What impact does the design of a particular parameter have on the overall system?
What alterations have what effect on achieving my development targets?
Which component errors lead to complex failures of the overall system?
Does my sensor concept perform as expected?
How does a vehicle behave in extreme or disastrous situations?
What impact does changing a particular parameter have on the system?
System simulation – The answer to ADAS requirements for holistic simulations of heterogeneous systems

SEMICON Europa 2016:
TechARENA – Electronics for Automotive

Christian Kehrer, Head of Sales
Torsten Blochwitz, Head of R&D
ESI ITI GmbH

SEMICON Europa 2016 - October 2016
Agenda

• Model-Based Development in the Automotive Industry

• Challenges of Next-Generation Driving
  ‣ Performance Increase for Virtual Testing of Electrified Systems
  ‣ New Toolchains for Emulating Electric Motors
  ‣ New Scenarios for Advanced Driver Assistance Systems
  ‣ Holistic Optimization of System Interactions

• Solutions
  ‣ Automotive Use Cases for Multiphysics System Simulation
  ‣ Openness Towards Your Requirements and Processes
  ‣ Connectivity Ensuring Cross-Company Collaboration
  ‣ Standardized Exchange and Co-Simulation of Functional Models

• Summary
Model-Based Development in the Automotive Industry

What is Multiphysics System Simulation?

- Mechanical sub-assemblies
- Hydraulic sub-assemblies
- Controls
Model Based Development in the Automotive Industry
System Simulation’s role in a Continuous Development Process

Veriﬁcation

Prototype Test

Functional Test

Integration Test

Offline Simulation

Real-Time Simulation

Model Refinement

Model Simpliﬁcation

Copyright © ESI Group, 2014. All rights reserved.
Model-Based Development in the Automotive Industry

Offline: Design and Optimization of Systems

- Modeling, analysis and post-processing for multiphysics systems
- Preconfigured model elements covering all levels of detail from 1D to 3D
- Fully integrated analysis methods
  - In the time and frequency domain
  - Linear modal analysis
  - Parameter studies
  - Performance analysis
  - Reliability studies (FTA, FMEA)
Model-Based Development in the Automotive Industry

SiL: Development and Testing of Control Software

- Integration of SW modules for tests against physical plant models
- Improving system reliability by evaluating failure probability of hazardous events incl. FTA and FMEA

USE CASE – DRIVER ASSISTANCE TESTTRACK

2 WD compact car
- Overall mass: 1290 kg
- CW: 0.32

Powertrain data
- Torque: max. 182Nm @ 5000rpm
- Consumption: max. 7.14 g/s @ 5000rpm
- Gearbox: 8 speed AT with torque converter
- Ratio differential front: 2.6

Street circuit in Nürburg: ~21 km
Model-Based Development in the Automotive Industry

HiL: Development and Test of Controllers in Real-Time

- Innovative component HiL-based test bench
  - Straightforward integration into heterogeneous toolchains using a standardized interface (FMI)
Agenda

• Model-Based Development in the Automotive Industry

• Challenges of Next-Generation Driving
  ‣ Performance Increase for Virtual Testing of Electrified Systems
  ‣ New Toolchains for Emulating Electric Motors
  ‣ New Scenarios for Advanced Driver Assistance Systems
  ‣ Holistic Optimization of System Interactions

• Solutions
  ‣ Automotive Use Cases for Multiphysics System Simulation
  ‣ Openness towards Your Requirements and Processes
  ‣ Connectivity Ensuring Cross-Company Collaboration
  ‣ Standardized Exchange and Co-Simulation of Functional Models

• Summary
Challenges of Next-Generation Driving
Performance Increase for Virtual Testing of Electrified Systems

• New performance requirements for virtual tests of controllers containing power electronics
  ‣ Frequency of power electronics (> 10 kHz)
  ‣ Real-time model has to run at higher sample rate (1 µs)
  → FPGA (Field Programmable Gate Array)
Challenges of Next-Generation Driving

New Toolchains for Emulating Electric Motors

- New model elements for emulators of electric motors take requirements for synthesizable FPGA designs in account:
  - Motor models, rotational mechanics
  - Electrical components
  - Sensors and interface elements
- Toolchain demonstrator
Challenges of Next-Generation Driving

New Scenarios for Advanced Driver Assistance Systems

- Completely new model classes (radar, lidar, camera...)
- Completely new and heterogeneous toolchains
- Real driving scenarios in complex environments instead of synthetic test cycles
Challenges of Next-Generation Driving
Holistic Optimization of System Interactions

• For overall optimization of systems, completely new interdependencies have to be taken into account incl. subsystems
  ‣ From different physical domains
  ‣ Characterized through different dynamics
  ‣ Working on different levels of autonomy
Agenda

• Model-Based Development in the Automotive Industry

• Challenges of Next-Generation Driving
  ‣ Performance Increase for Virtual Testing of Electrified Systems
  ‣ New Toolchains for Emulating Electric Motors
  ‣ New Scenarios for Advanced Driver Assistance Systems
  ‣ Holistic Optimization of System Interactions

• Solutions
  ‣ Automotive Use Cases for Multiphysics System Simulation
  ‣ Openness towards Your Requirements and Processes
  ‣ Connectivity Ensuring Cross-Company Collaboration
  ‣ Standardized Exchange and Co-Simulation of Functional Models

• Summary
Solutions

Automotive Use Cases for Multiphysics System Simulation

- HVAC
- Haptic HMI
- Belt Force Limiter
- Bowden Cables
- Fuel Supply
- Roll Stabilization
- Operating Strategy
- Vehicle Dynamics
- Thermal Management
- Inductive Charging
- Brake Balance
- Powertrain Design
- Actuation
Solutions

Openness towards Your Requirements and Processes

• SimulationX is based on advanced interface and modeling standards

  ‣ **Modelica**® | Specific model libraries for versatile applications from all physical domains based on an independent modeling language

  ‣ **Functional Mock-up Interface (FMI)** | Exchange of functional models between different tools using an independent interface standard ([www.fmi-standard.org](http://www.fmi-standard.org))

  ‣ Automatization of all workflows using application programming interfaces (API) for simulation tools
Solutions
Connectivity Ensuring Cross-Company Collaboration

• Various interfaces for a seamless integration into various toolchains

Universal Tool API

- Python, VBA, C, Java, MATLAB, ...

Model exchange (e.g. using FMI) through code import/export and co-simulation

Extensive import capabilities, e.g. for CAD geometries or FEM data
Solutions

Standardized Exchange and Co-Simulation of Functional Models

- SimulationX is a fully FMI-enabled simulation tool:
  - Models can be exported as FMUs for Model Exchange.
  - Models can be exported as standalone FMUs for Co-Simulation. A robust variable step-size solver is included.
  - FMUs (Model Exchange and Co-Simulation) can be imported and seamlessly integrated into SimulationX.
Agenda

• Model-Based Development in the Automotive Industry

• Challenges of Next-Generation Driving
  ‣ Performance Increase for Virtual Testing of Electrified Systems
  ‣ New Toolchains for Emulating Electric Motors
  ‣ New Scenarios for Advanced Driver Assistance Systems
  ‣ Holistic Optimization of System Interactions

• Solutions
  ‣ Automotive Use Cases for Multiphysics System Simulation
  ‣ Openness towards Your Requirements and Processes
  ‣ Connectivity Ensuring Cross-Company Collaboration
  ‣ Standardized Exchange and Co-Simulation of Functional Models

• Summary
Summary
THANK YOU