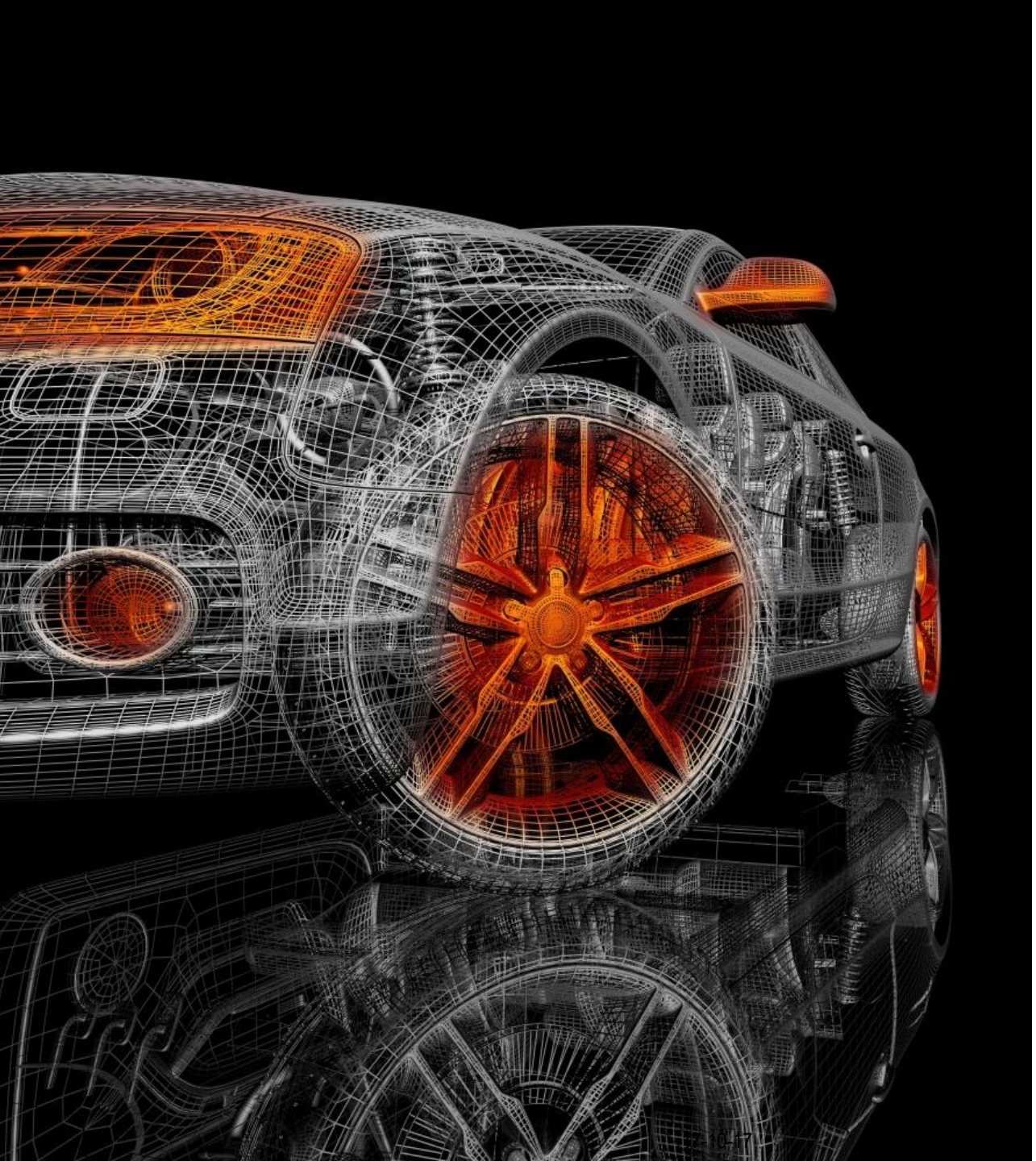

Choose certainty.
Add value.

Virtual Homologation of Software-Intensive Safety Systems: From ESC to Automated Driving

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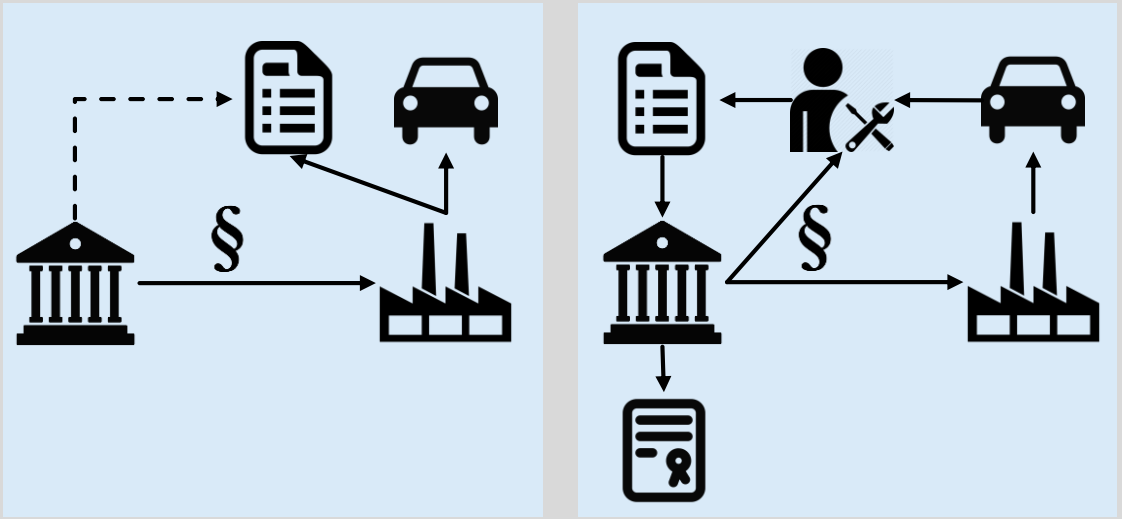
Homologation and Type Approval

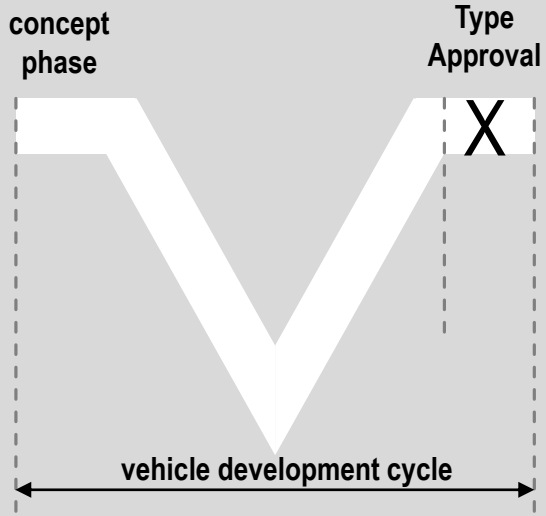
Definition

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





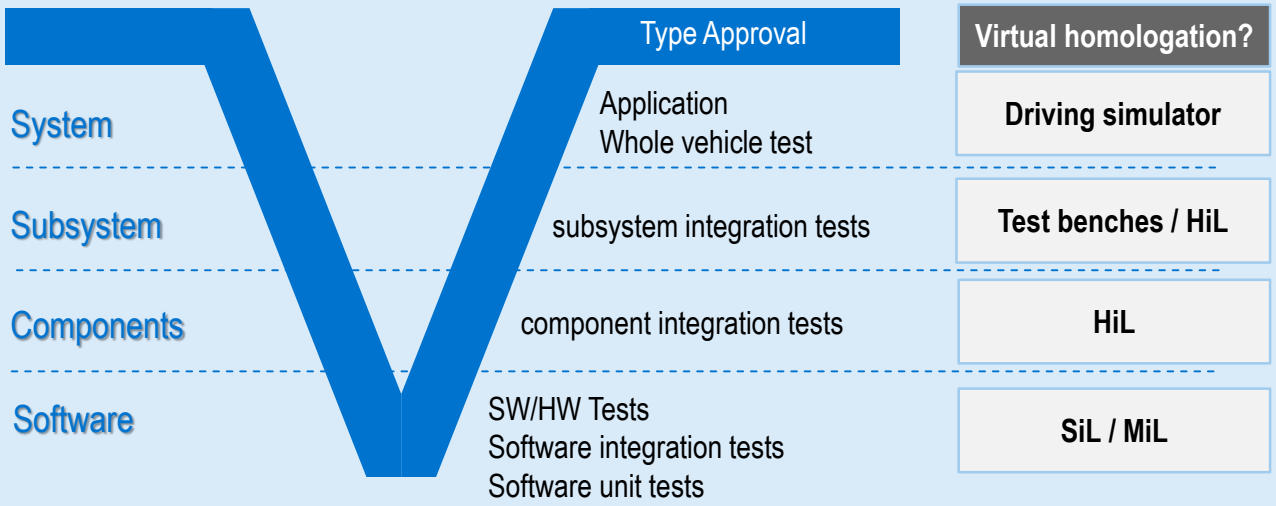
Type Approval in vehicle development

- 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.

Using Simulation in Homologation

Using simulation in vehicle development and testing



Simulation is used at different testing levels through the development cycle

- Software in the loop
- Model in the loop
- Hardware in the loop
- Vehicle in the loop
- Driving simulators

Can Simulation be used in the homologation process?

How would an approach looks like?

Motivation for simulation (virtual methods) in homologation

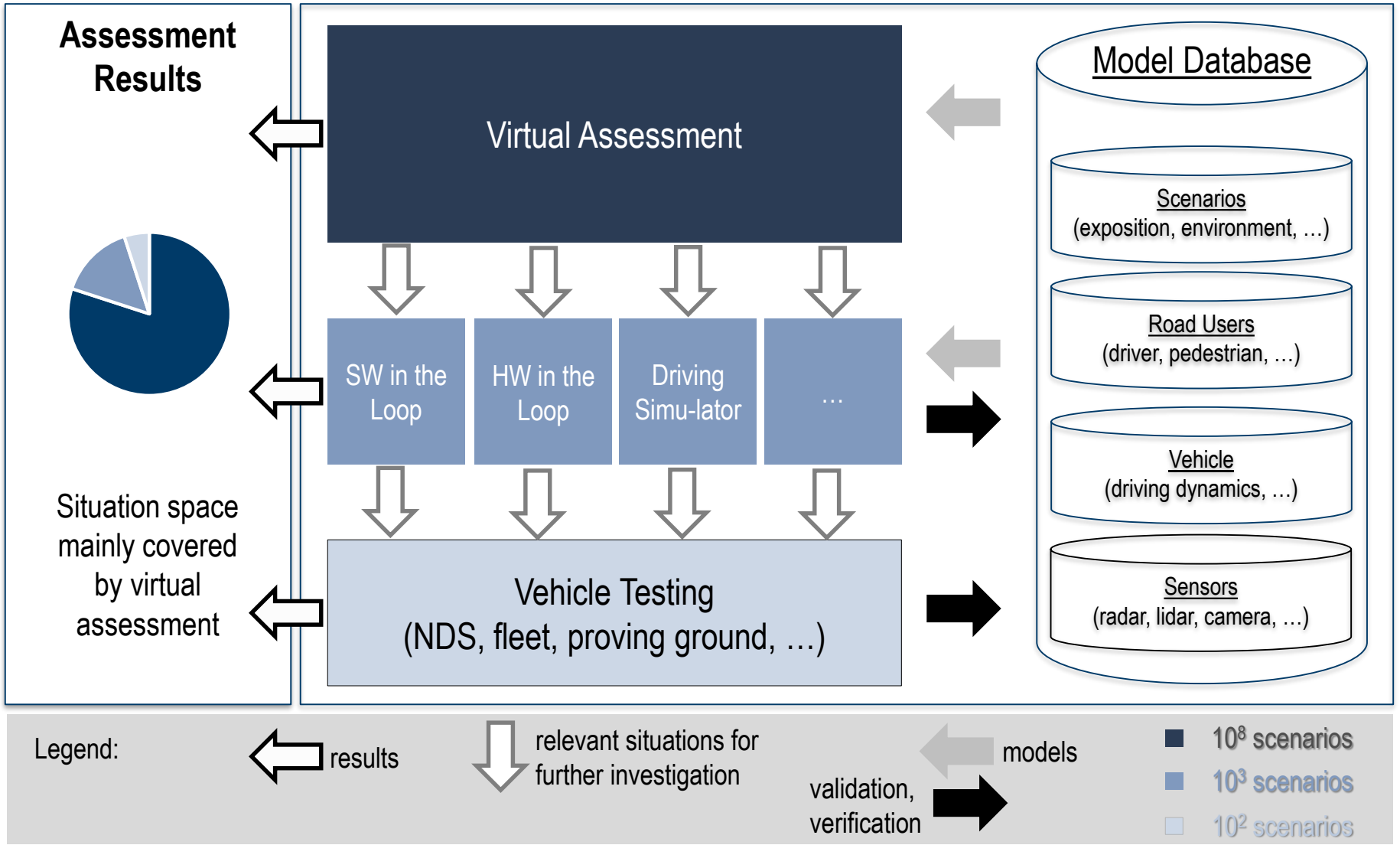
- Vehicle variant complexity
- Increasing active systems
- System complexity

⇨

- Huge testing parameter space
- not reasonably coverable by physical testing
- Limitation of physical testing

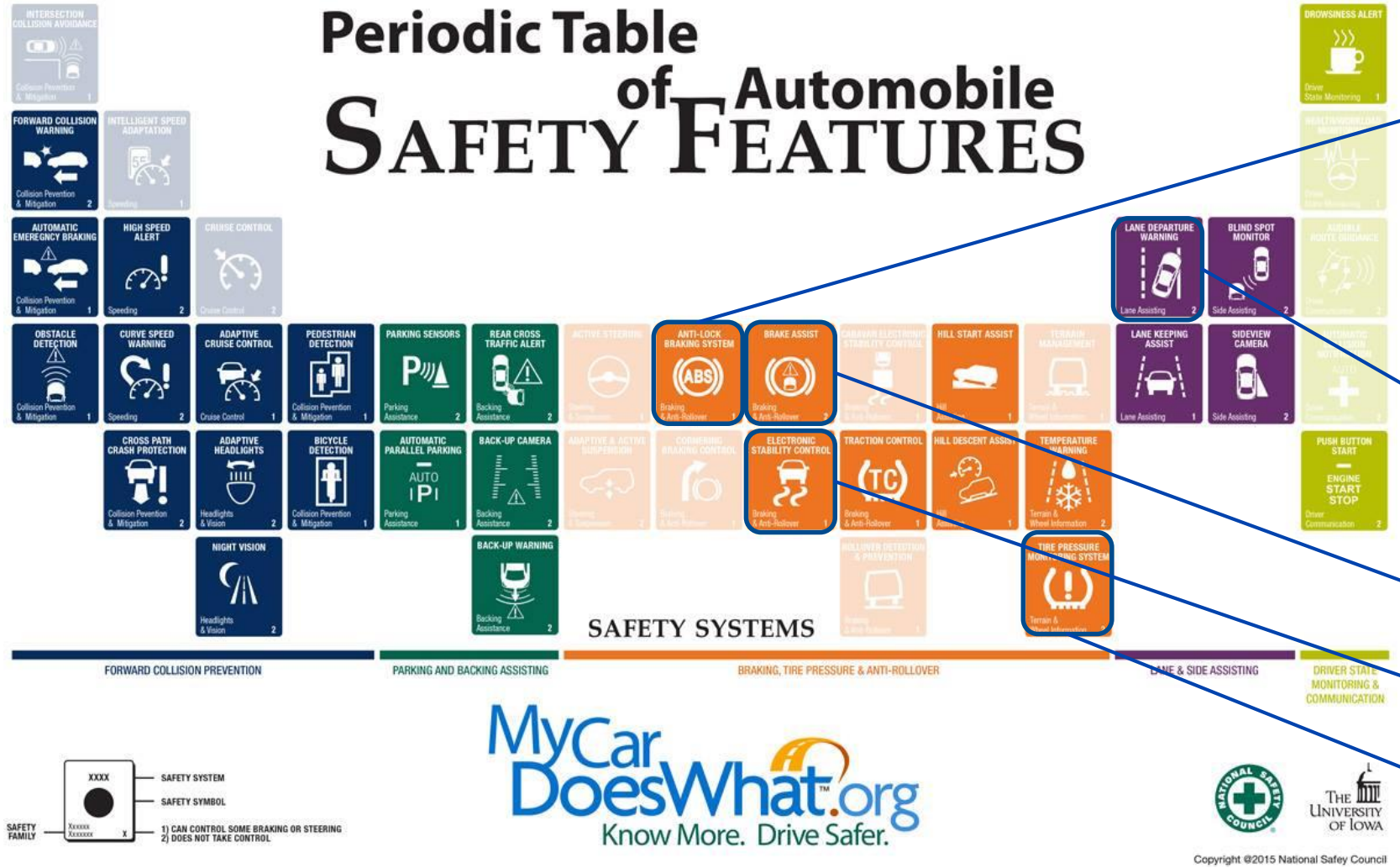
⇨ Highly relevant for ADAS and for automated driving

Assessment of ADAS/AD Systems



Source: Requirements on tools for assessment and validation of assisted and automated driving systems, Udo Steininger, TÜV SÜD Auto Service, Dr. Hans-Peter Schöner, Daimler, Dr. Mark Schiementz, BMW

Homologation of ADAS & Active Safety Systems: Current Situation



UN-ECE R13/H	Braking heavy vehicles, Braking passenger cars
UN-ECE R79	Steering Equipment
UN-ECE R123	AFS Lamps
UN-ECE R130	Lane Departure Warning Systems
UN-ECE R131	Advanced Emergency Braking Systems
UN-ECE R139	Braking Assist Systems
UN-ECE R140	Electronic Stability Control (ESC) Systems
UN-ECE R141	Tyre Pressure Monitoring System

Homologation of ESC (Electronic Stability Control)

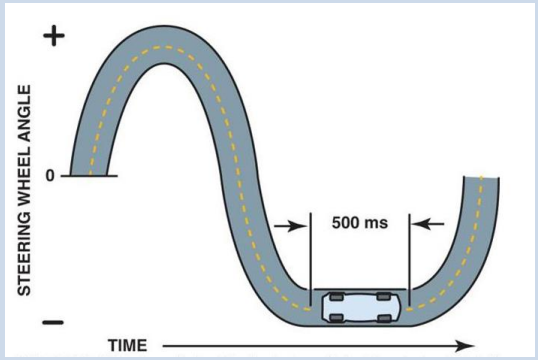
ECE-R 140 allows for simulation methods to support the homologation of electronic stability control systems (ESC)

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

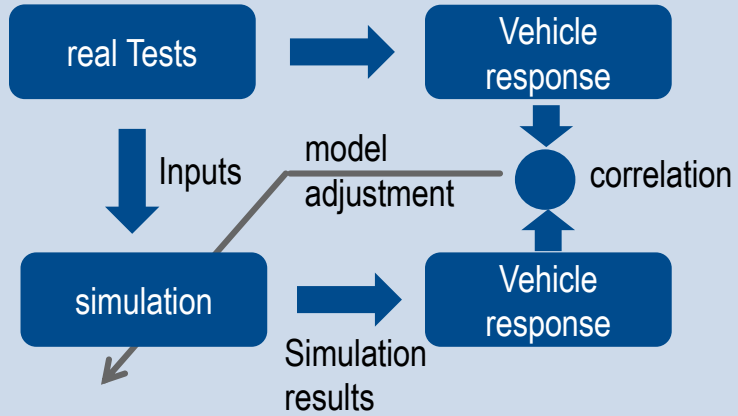
02 Generate the vehicle simulation and correlate the obtained data

03 Simulate critical variants

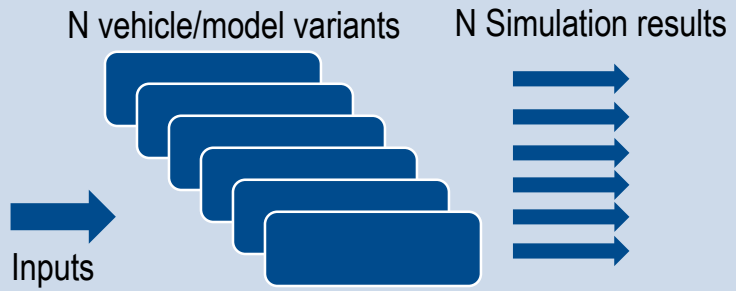
Sine with Dwell (SwD) maneuver



Approval testing & collecting data

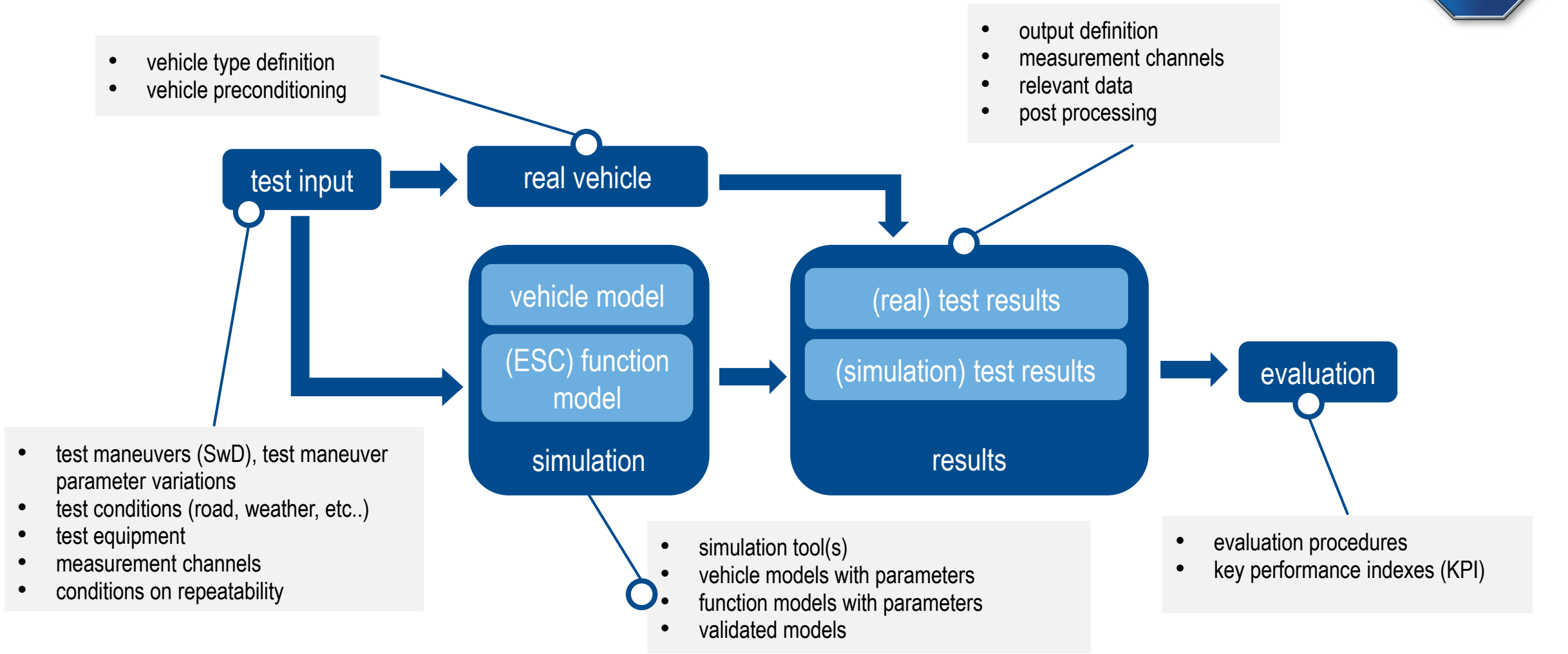


Model validation



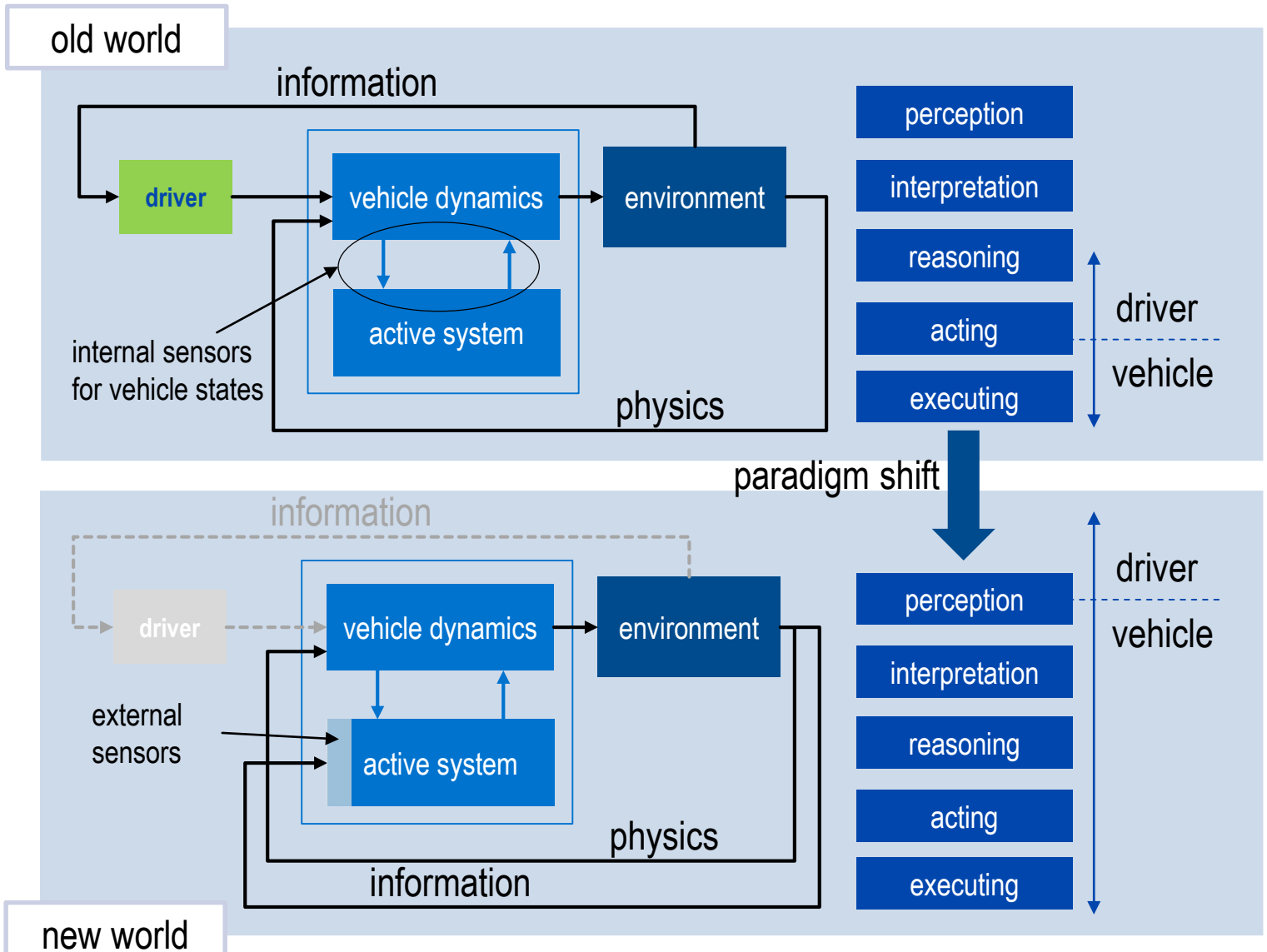
Approval & assessment of variants by using validated simulation model

Core Elements of the Simulation Aided ESC Homologation Process



How portable is the approach to highly automated driving?

ESC vs. Highly Automated Driving: What Makes the Difference?



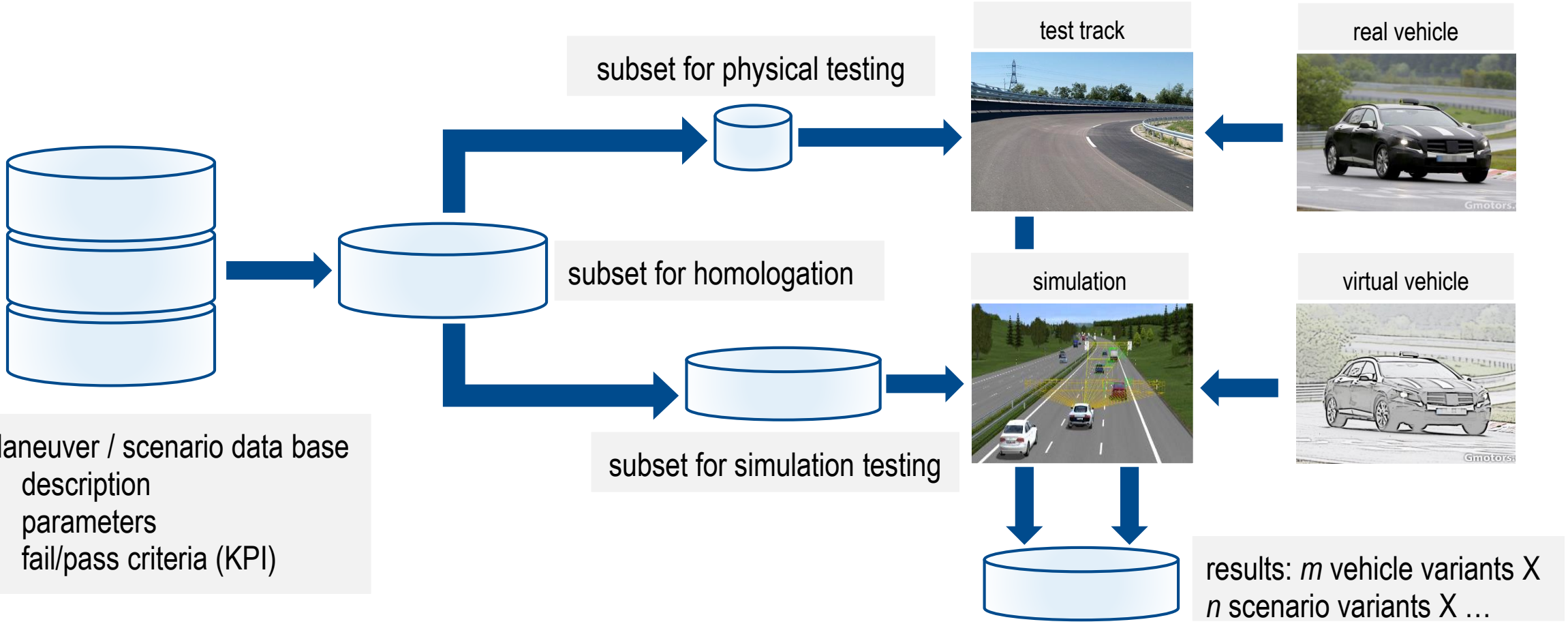
Vehicle parameter variation is sufficient

- principle of homologation remains the same
- new parameter dimensions
- Exploding number of testing parameters and parameter combinations
- Uncertainties increase
- Consequences are more severe

→ Scalable and flexible homologation
→ Simulation aided/supported homologation for HAD functions

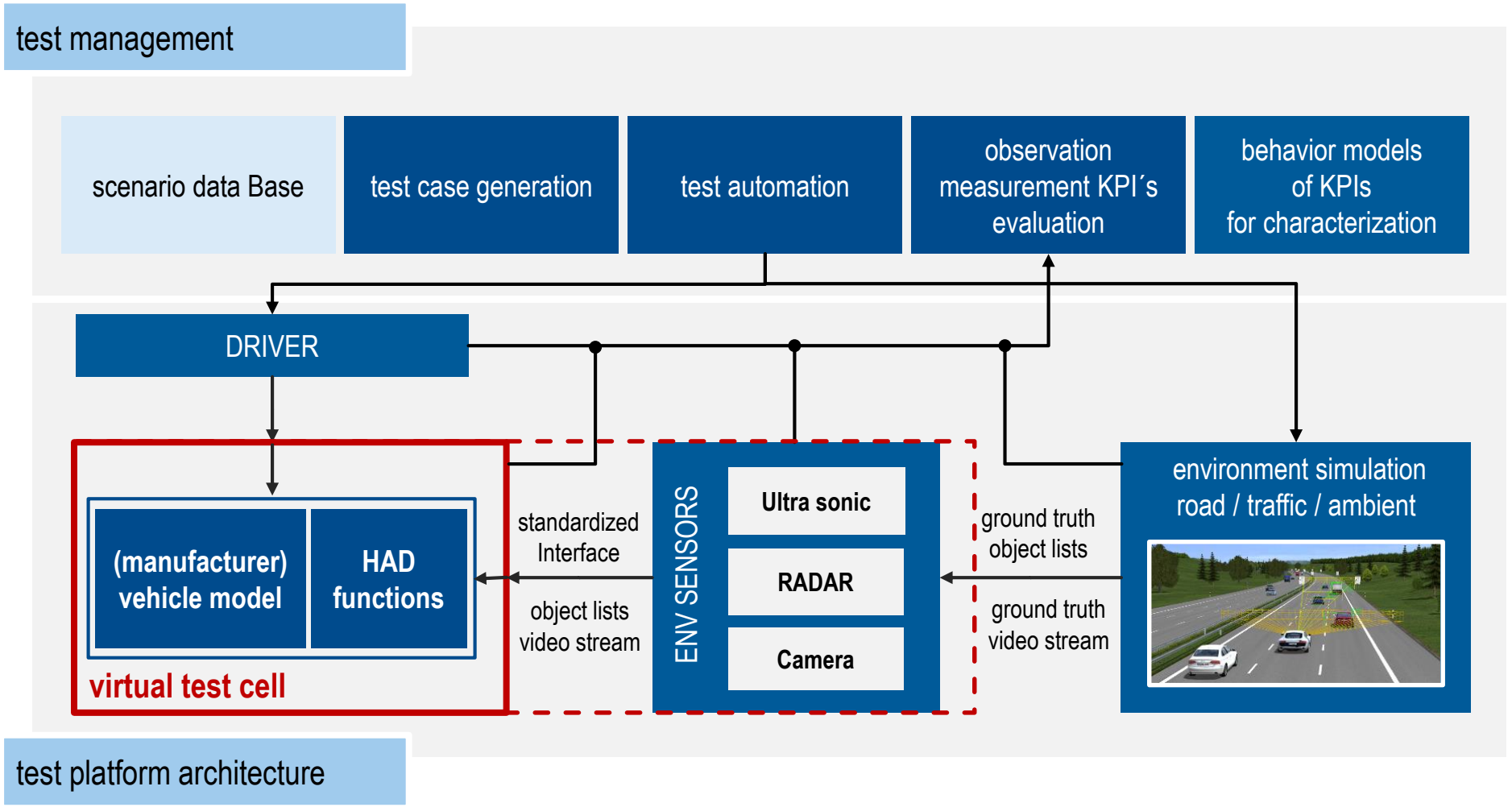
Vehicle parameter & situation variation are necessary

Adopting the Approach of ECE-R140 for Automated Driving



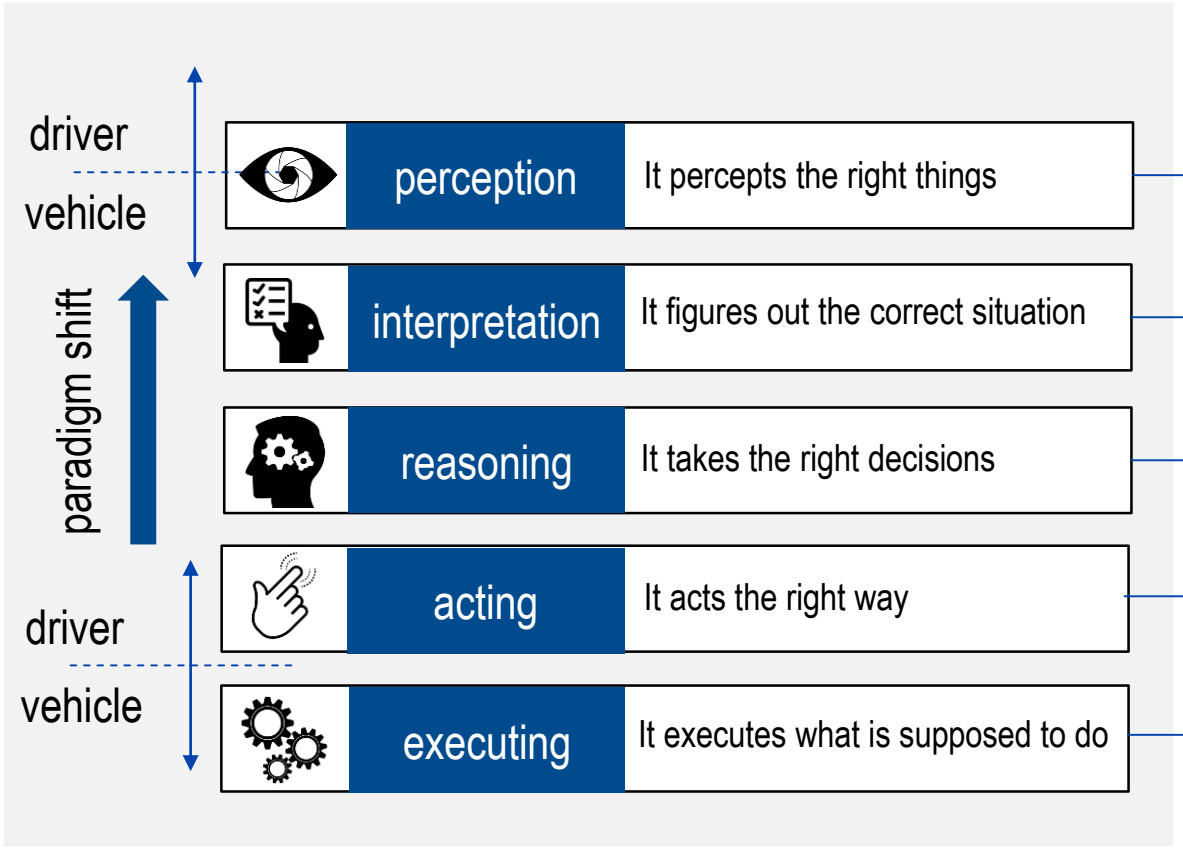
How to bring the virtual vehicle in the virtual test track (simulation)?

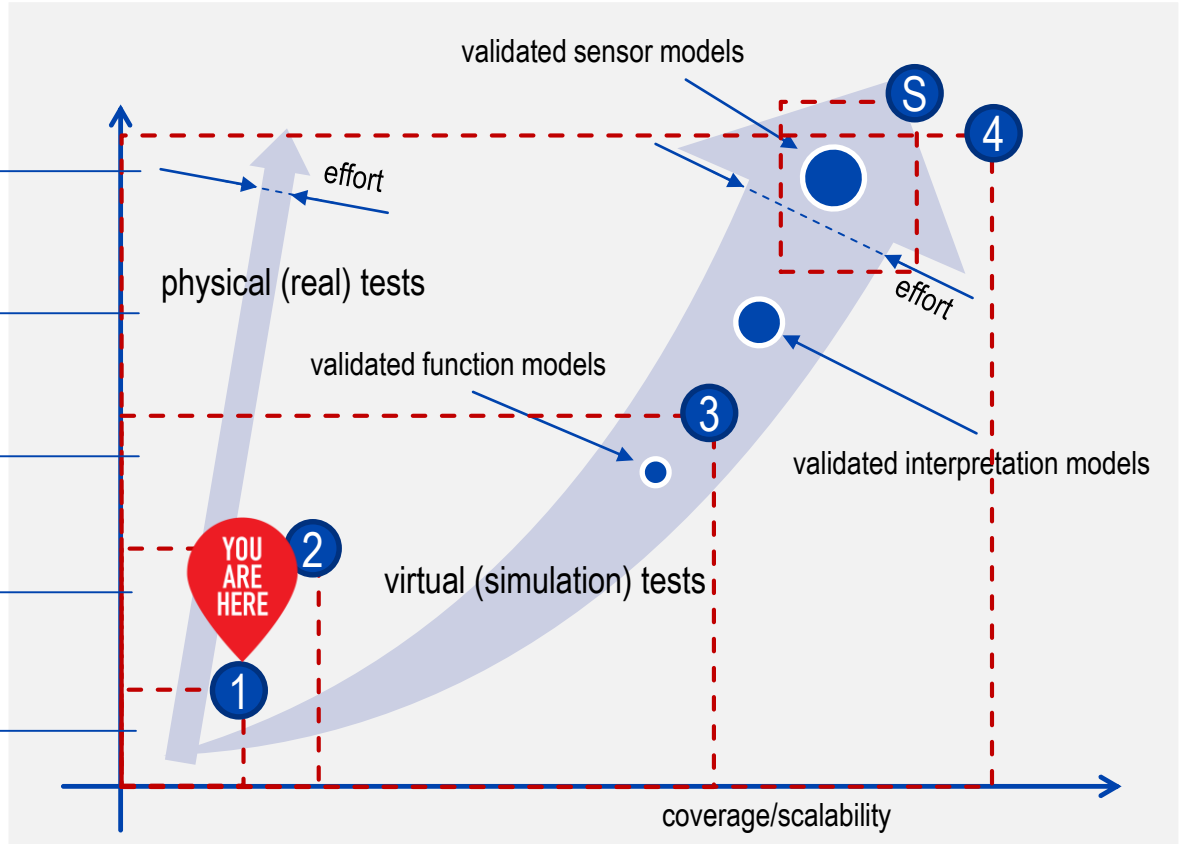
Possible Architecture for Virtual Test/Homologation Cell



Hear Nothing, See Nothing, Say Nothing: How to Deal With the Sensors?

Homologation is about (concept/functionality/principle) verification, but witch kind?





1 Starting from UNECE R140 ⇨ 2 Update UNECE R79 + new Regulation (longitudinal and lateral control) ⇨ 3 Integrate function models into homologation process

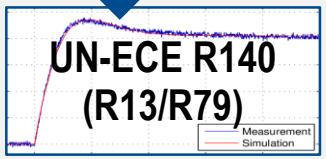
S Consider new single regulations for single senor homologation ⇨ 4 Virtual homologation

Model Validation: A Mandatory Step towards Virtual Homologation

Domain

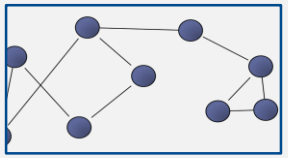
road dynamics | vehicle dynamics | E/E | functions | sensors | static surrounding | dynamic surrounding | traffic | weather

Validation criteria

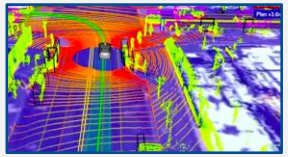


Model states (e.g. steering, yaw angles) shall meet reality within a defined accuracy

Simulation shall take the right decisions with respect to reality/specification



Simulation should recognize the same situation as predefined



Simulation shall sense the environment exactly

Just drive safely without accidents at any traffic situation

Well defined

To be defined

Category

executing | acting | reasoning | interpretation | Perception

Choose certainty.
Add value.

Thanks for your attention!

Christian Gnandt
Lead Engineer Virtual Methods

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