VUFO GmbH

Verkehrsunfallforschung
an der TU Dresden GmbH

TECHNISCHE UNIVERSITÄT DRESDEN

ein Unternehmen der TUDAG

APPLICATIONS IN TRAFFIC ACCIDENT RESEARCH TO IMPROVE VEHICLE SAFETY

MATLAB EXPO 2018, Germany

Dipl.-Ing. Florian Spitzhüttl

Institute for Traffic Accident Research

at Dresden University of Technology

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

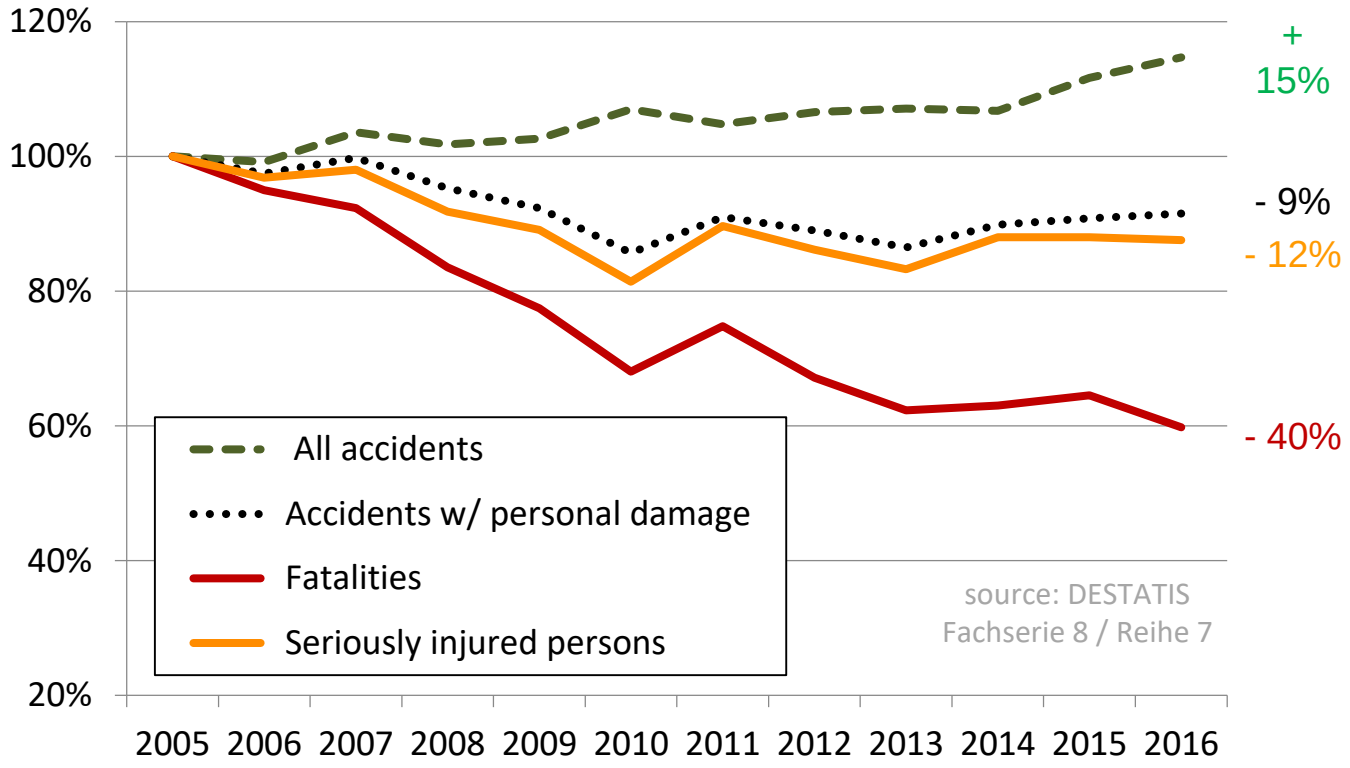
Source: Youtube

Applications in Traffic accident research to improve vehicle safety

Necessity of traffic accident research

Accident scenario in Germany

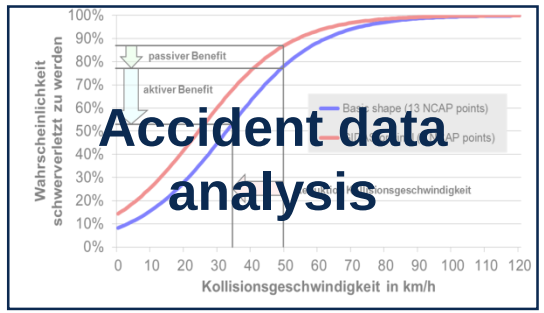
- Car occupants benefit from active and passive safety
- Numbers of accidents & casualties are stagnating since some years
- In 2016 persons:
  - Fatalities 3,206
  - Seriously injured 67,426
  - Slightly injured 329,240



→ **In-depth accident studies are absolutely essential to improve vehicle safety**

Applications in Traffic accident research to improve vehicle safety

Necessity of traffic accident research



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Institute for Traffic Accident Research
at Dresden University of Technology

Area of studies

- Automotive engineering
- Transportation engineering
- Medicine

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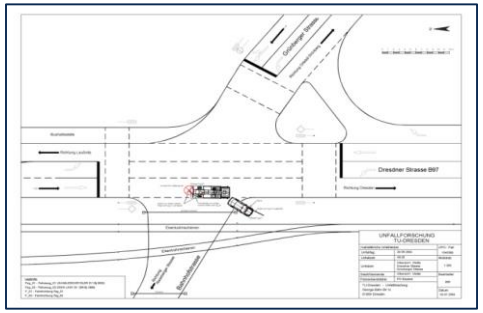
Necessity of traffic accident research

GIDAS – German In-Depth Accident Study, since 1999

General information

Accident sketch



GIDAS

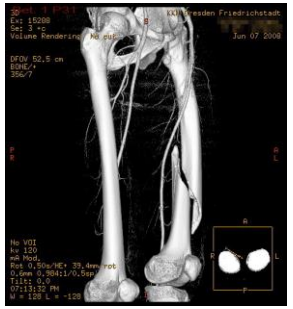
GERMAN IN-DEPTH ACCIDENT STUDY

≈ 2.000

accidents/year

Technical investigation

Medical investigation



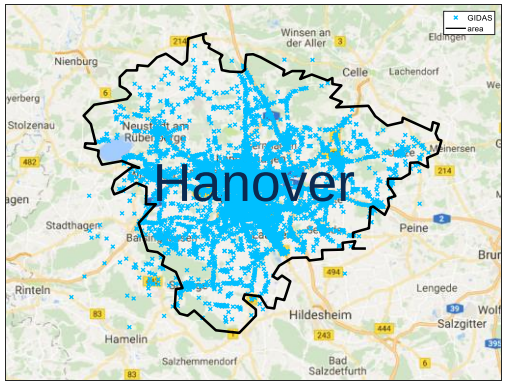
Applications in Traffic accident research to improve vehicle safety

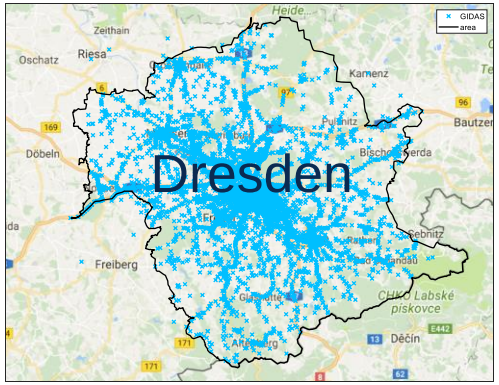
Necessity of traffic accident research

Criteria

Only accidents with personal damage

Investigation area





Source: Google Maps & GIDAS

Database

~33.000 accidents

~60.000 vehicles

~77.000 persons

⋮

Ø 3.500 single information/accident

Structure

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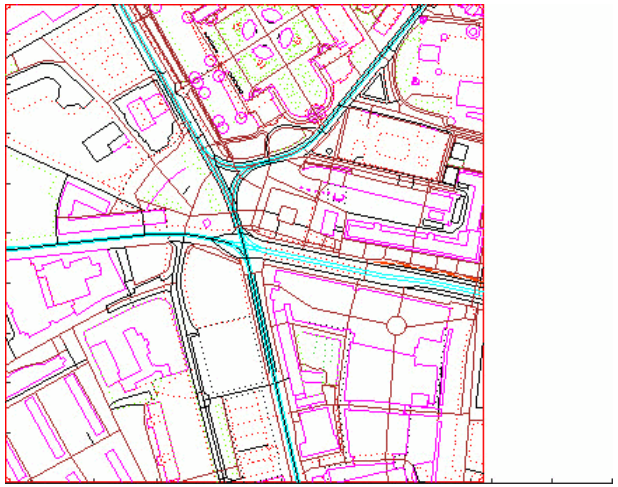
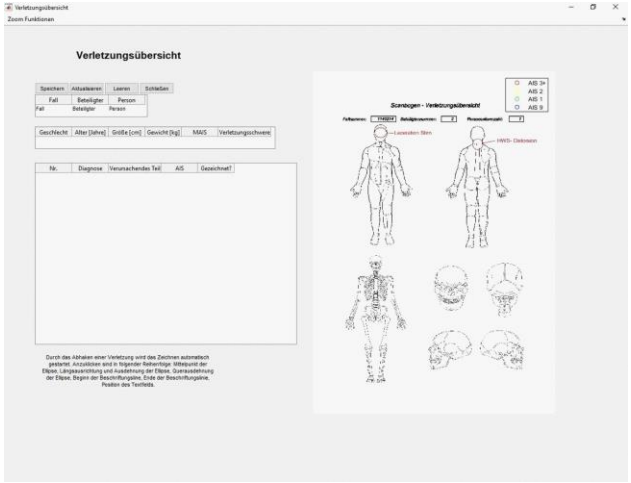
Application assisted accident investigation

Some examples

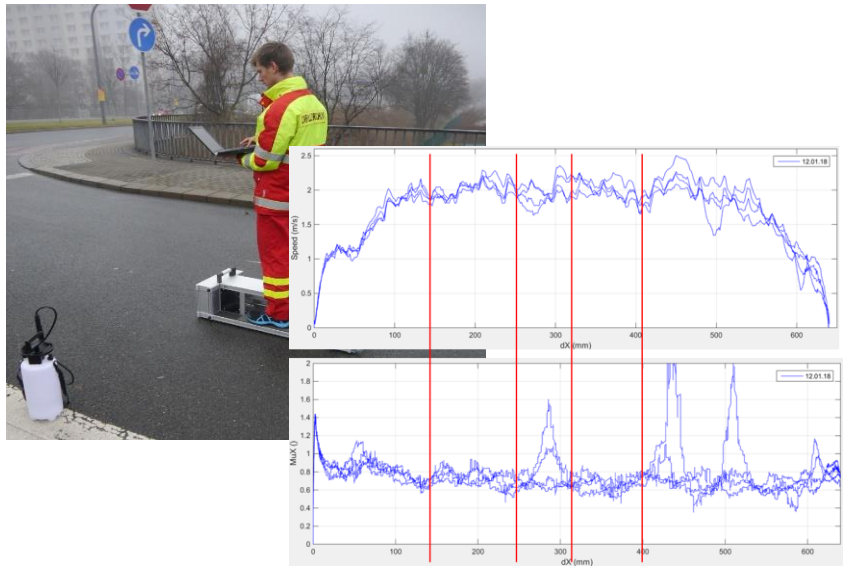
OpenStreetMap (OSM) for accident sketch



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

DESTATIS wissen.nutzen.

KBA

GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

NHTSA NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

GIDAS-PCM GERMAN IN-DEPTH ACCIDENT STUDY PRE-CRASH-MATRIX

NDS

IGLAD INITIATIVE FOR THE GLOBAL HARMONISATION OF ACCIDENT DATA

World Health Organization

EUSKA

POLIZEI Sachsen

POLIZEI Brandenburg

irtad International Traffic Safety Data and Analysis Group

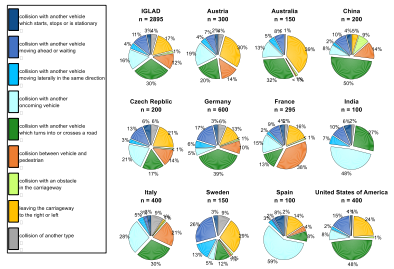
DWD

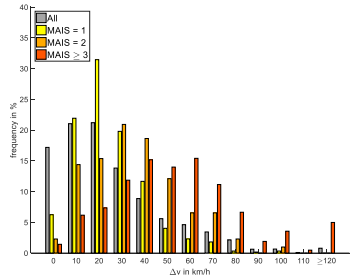
Microsoft SQL Server

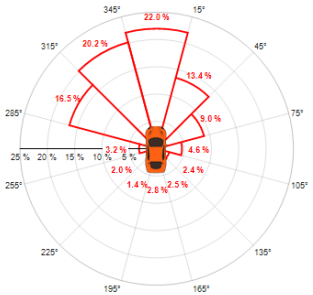
Access and processing

MathWorks Database Toolbox

MathWorks Statistics and Machine Learning Toolbox







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

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Applications in Traffic accident research to improve vehicle safety

Data analyses for research on traffic safety

Mathematical models – Injury Risk Functions (IRF)

What is it?

Model to describe the probability of the occurrence of a specific event (e.g. to be at least seriously injured) as a function of one or several influencing parameters (e.g. collision speed) for a given population.

→ Substantial tool for the assessment of vehicle safety systems

How is it calculated?

Based on real (accident) data, calculating the maximum likelihood estimation with an underlying logistic distribution

$$p = \frac{1}{1 + e^{-z}} = \frac{1}{(1 + e^{-(\beta_0 + \beta_1 \cdot x_1 + \cdots + \beta_n \cdot x_n)})}$$

β_0 ... β_n – regression coefficients

x_1 ... x_n – independent variables

Applications in Traffic accident research to improve vehicle safety

Data analyses for research on traffic safety

Mathematical models – Injury Risk Functions (IRF)

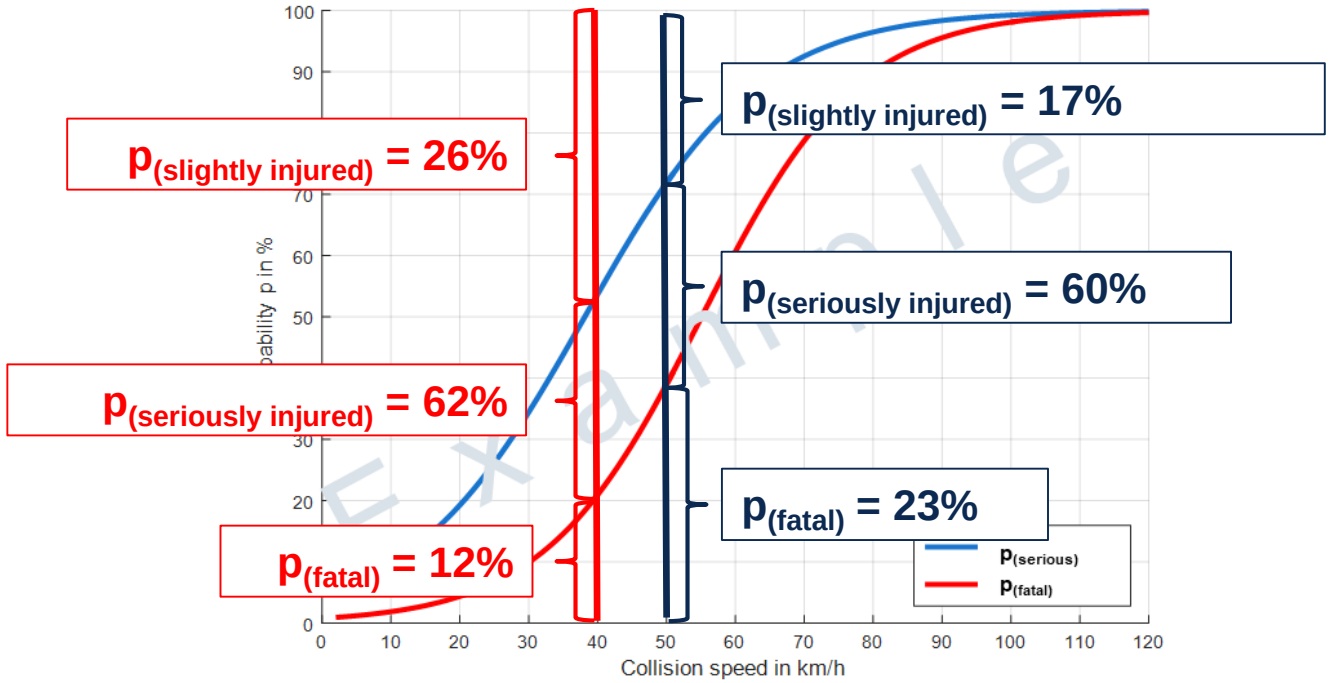
What is it used for?

Real accident:

v_{coll} = 50 km/h

Accident with system (e.g. AEB):

v_{coll} = 40 km/h

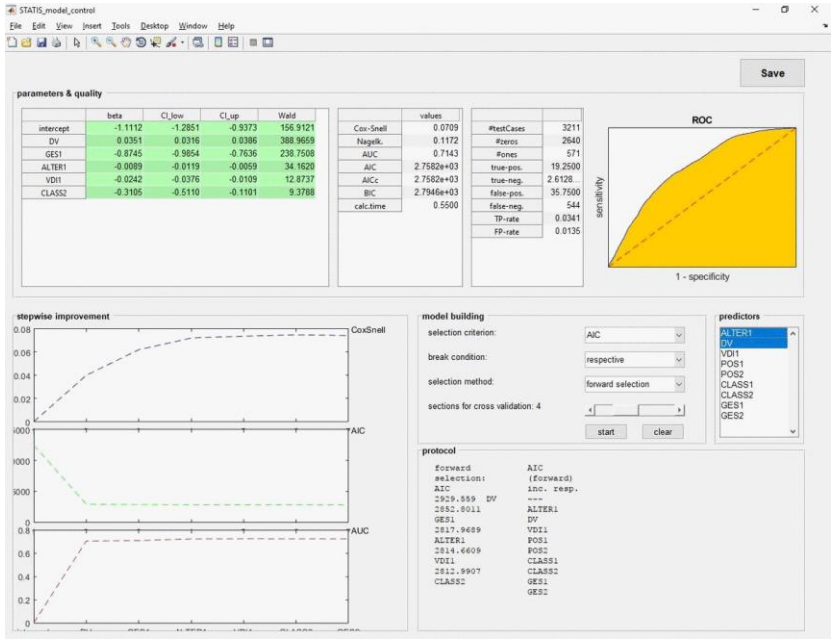


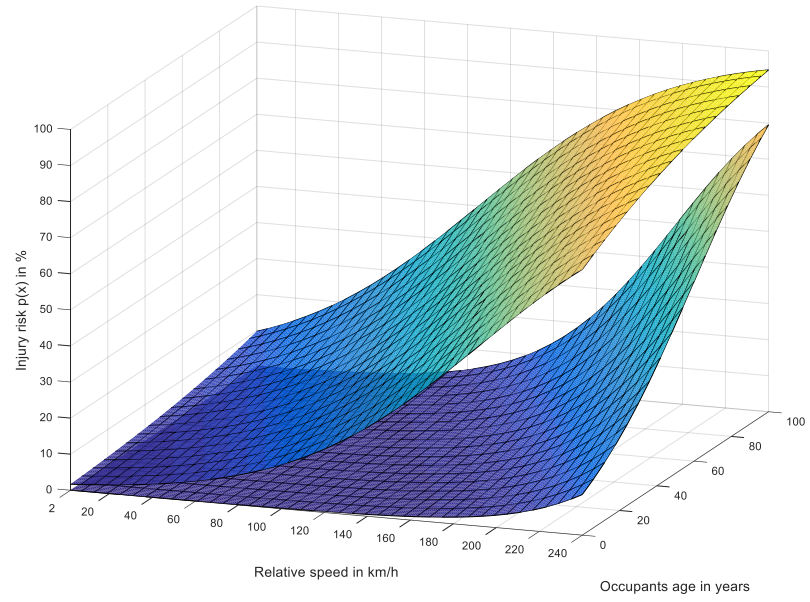
Applications in Traffic accident research to improve vehicle safety

Data analyses for research on traffic safety

Mathematical models – Injury Risk Functions (IRF)

Multidimensional





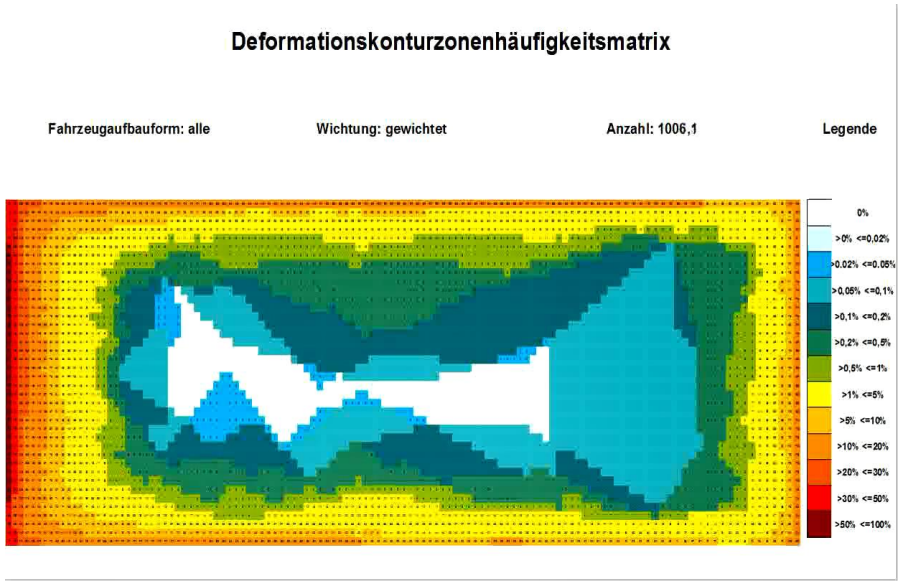
Applications in Traffic accident research to improve vehicle safety

Data analyses for research on traffic safety

Calculation of deformation frequencies

- Normalized car dimensions and discretization into voxel
- Accumulation of accident deformations for 1000 passenger car

→ Analyzation of potentially safe places for sensitive and/or dangerous energy storage (e.g. battery or gas)



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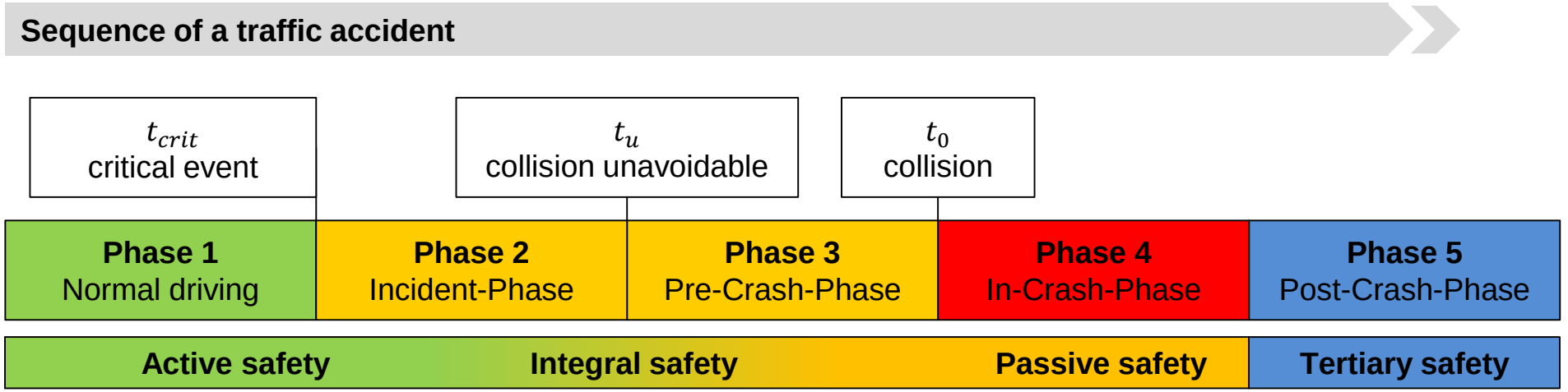
Applications in Traffic accident research to improve vehicle safety

Pre-crash simulation to enhance traffic safety

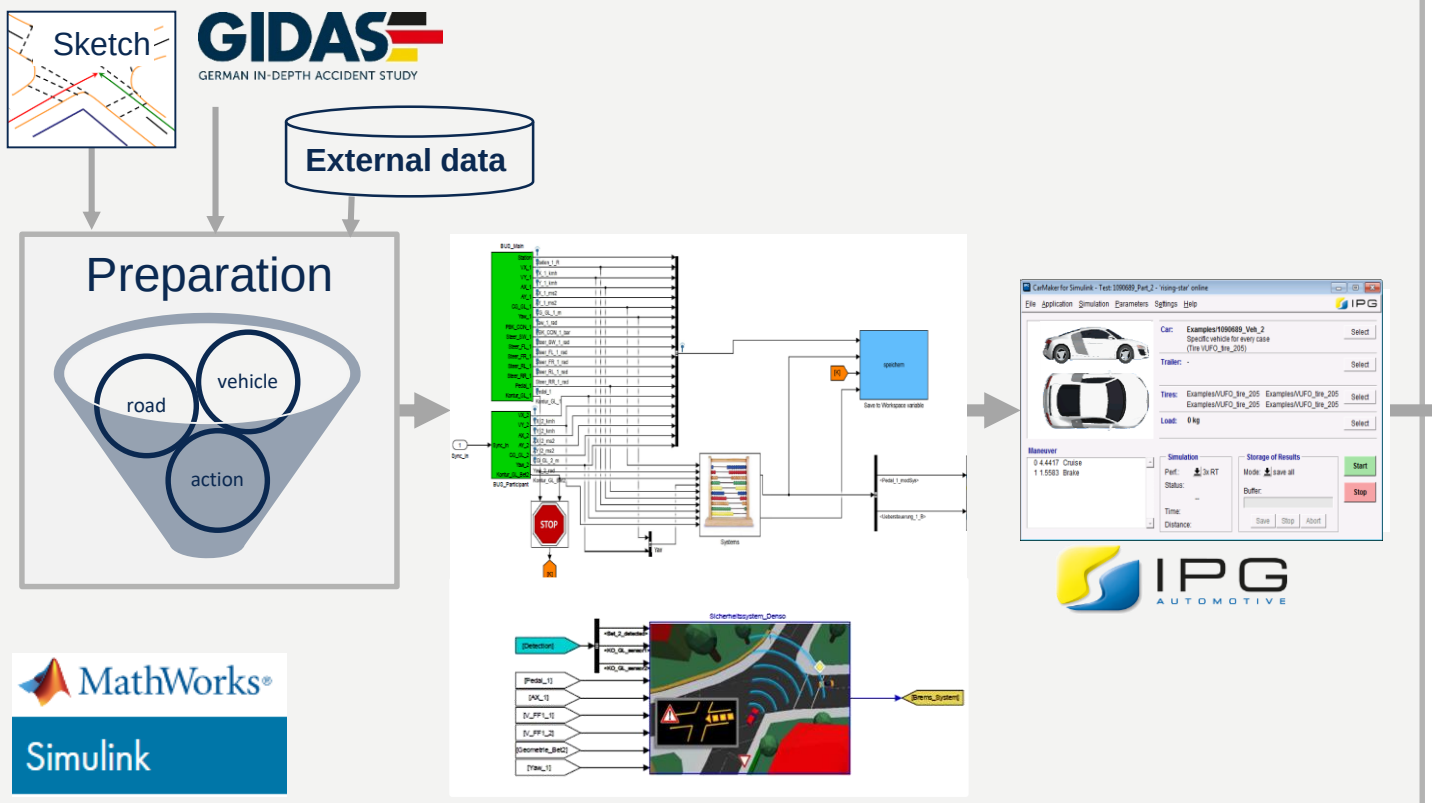
ACEA Safety Model



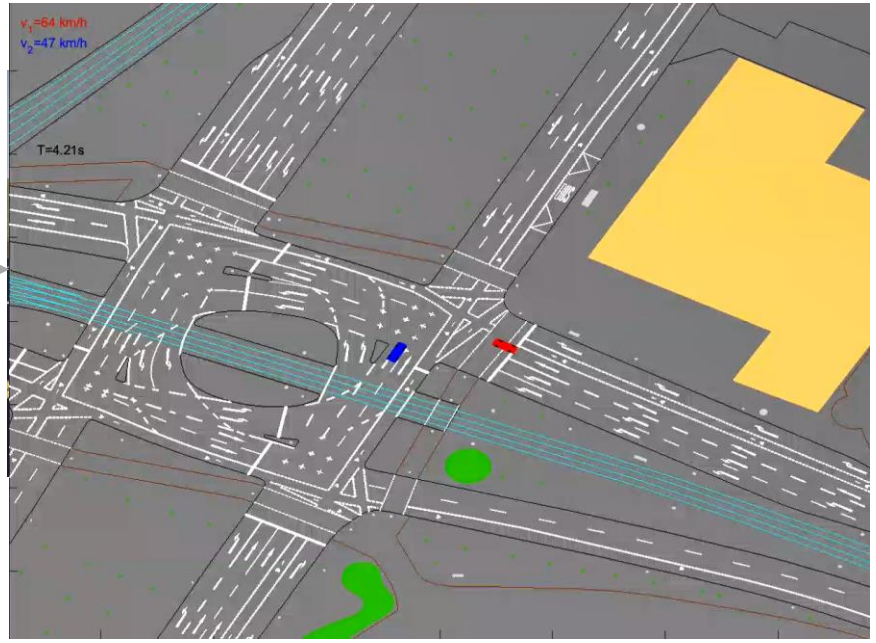
Applications in Traffic accident research to improve vehicle safety

Pre-crash simulation to enhance traffic safety

VUFO Accident Simulation Toolbox (VAST)



GIDAS-PCM
GERMAN IN-DEPTH ACCIDENT STUDY PRE-CRASH-MATRIX



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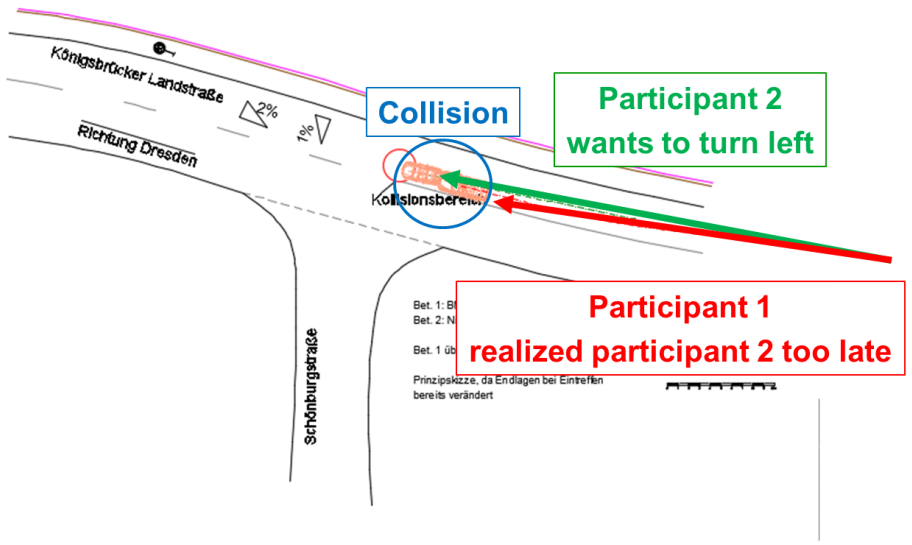
Applications in Traffic accident research to improve vehicle safety

Pre-crash simulation to enhance traffic safety

Example accident – Sketch



Accident scene

Applications in Traffic accident research to improve vehicle safety

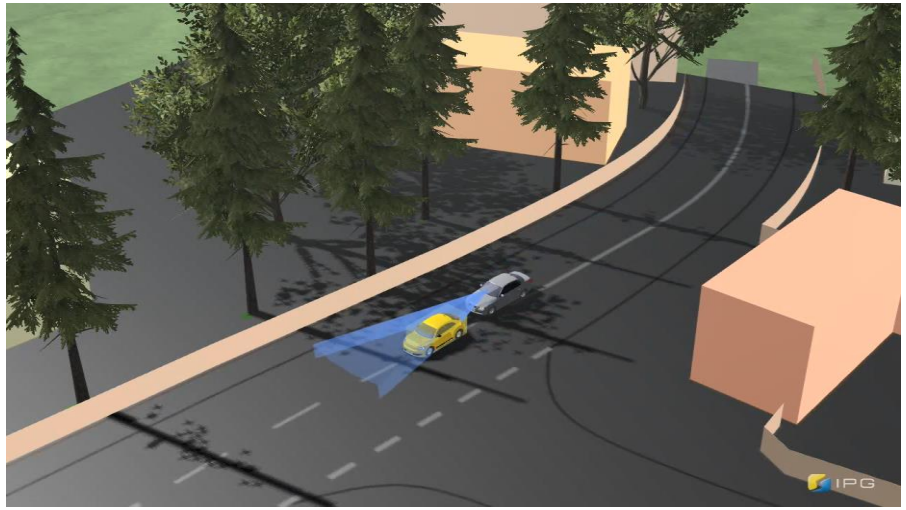
Pre-crash simulation to enhance traffic safety

Example accident – Simulation

real accident situation

real accident situation

with ADAS System



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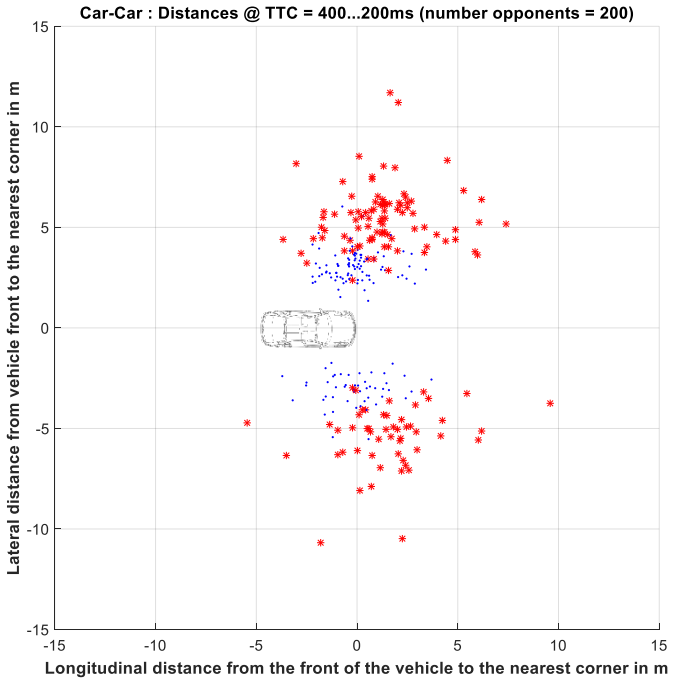
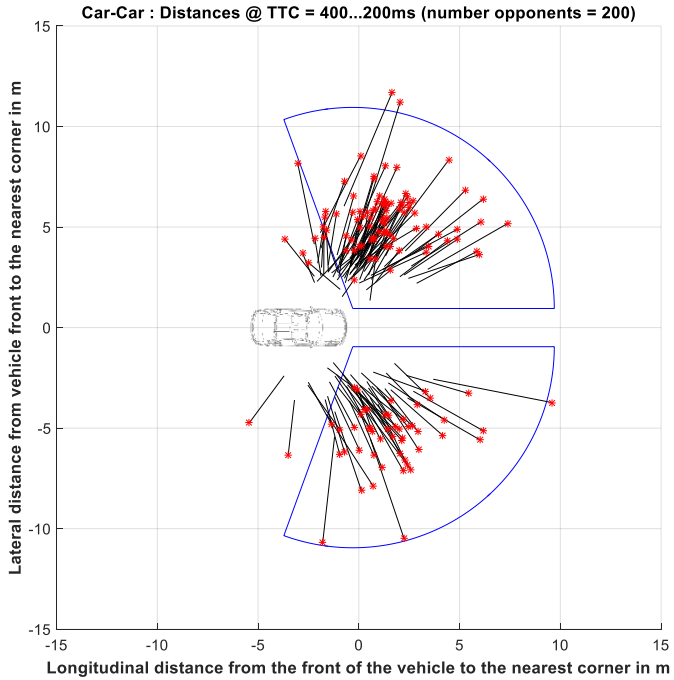
Pre-crash simulation to enhance traffic safety

Evaluation of opponent‘s position at specific TTC

* TTC = 400 ms
· TTC = 200 ms

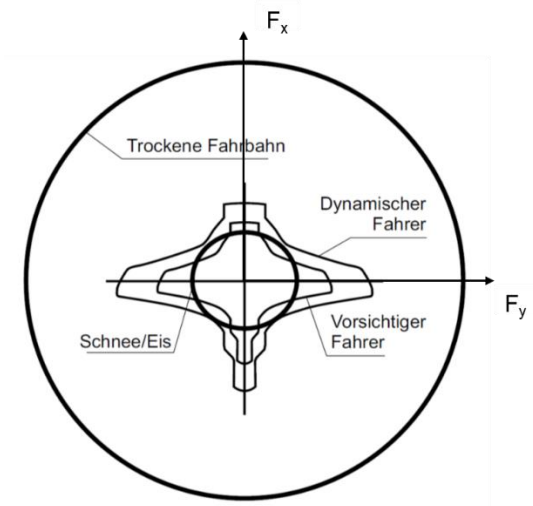


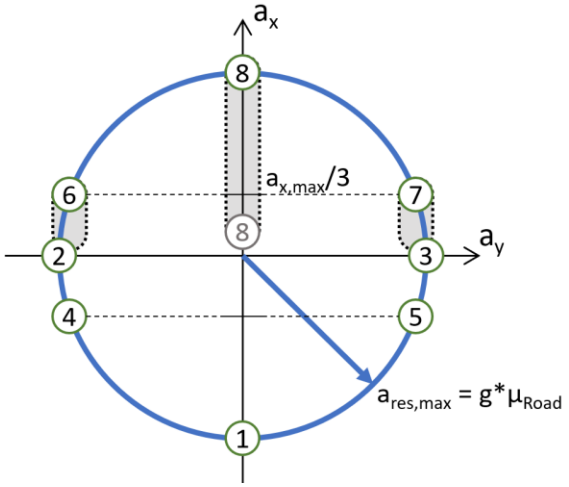


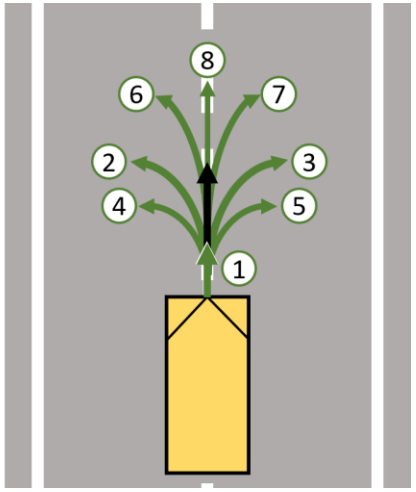
Applications in Traffic accident research to improve vehicle safety

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"

(1) - Max. deceleration
(2) - Steering to the left
(3) - Steering to the right
(8) - Max. acceleration
(4) - Max. deceleration + Steering to the left
(5) - Max. deceleration + Steering to the right
(6) - Max. acceleration + Steering to the left
(7) - Max. acceleration + Steering to the right

Applications in Traffic accident research to improve vehicle safety

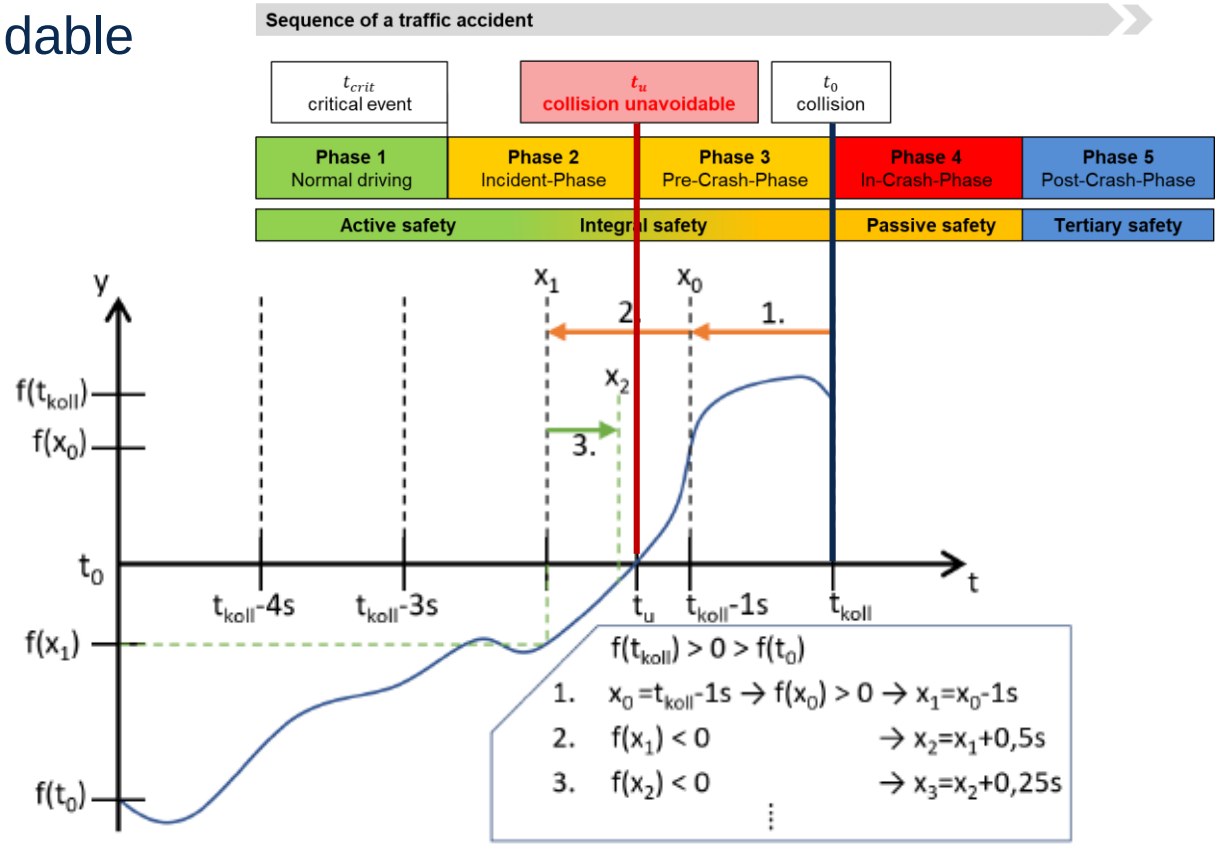
Pre-crash simulation to enhance traffic safety

Point of no return t_u when a collision is unavoidable

- Criticality 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

→ Efficient 2-step-approximation method

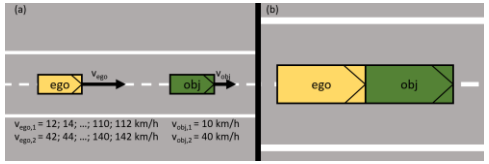
1) Fixed step size of 1s
2) Bisection method



Applications in Traffic accident research to improve vehicle safety

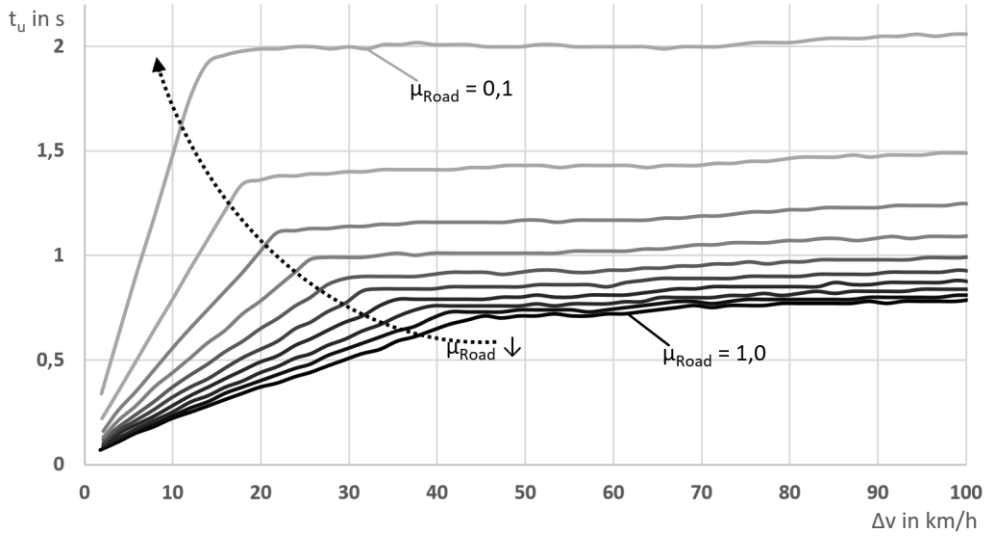
Pre-crash simulation to enhance traffic safety

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

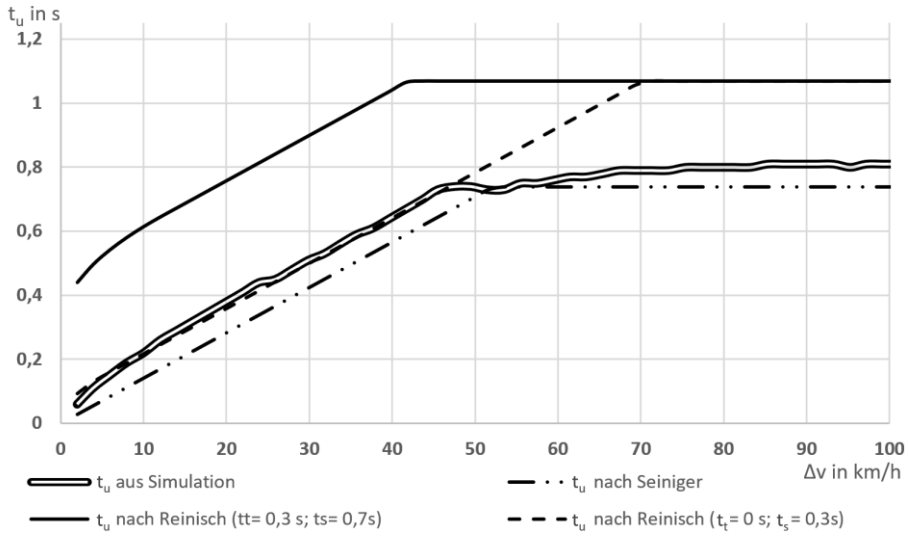


$t_u = f(\Delta v, \mu)$; $v_{obj} = 40$ km/h

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



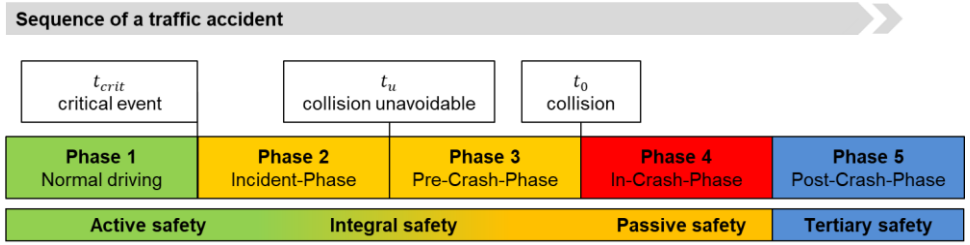
t_u comparison of simulation and literature

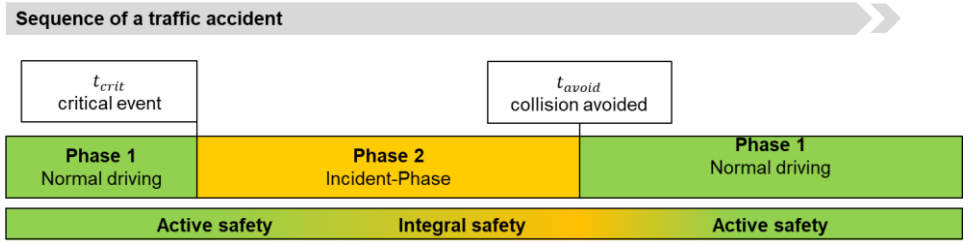


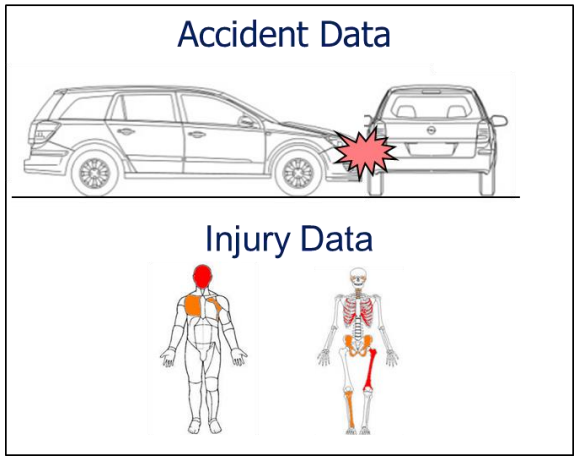
Applications in Traffic accident research to improve vehicle safety

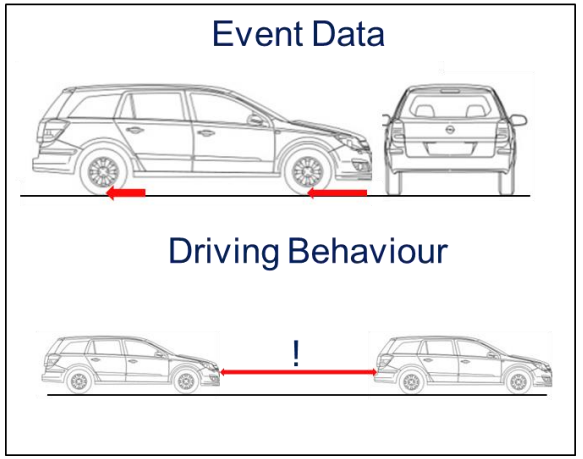
Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS) → Incidents and Events









Applications in Traffic accident research to improve vehicle safety

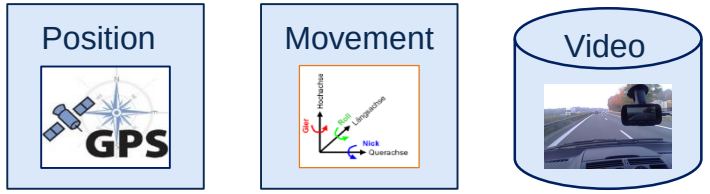
Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)

Real scenario

Recording

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



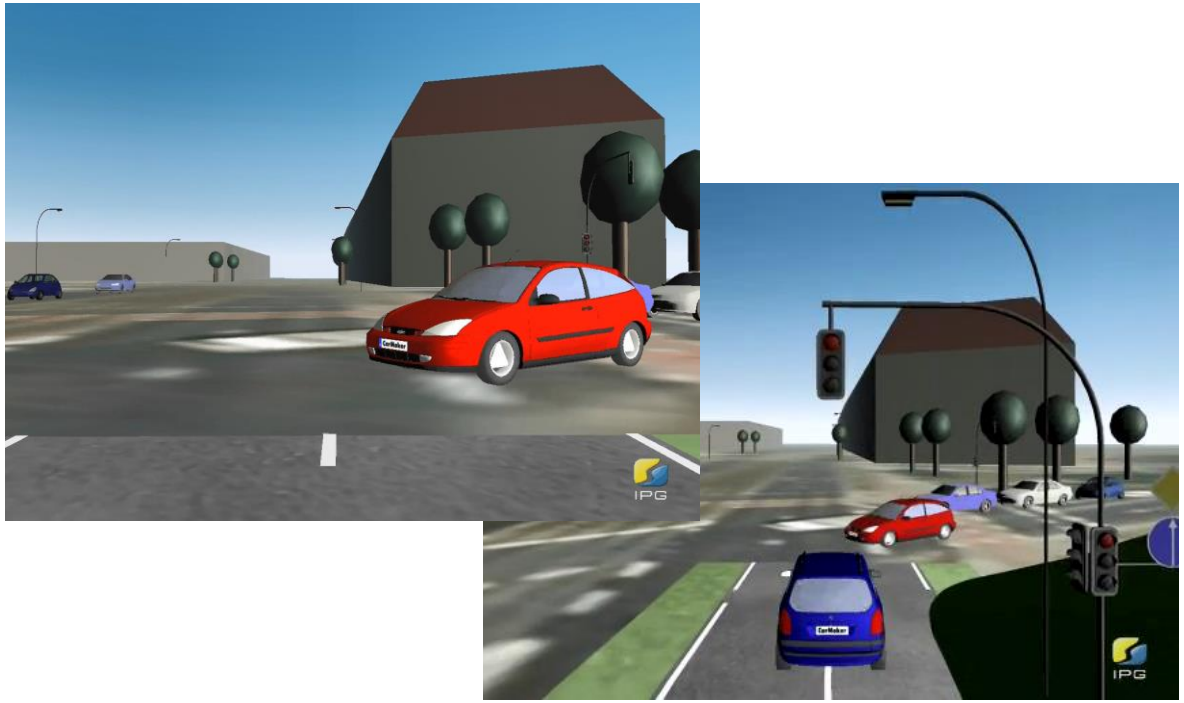
Applications in Traffic accident research to improve vehicle safety

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)

Ground truth labeling with

MathWorks®

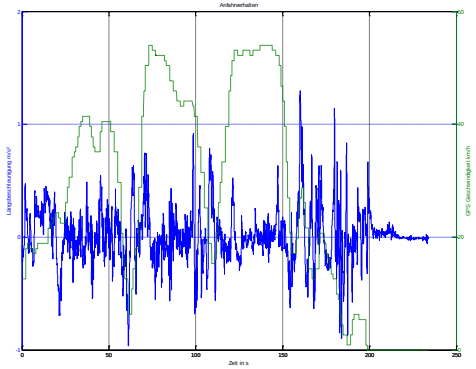
Automated Driving System Toolbox

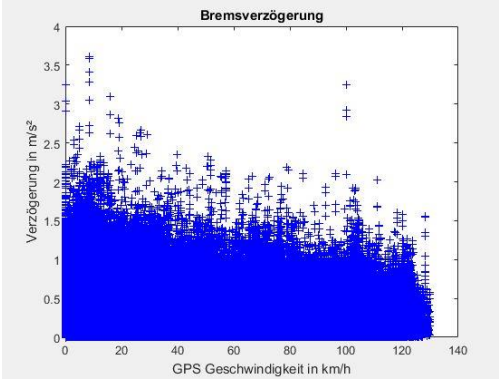
VUFO GmbH

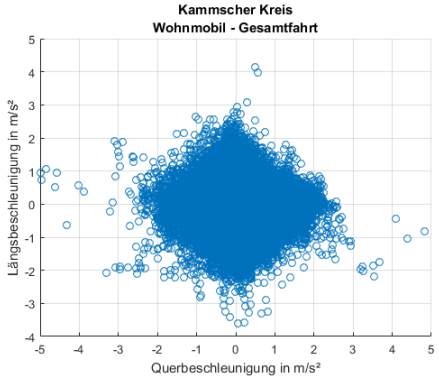
Applications in Traffic accident research to improve vehicle safety

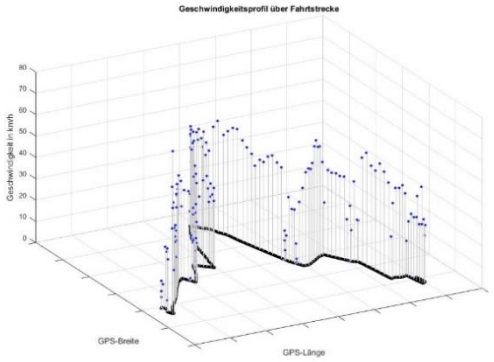
Pre-crash simulation to enhance traffic safety

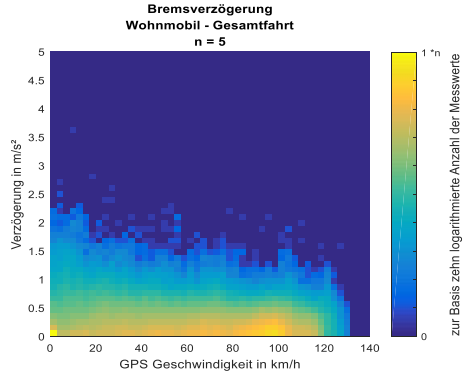
Naturalistic driving study (NDS)

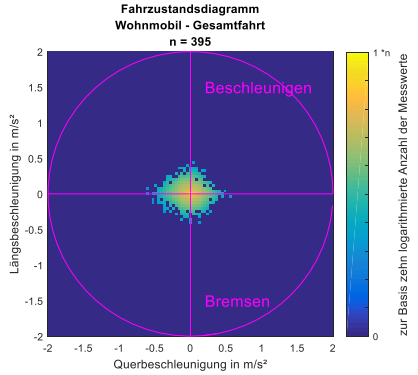








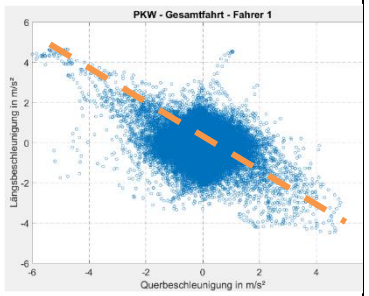
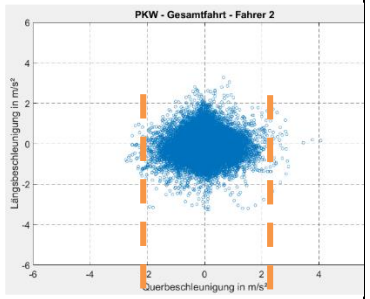
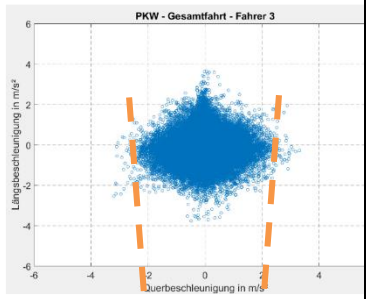
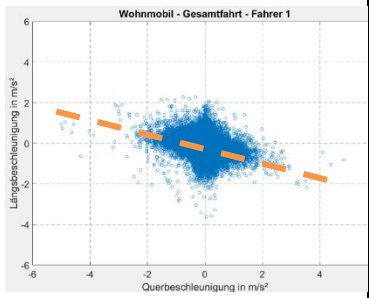
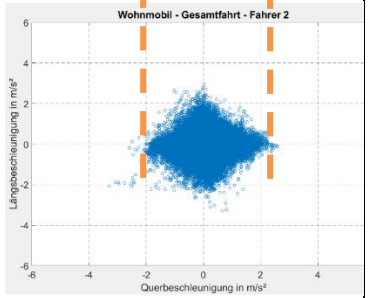
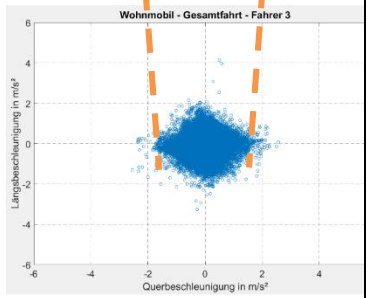




Applications in Traffic accident research to improve vehicle safety

Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)

	Driver 1	Driver 2	Driver 3
Passerner car			
Camping van			

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

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

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

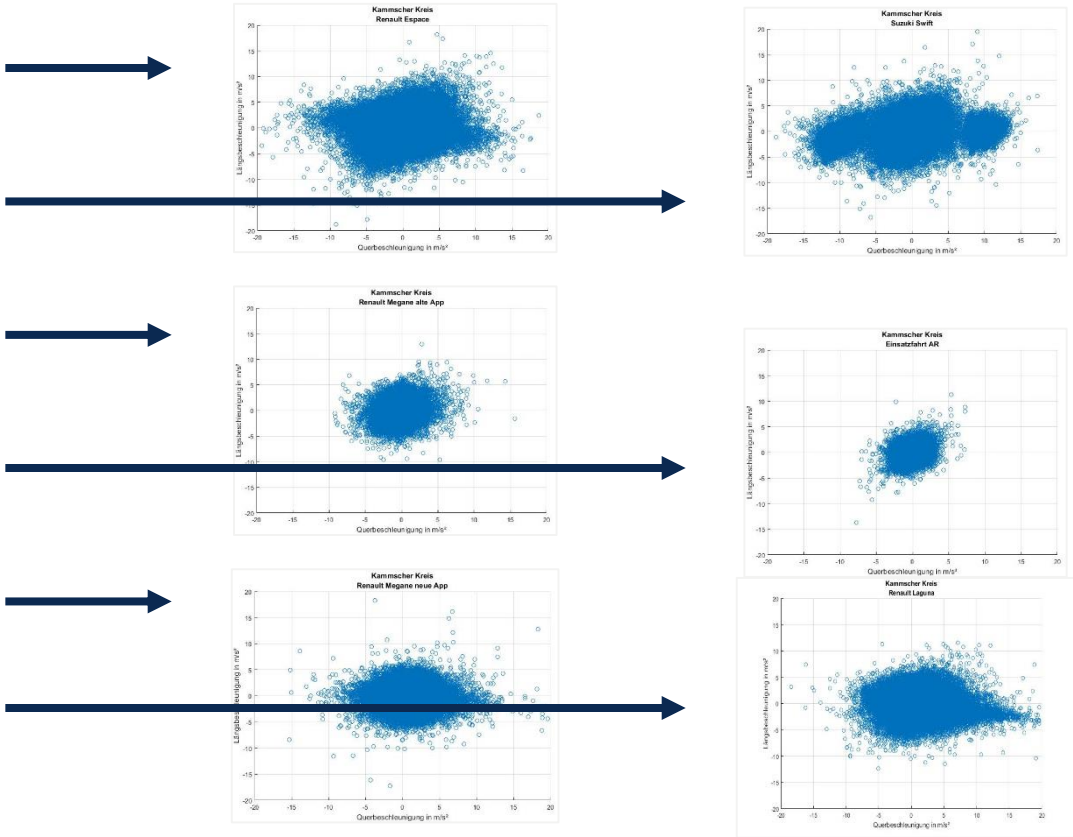
Renault Megane:

→ Crisis in relationship

2017

Renault Laguna:

→ On-Off relationship

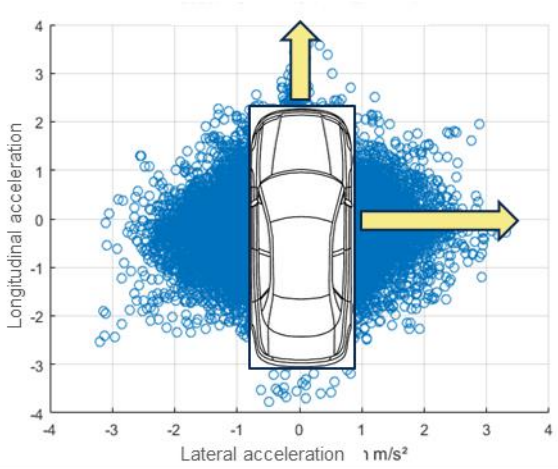


Applications in Traffic accident research to improve vehicle safety

Pre-crash simulation to enhance traffic safety

Naturalistic driving study (NDS)

Real driving behavior

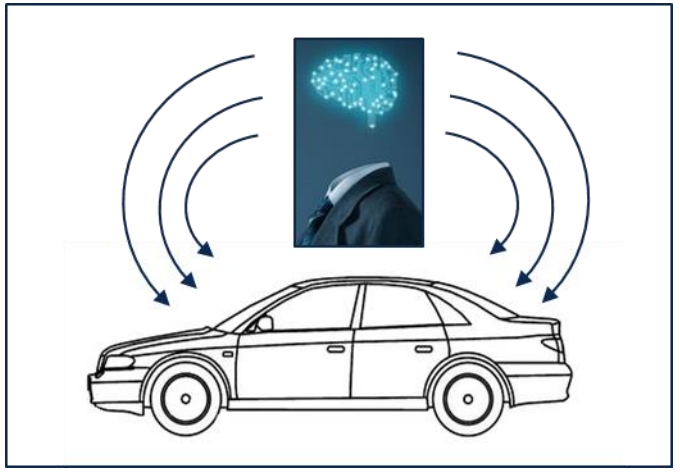


Individual sets of driving parameters

Driver models

Extraction of driving profiles

Automated driving



Train ADAS and HAD

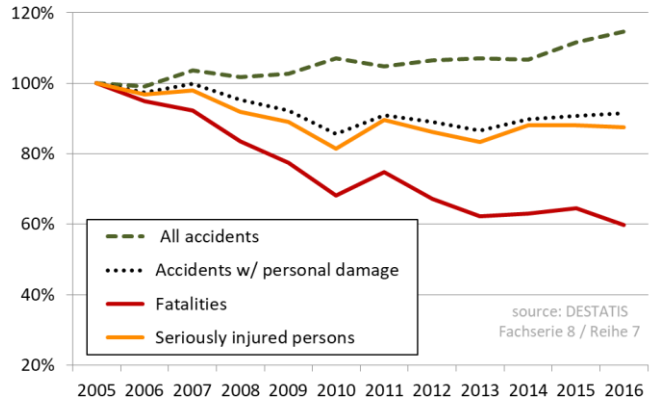
AGENDA

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
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.

Verkehrsunfallforschung
an der TU Dresden GmbH

ein Unternehmen der TUDAG

THANK YOU
FOR YOUR ATTENTION!

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Data analyses and simulation

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