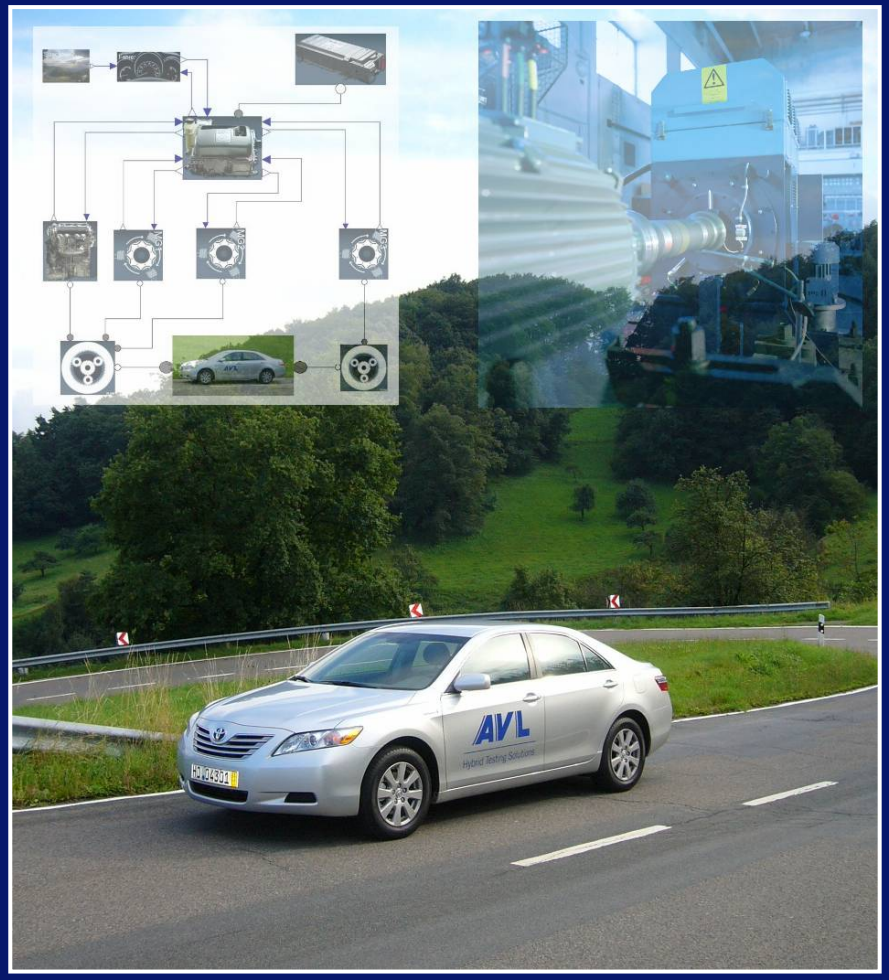
Engine Expo Stuttgart 2007

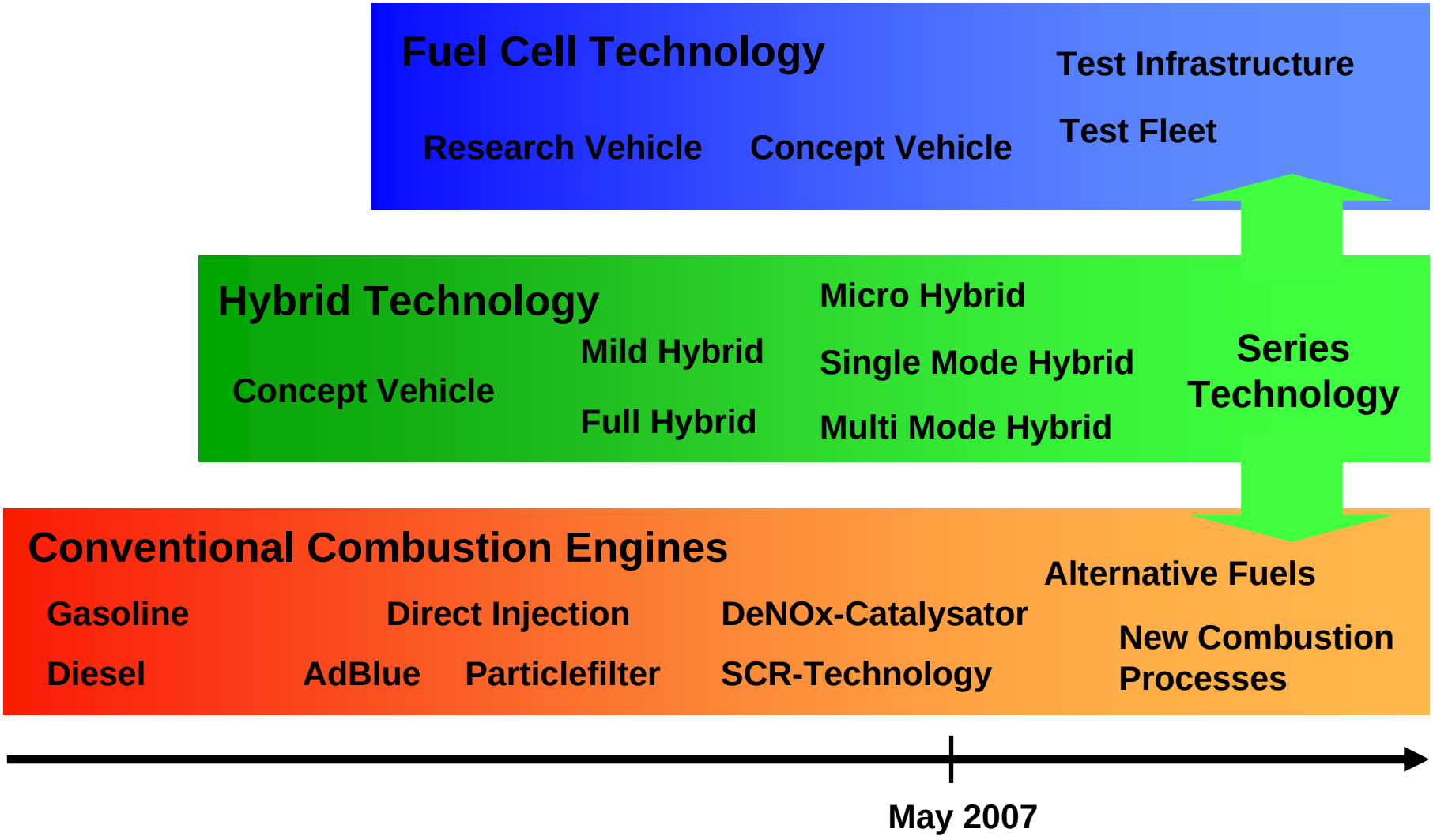



# Challenges and Solutions of Hybrid Engine Testing

**Dr. Christian Schyr**
**AVL List GmbH**

# Future hybrid powertrain ?

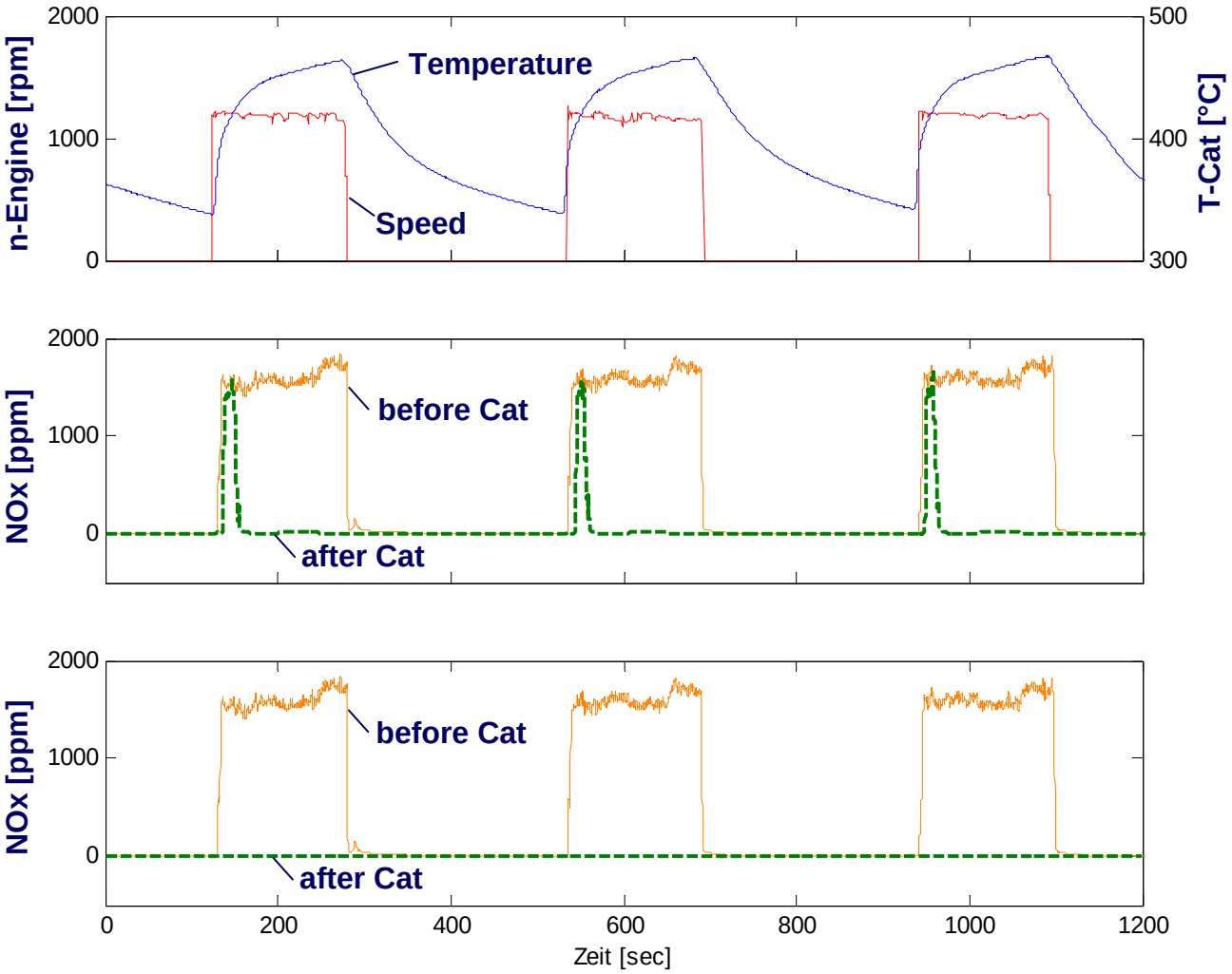
# Innovative Powertrain Technologies



# Components of Hybrid Vehicles


- Combustion Engine
- Electric Motors / Inverters
- Battery / Super Caps
- Transmission / Clutches
- Powertrain Operating Strategy
- Vehicle Stability
- Driver Assistance
- Human Machine Interface

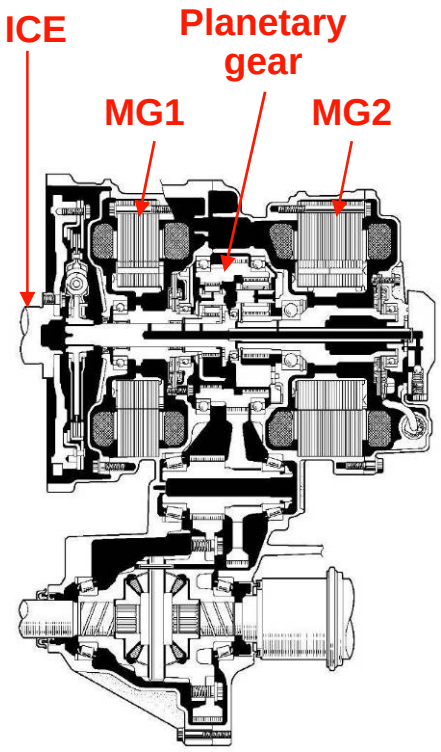
# Application:
# Start-Stop of Combustion Engine



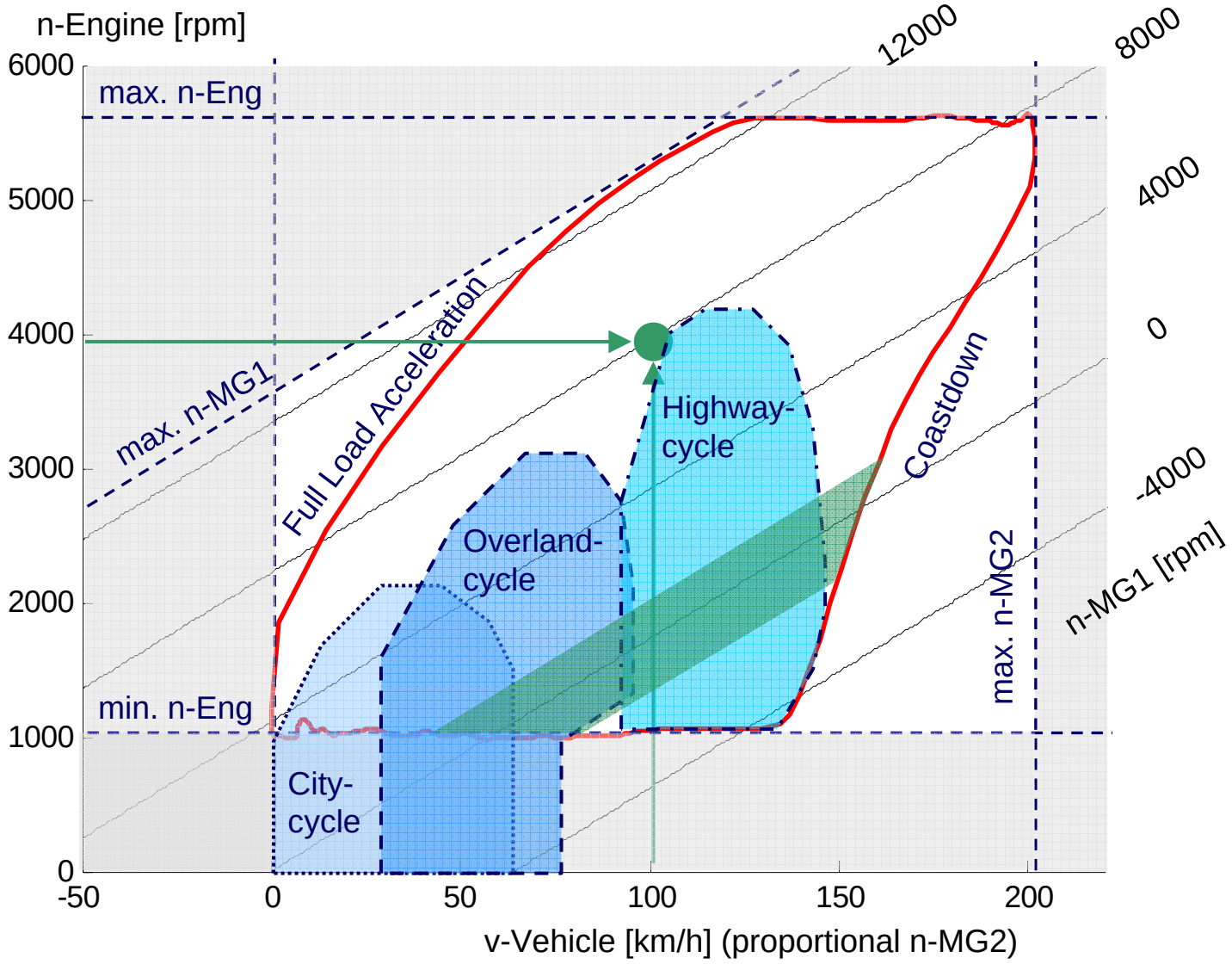

**Engine “Start-Stop” not optimized**

**Engine “Start-Stop” optimized**

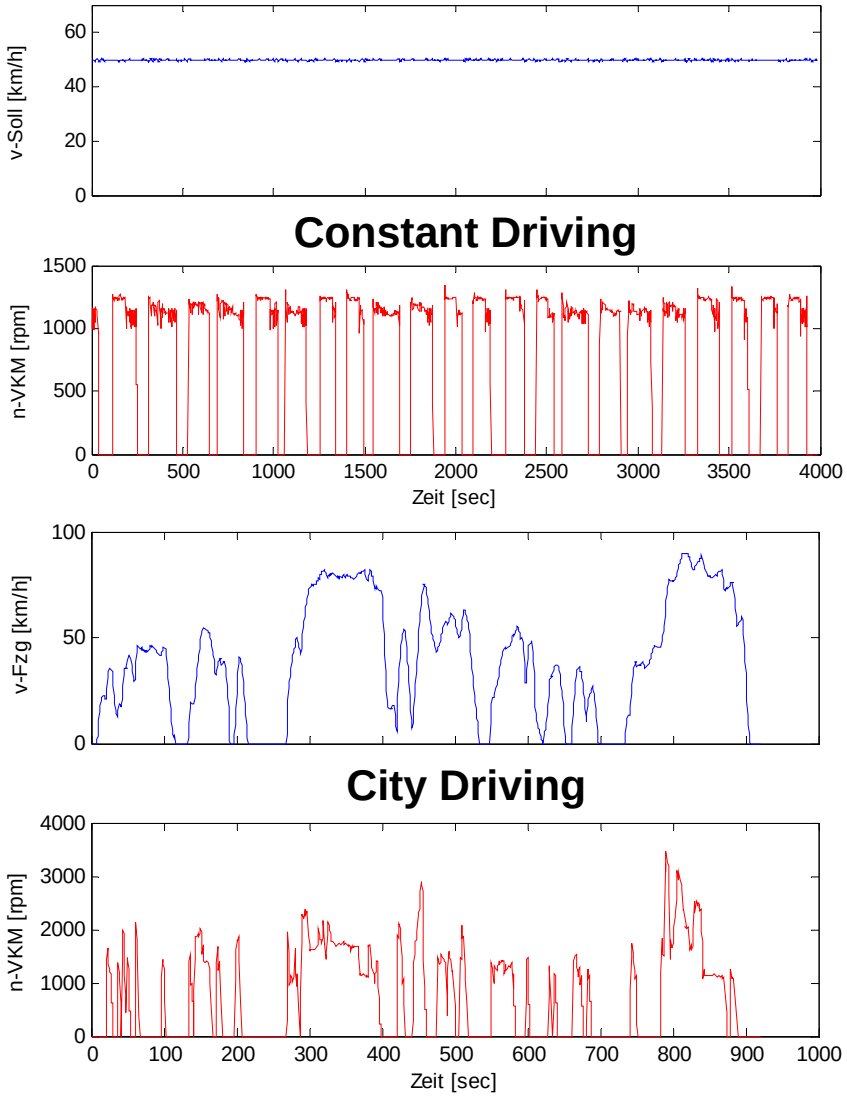
# Application:
# Load shifting of Combustion Engine



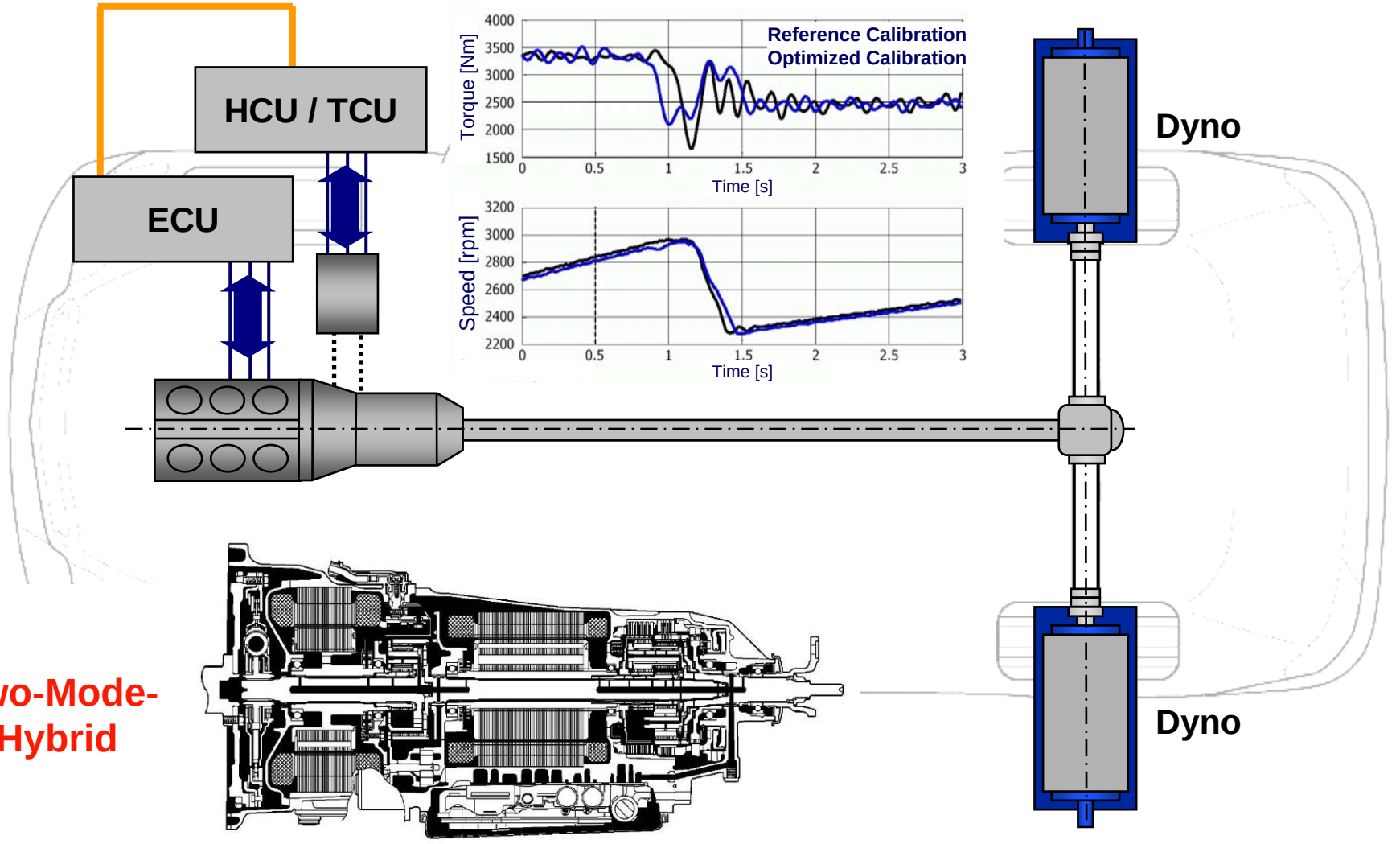

**Power Split Hybrid**



# Application:
# Load shifting of Combustion Engine

# Application:
# Mode-Shift Quality

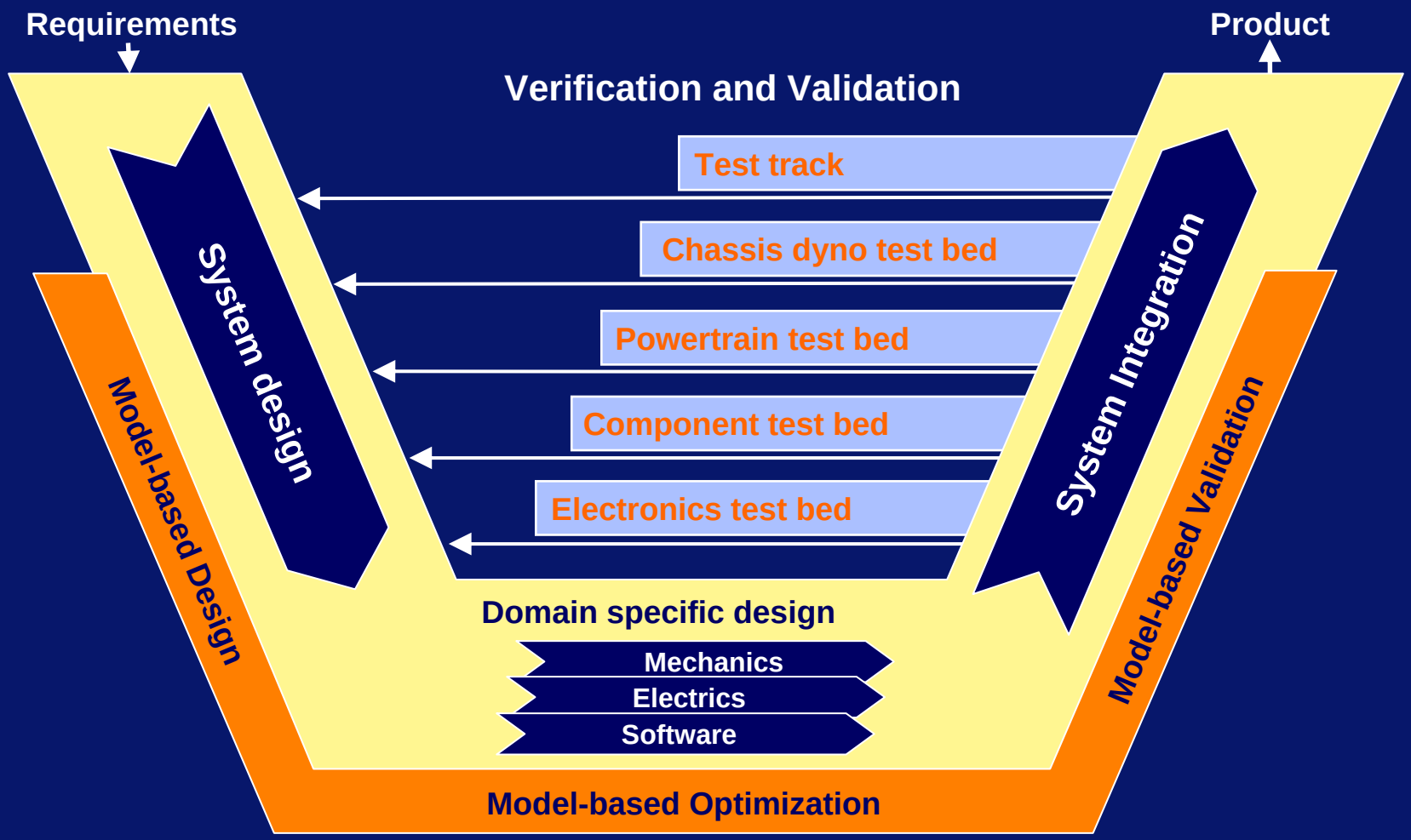



**Two-Mode-Hybrid**

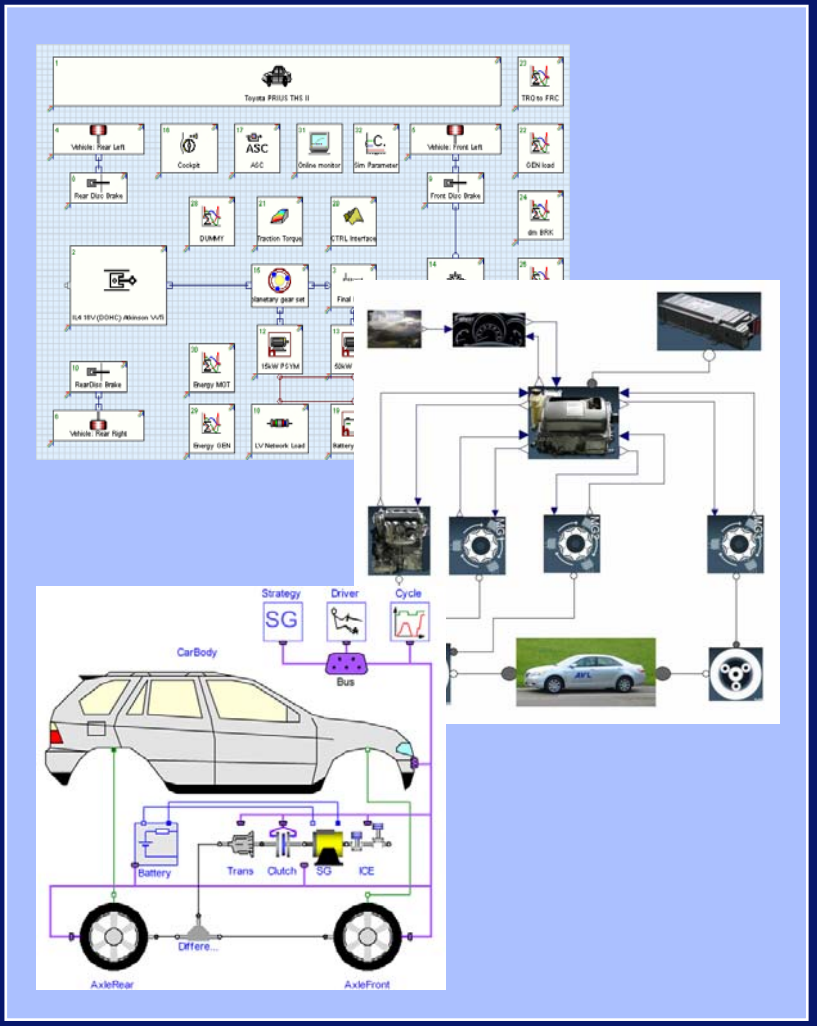


**Source: Toyota**

# Development Process for Hybrid Vehicles

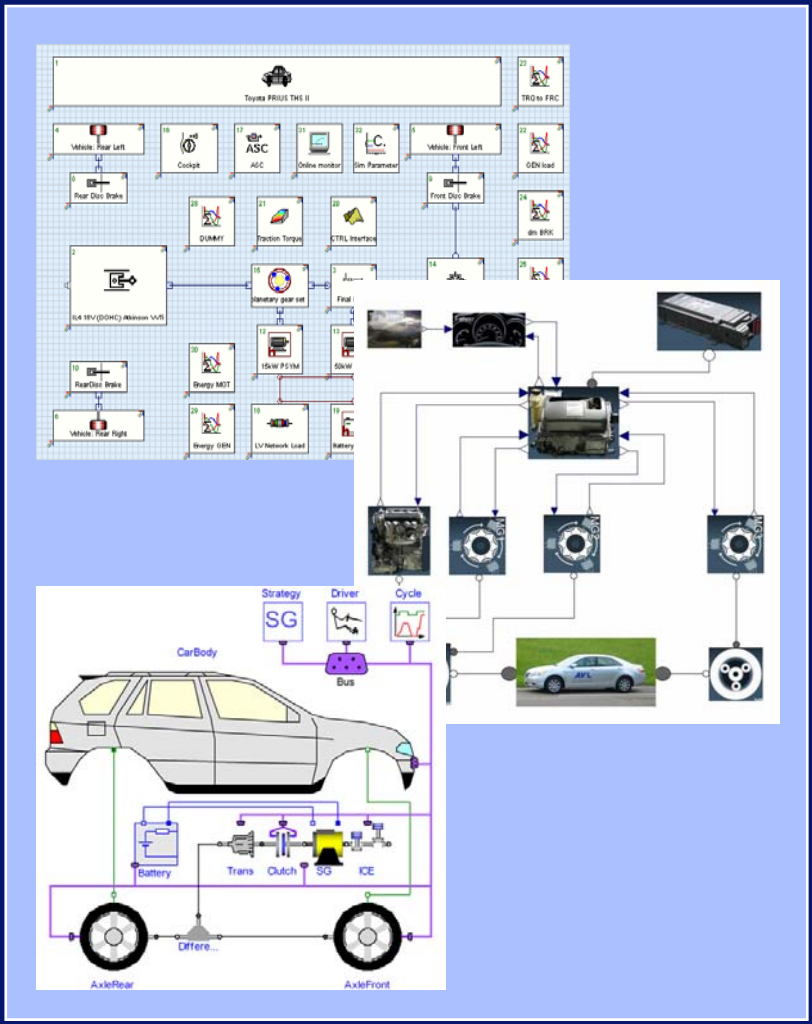


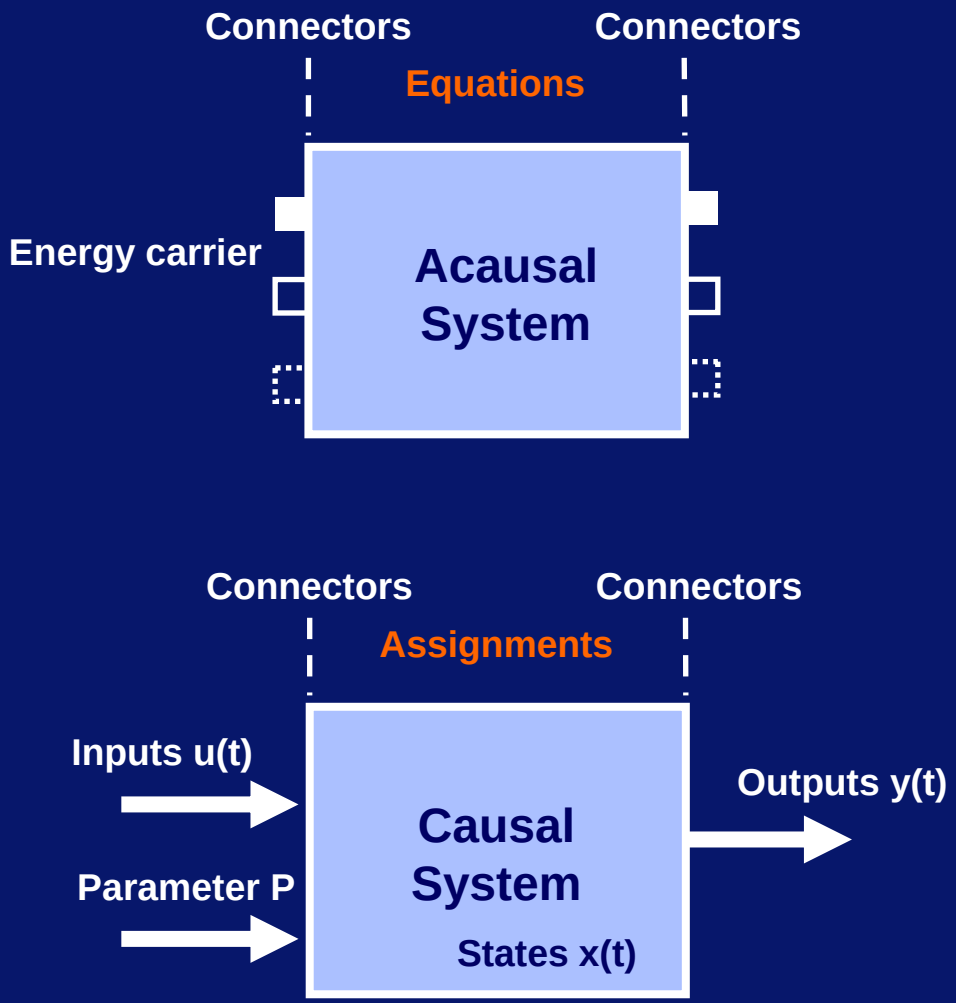
# Model-based Design



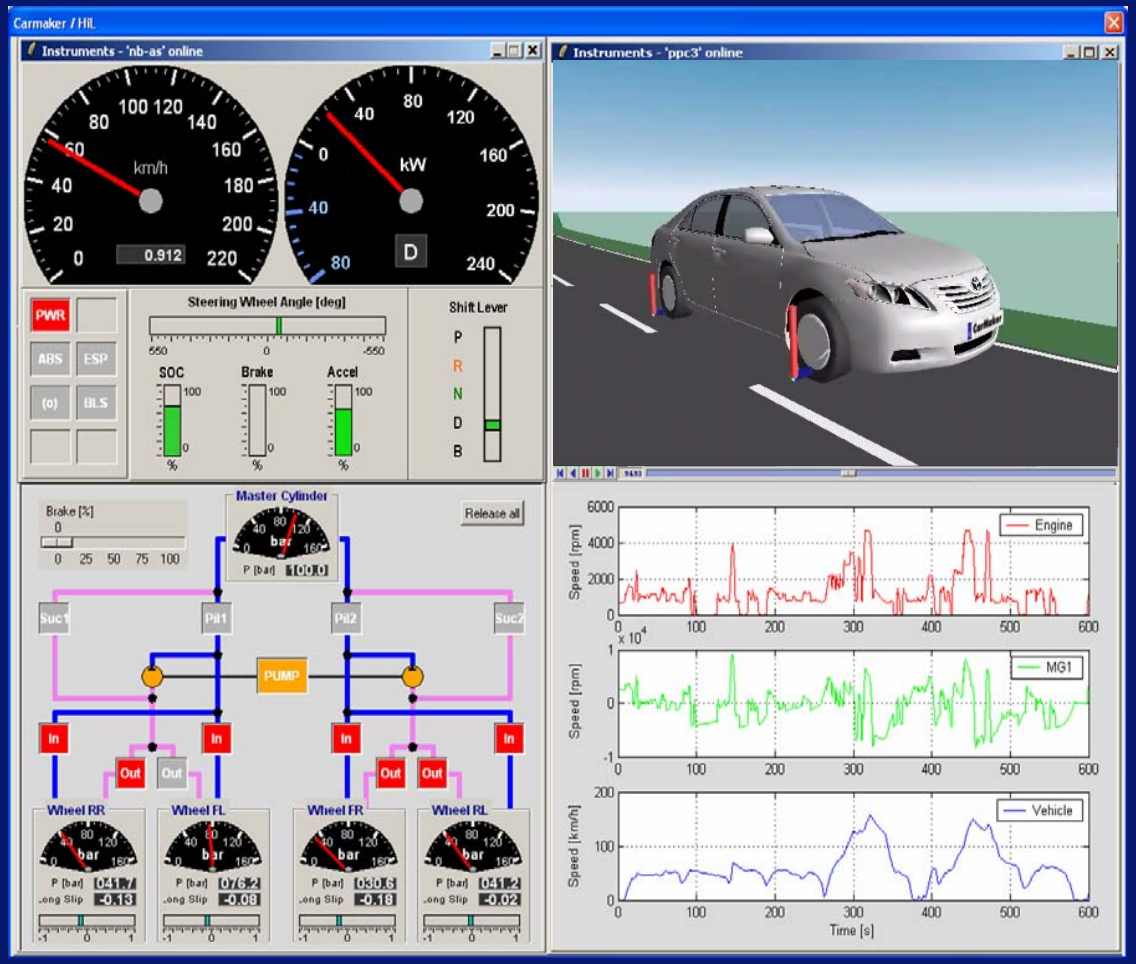

- Driver / 3D-Road
- Combustion engine
- Electric motor / Inverter
- Battery / Voltage Converter
- Torsional vibration damper
- Clutch
- Transmission
- Differential
- Brake
- Wheel and Tyre
- Chassis and Suspension
- Control Units
- Auxiliary devices

# Model-based Design



# Model-based Validation




## Mini-Driving-Maneuver

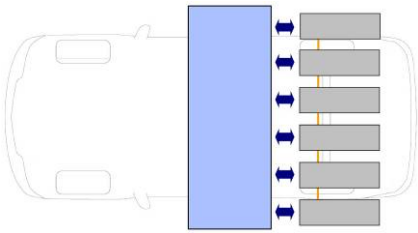
- Power On / Off
- AC with vehicle at rest
- Mode-Shift with selector
- Hill-Holding / Creep
- Partial load acceleration
- Full load acceleration
- Constant driving
- Braking / Coastdown
- ...

## Driving-Maneuver

- City
- Overland
- Highway
- Mountain
- Race track
- Handling course
- Emission cycle
- ...

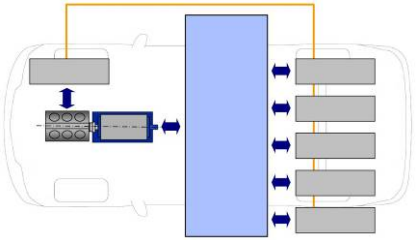
# Model-based Validation

**Simulation model of hybrid vehicle**



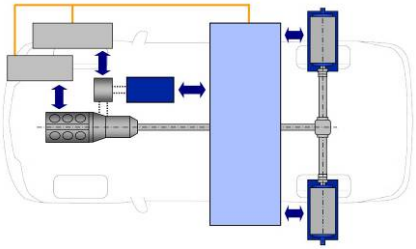
**Electronics Test Bed**

- Control Unit Network
- Power-Up and Shut-Down
- Function Development
- Basic Calibration



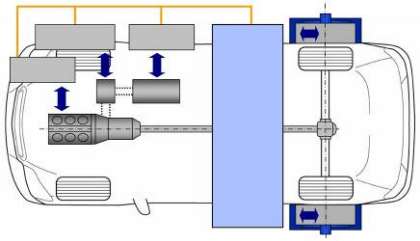
**Component Test Bed**

- Optimization and Validation of:
  Emissions
  Fuel Consumption
  Calibration



**Powertrain Test Bed**

- Optimization and Validation of:
  Vehicle Stability Functions
  Powertrain Dynamics
  Energy Management



**Chassis Dyno Test Bed**

- Optimization and Validation of:
  Thermal Behavior
  Acoustic Behavior
- Emission Certification

**Performance, Fuel Consumption, Emissions, Driveability**

# Electronics Test Bed

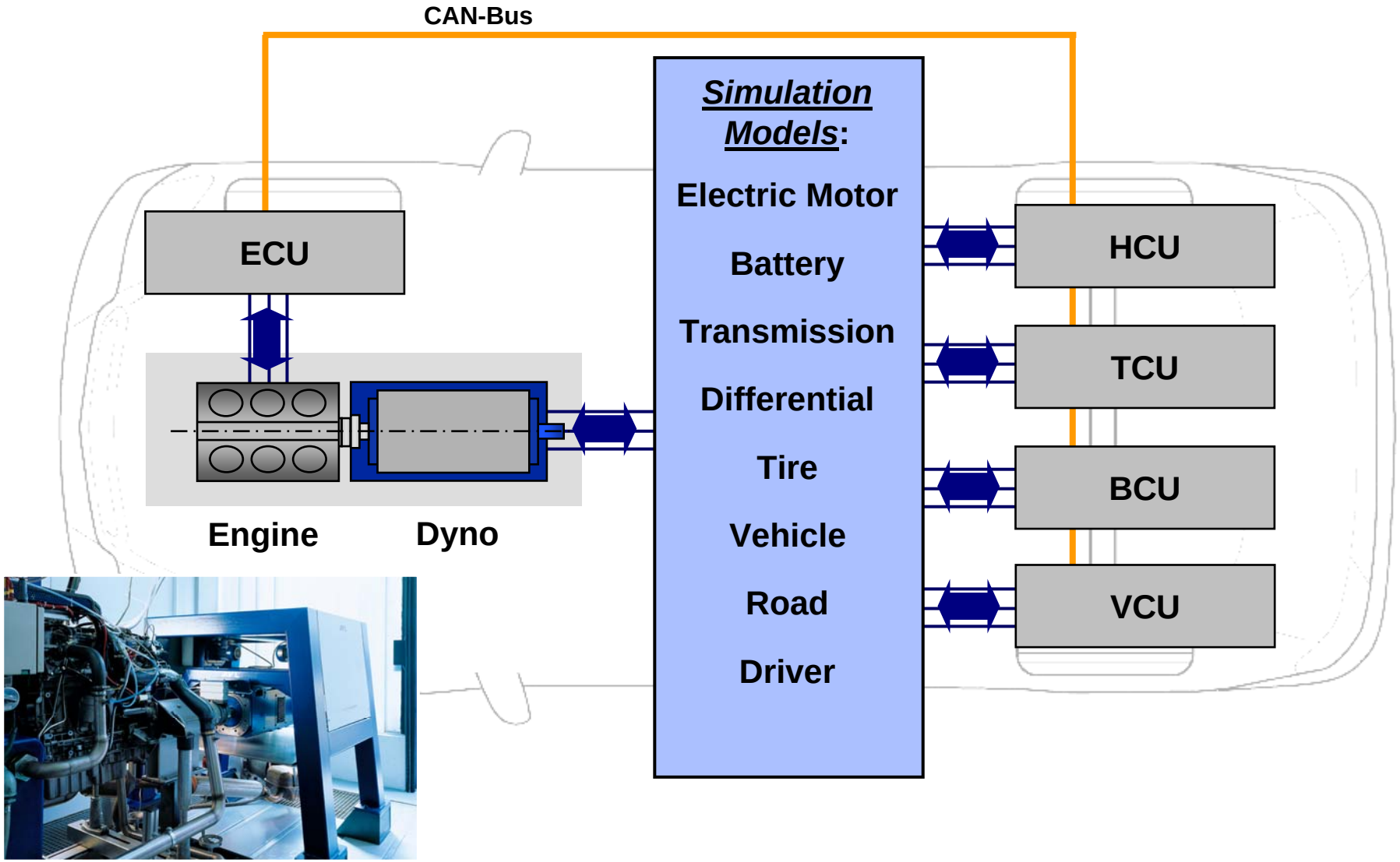
***Simulation Models*:**

- Engine
- Electric Motor
- Battery
- Transmission
- Differential
- Tire
- Vehicle
- Road
- Driver

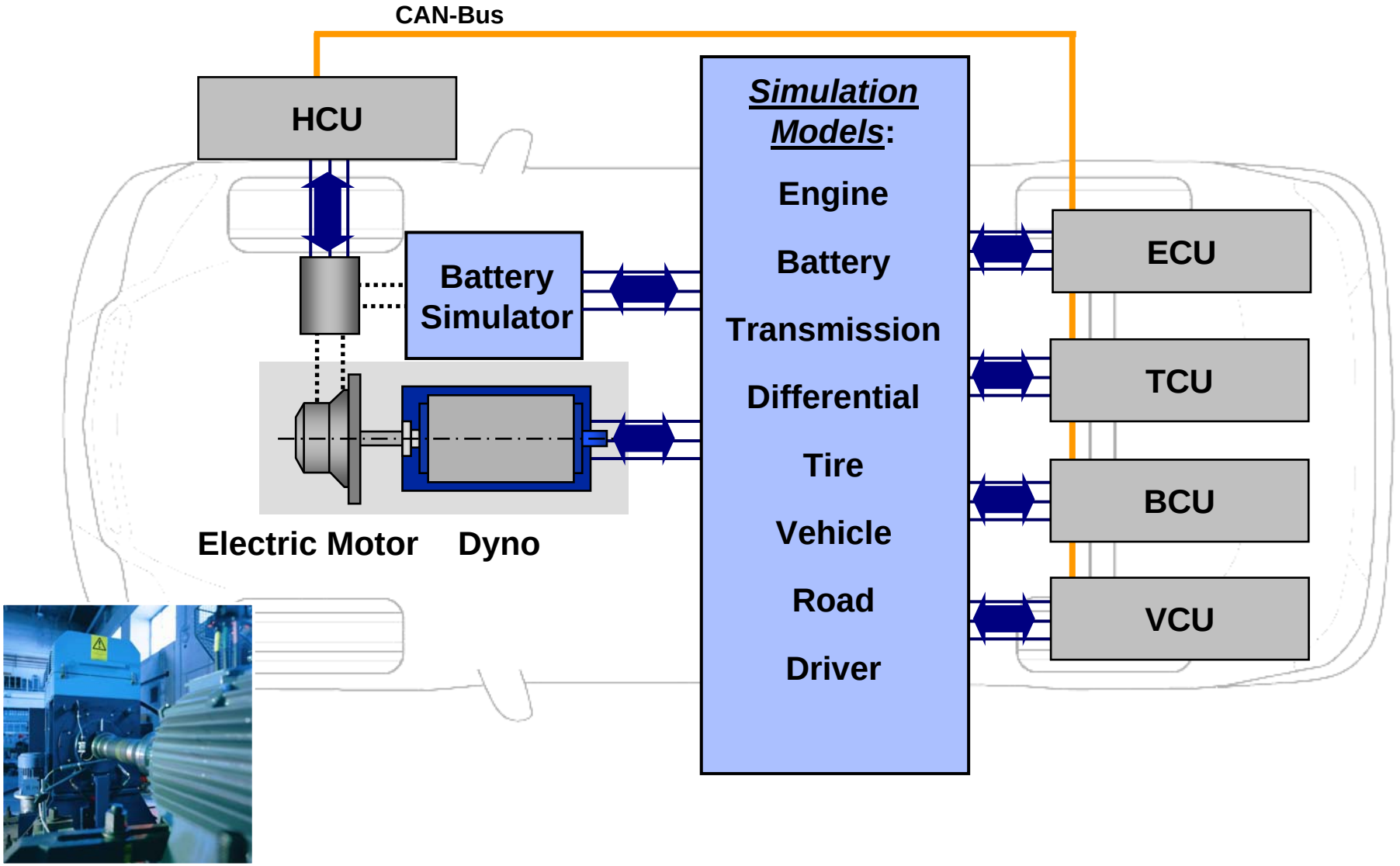
CAN-Bus

- ECU
- HCU
- TCU
- BCU
- VCU

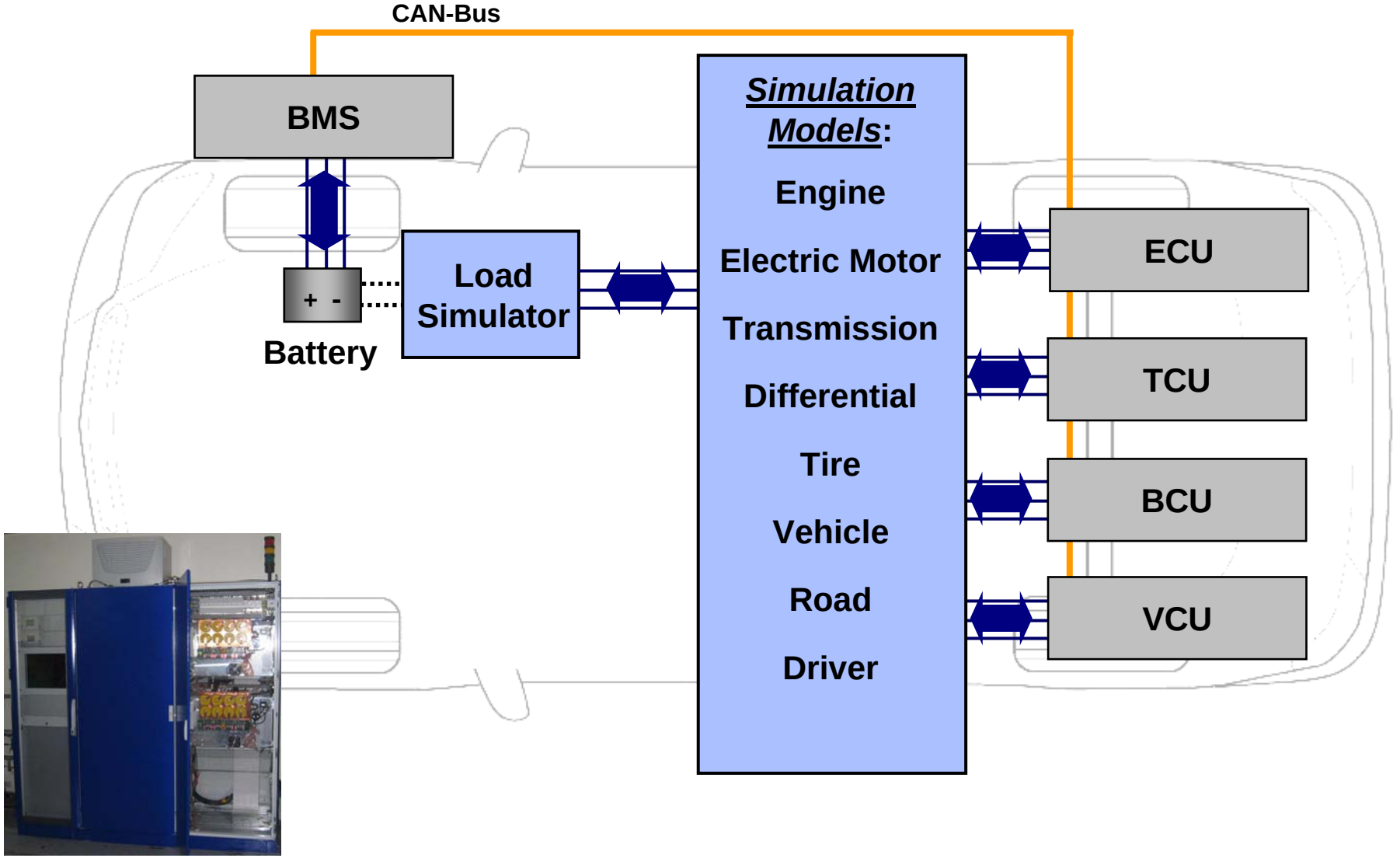
# Component Test Bed – Combustion Engine



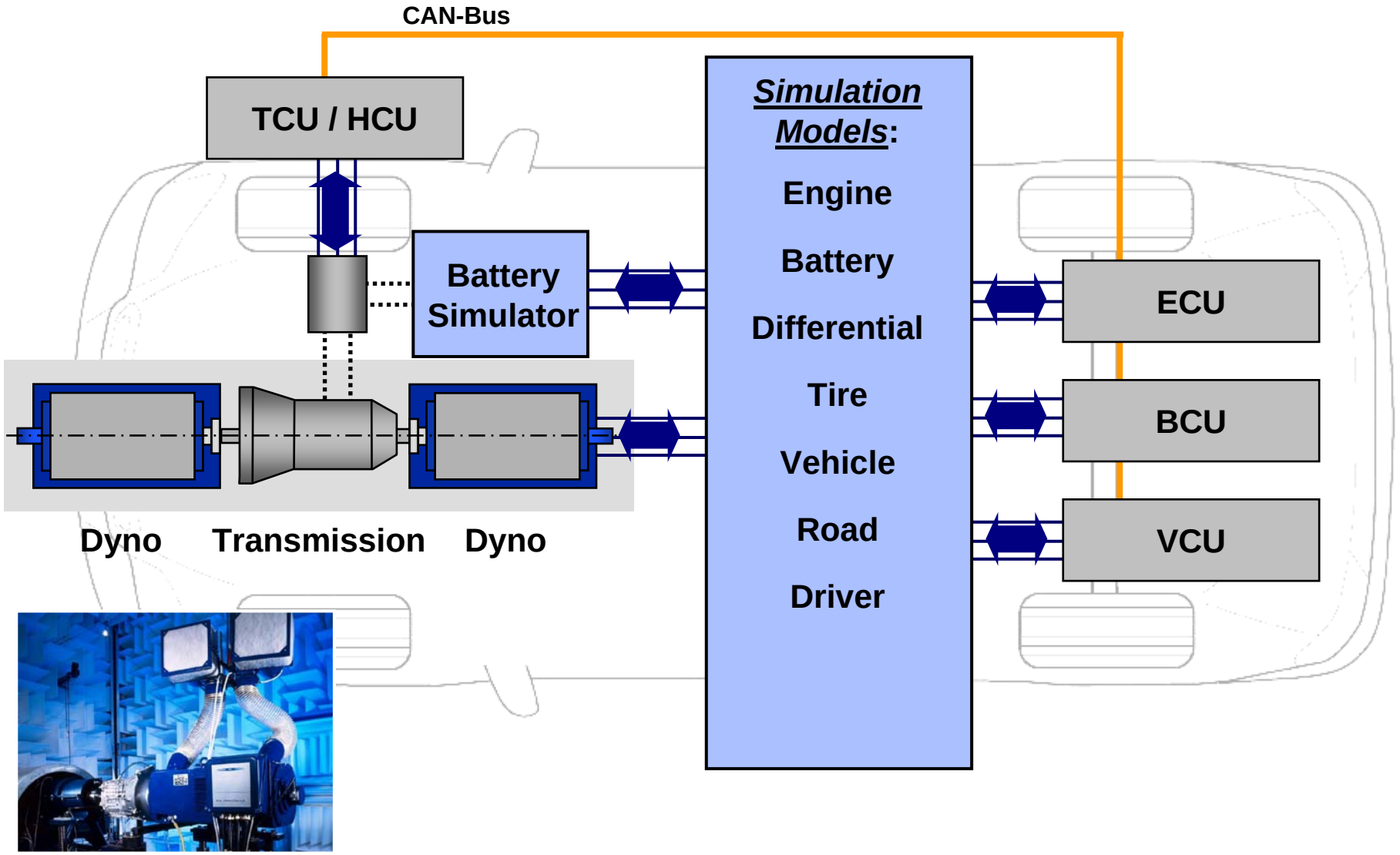
# Component Test Bed – Electric Motor



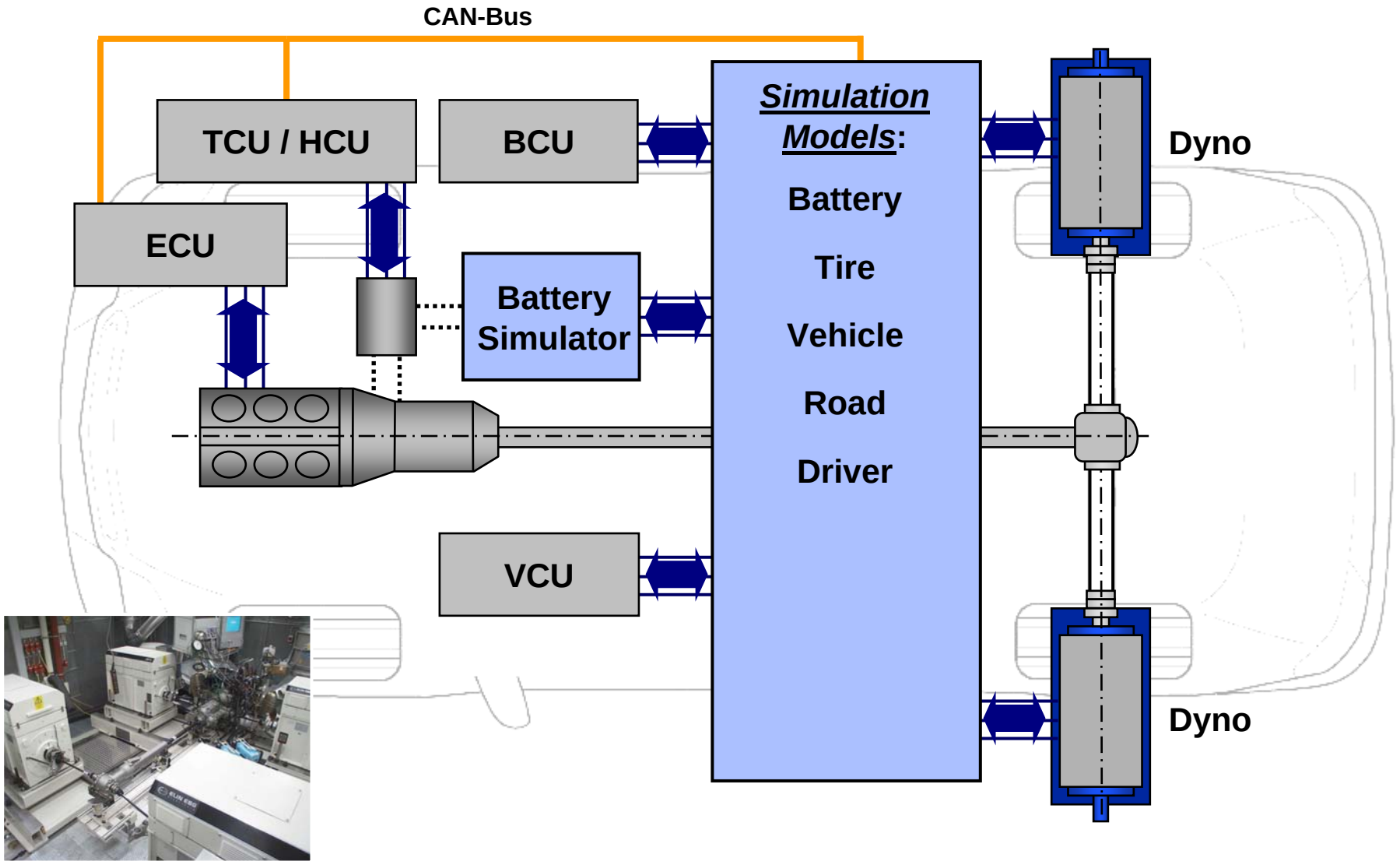
# Component Test Bed – Battery



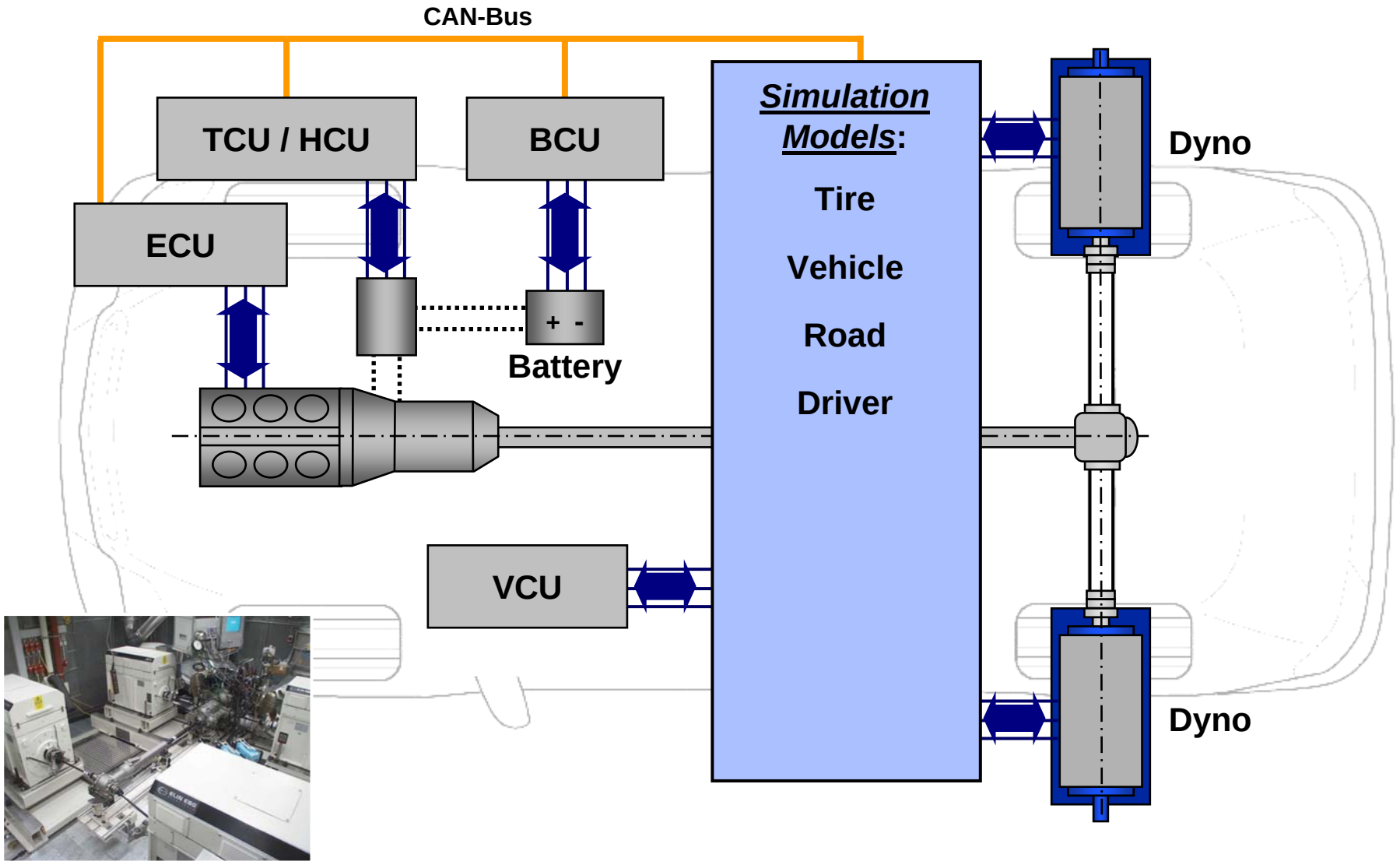
# Component Test Bed - Transmission



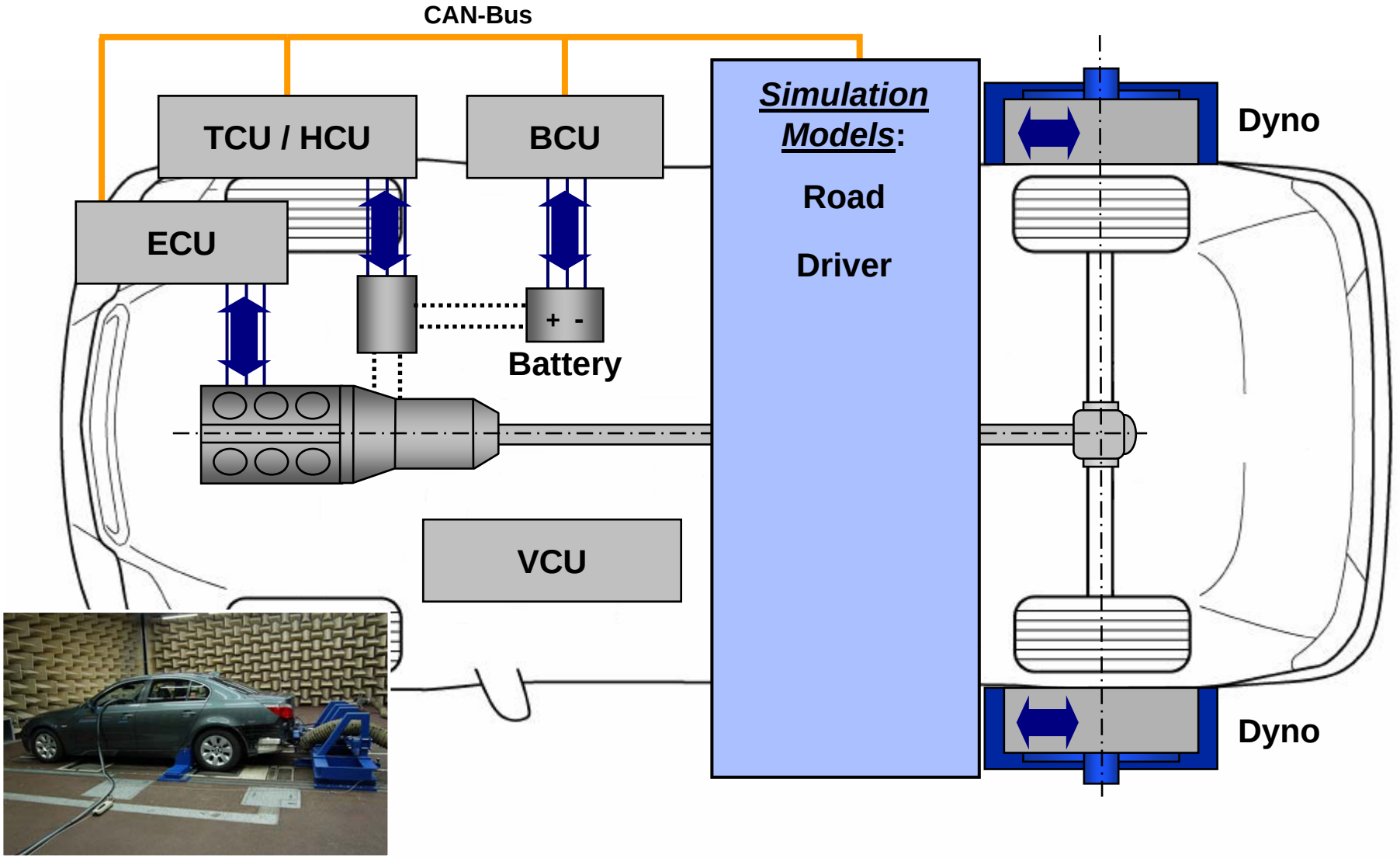
# Powertrain Test Bed



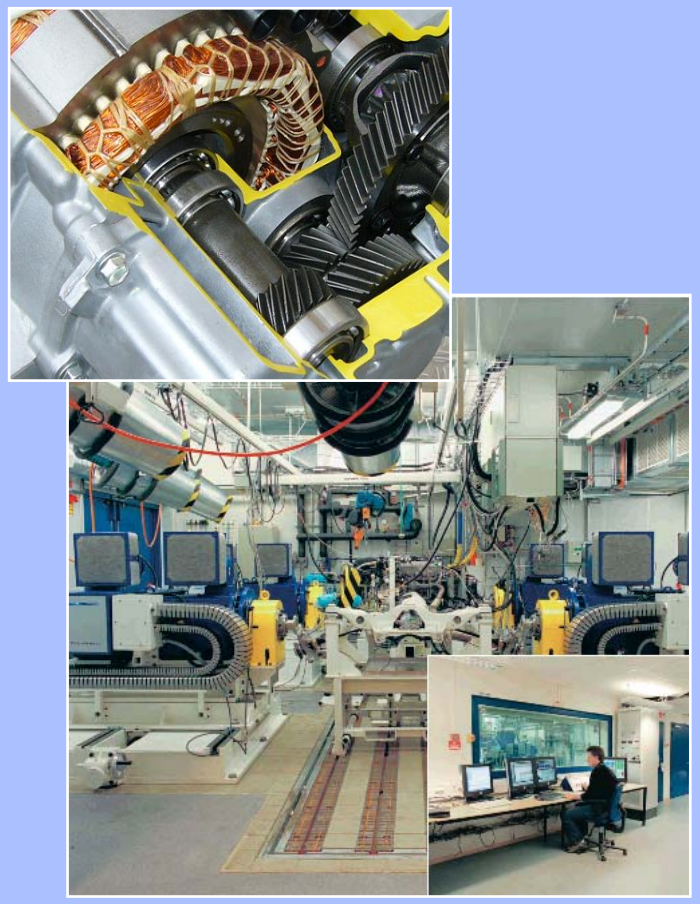
# Powertrain Test Bed



# Chassis Dyno Test Bed



# Summary



- Detailled simulation of the hybrid vehicle is essential in all development phases.
- Create one integrated testing environment for mechanical, electrical and software components.
- The relevant effects of non-existing vehicle components are simulated on all test bed configurations.