Use of Simpack at the DaimlerChrysler Commercial Vehicles Division

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Truck Product Creation (4P)
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 manoeuvres

- 30° steering angle within 0.7s at 80 km/h
- Yaw velocity
- Steering wheel angle
Driving dynamics and handling

Analysis of the influence of vehicle dynamics on the steering torque

- power steering model

Weave test: steering with 0.2 Hz

Steering torque (Nm) vs. steering angle (deg)
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 and brake control
- brake control systems for 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 controlled axles

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 generated 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

- 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
- Leaf Spring

**DYNAMIC TIRES**

**LOADCASES**
- Engine Excitations
- Road Excitation
- Testing Scenarios

Basis: fixed interfacing conventions
Model database:
Substructure definition

with / without steering
optional elastic body
joints and/or force elements
interface dummy

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
$Mlenkung
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

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-vehicle 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 substructures 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.