SIL standardization – the world driven by SIL

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Principle of Software-in-the-Loop (SIL)

System under test (SUT): **Software**

Test environment=vehicle

In-vehicle SW tests

System under test (SUT): **Software**

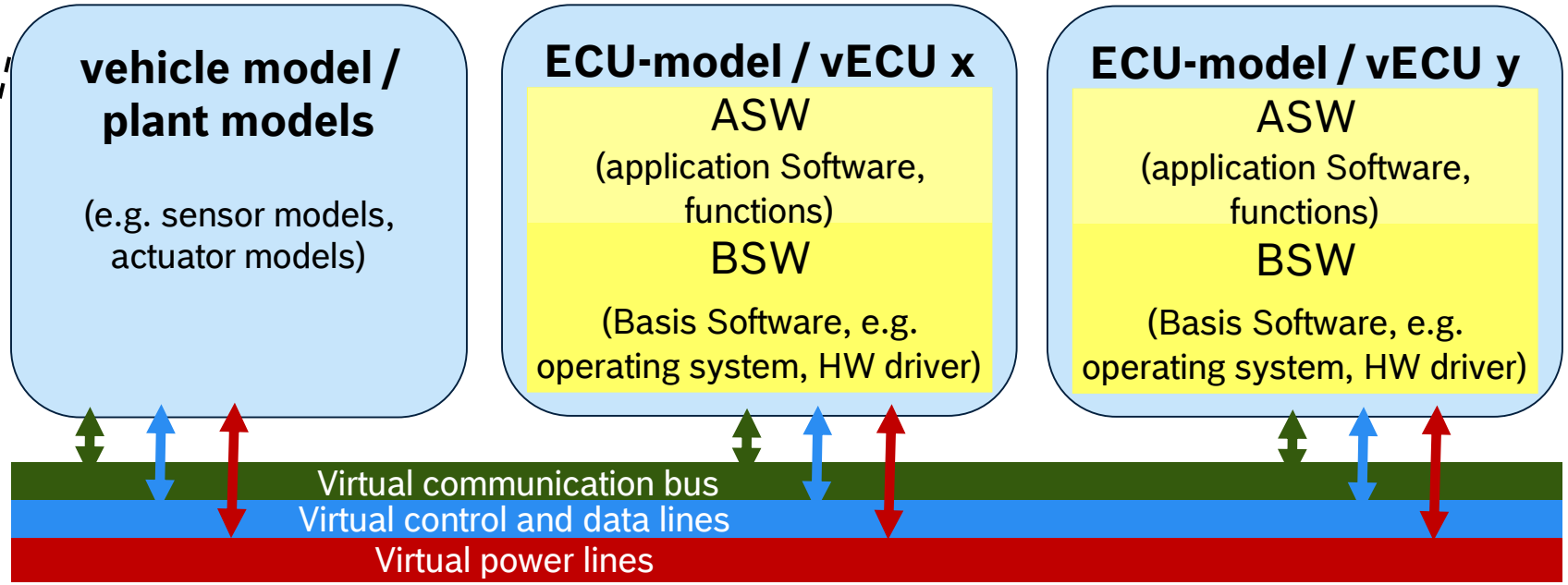
Test environment=labcar, lab equipment, Hardware-in-the-Loop (HIL)

HIL tests

System under test (SUT): **Software**

Test environment= virtual environment, PC, server or cloud

SIL tests



Main SIL components / core topics:

- vECUs = virtual ECUs, ECU models
- Virtual HW driver
- Virtual communication busses (e.g. virtual CAN, virtual FlexRay, virtual Ethernet)
- Plant models (“Streckenmodelle”) suitable for SIL

SIL is an efficient approach for testing software

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Expectations towards SIL

Function developer:
user-friendly SIL&MIL-environment to develop & test their algorithms and functional models

Application engineers:
usage of SIL environment for early SW and system application (efficiency increase)

Software developer and tester:
SIL environment integrated in existing tool chains & continuous testing strategy

OEMs:
SIL-tested software by suppliers, easily to be integrated into OEM-SIL-environments

HIL tester:
HIL test cases to be reused and run in SIL (but faster and with more input parameter combinations)

Everybody:
- seamlessly usable SIL system
- SIL components are combinable between different use cases, roles and companies

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Several levels of SIL testing and release

Release on Distributed Level

Requirement-based Testing
Real-life condition Test
Scenario Coverage
Field-based Validation
Security
Network
Virtual Release
…

Vehicle	-	
Virtual HiL / Vehicle in the loop	-	
vECU Release Test on SoS level (Multi-domain reference-SiL)	SiL	

Release on Component Level

Housekeeping, Middleware,
Timing, Memory, Runtime,
Concurrency, Fault-injection
…

Release Test on ECU level (Single ECU-HiL)	-	
Release Test on ECU level (Single ECU-SiL)	SiL	

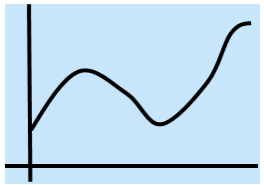
Release on Functional Level

Back-to-back Test,
Timing, Memory, Runtime,
KPI Metrics, Robustness, …

Interface Tests,
Component Tests,
Model Verification, …

Model Verification,
Static Code Analysis,
Code Coverage, …

Implementation Test on reference HW	-	
Implementation Test on complete function level	SiL	
SW Integration + Interface Test (“DLL / PC”)	SiL	
Model Test on functional component Level	SiL	
Unit Test and SCA on Unit Level	SiL	



= In-vehicle tests

= tests in target HW

= tests in virtual environment (SIL/simulation)

= closed loop

= open loop

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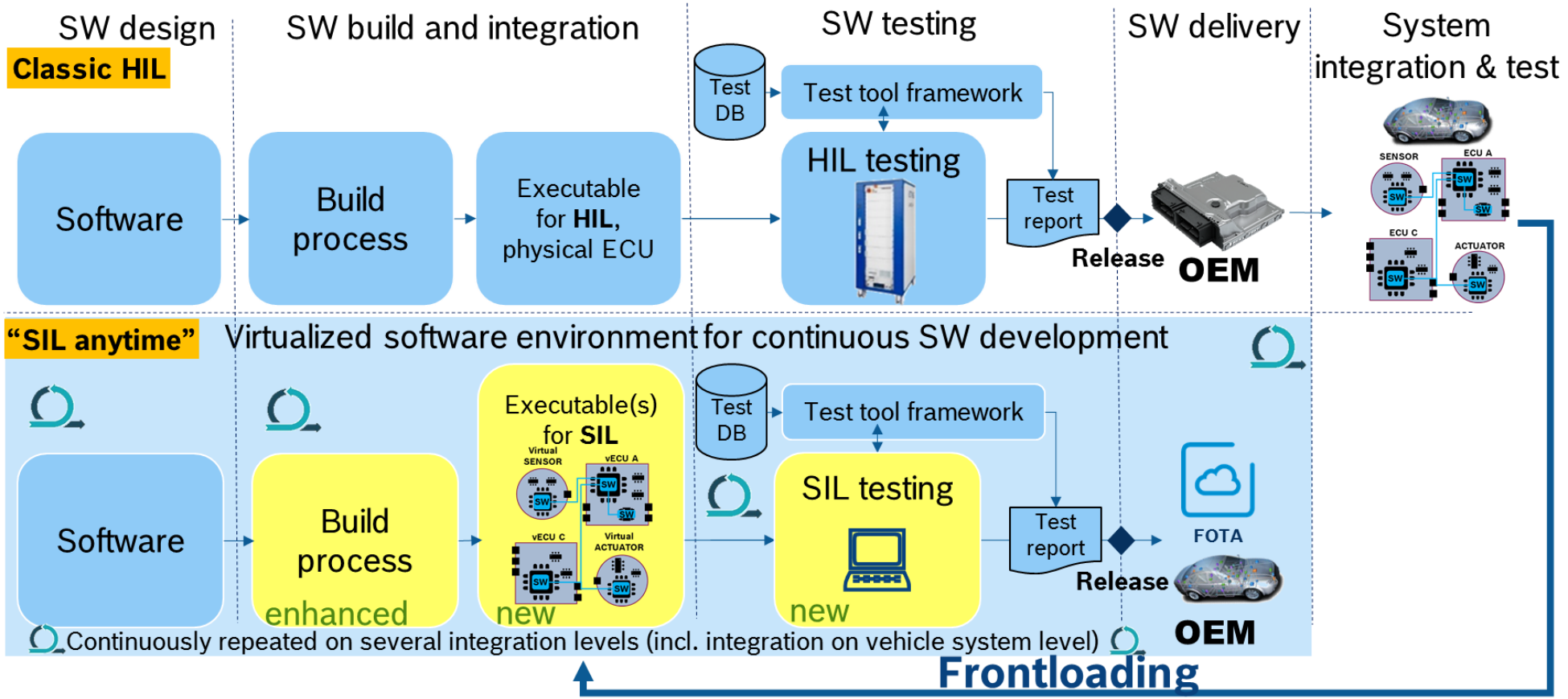
SIL: Target “SIL anytime”



SIL will be the continuous testing environment for the automotive industry

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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

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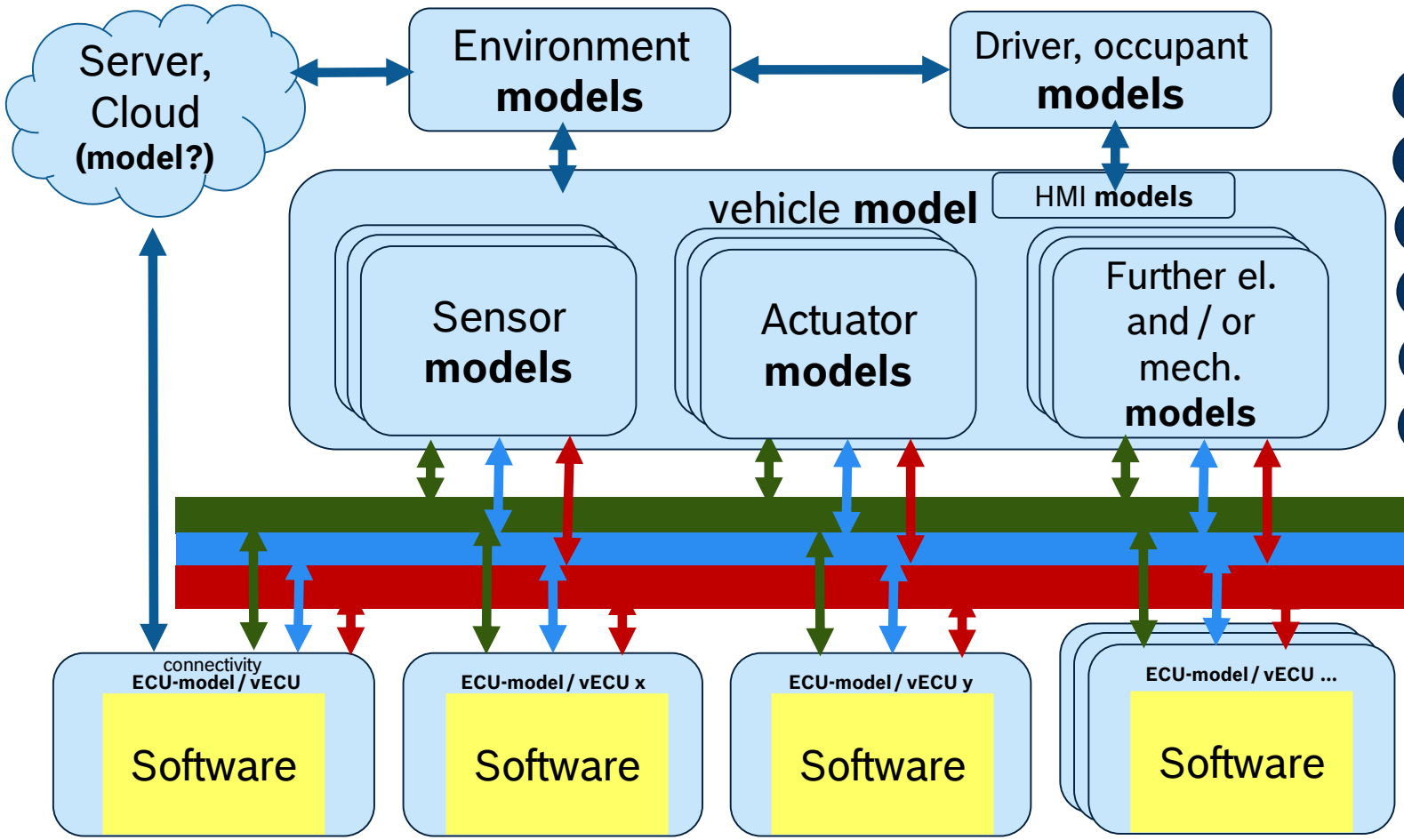
Examples for topics of the required SIL standardization



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”)

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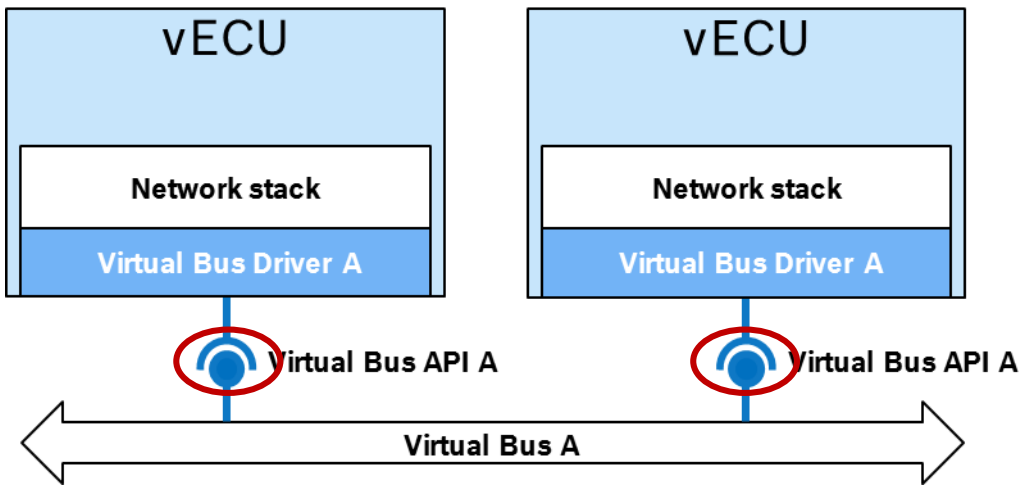
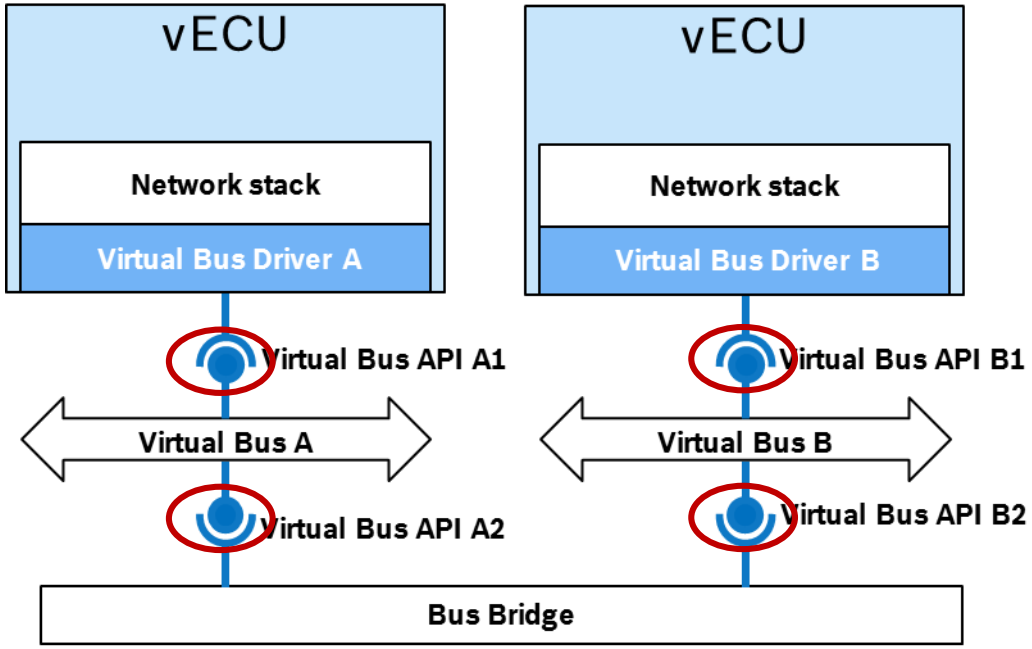
Example for interface standards – virtual networks



Target Configuration



Configuration with Bridge

= need for interface standards

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Status of the standardization in the industry

Selection of projects, initiatives and organizations contributing to the SIL standardization

Industry-wide

vECU-MBD WG

in Japan

Main players in the automotive industry say, we need to

- Strengthen these activities
- Increase the speed and scope of the SIL standardization

BOSCH supports the enforcement of SIL standardization

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BOSCH SILC ROAD spec

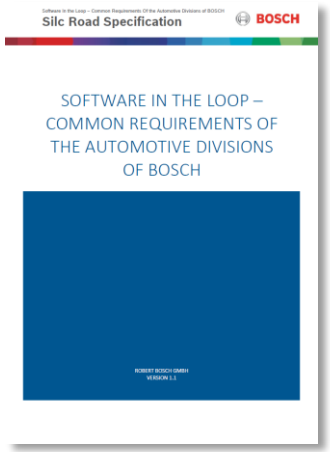
* SILC = SW in the Loop Common Requirements

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)

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Benefits of the SILC ROAD spec

The SILC ROAD specification can be the basis for

- Industry-wide SIL specification, standardized SIL tools and process frameworks
- Reference implementations
- Standardized SIL-capable products
- New efficient SW test environments and methods for the software, system and application engineers
- The OpenADx activities

Current status:

- discussion of the SILC ROAD spec between BOSCH and several different market players has started