OpenADx – xcelerate your Autonomous Driving development

Project Book

Workshop #4 – 06th November 2018
Leinfelden-Echterdingen

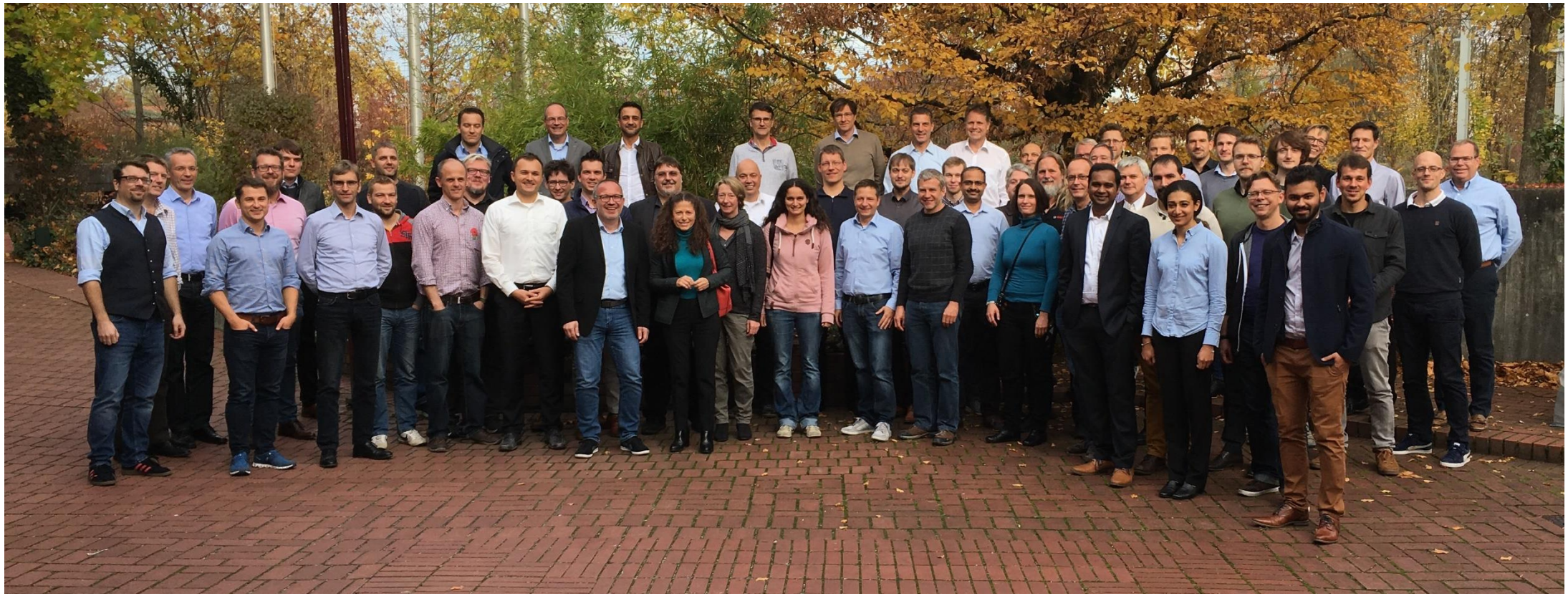
OpenADx Workshop #4 - Participants

- 63 participants on the list
  - 13 from Bosch
  - 5 from ETAS
- 29 companies (incl. Bosch and ETAS)
- Countries
  - Germany, UK, France, Italy, Finland, Netherlands, Austria

- 3DS / Dassault Systemes
- AUDI
- AVL
- Bosch
- Continental
- Digitalwerk
- Eclipse Foundation
- ETAS
- Fraunhofer IOSB
- Hella Aglaia
- IBM
- IPG Automotive
- itemis
- Linaro

- Mathworks
- Microsoft
- nttdata
- Prostep
- Red Hat
- Renesas
- Siemens Industry Software
- Silexica
- Streetscooter
- Tesis
- TU Lübeck
- University of Oulu
- Valeo
- Vector
- ZF Friedrichshafen

OpenADx Workshop #4 - Participants



OpenADx – xcelerate your Autonomous Driving development

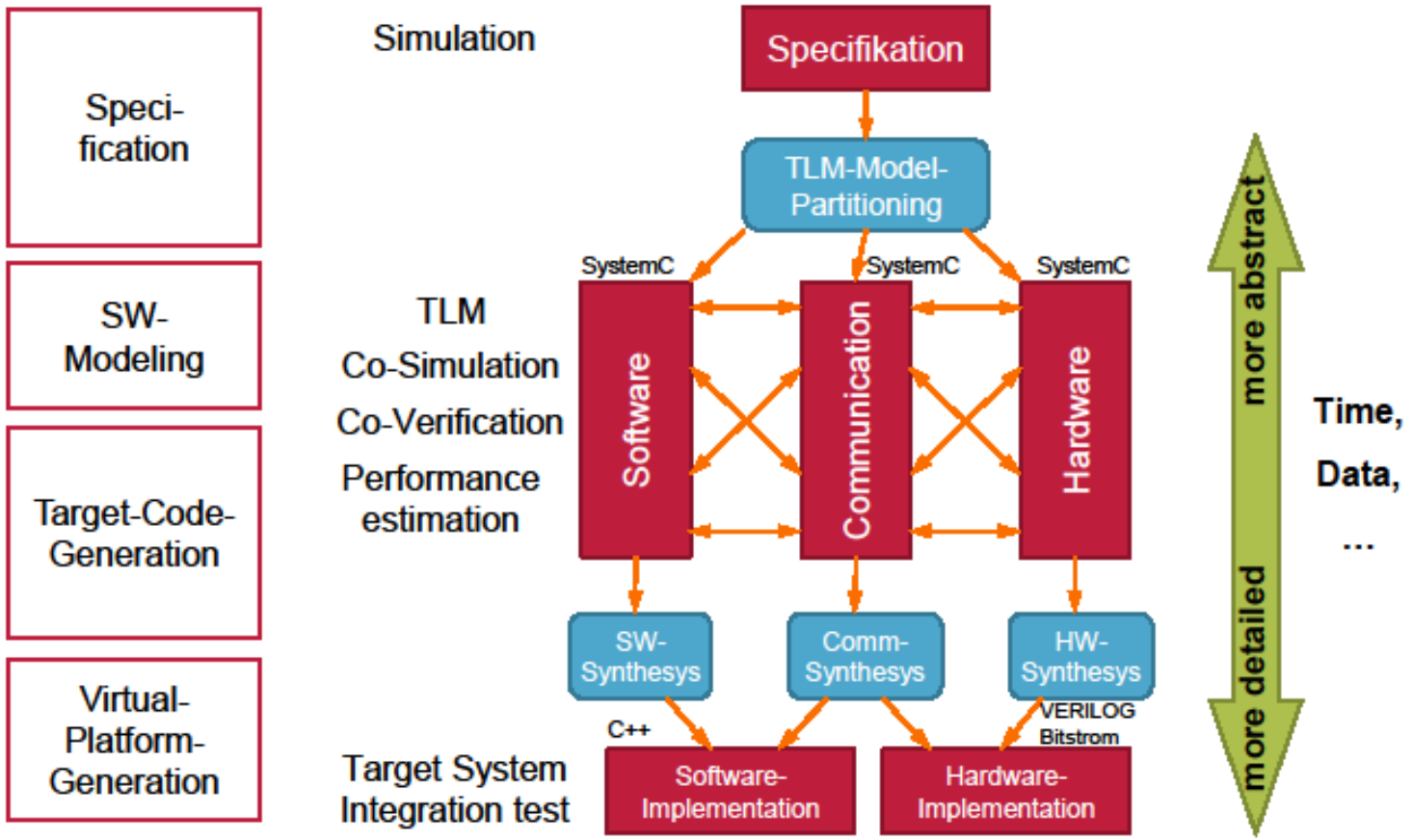
Open Source Hardware – Simulation with Virtual Hardware

University of Lübeck – Jan Haase

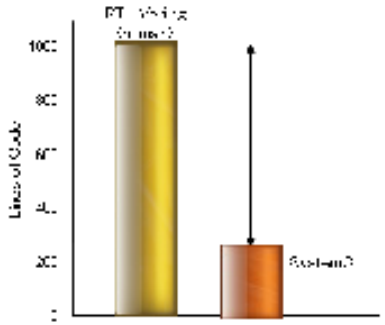
Realization of Virtual System-Platforms with Electronic-System-Level Design Methodology (ESL)

- **ESL** is a standard that is based on **SystemC/TLM** (IEEE 1666-2005) (C/C++ based) for fast Hardware-Simulation.
- HW und SW are developed in a **single** language (C++) instead of C/C++/Java and Verilog.
- **ESL** is based on the simplified modeling of HW/SW-Systems from a communication perspective (**TLM**: Transaction-Level Modeling).
- A System-Modeling on Transaction Level (**TLM**), delivers a speedup of the HW/SW-System Simulator by a factor of of 1000-10000. This enables **virtual prototyping** on a workstation without real hardware („Executable Spec“).
- A System-Modeling on Transaction-Level (**TLM**), is possible on 3 levels of detail that can also be mixed (mixed-mode simulation) for verification and validation purposes
  - LT (loosely timed): Abstract model for fast software verification,
  - AT (approximately timed): 90% Cycle-true, 90% speed
  - CT (cycle-true): Fully detailed hardware model
- The high Abstraction level together with the high simulation speed enables prototyping and design space exploration of complex hardware/software systems such as ECUs.

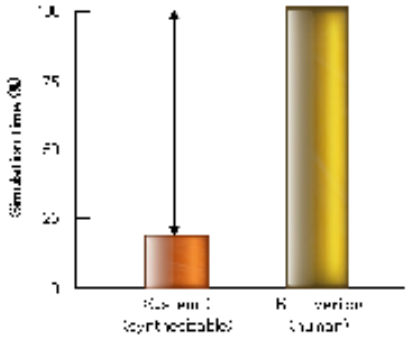
System-Realization with SystemC and TLM



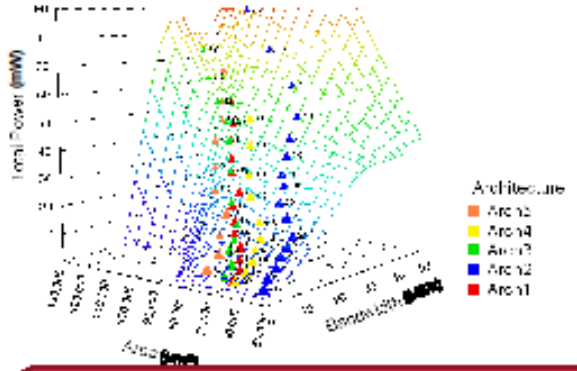
TLM-based Module-Design accelerates Time-To-Market



~3 x compact Design, efficiency increase



5–10 x faster Verification



Faster Design-Space-Exploration:
"Do we reach this with 200 MHz?"

SystemC → RTL in **10 days.**
vs. manual RTL in **3 month**

I/F-Controller-Modul

FPGA –reconfig in **1-2 days.**
vs. manual in **2-3 weeks**

controller

>10 x Productivity-increase

Source: Cadence

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OpenADx Workshop #4

Open Source Hardware – Simulation with Virtual Hardware

- About the presentation
  - Approaches of hardware/software codesign, particularly on SystemC/TLM.

- How does it fit with OpenADx?
  - It would fit to OpenADx since it is another way to cope with problems at simulator-coupling -- by avoiding it.

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - We (Prof. Berekovic and Prof. Haase) are open for collaboration. Possibly by representing the academic point of view.

- Contact: andreas.riexinger@de.bosch.com (I will connect you then)

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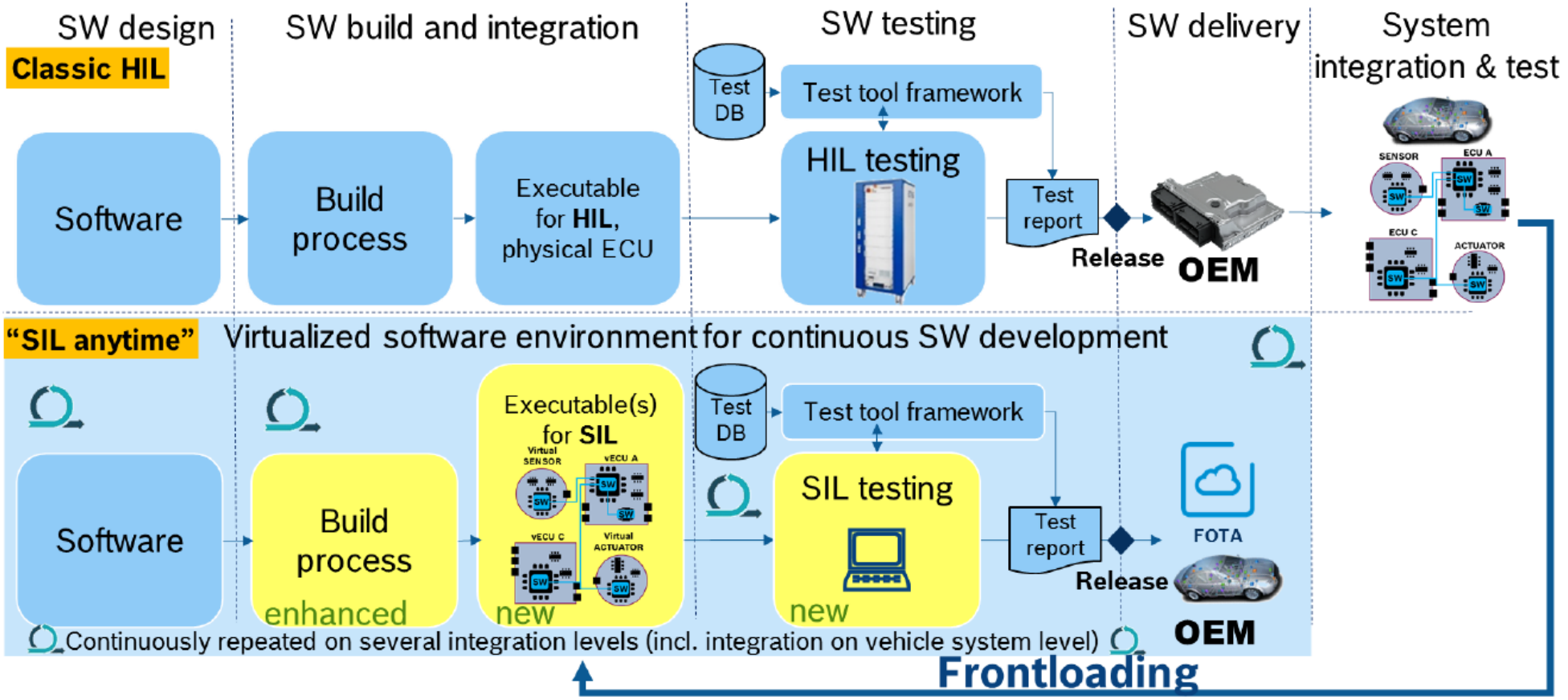
Software in the loop (SiL) – SiL Framework

Bosch – Thomas Huber

SIL standardization – the world driven by SIL

SIL: Target "SIL anytime"



SIL will be the continuous testing environment for the automotive industry

SIL standardization – the world driven by SIL
The need for standardization

- SIL components need to be compatible and therefore standardized, because
  - Functions being distributed across several nodes and domains need to be verified early in SIL environments (-> several vECUs to be combined in one SIL setup)

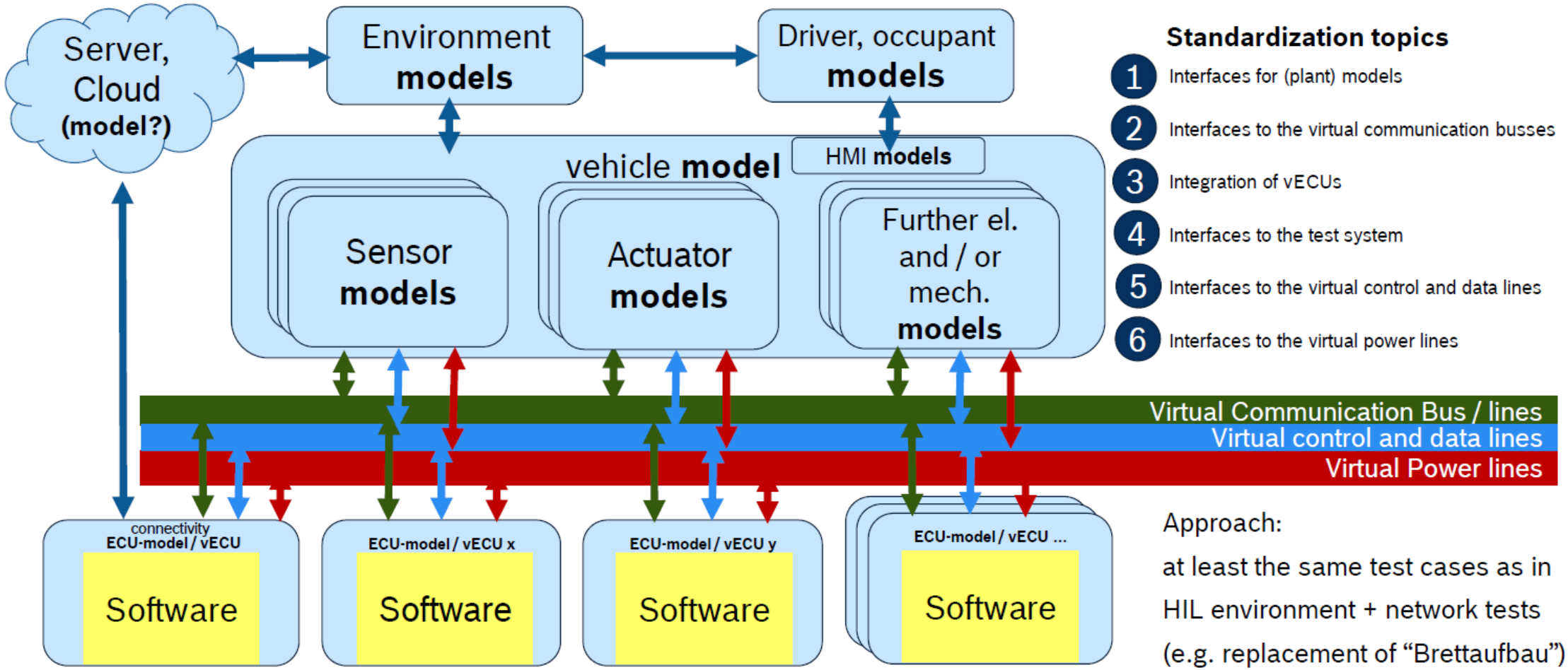
    X-domain compatibility
  - SIL components in projects are coming from different companies
    (e.g. OEMs / TIER1s / tool provider)

    X-company compatibility
  - Components need to be runnable in different execution platforms (e.g. PC, server, cloud)

    X-platform compatibility

SIL standardization – the world driven by SIL

Examples for topics of the required SIL standardization



Standardization topics

1. Interfaces for (plant) models
2. Interfaces to the virtual communication busses
3. Integration of vECUs
4. Interfaces to the test system
5. Interfaces to the virtual control and data lines
6. Interfaces to the virtual power lines

Approach:

at least the same test cases as in HIL environment + network tests (e.g. replacement of “Brettaufbau”)

BOSCH

SIL standardization – the world driven by SIL
BOSCH SILC ROAD spec

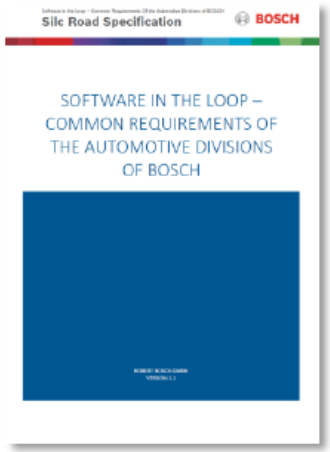
* SILC = SW in the Loop Common Requirements

Approach for the specification

- Develop, implement and use the open SILC ROAD architecture
- Bosch specification document serves for discussions with
  - OEMs,
  - tool providers and
  - other 3rd parties
- Agile x-divisional and x-company working structure
- Existing standards are used (e.g. FMI/FMU, ASAM XiL, XCP)

Contents SILC ROAD specification

- Use cases
- SIL properties and architecture
- Requirements for
  - Network virtualization
  - Virtual power lines
  - Virtual control and data lines
  - SIL tool framework
  - Plant models
  - Virtual ECUs
  - Reference implementation
  - Process framework



BOSCH SILC ROAD spec focusses on standards (not on specific implementations)

OpenADx Workshop #4

Presentation title

- About the presentation
  - SiL is about software tests and software verification in an virtual environment

- How does it fit with OpenADx?
  - The SILC ROAD specification can be the basis for an industry-wide SIL specification, standardized SIL tools and process frameworks, for reference implementations and standardized SIL-capable products and OpenADx supports SiL.

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - Discussions about the SILC ROAD already started, be part of it!

- Contact: andreas.riexinger@de.bosch.com (I will connect you then)

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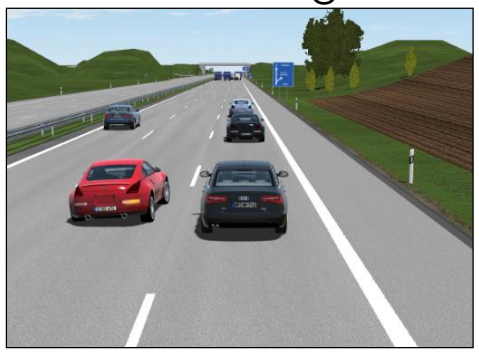
Cloe - Closed Loop Automated Driving Simulation Environment

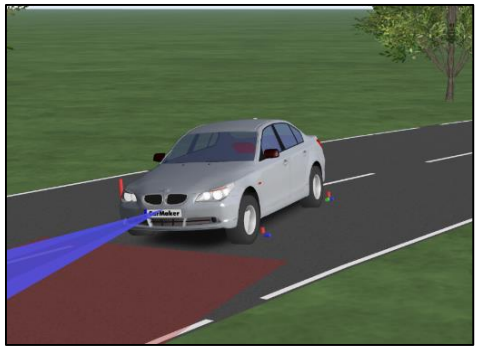
Bosch – Thomas Grosser

OpenADx – Simulation Middleware – Cloe

Closed loop simulation environment for functional SW tests on system level …

- **… as a development tool:**
  - Interactive or scripted workstation simulation
  - Code debugging
  - Automated tests on build server
- **… as part of the V&V strategy …**
  - …by supplementing real world testing with a scaling simulation framework



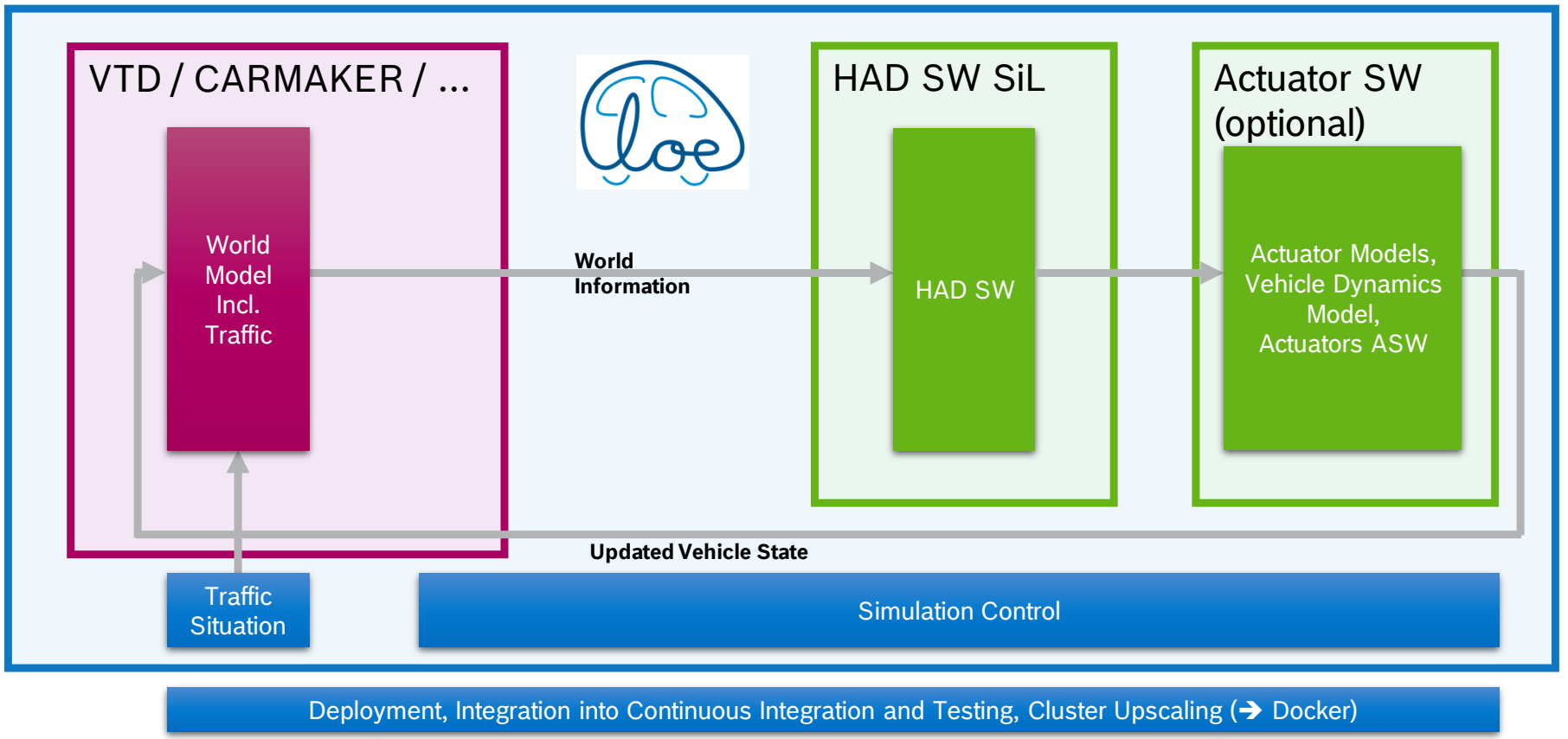


Product: Cloe (**C**losed **Lo**op Automated Driving Simulation **E**nvironment)

Vision: Modular simulation framework

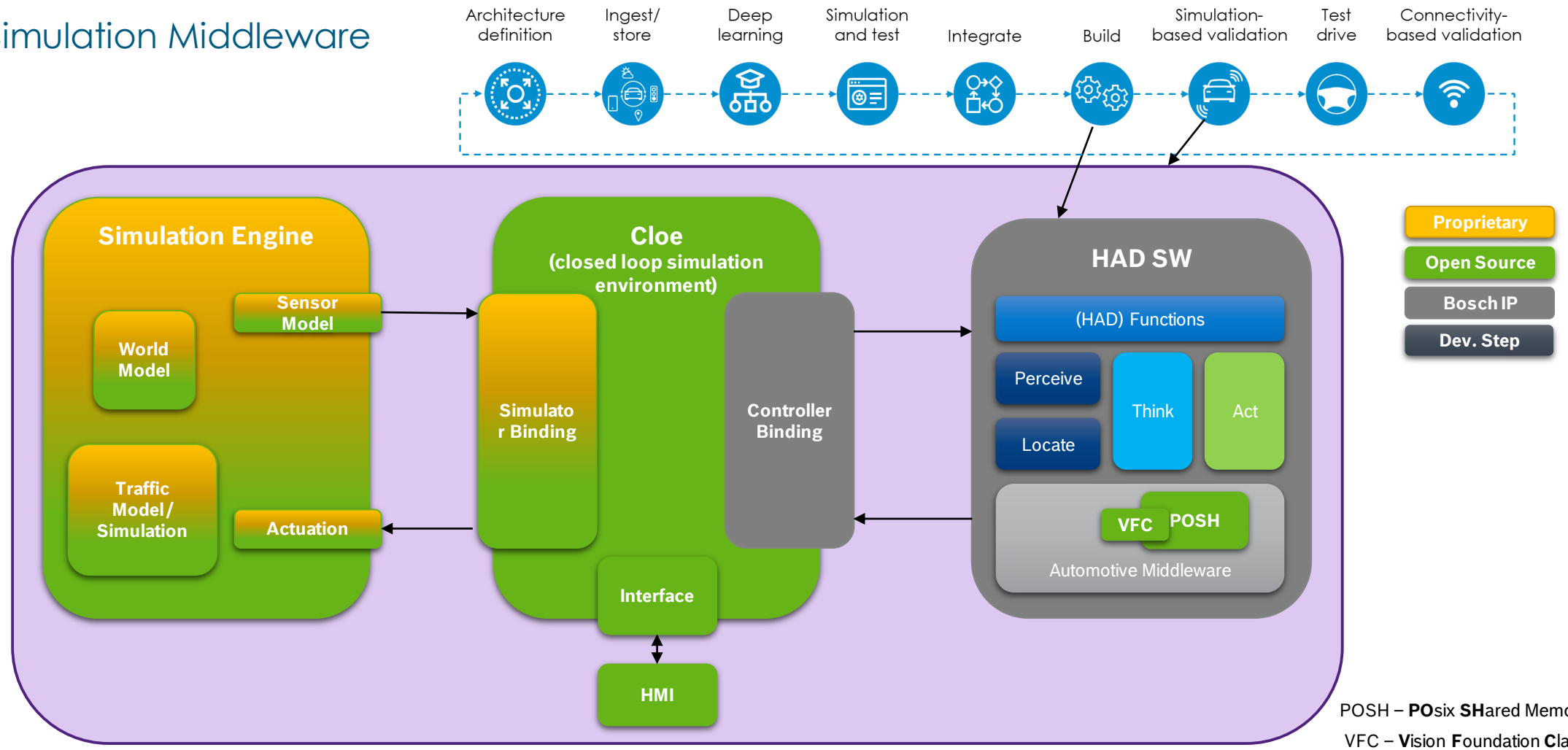
- Support for multiple simulation tools
  - Vires Virtual Test Drive
  - IPG CarMaker
  - Possibly more in the future
- Support for multiple AD software architectures
- Generalized interfaces for fault injection, ground truth and KPI extraction

OpenADx – Simulation Middleware – Cloe



OpenADx Workshop #4 – What we plan …

Simulation Middleware



POSH – **PO**six **SH**ared Memory

VFC – **V**ision **F**oundation **C**lasses

OpenADx – Simulation Middleware – Cloe

› We are using and developing Cloe internally and we are on the way to open source Cloe!

› Is Cloe interesting for you and will solve one of your problems?

› Do you want to join to improve Cloe? We will continue our work on Cloe anyway.

› Do you miss something?

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OpenADx "Autonomous Driving Simulation"

Renesas – Mark Walton

WHERE DOES RENESAS FIT IN?

- Renesas R-Car is aimed at providing SoCs (system on chips) for ADAS and AD systems.
  - The V device family is for vision processing e.g. V3M or V3H.
- We need a reproducible test environment for this Renesas IP development.
  - E.g. Convolution Neural Networks (CNN) or Shader IP.
- Simulators then provide a useful source of test data for this IP development.
- OpenADx would then allow easy connection of a simulator and the IP under test.
  - Customers can test their actual software within a wider test environment.
- Continuous integration test systems can be built on this technology.
  - Cost effective way to provide regression testing.

OpenADx facilitates this easy connection of different simulation environments to Renesas IP

R-Car OpenADx Demo

Manual Control (Steering wheel /pedals)

ROS2 Manual Input

Control Module

ROS2 Detected Object List Feedback

ROS2 Vehicle Control

Driving Simulator

ROS2/DDS Vehicle Control Server

ROS2/DDS Camera Image Server

ROS2 Camera Images

RENESAS

Target Simulator or Hardware

Renesas R-Car

ROS2/DDS Interface

Linux Application

Computer Vision & AI

CARLA

UNREAL ENGINE

ROS

DDS

Demo Output via HDMI

OPENADX COMPONENT SUBSTITUTION

- OpenADx has shown its benefit by allowing ROS2 compliant components to be easily interchanged.
- In this case,
  - The demo simulator was easily changed, substituting CARLA with AirSim.
  - The R-Car IMP-X5 virtual platform could be easily replaced with R-Car target hardware.

- Looped back AirSim image after IMP-X5 simulator annotates it with a white frame. --------->

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OpenADx "Autonomous Driving Simulation"

- About the presentation
  - Demonstration of applying OpenADx to a Renesas software platform.

- How does it fit with OpenADx?
  - Instead of designing a monolithic test system we used the OpenADx concept to split the software into interchangeable modules.

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - From a technical point of view we are seeing issues with scaling the system, which the community may be able offer help with. From a project point of view we are interested in how the OpenADx platform could become part of the Eclipse Foundation.

- Contact:
  - Paul Bell
paul.bell@renesas.com

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Cross Domain Tool Coupling in the area of Simulation – Use Case @ Bosch

Bosch – Martin Johannaber, Uwe Wilbrand

OpenADx Workshop #4

Cross Domain Tool Coupling in the area of Simulation – Use Case @ Bosch

› Presentation not released for external. Sorry!

OpenADx Workshop #4

Cross Domain Tool Coupling in the area of Simulation – Use Case @ Bosch

- About the presentation
  - Coupling of an OpenSource Traffic Simulation to a proprietary xDomain Simulation environment

- How does it fit with OpenADx?
  - Key issue is missing standardization of data format (e.g. road format in more than one tool) and interfaces to open source traffic simulation

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - Operative work to support standardization efforts (e.g. OpenDrive and OpenScenario inside the ASAM consortium)

- Contact:
  - Uwe Wilbrand

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AD and Collaboration for Labeling

Microsoft – Markus Loosen

Autonomous Driving and Labeling

- The road to L4/L5 involve collecting billions of miles of driving data from the real world and simulated world
- However the data is only useful if it has been labeled for Ground Truth
- The quality of Ground Truth impacts both the training and validation of the AI algorithms

Generating Ground Truth with Labeling

Semantic Segmentation

Each Pixel of the image is assigned a category

Object Detection and Classification

Bounding box drawn around each object of interest

3D Point Cloud Labeling

Objects of interest as assigned a category in 3D LIDAR point cloud

"Ground truth" is the accuracy of the training set's classification for supervised learning techniques

Currently done manually

Longer term – auto labelling

Partners provide

- Results based managed service contracts
- Trained workforce, on demand
- Mature labeling tools

Ground Truth is one of the most critical elements of Machine Learning for Training and Validation

Our Proposal

Work with OEMs and Tier 1's to define a standard schema for Labeling while also allowing for customization

Three tiers of information included in the label

1. Tier 1: System info: Acquisition equipment info, System info
    I. This information is static and does not change. It can be defined once per image folder and not needed per image
2. Tier 2: Common Labels
    I. This contains the labels for objects and obstacles defined as 2D bounding boxes, polygons, lanes etc
3. Tier 3: Custom Labels/modifier
    I. This enable any customizations needed to make the labels relevant for a region or a specific customer or to extend the labels

OpenADx Workshop #4

Presentation title

- About the presentation
  - Currently, there are no industry standards for object classes, no standards for hierarchy of class/sub-class defined, no standards defined for lane curvature, lane markings

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - Work with OEMs and Tier1sto define a standard schema for labeling while also allowing for customization

- Contact: andreas.riexinger@de.bosch.com (I will connect you then)

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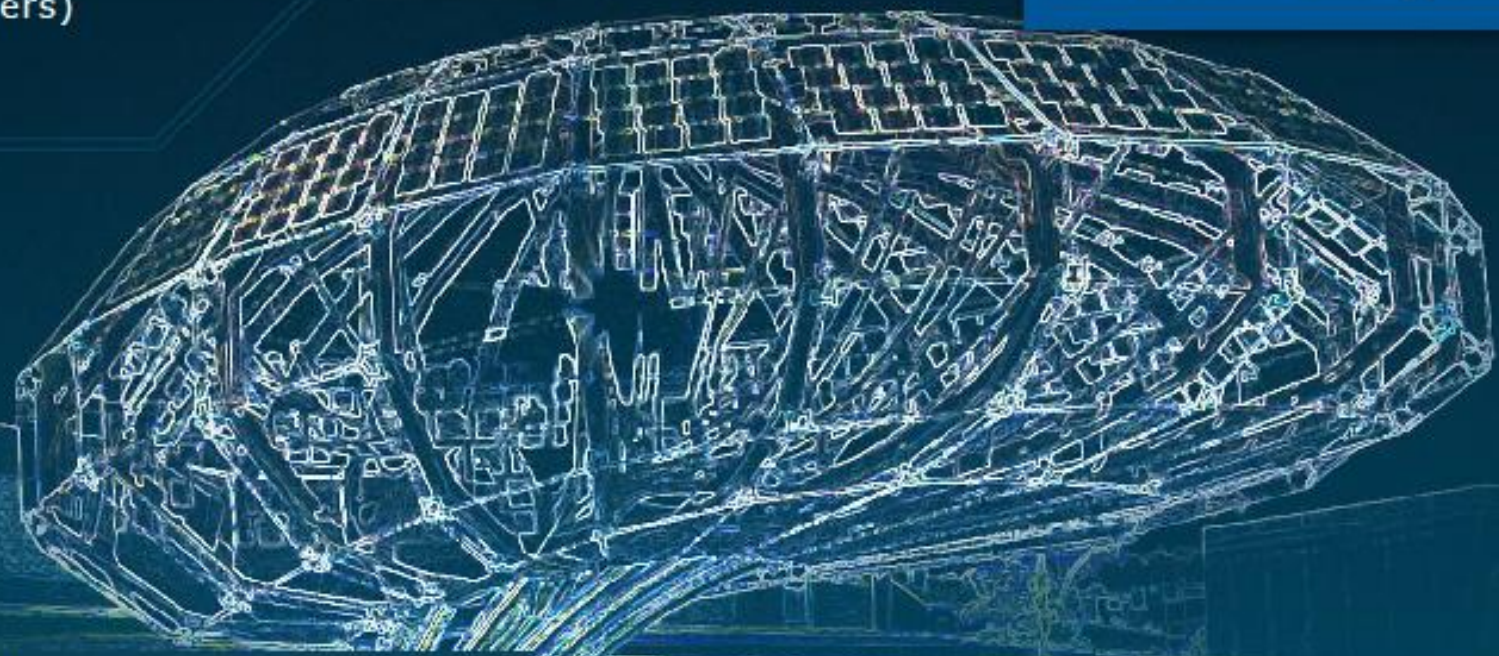
Co Simulation - Challenges in the continuous vehicle development process

AVL – Günter Lang

AVL List GmbH (Headquarters)



Co-Simulation

Challenges in the continuous vehicle development process

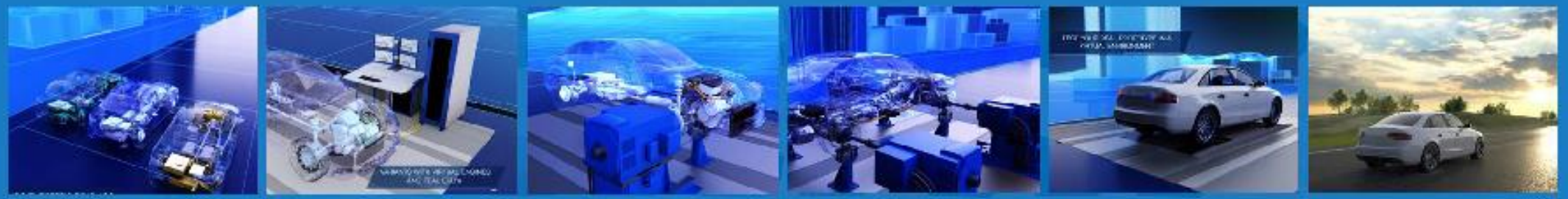
Dr. Josef Zehetner,
Günter Lang

Motivation

Why we use co-simulation?

- Modular design approach
- Development departments provide component models
- Integration of virtual / real components via co-simulation
- Multi-tool and multi-rate support

...modular approach ensuring system maturity assessment at any point of time



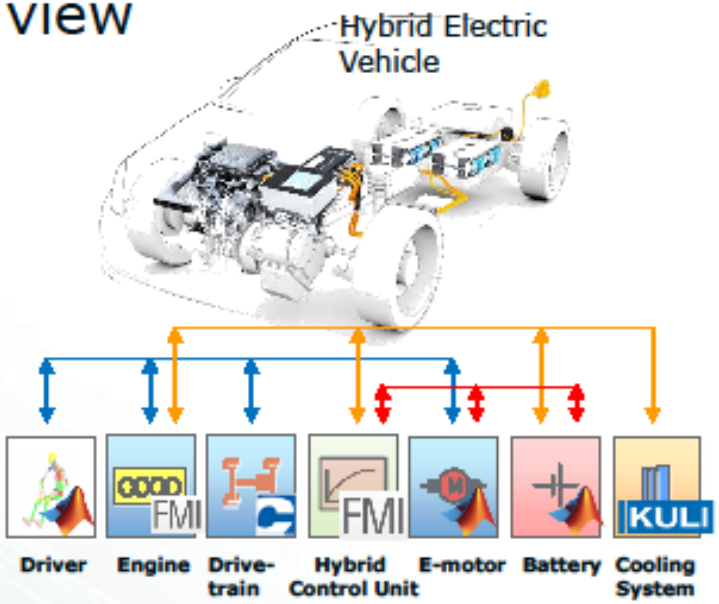
AVL Integrated and Open Development Platform

Models, Execution, Data, Automation, Process

Consistent Models	Same Test Procedures	Seamless Data Management	Efficient and Effective Methods	Connected Existing tools

Challenges for Co-Simulation

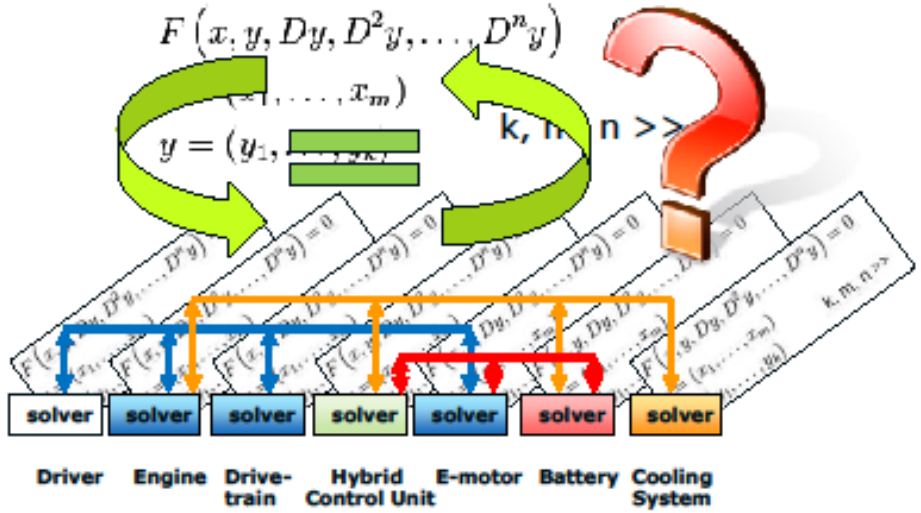
Technical view



- Multi-domain development
- Multi-tool approach
- Multi-vendor
- Dynamic coupling

➢ Virtual prototype representation

Mathematical view



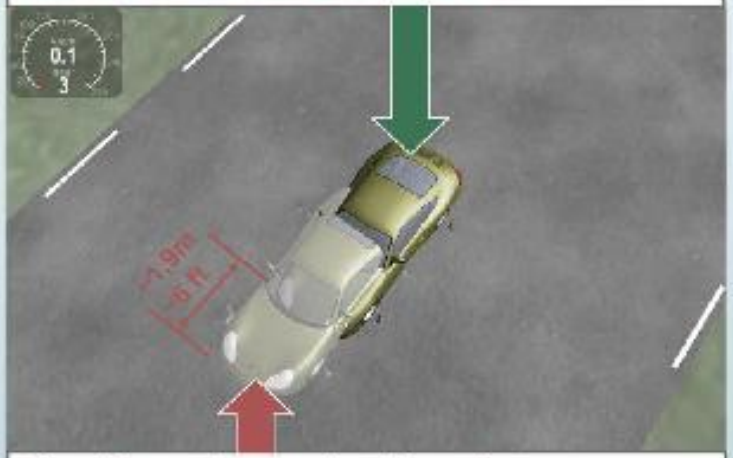
- Multi-method
- Multi-solver
- Multi-rate
- Dynamic coupling

➢ Coupling error

Model.CONNECT™
COUPLING ERROR REDUCTION

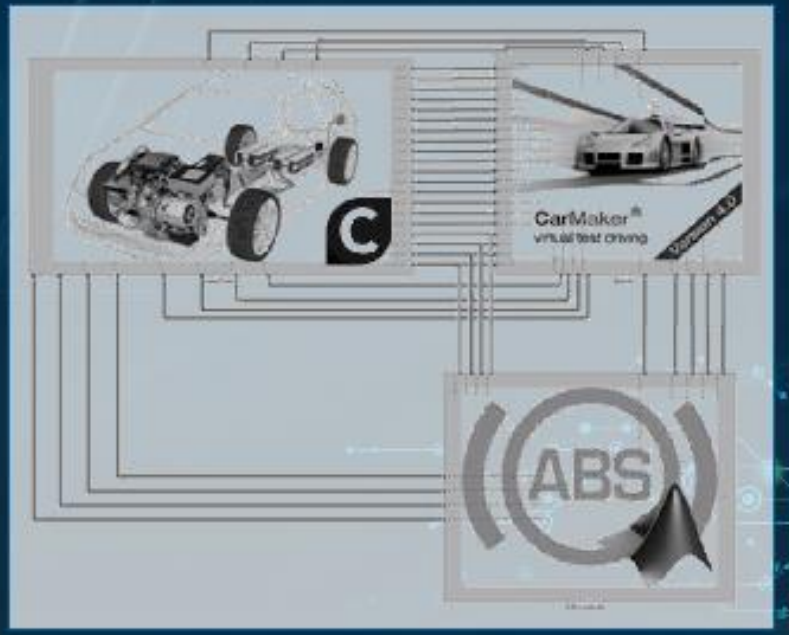
USE CASE: ABS Braking –
emergency stop from 100 kph to stand-still

Correct (co-)simulation result with NEPCE in Model.CONNECT™



Significant longer braking distance due to coupling error!

NEPCE … Nearly Energy Preserving Coupling Element

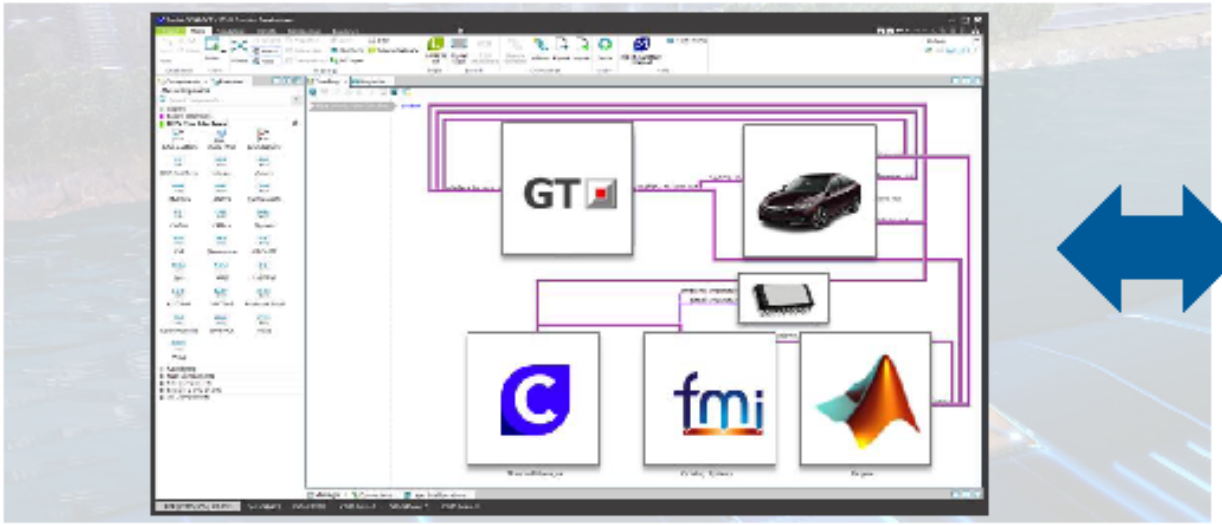


Increase results accuracy

Re-use models of your preferred modeling tool

- Create **physically correct** co-simulation
- Perform **numerically stable** co-simulation
- Increase **co-simulation speed**

Model.CONNECT™



- Neutral, Open, Tool-Free
- Coupling Error Compensation
- Local and Distributed Co-Simulation
- Connecting RT and non-RT Systems

Neutral and open model integration and co-simulation platform, opening the door from simulation to testbed.

Tools specific interfaces (25+ software vendors) and interface standards (FMI)

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Co Simulation - Challenges in the continuous vehicle development process

- About the presentation
  - Co-Simulation is more than purely exchanging data. One has to consider Co-Simulation setup to avoid coupling errors or model instabilities, and always check the results – which might be difficult when running millions of test kilometers.

- How does it fit with OpenADx?
  - As we have seen simulation models and/or hardware from different providers has to be connected to build a virtual prototype. To make these tools seamlessly work together a middleware approach is a good solution.

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - AVL is contributing to existing related standards FMI, DCP, OSI (Open Simulation Interface), OpenScenario, … and wants to understand relation to OpenADx.
    Additionally we build up virtual prototypes for ADAS/AD development to learn how well AVL's middleware solution can help improving AD development on different platforms like MIL, SIL, HIL and want to get input from the community regarding required tool interfaces etc.

- Contact:
  - Aakash.Sehgal@avl.com
  - Josef.Zehetner@avl.com
  - Guenter.Lang@avl.com

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Kubernetes and serverless technologies for high-performance Applications

Red Hat – Michael Hausenblas

OpenADx Workshop #4

Kubernetes and serverless technologies for high-performance Applications

› https://speakerdeck.com/mhausenblas/kubernetes-and-serverless-technologies-for-high-performance-applications

OpenADx Workshop #4

Kubernetes and serverless technologies for high-performance Applications

- About the presentation
  - Motivating and explaining the usage and use cases for containerized services and serverless frameworks based on Kubernetes.

- How does it fit with OpenADx?
  - The discussed technologies are mainly relevant for Sensor Data Processing and VUT areas.

- What would you like to do with the OpenADx community, respectively how can the community help you?
  - I'd like to stay in the loop concerning the developments and mentor others who plan to use Kubernetes and/or serverless technologies.

- Contact:
  - Michael Hausenblas
  - mhausenb@redhat.com

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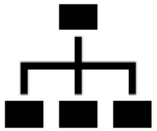
Title will follow! (ADTF)

Digitalwerk – Tobias Schmid

The Solution

Collaborate in development

Populate technologies



Integrate existing solutions

ADTF

- Multiple input and output streams
- Time synchronicity
- Deterministic processing

- Extensible toolset
- Use case oriented tools

- Open interfaces and SDK
- Open documentation
- Automation via shell/JSON-RPC

- Recording/playback of multiple streams
- Conversion to/from different formats
- Extraction/injection of streams

- Open file format
- Open source library for access

ADTF

- Connectivity to in-vehicle communication
- In-vehicle calibration and measurement

- Visualization of data samples in streams
- Open SDK for custom visualizations
- 2D/3D scene visualization

- Distibuted Simulation
- Time Synchronicity
- Open SDK → FEP

OpenADx Workshop #4

Title will follow!

- About the presentation
  - It´s about collaboration, populate technologies and integrate existing solutions

- How does it fit with OpenADx?
  - ADTF is becoming more and more open

- Contact: andreas.riexinger@de.bosch.com (I will connect you then)