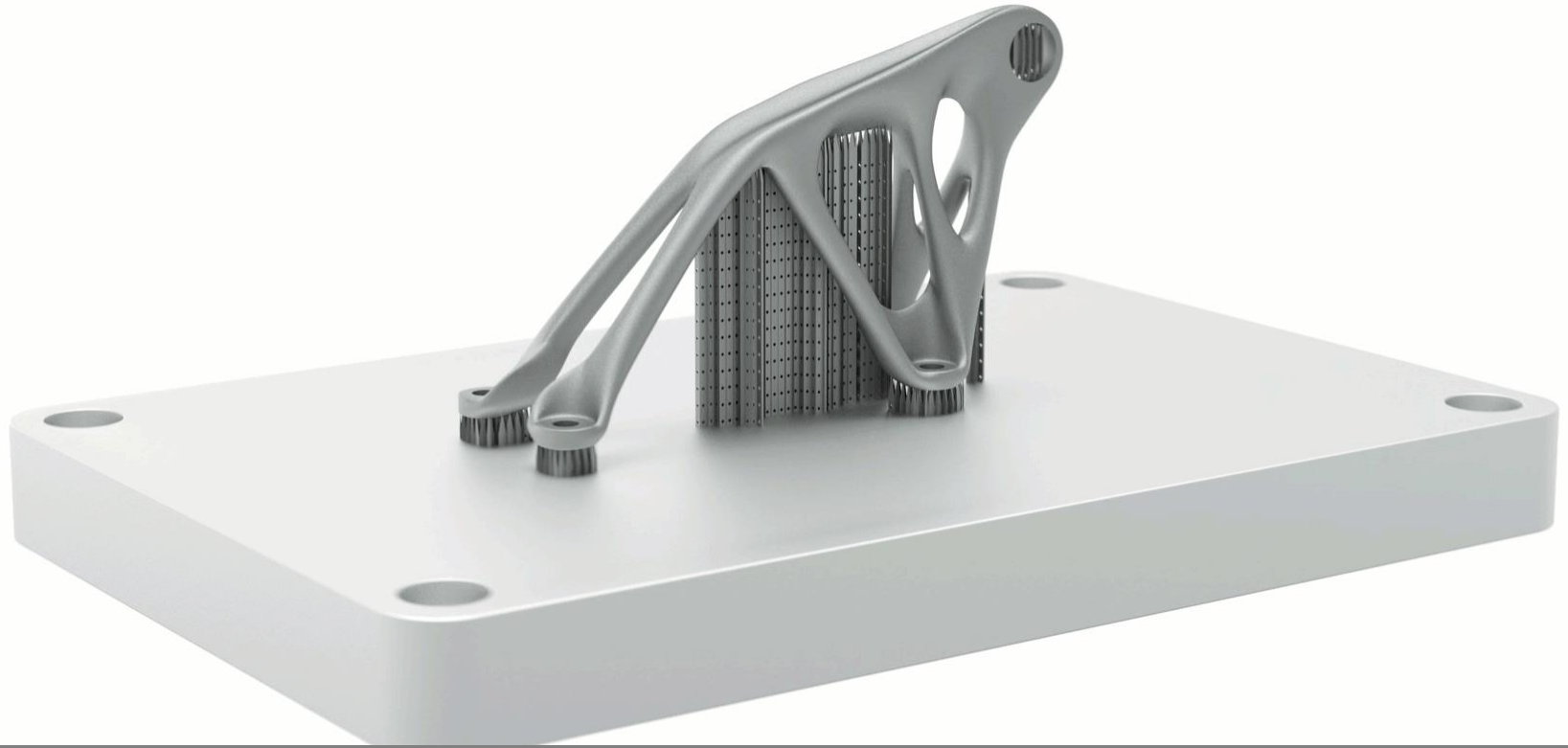


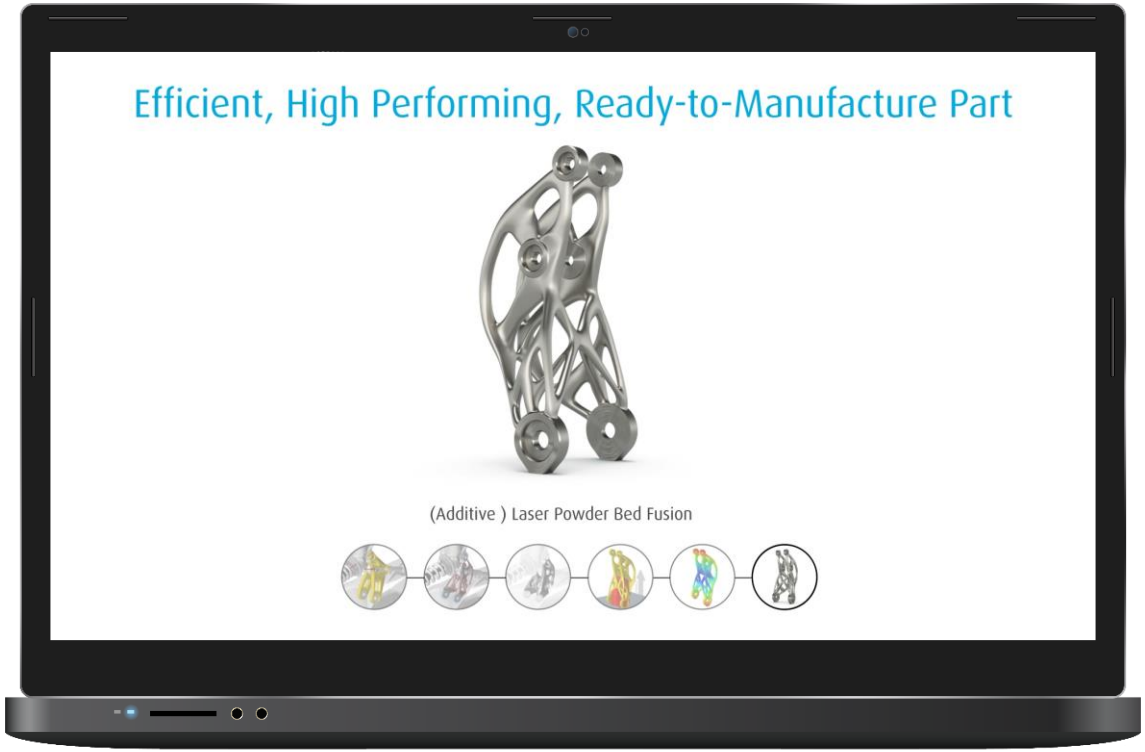
Simulation–Driven Design for Additive Manufacturing

Rob Hoglund · Applications Engineer
Altair Engineering · January 14, 2020

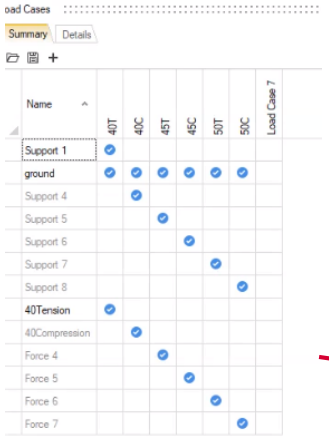
Altair

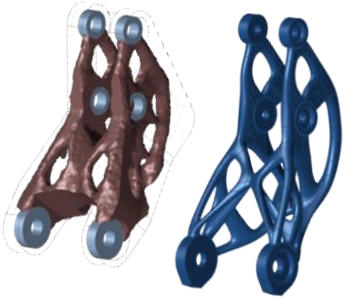
From Capability to Capacity

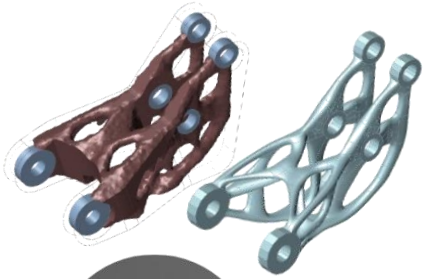
Moving additive manufacturing from an advanced capability for prototyping to a production capacity

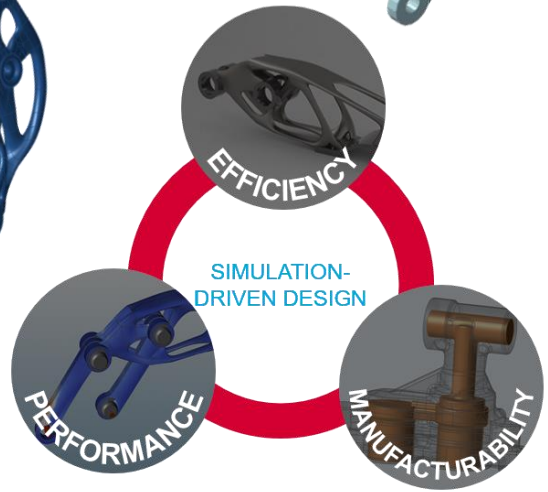


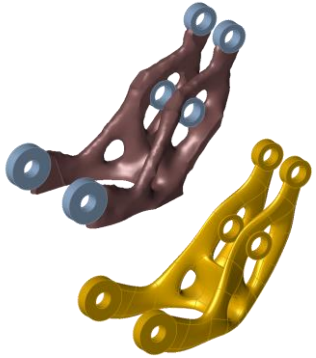
Multiple Scenarios







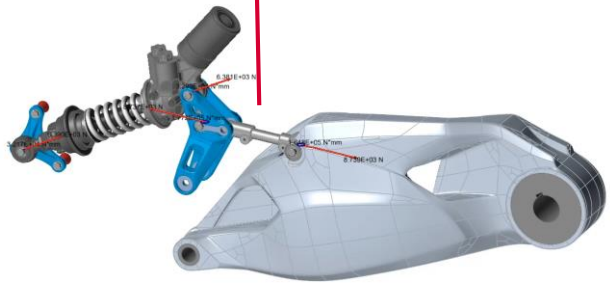




LPBF / SLM

Binder Jet

FDM



Performance

Hybrid casting

Metal FDM

LPBF

Traditional casting

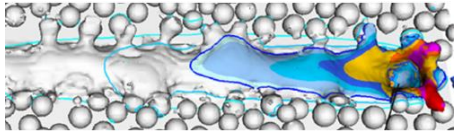
Traditional milling

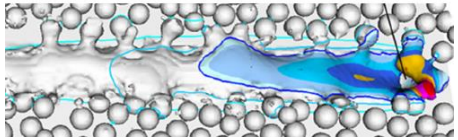
Binder jetting

Selective Laser Melting Process

Modeling scale for laser powder bed fusion

Powder scale

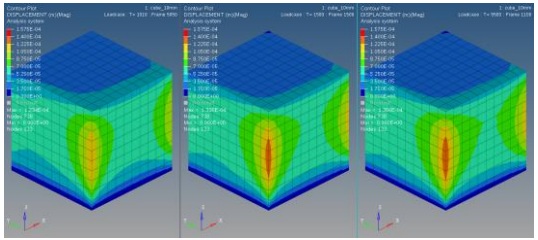




Thermal hydraulics model

- Densification
- Energy supplied by the laser
- Dimensions of melting pool

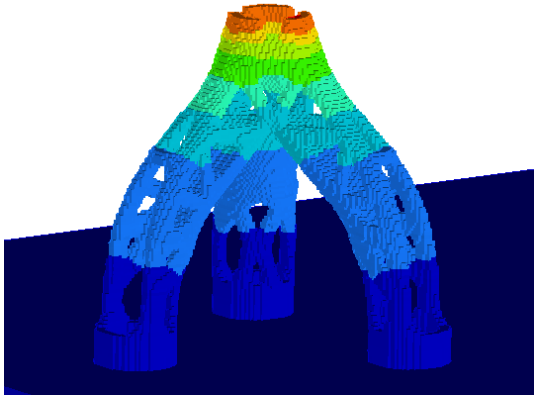
Mesoscopic scale



Thermo-mechanical model

- Study with different laser scan strategy
- Sequential activation of elements
- Prediction of residual stresses and plastic strains

Macroscopic scale



Thermo-mechanical model

- Study with complex parts
- Sequential activation of elements
- Prediction of residual stresses and plastic strains

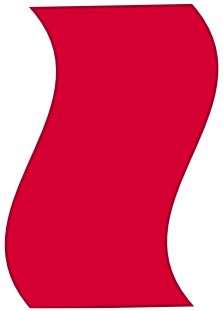
Macro-scale modeling : layer per layer approach

Layer activation

Cooling

Next layer activation

…



End Cooling

Springback

Convection + radiation

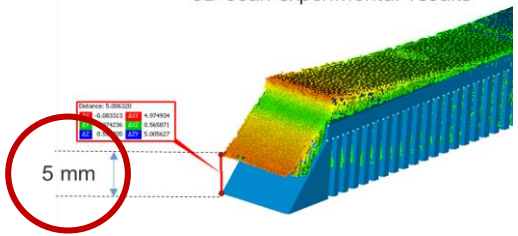
Conduction

Validation : cantilever beam test case

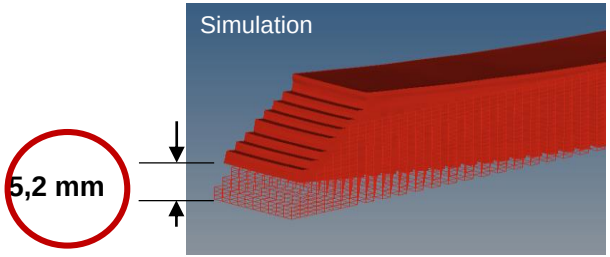
INNOVATION PLASTURGIE COMPOSITES

Experimental measurement

3D scan experimental results



Numerical result



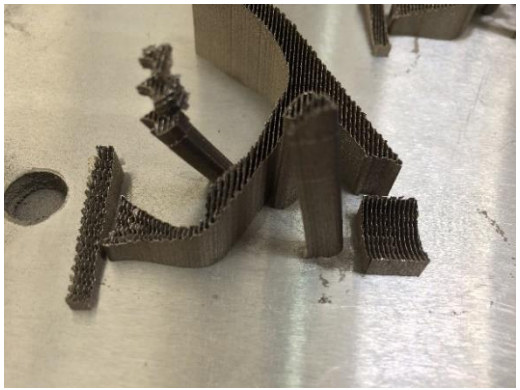
- Comparison with real part

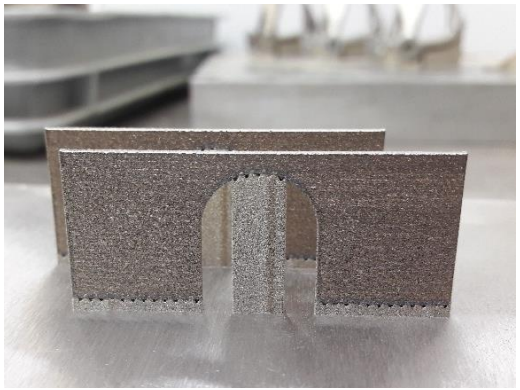
Von Mises

Displacements

Support Structure

It’s paramount to find a compromise between support removal time (can be hours) and support efficiency (must not degrade part quality)

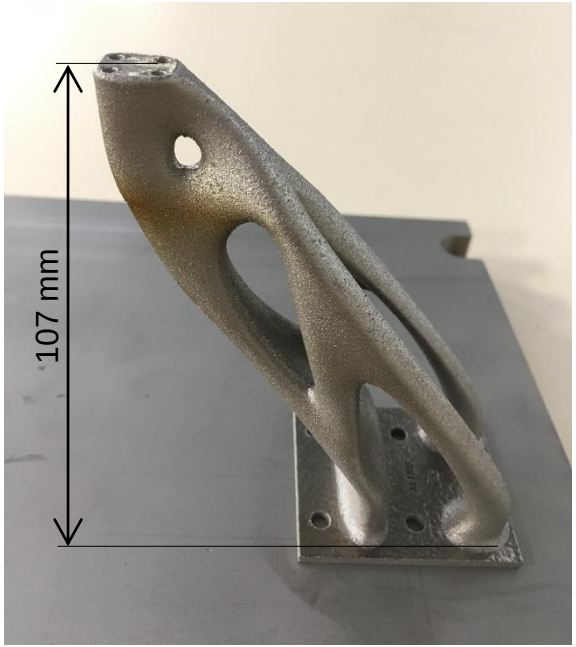




Images courtesy of: INNOVATION PLASTURGIE COMPOSITES

Importance of Part Positioning

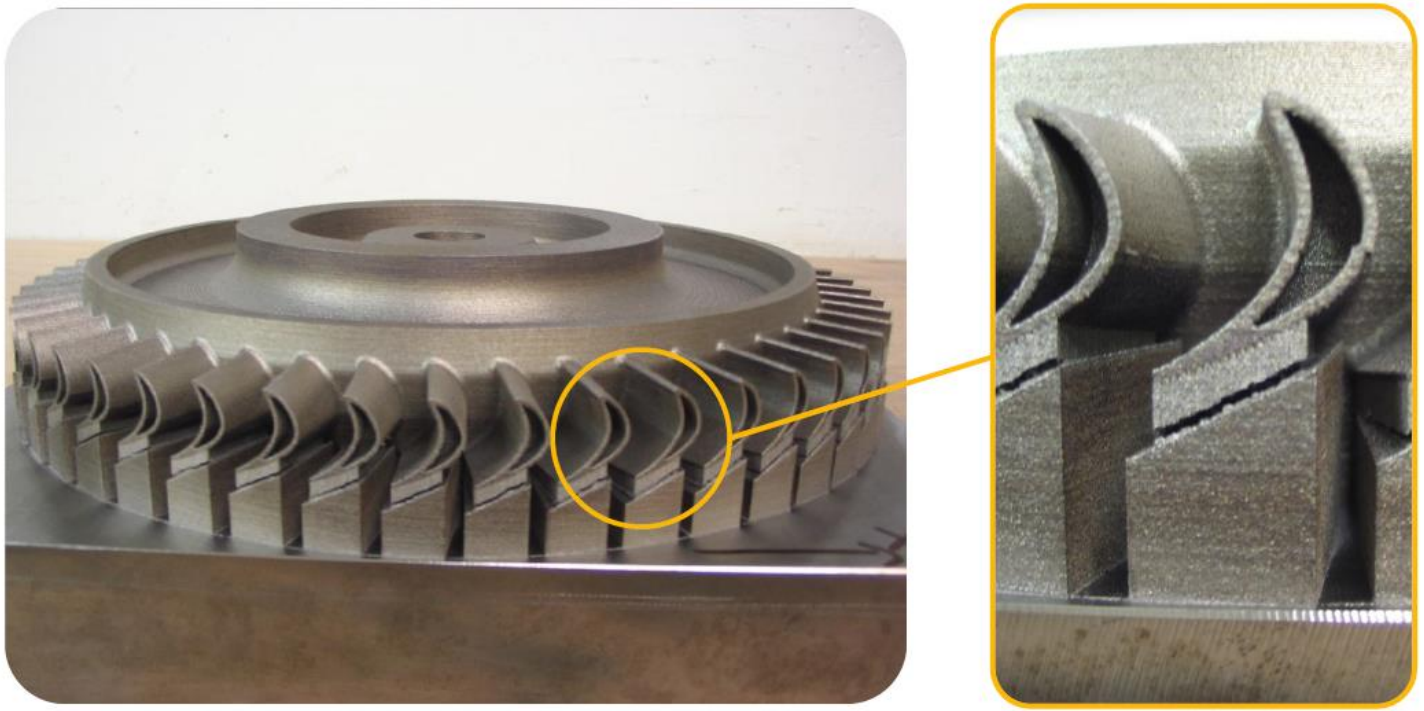
Printing time : 6h (per part)



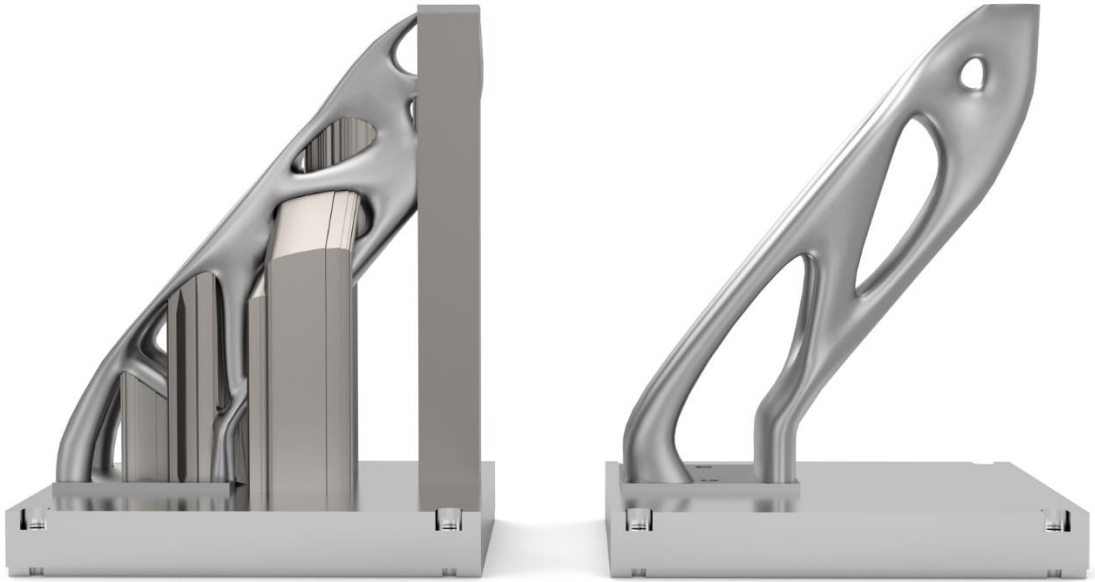
Printing time : 11h

Images courtesy of: IPC INNOVATION PLASTURGIE COMPOSITES

Typical Manufacturing Failures



Place Supports Only Where Needed



Original Design

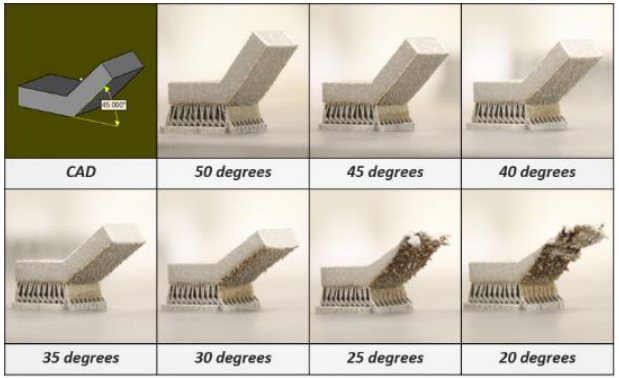
Optimal Design

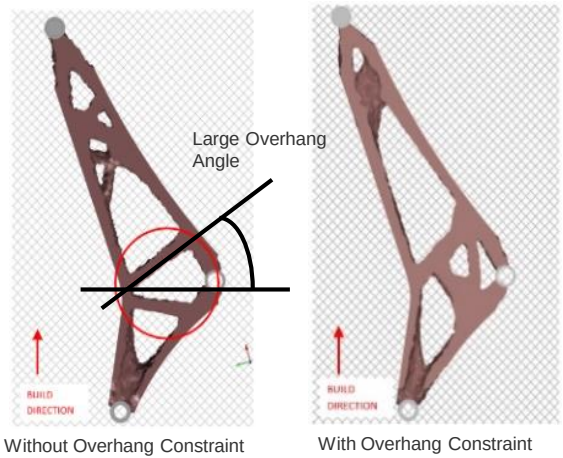
Images courtesy of: IPC INNOVATION PLASTURGIE COMPOSITES

SLM/LPBF – Design Considerations

- Defects:
  - Poor surface quality
  - Weak layer adhesion or bulging
  - Curling

- Solution: Use overhang angle design constraint while optimizing design

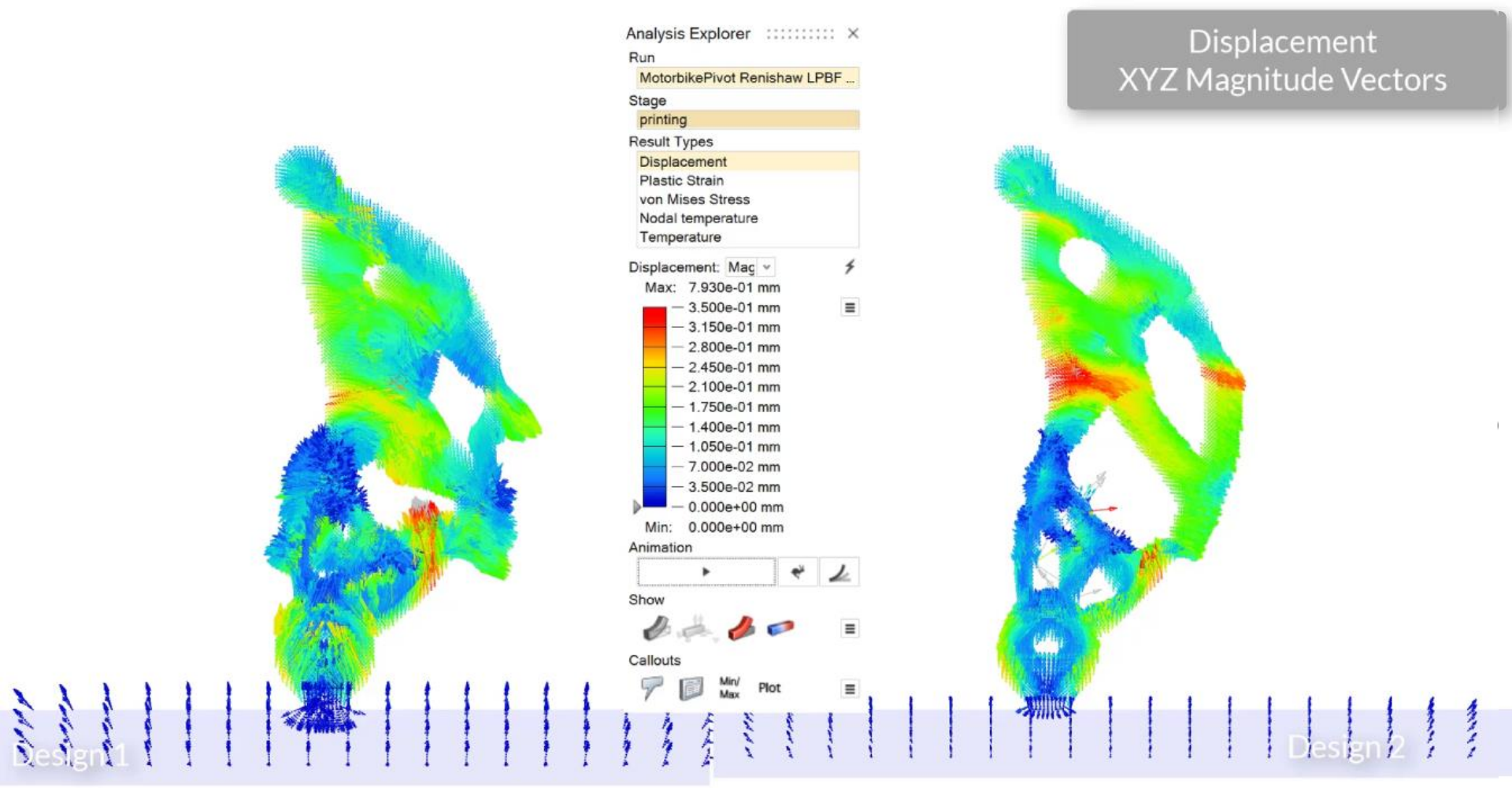




Without Overhang Constraint

With Overhang Constraint

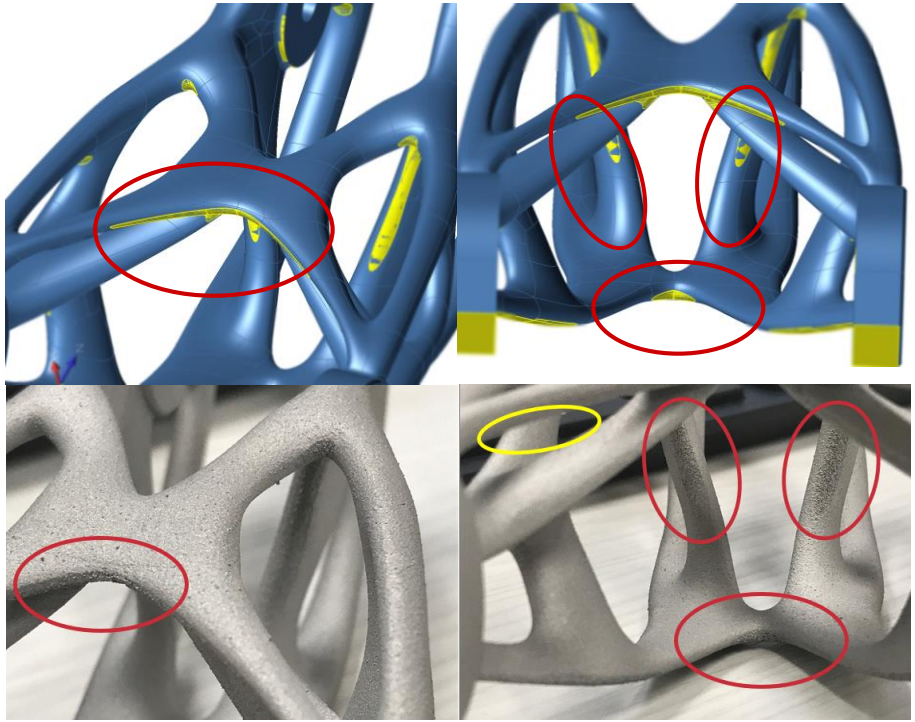
Design 1 vs. Design 2

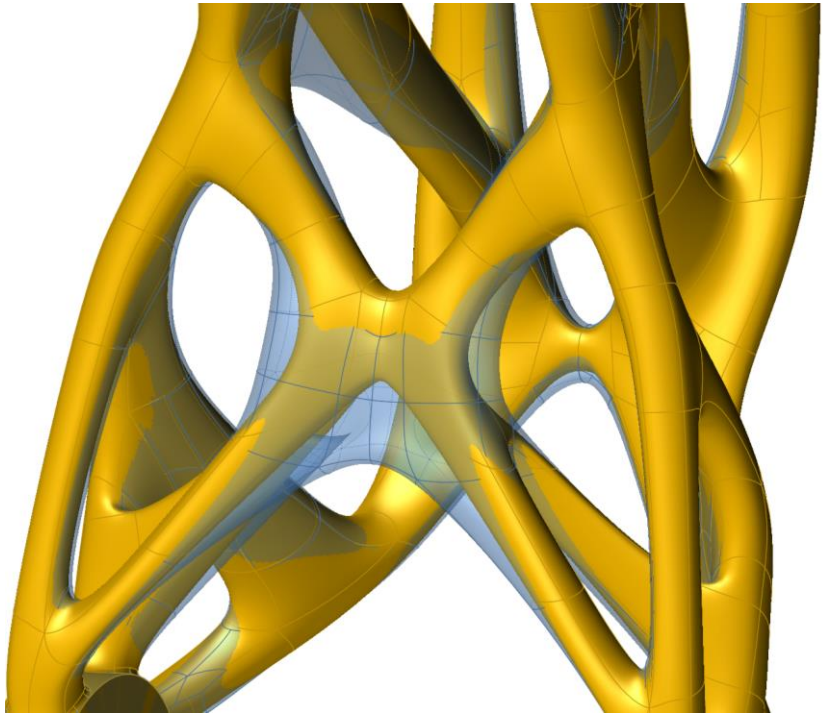

Displacement
XYZ Magnitude Vectors
Analysis Explorer
Run
MotorbikePivot Renishaw LPBF ...
Stage
printing
Result Types
Displacement
Plastic Strain
von Mises Stress
Nodal temperature
Temperature
Displacement: Mag
Max: 7.930e-01 mm
3.500e-01 mm
3.150e-01 mm
2.800e-01 mm
2.450e-01 mm
2.100e-01 mm
1.750e-01 mm
1.400e-01 mm
1.050e-01 mm
7.000e-02 mm
3.500e-02 mm
0.000e+00 mm
Min: 0.000e+00 mm
Animation
Show
Callouts
Min/ Max
Plot
Design 1
Design 2
1 / 162
1 / 162

Prevent Failures with DfAM

Defect: ***poor surface quality*** for overhangs beyond the threshold

Solution: Adding smaller radius, reducing overhang in design will quickly fix any surface quality drop-off

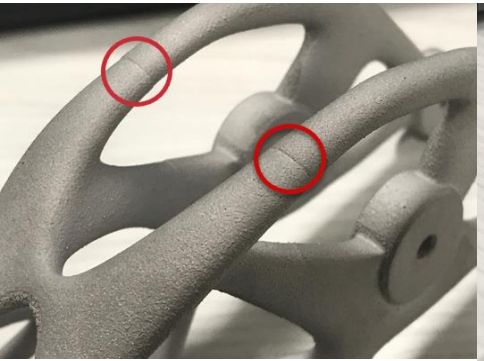


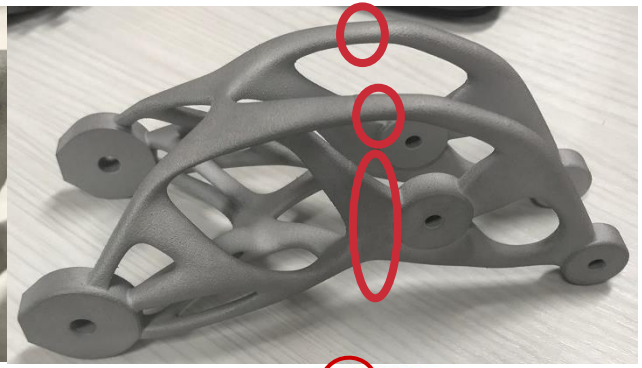


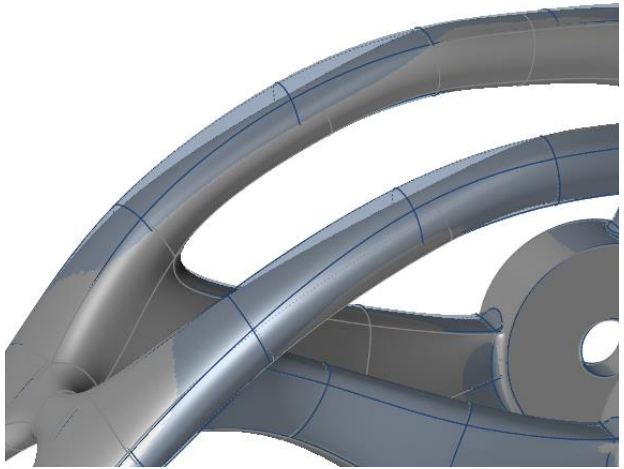
Prevent Failures using Print Simulation

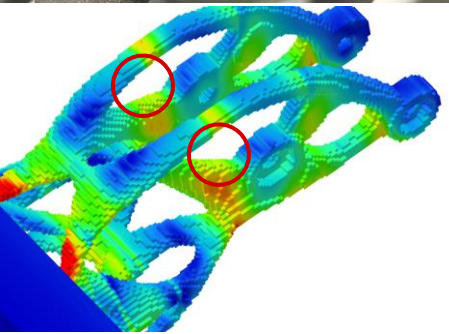
'***Snap lines***': The presence of a relatively large and smaller members create thermally induced tensile residual stresses that weren't present in the preceding layers

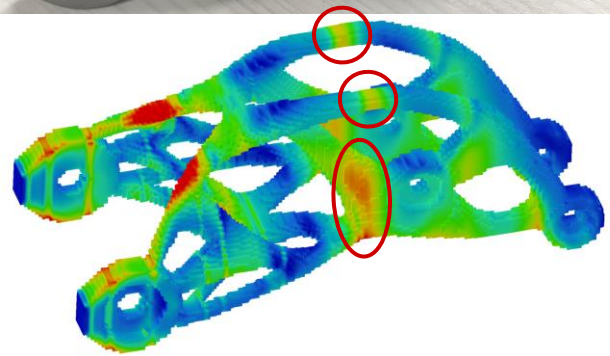
Solution: Modify geometry





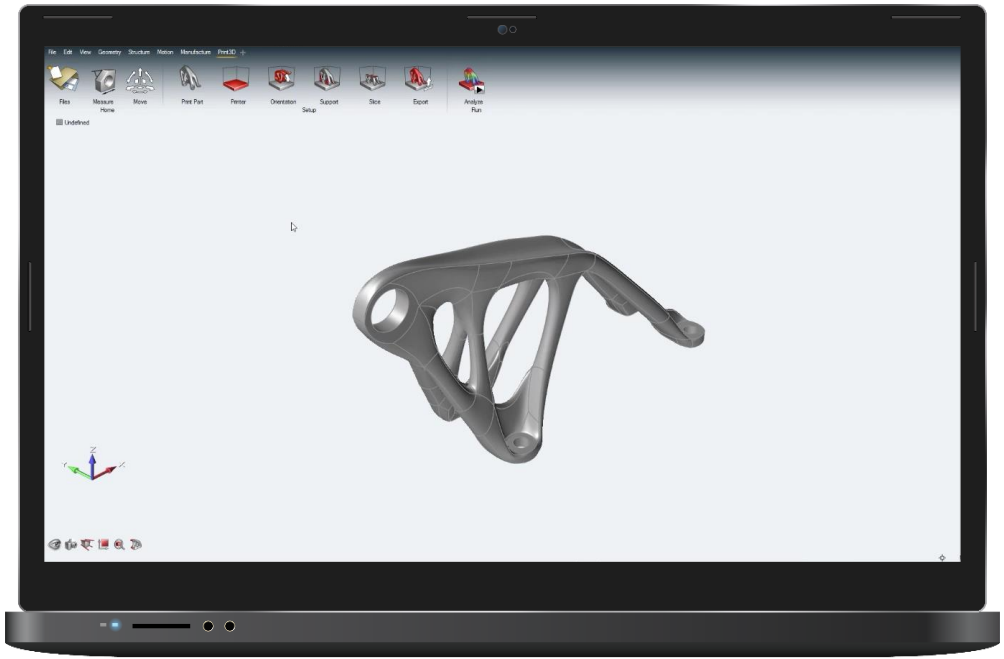






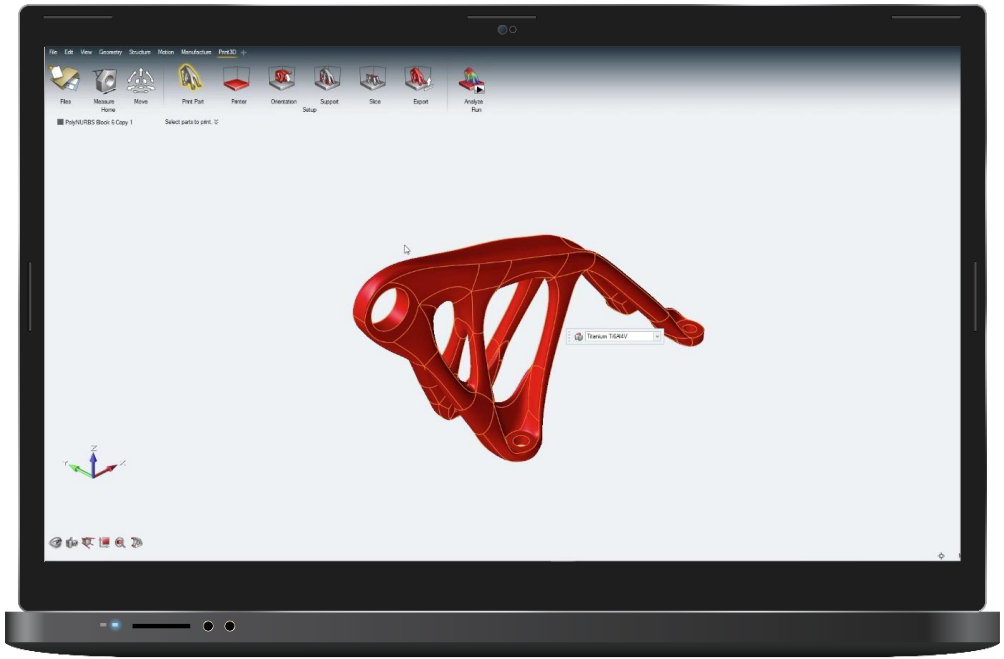
Process-driven Workflow - Select and Prepare Part

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



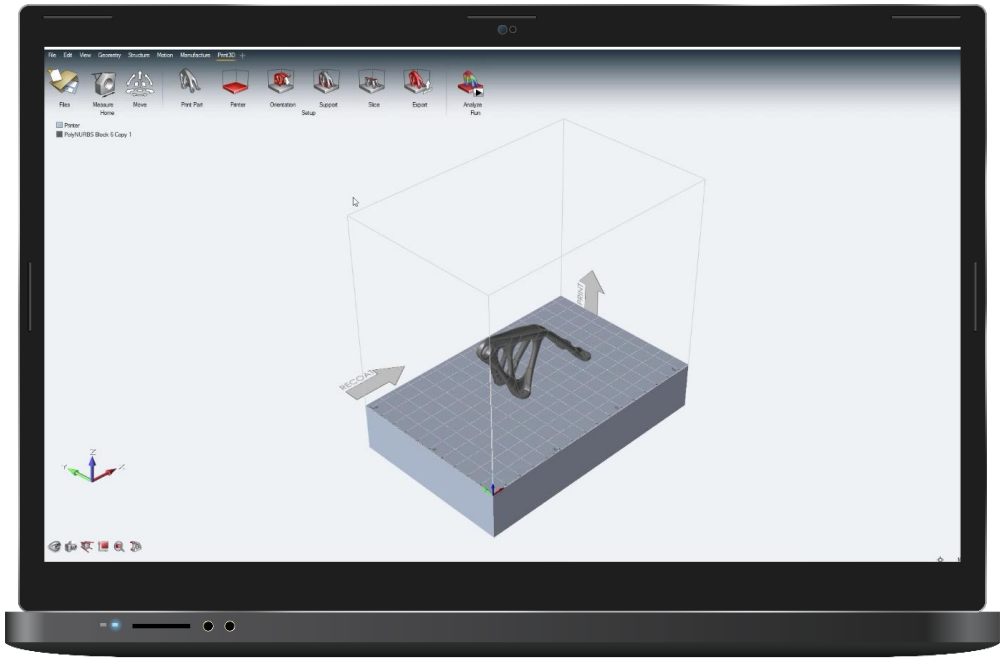
Process-driven Workflow – Configure Printer

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



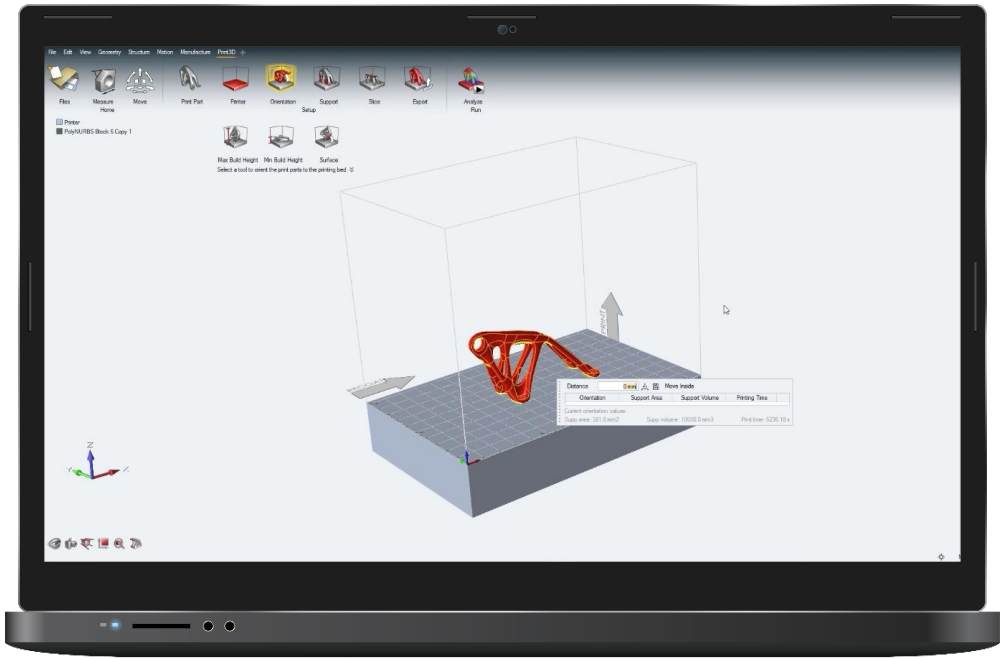
Process-driven Workflow – Orient Part(s)

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



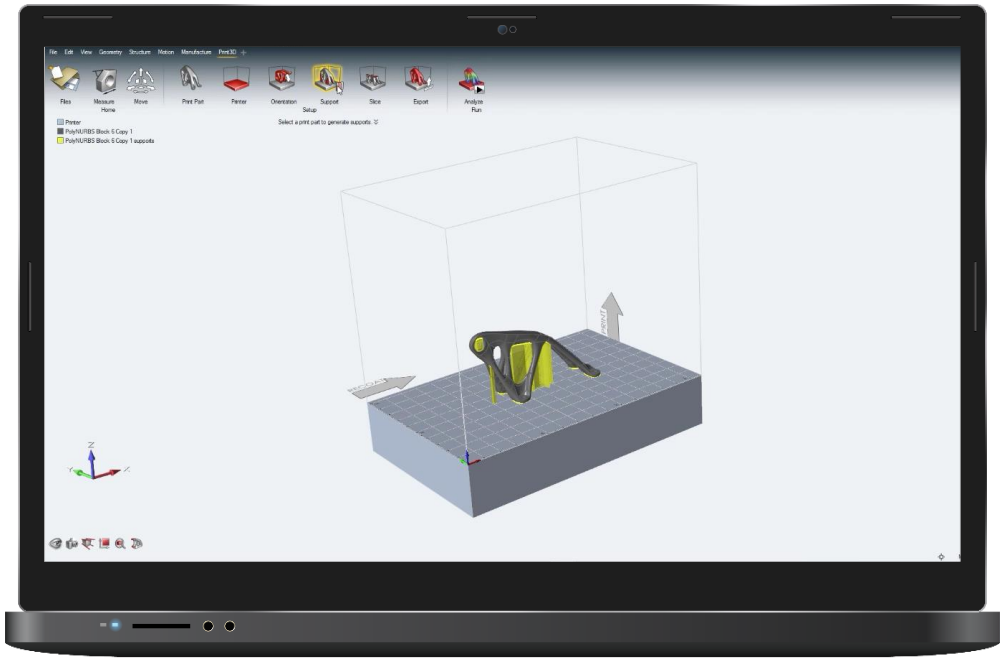
Process-driven Workflow – Generate Print Supports

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



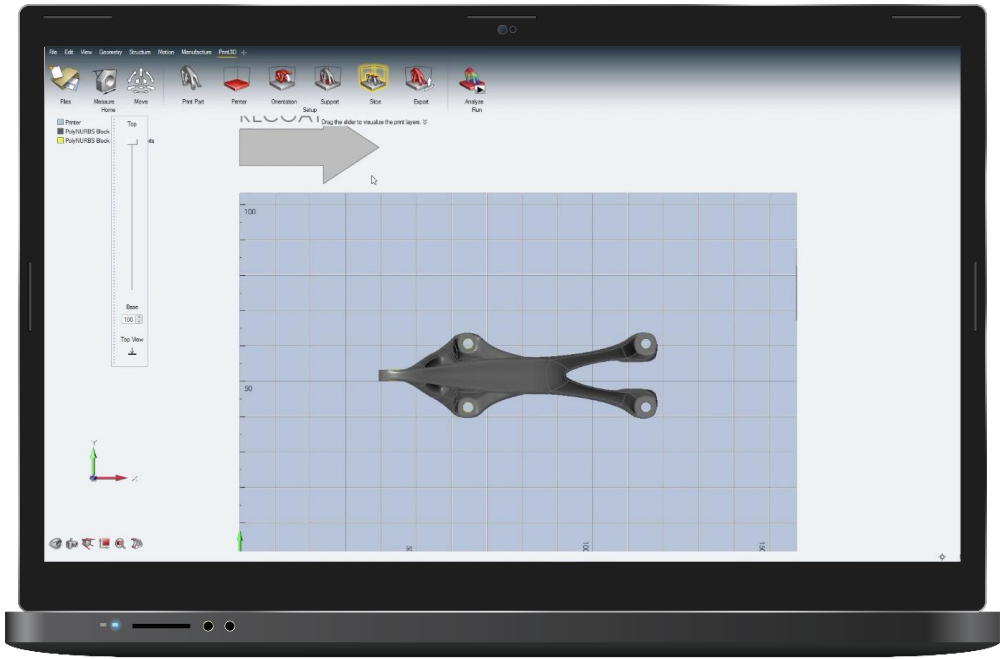
Process-driven Workflow – Preview Slices

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



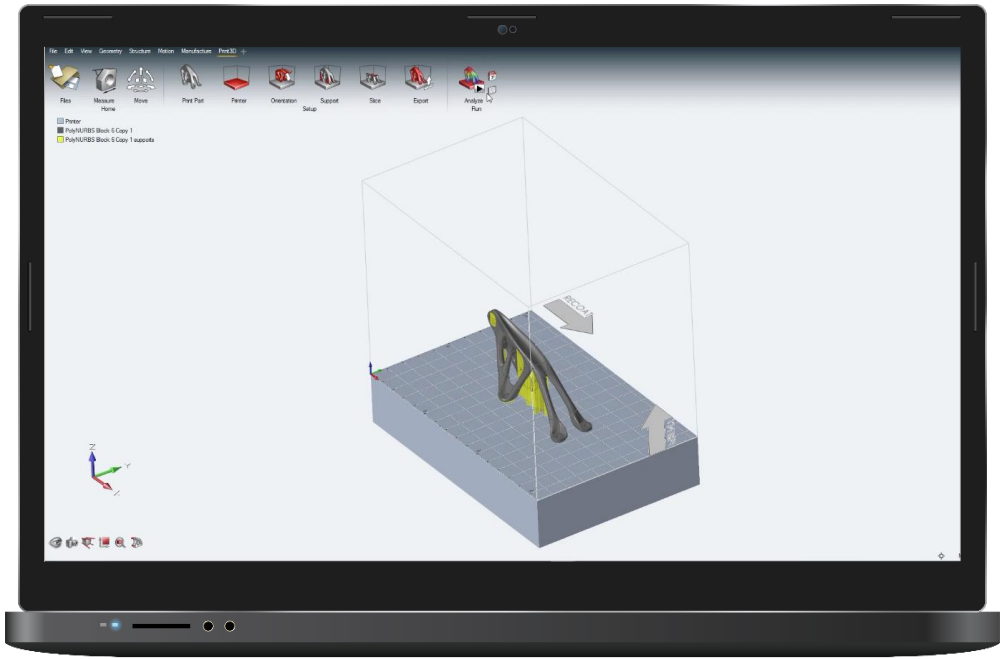
Process-driven Workflow – Export Part and Supports

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis



Process-driven Workflow – Run Thermo-mechanical Analysis

- Select and prepare part
- Configure printer
- Orient part(s)
- Generate print supports
- Preview slices
- Export part and supports
- Run thermo-mechanical analysis

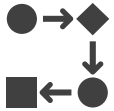


Key Features

Part and Support Design

Generate support structures as part of the design process, where you design the part

Easy-to-learn Environment



The intuitive, process-driven user experience enables users to gain deep manufacturing insights quickly

Thermo-mech. Printing Analysis

Run the embedded thermo-mechanical solver to accurately simulate the entire printing process

Defects Identification

Easily detect defects - large deformation, excessive heating, delamination - to aid design modifications

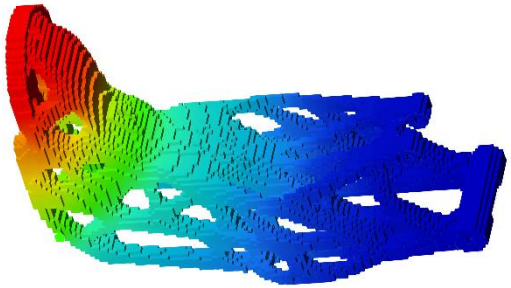
Materials and Printers

Select from the growing library of additive manufacturing materials and standard printers included

Ready for Printing

Assess the part to validate its geometry, then export a printing file containing part and supports

M&H CNC-TECHNIK GmbH



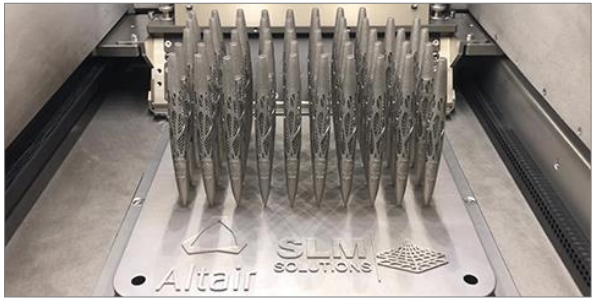
3D-printed prototype of a suspension arm for the **Protean 360+** electric drive module

“The introduction of Inspire Print3D adds new possibilities and greatly enhances the capabilities for us to evaluate our designs and customer parts prior to manufacturing in order to react accordingly to any arising problems upfront. Being able to make unique parts correctly the first time is a competitive advantage [for us].”

Dr. Jukka Pakkanen, additive manufacturing specialist M&H CNC-TECHNIK GmbH

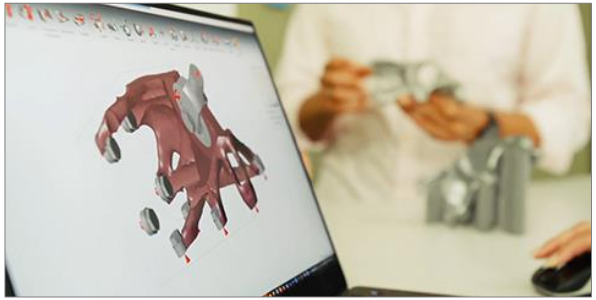
The Inspire Print3D Competitive Advantage

Reduce Manufacturing Cost



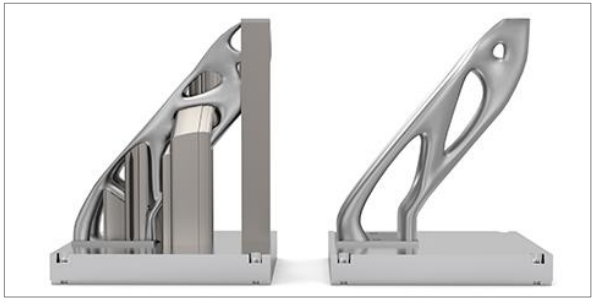
Minimize part supports and correct defects such as part deformation and overheating before printing

Increase Process Efficiency

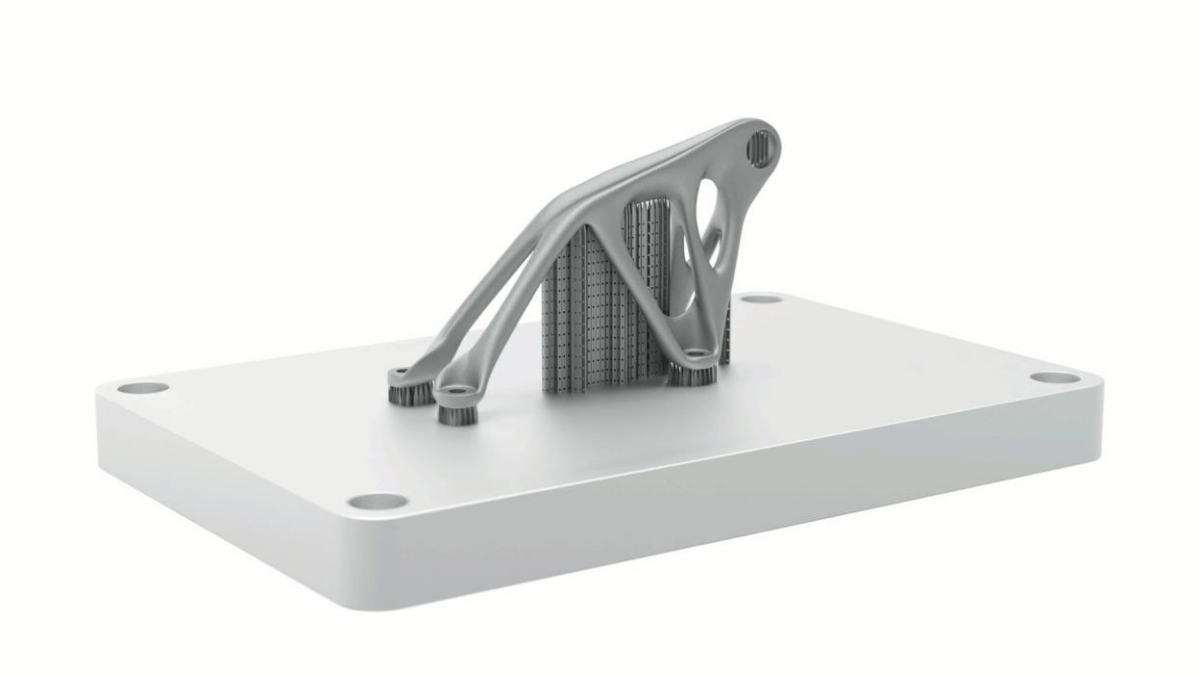


A single, easy, fast, and accurate environment from generative design to manufacturability assessment

Design Optimal Parts



Create best performing designs for the SLM process by applying advanced thermo-mechanical simulation



THANK YOU!

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rhoglund@altair.com
(248)-930-5143

Learn more at **altair.com/print3d**