Public relations
• Public & politic reactions in case of accidents
• Customer acceptance
• Cyber security
• Ethic
Technical
• Functional safety & Reliability in all conditions (Traffic, Weather & Road)
• Infinite high number of test cases
• Complex and new technology
• Time & Cost pressure during development
Legislative
• Homologation criteria
• Responsibility in case of accident
The rocky road to
ADAS/AD
Development, Validation and Homologation

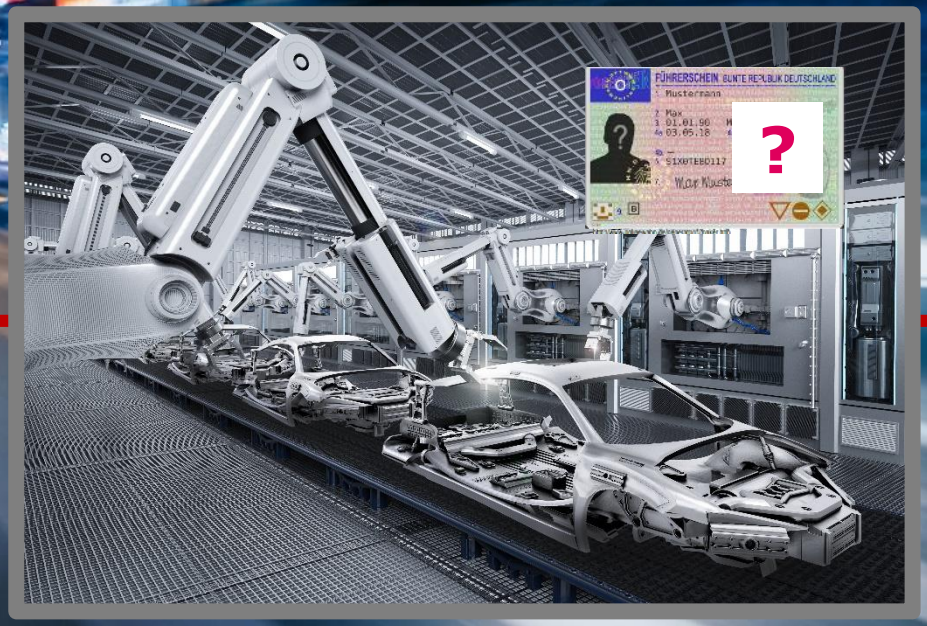
Now

Level 5
Future

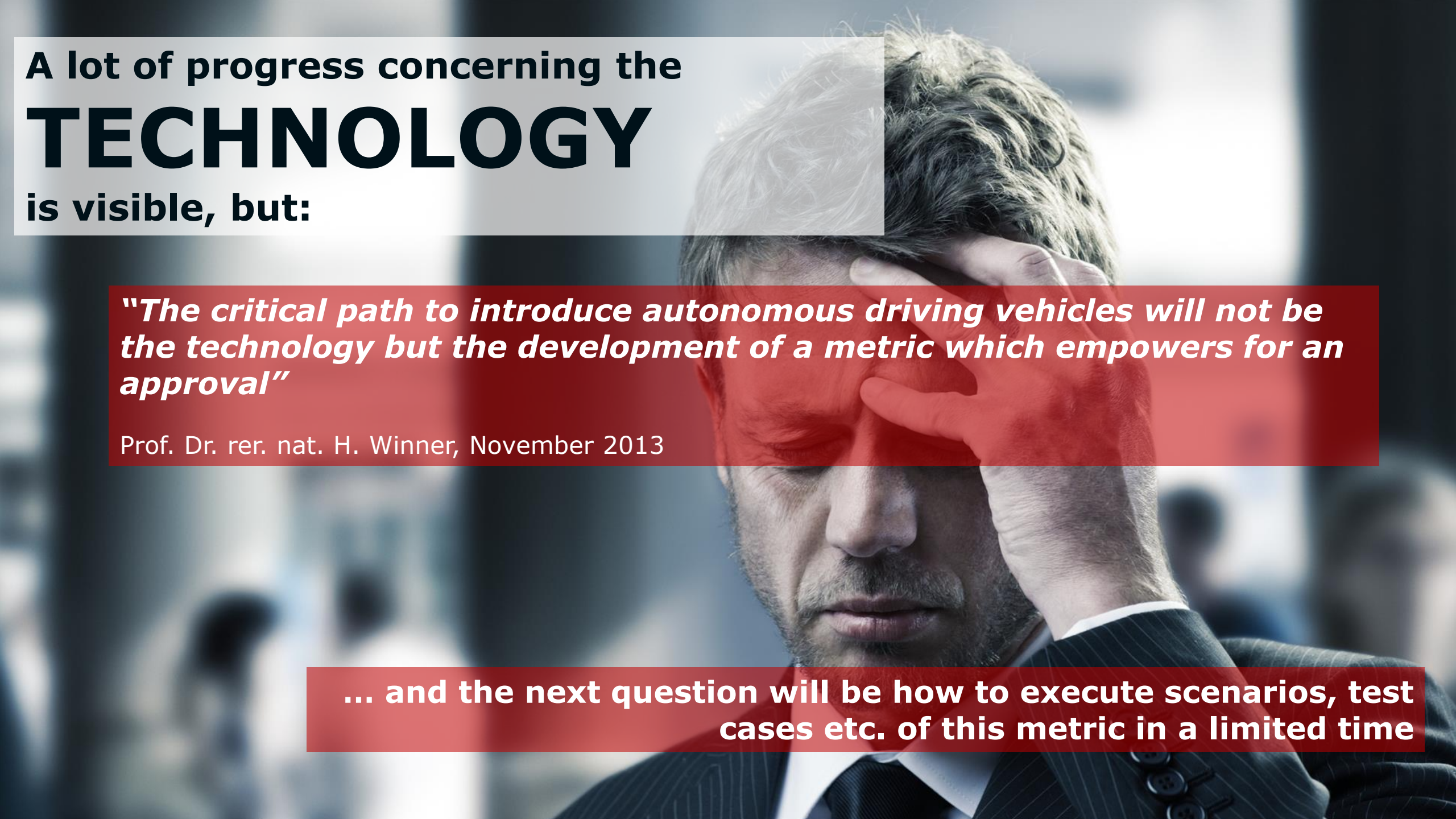
Driver's License

Regulations

?



Responsibility



A lot of progress concerning the

TECHNOLOGY

is visible, but:

"The critical path to introduce autonomous driving vehicles will not be the technology but the development of a metric which empowers for an approval"

Prof. Dr. rer. nat. H. Winner, November 2013

... and the next question will be how to execute scenarios, test cases etc. of this metric in a limited time

"The biggest hurdle is validation to confirm that the system does not cause failures. One has to execute 250 million test kilometers"

Bosch Executive Director.

Same approaches as 36 years ago?

Mercedes-Benz 190 E (1982) - Demonstration and advantages of ABS

New and Innovative Approaches in

Testing and Validation

are necessary!

Facing the Challenges of Development and Homologation of Autonomous Driving Using Virtual Approaches

AVL

Vehicle Validation and Self Driving Vehicle

NVIDIA

Driving Software and Digital Driver

TÜV SÜD

Legislation, Regulations and Conformity

In cooperation with research partners

Hochschule Kempten
University of Applied Sciences

Background and Homologation

Dr. Houssem Abdellatif

Global Head Autonomous Driving and ADAS

Driving Test: Human vs. Machine

Human → **!** → **Machine**

http://www.onlinewahn.de/generator/f-maker.htm

Responsibility

http://www.onlinewahn.de/generator/f-maker.htm

Today

- Level 0: Driver Only
- L1: Assisted
- L2: Partially automated

Tomorrow

- Level 3: Highly automated
- Level 4: Fully automated
- Level 5: Driverless

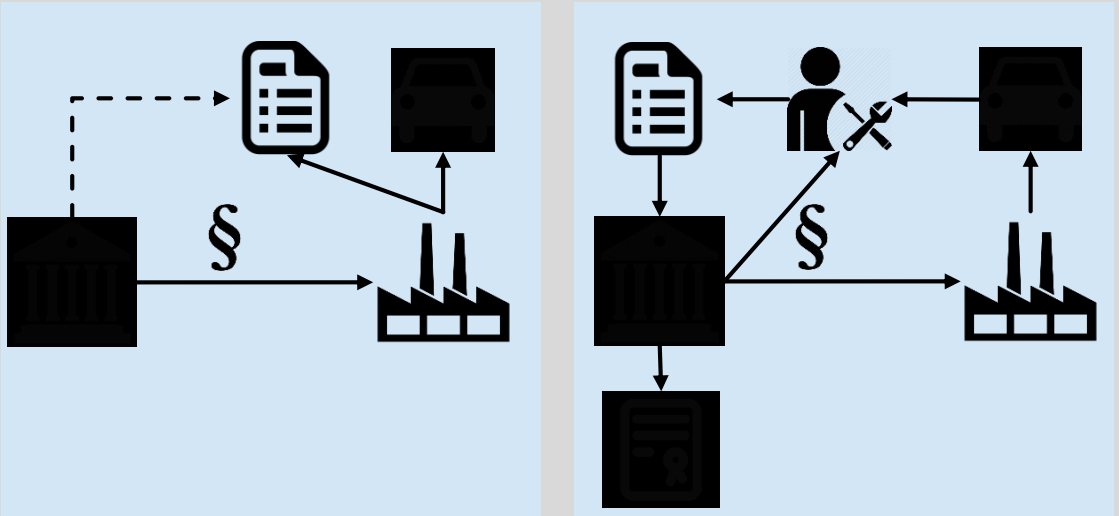
Homologation and Type Approval

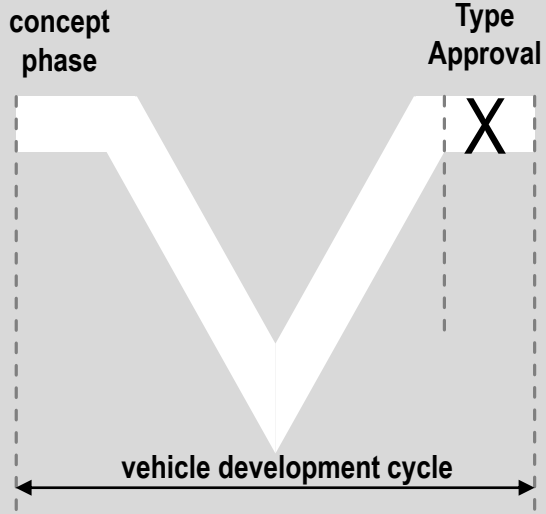
Definition

Homologation refers to the certification process of a product (vehicle) granting that it complies with all local standards and legal regulations such as safety and environmental regulation.

No homologation → No CoC → No sales

Self certification vs. type approval 3rd party principle





Type Approval in vehicle development

- Last step of development
- Accomplishment of the v-cycle
- legal and technical approval of the concept

- European Union: Directive 2007/46/EC Type approval, tests are based on United Nations Economic Commission for Europe (UN/ECE) procedures;
- North America: Federal Motor Vehicle Safety Standards (FMVSS) regulations released by the NHTSA;
- Australian Design Rules (ADR) regulations;
- Japan follows UN/ECE regulations and their own Test Requirements and Instructions for Automobile Standards (TRIAS) regulations;
- Other countries that accept or base their own regulation on those mentioned above, following the latest release or previous versions of the regulations.

UN/ECE-Regulation 140: Homologation of ESC Systems

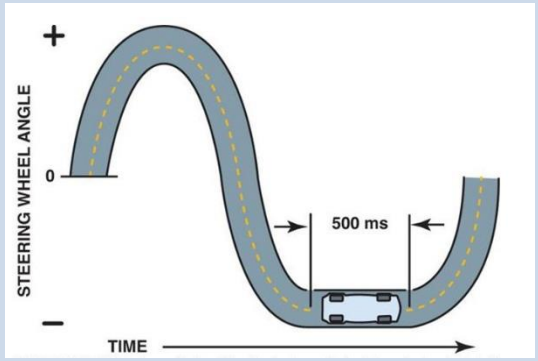
**„Where a vehicle has been physically tested in accordance with […],
the compliance of versions or variants of that same vehicle type may be demonstrated by a computer simulation […].”**

01 Define vehicle representative of the type to be homologated, and test it under dynamic maneuvers

02 Generate the vehicle simulation and correlate the obtained data

03 Simulate critical variants

Sine with Dwell (SwD) maneuver



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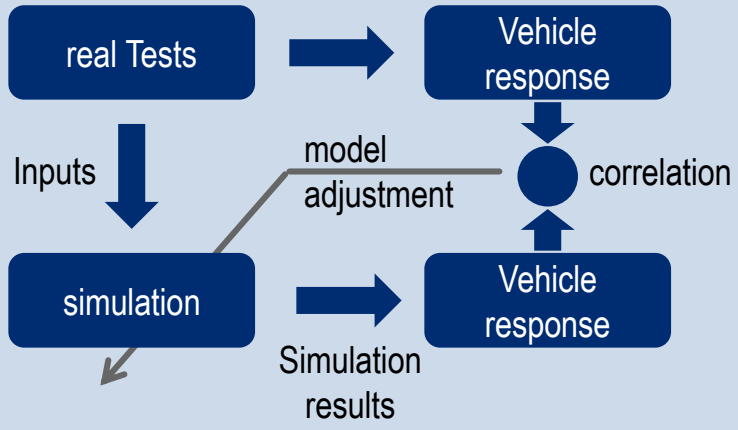
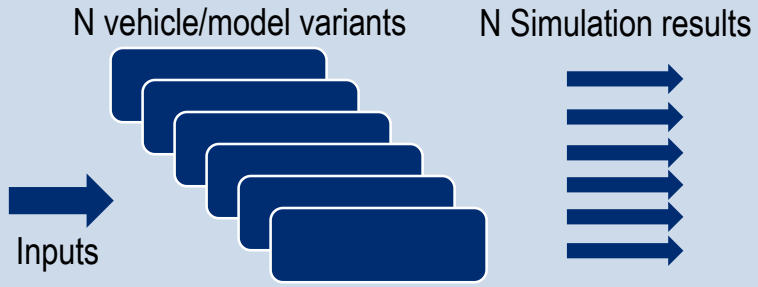
Approval testing & collecting data

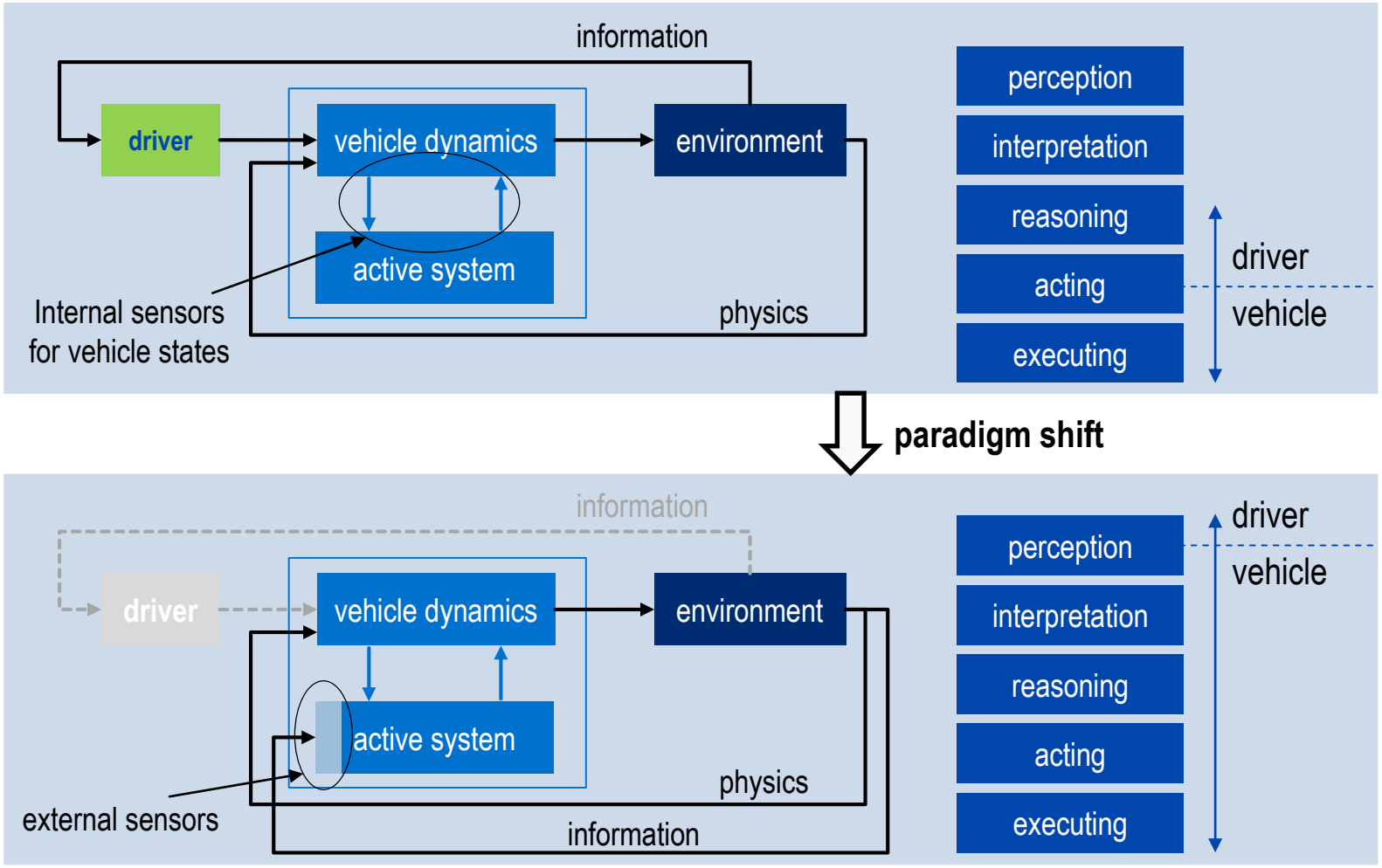


Model validation



Approval & assessment of variants by using validated simulation model

ESC vs. Automated Driving



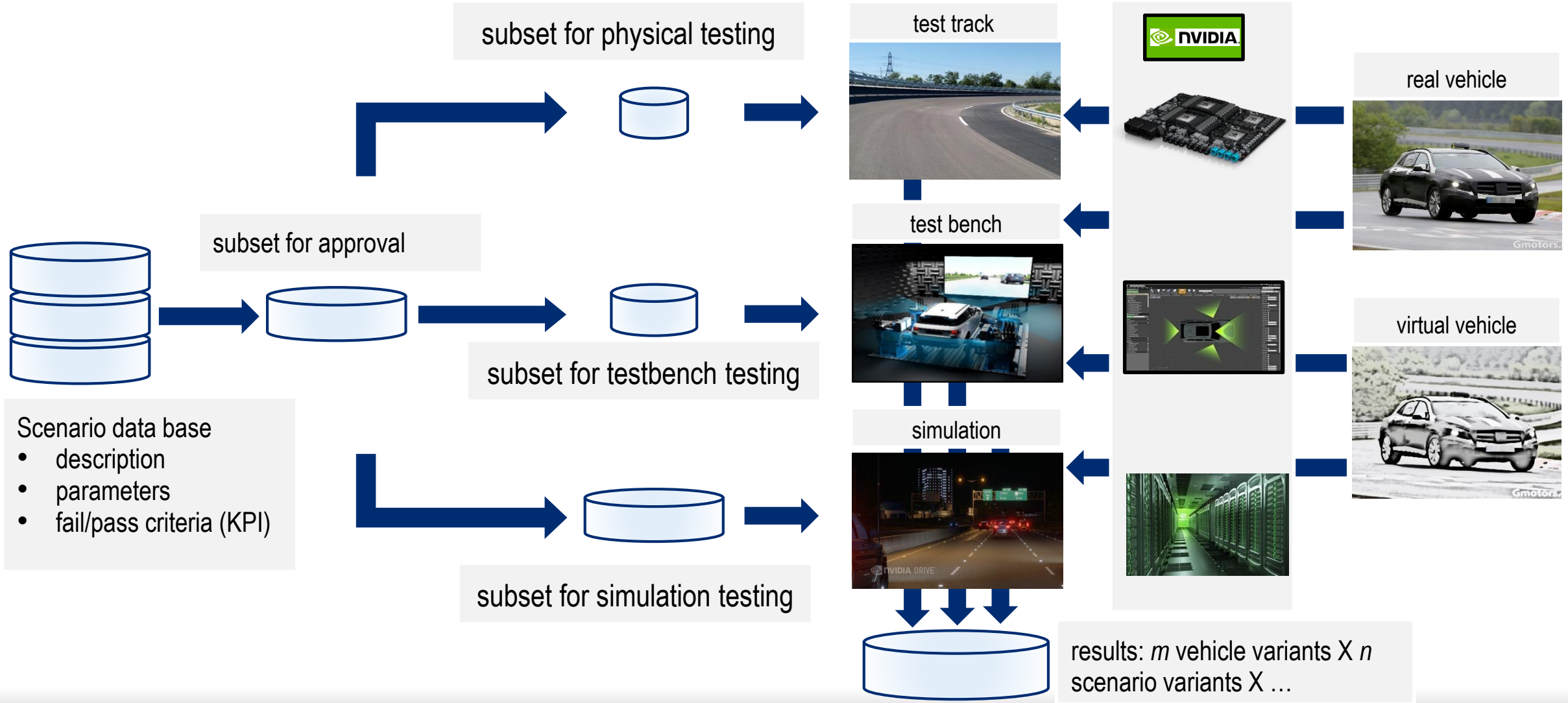
Sense and control of internal vehicle

- ✓ Similar homologation / validation architecture:
  - Environment
  - Sensor – Function / active system – Vehicle (dynamics)
  - (Driver)
- ✓ Methodology can be reused and extended to automated driving

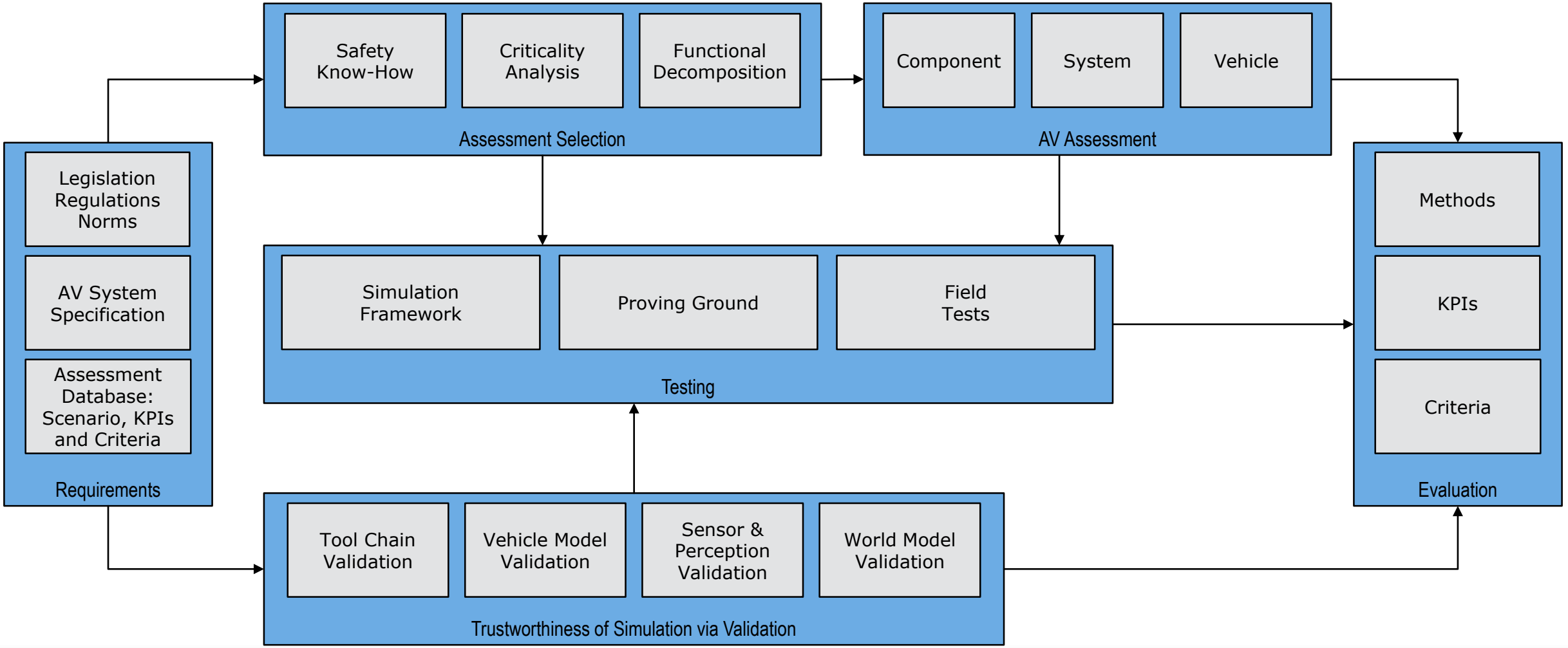
→ **Simulation aided / supported homologation of automated driving functions**

Sense and control in external environment

Combining Tools (Tool Chain) for Concise Approval



Virtual-based Assessment for L3+AVs



Virtual Testing Methods

Prof. Bernhard Schick

Professor for Vehicle Dynamics and Advanced Driver Assistance Systems

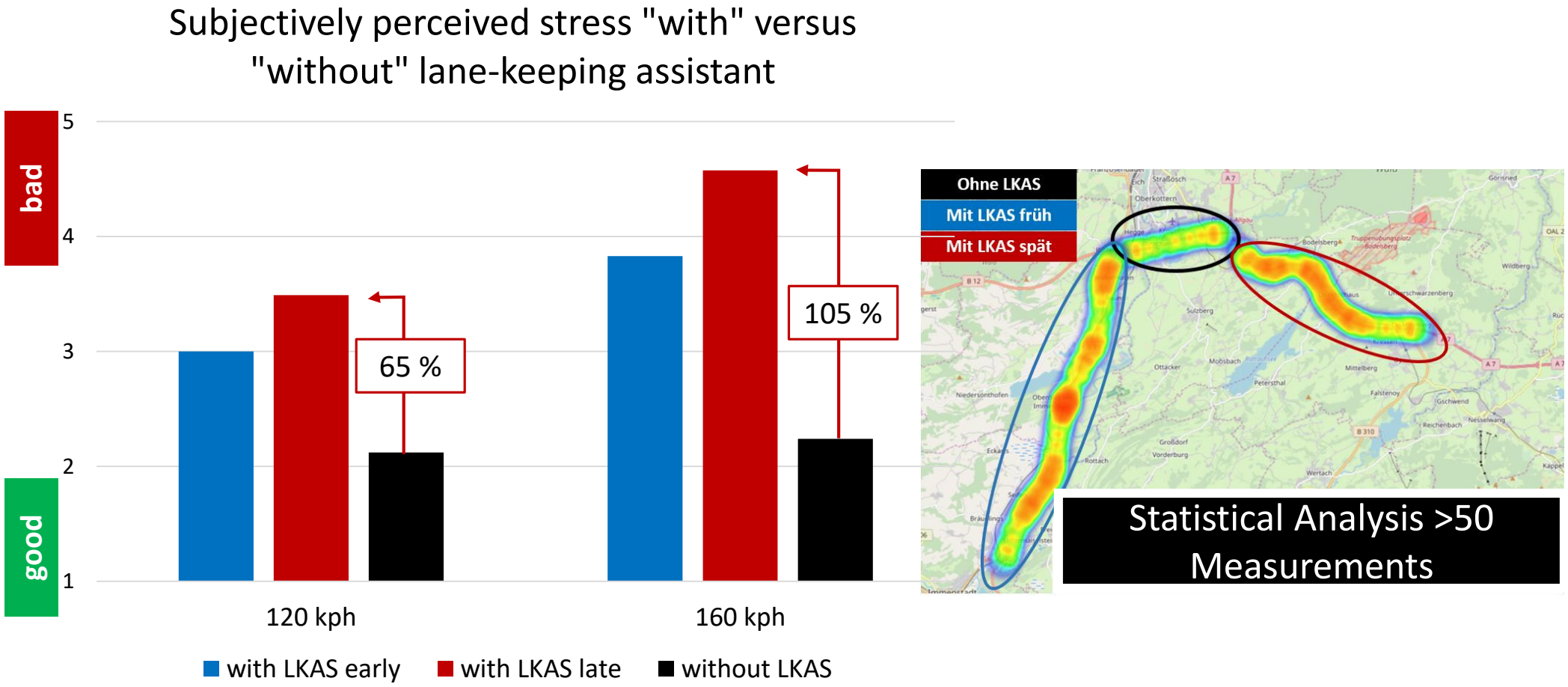
Hochschule Kempten
University of Applied Sciences

Positive driving experience remain important!

90
Alligator
289 km 9°C
14:45
1 Object Hopping
2 Object Lost
3 Sudden System Drop-Out

Challenges

Subjects feel more stressed and unsaved with LKAS instead of without LKAS



"The most important thing about a ADAS/AD is that it is common used.

And it's only used when it's experienced as safe, usefulness and ease of use.“

People want a perceived safety of 100%.

Paradigm change

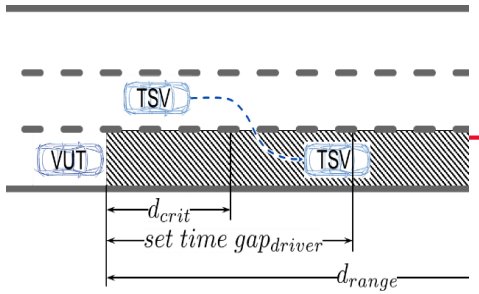
How to transfer todays “fun-to-drive” into future “fun-to-be-driven” within a attribute driven development?

We need a very high level of environment knowledge and anticipatory understanding of the situation!

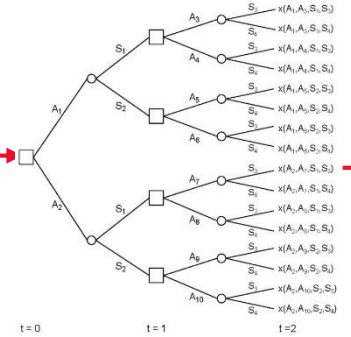
Rule based vs. artificial intelligence

How complex, reproducible and understandable are the methods?

Sensor Input
(Fused Sensors)



Maneuver Interpretation

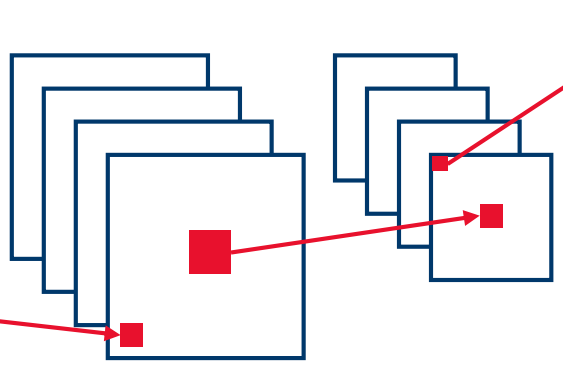


Decision Tree

Function

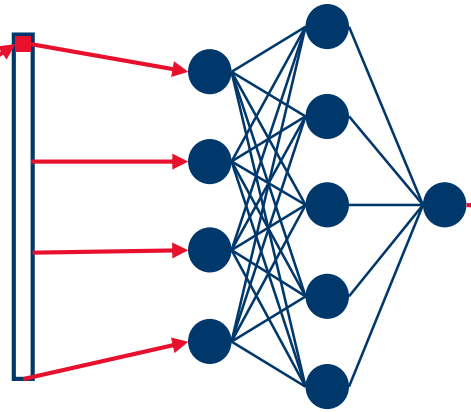
Output Vector

Sensor Input
(Image)



Folding Level

Pooling Level



Fully Connected Level

Output Vector

Lateral control in complex environments!

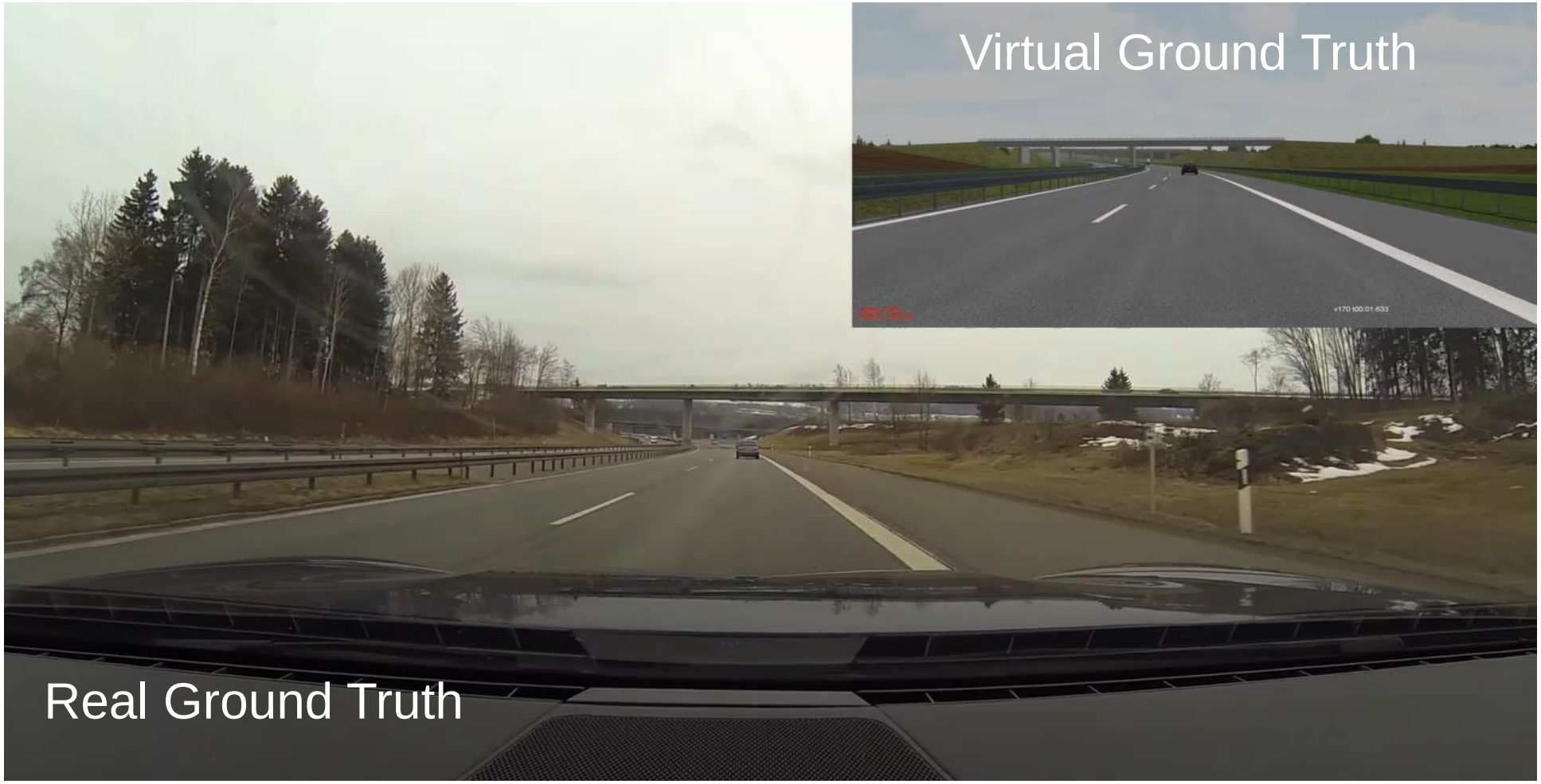
- markings heavily weathered
- partly no center marking
- dirty roads
- no side lines in sections
- uneven road with inclination changes
- heavy vehicle response

1 Drift Weaving

2 Sudden System Drop-Out

Learning challenges of artificial intelligence

Detailing of labeling and the process to build up the simulation environment will have a effect to the results.



The Toolchain

Dr. Tobias Düser

Department Manager
Advanced Solution Lab

AVL

A seamless but open toolchain with new approach is necessary

Simulation	Virtual Testing	Proving Ground	Real World

Maneuver, Scenario, Test Case Abstraction incl. KPIs

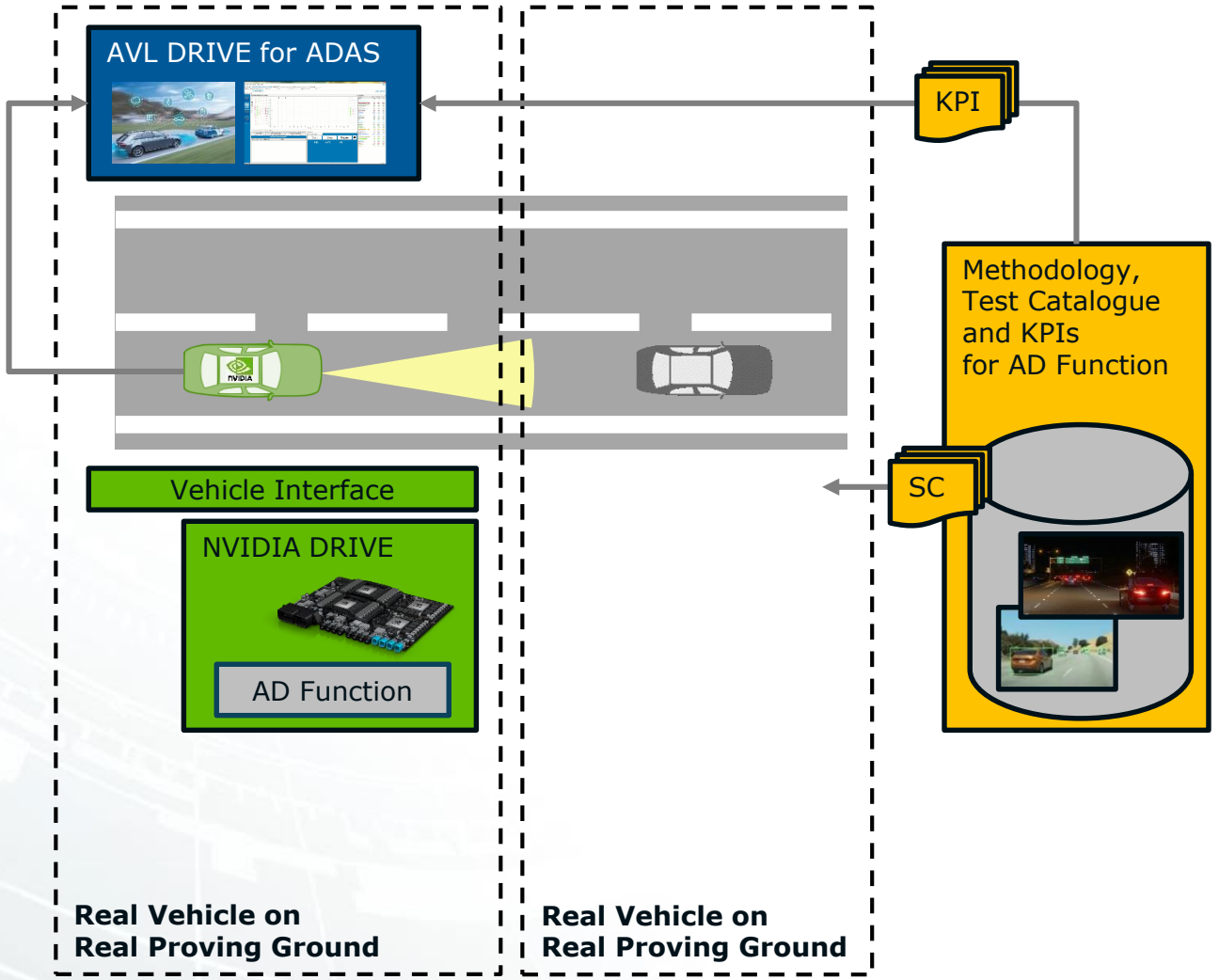
Environment Abstraction

Vehicle Abstraction

Same Results

The most efficient validation will be done by those who will use the best combination!

Reference: Proving Ground

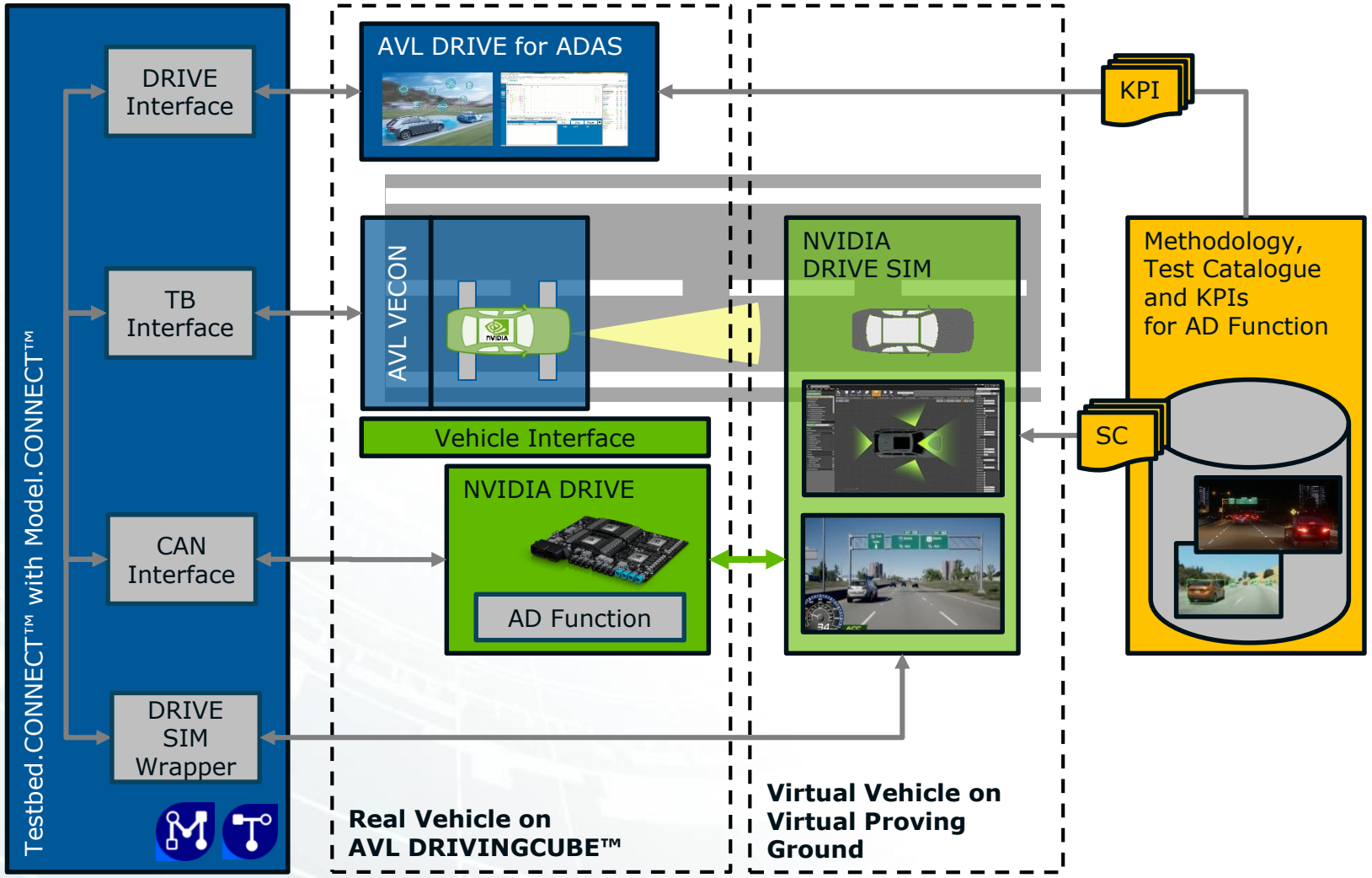


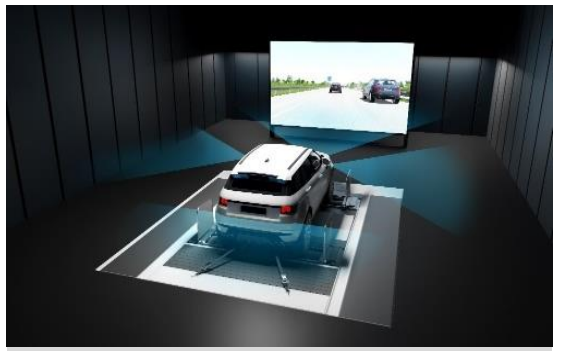
Proving Ground

- ✚ very close to the real operation
- ━ expensive, high effort, less repeatability

Vehicle Under Test

Architecture Virtual Testing @ the DrivingCube





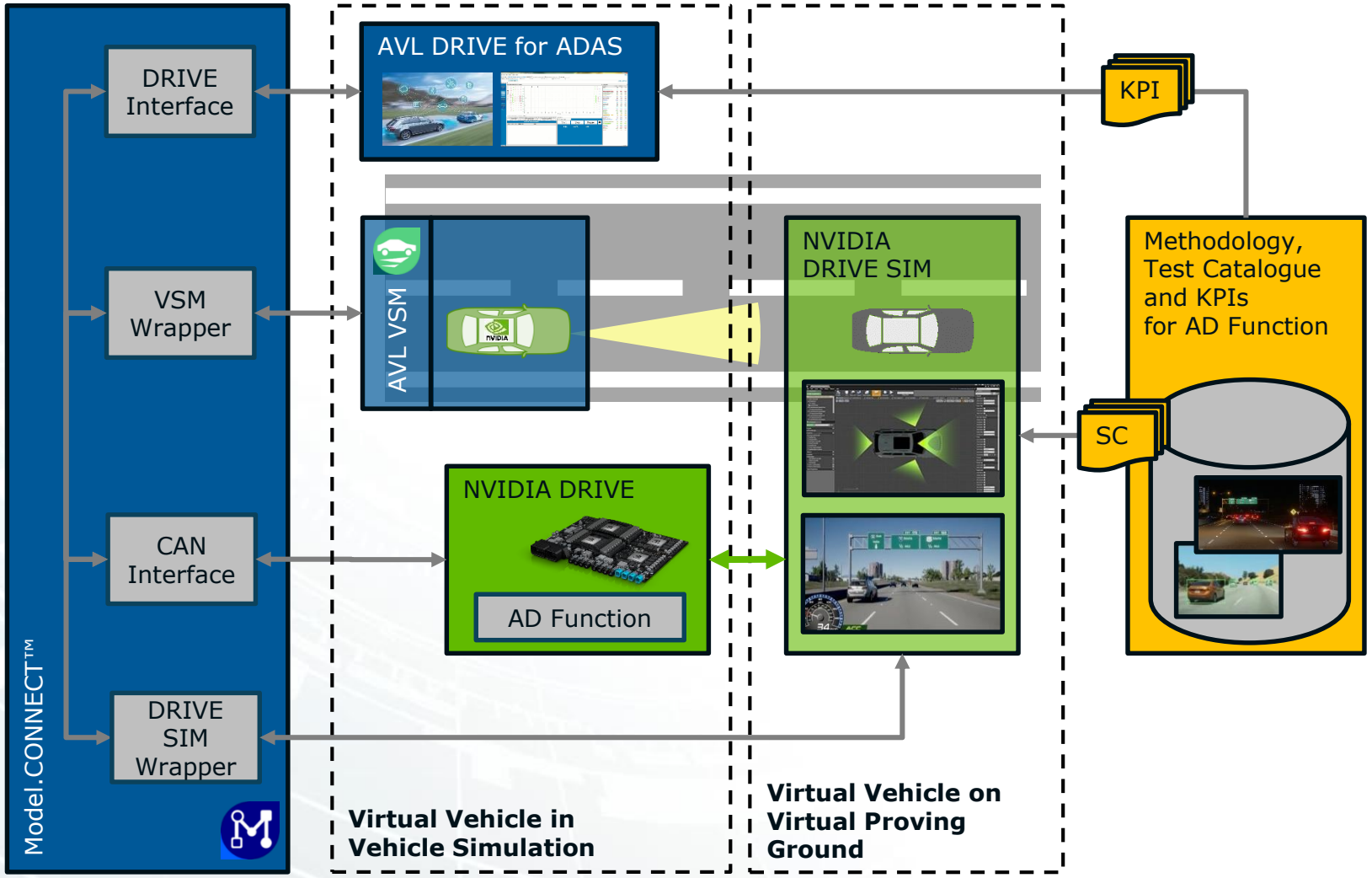
Virtual Testing

+ close to real operation, chassis dynos are already established for homologation (emissions)
- limited in terms of lateral dynamics

Vehicle Under Test

OMATED DRIVING
EVELOPMENT and VALIDATION

Architecture Simulation



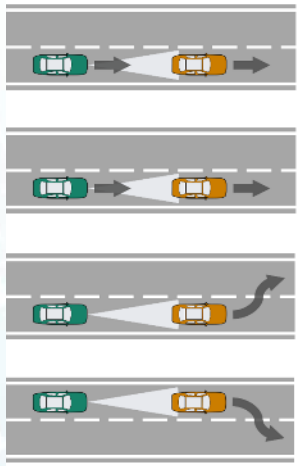
Simulation

+ fast, flexible and cheap in operation, there are already ESC homologation

– processes in simulation is only as good as the model(s)

Vehicle Under Test

First Results / First Comparison



Scenario 1:

From standstill follow-up with 50 km/h reducing to 30 km/h back up to 50 km/h and 30 km/h again

Scenario 2:

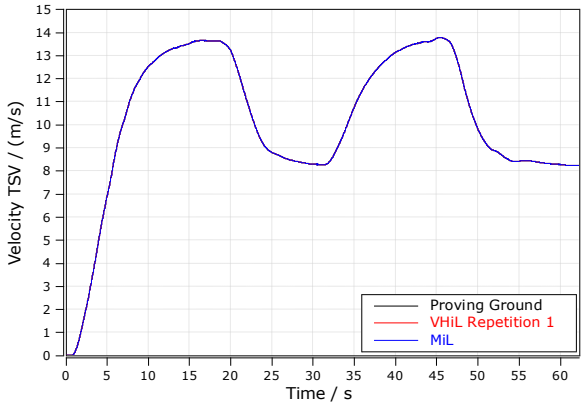
From standstill follow-up with 80 km/h reducing to 60 km/h back up to 80 km/h

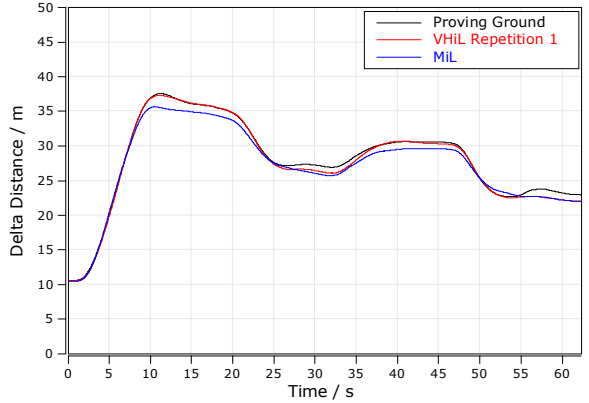
Scenario 3:

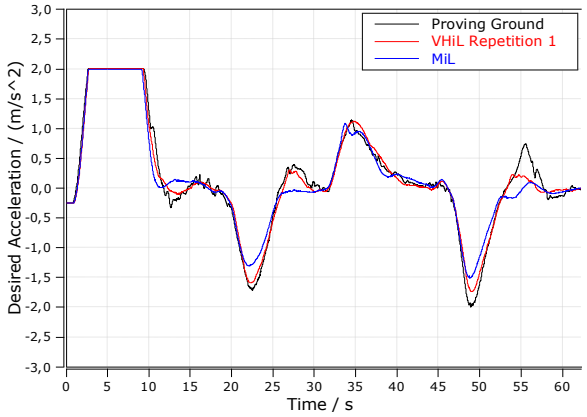
From standstill follow up with 60 km/h, TSV pull out left, VUT accelerate to 80 km/h

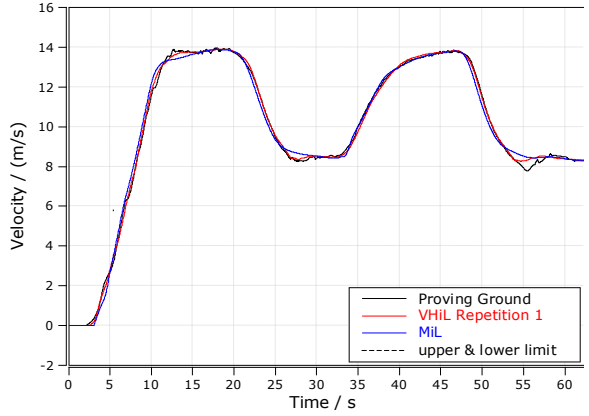
Scenario 4:

From standstill follow up with 60 km/h, TSV pull out right, VUT accelerate to 80 km/h

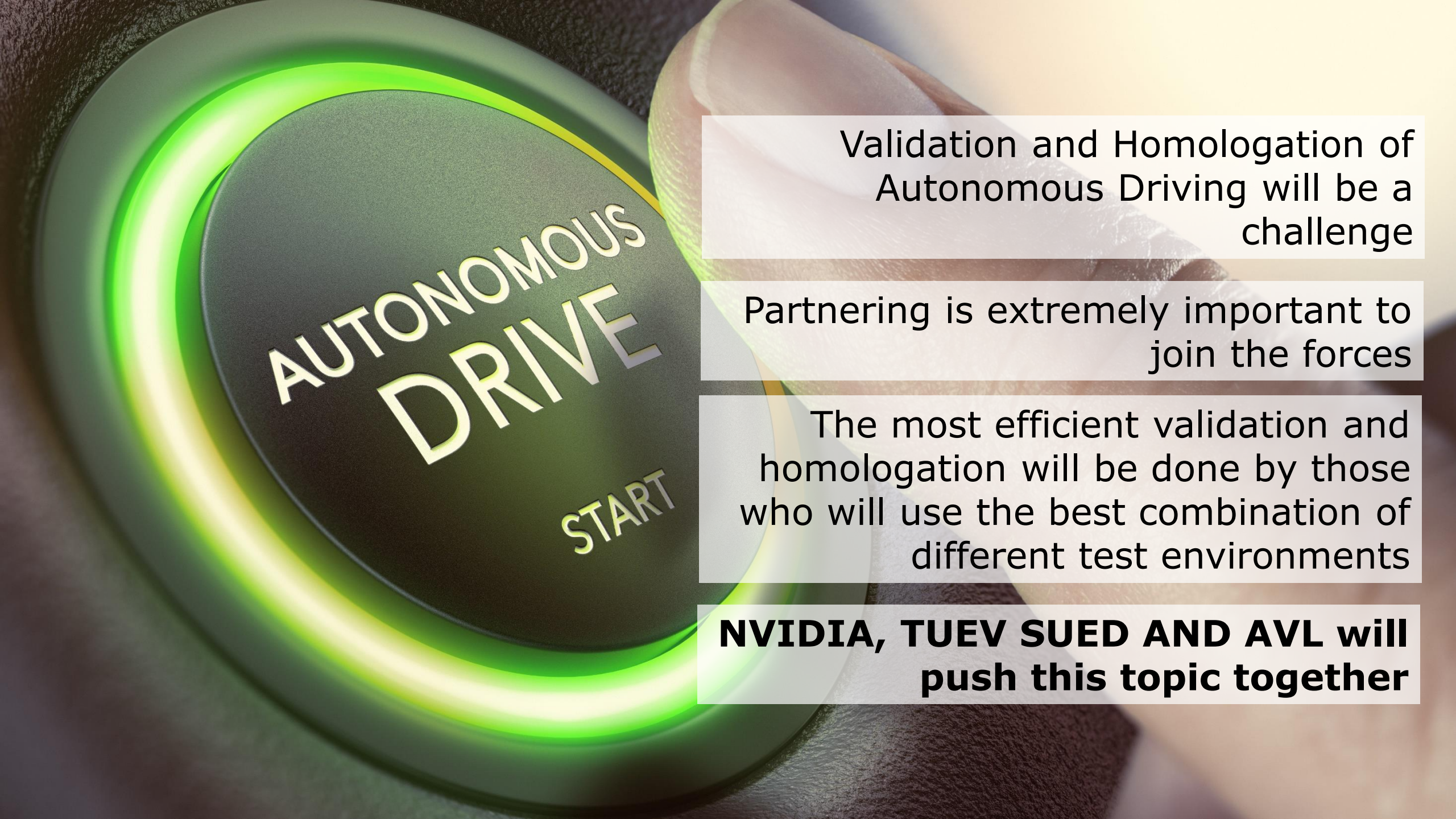








Riedmaier, S.; Nesensohn, J.; Gutenkunst, C.; Düser, T.; Schick, B.; Abdellatif, H.: **Validation of X-in-the-Loop Approaches for Virtual Homologation of Automated Driving Functions**, GSVF Symposium 2018, Graz



Validation and Homologation of Autonomous Driving will be a challenge

Partnering is extremely important to join the forces

The most efficient validation and homologation will be done by those who will use the best combination of different test environments

NVIDIA, TUEV SUED AND AVL will push this topic together

Source: https://de.upost.info/31383037343032393936