VALIDATION OF AUTOSAR SOFTWARE VIA VECU

EFFECTIVE USAGE OF MATLAB/SIMULINK FOR VECU DEVELOPMENT

Pune, November. 2022.
Dr. Vivek Venkobarao, Alexeev Konstantin Vitesco Technologies

Public

vitesco
TECHNOLOGIES

AGENDA

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

GOAL OF VECU

Goal

> Provide a configurable Virtual ECU (VECU) for development, integration calibration and functional testing

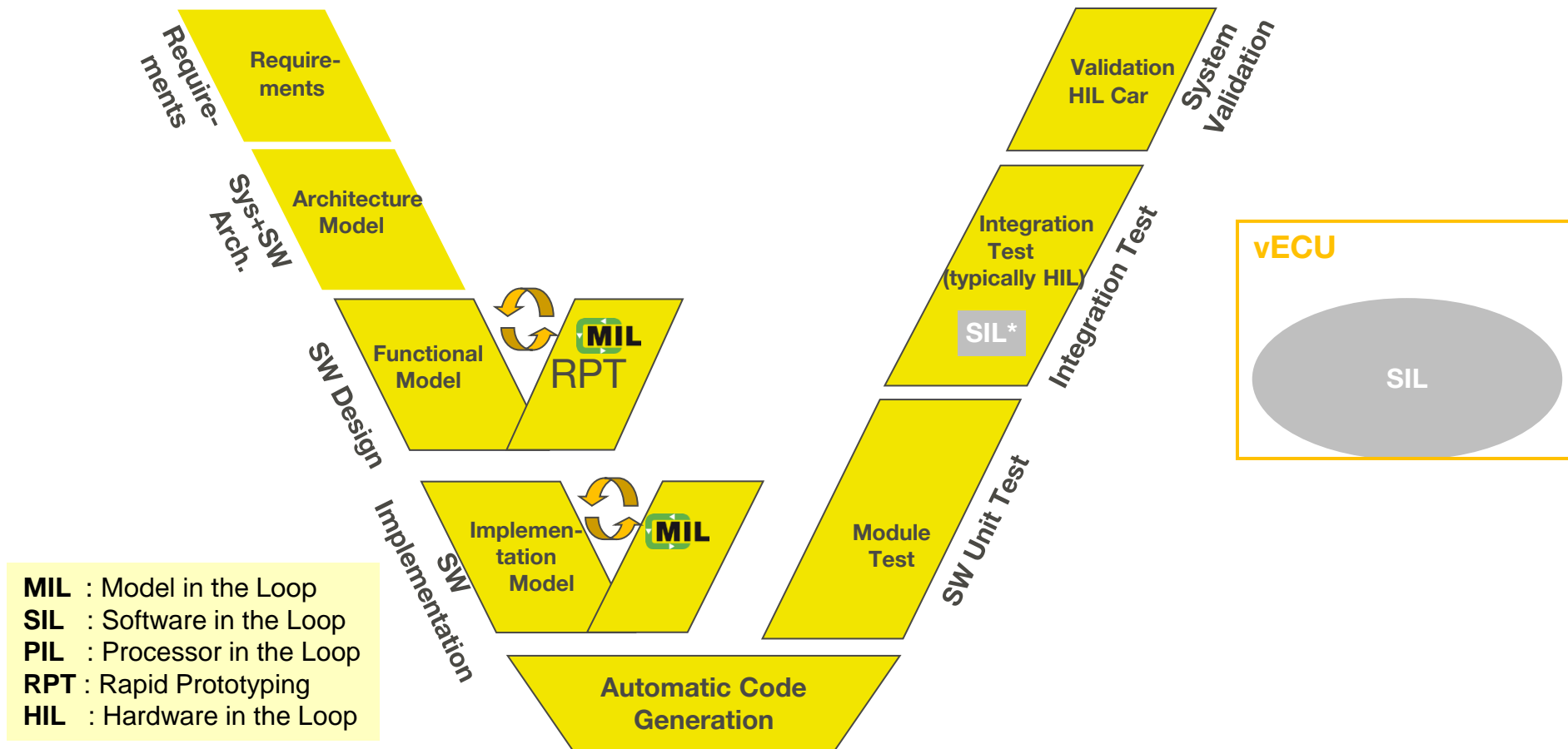> Provide simulation means for **earlier** functional testing (vs HIL) in development cycle

> Make a Virtual ECU and connect with other ECUs/Controllers (e.g. Vehicle controller, ADAS ECU etc.) to check the behavior much earlier

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

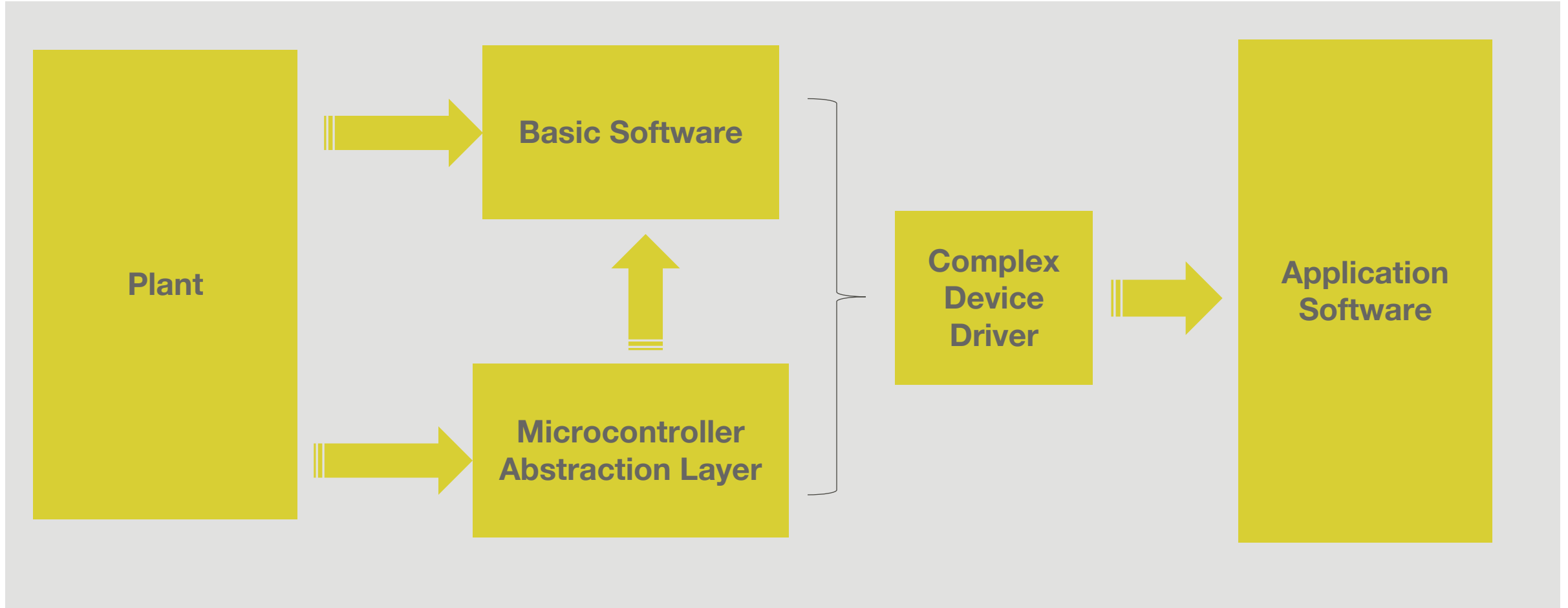## GOAL OF VECU - ALIGNMENT INTO V-CYCLE DEVELOPMENT PROCESS

Requirements

Sys+SW Arch.

SW Design

SW Implementation

Requirements

Architecture Model

Functional Model

MIL RPT

Implementation Model

MIL

Automatic Code Generation

System validation

Integration Test

SW Unit Test

Validation HIL Car

Integration Test (typically HIL)

SIL*

Module Test

vECU

SIL

MIL : Model in the Loop
SIL : Software in the Loop
PIL : Processor in the Loop
RPT : Rapid Prototyping
HIL : Hardware in the Loop

**Simulation of complete ECU Software (Production ASW-Code)
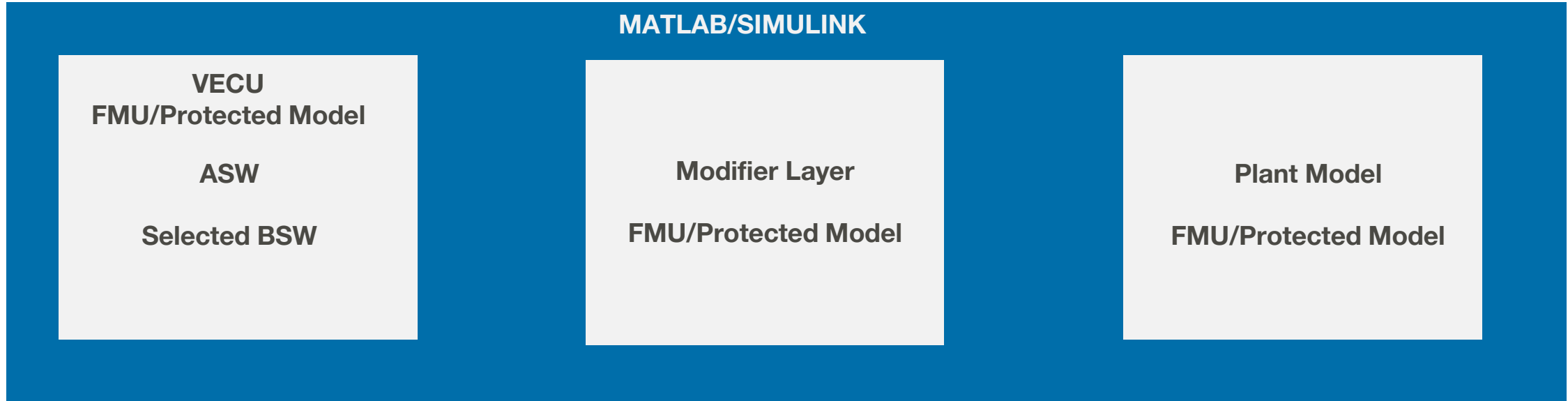Can be used for integration tests before going to the HIL** !

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

COMPONENTS OF VECU

Plant

Basic Software

Microcontroller Abstraction Layer

Complex Device Driver

Application Software

Simulink Connectors
AUTOSAR Composition

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

COMPONENTS OF VECU

MATLAB/SIMULINK

| VECU
FMU/Protected Model

ASW

Selected BSW | Modifier Layer

FMU/Protected Model | Plant Model

FMU/Protected Model |

Component of VECU	Type of Model in Simulink
Application Software Models(ASW)	Protected Models/FMI Models
Basic Software Models(BSW)	FMI Models
Plant Models	Protected Models/FMI Models
Modifier Layer	FMI Models

 Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

COMPONENTS OF VECU - DATA FLOW

ASW Features

Feedback signals

Module 1

Module n

Module n+1

Virtual Sensor responses

Virtual HW Signal 1

SW ADC

Virtual HW Signal 2

**BSW Features
+
Modified MCAL**

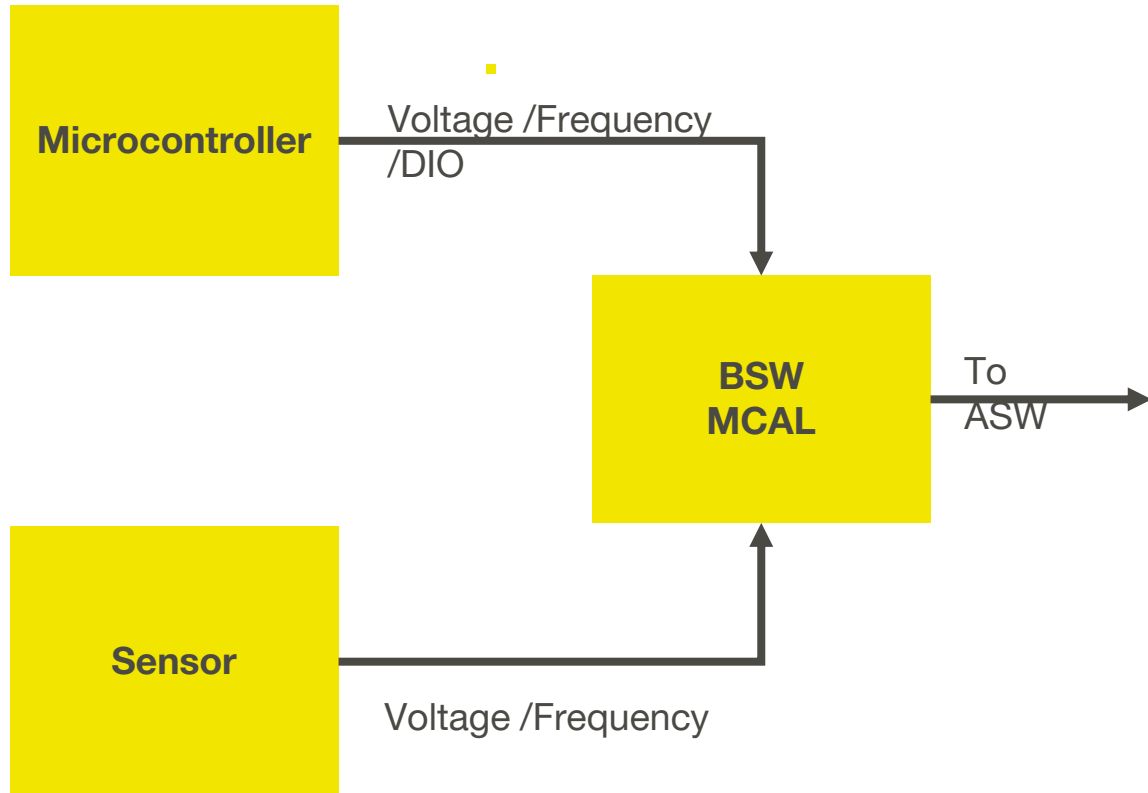Virtual HW signals

Plant

Feedforward signals(eg. Control signals)

vitesco
TECHNOLOGIES

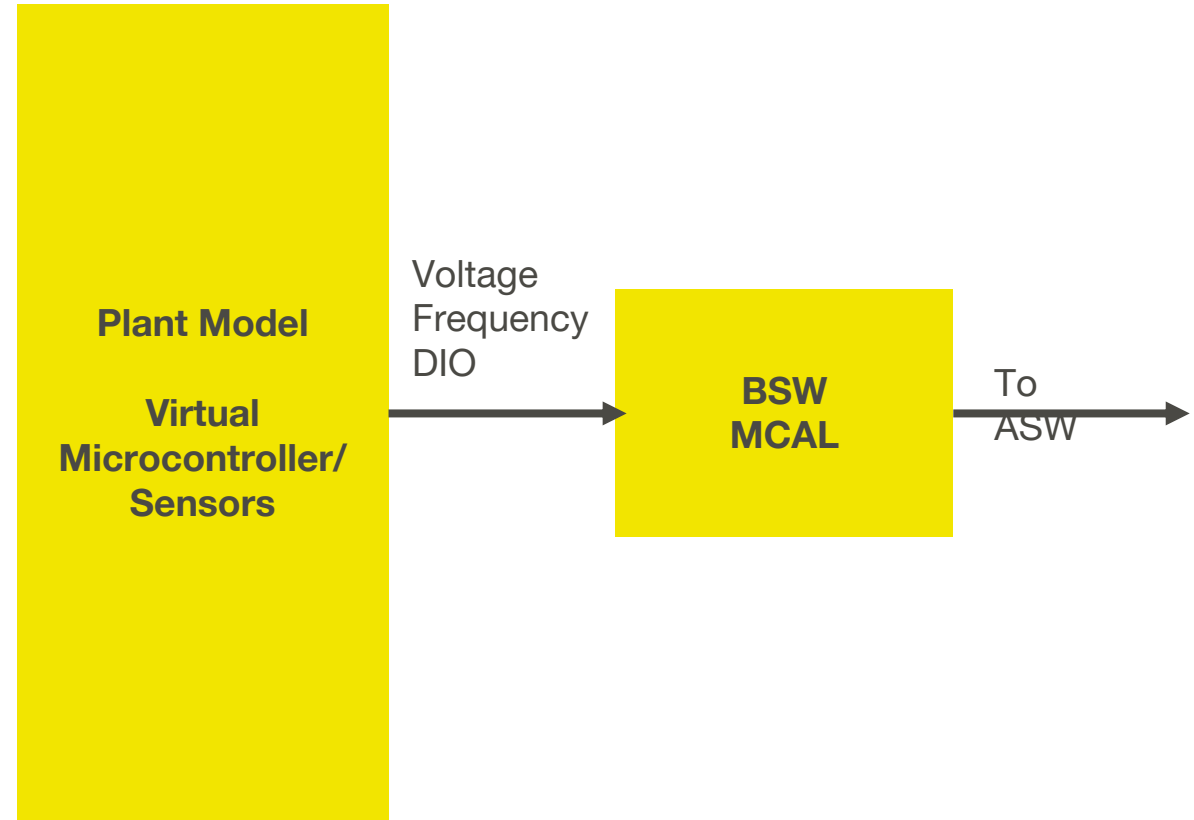# VALIDATION OF AUTOSAR SOFTWARE VIA VECU

COMPONENTS OF VECU - MICROCONTROLLER ABSTRACTION LAYER - MCAL

> MCAL in Software

> MCAL in VECU

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

ADVANTAGES OF FMI - BLACKBOX REAL TIME MODELS

FMI is an open standard for exchanging dynamical simulation models between different tools in a standardized format.

Tools Supported *
MATLAB/SIMULINK
ETAS - MOCA
dSpace
Qtronics – Silver

$t_0, \mathbf{p}$, inital values (a subset of $\mathbf{v}(t_0)$)

Enclosing Model

t time
$\mathbf{p}$ parameters of type Real, Integer, Boolean, String
$\mathbf{u}$ inputs of type Real, Integer, Boolean, String
$\mathbf{v}$ all exposed variables
$\mathbf{y}$ outputs of type Real, Integer, Boolean, String

FMU instance
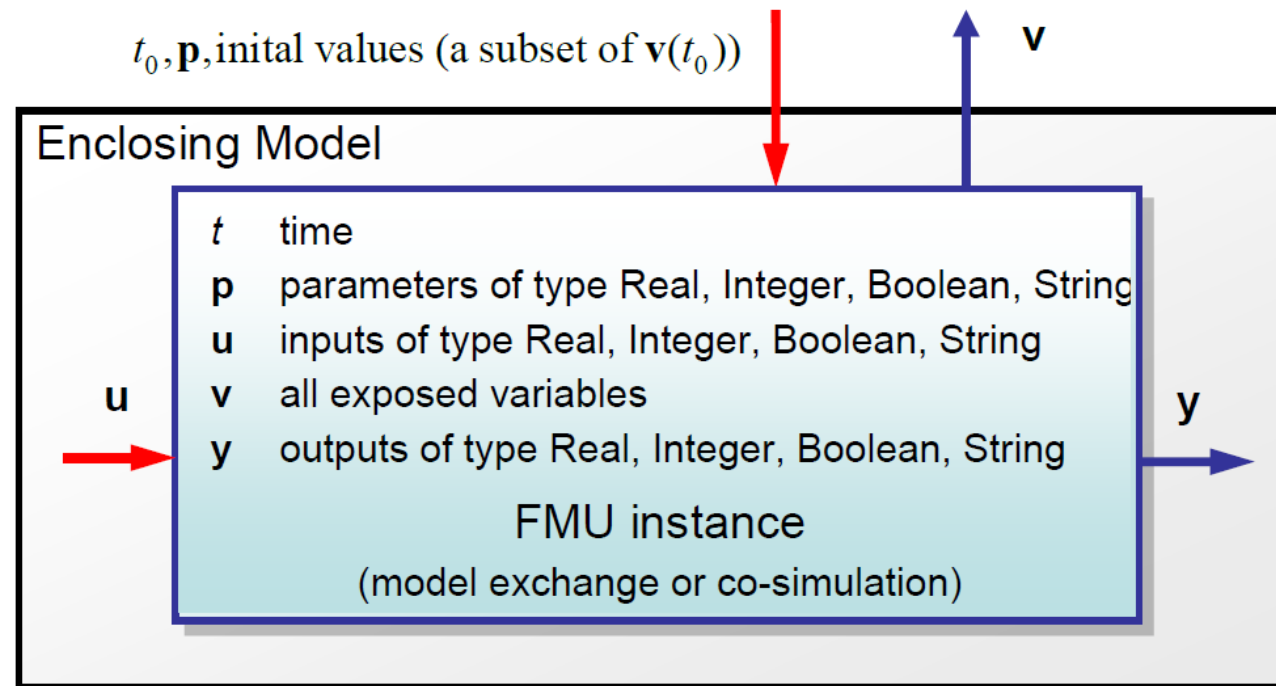(model exchange or co-simulation)

Figure 1: Data flow between the environment and an FMU. For details, see chapters 3 and 4.
Blue arrows: Information provided by the FMU.
Red arrows: Information provided to the FMU.

Reference: www.fmi-standard.org
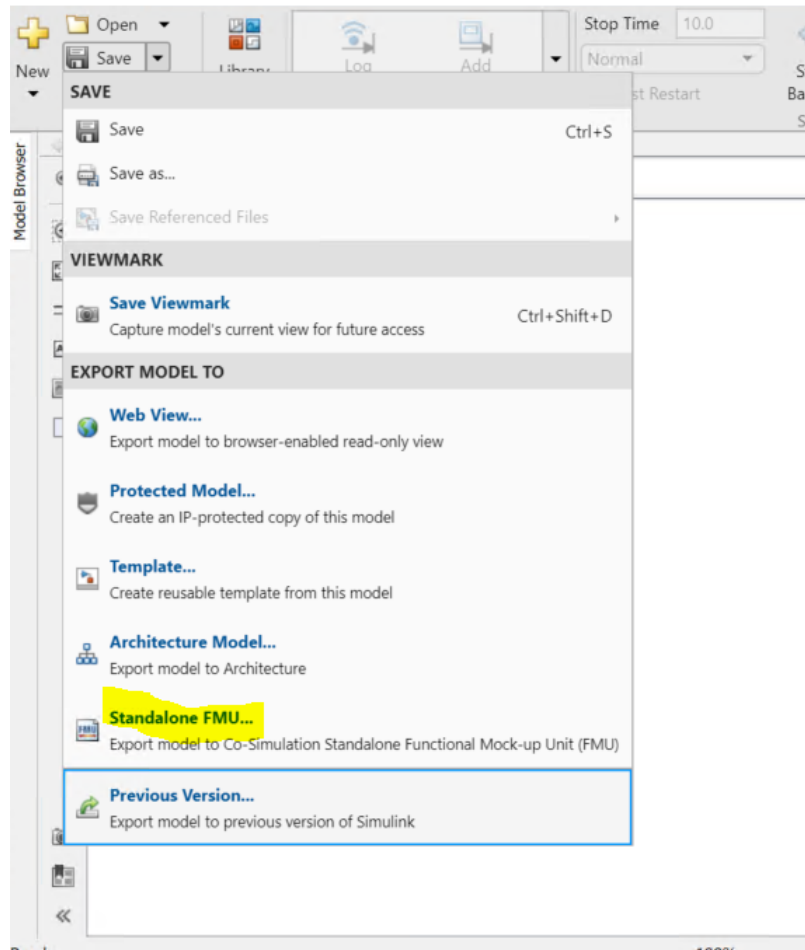https://fmi-standard.org/assets/releases/FMI_for_ModelExchange_and_CoSimulation_v2.0.pdf/

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

ADVANTAGES OF FMI

Feature	Simulink Simscape Protected Model	FMI	Legacy Code S-Function
Simulation speed	Fast	Fast	Fast
Share/Compatibility	Only for Simulink	**Any standard simulation tool**	Only for Simulink
Ease of generation	One click option in Simulink	One click option in Simulink	Command line
Debugging	Not possible	Optional --Source code debugging via VC++	Optional- Attach souce code to debug
CI/CT	Yes	Yes	Yes

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU
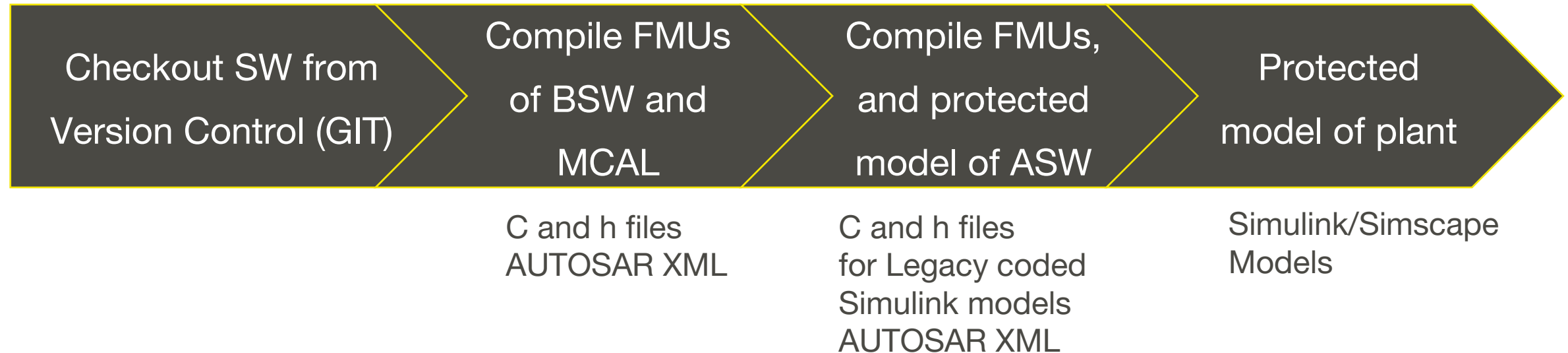
ADVANTAGES OF FMI - FMI GENERATION IN MATLAB/SIMULINK

> The Simulink offers one click option to generate FMI and protected model

> This feature is available from MATLAB 2020a and above

> No separate toolbox needed

> The Simulink automatically imports the generated FMI there by optimizing the efforts of importing the FMI generated.

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

VECU GENERATION AND TESTS - PROCESS FOR GENERATING VECU

Software build and VECU integration using Jenkins

Checkout SW from Version Control (GIT)	Compile FMUs of BSW and MCAL	Compile FMUs, and protected model of ASW	Protected model of plant
	C and h files AUTOSAR XML	C and h files for Legacy coded Simulink models AUTOSAR XML	Simulink/Simscape Models

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

**Connection via Composition Component
type.xml**

Interconnection within a component

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

Unit Testing	Integration Testing	System Testing
>Limit checks of ECU Software	>Interface Consistency check	>Sensitivity Analysis
>Data consistency	>Closed loop behavior	>Software FMEA
>Software Unit validation with	>Regression	>Model Based Calibration

Alixeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

VECU GENERATION AND TESTS - CHALLENGES FACED VECU TESTING
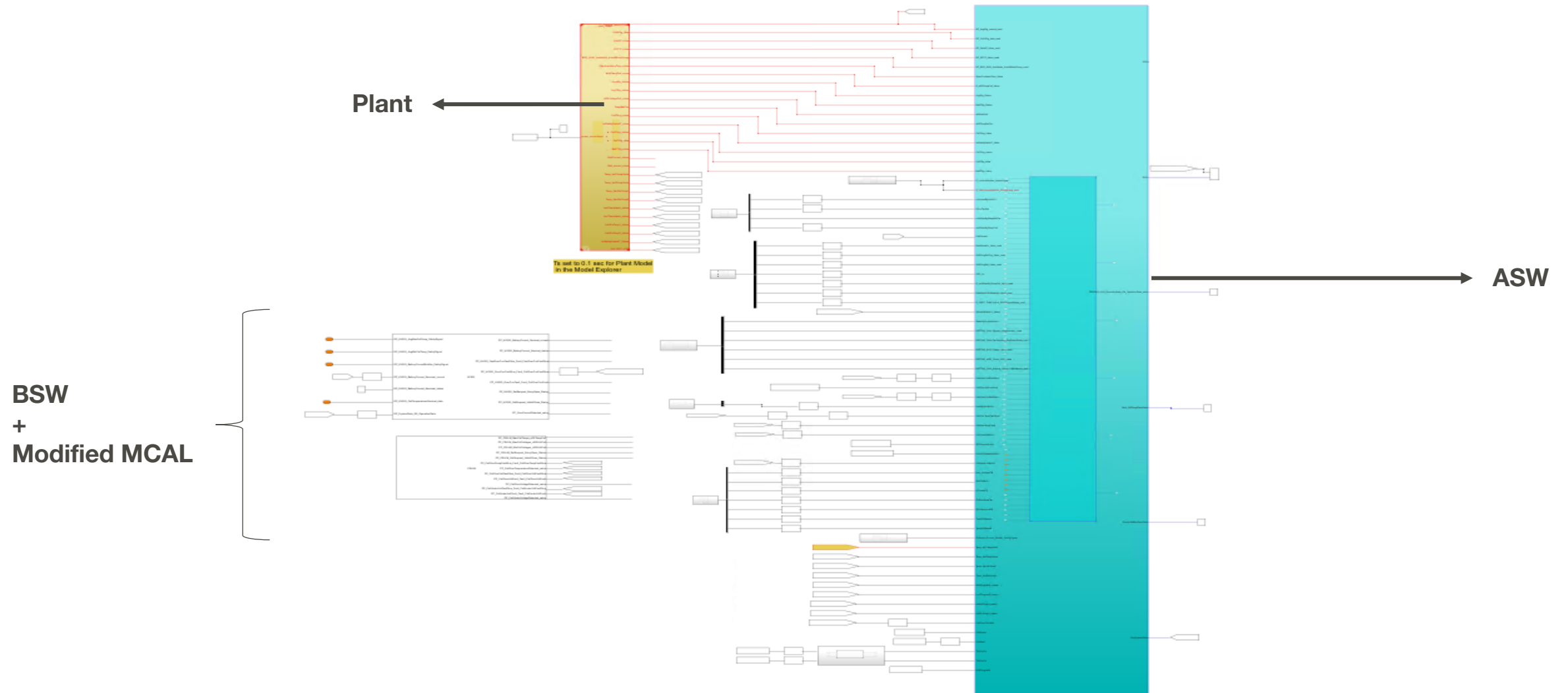
The xml parser for composition component type

EEPROM (NvM) and data consistency handling

Formation of automatic test case for Integration test

Tolerances definition for SW unit validation

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

CLOSED LOOP SIMULATION OF A BMS PROJECT

Plant

ASW

**BSW
+
Modified MCAL**

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

ADVANTAGES OF MATLAB/SIMULINK FOR VECU

Sl No	Simulink/Simscape Advantages
1	MATLAB/Simulink/Simscape implementation can replicate the hardware behavior
2	MATLAB/Simulink/Simscape can be easily used to test system-level performance and calibration.
3	Huge community – It has huge community support and MATHWORKS support
4	Easy implementation and realization of MAAB guidelines
5	Have a large database/libraries of built-in algorithms
6	One click solution to generate IP Protected (FMU+Protected) model
7	Easier co simulation across various components and sub-components.
8	Effective scheduling and sequencing of various components and sub-components.
9	Can be deployed to Jenkins to have CI/CT

vitesco
TECHNOLOGIES

VALIDATION OF AUTOSAR SOFTWARE VIA VECU

CONCLUSION

VECU improves efficiency of software

VECUs would be used for extensive testing and calibration

The production C code and basic software minimizes the behavioral gap between real and VECU

VECU reduces the development effort

The VECU developed can be easily deployed in HiL

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public

vitesco
TECHNOLOGIES

THANK YOU FOR YOUR ATTENTION!

Alexeev Konstantin, Vivek Venkobarao, Vitesco Technologies, Public