

# Recent developments



the dynardo Team

# version 3.2

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## Goal of further software developments

- easy and safe to use -

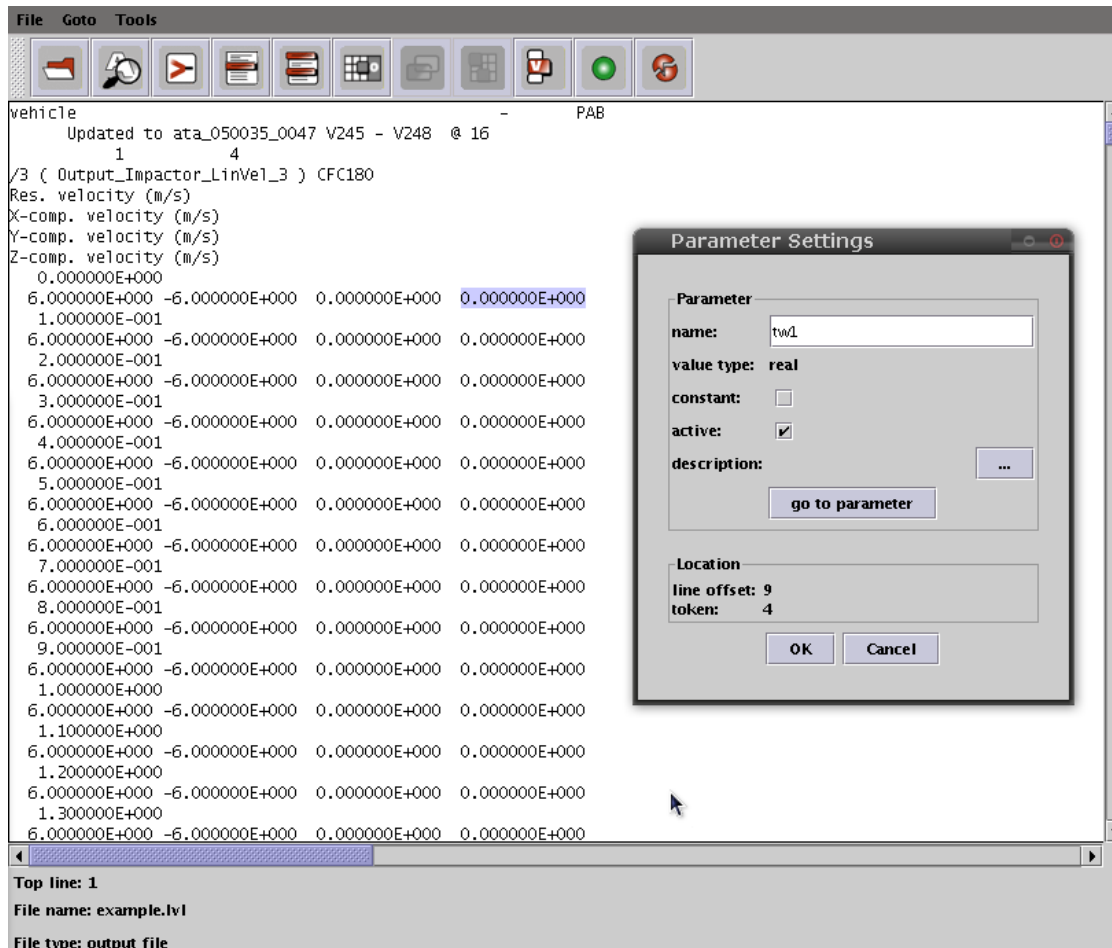
## Steps in version 3.2

- Metamodels of optimized Prognosis (MOP) can be used as solver, including check of optimal design
- MOP/Coefficient of Prognosis (CoP) generation is improved using cross correlation
- Wizard for Nature-inspired (population based = GA, EA, PSO, Pareto) Optimization Algorithm (NOA)
- Improved Pre and Post Processing

# Pre Processing

- Token wise parsing

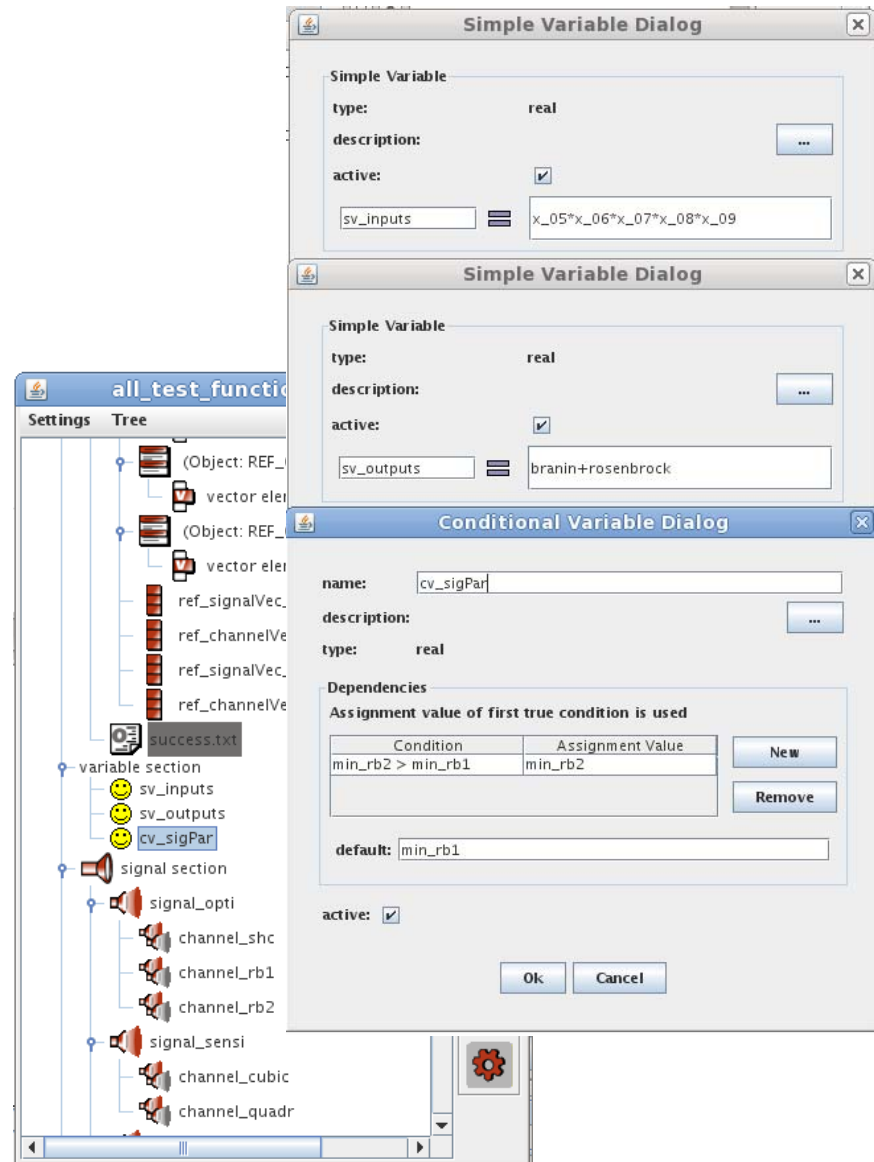
New: only numbers are considered and automatically identified



# Pre Processing

## Support of free variables

- The variable section within the parameter editor allows the definition of free variables
- **simple variables** can be defined by formulas, **conditional variables** by restrictions
- inputs, dependent input, output and signal parameters can be included.
- this can be useful for defining constraints, objectives and limit state functions.

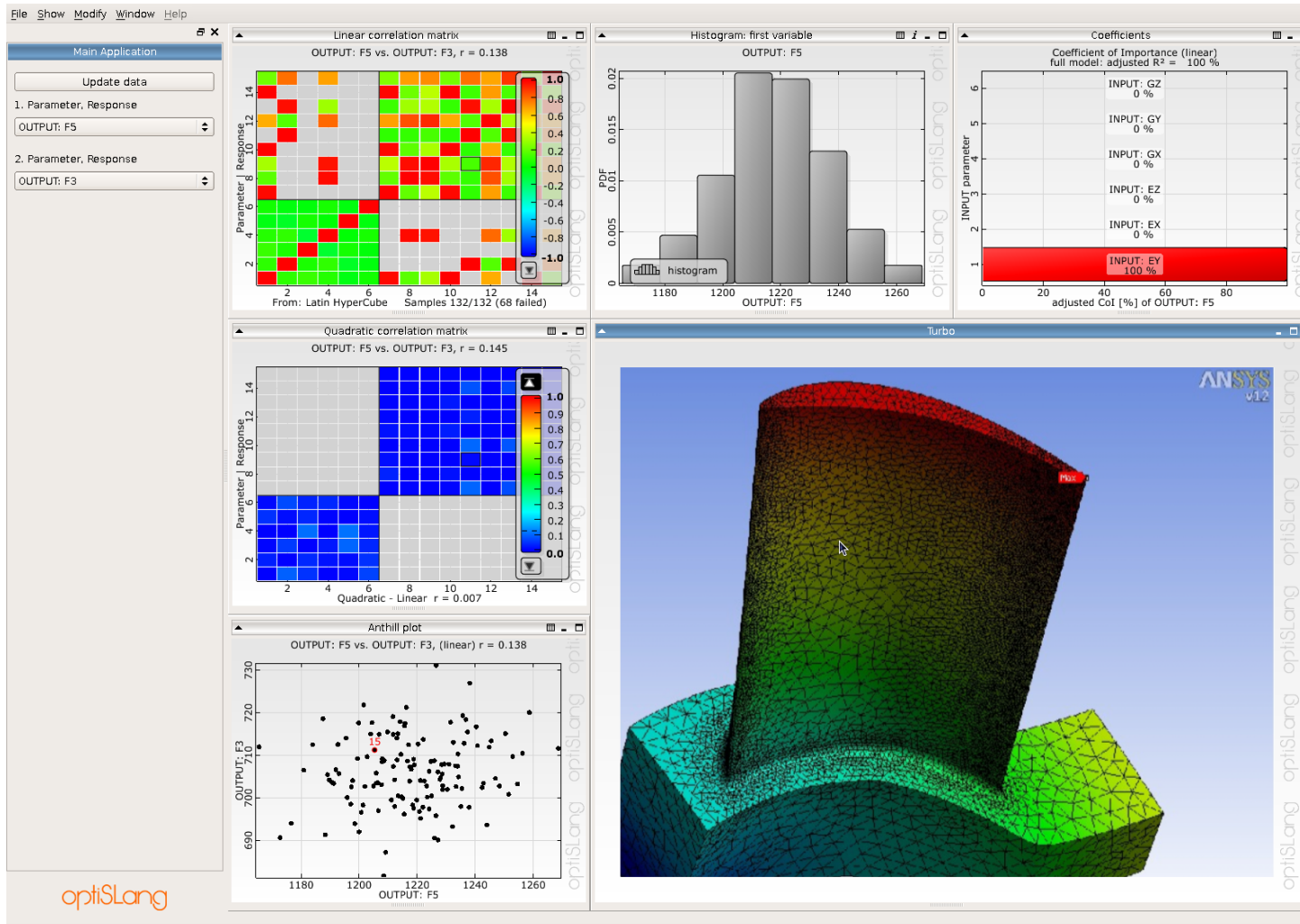


# Post Processing

- add Image Plot Window to post processing

Supported formats:

BMP  
GIF  
JPG  
JPEG  
PNG  
PBM  
PGM  
PPM  
TIFF  
XBM  
XPM

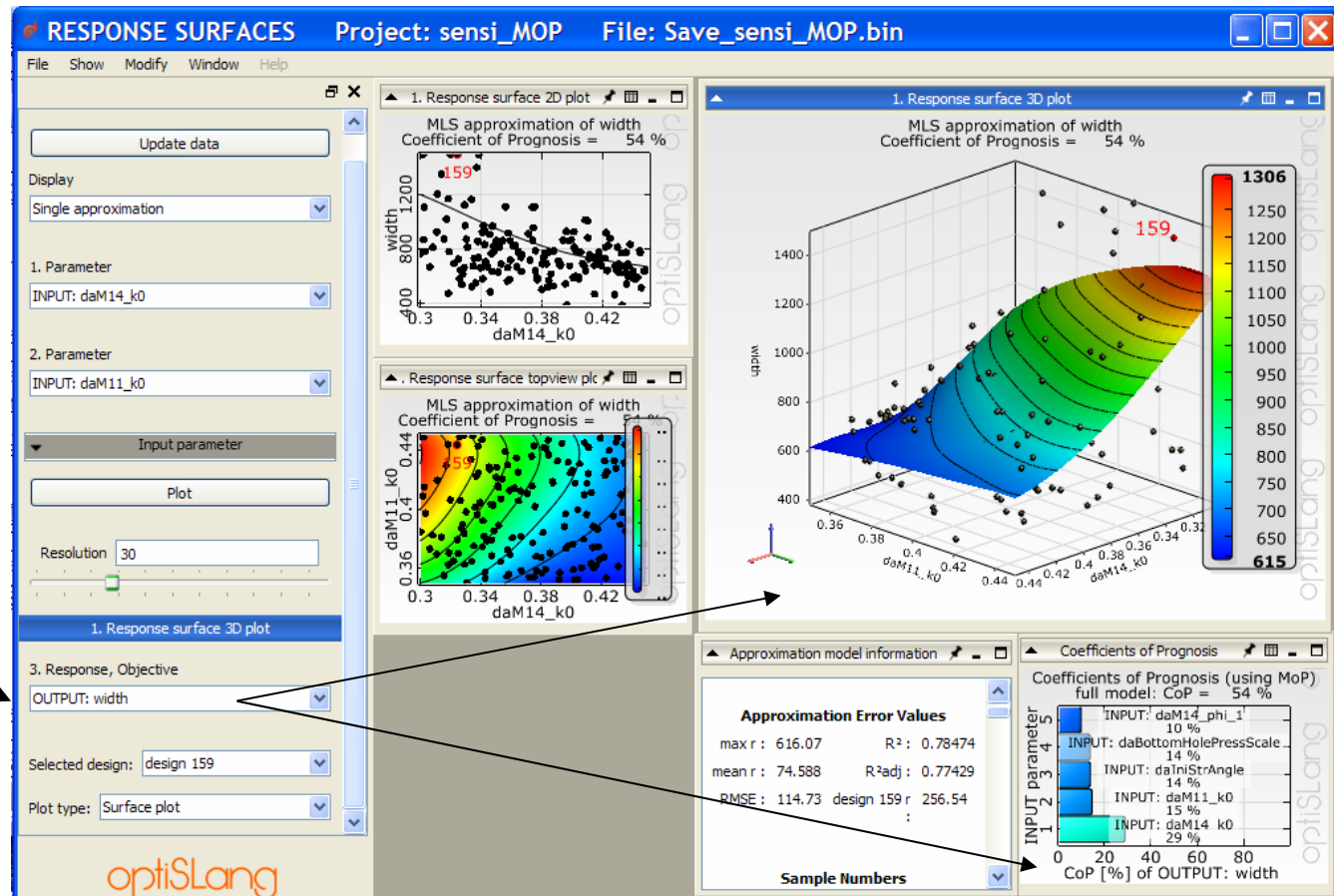


# Post Processing

- Improved approximation post processing mode for CoP/MoP

-CoP Plot now available at approximation post processing

- with selection of the response **CoP** and **MoP** plot of the two most important variables are automatically updated

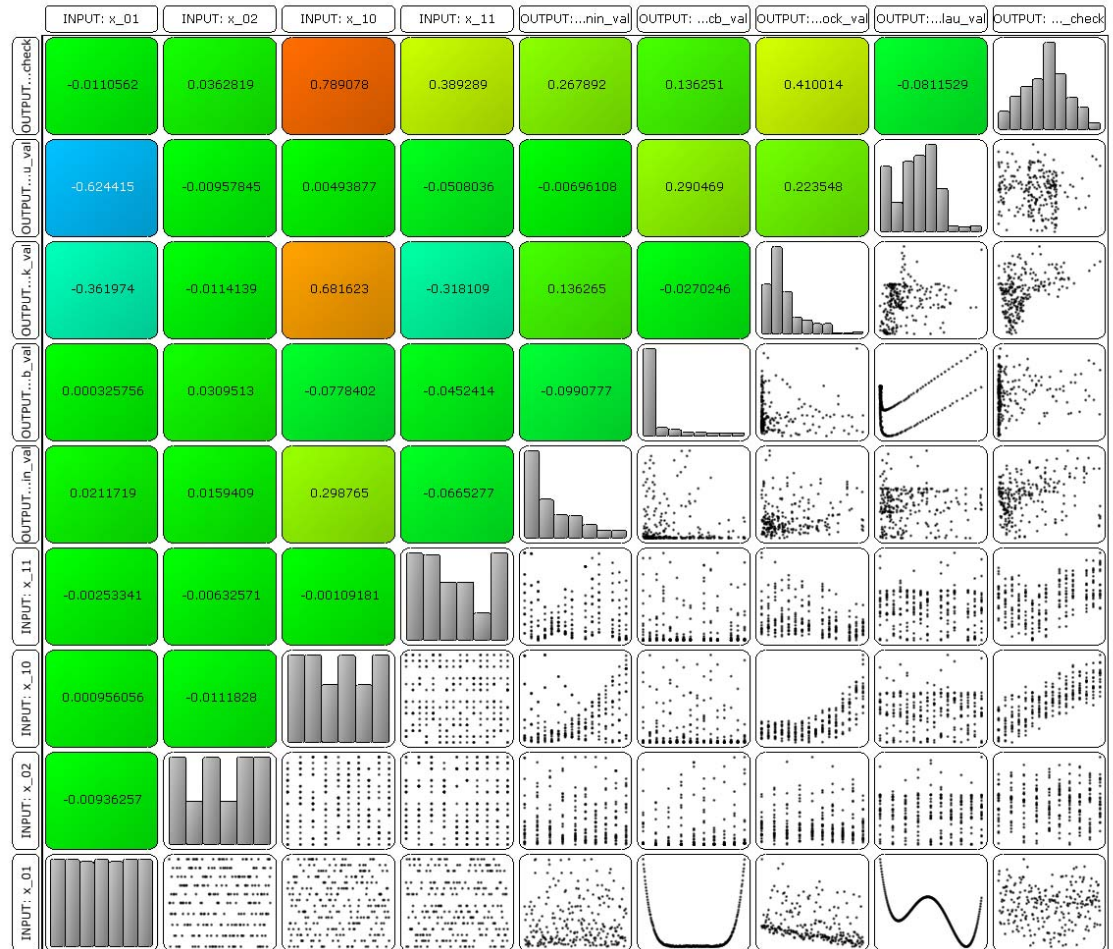




# Post Processing

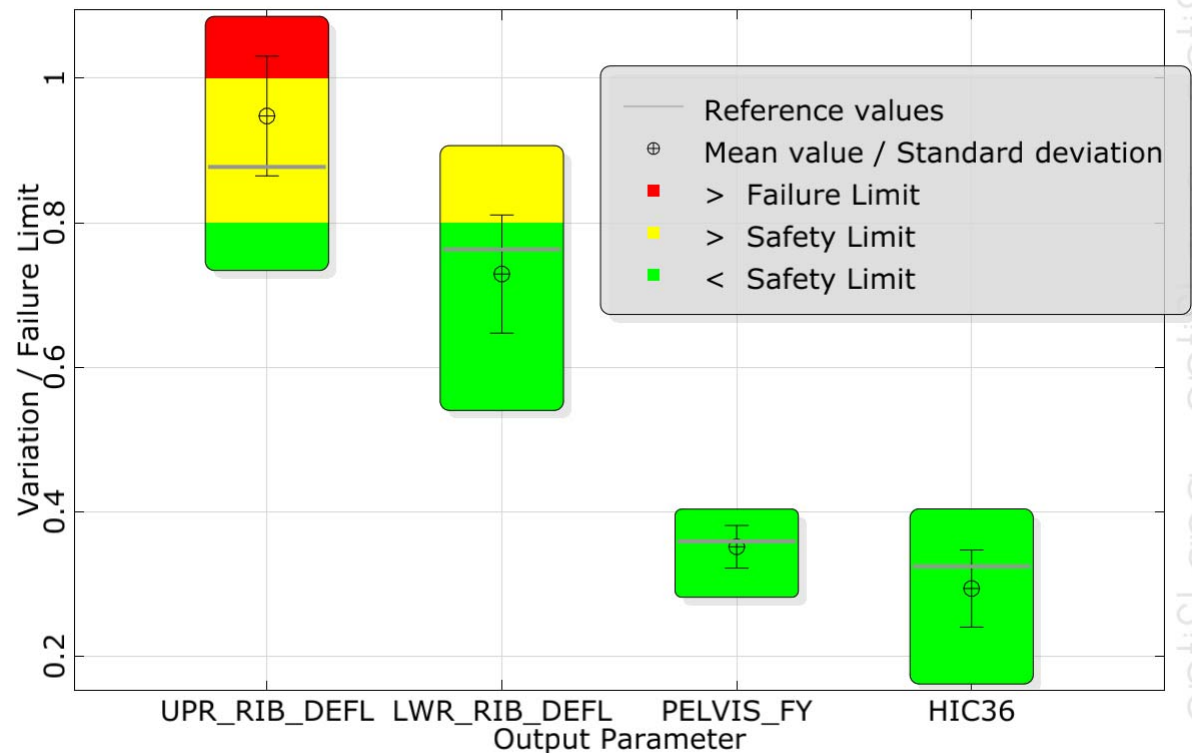
- Extended Correlation Matrix

- The matrix provides a overview of variation and pairwise **linear** correlation. The triangle above shows linear correlation coefficients and the diagonal represents histograms. The lower triangle presents 2d anthil plots for all pair-wise parameter combinations.



# Post Processing

- Traffic Light Plot
- the traffic light plot may serve as an indicator for safety and failure limit violations
- Mean value, standard deviation included





# Post Processing

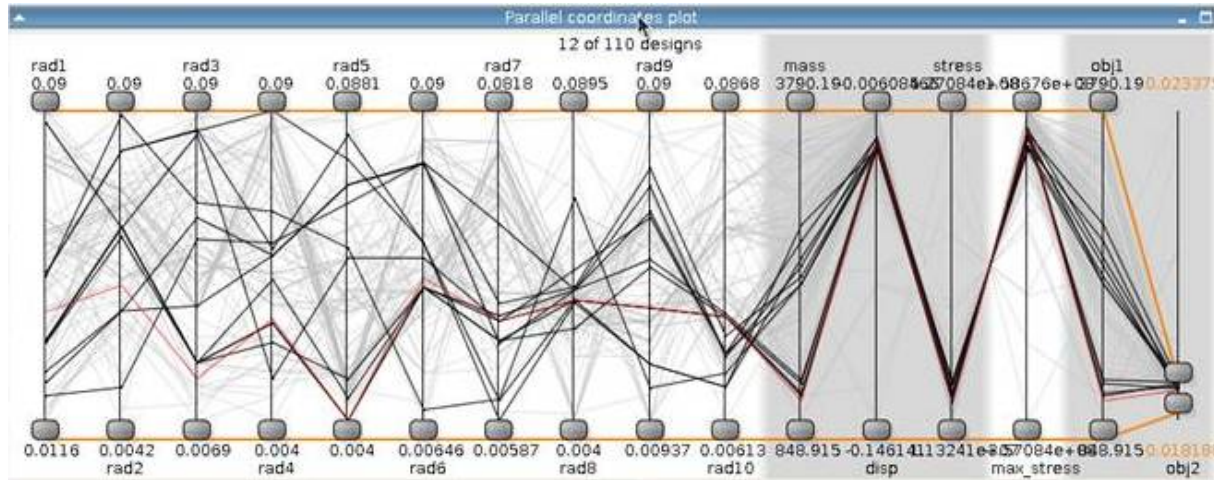
- support for incomplete designs
- now incomplete designs are written to \*.bin files and can be used in statistic post processing
- NaN values are filtered out for statistical evaluation



Responses					
quadratic	ishigami	sobol	min_shc	min_rb1	min_rb2
		0.8315181209			
131558642	2.167116119	0.9211656634	3.897667348	2777.318419	923.6325226
518055556	5.067198248	0.5902616959	0.1688660585	3350.722313	4765.260161
851388889	7.356728043	2.382017922	-0.5246922958	569.3062025	649.8297506
741512346	2.680323044	1.258062813	-0.1075880936	952.2333471	2677.900262
797067901	2.147671098	0.7065203099	22.83779618	741.1156574	371.1909998
548919753	2.734560812	1.333232606	46.02186697	440.3495449	872.3329952
784722222	5.203040795	0.6539377374	62.81182721	5310.522127	2107.210687
840277778	3.850646818	2.112976401	-0.9368102045	48.01988651	72.18343524
172916667	6.152833442	1.261925366	0.05312192424	1458.979271	727.0222086
138966049	3.313829032	1.893266232	0.4983265725	743.5829905	1035.722495
55632716	1.075029407	1.323388642	-0.1318552262	827.0849412	4004.091508
17970679	-0.7289505015	1.103220988			
36265432	6.134695002	0.3340195379	-0.9714578228	1611.486361	463.55317
17970679	0.3110963192	1.178659595	0.5371451358	412.4971477	823.2079994
3625	8.900435605	0.5399813429	-0.3708773973	2923.661444	823.5731352
178472222	3.068378314	0.6262751664	4.783955764	176.2690066	244.4085424
188966049	3.486063516	1.884322424	-0.06464261795	1273.67498	410.0787835
178472222	0.8469953473	0.518568547	0.5299383489	345.8507497	541.8485166
62191358	6.510022471	0.7099393185	0.05312192424	1327.343298	1336.843076
133410494	5.940479454	0.966887474			
55632716	5.990192027	0.7632321891	0.1407690431		598.5710243

# Post Processing

## - Parallel Coordinate Plot and Control



New: single Parameter, Responses, Constraints, Terms and objectives can be removed from the Window

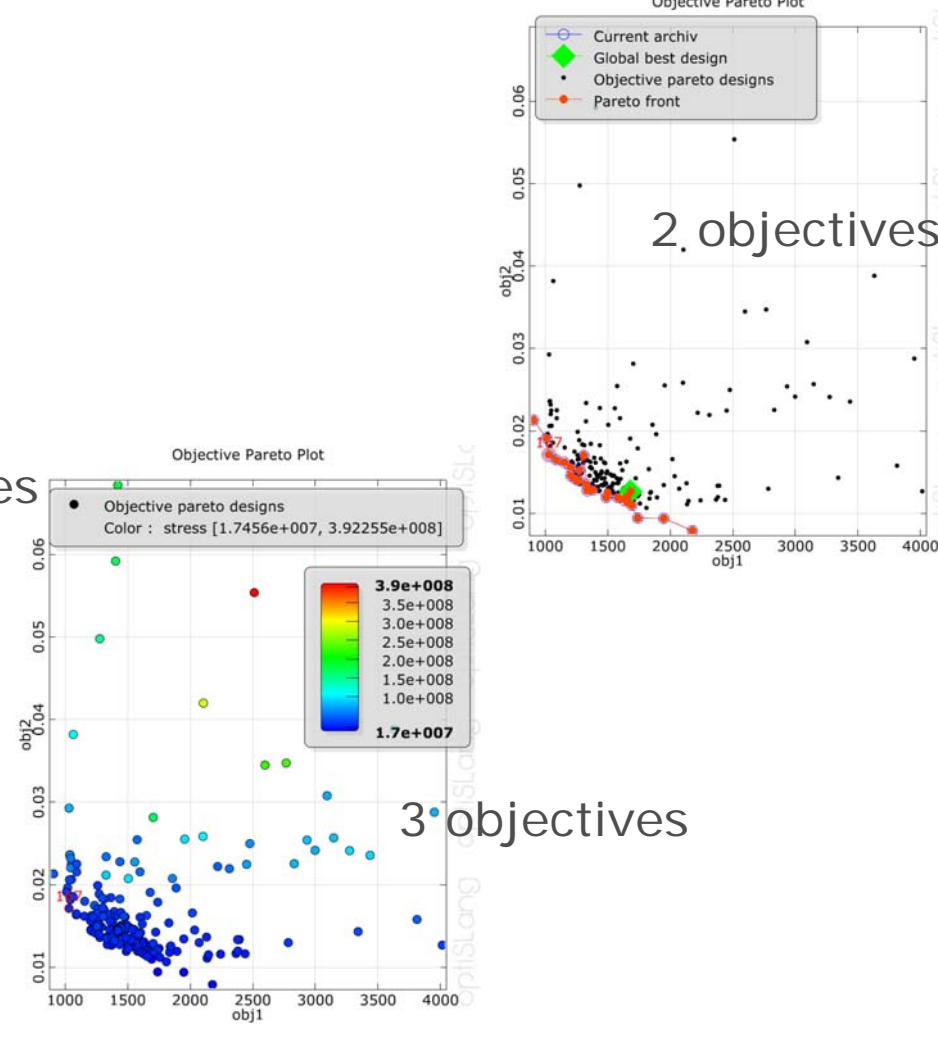
# Post Processing

- 4 (2+2) and 5 (3+2) dimensional Pareto Plot (colour & bubble size)

The screenshot shows the OptiSlang software interface. On the left, the 'Main Application' panel has an 'Update data' button and five objective selection dropdowns: 1. Objective (obj1), 2. Objective (obj2), 3. Objective (stress), 4. Objective (mass\_disp), and 5. Objective (stress\_disp). Below these are 'Select pareto front design' (design 167) and 'Selected design' (design 167) dropdowns, and a 'Best Design' button. The 'Objective data' panel at the bottom left has a 'Show' dropdown menu with options: 4 Dimensions, Archiv - Pareto front, 3 Dimensions, 4 Dimensions (highlighted), and Color. The main window displays an 'Objective Pareto Plot' with a scatter plot of objective values (obj1 vs obj2) and a color scale for stress. A tooltip for a selected point shows: Objective pareto designs, Color : stress [1.7456e+007, 3.92255e+008], Size : mass\_disp [908.525, 4013.16]. Below the plot is a table of 'Term, objective & constraint values' for the best design (#167):

Term	Value
OBJ: stress_disp	3.34368e+007
OBJ: stress	3.34368e+007
OBJ: obj2	0.0171227
OBJ: obj1	1031.58

4 objectives



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

# Definition - Coefficient of Prognosis

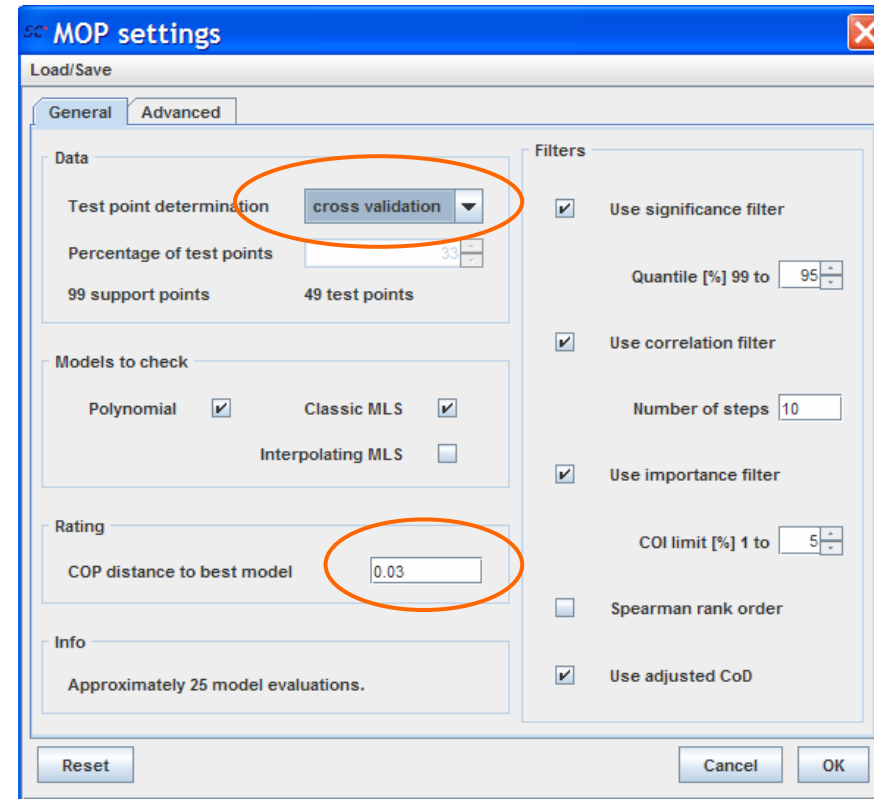
- What proportion of the variation of a response can be forecasted with identified arbitrary non-linear correlations to the input parameters?

CoP has three benefits

- we reduce the variable space with different filter = best subspace
- we check multiple correlation = best regression
- we split the sample set and check the forecast (prognosis) quality

New: version 3.2

- Cross validation
- iterative variable reduction and model complexity reduction
- improved variance based sensitivity indices for importance measurement (CoI/CoP)



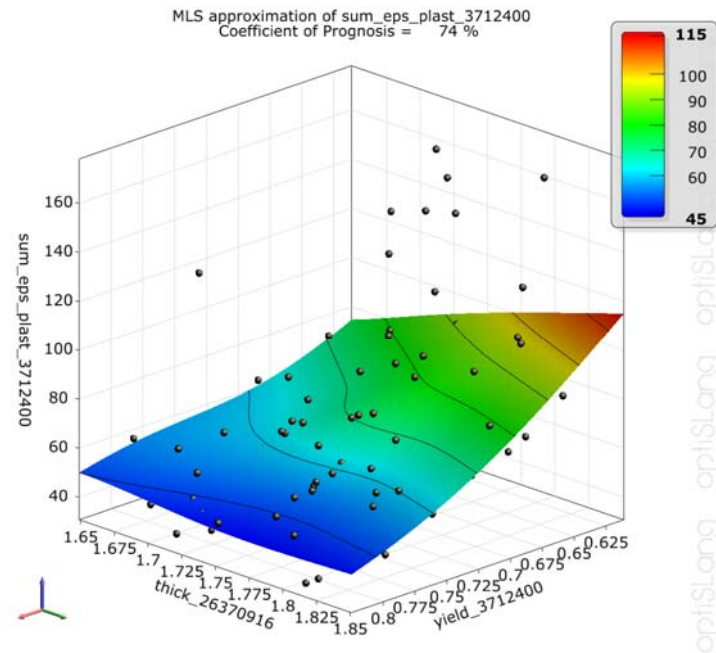
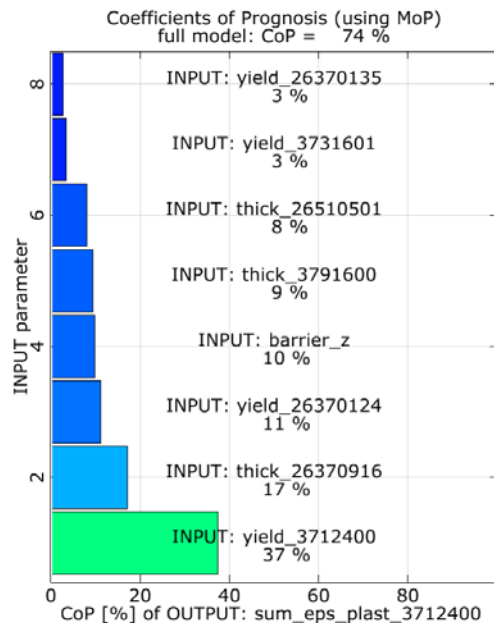
# Strategy "No Run to Much"

Using advanced LHS sampling, significance filter technology and forecast quality (CoP) we can check after  $\approx 50$  runs

⇒ can we explain the variation?

⇒ which input scatter is important?

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



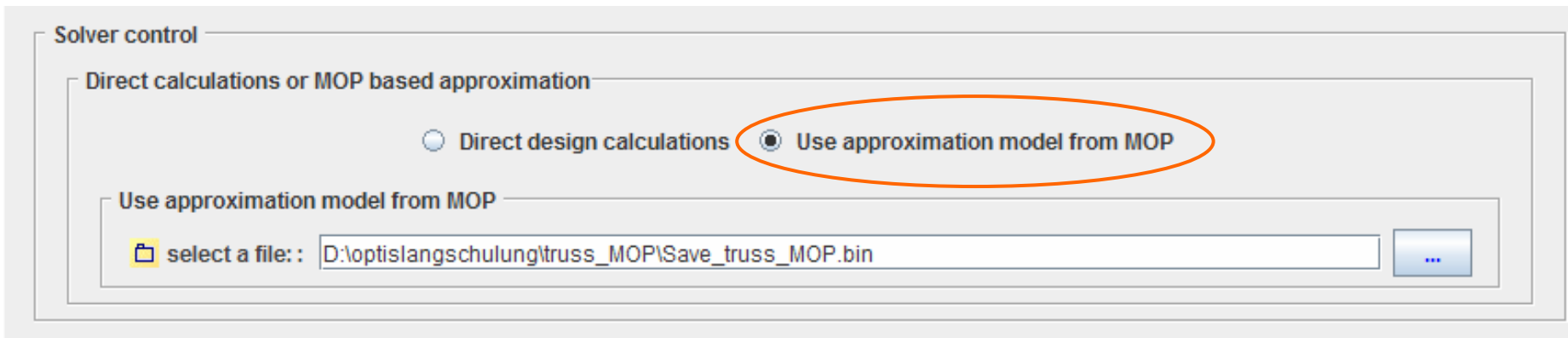


# MoP as solver

MoP's can now be used at optiSLang flows to replace external solver.

- Optimizer (Gradient, NOA [GA, ES, PSO], Pareto)
- Robust Design Optimization
  
- Sensitivity (DOE) and Robustness
- Reliability Analysis

(Attention: There is no optimal design which can be checked in real space)



# Check optima at RSM/MOP

It is recommended to check the optima found at approximations (RSM or MOP) with solver run in real space!

That functionality is available in all flows with RSM/MOP. Post Processing will show the difference between optimal design at approximation and real space.

**Solver control**

**Direct calculations or MOP based approximation**

Direct design calculations  Use approximation model from MOP

**Use approximation model from MOP**

select a file:

**Calculate best design**

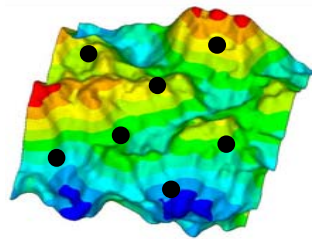
Do not calculate  Run a single command (found in PATH)  Run a script file

**Run a single command (found in PATH)**

type a command:

# From best practice to black box

1) Start with sensitivity study using LHS Sampling

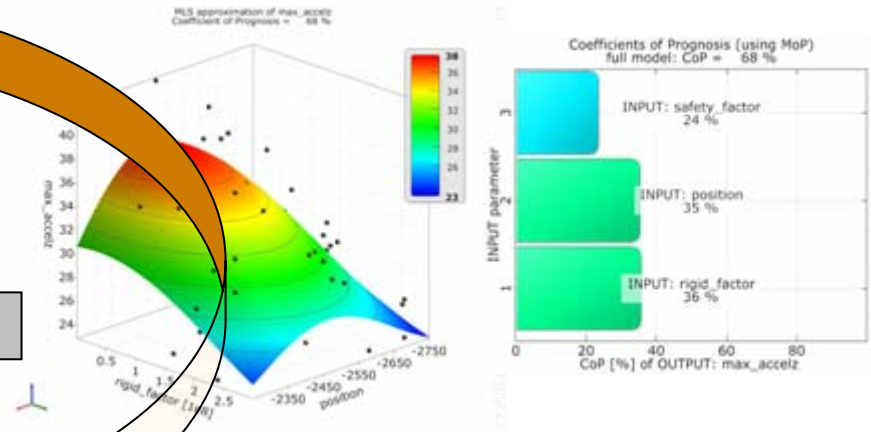


2) Automatic search for the meta model of best prognosis at best sub space using the best meta model and checking the prognosis quality

Sensitivity

optiSLang

Create MoP



Test Optima

4) Check Optima

3) Run Optimization at MOP

Goal: User friendly effective procedure using black box algorithm

# News on Optimization within optiSLang 3.2

Ease of use for Nature-inspired optimization algorithms (NOA)!

# Simple Design Improvement (SDI)

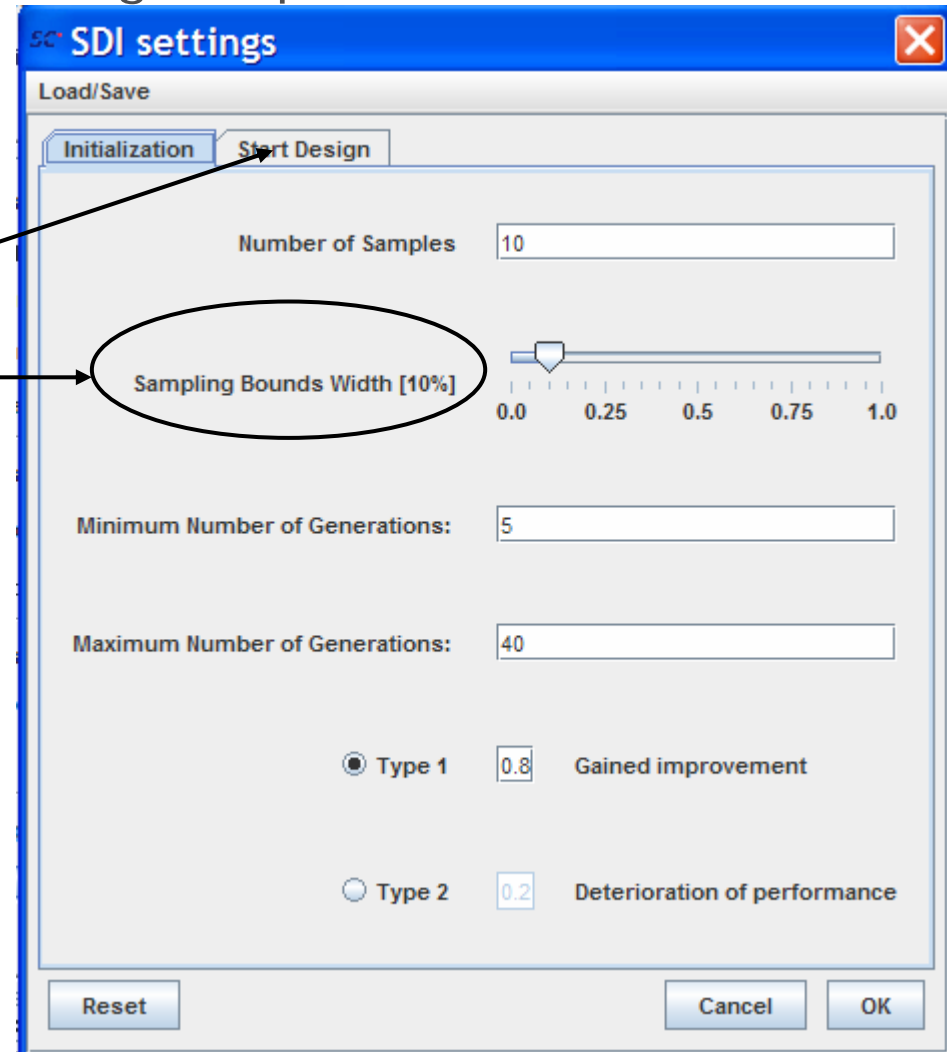
SDI also known as “Stochastic Design Improvement” was used in STORM for optimization

- former Storm user wanted to have that extremely simple to use strategy (only one start design is necessary input)

- basically a **cloud** of certain size are moved in the designs space

- SDI shows usually improvement in the first (5) iteration steps before improvement slows down

- main mechanism of the algorithm is the move of cloud center point



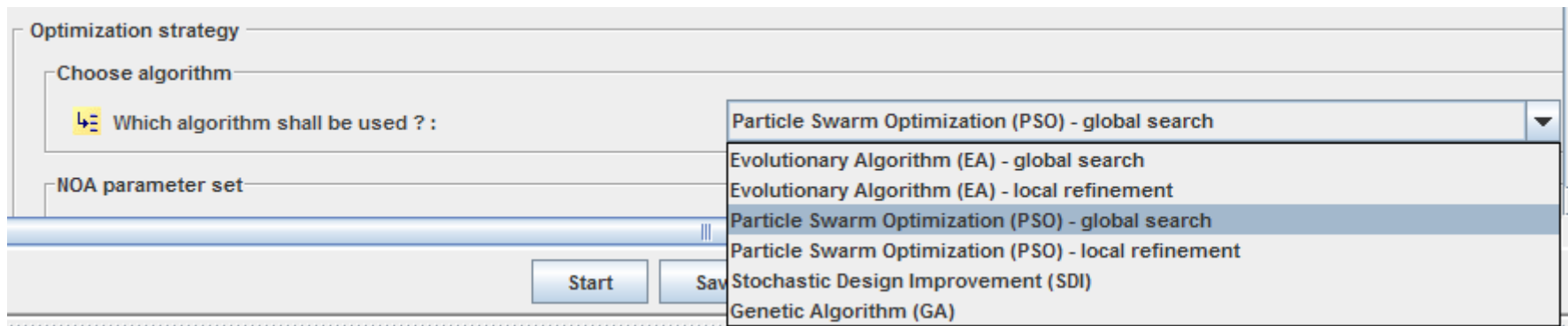
# NOA Wizard

Wizards help to select the appropriate single objective NOA

- First step in v3.2: wizard for Nature-inspired Optimization Algorithms unify 3 optiSLang flows
  - GA Flow
  - EA Flow with local improvement (ES) and global search (GA)
  - PSO Flow with local improvement, global search

(Attention: see manual for decision tree)

- Next Step in 4.0: decision tree included in wizard





# Improved Mutation Strategies

Available for single objective  
EA and PSO Algorithms

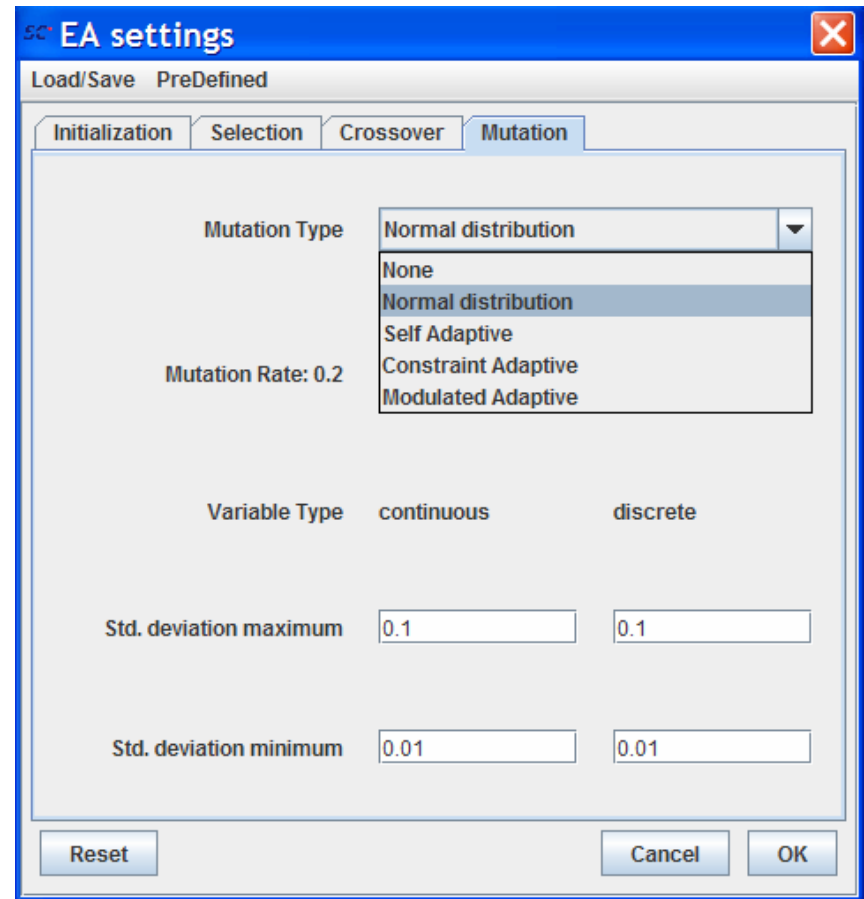
New:

- first choice: Self Adaptive (Bäck) =  
modifies mutation for single input  
variables

- Constraint Adaptive = decrease  
mutation of mutated variables which  
lead to constraint violation

- Modulated Adaptive = modifies  
distribution function due to  
successful mutations

Evolutionary Algorithm (EA) - global search  
Evolutionary Algorithm (EA) - local refinement  
Particle Swarm Optimization (PSO) - global search  
Particle Swarm Optimization (PSO) - local refinement  
Stochastic Design Improvement (SDI)  
Genetic Algorithm (GA)



# Pareto Wizard

Wizards help to select the appropriate Pareto optimization algorithm

- First step in v3.2: wizard for Nature-inspired Pareto optimization algorithms unify 2 optiSLang flows
  - Pareto (SPEA2) optimization flow
  - Pareto capability of PSO Flow

(Attention: see manual for decision tree)

- Next Step in 4.0: decision tree included in wizard

Optimization strategy

Choose algorithm

Which algorithm shall be used ? : Particle Swarm Optimization (PSO)

Evolutionary Algorithm (EA)

Particle Swarm Optimization (PSO)

Pareto parameter set

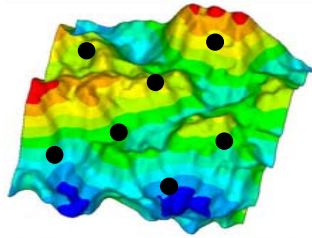
Create resp. Modify  Use previously defined

Create resp. Modify

Will be created, if not present in project directory : pareto\_parameters.set

# Sensitivity Analysis and Optimization

1) Start with a sensitivity study using the LHS Sampling

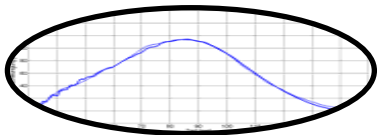


Scan the whole Design Space

optiSLang

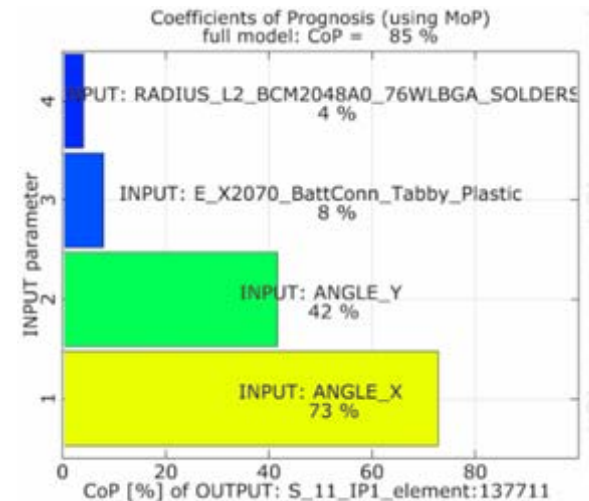
Understand the Problem using CoP/MoP

Search for Optima



2) Identify the important parameters and responses

- understand the problem
- use MOP for optima search



3) Run ARSM, gradient based or Nature-inspired Optimization Algorithms

4) Goal: user-friendly procedure needs as much automatism as possible

# optiSLang Integration Environment

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optiPlug

SoS - Statistics on Structure

ETK - Extraction Tool Kit



# ANSYS Workbench v12 optiSLang Interface

Parameter Manager

optiPlug WB 12

Write optimization project

Optimization problem

Lower bounds (-) 10 % Upper bounds (+) 20 %

Update mode

Don't write files, show a warning message

Save results

Show WB GUI during calculations

OK Cancel

optiSLang-Plugin:  
just click to integrate  
workbench in  
optiSLang

Parameter & Responses

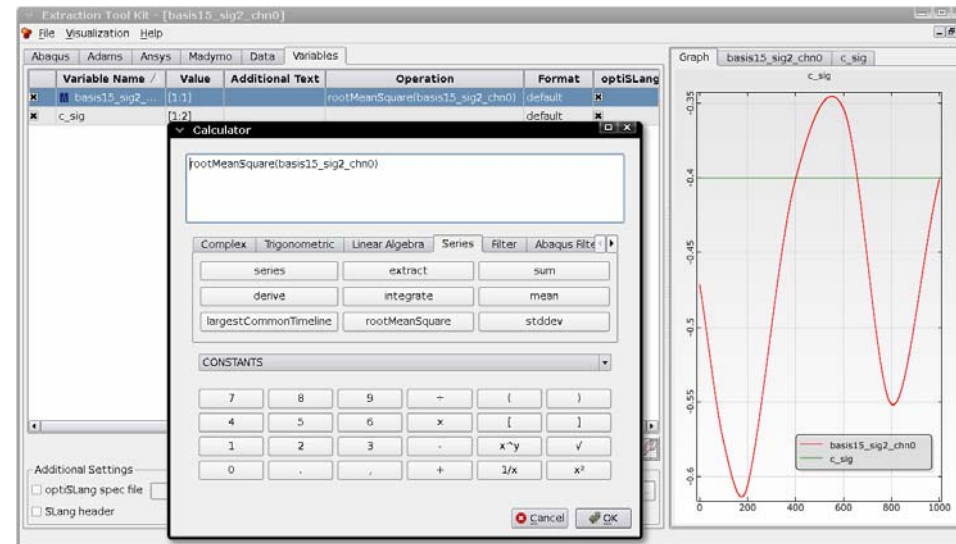
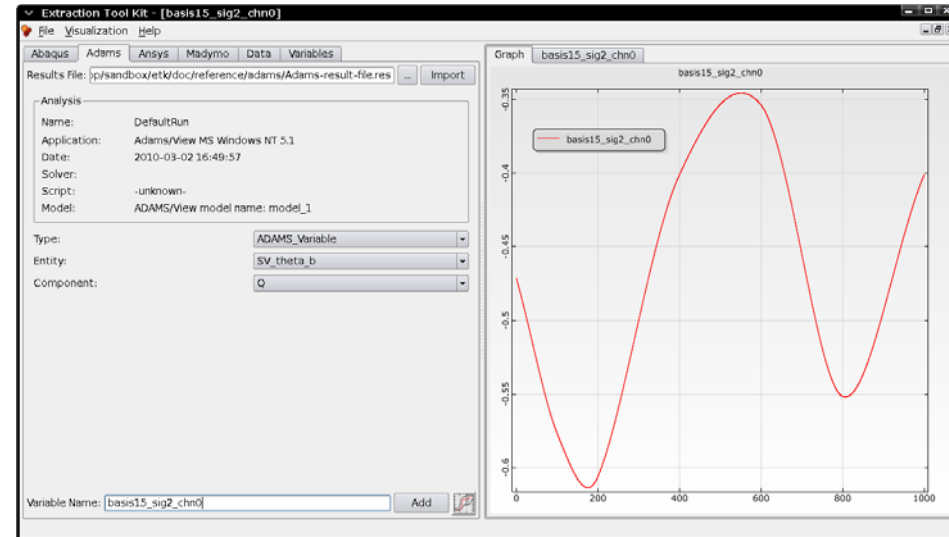
	A	B
2	Input Parameters	Parameter Name
3	P4	DS_Befestigungsbohrung
4	P5	DS_H
5	P6	DS_T1
6	P7	DS_Bohrung_1
7	P8	DS_H_Bohrung
8	P9	DS_L
9	P10	DS_B
		DS_D1
		DS_Rippenwinkel
		DS_Rippenhoehe
		DS_Rippe
		New name
		Parameters
		Gesamtverformung Maximum
		Vergleichsspannung Maximum
		Geometrie Masse
		output: parameter
		B
		Value

	A	B	C	P6
1	Name	P4 - DS_Befestigungsbohrung	P5 - DS_H	P6
2				
3	Current	10	140	24
*				

# Extraction Tool Kit



- Extraction toolkit to replace the scripting for result extraction and processing for ABAQUS, ADAMS, ANSYS & MADYMO
- Extraction
  - Single Value, vector, matrix, tensor
- Definition of free variables
- Processing
  - Mean value, MIN/MAX
  - Standard deviation, Integral
  - Improved Signal processing
  - Improved mathematics
- Batch execution mode
- Creates optiSLang \*.pro file
- Available on Windows/Linux





# Why SoS and what is SoS ?

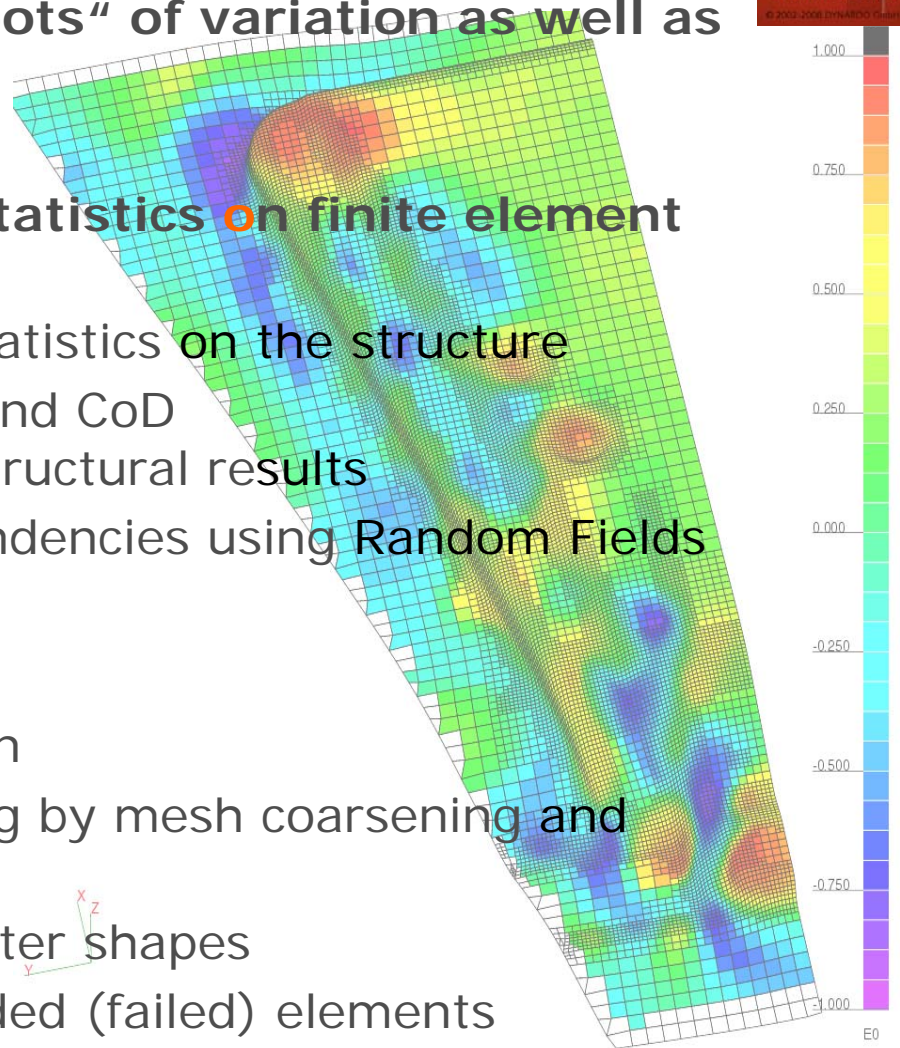
**Why:** Engineers need to evaluate statistical data on the structure to locate „hot spots“ of variation as well as investigate correlations

**What:** A post processor for **Statistics on finite element Structures**

- Visualization of descriptive statistics on the structure
- Visualization of correlations and CoD between random input and structural results
- Identification of spatial dependencies using Random Fields

**Key features:**

- Locate „hot spots“ of variation
- Data reduction and smoothing by mesh coarsening and random field projection
- Identification of relevant scatter shapes
- Visualization statistics of eroded (failed) elements



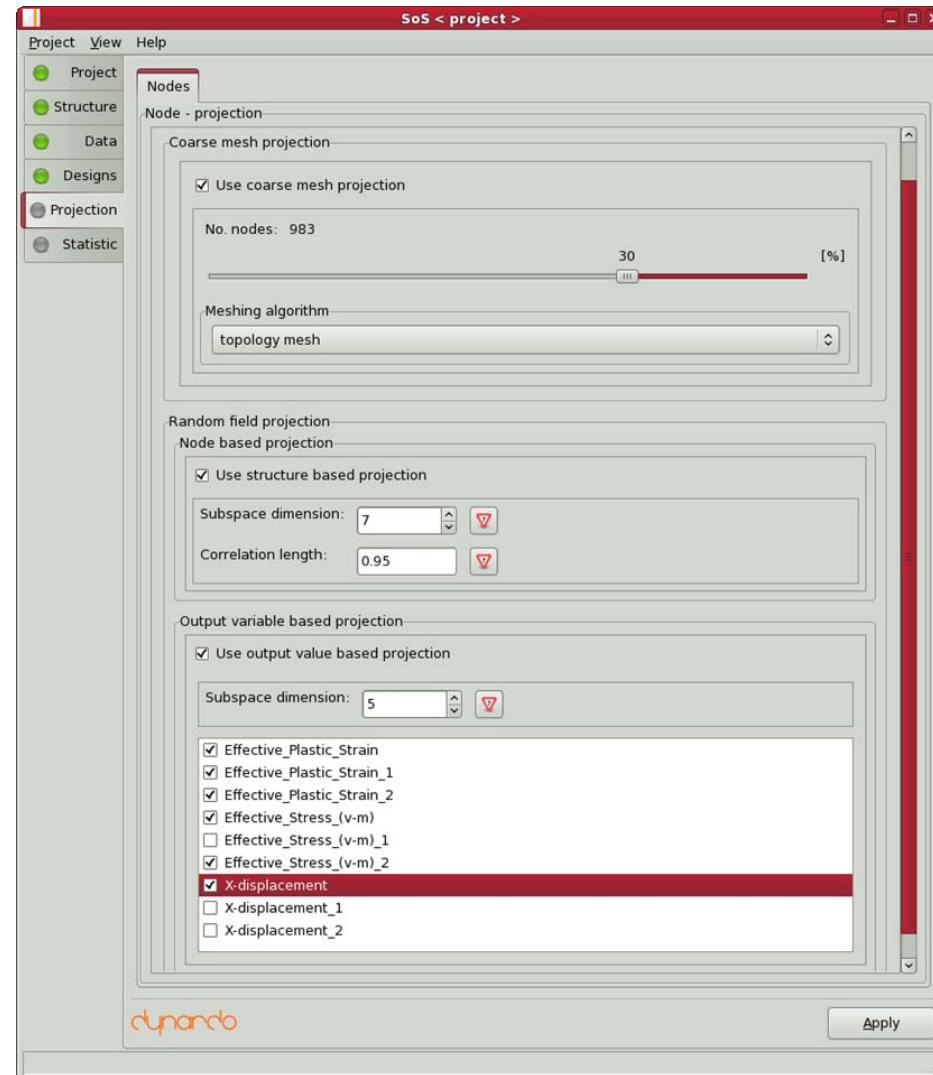
# SoS v2.3 – Developments new version

## Interfacing

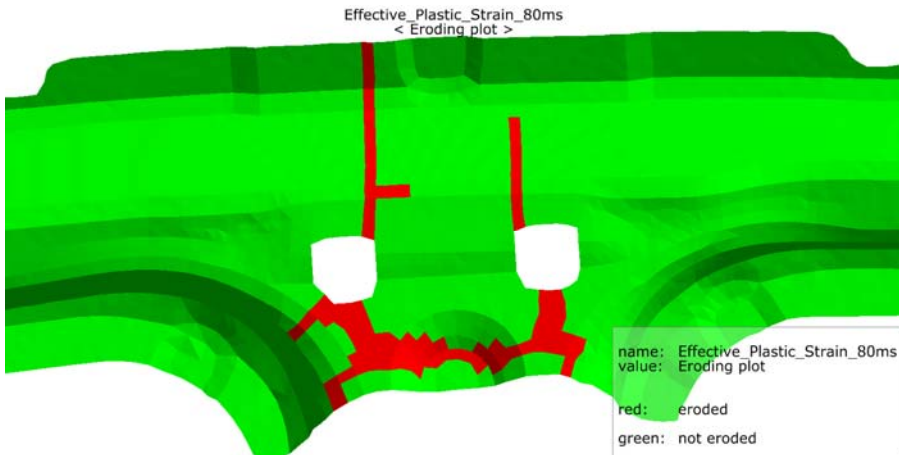
- ABAQUS (odb)
- Flexible user interface for other ASCII based Formats

## Statistical processing

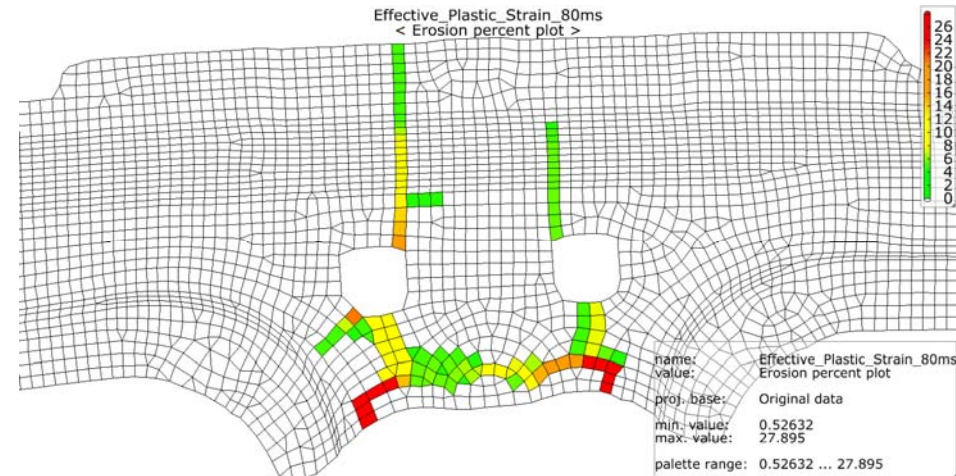
- Handling of element eroding
- Mesh coarsening (uniform and topology)
- Result based generation of Random Fields
- Visualization of Random Fields (Modes) with Significance (variability)



# SoS - Eroding elements



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



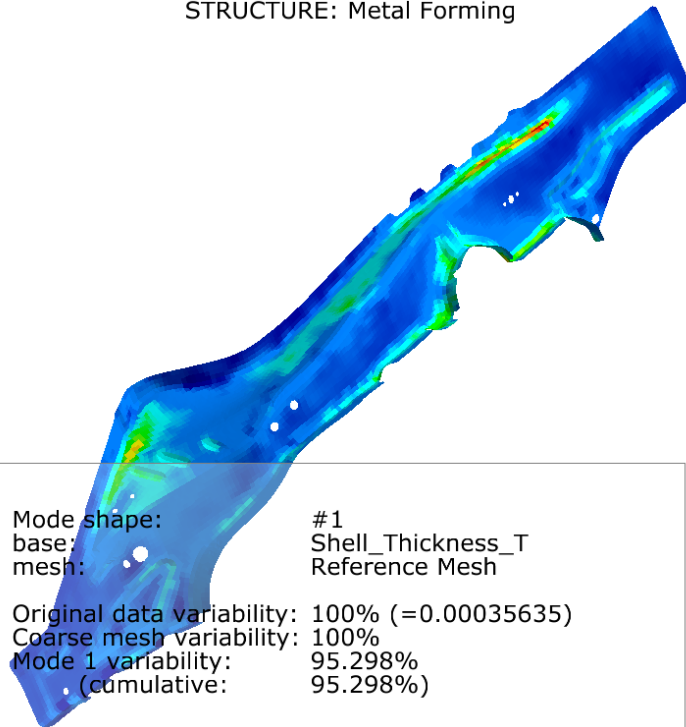
Eroding percent plot shows the percentage of eroded elements.

# SoS - Random Fields

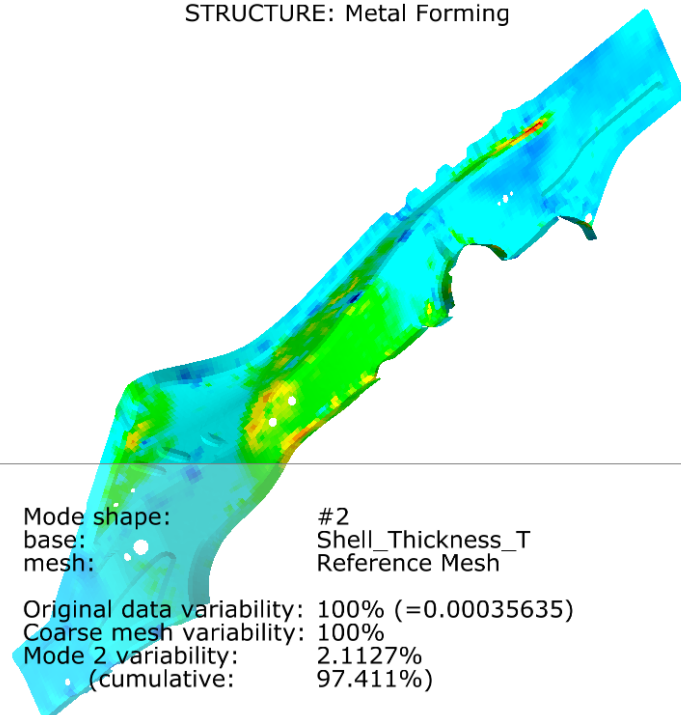
New: **output variable based projection**

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

STRUCTURE: Metal Forming

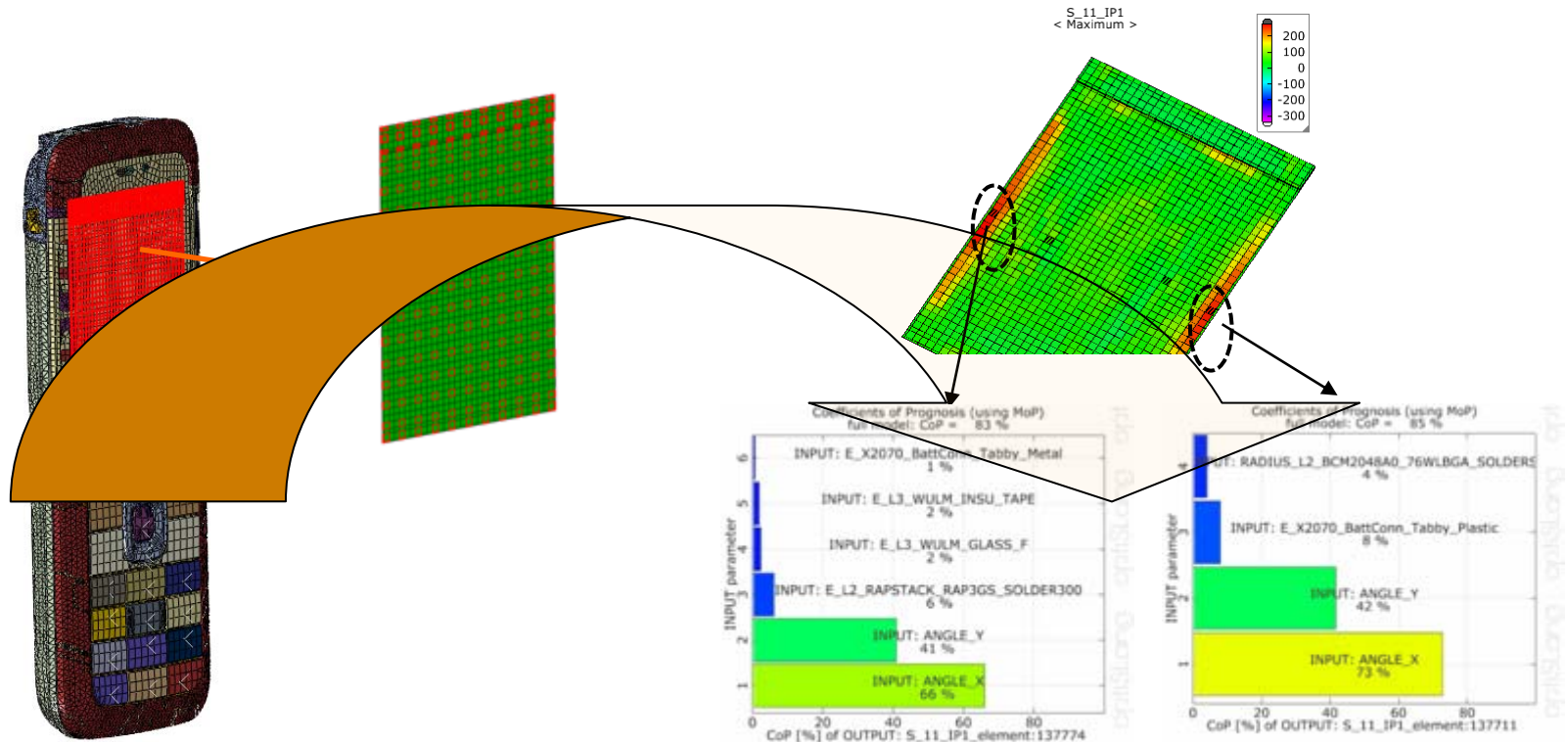


STRUCTURE: Metal Forming



# 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