Design Optimization with Parametric Geometry Variation

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  - Optimization in automotive development process: Merits, Limits, State of the Art
  - software products for design optimization with parametric geometry variation
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  - Optimization setup
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Introduction –
Optimization in automotive development process

Optimization in automotive development process

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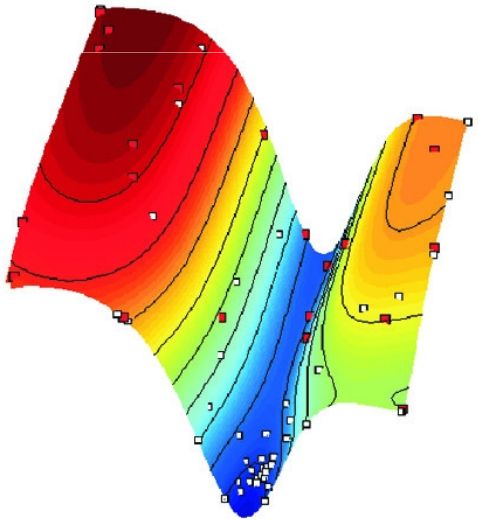
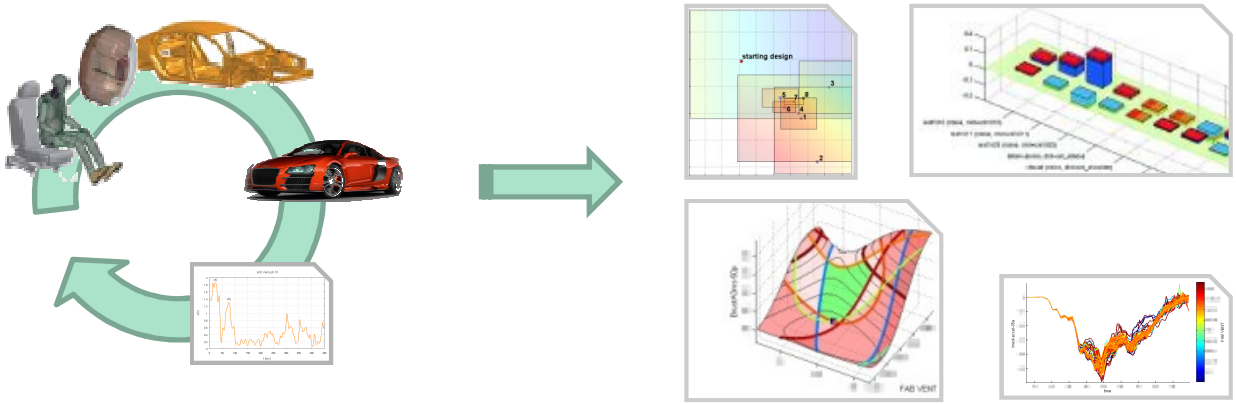
Application of mathematical optimization – state of the art, merits and limits

- Optimization
  - Size-/Shape Optimization
  - Topology Optimization
  - System-/Parameter Identification
  - Reliability Improvement
- Design Exploration
  - Study of design changes
- Sensitivity Studies
  - Parameter / Variable Screening
- Robustness Analysis
  - Consideration of uncertainties
  - Evaluation of reliability

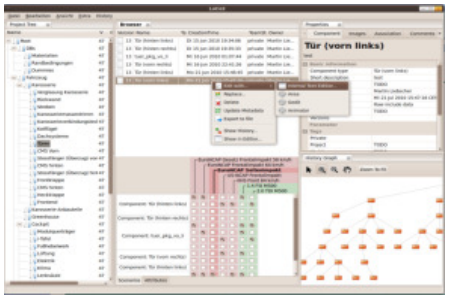


Optimization in automotive development process

- Integration in development process



- Integrated Optimization in Simulation Data Management Systems (SDM) – Future?
- Multi Disciplinary Optimization (MDO) ?
- Consideration of Design Constraints



Introduction Software Products for design optimization with parametric geometry variation

SFE Concept - Overview

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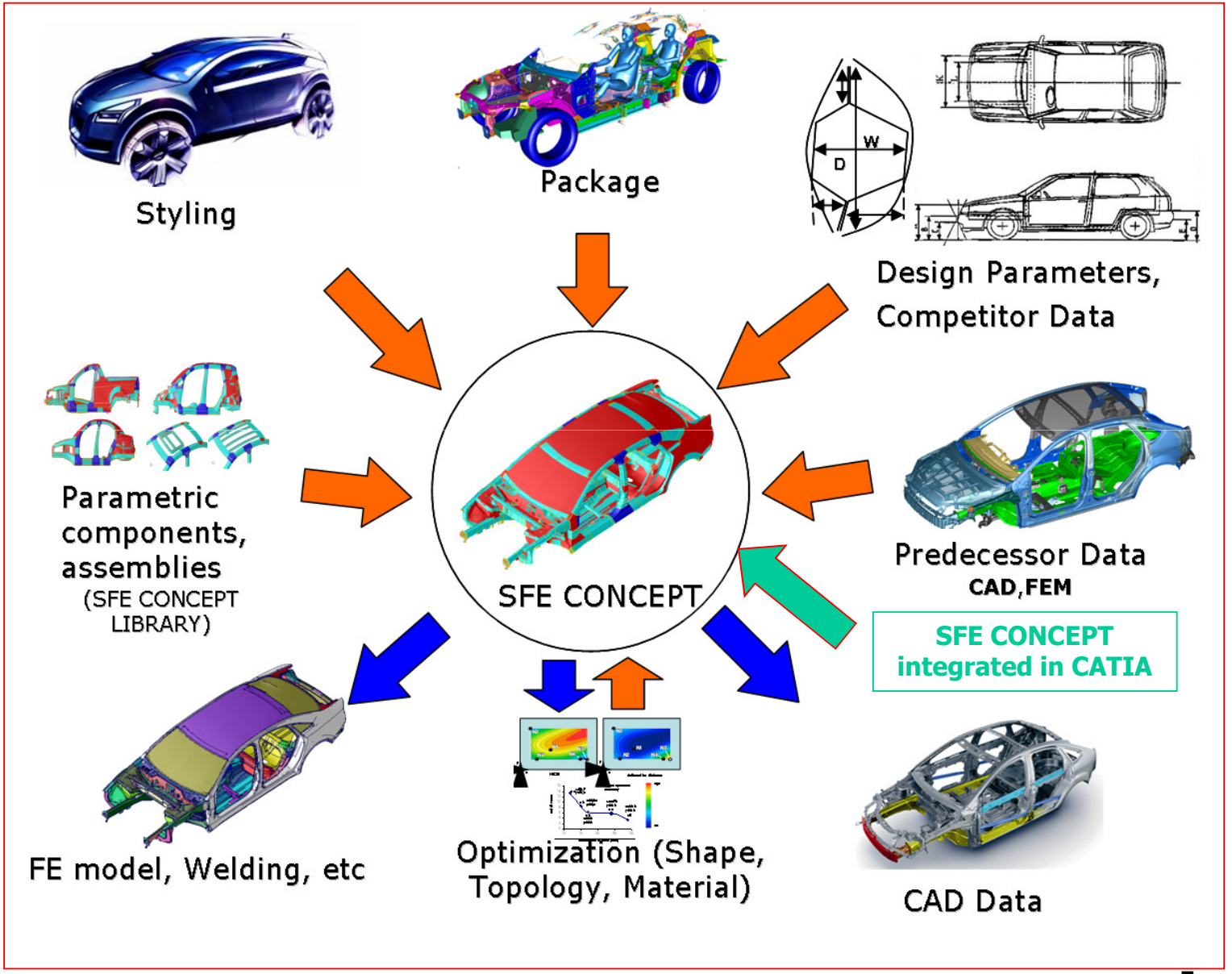
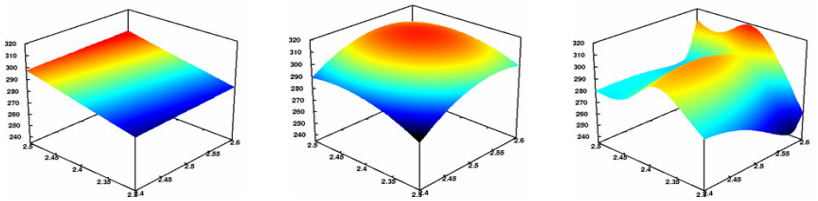
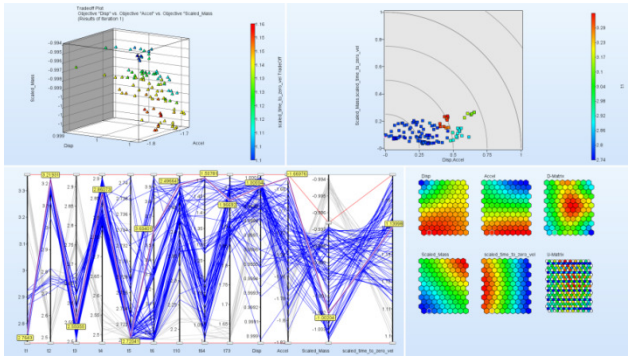


LS-OPT – Optimization Software – Overview

- Very effective optimization algorithms customized for crash applications
- Meta-Models
  - Polynomials
  - Radial Basis Functions
  - Neural Nets (FFNN)
- Genetic Algorithm (MOGA->NSGA-II)
- Multidisciplinary optimization (MDO)
- DOE-Studies (Sensitivity Analysis)
- Stochastic/Probabilistic Analysis
- Reliability Based Design Optimization (RBDO)
- Parameter- / System Identification

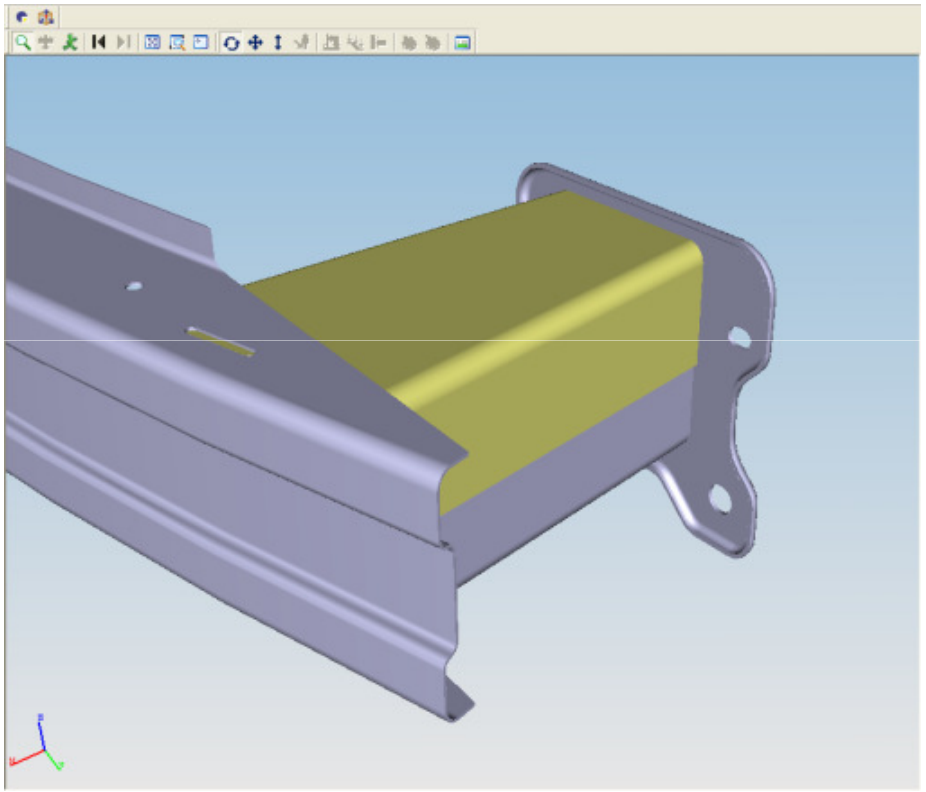




Case Study Description

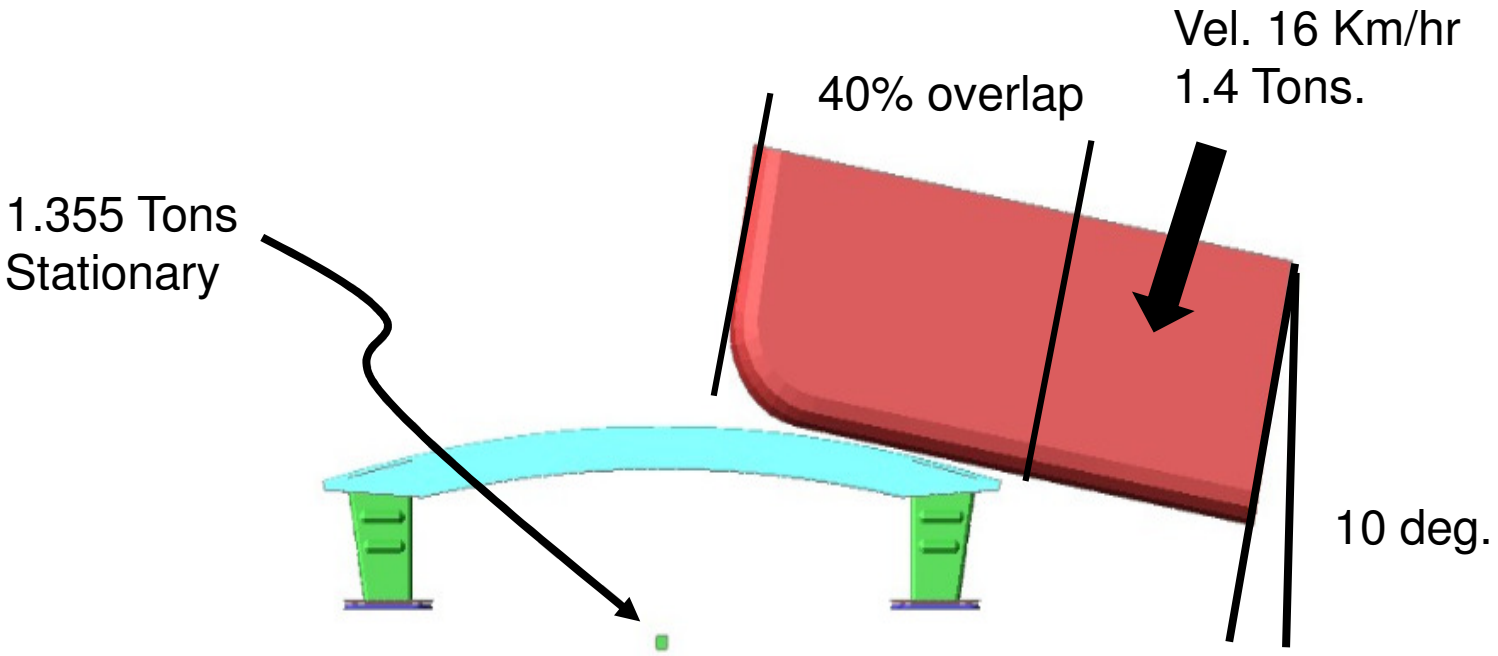
The Geometry

- CAD representation of low speed crash absorber



The Loading Case

- Simulation model capture the AZT (Alliance Center of Technology) rear impact test
- Important for insurance rating



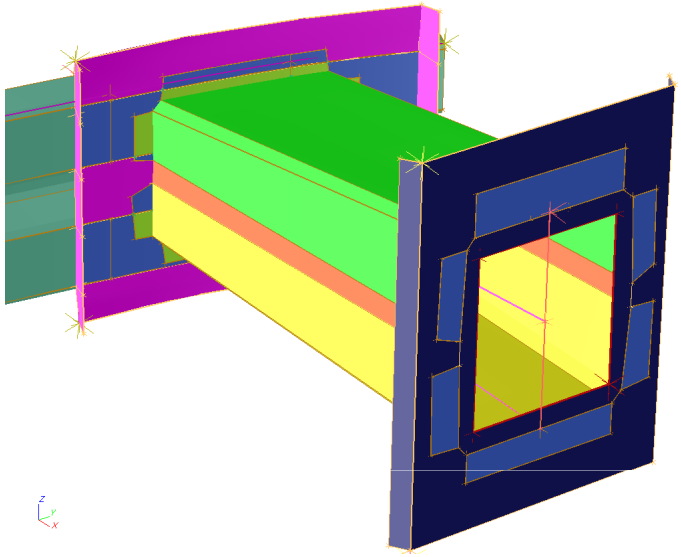
Case Study Objective

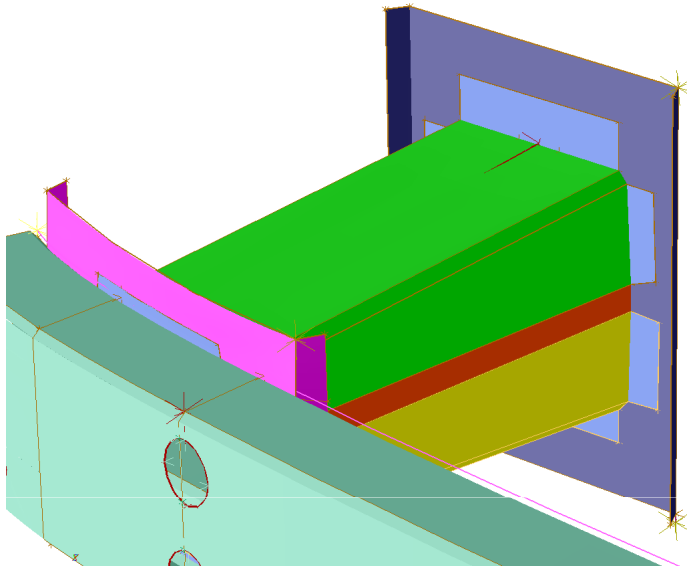
- Create the parameterised geometry model and to define the variables
- Formulation of optimization problem:

  Energy absorption without violation of
  - Max peak load of 90 KN
  - Max deformation of 90 mm

Modelling Process Overview

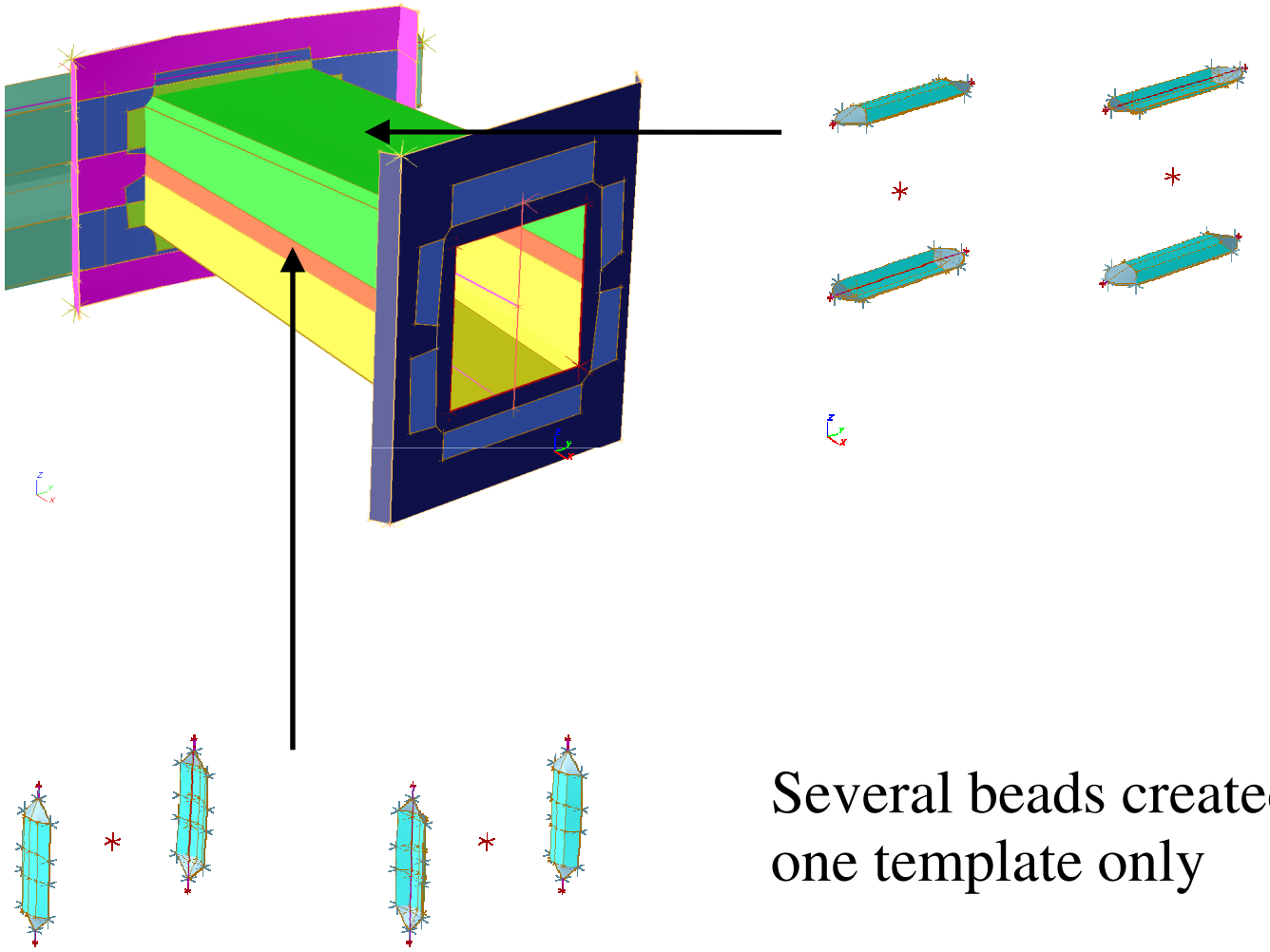
Crashbox





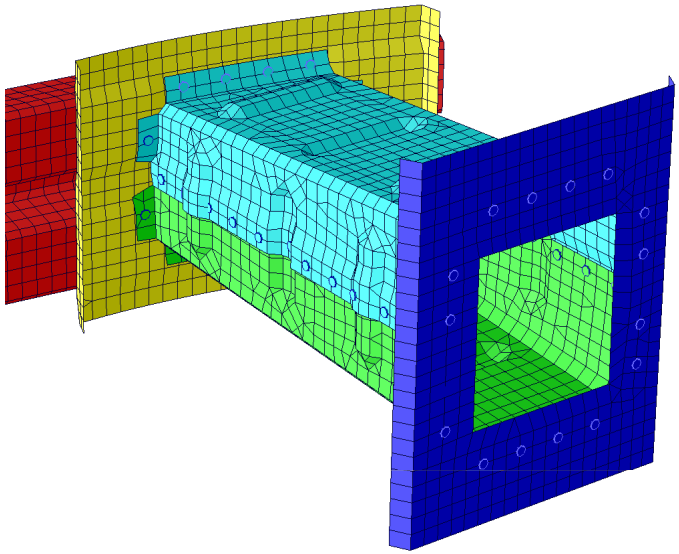
Initial model

Crashbox beads



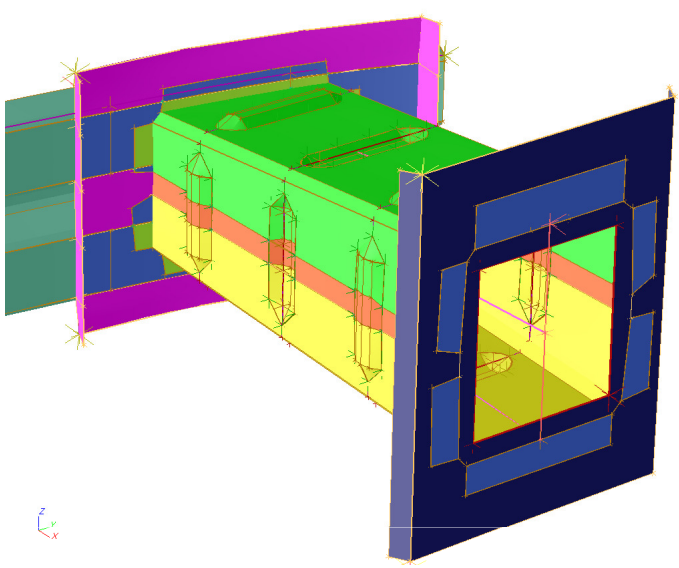
Several beads created from one template only

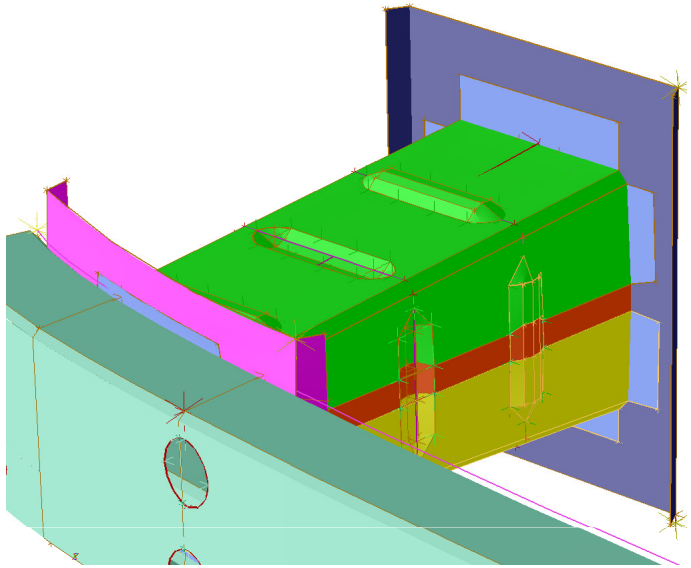
Crashbox

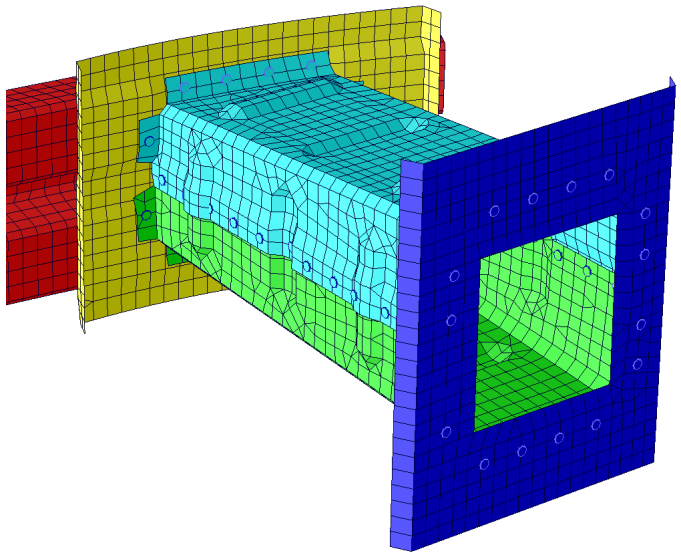


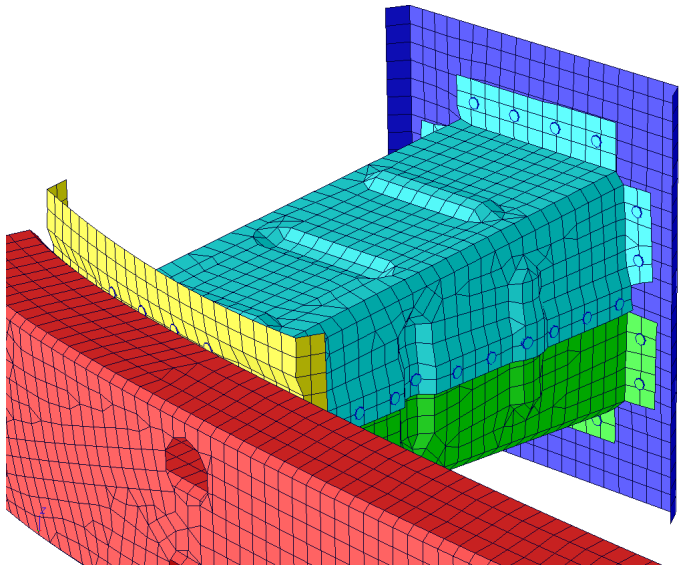
New variant

Crashbox

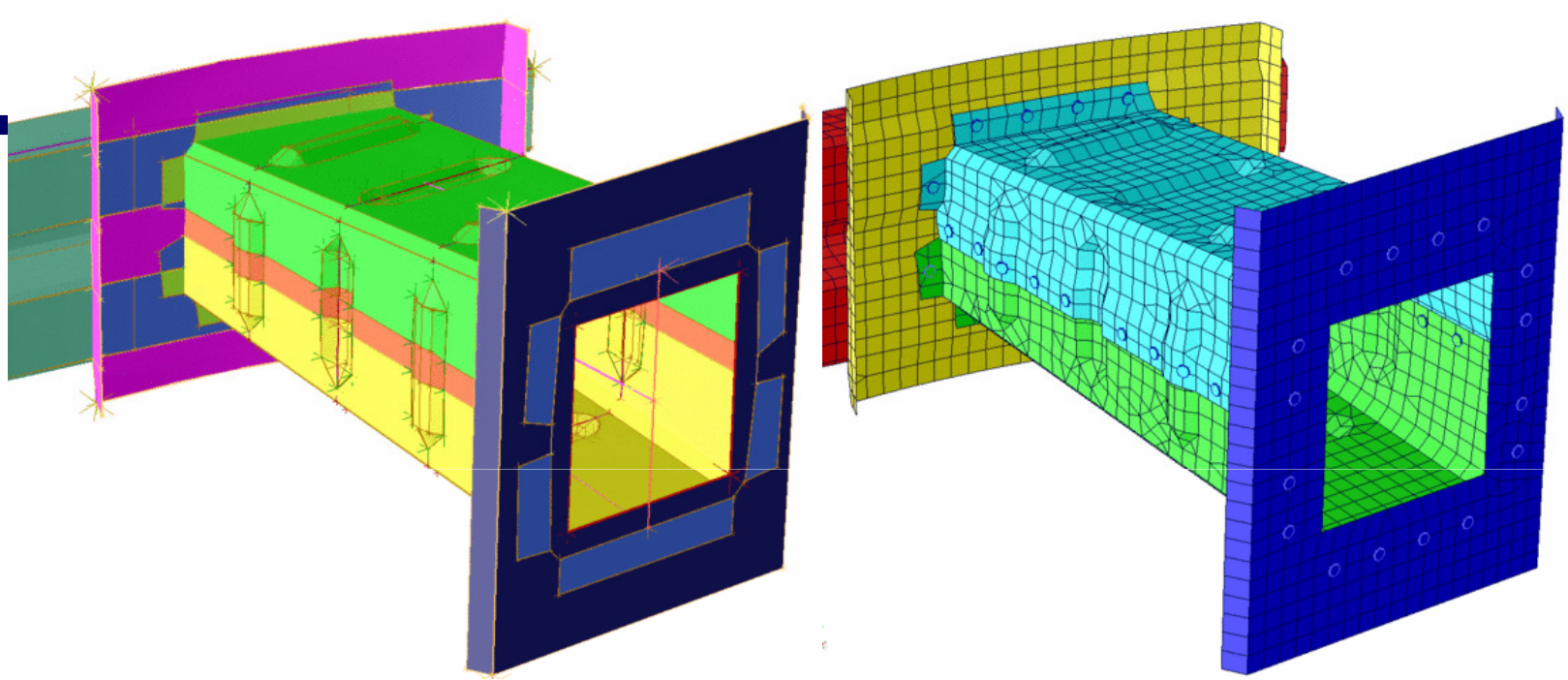






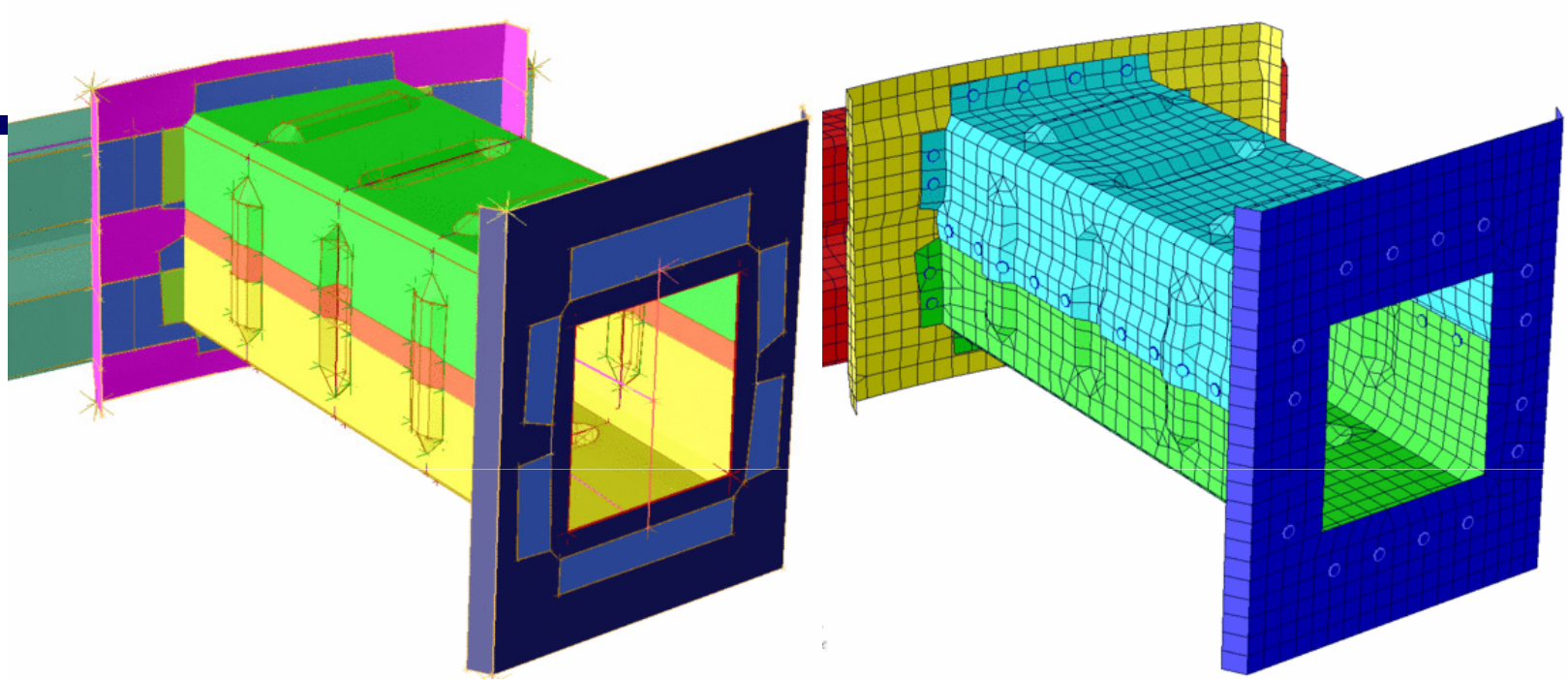


Crashbox



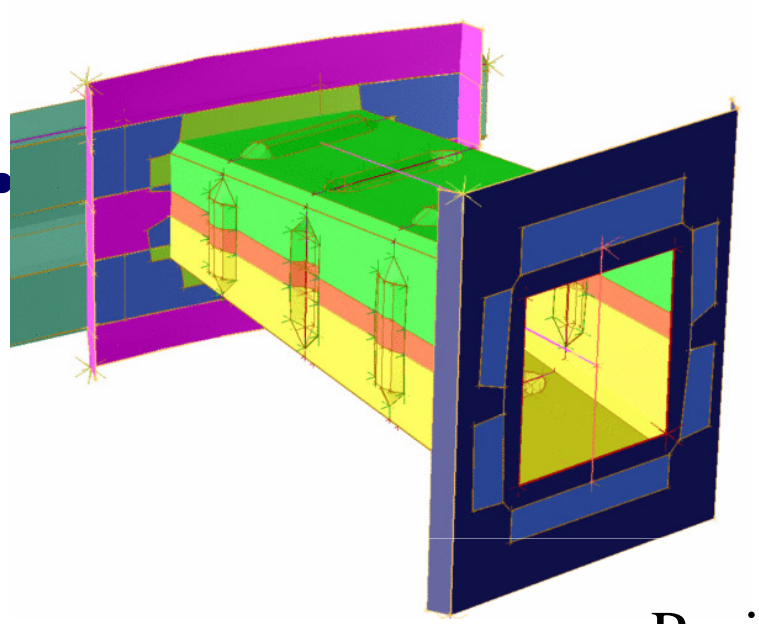
Taper horizontal modification

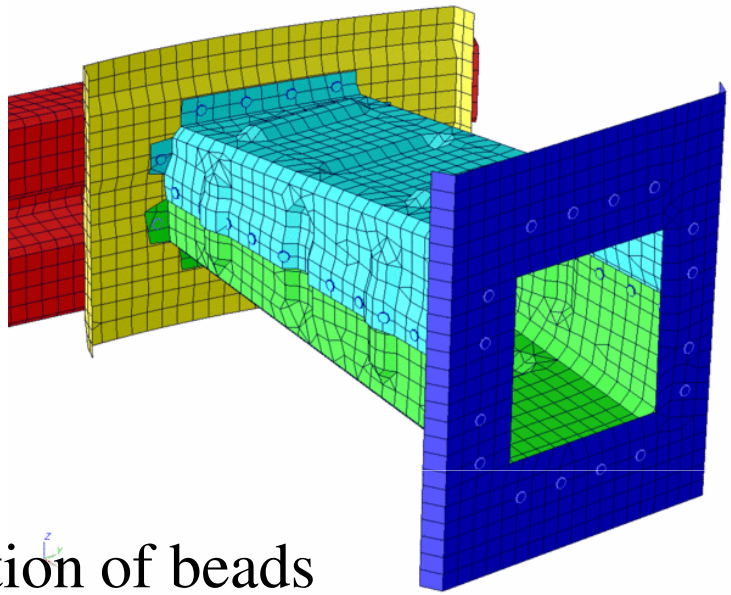
Crashbox



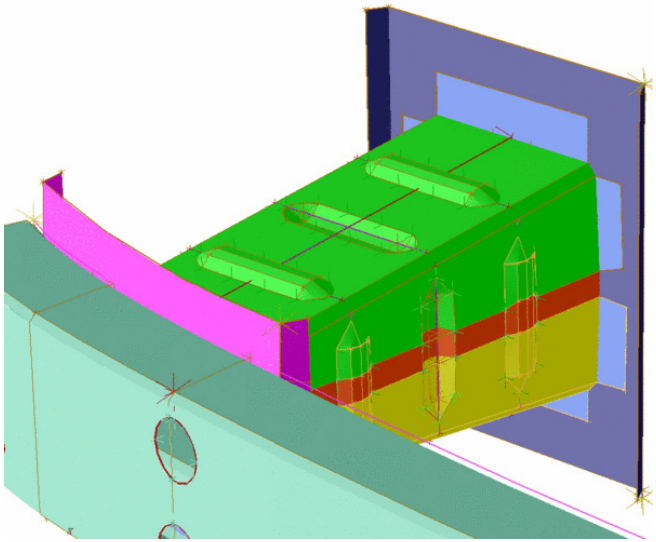
Taper vertical modification

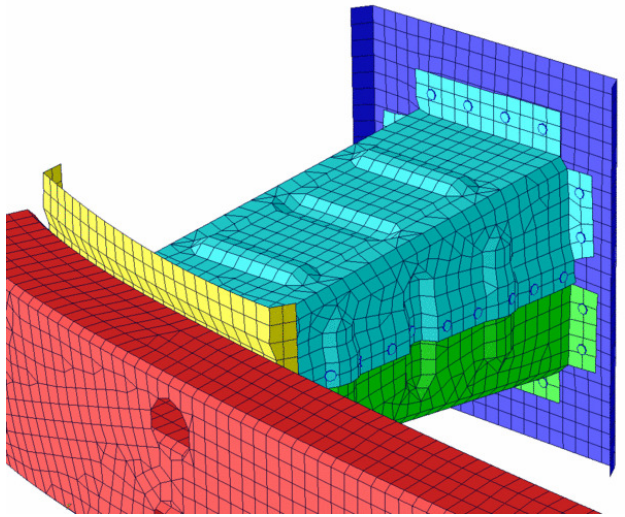
Crashbox



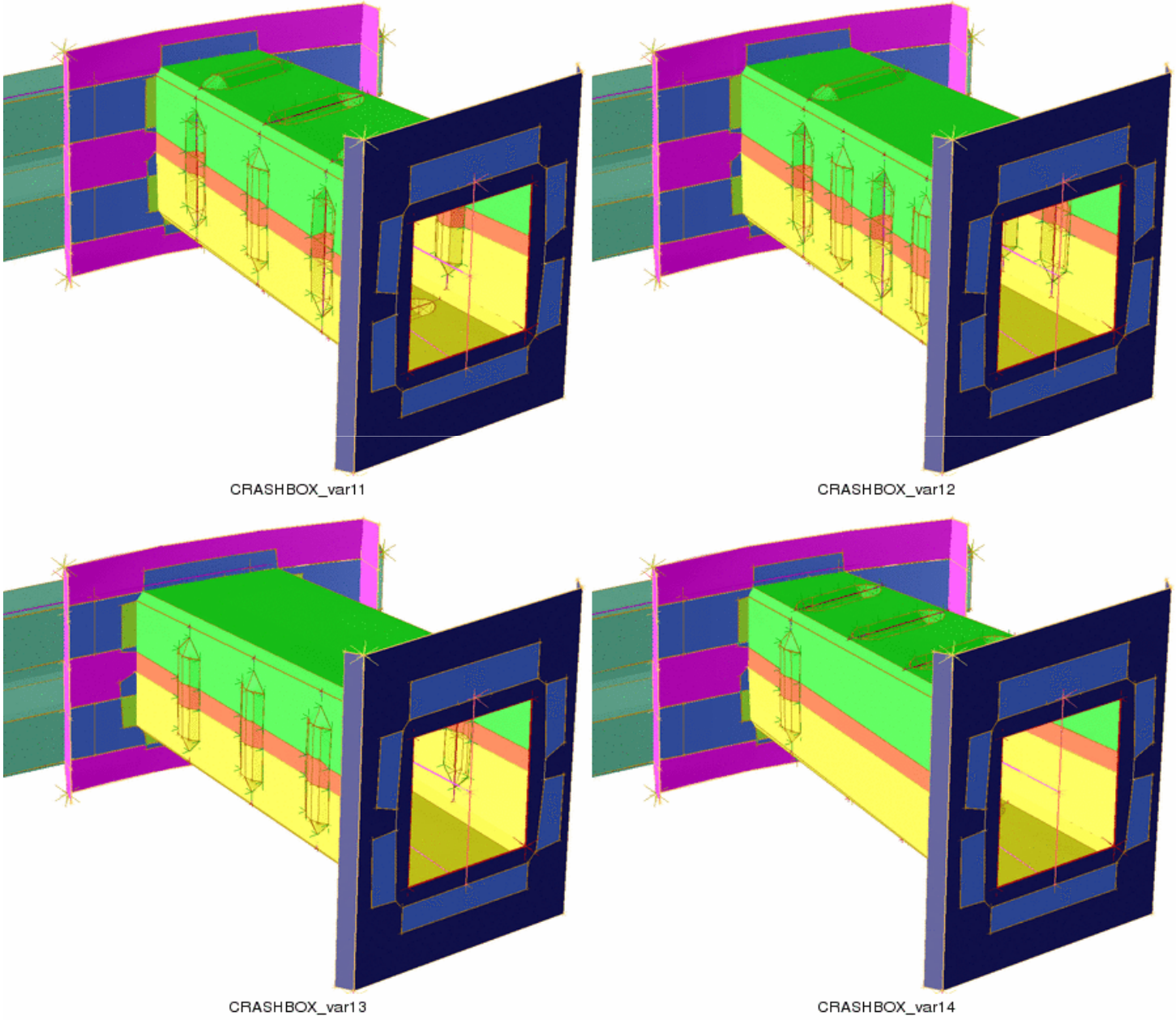


Position of beads

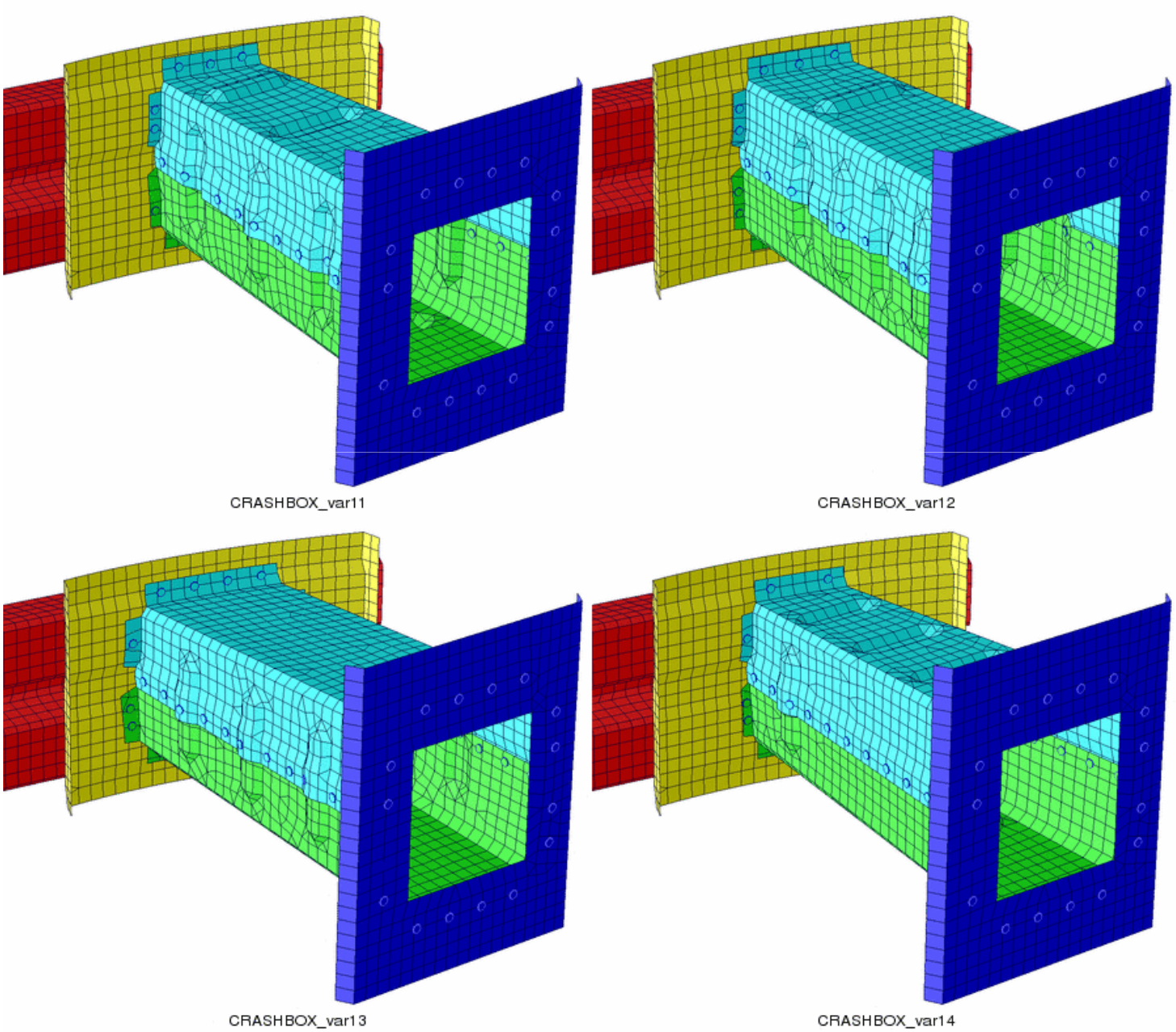




Randomly created topologies



Randomly created topologies



Optimization Setup

SFE Optimisation Setup

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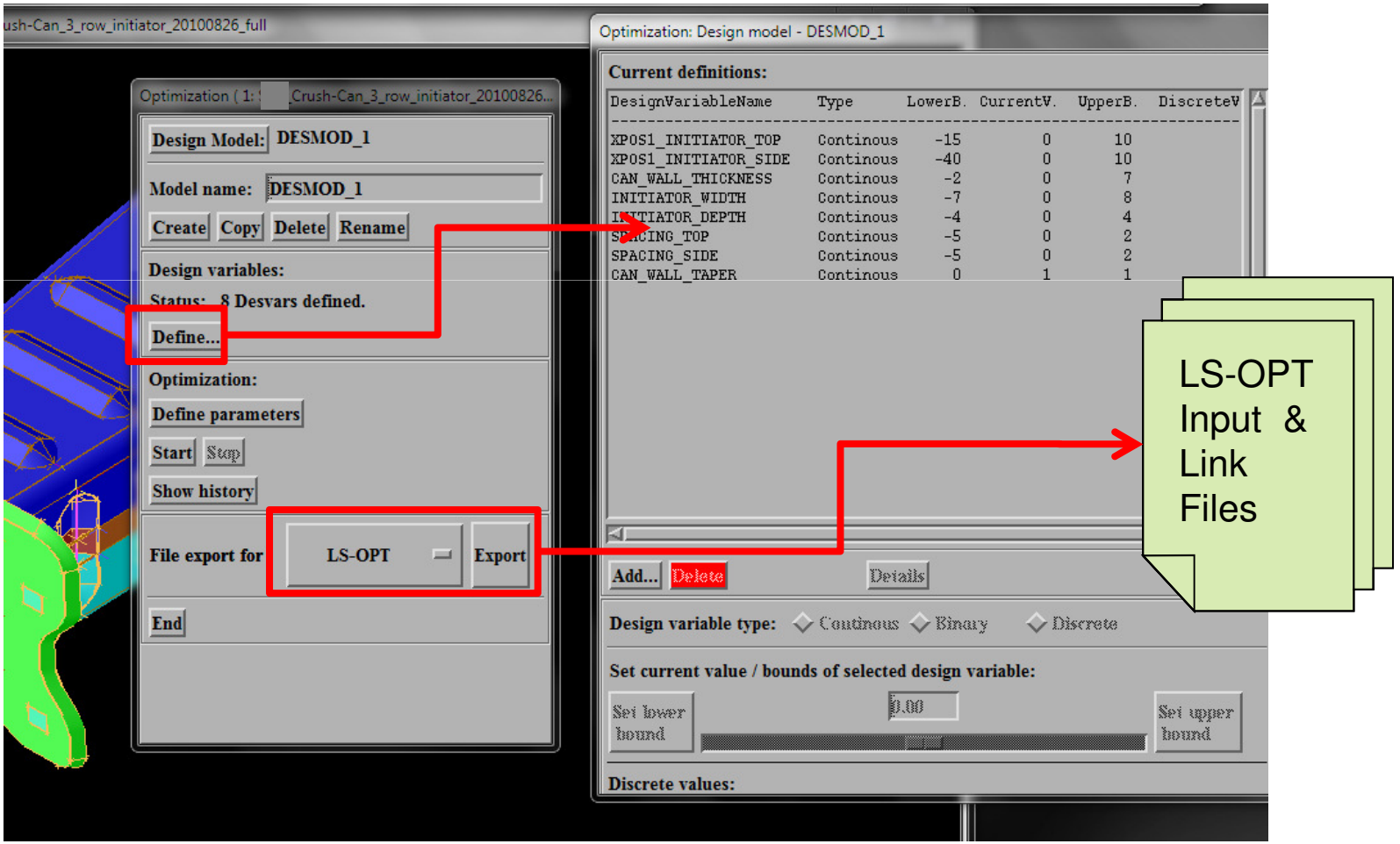
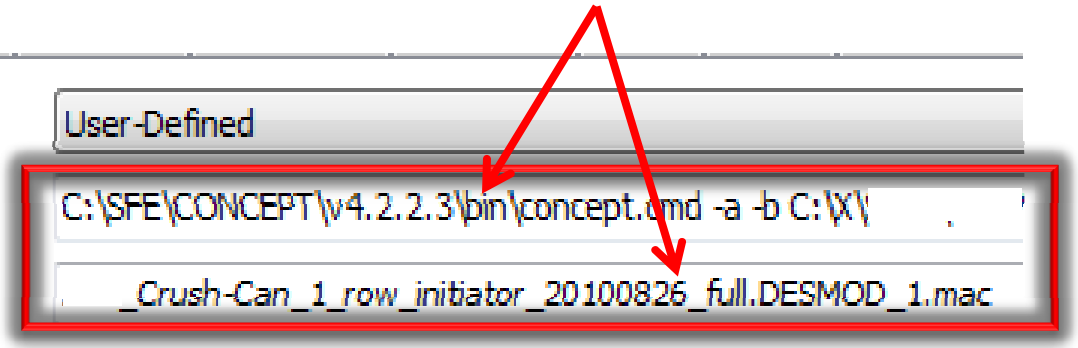
- Closed loop for structural optimization using SFE CONCEPT, LS-DYNA and LS-OPT



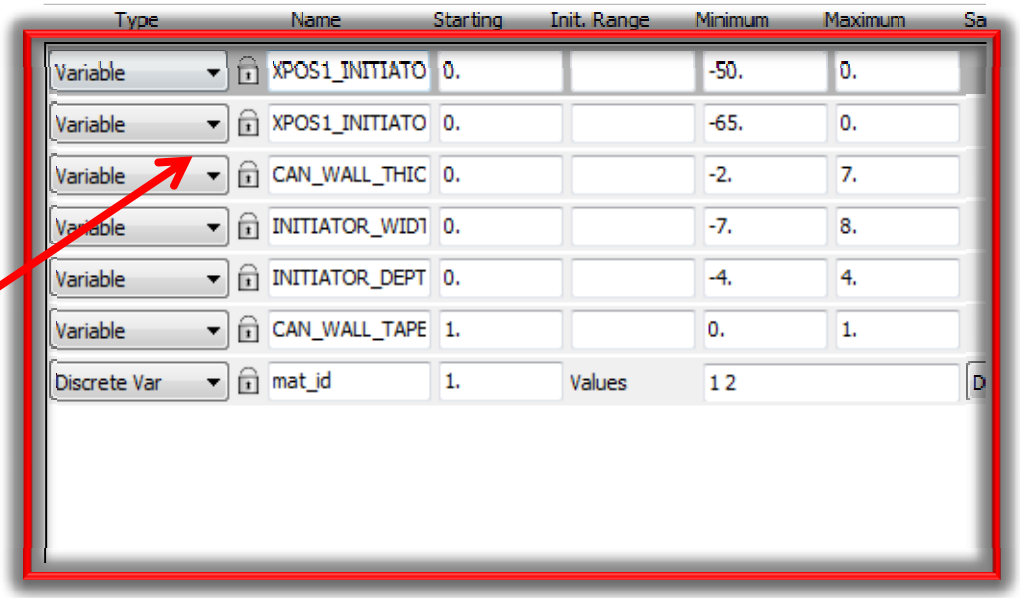
LS-OPT Optimisation Setup

LSTC Livermore Software Technology Corp.

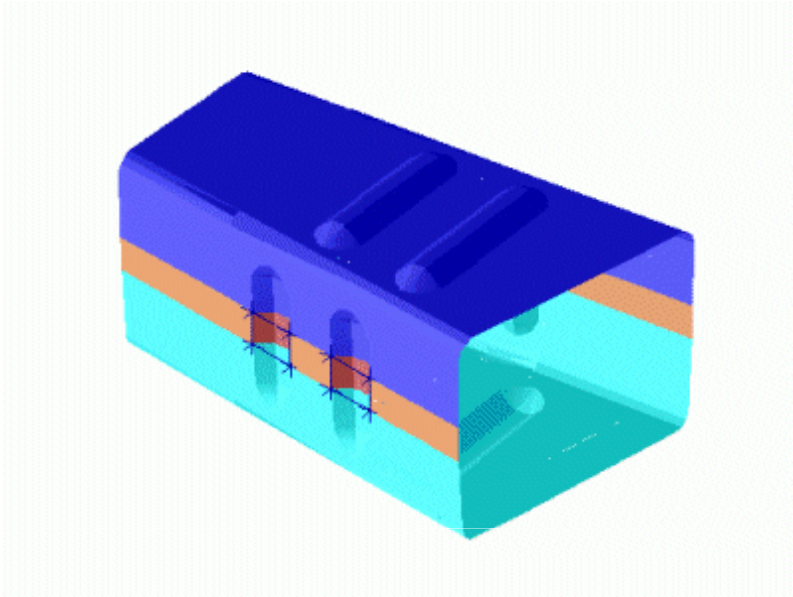
Linking files to run SFE CONCEPT in batch mode



LS-OPT file from SFE

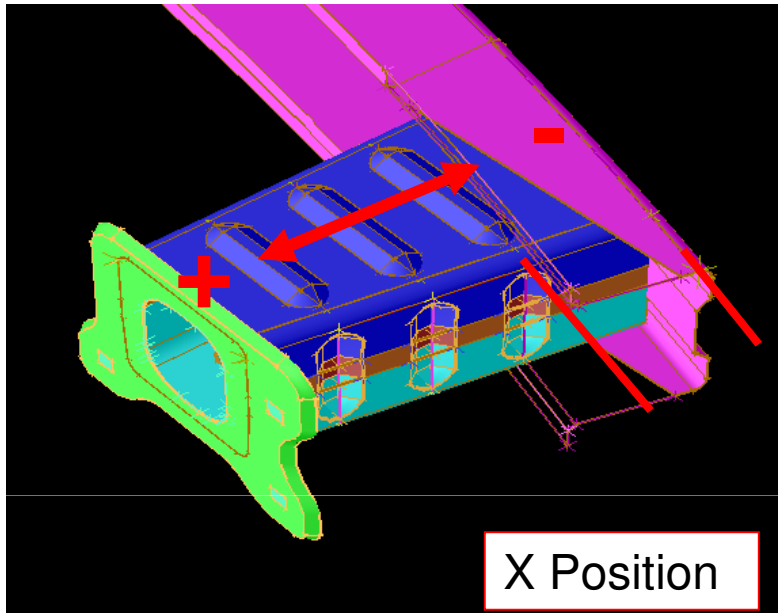


Variables for all variants



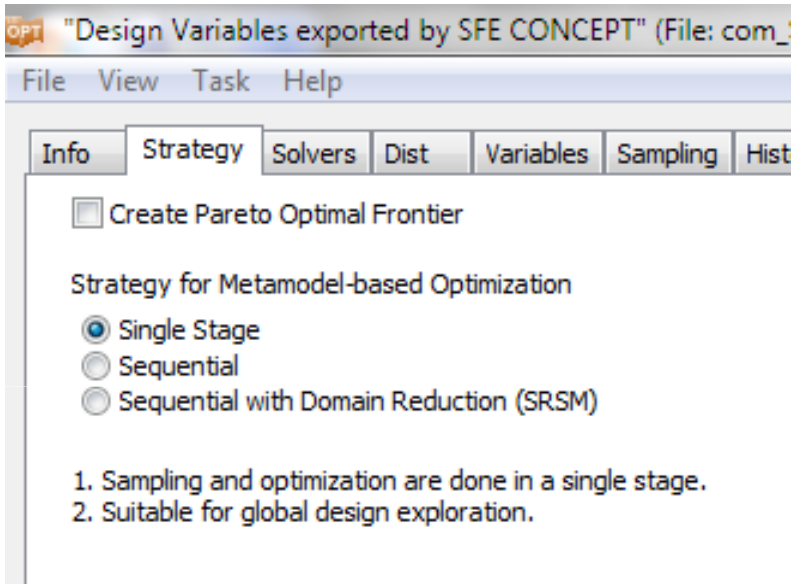
Description	Lower	Nominal	Upper
Can wall thickness	1.6mm	1.8mm	2.5mm
Can material	H340LAD	H340LAD	+30%
Can outer wall taper	0°	10°	10°
Depth of initiators	2mm	6mm	10mm
Width of initiators	15mm	22mm	30mm
Number of rows of initiators	1	3	3

Variables specific to number of beads

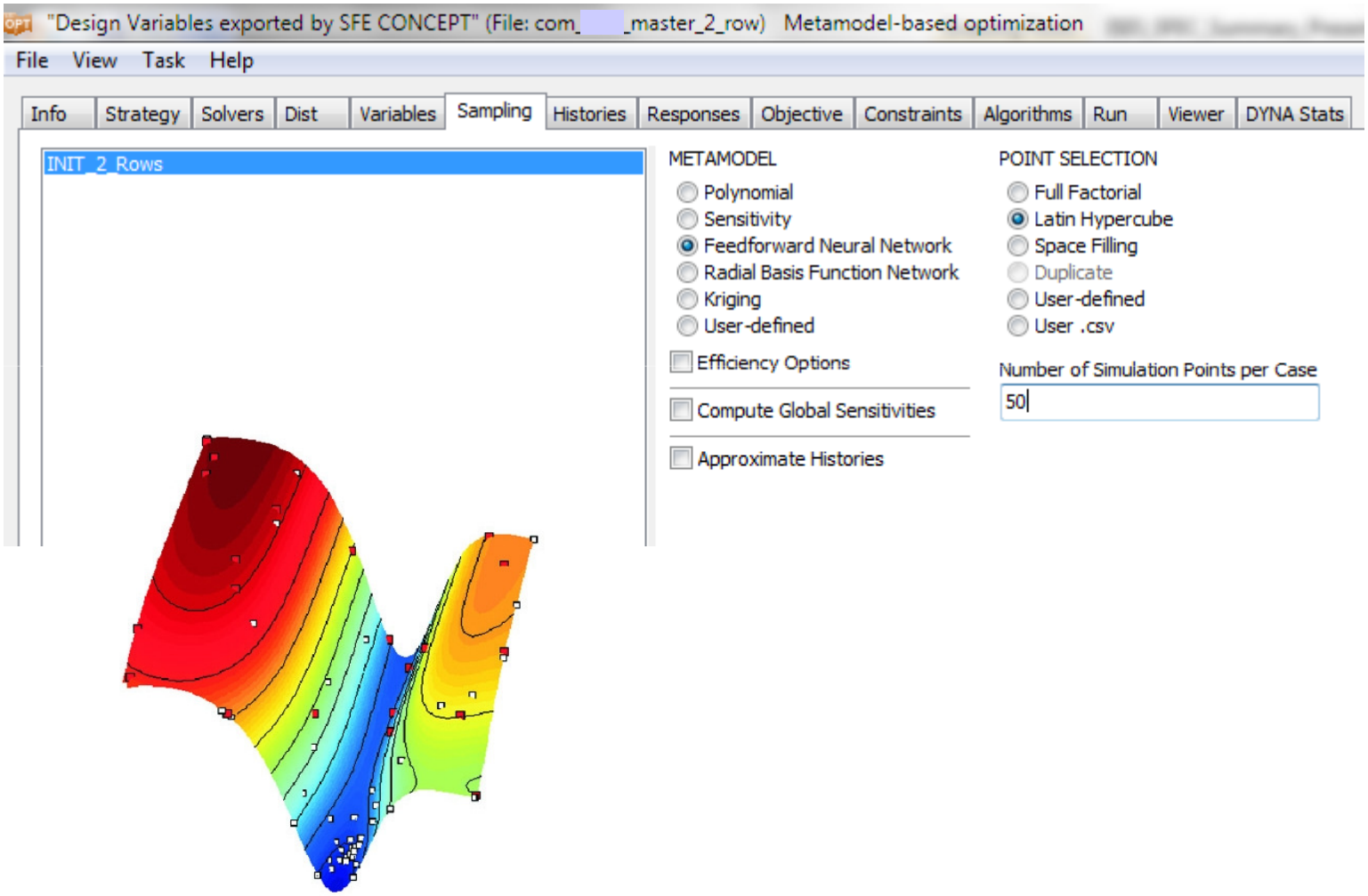


	Single Row			Two Rows			Three Rows		
Description	Lower	Nominal	Upper	Lower	Nominal	Upper	Lower	Nominal	Upper
X-position of top initiator	-50mm	0/92mm	+50mm	-15mm	0/48mm	40mm	-15mm	0/48mm	40mm
X-position of side initiator	-60mm	0/92mm	+50mm	-38mm	0/48mm	40mm	-38mm	0/48mm	40mm
Spacing between initiators top	-	-	-	-5mm	0/44mm	15mm	-5mm	0/44mm	5mm
Spacing between initiators side	-	-	-	-5mm	0/44mm	15mm	-5mm	0/44mm	5mm

Optimisation Strategy



Metamodel and Sampling



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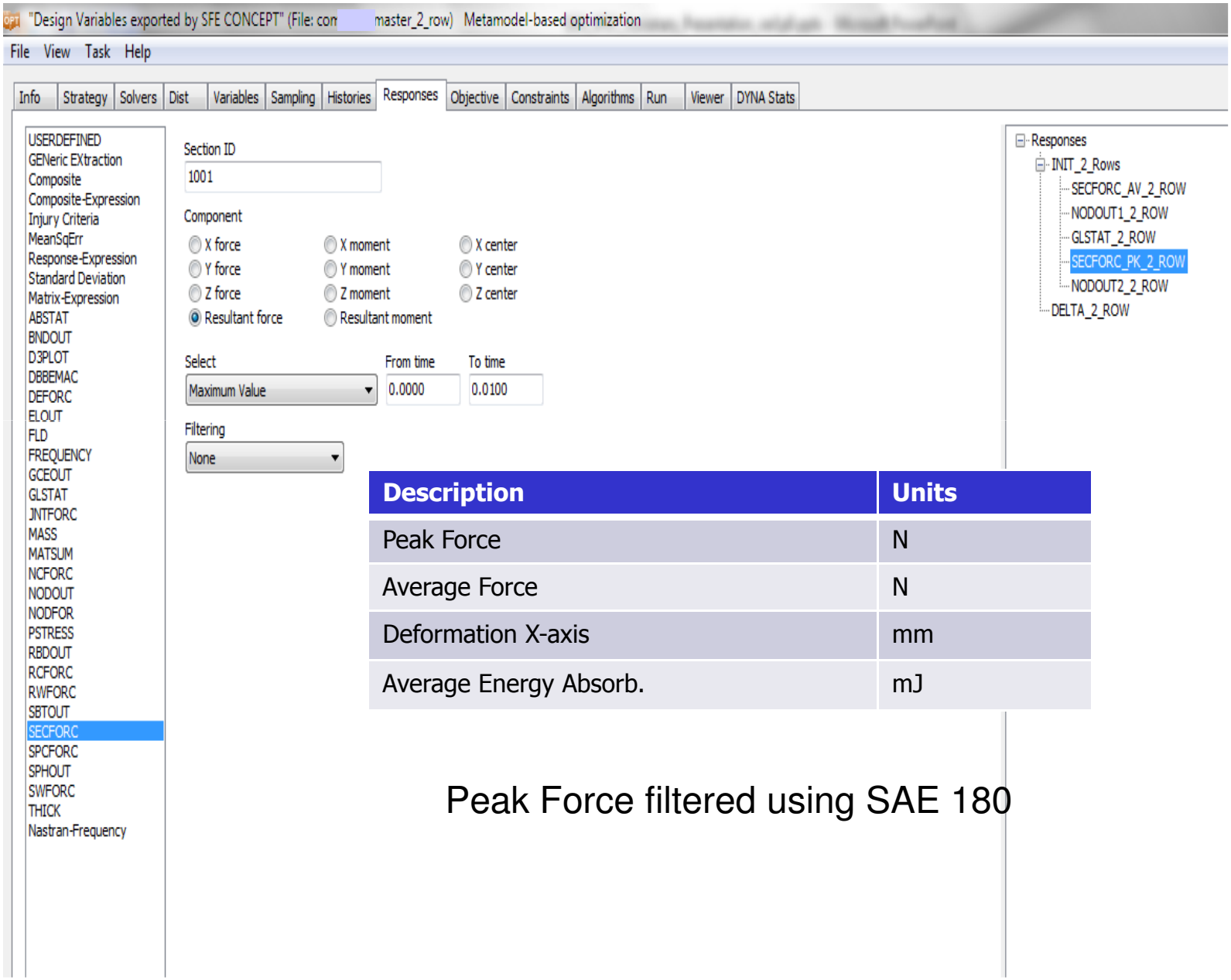
Responses

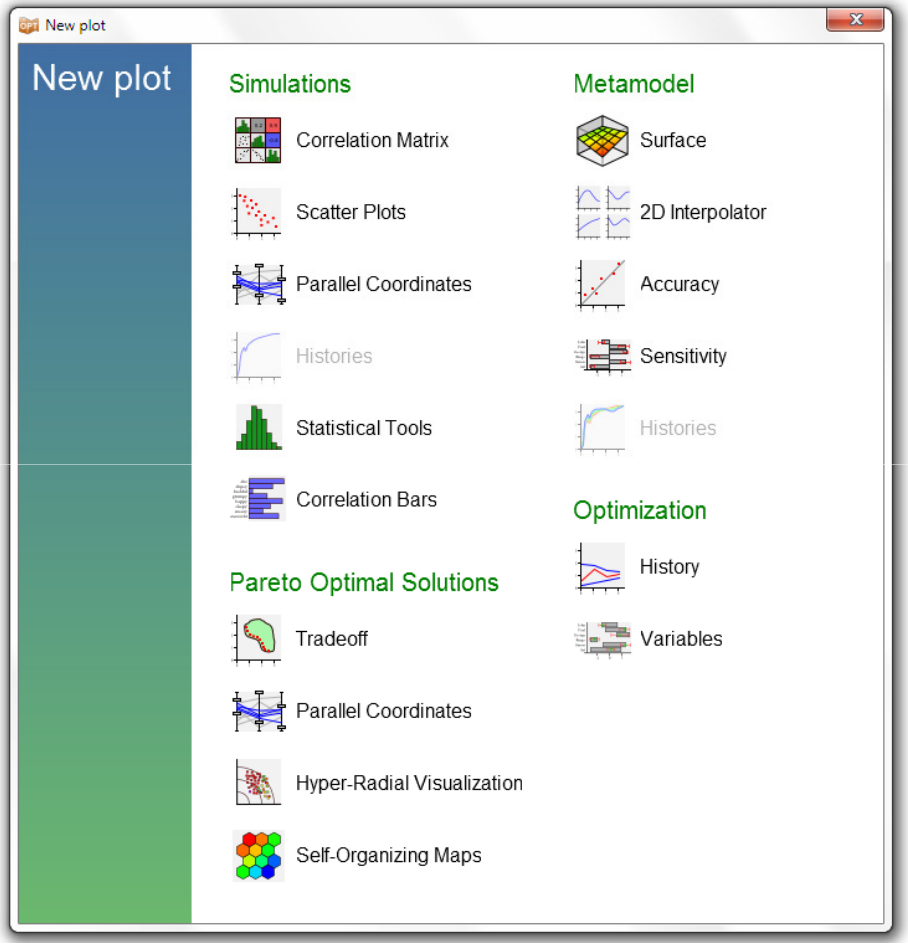


Description	Units
Peak Force	N
Average Force	N
Deformation X-axis	mm
Average Energy Absorb.	mJ

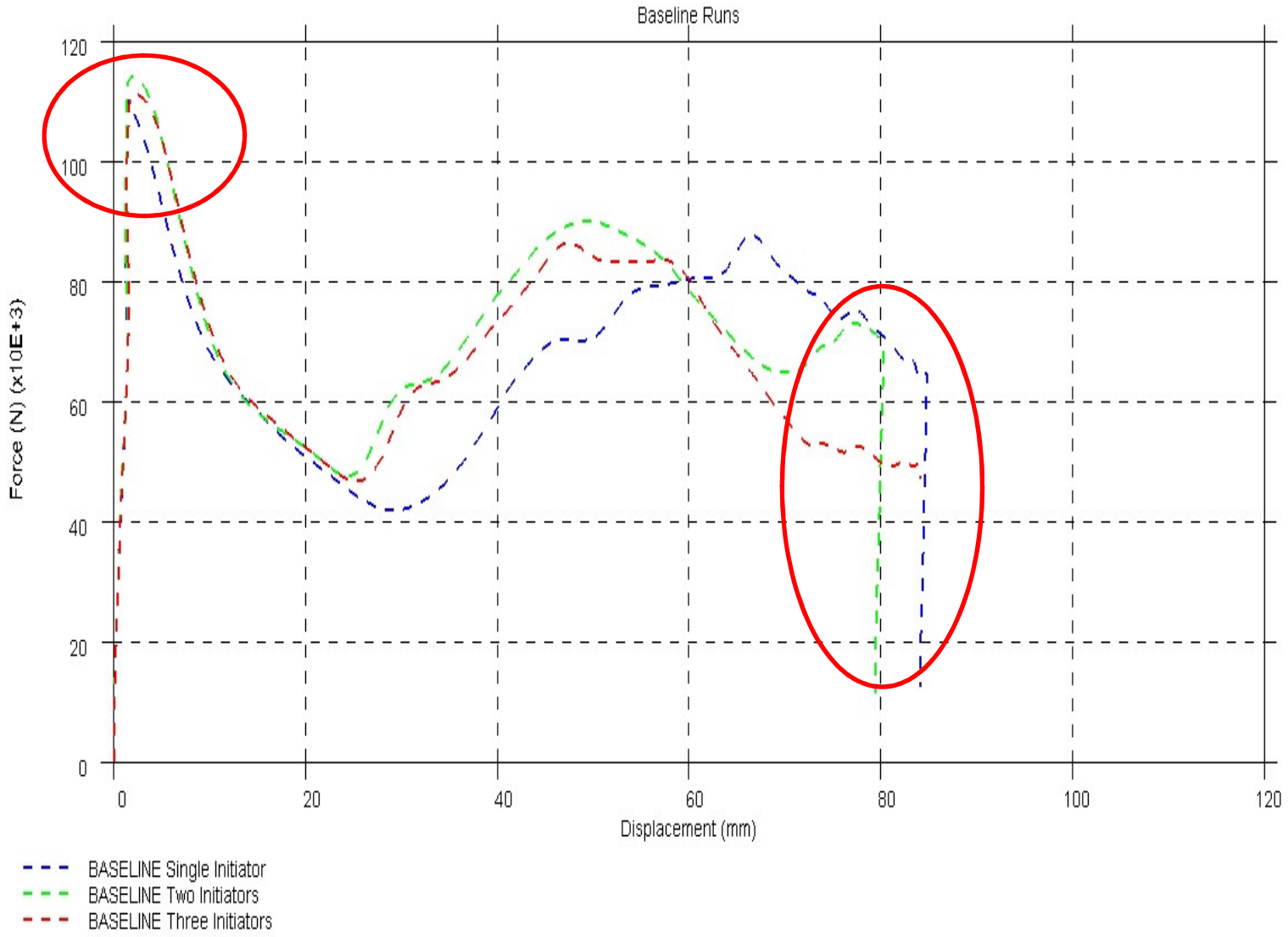
Peak Force filtered using SAE 180

Optimization Results

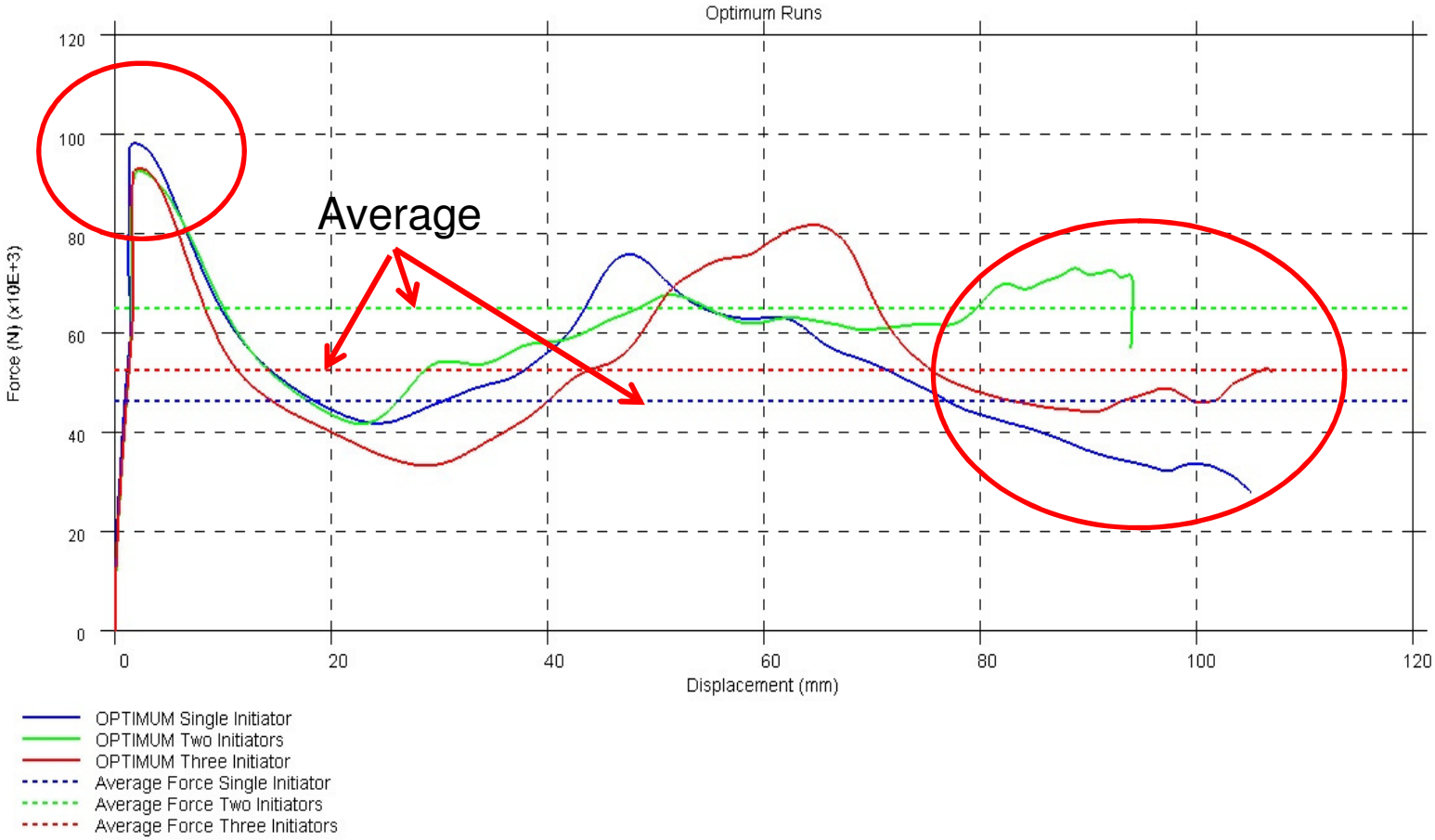
Post-Process



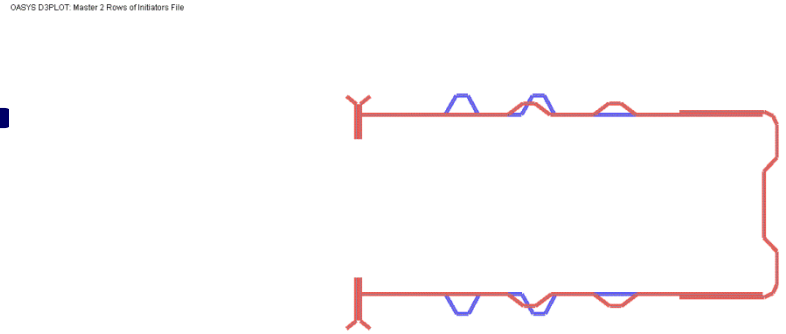
Baseline

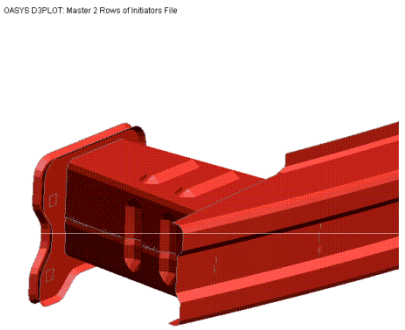


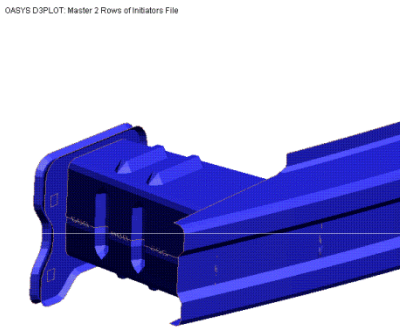
Optimum Comparison

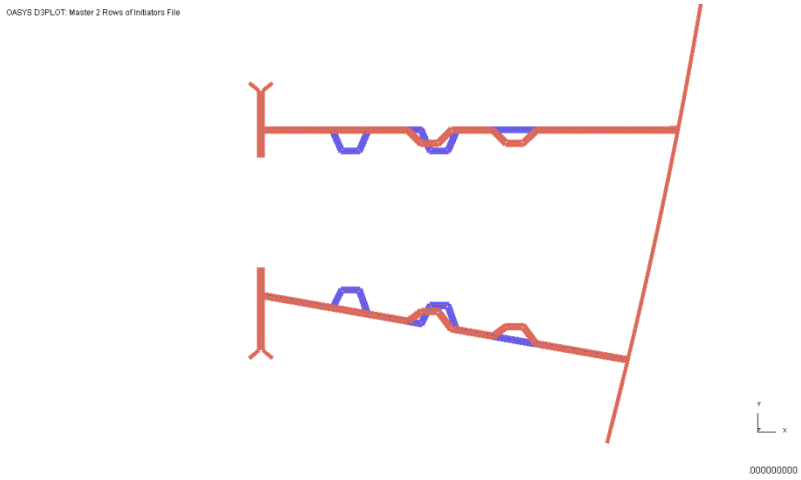


Two Initiators

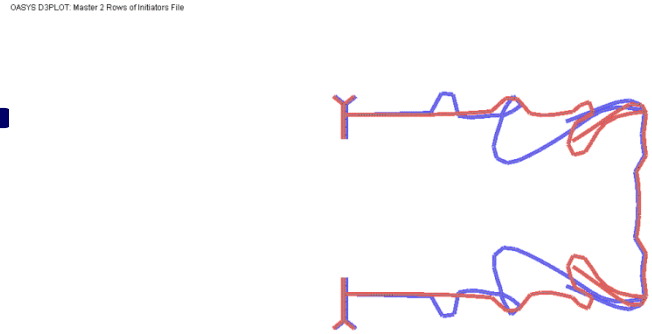


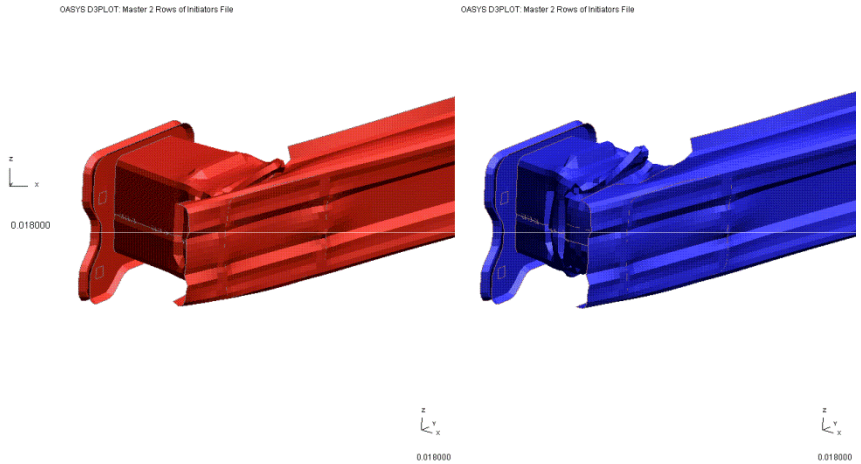


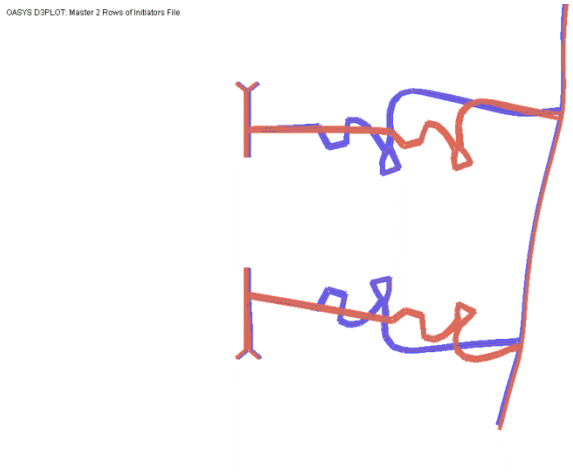




Two Initiators



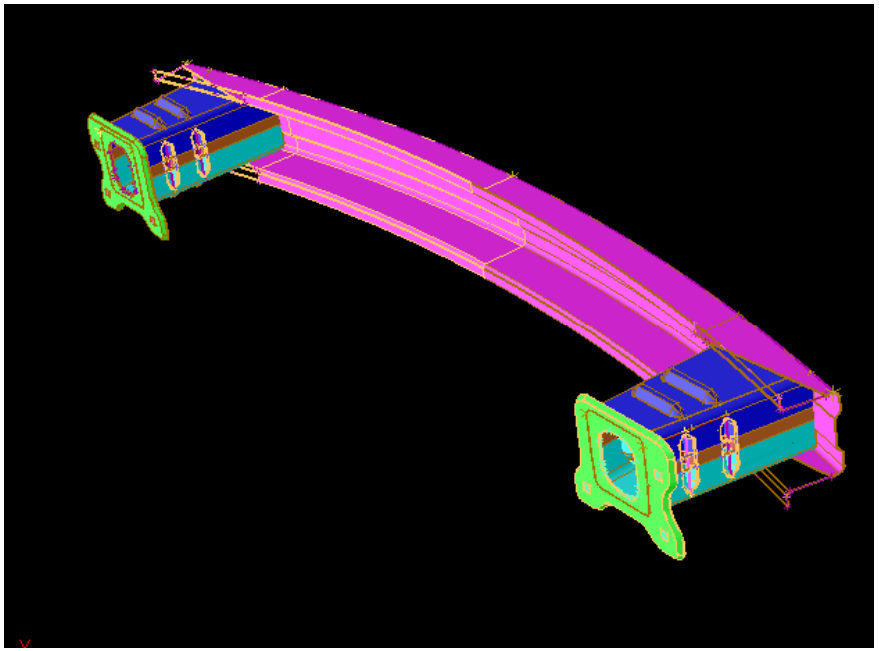




Results Summary

No. Of Initiator Rows	Response	Baseline	Optimum
One	Crush (mm)	84.0	105.4
	Average Load (KN)	65.6	46.4
	Peak Force (KN)	110.3	98.4
	Energy (MJ)	5.5	5.1
Two	Crush (mm)	79	94.4
	Average Load (KN)	66.7	65
	Peak Force (KN)	114.2	92.8
	Energy (MJ)	5.6	5.3
Three	Crush (mm)	84.4	106.8
	Average Load (KN)	60.7	52.5
	Peak Force (KN)	115.0	96.5
	Energy (MJ)	5.6	5.3

Two Rows Optimum



	Two Rows
Description	Nominal
X-position of top initiator	87mm
X-position of side initiator	87mm
Spacing between initiators top	39mm
Spacing between initiators side	46mm
Can wall thickness	1.6mm
Can material	H340LAD
Can outer wall taper	10
Depth of initiators	10mm
Width of initiators	18mm
Mass reduction	8%

Conclusions Case Study

- Two initiators provide the best results
- Optimisation driven by the requirement to reduce peak force
- Welds stopped the crumpling collapse of the crush can
- 8% mass reduction was achieved with marginal compromise on crush can deformation
- Further runs are required to find the best solution
- Although design targets were not met perfectly the integration of SFE CONCEPT was successful, opening the possibility to investigate further this designs