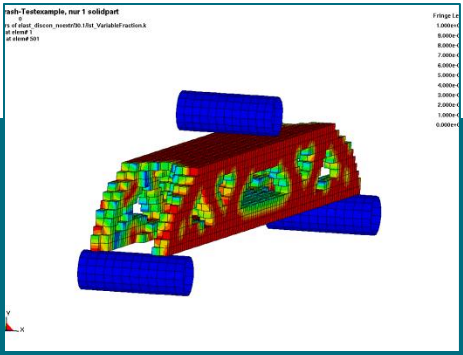
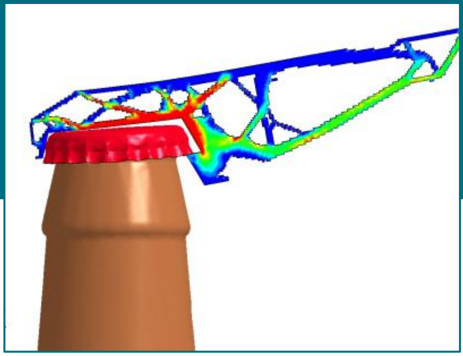
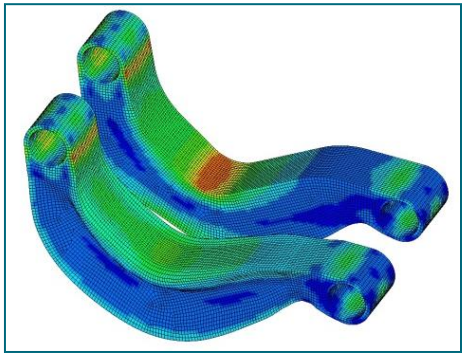




LS-TaSC™ Product Status

Katharina Witowski
DYNAmore GmbH
Willem Roux
Livermore Software Technology Corporation

Bamberg, 11.10.2016

LSTC Livermore Software Technology Corp.

DYNA MORE

Overview

- Multipoint approach
  - Motivation
  - Global vs. local variables
  - Examples
- Other new features
- Current development

Multipoint Method

Motivation

- Topology optimization for non-linear, dynamic load cases
  - Design Sensitivity Analysis too expensive
  - Heuristic methods (Hybrid Cellular Automata, Evolutionary Topology Optimization, Prescribed Plastic Strain/Stress, …)
  - Global constraints possible (force, displacement, …)
    - Constraints violated → increase or decrease mass to satisfy constraint
- Constrained topology optimization (multi-disciplinary problems including crash load cases)
  - → Multipoint method
  - → Allows more general constraints

Multipoint Method – Basic Idea

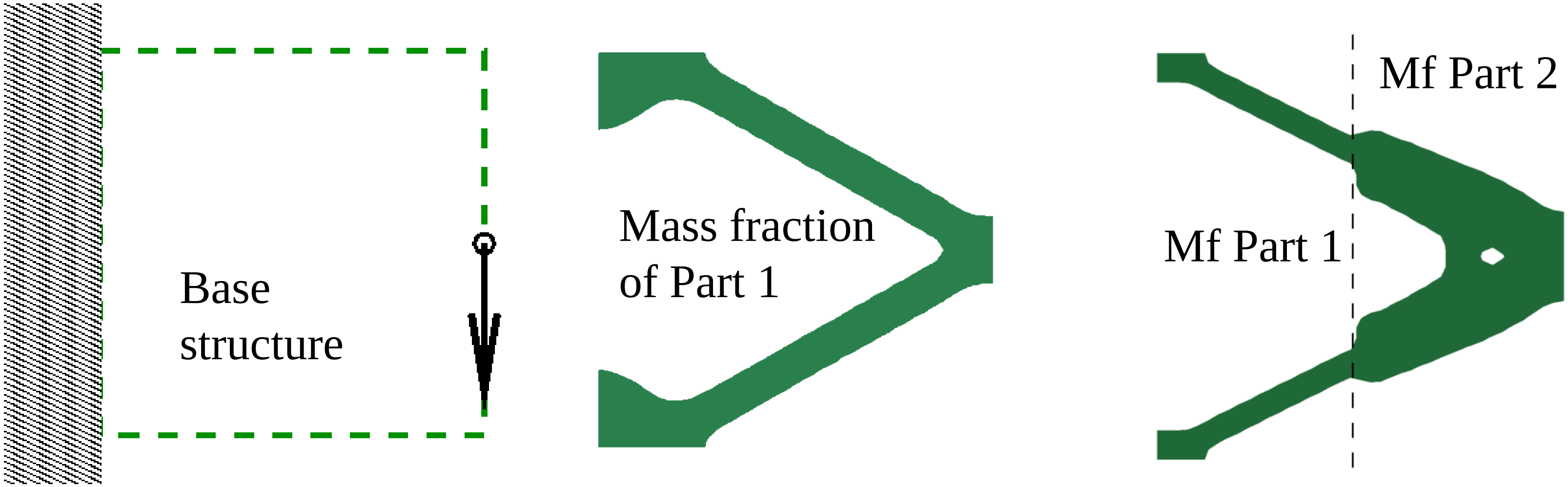
- Design Sensitivities
  - impracticable for standard topology variables,
  - but possible for a few global variables
- Gradient-based optimization methods, metamodel methods, … with respect to global variables

  → Used in constrained optimization

Multipoint Method - Variables

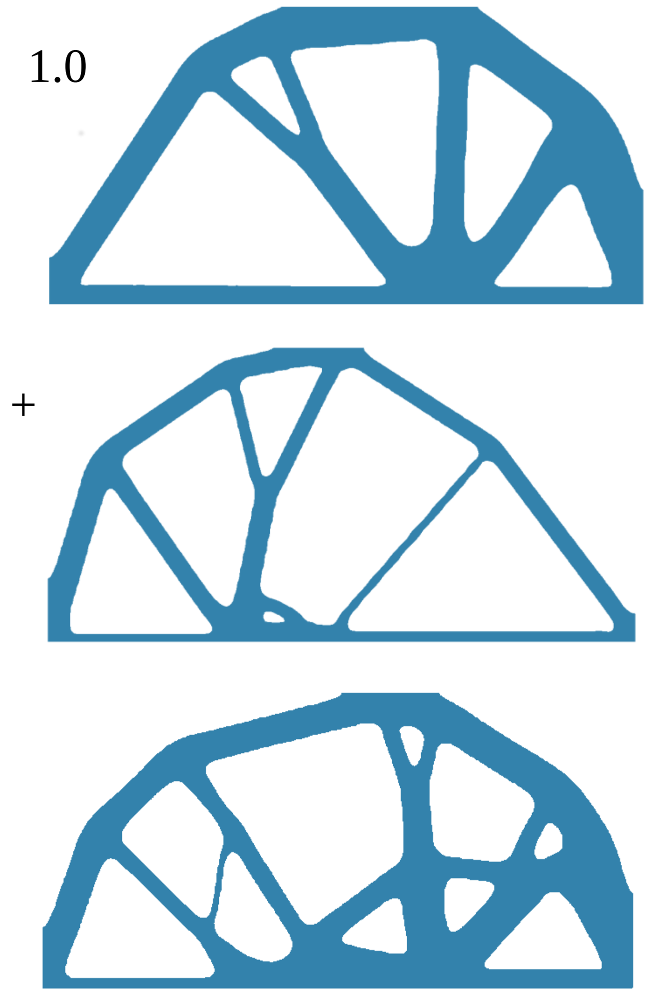
- Local variables
  - Amount of material in an element
- Global variables
  - Part mass fraction
  - Load case weights
  - Geometry kernels
  - Reduced bases

Currently available in LS-TaSC



Multipoint Method - Variables

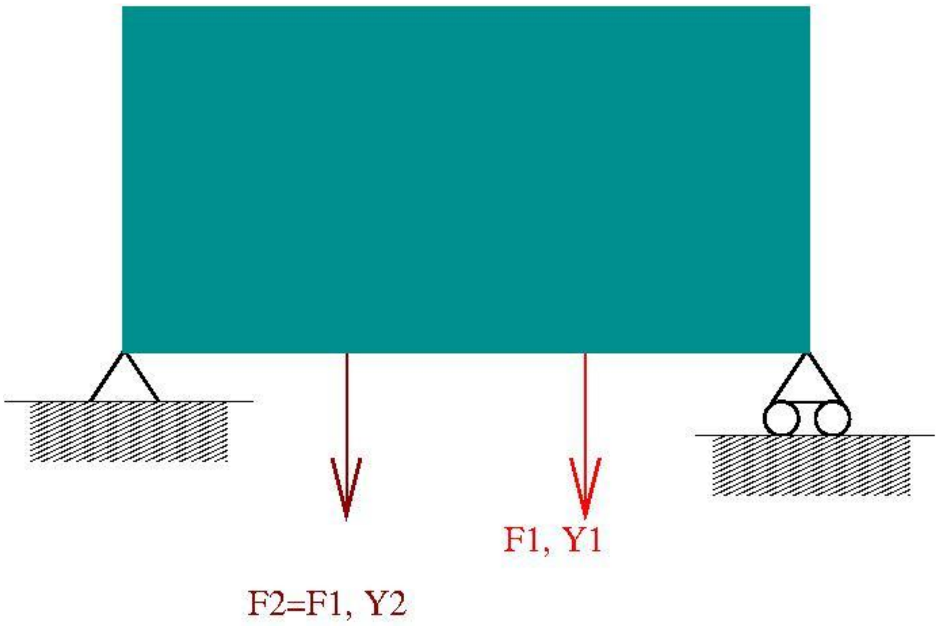
- Load case weights
  - Critical design variable for the analysis of multiple load cases
  - Controls relative values of constraints, as opposed to the absolute values
  - Variations weighing a specific time step are also possible



Example

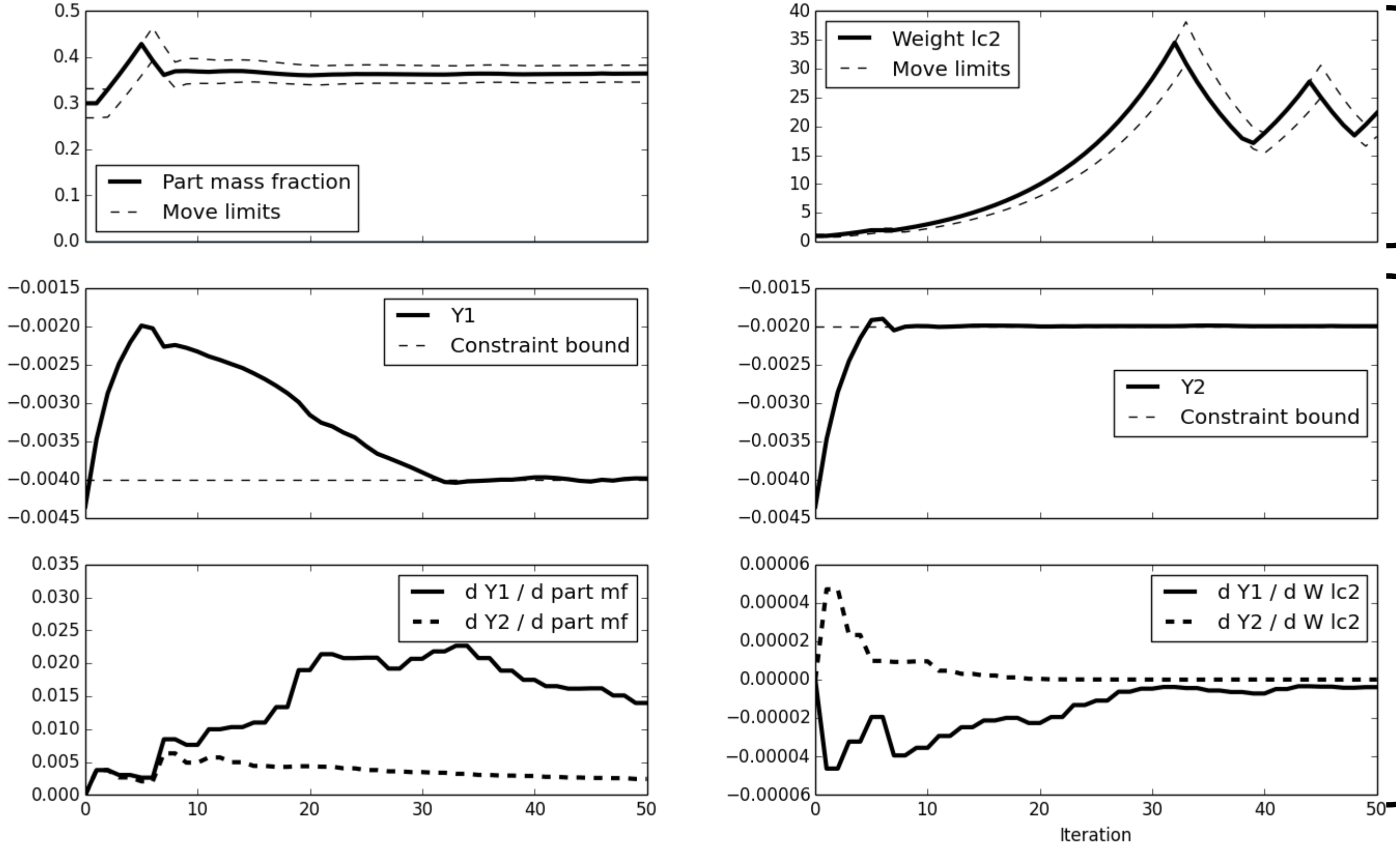
- Two Load Cases
  - F1 = F2
- Objective
  - Minimize Mass
- Constraints
  - Y1 > -0.002
  - Y2 > -0.004

  → Asymmetric results from a symmetric setup are therefore required
- Global variables
  - Part mass
  - Load case weight ratio



Example - Results

- Design Histories



Global variables

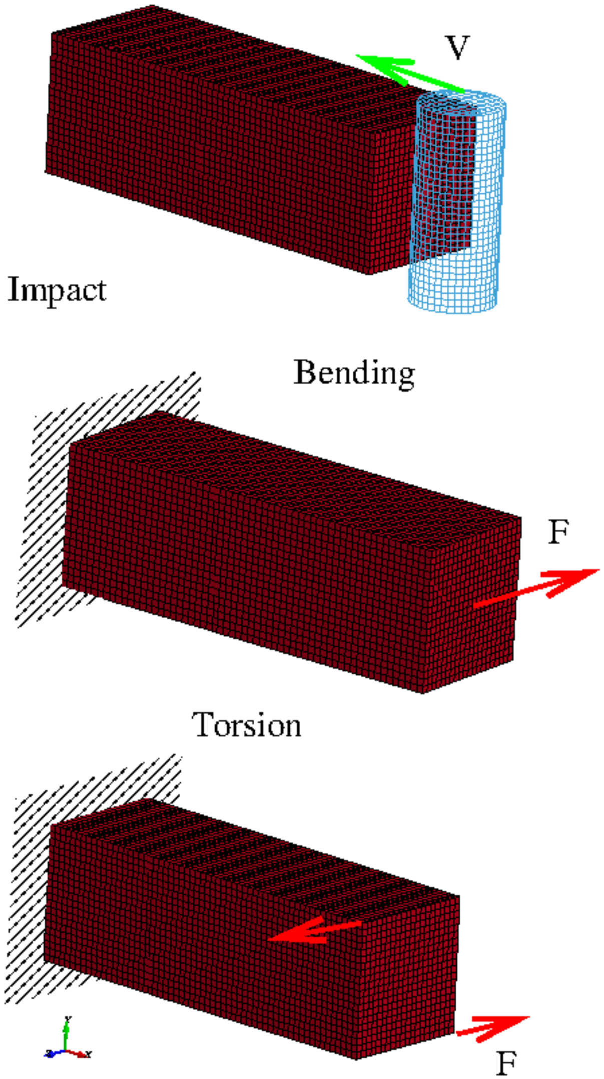
Constraints: values and derivatives

Example - Results

- Final topology
  → asymmetric due to the asymmetric constraints

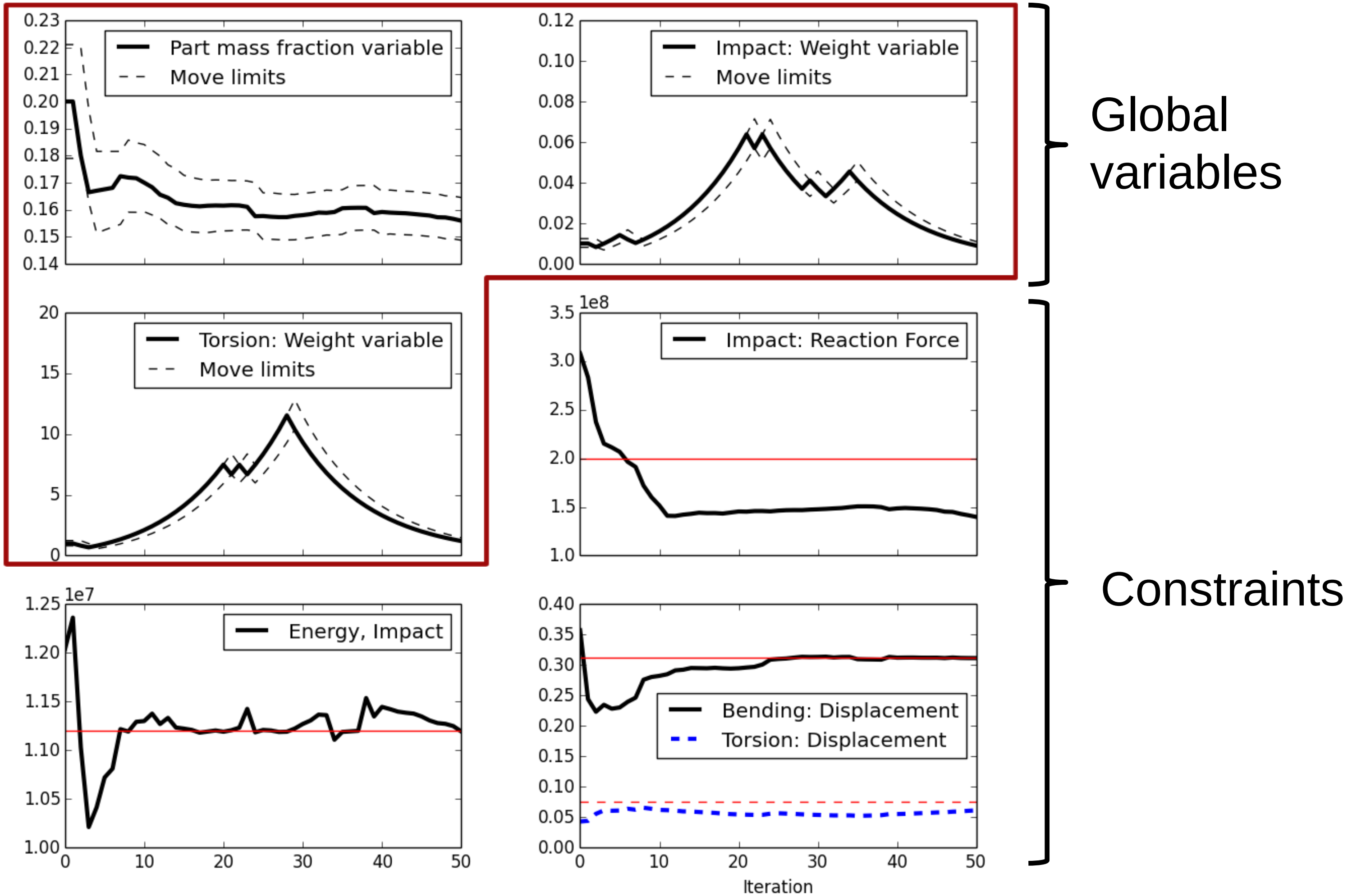
Multi-disciplinary Example

- Three load cases
  - Impact: Constraints
    - Energy absorption > 11.2e6
    - Reaction force < 200e6
  - Linear bending: Constraint
    - Displacement < 0.3125
  - Linear torsion: Constraint
    - Displacement < 0.075
- Global variables
  - Part mass fraction
  - Load case weights



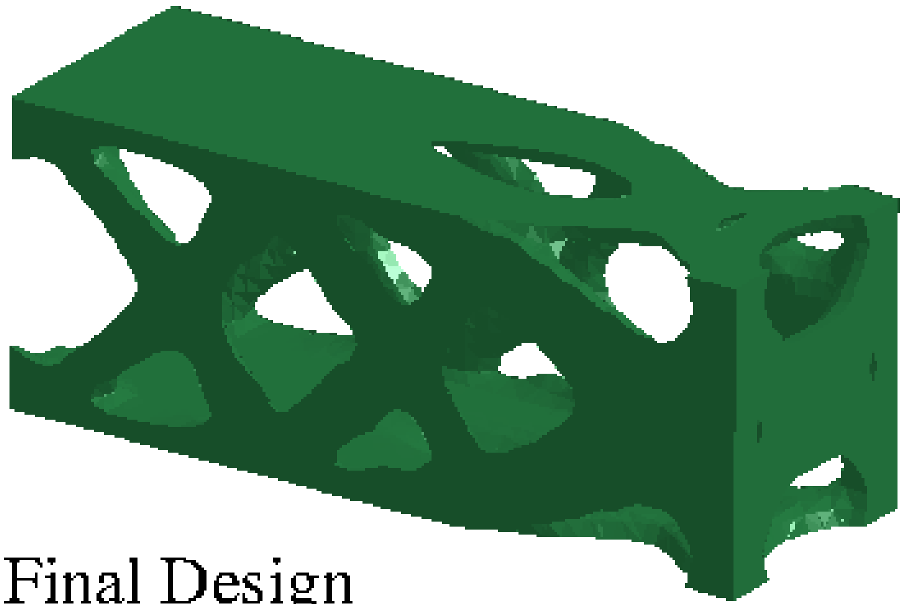
Multi-disciplinary Example

- Design Histories



Multi-disciplinary Example

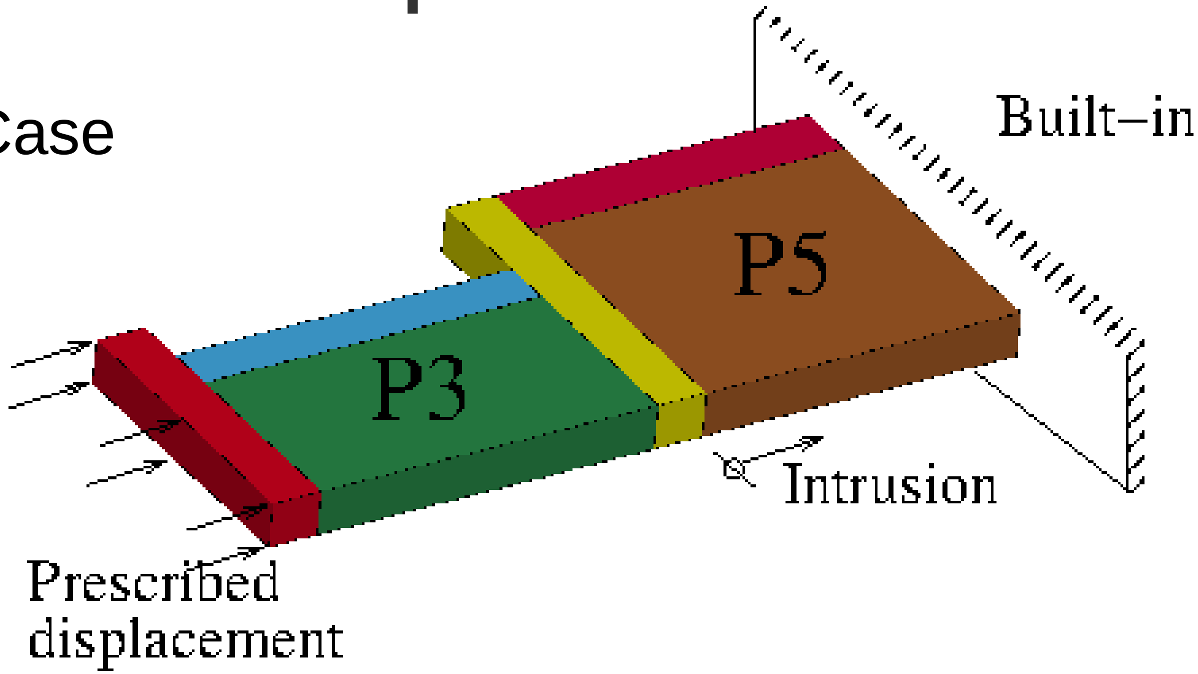
- Final topology



Final Design

Multiple Part Example

- Load Case



- Objective minimize mass
- Constraints
  - Intrusion: XDISP_N987 - XDISP_N1523 > 0.003
  - Energy ratio: ENER_P3 / ENER_P5 > 1.5
  - Energy absorption: ENER_P3 + ENER_P5 > 800.0

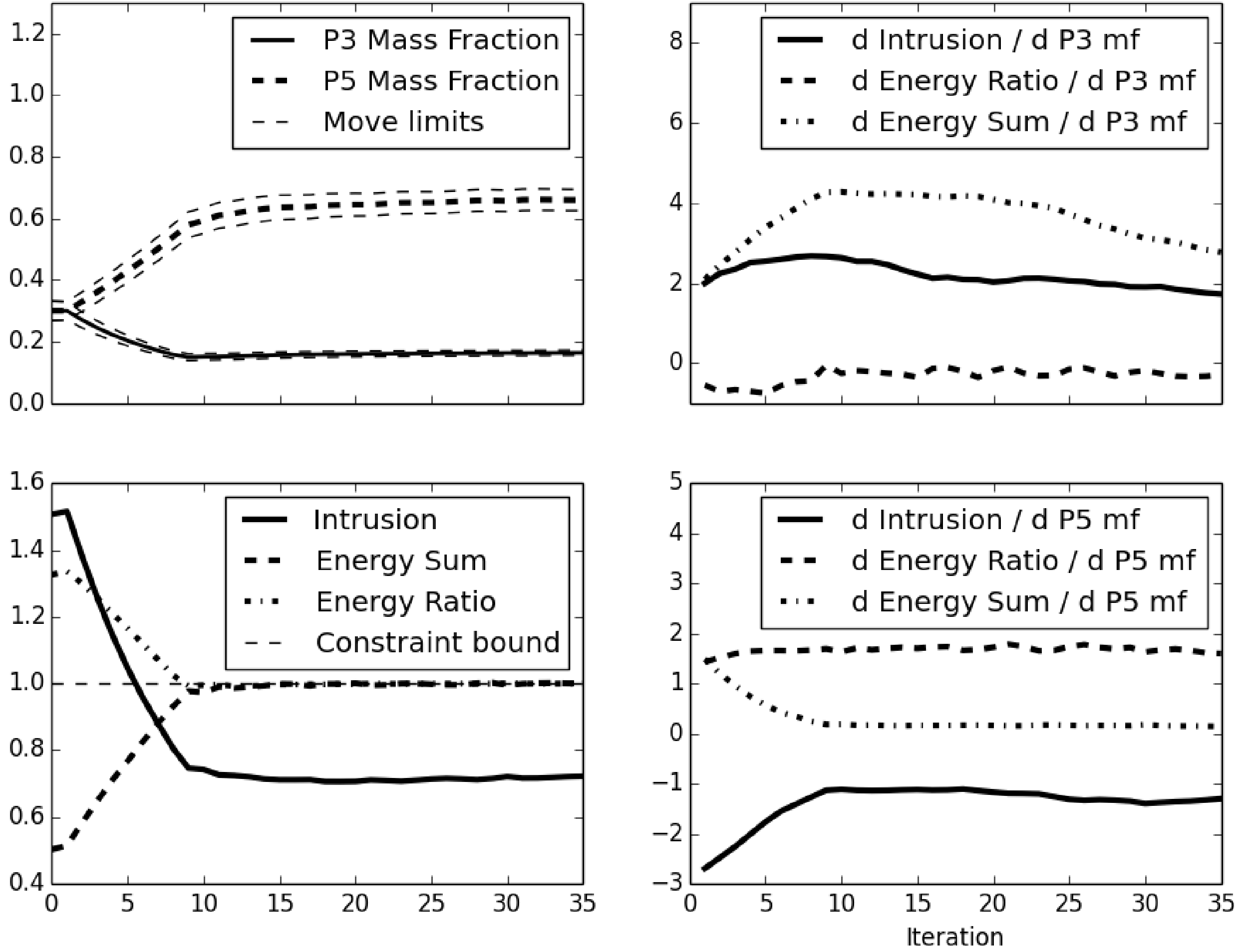
Multiple Part Example

- Design Histories

Global variables: Part mass fractions

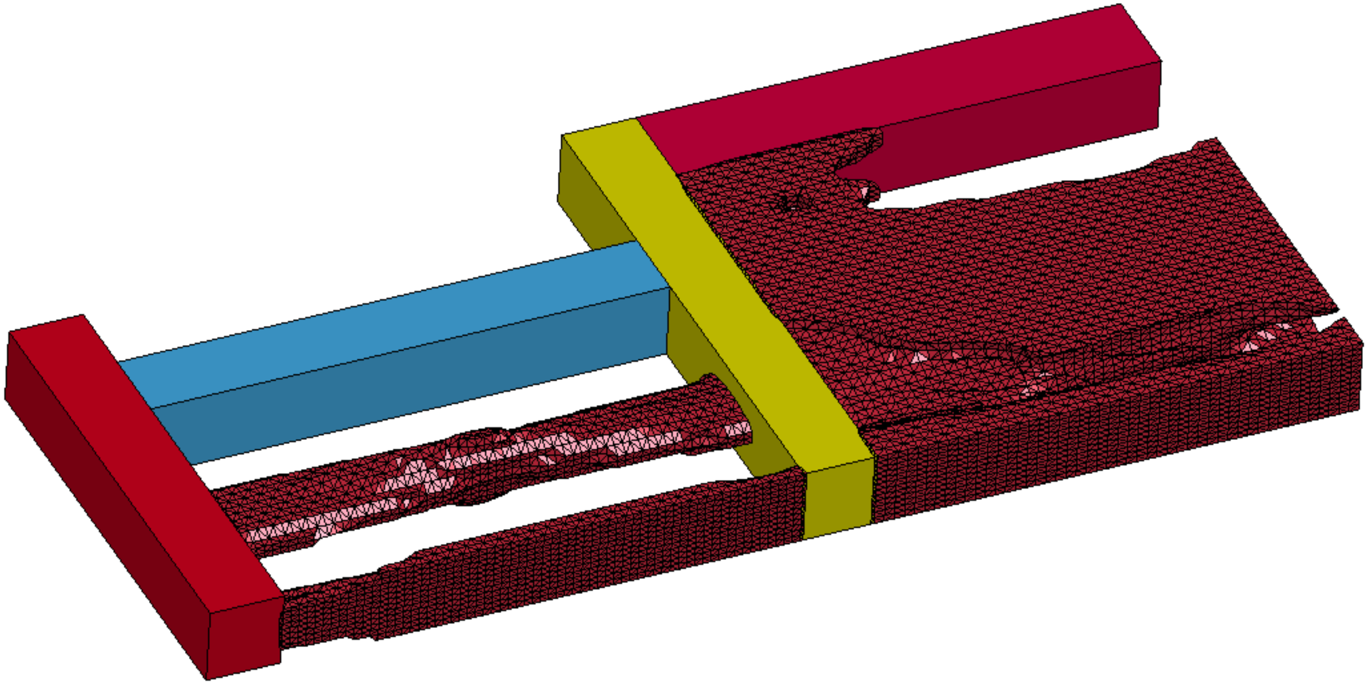
Constraints: derivatives

Constraints



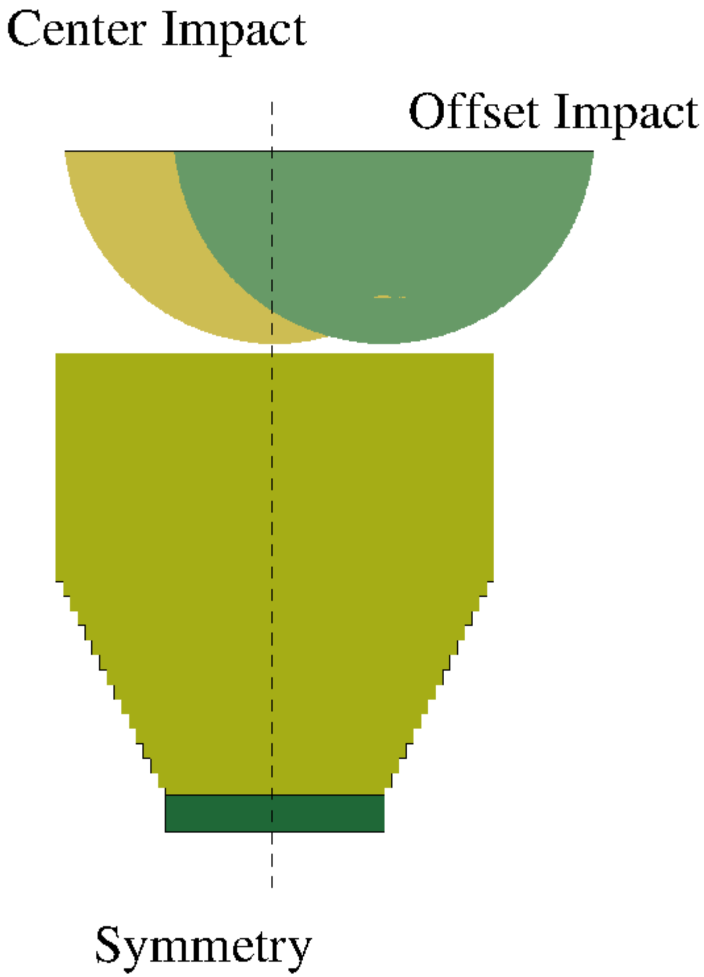
Multiple Part Example

- Final topology



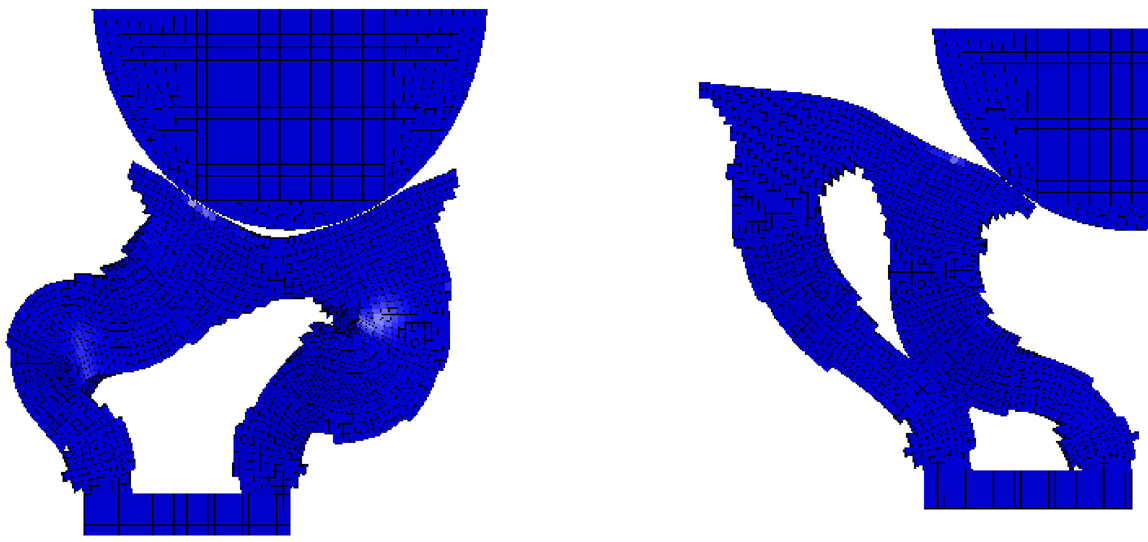
Highly nonlinear Example

- Load cases
- Objective
  - minimize difference in reaction force between load cases.
- Global variable
  - second load case weight
- The mass fraction is constant.



Highly nonlinear Example

- ***Buckling mode changes*** between iterations or within multipoint loop. Note the change of topology due to the ***contact closures***.



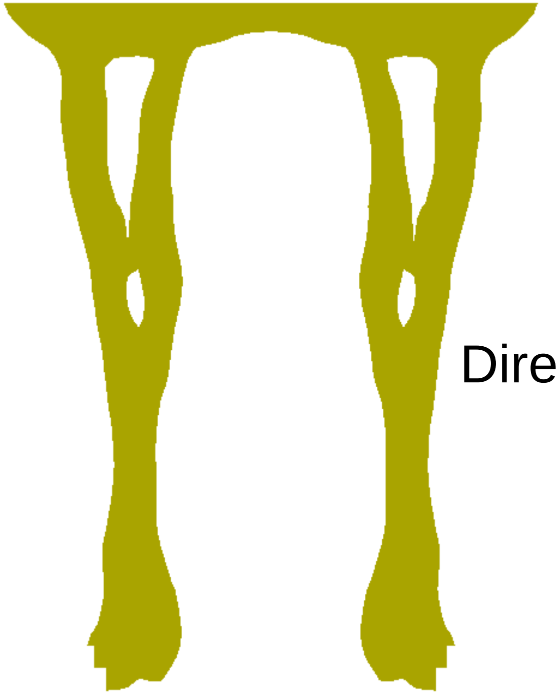
Iteration 20 Iteration 21

Offset impact load case

Highly nonlinear Example

- Final topologies
- Note the effect of the internal contact closure. The design algorithm must handle the load paths changes.

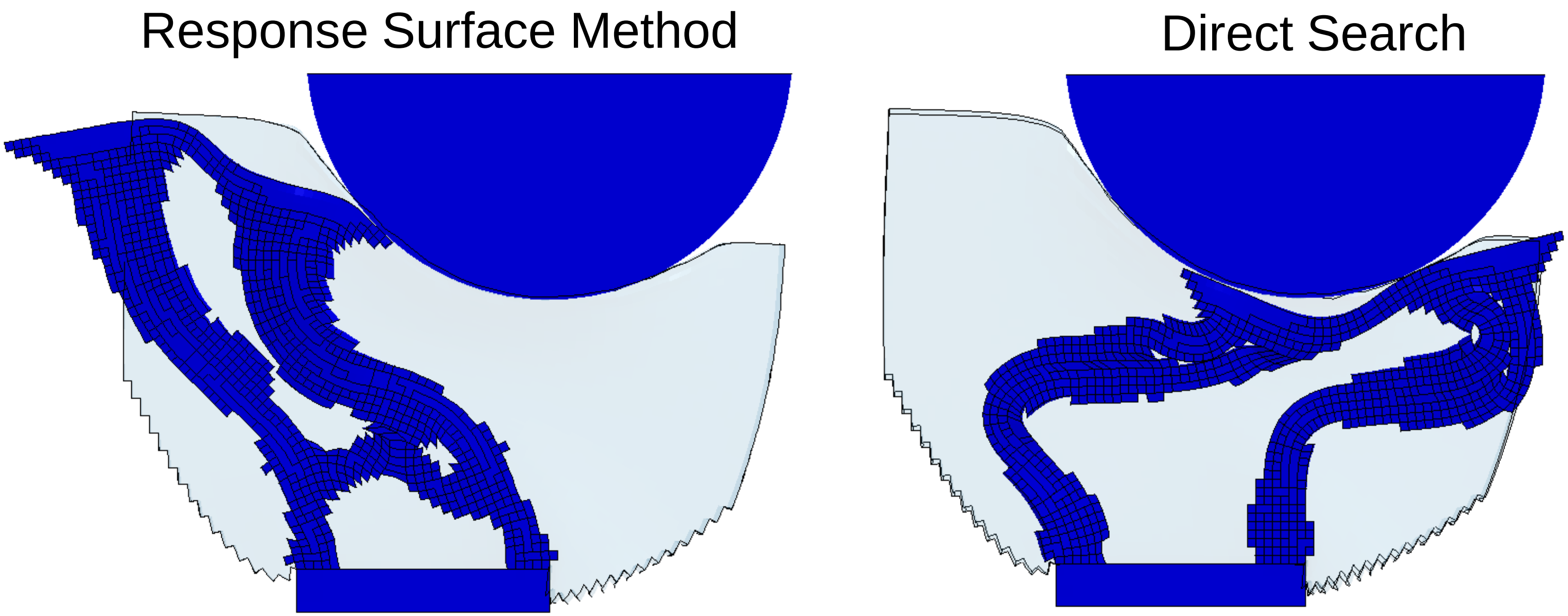
Response
Surface
Method



Direct Search

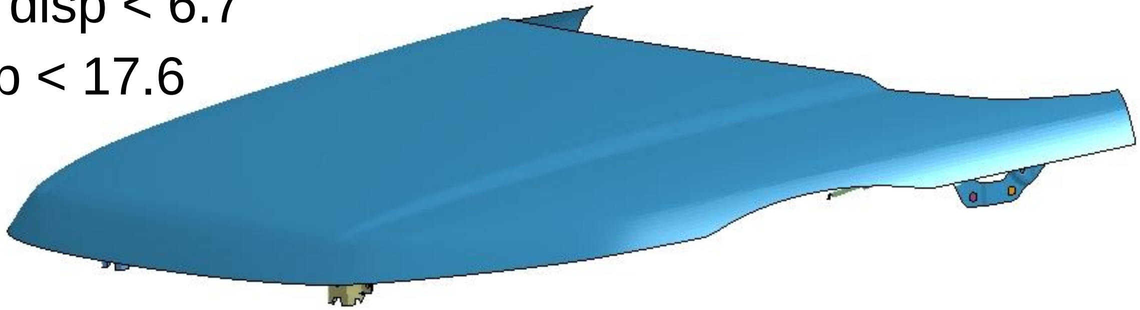
Highly nonlinear Example

- Deformed topologies



Bonnet Case Study

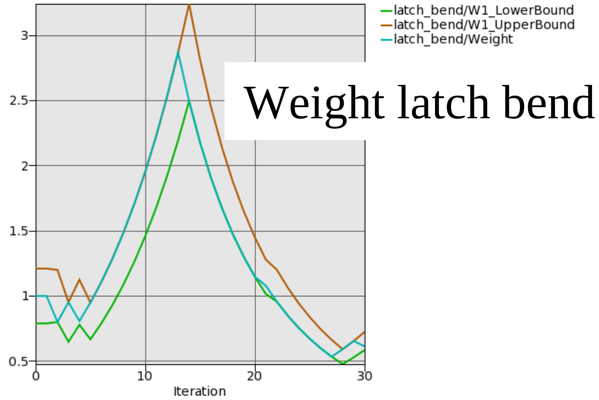
- Solid elements with layer of shell elements on top
  - Design part is solid part
- Three nonlinear load cases
  - Latch bend
  - Rear beam
  - Torsion
- Target mass fraction of 1%
- Constraints
  - Latch bend: z disp > -1.7
  - Rear beam: resultant disp < 6.7
  - Torsion: resultant disp < 17.6

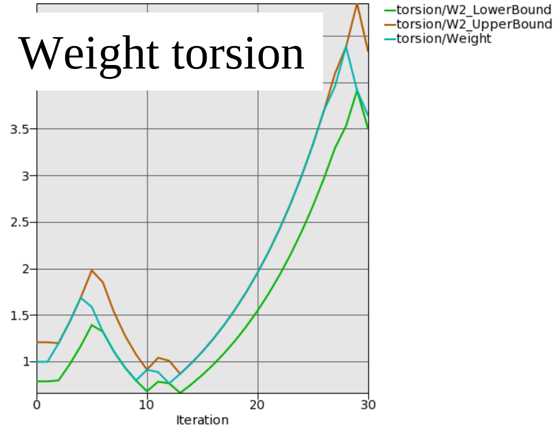


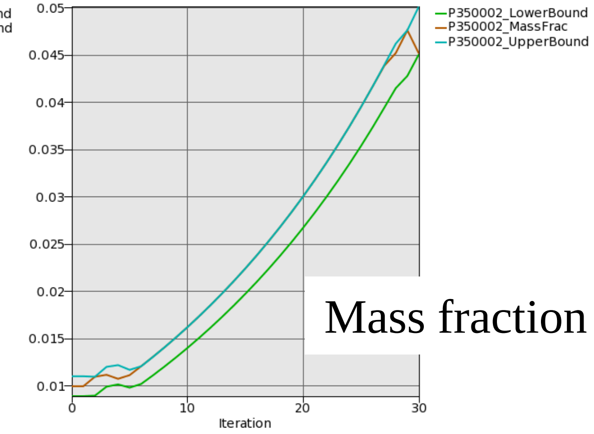
Example courtesy of JRL

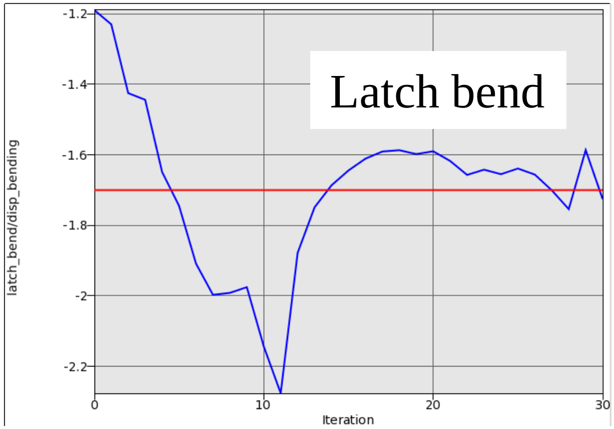
Bonnet Case Study - Results

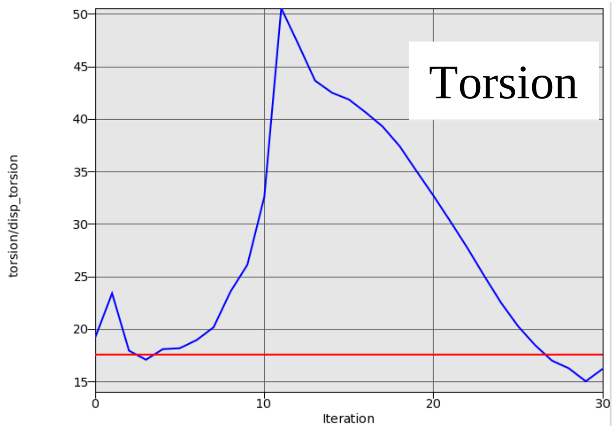
- Global variables and constraints

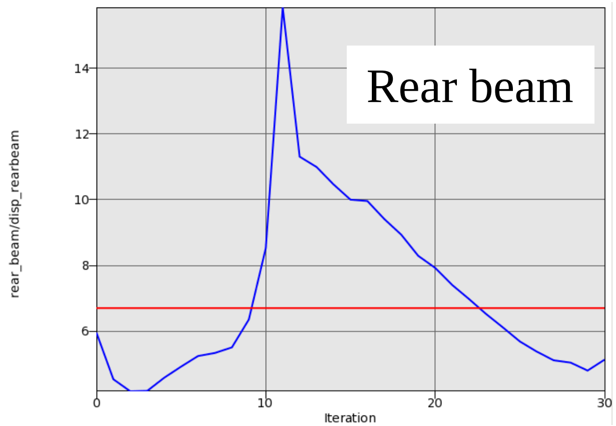








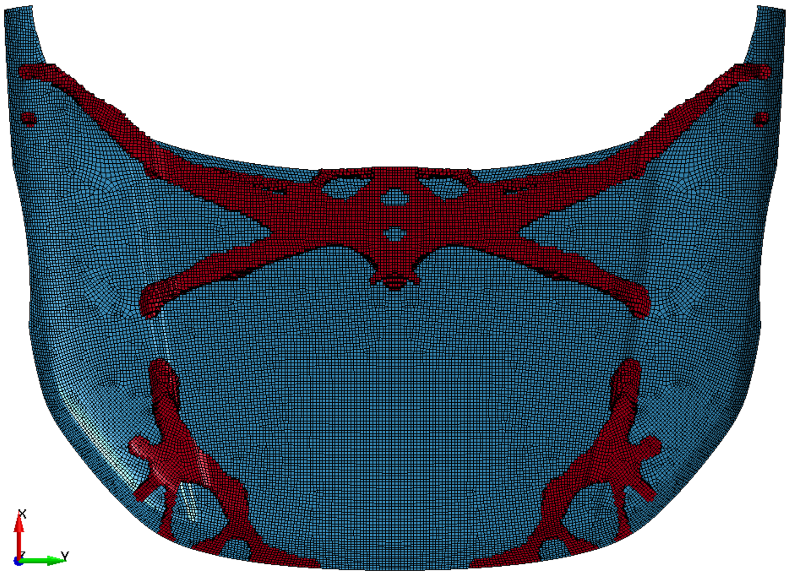




Bonnet Case Study - Results

- Final topology

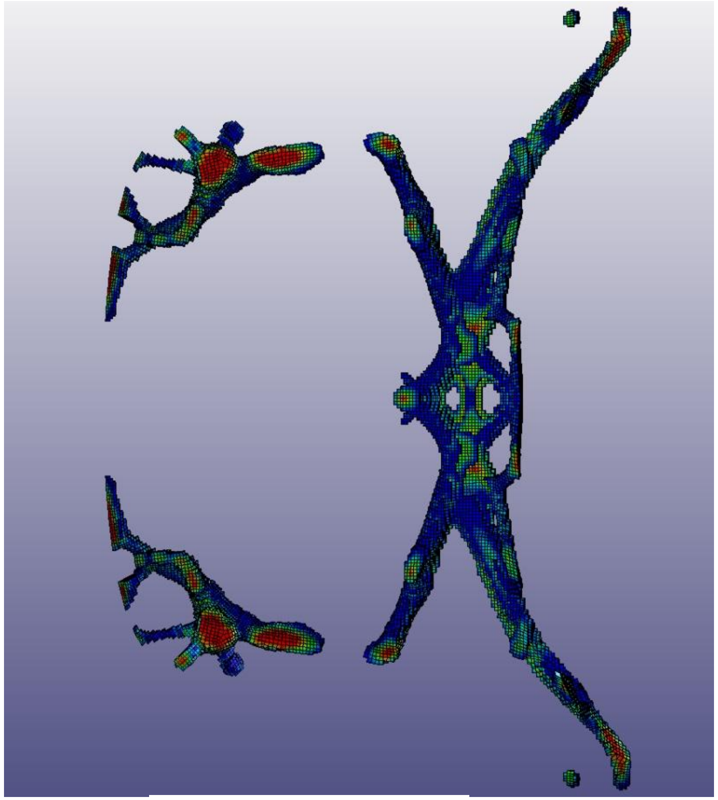
Initial design



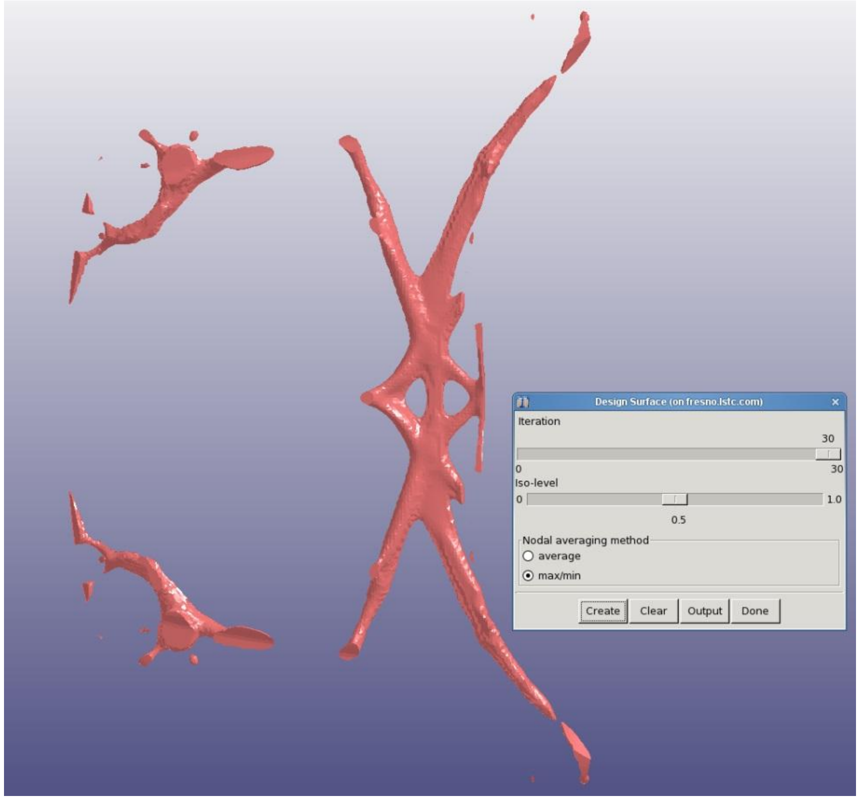
Optimal structure

Bonnet Case Study - Results

- Iso-surface



Final structure



Iso-surface

Other new Features

- Unconnected regions in a part can be identified and deleted
- The job submission system has been updated to match LS-OPT Version 5
- GUI improvements

Current Development

- Eigenfrequency Analysis
  - Topology optimization using
    Design Sensitivity Analysis in LS-DYNA
  - Objectives
    - Maximization of fundamental frequency

Thank you!