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Model Based Design of a Fuel Cell Vehicle

Efficient development of fuel cell simulation models

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Fuel Cell Seminar
Phoenix
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Content

- What is model based design?
- Example - Fuel cell vehicle
- Fuel Cell Systems Library - FClib
- What's the message?

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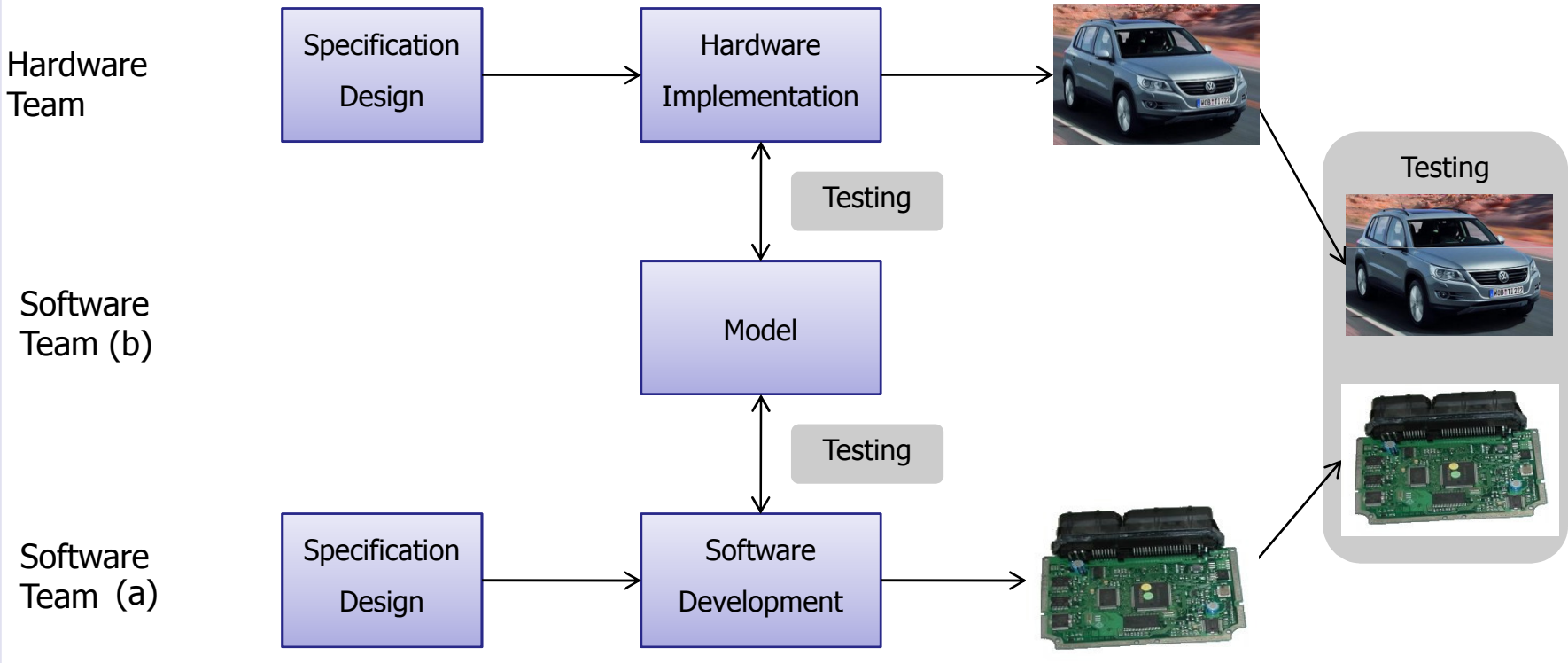
Development process



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Model Based Design

- MBD we understand as
  - a development paradigm for control applications
  - guided by a process model

- MBD allows for ...
  ... early testing of control applications against a realistic process behavior
  ... process design optimizations before process implementation
  … shortens your commissioning time dramatically

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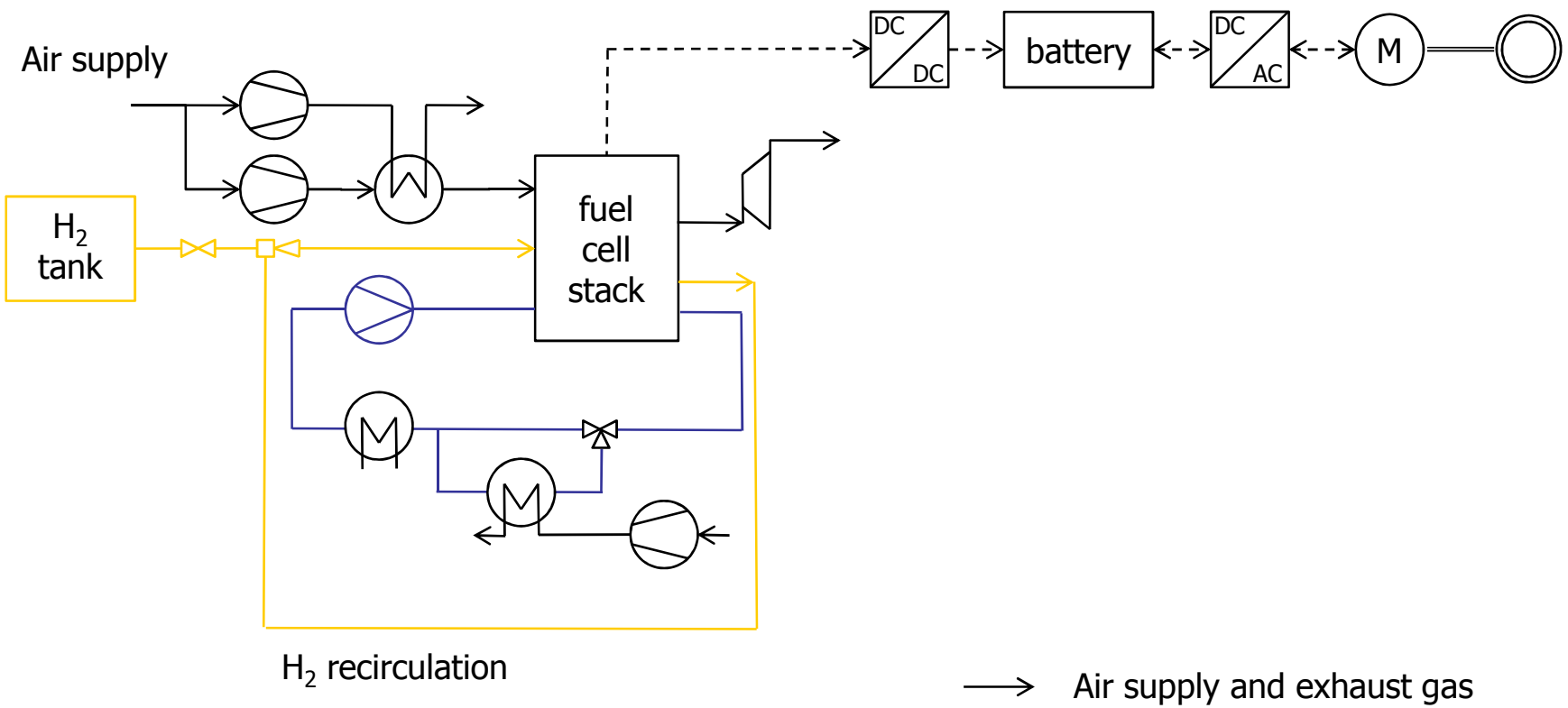
The process: Fuel cell and drive train



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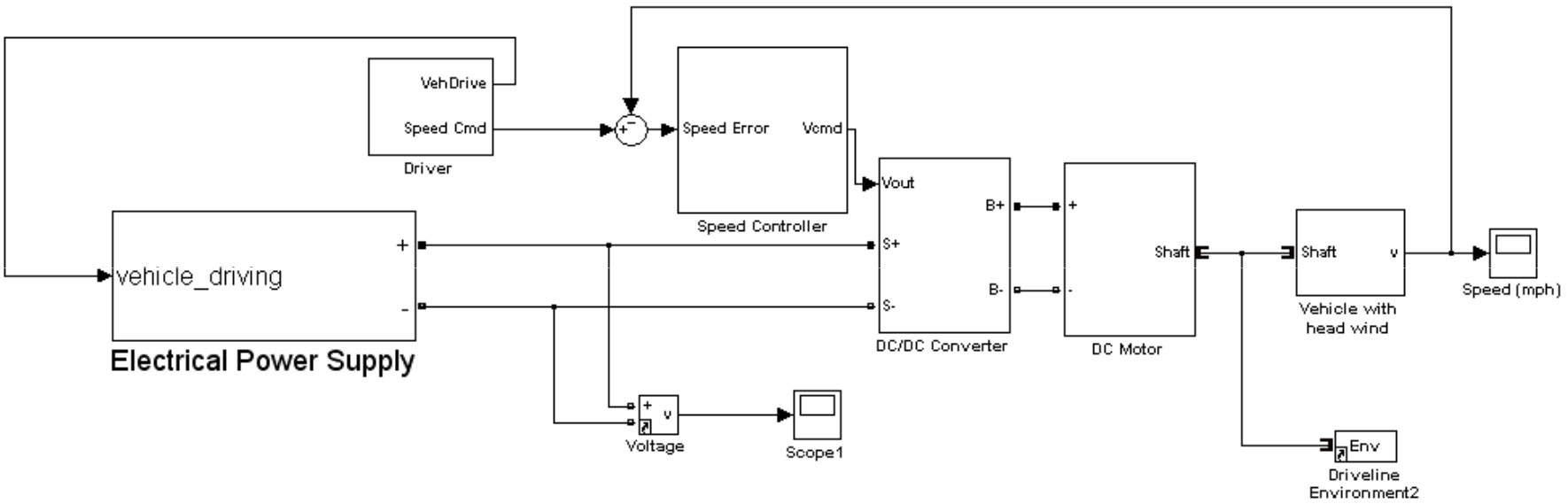
The process model – top level view



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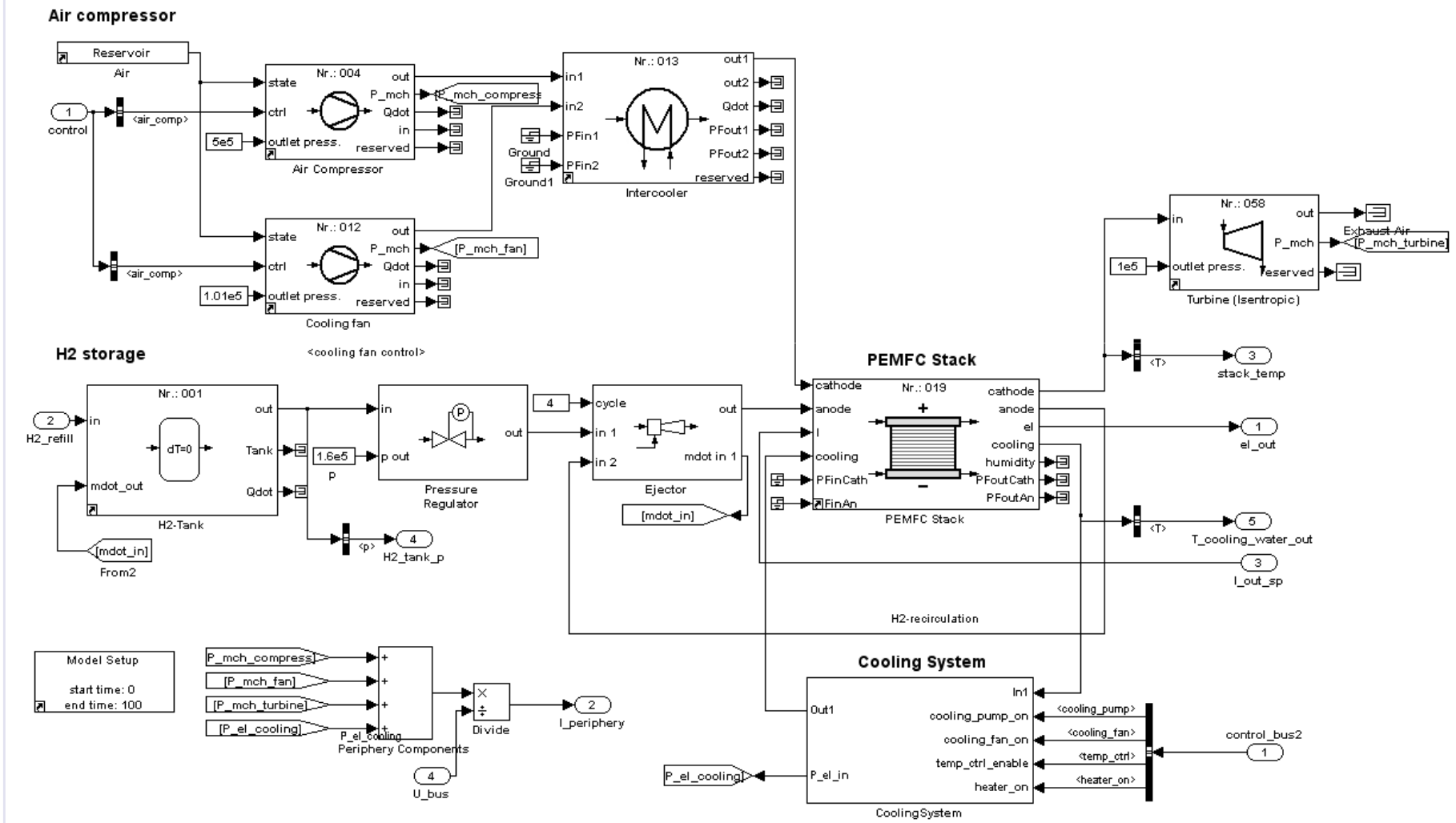
The process model – developed using libraries



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Process model: features

- Model contains multiple physical domains
  - thermodynamic components
  - reaction chemistry
  - mechanical components
  - electrical components
- Build using available library blocks for physical modeling
- Parameter can be adjusted to measurements
- System level modeling

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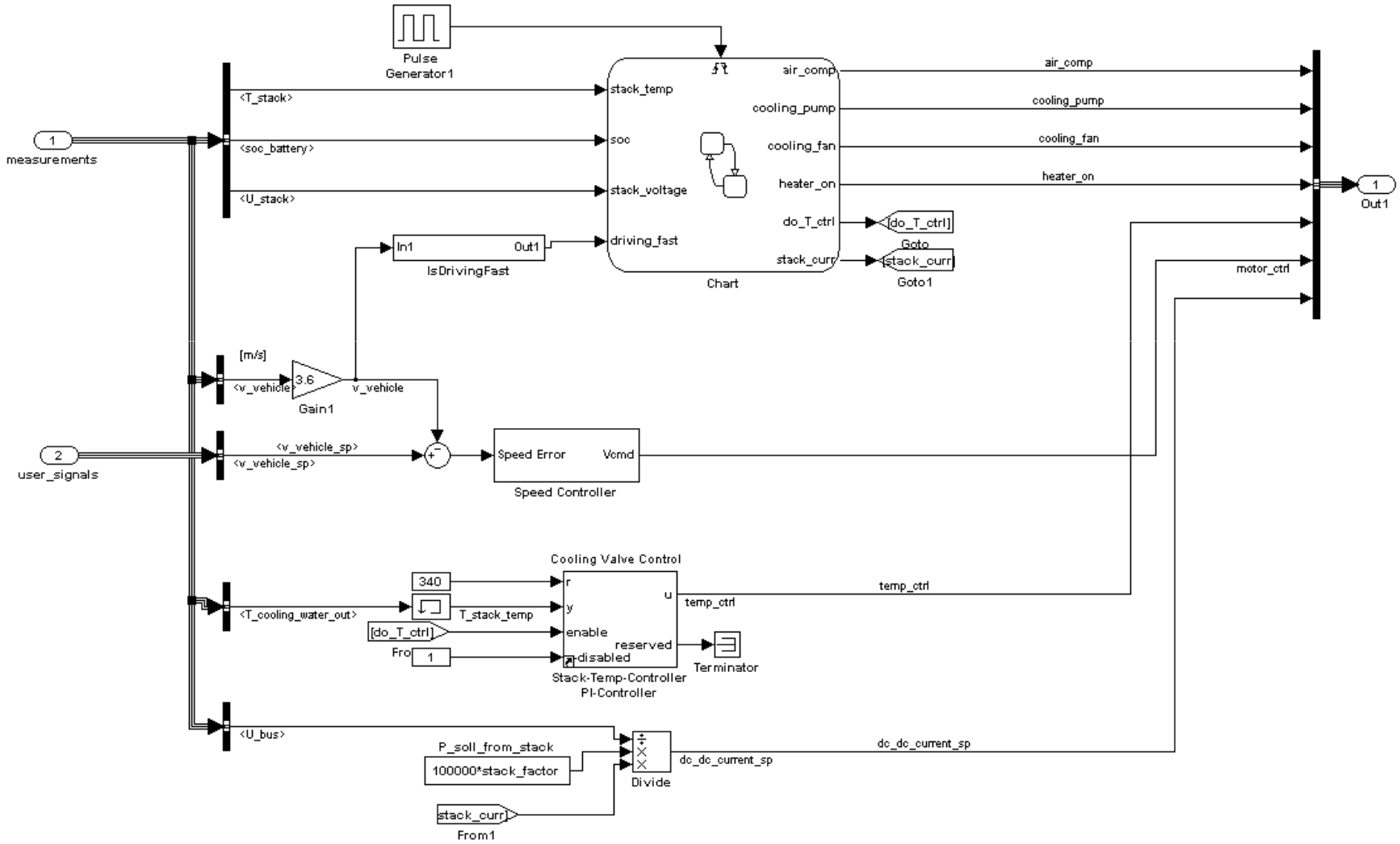
The controller model - detail



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Controller model: features

- PI-Controllers
- Feed forward controls
- State machines
- Signal supervision (alarm generation)
- Remanent data storage
- etc.

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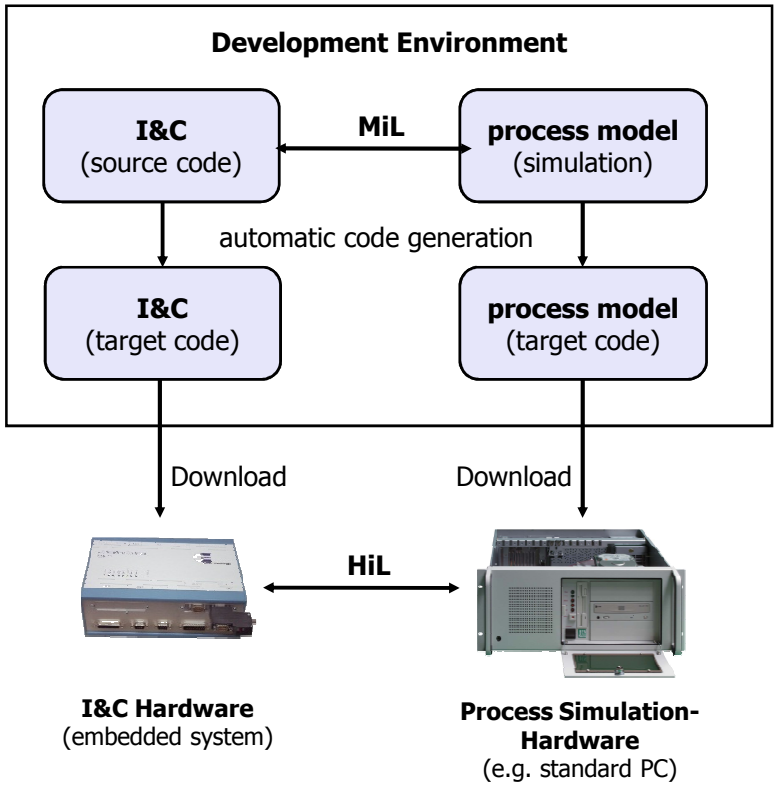
Development process

- Model-in-the-loop
- Hardware-in-the-loop



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Model-in-the-loop

- Classic approach:
  - replay static inputs to the controller
  - no reaction to controller outputs
- Closing control loops enables realistic testing
  - interaction between process model and controller
  - testing behavior at complex process failures
  - save testing environment

Hardware-in-the-loop

- e. g. Testing the final embedded hardware against a process model
- final I/O and communication

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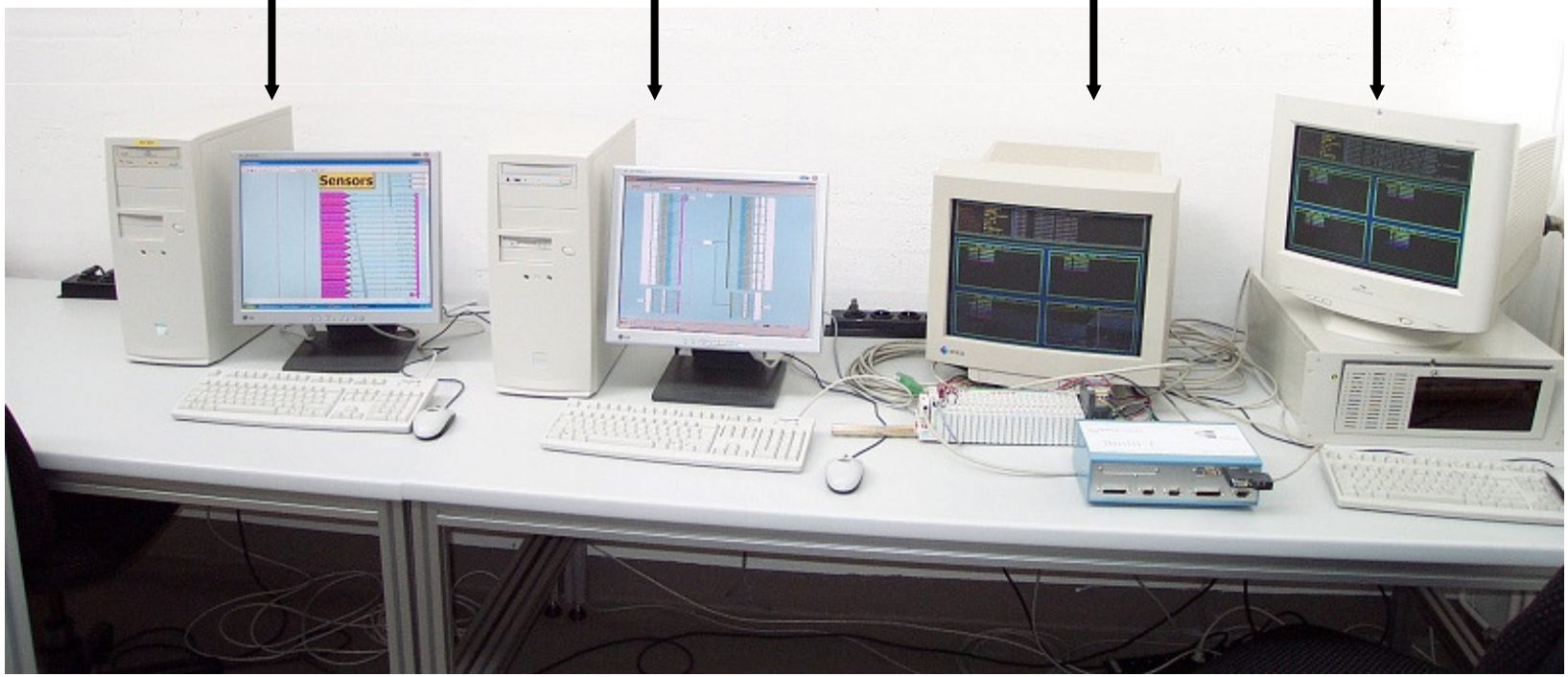
Hardware-in-the-Loop

Development Environment
Host PCs

Realtime Environment
Target Hardware

plant model | **I&C (source code)** | **I&C** | **HiL hardware**



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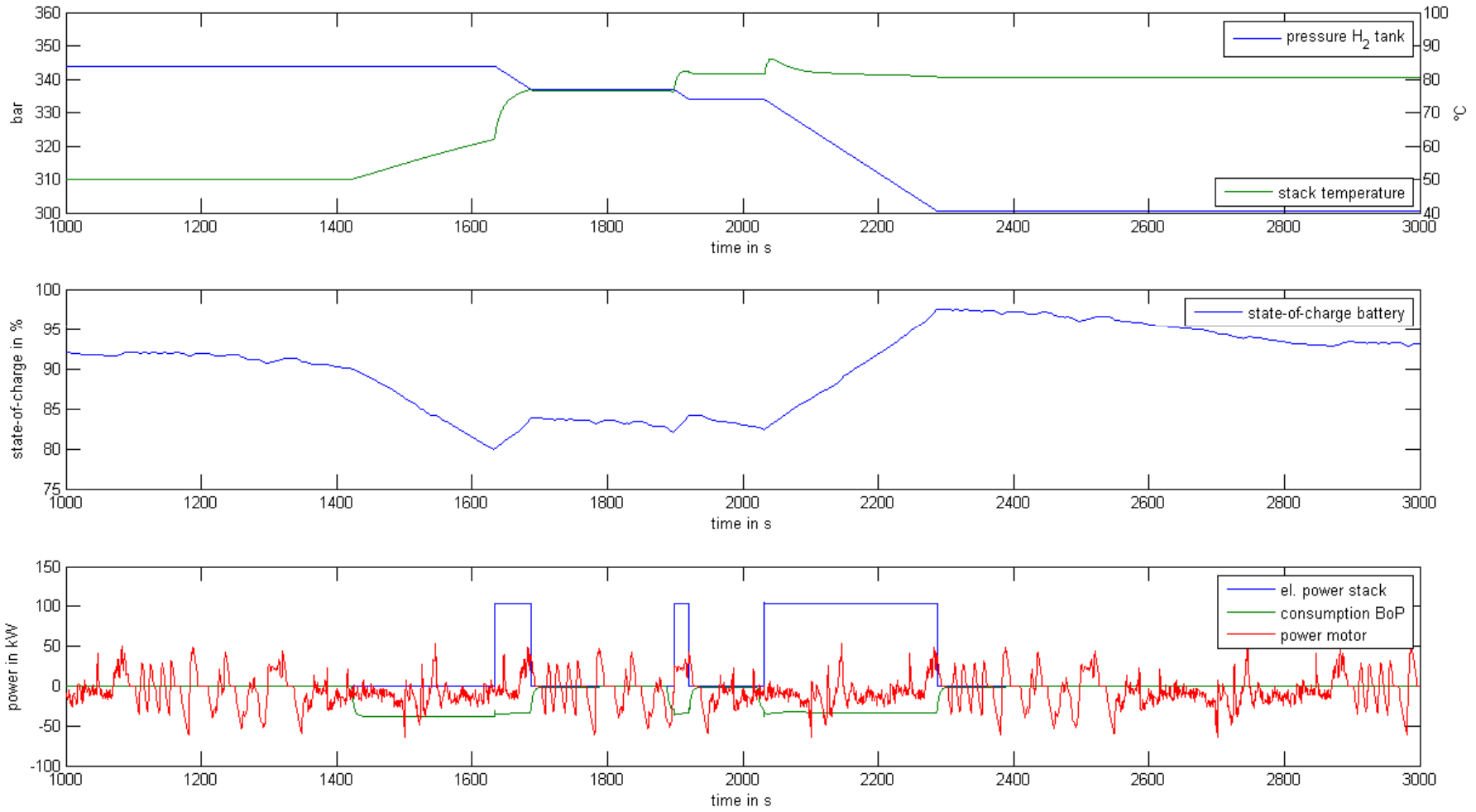
Simulation Results – detail of a US06 cycle



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What's the message?

- Design your controller using a process model! Do Model Based Design.
- Use Hardware-in-the-loop testing to verify your controller
- Use available libraries for system modeling!

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