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Early Verification and Testing of a Mechatronic Active Roll Control

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QTronic User Conference 2019, Berlin

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Agenda

1 **Background and Motivation**

2 Virtual Testing with Silver

3 Use Case @Schaeffler

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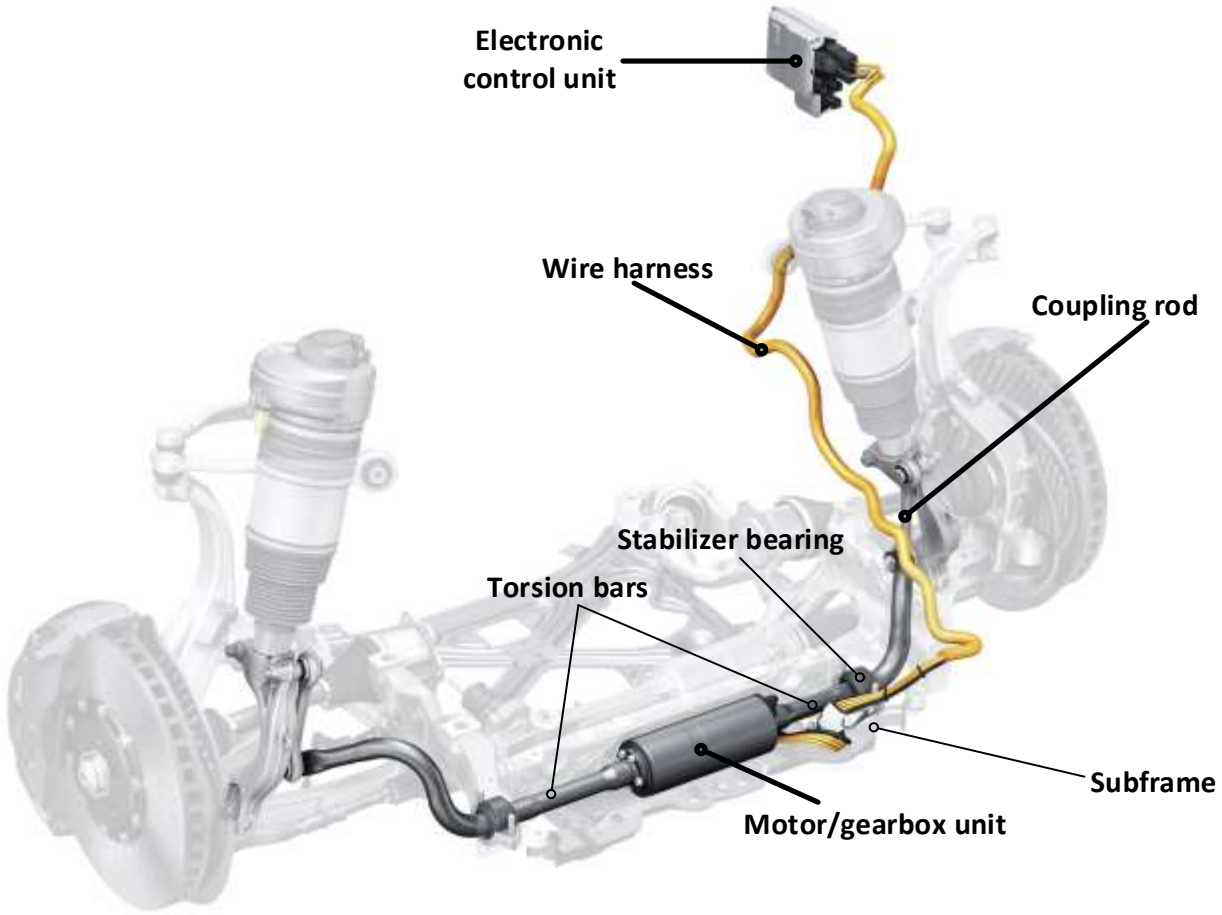
intelligent Active Roll Control (iARC)



- iARC system components, integrated in the front axle of an SUV (©Audi, Schaeffler)

Roll control

Active mechatronic roll control | Passive roll stabilization

Comfort

Decoupling: actuator torque front axle $T_{FA} \triangleq 0$

Agility and sportiness

Understeer $T_{FA} > T_{RA}$ | Neutral drivability $T_{FA} = T_{RA}$ | Oversteer $T_{FA} < T_{RA}$

Safety

Active mechatronic roll control | Passive roll stabilization

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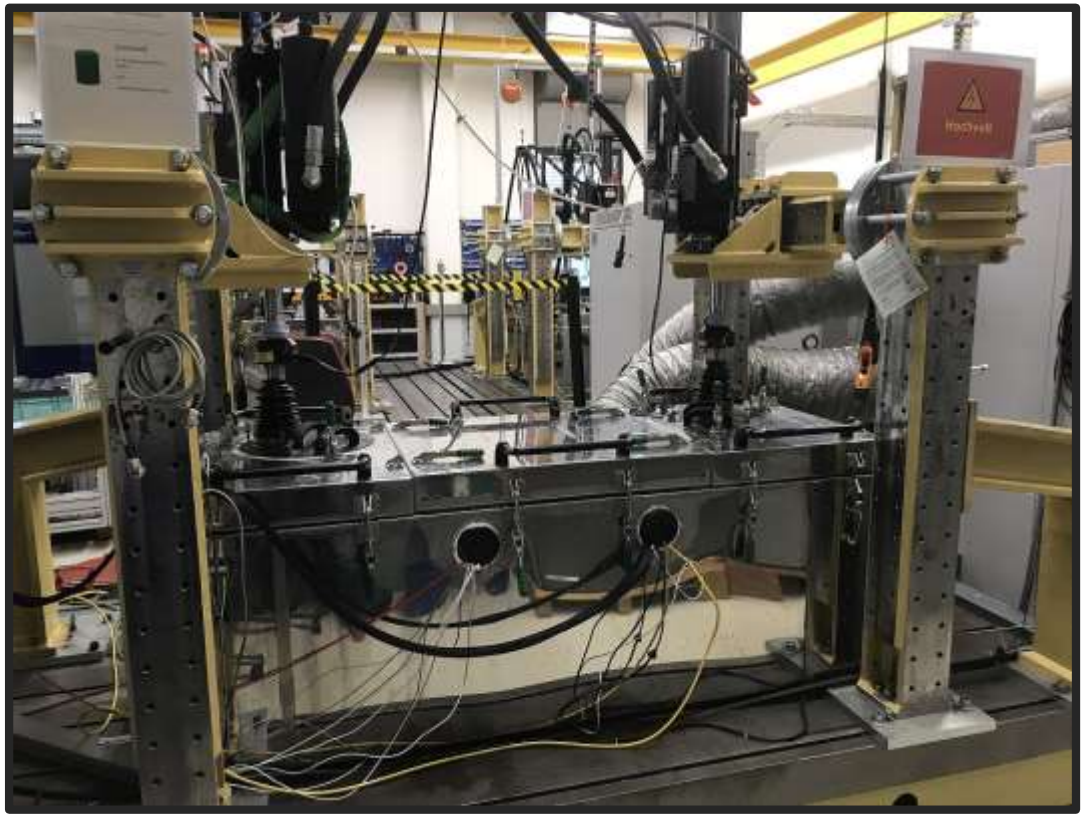
System Functional Test: Status and Challenges



Test Environment

- Target signals: Test profiles
- External disturbances at coupling rods: 2x hydraulic pulser system
- Vehicle/Chassis communication: Restbus simulation
- Supply voltage: 36V / 48V / 52V
- Ambient temperature: -30°C / 23°C / 80°C

Challenges

- Higher cost (compared with virtual testing)
- Bug-fix of unexpected errors brings more time consuming on test bench
- Test scheduling depends on the availability of the bench

Motivation

- Virtual testing on PC
  - Reduce cost on test bench
  - Increase the test coverage
  - Early verification and testing

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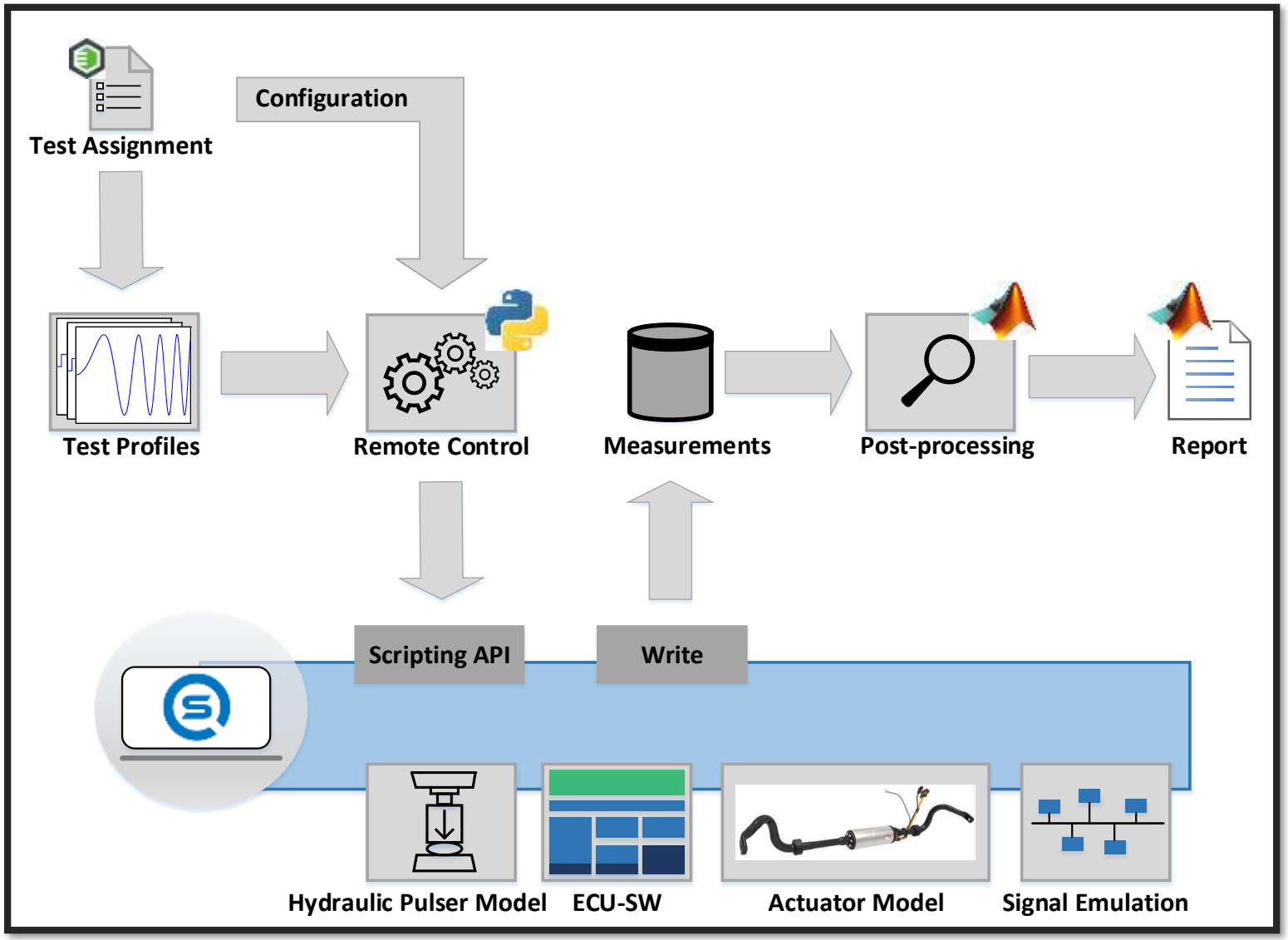
Workflow of Virtual Testing



- Virtual simulation platform in Silver
- Test assignments are synchronized with database, i.e. PTC Integrity
- Virtual simulation platform is parameterized by software release, parameter container, actuator type and so on
- Post-processing: e.g. boundary values
- Test report shown in the end with “pass/fail“ results

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Virtualization

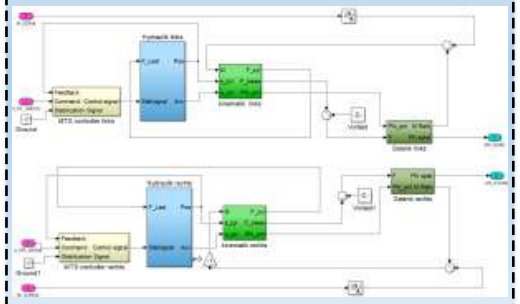
Real object

Hydraulic pulser system

iARC

virtualization **virtualization** **virtualization**

Modelling



Simulink

ECU functions

RTOS emulation

4GB virtual memory

A2L conve-rsion

XCP

flash

Simulation platform

Silver

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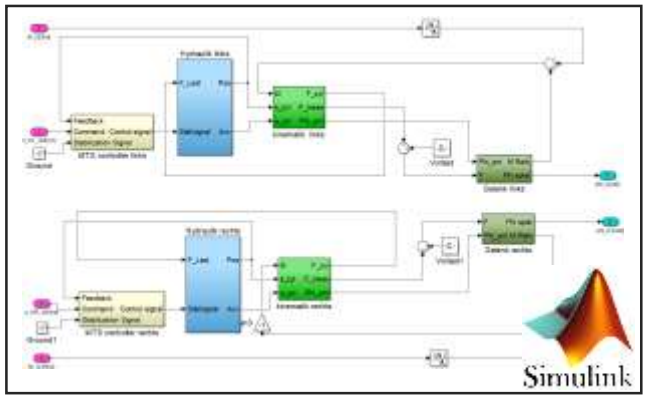
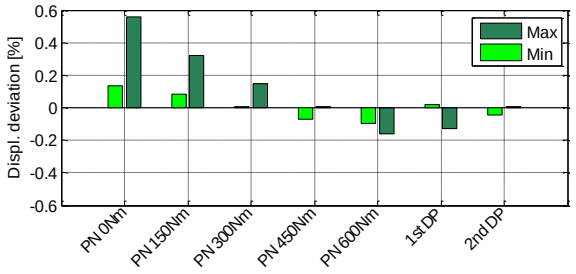
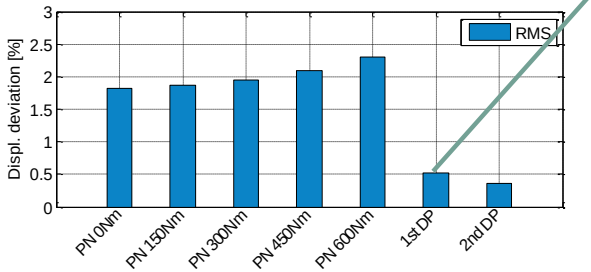
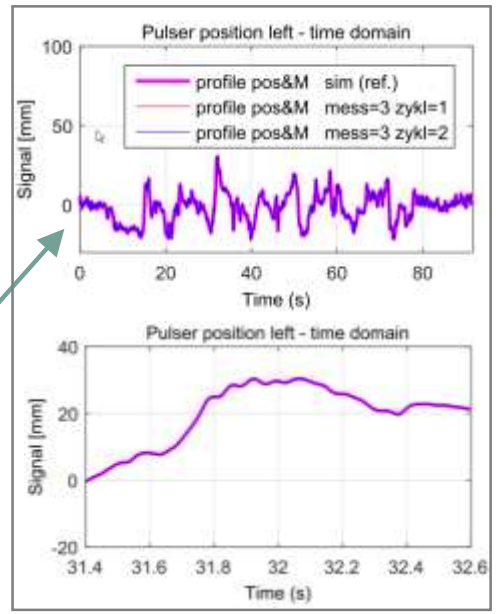
Virtualization of Physical Models

Hydraulic pulser system

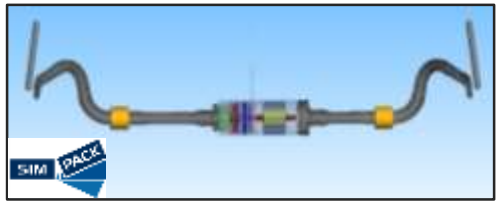


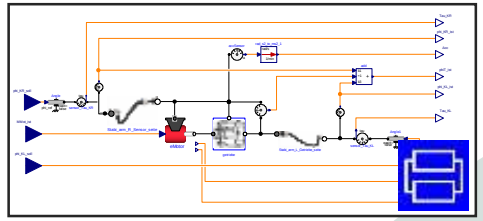






iARC (actuator component)

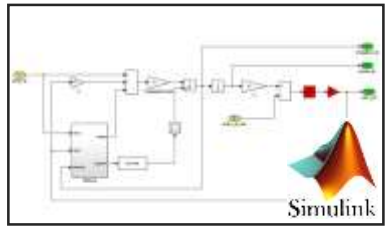




Advanced

Intermediate

Basic



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Virtualization of ECU-SW

Options

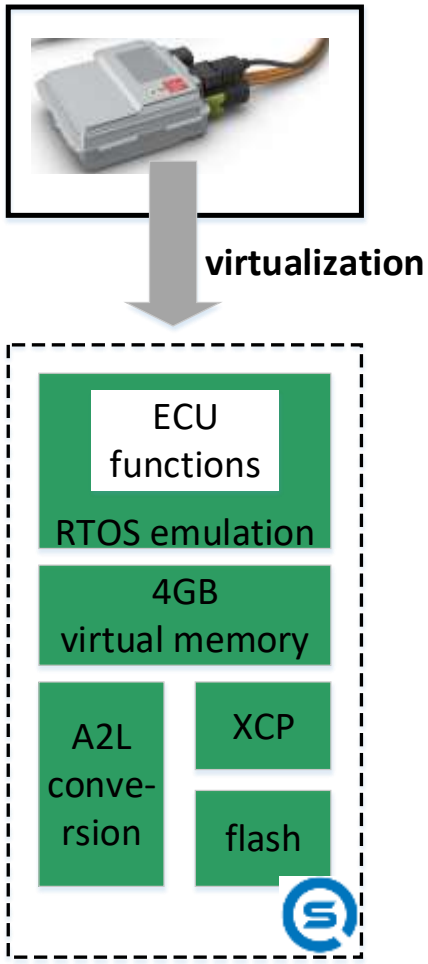
- MATLAB/Simulink modules in MiL (Model-in-the-Loop)
- C code in SiL (Software-in-the-Loop)
- Delivered Hex file (binary containing data and program code)

Status

- SW is developed together with another supplier
- Hex file is delivered from SW department and verified against specification
- Use the identical SW as the one on test bench

Virtualization

- Chip simulation



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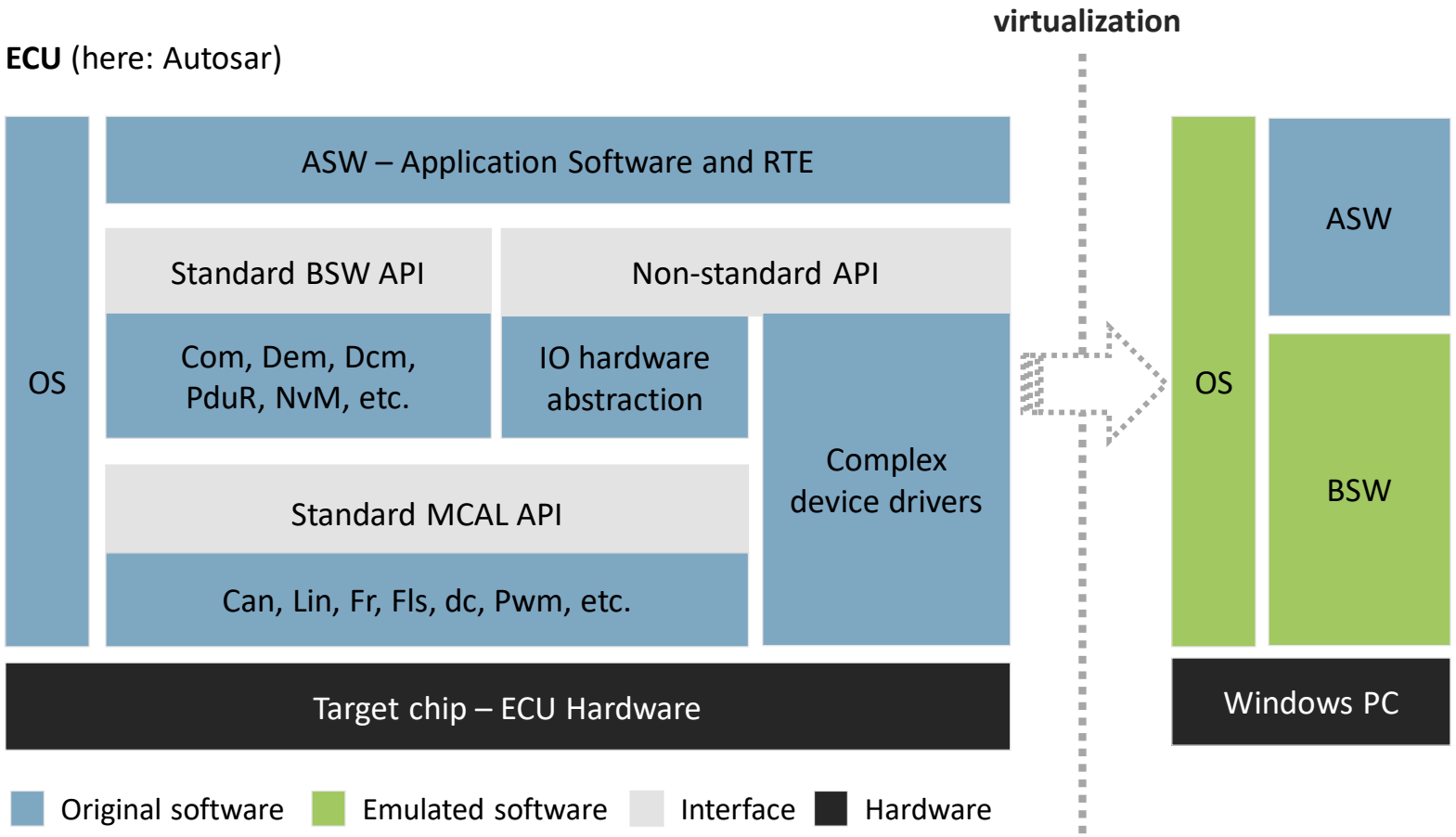
Virtual ECU with Chip Simulation



Principle of chip simulation

- Mapping the instruction set of the target processor to the instruction set of the host processor on PC

Use case of chip simulation

- Only application SW
- Basic SW is verified in HiL (Hardware-in-the-Loop)

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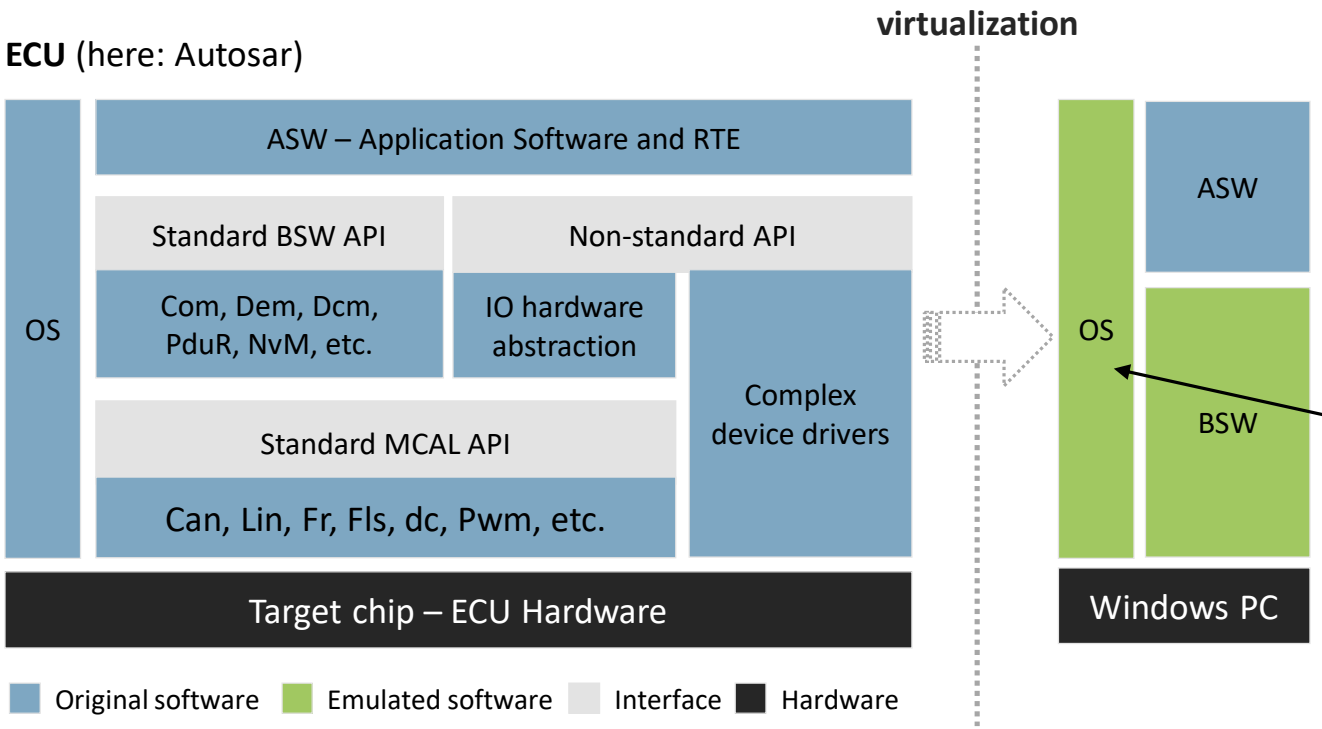
Virtual ECU with Chip Simulation

Needed files

- **Hex file**: Program code and data of the functions to run
- **A2L file**: Describes the inputs, outputs (MEASUREMENT elements) and parameters (CHARACTERISTIC and shared AXIS_PTS elements)
- **MAP file**: Maps function names to ECU memory addresses
- **DCM file** (for calibration): Calibration data to be flashed




```
01  # ============================================
02  # Spec file for tcbuild.exe and Silver module tcdebug.dll
03  #============================================
04
05  # Used files
06  hex_file(iARC_SW_H03.A.V01_R0.2.0.167.hex, TriCore_1.6.1)
07  map_file(iARC_SW_H03.A.V01_R0.2.0.167.map)
08  a2l_file(iARC_SW_H03.A.V01_R0.2.0.167_rear.a2l)
09
10  # Specification of startup code
11  chip_config(STEP_SIZE, 0.001)          # base clock tick in milli seconds
12  chip_config(TEXT_START, 0xa0000000)  # 4 bytes for Silver internal use
13
14  # List of functions to run, in order of execution
15  task_initial(ATC_TaskInit, 0)
16  task_periodic(ATC_step, 2, 0)
17
18  a2l_function_inputs(ATC_Gen)
19  a2l_function_outputs(ATC_Gen)
```

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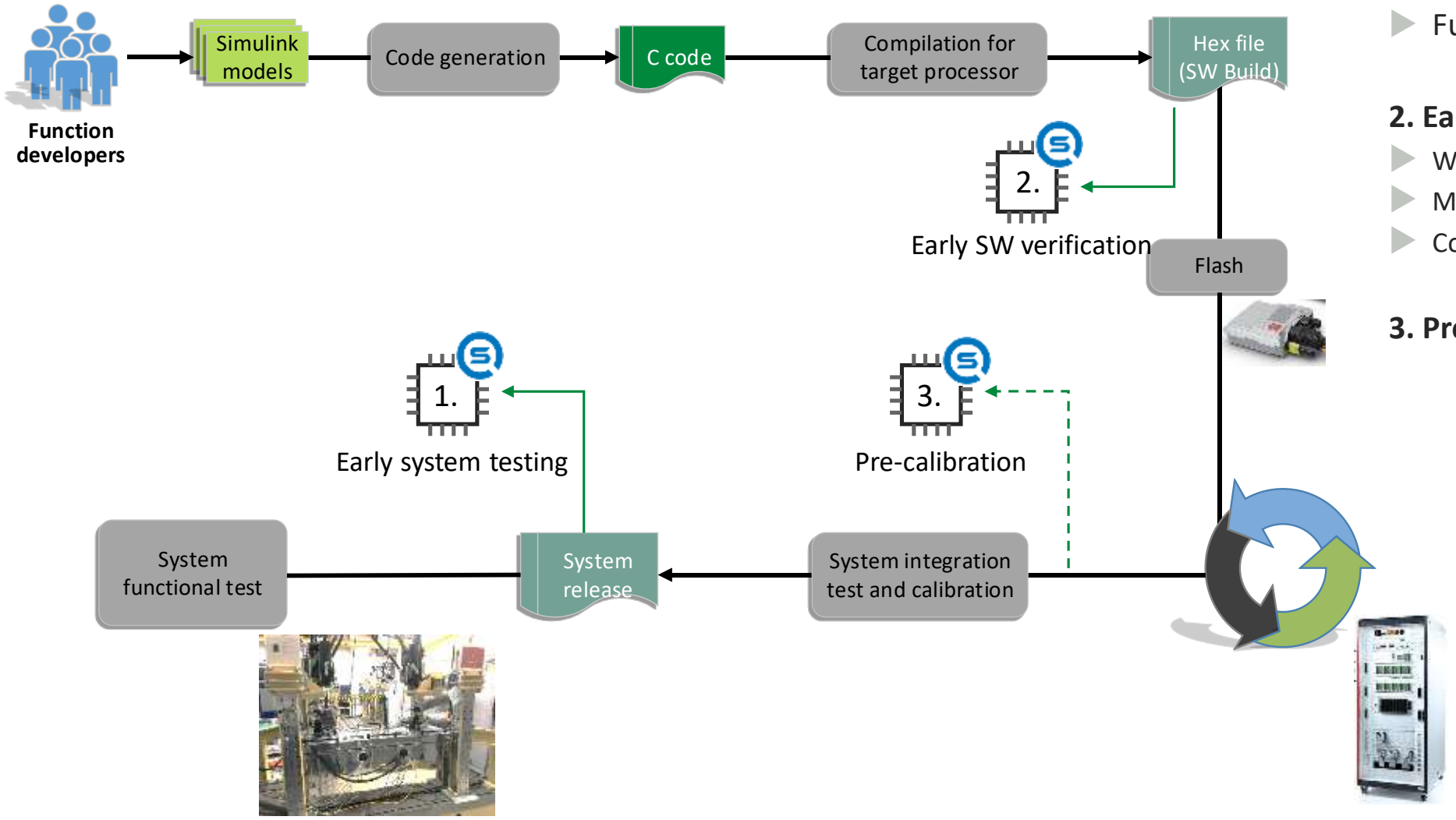
Early Software Verification and System Testing



1. Early system testing

- Functional testing in system context

2. Early software verification

- When SW-Build is deployed
- Move selected tests from HiL
- Component testing

3. Pre-calibration

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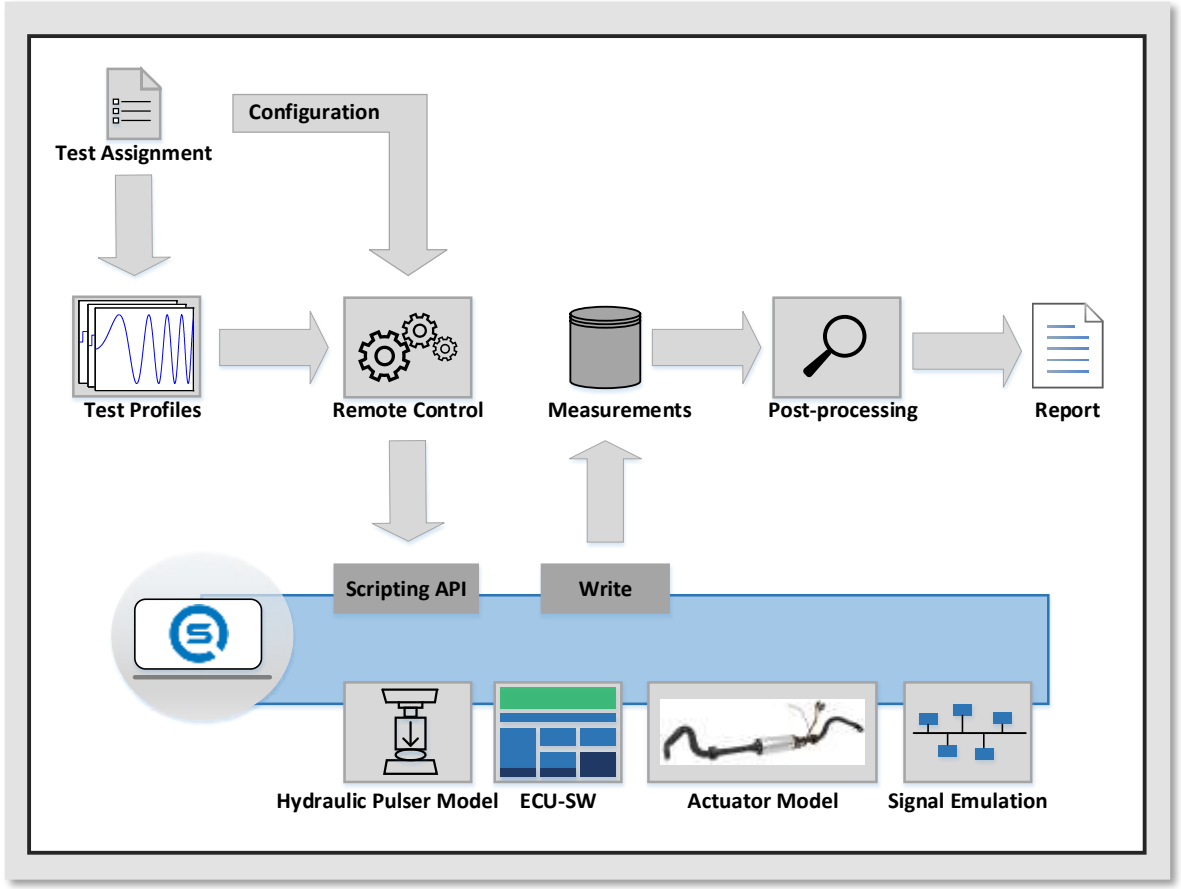
Status Quo

1. 46 % IDs of system functional test can be verified in virtual environment
2. Virtual testing has a good correlation with measurements
3. Enlarge test strategy in a cost-effective way
4. Has been established for more than one project, and is also planned for other chassis mechatronic systems
5. Continuing improvement of physical models to increase test scenarios



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