

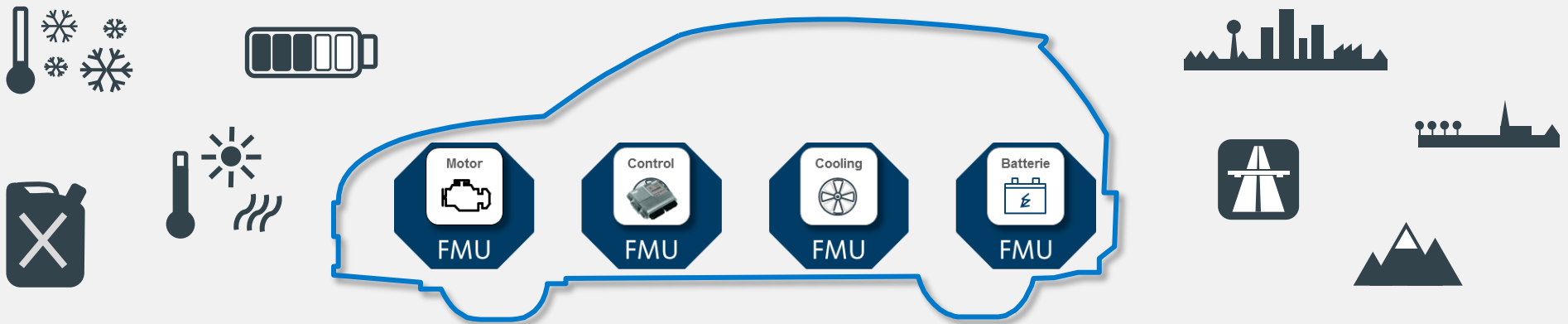
## **Usage of FMI at Audi and Volkswagen**

Christoph Bals, Thies Filler, Dr. Andreas Soppa, FMI User Meeting, 21.09.2015

# Agenda



1. Motivation
2. Usage of FMI
3. Experiences with FMI



# 1. Motivation



Models: About 310



Technical complexity



Shorter development times!



Rising relevance of simulations and virtual development!



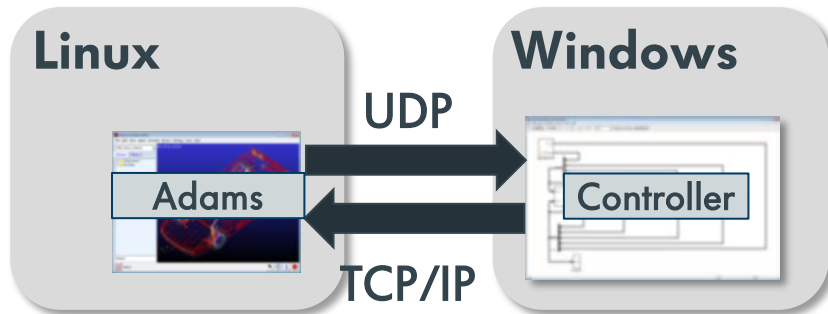
Functional Mock-up Interface (FMI) enables an efficient model exchange and the reuse of models with different tools

## 2. Usage of FMI

### In Use: Coupling of MBS and controller

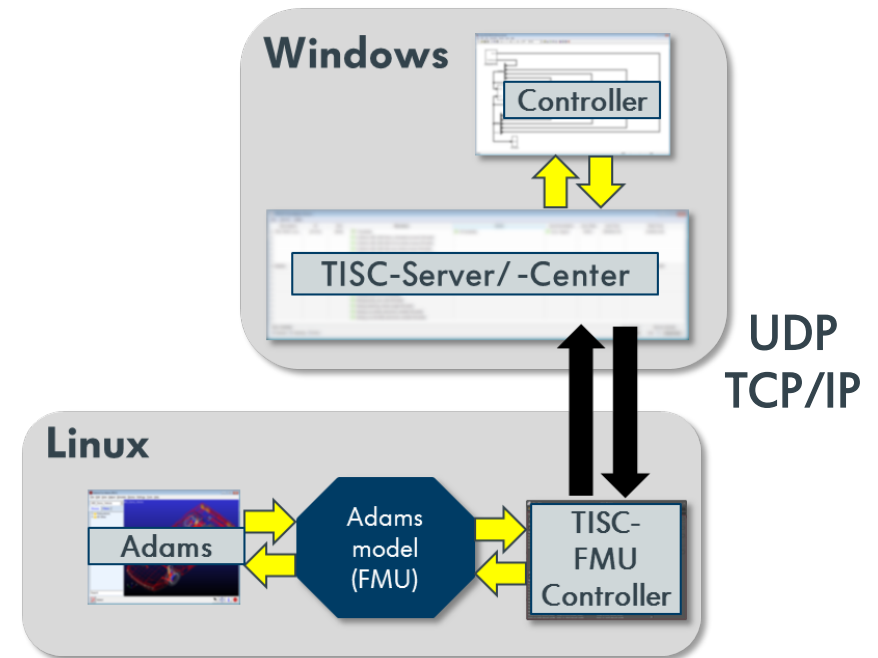


#### Direct Coupling



Release and platform dependencies complicate the coupling

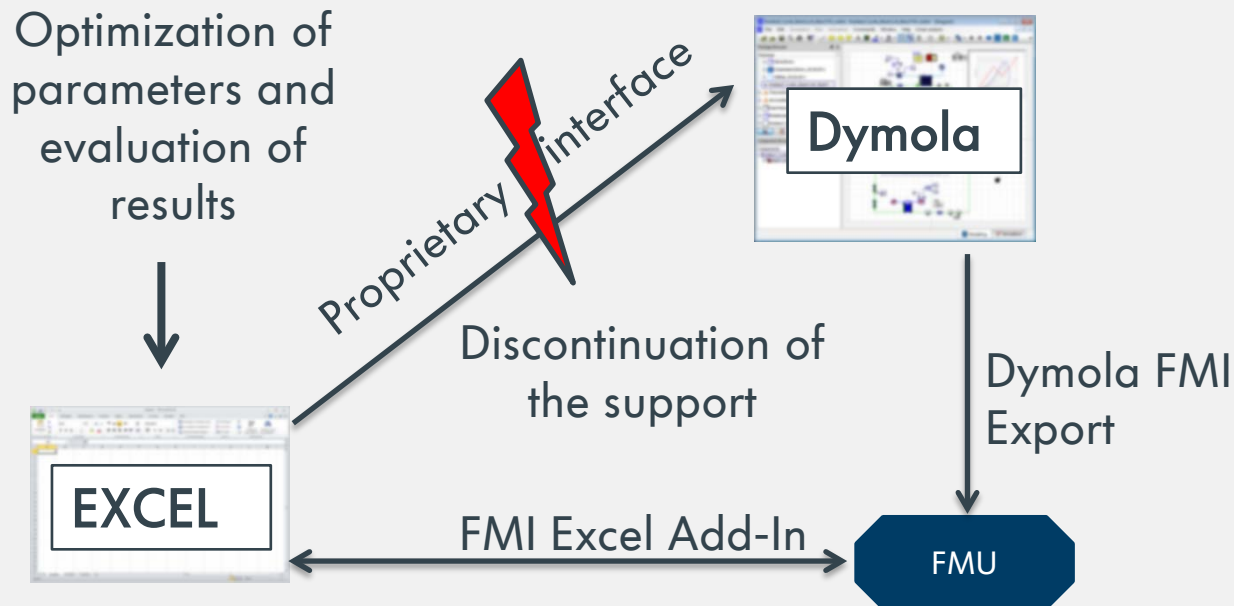
#### Co-Simulation via middleware TISC



No release dependencies

## 2. Usage of FMI

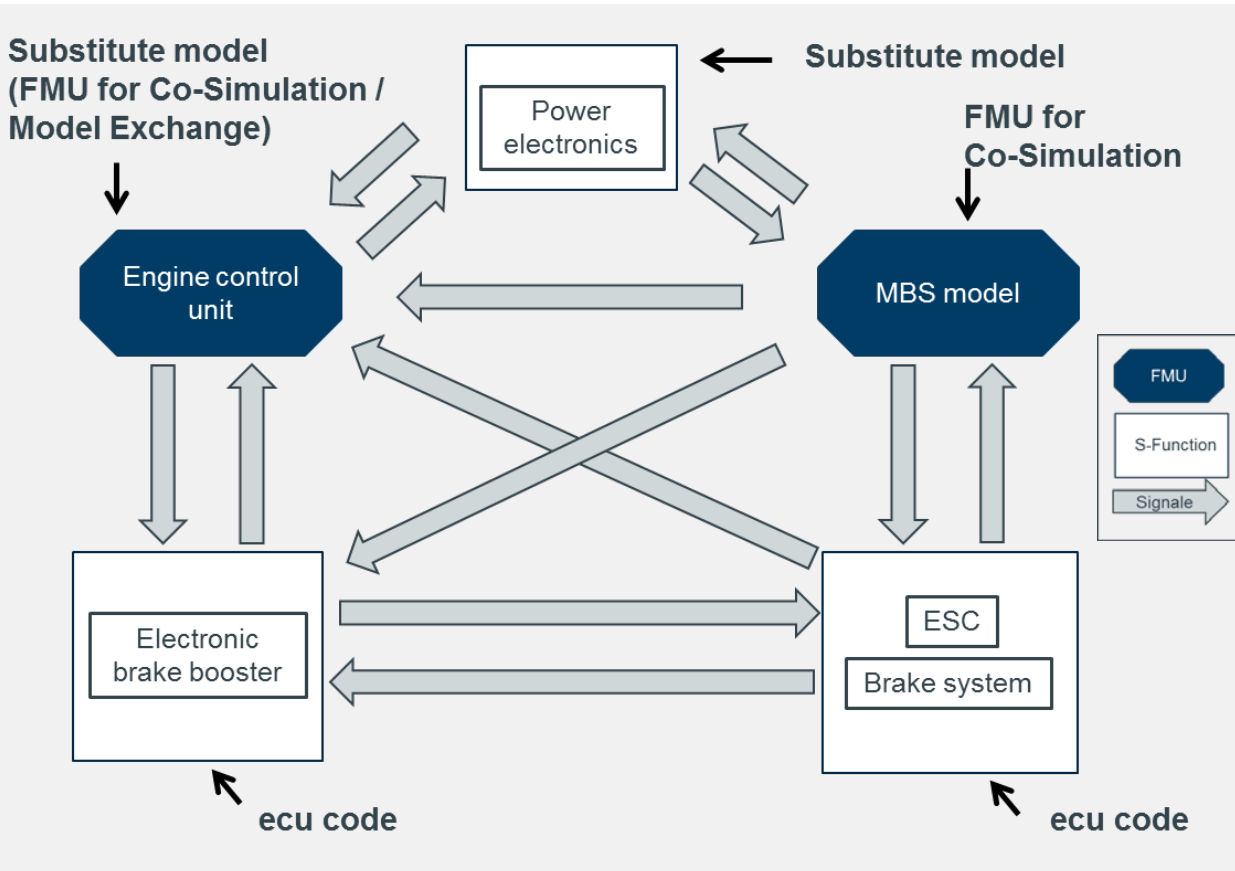
In Use: Parameter optimizations of a cooling circuit



- No Dymola installation necessary
- Identical simulation results
- No maintenance of a third party tool required

## 2. Usage of FMI

Pilot project (master thesis Filler):  
FMI as an exchange format for ecu tests

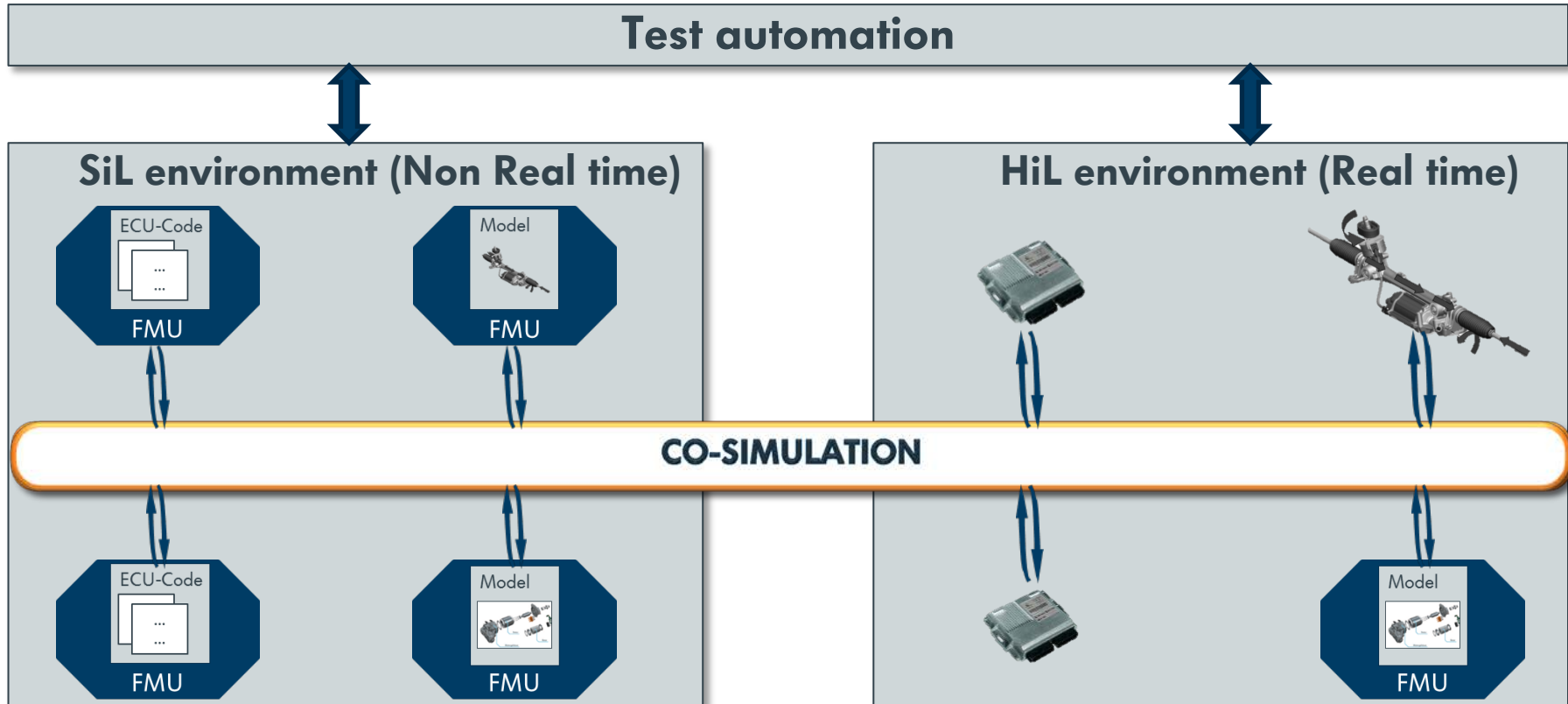


- Simulation results mostly identical to S-Function
  - Some FMI features missing for exchanging ecu-code
- ➔ addressed later

## 2. Usage of FMI

Pilot project (Ph.D. thesis Filler):

FMI for software tests (HiL <-> SiL)



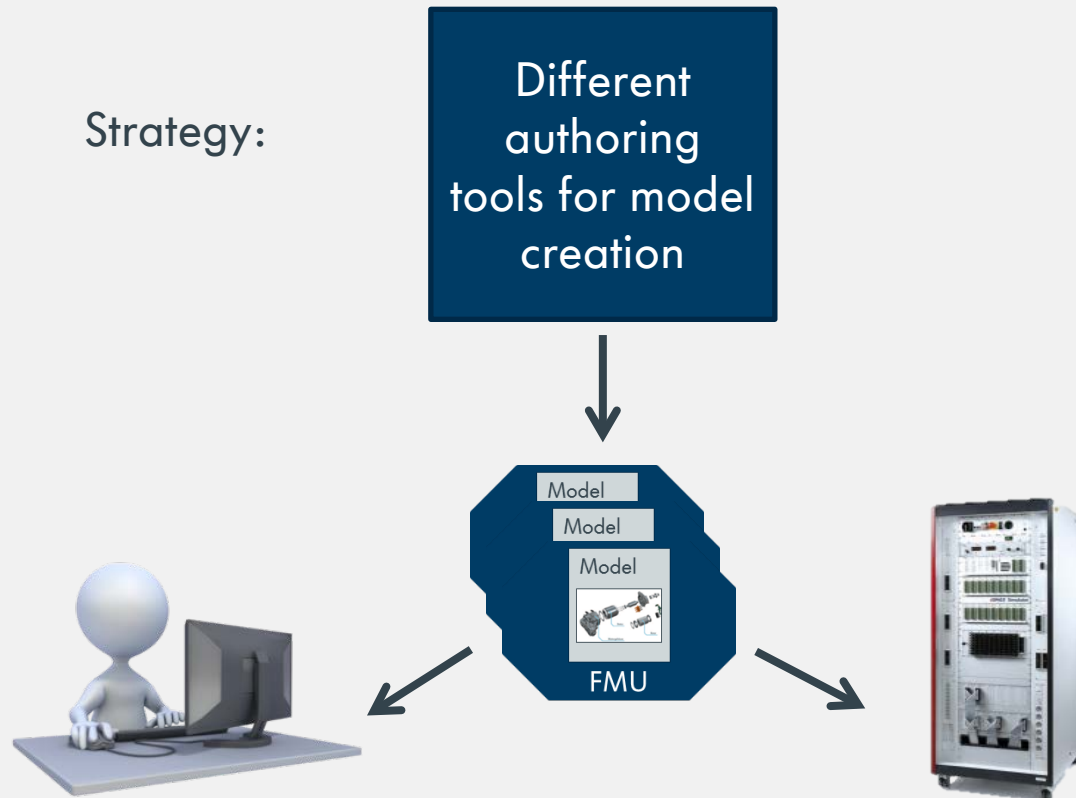
- Same test automation and reuse of models
- Use of advanced methods (Co-Simulation, ACoRTA) for flexible coupling
- Complex and not compilable physical models can be used for HiL applications

## 2. Usage of FMI

### Pilot project: Reuse of component models for HiL



Strategy:



- Authoring tools with FMI export functionality
- Usage of same models for offline simulation (MiL/SiL) and HiL
- C-code in FMU needed for recompilation to target system
- Question of IP-protection (model exchange with supplier)

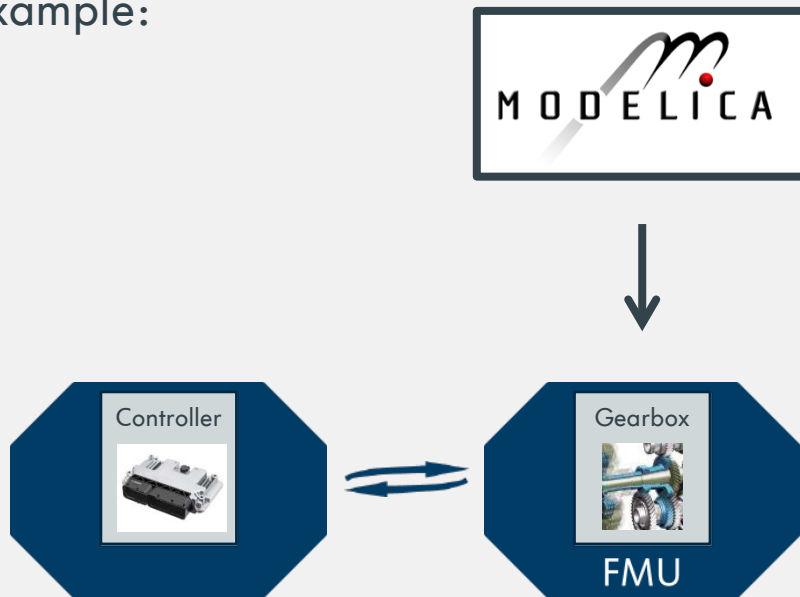


## 2. Usage of FMI

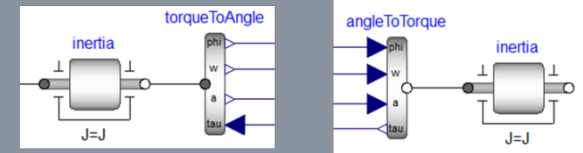
In Use: Plant / controller coupling



Example:



- Object-oriented modeling of the gearbox and export as FMU
- Coupling with the controller for parametrization
- Adaptors (noncausal / causal) necessary

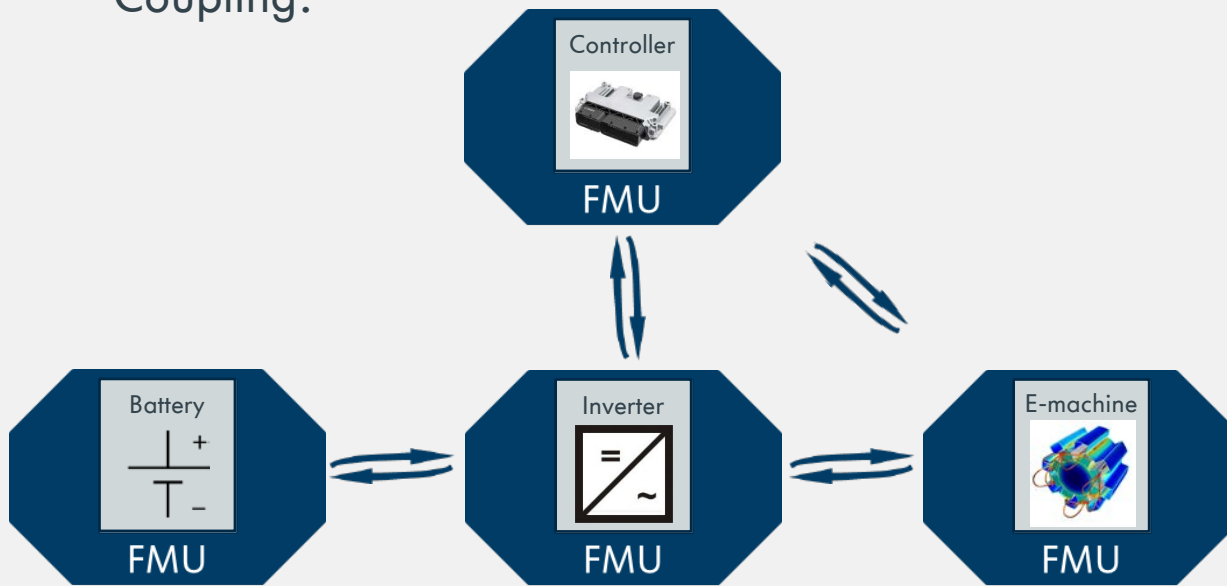


## 2. Usage of FMI

Pilot project (Ph.D. thesis Bals): Electric drivetrain



Coupling:

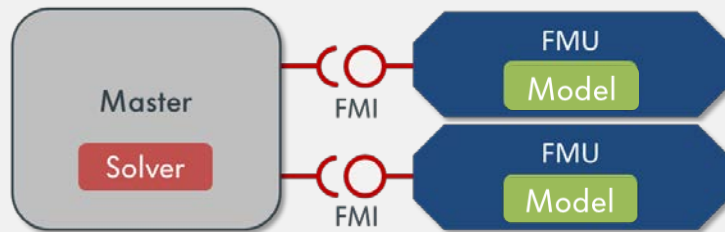


- Creation of a component library for the electric drivetrain
- Focus on models of electrical machines of different complexity
- Taking nonlinear effects into account
- Aim: Numerical stability and low computational effort

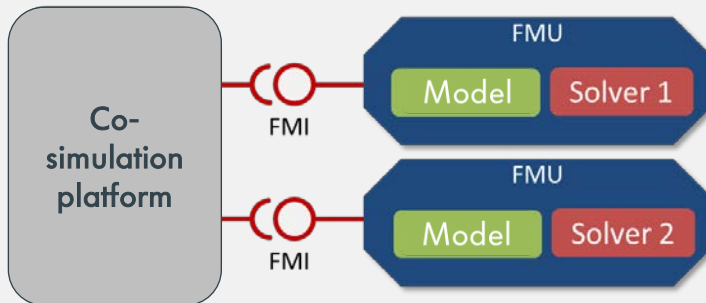
# 3. Experiences with FMI

## Which FMI format is to choose?

### FMI for Model Exchange



### FMI for Co-Simulation



### FMI for Model Exchange

Model behaves correctly within the master tool/one common solver

### FMI for Co-Simulation:

When different solver properties for different models are necessary

# 3. Experiences with FMI

## Open issues concerning the FMI Standard



### FMI for plant models

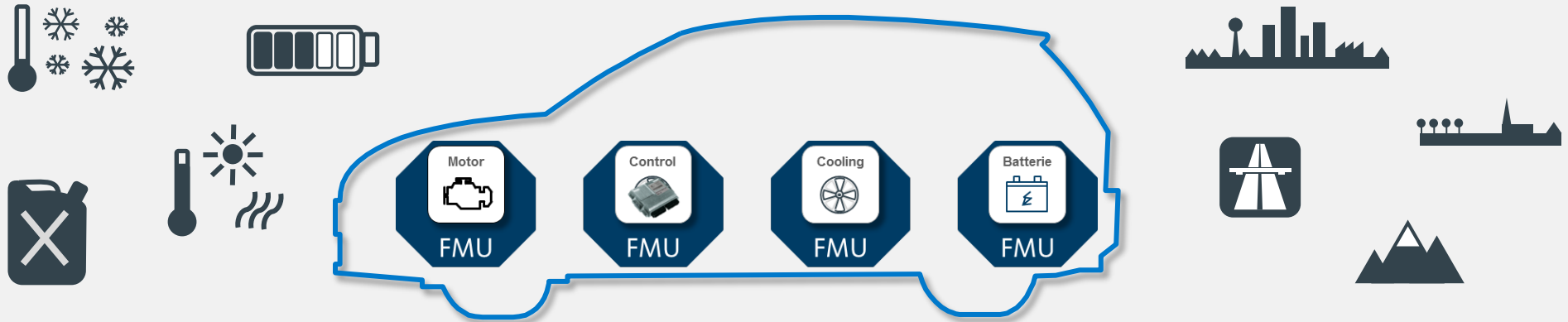
- Numerics of FMUs  
(wide use of Jacobian matrices)
- Object-oriented connectors

### FMI for Real Time (HiL Applications)

- Handling of C-Code (for cross compiling FMUs)
- IP-Protection

### FMI for ECU-code

- Bridge to standardized ASAM formats (use same data formats for ECU and for SiL tests)
- Array/bus and 64 Bit Integer support -> already addressed by FMI committee



**Thank you for your attention.**

Christoph Bals, Thies Filler, Dr. Andreas Soppa, FMI User Meeting, 21.09.2015