DAIMLERCHRYSLER

Use of Simpack at the DaimlerChrysler Commercial Vehicles Division

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Truck Product Creation (4P)
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Content

Introduction

Teams using Simpack in the Center CAE Commercial Vehicles:

Driving dynamics and handling

Braking systems

Vehicle vibrations (up to 30 Hz)

Drive-train vibrations (up to 200 Hz)

Active systems

Vehicle scope: Trucks – Vans – Buses

Consequences:

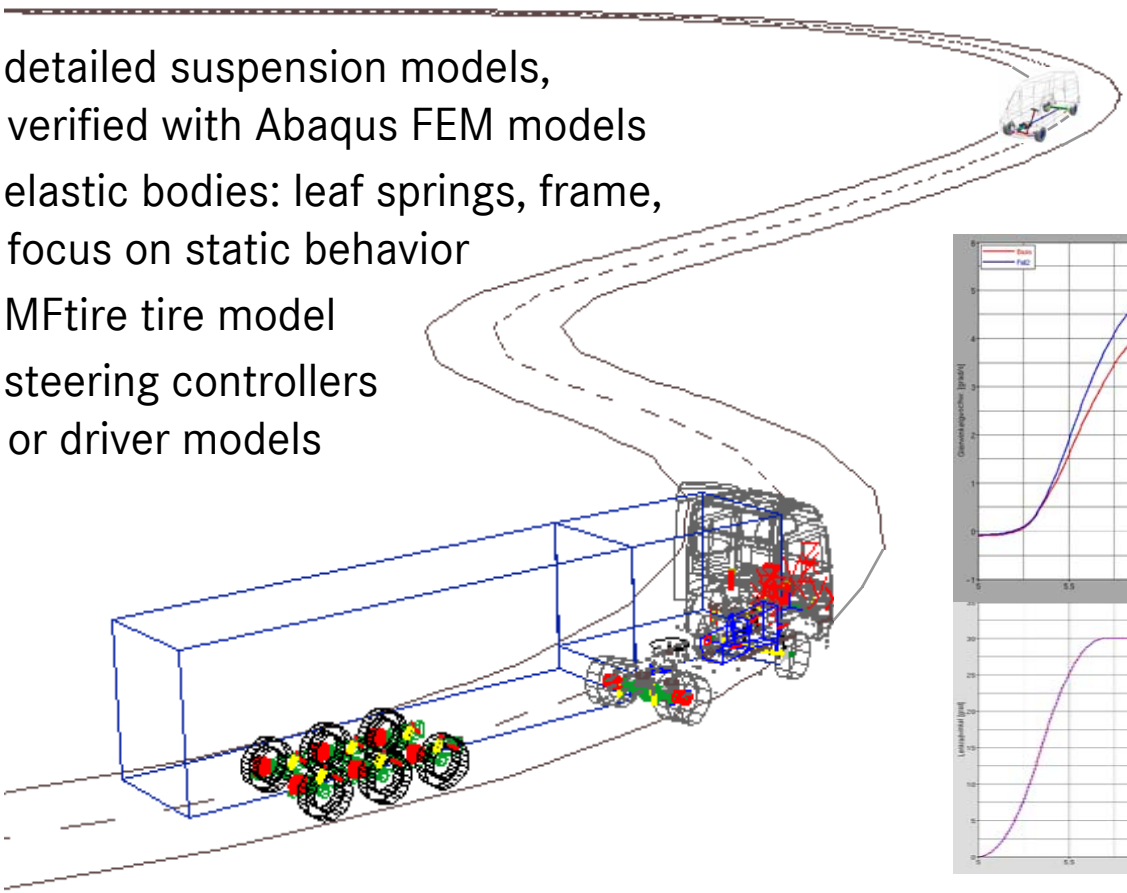
different focuses of analysis

different depth of modeling

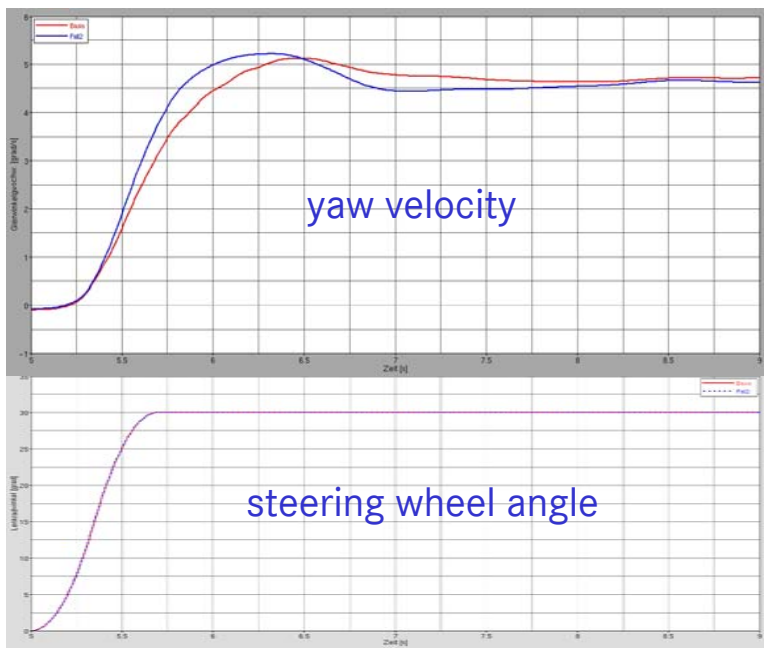
wide variety of vehicles, suspension systems, drivetrains etc.

Driving dynamics and handling

- detailed suspension models, verified with Abaqus FEM models
- elastic bodies: leaf springs, frame, focus on static behavior
- MFtire tire model
- steering controllers or driver models

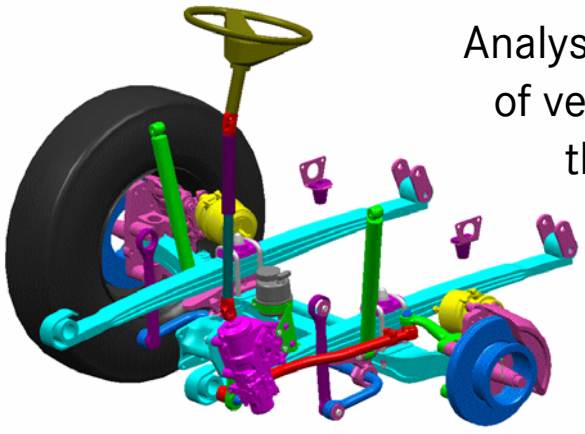


Steady-state and dynamic behavior of vehicles, open- and closed-loop manoevres

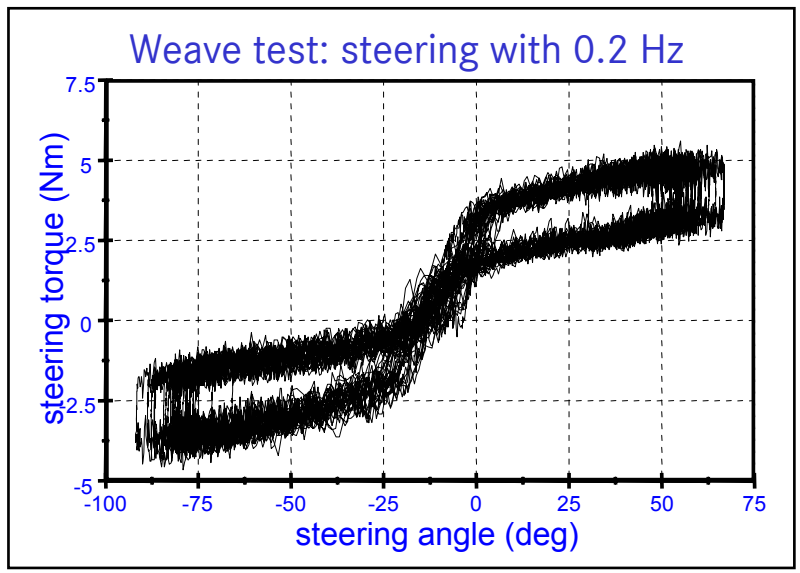


30° steering angle within 0.7s at 80 km/h

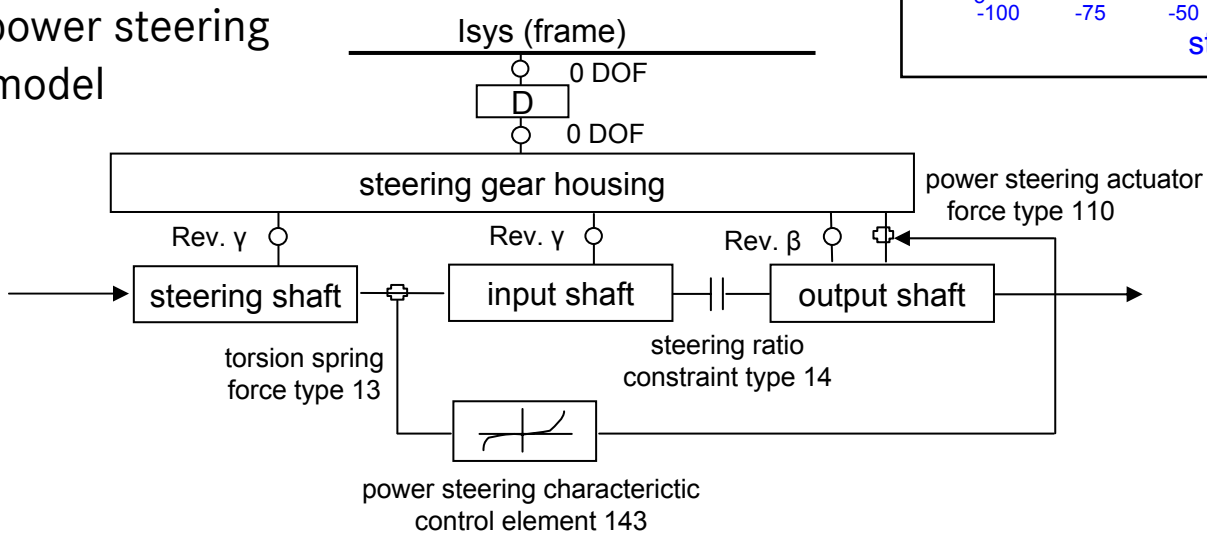
Driving dynamics and handling

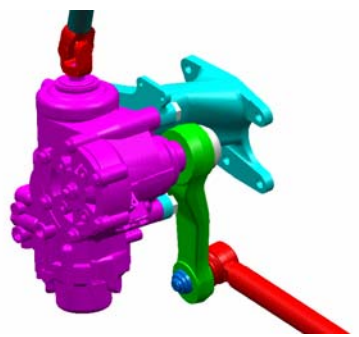


Analysis of the influence of vehicle dynamics on the steering torque



- power steering model



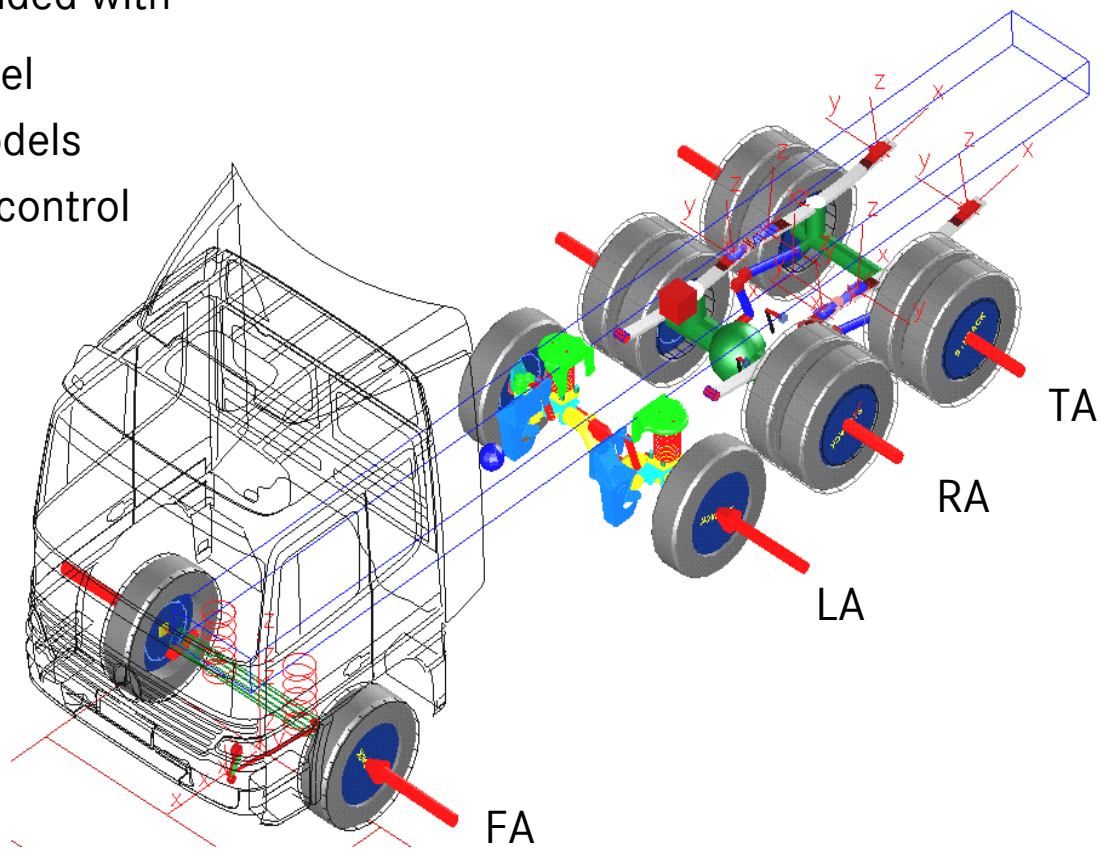


Braking systems

Layout and optimization of braking force distribution and braking systems

Driving dynamics models, extended with

- pneumatic braking system model
- engine braking and retarder models
- sensors for air spring an brake control
- brake control systems vor vans (ABS, ESP) and trucks (EPB) as software-in-the-loop

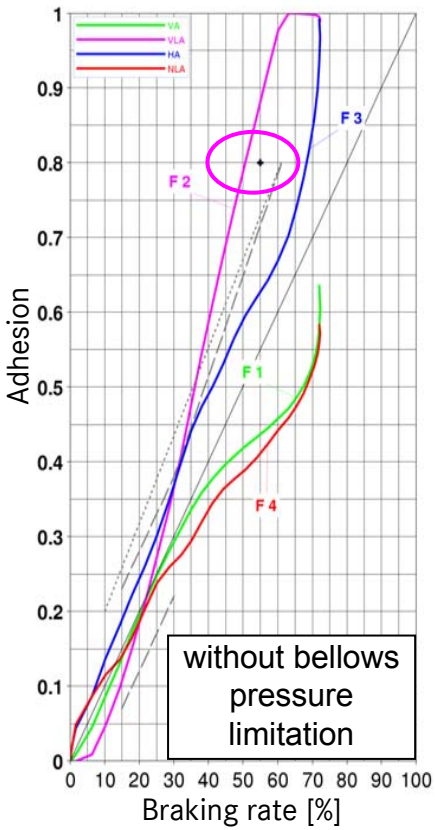


Special requirement:

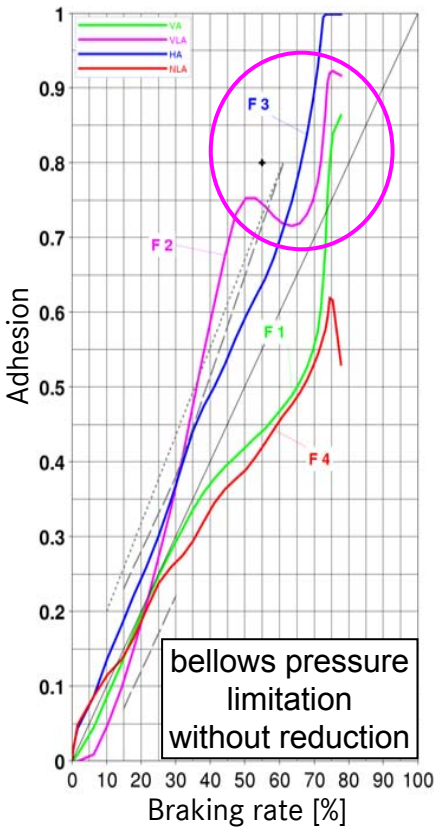
Models of multi-axle vehicles (e.g. 8x2/4) for layout of braking force distributions

Braking systems

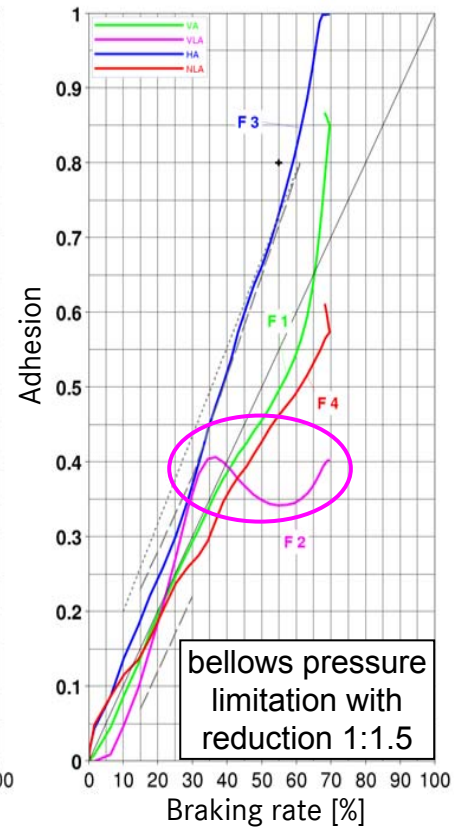
Example: locking behavior of 8x2/4 vehicle with indirectly ABS controllend axles



LA locks prematurely



LA not reliably lock-free



no locking of LA is guaranteed

Regulation: lock-free braking > 5 m/s², reliably met with a braking rate > 55 % at μ = 0.8

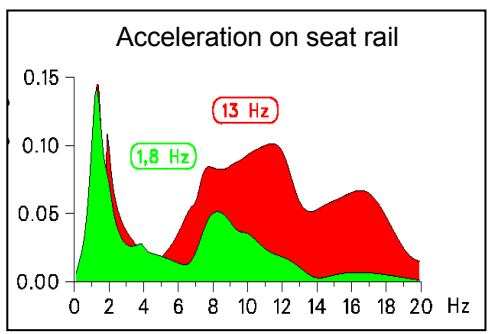
LA: (F2)
Indirectly controlled via FA. It is only lock-free with a bellows pressure limitation with a 1:1.5 reduction valve.

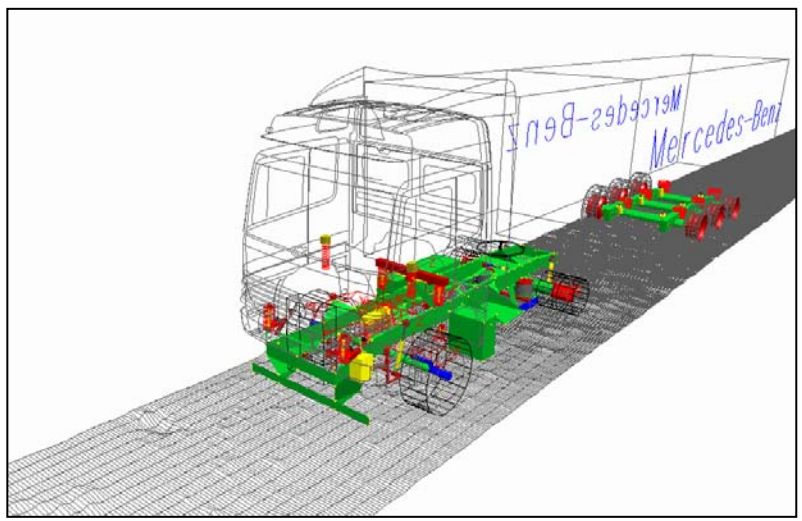
TA: (F4)
Indirectly controlled via RA. Adhesion curve F4 runs beneath the adhesion curve F3 of the RA
→ TA is lock-protected

Vehicle vibrations

Vibrations up to 30 Hz:
driving comfort and component loading

- detailed suspension models
- elastic bodies: e.g. leaf springs and frame, focus on dynamic behavior
- engine and drive-train mounts
- RMOD-K tire model
- measured or generatend 3D road surfaces





Comfort assessment: accelerations are weighted based upon the human sensitivity

Drive-train vibrations

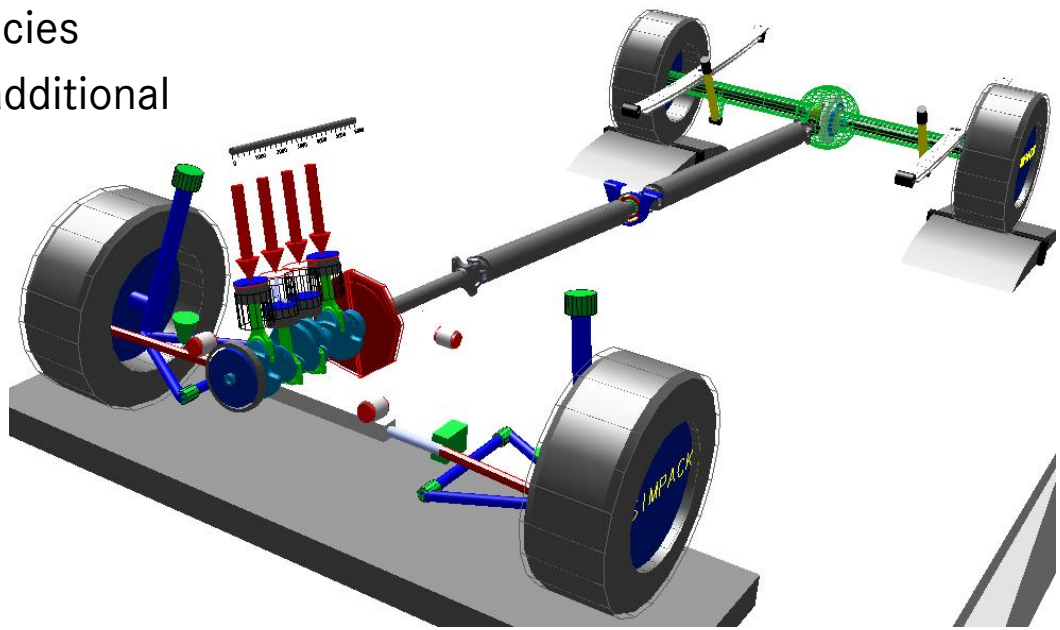
Influence of drive-train-induced vibrations on the vehicle up to 200 Hz

Vehicle vibration models extended with drive train and engine models:

- detailed drive train models with flexible bodies
- detailed engine models considering gas and inertia forces
- suspension force elements including effects of small amplitudes and high frequencies
- special tire models (Pacejka with additional stiffness and damping properties)

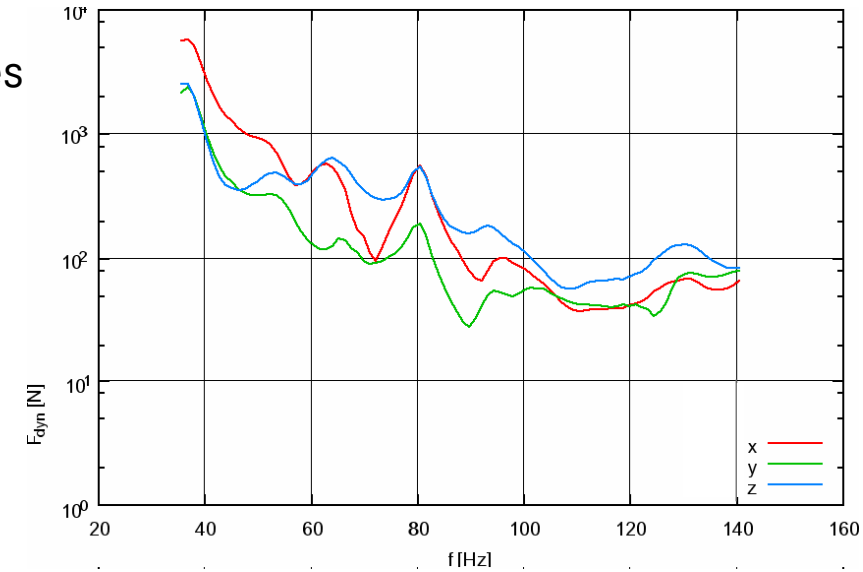
Load cases: e.g.

- engine run-up under part an full load
- vibrations at idle
- jump start
- tip in back out

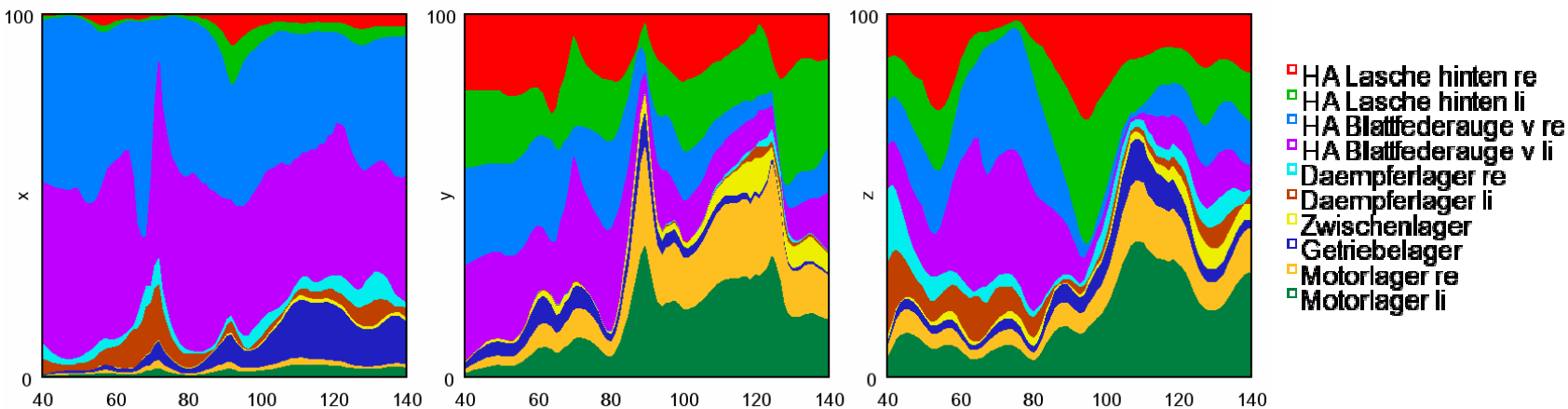


Drive-train vibrations

Sum of all dynamic forces in drive-train bearings

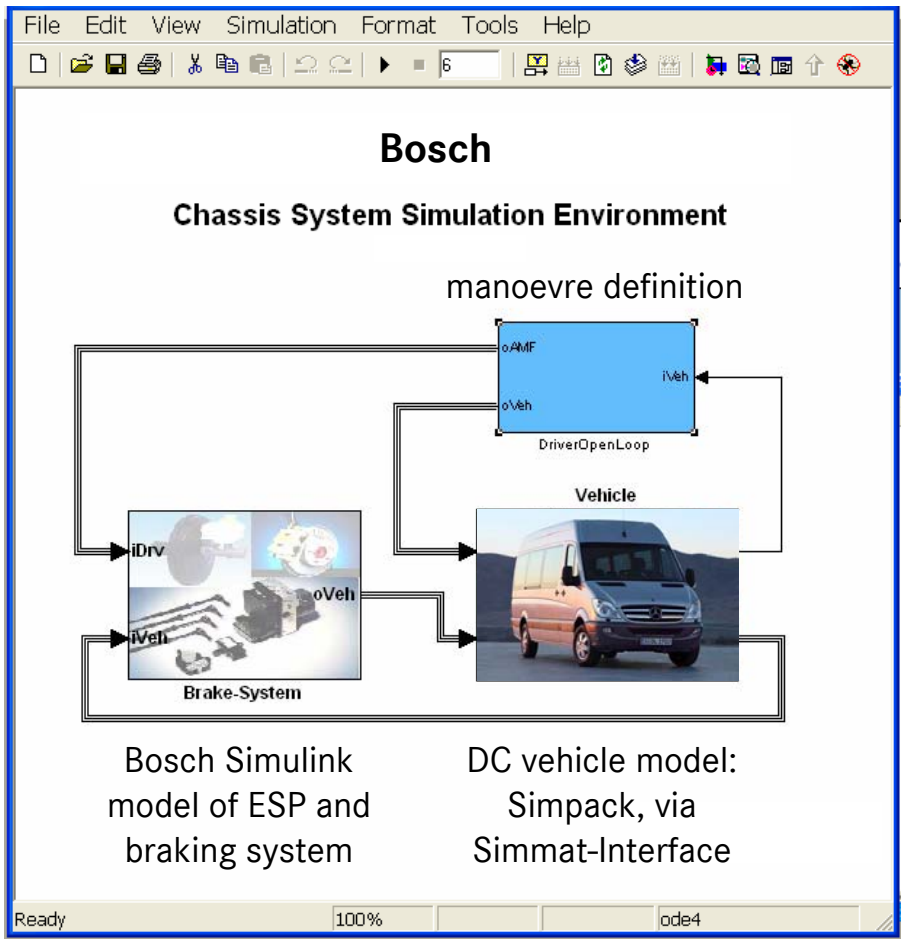


Distribution of dynamic forces to the bearings



Active systems

Driving dynamics or vehicle vibrations models, extended with active systems



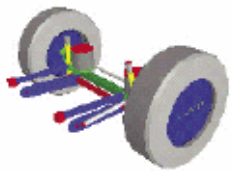
Bosch Simulink model of ESP and braking system

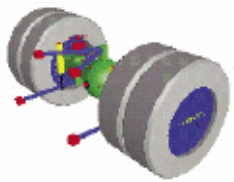
DC vehicle model: Simpack, via Simmat-Interface

- import of Matlab/Simulink models and control systems, models of actuators
- Simpack Code Export for software-in-the-loop simulations, e.g. cooperation with Bosch
- Build-up of Simpack real-time models, also using Simpack Virtual Suspensions
- Simpack Code Export of real-time models for hardware-in-the-loop applications, e.g. for a HIL test-bench for ESP function tests

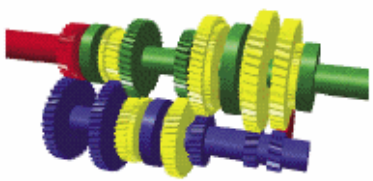
Model database:
Sharing of models and substructures

SUBSTRUCTURE COMPONENTS

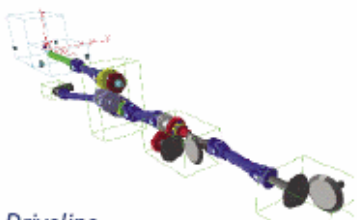




Front and Rear Suspensions

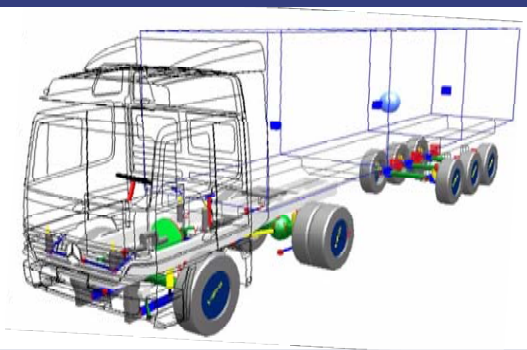


Gearbox Substructure

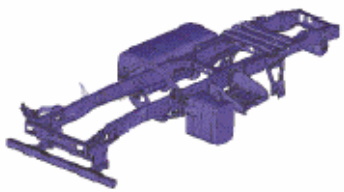


Driveline

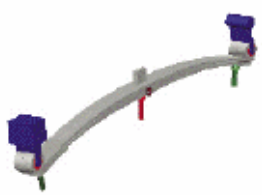
FULL VEHICLES



ELASTIC SUBSTRUCTURES

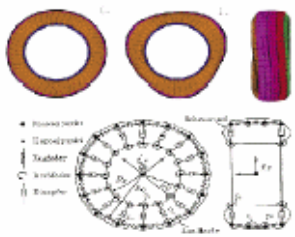


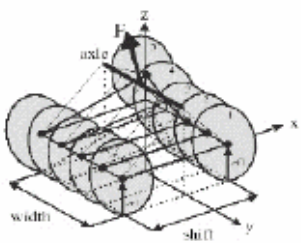
Flexible Frame



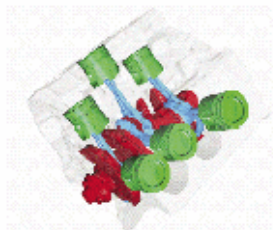
Leafspring

DYNAMIC TIRES

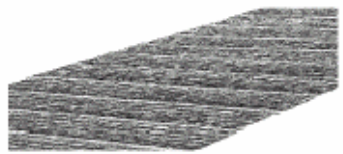




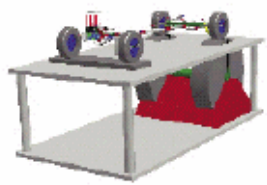
LOADCASES



Engine Excitations



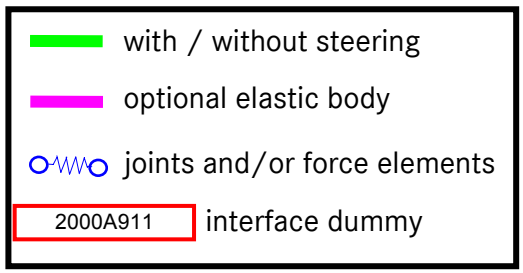
Road Excitation

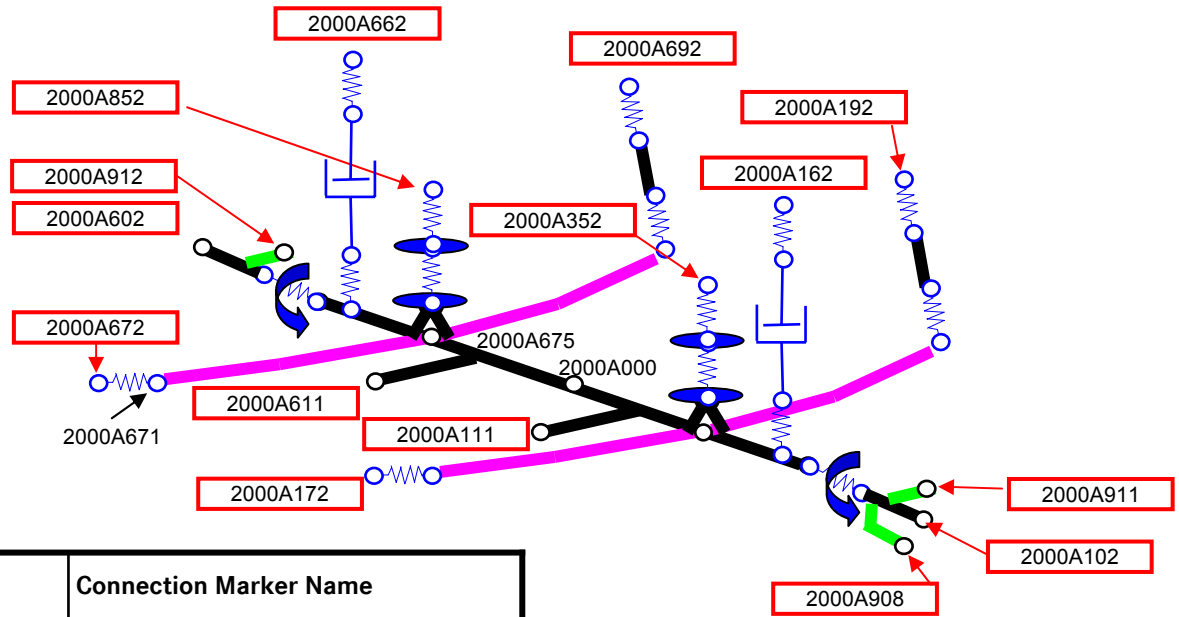


Testrig Scenarios

Basis: fixed inter-facing conventions

Model database: Substructure definition





FE-Node	Dummy Name (marker name = body name)	Connection Marker Name
2000A162	$B_____dummy_daemp_li_an_rahmen	$M_rahmen_va_daemp_li_koppel
2000A662	$B_____dummy_daemp_re_an_rahmen	$M_rahmen_va_daemp_re_koppel
2000A172	$B_____dummy_blafe_voli_an_rahmen	$M_rahmen_va_blafe_voli_koppel
2000A672	$B_____dummy_blafe_vore_an_rahmen	$M_rahmen_va_blafe_vore_koppel
2000A192	$B_____dummy_blafe_hili_an_rahmen	$M_rahmen_va_blafe_hili_koppel
2000A692	$B_____dummy_blafe_hire_an_rahmen	$M_rahmen_va_blafe_hire_koppel
2000A352	$B_____dummy_anschlag_li_an_rahmen	$M_rahmen_va_anschlag_li_koppel
2000A852	$B_____dummy_anschlag_re_an_rahmen	$M_rahmen_va_anschlag_re_koppel
2000A000	$B_____dummy_achskoerper_an_rahmen	$M_rahmen_va_achskoerper_koppel

Additional markers at the axle:

$M_achse_stabi_li
$M_achse_stabi_re
$M_achse_stabiruecken
$M_lenkung

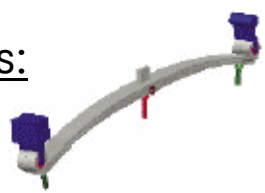
Process development

Data Supply

Data sources:

- data downloads of CAD geometries for coordinates, FE models and visualization
- non-geometry data from drawings and test results

Data transfer between tools:

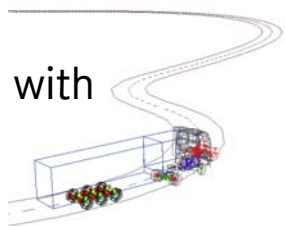


- Next step: leaf springs from Abaqus to Simpack
- Future step: Abaqus suspension calculation results as input for Simpack Virtual Suspension models (also for rigid axles)

Workflow

Process Automation:

- Script for model assembly connects substructures to main model, iterates CG x position for given load, calculates nominal forces (spring tire)
- Script for model preparation inserts tire model, sensors etc., starts a short test simulation
- Script for simulation creates and runs models with different load cases

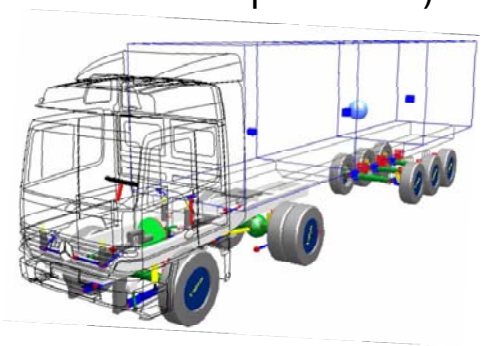


Postprocessing:

- Hypergraph template files for standard load cases

Man-in-the-loop: Simpack at the DC Driving Simulator

Simpack real-time model of a 40 t semitrailer truck (partially using Simpack Virtual Suspensions)



DC simulation environment CASCaDE for offline simulation

provides standard driving manoevres with auto-mated postprocessing

DC Driving Simulator for handling and low frequency ride

Goals of Driving Simulator tests:

make vehicle variants driveable without building it in hardware, support suspension concept decisions and parts specification, define target values for vehicle properties

Process advantages of Simpack:

- one tool for detailed and for real-time models
- flexible tool to build different real-time models for vehicle variants

Summary and Conclusion

- Simpack has become an important tool for the DaimlerChrysler Commercial Vehicles Development.
- With Simpack, we have the ability to design full-verhicle models for different investigations with one tool.
- We extended the use of Simpack to real-time models and to the DaimlerChrysler Driving Simulator.
- One part of the models and substructures can be used in different teams, other substructures are needed by a single team. The interfaces between the sub-structures are standardized.
- A common model database is used for the documentation of important model variants and for model exchange.
- Process development for easier data supply and automation of standard work steps is of high importance for us.