AUTHORS

Dr. Jochen Schaffnit
is Technical Integration Engineer Chassis Controls Simulation for Adam Opel AG in Rüsselsheim (Germany).

Dr. Henning Holzmann
is Director of Vehicle CAE for Adam Opel AG in Rüsselsheim (Germany).

Dr. Johannes Lauer
is Technical Lead Engineer for HiL and Test Automation for Adam Opel AG in Rüsselsheim (Germany).

Jan Klemmer
is Development Engineer HiL for HiL and Test Automation for Adam Opel AG in Rüsselsheim (Germany).

The increasingly interconnected functions lead to an intensified use of virtual testing and the consequent need for even earlier development with a high system maturity is to be expected. Therefore, Opel uses the master model concept with assistance of IPG Automotive.

EVER SHORTER DEVELOPMENT CYCLES

The improvements on driving safety and comfort of modern cars require constant innovation that is to be made available to the customer in ever shorter development cycles. Currently, development is increasingly focussing on the areas of safety and advanced driver assistance systems as well as V-to-X communication, which are considered preliminary stages of highly automated driving.

However, new functionalities and their close interconnection lead to an increased effort with regard to development, integration and testing for both OEMs and suppliers. As a result, the demand for virtual tools and methods grows constantly. The use of system simulation in an early stage of the development process is sensible here as well as the implementation of efficient frontloading with virtual test driving [1]. For this purpose, a high model quality, a flexible model configuration and efficient processes are important requirements. The fulfilment of these requirements and the organised management of models with a database system is presented here based on the master model approach developed by Adam Opel AG.

REQUIREMENTS FOR THE SEAMLESS USE OF SIMULATION

With the early use of system simulation in the development process, an initial validation already becomes possible on

Efficient and Sustainable Management of Vehicle Models

the requirement level. This facilitates the work in the different departments involved such as styling, design or function development. The Euro NCAP rating of new vehicles in development with a specific sensor equipment, for instance, can be predicted early on in the project by means of Model-in-the-loop (MiL) simulation [2]. Once the first ECU code of a supplier is available, a closed-loop analysis in a Software-in-the-loop (SiL) simulation is possible. One application is the simulation-assisted testing and calibration of steering systems [3]. This process can be completed on a PC before real ECU hardware is available without having to comply with real-time conditions. Once the real ECU hardware is at hand, the next step is Hardware-in-the-loop (HiL) simulation, during which embedded systems are operated in a simulated environment on a real-time simulator. One example of the use of HiL is the simulation-based homologation of the electronic stability control (ESC) [4, 5] as shown in **FIGURE 1**. A flexible model framework is required for the continuous system simulation for all simulation disciplines described. It is essential for this framework to facilitate the individual adaptation of the model according to the use case. **FIGURE 2** provides an overview of the variety of application areas and virtual test cases. In order to make use of these, it is further necessary for different users to have access to the same stage of validated models, data sets and scenarios. In addition, taking the tests to the virtual world requires a powerful simulation tool as well as an organisation of the system simulation that is efficient and focused on process reliability.

THE MASTER MODEL APPROACH

At Adam Opel AG, the requirements described above are fulfilled using the master model approach [6]. The underlying idea is a central integration model template for HiL and offline simulation which the user can adapt to the respective application. The open integration and test platform CarMaker for Simulink by IPG Automotive serves as the basis which has been extended with customised models in many components. The model enhancements are organised in special model libraries, in which each sub-model can be selected from variants of different levels of complexity depending on the use case. These range from variants without functionalities, which only supply the required input and output interfaces, up to very detailed versions. If the analysis of an ESC system, for instance, is the focus of a simulation, the original ESC ECU code can be integrated into the master model in the course of a SiL simulation, while the functionality of the lane keeping assist system, for example, can be disregarded in some circumstances. The model configurations selected can be saved as XML files and later be reused. The model libraries are strictly separated from CarMaker for Simulink and do not include any blocks from the CarMaker library in order to ensure universal usage.

DATABASE FOR THE RELIABLE ORGANISATION OF PROCESSES

The flexibility of the model structure described above allows for the continuous use of the master model during the entire vehicle development process for both offline and HiL applications. A global database solution was developed as a large number of users from different

FIGURE 1 Simulation-based homologation of ESC systems (© IPG)

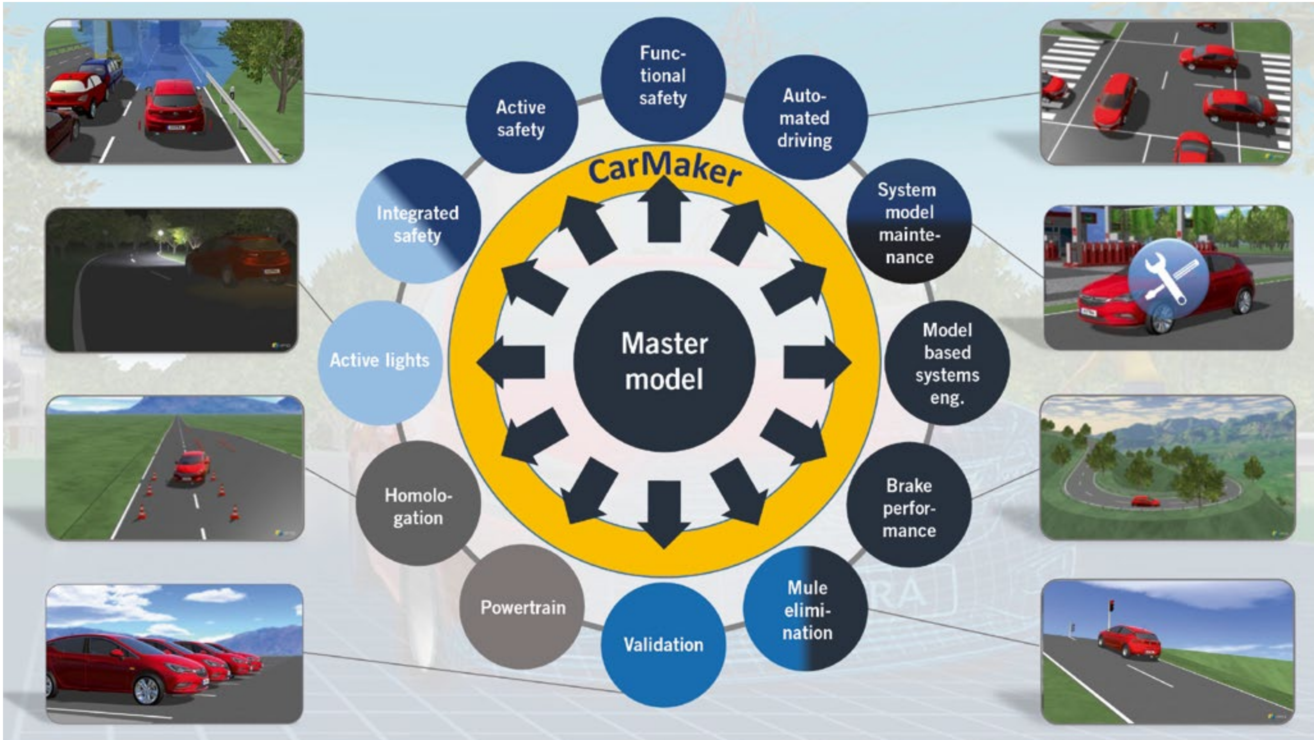

FIGURE 2 Overview of the different application areas of the master model (© Opel)

development divisions (who are also located on different continents in a corporation with a global network) is required to have access to the same stage of validated models, test scenarios, parameter files, documentations, software tools, etc. This database (IBM Rational Synergy) is the so called golden source for all files and also includes the configuration management as well as version control. The central features of the database software were efficiently integrated into the development process. The task-based approach of Synergy, for instance, enables groups to create work tasks that are linked to errors or change requests. When developers work on specific tasks, the objects concerned (file versions) are assigned to the task and both are jointly handed over into the development process. As configurations and releases can be generated via a combination of a number of tasks, complete traceability of the implementation of change requests and error correction is enabled. In addition, the creation of baselines allows for the generation of a fixed model and data status, which can subsequently be used for release testing, for example. Thus, it is ensured that all users involved use the same validated master model version as a basis. Another advantage is the documentation of test criteria and results, which records the model and calibration status that was used for a test. This allows for the traceability of the process and increased transparency of the development.

FIGURE 3 illustrates the database structure. The utilisation of the CarMaker folder structure in Synergy ensures that the simulation environment is executable without further adaptations after synchronising it with the database. The overall project is divided into several

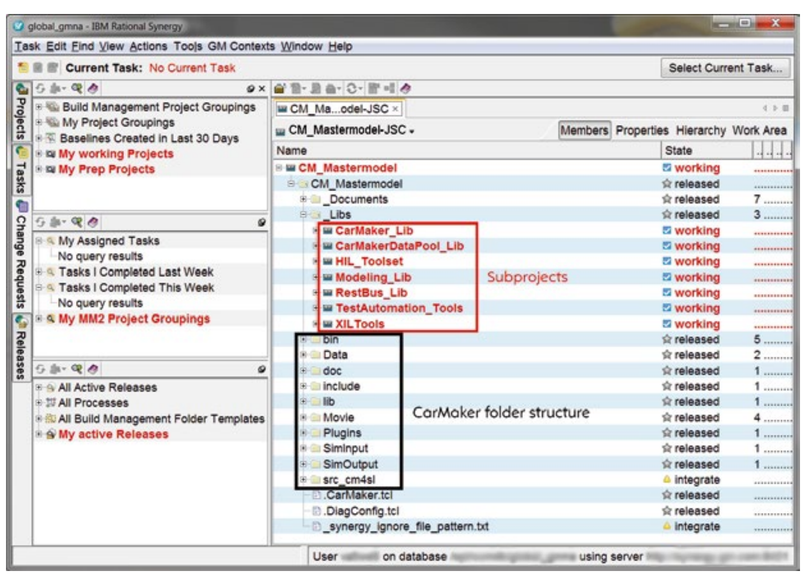

FIGURE 3 A global database is the golden source for all master model files and includes the configuration management as well as version control. The database project mirrors the CarMaker folder structure and includes several sub-projects (© Opel)

sub-projects. Thus, partial projects can be reused in other database projects. All internally developed models, for instance, are organised in a separate project (Modeling_Lib) and can therefore be used globally and independently of the master model.

INCREASED PROCESS EFFICIENCY

The use of the database automatically entails a networking of the users involved as illustrated in **FIGURE 4**. The modification or error correction of database objects by a developer, for example model enhancement, as part of a change request first involves the creation of a corresponding task in the database and checking out the respective files. After the changes are completed, these files undergo various validation tests in order to ensure high model quality. The respective files are checked back into the database after passing the tests, thus becoming available for all other users. With a shared use of simulation models and the corresponding files such as test scenarios, parameter files and software tools as presented here, parallel work can be avoided. This leads to significant savings in both development time and costs. This is achieved through the consistent use of fixed modelling conventions. There are guidelines for naming conventions of signals, parameters, files and model types, for instance, as well as rules for model interfaces, abbreviations and acronyms. This increases the model comprehension and traceability.

FIGURE 4 All users and developers of the master model are linked through the database (© Opel)

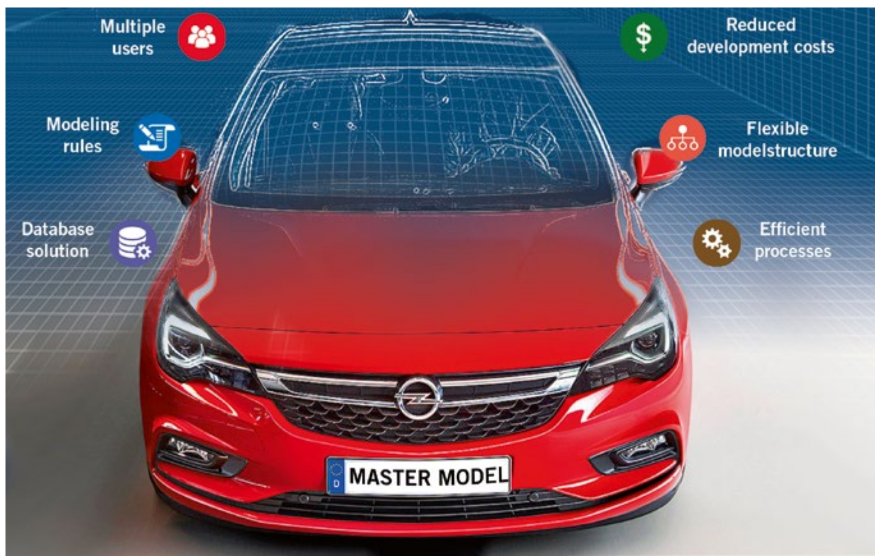

FIGURE 5 Summary of the most important aspects of the master model approach (© Opel)

CONCLUSION AND POTENTIALS OF THE MASTER MODEL

The increasingly interconnected functions, especially with regard to highly automated driving, will continue to require a considerably growing test effort in future. As a result, an intensified use of virtual testing and the consequent need for even earlier development with a high system maturity is to be expected. Here, the master model concept can help to ensure and also improve high model quality as well as an efficient development process. In addition, the cooperation between OEMs and suppliers can be facilitated through the work with one validated model status by all parties involved.

Establishing the master model has demonstrably increased the model quality. As a result, the user community has steadily grown. The superordinate database allows for the implementation of efficient processes and effective management of individual projects. Due to the shared and continuous availability of the models and CarMaker files, the development process can be efficiently optimised. The most important aspects of the master model approach are shown in **FIGURE 5**.

REFERENCES

[1] Schmidt, S.; Henning, J.; Wambera, T.; Kronimus, S.: Early PC-based Validation of ECU Software Using Virtual Test Driving. In: ATZelektronik worldwide 10 (2015), No. 1, pp. 14-17

[2] Schaffnit, J.: A Master Model approach for system simulation using IPG CarMaker. Technologiekonferenz Apply & innovate, Karlsruhe, 2014

[3] Bauer, M.; Kochem, M.; Hahn, K. M.: Virtuelle Applikation elektromechanischer Lenkungen. VDI-Tagung Autoreg, 2015

[4] Holzmann, H.; Hahn, K. M.; Weyer, F.; Römer, M.; Webb, J.; Boltshauser, S.; Tosolin, G.; Bu, Q.: Simulationsbasierte Homologation von ESP-Systemen gemäß ECE-R 13-H. 12th Stuttgart International Symposium Automotive and Engine Technology, March 2012

[5] Holzmann, H.; Hahn, K. M.; Webb, J.; Mies, O.: Simulation-based ESC Homologation for Passenger Cars. In: ATZworldwide 114 (2012), No. 9, pp. 40-43

[6] Schaffnit, J.; Kochem, M.: Virtual Validation – the OEM's Perspective. 2. Symposium Fahrsimulatoren, Berlin, 2016

THANKS

The authors thank IPG Automotive, especially Oliver Mies and the Service Team, for their support during the project.