
Iterative method for the coupling of arbitrarily many spatially distributed simulations and/or test rigs to a dynamic overall system

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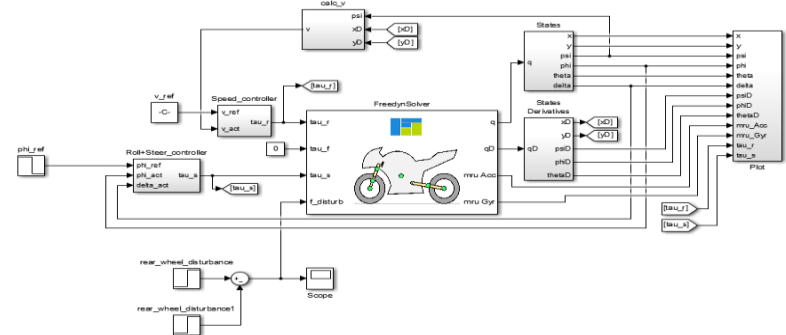
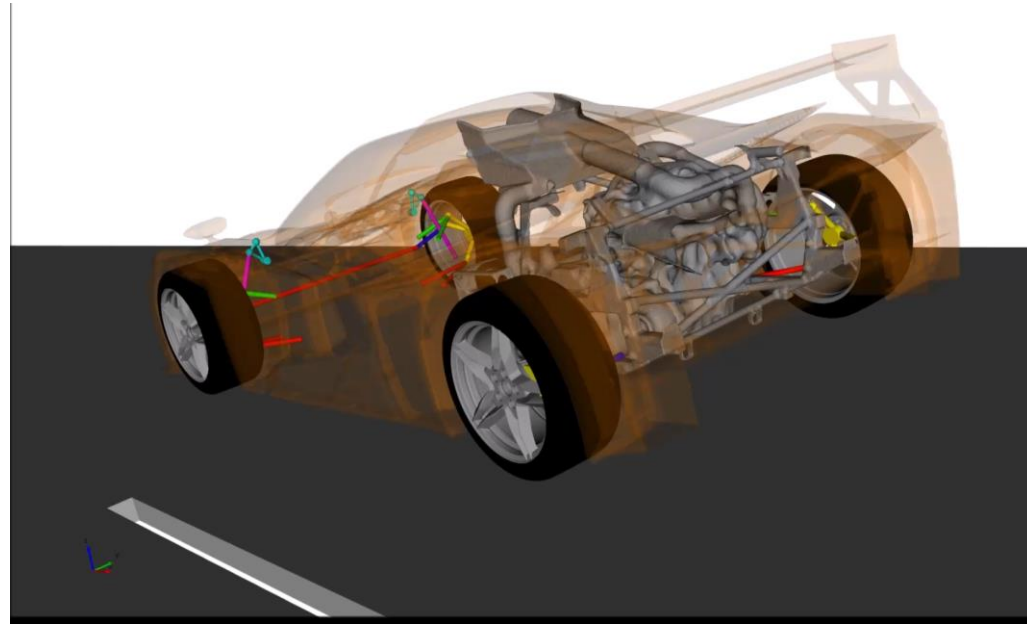
Upper Austria University of Applied Sciences

- 4 faculties, 20000 graduates, 6000 students
- >1000 research partners
- Faculty Wels: Engineering
- Degree Program: Mechanical Engineering
- Research Focus
 - Nonlinear Mechanics (Multibody Dynamics, Finite Element Method)
 - Fast & accurate consideration of contacts and geometric nonlinearities (Scientific partner of 3DS)
 - Model reduction in general
 - X optimal control
 - and more (don't hesitate to ask 😊)

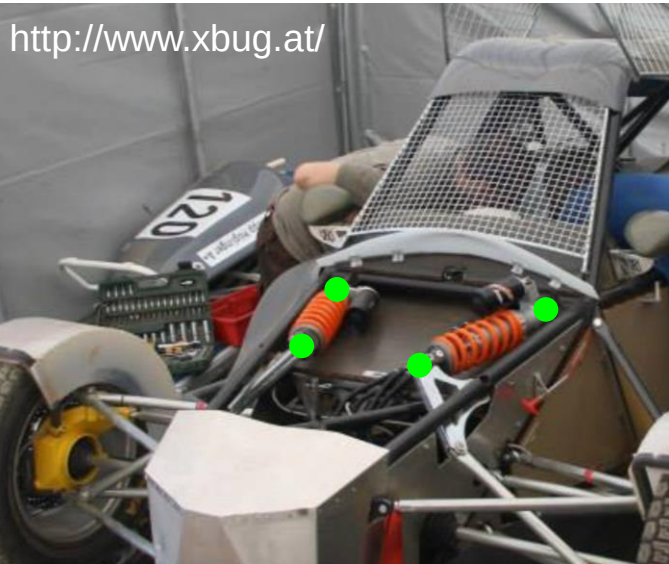


www.freedyn.at

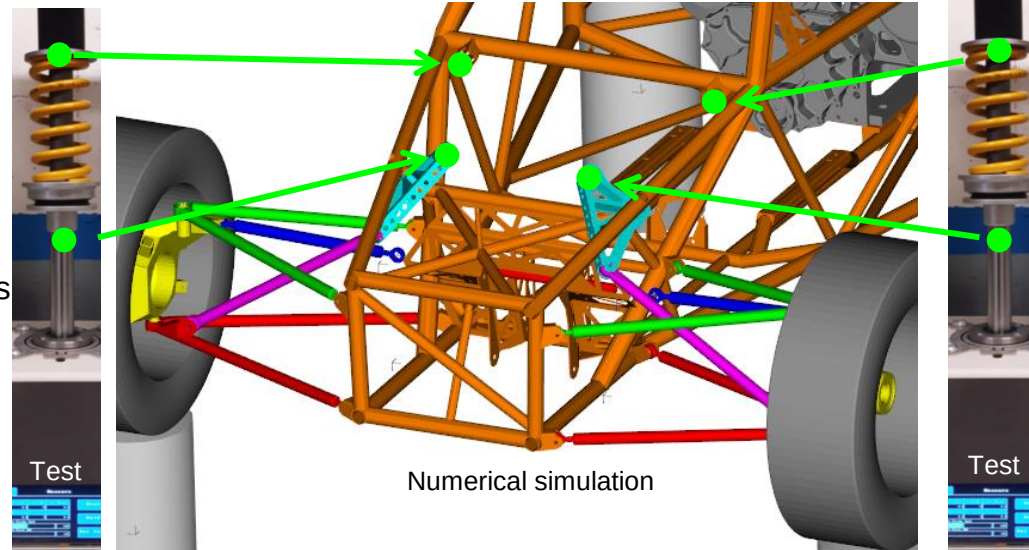
- Self developed MBS code
- GUI
- Standard modelling elements
 - Rigid bodies, Flex. bodies
 - Forces, Constraints
 -
- C - API für self written codes and for integration into MATLAB/Simulink and Scilab/Xcos



What is it actually about?



Dynamics &
Nonlinearities

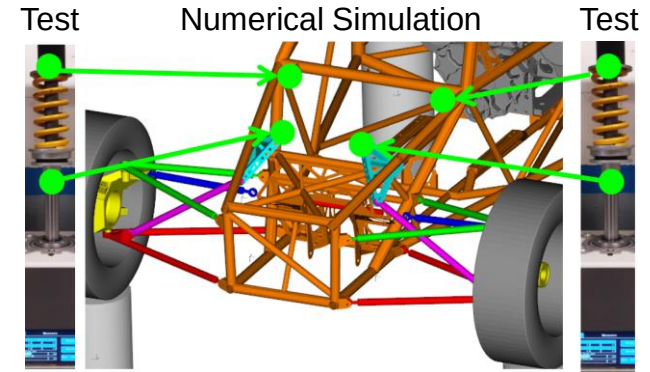


Overall (assembled) system
(Many subsystems)

Breakup into dislocated subsystems (Here: 3)
Subsystems: Just Test Rigs, Just Simulations,
Mixed – Test Rigs and Simulations (HIL)

Potential Scenarios

- (1) HIL (as on former slide)
 - Component change → Impact overall system?
- (2) Coupling of test rigs
 - Dislocated.
 - Confidential reasons of involved subsystem
 - Test field too small
- (3) Coupling of simulations



Monolythic Test

Dynamics
Nonlinearities

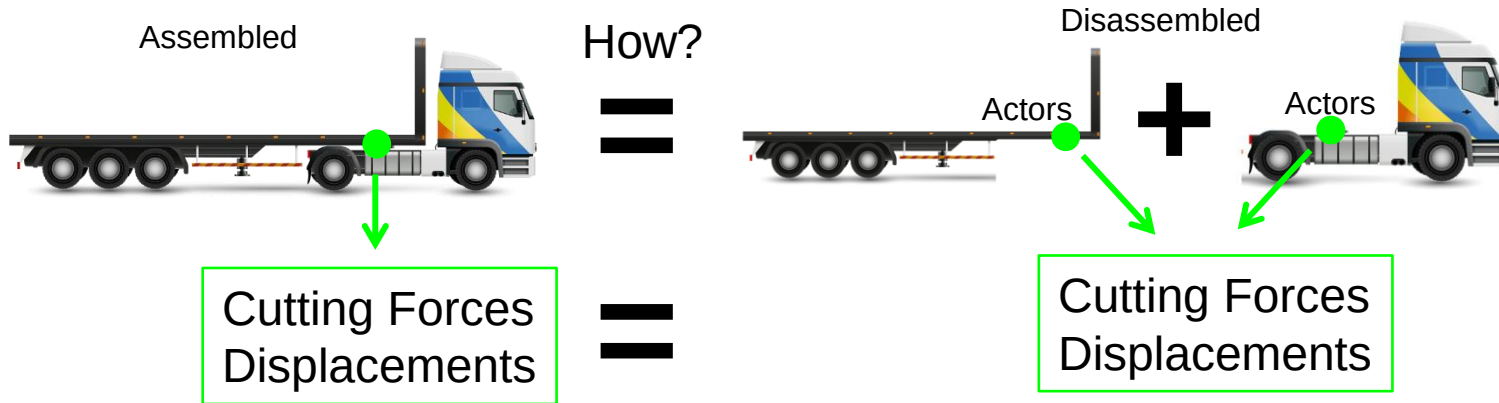


Test Field 1



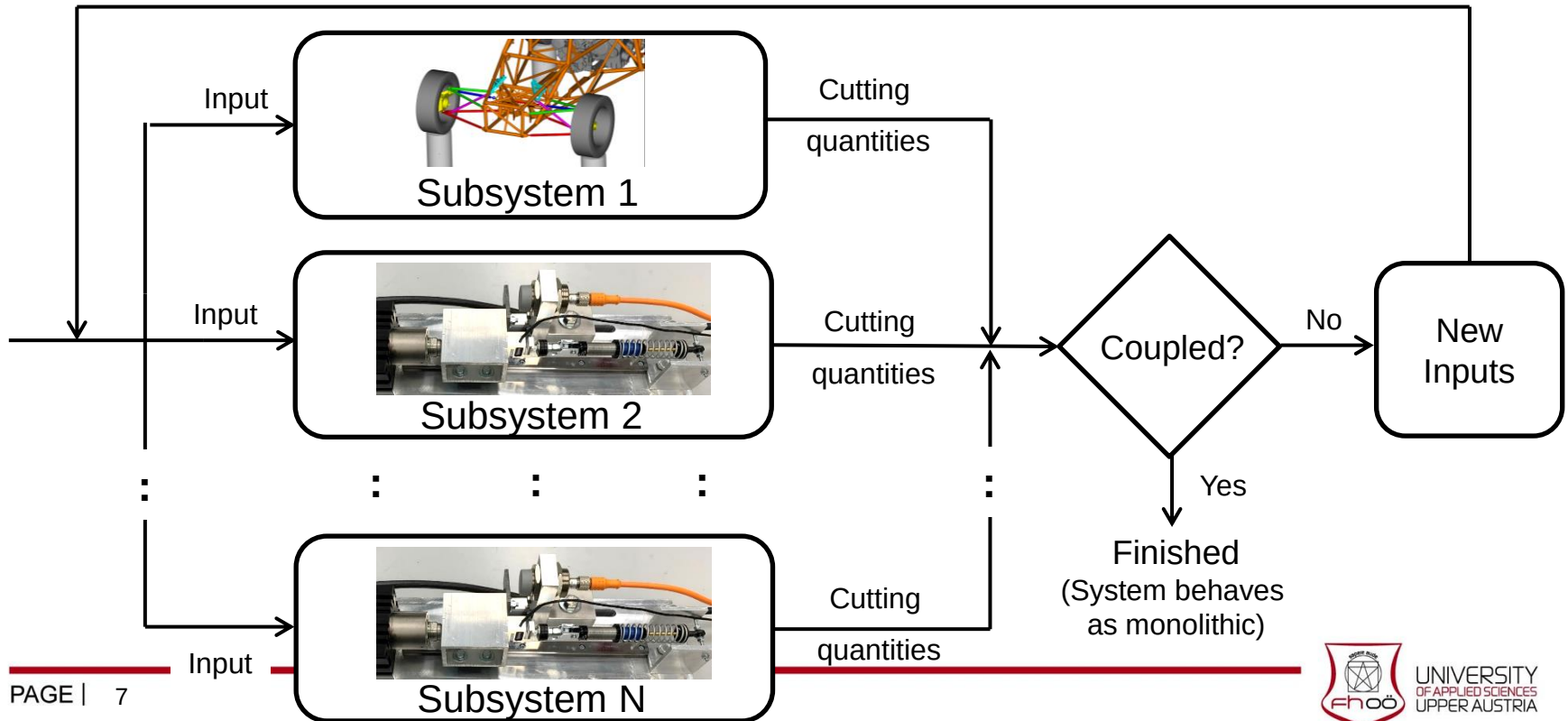
Test Field 2

Basic Idea



Find inputs for actors and/or simulation so that cutting quantities became equal

Basic flow



Characteristics of method

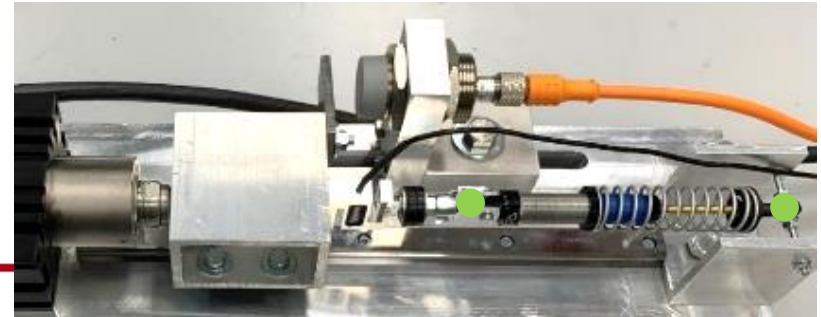
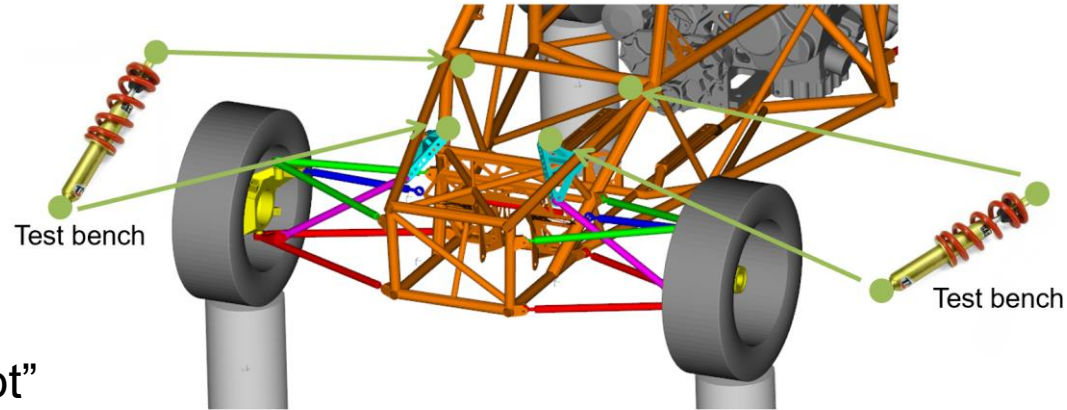
- For each subsystem: FRF's between inputs and cutting quantities required
 - Standard procedure
 - Interesting in terms of secrecy (no hardware, no models, ...)
- FRF's are kind of “search direction” (= Jacobi Matrix)
 - Works fine for many kind of nonlinearities
 - Very strong nonlinear behavior → more research
 - Principal limitation: Significant change of subsystem characteristic
 - › e.g., breaking components

Characteristics of method

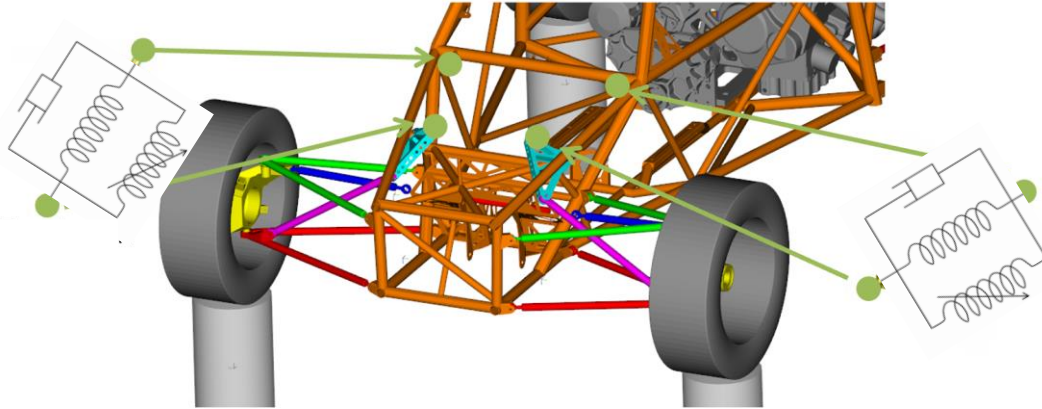
- Iterative Procedure
 - All Test are driven in real-time including dynamics and vibrations
- No controllers required
- No communication between subsystems during testing / simulation
 - Communication non-critical. Data exchange via Email possible
 - Experiment can be linked with complex (and “slow”) simulations
- Good convergence in case of moderate nonlinearities
 - Similar as “virtual iteration”

Example: Offroad vehicle

- 3 Subsystems
 - (1) Vehicle on four poster
 - (2) Shock absorber
 - (3) Shock absorber
- Pure virtual “Proof of concept”
- HIL
 - Four poster virtual (MBS of vehicle)
 - Shock absorber on test rig

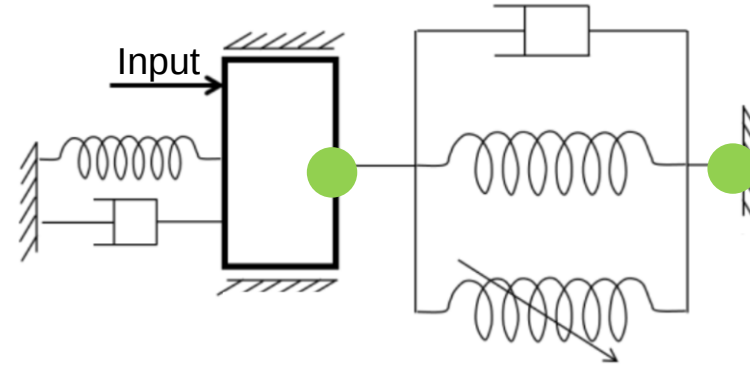


Virtual „proof of concept“



Multibody model of vehicle:

- www.freedyn.at
- 49 rigid bodies, 256 constraints, 46 force elements



Virtual shock absorber and test rig:

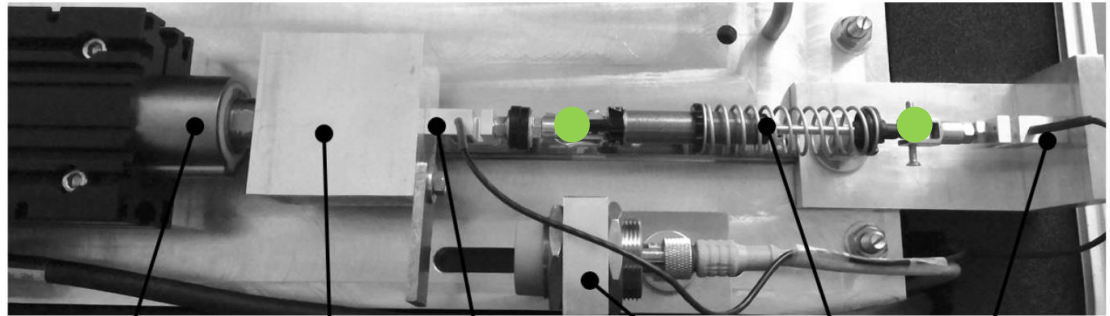
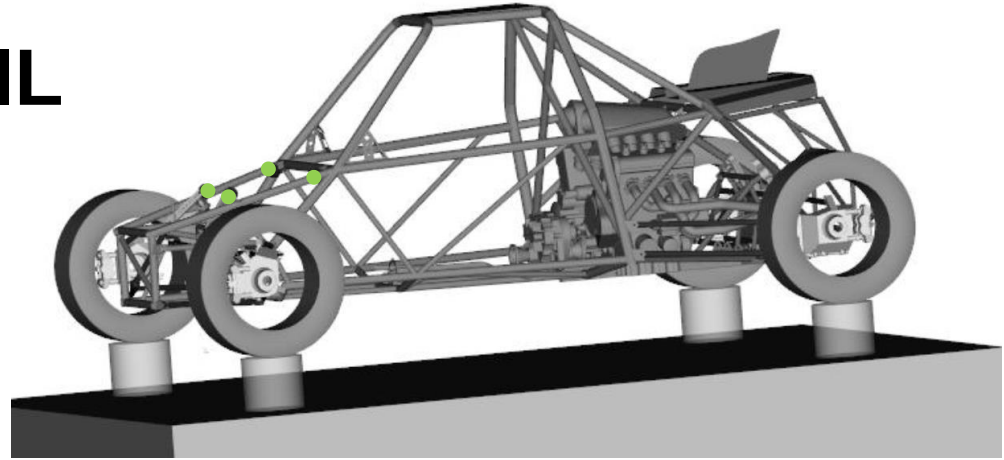
- Cubic Spring

Results of virtual „proof of concept“

- Cutting quantities of monolithic simulation and proposed procedure are identical
 - Number of iterations depends on cubic stiffness – around 5
 - No cubic stiffness → two iterations
- Not a big surprise

Offroad vehicle - HIL

- 3 Subsystems
 - (1) Vehicle on four poster
 - > Multibody Simulation
 - > See slide before
 - (2), (3) shock absorber on test rig
- Scaled to “crawler” size



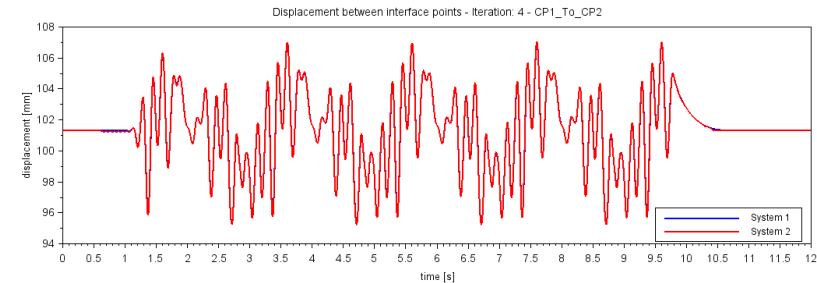
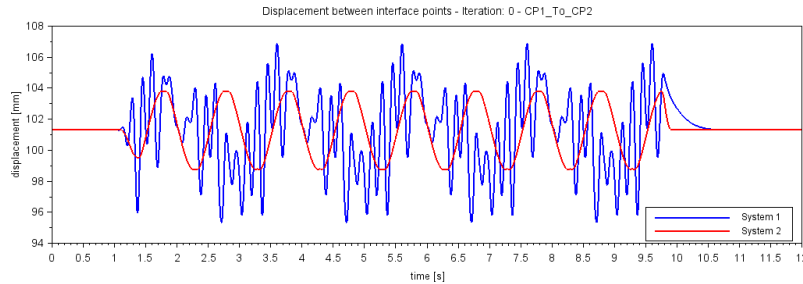
Results

- Length of shock absorbers (virtual vehicle on four poster, test rig)

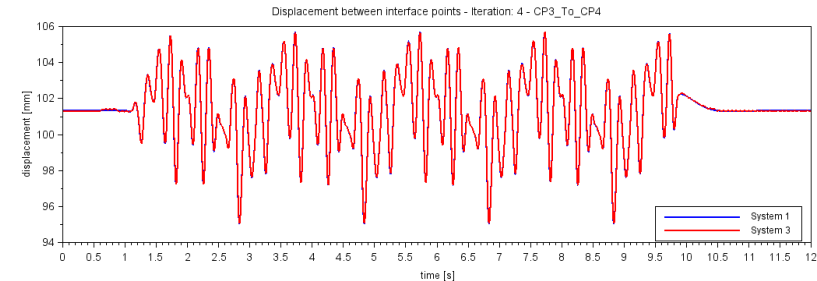
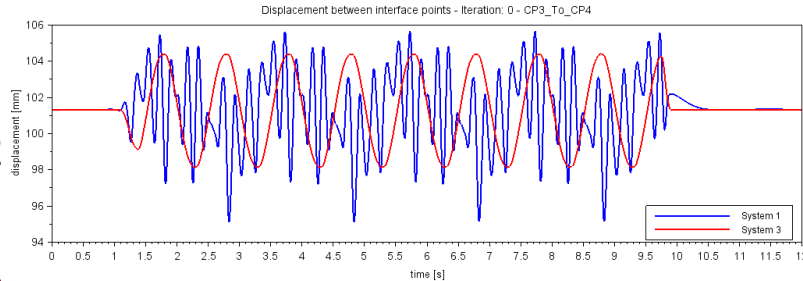
Initial run

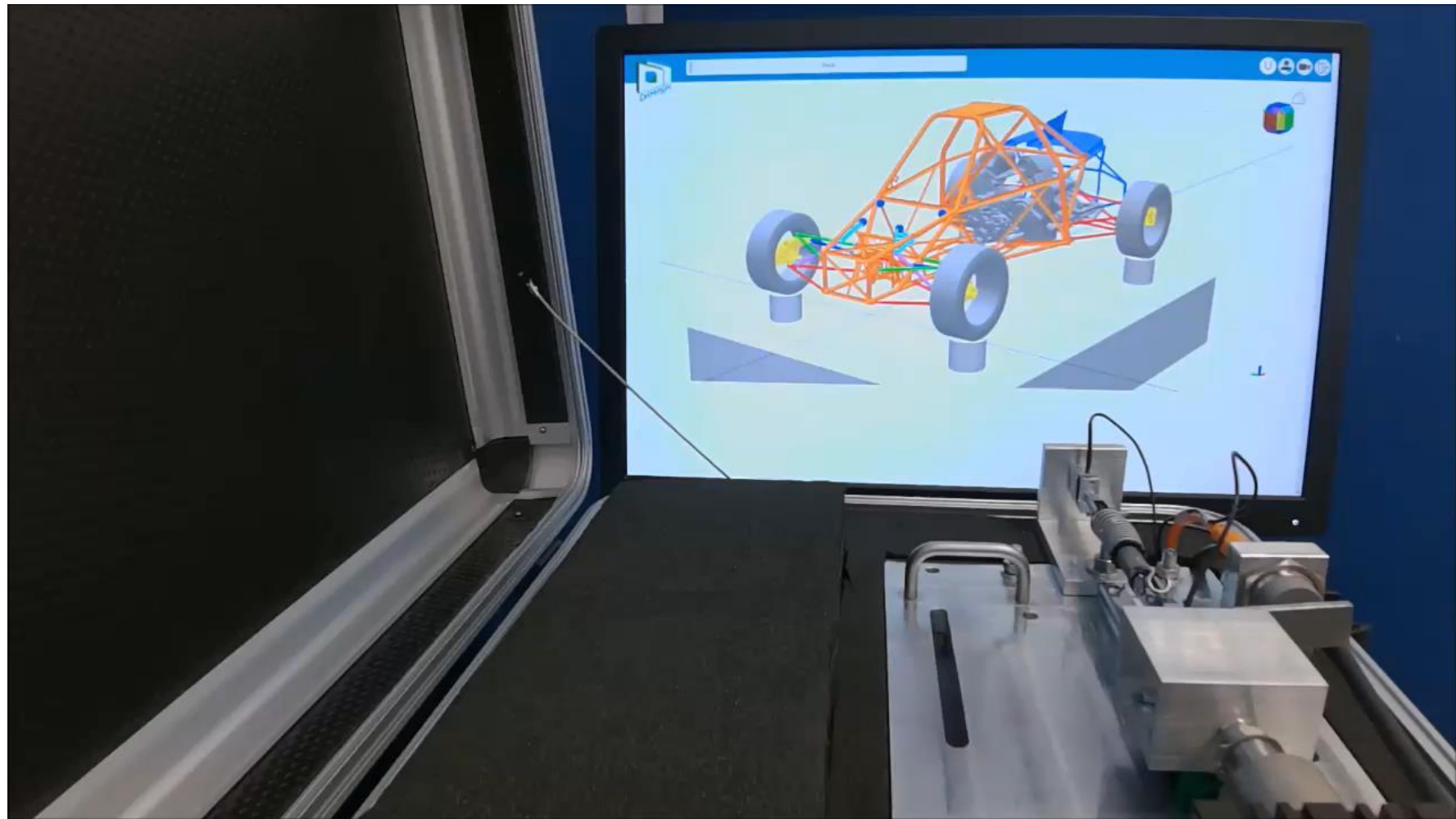
4th iteration

Shock
absorber # 1



Shock
absorber # 2





Summary

Iterative coupling of distributed dynamic systems:

- Coupling of arbitrary many distributed dynamic systems
 - Works for subsystems with invariant characteristics
- Tested for moderate nonlinearities
 - Good convergence
 - Strong nonlinearities → Research
- Secrecy: Just subsystems FRF's are required (no model data, no hardware, ...)

Summary

Iterative Coupling of distributed dynamic systems:

- Iterative procedure:
 - No communication between systems during one run
 - Test in real-time (vibrations!)
 - No real-time issues for data transfer
 - › Coupling of arbitrarily “slow” subsystems
 - › Data exchange uncritical – Email thinkable
 - No controller necessary

Interested? → wolfgang.witteveen@fh-wels.at