Sicherheit und Komfort für Insassen von autonomen Fahrzeugen

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Where today meets tomorrow.

Occupant Safety and Comfort – Autonomous Driving

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How does „Autonomy" affect the occupant safety and comfort?

Occupant simulation with Active Human Model AHM

Simulation of autonomous driving scenarios

Occupant safety for autonomous vehicles – examples

How does „Autonomy" effect the Occupant Safety and Comfort?
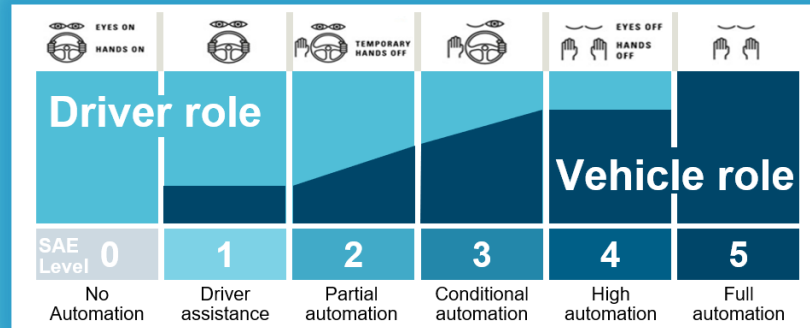
Individual seats for all occupants

New seat arrangements

Active Safety

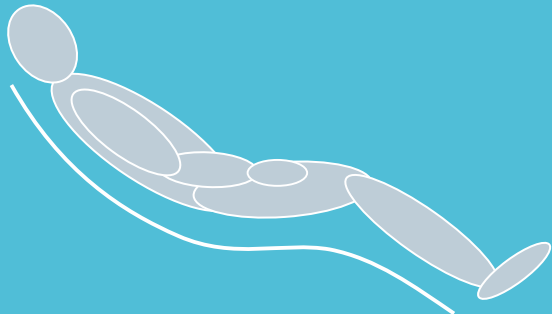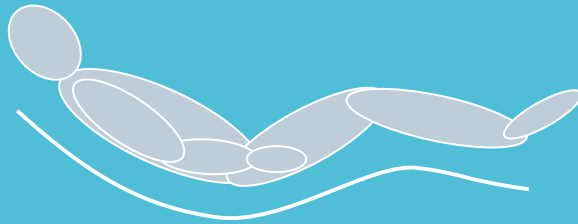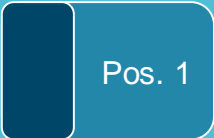Productive working

New load cases

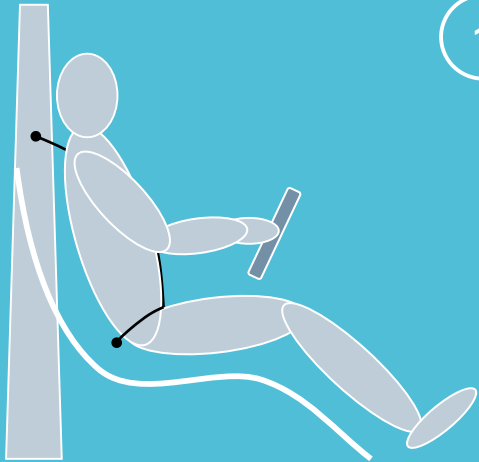Seat belt positions

Relaxation

Passive Safety

New seating positions

Seating Positions and Space

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Side View

(1) Manual / assisted driving position

(2) Working position

(3) Relaxing position

(4) Zero-gravity position

Top View

Pos. 1

Pos. 2

Pos. 3

Pos. 4

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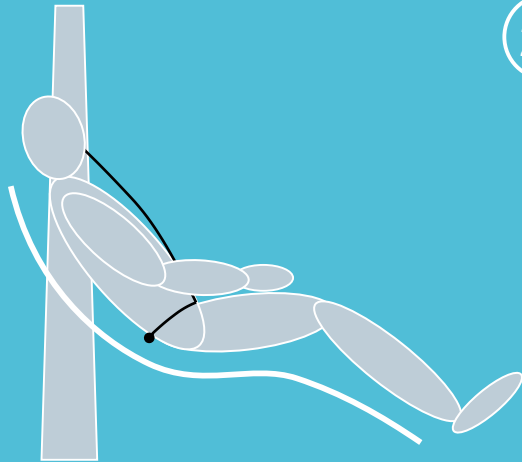# Seat Belt Position – Design of New Restraint Systems Needed

1
- Seat belt in B-pillar
- Manual / assisted driving
- Driving position
- Seat belt fits correctly
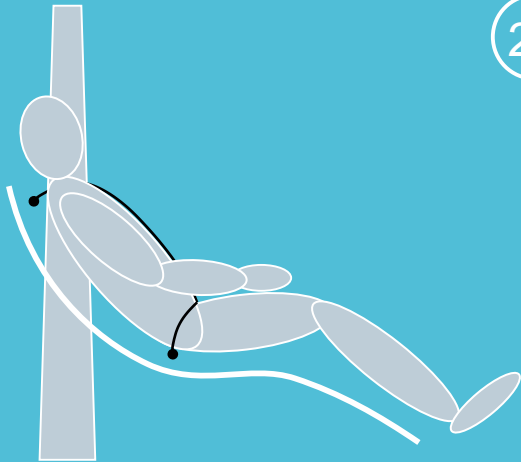
- Safe position

2a
- Seat belt in B-pillar
- Autonomous driving mode
- Working position
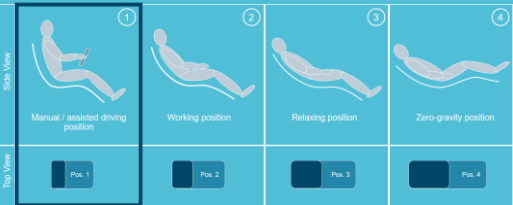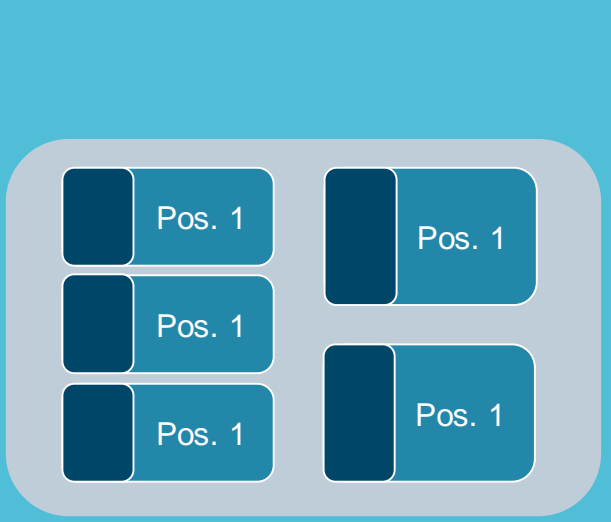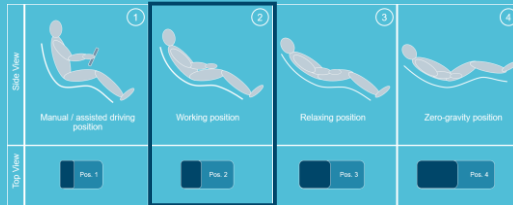- Seat belt does not fit correctly

- Unsafe position

2b
- Seat belt in seat integrated
- Working position
- Autonomous driving mode
- Seat belt fits correctly

- Safe position

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Seating Arrangements – New Cabin Concepts
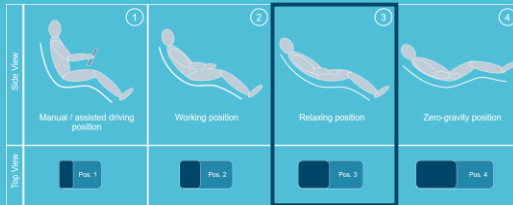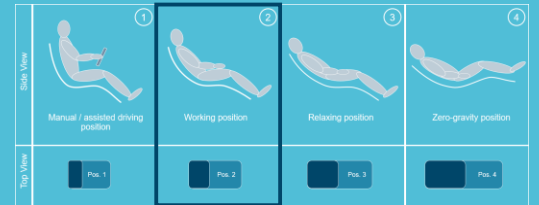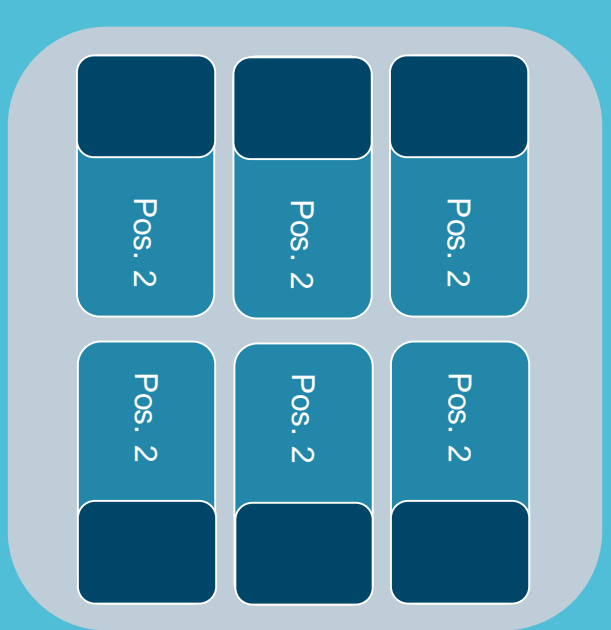
How to ensure occupant safety
when in autonomous mode?

Predict with simulation.

Occupant Safety and Comfort – Autonomous Driving

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Simcenter Madymo
Active Human Model

Where today meets tomorrow.

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Dummy vs. Active Human Model
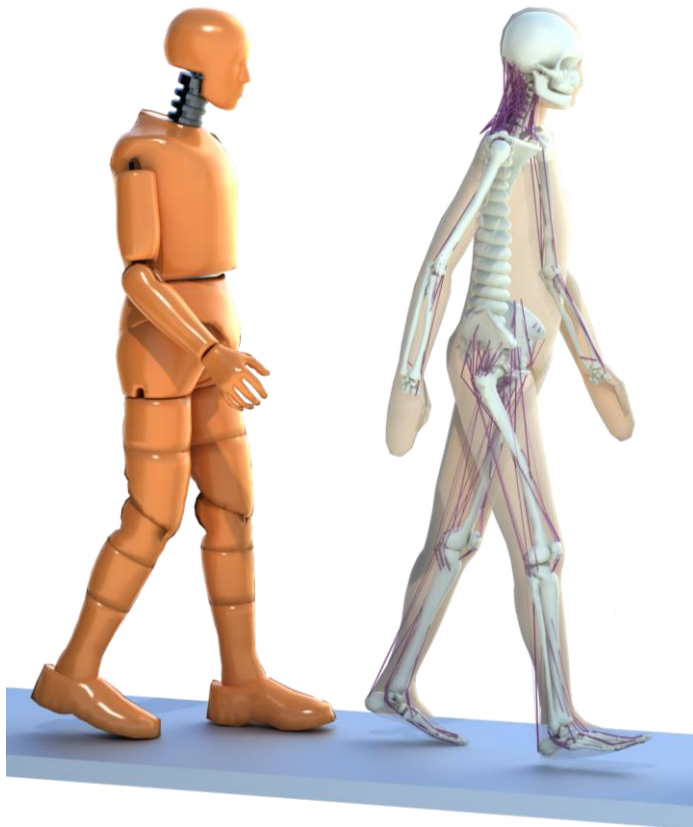
Dummy Model

Active Human Model

Active Human Model AHM

- Digital Twin representing a human and not a dummy
- Very precise model
- Reactive responses compared to dummy
- Best suitable model for active safety and pre-crash estimations
- Fast simulation due to multi-body solver
- Full parametrizable model

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Unconsciousness Modeling

"Act like a Human"
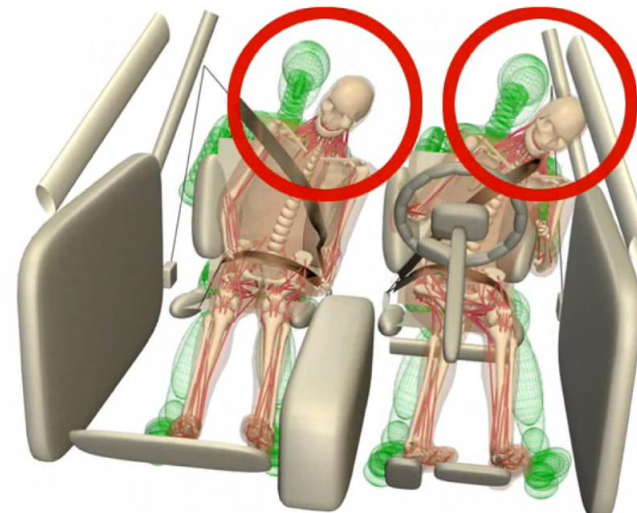
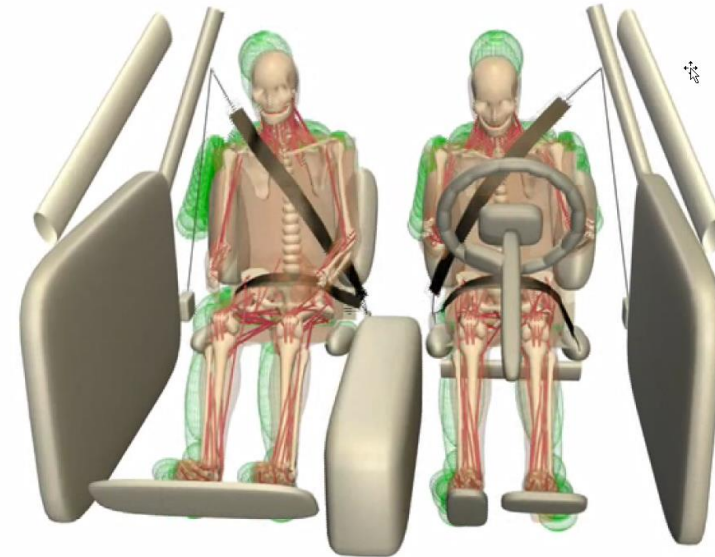| HEAD	Controlled using neck muscles & balanced muscle recruitment (co-contraction)
ELBOW	Controlled using arm muscles
SPINE	Controlled using actuators
HIP	Controlled using leg muscles

This functionality greatly assists the development of fully autonomous (level 5) vehicles where the occupant is no longer in control

Features and Capabilities

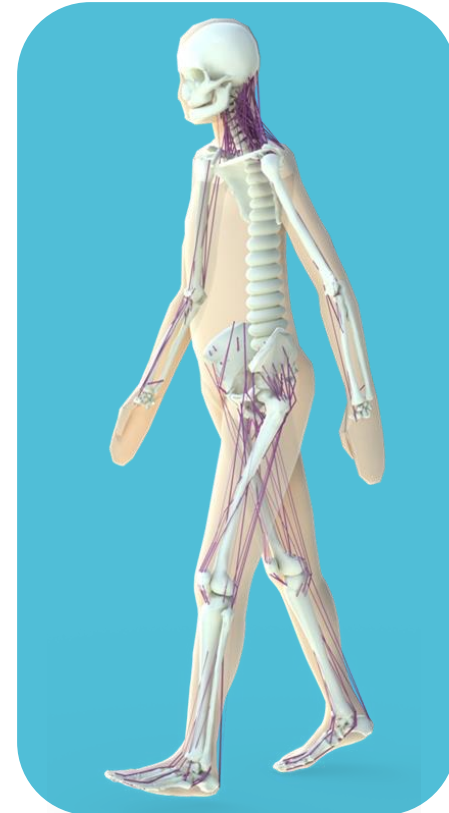**AHM simulates occupant & pedestrian impacts**

Simulates **passive**, **active** and **reactive** (stabilizing) behavior fully automatically.

(RE-)ACTIVE — The model moves to a user-defined position or stabilizes to its initial posture.

PASSIVE — no stabilization occurs and the model behaves as a Post Mortem Human Subject (PMHS).
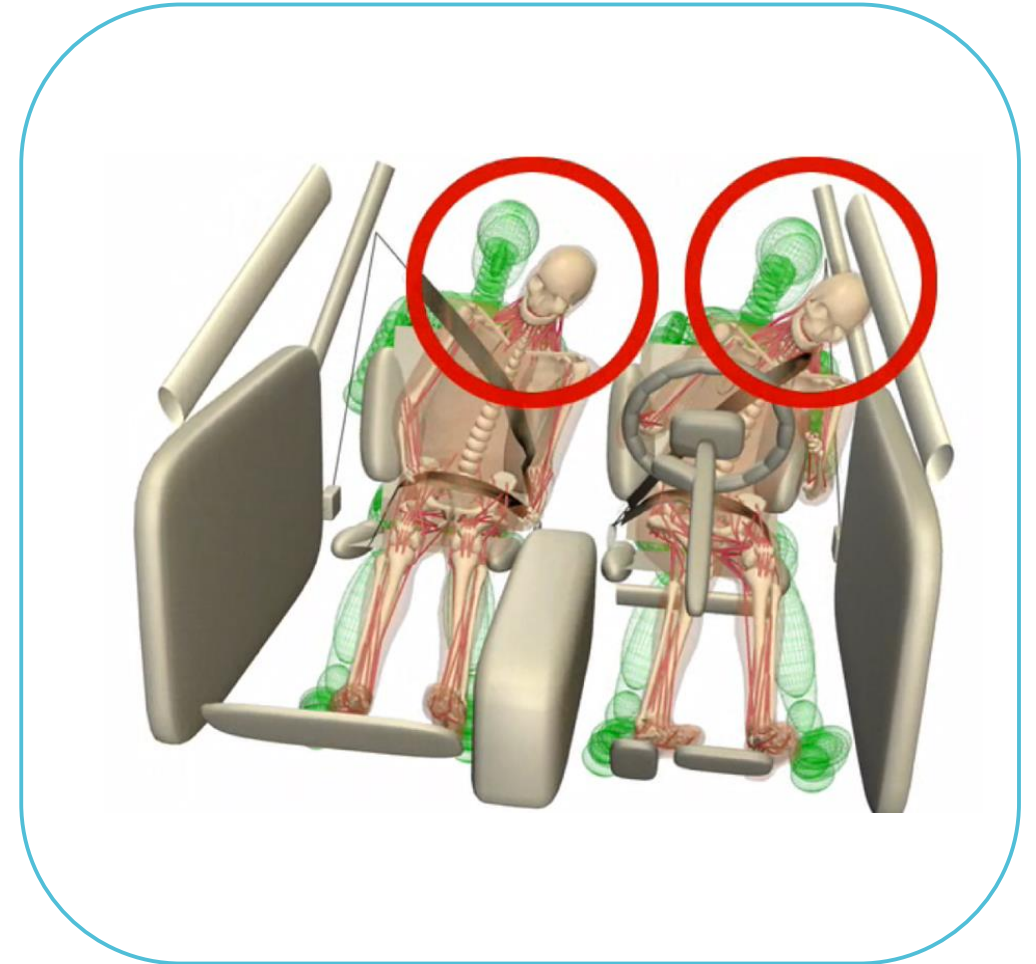
Validation of Active Human Model

Volunteer Data

- Validated for a number of **low-G** scenarios covering **braking** and **evasive** maneuvers
- Simulation results accurately follow the measured **head** and **chest** displacements
- Human responses are much more varied than ATD responses

PMHS Data

- Validated for a wide range of **medium** and **high-G** loading scenarios

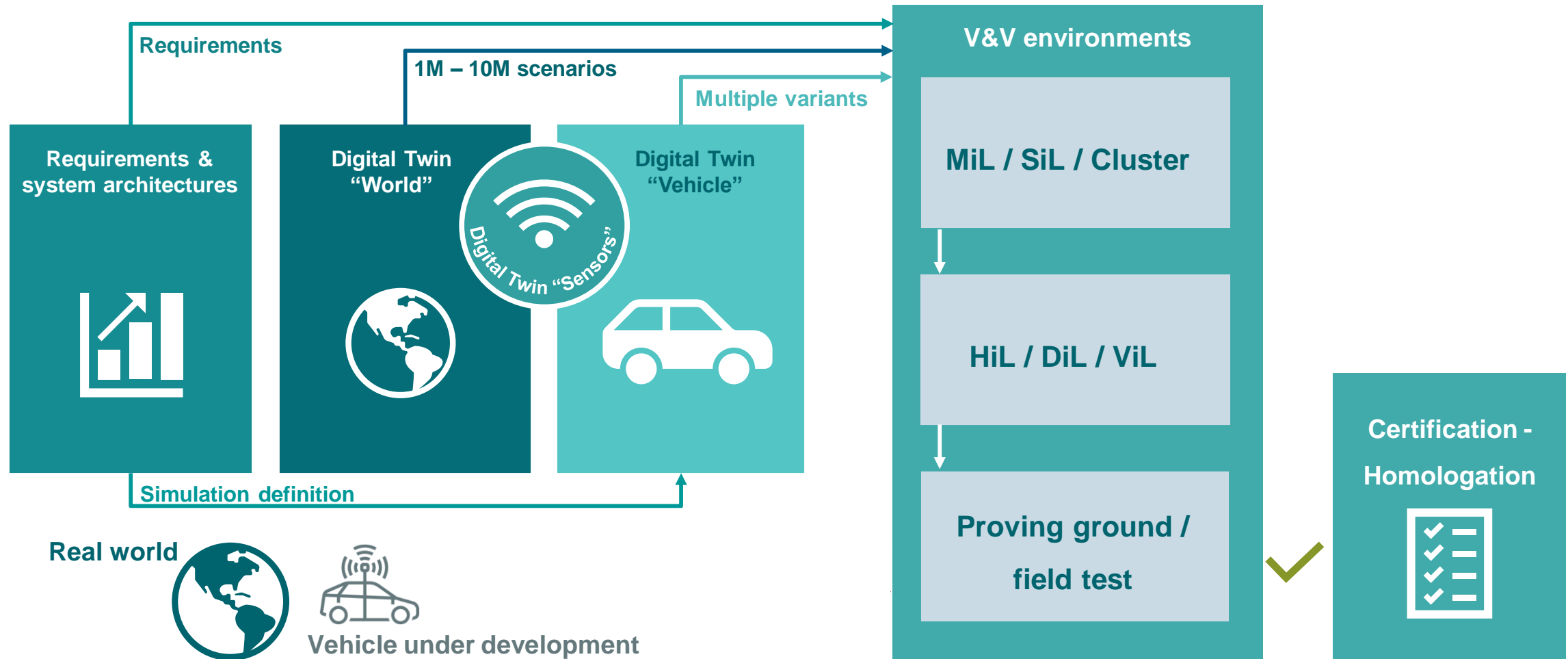# Occupant Safety and Comfort – Autonomous Driving

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Occupant simulation with Active Human Model AHM

Simulation of autonomous driving scenarios
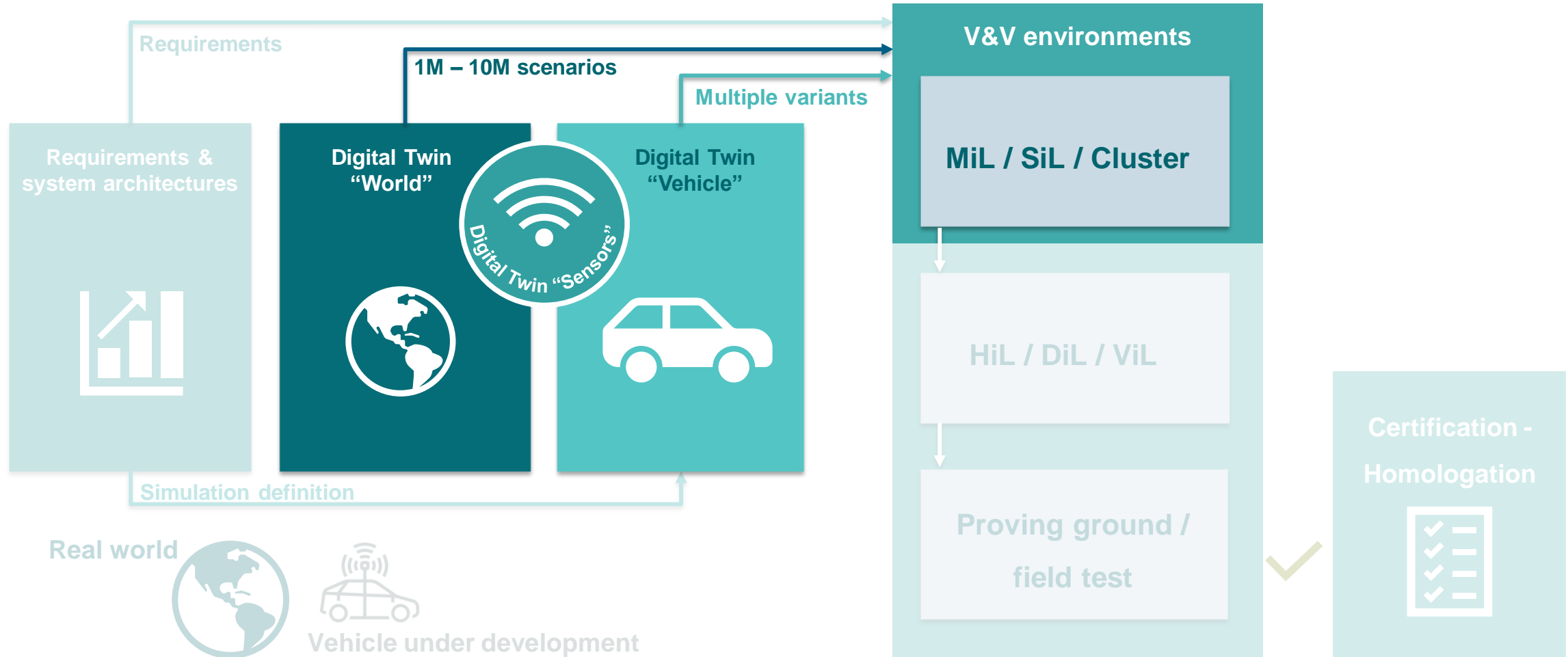
Occupant safety for autonomous vehicles – examples

Siemens Digital Industries Software
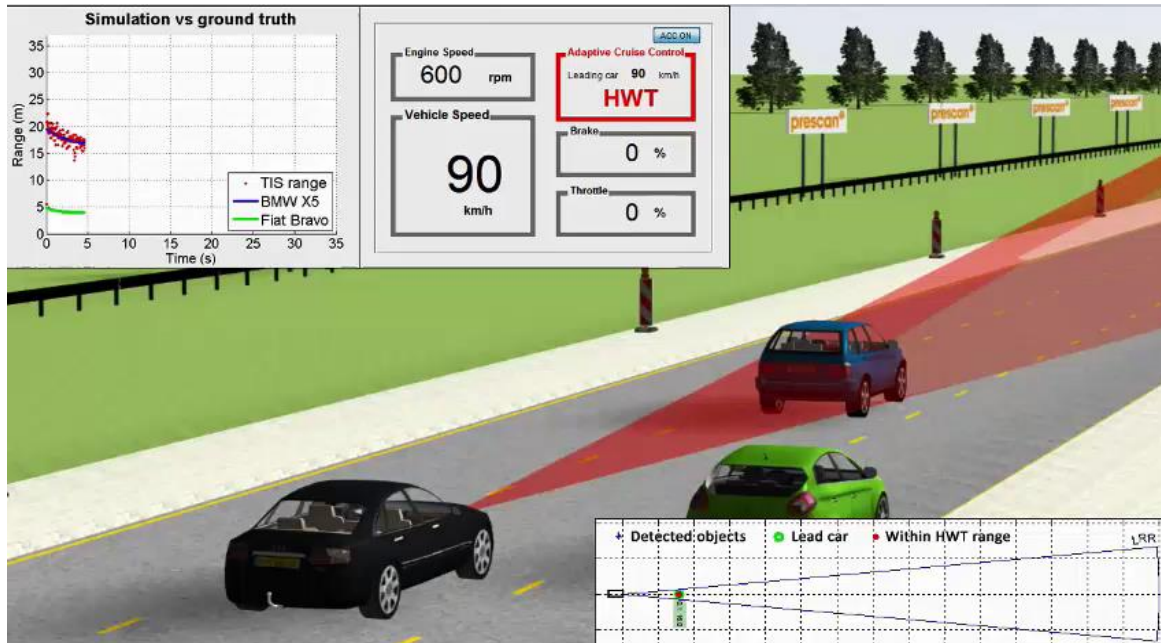
Virtual ADAS and AV Development

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Requirements

1M – 10M scenarios

Multiple variants

Requirements & system architectures

Digital Twin "World"

Digital Twin "Sensors"

Digital Twin "Vehicle"

V&V environments

MiL / SiL / Cluster

HiL / DiL / ViL

Proving ground / field test

Certification - Homologation

Simulation definition

Real world

Vehicle under development

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Simcenter Prescan
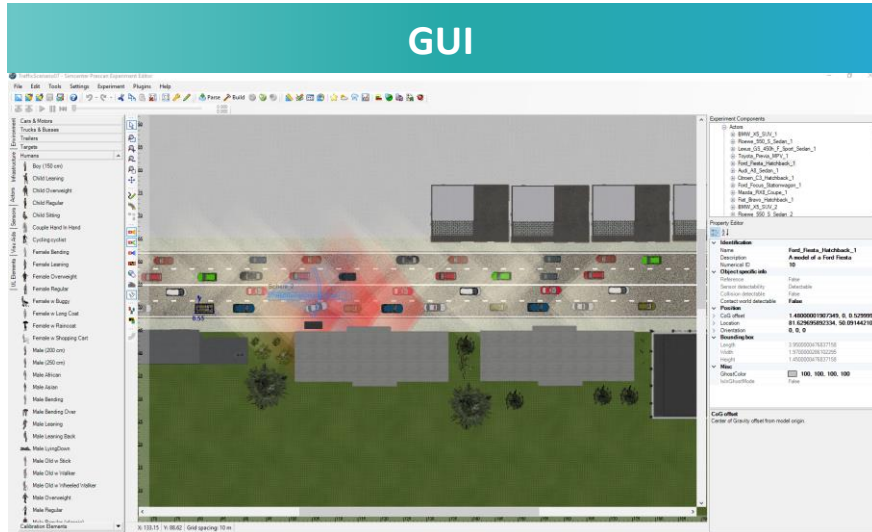*Virtual testing of autonomous driving functions*

Scenario 1 - Adaptive Cruise Control ACC
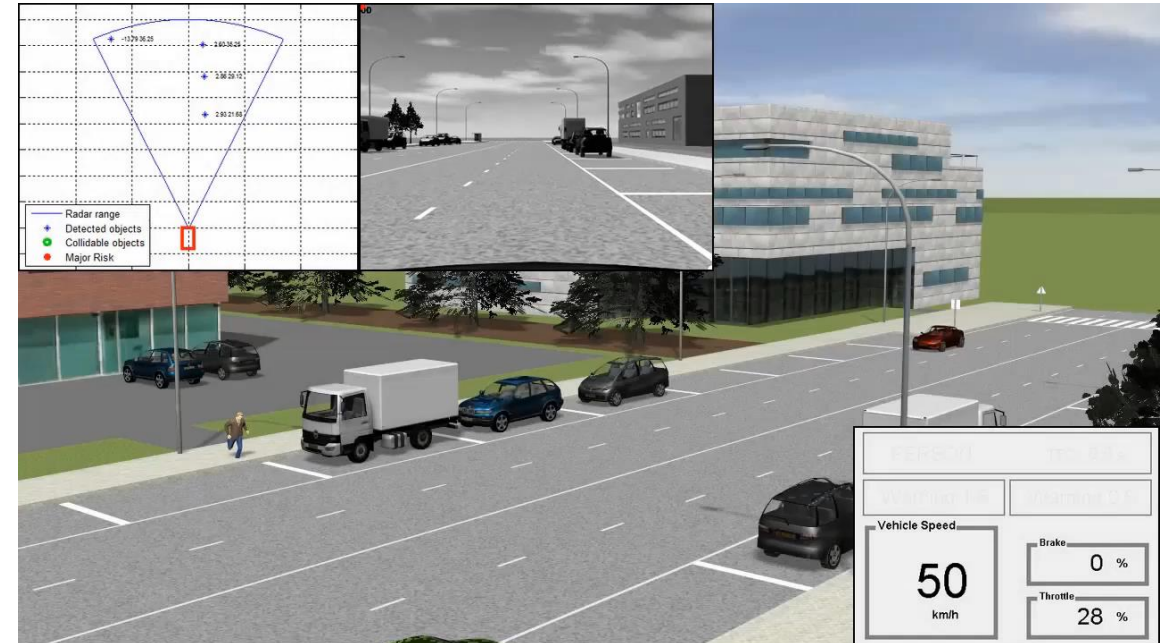
Scenario 2 – Advanced Emergency Braking System AEBS

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

Simcenter Prescan
World modelling solutions

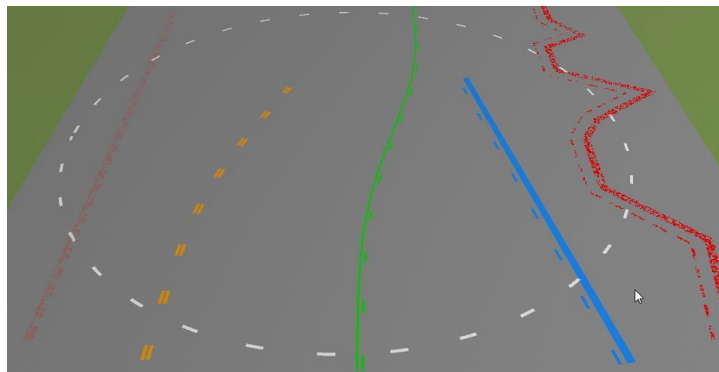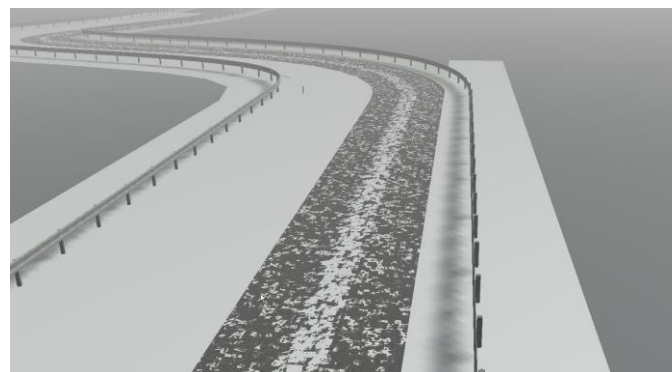**SIEMENS**
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GUI

Scripted scenario generation

Scenario import

Ready to use scenarios

Siemens Digital Industries Software
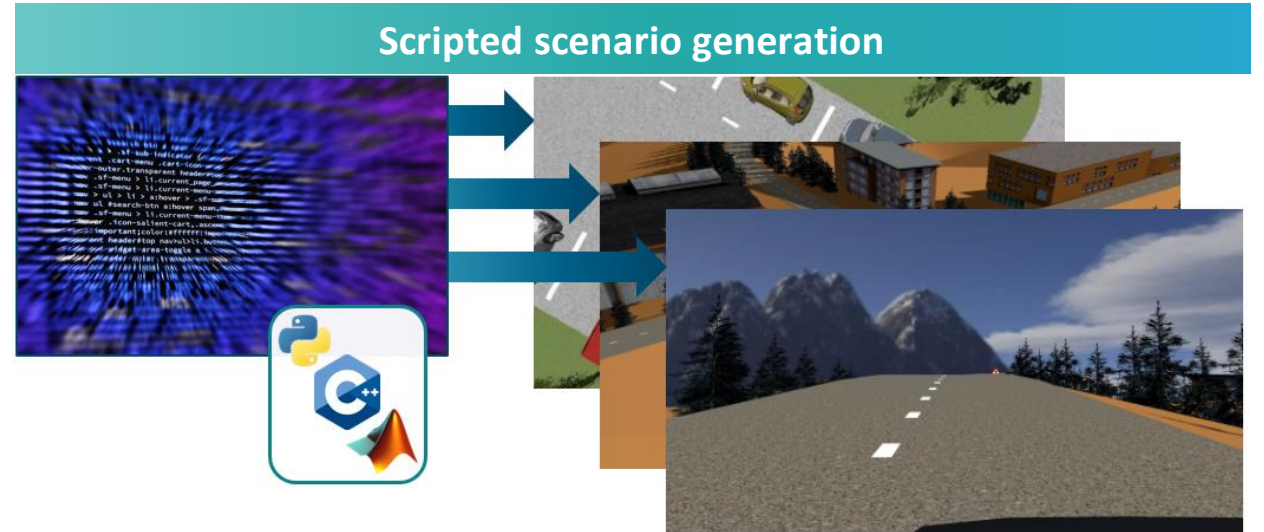
Simcenter Prescan
World modelling: non-ideal environment

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Realistic bumped asphalt

Faded, dirty lane markers
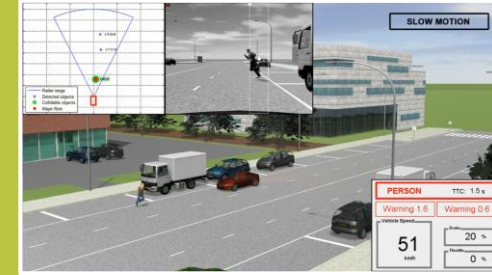

Non-perfect lane markers

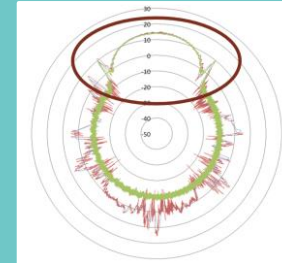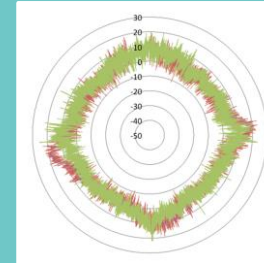**Lane markers with snow**
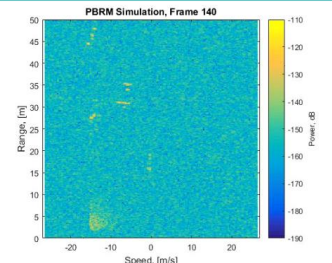

Mud, water puddles on the road

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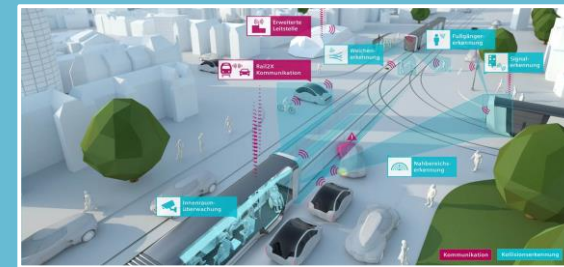# Simcenter Prescan
Ready to use sensor models

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Camera

Radar & Lidar

V2X & Ultrasonic

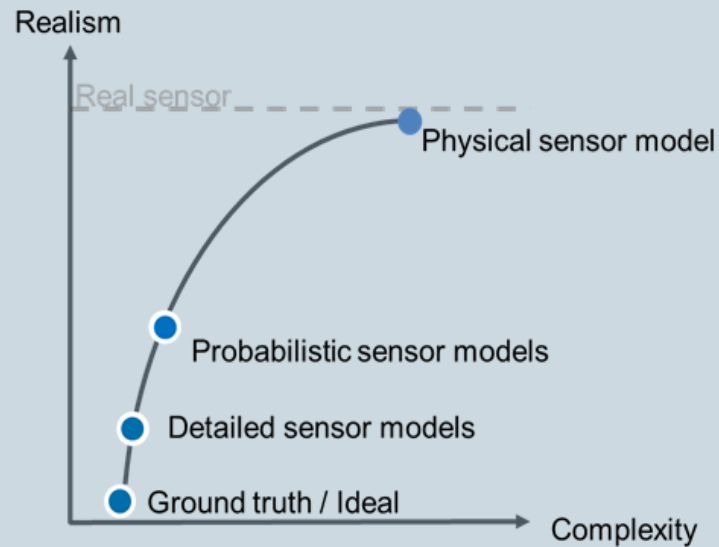Siemens Digital Industries Software
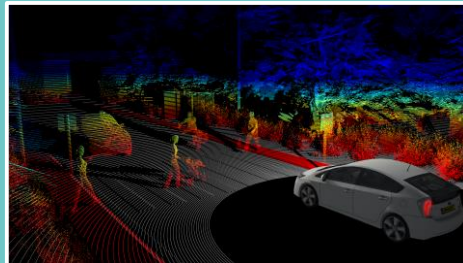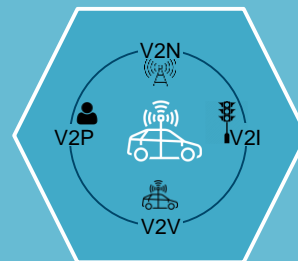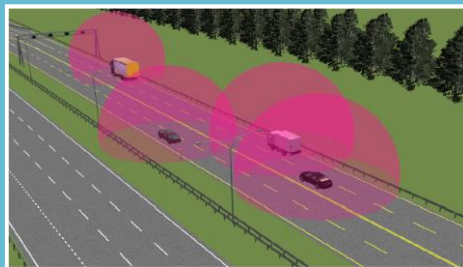
Sensors models: the right fidelity level for scaled-up simulation

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Balancing accuracy and computation time of sensor simulations

Realism

Real sensor

Physical sensor model

Probabilistic sensor models

Detailed sensor models

Ground truth / Ideal

Complexity
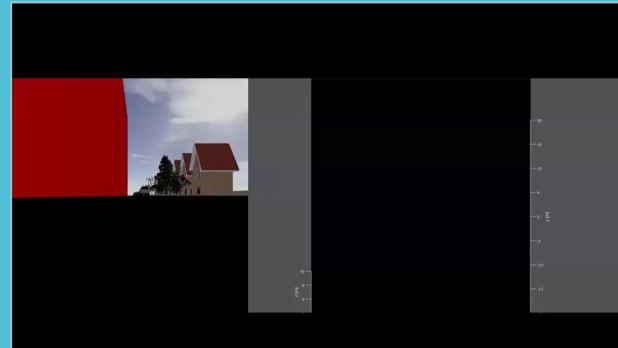
Lidar (spinning and solid-state)
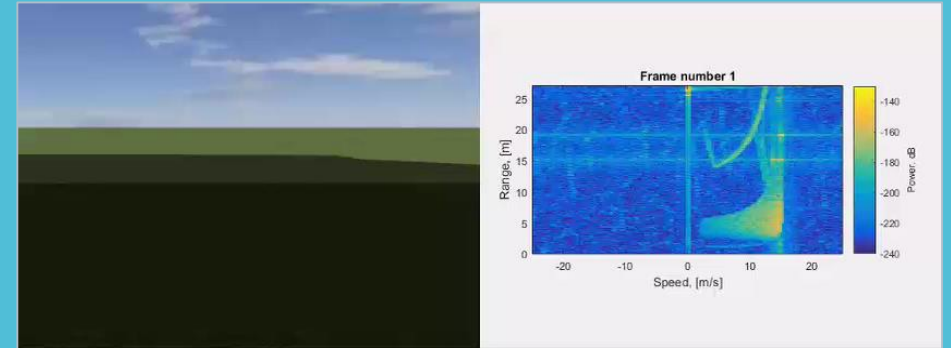
Physics-based Radar simulation

Example: during night-time driving

Example: Realistic lighting conditions

Simcenter Prescan Physics Based Camera (PBC) simulation

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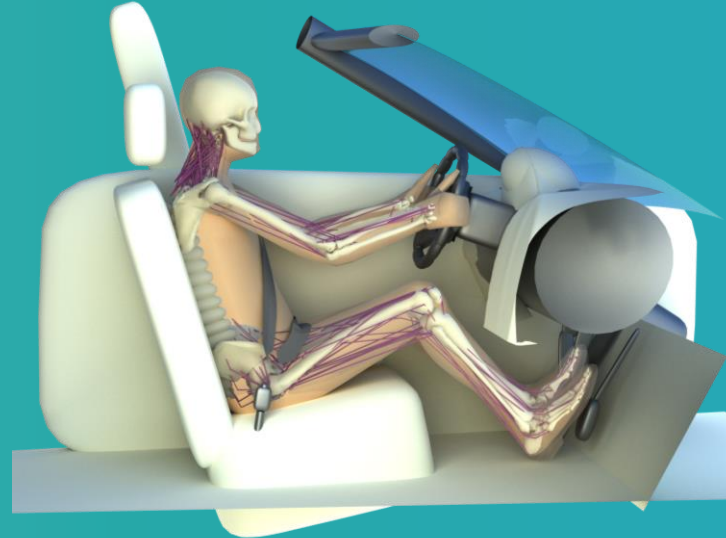
Simulation of autonomous driving scenarios

Occupant safety for autonomous vehicles – examples

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Occupant Safety for Autonomous Vehicles

Combine ADAS/AV function development and Occupant Safety

fast & accurate

passive & re-active

Occupant Safety verification in ADAS Scenarios

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Lane change scenario – How does the human body behave?

Driving with autonomous evasive system

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How Does Autonomous Vehicle Occupant Protection Work?

prescan
Real world traffic scenario
ADAS deployment

Vehicle motion ⬇ TTC ⬇ Impact conditions ⬇

madymo
Occupant motion
Restraint deployment
Pre-crash

madymo
Occupant injury
In-crash

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How Does Autonomous Vehicle Occupant Protection Work?

prescan ·))

Real world traffic scenario
ADAS deployment

Vehicle motion ↓   TTC ↓   **Impact conditions** ↓

madymo Occupant motion
Pre-crash Restraint deployment

madymo Occupant
In-crash injury

How Does Autonomous Vehicle Occupant Protection Work?

prescan

AEBS deployment followed by rear impact

Vehicle motion → TTC → Impact conditions →

madymo Pre-crash — Occupant motion Restraint deployment

madymo In-crash — Occupant injury

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How Does Autonomous Vehicle Occupant Protection Work?

Autonomous driving People Mover

- 6 individual seats and different orientations
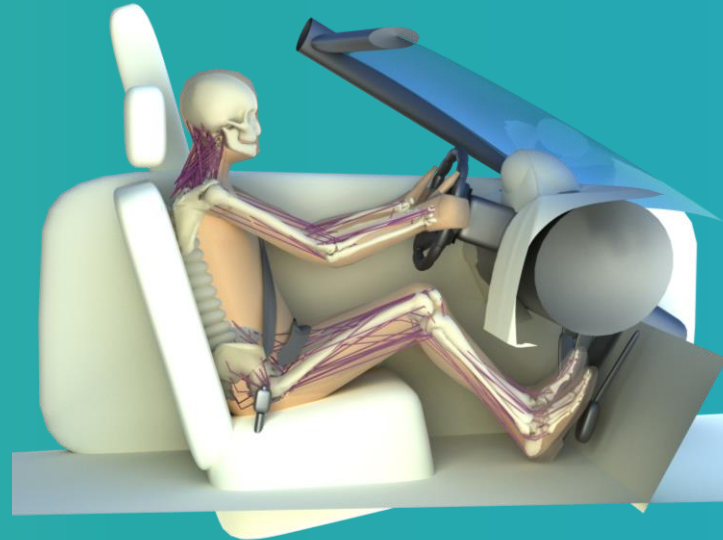- AEBS avoids crash
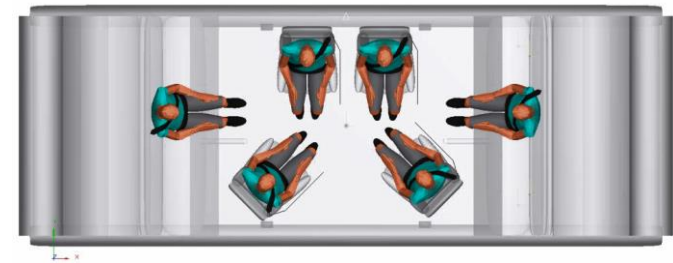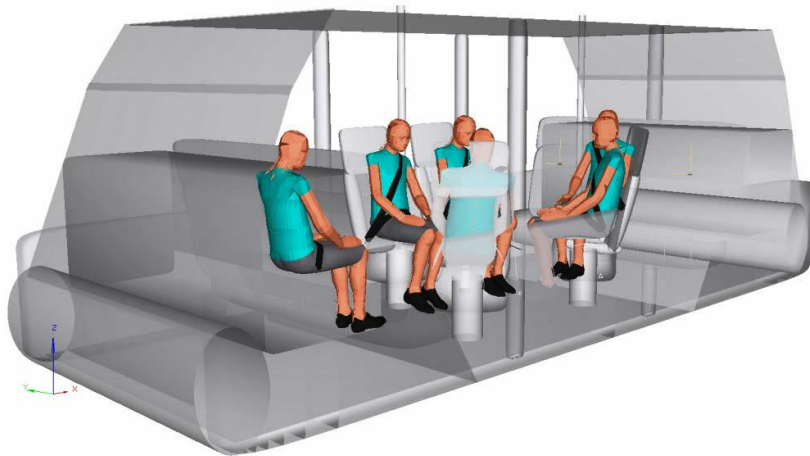
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Siemens offers solutions that help to design next generation safety systems for autonomous vehicles

Occupant Safety for Autonomous Vehicles

+

- Validate AV algorithms including occupant safety
- Precise model representing human behavior
- Process automation allows efficient calculation of different scenarios
- Realistic simulations
- Parametric studies for design exploration DoE
- Fast simulations due to rigid body solver

fast & accurate

passive & re-active

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Nico Nagl

nico.nagl@siemens.com

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