Ansys SPEOS | The engineering of optics




Optics

Optiks / noun singular

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

Ansys Simulation Platform

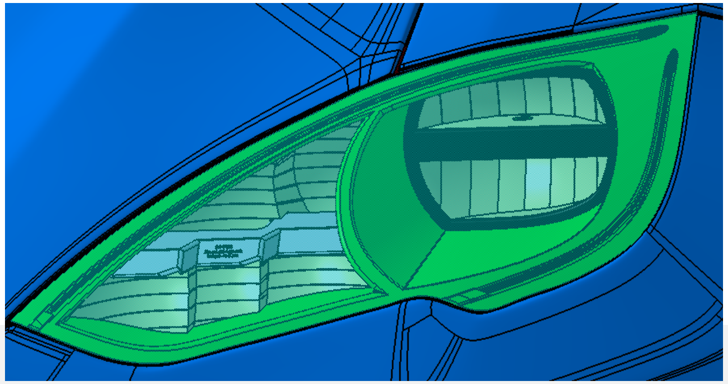
Ansys / OPTISLANG — Simulation Automation and Optimization

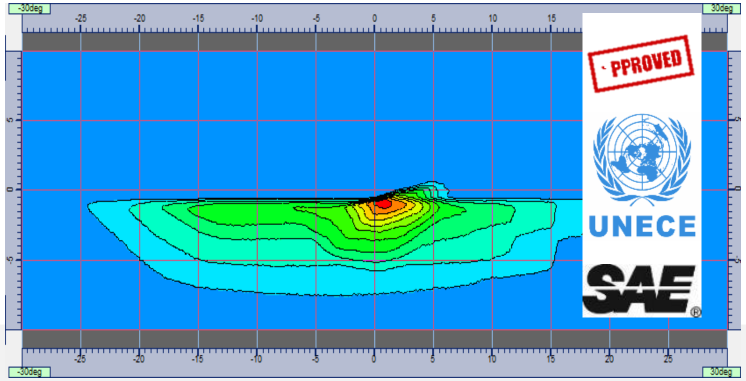
FLUIDS | STRUCTURES | ELECTROMAGNETICS | SEMICONDUCTOR | EMBEDDED SOFTWARE | OPTICAL

Ansys / GRANTA — Materials Information Management

Ansys / MINERVA — Simulation Process and Data Management

Ansys SPEOS | A collaborative design platform





Imagine

Engineer

Comply

Compatible with all CAD platforms

Ansys SPEOS | Predictive simulation for informed decision-making

Experience through
customers' eyes

Deliver
perceived quality

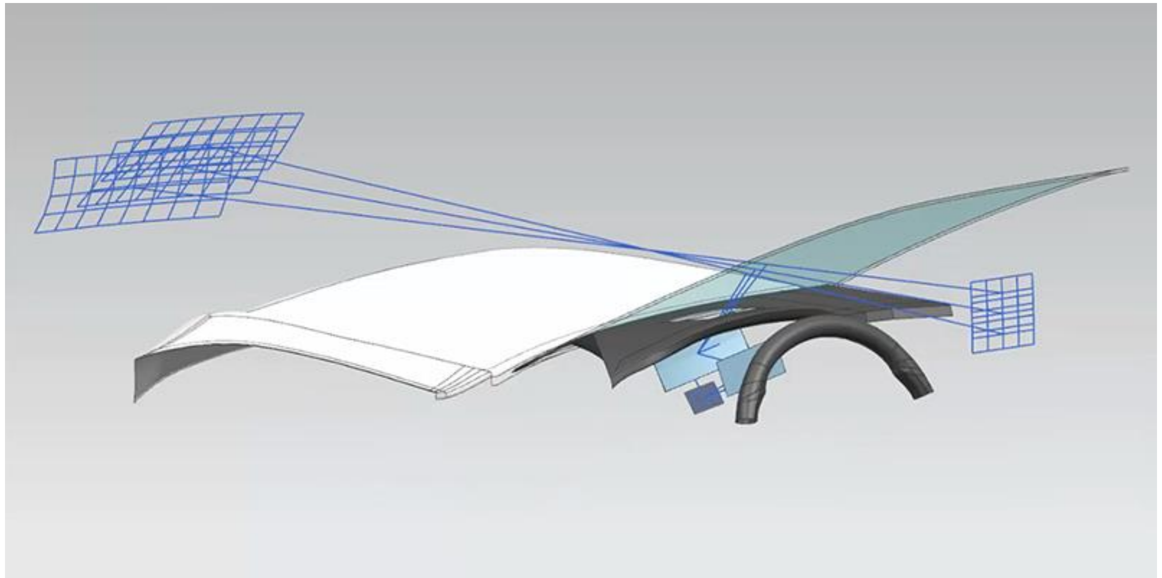
Do it right the first time

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

SPEOS CERTIFIED CIE 171:2006

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?


```
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degree,5
closed,0
periodic,0
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U_Parameter,6,5,6
V_Multiplicity,0,699.0787532
V_Parameter,6,6
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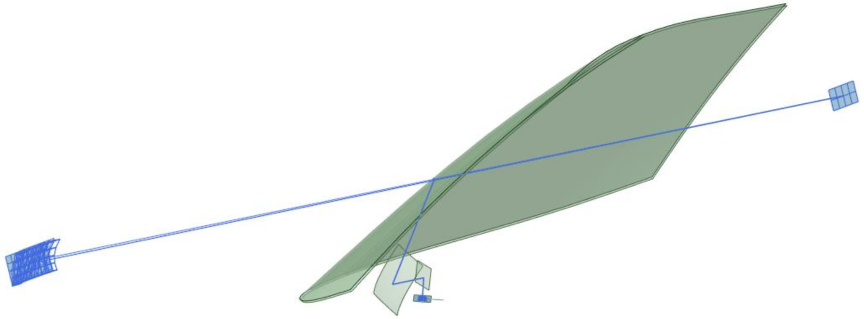
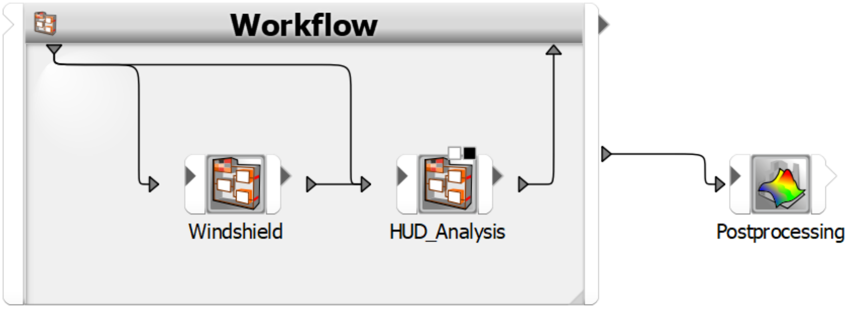


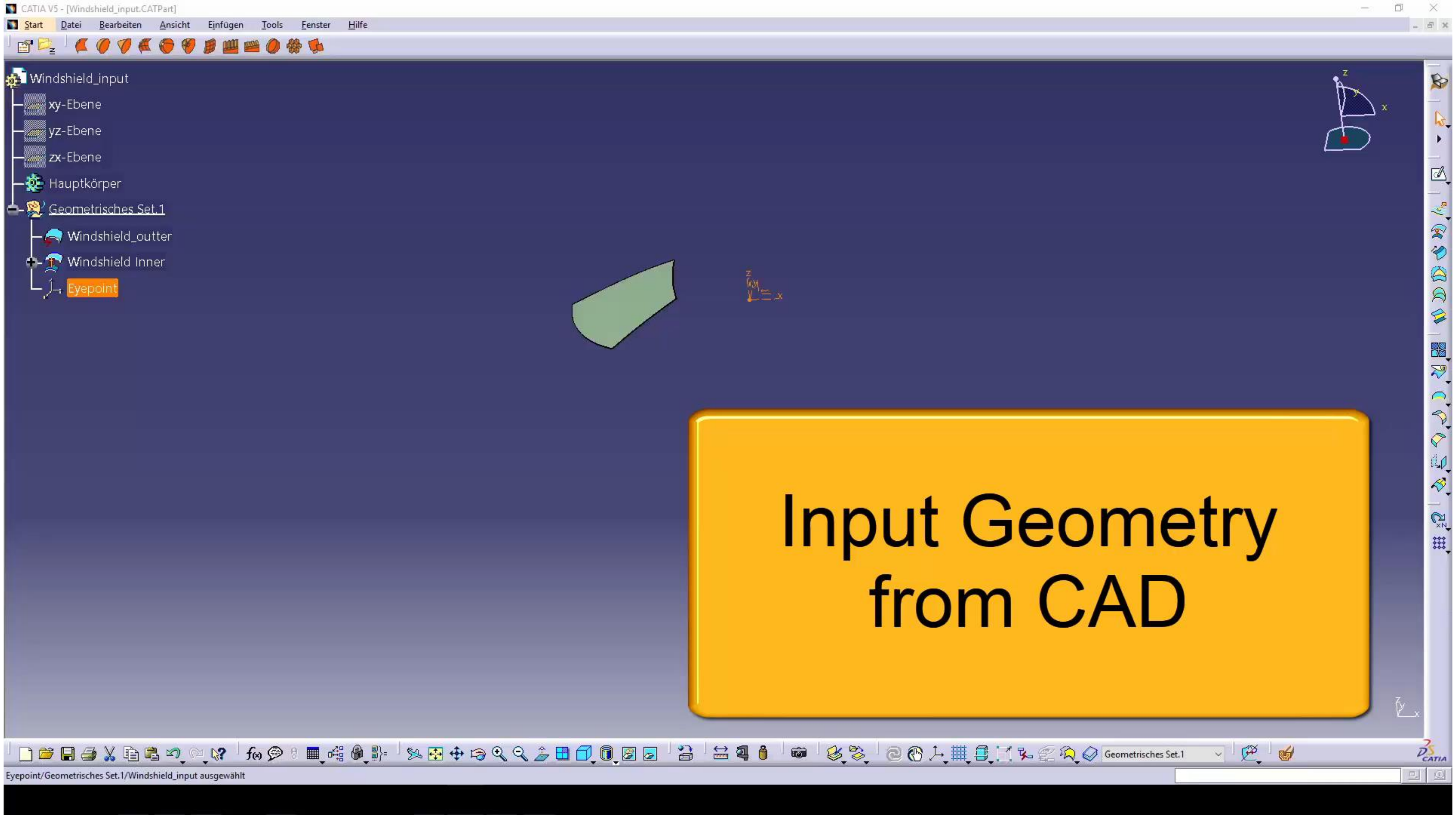


Get Initial Data from CAD	Define Geometry and Simulation in Ansys SPEOS	Process automation in Ansys optiSLang
CAD-agnostic workflow	Postprocess geometry in Ansys Speos Simulate the Design	Simulation automation Design optimization & exploration

Design Generation with Ansys SPEOS

Ansys

Initial Design of Windshield & HUD



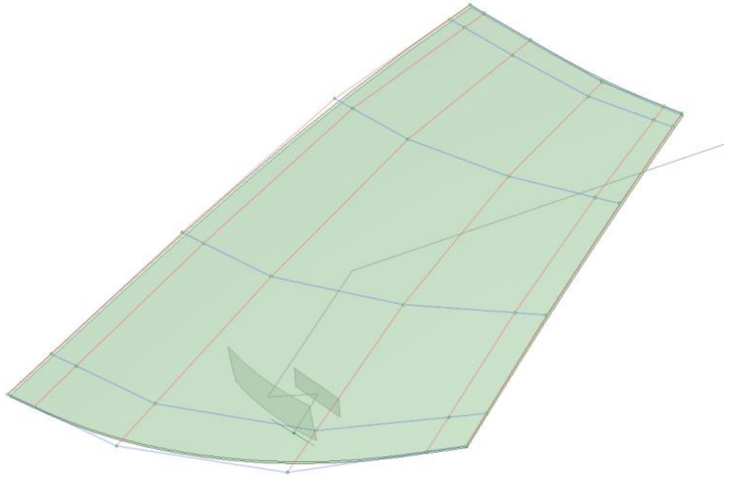
Initial Design of Windshield & HUD

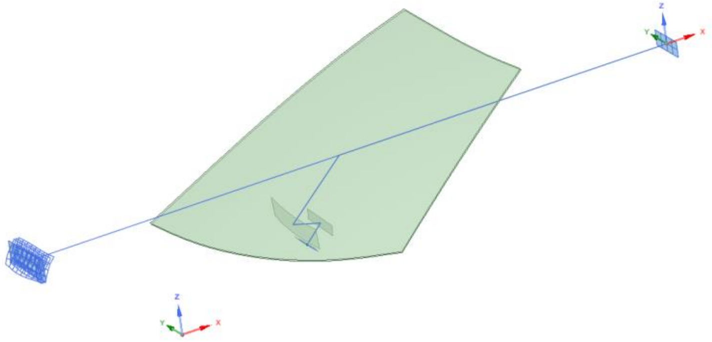
Windshield

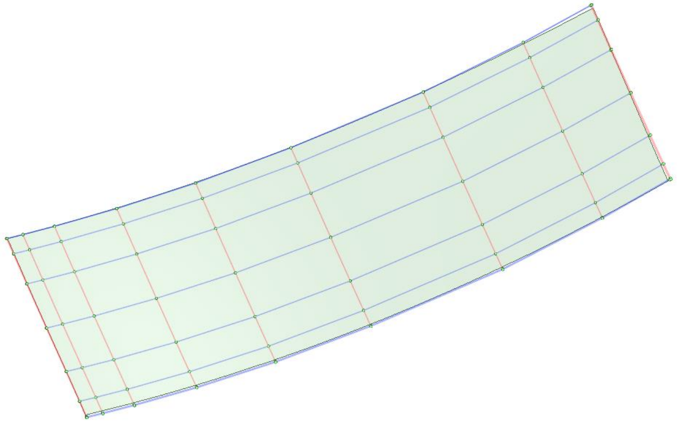
- Optimization geometry
- Symmetry assumption
- Implement design and regulation constraints

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

Ansys

What possibilities are included in Ansys optiSLang ?

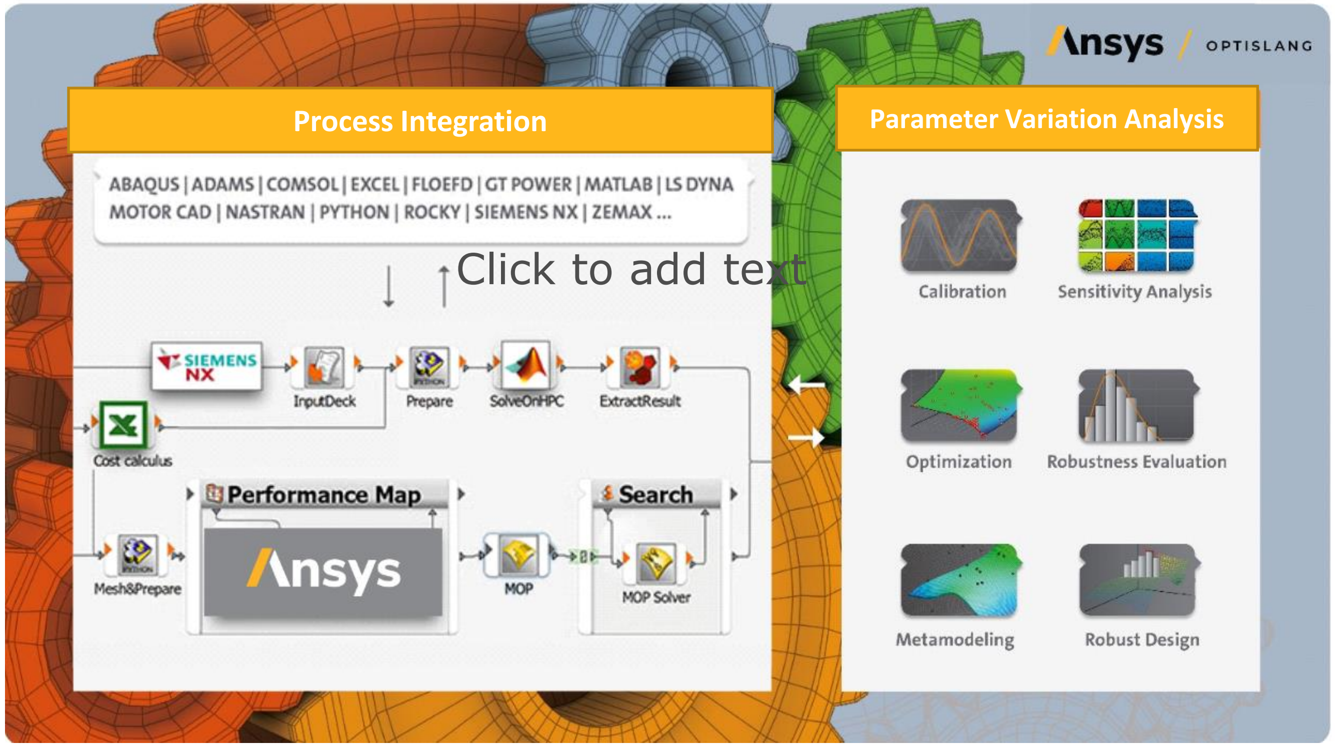
Process integration

Workflow Building and Process Automation

Variation Analysis

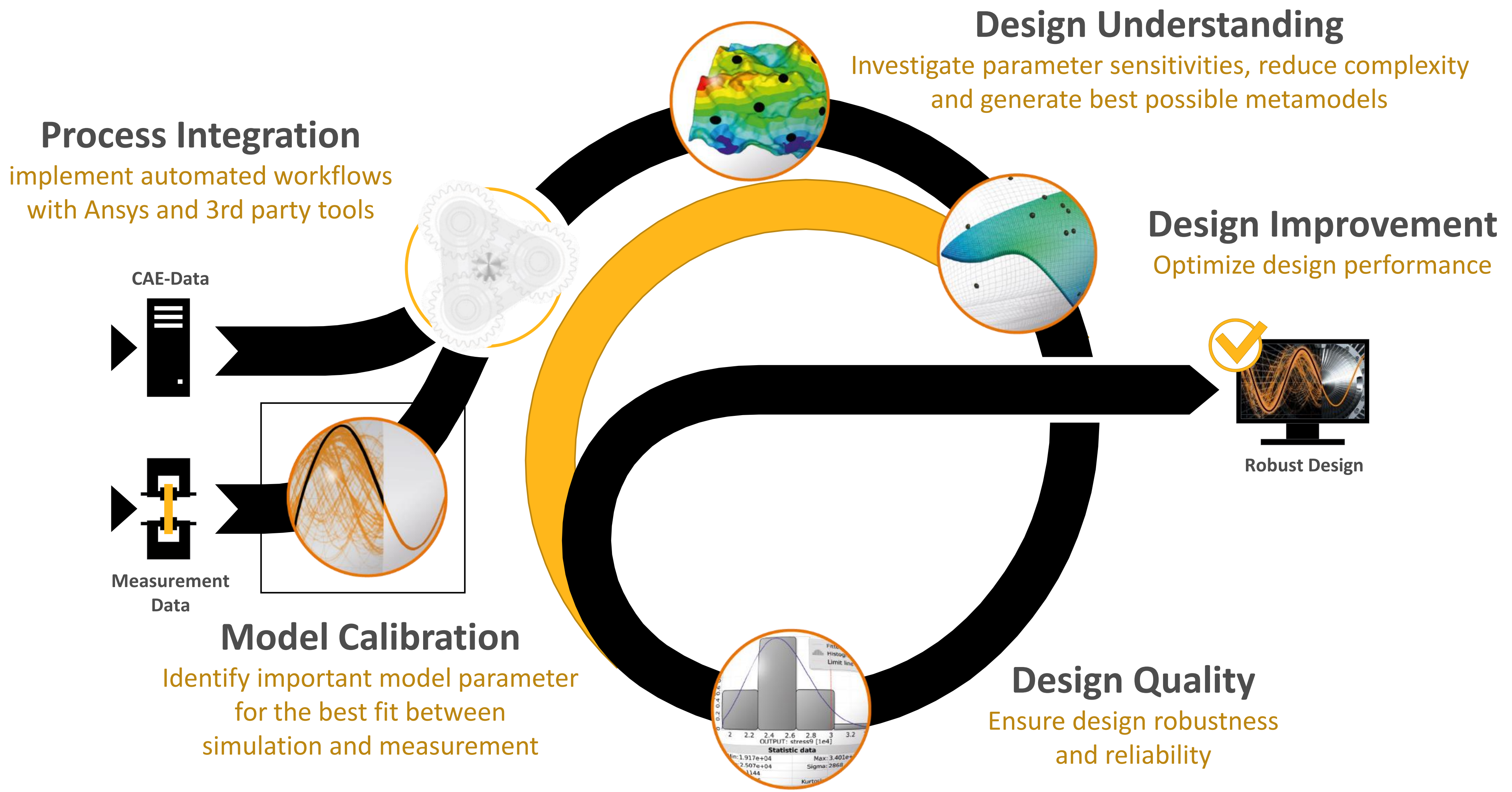
Algorithms for robust design optimization

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



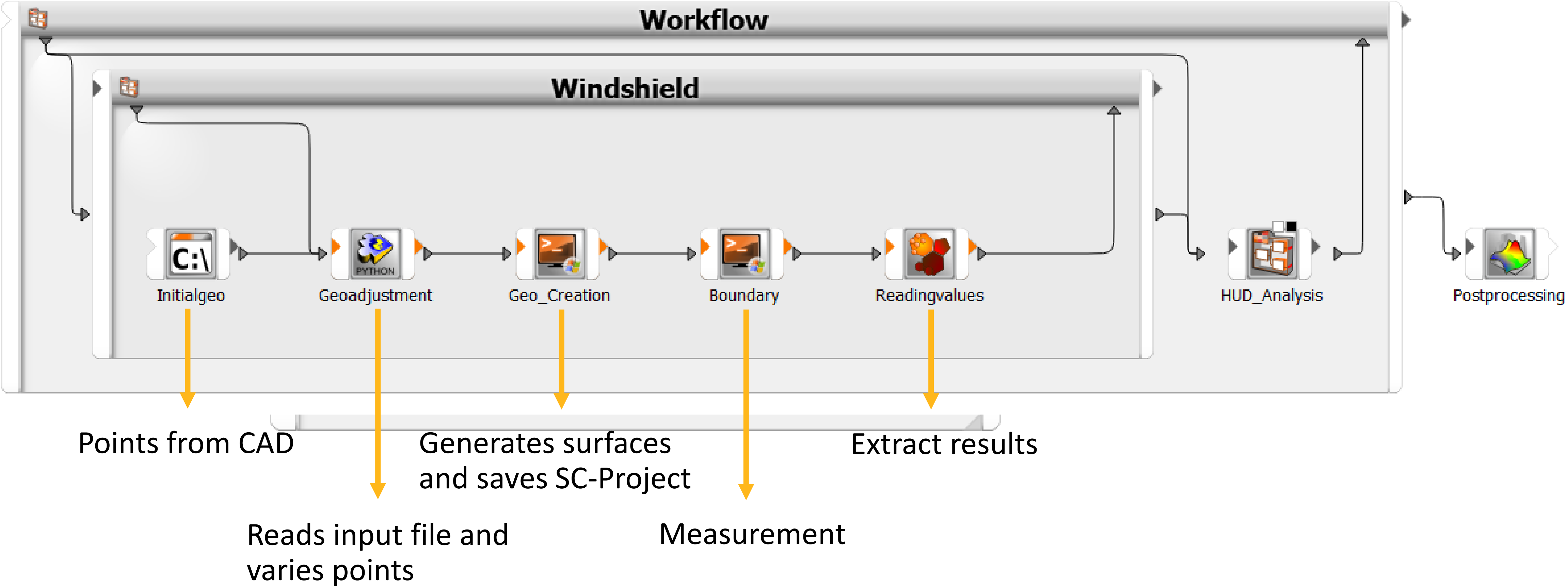
- Identify relevant parameters
- Reduce complexity
- Understand your design
- Optimize your product with minimal effort
- Verify the robustness and reliability of your design
- Creates Data-based ROMs for digital twins

Best Practice Guideline for Virtual Product Development



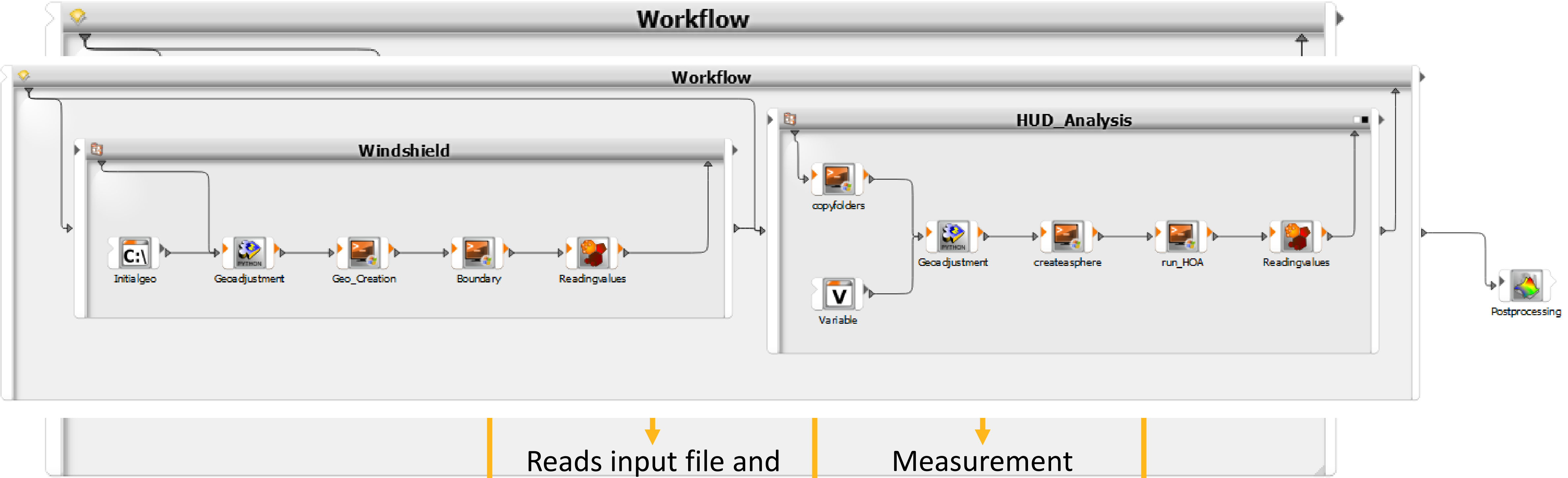
Workflow

- Combination of HUD and Windshield optimization



Workflow

- Combination of HUD and Windshield optimization



Reads input file and varies points

Measurement

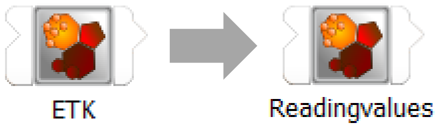
Number of points

Generates surfaces and saves SC-Project

Reads results out of Html

Workflow

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



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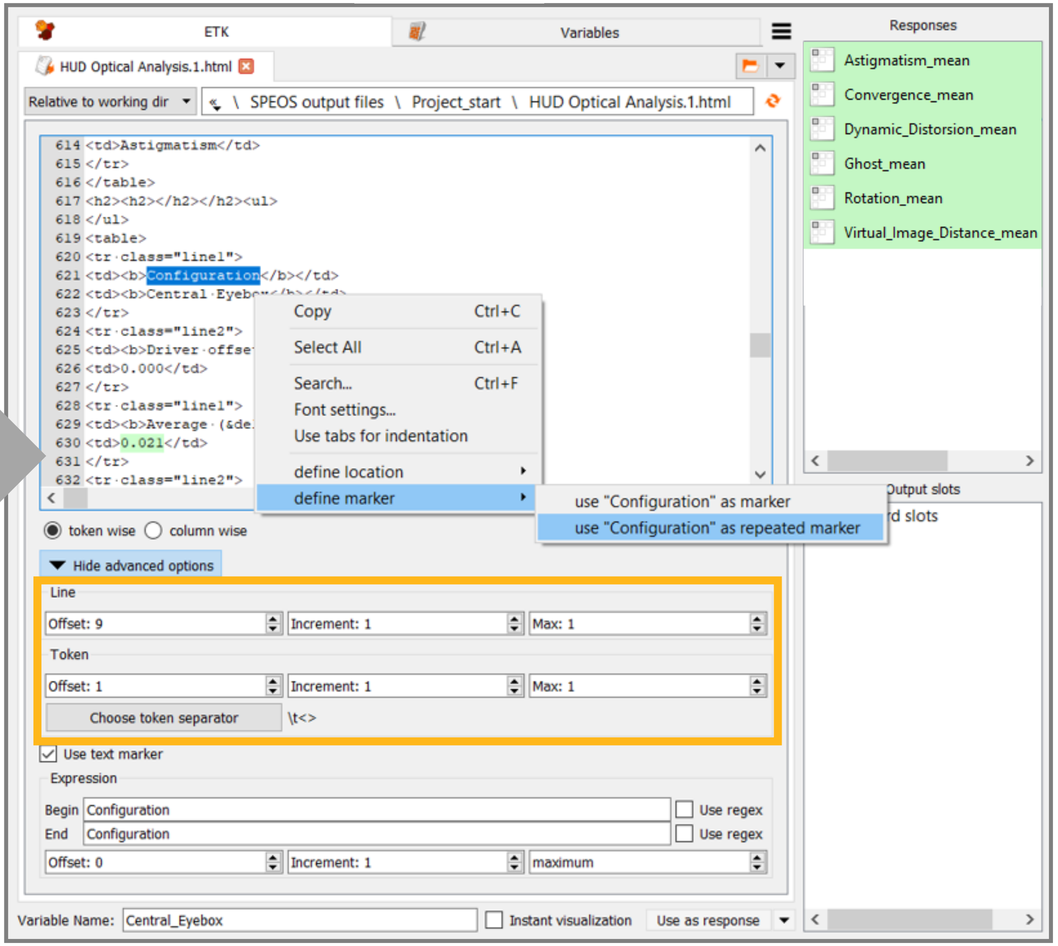


Inputs & Responses

Inputs

- Support points
  - Windshield: variation of coordinates ± 1cm (≠ variation of windshield surfaces) - 36 points
  - Asphere: variation of coordinates ± 0.1mm (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

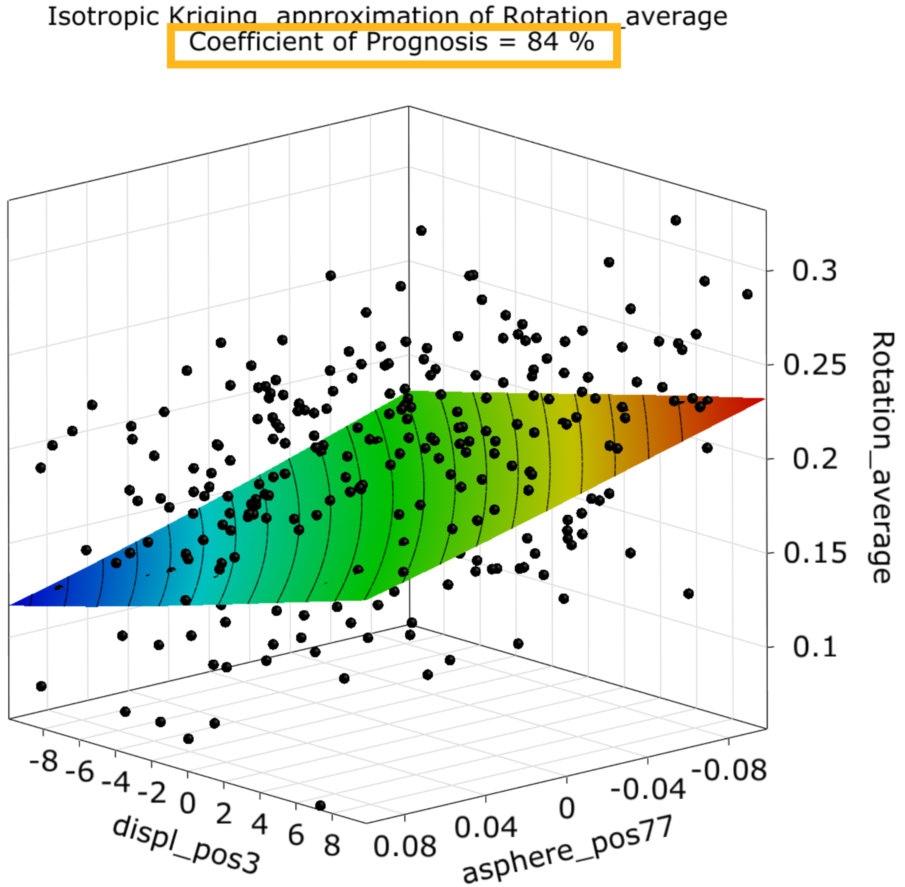
- Challenge: compromise between contradicting optical and geometrical responses
  - Multiobjective Optimization
  - Objectives: minimization of the geometrical and optical responses

Criteria

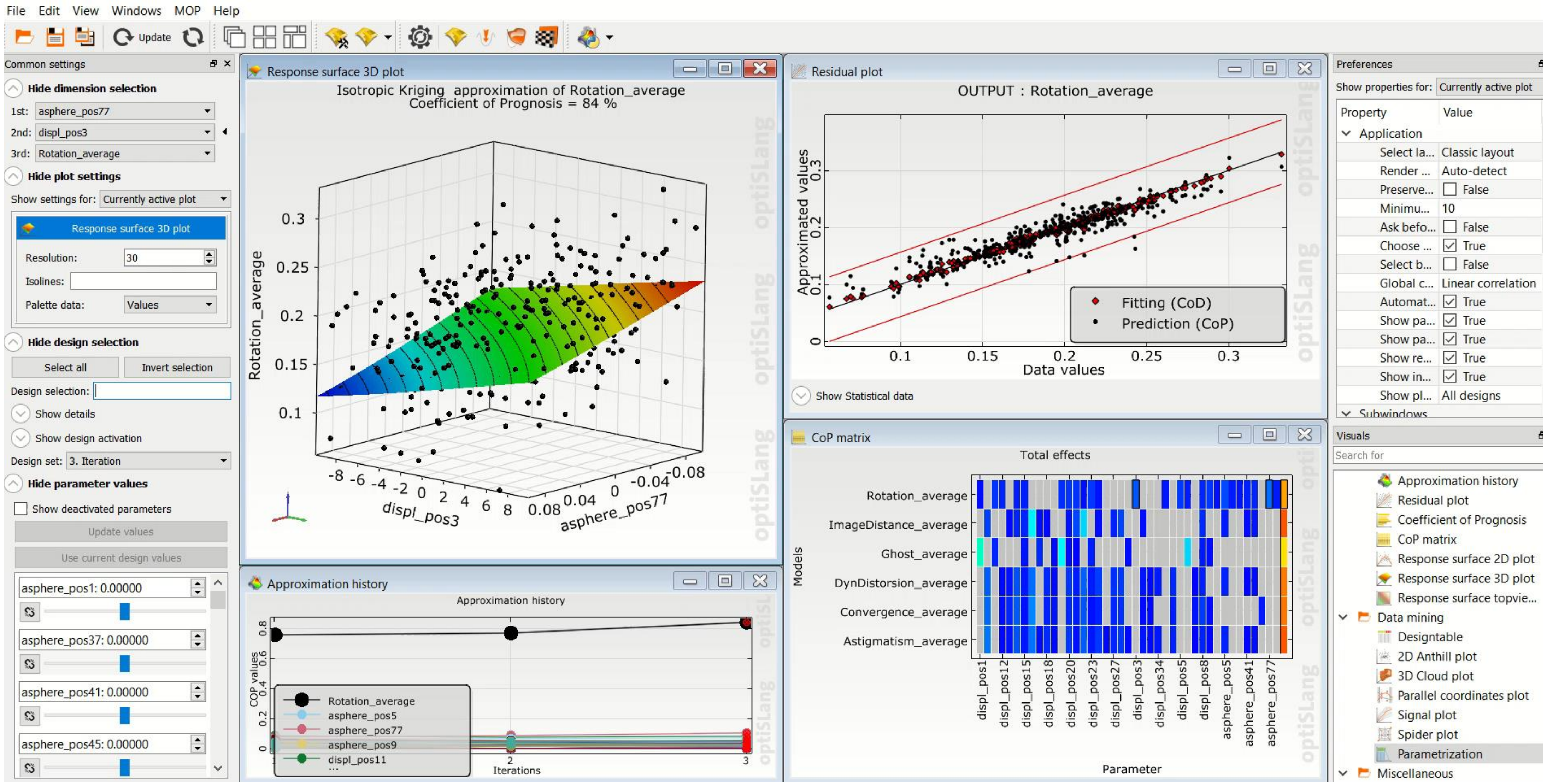
Name	Type	Expression	Criterion	Limit	Evaluated expression
obj_optics	Objective	(Ghost_average+Astigmatism_average+Convergence_average+Image_Distance_criterium)/3	MIN		3.00114
obj_geometry	Objective	(DynDistorsion_average+Rotation_average)	MIN		2.41782
Image_Distance_criterium	Variable	(2000-ImageDistance_average)/300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

Sensitivity Analysis

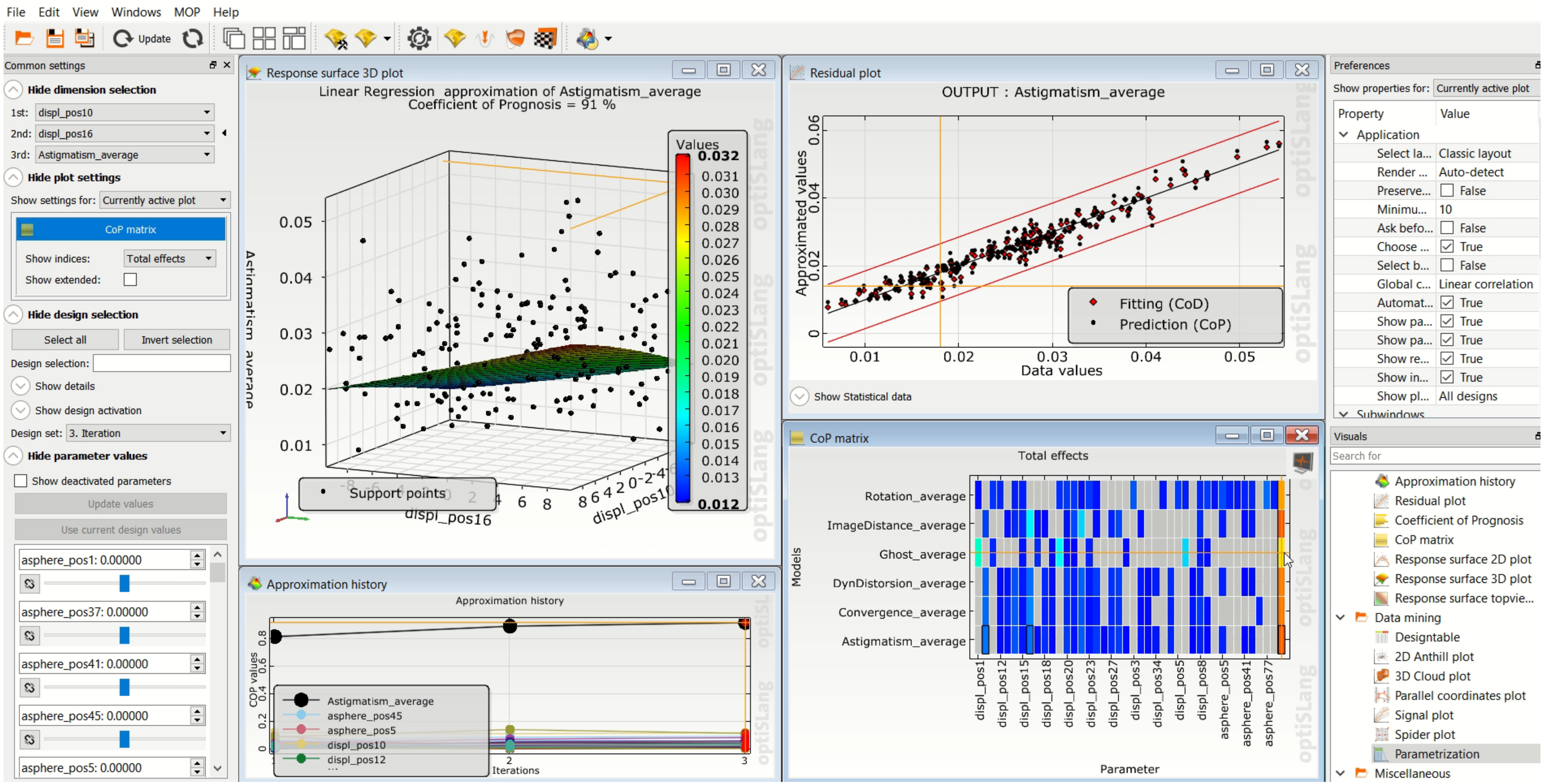
- MOP – Metamodel of Optimal Prognosis
- Representation of the 3D Surface Response Plot of *“Rotation_average”* as response with the two most important parameters *“displ_pos3”* and *“asphere_pos77”*
- High approximation quality (CoP = 84 %)



Sensitivity Analysis



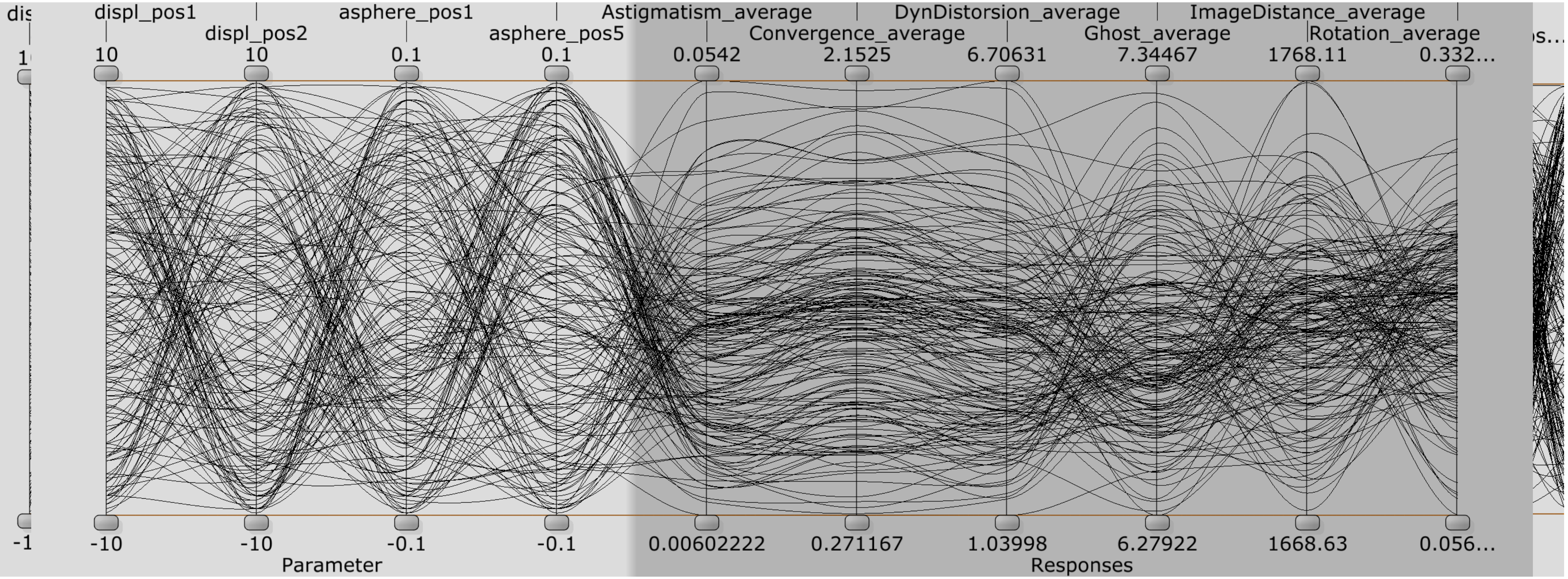
Sensitivity Analysis



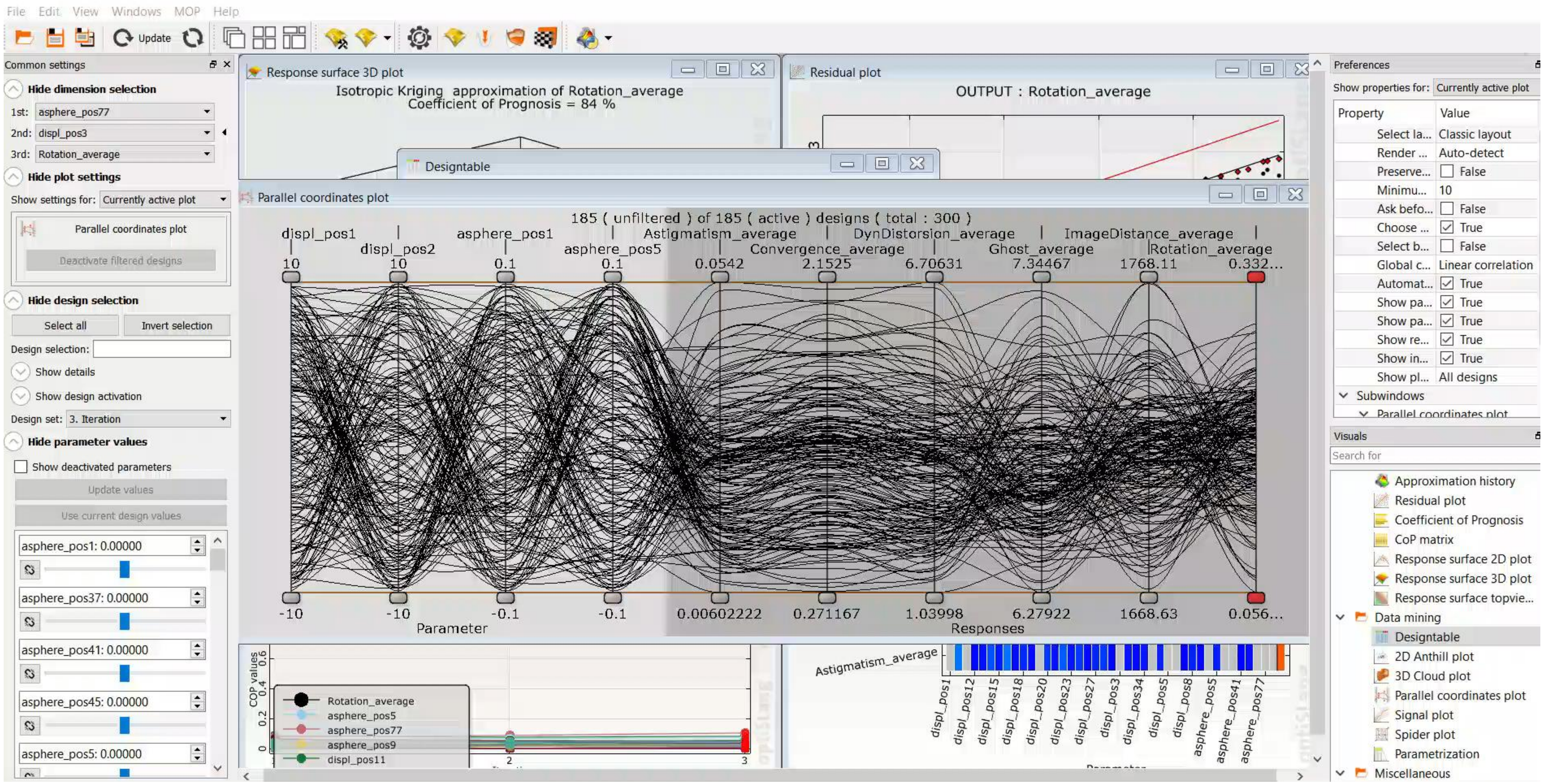
Ansys

Sensitivity Analysis

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

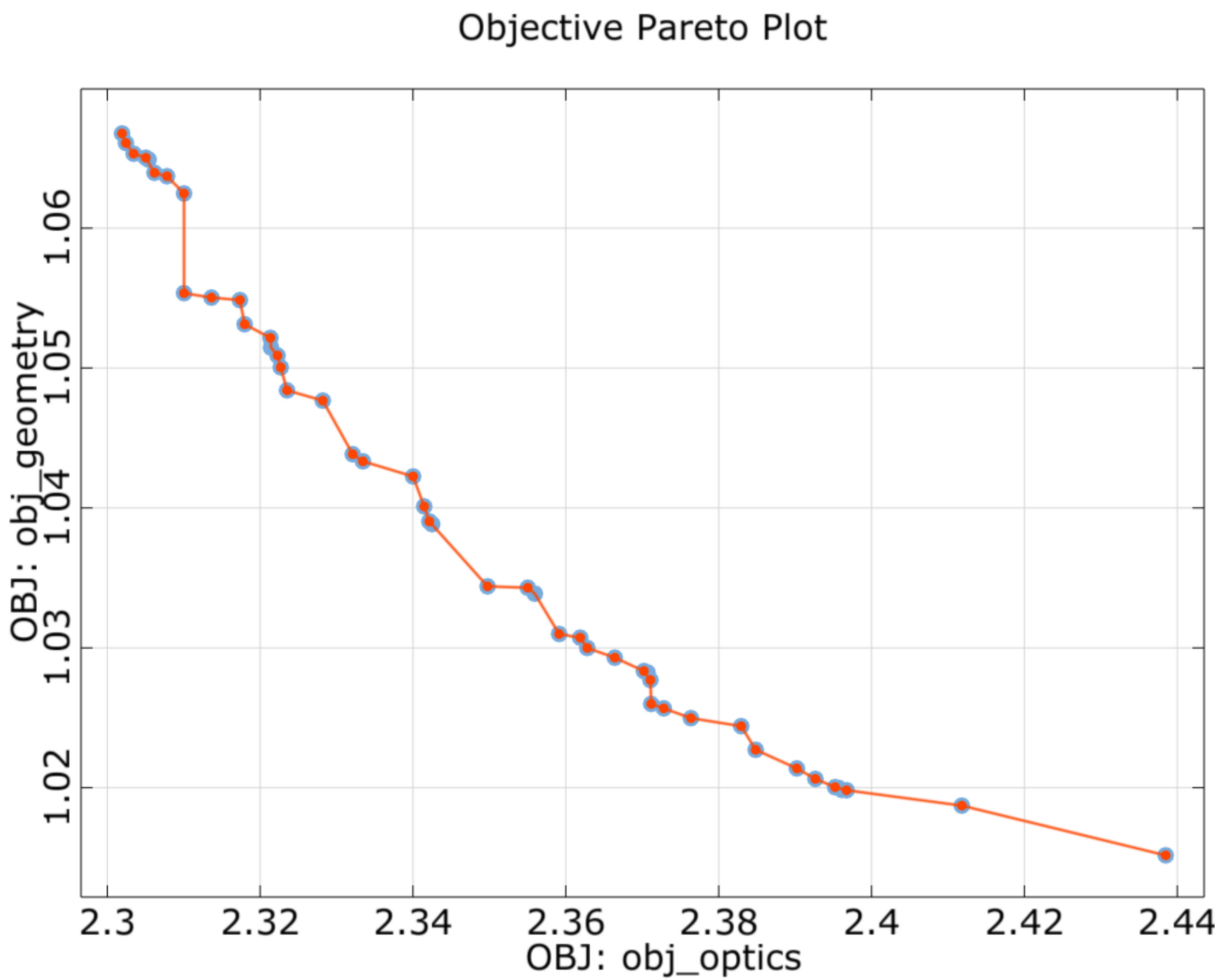


Sensitivity Analysis



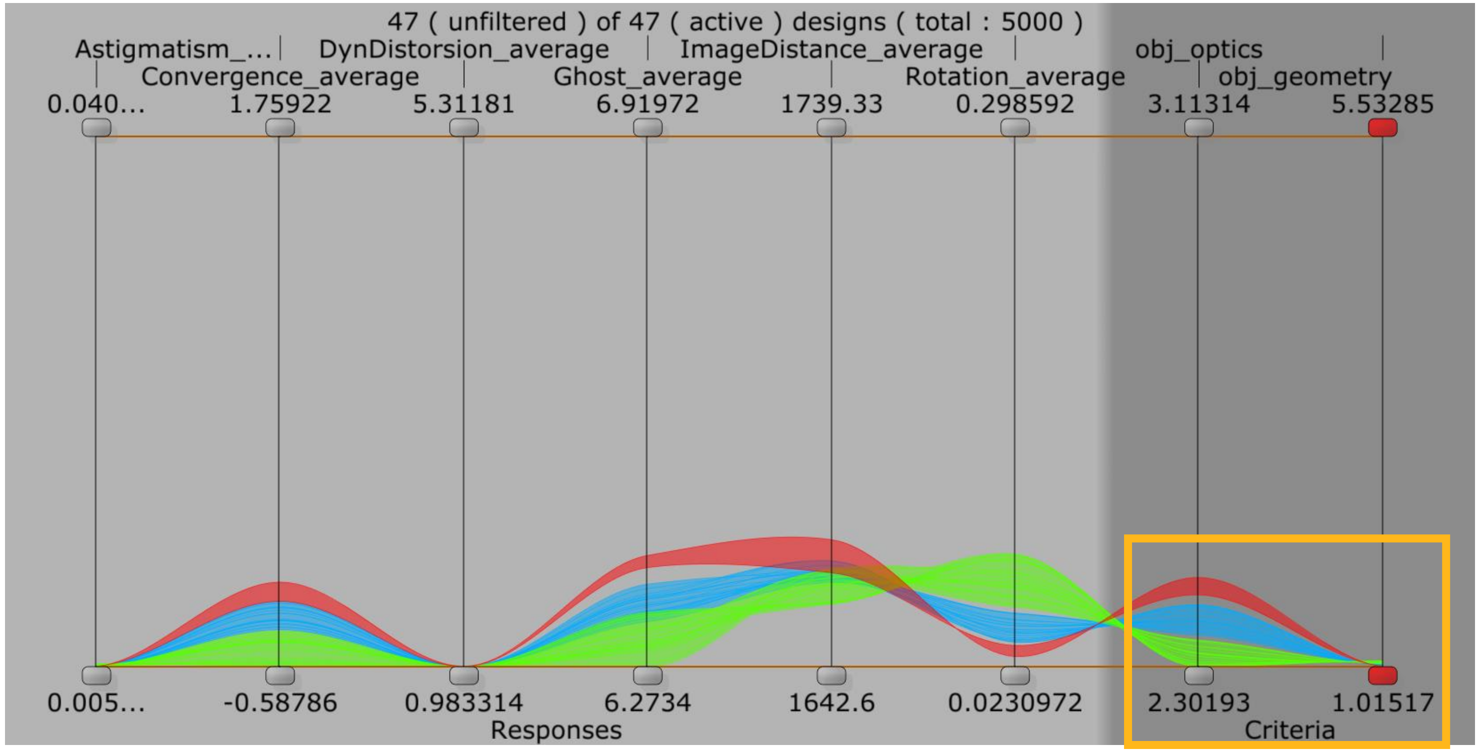
Optimization

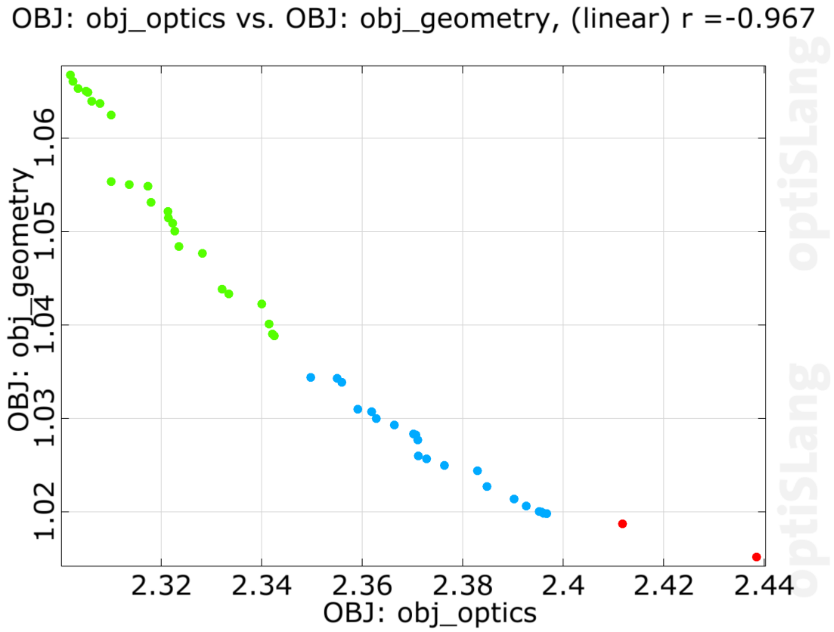
- Paretofront: best designs without domination between designs



Optimization

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





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

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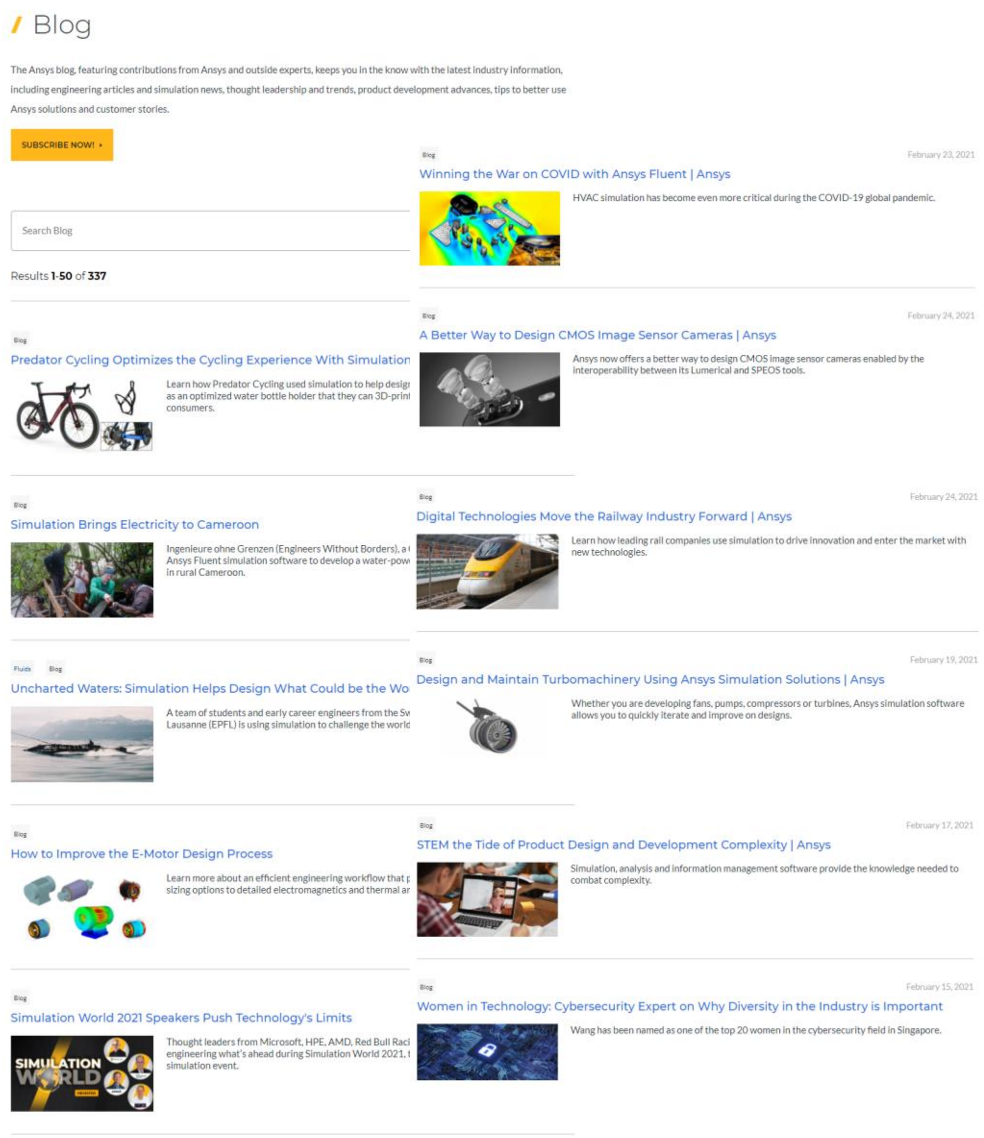
Thank you

Join the Ansys conversation!

Read and comment.

Find the Ansys blog:
ansys.com/blog



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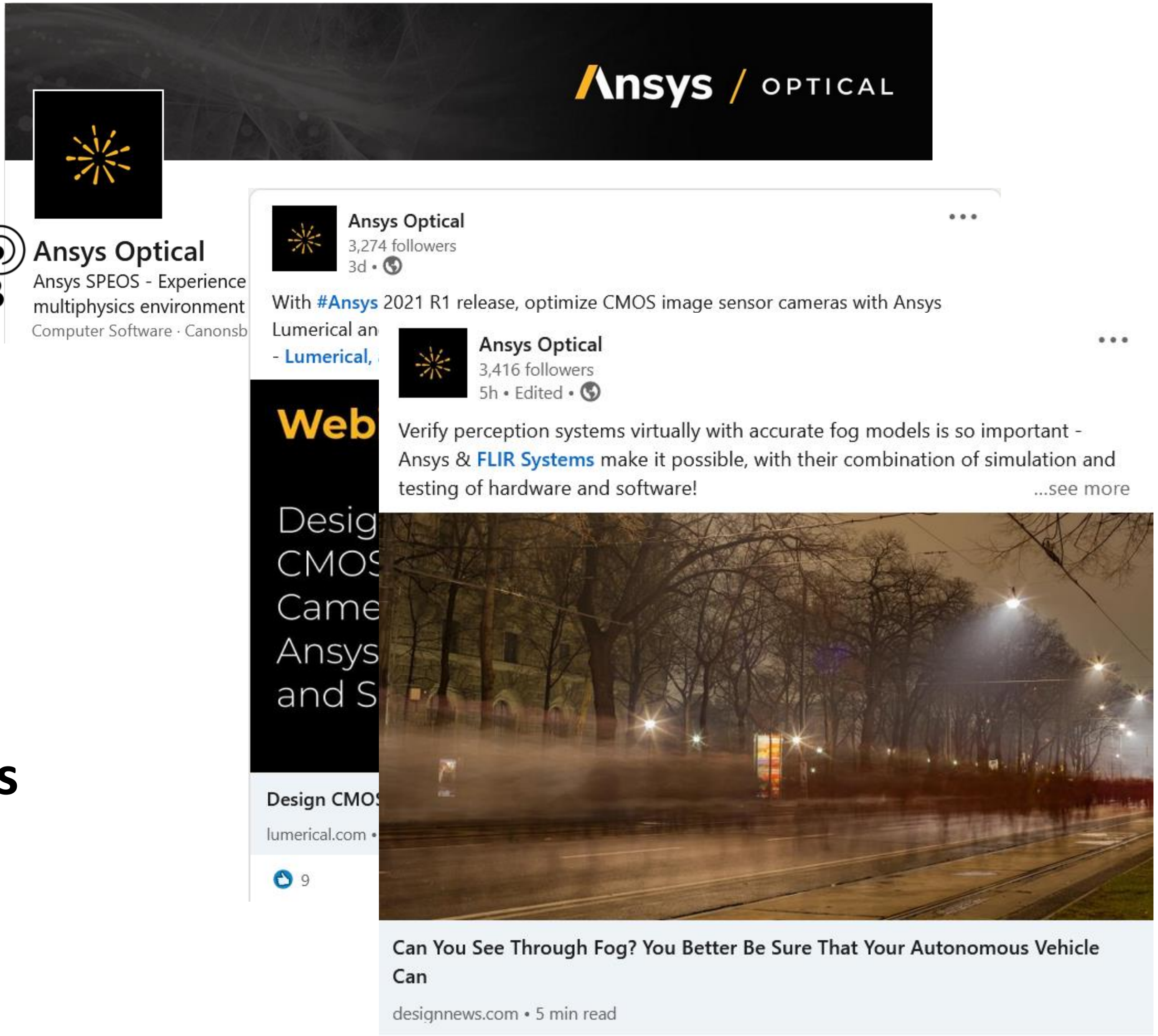

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Ansys WOST CONFERENCE

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!

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Application Engineer

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Stefan Thoene

Lead Application Engineering

Ansys Speos

Stefan.Thoene@ansys.com

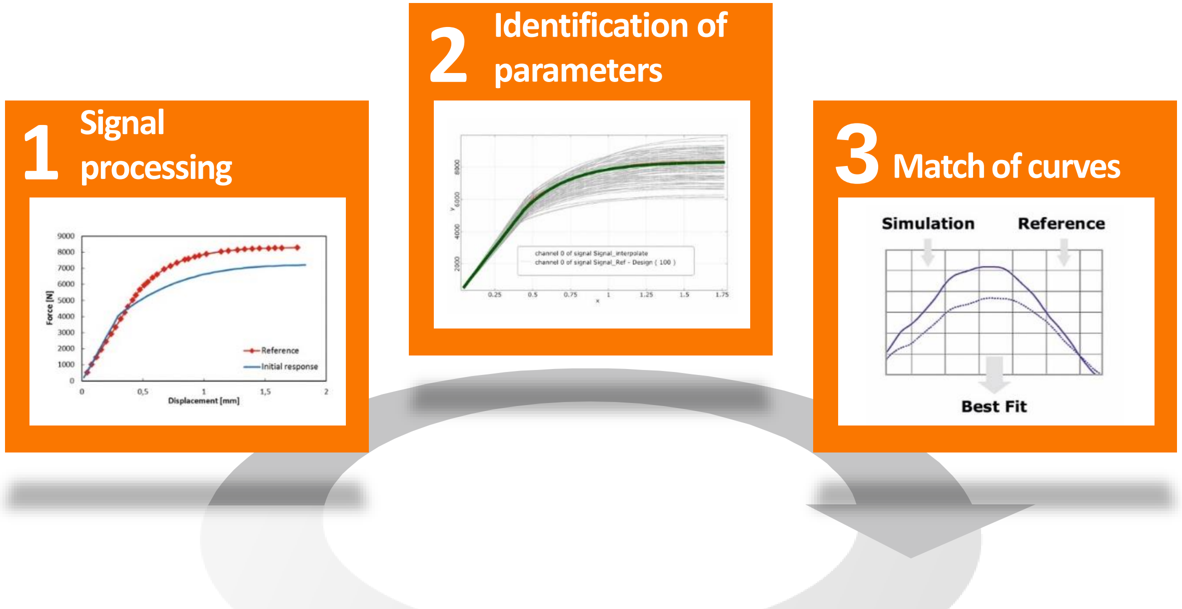
Appendix

Parameter Identification

Model Calibration

Model update to increase your simulation quality

- 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)

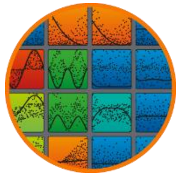


Use scalar values or signals inside ANSYS Workbench
Identify which parameters have influence and can be calibrated
Match experimental data with simulation

DoE & Sensitivity Analysis

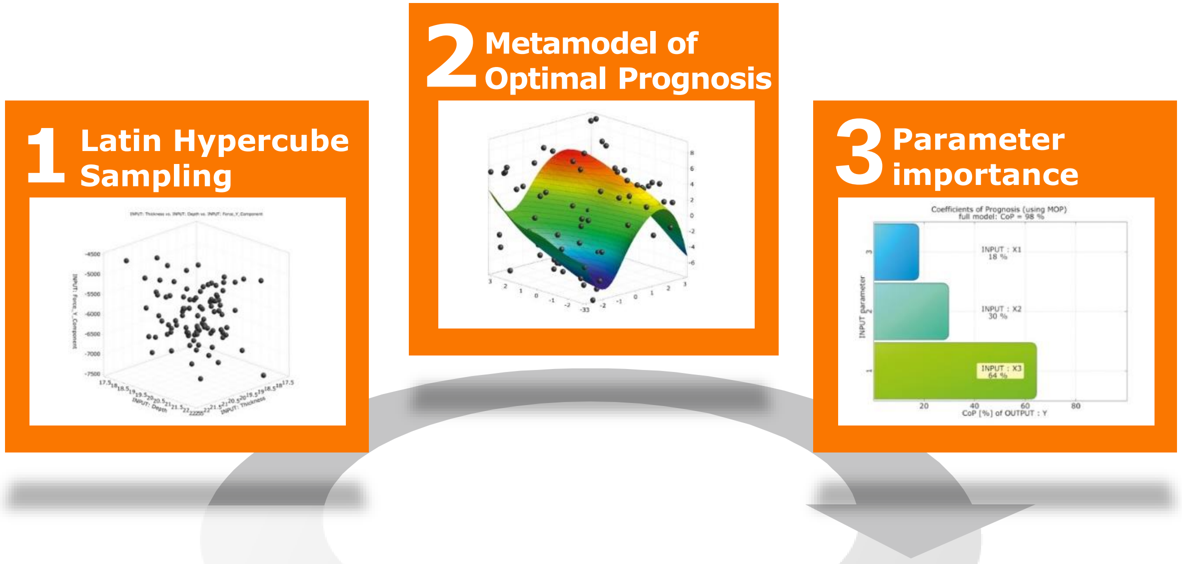
Understand your possibilities:

- 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

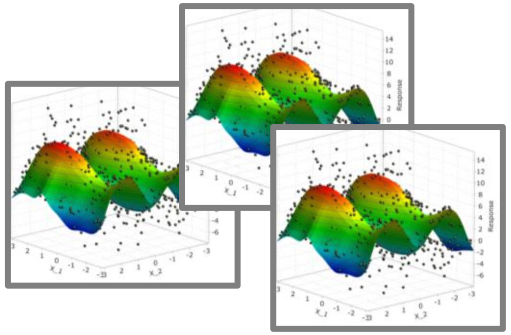
Dynardo‘s metamodels: MOP – **M**etamodel of **O**ptimal **P**rognosis

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

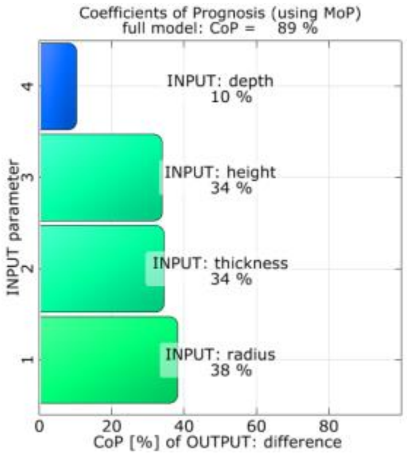
investigate response by response based on LHS sampling

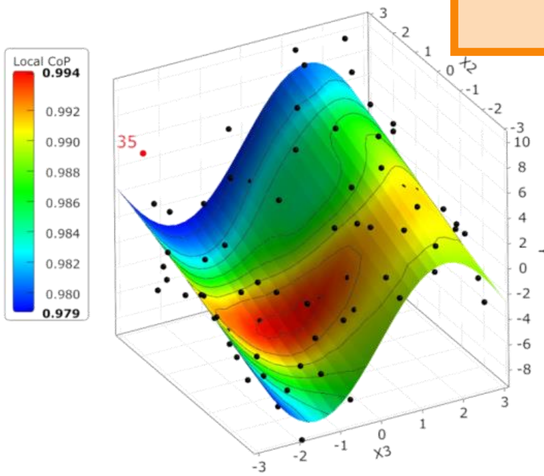
generate competing meta-models

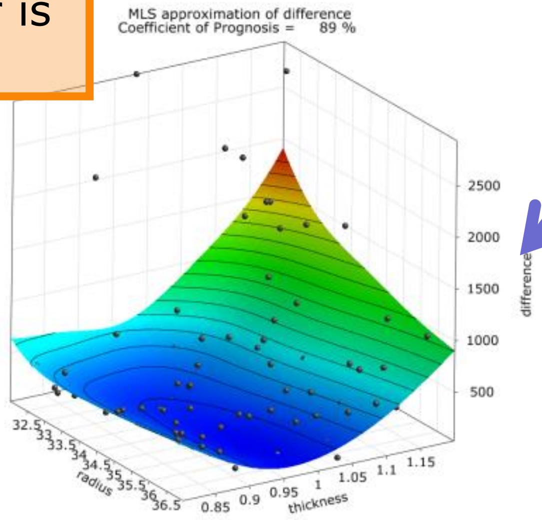


calculate forecast quality using **CoP** (**C**oefficient **o**f **P**rognosis)

The winner is … **MOP**





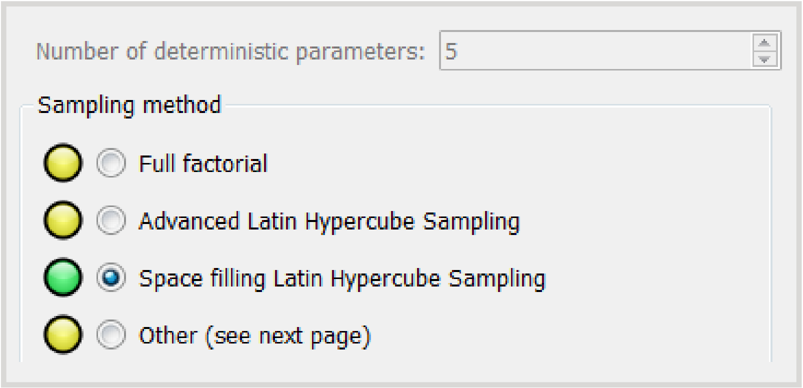


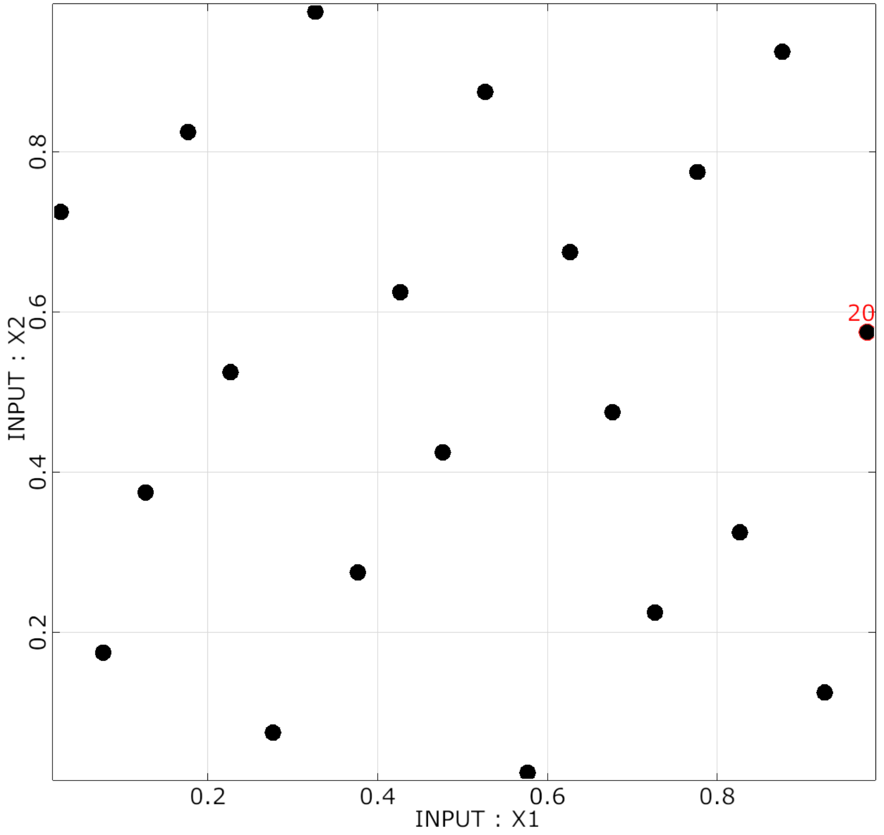
DoE & Sensitivity Analysis

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**



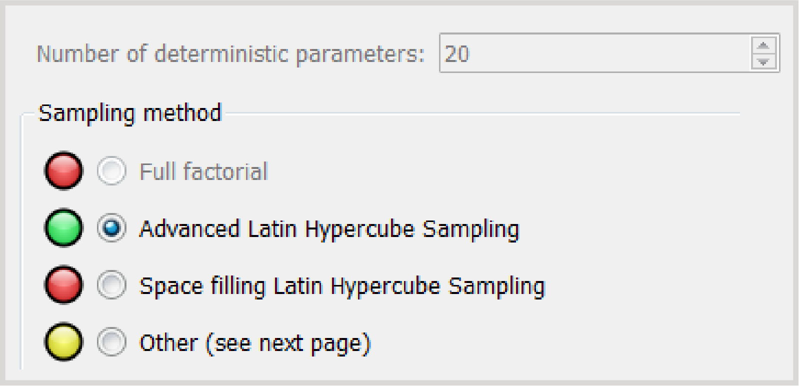


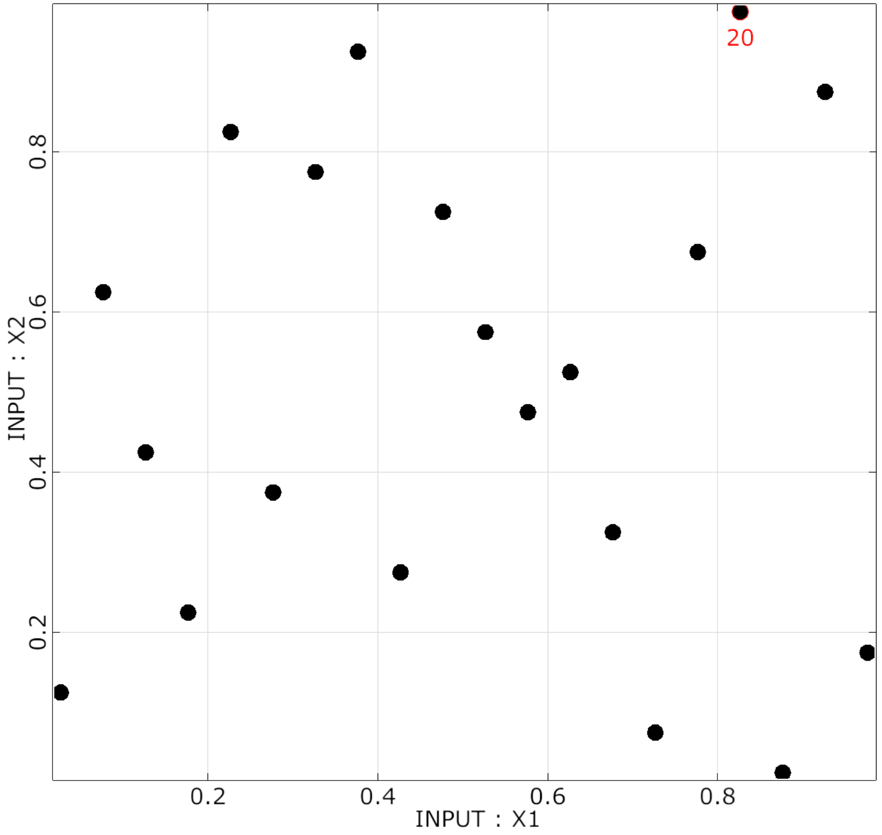
DoE & Sensitivity Analysis

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**

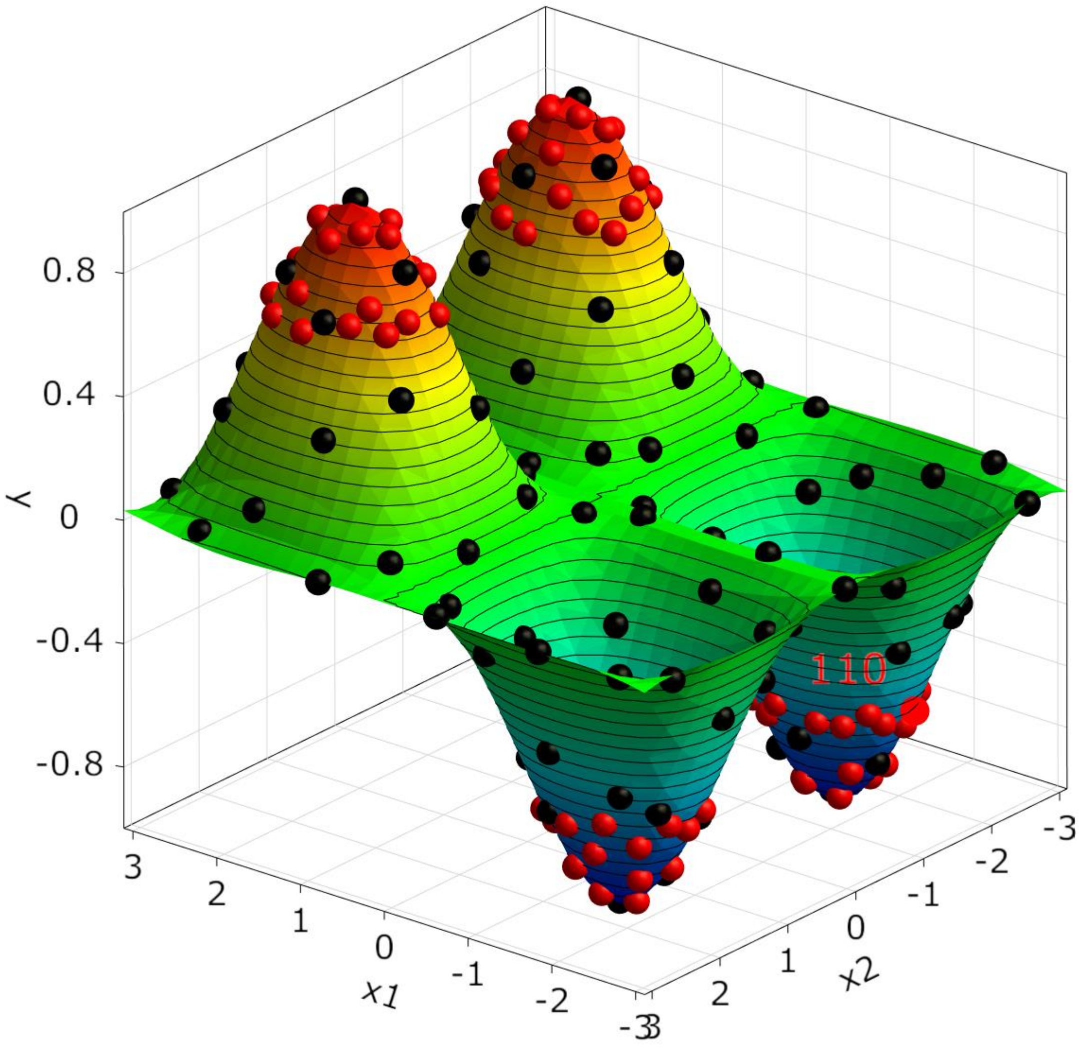




Adaptive Metamodel of Optimal Prognosis - AMOP

- 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 abs(y) > 0.6



AMOP – Global Refinement

Start iteration

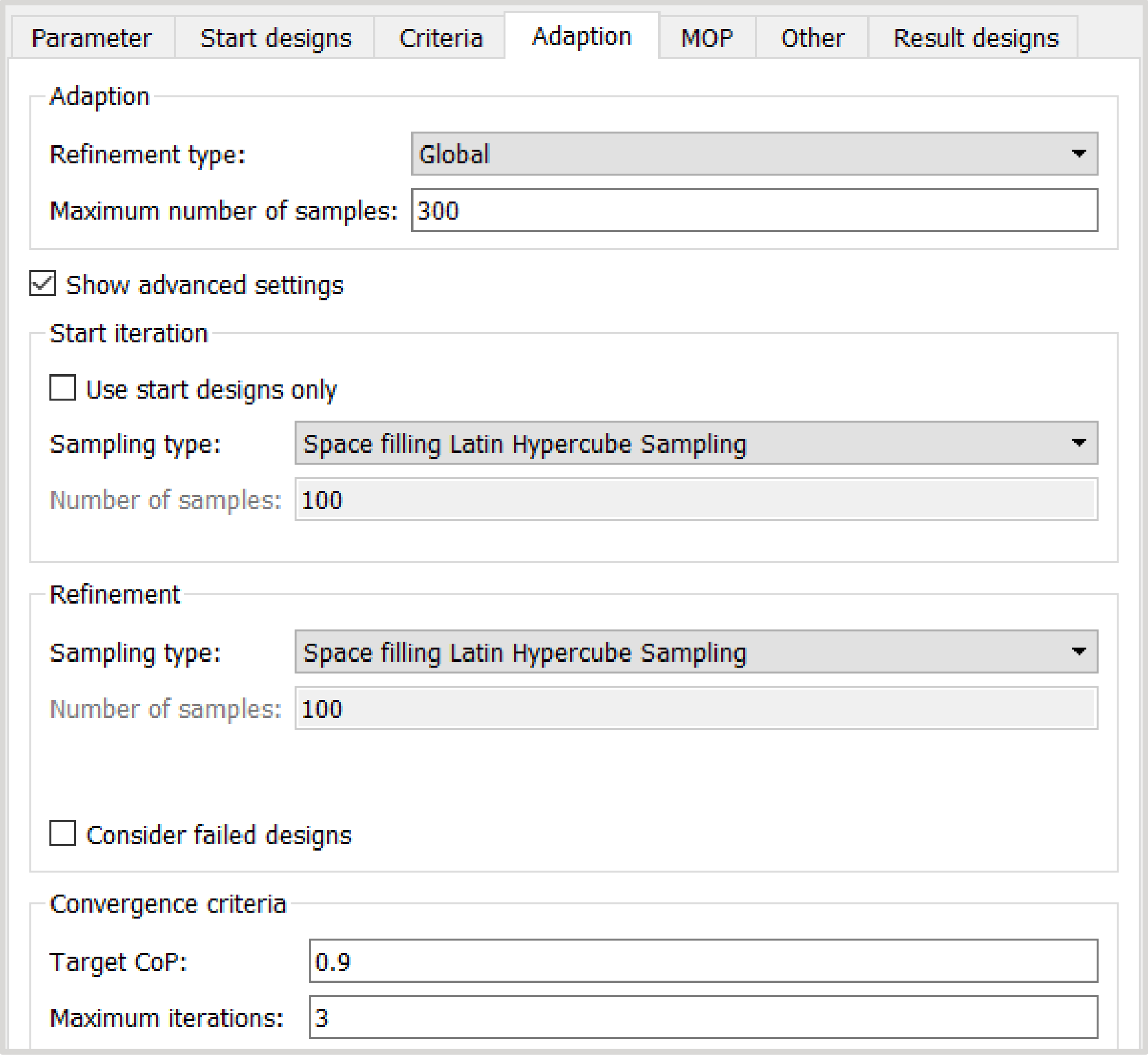
- Works as Sensitivity system
- Sampling and deterministic DoE schemes are possible
- Considers start designs

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

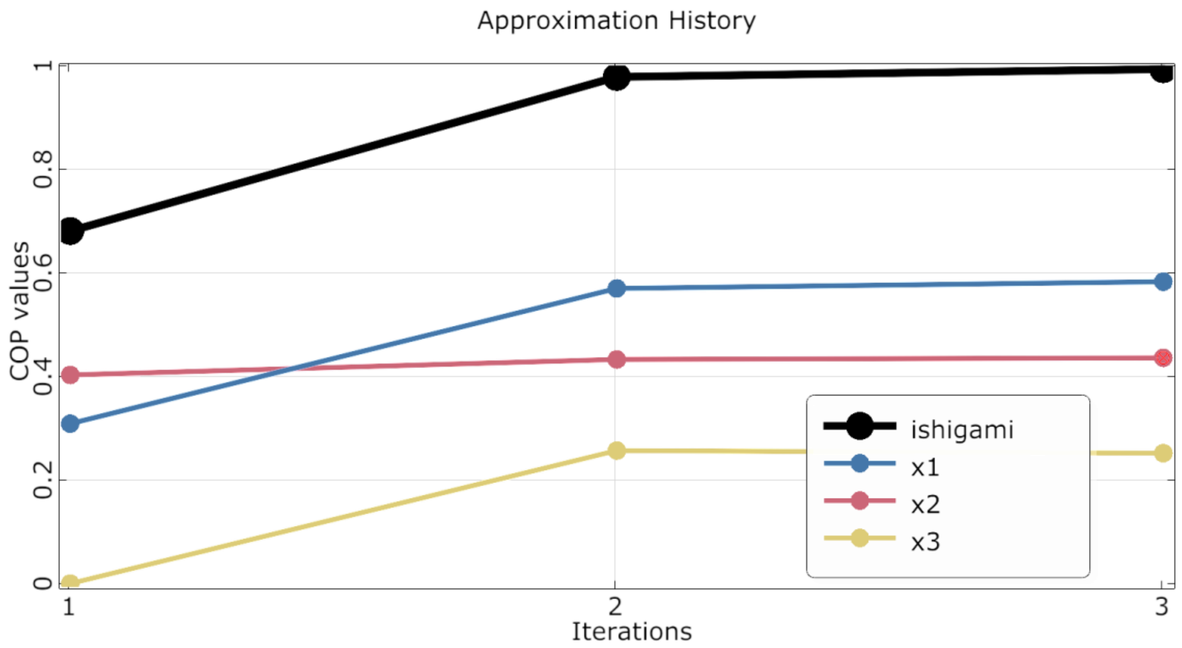


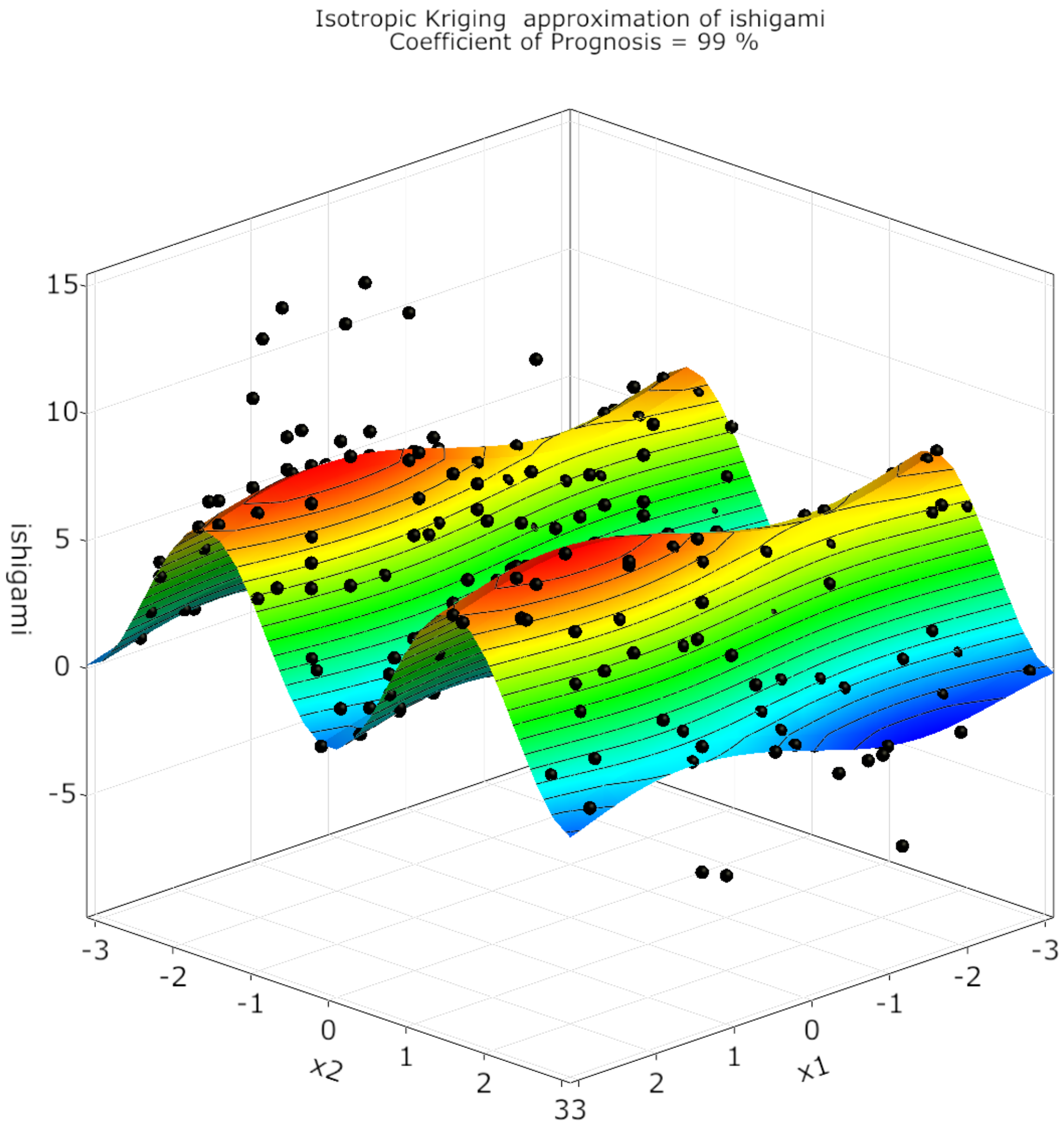
AMOP – Global Refinement

Example Ishigami function

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

➢Target CoP is reached





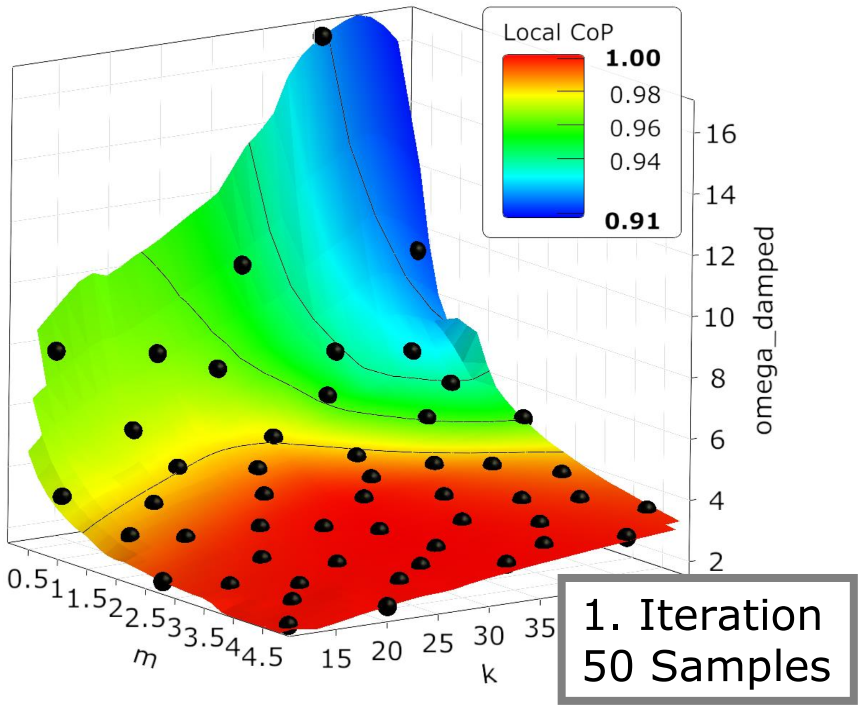
AMOP – Local Refinement

Using local CoP

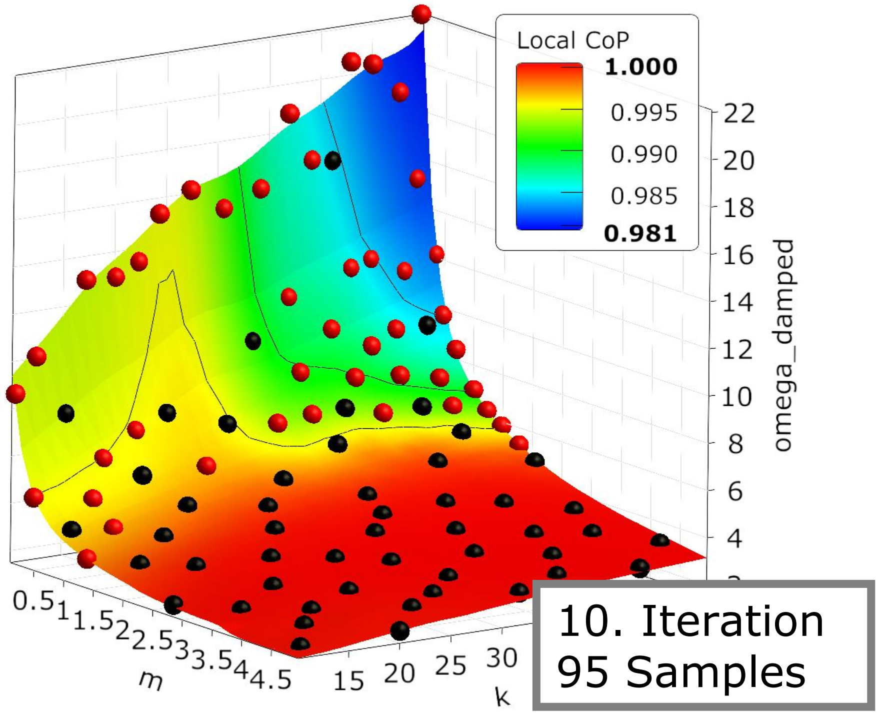
Example Oscillator

- 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 %



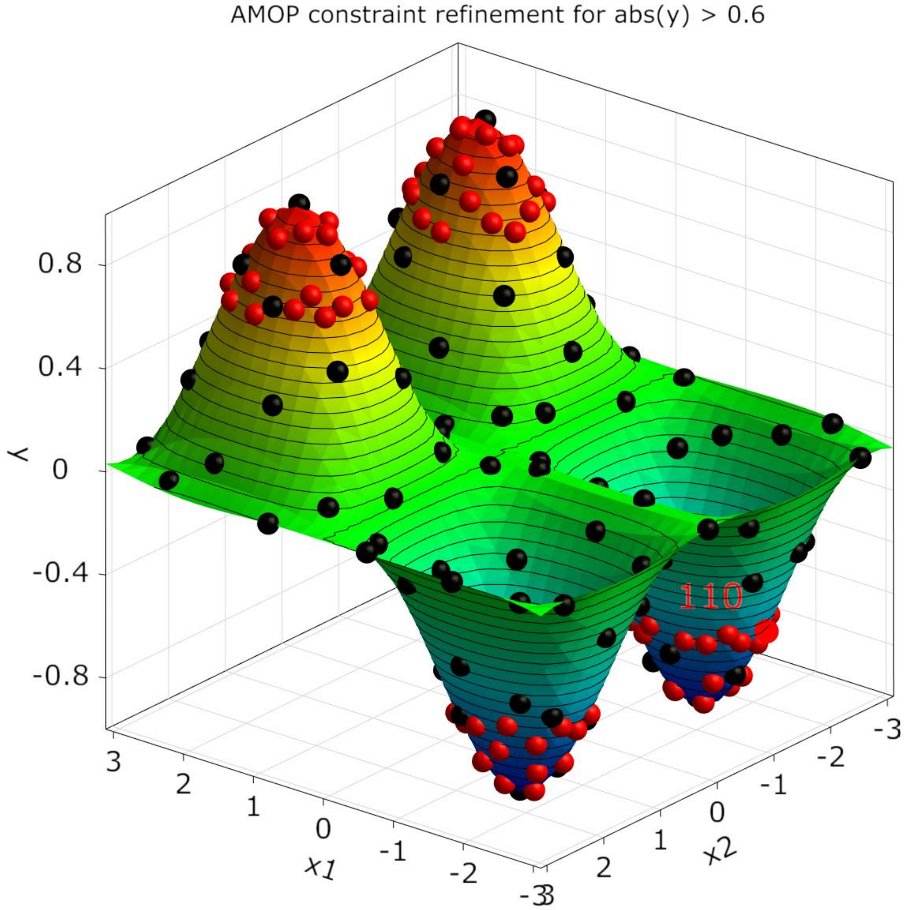
Moving Least Squares approximation of omega_damped
Coefficient of Prognosis = 99 %

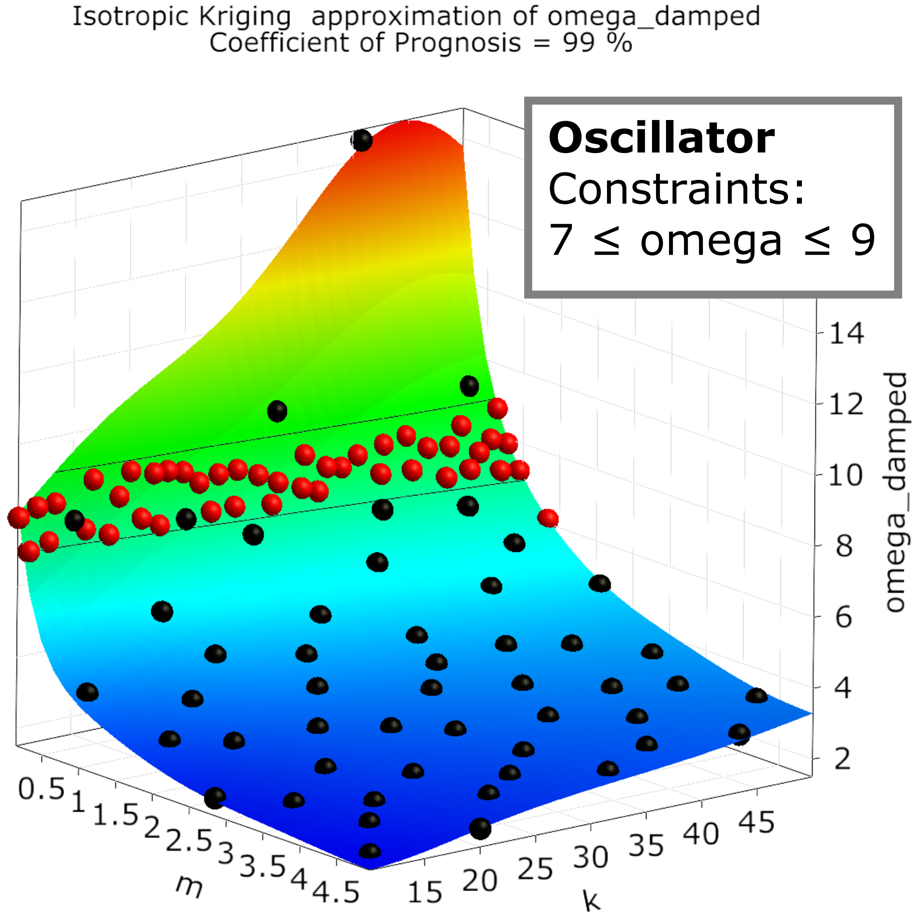


AMOP – Local Refinement

Constraint refinement

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



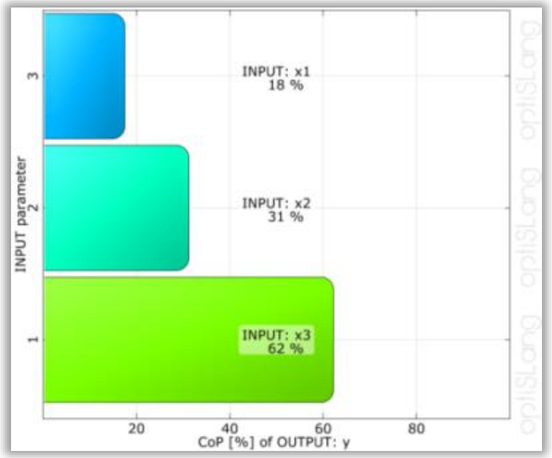


Oscillator
Constraints:
7 ≤ omega ≤ 9

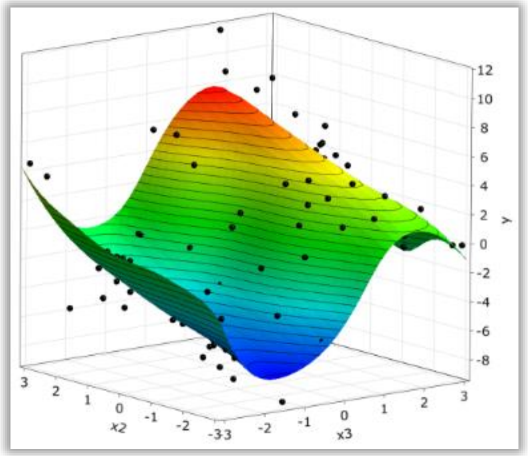
Decision Making by Data Exploration

Data Visualization and Interactive Postprocessing for Design Understanding

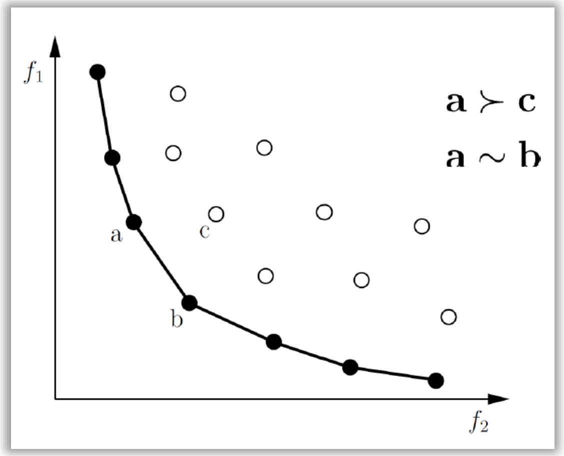
Parameter Ranking



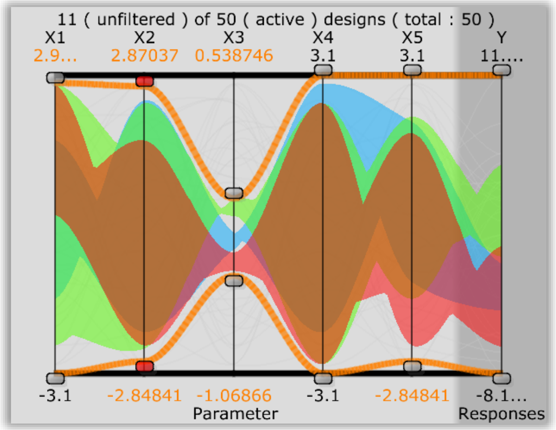
MOP

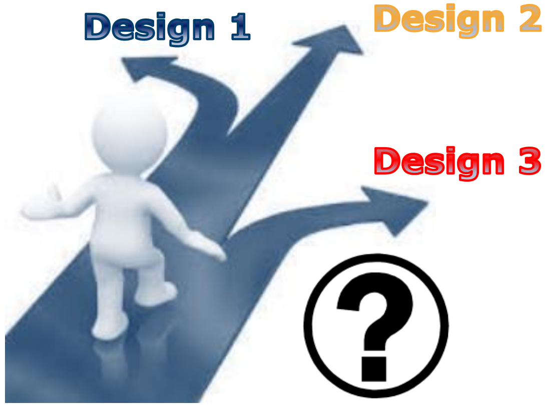


Pareto Optimal

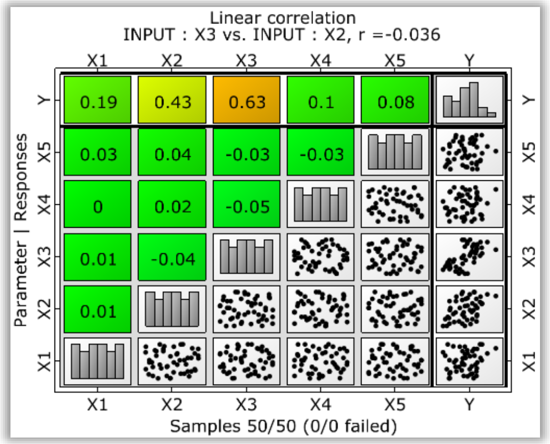


Parallel Coordinates Plot





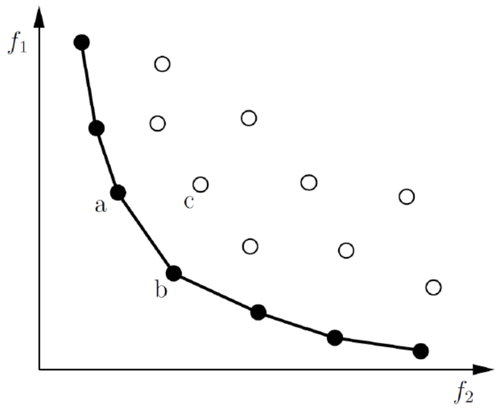
Correlation Matrix

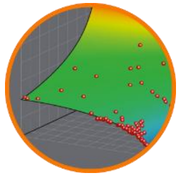


Design Improvement

- 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?

Pareto Optimality

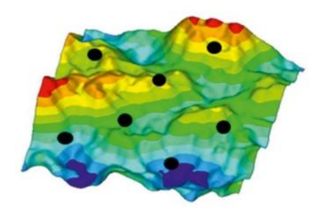




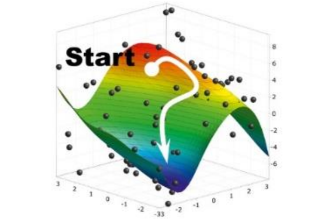
Optimization

Optimize your product design

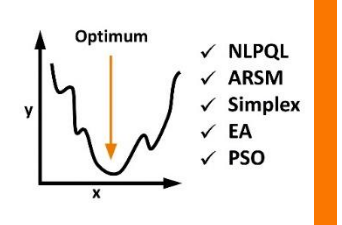
1 Sensitivity analysis for pre-optimization



2 Optimization using MOP



3 Direct optimization with algorithms



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

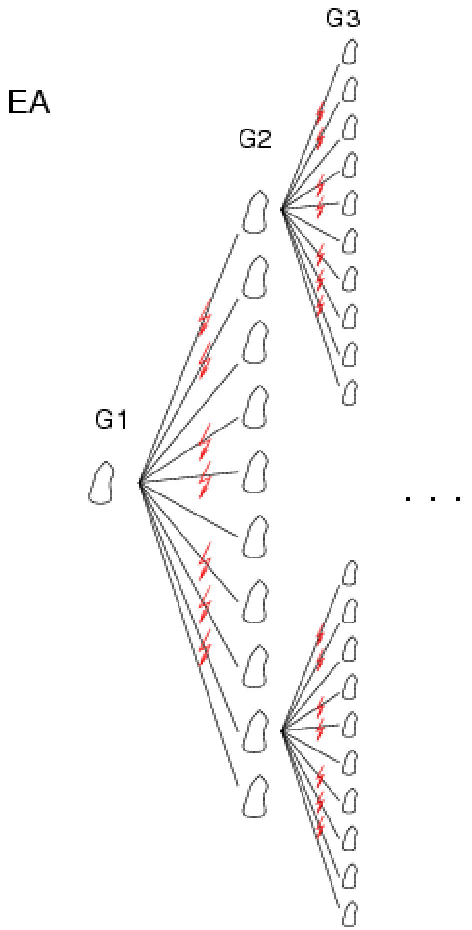
Ansys

Evolutionary Algorithm (EA)

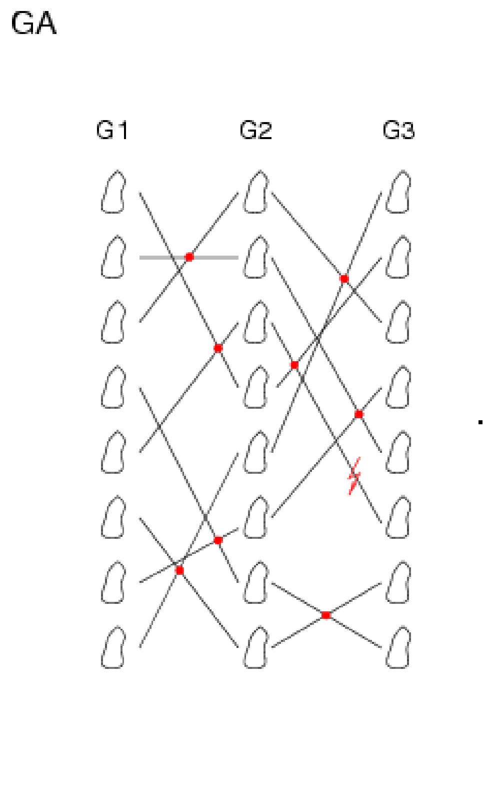
Imitates Evolution ("Optimization") in Nature:

- 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

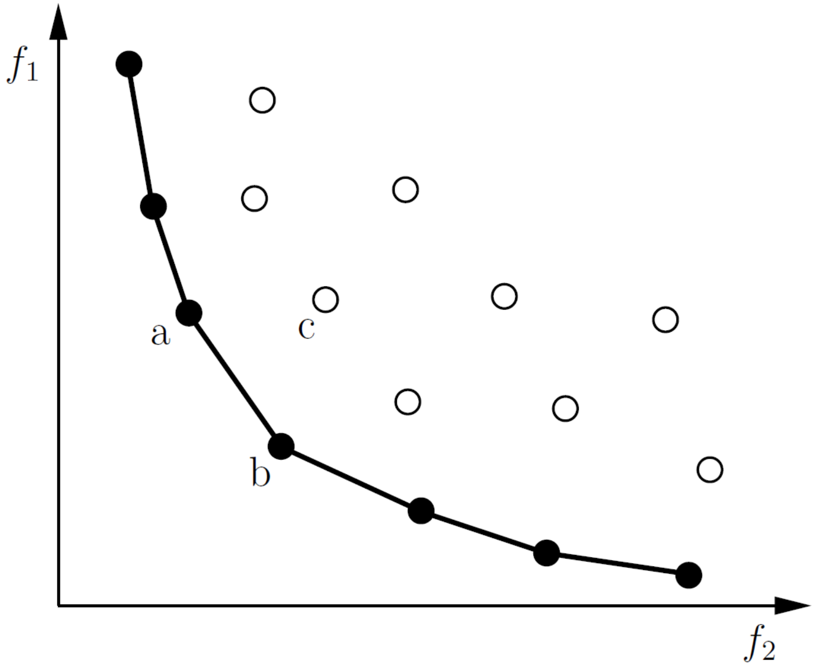
- Stochastic generation of new designs -> robust search approach
- No gradient information or regression is necessary
  (More efficient than NLPQL or ARSM for large number of variables)
- Failed designs can be considered in selection procedure
- Ordinal and nominal discrete variable types can be considered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

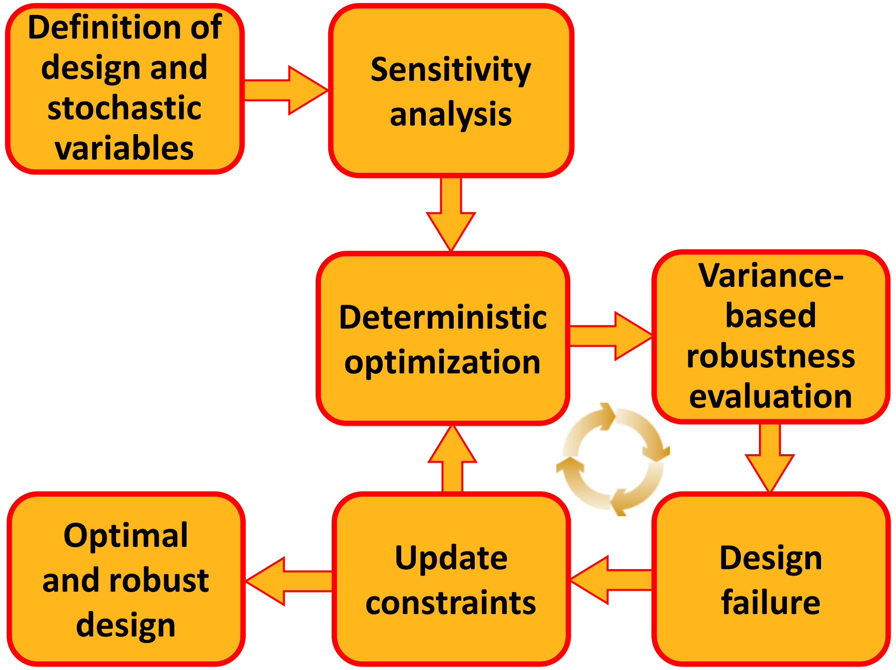


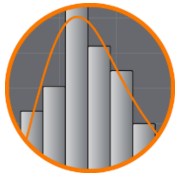
$$\mathbf{a} \succ \mathbf{c}$$ (**a** dominates **c**)

$$\mathbf{a} \sim \mathbf{b}$$ (**a** is indifferent to **b**)

Design Quality

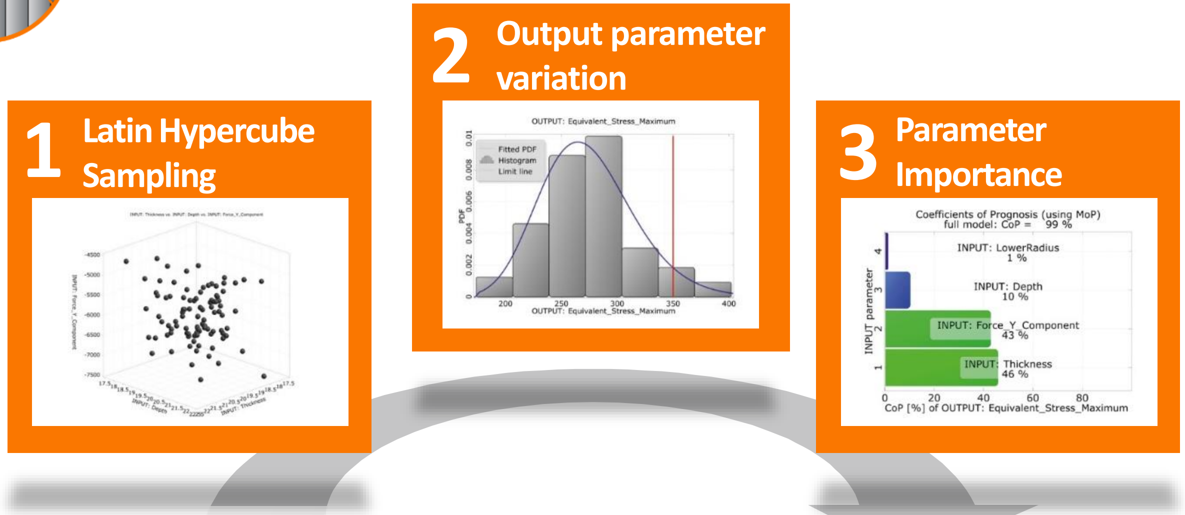
- For each optimization run the safety factors are adjusted for critical model responses
- How big are the influences of tolerances from material, geometry and production





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

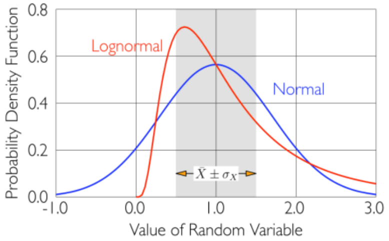
Check variation interval limits and probabilities of overstepping

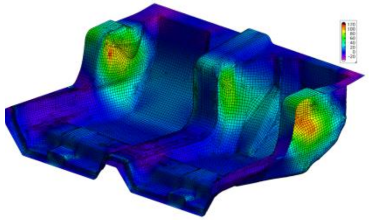
Identify the most important scattering variables

Decision tree for robustness algorithms

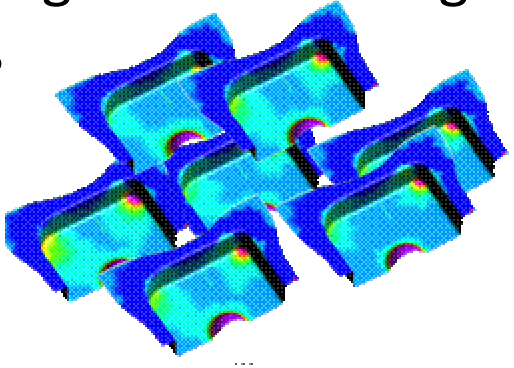
Variance based Robustness Analysis

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

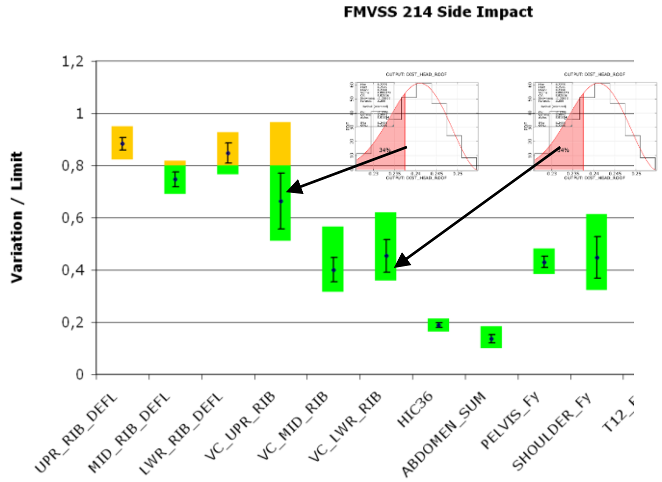




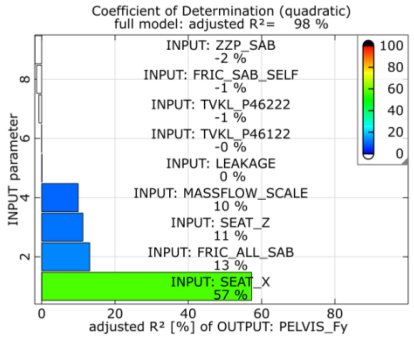
2) Scan the robustness space by producing and evaluating *n* designs



3) Check the variation



4) Check the explainability of the model



5) Identify the most important scattering