SAFETYUPDATE

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May 18 – 19, 2022|Würzburg

carhs Empowering Engineers

SAFETYUPDATE

Insights from Accident Data: Possibilities and limitations of calculating accident avoidability, accident and injury severity

Thomas Unger, Henrik Liers, Stefan Babisch, Angela Schubert

May 18 – 19, 2022|Würzburg

carhs Empowering Engineers

- Introduction
  - Current accident situation (Germany)
  - GIDAS
- Methodology
  - Prediction of future accident scenario
  - Analyses of the remaining accidents
  - Prediction of Mitigation effects
- Results & Conclusions

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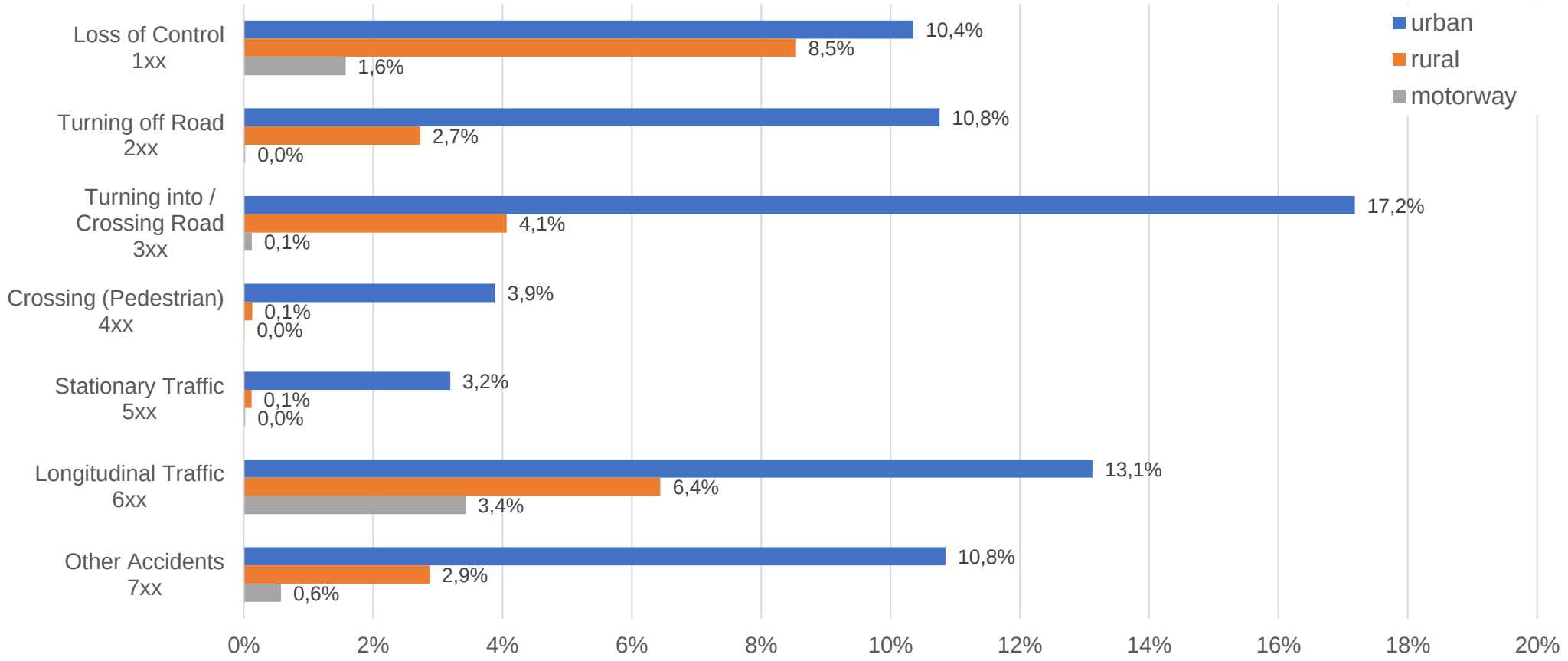
- Germany's national road traffic accident statistics (2020):
- **Total:**

- 264,499 accidents with personal damage of which
  - **2,582** fatal accidents (1.0%), with **2,719** fatalities
  - 51,243 accidents (19.4%) with serious injuries
  - 210,674 accidents (79.6%) with slight injuries

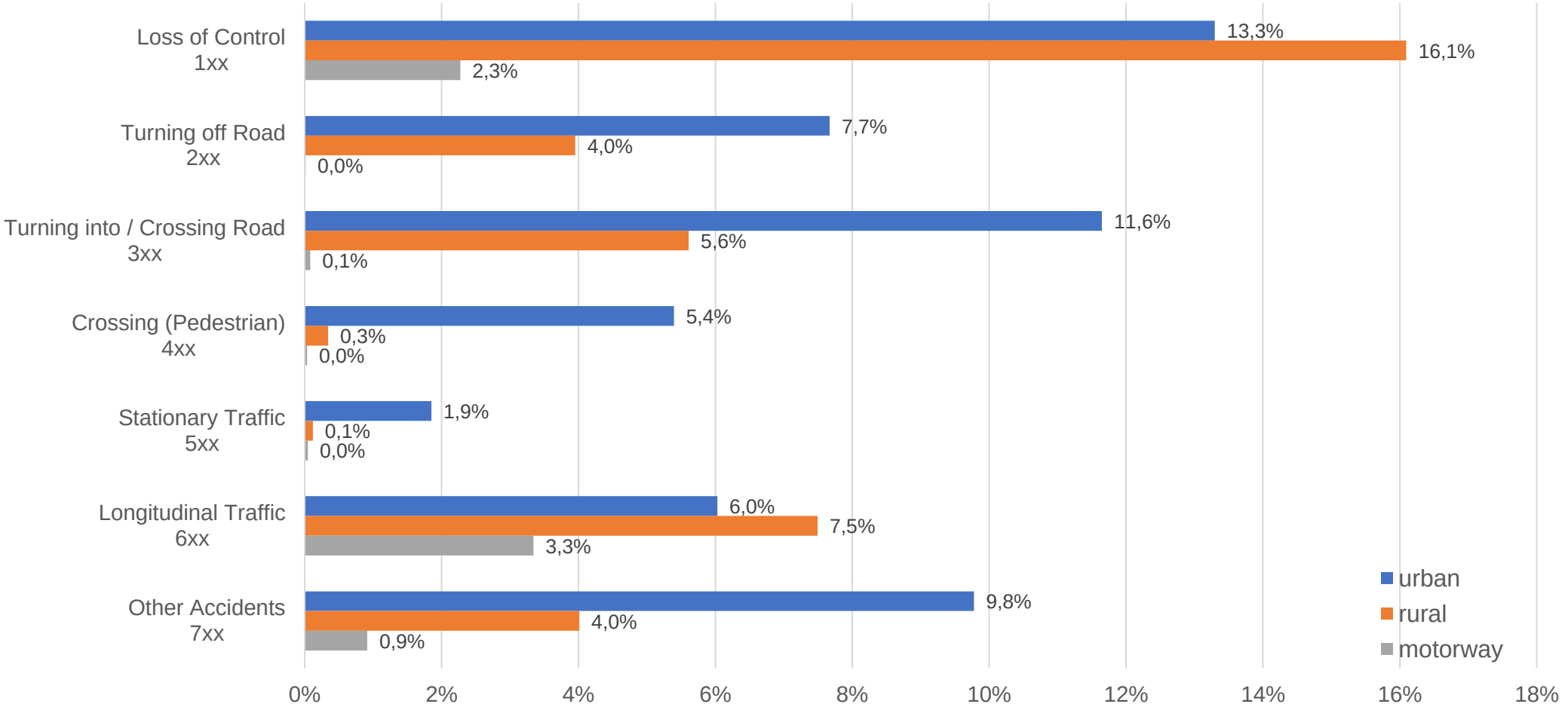
Source: Federal Bureau of Statistics (DESTATIS). Fachserie 8 Reihe 7 – Verkehrsunfälle 2017., Wiesbaden, Germany 2018.

Accidents with personal damage - Type of Accident regarding Location



Source: Federal Bureau of Statistics (DESTATIS). Fachserie 8 Reihe 7 – Verkehrsunfälle 2017., Wiesbaden, Germany 2018.

Accidents with serious or fatal injuries - Type of Accident regarding Location



Source: Federal Bureau of Statistics (DESTATIS). Fachserie 8 Reihe 7 – Verkehrsunfälle 2017., Wiesbaden, Germany 2018.

- Loss of control accidents in the current accident scenario still relevant
- These accidents have a higher severity – especially on motorways and rural roads
- Turning and crossing traffic accidents become more and more important

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Accident research is **pre-competitive research.**

FAT

Association for Research on Automobile Technique

VUFO GmbH

Traffic Accident Research Institute at TU Dresden

bast

Federal Highway Research Institute

MHH

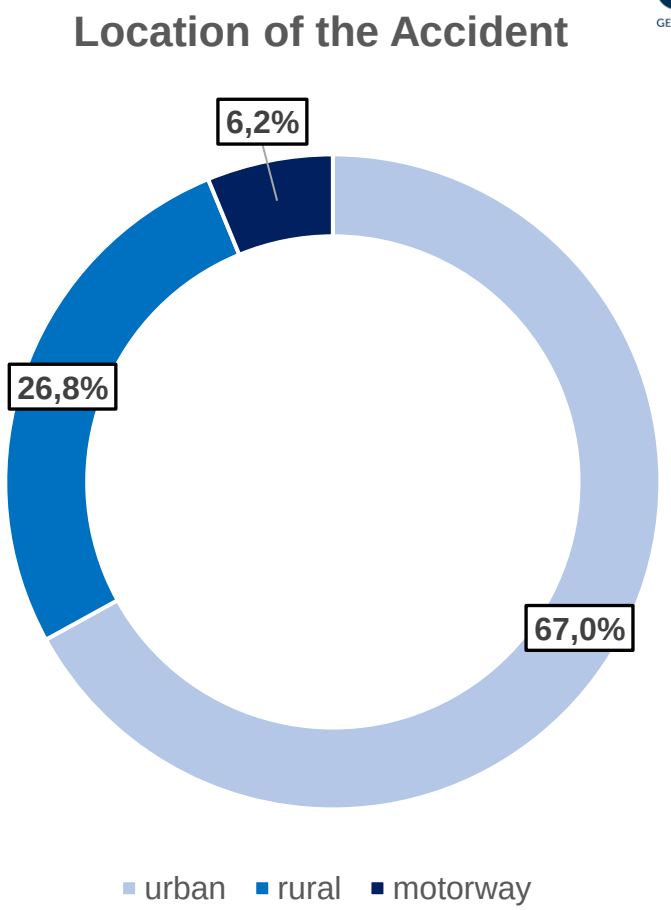
Medical University of Hannover

GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

≈ 2.000 accidents w/ personal damage/year since July 1999

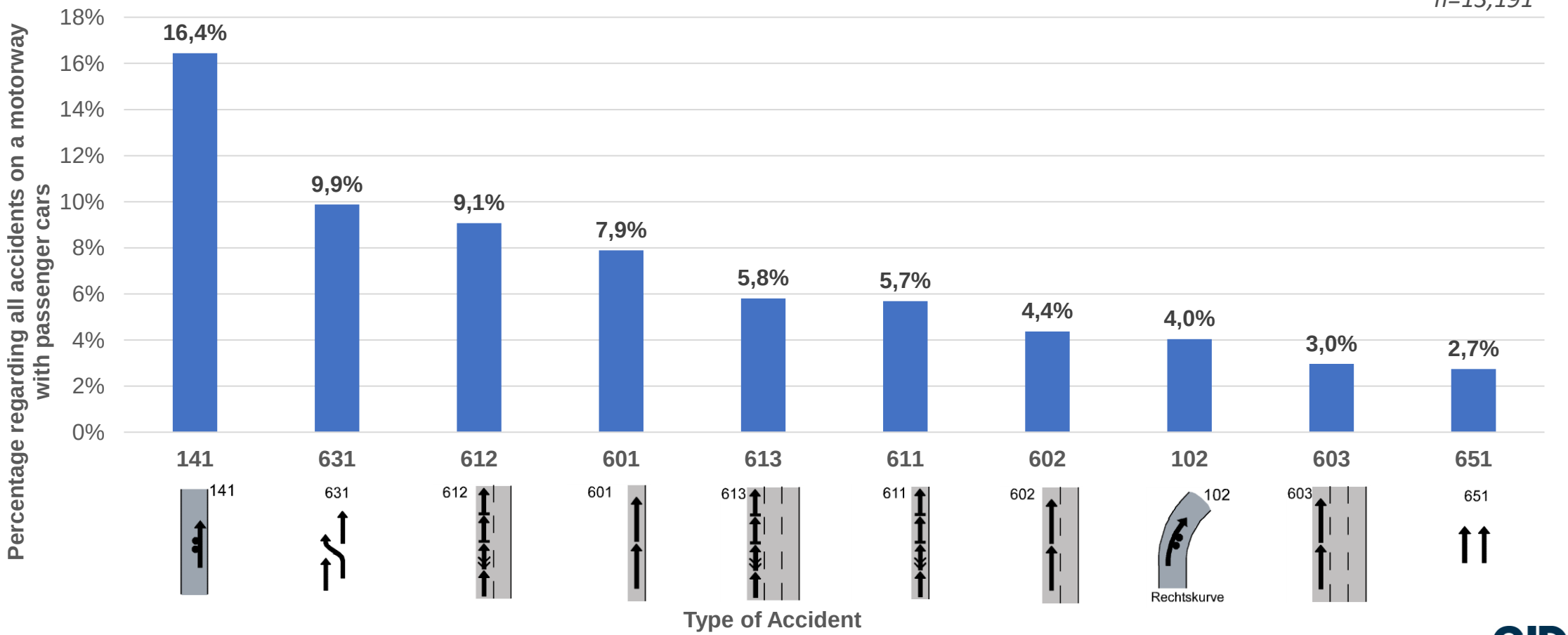
- Analyzed are traffic accidents with:
  - at least one car (M1 / N1) involved
  - car must be involved in the accident causing situation (UTYPA or UTYPB).
- In total, **32,923 traffic accidents** could be identified in the GIDAS database
  - Issue 31.12.2021
  - Weighted towards the German Traffic Accident Statistics in 2020.

GIDAS GERMAN IN-DEPTH ACCIDENT STUDY



Top 10 Types of Accidents - Motorway

n=13,191

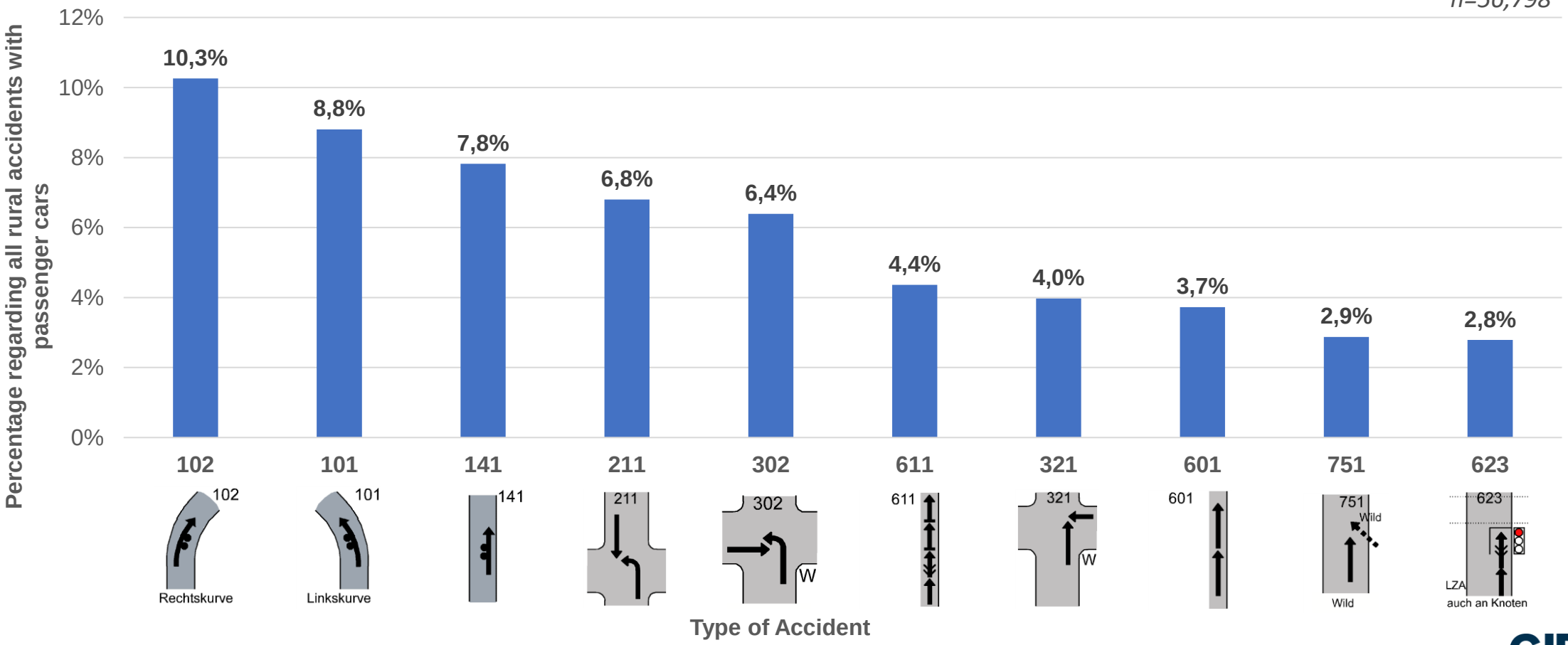


GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

Top 10 Types of Accidents - Rural

n=56,798

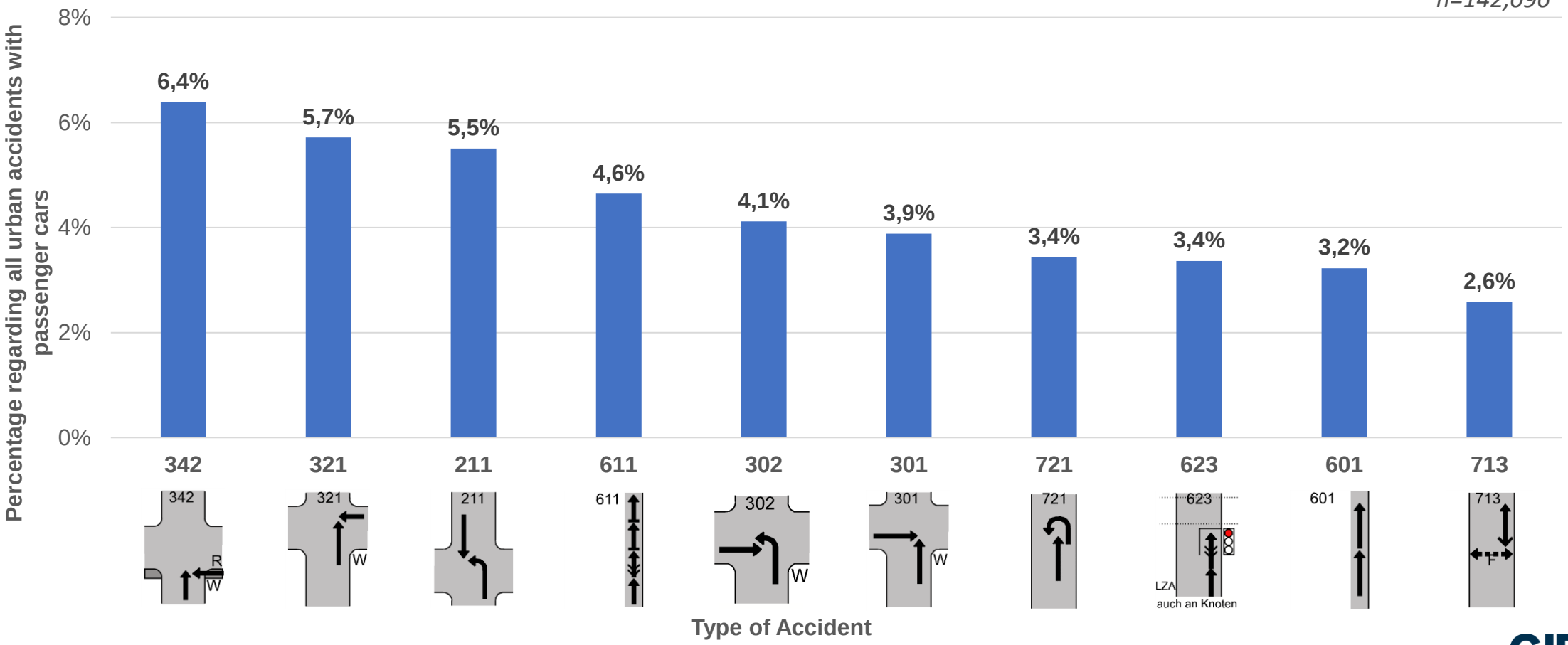


GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

Top 10 Types of Accidents - Urban

n=142,096



GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

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- Part I
  - Retrospective analysis of historical accident data
  - Police-recorded accidents on all German motorways
  - Motorway accidents out of the GIDAS database

Previous work [1]

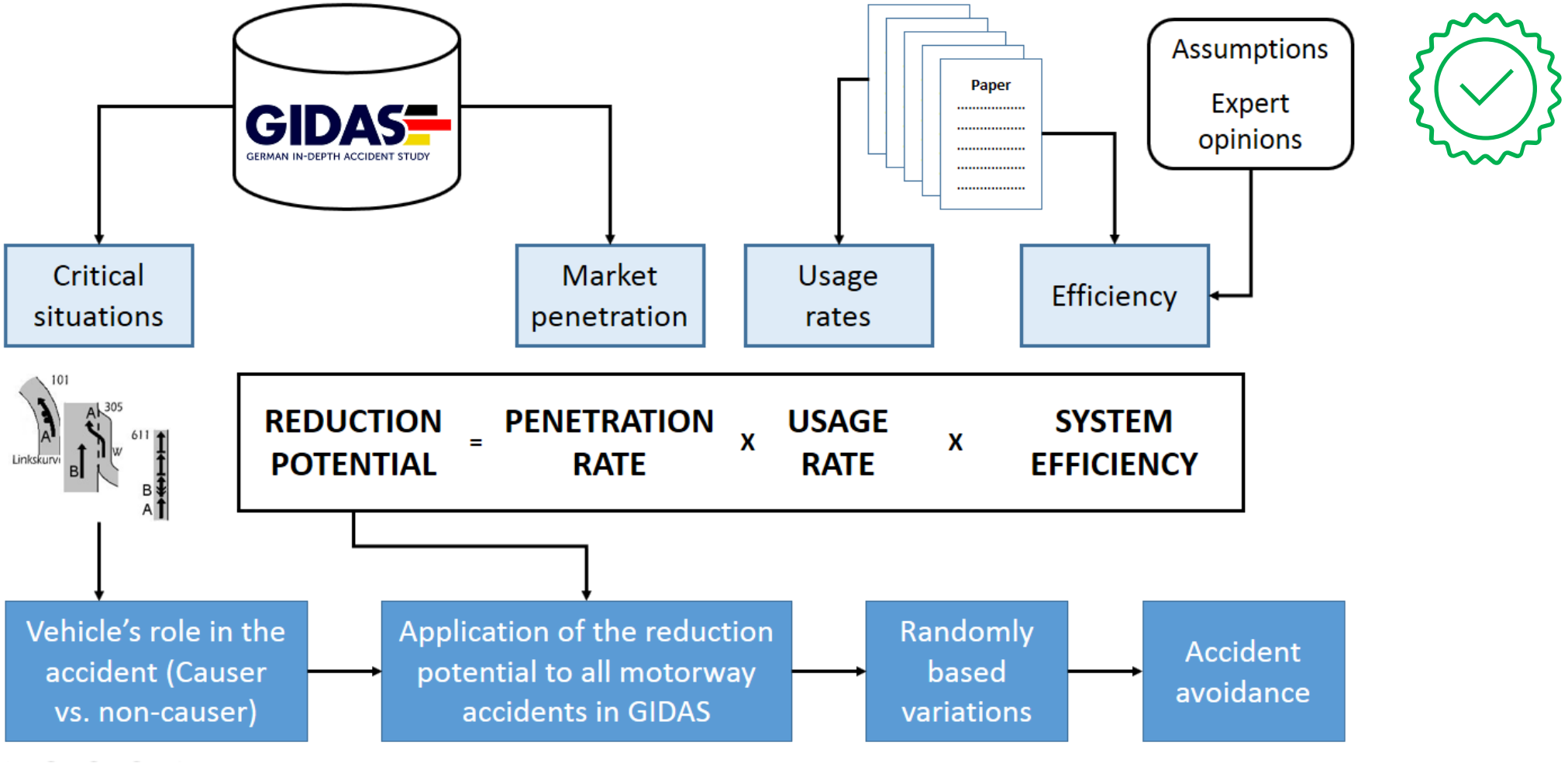
- Part II
  - Definition of Level 2 and Level 3 vehicles
  - usage/activation rates of systems
  - market penetrations of various safety systems
  - system efficiencies

- Part III
  - Estimation of the effect on the German motorway accident scenario
  - Analyses regarding the remaining accidents
  - Estimation of the effect on the German motorway accident scenario

- Part IV
  - Analyses of the remaining accidents
  - Estimation of the injury risks

[1] Unger, T; Liers, H: Prediction of the expected accident scenario of future Level 2 and Level 3 cars on German motorways; IRCOBI 2019

- SAE J3016 definitions:
  - modern vehicles already include functionalities, which fulfill the criteria of Level 2 automation.
  - The first applications of Level 3 automation in vehicles will probably include motorway scenarios only.
- Question: What is the safety potential of Level 2 and Level 3 automation on motorways in Germany (baseline: current situation)
  - Are there blind spots of automated cars
  - Which effects are due to the vehicle fleet



	L2 motorway functions			L3 motorway functions		
Market penetration scenario	10.0%	20.0%	50.0%	10.0%	20.0%	50.0%
Integrated efficiency	depending on acident type / critical situation according to assumptions					
Usage rate	depending on single systems according to literature and assumptions			90%		
Motorway accidents involving M1/N1 cars [2017, 100%]	18318			18318		
Avoided accidents due to L2 functions [result of 50 randomly based variations]	653 ± 70	1,308 ± 112	3,271 ± 126	1,425 ± 156	2,804 ± 216	6.962 ± 215
Potential effect (acident avoidance)	3.6% ± 0.4%	7.1% ± 0.6%	17.9% ± 0.7%	7.8% ± 0.8%	15.3% ± 1.2%	38.0% ± 1.2%

Level 2 systems address many of the typical motorway situations

Beside the slow increase of the market penetration of such systems, the usage rate is one crucial factor that has a strong influence on the enhanced vehicle safety

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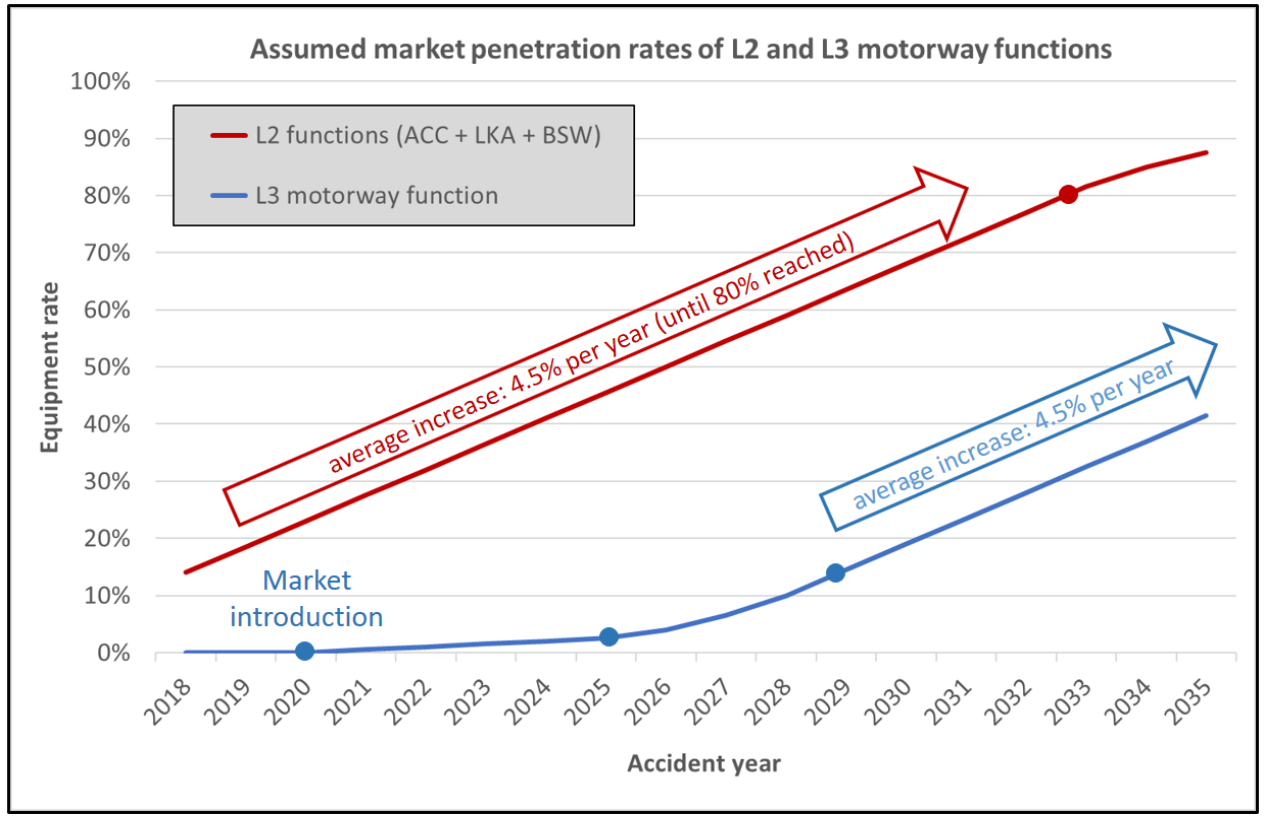
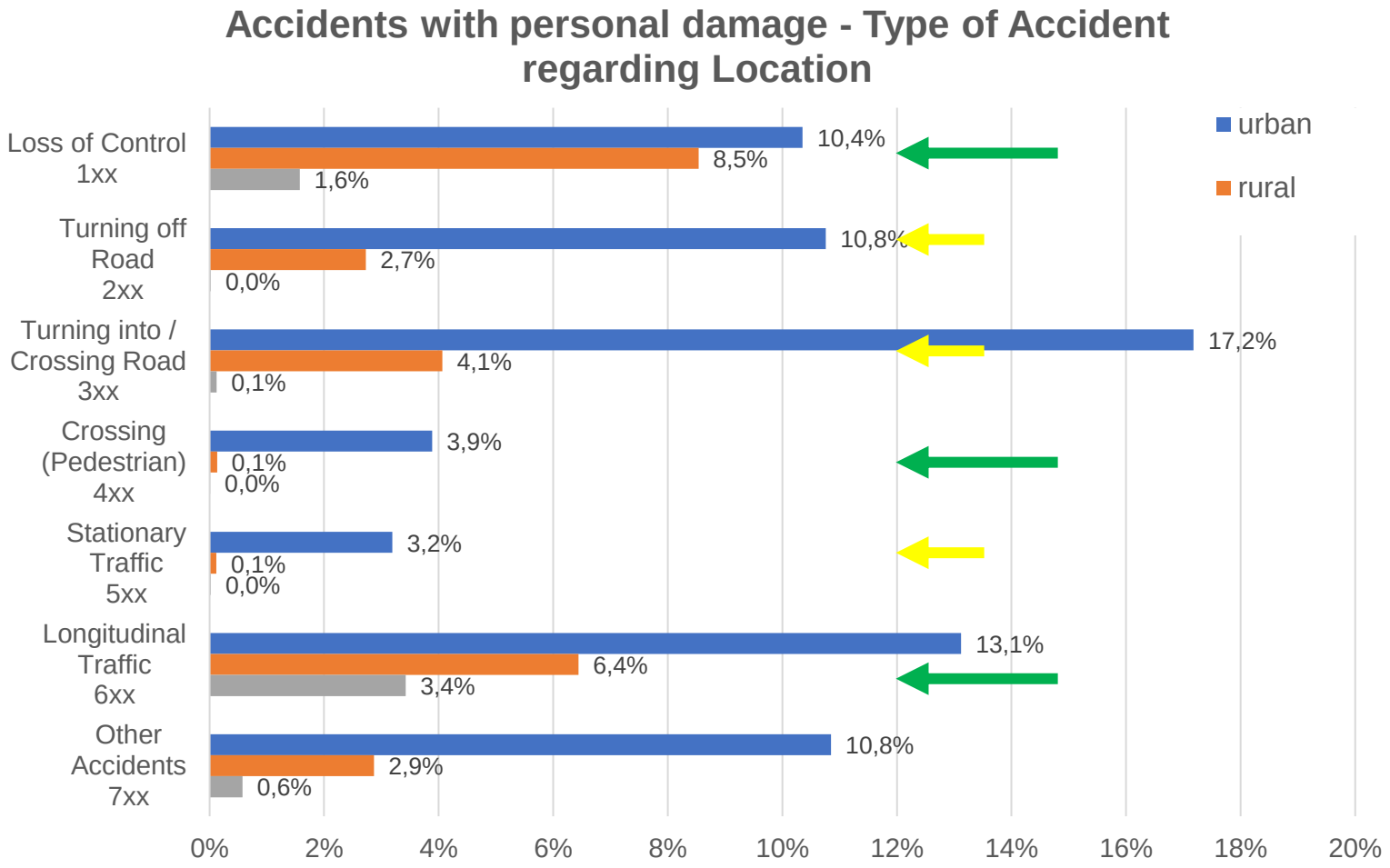
Level 2 and Level 3 vehicles



L2: 20%: 2020
50%: 2026

L3: 10%: 2028
20%: 2031
50%: 2037

- Optimistic market penetration scenario is assumed for the L3 motorway function.
  - market introduction phase (5 years with +0.5% /a)
  - penetration will steadily increase by +1% annually until 4.5%



Due to the market penetration rates, There will be a remaining accident scenario, maybe some „whitespots“.

The remaining accidents are very complex (turning, crossing).

Analyses have to be done for development of avoiding systems and safety functionalities.

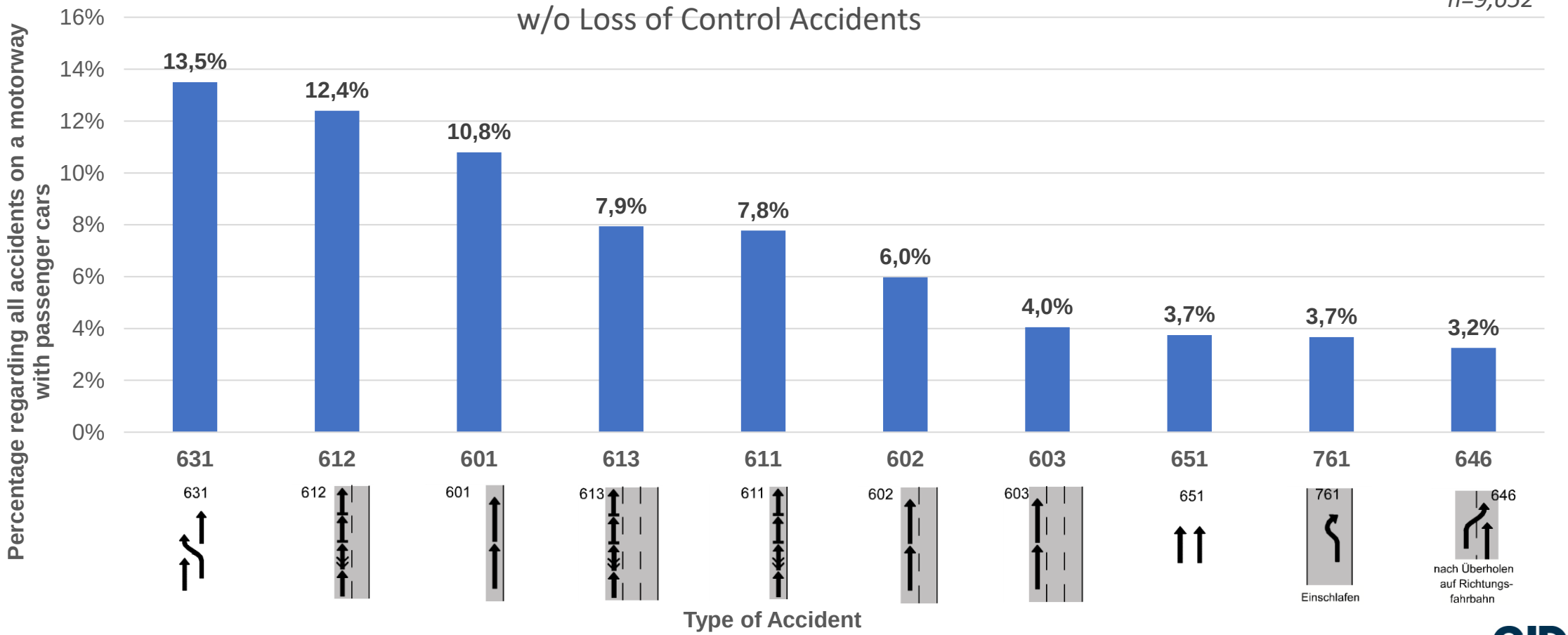
GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Source of data: Federal Bureau of Statistics (DESTATIS). Fachserie 8 Reihe 7 – Verkehrsunfälle 2017., Wiesbaden, Germany 2018.

Top 10 Types of Accidents - Motorway

w/o Loss of Control Accidents

n=9,652



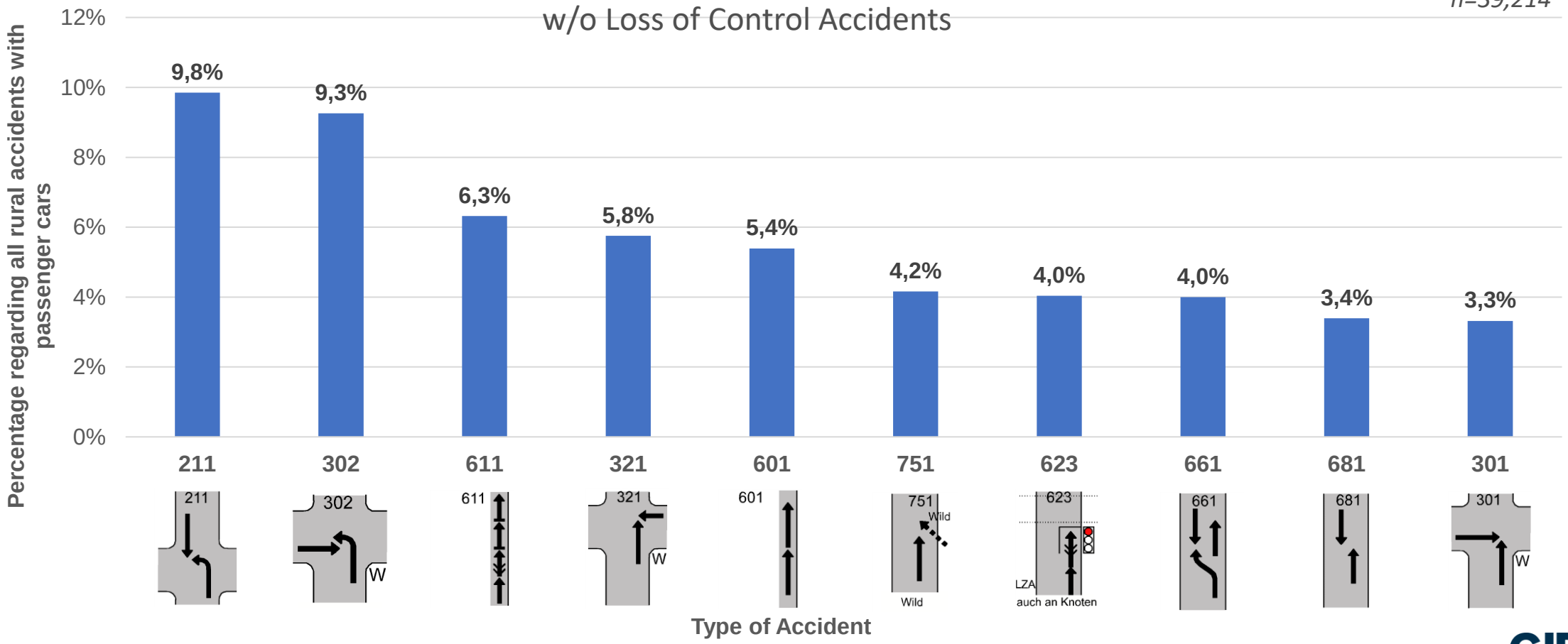
GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

Top 10 Types of Accidents - Rural

w/o Loss of Control Accidents

n=39,214



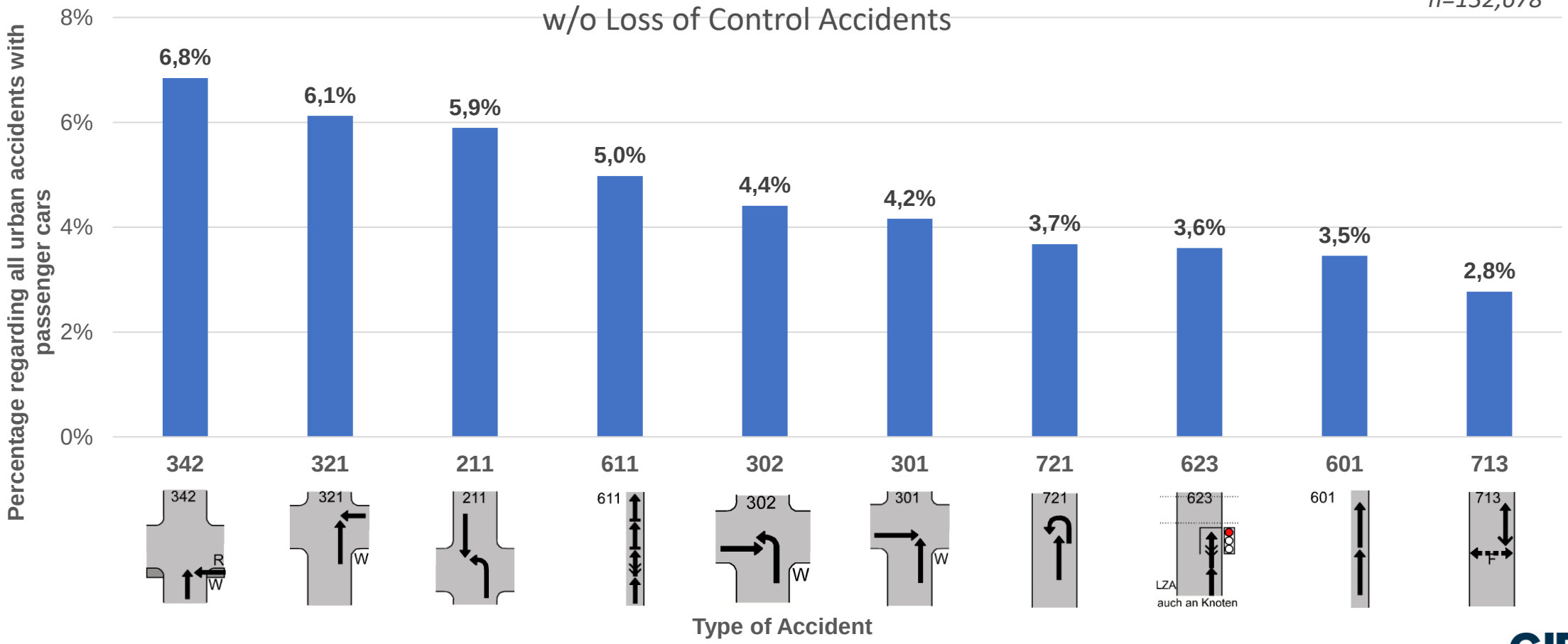
GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

Top 10 Types of Accidents - Urban

w/o Loss of Control Accidents

n=132,678



GIDAS GERMAN IN-DEPTH ACCIDENT STUDY

Data is weighted towards the German accident statistics 2020.

- For different locations → different types of accidents / scenarios are ‚relevant'
  - Urban: Mostly interactions between 2 (or even more) traffic participants, e.g. Crossing & Turning Scenarios → UTYP 3xx (5x in Top10), 6xx (3x in Top 10), 2xx (2x in Top 10)
  - Rural: Different Types as well, but especially Loss of Control Accidents (1xx, ranked first – 3rd, >35%)
  - Motorway: Often Loss of Control (1xx) & Longitudinal Traffic Accidents (6xx), but also Other Accidents (7xx) with sudden physical inabilities or technical damages

- Clustering of scenarios regarding different aspects possible or even single case analyses, depending on requirements of the research task
- Available toolchain:
  - Criticality metrics (Time To Collision TTC and Trajectory-based criticality)
  - Determination of the Point Of No Return PONR for almost all cases out of the GIDAS-PCM

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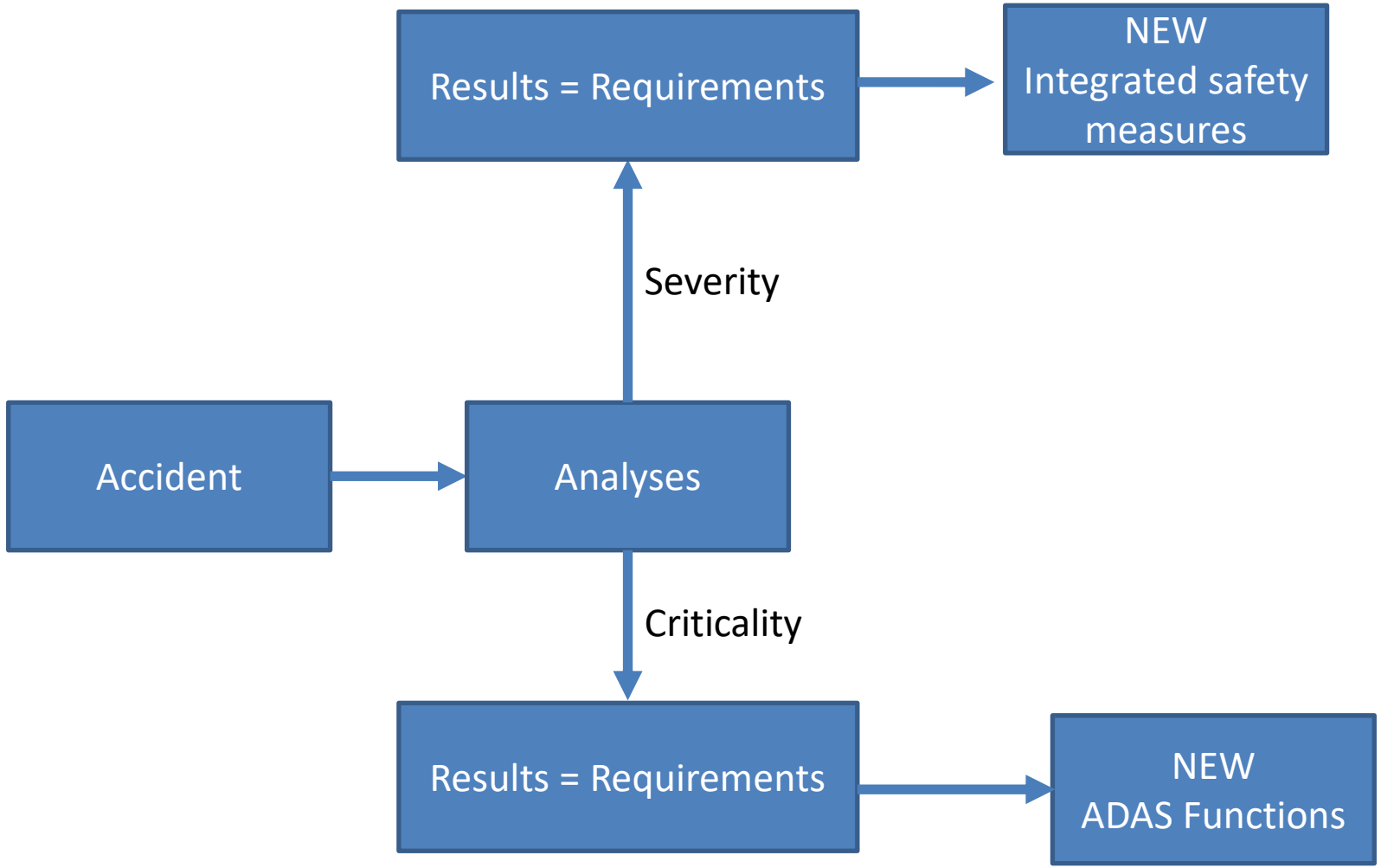
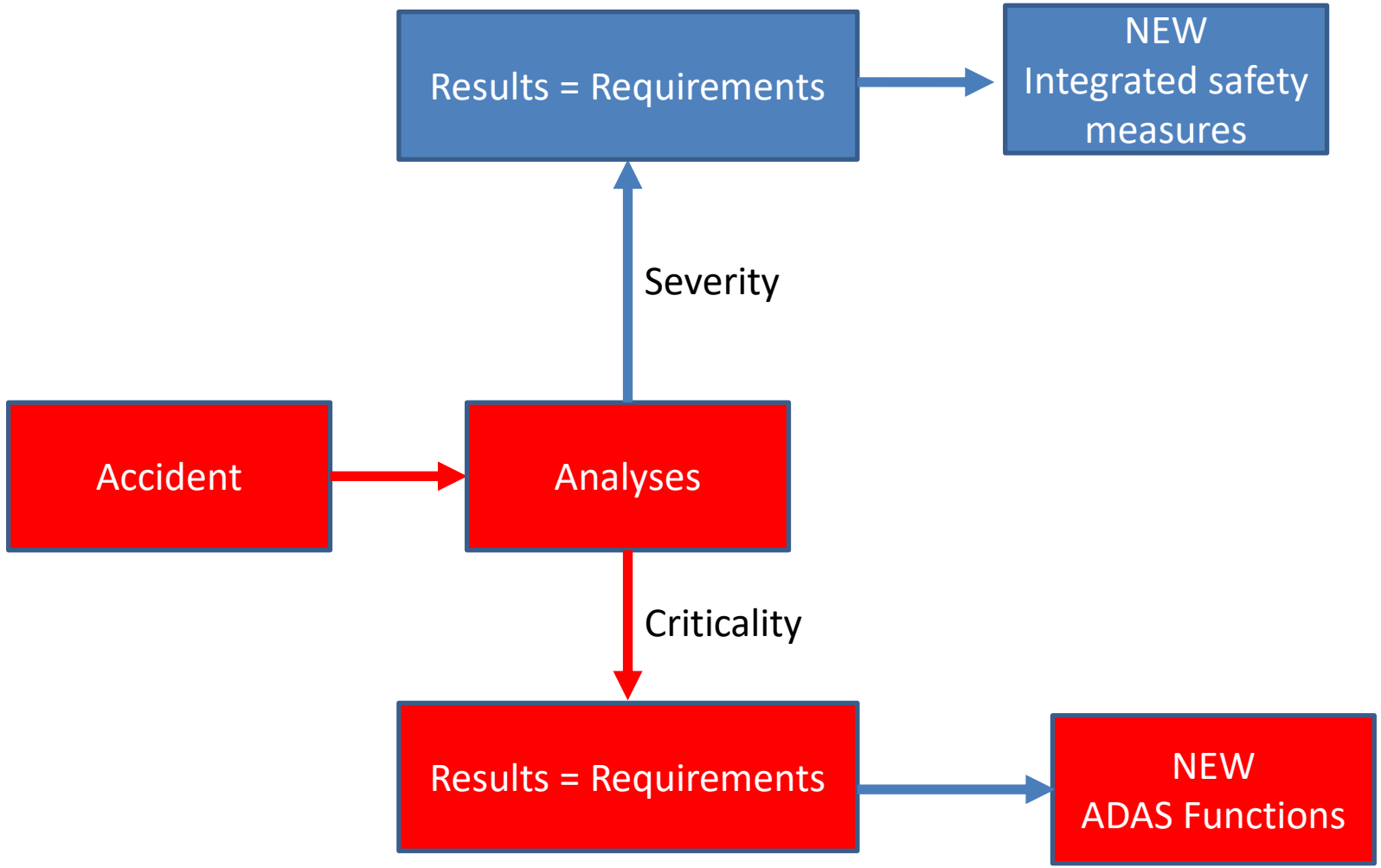
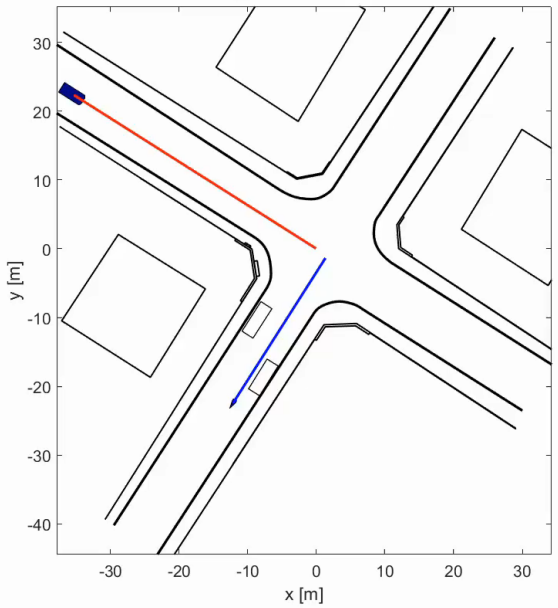
- Analyses of the Remaining accidents:
  - **Criticality analyses**
    - TTC (Time to Collision)
    - FSK (driving tube criticality)
    - PONR (Point of no return)
  - **Severity analyses**
    - Impact severity
    - Injury severity



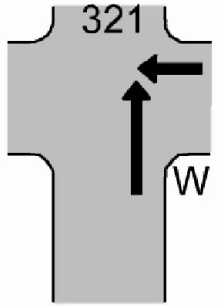


Methodik Kritikalitätsberechnung
Exemplarische Visualisierung eines GIDAS-PCM-Falles mit UTYP 321

Unfallskizze



Unfalltyp



Quelle: Gesamtverband der Deutschen Versicherungswirtschaft e.V.; Unfallforschung der Versicherer; Unfalltypen-Katalog, Stand: 08.01.2016

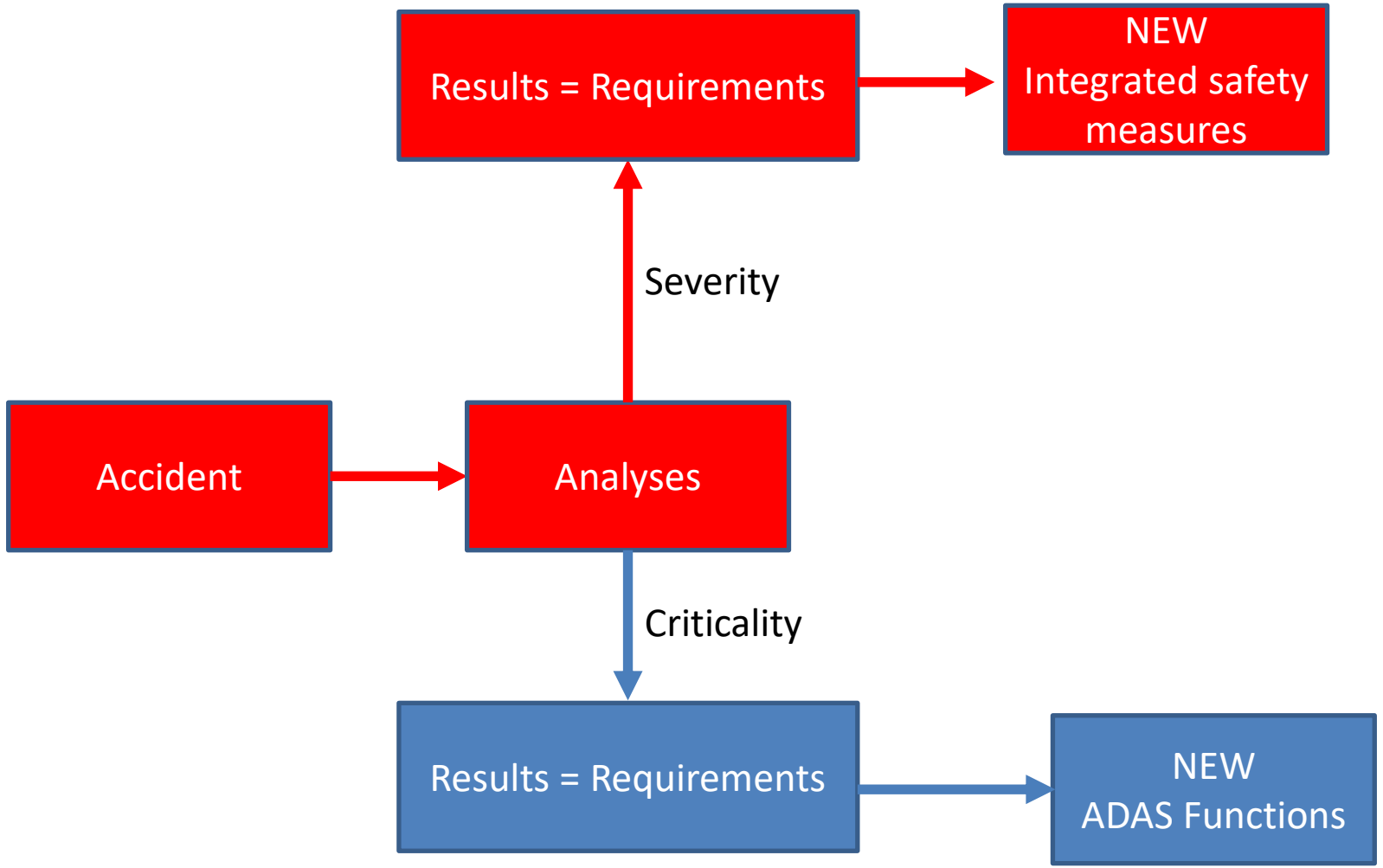
VUFO GmbH

Criticality tool chain:

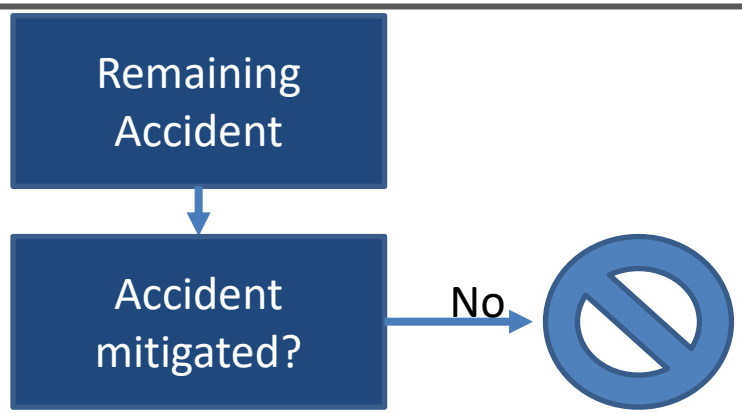
- **TTC calculation**
- **Trajectory based criticality**
- **Point Of No Return calculation**

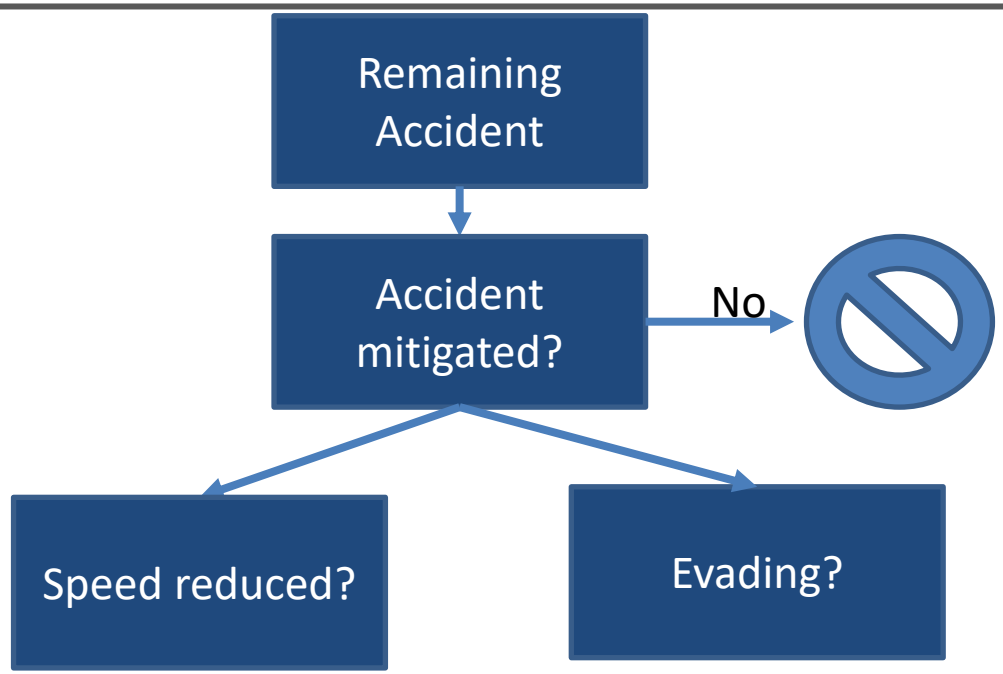
Development of new functions:

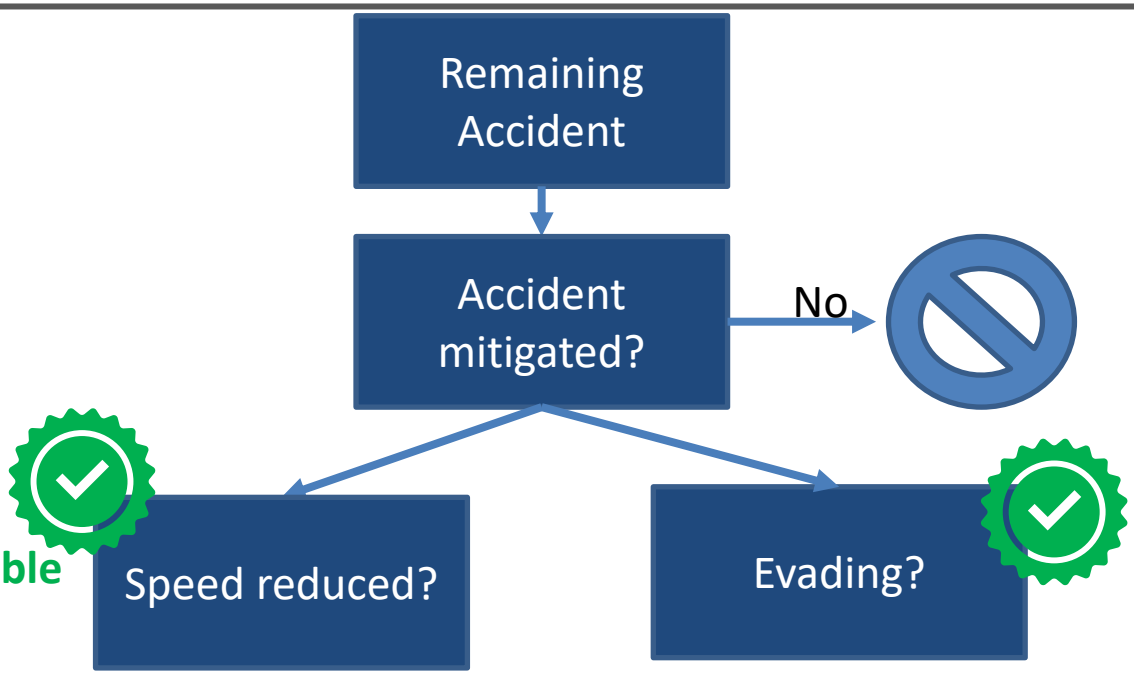
- **Possible to implement connective systems**
- **Counting of avoidable accidents**
- **Sensor field analyses**
- **System action analyses**
- **Avoidance strategy assessment**



Remaining Accident

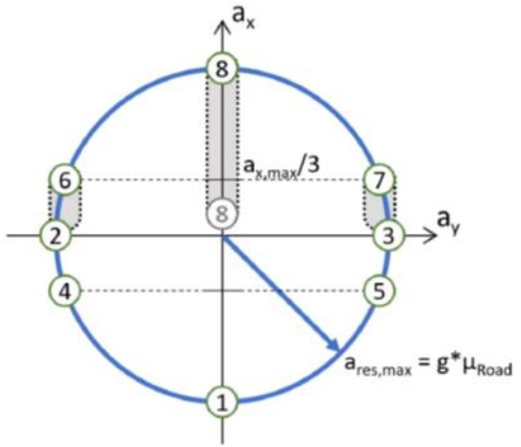


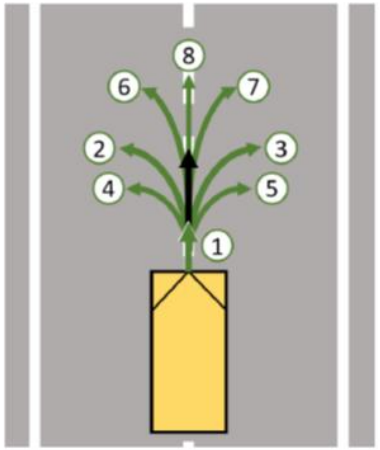


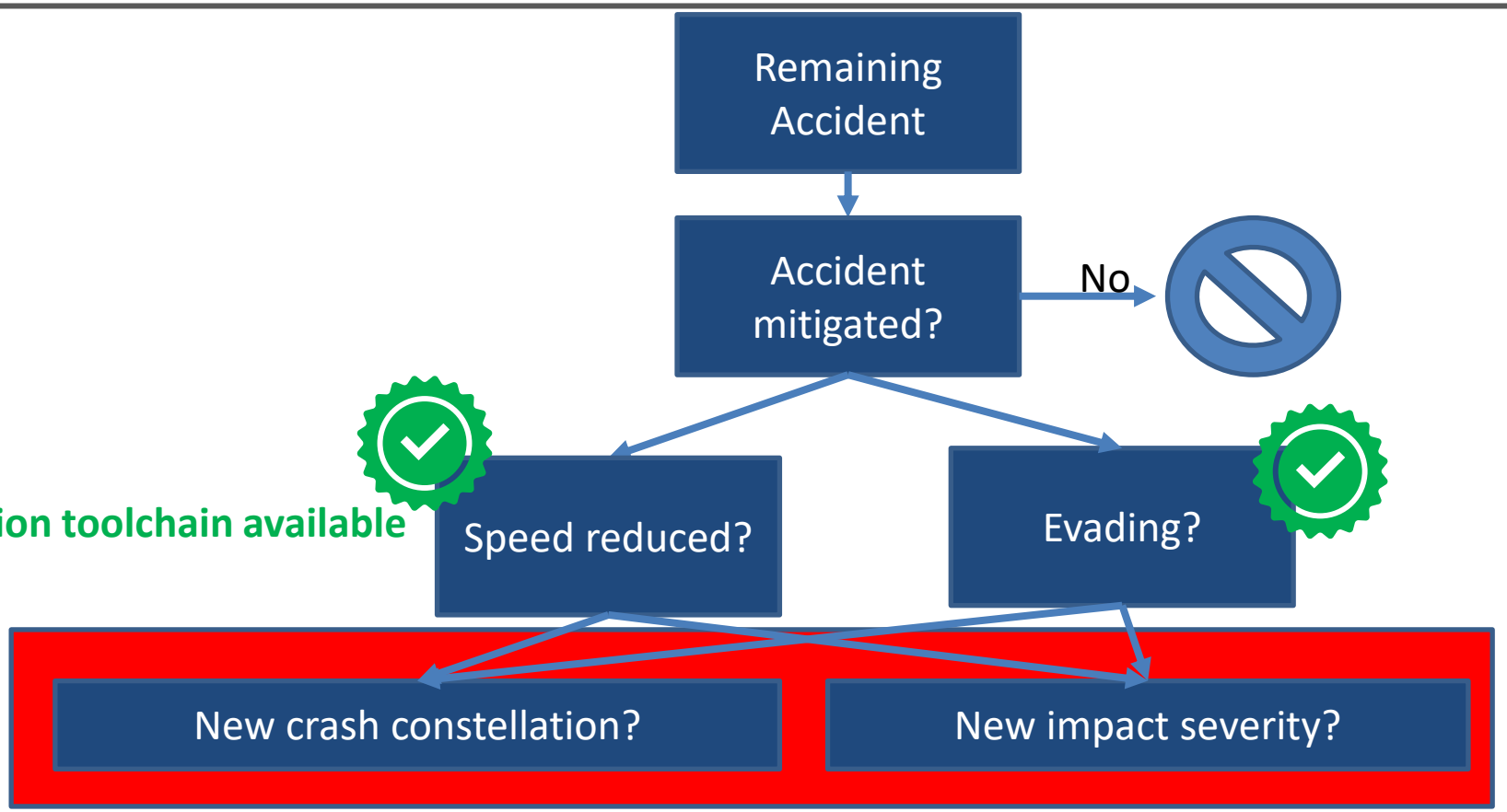


Evaluation toolchain available

Simulation-based Analyses



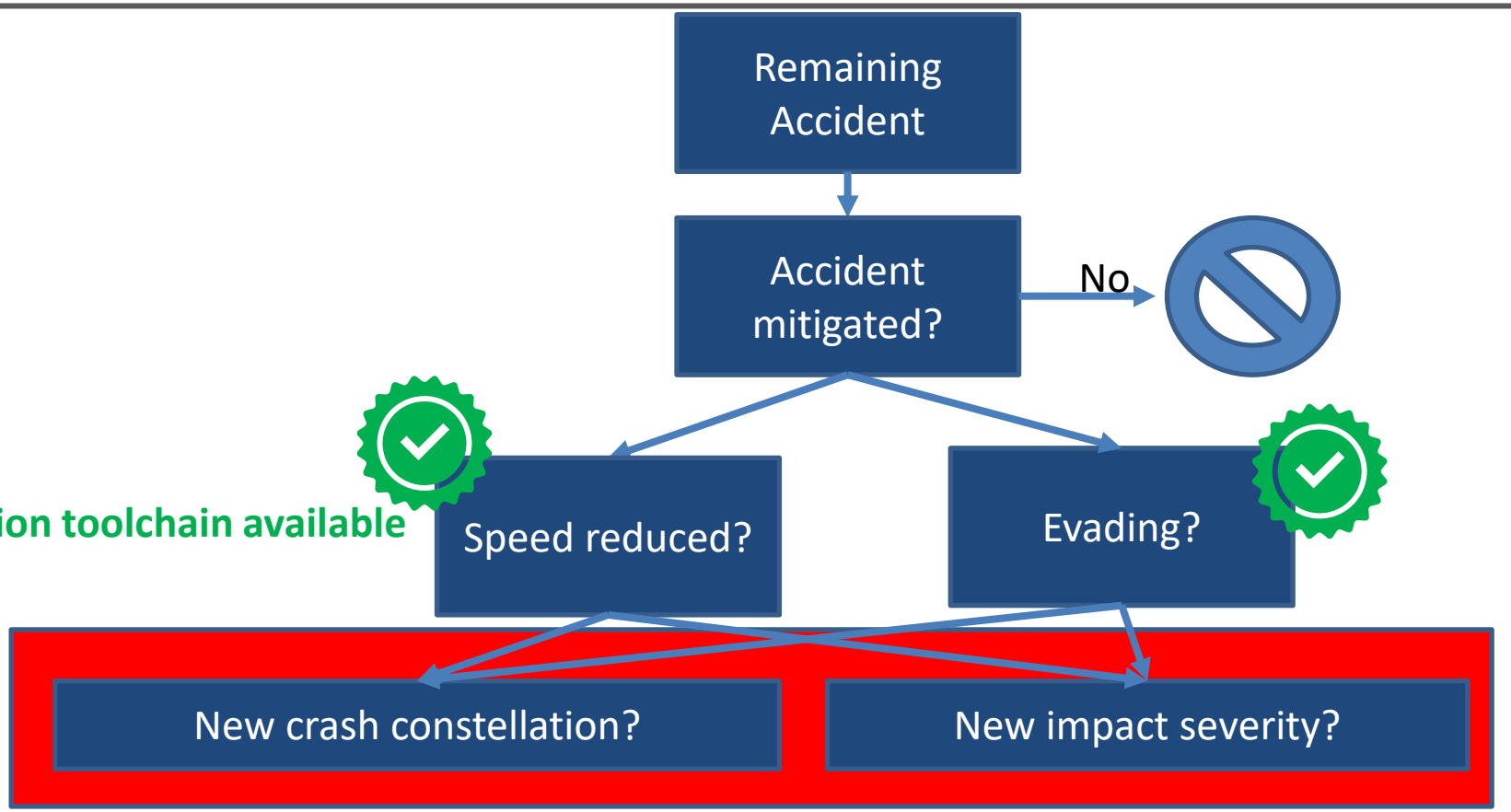




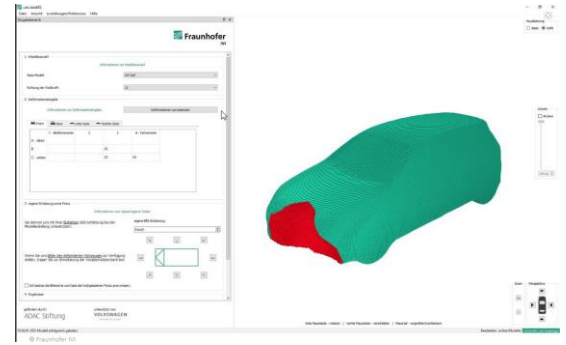
Evaluation toolchain available

Black spot in toolchain

- With first models, the accident severity can be estimated.
  - **Estimation of the accident constellation (CrashConstellationPredictionSystem - CCoPS)**
  - EES-Analyses resp. estimations
  - Estimation of Delta-V
  - Iterative calculation → Injury risk functions with different input parameters
    - calculation model is available

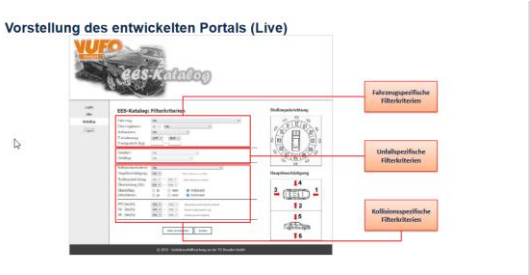


Evaluation toolchain available



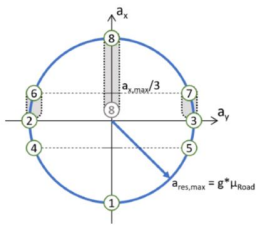
IVI Calculate EES [1]

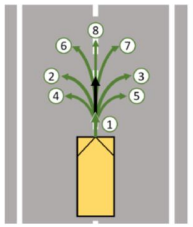
Several approaches



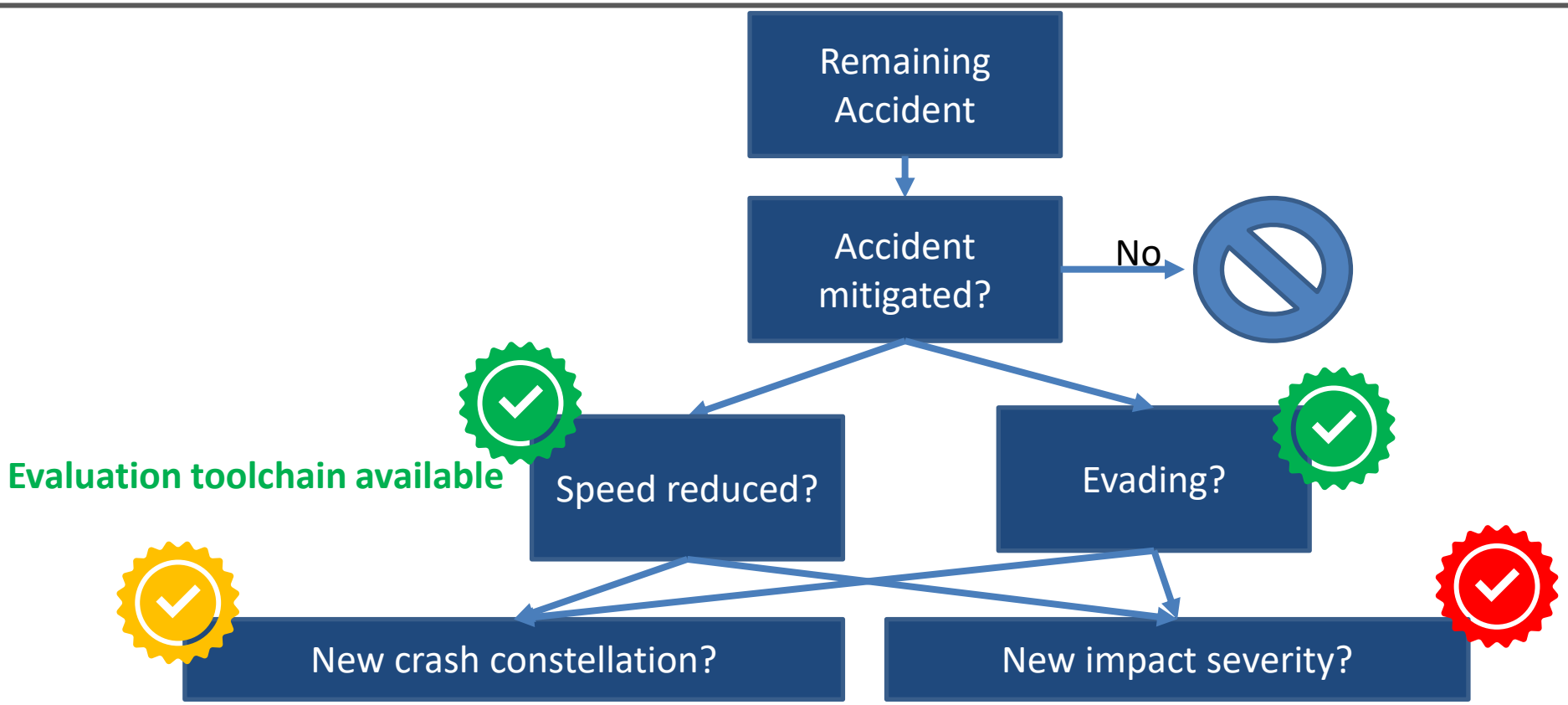
VUFO GIDAS based EES Analyses

Crash Constellation Prediction System (CCoPS)

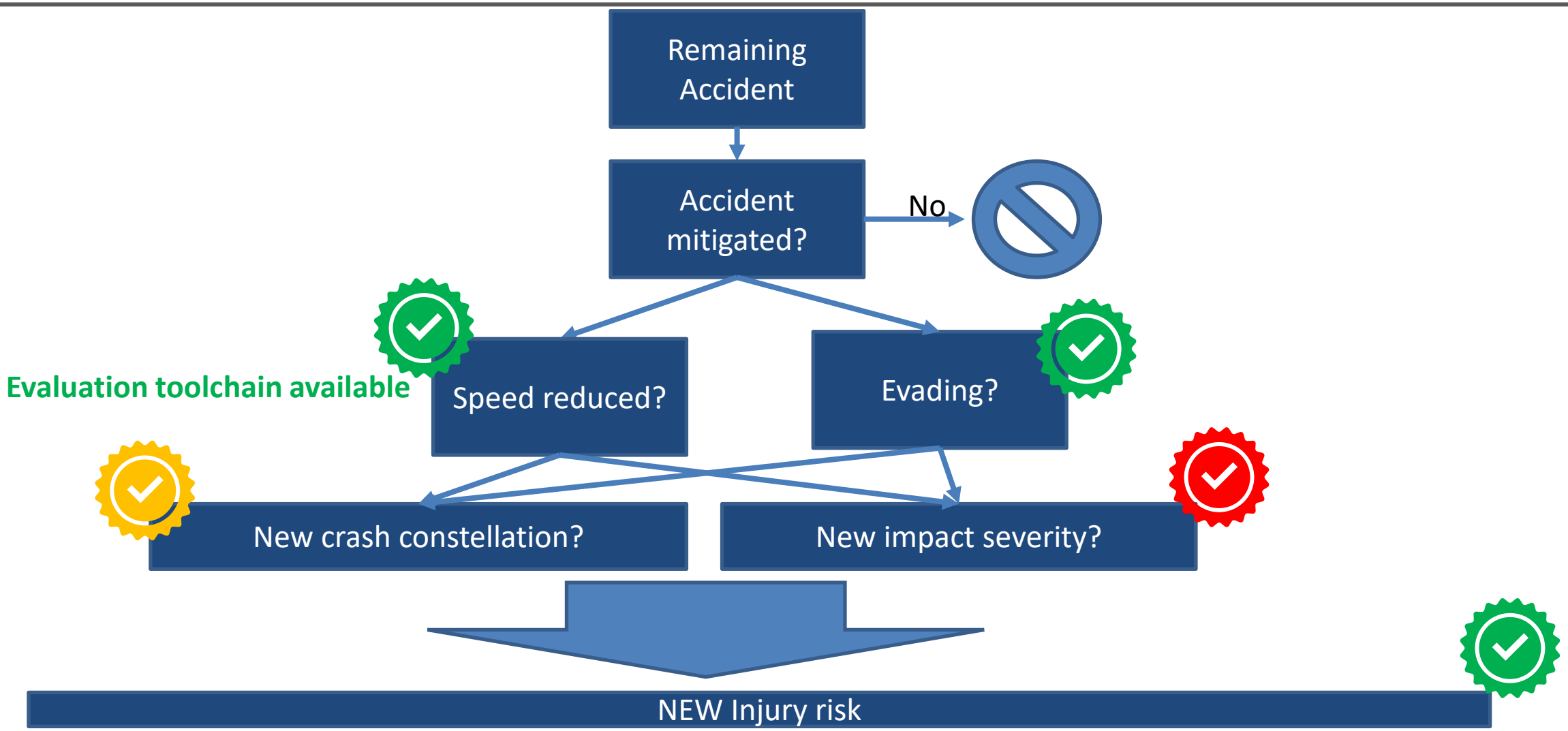




[1] https://www.ivi.fraunhofer.de/de/forschungsfelder/fahrzeug-und-antriebstechnik/fahrzeug-und-verkehrssicherheit/unfallsimulation/calculateees---eine-objektive-schaetzung.html
[2] https://www.vufo.de/wp-content/uploads/2021/12/Praesentation_EES.pdf



Evaluation toolchain available



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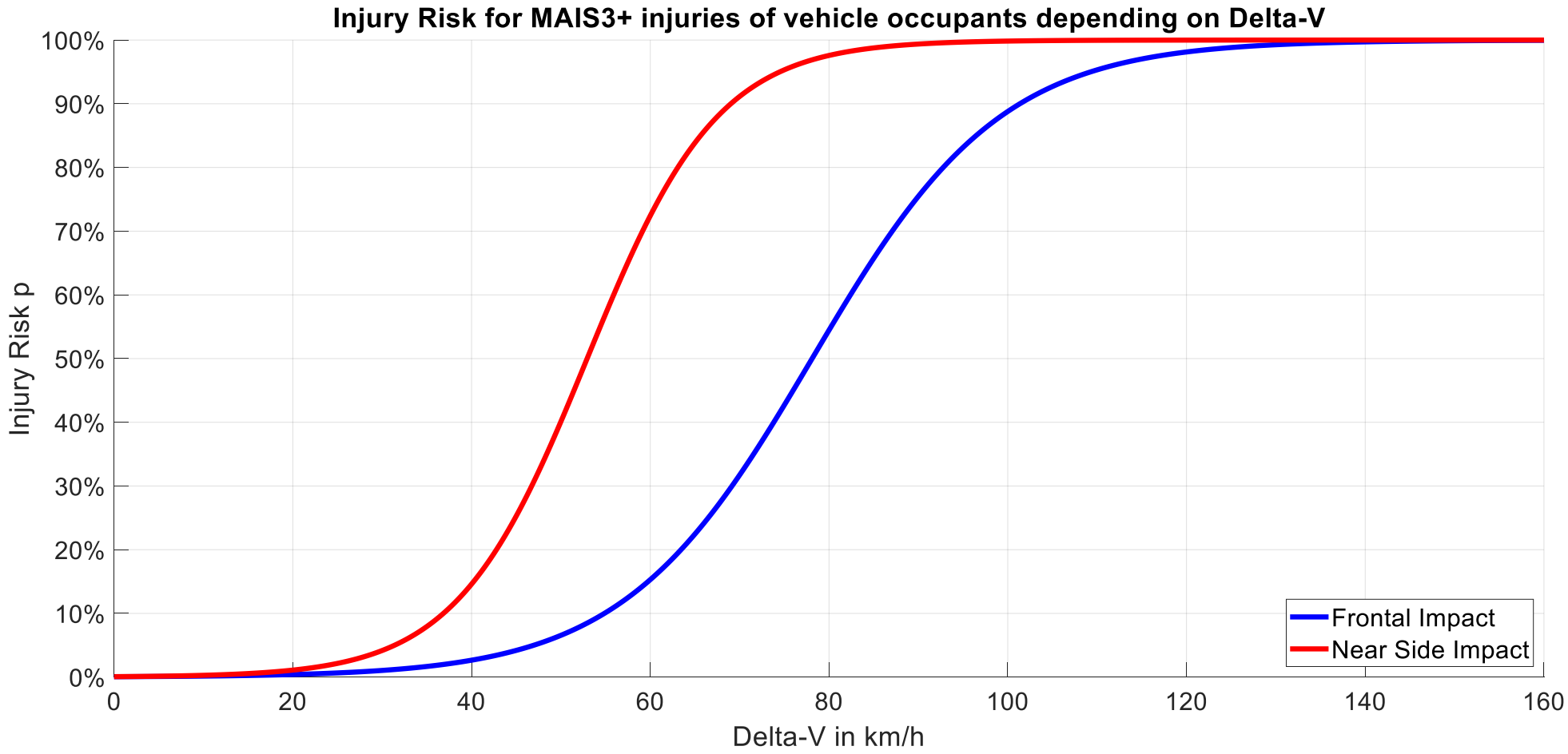
Injury Risk Function

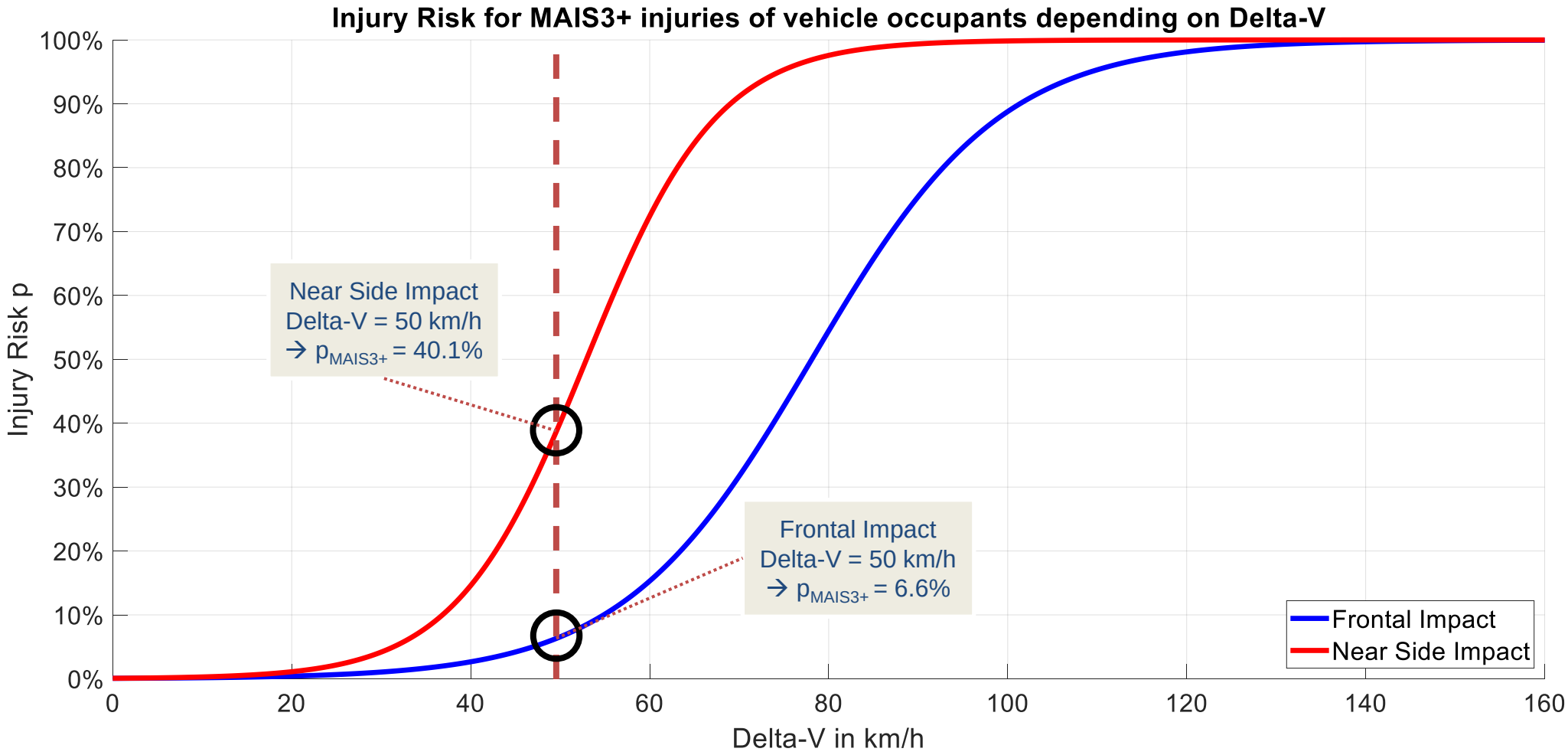
- Exemplary, an injury risk function considering following parameters was created:
  - Delta-V
  - Usage of Seatbelt
  - Crash weight (of the own vehicle)
  - Age group of the occupant (child / adult / elderly)

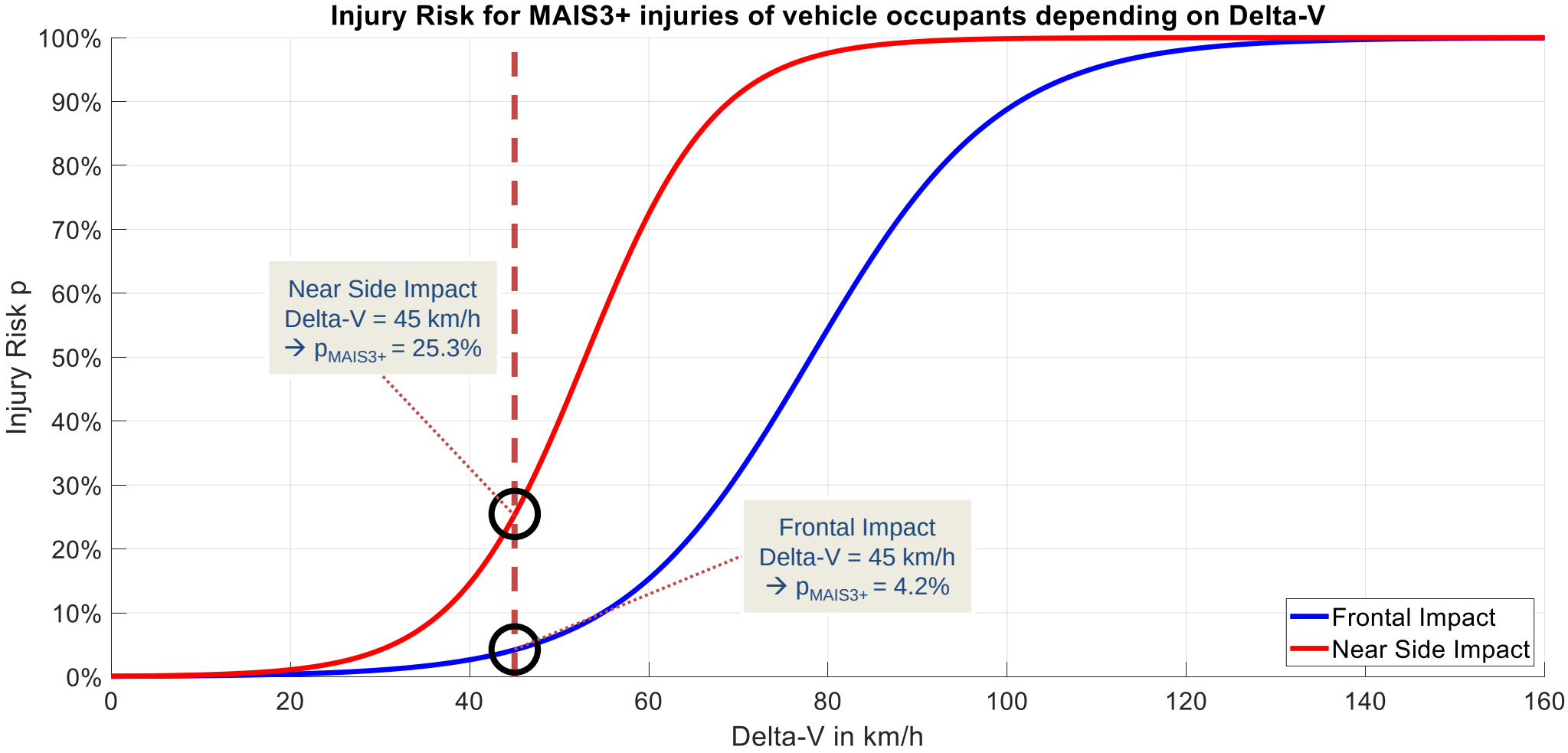
- The injury risk functions were grouped for different impact directions, here:
  - Frontal impact
  - Near side impact

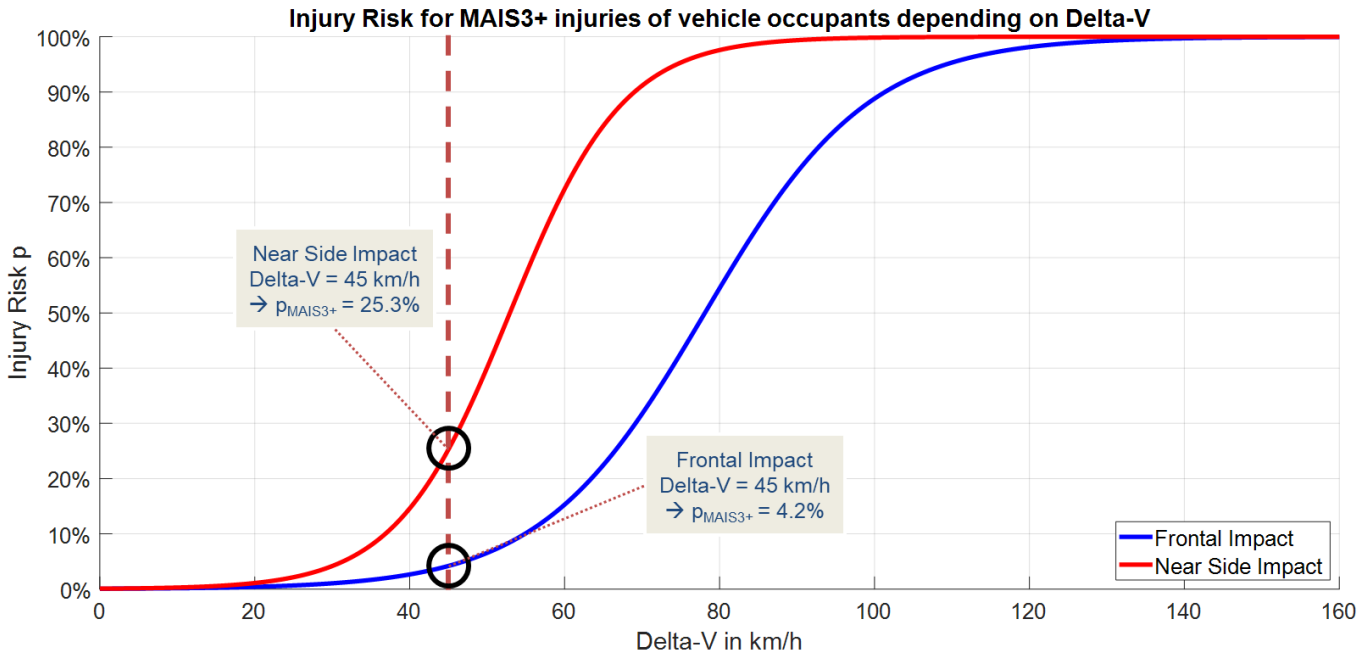
- The parameters ‚crash weight‘, ‚usage of seatbelt‘ and ‚age group‘ cannot be varied and are therefore determined as follows:
  - Sealtbelt fastened
  - Crash weight = 1,500 kg
  - Age group: Adult

- Delta-V and the impact direction can be influenced → Challenge: Identify the „Best Case“ (lowest injury risk)









- Delta-V and the impact direction can be influenced → Challenge: Identify the „Best Case“ (lowest injury risk)
- In general, a reduction of Delta-V is desired to reduce the injury risk.
- Like the figures showed, a frontal impact is preferable to a side impact (at least for near side impacts).

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Conclusion

- In a previous publication by VUFO, the potential of accident avoidance for different types of accidents on motorways has already been investigated [1].
- It is important to distinguish between the vehicles who caused the accident and other participants involved.
- This leads (or would lead) to a shift in the ranking of the types of accidents, depending on the rate of market penetration.
- Not all traffic accidents can be addressed with current assistance systems, especially not with Level 2 and 3.
- However, the remaining accidents provides indications for upcoming spots in the field of traffic accidents.

[1] Unger, T; Liers, H: Prediction of the expected accident scenario of future Level 2 and Level 3 cars on German motorways; IRCOBI 2019

- **Important:** Integral safety systems are still necessary in L2/L3
- Analyses of the remaining accidents needed
- **Black box:** accident severity estimation
  - many parameters which influence the injury/accident severity
  - some of them can be varied, some cannot.
  - Variable: EES, Delta-V or the impact direction
  - Fixed: Age of the person, weight of the vehicle or even the (non-) usage of the seatbelts
- With the „new“ or remaining constellations / crash parameters the injury severity can be predicted (IRF)
- Depending on the new parameters the risk of being sdeverely injured could be decresing/increasing