Siemens-Microsoft

Enabling simulation at scale

ADAS/AD V&V framework

1. Context and challenges
2. Siemens ADAS/AD V&V framework
   a) Overview
   b) Environment and sensor simulation
   c) Vehicle dynamics and powertrain
   d) Simulation orchestration
3. Wrap-up and next steps

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Disruptive Innovation

Key to sustained business

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Engineering the NEXT product not just the best product for the future

FROM ADAS TO AUTONOMOUS DRIVING…

“+25% CAGR (through 2030) for Sensors”

Roland Berger , on “Autonomous Driving”, 2014

““…14.2 billion kilometers (8.8 billion miles) of testing, including simulation, are required.”

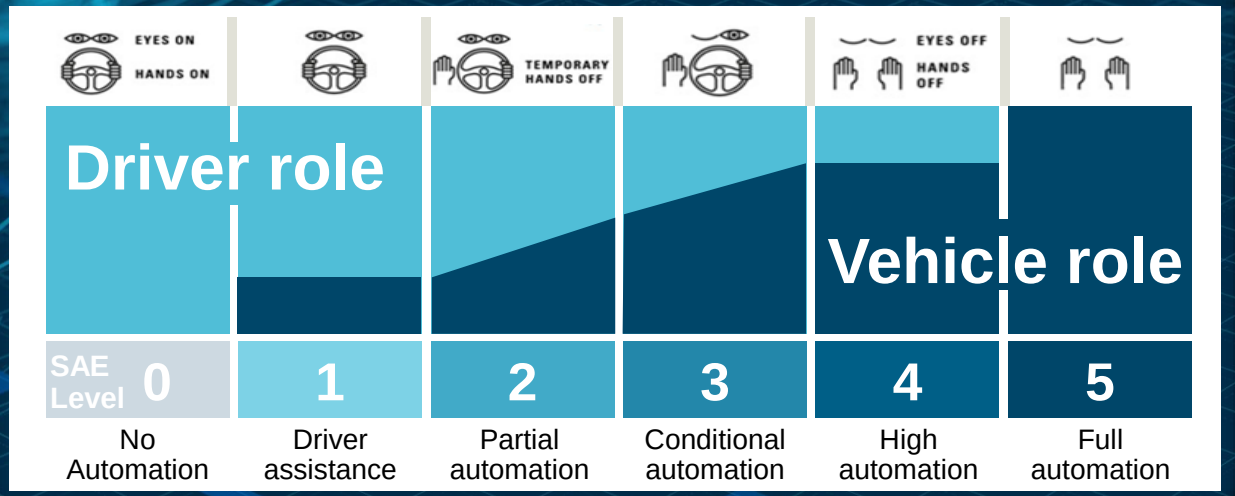
Akio Toyoda, CEO of Toyota
Paris Auto Show 2016

“Design validation will be a major – if not the largest – cost component”

Roland Berger
“Autonomous Driving” 2014

“While hardware innovations will deliver - software will remain a critical bottleneck”

McKinsey
“When will the robots hit the road?”



ADAS/AD systems virtual V&V

Automotive industry needs

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- The number of scenarios needed to properly validate ADAS/AD systems will explode from SAE level 1 up to level 5.
- The major part of AD V&V cannot be achieved through semi-virtual or real validation.
- Frontloaded virtual V&V at MiL and SiL stages will have to play a much bigger role.

Need for efficient and automated simulation orchestration

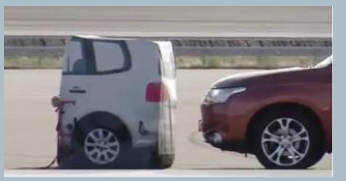
Virtual validation (MiL, SiL)

~10^2 test cases → SAE level 1 to 5 → **~10^6 test cases**

Semi virtual validation (HiL, DiL, VehiL)

~10^2 test cases → SAE level 1 to 5 → **~10^3 test cases**

Real validation vehicle testing (proving ground, public road)



~10^2 test cases → SAE level 1 to 5 → **~10^2 test cases**

ADAS/AD systems virtual V&V

Automotive industry needs

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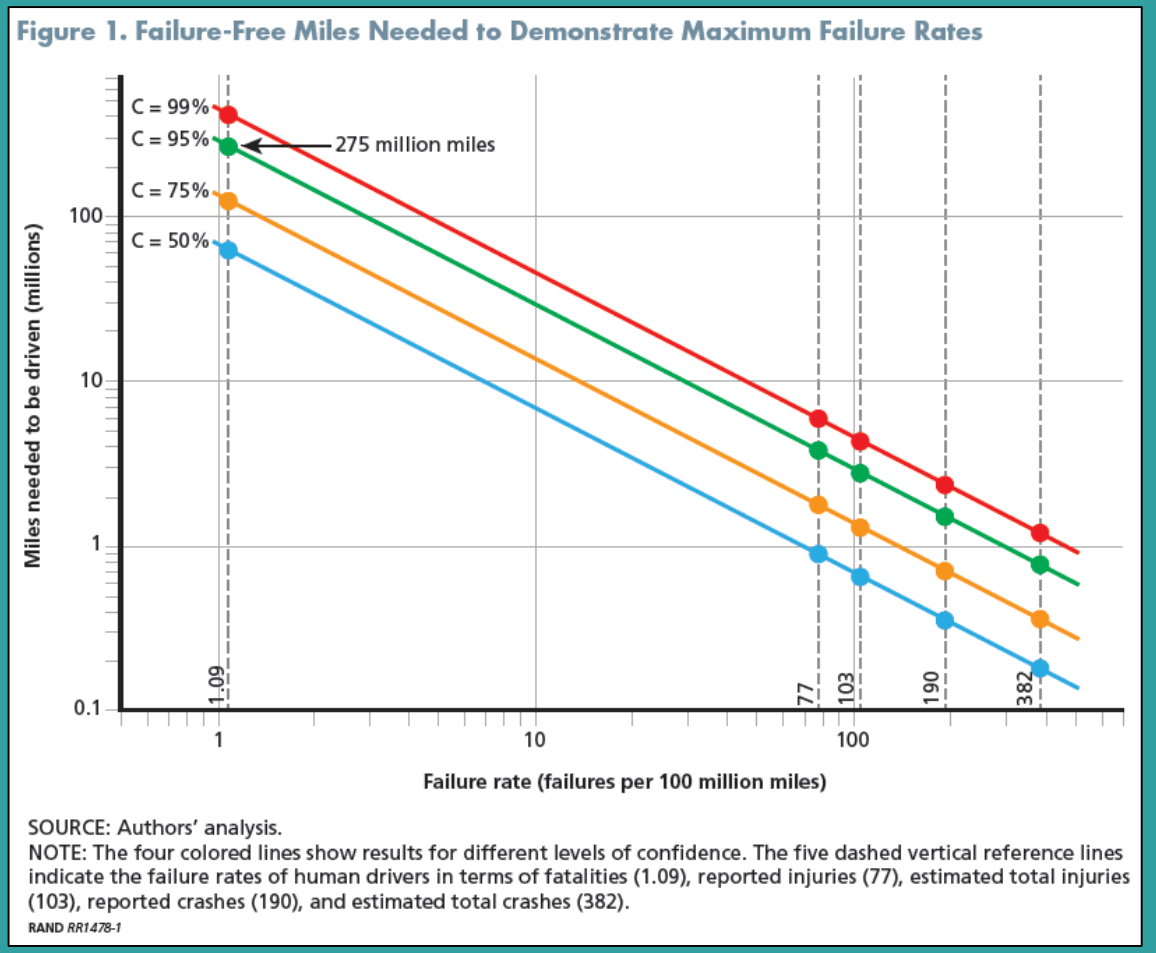
- Demonstrating an ADAS/AD system performs at least as well as human drivers (fatality criteria) requires **275 million miles** to be driven**.**
- Demonstrating the needed improvement over human drivers statistics will require **billions miles** to be driven**.**



RAND RR1478-3 "Driving to safety"

ADAS/AD systems virtual V&V

Automotive industry needs

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- How to build a minimal and covering validation profile?
- Scenarios are numerous, but also qualitatively very diverse.

Need to learn about new relevant scenarios and bring them to the simulation world

- Our world is not an ideal environment
- Pollutant emissions regulations and electrical vehicles range expectations will still apply to autonomous vehicles.

Need for realistic and non-ideal environments

Need for more vehicle physics than before

Validation and Verification – Test Orchestration

Covering the entire virtual V&V workflow

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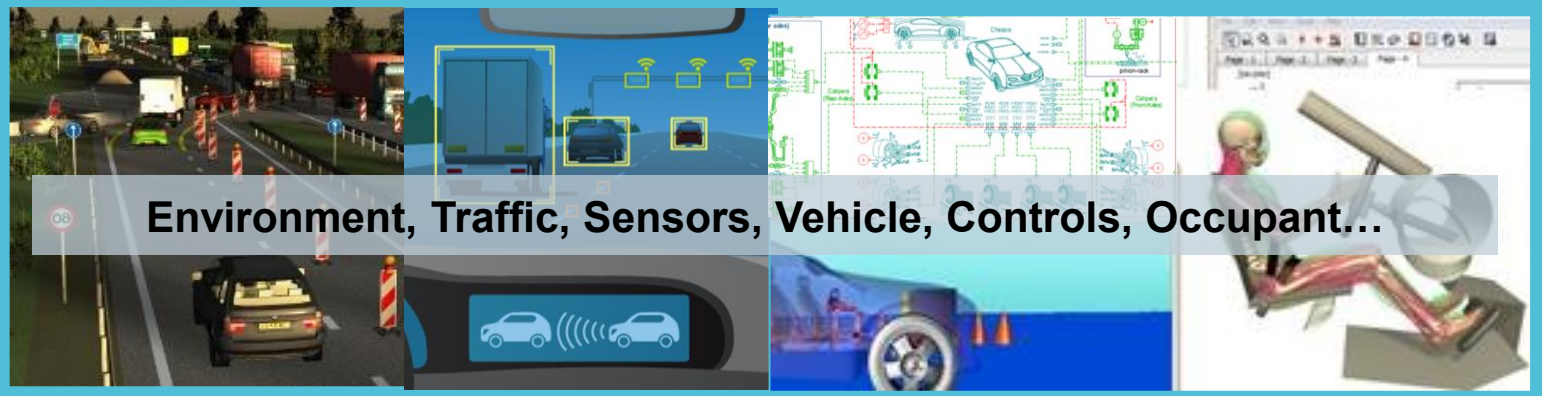
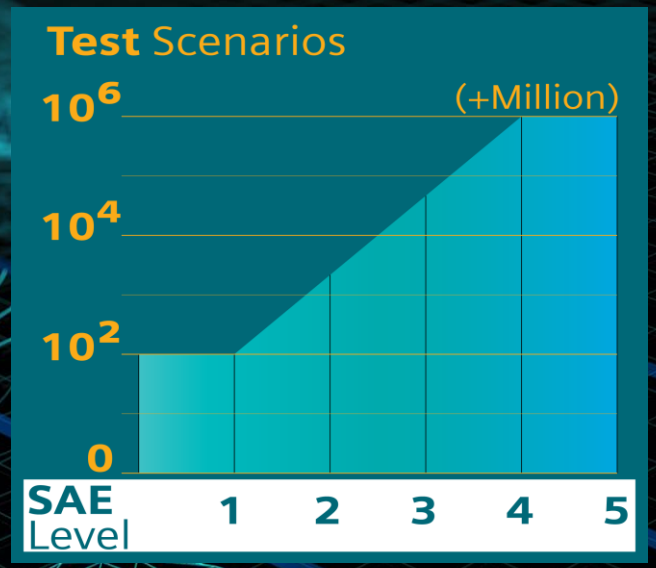
Massive HPC

Real Time





"14.2 billion miles of testing is needed"
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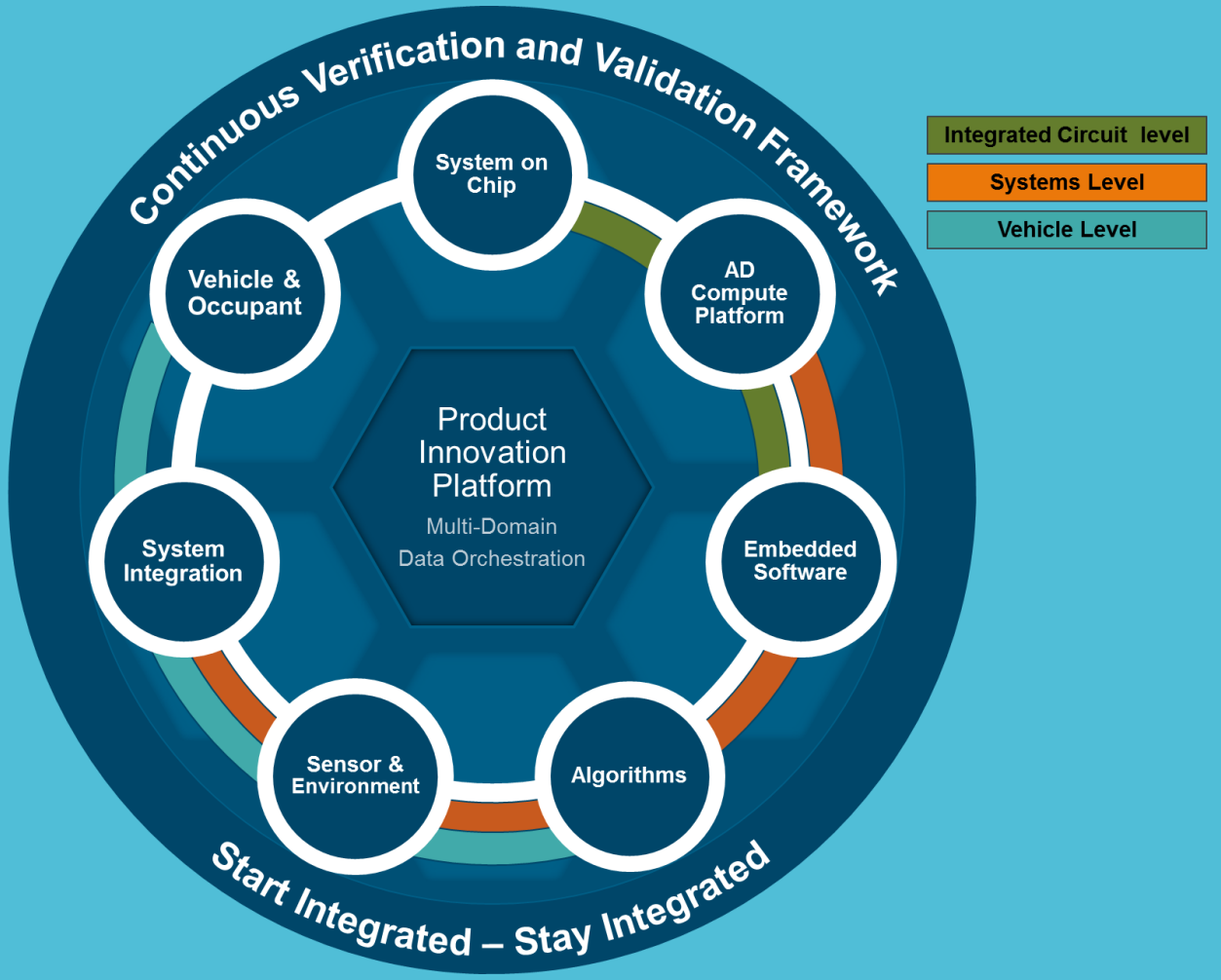
Our solutions support autonomous vehicle development needs

across all engineering domains with a focus on software



Ensuring digital continuity, multi-domain traceability and functional safety of autonomous systems

ADAS / AD V&V framework on Azure cloud

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Plan

Execute

Report

Realistic simulation, ready for robust virtual verification:

- **Real data import**
- **High fidelity sensors, environments and vehicle physics**

Massive simulation: advanced parametric sampling, automated processes and extensible execution infrastructure

Requirements-driven simulation: assets continuity and verification traceability

ADAS/AD V&V framework on Azure cloud

Benefits

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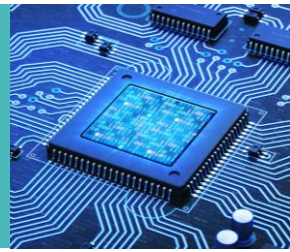
Shorter time-to-market and lower development costs

Use powerful modeling capabilities to frontload system simulation
Use next generation simulation orchestration for improved coverage
Troubleshoot implementation issues earlier in development



Enabling HAD verification in a reasonable amount of time

Efficient execution platform for planning and submission
Advanced parametric sampling and results reporting
Faster insight into system under test

Development process efficiency increase

Scenarios-driven and metrics-driven requirements as input for simulation
Connect critical scenarios experience to system engineering
Enable rapid and robust development process

Compliance with audits and relevant standards

Full simulation activity traceability to be ready for liability issues
Validation methodology (e.g. ISO26262) is reflected by Polarion data management

ADAS/AD V&V framework

Generation 1 launch

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- HEEDS / Simcenter Prescan interoperability
- Extended externally-pilotable scenarios concepts

Off-the-shelf validation scenarios, metrics and dashboards

HEEDS
Simulation plan orchestrator
Process automation
Results analysis and reporting

Simcenter Prescan
Scenario authoring
Models integration environment
Sensors and environment simulation

Third party
Vehicle dynamics

OR

Simcenter Amesim
Vehicle dynamics

- Simulation batch planning
- Enhanced selective test cases generation methodology
- Unique results analysis environment, from test plan level down to detailed run analysis

Improved execution teamwork for tire / ground contact for intensive vehicle dynamics safety cases

ADAS / AD V&V framework on Azure cloud

Covered use cases

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Functional testing, robustness mapping or verification coverage

At-scale Model-in-the-Loop and **Software-in-the-Loop orchestration**
for ADAS/AD CAE groups

Open-loop cases:
sensor design or specification, computer vision, sensor fusion, embedded software components testing

Closed-loop cases:
testing integrated systems, full autonomous vehicles or V2x ecosystems in their environments

Vehicle physics optimal fidelity available when needed
(vehicle dynamics, powertrain, actuators)

ADAS/AD V&V framework

Simulation production: overall workflow

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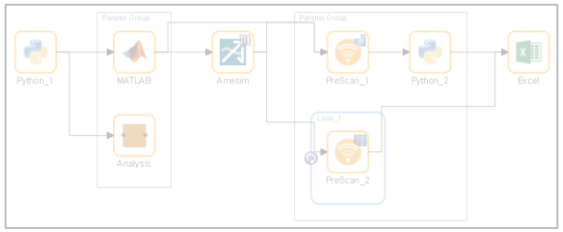
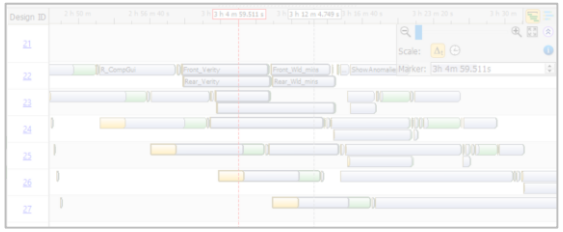
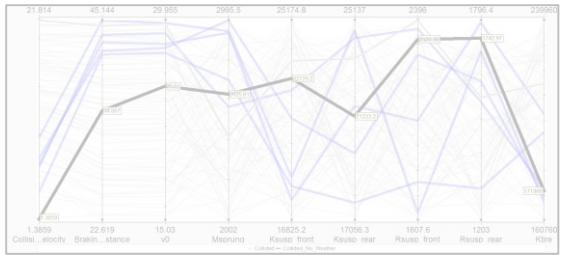






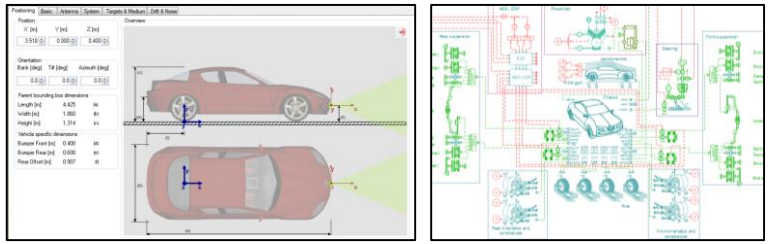
Scenarios | **Ego models**

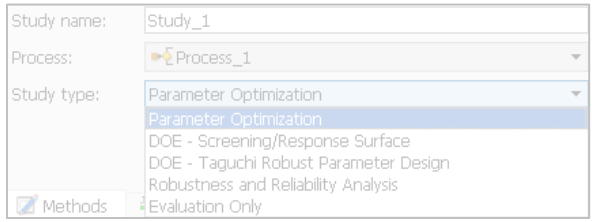
Simulation plan definition

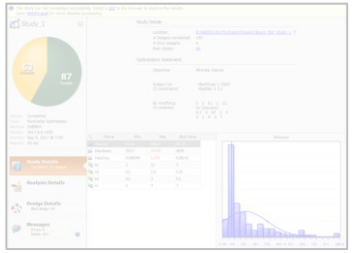
Simulation plan execution

Numerous results analysis

Reporting

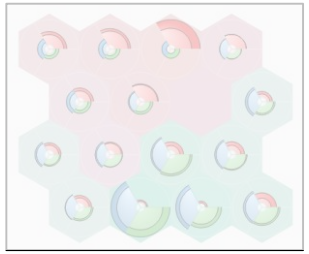


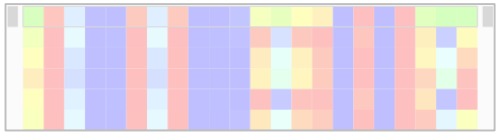




Azure

kubernetes





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Simcenter Prescan World Modelling

Solutions

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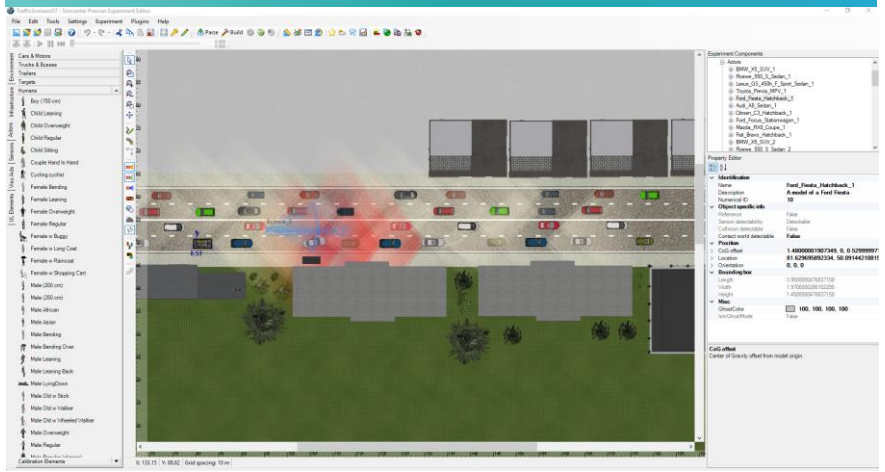
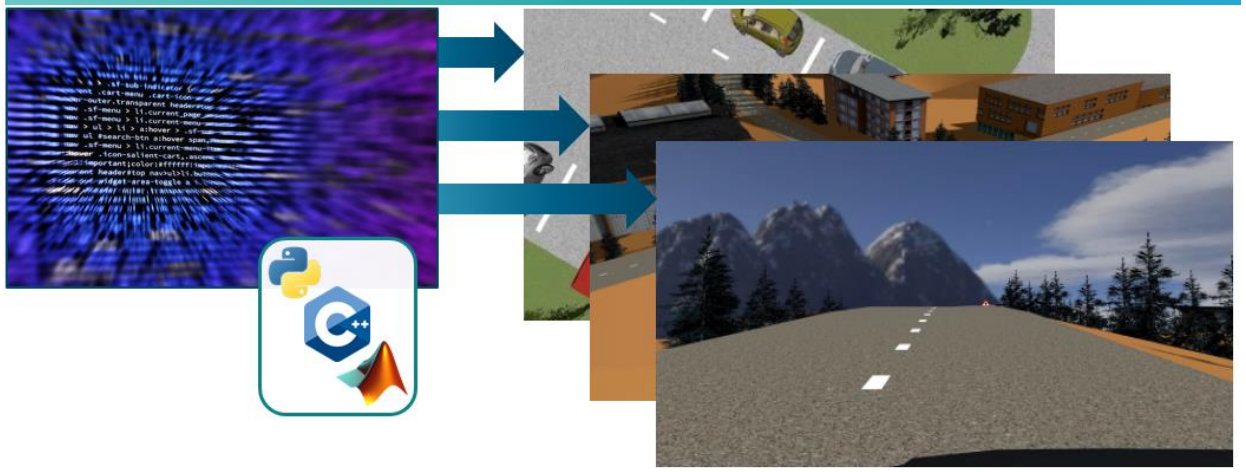
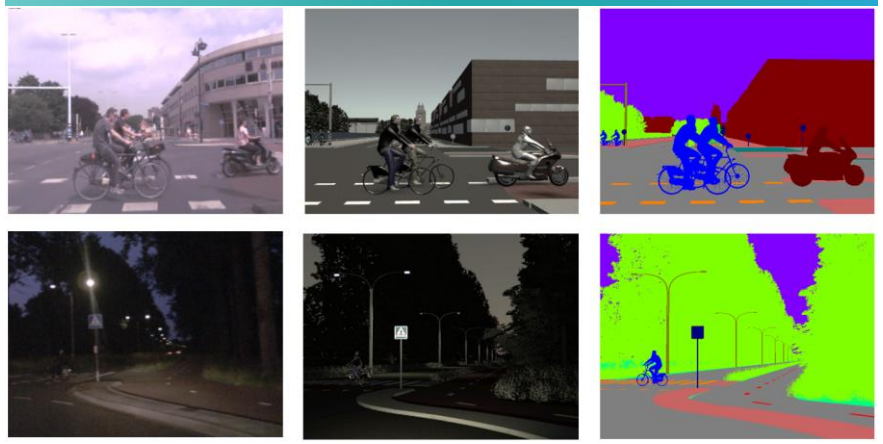
GUI



Scripted scenario generation



Scenario import



Ready to use scenarios

Simcenter Prescan World Modelling

Non-ideal environment

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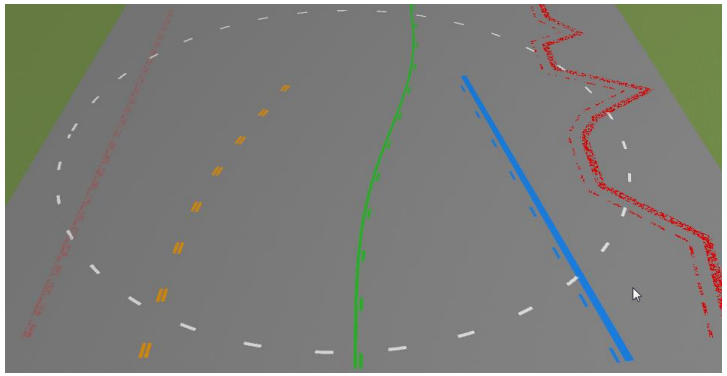
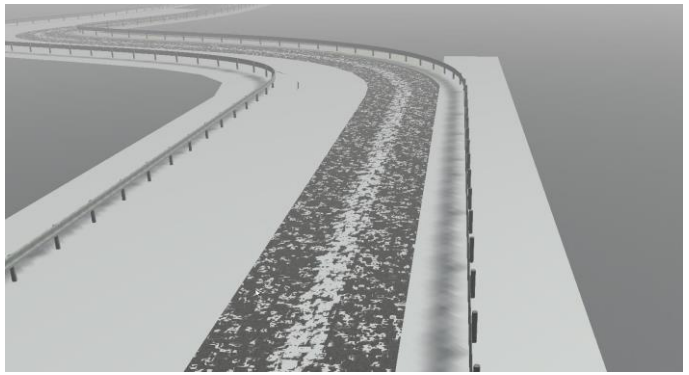
Realistic bumped asphalt

Faded, dirty lane markers

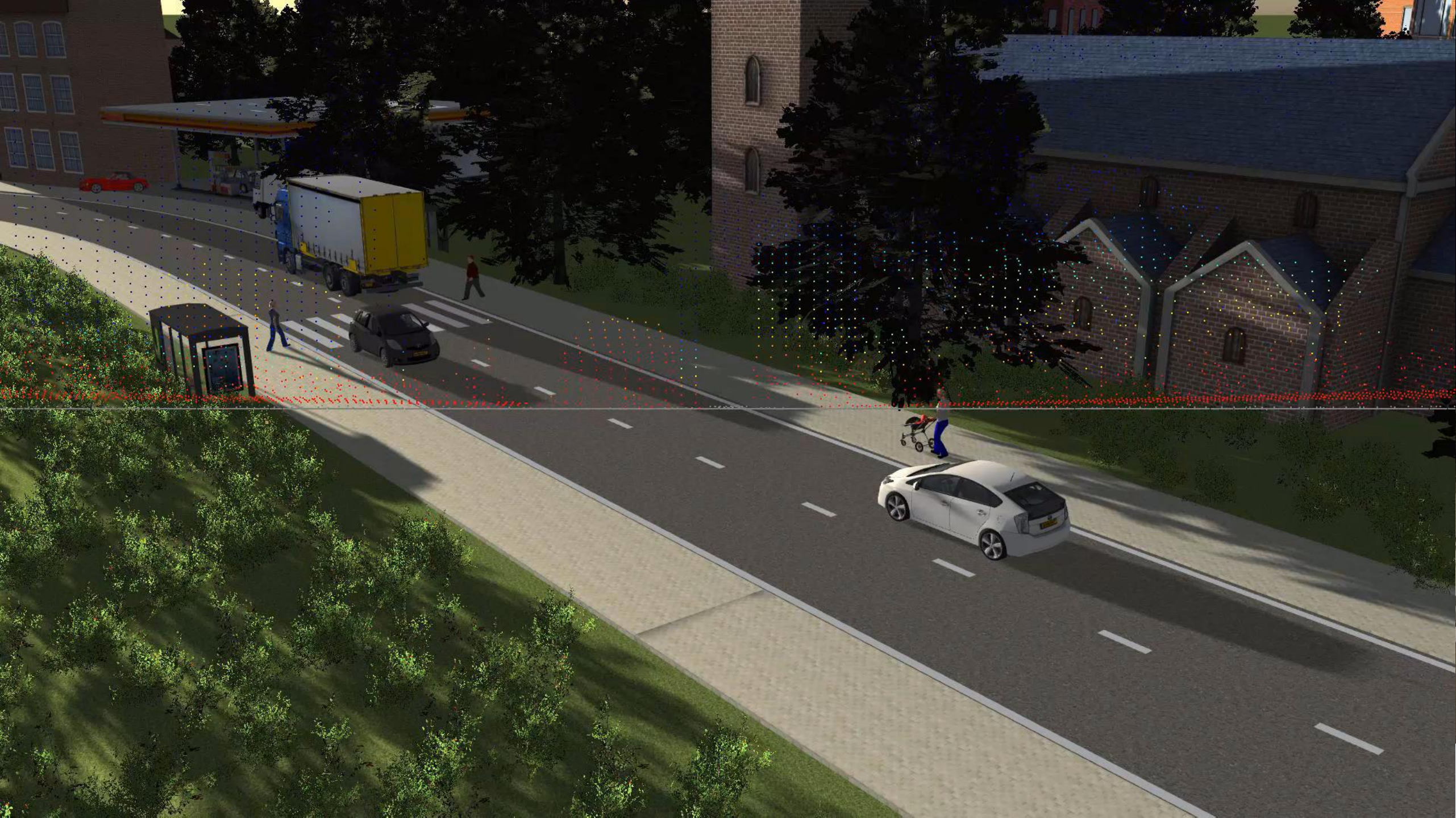


Non-perfect lane markers



Lane markers with snow

Mud, water puddles on the road



Simcenter Prescan

Virtual testing of autonomous driving functions

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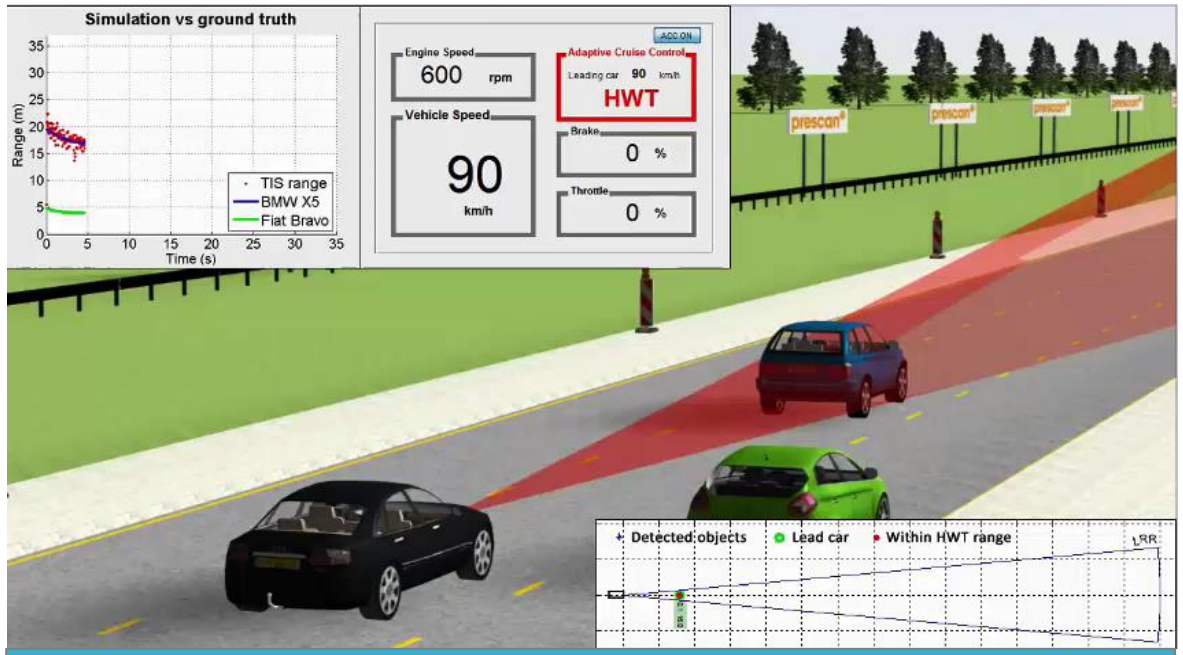
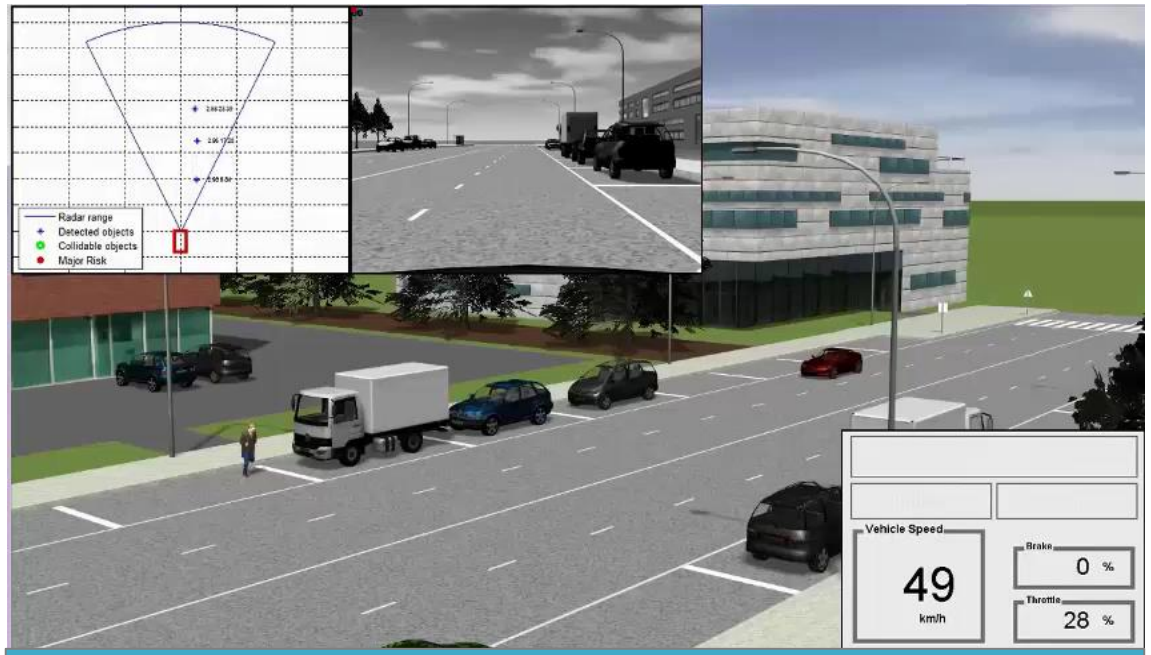


Adaptive Cruise Control

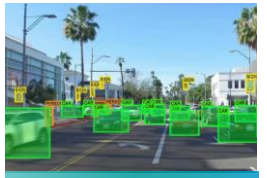


Pedestrian AEB
based on radar-camera fusion

Complete sensor models library:
Camera, Radar, LIDAR, Ultrasone, Infrared, V2X, GPS

Simcenter Prescan

Ready to use sensor models



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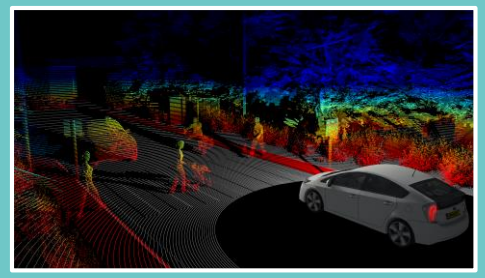
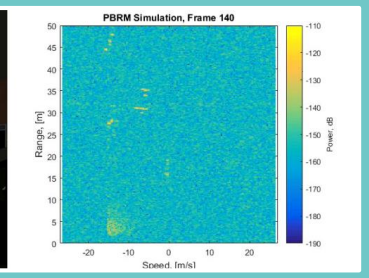
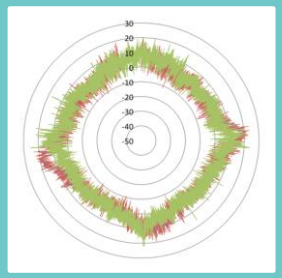
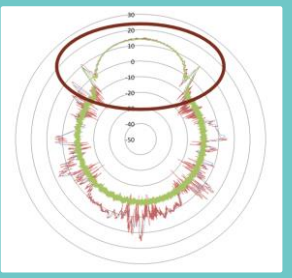
Camera



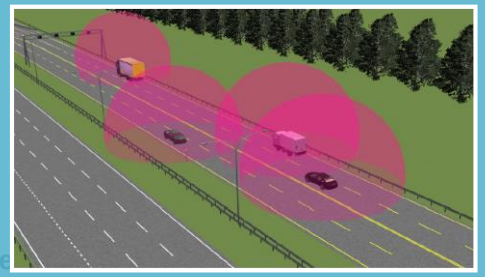

Radar & Lidar

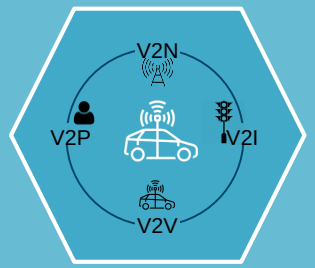


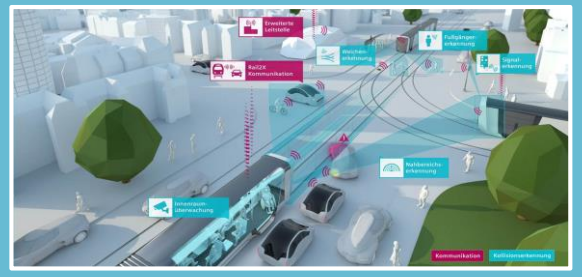


V2X & Ultrasonic





Simcenter Prescan: sensors models

The right fidelity level for scaled-up simulation

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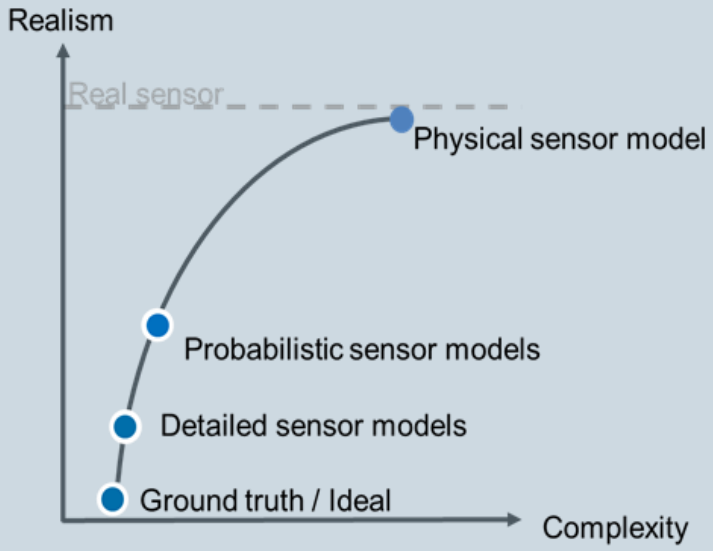
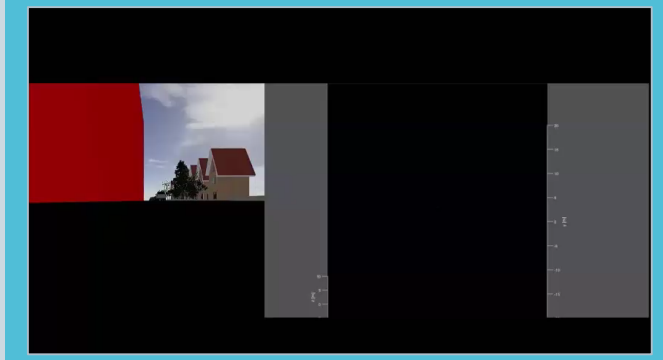
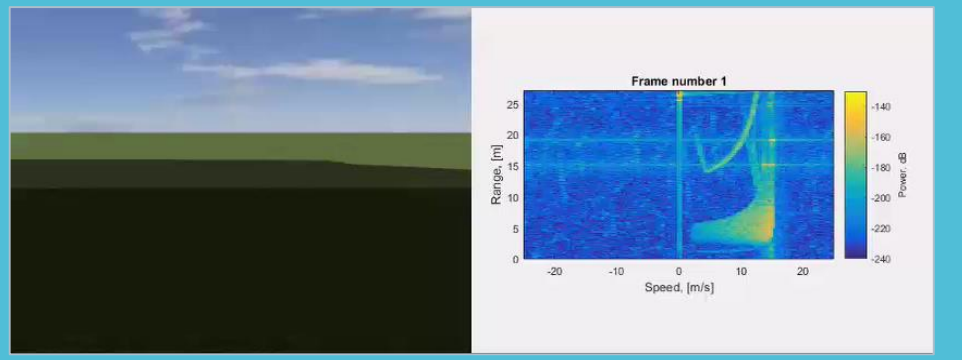
Balancing accuracy and computation time of sensor simulations





Lidar (spinning and solid-state)



Physics-based Radar simulation

Example: during night-time driving

Example: Realistic lighting conditions

Simcenter PreScan Physics Based Camera (PBC) simulation

Radar Simulation example

Development with models validation in mind

Validation

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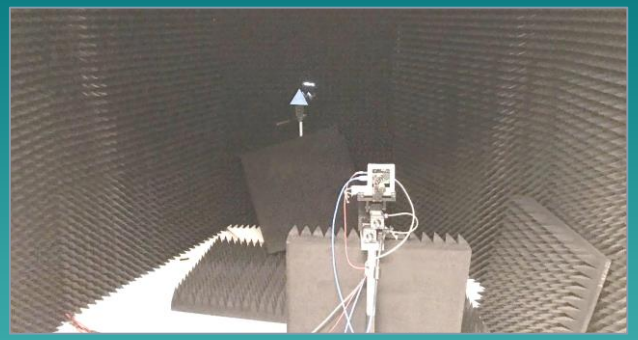
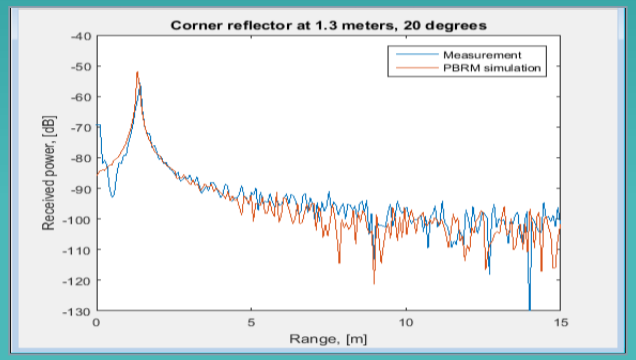
Two projects for radar models validation performed in close collaboration with major Dutch Tier2 and Japanese Tier1





From a lab…

To a test track…

To the real world…

Simcenter Prescan: World Modelling

DataModel API

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- The Prescan DataModel API allows for a programmatic way of creating scenarios
  → Repeatability is ensured

- All important assets can be created via scripting:
  - Roads
  - Actors
  - Traffic signs
  - Nature elements
  - Trajectories
  - Environmental conditions
  - Etc.

- Parameters can also be changed automatically via the API by HEEDS

Leveraged by the ADAS/AD V&V framework

Simcenter Prescan: World Modelling

DataModel API – languages supported

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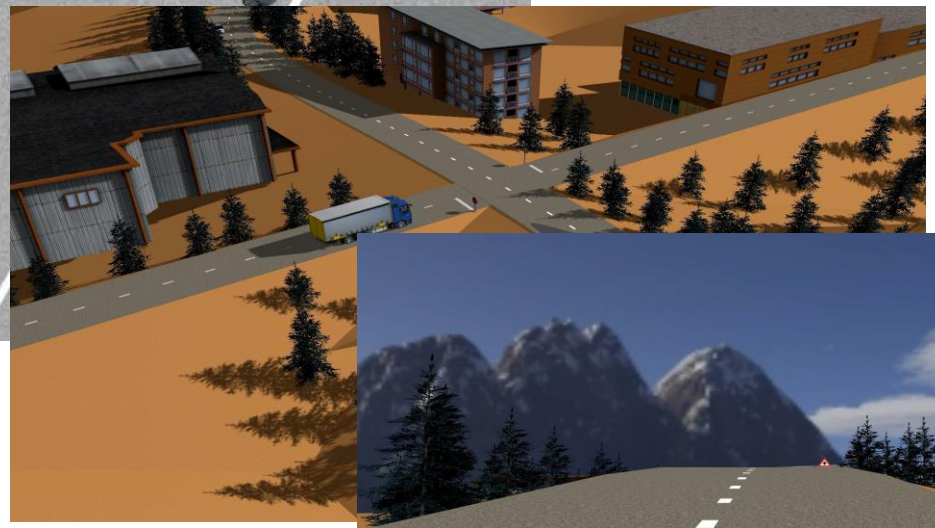

APIs in
Matlab
C++
Python

Go from code…

…to scenarios at scale

APIs available in Matlab, C++, and Python

Leveraged by the ADAS/AD V&V framework

Simcenter Prescan: World Modelling

Combination of scenarios and ego assets

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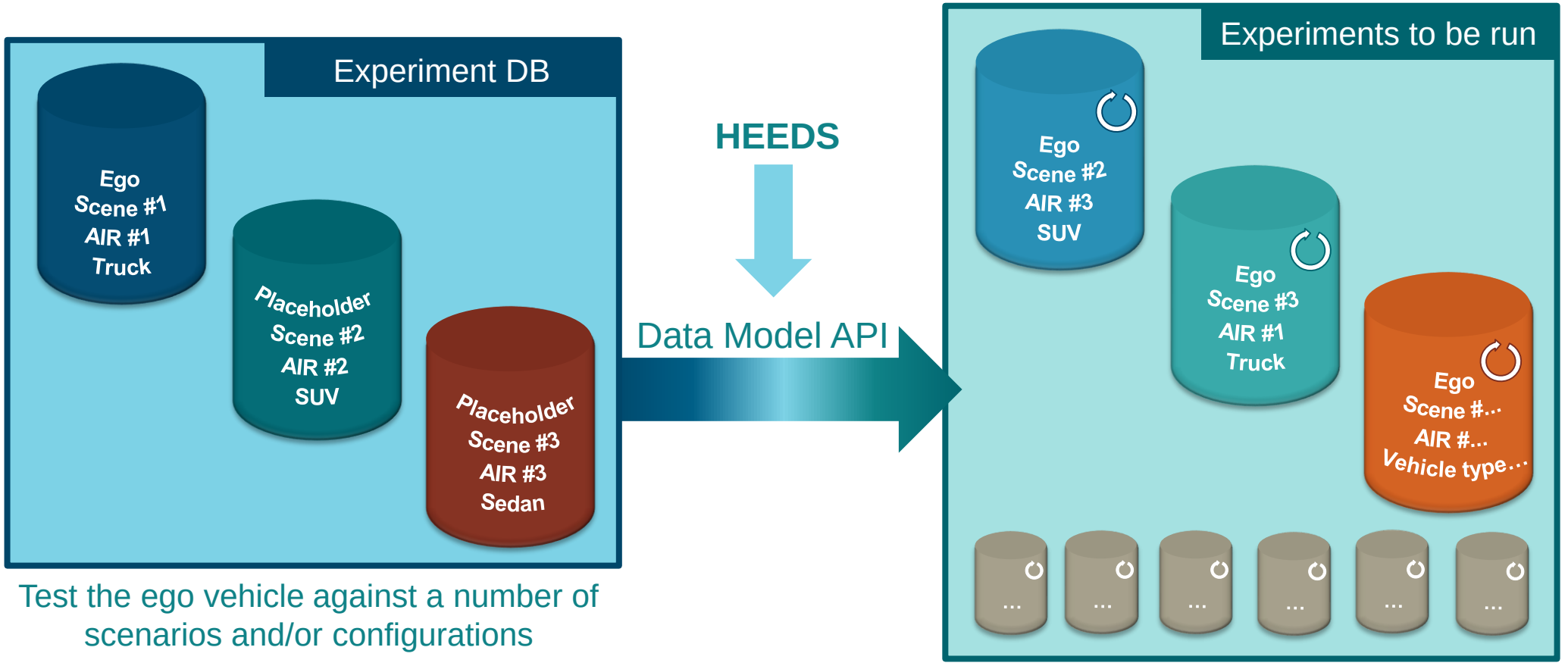

Test the ego vehicle against a number of scenarios and/or configurations

With the Data Model API, 3rd party can combine different experiments

Leveraged by the ADAS/AD V&V framework

Simcenter Prescan:

Cluster Solution

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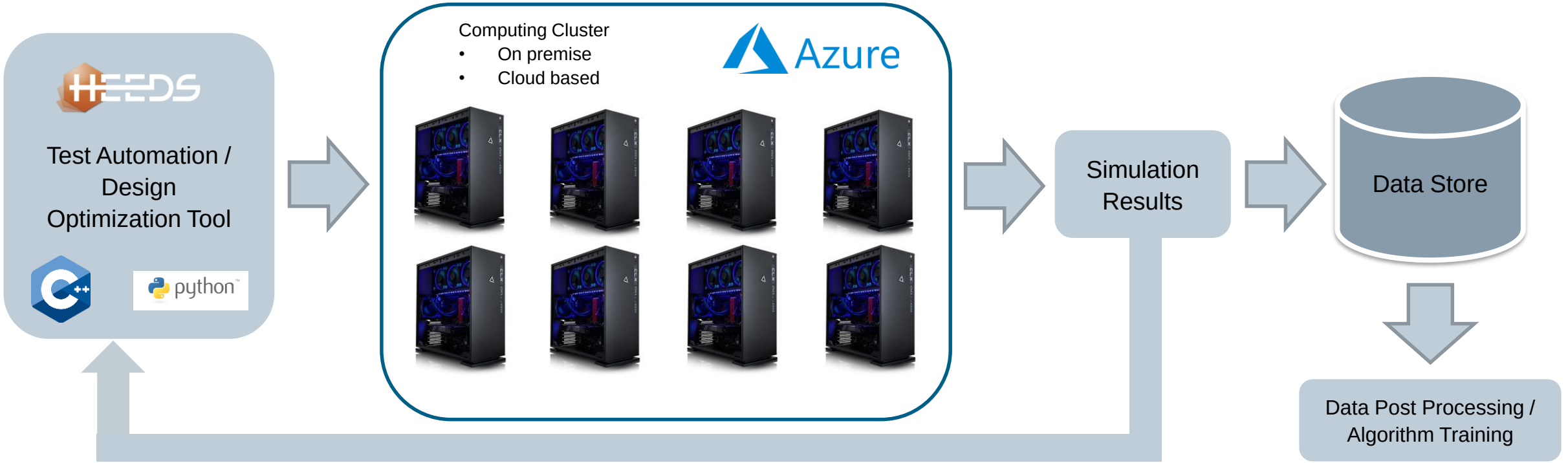

- A Test Automation Interface provides a way of sending parameter variations to the computing cluster
- Multiple unique PreScan experiments can be run in parallel on the computing cluster
- The simulation results are accessible from either the Test Automation Interface or the Data Store
- The Data Store can be accessed for further data analysis or algorithm training (in the case of deep learning applications for example)
- Two solutions are available:
  - Cloud – Microsoft Azure
  - On-Premises

Leveraged by the ADAS/AD V&V framework

kubernetes by Google

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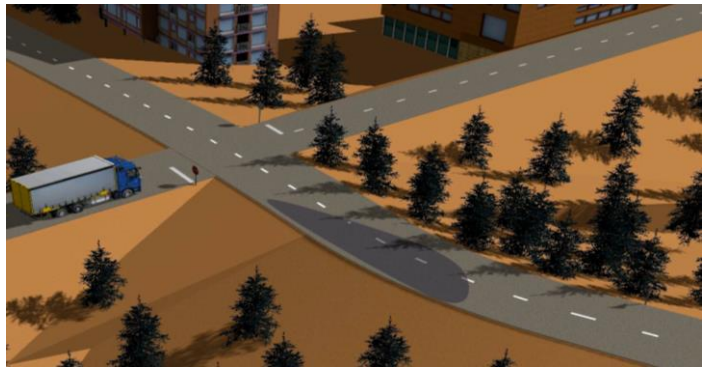
3. Wrap-up and next steps

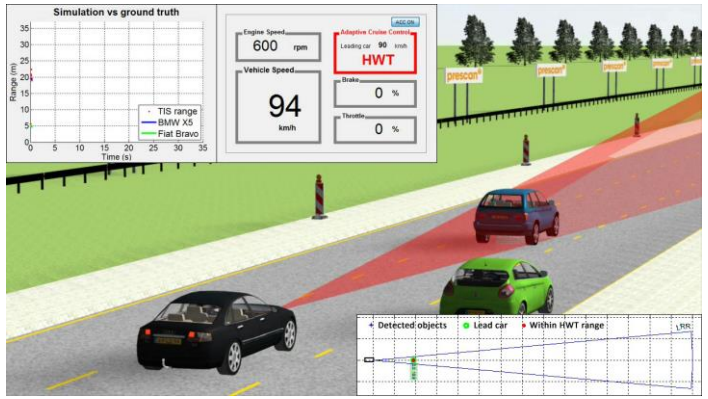
Simcenter Amesim

When higher fidelity vehicle dynamics and powertrain are needed

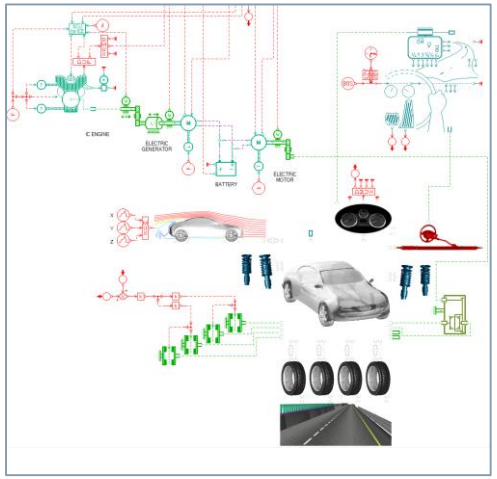
SIEMENS
Ingenuity for life



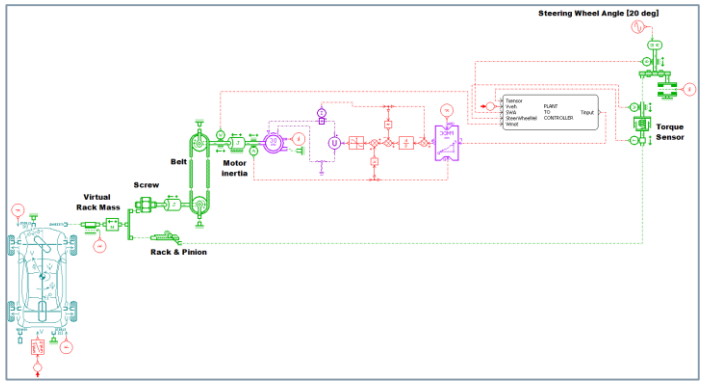
Full vehicle dynamics models for AEB safety cases

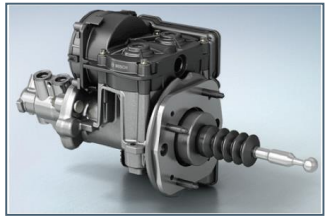


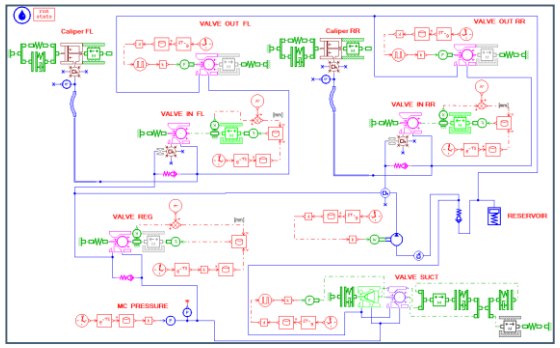
Powertrain and braking systems models for ACC cases



Pick the relevant fidelity level from Simcenter's Amesim scalable modeling offer

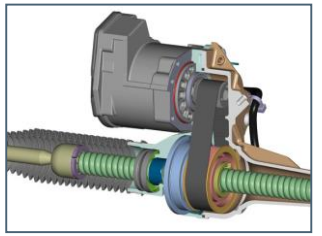






For AEBS, ESC pump dynamics is critical.

For level 4-5, redundancy will be ensured by the ESC, the EPB and the eBooster.



When level 4-5, we will probably work with steer by wire and motor redundancy.

Simcenter Amesim

When higher fidelity vehicle dynamics and powertrain are needed

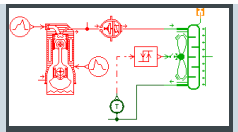
SIEMENS
Ingenuity for life

45 Libraries / 4,000 Multi-physics Models

- Validated and maintained
- Supporting multiple levels of complexity
- No need for details physics expertise

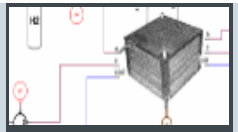
Fluids

- Hydraulic, hydraulic component design
- Hydraulic resistance, filling
- Pneumatic, pneumatic component design
- Gas Mixture, moist air



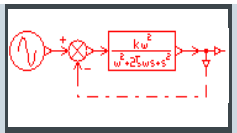
Thermal

- Thermal, thermal hydraulics
- Thermal-hydraulic component design
- Cooling, air-conditioning
- Two-phase flow



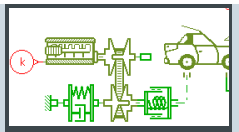
Energy

- Fuel cell
- Battery
- Power generation



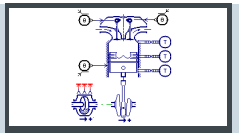
Control

- Signal and control
- Engine signal generator
- Real time, MIL – SIL – HIL



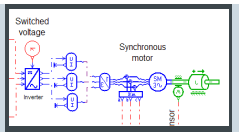
Mechanics

- 1D – 2D – 3D mechanical,
- Transmission, cam and followers
- Finite-elements import
- Vehicle dynamics



IC Engine

- IFP drive, IFP engine
- IFP exhaust
- CFD-1D



Electrics

- Electrical basics, electromechanical
- Electrical motors and drives
- Electrical static conversion
- Automotive electrics, electrochemical

ADAS/AD V&V framework

Simulation production: overall workflow

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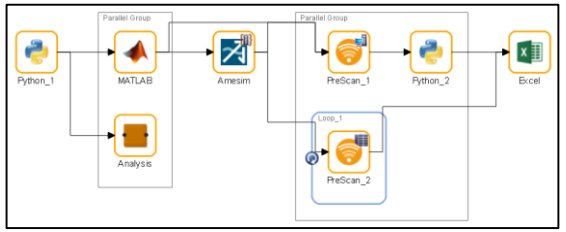
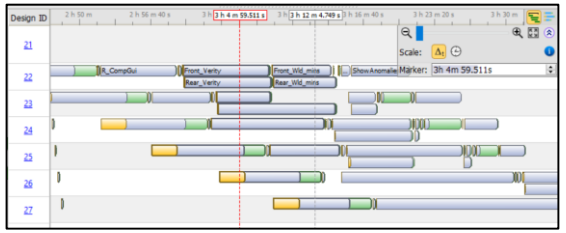
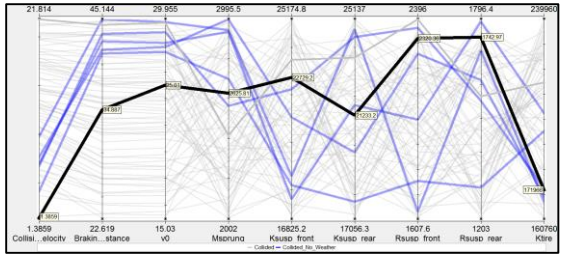






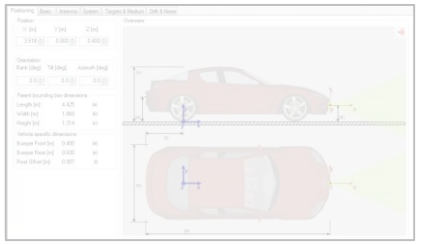
Scenarios | **Ego models**

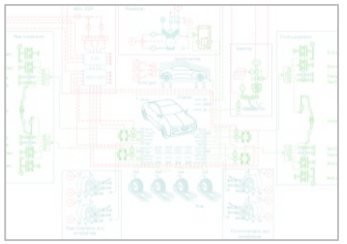
Simulation plan definition

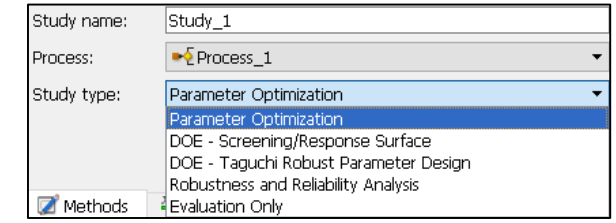
Simulation plan execution

Numerous results analysis

Reporting

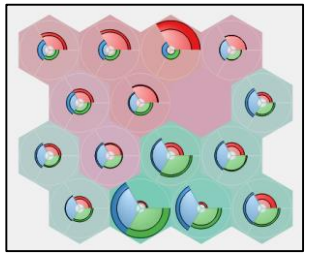


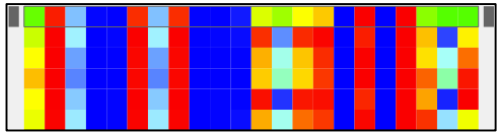




Azure

kubernetes





ADAS/AD V&V framework

1. Context and challenges
2. **Siemens ADAS/AD V&V framework**
   a) Overview
   b) Environment and sensor simulation
   c) Vehicle dynamics and powertrain
   d) **Simulation orchestration**
3. Wrap-up and next steps

HEEDS as simulation orchestrator

Scenarios space exploration to verify and validate systems

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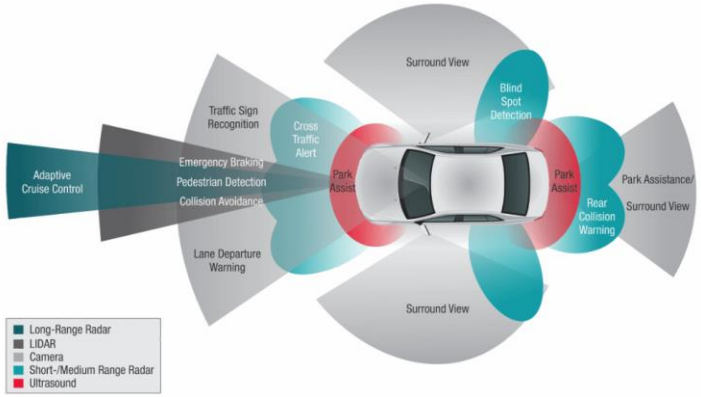
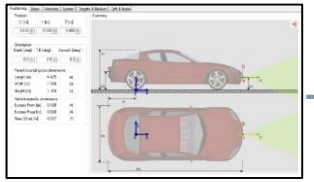
Ingenuity for life

Scenarios Space Exploration

- Process Automation (Automate building of simulation plan)
- Distributed Execution (Accelerate testing of virtual prototype)
- Map system's performance limit in scenarios space (Robustness)
- Assess system on defined test plan (Verification)
- Insight & Discovery (Ensure reliable product performance)



ADAS/AD system

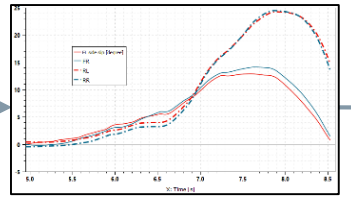


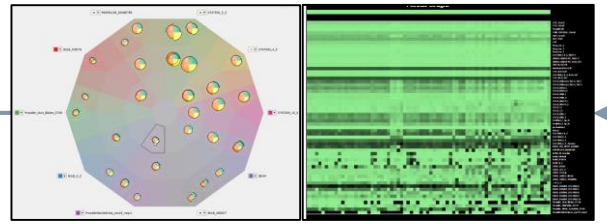
System models

HEEDS

Scenarios variability

Post-processing





Assessed system performance mapping

ADAS/AD V&V framework

Simulation production: overall workflow and AEBS example

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❖ IBEO imported highway and city scenarios
❖ Created highway and city scenarios with OpenDrive import
❖ Off-the-shelf Euro NCAP and ADAC scenarios content in Simcenter Prescan
Total: 50 parametrizable safety scenarios

❖ Long and short range radar probabilistic models
❖ AEBS in C/C++ code
❖ ABS, ESC models
❖ 15 DOF chassis with Pacejka tires
❖ Braking system physics including actuation and its controls

Process automation:
❖ Write preliminary auxiliary files
❖ Pre-guesstimate relevance of current test case (challenge level) with some expressions. If unreasonable, test case replaced.
❖ Vehicle dynamics-only initialisation run to determine initial ego chassis state
❖ Execute the main co-simulation run
❖ Run a specific post-processing python script

❖ Scenarios parametric sampling method: latin hypercube sampling on 5 to 10 parameters, with 100 test cases per scenario allocated budget
❖ Input parameters dependencies enforcement across models: drives parameters consistency and relevance of generated test cases
❖ Post-process metrics with expressions: gives safety and performance high level insight

❖ Azure cloud submission and execution
❖ Parallelized execution monitoring from local machine
❖ Result analysis during execution from local machine

❖ Display safety and performance metrics at simulation plan level (5000 runs) to provide failure modes patterns view in test cases space.
❖ In-depth results analysis for some selected runs based on overview
❖ **Discovered problem 1**: Bad weather conditions provoke too much radar waves attenuation, which leads to targets non detection and sometimes near accidents situations
❖ **Discovered problem 2**: AEBS' road network mapping contains flaws and leads to wrong emergency braking triggers generating very bad comfort or even collisions

Automated reports generation: AEB testing key findings and simulation activity summary

HEEDS' for ADAS/AD simulation orchestration

Projects structure

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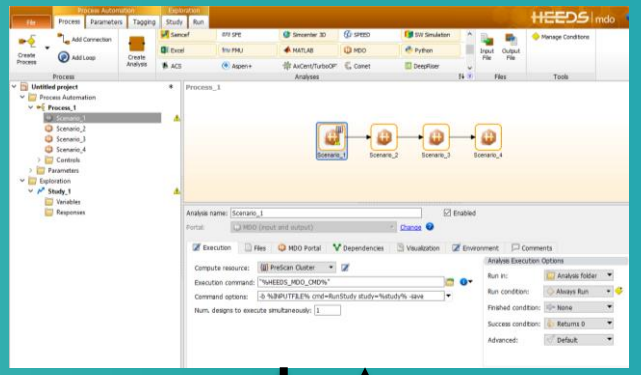
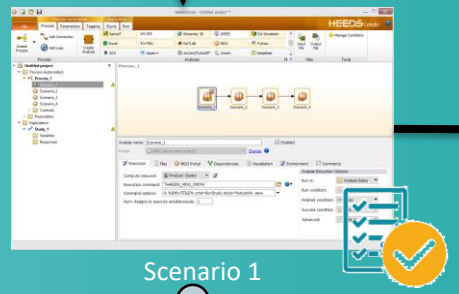
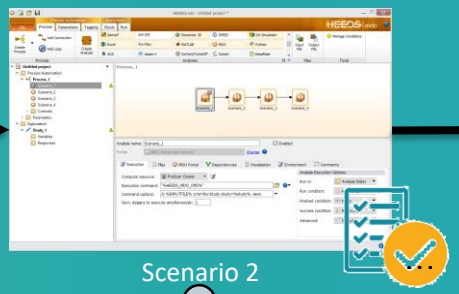
Master project



Scenario-specific projects





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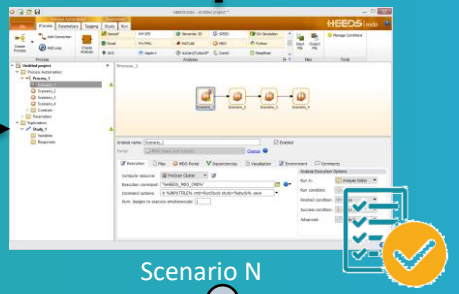


Test cases

Test cases

Test cases

Scenario_1* - Simcenter Prescan Experiment Editor

File Edit Tools Settings Experiment Plugins Help

Parse Build

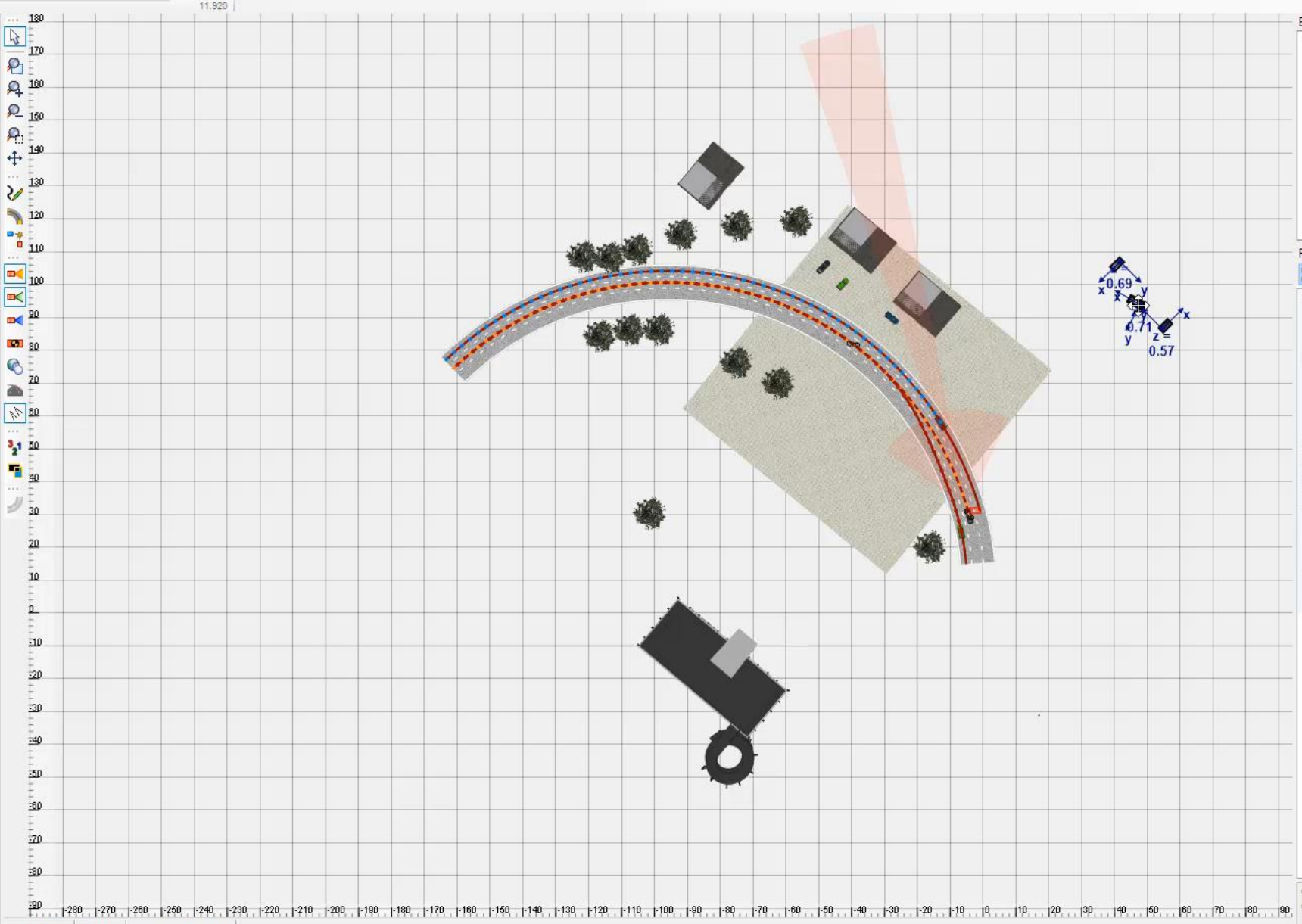
0.000
11.920

Environment | Infrastructure | Actors | Sensors | Visu Aids | UL Elements

Underlays (2-D)
- Chessplane
- Concrete
- Grass
- Pavement

Nature Elements

Dirt Spots



X: 47.29 | Y: 93.55 | Grid spacing: 10 m

Experiment Components
- Scenario_1
  - Environment
  - Infrastructure
  - Actors
    - Articulated Actors
    - PluginSensors
  - Paths
  - SpeedProfiles
  - Visu Aids

Property Editor

Identification	
Name	
Description	
Numerical ID	
Object specific info	
Reference	False
Sensor detectability	Invisible
Collision detectable	False
Contact world detectable	**False**
Position	
CoG offset	
Location	
Orientation	
Bounding box	
Length	
Width	
Height	
Misc	
GhostColor	**100, 100, 100, 100**
IsInGhostMode	False

CoG offset
Center of Gravity offset from model origin.

Progress:

ADAS/AD V&V framework

1. Context and challenges
2. Siemens ADAS/AD V&V framework
   a) Overview
   b) Environment and sensor simulation
   c) Vehicle dynamics and powertrain
   d) Simulation orchestration
3. **Wrap-up and next steps**

Customer Success Story

SIEMENS
Ingenuity for life

Info:

Region: Japan

Test case automation for hardware-in-the-loop Radar and Camera simulation use-cases

PreScan at Honda R&D

Masahito Shingyoji, Chief Engineer, Honda R&D

" We applied PreScan real-time HIL for testing our camera – radar system. Extensive test scenarios were simulated using test automation to maximize the efficiency of development cycle. We used it to test our ADAS applications such as LDW, FCW and TSR, and are now extending to AEB and ACC along with precise vehicle dynamics models of CarSim. "

Customer Success Story

SIEMENS
Ingenuity for life

Info:

Region: Korea

ADAS algorithm development and R&D

PreScan at HMC

Yongsun Kim, Part Manager, Hyundai Motor Company R&D Center

" Hyundai Motor Company (HMC) has been using PreScan software for several years now to develop and verify new ADAS functions such as pre-crash. We particularly value the capabilities of the software in the area of scenario definitions, the easy interface to our existing vehicle dynamics models, the broad database of different sensing technologies and the professional support that we receive from the local TASS team. As a result we recently planned to extend our PreScan usage to our autonomous driving development and research. "

Customer Success Story

SIEMENS
Ingenuity for life

Info:

Region: Germany

ADAS and HMI development R&D

PreScan for Driving Simulator

Thomas Passegger, Truck Product Engineering, Daimler Trucks

" When upgrading our truck driving simulators for ADAS and HMI studies, we selected the PreScan software from TASS International for the world, scenario and sensor simulation. Its accurate sensor models and flexible scenario definition enable us to do active safety system analysis and HMI studies with a driver in the loop. Their engineering team did a great job connecting PreScan to our existing control and vehicle dynamics models. "

Wrap-up

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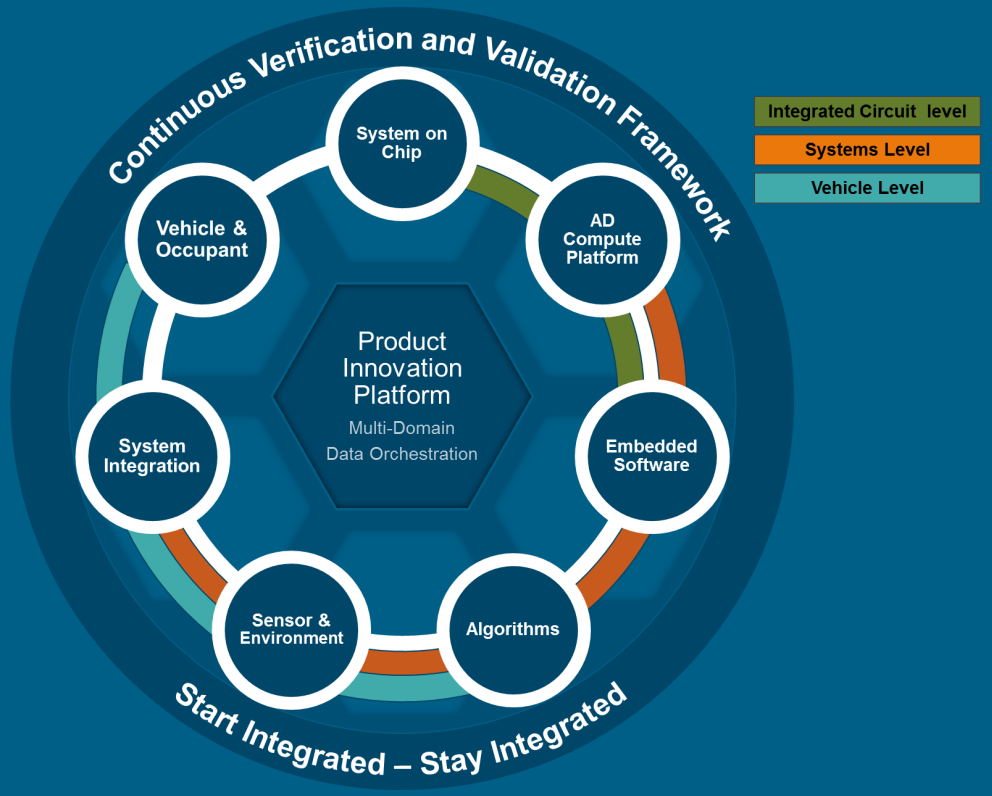
The strength of combining:

- **Simcenter Prescan**
  - World and sensor modelling capabilities
  - Data Model API
  - Cloud submission
- **HEEDS**
  - Process automation capabilities
  - Parametric sampling methods
  - Execution submission capabilities
  - High level results analysis
- **Simcenter Amesim's vehicle dynamics**



… is the first step to achieve the scale up ADAS / AD virtual verification requires.

Thank you!
Any question?