

Airbag Systems and Occupant Protection

Recent Trends in Simulation

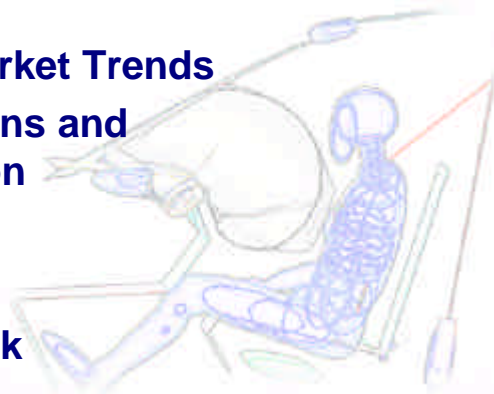
Kurt Fograscher - Autoliv B.V. & Co. KG
LS-DYNA FORUM 2006
Ulm
12.10.2006



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Outline

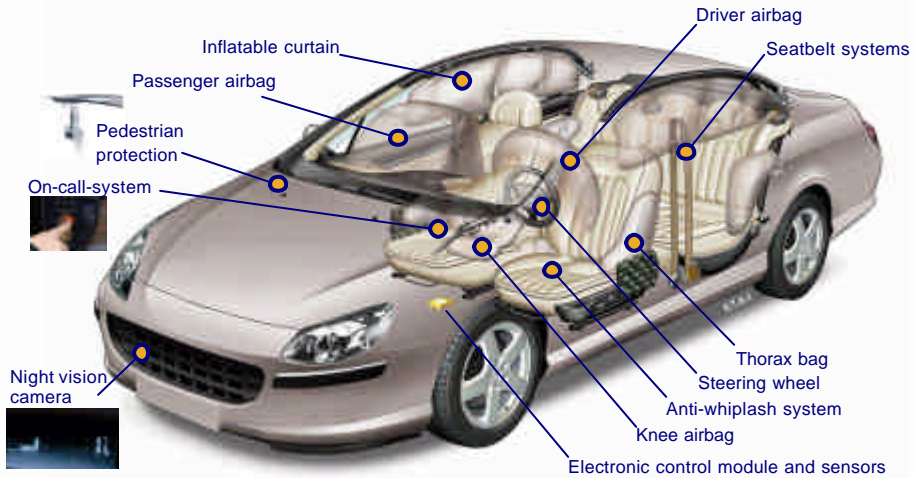
- **Passive Safety Market Trends**
- **CAE Process Chains and Process Integration**
- **CAE Methods**
- **Some examples**
- **Trends and outlook**



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Vehicle Passive Safety Systems To Date



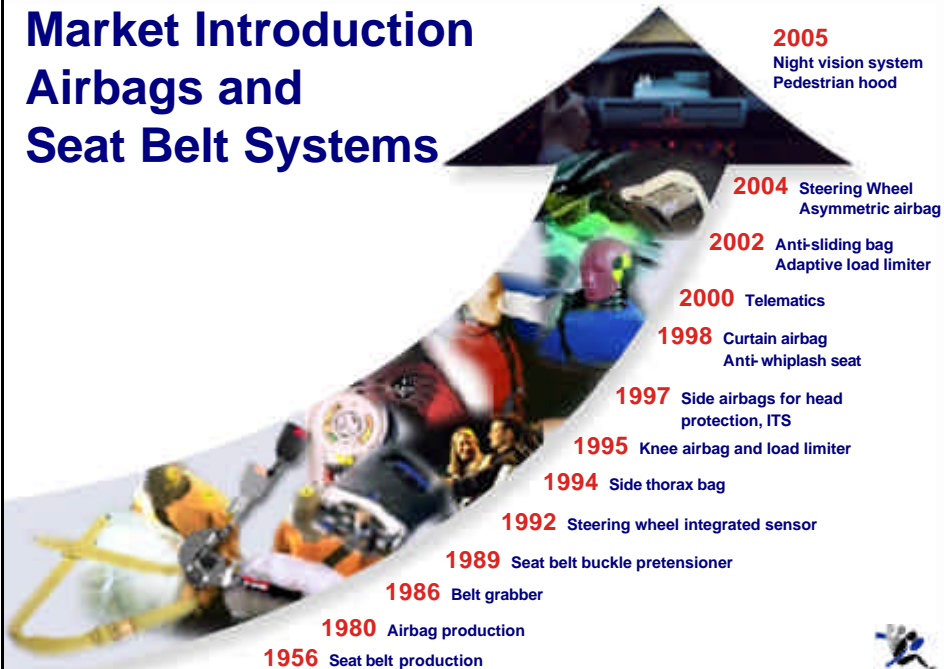
Integrated Automotive Safety Systems

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Market Introduction Airbags and Seat Belt Systems



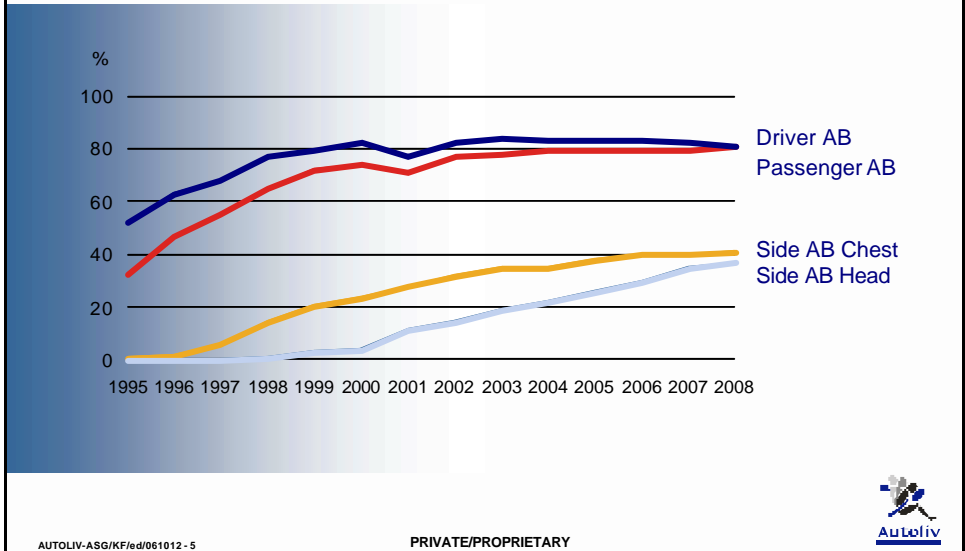
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Increasing Vehicle Safety Content

Global average installation rates of airbags



Death Causes

Disease or Injury

1998

1. Respiratory Infections
2. HIV/AIDS
3. Perinatal Conditions
4. Unipolar Major Depression
5. Diarrhoeal Diseases
6. Ischaemic Heart Disease
7. Cerebrovascular Disease
8. Malaria
- 9. Road Traffic Accidents = 1,170,694**
10. Obstructive Pulmonary Disease

2020

1. Ischaemic Heart Disease
2. Unipolar Major Depression
- 3. Road Traffic Accidents = 2,300,000**
4. Cerebrovascular Disease
5. Obstructive Pulmonary Disease
6. Respiratory Infections
7. Tuberculosis
8. War
9. Diarrhoeal Diseases
10. HIV/AIDS



Source: Prof. M. Mackay based on data from WHO

Airbag Products



Driver Airbag



Steering Wheels



Passenger Airbag



Side Airbag (Thorax)



ITS Side Airbag (Head)



IC Side Airbag (Head)



Knee Airbag

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Products in Focus



Adaptive Airbag



Night Vision



Pedestrian Protection



Curtain Airbag

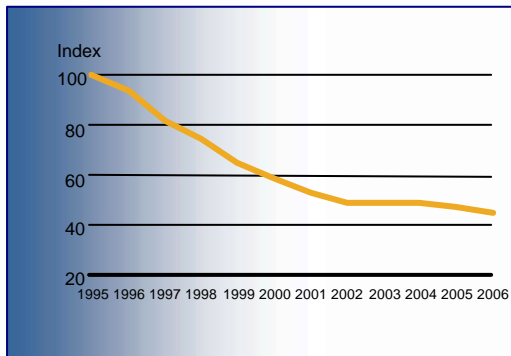
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Pricing Trends

Average selling price Frontal Airbag (normalized)

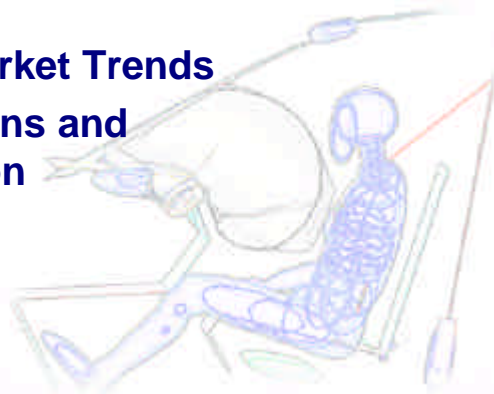


- Requires optimized products and processes
 - Strong pressure to reduce development costs
- Continuous push for virtual development and CAE tools

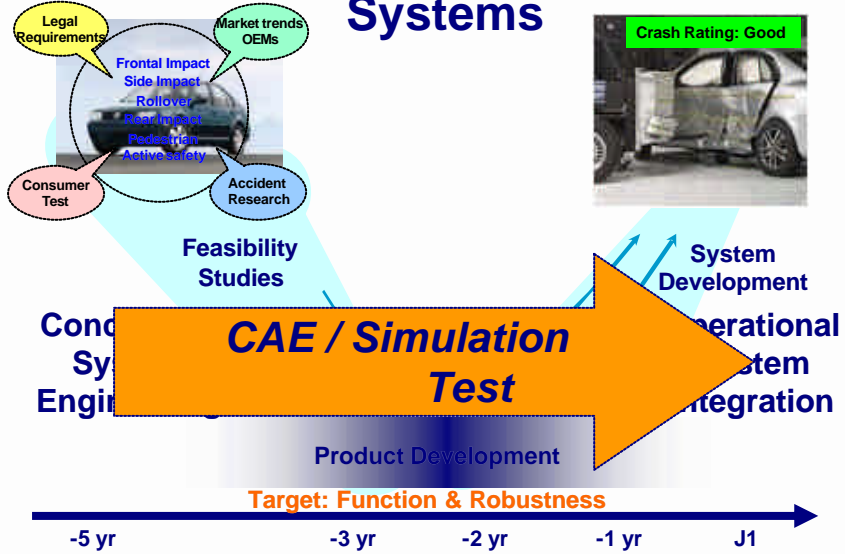


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- CAE Methods
- Some examples
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Development Process of Restraint Systems

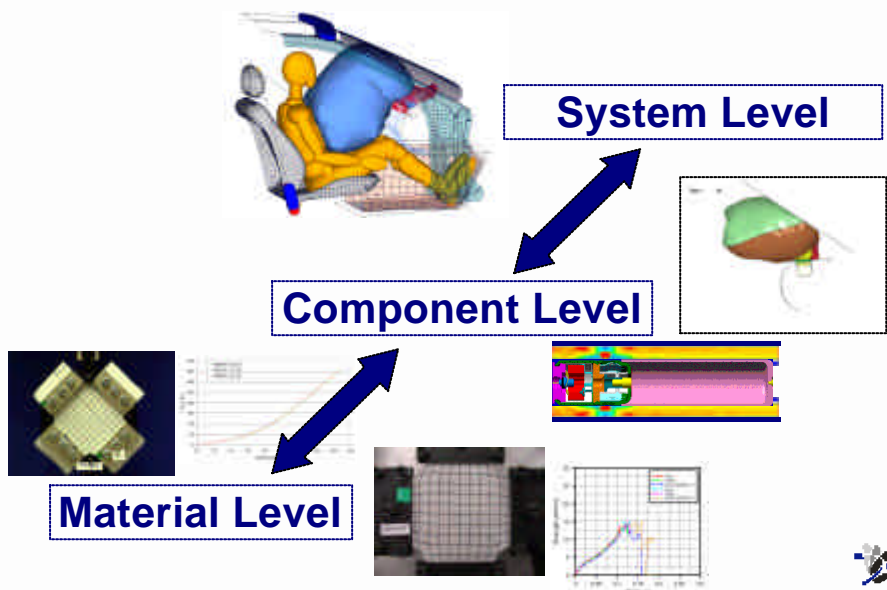


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CAE Process Chains

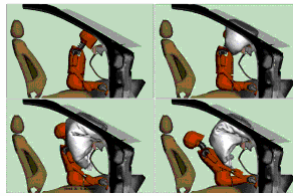


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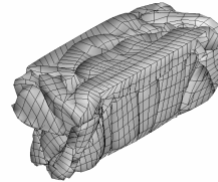


CAE Process Chains

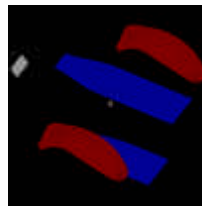


Function

Process (Manufacturing)



Raw Material



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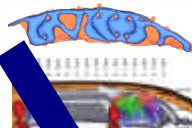


CAE Process Chains



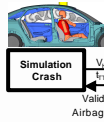
CAE Crash Data Analysis

- Velocities
- Distances vs. time
- Timing



Airbag Chamber Design

- Head position area
- Volume and pressure distribution
- Loads on stitching and seam



Validation

- Acceleration
- Bag pressure
- Remaining



Occupant Protection Position



Occupant Protection OnP-Position

OEM

OEM

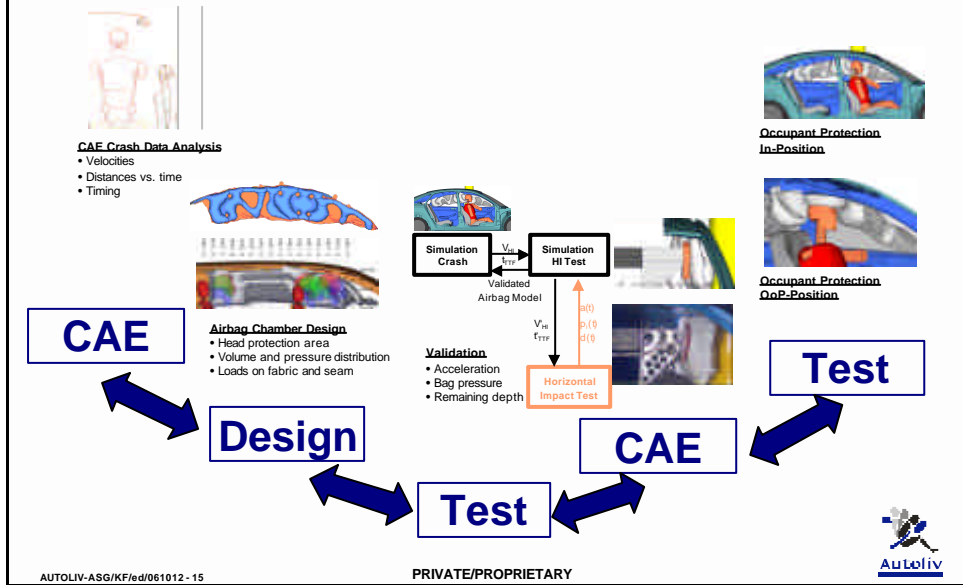
Restraint Supplier

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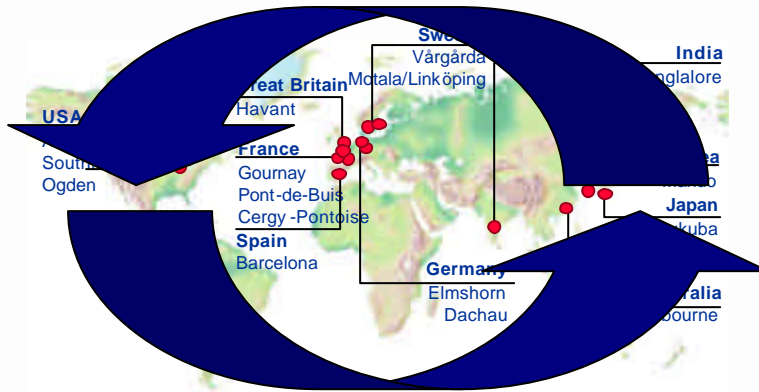
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CAE Process Chains



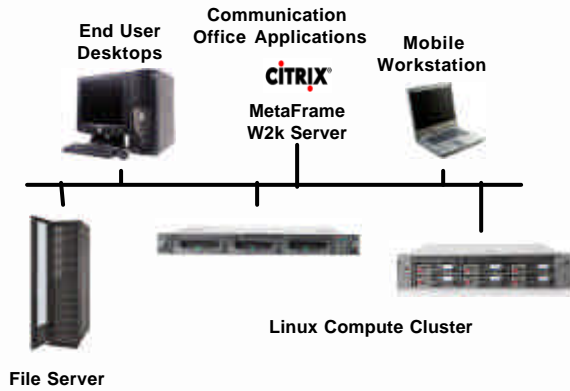
CAE Process Chains



- Global organisations require global processes
- New CAE processes must be capable for worldwide application
- CAE processes must integrate 'parts & pieces' from different locations
- OEM global standards and diversity must be considered
- Cultural aspects, local history and acceptance must be considered

CAE Process Chains

Computational Process



- Application Resource Management
- User Management
- Projects
- Data Management
- Databases
- Software
- File Storage
- Archiving
- Load Sharing
- Accounting

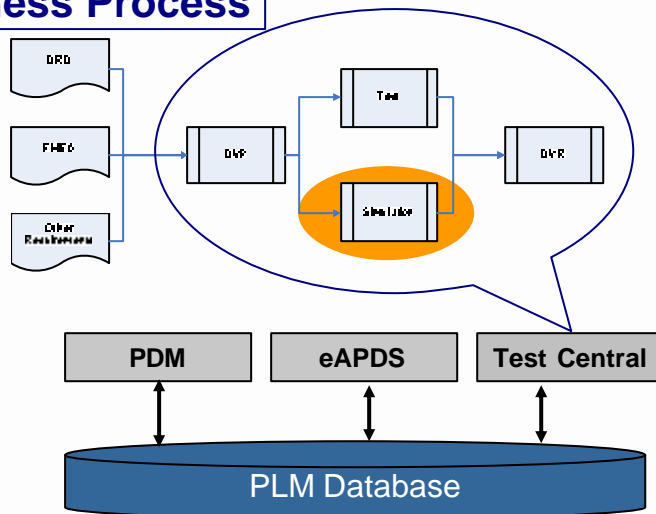
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CAE Process Chains

Business Process



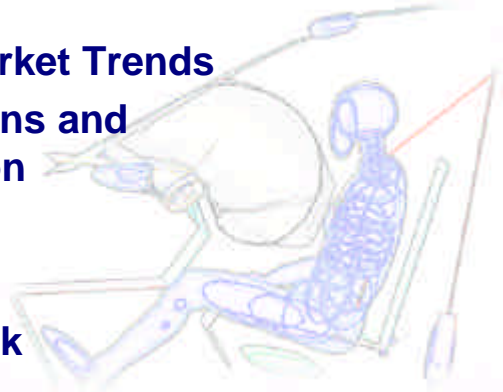
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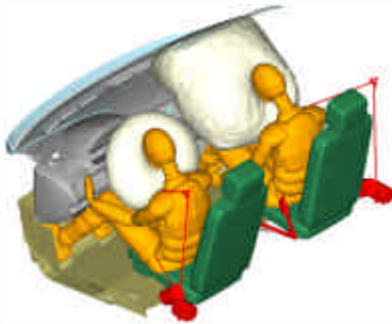
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Occupant Simulation

Frontal Impact



Multi-Body Simulation (MBS)

Side Impact

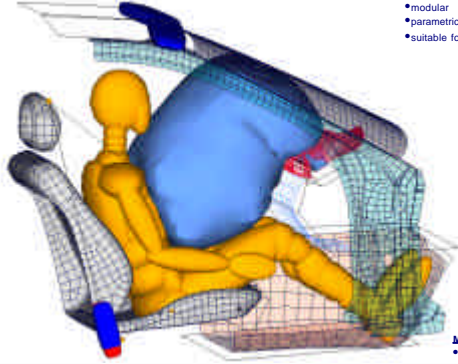
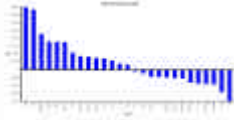


Finite-Element-Method (FEM)

Occupant Simulation Frontal Impact

Application Area

- Analysis
- Design
- Assessment
- Optimization
- Verification



AuLoliv-Master-Model (AMM)

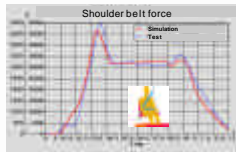
Master Modell for frontal simulation („Bestpractice“)

- modular
- parametric
- suitable for all In-Position load cases

Validation

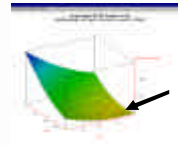
Model validation on

- Material level
- Component level
- System level



Methods

- Design of Experiments (DoE)
- Optimization
- Stochastic Methods
- Parameter Study

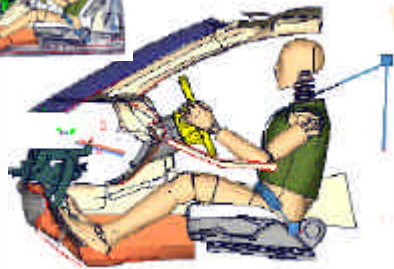


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Occupant Simulation Frontal Impact



Source: Audi AG, M. van den Hoove, Dr. B. Mlekusch, 2005

Trends

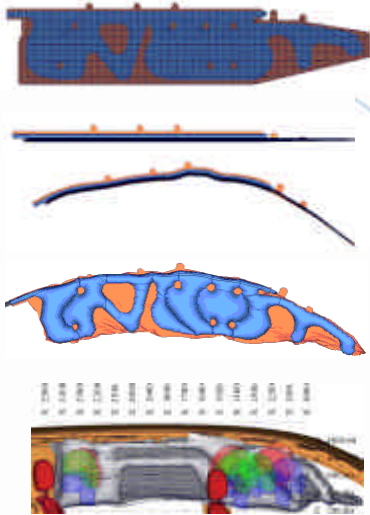
- More details for geometry and deformable structures
- More FE content, gap MBS to FE becomes smaller
- Angular impacts require combination of front and side impact methods

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Occupant Simulation Side Impact



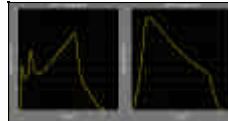
Occupant Protection In-Position



Occupant Protection OoP-Position

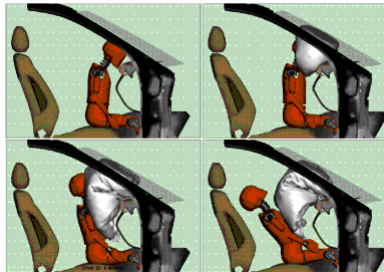
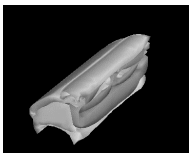


Occupant Simulation Out-of-Position



Tools for Airbag Modeling

- joefold: Software for geometry based airbag folding
- S-Mesh: Automatic Mesher
- joeform: Positioning of the folded mesh in the package



Important parameters

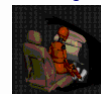
- Vehicle package IP, windscreen
- Module position
- Door design
- Airbag folding
- Inflator characteristics

Load Cases

Driver side 5%-Dummy



Passenger side 3yr/6yr child



Gas Flow Dynamics



Simulation with gas flow

Test

Simulation without gas flow



CAE-Toolbox Passenger Airbag Module

- CAE application
- Description of model set-up and standards
- Required input / delivered output
- Timing in process
- Expense and lead time

Bereich System Level
Simulation Kopflaufschlag (ECE-R 21, FMVSS 201)
Modell- Instrumentaltafel mit Einbauten und PAB Modul
umfang

Beispiel

Software Pam-Crash (LS-Dyna, Abaqus)
 CAD Daten
 Nichtlineare Materialdaten mit Dehnstreckenabhängigkeit von RT
 Kopflaufschlagspunkte
 Verzögerungskurve mit albrms Wert
 Schrittwiederholer
 Animationen

Output / Ergebnis

Kosten

Laufzeit

Beispiel: CAE Toolbox für PAB Modul

Bereich	System Level	Sub-System Level	Sub-System Level	Sub-System Level	Sub-System Level	Component Level	Component Level	Component Level	Sub-System Level	Kundenmodell	Kundenmodell	Kundenmodell
Simulation	Kopflaufschlag WCE-R 21	Dooröffnung	Airbag Integrität	Eigenfrequenz	Falttest	Container Preloadtest	Schraubverbindertests	Cover Steifigkeit	DoP Simulation	NVR Modell	Kopflaufschlag Modell	Safety Modell

CAE-Masterplan PAB

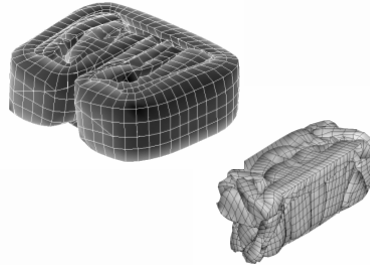
	TG0				TG1				TG2				TG3			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4



Other Tools

- **Airbag modeling and folding**

Specific to airbag applications
Mesh, scale, fold, form, position



- **Result evaluation**

- **Management of complexity for DoE and stochastics**

Commercial software

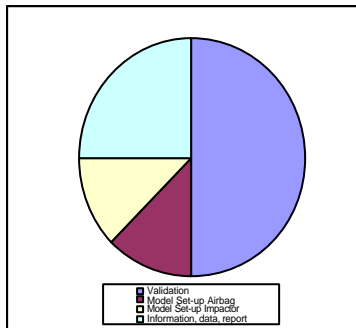
In-house software

- joe-Tools
- Datalyser

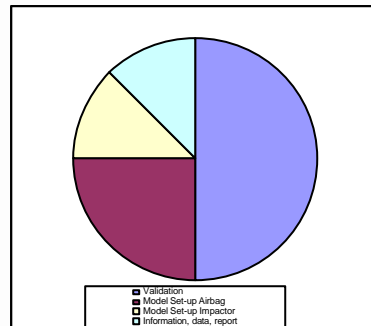


Validation

**Total time for validated model
Unfolded (scaled) Airbag**



**Total time for validated model
Folded Airbag**

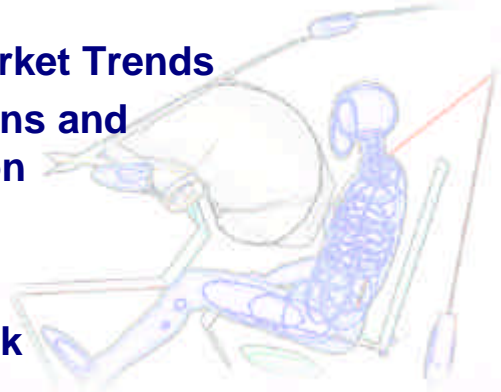


Validation is the relevant factor for process lead times and simulation efficiency



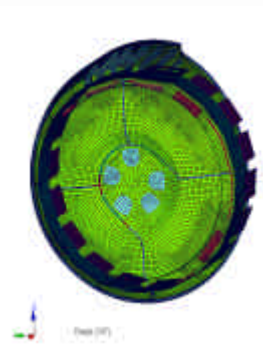
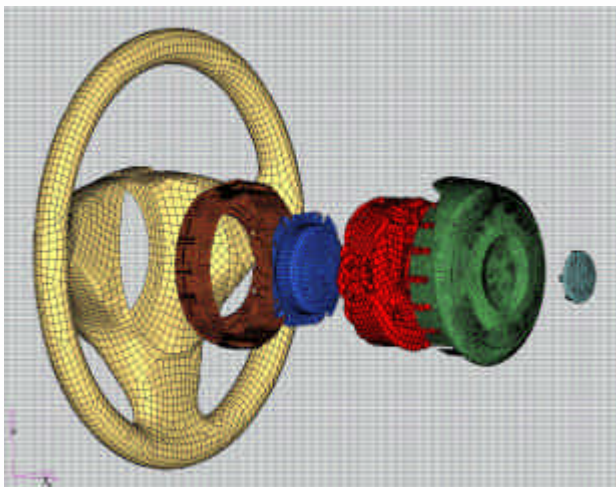
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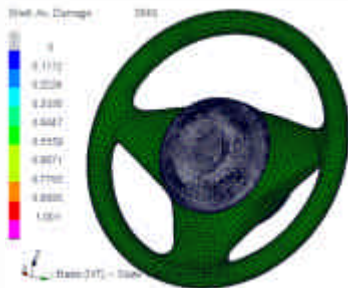
Simulation Driver Airbag Cover Opening

FE Model

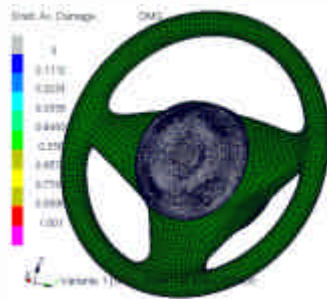


Simulation Driver Airbag Cover Opening

Basic Design



Improved Design

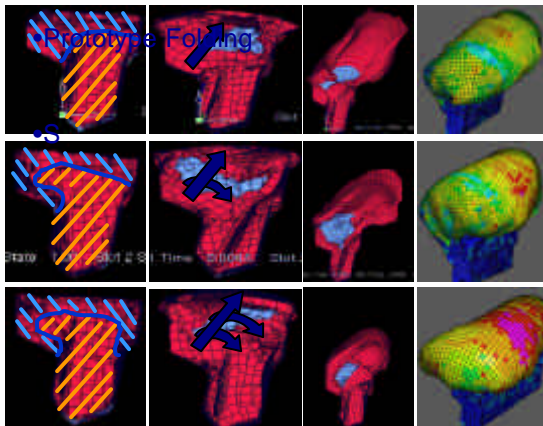


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Passenger Airbag Integrity Problem



Lower Limit
→ Ok.

Design State
→ Ok.

Upper Limit
→ Problem !

Integrity problem on PAB solved by use of CAE tools

- CAE model could reproduce non-failure / failure
- Identification of significant effects for proper function
- Definition of necessary changes in folding process
- Physical part verification ok.!

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Pelvis Pusher Airbag



High pressurized airbag
in pelvis area

Rib deflection reduced by
>20% for IIHS Load Case

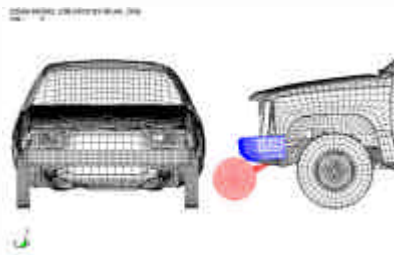
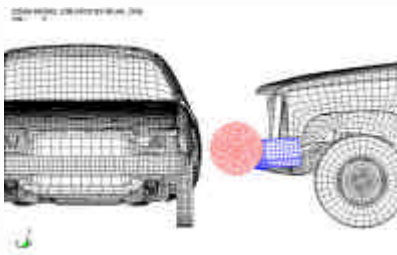


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Active Structures



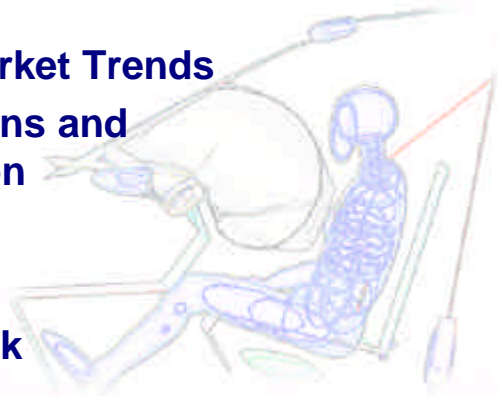
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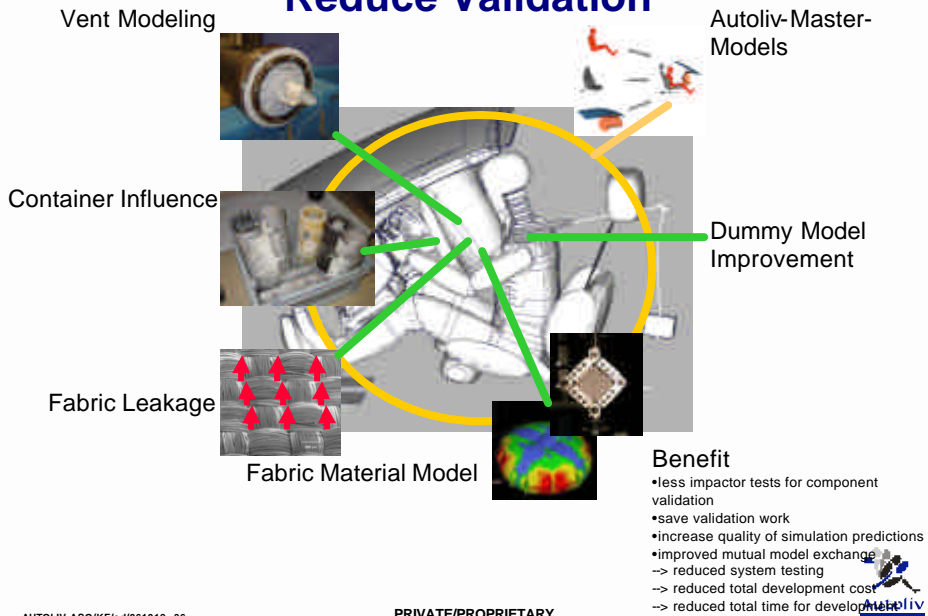


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New Methods: Increase Model Predictivity Reduce Validation



Trends and Outlook

Increasing importance of Multi-Physics

- CFD / ALE / Particle methods
- Material thermo-loading
- Material aging

Switch Explicit – Implicit

- Use same model

Critical factor: Material data

- Dynamic, temperature band
- Availability on time

From project engineers strong request for prediction of material failure

- Difficult to handle



Trends and Outlook

Key success factors

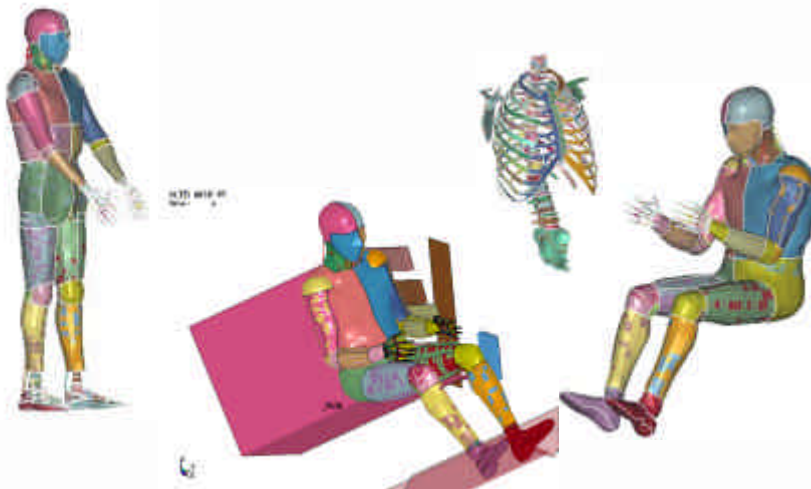
- **Process integration of tools and methods**
- **Efficient processes**
- **Process and data management**
- **Stability of new methods**
- **Methods ease of use
(cross-user, cross-site, cross-cultural)**
- **Suitability of tools for standardisation**



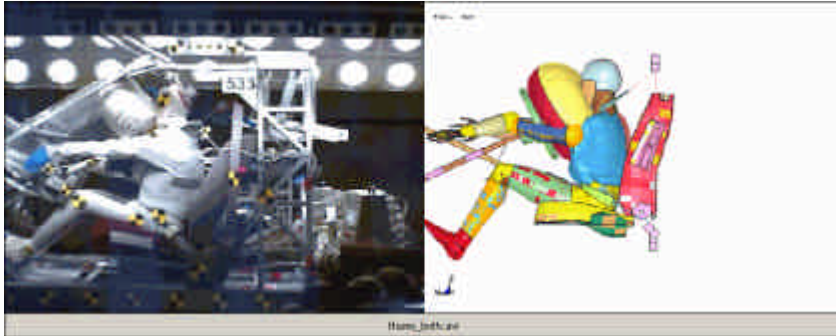
Trends and Outlook

- **New safety regulations (legal and consumer) drive system complexity**
- **Optimisation of adaptive systems requires huge number of (quick) simulations**
- **Accurate / detailed methods required to explore close optimisation margin**
- **DoE and stochastics**
- **Human body models beyond dummy responses ...**

Human Body Models THUMBS



Status Human Model Frontal Impact Evaluation



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What Consumers Want on Their Next Vehicle ...



**Have a
Safe Journey !**

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