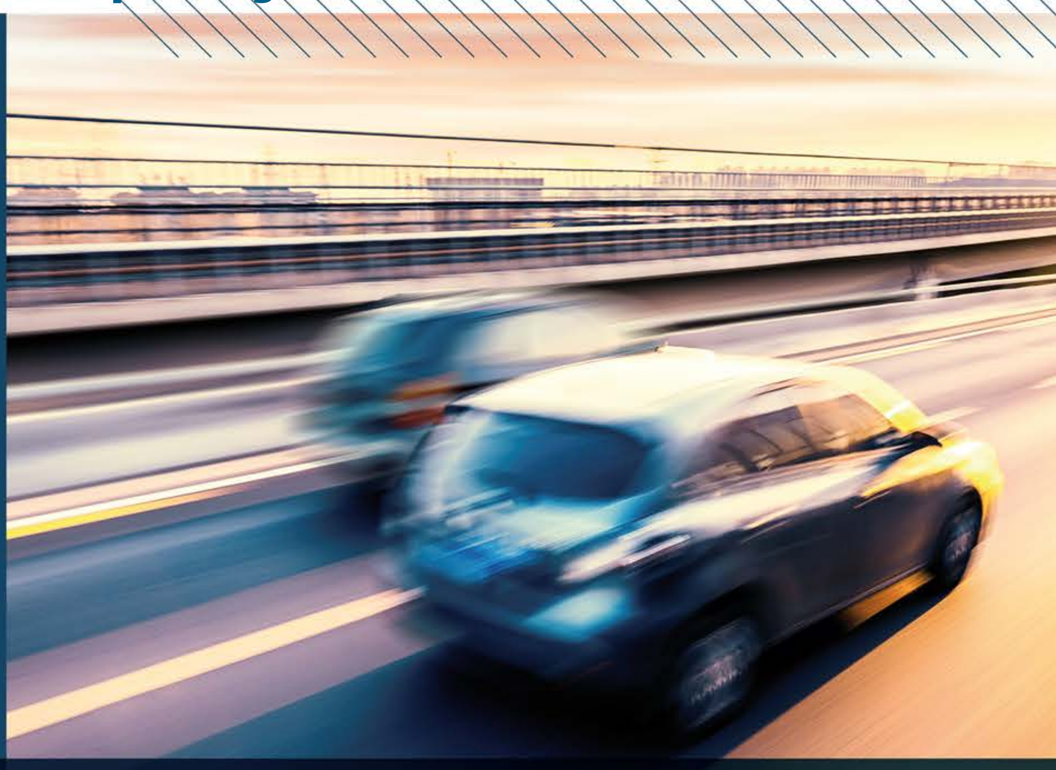
www.pegasusprojekt.de



Requirements & Conditions - Stand 5

CRITICAL SCENARIOS FOR HUMAN DRIVERS

PEGASUS

Human performance in critical scenarios.

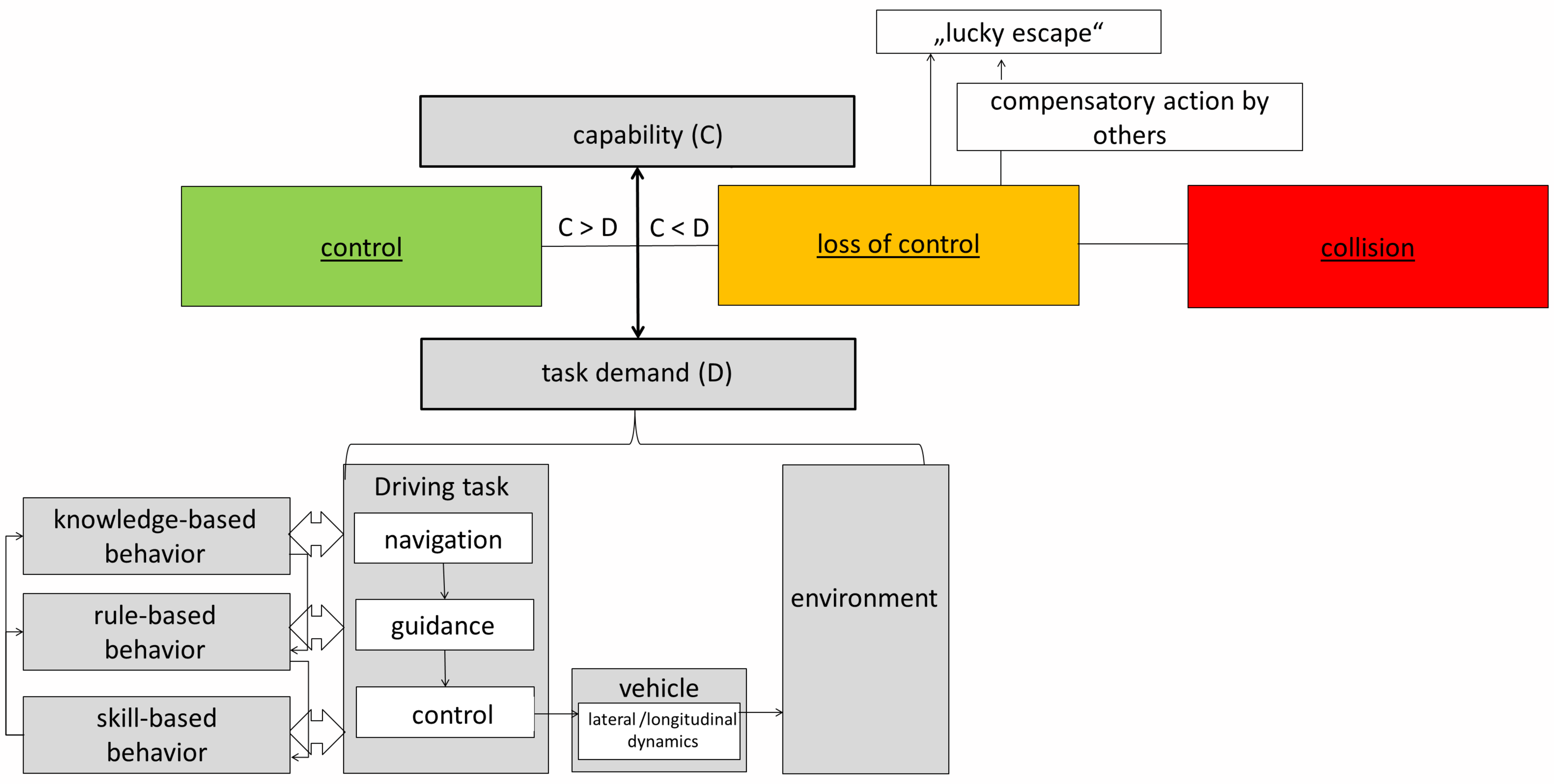
How well do drivers perform in safety critical scenarios?

Why is human performance relevant ~~for~~ PEGASUS?

- Human performance can serve as a benchmark for the performance of highly automated cars, because human drivers appear to perform well - they have a low crash risk [1, 2]. Aim of this work is to identify scenarios critical for human drivers and asses their performance.

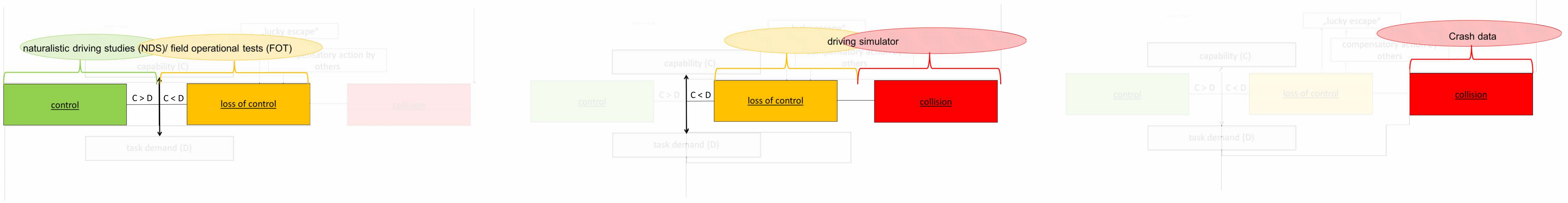
How is human performance defined in PEGASUS?

- Human performance is a product of drivers' capabilites and the task demand of the driving scenario [3].
- In critical scenarios, drivers have to control their car to prevent crashes (i.e., by accelerating, decelerating, steering) [4]. Here, drivers show mainly skill-based behavior, their control actions directly influence the safety of the scenario [5].



Picture 1: Model of human performance in PEGASUS based on the task-capability-interface model [3], three-level hierarchy of the driving task [4] and levels of human performance [5].

How is human performance observed and analyzed in PEGASUS?



Picture 2: In NDS/FOT scenarios, drivers maintain control or lose it, but no crashes occur (left). Very critical scenarios can rarely be found in NDS/FOT. Here, the driving simulator can be used to study human performance in these very critical scenarios finding thresholds of human performance (middle). Crash data contains information about crash scenarios. Here human performance was mainly affected by so-called human factors such as distraction (right).

[1] Statistisches Bundesamt (2013). *Verkehr aktuell - Stand 01.11.2013*. Fachserie 8 Reihe 1.1 -10/2013.
[2] Statistisches Bundesamt (2010*). Unfallstatistik – Verkehrsmittel im Risikovergleich*.
[3] Fuller, R. (2005). Towards a general theory of driver behaviour. *Accident Analysis & Prevention, 37*(3), 461-472.
[4] Donges, E. (1999). A conceptual framework for active safety in road traffic. *Vehicle System Dynamics, 32*(2-3), 113-128.
[5] Rasmussen, J. (1983). Skills, rules, and knowledge; signals, signs, and symbols, and other distinctions in human performance models. *IEEE transactions on systems, man, and cybernetics*, (3), 257-266.
[6] Preuk, K. & Schießl, C. (2017). Menschliche Leistungsfähigkeit als Gütekriterium für die Zulassung automatisierter Fahrzeuge: Methode zur Ermittlung der Grenzen menschlicher Leistungsfähigkeit. 9. VDI-Tagung: Fahrer im 21. Jahrhundert, Braunschweig, Deutschland.

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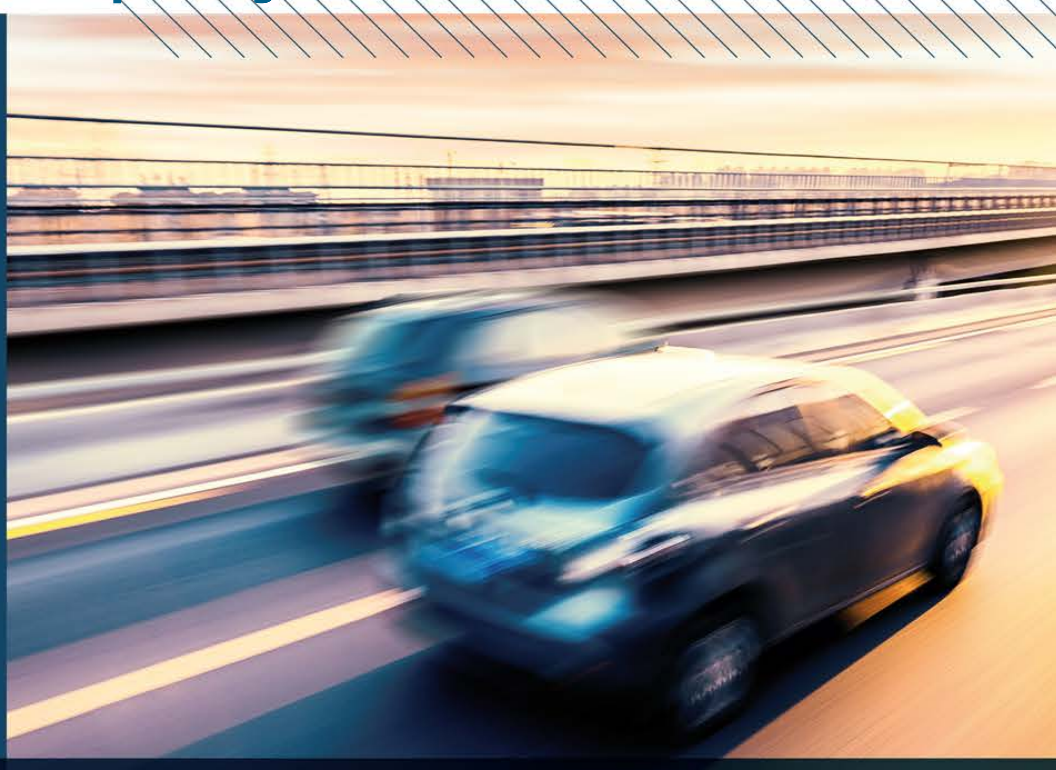
Requirements & Conditions - Stand 5

CRITICAL SCENARIOS FOR HUMAN DRIVERS



PEGASUS

Critical cut-in maneuver.

Analysis of human driver's response to cut-in maneuvers.

Relationship between human performance and the criticality of sudden cut-in maneuvers that drivers have to react to: up to a time-to-collision (TTC) of 8 s of sudden cut-in maneuvers, a relationship between the strongest deceleration and the criticality of the cut-in maneuver can be found: The more critical the scenario (low TTC between ego-vehicle and cut-in vehicle), the earlier and the heavier do drivers decelerate (Figure 1 left, middle). The most critical lane changer occurred with a TTC of 1.7 s.

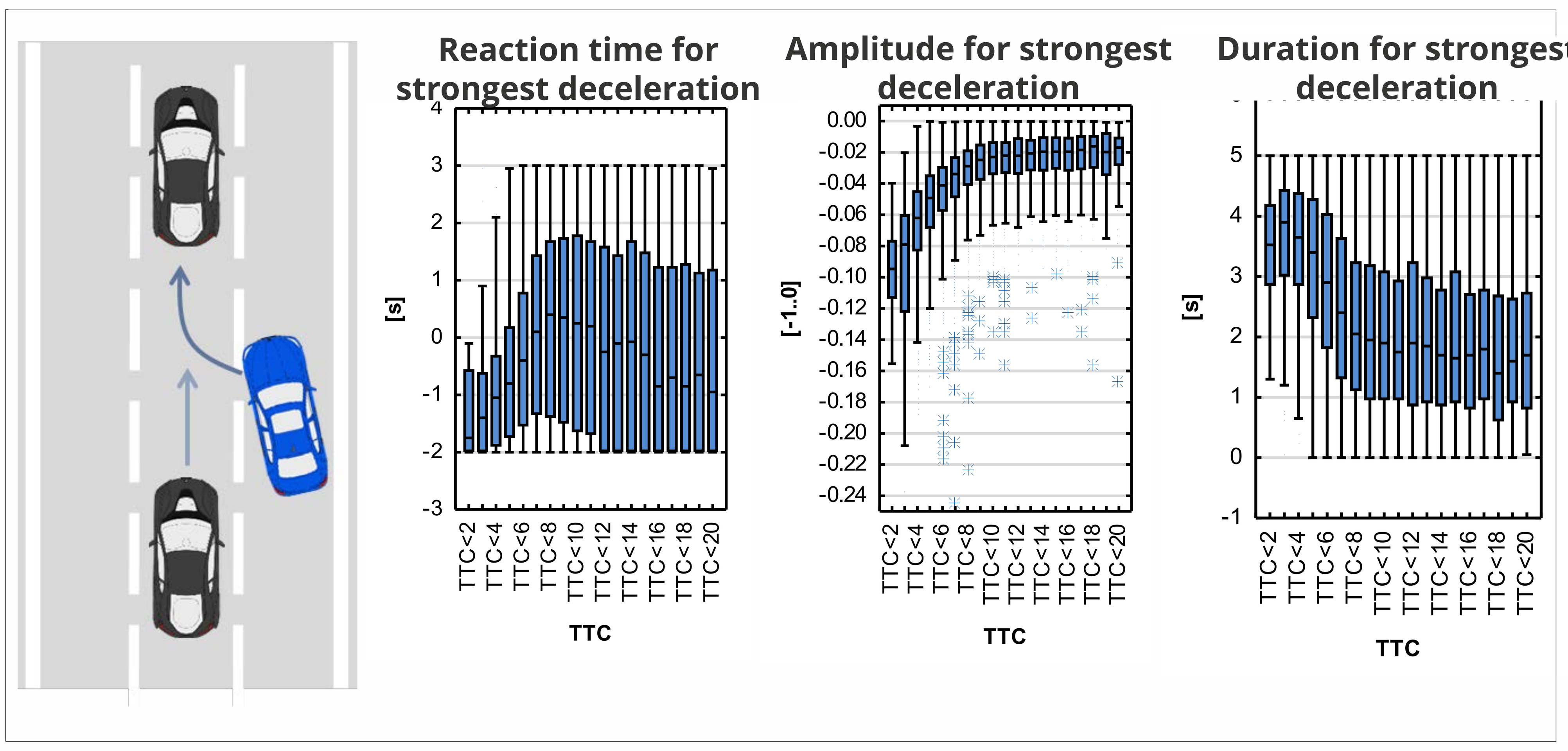
A driver reaction is observable even before the cut- in maneuver can be detected by the ACC sensors, resulting in negative reaction times. A significant dependency to the amplitude of braking can be seen in Figure 1, middle.

Moreover, the more critical the scenario (low TTC), the longer do drivers apply the brake pedal (Figure 1, right), although there is quite a high variance in this driving behavior.

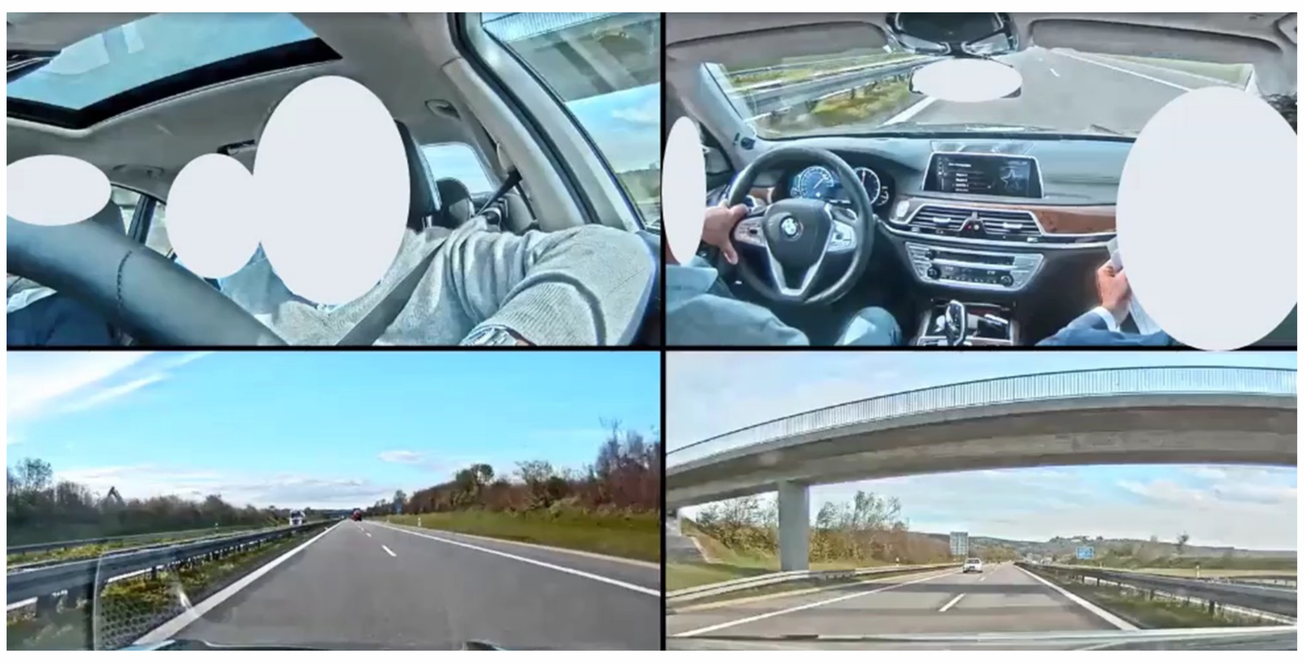
Analysis of critical situations, their characteristics and human behavior with the help of Field Operational Tests and Naturalistic Driving Studies.

Identification of exposure of different scenarios and maneuvers (cut-in, highway entrance and exit, reaction to sudden traffic jams) and description of their characteristics based on measured data

HUMAN PERFORMANCE
HOW DO DRIVER REACT TO CUT-IN MANEUVERS?



[Figure 1] Distribution of reaction times (left), amplitude (middle) and duration of deceleration (negative = gas pedal release) for different categories of TTC.



Exemplary video recordings of critical scenarios.

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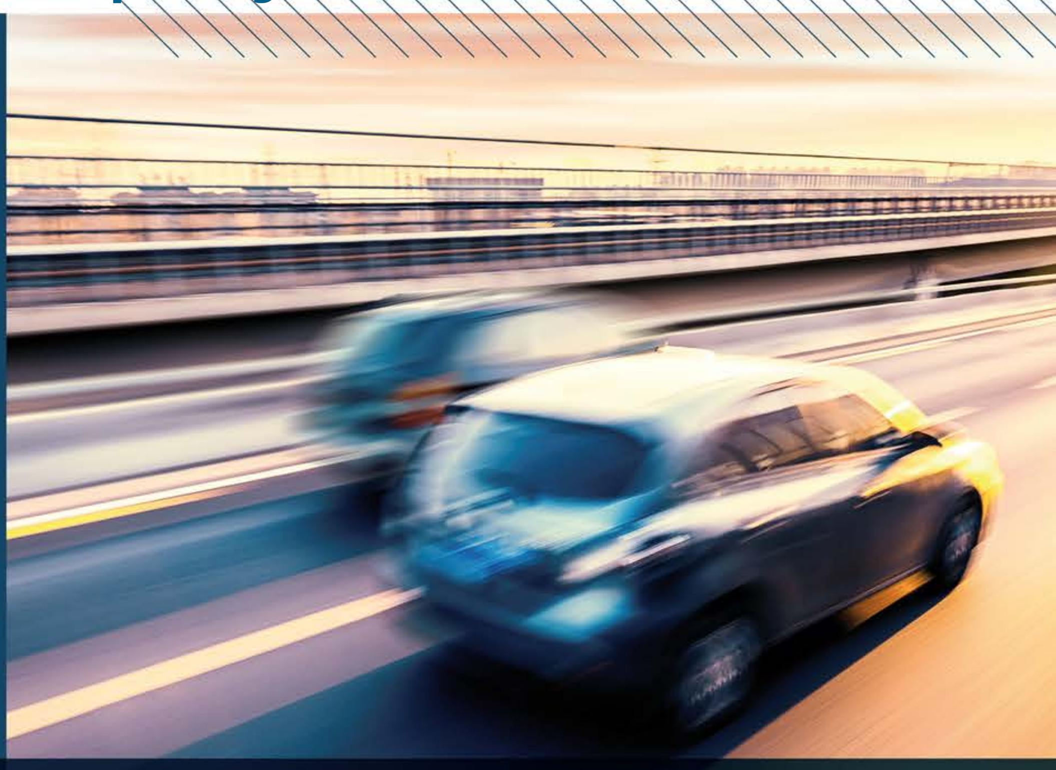


Requirements & Conditions - Stand 5

CRITICAL SCENARIOS FOR HUMAN DRIVERS

PEGASUS

German In-Depth Accident Study (GIDAS)

Regarding GIDAS, What is the field effectiveness?
How many accidents are caused by “Human Factors“?

GIDAS
GERMAN IN-DEPTH ACCIDENT STUDY
31.12.2016

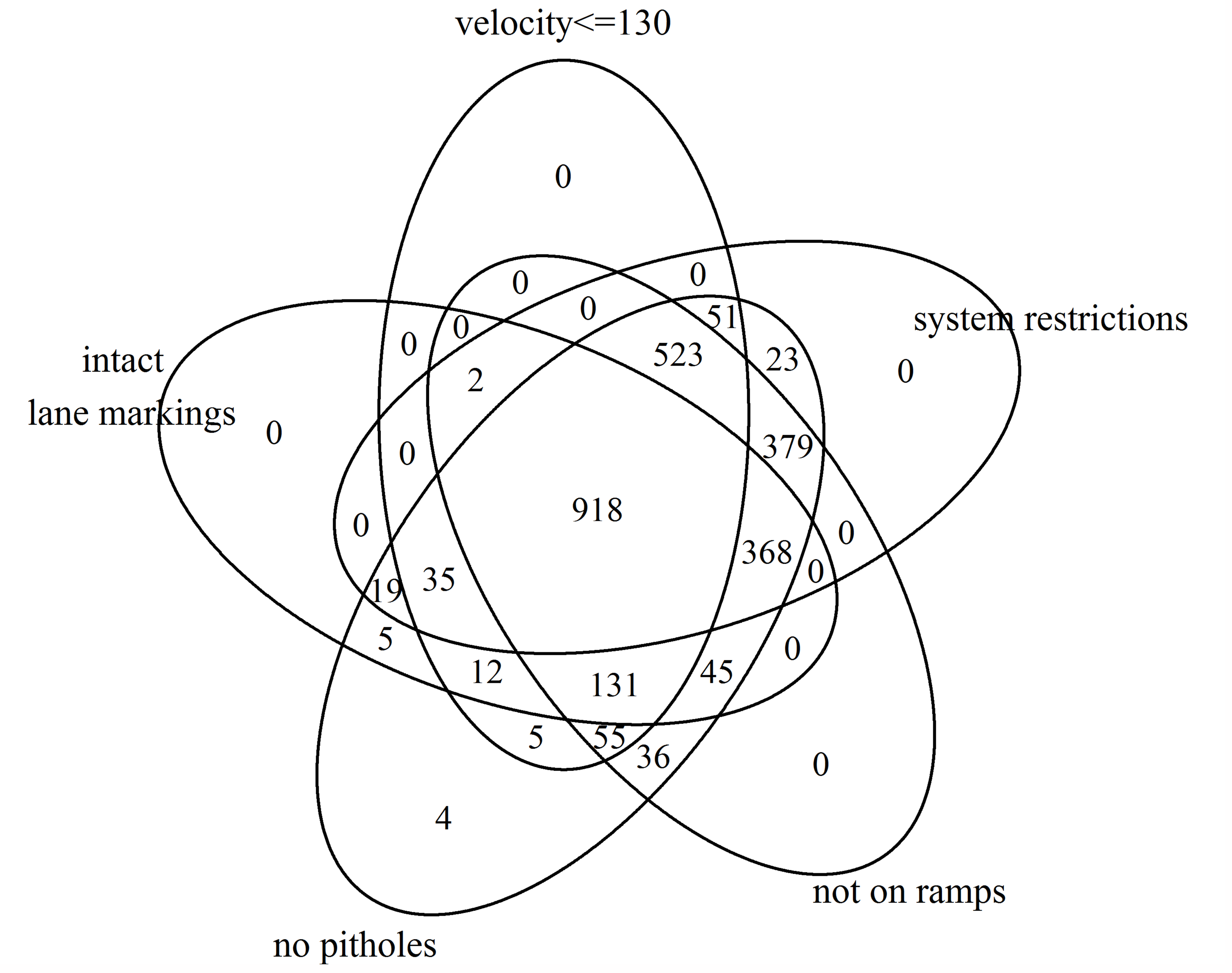
- ~29 400 accidents
- ~55 700 participants
- ~73 000 individuals
- ~33 000 cars with occupants and without trailer
- ~2 600 of them occurred on motorways or motorway-style roads.

Additional to domain restrictions (cars without trailer on motorways and motorway-style roads) five main filter are applied

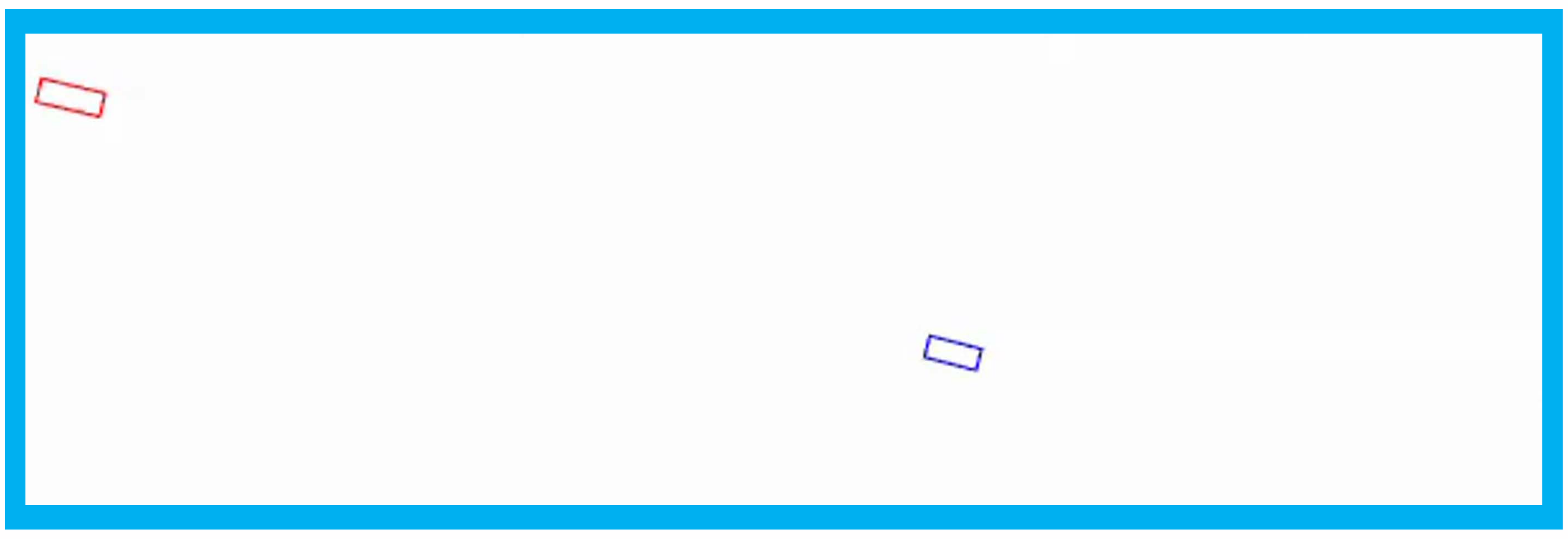
1. The velocity before reaction of the driver was less or equal 130 km/h
2. The lane markings are existend and in good condition
3. The road has no potholes (as cause of the accident)
4. The cars is not driving on a ramp
5. Further system restrictions like the influence of weather

Further investigations of the accident data are planned

- Automated clustering and assignment to logical scenarions
- Identification of “Human Factors“ in the accident scene to identify which accidents are caused by “Human Factors“. That can be used to find the accidents which are related to and possibly influenced by the human efficiency



Field efficiency of the “Autbahnchauffeur“ in the GIDAS sample. 918 cars fulfill all requirements, i.e. the “Autobahnchauffeur“ could have an influence. This corresponds to 2,8% of all cars in GIDAS and 35,2% all cars on motorways. It can be seen, that an advanced system which does not require intact lane markings and functions with greater velocities could double the field efficiency. An development to 160 km/h and advanced detection of lane markings results in 1734 cars, i.e. 5,3% of all cars and 66,4% of all cars on motorways, respectively.



Two examples in the GIDAS sample of cars veer into the lane of the other resulting in different constellations. Both participants are cars. The red party can be under the influence of the „Autobahncauffeur“ and, therefore, it could be equiped with this function and activated in this scenario.
Above: The overtaken party drives into the side of the other car.
Below: The overtaken party is driven into the side by the other car.
Rear-end collisions are also possible in this scenario, but not pictured here.

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