

Leaf Spring Modeling in SIMPACK: A New Approach to Model-Diversity

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- Motivation
- Component-modeling – leaf spring
 - Functionality
 - Model-diversity
 - „Massless“-model
 - SIMBEAM-model
- Validation by test rig results
- Leaf-Spring-Generator (LSG)
- Summary

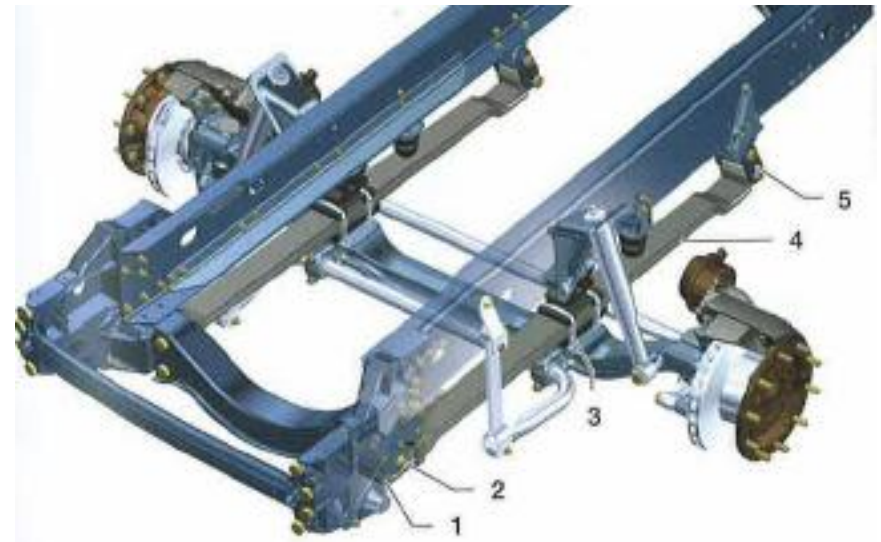


image courtesy of MAN Truck & Bus AG

State of the Art

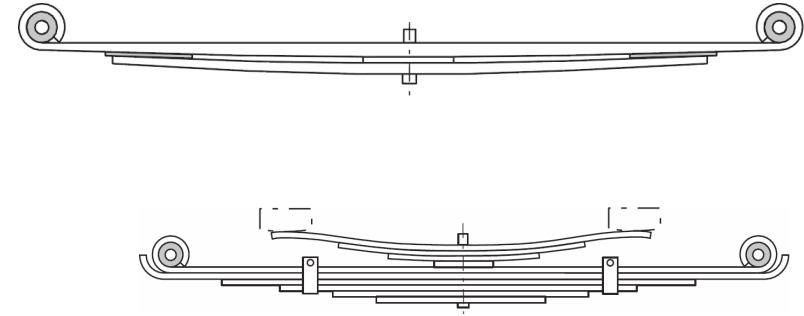
- No standards in component-modeling (air-, leaf-spring, etc.)
 - Uncertain and fault-prone modeling process
 - Hard-to-compare simulation results
- The quality of the model depends on the
 - Experience of the user
 - Methodology
 - Availability of measurement data

Main goal of this Project

- Knowledge-based and standardized component modeling
- Model-generator and data input process

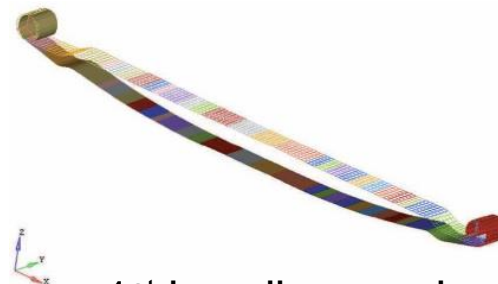
Leaf springs

- Widely used in heavy vehicles
- Robust component
- Low cost
- Main tasks
 - Spring function (z)
 - Control of the axle (y, x)



- Main deformations

- 1st bending – deflection
- 2nd bending (S-shape) – braking



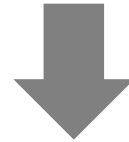
1st bending mode



2nd bending mode

Model-Diversity

Choice of the
model-complexity



Simple model

Standard model

Complex model

- e.g. linear vertical stiffness
- high computational efficiency
- only for the concept phase

- important physical effects
- S-bump
- geometrical coupling

- more necessary effects
- bearing eye
- twisting
- dynamic effects

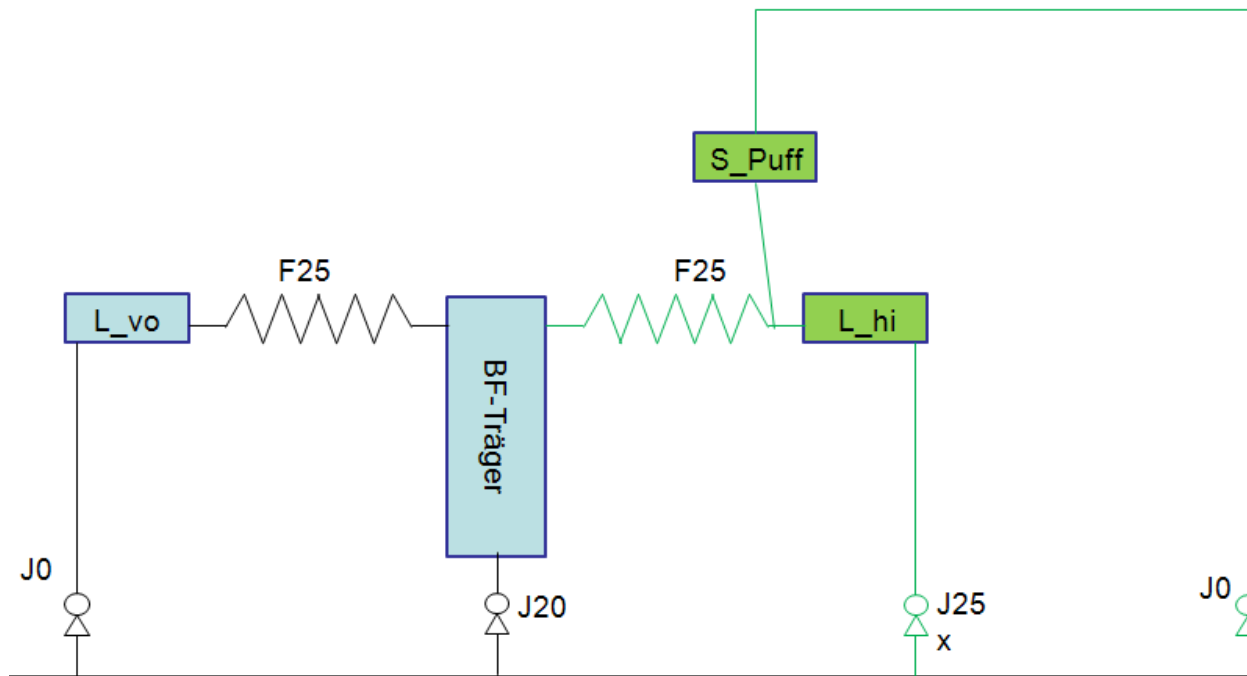
- Higher model-complexity → more modeling demand and CPU time
 - Switching between model-types → no flexibility, in most of the cases new model necessary
- Leaf-Spring-Generator: automatized process

„Massless“-model

- User Routine - force element (UForce – massless beam)
- Neglects the mass influence – static model
- Concept
 - 2..10 3D beam elements
 - Deformed shape → linear beam static
 - Nonlinear coupling between displacement and rotation
 - Data-input modes
 1. Geometry-based: discretized sections $\{x_i, h_i, b_i\}$
 2. Vertical stiffness-based: requested stiffness with deviation ($C_z, \Delta C_z$)

„Massless“-model

- One force element for the half of a leaf spring
- Model approach: cantilever beam
- Generalized coordinates only at the end nodes → Guyan-reduction → efficient time integration
- S-bump internally handled



„Massless“-model

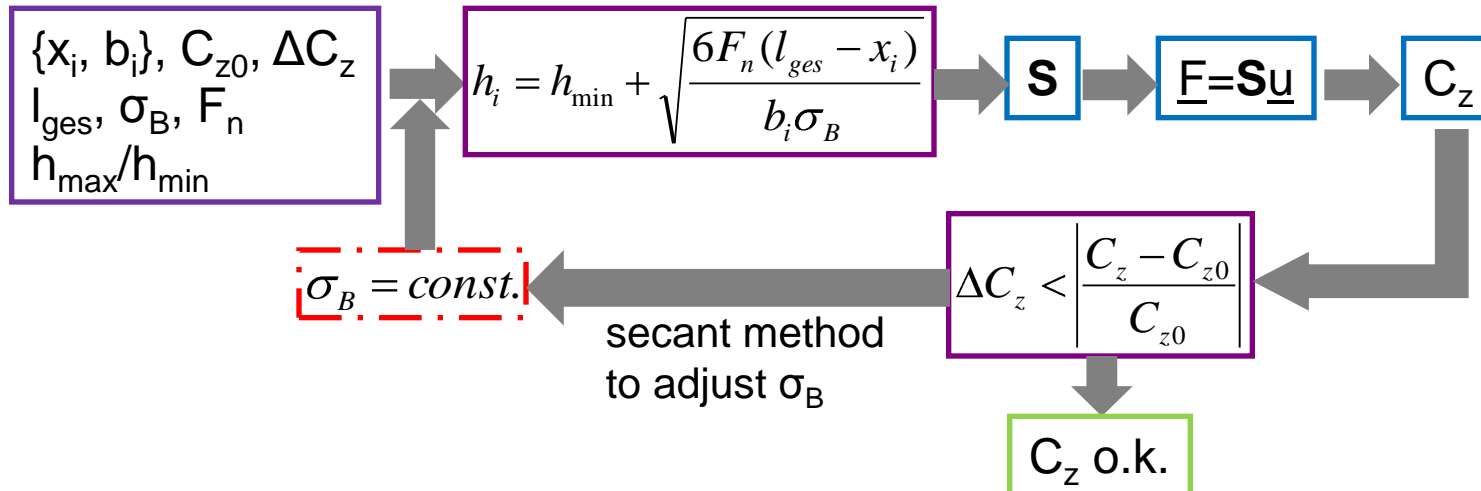
- Data-input process

- Geometry-based

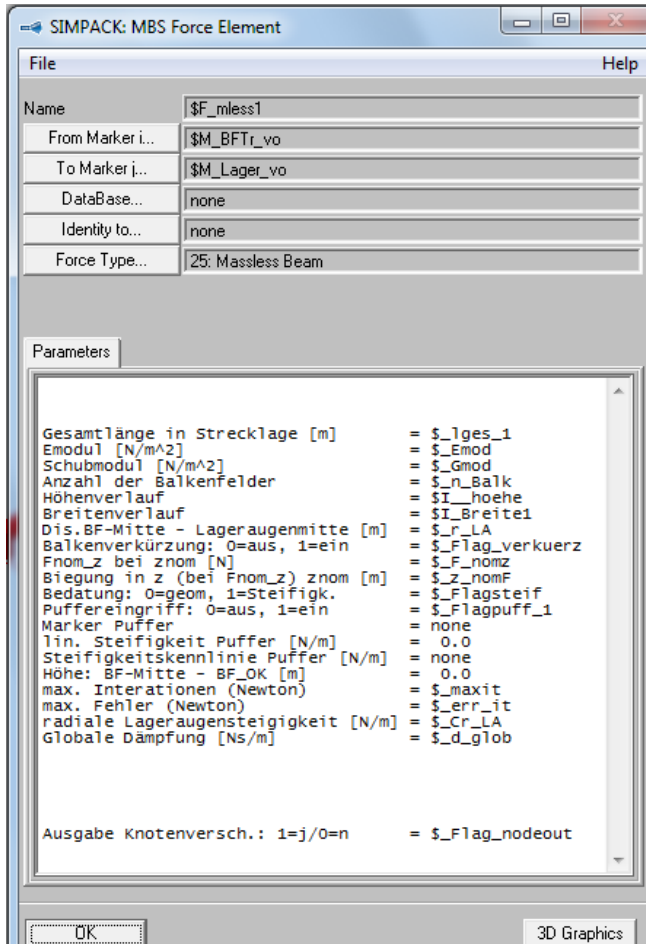


- Stiffness-based

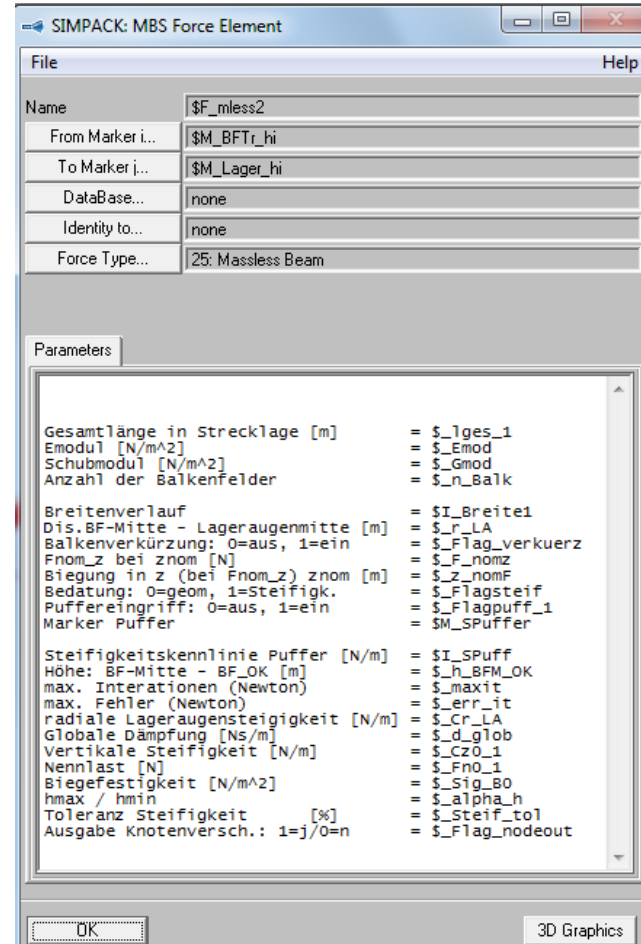
- Iterative process
- Assumption: bending stress (σ_B) is constant over the cantilever beam



„Massless“-model in SIMPACK



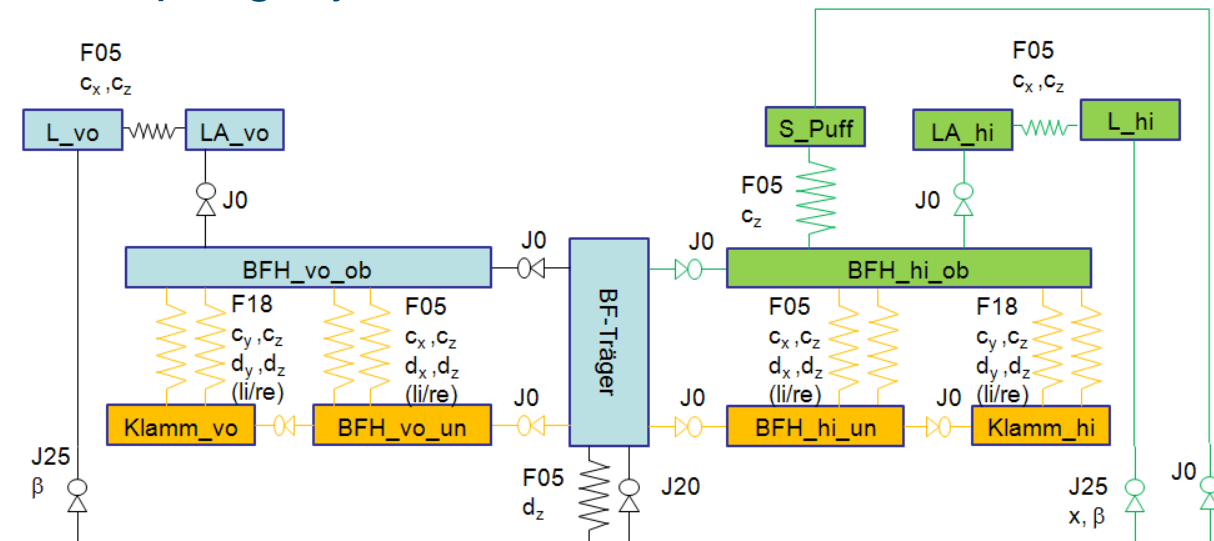
Input data based on geometry, without S-bump



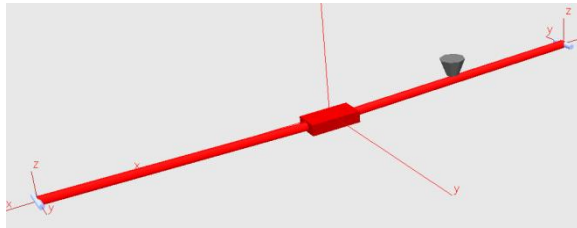
Input data based on stiffness, with S-bump

SIMBEAM-model

- A cantilever beam for each leaf spring halves
- Considered modes:
 - First 2 bending modes in vertical direction
 - First bending mode in lateral direction
 - First torsional mode
- Geometric stiffness (coupling x-z)
- More leaf spring layers can also be modelled

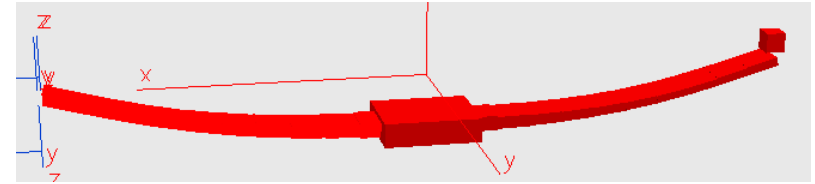


„Massless“-model vs. SIMBEAM-model



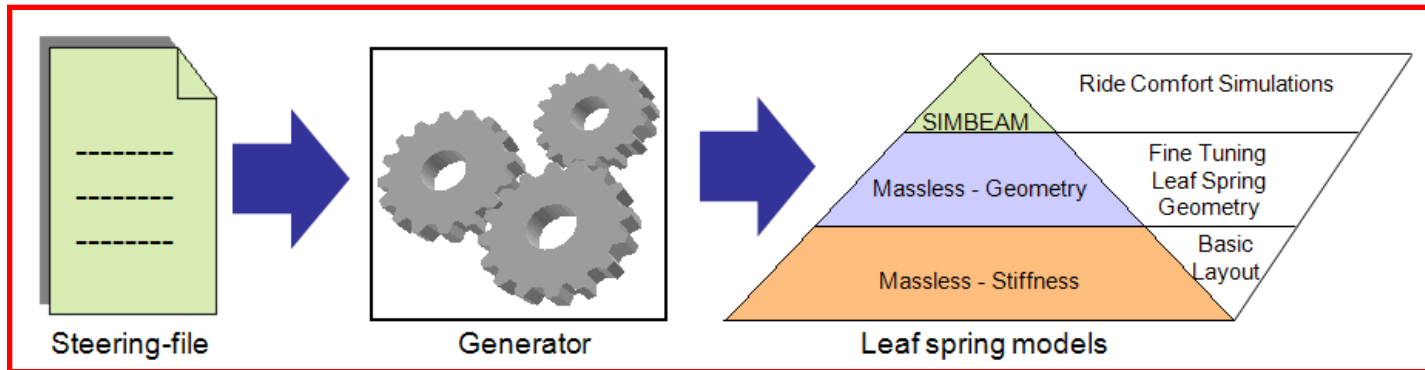
- Only one layer is considered
- Input:
 1. Geometry
 2. Stiffness
- Force element
- No structural dynamics

Masless-Model

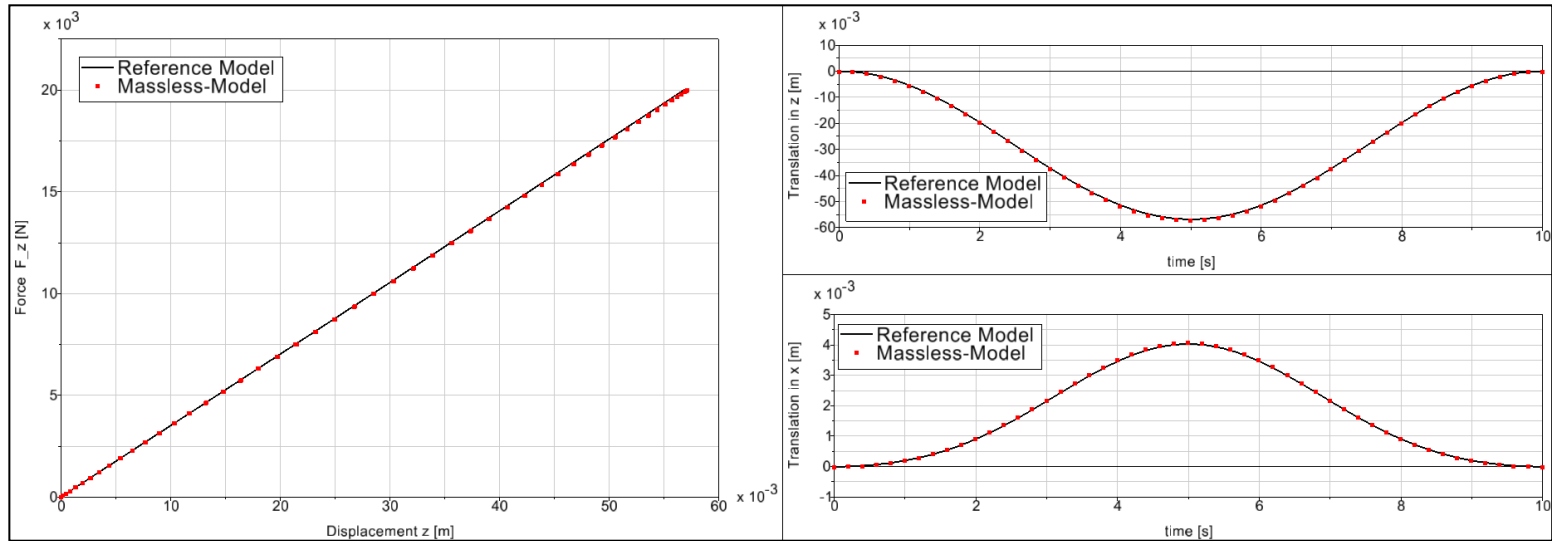


SIMBEAM-Model

- One or more layers can be considered
- Input:
 1. Geometry
- Elastic body
- Structural dynamics



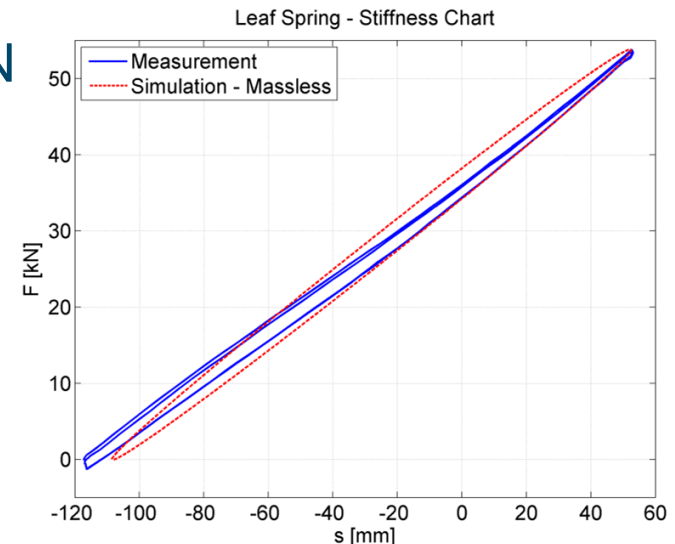
Comparison „Massless“- SIMBEAM-Modell



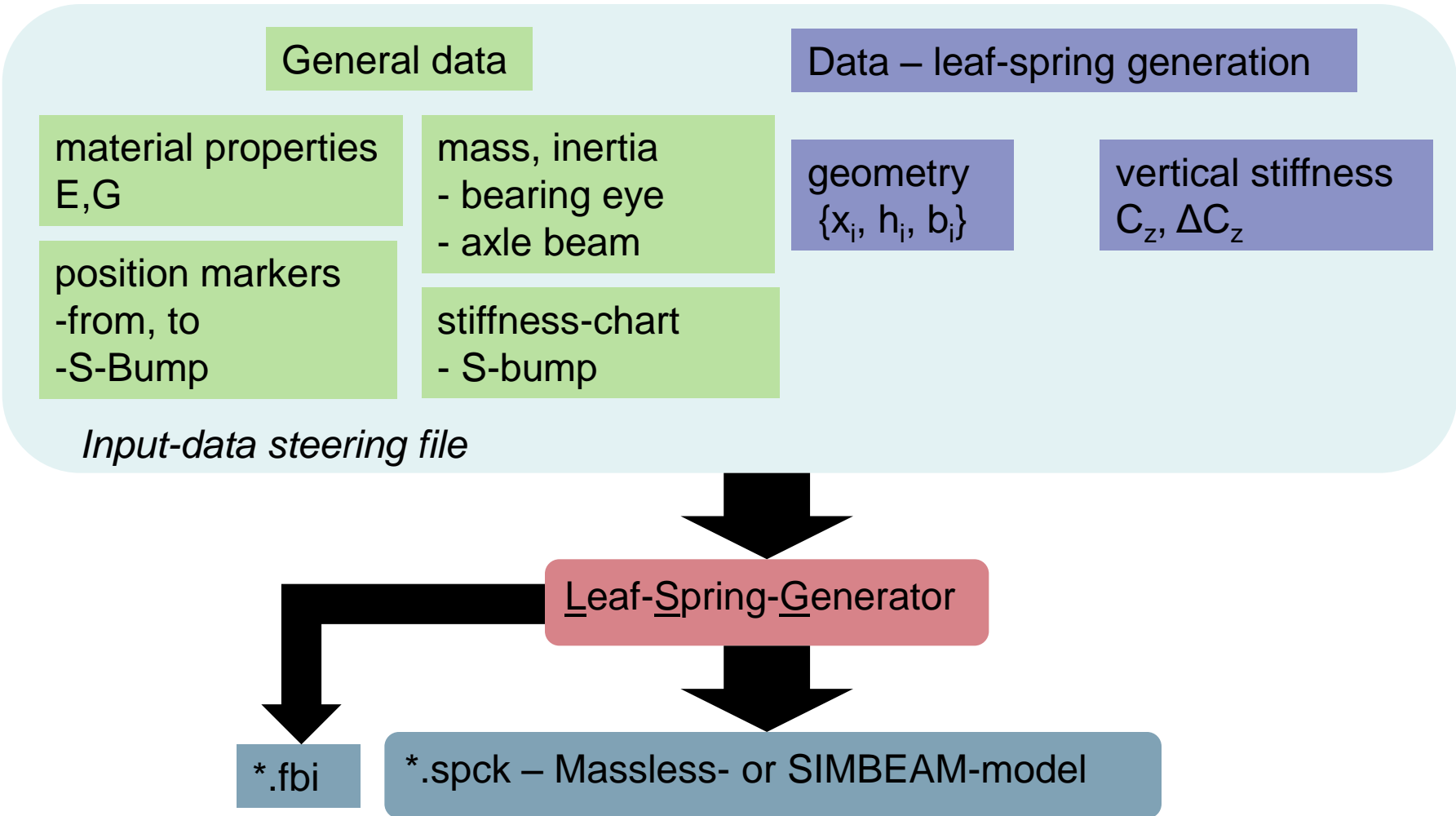
Validation with test-rig measurements at MAN

More about validation:

Müller et al: „A New Massless Leaf Spring Model and Its Application in The Simulation of Heavy Commercial Vehicles“, IAVSD 2011

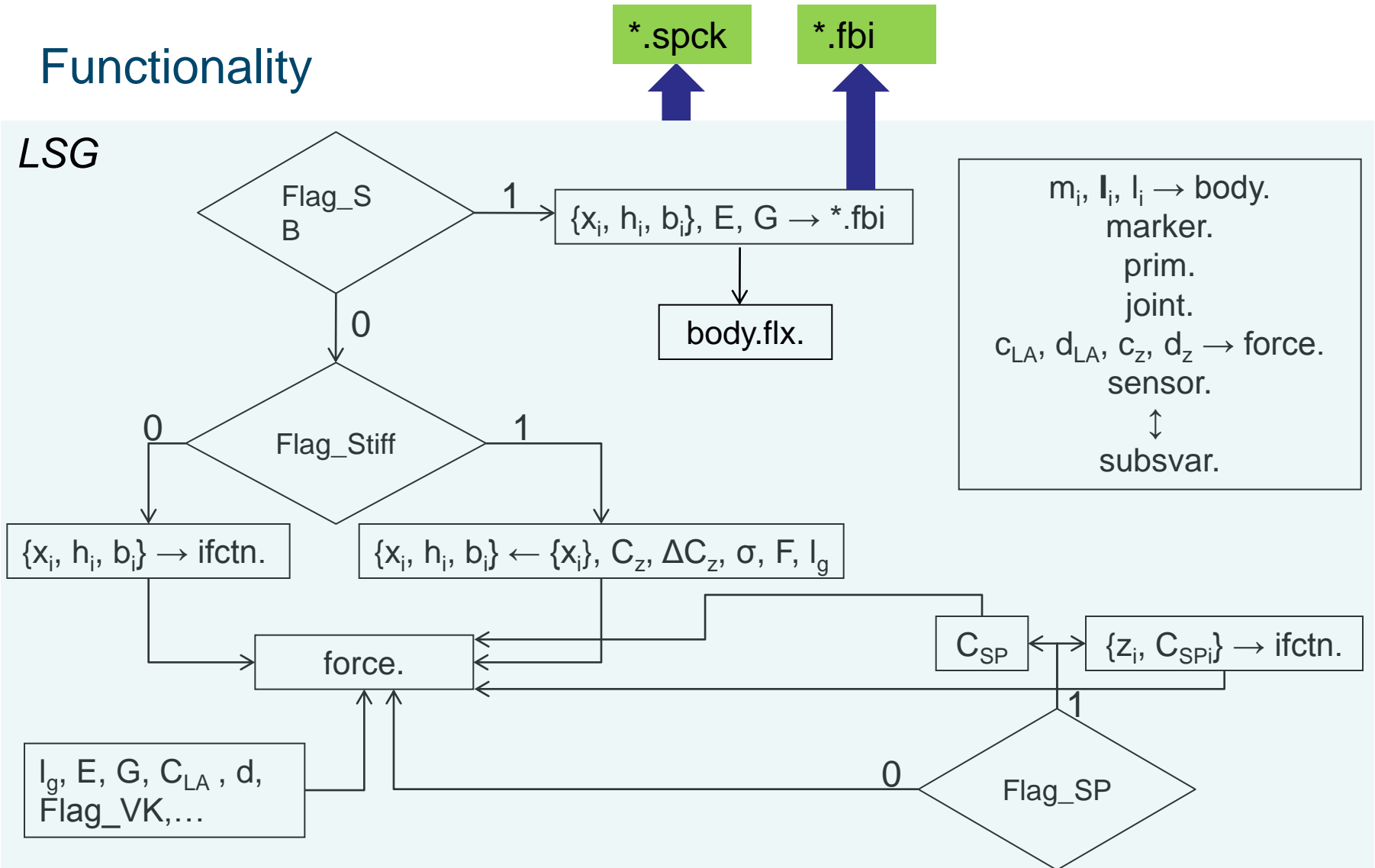


Modeling concept



Functionality

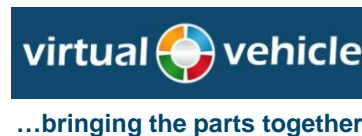
LSG



- Standardized and unique leaf spring modelling for the different simulation phases
 - „Massless“-model – stiffness-based → basic layout
 - „Massless“-model – geometry-based → fine tuning leaf spring geometry
 - SIMBEAM-model → ride comfort simulation
 - Good correlation with test-rig measurements
- Leaf-Spring-Generator
 - Flexible parameterization for all model levels
 - Steering-file in ASCII-format
 - Automatized model generation

Have a good time at SIMPACK Usermeeting 2011

Questions?



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