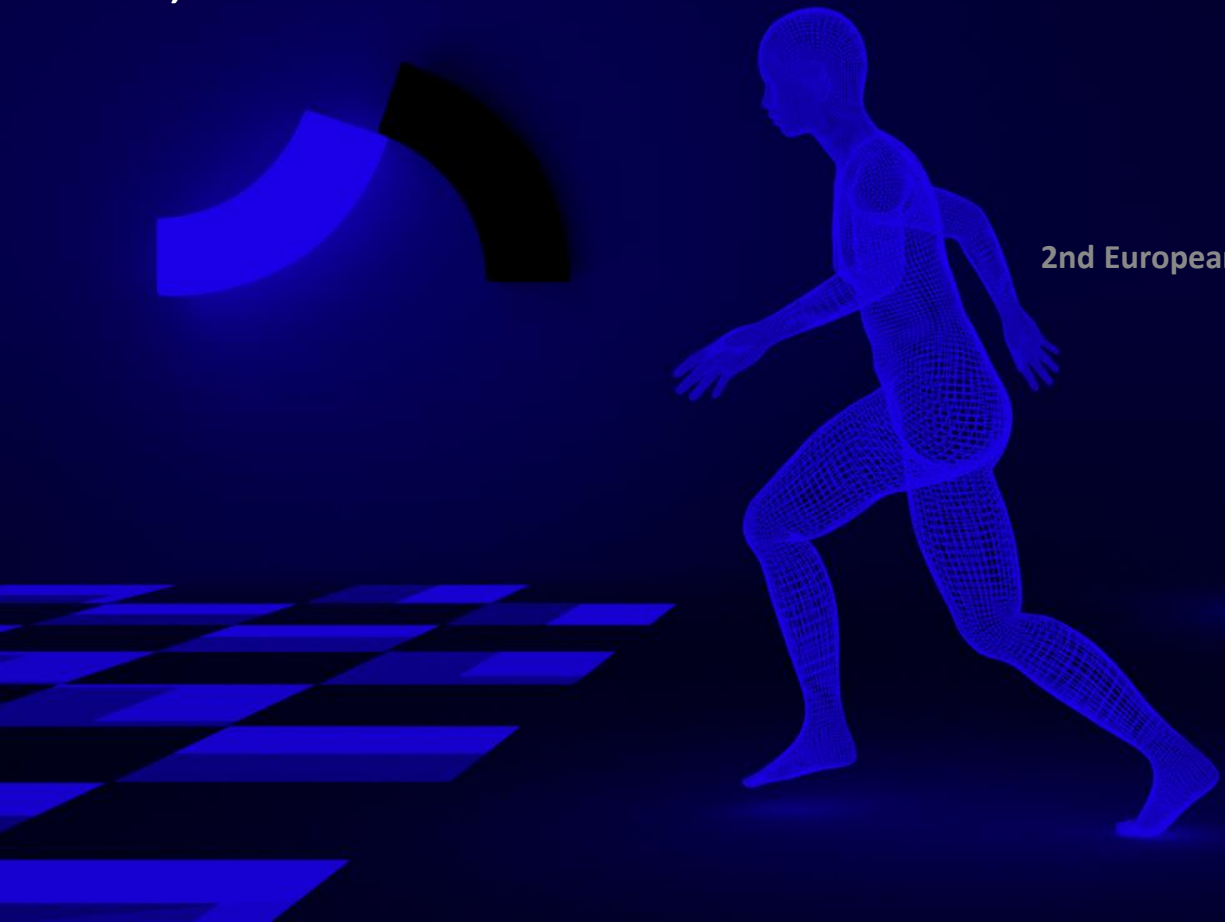
SIMPACK Biomotion driver and occupant models for single-track, multi-track and other vehicles



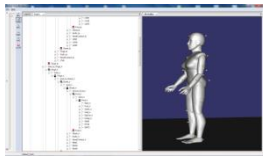
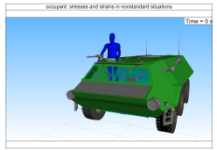
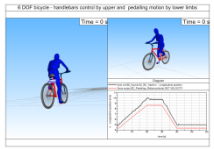
Dr. Valentin Keppler
Biomotion Solutions

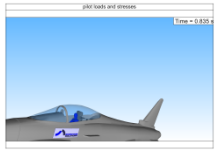
2nd European Multibody Simulation User Group Meeting
2017
Braunschweig

BIOMOTION SOLUTIONS

agenda

- biomechanical human body models
- application as passive occupant
- application as active driver for single track vehicles
- application as active driver for multi-track vehicles
- conclusion & outlook

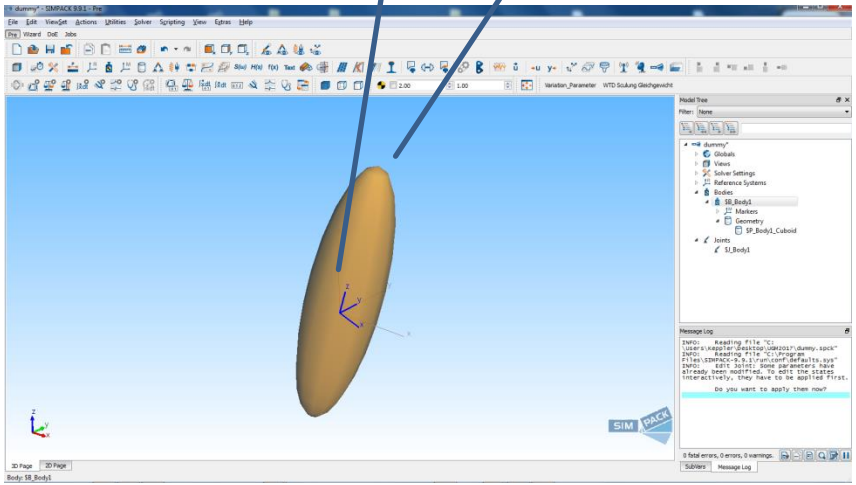



MODEL GENERATION

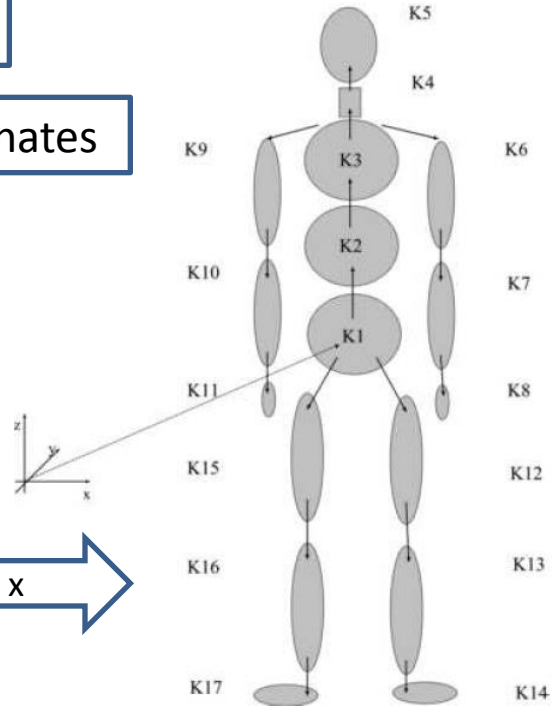
human body model in mbs

mass & inertia,

length, joint coordinates

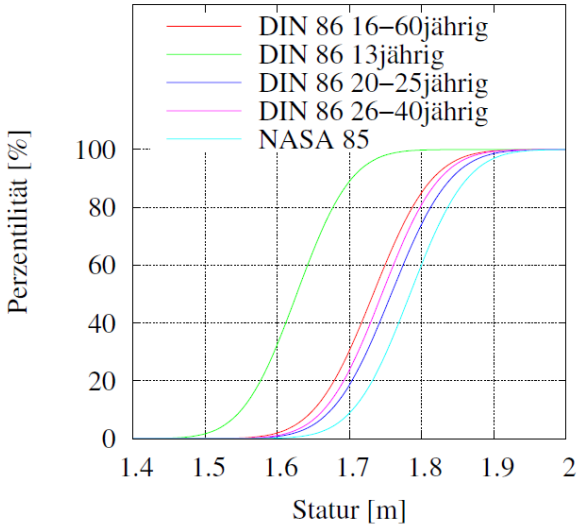


17 x

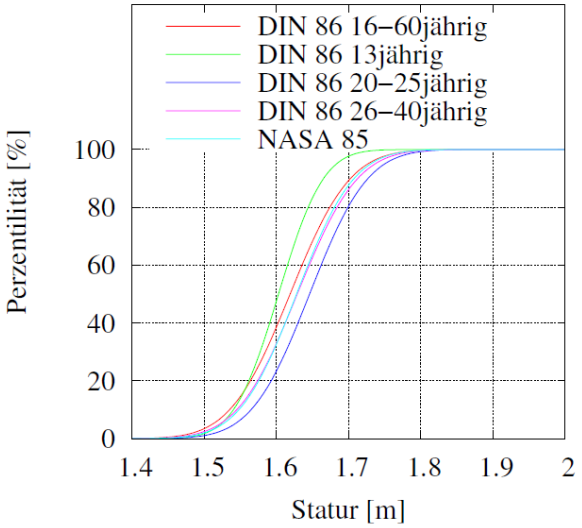


statistical bases

stature: percentile male



stature: percentile female



A percentile (or a centile) is a measure used in statistics indicating the value below which a given percentage of observations in a group of observations fall. For example, the 20th percentile is the value (or score) below which 20% of the observations may be found.

regression equations for segment length

segment length given by stature and coefficients

$$l_s(l_0) = a_{sl} * l_0 + b_{sl}$$

l_s	:	segment length	$[m]$
l_0	:	stature	$[m]$
a_{sl}	:	coefficient of segment length	$[]$
b_{sl}	:	offset of segment length	$[m]$

segment mass parameters

segment mass as function of total body mass and coefficients

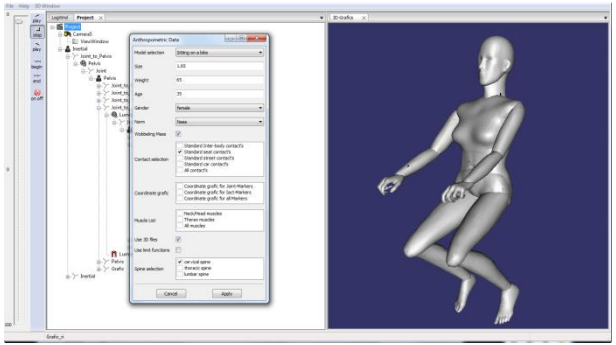
$$m_s(m_0) = a_{sw} * m_0 + b_{sw}$$

m_s	:	segment mass	$[kg]$
m_0	:	total body mass	$[kg]$
a_{sw}	:	coefficient of segment weight	$[]$
b_{sw}	:	offset of segment weight	$[kg]$

human body models wizard of Biomotion Workbench

input parameters for model:

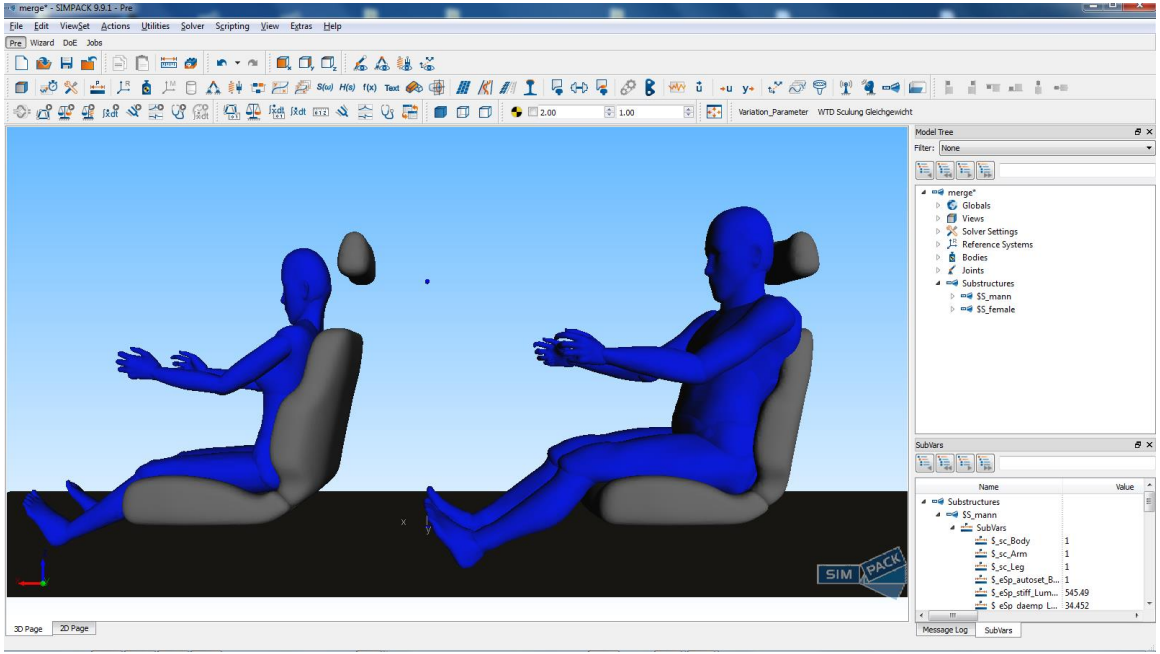
- stature
- weight
- gender



all necessary elements like joint actuators, wobbling mass elements or contact force elements are also generated by the model generator.

17 segments

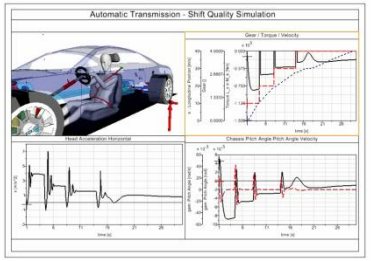
5% female and 95% male

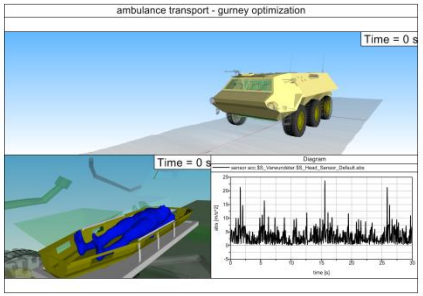


data can be found e.g. in: NASA (McConville und Laubach, 1978) und DIN (DIN, 1986).

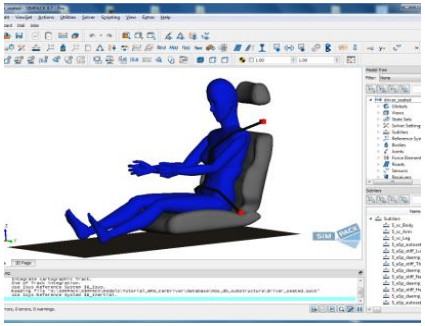
application: passive occupant

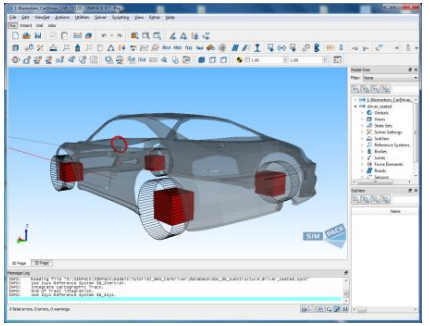
- the generated models can be used as passive substructure in vehicle models
- e.g. shift comfort
- e.g. comfort & safety optimization for transport of injured persons

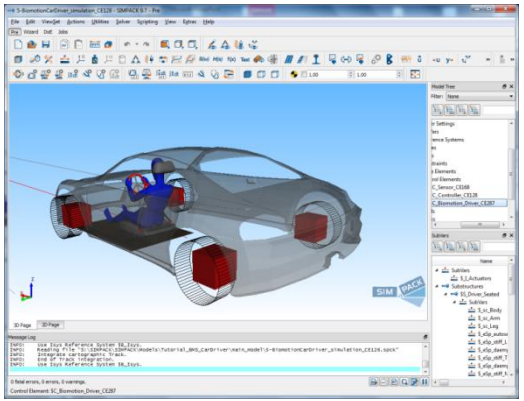




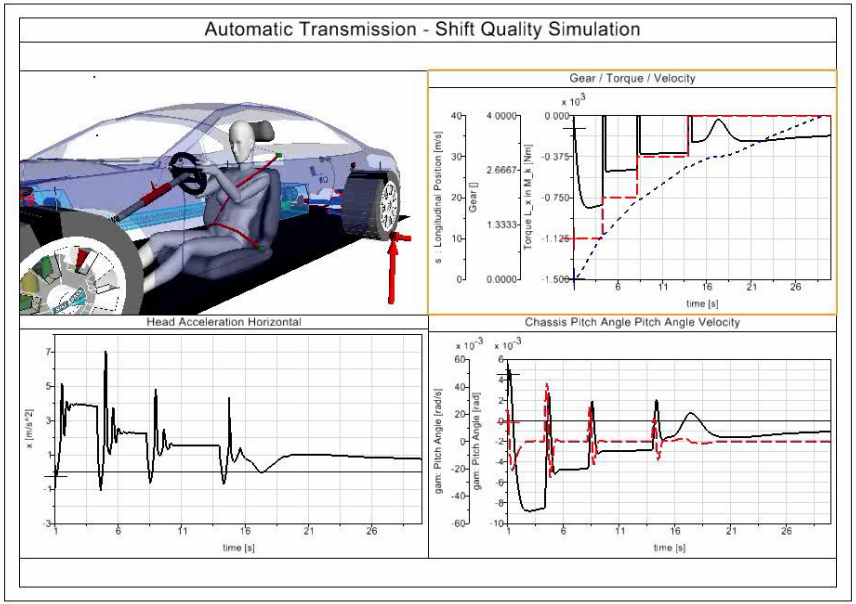
human as substructure in car model



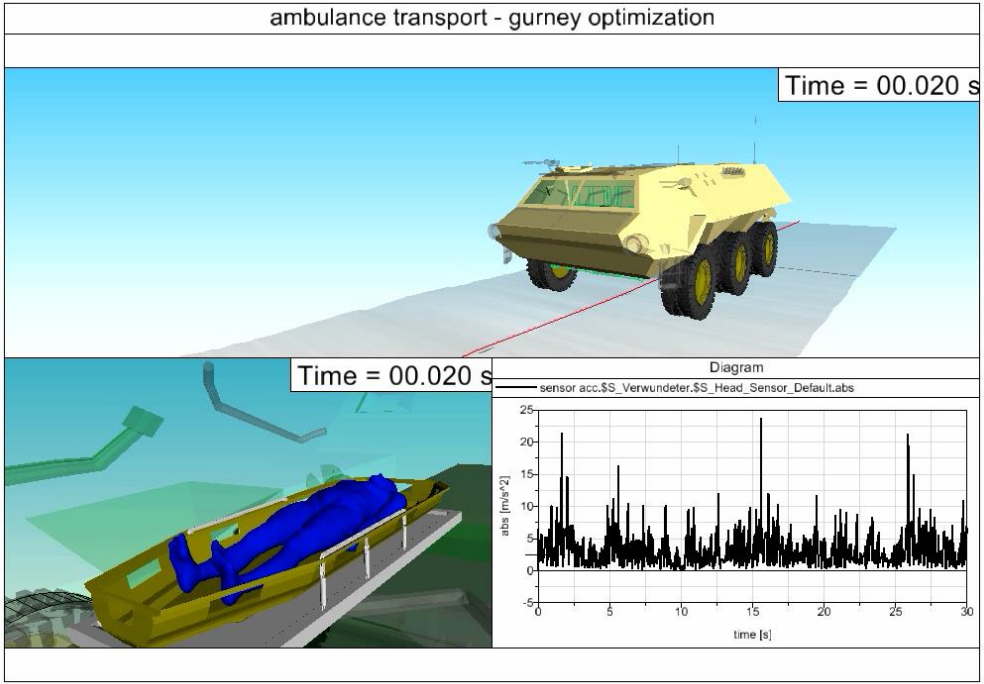




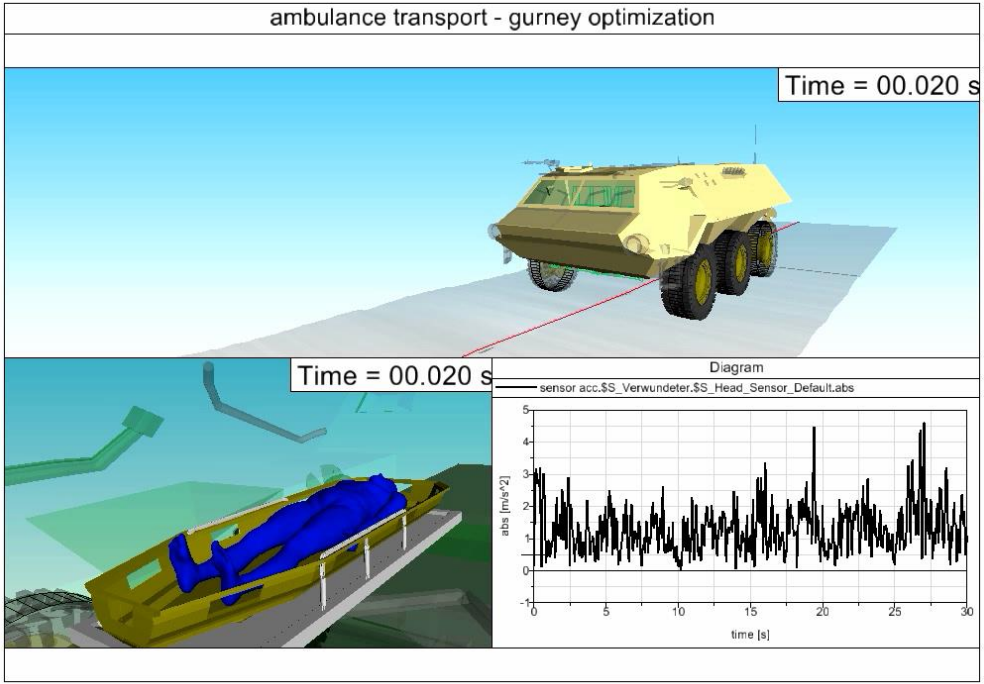
application: shift comfort analysis



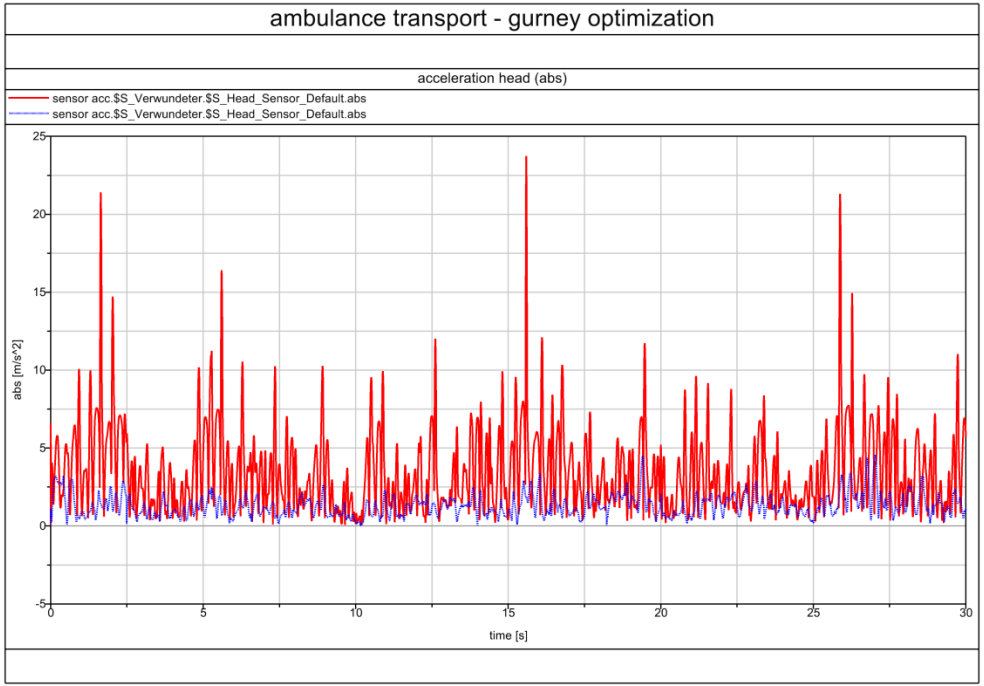
application: rescue & defense



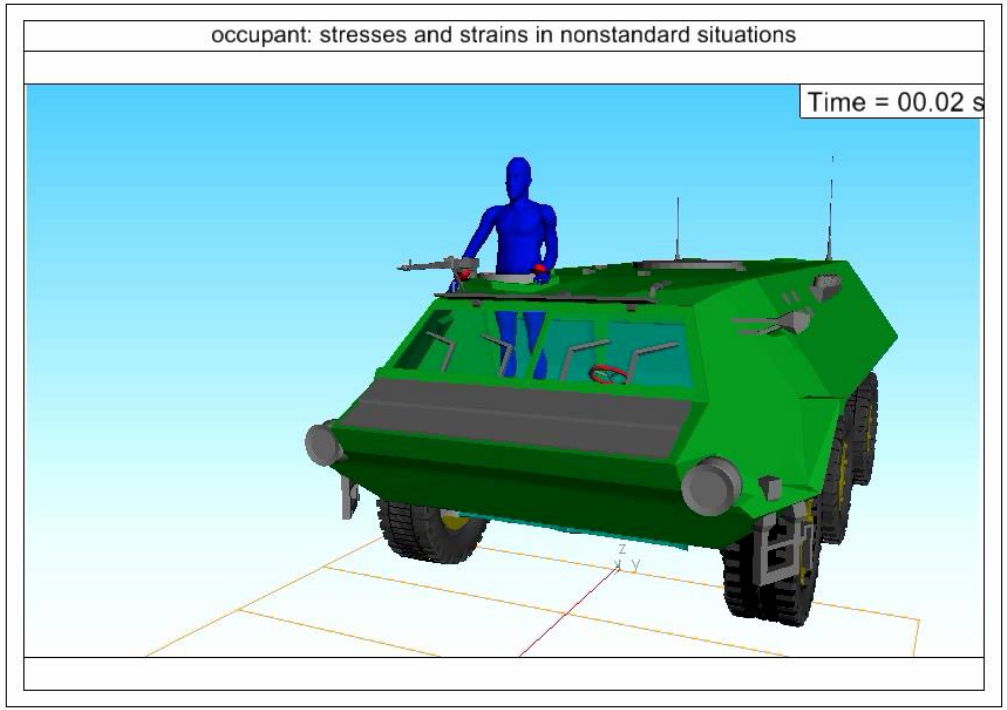
application: rescue & defense



application: rescue & defense



application: rescue & defense



Human & Dummy differ

ACTIVE MODELS

bicycle riding

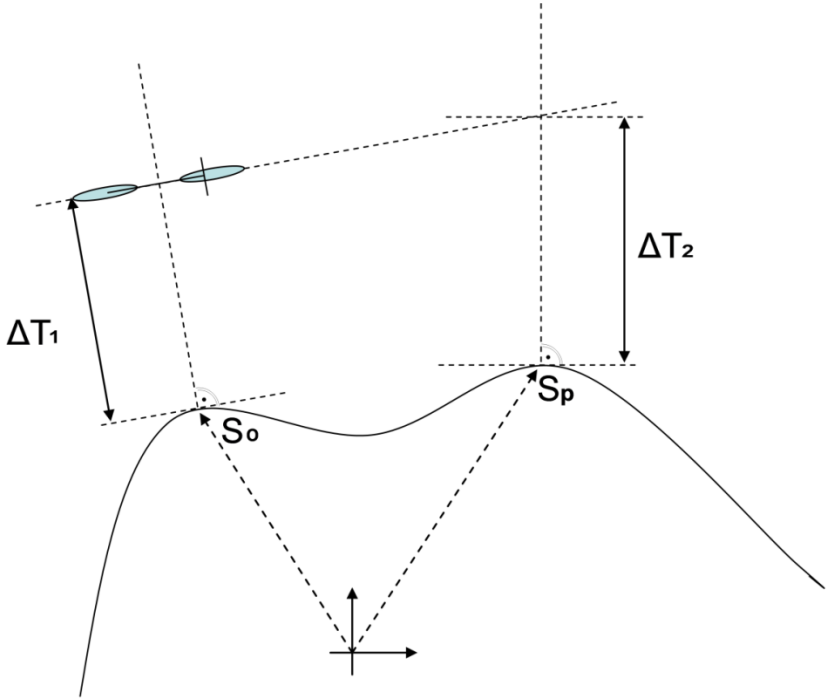
- steering by handlebars movement
- propulsion by pedaling

The Skill of **Bicycle Riding**. A.J.R. **Doyle (1987)**

the model

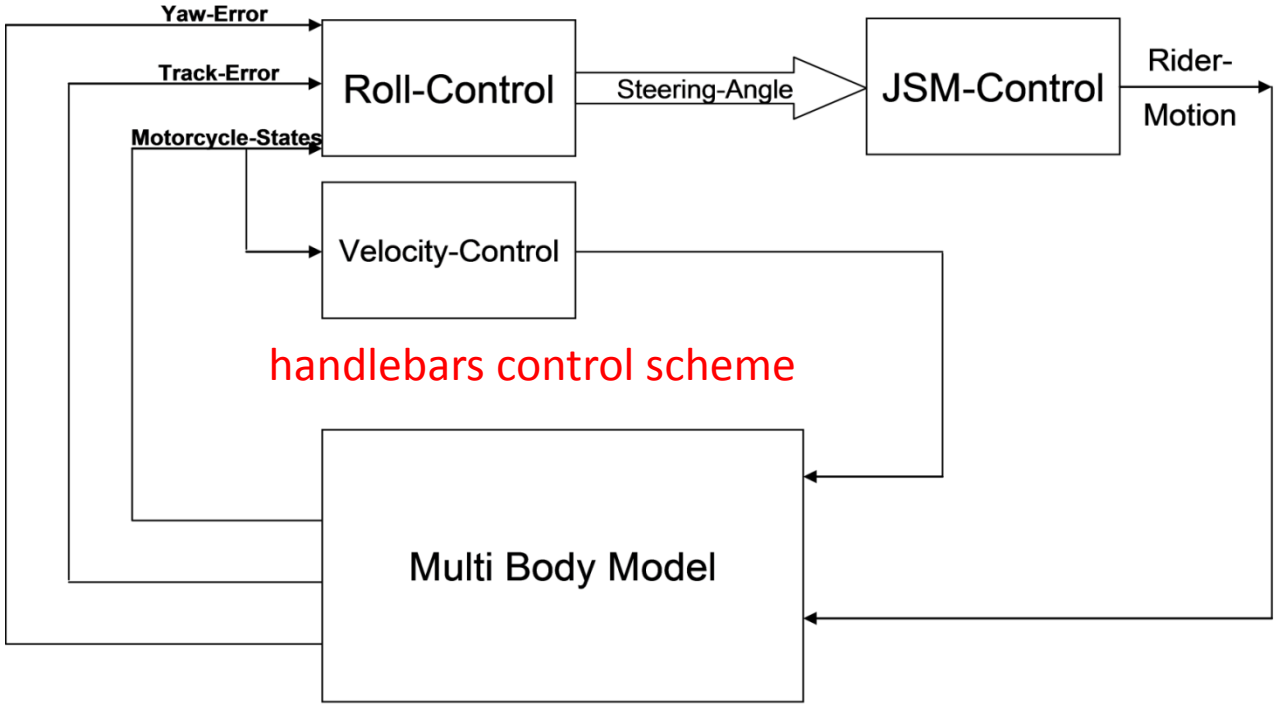
- bicycle model
- tire force model
- human body model
- motion control for handlebars
- motion control for pedaling motion

CEL 168: Automotive Track Sensor



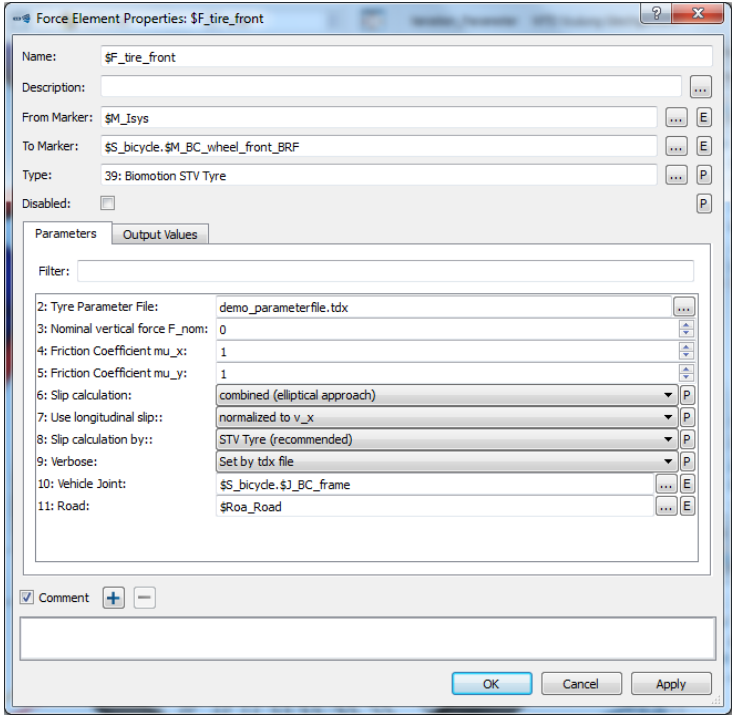
- control approach: road preview 168: Automotive Track Sensor
- counter steering → ”steer into the fall“
- to control roll angle the steering angle has to be controlled
- the desired steering angle is input to Joint Space Model (JSM) controller (285 – Biomotion Motorcycle Rider)

CEL 285: Biomotion Motorcycle Rider



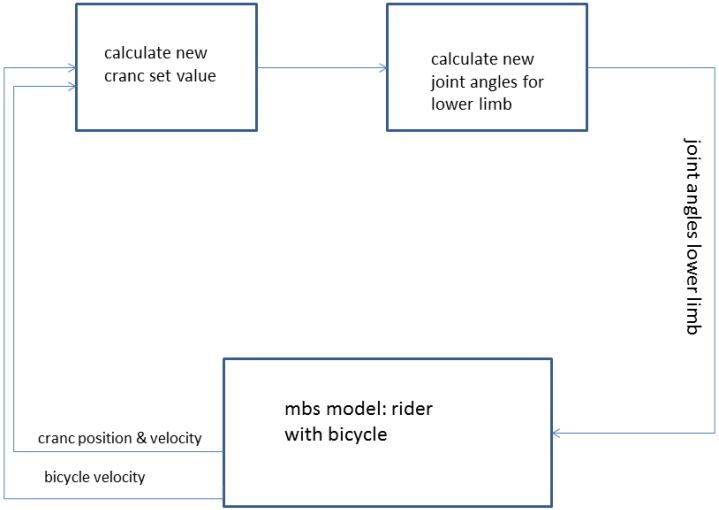
tire model: user element (class tire)

- SIMPACK user function
- force class tire force (“spck_df_ForceTire”)



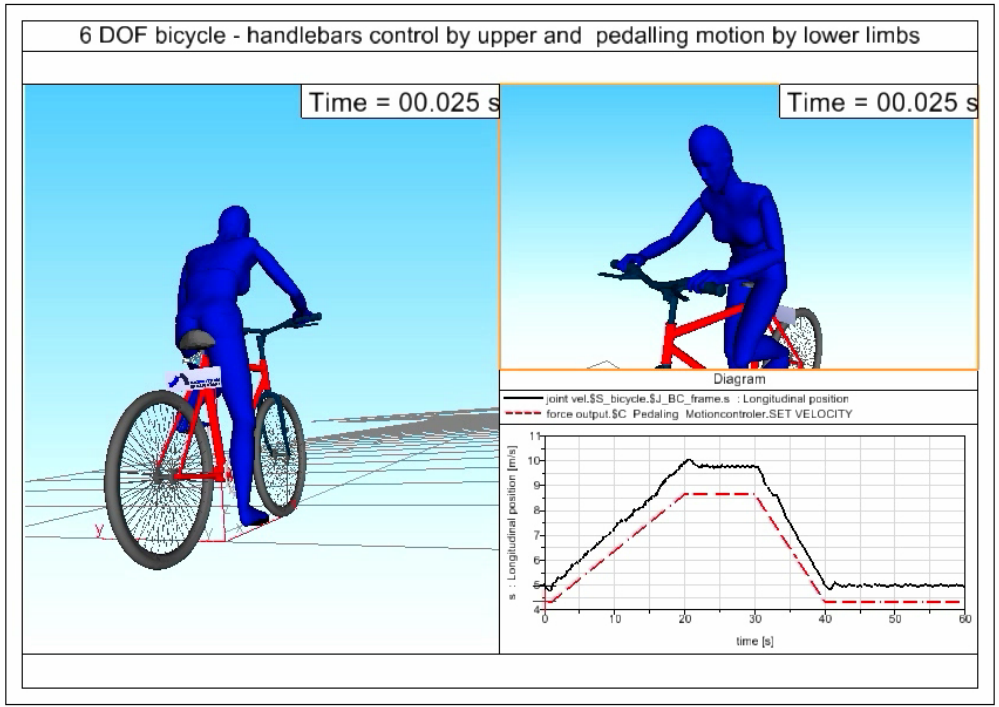
Tire force calculation : A Motorcycle Tire Model for Dynamic Simulations: Theoretical and Experimental Aspects (Lot, R. Meccanica (2004) 39: 207)

pedaling motion: user element (control)

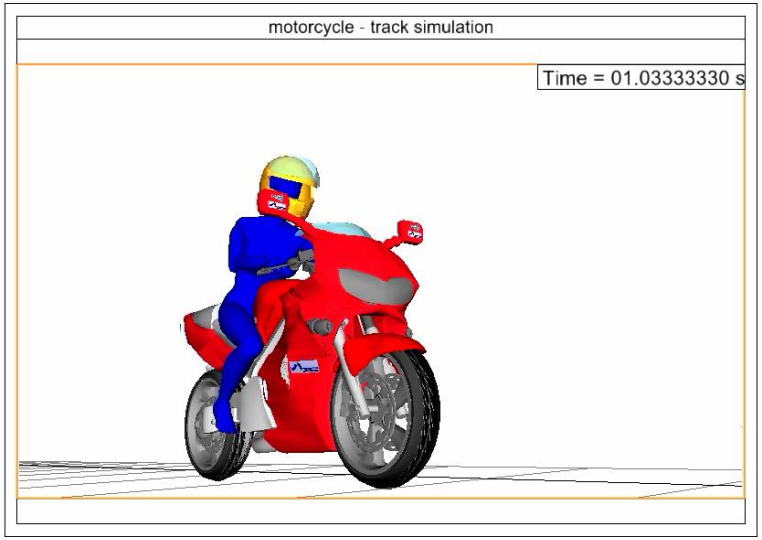


- user element
- force class control element
- generates output for joint actuators (FEL 283: Biomotion Actuators)

6 DOF bicycle simulation

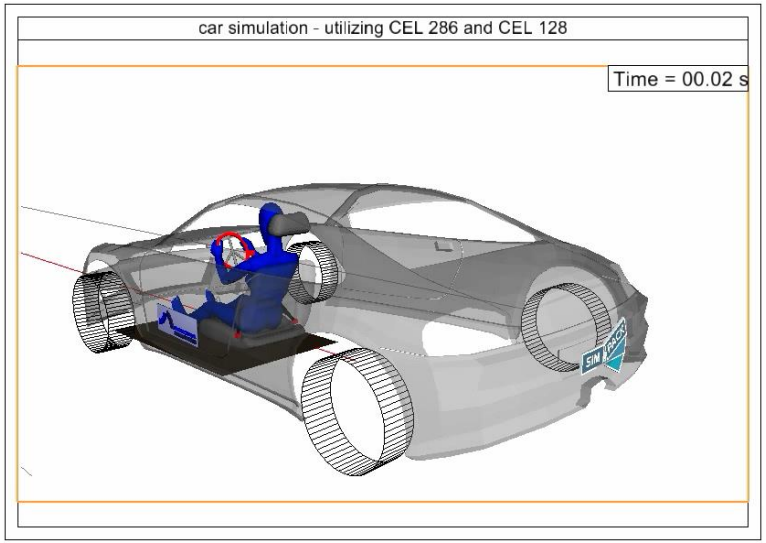


CEL 285: Biomotion Motorcycle Rider



- compatible to SIMPACK automotive
- generates output for joint actuators (FEL 283: Biomotion Actuators)
- velocity control: output moment front / rear wheel)
- wheelie / stoppy (by pitch angle control)

CEL 285: Biomotion Car Driver



- compatible to SIMPACK automotive
- compatible to SIMPACK CEL 128
- generates output for joint actuators (FEL 283: Biomotion Actuators)

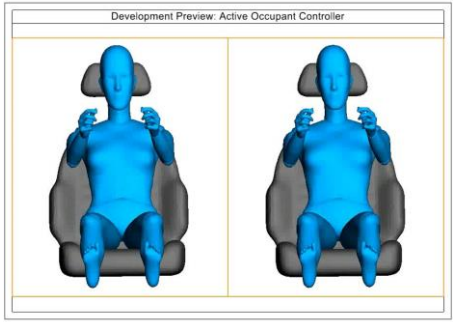
CONCLUSION & OUTLOOK

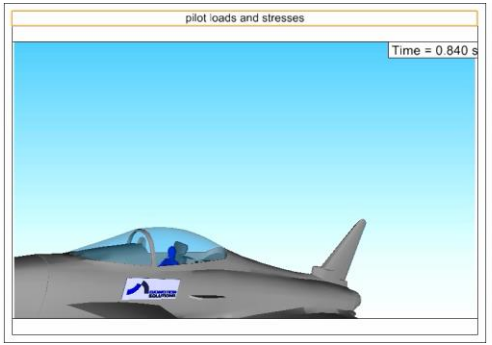
conclusion

- human body models can be generated by a model wizard (manual generation would be error-prune and costly)
- it is easy to include a human body model as substructure in existing SIMPACK models
- sometimes passive models are not adequate
- active driver models can be combined with existing vehicle models

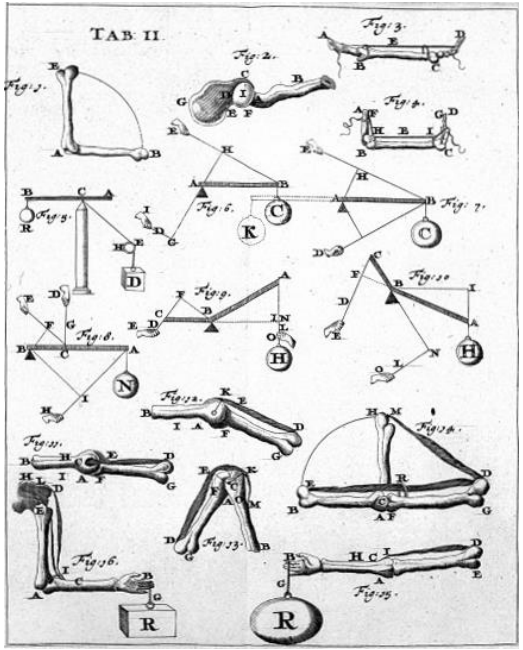
outlook

- enhance the existing motion controllers
- extend the principle to other vehicles (boats, planes)





thank you for your time!



De motu animalium by Giovanni Alfonso Borelli (1608-1679)