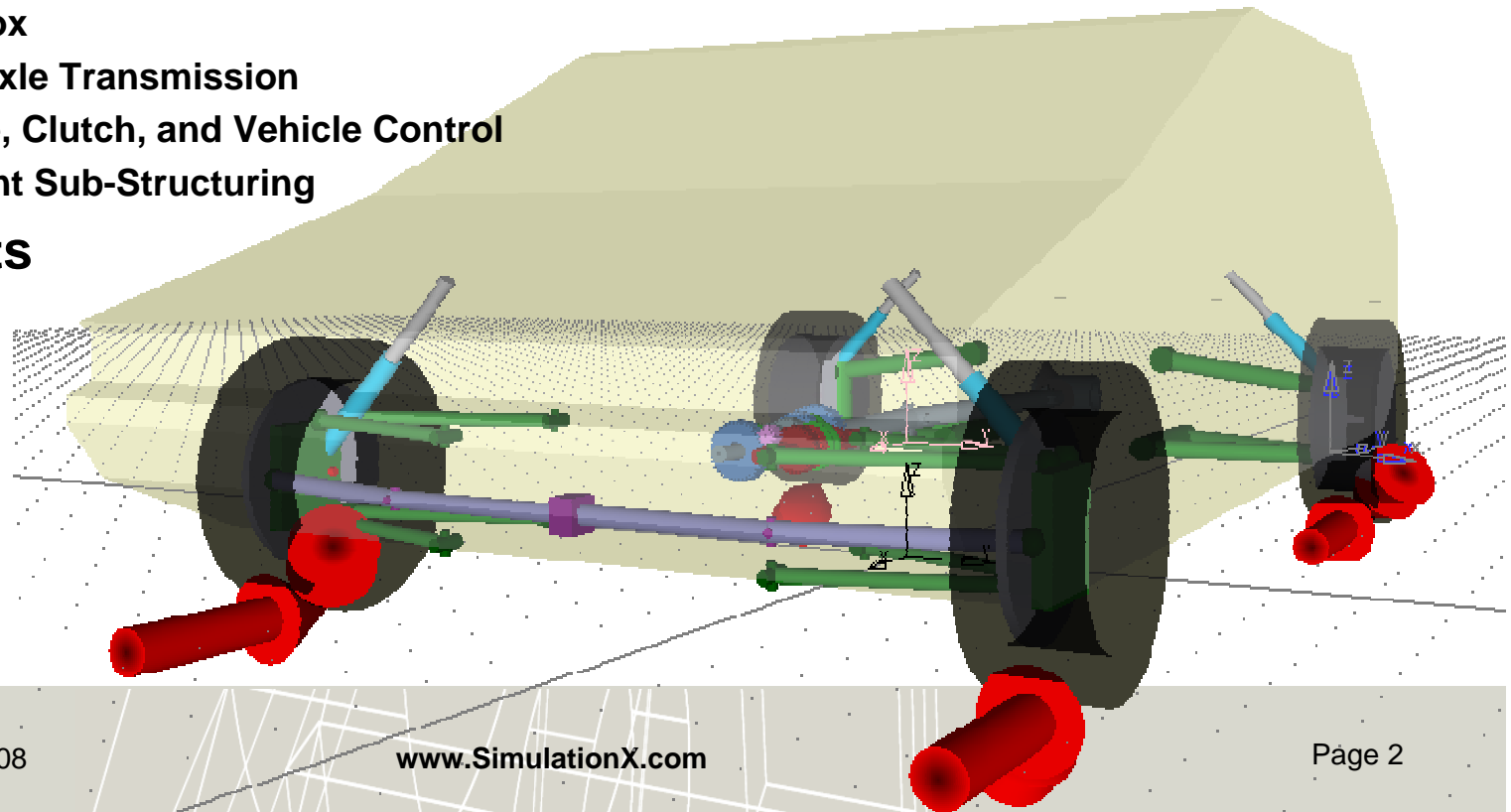


# Analyzing Gear Shifting and its Interaction with Vehicle Dynamics

*in*

**SimulationX<sup>®</sup>**

- 1. Introduction
- 2. Vehicle Model in SimulationX
  - Overview
  - Front Axis
  - Steering Kinematics and Control
  - Rear Axis
  - Gearbox
  - Rear Axle Transmission
  - Engine, Clutch, and Vehicle Control
  - Efficient Sub-Structuring
- 3. Results

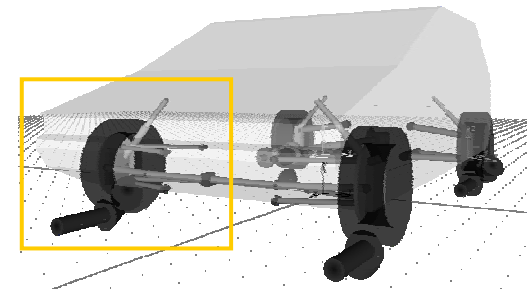


- *Objective:*
  - Analyzing of gear shifting in MTs or AMTs and its interaction with vehicle dynamics
- *Requirements:*
  - Specialized modeling and simulation approaches
  - Multi-domain simulation (MBS, Control Systems, ...)
- *Results:*
  - Satisfactory and holistic solutions
  - Improvement in vehicle dynamics as well as comfortable gear shifting processes

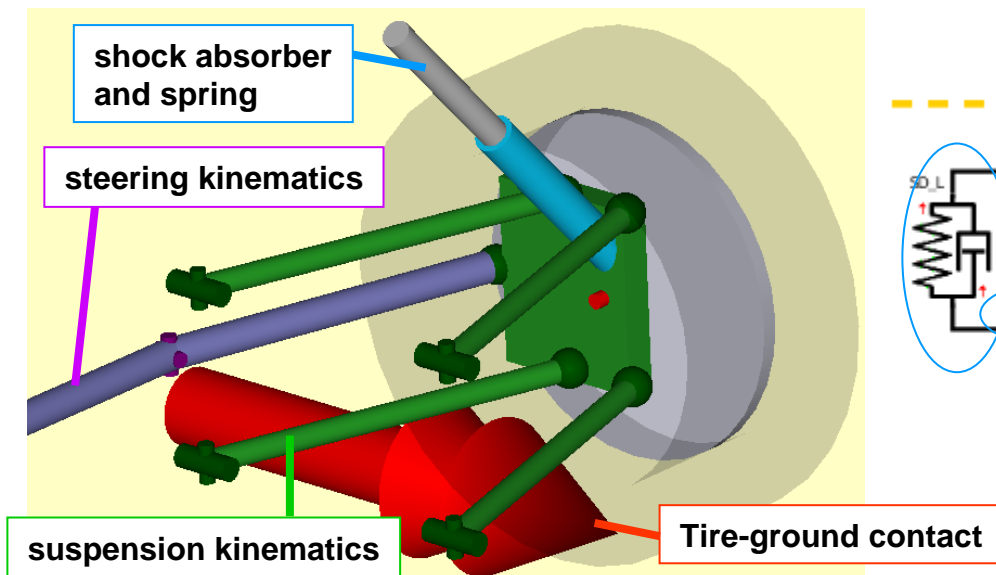
- Combination of various subsystems within one model:
  - Multi-Body systems (local and global coordinates)
  - 1D Mechanics (only local coordinates)
  - Control / actuation systems
  - Hydraulic, pneumatic, electric, thermal effects can be considered
- Example: **Vehicle** model including:
  - Independent, detailed wheel suspensions, springs and shock absorbers,
  - Shiftable gearbox (automated manual transmission (AMT)),
  - Engine, clutch, rear differential,
  - Engine model (based on engine map), and
  - Control systems for engine, gear shifting, clutch, and steering

## ■ Front Wheels

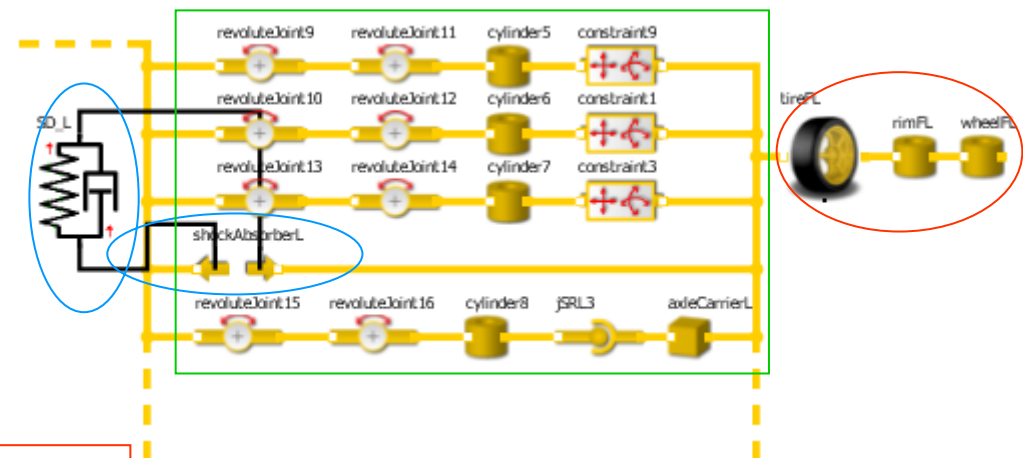
- Independent, detailed **wheel suspension**
- Space Arms suspension kinematics
- Connection of the steering mechanism



*3D View*

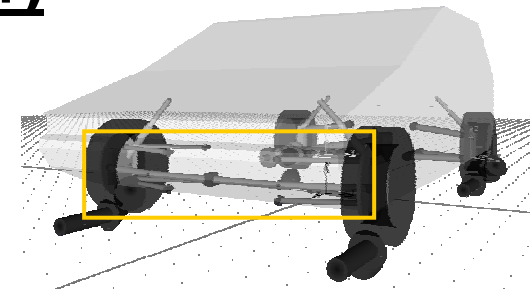


*Diagram View*



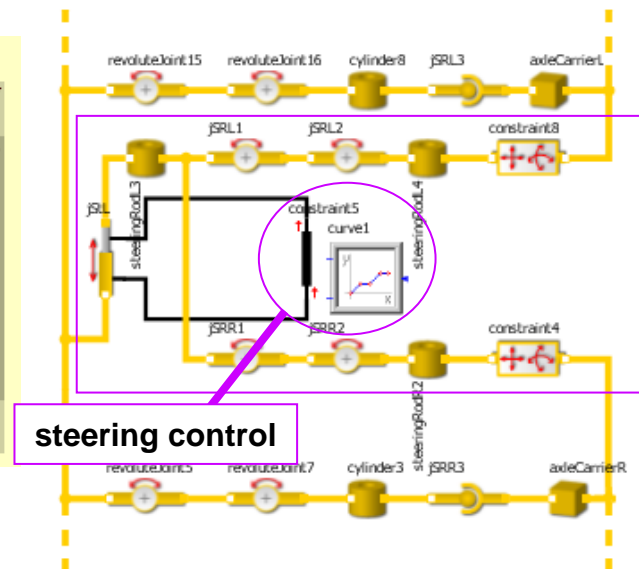
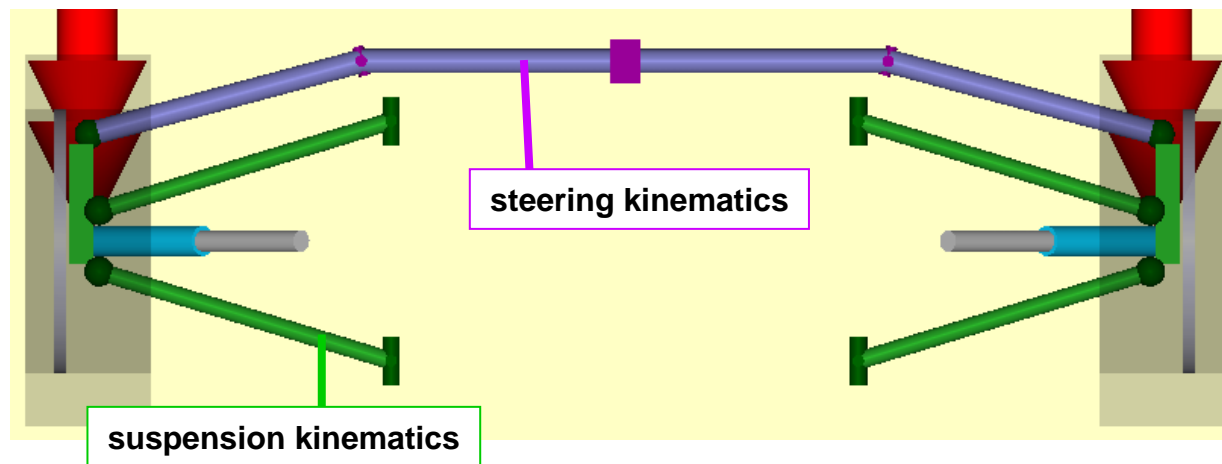
- **Steering kinematics and control (driver)**

- linkage mechanism of the steering system



*3D View*

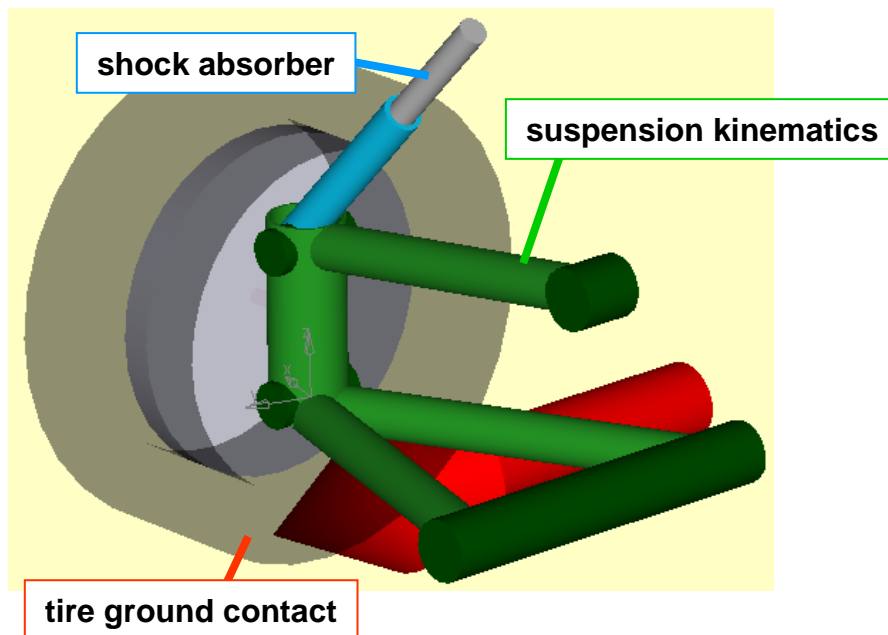
*Diagram View*



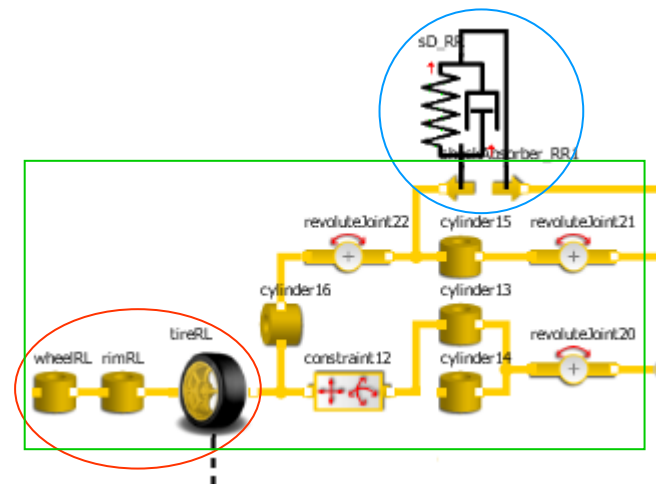
## ■ Rear Axle

- Independent, detailed **wheel suspension**
- Double wishbone linkage

*3D View*



*Diagram View*



## Shiftable 6 Speed Automated Manual Transmission

3D View

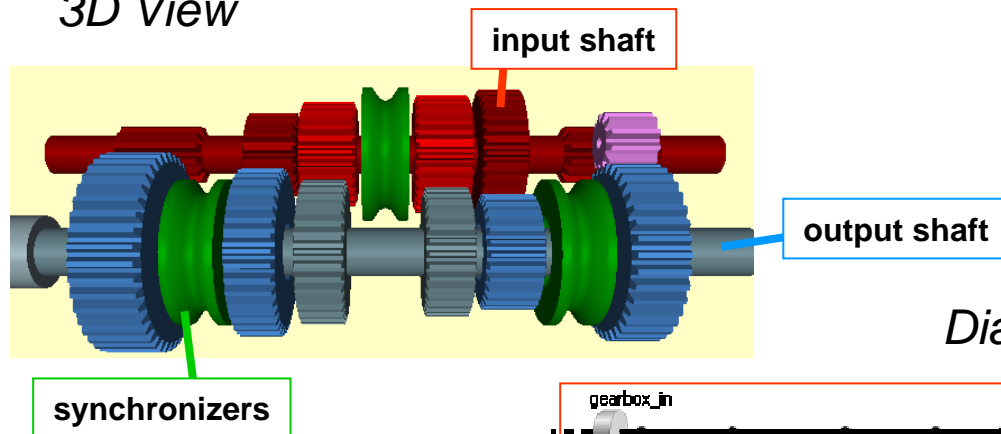
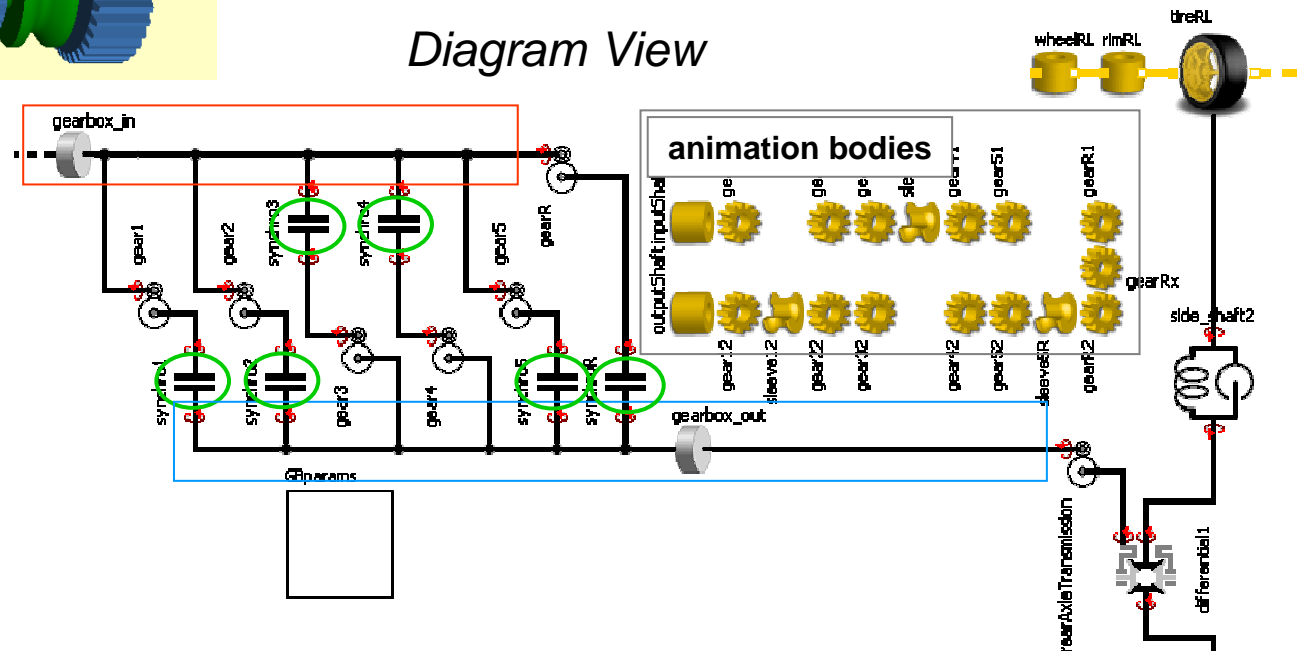


Diagram View





## ■ Rear Axle Transmission and Differential

3D View

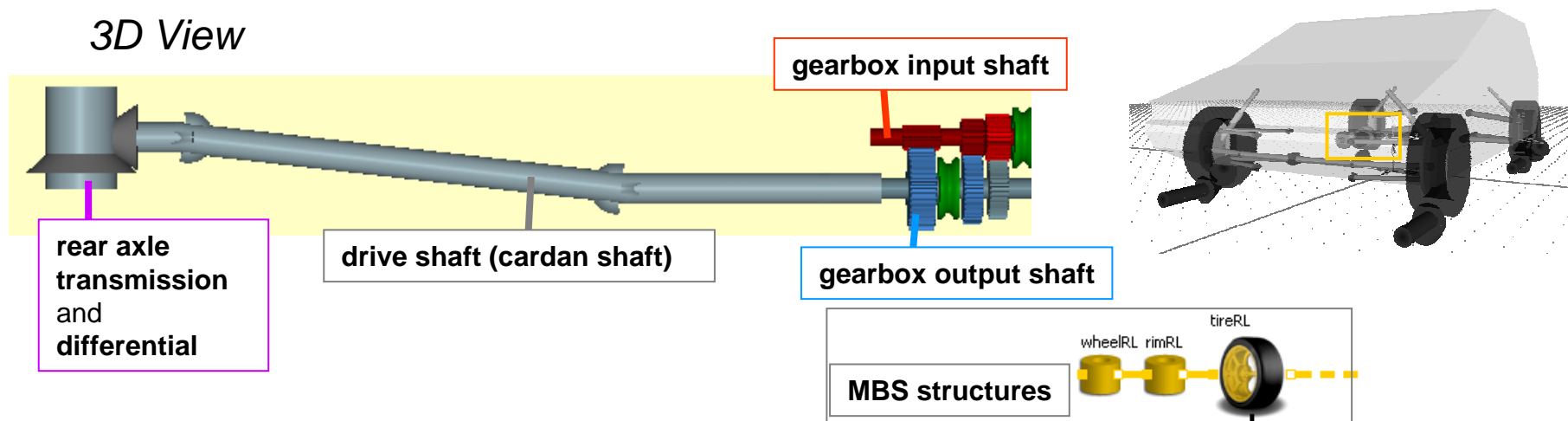
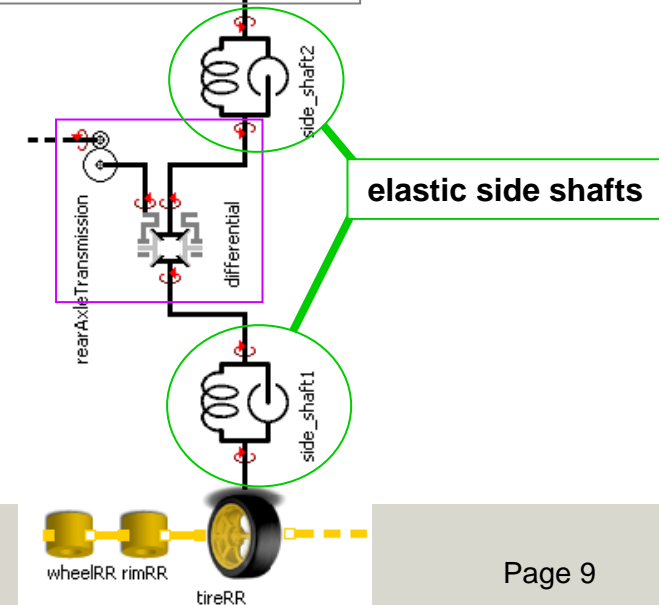
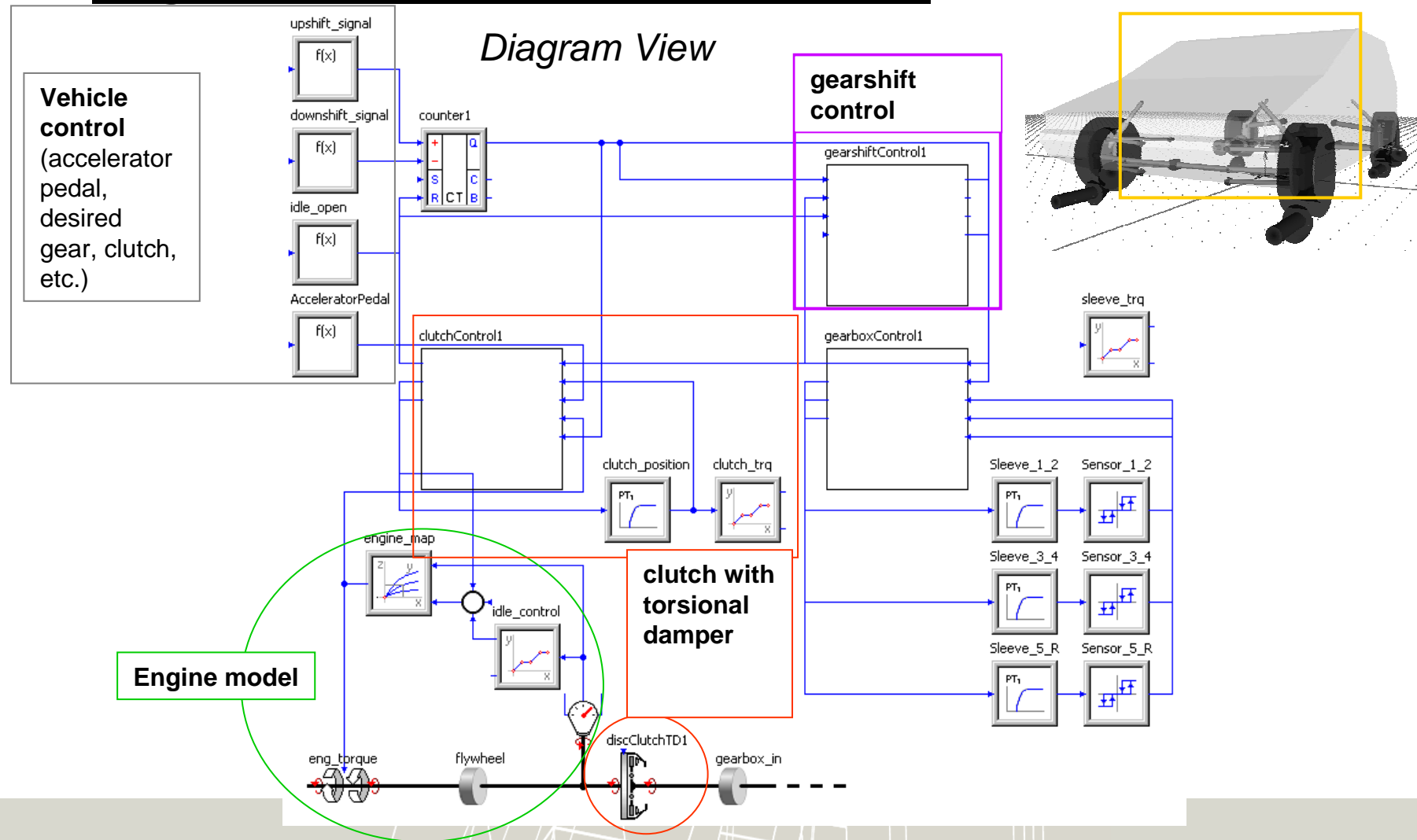


Diagram View

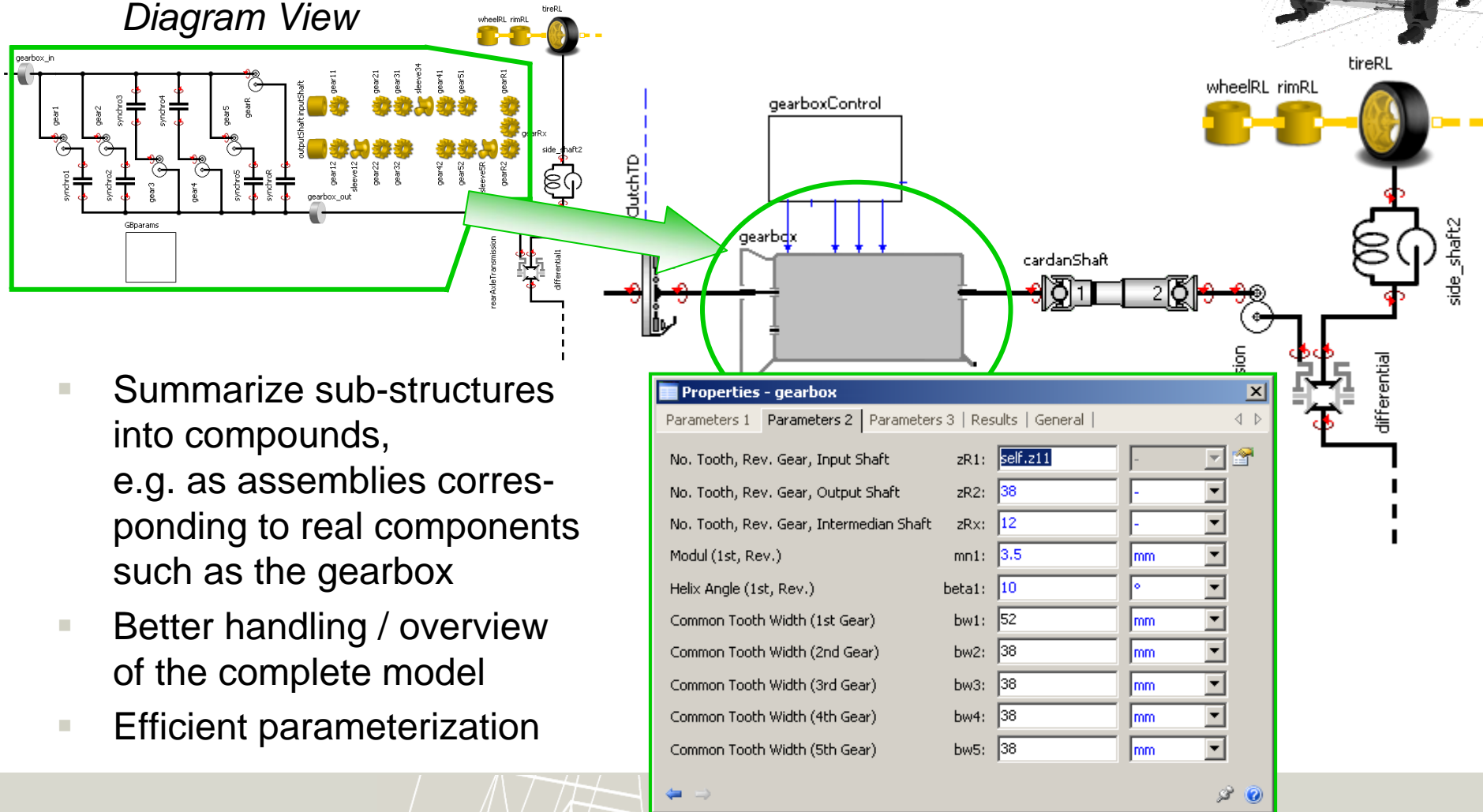


## ■ Engine, Clutch and Vehicle Control



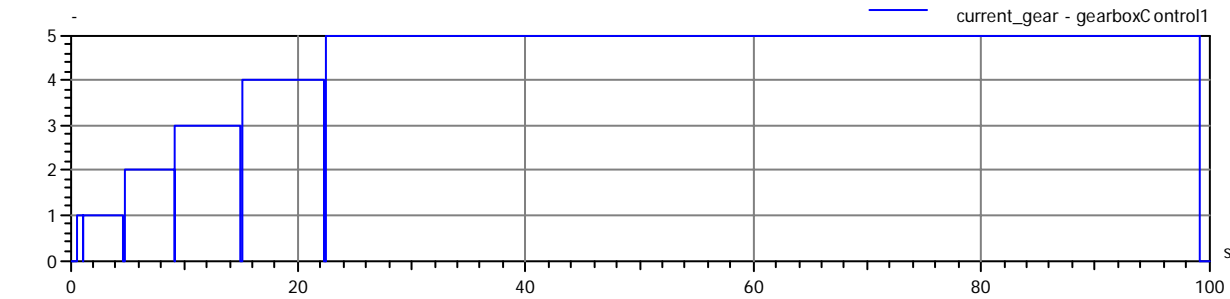
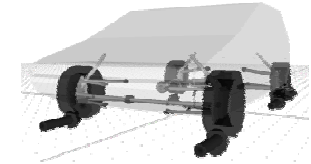
## ■ Efficient sub-modeling (Example: Gearbox)

### Diagram View

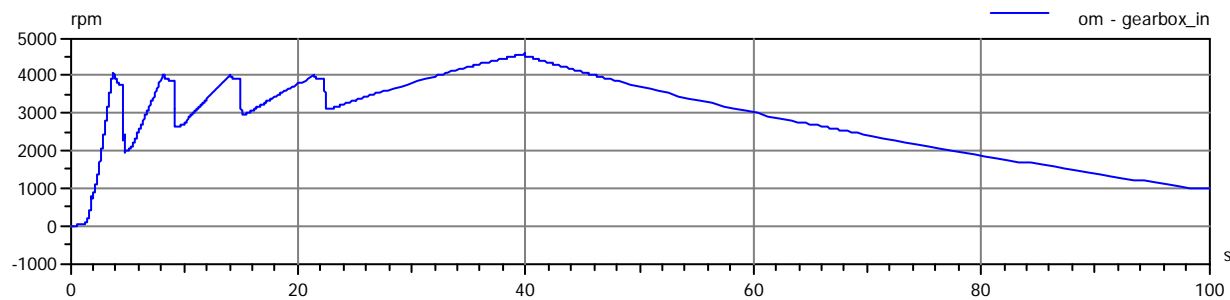


- Summarize sub-structures into compounds, e.g. as assemblies corresponding to real components such as the gearbox
- Better handling / overview of the complete model
- Efficient parameterization

# Results

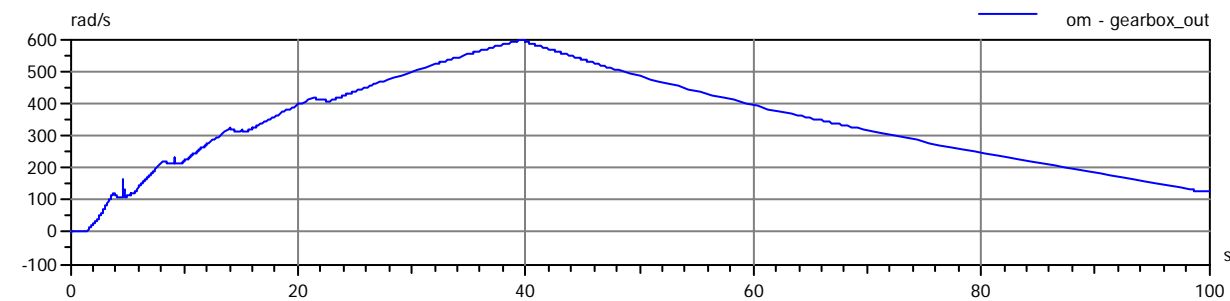


current gear



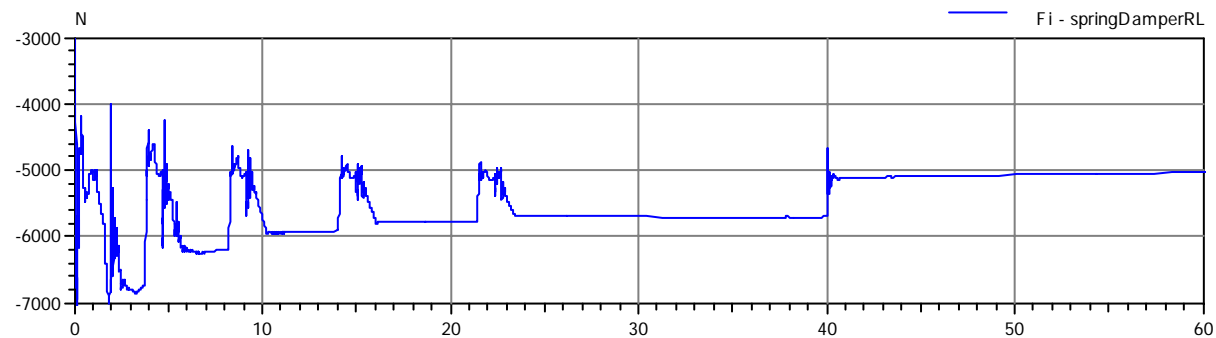
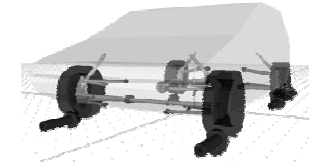
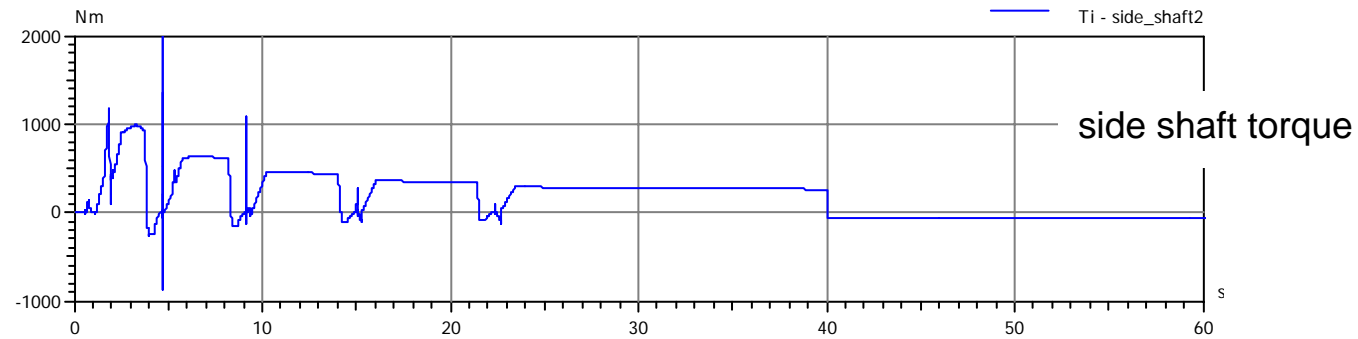
gearbox  
input

and

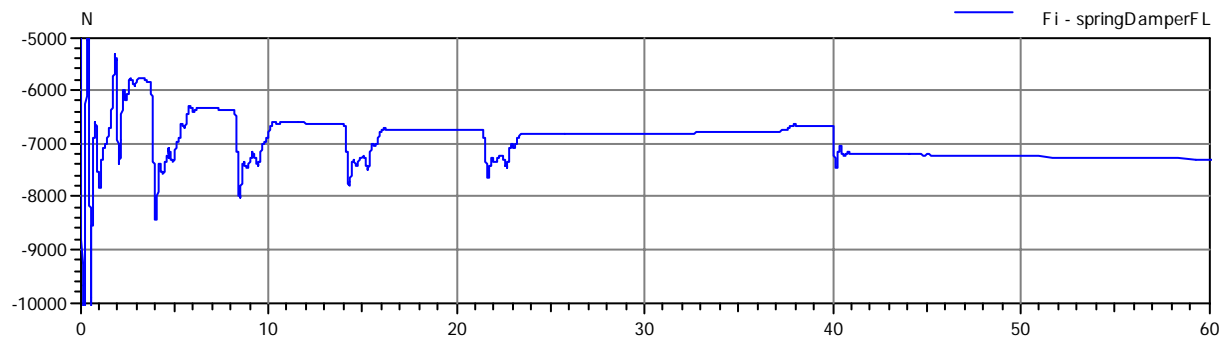


output  
shaft  
speeds

# Results



internal force of the  
spring and shock  
absorber  
(rear left)



internal force of the  
spring and shock  
absorber  
(front left)

- Efficient modeling in several physical domains
- Multi-domain model of a vehicle and transmission incl. MBS, 1D driveline model and control structures
- Efficient sub-modeling by creating compounds of assemblies as in the real vehicle (e.g. gearbox)
- Generation of holistic results using several methods
- All-in-one: **The Driving Force in System Simulation**

