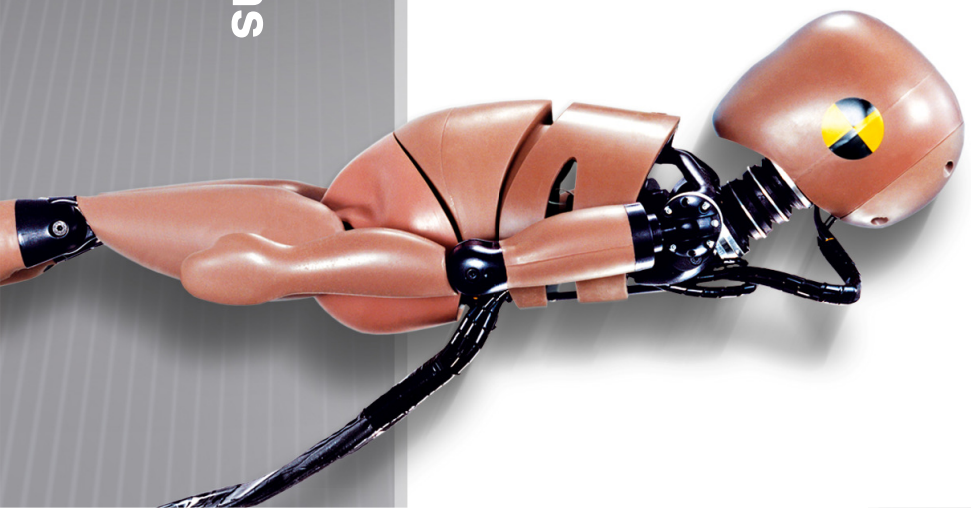




# - Out of Position - Possibilities and Limitations of Numerical Simulation

Sami Al-Samarae, [Axel Heym](#)



## | Contents & Targets

**Results,  
Possibilities and Limitations**

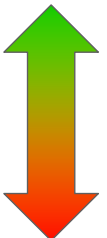
**Methodology and Input**

**Background,  
Basics and History**

## | Background



**Restraint  
Performance**



**Aggressiveness**

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## | Background

### Out of Position – Real life scenarios



[www.dvr.de](http://www.dvr.de)



[www.autozentrale.at](http://www.autozentrale.at)



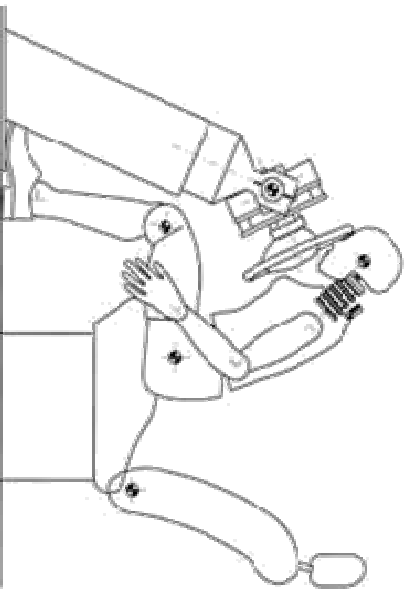
[www.nrtma.com](http://www.nrtma.com)

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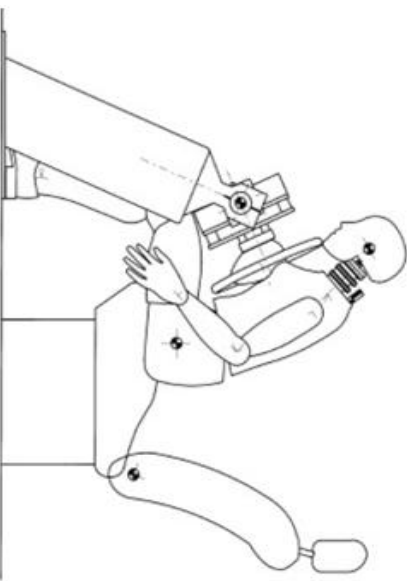


## Basics

### Out of Position – Standard scenarios on driver side



Position I (chin on module)



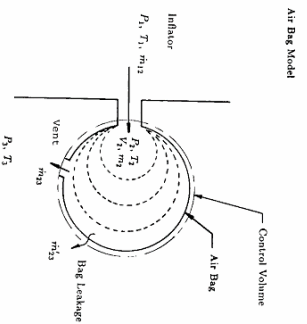
Position II (chin on rim)

### Out of Position - Possibilities and Limitations of Numerical Simulation

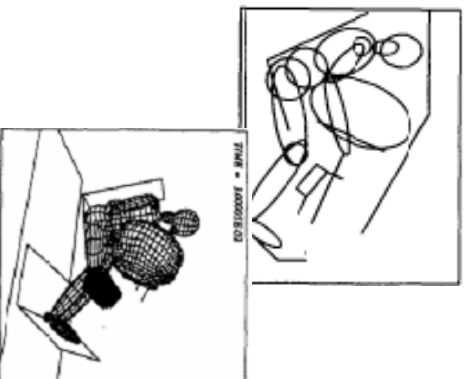
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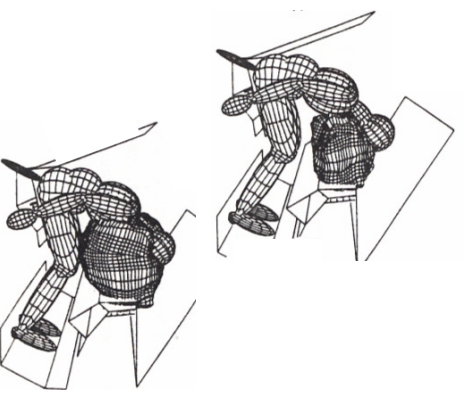
## History



**1988**  
„Wang-Nefske“  
gas model



**1988-90**  
1<sup>st</sup> simulations  
of crashes



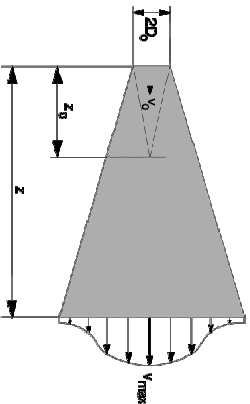
**1992**  
1<sup>st</sup> simulations of OoP  
(coupling FEM & MBS)

### Out of Position - Possibilities and Limitations of Numerical Simulation

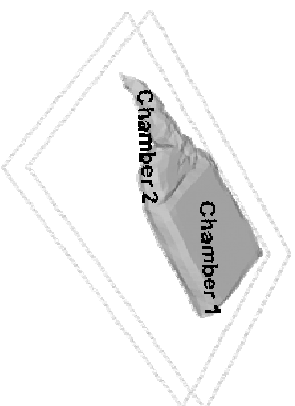
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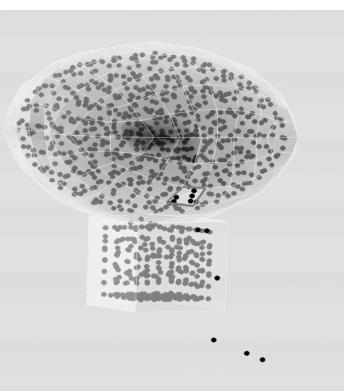
## | History



**1993**  
Gas jet model  
option



**1996**  
Multi-Chamber airbag



**2000**  
Meshless methods for  
gas dynamic models

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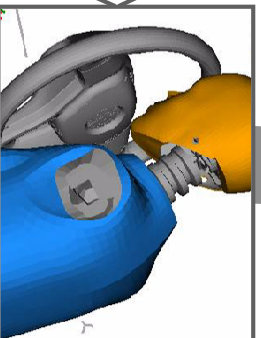
## | Methodology

### Input

- ⇒ Know How
- ⇒ Data and parameter of airbag module
  - Inflator data
  - Fabric
  - Folding
  - Cover
- ⇒ Test Device

### Results

#### Forecast



#### Evaluation

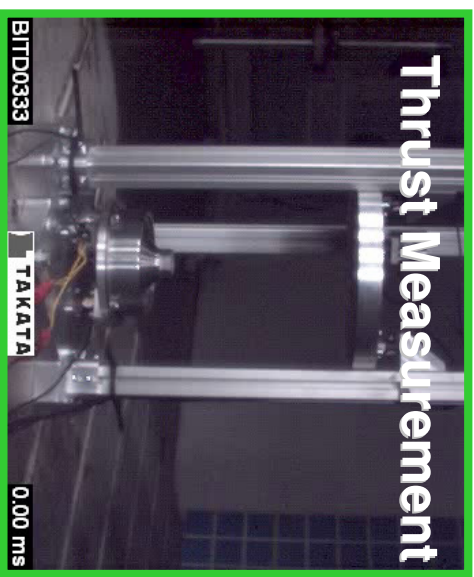
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## Input data

Alternative method for calculation of mass flow



$$\dot{p}_t \sim \dot{m}_i$$

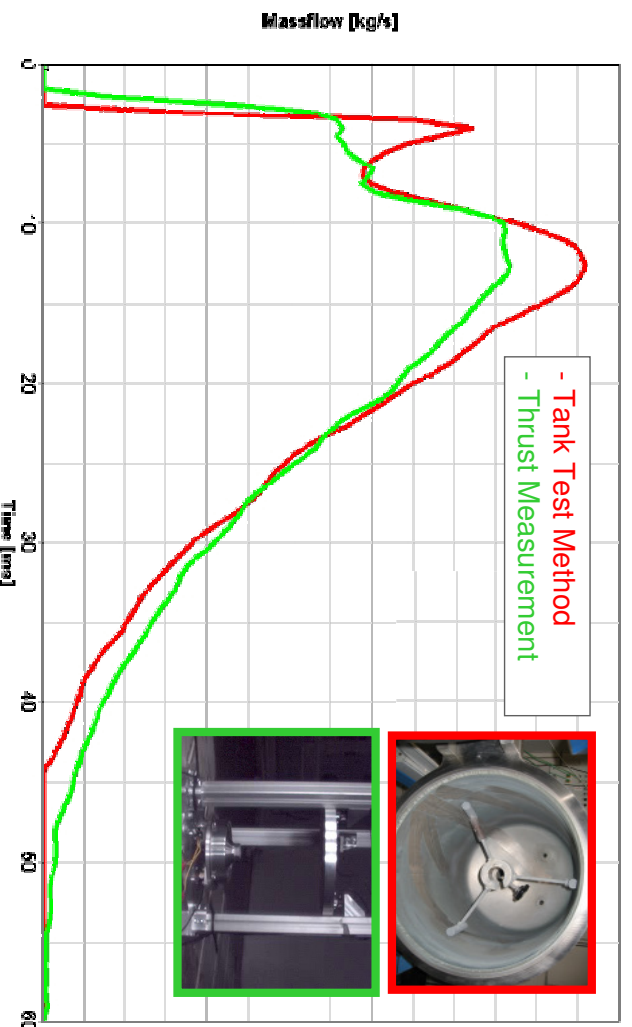
$$F_s \sim \dot{m}_i$$

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## Input data

Alternative method for calculation of mass flow



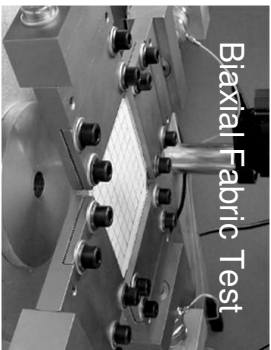
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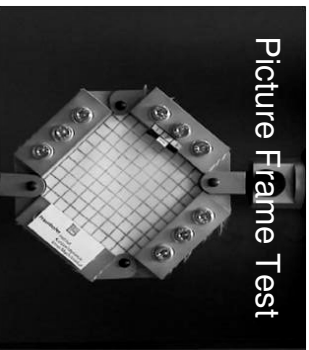
## Input data

State of the Art  
fabric tests



Biaxial Fabric Test

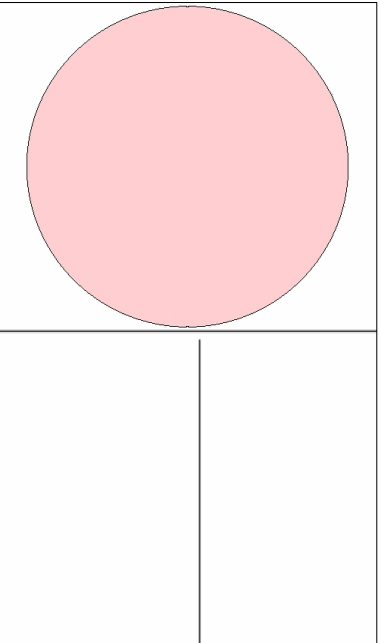
Picture Frame Test



Proposed test to determine bending  
stiffness of airbag fabric



Drape Fabric Test  
according DIN 54306  
for folding simulation



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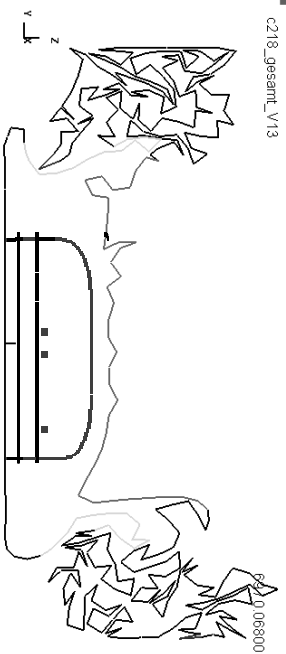


## Input data

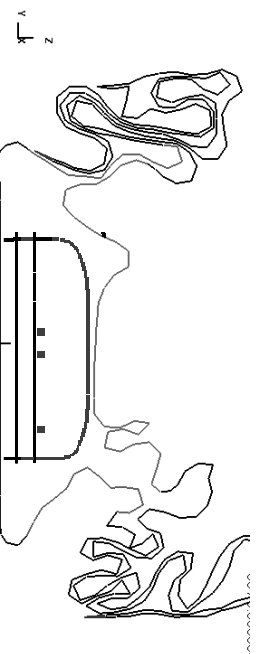
Comparison of airbag foldings without and with  
super-positioned shells

c218\_gesamt\_V13

p23.0.068001



Folding with  
membrane elements



Membrane elements  
with super-positioned  
elastic shells

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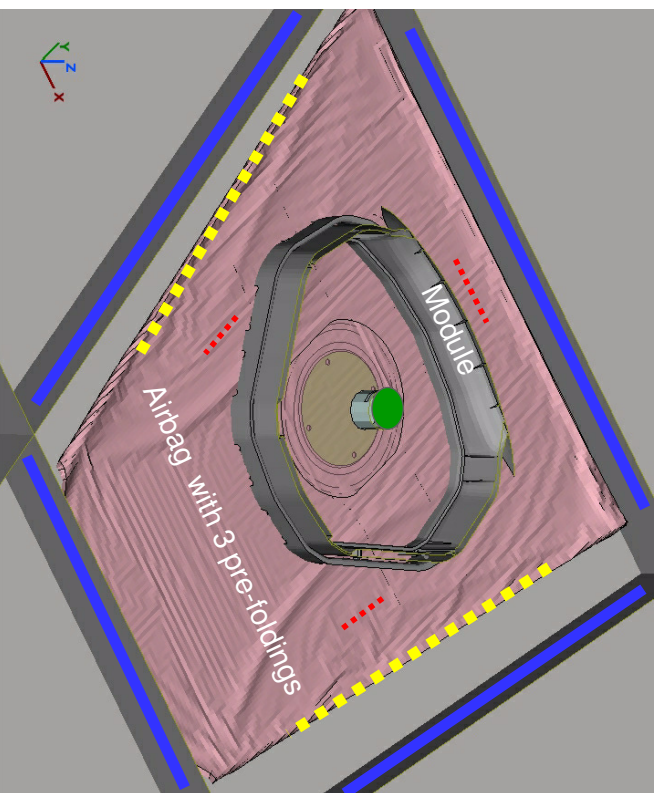
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## | Input data

### Simulation PETRI folded airbag

- Airbag with three pre-foldings
- **Tacked** and **tear** seams
- **Folding sliders** with **place holder** and **diffuser**
- SIM-Folder® folding software



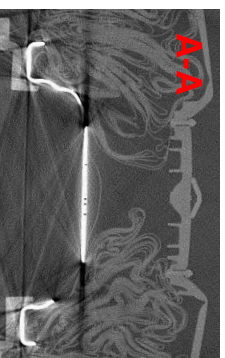
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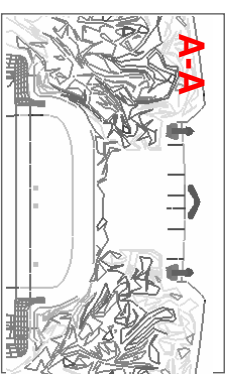


## | Input data

### Section cut through module by Micro Computer Tomography (MCT)



**Sample**



**Model**

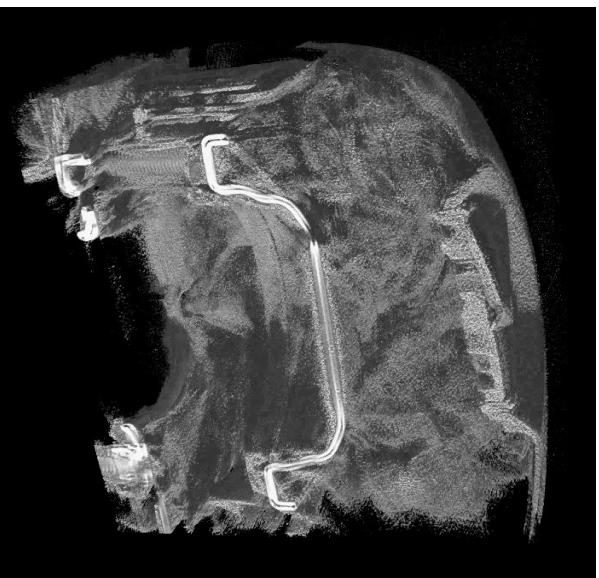
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## | Input data

### Section cut through module by Micro Computer Tomography (MCT)



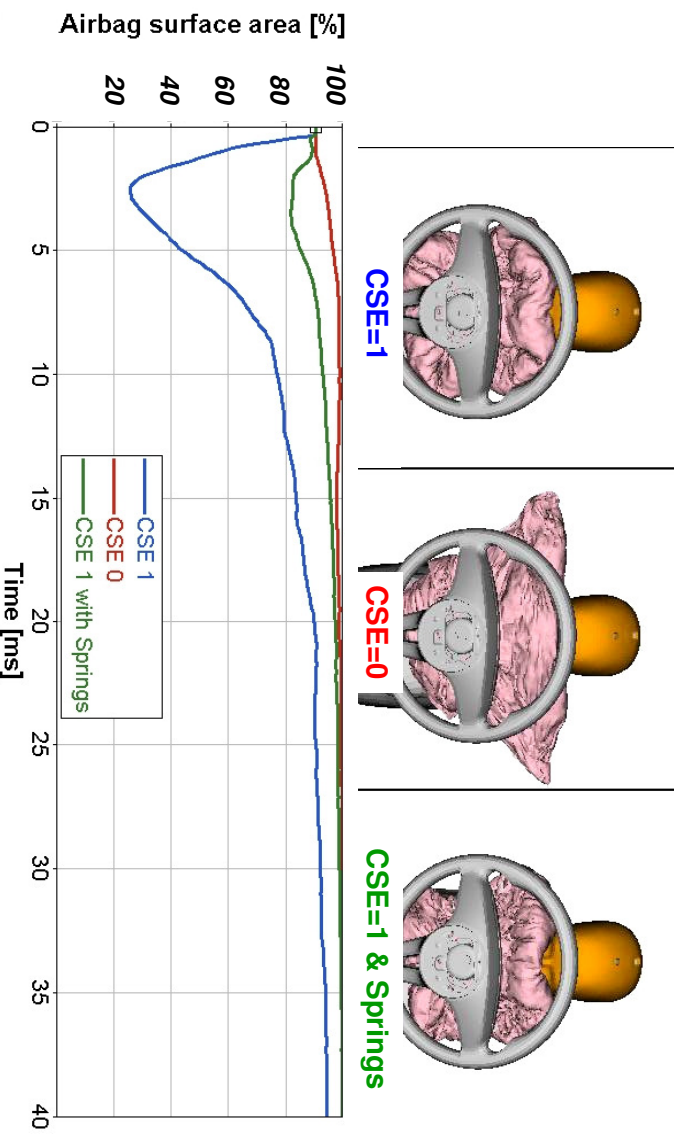
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## | Input data

### Compressive stiffness of Membrane Elements



Out of Position - Possibilities and Limitations of Numerical Simulation

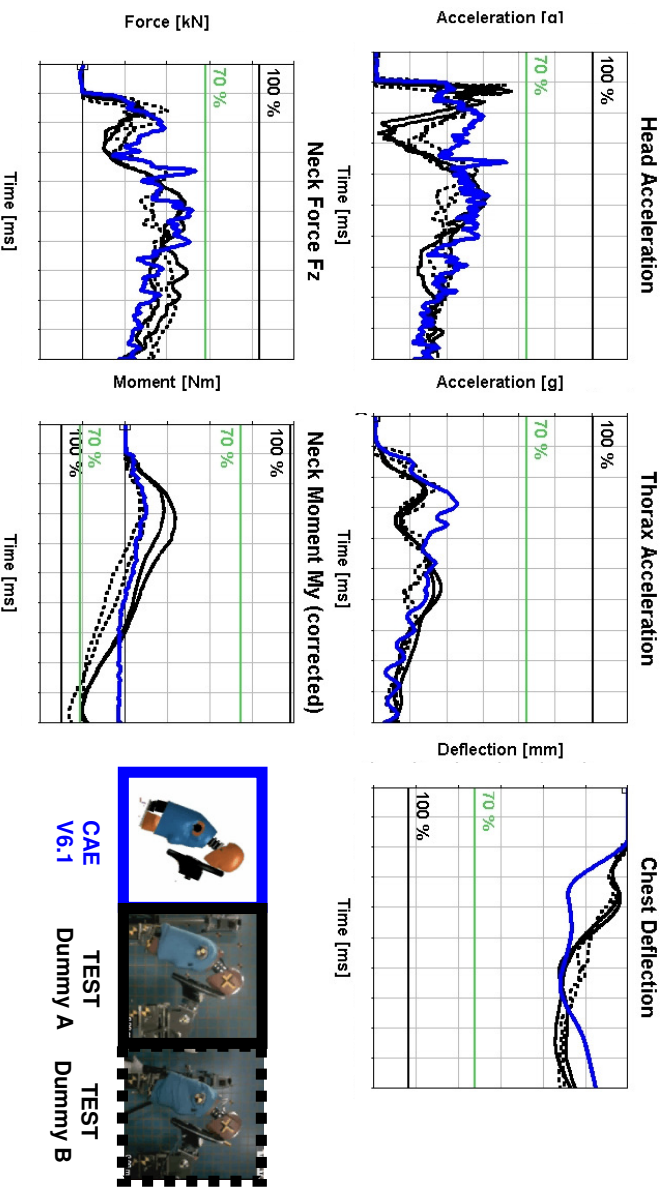
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# Results

## Prediction vs. Test – Position 1



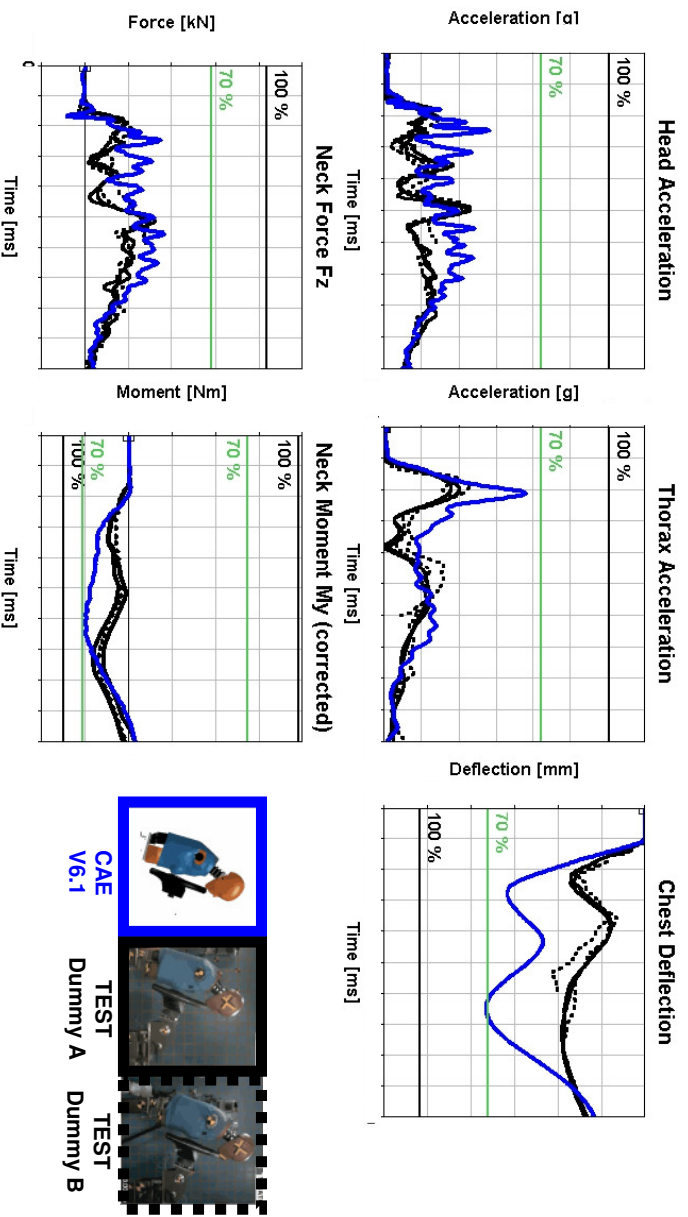
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# Results

## Prediction vs. Test – Position 2



### Out of Position - Possibilities and Limitations of Numerical Simulation

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## | Possibilities and Limitations

**Main injury mechanisms** of OoP situations can be **predicted** by numerical simulation

The characteristics of occupant **load curves are proper** but **peak values are too high** generally

Influences of airbag **folding, cover design** and **inflator performance can be evaluated** (currently driver's side only)

| Out of Position - Possibilities and Limitations of Numerical Simulation

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## | Possibilities and Limitations

Improved quality of **dummy models**

Right Assumptions for **contact interactions**

Reduced **answering time** of numerical simulation (modeling and calculation time)

**Same models** for **in- and out-of-position** simulations

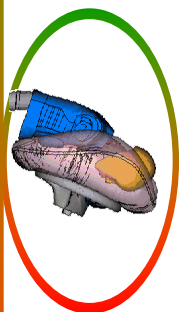
Further studies for **passenger and side bags**

| Out of Position - Possibilities and Limitations of Numerical Simulation

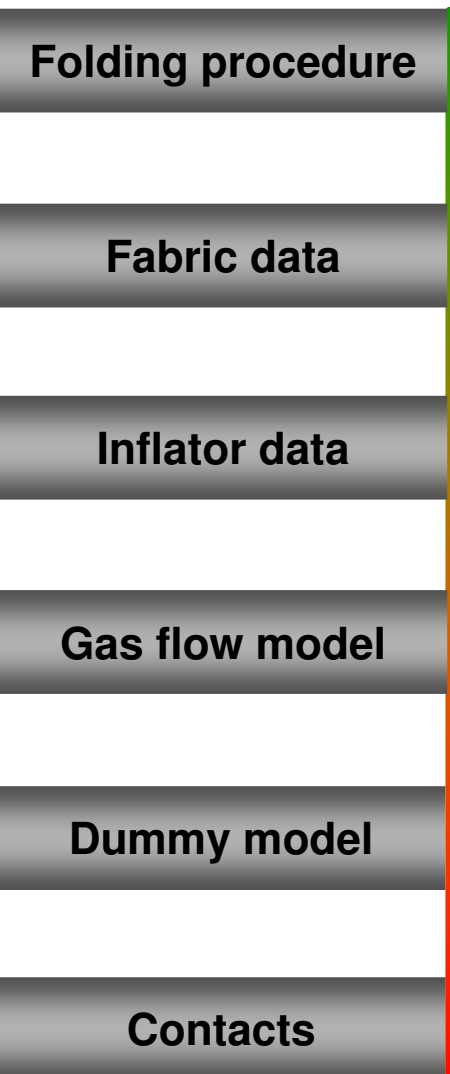
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# | Possibilities and Limitations



## Predictable OoP Simulation



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