17h - 18th
OCTOBER
2016

PARMA
PAGANINI CONGRESSI
ITALY

INTERNATIONAL CAE CONFERENCE

A CAD-MESH MIXED APPROACH TO ENHANCE SHAPE OPTIMIZATION CAPABILITIES

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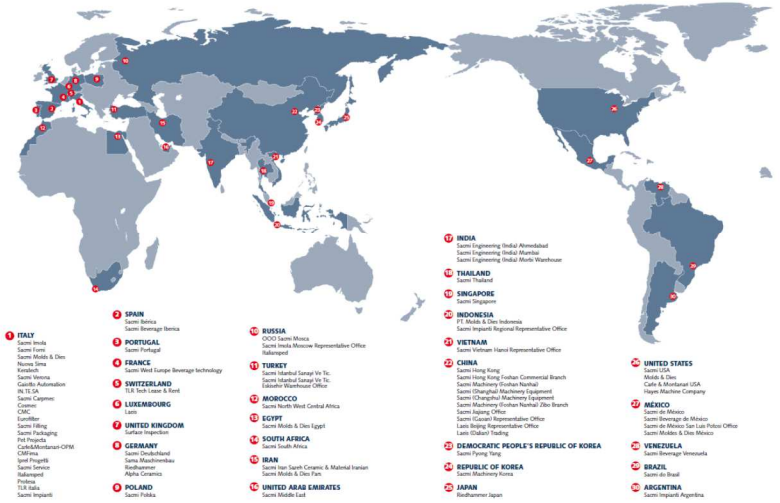
Outline

- Company profile
- Shape optimization
  - CAD-based
  - MESH-based
- Proposed CAD-MESH mixed approach
- Application
- Conclusion

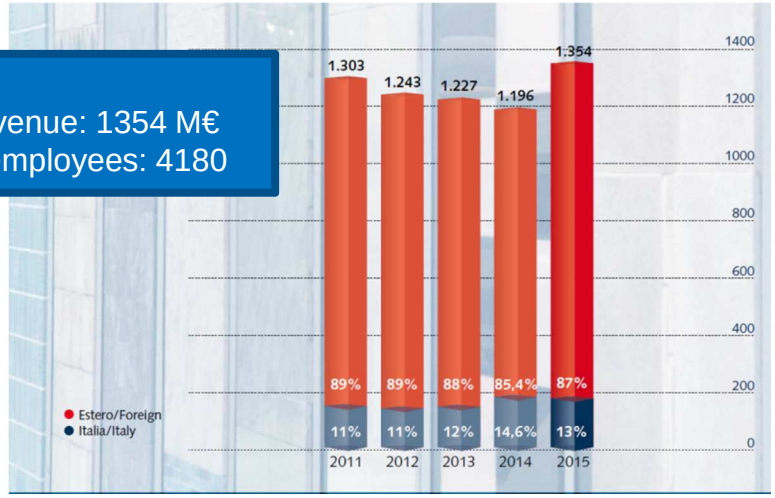
SACMI

Ceramics Packaging Food Services

Since 1919

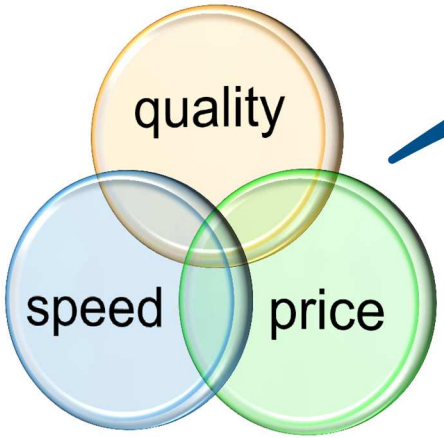


2015
Total revenue: 1354 M€
Group employees: 4180



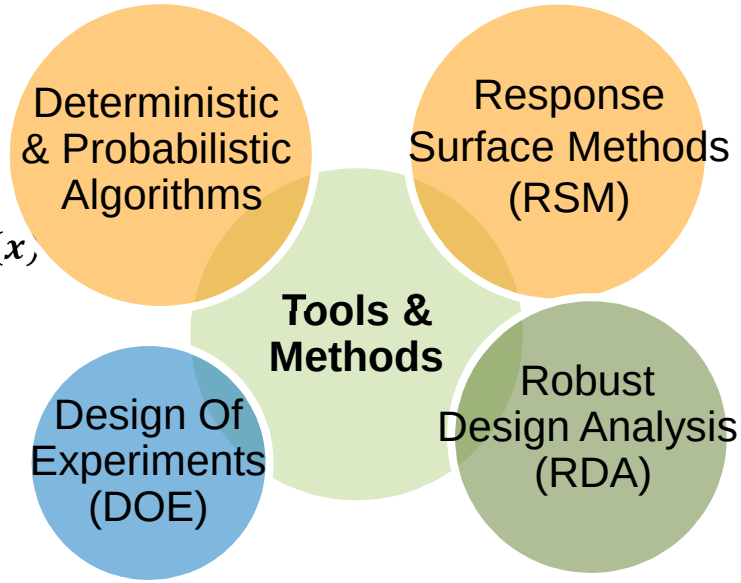
Your today's presenter:
CAE Engineer of Ceramic Engineering Department

Structural Optimization in Industrial Design Process



Find the best compromise through

$$\begin{cases} minimize\ f(\boldsymbol{x}) \\ s.t.: \\ x \in X \subseteq \mathbb{R}^k \\ \boldsymbol{c}(\boldsymbol{x}) \leq 0 \end{cases}$$

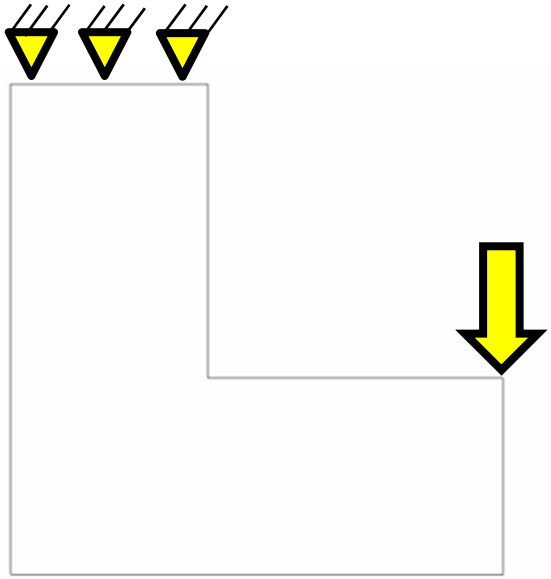


Increase **structural performance** (Reliability, Stiffness,…)

Reduce **weight** or **cost**

Structural Optimization in Industrial Design Process

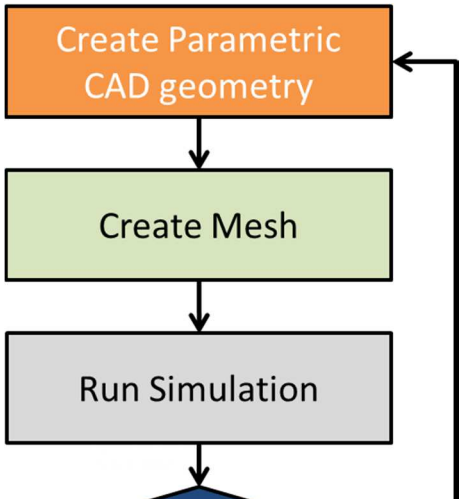
Topology Optimization

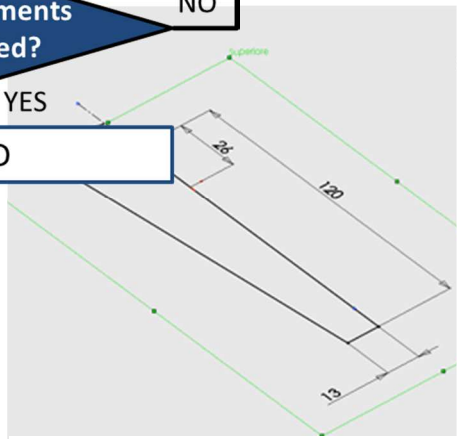


Shape Optimization

Shape Optimization

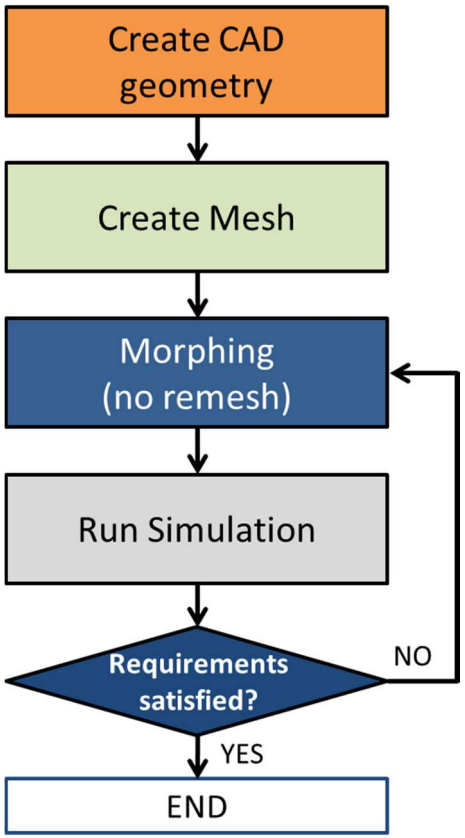
❖CAD-based

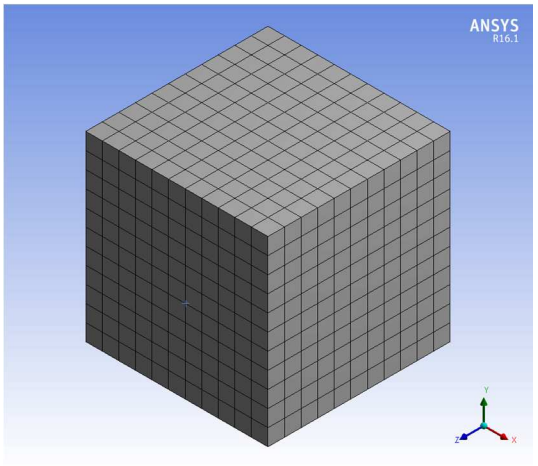




.gif from FreeCAD

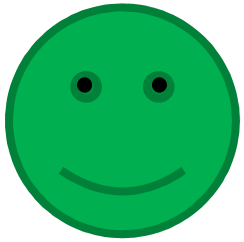
❖MESH-based





.gif from RBF Morph

Shape Optimization: CAD-based



↑Designer oriented

↑Strict geometric requirements

↑Geometric dependent loads

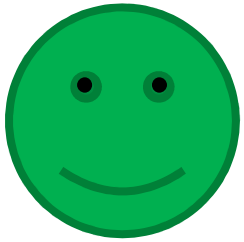
↓Geometry coherence

↓Remeshing performance and quality

↓CAD-FE data transfer efficiency

↓Not all CADs work on dead-geometries

Shape Optimization: MESH-based

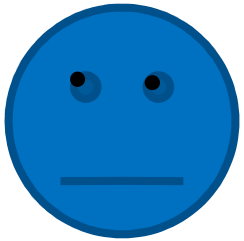


- ↑No remeshing
- ↑Generally faster
- ↑No geometry coherence issues
- ↑Works on dead meshes

- ↓Analyst oriented
- ↓Strict geometric requirements

Shape Optimization: CAD-MESH mixed approach

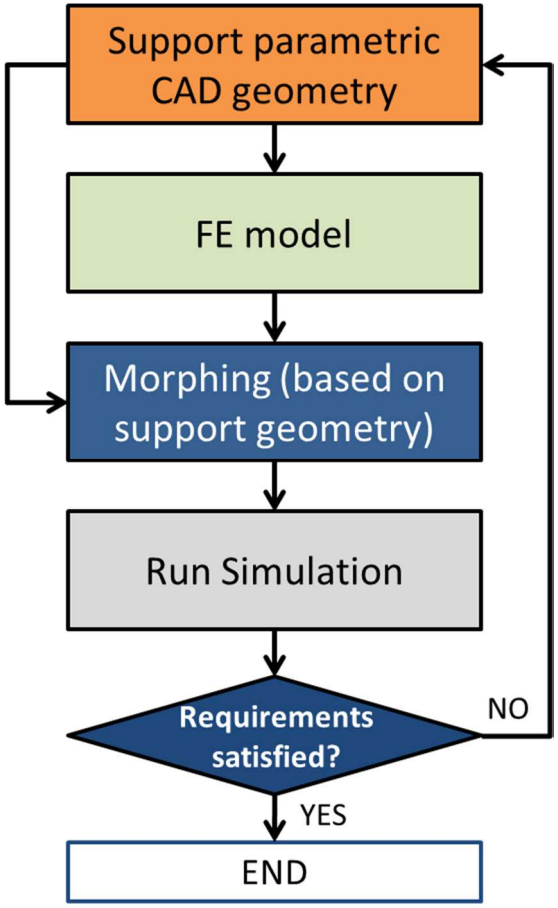
How could I mix the goods?



- Designer oriented
- Strict geometric requirements
- Geometric dependent loads

- No remeshing
- Generally faster
- No geometry coherence issues
- Works on dead meshes

Shape Optimization: CAD-MESH mixed approach



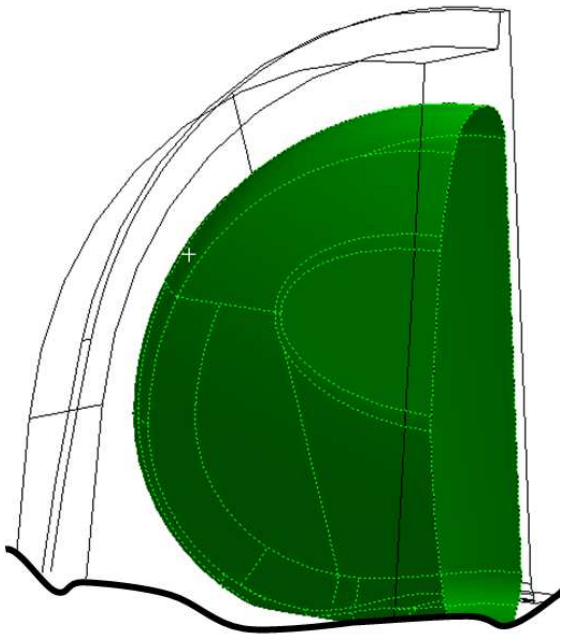
I'll use a support geometry to manage mesh-morphing !!!

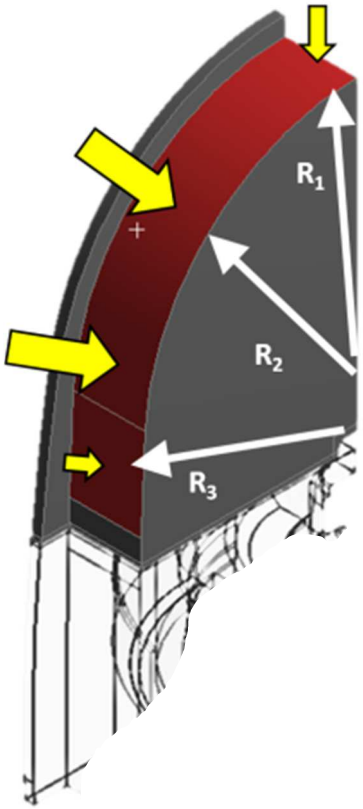
KEY-POINTS

- The geometry of the FE model is not changed during the optimization.
- A "dummy" support geometry to control shape optimization is created and controlled by the optimization design variables.
- The mesh morphing is used to modify the FE model by following the support geometry.

CAD-MESH mixed approach: application

- Complex geometry: **NO** easy way to directly handle it with parametric **CAD**





- Pressure loads related to geometry: **NO** easy way to directly handle it with **MESH** morphing

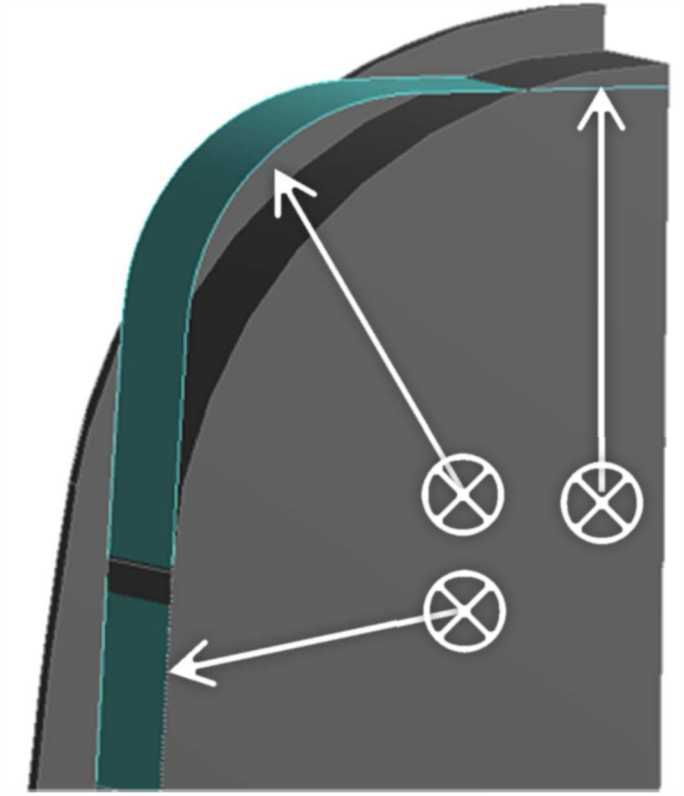
- Strict geometry requirements: **NO** easy way to directly handle it with **MESH** morphing

CAD-MESH mixed approach: application

Parametric support geometry

Parameters:

- Radii
- Global coordinates of fillet centers

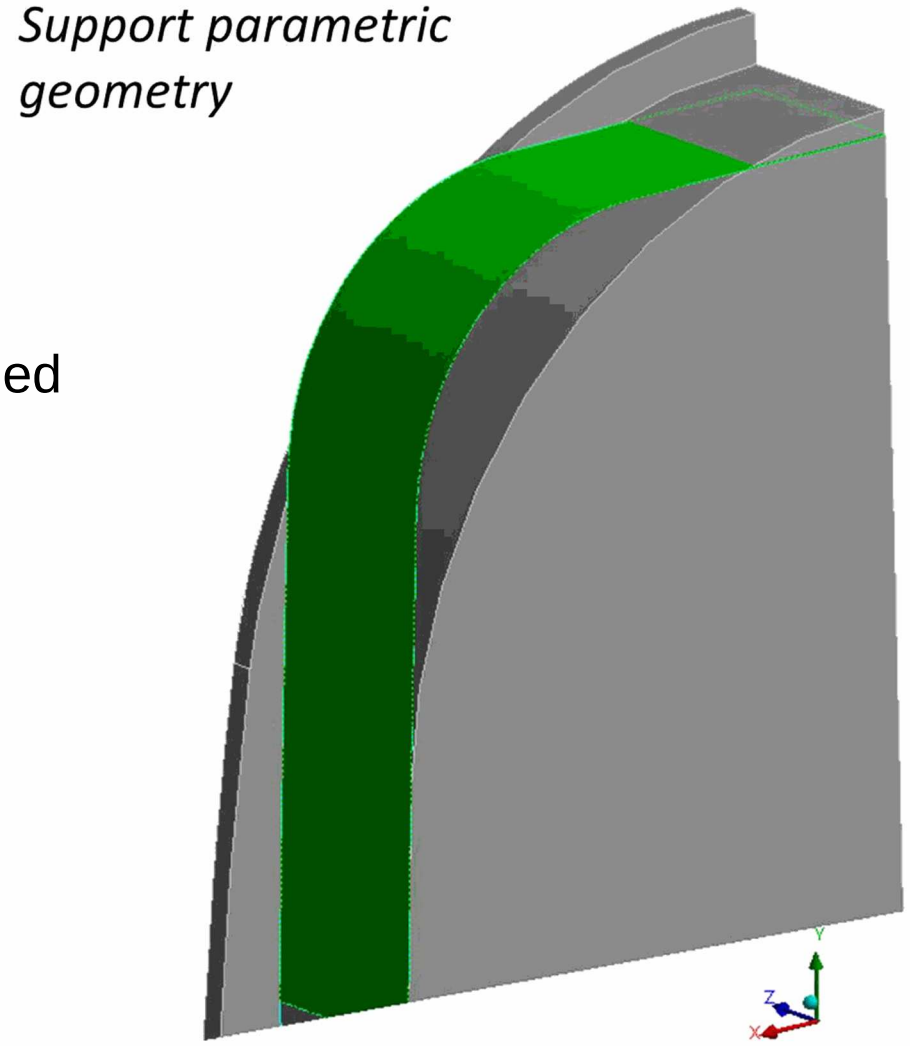


CAD-MESH mixed approach: application

MESH morphing managed by support geometry

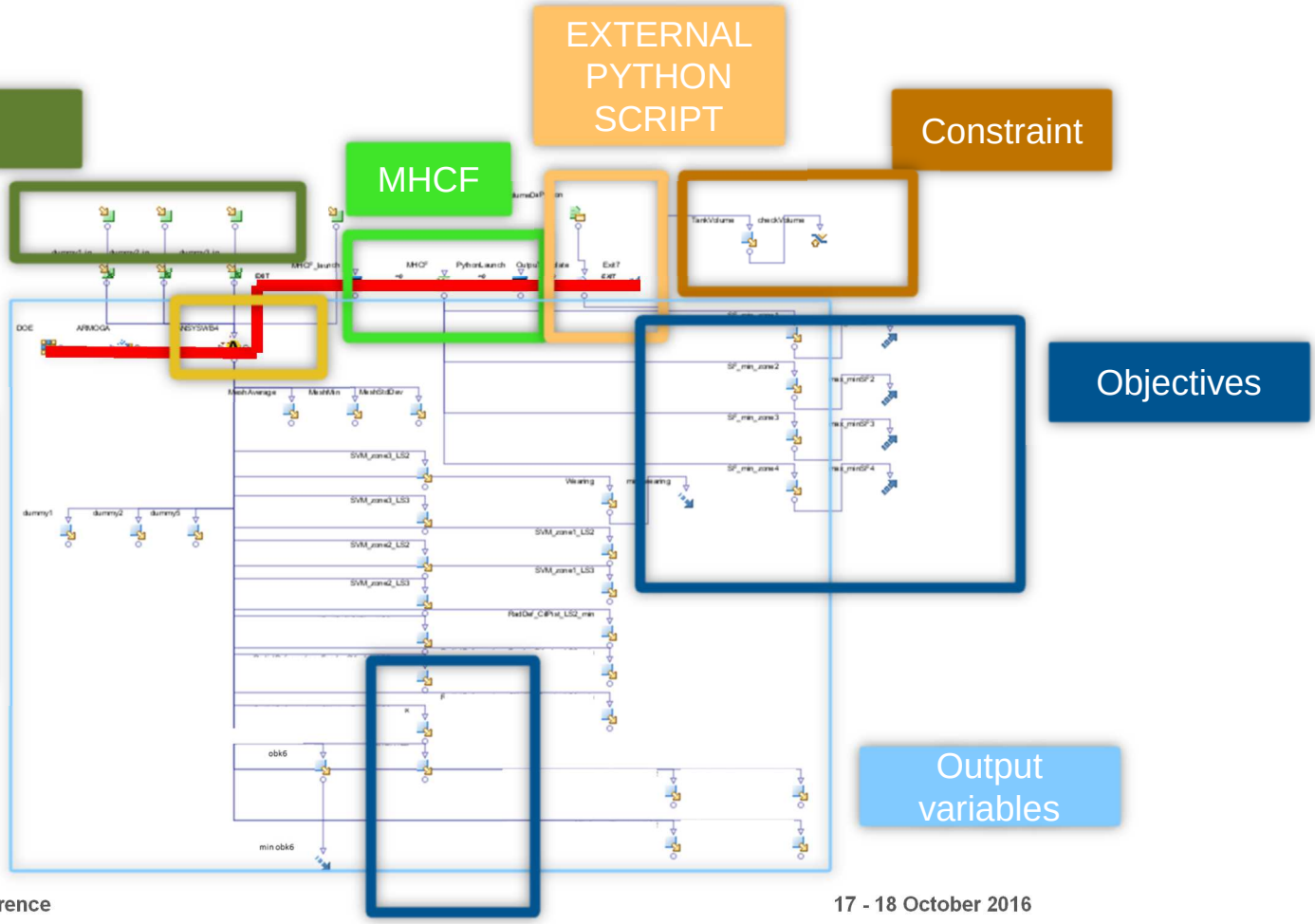
(rbf-morph)™

ACT Extension for ANSYS Mechanical



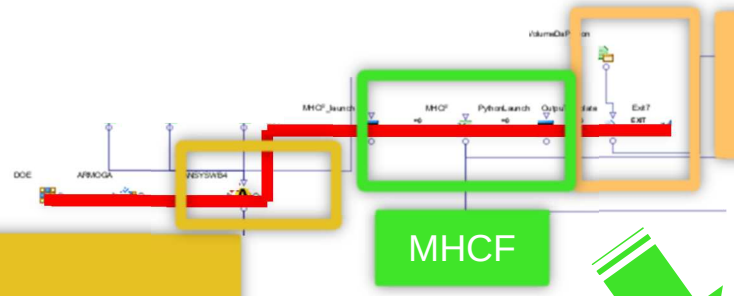
CAD-MESH mixed approach: application

modeFrontier workflow



CAD-MESH mixed approach: application

Simulation details



EXTERNAL PYTHON SCRIPT

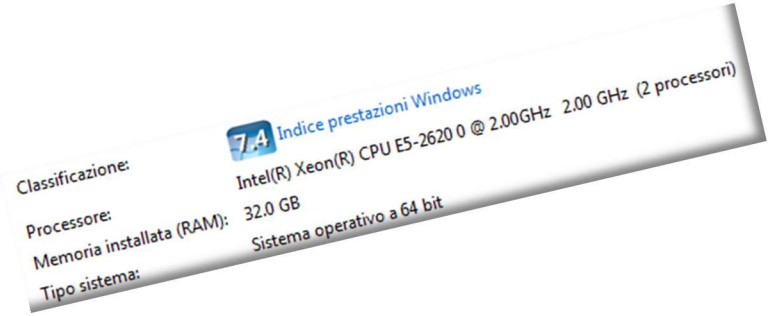
Convex-hull algorithm [1 min]

MHCF

In-house MHCF analysis solved in Excel. [3 min]

ANSYS WORKBENCH
- Design Modeler
- Ansys Mechanical
- RBF Morph

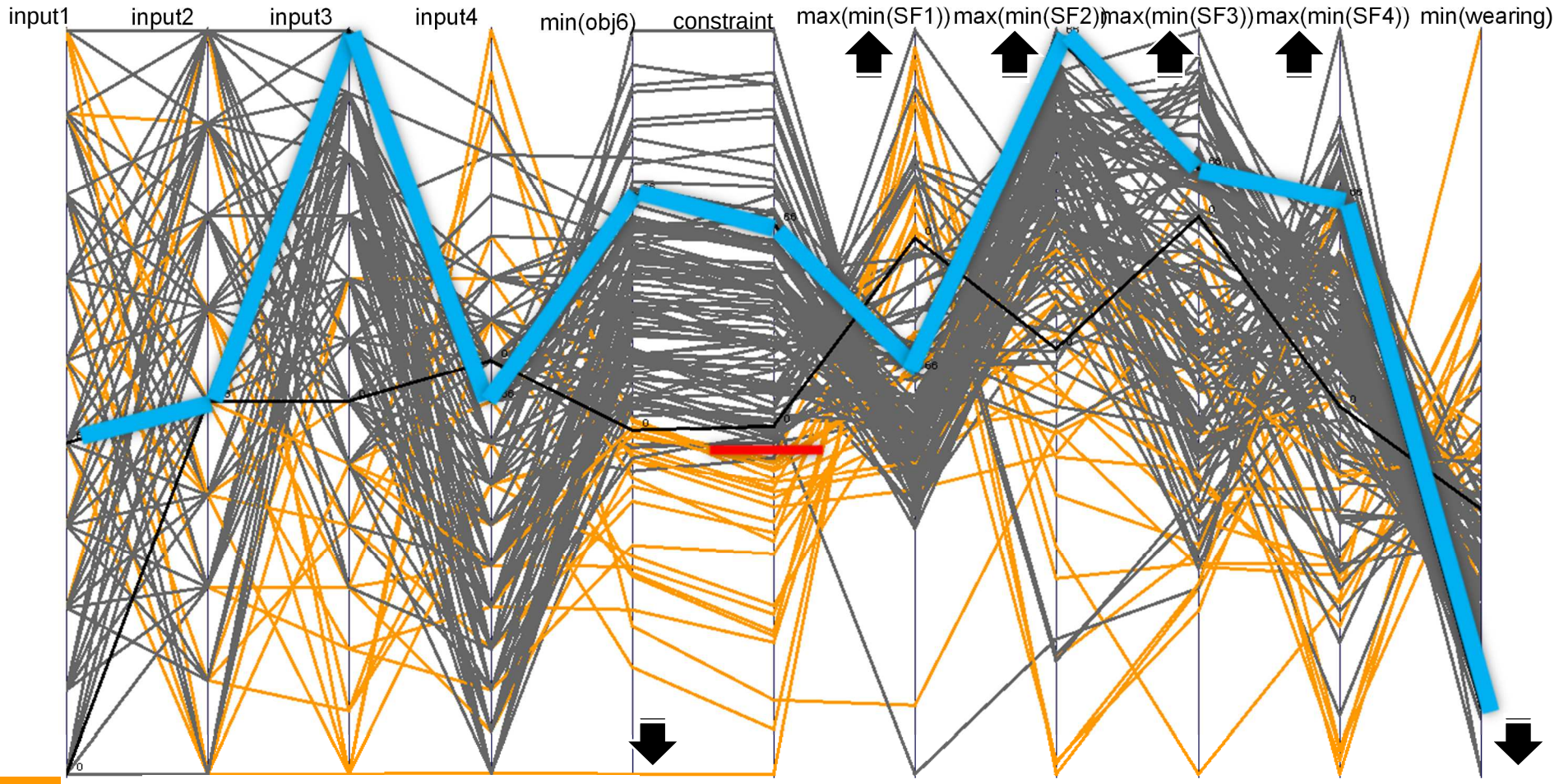
- Support geometry reconstruction
- Morphing of the model [1 min]
- Structural analysis: [19 min: optimized]
  - Total nodes ~ 150.000
  - Morphed nodes ~ 70.000
  - 3 Load Steps
  - Non-linear contacts



Total time for 1 Design Point ~ 30 min
(comprising copy&paste operation)

CAD-MESH mixed approach: application

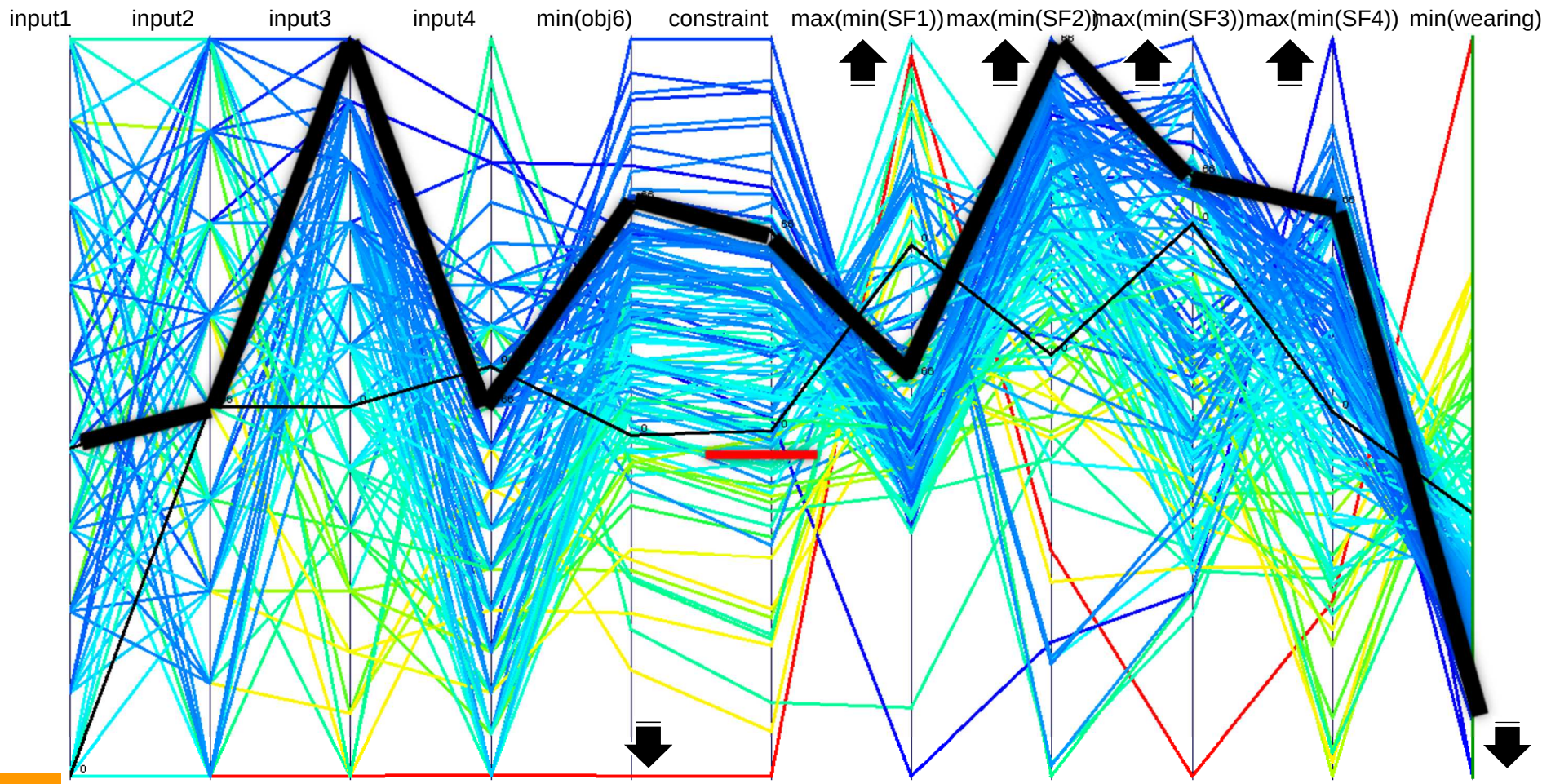
Results after 156 (real) design points: ~ 3 days



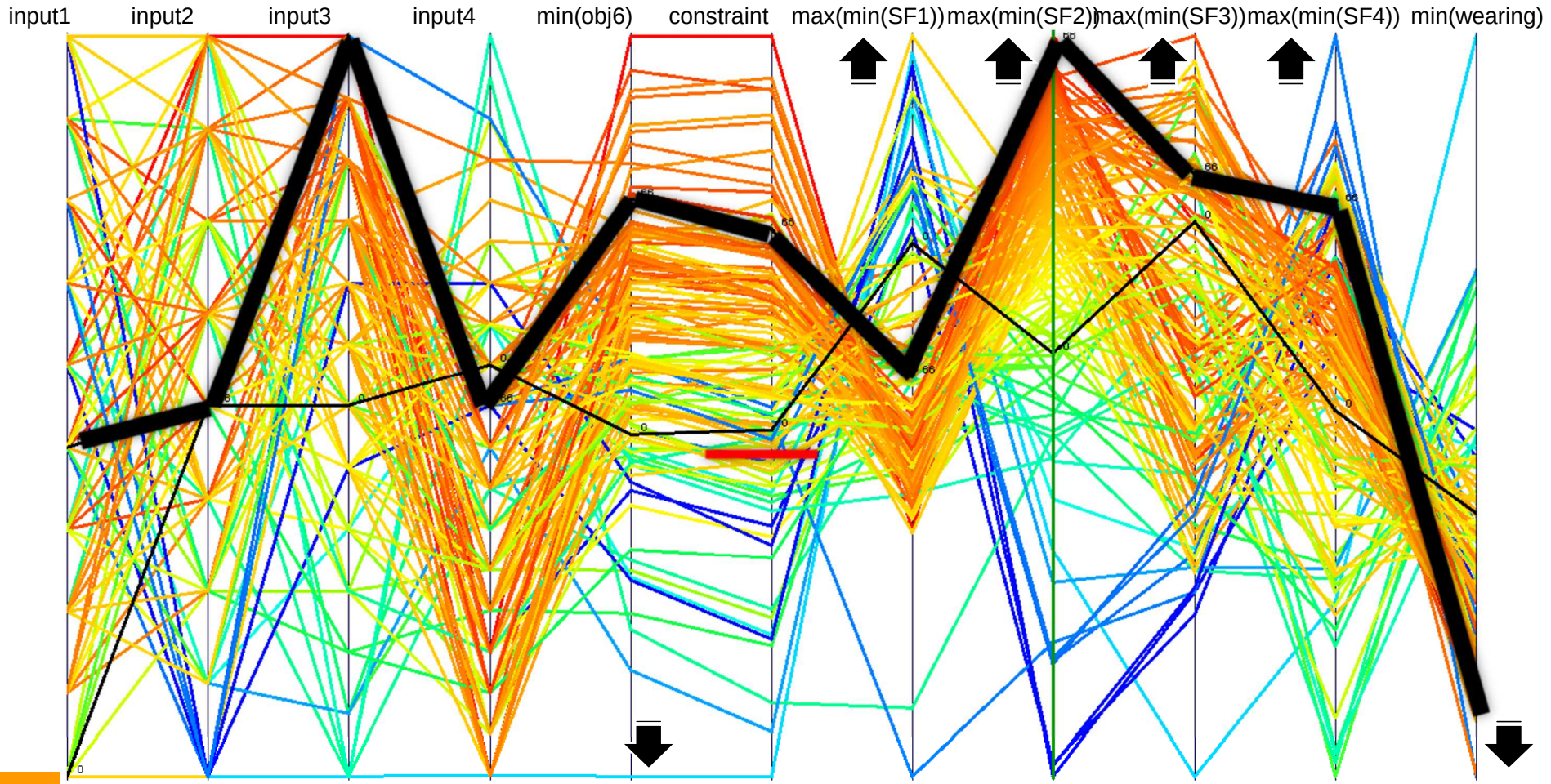
Feasible & Unfeasible

SOBOL + ARMOGA (multi-objective optimization with high calculation time)

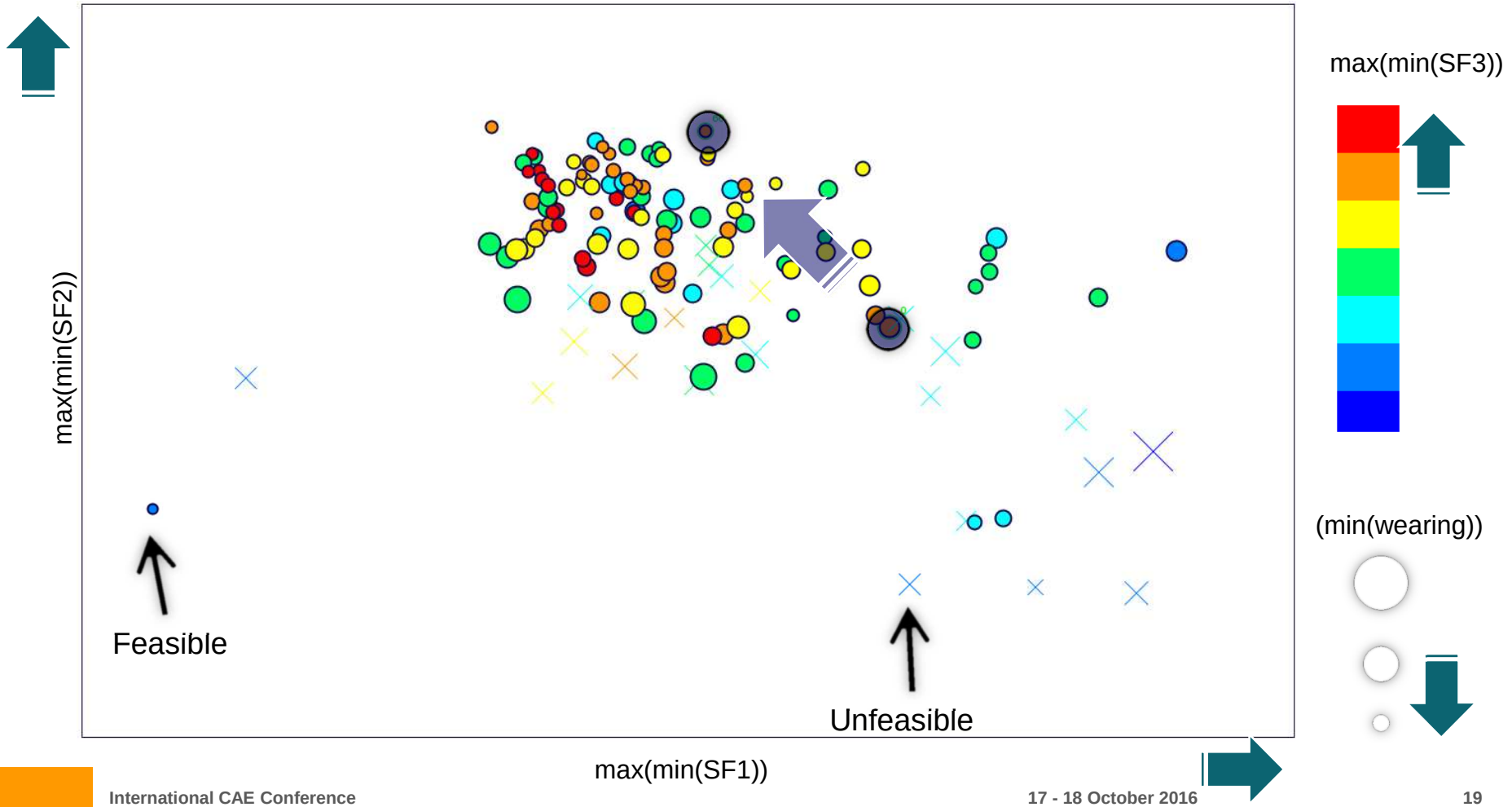
CAD-MESH mixed approach: application



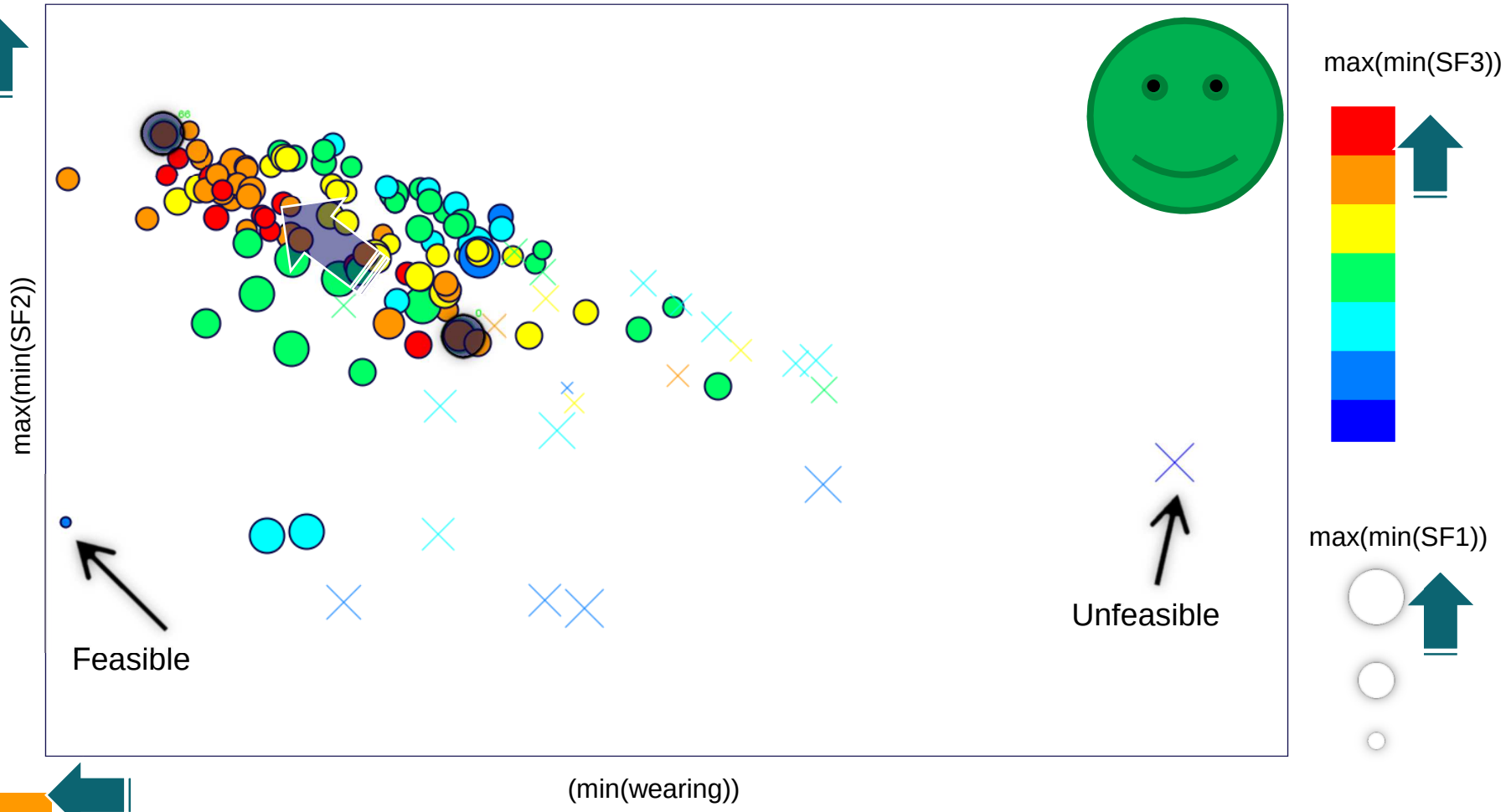
CAD-MESH mixed approach: application



CAD-MESH mixed approach: application



CAD-MESH mixed approach: application



Conclusions

- A methodology to overtake the limits in CAD and MESH based shape optimization has been developed and applied on an industrial component.
- The proposed setup can be easily extended to **different kind of simulation problems** (e.g. FEA, CFD, Multiphysics…)
- Shape optimization is a recognized tool to **speed up** the design of Mechanical components. The proposed methodology allows to integrate the advantages of MESH morphing techniques with the flexibility of parametric CAD
- modeFrontier works fine in managing complex workflow with multiple analysis solved with different software.

THANKS FOR YOUR ATTENTION

SACMI

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