Diesel-Hybrid Vehicles for Environmentally Conscious Mobility:

A Networked System Development in a Physical and Virtual Environment (DUETT)

An important step towards reaching ambitious climate- and environment protection goals is the progressive hybridization of powertrains. Especially the potentials of Diesel hybrid powertrains, which are burdened by increased development costs, have not been fully exhausted yet. Specifically, the advantages of combining innovations in the field of powertrain electrification and digitalization, such Car-2-X-technologies, need to further be exploited in this context.

To achieve progress regarding this objective, a new interdisciplinary research project has been launched with the goal of implementing a new development methodology ("virtual development", figure 1) that allows investigating an extensive variety of vehicle hybrid powertrains with respect to their compliance with future legislations like Real Driving Emissions (RDE). For that purpose, the simulated vehicle is interconnected with other traffic participants in a virtual environment, which is connected with physical components in the real world. This kind of simulation, called Hardware-in-the-loop (HiL) simulation, is a technique that successfully is being used in the development and test of complex real-time embedded systems.

As shown in figure 1, such real-time embedded systems have a very high degree of complexity, which substantially increased during recent years. In order to work within certain standards, structures that are even more complex are needed for some projects, because there is no methodology or other established way of implementation at this stage. Coming from the age of testing, the technical development has passed through the age of simulation to the current age of HiL testing in combination with simulation. Because of this, a
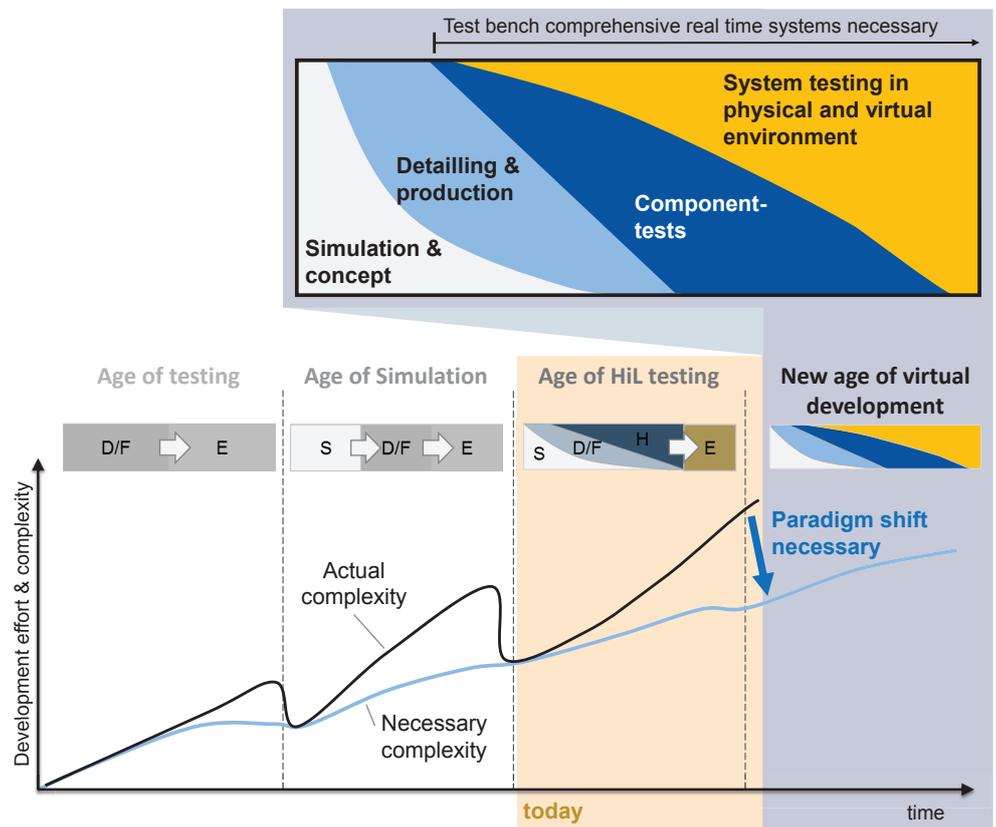

Figure 1: Transition to the new future development process

new development methodology is needed to bring the next paradigm shift to the age of virtual development. This is important to lower the already high degree of complexity to a new manageable level.

As shown in figure 2, optimization of hybrid powertrains and their operating strategies as well as the combination of virtual and physical systems are selected applications for introducing the new development methodology within the scope of a Diesel hybrid powertrain research project.
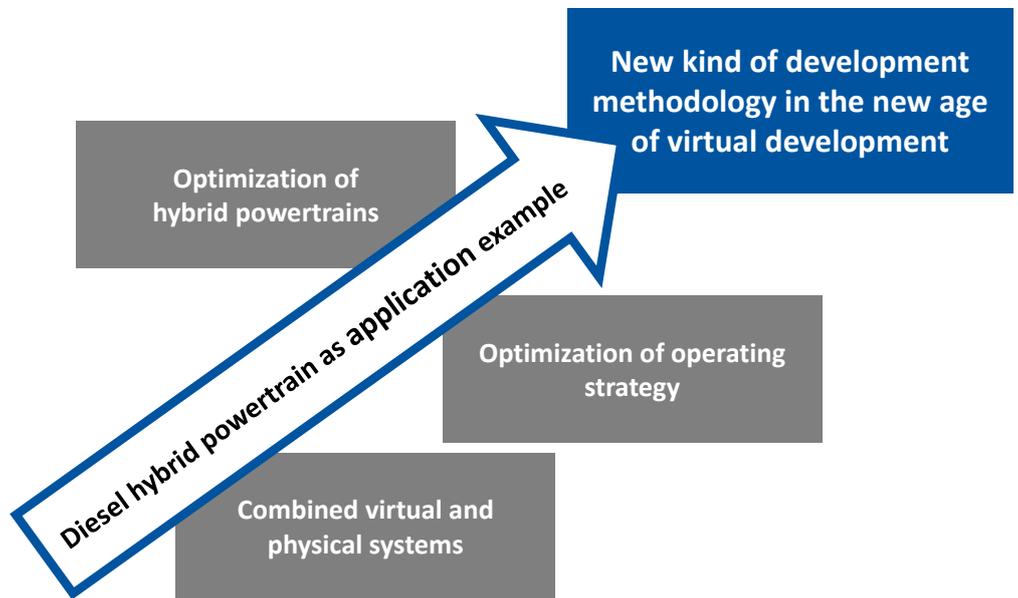

Figure 2: Pathway to a new kind of development methodology

The new development methodology is being implemented for two different applications. In use case 1 (individual mobility), the methodology is applied to a vehicle with a Diesel hybrid powertrain, where the powertrain configuration and the operating strategy are optimized in particular to achieve lowest possible emissions under RDE conditions. This scenario is of overriding relevance due to the latest emission legislation in Europe. Especially the possibility of emission-free driving in the inner-city area in combination with low fuel consumption on longer driving distances is a sustainable and efficient contribution of a full hybrid powertrain to future mobility. In this context, the relationship between the distribution of electrical and internal combustion engine power plays an essential role.

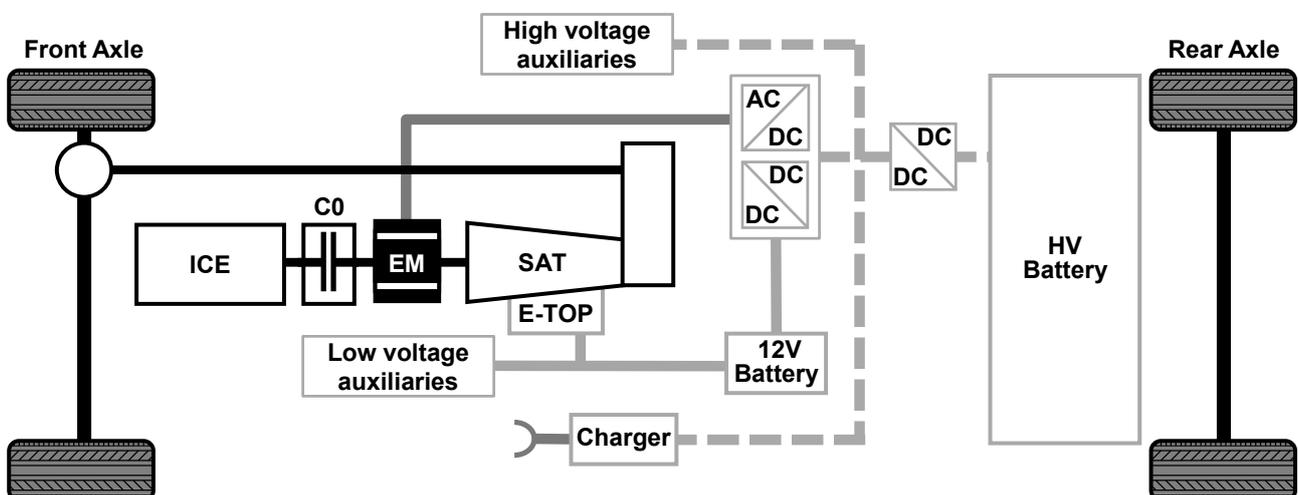Figure 3 shows the selected topology for this use case, a P2 Plug-in Hybrid Electric Vehicle (PHEV).

Figure 3: Selected topology of the vehicle (P2 Plug-In Hybrid Electric Vehicle)

In use case 2 (logistics), the focus is on the distribution traffic of vehicles with up to 3.5 t weight. With the aid of virtual scaling, concepts for hybrid powertrains of such light commercial vehicles are simulated and evaluated analogously to use case 1. The focus in the area of operations management is on economic route optimization (economic efficiency strategy). In order to avoid downtimes with high local pollution of the environment, bottlenecks in urban areas can be specifically bypassed. The online optimization of driving routes helps to reduce energy consumption and improve traffic flow.

Essential parts of both use cases are real-time capability and scalability of the powertrain component simulation models, which are the outcomes of this interdisciplinary working environment. In summary, a new developmental method, which enables a cost-efficient introduction of optimized powertrain technologies in the context of digital and networked mobility, is created in this way.

The Center for Mobile Propulsion (CMP) of the RWTH Aachen University with its real-time capable system for test bench interconnection as well as the environment for close cooperation of research specialists provides optimal conditions for realizing this new development methodology. The research project unites several departments of engineering from the RWTH Aachen University and external enterprises: Institute for Combustion Engines (VKA), Institute for Automotive Engineering (IKA), Institute for Machine Elements and Machine Design (IME), Institute of Electrical Machines (IEM), Institute of Automatic Control (IRT), Institute for Power Electronics and Electrical Drives (ISEA) – Chair of Switched Mode Power Supplies and Electrical Drives (ISEA-LEA) as well as Chair of Electrochemical Energy Conversation and Storage Systems (ISEA-ESS) and BatterieIngenieure GmbH, DENSO Automotive GmbH, Ford-Werke GmbH as well as dSPACE GmbH.

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