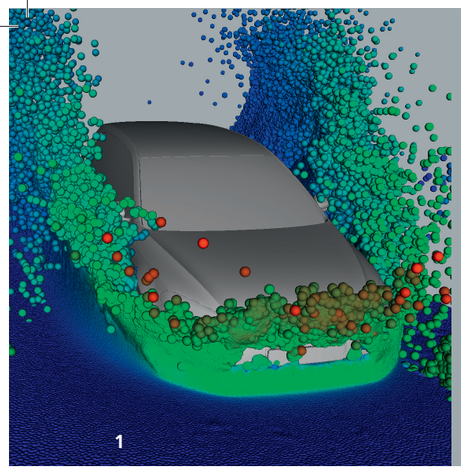

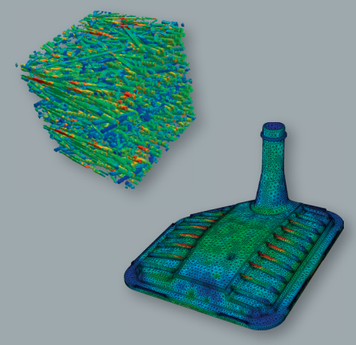

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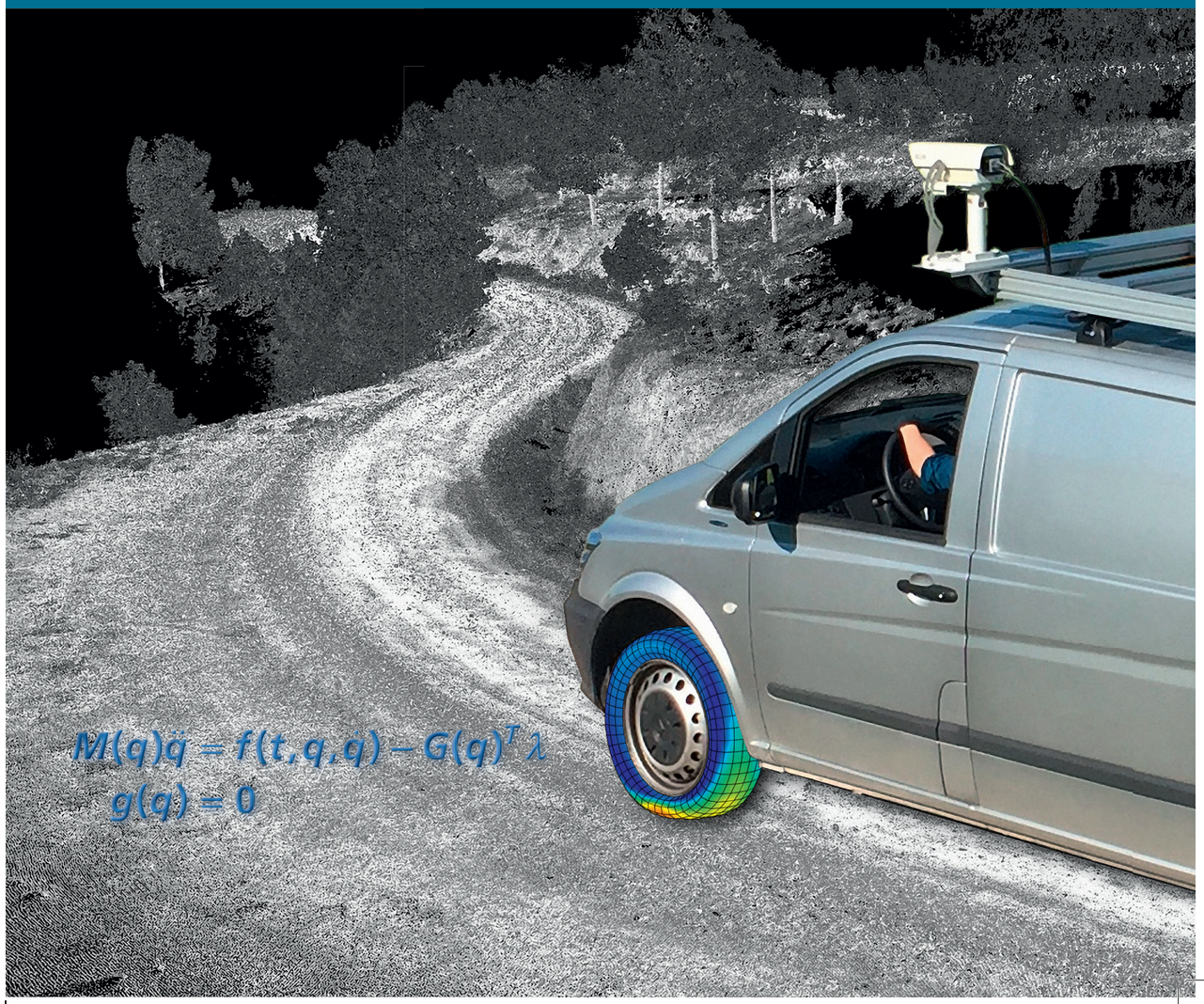
FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS ITWM

PARTNER TO THE VEHICLE INDUSTRY



1 Parallel interactive visualization of aquaplaning

2 Virtual lightweight design

3 Detection of dirt residues

Fluid dynamics

The Finite Pointset Method (FPM) is a mesh-free numerical simulation system for problems in continuum and fluid mechanics. It is based on a numerical cloud of points representing the fluid. The point cloud moves with material velocity, thus the method is geometrically self-adaptive and no additional computational effort is needed for handling moving parts of the geometry, free surfaces, as well as phase boundaries. For some applications in car industry, the method is a unique tool in the development and design process: water crossing, spray, filling and sloshing phenomena in tanks, as well as airbag deployment. Moreover, simulations run fast and the method is characterized by extremely short preprocessing times, as no meshes are needed.

Multiscale simulation / Virtual material design

Effective material properties (such as permeability, thermal conductivity, damping, mechanical stiffness and strength) of porous materials (e. g. textiles, nonwovens) and composite materials (e. g. GFRP, CFRP) can be computed from the geometrical microstructure and physical properties of the single constituents. By using methods and software developed at ITWM, the influence of microstructural parameters on the effective material behavior is obtained straightforwardly and without the necessity of manufacturing all material variants. The commercially available software GeoDict is especially qualified for this purpose. Virtually determined effective mechanical properties for small or large (finite) deformations are widely used for crash simulation as well as for the simulation of long-term creep / fatigue (mechanical aging). For porous materials the permeability often depends on compressive loads appearing in applications. The simulation of such dependencies is frequently applied for the design of filter media or fuel cell components.

Automated solutions for the surface inspection

The quality of a product often depends on the quality of its surface, and each type of surface has its own quality metrics, which can include a wide range of properties. The surface inspection system of Fraunhofer ITWM – Modular Algorithms for Surface InspeCtion (MASC) – includes a large number of ready-to-use tools and system components, which are individually adapted and combined. Before an automated inspection is installed in the production line, the technical feasibility is investigated in a preliminary study. Possible hardware setups are developed and tested using suitable sample parts in the image processing laboratory, always taking into account the later production conditions. Fraunhofer ITWM offers inspection systems for the automotive industry, e. g. for expansion cells, brake discs and gaskets. Also the quality control of filters for vehicles is possible or the inspection of the car painting.

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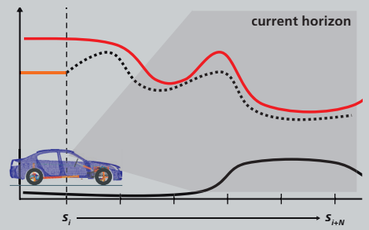

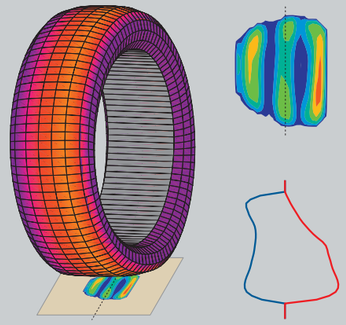

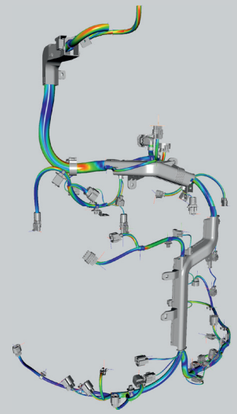

Numerical simulation is a big and still growing part in all vehicle-engineering processes. Fraunhofer ITWM is actively driving this with the development of advanced mathematical modelling and simulation technologies for virtual product development, i. e. for the assessment, optimization and validation of vehicle performance and manufacturing.

System simulation

The goal of system simulation is both the analysis and the optimization of system properties (e. g. driving dynamics, vibrations, ride comfort) and the derivation of relevant output quantities, such as section forces for components or subsystems. The latter can be combined with detailed models to evaluate and to optimize a component with respect to durability and reliability.

Modern vehicles and their modules are mechatronic systems of high complexity. Thus, corresponding simulation models from different physical domains with different numerical properties are inevitable. Fraunhofer ITWM develops methods and algorithms for coupled simulation approaches (co-simulation). Moreover, an appropriate system excitation plays a crucial role for a realistic simulation: modern methods from the area of nonlinear optimal control are developed and applied, in order to compute such excitations based on measured quantities. For instance, one is able to derive virtual road profiles based on measured wheel forces or accelerations. Finally, Fraunhofer ITWM develops realtime capable models and highly efficient numerical solvers, which can be used during runtime of a machine (e. g., for monitoring purposes) or in connection with interactive (driving-) simulators.

Interactive simulation / RODOS®

During very early stages of vehicle development process the human-vehicle interaction is a challenge. All relevant interactions between vehicles, drivers, conventional non-automated vehicles, pedestrians and the infrastructure have to be considered during development process. Vehicle manufacturers and suppliers can accelerate the iteration cycle time for system development significantly. Additionally the use of our interactive simulation tool chain allows a reduction of development risk and costs. The new development environment available at ITWM uses georeferenced 3D laser scanner data for the scenario design, which brings real streets or entire test areas into the simulation. The modular design allows the integration of hardware-in-the-loop simulations such as ECUs testing combined with a human operator in the simulator.

Durability and reliability

Fraunhofer ITWM performs numerical fatigue life calculations based on state-of-the-art methods and software solutions. If required, methods are adapted to specific needs, e. g. for turbochargers, and results are used for the assessment of the load path in the system and the durability of components. In case of physical testing on a rig, one often needs to reduce the high number of section loads to a small number of actuators without distorting the hot spots and the fatigue life. Once the rig configuration and corresponding loads are given, one has to decide how many specimens need to be tested to guarantee a certain reliability and confidence level for releasing the component or for estimating a fatigue life quantile.

In all these fields, Fraunhofer ITWM offers a variety of methods and solution approaches, develops adaptions and new algorithms, applies those within consulting projects, and provides software solutions.

Fuel consumption and emission in different applications

Statistical methods play an important role not only during development of mechanically loaded components but also for the assessment of consumption and emission of a vehicle in its real field usage. Initially, the usage variability needs to be described and modelled according to the combination of different users and different environments. Which road types are used by a Van in Eastern Europe in a mainly city-dominated application? What is the distribution of upward and downward slopes and what is different compared to Western Europe?

Such and similar questions are treated systematically at Fraunhofer ITWM based on statistical methods and a geo-referenced database. Amongst other things, this comprises the simulation of usage scenarios (e. g. commuters in France) using VMC® methods, the geo-referenced evaluation of data measured on public roads (VMC® GeoLDA), and the extrapolation of such data to expected load distributions in the field (U·Sim). The department Mathematical Methods in Dynamics and Durability develops methods towards the solution of all these tasks, executes application projects, and offers corresponding software solutions.

Tire

In the virtual development process, the assessment and optimization of vehicle suspension and chassis performance are based on the forces that are transferred by the tire from road into suspension. In this load transfer, the tire is one of the most critical components because it has a strong nonlinear behavior and is very difficult to model. ITWM's tire model CDTire supports engineers in almost all analysis scenarios used in modern vehicle development processes within modern multibody simulation tools. Special focus on tire belt dynamics and interaction with 3D road surfaces allows to accurately capture the vibrations in both amplitude and frequency behavior. CDTire supports different applications by adapting the model complexity in balancing the simulation performance and the problem requirements. The CDTire/3D is a structural 3D shell based bead-to-bead model with sidewalls and belt that separately models all functional layers of a modern tire. Derived from this model are: CDTire/Realtime, which is a hard-realtime capable tire model for ride, comfort and durability applications; CDTire/MF++, which is an enhanced Magic Formula to feature the temperature dependency of an tire and CDTire/NVH, a linearized version of CDTire/3D for usage in FEM based NVH-tools.

Furthermore, within the CDTire family there is a dedicated temperature model CDTire/Thermal to predict the temperature creation and propagation in a tire. This can be coupled with the mechanical tire model CDTire/3D and CDTire/MF++. CDTire is available for the following simulation-tools: MSC.Adams, Simpack®, Altair MotionSolve, LMS Virtual Lab® Motion, Matlab® and Simulink®.

Cables and hoses

The software IPS Cable Simulation provides an easy-to-use and extremely helpful tool to perform physically correct interactive simulations of the deformation behavior of cables and hoses for functional digital mock-up and digital validation. Besides virtual assembly planning for slender flexible parts like single cables, wiring harnesses and hydraulic or pneumatic tubes and hoses, the software supports also robotics simulation with flexible dress packs. IPS Cable Simulation is jointly developed by ITWM and the Fraunhofer-Chalmers Research Centre FCC.

1 *Inclusion of vehicle-environment-human interaction in virtual product development*

2 *Interactive simulation with RODOS in a point cloud scenario*

3 *Calculation of speed profiles along a route*

4 *Tire simulation with temperature and contact force distribution*

5 *Simulation of wiring harness*