VMC® – Geo-Referenced Data for Vehicle Development

Environmental Data and Simulation for Vehicle Engineering

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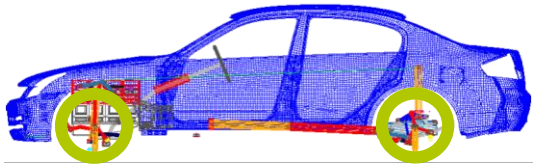
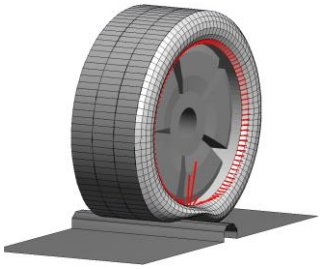
Fraunhofer ITWM

Fraunhofer ITWM
‘Vehicle – Environment – Human Interaction’

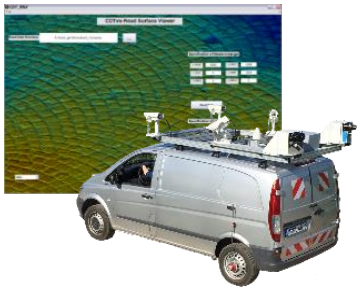
driver / operator



vehicle



tire



ground/road, environment

Challenge: designing vehicles for different countries, different ‚tasks‘ (commuters, parcel service, taxi,…), different individuals

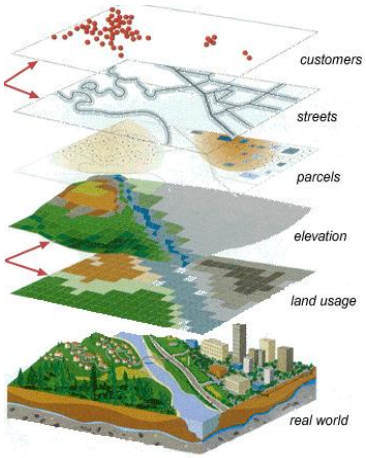
Database and modules

VMC

VMC® Data Base

Data sources
synthesized by ITWM

Regulations	Road network	Traffic
Topography	Climate	Road quality
■ Slope	■ Temperature	■ Roughness
■ Curves	■ Humidity	■ Surface
■ …	■ …	■ …



VMC
GeoStatistics
Fahrzeugunabhängige statistische Analyse von Regionen und Routen

VMC
GeoLDA
Geo-referenzierte Lastdatenanalyse

VMC
Simulation
Geschwindigkeitsprofile, Energieverbrauch, Emission und Beanspruchung

U·Sim
Simulation von Verteilungen über Nutzungsarten

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Exploring vehicle performance in its environment

Goal: Geo-referenced simulation of vehicle performance on the road.

Typical applications

- **Durability:** Estimation of loads for chassis, suspension, other components
- **Drivetrain development:** Calculation of vehicle and drivetrain loads on any route in the world. Prediction of customer-specific usage profiles in terms of drivetrain characteristics.
- **Fuel Consumption and efficiency:** Estimation of fuel consumption, prediction of potential savings. Fast derivation of reference routes for analyzing real driving emissions (RDE).
- **ADAS and AD:** Derivation and provision of environmental data (scenarios) for simulation and testing based on statistical reasoning.

VMC Database: Environmental Data

VMC

Route Data

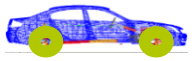
- Geometry, altitude, slope, curvature,…
- Legal speed limits, traffic signs, stops,….
- Road types, road roughness

Traffic Simulation

Driver Model

driver characteristics: careful, aggressive;
objectives: time, consumption, comfort,….

Vehicle Model



vehicle characteristics; vehicle type, drivetrain parameters,…

VMC Simulation Core

- ***Optimal Control Methods***
- Calculation of
  - speed profiles and other drivetrain quantities
  - driving resistance forces
  - energy consumption

VMC Simulation

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Data and simulation for the generation of dynamic scenarios

OpenSCENARIO®
bringing content to the road

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VMC

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Route Data

Export

OpenDRIVE®
managing the road ahead

VMC TrafficSimulation

Driver Model

Vehicle Model

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VMC Simulation

traffic

speed profiles,
usage models,

….

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VMC traffic allows different options to include traffic dynamics

1. Stochastic Macroscopic Traffic Simulation

- Based on traffic densities as starting point
- Traffic dynamics are modelled by a specific stochastic process (log-AR1)
- „Safe-Distance-Rule“ is used to transform traffic densities on speed level
- Status / rules for traffic lights …

Traffic Densities → **Stochastic Process for Traffic Dynamics** → **Safe-Distance-Rule**

- Available default values per road type
- Adjustable by user to study sensitivities
- Measured data can be included, if available

$$d_{veh}(s) = X_{traffic}(s) \cdot D_{veh}(s)$$

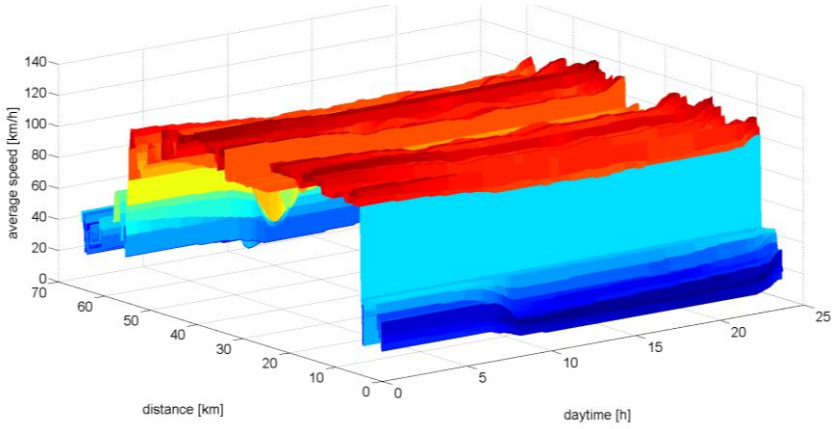
log-AR1 process

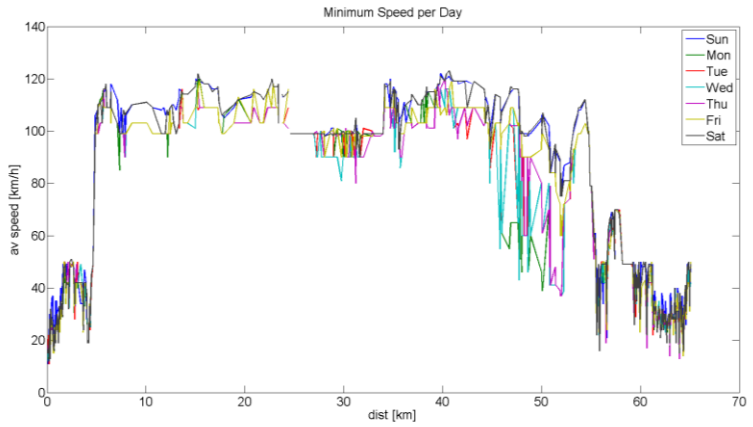
$$\Delta s_{save}(s) = l_{veh} + \alpha \cdot v + \beta \cdot v^2$$

VMC traffic allows different options to include traffic dynamics

2. „Traffic Pattern“ from the here database

- For specific routes, „traffic patterns“ may be gathered from the here database.
- Traffic pattern: Historic average speeds by kilometer along the route and by daytime (in a 15min-grid) for seven weekdays.
- Can be directly included in longitudinal dynamics simulation (speed level).





VMC Driver Model

Driver Modelling in general is an active field of research in the ITWM

- Within VMC, the driver is modelled by:
  - **bounds** due to maximal and minimal tolerated longitudinal and lateral accelerations,
  - a **stochastic process** modelling the driver‘s willingness to (slightly) violate these bounds,
  - a **stochastic process** modelling the driver‘s willingness to (slightly) violate legal speed limits,
  - **weight factors** in the objective of the formulated optimal control problem balancing, e.g., time and energy consumption

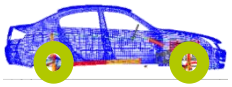
Longitudinal Dynamics in VMC Simulation

Only very few parameters needed!

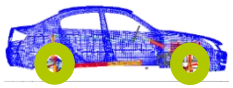
Drivetrain-Parameters needed.

Driver

Vehicle – 1st level



Vehicle – 2nd level



Quelle: www.technik.-welten.de

Traffic Model

VMC-DB

- ✓ Curvature,
- ✓ Slope,
- ✓ Traffic (-signs)

Phase 1
Preprocessing
Speed profile generation: considering vehicle's mass and driving power

v_1

Phase 2
Full dynamic model including drivetrain
Formulation and Solution of an optimal control problem

v_2

Phase-1-Results

- Speed, acceleration
- Estimation of driving- and resistance-forces
- Estimation of energy and power

Phase-2-Results

- Speed, acceleration
- Estimation of driving- and resistance-forces
- Estimation of energy and power
- **Engine-Speed, -Torque**
- **Gear**
- **Consumption**

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