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.

**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 parametrizable scenario
- standardized output format for the generation of scenarios with parameter distributions
### Data Sources for Scenario Database

How can naturalistic road user behavior be recorded efficiently?

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

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**

---

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?

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.
Six-Layer Model
How can traffic elements be structured?

Layer 6

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

Layer 5

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

Layer 4

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

Layer 3

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

Layer 2

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

Layer 1

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

More details on next slide
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

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

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

---

**Scenario Database**

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**Possible relative paths between challenger and subject vehicle**

**Impact**

**Initial Position**

**Path**

**Indication**

<table>
<thead>
<tr>
<th>Impact</th>
<th>Initial Position</th>
<th>Path</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Front</td>
<td>1</td>
<td>A</td>
<td>Lead vehicle challenger</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>B</td>
<td>Slower turn into path challenger</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>C</td>
<td>Overtaking turn into path challenger</td>
</tr>
<tr>
<td>Side</td>
<td>2</td>
<td>D</td>
<td>Slower side swipe challenger</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>E</td>
<td>Side swipe challenger</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>F</td>
<td>Overtaking side swipe challenger</td>
</tr>
<tr>
<td>Rear</td>
<td>2</td>
<td>G</td>
<td>Slower Rear End Challenger</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>H</td>
<td>Rear end turning into path challenger</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>I</td>
<td>Rear end challenger</td>
</tr>
<tr>
<td>Non</td>
<td>-</td>
<td>-</td>
<td>Uninfluenced/Free driving</td>
</tr>
</tbody>
</table>