ADAS Verification and Validation: Ensuring Safety and Reliability

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Iskra Gasparic

Today’s Presenters

Iskra Gasparic

Simulation Engineer ADAS/AD
Master’s Degree in Mathematics
Working in AVL since 2021

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Simulation Engineer ADAS/AD
Master's Degree in Electrical Engineering
Working in AVL since 2022

Today’s Agenda

1 **About Us**

2 **ADAS/AD Testing**

3 **ADAS/AD Testing: AVL Approach**

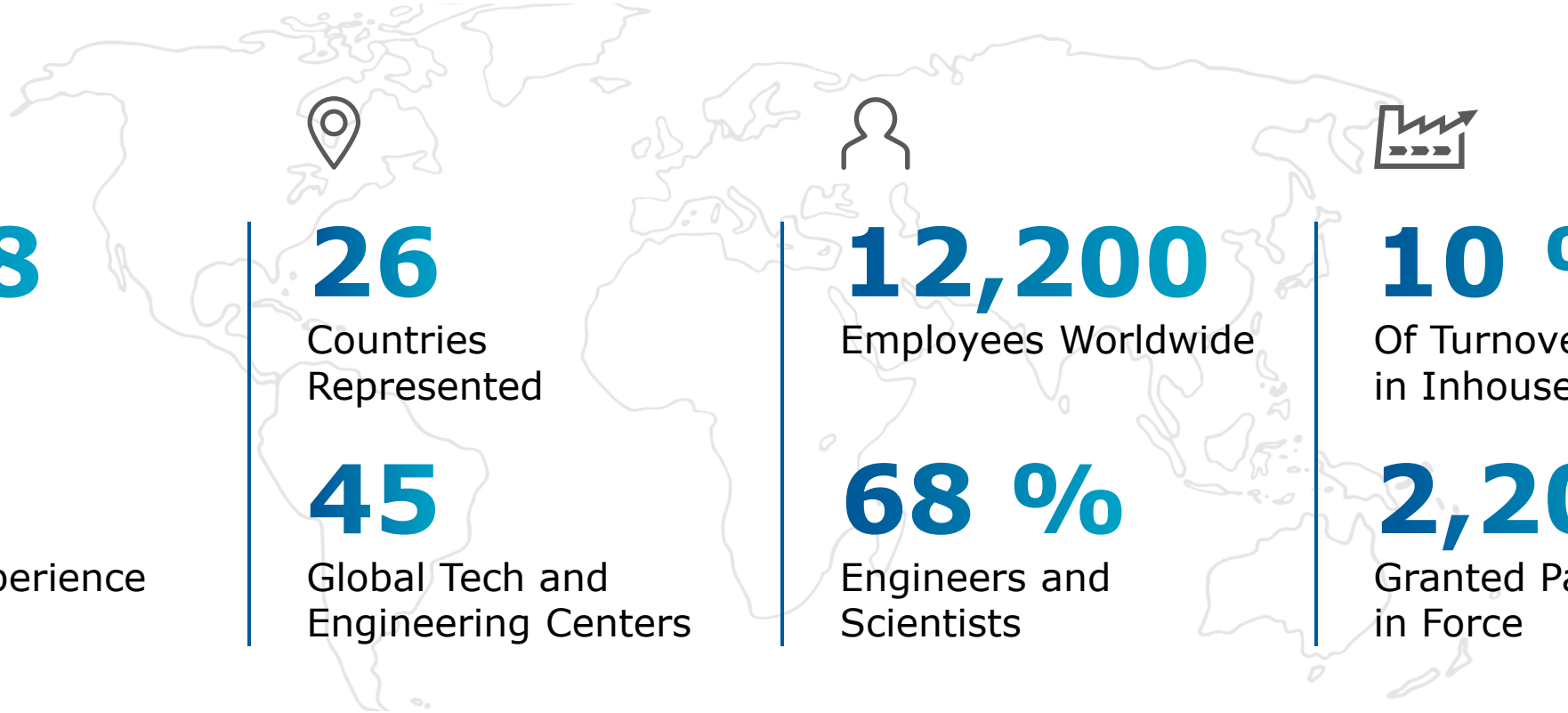
4 **Q&A**

ADAS Verification and Validation: Ensuring Safety and Reliability

About Us

Public

AVL at a Glance



1948
Founded

75+
Years of Experience

26
Countries Represented

45
Global Tech and Engineering Centers

12,200
Employees Worldwide

68 %
Engineers and Scientists

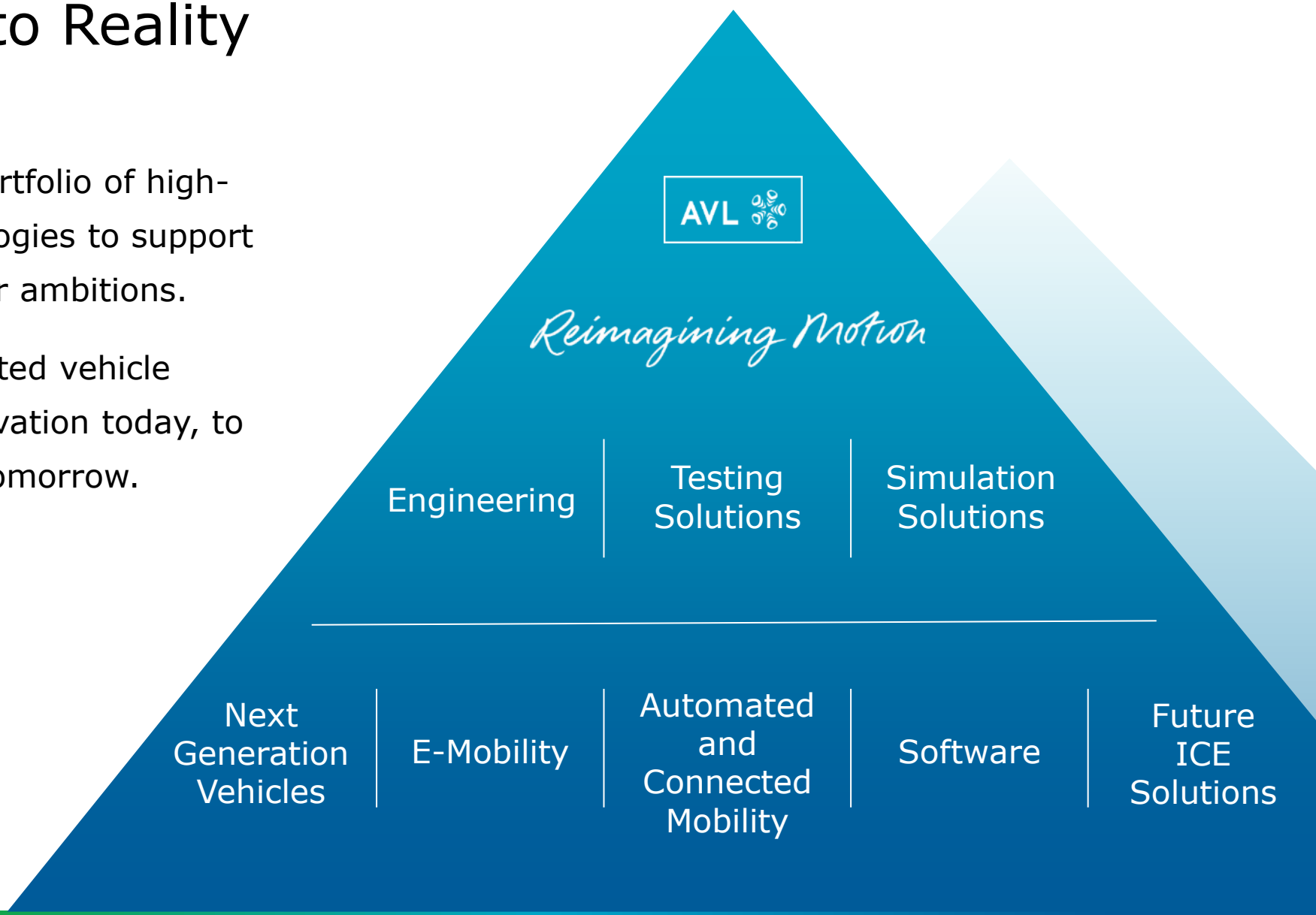
10 %
Of Turnover Invested in Inhouse R&D

2,200
Granted Patents in Force

Turning Visions Into Reality

We constantly transform our portfolio of high-end methodologies and technologies to support our customers in achieving their ambitions.

From future fuels to the connected vehicle ecosystem, we are driving innovation today, to build the mobility concepts of tomorrow.



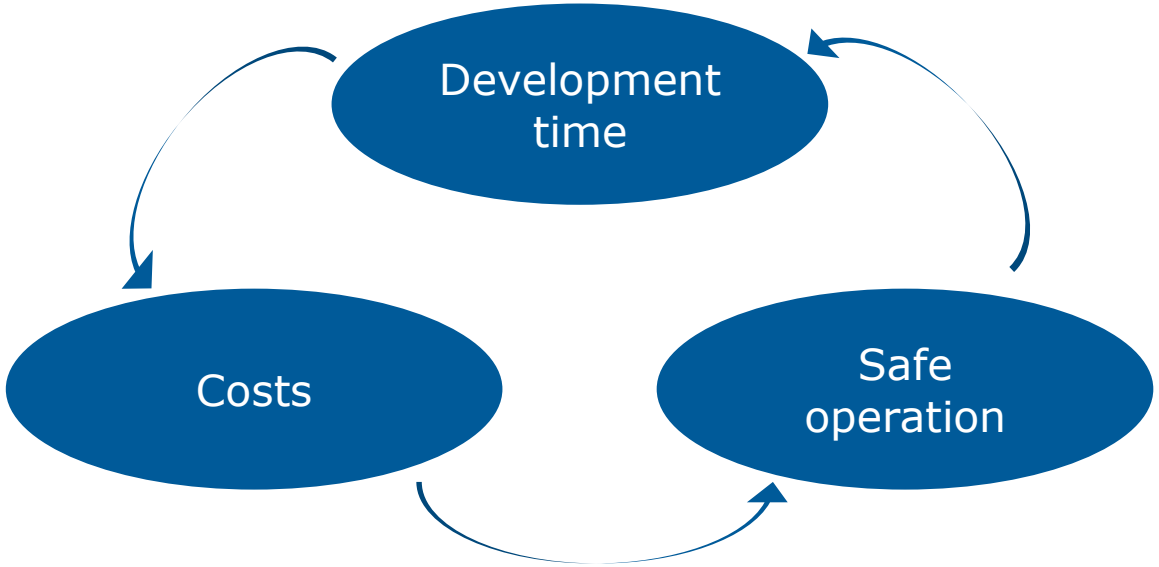
ADAS Verification and Validation: Ensuring Safety and Reliability

ADAS/AD Testing

Public

Challenges in ADAS/AD Development and Validation

The absence of unreasonable risk due to hazards resulting from functional insufficiencies of the intended functionality or by reasonably foreseeable misuse by persons is referred to as the **Safety Of The Intended Functionality**.



General Safety Regulation II (GSR II)

European Commission

General Safety Regulation (GSR – Regulation (EC) No 661/2009)
Pedestrian Safety Regulation (PSR – Regulation (EC) No 78/2009

As of July 7, 2024, the new measures introducing safety features to assist the driver include:

For all road vehicles:

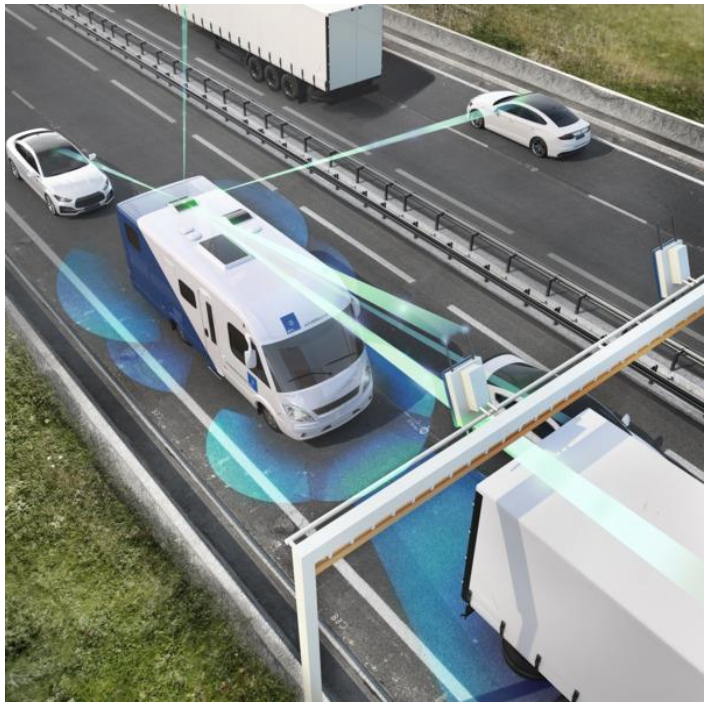
- Alcohol Interlock Installation Facilitation
- Driver Drowsiness and Attention Warning
- Emergency Stop Signal
- Intelligent Speed Assistance
- Reversing Detection Systems
- Tyre Pressure Monitoring Systems

For cars and vans:

- Advanced Emergency Braking
- Emergency Lane-Keeping Systems
- Event Data Recorder

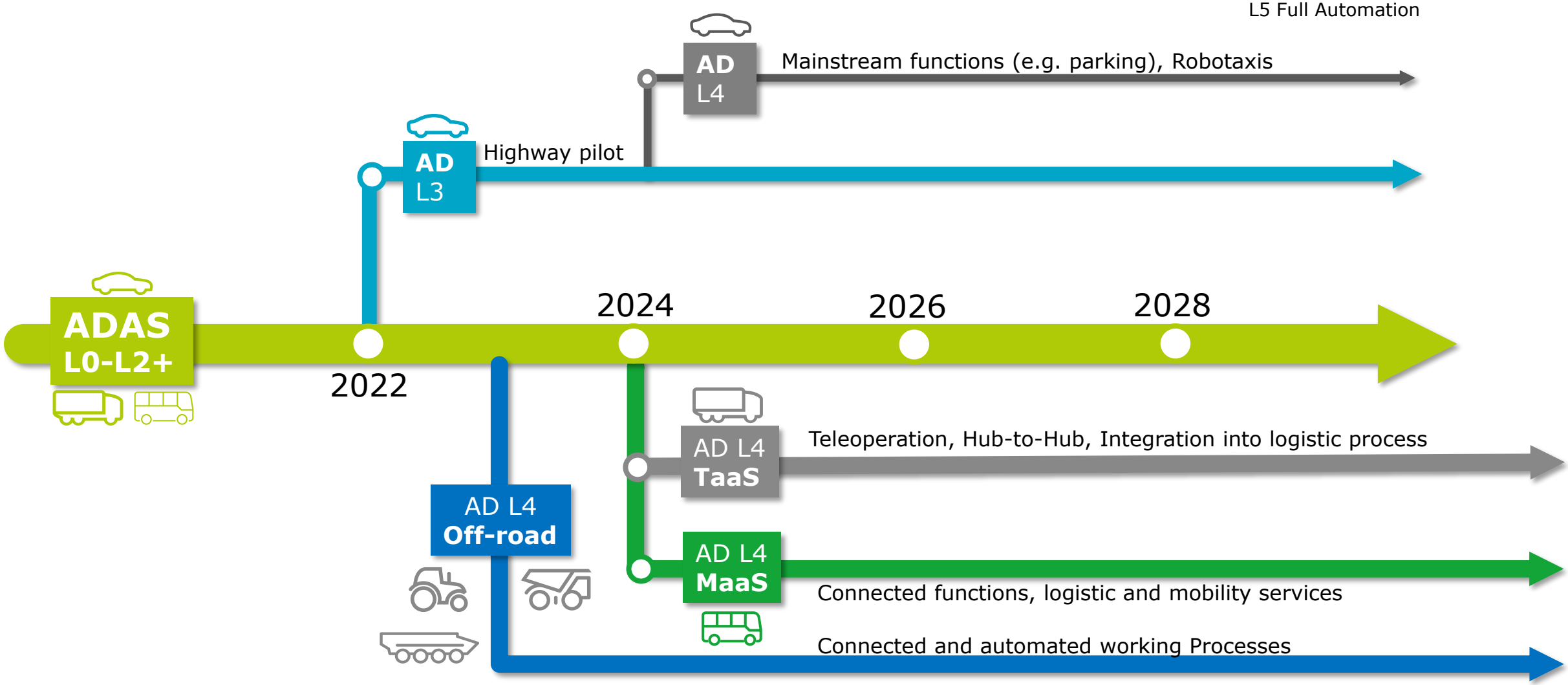
For buses and trucks:

- Blind Spot Information Systems
- Moving Off Information System



ADAS/AD Industry Road Map

***SAE Levels of Automation:**
L0 No Automation
L1 Driver Assistance
L2 Partial Automation
L3 Conditional Automation
L4 High Automation
L5 Full Automation



Legend: MaaS Mobility as a Service | TaaS Transport as a Service | AD Automated Driving | ADAS Advanced Driver Assistant System

Challenges in ADAS/AD Development & Validation

***SAE Levels of Automation:**
L0 No Automation
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L2 Partial Automation
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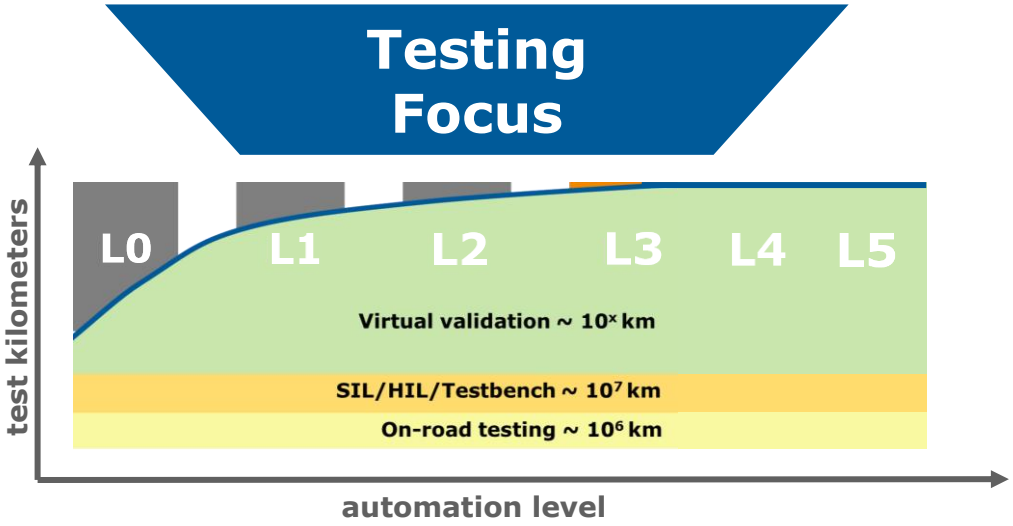
L4 High Automation
L5 Full Automation

Assisted Driving (ADAS)

Automated Driving (AD)



Safety as ADAS/AD Focus

High Testing Volume & High Complexity in Validation

Automakers are under Pressure to be Fast and Make Autonomy Profitable

Efficient ADAS/AD Vehicle Testing only possible with Scenario-based & Virtual Approach

ADAS Verification and Validation: Ensuring Safety and Reliability

ADAS/AD Testing:AVL Approach

Public

From Requirements to Function Release

AVL Competences

Requirements
Expected behaviour of the functionality

Requirement management for SOTIF compliance

System Design, Development

Testing V&V

Scenario Definition

Scenario Generation

Test Planning

Multi-pillar Test Execution
- Simulation, proving ground, public road testing
- Homologation support

Model Creation

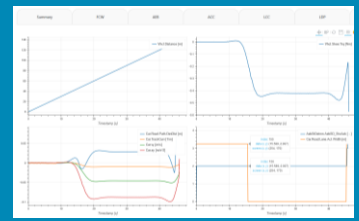
Model Correlation

Domain Coverage

Domain (ODD) coverage proof

Testing Results Risk Quantification

Safety Assessment
KPI implementation
KPI evaluation



System design update (based on results)

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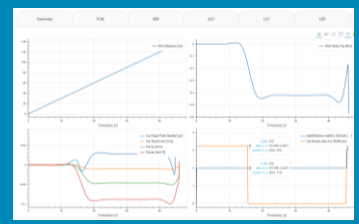

System design update (based on results)

ADAS/AD Scenario Generation Engineering Services

Key for a successful V&V strategy is to combine different scenario sources!

Scenario definition

Define scenarios **based on customer input and official documents** and support with selection of test case variations

Scenario generation

Generate scenarios in a format **suitable for a customer's toolchain**

ASAM
OpenDRIVE
Digitized Road Network
OpenSCENARIO
1.0/2.0
Digitized Traffic
VTD
CM

Edge case generation

Detection and generation of edge cases specific for the function using **AI methodology**

Data virtualization

Bring recorded data into simulation by virtualization methodology able to handle measurements **with or without GNSS data**

Data generation

AI-based **synthetic data generation** with adversarial weather conditions for perception testing.

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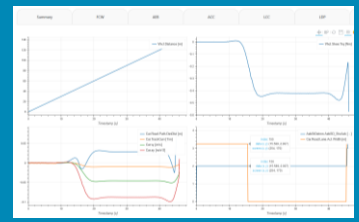


System design update (based on results)

Multi-Pillar Approach for SOTIF Validation across Test Environments

System Design | Targets KPI Development | SW and Controls Development | Integration | Verification | Calibration | Validation | Homologation

Software-in-the-Loop

Hardware-in-the-Loop

Driver-in-the-Loop

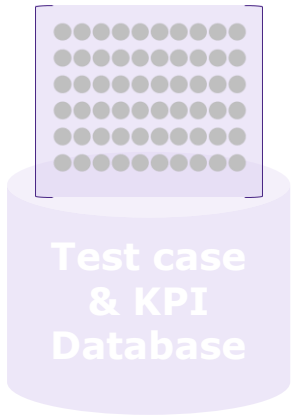
Vehicle-in-the-Loop

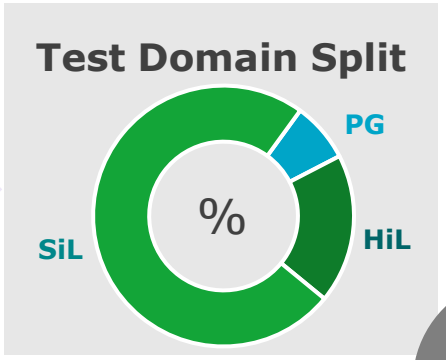
Proving Ground

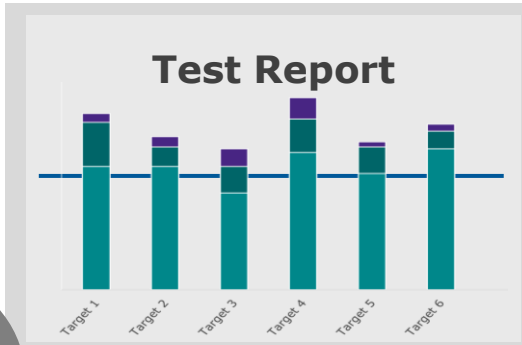
Public Road

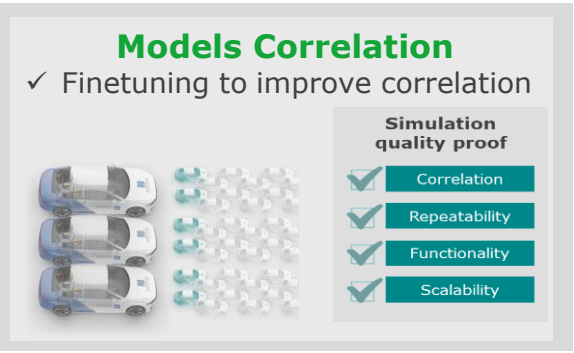
Consistency & Traceability

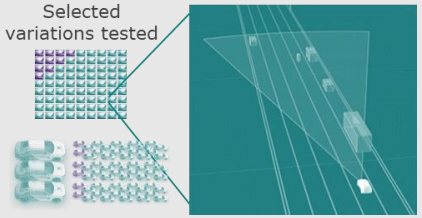
Multi-Pillar Testing
AVL Services

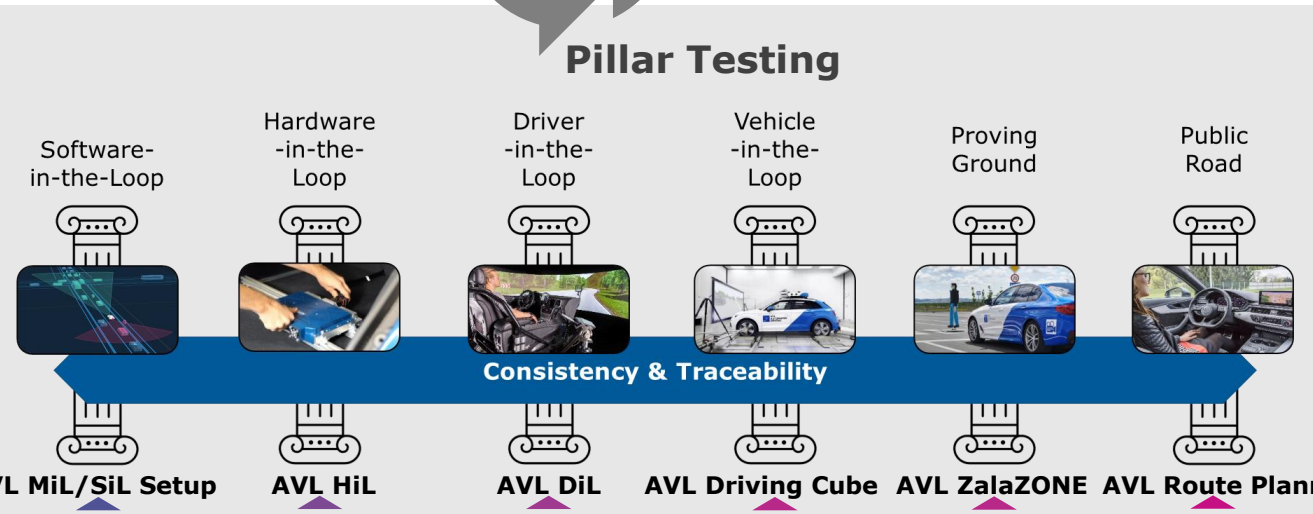








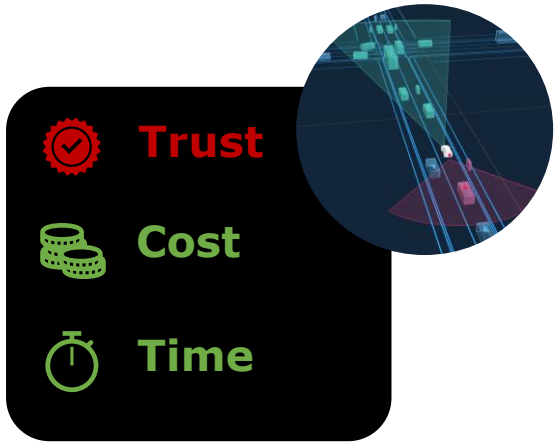




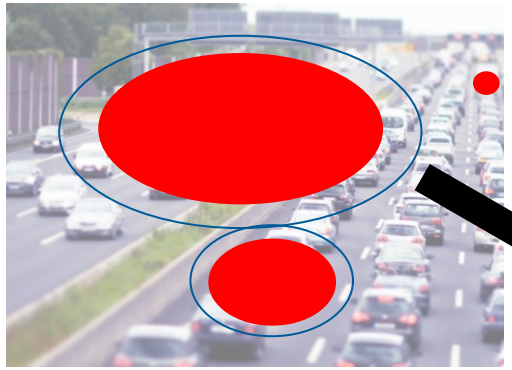
Test Management

Applicable for OEM-specific test programs (robustness, safety, performance, FuSa,…), UNECE, NCAP, GSR, ALKS

Multi-level controls validation toolchain

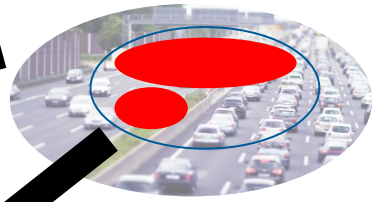


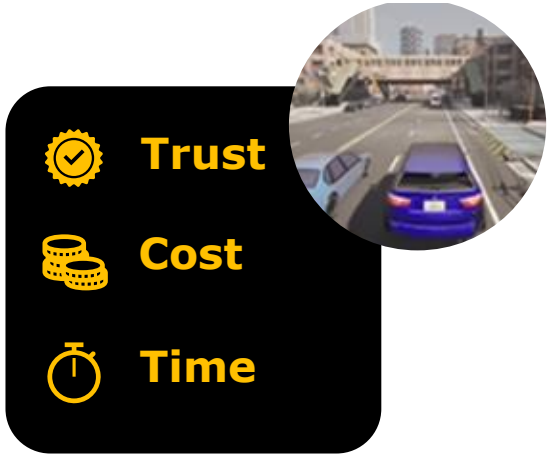
1) High-Performance Simulation
Cost-optimized, high-performance simulation to sweep huge parameter spaces for critical parameter regions.



Millions of Scenarios

Thousands





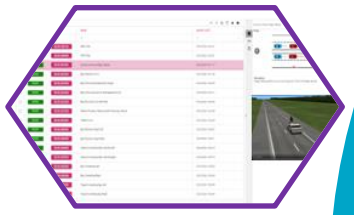
2) High-Detail Simulation
Re-testing in high-fidelity simulation environment to narrow down critical parameter region.

Hundreds

3) Real World
Proving ground or road testing for final validation.

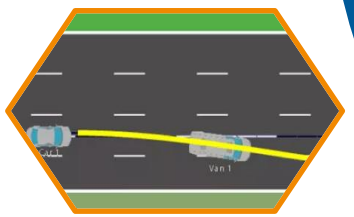
AVL SCENIUS™ – Systematic Safety Validation and Risk Assessment for ADAS/AD

SOTIF, FUSA



ASAM OpenSCENARIO®

ASAM OpenDRIVE®



01 SCENARIO DESIGNER

Easy traffic scenario design, editing and verification

02 SCENARIO DATA MANAGER

Efficient and high-quality scenario handling guided by a standardized workflow

03 TEST CASE GENERATOR

Optimized test planning with increased test performance and maximized test coverage

AVL SCENIUS™

plan

manage

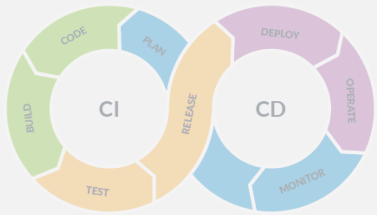
create

ASAM OpenODD

validate

verify

release



04 SiL / MiL SCENARIO SIMULATOR

Simulation Package for Co-Simulation on desktop and cloud environments

05 ViL - AVL DRIVINGCUBE

Test of safety critical situations without risk. Efficient and highly reproducible tests

ASAM OpenCRG®

06 PROVING GROUND

Proving Ground Automation with AVL SMART ADAS ANALYZER

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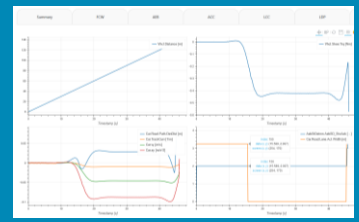
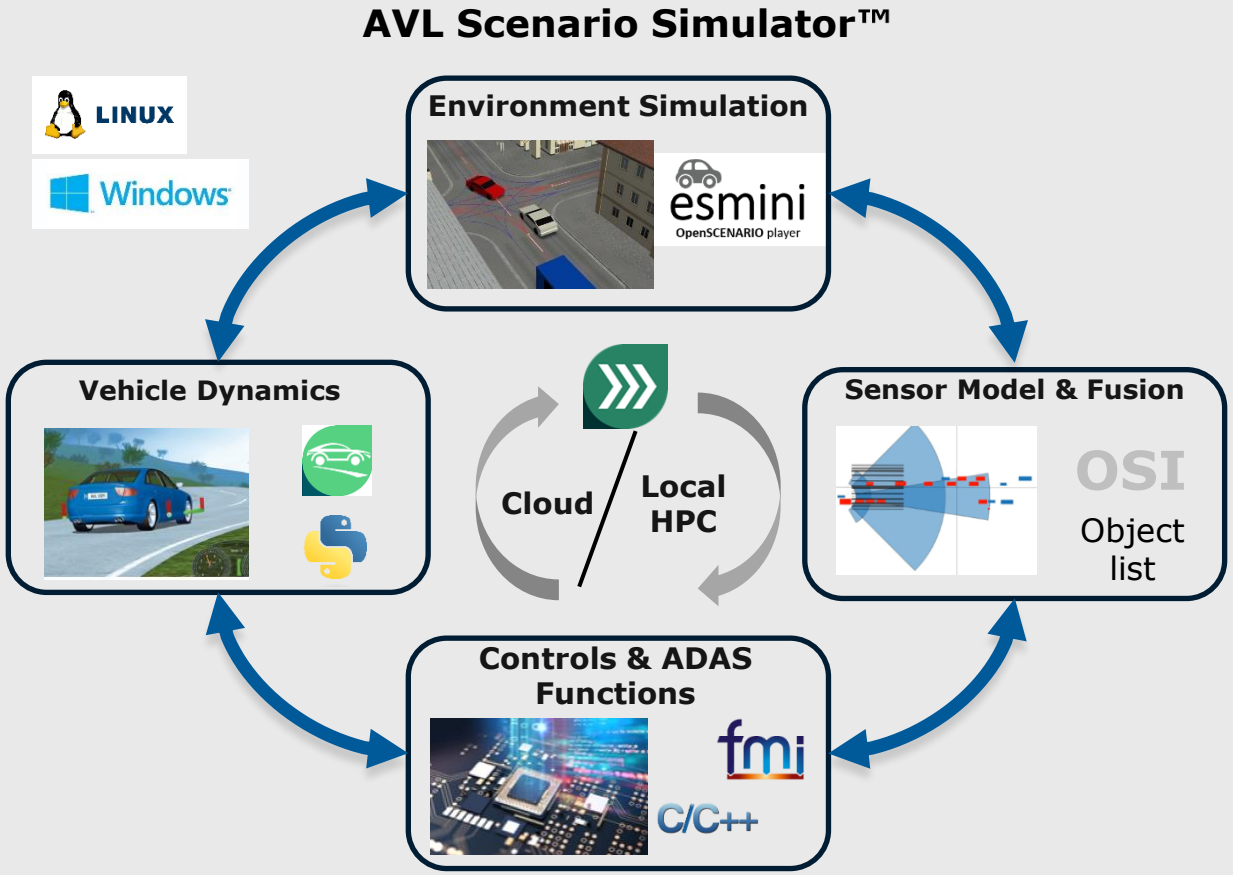


System design update (based on results)

Virtual Validation



- ✓ **High Performance Simulation Platform**
  Parallel simulations on local machine or scaled in cloud
- ✓ **Modularity**
  Create use-case optimized simulation setups
- ✓ **Included Models**
  included performant CPU-only object-based sensor models and vehicle dynamics
- ✓ **ASAM OSI®**
  Standardized sensor interface and result visualization
- ✓ **ASAM OpenSCENARIO® & ASAM OpenDRIVE®**
  Native support with embedded scenario engine (esmini)
- ✓ **Full Automation**
  seamless integration via Python API in CI/CD toolchains and existing testing pipelines

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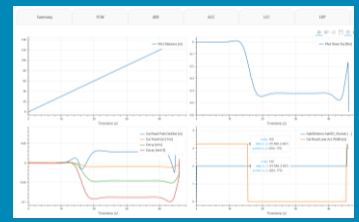
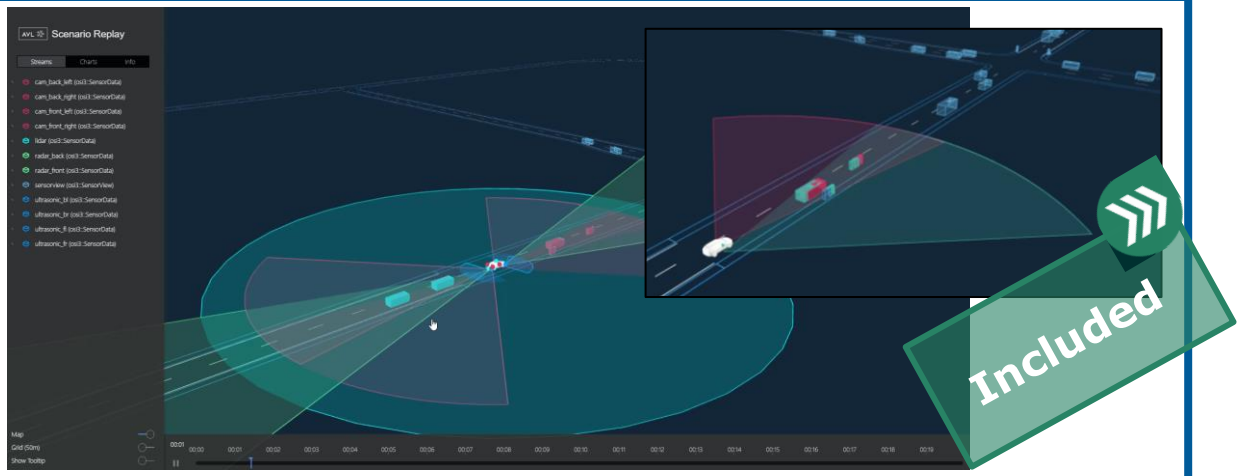


System design update (based on results)

Virtual Validation - Sensor Models

Object-based sensor models
compliant to ASAM OSI® standard

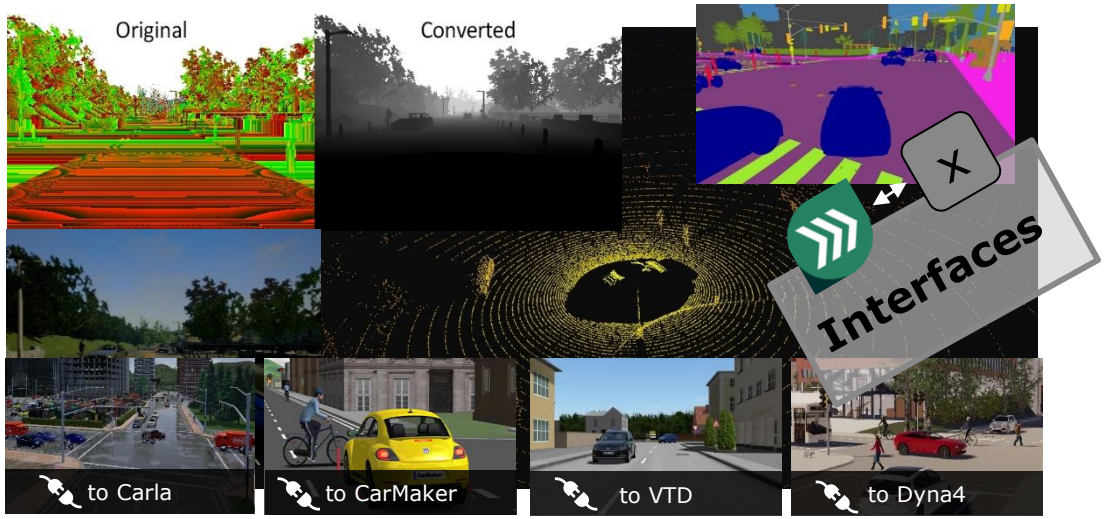


- Input is Ground Truth data from scenario engine
- **Geometrical, phenomenological and statistical effects** are applied on object-list level.
- No detailed environment modeling required

→ **Planning & controls testing**

fmi Functional Mock-Up Interface

Physics-based sensor models



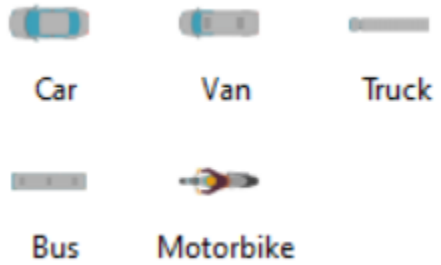
- Physics based sensor models generate **raw sensor data** (camera, LiDAR point clouds, radar, …) or **labeled, semantic training data for machine learning**

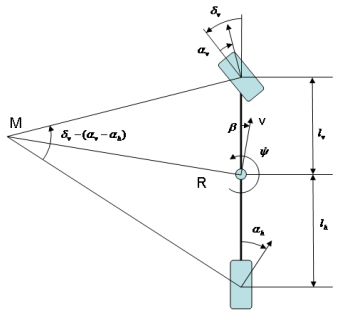
→ **Perception training & testing**

PERFORMANCE ← **CPU** | up to **1000x** faster than real time | → **GPU** **DETAIL**

Virtual Validation - Vehicle Dynamics

OSCar: Linear single-track model

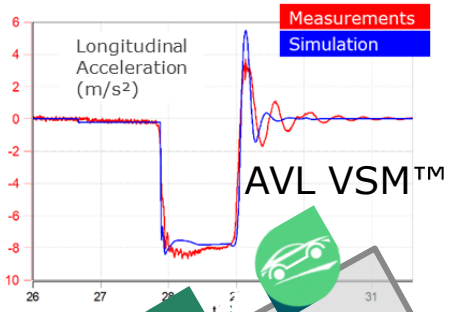




Included

- **Extreme performance**, 2d+ vehicle dynamics
- Vehicle attributes are **fully compatible to ASAM OpenSCENARIO standard.**

High-Fidelity Vehicle Dynamics



Interface

- **Extreme precise, physical vehicle dynamics** with library of **validated digital twins**

PERFORMANCE — **DETAIL**

up to **72%** correlation

up to **1000x** faster than real time

up to **4x** faster than real time

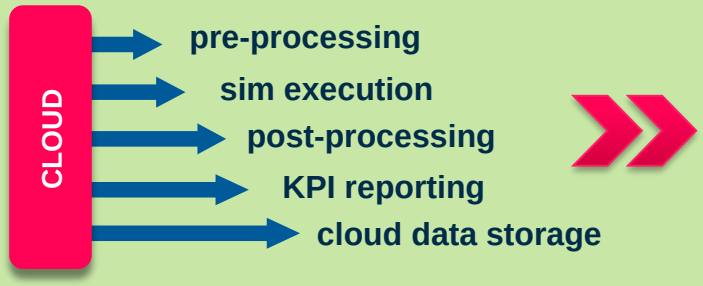
up to **97%** correlation

Virtual Validation Scalability

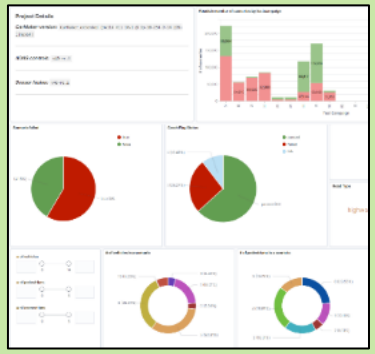
Cloud Solution

- Targeting **500 000 – 1 000 000** scenario simulations per day
- Targeting CI/CD fully integrated with Cloud pipeline

CI/CD PIPELINE



Interactive Cloud Dashboard



Model/Data repository

aws

Azure

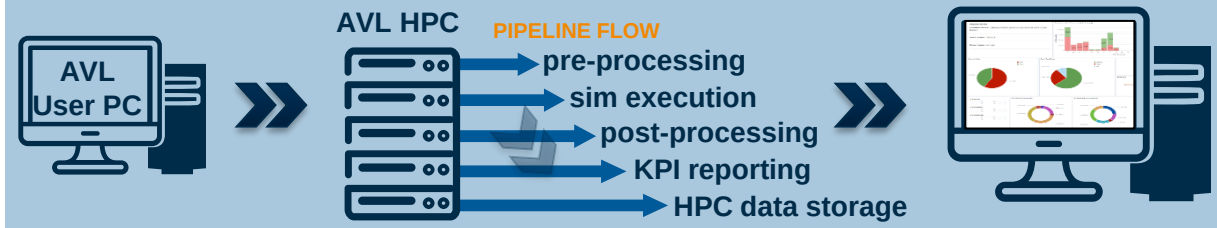
LINUX

Windows

Local HPC

- Targeting **1 000 000 – 3 000 000** scenario simulations per day
- Automated pre- and post-processing of the data
- **Executes** the whole workflow process and provides data, comprehensive reporting and analysis

Local HPC



LINUX

Windows

Key Takeaways

- **Vehicle testing** alone is Impractical
- Brute-force **software testing** is Inefficient and overly Time-Consuming

- Smart Testing Methods are **Essential** to enable real progress
- Reliability and Safety are **Paramount**
- **Multi-Pillar Approach** is a key factor in successful implementation of a testing strategy
- **AVL** provides necessary solutions throughout all phases of development, offering scenario generation and a tailored testing approach to meet specific needs

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Q&A

Public

Contact

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