



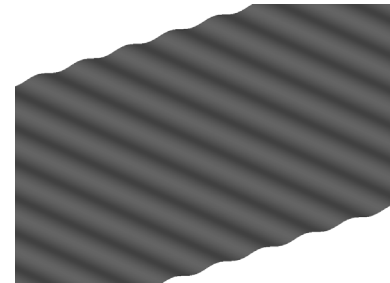
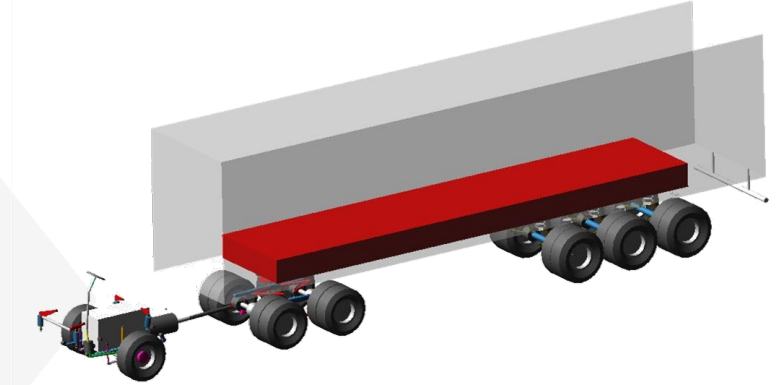
Virtual road for loads in concept phase using MBS and FEMFAT LAB

Otmar Gattringer, Engineer Vehicle
Dynamics Analysis, Magna

ECS Simulation Conference, 10th May 2023
Linz, Austria

Content

- Introduction
- Model
- Road load data measurements
- Full vehicle simulation
- Mixing tracks by FEMFAT LAB
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 - Mixing tracks of rear axles
- Conclusion

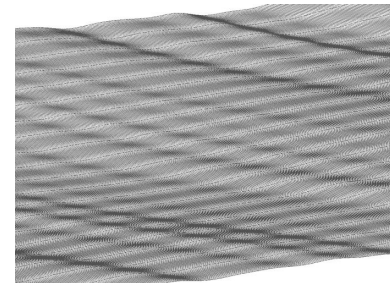


2	Bremsen_FTireA_ab0k1secF.RSP	0
3	DLC_FTireA_ab1sF.RSP	0
5	PH_asym_20kmhA_ab1sF_REQ.RSP	5300
6	PH_asym_22kmh_FTireA_ab1sF.RSP	0
8	PH_asym_25kmhA_ab1sF_REQ.RSP	500
9	PH_asym_FTireA_ab1sF.RSP	0
10	PH_sym_20kmh_80mm_FTireA_ab1sF.RSP	3000
12	PH_sym_22kmh_FTireA_ab1sF_REQ.RSP	0
13	PH_sym_25kmh_80mm_FTireA_ab1sF.RSP	0
14	PH_sym_FTireA_ab1sF.RSP	0
15	PSD_C_FTireA_ab1sF.RSP	0
17	PSD_DA_ab1sF_REQ.RSP	59200
18	Schwelle_steil_40mm_30kmh_FTireA_ab1sF.RSP	0
19	Schwelle_steil_40mm_50kmh_FTireA_ab1sF.RSP	0

Introduction

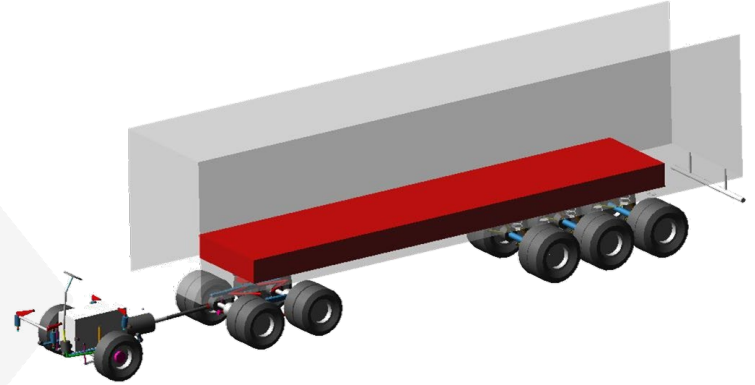
- Usage of full vehicle simulation on digital roads for loads of parts in concept phase of development
- Vehicle type
 - Tractor truck with trailer
- Target
 - Selection of virtual roads
 - Computation of repetition numbers for fatigue life based on road load data measurements

		Current rep.
1	Braking_01.RSP	0
2	Braking_03.RSP	14500
3	Double_lane_change.RSP	0
4	Pothole_asym_20kmh.RSP	6000
5	Pothole_asym_22kmh.RSP	0
6	Pothole_asym_25kmh.RSP	900
7	Pothole_asym_27kmh.RSP	0
8	Pothole_sym_20kmh.RSP	0
9	Pothole_sym_22kmh.RSP	200
10	Pothole_sym_25kmh.RSP	0
11	Pothole_sym_27kmh.RSP	0
12	RR_C.RSP	0
13	RR_D1.RSP	0
14	RR_D2.RSP	71600
15	Threshold_A.RSP	0
16	Threshold_B.RSP	0
17	Threshold_C.RSP	0
18	Twist.RSP	2300

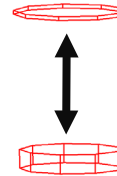


Model

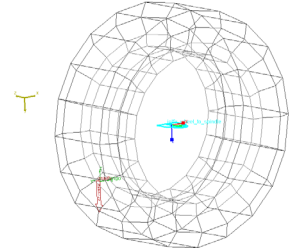
- ADAMS model of full vehicle including trailer
 - The model of the tractor truck shows good quality because it was used and trimmed in a previous project
- Trimmed by measured wheel loads and bumpstop clearances
- FTire model
- Requests for comparison with measured signals



Bumpstop clearance

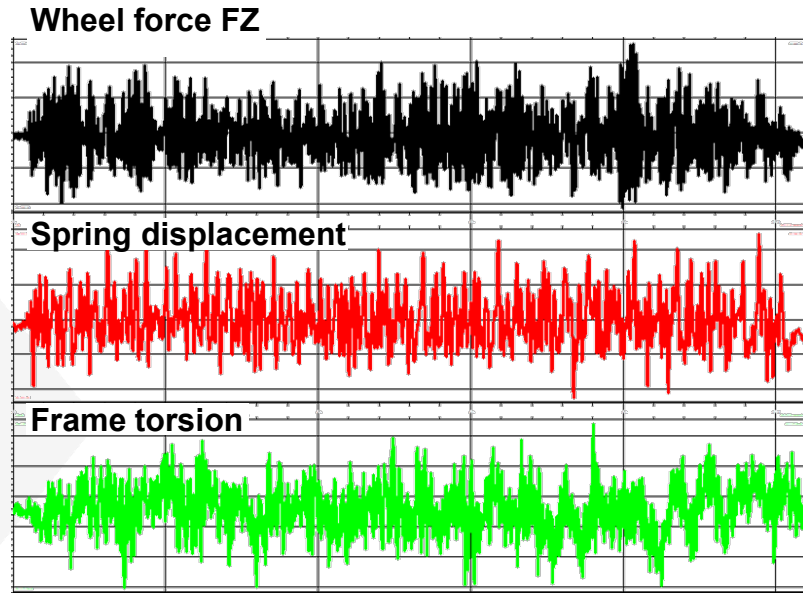


Wheel forces (WFT)



Road load data measurements

- More than 200 channels at tractor truck, 56 selected channels for rear axles investigations
 - Wheel forces (WFT)
 - Damper forces
 - Rod forces
 - Fifth wheel forces
 - Spring displacements at rear axles
 - Accelerations at frame close to rear axles
- Different tracks on road and proving ground
 - 100% fatigue life target for each channel (damage content of signals)



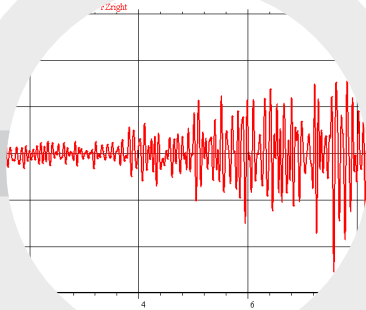
Road load data measurements

Computation of damage value of signals

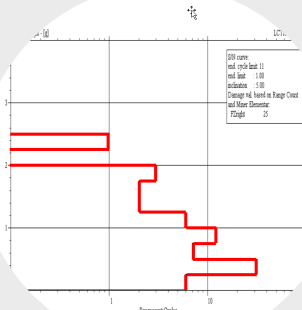
FEMFAT LAB software

LOAD DATA ANALYSIS

Time signal

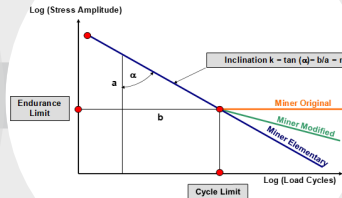


Rainflow counting

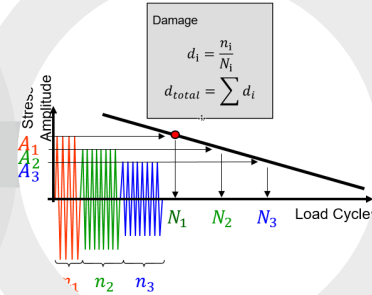


Fictive S/N curve

- Inclination 5
- Endurance limit
- Endurance load cycles

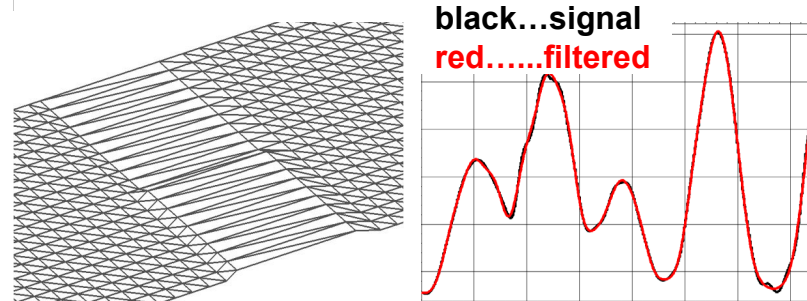
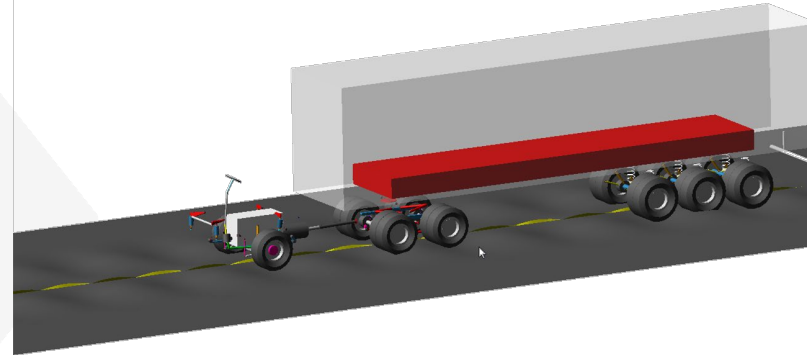


Damage value of signal by Miner Elementary



Full vehicle simulation

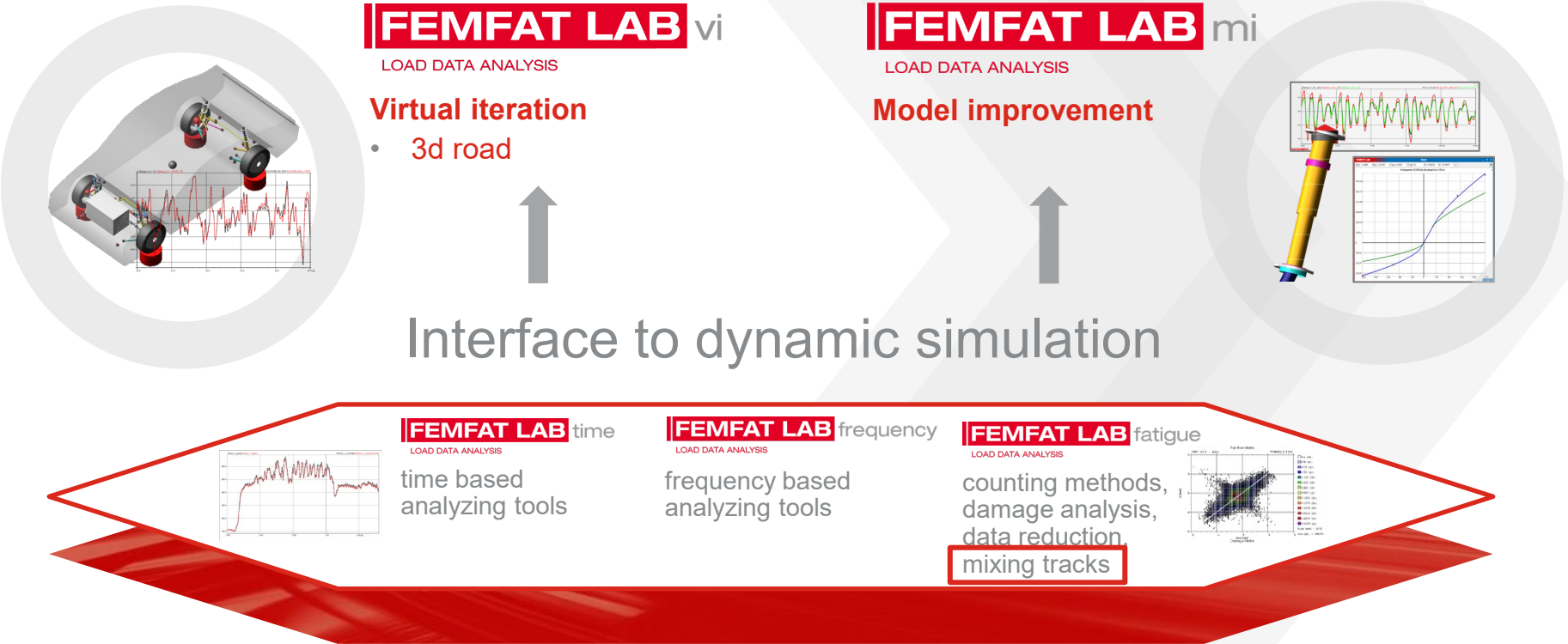
- Constant velocity and straight forward events
- Virtual roads
 - Variants of
 - Rough roads
 - Potholes
 - Thresholds
 - Braking
 - Double lane change
 - Twist
- Data processing of resulting signals
 - Conversion to same units regarding measurement
 - Low pass filter with 50Hz



Mixing tracks by FEMFAT LAB

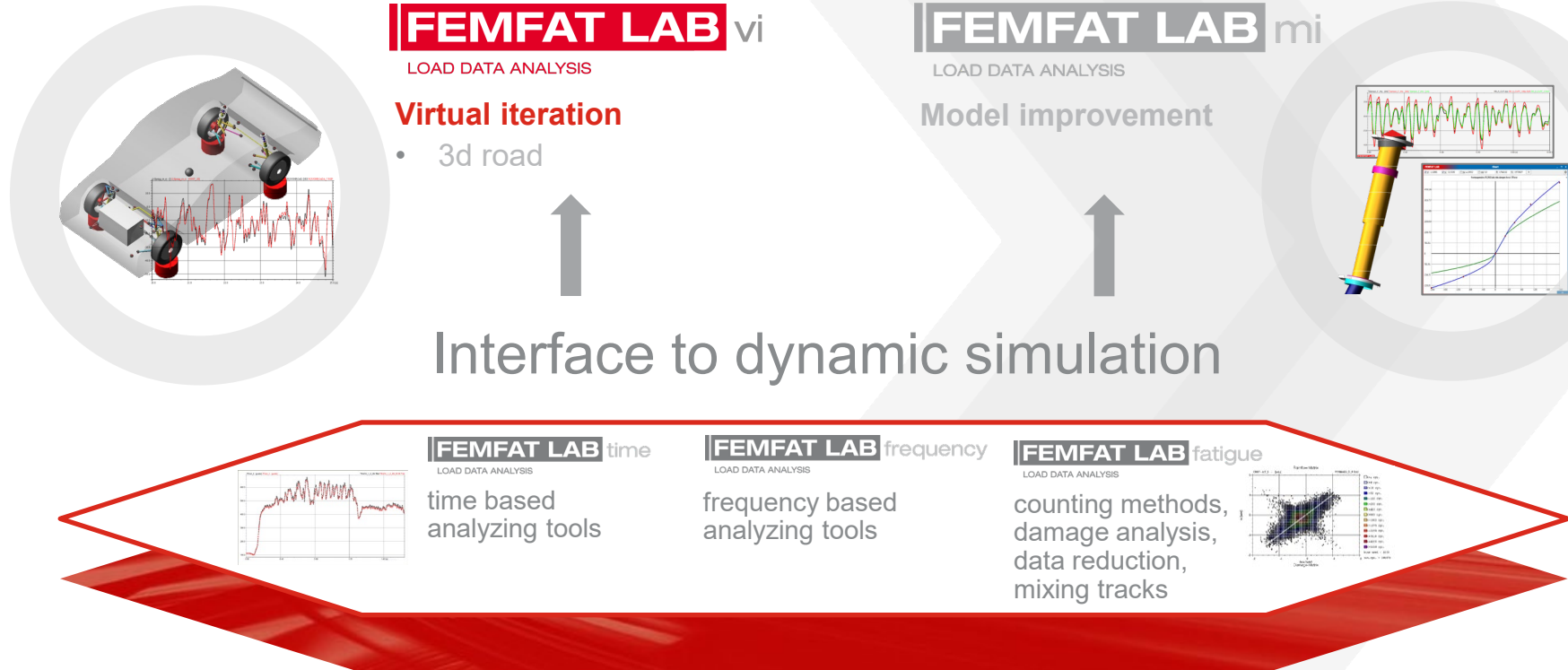


- Introduction



Mixing tracks by FEMFAT LAB

- Overview

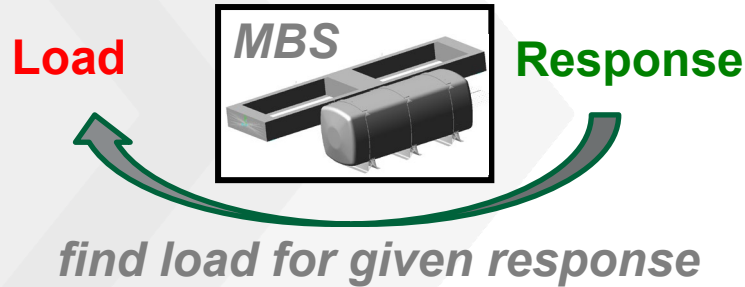


Mixing tracks by FEMFAT LAB

FEMFAT LAB vi

Benefits

- Load data generation for simulation models based on measured responses (accelerations, relative displacements, strains,...)



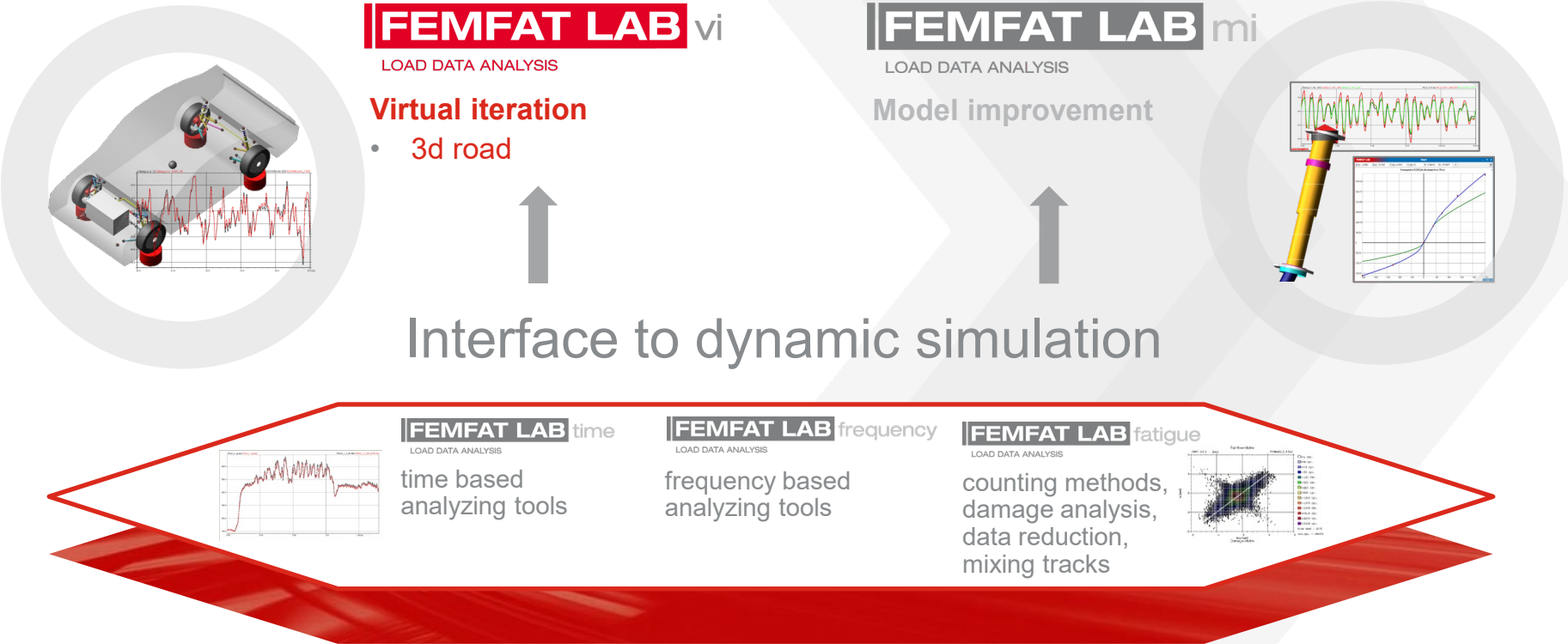
Link to simulation (MBS)

- Excellent convergence between measurement and simulation
- Convenient and automated process for ADAMS, SIMPACK, MotionSolve, RecurDyn and VI-Grade

Mixing tracks by FEMFAT LAB



- Overview

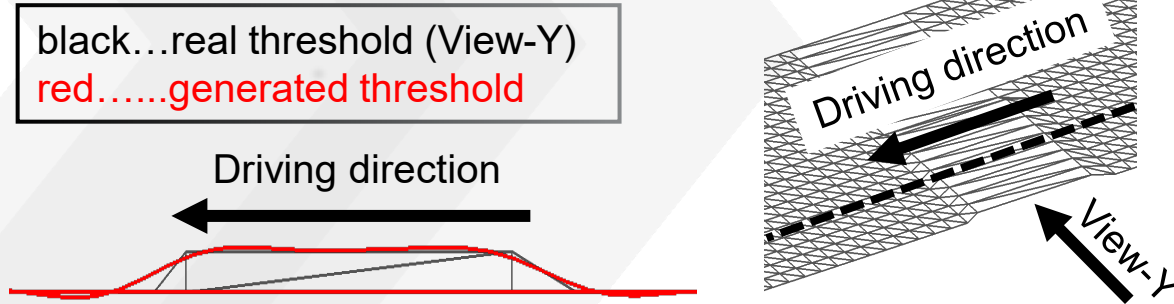


Mixing tracks by FEMFAT LAB

FEMFAT LAB vi 3d road

Benefits

- Generation of road surface without scanning because
 - often not permitted (confidential proving grounds)
 - too expensive (customer usages)
 - not reasonable (weak, mud or wet conditions)



Road surface for simulation (MSC.ADAMS/Car)

- Generation of 3D road based on measured responses of a full vehicle (accelerations, relative displacements, strains,...)
- Using virtual iteration

Mixing tracks by FEMFAT LAB



- Overview

FEMFAT LAB vi

LOAD DATA ANALYSIS

Virtual iteration

- 3d road

FEMFAT LAB mi

LOAD DATA ANALYSIS

Model improvement

Interface to dynamic simulation

FEMFAT LAB time

LOAD DATA ANALYSIS

time based
analyzing tools

FEMFAT LAB frequency

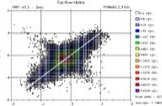
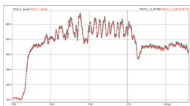
LOAD DATA ANALYSIS

frequency based
analyzing tools

FEMFAT LAB fatigue

LOAD DATA ANALYSIS

counting methods,
damage analysis,
data reduction,
mixing tracks

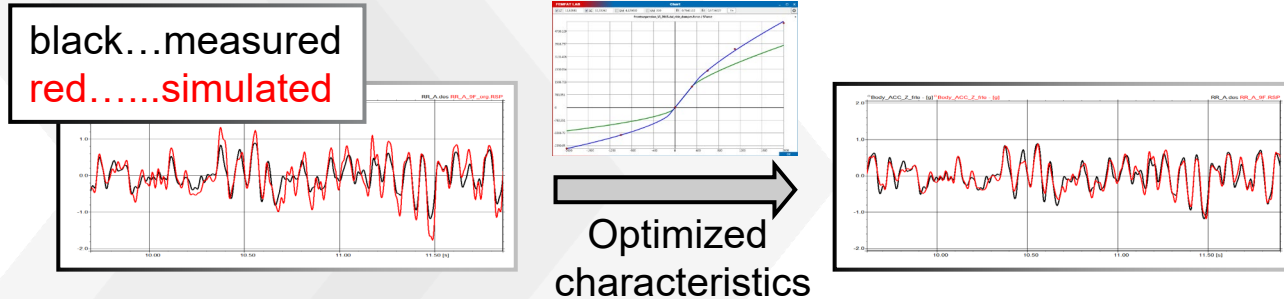


Mixing tracks by FEMFAT LAB

FEMFAT LAB mi

Benefits

- Optimized MSC.ADAMS model



Optimization of MBS models

- Automated improvement of model quality based on measured responses (accelerations, relative displacements, strains,...)
- Linear and nonlinear parameters
- A diagnose tool assists to identify the relevant parameters
- Convenient and automated process
- Fast algorithm (less number of simulations required)

Mixing tracks by FEMFAT LAB



- Overview

FEMFAT LAB vi

LOAD DATA ANALYSIS

Virtual iteration

- 3d road

FEMFAT LAB mi

LOAD DATA ANALYSIS

Model improvement

Interface to dynamic simulation

FEMFAT LAB time

LOAD DATA ANALYSIS

time based
analyzing tools

FEMFAT LAB frequency

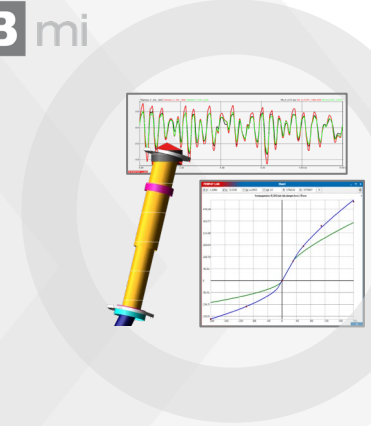
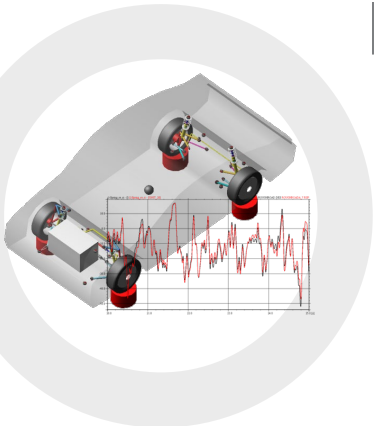
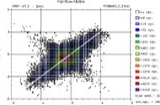
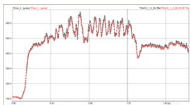
LOAD DATA ANALYSIS

frequency based
analyzing tools

FEMFAT LAB fatigue

LOAD DATA ANALYSIS

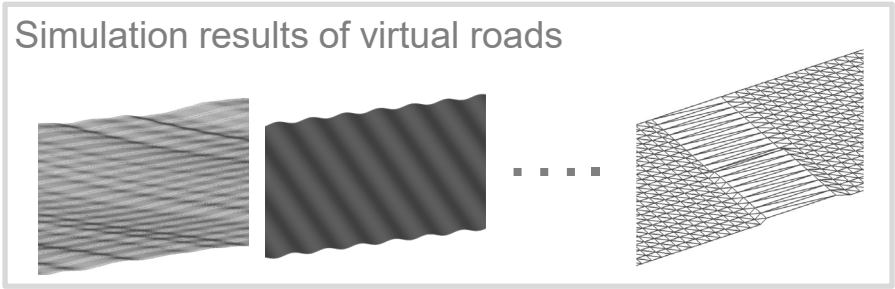
counting methods,
damage analysis,
data reduction,
mixing tracks



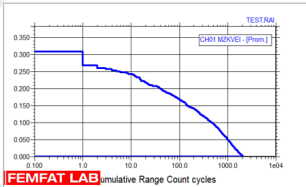
Mixing tracks by FEMFAT LAB



FEMFAT LAB fatigue



Target load



Target damage



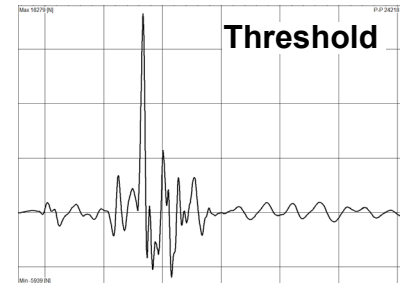
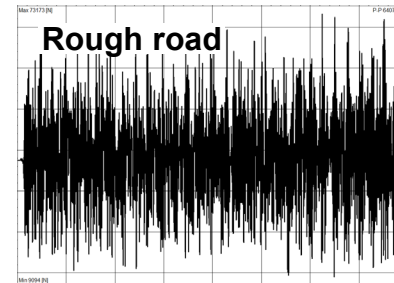
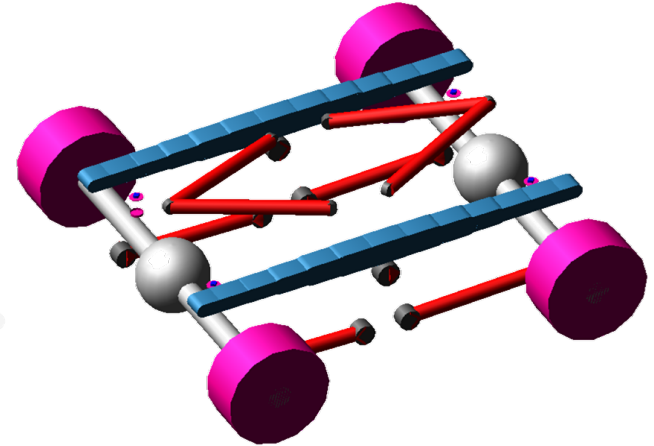
Mixing tracks

	Cum.
Bremsen_03g_FTireA_ab_0k1secF.RSP	14400
Bremsen_FTireA_ab0k1secF.RSP	0
DLC_FTireA_ab1sF.RSP	0
PH_asym_20kmhA_ab1sF_REQ.RSP	5300
PH_asym_22kmh_FTireA_ab1sF.RSP	0
PH_asym_25kmh_80mm_FTireA_ab1sF.RSP	500
PH_asym_FTireA_ab1sF.RSP	0
PH_sym_20kmh_80mm_FTireA_ab1sF.RSP	3000
PH_sym_22kmh_FTireA_ab1sF_REQ.RSP	0
PH_sym_25kmh_80mm_FTireA_ab1sF.RSP	0
PH_sym_FTireA_ab1sF.RSP	0
PSD_C_FTireA_ab1sF.RSP	0
PSD_DA_ab1sF_REQ.RSP	59200
Schwelle_steil_40mm_30kmh_FTireA_ab1sF.RSP	0
Schwelle_steil_80mm_30kmh_FTireA_ab1sF.RSP	0
Schwelle_steil_80mm_30kmh_FTireA_ab1sF.RSP	0
Schwelle_steil_80mm_30kmh_FTireA_ab1sF.RSP	340

Repetitions of virtual roads

Mixing tracks by FEMFAT LAB

- Target: Mixing simulated tracks to achieve measured 100% fatigue life
- Mixing tracks of rear axles
 - Is it possible to represent the main channels in good quality?
 - Which accuracy can be reached?
(desired target damage value 0.5 to 2)



Mixing tracks by FEMFAT LAB

- Convenient handling of mixing tracks process
- Main steps of process
 1. Select tracks
 2. Define used channels
 3. Import target damage values for the channels (can be also copied from EXCEL)

		Current rep.
1	Braking_01.RSP	0
2	Braking_03.RSP	0
3	Double_lane_change.RSP	0
4	Pothole_asym_20kmh.RSP	0
5	Pothole_asym_22kmh.RSP	0
6	Pothole_asym_25kmh.RSP	0
7	Pothole_asym_27kmh.RSP	0
8	Pothole_sym_20kmh.RSP	0
9	Pothole_sym_22kmh.RSP	0
10	Pothole_sym_25kmh.RSP	0
11	Pothole_sym_27kmh.RSP	0
12	RR_C.RSP	0
13	RR_D1.RSP	0
14	RR_D2.RSP	0
15	Threshold_A.RSP	0
16	Threshold_B.RSP	0
17	Threshold_C.RSP	0
18	Twist.RSP	0
		Channel used
		Weighting
	Values from logfile	Target dam.
		Current dam.
		Ratio

Mixing tracks by FEMFAT LAB

- Convenient handling of mixing tracks process
- Statistical values can be listed
 - For each track and channel
 - Required files to cover statistical values in percentage

1	Braking_01.RSP			0001	0001	0001	0001	0001	0001
2	Braking_03.RSP	x	x	0001	0001	0001	0001	XXXX	0001
3	Double_lane_change.RSP			0001	0001	0001	0001	0001	0001
4	Pothole_asym_20kmh.RSP			0001	0001	0001	0001	0001	0001
5	Pothole_asym_22kmh.RSP	x	x	0001	00X1	0001	0001	0001	XXXX
6	Pothole_asym_25kmh.RSP	x	x	0001	0001	0001	00X1	0001	XXXX
7	Pothole_asym_27kmh.RSP		x	XXXX	0001	XXXX	0001	00X1	0001
8	Pothole_sym_20kmh.RSP			0001	0001	0X01	0001	0001	0001
9	Pothole_sym_22kmh.RSP	x	x	0001	XXXX	0X01	0001	0001	0001
10	Pothole_sym_25kmh.RSP	x	x	0001	0001	XXXX	0001	0001	0001
11	Pothole_sym_27kmh.RSP			XXXX	0001	XXXX	0001	00X1	0001
12	RR_C.RSP			0001	0001	0001	0001	0001	0001
13	RR_D1.RSP			0001	0001	0001	0001	0001	0001
14	RR_D2.RSP			0001	0001	0001	0001	0001	0001
15	Threshold_A.RSP			0001	0001	0001	0001	0001	0001
16	Threshold_B.RSP			0001	0001	0001	0001	0001	0001
17	Threshold_C.RSP			0001	0001	0001	0001	0001	0001
18	Twist.RSP	x	x	0001	0001	0001	XXXX	0001	0001

Overall

Overall

Extrem values

Minimum

Maximum

Damage

Peak-Peak

Min %: 80

Cover extreme values

Mixing tracks by FEMFAT LAB

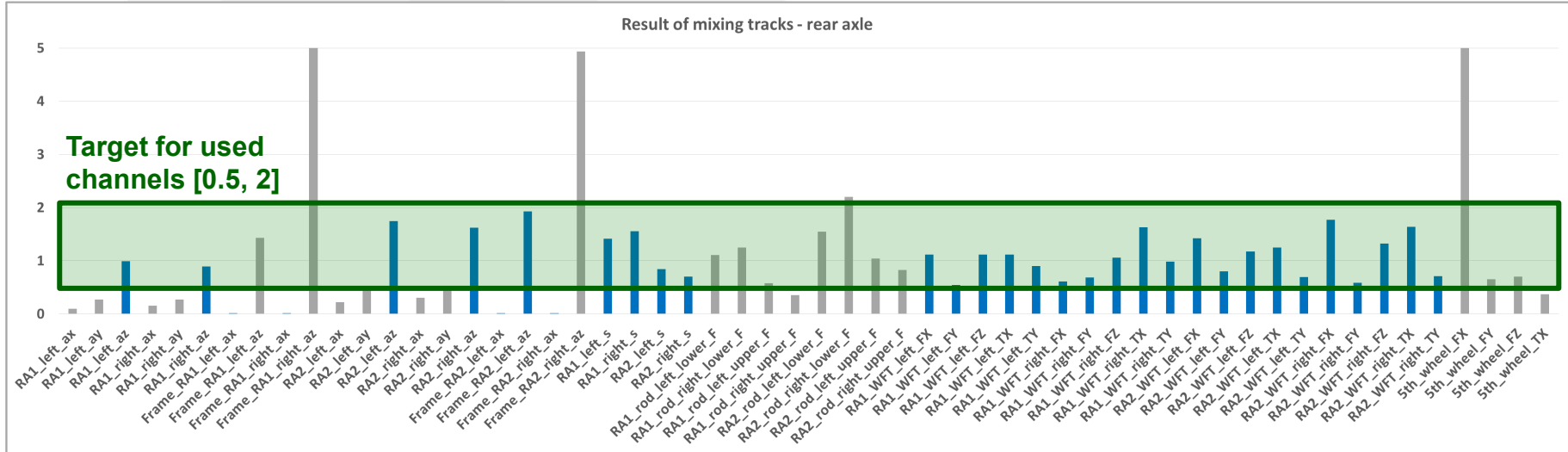
- Mixing tracks of rear axles
 - 56 channels
- 28 channels used for optimization
 - Wheel forces FX, FY, FZ, TX and TY
 - Spring displacements
 - Vertical axle accelerations
- Remaining channels to overview

Overview of results	
Result	Value
Calc. time [h]	836.5
Used files	6
Min	0.546
Max	1.77
Mean	1.04
Used channels	28
Sum. time of used files	91.6 [sec]

Mixing tracks by FEMFAT LAB

- Relative damage values for all channels

blue...used for optimization / gray...comparison



- Remaining channels
 - Longitudinal accelerations at frame too small
 - Vertical acceleration at frame right too high, left ok (simulation symmetric, measurement unsymmetric)
 - 5th wheel load longitudinal too high (modeling inaccuracy)

Mixing tracks by FEMFAT LAB

- Mixing tracks of rear axles
 - 6 tracks are used including repetition numbers
 - 14500 x Braking
 - 6000 x Pothole asymmetrical, 20km/h
 - 900 x Pothole asymmetrical, 25km/h
 - 200 x Pothole symmetrical, 22km/h
 - 71600 x Rough road
 - 2300 x Twist

		Current rep.
1	Braking_01.RSP	0
2	Braking_03.RSP	14500
3	Double_lane_change.RSP	0
4	Pothole_asym_20kmh.RSP	6000
5	Pothole_asym_22kmh.RSP	0
6	Pothole_asym_25kmh.RSP	900
7	Pothole_asym_27kmh.RSP	0
8	Pothole_sym_20kmh.RSP	0
9	Pothole_sym_22kmh.RSP	200
10	Pothole_sym_25kmh.RSP	0
11	Pothole_sym_27kmh.RSP	0
12	RR_C.RSP	0
13	RR_D1.RSP	0
14	RR_D2.RSP	71600
15	Threshold_A.RSP	0
16	Threshold_B.RSP	0
17	Threshold_C.RSP	0
18	Twist.RSP	2300

- Investigations of rear axles showed that the usage of virtual roads is quite applicable
- Resulting roads can be used for similar investigations
- Outlook
 - Comparison of fatigue life
 - FEMFAT results using loads from virtual testrig based on RLD signals
 - FEMFAT results based on virtual roads
 - Extend the method for mixing tracks of
 - Full vehicle
 - Subsystems
 - Front axle
 - Frame
 - Cab
 - Fuel tank, muffler



Forward. For all.

