LS-DYNA Anwenderforum
25. September 2013

Filderstadt bei Stuttgart

Die Nutzung von LS-DYNA und LS-OPT bei der Entwicklung von Bauteilen aus thermoplastischen Kunststoffen

Andreas Wüst – BASF SE

Co-Autoren:

Stefan Glaser
Torsten Hensel
Andreas Wonisch
Daniel Fertig
Sebastian Ebli

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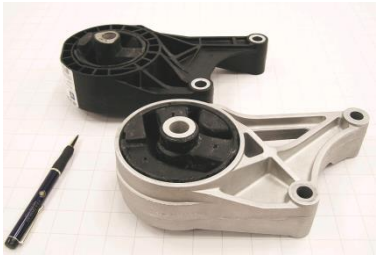
The Chemical Company

Inhalt

- Motivation: Faserverstärkte Thermoplaste
  - Bauteilentwicklung - Integrativer Ansatz
- Beispiele
  - Lower Bumper Structure
  - Energy Absorber
  - Motorträger
  - Optimierung des Anspritzpunkts
  - Optimierung der Faserorientierungsvorhersage
  - Optimierung der Planarität eines Bauteilflansches
- Integrative Optimierung
- Ausblick: Endlosfaserverstärkte Thermoplaste
- Zusammenfassung, Ausblick

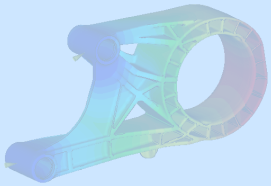
Ganzheitlicher Blick auf die Bauteilentwicklung - Integrativer Ansatz

Herstellprozess

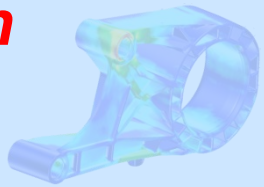


Nutzung

Prozess Simulation

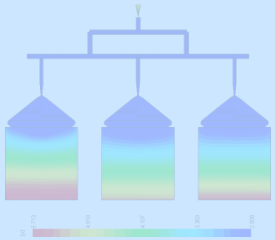


Struktur Simulation

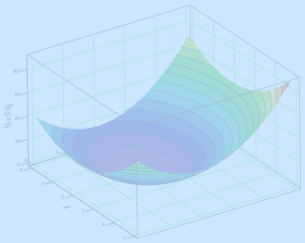


Integrative Simulation ULTRASIM®

Numerische Optimierung

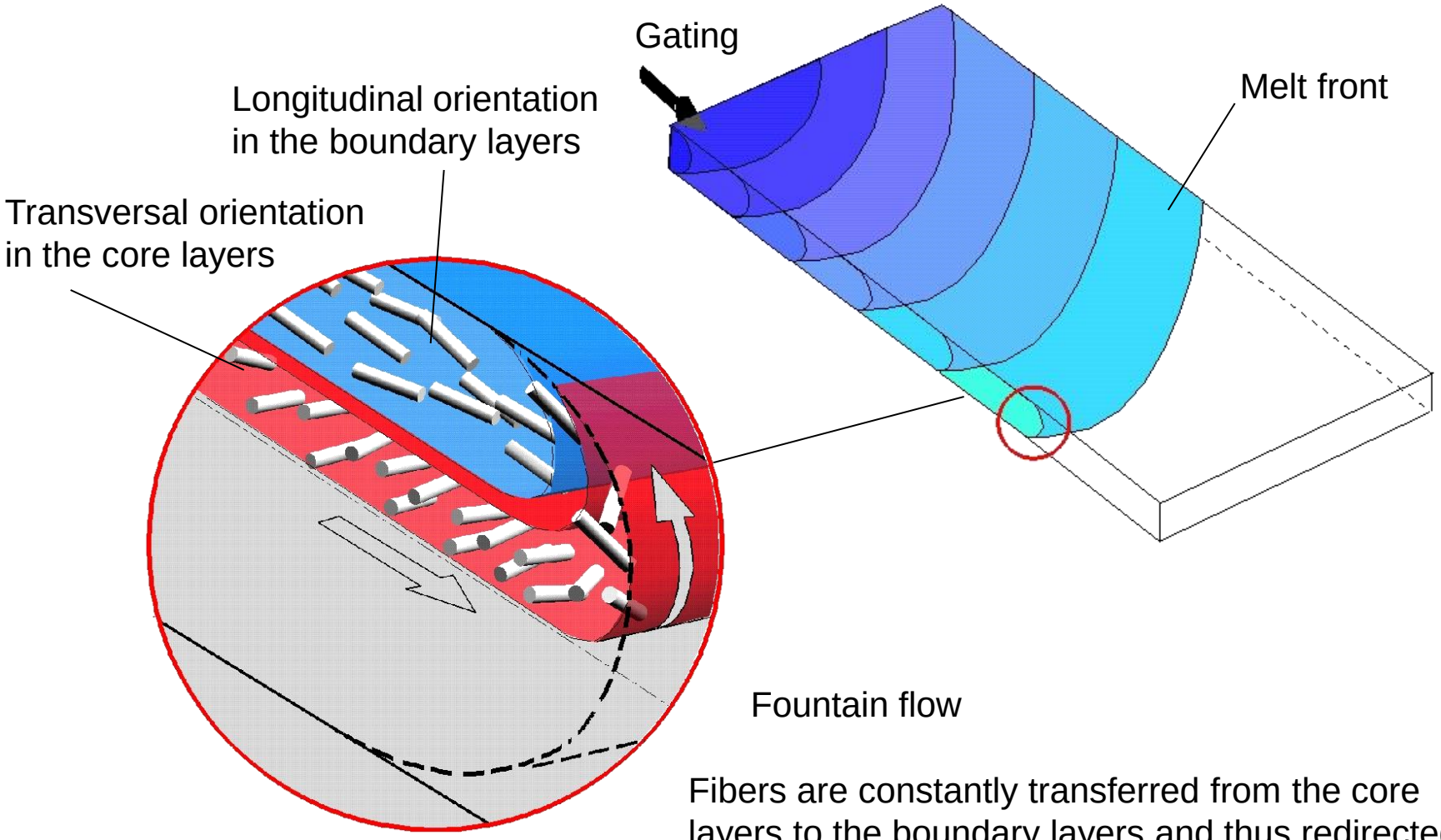


Numerische Optimierung



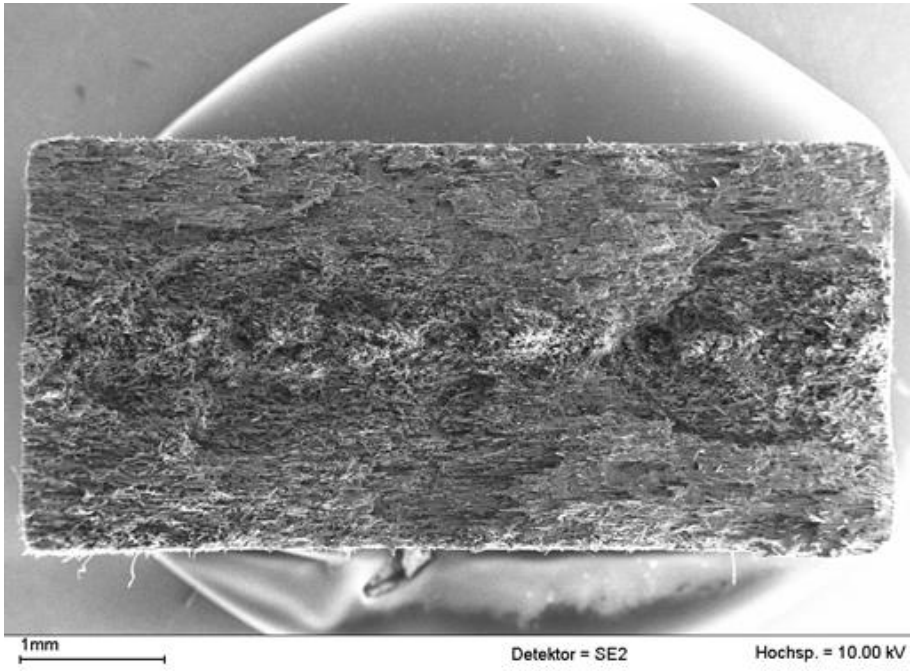
Integrative Optimierung ULTRASIM®

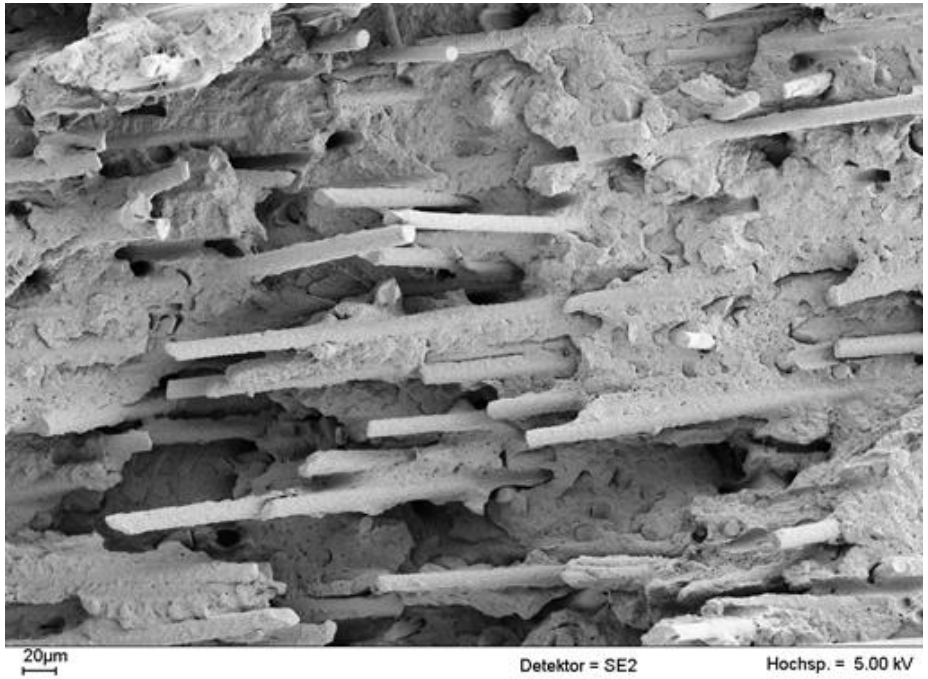
Evolution of Fiber Orientation in Mould Filling Process



Fibers are constantly transferred from the core layers to the boundary layers and thus redirected

Cross section of a plastic part, microscopic view
REM Photo of glassfibers in polymer matrix

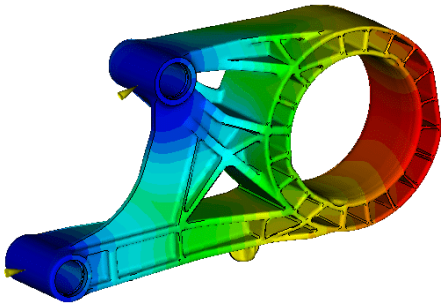




Integrative Simulation ULTRASIM®

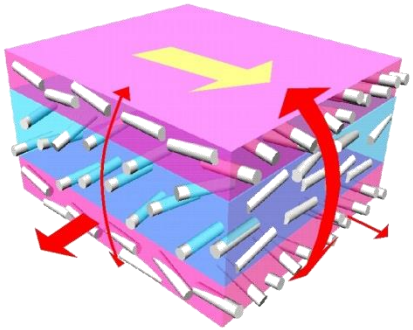
for short fiber reinforced thermoplastics

Process

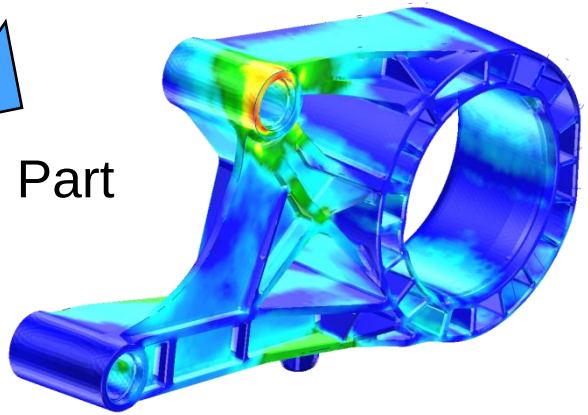


Measurement

Material



Part



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

Integrative Simulation ULTRASIM® for Continous Fiber Reinforced Plastics

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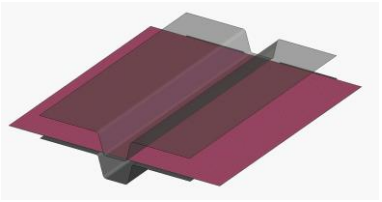
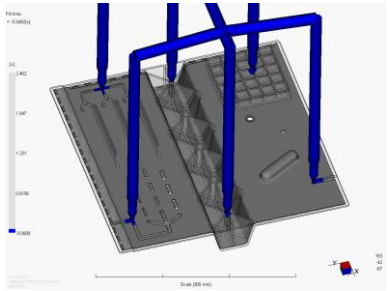
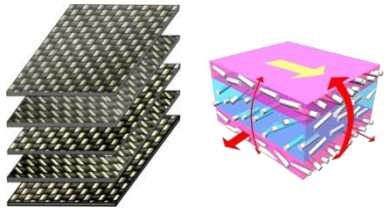
Process

Draping / Overmolding



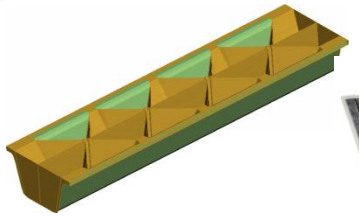


Material



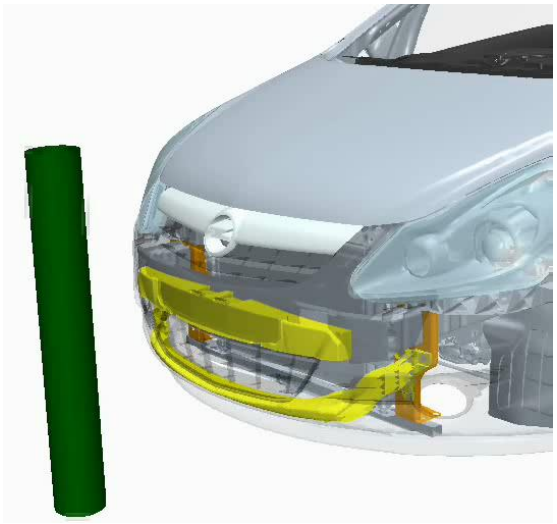
Measurement

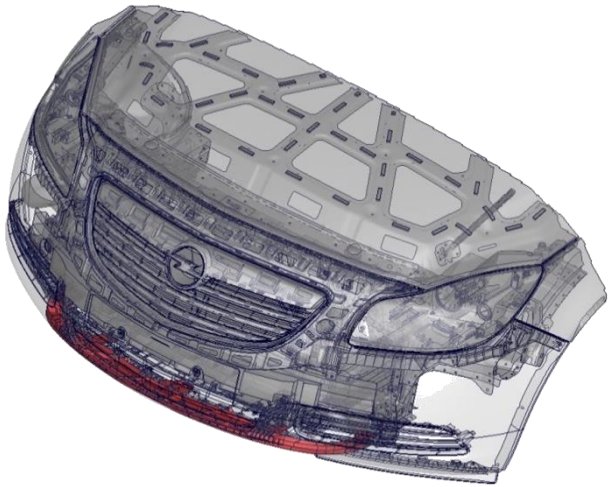
Part



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

Lower Bumper Support



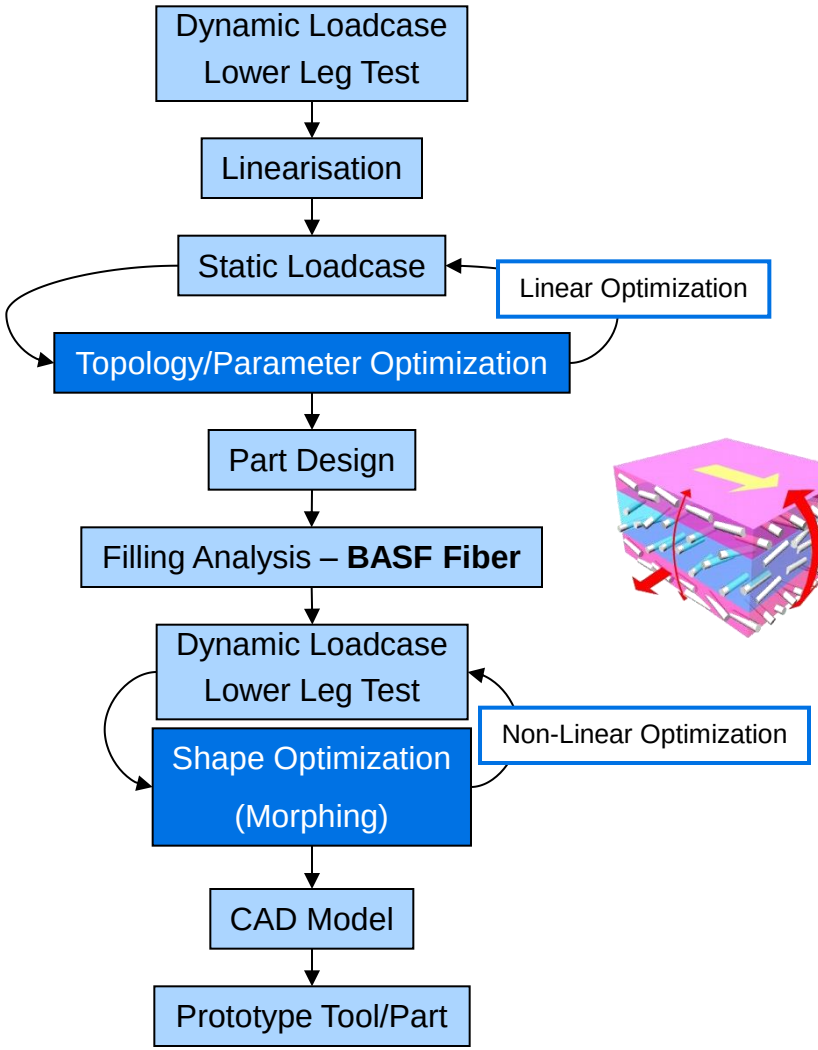


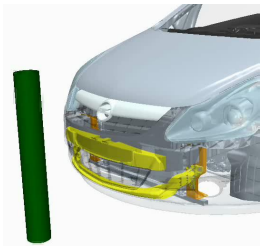
Development targets

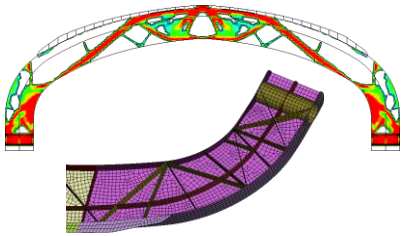
- Optimized, ribbed plastic structure to provide sufficient support for lower leg during the impact
- Needs to fail in a controlled manner during RCAR impacts in order not to damage other components
- Low weight at reasonable costs

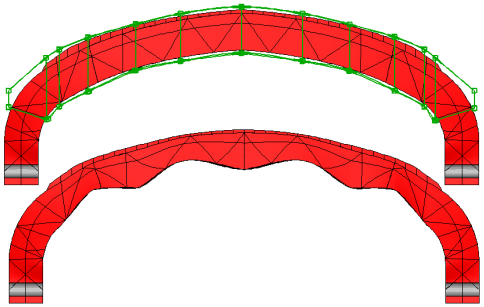
Optimization in CAE

Example of optimization types used in an LBS project









Optimization in CAE
Linearization of dynamic loadcase: Lower Leg Test

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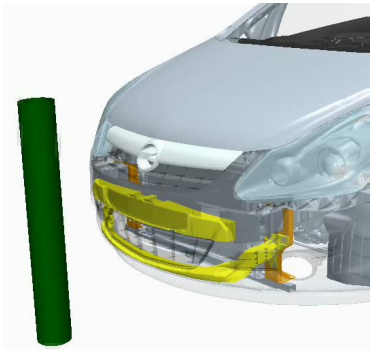
Real World



Linear World

Static forces applied at different positions

Loadcase 1: y = 0
Loadcase 2: y = -50
… ….

Different impact positions in Lower Leg Test lead to different loadcases

Optimization in CAE

OptiStruct for designing a reasonable rib pattern
Selected solutions of Topology Optimization

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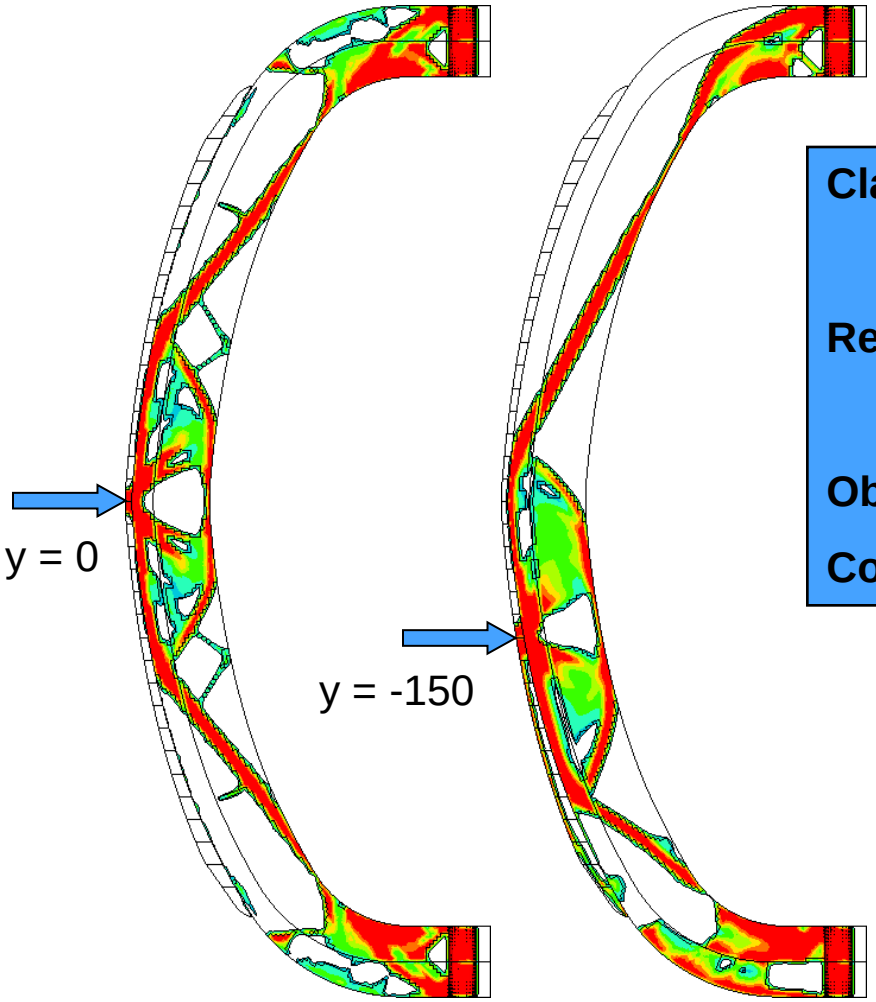


Classical Topology Optimization Problem Setup

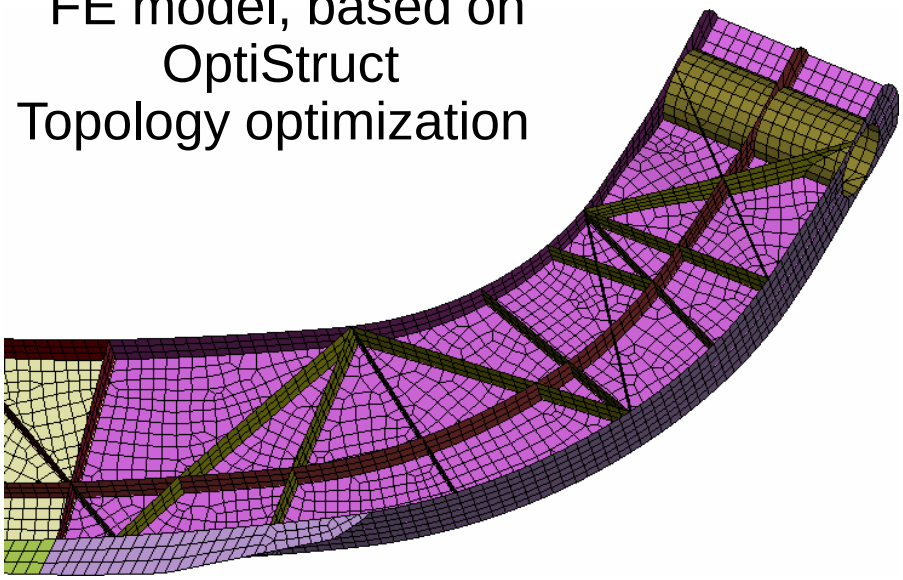
Responses:	**1. Compliance WCOMP**
	2. Volume Fraction VFRAC
Objective:	**Minimize weighted compliance**
Constraint:	**VFRAC < 0.3**

OptiStruct gives clear hints for the rib pattern!

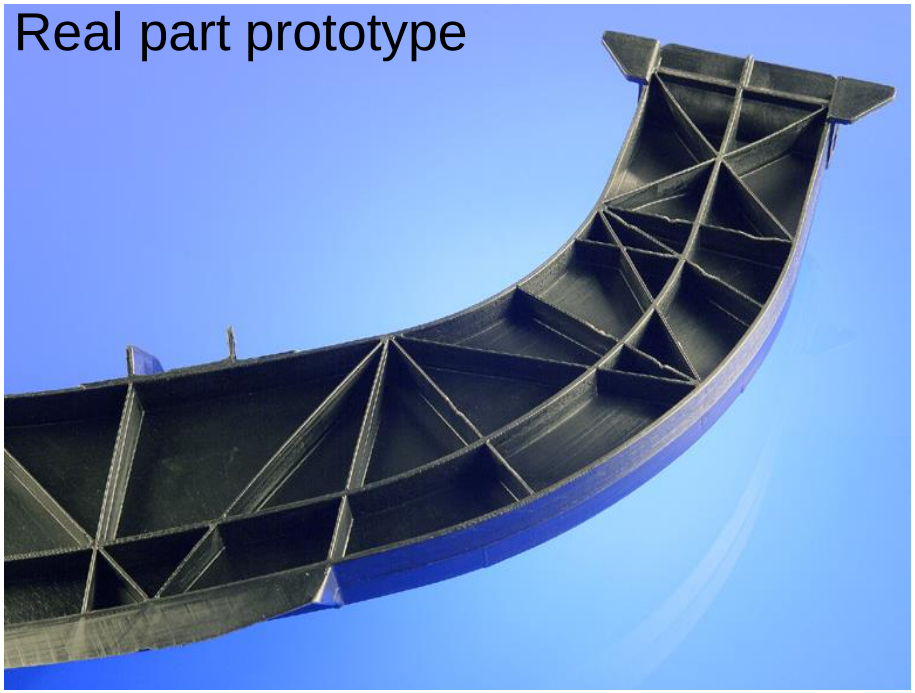
Optimization in CAE

OptiStruct for designing a reasonable rib pattern
Prototype realized

FE model, based on
OptiStruct
Topology optimization



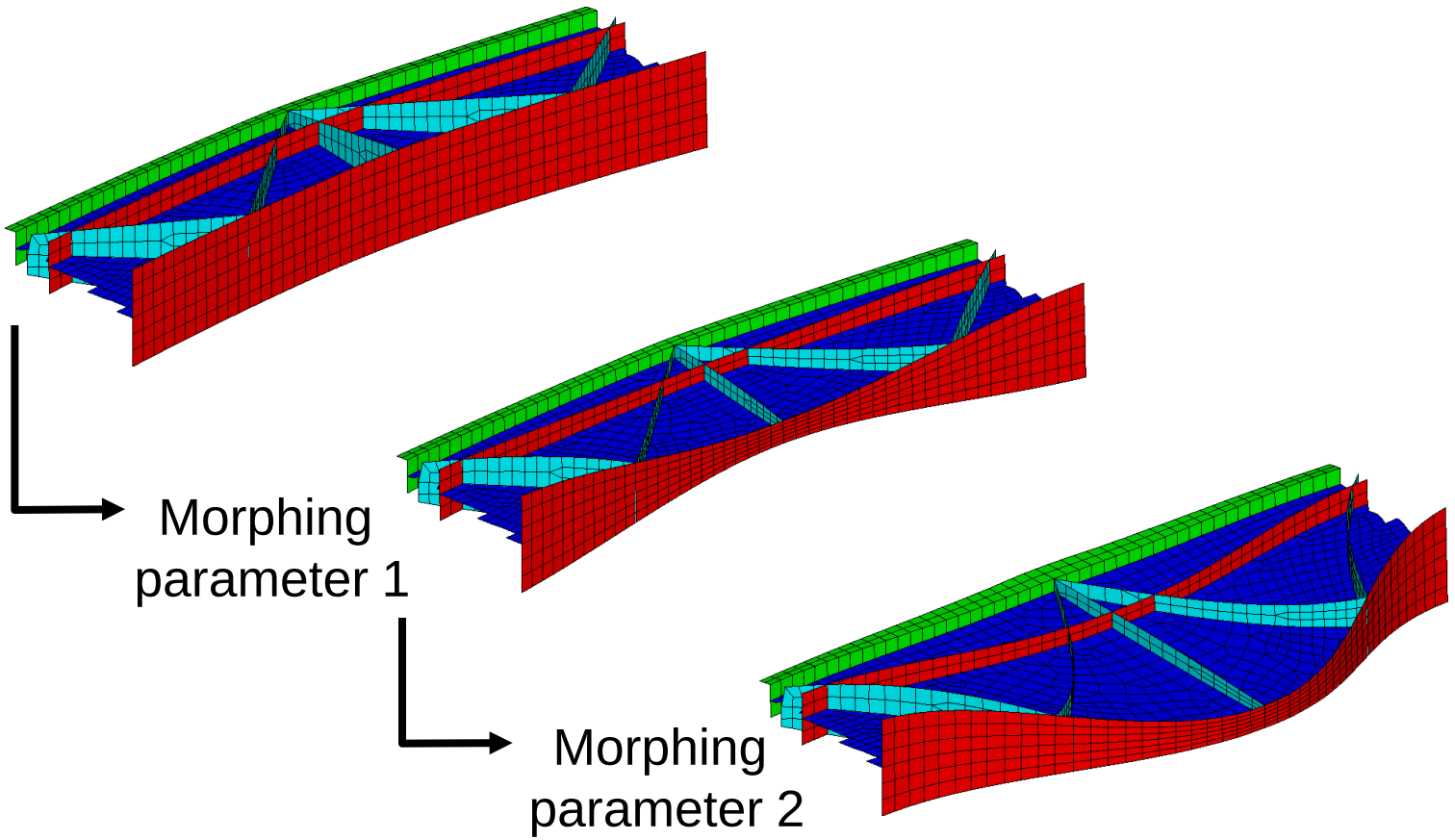
Real part prototype



Part showed very good behavior in pedestrian protection test

Shape Optimization using Morphing

Goal: reduce weight without significantly losing performance



Optimization in CAE

Nonlinear Shape Parameter Optimization

Morphing of the part‘s rear edge: selected shape combinations

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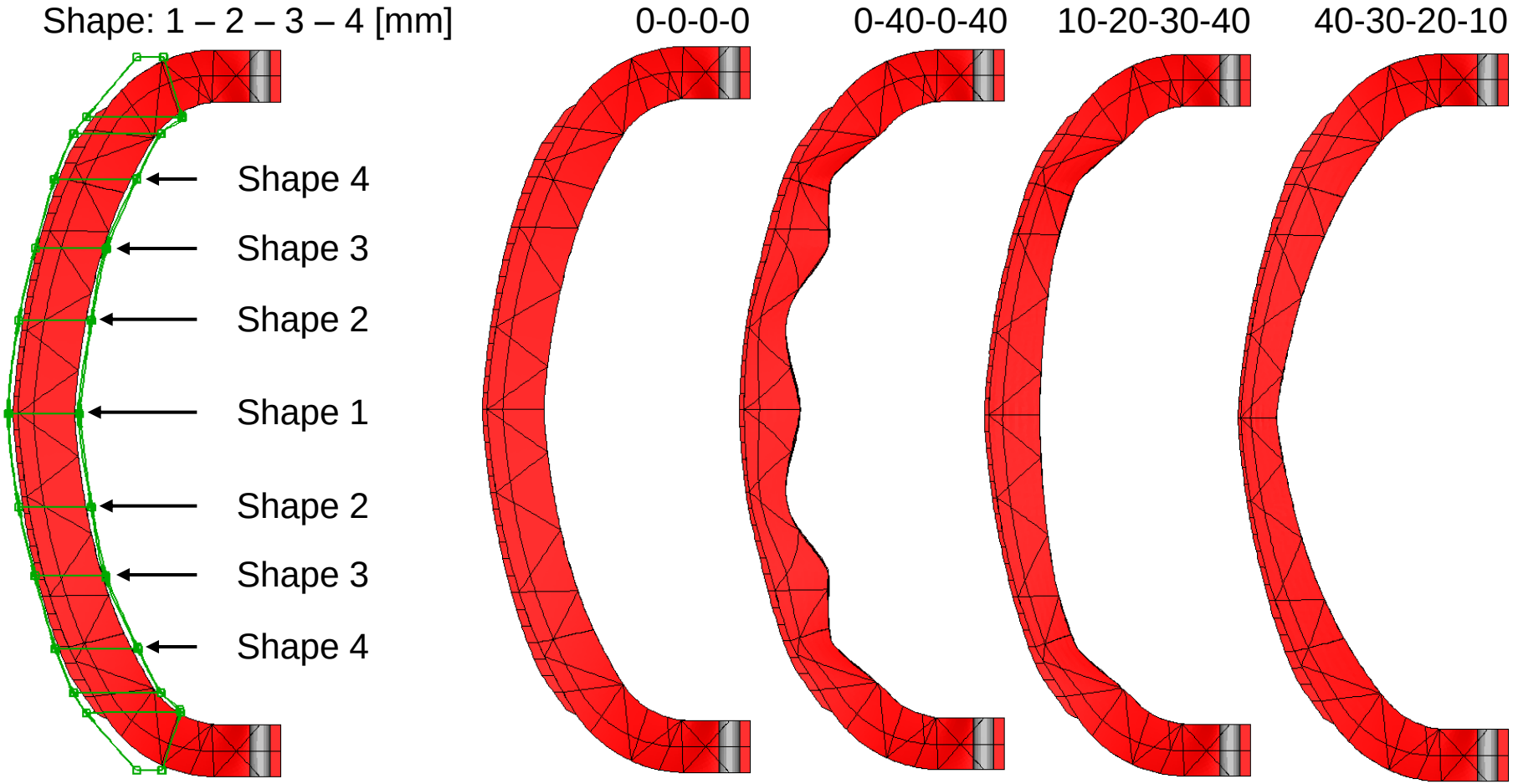
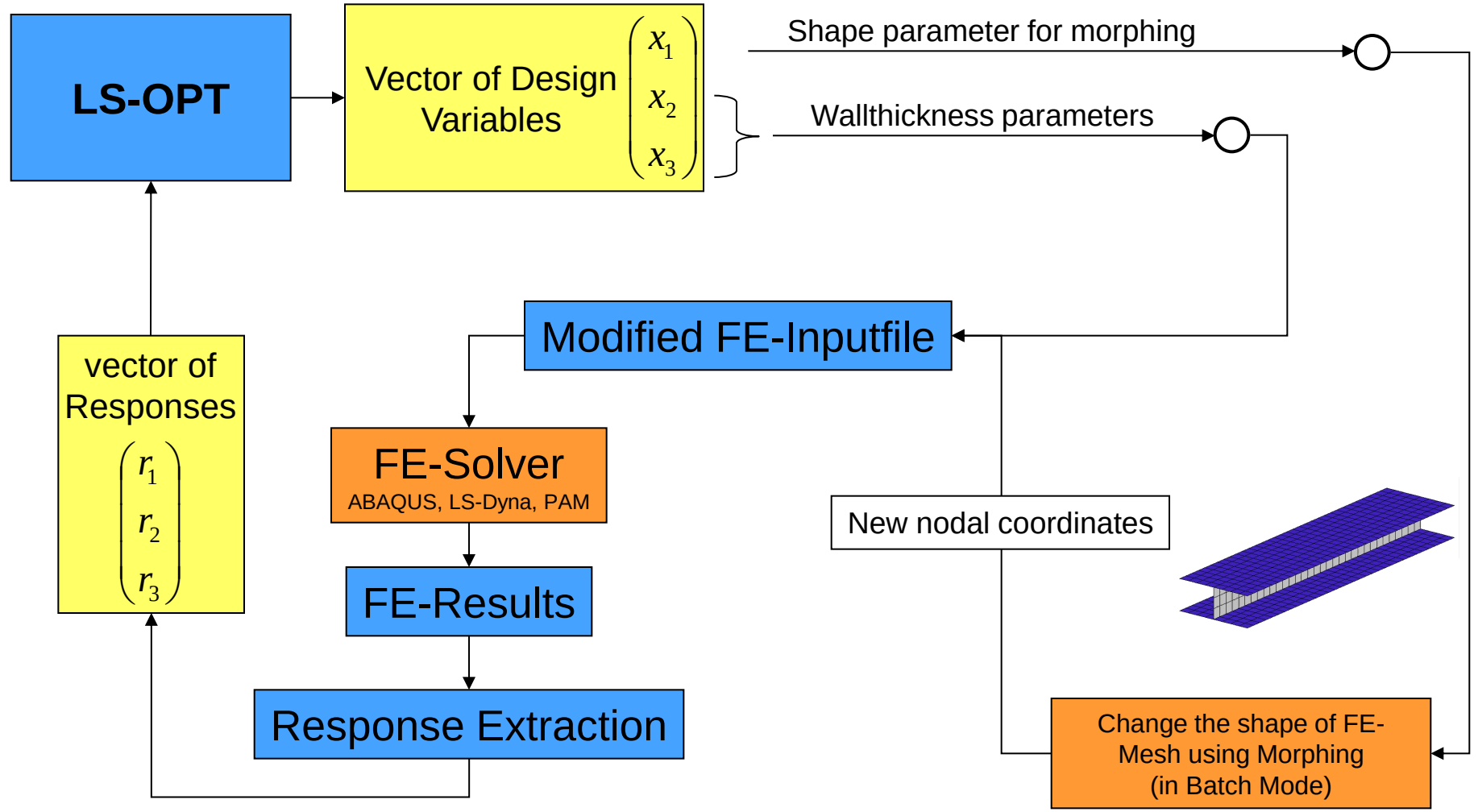
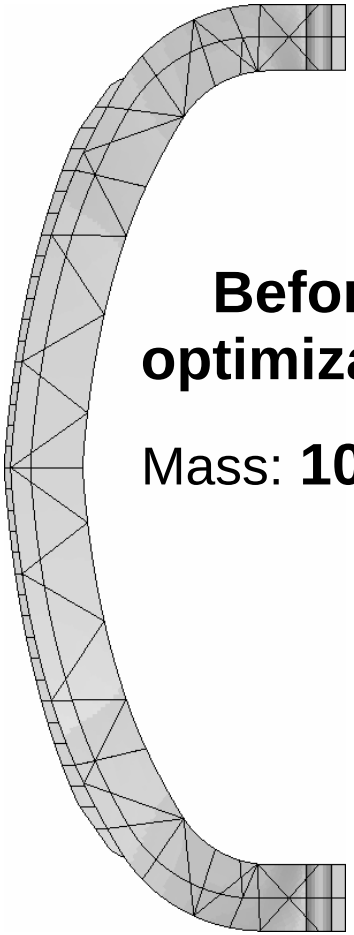


Part Development II – Detailling
Implementation of Morphing

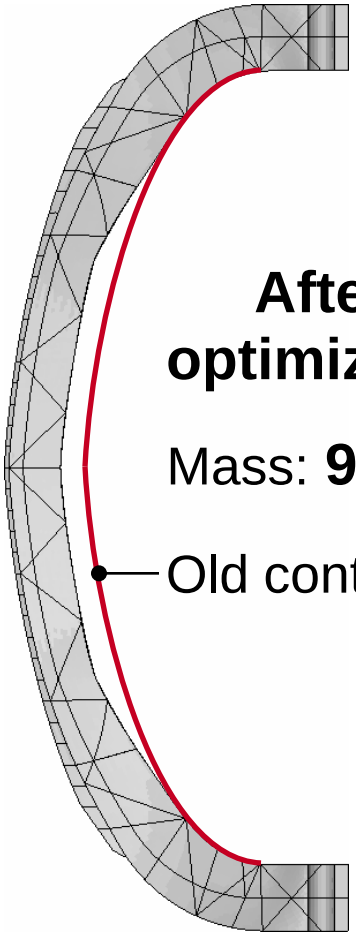


Optimization in CAE
Nonlinear Shape Optimization - Result



Before optimization

Mass: **100%**



After optimization

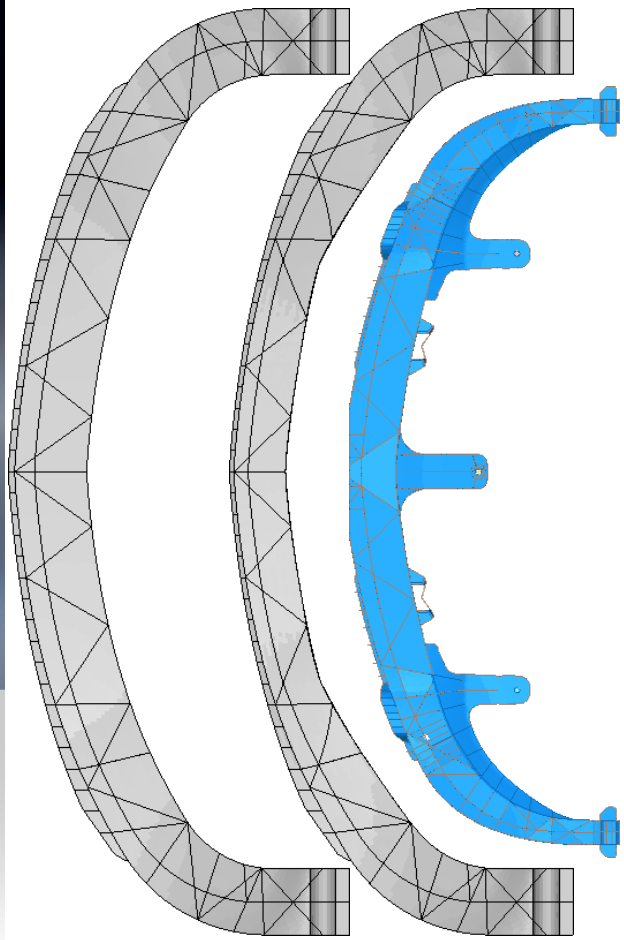
Mass: **93%**

Old contour

Shape Results
(0-40 mm)

1: 31.0 mm
2: 30.5 mm
3: 32.0 mm
4: 10.1 mm

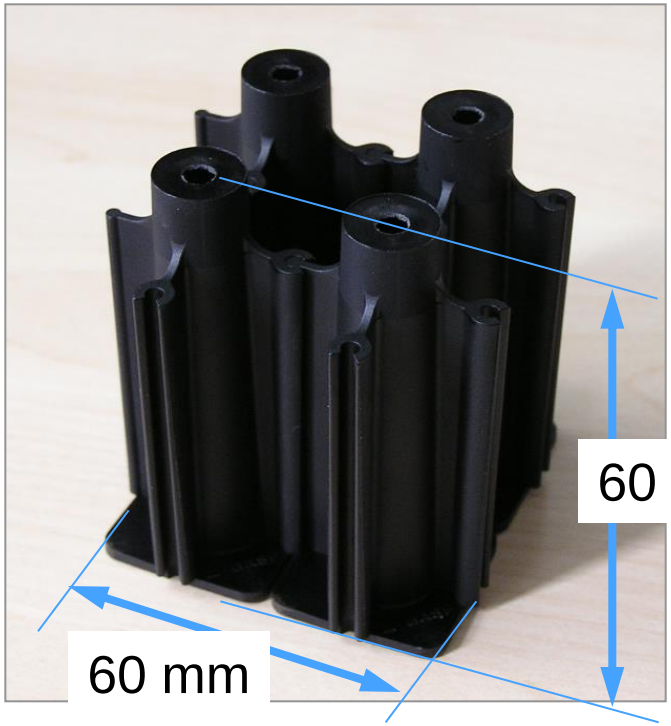
Insignia LBS – Ultramid® B3WG6CR

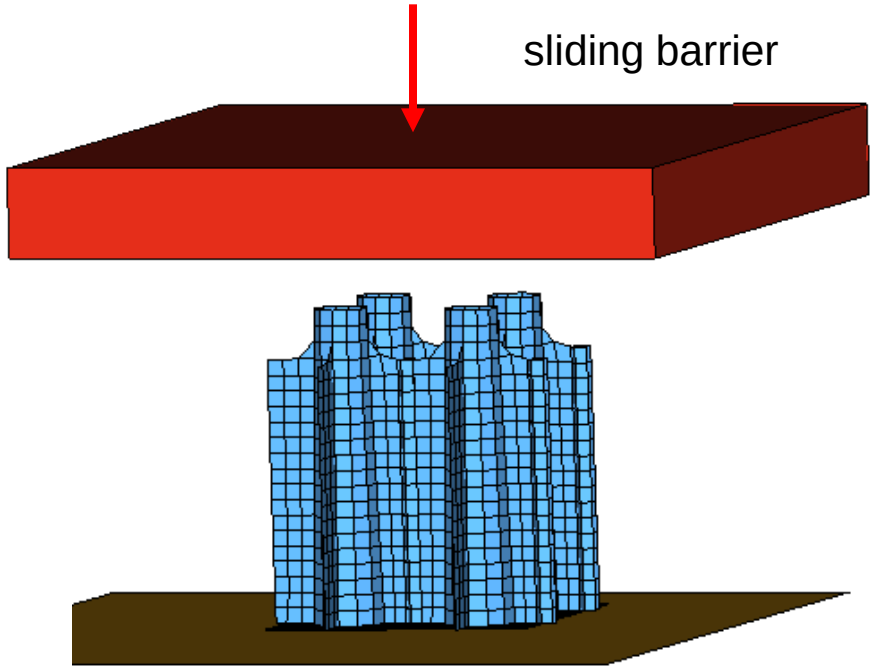


Example for an Energy absorbing plastics structure – BASF Test Specimen for compression load Needed for Calibrating Failure Simulation Parameters

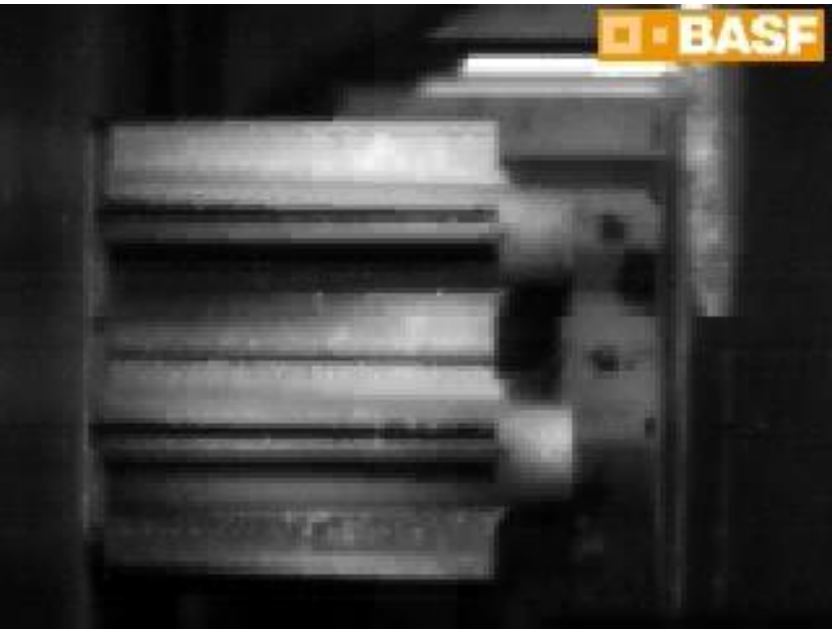
Specimen is designed for controlled collapse

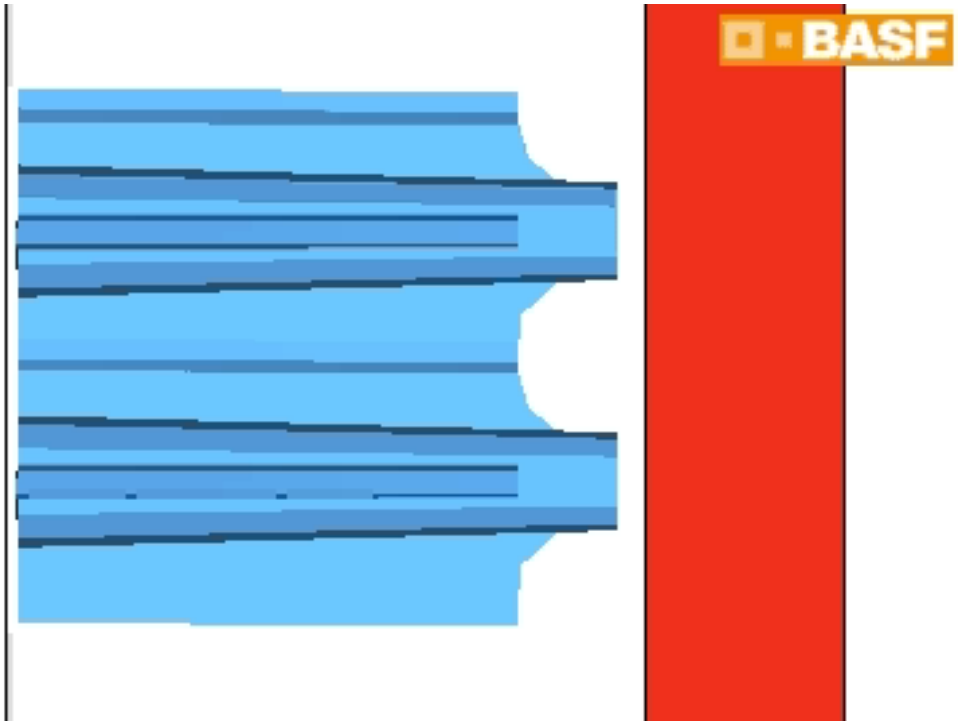
Material: B3WG6 CR (PA6 GF30%)





Plastic specimen under compression load
Simulation and Experiment

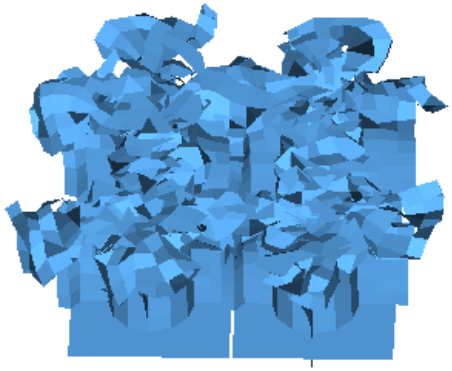


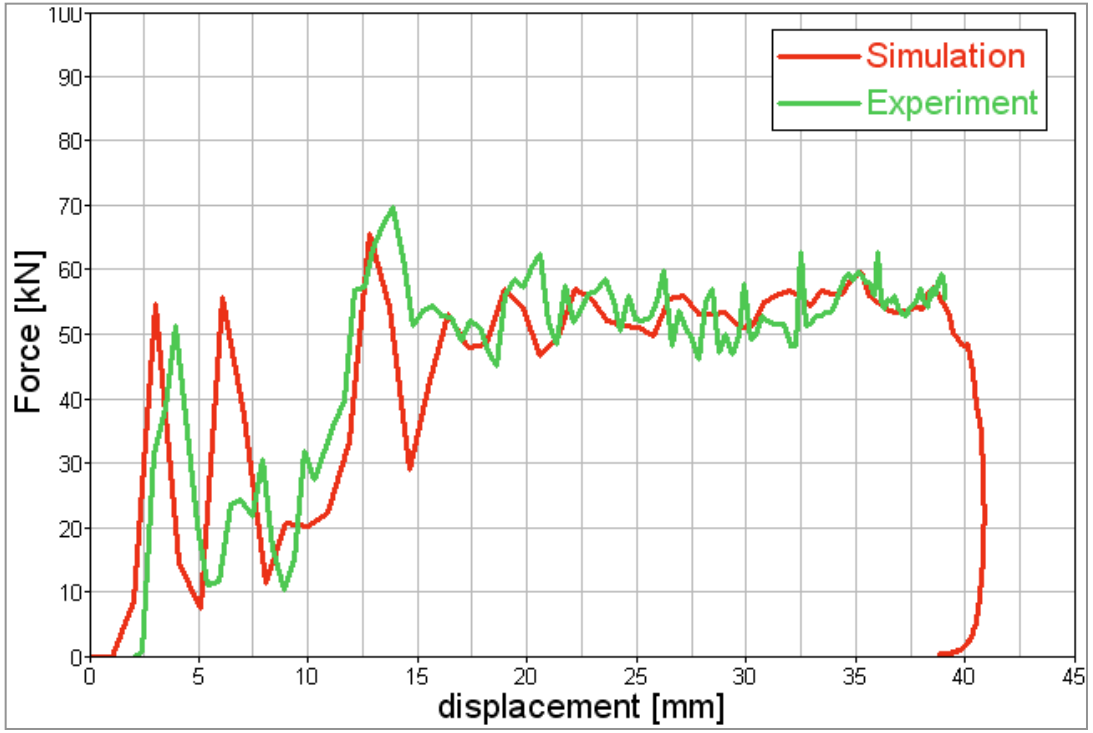


Test-specimen under compression load

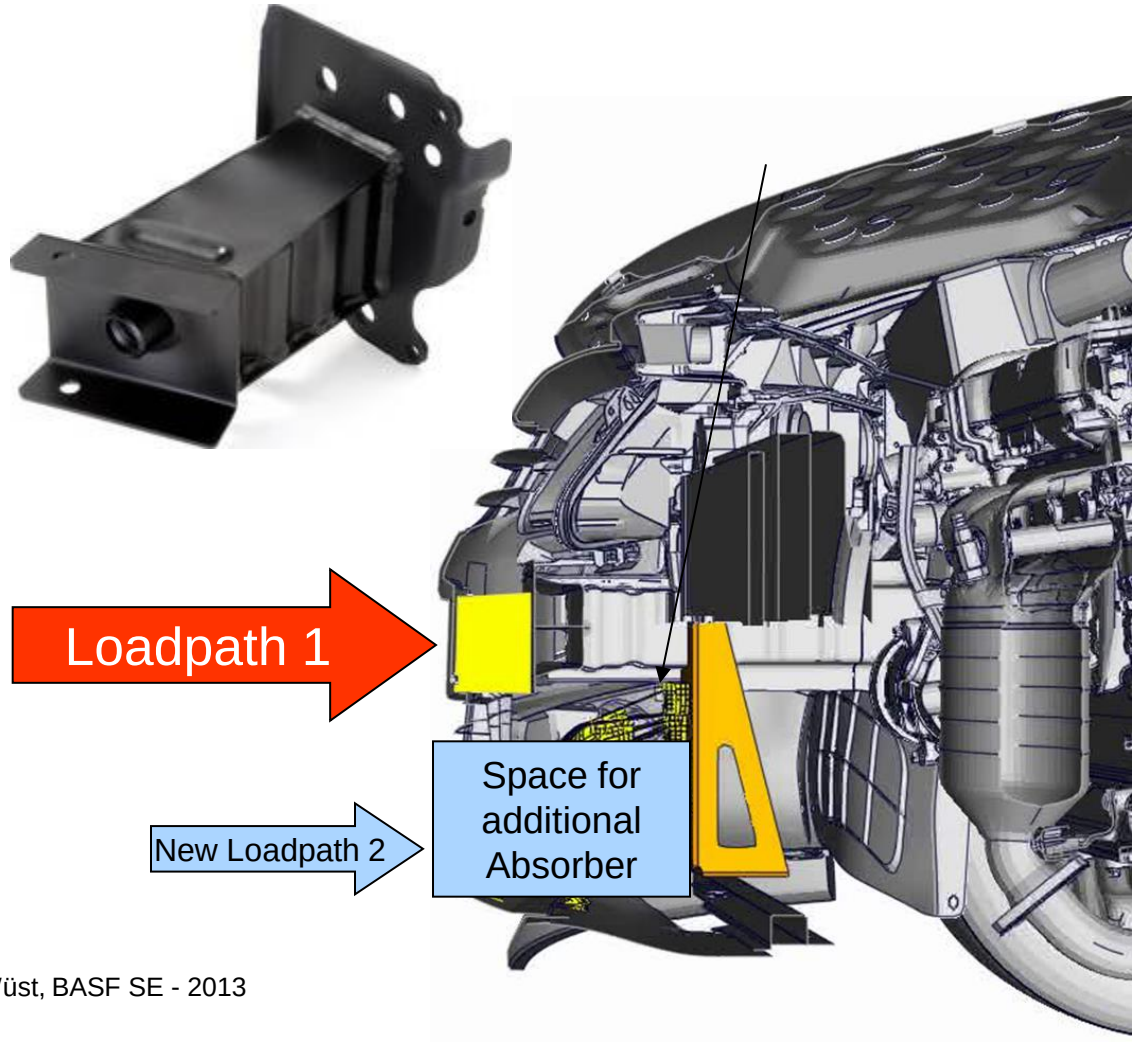
Simulation and Experiment

60 mm

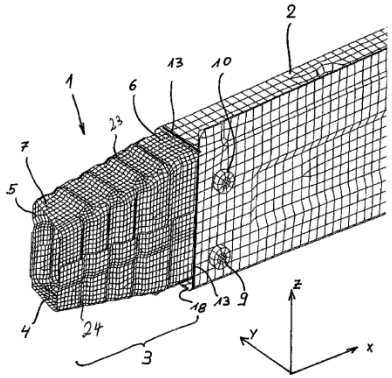




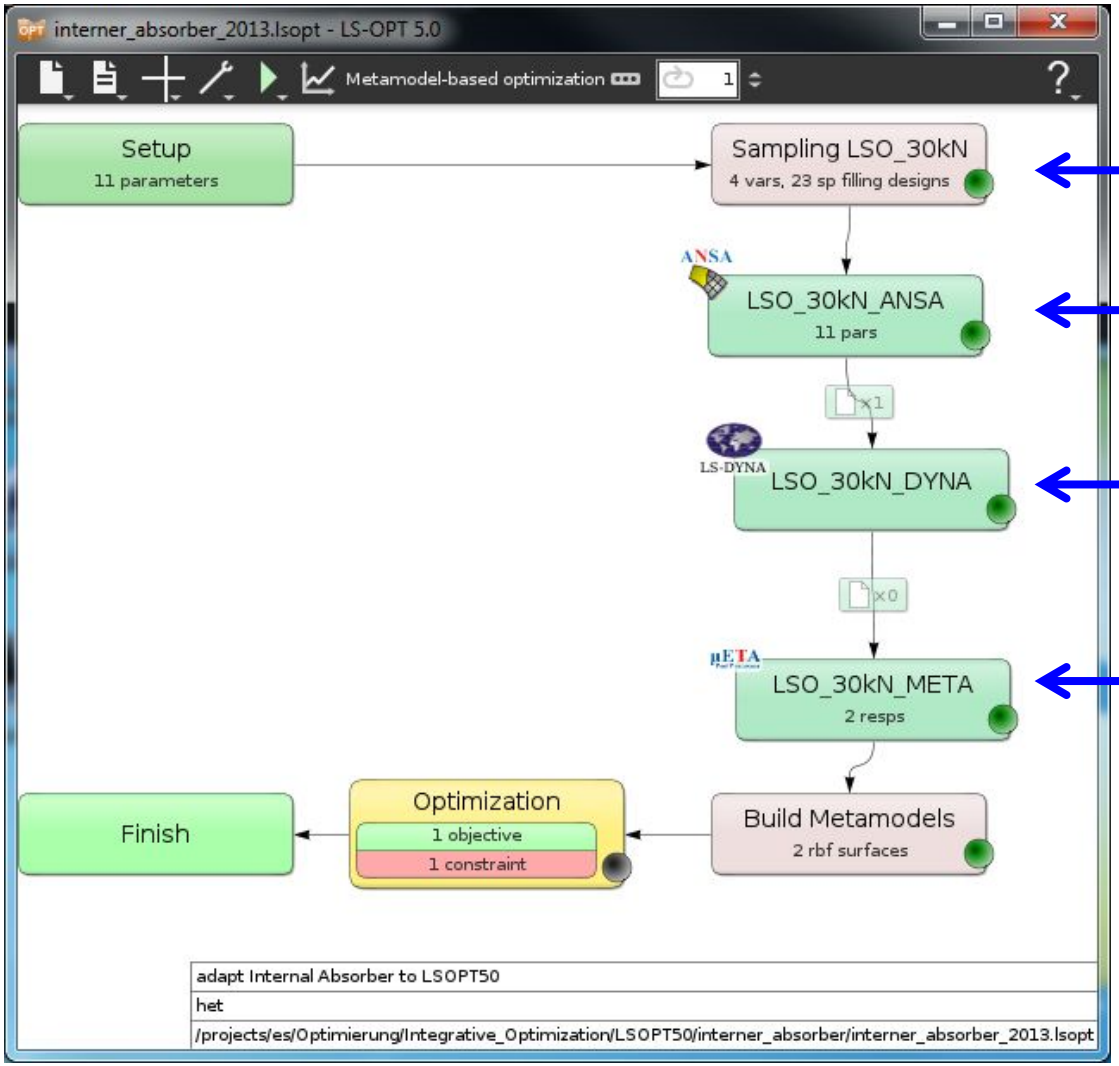
Lower Loadpath



Traditional Metal Crashbox:



LS-OPT GUI
Graphical – Stage based - hierarchical



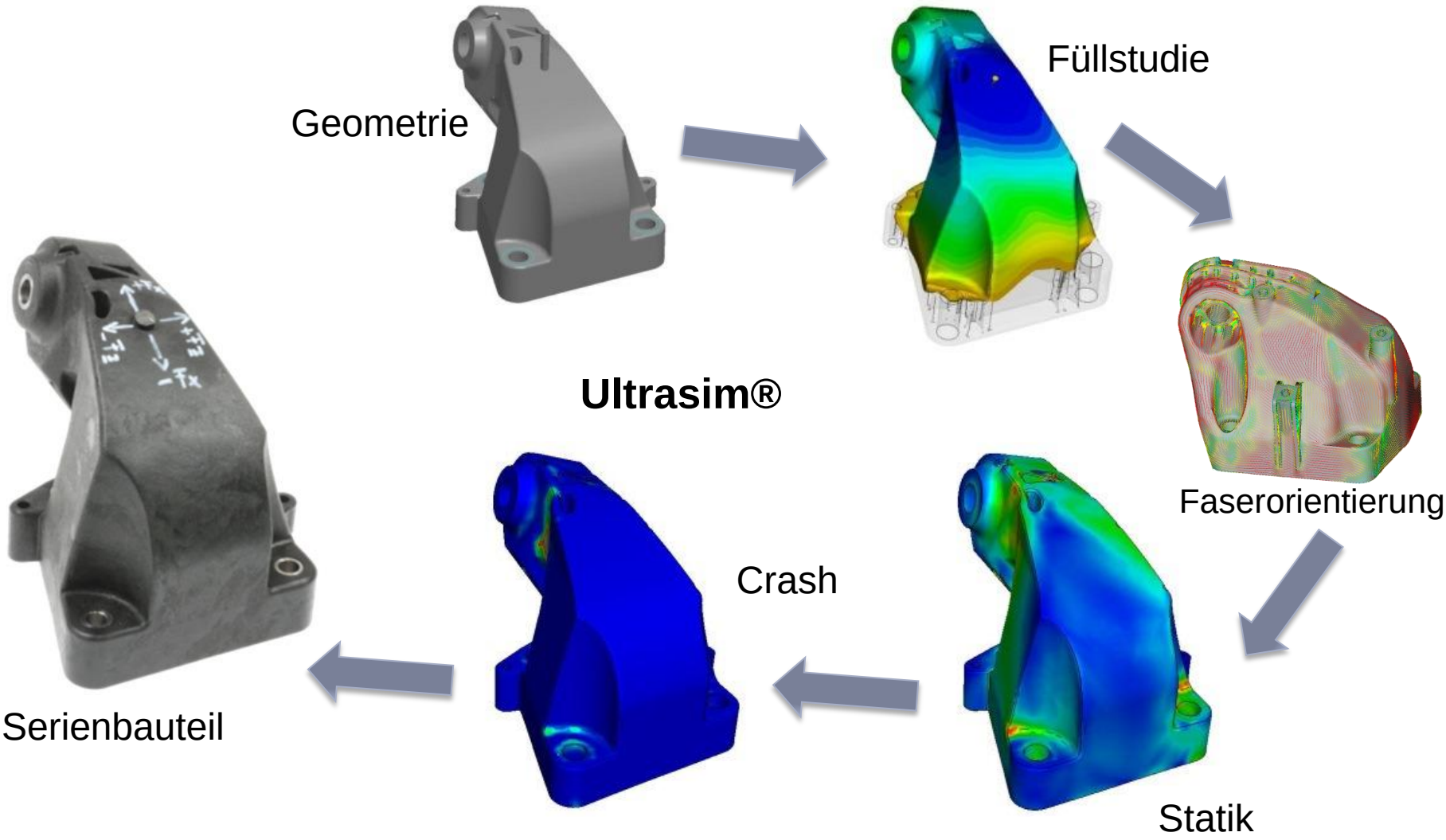
Sampling Stage

Preprocessor Stage

Solver Stage

Postprocessor Stage

Ultrasim Approach
Engine Mount GL Class



Integrative Optimization
Standard Optimization and Integrative Approach

Plastics granulate with glass fibers

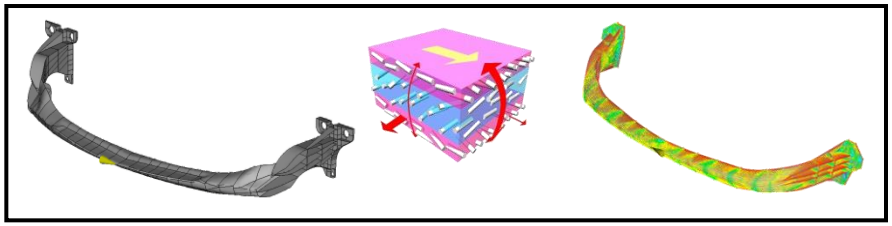
Injection molding process

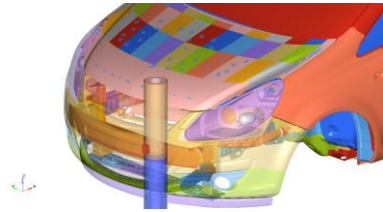
Part

Assembly

Product in use

BASF ULTRASIM



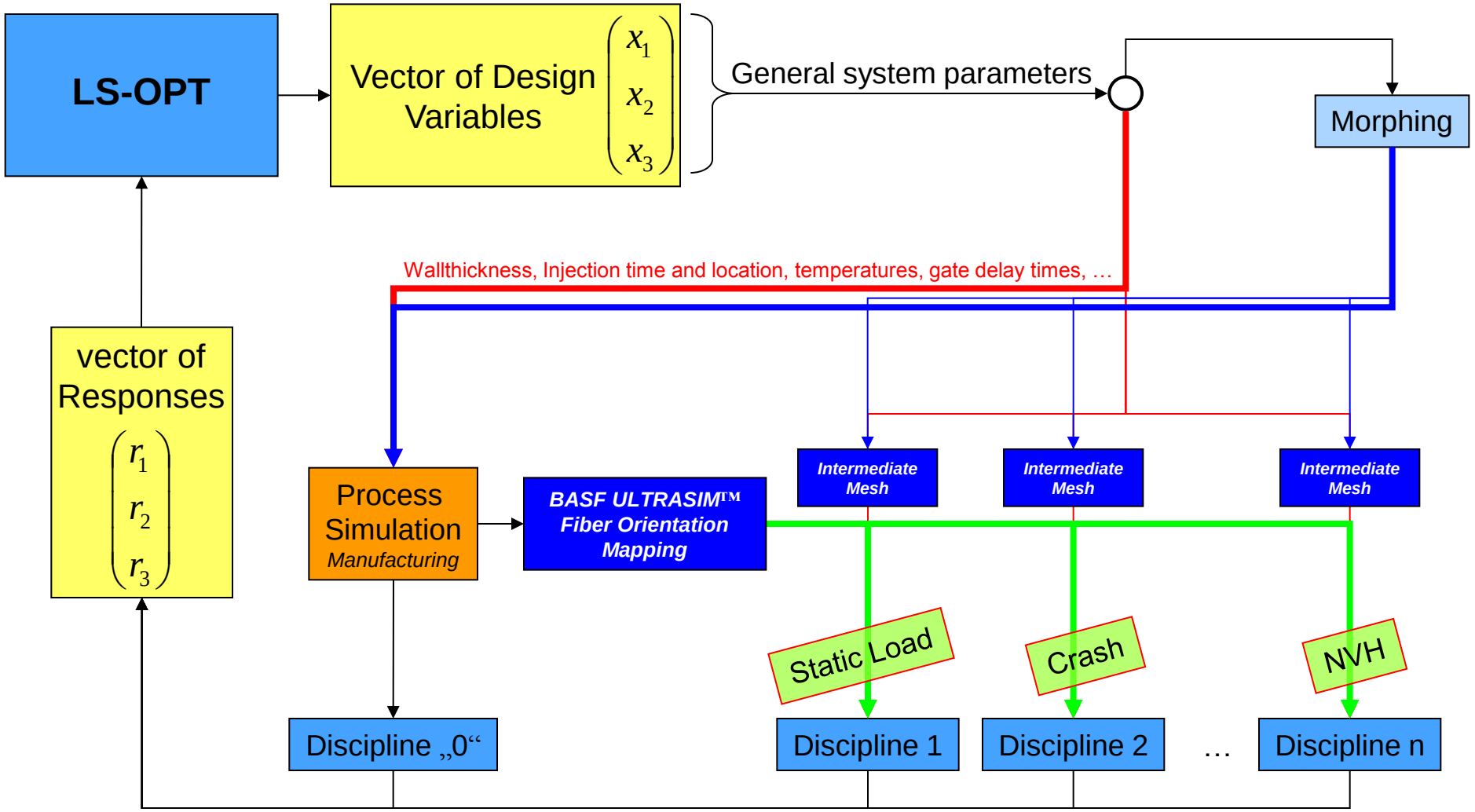


- Crash
- Static Loads
- NVH
- Warpage
- …

Standard Approach

Integrative Optimization Approach

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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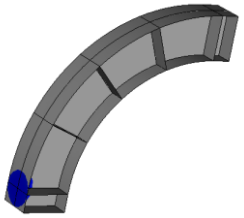
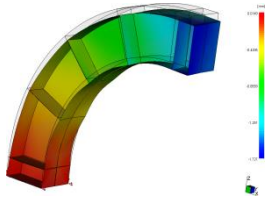
Integrative Optimization

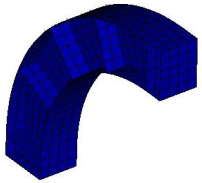
- Filling



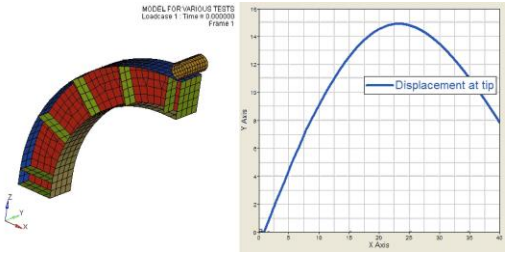
- Warpage

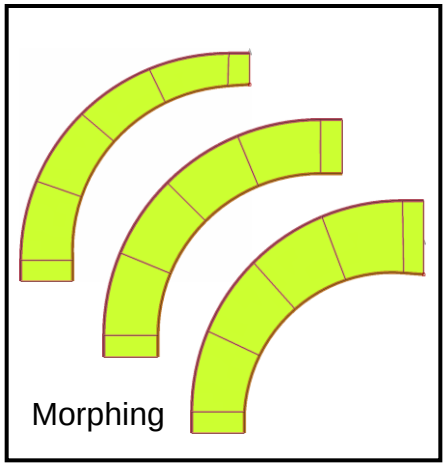


- Static Load



- Impact





Optimization with LSOPT
Present (LSOPT 4.2 and earlier)

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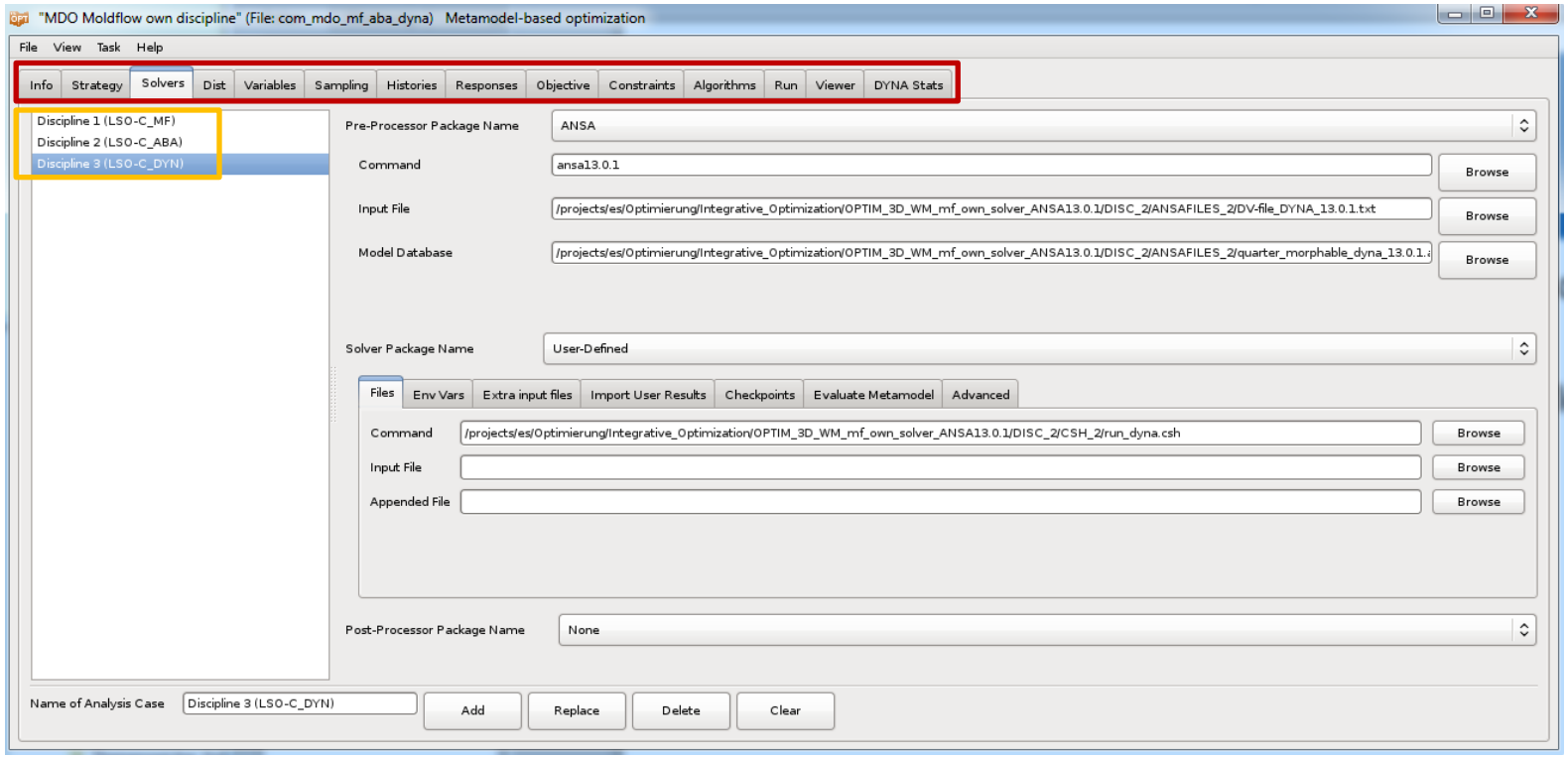
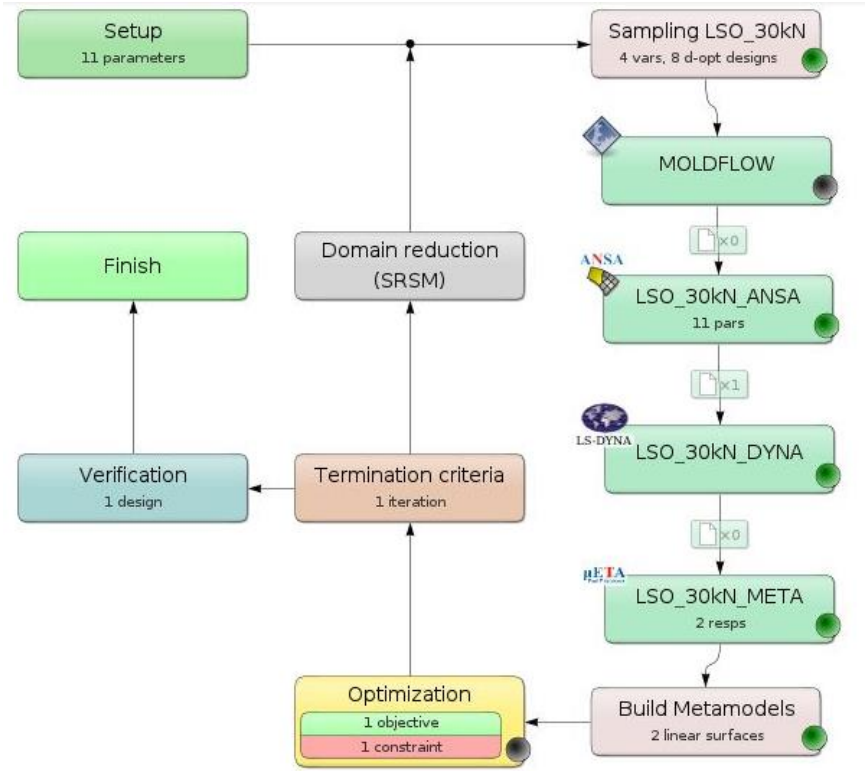
- Tab based GUI requires to input design variables, solvers, objectives etc. sequentially



- Confusing at first, no link to workflow, all dependencies hard-wired

LS-OPT 5.x – Hierarchical Definition

- New GUI directly represents workflow and dependencies



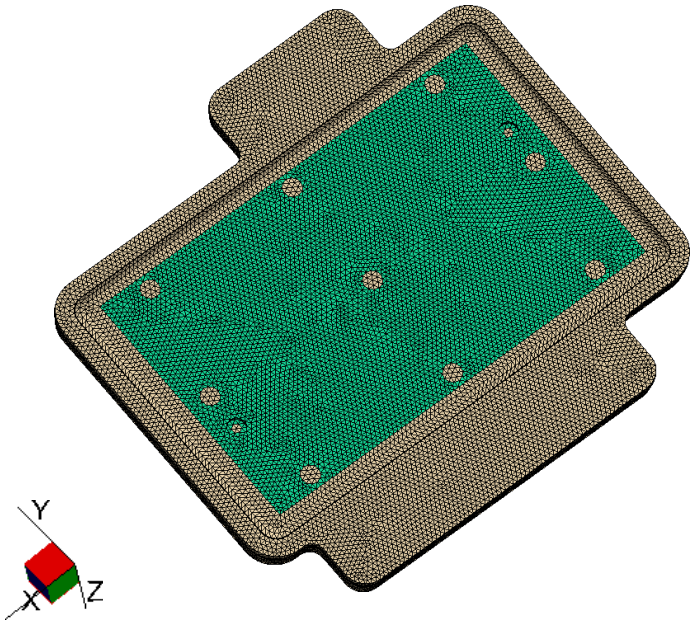
1. Manufacturing Stage
MOLDFLOW

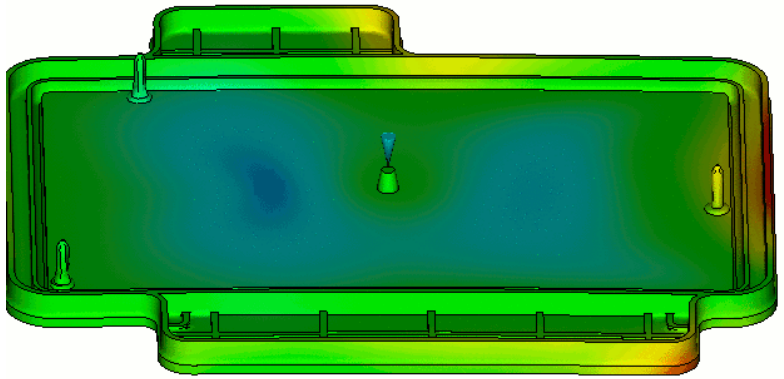
2. Crash Stage
LS-Dyna

- User-friendly, easy addition and removal of disciplines possible

Example: Two-Component Cap
Warpage optimization

- Two component cap

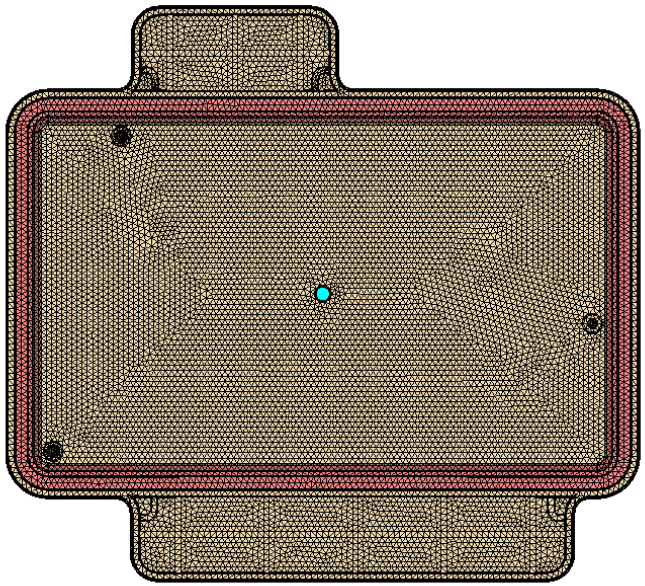




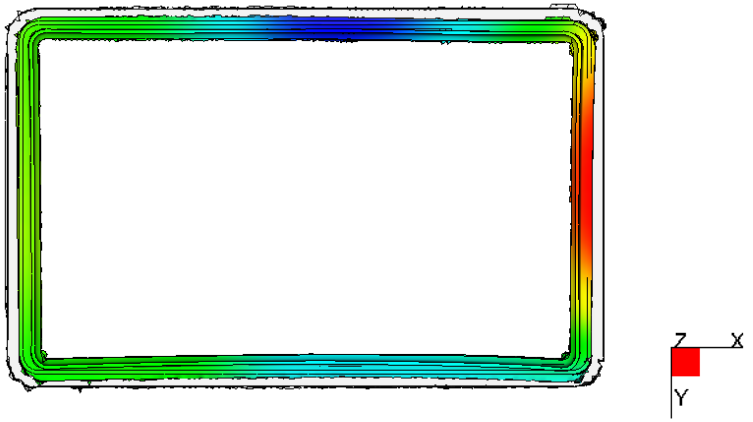
→ Goal: Find optimal injection location that minimizes customer specified warpage criterion

Example: Two-Component Cap
Calculation of unevenness

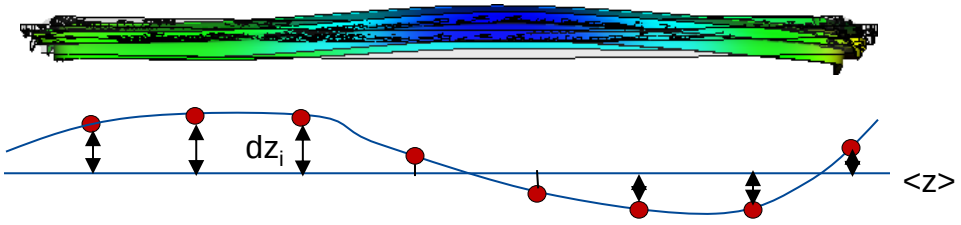
- Goal: Minimize unevenness of revolving seal



Deflection in z direction

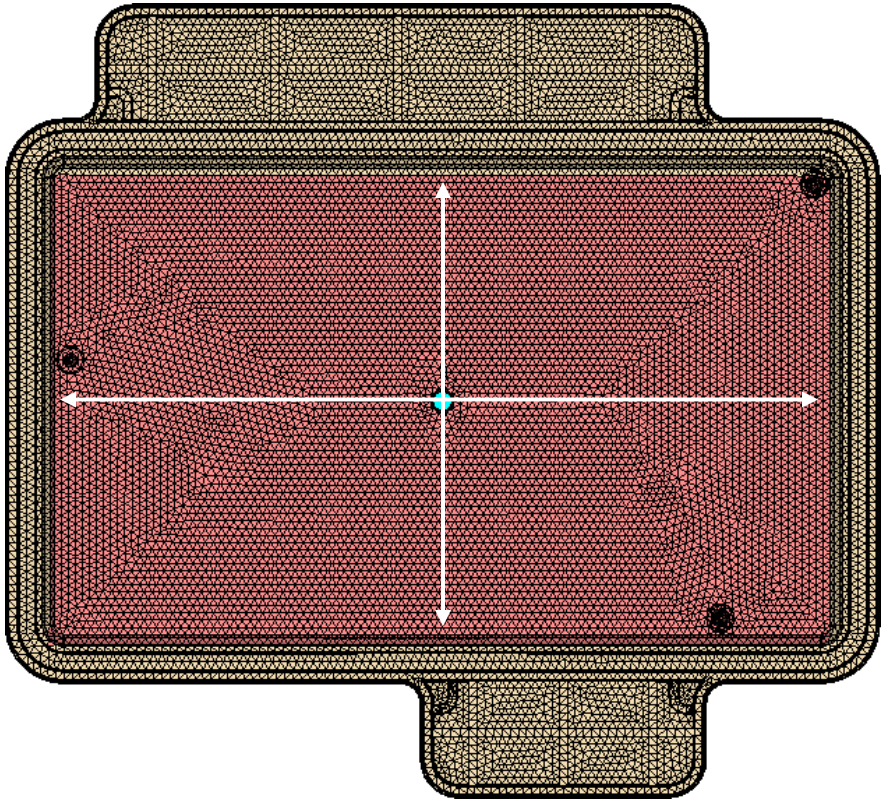


Square deviation: $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{N}(dz_i)^2}$



Example: Two Component Cap
Customer specified area

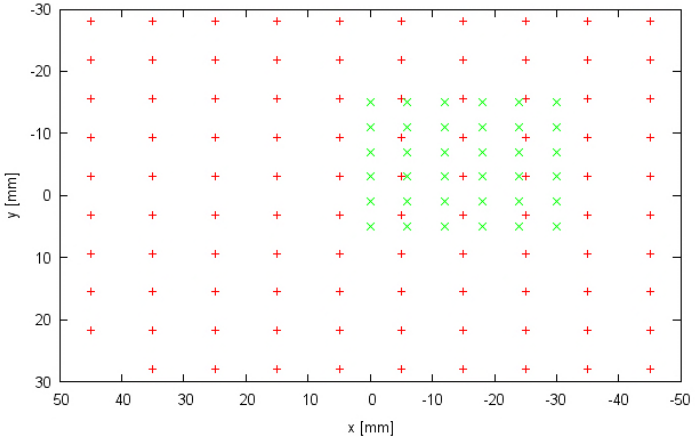
- Search for optimal injection point for second component within area specified by customer



Objective (is minimized):

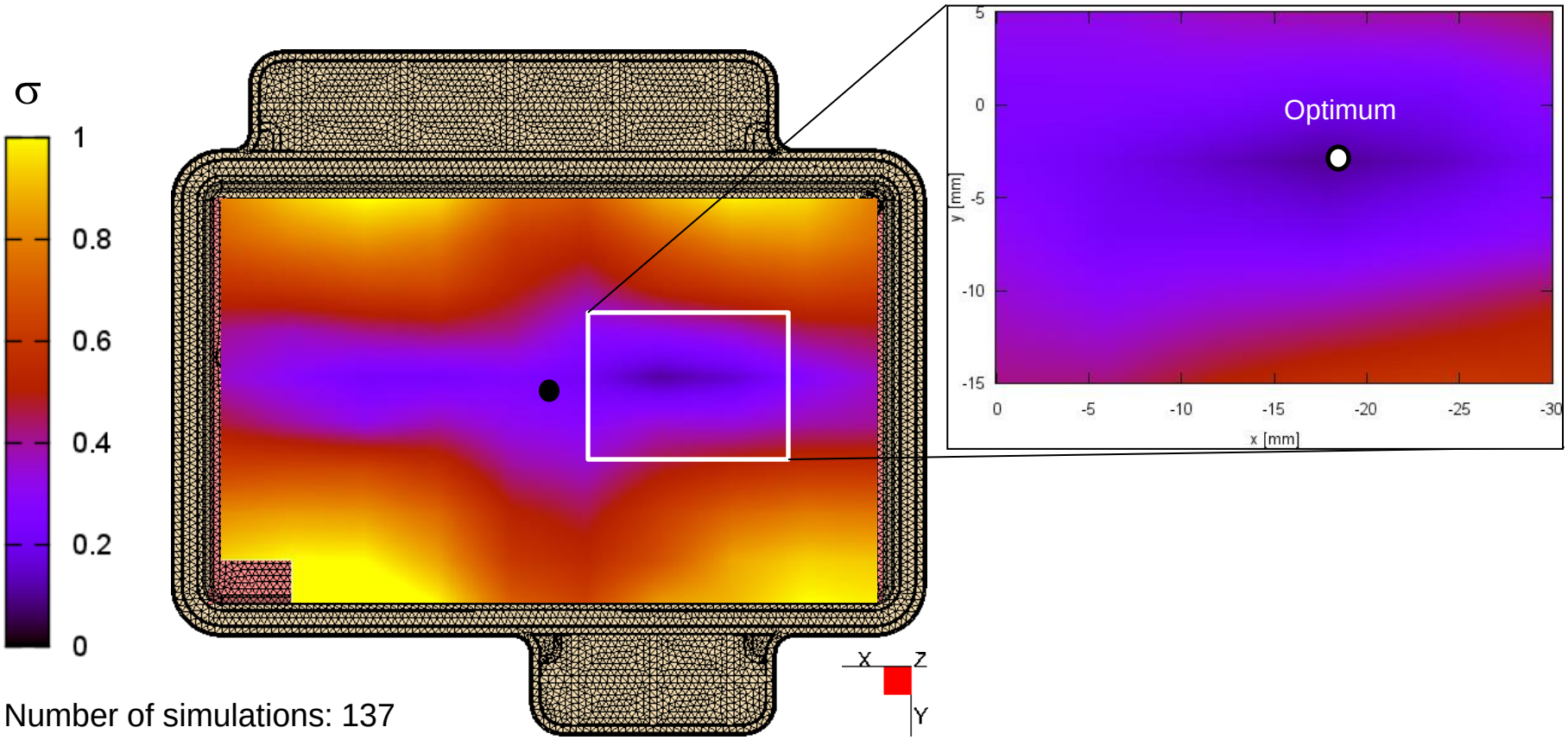
Unevenness seal σ

Simulated injection points:



Example: Two Component Cap
Optimum injection location

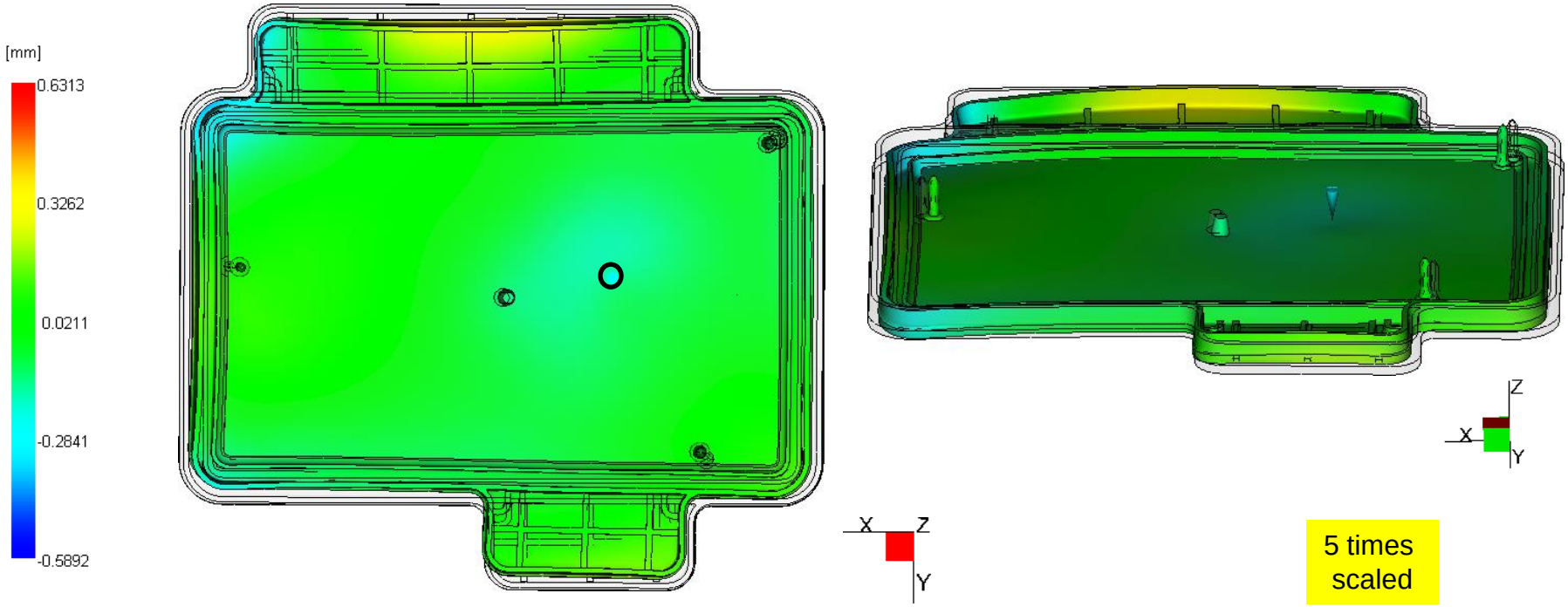
- Dependence of unevenness σ from injection location:



Number of simulations: 137

Example: Two Component Cap
Warpage optimum injection location

- Warpage in z direction:



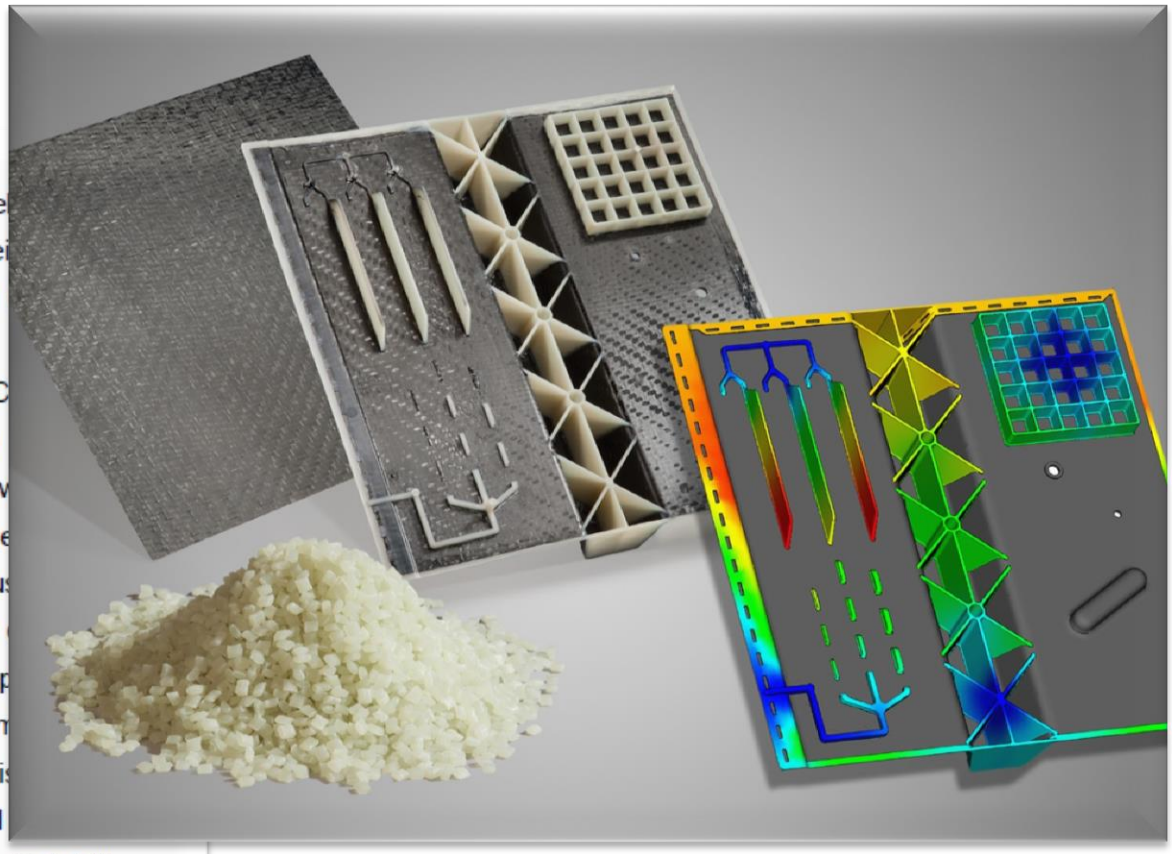
Unevenness seal: σ = 0.097 mm

Outlook
Continous Fiber Reinforced Parts
BASF Ultracom™

BASF
The Chemical Company

Die ersten kommerziellen Ultracom-Pakete

Zur K 2013 wird die BASF die ersten kommerzie
Produktpakete anbieten: Für Kundenprojekte im Berei
Bauteile besteht das Paket aus einem auf Polyamid
Ultralaminate™ (oder Ultratape™ für hoch
Verstärkungsstrukturen) sowie einem Ultramid G12 C
Glasfaserverstärkung als Umspritzmasse. Bei
Anforderungen an die Schlagzähigkeit des Bauteils w
zusammen mit dem Kunden ein auf hohe Ene
optimiertes Paket einsetzen. Es besteht ganz analog aus
und einem Ultramid ZG7 COM. Auch hier existiert eine
Tape-Variante für lokale Verstärkungen, beisp
Sitzstrukturen, die mit demselben Ultramid COM ZG7 un
kann. Zunächst wird für die Laminate die bei den techni
bekannte orthotrope Köper-2/2-Struktur sowie Polyamid
kommen. Auf der Kunststoffmesse werden die ersten mittels Ultracom
umgesetzten seriennahen Bauteile zu sehen sein.



Integrative Simulation ULTRASIM® for Continous Fiber Reinforced Plastics

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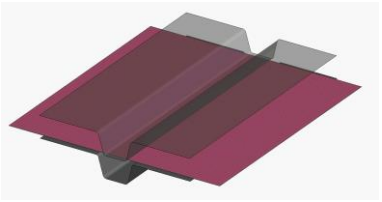
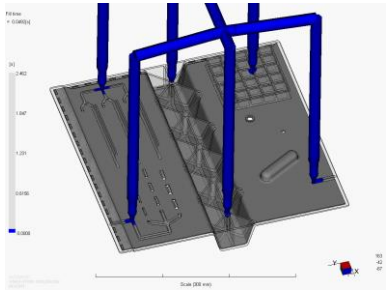
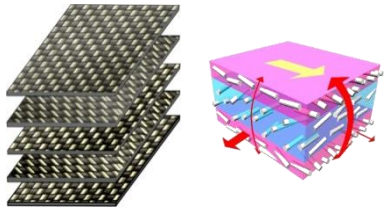
Process

Draping / Overmolding



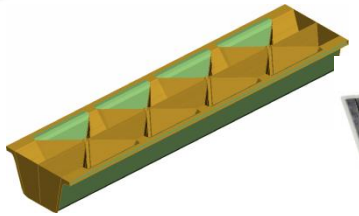


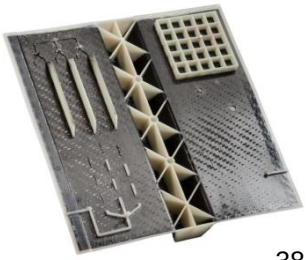
Material



Measurement

Part





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

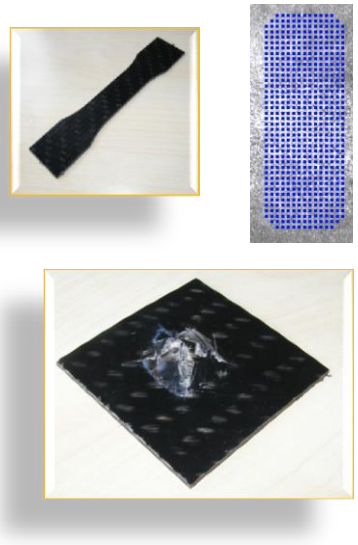
Ultrasim
Material modelling for Ultracom

BASF
The Chemical Company

Material Modelling

Mechanical testing

- Tensile Test
  - Angular Variations
- 3 Point Bending
- Puncture Test
- Compression Test
- Sheartests
  - Tensile 45°
  - Shear Frame
- Molding Trials
  - Overmolding
- Draping
  - Picture Frame
  - Part tests



- Orientation
- Strainrate
- Wallthickness
- Humidity
- Temperature

Full nonlinear material modelling
- Crash
- Failure
- Degradation

Example: Astra OPC Seat Draping and Overmolding

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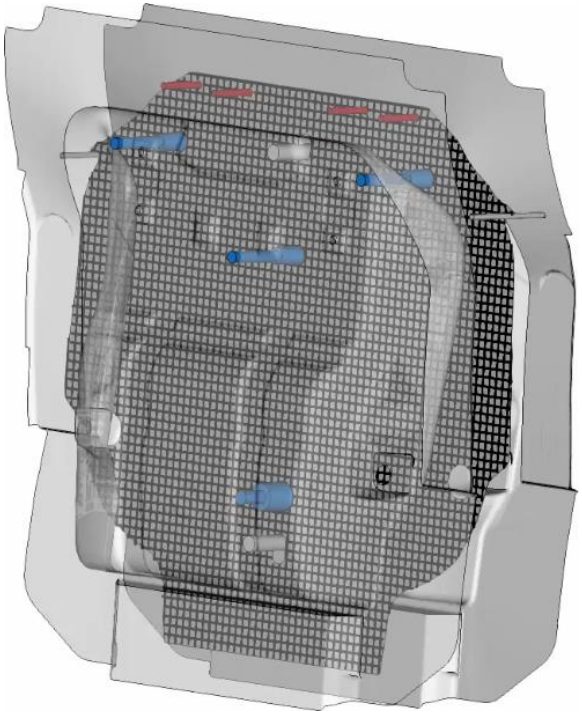
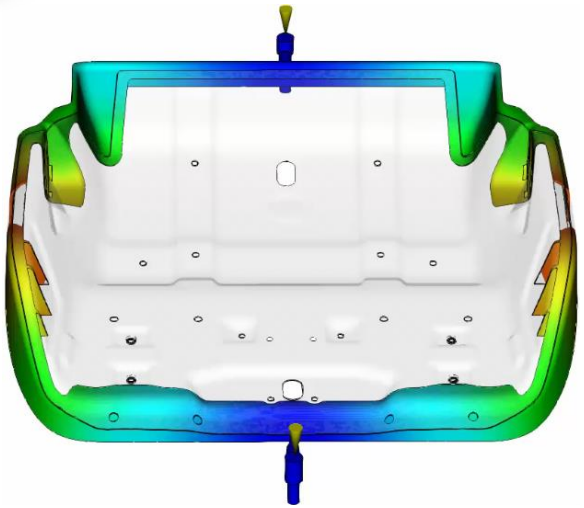


Draping

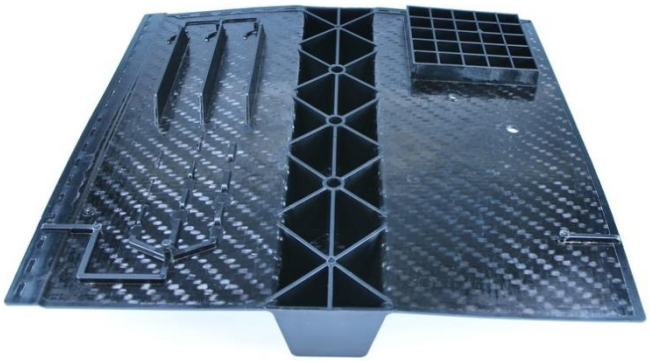
Thermoplastic Laminate Insert

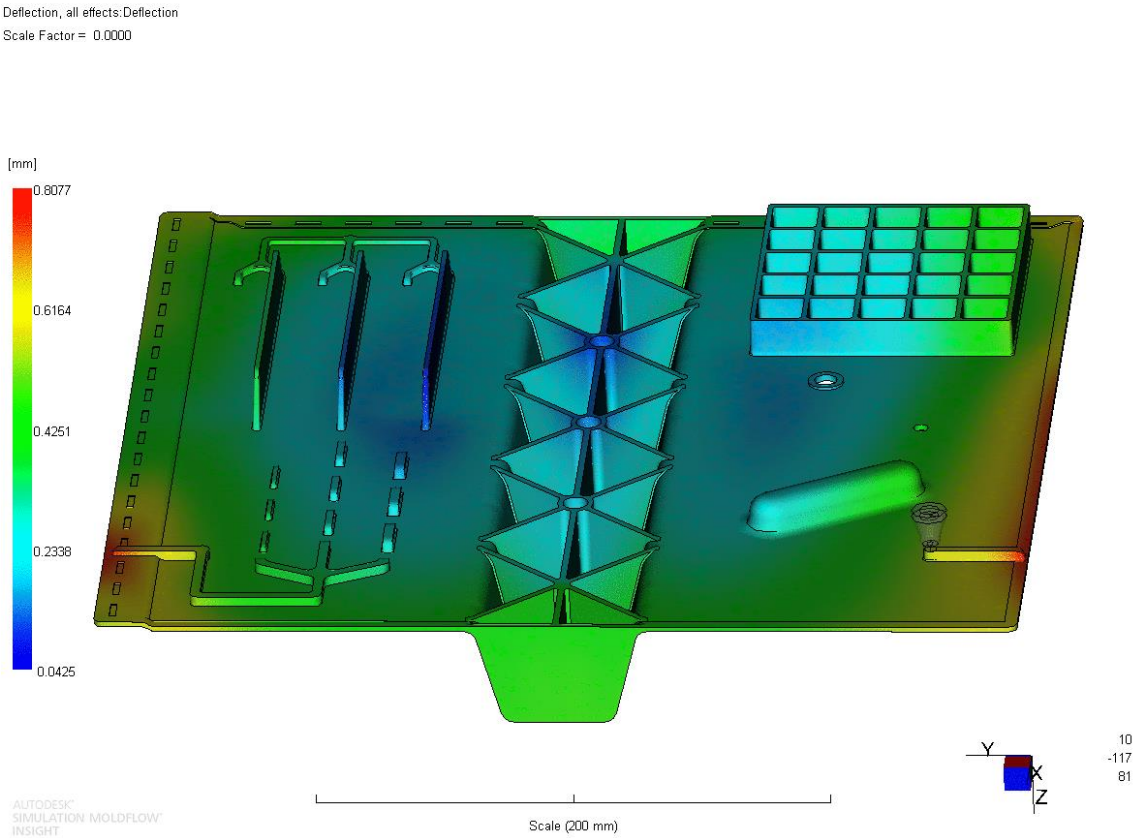


Overmolding

Warpage

Shrinkage contribution: Short fiber plus endless fiber





Serial Applications supported by ULTRASIM®

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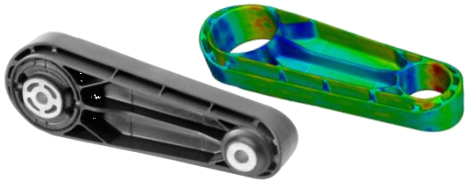
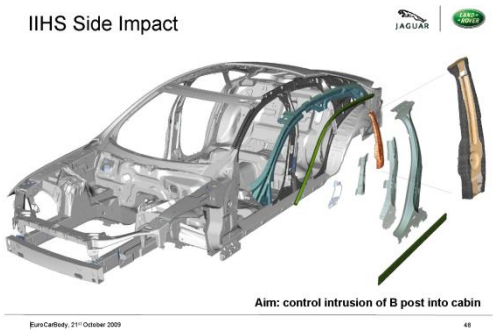
Engine Mounts

Torque Stabilizer



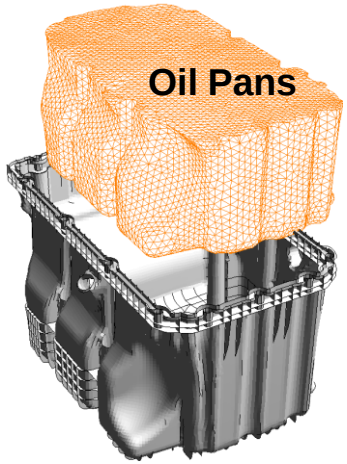


Structural Stiffeners

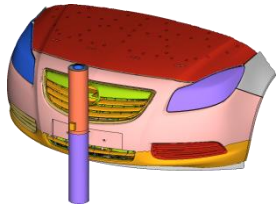
ULTRASIM®

Transmission Cross Beam

Oil Pans



Lower Bumper Stiffeners



Summary

- More and more parts are made of anisotropic polymers
- Manufacturing process determines fiber orientation and thus local mechanical properties
- Integrative, holistic view in development is crucial for success
- ULTRASIM® approach has been applied for numerous applications
- Integrative Optimization Approach allows simultaneous optimization of process and mechanical characteristics
- LS-Dyna and LS-OPT are important tools for CAE at BASF
- Endless Fiber parts further raise the bar for predictive CAE simulations

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