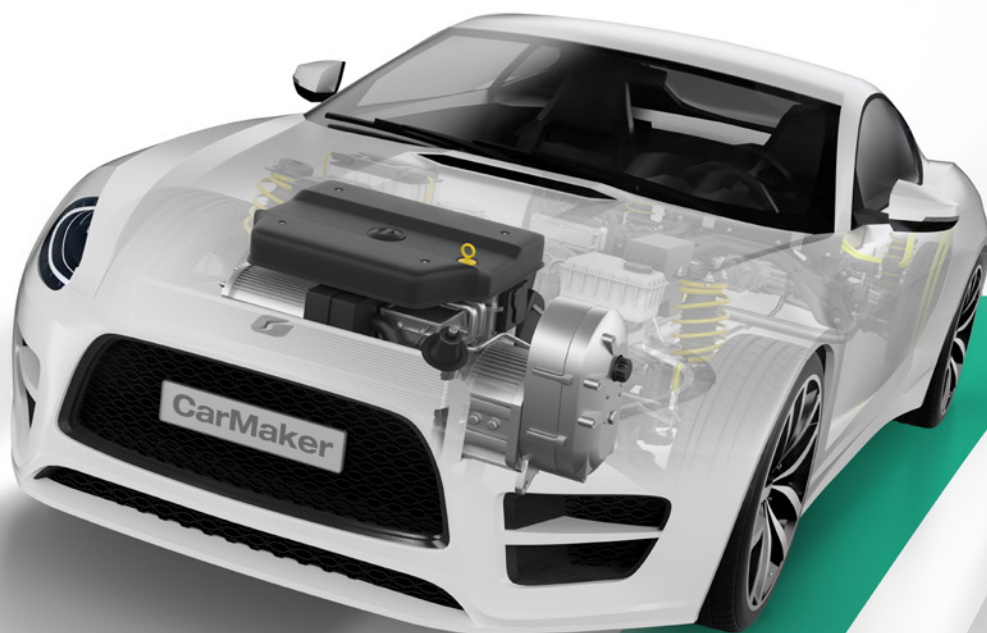


# Powertrain

Real Driving Emissions, RDX, thermal management, functional and performance testing, virtual electrification, virtual vehicle integration and attribute balancing with CarMaker, TruckMaker and MotorcycleMaker.



SOLUTIONS FOR VIRTUAL TEST DRIVING





## Why Use CarMaker for Powertrain Applications?

Realistic load duty cycles are the basis for the development, analysis and testing of powertrain systems. In many cases, speed and torque profiles from vehicle measurements or simplified longitudinal dynamics vehicle models are used in simulation and on test benches to evaluate the energy consumption, thermal behavior, durability and emissions of new powertrain concepts, components and systems. However, this approach offers very limited options to investigate system variations and calibration within a full vehicle under real driving conditions and has low flexibility concerning changes in vehicle configuration, driver behavior and operating strategy.

The CarMaker product family consisting of CarMaker, TruckMaker and MotorcycleMaker is a comprehensive and easy to use open integration and test platform with representative models of the vehicle, driver, road, traffic and environment. The provided model environment is used for closed-loop applications to generate realistic load duty cycles for powertrain system development and analysis in office simulation, HIL simulation and for testing on test benches. The closed-loop approach offers a high degree of flexibility, because realistic load

duty cycles are not needed as an input for this type of maneuver-based closed-loop simulation and testing on test benches. Driving cycles defined by vehicle speed and real driving scenarios can easily be performed with virtual prototypes driven by a representative driver model. IPGDriver is capable to follow a predefined target speed as well as to choose the driving speed according to the course and the vehicle behavior. With the road data import functionality, open interfaces to third-party tools, its model integration capability and real-time performance, CarMaker offers an outstanding open integration and test platform for powertrain applications.

Virtual test driving with CarMaker allows for a seamless development, analysis and testing of powertrain systems taking into account all relevant interdependencies between the powertrain, chassis/suspension and brake system. Especially for the development and testing of hybrid electric vehicles, but also for all other current and future powertrain concepts, this approach is essential to evaluate real driving energy consumption, performance and emissions.

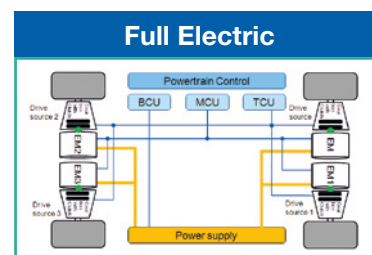
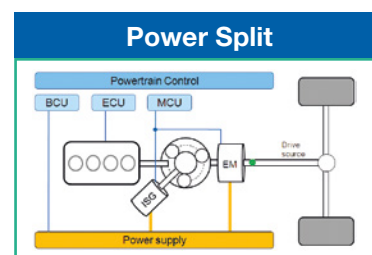
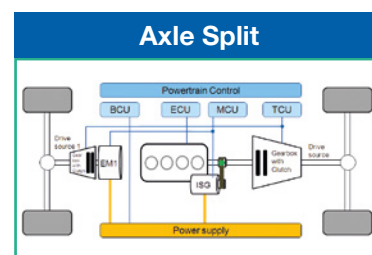
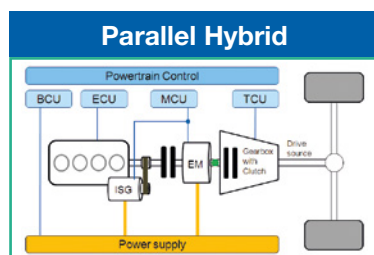
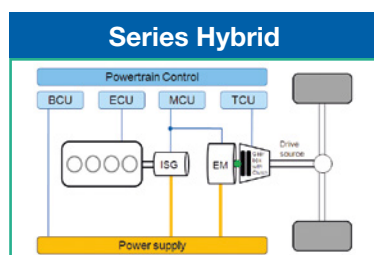
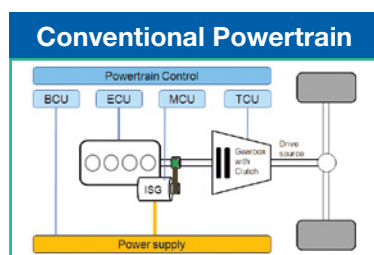


Karlsruhe Institute of Technology (IFKM), Source: Silke Voss Fotografie



## Electric/Hybrid Powertrains in CarMaker – Model Architecture

Entire virtual vehicle – driving cycles – real driving scenarios



### Main Application Areas

- Energy efficiency, emissions & performance investigation
- Powertrain concept and control analysis and testing
- Vehicle thermal management layout and optimization

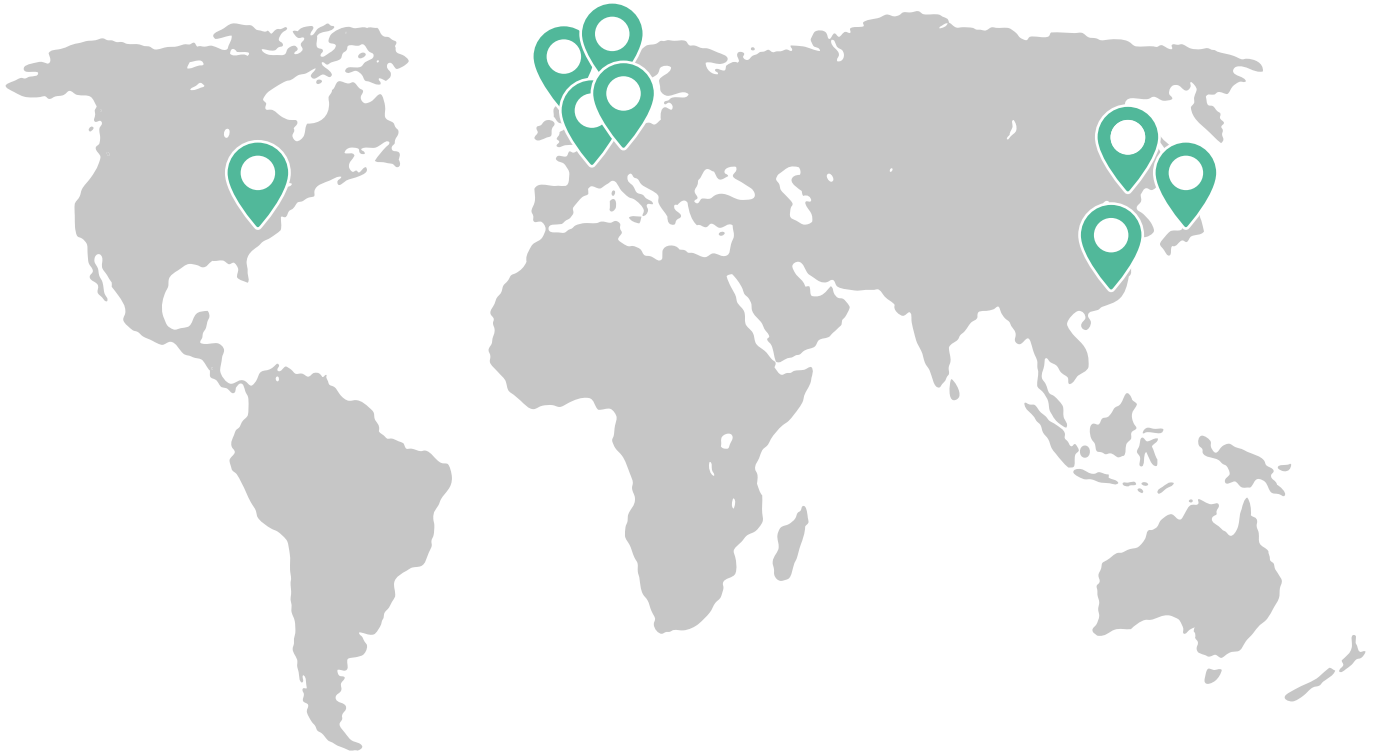
### Key Applications

- HEV/BEV and conventional powertrain concept studies
- Engine and transmission development and optimization
- Test bed integration (engine, powertrain, chassis dyno, battery)
  - Real Driving Emissions (RDE) investigation
  - Real-world energy consumption
  - Virtual electrification/hybridization
  - Durability testing
- Powertrain/engine ECU calibration and testing
- Operating strategy and driver behavior investigations
- Electronic horizon: predictive energy management using road property sensors or the ADASIS v2 standard

### Features

- Closed-loop vehicle-driver-environment simulation
- Connected powertrain testing
- Real-time simulation environment for setup of virtual vehicle prototypes with conventional, hybrid and full electric powertrains
- Generation of virtual vehicle prototypes using the Data Set Generator
- Tunable driver model with emission driver functionality
- RDX Test Generator for RDE-compliant “real driving” test scenario generation
- Road data import (GPS- and map-based)
- Model integration from different sources such as AVL CRUISE, Dymola, GT-SUITE, LMS Amesim, MapleSim, Ricardo WAVE, SimulationX, Simulink, ...
- Functional Mock-up Interface (FMI)
- Open interfaces to third-party tools such as navigation systems, DoE tools and PLM systems
- Virtual xCU integration (e.g. QTronic Silver)
- Robust and industrialized test bed packages to connect with engine, powertrain, chassis dynos or e-motor test beds

## About IPG Automotive



**Locations: Germany | China | France | Japan | Korea | Sweden | UK | USA**

Sales partners: India | Italy | Taiwan | Turkey

As a global leader in virtual test driving technology, IPG Automotive develops innovative simulation solutions for vehicle development. Designed for seamless use, the software and hardware products can be applied throughout the entire development process, from proof of concept to validation and release. The company's virtual prototyping technology facilitates the automotive systems engineering approach, allowing users to develop and test new systems in a virtual whole vehicle.

IPG Automotive is an expert in the field of virtual development methods for the application areas of ADAS & Automated Driving, Powertrain and Vehicle Dynamics.

The company's CarMaker product family is used around the world to address the challenges associated with evaluating powertrain efficiency, emissions, and driving performance in addition to predictive and connected propulsion systems already during development. The seamless implementation of virtual test driving under real driving conditions is a key success factor in the development and optimization of all types of propulsion systems.

IPG Automotive stands for quality, holistic user orientation, efficiency, promotion of innovation and lasting partnership.



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