Verifikation und Validierung von automatisierten Fahrzeugen
Bridging the Gap between Real Word Test Driving and Simulation for Automated Vehicles
TASS International
Expanding our solution for Autonomous Driving

Domain expertise, software solutions and services in automotive high growth segments:

Autonomous driving
Advance driver assistance systems (ADAS)
Integrated safety (active and passive)
Tire modelling and testing

Since 2017
Accident Statistics Germany: EU-Targets
Almost Stagnation of the Numbers for slightly and seriously injured People since 2010

- EU 2010 target: 50% reduction of seriously injured people was almost reached (44%)
- EU 2020 target: Another 50% reduction of seriously injured people does not appear to be viable anymore.

Mercedes-Benz, VDI Safety Systems | Jochen Feese | May 2018
Accident Statistics Worldwide
Motivation for Further Safety Initiatives

1 250 000 Road Fatalities worldwide¹

Sources:
¹ WHO status report 2015
² CARE database 2015/17
³ NHVSA Status Report 2014/18
⁴ Brazilian Ministry of Health 2012
⁵ Russian traffic police 2013
⁶ Government of India 2016
⁷ Statistisches Bundesamt 2014/17
⁸ National Police Agency Japan 2016
⁹ Australian Road Death data 2016, child < 15
¹⁰ National Bureau of Statistics of China
Automation can reduce the largest risk... The Driver!
Addressing engineering challenges for autonomous driving …

FROM ADAS TO AUTONOMOUS DRIVING

“14.2 billion kilometers of testing is needed”
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
Vehicle Certification
Proving compliance to meet regulatory and liability requirements

BUSINESS PROBLEM
Reaching Level 4/5 autonomous vehicle certification is not feasible with physical testing.
Bridging the Gap between Simulation and Physical Testing

Why Bridging?
To connect virtual and real world testing with the purpose to:

1. Increase effectiveness and efficiency (saving time, saving money)
2. Enhance quality and robustness (less risks, better products & services)
**Bridging the Gap between Simulation and Physical Testing**

Main pillars:

1. Suite of simulation models with various levels of fidelity & performance

2. Using measurement data for model correlation & model validation

3. Tool-suite used throughout the entire verification & validation

**Bridges need pillars!**
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Bridges need pillars!
Sensors in Environment
Varying fidelity level sensor modelling

Balancing accuracy and computation time of sensor simulations

Lidar point cloud sensor

Example: during night-time driving

Physics-based Radar simulation

Example: during tunnel entrance/exit

PreScan Physics Based Camera (PBC) simulation

Graph showing the trade-off between realism and complexity for different types of sensor models.
Sensors in Environment
Raw Camera Sensor Model

World Model
- Broad spectral range and user defined bands of interest
- Increased intensities, High Dynamic Range
- 32bit color depth
- Full Spectrum
- Atmospheric Model

Camera sensor
- Optics
- Color filter array
- Shutter
- Imager

Algorithm
- Object Detection & Classification
- Sensor Fusion & Risk Estimation
- Driver Warning & Vehicle Control

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Page 13 2019.04.16
Sensors in Environment
Ground-truth annotated reference data

- Image Segmentation not only for camera simulation, but also usable for radar and lidar simulation
- Image Segmentation can be combined with other “reference sensors” (e.g. bounding boxes, depth cameras)
Sensors in Environment
Using for data for deep learning

- Real images from automotive camera
- Synthetic images from PreScan
- Segmented images from PreScan
- Physics Based Camera (PBC) model
- Image Segmentation Sensor (ISS)
Occupant modelling for safety and comfort

Active human modelling in an autonomous evasive lane change scenario
Autonomous controls simulation combined with accurate vehicle dynamics modelling to predict human behavior in pre-crash and crash stages.
New Mobility Safety Requirements
(Source ZF Group, Dr. Büchsner, VDA Kongress 2018)

Systemkonzept Insassenschutz

Vehicle environment and seating system

Examples seating systems

System approach for occupant protection

Unrestricted © Siemens AG 2019
Active Human Fidelity

- Scenario coverage
  - 10's scenarios
  - Test Driving
  - 100's scenarios (FE models like THUMS, GHBM)
  - 10,000's scenarios (MB models like MADYMO Active Humans)
  - 1,000,000's scenarios (Real-time Active Humans)

- Real World Test Driving
  - 10's scenarios

- Simulation speed

- REAL/SE
  - Ingenuity for Life

Siemens PLM Software
Tyre models for scalable roads conditions and temperatures
**Main pillars:**

1. **Suite of simulation models with various levels of fidelity & performance**

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3. **Tool-suite used throughout the entire verification & validation**

**Bridges need pillars!**
Raw radar sensor model validation

- Transmitter
- Receiver
- ADC
- FFT
- Processing
- Object recognition

Waveform

Raw data → Beat signal → Raw radar sensor model validation

Wind

Measurement

PBRM Simulation, Frame 26
Example: Stochastic Sensor Model Creation

- Using measurements in laboratory to characterize sensor’s
  - Range accuracy
  - Angular accuracy
  - Maximum range
  - FOV
- From multiple runs, the statistical error on range and angle is determined
- Sensor model parameters are tuned to match results of the experiments
Validation and Verification – Scenario Modeling
Translation real world recordings into Prescan scenario definitions
Validation and Verification – World Modeling
Based on real world recording – Compatible with standard data bases

OpenDrive / OpenScenario / Open Street Map importer

✓ Import a road network from OSM as an alternative to building it yourself
✓ The road network is automatically placed at the correct GPS location in the PreScan experiment
Validation and Verification – Scenario Modeling
Based on real world recording – Compatible with standard data bases

The GIDAS database contains approximately 30,000 accidents collected since 1999

A GIDAS dataset describes the 5-second pre-crash phase of a traffic accident at 100Hz, including information about the motion of the traffic participants, the road network and the road environment.

The PreScan-GIDAS plug-in converts GIDAS datasets into PreScan experiments.
BMW
Trajectory planning in automated parking scenarios with Delft-Tyre

Validation by means of instrumented vehicle tests

• Tyre behavior in slow speed parking manoeuvers significantly influences the trajectory of the parking car
• For the design and validation of automated parking scenarios dynamic tyre behavior prediction is critical

Example: Ramp steer test at 5 km/h
• Prescribed steering angle and velocity
• Measured trajectory (x,y)
• Measurements done on the vehicle to validate the Delft-Tyre models
• Comparison with MF-Tyre 5.2 (no turn slip functionality)
• Significantly improved response with MF-Swift 6.2 (with turn slip)
Application example: ABS braking

- Comparison at vehicle level: simulation model compared with a test vehicle
- Different ABS settings have been tested with:
  - Full measurements on a closed proving ground
  - Full vehicle simulation
- Influence of ABS settings on braking distance are predicted well in simulation
- Difference between simulations and measurements is within test repeatability
Example: Active Human model validation

Frontal braking

Lateral acceleration
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Bridges need pillars!
Validation and Verification framework for AVs

Requirements

1M – 10M scenarios

Multiple variants

V&V environments

MiL / SiL / Cluster

1k – 10k scenarios

HiL / DiL / ViL

10 – 100 scenarios

Proving ground / field test

Certification - Homologation

Requirements

Digital Twin “World”

Digital Twin “Vehicle”

Real world

Vehicle under development

Requirements

External requirements

Internal requirements

Static world models

Dynamic world models

Occupant models

Sensor models

Algorithm

Chassis models

Powertrain models

10 – 100 scenarios

100k – 1M scenarios

1M – 10M scenarios

1k – 10k scenarios

Certification - Homologation

Approve

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Certification - Homologation

Approve
Validation and Verification
Real-Time Models – HIL Testing – Vehicle in the Loop Testing

Real-Time “Digital Twin”
Bridging between Virtual and Physical

3D Multi-Body
1D Multi-Physics
Environment, Traffic
Validation and Verification up to Certification
Proving ground testing of autonomous vehicle technology

Laboratory testing
validating modules & systems in a controlled environment

Closed test-site testing
validating complete vehicle in a pre-conditioned environment

Open test-site testing
validating the networked system in a realistic environment

EuroNCAP active safety testing

A270 Instrumented Motorway, Rural & Urban
Joint Press Release

by Siemens and American Center for Mobility

Ypsilanti, Michigan, April 30, 2018

Siemens strengthens position in connected and autonomous vehicles through partnership with American Center for Mobility

Siemens PLM Software and the Michigan-based American Center for Mobility (ACM) announced today a new partnership that brings Siemens’ Simulation and Test solution for Automotive to ACM to support virtual and physical testing and validation of automa-
What are we doing it for?
Emergency brake scenario in PreScan software used by Volvo Trucks
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