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Automated Driving Applications and Technologies for Intelligent Vehicles

Validating the safety of automated driving

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// Today we talk about…

- … research fields of **RESPONSE4**
- … challenges on the way to **automated driving**
- … **highlights** and further **research needs**

//Research fields of RESPONSE4

System classification	Technical system limits	Safety validation
What do we mean when we say automated driving (AD) functions?	Which sensor technologies are relevant for AD functions? What are examples for limitations of these sensors and systems required for AD?	What is the challenge with the „demonstrable level of safety“? Which knowledge will help us to find answers and new methodologies?

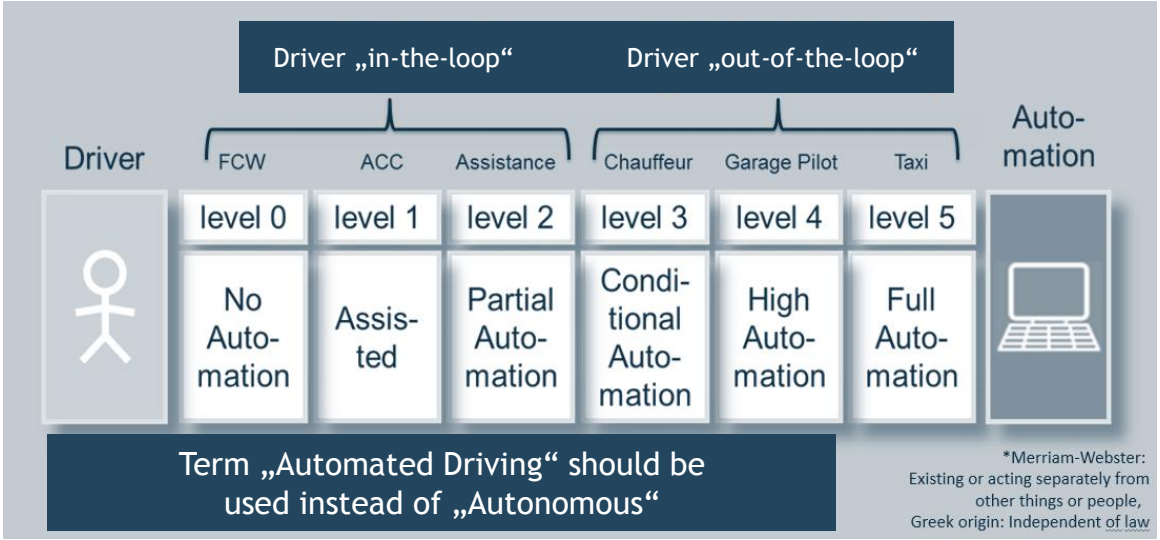
//What do we mean when we talk about AD?

System classification

OPERATION TYPE A INFORMING & WARNING	OPERATION TYPE B CONTINUOUS AUTOMATED FUNCTIONS	OPERATION TYPE C INTERVENING EMERGENCY FUNCTIONS
INDIRECT INFLUENCE ON VEHICLE VIA DRIVER	DIRECT INFLUENCE: TASKS SHARED BETWEEN DRIVER & FUNCTION	IMMEDIATE & DIRECT TAKEOVER OF CONTROL IN NEAR ACCIDENT

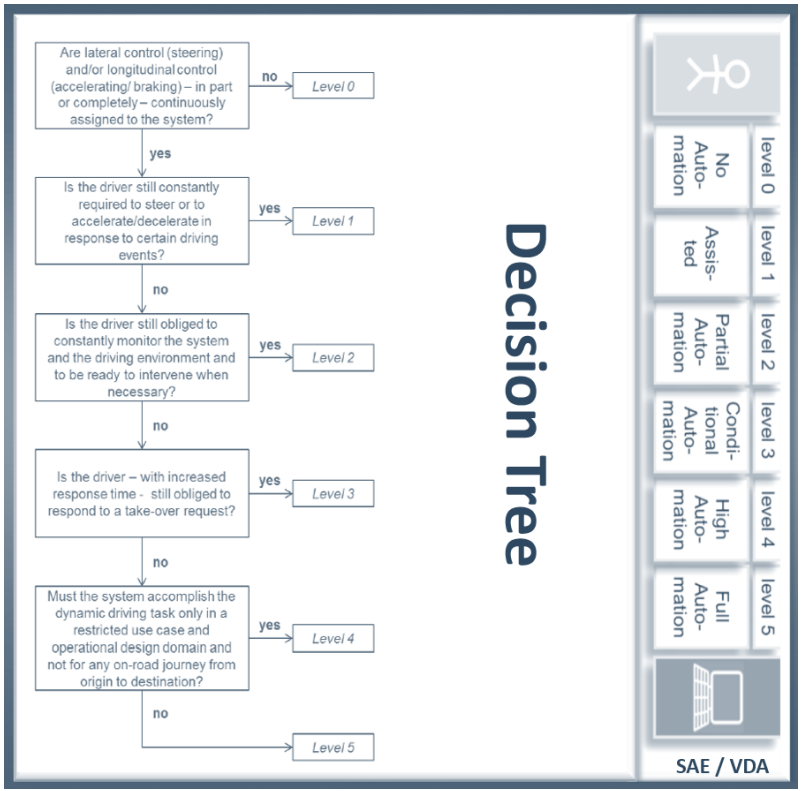
//What do we mean when we talk about AD?

System classification



// What do we mean when we talk about AD?

System classification



Are lateral and/or longitudinal control assigned continuously to the system?

If No

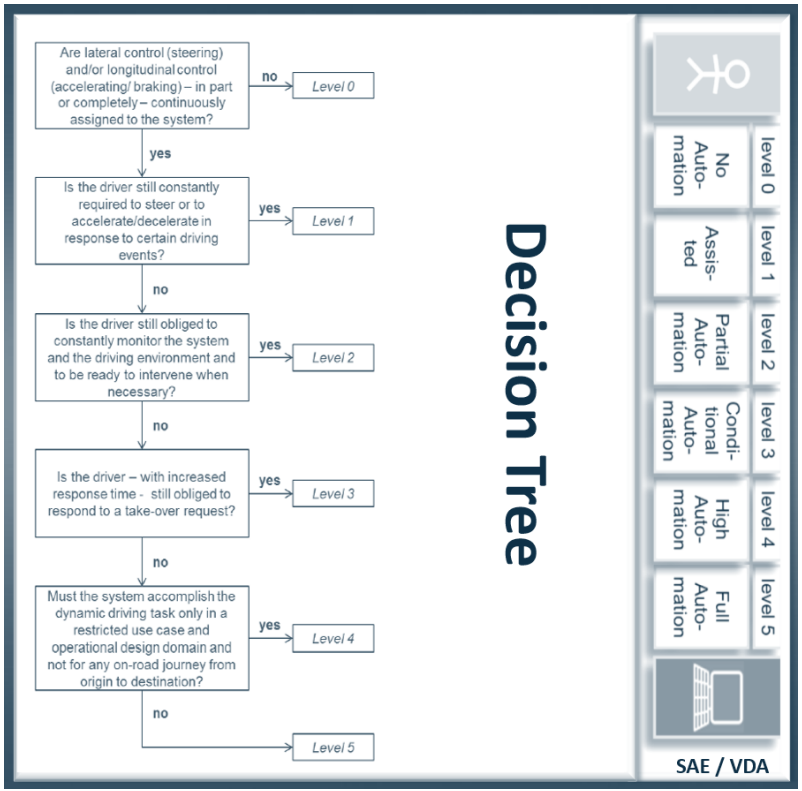
Level 0

Lane Departure Warning

Green Light Speed Advisory

//What do we mean when we talk about AD?

System classification



Must the system accomplish the dynamic driving task just in a restricted use case?

If Yes

Level 4

Valet Parking
Motorway Pilot

If No

Level 5

Universal
Robot Vehicle

// What do we mean when we talk about AD?

System classification

- Provided a **SYSTEMATIC APPROACH** on the description of Automated Driving
- Collection and Priorisation of **RELEVANT PARAMETERS** for AD classification
- Provided a **COMPARISON** on AD nomenclature
- Collected a **GLOSSARY** of technical AD terms and functions
- Establish a unified community-wide **COMMON UNDERSTANDING**
- Disseminated and supported **SAE J3016** in Europe and beyond

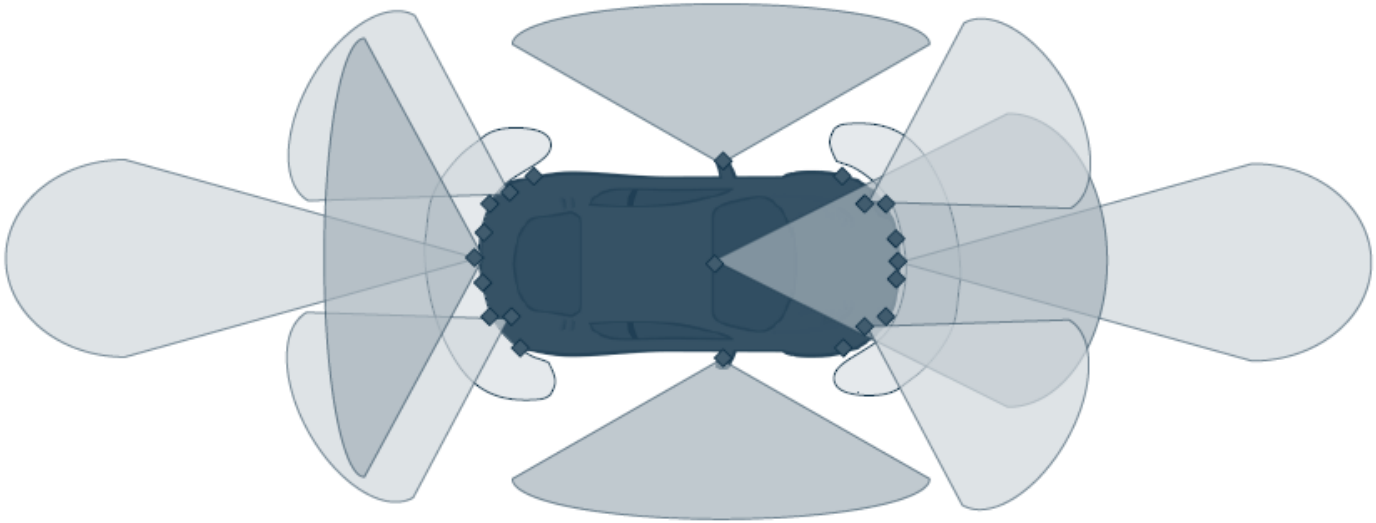
→ For details, see **PUBLIC DELIVERABLE „System classification“** on AdaptIVe website

//Research fields

System classification	Technical system limits	Safety validation
What do we mean when we say automated driving (AD) functions?	Which sensor technologies are relevant for AD functions? What are examples for limitations of these sensors and systems required for AD?	

//What are the technical limits of our systems?

Technical system limits



Categorisation of Sensor Types

CAMERA … RADAR … LIDAR … ULTRASONIC

// Exemplary Sensor Technologies

Technical system limits

- **Camera**
  - Very high resolution for vertical and horizontal displacement
  - Objects could be classified
  - Traffic signs are visible and could be recognized by a camera
  - Vehicle-Lane assignment

- **Radar**
  - Active sensors: 77-79GHz for long range radars and 24GHz for mid/near range radars.
  - By measuring time of flight and the Doppler effect, distance and relative speed could be measured.
  - Small and far away objects can be measured

- **LIDAR**
  - Very high resolution
  - Wide field of view
  - Long detection range
  - Do not need special materials for reflecting the emitted light
  - Small and far away objects can be measured

Each sensor technology has specific deficiencies that require the application of a combination of multiple technologies

//Sensor Fusion

- Since each sensor technology also provide specific drawbacks and do not cover all aspects required over the complete chain

Sensing – Interpreting – Decision making

SENSOR FUSION

- BUT: Sensor fusion could also have side effects. Measurements have to be assigned to an object:

  - If they are assigned to the wrong object, **Ghost objects** could occur
  - **Real objects** will be tracked with a lower probability of existence.
  - Higher **uncertainty** caused in case of conflicted information

//Vehicle - to - X

- Using **V2X technologies** will reduce the occurrence of critical situations and is a helpful addition to onboard-technologies
  - **Objects** are recognized even before a sensor can detect them
  - Driving **Comfort** enhanced
  - When combined with a defensive driving style, **safety** enhanced as well

//Research fields

System classification

Technical system limits

Which sensor technologies are relevant for AD functions?

What are examples for limitations of these sensors and systems required for AD?

Safety validation

What is the challenge with the „demonstrable level of safety“?

Which knowledge will help us to find answers and new methodologies?

A Comparison for Automated Driving Technology

… the control system „Homo Sapiens“

E.g. Distance between two severe accidents on a German Autobahn

→ **12 Mio. km** or 120,000 operating hours

About 10x the distance is required for AD tests
in order to to reach a sufficient statistical signficance

→ **Ca. 120 Million km** or ca. 1.2 million operating hours
→ Enormous cost and time effort
→ Procedure needs to be repeated for new AD functions

What is the challenge with a demonstrable level of safety?

Safety validation

Response3 Code of Practice (CoP) comprises a suitable ADAS (Advanced Driver Assistance System) description concept including

- ADAS specific requirements for system development.
- Summary of best practices and
- Proposals for risk management and controllability evaluation.

Response4

Transition from **Driver Assistance**

to **Automated Driving**

An eventual **AD CoP** has two main targets:

- Systematics: the CoP should provide the developers with the relevant aspects systematically with regard to the development phases.
- Methodological recommendation: the CoP should support the developers by recommendation of methods and activities, which could be taken in the consideration in the context of their Automated Driving functions

Requirements derived –
Foundation stone laid for further research

// Highlights

System classification

- Dissemination of SAE levels to harmonize communication with institutions, manufacturers, suppliers as well as technical and legal experts
- Creation of a community-wide common understanding

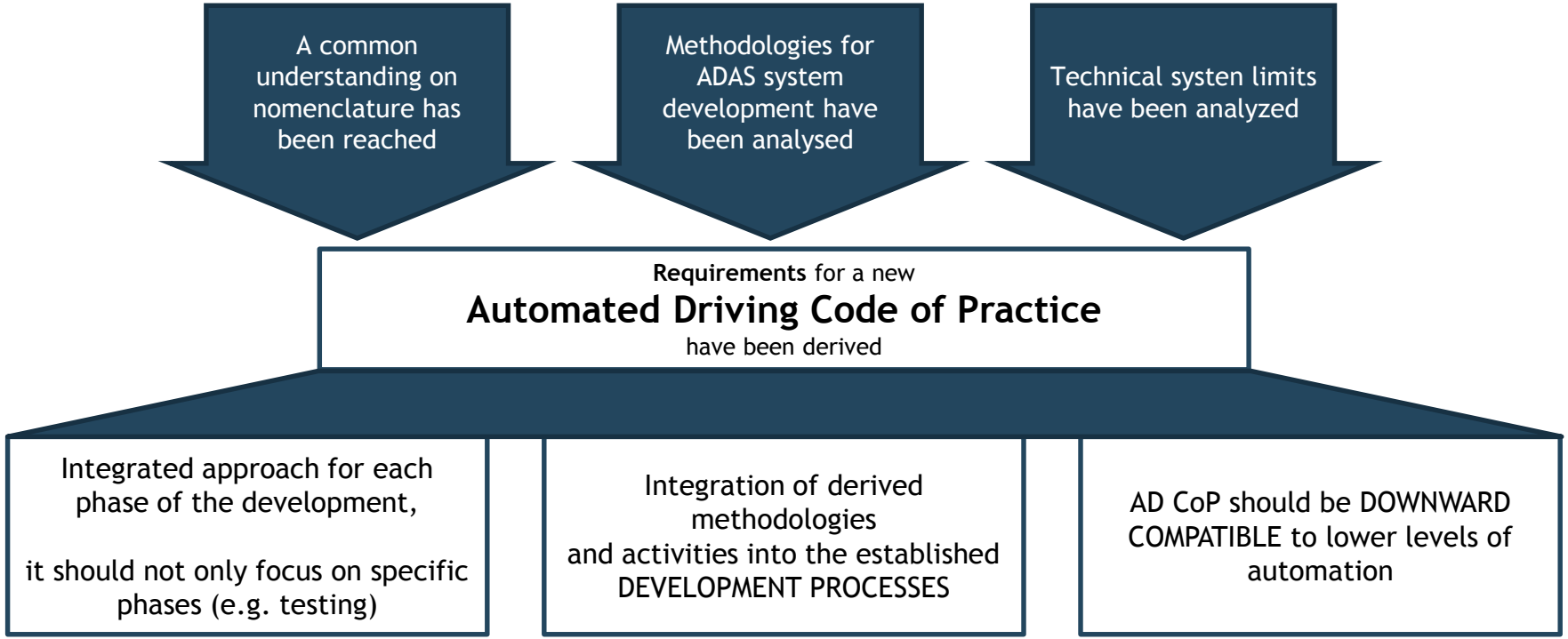
Technical system limits

Overview of technical systems and sensors with their technical system limits including the challenges and opportunities via sensor fusion and V2X

Safety validation

RESPONSE4 derived requirements for an Automated driving CoP as a foundation stone for further research and development

// Outlook „Towards an integrated approach“



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Thank you.

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