

Webinar

New Features in LS-OPT® 6.0

Katharina Witowski - DYNAmore GmbH
Nielen Stander, Anirban Basudhar – LSTC

Stuttgart, 24.10.2019

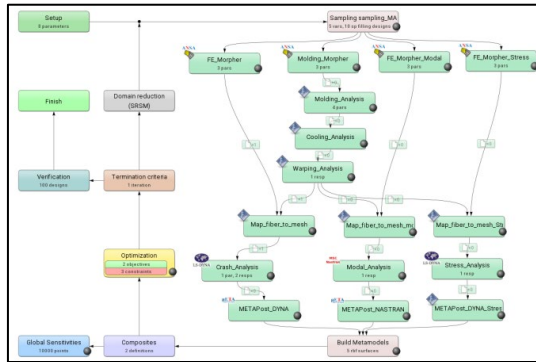
Outline

- Overview of LS-OPT
- New features in LS-OPT 6.0
 - DIC-based parameter identification
 - Support Vector Classification
 - Interactive tables
 - Other new features

LS-OPT[®] - Optimization, Probabilistic Analysis & System Calibration

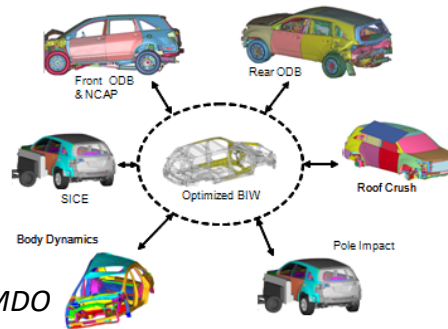
■ Process manager

- multi-stage
- multi-case
- multi-level



■ Optimization

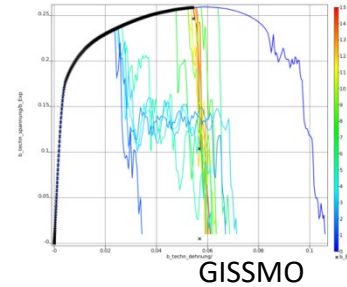
- MDO
- MOO
- Shape Optimization



Multi-case MDO

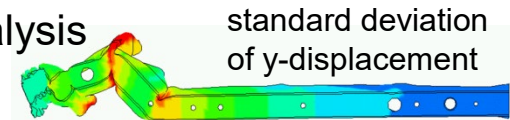
■ Material Calibration

- Curve matching
 - Hysteresis
 - Noise
- Full-field Calibration



■ Statistics and Uncertainty

- Robust Design
- Sensitivity Analysis
- LS-DYNA[®] Statistics
 - Outlier Analysis

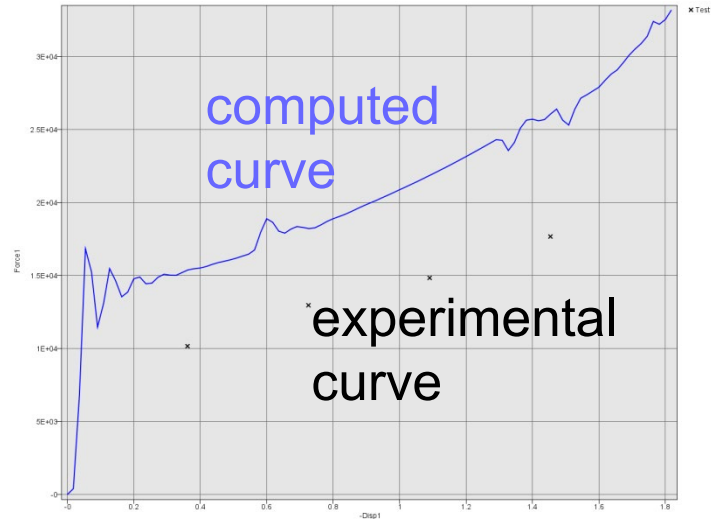


standard deviation of y-displacement

Parameter Identification

Parameter Identification

- Parameter Identification problems are non-linear inverse problems solved using optimization
- Computed curves (from LS-DYNA[®]), dependent on parameters, are matched to experimental curves
- Optimization provides a calibration of the unknown parameters

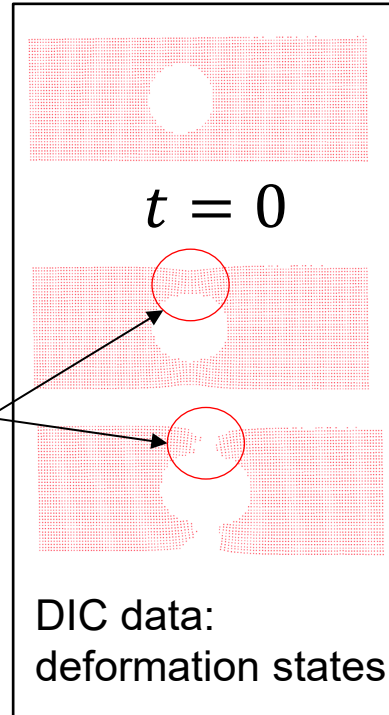


Calibration of material parameters - Standard approach

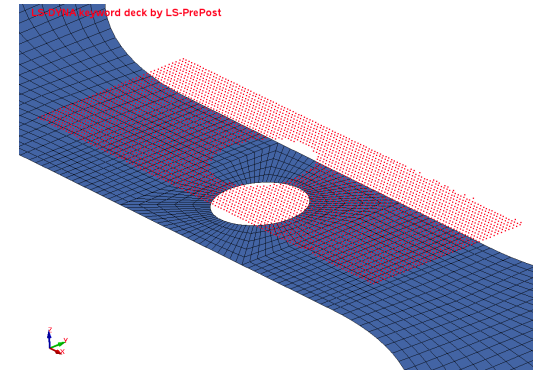
- Global data from experiment is used
- Problems:
 - Instability typical in calibration problems, especially complex models with many parameters
 - Local phenomena such as coupon necking/barreling missed

→ Use full-field data

Local deformation

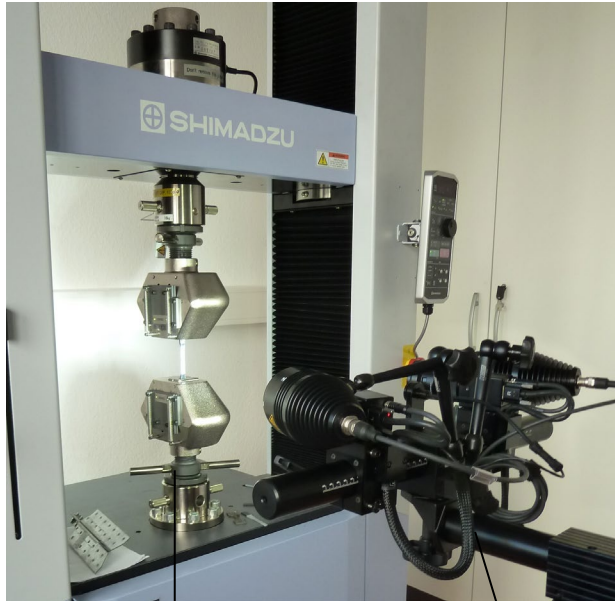


Full field test result
(4557 pts)
from optical scan is
mapped and tracked



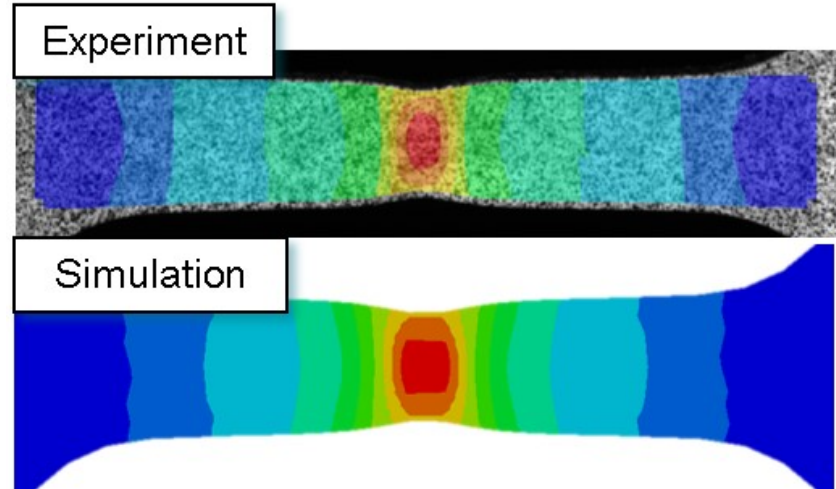
Digital Image Correlation

- Optical method for tracking changes in images



Tensile testing equipment

Measurement system

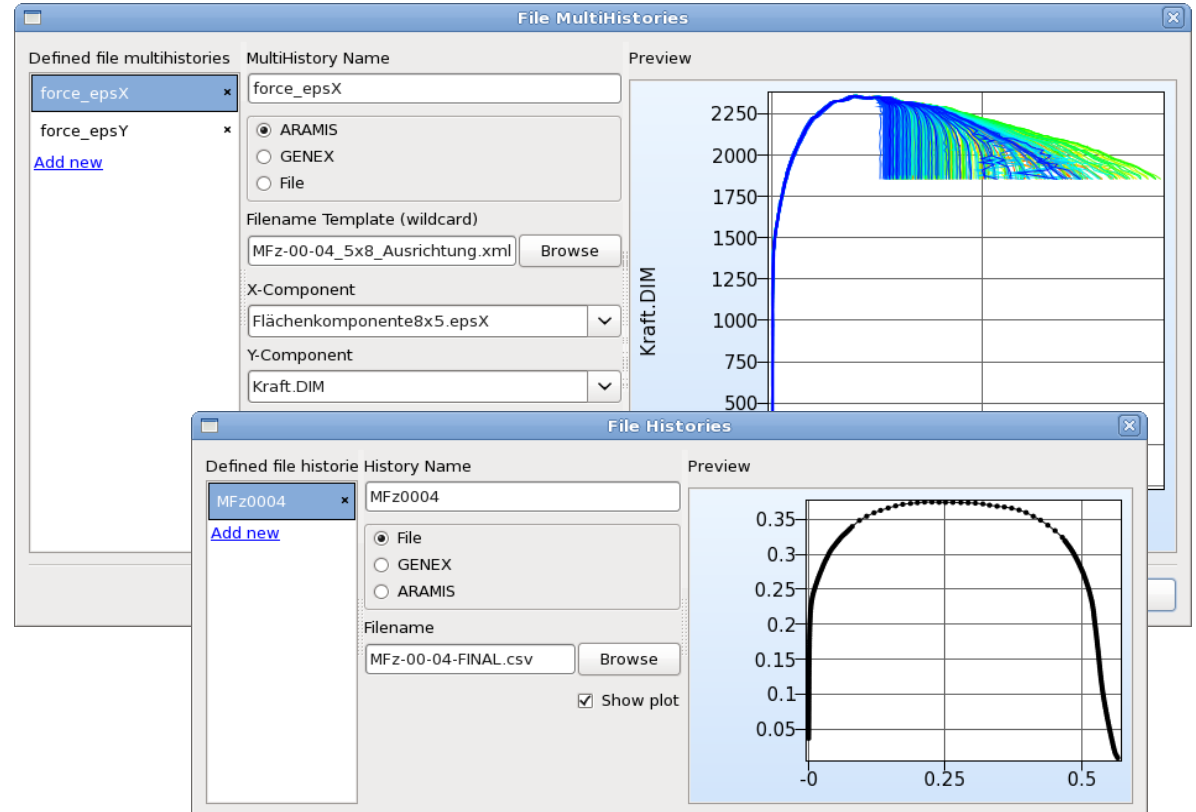


gom/ARAMIS setup at DYNAmore GmbH

Import DIC data into LS-OPT

■ Interfaces (LS-OPT 6.0) Multihistories and Histories

- ARAMIS (gom)
- GENEX
 - Extraction from ASCII files
- DIC data may be stored in multiple files
 - One file per time stage

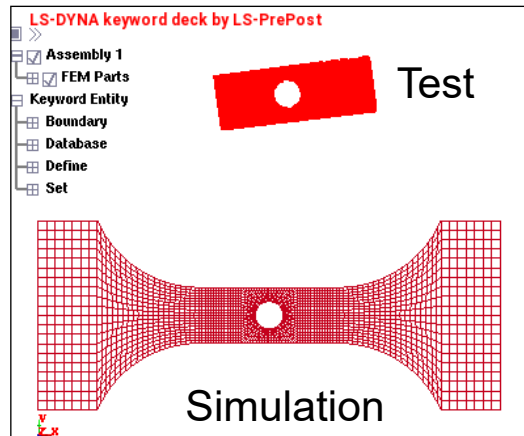


Alignment of test and simulation data

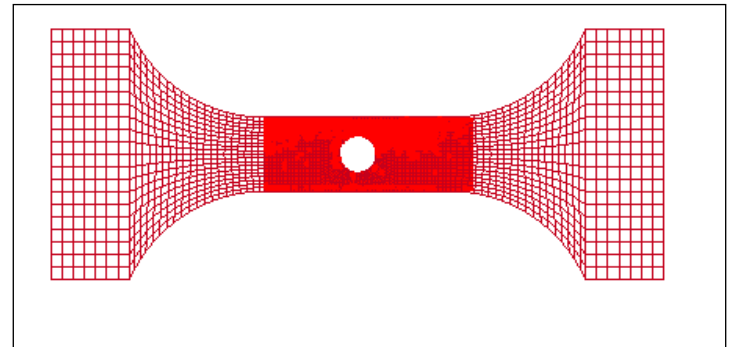
- Test and simulation geometries are typically in different coordinate systems
- Transformation of coordinates using least square formulation

$$\min_T \|\hat{s}X_{\text{Test}}T - X_{\text{FE}}\|$$

- X_{Test} : Test points (subset), X_{FE} : FE model points, T : transform, \hat{s} : Isotropic scaling



Alignment



Extraction of Multihistories from simulation

■ D3PLOT Interface (LS-OPT 6.0)

Edit multipoint history

Name: D3PlotXStrain00

Subcase: [dropdown]

Results Type: Strain

Component: M_surf_xx_strain

Source: ARAMIS

Align test and simulation geometry: align

New alignment

Open in LSPP

visualization in LSPP

LS-PrePost(R) V4.2 - 15Aug2015(09:00) 64bit T:SHELL.GOM.Lochflachzug/Strain.NODE_test.transformed_0.lsp

LS-DYNA keyword deck by LS-PrePost

Alignment

Defined transformations: trans_tensile

Transformation Name: trans_tensile

Test: Simulation

Coordinates: Node ID

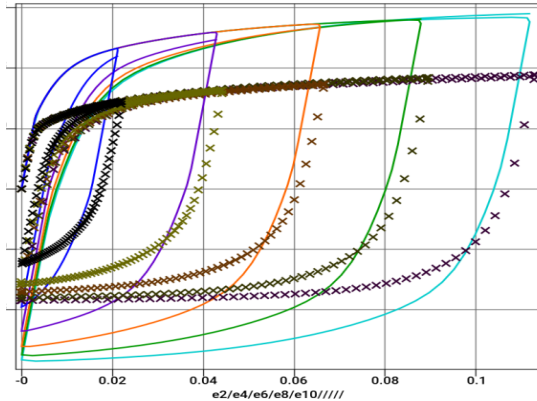
Test x coord	Test y coord	Test z coord	Node ID
-8.47391	.78577	2.02715	495
17.57689	6.08299	2.38169	1435
-8.19484	-6.23842	2.0367	1925
16.96481	-3.20172	2.38046	2771

Scale factor: 1.0 (default)

alignment

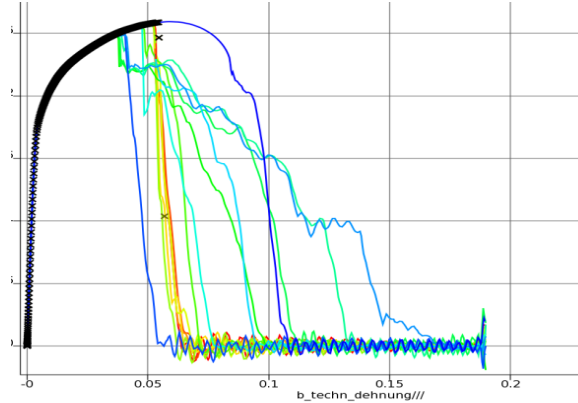
Calibration: Computational challenges

- Experimental and computational results can be difficult to compare



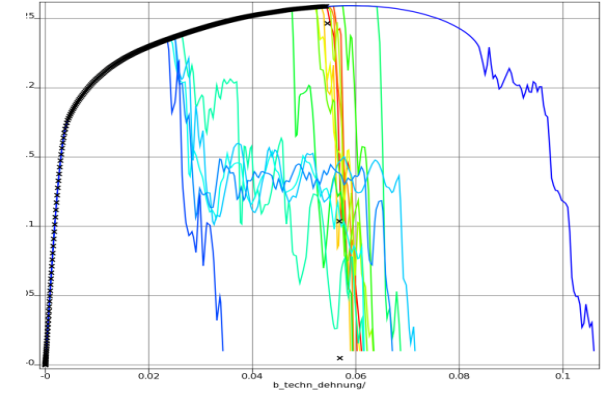
Hysteresis

Material 125 -
Loading/Unloading
→ Partial Curve Mapping



Partial Matching

Failure model: GISSMO -
post-failure oscillation
of coupon
→ Partial Curve Mapping

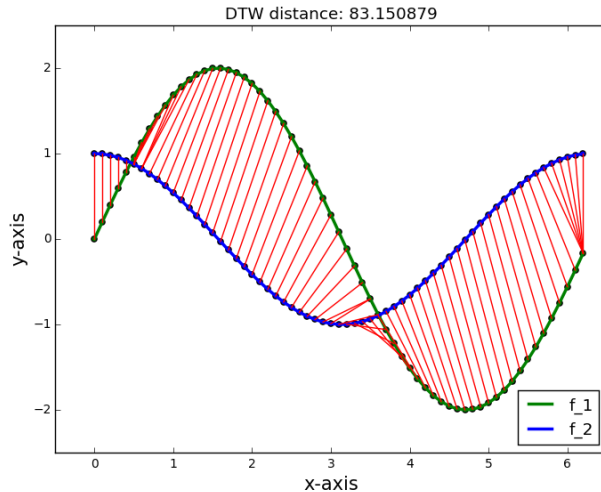


Noise

Failure model: GISSMO -
element erosion a discrete
process

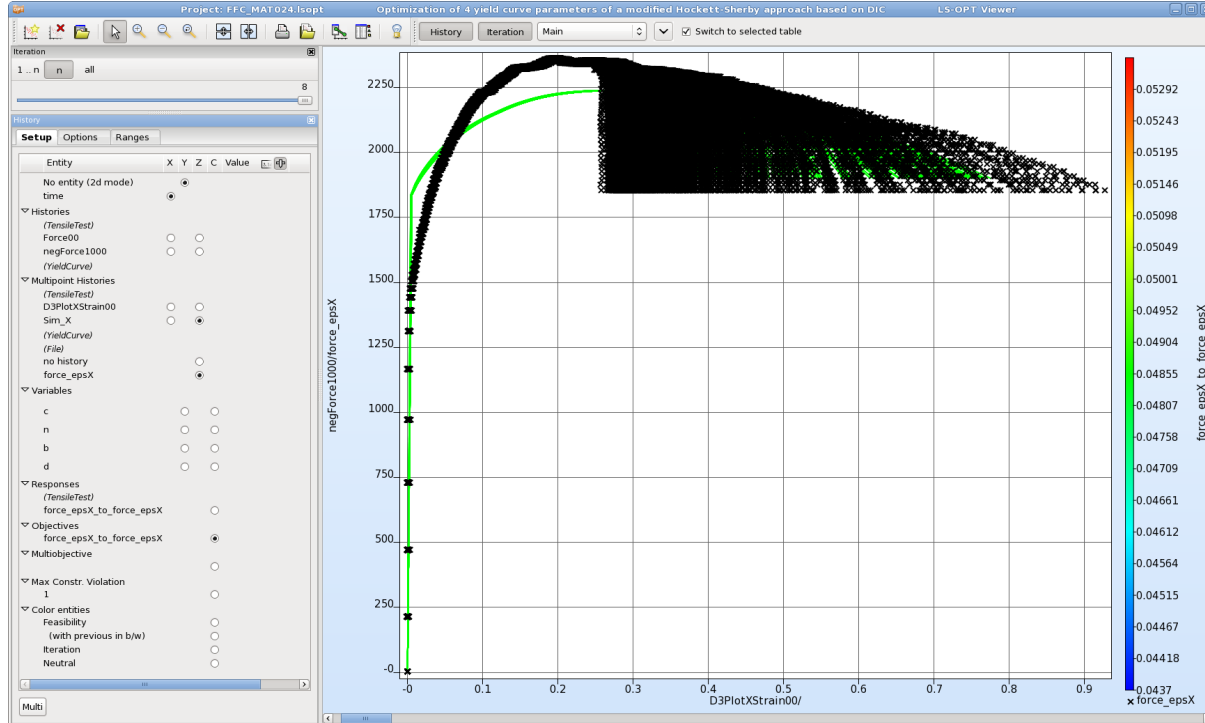
Dynamic Time Warping

- Suitable for noisy curves
- Not suitable for partial mapping
- **Warping path: minimum accumulated distance**
which is necessary to traverse all points in the curves

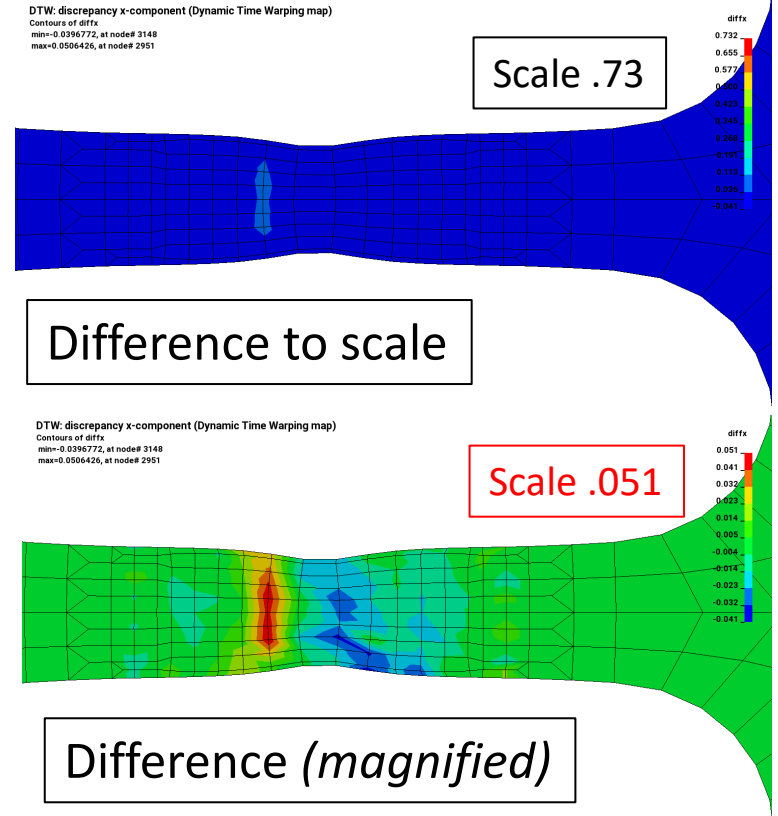
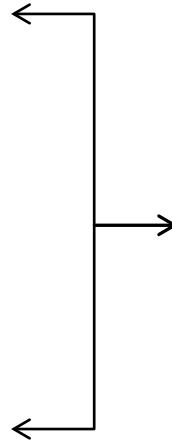
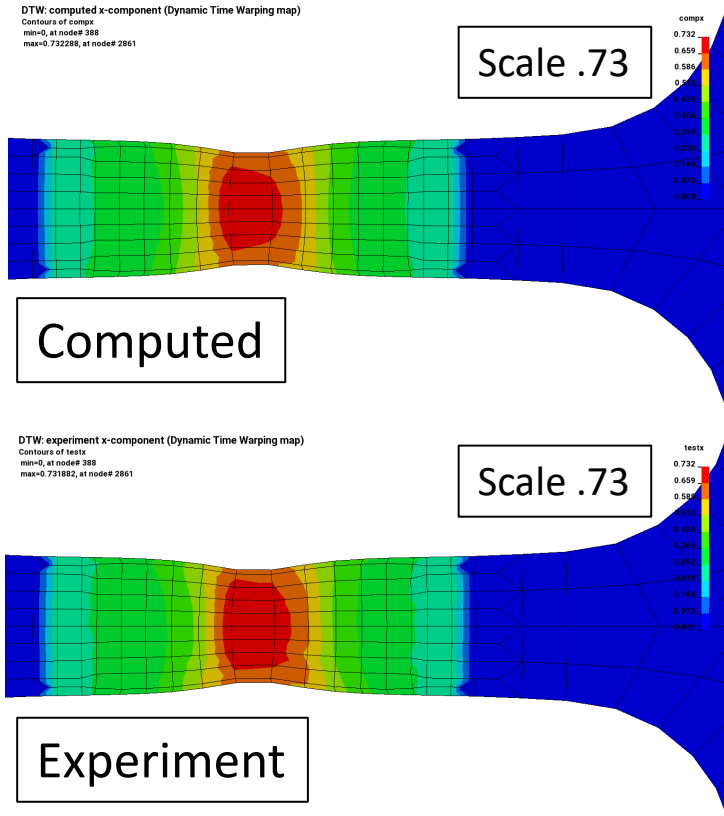


Postprocessing: Multihistory plot

■ Visualization of test and simulation curves



Postprocessing: Contour plots in LS-PrePost

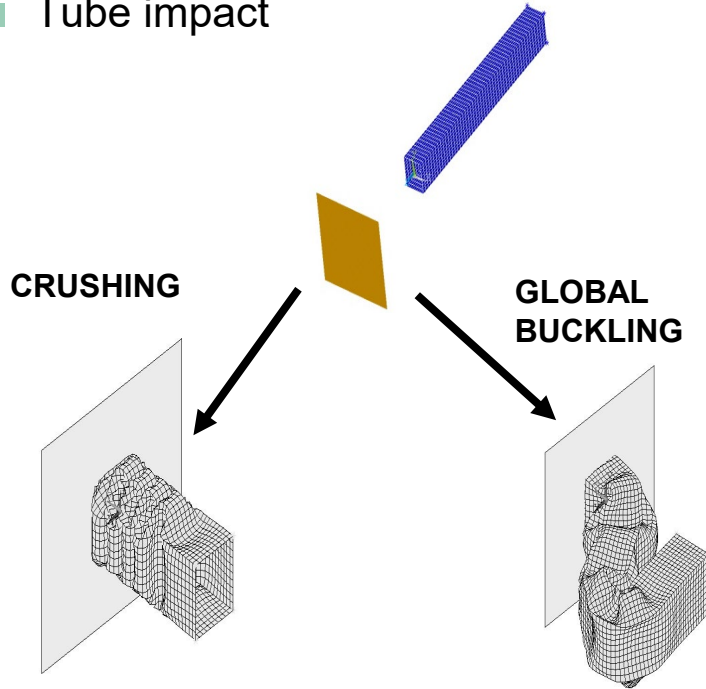


Support Vector Machine Classification

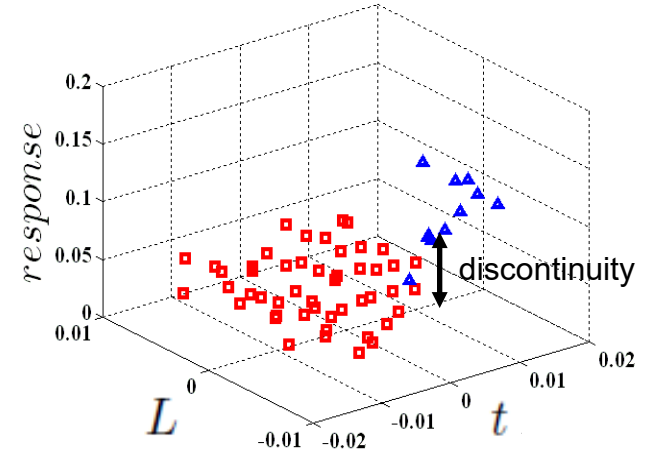
Metamodeling Challenges

■ Discontinuous responses

- Tube impact



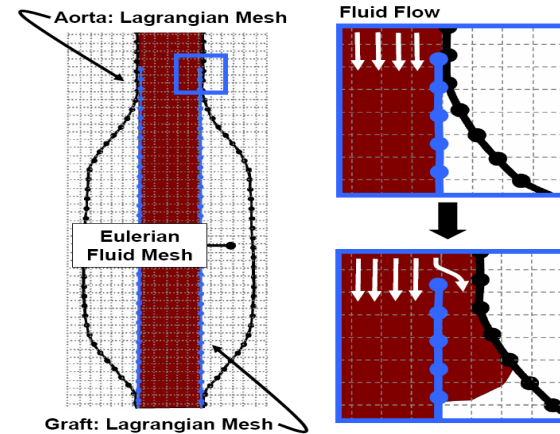
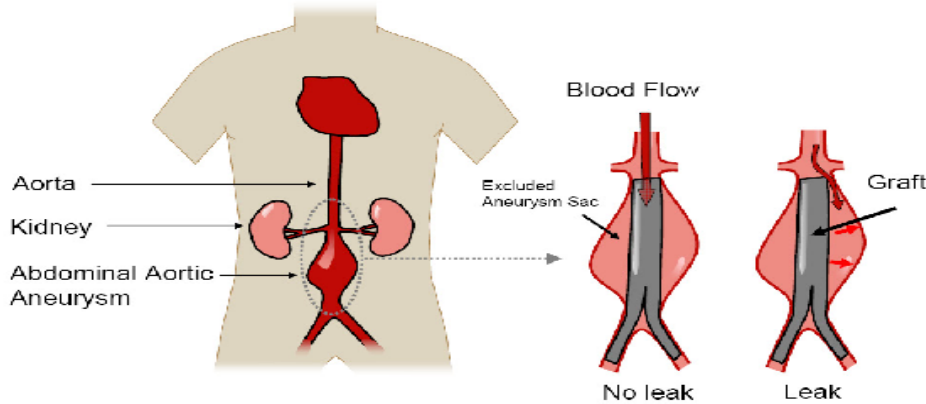
Maximum transverse displacement



Metamodeling Challenges

■ Binary responses

■ Blood leakage from stent



Layman, R. et al. "Simulation and probabilistic failure prediction of grafts for aortic aneurysm."
Engineering Computations 27.1 (2010): 84-105.

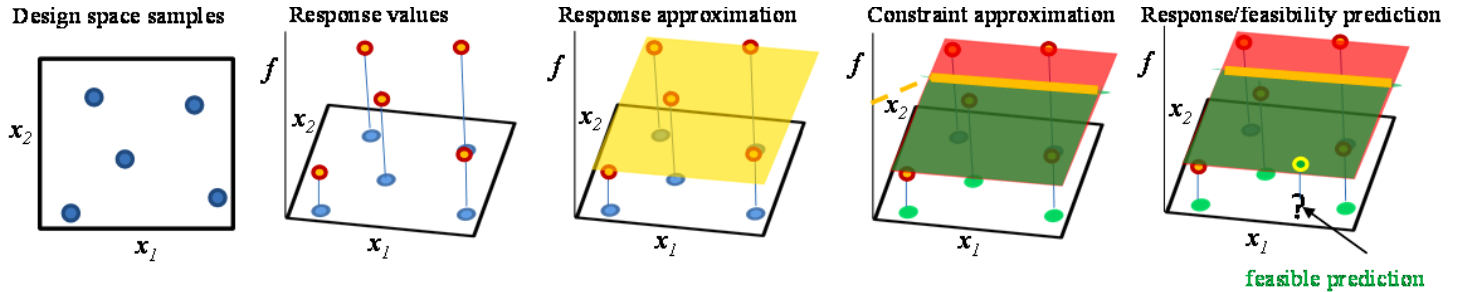
Binary information:
Failed (leaked) or not (no leakage)

Support Vector Machine Classification

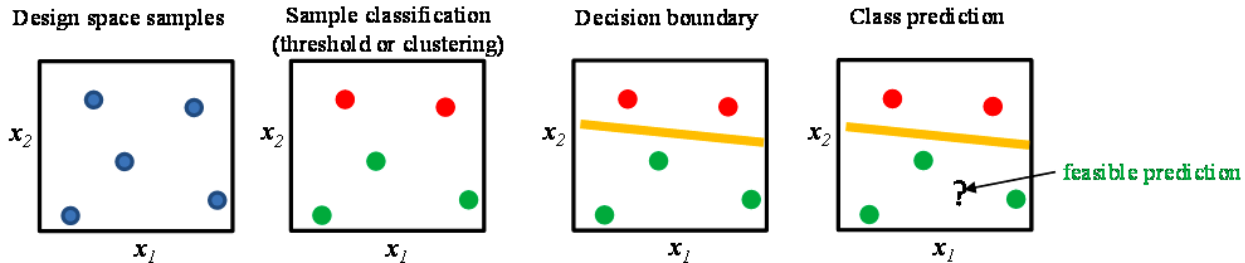
■ Discontinuous and binary responses

- Map input data to category

Metamodeling



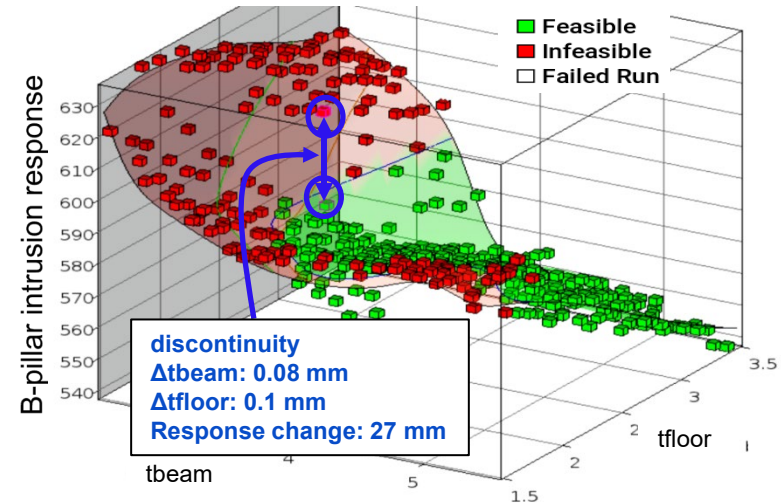
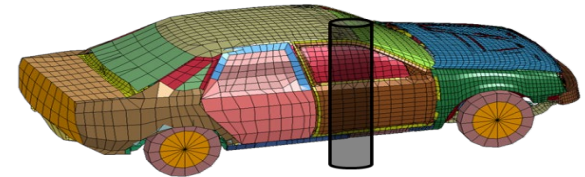
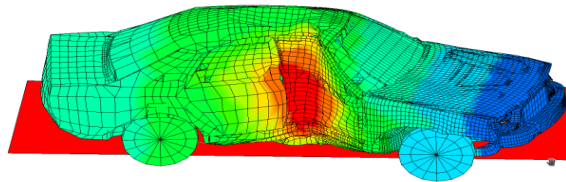
Basic classification method



Application 1: Discontinuous Constraint Reliability

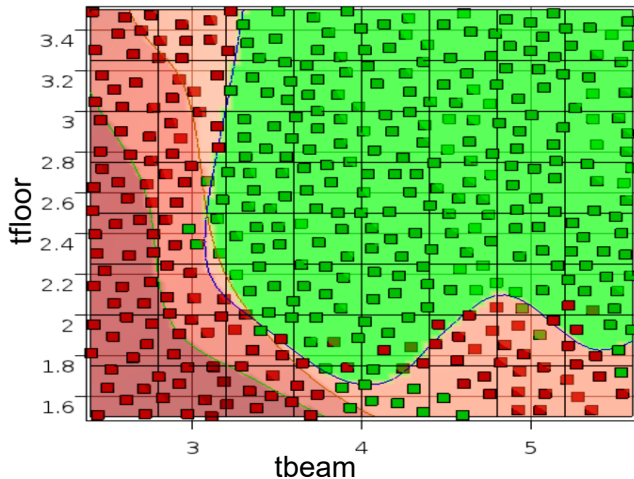
■ Side Pole Impact

- Random/Noise Variables (Normal distribution)
 - Beam thickness
 - Floor thickness
- Reliability assessment
 - B-pillar intrusion < 585 mm
 - Lower beam intrusion < 710 mm
 - Door intrusion < 638.23 mm

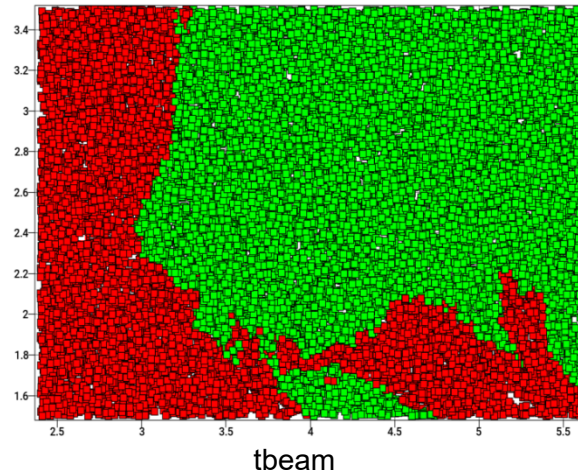


Application 1: Discontinuous Constraint Reliability

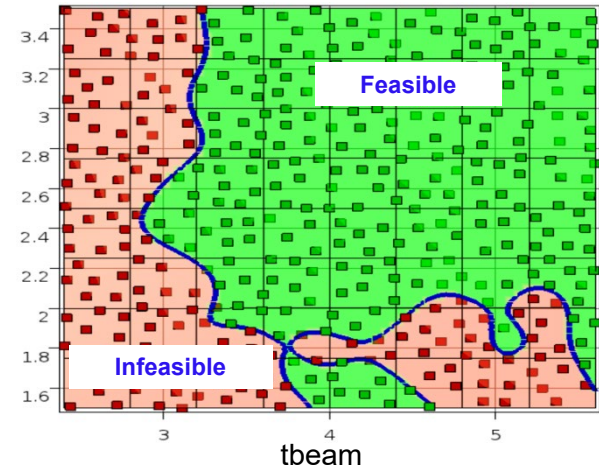
- Classifier able to approximate highly nonlinear boundaries accurately
 - Failure probability using Neural Network Metamodel (400 samples): **0.0217**
 - Failure probability using SVM Classifier (400 samples): **0.0218**
 - Actual Failure probability (20,000 LS-DYNA runs): **0.0219**



Neural net approximation of constraint (*inaccurate*)



Actual constraint feasibility (LS-DYNA)



SVM classifier-based constraint (*accurate*)

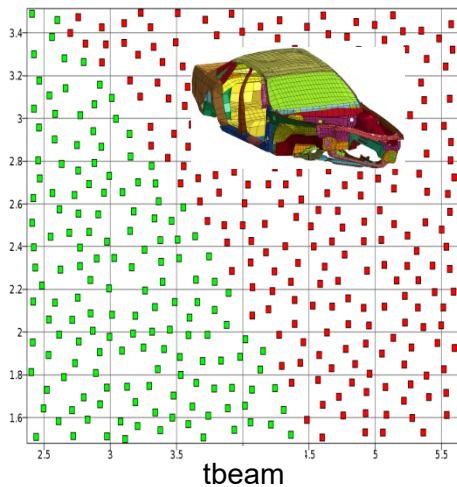
Application 2: Multidisciplinary Analysis

■ Optimization Cost Savings

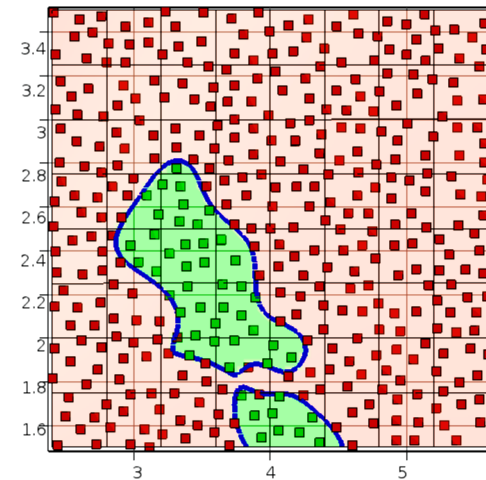
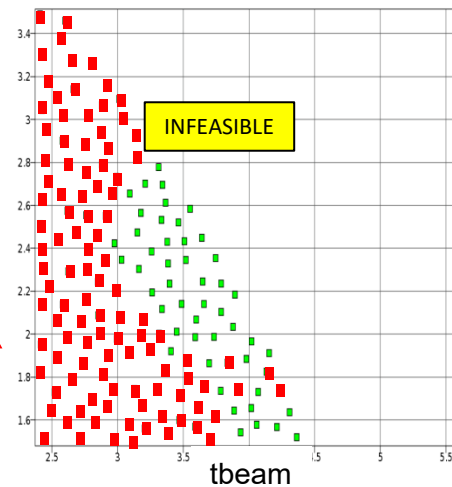
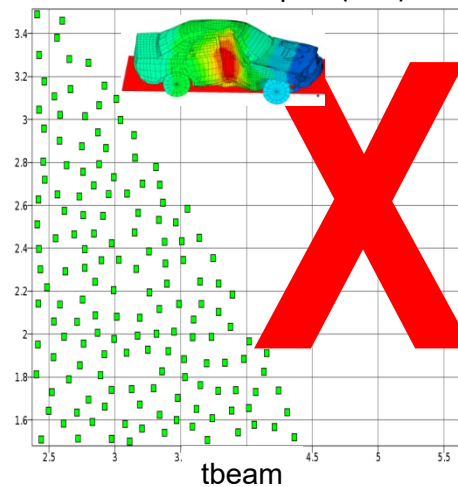
■ NVH analysis followed by crash analysis

- Because classifier is used, crash analysis needed only at feasible NVH points
- Crash simulation savings: 246 out of 400 (61.5 %)

NVH Samples (400)



Crash Samples (154)



Interactive Tables

Interactive Tables

Overall Feasibility

Category

Filter

Constraint Feasibility

Sorting

The screenshot displays a software interface with a data table, a 'Define Categories' dialog, and a parallel coordinate plot. The table has columns for Points, Marked, Category, Type, Variables (tbumper, thood), Composites (Intrusion), Constraints (Mass, Acc_max), Objectives (HIC), Multi-Objective, Max Const Violation, and Success run. A 'Define Categories' dialog is open, showing a list of categories: Design 1 (14 points), Design 2 (20 points), Feasible designs (1 points), and Design 5 (16 points). A parallel coordinate plot is shown on the right, with axes for tbumper, thood, Intrusion, Mass, Acc_max, and HIC. A red dashed line connects a point in the table to a point in the plot.

Points	Marked	Category	Type	tbumper	thood	Intrusion	Intrusion	Mass	Acc_max	HIC	Multi-Objective	Max Const Violation	Success run
1.11	<input type="checkbox"/>	Design 1	Analysis	5	1	573.647	573.647	0.532248	2.64094e+06	57.56	57.56	1409.40	<input checked="" type="checkbox"/>
1.9	<input type="checkbox"/>	Design 1	Analysis	4.11111	1	570.969	570.969	0.478048	2.63235e+06	57.74			
1.10	<input checked="" type="checkbox"/>	Design 1	Analysis	455556	1	571.191	571.191	0.505178	2.61078e+06	51.52			
1.21	<input type="checkbox"/>	Design 1	Analysis	5	1.44444	554.096	554.096	0.633217	2.57591e+06	110.9			
1.8	<input type="checkbox"/>	Design 1	Analysis	3.66667	1	574.76	574.76	0.450978	2.5734e+06	65.39			
1.20	<input type="checkbox"/>	Design 1	Analysis	455556	1.44444	554.918	554.918	0.606147	2.53865e+06	115.8			
1.3	<input type="checkbox"/>	Design 1	Analysis	1.44444						44			
1.5	<input type="checkbox"/>	Design 1	Analysis	2.33333						46			
1.4	<input checked="" type="checkbox"/>	Design 1	Analysis	1.88889						76			
1.2	<input type="checkbox"/>	Design 1	Analysis	1						74			
1.6	<input type="checkbox"/>	Design 1	Analysis							77			
1.1	<input type="checkbox"/>	Design 1	Analysis							11			
o.01	<input type="checkbox"/>	Design 1	Analysis							11			
1.7	<input type="checkbox"/>	Design 1	Analysis							46			
1.14	<input type="checkbox"/>	Design 1	Analysis							44			
1.13	<input type="checkbox"/>	Design 1	Analysis							13			

Define Categories

- Design 1 (14 points)
- Design 2 (20 points)
- Feasible designs (1 points)
- Design 5 (16 points)

Buttons: Add new, Cancel, OK

Interactive Tables

■ Interactive Constraint management

Constraints are only changed for the active tab Reset

Constraint	Lower Bound	Strict	Upper Bound	Strict
Intrusion	Set lower bound	× <input type="checkbox"/>	<input type="text" value="550"/>	<input type="checkbox"/>
Mass	Set lower bound	× <input type="checkbox"/>	<input type="text" value="0.7"/>	<input type="checkbox"/>
Acc_max	Set lower bound	× <input type="checkbox"/>	<input type="text" value="2.5e+06"/>	<input type="checkbox"/>

■ Statistics of selected point

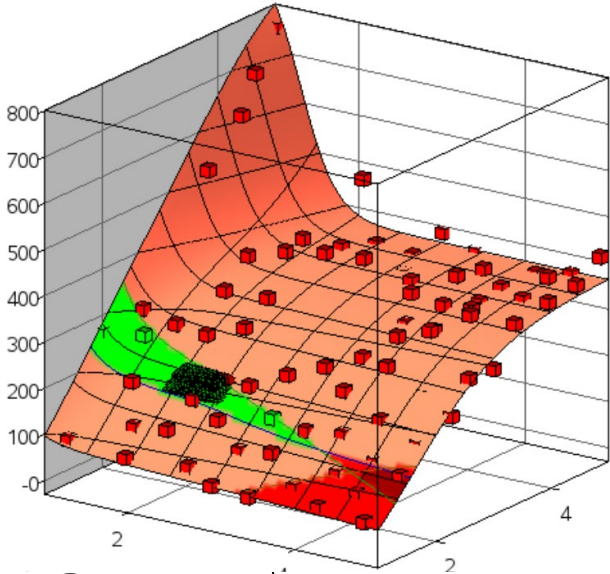
Point selection

Points	Variables		Composites	Constraints		
	tbumper	thood	Intrusion	Intrusion	Mass	Acc_max
Nominal	0	0	0	0	0	0
Mean	2.97523	2.93732	521.056	521.056	0.849357	1.99565e+06
StdDev	1.27034	1.29872	33.3185	33.3185	0.306708	288499
SS	1086.83	1071.02	2.83503e+07	2.83503e+07	84.7155	4.22765e+14
Min	1	1	450.81	450.81	0.288374	1.4871e+06
Max	5	5	583.545	583.545	1.44187	2.64094e+06
Lower Constraint	N/A	N/A	N/A	N/A	N/A	N/A
Lower Exceeded	N/A	N/A	N/A	N/A	N/A	N/A
Prob. Exceed Lower	N/A	N/A	N/A	N/A	N/A	N/A
Upper Constraint	N/A	N/A	N/A	550	0.5	2.5e+06
Upper Exceeded	N/A	N/A	N/A	24	88	6
Prob. Exceed Upper	N/A	N/A	N/A	0.230769	0.846154	0.0576923
Num. Values	104	104	104	104	104	104

Output Table1 Table2

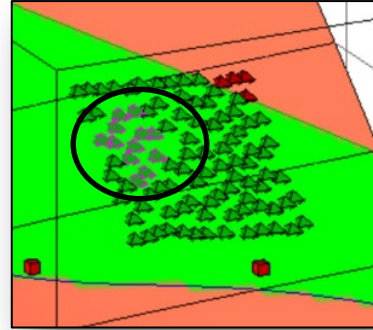
Interactive Tables

Virtual points



① Generate in Viewer

② Select



Virtual points

Run simulations

Point selection

Points	Marked	Type	Variables		Constraints			Objectives	Ma	V
			tbumper	thood	Intrusion	Mass	Acc_max	HIC ▲		
vo1.109	<input checked="" type="checkbox"/>	Virtual	2.25259	1.86465	544.755	0.561377	1.88095e+06	200.142		
vo1.144	<input checked="" type="checkbox"/>	Virtual	2.19286	1.87575	544.488	0.560259	1.85526e+06	202.227		
vo1.149	<input checked="" type="checkbox"/>	Virtual	2.23566	1.9226	542.64	0.573522	1.85635e+06	208.534		
		Virtual	2.16694	1.93914	542.235	0.573095	1.82604e+06	211.42		
		Virtual	2.3141	1.89203	543.545	0.571354	1.89467e+06	203.571		
		Virtual	2.12216	1.88888	544.171	0.558934	1.82481e+06	204.703		
		Virtual	2.3527	1.84454	545.248	0.562909	1.92413e+06	196.428		

③ Evaluate & Simulate

Other new Features

Other new Feature

■ Taguchi method

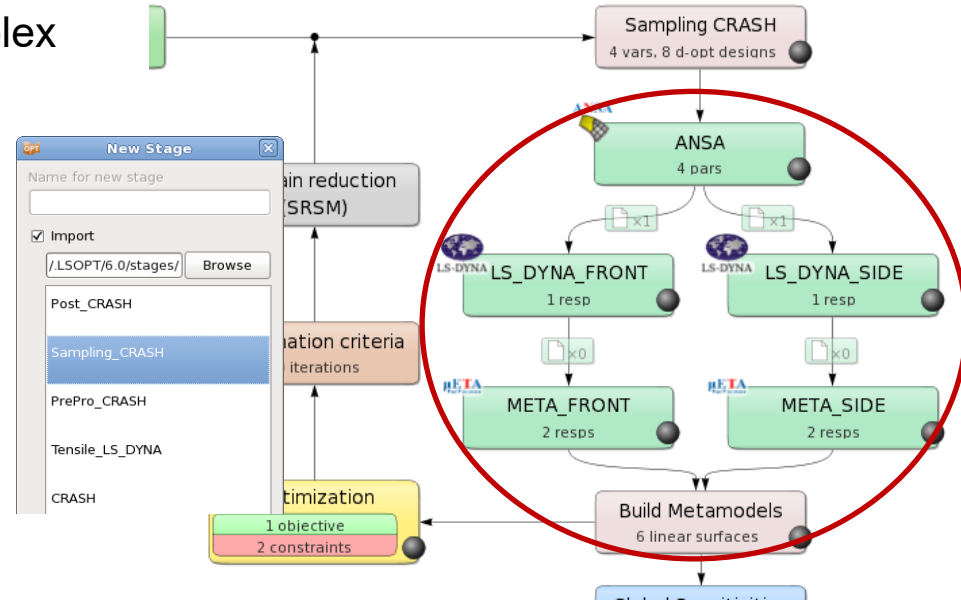
- Classical robust design approach using Orthogonal Arrays

■ Interface to LS-TaSC

- Facilitates LS-TaSC to work with complex design schemes and constraints

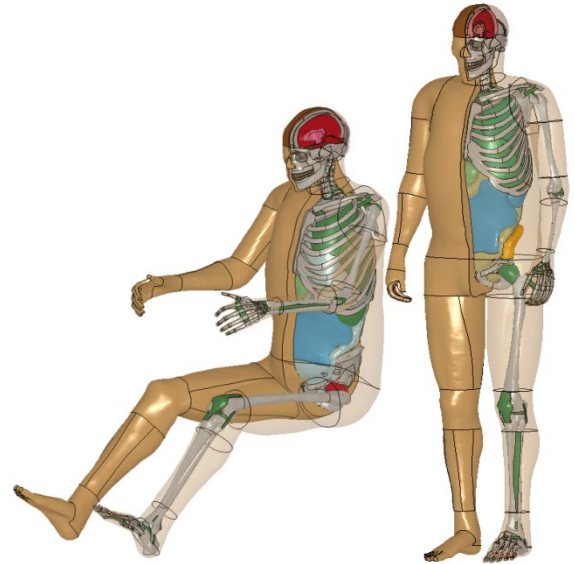
■ Export and import of stages

- Individually
- Full case-based process
 - E.g. Frontal Crash including its pre- and post-processing could be imported/exported as a unit with a given name



More Information on the LSTC Product Suite

- Livermore Software Technology Corp. (LSTC)
www.lstc.com
- LS-DYNA
 - Support / Tutorials / Examples / FAQ
www.dynasupport.com
 - More Examples
www.dynaexamples.com
 - Conference Papers
www.dynalook.com
 - European Master Distributor
www.dynamore.de
- LS-PrePost
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