

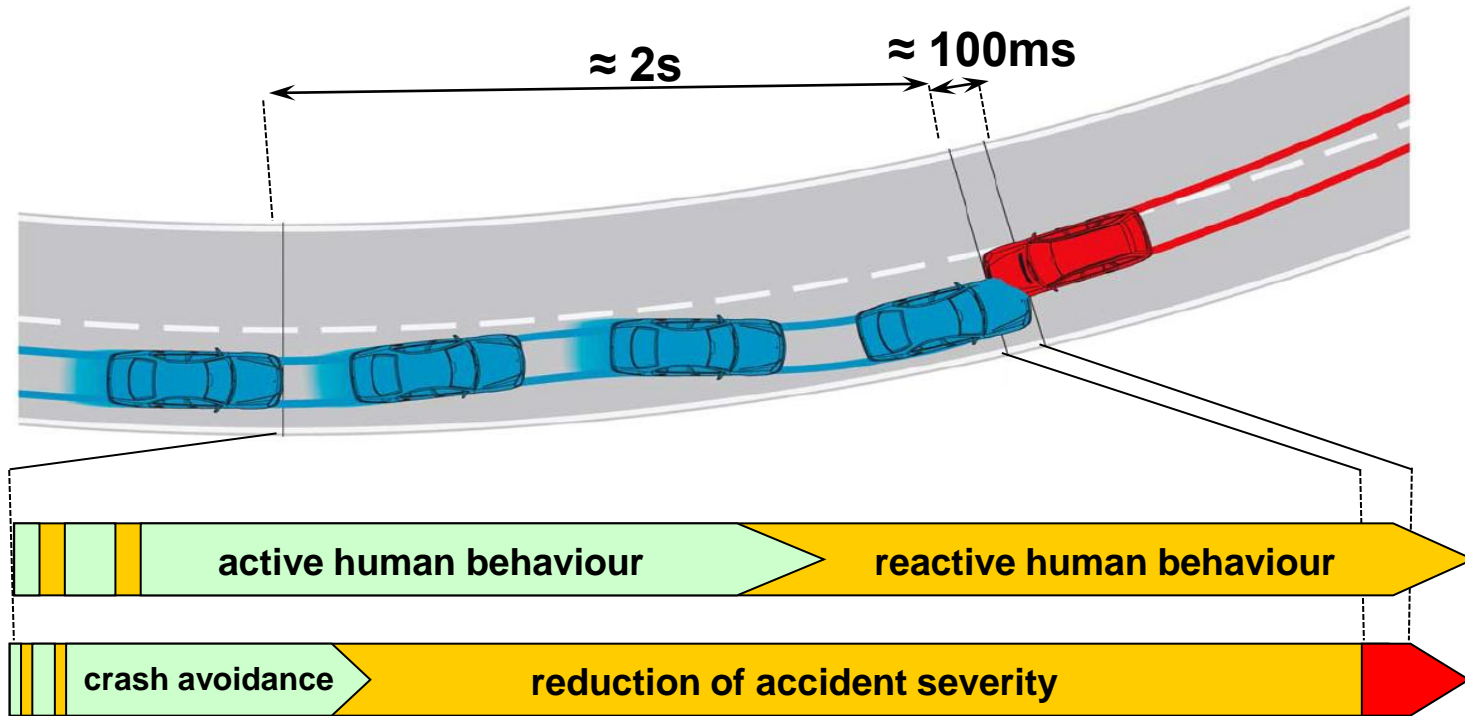
# Menschmodelle - Überblick und Erweiterungsmöglichkeiten

## 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)**

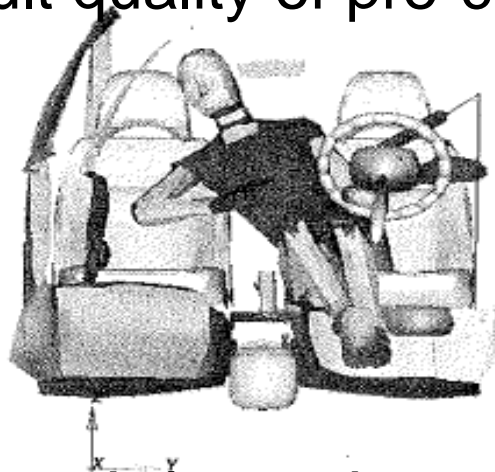
# Low-g-phase (pre-crash)



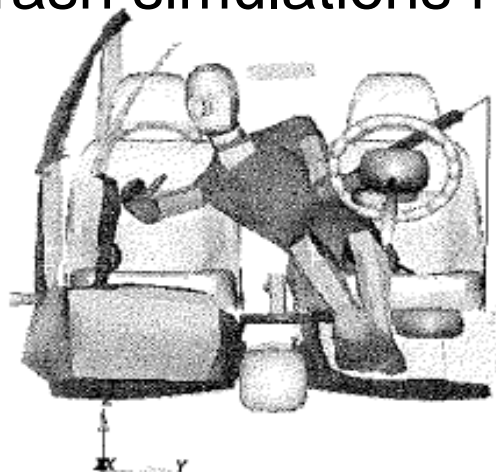
Source: Daimler



Result quality of pre-crash simulations not satisfying



Active muscles

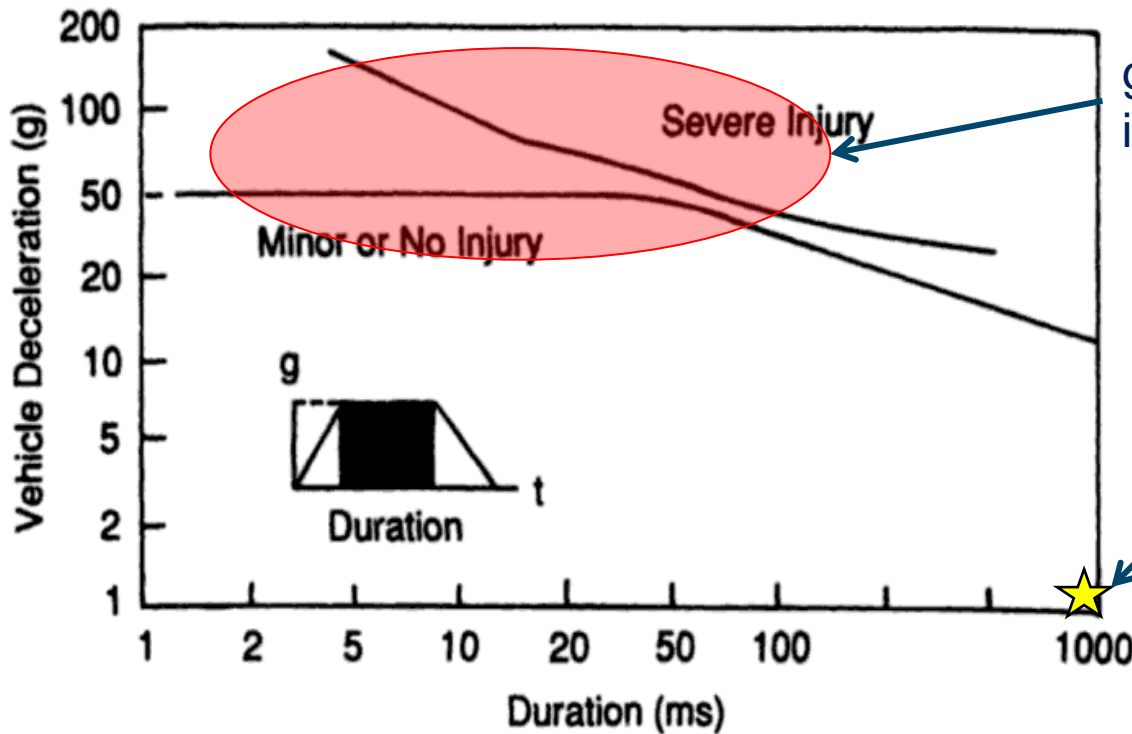


Passive muscles



Source: Meijer 2008: Far side impact

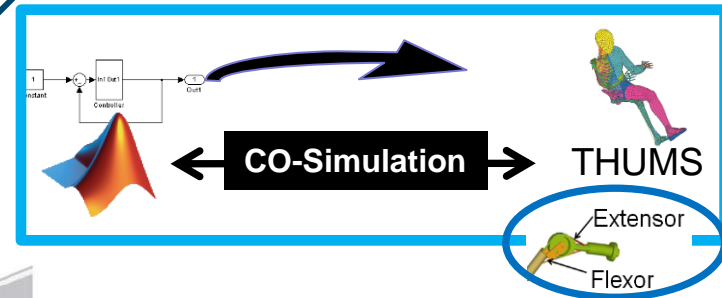
Dummy model



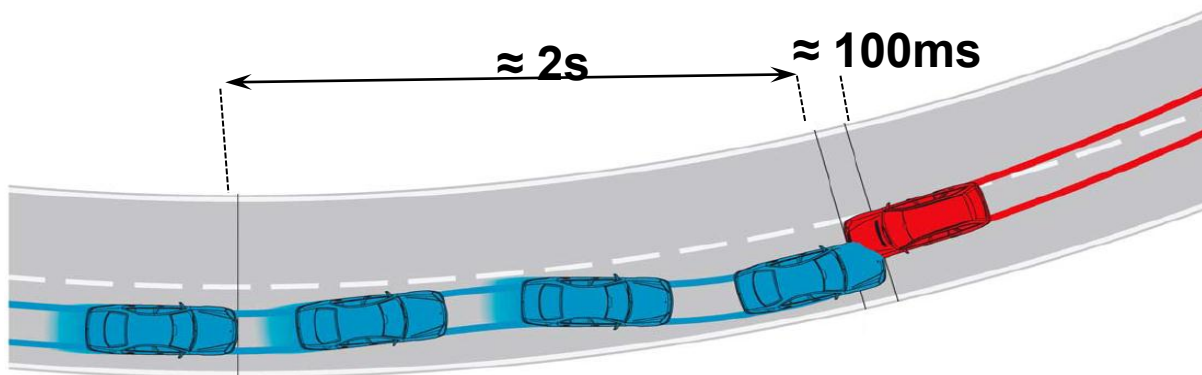
good model quality for injury prediction

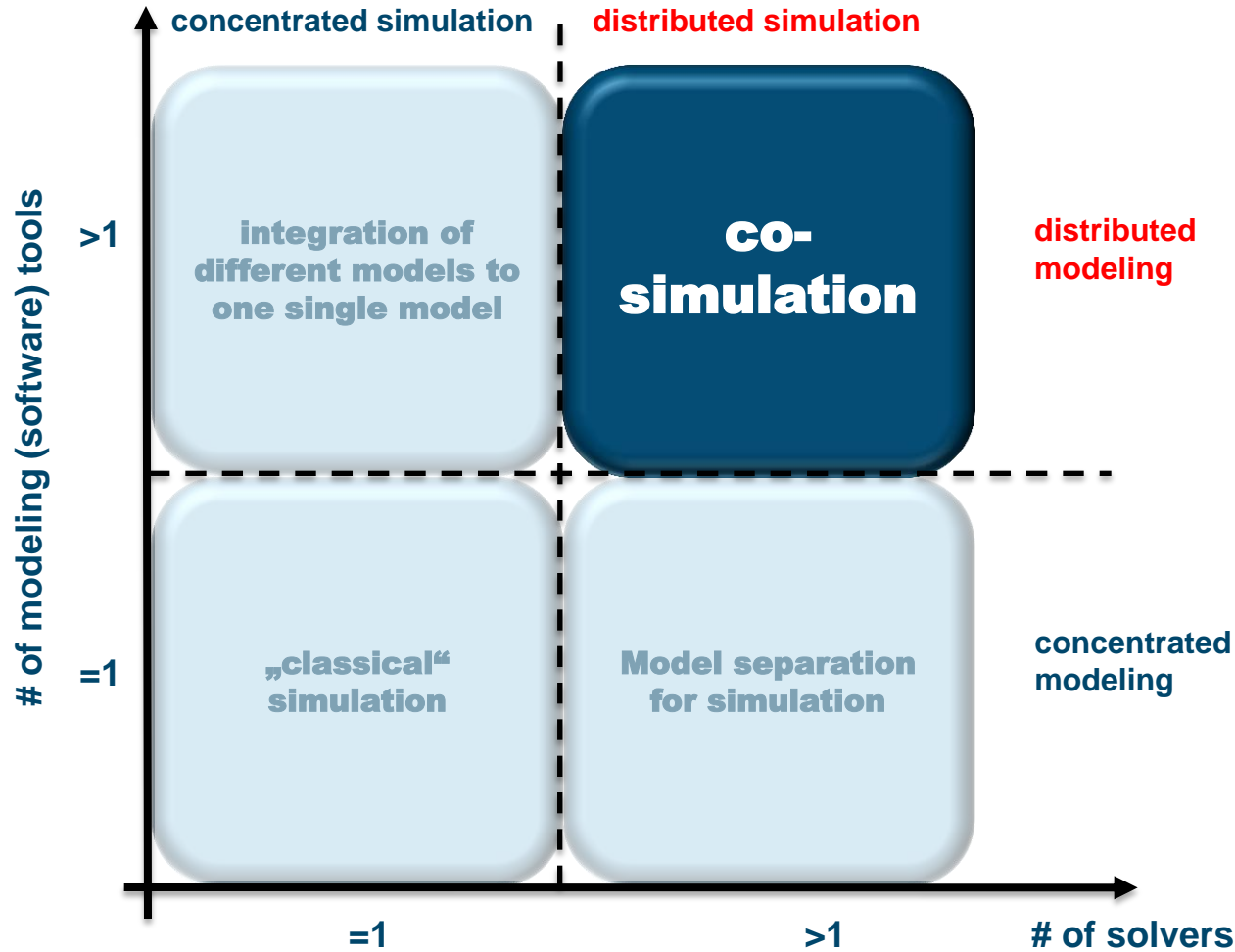


realistic kinematics for pre-crash

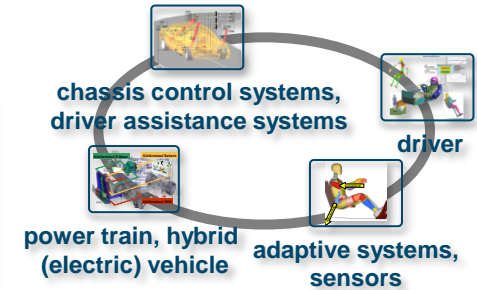


Bronzino, The Biomedical Engineering Handbook, CRC Press, 2000





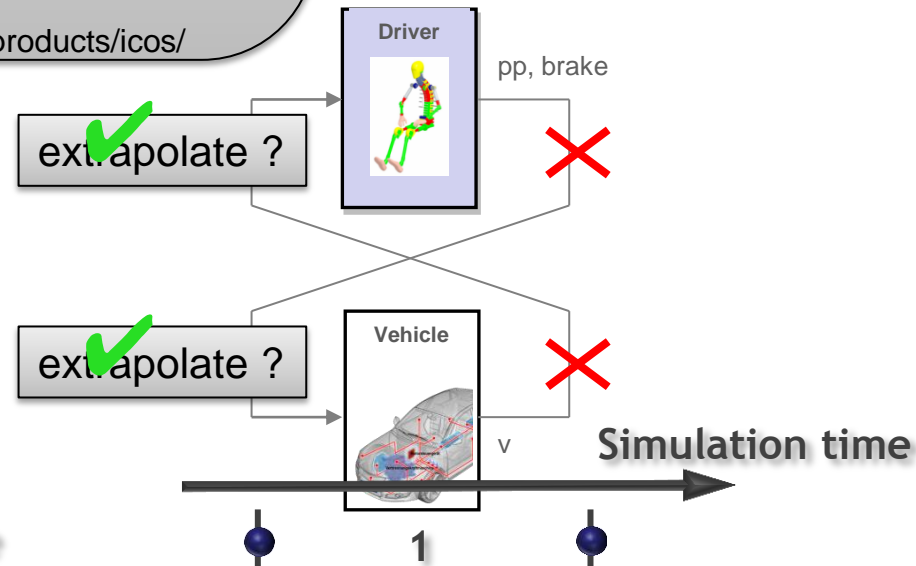
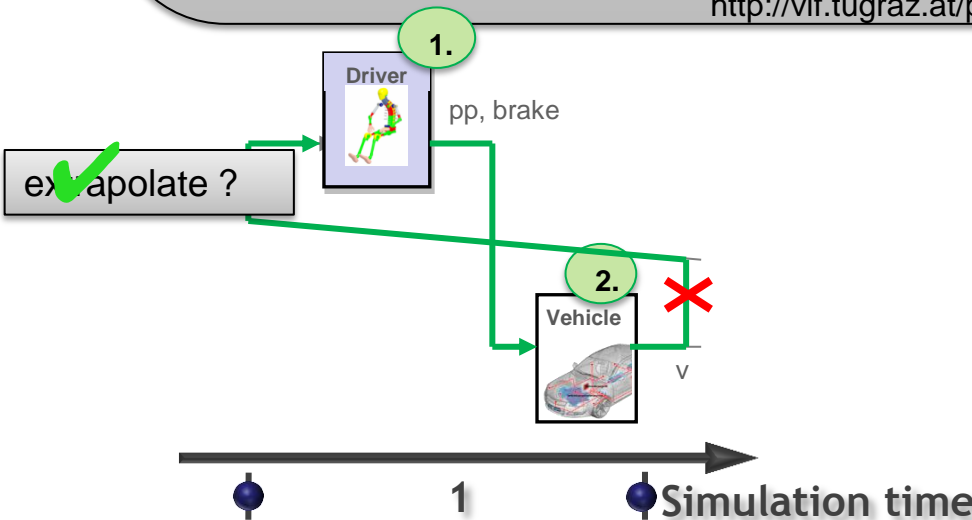
Source: Geimer M. et al: „Co-Simulation, gekoppelte Simulation oder Simulatorkopplung?“, O + P Zeitschrift für Fluidtechnik, 50 (2006), Nr. 11-12, S. 572-576

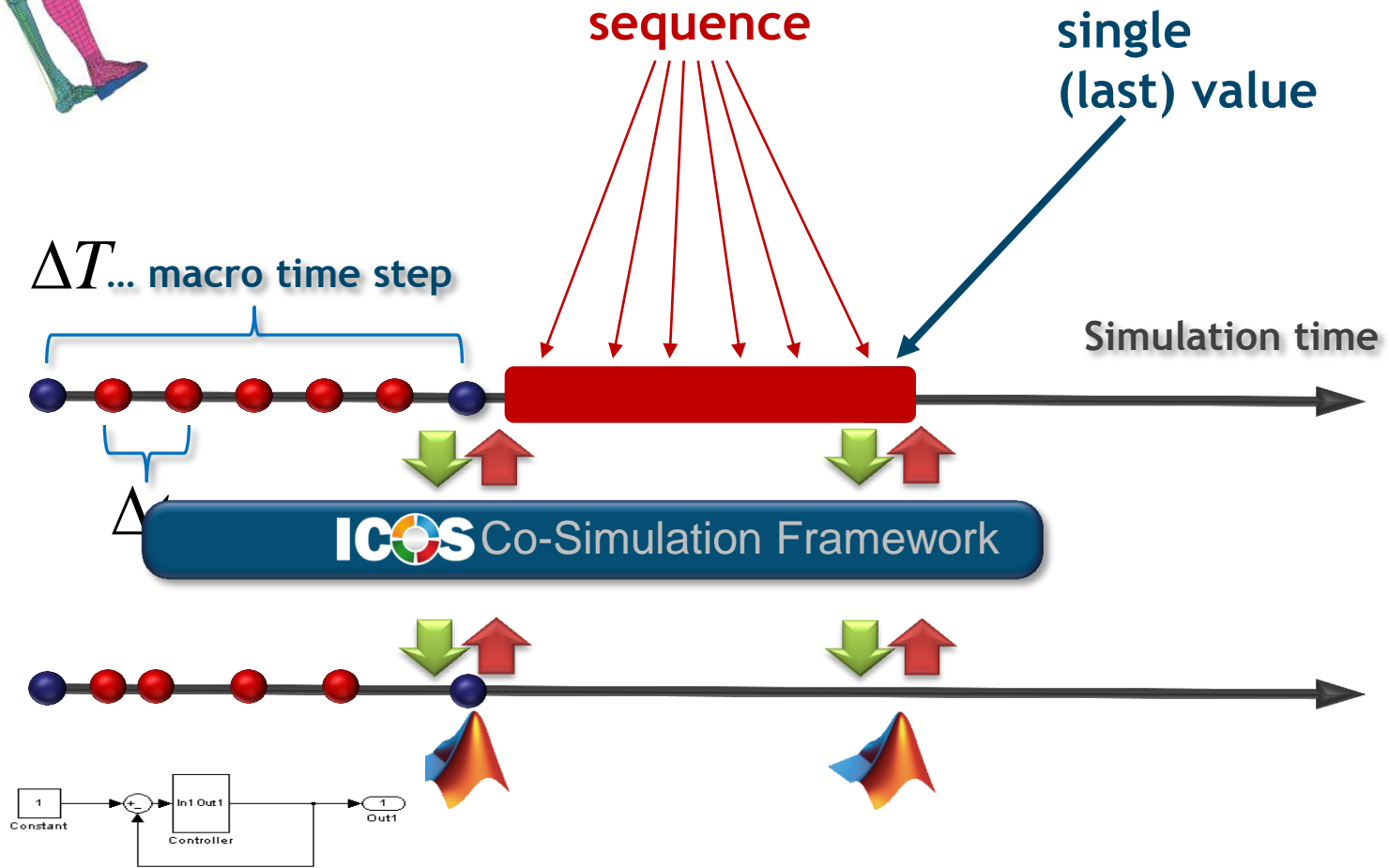


**Requirements** on the co-simulation platform

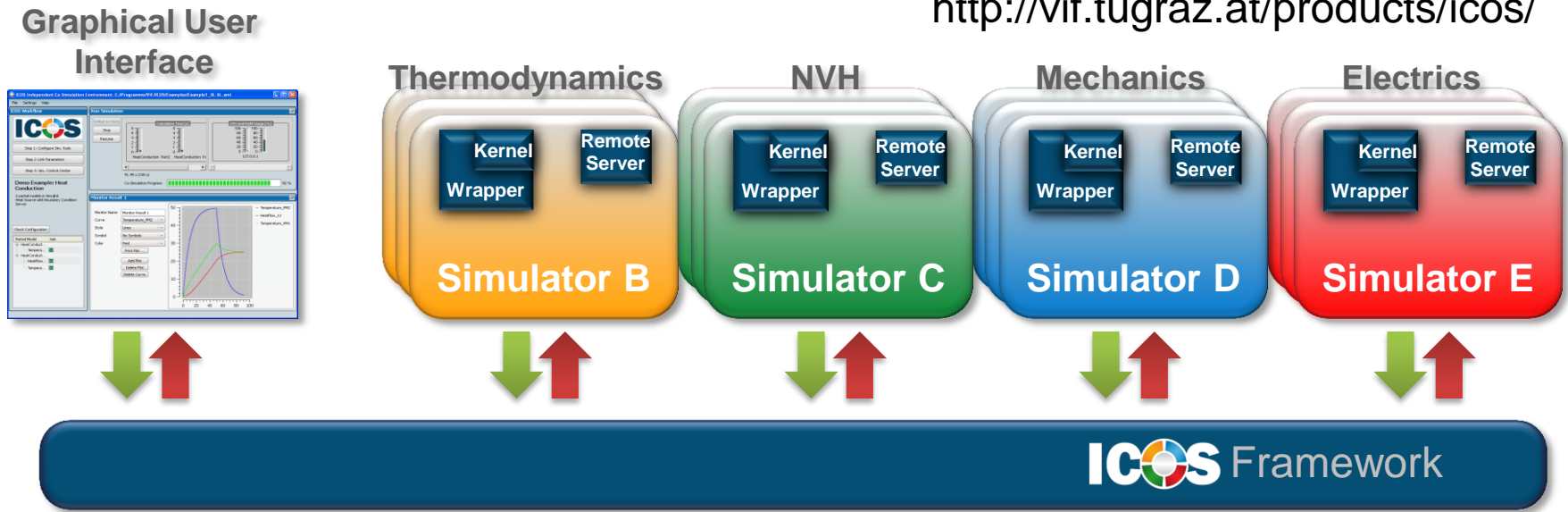
- Integration of simulation tools
- Coupling of the tools
- Handling of simulation step sizes
- Handling of interaction loops
  - Scheduling
  - Extrapolation

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





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

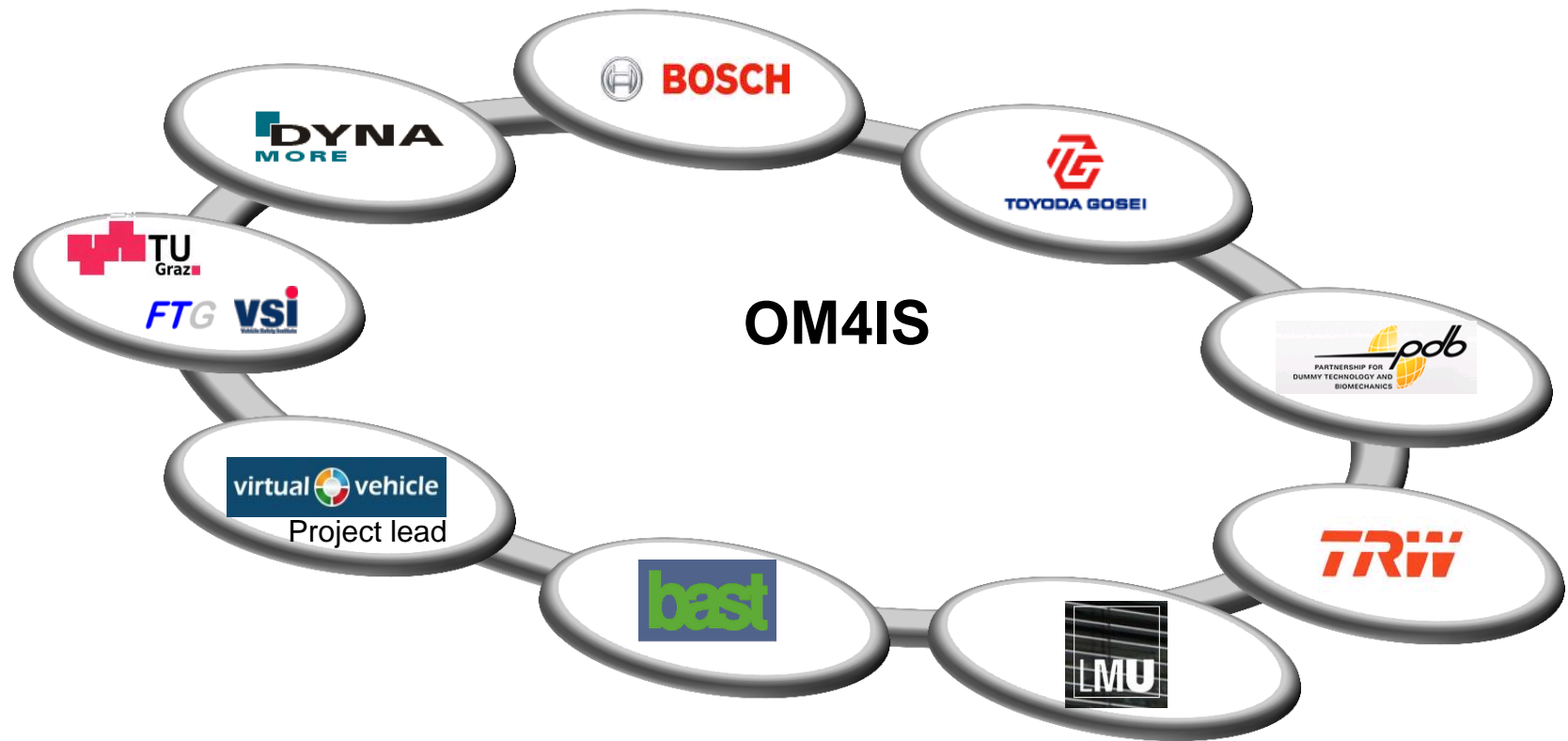


GUI...Graphical User Interface

## • ICOS Framework:

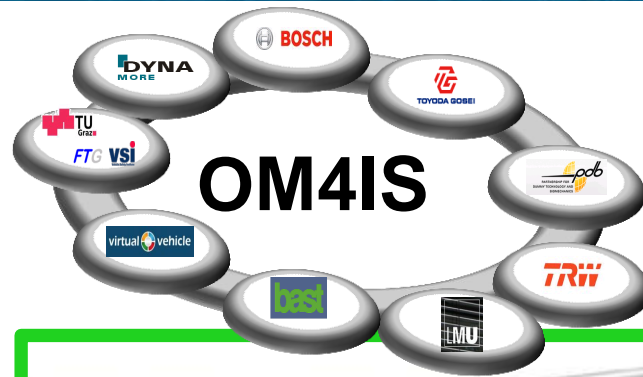
- Integration: multi-tool, **networked**, **cluster** integration, re-use licenses, data exchange & conversion
- Synchronization: **micro step** (tools) / **macro step** (ICOS), **fixed/variable step** size, adaptive step size control
- Coupling: **serial/parallel**, **iterative/non-iterative**, dead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



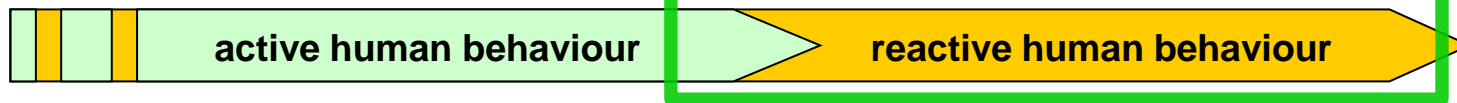
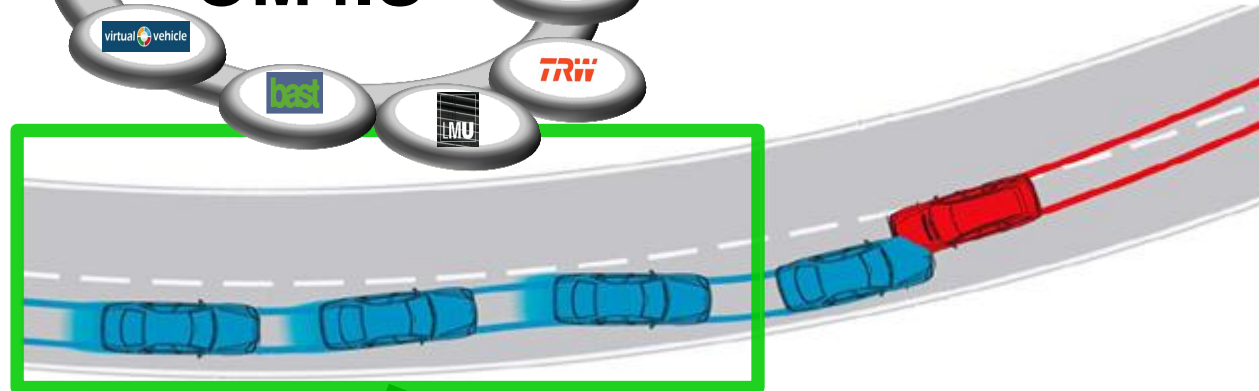


**OM4IS (Occupant Model For Integrated Safety)**

Research project: Duration 2009 - 2012

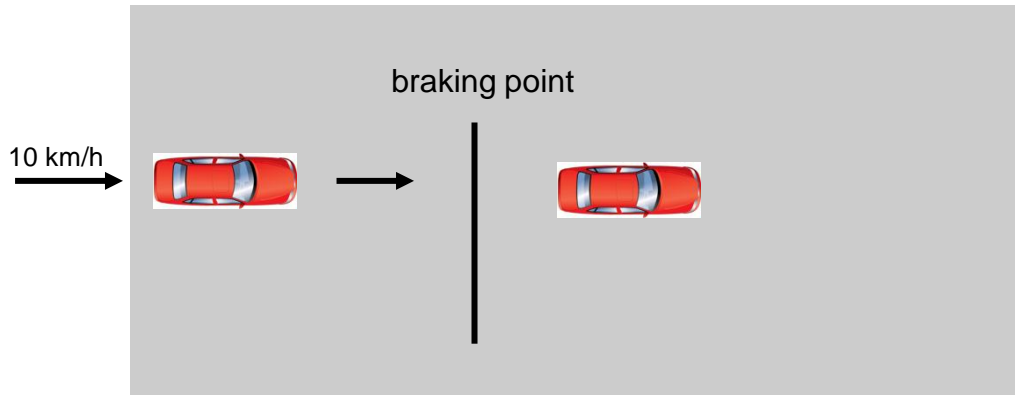


OM4IS (Occupant Model For Integrated Safety)

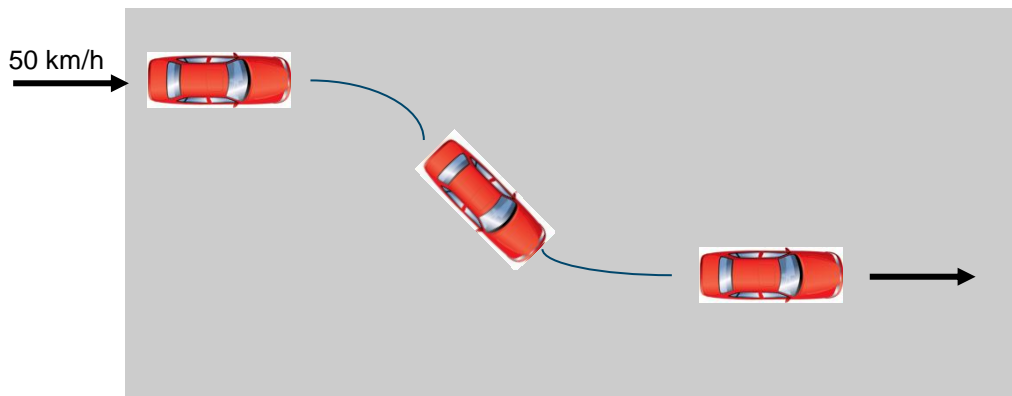


- Observing the reactive behaviour of volunteers within the collision phase (~2 s)
- Implementation of a numerical human body model (HBM)

## 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

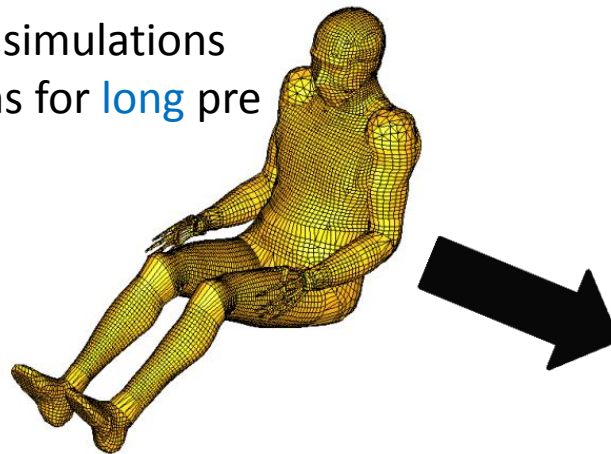
➔ Validation database

## Toyota THUMS ("Total HUMAN Model for Safety")

### THUMS v3:

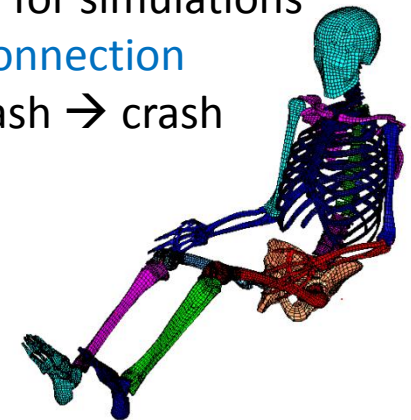
#### ➤ Detailed modelling

- Time consuming simulations
- Stability problems for long pre crash durations

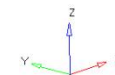


### THUMS v3- THUMS simplified:

- 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

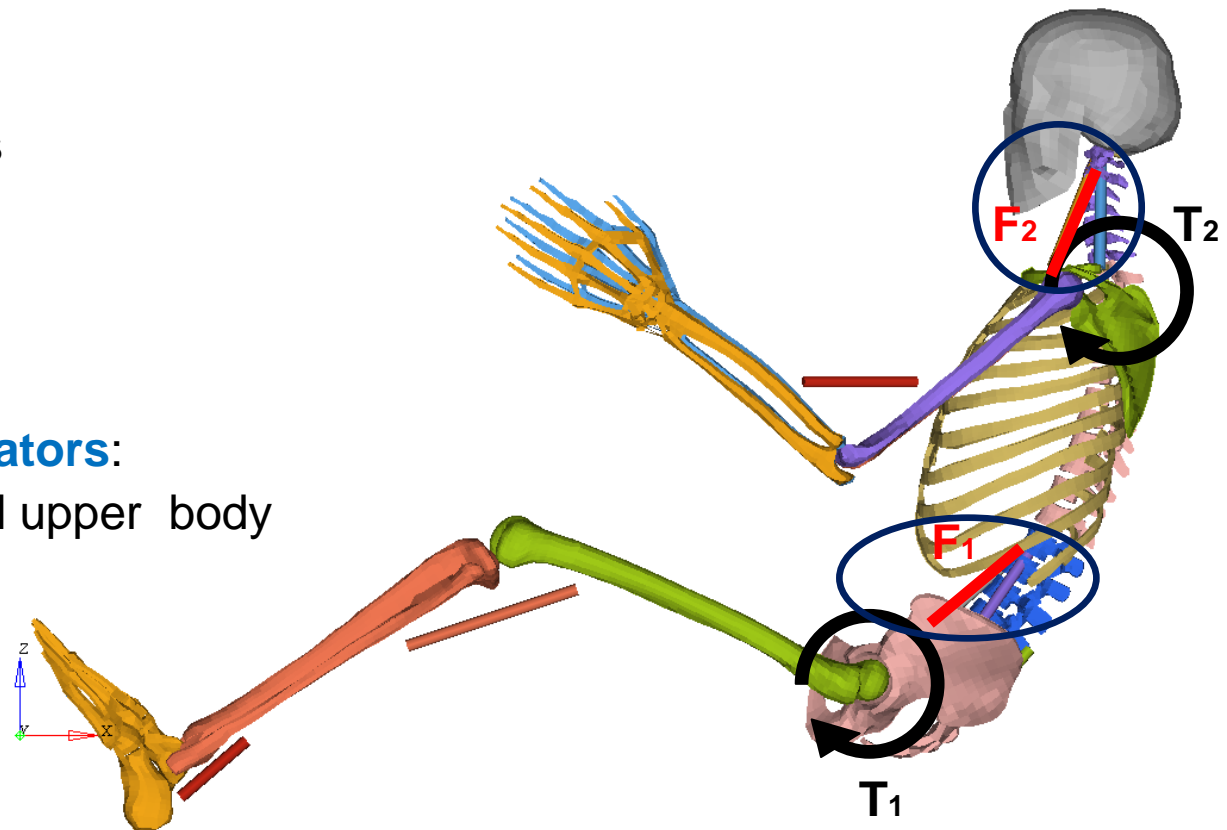
## Muscle force:

- anatomically correct
- correct internal stresses

**Using torque!**

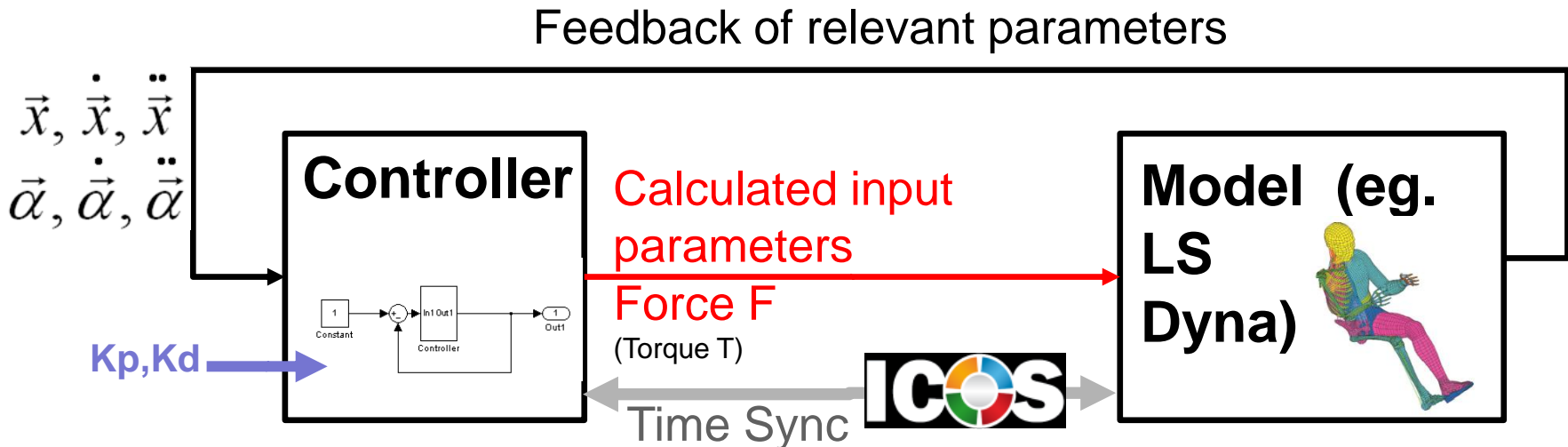
## → calculated via 2 actuators:

- lower extremity and upper body
- controller:  $T \rightarrow F$

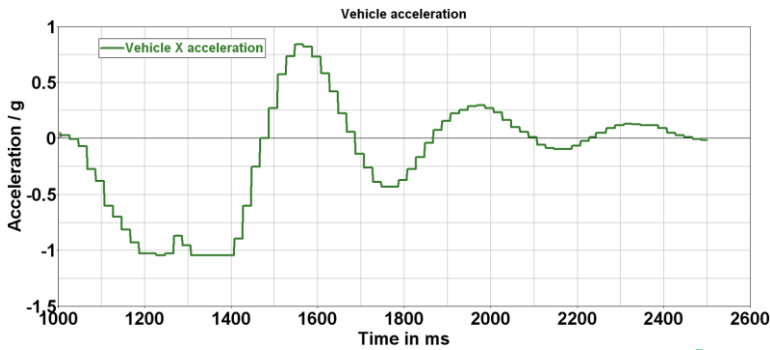


# One controller for different models (MKS, FE)

- **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)

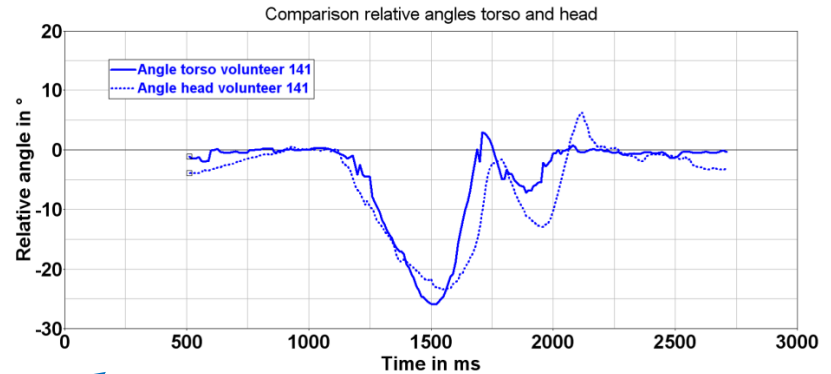


## Acceleration vehicle(database)

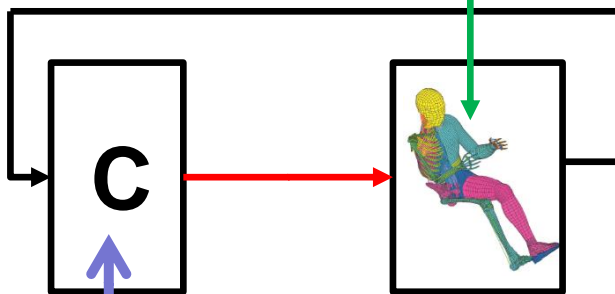


30 volunteers (3 tests each per case)

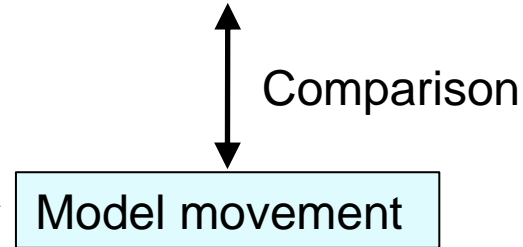
## Kinematic data human (database)

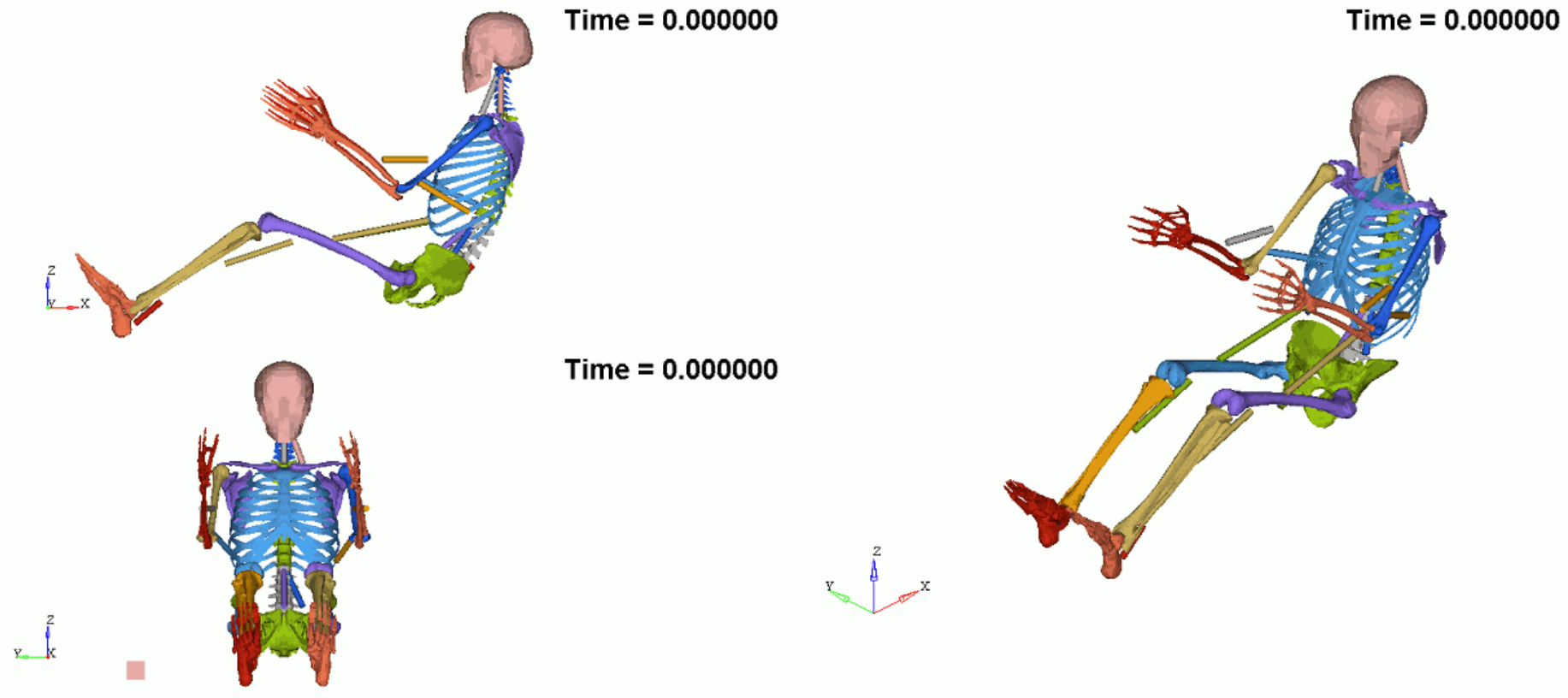


$$\begin{matrix} \vec{x}, \dot{\vec{x}}, \ddot{\vec{x}} \\ \vec{\alpha}, \dot{\vec{\alpha}}, \ddot{\vec{\alpha}} \end{matrix}$$



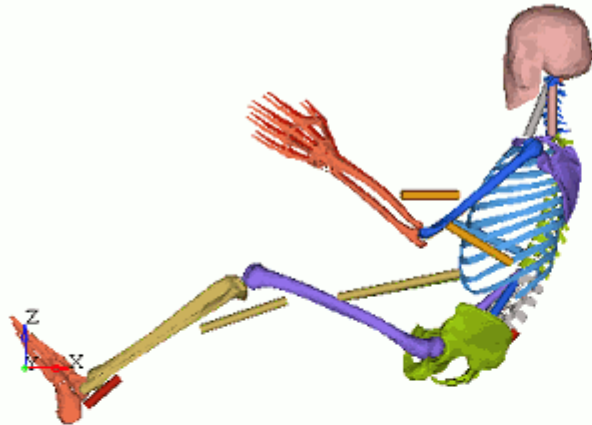
variable parameters  
parameters  
parameters



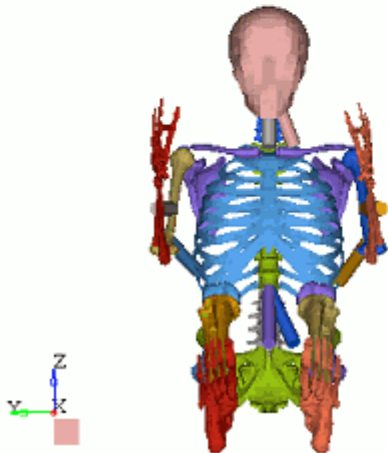




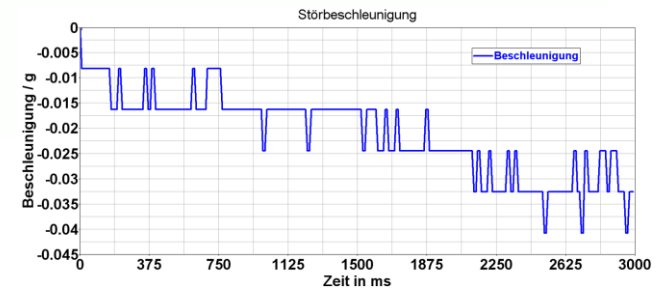
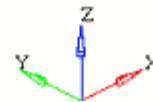
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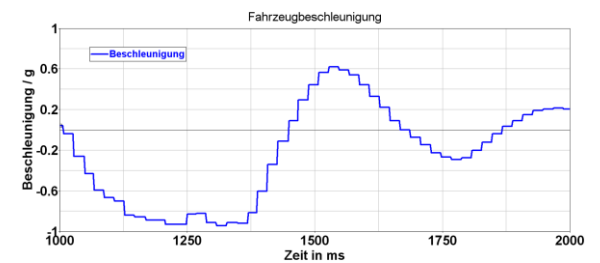
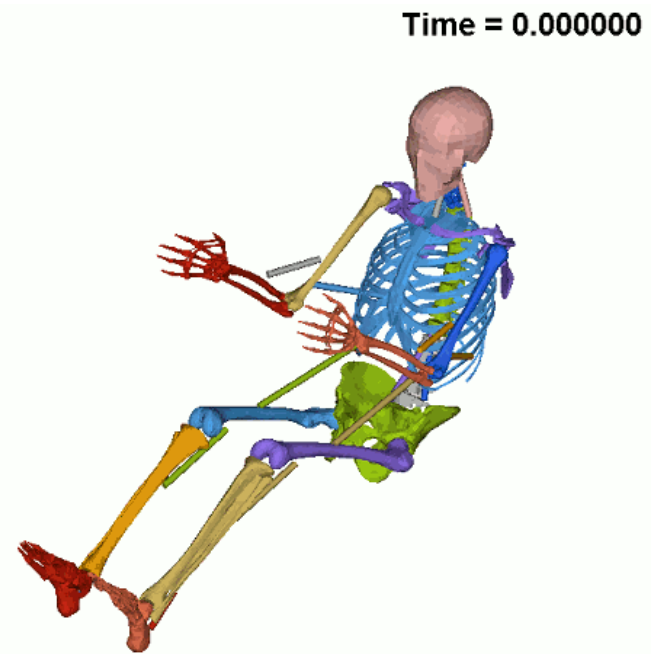
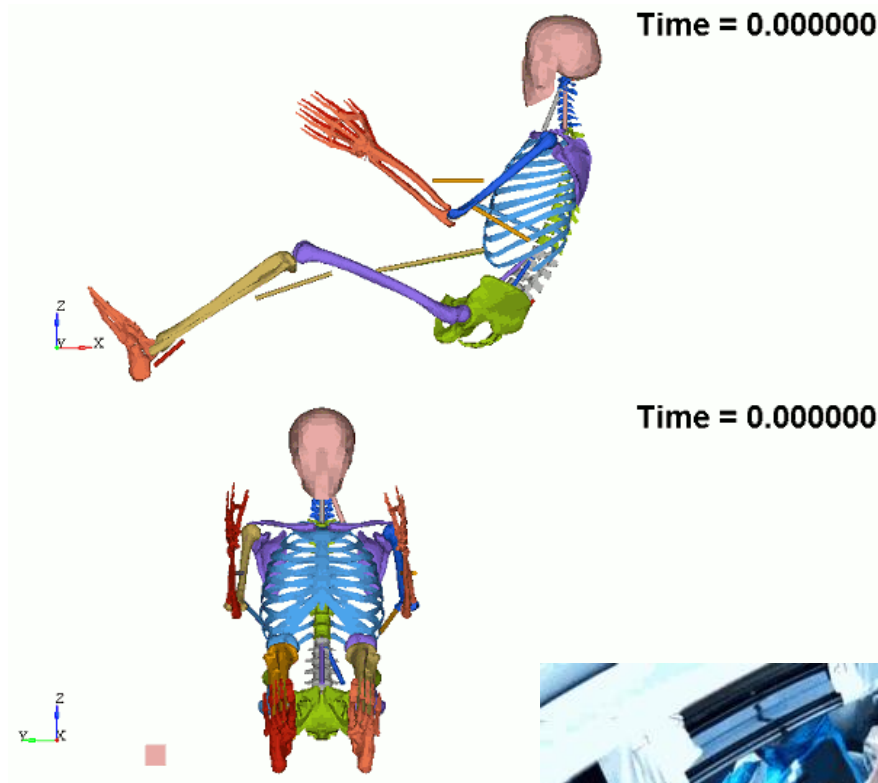


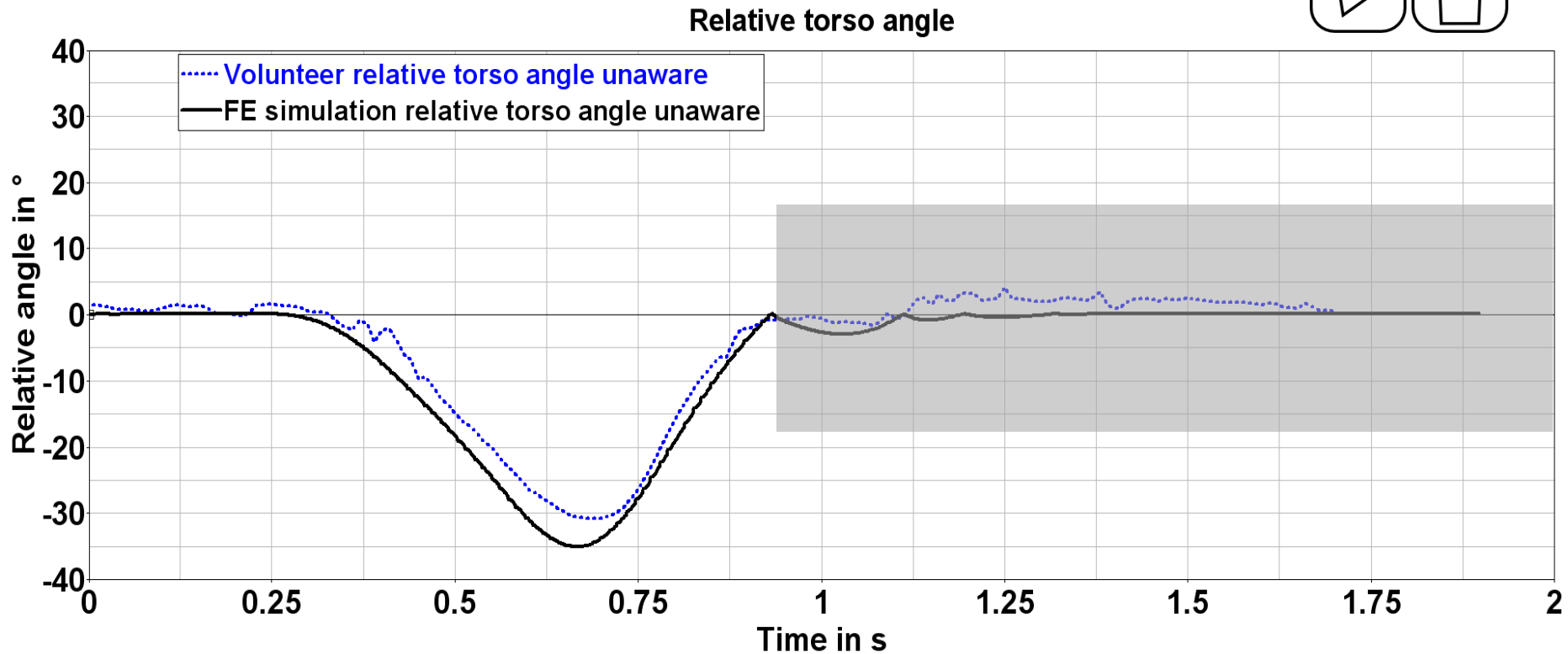
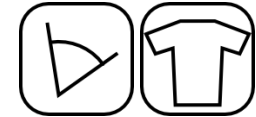
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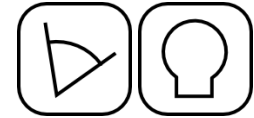


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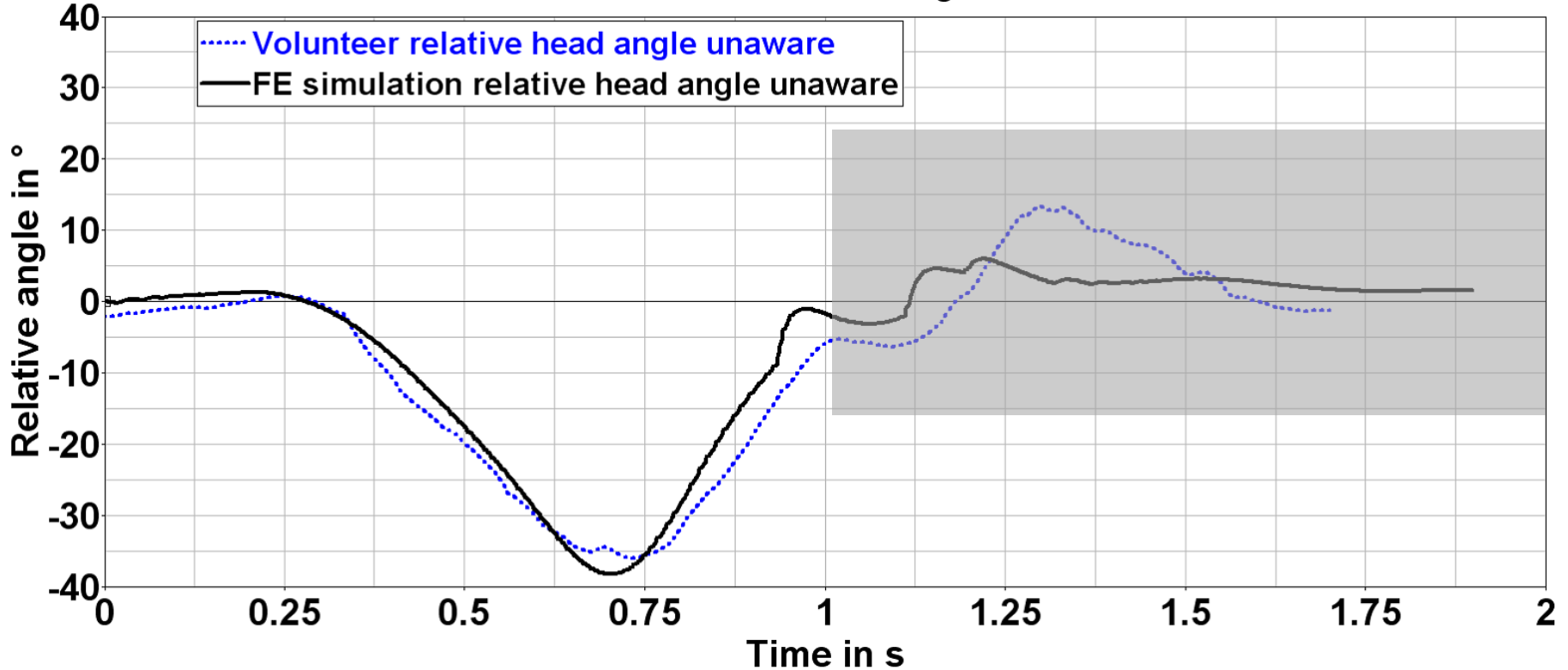








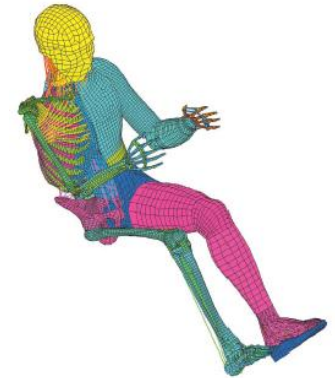
Relative head angle



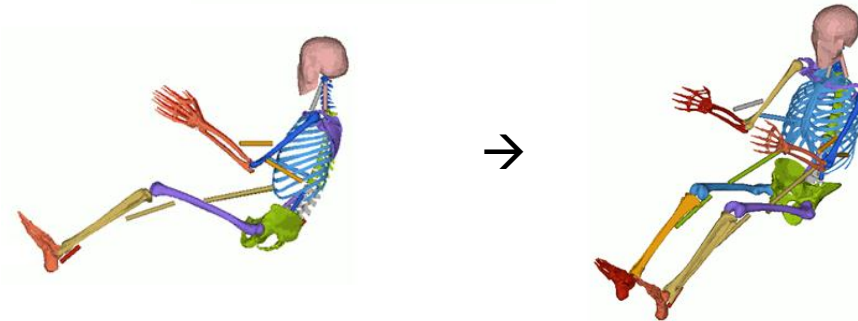
➤ THUMS less reduced:



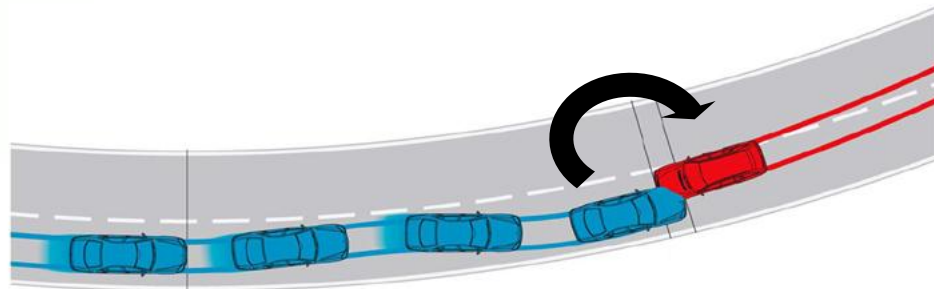
VS



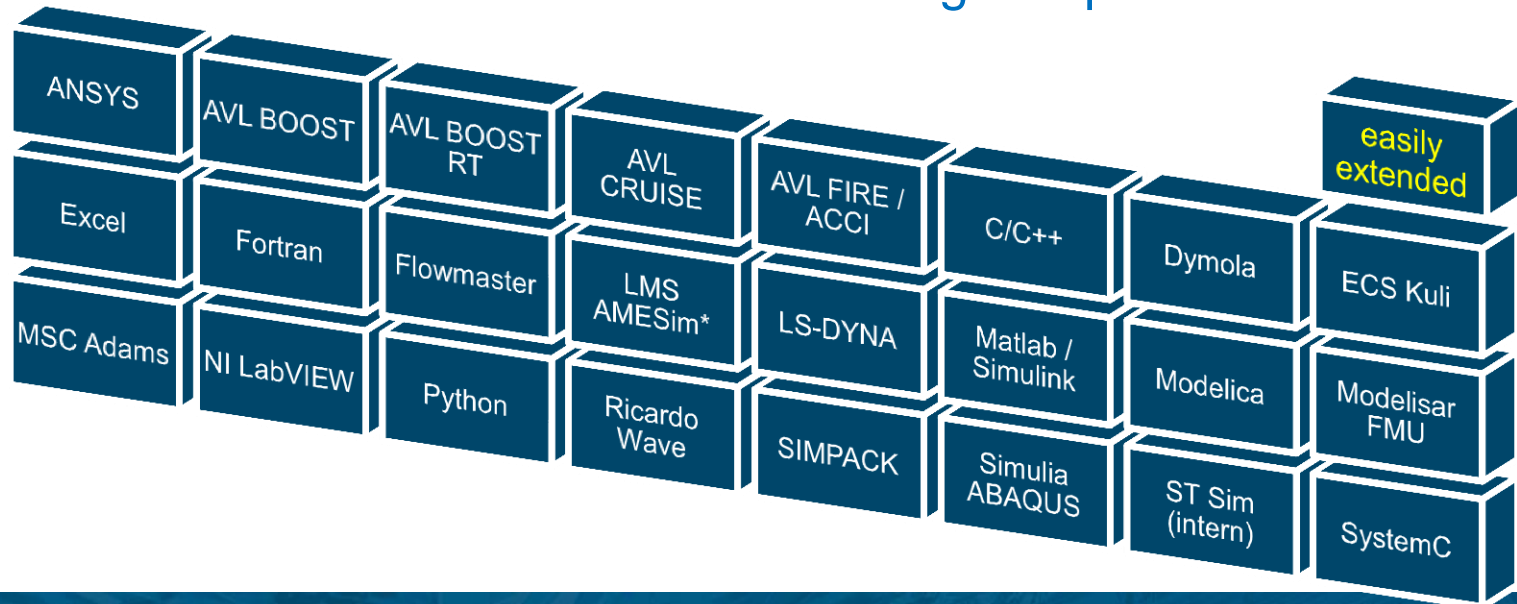
➤ 2D → 3D:



➤ 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

