Optimierung von Kunststoffbauteilen im Crash: Status und Ausblick

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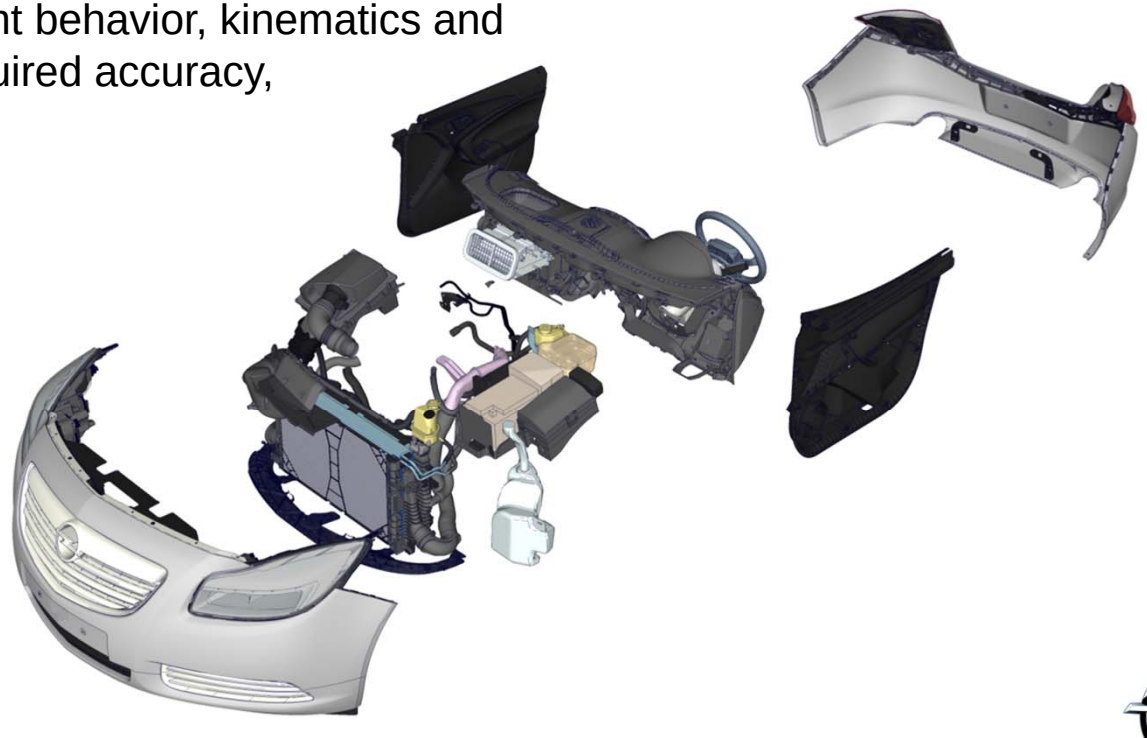
Content

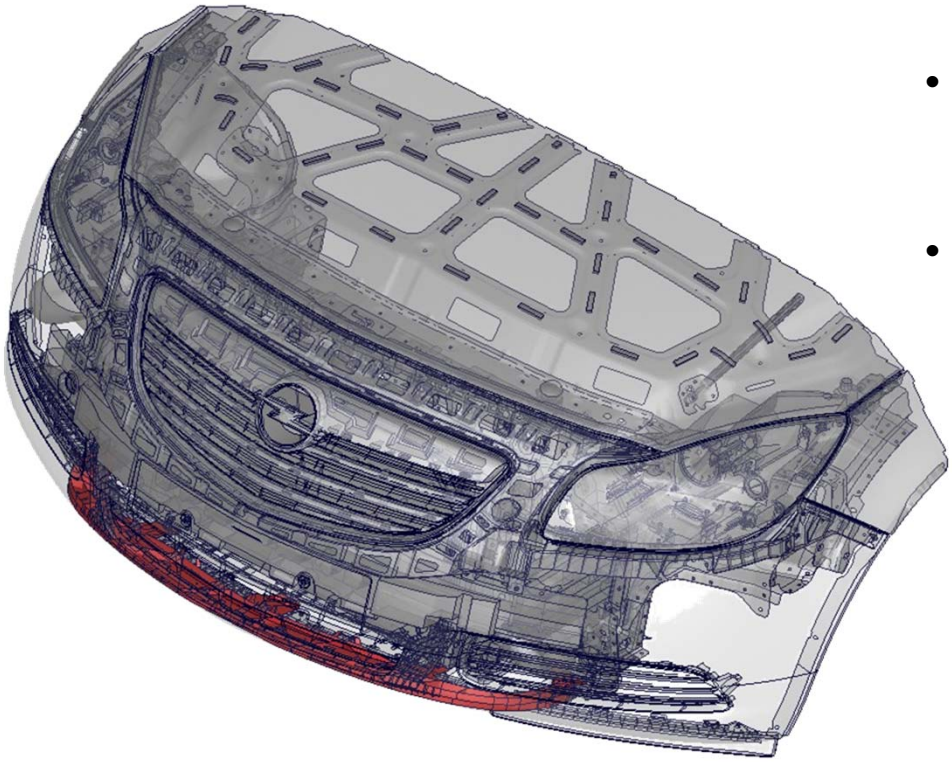
- Motivation
- Material modelling of Short fibre reinforced thermoplastics for Crash
- ULTRASIM™ examples and applications at OPEL
- Modelling Energy absorbing structures out of glass-filled thermoplastic materials
- Vision → Integrative Approach
- Summary

Motivation
Application of Polymers

- More and more structural components are made of polymers (e.g. short fiber reinforced polymers)
- These materials show significant anisotropy due to fiber orientation caused by injection molding
- In order to predict component behavior, kinematics and structural response with required accuracy, anisotropy must be captured



Lower Bumper Support

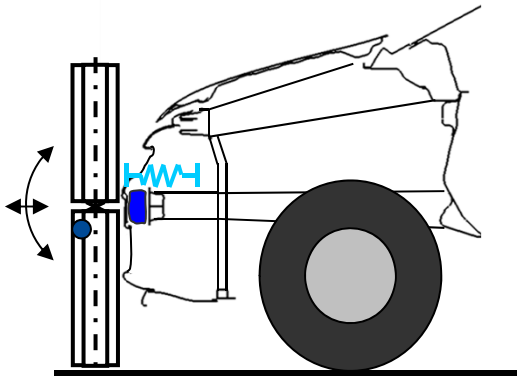


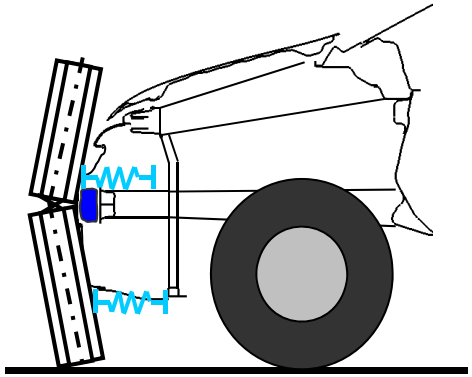
Development targets:

- Optimized, ribbed plastic structure to provide sufficient support for lower leg during the impact
- Needs to fail in a controlled manner during RCAR impacts in order not to damage other components
- Low weight at reasonable costs

Lower Leg Impact Kinematics

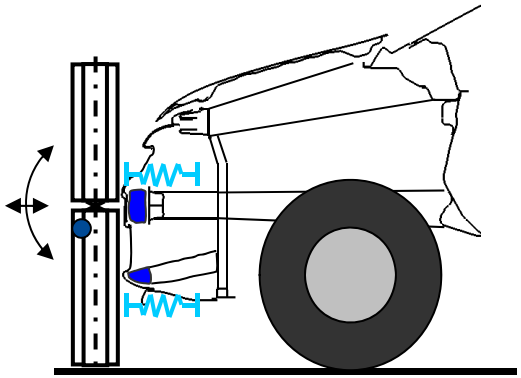
Without Lower Bumper Support

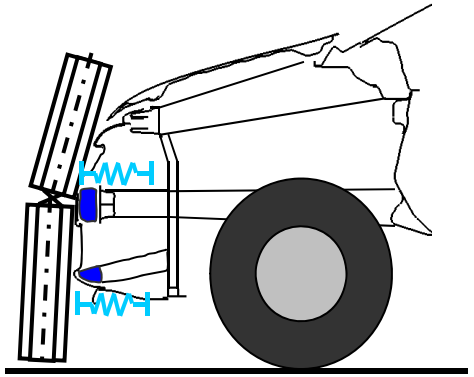




No support of lower leg

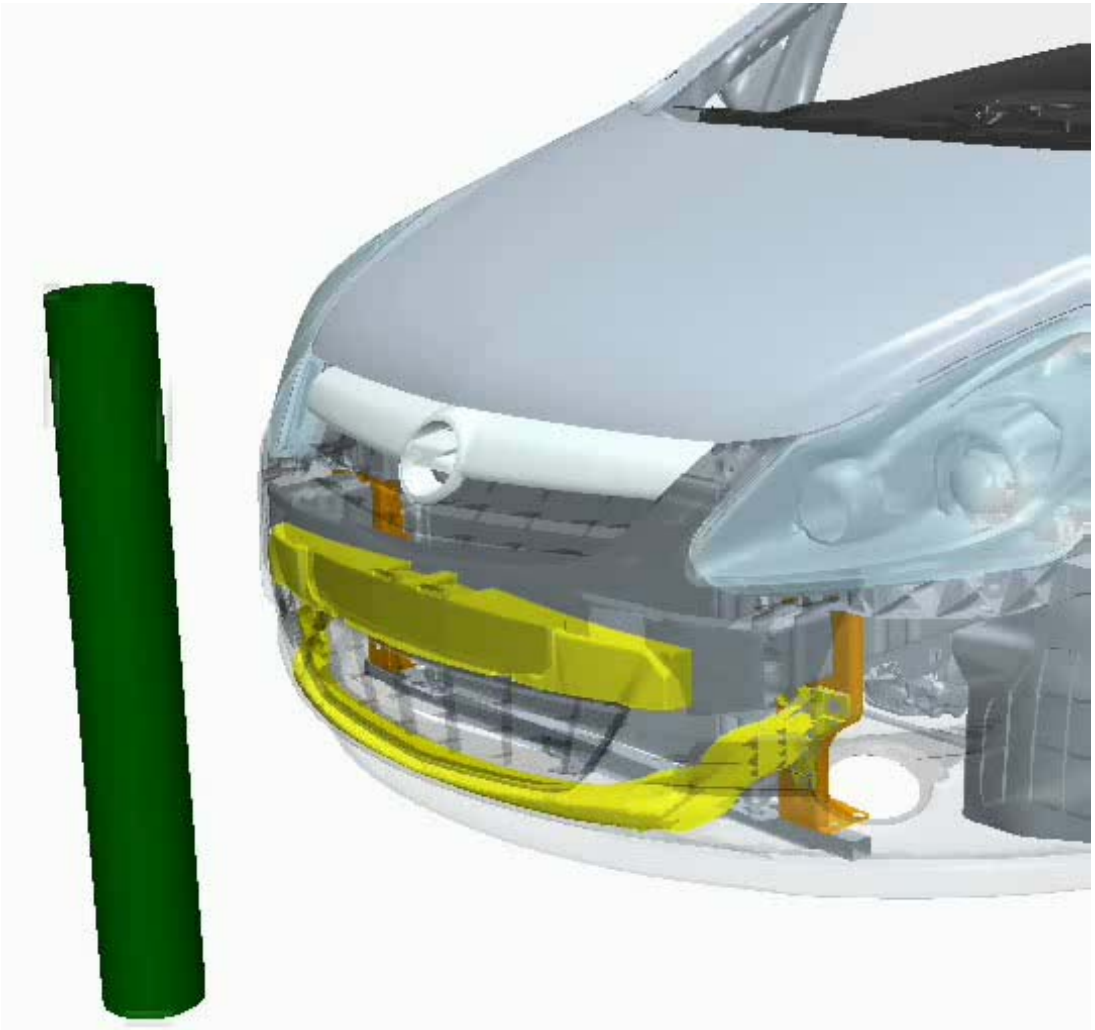
With Lower Bumper Support



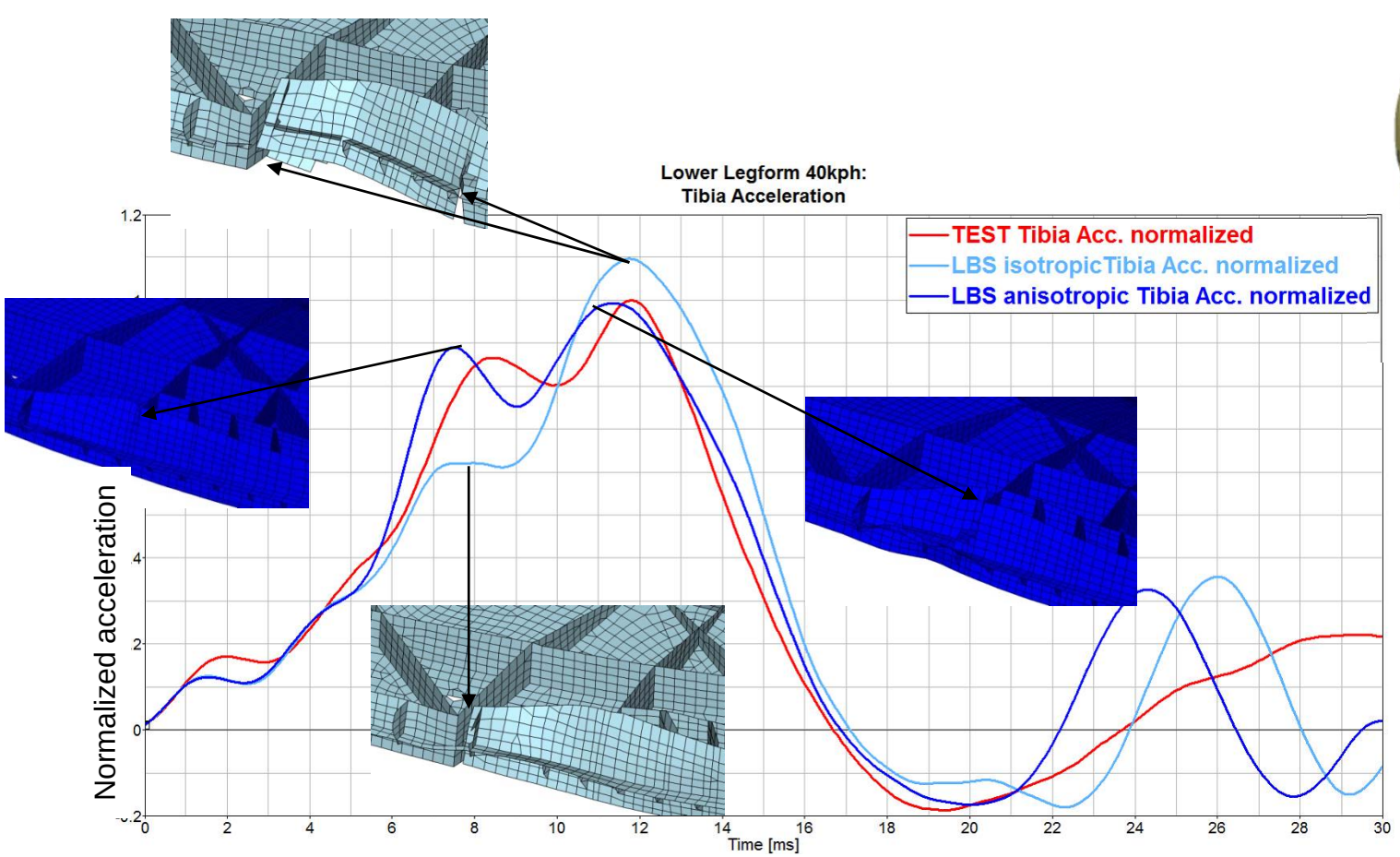


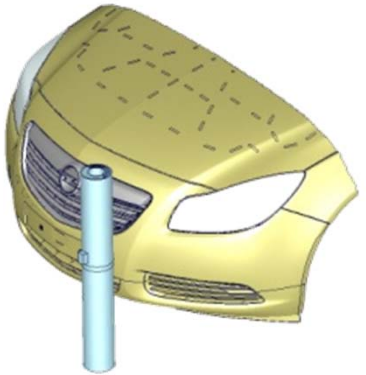
Support lower leg,
reduce knee bending angle

Lower Leg Impact (Full Model)



Simulation Results
Impact on stiffness and rupture





Integrative Simulation ULTRASIM™
for fiber reinforced thermoplastics

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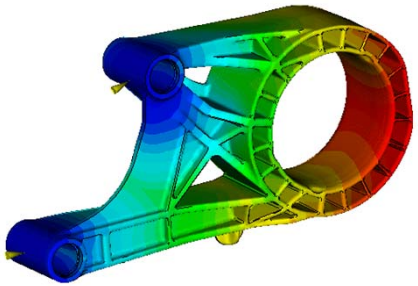
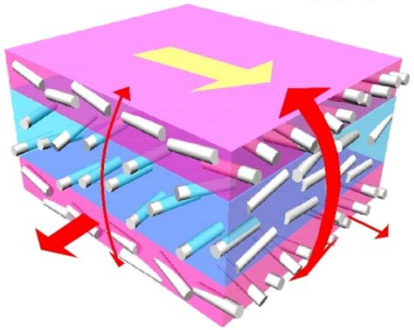
Process

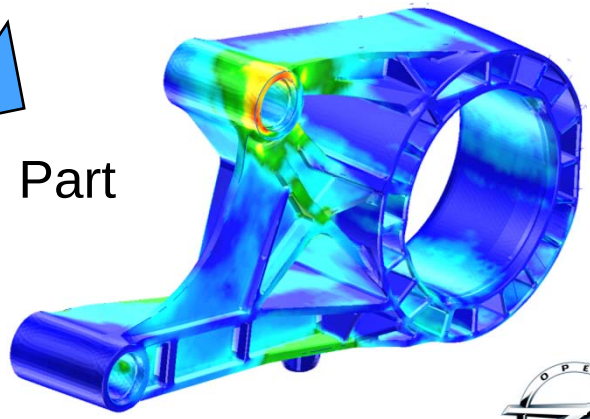


Measurement

BASF Material model



Part



- Anisotropic
- Nonlinear
- Strain-rate sensitive
- Tension-compression asymmetric
- Failure modelling
- Temperature dependent

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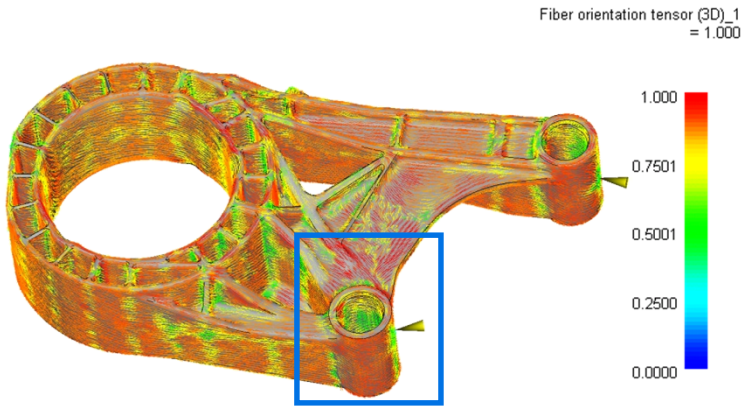
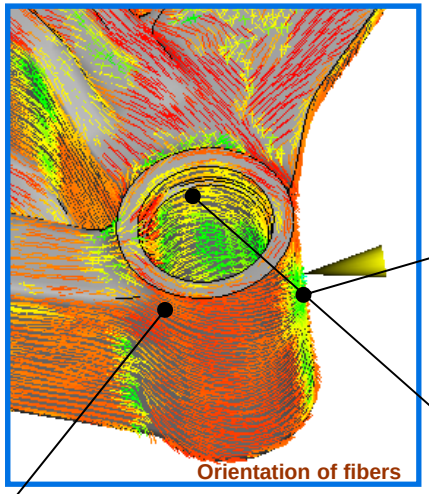
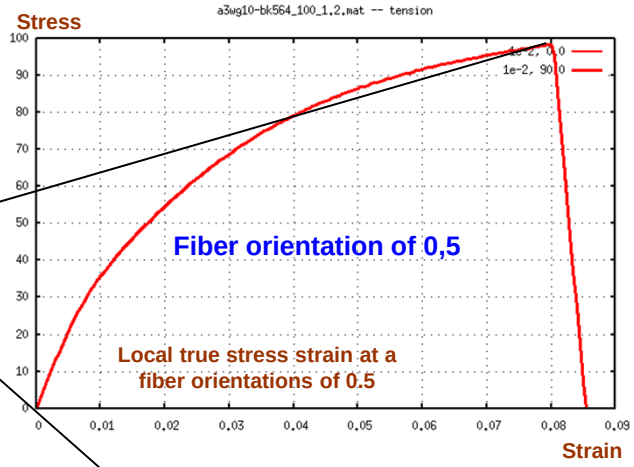
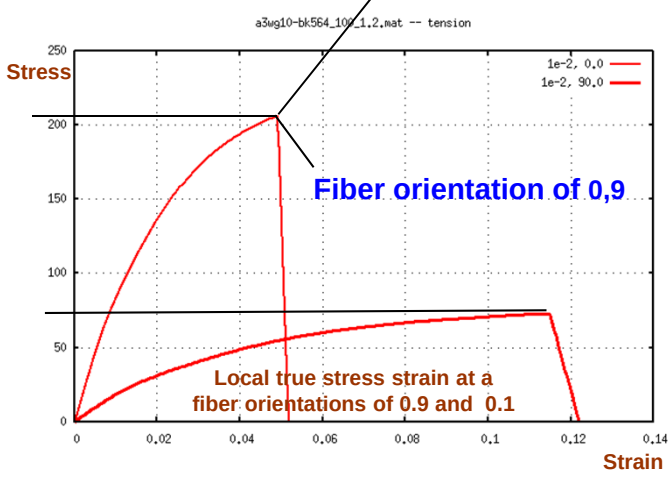
Integrative Simulation ULTRASIM™
Fiber orientation and material behaviour

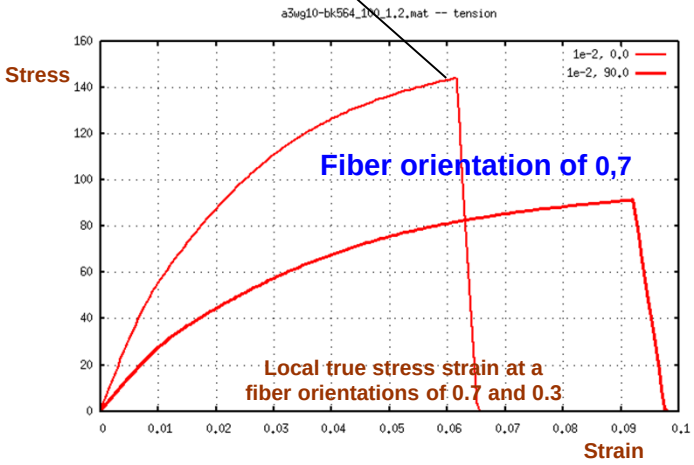
Calculated glass fiber orientation based on optimum processing conditions





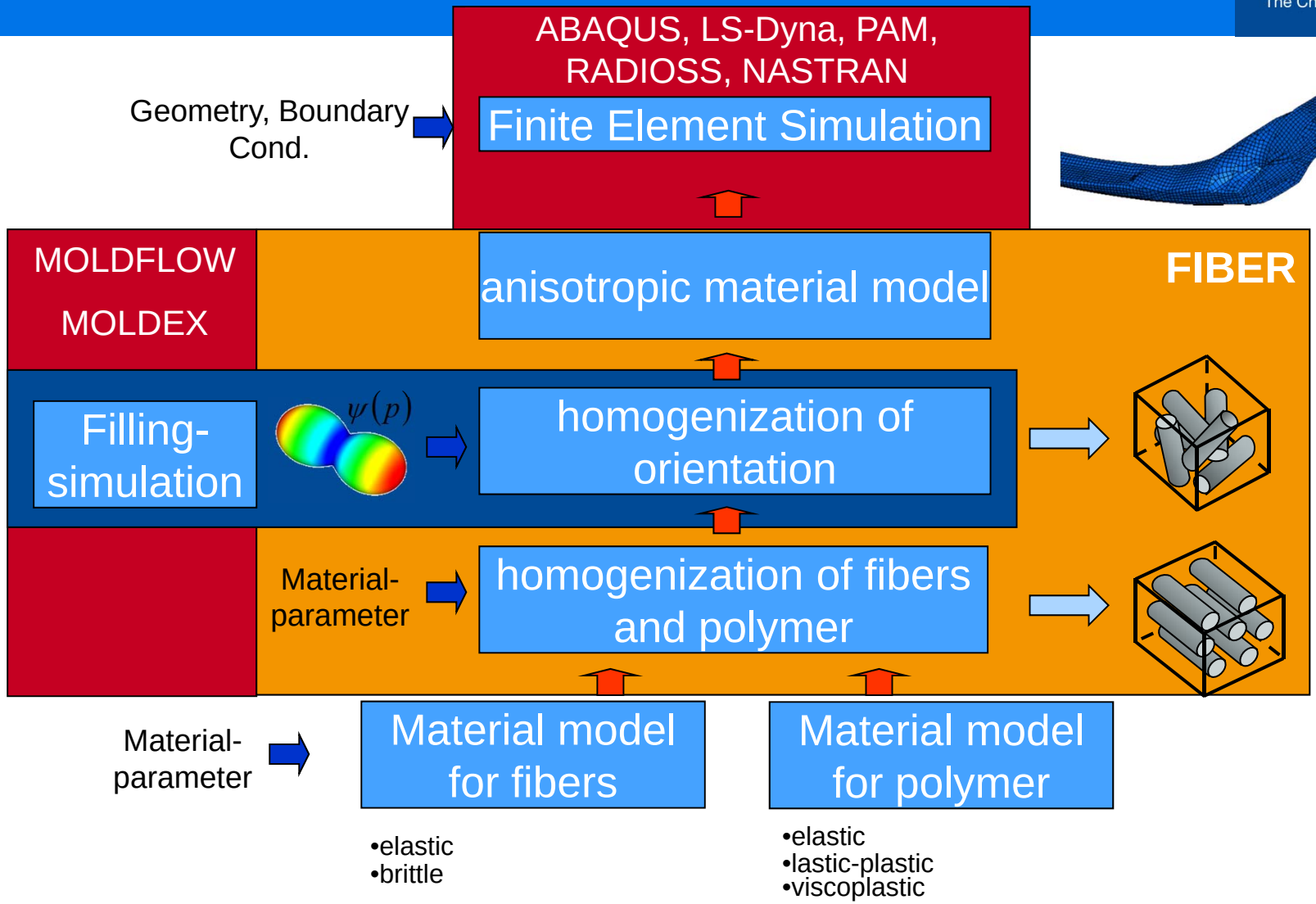




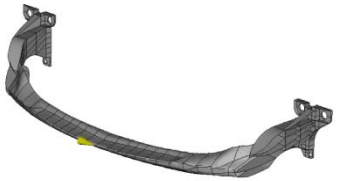


Integrative Simulation ULTRASIM™

Data flow structure



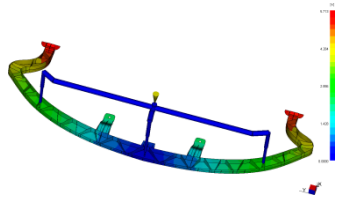
LBS Implementations

2006


2008


2009

2010

Additional Applications

- Engine Mounts (e.g. Insignia)

- Special Seats (e.g. Insignia OPC)

Stress-Strain behaviour
Tension-Compression Asymmetry

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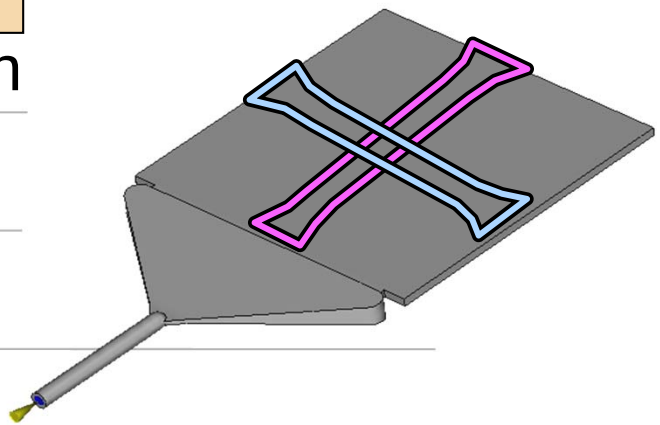
influence: fiber orientation
and hydrostatic stress state

Injection moulded plate



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Example for an Energy absorbing plastics structure – BASF Test Specimen for compression load Needed for Calibrating Failure Simulation Parameters

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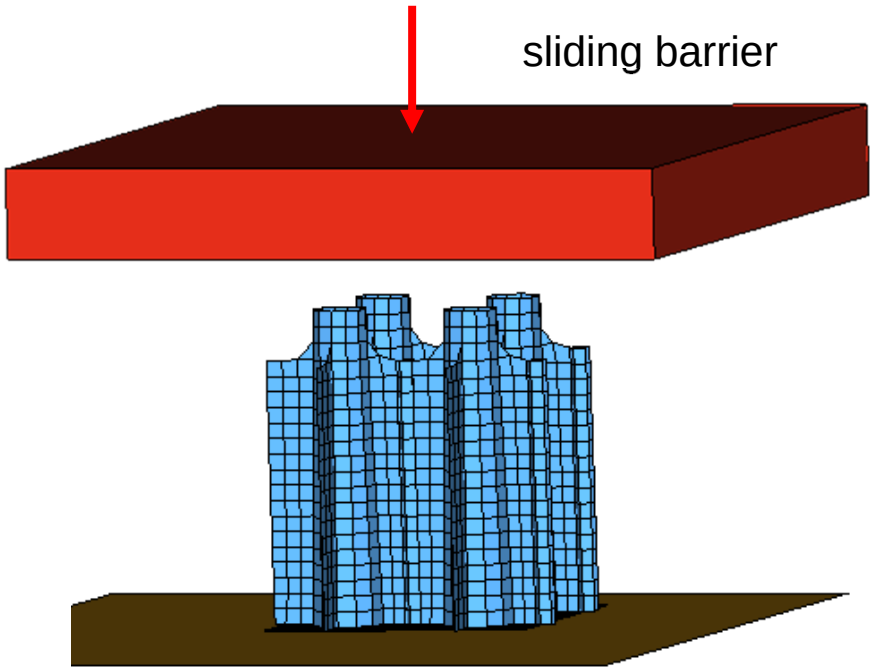
Specimen is designed for controlled collapse

Material: B3WG6 CR (PA6 GF30%)



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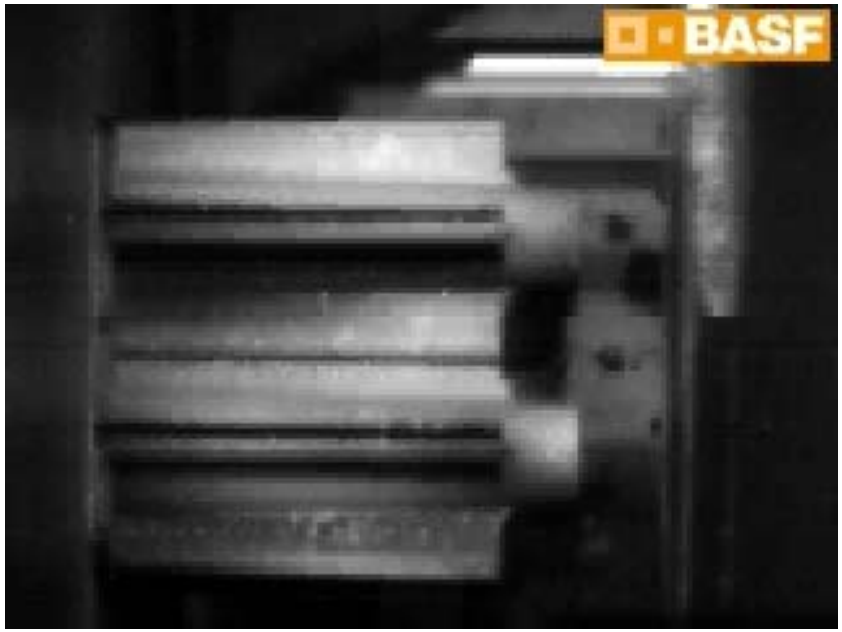
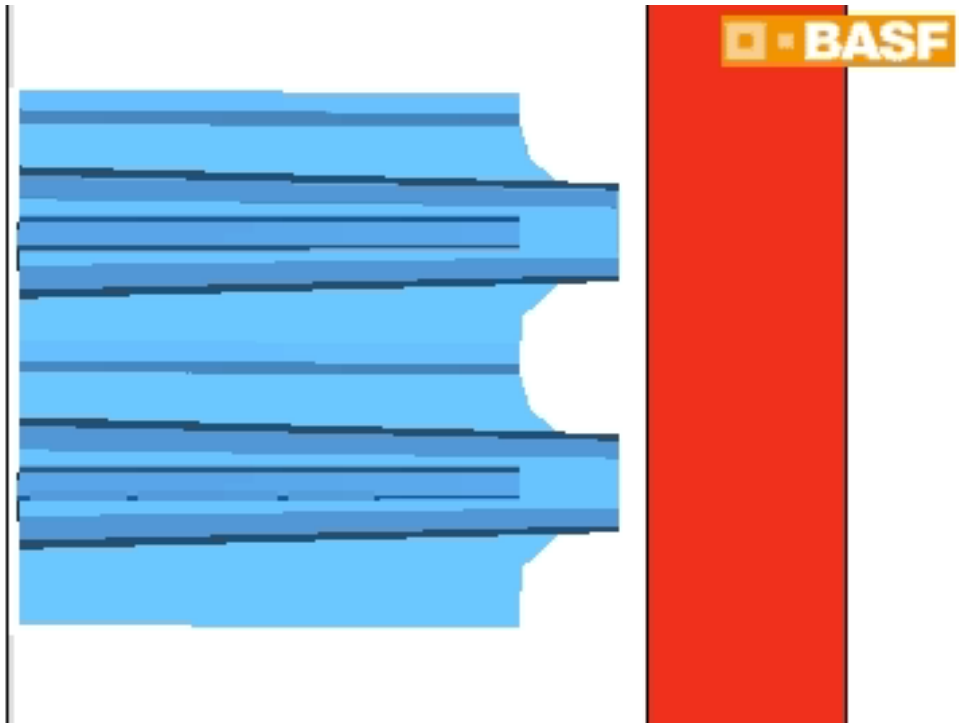
Plastic specimen under compression load
Simulation and Experiment





Test-specimen under compression load

Simulation and Experiment

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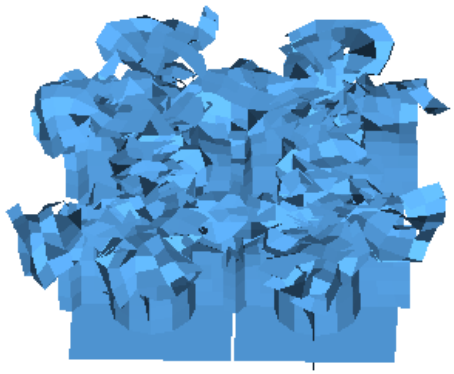
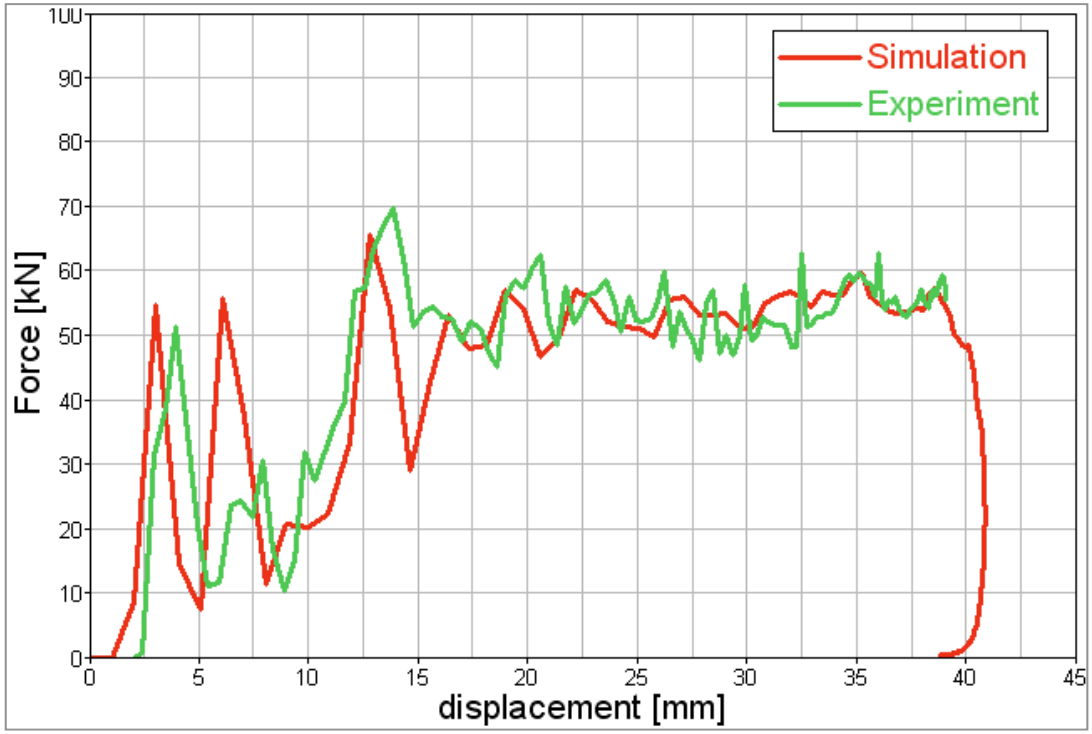
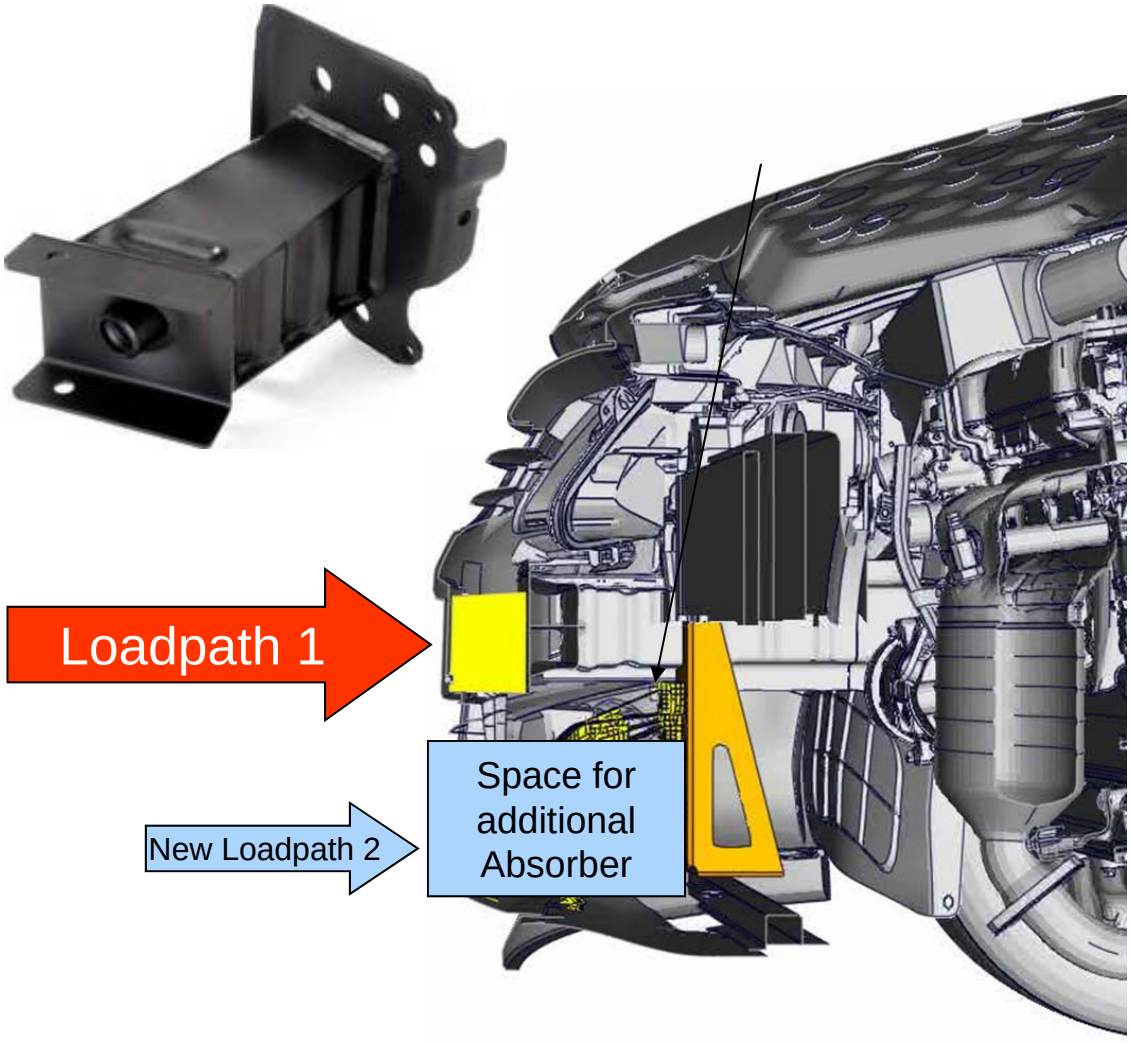
60 mm

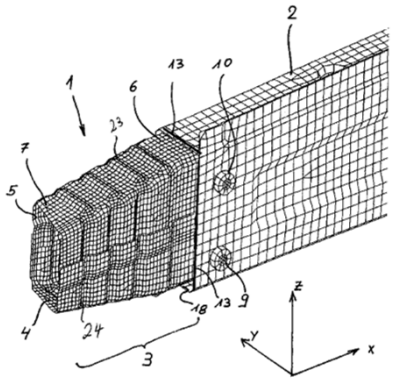




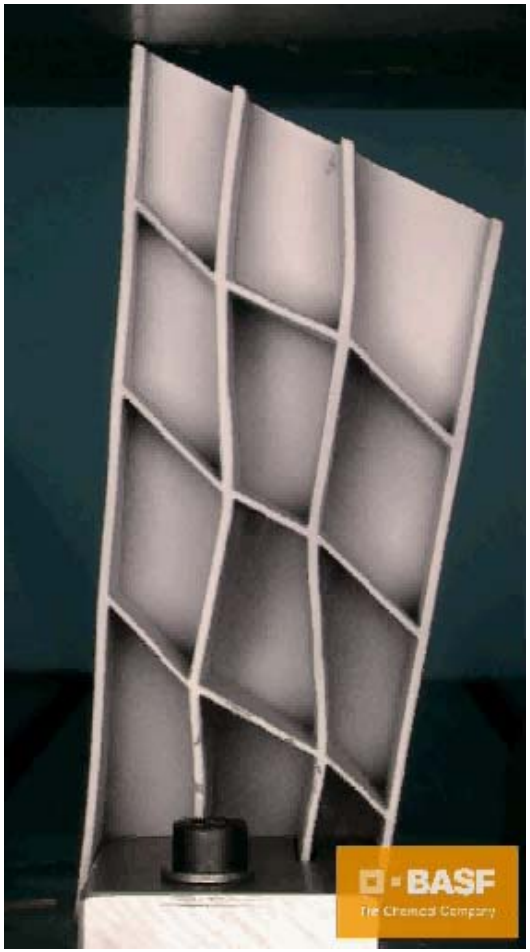
Lower Loadpath

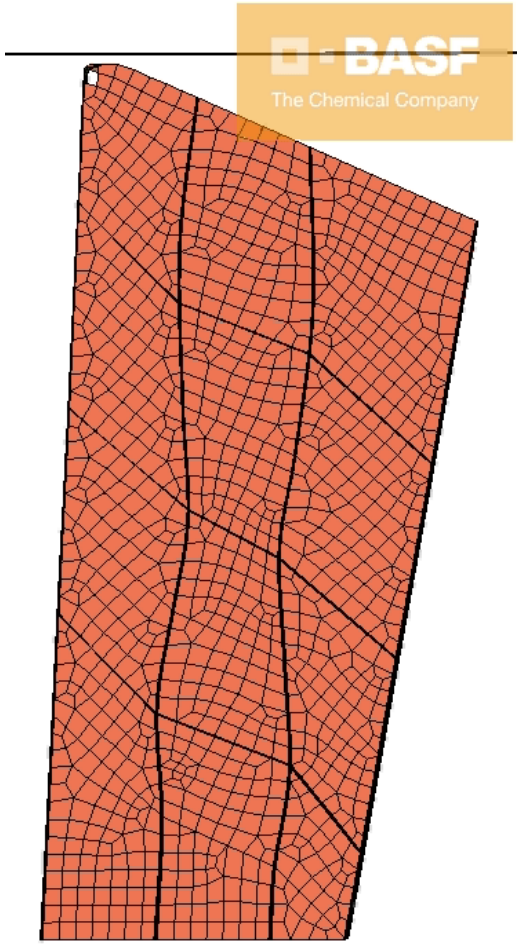


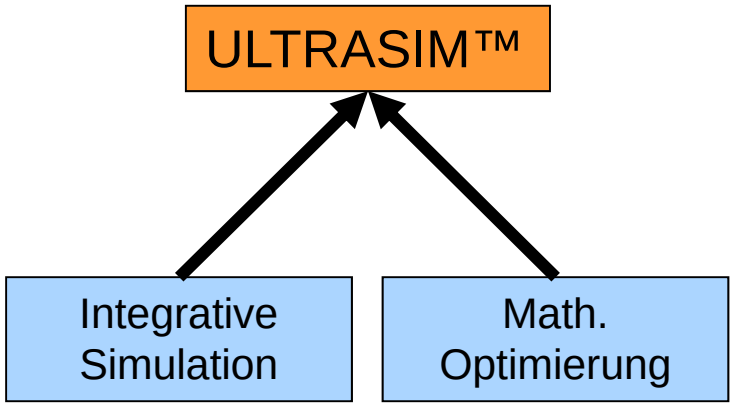
Traditional Metal Crashbox:

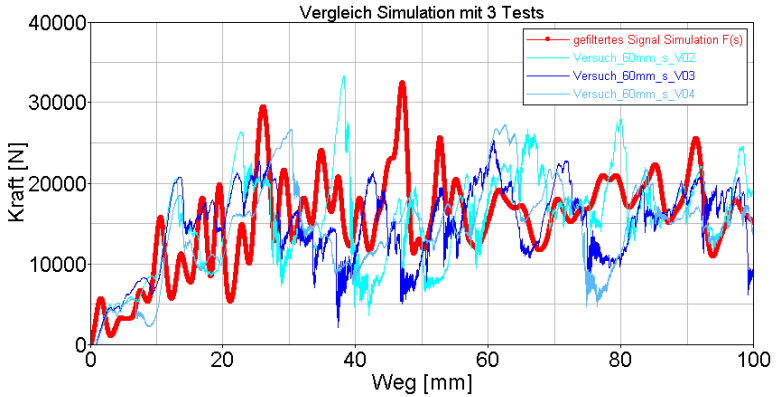


Videocomparison Absorber
→ enhanced ULTRASIM™ failure modelling

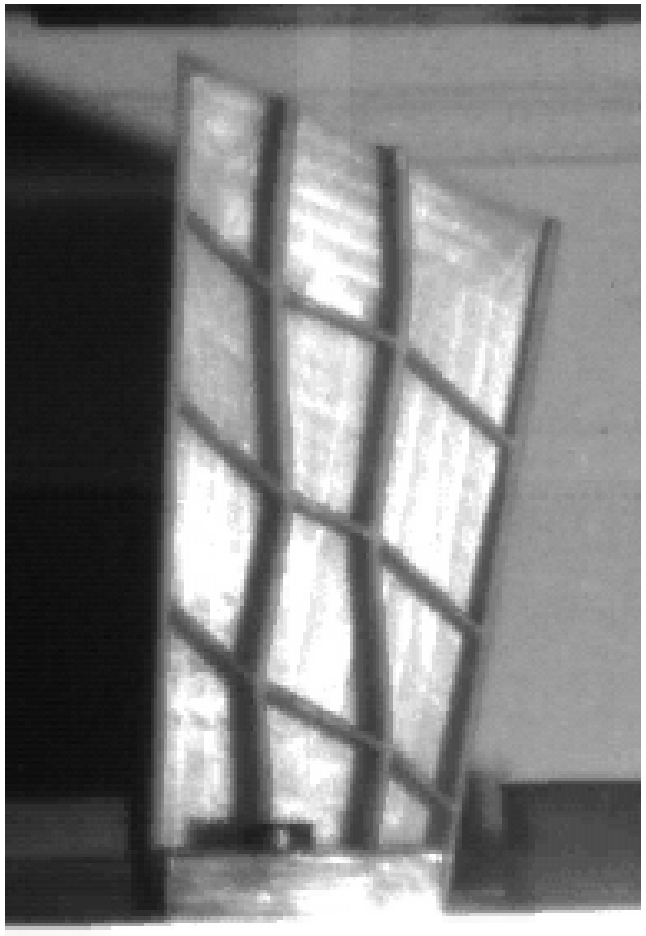




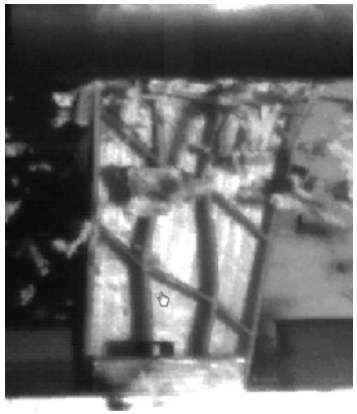




Dynamic Test Video



Drop mass:	60 kg
Drop height:	2.5 m
Drop Energy:	1.47 kJ
Duration:	≈ 25 msec
Displacement:	≈ 75 mm
Part weight:	~130gr



Parameter Optimization in CAE

Iterative process based on mathematical optimization methods

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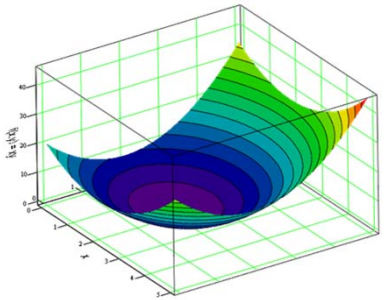
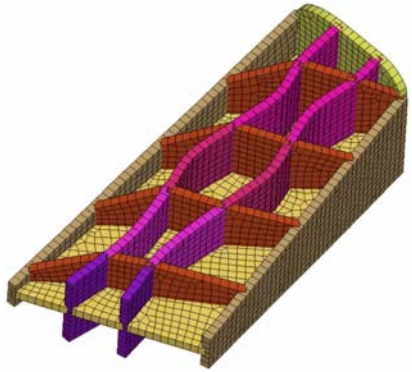


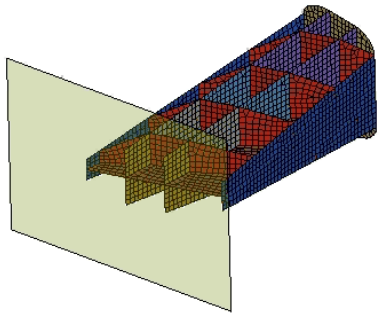
Design Variables



Mathematical Optimization Methods

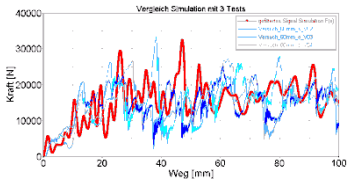
FE-Solver

System responses



Design parameters

- Wallthickness
- Contours
- Rib heights
- …



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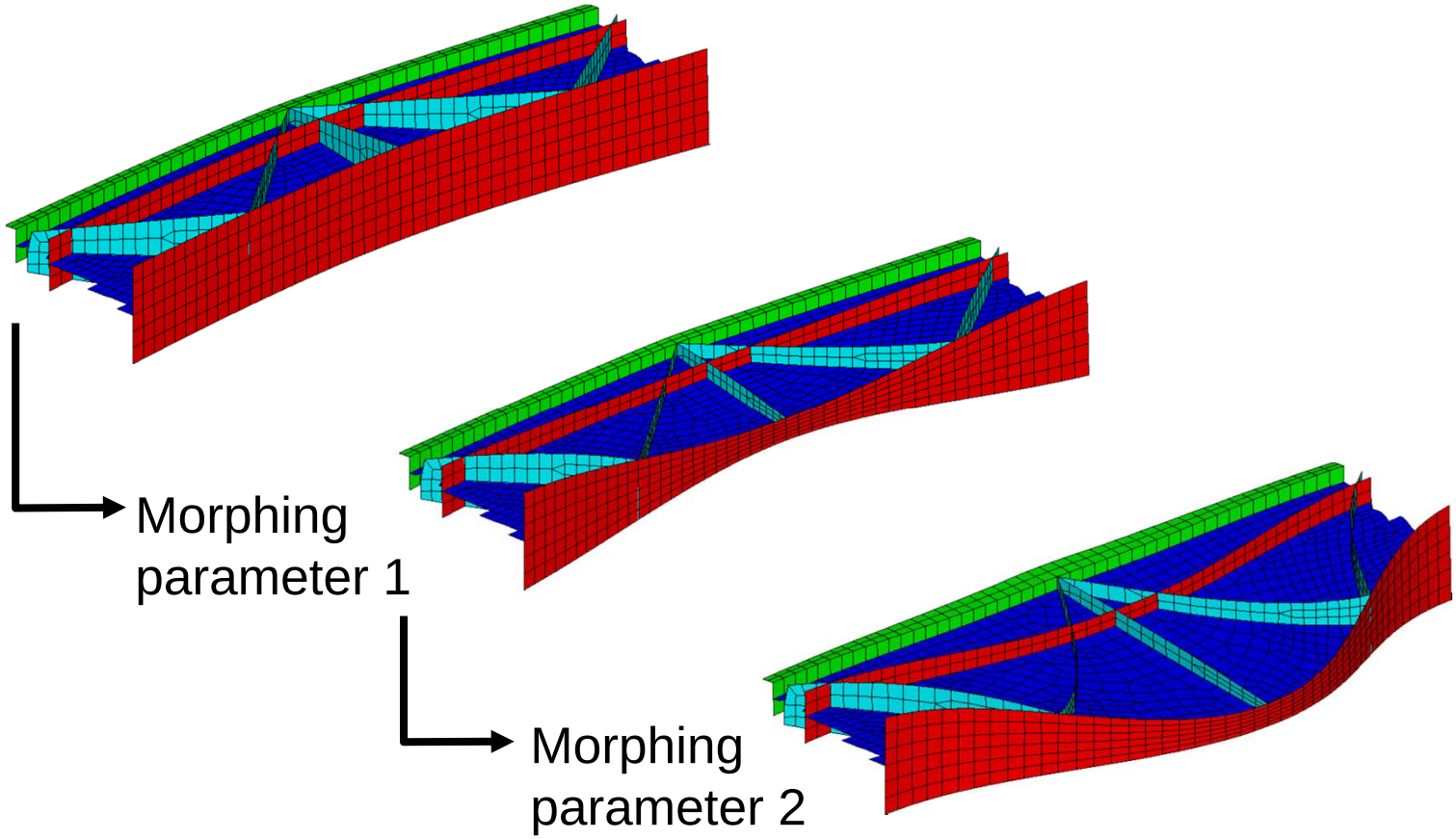
Shape Optimization using Morphing



Vision – Integrative Optimization
Standard Optimization and Integrative Approach

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Plastics granulate with glass fibers

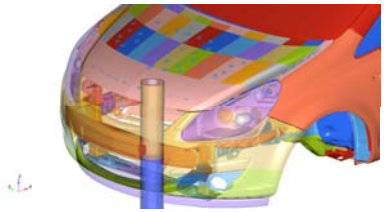
Injection molding process

Part

Assembly

Product in use

BASF ULTRASIM



- Crash
- Static Loads
- NVH
- Warpage
- …

Standard Approach

Integrative Optimization Approach

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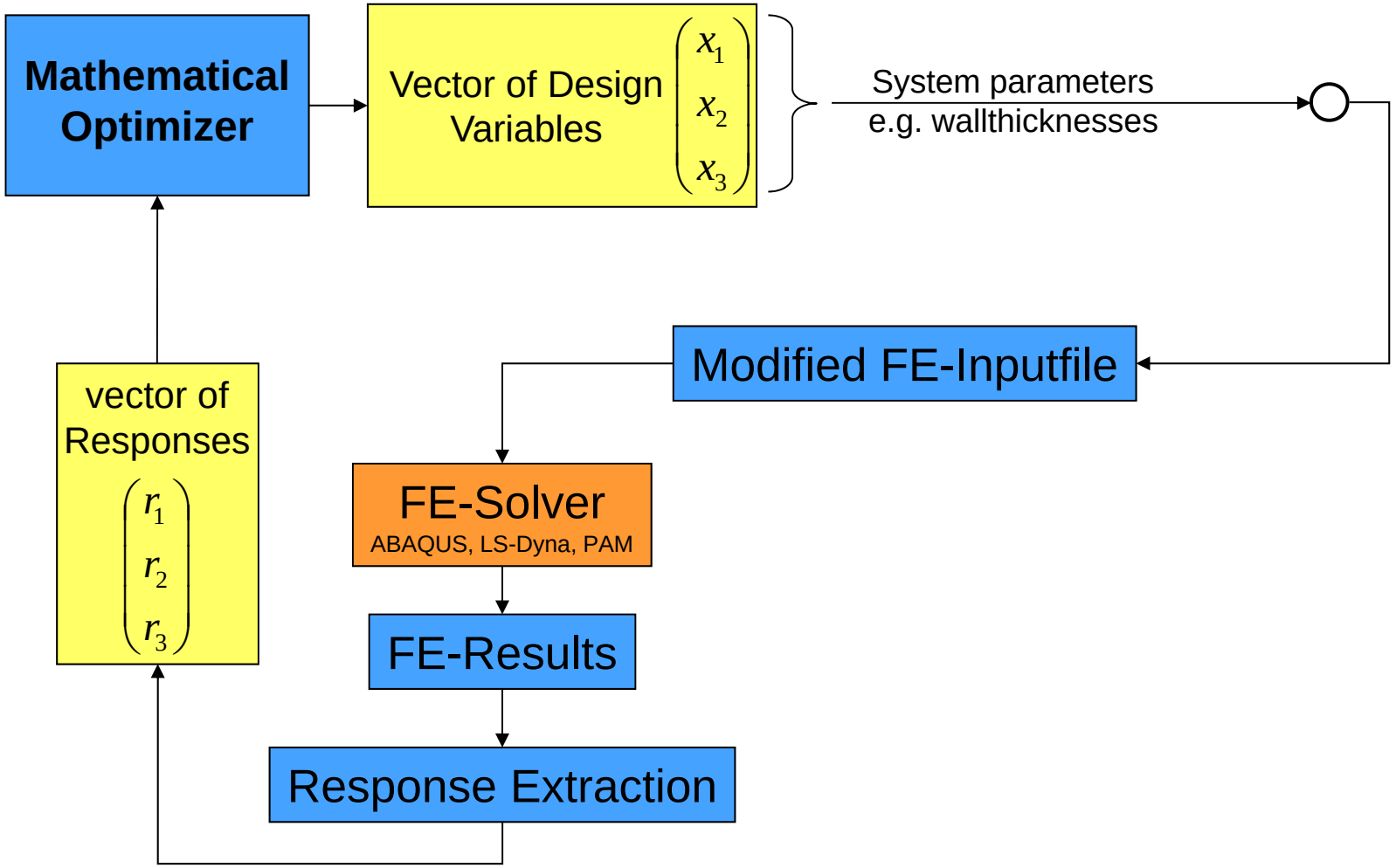
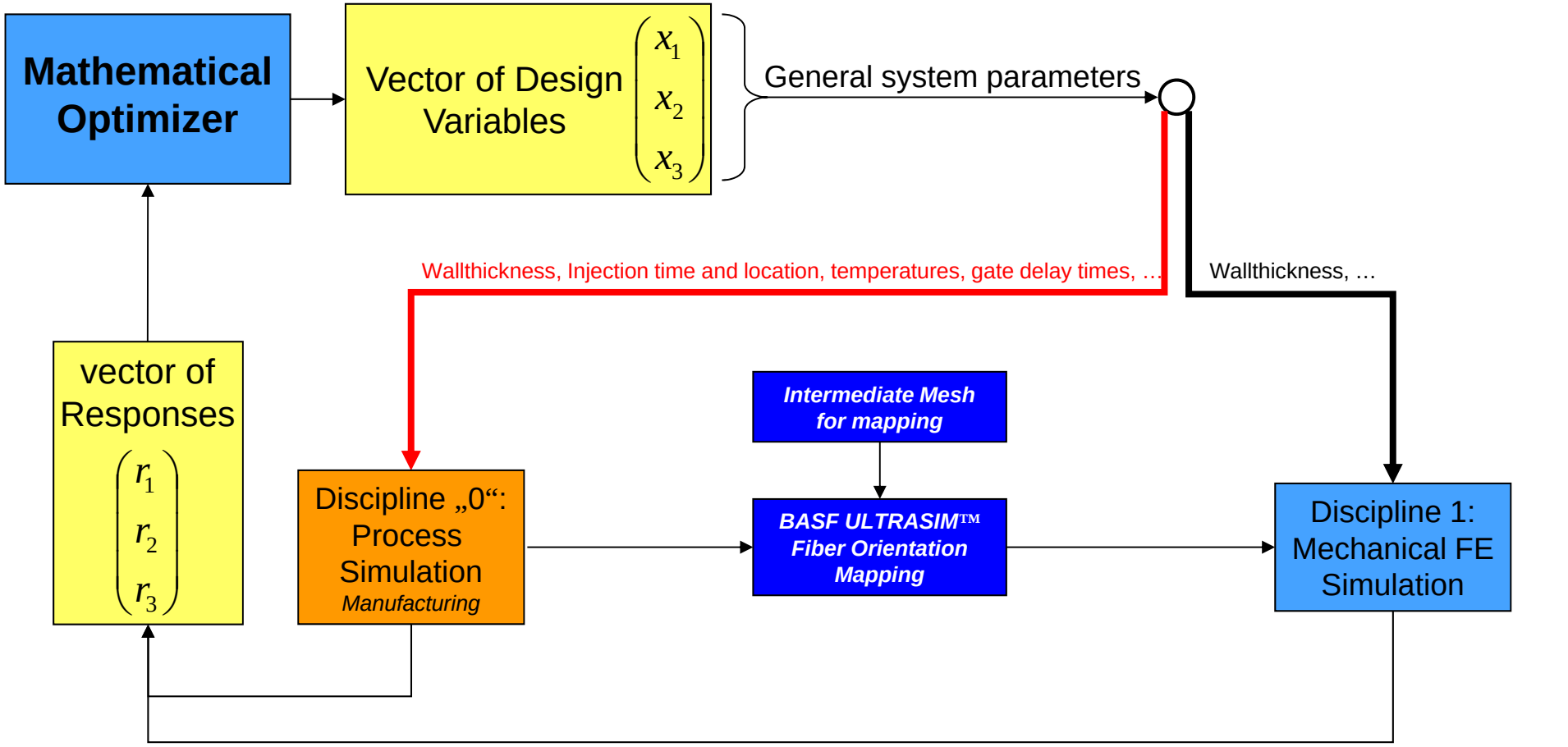
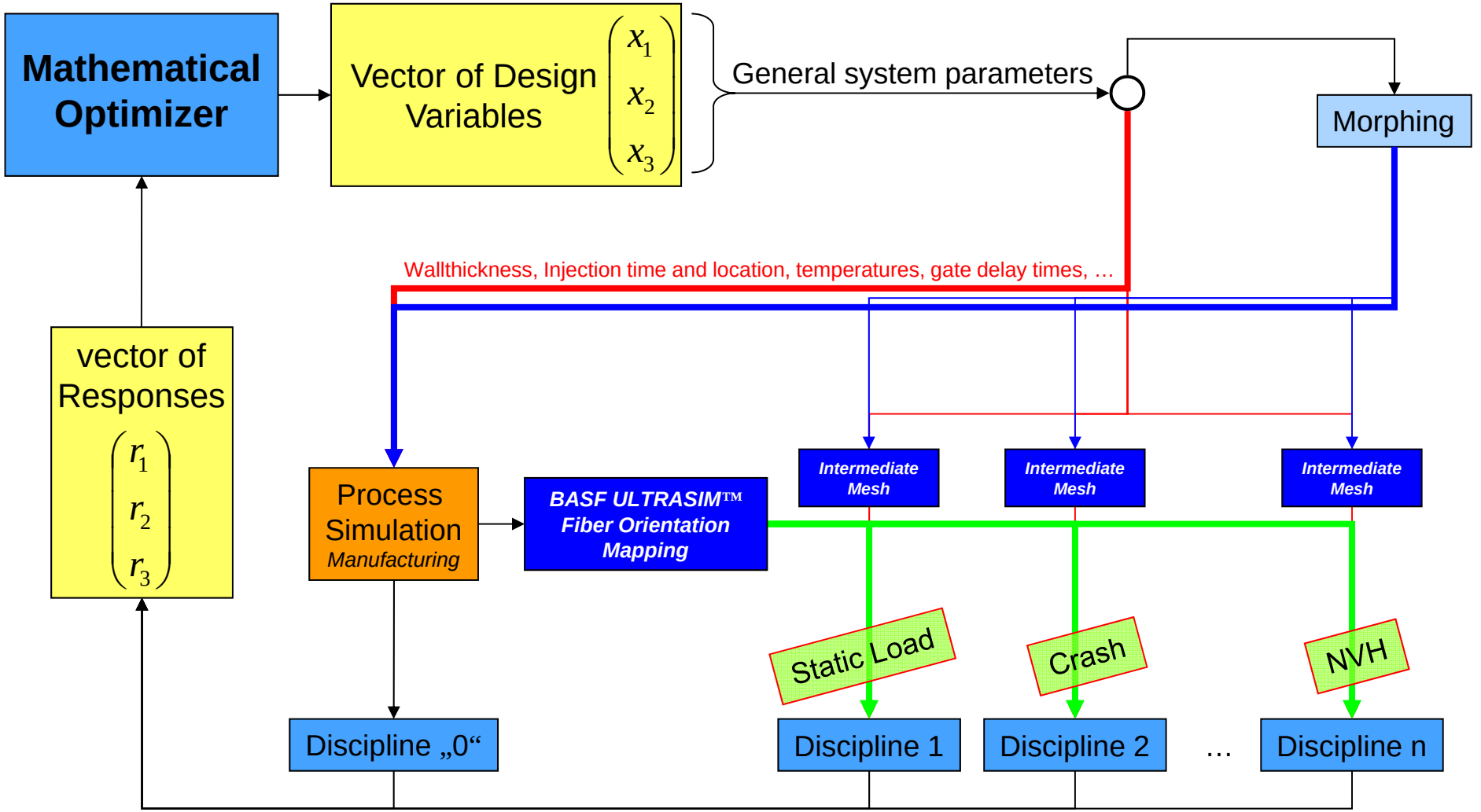
Workflow for Standard Optimization Approach



Workflow for Integrative Optimization Approach
Single disciplinary (without morphing)



Workflow for Integrative Optimization Approach
Multi disciplinary (with morphing)



Integrative Optimization Example

Filling, Warpage, Impact, Static Load, Shape Optimization by Morphing
LS-OPT, MOLDFLOW, LS-Dyna, ANSA, ABAQUS

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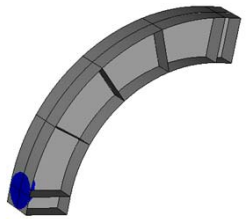
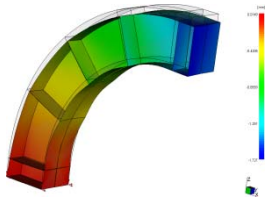
Integrative Optimization

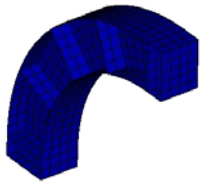
- Filling



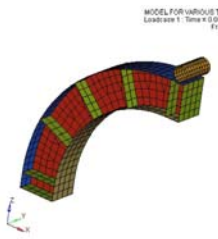
- Warpage

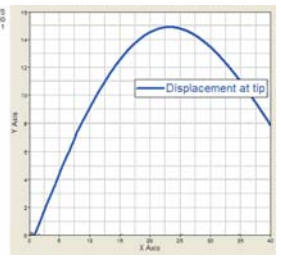


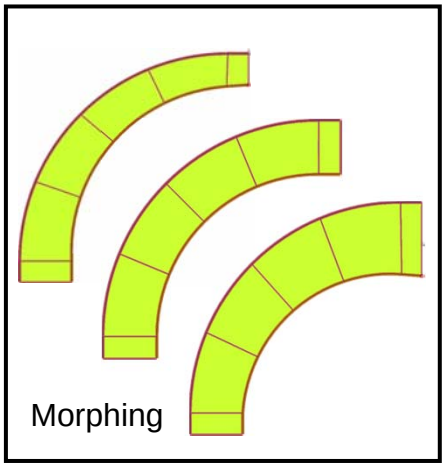
- Static Load



- Impact







Summary

- More and more structural vehicle parts are made of anisotropic polymers
- Injection molding process determines fiber orientation and thus local mechanical properties
- ULTRASIM™ approach has been applied for numerous applications
  - Initially: Lower bumper support for pedestrian protection
  - Extended to engine mounts and seats
- Simulation results show excellent correlation with physical tests
- Extended ULTRASIM™ failure model is crucial for the accurate design of energy absorbing structures
- Integrative Optimization Approach allows simultaneous optimization of process and mechanical characteristics