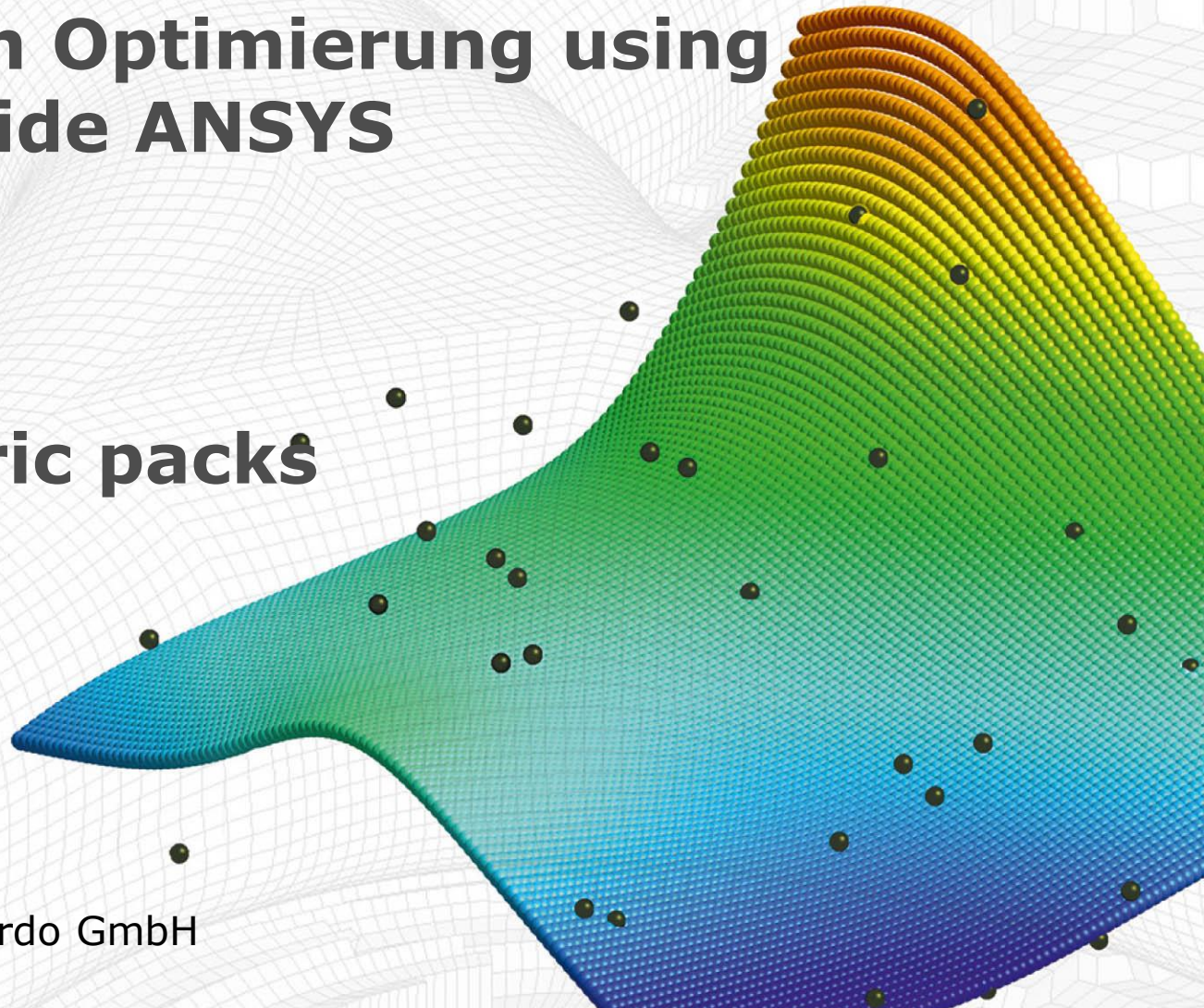


# Robust Design Optimierung using optiSLang inside ANSYS Workbench

## supported by HPC parametric packs

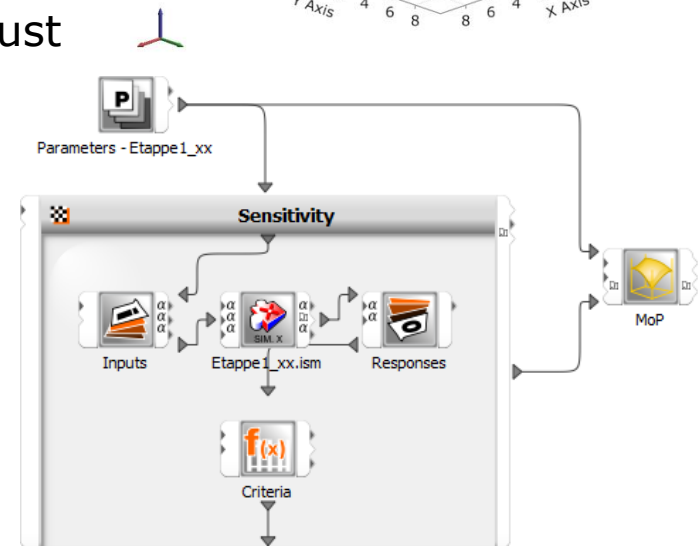
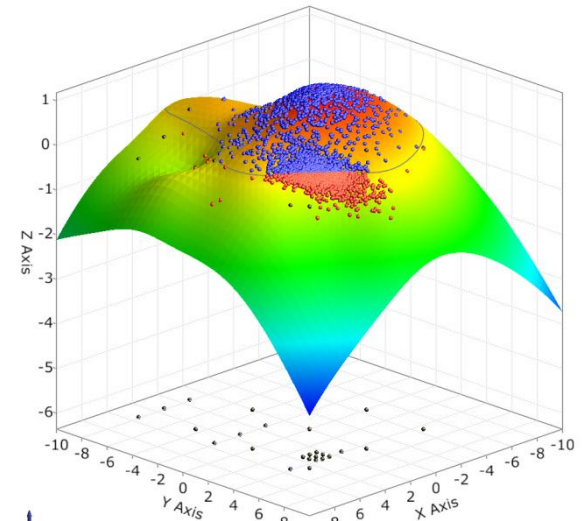
Dr.-Ing. Johannes Will

Managing director Dynardo GmbH



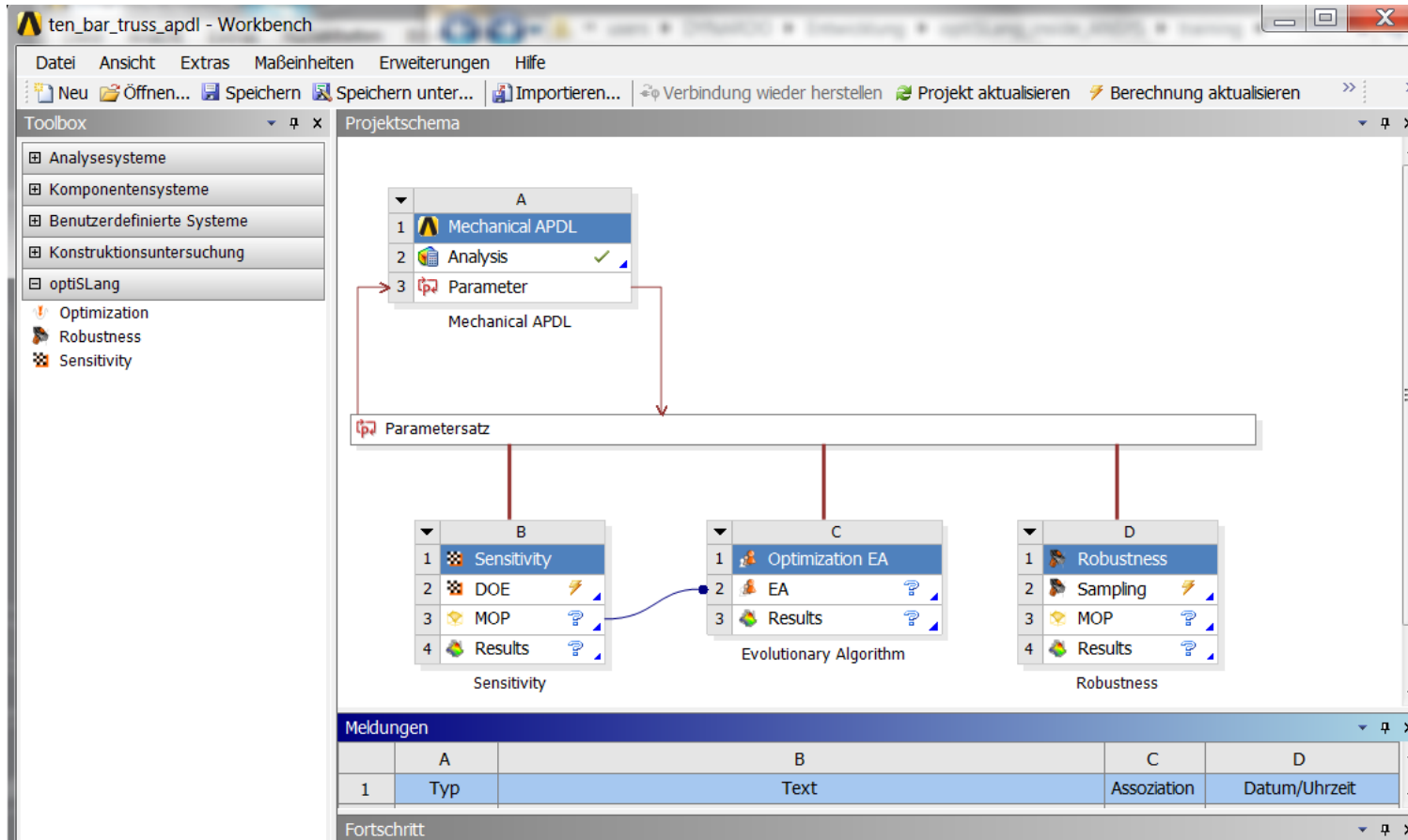
# Excellence of optiSLang

- optiSLang is an algorithmic toolbox for sensitivity analysis, optimization, robustness evaluation, reliability analysis and robust design optimization
- optiSLang is the commercial tool that has completed the necessary functionality of sensitivity analysis, optimization and stochastic analysis to run real world industrial applications in CAE-based robust design optimizations
- optiSLang offers the beginner and expert users **easy and safe to use** predefined workflows of best practice
- Since 2009 interfacing via optiPlug support ANSYS workbench-optiSLang applications



# optiSLang inside ANSYS Workbench v14

Modules Sensitivity+MOP, Optimization and Robustness+MOP provide „best practise“ optiSLang functionality



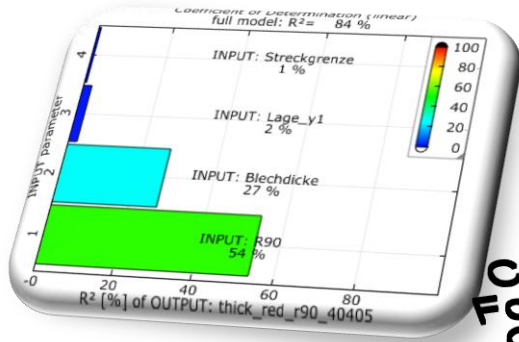
# Sensitivity Analysis



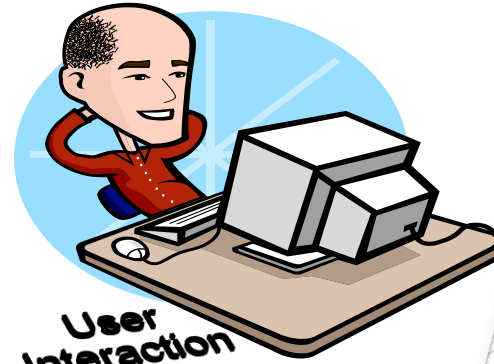
(Design Exploration)



# Sensitivity Analysis



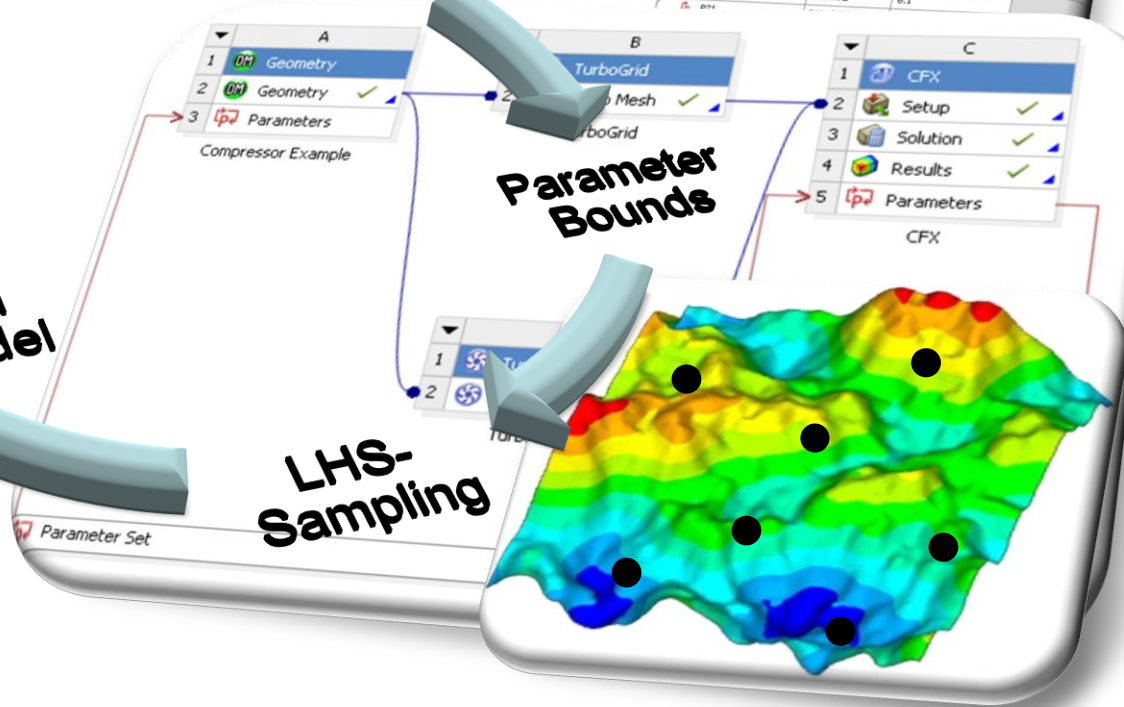
Check Forecast Quality



User Interaction

Parameter	Value
P1	InletWidth 53.1
P8	ExitWidth 36.2
P9	RImpeller 305.3
P10	HUBbeta1 -48.4
P11	HUBbeta2 -25.5
P12	HUBbeta3 -25.6
P13	ShdBeta1 -55.7
P14	ShdBeta2 -45.7
P15	ShdBeta3 -30.7
P16	HdTH1 1.1
P17	HdTH2 6.2
P18	ShdTH1 1.1
P19	ShdTH2 6.1

Identify best subspace and best meta model



# Sensitivity Module

## Minimal required user input:

- Definition of parameter variation

The screenshot illustrates the minimal user input required for the Sensitivity Module. It shows a project tree on the left and a 'Parameter set' dialog box on the right.

**Project Tree (A):**

- 1 Microsoft Office Excel
- 2 Analysis
- 3 Parameters

**Project Tree (B):**

- 1 Sensitivity
- 2 Parameters
- 3 Criteria
- 4 DOE
- 5 MOP
- 6 Results

**Parameter set dialog box:**

Name	Parameter type	Reference value	Resolution	Constant	Range	Range plot
1 WB_X1	Deterministic	0	Continuous	<input type="checkbox"/> non const	-3.14 3.14	
2 WB_X2	Deterministic	0	Continuous	<input type="checkbox"/> non const	-3.14 3.14	
3 WB_X3	Deterministic	0	Continuous	<input type="checkbox"/> non const	-3.14 3.14	
4 WB_X4	Deterministic	0	Continuous	<input type="checkbox"/> non const	-3.14 3.14	
5 WB_X5	Deterministic	0	Continuous	<input type="checkbox"/> non const	-3.14 3.14	

Buttons: OK, Cancel, Apply

Use design as reference

# Sensitivity Module

The Meta Model of optimal Prognosis (MOP) is automatically created out of the DOE-Sampling

**Minimal required user input: non**

Additional features:

- supports removing designs out of DOE Post Processing

The diagram illustrates the workflow. On the left, a tree view shows a 'Parameter Set' box connected to a 'Microsoft Office Excel' box (containing steps 1: Microsoft Office Excel, 2: Analysis, 3: Parameters) and a 'Sensitivity' box (containing steps 1: Sensitivity, 2: Parameters, 3: Criteria, 4: DOE, 5: MOP, 6: Results). An orange arrow points from the 'MOP' step in the Sensitivity box to the 'Mop' dialog box on the right.

The 'Mop' dialog box contains the following settings:

- Data:**
  - Type of testing: cross validation
  - Splitting ratio: 33
  - Models to check:  Polynomial,  Classic MLS,  Interpolating MLS
  - Delta COP: 0.030
- Filters:**
  - Use significance filter:
  - Quantile [%] 99 to: 95
  - Use correlation filter:
  - Number of steps: 10
  - Use importance filter:
  - COI limit [%] 0 to: 5
  - Spearman rank order:
  - Use adjusted CoD:
- Inputs:**

	Parameter	Importancy
1	WB_X1	Selectable
2	WB_X2	Selectable
3	WB_X3	Selectable
4	WB_X4	Selectable
5	WB_X5	Selectable
- Outputs:**

	Response	Use
1	WB_Y	<input checked="" type="checkbox"/>

Buttons at the bottom: Reset to defaults, OK, Cancel, Apply.

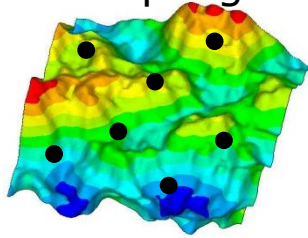
# Optimization





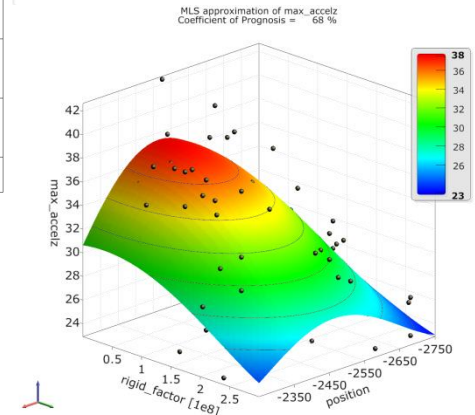
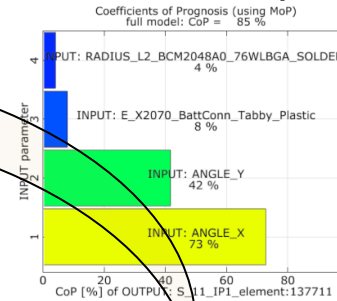
# Sensitivity Analysis and Optimization

1) Start with a sensitivity study using the LHS Sampling



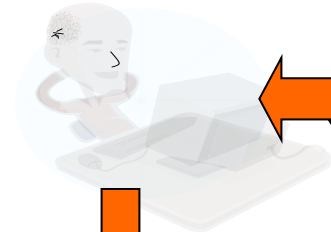
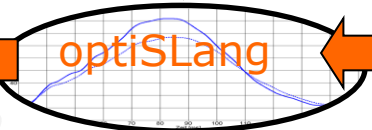
2) Identify the important parameters and responses

- understand the problem
- reduce the problem

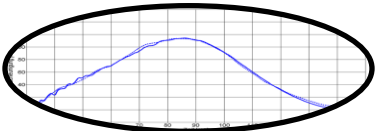


Scan the whole Design Space

Understand the Problem using CoP/MoP



Search for Optima



3) Use MOP+gradient solver for fast Design Improvement

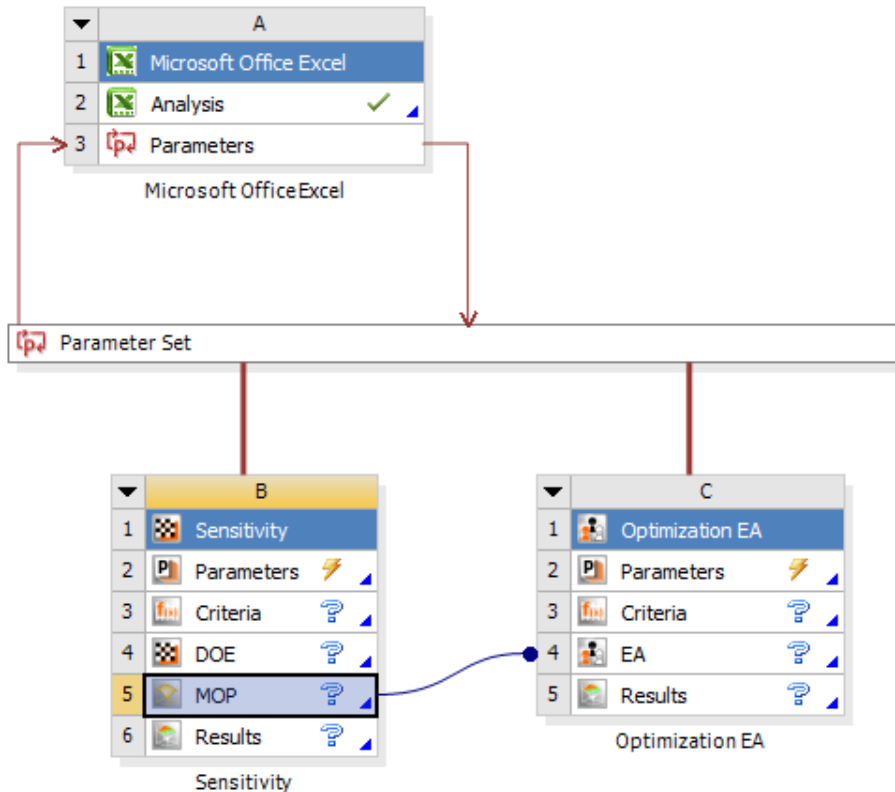
4) Run an ARSM, gradient based or biological based optimization Algorithms

# Optimization using MOP

After sensitivity analysis optimization using MOP is supported.

## Minimum required user input:

- drop the optimization module onto MOP
- defining objective and constraints



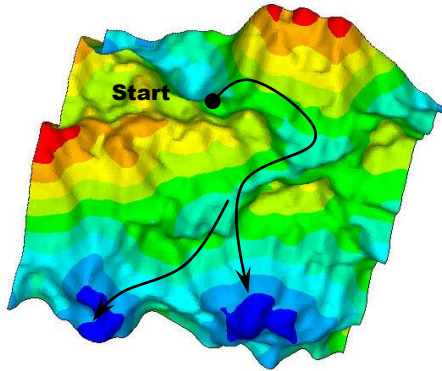
“Optima” which are based on meta models need to be verified!

## Proof optima:

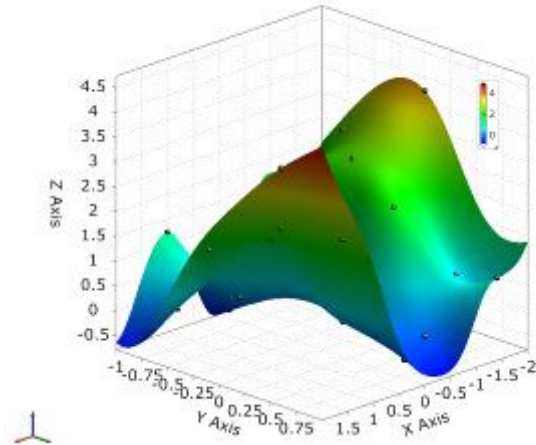
- Automatic verification with real ANSYS call
- Check differences in post processing

# Optimization Algorithms

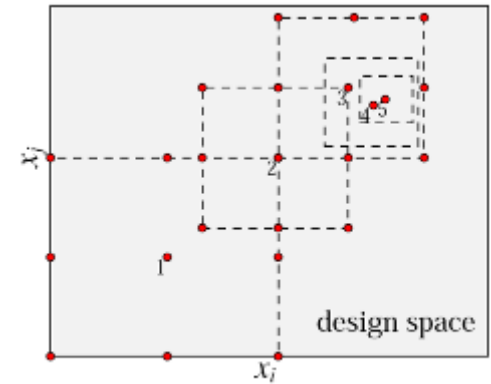
## Gradient-based



## Response surface method

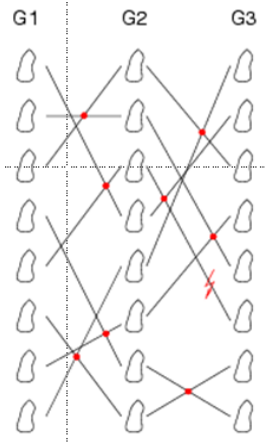
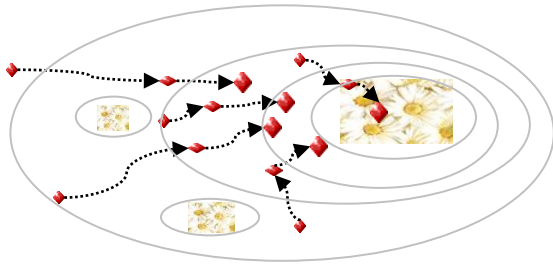


## Adaptive RSM

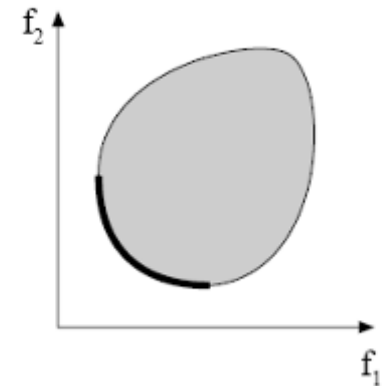


## Nature inspired optimization algorithms:

- Genetic algorithms,
- Evolutionary strategies
- Particle Swarm Optimization

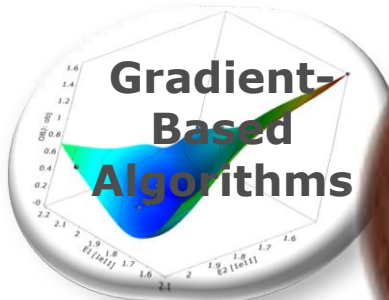
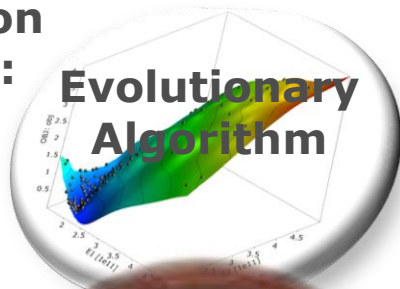


## Pareto Optimization

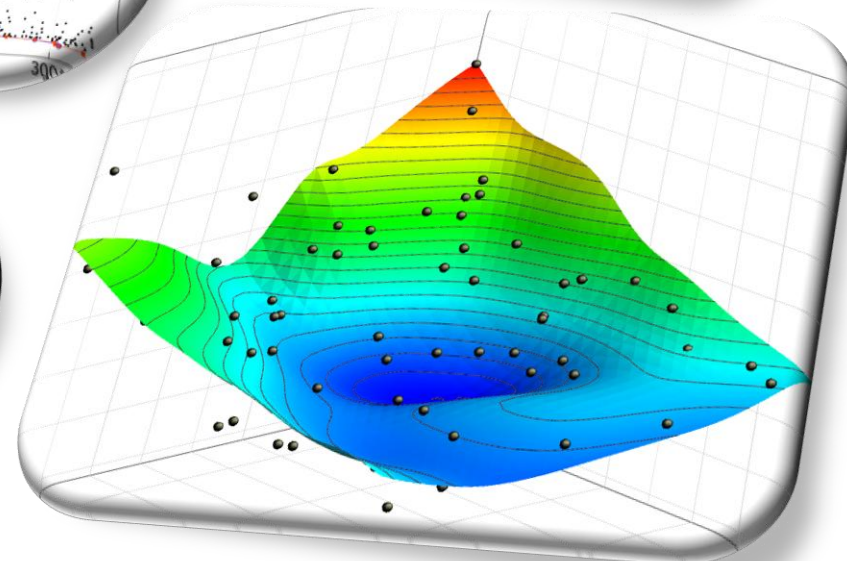
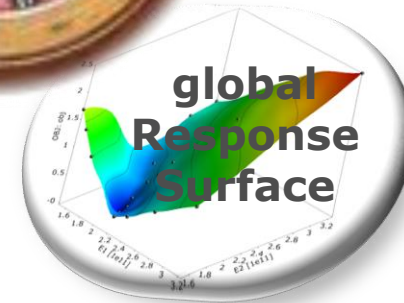
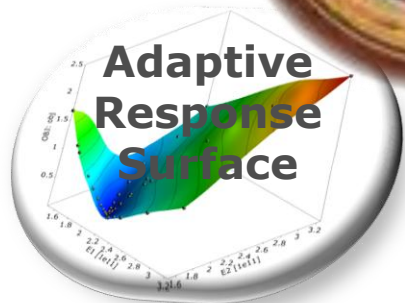
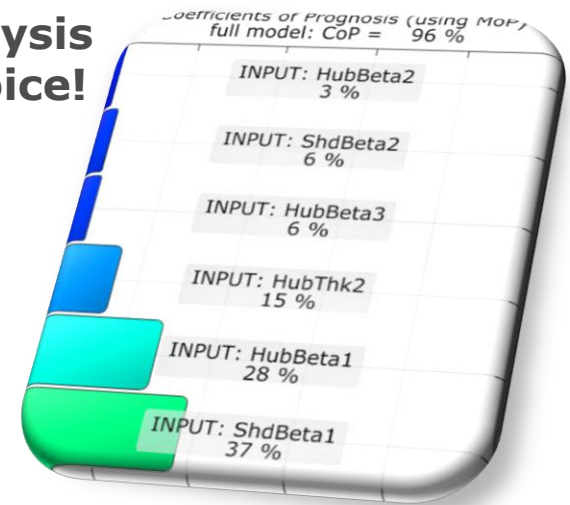
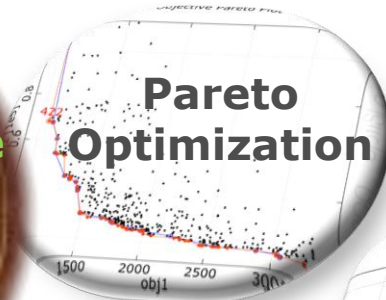


# When to use which Algorithm

**Optimization Algorithms:**



**Sensitivity Analysis allows best choice!**



## Optimization Wizzard

optiSLang helps you to select a suitable optimization algorithm. Support the underlying (automatic) selection process with some additional information about the solver and the problem itself.

Exampel for using MOP and best\_design\_Sensitivity:

1. Set the analysis status as "Preoptimized" (best design from Sensitivity)
2. Set the constraint violations to "Seldom"
3. Set failed designs to "None" (MOP gives always response values)
4. Set solver noise to "None" (MOP gives a smooth surface)

Analysis status:	<input type="text" value="Preoptimized"/>
Constraints violations:	<input type="text" value="Seldom"/>
Failed designs:	<input type="text" value="None"/>
Solver noise:	<input type="text" value="None"/>

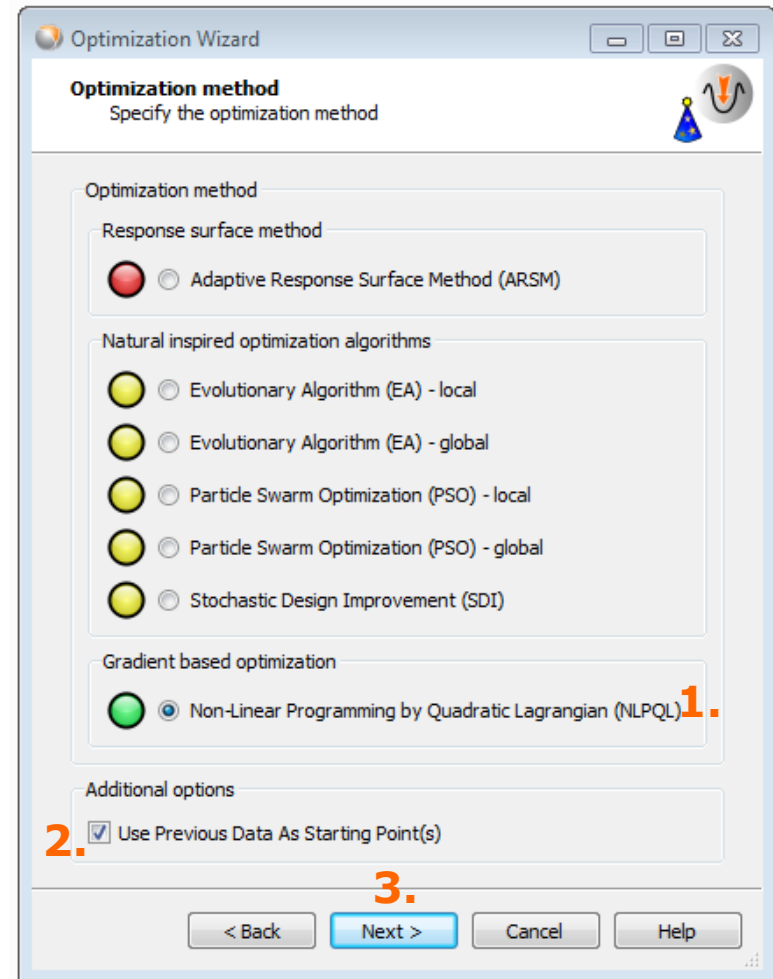


# Optimization Wizzard using MOP

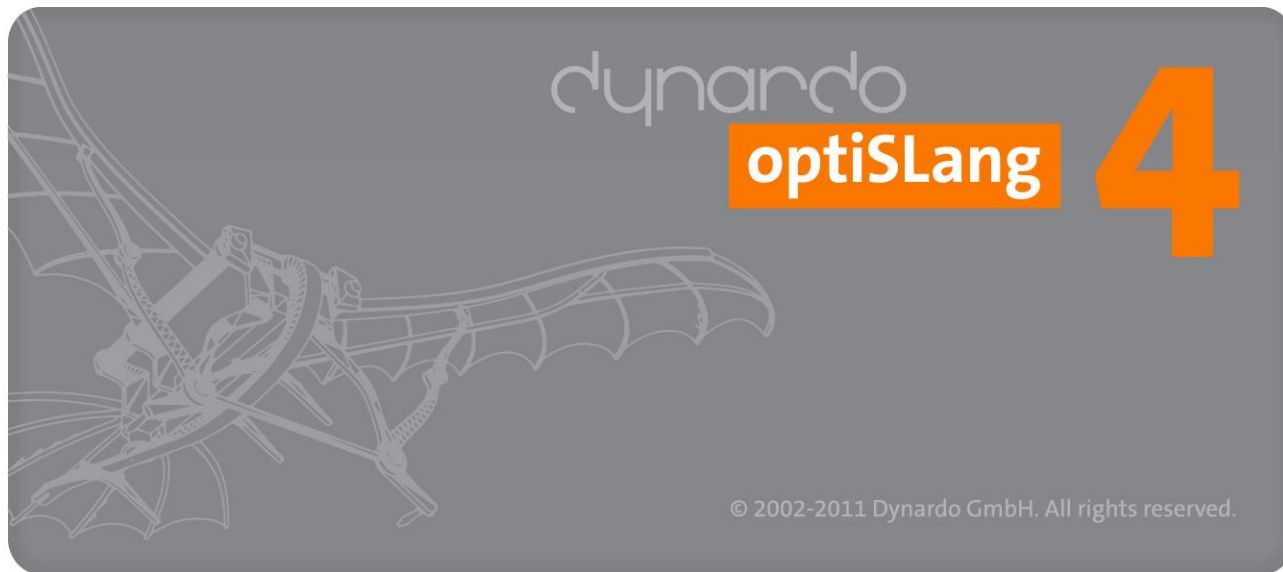
Suggested algorithm is NLPQL

Start point is automatically selected

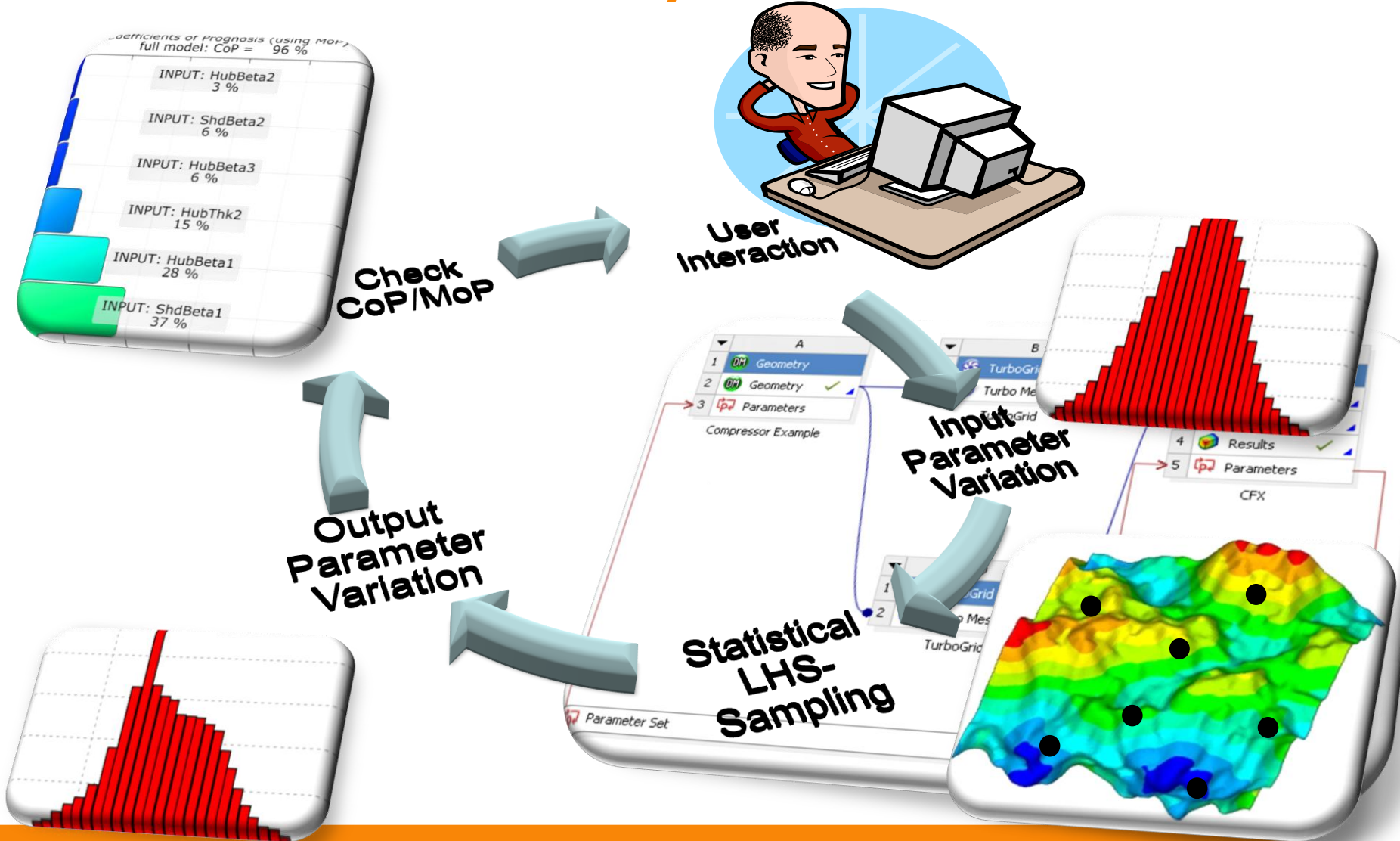
Press "Next"



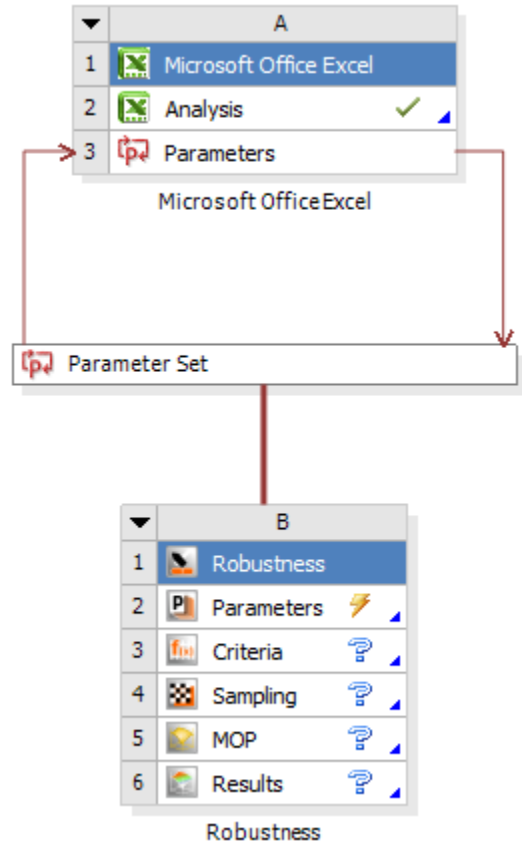
# Robustness Design Optimization



# Robustness = Sensitivity of Uncertainties



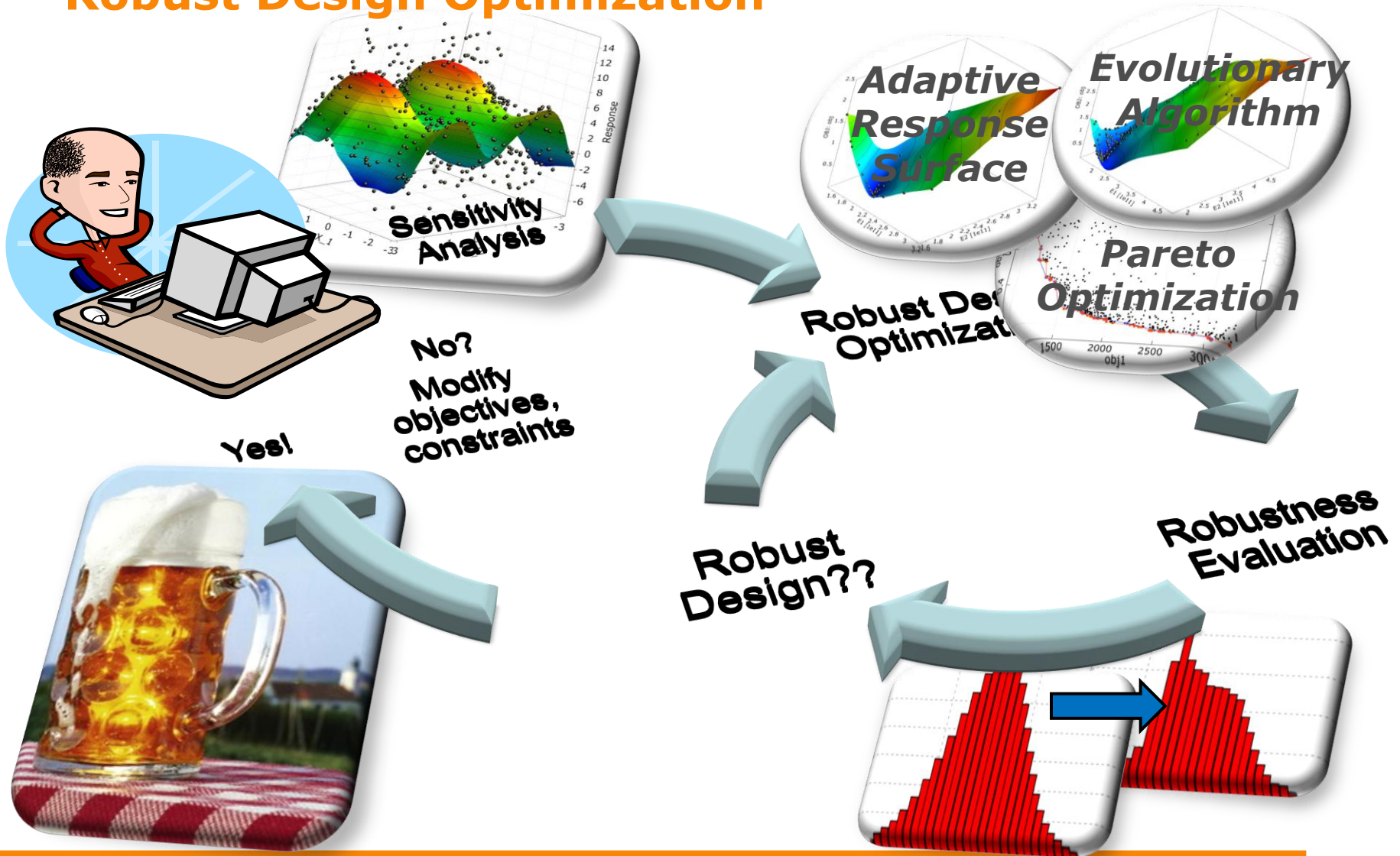
# Robustness Evaluation



## Minimum required user input:

- definition of input variation /scatter
- definition of robustness criteria
- number of samples for ALHS

# Robust Design Optimization





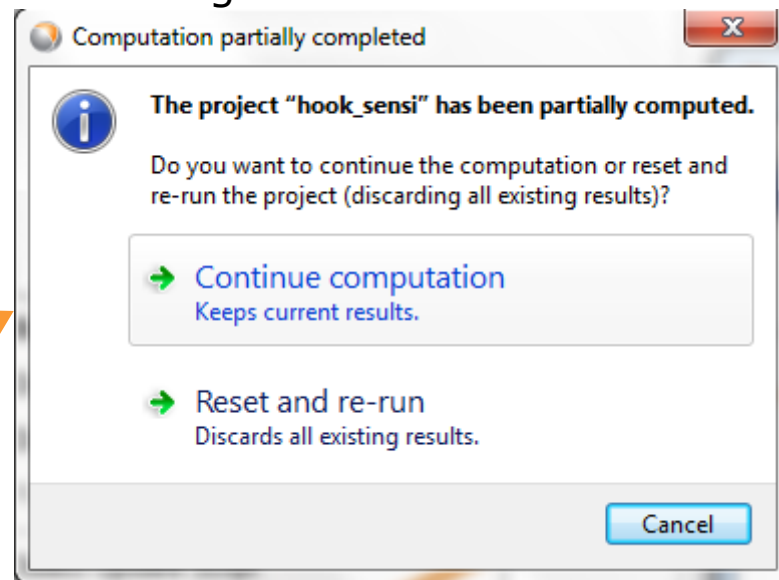
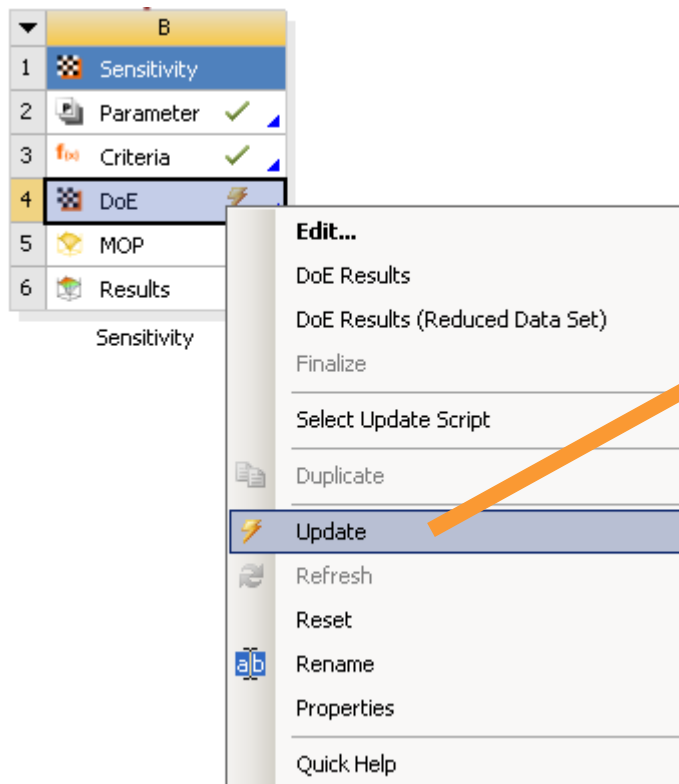
# Update Functionality optiSLang inside ANSYS v14.5





# Continue crashed session option inside ANSYS

optiSLang saves every design which was successfully calculated using update at optiSLang container continue or reset can be chosen using continue optiSLang only send unsolved designs





# Recalculate failed designs

- Due to different reasons design evaluations may fail
- With “Recalculate Failed Design Points” you can start them again

The screenshot shows the 'Sensitivity' dialog box with the 'Result designs' tab selected. The table below lists the design points, their status, and associated values. A context menu is open over the table, highlighting the 'Recalculate Failed Design Points' option.

	Id	Activation	Violated	Duplicates	Status	AREA01	AREA
1	0.50	<input checked="" type="checkbox"/> active	false		Succeeded	5.871	17.75
2	0.49	<input checked="" type="checkbox"/> active	false		Not succeeded	16.617	1.25
3	0.48	<input checked="" type="checkbox"/> active	false		Succeeded	14.627	11.25
4	0.47	<input checked="" type="checkbox"/> active	false		Not succeeded	9.453	19.75
5	0.46	<input checked="" type="checkbox"/> active	false		Succeeded	2.289	13.75
6	0.45	<input checked="" type="checkbox"/> active	false		Not succeeded	14.229	12.75
7	0.44	<input checked="" type="checkbox"/> active	false		Not succeeded	7.065	11.75
8	0.43	<input checked="" type="checkbox"/> active	false		Not succeeded	18.209	15.75
9	0.42	<input checked="" type="checkbox"/> active	false		Not succeeded	15.025	6.75



# Update via Python scripting

- ANSYS initialize per default an update mechanism, which updates a complete ANSYS Workbench project
- Mechanism can be overridden via python file
- optiSLang provides this feature for optiSLang design evaluations
- user has full access to his ANSYS model update

	A	B
1	Property	Value
2	[-] General	
3	Component ID	DoE (optiSLang)
4	Directory Name	Sensitivity
5	Open Postprocessing during Solver Run	<input type="checkbox"/>
6	Save Design Point Directories	<input checked="" type="checkbox"/>
7	[-] Update Options	
8	Run Python Script for Update	<input checked="" type="checkbox"/>
9	Python Script:	C:\Users\Verwalter\Desktop\Python Scripts\update.py



# Parallel evaluation using Ansys RSM

- ANSYS RSM is the powerful tool to distribute jobs
- optiSLang can fill the Workbench design table with a predefined number of designs
- ANSYS RSM organizes distribution of jobs
- If ANSYS RSM is installed you only need to:
  - Choose RSM Mode
  - Set max. number of parallel jobs

	A	B
1	Property	Value
2	General	
3	Component ID	DOE (optiSLang)
4	Directory Name	Sensitivity
5	Open Postprocessing during Solver Run	<input checked="" type="checkbox"/>
6	Open Postprocessing after Calculation	<input type="checkbox"/>
7	Save Design Point Directories	<input type="checkbox"/>
8	Update Options	
9	Use RSM Mode	<input checked="" type="checkbox"/>
10	Preferred Number of Design Points in Parallel	25



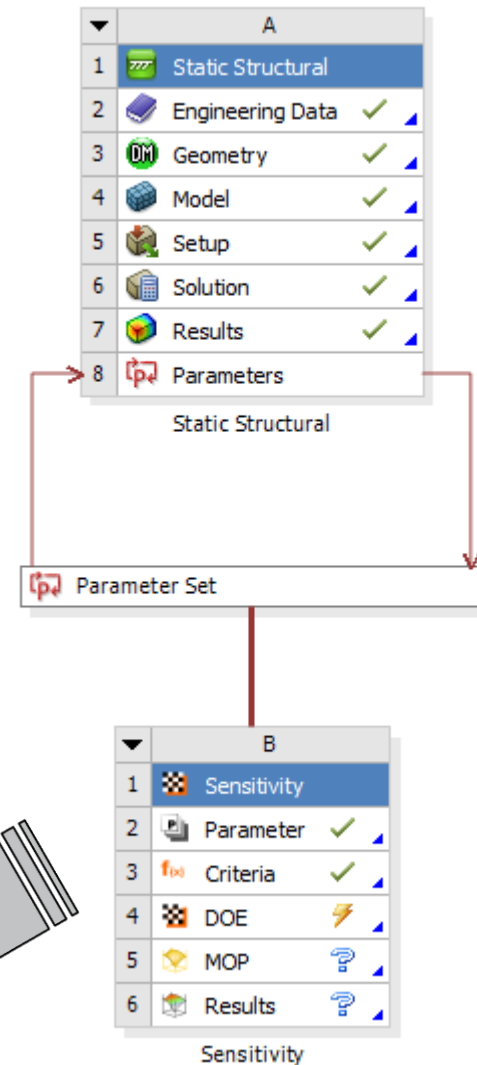


# ANSYS HPC Parametric Pack

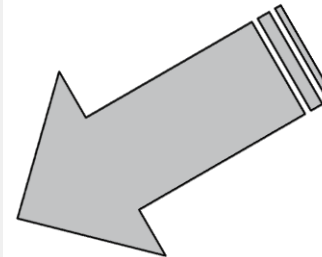
## optiSLang inside Ansys Workbench v14.5

### optiSLang Algorithm Settings

- Select "Use RSM Mode" to enable parallel design point submission
- Set the "Preferred Number of Design Points in Parallel" to the intended RSM job size



Properties of Schematic B4: DOE		
	A	B
1	Property	Value
2	General	
3	Component ID	DOE (optiSLang)
4	Directory Name	Sensitivity
5	Open Postprocessing during Solver Run	<input type="checkbox"/>
6	Open Postprocessing after Calculation	<input type="checkbox"/>
7	Save Design Point Directories	<input checked="" type="checkbox"/>
8	Notes	
9	Notes	
10	Update Options	
11	Use RSM Mode	<input checked="" type="checkbox"/>
12	Preferred Number of Design Points in Parallel	4



# Flow simulation of LCD manufacturing process

## Problem Description

- Identify model inflow parameter to match outflow
- Identified output velocities have to be in 10% error ranges comparing with reference values
- Input parameter: 10 pressure areas (100 design points)

## Detail:

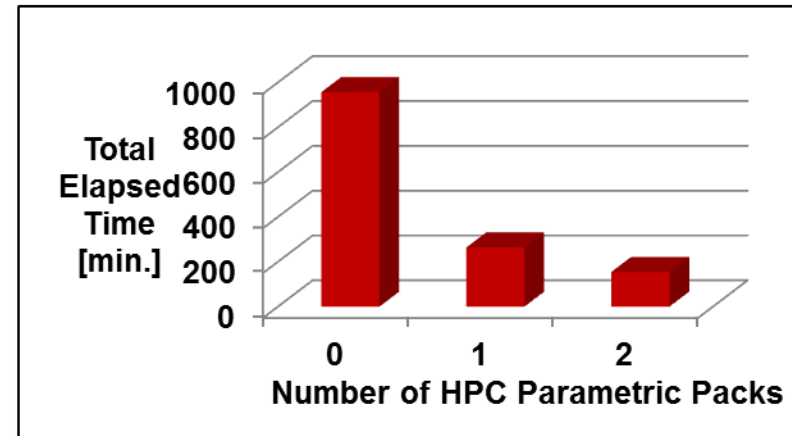
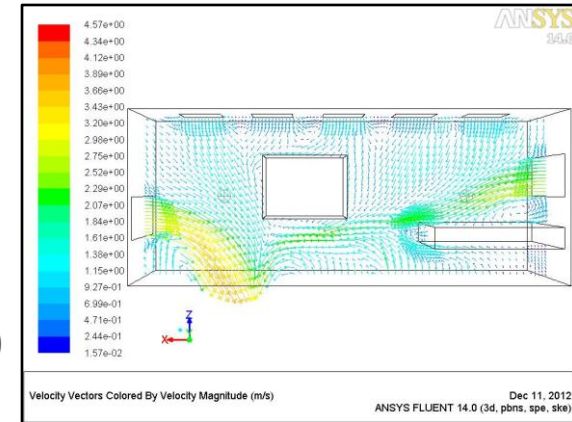
- Pressure-Based solver, K-Epsilon Model with Standard Wall Functions
- 78.800 nodes, 66.900 hexahedral elements
- Hardware: Workstation with dual Intel® Xeon® E5645 (2,4 GHz, 12 Cores), 96 GB, all jobs running 1 core

## Licensing Solution

- 1 Ansys Fluent
- 2 Ansys HPC Parametric Packs

## Result/Benefit

- ~6,2x speedup over sequential execution



# Temperature analysis of a Seal

## Problem Description

- Sensitivity study of influence of geometry variation to seal deformation
- 15 Input geometry parameter (100 design points)

## Detail:

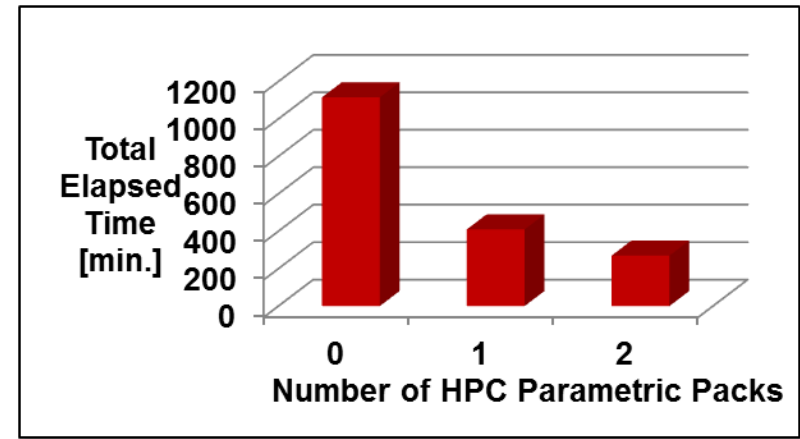
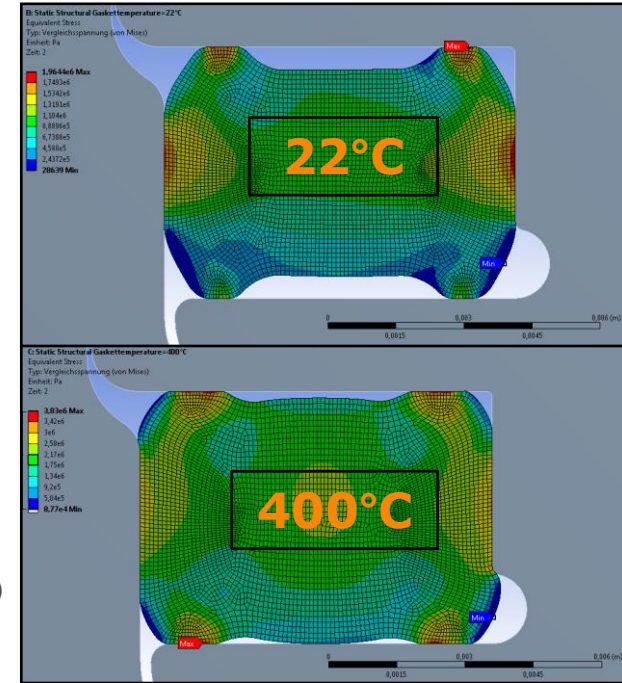
- Mechanical analysis with temperature loading
- 6.100 nodes, 5.500 elements (2D)
- Hardware: - Workstation with dual Intel® Xeon® E5645 (2,4 GHz, 12 Cores), 96 GB, all jobs running 1 core

## Licensing Solution

- 1 Ansys Mechanical, 1 Ansys DesignModeler
- 2 Ansys HPC Parametric Packs

## Result/Benefit

- ~4,1x speedup over sequential execution
- Easier and fully automated workflow!



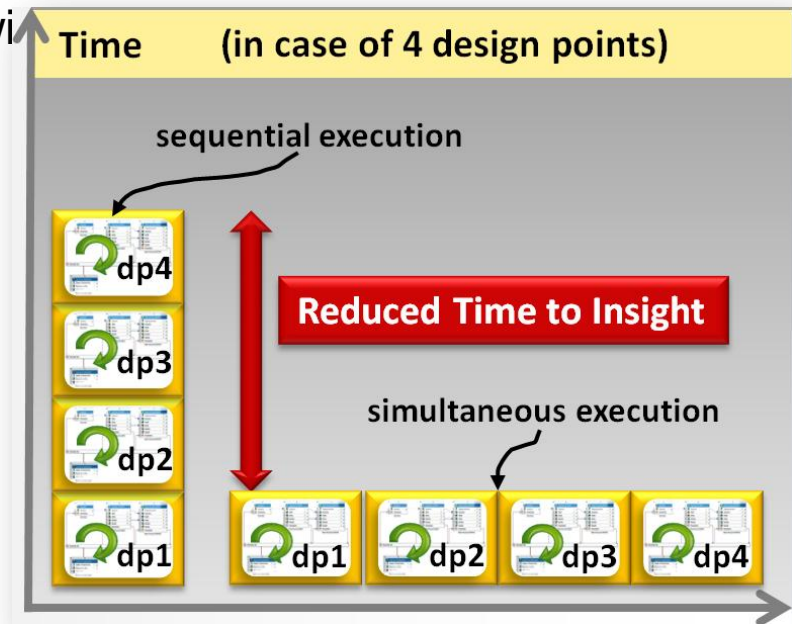
# Benefit of ANSYS HPC Parametric Pack

Faster turn around time for multiple jobs

- Geometry update and Result processing will be performed sequentially on local resource
- Meshing, solution, result extraction executed in parallel

Scaling factor depend on:

- time for geometry update
- time for meshing & solution
- hardware environment

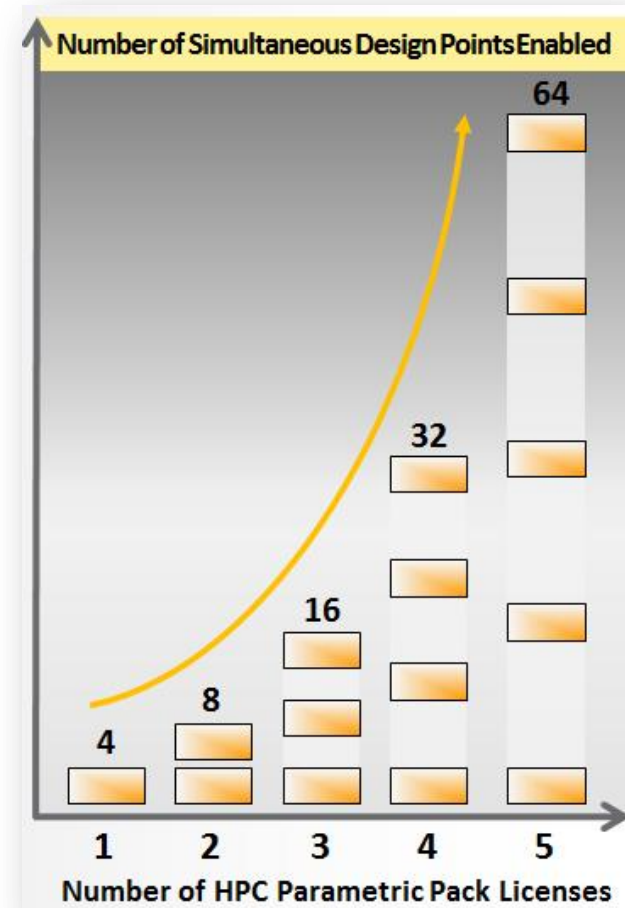


# Benefit of ANSYS HPC Parametric Pack

Get ready for RDO by multiplying base licenses

One base license set can be multiplied by ANSYS HPC Parametric Packs

**Now small, medium & large companies can increase significantly the number of parallel jobs!**



# Get ready for RDO using ANSYS HPC Parametric Pack

HPC Parametric pack is available in ANSYS workbench only

all parametric models from ANYS classic needs to be integrated in ANSYS workbench

optiSLang v4 supports integration node for ANSYS workbench including parameterization of additional responses (signals,..)

Dynardo Consulting switched to HPC Parametric Pack for all ANSYS RDO tasks Q2/2013

