



**Engineering  
with a difference**

**Case examples of simulation use  
in metal 3D printing of products  
for Finnish industry**

Erin Komi, AM Specialist

3.12.2019

# Etteplan

## Expertise & Services

1. Engineering Solutions
2. Software & Embedded Solutions
3. Technical Documentation Solutions

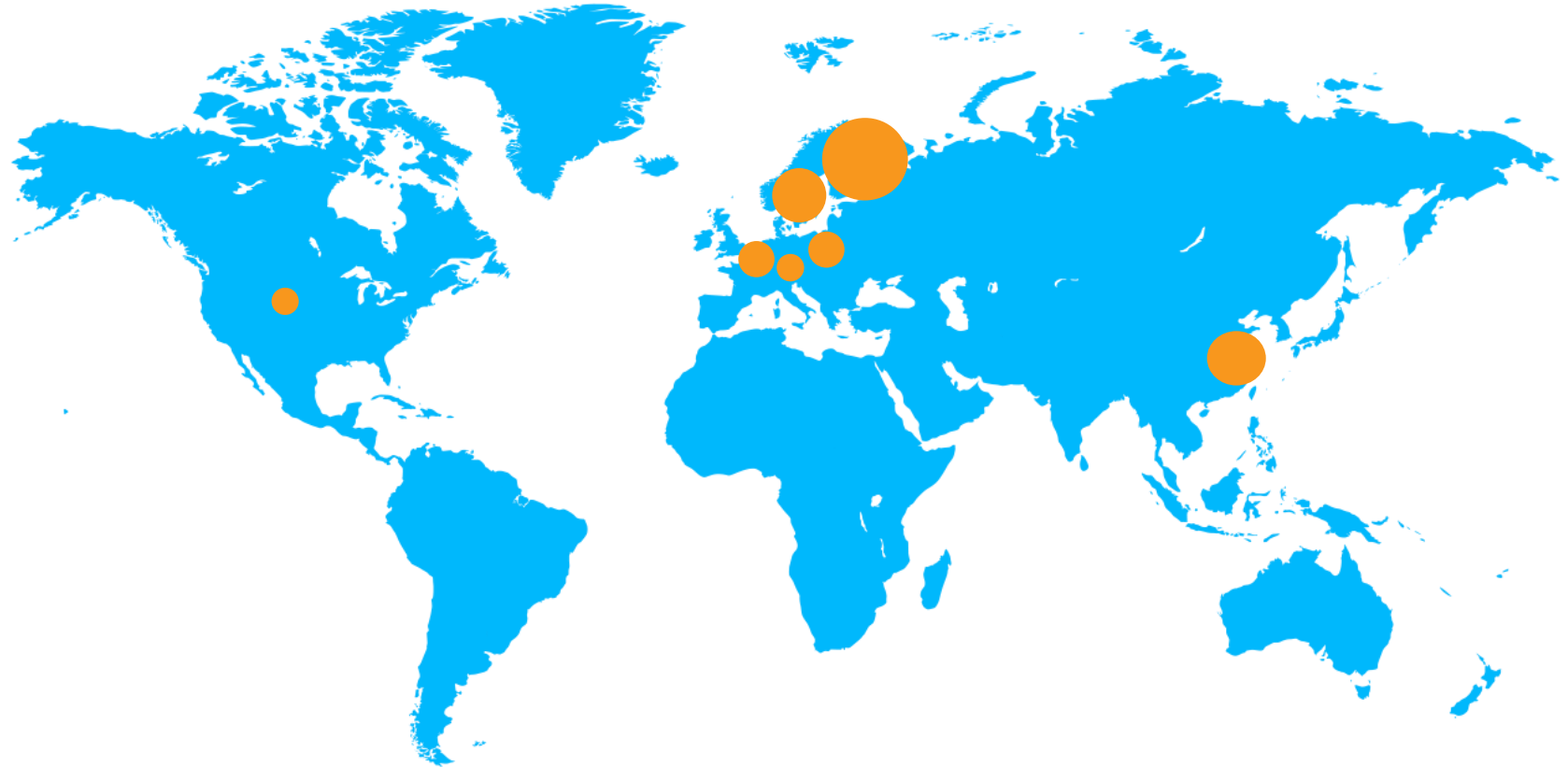
**236,5**

REVENUE, EUR MILLION 2018

**~ 3,500**

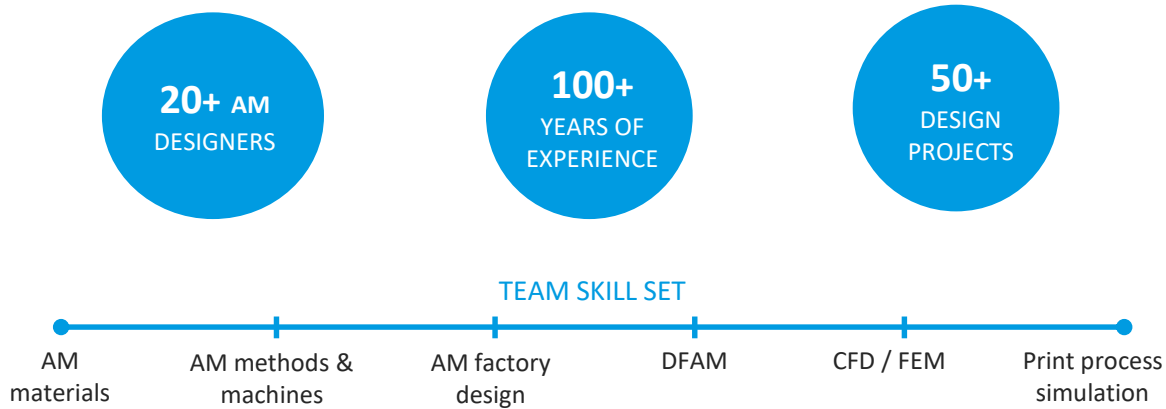
NUMBER OF PERSONNEL

Employees by geographical area  
2018






~60 offices in Finland, Sweden, China, Poland, the Netherlands, Germany, USA

## AMO TEAM OVERVIEW



## STRENGTHS

-  Heavy industry expertise
-  Simulation driven design for AM
-  AM business case creation
-  Strong partner network

*And many more...*

## ADDITIVE MANUFACTURING SERVICES

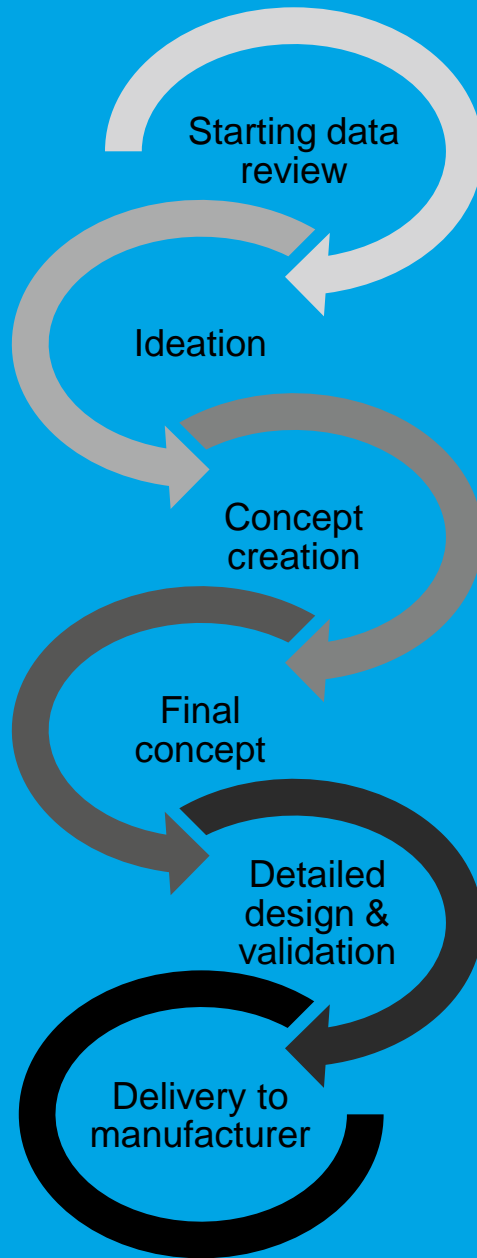


## OWN RESEARCH

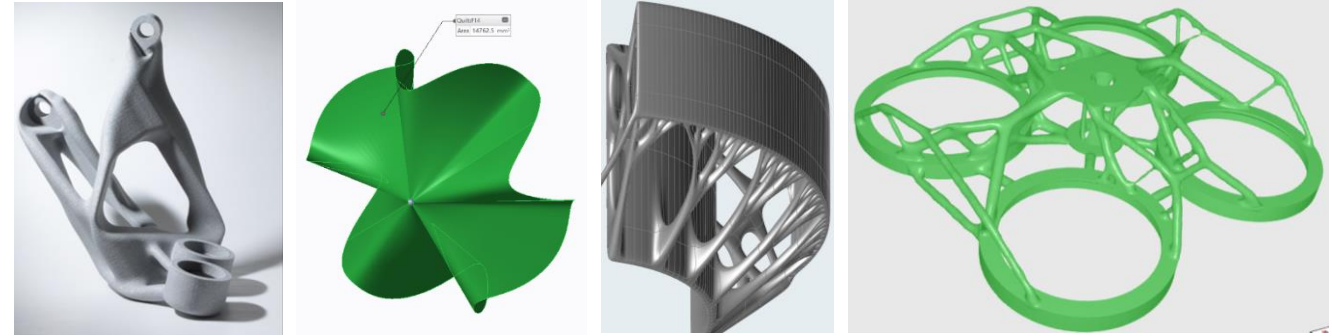
*Etteplan AM screening service  
Etteplan AM Engineering service  
Etteplan AM SCAN to Print service  
Design & Manufacturing process for electronics*

*Own research continues...*

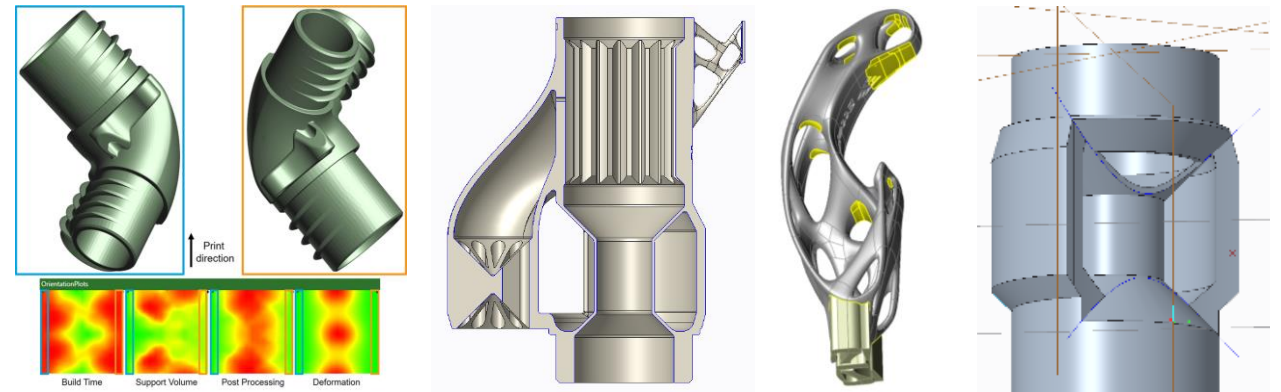
# Simulation driven AM design



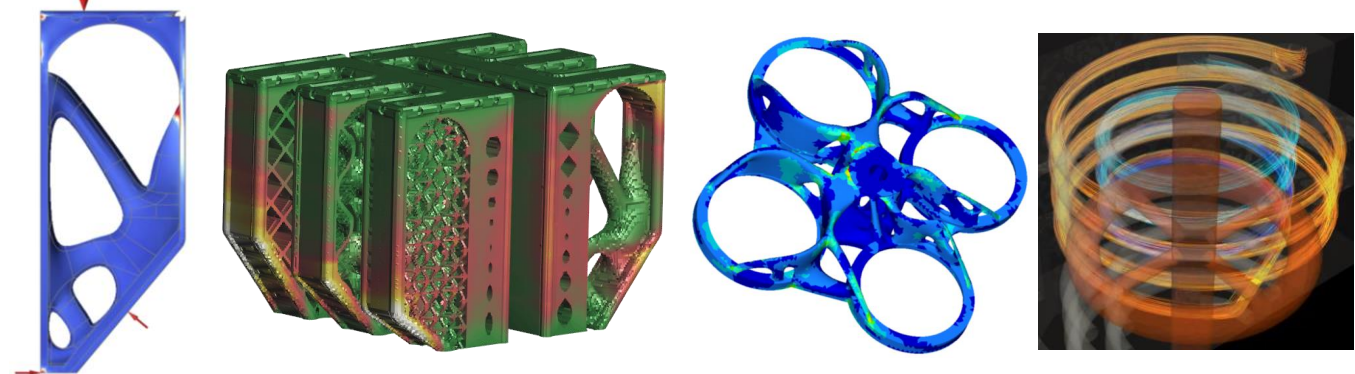
Topology optimization  
Generative design  
Lattice/infill/3D modelling  
FEM, CFD



Orientation optimization  
Self-supporting design



Print process simulation  
FEM/CFD validation  
Support optimization



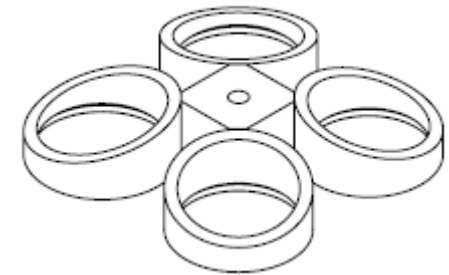
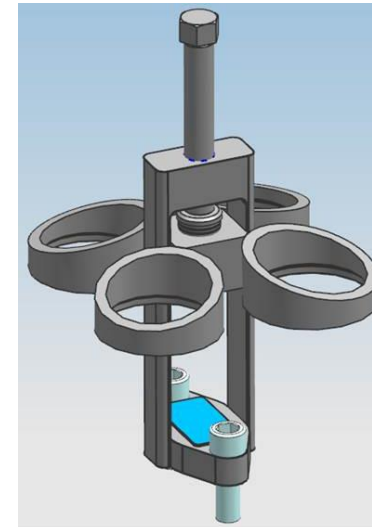
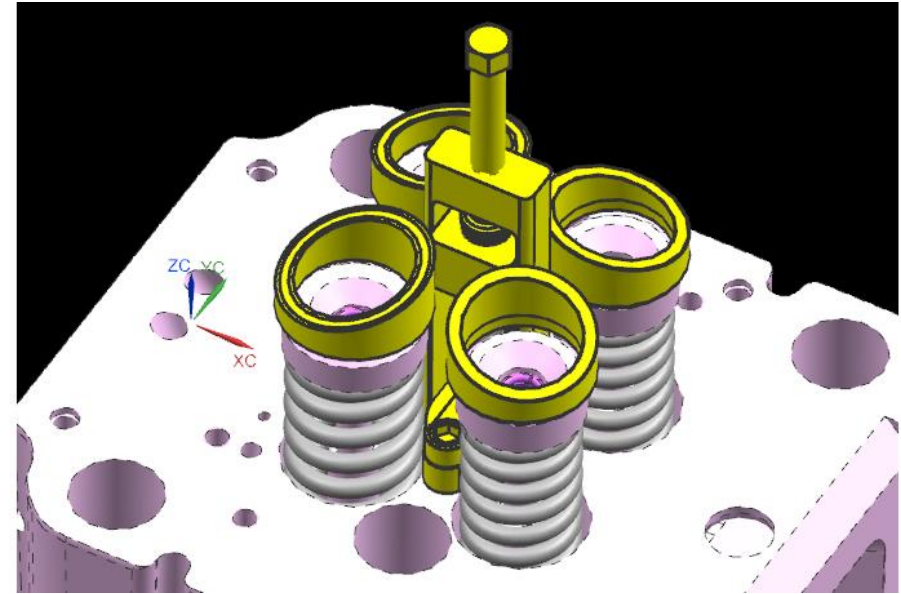




# Case: pressing tool for Wärtsilä

# Challenge

- Wärtsilä needed to quickly create a tool to help install cylinder head valves in a new engine
- There were concerns that the initial design could not withstand the high spring forces generated during use
- Etteplan was called to redesign the part for AM – with time and manufacturing costs both being closely monitored

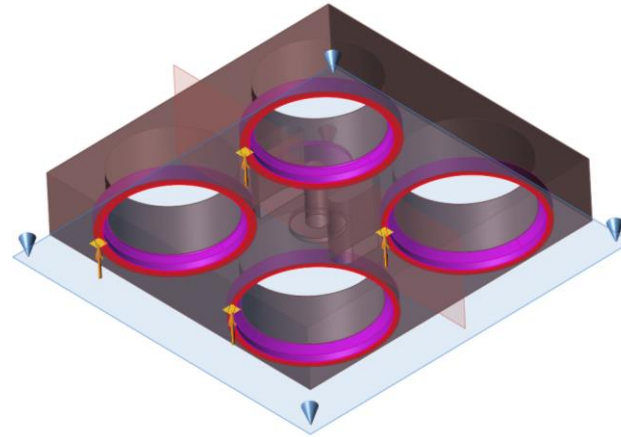


*Original welded pressing tool design*



# Topology optimization & design analysis

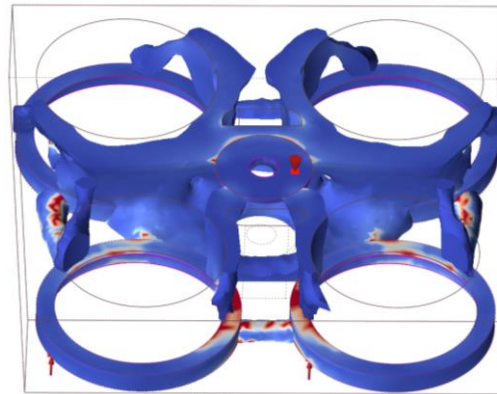
- Loads, boundary conditions & design space restrictions defined with the help of Wärtsilä tooling expert
- Materials considered: 316L, Ti6Al4V, MS1
- Manufacturing constraints: symmetry plane, overhang limit ( $45^\circ$ )
- Design concepts were generated and evaluated for variations in material, design space definition, and manufacturing constraints



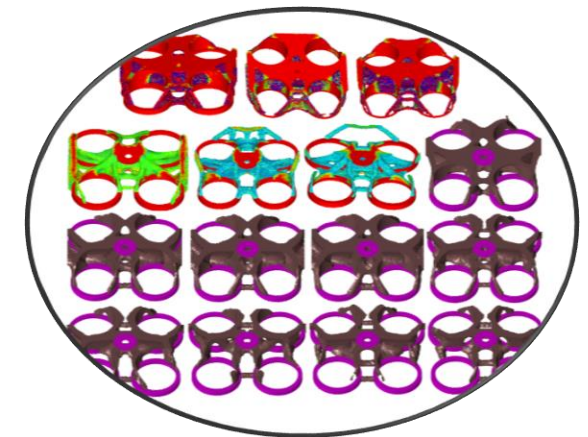
Load case & design space definition



Topology optimization



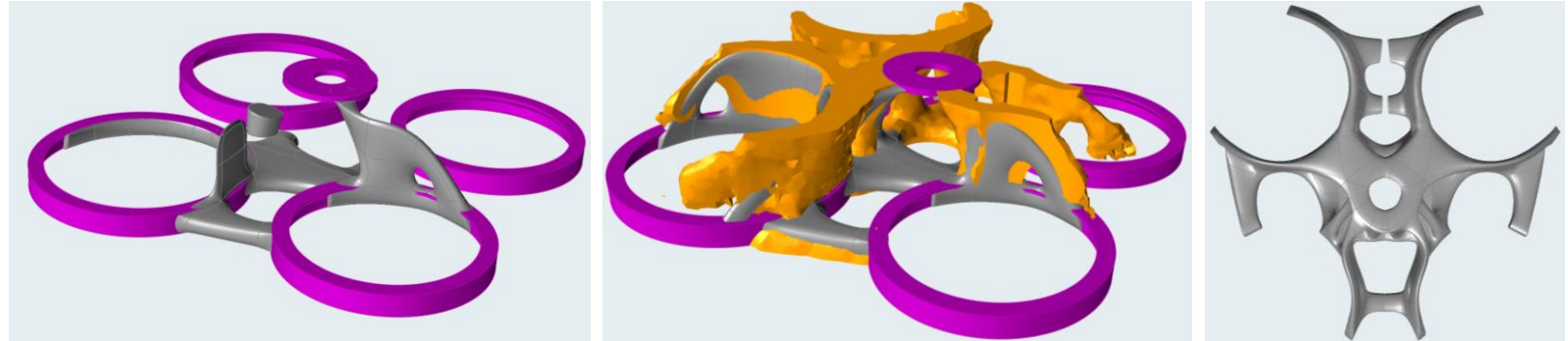
Preliminary design analysis



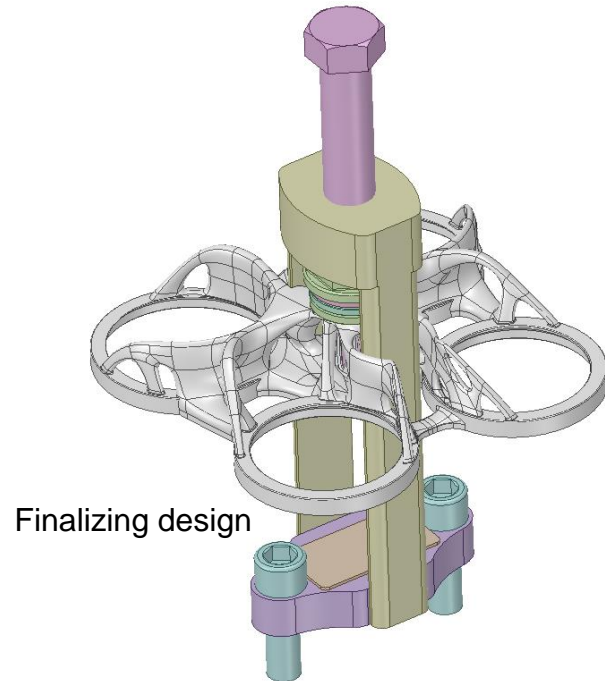
Design concept generation

# Finalizing design – geometry & analyses

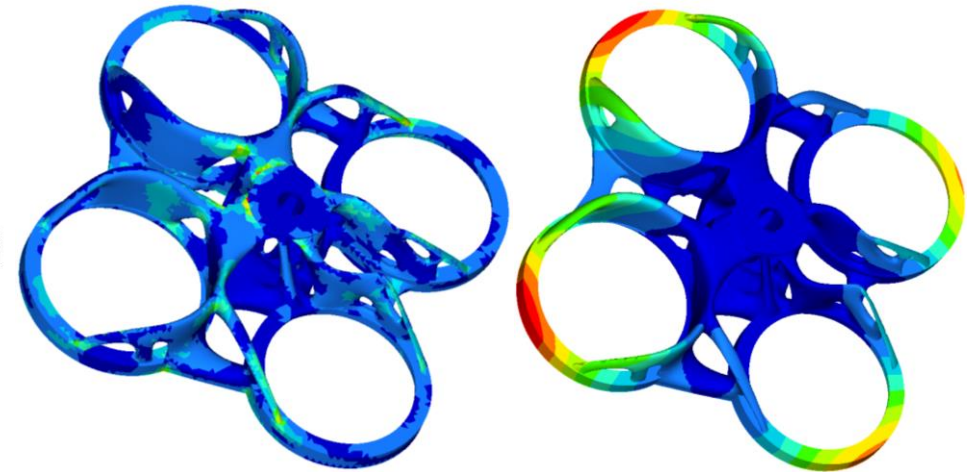
- PolyNURBS created using chosen topology optimization result as a guide
- 45° overhang rule followed to ensure self-supporting design
- FEM analysis to ensure performance criteria were met



Creating polyNURBS



Finalizing design

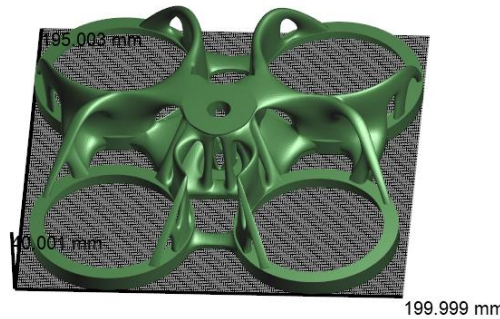


Design analysis

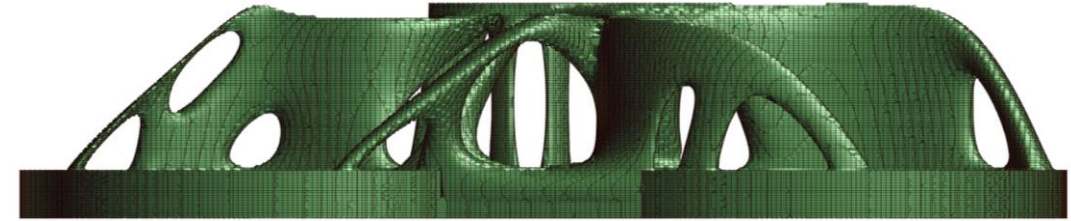


# AM Process Simulation

- Additive Works Amphyon software used to run print process simulation
- Material calibration: steel 1.2709 preset
- Supports: Part built directly on build plate, supports created at washer opening
- Low distortion levels (max. 19.3  $\mu\text{m}$ ) show that recoater crash during printing is not an issue



Tool positioned on build plate



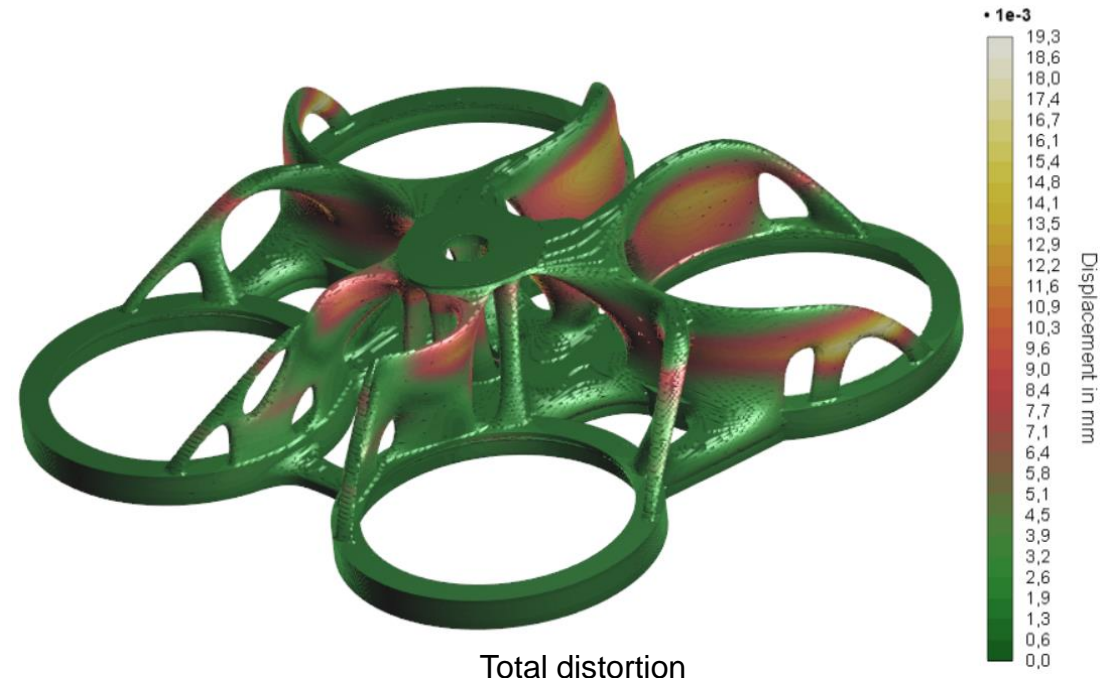
Mesh: 296k elements, 43 layers



Support volume identified

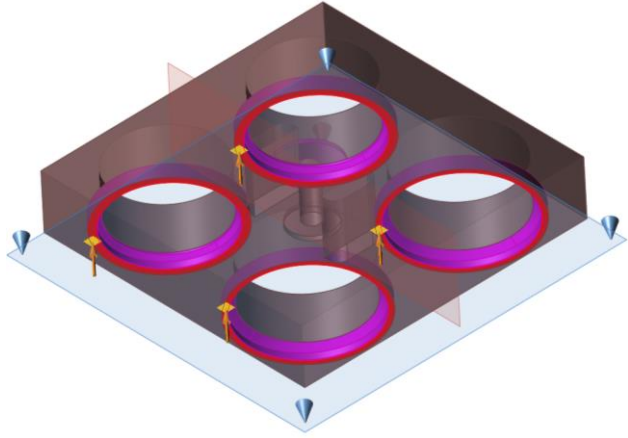


Support generation



Total distortion

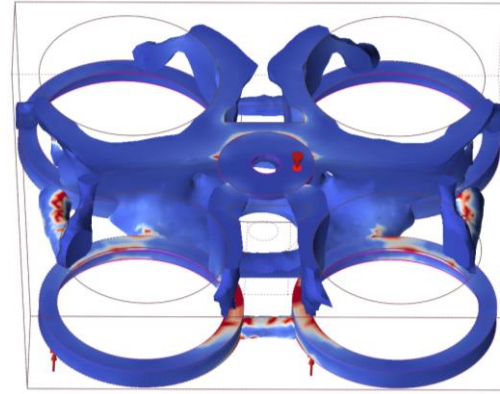
# Approach summary: Simulation-driven AM design



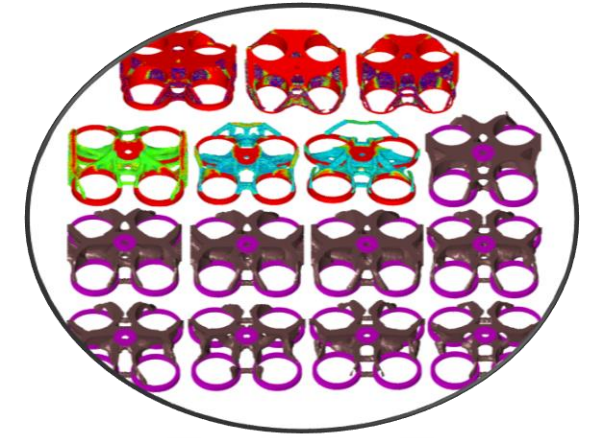
Load case & design space definition



Topology optimization



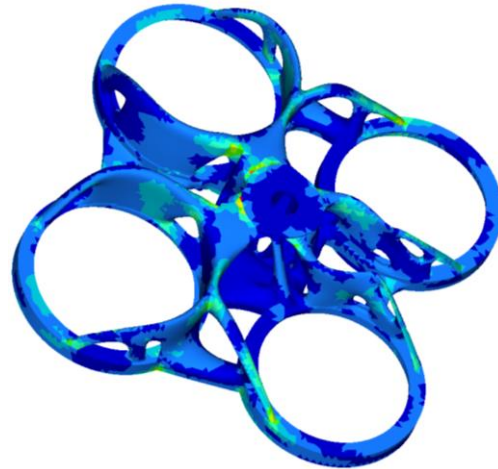
Preliminary design analysis



Design concept generation



Finalizing design



Design analysis



AM process simulation



Optimized design geometry



# Benefits

- Time from when starting data was set to final design sent to be printed **< 1 week!**
- Manufacturing costs below budget
- Safer design



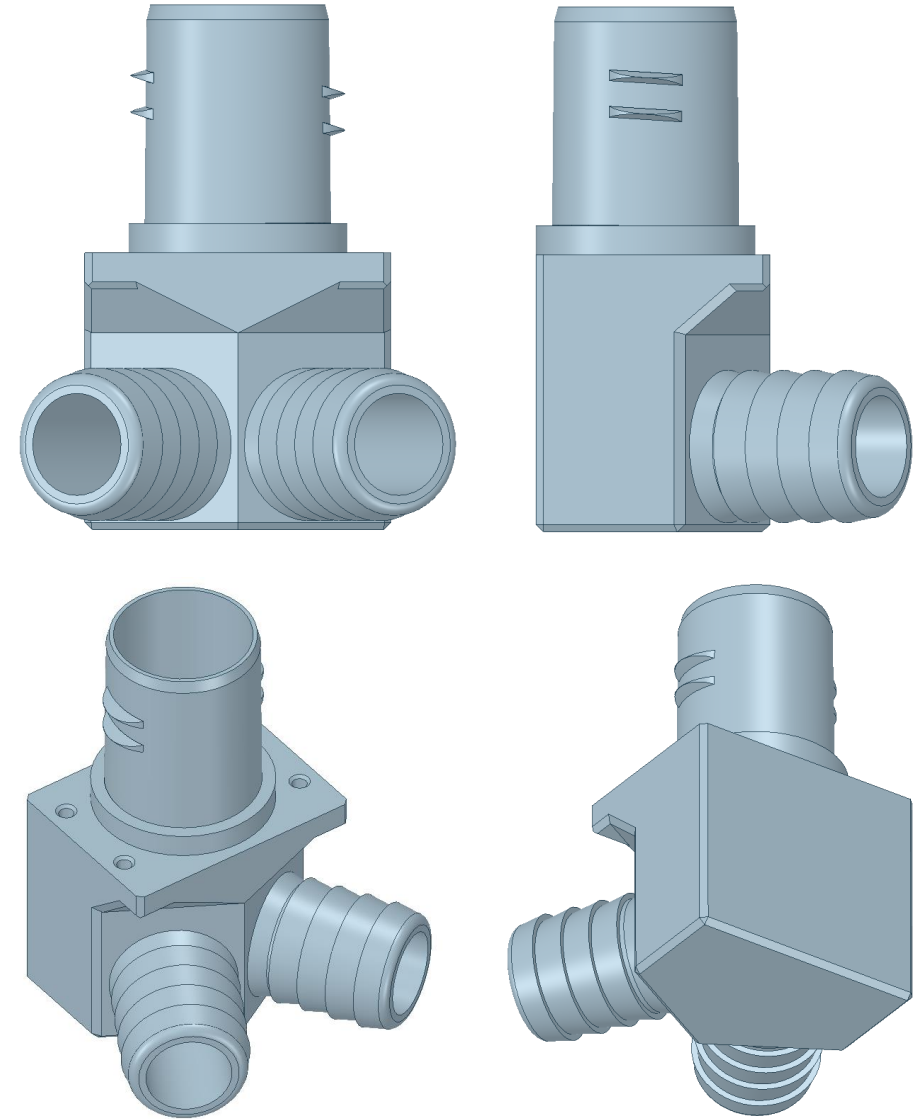




# Case: dust extraction channel for robotic sander

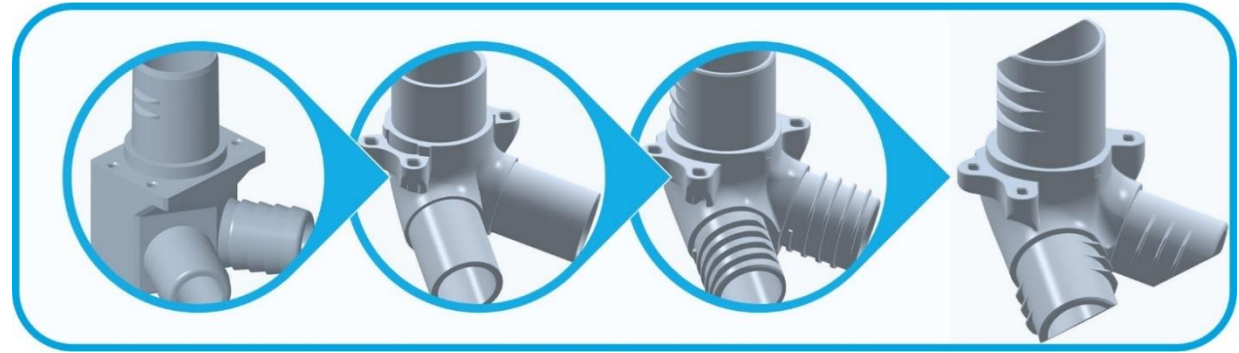
# Background

- A customer identified a product that would benefit from AM
  - Lighter
  - Significantly better airflow characteristics
  - Lower manufacturing costs
  - Better looking
- Size: ~70 x 40 x 50 mm
- Annual volume: ~1000 pieces
- Material: aluminum or similar, painted matte black after printing
- Goal: AM redesign to reduce costs and improve surface finish → move manufacturing back to Finland

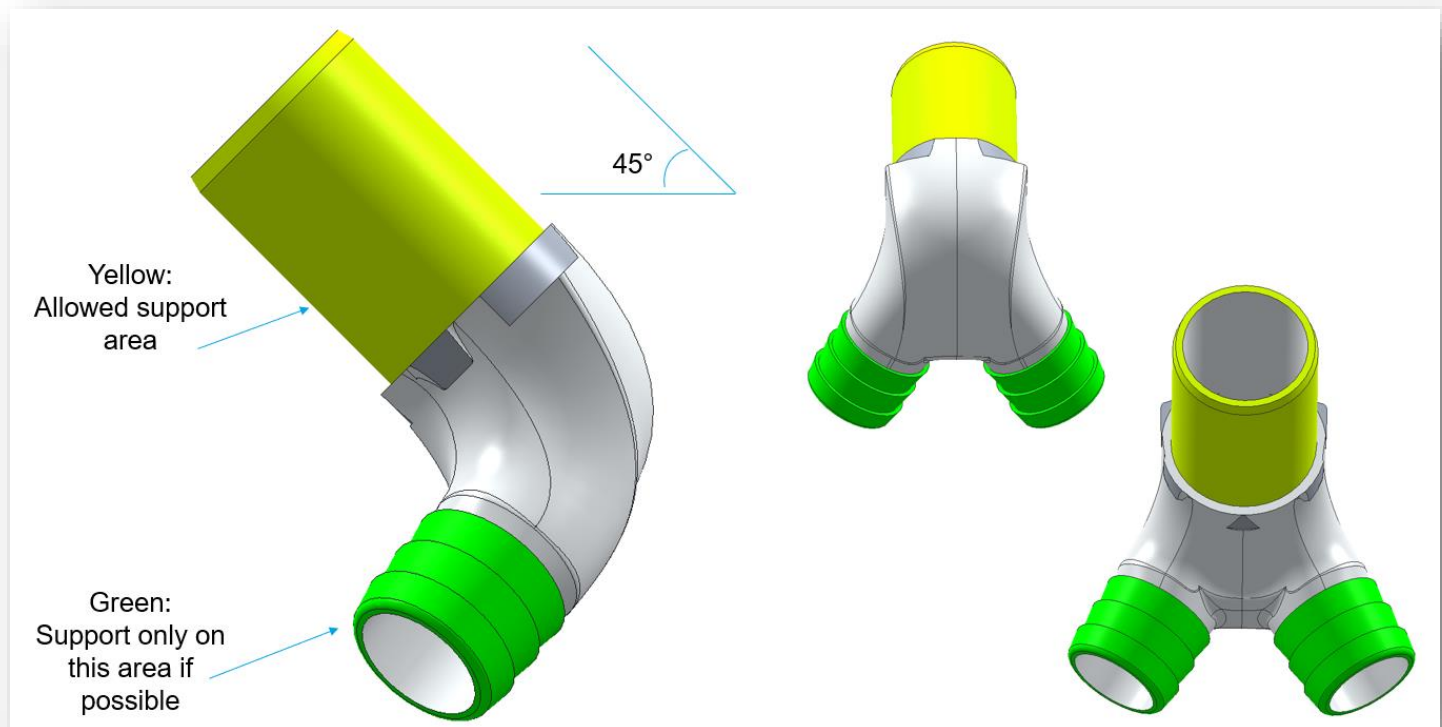


# Approach

- Initial DfAM – remove excess material, optimize inner channel
- Etteplan cost estimation tool
- Orientation optimization
- Design for stacking
  - 30 pc/layer, up to 5 layers per job in SLM 280
- Print process simulation



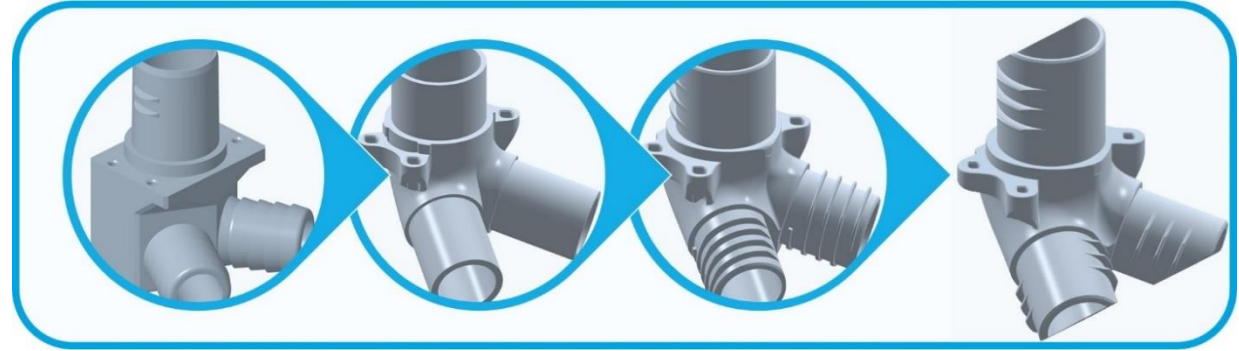
Design evolution





# Approach

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Design evolution

## Etteplan Cost Estimation Tool Results

1 pc/batch

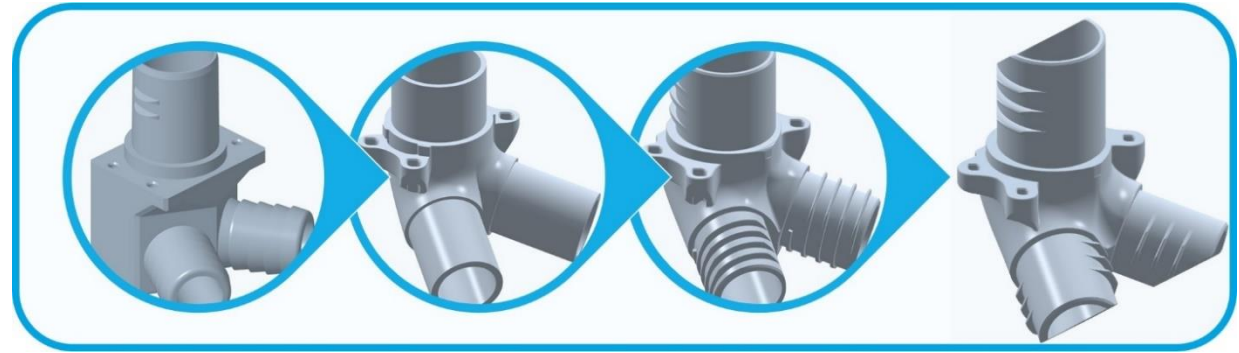
Costs 6x  
traditional  
manufacturing

11 pc/batch

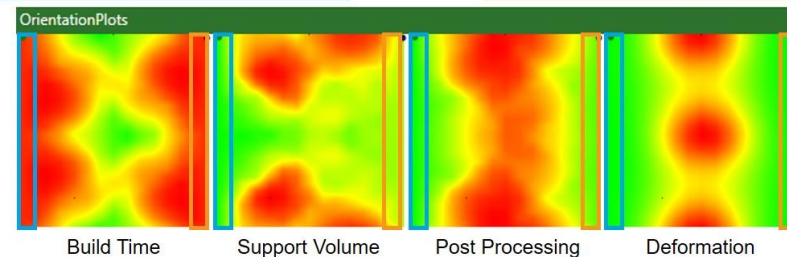
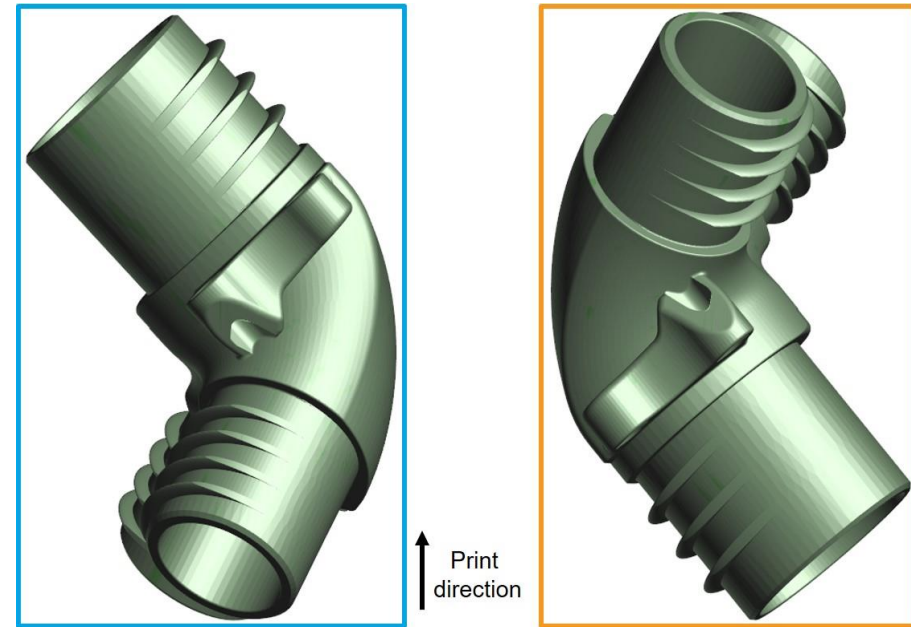
Breakeven point

# Approach

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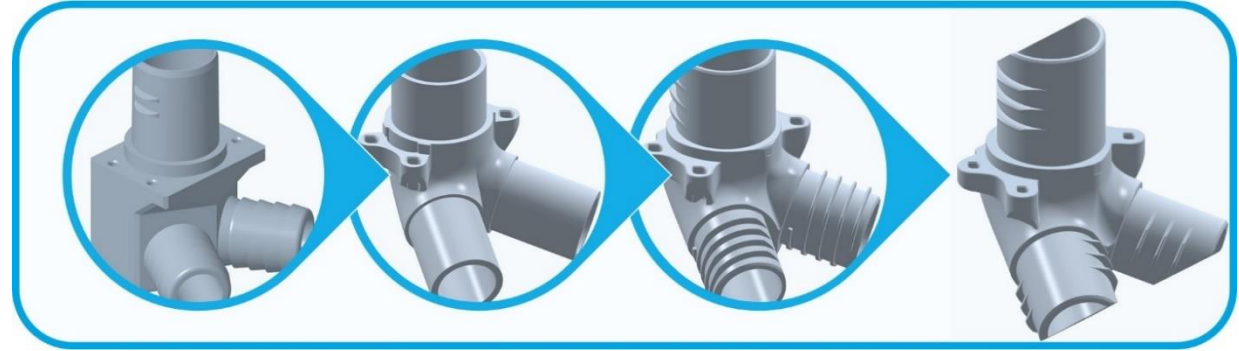


Design evolution

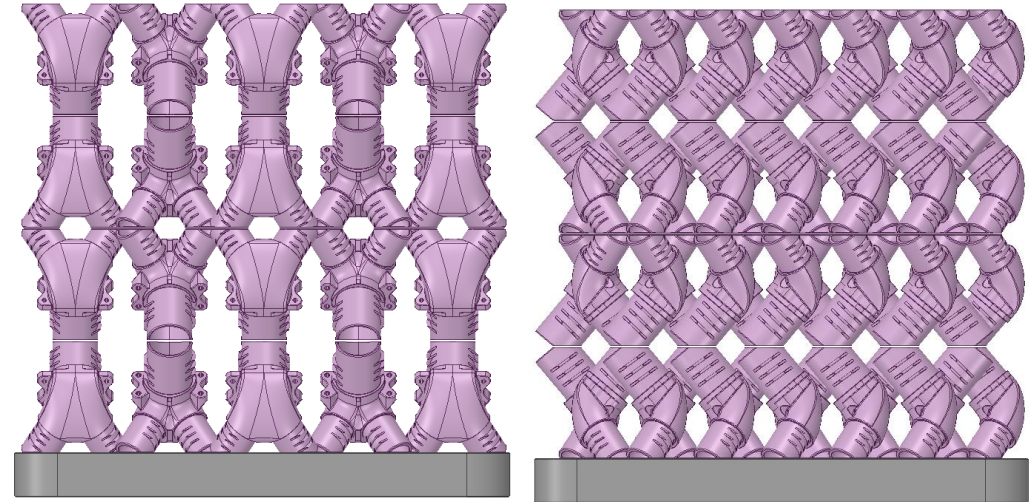


# Approach

- Initial DfAM – remove excess material, optimize inner channel
- Etteplan cost estimation tool
- Orientation optimization
- **Design for stacking**
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- Print process simulation



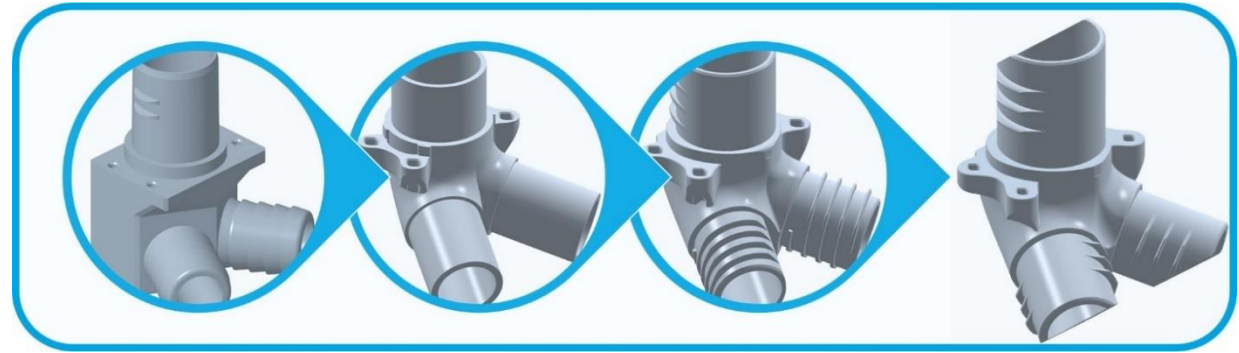
Design evolution



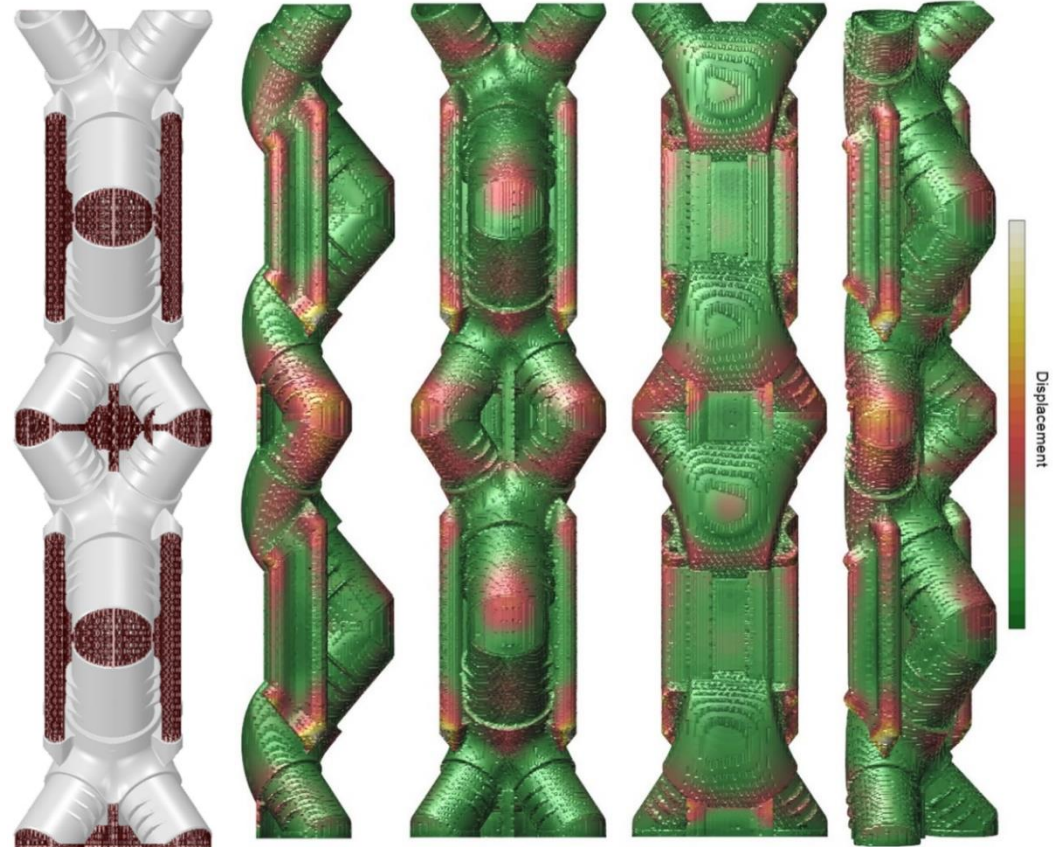


# Approach

- Initial DfAM – remove excess material, optimize inner channel
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- Orientation optimization
- Design for stacking
  - 30 pc/layer, up to 5 layers per job in SLM 280
- Print process simulation



Design evolution





# Benefits

- Manufacturing costs reductions:
  - Fully nested build → 40% cost reduction
  - Process parameter optimization with SLM Solutions reduced printing time and costs by an additional ~25%
- Exceeded customer's expectations:
  - Improved surface finish
  - More aesthetically pleasing
  - Significantly better airflow characteristics
  - Over 50% reduction in weight
  - New style of tube connection (thread) was introduced for easier assembly
  - Component codes embedded on the surface





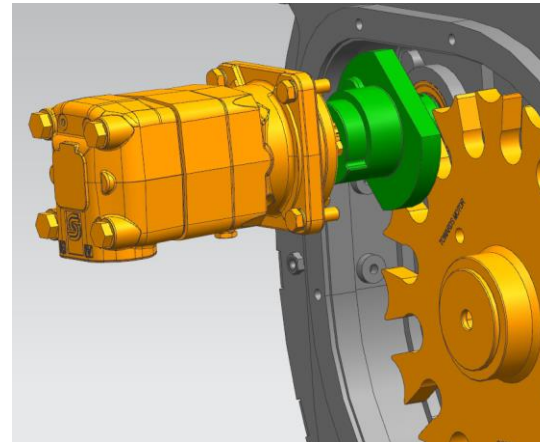
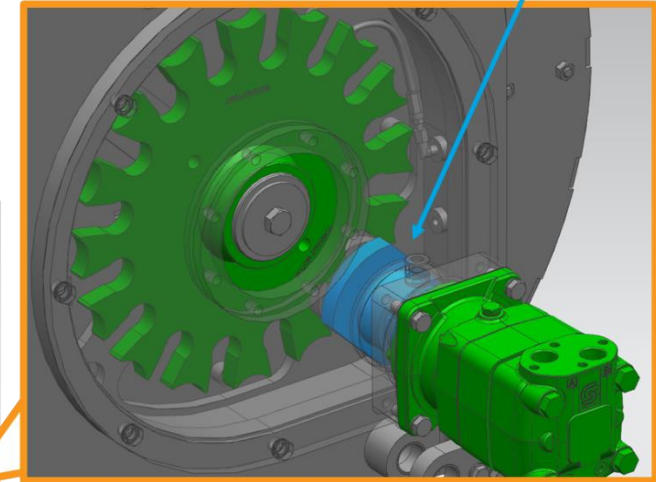
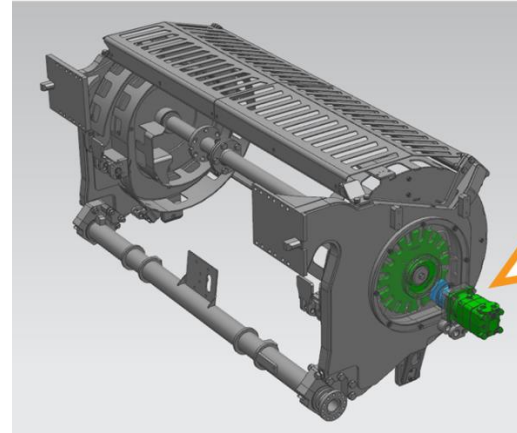
# Case: Sandvik AM pilot



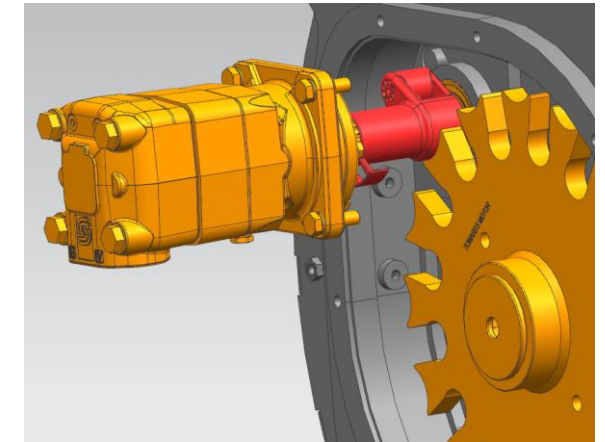


# Background

- Sandvik wanted to optimize Geneva drive rotator piece for AM
- Goals
  - Feasible solution
  - Interchangeable
  - Lower costs
  - Lightweight
- First optimization project was done by Sandvik as a thesis work
- Sandvik decided to pilot Etteplan's AM design services with same part



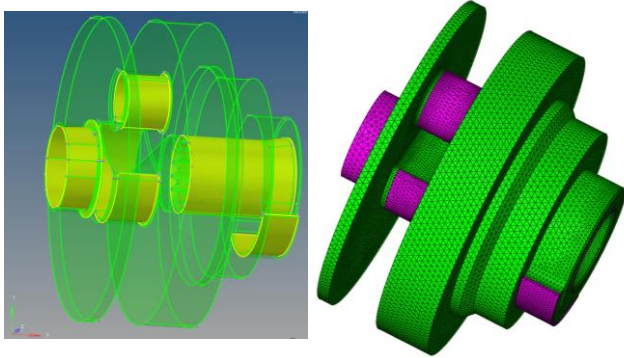
Original design



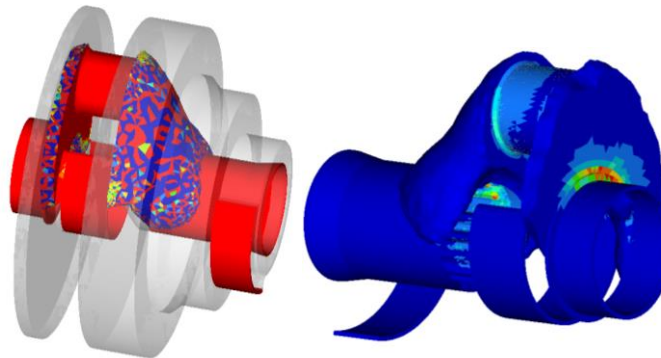
Thesis worker's AM redesign

# AM workflow – Sandvik Geneva drive rotator piece

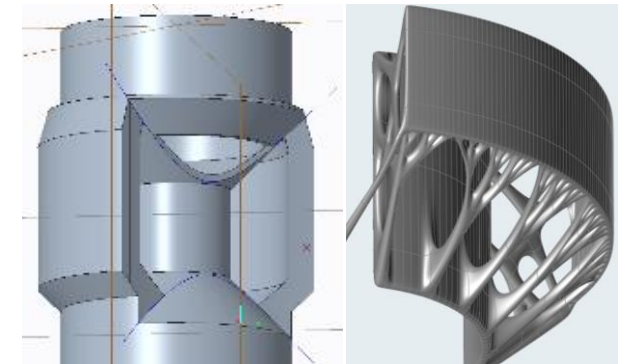
Design requirements



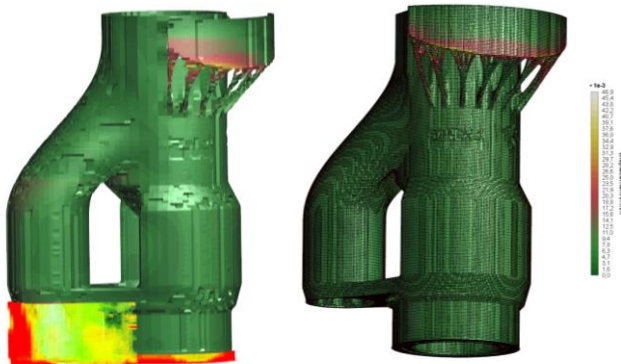
Topology Optimization



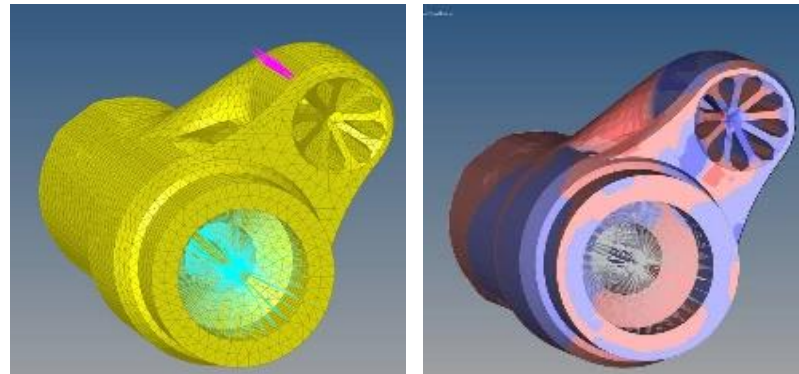
AM design



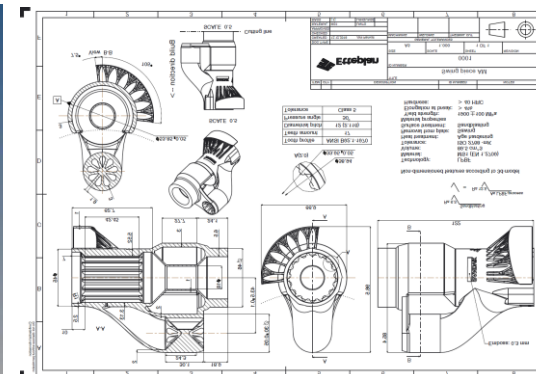
Print Simulation



Final FEA



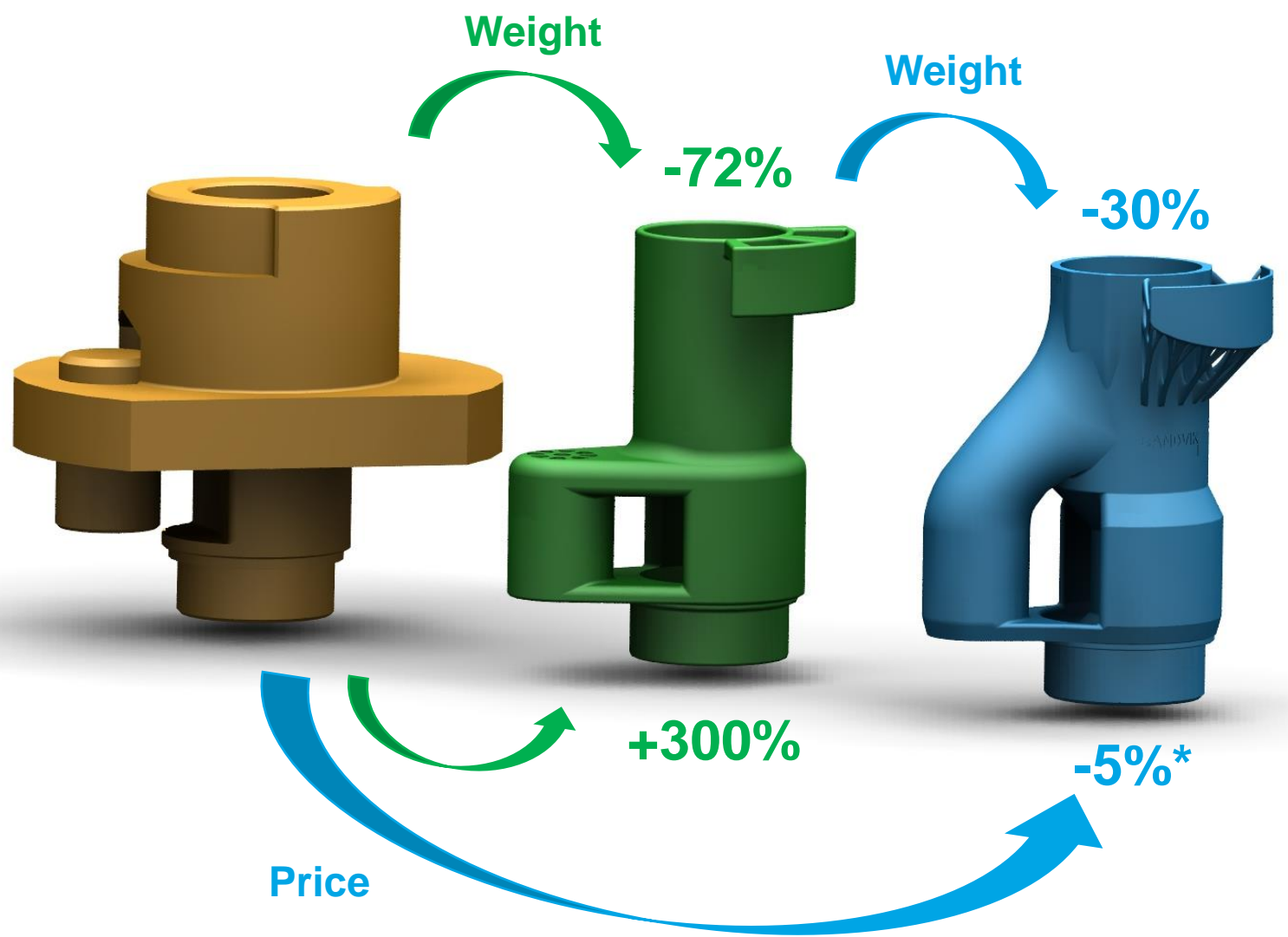
Documentation



Manufacturing





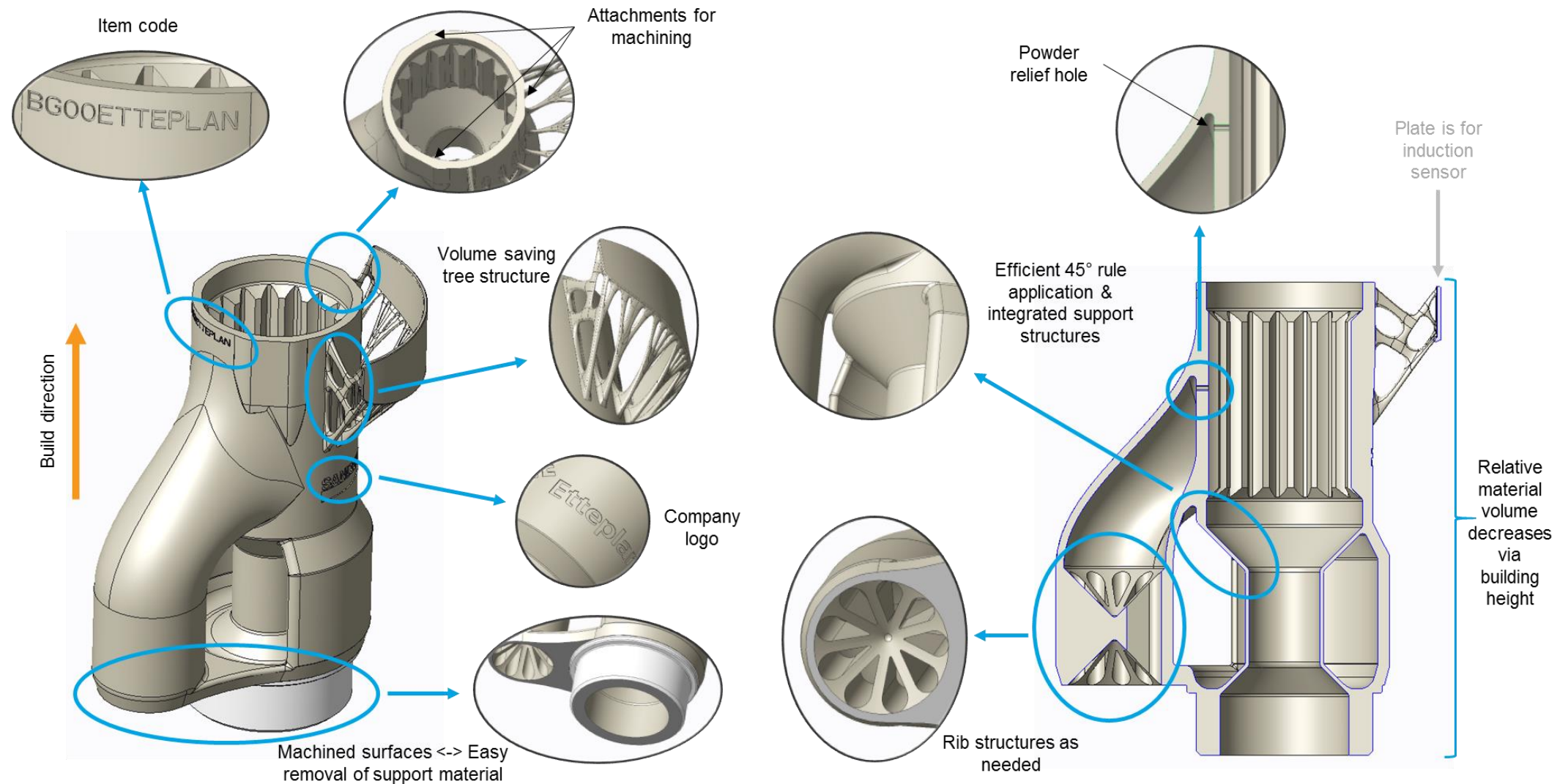


Original component by Sandvik  
Design for AM as a thesis work by Sandvik  
Designed for AM by Etteplan

\*Price based on batch size of 50 pieces



# AM design features



# Contact details

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<https://www.etteplan.com/services/engineering/additive-manufacturing>