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# Mechatronic Test Concepts for Vehicle Dynamics Controllers

**Thomas Gockeln**

**dSPACE GmbH · Technologiepark 25 · 33100 Paderborn**

**Stuttgart· 17.06.09**

# *About dSPACE* – Products and Services

- World's leading provider of solutions for developing ECU software and mechatronic controls

- dSPACE worldwide
  - Headquarters in Paderborn, Germany
  - Subsidiaries in the USA, France, the UK, and Japan; Representative Office in China
  - Distributors in 9 other countries

- 55% of sales are in exports
- Over 800 employees worldwide

# dSPACE in Germany

**Location Paderborn – Headquarters**

- Development
- Administration
- Engineering
- Sales

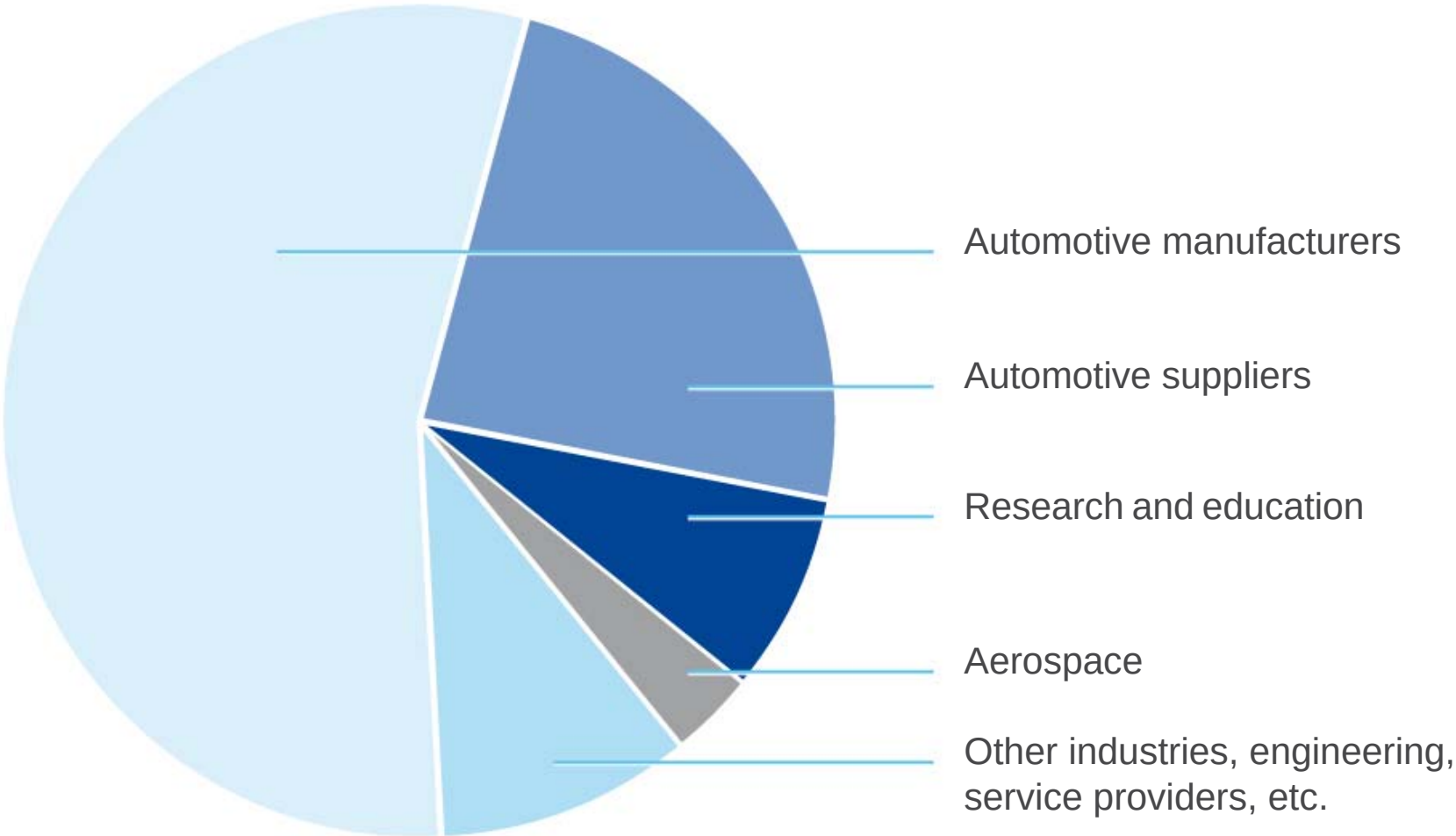
**Location Pfaffenhofen/Munich**

- Engineering
- Sales

**Location Holzgerlingen/Stuttgart**

- Engineering
- Sales

# Business Fields



# Product Areas

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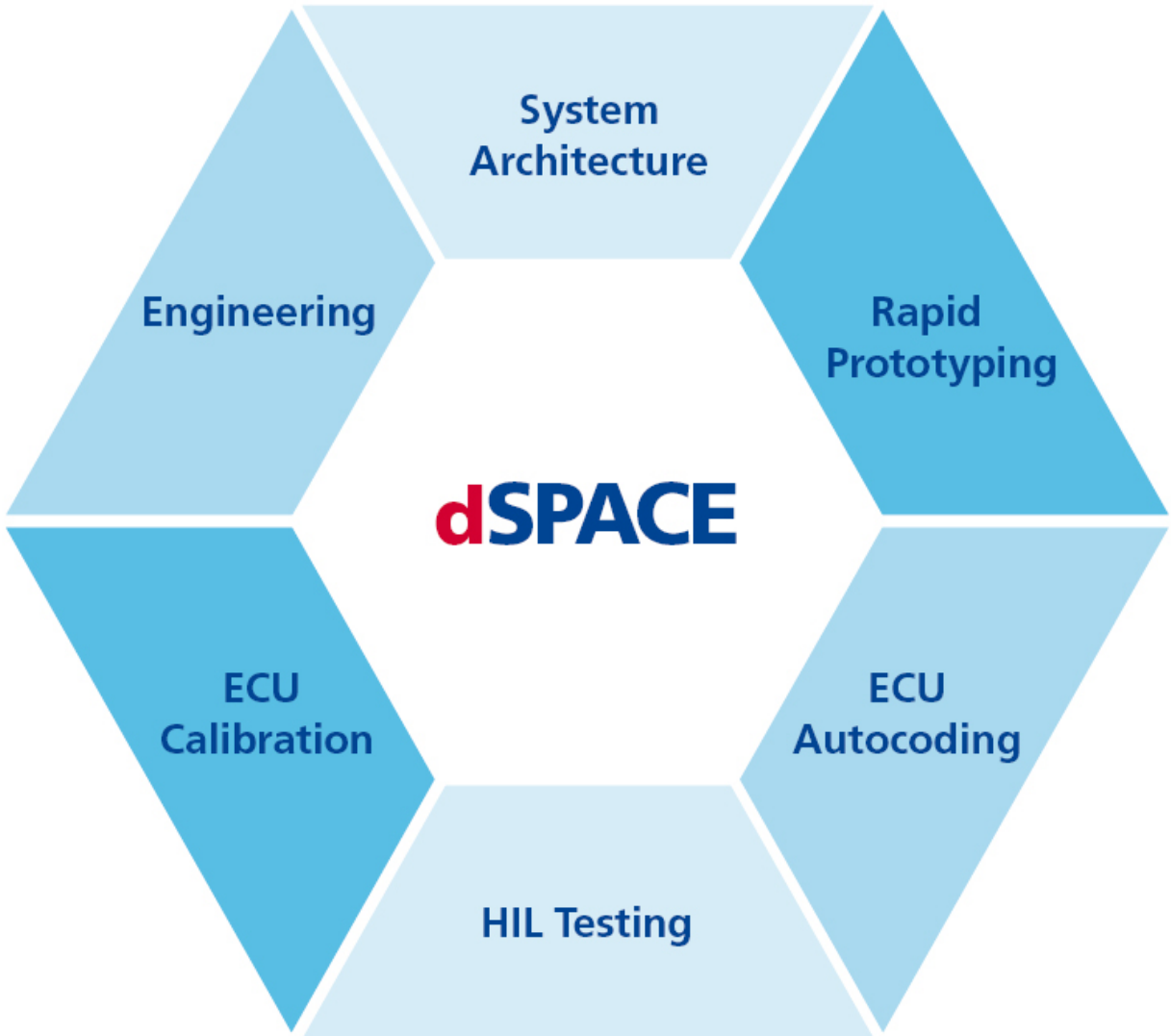
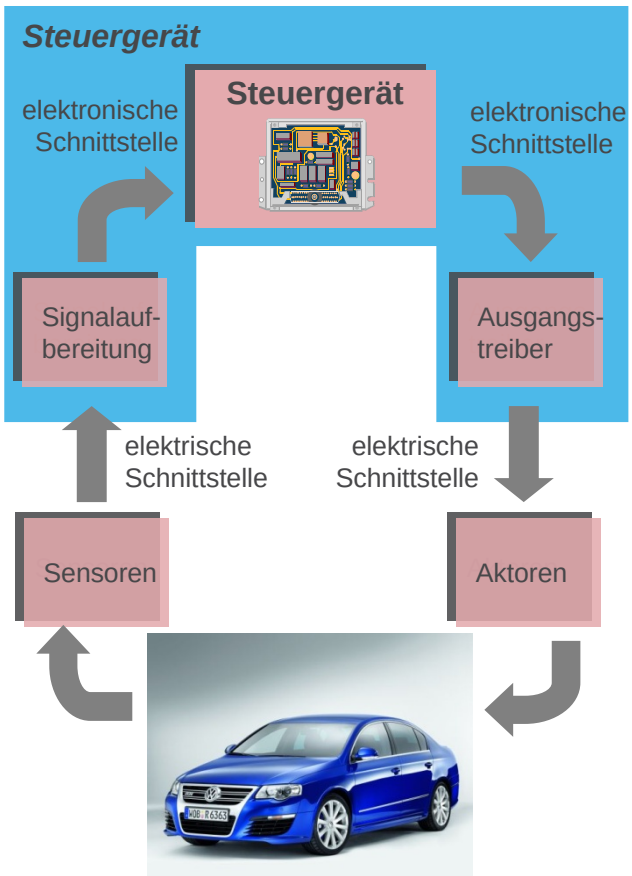
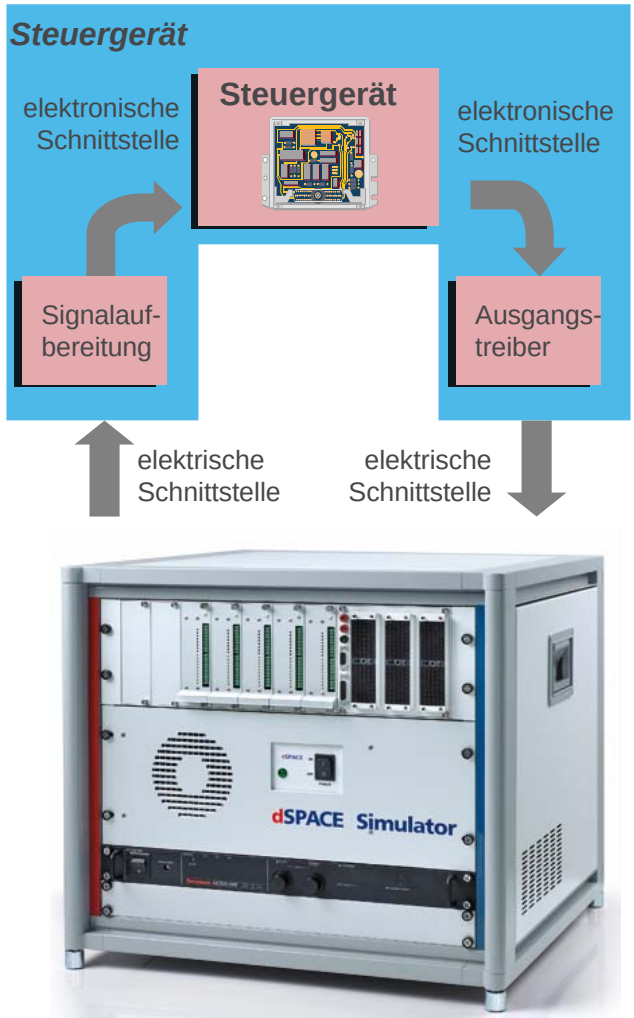


# Hardware-in-the-Loop-Simulation



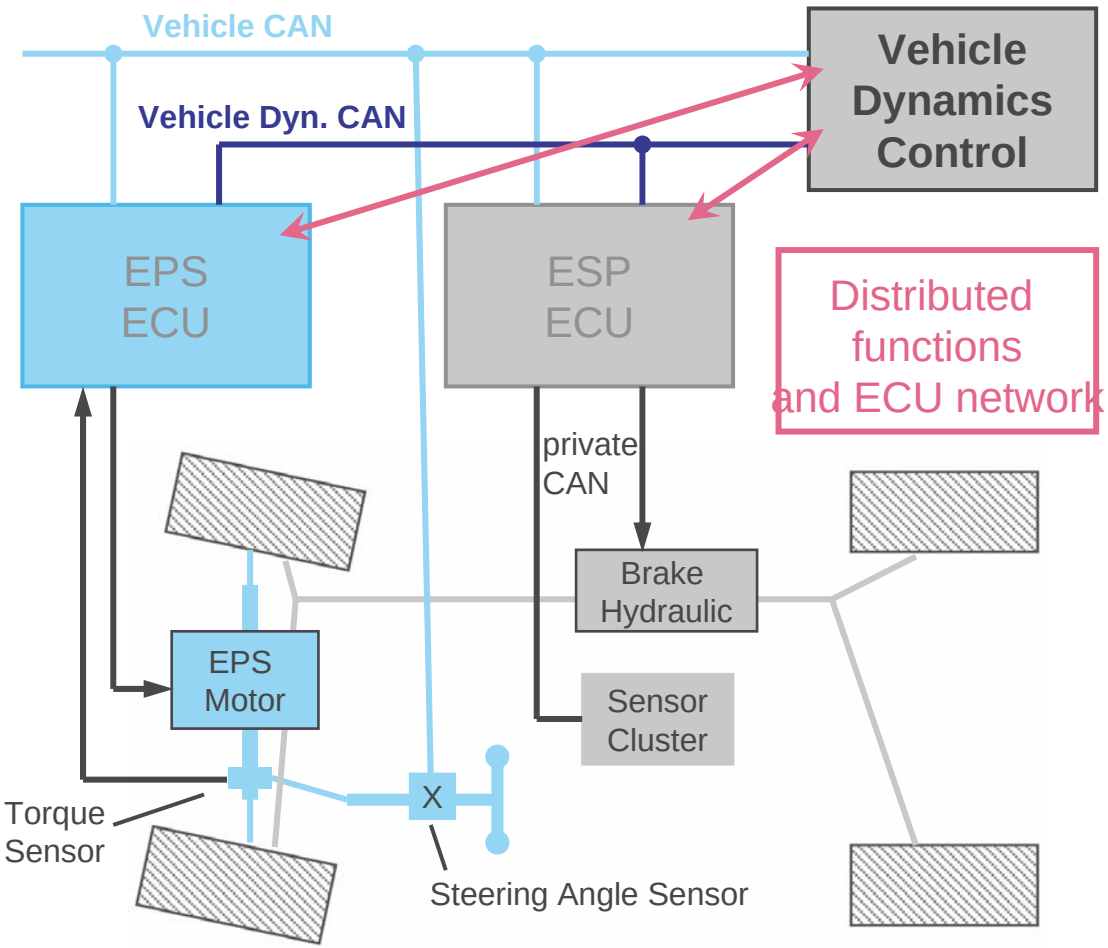

**Reale Fahrzeugumgebung**




**Simulierte Fahrzeugumgebung**

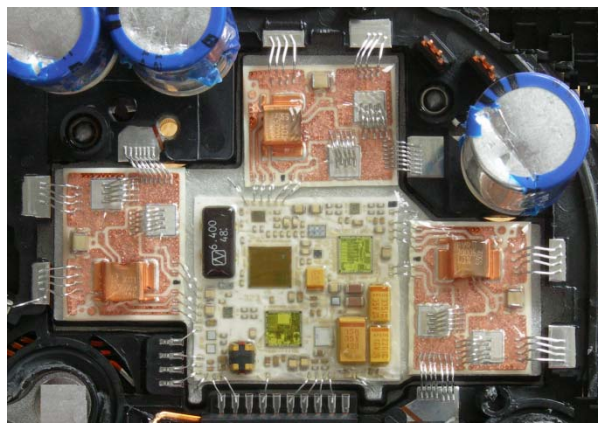
# Introduction - Structure of Vehicle Dynamics System

**ECU network for Vehicle Dynamics** (example structure)**:**




- Distributed functions, ECU network
- Safety critical functions → comprehensive testing
- Very high hardware integration level:
- ECUs and systems come mainly from suppliers

**→ simulation on power level (electrical or mechanical)**



# HIL Setup

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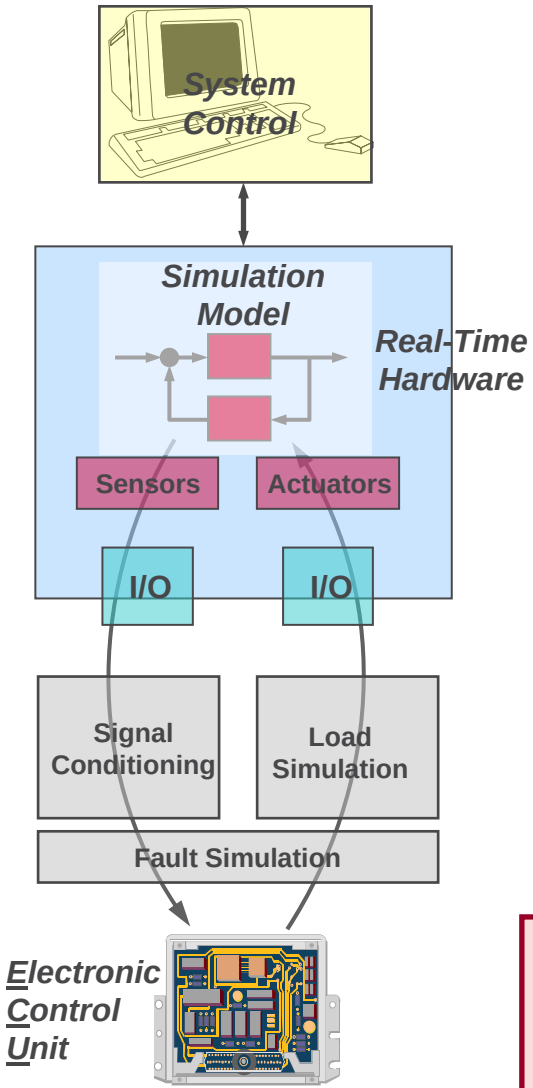
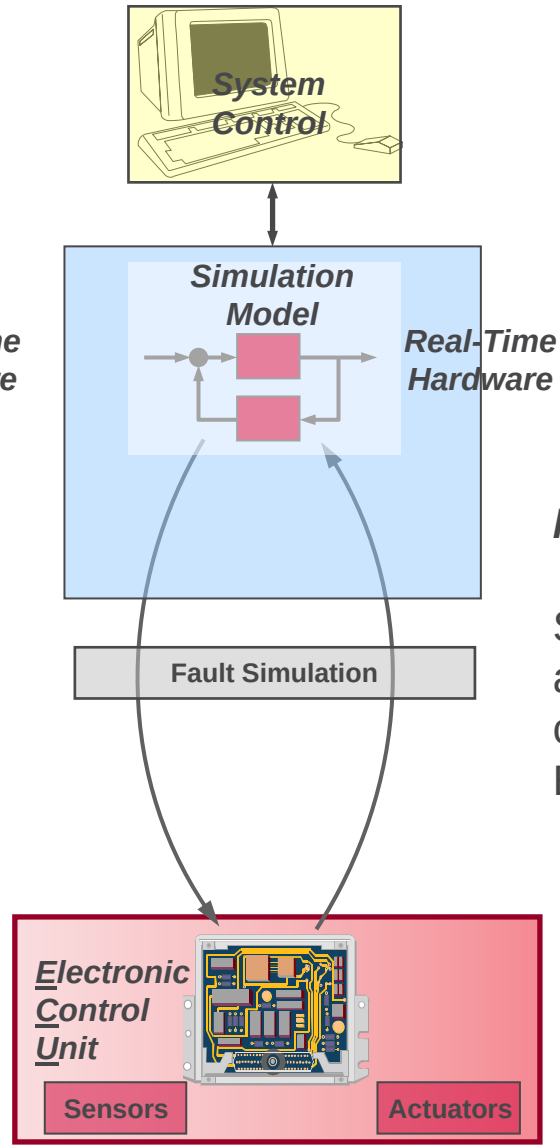
***Standard Setup***

Sensors and actuators are not part of the ECU

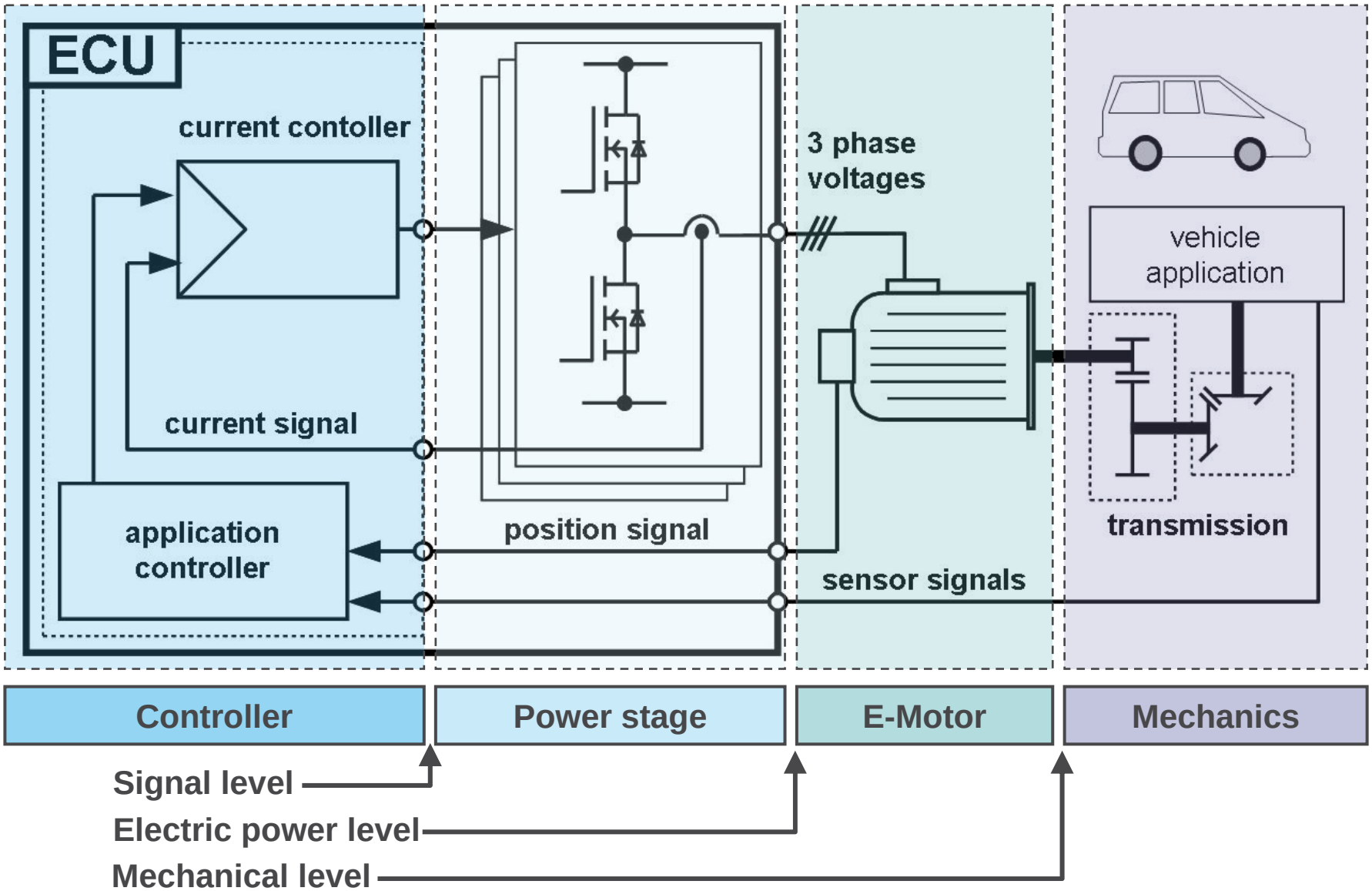



***Mechatronic ECU***

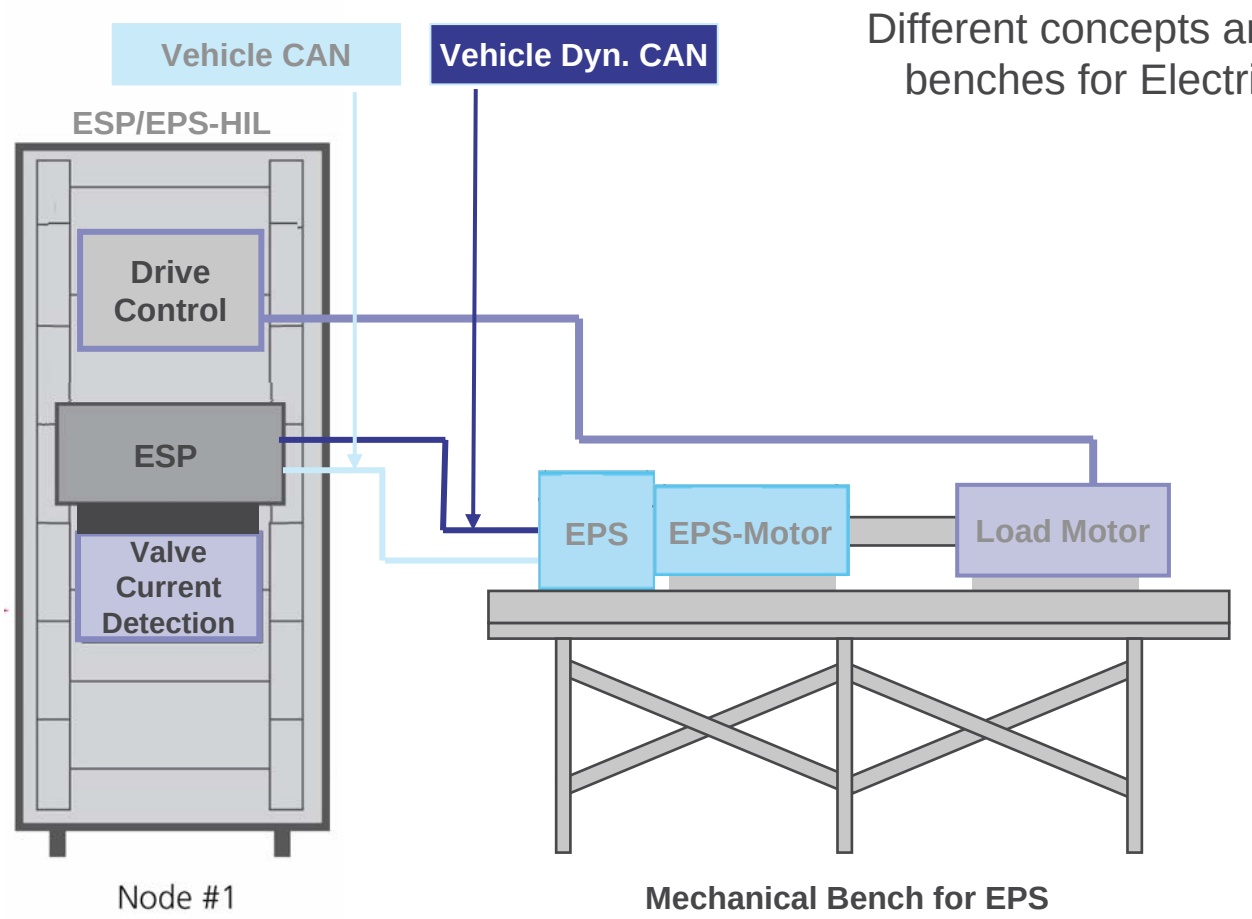
Sensors and actuators are internal components of the ECU

# Introduction – HIL Interfaces



# EPS/ESP HIL-Simulation - Structure of HIL-Simulator

**HIL Topology for Vehicle Dynamics HIL** (alternative structure)**:**

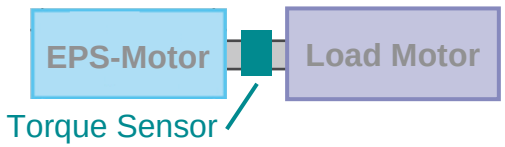



Different concepts are possible for mechanical benches for Electric Steering Systems

# EPS/ESP HIL-Simulation – Mechanical Benches

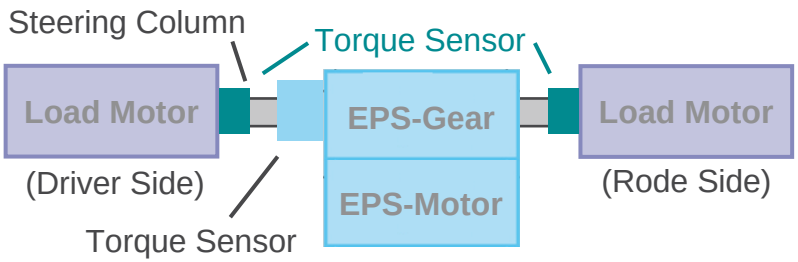
## Different Types of Electric Steering Test Benches:

Single rotary motion load motor:



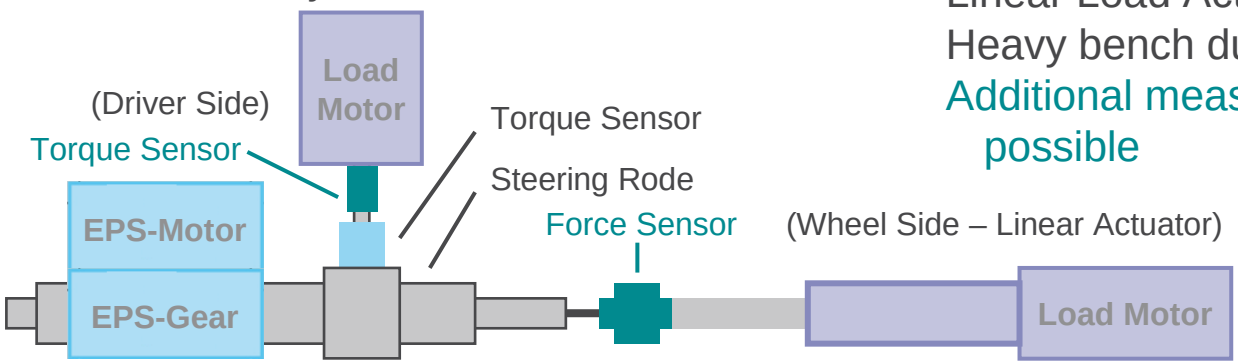

EPS Motor need to be separated from any gear
Torque Sensor need to be simulated
Additional measurement equipment possible

Double rotary motion load motors:




Only possible for column mounted EPS
Possible for AFS
Additional measurement equipment possible

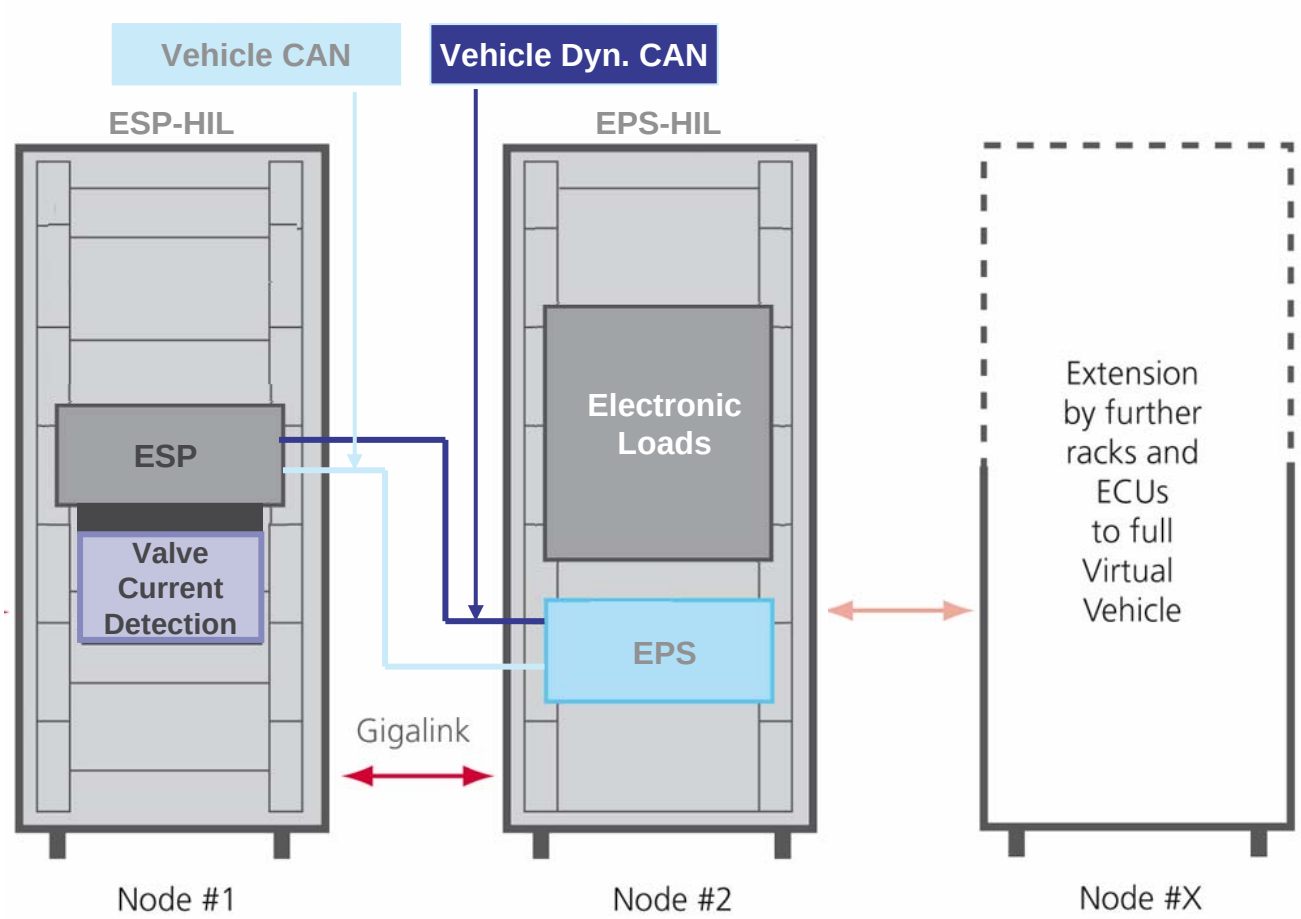
Linear and rotary motion load motors:




Linear Load Actuator
Heavy bench due to high forces (e.g. 20kN)
Additional measurement equipment possible

# EPS/ESP HIL-Simulation - Structure of HIL-Simulator

**HIL Topology for Vehicle Dynamics HIL** (example structure)**:**

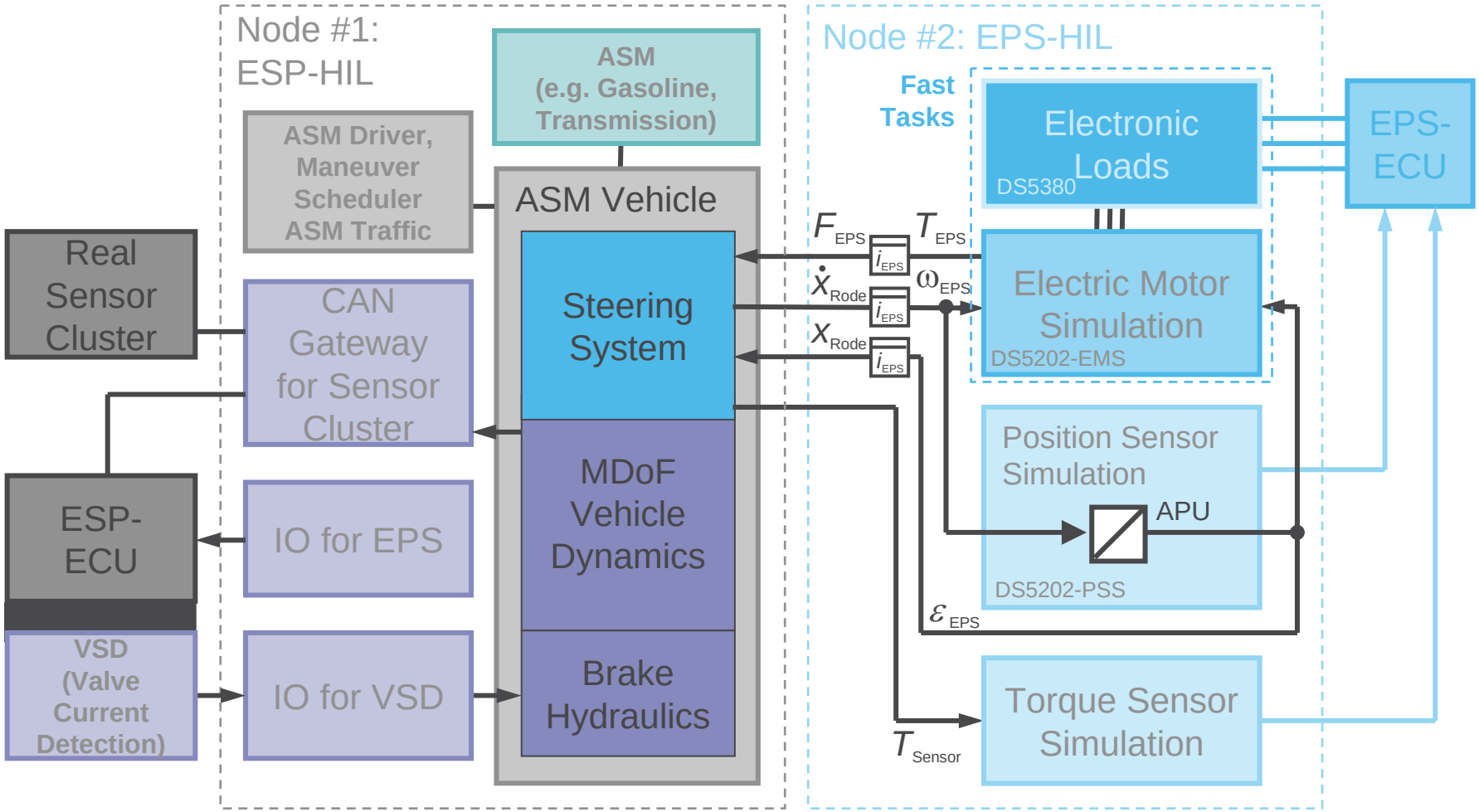



Different HIL Hardware Topologies are possible depending on

- the ECUs,
- maximum power,
- the number of desired reserves
- simulation type for the EPS-HIL

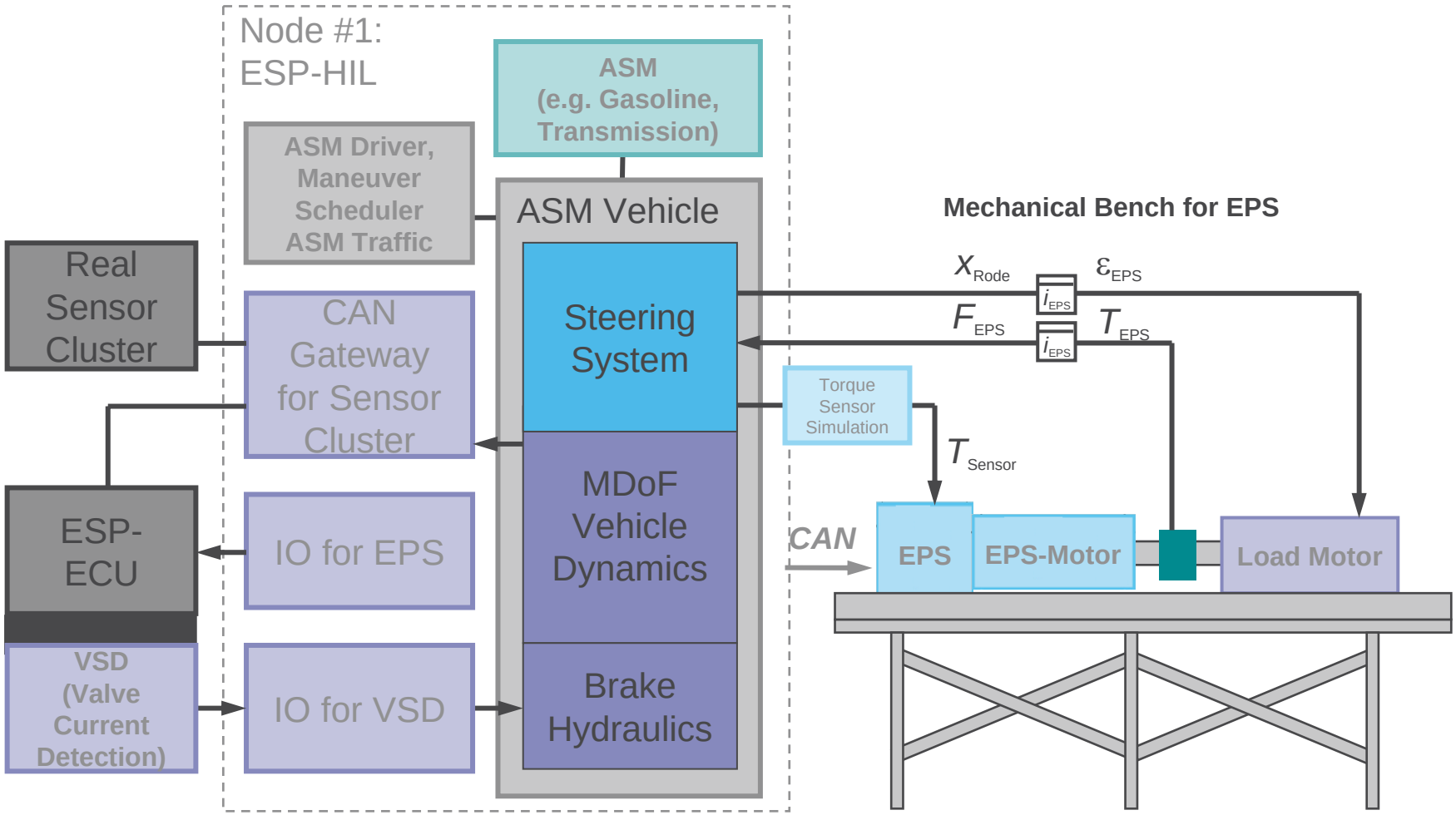
# 2: EPS/ESP HIL-Simulation - Structure of HIL-Model

**Overall integration of EPS electric motor simulation in the vehicle model:**



# Connection to Real Time Model

**Overall integration of EPS electric motor simulation in the vehicle model:**



# HIL Interfaces - Comparison

| | Electric Power Level | Mechanical Level (simple bench) | Mechanical Level (heavy bench) |
|---|---|---|---|
| Pros | Flexible (e.g. motor parameter)<br>Full access to the model<br>No safety restrictions | Little knowledge of ECU and electric motor required | Little knowledge of ECU and electric motor required<br>Testing of mechanical parts is possible |
| Contras | Knowledge of motor characteristics and electric diagnostic functions | Inflexible<br>Testing deviation of motor parameters is impossible | Inflexible<br>Testing deviation of motor parameters is impossible<br>Safety restrictions (mechanics) |
| Use Case | Component, Diagnosis testing<br>Integration testing of dynamic systems e.g., vehicle dynamics incorporating steering system and ESP or virtual vehicles | Component, Diagnosis testing<br>Integration testing of dynamic systems e.g., vehicle dynamics incorporating steering system and ESP or virtual vehicles | Testing of the mechanical system<br>Testing of entire steering system |

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# Thank you for your attention!

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# Important Notice