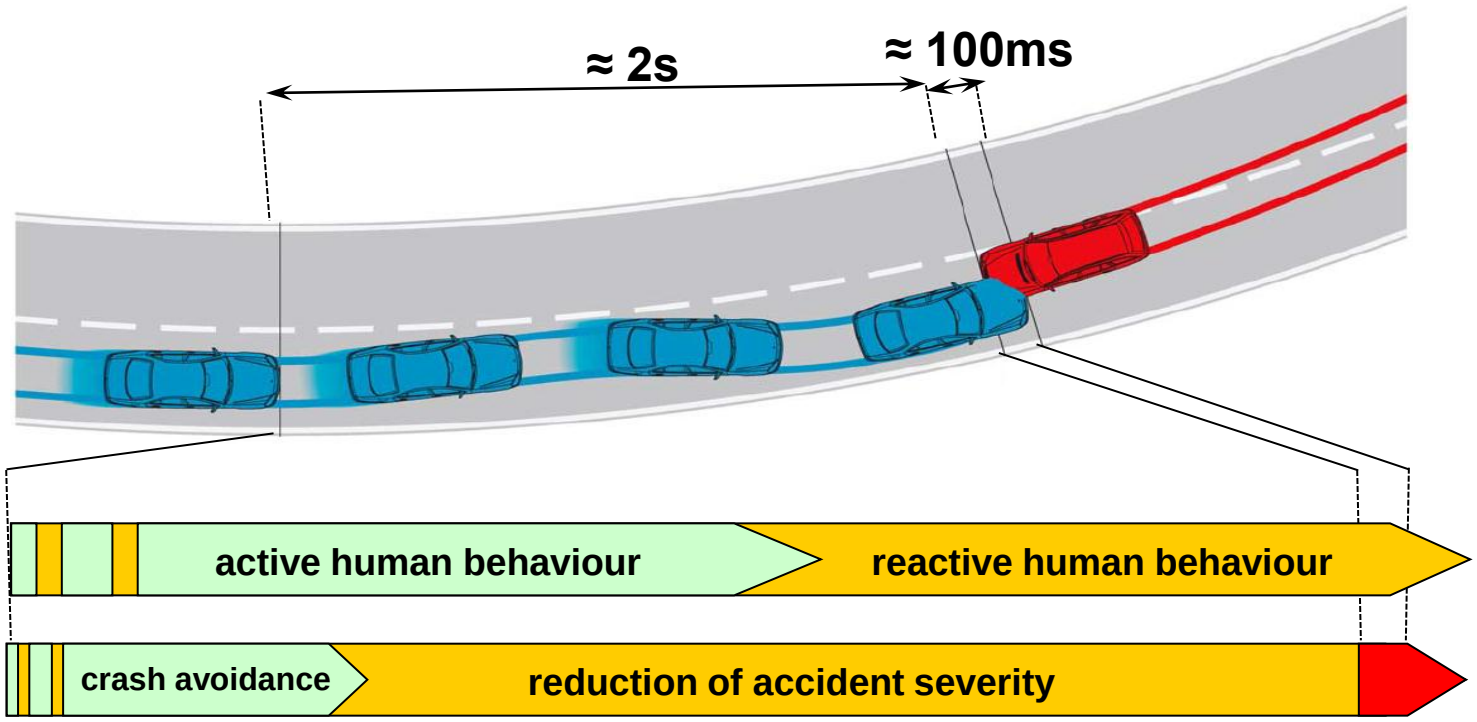
Menschmodelle - Überblick und Erweiterungsmöglichkeiten

Aktive Muskelansteuerung des THUMS mit dem Co-Simulationstool ICOS

Steidl Thomas

K2 / K plus Competence Center - Initiated by the Federal Ministry of Transport, Innovation & Technology (BMVIT) and the Federal Ministry of Economics & Labour (BMWA). Funded by FFG, Land Steiermark and Steirische Wirtschaftsförderung (SFG)



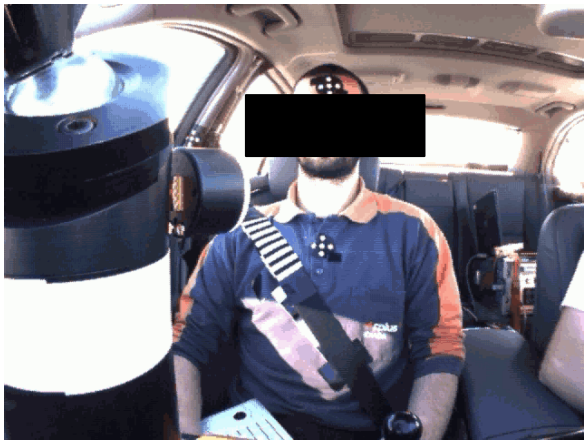
Up to now:

- Testing and simulation focuses on crash situations
- Use of dummy models

In future:

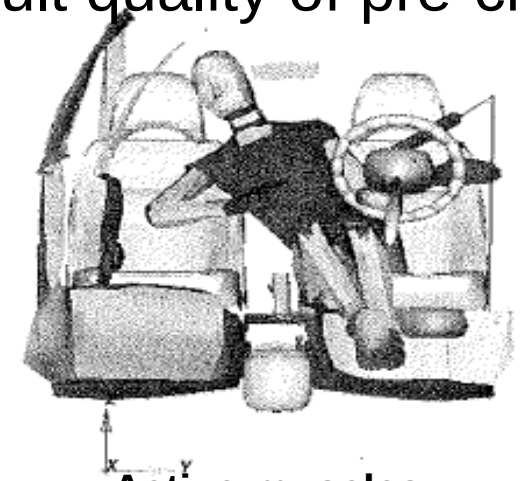
- Including the pre-crash phase (low g phase)
- Increasing use of numeric human body models (HBM)

Low-g-phase (pre-crash)

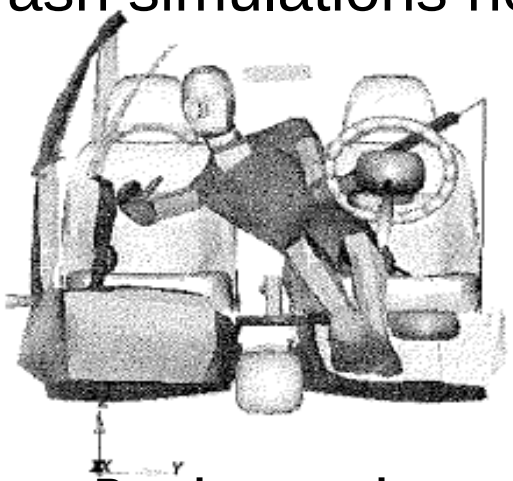


Source: ***Daimler***

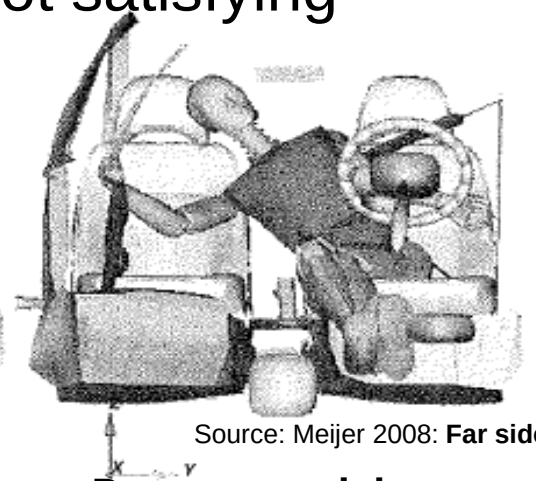
Result quality of pre-crash simulations not satisfying



Active muscles



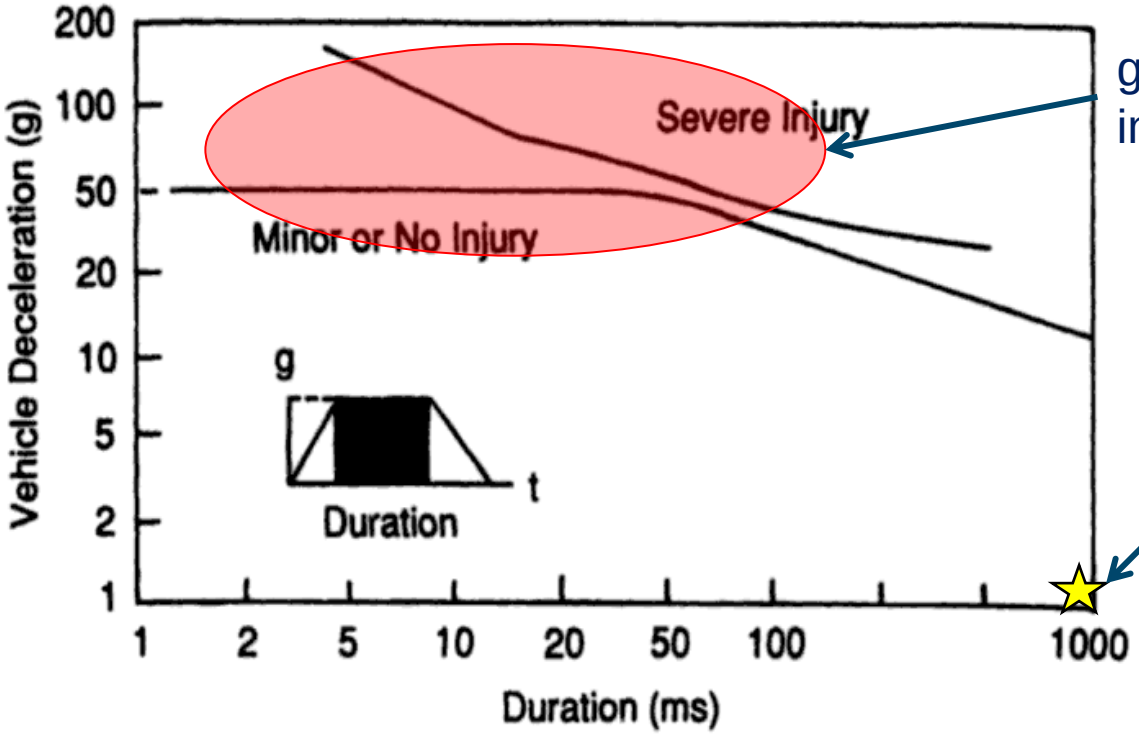
Passive muscles



Dummy model

Source: Meijer 2008: **Far side impact**

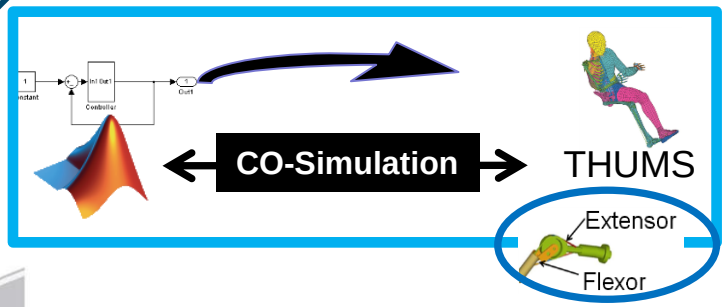
High-g vs low-g (Wayne State Tolerance Curve)

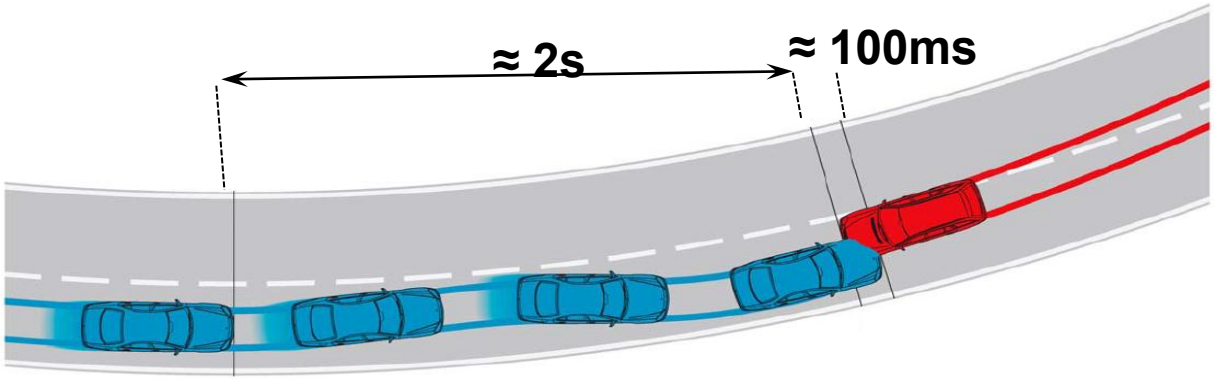


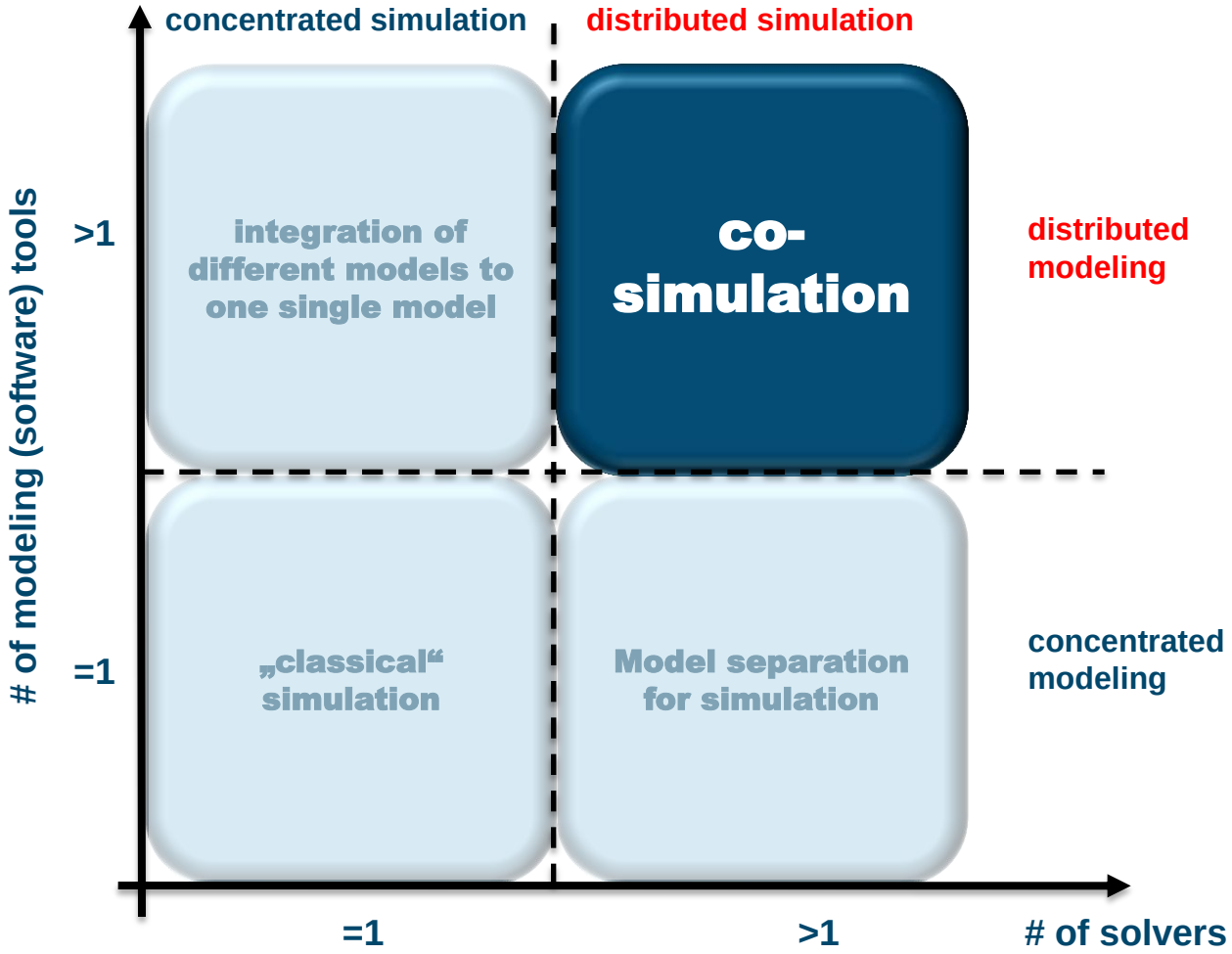
Bronzino, The Biomedical Engineering Handbook, CRC Press, 2000

good model quality for injury prediction

realistic kinematics for pre-crash





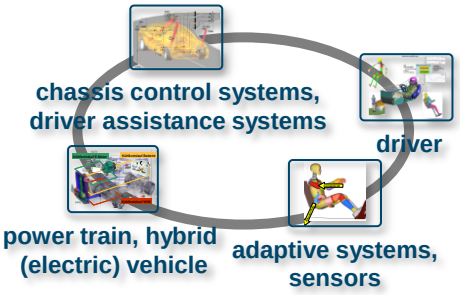


Source: Geimer M. et al: „Co-Simulation, gekoppelte Simulation oder Simulatorkopplung?“, O + P Zeitschrift für Fluidtechnik, 50 (2006), Nr. 11-12, S. 572-576

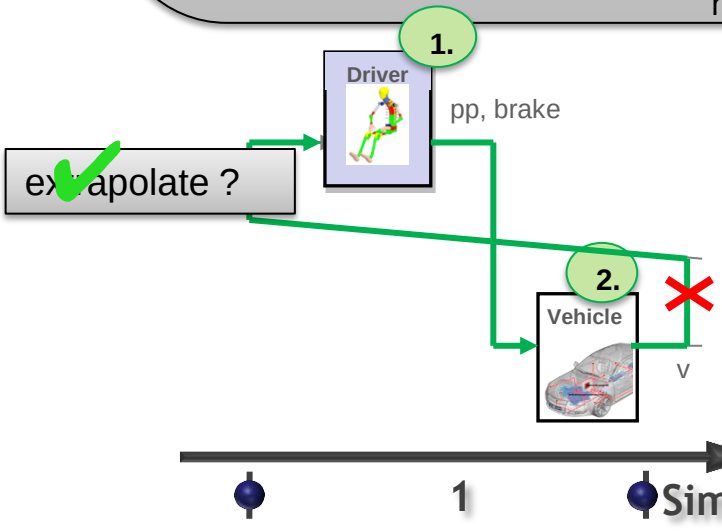
Requirements on the co-simulation platform

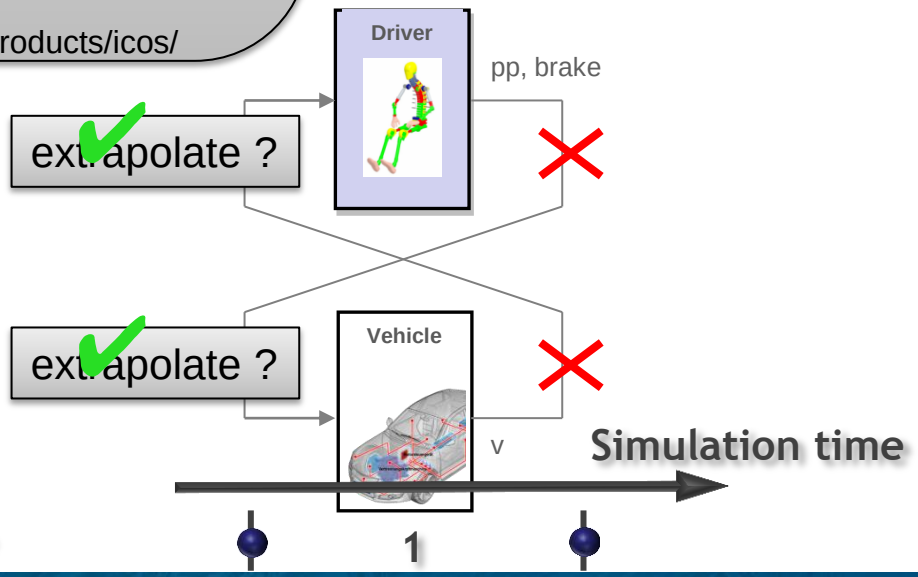
- Integration of simulation tools
- Coupling of the tools
- Handling of simulation step sizes
- Handling of interaction loops
  - **Scheduling**
  - **Extrapolation**

http://vif.tugraz.at/products/icos/



ICOS ✔





sequence

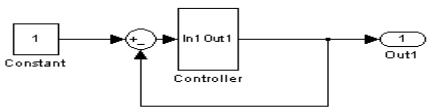
single
(last) value

ΔT... macro time step

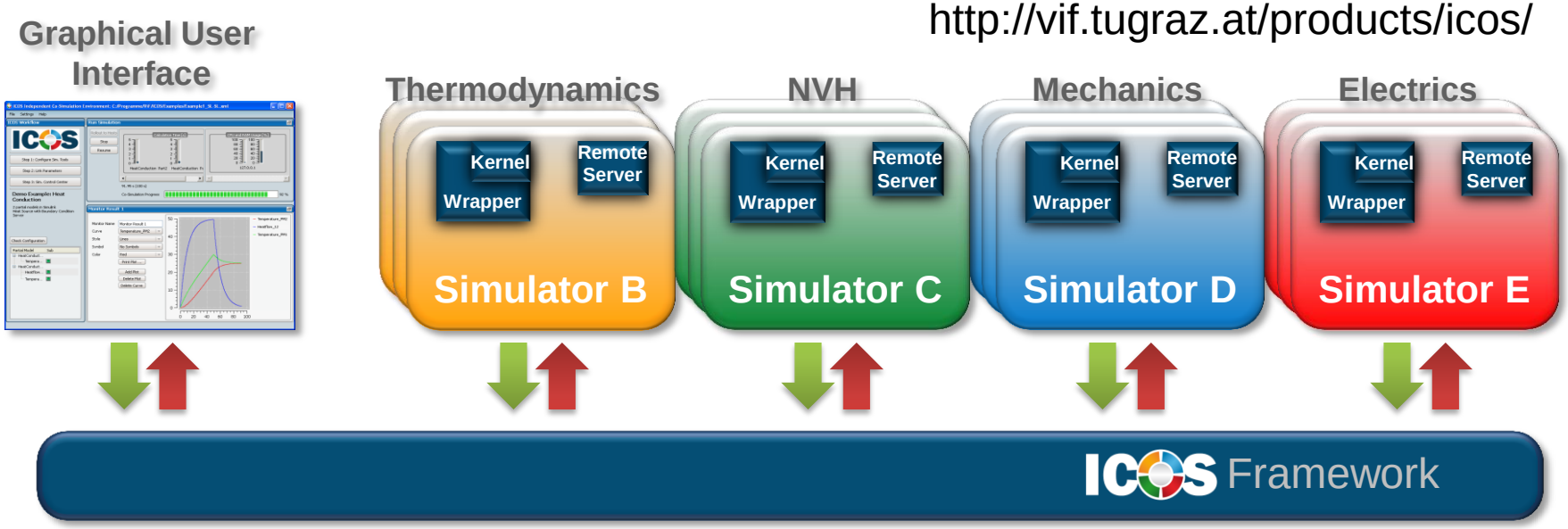
Simulation time

Δt

ICOS Co-Simulation Framework

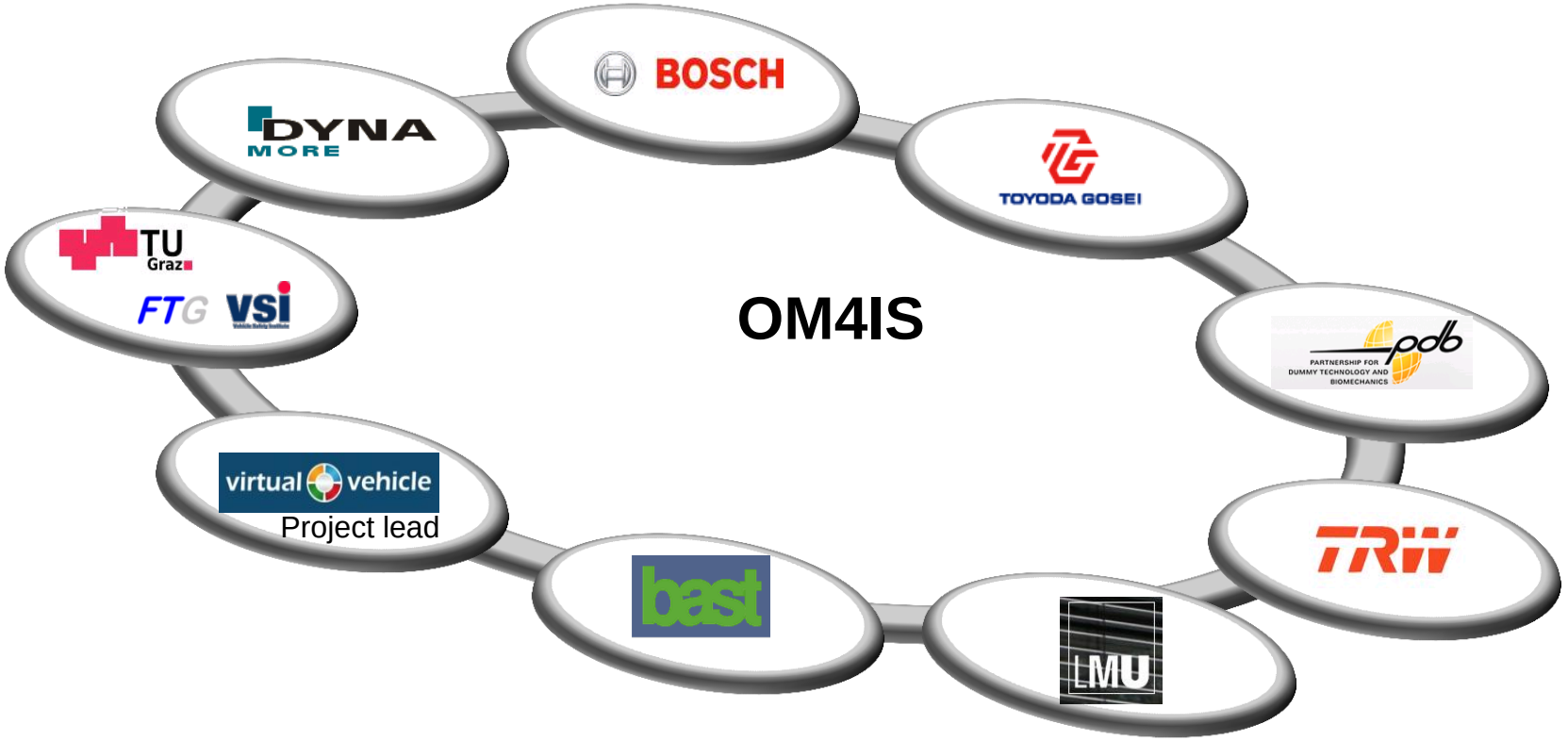


http://vif.tugraz.at/products/icos/



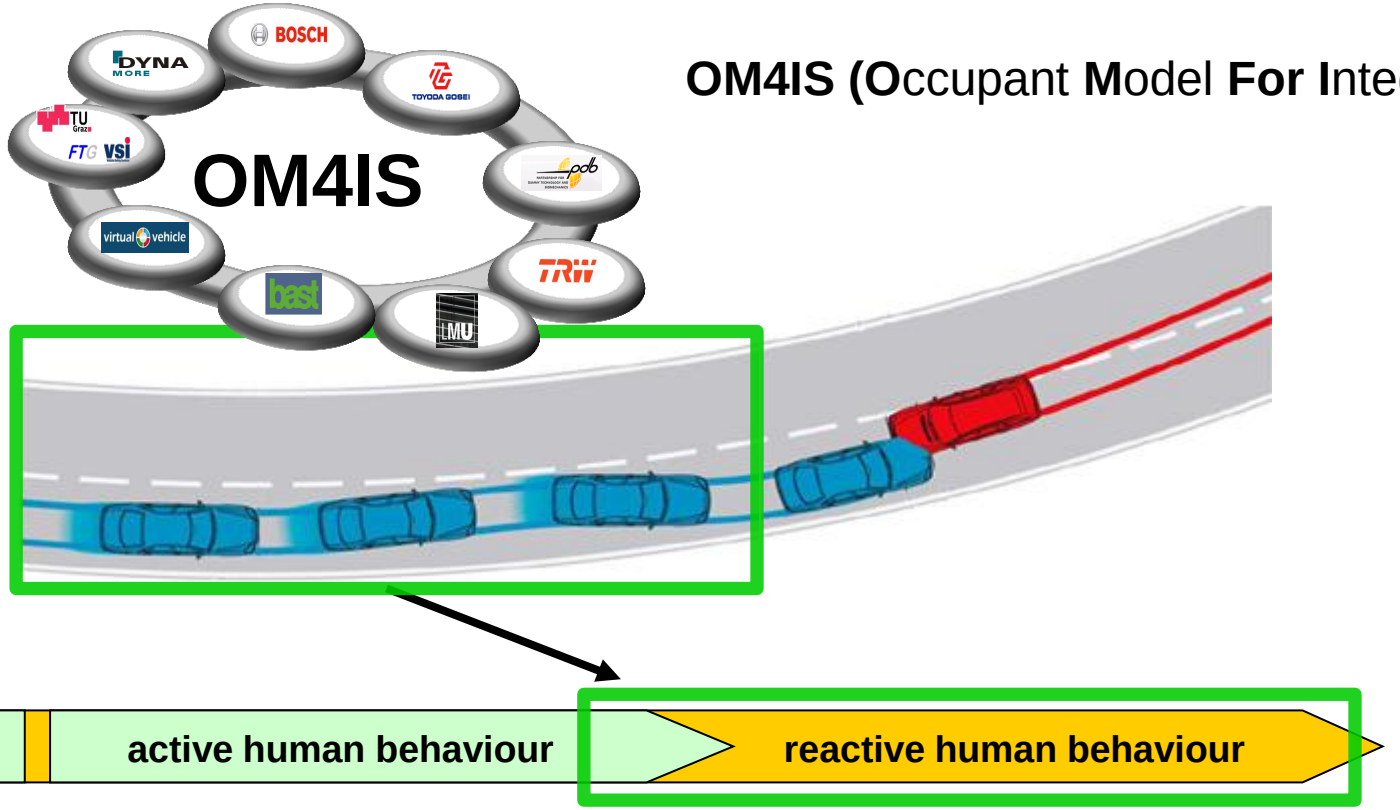
GUI…Graphical User Interface

- **ICOS Framework:**
  - Integration: multi-tool, networked, cluster integration, re-use licenses, data exchange & conversion
  - Synchronization: micro step (tools) / macro step (ICOS), fixed/variable step size, adaptive step size control
  - Coupling: serial/parallel, iterative/non-iterative, dead time compensation for reduced quantization errors (energy preserving coupling)



OM4IS (Occupant **M**odel **For I**ntegrated **S**afety)

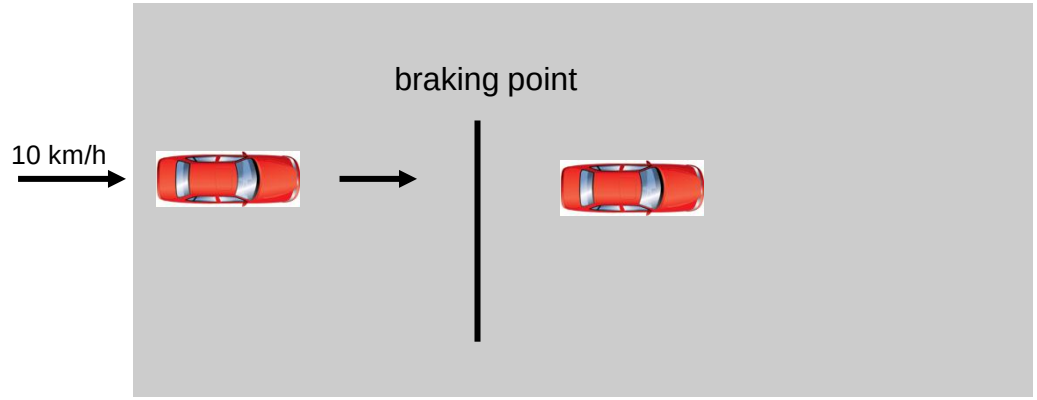
Research project: Duration 2009 - 2012



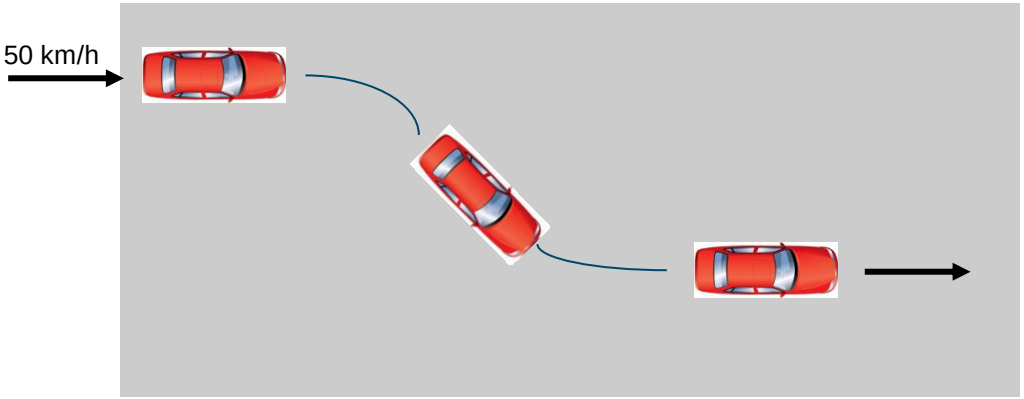
OM4IS (Occupant Model For Integrated Safety)

- Observing the reactive behaviour of volunteers within the collition phase (~2 s)
- Implementation of a numerical human body model (HBM)

1. Case: Front braking maneuver 10 km/h



2. Case: lane change 50 km/h



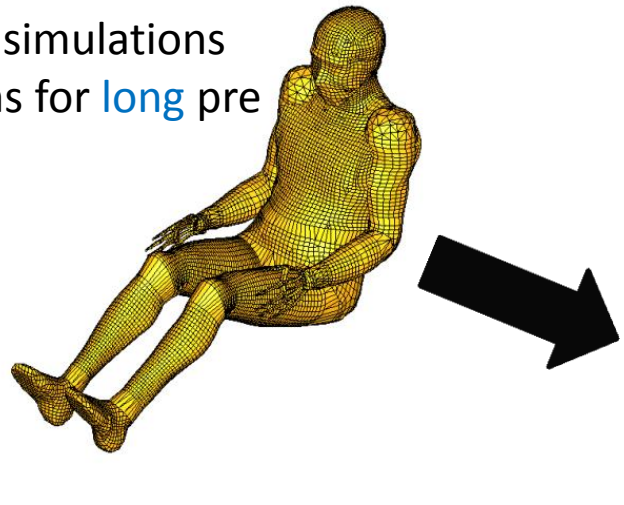
- 30 volunteers
- Different awareness states
- Kinematics of vehicle and occupant

➔ **Validation database**

Toyota THUMS ("Total HUman Model for Safety")

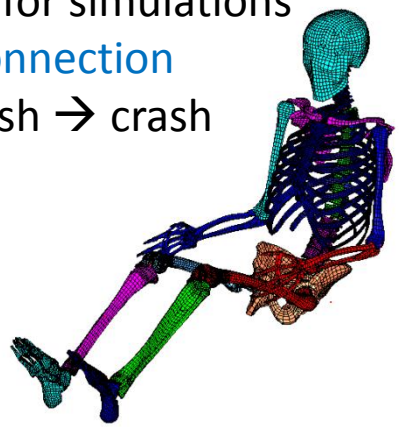
THUMS v3:

- **Detailed** modelling
  - → Time consuming simulations
  - → Stability problems for long pre crash durations



THUMS v3- THUMS simplified:

- Extracted rigid **bone model** with adapted masses and inertia
- Introduced **kinematic joints**
  - → No stability problems
  - → Less time for simulations
  - → Vision: Connection pre-crash → crash



Assumption: Deformation not relevant for pre-crash

Movement:

Joint torque:

→ easier to handle

→ no internal joint forces

Muscle force:

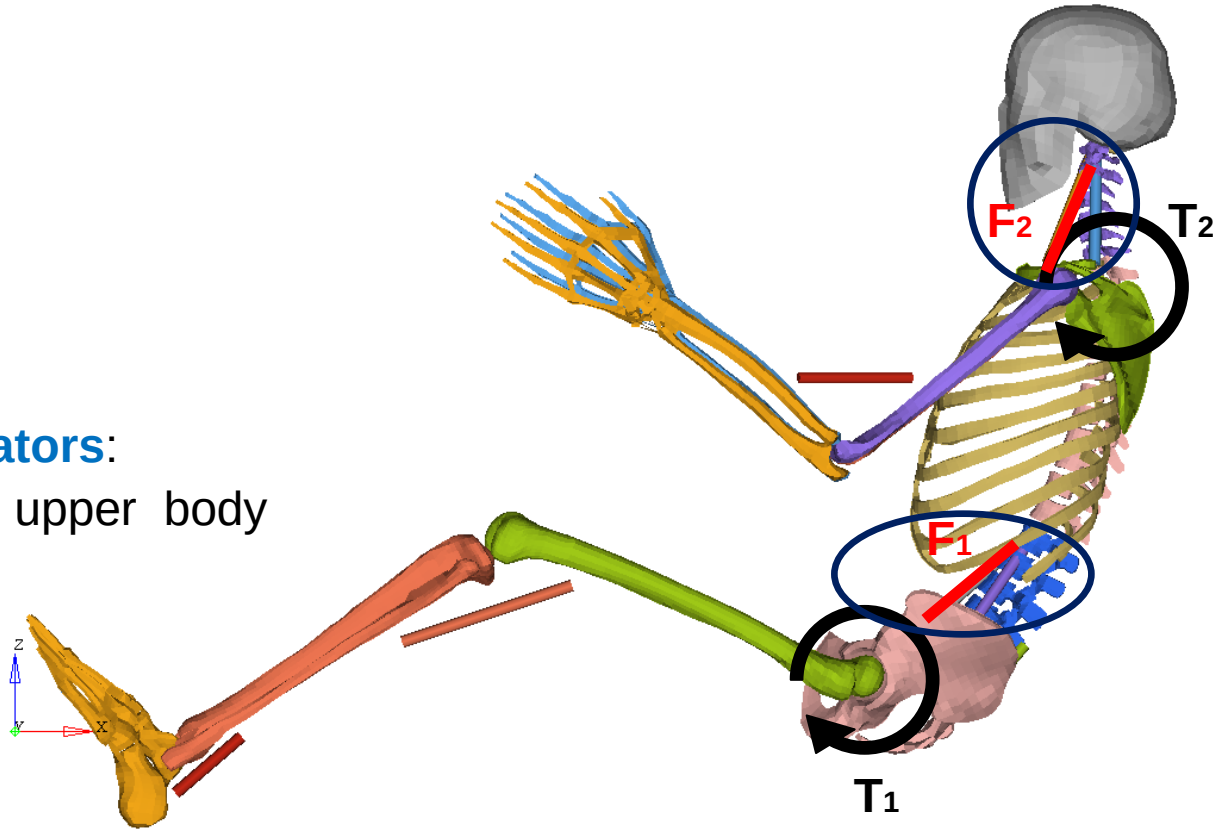
→ anatomically correct

→ correct internal stresses

Using torque!

→ **calculated via 2 actuators**:

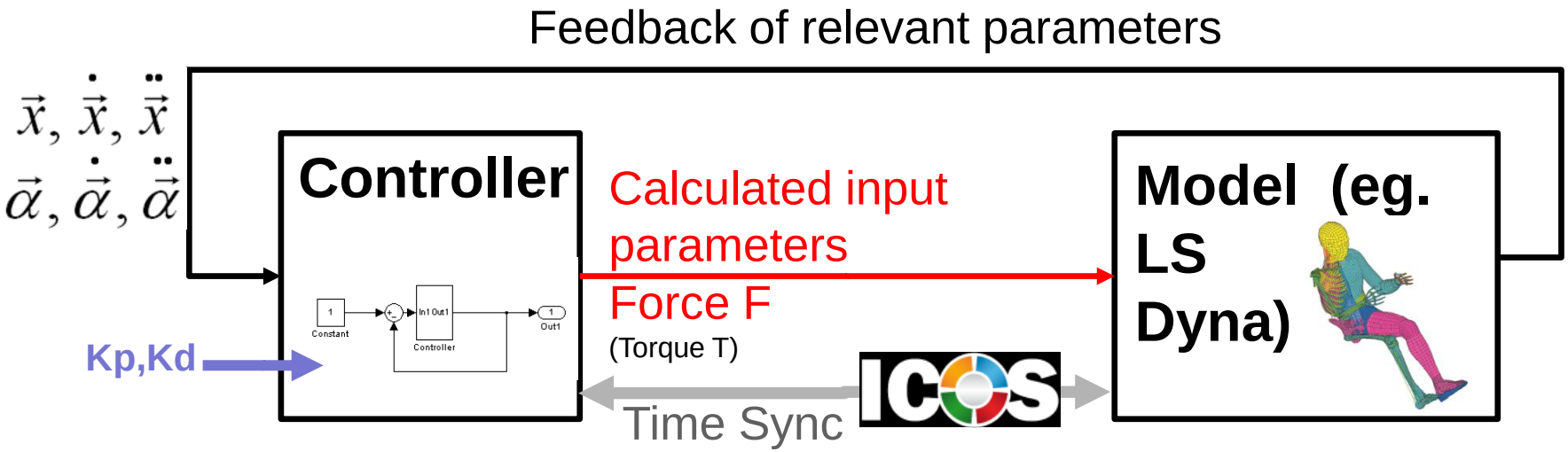
- lower extremity and upper body
- controller: **T** → **F**



One controller for different models (MKS, FE)

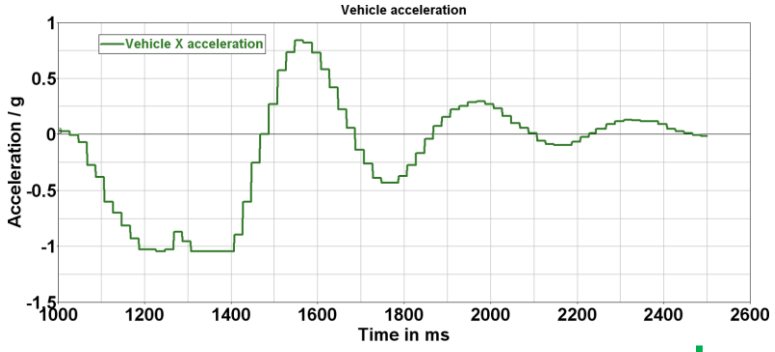
- Code independent implementation of Controller (not directly implemented in simulation code - independent of FE code or multi body systems language)

- Coupling between Matlab/Simulink or C/C++ and explicit FE Solver (LS Dyna)

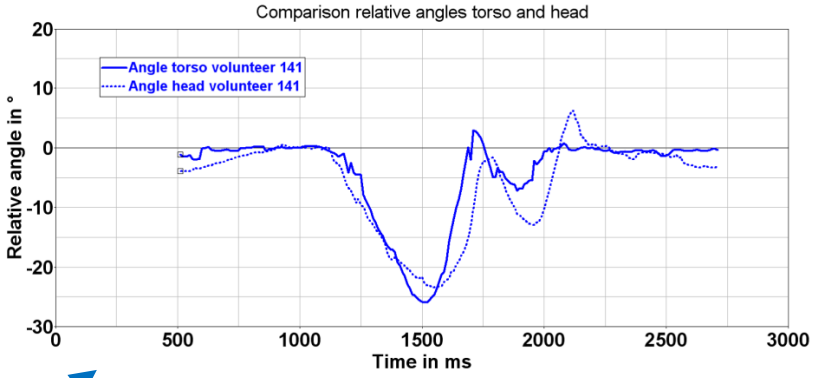


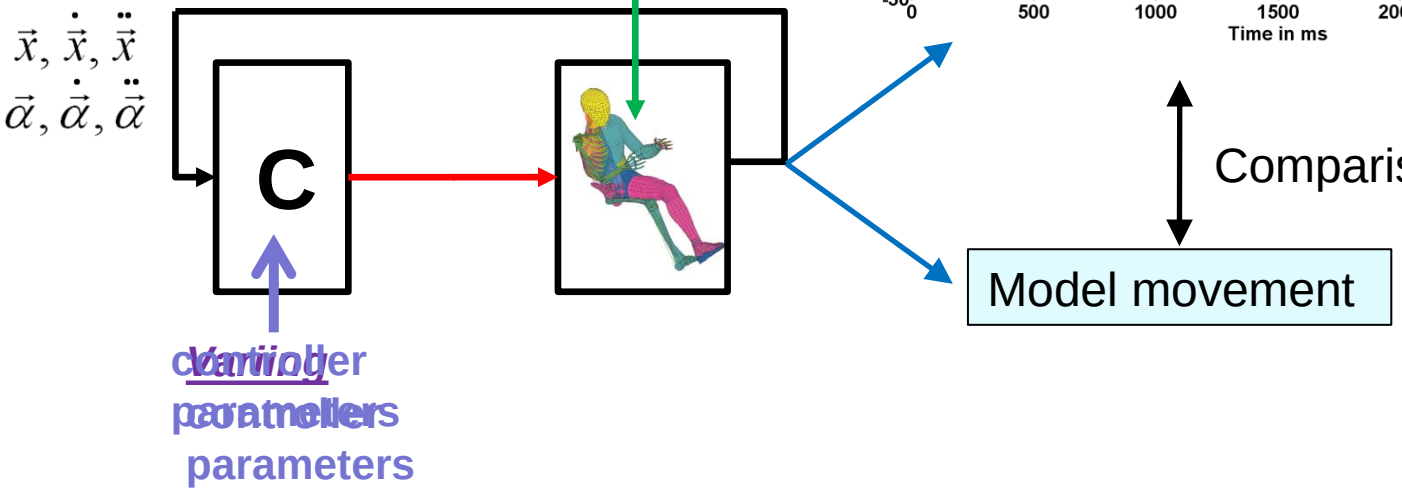
30 volunteers (3 tests each per case)

Acceleration vehicle(database)

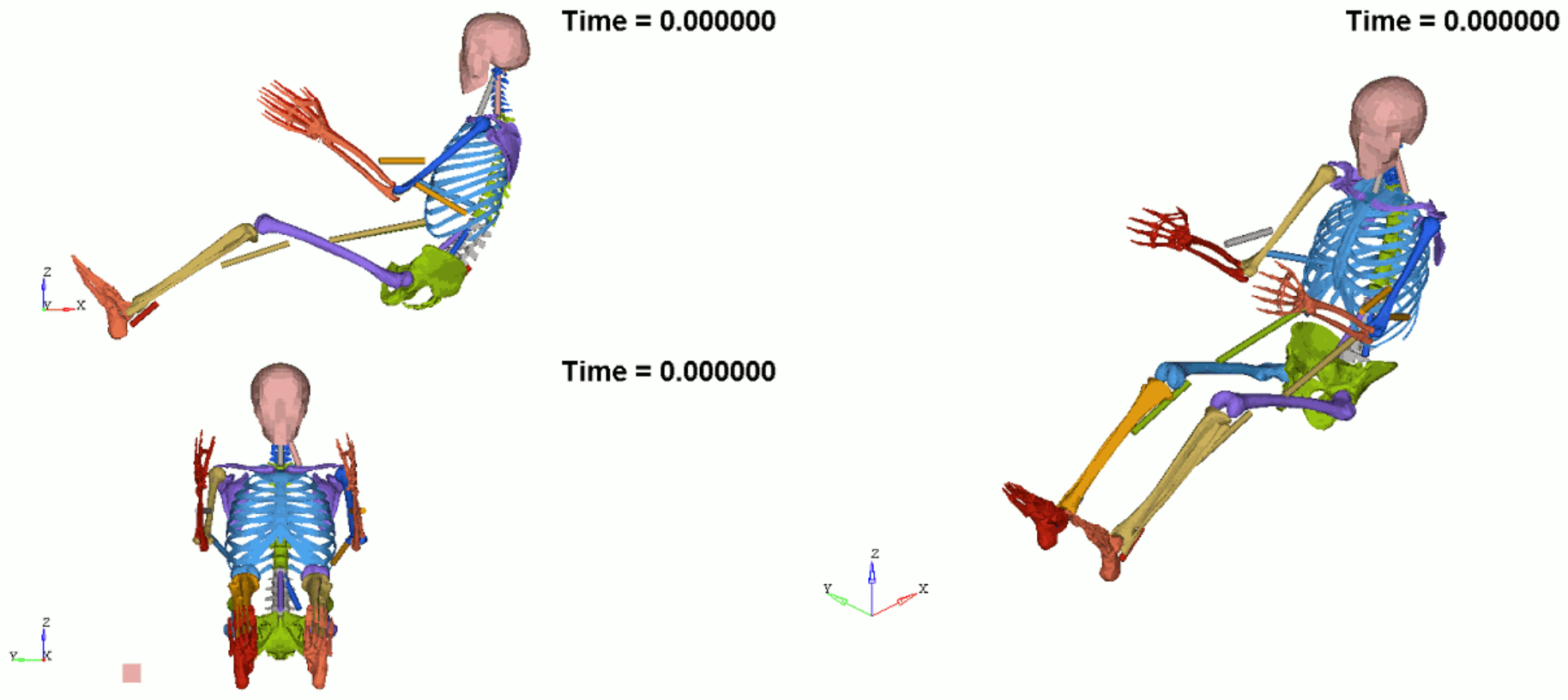


Kinematic data human (database)

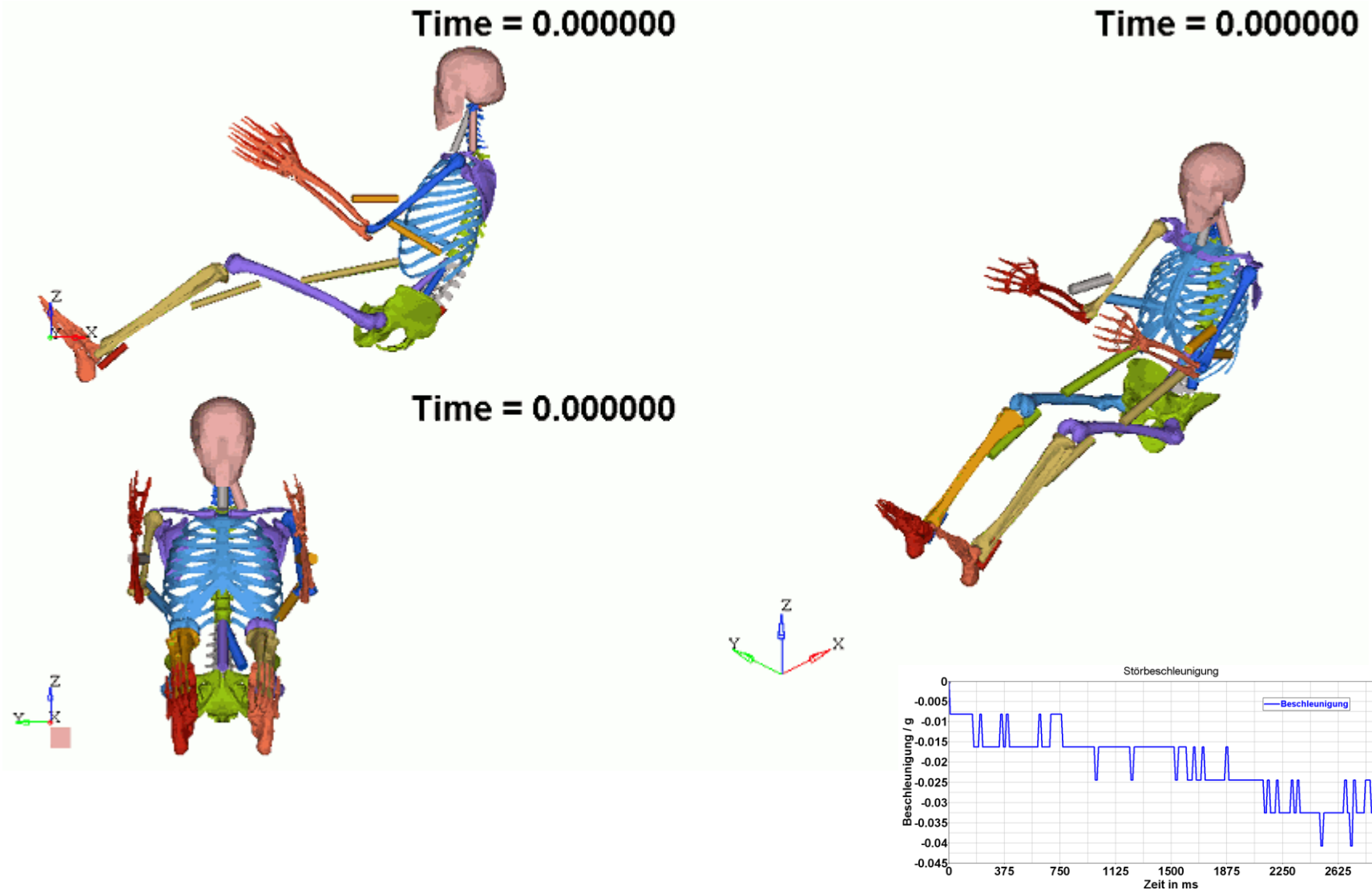


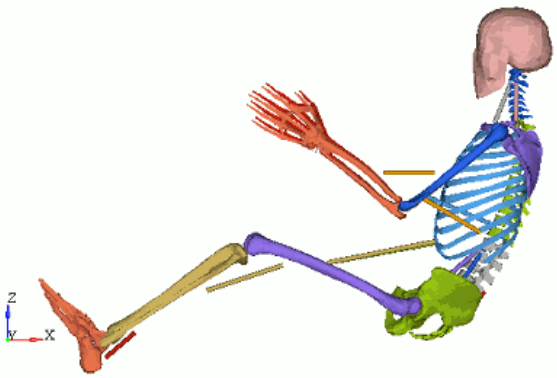


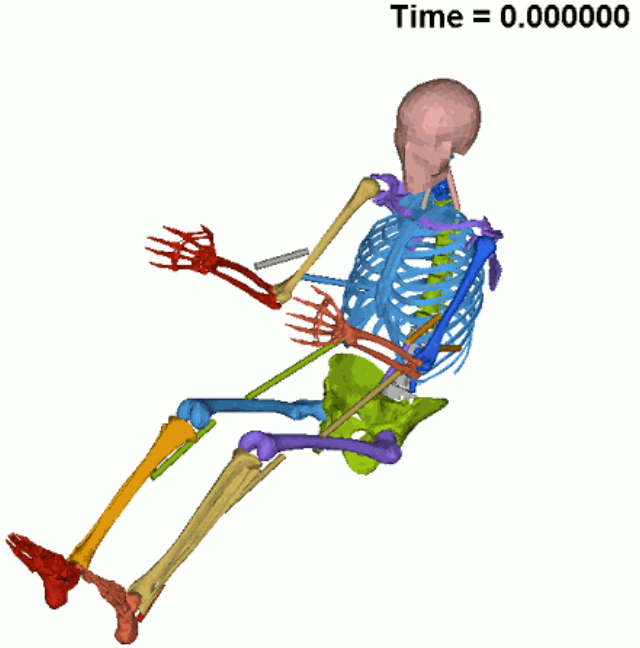
OM4IS Results: Gravitation only, passive model



OM4IS Results: Gravitation, small acc, active model




Time = 0.000000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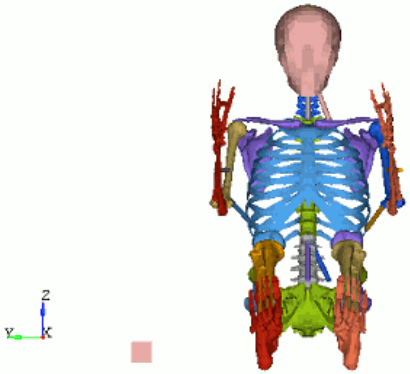
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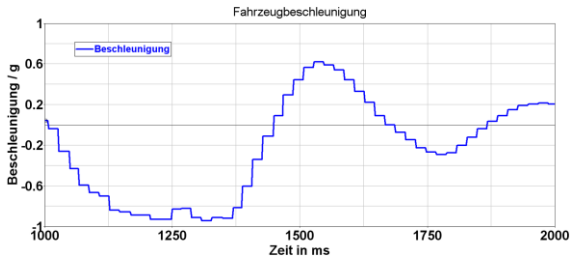
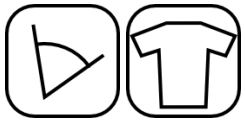
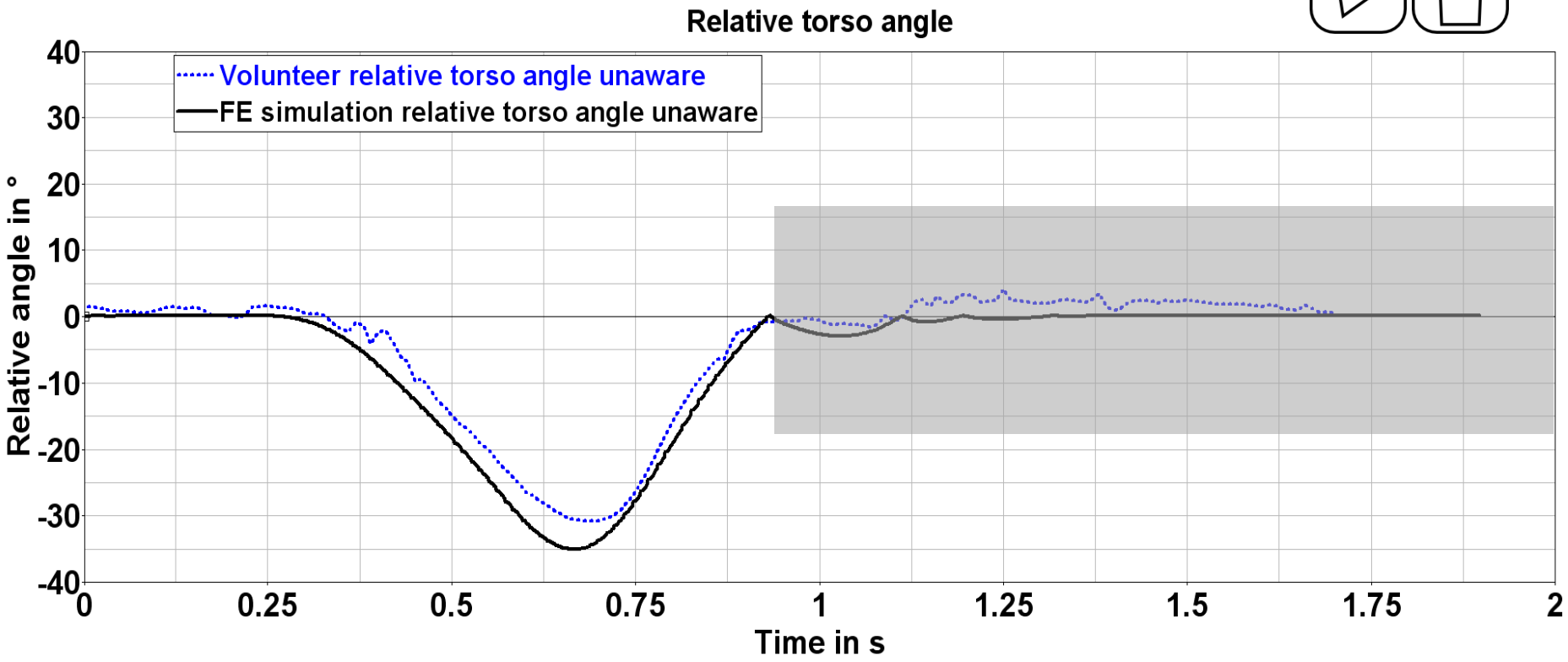
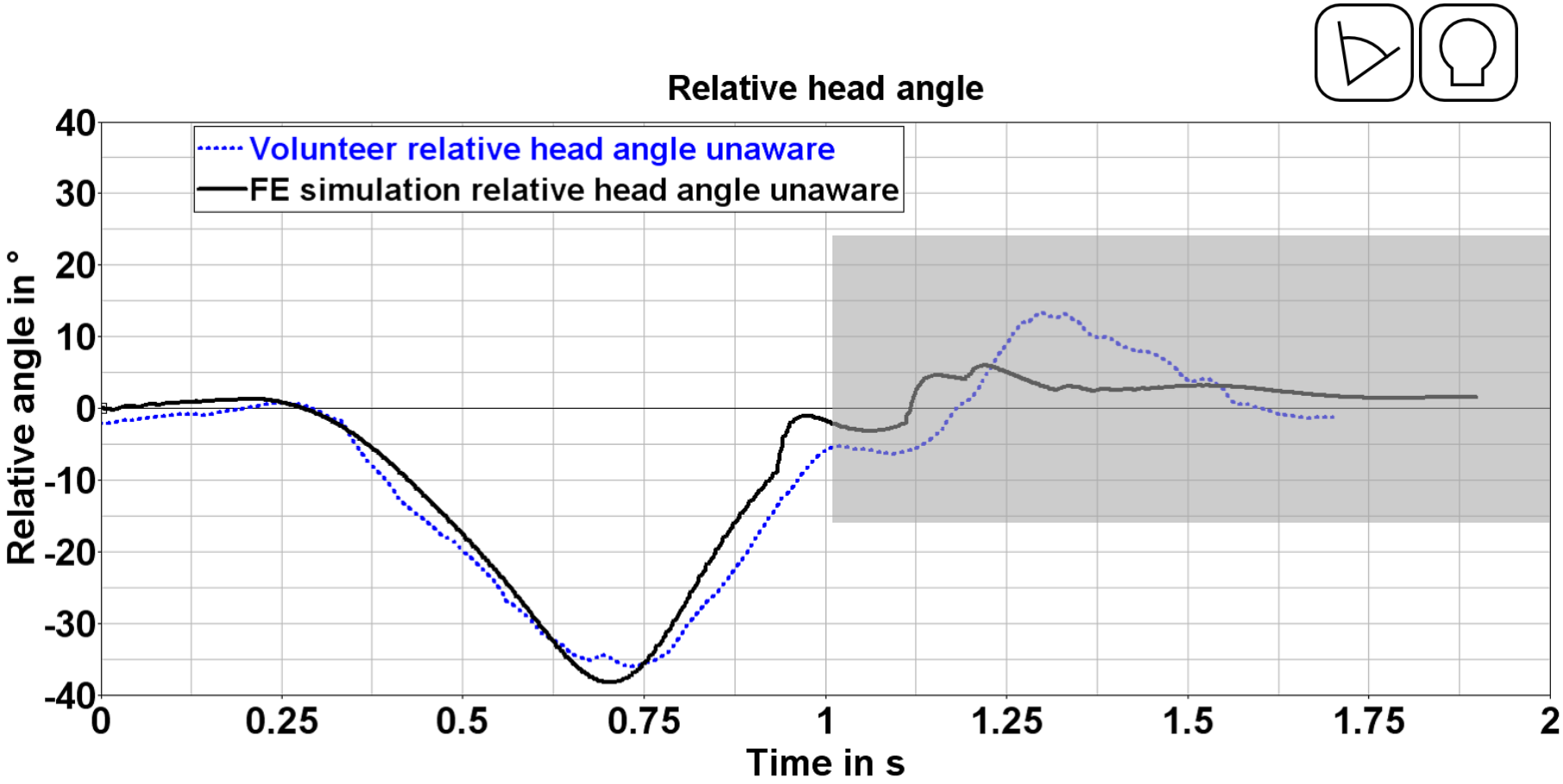

Fahrzeugbeschleunigung
Beschleunigung
Beschleunigung / g
1
0.6
0.2
-0.2
-0.6
-1
1000
1250
1500
1750
2000
Zeit in ms



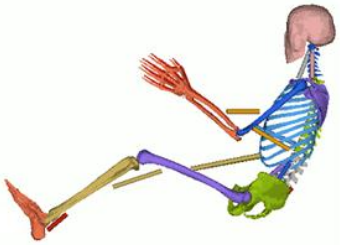

Relative torso angle
Volunteer relative torso angle unaware
FE simulation relative torso angle unaware
Relative angle in °
40
30
20
10
0
-10
-20
-30
-40
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
Time in s



- THUMS less reduced:

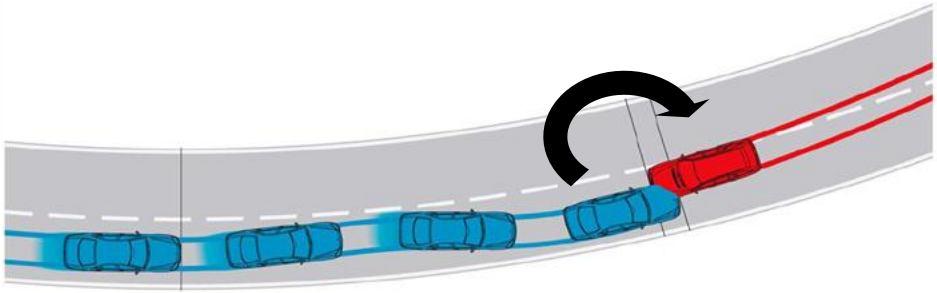
vs

- 2D → 3D:



→

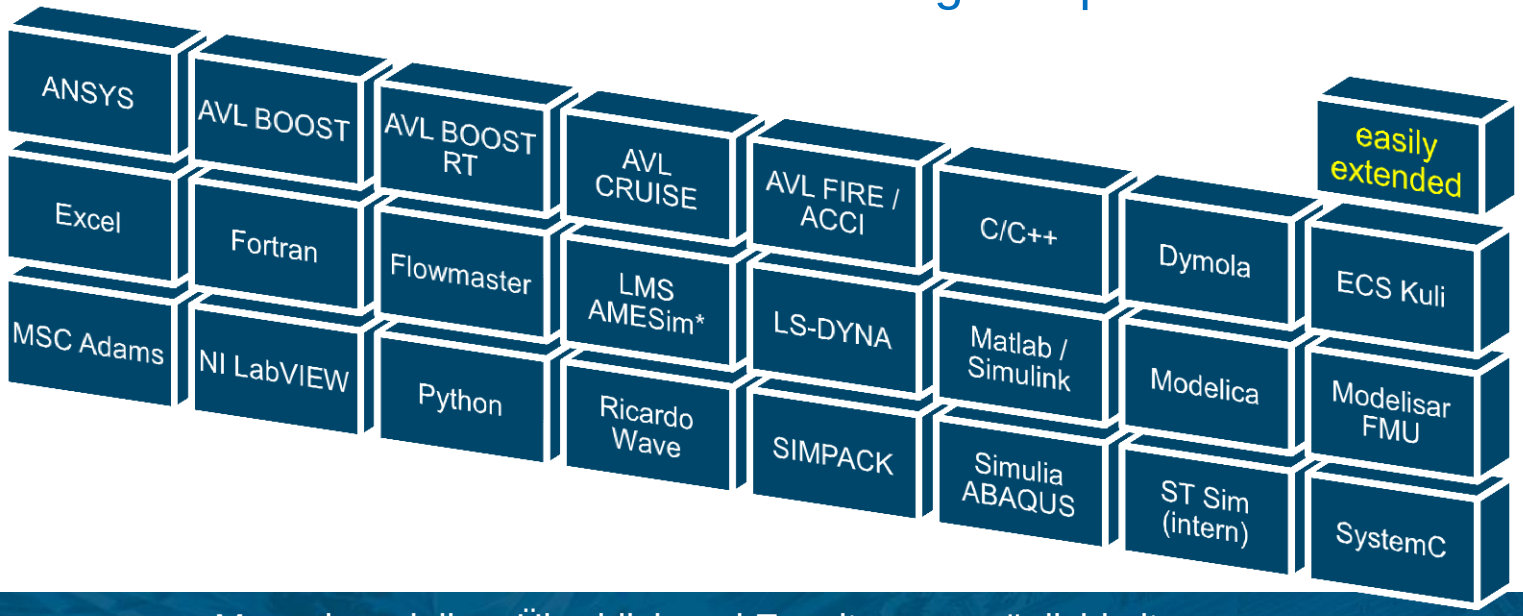
- Pre-crash → Crash:



- Re-active models: Very important for modelling process of active systems in cars (autonomous braking, active belt systems, …) and for crash-cases

- Combination of the two domains pre-crash (muscle contributions) and crash (injury mechanisms) is a challenge for simulation models

- ICOS: Potential all-round-tool for simulating complex models



Thank you for your attention