AUTOMATED DRIVING

Demonstrate automated driving in complex traffic environments taking into account full range of automation levels.
Validation & Verification

Definition according to "IEEE Guide--Adoption of the Project Management Institute Standard A Guide to the Project Management Body of Knowledge"

- **Validation**
  - The assurance that a product, service, or system meets the needs of the customer and other identified stakeholders. It often involves acceptance and suitability with external customers.

- **Verification**
  - The evaluation of whether or not a product, service, or system complies with a regulation, requirement, specification, or imposed condition. It is often an internal process.

- **Main objectives of SP7 in AdaptIve:**
  - Evaluation of automated driving research functions in four assessments (technical, user-related, in-traffic, impact assessment)
  - Development of an evaluation framework for automate driving functions
    - **Verification** is part of the technical assessment (checking requirements)
  - Methodology for impact analysis of automated driving applications
    - **Validation** is part of safety and environmental impact assessment as well as the user-related, in-traffic and technical assessment
Classification automated driving functions

• Classification of automated driving functions for the evaluation
  – According to the SAE definition
  – According the operation time
    • Event based operating
      – Function that operates for a short period in time (typically vehicle stands still at the end or the automated driving ends)
    • Continuously operating
      – Function that operates for a longer period in time (typically vehicle is still moving at the end of an manoeuvre respectively automated driving is continued)
Evaluation approach technical assessment

- How to limit the test amount to feasible amount?

Different approaches for event-based and continuously operation function

- Event-based functions: similar approaches as in previous research project e.g. interactIVe
- Continuously operating functions: test on public road

Evaluation criteria

- Automated driving functions need to operate within the range of normal driving behaviour (not disturb normal driving in mixed traffic conditions) and should at least be as safe as non-automated driving
Evaluation approach technical assessment

1. Defining evaluation scope
   • Definition of research questions, hypotheses & indicators

2. Planning of assessment
   • Analyse system description and adaption of hypotheses
   • Planning of test cases
   • (Risk assessment)

3. Tests in controlled field
   • Number of test variations
   • Logging of test data

4. Assessment of tests
   • Analysis of hypotheses based on test data & indicators

5. Assessment of tests
   • Analysis of hypotheses based on test data & indicators

Simulation (SiL)
• In case test effort for other test tools is too high or tests are not feasible (optional)
• Higher relevance for the (serial) development

Event-based
2. Planning of assessment
• Analyse system description and adaption of hypotheses
• Planning of test cases
• Definition evaluation criteria (distributions & boundaries)
• Risk assessment

3. Pre-/component tests in controlled field
• Basic tests of functionality
• Sensor tests

4. Tests in real traffic
• Test route and test amount to be determined

5. Assessment of tests
• Analysis of hypotheses based on test data & indicators

Continuous
1. Defining evaluation scope
• Definition of research questions, hypotheses & indicators

2. Planning of assessment
• Analyse system description and adaption of hypotheses
• Planning of test cases and test route
• Definition evaluation criteria (distributions & boundaries)
• Risk assessment

3. Pre-/component tests in controlled field
• Basic tests of functionality
• Sensor tests

4. Tests in real traffic
• Test route and test amount to be determined

5. Assessment of tests
• Analysis of hypotheses based on test data & indicators
Safety Impact Assessment

Research Question:
- What is the safety benefit of automated driving functions?

State of the art approaches for ADAS:
- Field of application
- Accident re-simulation
- Field test

Open issues for the impact assessment of automated driving applications
- Today’s accident data do not consider collisions of automated vehicles
- Automated driving function operate already before a critical situation occurs → Re-simulation of accidents gets more difficult
- Interaction with other road users (automated / non-automated) → mixed traffic
Safety Impact Assessment

Safety impact assessment in AdaptIVe bases on three main steps

1. **Identify relevant situations**
   - Focus on accident and other (relevant) driving situations
   - Use of microscope traffic simulation

2. **Investigate the relevant situation in detail**
   - Approach is similar to the re-simulation approach
   - Input data from other assessment (technical, user-related, in-traffic assessment) are considered

3. **Identification of new situations**
   - e.g. transition of control or minimum risk maneuver
Outlook: ika’s approach for the safety validation

- How to validate / verify that the automated driving functions are safe enough for the market introduction?
  - Circle of relevant situation approach [ECK13] [ZLO15]

Combining existing test tools in effective and cost-effective manner

Re-use of logged data field data to cover the overall situation space

Source: IPG.com
Database of relevant situations

[Refs: [ECK13]: Eckstein, Zlocki; Safety Potential of ADAS - Combined Methods for an Effective Evaluation; 23rd ESV; 2013
  [ZLO15]: Zlocki, Eckstein, Fahrenkrog; Evaluation and sign-off methodology for automated vehicle systems based on relevant driving situations; 94th Annual TRB Meeting; Washington D.C.; 2015]
Thank you.

Felix Fahrenkrog
Institut für Kraftfahrzeuge,
RWTH Aachen University
fahrenkrog@ika.rwth-aachen.de