Efficient design creation

and validation

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1 Introduction

PERMAS Users' Conference Stuttgart 2018

Challenge to find an appropriate Design

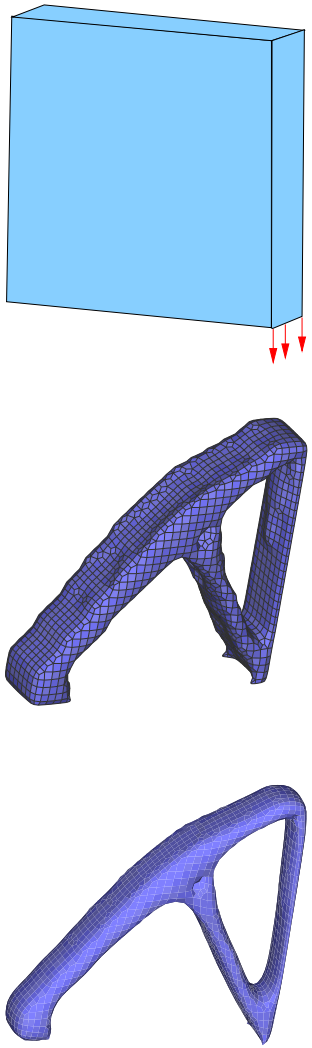
- Produce the best possible design, i.e. fulfilling all requirements, cheap to produce, lightweight
- Be flexible to adapt to changing conditions
  - Statics, eigenfrequency, NVH, . . .
  - Different limits for different OEMs
- Organize fast design cycles
  - With low human interaction (costs)
  - To give fast answers to questions
    "The most useless simulation result is one that is delivered too late"

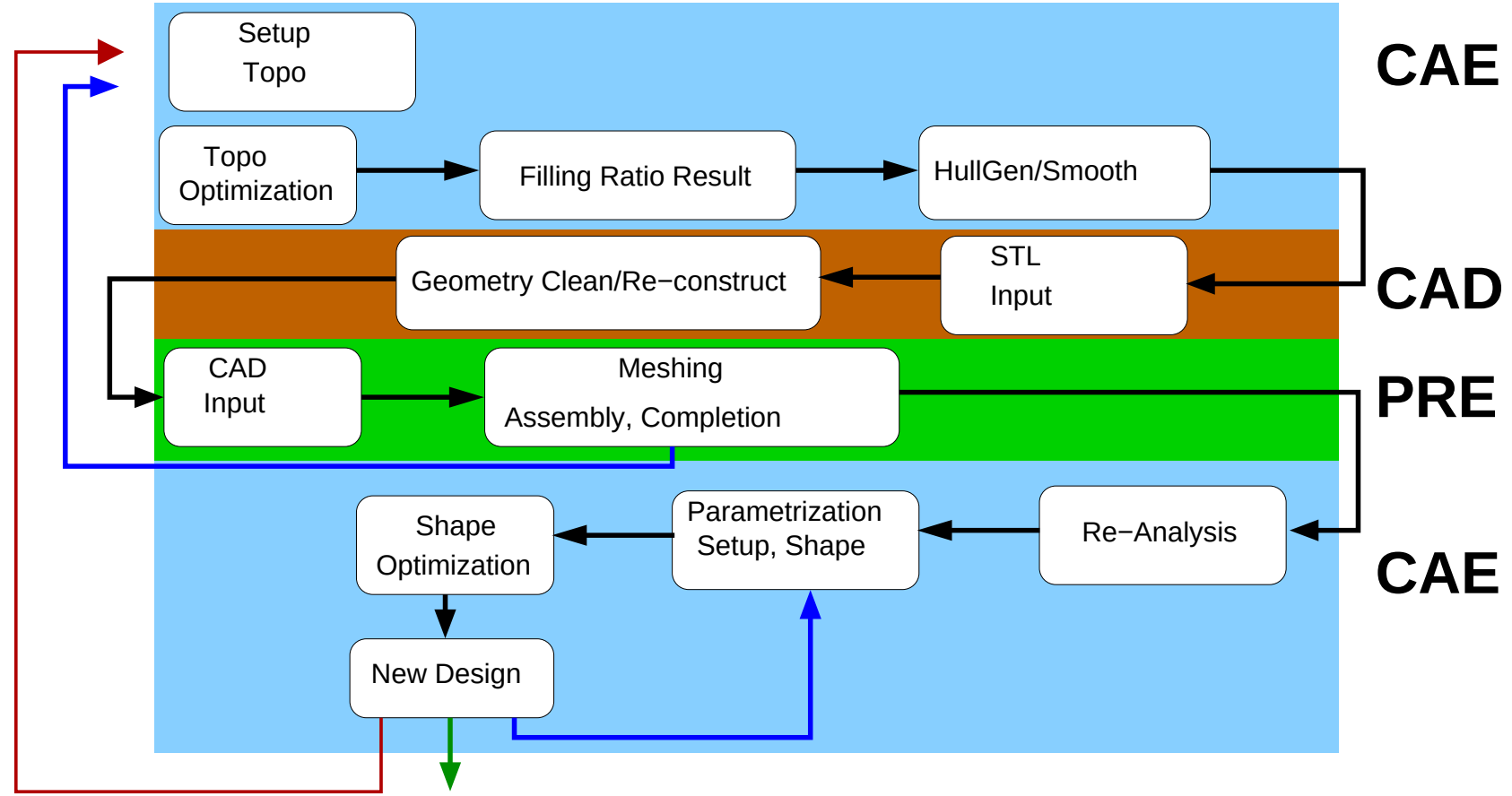
Ideally suited for an engineer !

Simulation Driven Design

- Topology optimization has great potential to create new design ideas.
- Clear separation of material/void areas essential for automated process to select basic geometry.
- After having derived a new design, further detailed requirements have to be fulfilled (e.g. by optimization).
- Hence, a simulation process chain has to be followed in order to derive a satisfying result.

“Classical” Process Chain

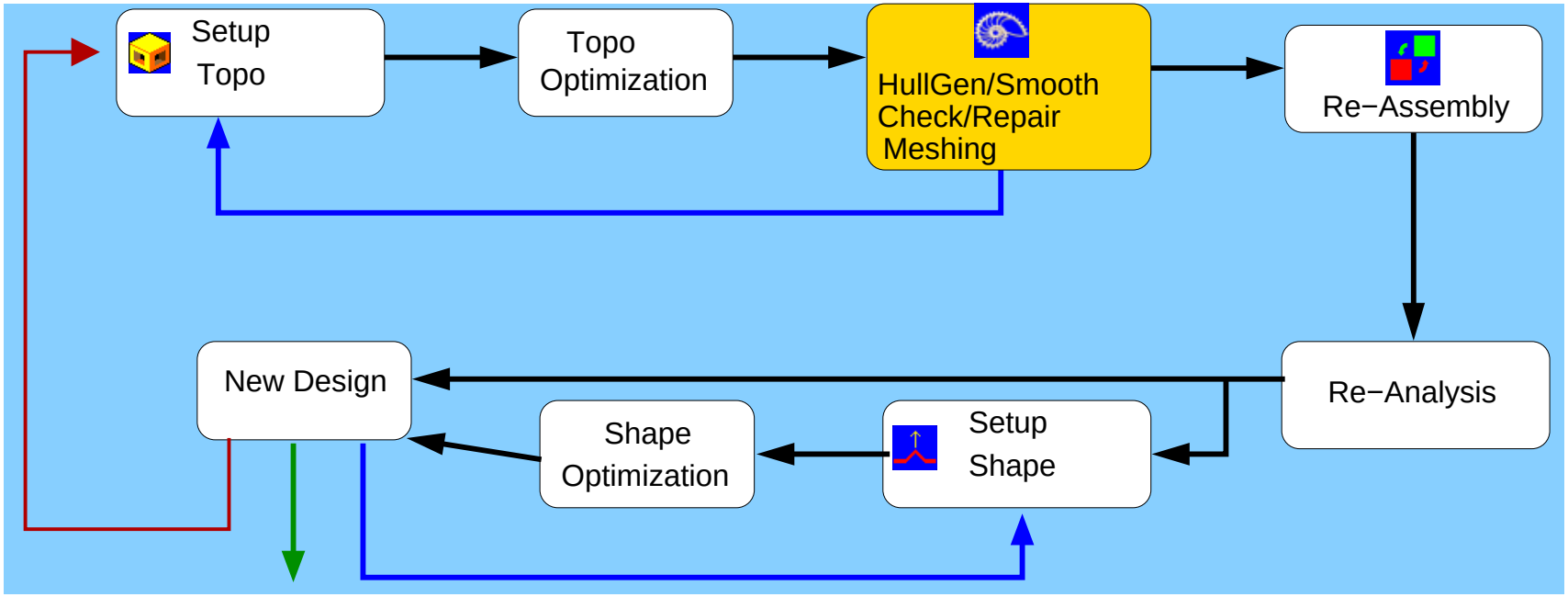




“Classical” Process Chain (2)

- Re-Construct in CAD often requests a different specialist (designer). This leads to organisational issues.
- Significant effort to derive a new design proposal
  - Manual cleanup of geometry
  - Preparation of parametrized CAD surfaces
  - Ensuring a “Waterproof” hull suited for meshing
- Potentially a long way from design space definition to final design

Target Simulation Process Chain



- Enable a simulation process chain that meets requirements best
- Bridging the Gap between Topo and Shape
- Goal: Digital Prototype enabling performance based design decisions

2 Design Creation

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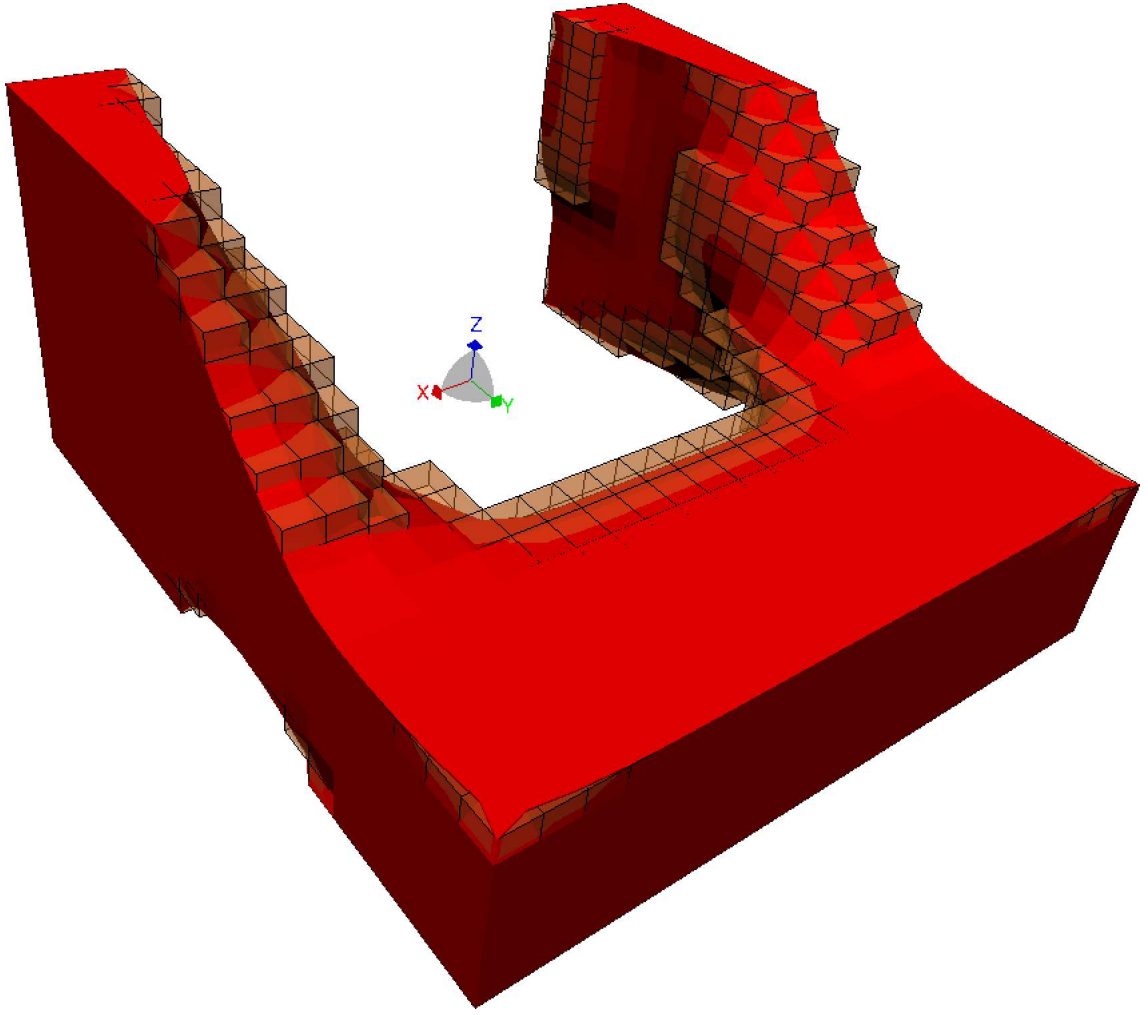
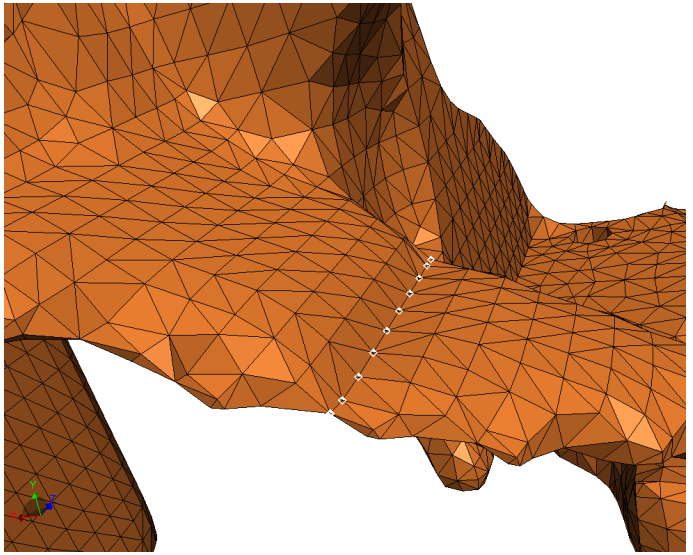
Goals for Hull Creation



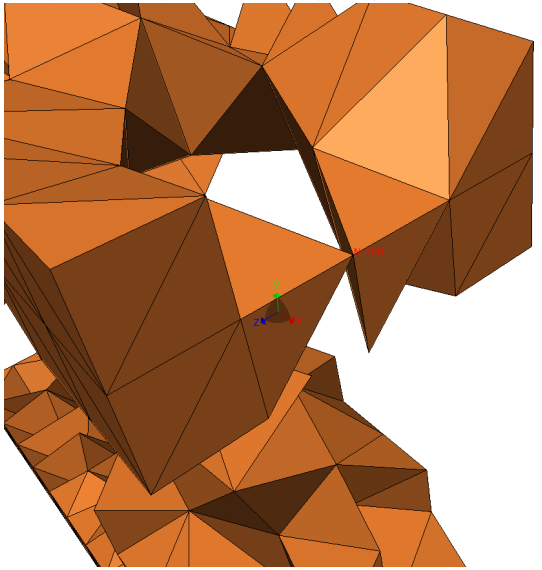
- New geometry as close as possible to simulation result of topology optimization
- Closed “waterproof” hull, suited for a subsequent automatic meshing process
- Creation of a surface mesh of good quality. Key point for automatic (TET)-meshing.

Hull Creation Problems

T-Edge



Point Connection



- The pure selection of filling ratios does not always lead to a valid design space volume definition
- Detection of deficiencies to create a regular volume
- Extension of volume by a minimum amount of element neighbours at singular regions

Hull Smoothing Problems

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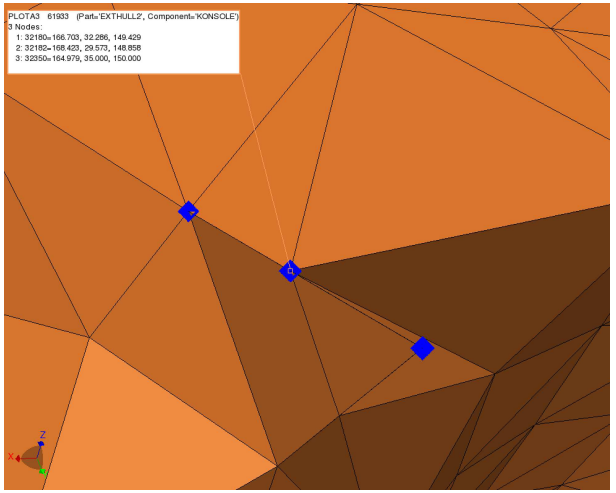
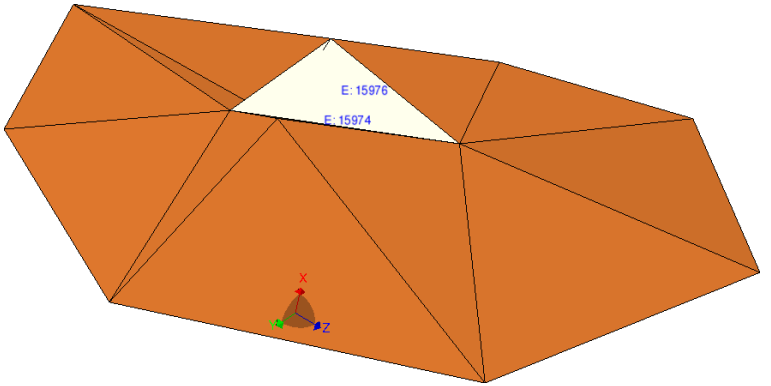
Collapsed Element



Folded Element



- Mesh defects through smoothing process may lead to invalid elements or topological defects
- In order to create a valid surface mesh, a remeshing process has to be based on a regular hull

3 Application Example

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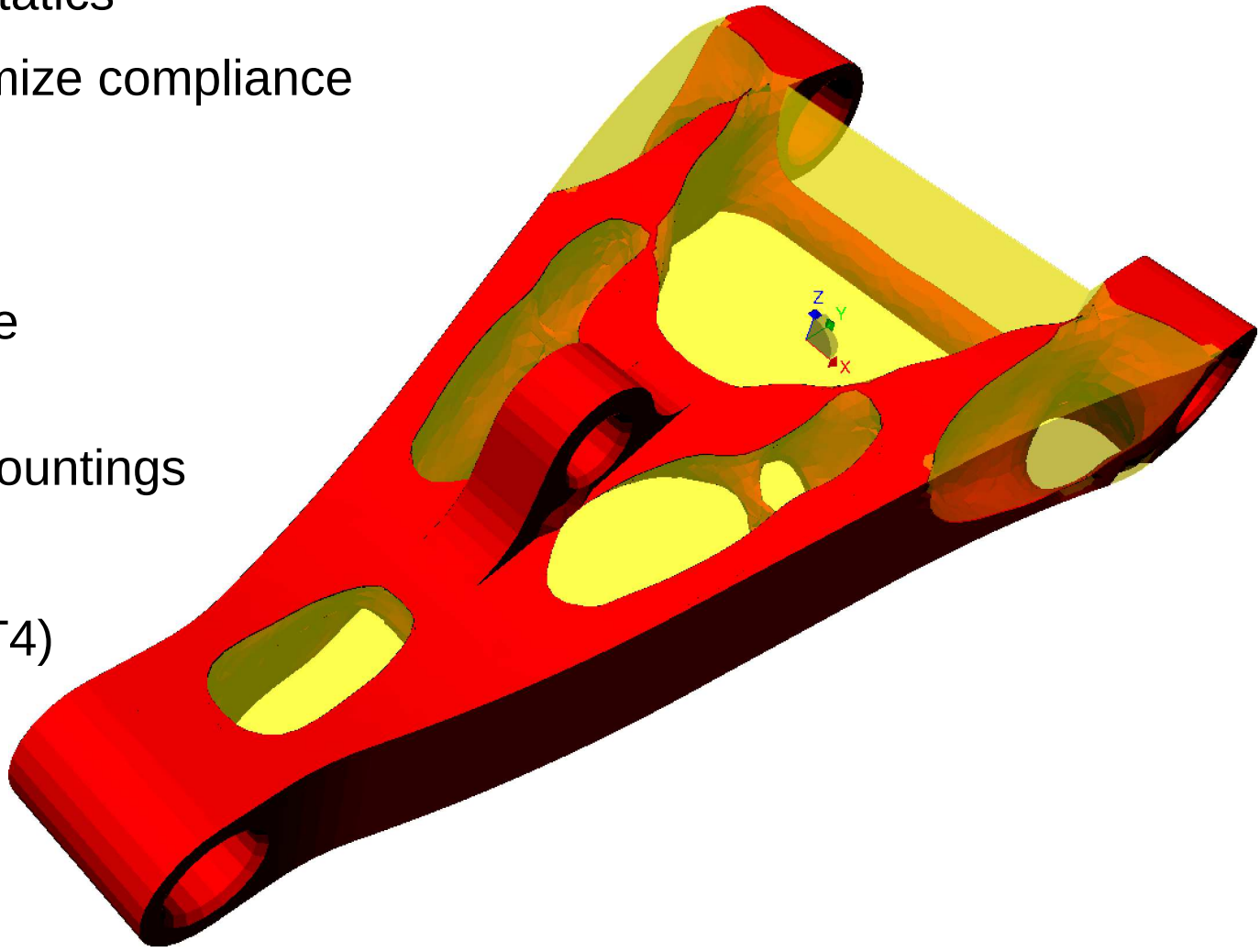
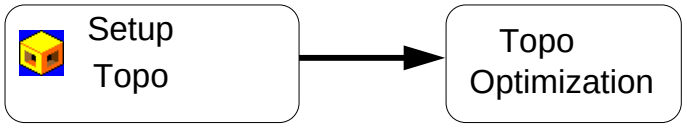
UC2012: Chassis Suspension

- **Analysis type:** Linear Statics
- **Design objective:** Minimize compliance
- **Design constraints:**
  - Maximum weight
  - Minimum member size
  - Release direction
  - Freeze condition at mountings
- **New Analysis**
  - TET10 elements (TET4)
  - Reduced weight (300g instead 500)
  - Usage of ACP solver

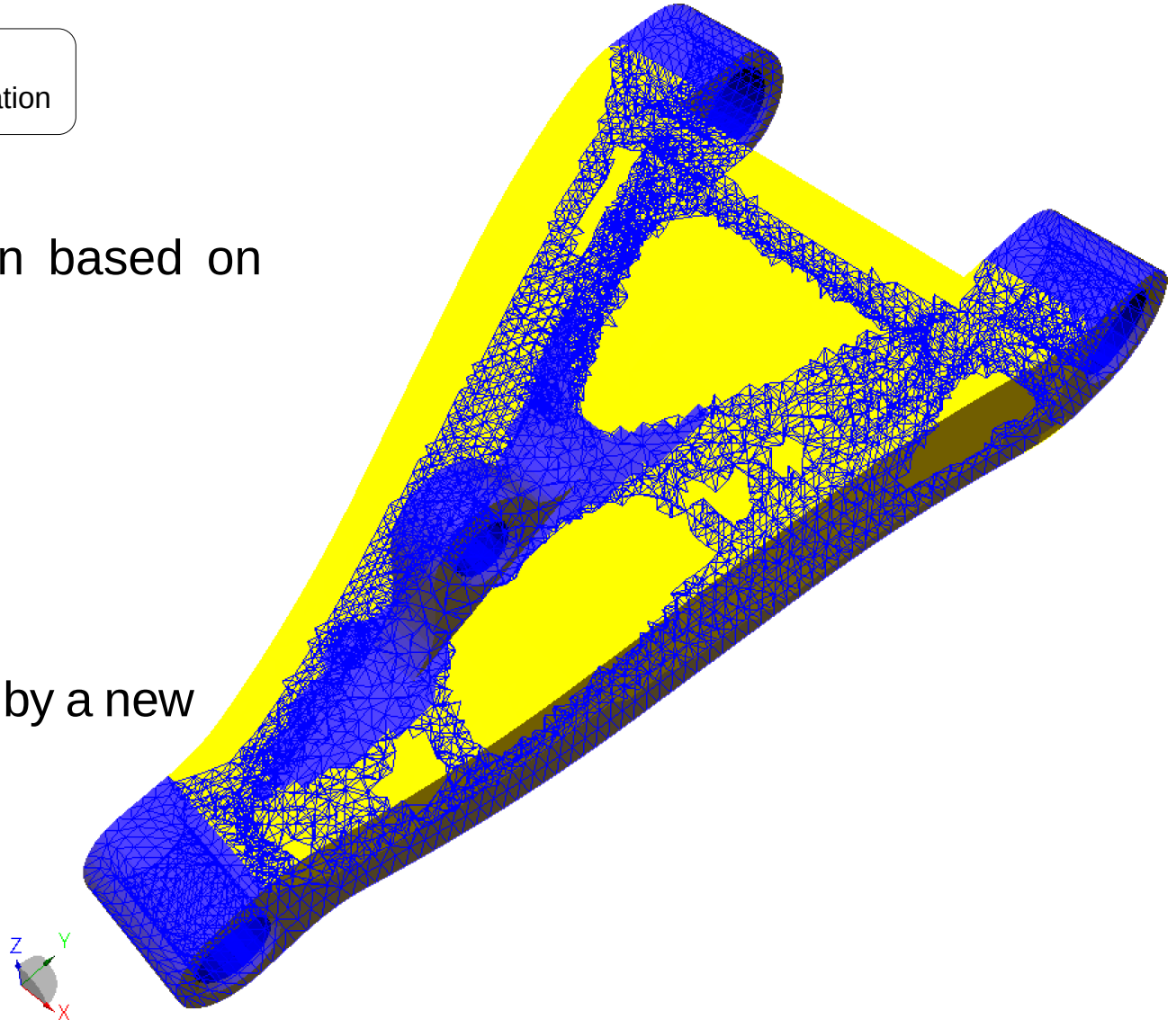


Start of Workflow



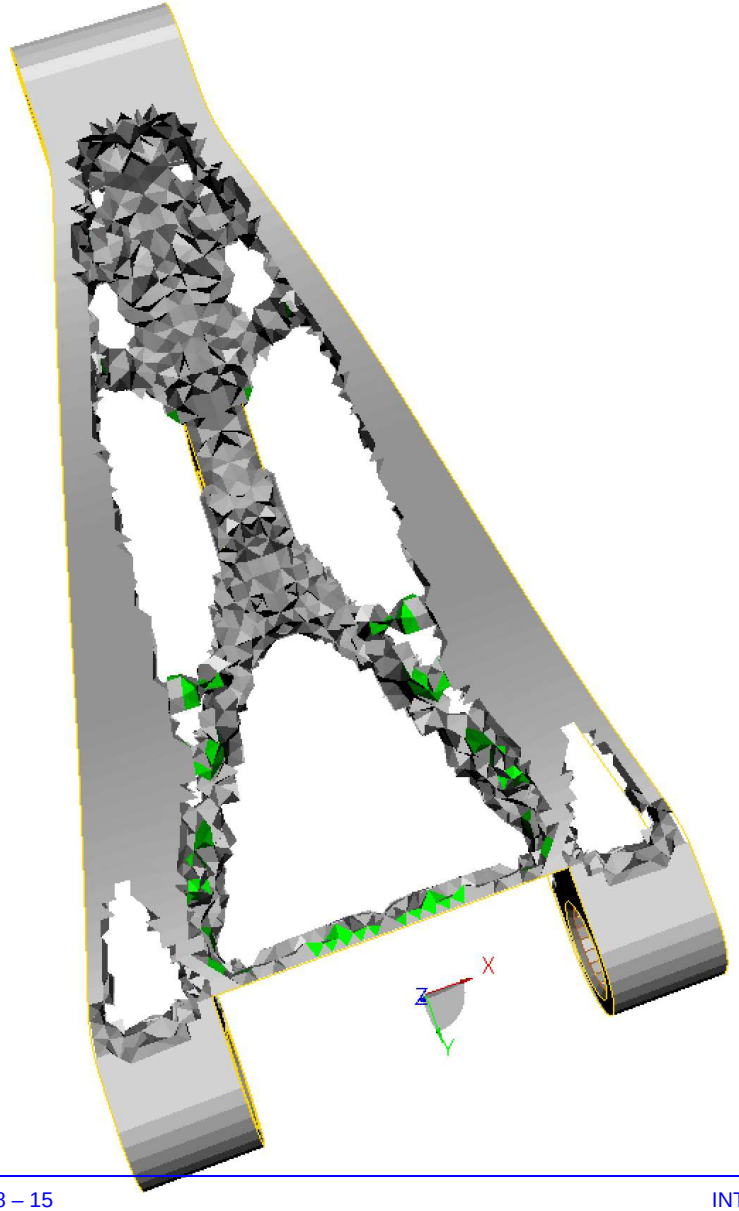
Task: Create a new design based on topo results

Approach: Specific support by a new **DesignWizard**



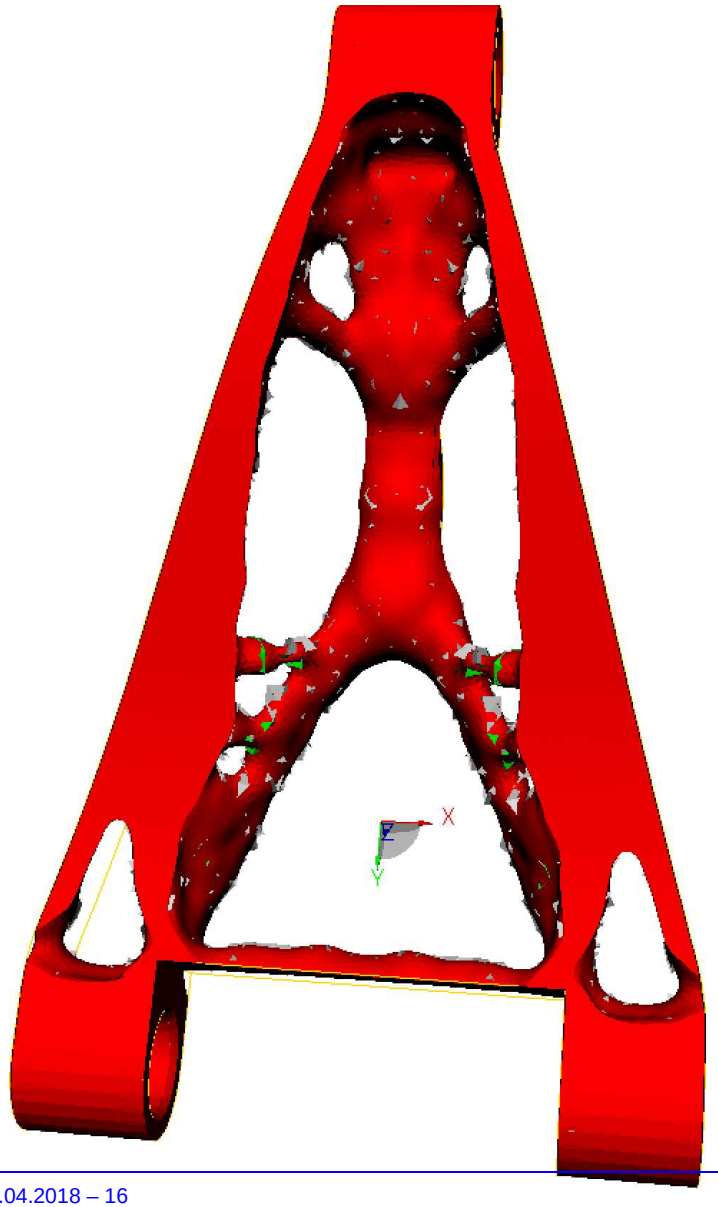
Chassis, Volume generation

- Selection of volume for subsequent smoothing process, based on filling ratios and/or element set
- Check on defects (singular connections)
- Selection of additional elements to repair connectivity defects (green)
- **Result**: Regular and closed volume



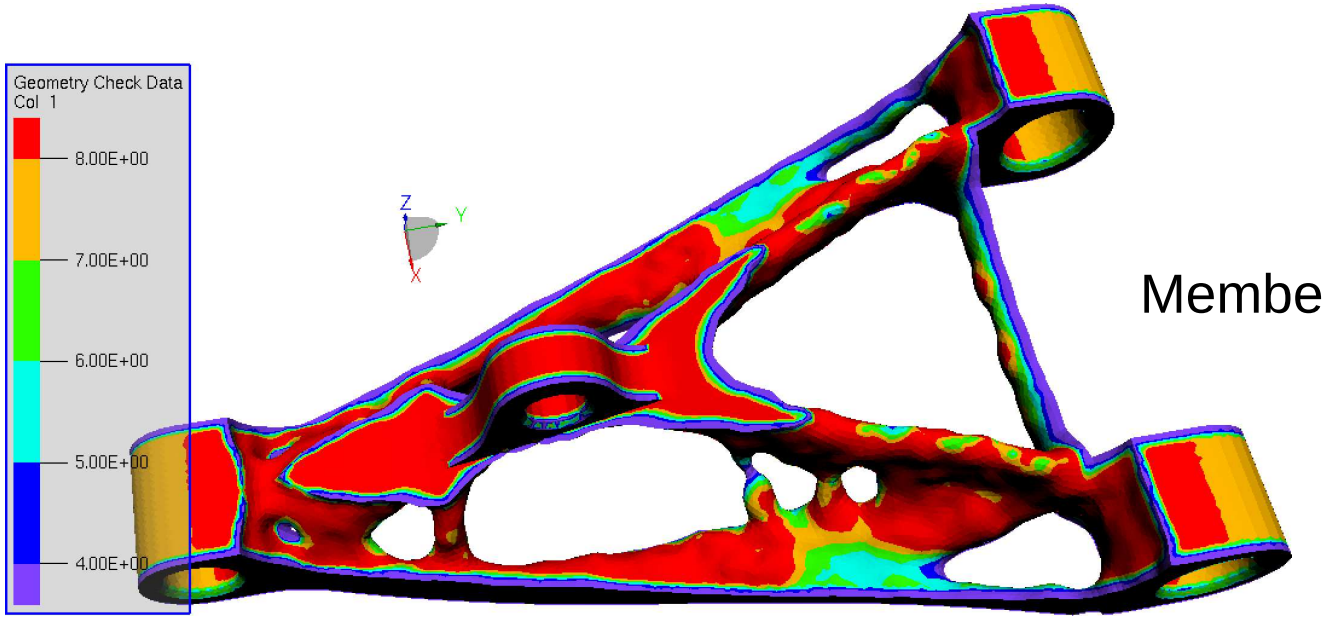
Chassis, Smoothing/Hull Mesh

- Simultaneous visualization of initial volume selection and smoothed geometry
- New iso-surface based smoothing
- Subsequently re-meshing of the surface to get a good quality mesh
- Transfer of hullmesh to a new component for further actions



Chassis, Check

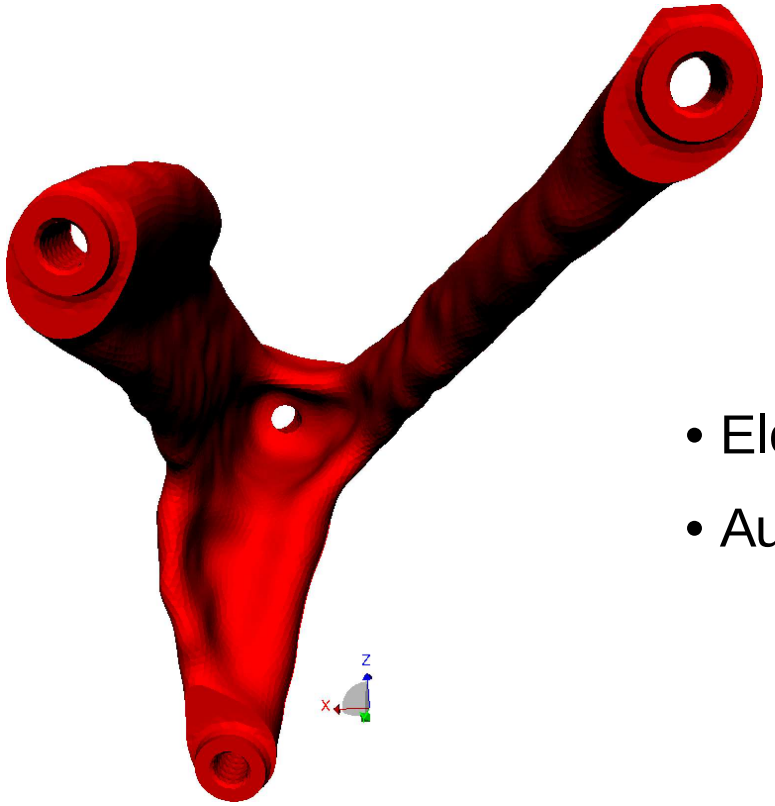
- Select check criterion, with specific explanations
- Direct evaluation of violations, with all options of the visualization dialog
- Derive adequate geometry modifications

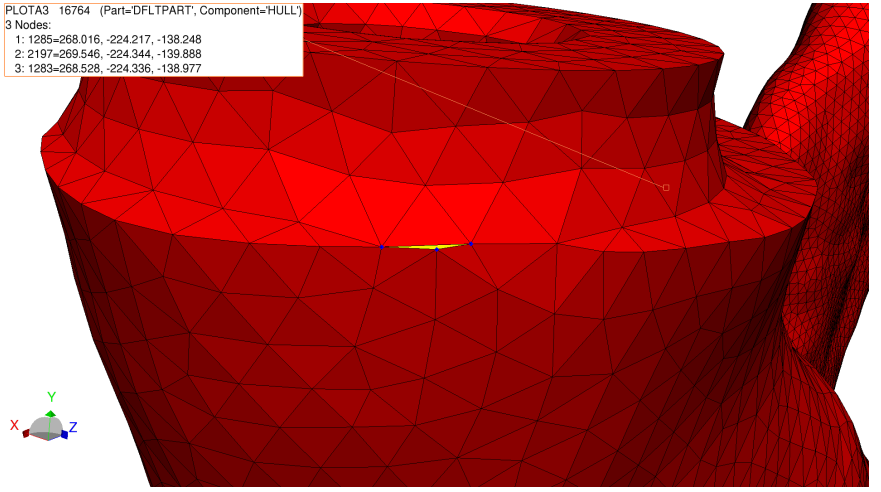


Membersize Result

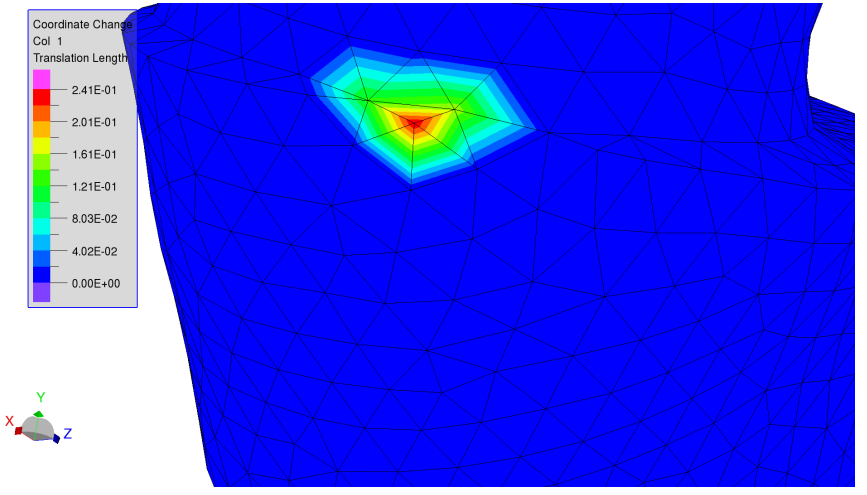
Bracket, Hull Mesh

Hullmesh: 45748 E, 22868 N

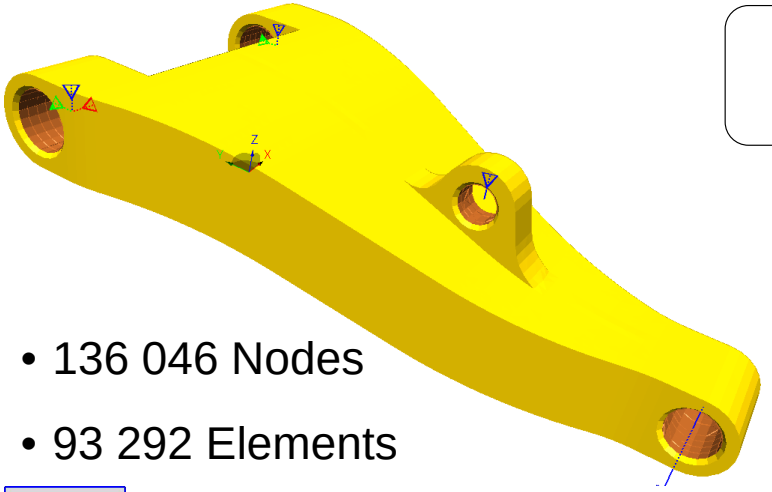




- Element test, 1 *W*
- Automated fix by minimum geometry modification

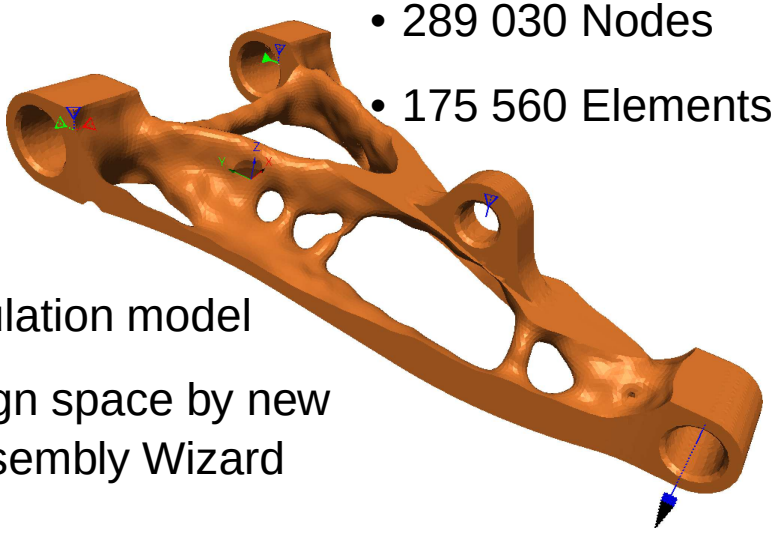


Creation of basic shape model
Re-Analysis



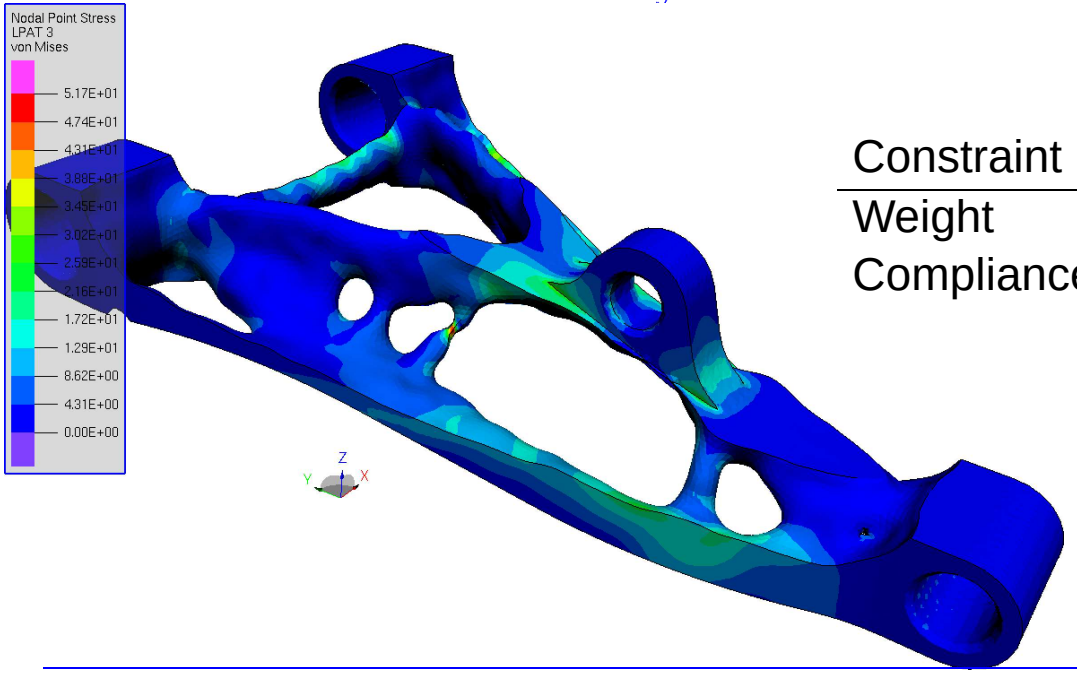
- 136 046 Nodes
- 93 292 Elements

Re−Assembly



- 289 030 Nodes
- 175 560 Elements

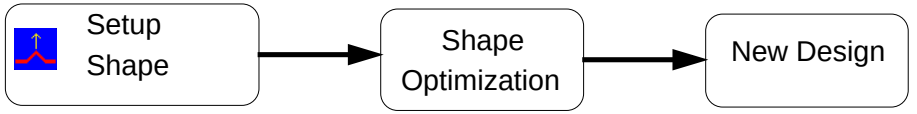
- Create new simulation model
- I.e. replace design space by new design using Assembly Wizard



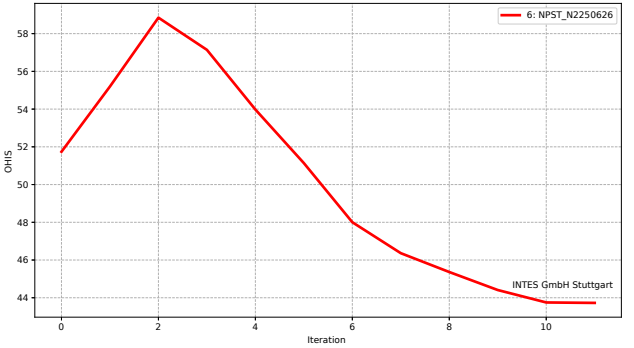
Constraint	Topology	Var0
Weight	300	336
Compliance	38.6	28.2

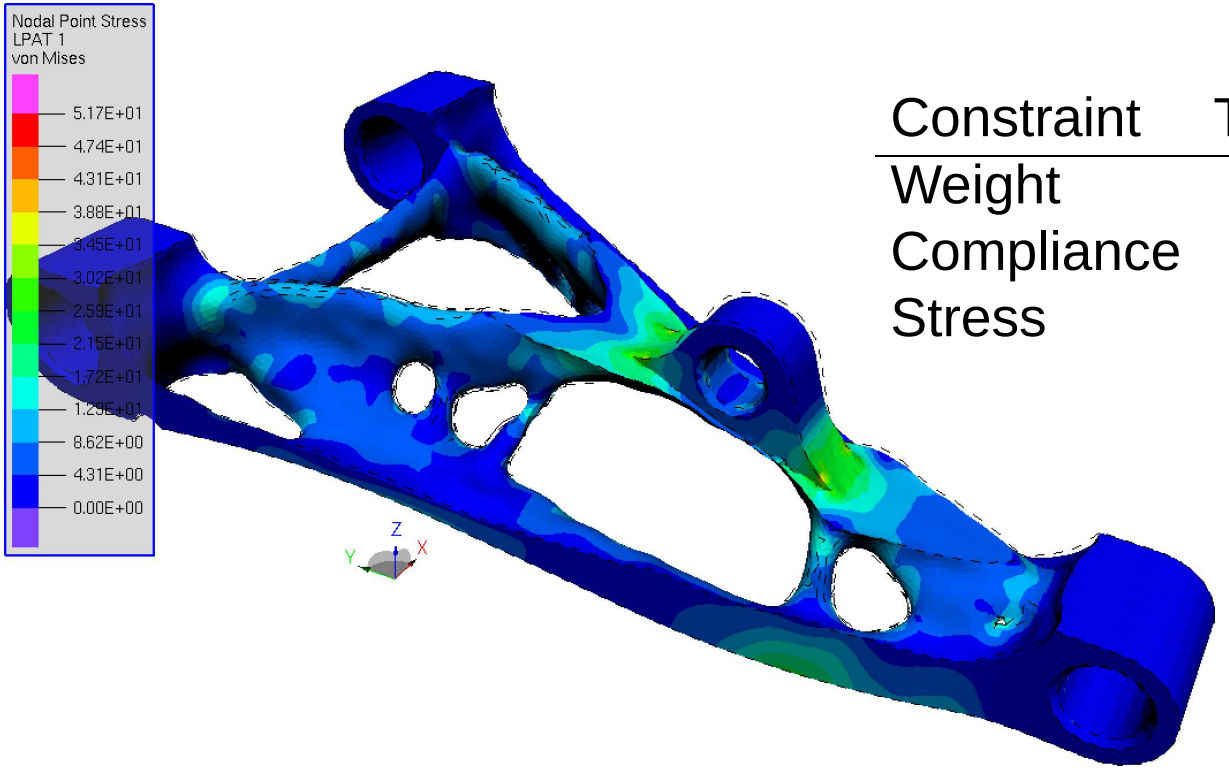
- Some weight (and stiffness) increase
- Potential to reduce local stress peaks/weight

FreeForm Optimization

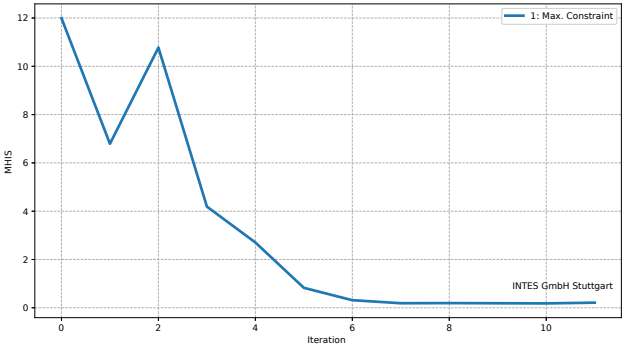


- Stress reduction as target
- Weight, compliance and element quality constraints





Constraint	Topology	Var0	Var1	Var2
Weight	300	336	315	300
Compliance	38.6	28.2	27.7	32
Stress	-	51.7	40	43.7



4 Summary

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Outlook

http://optiamix.de/

INTES

Hirschvogel Automotive Group

KRAUSE DiMaTec

Kemper Baker's friend

EDAG

UNIVERSITÄT PADERBORN
Die Universität der Informationsgesellschaft

- Motivation, partial background and future perspective.
- Perform Additive Manufacturing (AM)-specific design checks
  Enable also manual geometry modifications based on check results.
- Take specific restrictions for AM into account;
  also for (Topology-)Optimization
- Derive design constraints from check process
- **Target:** Digital prototype directly producable by additive manufacturing (no CAD backtransition step).

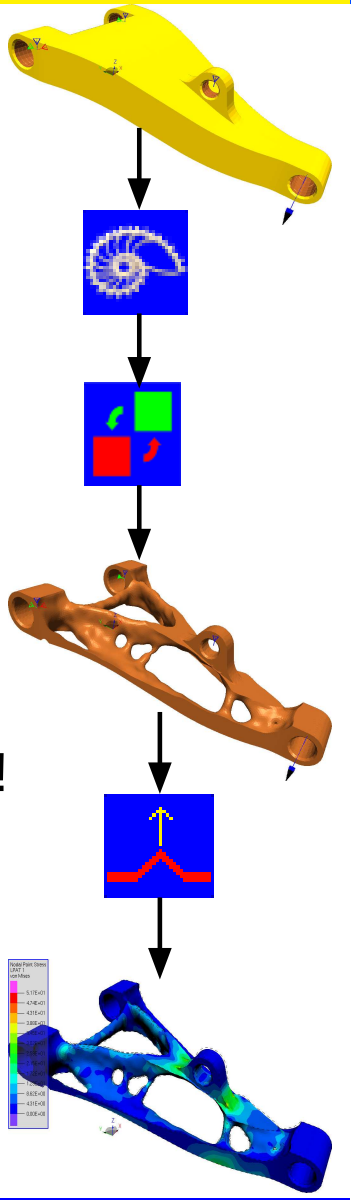
Digital Product Development

Conclusion

- **Status Before**: “Solid mesh obtained by some meshing tool”
  - Geometry re-construct from STL
  - Meshing
  - Model completion
  - Manual checks of manufacturing conditions

  Effort: Several person-days, CAD+CAE specialist

- **Status 2018**:
  - Smooth, wizard-guided process, not a sequence of pictures!



Efficient workflow for simulation driven design