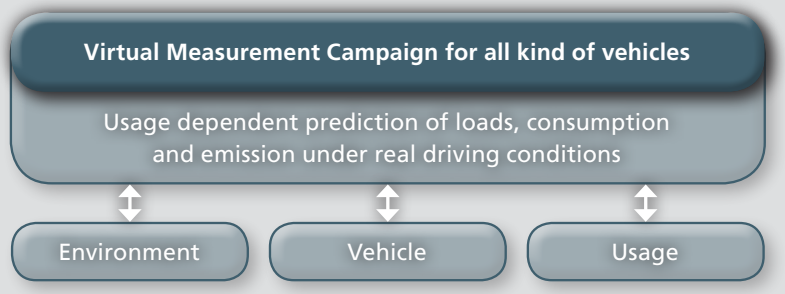
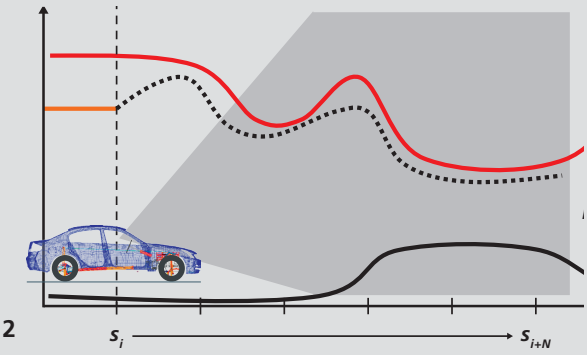
Fraunhofer
ITWM

FRAUNHOFER INSTITUTE FOR INDUSTRIAL MATHEMATICS ITWM



1



2

VMC

VMC® – Simulation

1 *VMC platform: main components*

2 *Speed profile computation based on driver, vehicle, and route information*

Fraunhofer-Institut für Techno- und Wirtschaftsmathematik ITWM

Fraunhofer-Platz 1
67663 Kaiserslautern
Germany

Contact
Dr. Michael Speckert
Phone +49 631 31600-4565
michael.speckert@itwm.fraunhofer.de

Dr. Michael Burger
Phone +49 631 31600-4414
michael.burger@itwm.fraunhofer.de

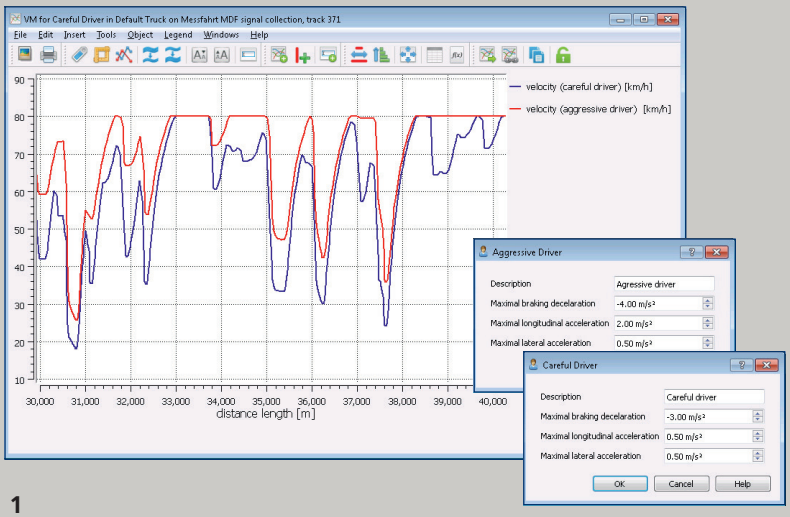
www.itwm.fraunhofer.de/en/vmc-simulation

Geo-referenced Simulation of Loads and Energy Efficiency for Vehicle Engineering

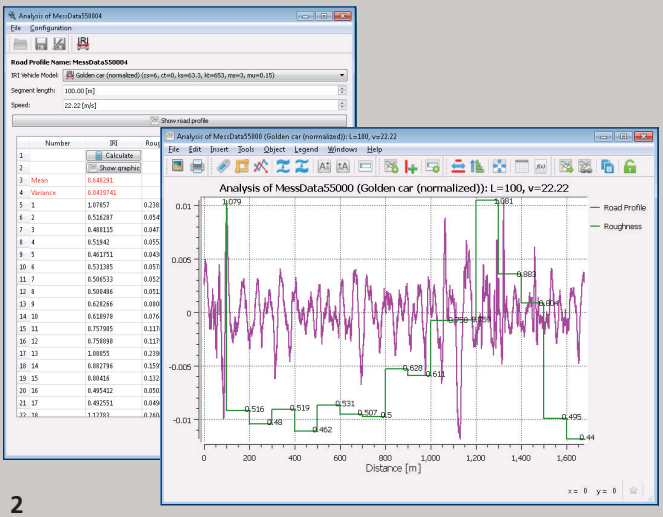
In the modern vehicle development process for global markets, sufficient information and knowledge of the corresponding environmental conditions are crucial for targeted design requirements. This concerns both durability of chassis, suspension and other components as well as consumption and energy efficiency for drivetrain design. Thus, global geo-referenced data plays an important role in the statistical assessment of usage variability and dervied design targets. In addition to VMC GeoStatistics, VMC Simulation provides the possibility to simulate vehicle loads and performance based on suitable vehicle and driver models embedded in an environmental model, which obtains its key information from the VMC geo-referenced database. VMC Simulation contains models that feature longitudinal, lateral and vertical dynamics. Those models can be used to predict vehicle loads for different vehicle and driver types, on different routes in the world and, thus, reveal a deeper insight in the effects of locally different conditions.

Use Cases

- **Drivetrain development:** Calculation of vehicle and drivetrain loads on routes in different regions of the world. Prediction of **customer-specific usage profiles** in terms of drivetrain characteristics (e. g. engine speed and gear collectives). Fast derivation of reference routes for analyzing **real driving emissions (RDE)** and developing **advanced driver assistance systems (ADAS).**
- **Fuel Consumption and efficiency:** Estimation of fuel consumption, prediction of potential savings and assessment of constructive modifications
- **Durability:** Estimation of longitudinal, lateral and vertical loads for the development of chassis, suspension and other components



1



2

VMC Simulation: Speed Profiles

A core functionality of VMC Simulation is the calculation of speed profiles for chosen vehicle model, driver type and route. Depending on the available information, vehicle models of different complexities can be considered. Relevant vehicle characteristics are, among others, vehicle mass, maximal driving power and torque and, if available, drivetrain parameters, such as transmission ratios. Route information, including slope, curvature, legal speed limits and traffic signs, are gathered from the database and, together with a driver model and traffic information, an optimal control problem is formulated and solved numerically to generate the speed profile result.

Apart from the speed profile, the simulation results contain longitudinal and lateral vehicle forces, resistance and driving forces, selected gears (if drivetrain parameters are available), fuel consumption and possible savings, e. g., in order to assess aerodynamic modifications.

VMC Simulation: Road Profiles

VMC Simulation also addresses vertical dynamics stimulated by road roughness and travelling. The software provides methods to compute road roughness indices (e. g. the international roughness index (IRI)) from measured road profiles as well as methods to compare different indicators. VMC Simulation also allows to generate road profiles based on a given set of indicators (using stochastic processes) Moreover, if information about the vehicle suspension is available (sprung/unsprung masses, stiffnesses and damping characteristics), VMC Simulation is able to estimate vertical forces and damage indicators. ITWM also offers methods to back-calculate road profiles from measured vehicle quantities (such as accelerations and spring displacements) on request.

VMC Simulation and Related Activities

The department **Mathematical Methods in Dynamics and Durability** at Fraunhofer ITWM is active in modeling and simulation of usage variability, dynamic loading and energy efficiency of vehicles and machines. We are developing statistical methods for durability, reliability and energy efficiency.

Our software development projects **Virtual Measurement Campaign (VMC), Usage Simulation (U·Sim)** and **Statistics for Fatigue Testing and Reliability (Jurojin)** combine statistical and simulation methods with geo-referenced data in a unique novel way. These tools support the entire process from the description and modeling of the usage variability, the derivation of reference loads and consumption related quantities to the design of rig tests or reference routes. VMC Simulation is an important part within these activities.

1 *Two speed profiles for different drivers*

2 *Road profiles with computed IRI values*

Database

- World-wide road network
- Traffic signs, limitations, one-ways, bridges, etc.
- Topography (hilliness, curviness, etc.)
- Traffic and road quality (selected regions only)

Main features of VMC Simulation

- Driver models characteristic acceleration stochastic variations
- Vehicle models mass, engine power, air and rolling resistance as well as parameters describing longitudinal and vertical dynamics (such as transmission ratios or suspension stiffnesses)
- Definition of traffic on road segments including stochastic variations
- Calculation of speed profiles respecting vehicle-, driver- and route-dependent restrictions and conditions
- Import or back-calculation of road profiles or road roughness indicators
- Calculation of roughness indicators for given profiles
- Calculation of longitudinal, lateral and vertical loads and other quantities

System requirements

- Windows 7 64-Bit or later
- 4GB RAM or more
- PostgreSQL database server with at least 2TB storage (database and workspace)