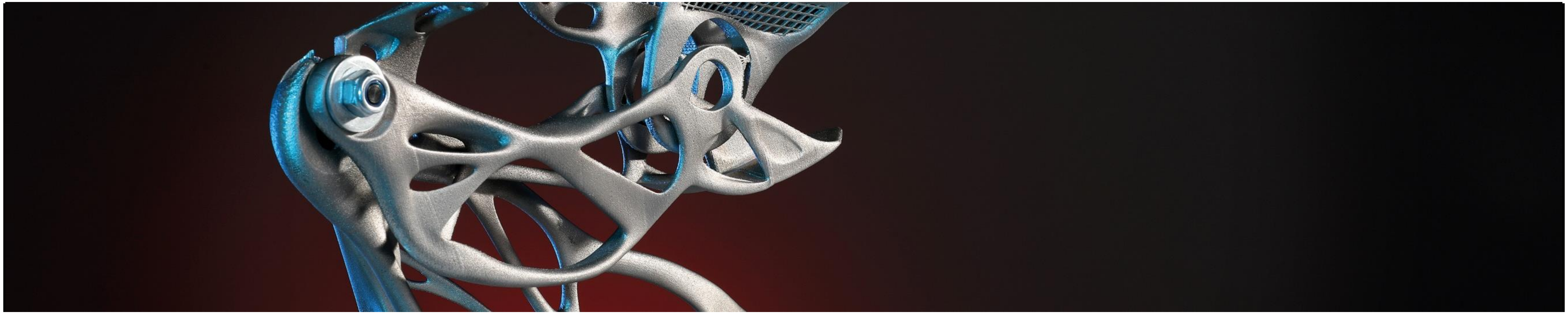
# LightHinge+

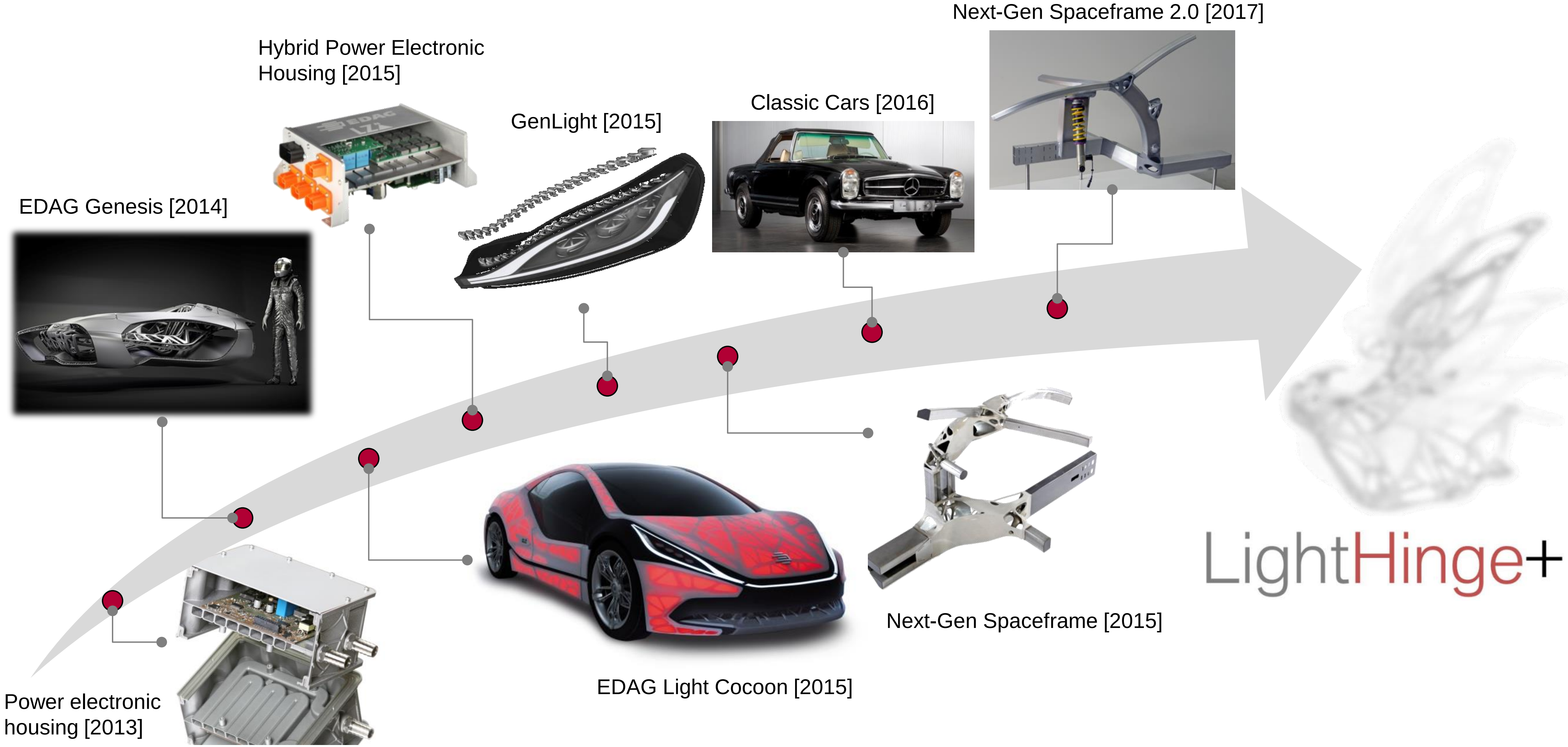
## Additively manufactured lightweight hood hinge with integrated pedestrian protection



Sebastian Flügel | EDAG Engineering GmbH | HANNOVER MESSE | 26.04.2018

# **EDAG Engineering GmbH:** Portfolio

# **EDAG Engineering GmbH:** AM projects



# Agenda

**1** **Introduction**
active engine hood | project team

**2** **Engineering**
conception | topology optimization | design | prototyping | testing

**3** **Process simulation**
calibration | model setup | simulation | compensation | validation

**4** **Conclusion**
outlook | award

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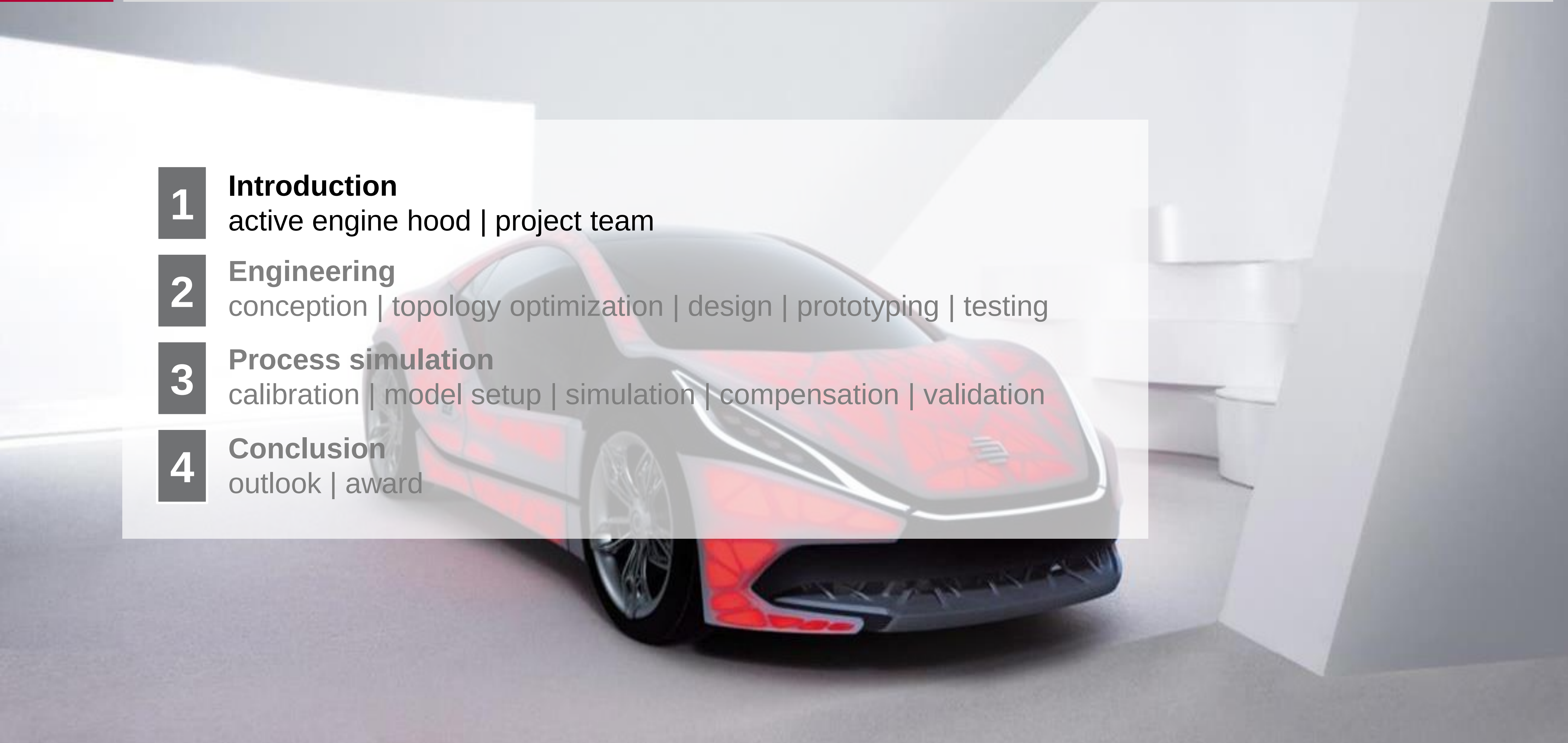

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## **Introduction:** Active engine hood lifting system

- Active engine hood lifting systems are established as an important pedestrian protection device in mass production

- Reasons against use in small-series and sports cars:
  - complex kinematics
  - many components
  - high weight
  - negative impact on design
  - high costs for small quantities

example:
https://www.youtube.com/watch?v=E4hIkEmtZ8U&index=5&list=PLWRABoOo98KQiHsECrNzf4836P9eKYXmO

**Active hood systems are rarely used in the small-series and sports car segment**

## EDAG Engineering GmbH

- Initiator and independent engineering company
- Experts for lightweight construction and additive manufacturing
- Project lead, concept and component development

## voestalpine Additive Manufacturing Center GmbH

- Material supplier and AM contract manufacturer
- Prototype production and AM know-how

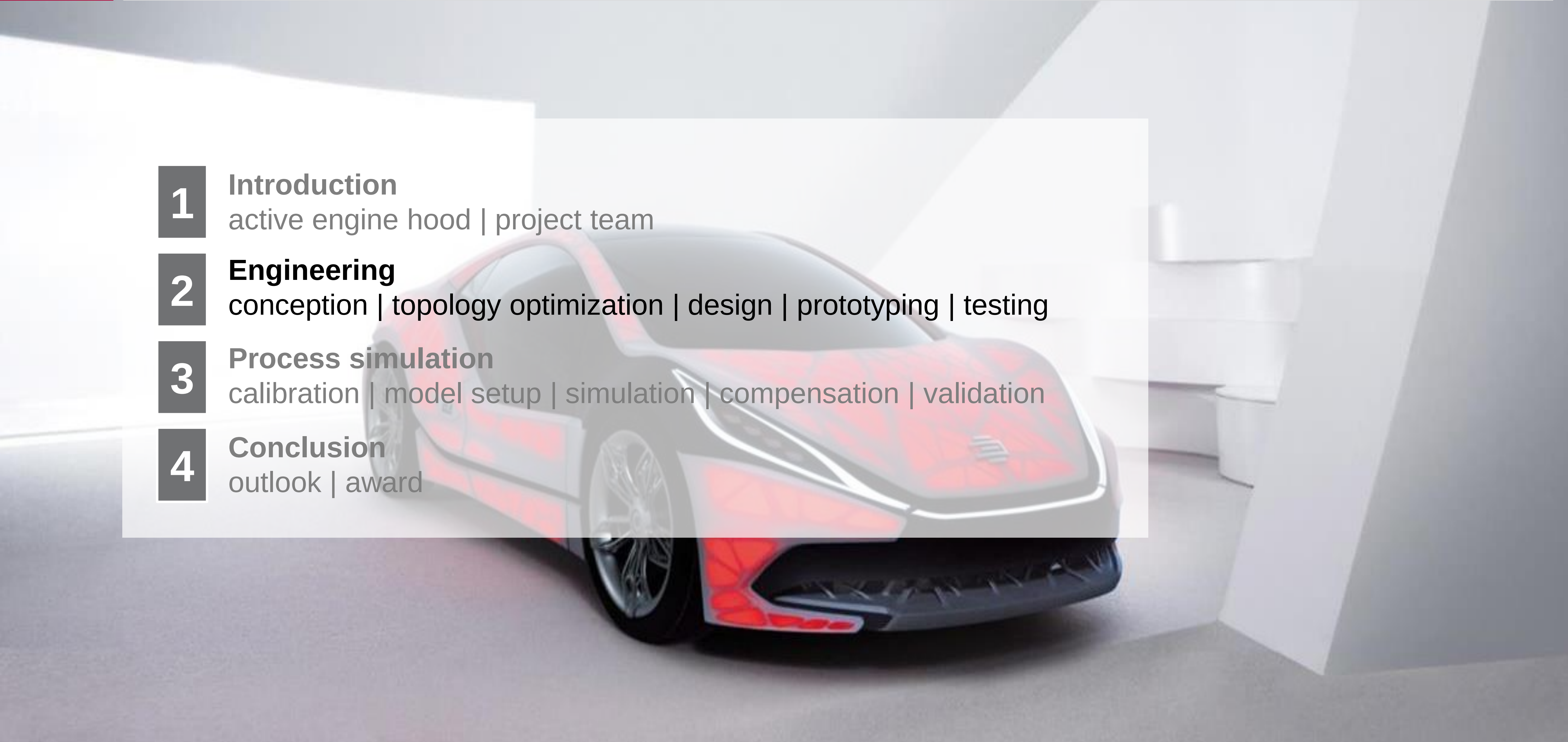
## simufact engineering GmbH

- Simulation software provider for manufacturing processes
- Distortion minimization through Simufact Additive Software

LightHinge+

With kind support from:

# Agenda



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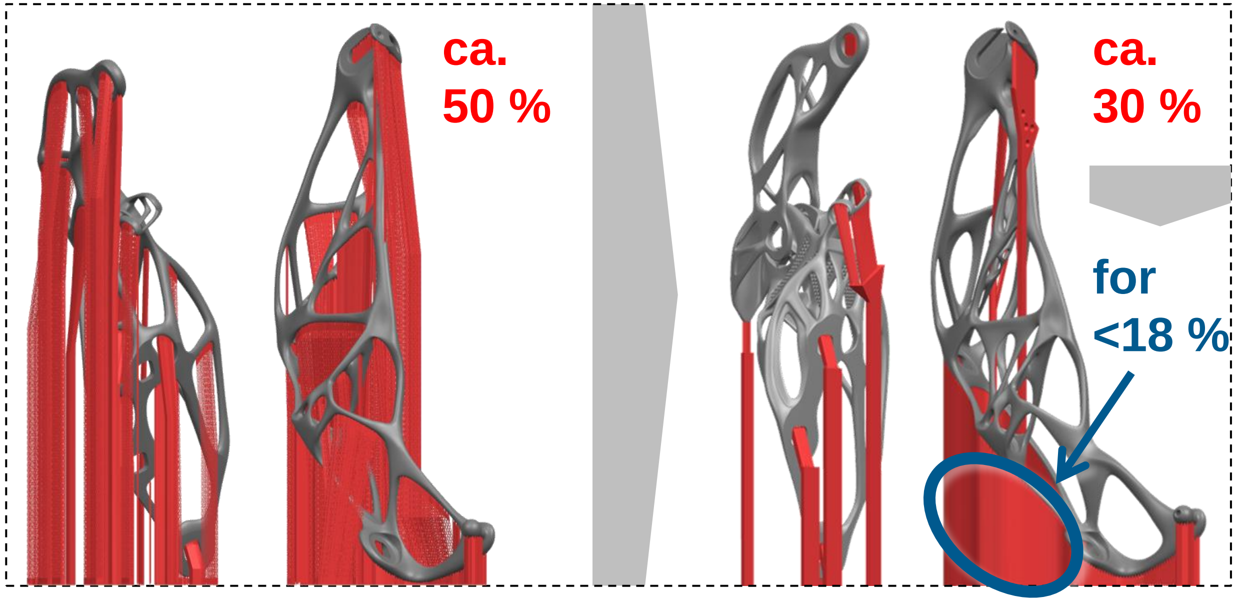
# **Engineering:** Conception

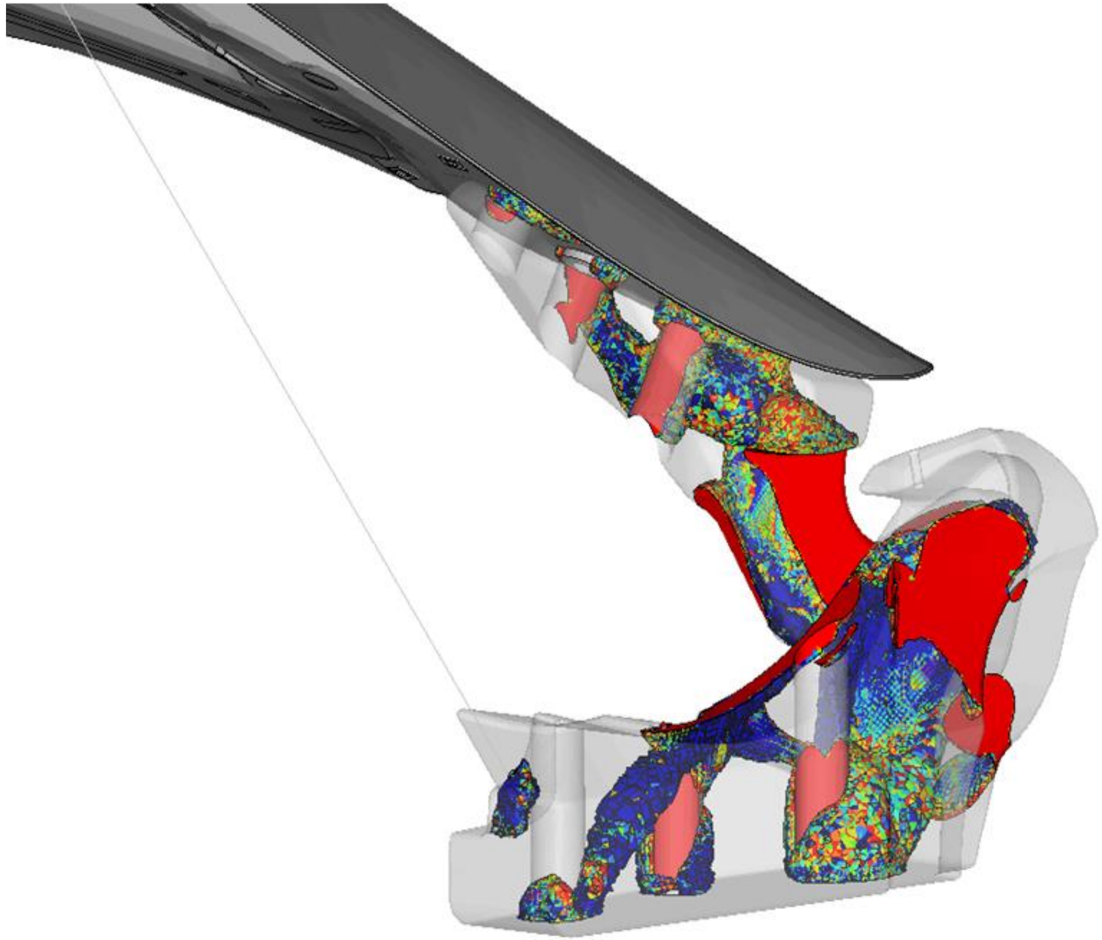
*DE: https://www.youtube.com/watch?v=2z-3vqAKkBU* *ENG: https://www.youtube.com/watch?v=n1tm-fwFmO4*

## **Engineering:** Topology and support structure optimization

- Topology optimization for weight reduction
- Resulting in a support volume of over 50 %
- Support reduction due to design adaptations
  - 1st step: 30 %
  - 2nd step: < 18 %

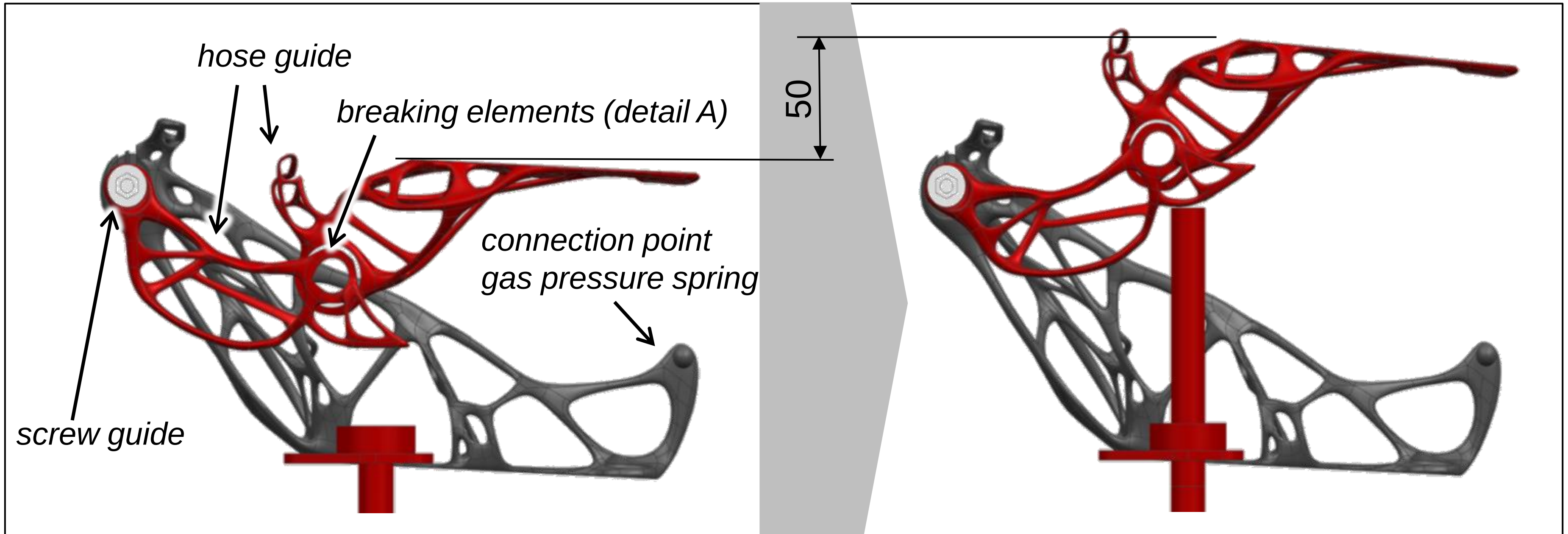


**Support reduction for low post-processing and low costs**

- Maximum component and function integration in a design- and weight-competitive package
- Use of bionic principles
  - E.g. tension triangle method and tree branching according to C. Mattheck
- Integrated pedestrian protection
  - Predetermined breaking elements for an additional degree of freedom

| | |
|---|---|
| lightweight construction potential | ↗ |
| function integration | ↗ |
| cost impact | → |
| Sustainability & resource efficiency | ↗ |




*opening fuction* *pedestrian protection function*

*detail A: breaking elements*


DE: https://www.youtube.com/watch?v=2z-3vqAKkBU
ENG: https://www.youtube.com/watch?v=h1tm-fwFmO4

*DE: https://www.youtube.com/watch?v=2z-3vqAKkBU*

*ENG: https://www.youtube.com/watch?v=n1tm-fwFmO4*

## **Engineering:** The result

| | | | |
|---|---|---|---|
| weight: | 1.490 g | **- 51 %** | 720 g |
| number of components: | 19 | **- 68 %** | 6 |
| tied-up capital: | high | | very low |
| needed package: | high | | low |

**Lightest construction for a hood hinge**

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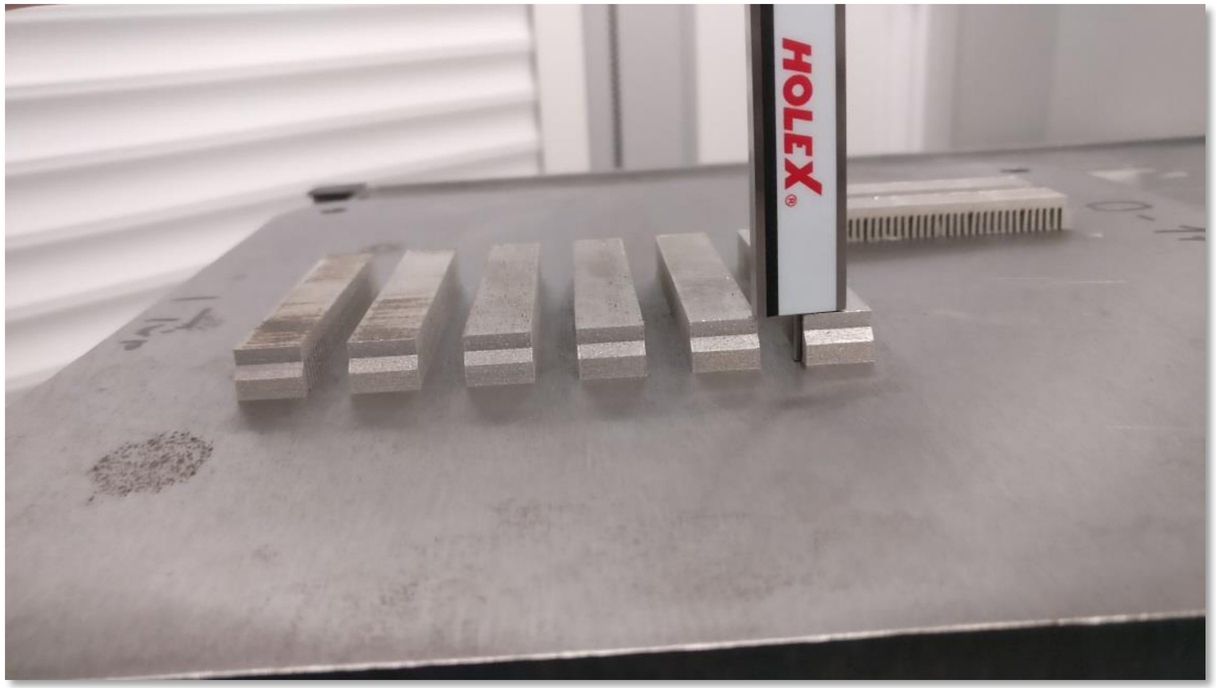
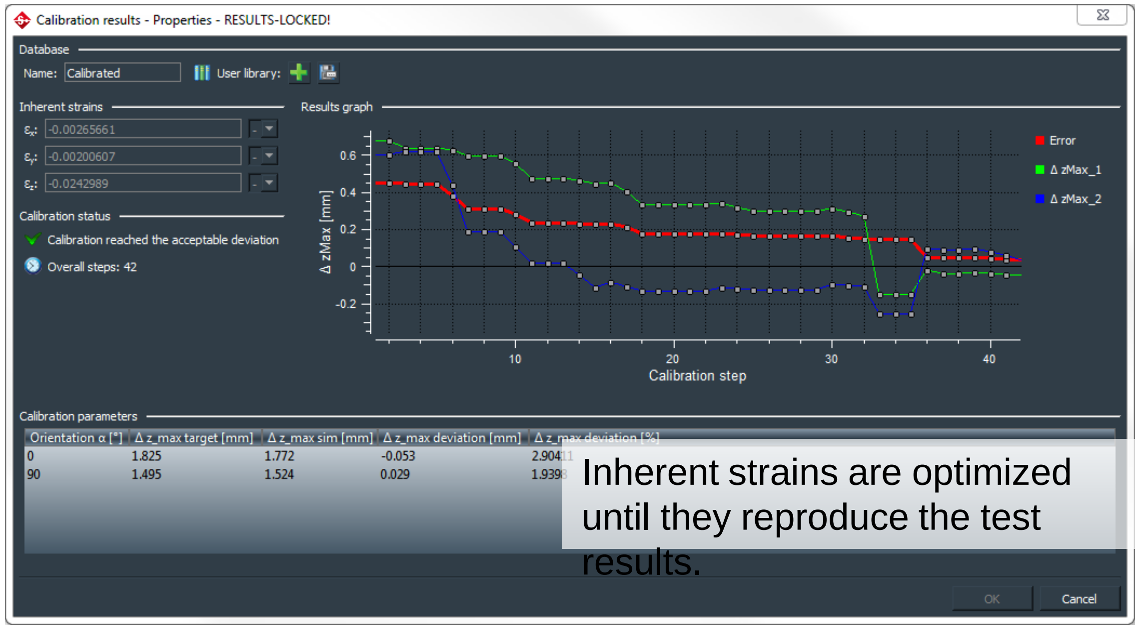
# **Process simulation:** Calibration of manufacturing process loads

- Cantilever specimens with different scanning strategies were printed by voestalpine.
- The cantilevers were cut and the deformation measured.
- Deformations were translated into simufact additive.
- The inherent strains that reflect the manufacturing process loads were calibrated.

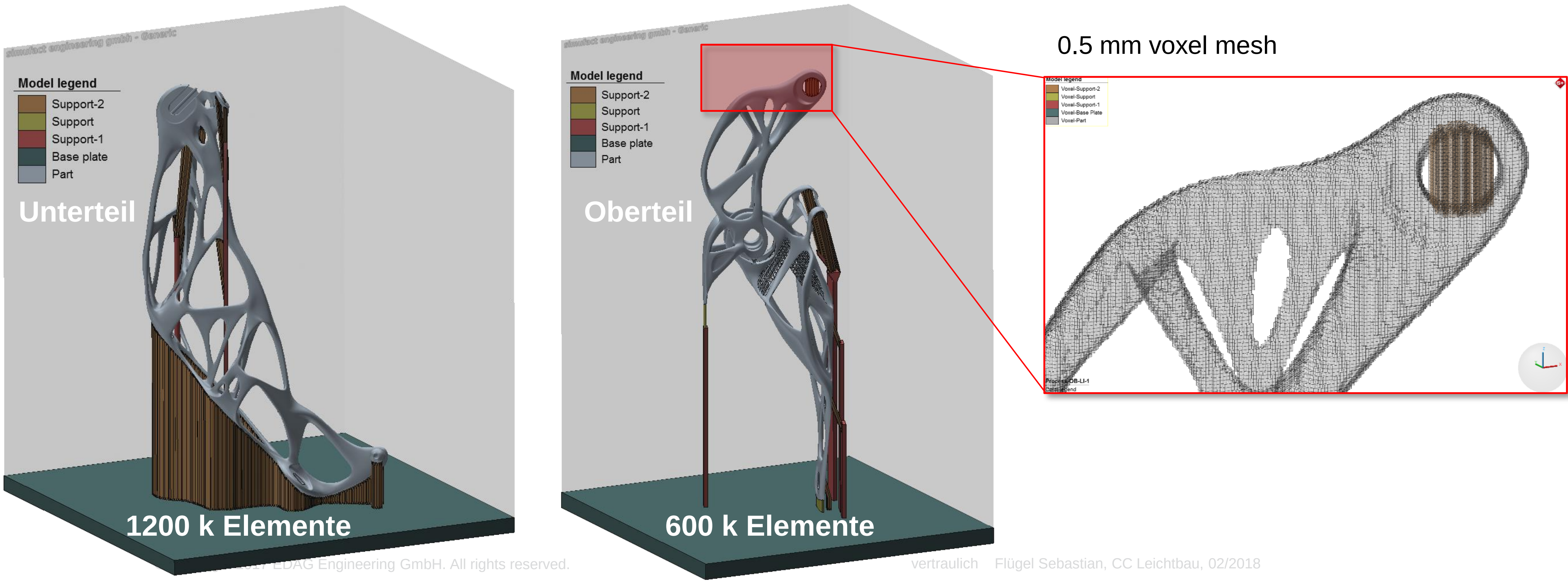



Inherent strains are optimized until they reproduce the test results.

# **Process simulation:** Model setup for AM simulation

- Import part geometry
- Import support structure geometries
- Select material from database – 316L steel
- Define process chain to be simulated (build part, cut from plate, remove supports)
- Mesh geometries with voxels

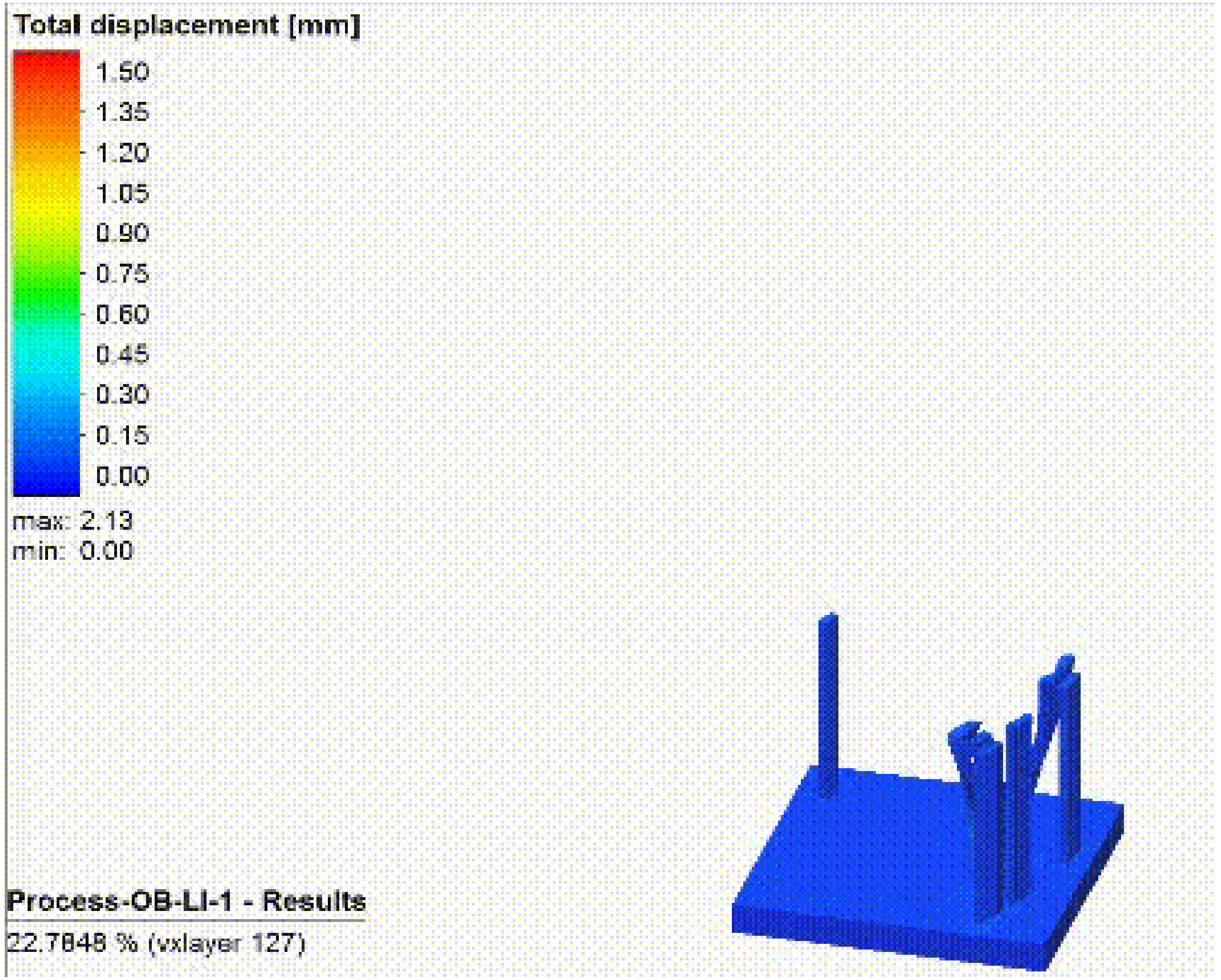


## **Process simulation:** AM simulation of single parts

- Simulation of
  - Building of the part
  - Cutting from plate
  - Removing support structures

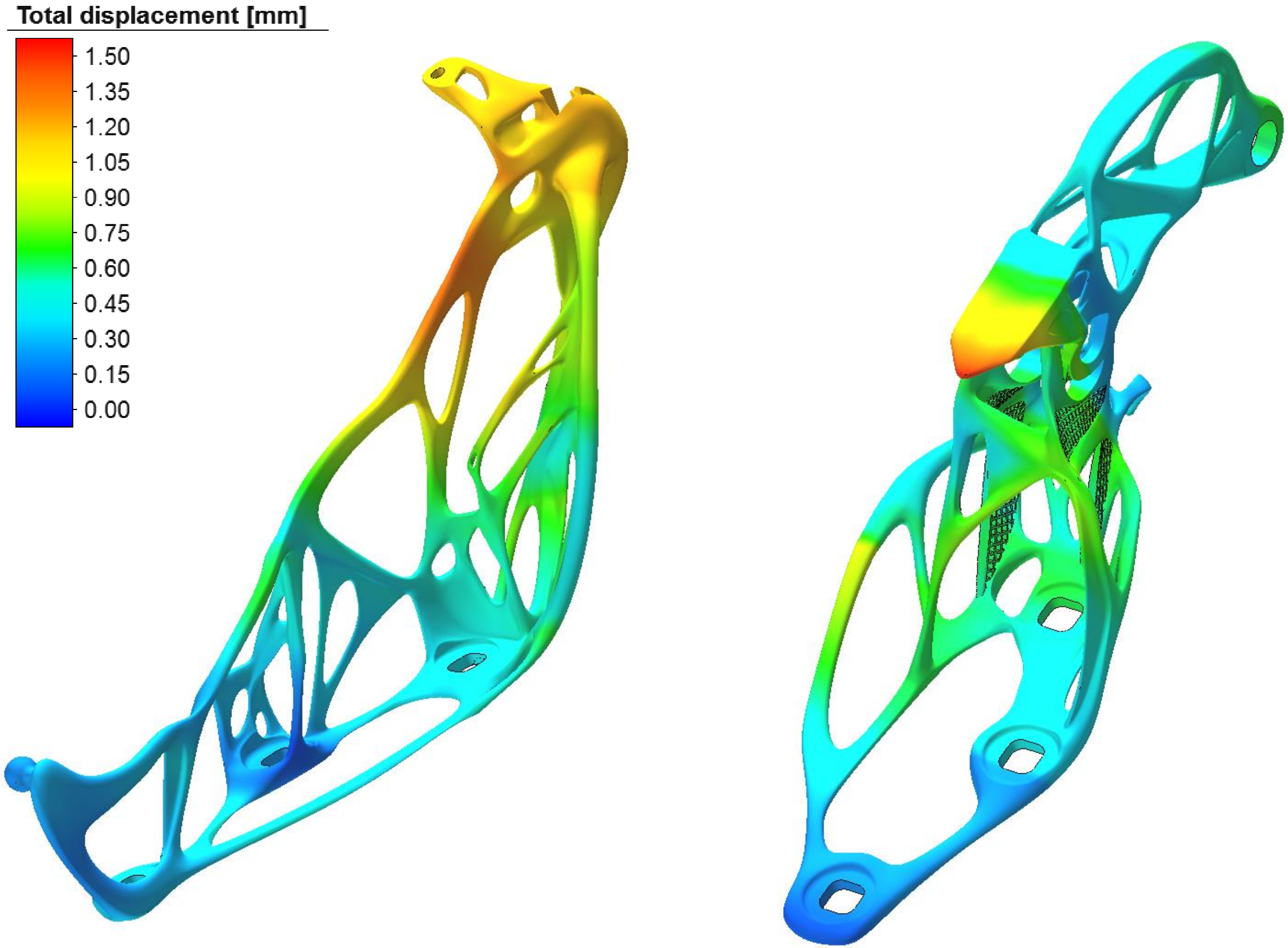
- Calculation times
  - Lower bracket
    - 13.6 hrs on 14 cores
  - Upper bracket
    - 8.6 hrs on 8 cores

*https://www.youtube.com/watch?v=VJaFm7Fj8Dw*



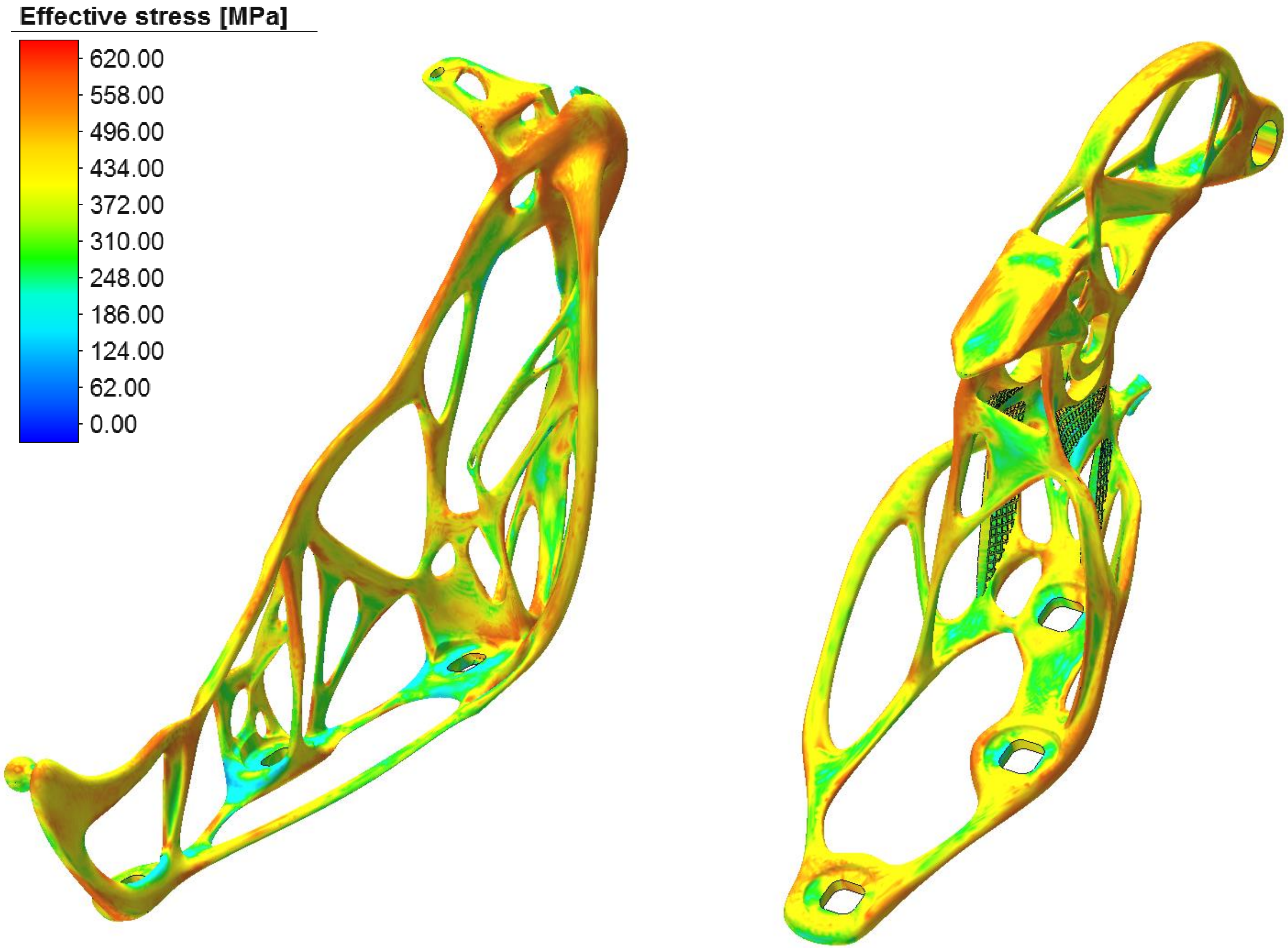
## **Process simulation:** AM simulation results

- Model is stabilized as it loses its reference after being cut from the plate
- Therefore displacement values are not unique, but dependent on relative position to original mesh
- Nevertheless prediction of part distortion is unaffected



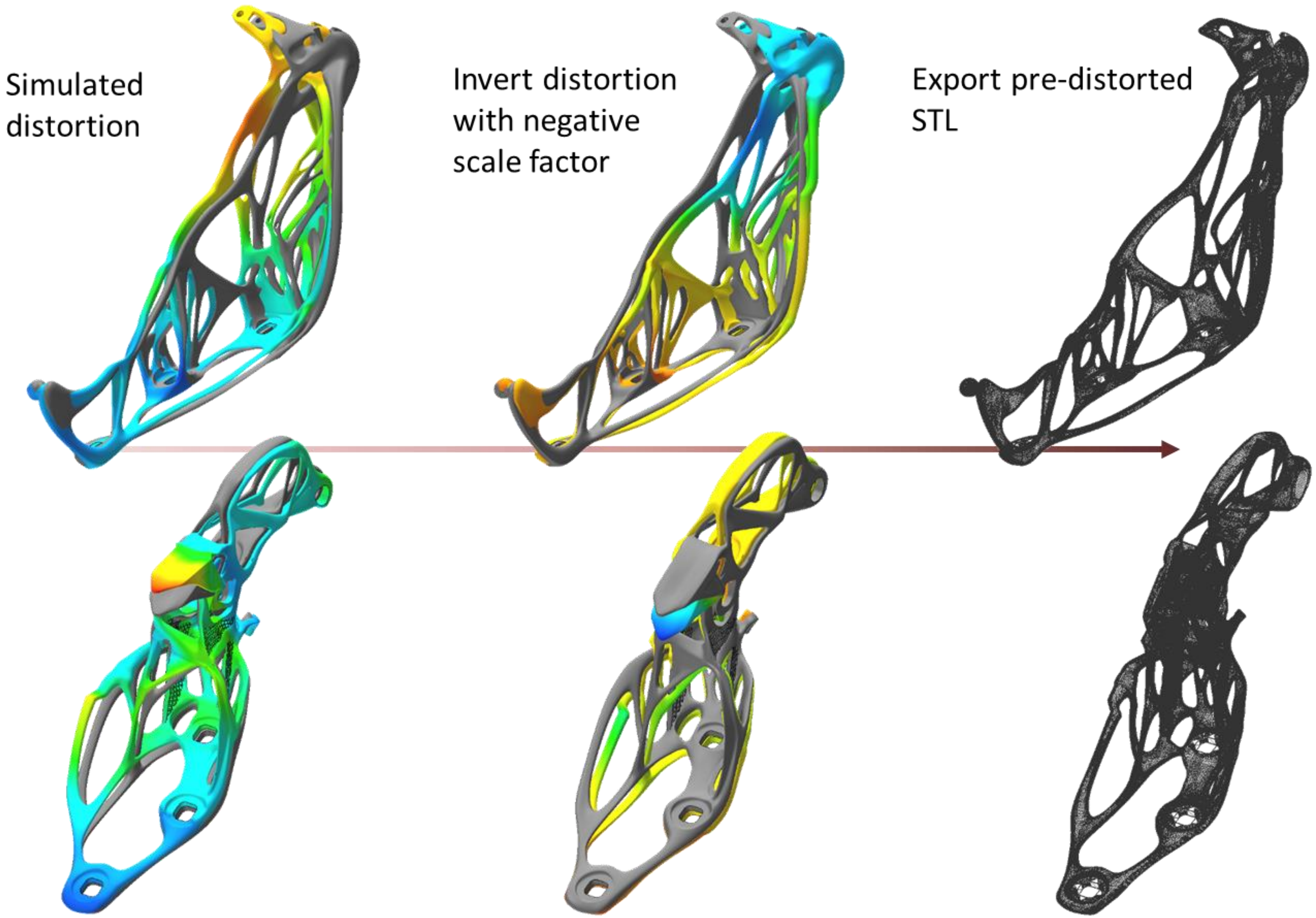
## **Process simulation:** AM simulation results

- Effective stresses shown
- Stresses are calculated based on non-linear elastic-plastic material model with realistic stress-strain relationship (flow curve)
- Yield stress at 585 MPa
  - Plastification leads to permanent deformation = distortion
- Ultimate strength is 685 MPa



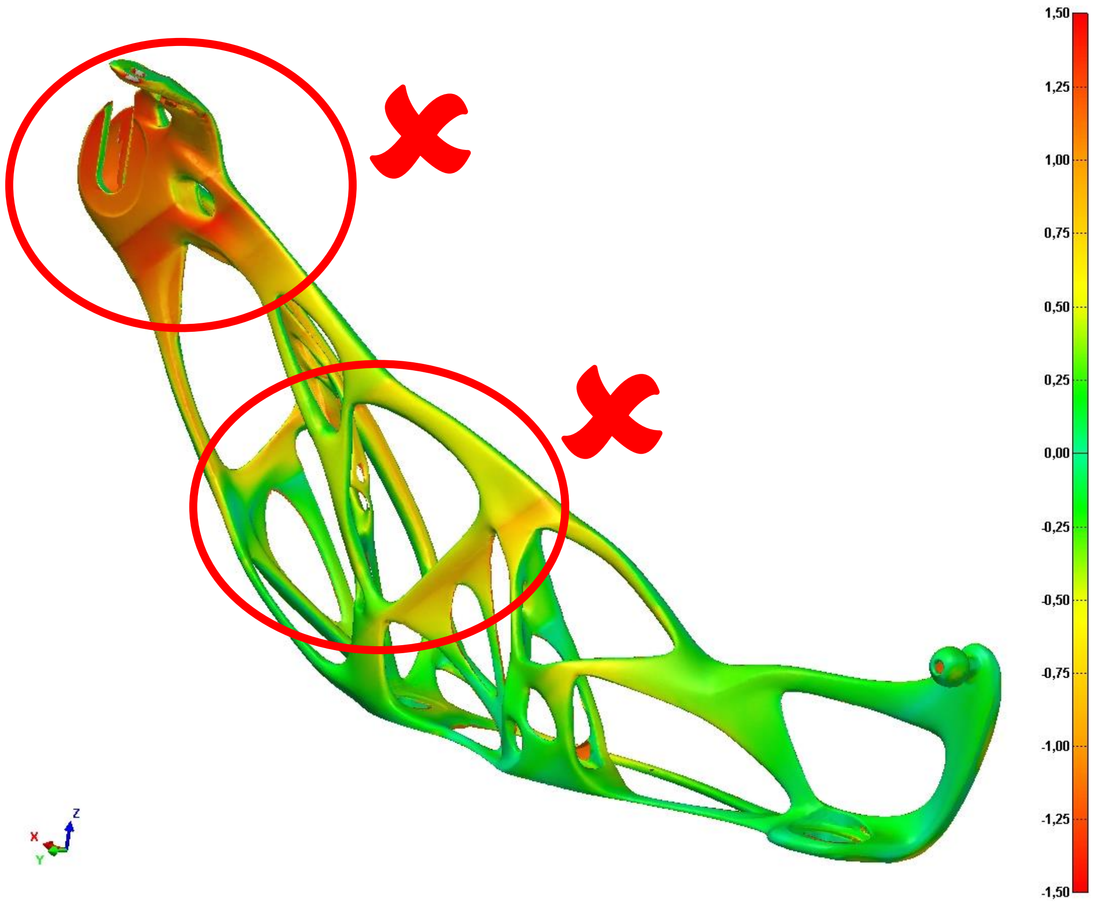
## **Process simulation:** Pre-deformed shape for distortion compensation

- Simulated distortion is inverted
- Inverted distortion is mapped on surface STL
- Pre-distorted STL is exported
- Exported STL was used for optimized AM of distortion compensated parts

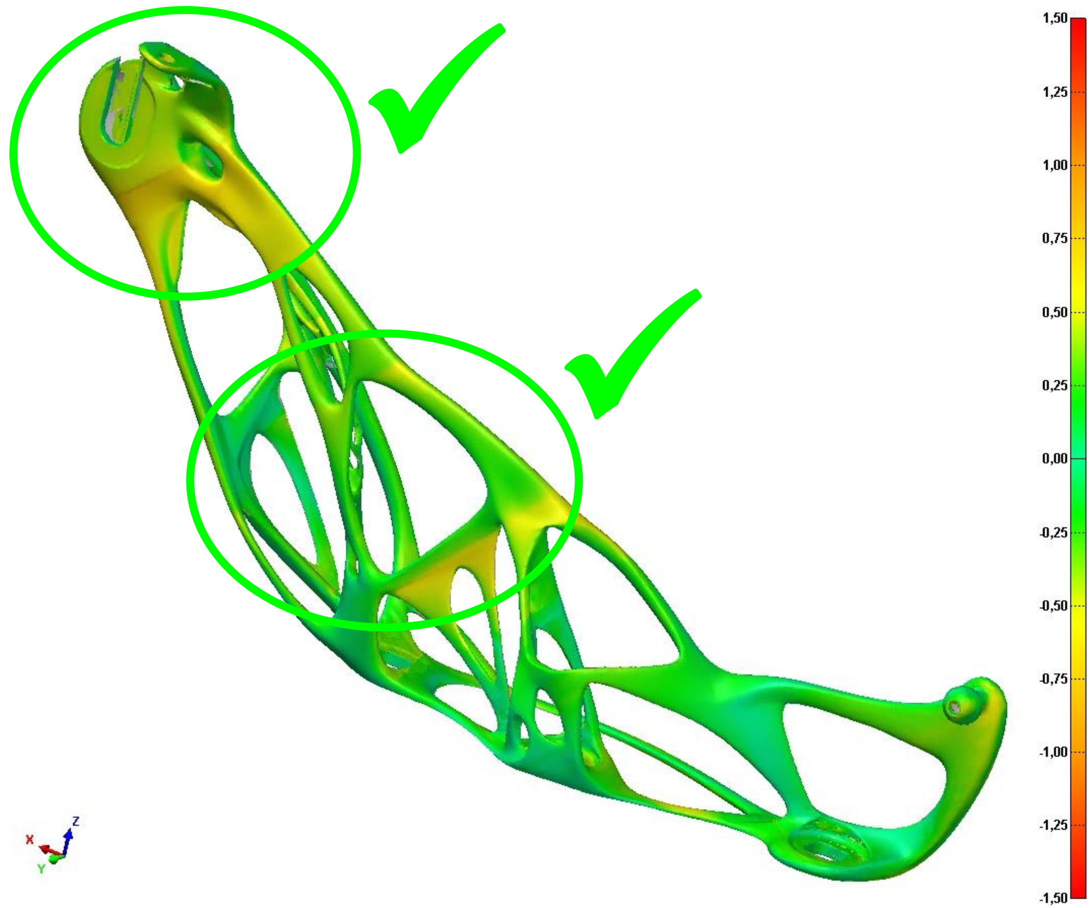



NB: shown distortions are overscaled by a factor of 10 for better visualization

# **Process simulation:** Distortion compensation

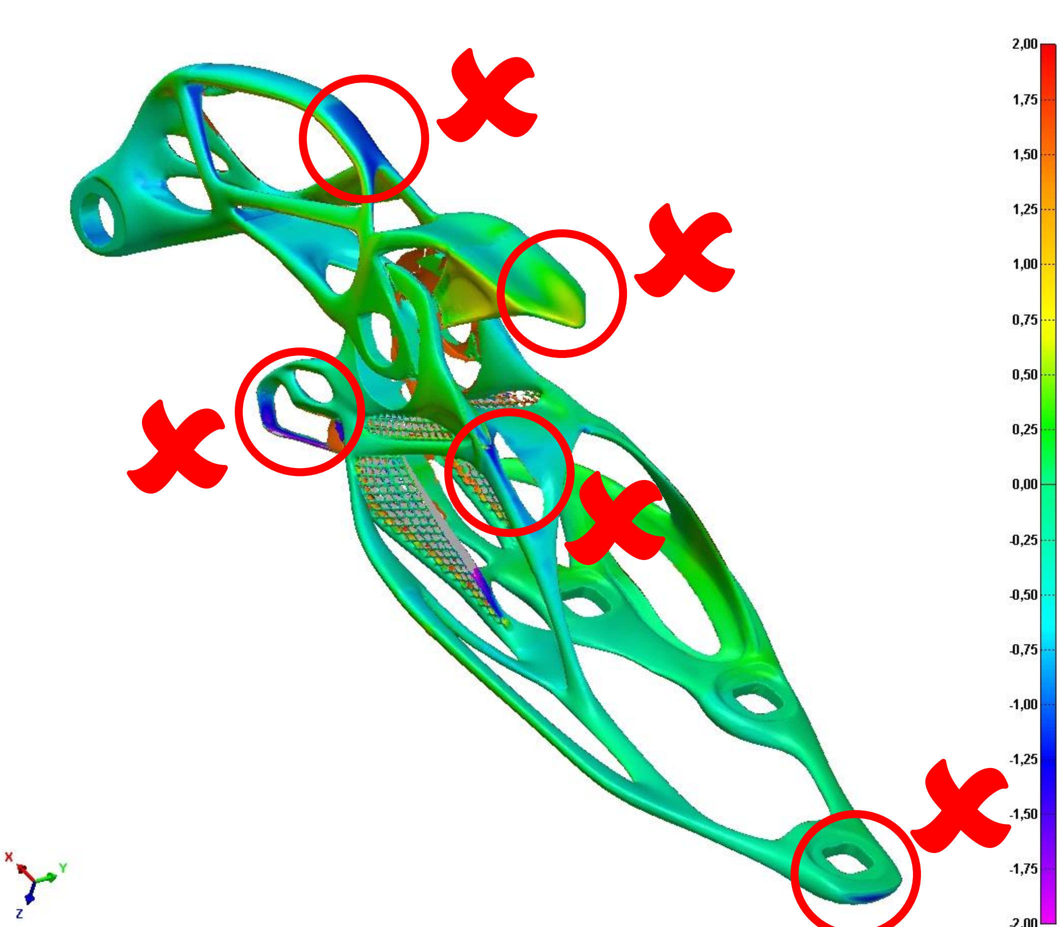



Original distortion of manufactured part vs. CAD




Distortion compensated based on simulation results

## **Process simulation:** Distortion compensation

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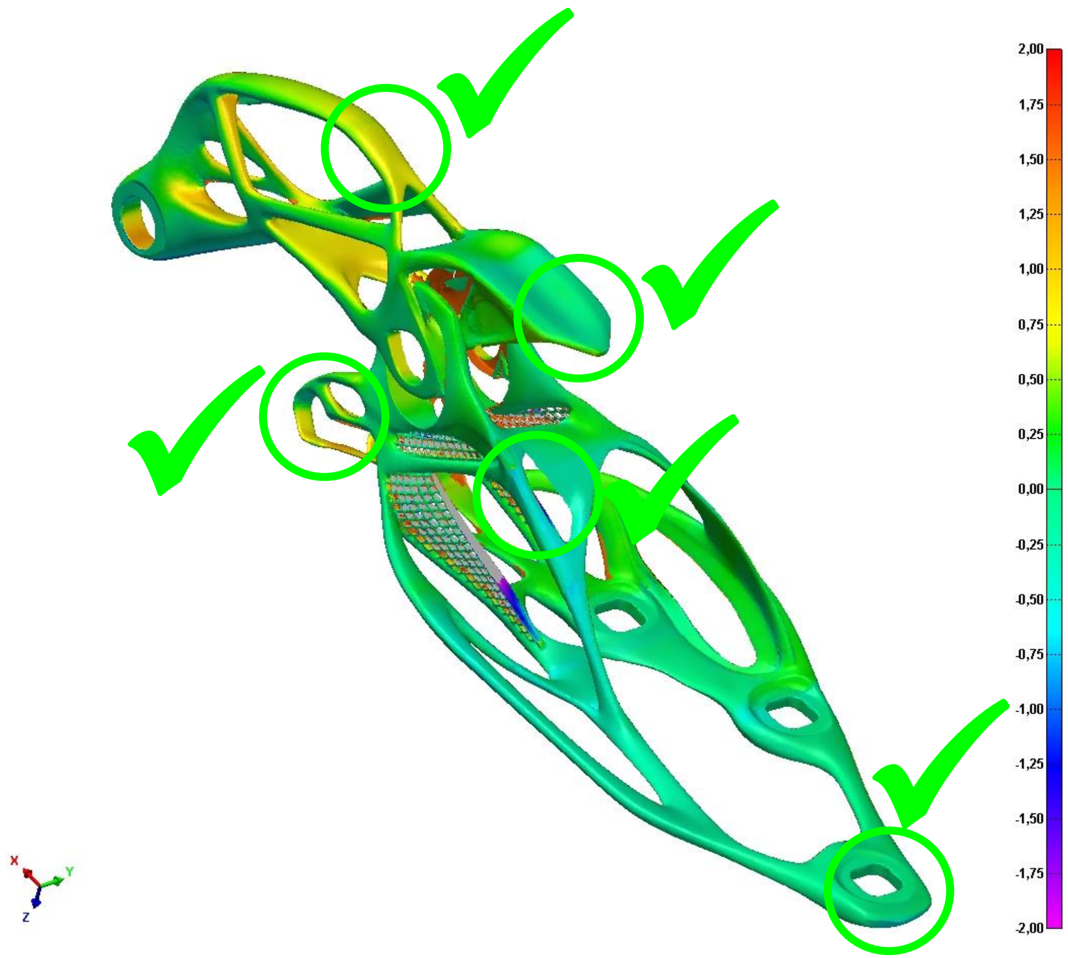


Distortion compensated based on simulation results

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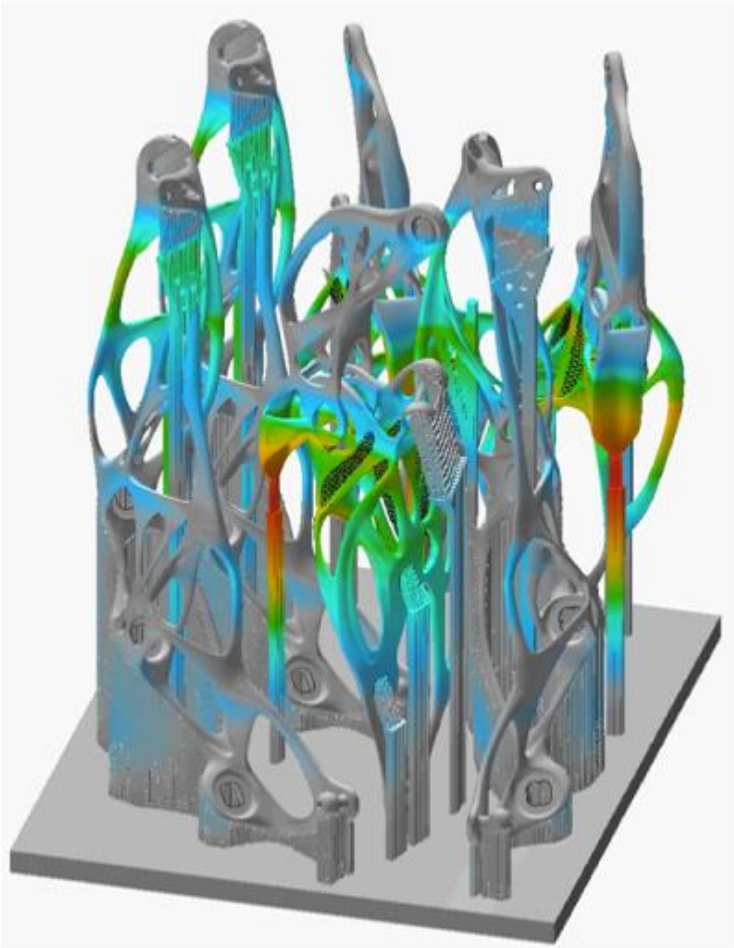
## **Conclusion:** Process simulation

- Significant reduction of the initial distortion up to 80% by AM simulation
- Further improved results possible by additional simulation iterations (Only one in project)
- No necessity for building expensive and time consuming trial parts
- No necessity for expensive compensation of distortion based on optical measurements
- AM part can already be within the given tolerances after the first build job



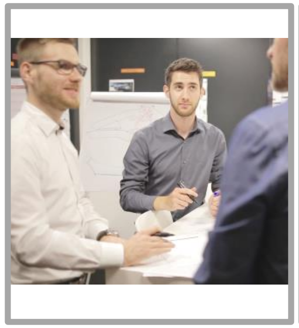
**Manufacturing time and costs are reduced dramatically**

# **Conclusion:** Engineering

- Safety and lightweight construction combined in a distortion- and production-optimized design
- Exploiting the full potential of additive manufacturing
  - Rethinking applications from scratch
  - Solving problems and generating added value
  - Apply to visible components in order to be recognizable to end customers

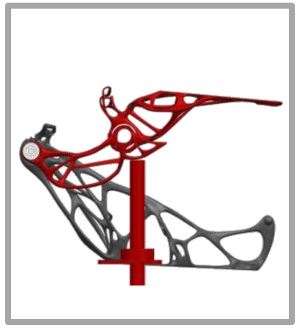
YouTube

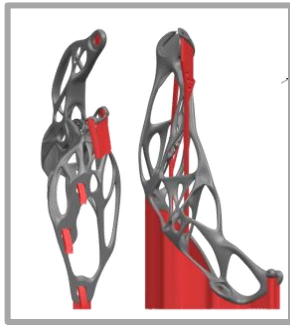

*ENG: https://www.youtube.com/watch?v=n1tm-fwFmO4*
*DE: https://www.youtube.com/watch?v=2z-3vqAKkBU*

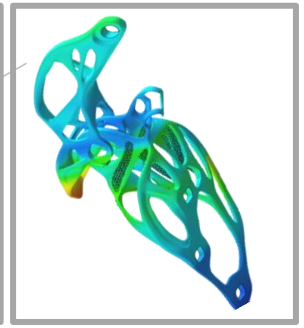

Idea creation


Topology opimization


Design


Active hood function


Support minimization


Distortion minimization


Manufacturing


Testing and validation

GOLD AWARD $CO_2$

**Preparing the way for automotive small series production**

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ONE STEP AHEAD.

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