Self-driving vehicles and their impact on the efficiency and safety of future transport

Dipl.-Ing. Alexander Kraus
Senior Vice President Automotive
TÜV SÜD Group
1866 On 6 January, 22 industrialists united to establish the Steam Boiler Inspection Association Baden in Mannheim.

1881 The first binding standards related to boiler safety were agreed, paving the way for uniform technical inspections.

1906 Our first vehicle periodic technical inspection was carried out.

1951 TÜV organisations were tasked with performing regular inspections of all motorised vehicles.

1989 TÜV Product Service GmbH was launched, pioneering the concept of worldwide approvals.

1996 The TÜVs from Germany’s southern states united to form TÜV SÜD.

2001 The TÜV SÜD octagon certification mark became the official company logo.

Today TÜV SÜD continues to pursue a strategy of internationalisation and growth.
TÜV SÜD in numbers: Growing from strength to strength

1 one-stop technical solution provider
150 years of experience
850 locations worldwide
2,220 million Euro in sales revenue for 2015
24,000 employees worldwide as of February 2016*

Note: Figures have been rounded off.
Adding value through quality, safety and sustainability solutions across the 3 Strategic Business Segments

**MOBILITY**
- Ensure 100 years in safe mobility:
  - Periodical Technical Inspections
  - Car business services
  - Fleet management
  - Automotive

**INDUSTRY**
- Maximise reliability, safety & efficiency for:
  - Chemical, oil & gas
  - Power & energy
  - Manufacturing & industrial machinery
  - Rail
  - Real estate and infrastructure

**CERTIFICATION**
- Achieve market access for:
  - Manufacturing & industrial machinery
  - Consumer products & retail
  - Healthcare & medical devices
  - Telecommunications & IT
  - Transportation (Automotive, Aerospace and Marine Component)
Automotive Service Portfolio

- **International Homologation**
  - Consulting
  - Document management
  - Testing
  - Approval

- **Testing**
  - Components
  - Systems
  - Fuel Consumption
  - Type Approval
  - NEDC / WLTP
  - RDE
  - Engineering

- **Emission**
  - Battery tests
  - Charging infrastructure
  - Powertrain testing
  - EMC

- **E-Mobility**
  - Functional safety
  - Approval of experimental vehicles
  - Data Security

- **Automated Driving**
  - “Cross-Industry” experience
  - Project “TÜV SÜD HAD”

**Services**
- International network of experienced experts
- Worldwide network of various laboratories
- Largest independent emissions lab in EU
- Services for all topics related to E-Mobility

**Benefits**
- International network of experienced experts
- Worldwide network of various laboratories
- Largest independent emissions lab in EU
- Services for all topics related to E-Mobility
- Functional safety
- Approval of experimental vehicles
- Data Security

TÜV SÜD AG
12/12/2016
Solutions for the Automotive Industry
Slide 5
Urban traffic development: Example Munich

1. Herausforderung Wachstum: Pendlerverkehr

Menge der über drei Autobahnen in die LH München einströmenden KFZ
im Tagesverlauf eines Werktages im Vergleich der Jahre 2007 und 2012

Prediction:
230,000 vehicles per day by 2025!

Vision from the perspective of a leading OEM

Challenges in Urban Mobility

EMISSIONS
Traffic is one of the triggers of high pollution and CO2 emissions

SPACE
Increased traffic needs more and more space

Stationary Traffic
I can't find a parking spot

Moving Traffic
I am stuck in a traffic jam

Intelligent Technologies provide Solutions

Traffic Technologies to manage traffic flow

Driving Assistance for more safety and comfort

Intermodality & Multimodality in mobility planning

Complement framework conditions for new transport and mobility services

Future twowheel Concepts as new sustainable innovations

(E-)Carsharing: Sharing instead of owning

Connecting Human & Technology to optimize mobility planning

Parking reinvented sustainably

Mobile Deposit
Car Trunk as a delivery location always available and convenient

Source: BMW
Potentials for efficiency increase through vehicle automatization and connectivity

**Predictive driving**
- Savings potential by means of forward-looking driving and traveling at constant speed
- Less braking situations in traffic
- Driving vehicle in "sailing mode" to minimize friction losses

**Car2X communication**
- Interconnectivity with infrastructure
- Detection of traffic volume to control traffic flow
- Synchronisation of acceleration and braking operations
- Reduce the circulation times of the traffic light systems

**Efficient route selection**
- Apply current traffic as the basis for efficient route selection
- Constant traffic flow through optimal route selection
- Relief of traffic intersections
Intelligent interconnectivity of the vehicles (Car2Car and Car2X)

- Reduction of the vehicle distance to 3–15 meters
- Fuel saving potential of up to approx. 15%

Reduction of active and passive safety systems

- Reduced risk of accidents by automated vehicles
- Reduction of safety systems such as airbags, frame constructions,…
  → Reduction of vehicle weight
  → Reduction of engine power

Use of the slipstream potential (platooning)

- Intelligent interconnectivity of the vehicles (Car2Car and Car2X)
- Reduction of the vehicle distance to 3–15 meters
- Fuel saving potential of up to approx. 15%

Regrouping of private transport to taxis / buses

- Change of individual traffic to autonomous taxis (see Singapore)
- New fleet concepts for the reduction of company fleet vehicles
- Relieve of traffic hot spots
Example: The Digital Shadow

Creation of a complete virtual counterpart of the real vehicle moving through a completely digitized world. Functions of the real vehicle are being generated by unlimited availability of context.

Source: BMW
Example: Load-Balancing Routing

Vehicle data are used for significant travel time reduction

There is a lot of potential by vehicle automatization and interconnectivity to reduce traffic and increase transportation efficiency!
### HAD Roadmap

Source: VDA 2015

<table>
<thead>
<tr>
<th>Automation 2nd gen.</th>
<th>Automation 1st gen.</th>
<th>New DAS</th>
<th>Established DAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highway pilot</td>
<td>High congestion pilot</td>
<td>Eco ACC, Work site assistant</td>
<td>LCA, PDC, LDW, FCW</td>
</tr>
<tr>
<td>Parking garage pilot</td>
<td></td>
<td>Congestion assistant, Park assist.</td>
<td>ACC, S&amp;G, PSA, LKA</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Driver only</td>
<td>LCA, PDC, LDW, FCW</td>
</tr>
<tr>
<td>1</td>
<td>Assisted</td>
<td>ACC, S&amp;G, PSA, LKA</td>
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<tr>
<td>2</td>
<td>Partially automated</td>
<td>LCA: Lane Change Assistant, PDC: Park Distance Control</td>
</tr>
<tr>
<td>3</td>
<td>Highly automated</td>
<td>LDW: Lane Departure Warning, FCW: Forward Collision Warning</td>
</tr>
<tr>
<td>4</td>
<td>Fully automated</td>
<td>ACC: Adaptive Cruise Control, S&amp;G: ACC incl. Stop &amp; Go</td>
</tr>
<tr>
<td>5</td>
<td>Driverless</td>
<td>PSA: Park Steering Assistant, LKA: Lane Keeping Assistant</td>
</tr>
</tbody>
</table>

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*Driver is always in the loop and monitors environment.*

*System monitors environment, driver is (temporarily) out of the loop.*

---

LCA: Lane Change Assistant
PDC: Park Distance Control
LDW: Lane Departure Warning
FCW: Forward Collision Warning
ACC: Adaptive Cruise Control
S&G: ACC incl. Stop & Go
PSA: Park Steering Assistant
LKA: Lane Keeping Assistant
Current Trend

Necessity to engage in the field of safeguarding autonomous vehicles

- Launch of autonomous vehicles earlier than announced (2030 → 2020 → 2017?)
- Cooperation Mobileye and Delphi plans an upgrade –plugin module for autonomous driving in 2019
- Competition about „Deutungshoheit“, strong increase of research projects, consortiums
- OEMs and TIER high personnel requirements, leading to a lack of skilled workers
- Since Tesla's Beta-tests on public roads: Demand of certifications and standardisation by an expert with know-how in automotive and IT

Forecast about the launch of first autonomous vehicles

- 2010: Audi, Volvo
- 2020: GM, Tesla, Audi, BMW, Google, Lockheed Martin
- 2030: Mobileye - Delphi, Royal Academy of Eng., Volvo, Mercedes Toyota, NASA, TU Wien, JD Power, Stanford University
What is new/different about autonomous driving?

- Autonomous driving is an automotive system, like many others, a little bit more complicated. So what! why worrying? Why should we think different?
- E.g. the powertrain and exhaust system is highly complicated too, with many sensors, distributed control systems, complicated software elements and not easy to manage?
- Powertrain is a control task with quantitative well defined Target
- Autonomous Driving is a control task with qualitative defined multi targets with mutual interaction

- Approval of Deterministic (sub)Systems
- Scale Approval of multtarget (sub)systems
- Ensure/guarantee traceability
Example: From fail safe to fail operational systems

- Safety of conventional vehicles based on driver’s emergency intervention through mechanical connection between control elements and actuation (steering column, brake linkage) in case of technical malfunctions (e.g. loss of power)

  - This works as long as the driver is able to intervene immediately, i.e. in level 0 to level 2 systems
  - In level 3 and beyond, driver is - at least temporarily - not available for prompt emergency intervention
  - Mechanical connection between control elements and actuation is not longer sufficient / makes no longer sense

- Highly and fully automated vehicles will have redundant or diverse by-wire systems for steering and braking
Automated Driving: Complexity evolution
Can we handle this complexity with existing methodologies?

Latest examples

**Example 1**
Proof of effectiveness and reliability

- “Autopilot” keeps/changes lanes and brakes automatically
- Wireless transfer of software updates

**Example 2**
Security and functional safety

- Relevant safety gaps in software directly linked to hardware

Regulatory grey area
Customer = Test driver

Hackers could gain control over essential vehicle functions.
## Challenges for safe and secure HAD

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>Feasibility</th>
<th>IT security</th>
<th>Regulations</th>
</tr>
</thead>
</table>
| • Real testing no longer sufficient  
• Definition of scenarios needed  
• New concepts with different interests | • Proof of safety with a small number of real testing  
• Continuous development of the system “vehicle” via updates | • IT security as a new pillar of vehicle safety  
• View of the overall system - end to end communication  
  (vehicle – data transfer – data centre - applications) | • Development of existing regulations  
• International standards are necessary |
Safe and Secure vehicle automatization –
Focus Areas for type approval methodology development

- Simulation
- Proving ground tests
- Field / Accident data

- Safety of use
  Functional safety
  IT security

- Threat & risk analyses

- Future PTI

- E.g. Periodical Certification??
- E.g. Conformity of Production??
- E.g. Software Homologation??

'\textit{HAD}' = \textbf{Highly Automated Driving}
TÜV SÜD „Project HAD“ – Organisational Structure

30 FTE in total

**Steering committee**
Fruth, Kraus, Dr. Schlesinger

**Committees & Partnerships**
Dr. V, PP, GM, Dr. A, Kraus,
starting Q2/2017

**Effectiveness assessments**
RM

**Simulation**
5FTE
JN

**Testing**
4FTE
SW

**Field / accident data**
2FTE
MS

**PEGASUS**
Dr. V
Autobahn Use

**CETRAN**
EQ
Urban Use test field Singapore

**GeSi, FuSi, IT-Sec**
Dr. A

**Functional safety**
MJ

**IT security**
TR

**GIL**
WS
IT security / Test Field Garching

**CYSREN**
EQ
IT Security Singapore

**Future PTI**
3 FTE
RB

**Target structure**

**Funding projects**

Project Budget 10.6 mEUR
Project Duration 2017-2020

Cooperations with Universities desireable!

'**HAD**' = Highly Automated Driving

TÜV SÜD AG 16-09-15 Slide 20
New methods for a safe and secure product lifecycle

Development phase will be extended to entire vehicle lifetime with focus on safety relevant Software. Agile development, testing and approval methodologies are required.

Scope 1 – New Type Approval methodologies

Scope 2 – P(C)TI (Periodical Certification of SW)

Vehicle field usage

SoP

Safety of use, functional safety, IT security

Concept

Simulation

Validation

Verification

Testing

Conventional vehicle development

SoP

Vehicle field usage

Safety of use, functional safety, IT security

Concept

Simulation

Validation

Verification

Testing

Conventional vehicle development
Actual Example: Complicated scenario of ADS proving ground testing for type approval

<table>
<thead>
<tr>
<th>Object</th>
<th>Description</th>
<th>Lateral / Longitudinal controled by:</th>
<th>Accident avoidance</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1.png" alt="Vehicle Under Test" /></td>
<td>Vehicle Under Test</td>
<td>AV</td>
<td>Safety driver</td>
</tr>
<tr>
<td><img src="image2.png" alt="Traffic Simulation Vehicles" /></td>
<td>Traffic Simulation Vehicles</td>
<td>Control room (CR)</td>
<td>Safety driver / CR</td>
</tr>
<tr>
<td><img src="image3.png" alt="Soft Crash Target" /></td>
<td>Soft Crash Target</td>
<td>Control room (CR)</td>
<td>CR</td>
</tr>
</tbody>
</table>
Actual Example scenarios of complex HAD virtual testing
Relation of functional safety and IT security

**Functional Safety**
- static environment
- handling of random faults

**IT Security**
- dynamic environment
- OBD
  - external manipulation
  - faulty sensors
  - remote access
- data privacy
- theft protection

- remote access
Threat analysis for HAD security

- Engine Control
- Gearbox Control
- Brake Control
- Door Lock Control
- HVAC Control
- Light Control

Gateway

Diagnostic Systems

Dashboard

PSIS

V2V & V2X

Off-board

On-board

CAN

Powertrain, ...

Ethernet

On-board

Off-board

Head Unit

USB

Bluetooth

On-board

Off-board

No physical access necessary, Attack scaled

Physical access necessary, Attack does not scaled

Engine Control

Gearbox Control

Brake Control

Door Lock Control

HVAC Control

Light Control

V2V & V2X

GPS

Diagnosis Systems

OBD2

3G

4G

5G

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Remove image from the answer.
To evaluate new technologies it is vital to be – and remain – state of the art!
All aspects covered?

Functional safety: 
*Protection of people*
ISO 26262 2nd ed. ✓

Integral approach for safety & security: No safety without security!

Privacy: 
*Protection of data*
Applicable standard for V2X communication - does, e.g., ISO TC22/SC31 provide this?

Cyber security: 
*Protection of systems*
SAE J3061 ✓
Future evolution of ADS

- Revision of „Vienna Convention on Road Traffic”
- Driver has to intervene in case of malfunction
- Highly automated driving on highway
- Fully autonomous driving in first urban areas
- Drive-by-wire solutions
- Driver out of loop
- V2V, V2X communication approved

© Audi

2016  2020  2025
A possible scenario: car driving license
Acceptance of automated systems

Would you take your hands off the wheel?

Some companies are developing ‘driverless cars’ - cars that are driven by sensors and a computer rather than a human driver. If money were no object, would you buy a driverless car? Yes:

- 38% (18-29)
- 37% (30-44)
- 50% (45-64)
- 59% (65+)

We have to seriously work on the promotion of driverless cars to:
- increase the acceptability
- avoid illusions and false expectation on driver responsibility
- Marketing roadmap is necessary and should be synchronized to technological roadmap
We experience the most significant technological revolution in vehicles since introduction of combustion engines.

Massive potential to reduce accidents, emissions and increase efficiency and availability of individual mobility.

Functional Safety and public acceptance are significant key issues to be handled.

Verification and validation needs a tool chain including virtual testing and simulation methods, also for type approval.

IT Security as important as functional safety and safety of use. Harmonisation of standards and methods is necessary.
Thank you very much for your attention.
3 A) PEGASUS for the assessment of HAD

- Project for establishing generally accepted quality criteria, tools and methods as well as scenarios and situations for the release of highly automated driving functions
- 17 partners from industry, 12 subcontractors, 42 month project duration
- PEGASUS will close gaps in the area of testing and approval of automated vehicles with the aim to transfer existing highly automated vehicle-prototypes into products

SP 1
SCENARIO ANALYSIS & QUALITY METRICS
- Application scenario
- Quality metrics
- Extended application scenario

Lead: Volkswagen

SP 2
IMPLEMENTATION PROCESSES
- Process methodology
- Process specification

Lead: Adam Opel

SP 3
TESTING
- Test specification database
- Laboratory and simulation tests
- Proving ground tests
- Field tests

Lead: Daimler, BMW, TÜV SÜD

SP 4
PROFIT REFLECTION & EMBEDDING
- Proof of concept
- Embedding

Lead: Continental
3 A) PEGASUS - Characteristics of test levels

- **Virtual tests**
  - Analysis of a huge number of scenarios, environments, system configurations and driver characteristics

- **Proving ground tests**
  - Reproducibility by use of driving robots, self driving cars and targets; critical manoeuvres are possible

- **Field tests**
  - Investigation of real driving situations and comparison with system specifications

---

Effort for coverage of all relevant scenarios & environments

---

Uncertainties & simplifications
3 B) Similarities between safety and security

- Similar general understanding: Safety and security by design
- Common methods: for example HARA → TARA
- Common process framework:


Management of Cybersecurity

Supporting Processes
Existing regulations for type approval

- European type approval for passenger cars based on Commission Regulation (EU) No. 46/2007 and ECE Regulations 13 & 79 brake and steering with so called electronic annexes
  - No influence of E/E systems on mechanical brake and steering functions
  - Regulations only sufficient as long as systems are fully controlled by drivers according to the Vienna Convention

- Commission Regulation (EU) No. 351/2012 & 347/2012 and ECE Regulations 130 & 131 for LDWS and AEBS for trucks and buses deliver relatively simple test procedures

Increasing level of automation calls for revision of existing regulations or additional regulations, respectively, for type approval
### Existing standardisation for safety and security

<table>
<thead>
<tr>
<th>1. Vocabulary</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Management of functional safety</td>
</tr>
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<td>3. Concept phase</td>
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<td>4. Product development: system level</td>
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<td>5. Product development: equipment</td>
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<td>6. Product development: component</td>
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<td>7. Production and operation</td>
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<td>8. Core processes</td>
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<td>9. Risk management and safety critical analysis</td>
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<tr>
<td>10. Outline on ISO 26262 (informal)</td>
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#### Key Points:

- **Product safety confirmation based on ISO 26262** for functional safety of E/E systems in road vehicles.

- **Limitations**: ISO 26262 doesn’t cover functional insufficiencies, for example misinterpretation of objects or traffic situations.

- **SAE J3061:2016-01-14(!)** – 1st automotive specific IT security standard – delivers at least a framework for IT security, very similar to ISO framework.

**With increasing level of automation, upgrade of functional safety standard is necessary as well as extension to safety of use and IT security.**
On the one hand systems for HAD have to fulfil very high functional safety requirements, e.g. random hardware failure rates < 10^-8 / h for ASIL D → it is not possible to prove those failure rates by conventional field tests with reasonable effort

On the other hand we have to deal with a huge number of traffic situations, environmental conditions and driver behavior → it is not possible to cover this test space by real tests at all

Field testing is obviously not sufficient for verification & validation of highly automated driving systems, a tool chain is necessary