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BASICS FOR TESTING - Booth No. 15

SCENARIO DATABASE

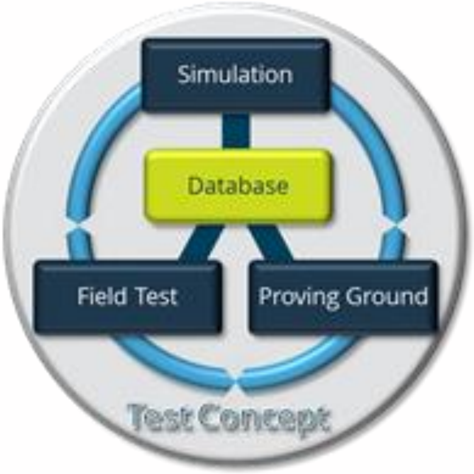
PEGASUS

PEGASUS Method for Testing of HIGHLY Automated Driving Functions

The objective of PEGASUS Testing was to develop the PEGASUS method regarding completeness, correctness and consistency.

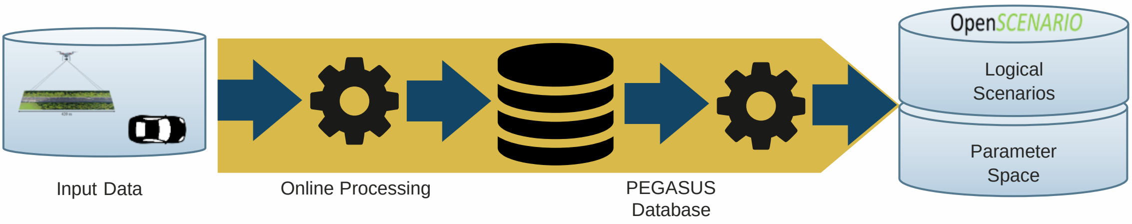
The methods developed for the Database are key for the identification of testing scenarios:

- The 6-Layer model as unified consistent data model for the testing of HIGHLY Automated Driving Functions.
- The generation of relevant scenarios with input from real-world data as parameter distribution.
- Robust framework for processing from standardized input data to standardized output data



Database

Goal: Representative collection of all relevant scenarios, metrics, pass criteria
Input: Data from field, derived test cases from knowledge, certification, automation risks …
Output: Logical Scenario and parameters (incl. distributions), pass criteria, Metric



Prototype for a

- standardized setup for the recording and signal definitions
- standardized processing of different data sources
- standardized storage
- generalized, systematic data model for a parametrisable scenario
- standardized output format for the generation of scenarios with parameter distributions

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Data Sources for Scenario Database

How can naturalistic road user behavior be recorded efficiently?

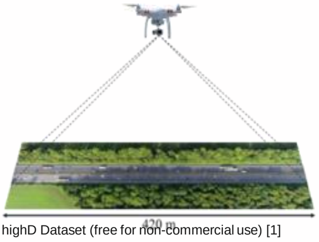
	Scenario Description	Scenario Relevance	Scenario Reference
Aerial Traffic Measurement (uninfluenced driving)	Complete	Frequency of scenarios for current traffic	
FOT with active ADAS/HAF function	Complete (depending on sensor setup)	Frequency of scenarios with HAD/ADAS-function	
FOT without active ADAS/HAF function	Complete (depending on sensor setup)	Frequency of scenarios with human driver, but influenced driving	
Proving ground (test track)			Identification of human performance
Simulation	Identification of physical boundaries of the scenarios		Theoretical performance
Accident data	Limited (just two main accident participants)	Limited, only with statistical population	Examples for negative human performance
Driving simulator			Identification of human performance

Road user trajectories extracted from aerial videos captured by UAV using Deep Learning

Advantages:

- **All road users** are detected and tracked
- Completely **naturalistic**, uninfluenced driving behavior
- **No or little occlusion** due to “bird`s eye” perspective
- **Very accurate** with 4K camera and **our algorithms**
- **High efficiency** regarding cost and effort
- Recordings unbound to **any location**

→ Creation of a **large-scale naturalistic trajectory dataset**



highD Dataset (free for non-commercial use) [1]

- **6 locations**
- **Number of vehicles: 110 000**
- Driven distance: **45 000 km**
- **Pixel-level accuracy** = 0.1-0.2 m

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highD

[1] Krajewski, Bock et al. 2018: The highD Dataset: A Drone Dataset of Naturalistic Vehicle Trajectories on German Highways for Validation of Highly Automated Driving Systems

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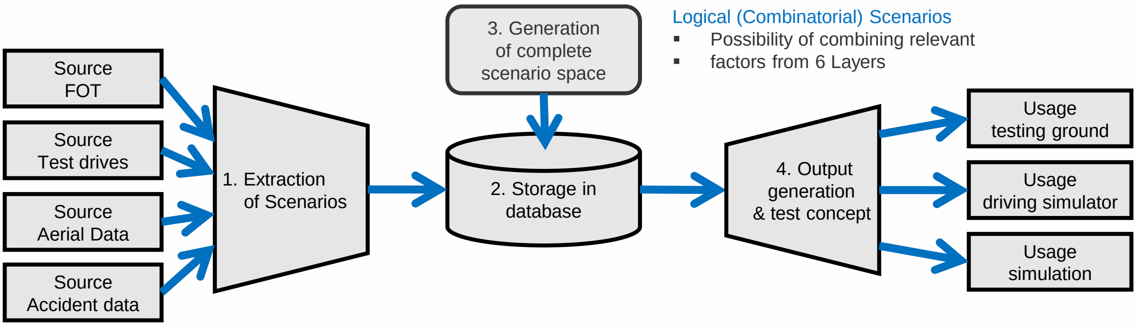
The Processing Chain is a Key Component of the Database.

Which processing steps are necessary to extract parameter spaces for logical scenarios from the input data?

Data with traffic events	Scenario Type Scenario Parameters Relevance	Scenarios	Logical Scenarios with X parameters Concrete scenarios	Testcases



<source> event
- FOT event
- Testdrive event
- …
- Accident event

<source> Scenario
- FOT scenario
- Testdrive scenario
- …
- Accident scenario

<instance> Testcase
- Proving ground testcase
- Driving simulator testcase
- Simulation testcase

➡ Processing chain handles different data sources with heterogeneous data quality.

➡ Input data is enhanced by continuous values such as time-to-collision.

➡ Continuous measurements are divided into logical scenarios. Measurement data scenarios are created.

➡ Scenario parameters are derived for the measurement data scenarios. For every logical scenario, a parameter space is spread out.

➡ The database makes it possible to efficiently process large amounts of data through a flexible yet uniform processing chain.

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Six-Layer Model

How can traffic elements be structured?

Layer 6

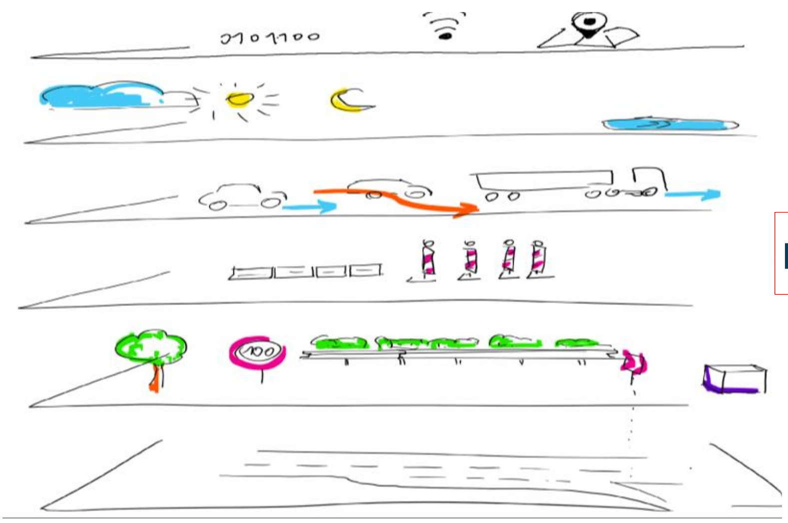
Layer 5

Layer 4

Layer 3

Layer 2

Layer 1



More details on next slide

L6 - Digital information:
e.g. V2X information on traffic signals, digital map data
=> *Availability and quality of information communicated to ownship*

L5 - Environmental conditions
Light situation, weather (rain, snow, fog…) temperature
=> *environmental influences on system performance*

L4 - Moving objects
Vehicles, pedestrians moving relatively to ownship
=> *relevant traffic participants and their motion incl. dependencies*

L3 - Temporal modifications and events
Road construction, lost cargo, fallen trees, dead animal
=> *temporary objects minimizing / influencing the driving space*

L2 - Road furniture and Rules
traffic signs, railguards, lane markings, bot dots, police instructions
=> *including rules, where to drive how*

L1 - Road layer
road geometry. Road uneveness (openCRG),
=> *physical description, no scenario logics*

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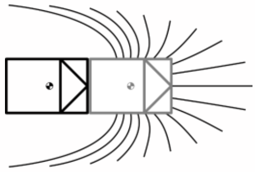
Scenario Concept on Layer 4

Which road users are relevant and how do they need to be modeled?

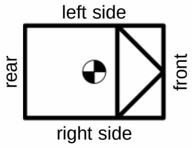
- **A challenging vehicle requires a reaction of the ego-vehicle to prevent an accident**
  - Based on **accident reconstruction**
  - Relational description **from the ego vehicle perspective with relative paths**
  - Considering the **potential impact location** (front, side, rear) and the **initial position of a challenger vehicle**

- **Challenger Vehicle**
  - 9 Base Scenarios for influenced driving
  - 1 (non-) Scenario for uninfluenced driving

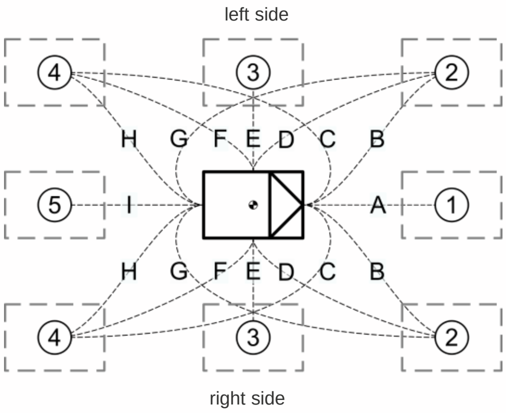
Possible relative paths between challenger and subject vehicle



- **Further Vehicles:**
  - Action constraints
  - Dynamic occlusion
  - Parallel challenger
  - Challenger-chains



- **Every other vehicle is not relevant (enough) for scenario-description**



Impact	Initial Position	Path	Indication
Fron t	1	A	Lead vehicle challenger
	2	B	Slower turn into path challenger
	4	C	Overtaking turn into path challenger
Side	2	D	Slower side swipe challenger
	3	E	Side swipe challenger
	4	F	Overtaking side swipe challenger
Rear	2	G	Slower Rear End Challenger
	4	H	Rear end turning into path challenger
	5	I	Rear end challenger
Non	-	-	Uninfluenced/Free driving

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