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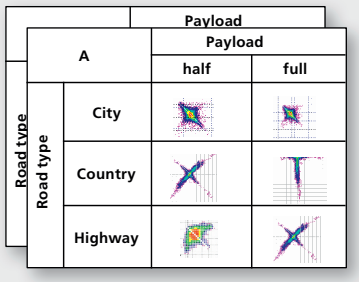
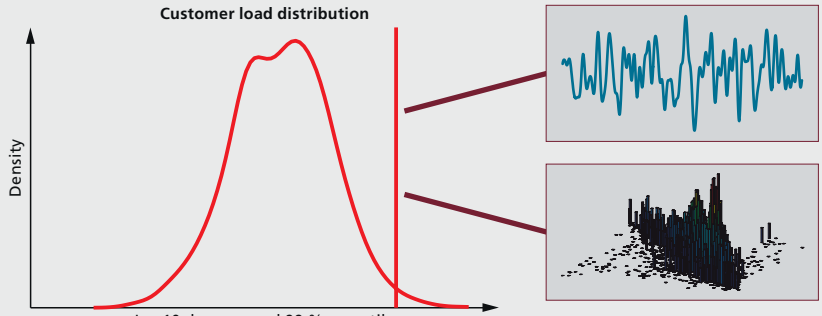


1 Data of measurement campaign



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U·Sim

U·SimOpt

U·SIM – SIMULATING VEHICLE USAGE FOR DURABILITY AND RELIABILITY

1 *Factor model schematics*
2 *Load distribution*

Vehicle design has to strike a compromise between durability and reliability on one hand, as well as cost and energy efficiency on the other hand. An ideal design target for a component introduces only moderate overdesign as a safety margin. To obtain such a target, it is necessary to understand actual vehicle usage on public roads by different customer groups over the entire design life.

For this purpose, most vehicle manufacturers nowadays conduct extensive measurement campaigns on public roads. To derive a qualified design target, they need to answer the questions of (a) what and where to measure and (b) how to extrapolate the results to a certain target mileage.

As there are usually different kinds of customers – e. g., commuters, taxi drivers, etc. – it is not sufficient if the measurement campaign replicates one particular customer. Also, an average customer mostly uses the vehicle in a manner that causes little fatigue damage. Instead, a measurement campaign should ensure that all corner cases are covered, even if they are only experienced by a small fraction of the customer base.

The scope of U·Sim

The purpose of the U·Sim software developed at Fraunhofer ITWM is to simulate durability loads representing a vehicle's entire design life ("virtual customers") based on selective measurements on public roads. The key to the solution is to separate between (a) the exploration of the different operating states by appropriate measurements and (b) the recombination of these states based on usage models.

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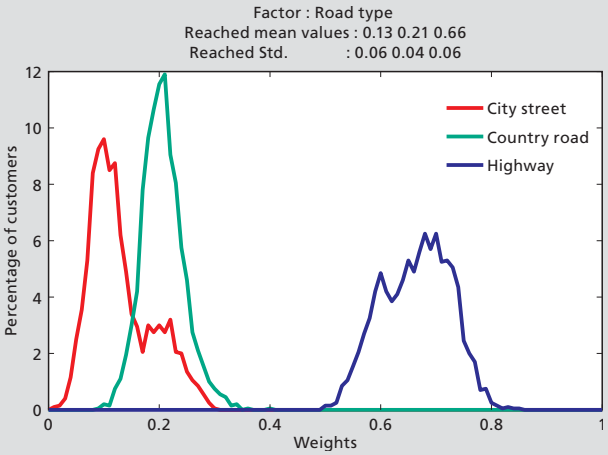

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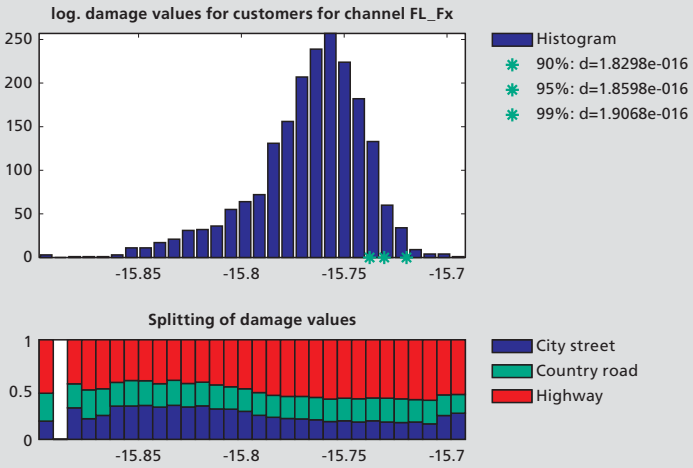

2

Usage modeling

For this task, the measurement data needs to be cut into atoms (tracks of a certain maximum length) and classified according to a factor model. For example, each track could be ranked according to road type, payload, and traffic conditions. Customer groups are then defined by prescribing the frequency and variability of the operating states constituting the factor model.

Deriving design targets by simulating "virtual customers"

The U·Sim software generates a large number of customers with different mission profiles by recombining the atoms using Monte-Carlo simulation. Each customer is represented by a multi-channel load collective – rainflow matrices for measured forces, torques, accelerations, etc. – consisting of a selection of atoms with repetition factors. Using pseudo-damage numbers, quantile customers for each load channel (often a 99 % worst customer) can be identified. Together with safety factors and special maneuvers, these customers define a design target that is explicitly related to public road conditions.

Mapping to the proving ground by U·SimOpt

U·SimOpt supports mapping the design target to proving ground measurements to generate a real-life test schedule or provide a compressed description of the load for simulation of sectional forces using MBS and FEM. Also, the proving ground schedule can be considered a vehicle-independent description of usage, at least with respect to the same class of vehicle and customers.

Benefits of U·Sim

- Measurement campaigns can focus on covering all states of interest, not only one particular customer.
- By changing the parameters describing the customers, different customers and markets can be simulated from the same set of measurement data.
- Customers are related explicitly to public road conditions, realistic load spectra (rainflow) are available.
- No simplifying assumptions regarding the load distribution (e. g., log-normal probability density) are necessary.
- U·Sim Opt has various options for mapping the design target to proving ground tracks, depending on the requirements (actual proving ground tests or simulations).
- The approach also applies to construction or agricultural machinery.

1 *Simulated weights for factor road type*

2 *Damage histogram*

Features of U·Sim

- Analysis of input data (measurements, factor-model etc.)
- Definition and simulation of customer groups and populations
- Calculation of quantiles and analysis w. r. t. factors
- Sensitivity analysis of customer group parameters
- Automatic simulation, analysis and export for predefined populations and parameters
- Superposition and extrapolation of quantile customers
- Visualization and Excel export of simulation and evaluation results

Features of U·SimOpt

- Map the design target to a proving ground schedule subject to various constraints
- Interactive modification and re-optimization of constraints and objective function
- Visualization and Excel export of evaluation results

System requirements

Minimal: U·Sim and U·SimOpt run on any 32-bit Windows system. MS Excel 2007 or later must be installed since U·Sim uses .xlsx as standard input/output format.

Recommended: A 64-bit Windows system is recommended for handling larger datasets.