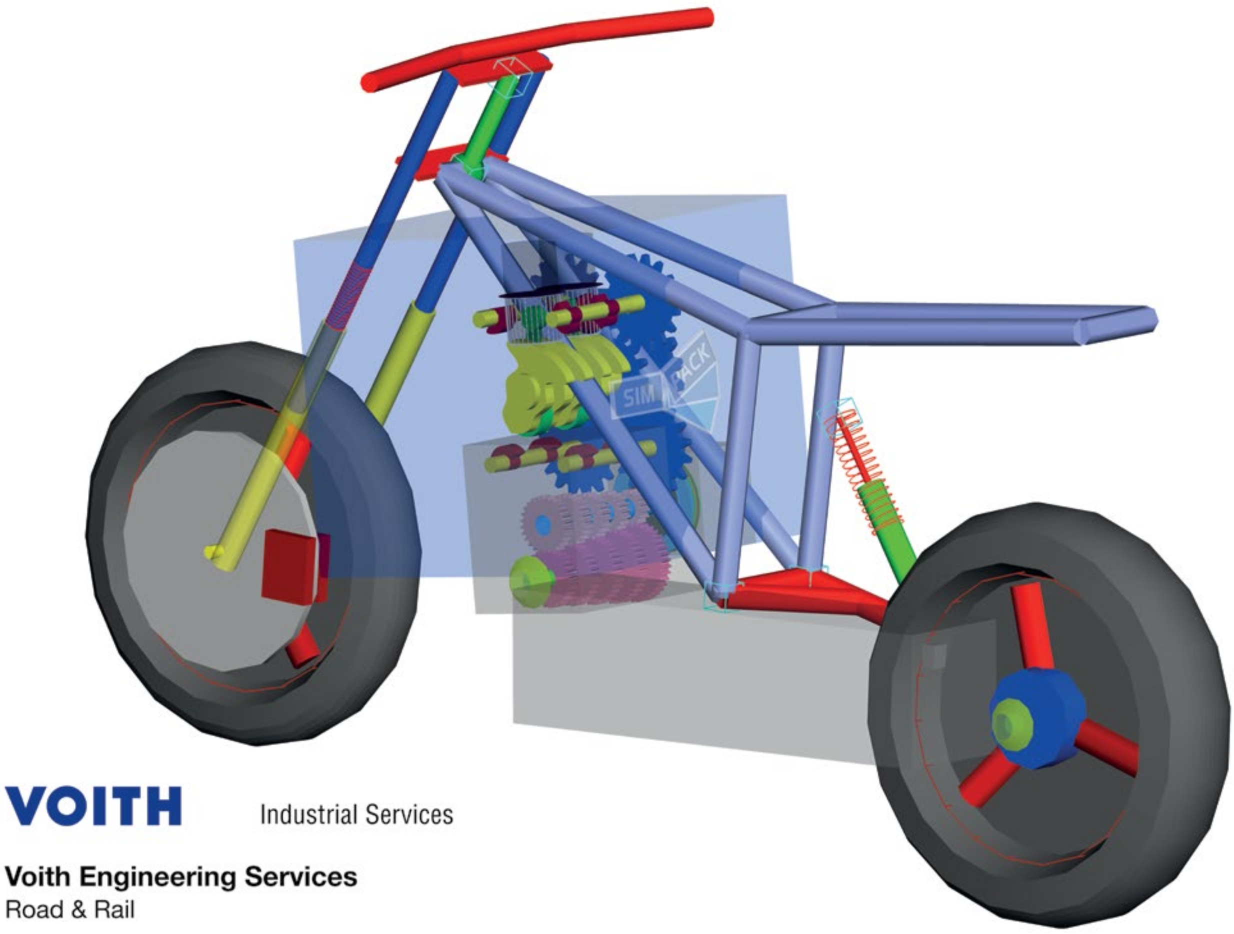
Development of a Model Library for Motorcycle Drivetrain Components



Although just a few years ago a lot of time-consuming test series were still being carried out during the road vehicle development process, these are now increasingly being replaced by complex multi-body simulations. The great advantage over physical testing is the possibility of quickly and cost-effectively varying the vehicle configuration and then comparing the different versions to each other. This can be based on a model database such as the one for motorcycle simulations at the Technical University of Dresden.

INTERACTIONS BETWEEN VEHICLE, DRIVETRAIN AND DRIVER

The previous model database included several constellations for frame and chassis. The drivetrain was "simulated" via a drive torque that acts directly on the rear wheel. However, all of the interactions between drivetrain and vehicle were lost as a result, even though they have a major impact on safety and comfort, especially for two-wheelers. For example, the drive torque could be too large and lift the front of the vehicle, or if the delay when down shifting is too long, the rear wheel can lock.

The driver can, however, considerably influence the vehicle's handling characteristics through his behavior and, in turn, react to any changes while driving. In order to take this into account, the TU Dresden has a driver controller that controls the multi-body simulation by means of a Simulink® co-simulation. However, since every driver acts and reacts differently, several driver profiles are stored in order to represent typical driving behaviors.

> *"...several driver profiles are stored in order to represent typical driving behaviors."*

MODEL LIBRARY FOR MOTORCYCLE DRIVETRAINS

In order to consider the influence of the drivetrain in future simulations, the creation of a model library including the customary motorcycle drivetrain constellations is now planned. These include engines with in-line, V and Boxer design, a friction clutch, two and three-shaft transmission, as well as secondary drives in a belt, chain and drive shaft design. For the exact configurations, only a few different components are connected to each other within a housing in the desired number and position.

The idea is to construct the models from a library in this way as well. A few modeled components are assembled to form an overall unit. The modeling depth will initially be limited to the most important functions and individual components. The use of flexible bodies is not yet planned.

Models are created using a script to facilitate the process as much as possible for library users. The script queries the desired configuration via user interfaces (see Fig. 1), and then creates the appropriate model.

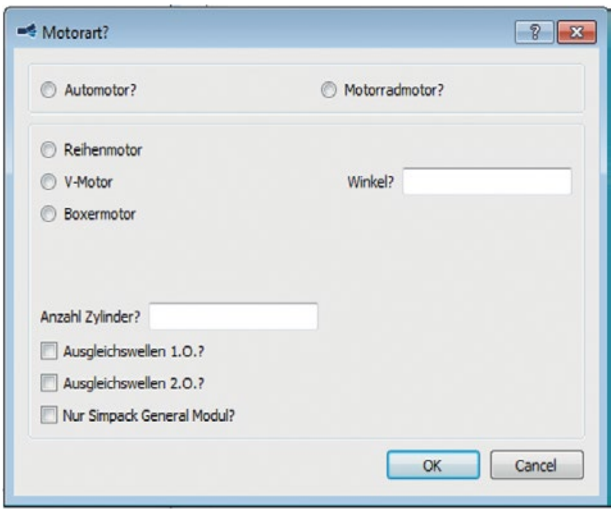


Fig. 1: Example of a GUI

The model can then include individual drive components or an entire motorcycle drivetrain. One possible result of such a query is shown in Fig. 2, a complete drivetrain consisting of a two-cylinder engine, a five-speed gearbox and a belt drive.

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Thanks to the complete parameterization of the individual models and sub-components, complete vehicles can be easily adapted to suit desired performance characteristics.
By simulating various typical scenarios, the functionality of the mod-els was ensured. This was checked on a purely qualitative basis as there was too little experimental data to carry out a quantitative validation.

ADJUSTING THE DRIVER CONTROLLER

In order to account for the drivetrain by using co-simulation in the future, the driver controller must be adjusted accordingly. Previously, one control loop for longitudinal and one for lateral dynamics was included. These are linked together in order to model the driver's intelligence. As a complete reworking of the driver controller was not part of this actual project, only one drive control was added to the longitudinal dynamic control loop. Information on the throttle and clutch operation, as well as gear selection is also provided via the SIMAT interface during co-simulation.

INTEGRATING THE DRIVETRAIN INTO THE OVERALL VEHICLE

In order to simulate the entire vehicle, including the drivetrain, the latter is integrated as an overall model into a vehicle model (see Fig. 3) using the previous model database.
This merely requires connecting the two interfaces (vehicle frame plus drive housing and secondary drive plus rear wheel) to each other. Functionality was tested using typical scenarios that could be easily understood by anyone. Shifting up into highest gear was thus simulated by way of example, ensuring the main function of the vehicle drive system. The typical "pitching" motion of the vehicle during shifting operations was also observed in the process.

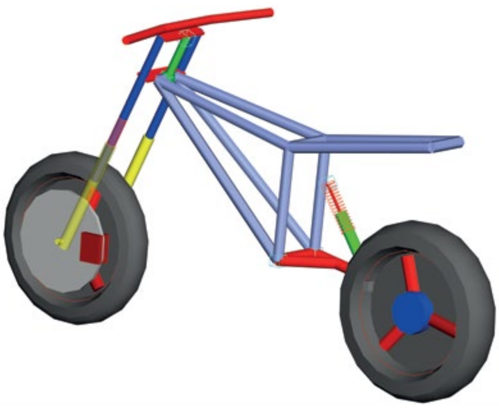

Fig. 3 : Example from an old model library

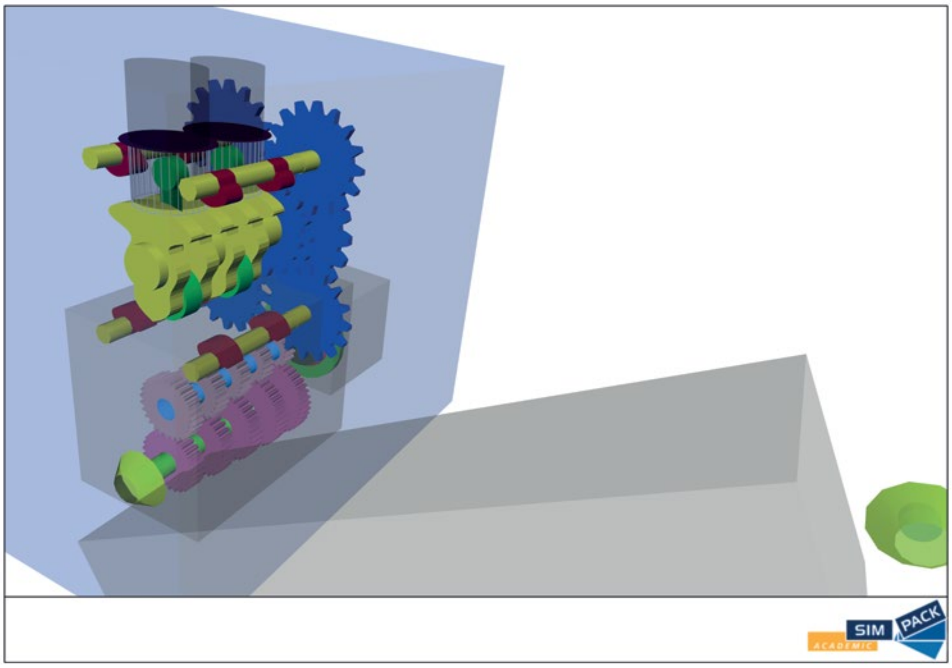

Fig. 2 : Example of a complete drivetrain

PROSPECTS

Using the model library, different drivetrains can be modeled at the Technical University of Dresden and then integrated into an existing motorcycle model. This overall model can be used for illustration in teaching or for research purposes. It is easy to extend the version options and modeling depth thanks to scripted construction and almost complete parameterization. Even its use in simulating passenger car models is conceivable with minor adjustments. However, to completely take into account the considerable influence of the driver's intelligence, a relevant adjustment of the driver controller is required.

NOTE

This article is based on a diploma thesis created at Voith Engineering Services GmbH Road & Rail in cooperation with the Technical University of Dresden.