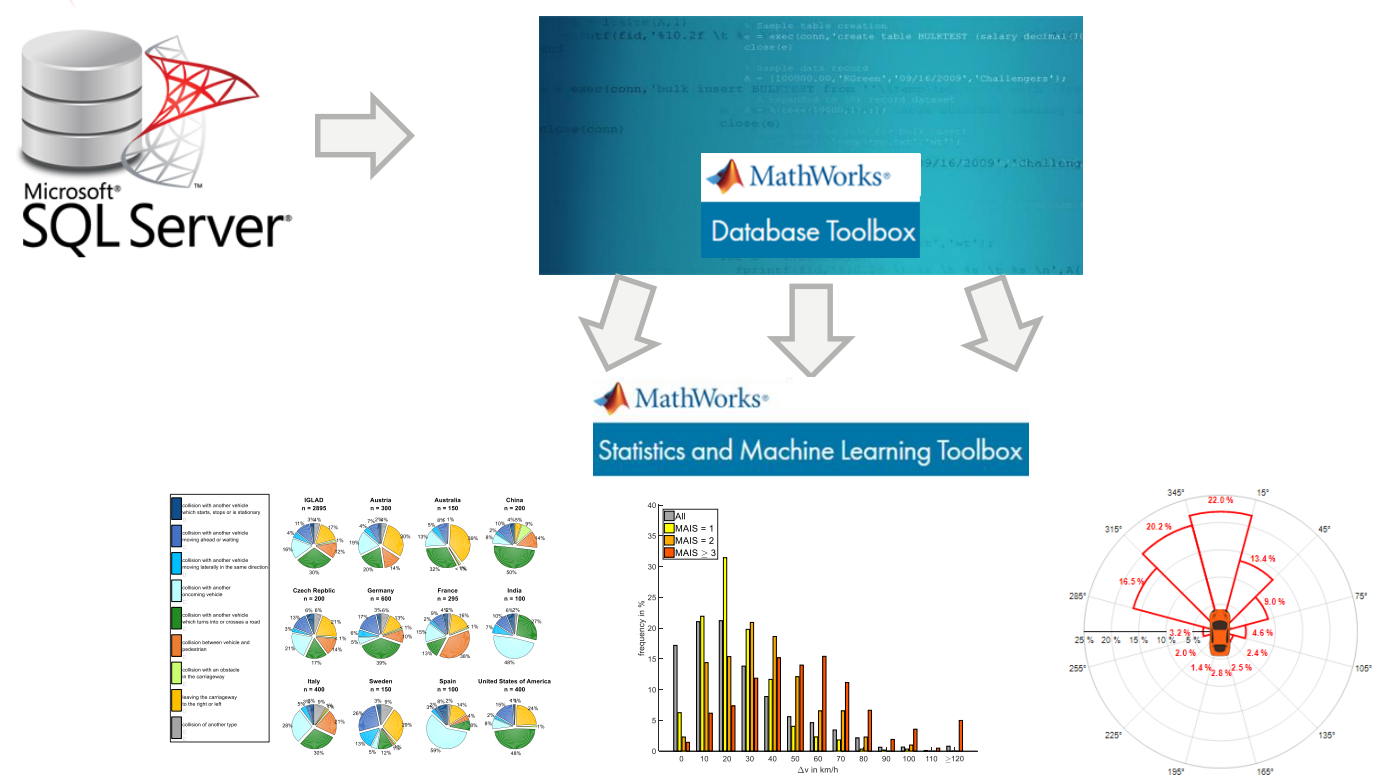
# Applications in Traffic accident research to improve vehicle safety

## Data analyses for research on traffic safety

### Databases



### Access and processing



Source: ESV 2017 – Bakker, Spitzhüttl et al.:  
 “IGLAD - International harmonized in-depth accident data”

# Applications in Traffic accident research to improve vehicle safety

## Data analyses for research on traffic safety

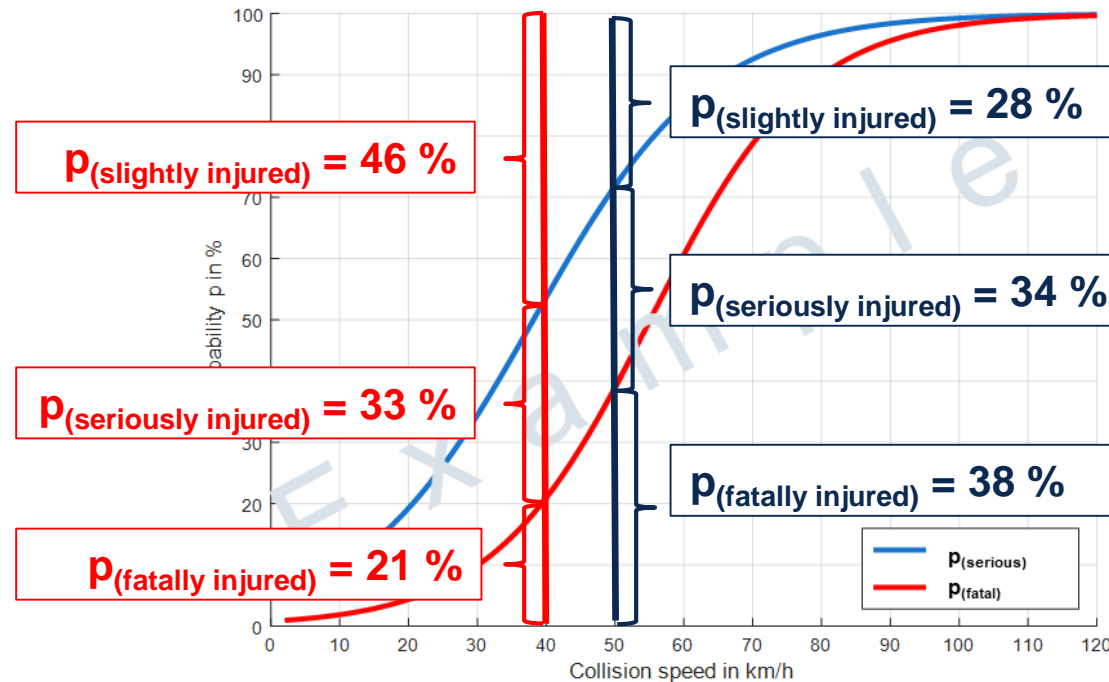
Mathematical models – Injury Risk Functions (IRF); example: pedestrians in car accidents

Real accident:

$v_{\text{coll}} = 50 \text{ km/h}$

Accident with system  
(e.g. AEB):

$v_{\text{coll}} = 40 \text{ km/h}$

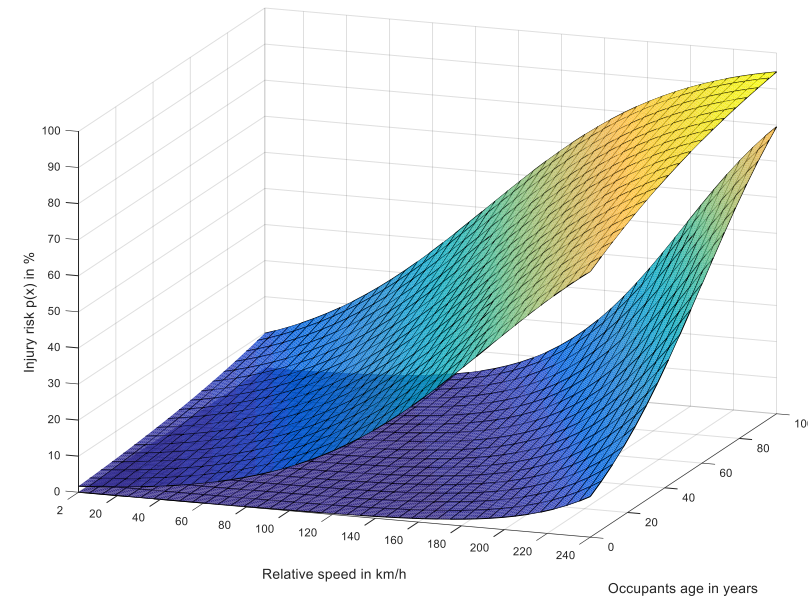
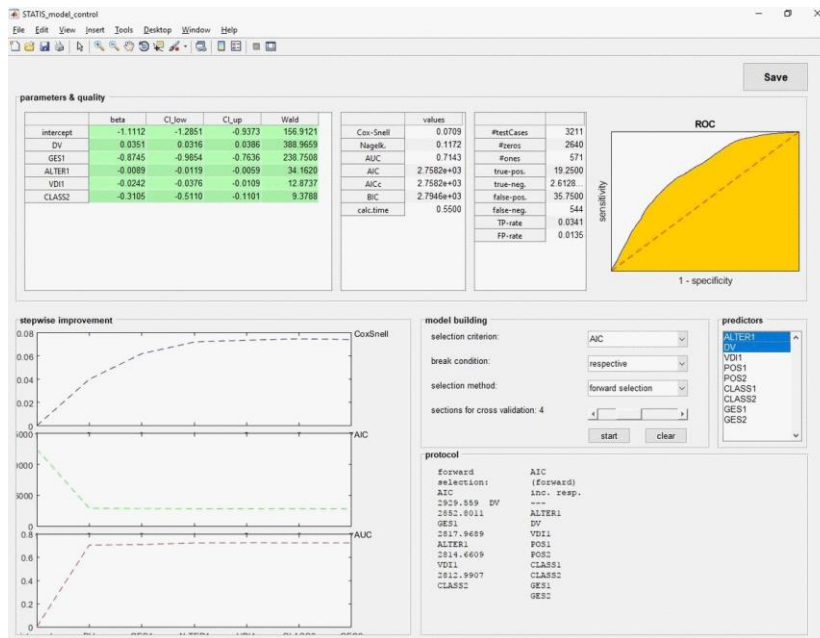


# Applications in Traffic accident research to improve vehicle safety

## Data analyses for research on traffic safety

### Mathematical models – Injury Risk Functions (IRF)

### Multidimensional

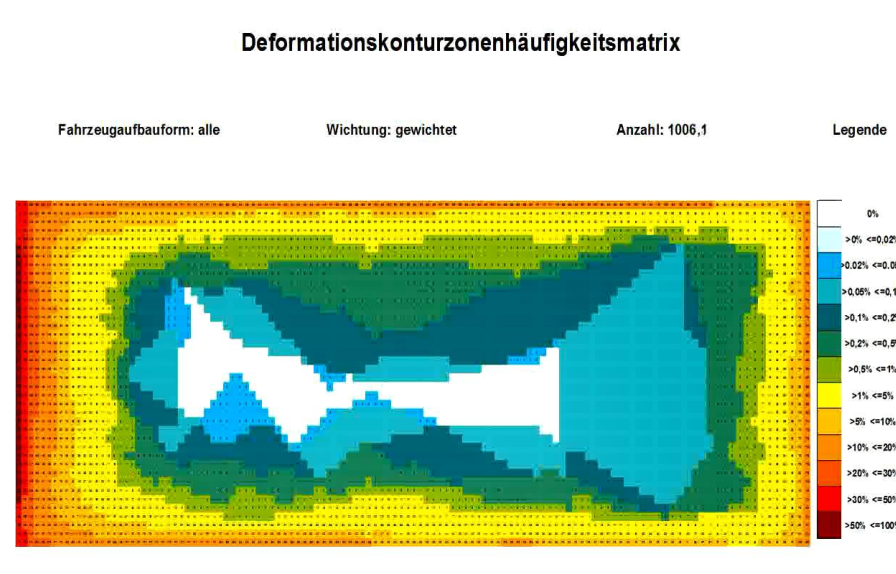


# Applications in Traffic accident research to improve vehicle safety

## Data analyses for research on traffic safety

### Calculation of deformation frequencies

- Normalized car dimensions and discretization into voxel
  - Accumulation of accident deformations for 1,000 passenger cars
- Analyzation of potentially safe places for sensitive and/or dangerous energy storage (e.g. battery or gas)



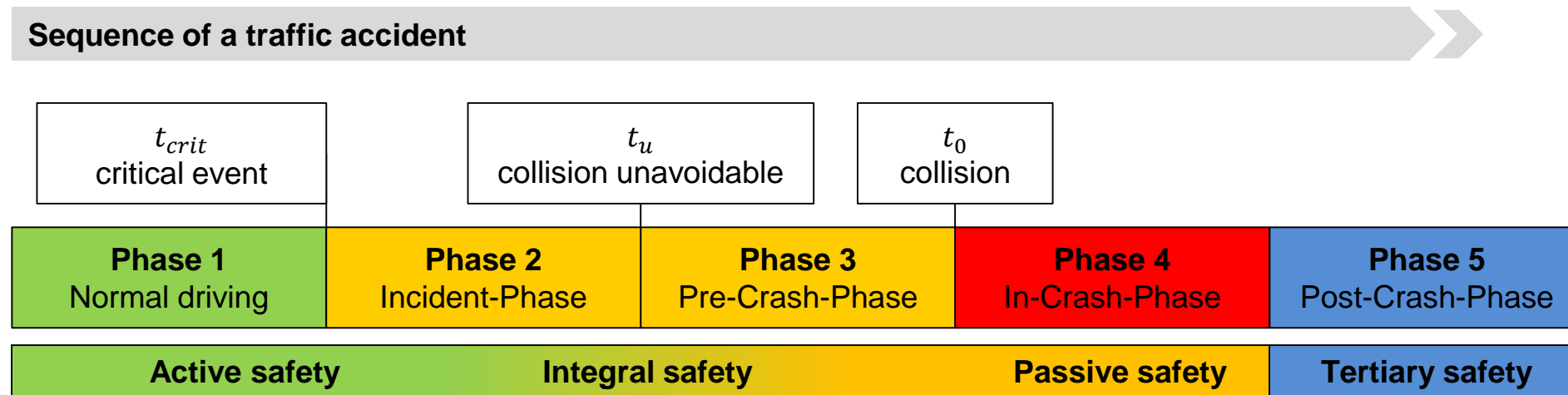
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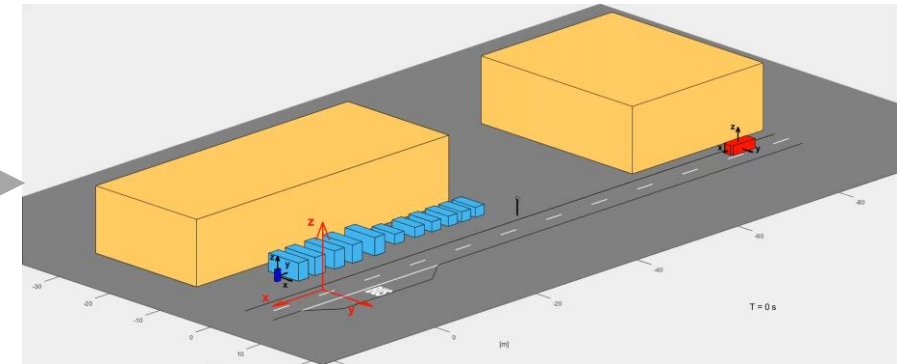
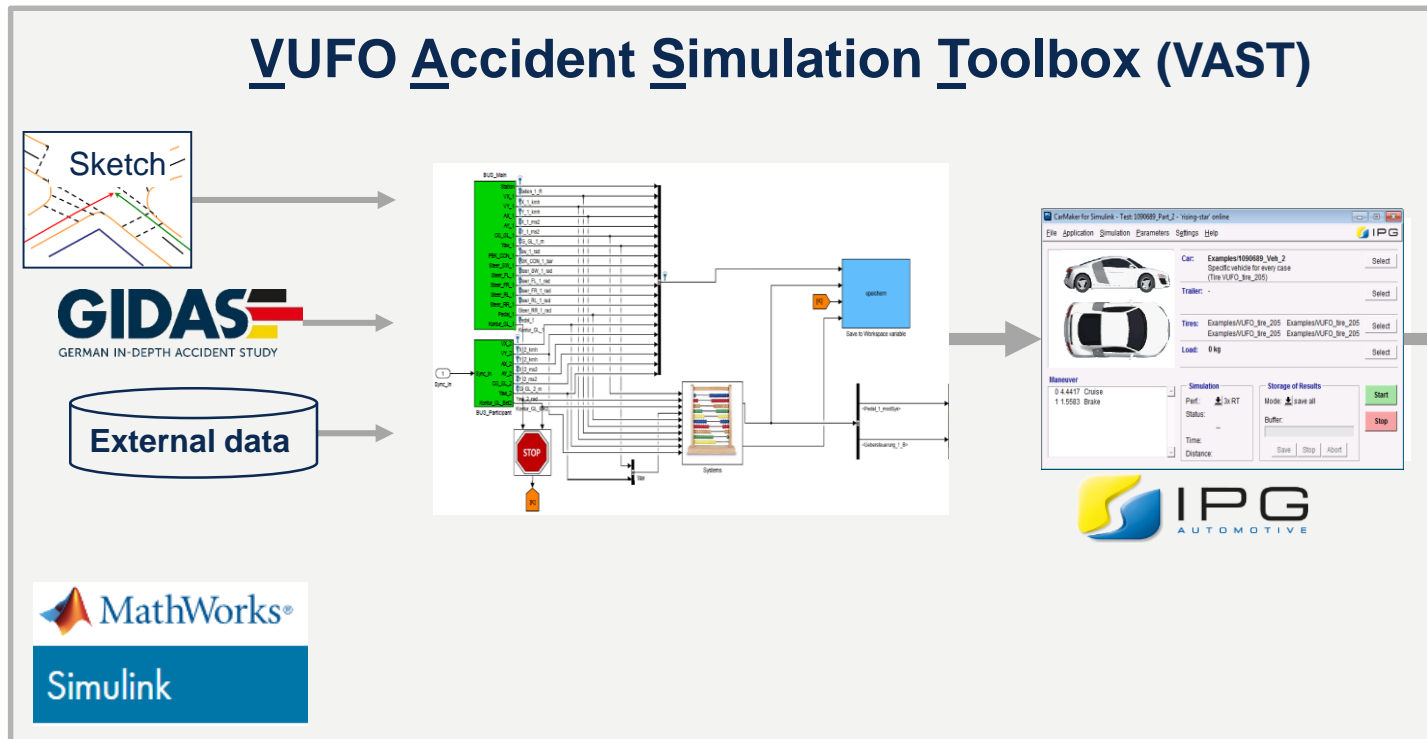
## Pre-crash simulation to enhance traffic safety

### ACEA Safety Model



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

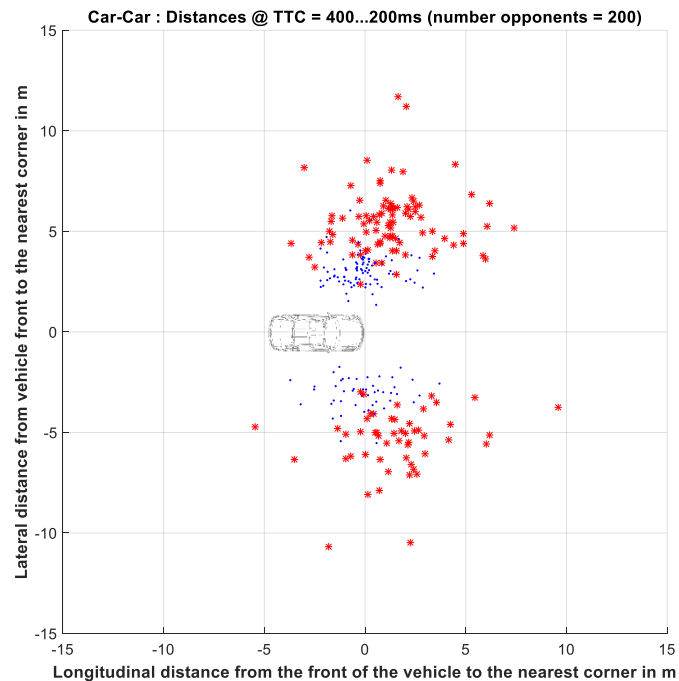




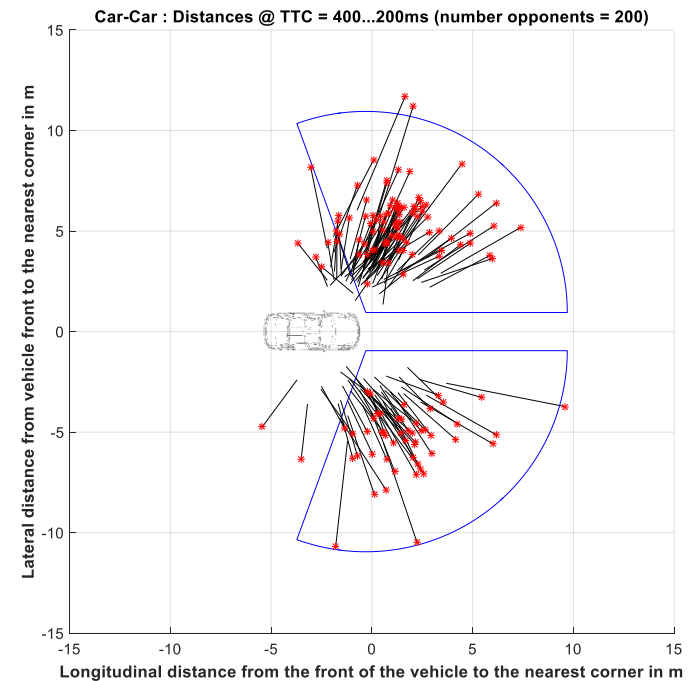
# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

### Evaluation of opponent's position at specific TTC



- \* 400 ms before crash
- 200 ms before crash

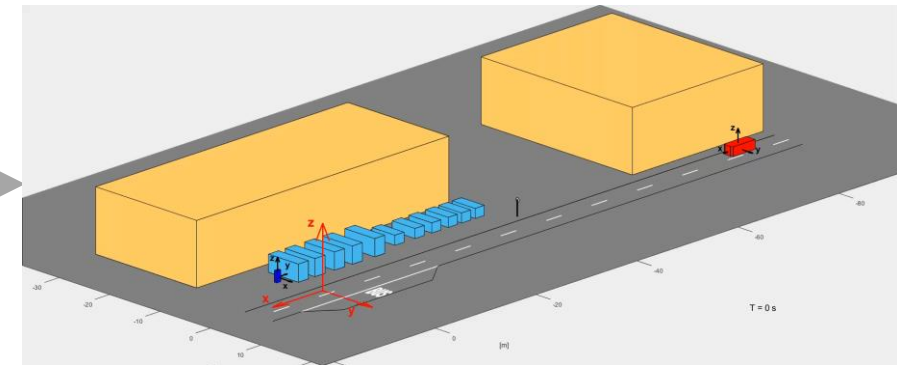
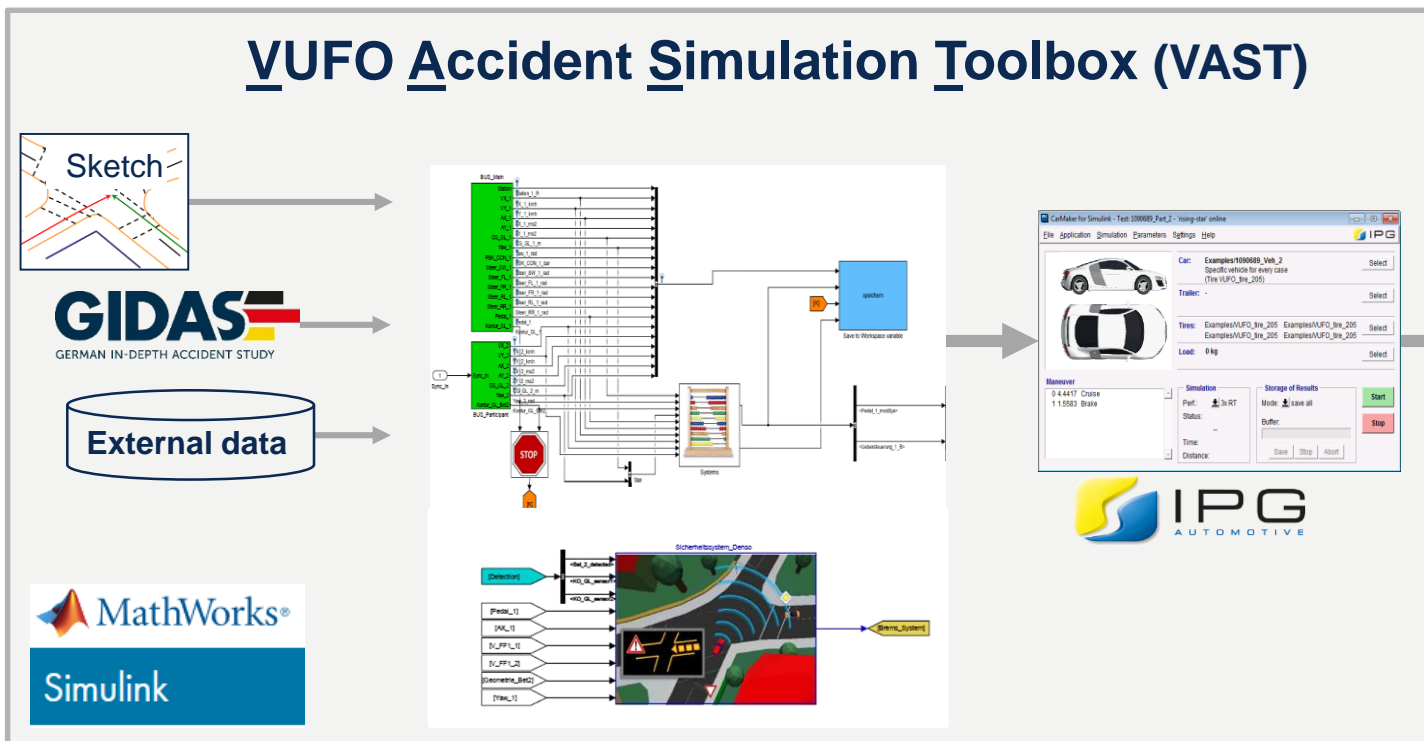


# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety



### VUFO Accident Simulation Toolbx (VAST)





# Applications in Traffic accident research to improve vehicle safety

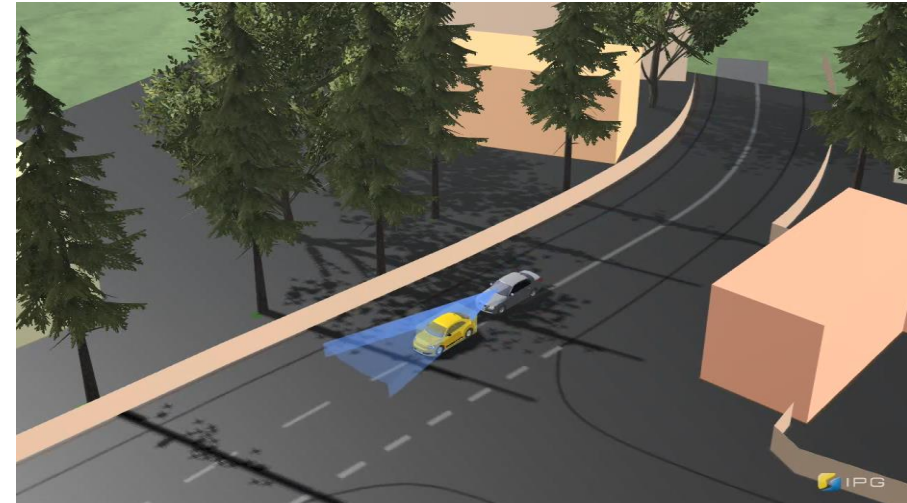
## Pre-crash simulation to enhance traffic safety

Example accident – Simulation

real accident situation



real accident situation  
with ADAS System

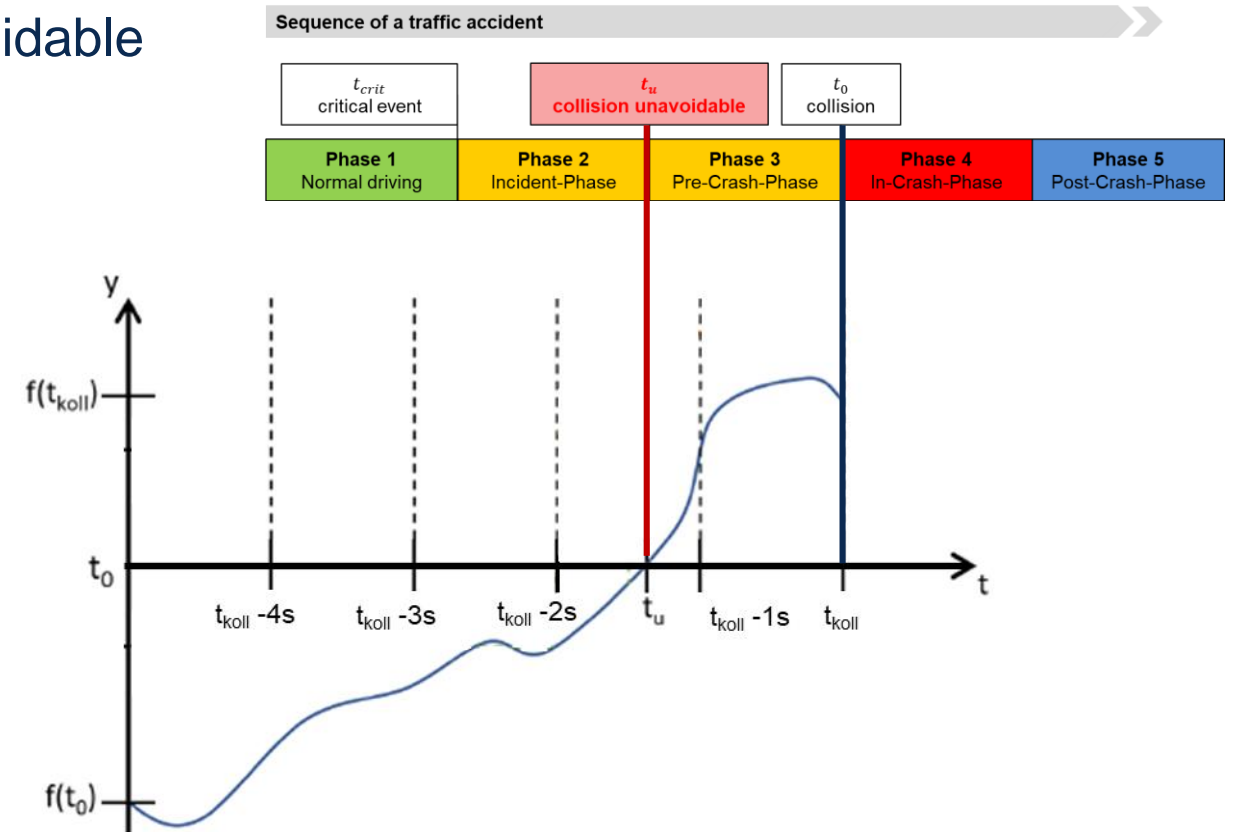


# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Point of no return  $t_u$  when a collision is unavoidable

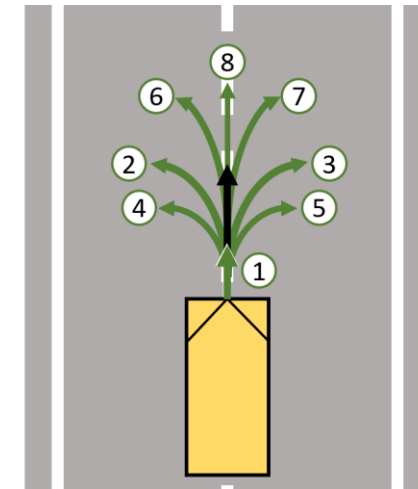
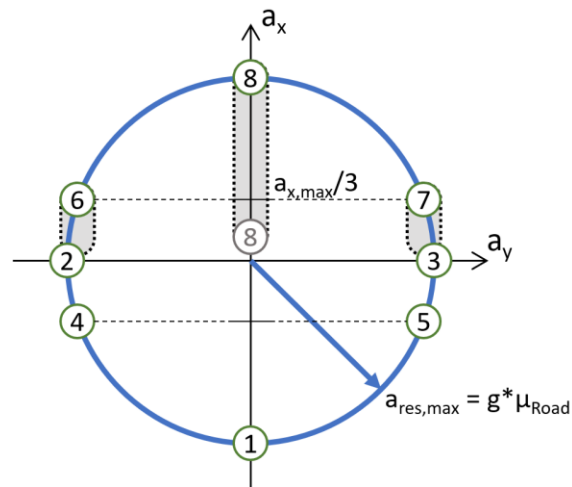
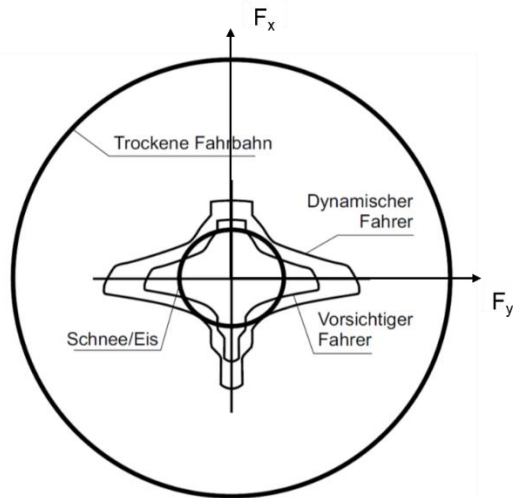
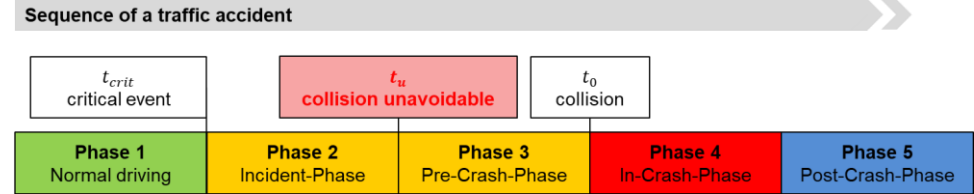
- Severity of damages as a function of time
  - continuous
  - differentiable
- No knowledge about the exact function
- $f(t_u) = 0$ 
  - no analytical solution possible



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Point of no return  $t_u$  when a collision is unavoidable



### Circle of forces / „Kamm'scher Kreis“

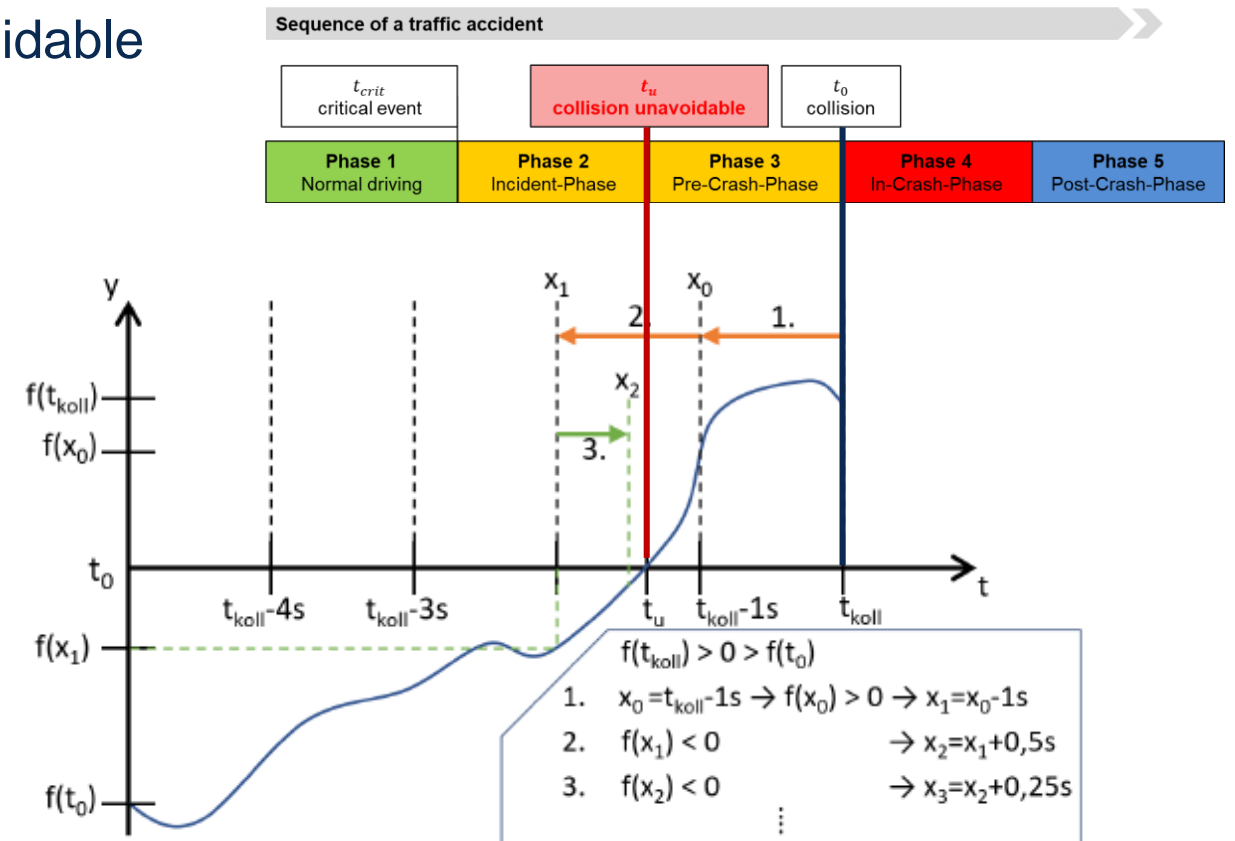
Source: Winner et al., H. (2015). „Handbuch Fahrerassistenzsysteme, Grundlagen, Komponenten und Systeme für aktive Sicherheit und Komfort“

# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Point of no return  $t_u$  when a collision is unavoidable

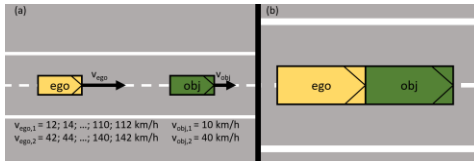
- Severity of damages as a function of time
  - continuous
  - differentiable
- No knowledge about the exact function
- $f(t_u) = 0$ 
  - no analytical solution possible
  - approximation by iterative process and variable integration step size



# Applications in Traffic accident research to improve vehicle safety

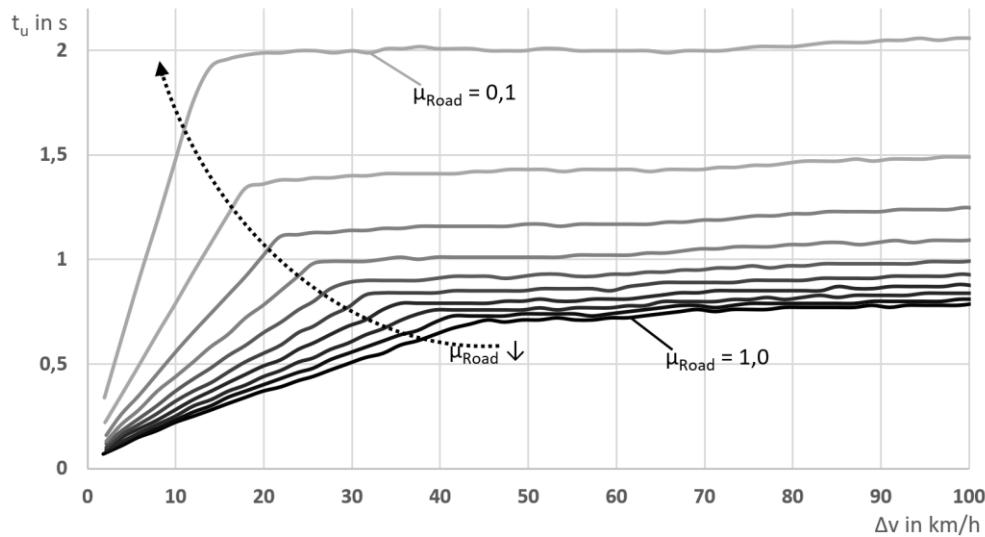
## Pre-crash simulation to enhance traffic safety

Point of no return  $t_U$  when a collision is unavoidable – Generic rear-end collision

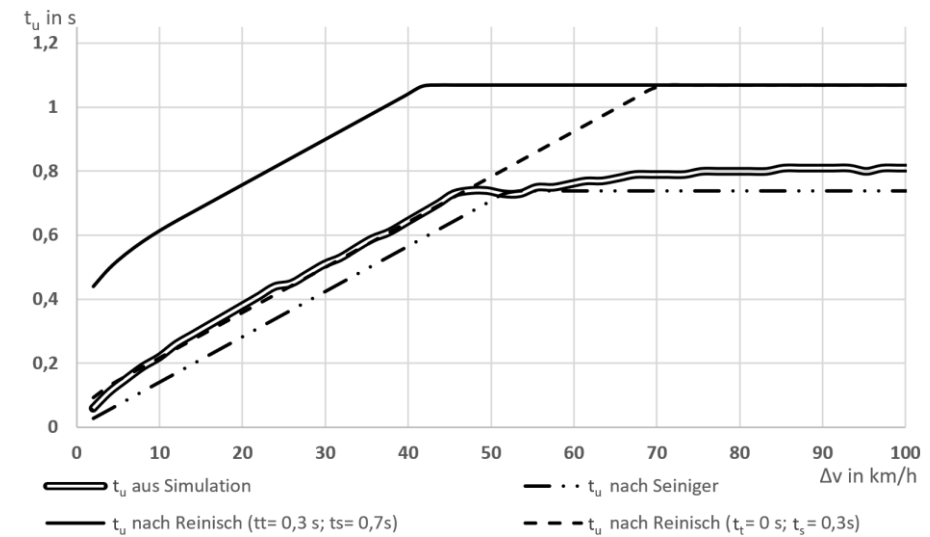


$$t_U = f(\Delta v, \mu); v_{obj} = 40 \text{ km/h}$$

$$\Delta v = 2 \dots 100 \text{ km/h}, \mu = 0,1 \dots 1,0$$



$t_U$  comparison of simulation and literature





# Applications in Traffic accident research to improve vehicle safety

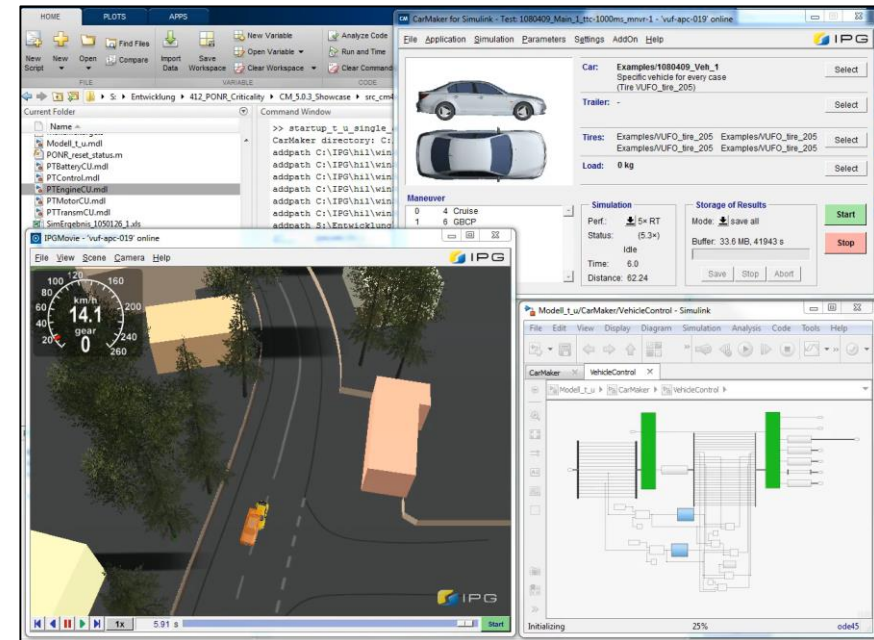
## Pre-crash simulation to enhance traffic safety

Point of no return  $t_u$  when a collision is unavoidable – real accident's rear-end collision

real accident situation



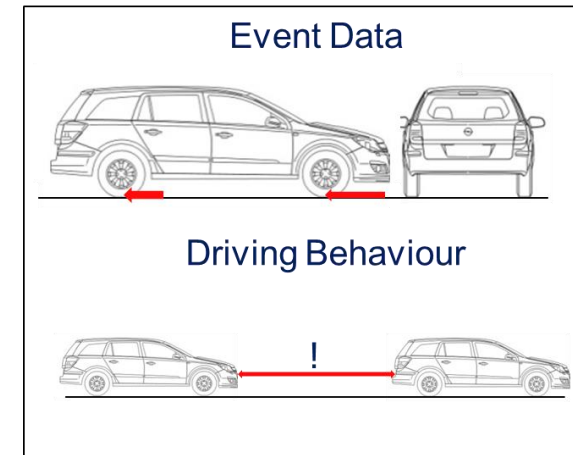
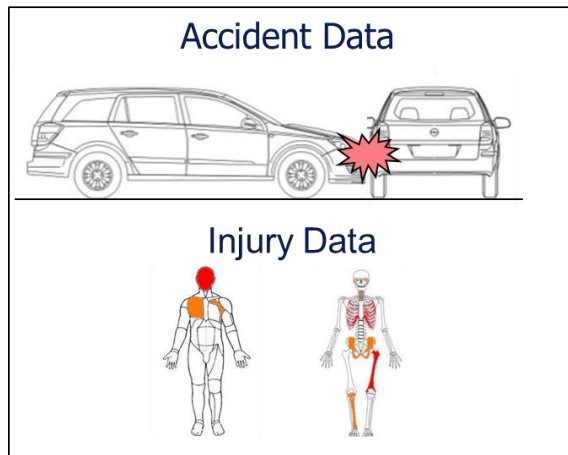
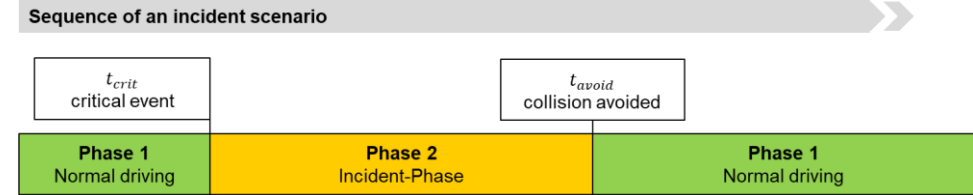
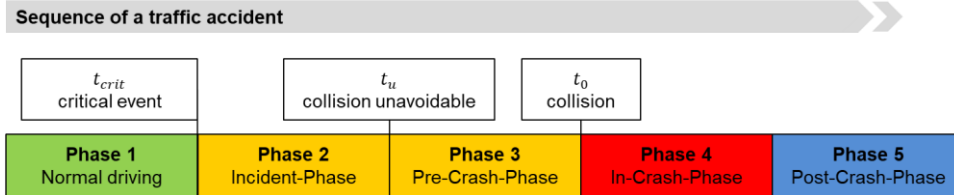
$t_u$  simulation



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS) → Incidents and Events



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

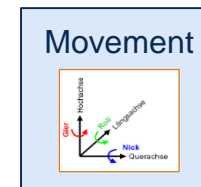
Naturalistic driving study (NDS)

Real scenario



### Recording

- Camera
- Accelerometer
- Rotation rate sensor
- GPS
- Sender and receiver device
- Processor und ring memory



# Applications in Traffic accident research to improve vehicle safety

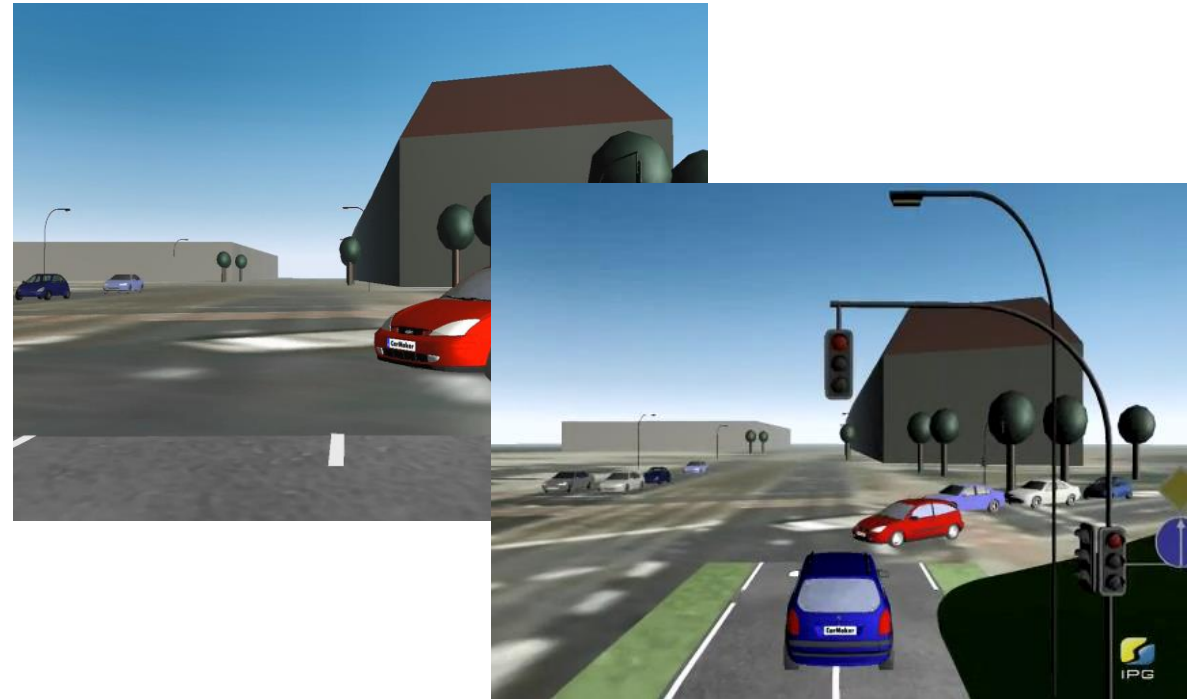
## Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)

Real scenario



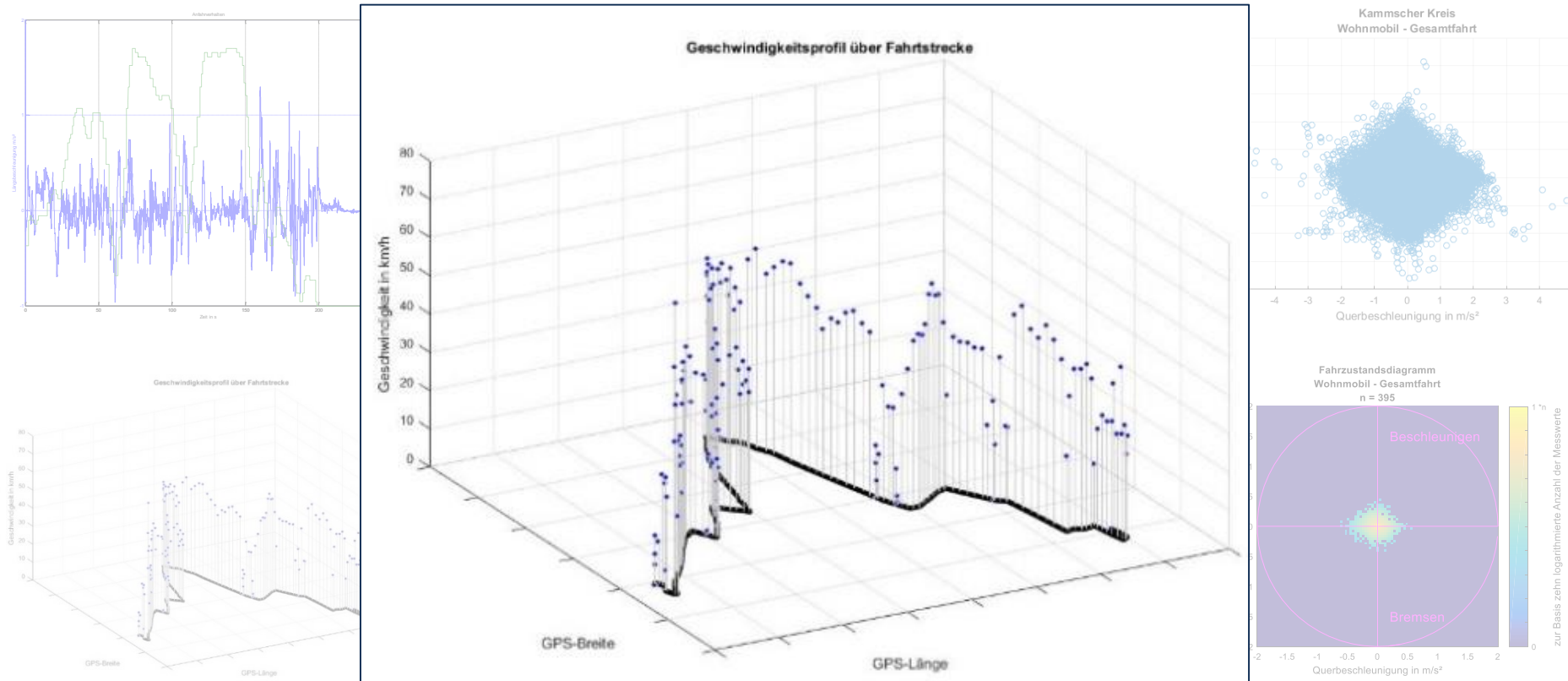
Simulation



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

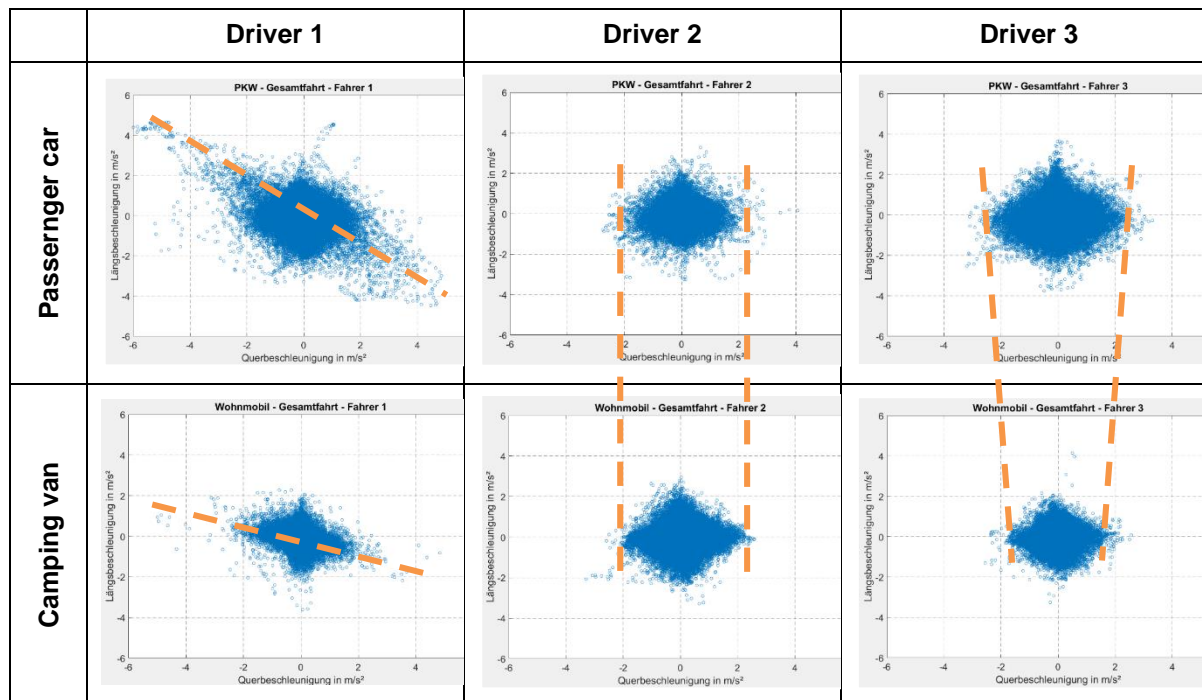
### Naturalistic driving study (NDS)



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

### Naturalistic driving study (NDS)



#### Driver 1:

- Large scatter range
- Significant difference between passenger car and camping van
- High accelerations

#### Driver 2:

- Marginal difference between passenger car and camping van
- Experienced driving

#### Driver 3:

- Low scatter range
- Higher acceleration in passenger car

Source: GDV, VUFO (2016): „Unfälle mit Beteiligung von Wohnmobilen in Deutschland“

# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

### Naturalistic driving study (NDS)

2015

Renault Espace:  
→ Marital-problems

Suzuki Swift:  
→ Divorce

2016

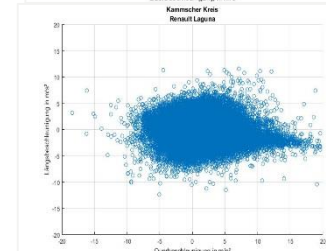
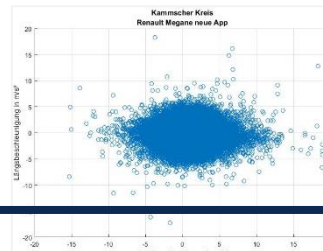
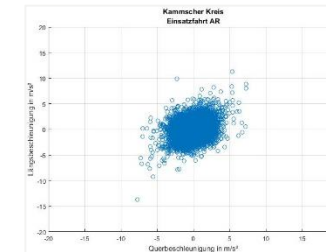
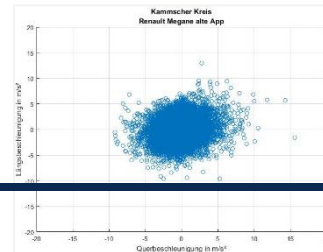
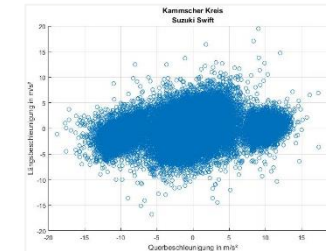
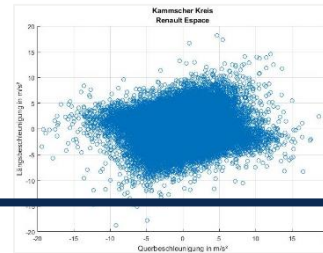
Renault Megane:  
→ New relationship

VW Caddy:  
→ Responsibility for children

2017

Renault Megane:  
→ Crisis in relationship

Renault Laguna:  
→ On-Off relationship



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)



Ground truth labeling with



Automated Driving System Toolbox



# Applications in Traffic accident research to improve vehicle safety

## Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)

vs.

Real world accident



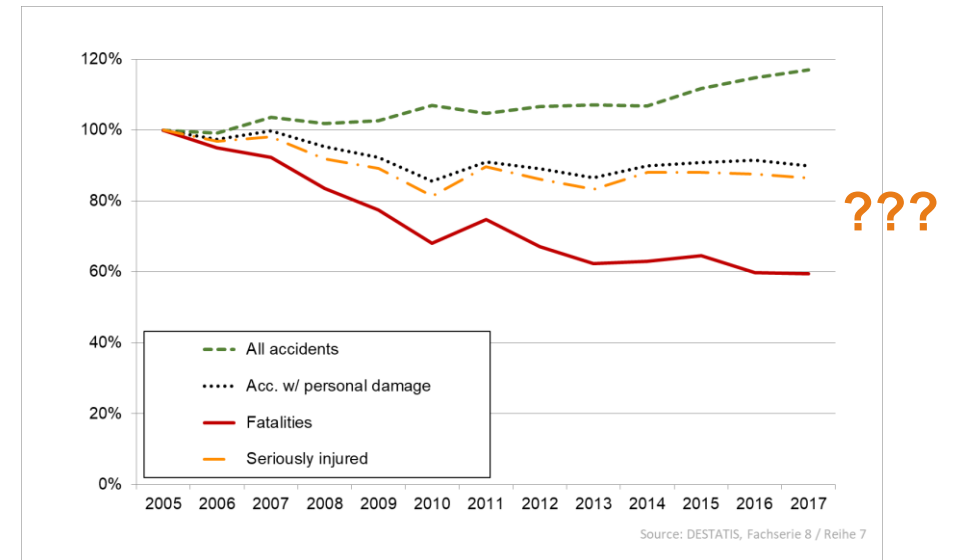
# AGENDA

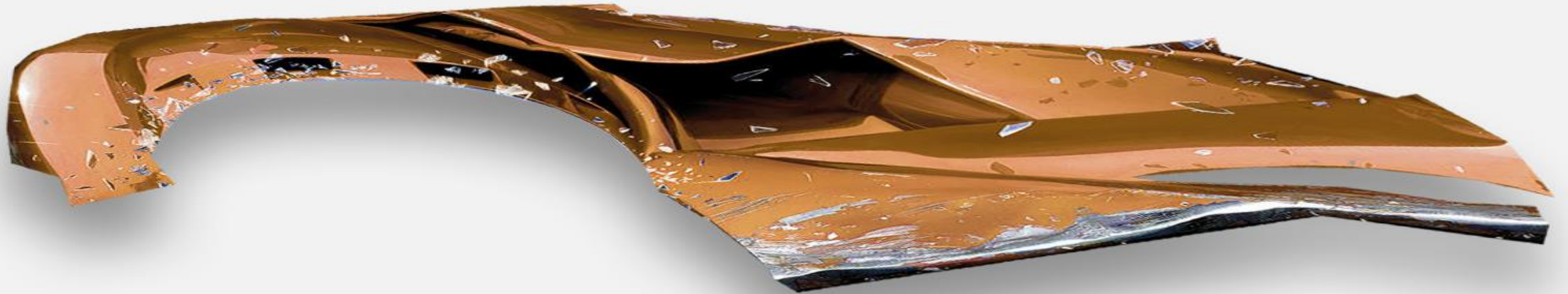
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# Applications in Traffic accident research to improve vehicle safety

## Conclusion

- Assurance of **traffic safety** must be a very high society target.  
Human errors must not lead to fatalities in a modern traffic environment!
- In contrast to past trends, recent statistics show a **stagnation in the accident numbers.**
- The development of Highly Automated Driving needs some more efforts to ensure a **safe and modern concept of movement.**
- Therefore it is very important to improve on crucial aspects of
  - ensuring **functional safety**
  - study **real world scenarios**
  - progress on **perception infrastructure** to support vehicle systems.





**THANK YOU  
FOR YOUR ATTENTION!**

**Florian Spitzhüttl**

Data analyses and simulation

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