From development to type approval

Technical Workshop

Athens, Greece
21-22 APRIL 2016
Motivation

Challenges & Goals of Automobile Development

- **ADAS and automated driving** show high potential for current challenges

- Definition of test protocols for ADAS (e.g. Pedestrian AEB) and higher levels of automation are in research stage

- Today manufacturers perform evaluation by means of individual test methods and tools

- Evaluation framework for automated driving **does not exist and requires research**
Challenges & Goals
Structured Approach of Evaluation areas
Challenges & Goals
Structured Approach of Evaluation areas

Societal Level
- Evaluation of acceptance, e.g.
  - by different societal groups and stakeholders

Legal Level
- Risk-Benefit Analysis
  - Traffic Safety and Efficiency
  - Economic potential

Human Factors Level
- Technical Options require societal reflection

Technical Level

Technical Standards

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//Challenges & Goals
Structured Approach of Evaluation areas

Societal Level
- Technical Regulation, e.g.
  - National level (StVZO)
  - ECE R79, ...

Legal Level
- Driver Behavior Law, e.g.
  - National Level (StVO)
  - Vienna Convention

Human Factors Level
- Scientific evidence motivates changes/revision of laws

Technical Level

Standardization

TECHNICAL STANDARDS
Challenges & Goals
Structured Approach of Evaluation areas

Driver - Vehicle Interaction, e.g.
- Criteria to design the take-over of the driving tasks ⇒ HMI?
- Criteria for well-accepted trajectories avoiding driver intervention ⇒ functionality?
- HMI supporting driver’s trust in AD?
- Controllability ⇒ Functional safety

Driver related research questions, e.g.
- Influence of AD on vigilance – what are suitable indicators? ⇒ driver monitoring?
- Situational Awareness ⇒ time constants?
- Mode Awareness ⇒ Number of modes?
- Influence of non-driving related tasks?

Driver – Environment - Interaction
- Driver’s Perception of situations
- Reaction of other traffic participants (cooperation, provocation ....?)

Methodological Questions
- Valid simulation of automated driving?
- Long-term evaluation?
- ...

Societal Level
Legal Level
Human Factors Level
Technical Level
Standardization

TECHNICAL STANDARDS
// Challenges & Goals
Structured Approach of Evaluation areas

Societal Level
- Test & Evaluation, e.g.
  - Functional Safety
  - Coverage of critical/relevant situations

Legal Level
- Driver Performance Algorithms
  - Driver state estimation
  - Driver performance estimation

Human Factors Level
- HMI Design
  - Display of System State
  - Multimodal take-over
- Vehicle Guidance
  - Planning of trajectories
  - Decision making

Technical Level
- Design of Infrastructure, e.g.
  - Physically, e.g. lane markers, …
  - Logically, e.g. Communication, …

Standardization
- Standardization Needs, e.g.
  - Terms & Definitions
  - Communication Standards
  - Methods & Processes
Overview on test tools

Overview on selected test tools along the development process

- **Component Level**
  - **Scope:** Enable new functions
  - **Methodology:** Model based tool chain for development of ADAS and automated driving functions

- **System & Function Level**
  - **Dynamic Driving Simulator**
    - **Scope:** Driving Experience
    - **Methodology:** 6DoF Driving Simulator studies for determination of driving experience

- **Vehicle Level**
  - **Component Tests**
    - **Scope:** Sensor Test/Benchmark
    - **Methodology:** Accepted test procedures and test tools for ADAS sensor testing

- **Field Operational Test**
  - **Scope:** Impact Assessment
  - **Methodology:** FOT tool chain from data acquisition to analysis and impact calculation

- **Concept**
  - **Simulation**
    - **Scope:** Potential/Effectiveness
    - **Methodology:** Traffic flow simulation tool "PELOPS" for MiL/SiL/HIL simulations

- **Development**
  - **Dynamic Driving Simulator**
  - **Function Development**
    - **Scope:** Enable new functions
    - **Methodology:** Model based tool chain for development of ADAS and automated driving functions

- **Approval**
  - **Field Operational Test**
  - **Expert Evaluation**
    - **Scope:** Expert Evaluation
    - **Methodology:** Trained test driver evaluation of functions on public road and controlled field

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Outlook: 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

[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
Evaluation Methodology
Sources and Population of relevant Situations

- **accident situations**
- **abstraction critical situations**
- **abstraction relevant situations**

**cause?**
- **accident reconstruction**

**criteria?**
- **metrics?**

- **test vehicle + test track**
- **dynamic driving simulator**
- **traffic simulations**

**basic population of relevant situations**

- **accident data**
- **no systematic knowledge**

**accidents = rare events**

**field operation test with limited scope**

**generation of traffic constellations**

**which new traffic situations are created due to automated driving?**

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Evaluation Methodology

Increase of relevant Situation Space

- Measurable relevant situations determined
- Measurable relevant situations are independent of functions
  - Missuse - cases
  - Interactions with other traffic participants
  - etc.

- Simulative variation of determined situations
- Measurable situation space enhanced by simulations
- Overall situation space filled by means of generated constellations
- Overlap ensures completeness of situations space
Evaluation Methodology

Data Base Population over Time

Recommended data amount for sign-off

- relevant situations
- generated constellations
- variations of the situations
- generated constellations
- variations of the situations
- relevant situations

accident data
field operational test with limited size
coordinated field tests with reference data logging
generated constellations
variations of the situations

presence future
Research on Automated Driving in Germany

1990 - 2000
- MOTIV
  - BMBF
  - 1996 - 2000

1987 - 1995
- PROMETHEUS
  - EUREKA

1990
- VaMoRs
  - Prometheus

2000
- Kognitive Automobile
  - SFB/Transregio 28, DFG
  - 2006 - 2009
- KONVOI
  - RWTH Aachen / BMBF
  - 2005 - 2009
- Golf 53+1
  - VW

2001 - 2005
- INVENT
  - BMBF
  - 2001 - 2005
- Track Trainer
  - BMW

2005 - 2009
- Stadtˌpilot (Leonie)
  - TU Braunschweig

2006 - 2010
- AKTIV
  - BMWi
  - 2006 - 2010
- Autonomous Labs
  - TU Berlin / BMBF

2009 - 2012
- Definitions/Legal Aspects
  - BASı
  - 2009 - 2012
- Smart Senior
  - BMBF

2011 - 2013
- H-Mode
  - DFG
  - 2011 - 2013
- PEGASUS (BMWi)
  - starting 2016

2012 - 2014
- SPP 1835
  - DFG
  - 2012 - 2014
- Villa Ladenburg
  - Berta Benz Stiftung

2014 - 2020
- UR:BAN
  - BMWi
  - 2014 - 2020

2014 - 2017
- ASHAS
  - MCTS
  - 2014 - 2017

2018 - 2020
- Ko-FAS
  - BMWi
  - since 2018

Today
- Berta Benz Drive
  - Daimler
  - since 2012
• German research project for test standards of automated driving
• German research project for test standards of automated driving

• Project duration:
  – 01st January 2016 to 30th June 2019

• Partners:
  – Audi, BMW, Daimler, Opel, Volkswagen, Automotive Distance Control, Bosch, Continental, TÜV Süd, fka, iMAR, IPG, QTronic, TraceTronic, Vires, DLR, TU Darmstadt + 12 subcontracting partners

• Budget:
  – 34,5 Mio. Euro (16,3 Mio. Euro Funding)

• Research Questions:
  – How can the quality and (functional) safety of the automated driving function be tested and verified?

• Considered System:
  – Highway Chauffeur

[Köster, Lemmer, Plättner, Wie gut müssen automatisierte Fahrzeuge fahren?, AAET, 2016]
Conclusion

- Future ADAS and Automated Driving offer the potential to significantly improve traffic safety, efficiency and driving experience.

- Automated Driving not only offers potentials but also many challenges - these can be structured according to the 4-level model.

- Research activities on automated driving have started, yet many research areas require new methods and solutions especially for valuation.

- The circuit of relevant situations offers an efficient and valid evaluation and sign-off procedure for all existing evaluation methods.
Thank you.

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Adrian Zlocki

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