



# Vorstellung von LS-OPT<sup>®</sup> Version 5

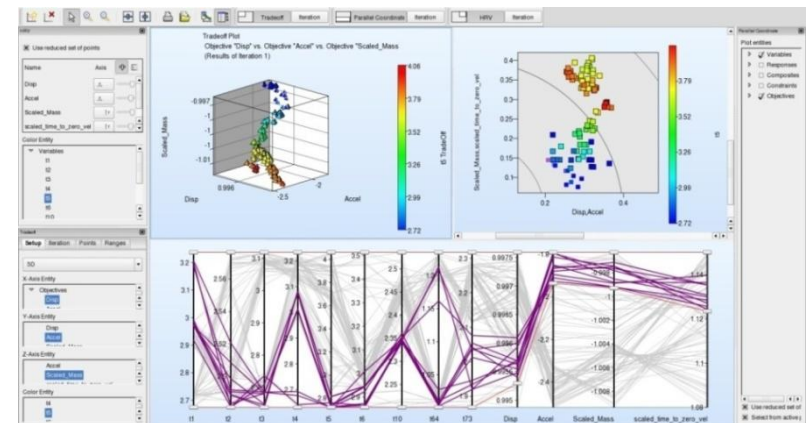
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## Outline

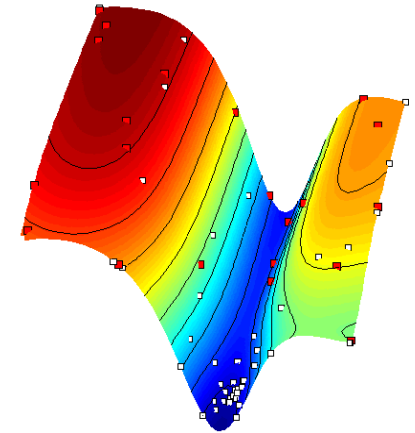
- Overview of methodologies and applications of LS-OPT
  - *DOE/Sensitivity analysis*
  - *Parameter identification*
  - *Shape optimization*
  - *Robustness analysis*
- Live demonstration of Graphical User Interface of LS-OPT V5
- Visualization of optimization results



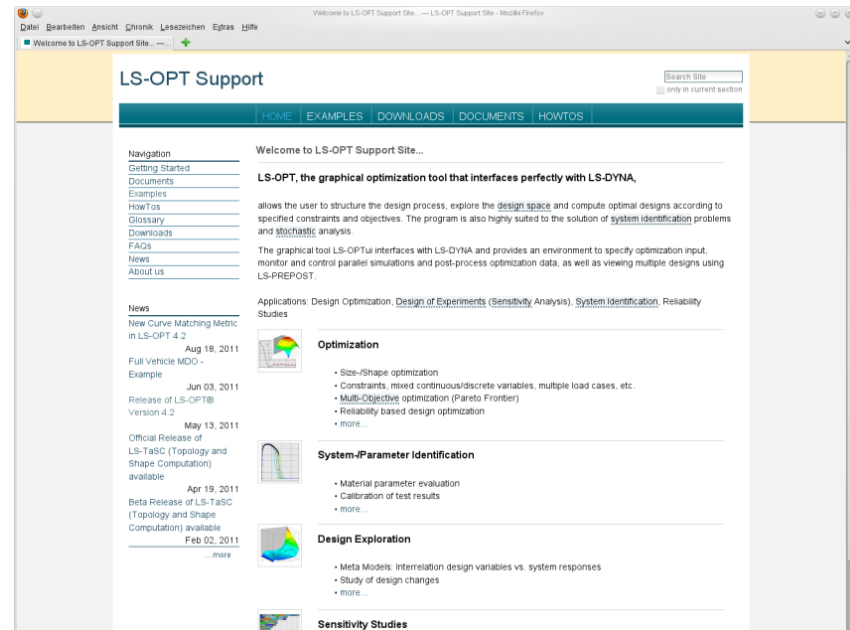
# Introduction

## ➔ About LS-OPT

- LS-OPT is a standalone optimization software
  - ➔ can be linked to any simulation code
    - Interface to LS-DYNA and MSC-Nastran
    - User-defined Interface
- Current production version is LS-OPT 5.0
- LS-OPT Support web page
  - ➔ [www.lsoptsupport.com](http://www.lsoptsupport.com)



- *Download of Executables*
- *Tutorials*
- *HowTos / FAQs*
- *Documents*
- *.....*



## → About LS-OPT – General Aspects

### ■ Job Distribution - Interface to Queuing Systems

- *PBS, LSF, LoadLeveler, SLURM, AQS, User-defined, etc.*

### ■ LS-OPT might be used as a “Process Manager”

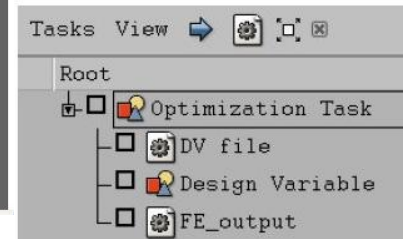
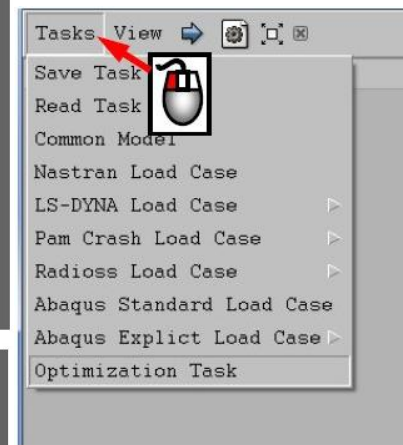
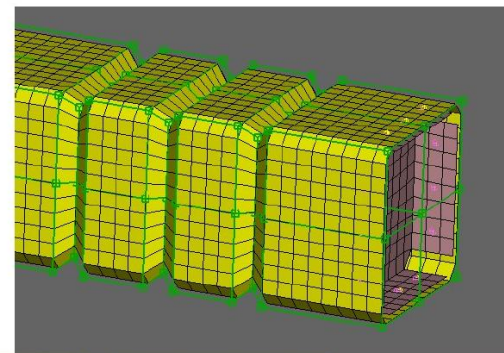
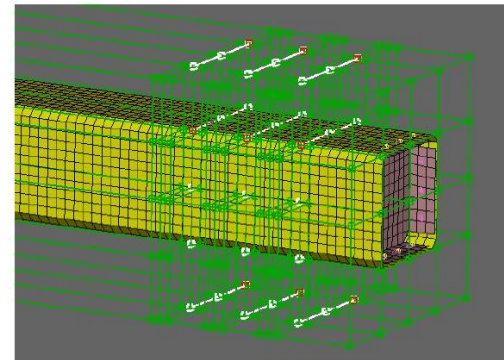
### ■ Shape Optimization

- *Interface to LS-PrePost, ANSA, HyperMorph*

- *User-defined interface*

### ■ META Post interface

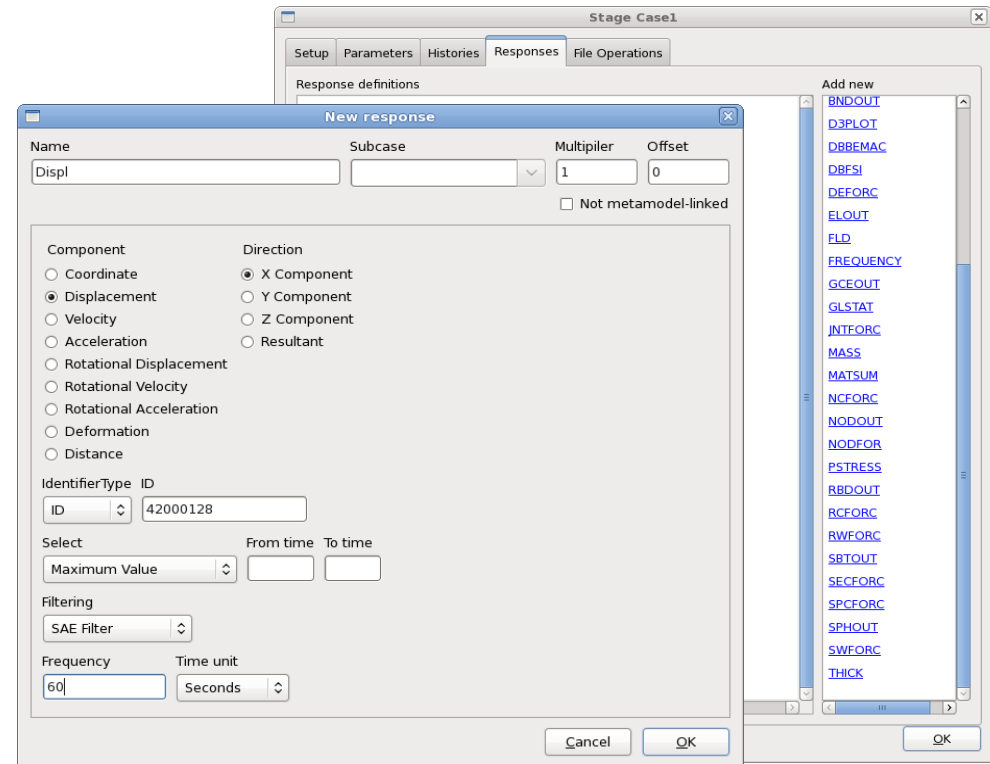
- *Allows extraction of results from any package (Abaqus, NASTRAN, ...) supported by META Post (ANSA package)*



## ➔ About LS-OPT

### ■ LS-DYNA Integration

- *Checking of LS-DYNA keyword files (\*DATABASE\_)*
- *Importation of design parameters from LS-DYNA keyword files (\*PARAMETER)*
- *Support of include files (\*INCLUDE)*
- *Monitoring of LS-DYNA progress*
- *Result extraction of most LS-DYNA response types*
- *D3plot compression (node and part selection)*





## LS-OPT – Overview Methodologies

### ■ Response Surface Method (RSM)

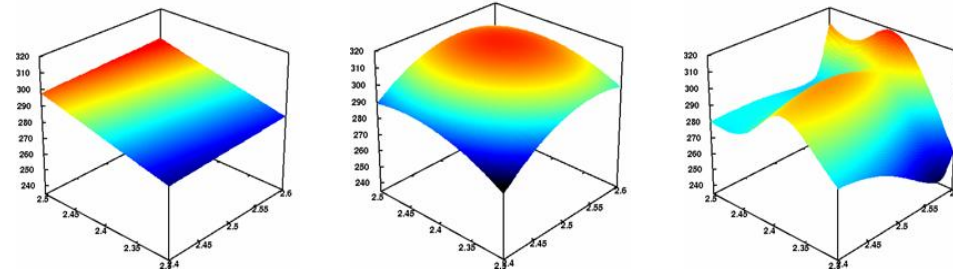
#### ■ *Sequential Response Surface Method (SRSM)*

#### → Metamodels

#### ■ *Polynomials*

#### ■ *Radial Basis Functions*

#### ■ *Feedforward Neural Networks ...*



### ■ Genetic Algorithm (MOGA->NSGA-II)

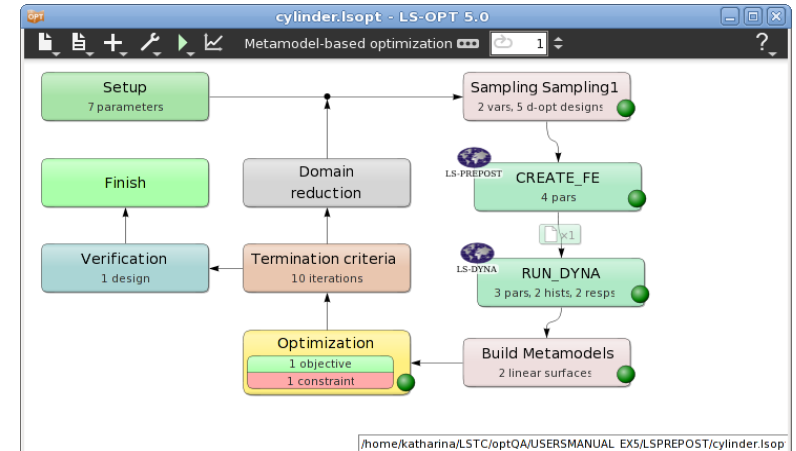
#### ■ *Direct*

#### ■ *Metamodel-based*

### ■ Monte Carlo Analysis

#### ■ *Direct*

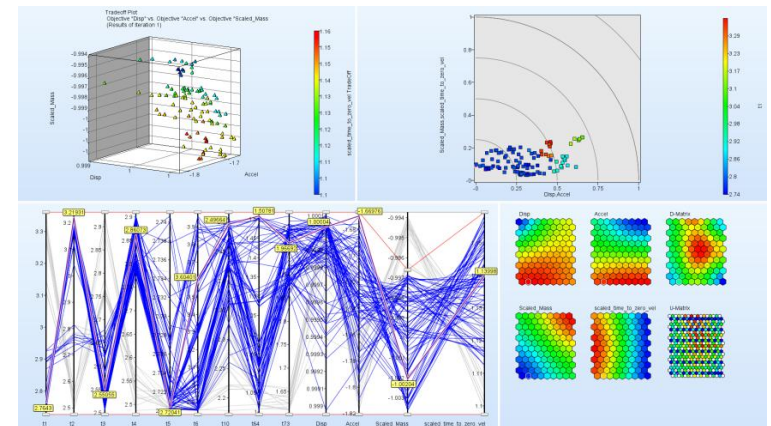
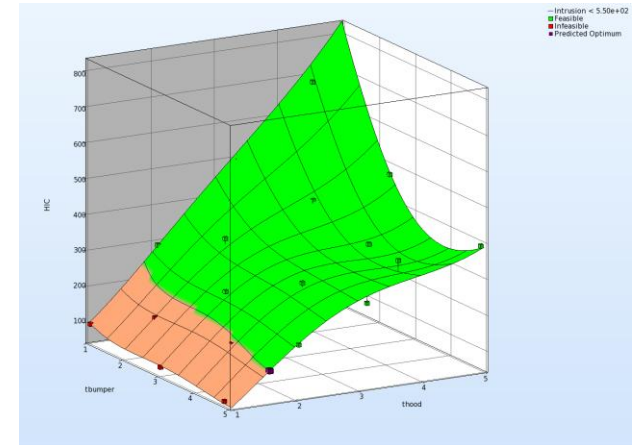
#### ■ *Metamodel-based*



# Applications of LS-OPT

## ■ Optimization

- *Size-/Shape optimization*
- *Constraints*
- *Mixed continuous/discrete variables*
  - *Specify sets of discrete variables (e.g sheet thicknesses)*
- *Multiple load cases*
  - *Multi-disciplinary optimization (MDO)*
- *Multi-objective optimization (Pareto Frontier)*
- *Reliability based design optimization*
- *Methodologies*
  - *Meta-model based approaches*
  - *Genetic Algorithms (MOGA->NSGA-II)*



# Applications of LS-OPT

## ■ Parameter/System Identification

- Calibration of test and simulation curves or scalar values
- Visualization of test and simulation curve for comparison

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



History matching composite

Name:

Algorithm:

- Mean Square Error (difference in curve Y values)
- Curve Mapping (size of area between curves)

Target curve:  add new file history

Computed curve:

Regression points

- From target curve
- Fixed number (equidistant, interpolated)

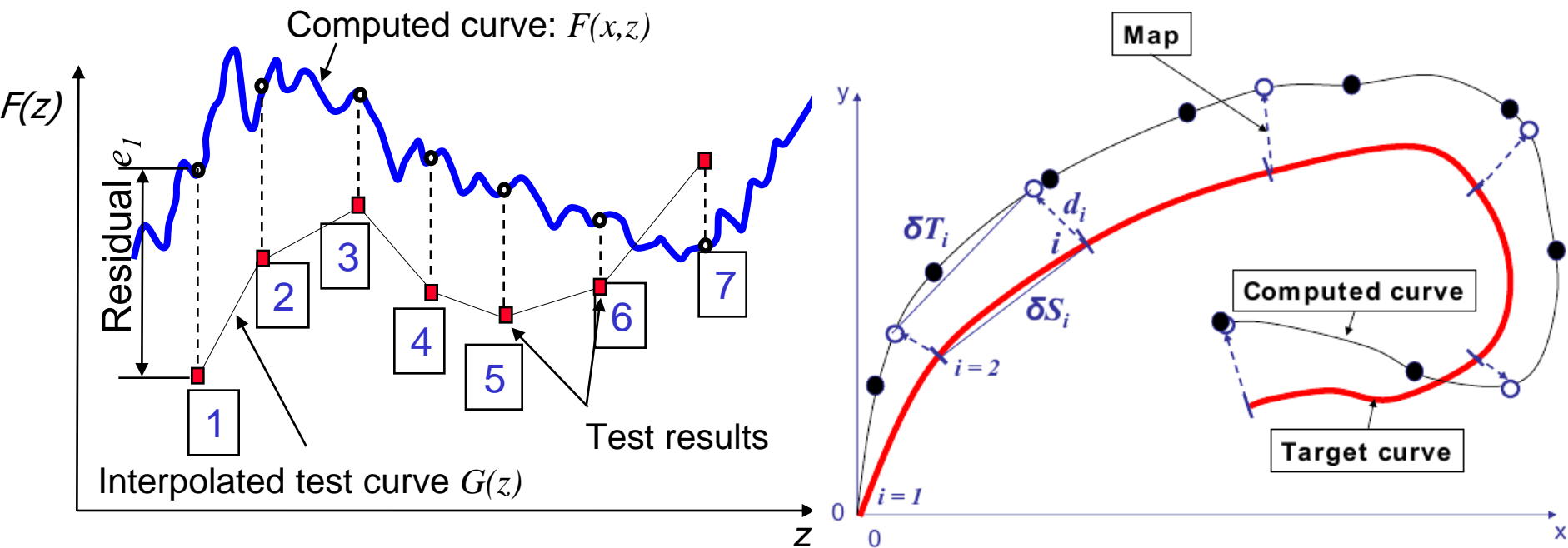
You can [convert this composite to an expression](#) for further fine-tuning.

OK



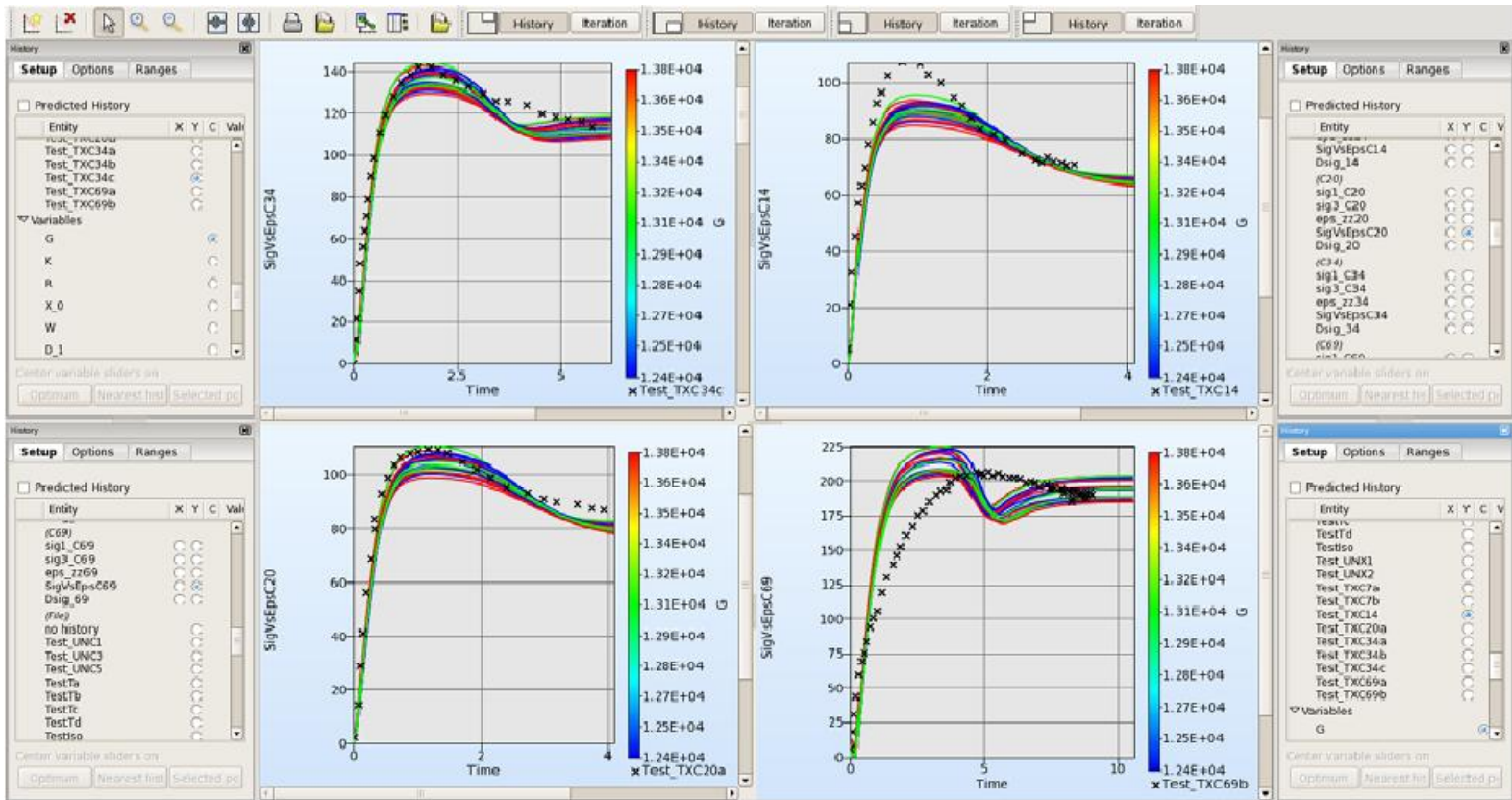
# Applications of LS-OPT

## Parameter Identification with Test Curves



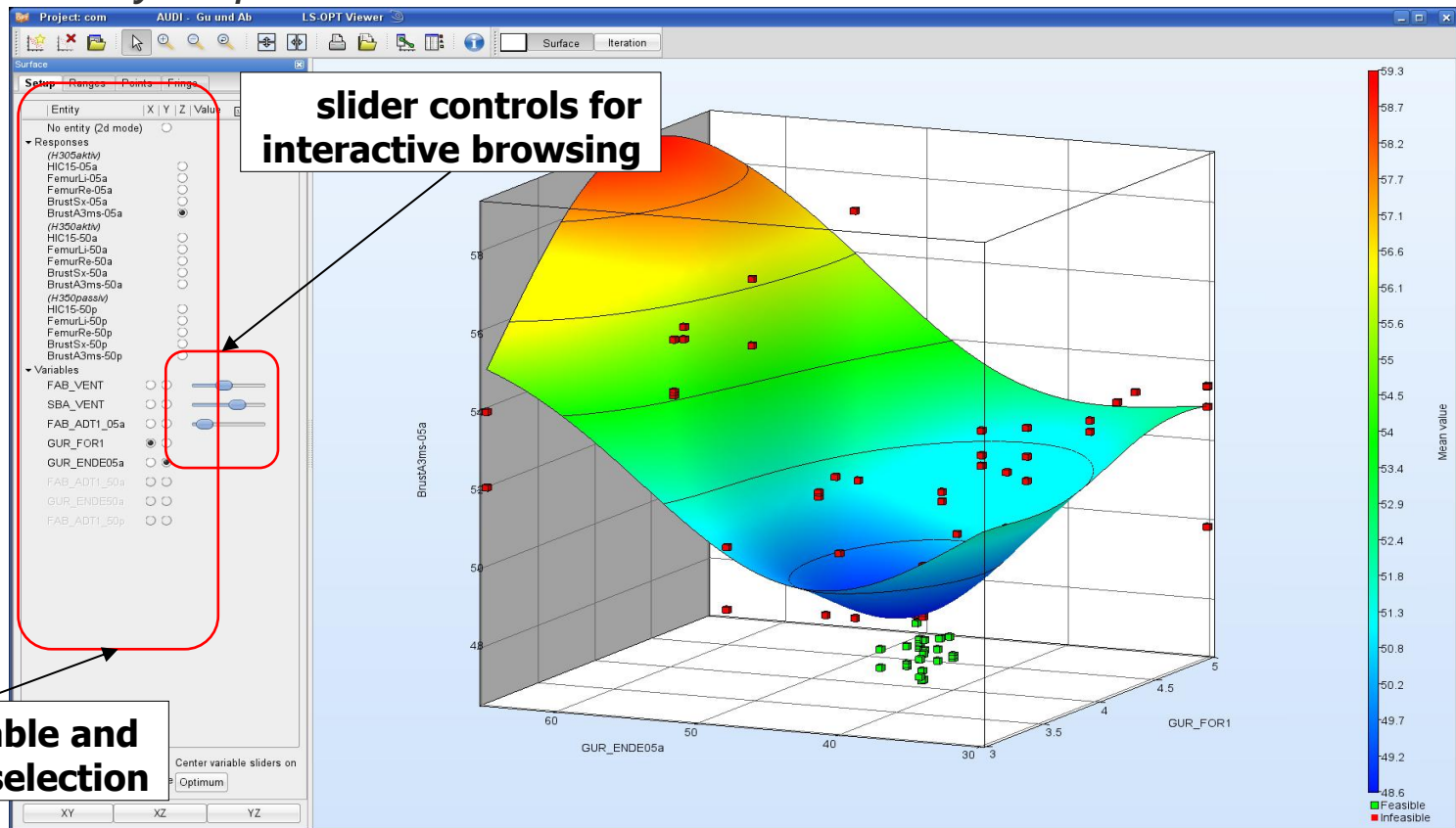
# Applications of LS-OPT

## ■ Computed history curves vs. Target curves



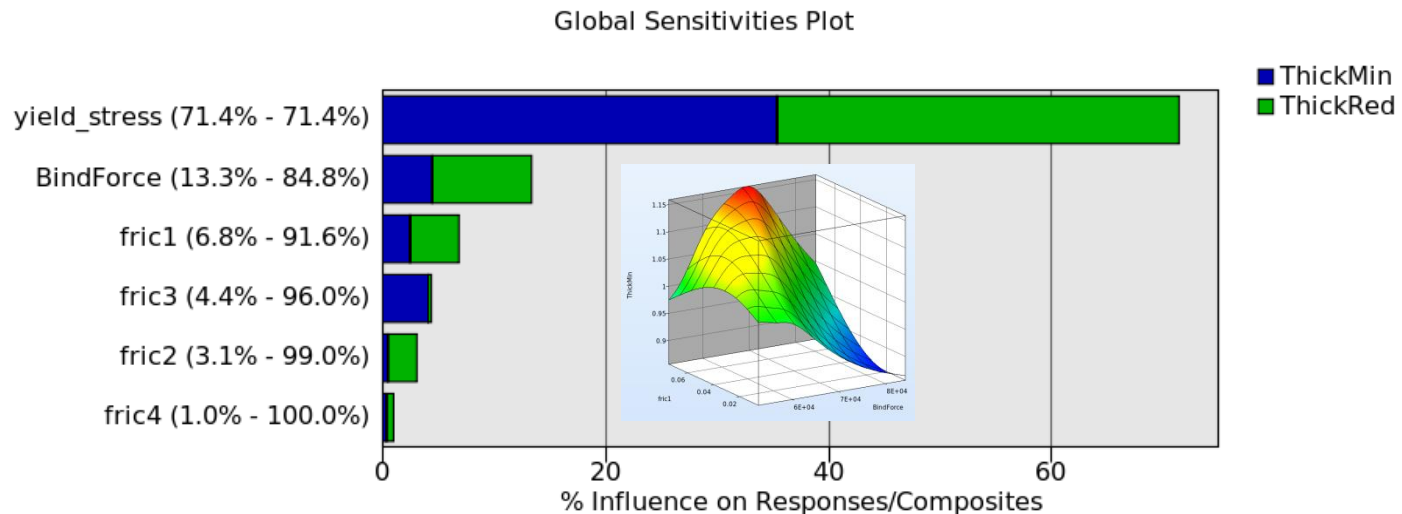
# Applications of LS-OPT

- DOE-Studies, Design Exploration
  - *Visualization: 2D/3D sections of the surfaces, 1 or 2 selected variables vs. any response*



# Applications of LS-OPT

- Sensitivity Studies (ANOVA, Sobol)
  - *Contribution of variables to system performance*
  - *Identification of significant and insignificant variables*
  - *Ranking of importance*

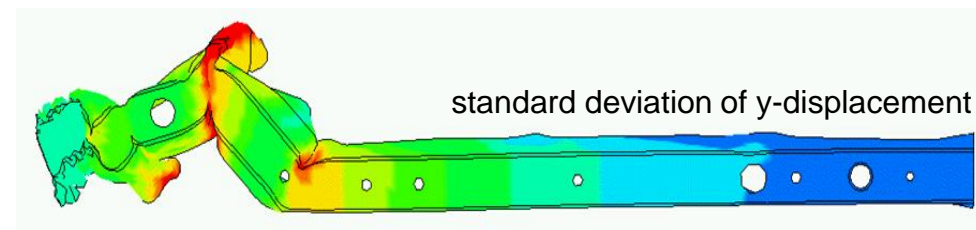
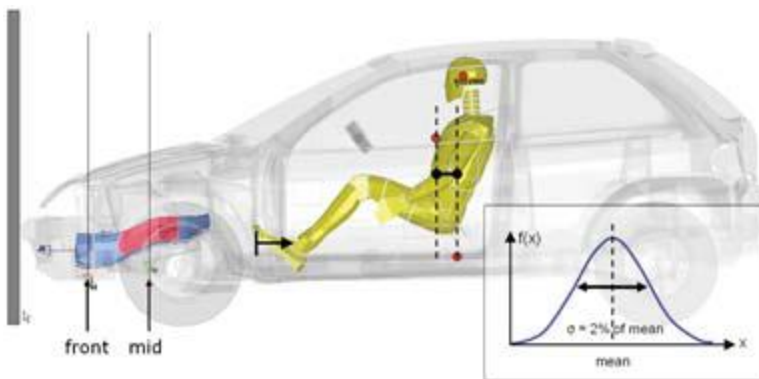
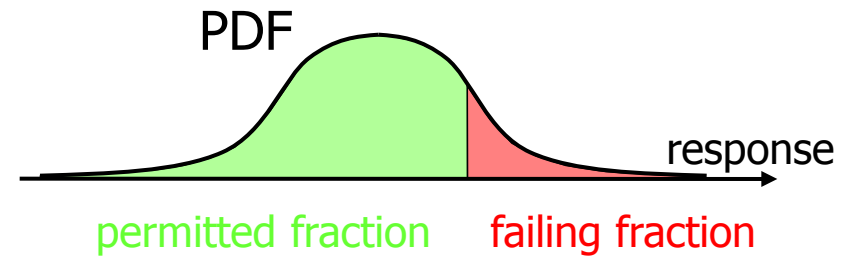




# Applications of LS-OPT

- Robustness/Reliability Analysis

- *Consideration of uncertainties*
- *Evaluation of reliability (probability of failure)*
- *Statistics (mean, std, ...)*
- *Correlation analysis*
- *Confidence intervals*
- *Outlier analysis*
- *Fringe statistical results on FE model*





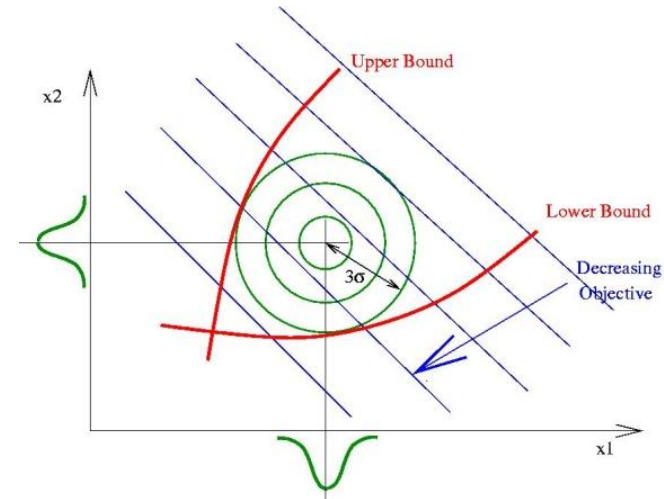
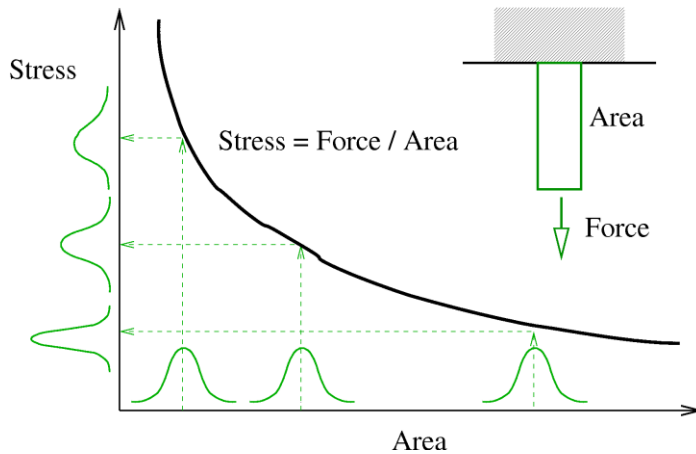
# Applications of LS-OPT

## ■ Robust Parameter Design (RDO)

- *Improve/Maximize the robustness of the optimum*

## ■ Reliability Based Design Optimization (RBDO)

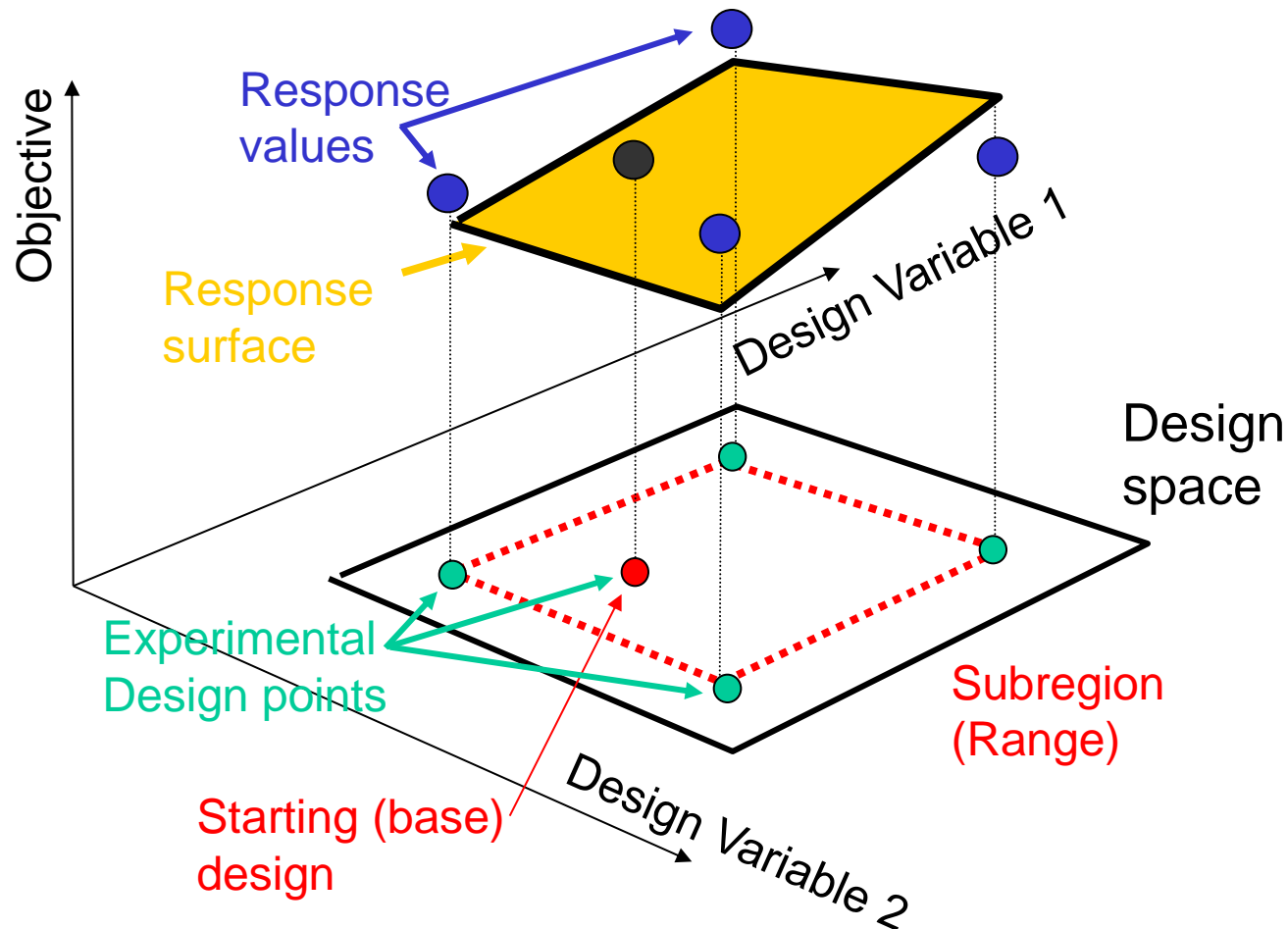
- *Improve failure probability of optimum*



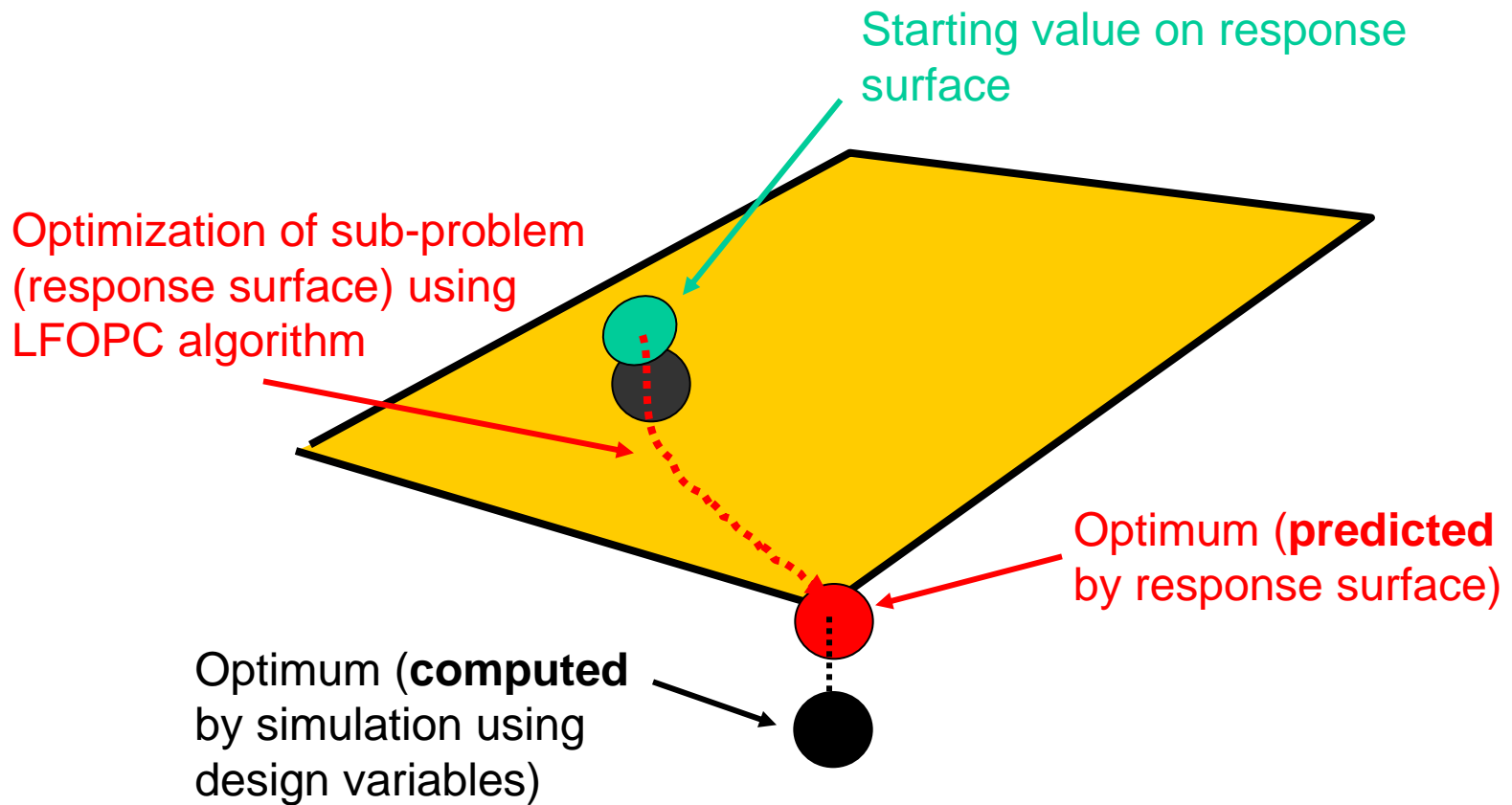


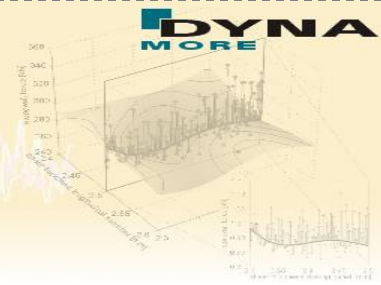
# Sequential Response Surface Method (SRSM)

## Response Surface Methodology - Optimization Process

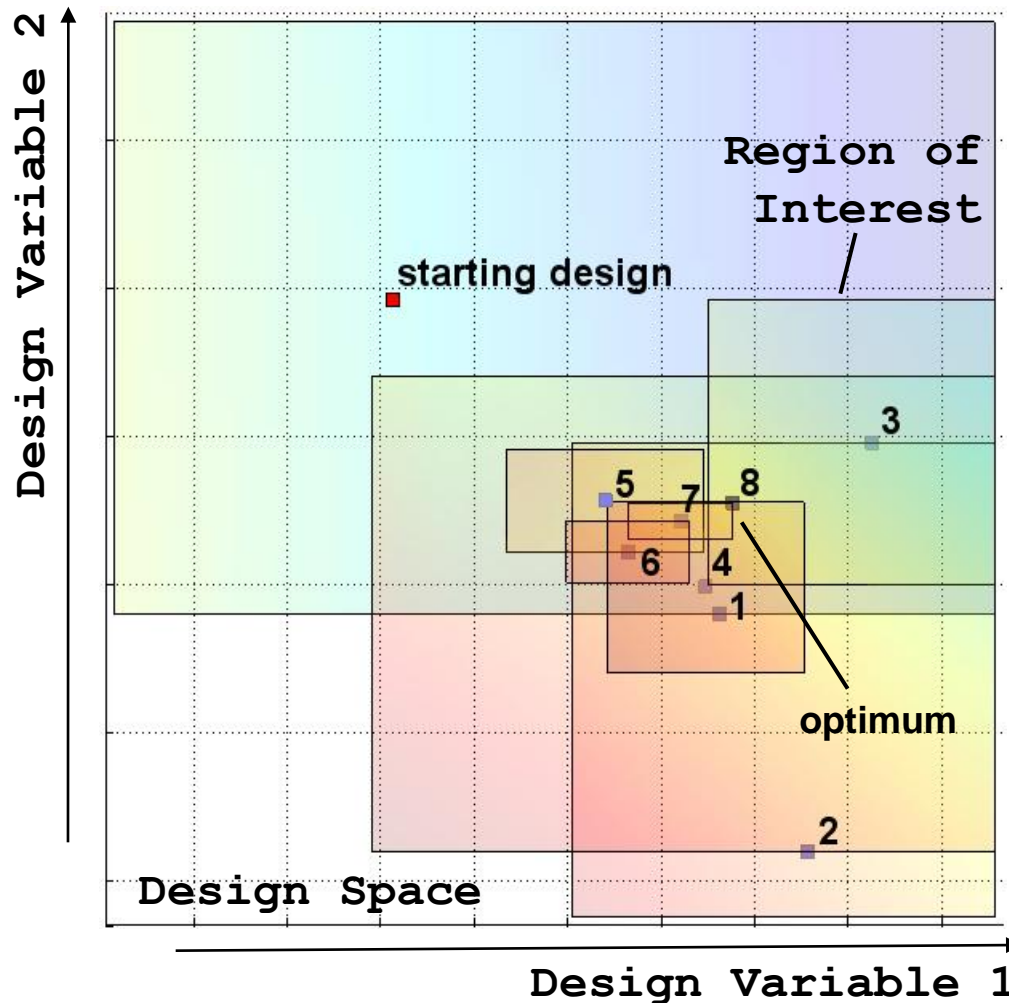


## Find an Optimum on the Response Surface (one iteration)





## Successive Response Surface Methodology







# Outlook LS-OPT 5.1

- Interface to Excel as a stage
- Multi-level optimization
  - *Define LS-OPT as a stage*
- Deactivation of variables
  - *Seamless deactivation between iterations*
- Response variables
  - *Transfer of output variables (responses) from one stage as input variables to the next stage*
- Collaborative optimization
  - *De-activate selected cases in an MDO problem*
  - *Allows synthesis and decomposition of MDO setup*
- Mathematical formulas of meta-model functions
- Global Sensitivity Analysis in sub-domain of design space