



Optics

Optiks / noun singular

Science of **vision, generation,**
Propagation and behavior of light.

Ansys Simulation Platform

Ansys / OPTISLANG

Simulation Automation and Optimization

FLUIDS



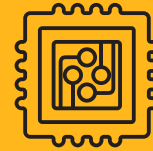
STRUCTURES



ELECTROMAGNETICS



SEMICONDUCTOR



EMBEDDED SOFTWARE



OPTICAL



Ansys / GRANTA



Materials Information Management

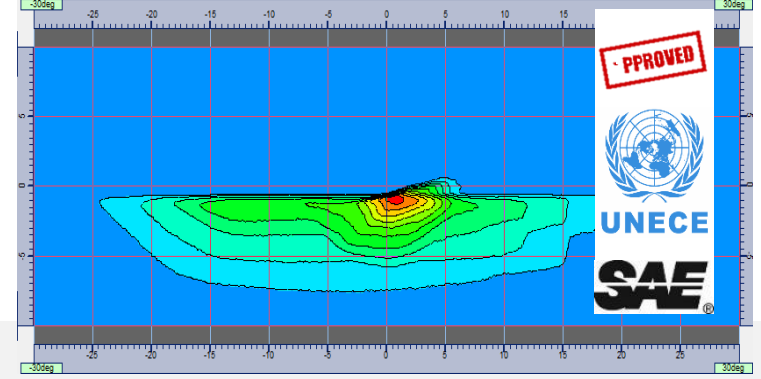
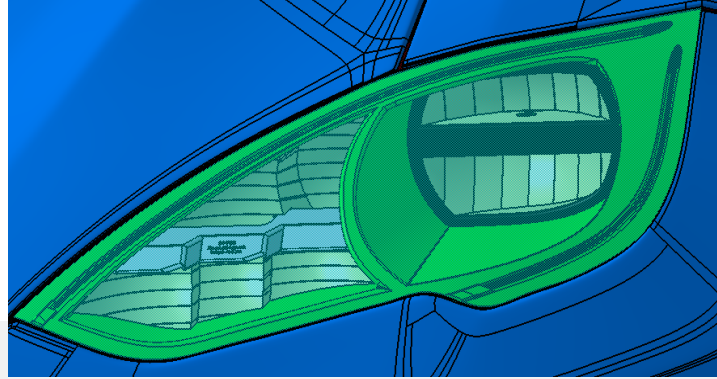
Ansys / MINERVA



Simulation Process and Data Management

Ansys

Ansyes SPEOS | A collaborative design platform



Imagine



Engineer

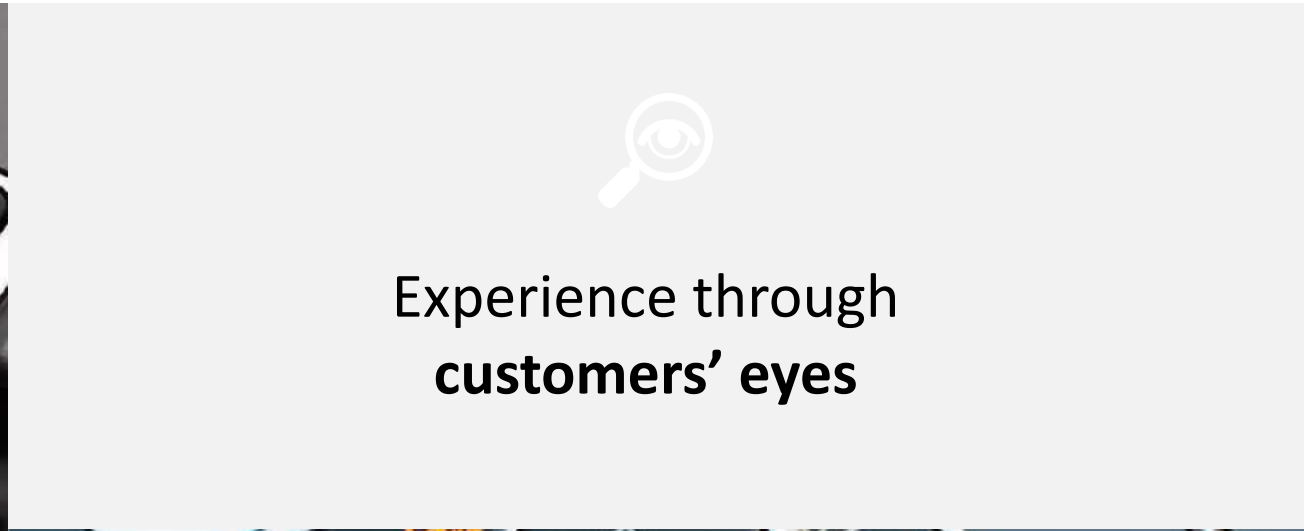


Comply

Compatible with all CAD platforms



ANSYS SPEOS | Predictive simulation for informed decision-making

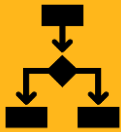


Do it right the first time



Compatible with all CAD platforms

- ▶ Easy-to-use and deploy
- ▶ CNC ready: direct manufacturing



Physics-based modeling

- ▶ Reliable decision-making tool
- ▶ Simulation of all materials and sources



Industry-oriented

- ▶ Powerful easy-to-use analysis tools + library
- ▶ IP management: secured data exchanges

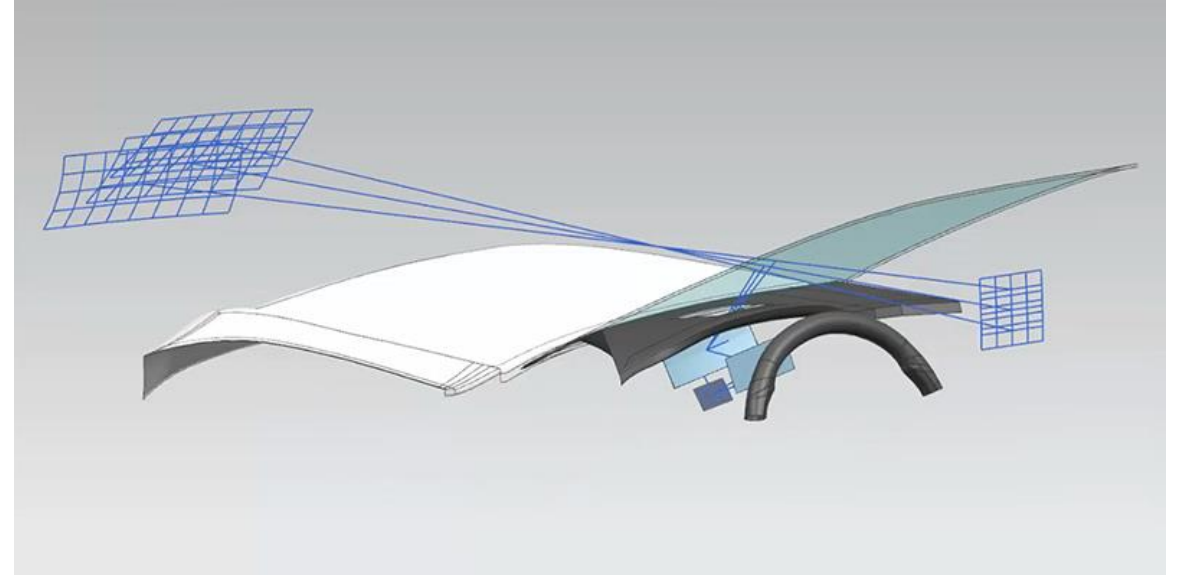


Dedicated engine & algorithms

- ▶ Precise true-to-life results in a fast time
- ▶ Cloud ready

/ What is a HUD?

- Head-up display (HUD)
- Transparent display within the windshield
- Application in automotive, aircraft, military, etc.
- Data presentation, e.g. speed, pressure, height, navigation, etc.



How to optimize a HUD?

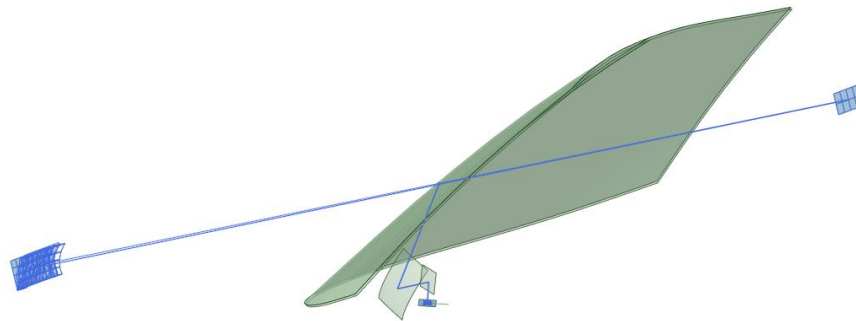
Current state of the art

- Sequential optimization of windshield and HUD
- Create windshield with known working criteria
- Optimize a mirror system for this windshield

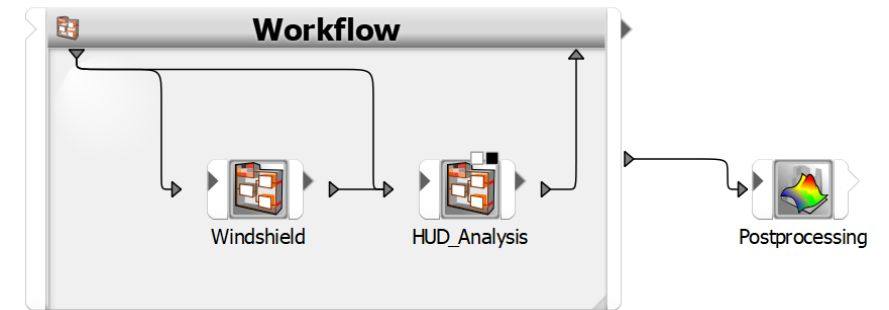
Process automation with Ansys SPEOS & optiSLang

- Using an automotive head-up display (HUD) imaging system
- Optimization of the aspherical mirror
- Combine optimization of HUD and Windshield
- Improve the system's quality during development by identifying potential issues early in the design, including complex boundary conditions
- Identify critical input values
- Less user input through process automation & higher information generation

How to optimize a HUD?



```
border,6  
degree,5  
closed,0  
periodic,0  
U_Multiplicity,-839,0,839  
U_Parameter,6,5,6  
V_Multiplicity,0,699.0787532  
V_Parameter,6,6  
U_range,-838.14584961889466,838.171119234  
V_range,0,699.0787532  
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780.65830733457915,-641.80396376222268,655.88916819922122,  
585.41755981000836,-716.10853116064504,542.18490633319539,  
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938.54045326812286,-530.54223682278621,744.47552484085134,  
911.32306062416706,-540.93539690466127,731.83232829573558,
```



Get Initial Data from CAD

Define Geometry and Simulation
in Ansys SPEOS

Process automation in Ansys optiSLang

CAD-agnostic workflow

- Postprocess geometry in Ansys Speos
- Simulate the Design

- Simulation automation
- Design optimization & exploration

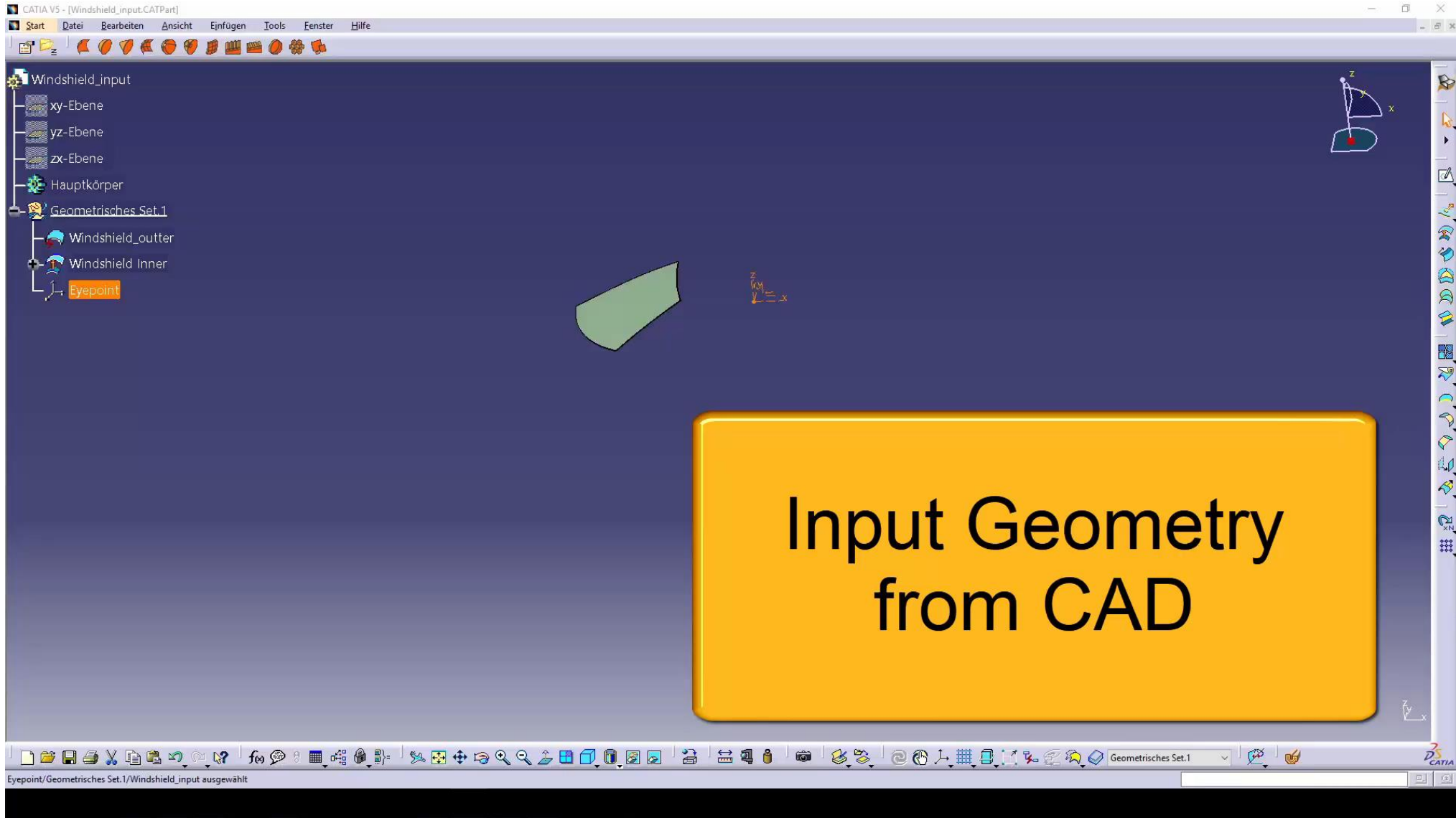




Design Generation with Ansys SPEOS



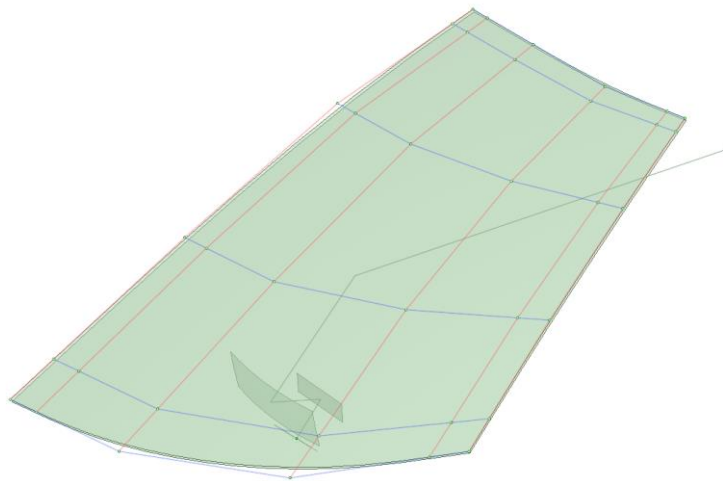
Initial Design of Windshield & HUD



Initial Design of Windshield & HUD

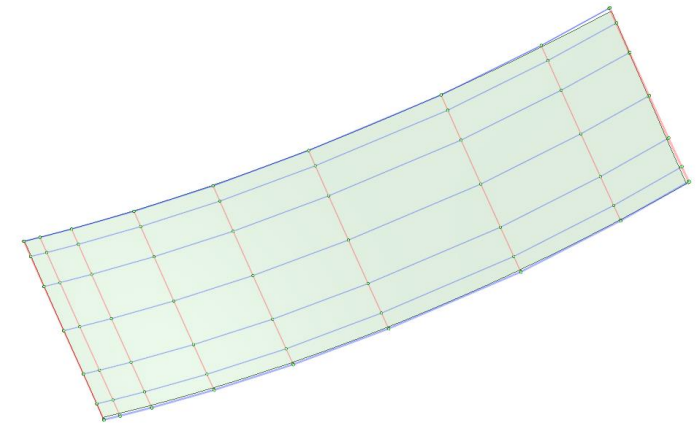
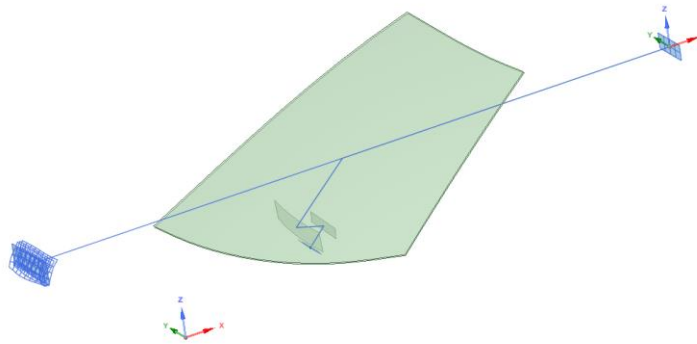
Windshield

- Optimization geometry
- Symmetry assumption
- Implement design and regulation constraints



Head-up display (aspherical mirror)

- Create initial design using Ansys SPEOS
- 81 points for design of aspherical mirror
- Eyeboxes: analysis of 1 point per eyebox
- Eyedistance = 65 mm





Workflow and Postprocessing with Ansys optiSLang



What possibilities are included in Ansys optiSLang ?

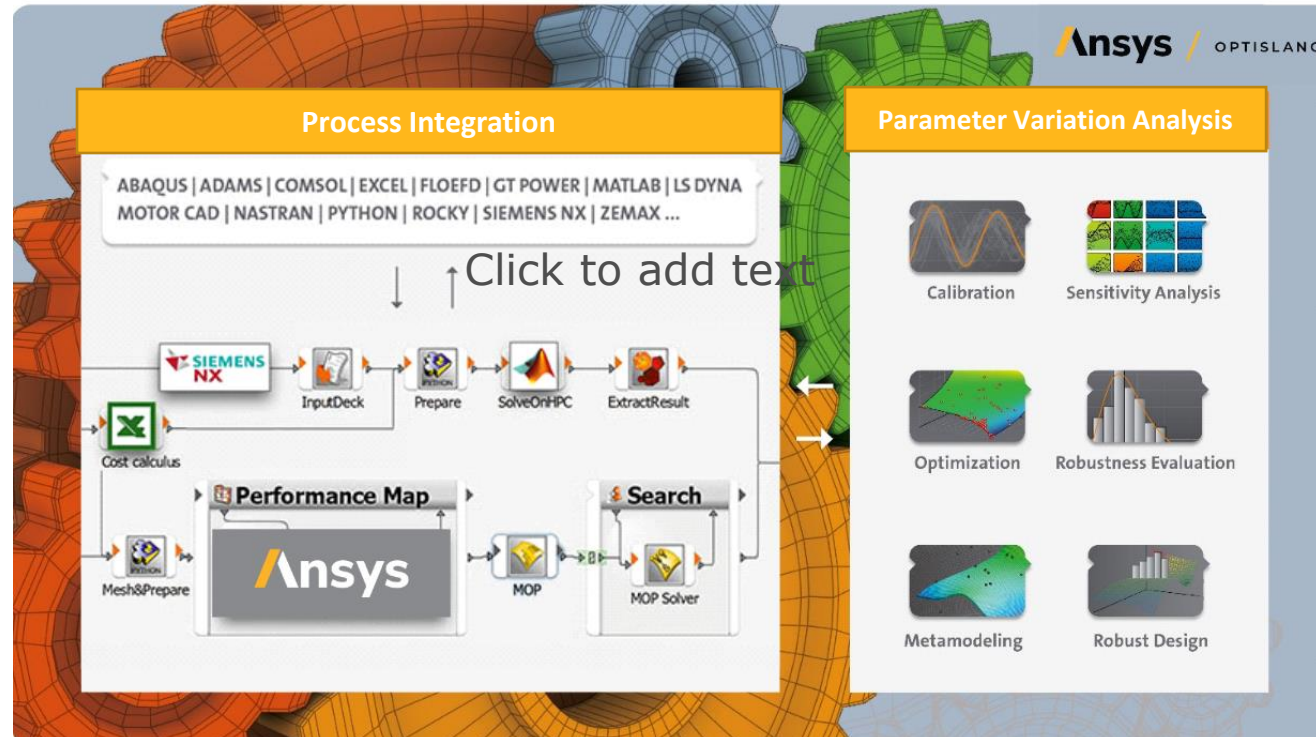
Process integration

Workflow Building and Process Automation

Variation Analysis

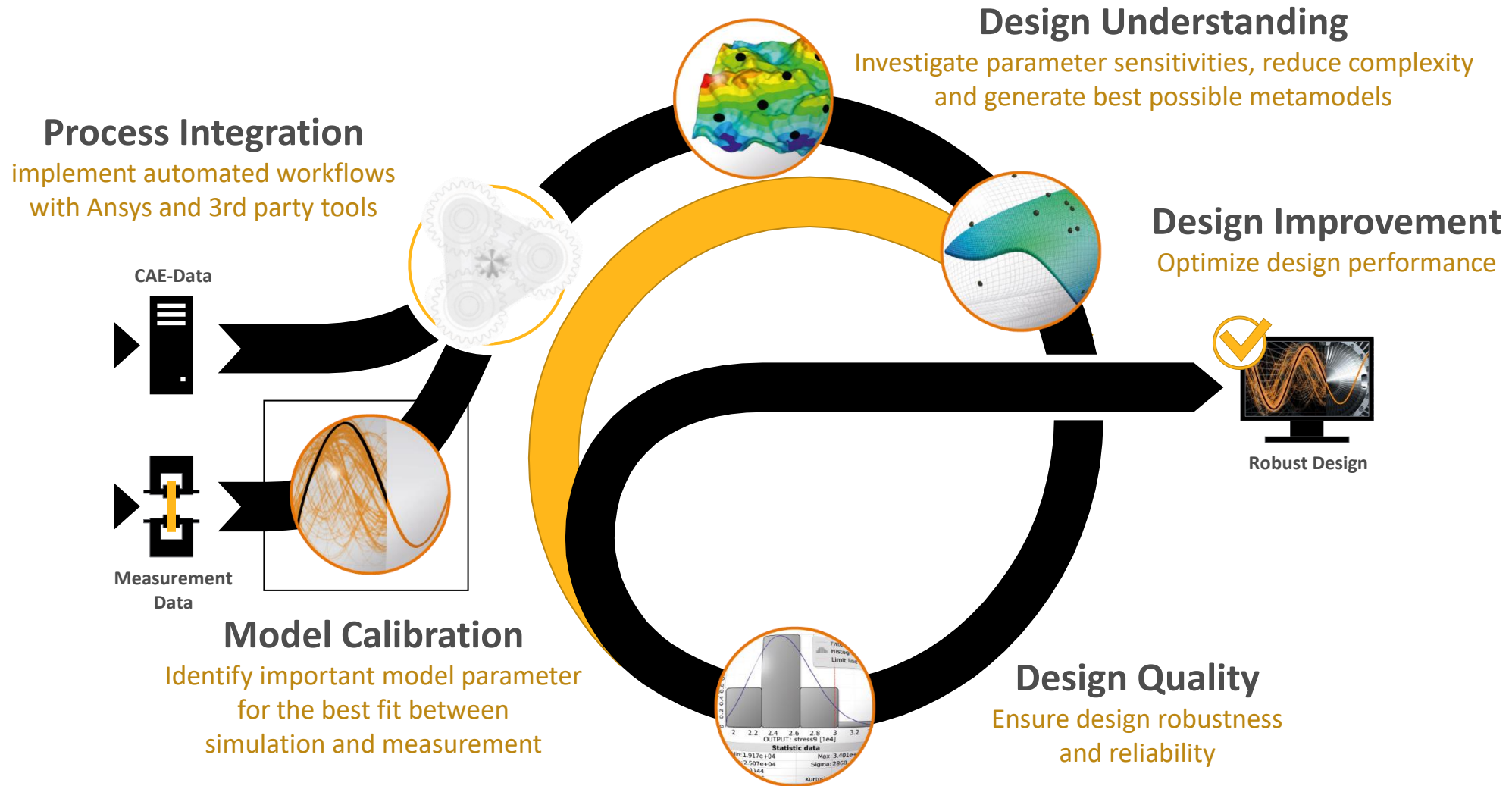
Algorithms for robust design optimization

- Automated workflows
- Support all Ansys tools
- Support 3rd party tools
- Open and flexible
- Build vertical apps
- Integration with Minerva
- "Simulation for non-simulation experts"



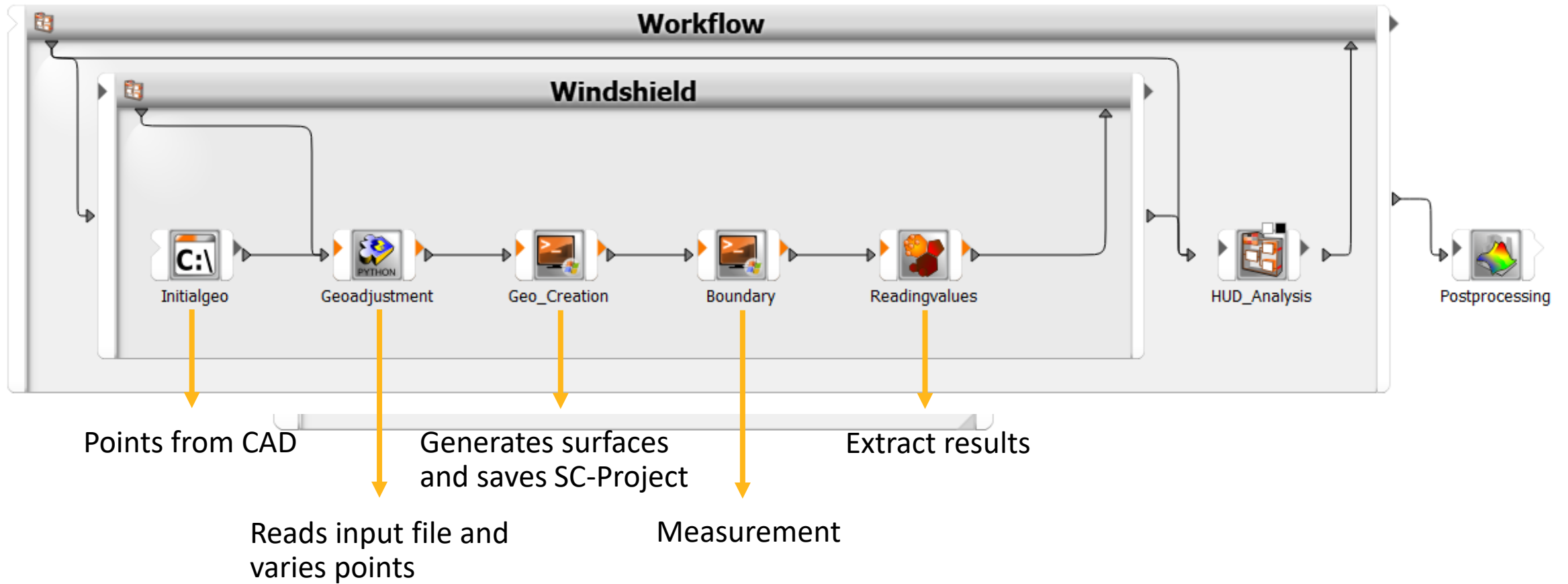
- Identify relevant parameters
- Reduce complexity
- Understand your design
- Optimize your product with minimal effort
- Verify the robustness and reliability of your design
- Creates Data-based ROMs for digital twins

Best Practice Guideline for Virtual Product Development



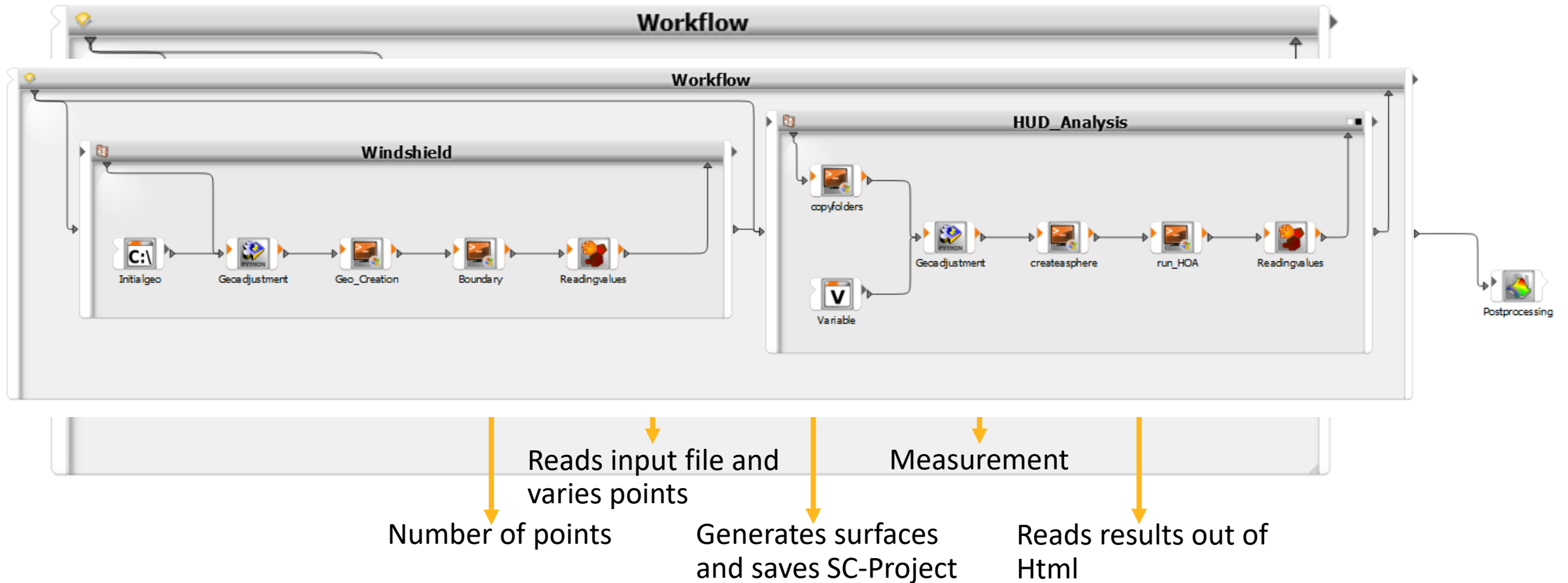
Workflow

- Combination of HUD and Windshield optimization



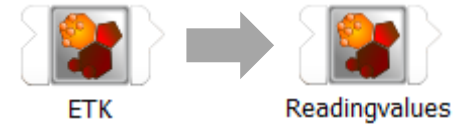
Workflow

- Combination of HUD and Windshield optimization



Workflow

- Extract responses out of Html file with ETK-node
 - Extraction Tool Kit
 - Very powerful



```
353 <td>Virtual · Image · Distance</td>      424 <td>Ghost</td>
354 </tr>                                     425 </tr>
355 </table>                                 426 </table>
356 <h2><h2></h2></h2><ul>                   427 <h2><h2></h2></h2><ul>
357 </ul>                                     428 </ul>
358 <table>                                   429 <table>
359 <tr · class="line1">                     430 <tr · class="line1">
360 <td><b>Configuration</b></td>            431 <td><b>Configuration</b></td>
361 <td><b>Central · Eyebox</b></td>          432 <td><b>Central · Eyebox</b></td>
362 </tr>                                     433 </tr>
363 <tr · class="line2">                     434 <tr · class="line2">
364 <td><b>Driver · offset · (mm)</b></td>      435 <td><b>Driver · offset · (mm)</b></td>
365 <td>0.000</td>                           436 <td>0.000</td>
366 </tr>                                     437 </tr>
367 <tr · class="line1">                     438 <tr · class="line1">
368 <td><b>Average · (mm)</b></td>            439 <td><b>Average · (')</b></td>
369 <td>1707.623</td>                       440 <td>0.000</td>
370 </tr>                                     441 </tr>
```

The screenshot shows the ETK software interface. The main window displays HTML code from 'HUD Optical Analysis.1.html'. A context menu is open over the word 'Configuration' in the code. The 'define marker' option is selected, and a tooltip shows 'use "Configuration" as marker' and 'use "Configuration" as repeated marker'. Below the code, there are configuration options for 'Line' and 'Token' extraction, including 'Offset', 'Increment', and 'Max' values. The 'Variable Name' is set to 'Central_Eyebow'. On the right side, there is a 'Responses' panel listing various mean values like 'Astigmatism_mean', 'Convergence_mean', etc.



Inputs & Responses

Inputs

- Support points
 - Windshield: variation of coordinates $\pm 1\text{cm}$ (\neq variation of windshield surfaces) - 36 points
 - Asphere: variation of coordinates $\pm 0.1\text{mm}$ (81 points)
 - 3x3 inputs through neighbors relationship

HUD NurbsPoint

81				45				9
77				41				5
73				37				1

Responses

- Optical responses
 - Ghost
 - Astigmatism
 - Convergence
 - Image Distance
- Geometrical responses
 - Rotation
 - Dynamic Distorsion

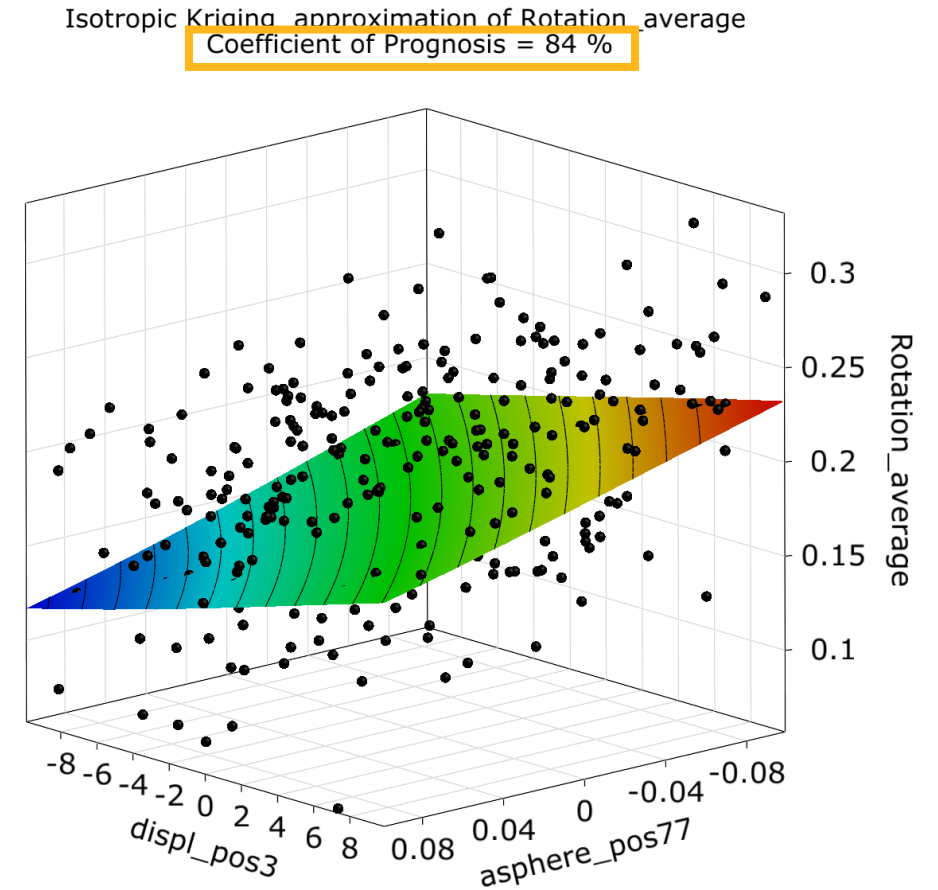
Criteria

- Challenge: compromise between contradicting optical and geometrical responses
 - Multiobjective Optimization
 - Objectives: minimization of the geometrical and optical responses

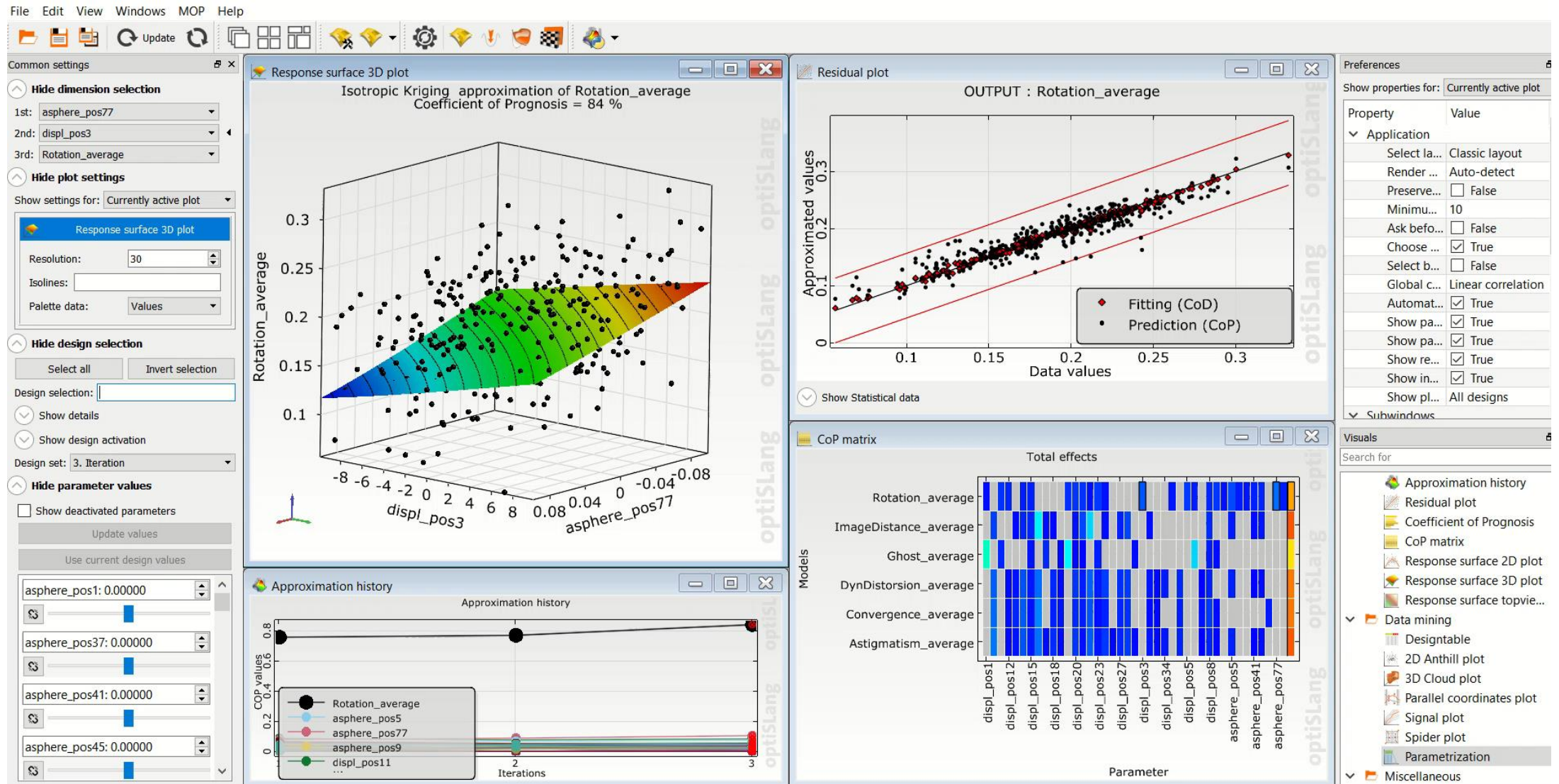
Criteria					
Name	Type	Expression	Criterion	Limit	Evaluated expression
obj_optics	Objective	$(\text{Ghost_average} + \text{Astigmatism_average} + \text{Convergence_average} + \text{Image_Distance_criterium})/3$	MIN		3.00114
obj_geometry	Objective	$(\text{DynDistorsion_average} + \text{Rotation_average})$	MIN		2.41782
Image_Distance_criterium	Variable	$(2000 - \text{ImageDistance_average})/300$			1.0191

Sensitivity Analysis

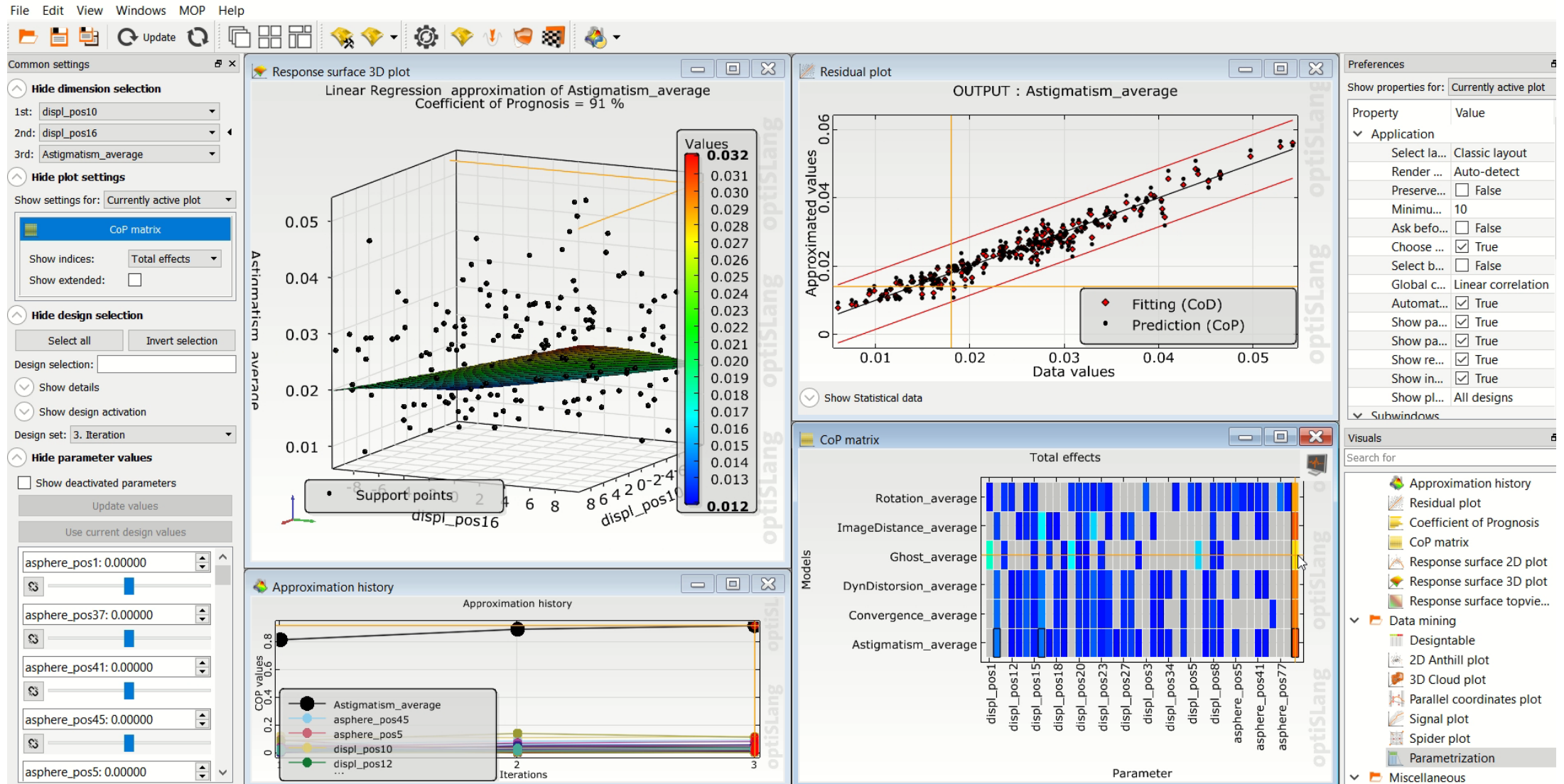
- MOP – Metamodel of Optimal Prognosis
- Representation of the 3D Surface Response Plot of “*Rotation_average*” as response with the two most important parameters “*displ_pos3*” and “*asphere_pos77*”
- High approximation quality (CoP = 84 %)



Sensitivity Analysis

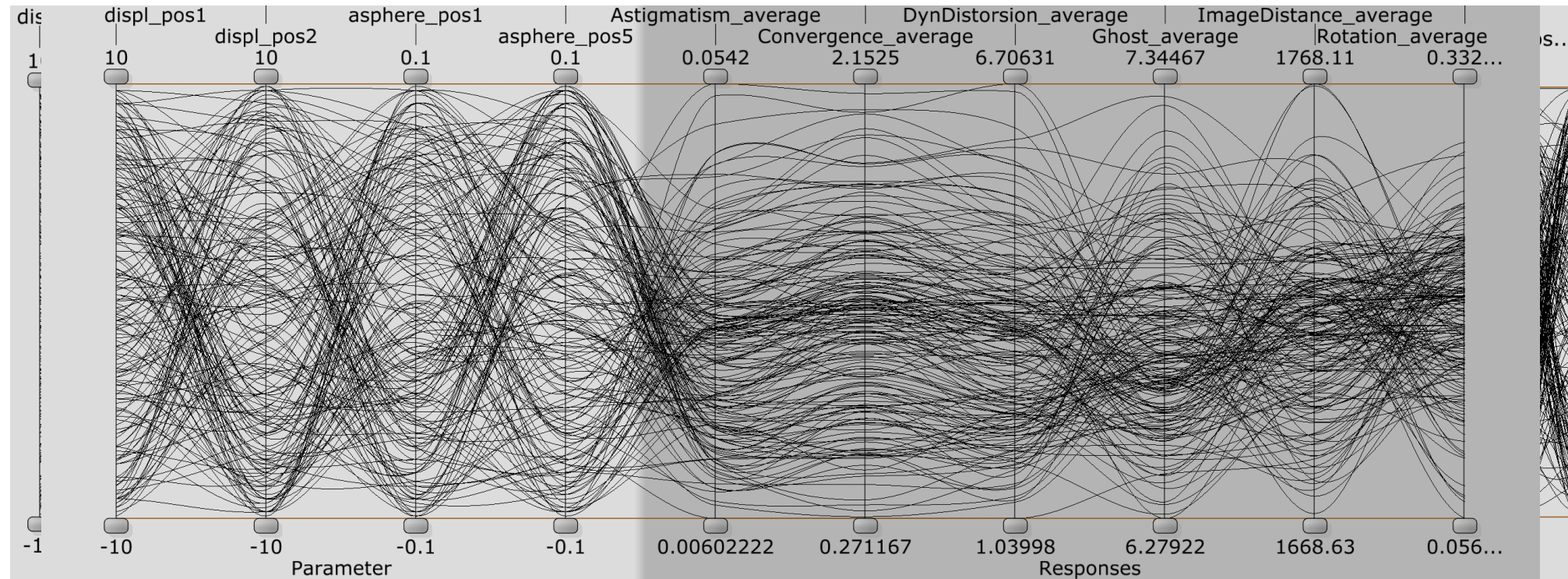


Sensitivity Analysis

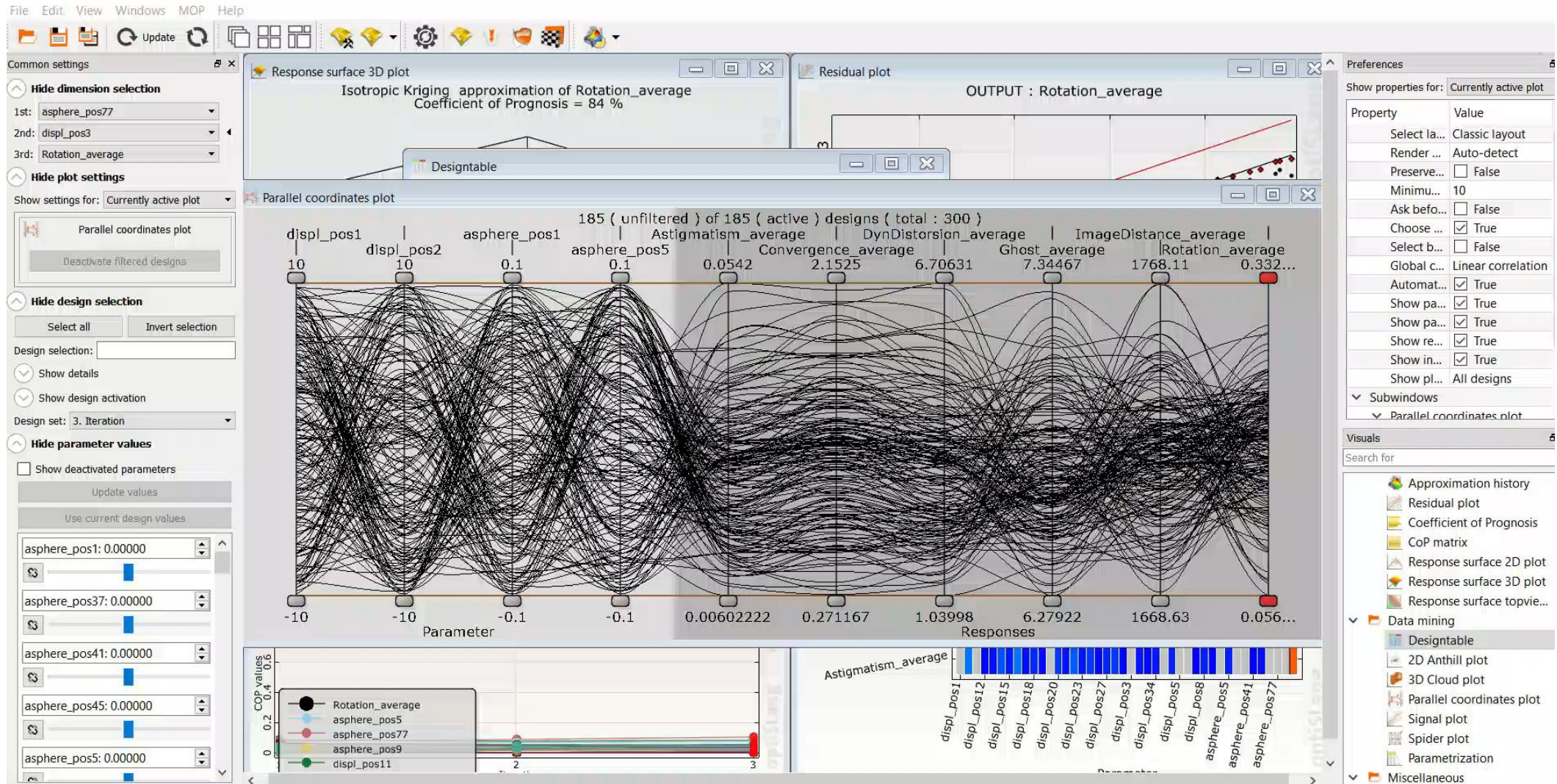


Sensitivity Analysis

1. Parallel Coordinates Plot: each line represents one design → demonstrates the conflicting responses

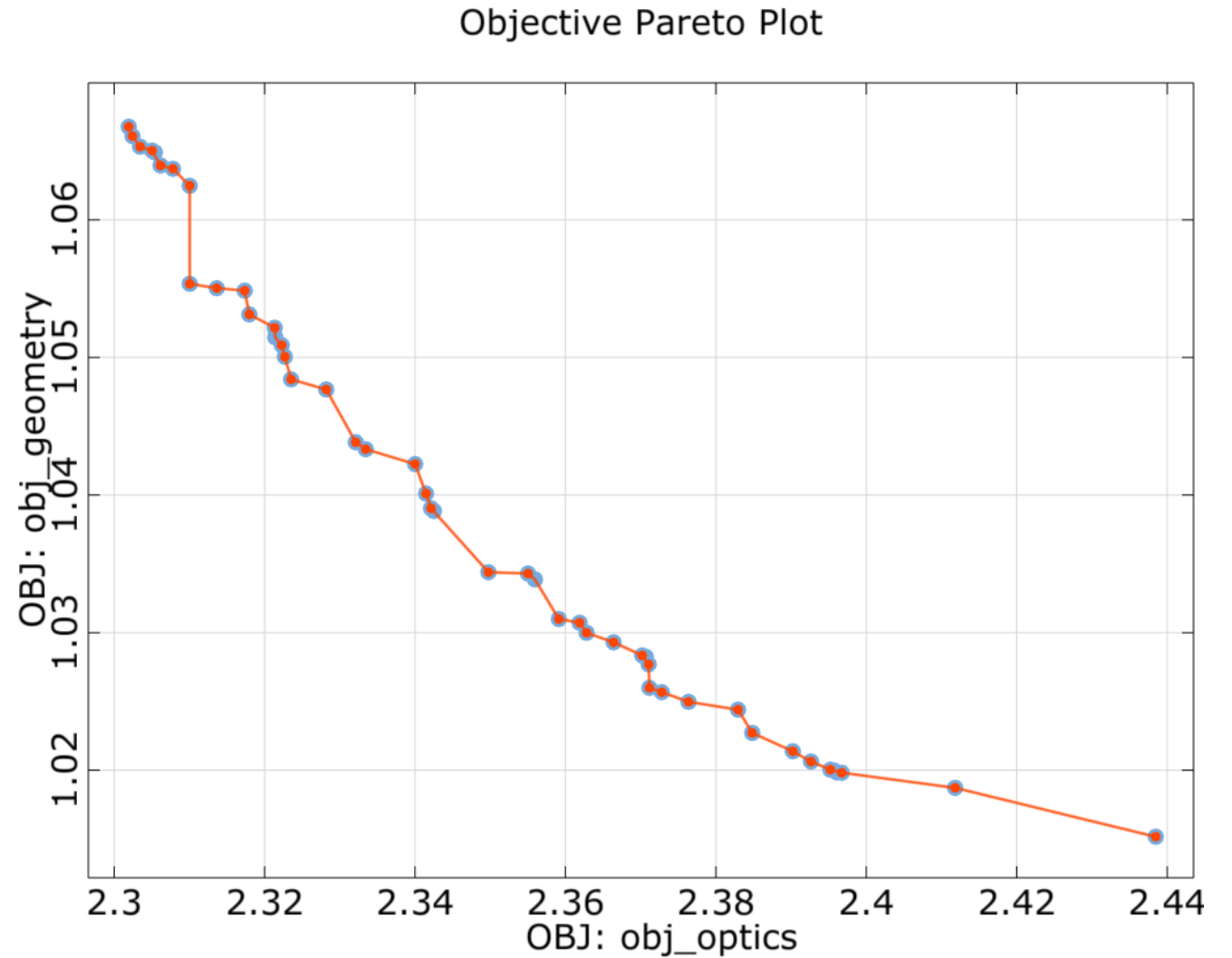


Sensitivity Analysis



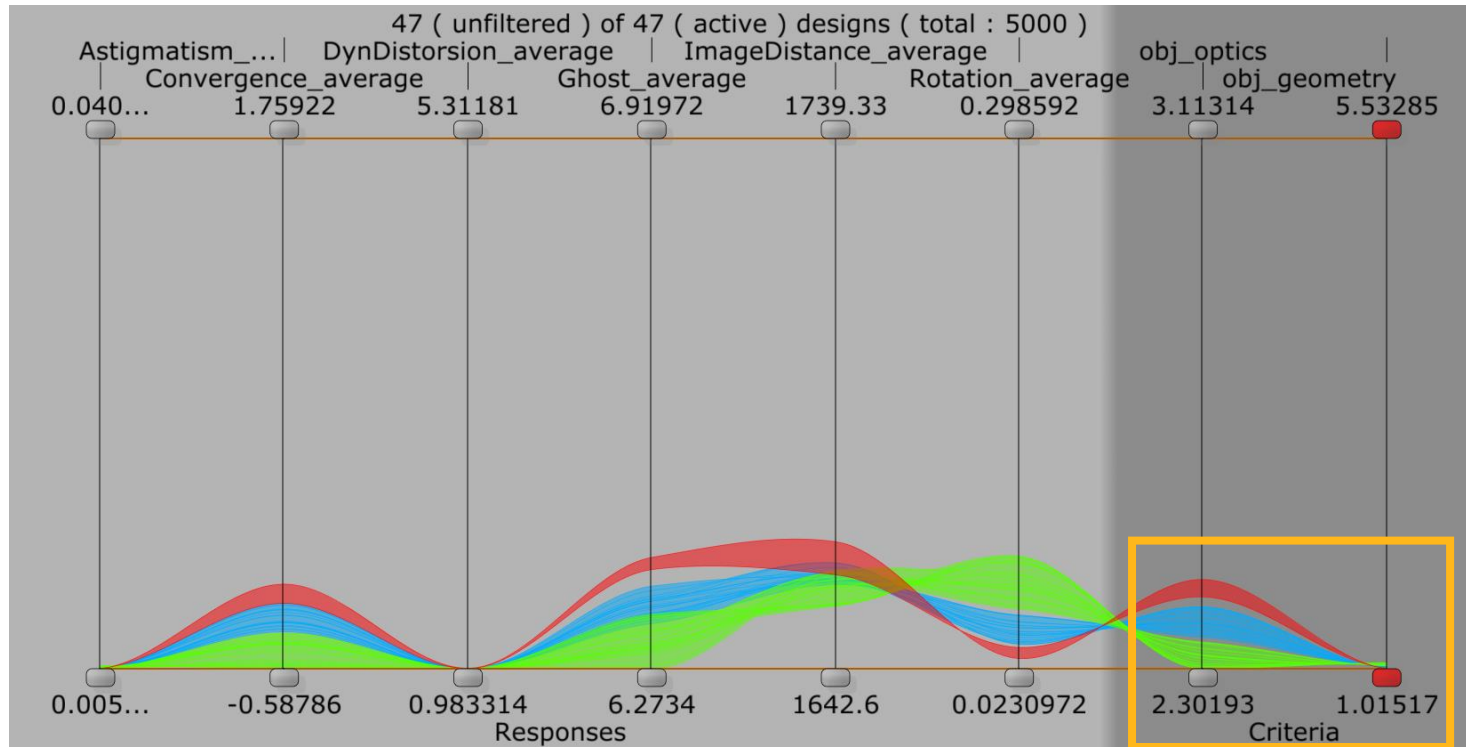
Optimization

- Paretofront: best designs without domination between designs

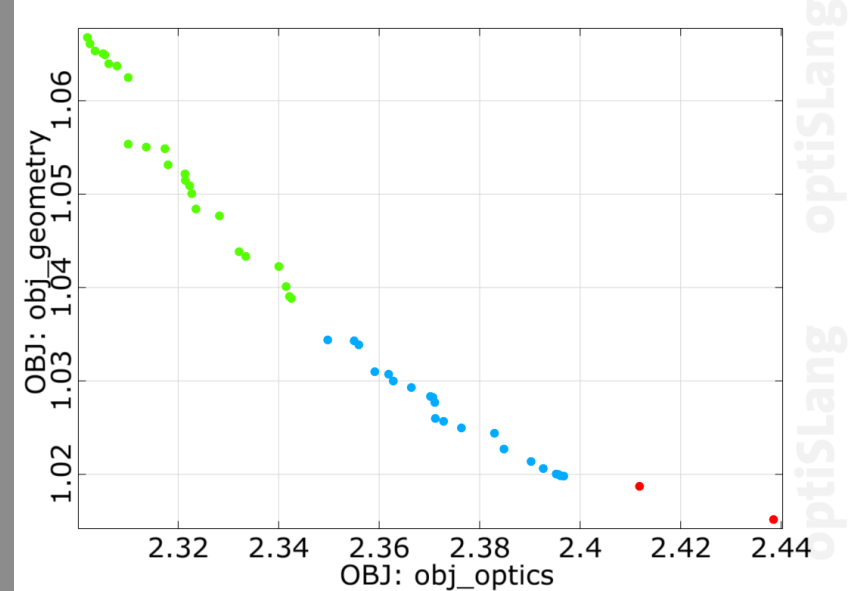


Optimization

- Contradicting objectives visualized by clustering the best designs
- better understanding of relation between parameters, responses and objective space



OBJ: obj_optics vs. OBJ: obj_geometry, (linear) $r = -0.967$



Summary

/ Summary

- Design Generation
 - Variation of support points usable for every other application (e.g. lens systems, freeforms, headlamps, reflectors)
- Workflow and Postprocessing
 - Automation for combined optimization of HUD and Windshield
 - Designunderstanding
 - Solution for contradicting responses through multiobjective optimization



Thank you



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Blog

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Ingenieurs ohne Grenzen (Engineers Without Borders), a 3D-printed Ansys Fluent simulation software to develop a water-pow in rural Cameroon.



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Learn how leading rail companies use simulation to drive innovation and enter the market with new technologies.

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Fluids Blog

Uncharted Waters: Simulation Helps Design What Could be the Wo



A team of students and early career engineers from the Swiss Federal Institute of Technology (EPFL) is using simulation to challenge the world



Blog

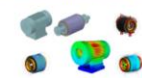
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Thought leaders from Microsoft, HPE, AMD, Red Bull Racing and others are pushing the boundaries of engineering what's ahead during Simulation World 2021, the world's largest simulation event.



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Wang has been named as one of the top 20 women in the cybersecurity field in Singapore.

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9

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18th Weimar Optimization and Stochastic Days 2021
June 17th & 18th -- We meet virtually this time

6 PLENARY SESSIONS

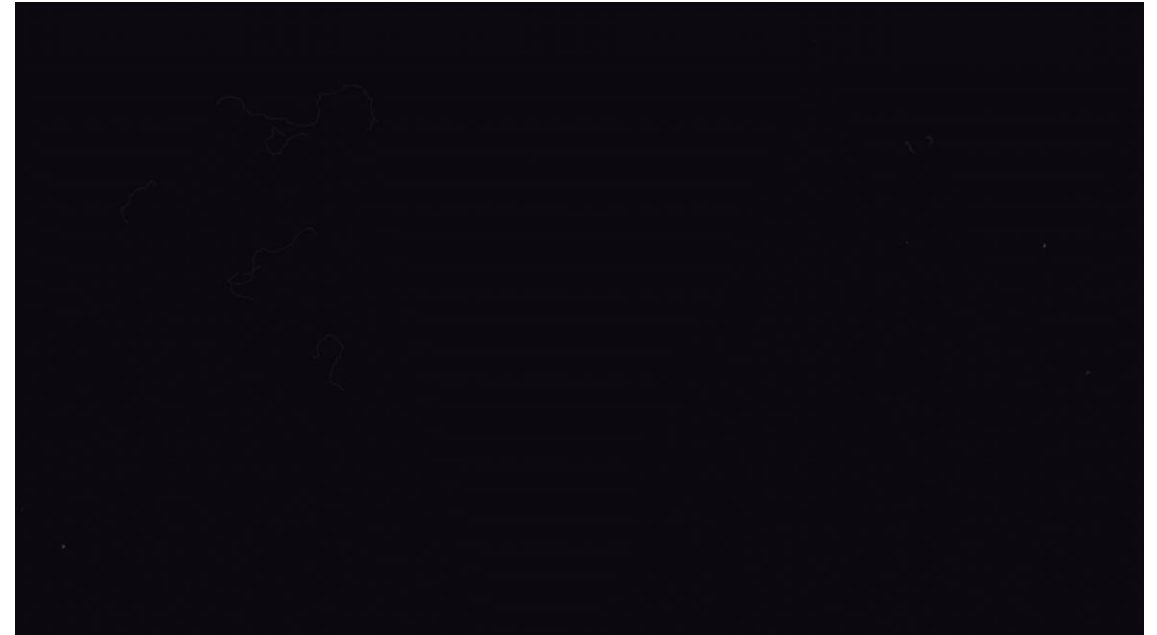
5 INDUSTRY APPLICATION TRACKS

2 ROUNDTABLES

+30 SPEAKERS

TOPICS:

- Design Optimization
- Simulation Process Automation and Orchestration
- Platform R&D Update
- Metamodeling
- Reliability Analysis & Calibration

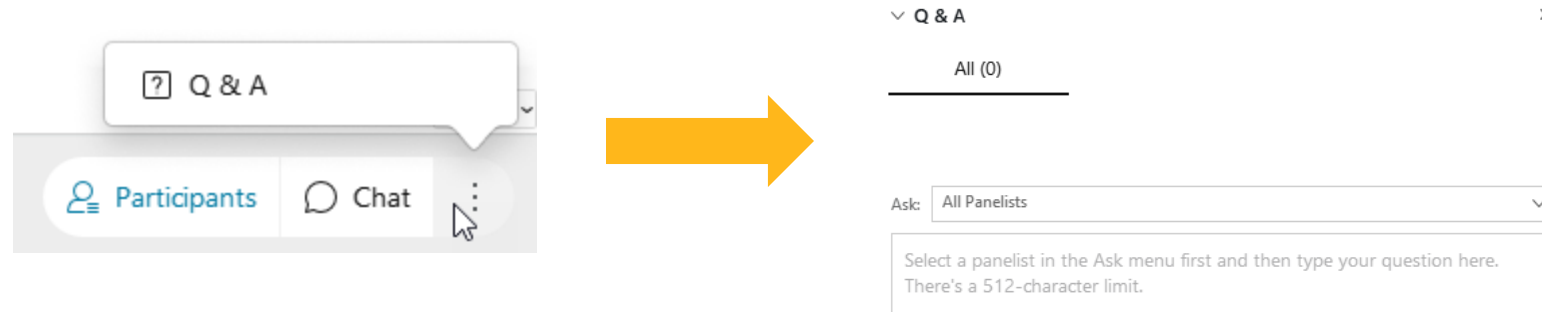


Agenda & Registration



/ Questions?

To ask a question, click on the Q&A button at the bottom of the screen to display the Q&A window:



The recording will be available in about one week on the Ansys resource center:

ansys.com/resource-center


/ Ask our Experts!



Sabrina Niemeyer

Application Engineer

Ansys optiSLang

 Sabrina.Niemeyer@ansys.com



Stefan Thoene

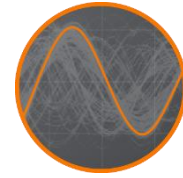
Lead Application Engineering

Ansys Speos

 Stefan.Thoene@ansys.com

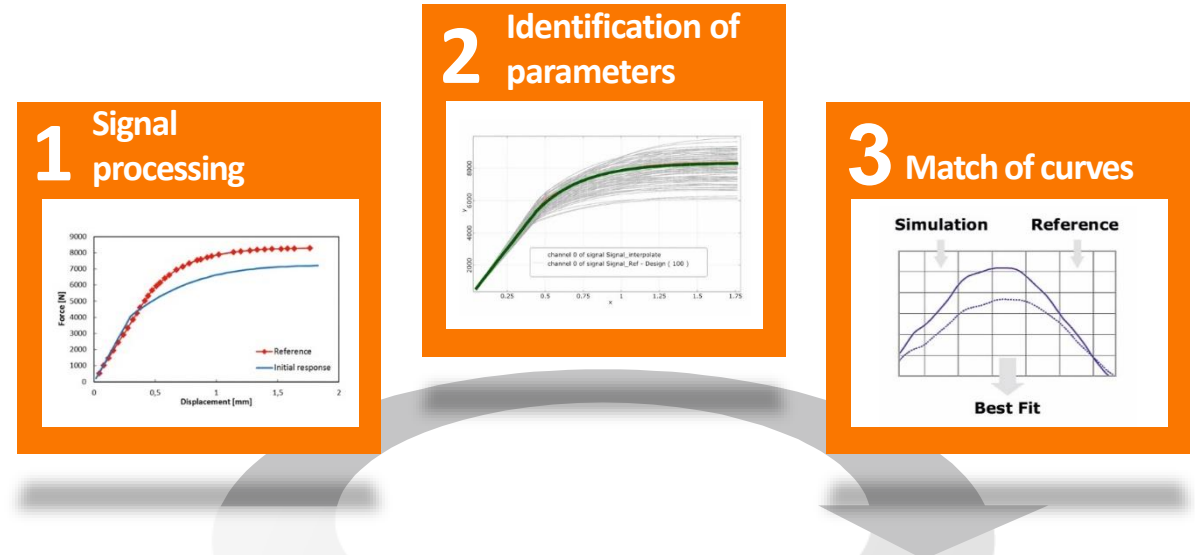
Appendix

- How good fits your simulation to measurements?
- Do you need to qualify your model?
- Do you have unknown parameters?
- Automatic calibration incl. curves
- Possibility to test different model definitions (from simple to complex)



Model Calibration

Model update to increase your simulation quality

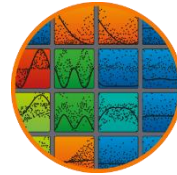


Use scalar values or signals inside ANSYS Workbench
Identify which parameters have influence and can be calibrated
Match experimental data with simulation

DoE & Sensitivity Analysis

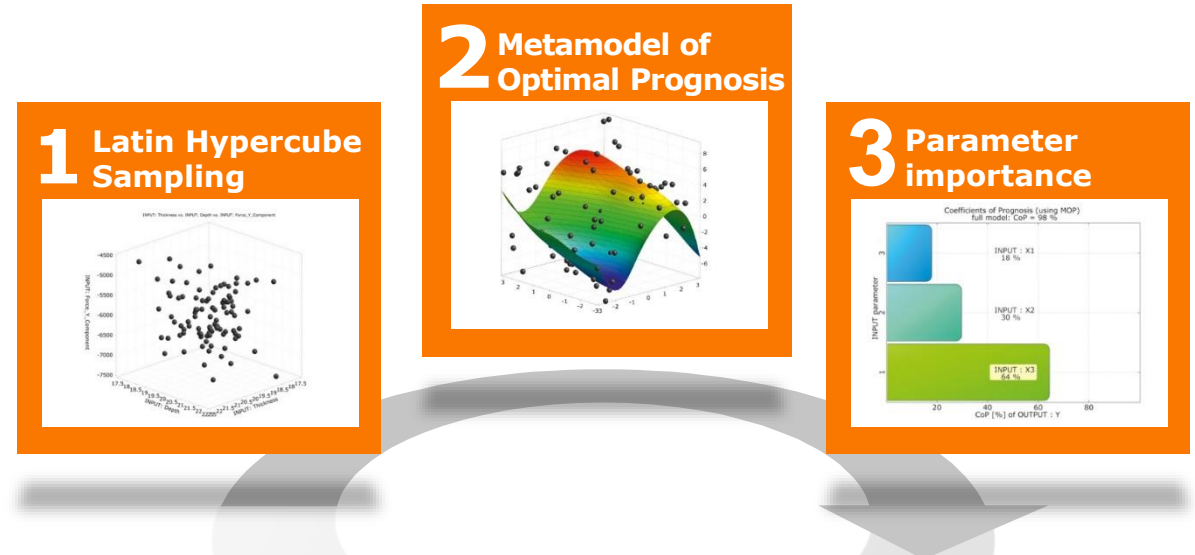
Understand your possibilities:

- Take a deep look at the **space of opportunities**
- Learn which design parameter is important and how to define the goals and the limitations to **find the right way**



Sensitivity Analysis

Understand the most important input variables



Automatic workflow with a minimum of solver runs to:

- Identify the important parameters for each response
- Generate best possible metamodel (MOP) for each response
- Understand and reduce the optimization task
- Check solver and extraction noise

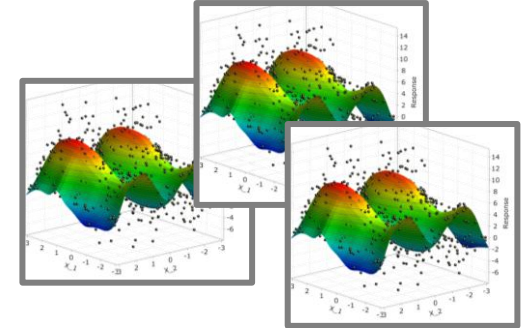
Dynardo's metamodels: MOP – Metamodel of Optimal Prognosis

MOP for scalar values:

- Objective measure of prognosis quality = **CoP**
- Determination of relevant parameter subspace
- Determination of optimal approximation model
- Approximation of solver output by fast surrogate model without over-fitting
- Evaluation of variable sensitivities

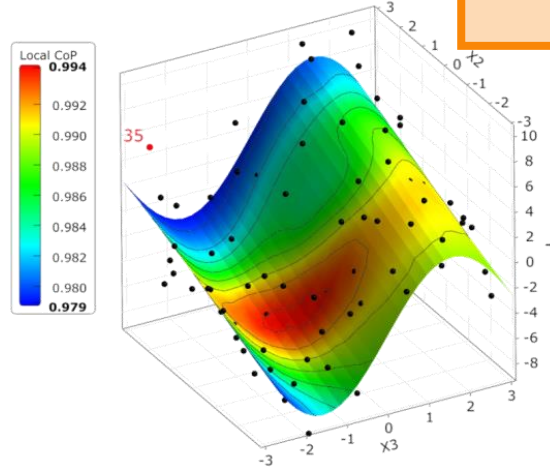
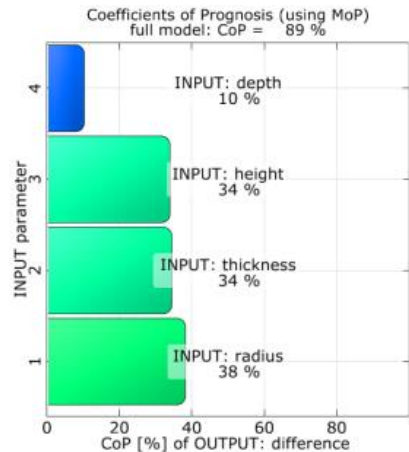
investigate response by response based on LHS sampling

generate competing meta-models

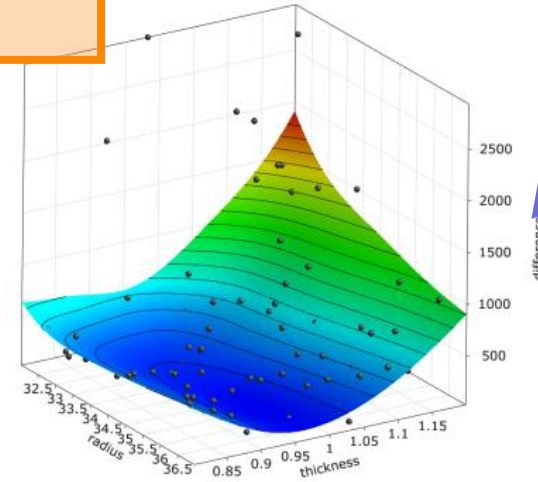


The winner is ... **MOP**

calculate forecast quality using **CoP** (Coefficient of Prognosis)



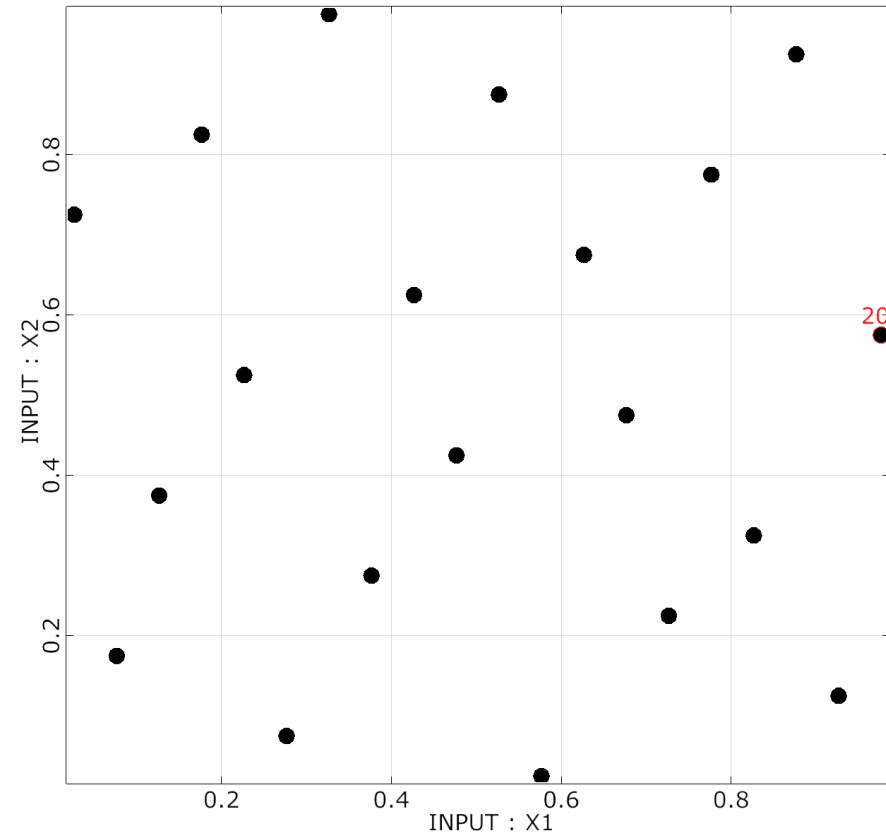
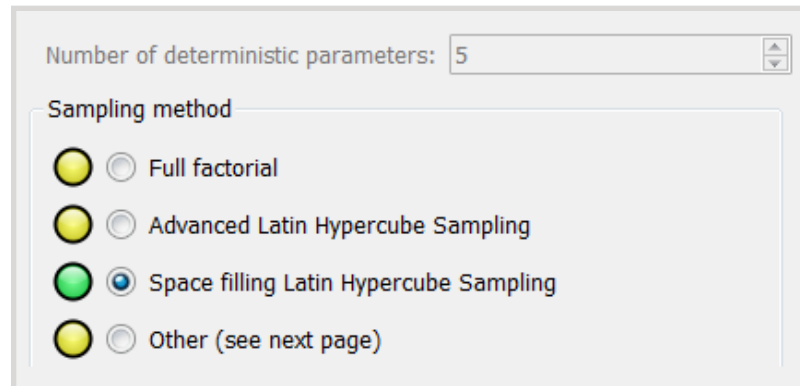
MLS approximation of difference
Coefficient of Prognosis = 89 %



DoE & Sensitivity Analysis

Space-filling Latin Hypercube Sampling:

- Samples are located at the mid-points of intervals
- Considers existing start designs
- Considers discrete parameters
- **Space filling property is optimized**
- Very efficient in low dimensions
- Recommended for **up to 5 parameters**



DoE & Sensitivity Analysis

Advanced Latin Hypercube Sampling:

- Samples are located at the mid-points of intervals
- Considers existing start designs
- Considers discrete parameters
- **Input correlation errors are minimized**
- Highly efficient in higher dimensions
- Recommended for **more than 5 parameters**

Number of deterministic parameters: 20

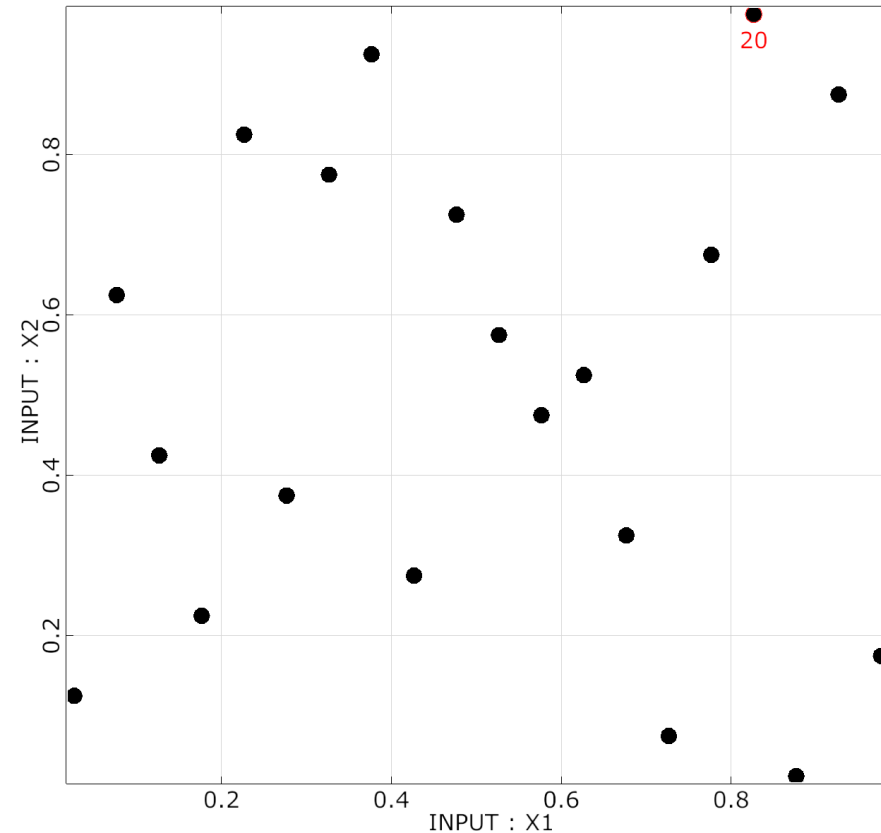
Sampling method

Full factorial

Advanced Latin Hypercube Sampling

Space filling Latin Hypercube Sampling

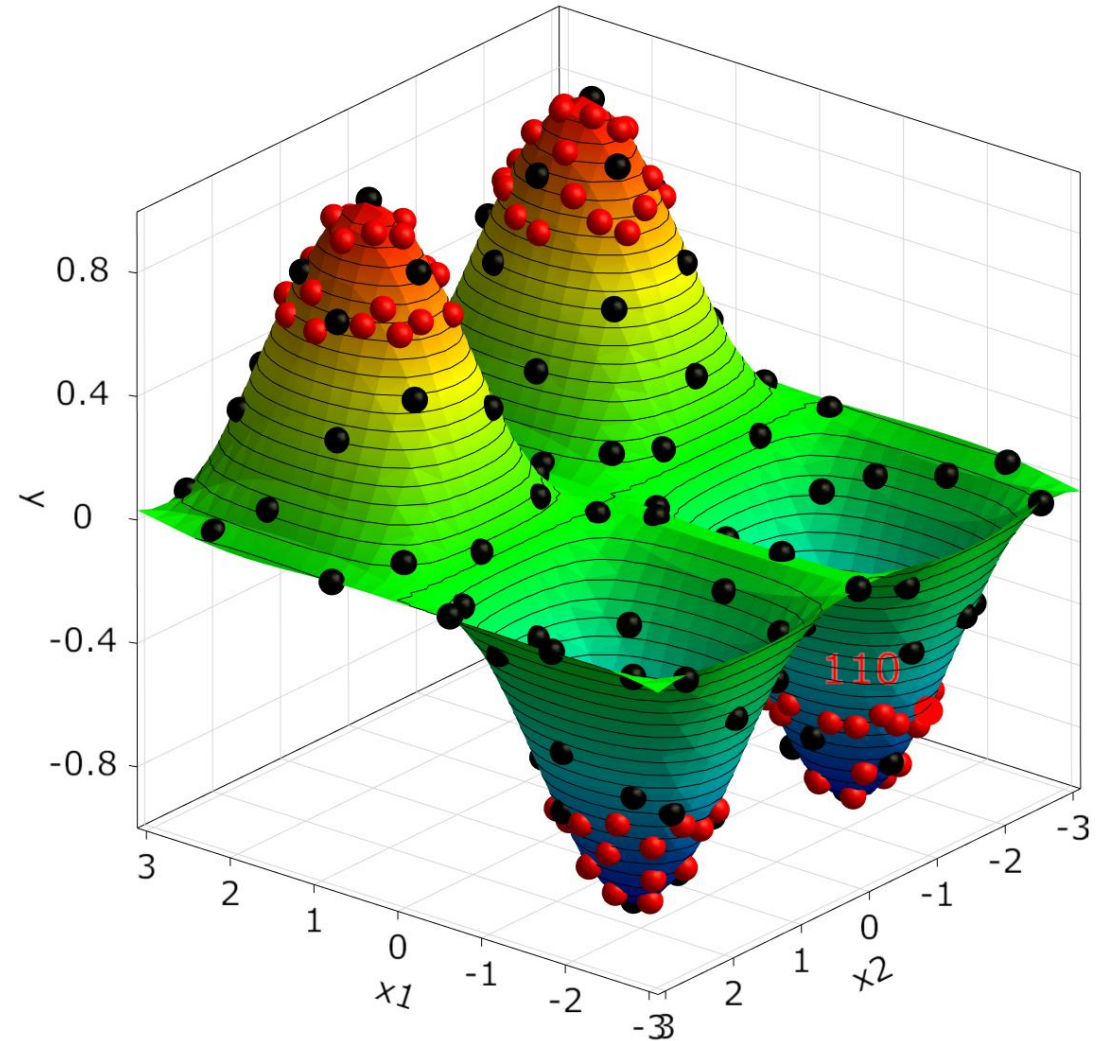
Other (see next page)



Adaptive Metamodel of Optimal Prognosis - AMOP

- Automatic adaptation of an initial sampling set
- **Global refinement** with advanced and space-filling Latin Hypercube Sampling
- **Local refinement** considering
 - Sample density
 - Local approximation errors
 - Optimization criteria

AMOP constraint refinement for $\text{abs}(y) > 0.6$



AMOP – Global Refinement

Start iteration

- Works as Sensitivity system
- Sampling and deterministic DoE schemes are possible
- Considers start designs

Refinement

- Analogous Sensitivity wizard on Sensitivity
- Only sampling schemes
- Considers all previous designs

Convergence/Stop if

- Target CoP is reached for all global CoPs of selected responses
- Maximum number of iterations reached

The screenshot shows the 'Adaption' tab of the AMOP settings dialog. It is divided into several sections: 'Adaption', 'Start iteration', 'Refinement', and 'Convergence criteria'. The 'Adaption' section has 'Refinement type' set to 'Global' and 'Maximum number of samples' set to 300. The 'Start iteration' section has 'Use start designs only' unchecked, 'Sampling type' set to 'Space filling Latin Hypercube Sampling', and 'Number of samples' set to 100. The 'Refinement' section has 'Sampling type' set to 'Space filling Latin Hypercube Sampling' and 'Number of samples' set to 100. The 'Convergence criteria' section has 'Target CoP' set to 0.9 and 'Maximum iterations' set to 3. A 'Show advanced settings' checkbox is checked.

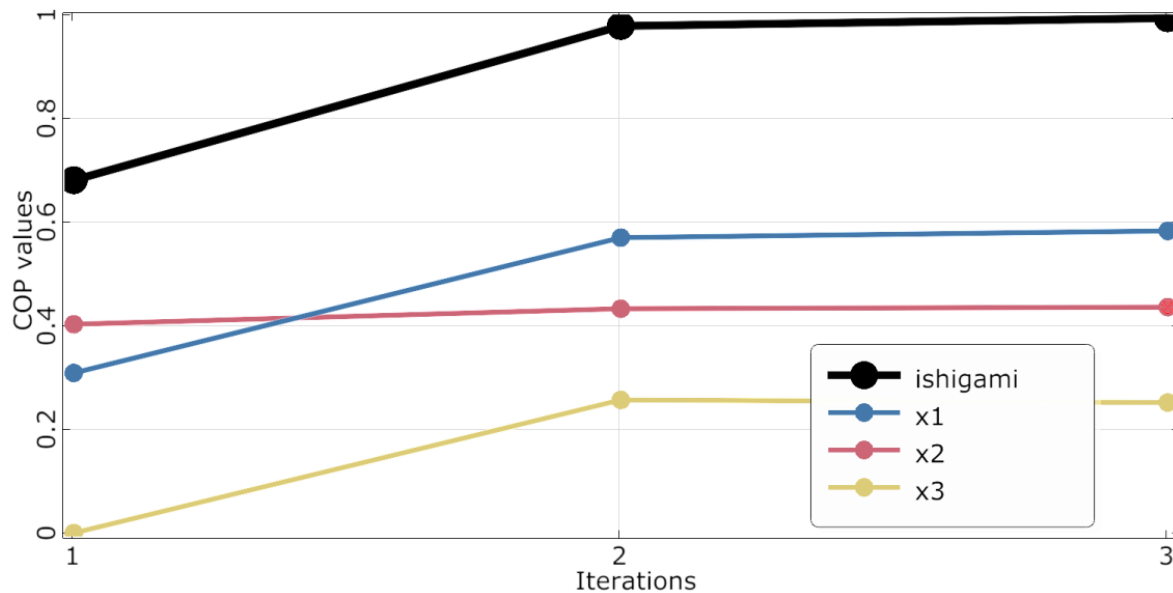
Parameter	Start designs	Criteria	Adaption	MOP	Other	Result designs
Adaption						
Refinement type:			Global			
Maximum number of samples:			300			
<input checked="" type="checkbox"/> Show advanced settings						
Start iteration						
<input type="checkbox"/> Use start designs only						
Sampling type:			Space filling Latin Hypercube Sampling			
Number of samples:			100			
Refinement						
Sampling type:			Space filling Latin Hypercube Sampling			
Number of samples:			100			
<input type="checkbox"/> Consider failed designs						
Convergence criteria						
Target CoP:			0.9			
Maximum iterations:			3			

AMOP – Global Refinement

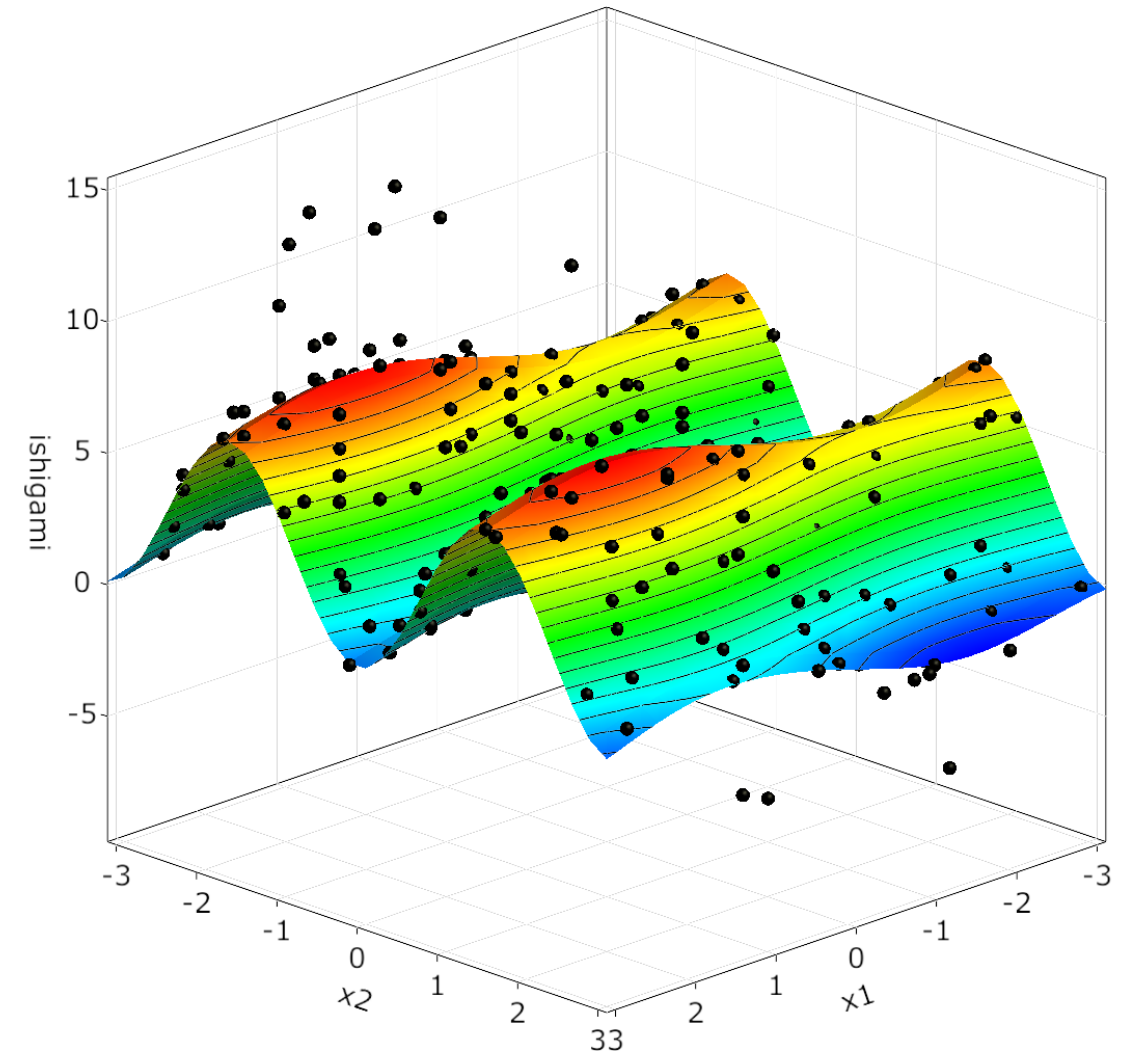
Example Ishigami function

- Iteration 3: CoP = 99 %
- All three important variables are detected
- Target CoP is reached

Approximation History



Isotropic Kriging approximation of ishigami
Coefficient of Prognosis = 99 %



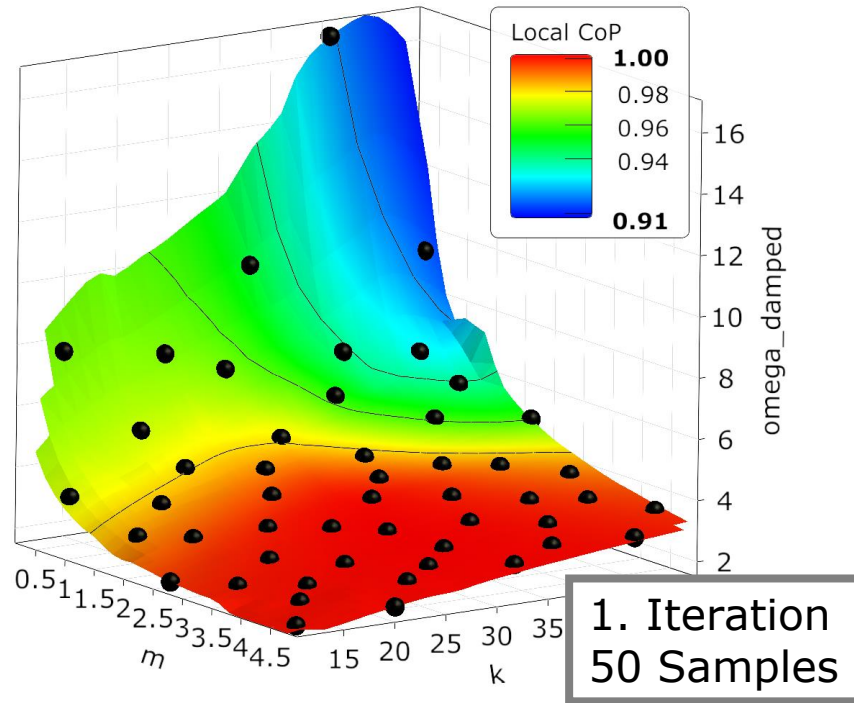
AMOP – Local Refinement

Using local CoP

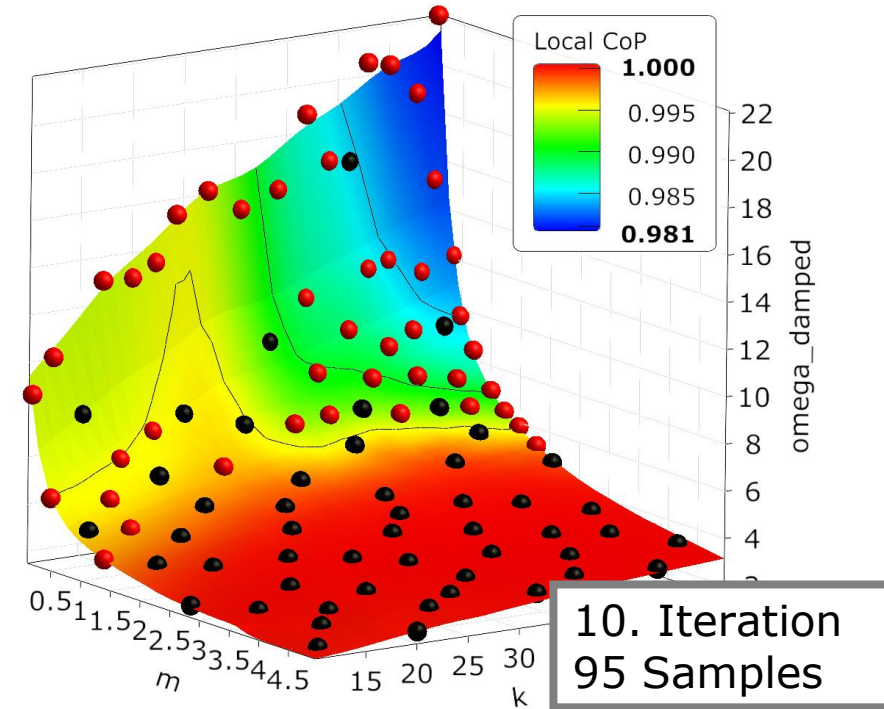
Example Oscillator

- New points are placed in region with large gradients
- Local CoP is improved significantly

Moving Least Squares approximation of omega_damped
Coefficient of Prognosis = 97 %



Moving Least Squares approximation of omega_damped
Coefficient of Prognosis = 99 %

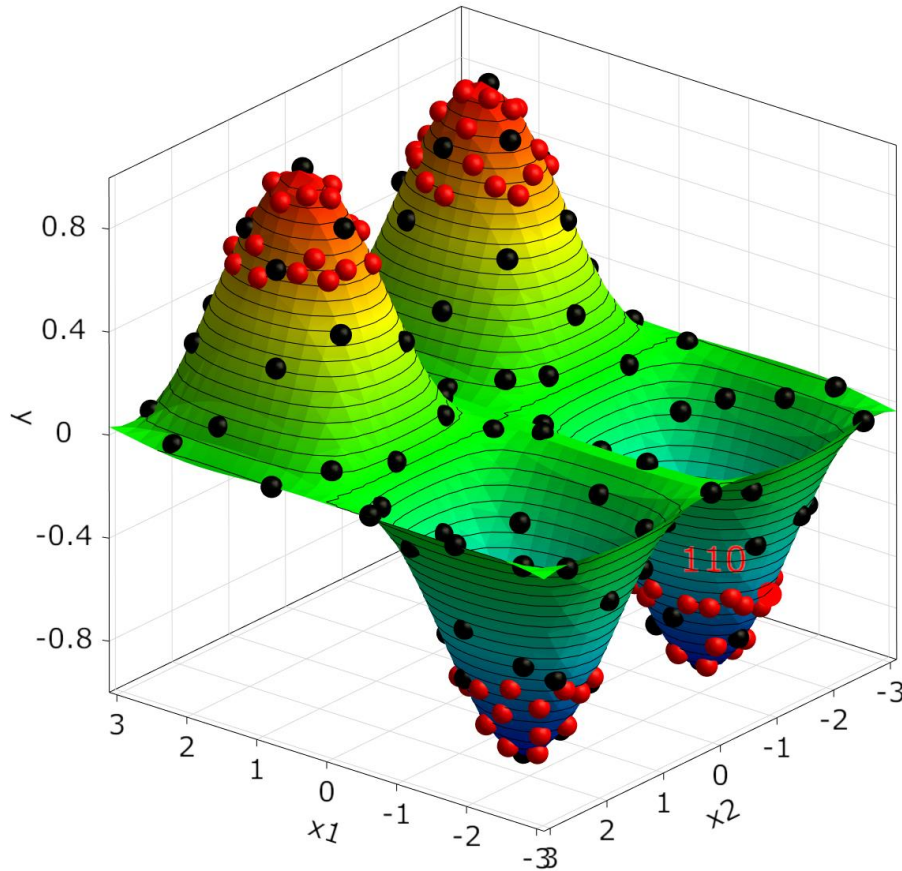


AMOP – Local Refinement

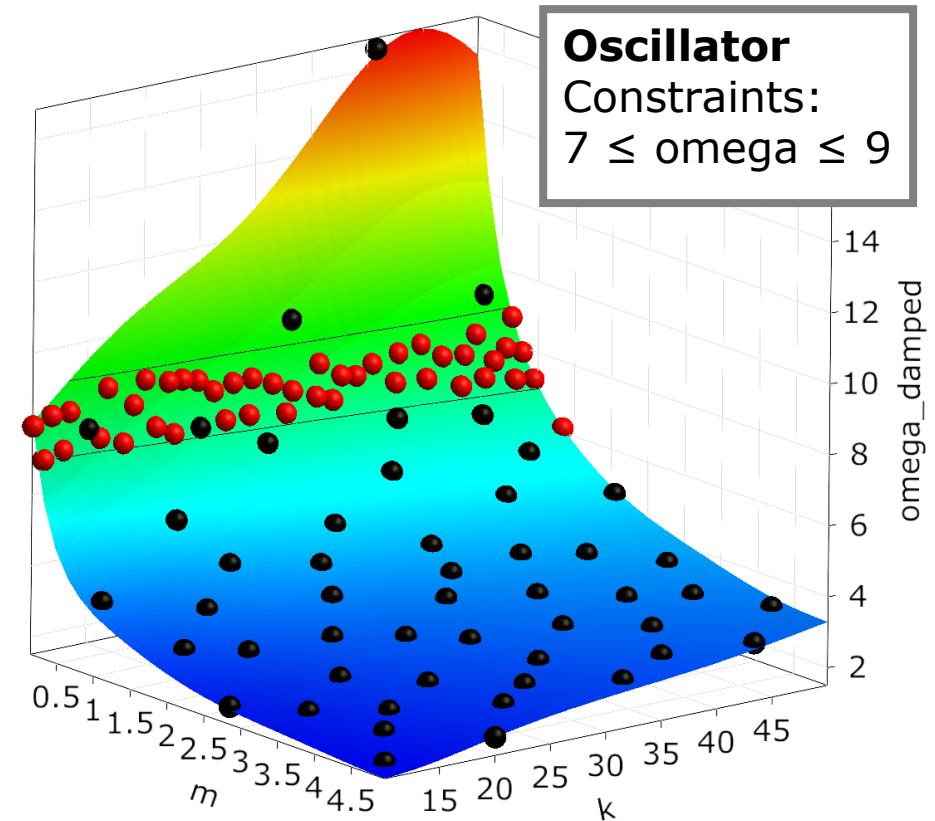
Constraint refinement

- New points are placed in the region where constraints are fulfilled

AMOP constraint refinement for $\text{abs}(y) > 0.6$



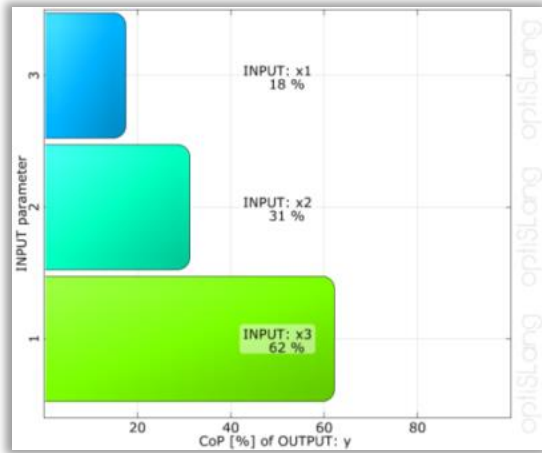
Isotropic Kriging approximation of ω_{damped}
Coefficient of Prognosis = 99 %



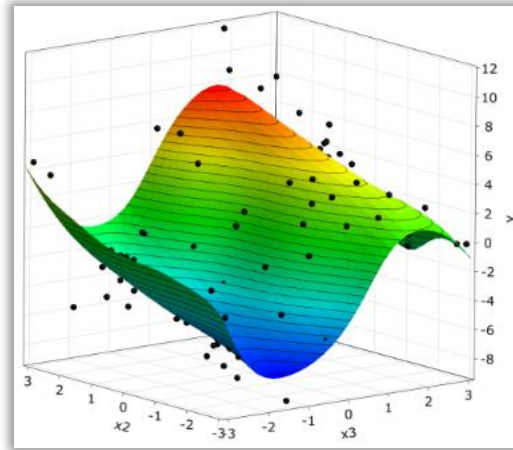
Decision Making by Data Exploration

Data Visualization and Interactive Postprocessing for Design Understanding

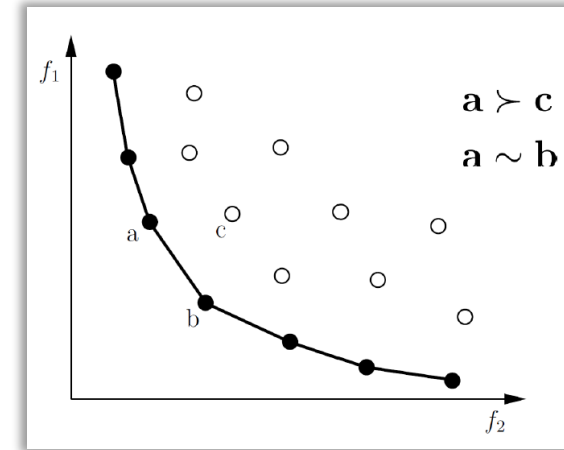
Parameter Ranking



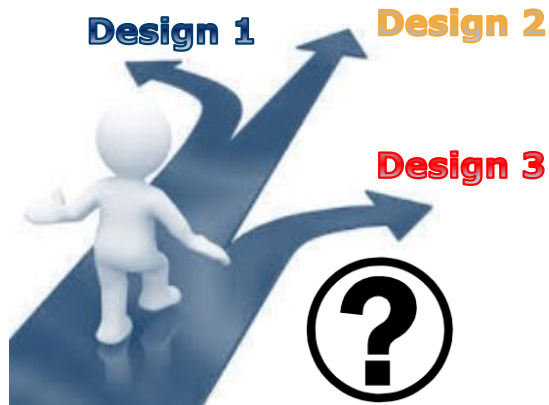
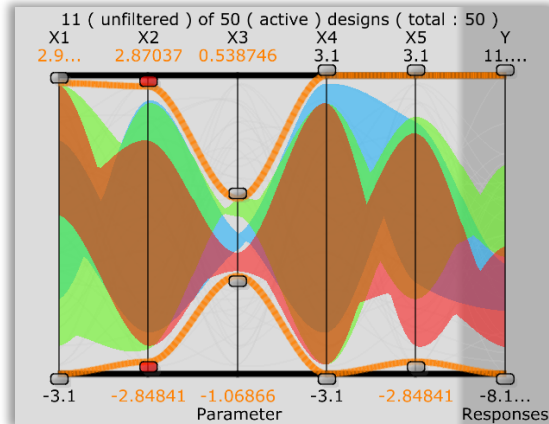
MOP



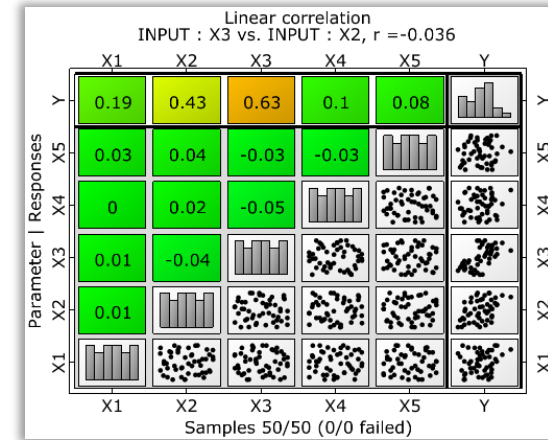
Pareto Optimal



Parallel Coordinates Plot

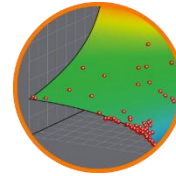
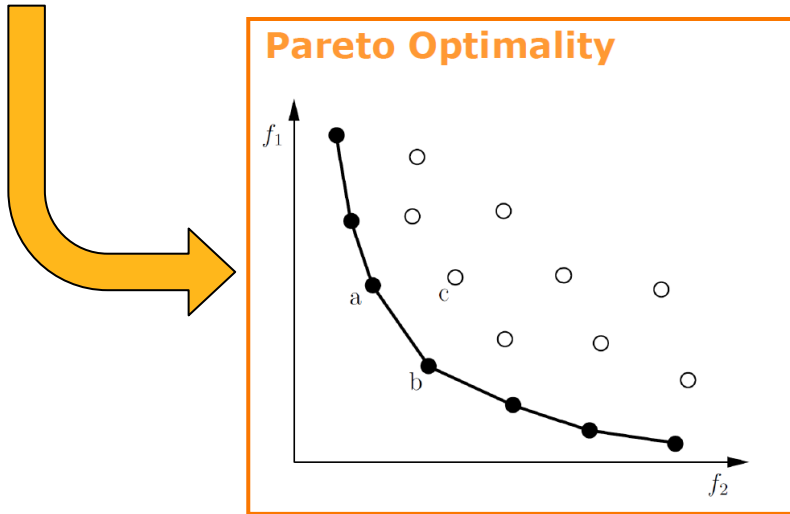


Correlation Matrix



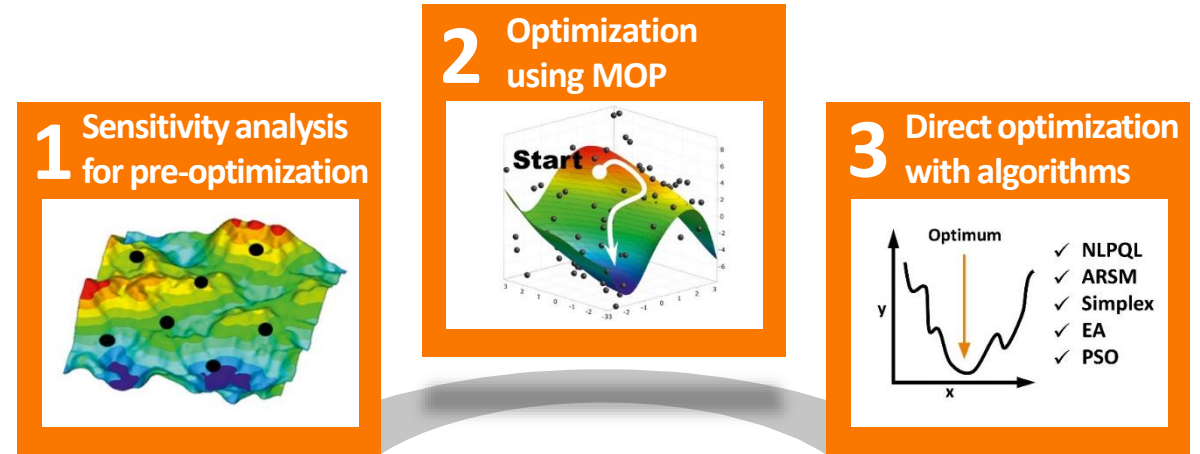
Design Improvement

- How to define your objective?
- Use the MOP from Sensitivity to compare different optimization strategies in minutes (no simulation run)
- Do you have constraints?
- One goal or maybe multi disciplinary optimization?



Optimization

Optimize your product design



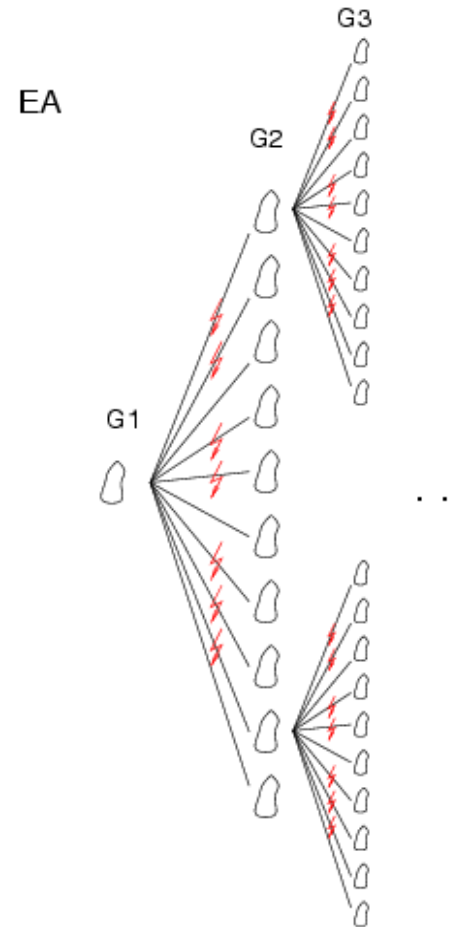
Work with the reduced subset of only important parameters
Pre-optimization on meta model (one additional solver run)
Optimization with leading edge optimization algorithms
Decision tree for optimization algorithms

Evolutionary Algorithm (EA)

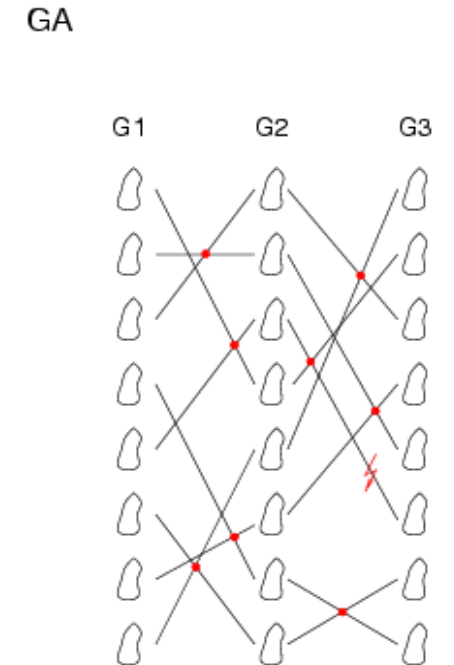
Imitates Evolution (“Optimization”) in Nature:

- Survival of the fittest
- Evolution due to mutation, recombination and selection
- Developed for optimization problems where no gradient information is available, like binary or discrete search spaces

Evolution Strategies



Genetic Algorithms



Evolutionary Algorithm (EA)

Properties

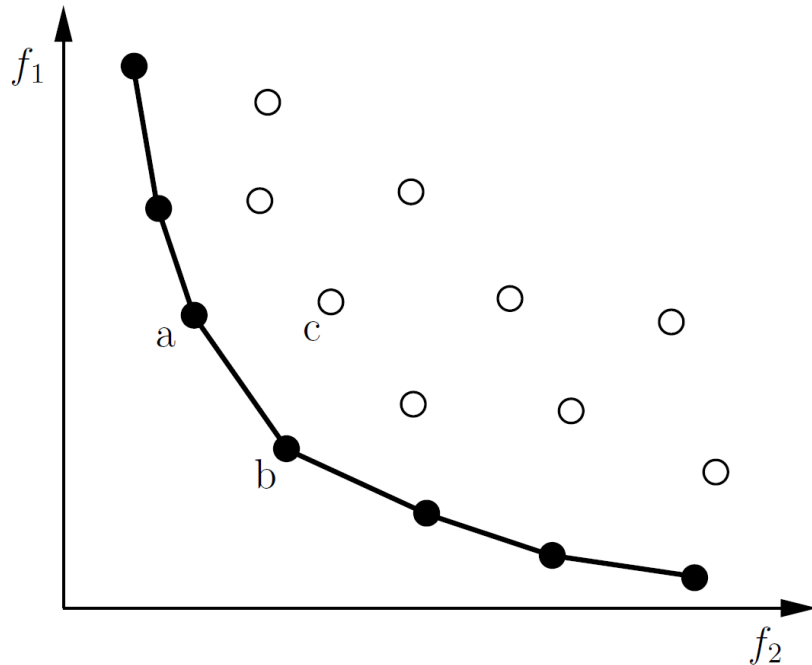
- Stochastic generation of new designs -> robust search approach
- No gradient information or regression is necessary
(More efficient than NLPQL or ARSM for large number of variables)
- Failed designs can be considered in selection procedure
- Ordinal and nominal discrete variable types can be considered
- Global search can treat multiple local optima

Recommended area of application

- Optimization tasks with multiple local minima
- Discovering of new design variants
- Many (nominal) discrete and binary design variables
- Many constraint conditions
- Elevated ratio of failed designs
- Strong solver noise

Pareto Optimality

- Solution **a** dominates solution **c** since **a** is better in both objectives
- Solution **a** is indifferent to **b** since each solution is better than the respective other in one objective
- A design is Pareto optimal, if it is not dominated by any other design
- The set of Pareto optimal solutions forms the Pareto front



$a \succ c$

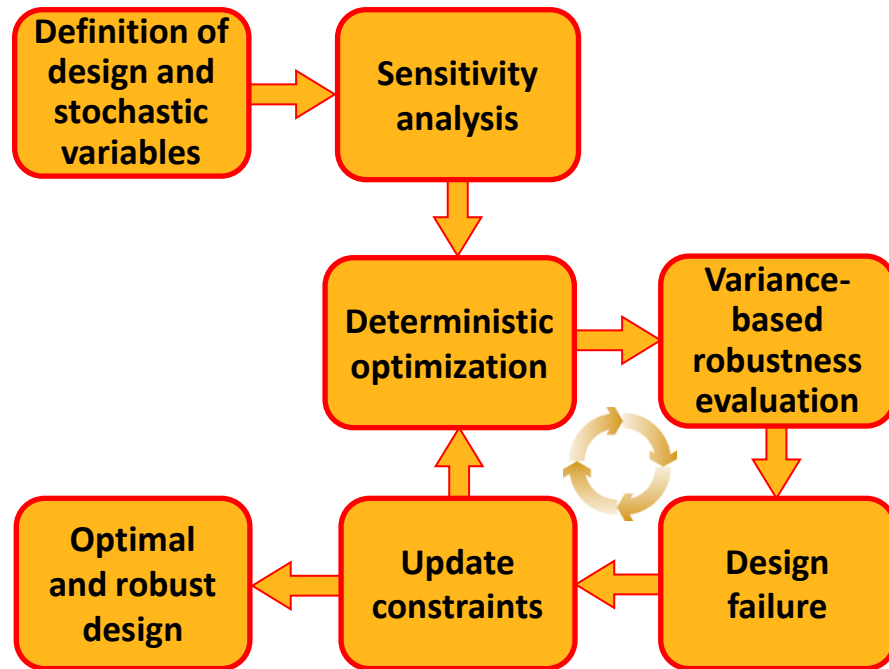
(a dominates c)

$a \sim b$

(a is indifferent to b)

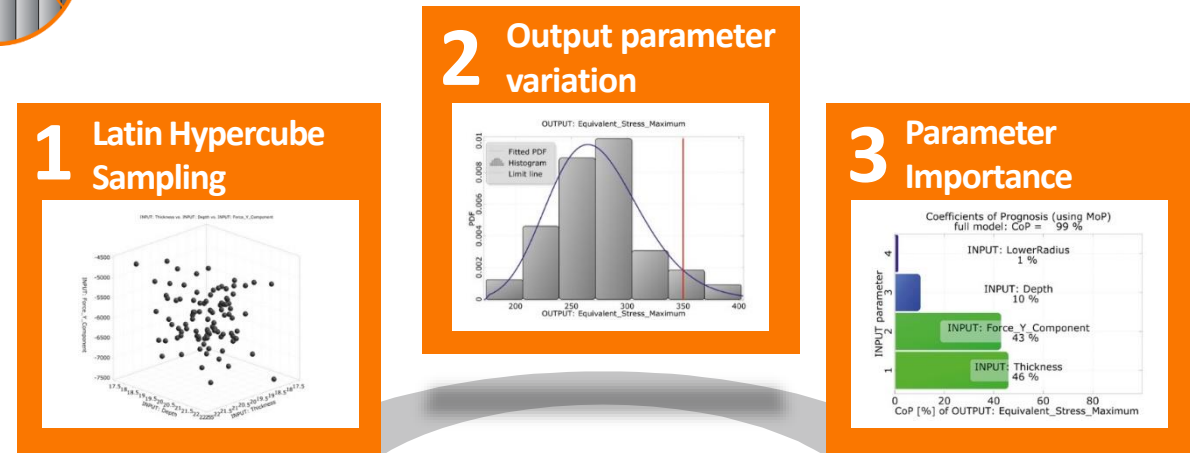
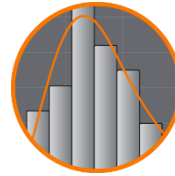
Design Quality

- For each optimization run the safety factors are adjusted for critical model responses
- How big are the influences of tolerances from material, geometry and production



Robustness Evaluation

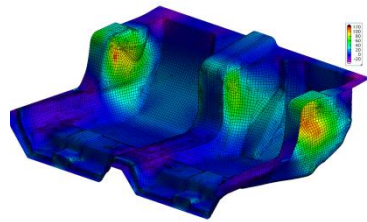
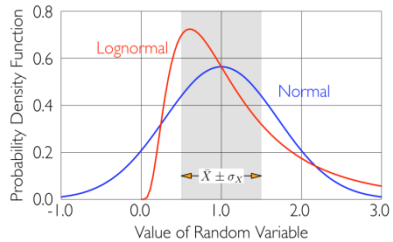
Ensure your product quality



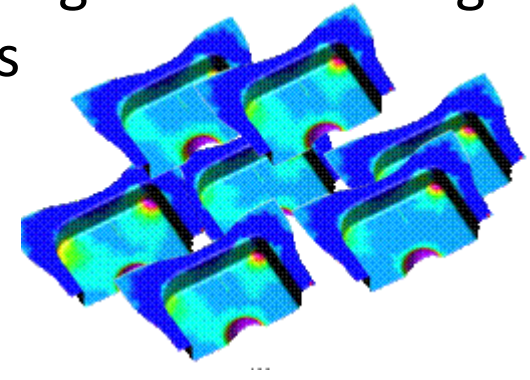
Powerful procedure to check design quality:
 Robustness evaluation with optimized Latin Hypercube Sampling
 Proof of Reliability with leading edge algorithms
 Check variation interval limits and probabilities of overstepping
 Identify the most important scattering variables
 Decision tree for robustness algorithms

Variance based Robustness Analysis

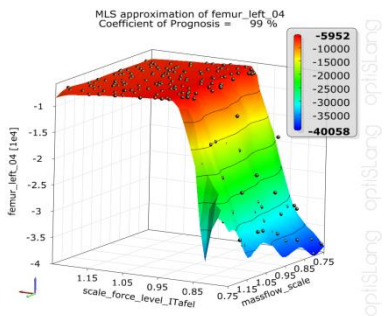
1) Define the robustness space using scatter range, distribution and correlation



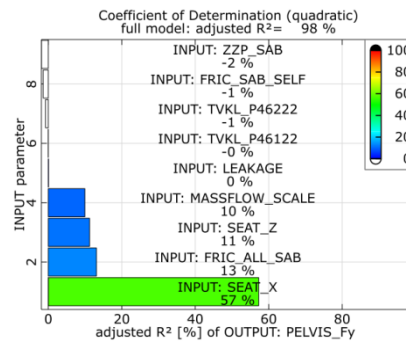
2) Scan the robustness space by producing and evaluating n designs



5) Identify the most important scattering



4) Check the explainability of the model



3) Check the variation

