FMI-based simulation workflows based on open source and commercial tools

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FMI-based simulation workflows
FMI in use at all Bosch sectors

fmi Functional Mock-Up Interface

Mobility Solutions

Industrial Technology

Energy and Building Technology

Consumer Goods

B/S/H/

FMI is well established for Model Exchange and Co-Simulation

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FMI-based simulation workflows
New use cases

- *From manual export of FMUs to automated workflows*
- *From local usage of FMI to large-scale usage*
- *From local simulation on a PC to cloud, web, and HPC (high-performance clusters)*

The combination of commercial model authoring tools and open source tools enables new use cases, such as

- Engineering tools: Dimensioning in specialist departments (not by simulation expert) **Demo**
- Automatic Virtual ECU generation as FMU from Bosch ECU software toolchains
- Software-in-the-loop tests **Demo**
- Cloud-based simulation (at Bosch sectors + subsidiaries BSH, ETAS, ITK, Rexroth)

FMI-based simulation workflows
Need for „Portable FMUs“

- Limitations of some FMU exporting tools:
  - Some FMUs need extra installations to execute (libraries or full installation)
  - Some FMUs need runtime licenses

- To get the maximum benefit of FMI-based simulation, we need **„portable FMUs”**
  - **that do not rely on a tool installation during runtime**
  - **with licensing models that allow for simulation without a runtime license**
- We select suitable tools and are requesting portable FMUs from tool vendors

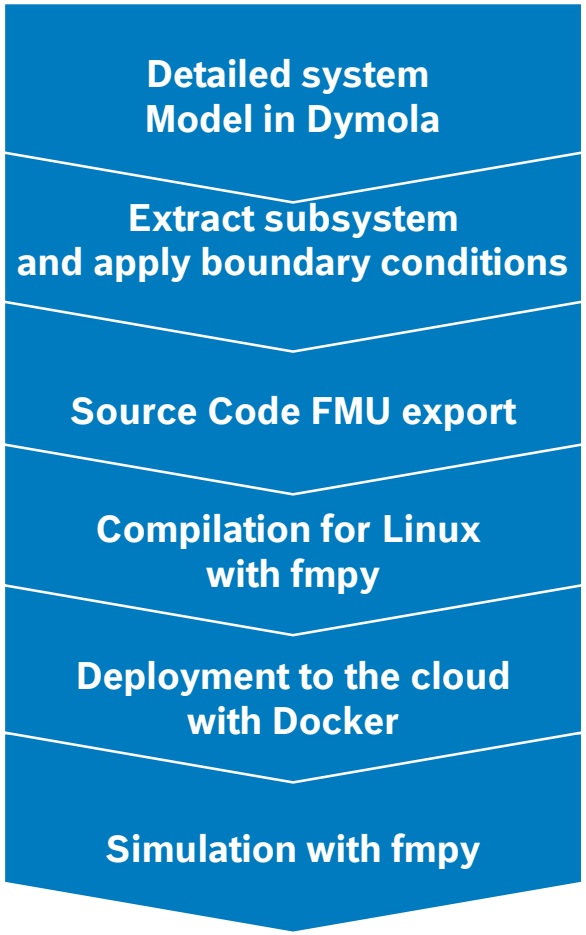
- **Source code FMUs** are helpful for model porting to new platforms, e.g. to the cloud

FMI-based simulation workflows
Example 1: Engineering tools

Goal: Engineering tools can be used for dimensioning of components in specialist department

- Re-use of parts of detailed overall system models that were created by simulation experts

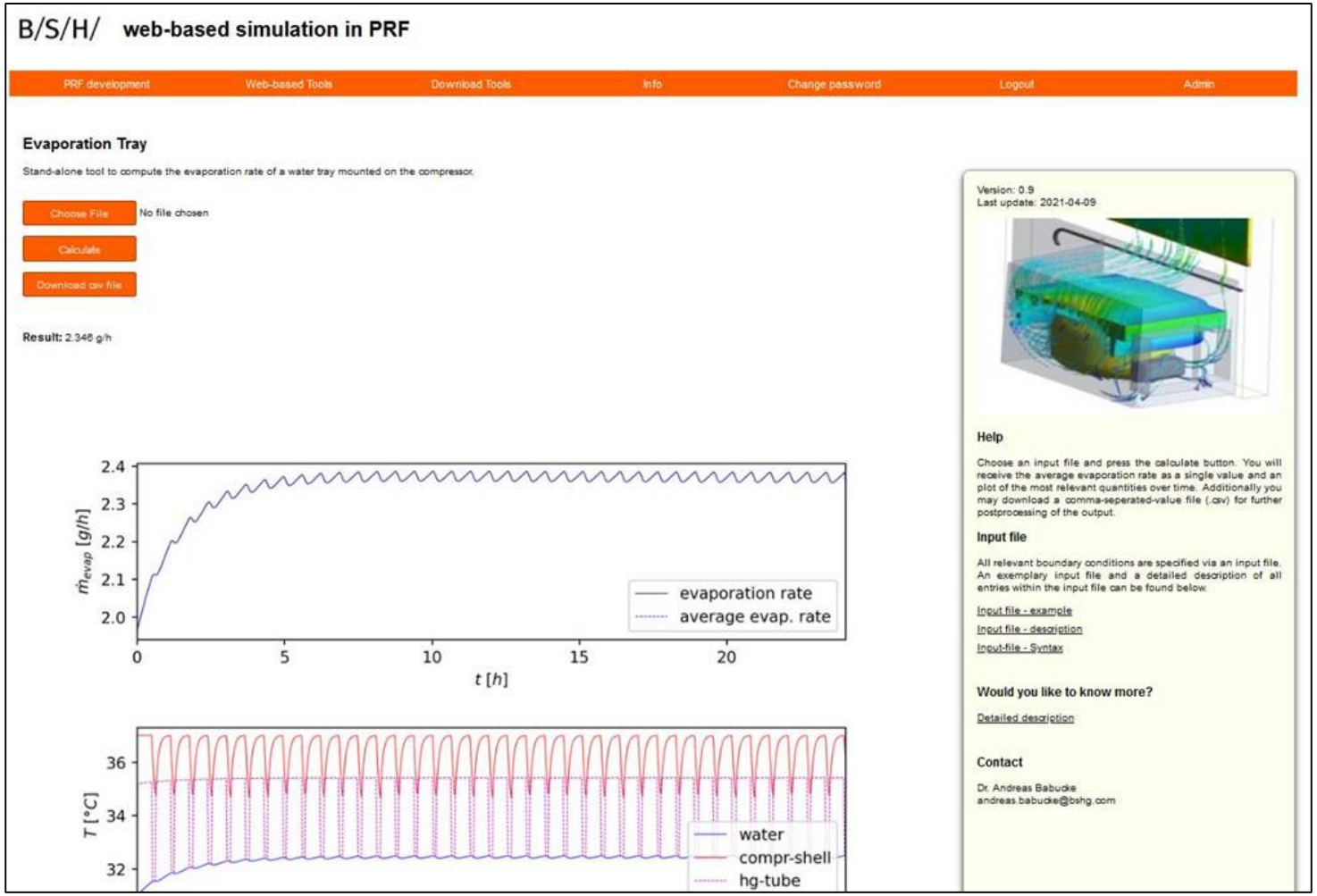
- **Benefits**
  - Full functionality of powerful simulation tools made available to specialist departments without local tool installation
  - Documentation can be easily added (as HTML)
  - Protected models (allows only for defined modifications)
  - No additional license costs



FMI-based simulation workflows

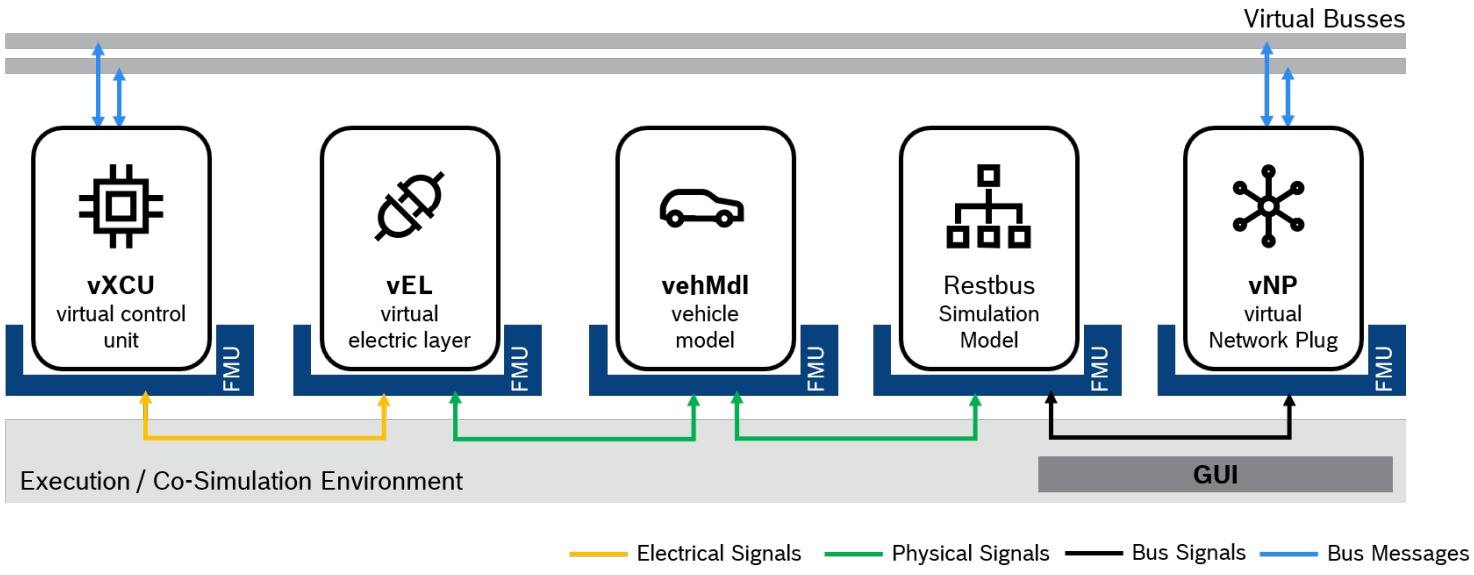
Example 1: Demo

- Engineering tool for the design of evaporation trays of refrigerators
- Developed and used at B/S/H/



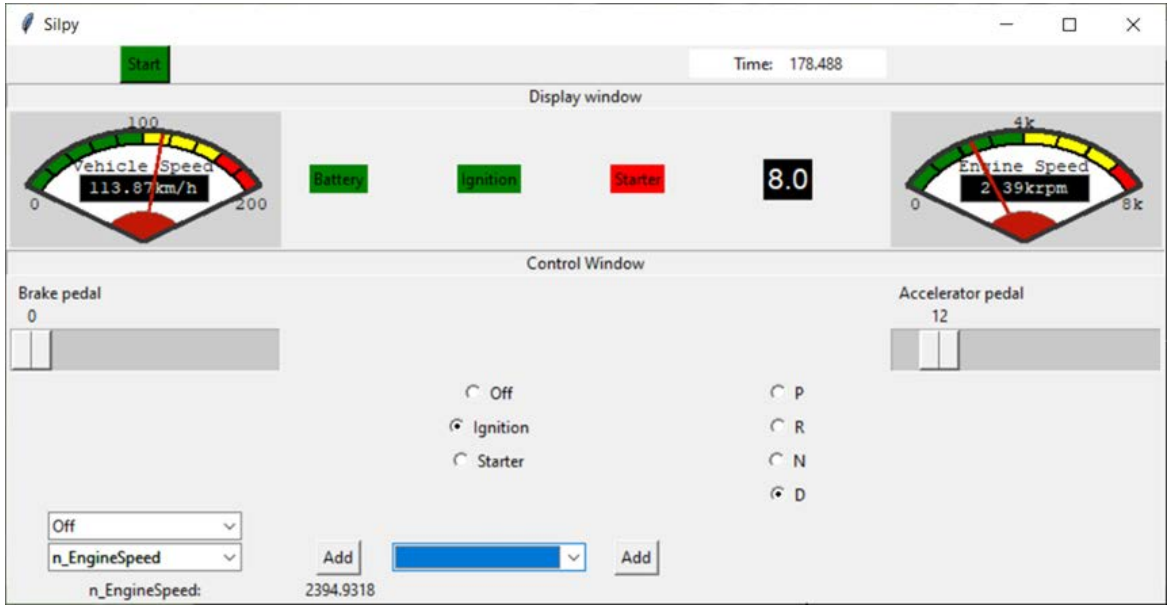
FMI-based simulation workflows
Example 2: FMI-based SiL-Simulation

- Software-in-the-Loop (SiL) simulation with FMI 2.0 Co-Simulation:
  - Engine Control Unit (ECU) Software (system under test)
  - Model of electronic components in the ECU, Sensors and Actuators
  - Model of the engine and vehicle
  - Models of the other control units
  - Bus simulation
- vEL, vehMdl and Restbus
  - Simulink model
  - FMI Kit for FMU creation
- vECU and vNP
  - Created by Bosch tooling
- Virtual Busses
  - Currently not via FMI, plan to change this to FMI 3.0 and a layered standard



FMI-based simulation workflows
Example 2: FMI-based SiL-Simulation

- Different execution tools:
  - ETAS COSYM
  - Synopsys Silver
  - Mathworks MATLAB/Simulink
  - Tracetronic ECU-Test (FMPy Container FMU)
  - Silpy (based on FMPy and Container FMU)
- Different execution environments:
  - Manual usage on local PC
  - Test automation on premises
  - Test automation in the cloud
- Platform independence (win32, win64, linux64) with FMPy remoting
- Continuous FMU generation, integration and testing
- Automated toolchain for many ECU projects with many OEMs



Silpy: Simple SiL co-simulation environment for manual usage, based on FMPy

FMI-based simulation workflows
Conclusion & Outlook

fmi Functional Mock-Up Interface

Conclusion:

- **FMI enables highly automated simulation workflows**
- Best suited with tools that offer export of **“portable FMUs”** (that do not need a tool installation or runtime license for simulation)
- The **combination of commercial and open source tools** enable **large-scale deployment** and **new use cases** such as web-based simulations

Outlook

- **FMI 3.0**: will offer better support for virtual ECUs
  - arrays, data types, binary data, layered standards (specific: networking)
- **eFMI will extend the scope automated workflows** from simulation to online operation of model-based functions **on embedded systems**

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