presented at the 6th Weimar Optimization and Stochastic Days 2009
Source: www.dynardo.de/en/library

Recent developments

the dynardo Team

version 3.1.0

Significantly improved quality management

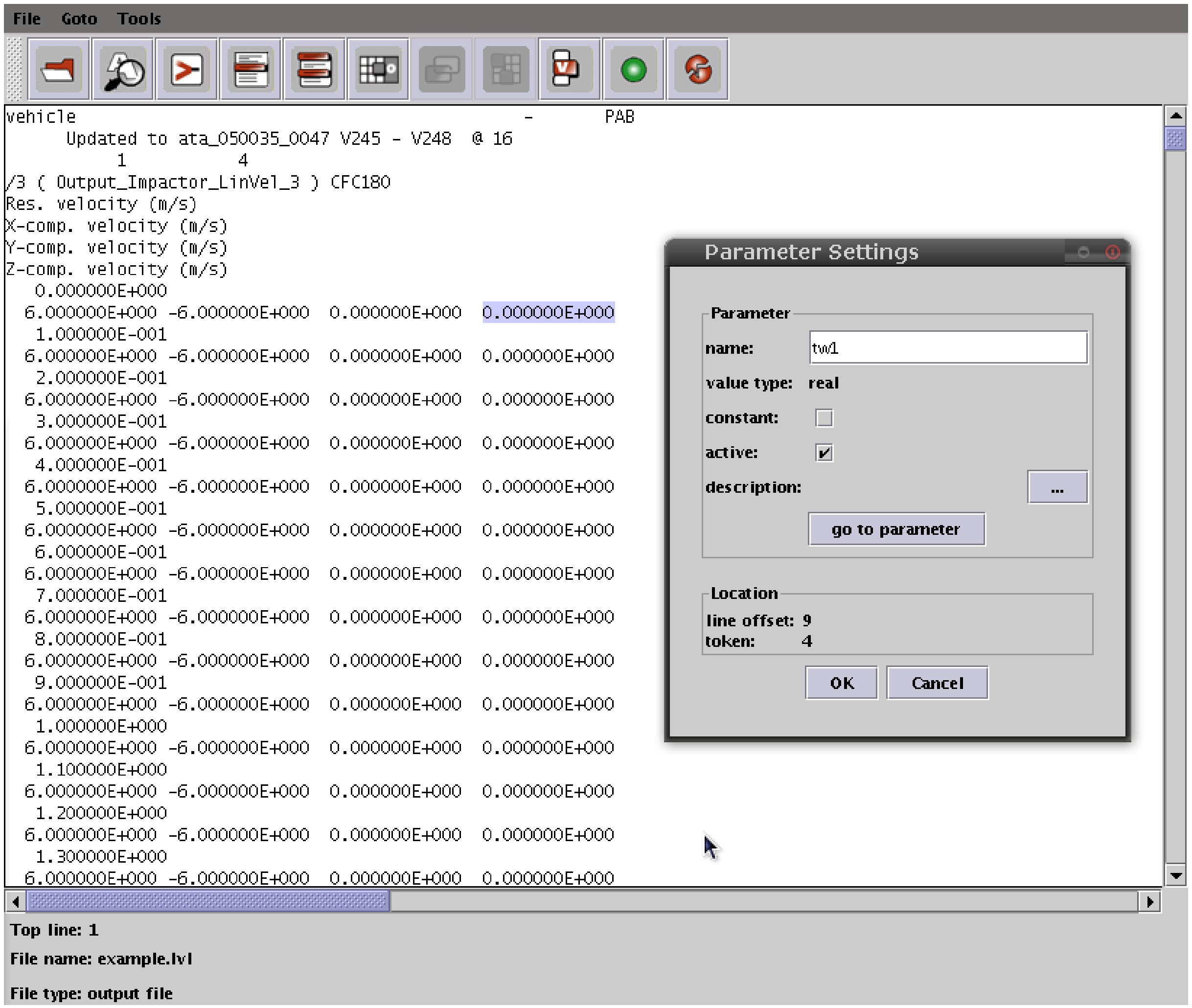
V3.1.0_rcx: since September 2009 in productive use
V3.1.0: Release October 2009

History of “productive versions”
- optiSLang v1: 1.0.12
- optiSLang v2: 2.1.5
- optiSLang v3: still 3.0.1

Step 1: improve quality management
Step 2: quality management flexible enough to deliver beta-versions more frequently

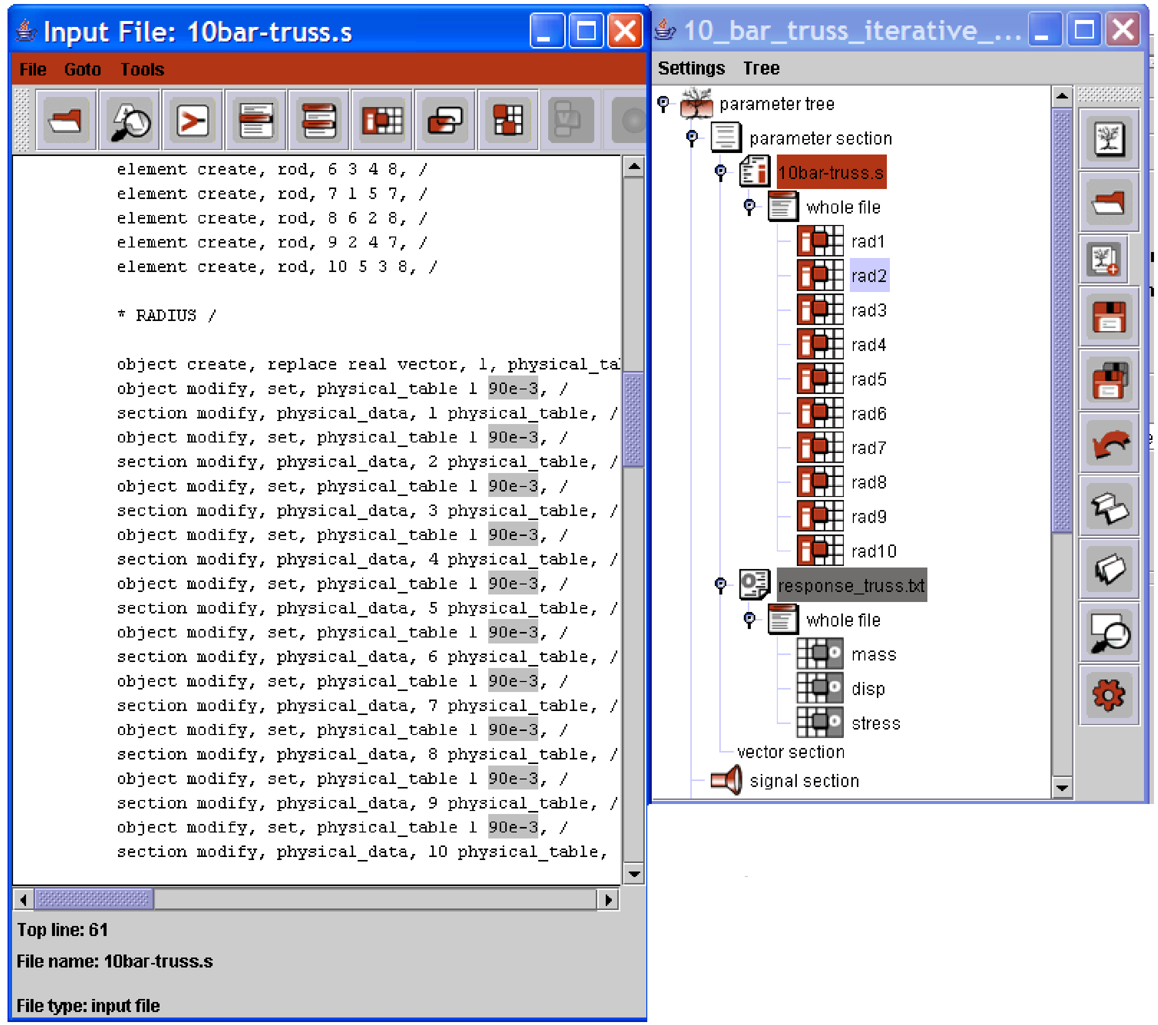
Parametrize Editor

- Token wise parsing



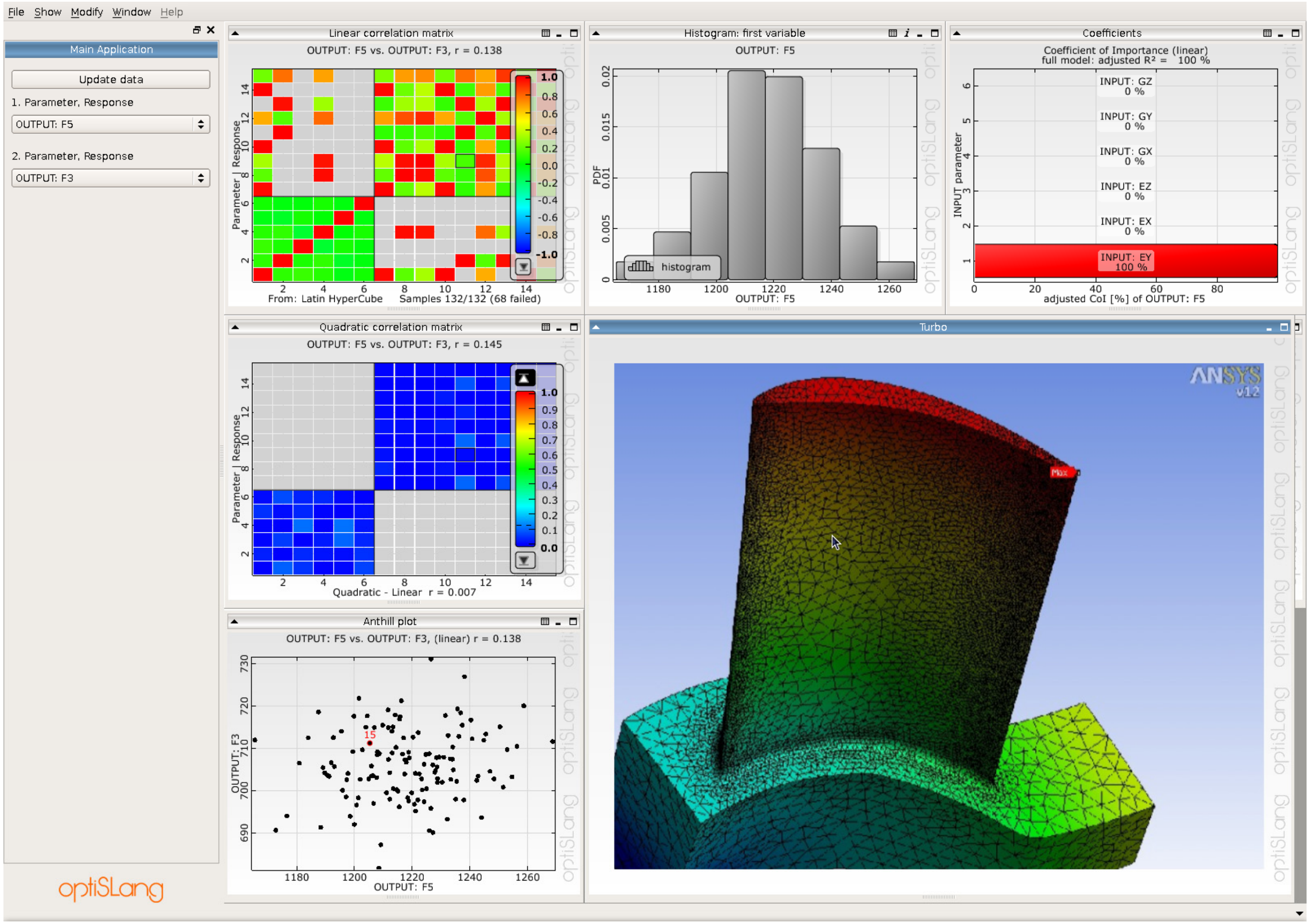
Parametrize Editor

- Improved icons
- multiple highlighting
- add/import additional trees
- additional mathematical functionality for signal processing



Post Processing

- add Image Plot Window to post processing



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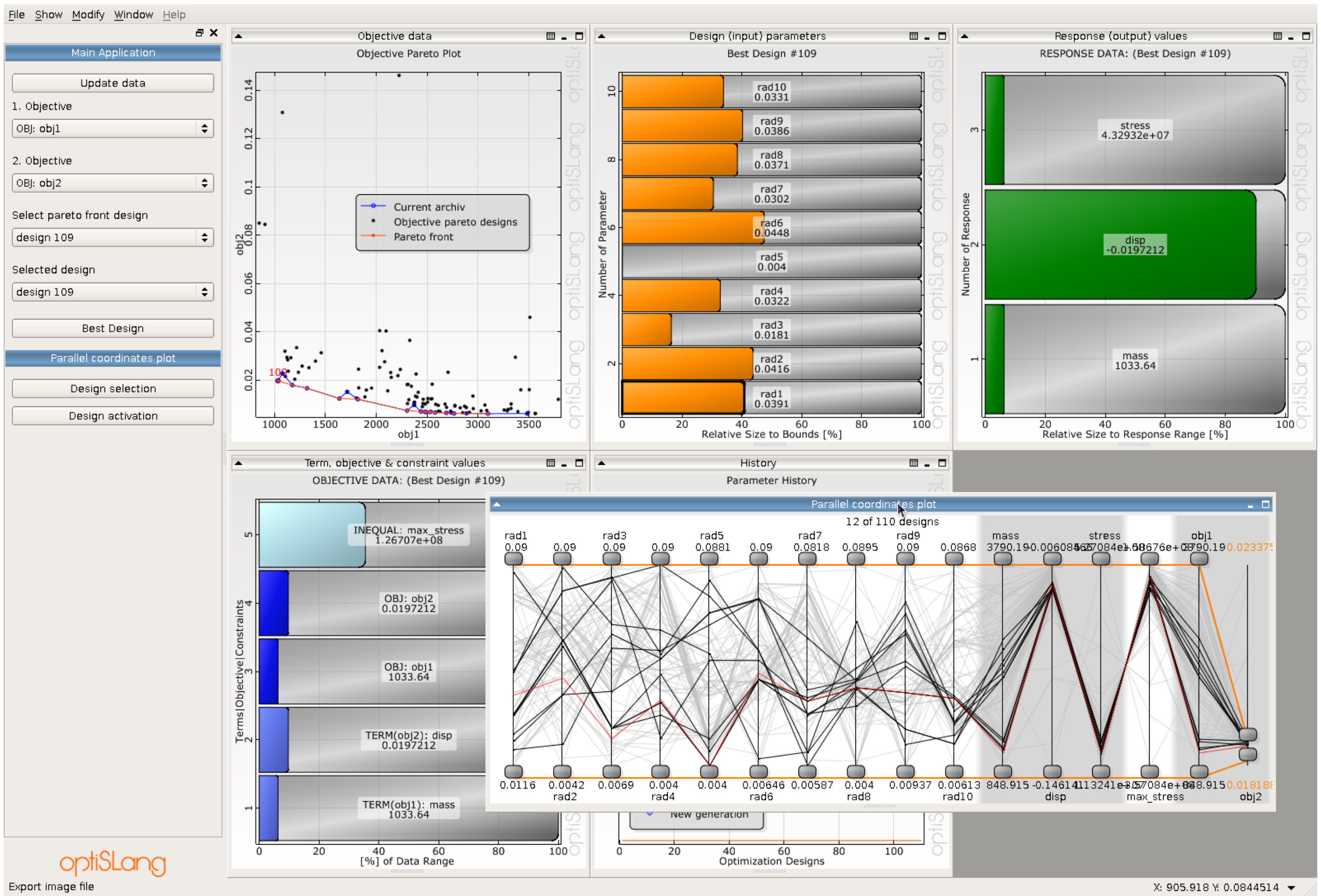
Multi Criteria Optimization Strategies

Pareto Optimization Strategies

- Parallel Coordinate Plot and Control



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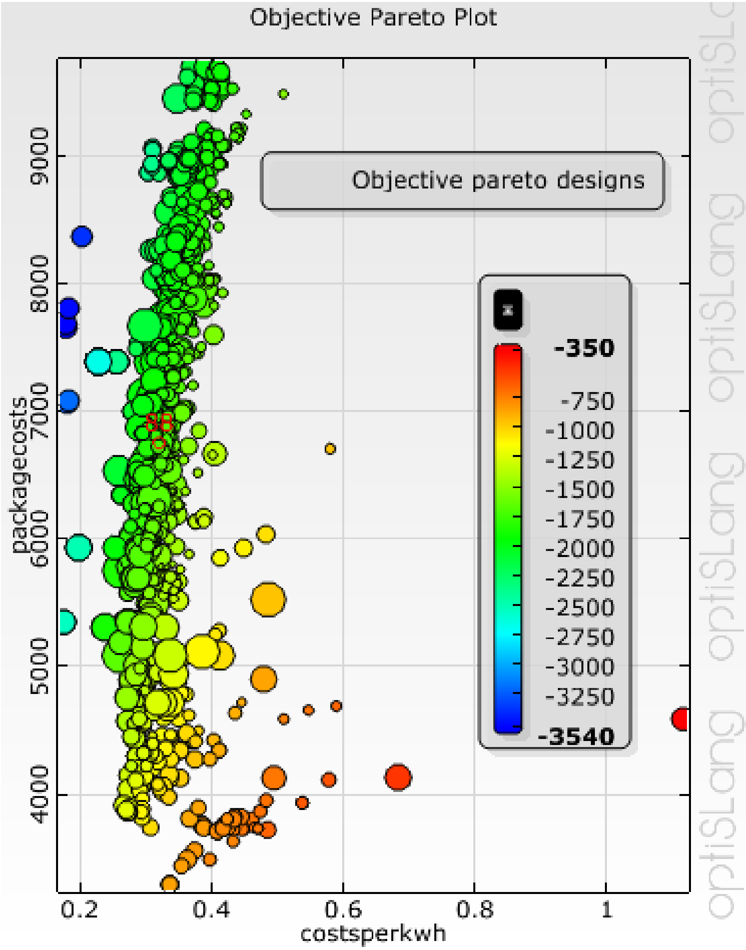
Multi Criteria Optimization Strategies

Pareto Optimization Strategies

- 4 dimensional Pareto Plot (colour)
- 5 dimensional Pareto Plot (bubble size)



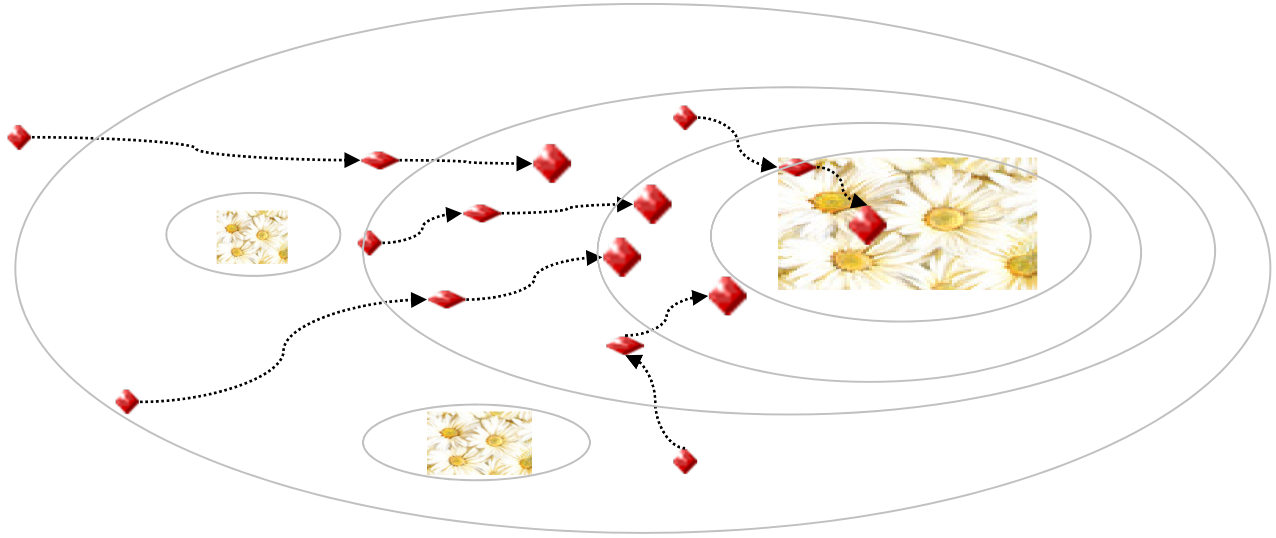
Optimization within optiSLang 3.1

Improve biological algorithms!

Particle Swarm Optimization

Motivation: fester and better resolution of Pareto Frontier

- - fast and easy to drive algorithm
- - applicable for single-objective problems (comparable to EA-quality)
- - shows good performance for multi objective test problems



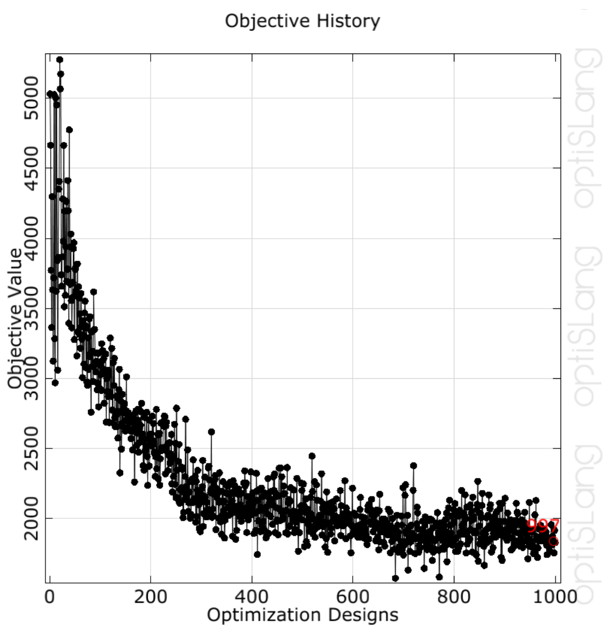
Particle Swarm Optimization

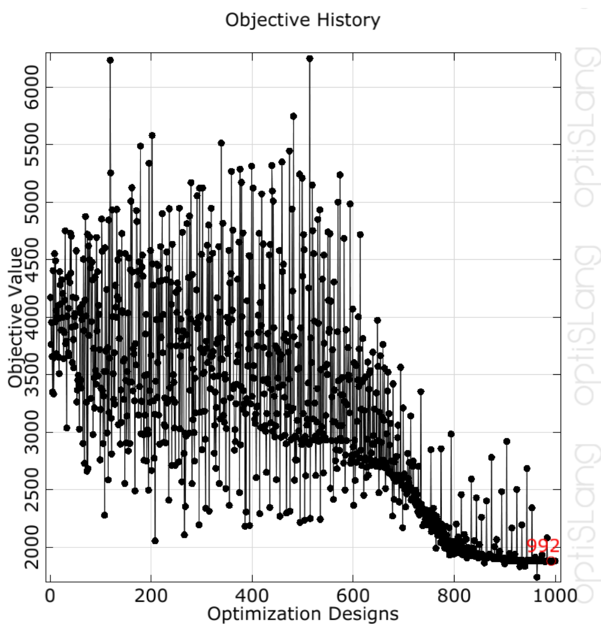
- - swarm intelligence based algorithm
- - imitates the social behaviour of a bees swarm searching for food
- **selection:** design with best objective becomes swarm leader and will be stored in an archive
- **adaption:** each particle flies into direction of its personal best position and the global best position (swarm leader)
- **mutation:** the calculated new position will be modified in a randomly selected dimension
- **selection for multi objective:**
- - non dominated are stored in archive (sorted by e.g. distances)
- - select swarm leader to assure diversity

Particle Swarm Optimization

- <u>single objective optimization</u>
- 10 bar truss example:
- - a typical run shows global search and late convergence
- - results for single objective problems were not better than EA

-

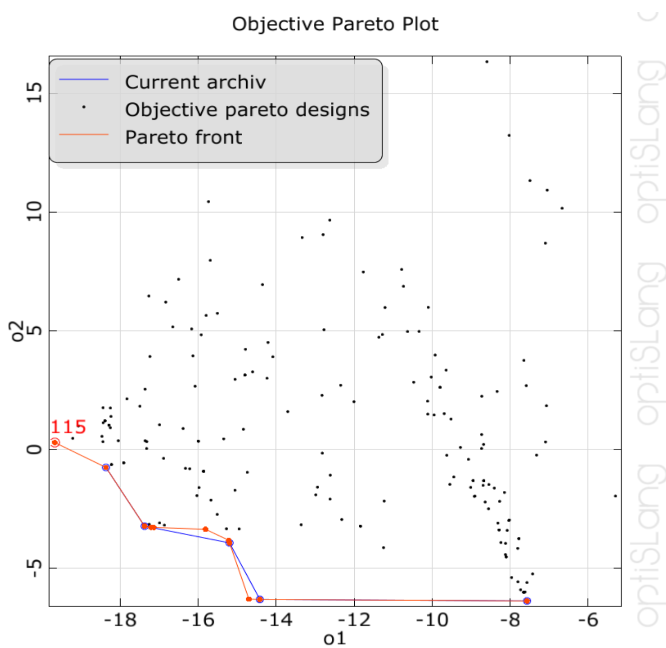




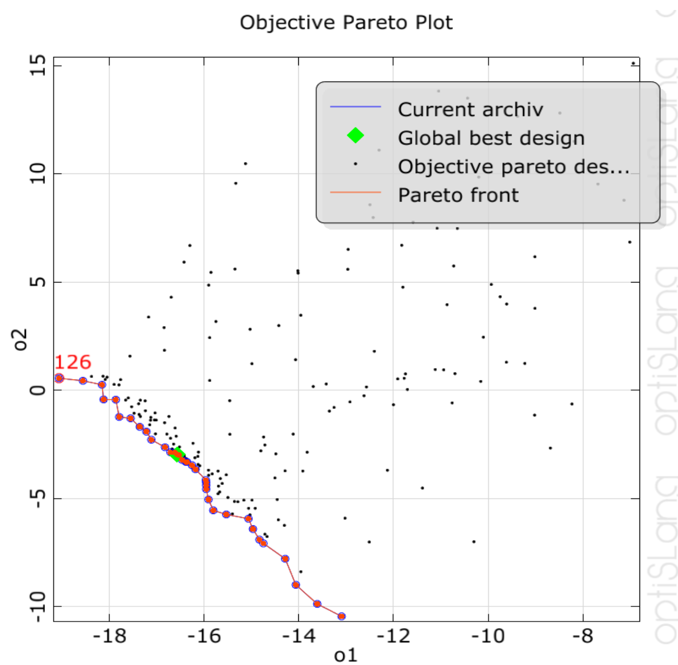
convergence with EA	convergence with PSO
mass = 1839,15 lbs (834 kg)	mass = 1880,67 lbs (853 kg)

Particle Swarm Optimization MOO

- more designs on pareto front than EA
- better diversity of pareto front
- Kursawe: $f_1(x) = \sum_{i=1}^{n-1} \left(-10 \exp\left(-0.2 \sqrt{x_i^2 + x_{i+1}^2} \right) \right)$ $\quad f_2(x) = \sum_{i=1}^{n} \left(|x_i|^{0.8} + 5 \sin(x_i)^3 \right)$



200 designs EA



200 designs PSO

Variation Analysis (Sensitivity and Robustness Evaluation) within optiSLang 3.1

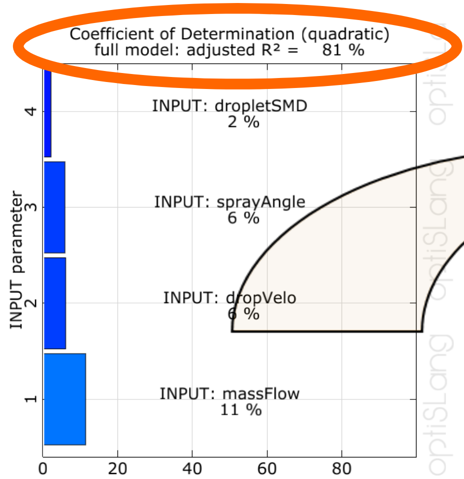
Coefficient of Prognosis (CoP) & Metamodel of best Prognosis (MoP)

statistical measurement of importance CoD/CoI

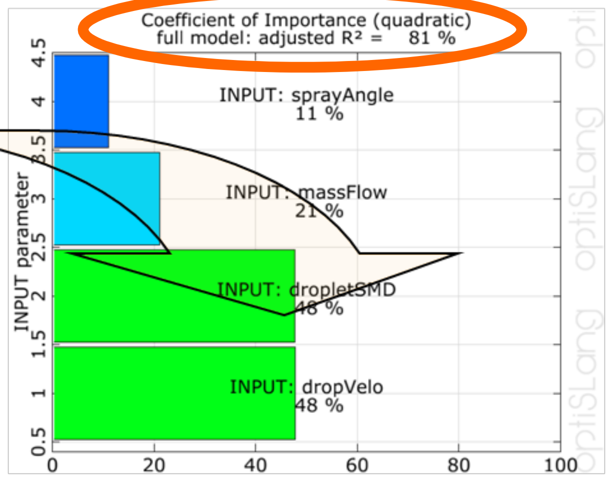
Coefficient of Determination (CoD) optiSLang 2.0 (multiple correlation coefficient) shows only pair wise correlation

Coefficient of Importance (CoI) optiSLang 3.0 improves measurement of the influence of a single input parameter to the fraction of variability

- Show more importance:
  - correlations of multiple variables are included



optiSLang Version 2
(CoD does not quantify importance)

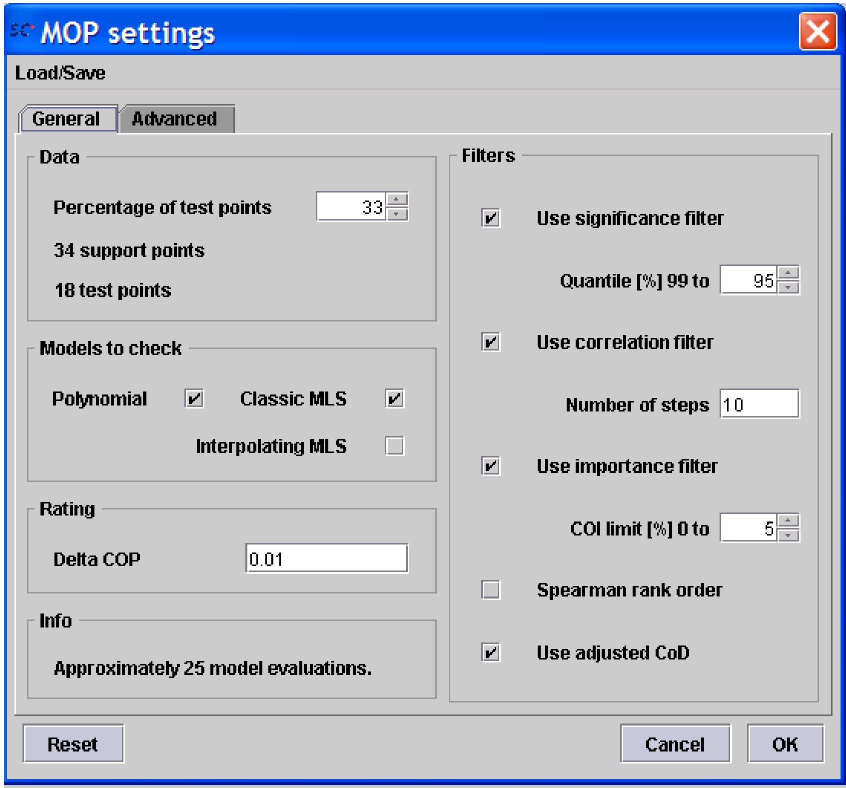


optiSLang Version 3
(CoI does quantify importance)

- Show less importance:
  - better noise effect filtering
  - in case of correlated input variables

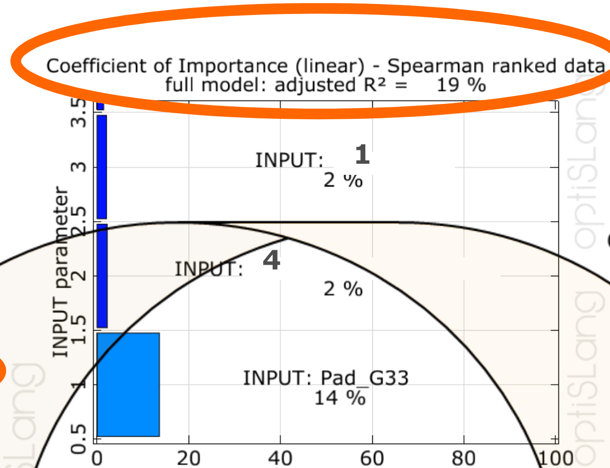
Definition - Coefficient of Prognosis

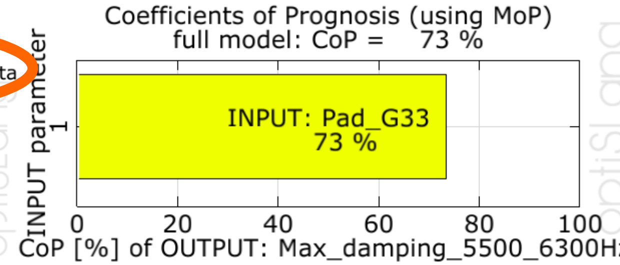
- What proportion of the variation of a response can be forecasted with identified arbitrary non-linear correlations to the input parameters?
- CoP has three benefits
  - We reduce the variable space with different filter = best subspace
  - We check against arbitrary non linear correlation by checking numerous MLS/Polynomial regression = best regression
  - We split the sample set and check the forecast (prognosis) quality of the identified correlations at the test samples.

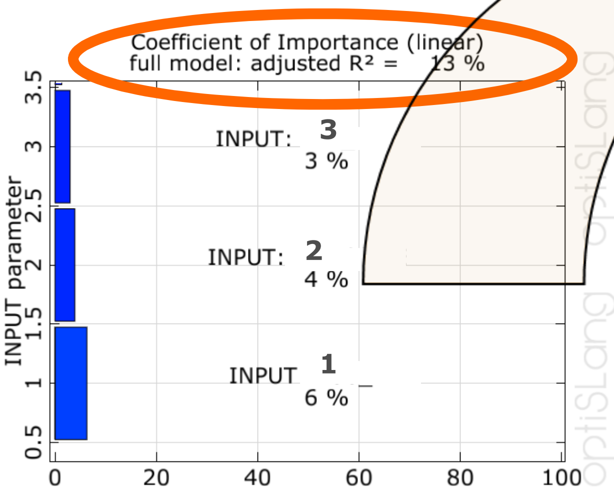


CoD/CoI/CoP

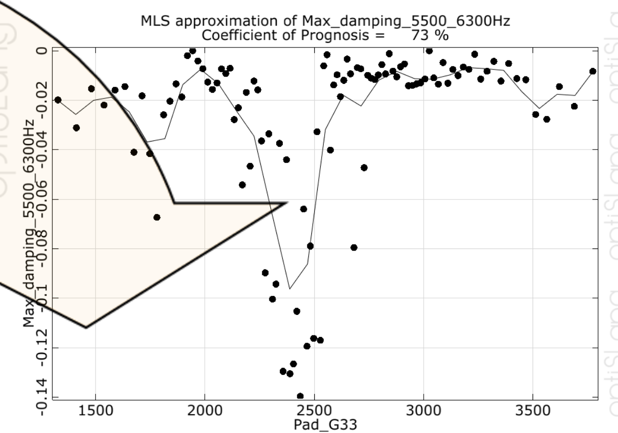
Get ready for productive use.







optiSLang Version 3
(CoI find most important variable)



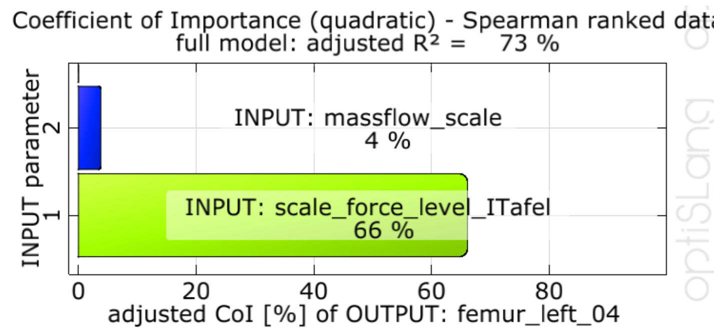
optiSLang Version 3.1
(CoP quantify nonlinearity)

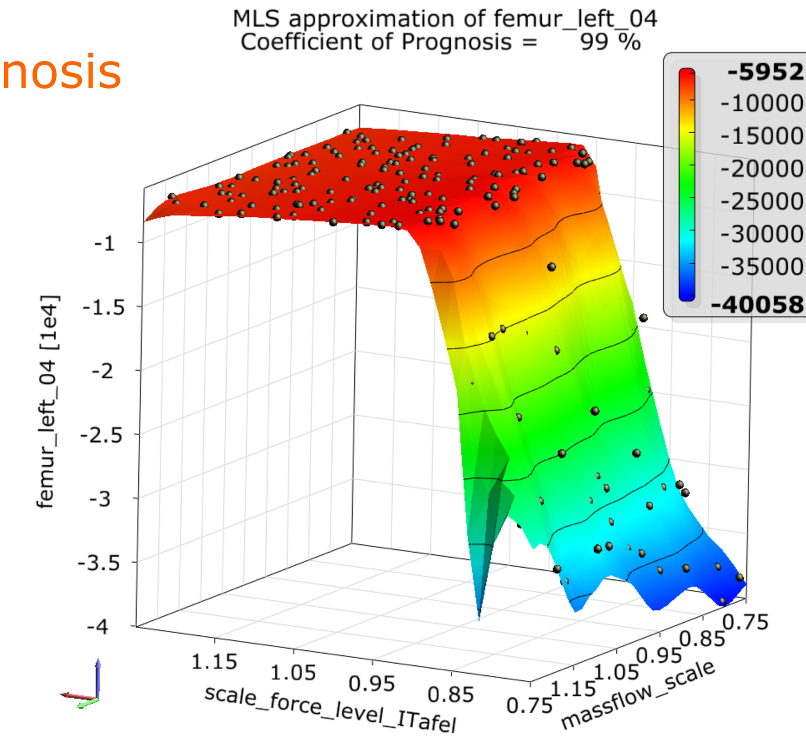
optiSLang Version 2
(CoD shows no importance)

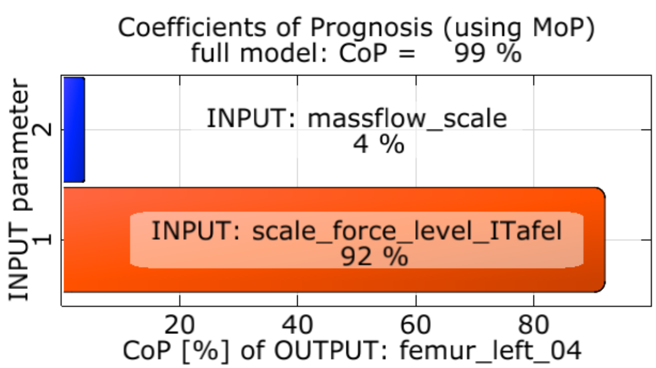
optiSLang Version 3.1
CoP: 0.73
MoP: MLS-Approximation
Sample Split 70/30

MOP benefits

- To calculate the CoP a metamodel of optimized prognosis (MoP) is created
    - Best subspace and best regression model
- MoP can be used for visualization
- global prognosis quality and local prognosis quality can be evaluated!

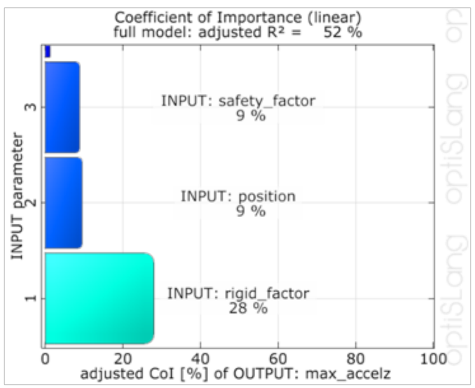


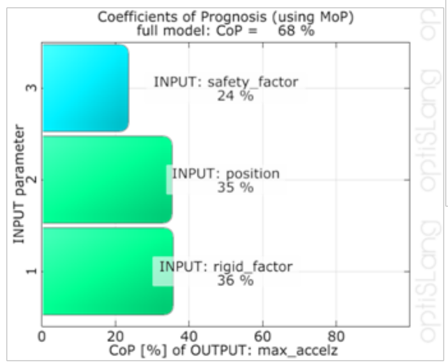


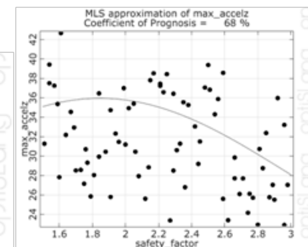


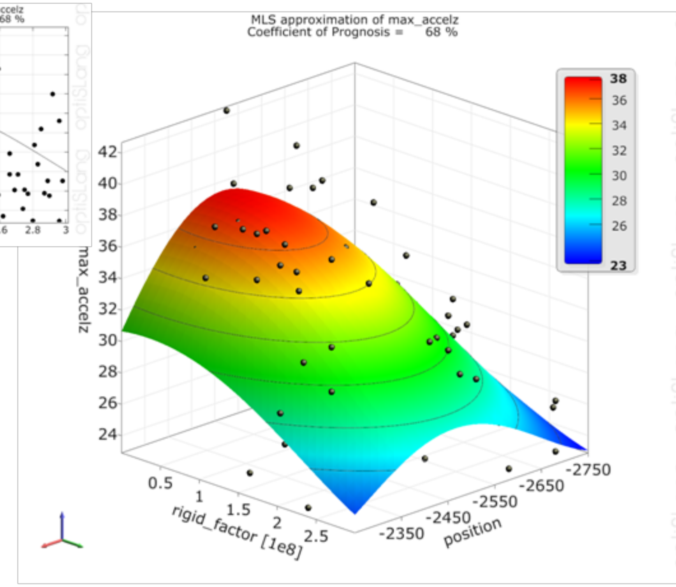
How to verify the CoP/MoP

- compare CoI/CoD and CoP
- check plausibility and correlations (2D/3D visualization)
- in comparison to CoI, CoP may be more optimistic for single variable importance





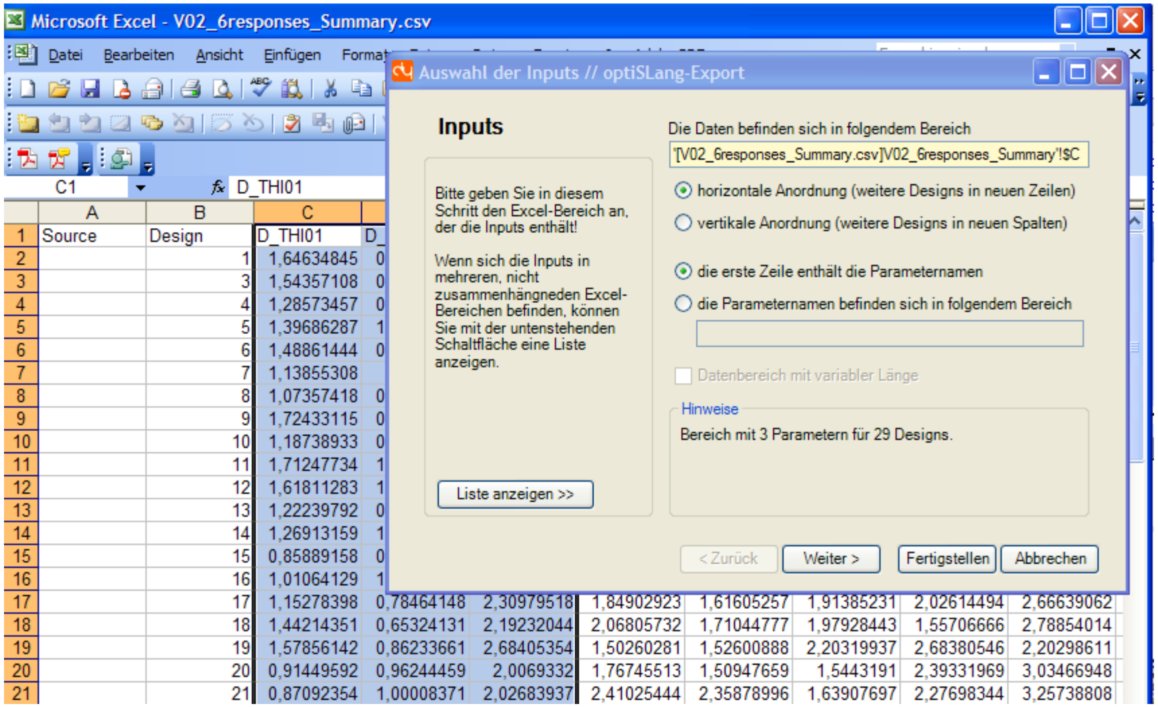




If plausibility is not verified:

- repeat CoP with single response value
- add samples and repeat CoP

Data Import/Export



Excel Plugin via support@dynardo.de

Exporting Excel Data to optiSLang

New Version 3.1: support of MoP/CoP Flow

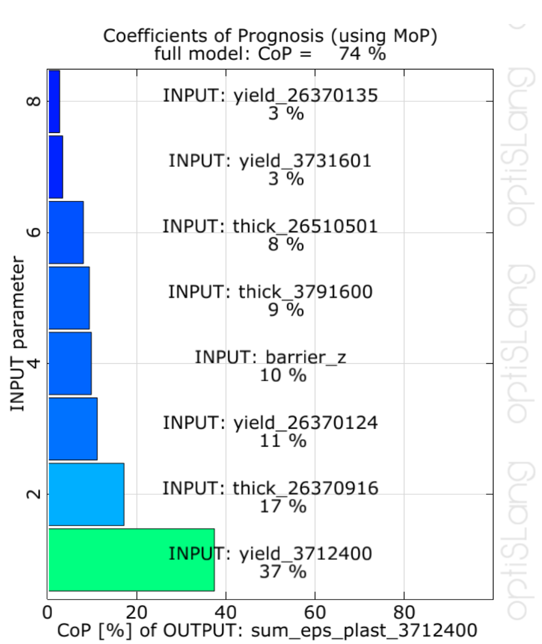
Strategy “No Run to Much”

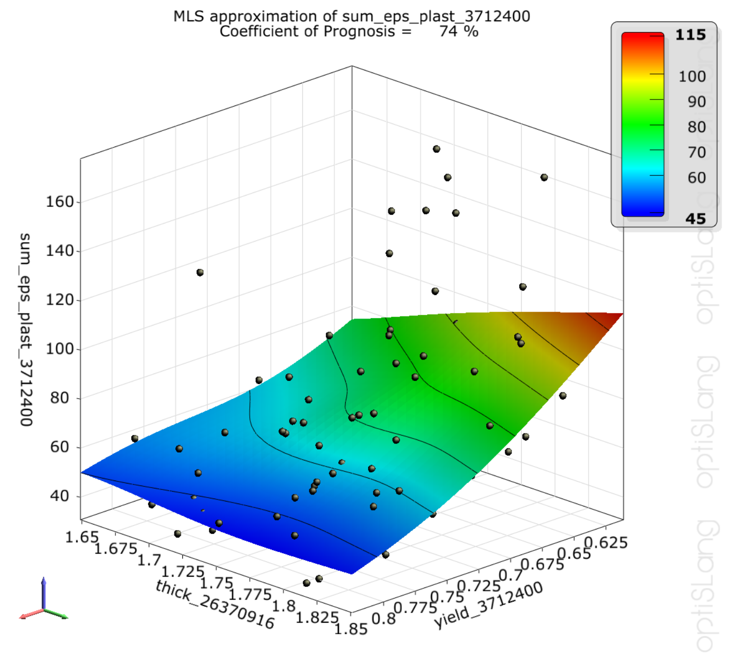
Using advanced LHS sampling, significance filter technology, CoI, CoP we can check after ≈ 50 runs

⇒ can we explain the variation

⇒ which input scatter is important

⇒ how large is the amount of unexplainable scatter (potentially noise, extraction problems or higher order non linearity)

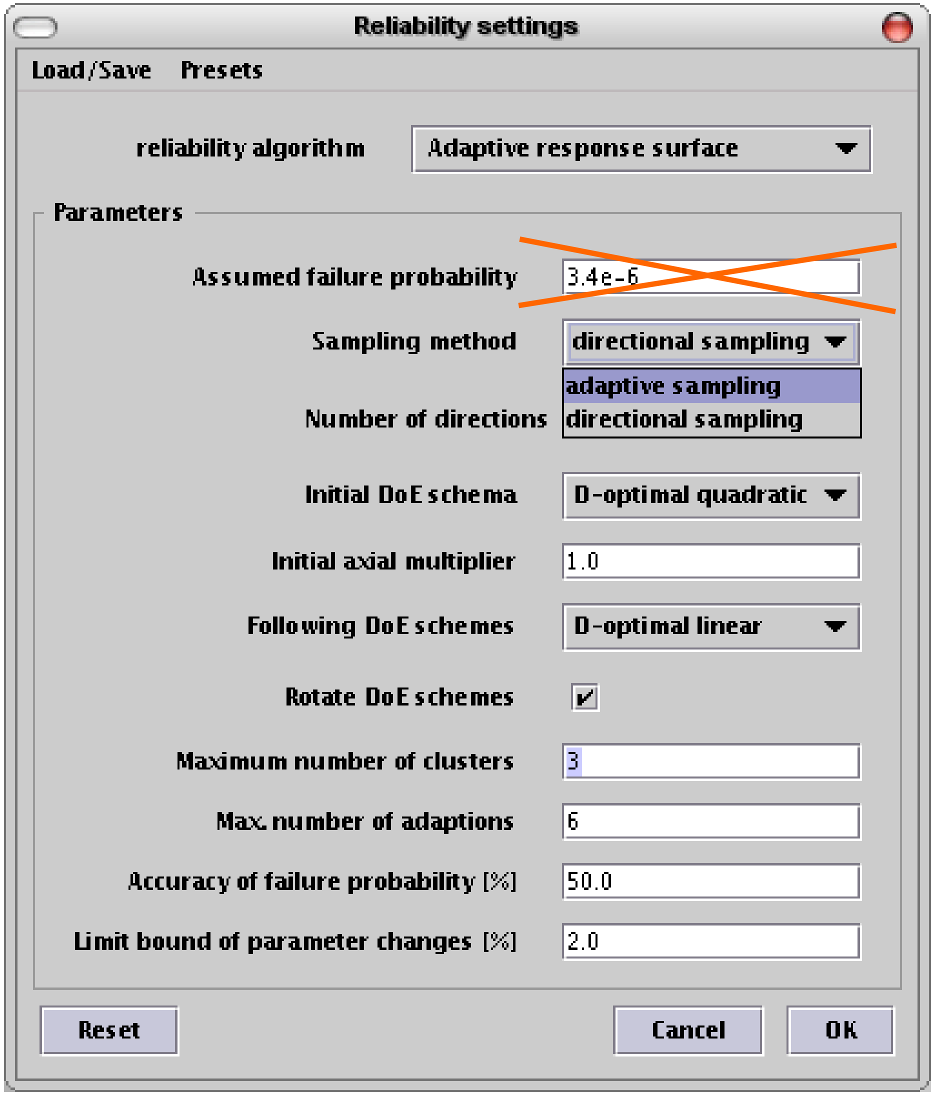




Reliability Analysis within optiSLang 3.1

Get ready for productive use!

Adaptive Response Surfaces



- Sampling methods on the MLS approximation:
  - Adaptive Sampling
  - Directional Sampling (supports more than two failure domains and sigma level independent)
- Cluster analysis to detect number of failure domains with high failure probability
- Rotatable, adaptive DOE to improve the approximation accuracy

- Improved defaults

Advanced information

Method : Adaptive Sampling on Adaptive Response Surfaces (ARSM)

Complete iterations : 3 / 3

Selected data : 2. Approximation
All samples

Number of designs : 42 (0 failed)

Number of samples :
Total : 4182 / 4182
Safe domain : 2262
Unsafe domain : 1920
Failure strings : 0

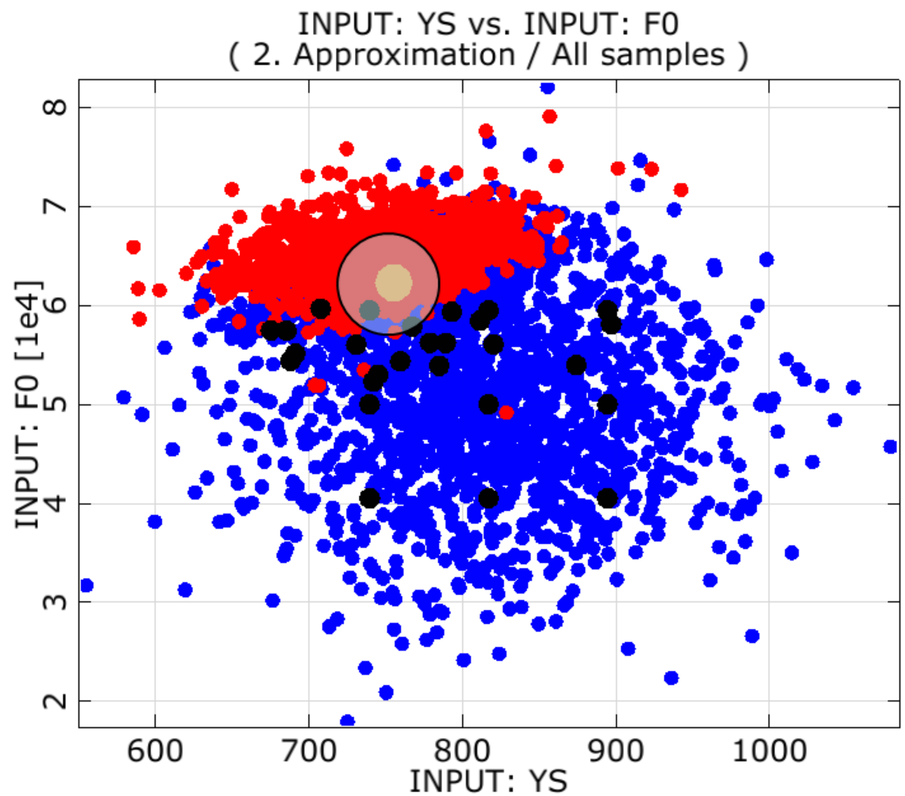
Probability of failure : 0.0002072 (0.0002072)
Standard deviation error : 6.272e-06 (6.272e-06)

Most probable failure point:

DO :68.9287850365
DA :75.5617433774
F0 :62284.2219661
YS :755.333557655

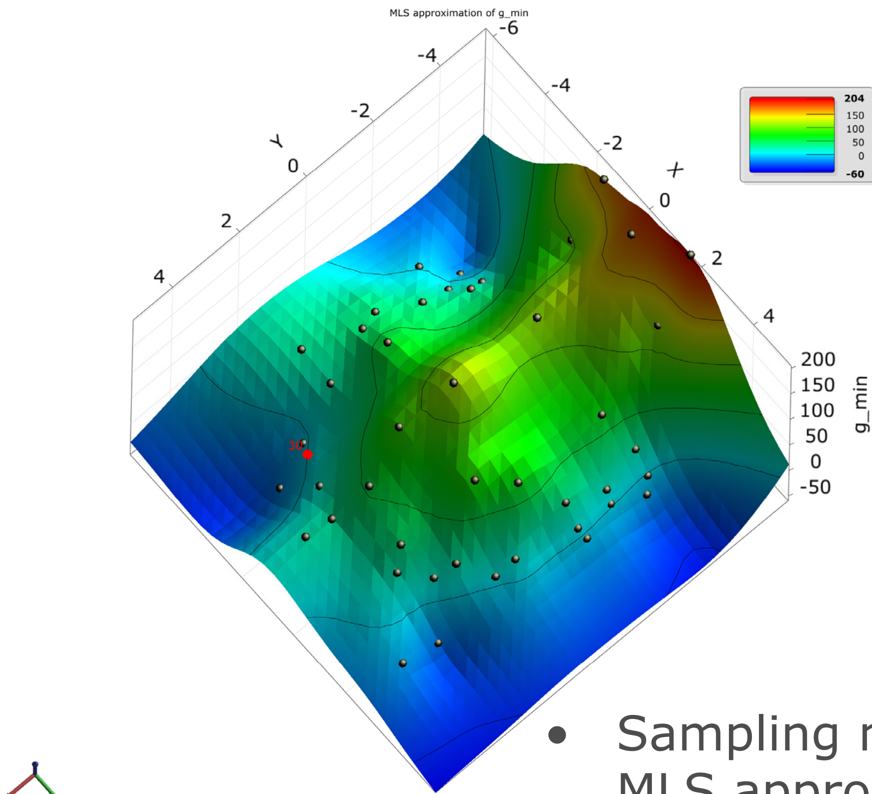
Distance median - design point (beta) : 3.349

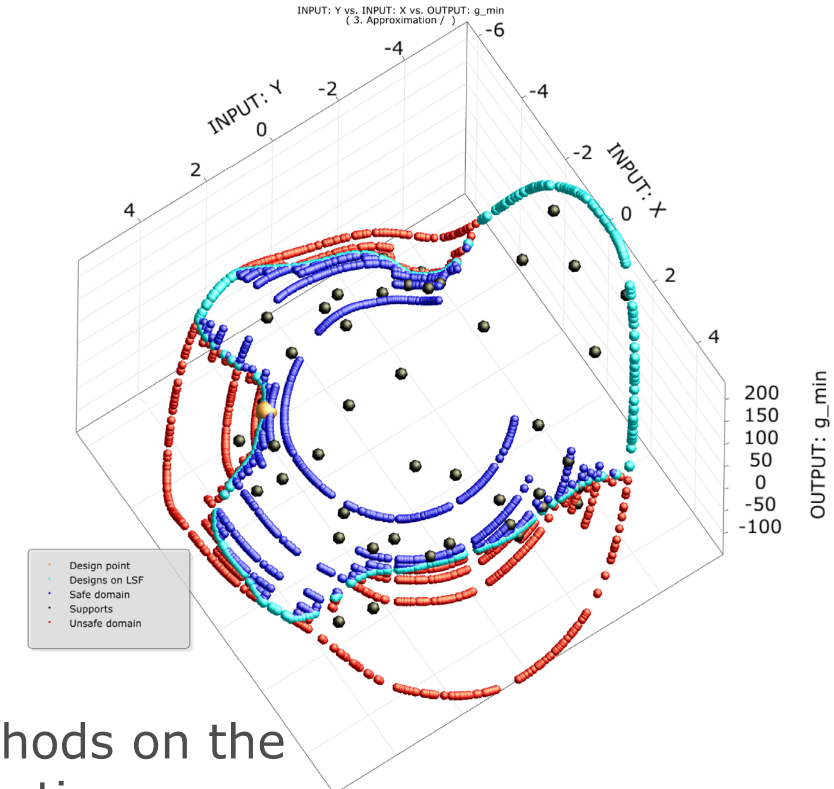
Probability of failure (FORM): 0.0004051
Standard deviation error (FORM): 0.2986



- Calculation of the MPP or design point
- Corresponding FORM result

Directional sampling on MLS

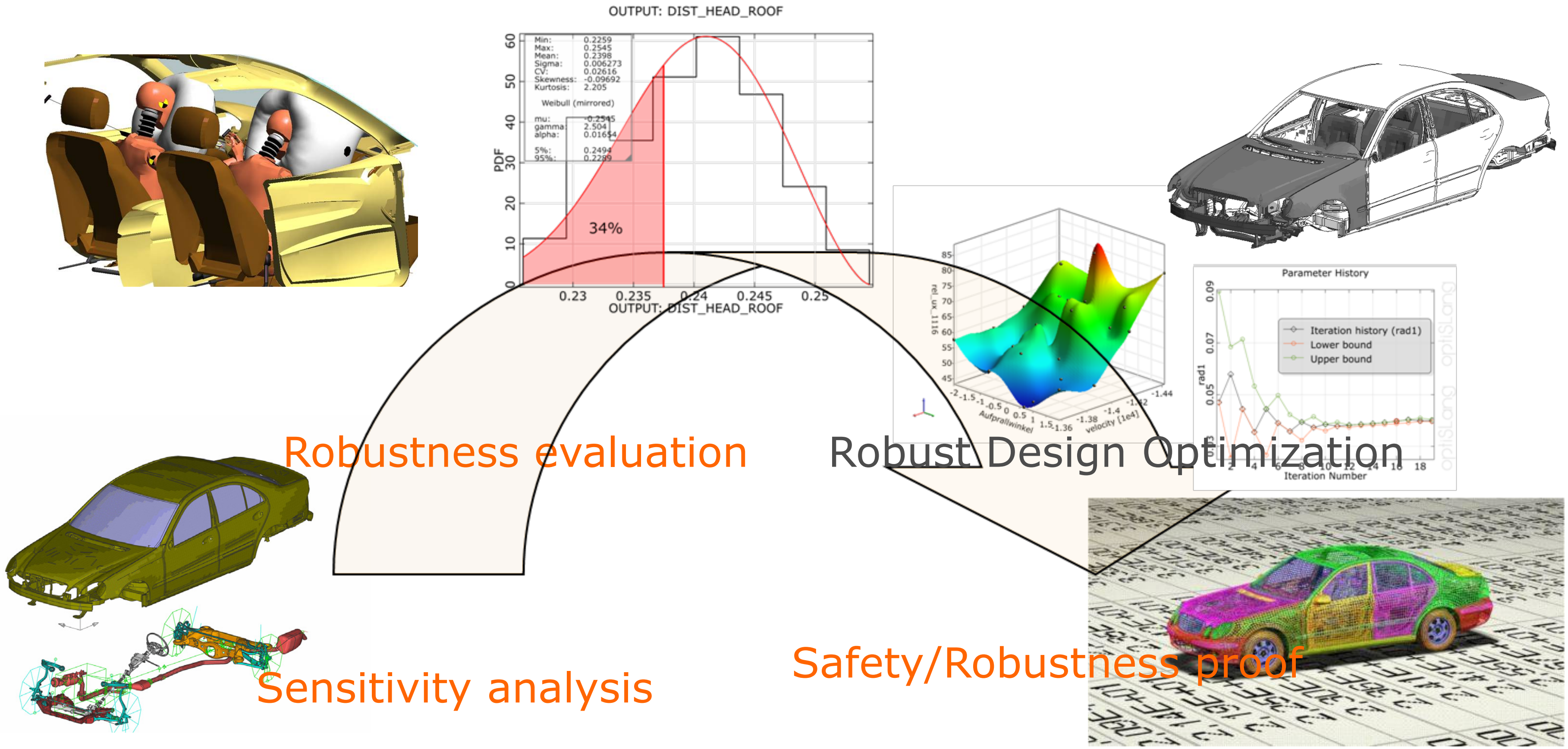




- Sampling methods on the MLS approximation:
  - Directional Sampling (supports more than two failure domains and sigma level independent)

RDO Procedure

All about efficiency and balance of optimization and robustness part



Key developments for version 3.xx

Automatic generation of reduced response meta models

using optimized LHS Samplings to scan the approximation space

using statistical significance filter for correlation coefficients and coefficient of importance filter to reduce approximation space

using of prognosis measurements (CoP) to select the most effective meta modal (polynomial/MLS/support vector)

using meta model for visualization, optimization, robustness and robust design

development of adaptive Sampling strategies for reduced meta models

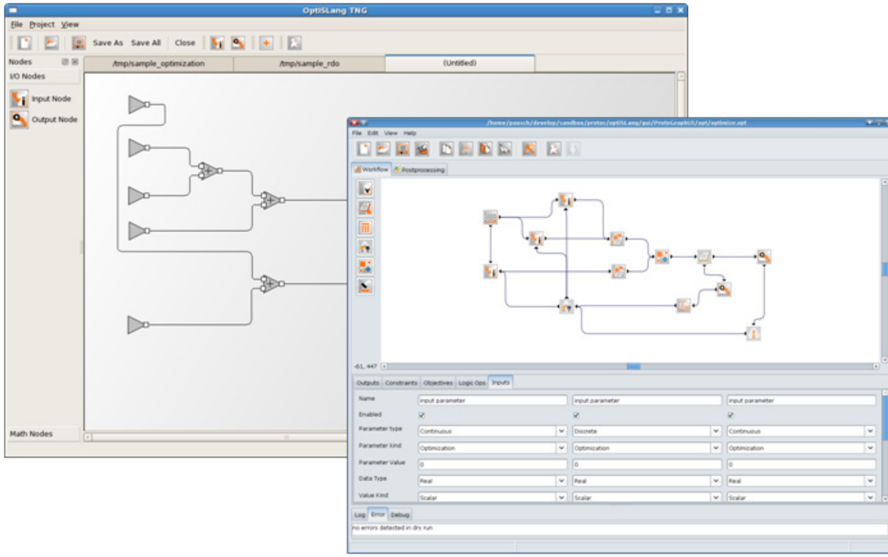
optiSLang 3.xx

- Use of MOP as solver module for all optiSLang flows
- Release: ASAP

- GUI based Job Distribution System
- Simplified Signal parametrization
- Release: Q3 2010

optiSLang LT (v4.x)

- Ongoing developments:
  - database
  - covert Algorithms
  - GUI setup
  - Python bindings



- preparations for **Matlab** and **Octave** integration
- integration of moduls for ETK (**Ansys** und **Abaqus)**
- First customer version: Q2/2010

optiSLang Integration Environment

optiPlug

SoS - Statistics on Structure

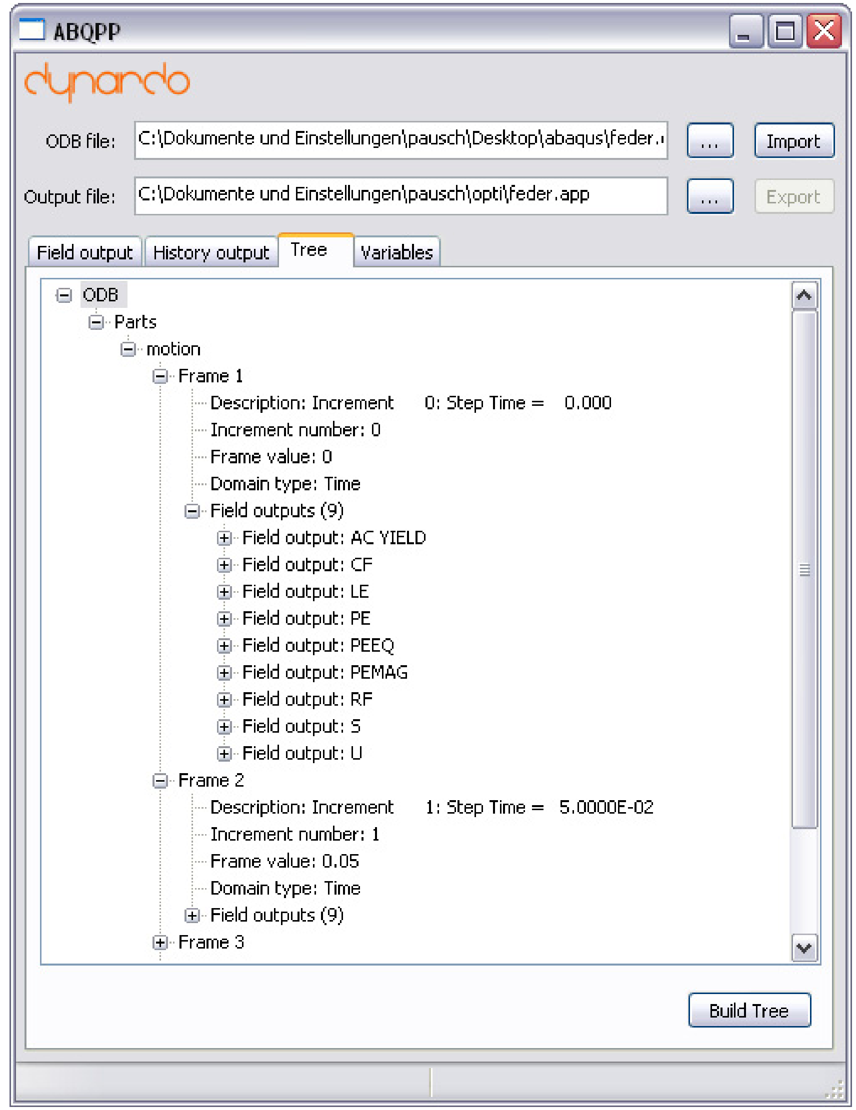
ETK - Extraction Tool Kit

Extraction Tool Kit (ETK)

- Extraction toolkit to replace the scripting for result extraction and processing

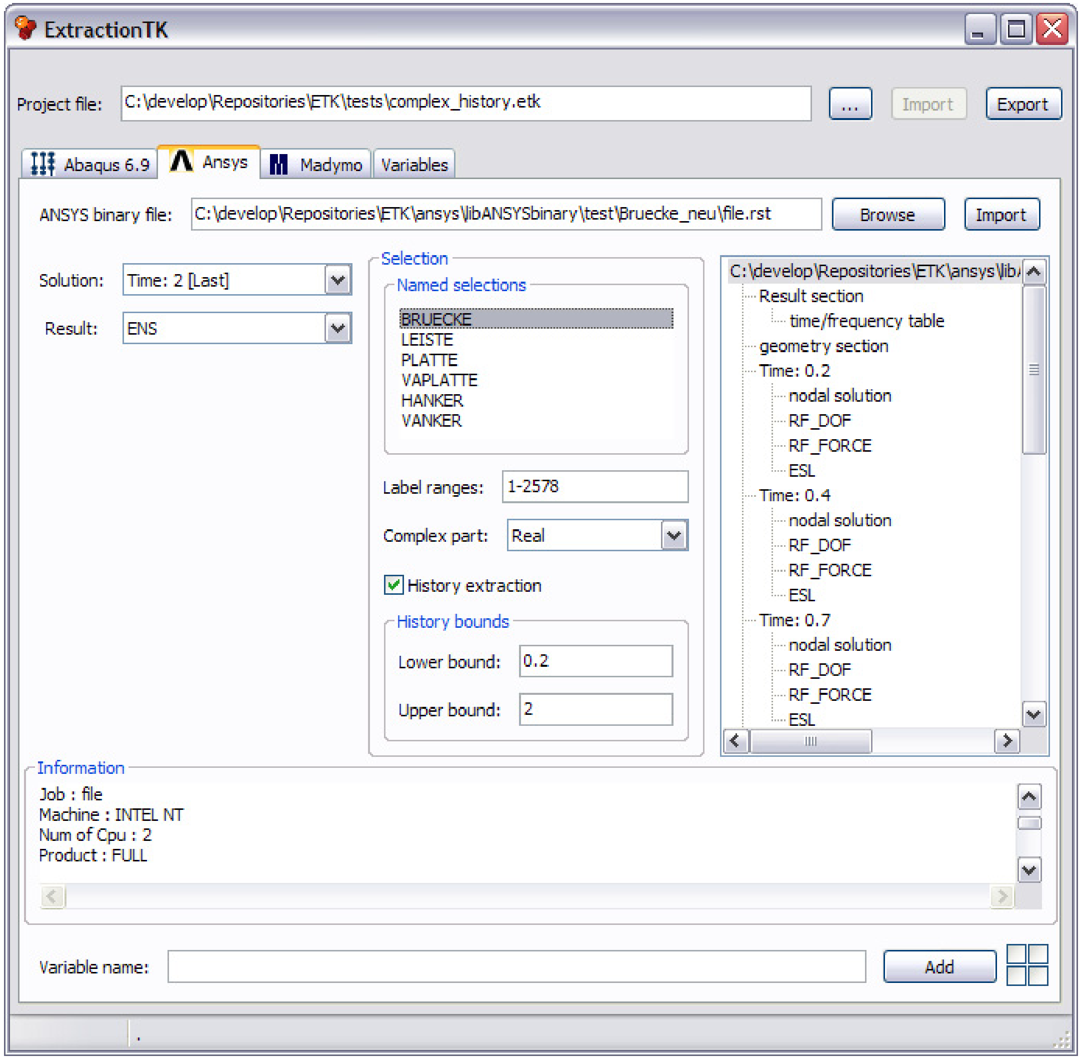
- GUI interface for extraction and processing
- Batch execution mode
- Creates optiSLang *.pro file

- improved support of Abaqus *.odb and ANSYS binary files (RST, RTH,RMG, RFL)
- Improved mathematical function base
- Support of ASCII output for MADYMO
- Available on Windows/Linux



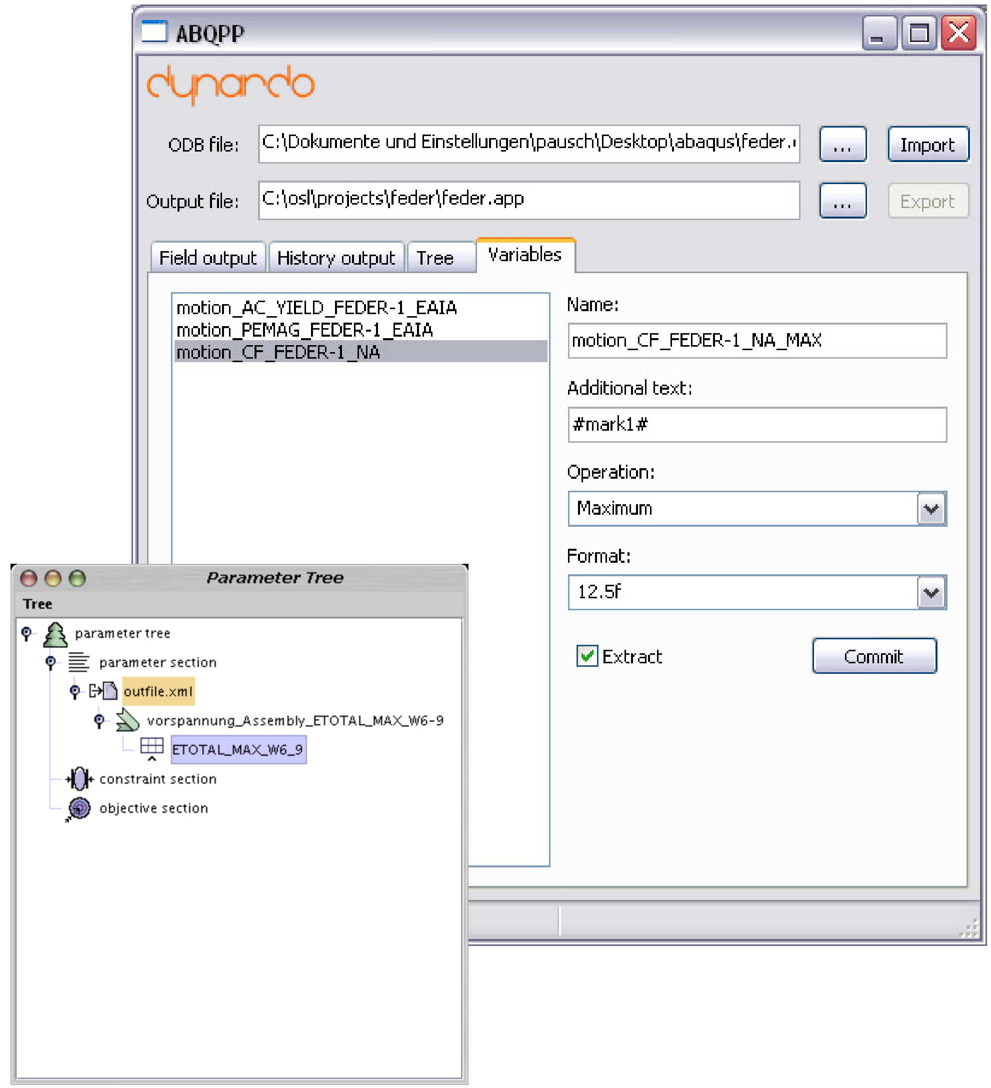
Extraction Tool Kit - ANSYS

ANSYS binary files (RST, RTH,RMG, RFL)



Extraction Tool Kit

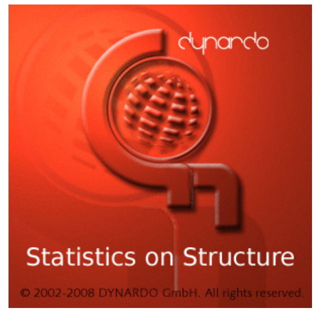
- Extraction
  - Single Value, vector, matrix, tensor
- Definition of new variables
- Processing
  - Mean value
  - MIN/MAX
  - Standard deviation
  - Integral/difference integral
  - Signal processing
  - Filtering
- Export of optiSLang problem file

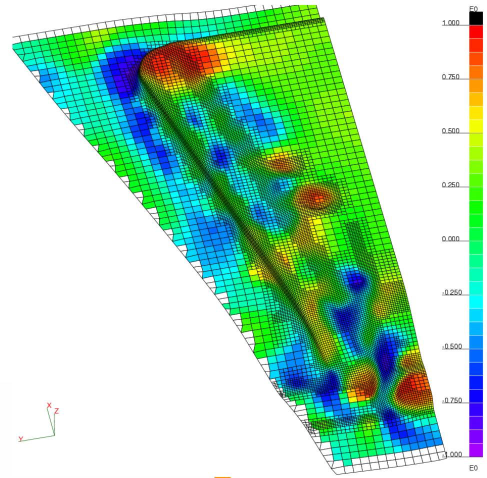


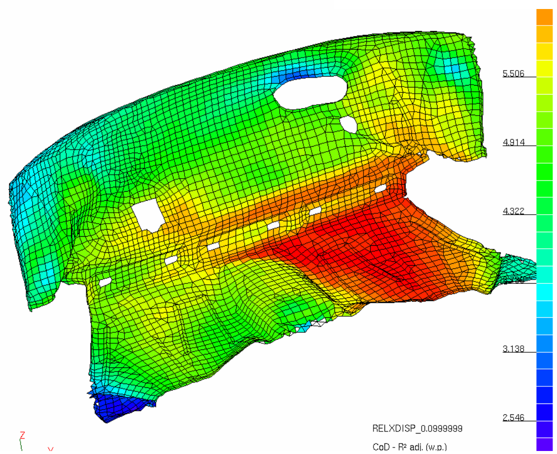
SoS – Post Processing

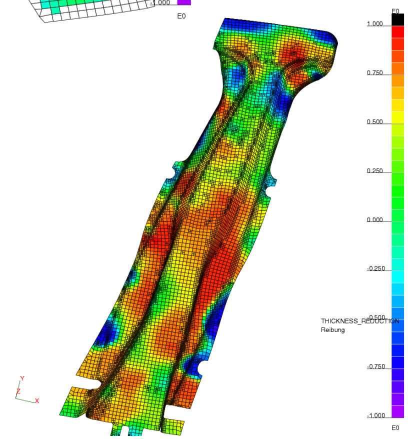
- Statistic Measurements
  - Single Designs
  - Differences between Designs
  - Variation interval
  - Minimum/Maximum
  - Mean Value
  - Standard deviation
  - Coefficient of variation
  - Quantile (± 3 σ)
- Correlation & CoD
  - Linear correlation & CoD
  - At nodal/element level
- Process quality criteria Cp, Cpk process indices

- Random field generation
  - Mesh coarsening
  - Mode extraction and visualisation









[Will, J.; Bucher, C.; Ganser, M.; Grossenbacher, K.: Berechnung und Visualisierung statistischer Maße auf FE-Strukturen für Umformsimulationen; Proceedings Weimarer Optimierung- und Stochastiktage 2.0, 2005]

SoS v2.2 – Developments new version

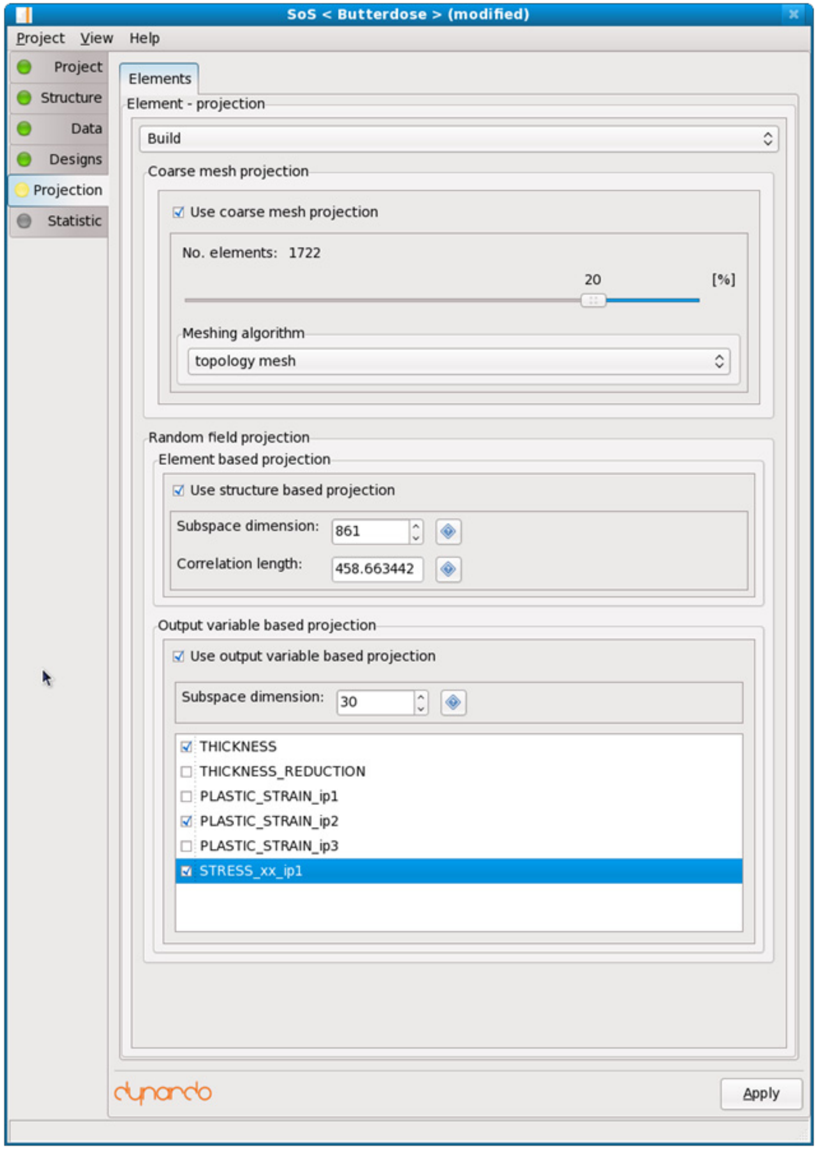
Interfacing

- ABAQUS (odb)
- Flexible user interface for

other ASCII based Formats

Statistical processing

- Handling of element eroding
- Mesh coarsening (uniform and topology)
- Result based generation of Random fields
- Visualization of Random Fields (Modes) with Significance (variability)



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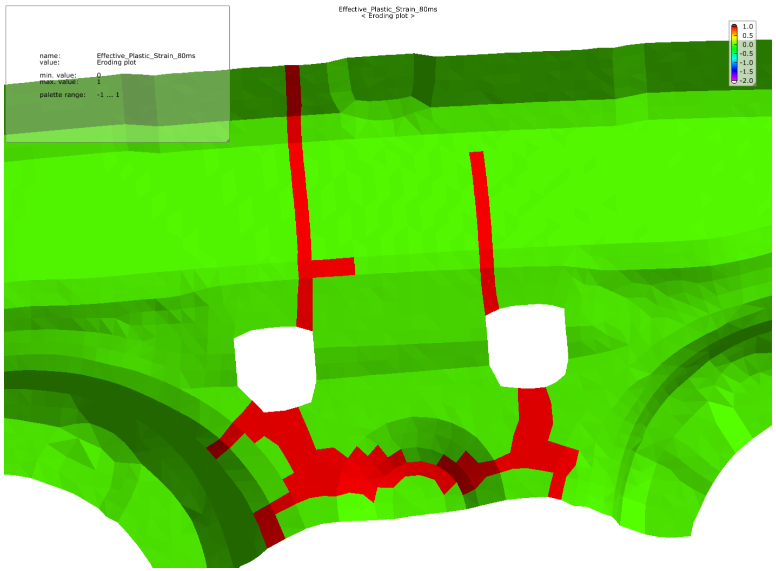
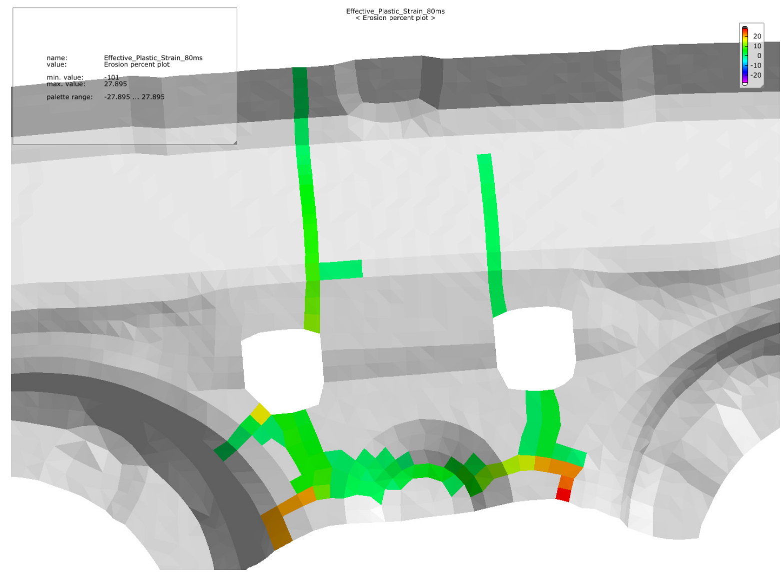
SoS - Eroding elements



General eroding information.
Green area: no elements eroded.
Red area: there were eroded elements.

Eroding percent plot shows the percentage of eroded elements.



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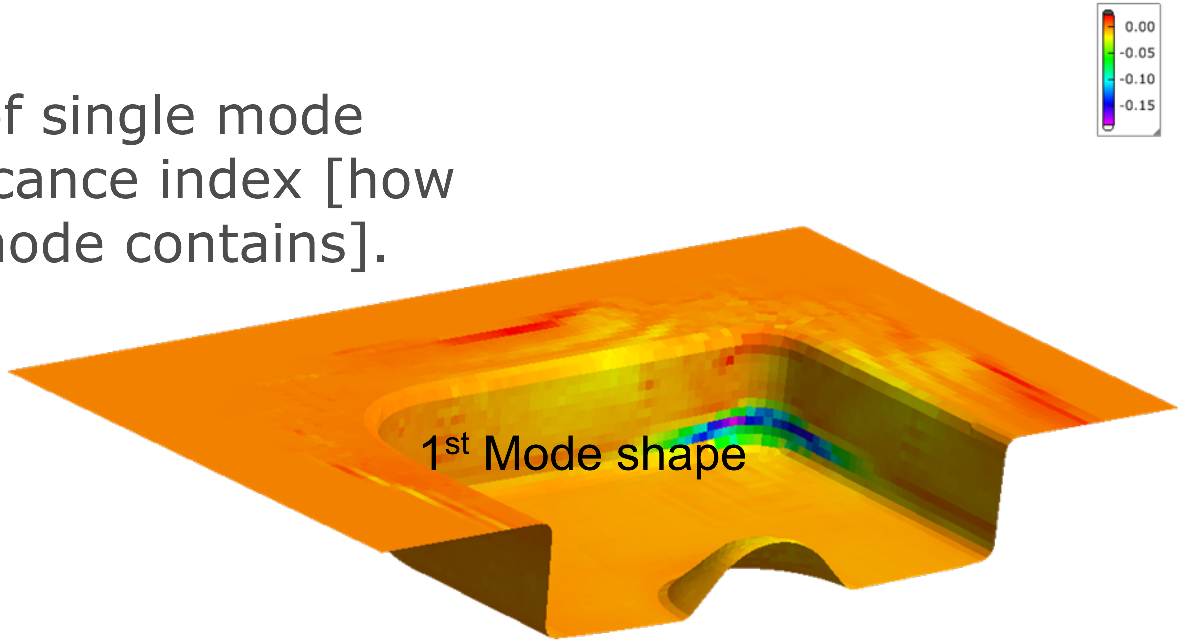
SoS - Random Fields

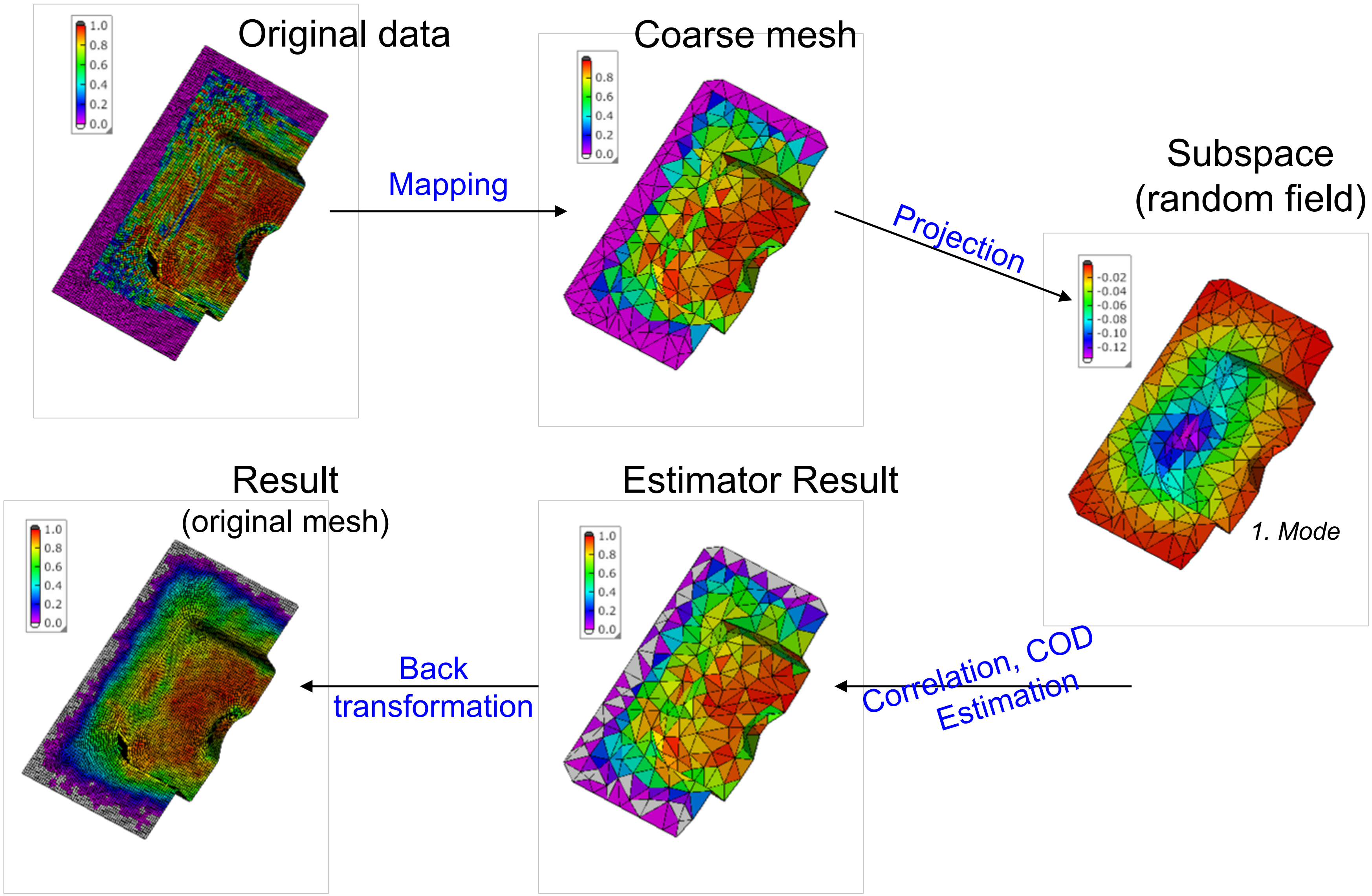
Version 2.0: structure based generation of random fields [input: dimension/correlation length]

New: output variable based projection [input: dimension]

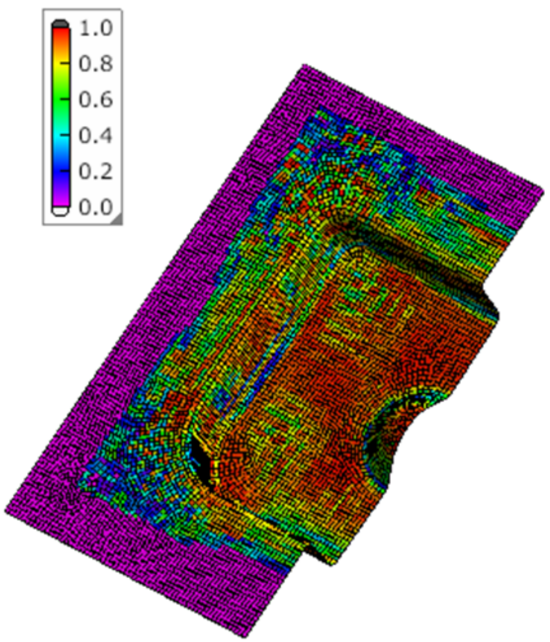
New: Visualization of single mode shapes including significance index [how much variation the mode contains].



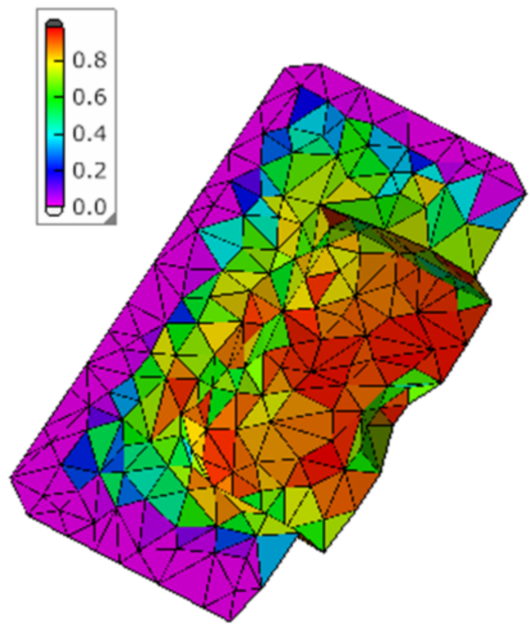
SoS -Multi level data environment



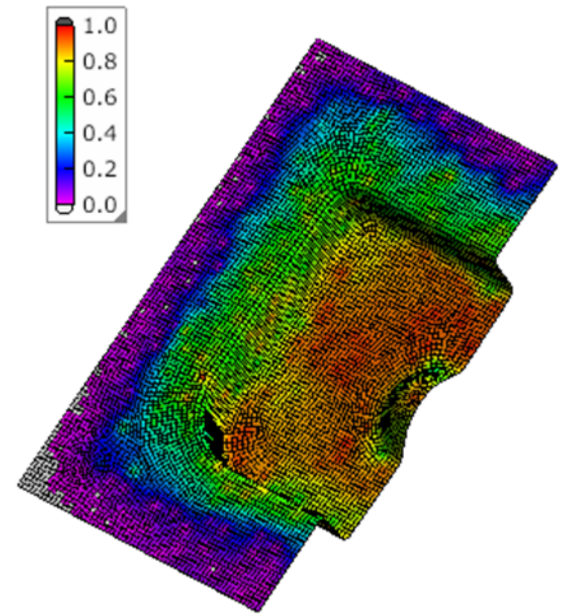
SoS - Using data projection for filtering



Coefficient of determination of Robustness evaluation at **6000 FE-elements** using 100 LHS



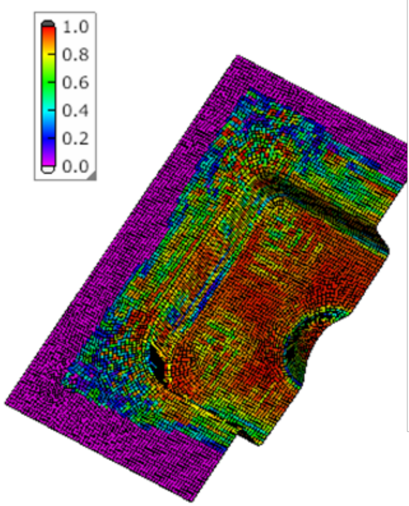
Generation of **200 measurement point** with result mapping

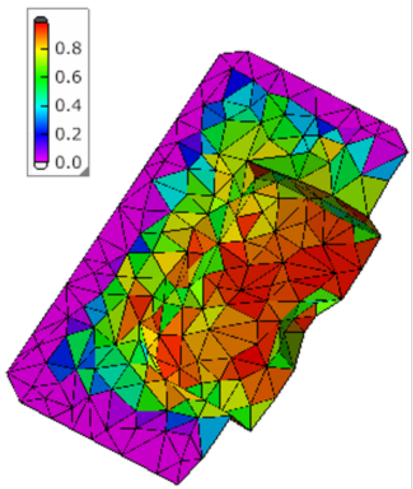


Smooth noise statistical results via projection back to original mesh using MLS interpolation

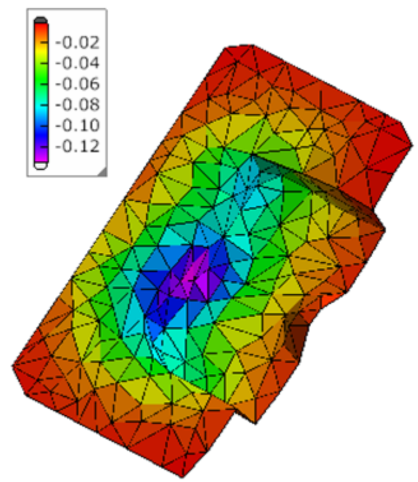
SoS - identify random field parametric

- Subspace generation structure based or output based

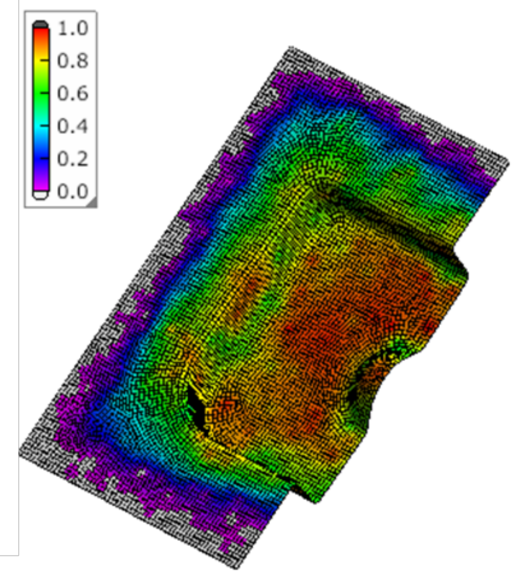




Generation of **200 measurement point** with result mapping



Indentification of scatter shapes using **100 Random Fields**

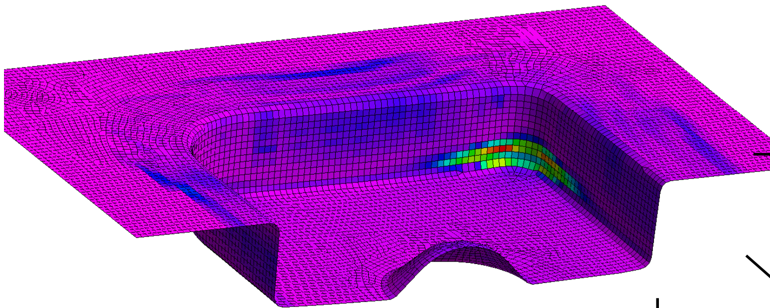


Generate COD using 100 random fields at measurement points level + back projection to original mesh using MLS interpolation

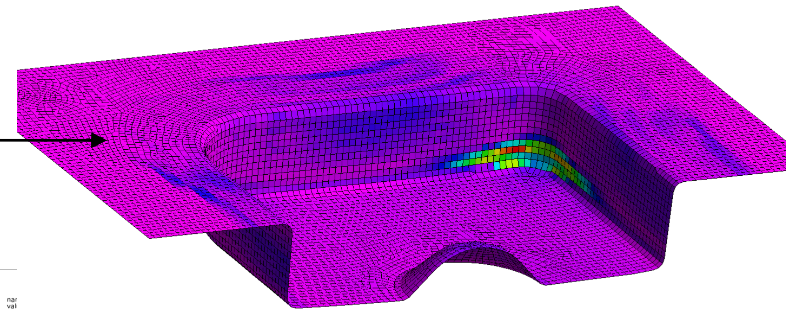
Coefficient of determination of Robustness evaluation at **6000 FE-elements** using 100 LHS

SoS - Output Variable based projection

Original data thickness

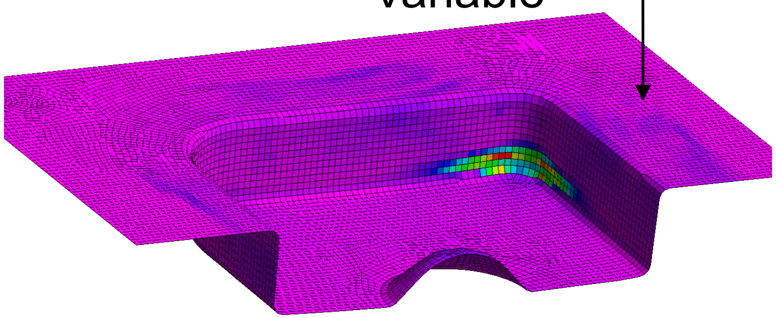


Thickness: self projected with first n-Eigenvectors



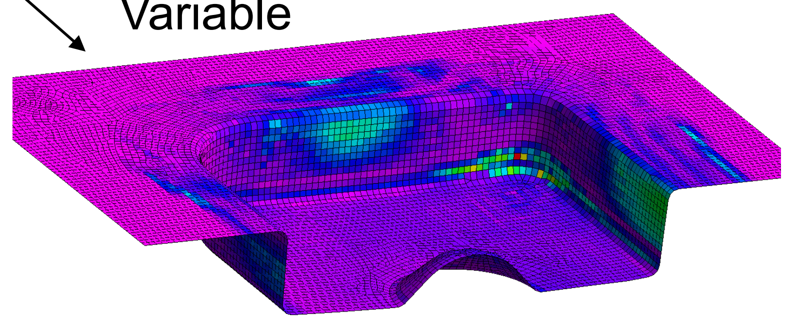
Correlated Variable

Non correlated Variable



Plastic strain

for correlated outputs the projection can be used



Stress

For uncorrelated data projection not useful

SoS - Qualify reduction quality

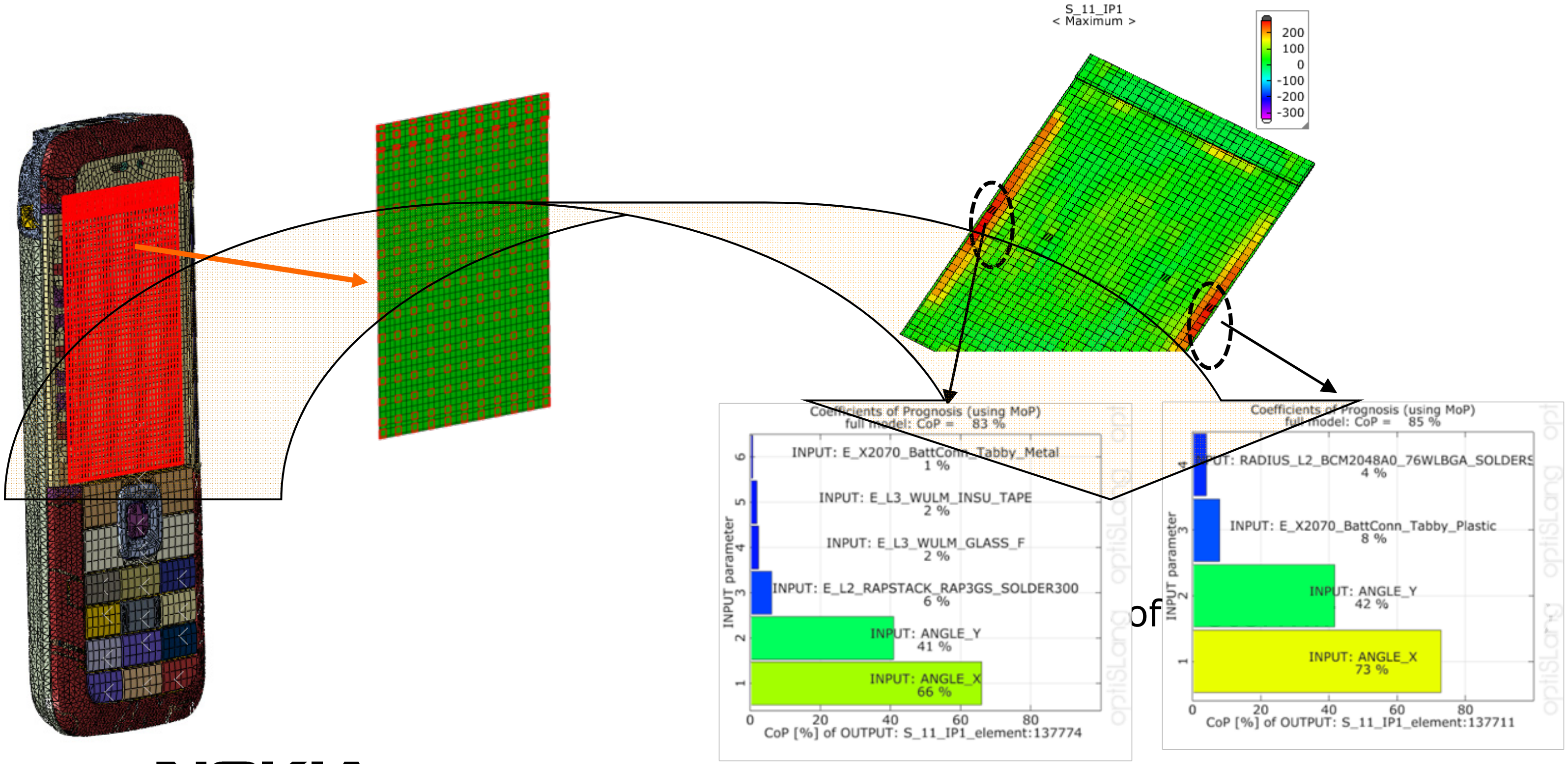
- Variability will be smoothed via mesh coarsening and mode reduction
- Variability loss is measured with normalized variability fraction
- Main smoothing effects from mesh coarsening!

- Example forming simulation:

coarsening	nodes	Number of modes	Represented Variability	Represented variability
uniform	7550	7550	100 %	68 %
uniform	7550	40	99 %	67 %
uniform	7550	10	94 %	64 %
topology	7550	7550	100 %	82 %
topology	7550	40	99 %	81 %
topology	7550	10	94 %	77 %

SoS - Applications

- use SoS for robustness evaluation of forming processes
- use SoS for visualization and hot spot investigation at robustness evaluations in crashworthiness or drop test applications



by courtesy of NOKIA

- use SoS for the identification of random fields from simulation or measurements

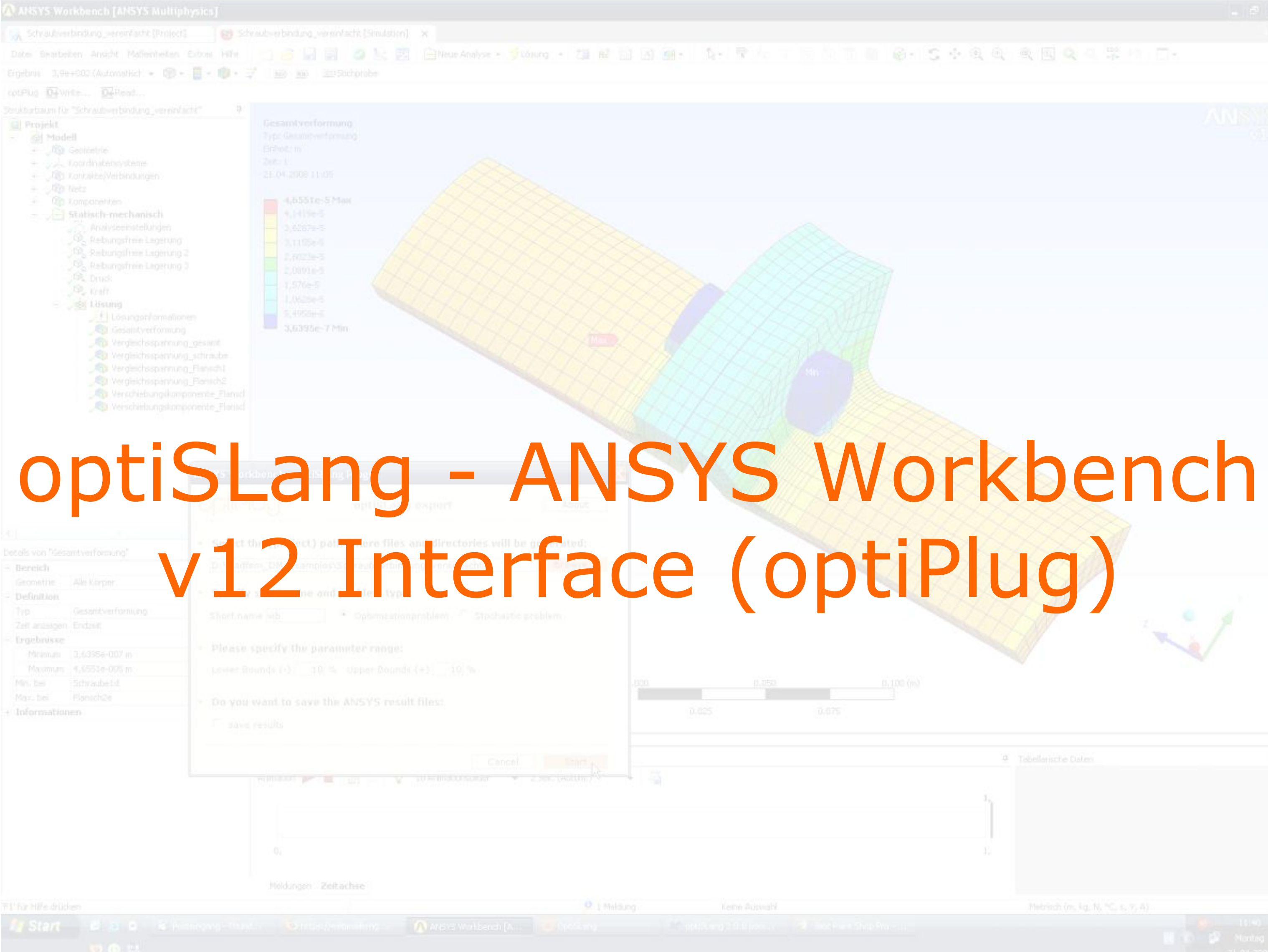
ongoing development

- Additional interfaces to FE-solver

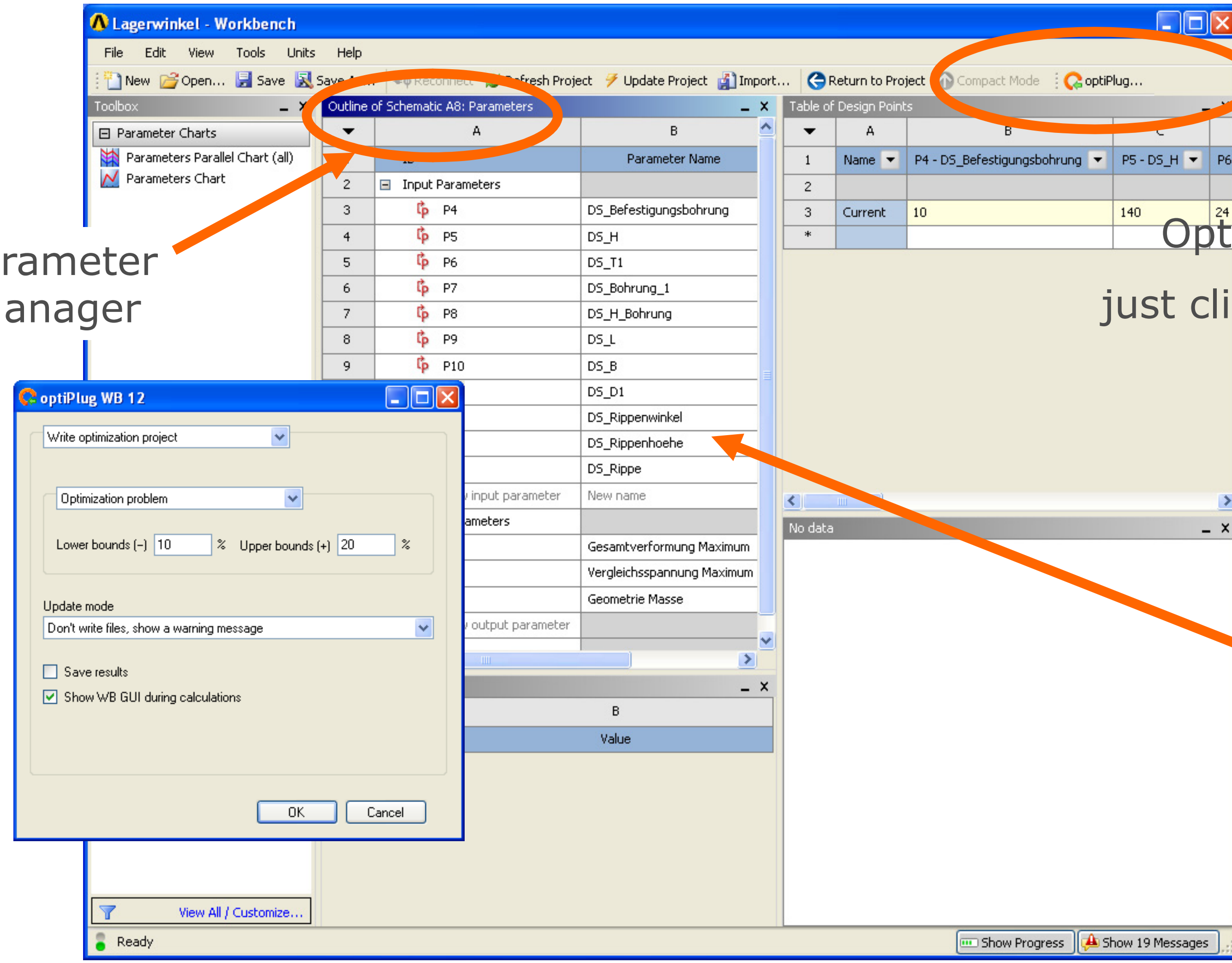
- Algorithm:
  - Improve Random Fields identification from simulation data and measurements
- Post processing:
    - Reliability fraction index (random field)
    - Quality index for interpolation (coarsening+subspace for every statistical data, (how much RF are necessary to represent 90% of variation)

- Improvements for forming simulation
  - Identification of Random Fields from forming part and projection to crash part
- Improvement for Crashworthiness Applications
  - Ranking of input correlation to single output correlation

optiSLang - ANSYS Workbench v12 Interface (optiPlug)



ANSYS Workbench v12 optiSLang Interface



Parameter Manager

OptiSLang-Plugin:

just click to integrate workbench in optiSLang

Parameter & Responses

ANSYS Workbench v12 optiSLang Interface

new Version optiPlug 3.0 for WB 12

- Available at project page – support of all workbench parametrik
- Update mechanism for existing optiSLang projects
- Default: workbench batch mode
- copy all workbench files into Design directory
- Parallel job distribution supported