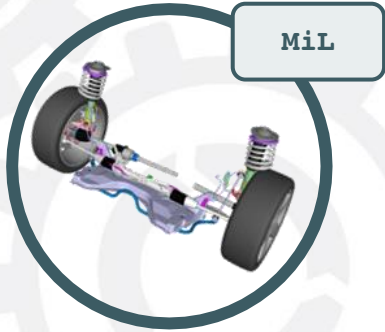


MiL: the beginning of the process



- # Superior understanding of the phenomena
- # Deployment of the specification framework
- # Easy and quick benchmark of different architectures
- # Human-centred design from scratch with **driving simulators**

Feasibility

Requirements
deployment

Functional
allocation

Architectural
verification

Digital twin
validation

Numerical
support for
executive design

Case study: Real-time steering system model

Development of an Angle-Driven 2 DOF steering system model specific for real-time applications

Model requirements:

- » Accurate steering wheel angle to rack position relation
- » Accurate power steering assistance modelling
- » Friction effects properly modelled
- » Real-time features
- » High numerical stability
- » Ease of parametrization
- » Implementation at the simulator possible

Modelled key phenomena:

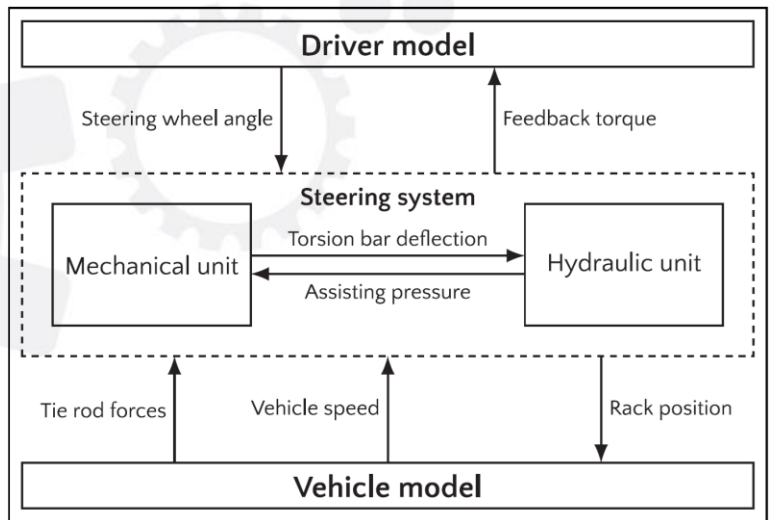
- » System elasticities
- » Power steering effects
- » Friction hysteresis

Modelled components:

- » Rack
Friction force, viscous coefficient, Stribeck velocity, inertia
- » Torsion bar
Stiffness, damping
- » Steering column
Friction force, viscous coefficient, inertia

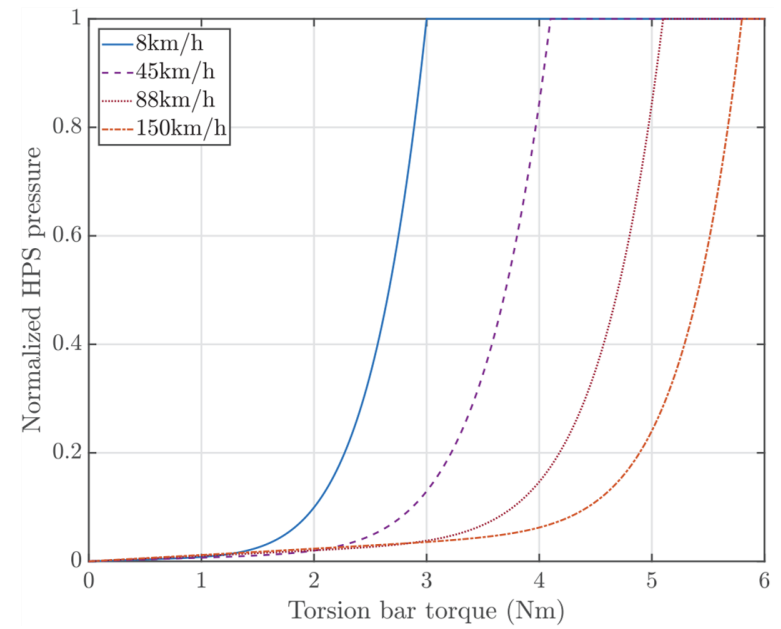
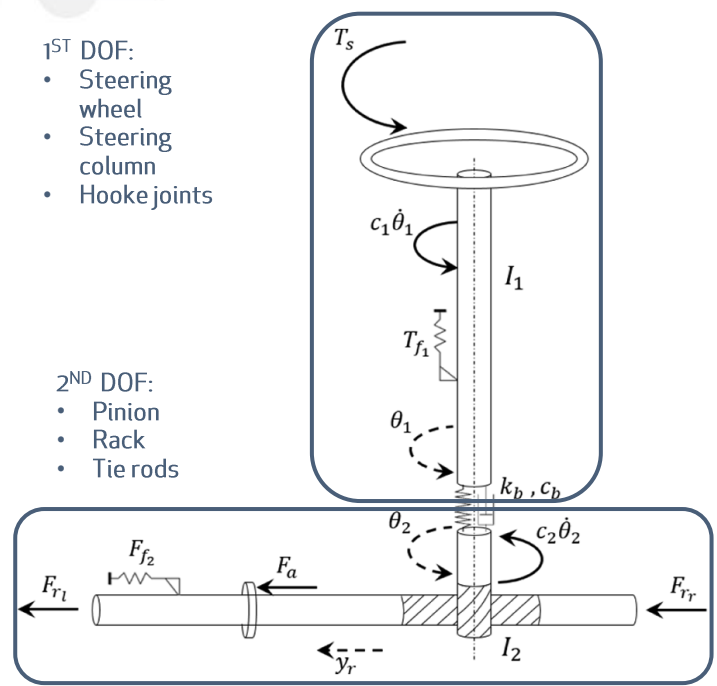
HPS Hydraulic Power Steering:

- » Steady state curves
- » Time constant



- 1ST DOF:
- Steering wheel
 - Steering column
 - Hooke joints

- 2ND DOF:
- Pinion
 - Rack
 - Tie rods

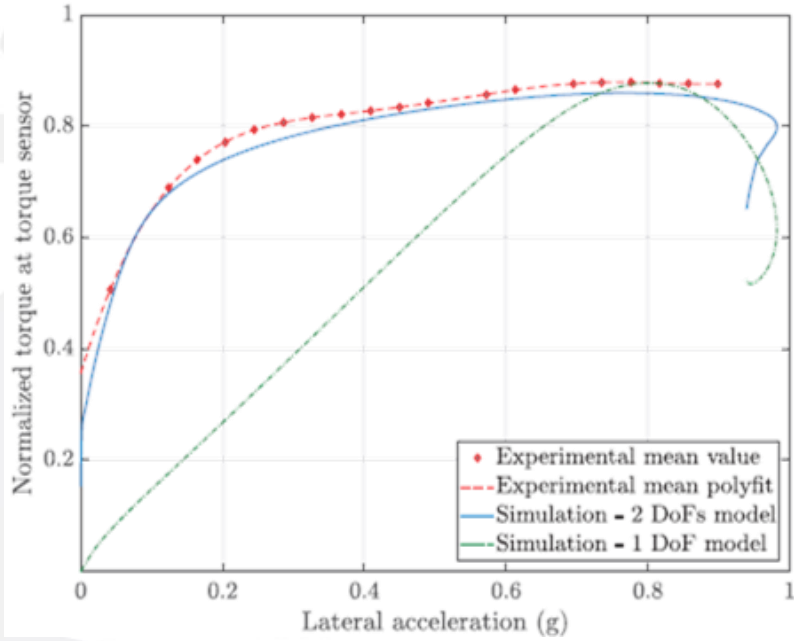


Case study: Real-time suitable steering system model

Model validation: Objective Assessment

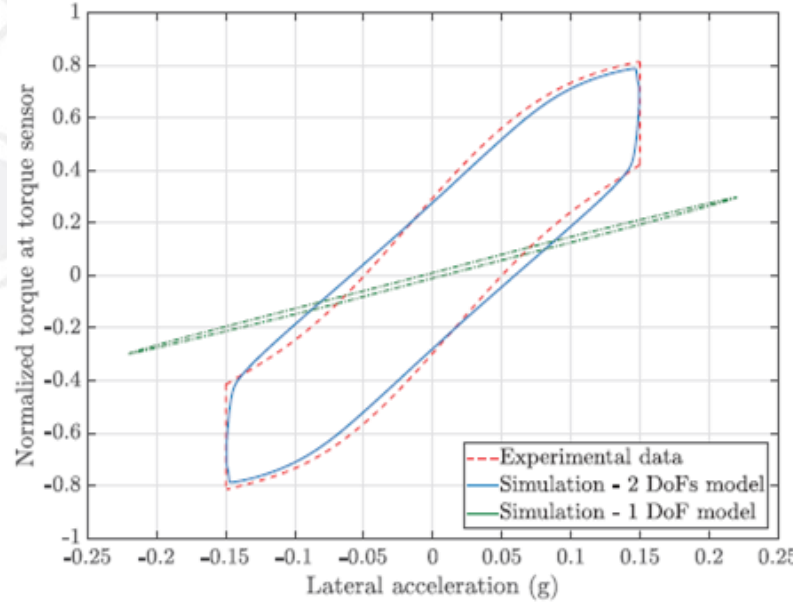
Model comparison

- » Proving ground data
- » 2 DOF Model
- » 1 DOF Model



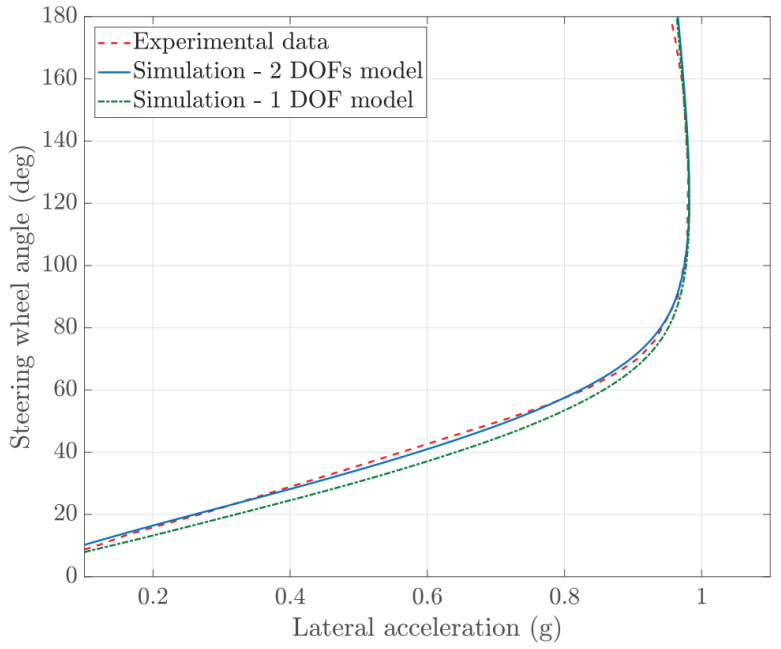
Slow ramp steer ISO 4138

- » Constant velocity
- » Constant slope steering wheel ramp profile



Weave test ISO 13674

- » Constant velocity
- » Constant sine amplitude
- » Constant sine frequency



Results

- » High fidelity steer torque reproduction from low to high lateral acceleration

- » On center stability
- » Effective reproduction of hysteresis effects

- » Accurate Steering wheel angle to vehicle lateral acceleration relation

Reference:

Development of a real-time steering system model for driving simulators - Cesare Certosini, Francesco Vinattieri, Renzo Capitani, Claudio Annicchiarico, 2019 (sagepub.com)



Case study: Real-time suitable steering system model

Model use: requirements allocation

