Introduction and Live Demonstration of LS-OPT® Version 5

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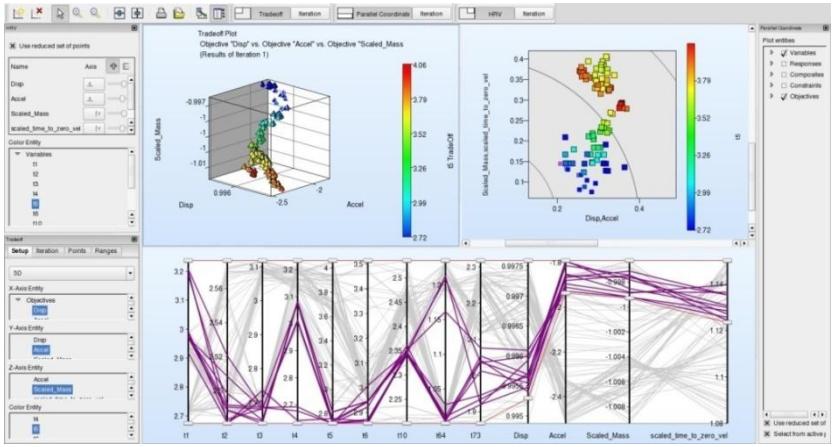
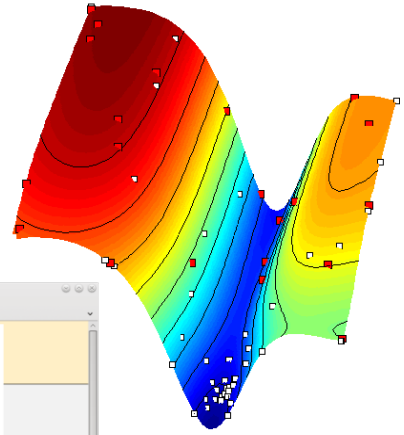
Überblick

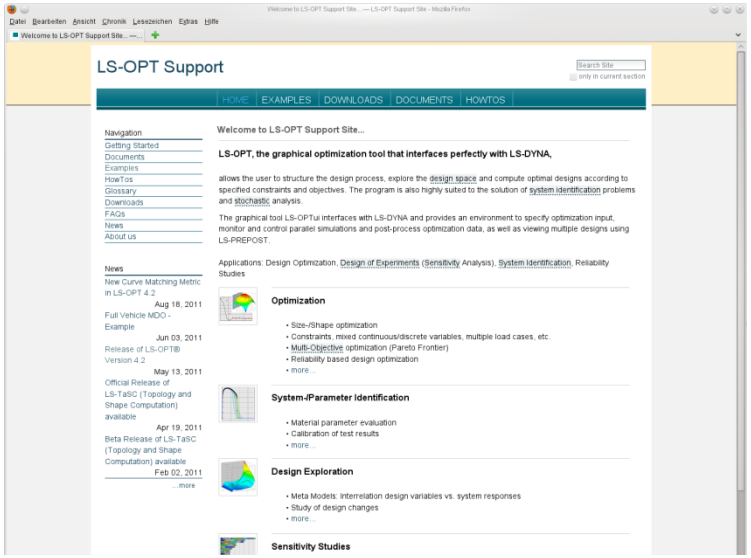
- Einführung LS-OPT
- LS-OPT 5 - Ziele und Anforderungen
- Aufsetzen einer DOE-Studie anhand eines Beispiels mit LS-OPT 5
  - Problembeschreibung
  - Definition von Variablen
  - Extraktion von Antworten
- Visualisierung der Optimierungsergebnisse
  - Simulationsdaten
  - Metamodelle
  - Sensitivitäten



➔ About LS-OPT

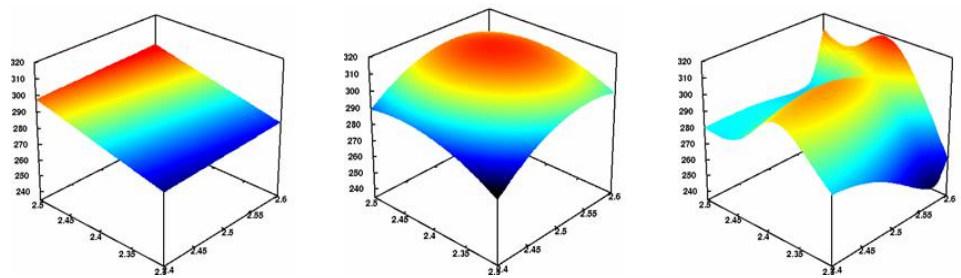
- Two main products LS-OPT and LS-TaSC
- LS-OPT can be linked to any simulation code – stand alone optimization software, but perfect suitable with LS-DYNA
- Current production version is LS-OPT 5.0
- LS-OPT Support web page -> www.lsoptsupport.com
  - *Download of Executables*
  - *Tutorials*
  - *HowTos / FAQs*
  - *Documents*
  - *….*



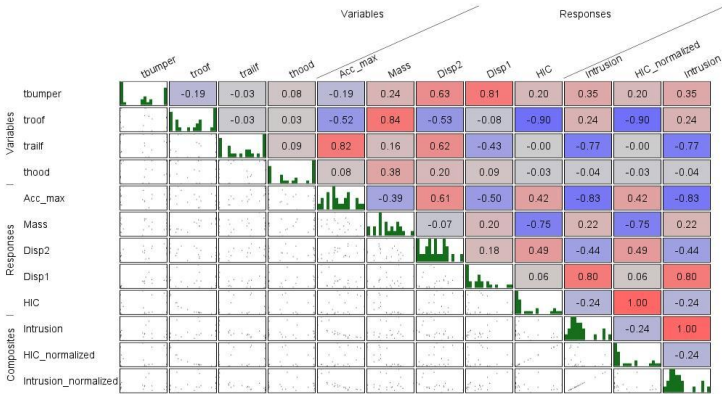


LS-OPT – Overview Methodologies

- Successive Response Surface Method (SRSM)
- Meta-Models
  - *Polynomials*
  - *Radial Basis Functions*
  - *Neural Nets (FFNN)*

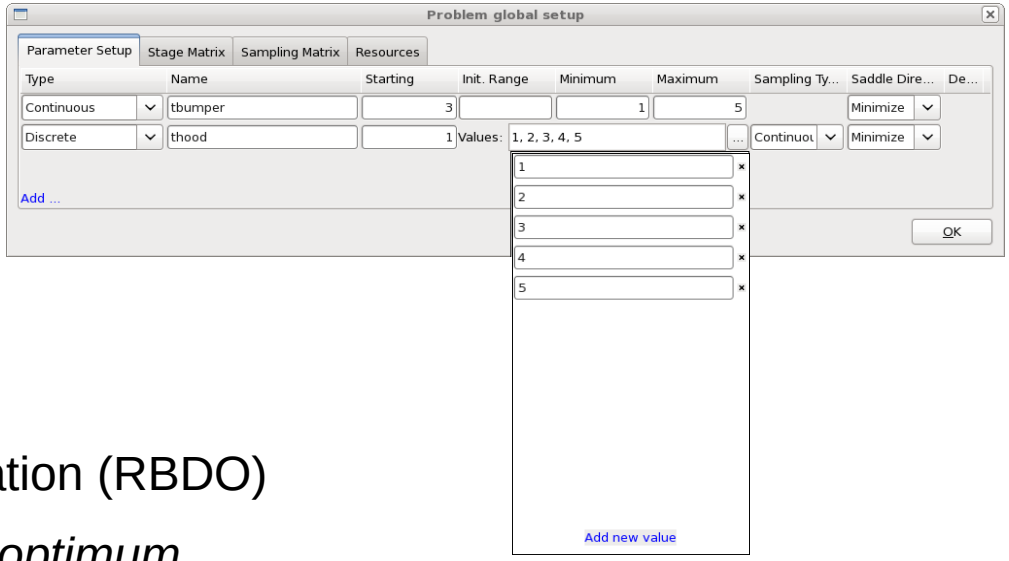


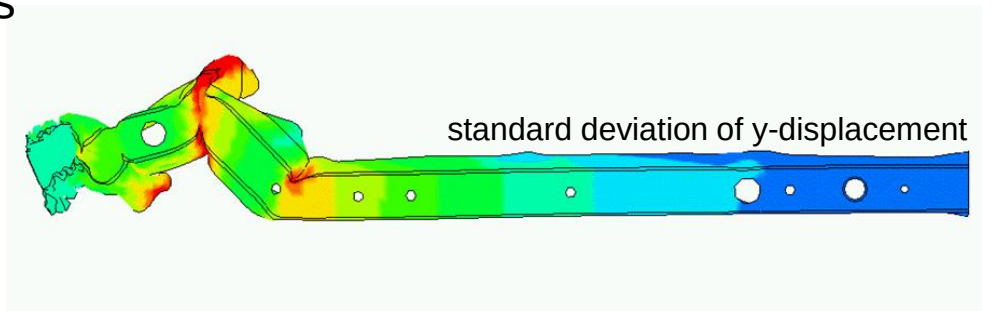
- Genetic Algorithm (MOGA->NSGA-II)
- Multidisciplinary optimization (MDO)
- DOE-Studies (ANOVA, Sobol)
- Stochastic/Probabilistic Analysis
  - *Evaluation of stochastic quantities: mean, std.-dev., correl.-coeff.,…..*
  - *Confidence Intervals*
- Monte Carlo Analysis using Meta-Models



LS-OPT – Overview Methodologies

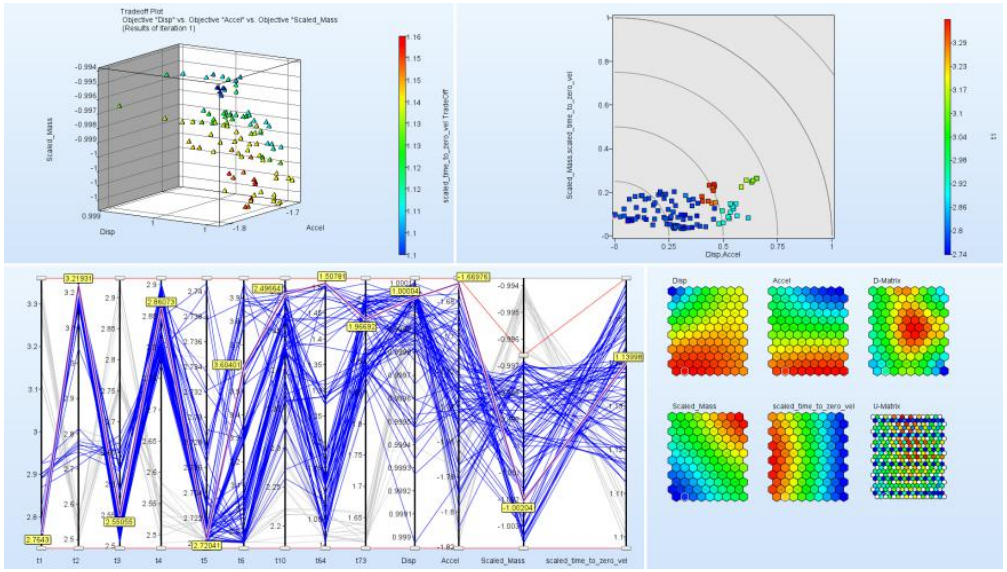
- Mixed Discrete-Continous Optimization
  - *Specify sets of discrete variables (e.g. sheet thicknesses)*
- Robust Parameter Design (RDO)
  - *Improve/Maximizing the robustness of the optimum*
- Reliability Based Design Optimization (RBDO)
  - *Improve failure probability of optimum*
- Visualization of Stochastic Results
  - *Fringe of statistic results on the FE-Model*





➔ LS-OPT – Multi-Objective Optimization

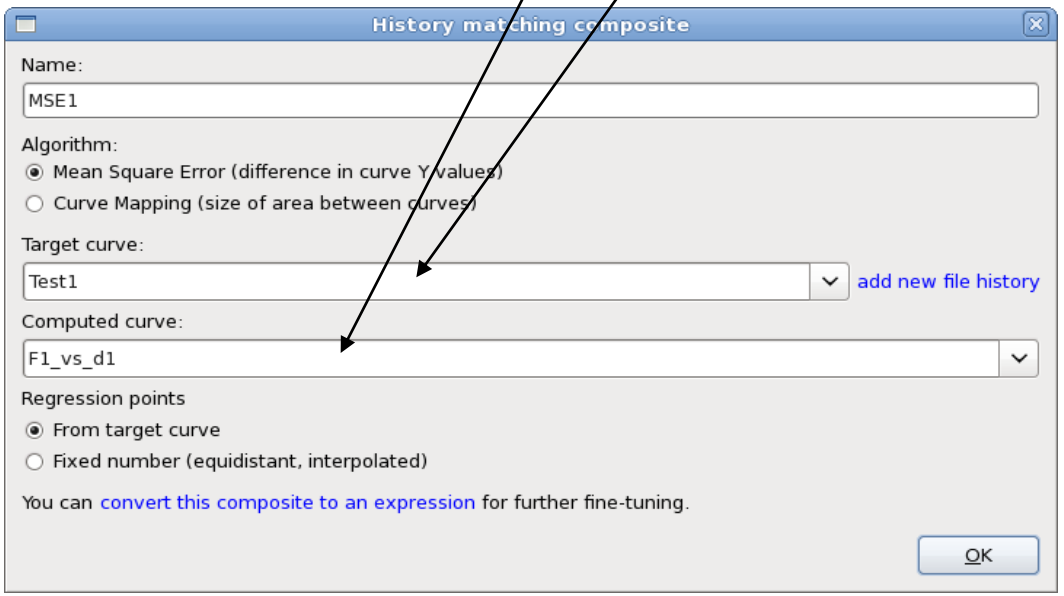
- Genetic Algorithm (MOGA->NSGA-II)
  for Multi Objective Optimization (Pareto Frontiers)
- Visualization Strategies for Pareto Optimal Data
  - Tradeoff Plot
  - Parallel Coordinate Plots
  - Hyper-Radial Visualization
  - Self Organizing Maps



About LS-OPT

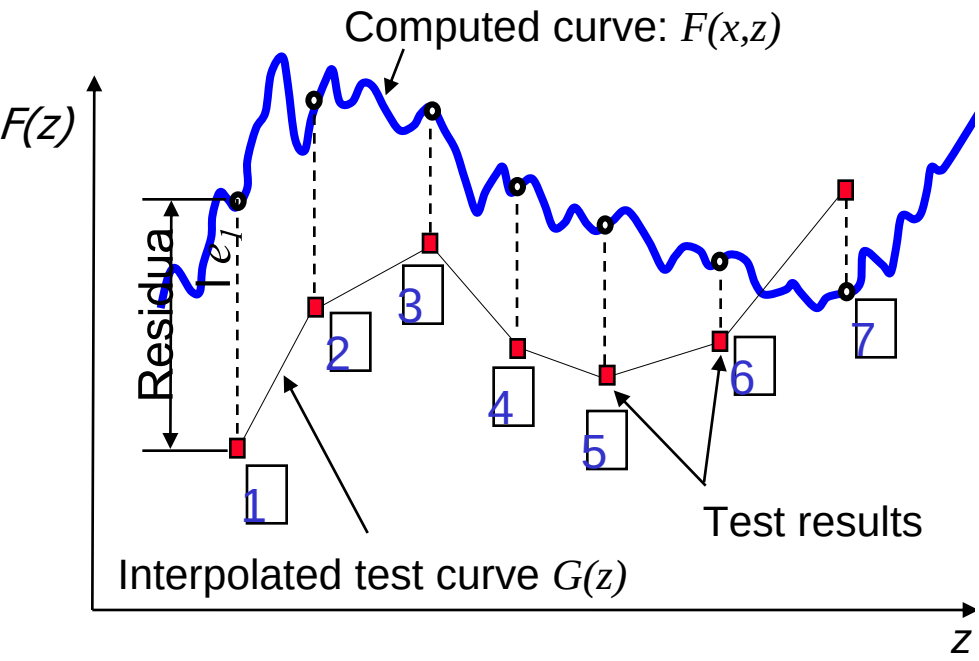
- Parameter Identification Module
  - *Handles "continuous" test curves*
  - *Automated use of test results to calibrate materials/systems*
  - *Simplify input for system identification applications*
  - *Visualization of test and simulation curve to compare*
  - *Confidence intervals for individual parameters in parameter identification*

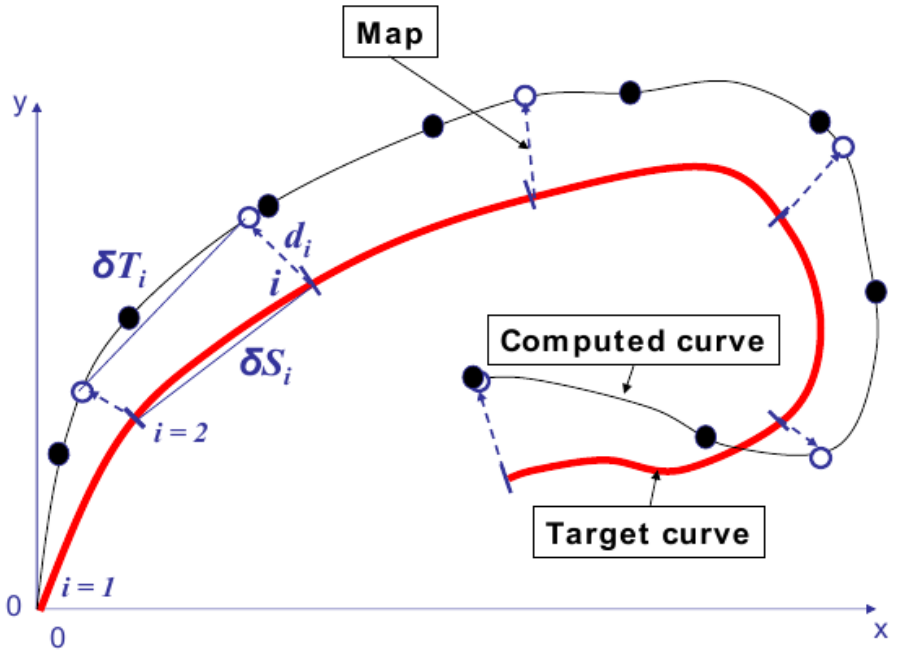
$$\frac{1}{P}\sum_{p=1}^{P} W_i \left(\frac{F_i(\boldsymbol{x}) - G_i}{s_i} \right)^2$$



About LS-OPT

- Parameter Identification with Test Curves

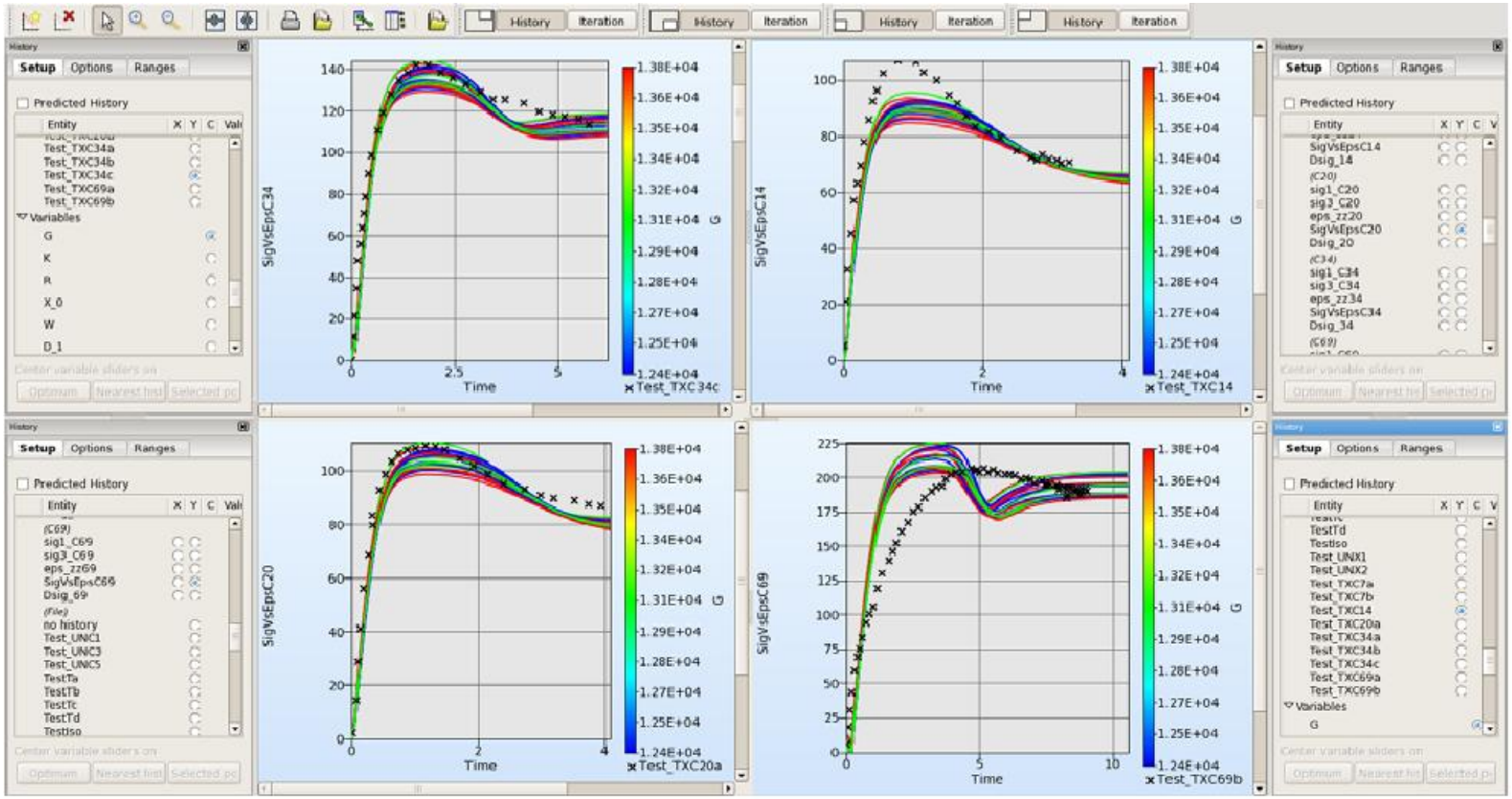




Introduction / Features

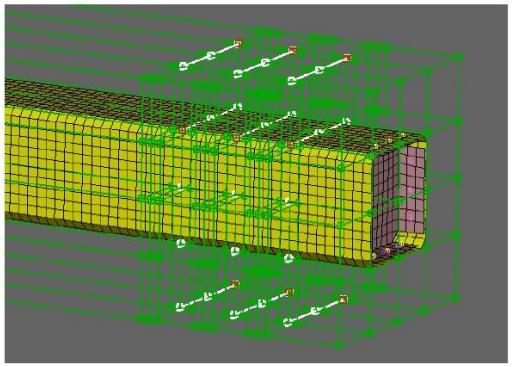
➔ About LS-OPT

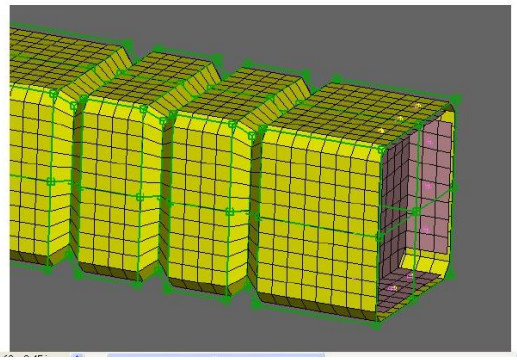
- Computed history curves vs. Target curves

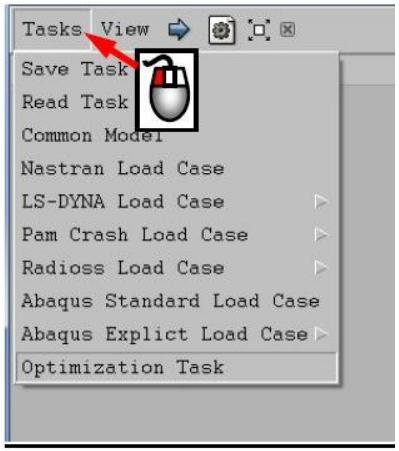


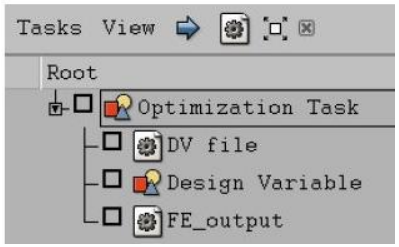
About LS-OPT – General Aspects

- Job Distribution - Interface to Queuing Systems
  - *PBS, LSF, LoadLeveler, SLURM, AQS, etc.*
  - *Retry of failed queuing (abnormal termination)*
- LS-OPT might be used as a “Process Manager”
- Shape Optimization
  - *Interface to **ANSA**, HyperMorph, LS-PREPOST,*
- META Post interface
  - *Allows extraction of results from any package (Abaqus, NASTRAN, …) supported by META Post (ANSA package)*



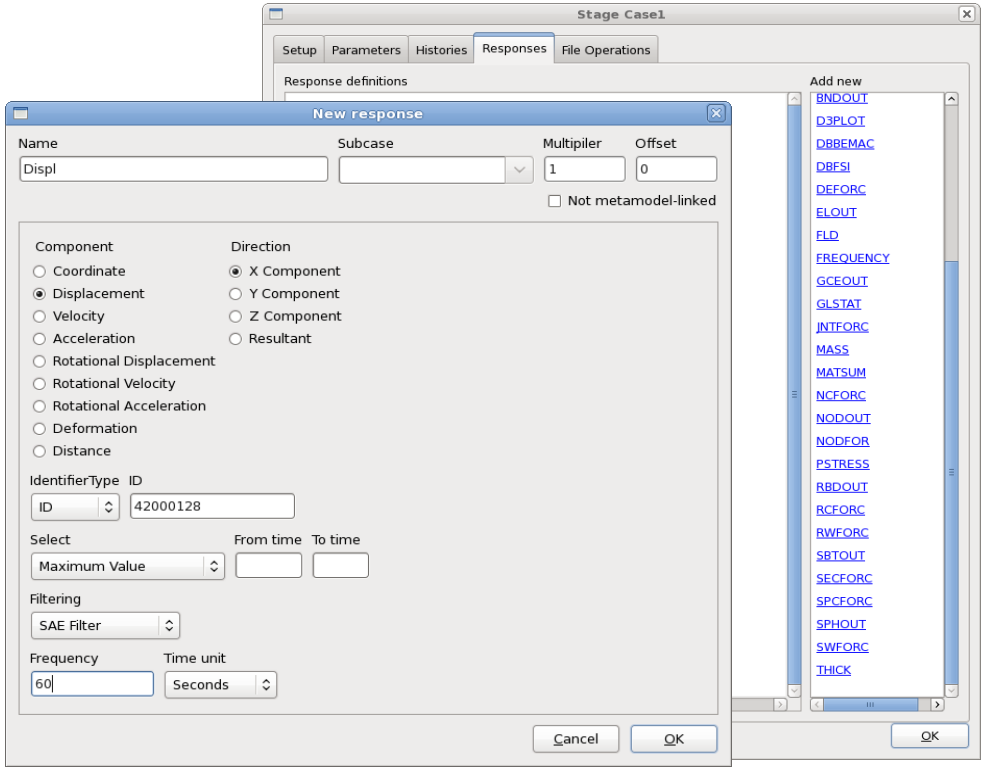






About LS-OPT

- LS-DYNA Integration
  - *Checking of Dyna keyword files (*DATABASE_)*
  - *Importation of design parameters from Dyna keyword files (*PARAMETER_)*
  - *Monitoring of LS-DYNA progress*
  - *Result extraction of most LS-DYNA response types*
  - *D3plot compression (node and part selection)*



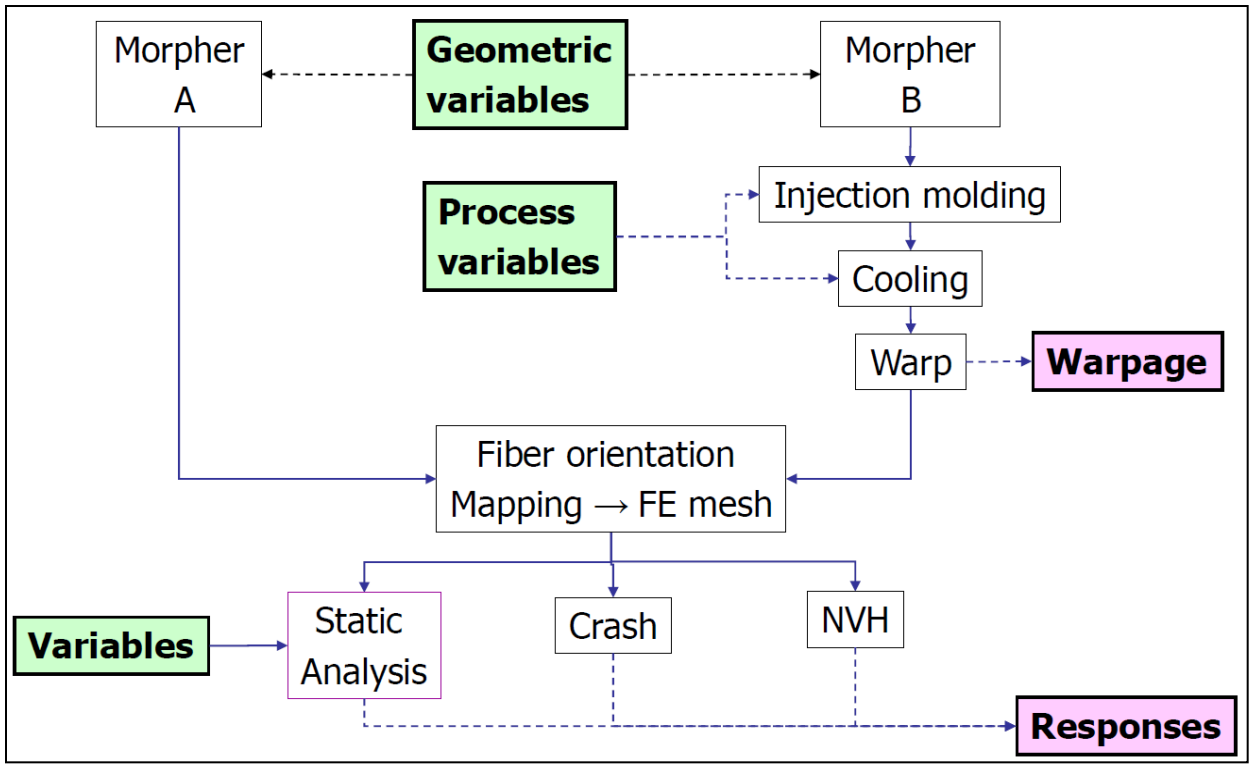
LS-OPT 5
Ziele und Anforderungen

LS-OPT 5 – Ziele und Anforderungen

- Bisher mögliche Prozessketten innerhalb Optimierung mit LS-OPT:

Preprozessor → Solver → Postprozessor

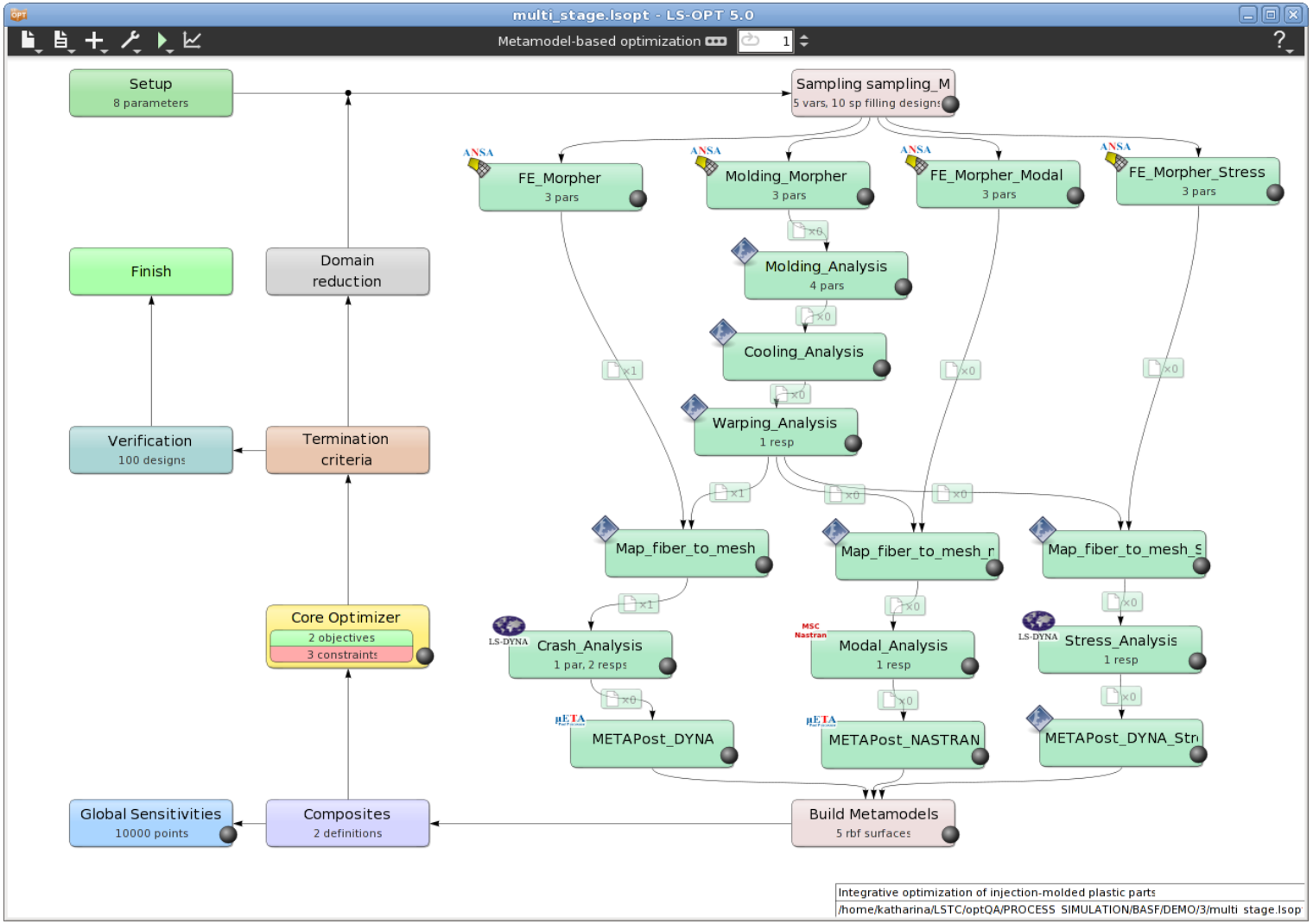
- Neue Anforderungen: längere Prozessketten, Verzweigungen



LS-OPT 5 – Ziele und Anforderungen

- Prozesssimulation & Optimierung
  - *Prozess-Ablauf mit Verzweigungen und Zusammenführen*
  - *Ausgabe-Dateien: kopieren, löschen, verschieben, …*
- Schrittweise Ausführung möglich
  - *z.B. nur Sampling*
  - *oder einzelner Teilschritt der Prozesskette*
- Status der Berechnungen bzw. Optimierung wird dargestellt

LS-OPT 5 – neue graphische Oberfläche



LS-OPT 5 – neue Datenbasis

- XML-Format

```
<lsoptproject version="5.0.0">
  <head>
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    <meta name="original-filename" content="com.iterate.correct"/>
  </head>
  <variables>
    <variable name="v_tbumper" value="3" min="1" max="5"/>
    <variable name="v_thood" value="1" min="1" max="5"/>
  </variables>
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    <sampling name="e_1">
      <design type="dopt"/>
      <metamodel type="polynomial" order="linear"/>
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        <stage name="s_1" type="dyna960">
          <command>ls971_s_7600</command>
          <inputfile>main.k</inputfile>
          <scheduling concurrent="4"/>
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            <response name="r_Disp2">BinoutResponse -res_type Nodout  -cmp x_displacement -id 432  -select TIME </response>
            <response name="r_Disp1">BinoutResponse -res_type Nodout  -cmp x_displacement -id 167  -select TIME </response>
            <response name="r_Acc_max">BinoutResponse -res_type Nodout  -cmp x_acceleration -id 167  -select MAX -filter SAE  -filter_freq 60</response>
            <response name="r_Mass">DynaMass 2 3 4 5 MASS</response>
            <response name="r_HIC">BinoutResponse -res_type Nodout  -cmp HIC15 -gravity 9810.00000  -units S -id 432 </response>
          </responses>
        <guidata><position y="100,000000" x="400,000000"/></guidata></stage>
      </stages>
    </sampling>
  </samplings>
  <composites>
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      <component entity="r_Disp1"/>
    </cresponse>
```
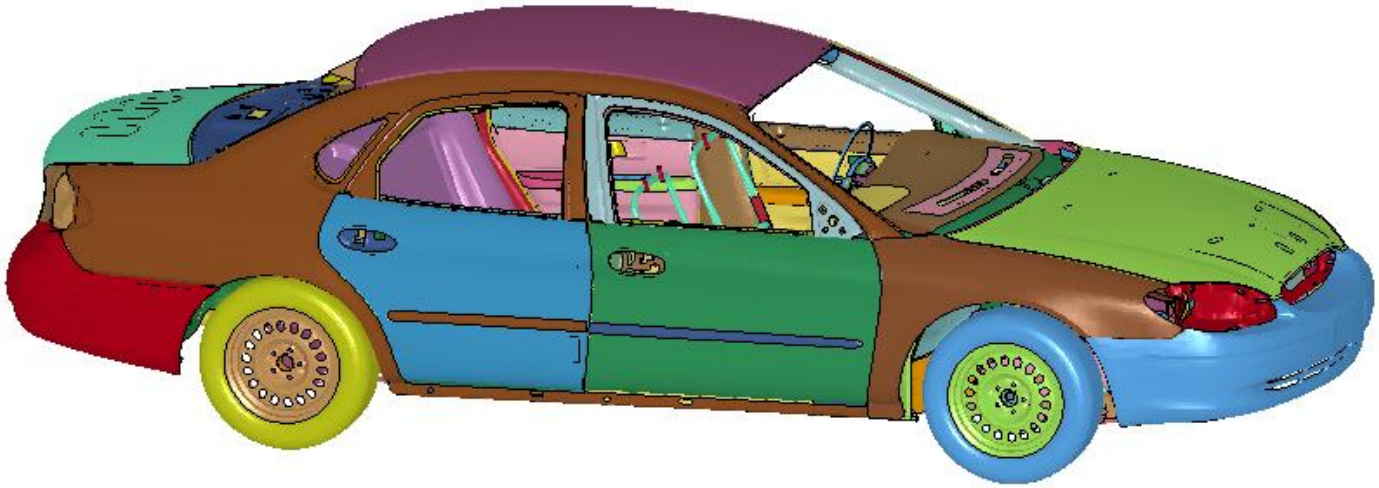

Beispiel

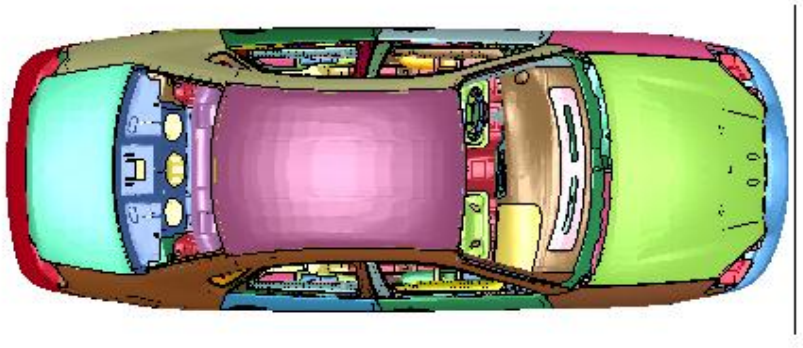
Example Problem - Model

- NCAC Model http://www.ncac.gwu.edu/, Ford Taurus
  - *Number of Parts* *771*
  - *Number of Shells* *776209*
  - *Number of Nodes* *858117*
  - *Number of Beams* *4*
  - *Numher of Solids* *48227*
  - *Number of Elements* *824452*

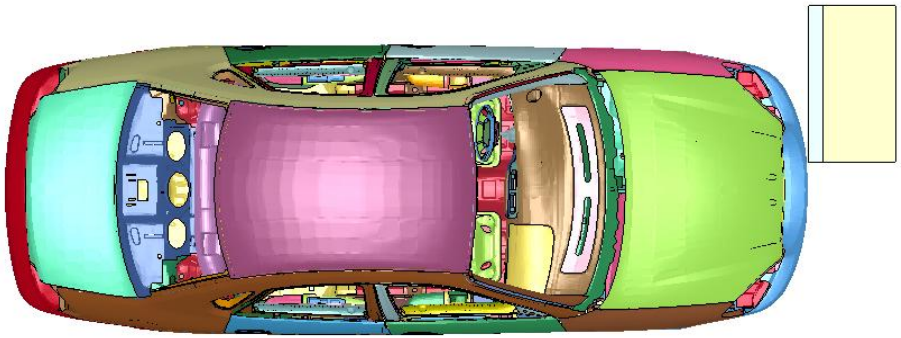


Example Problem – Load Cases

- US-NCAP
  - *56.6km/h*

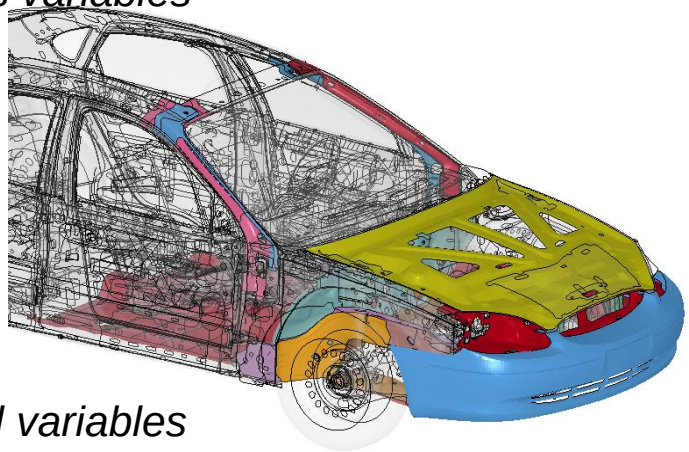


- IIHS ODB
  - *64.4 km/h*
  - *40% overlap*

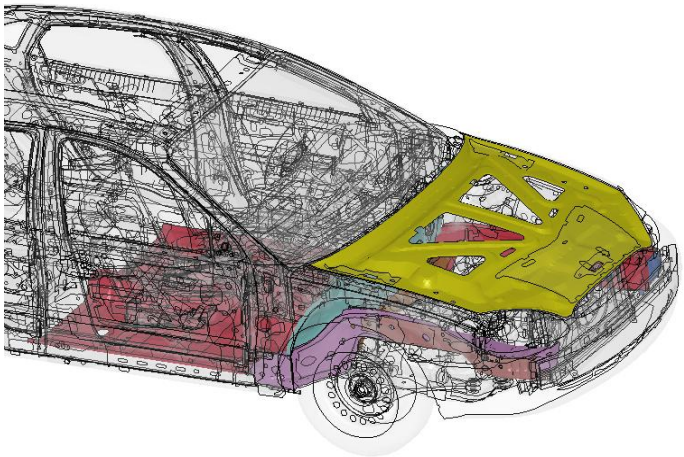


Example Problem - Variables

- 27 variables
  - *21 sheet thickness variables*

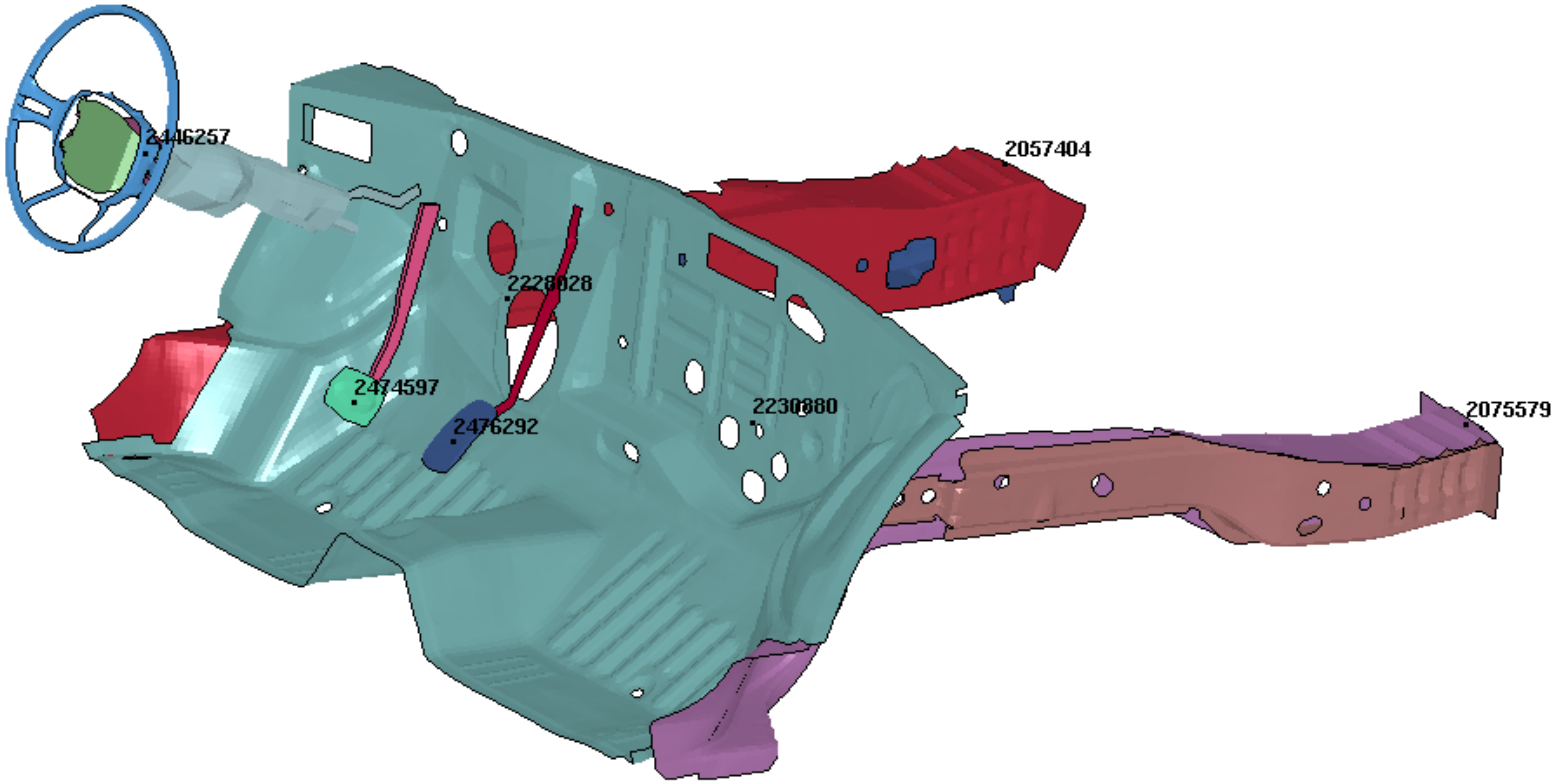


  - *6 discrete material variables*



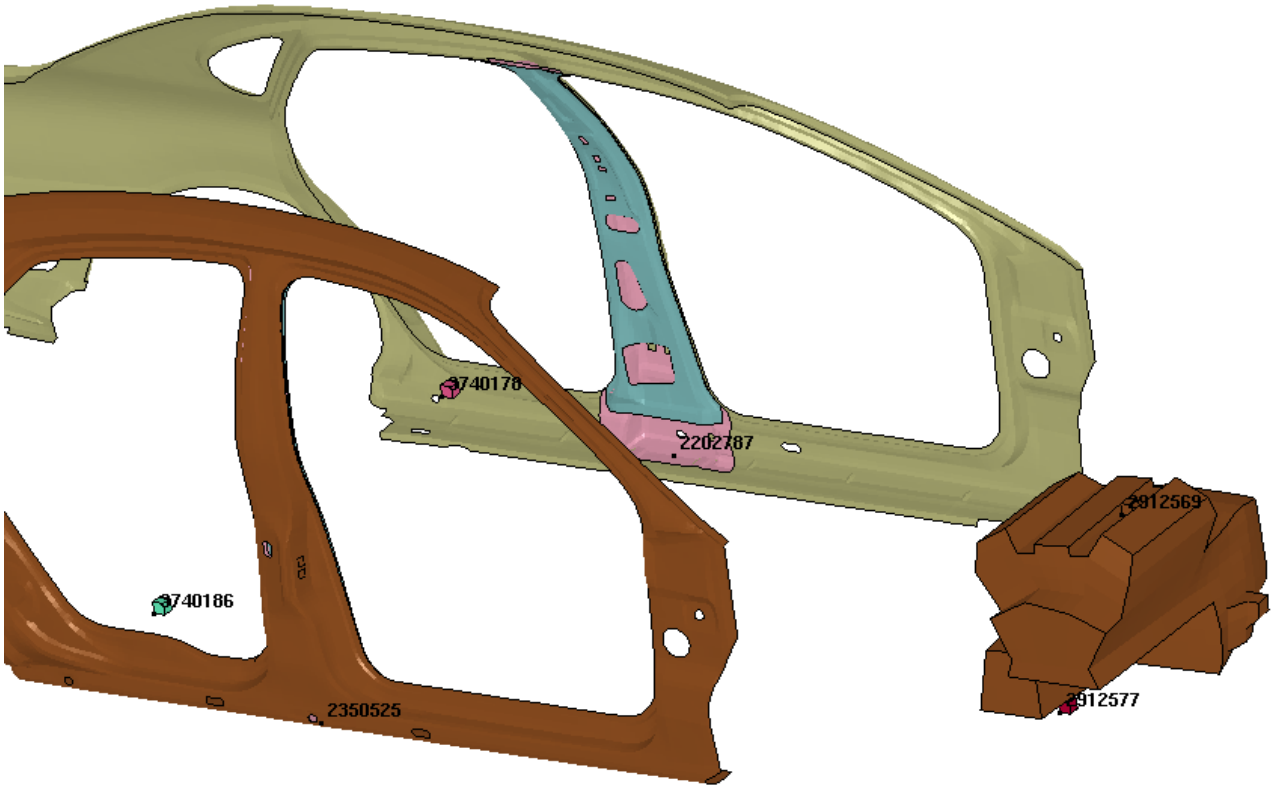
Example Problem - Responses

- Responses US-NCAP and IIHS ODB
  - *Mass*
  - *Intrusions*



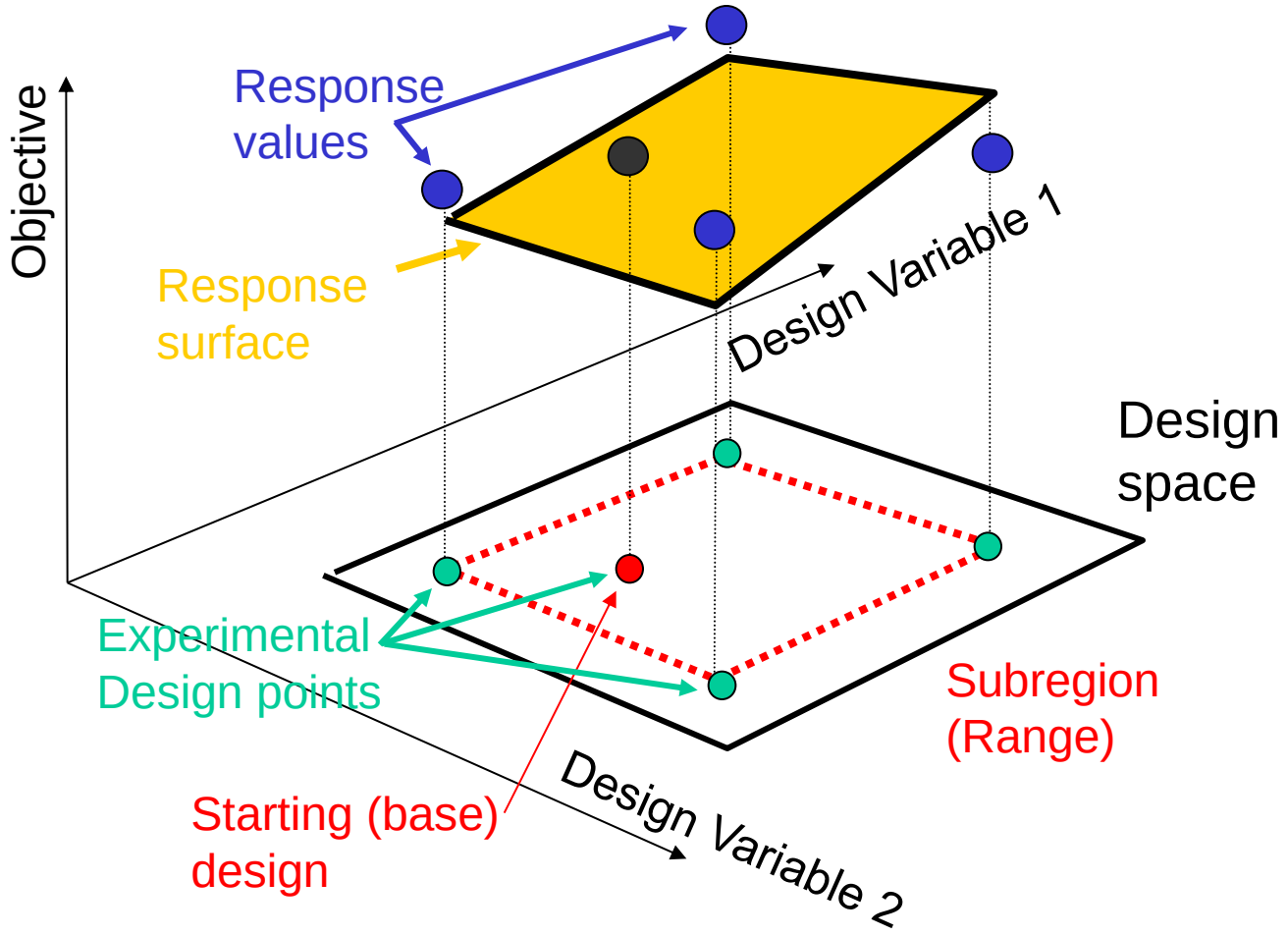
Example Problem - Responses

- Responses US-NCAP and IIHS ODB
  - *Accelerations*

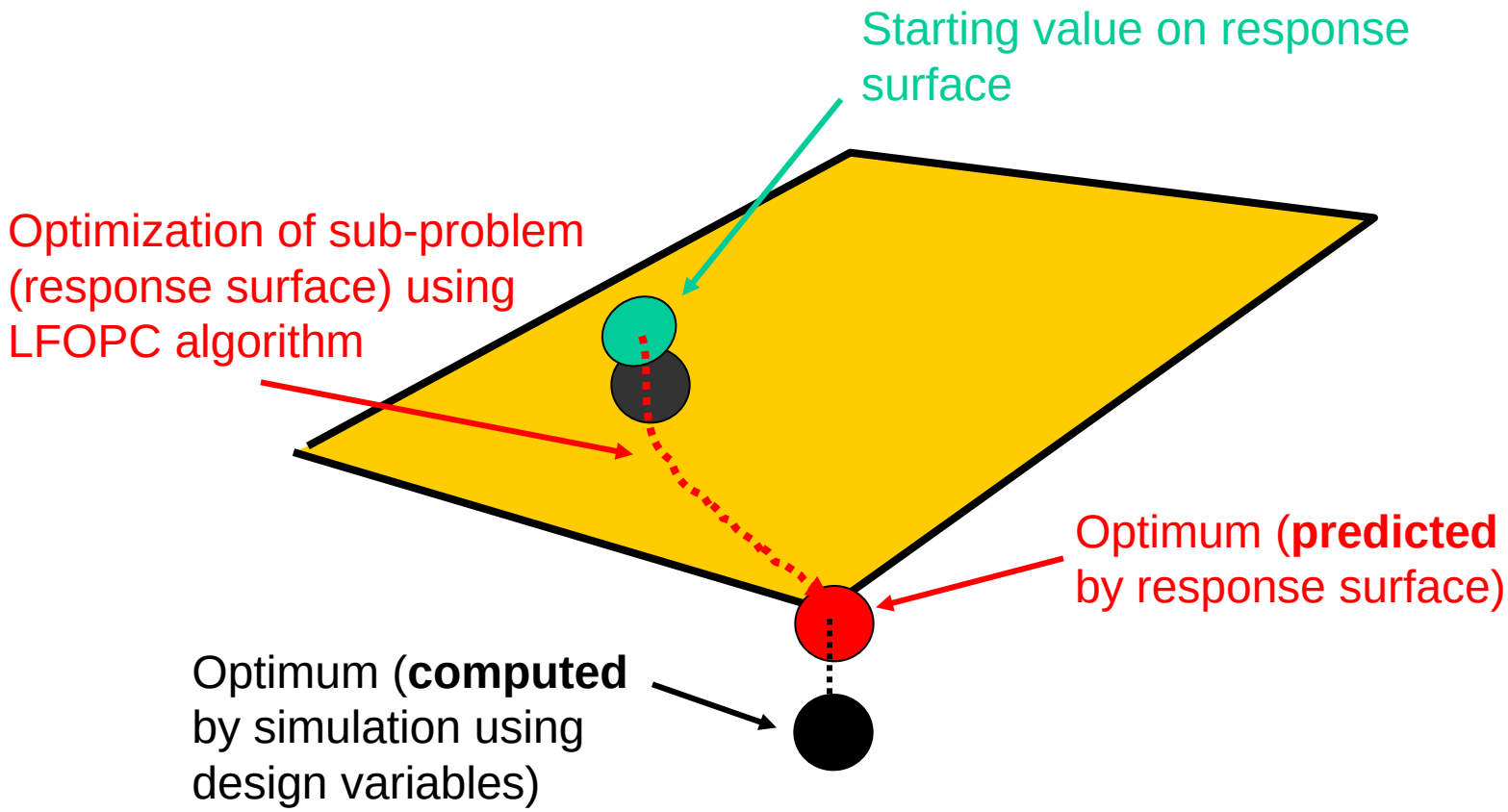


Einschub – Sequential Response Surface Method (SRSM)

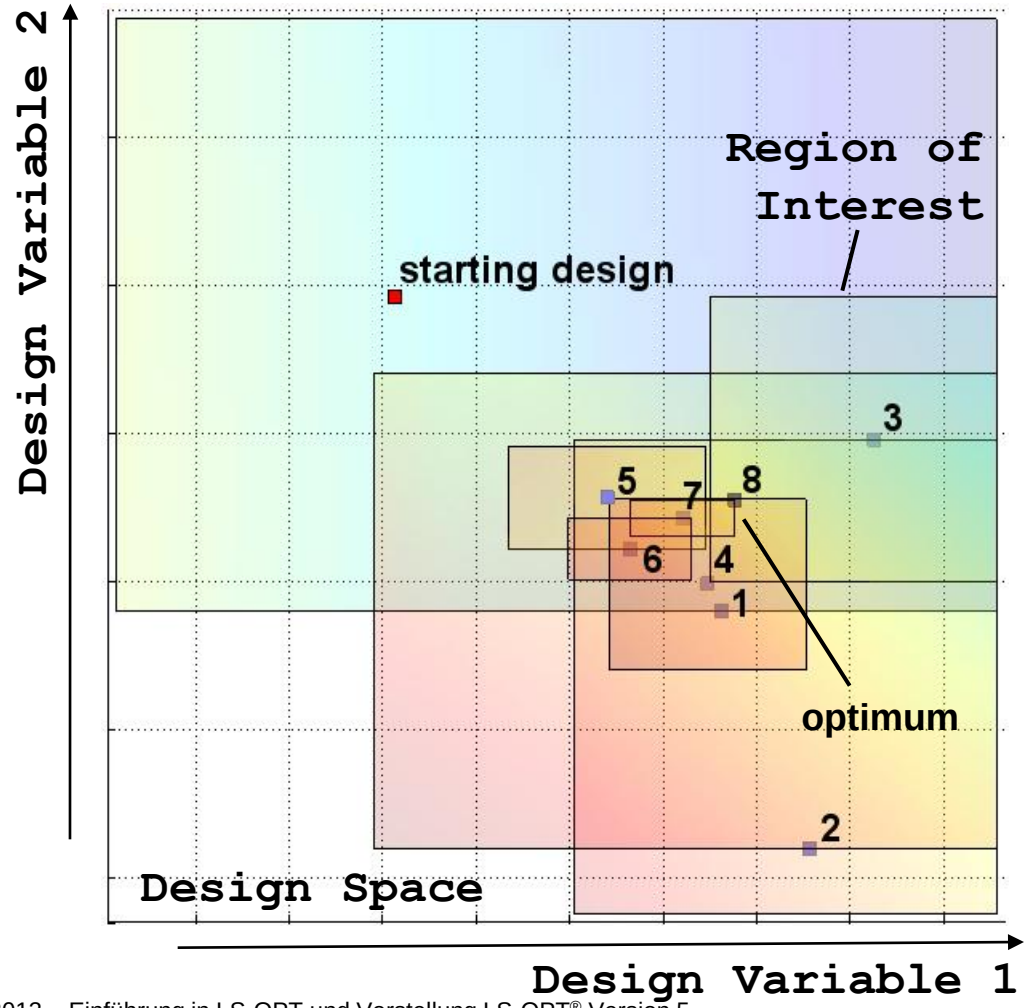
Response Surface Methodology - Optimization Process



Find an Optimum on the Response Surface (one iteration)



Successive Response Surface Methodology



LS-OPT 5 - Datenstruktur

- Früher „Solver“ → „Sampling“ und „Stage“ → neue Datenstruktur