What are the key challenges around automated driving feature validation in a simulated environment, and how would you mitigate them?

Domonkos VARGA

Budapest, 23rd April, 2019

Outline

Model based simulation overview.

(No time for model driven scenarios like PEGASUS, ...)

Reasons for Exposure to Accidents.

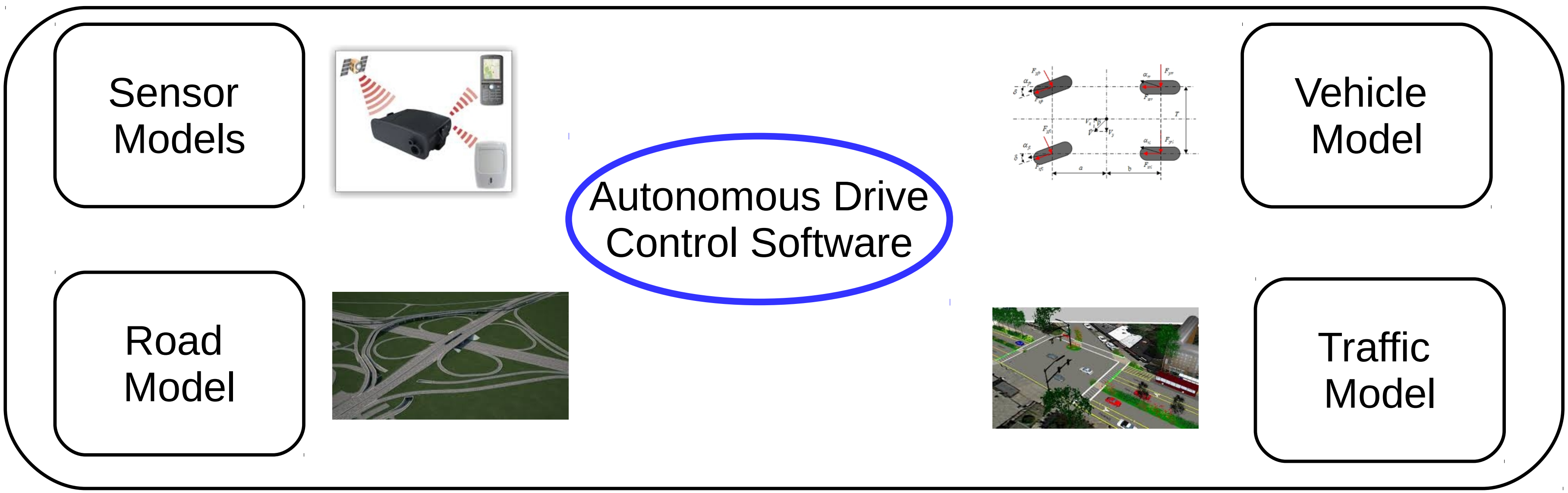
Selecting two areas:

= Deficiencies in sensing road, traffic and environmental conditions

= Deficiencies in Control Algorithms

General Guidelines

Virtual Driving with Model Based Simulation



Sensor Models:
radar, camera, lidar, ultrasonic
models should reflect sensor typical phenomena (noise, incorrect, missing information)
sensor fusion, ...

Vehicle Model:
behaviour in detail based on steering, acceleration, braking commands, under/oversteering
Tire-road contact

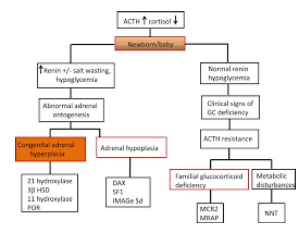
Road Model:
layout including markings, intersections, traffic lights, obstruction of view, …
map for look-ahead information

Traffic Model:
vehicles and other moving objects
behaviour of traffic participants (politeness/dominance, ...)

Reason for Exposure to Accidents

a) Failure of hardware components

b) Deficiencies in sensing road, traffic and environmental conditions

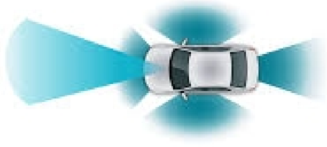


c) Deficiencies in control algorithms

d) Behaviour dependent accidents (traffic rule violation, ...)

e) Faulty driver and vehicle interaction (false command)

Deficiencies in Sensing Env. Conditions



Radar, camera, lidar, ultrasonic sensors …

Sensors in general are well tested by the manufacturer and in the field tests under various conditions (weather, lightning etc.).

However virtual simulation offers the possibility of extended tests if adequate sensor models are available which describe the phenomenological effects of sensors.

a) Fault injection.
b) Simulating incorrect sensing by image and signal manipulation.
c) Simulating extreme weather (lightning) conditions.

Fault injection (robustness testing)

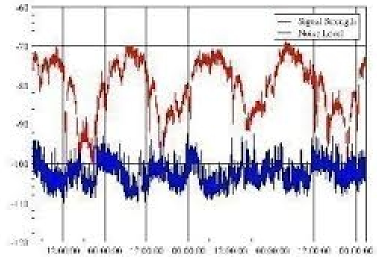
Simulating

a) tracking errors
   (pedestrians, cars, animals, …)
b) loss of object or non-existent object
c) partly missing, uncomplete information to the sensor

What is the effect on sensor fusion and decision making?

It can be done by image, signal manipulation and video manipulating algorithms.

Simulating incorrect sensing



Simulating

a) decrease in sensing range
b) decrease in image and sensor signal quality
c) quantifying results

What is the effect on sensor fusion and control algorithms?

It can be done by No-Reference Image Quality software (Neural Networks). At the same time it will also give a parameter range for the correct and incorrect behavior.

Simulating extreme weather (lightning) conditions

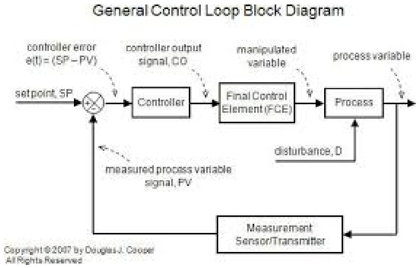
Simulating

a) heavy rain, fog, smoke, snow, ...
b) quick change in lightning conditions
c) quantifying results

What is the effect on sensor fusion and control algorithms?

It can be done by image and video manipulating software. Quantifying by NIQA.

Deficiencies in Control Algorithms



Challenges

a) challenges in stochastic systems;
- core operation of algorithms is based on random generation of candidates
- successful perception algorithms tend to be probabilistic

b) challenges in machine learning systems
- inductive learning, transfer learning
- decision algorithms (false positive – false negative trade -off)

Extremely challenging field. Algorithms, techniques under constant development. Always follow development in theory and low-risk area methods (medical systems, aerospace, ...)

General guidelines

a) Know your profession and develop yourself.

b) Know the standards, regulations, …

c) Have an overview about the whole project.

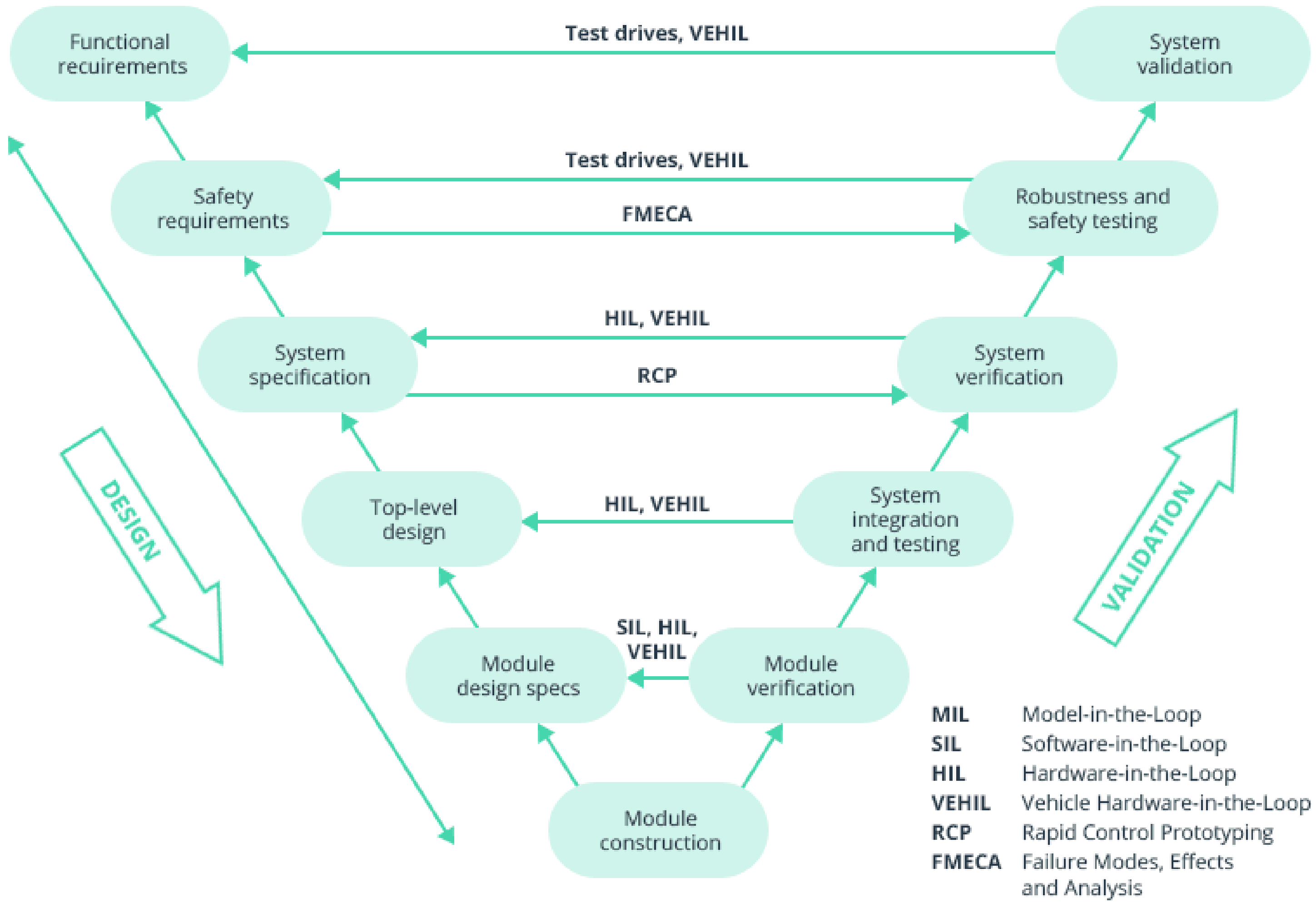
d) Always communicate upstream and downstream.

e) Follow the development in theory, sensors, concepts, …

f) Safety is not supposed but proven.

Background

V model of development



Development process in ISO 26262

3. Concept phase	4. Product development at the system level		7. Production and operation
3-5 Item definition	4-5 General topics for the product development at the system level	4-9 Safety validation	7-5 Planning for production, operation, service and decommissioning
3-6 Hazard analysis and risk assessment	4-6 technical safety concept	4-8 Item integration and testing	7-6 Production
3-7 Functional safety concept	4-7 System architecture design		7-7 Operation service and decommissioning
	5. Product development at the hardware level	**6. Product development at the software level**	
	5-5 General topics for the product development at hardware level	6-5 General topics for the product development at software level	
	5-6 Specification of hardware safety requirements	6-6 Specification of software safety requirements	
	5-7 Hardware design	6-7 Software architectural design	
	5-8 Evaluation of the hardware architectural metrics	6-8 Software unit design and implementation	
	5-9 Evaluation of the safety goal violations due to random hardware failures	6-9 Software unit verification	
	5-10 Hardware integration and verification	6-10 Software integration and verification	
		6-11 Testing of the embedded software	

Scenarios in three phases

Scenarios may support the whole development process so it is mandatory to define requirements on scenarios resulting from process steps

Scenarios in **concept phase**

= hazard analysis
= risk assessment
- situation analysis
- hazard identification, Classification
...

C1 human experts formulate scenarios in natural language

C2 represented in a semi-formal way

Scenarios in the system **development phase**

= functional safety concept is developed
= criteria physically quantified
- list of variables
- state values
...

S1 parameter ranges for the state values

S2 formal notation for automated processing

Scenarios for **verification and validation**

Test case specifications
= unique ID
= reference to the work product
= preconditions/configurations
= environmental conditions
= input data/time sequences
= expected behavior/acceptable variations

T1 modelled via concrete state values, reproducibility

T2 without any inconsistencies

T3 represented in an efficient machine readable way

Terminology along design/test process

Some researchers (Menzel, Bagschik, Maurer; ICE Braunschweig) find scenario representations in ISA 26262 contradictory and they suggest on three levels of abstraction

A) **Functional scenarios;**

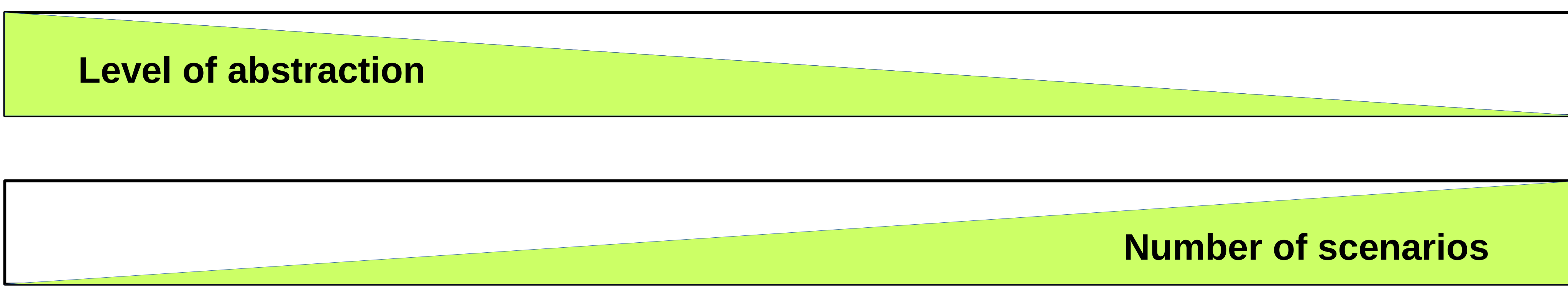
- operating scenarios on a semantic level
- linguistic scenario notation
- vocabulary for use case and domain

B) **Logical scenarios;**

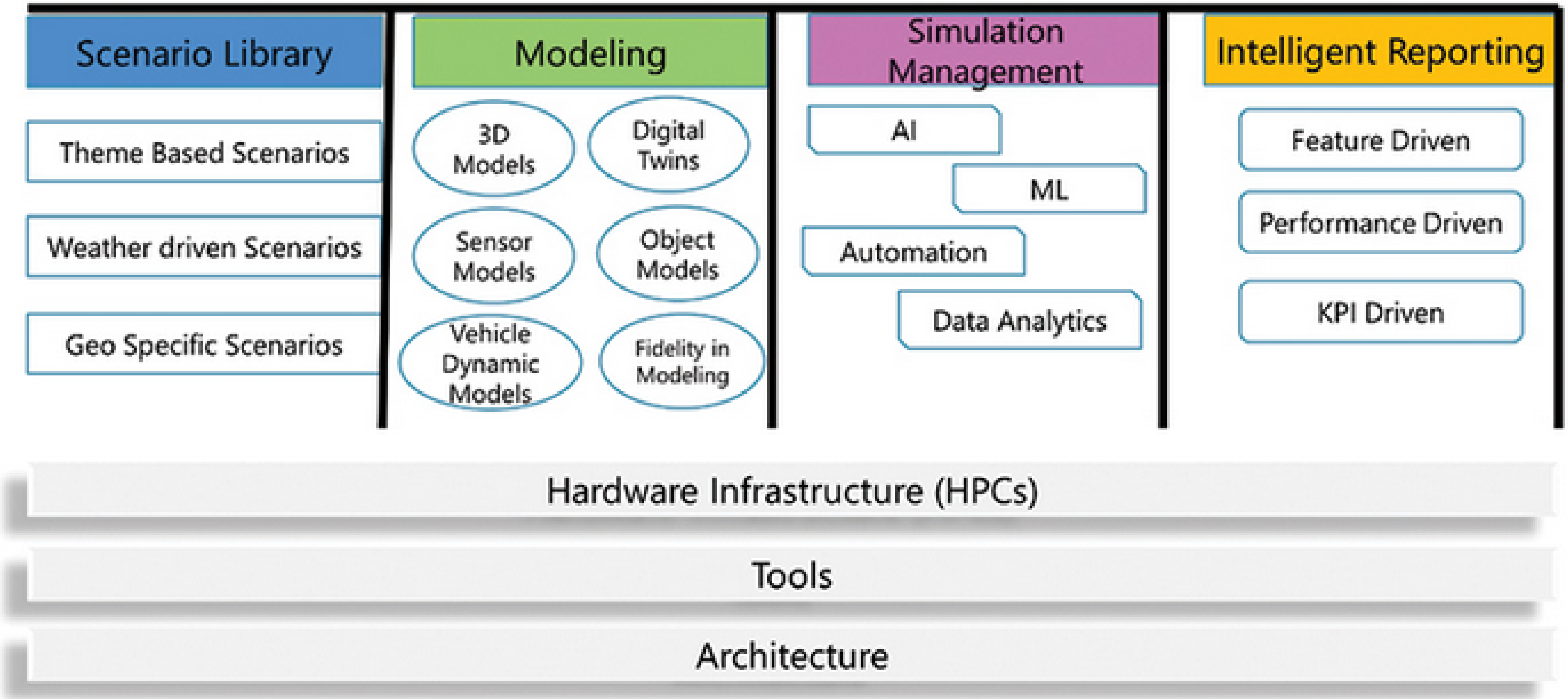
- operating scenarios on a state space level
- entities/relations represented with parameter ranges/evt. probability distributions
- relation evt. with correlations
- formal notation

C) **Concrete scenarios;**

- operating scenarios distinctively on a state space level
- entities/relations with concrete values for each parameter



Areas in virtual environmental simulation



Pegasus project – Key Figures

42 months term	January 1, 2016 – June 30, 2019
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

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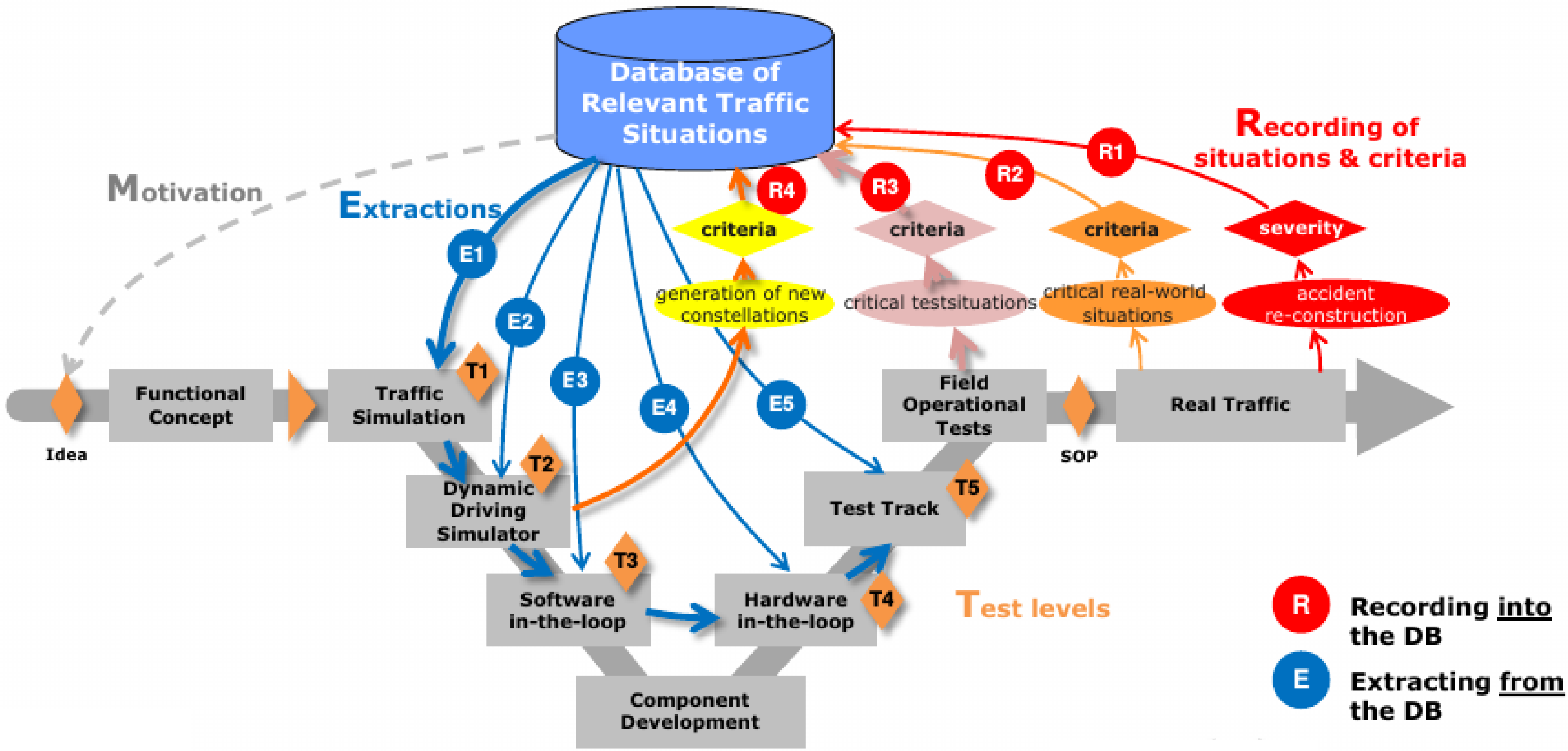
Database Approach



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Database Processing Chain

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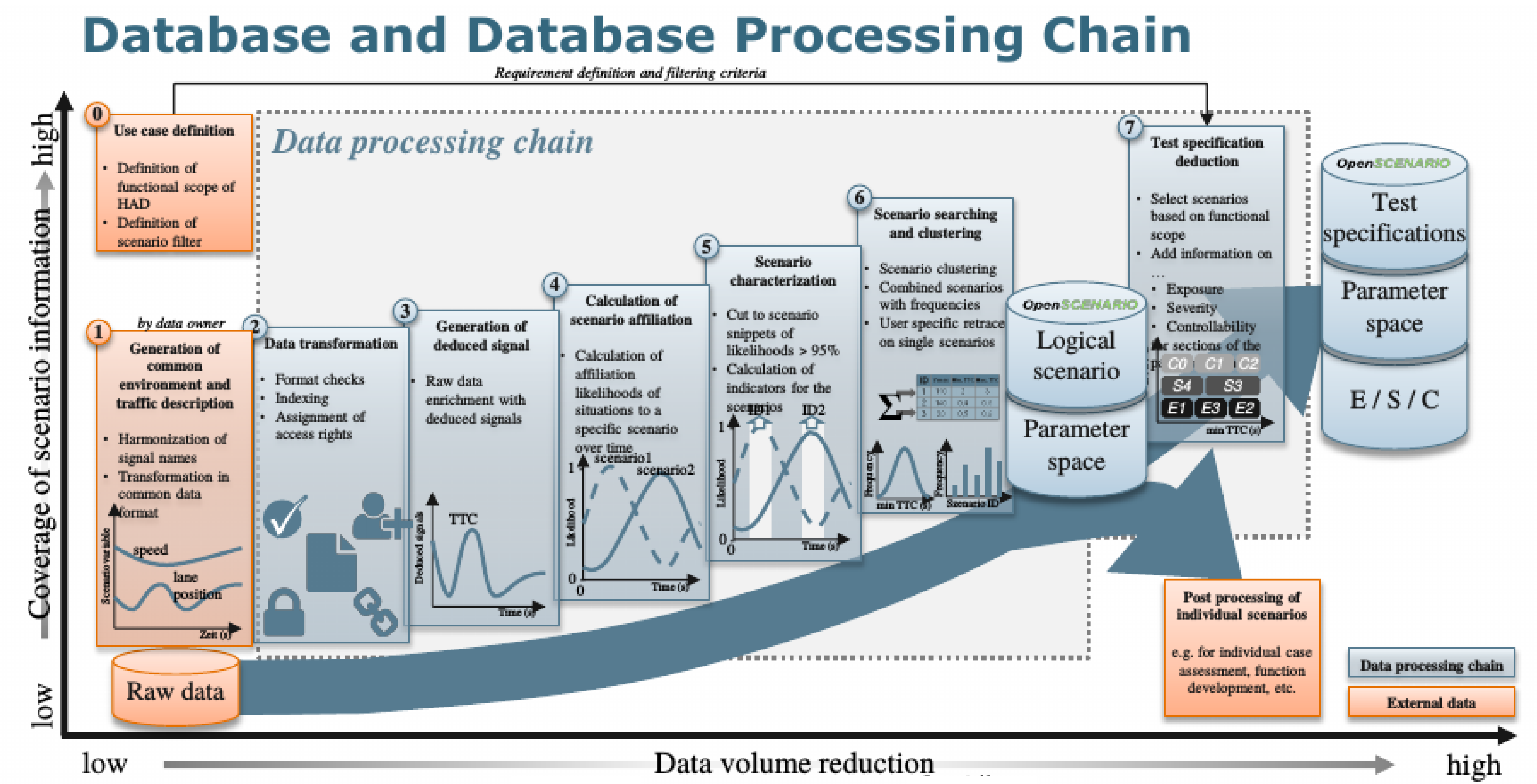
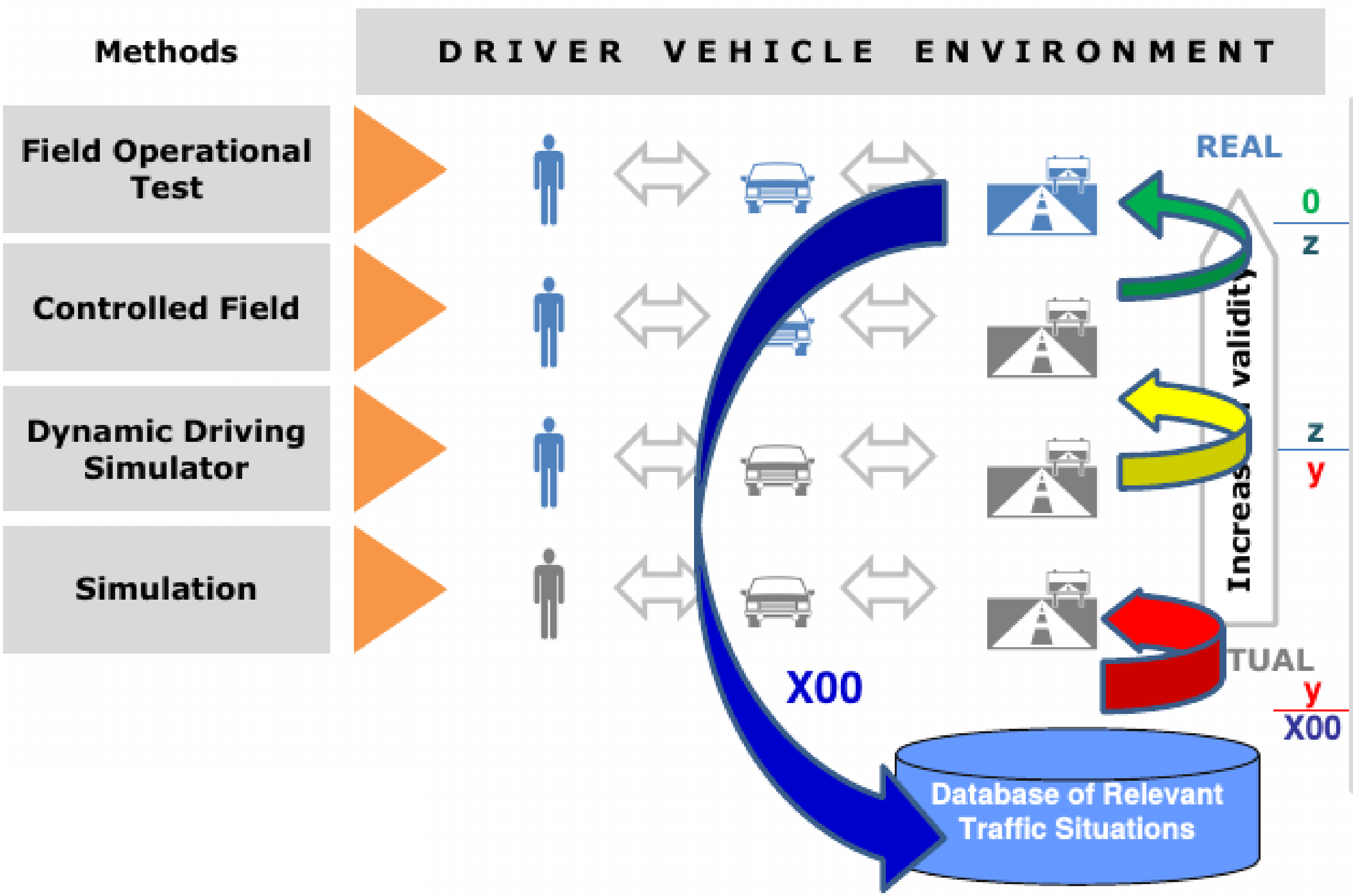


Challenges Validation CAD



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).

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Pegasus; Research Questions

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

Scenario Analysis & Quality Measures

- What human capacity does the application require?
- What about technical capacity?
- Is it sufficiently accepted?
- Which criteria and measures can be deducted from it?

Implementation Process

- Which tolls, methods and processes are necessary?

Testing

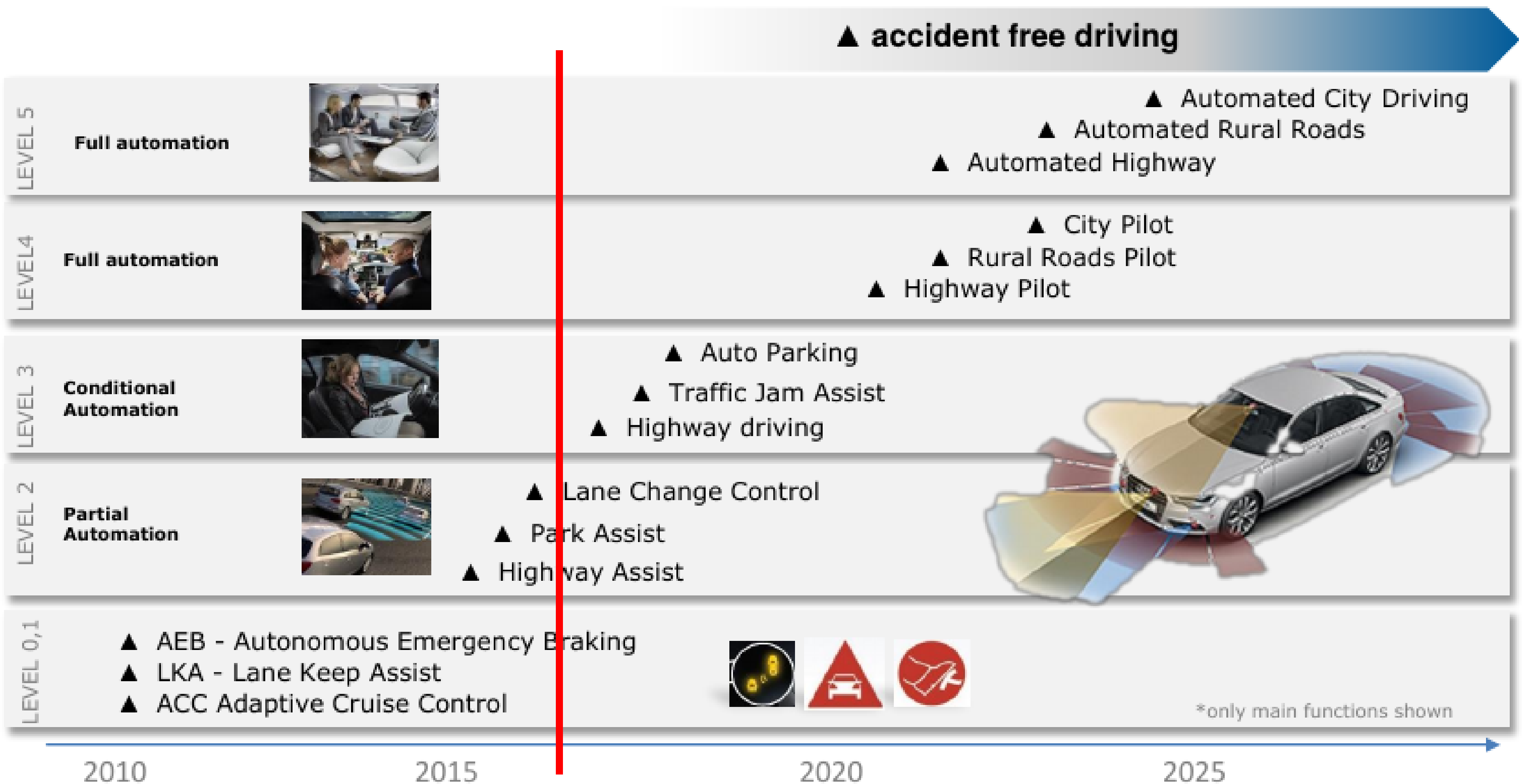
- How can completeness of relevant test runs be ensured?
- What do the criteria and measures for these test runs look like?
- What can be tested in labs or in simulation? What must be tested on test grounds, what must be tested on the road?

Reflection of Results & Embedding

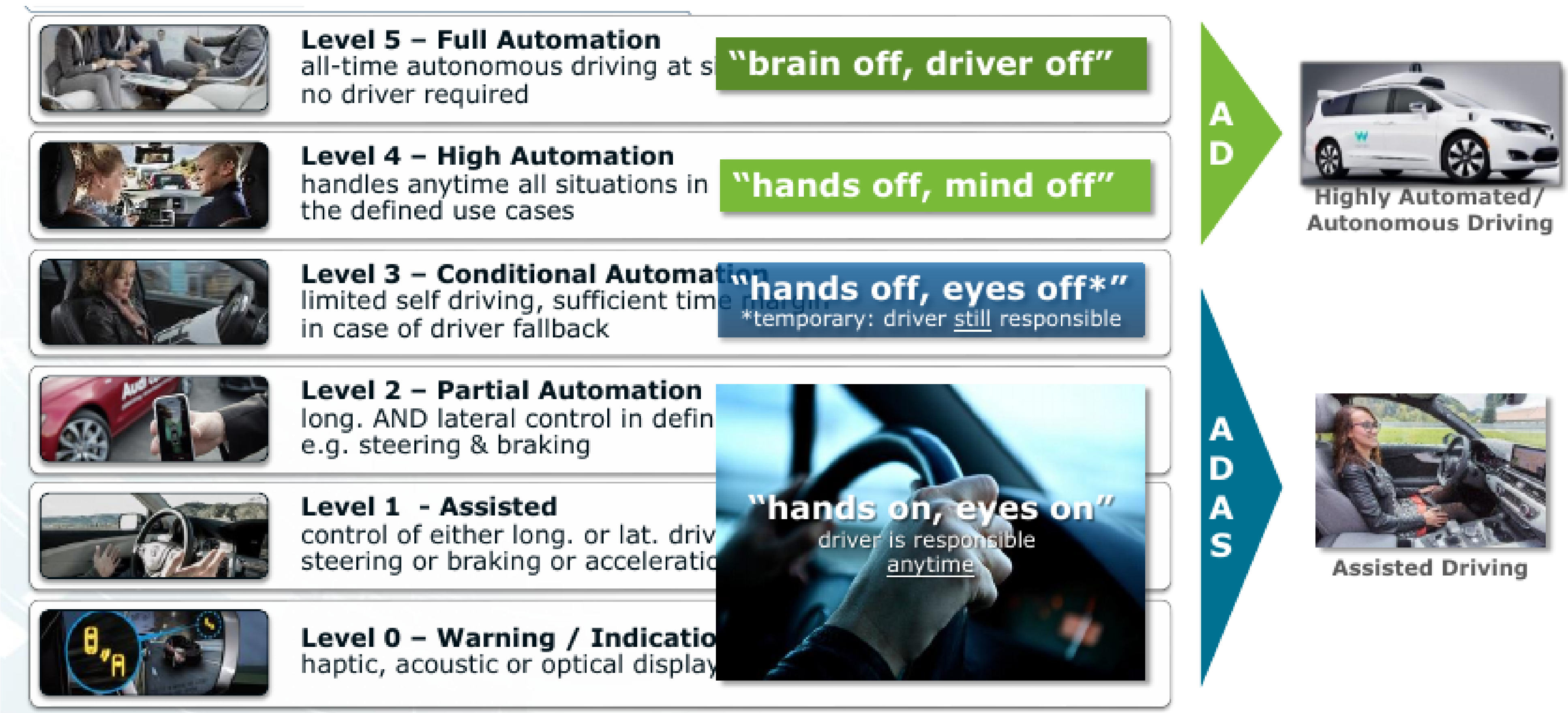
- Is the concept sustainable?
- How does the process of embedding work?

Race for ADAS

Prof. Dr. Stefan Schneider
Gerhard Steininger
Steffen Lange



6 levels of Automated Driving (SAE)



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