FEMFAT LAB software

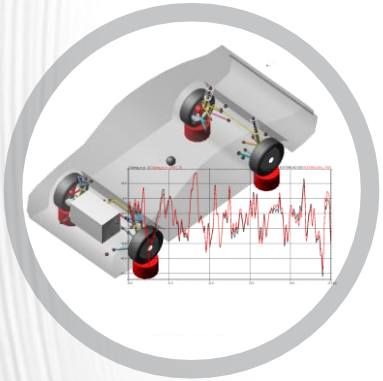
LOAD DATA ANALYSIS

Powertrain

New Features in combination with MBS

O. Gattringer, J. Traunbauer

January 2019



FEMFAT LAB vi
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Virtual iteration

- 3D ROAD (NEW 2018)

FEMFAT LAB mi
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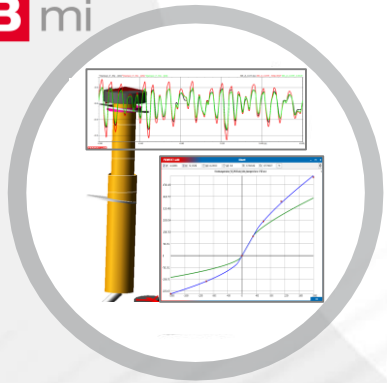
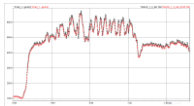
Model improvement

- Released 2017



Interface to dynamic simulation



FEMFAT LAB time
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time based analyzing tools

FEMFAT LAB frequency
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frequency based analyzing tools

FEMFAT LAB fatigue
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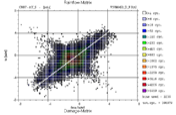
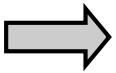


counting methods, damage analysis, data reduction, mixing tracks

Load data analysis software

- MBS simulation results depend mainly on ***excitation*** and ***model accuracy***
- Excitation
  - Defined, e.g. stochastic road, standard load cases, …..
  - Measured, e.g. digital road, wheel forces (WFT), mount forces, …..
  - Computed based on internal measured signals



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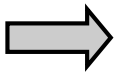
vi provides well developed process for generating an accurate excitation

- Model accuracy
  - Parameters defined by user (CAD/CAE data, supplier values, measurements, experience, ….)
  - Some parameters can be also measured during road load data (RLD), e.g. damper characteristics
  - Model parameters can be modified manually depending on correlation of simulated and measured channels (manual model verification and trimming by additional checking signals is an important part of VI process)



FEMFAT LAB mi
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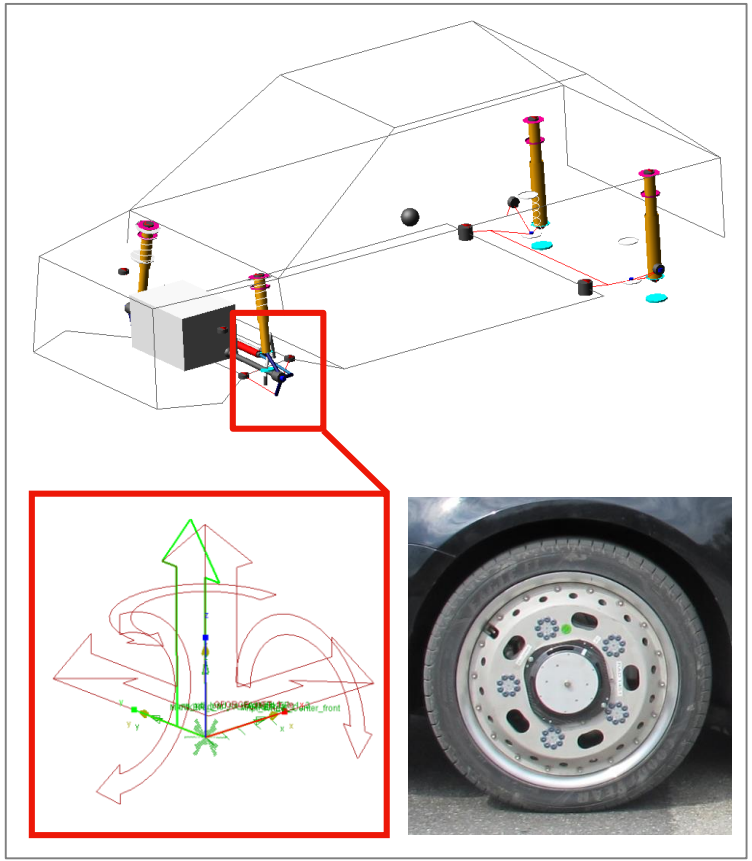
Automated model parameter improvement

mi – nonlinear application damper

Model



- MSC.ADAMS/Car full vehicle model
- Load computed by vi
  - 4-poster using additional WFT channels
  - Based on RLD measurements (rough road)
    - WFT (wheel force transducer) signals
    - Spring displacements
    - Damper forces
    - Tierod forces
    - Vertical accelerations at wheel centers
    - Vertical accelerations at body close to damper mounts

FEMFAT LAB mi
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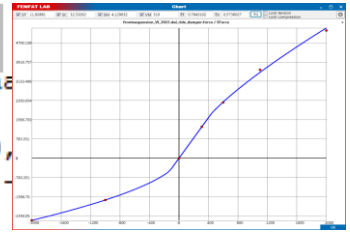
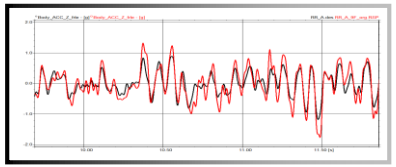
Inexact parameter

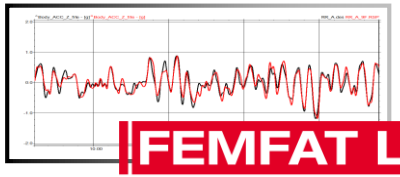
```
!          adams_view_na
SPLINE/122
, X = -2000, -1000, 0,
, Y = 2530, 1700, 0, -
!
```



Simulation



Model improvement



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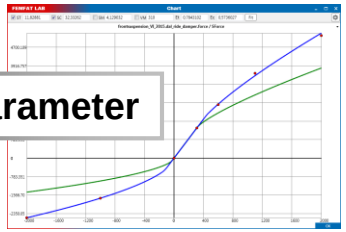
Improved parameter

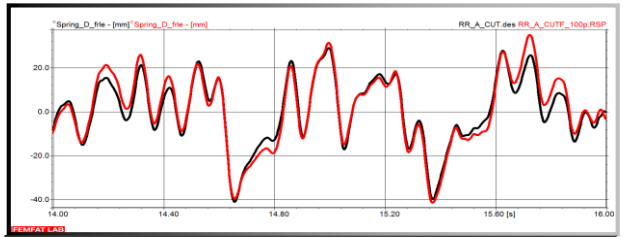


Process

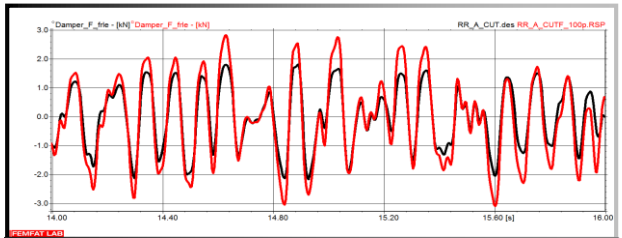
- Model
- Simulation
  - Good correlation in desired signals
  - Bad correlation in damper forces and vertical body accelerations front
- Model improvement
  - Improve relevant parameter

Results of rough road maneuver - relative damage values (target is 1)

black…measurement / red…simulation



Spring displacement front left



Damper force front left

– Desired channels show well correlation

- 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 model check

- 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 has to be improved to achieve better correlation in damper forces and body accelerations front

FEMFAT LAB mi
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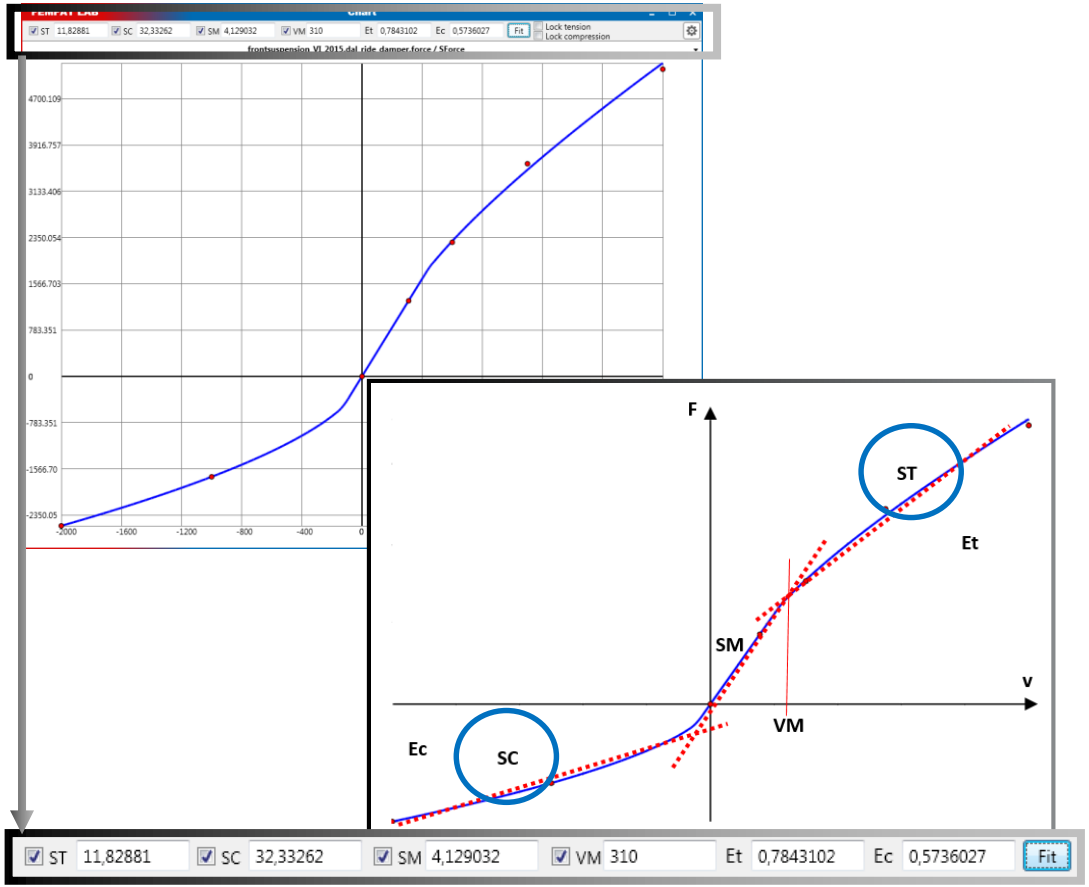
mi - damper

mi - settings



- Fit function to interpolate the points of the *.adm file
- Mathematical approximation uses 6 coefficients
- Coefficients can be fitted or defined manually
- 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)

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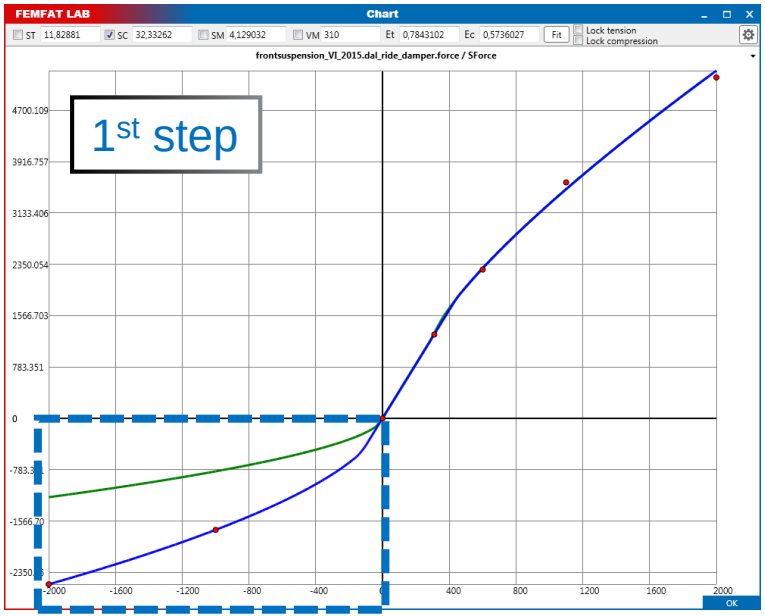
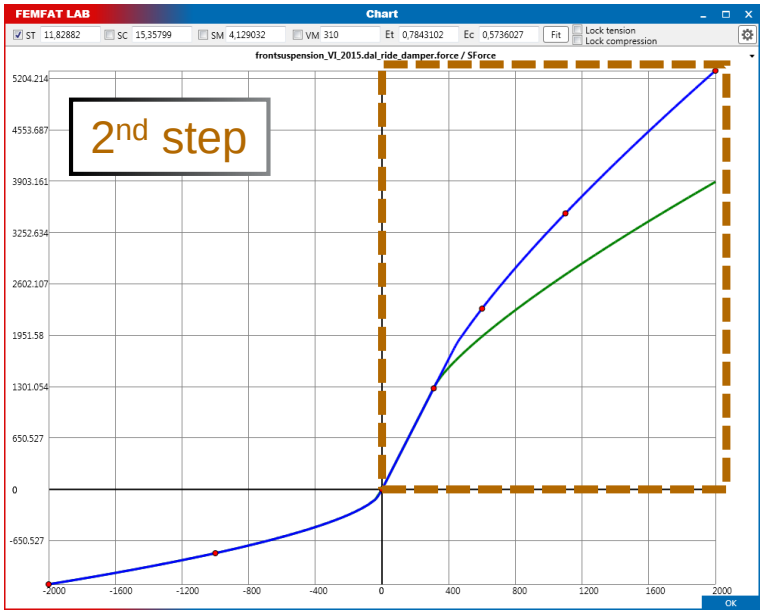
mi - damper

mi results

Improvement performed in 2 steps sequentially
- 1st step: stiffness compression SC
- 2nd step: stiffness tension ST

Target:
- Improve front damper forces
- Sum of RMS values (simulation compared to measurement)





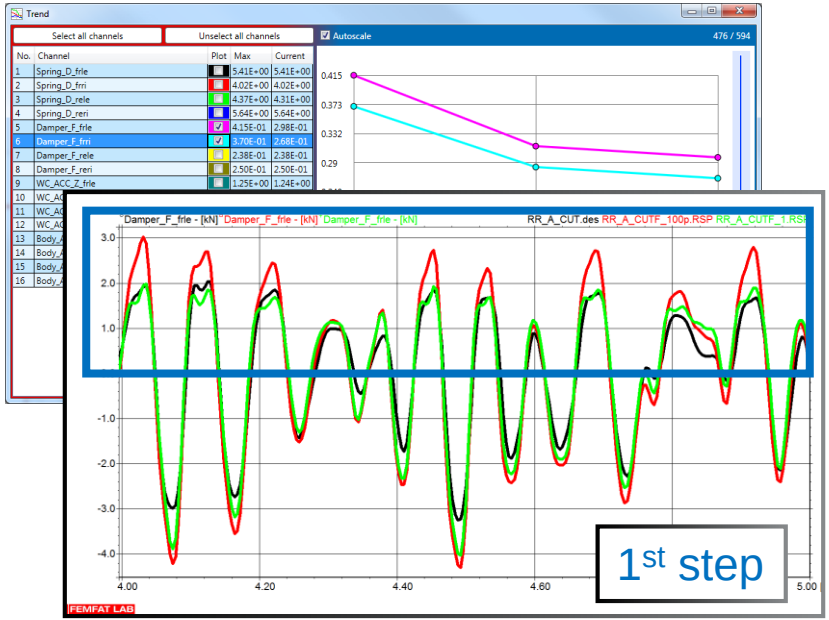
mi - damper

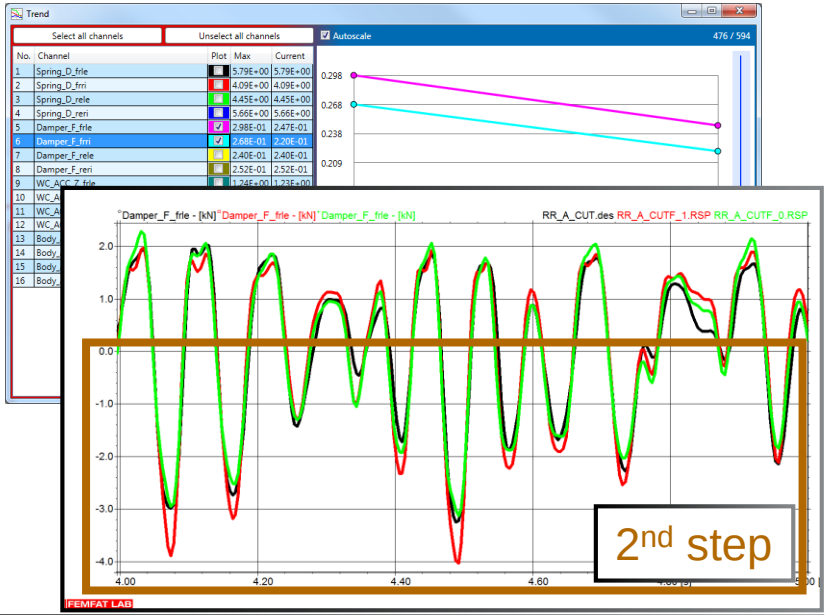
mi results

Improvement performed in 2 steps sequentially

- 1st step: stiffness compression SC
- 2nd step: stiffness tension ST

Time plot black…desired
red……basic model*
green...improved model





*…2nd step: stiffness compression modified

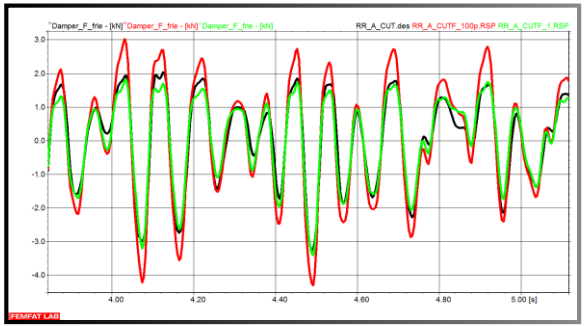
mi - damper

mi results

Improvement performed in 2 steps sequentially

- Improved damper characteristic leads to better correlation in damper forces

- Damper force front left:	4.78	**Improved to**	0.73
- Damper force front right:	4.47		0.72
- ACC body front left:	3.95		1.41
- ACC body front right:	4.18		1.63



- 9 ADAMS simulations were required in total

Time plot black…desired
red……basic model
green...improved model

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mi - conclusion

Fields of work

- FEMFAT LAB mi supports improvement of the model quality by means of adjusting linear / non linear parameters of:
  - Part (mass, mass moment of inertia and center of gravity)
  - Spring and/or Damper
  - Bushing
  - Beam - single element or several beams using group (stabilizer, leaf spring, …)
  - Clearances of bump or rebound stops
- Not well defined parameters can be identified with suitable measurement channels by means of a diagnose tool
- Nonlinear characteristic can be approximated by mathematical terms and handled conveniently by the GUI to fit and interpolate the curve

- Video tutorial is available
  - Getting started
  - Step by step tutorial
  - Including explanations

FEMFAT LAB mi
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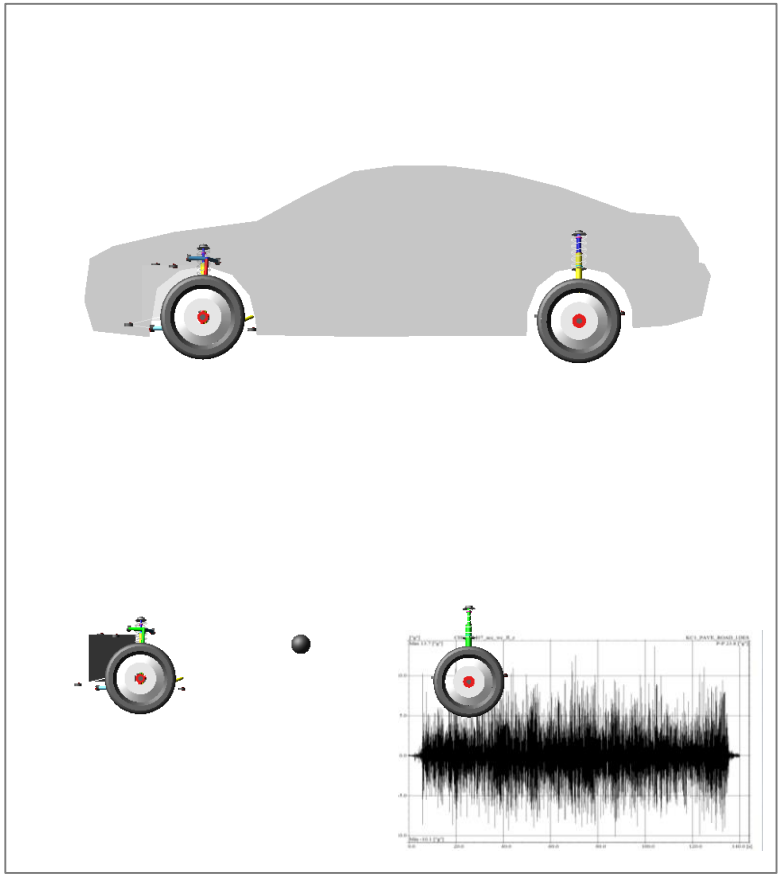
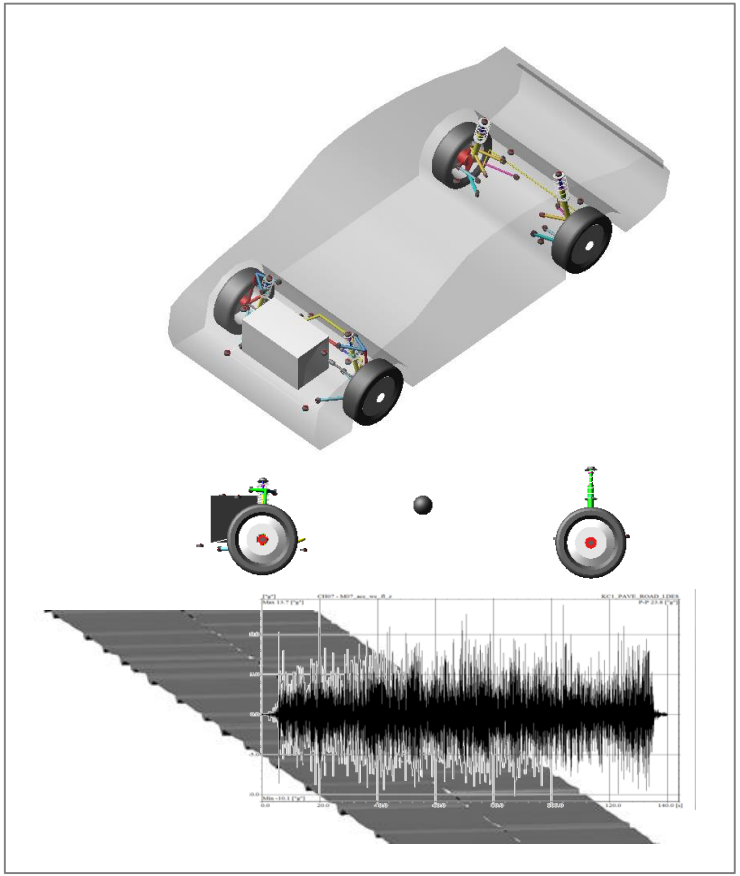
3D Road - overview



- **Goal**
  - Use road loads for vehicle development in design phase (no physical prototype exists)
- **Situation - Requirement**
  - New vehicle
    - No physical prototype – no RLD available
    - CAD model exists
- **Necessary input data (data base)**
  - RLD, measured on test tracks with comparable / similar vehicle (mini car, middle class, SUV...)
  - MBS model of measured and comparable vehicle

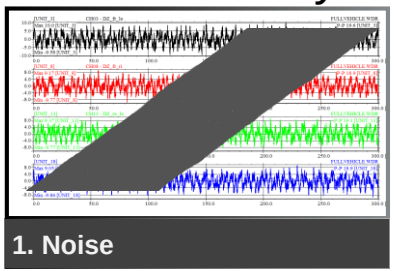


- **Idea**
  - Use of 3D road and F-Tire model for simulation of vehicle in design phase (no measurement required)
- **3D road generation (not measured/scanned)**
  - Computed by VI
  - Verified by existing data
    - (Well) known simulation model
    - Measured RLD

⇨ ***3D road must be generated only once for a family of vehicles***

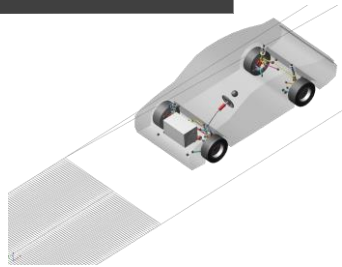
3D Road - workflow

Identification of system

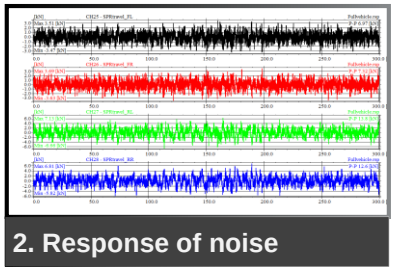


1. Noise

u_{Noise}



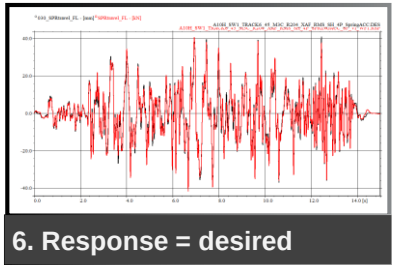
y_{Noise}



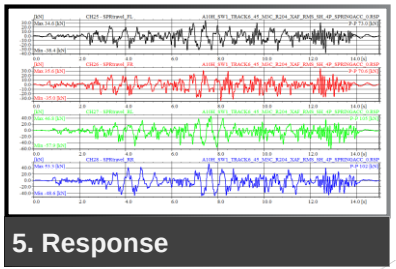
2. Response of noise

$$F = \frac{y_{Noise}}{u_{Noise}}$$

Iterative calculation of excitation

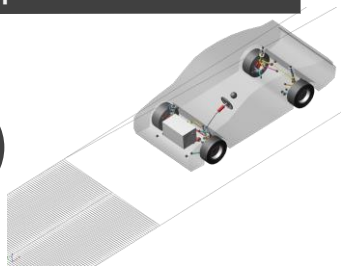


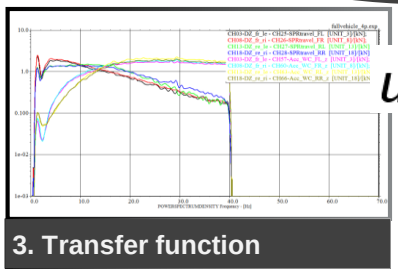
6. Response = desired



5. Response

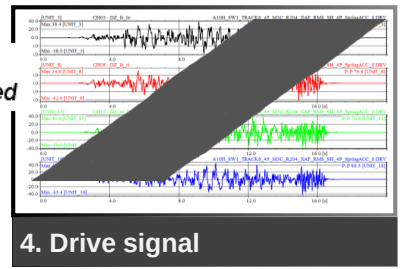
$$u_{n+1} = u_n + F^{-1}\,(y_{Desired} - y_n)$$





3. Transfer function

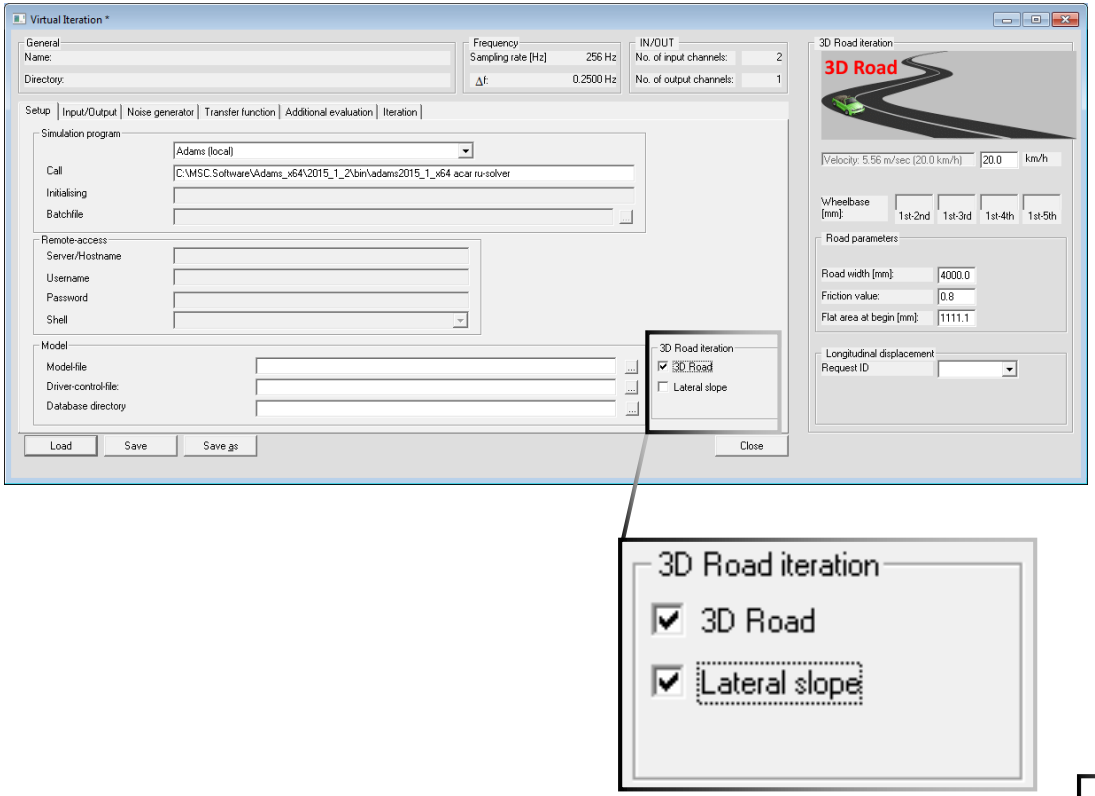
$$u_0 = F^{-1}\,y_{Desired}$$



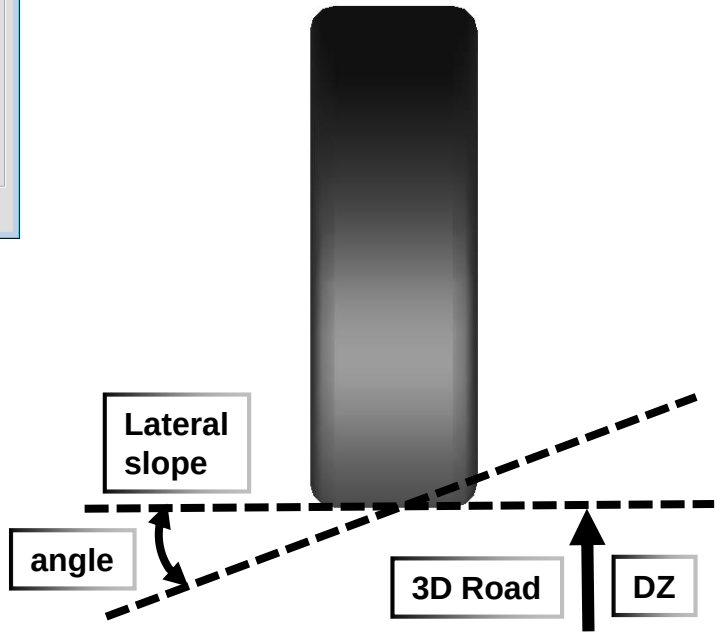
4. Drive signal

3D Road

Input data



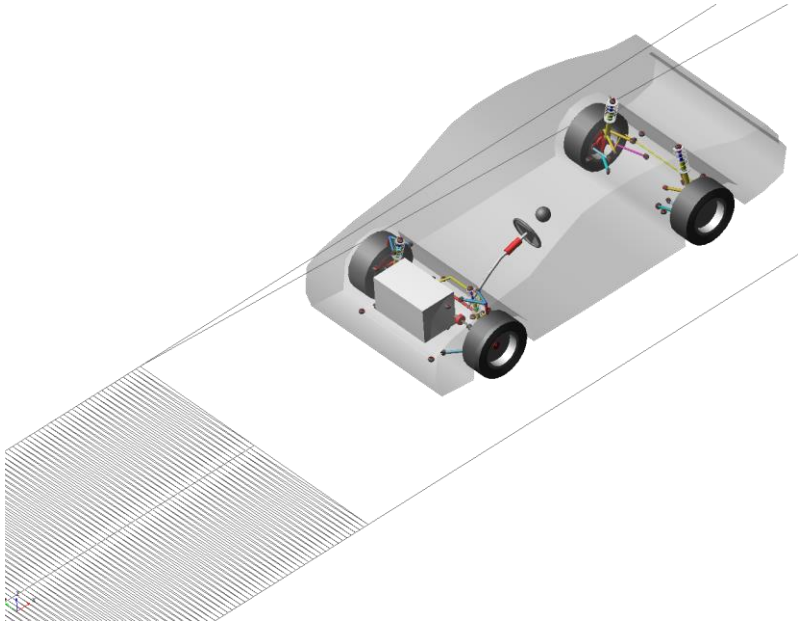
- 3D Road: constant road profile height along y-direction
- Lateral slope: inclination of road surface across tire patch



3D Road – verification of method

Roads

- Different road tracks
- Single event: threshold (validation)



Virtual measurement data

- Full vehicle model including F-Tire
- Different digital roads
- Simulation:
  requests of virtual measurement channels
  which are used for 3D Road iteration afterwards
  (no real measurement data is used)

⇨ No influence of F-Tire, model and measurement for check of method

Verification of method

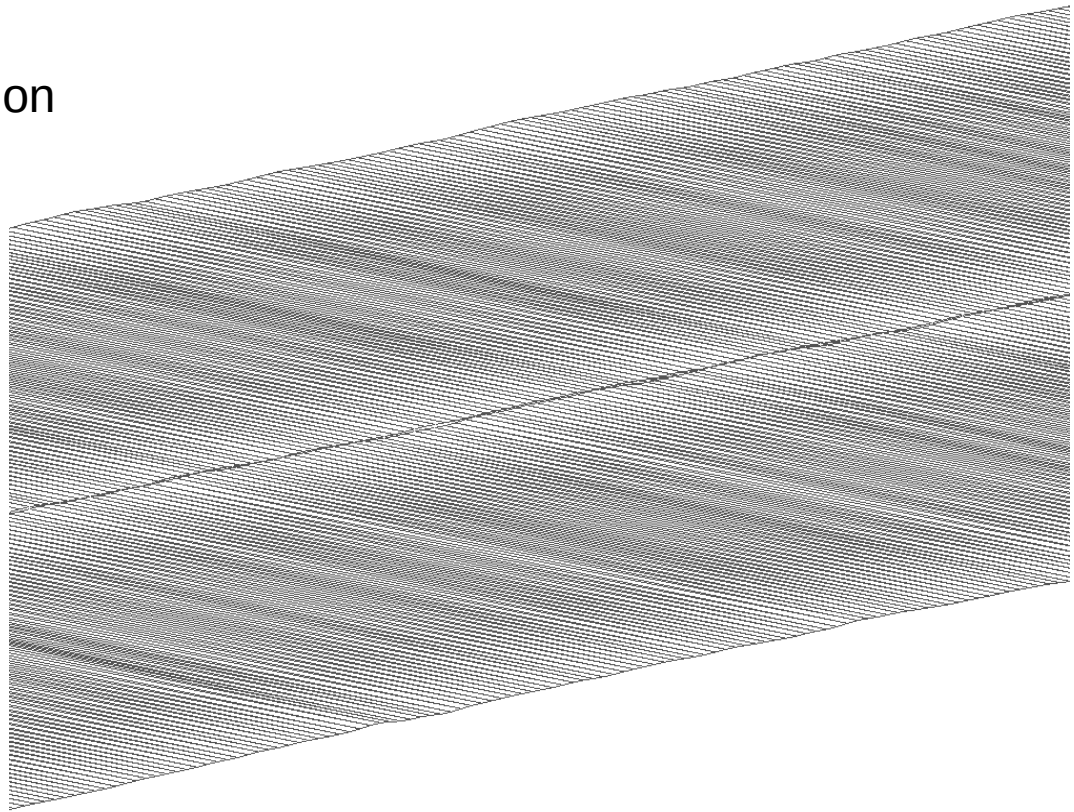
Virtual measurement channels – 70 channels
Used as desired signals for 3D Road iteration

• Wheel forces	24 channels
• Spring displacements	4 channels
• Damper forces	4 channels
• Wheel center accelerations X, Y, Z	12 channels
• Body accelerations Z	4 channels
• Ball Joint forces front suspension	10 channels
• Ball Joint forces rear suspension	4 channels
• Tie rod forces front suspension	2 channels
• Link forces rear suspension	6 channels

Road profile #1

Road_C_even_41kmh.des

- Road C even, constant in y-direction
- Velocity: 41 km/h
- 20 seconds
- “Soft” road

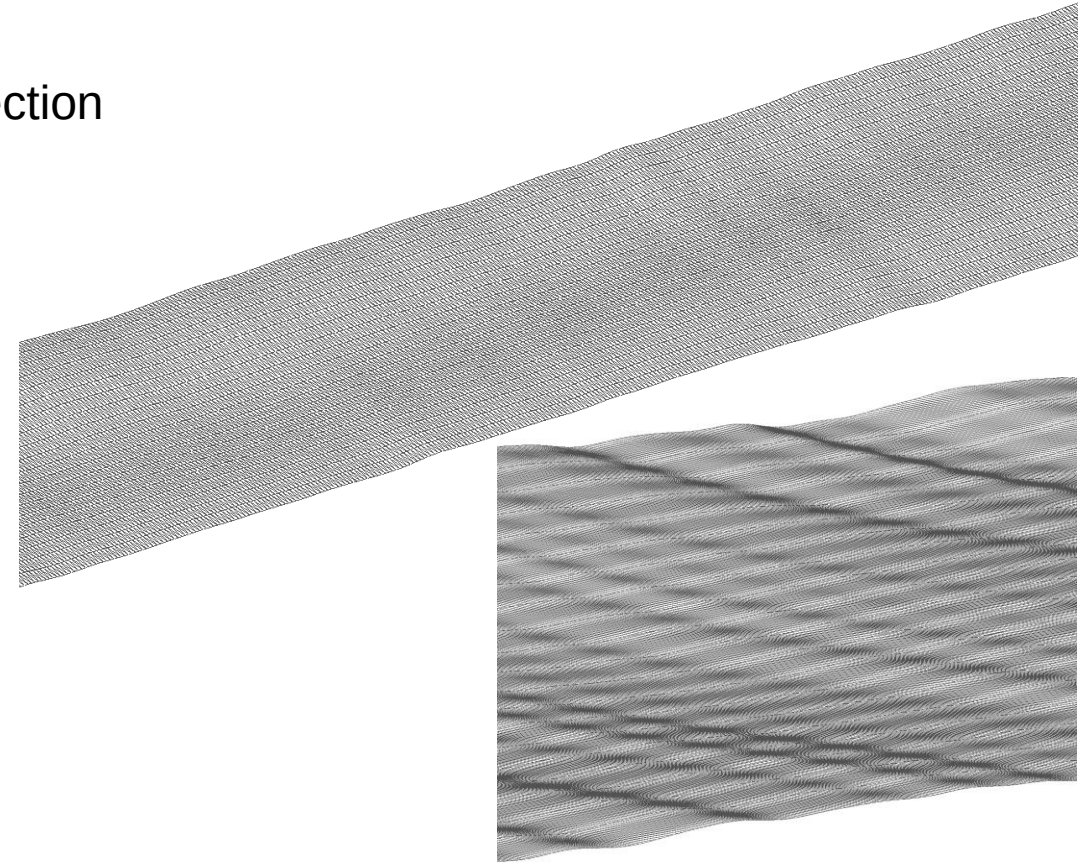


⇨ Simulation to get desired signals for iteration

Road profile #2

Road_D_uneven_41kmh.des

- Road D uneven, variable in y-direction
- Velocity: 41 km/h
- 20 seconds
- “Hard” road



⇨ Simulation to get desired signals for iteration

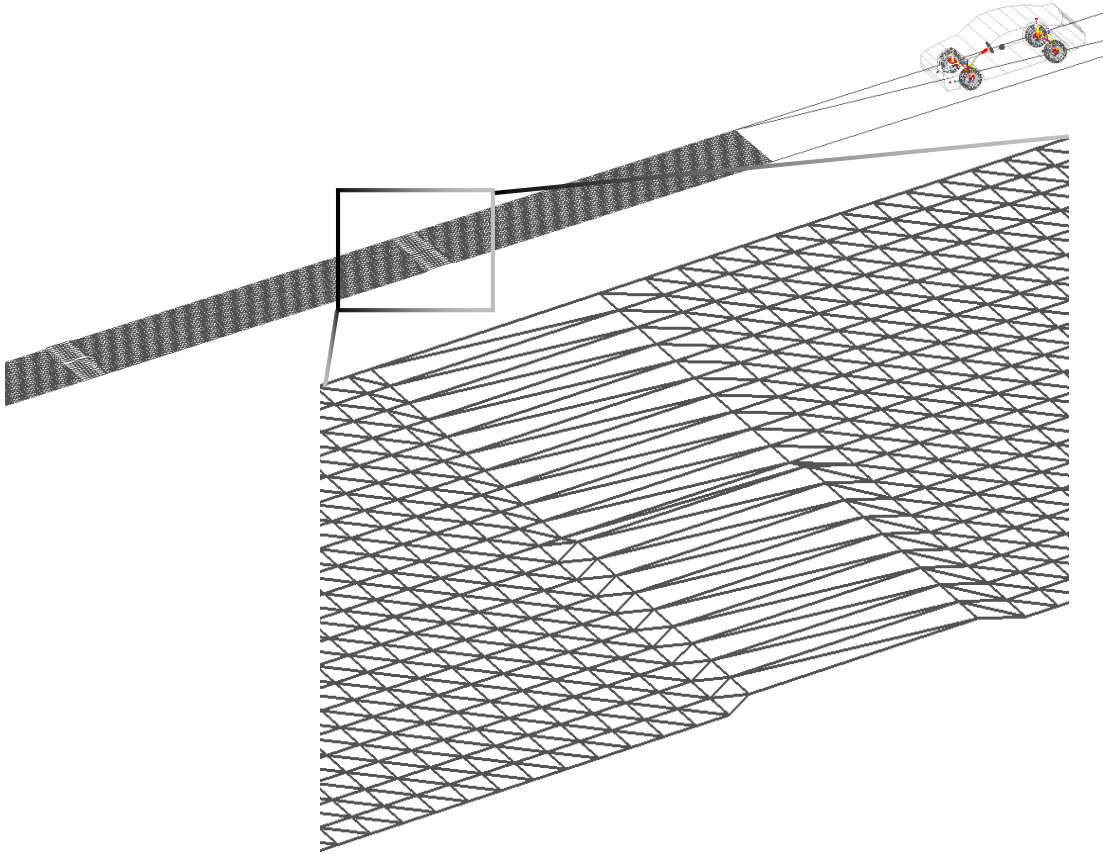
3D Road

Road profile #3

Threshold_normal_50kmh.des

- Threshold
  - 1st left side only
  - 2nd right side only
- Height: 40mm
- Length: 1500mm
- 4 seconds

⇨ Simulation to get desired signals for iteration

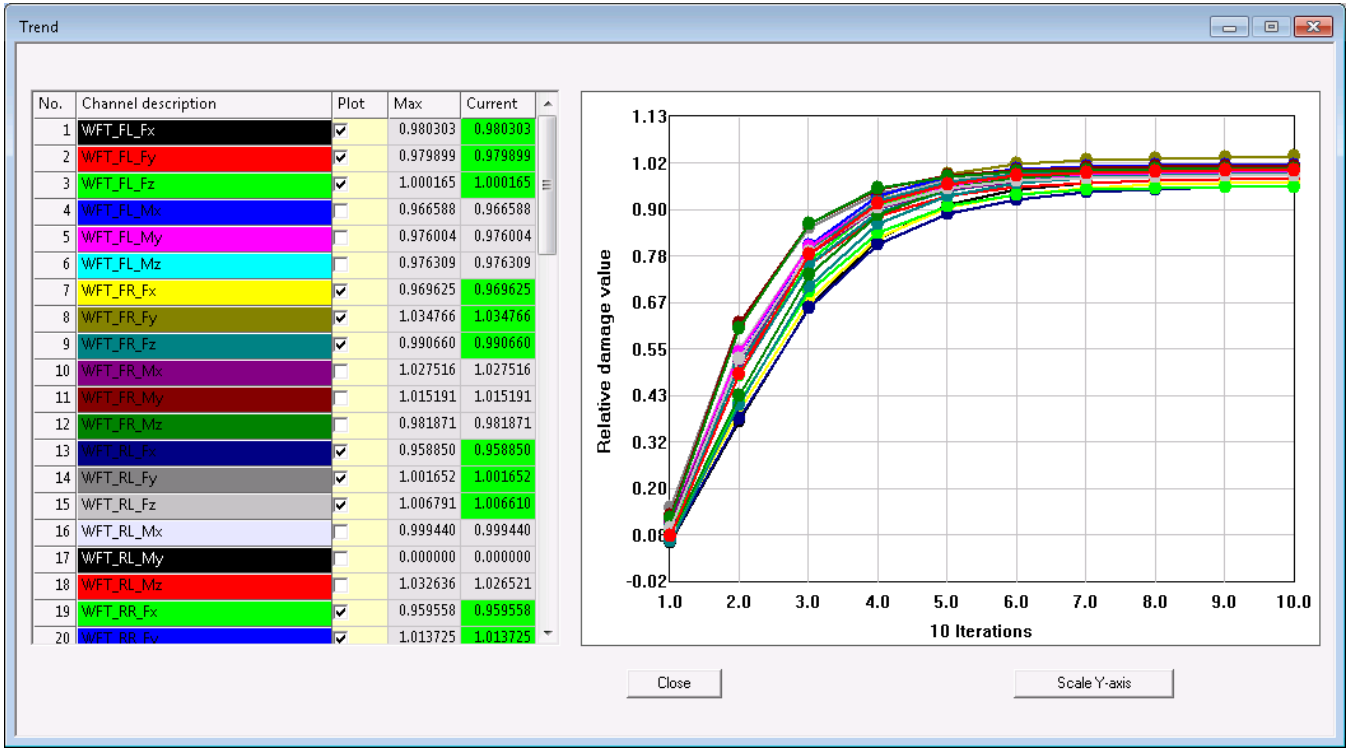


3D Road - validation of process

Result road profile #1

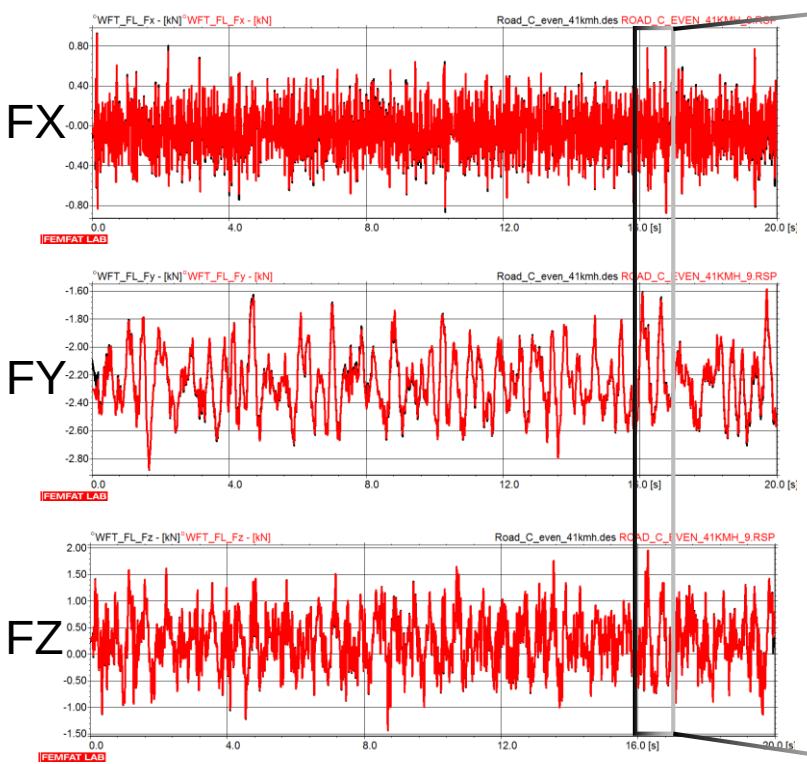
Road C even 41km/h – trend in relative damage values

- Convergence
- Very accurate



Result road profile #1

Road C even 41km/h – time signals, WFT front left

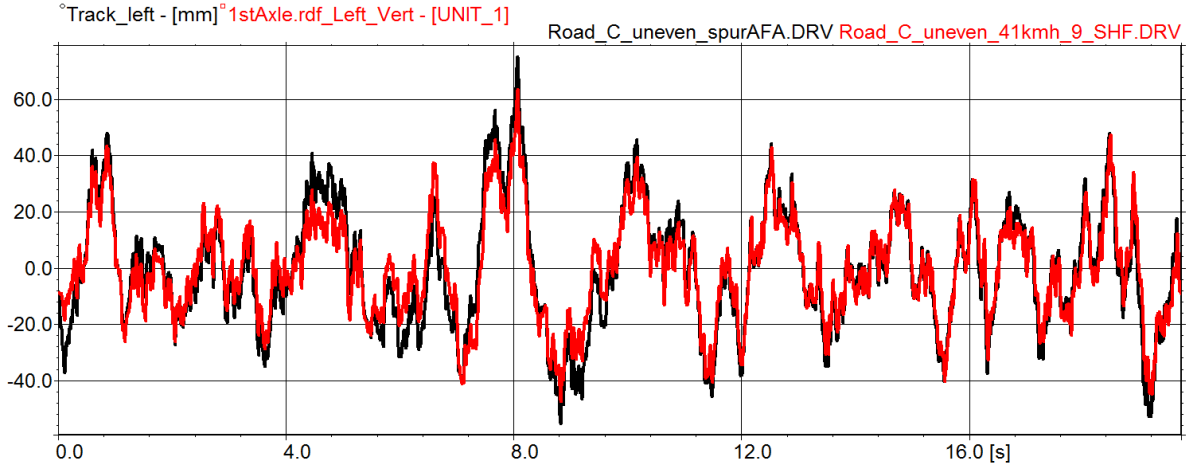


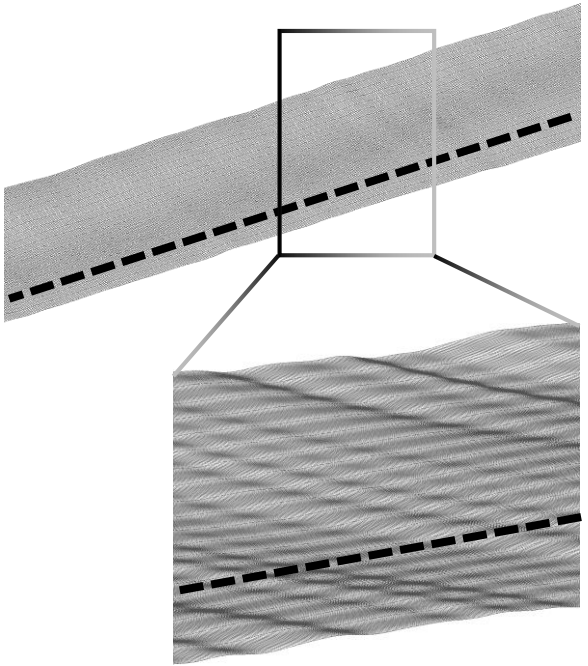
Method of 3D Road works well

Validation road profile #2

Road uneven 41km/h – transferred in time domain

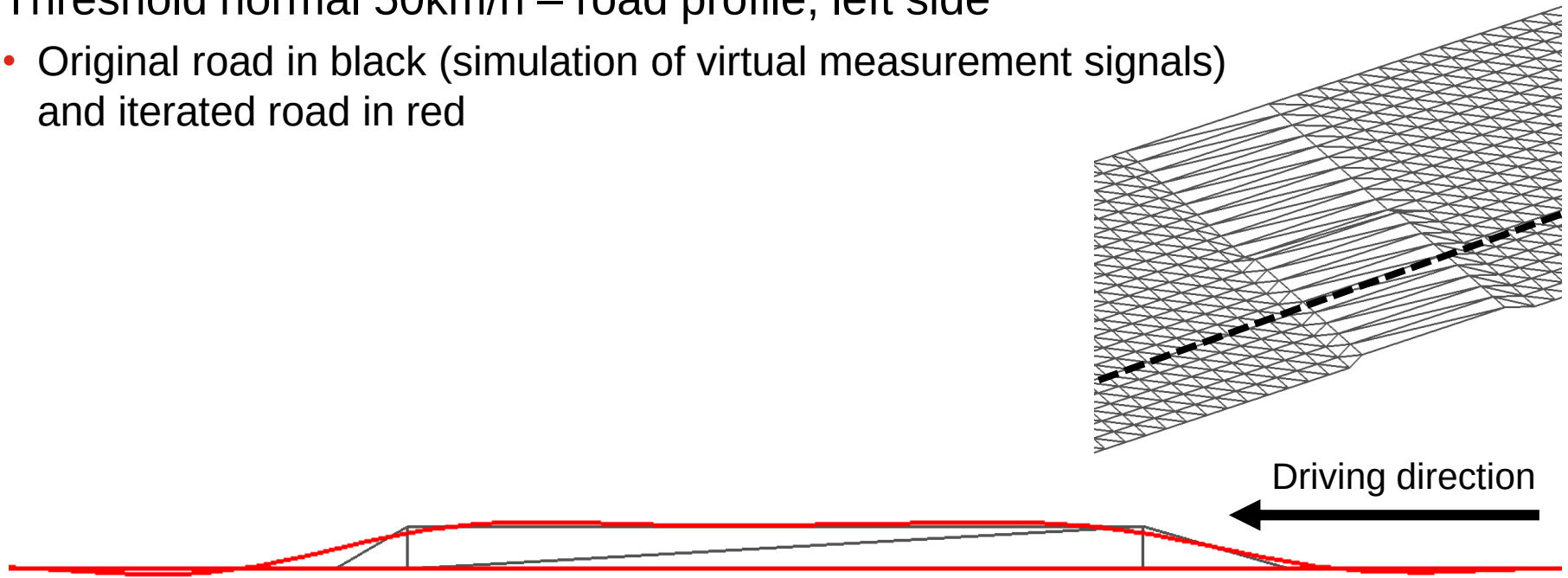
- Original road left side in black (simulation of virtual measurement signals)
  - Cut along left track
  - Filtered by 0.25Hz – 40Hz (same as transfer function)
- Iterated road left side in red





Threshold normal 50km/h – road profile, left side

- Original road in black (simulation of virtual measurement signals) and iterated road in red



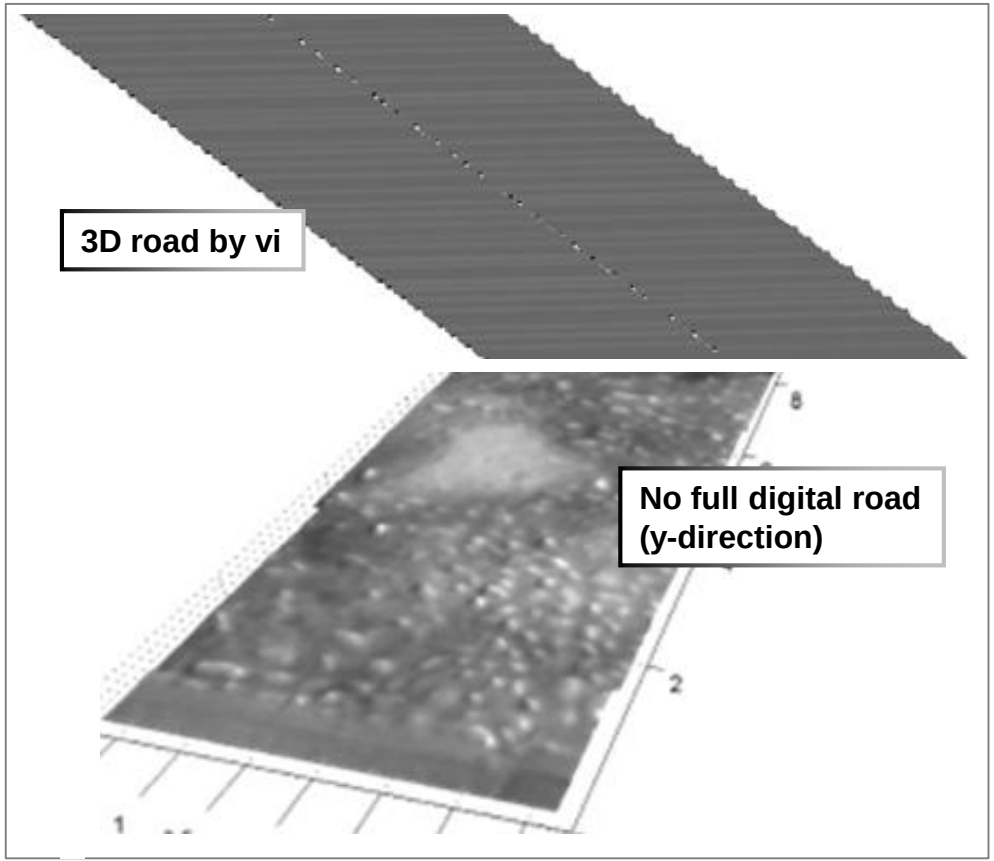
3D Road – advantages / restrictions

Computed roads

Advantages

- No 3D road scan required
- Special maneuvers possible (outside of proving ground,…)
- Customer usage
- Scan not always possible (water, mud,…)

Computed roads



Restrictions

- Results depends strongly on the used tire model
- 3D road for tire patch width (y-direction) only, result is not a full scan of road in Y-direction

Sing V.: Use of virtual iteration in commercial vehicle development
FEMFAT User Meeting 2007

3D Road - conclusion

Embedded in FEMFAT LAB software LOAD DATA ANALYSIS

- Full vehicle MBS model including tire model is required
- Use of vi required (standard process)
  - Some additional settings
  - Results show good correlation with 3D road simulation
    (influence of model, tire and measurement inaccuracies are eliminated)

3D Road was released in 2018

- Video tutorial is available
  - Getting started
  - Step by step tutorial
  - Including rough explanations

DRIVING **EXCELLENCE.**
INSPIRING **INNOVATION.**