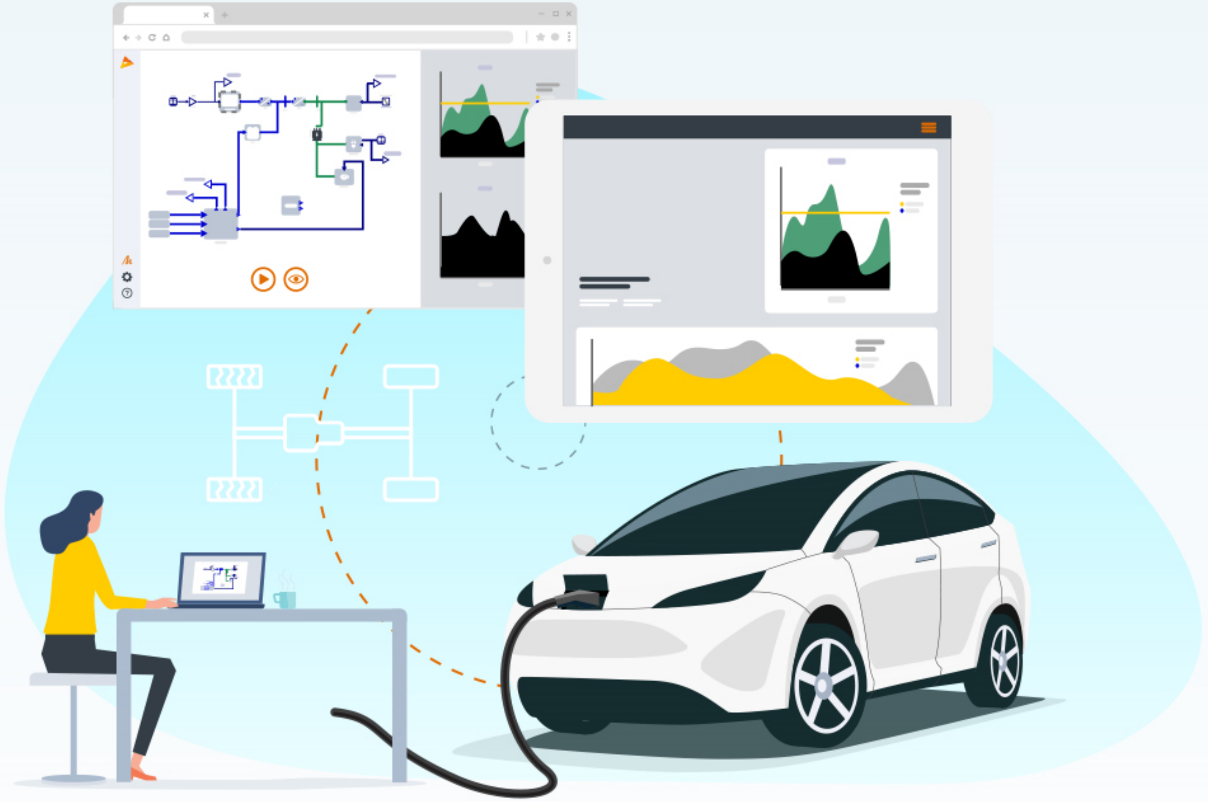
Vehicle Dynamics Library

Topics on vehicle analysis



Modelon

Peter Sundström

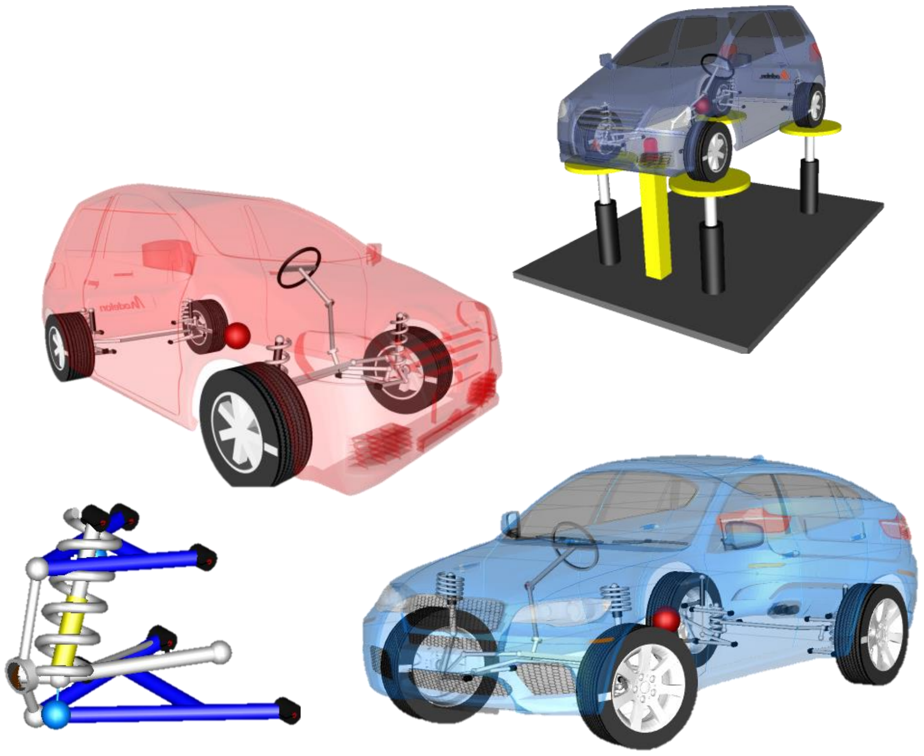
Industry Product Lead Mechanical

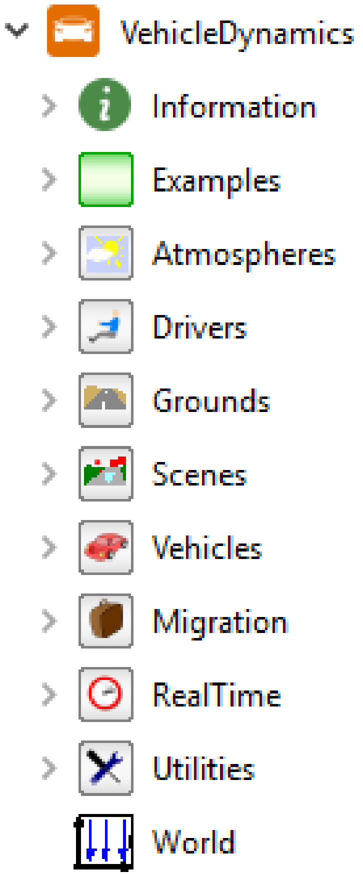
Modelon

ABOUT VEHICLE DYNAMICS LIBRARY

An environment for the design and analysis of vehicles and vehicular components

On the market since 2004



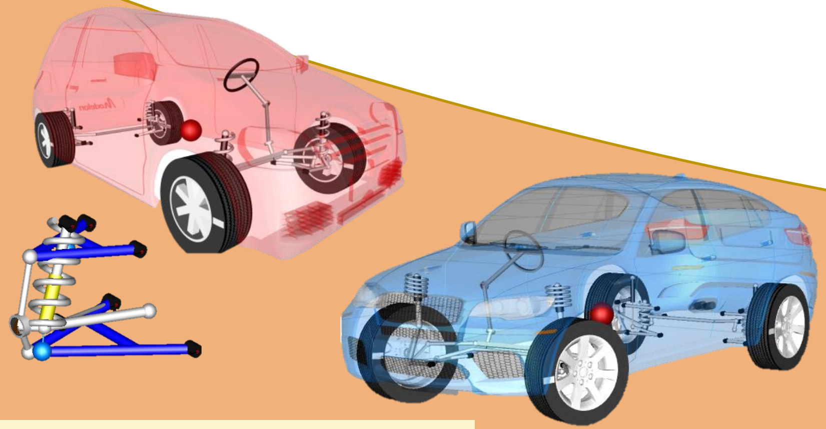


Wide range of model fidelities

Desired characteristics, KPIs

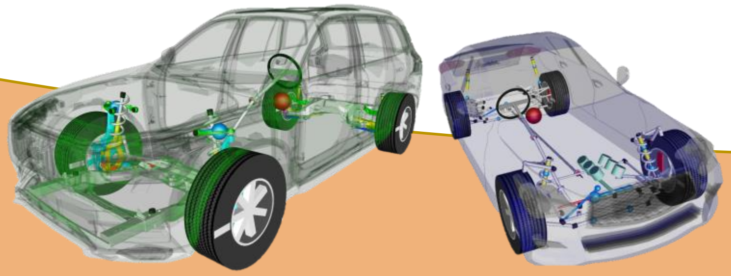
Characteristics based suspension models
Extract KPIs
Define requirements

Parametric multibody



Evaluate specific suspension topologies towards requirements
Lumped compliance at hub or individual bushings
Generate load cases for part design

Full fidelity verification



Verify requirements
Final design of components
Reduced FEA components

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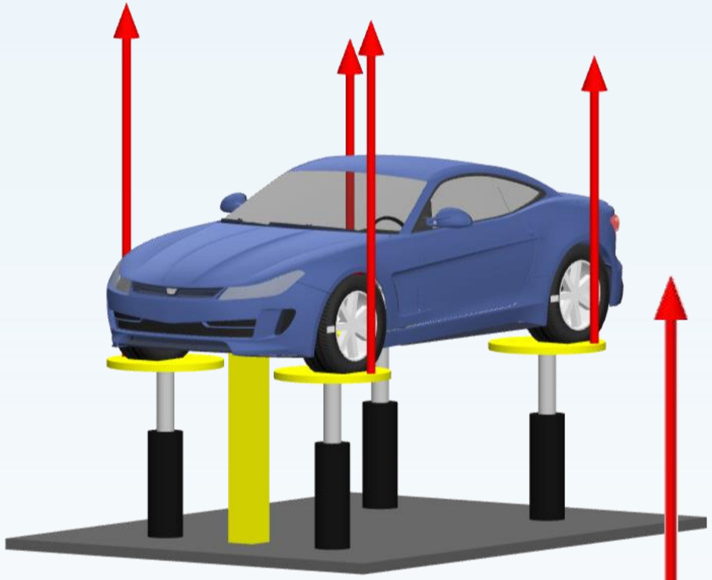
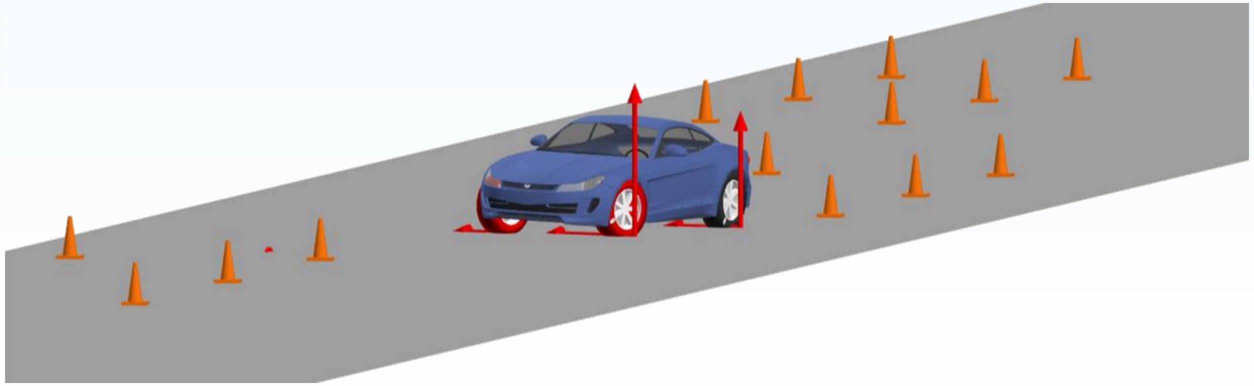
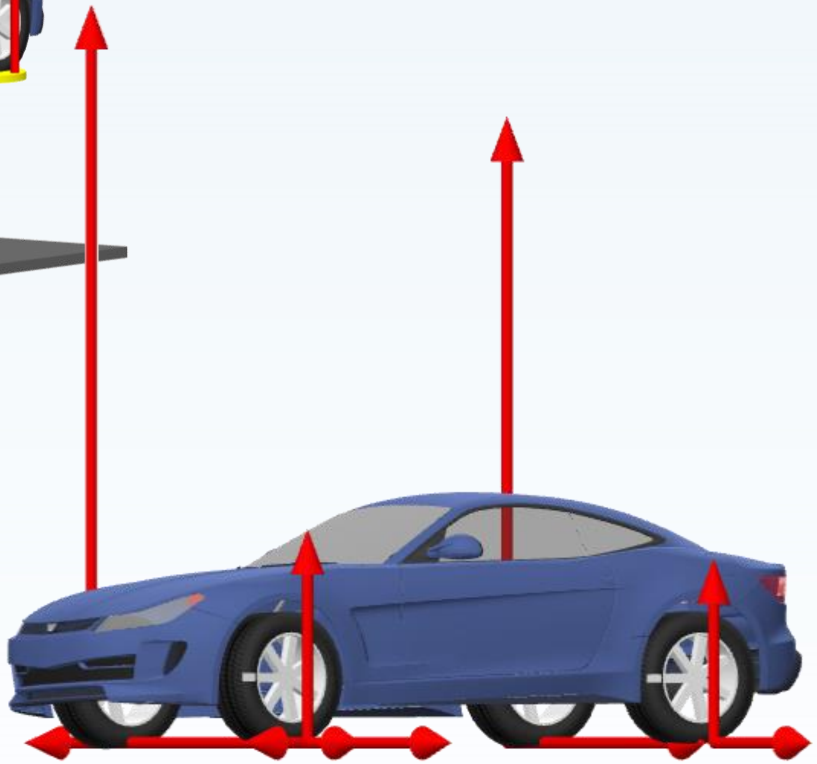
Chassis

Analysis and design

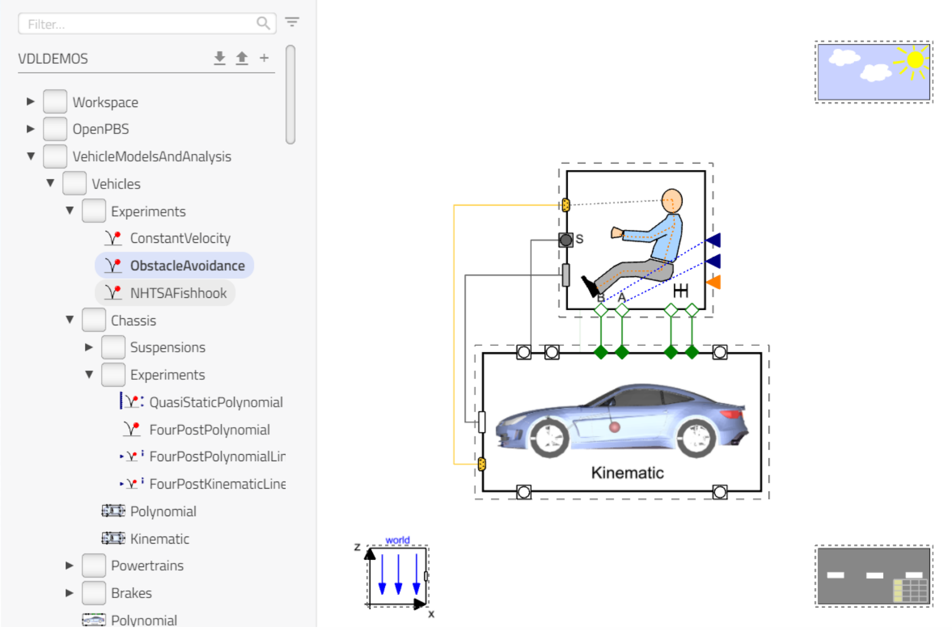




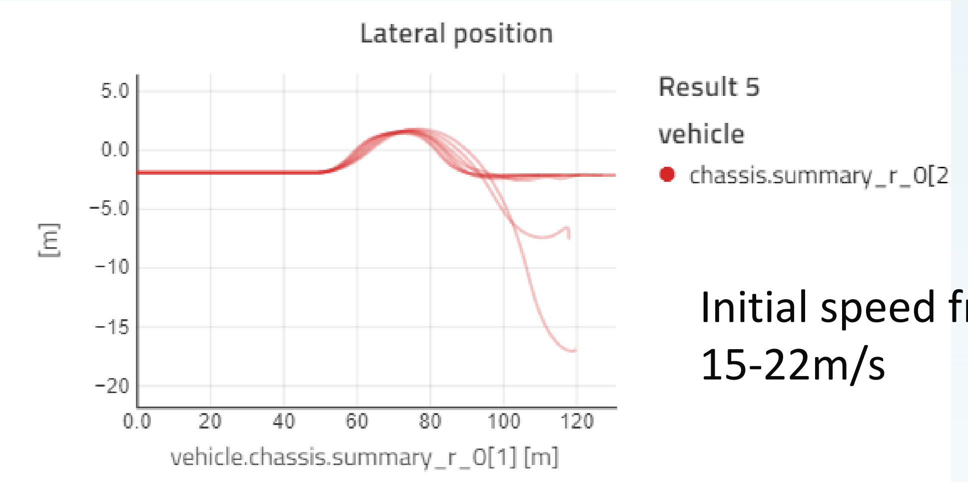


Dynamic Maneuver

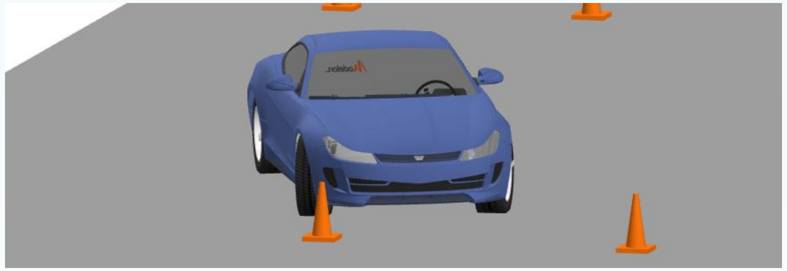
Example: Obstacle Avoidance test - Find highest possible initial speed into maneuver without hitting cones

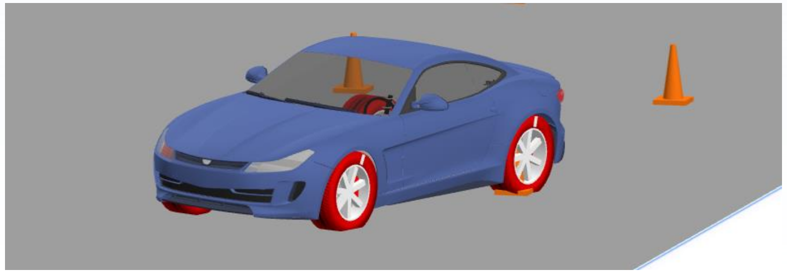


Closed loop driver, path defined in ground model

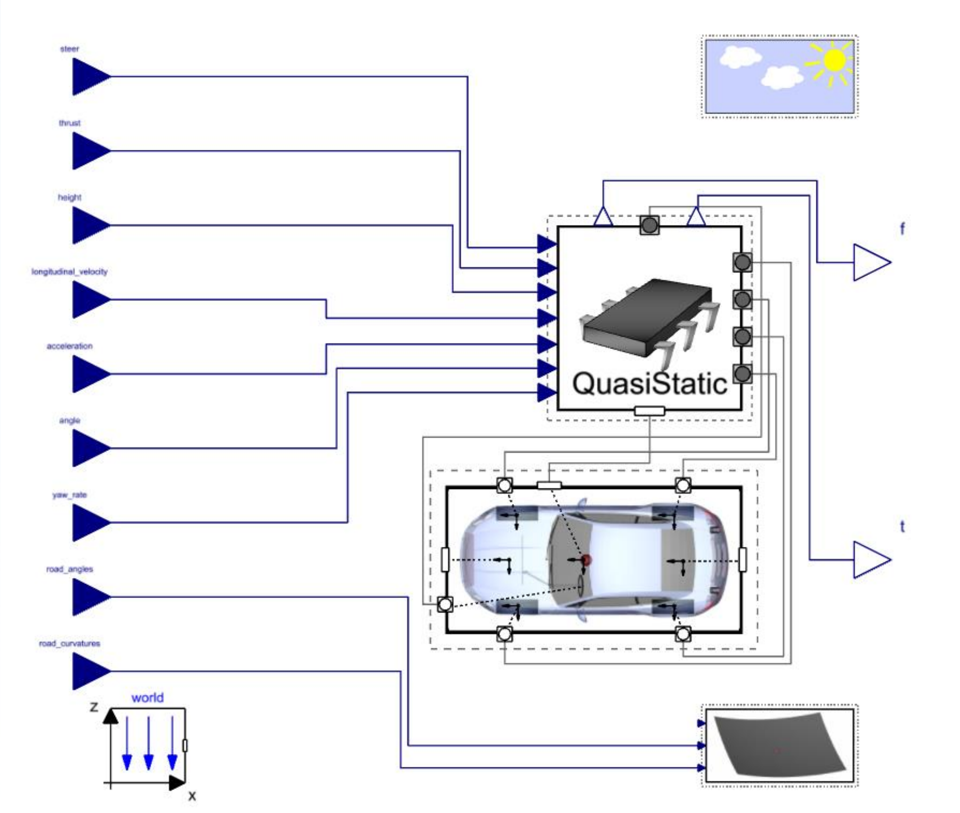


Initial speed from 15-22m/s



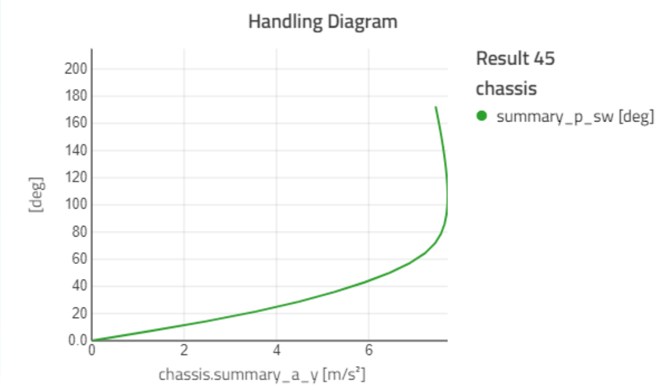


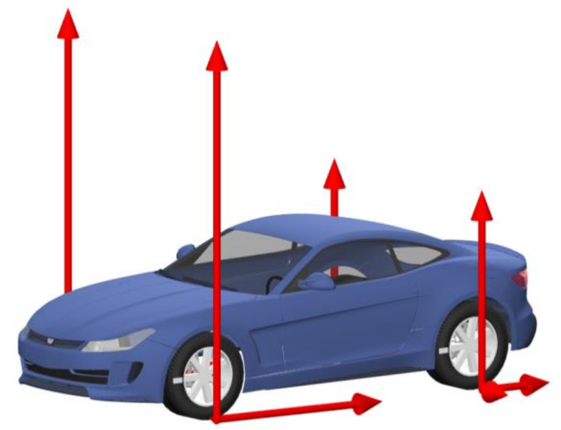
Steady state chassis analysis



Template with quasi-static robot and inputs/outputs to hook up with the steady-state solver in OCT

Handling diagram from ramp steer

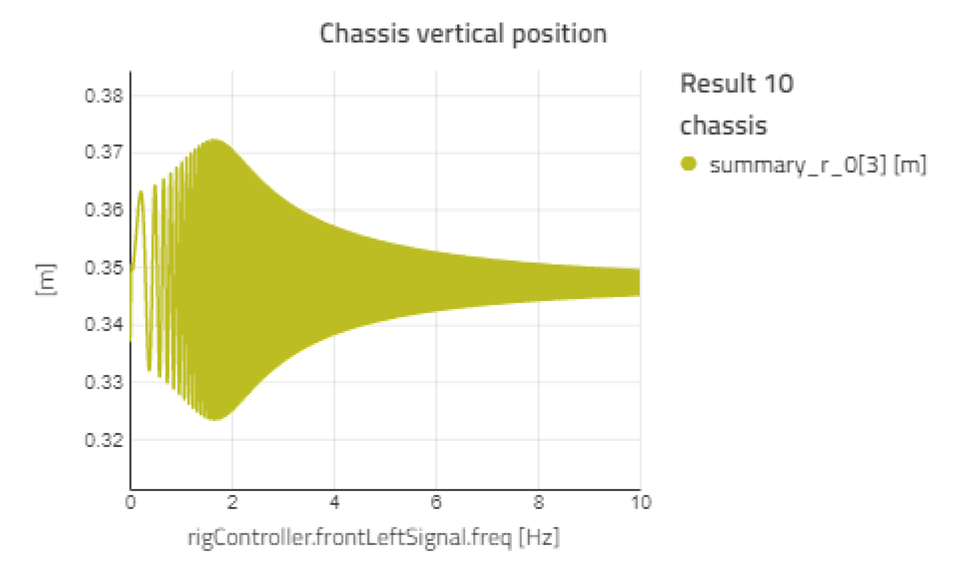


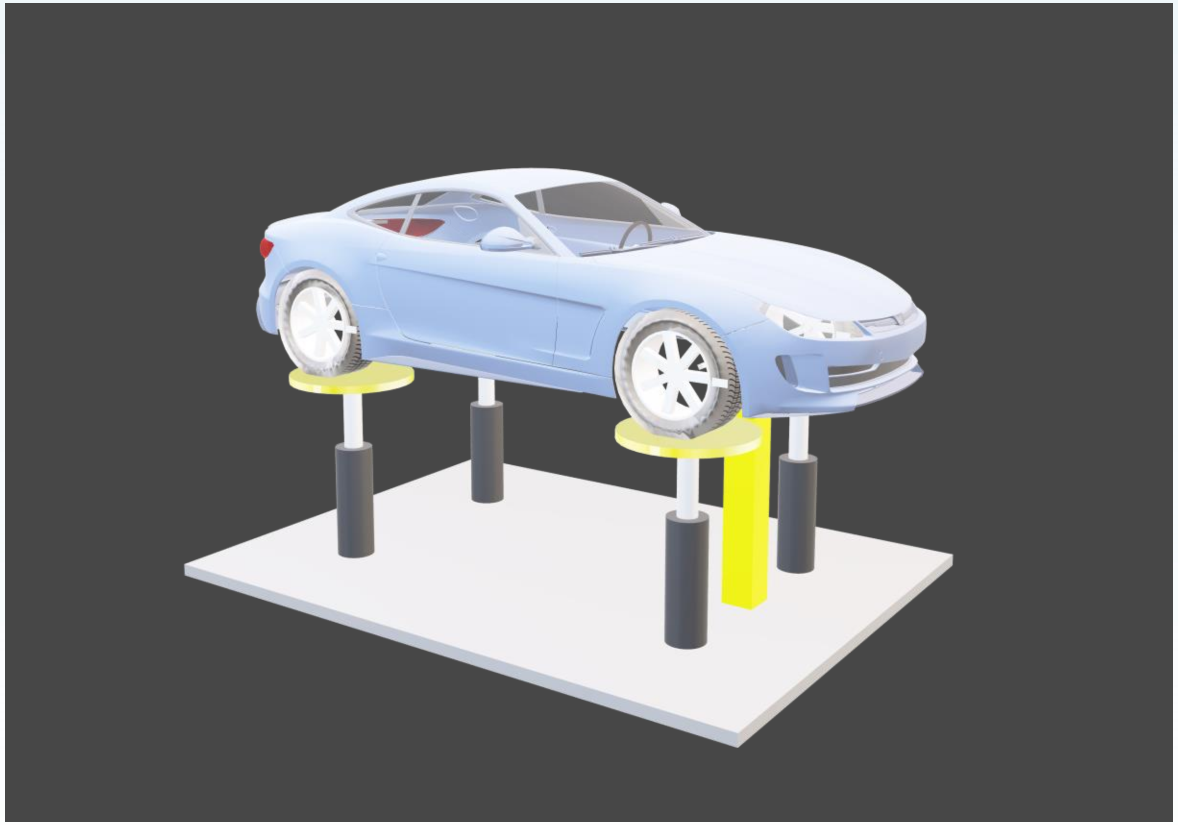


Acceleration ramp for brake dive, brake bias

Frequency Analysis

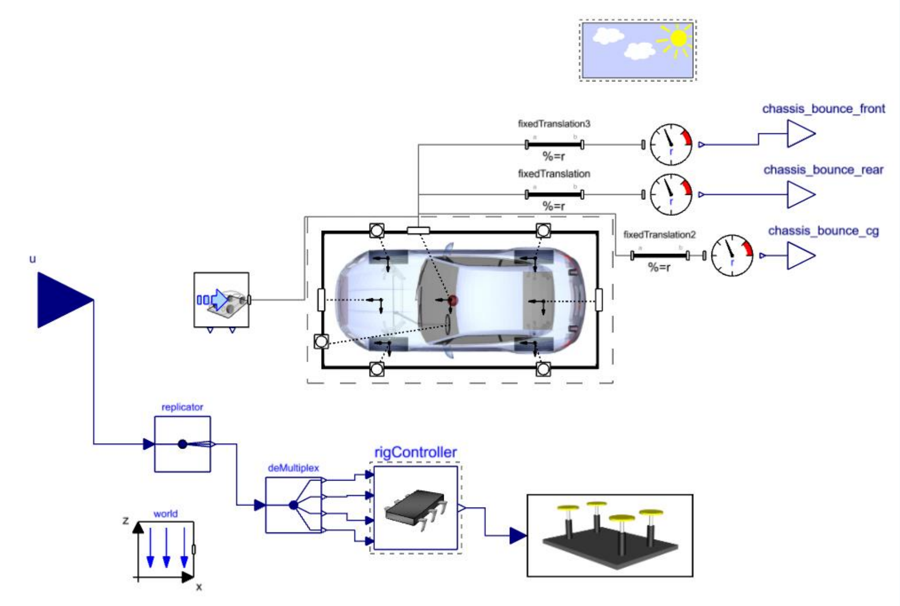
Dynamic simulation
Run sine frequency sweep on pad positions, analyze output



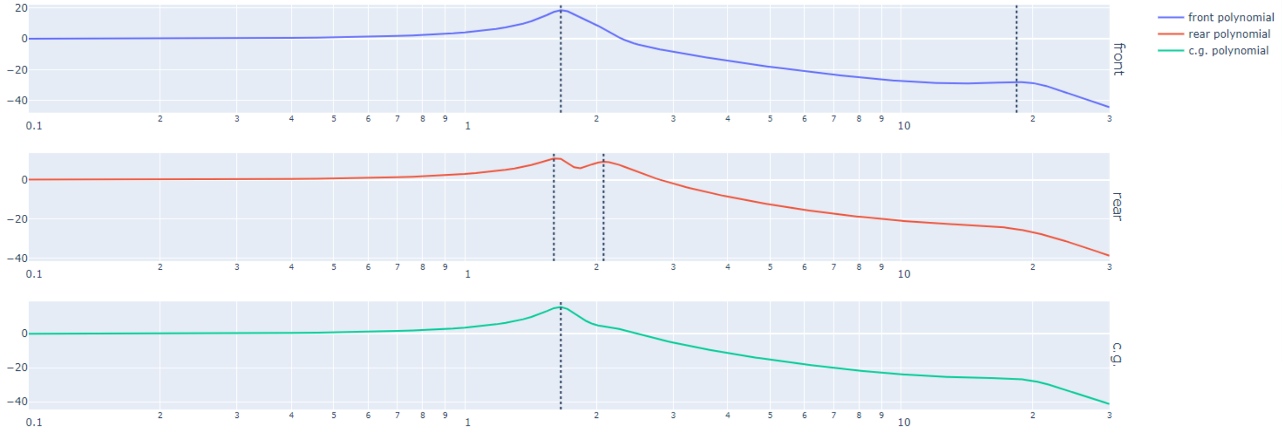


Frequency Analysis

Linearization
Set up inputs/outputs
Linearize system
Analyze frequency response

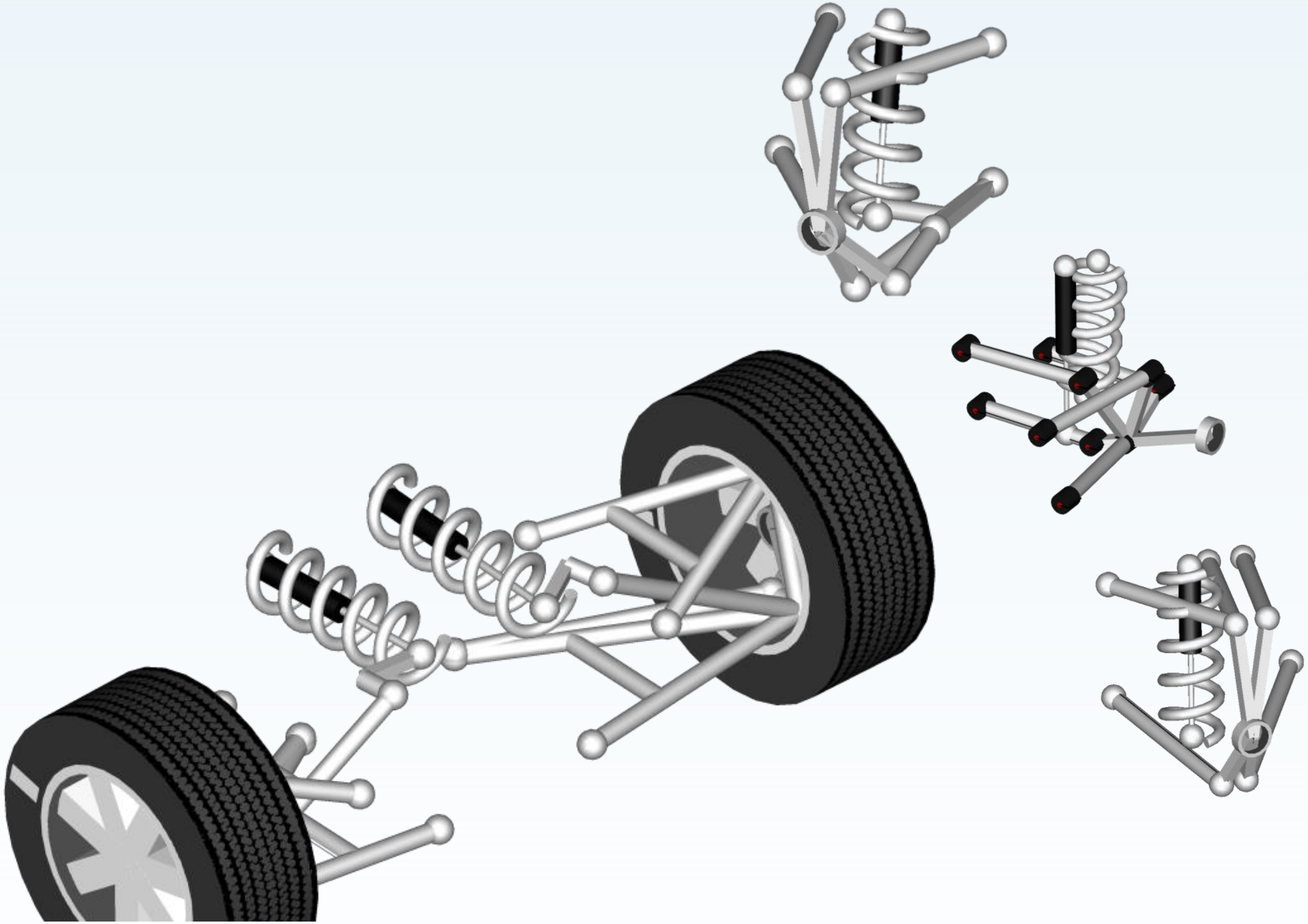



```
0
Sprung mass: 1.6579158316633267 Hz
Unsprung mass: 18.37555110220441 Hz
1
Sprung mass: 1.597995991983968 Hz
Unsprung mass: 2.0773547094188376 Hz
2
Sprung mass: 1.6579158316633267 Hz
```

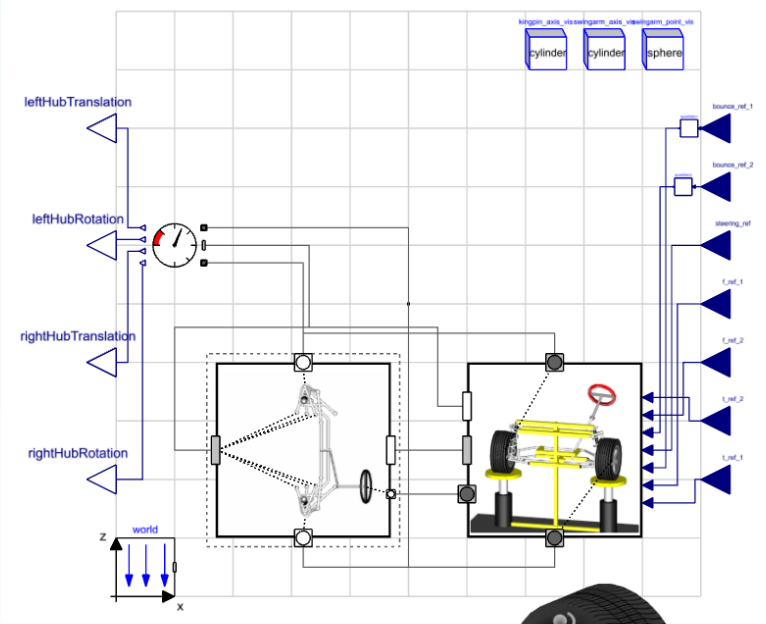


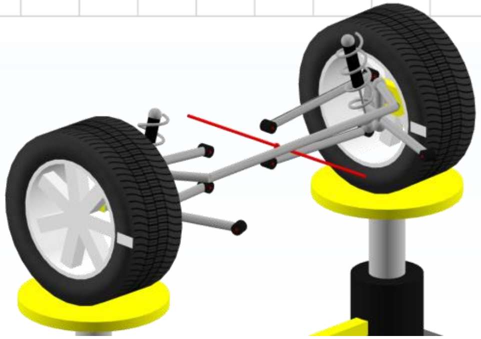
Suspensions

Analysis and design

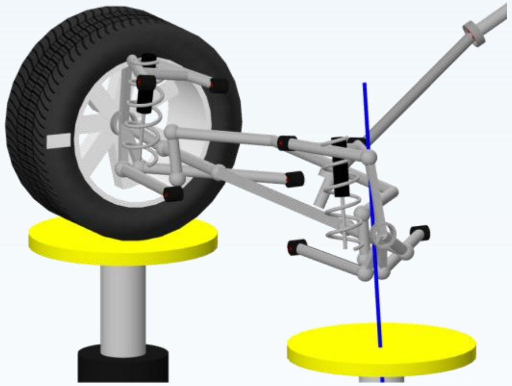


Suspension Analysis

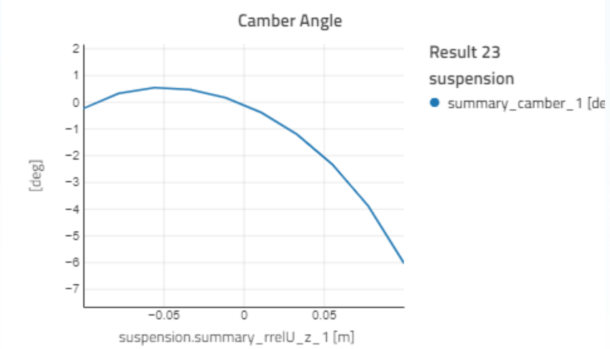




Template with inputs and outputs for steady-state solver
Solve for steady state (der(*)=0) in each point

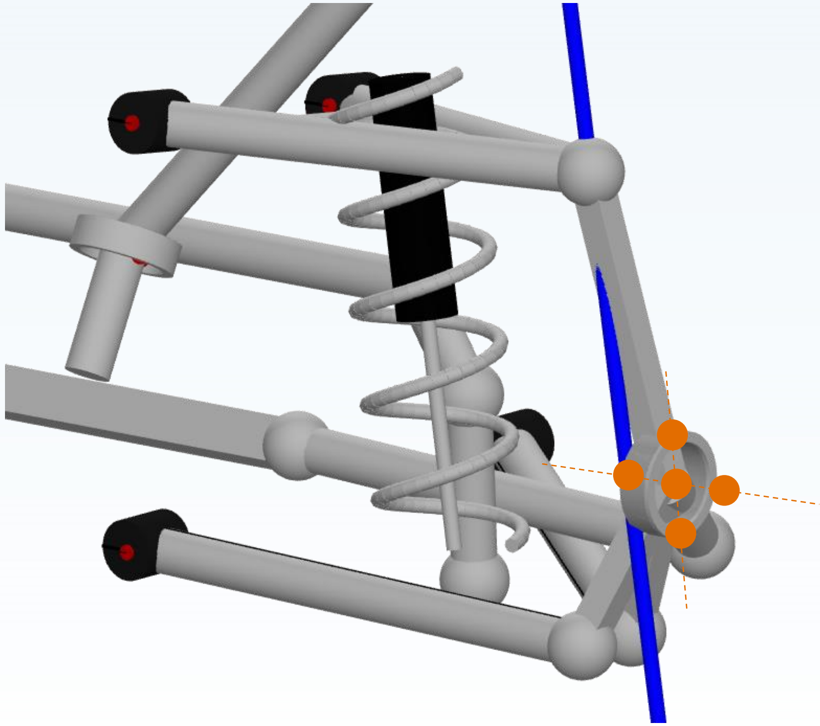


Kingpin axis and instant centers can be calculated accurately in each point



Accurate solutions in each point, damping effects excluded automatically

Early prototype: Hardpoint optimization



Optimization using steady-state solver and Scipy.optimize

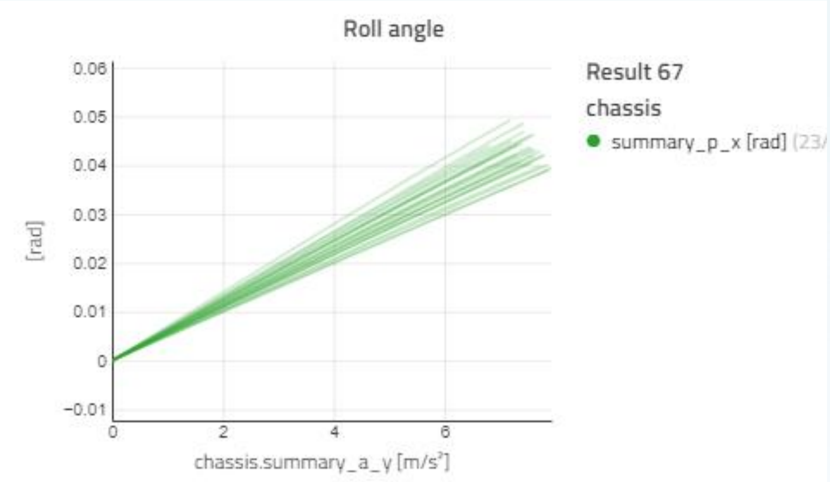
Make small perturbations around z=0 to get gradients and compare to targets

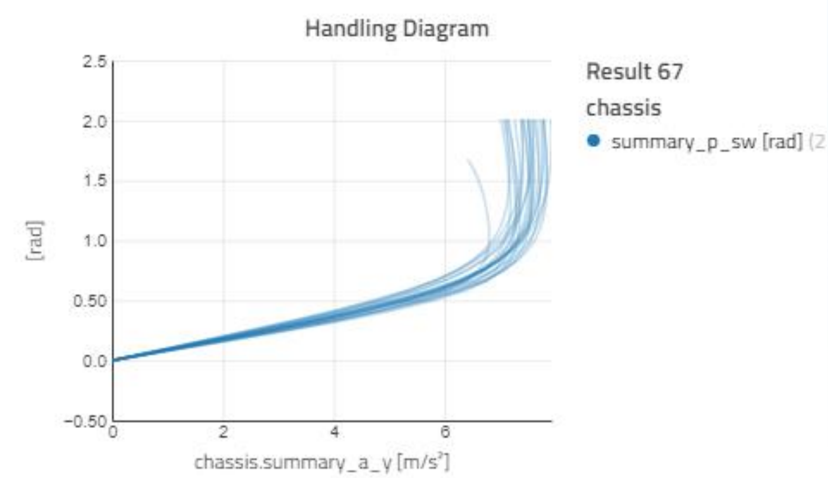
Adjust hardpoint parameters to get as close as possible to targets

(also force based gradients can be included, to set bushing stiffnesses)

Verification

- Evaluate performance with varying parameters
  - Example: Payload, changing c.g. position



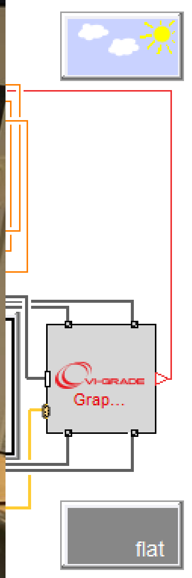


Real-time: DIL

Vehicle Dynamics Library is compatible with driving simulators from VI-Grade

Fmus exported from Modelon Impact Cloud are directly compatible with Concurrent iHawk (running RedHawk 7.x)

With templates in VDL, any model (that runs fast enough) can be exported and driven on a VI-grade simulator



Bonus: Unconventional vehicles