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Virtual assessment of protective systems for motorcyclists based on real-world accident data

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Biomechanics and Accident Analysis
at the Institute of Legal Medicine
LMU University of Munich

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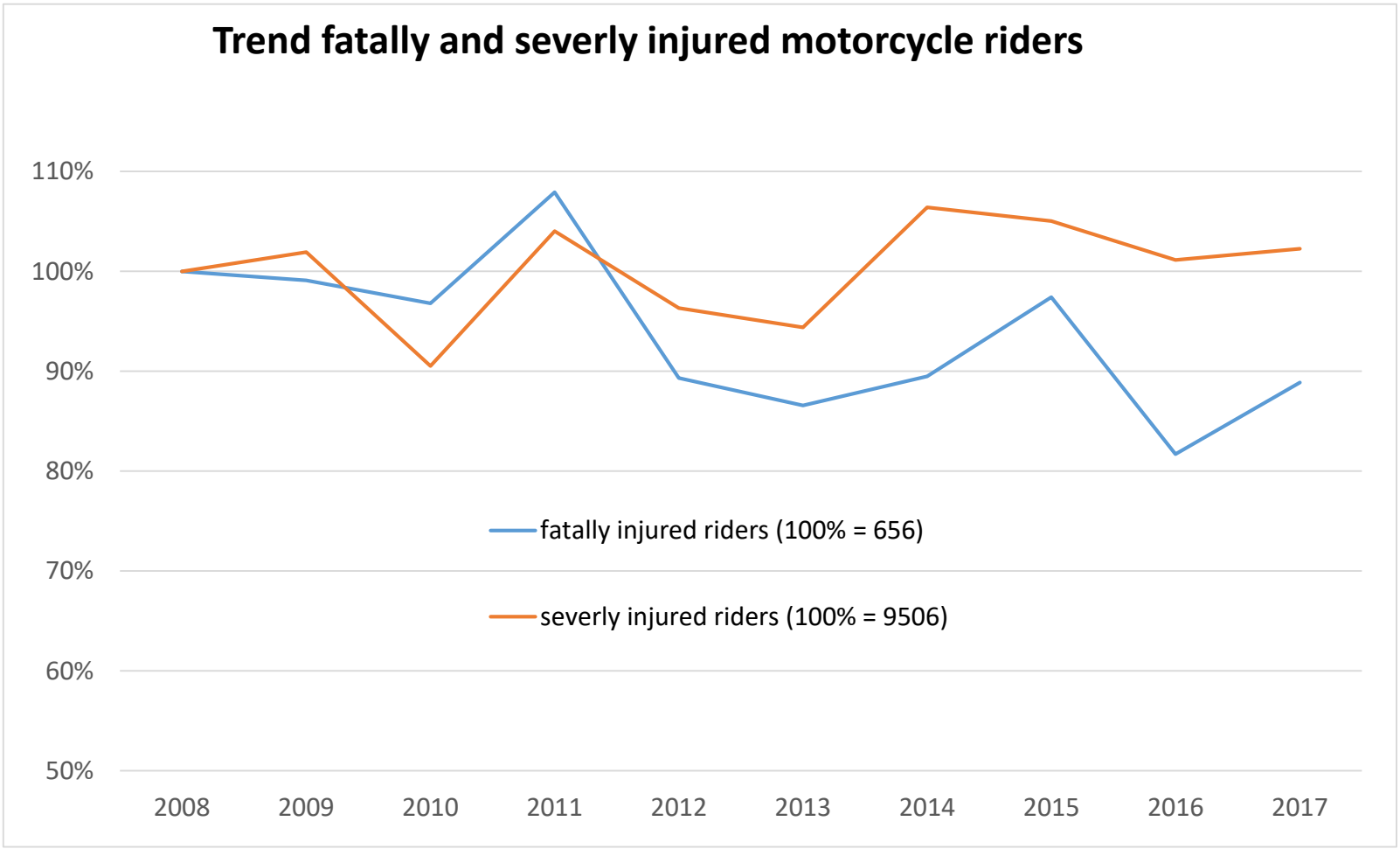
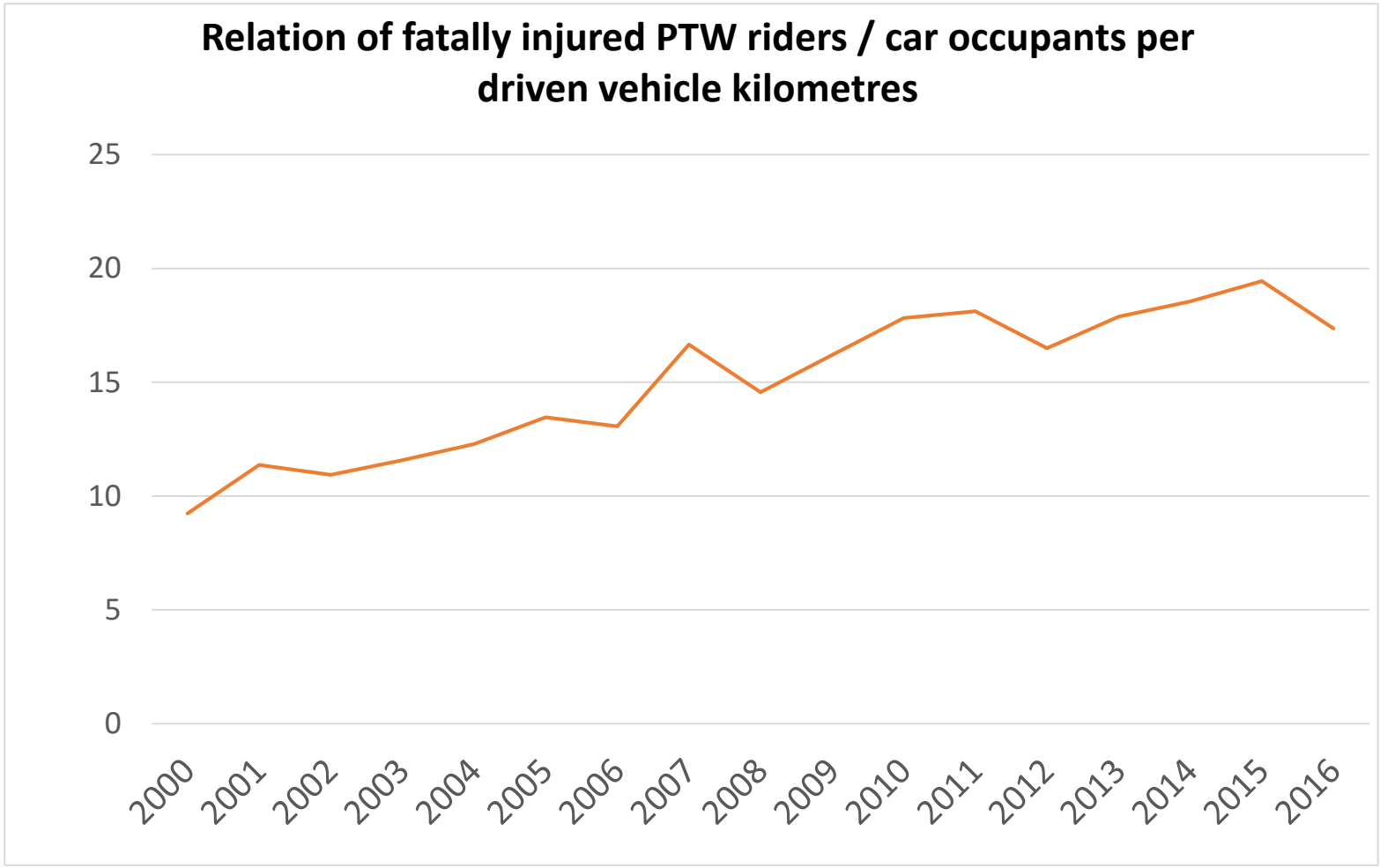
Outline

- Background
- Challenge
- Methods
  - Basic kinematic analysis
  - Multibody-Simulation
  - Finite-Element-Simulation
- Conclusion & Outlook

Background


Trend fatally and severly injured motorcycle riders
110%
100%
90%
80%
70%
60%
50%
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
fatally injured riders (100% = 656)
severly injured riders (100% = 9506)

Background


Relation of fatally injured PTW riders / car occupants per driven vehicle kilometres
25
20
15
10
5
0
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016

Challenge

PPE to be assessed acc. to EN 1621

→ Realistic test conditions?

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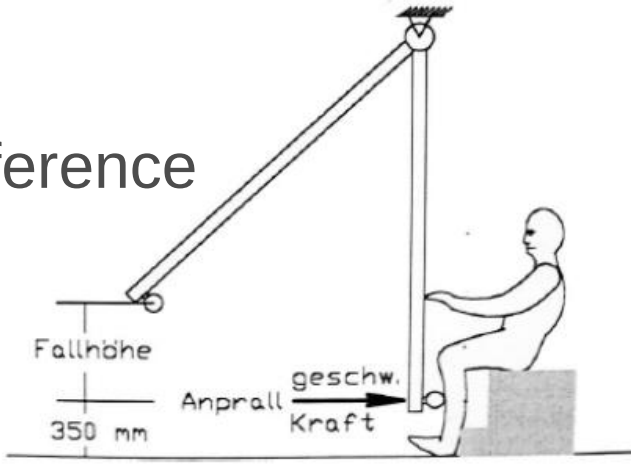
Related publications IfZ Motorcycle Conference

- Otte et al. 2002



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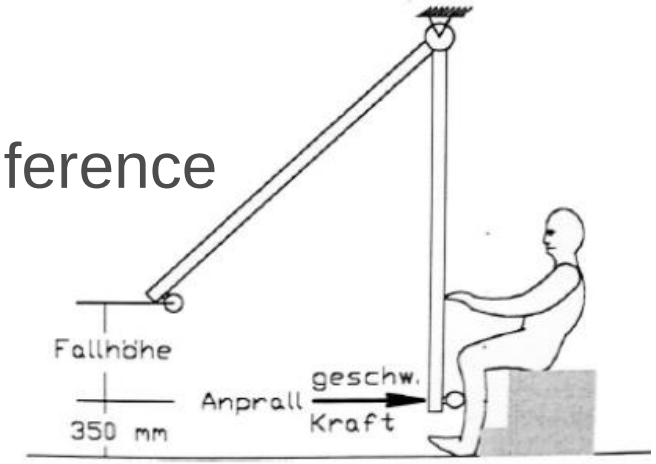

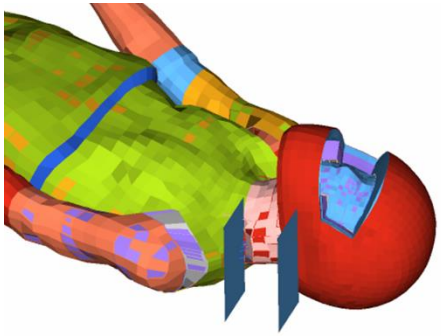

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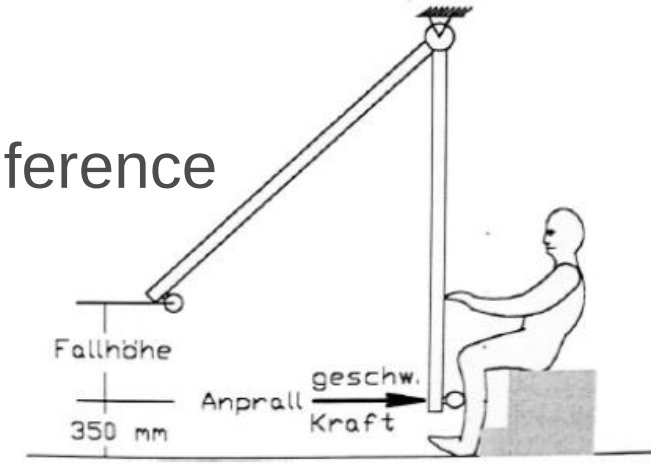

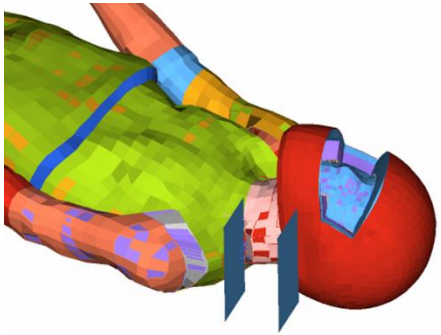

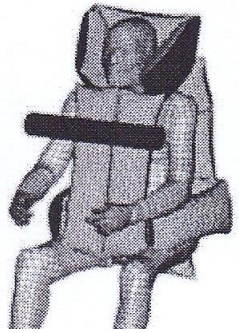

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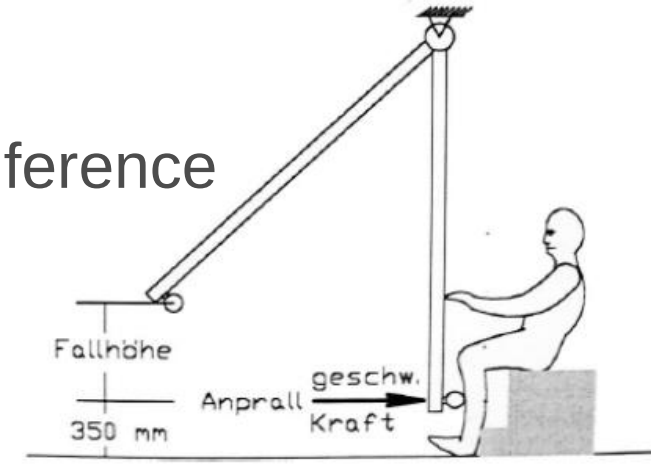
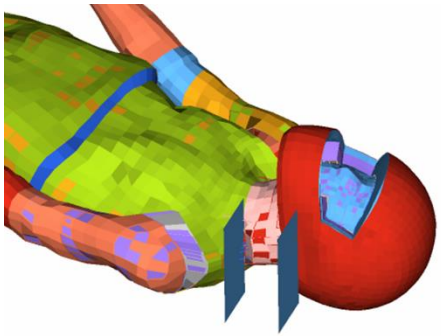
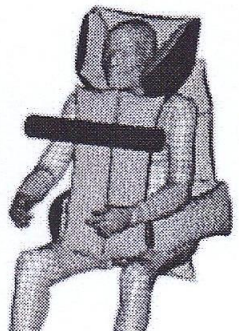
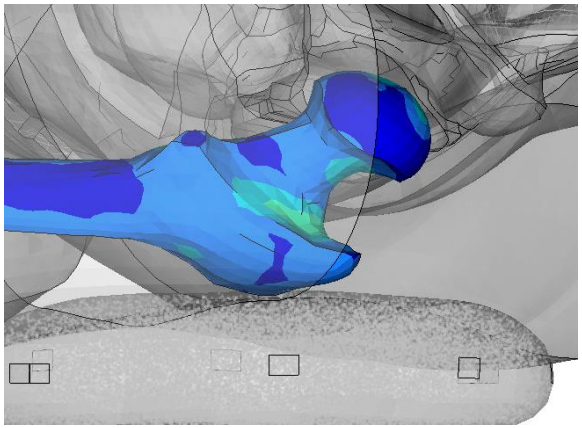


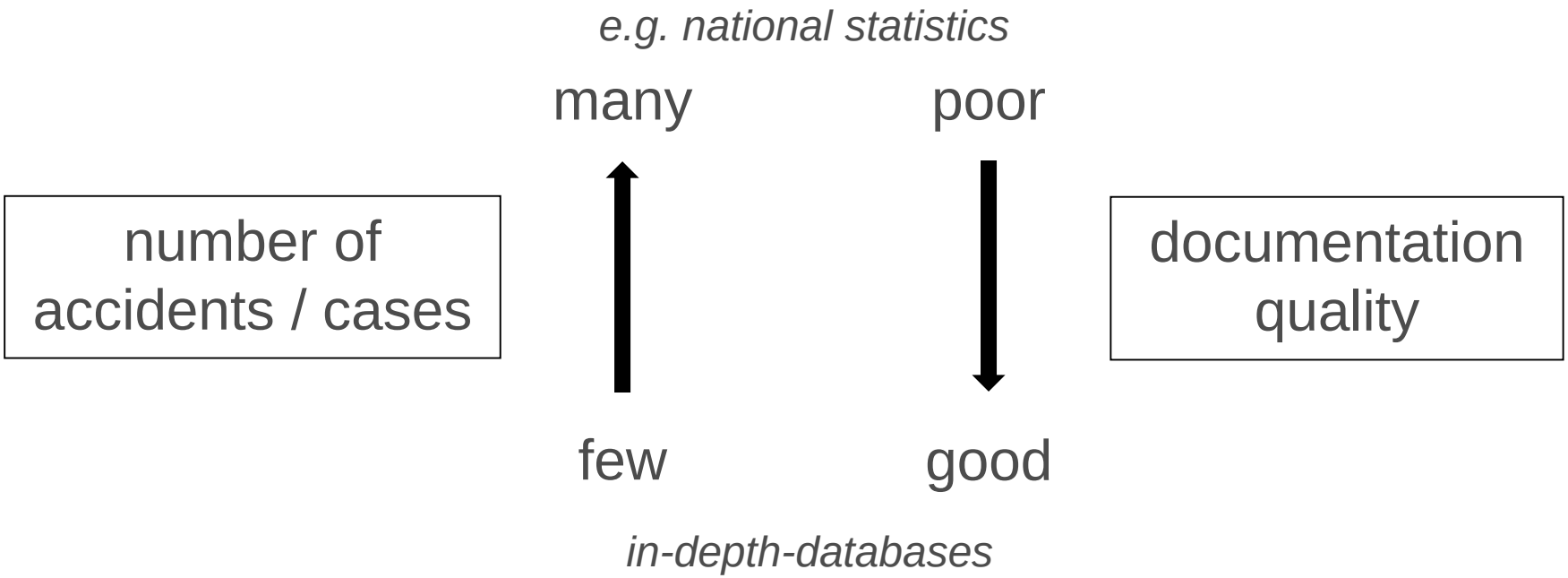






Challenge

- Reconstruction of PTW-accidents and reasonably narrowing down the potentially preceding (typically complex) kinematics often difficult
- Conflict of objectives:

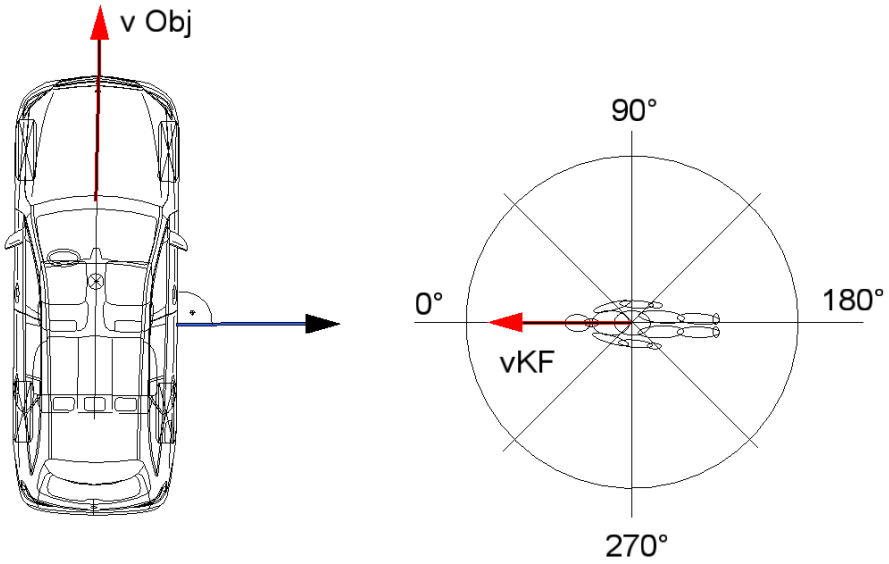


Methods

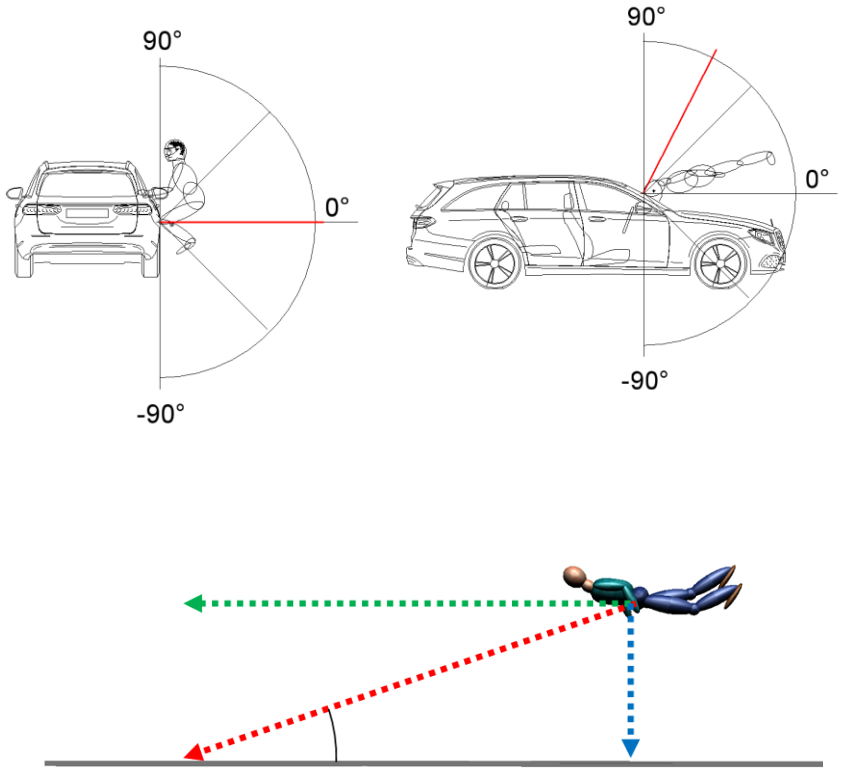
1. Narrowing down kinematics / impact conditions with existing data / basic kinematic analysis
2. Summarize kinematic groups
3. Identification of most relevant scenarios
4. Detailed reconstruction / simulation using multibody Simulations (PC-Crash, MADYMO), computation of boundary conditions
5. FE simulations using HBM, determination of injury risks and assessment of effectiveness of protective equipment

Basic kinematic analysis

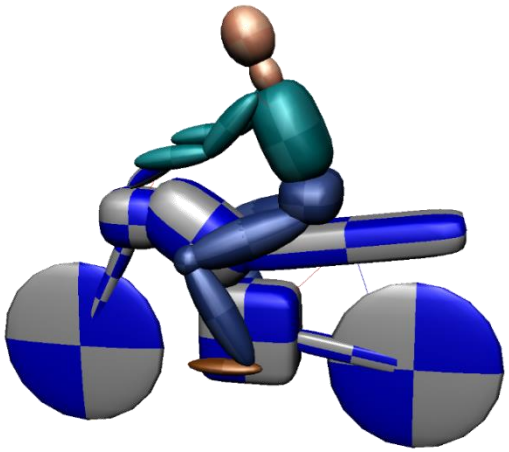
horizontal plane



vertical plane



Accident Reconstruction & Multibody Simulation

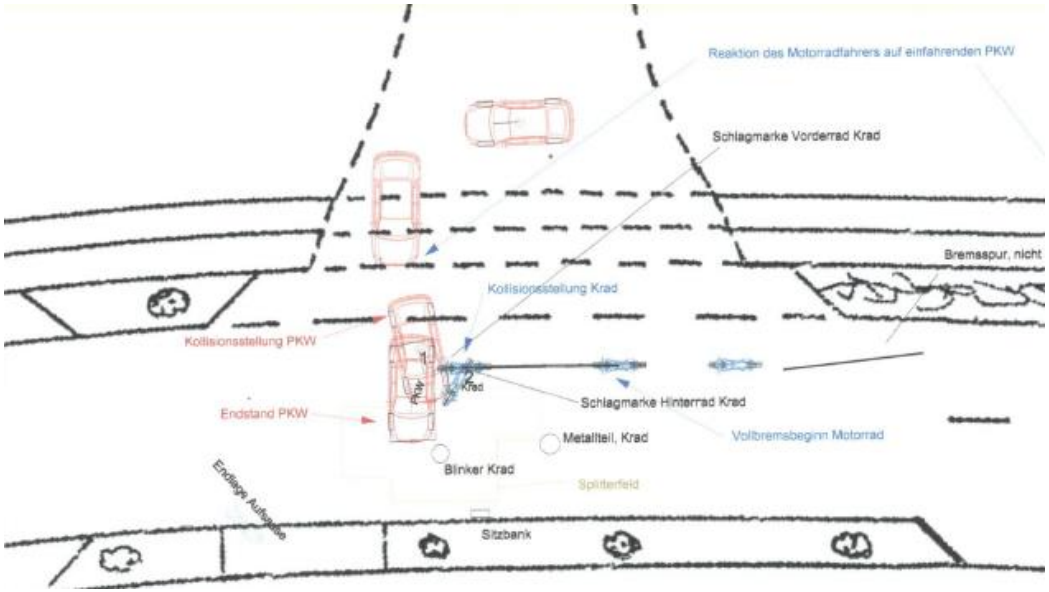


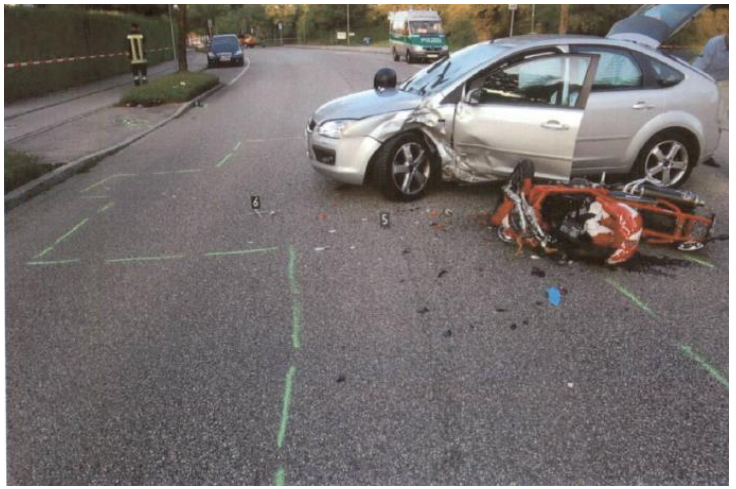
Source: PC Crash Software (www.dsd.at)

PC-Crash Software:

- One of the leading tools for accident reconstruction
- Calculation of collisions between multiple vehicles
- Included vehicle models / multibody-systems
- Relatively short calculation periods

Case example 1





Collision speeds:

car: about 15 km/h

PTW: 60 – 65 km/h

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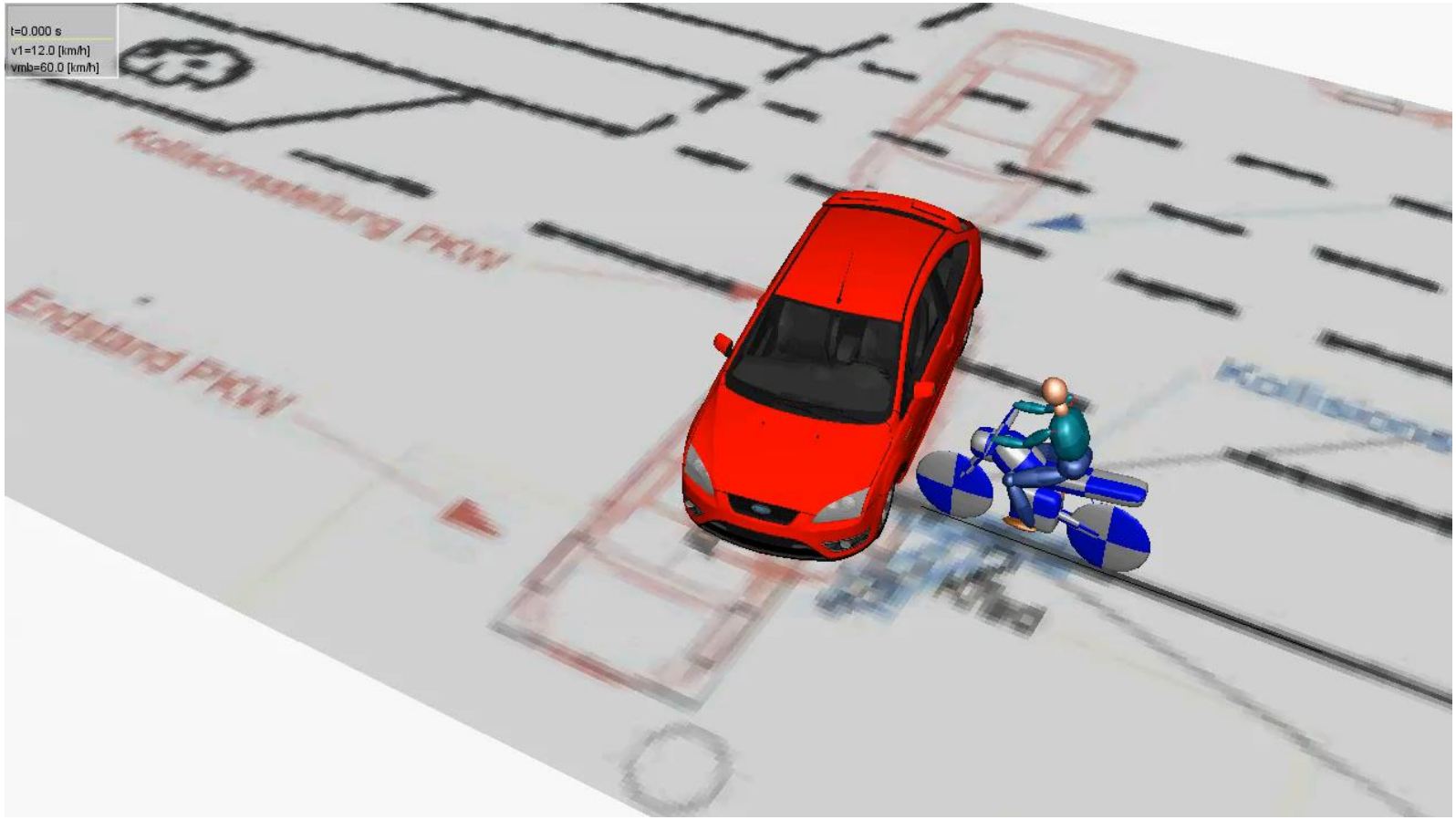
Case example 1



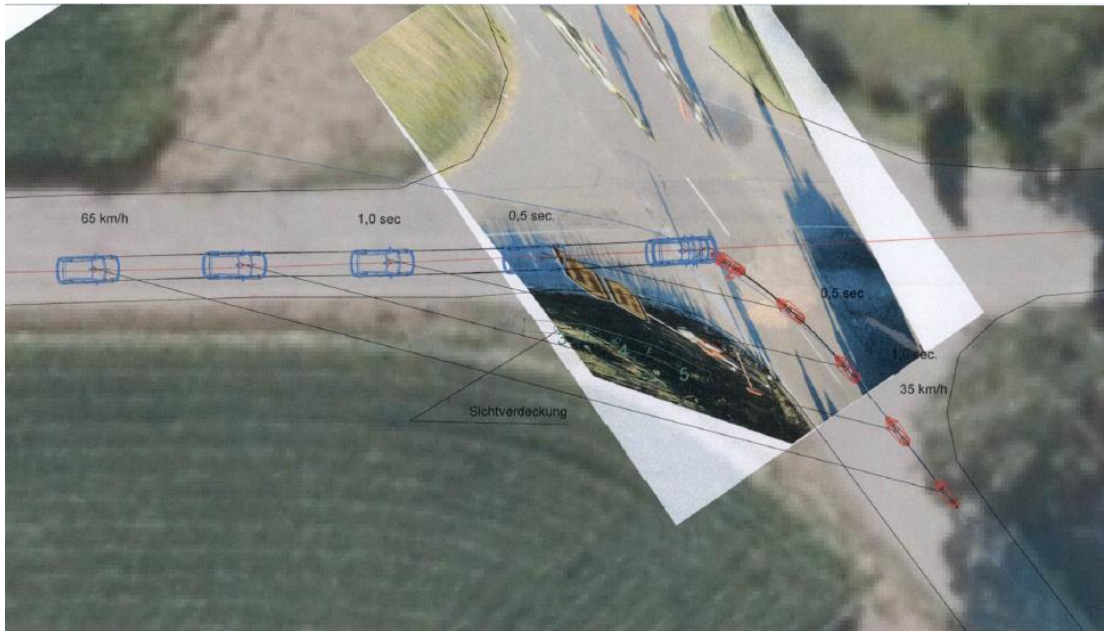
Multibody Simulation

MADYMO Software:

- „Standard“ software for analysing occupant safety and kinematics of bicycle / motorcycle riders
- Included human-body-models (HBM)
- Development of a motorcycle model (LMU)
- More complex and time consuming simulations

LMU motorcycle model, MADYMO HBM

Case example 2



Collision speeds:

car: 55 – 65 km/h

PTW: 35 – 40 km/h

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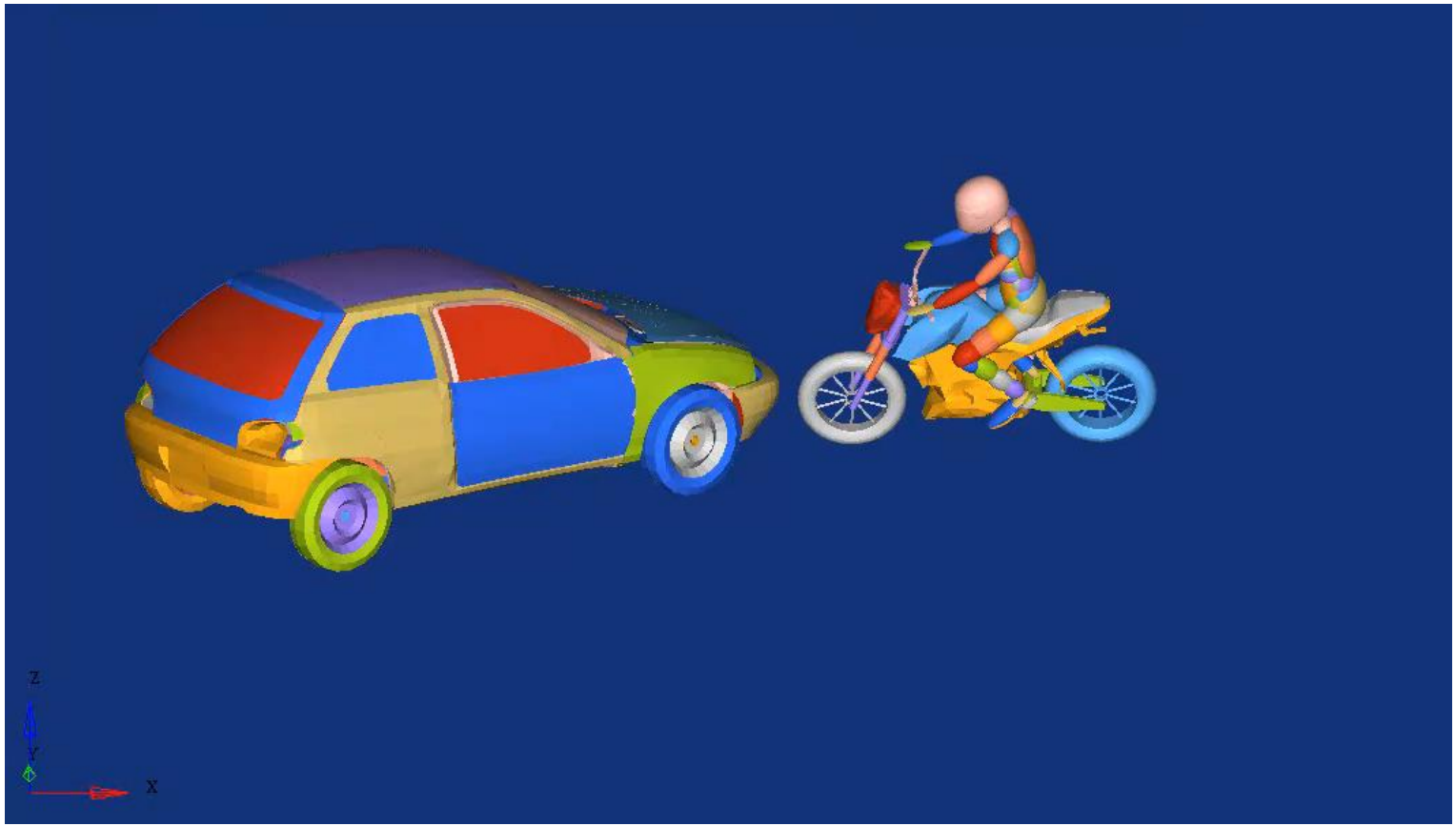
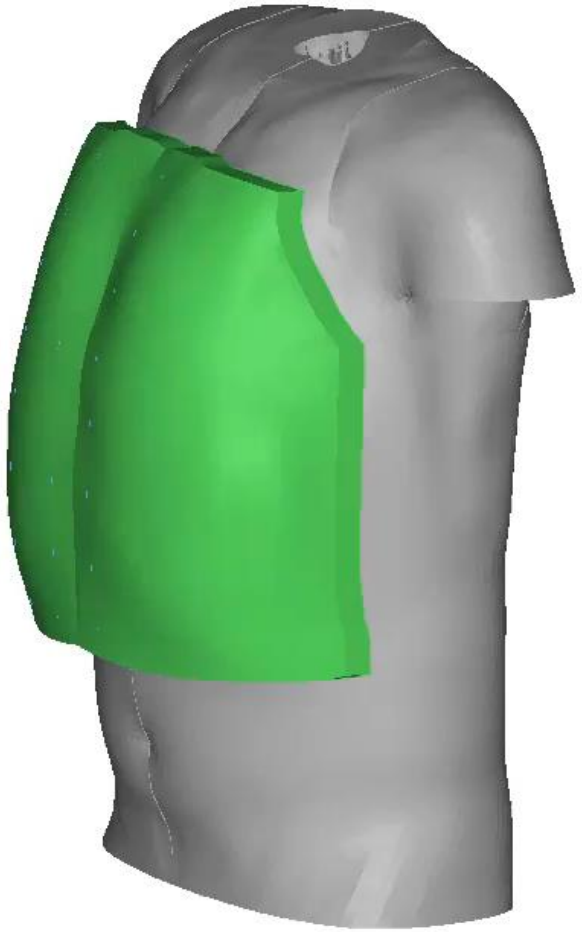
Case example 2



Finite-Element Simulation

FE-Simulation:

- Results from MBS as boundary conditions
- Determination of loading / injury risks using FE-HBM
- Development of conceptual protective systems / models
- Assessment of the effectiveness of PPE



Conclusion

Multi-Step-approach (basic kinematic analysis, MBS, FEM) allows

- a broad application of the presented method
- a better understanding of motorcycle accidents in order to help defining test conditions for personal protective equipment
- supporting the reduction of PTW riders' accidental injury

Conclusion & Outlook

- The inclusion of generic approaches and models is seen as a contribution to solving the general conflict of objectives in motorcycle safety research (reasonable coverage of real-world accidents and necessary data depth in the single case)
- Among others, the presented method is applied in the European projects MOTORIST, ISABELLE and PIONEERS

THANK YOU!