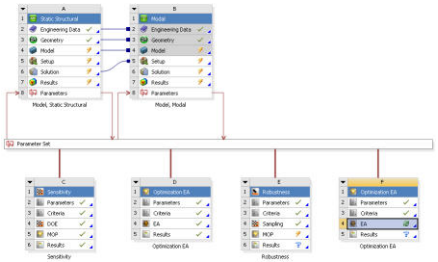
From Topology Optimization to Robust Design Optimization

Dipl.-Ing. Markus Kellermeyer, CADFEM GmbH

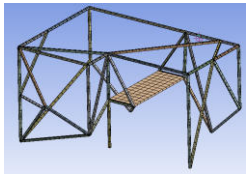
Robust Design Optimization

Outline

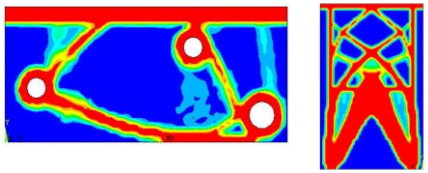
1. Overview for Optimization in ANSYS Workbench



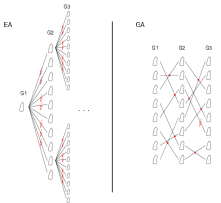
2. Project Description

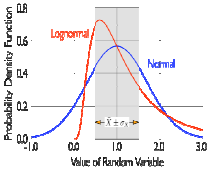


3. Topology Optimization inside ANSYS Workbench



4. Robust Design Optimization with „optiSLang inside Workbench“





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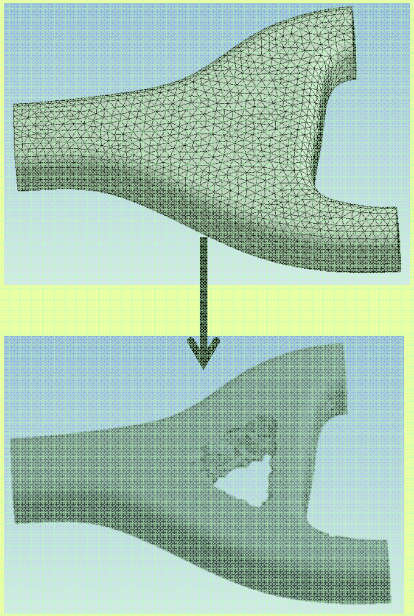
Overview for Optimization in ANSYS Workbench

Parameterfree optimization

Topology Optimization



Parameter optimization

optiSLang inside Workbench

Easy-to-use tool for **difficult & nonlinear** optimization tasks, robustness evaluation and robust design optimization

optiSLang with optiPlug

Advanced tool for **all** tasks

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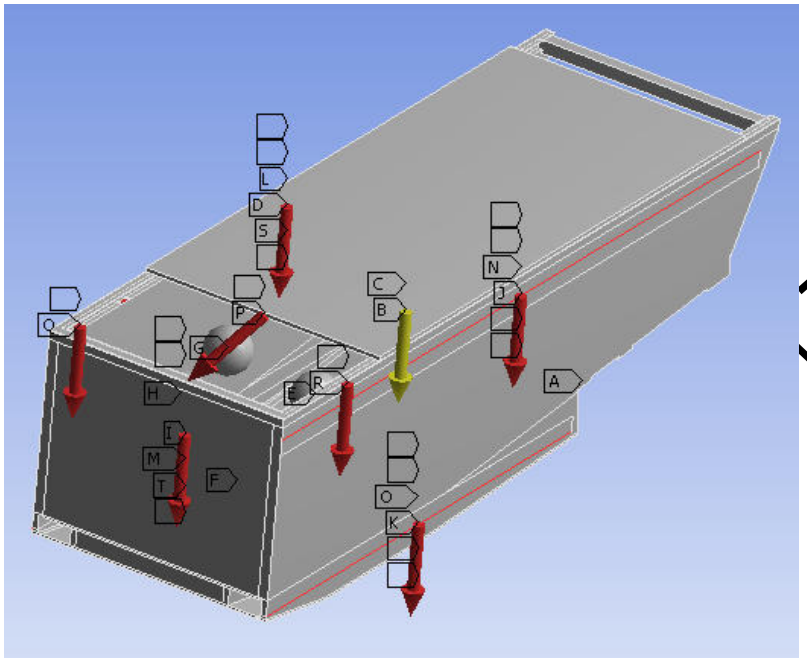
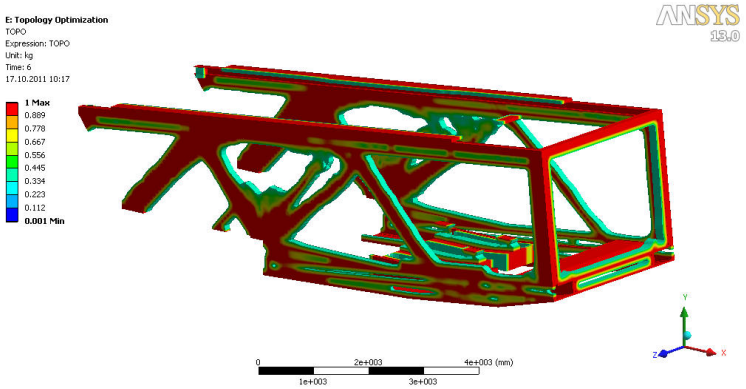
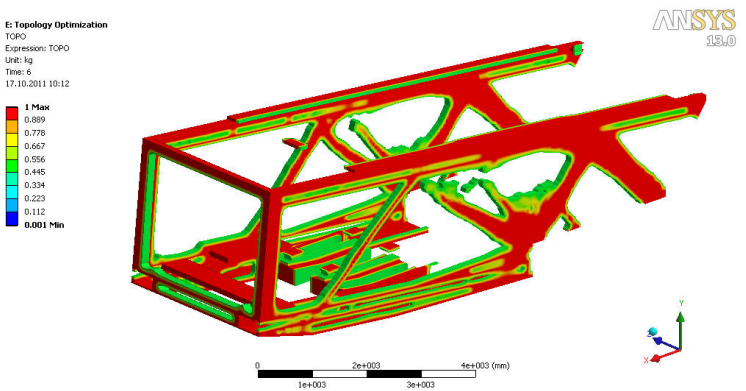
Example for Topology Optimization: PowerWind GmbH

6 different loadcases were considered

- Standard Earth Gravity
- Acceleration
- Fixed Support
- LF1_Wind_links
- LF1_Wind_links 2
- LF1_Wind_rechts
- LF1_Wind_rechts 2
- LF2_Schnee_links
- LF2_Schnee_links 2
- LF2_Schnee_rechts
- LF2_Schnee_rechts 2
- LF3_Winde
- LF3_Kran_links
- LF3_Kran_rechts
- LF3_Haubengewicht_links
- LF3_Haubengewicht_links 2
- LF3_Haubengewicht_rechts
- LF3_Haubengewicht_rechts 2
- LF4_Haubengewicht_links
- LF4_Haubengewicht_links 2
- LF4_Haubengewicht_rechts
- LF4_Haubengewicht_rechts 2
- LF5_Wind_links 3
- LF5_Wind_links 4
- LF5_Wind_rechts 3
- LF5_Wind_rechts 4
- LF6_Winde
- LF6_Kran_links
- LF6_Kran_rechts
- LF6_Haubengewicht_links
- LF6_Haubengewicht_links
- LF6_Haubengewicht_rechts
- LF6_Haubengewicht_rechts







by courtesy of PowerWind GmbH

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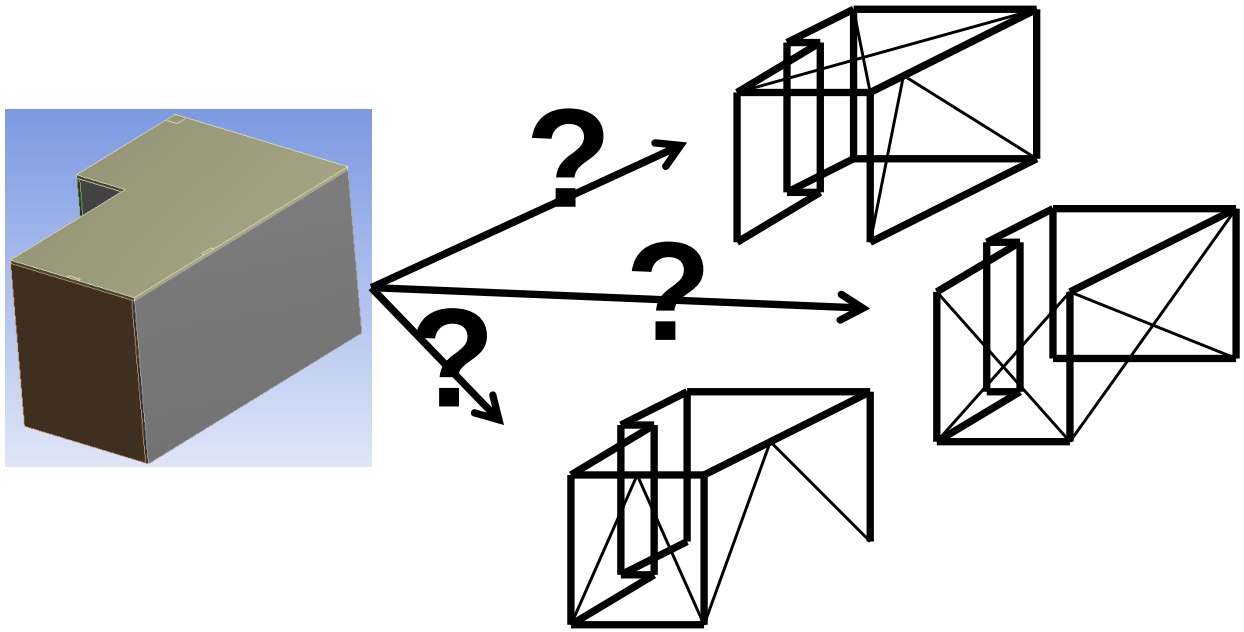
Project Description

Create a design within a predefined space, that

- consists of beams with predefined cross section profiles
- where the beams do not exceed a predefined stress
- where the 1st frequency will be as large as possible
- where the structure will be a 2-σ design or higher due to appearing stresses



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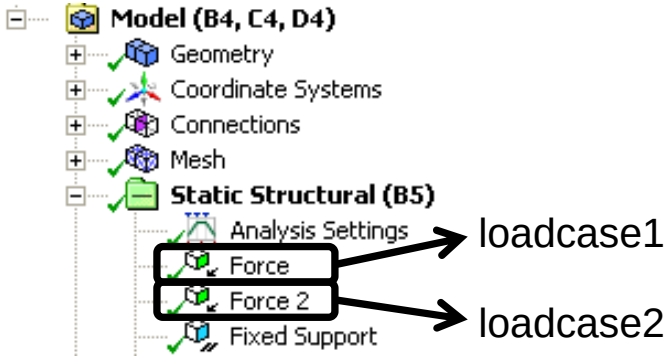
Topology Optimization

Steps to do topology optimization with several load cases:

Define several load steps…



These will represent the loadcases

Run Macro…

Solve…

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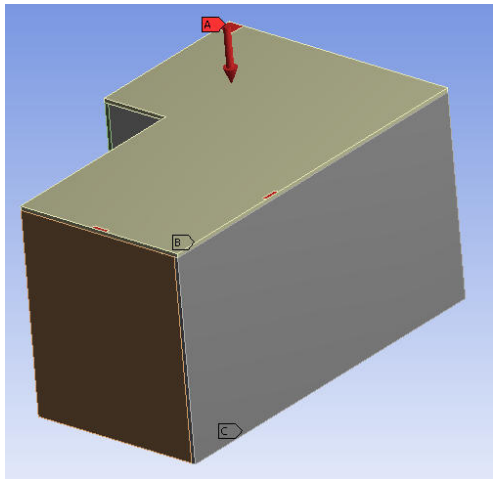
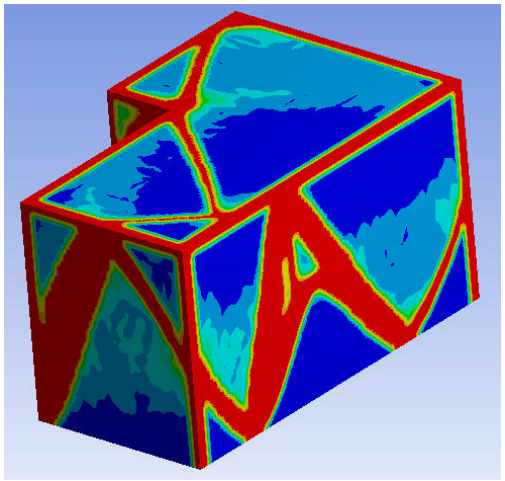
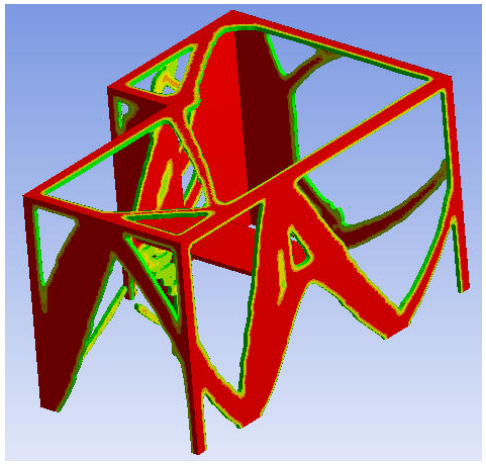
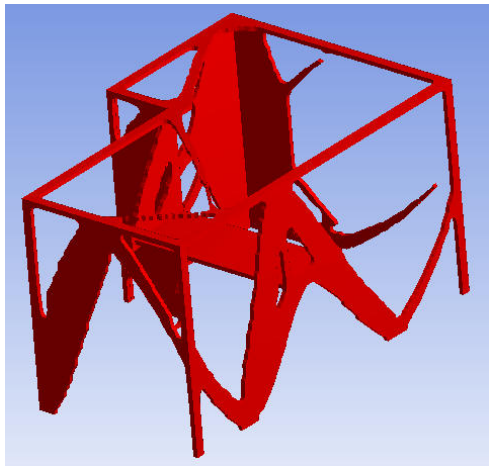
Topology Optimization



→ Use Topology Optimization in Workbench
→ Several load cases can be considered: Topologyoptimization.js
→ a „one-click-solution“

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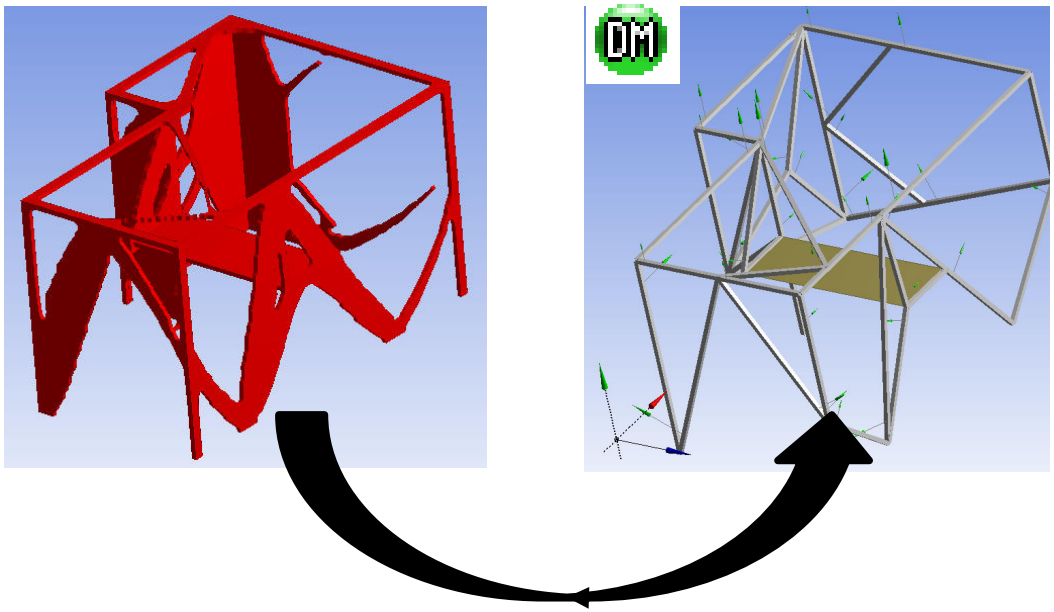
Topology Optimization

Use topology idea, to create a manufacturable concept:



Parameterize the beam structure
to allow different design constellations:

Parameter Manager

```
split1 = 0.64
split2 = 0.45
split3 = 0.75
split4 = 0.45
split5 = 0.65
split6 = 0.5
```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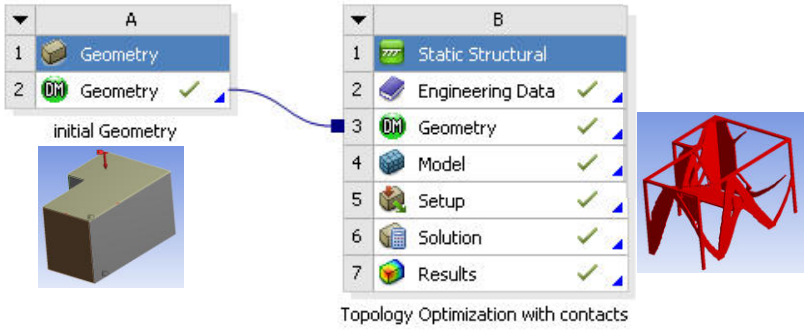
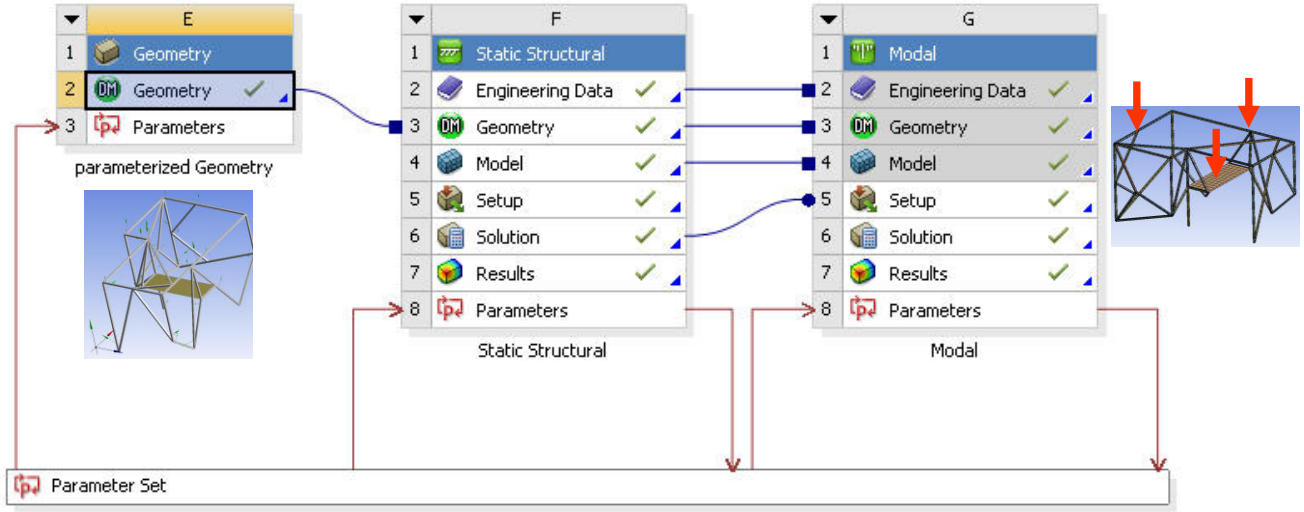
Topology Optimization

What‘s been done so far:





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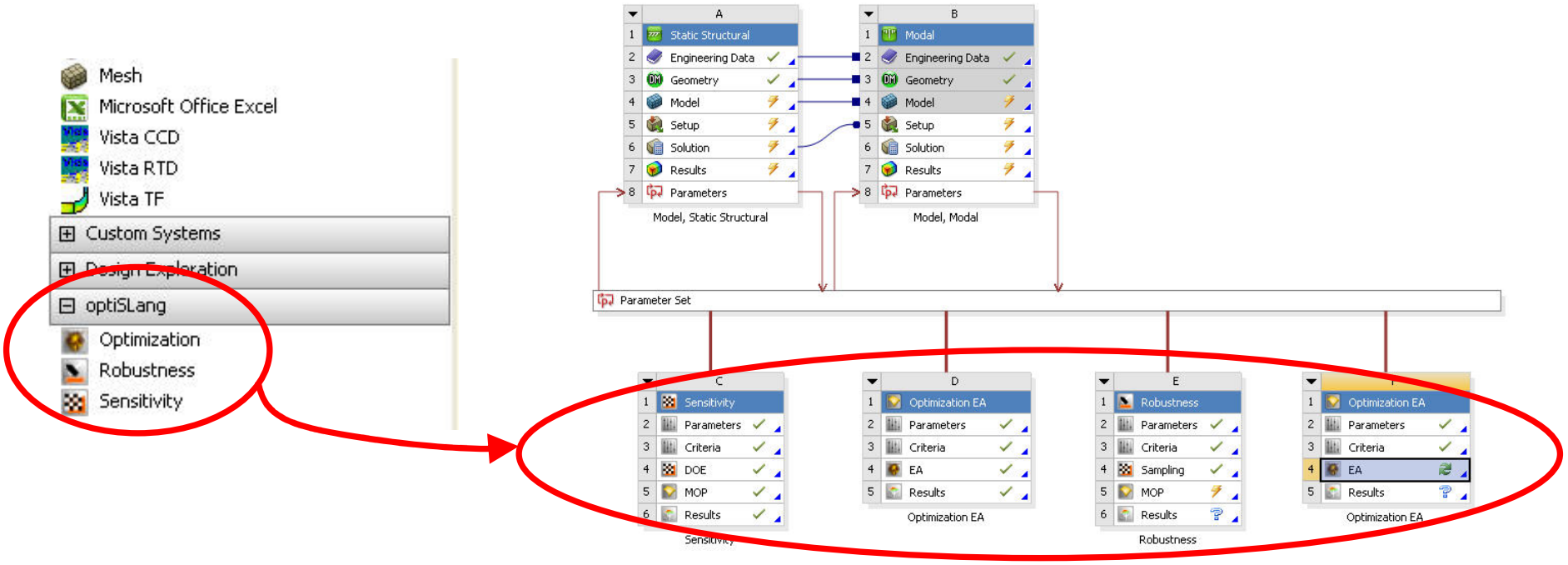
Robust Design Optimization with „optiSLang inside Workbench“

General Information:
Dynardo integrated „optiSLang“ in ANSYS Workbench as an easy-to-use tool.
It‘s called „optiSLang inside Workbench“



→ It will be used for the „Robust Design Optimization“ Workflow

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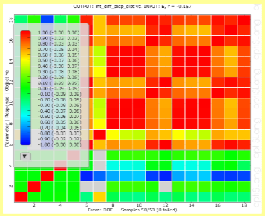
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

General Workflow:

Sensitivity Analysis:

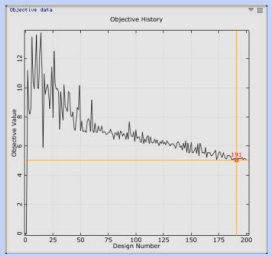
Input1 Input2
Input3 Input4
Input5 Input6
Input7 …



Optimization:

Input1 Input4

Objectives
Constraints

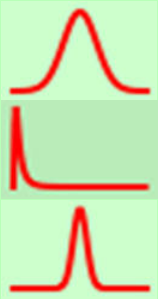


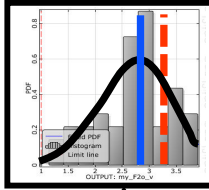
→ Input1‘ Input4‘

Robustness Eva.:

Input1‘ Input2
Input3 Input4‘
Input5 Input6
Input7 …

Constraints





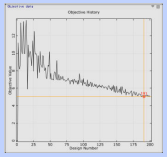
→ 1-sigma level

Modify Constraints for a new Optimization

Optimization 2:

Input1‘ Input4‘

Objectives
Constraints‘

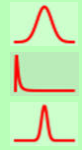


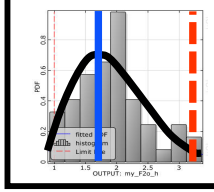
→ Input1“ Input4“

Robustness Eva. 2:

Input1“ Input2
Input3 Input4“
Input5 Input6 …

Constraints



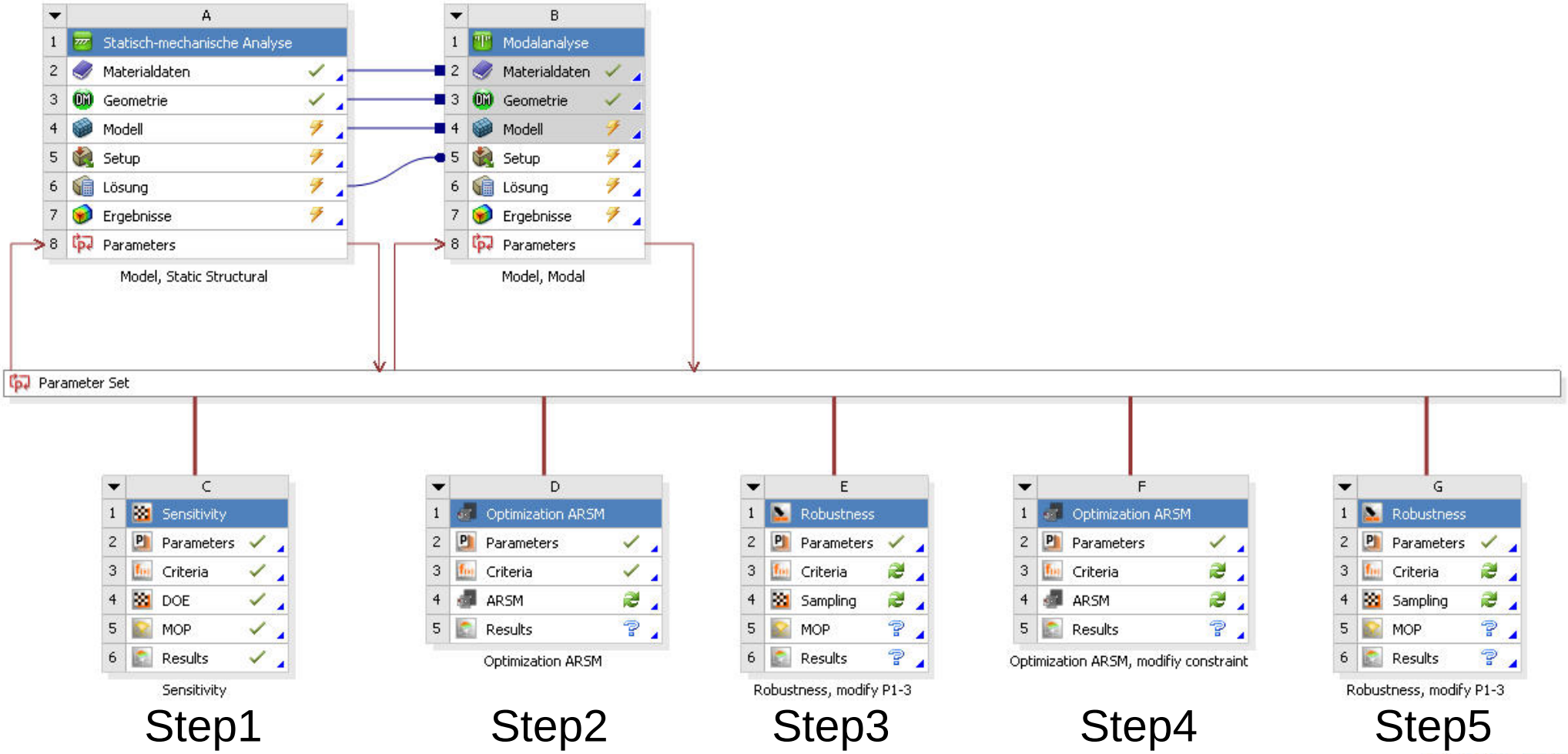


→ 3-sigma level

Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

General Workflow in ANSYS Workbench:



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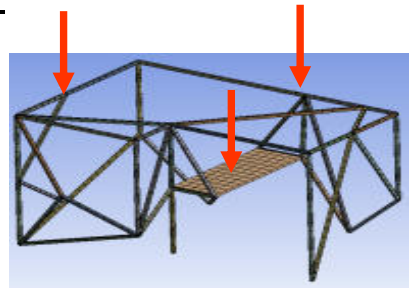
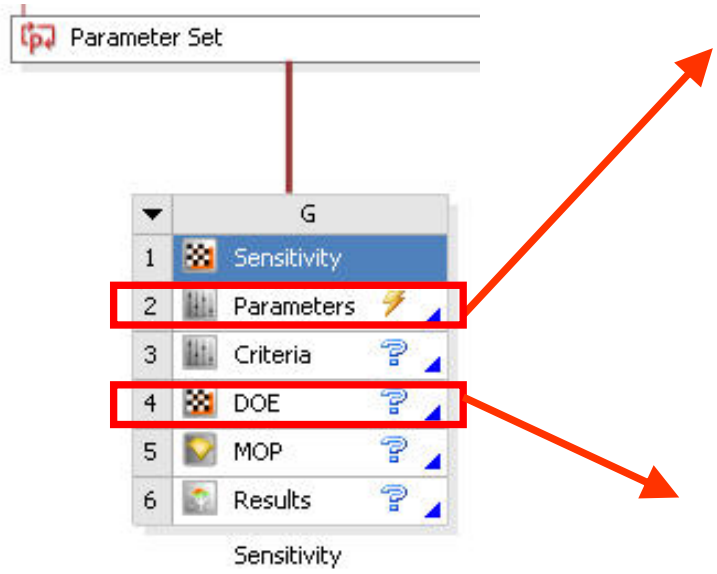
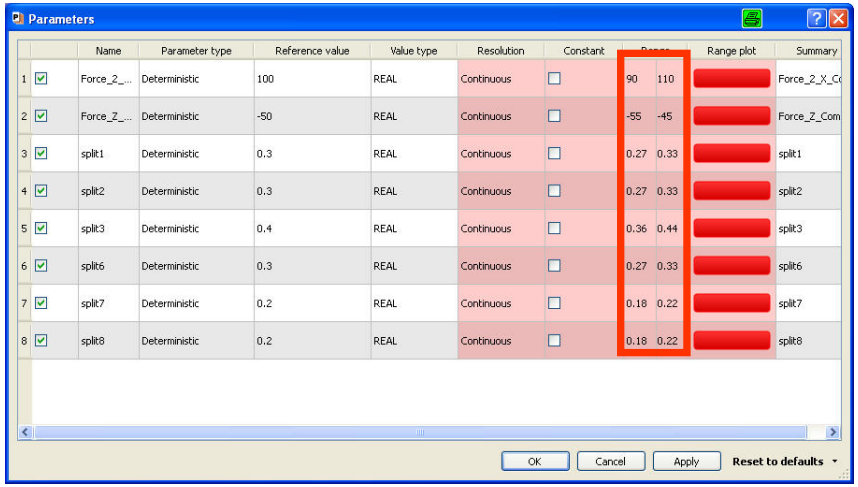
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

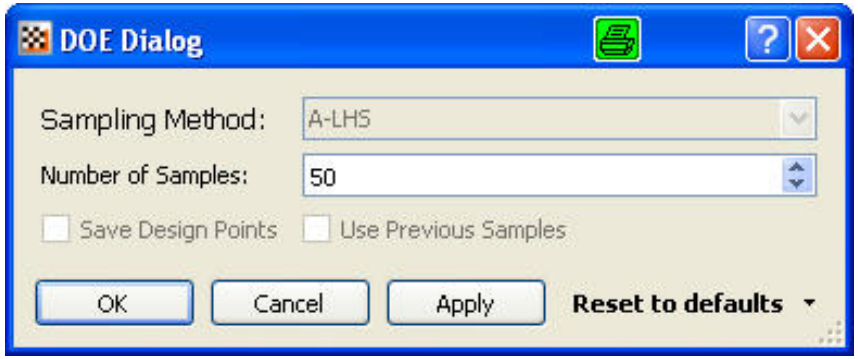


Step 1: Sensitivity Analysis - Setup





1. Define lower & upper bounds



2. Define number of samples

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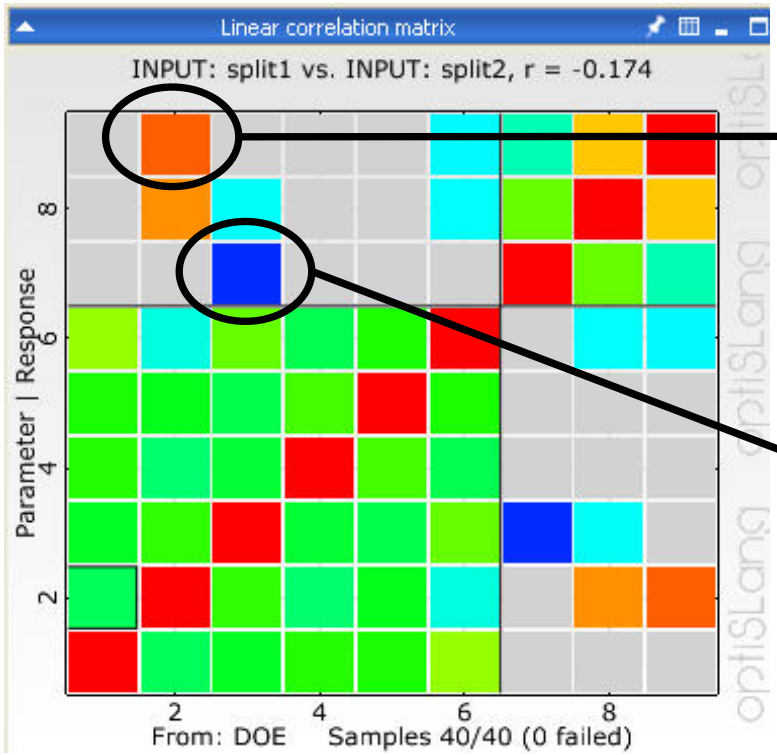
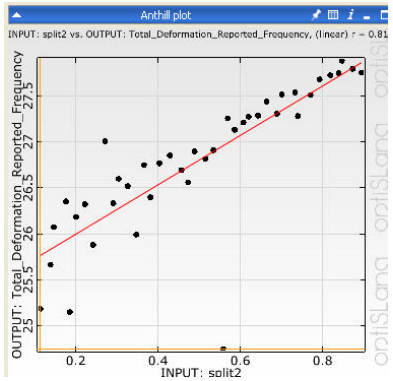
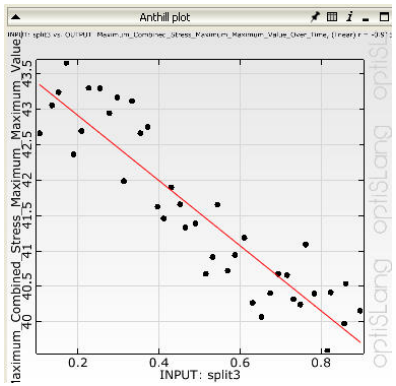
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

Step 1: Sensitivity Analysis - Results







Stress: 88 %

Deformation: 84 %

Frequency: 80 %

→ Important parameters: split2, split3, split6

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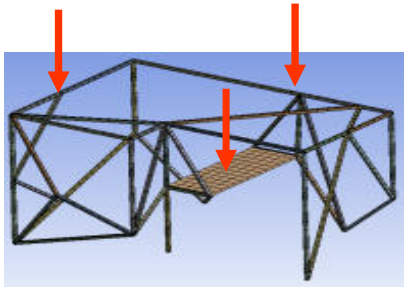
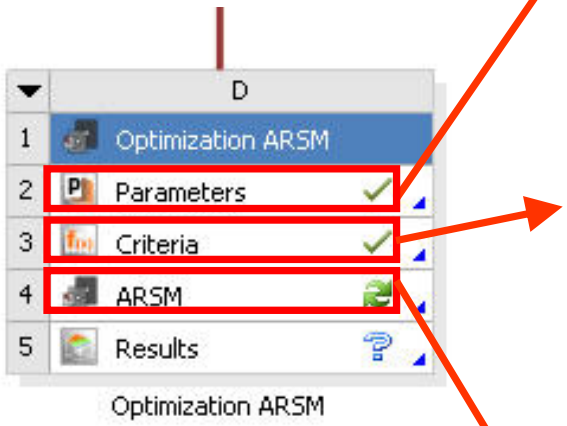
Robust Design Optimization with „optiSLang inside Workbench“

Step 2: First Optimization

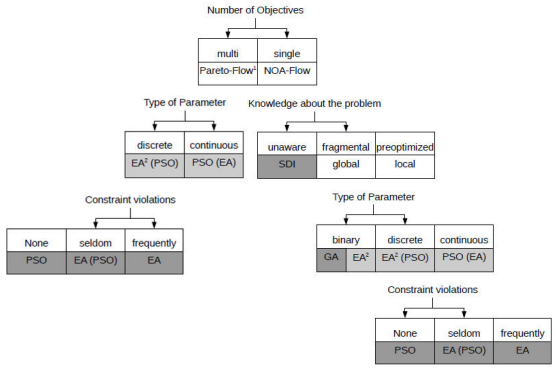




Parameter setting

Define constraints & objectives:
σ < 43.5
d < 0.17
frequency → max

Just choose an algorithm.
The ‚decision tree‘ helps!



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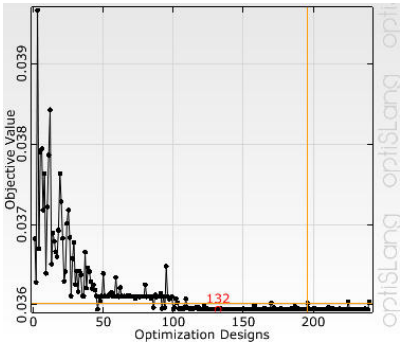
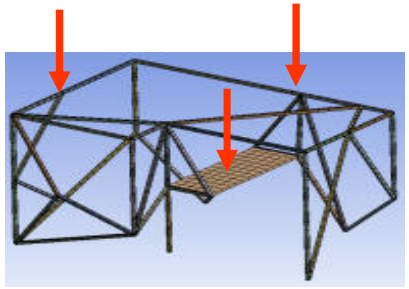
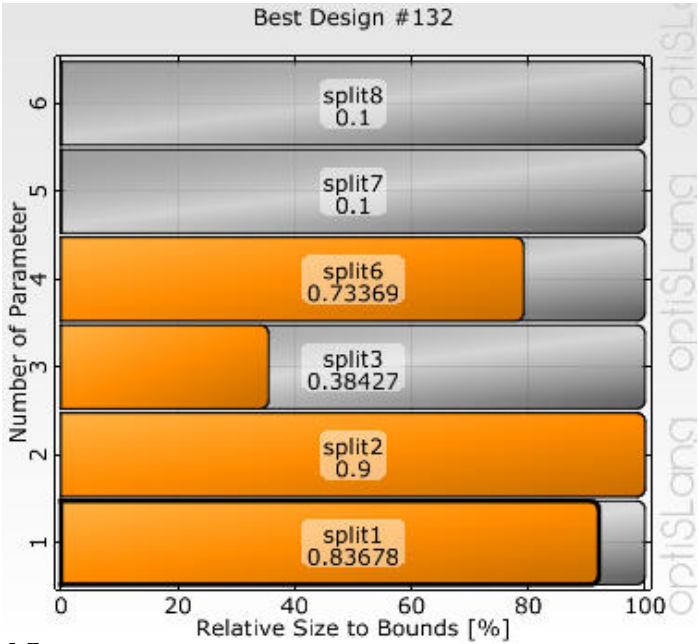
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

Step 2: First Optimization - Results







Stress = 40.87 < 41.5 (limit) ✓

Deformation = 0.169 < 0.17 (limit) ✓

1st Frequency = 27.9

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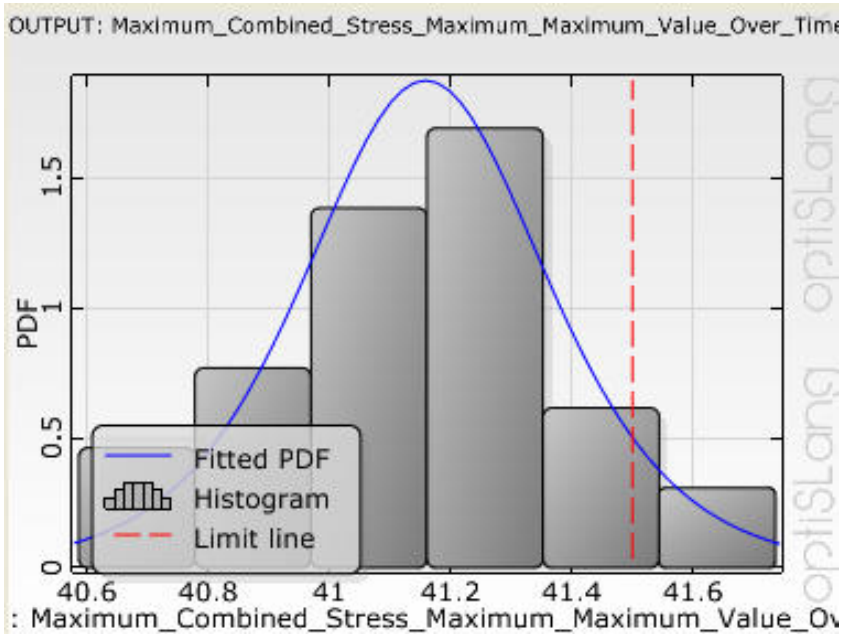
Robust Design Optimization with „optiSLang inside Workbench“

Step 3: Robustness Evaluation with optimized design



The current sigma level for this design is: (41.5-41.16)/0.242 = **1.4**

→ not good enough

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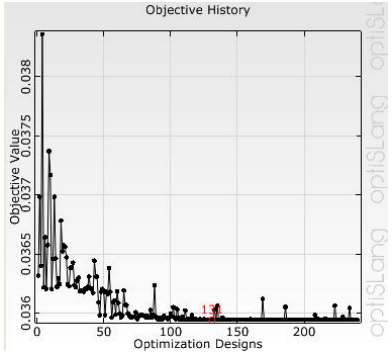
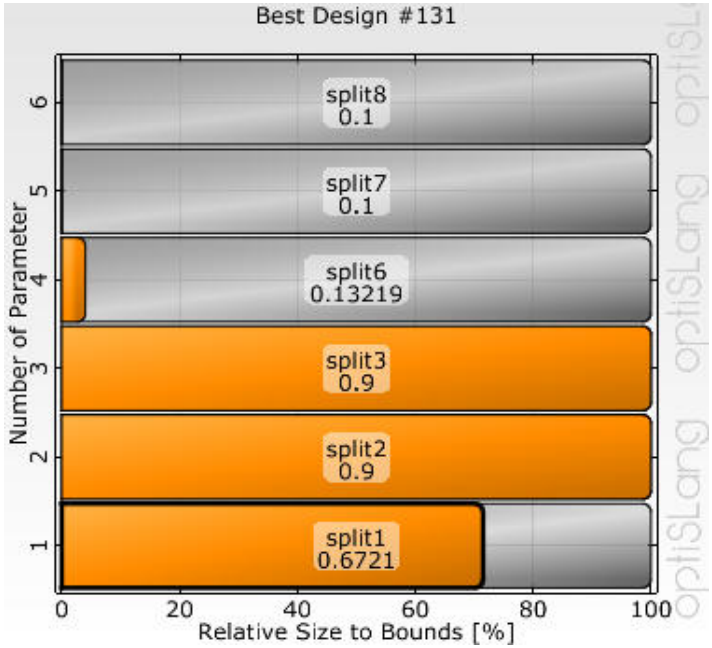
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

Step 4: Second Optimization with changed constraint

Define new stress constraint:
σ < 41.2
d < 0.17
frequency → max





Stress = 39.0 < 41.5 ✓
Deformation = 0.168 < 0.17 ✓
1st Frequency = 27.8

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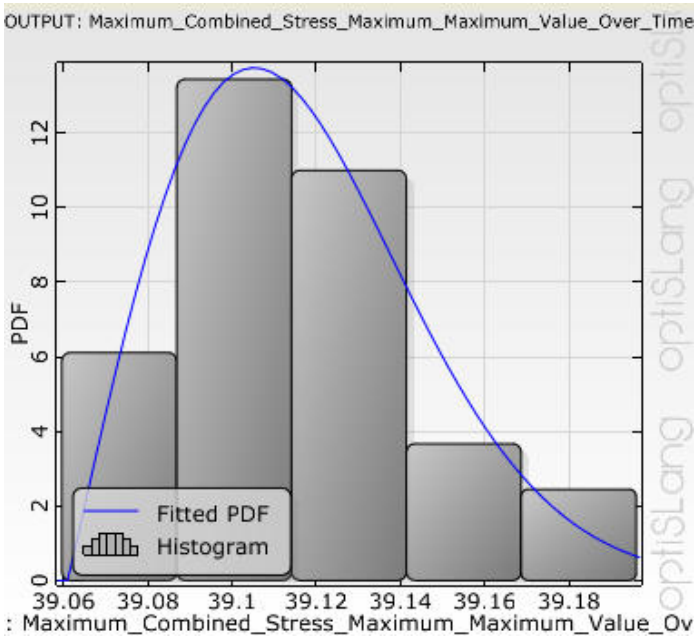
Robust Design Optimization

Robust Design Optimization with „optiSLang inside Workbench“

Step 5: Robustness evaluation with second optimized design



Now, the sigma level is > 2σ

→ **ok**! optional: 3rd run with interpolated stress-constraint

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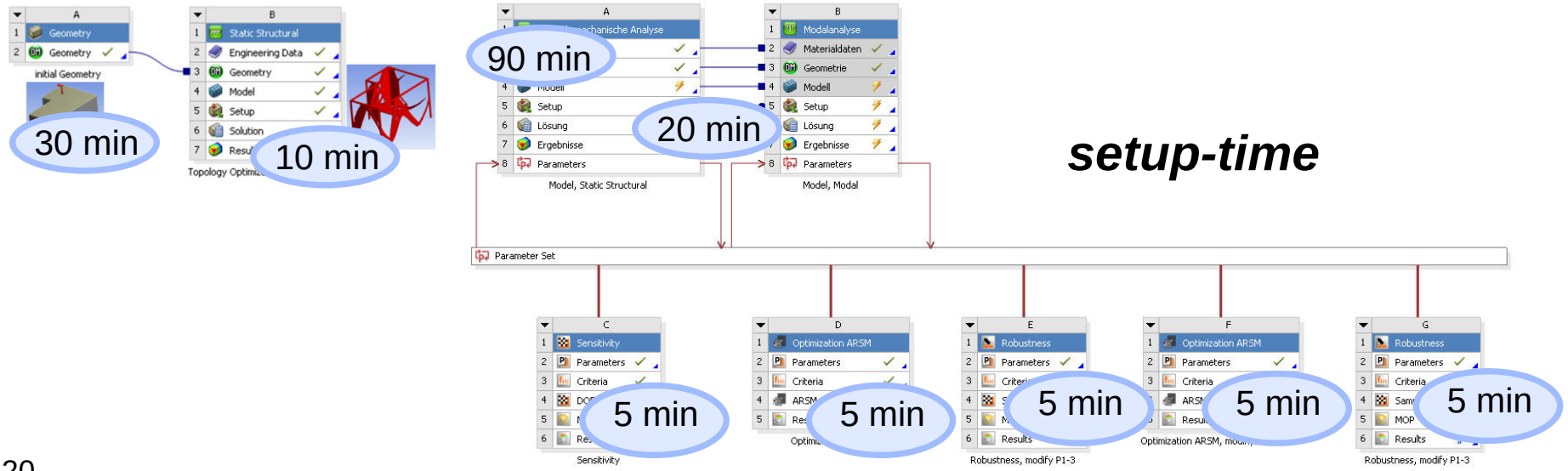
Robust Design Optimization

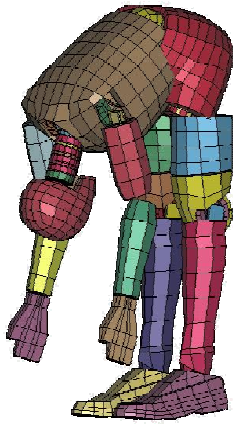
Conclusion

- → Topology Optimization good for finding a concept
- → Parametric Optimization good to work with manufacturable parameters and in more than 1 physics domain
- → Robust Design Optimization can now be done inside Workbench in a very quick way: „optiSLang inside Workbench“
- → easy-to-use tool, that safes time for the user:



Robust Design Optimization

Thanks for your attention!



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