Real Time Driving Dynamics Simulation in Heavy Commercial Vehicles

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Variety in Commercial Vehicle
Suspension

- Heavy, medium and light trucks, off-highway, special-purpose vehicle
- City-bus, intercity-bus, coach
- Up to 5 axles, variety in configuration and wheel base
- Up to 3 steered axles (mechanically, hydraulic, electrically)
- Suspension: Leaf spring, air spring, coil spring, hydropneumatic
- Powertrain: Configurations (up to 8x8), gearboxes, diff. gear units, tires, retarders
- Wide range between empty and laden vehicle
- Variety in platforms (tractor, body, flatbed, tipper, swap body, tanker, mixer, fire truck, urban)
Virtual development of varieties

- Reliable modeling of variants in simulation
- Real time capability
- Detailed consideration of components relevant for driving dynamics (here)
- IPG-TruckMaker benchmark
1 Motivation

2 Scope of work

3 MBS model (reference vehicle)

4 TruckMaker model with different suspension modeling

5 Results: First benchmark

6 Integration into MAN development framework

7 Conclusion and outlook
Scope of Work

- TruckMaker as a real-time simulation environment
- Integration of sophisticated subsystem models (compare the MODELON presentation)
- Management of variants

**Integrative real-time capable vehicle**
- Driver, road, environment
- Vehicle variants (truck / bus)
- Ridable basic vehicle
- Modules in different LOD*
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Vehicle data
- MAN TGX 4x2 BL Tractor
- Additional load on fifth wheel 10,5 t
- Front axle with leaf spring
- Rear axle with air spring and 4 point steering rod

Model properties
- Modeling in SIMPACK
- Elastic parts: frame, axle parts, 4 point steering rod
- Steering controller
- Drive controller
- Tire model TMEasy
SIMPACK MBS-Model
Reference suspension

**Rear axle kinematics**
- 4 air springs
- 2 dampers
- 2 lower steering rods
- 4 point steering rod

**Front axle kinematics**
- 2 leaf springs
- 2 dampers
- stabilizer bar
- steering system (not shown)
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Model variants: Chassis / Suspension
- Linear kinematics
- IPG Kinematics analysis
- K&C analysis (SIMPACK)

Other model properties
- IPG Driver
- Pneumatic brake system
- Elastic cabin mount
- Elastic body
- Test runs with and without trailer
Required effects (e.g. for chassis controller development)

- Elasto-kinematics (e.g. bending of axle body)
- Axle buffer and “S-Schlag” buffer
- Compliance in steering rods
- 3D-nonlinear bushing characteristics
- 3D-nonlinear leaf spring behavior

Today, requirements can only be fulfilled with a MBS analysis
Kinematics and Compliance Analysis*

- Automated integration of axle model in K&C test rig
- Generation of test procedure in K&C Manager for SIMPACK (.if2)
- Simulation and result data export (.sbr) through scripted post processing
- Generation of SKC file according to TruckMaker specifications

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- Interface to TruckMaker: Segment shaft angle (steering gear)
- Equals the steering rack travel
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Comparison of results

- Steady-state circular test with 47m radius, constant velocity 15 m/s
- IPG Driver and SIMPACK driver tests (similar behavior in steady state)
- Different “Level of Detail” in modeling
  - IPG Kinematics
  - K&C analysis with SIMPACK
Roll behavior of rigid axles in steady-state circular test (accelerated)

- Kinematic coupling of left and right wheel (bending and torsional stiffness)
- Kinematic constraints due to leaf spring and 4 point steering rod
- Stabilizing mechanism is considered by kinematic constraints in K&C
  - No additional force element required in TruckMaker
Behavior of rigid axles in ISO lane change test

- Comparison of different driver models (SIMPACK vs. IPG Driver)
- Equal trajectory
- Slight differences in steering behavior => differences in vehicle reaction
- Correlation for identical steering input (IPG Driver in SIMPACK)
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Simulation of Variants

- SPM* - system for automated export functionalities
- K&C results can be exported from database
- Direct export of vehicle data (based on parts and modules) into TruckMaker model file

* Simulation Parameter Management
Today

- Manual export of parts and subsystems
- Direct export to TruckMaker ASCII-file
Today

Manual export of parts and subsystems

Direct export to TruckMaker ASCII-file

Example

Damper
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Conclusion and Outlook

Conclusion
- Good results in vehicle dynamics on the first try
- Suspension have to be considered with K&C-analysis to correlate MBS
- Constraints between right and left wheel (rigid axle) lead to new approaches
- TruckMaker vehicle models can be generated by database

Outlook
- Integration of MBS-Suspension (C-Code export)
- Establish a SPM model base
- Automated generation of enquiry vehicle model variants
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