Powertrain

Automated model improvement in dynamic simulation based on road load data measurements

Otmar Gattringer

Content

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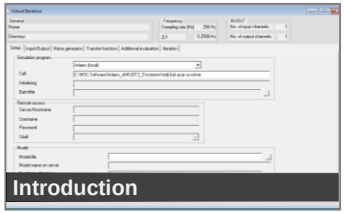
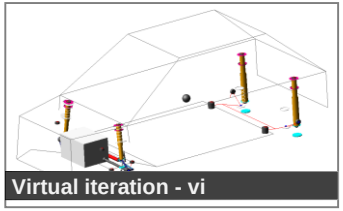
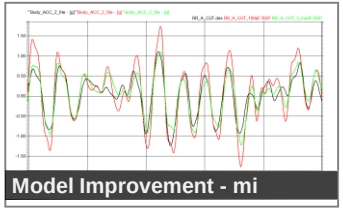
Automated model improvement

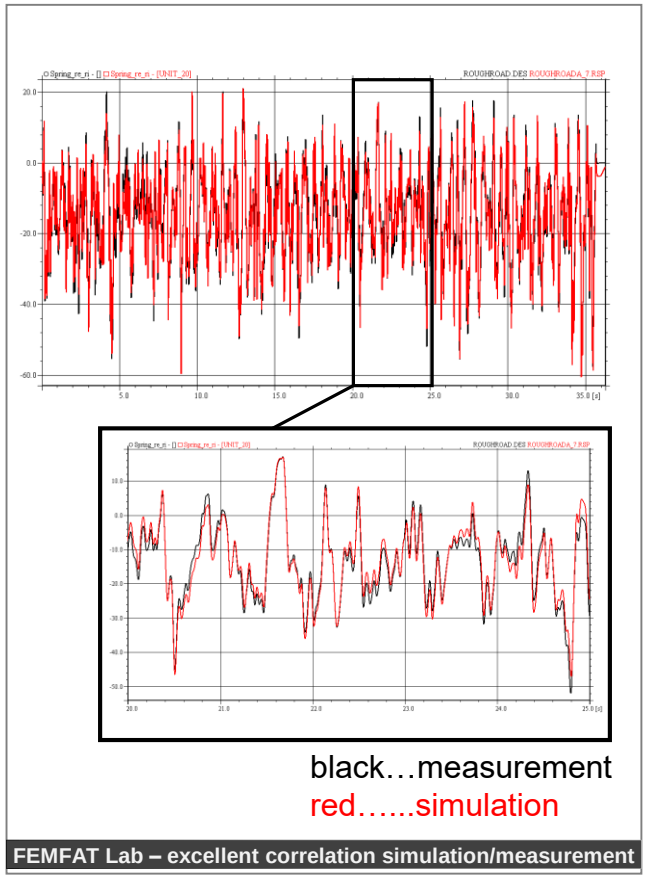
Content


Introduction

Measurement signals


Virtual iteration - vi


Model Improvement - mi



FEMFAT Lab – excellent correlation simulation/measurement

- Introduction / motivation
- Full vehicle example
  - Model
  - Measurement signals
  - Simulation
  - Model improvement
- Conclusion

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Introduction

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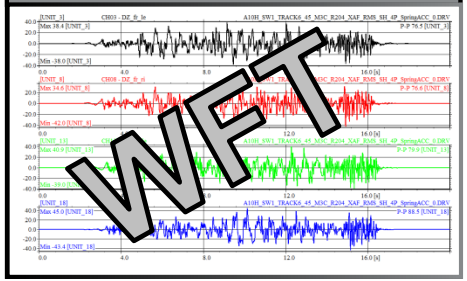
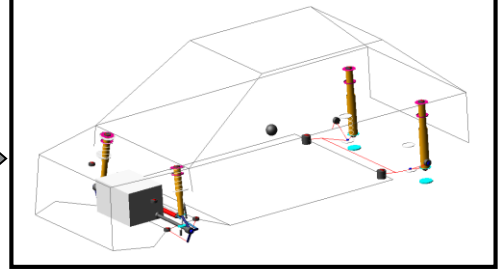
Motivation illustrated by full vehicle simulation

Input

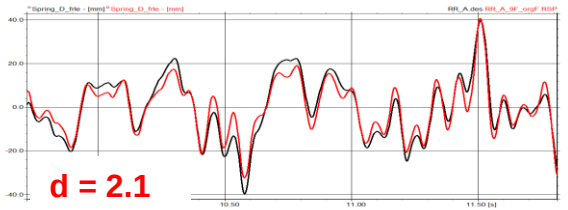


MBS

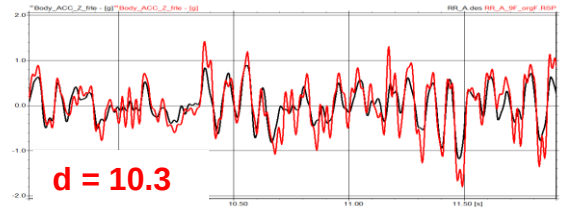


Output

Spring displacement front left



Body acceleration Z front left



black…measurement / red…simulation

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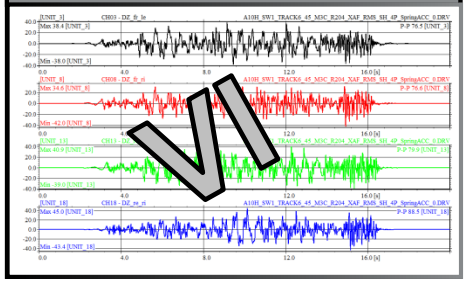
Motivation illustrated by full vehicle simulation

Input



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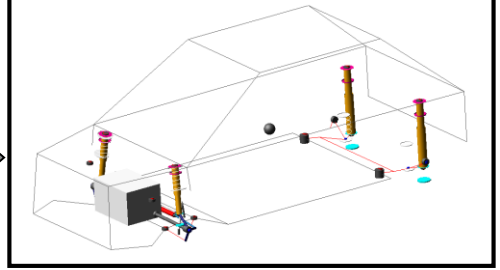
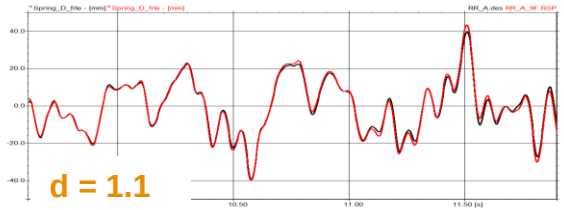
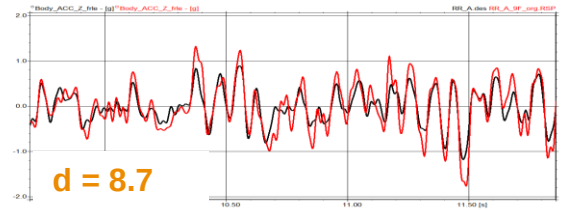


Output

Spring displacement front left



Body acceleration Z front left



black…measurement / red…simulation

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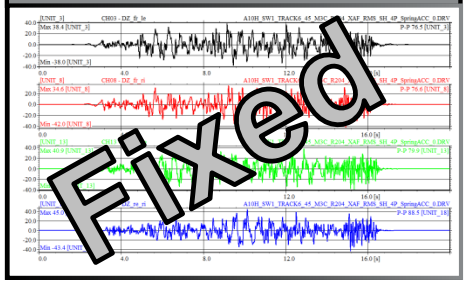
Motivation illustrated by full vehicle simulation

Input



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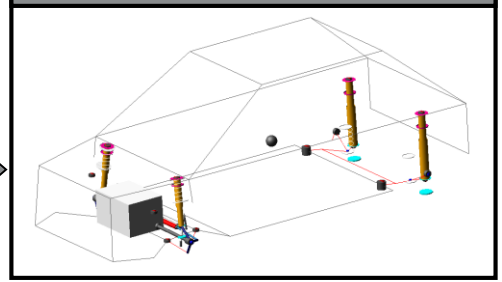
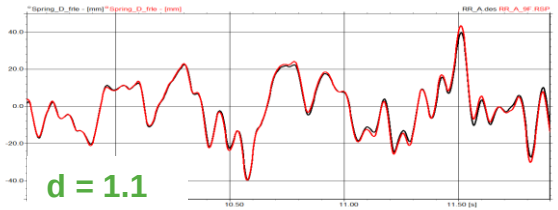


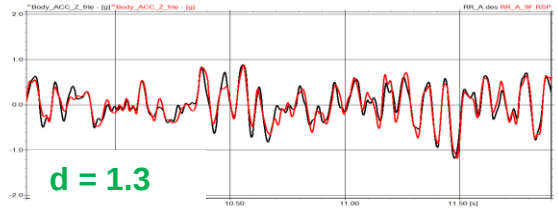
- Excitation fixed
- Trim model parameters to achieve better correlation in channels used for model check (e.g. body accelerations)

Output

Spring displacement front left



Body acceleration Z front left



black…measurement / red…simulation

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Introduction

Overview

- Automated model improvement:
  Manual trimming of an experienced engineer should be partially automated respectively supported (no absolute optimum because of feasible run-times)
- Model parameters improved based on road load data (RLD)
- Parameters must be defined and will be updated automatically
- Excitation is well known (measured or computed by VI) and fixed during investigations
- A diagnose tool assists to identify the relevant parameters
- Available for MSC.ADAMS (interface to MOTIONSOLVE is planned)

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Supported model parameters which can be automatically improved

- Mass, center of gravity
- Mass moment of inertia
  - I_X or I_Y or I_Z
  - Common factor on I_X, I_Y and I_Z
- SFORCE
  - Stiffness by value or spline, translational (e.g. coil spring) or rotational (e.g. stabilizer stiffness)
  - Damping by value or spline, translational or rotational
- VFORCE, GFORCE, FIELD (bushing)
  - Stiffness by value or spline, common factor for all directions or directions separately
  - Damping by value or spline, common factor for all directions or directions separately
- BEAM
  - Area and polar moment of inertia
  - Young's and shear modulus
- Define groups (e.g. leaf spring)
- Clearance of bumpstop and reboundstop

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Full vehicle example

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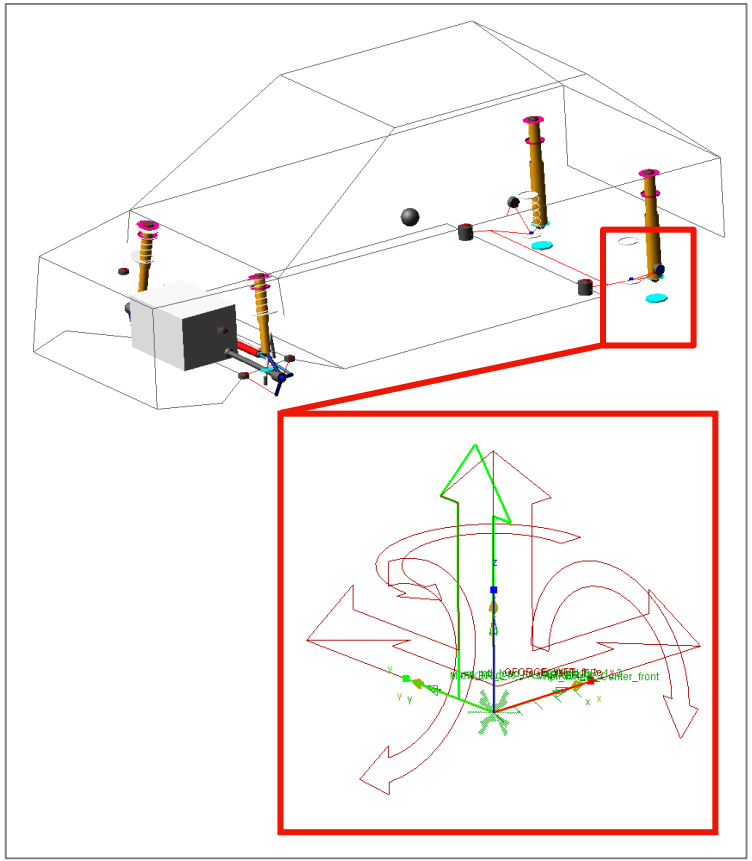
Full vehicle example



- MSC.ADAMS/Car full vehicle model
- Load computed by virtual iteration
  - Based on RLD measurements (rough road)
  - 4-poster
    vertical displacement computed to reproduce measured spring displacements and vertical wheel center accelerations
  - WFT signals are applied additionally at wheel centers
    FX, FY, TX, TZ

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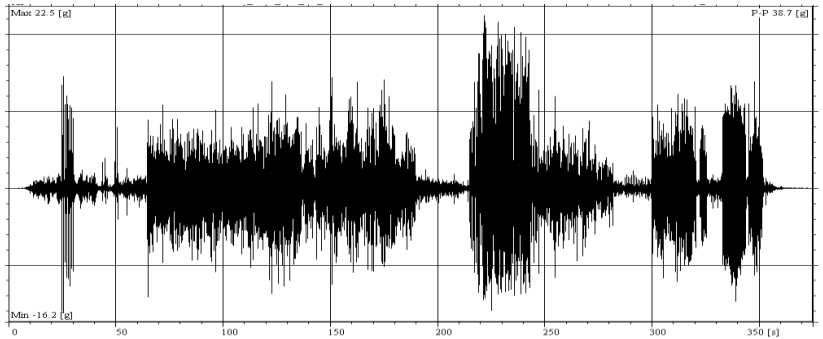
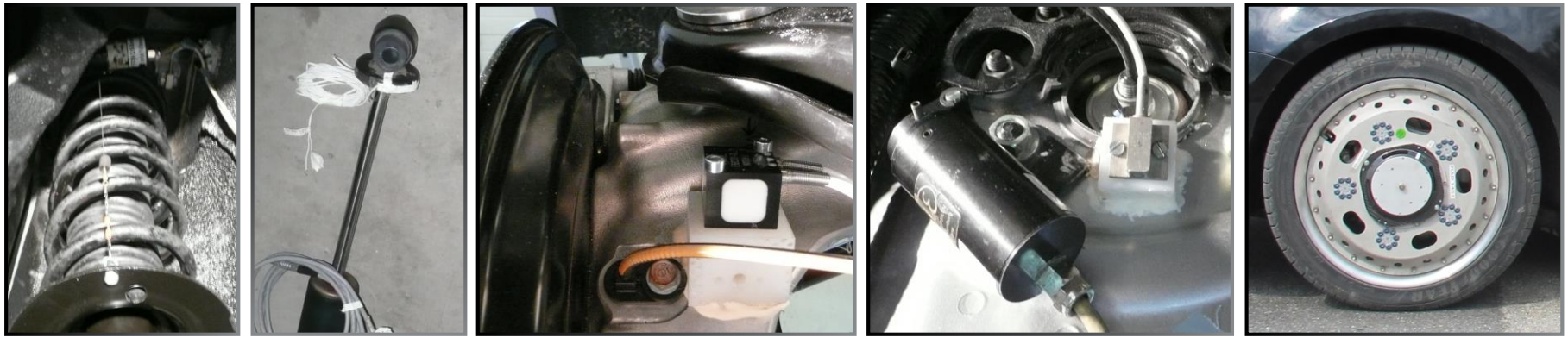
Full vehicle example



- Measurement signals
  - Spring displacements
  - Damper forces
  - Vertical wheel center accelerations
  - Vertical accelerations at body close to damper mounts
  - Wheel force transducer (WFT) signals



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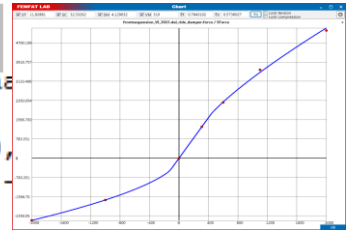
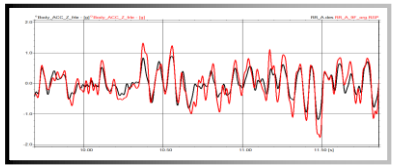
Full vehicle example

Inexact parameter

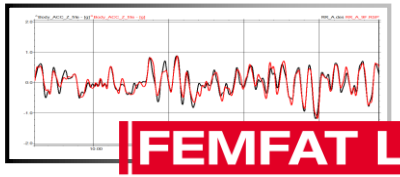
```
!          adams_view_na
SPLINE/122
, X = -2000, -1000, 0,
, Y = 2530, 1700, 0, -
!
```



Simulation



Model improvement



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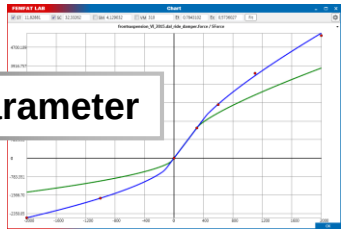
Improved parameter



Process

- Model
- Simulation
  - Well correlation in spring displacements, vertical wheel center accelerations, WFT signals
  - Worse correlation in damper forces and vertical body accelerations
- Model improvement
  - Improve relevant parameter

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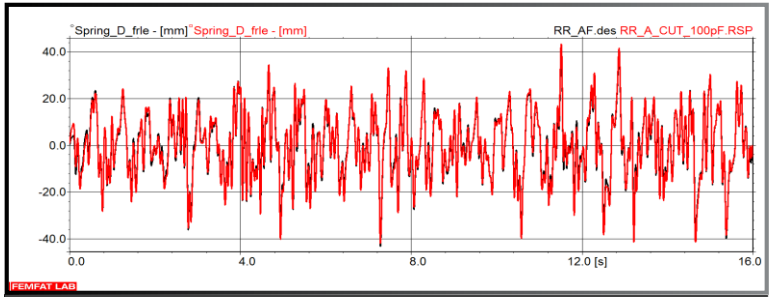
Full vehicle example

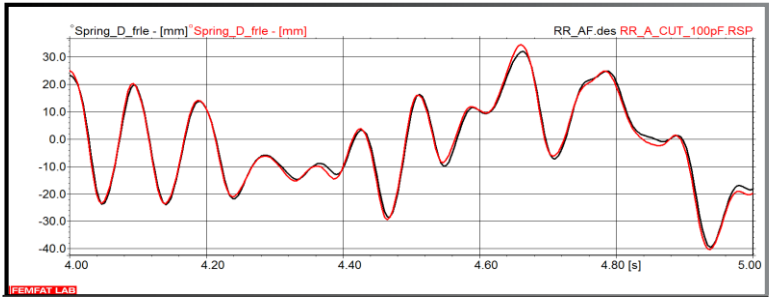
Simulation results

Results of rough road maneuver

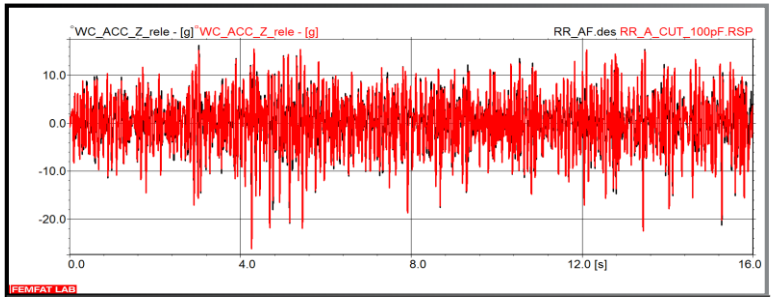
black…measurement / red…...simulation



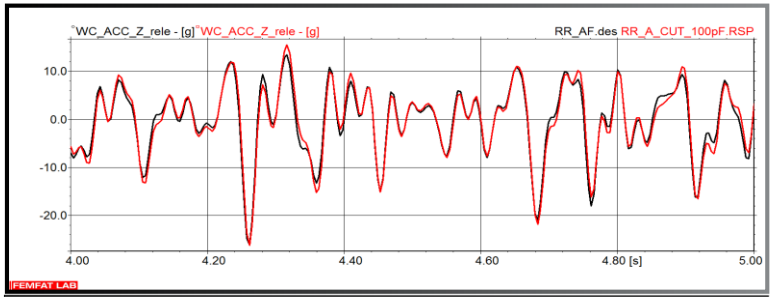
Spring displacement front left



Spring displacement front left – interval of 1 second



WC acceleration Z rear left



WC acceleration Z rear left – interval of 1 second

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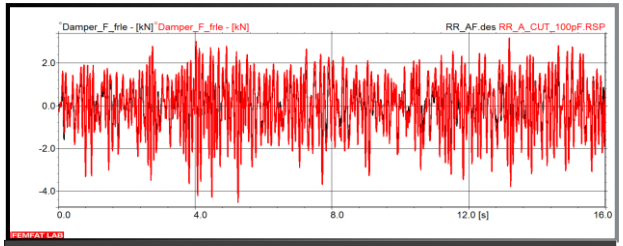
Full vehicle example

Simulation results

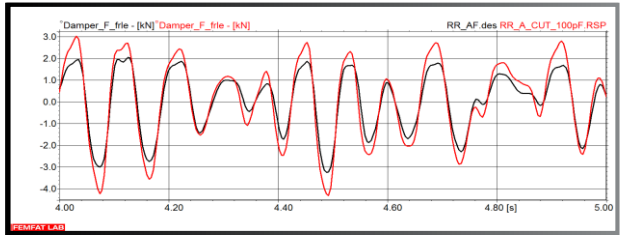
MAGNA

Results of rough road maneuver

black…measurement / red…simulation



Damper force front left



Damper force front left - – interval of 1 second

Relative damage values (target is 1)

– Signals used for generation of 4-poster excitation

- Spring front left:	1.33	- ACC WC front left:	0.83
- Spring front right:	0.95	- ACC WC front right:	0.84
- Spring rear left:	1.10	- ACC WC rear left:	1.14
- Spring rear right:	1.14	- ACC WC rear right:	1.07

– Channels for check of model quality

- Damper force front left:	4.78	- ACC body front left:	3.95
- Damper force front right:	4.47	- ACC body front right:	4.18
- Damper force rear left:	1.02	- ACC body rear left:	0.99
- Damper force rear right:	1.09	- ACC body rear right:	1.34

⇨ Model should be improved to achieve better correlation in damper forces front

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Model improvement

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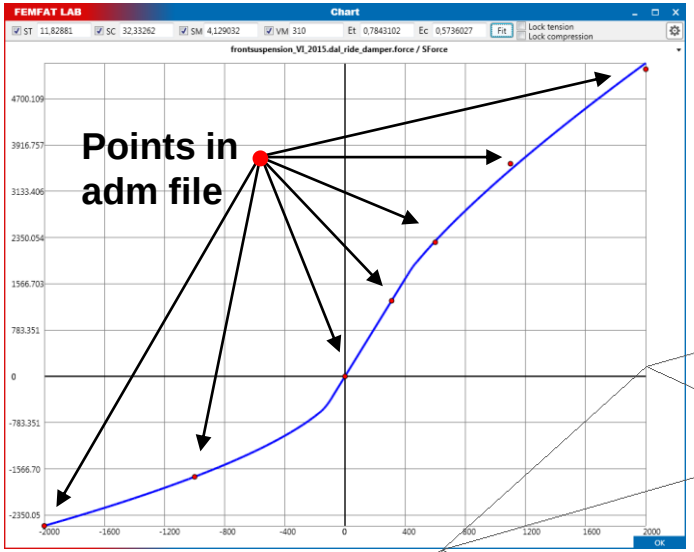
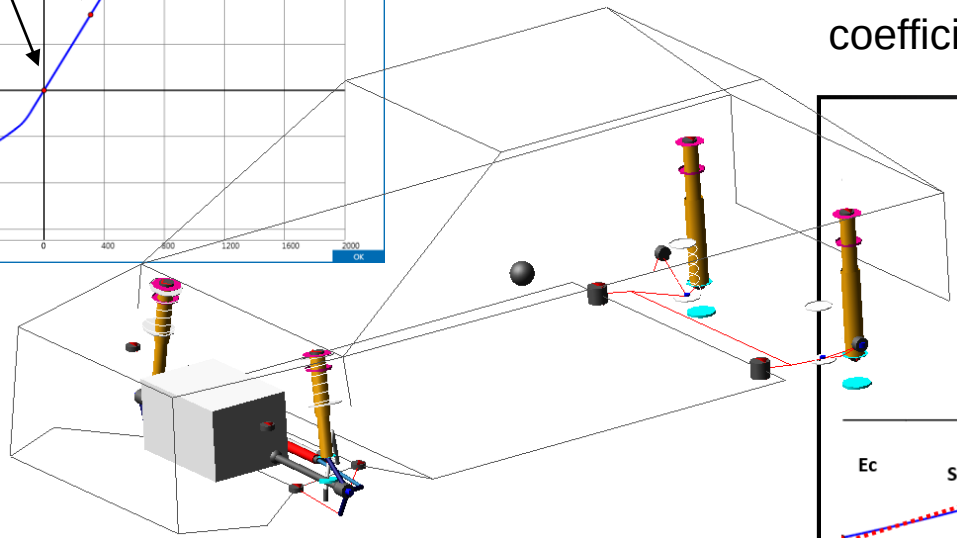
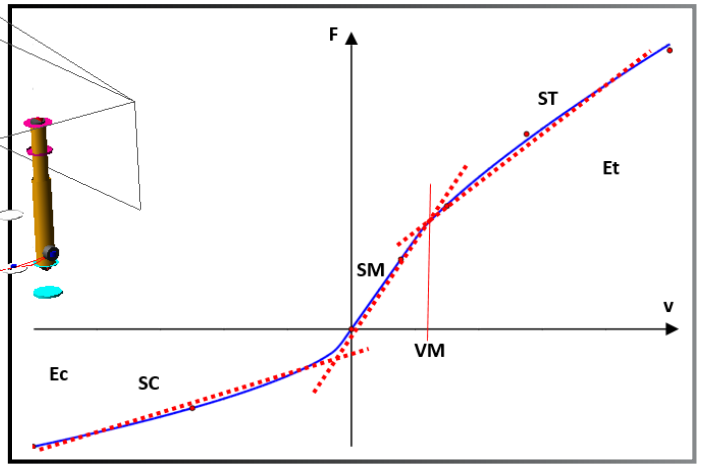
Full vehicle example





Damper

- Characteristics interpolated by the points of the adm file
- Characteristics approximated by a mathematical function using 6 coefficients



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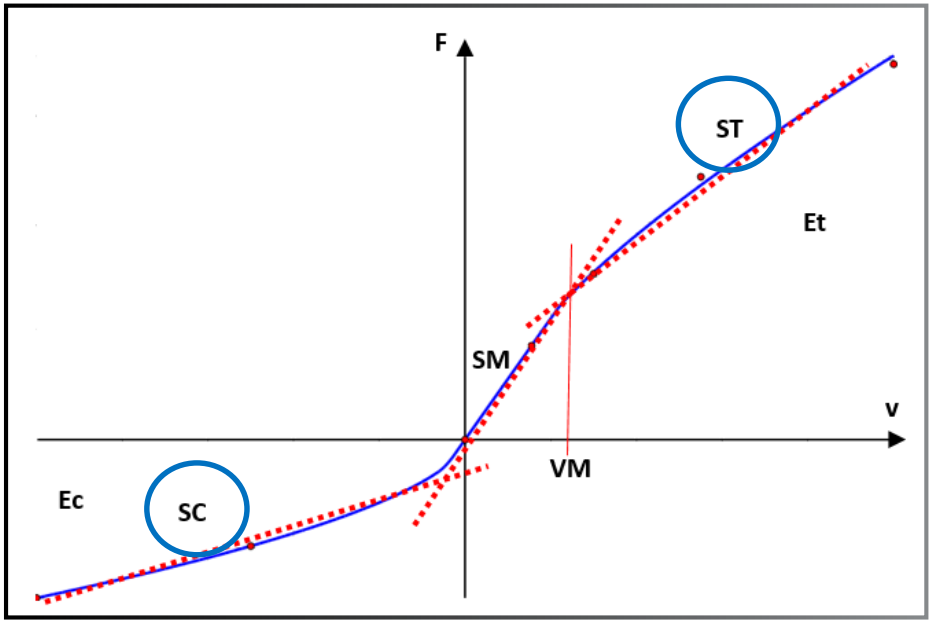
Full vehicle example



- Each coefficient can be deactivated for fixing it in the improvement process
- The challenge is that the process should be unique
  (several inputs for one output and interactions between the inputs)
- SC and ST are used to improve correlation between simulated and measured damper forces

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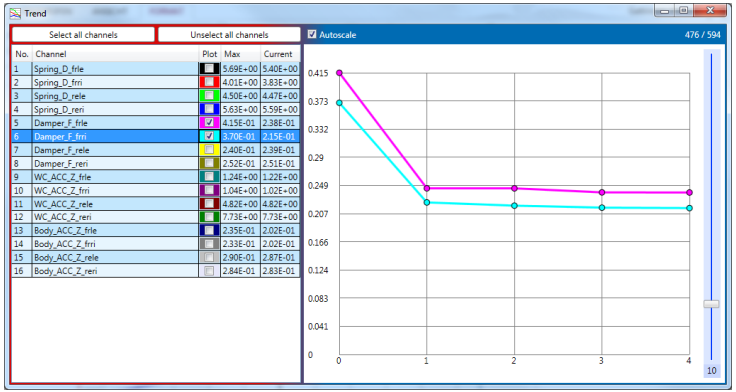
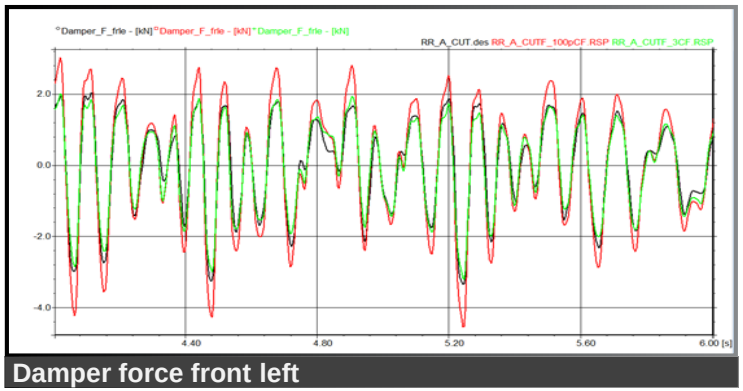
Full vehicle example





Damper force front left

Target:

- Sum of the 2 RMS values of damper forces front (simulation to measurement)

Stop criteria

- Difference of highest parameter change is smaller than 5% between 2 consecutive steps

Results

- Resulting damper force

black…measurement
red……simulation using inexact damper characteristics
green.. simulation using improved damper characteristics

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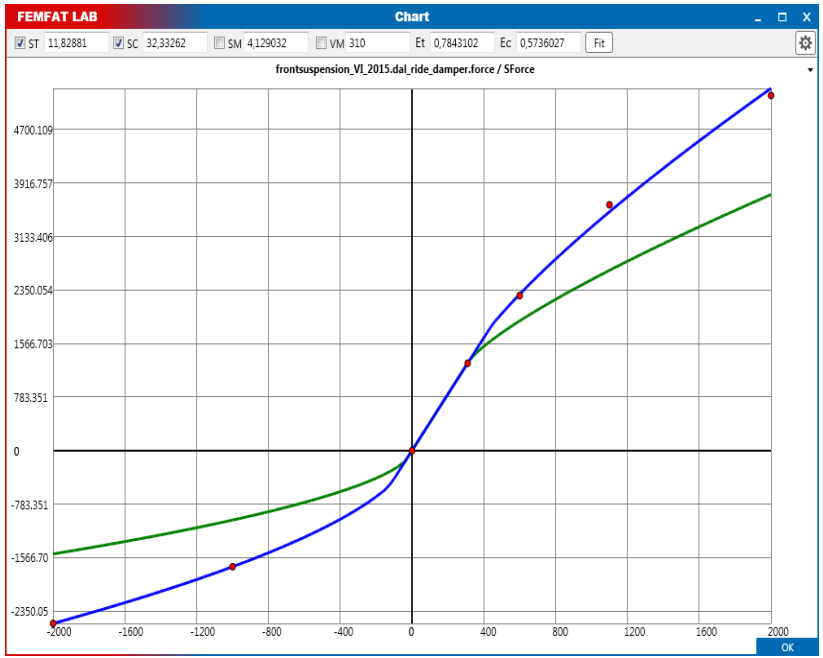
Full vehicle example



Result

- 4 improvement steps were required (1 improvement step requires several ADAMS runs)
- 14 ADAMS simulations in total

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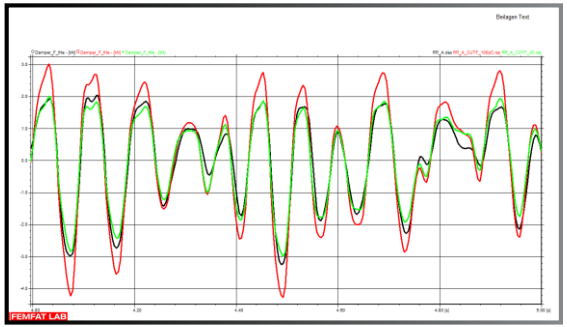
Full vehicle example

- Improved damper characteristic leads to better correlation in damper forces

- Damper force front left:	4.78	**Improved to**	0.89
- Damper force front right:	4.47		0.85
- ACC body front left:	3.95		0.66
- ACC body front right:	4.18		0.59



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Conclusion

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Conclusion

- FEMFAT Lab connects simulation with measurement

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  LOAD DATA ANALYSIS

  FEMFAT LAB mi
  LOAD DATA ANALYSIS

- Model improvement
  - mi supports to improve the model quality
  - Worse defined parameter can be identified with suitable measurement channels
  - Linear or nonlinear parameter can be improved
  - Full vehicle example shows capability of the method regarding damper characteristics

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