Securing Automated Driving -
The Database Approach in PEGASUS

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## The PEGASUS Project – Key Figures

<table>
<thead>
<tr>
<th>Category</th>
<th>Details</th>
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</thead>
<tbody>
<tr>
<td>42 months term</td>
<td>January 1, 2016 – June 30, 2019</td>
</tr>
</tbody>
</table>
| 17 Partners                | - OEM: Audi, BMW, Daimler, Opel, Volkswagen  
- Tier 1: Automotive Distance Control, Bosch, Continental Teves  
- Test Lab: TÜV SÜD  
- SMB: fka, iMAR, IPG, QTronic, TraceTronic, VIRES  
- Scientific institutes: DLR, TU Darmstadt |
| 12 Subcontracts            | - i.a. IFR, ika, OFFIS |
| Project Volume             | - approx. 34.5 Mio. EUR  
- Subsidies: 16.3 Mio. EUR |
| Personnel deployment       | - approx. 1.791 man-month or 149 man-years |
Central Research Questions of the Project

What level of performance is expected of an automated vehicle? How can we verify that it achieves the desired performance consistently?

<table>
<thead>
<tr>
<th>Scenario Analysis &amp; Quality Measures</th>
<th>Implementation Process</th>
<th>Testing</th>
<th>Reflection of Results &amp; Embedding</th>
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</thead>
<tbody>
<tr>
<td>What human capacity does the application require?</td>
<td>Which tolls, methods and processes are necessary?</td>
<td>How can completeness of relevant test runs be ensured?</td>
<td>Is the concept sustainable?</td>
</tr>
<tr>
<td>What about technical capacity?</td>
<td></td>
<td>What do the criteria and measures for these test runs look like?</td>
<td>How does the process of embedding work?</td>
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<tr>
<td>Is it sufficiently accepted?</td>
<td></td>
<td>What can be tested in labs or in simulation? What must be tested on test grounds, what must be tested on the road?</td>
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<tr>
<td>Which criteria and measures can be deducted from it?</td>
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Supported by:
Federal Ministry for Economic Affairs and Energy
European Commission

on the basis of a decision by the German Bundestag
SP 3 Testing

- Detailing and completion of test scenarios of subproject 1, including technical quality measures as well as approval criteria
- Compilation of a test catalog and requirements for lab, testing ground and field coverage
- Construction and filling of test specification database
- Construction of reference elements for practical testing and demonstration of functions
- Establishment and verification of testing methods, interfaces, tools in the lab, on testing grounds and in real traffic
- Testing in the lab, on testing grounds and on the street
- Development and coordination of industrywide established models, tools and interfaces for the simulation
- Supported by:
  - Federal Ministry for Economic Affairs and Energy
  - European Commission
  - on the basis of a decision by the German Bundestag
Challenges for Automated Driving

- No accepted evaluation framework for ADAS is available balancing effectiveness, controllability and acceptance (<Level 3).
- No evaluation methodology available for automated driving (>Level 3).
- Safety impact of automated driving of higher automation levels is difficult to determine, no measurements possible.
- Often user related issues are the limit of automated functions (e.g. take over, mixed mode).

Methods

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Field Operational Test</td>
</tr>
<tr>
<td>Controlled Field</td>
</tr>
<tr>
<td>Dynamic Driving Simulator</td>
</tr>
<tr>
<td>Simulation</td>
</tr>
</tbody>
</table>

Database of Relevant Traffic Situations
Database Approach to Develop and Validate CAD

**Motivation**

- Idea

**Extractions**

- E1
- E2
- E3
- E4
- E5

**Database of Relevant Traffic Situations**

**Database Approach Flow**

1. **Functional Concept**
2. **Traffic Simulation**
3. **Dynamic Driving Simulator**
4. **Software in-the-loop**
5. **Hardware in-the-loop**
6. **Component Development**
7. **Field Operational Tests**
8. **Test Track**
9. **Real Traffic**

**Test Levels**

- T1
- T2
- T3
- T4
- T5

**Recordings**

- R1
- R2
- R3
- R4

**Extracting from the DB**

- E1
- E2
- E3
- E4
- E5

**Recording into the DB**

- Recording of situations & criteria
- Severity
- Accident reconstruction
- Generation of new constellations
- Critical test situations
- Critical real-world situations
- Recording into the DB
Database and Database Processing Chain

Data processing chain

0. Use case definition
   - Definition of functional scope of HAD
   - Definition of scenario filter

1. Data transformation
   - Generation of common environment and traffic description
   - Data owner: raw data
   - Format checks
   - Indexing
   - Assignment of access rights

2. Scenario searching and clustering
   - Scenario clustering
   - Combined scenarios with frequencies
   - User specific retrace on single scenarios

3. Data volume reduction
   - Low
   - High

4. Scenario characterization
   - Calculation of scenario affiliation
     - Cut to scenario snippets of likelihoods > 95%
     - Calculation of indicators for the scenarios

5. Logical scenario

6. Test specifications deduction
   - Select scenarios based on functional scope
   - Add information on exposure, severity, controllability
   - Parameter space

7. Generation of common environment and traffic description
   - Harmonization of signal names
   - Transformation in common data format

8. Coverage of scenario information
   - Low
   - High

Post processing of individual scenarios
- e.g. for individual case assessment, function development, etc.

Raw data

Data processing chain

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PEGASUS
03-04 April 2017 Brussels
Database User Interface

2017-03-23 10-29-54.flv
Summary

- Testing and Validation of automated vehicles requires new methods and tools for an efficient safeguarding process.

- Available and known methods and tools can be utilized in the overall circuit process and therefore increase effectiveness.

- Core element of the circuit process is a database and a data processing chain for the relevant scenarios, which is currently established in the German PEGASUS project.

- The data processing chain needs to be able to process different data sources and heterogeneous data quality in order to provide common test specifications.

- The presented database concept allows an efficient processing of high data volumes by means of a flexible tool chain.
Thank you!

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