SIMULATION DRIVEN DESIGN

Unleash the ALM potential

Ing. Alessandro Amorese • Aerospace Application Engineer • 20 March 2019

Altair

ALTAIR AT A GLANCE

Founded **1985**

Headquartered in Troy, MI US

69offices

in 24 countries

ALTR

Nasdaq

50+

ISV partners under our unique, patented licensing model

2000+

Engineers, scientists and creative thinkers

5000+

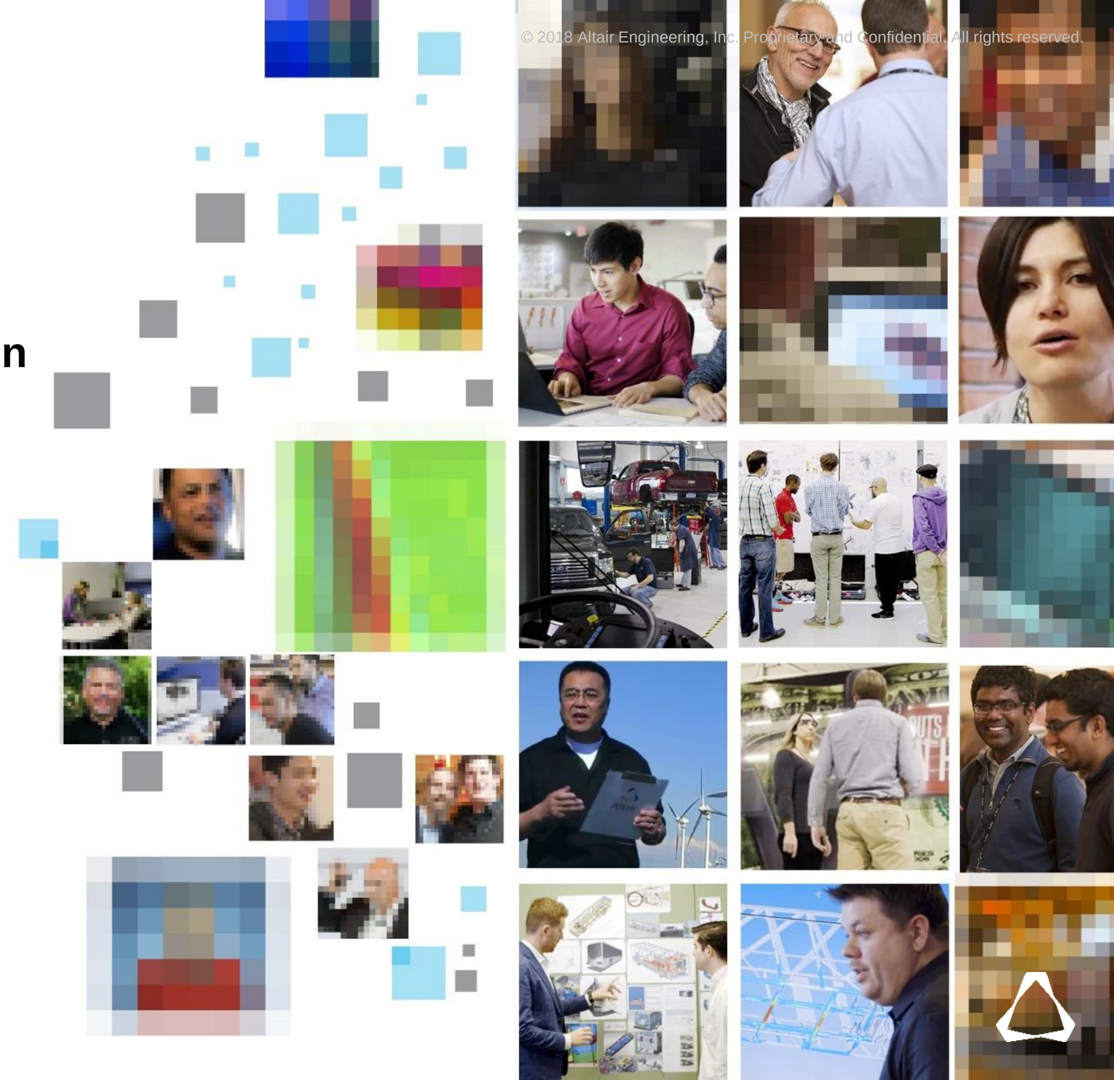
Customer installations globally

60,000+

Users

CULTURE & VALUES

Altair transforms design and decision making by applying simulation, machine learning and optimization throughout product lifecycles.

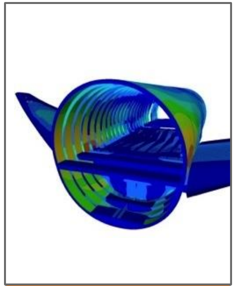


5,000 CUSTOMER INSTALLATIONS WORLDWIDE

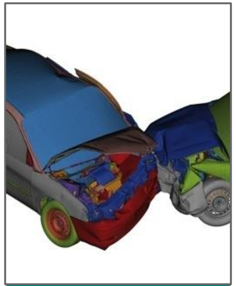
Automotive	Aerospace	Heavy Equipment	Government
Ford, Toyota, FCA Fiat Chrysler Automobiles, GM, Renault, Honda, BMW	BAE Systems, Boeing, Airbus Group, Bombardier, Embraer, Honeywell	Alstom, John Deere, JFE, Caterpillar, Oshkosh	AIST, NASA, U.S. Air Force, Los Alamos National Laboratory Est. 1943, National Research Council Canada

Life/Earth Sciences	Electronics/Consumer Goods	Energy	Architecture
BASF The Chemical Company, Bayer, Dow, Alcoa, Merck	acer, intel, IBM, LG, Bosch	ABB, Chevron, Valero, ConocoPhillips, ExxonMobil	AECOM, LIXIL, SOM, Weidlinger, WorleyParsons resources & energy

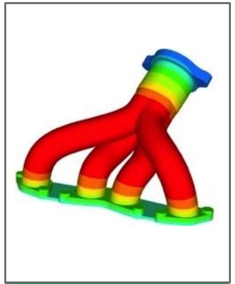
ALTAIR SOLVER TECHNOLOGY



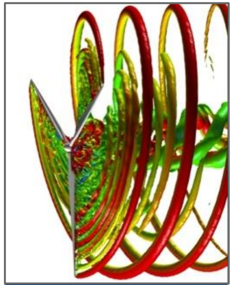
Structural Analysis



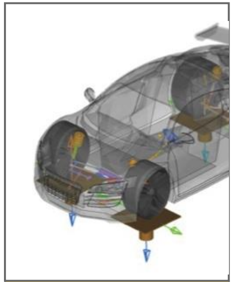
Crash, Safety, Impact & Blast



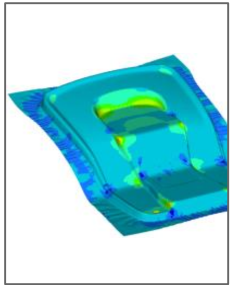
Thermal Analysis



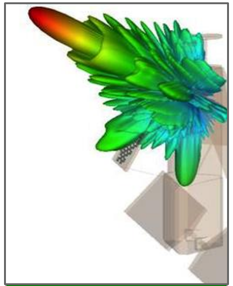
Fluid Dynamics



Systems Simulation



Manufacturing Simulation



Electro-Magnetics

Multiphysics Simulation and Optimization

DESIGN FOR ALM

MAIN ELEMENTS OF ALM & 3D PRINTING TECHNOLOGIES

Design for Additive Manufacturing

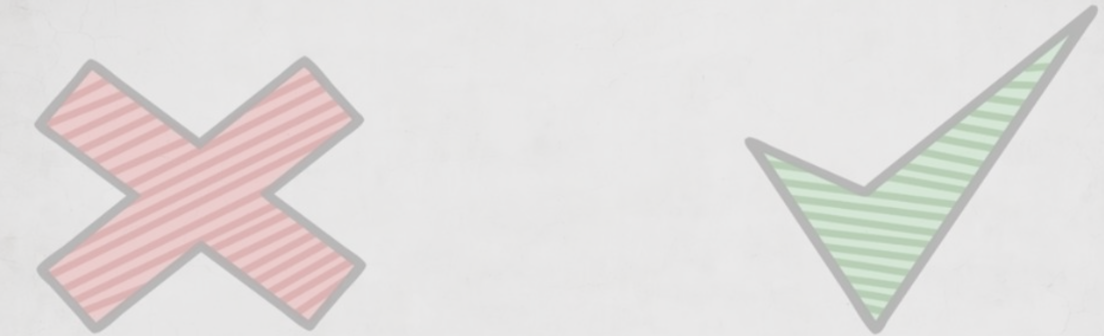
Metallic Powders

Plastic filaments

ALM Machines

3D Printing Machines

HOW TO GET BENEFITS



Slow Process

Very **expensive** Powders

Massive parts have huge **distorsion**

Simple Replacement

Huge **ratio** between material and void

Complexity is for free

Parts **consolidation**

Lattice is allowed

Mass reduction has a big impact on the whole result

To get most benefit we need to think complex shapes

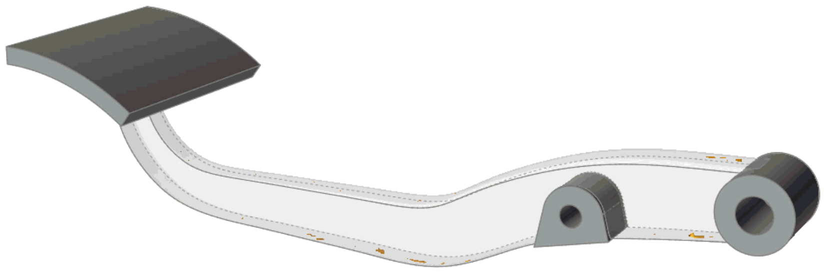
THE ADDITIVE MANUFACTURING DESIGN CHALLENGE

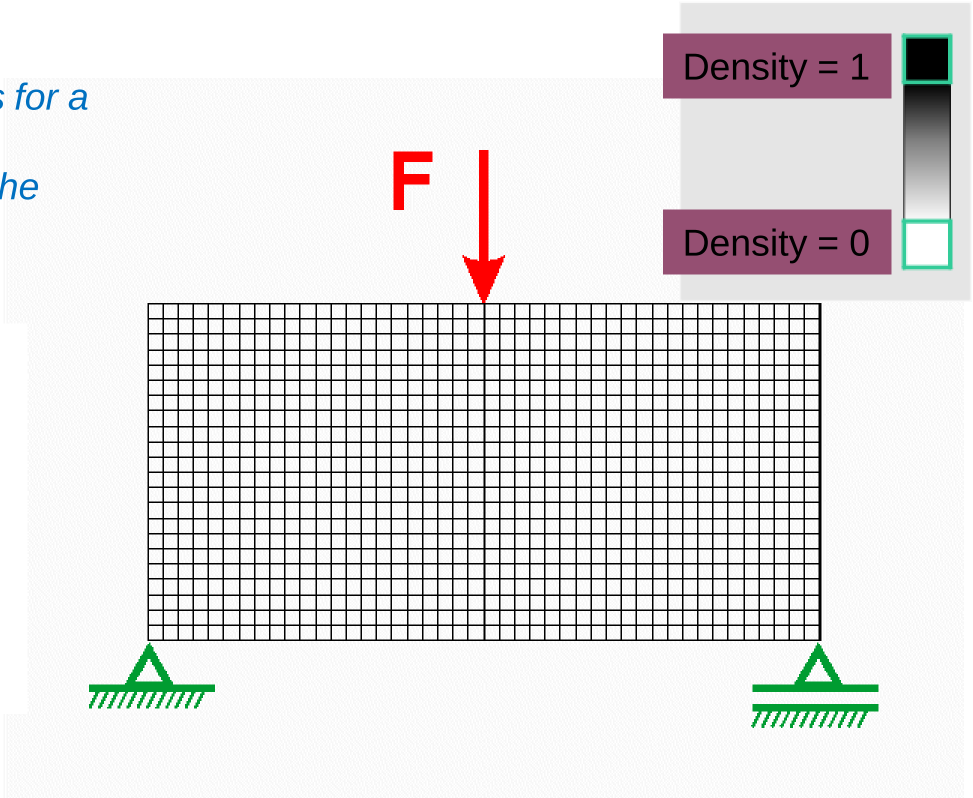
How can a designer come up with the best possible shape?

picture by courtesy of Laser Zentrum Nord

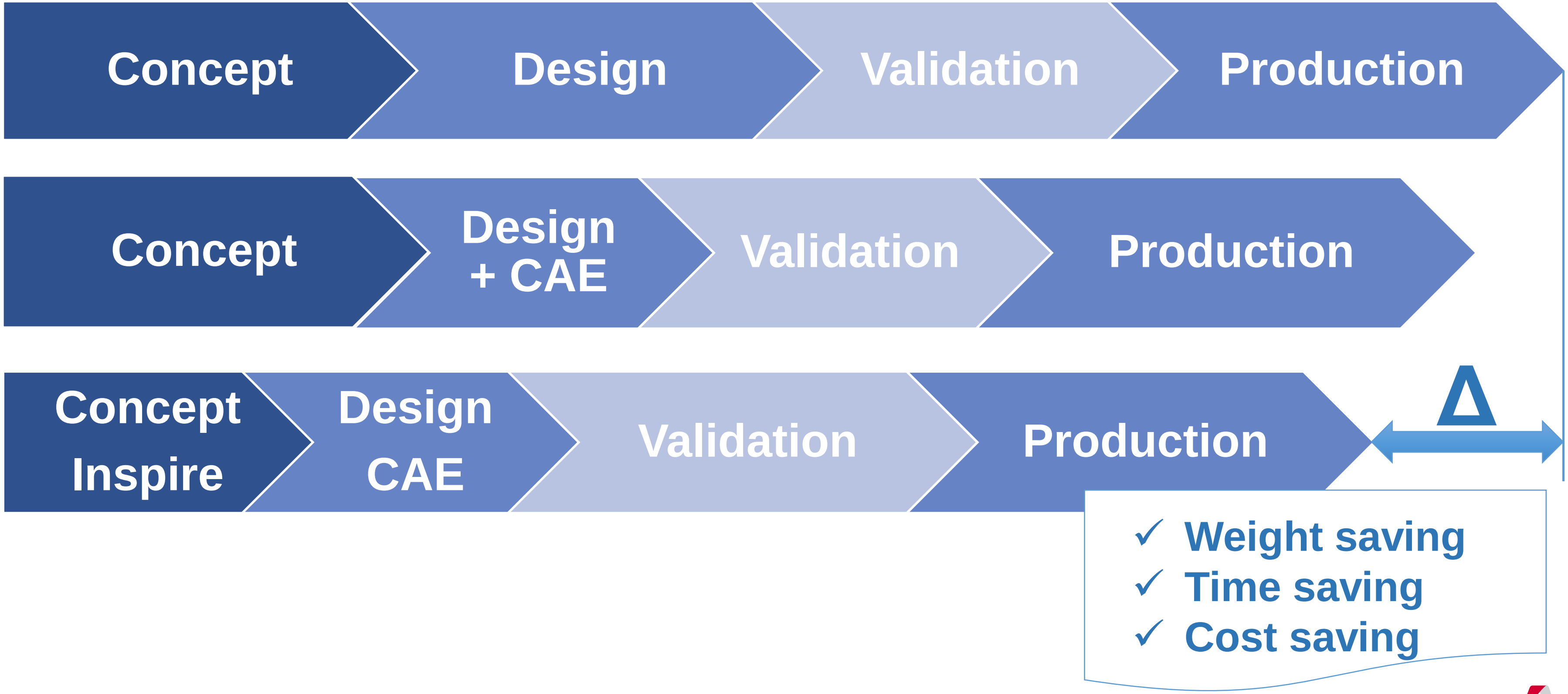
TOPOLOGY OPTIMIZATION

Given the package space and loading conditions for a design problem, optimization quickly generates the ideal shape.



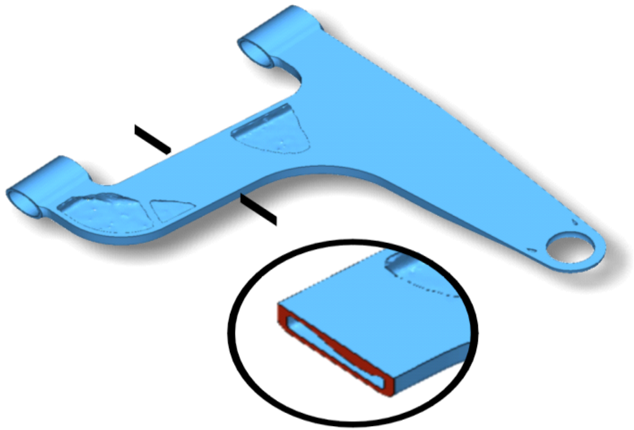


NEVER TOO SOON TO OPTIMIZE



MAKE THE DESIGN MANUFACTURABLE

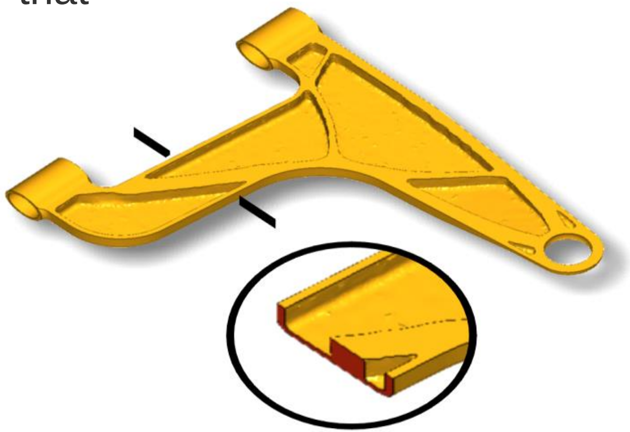
Introducing Manufacturing constraints the final desing has more doable shape for that manufacturing technology,
But with the



Suitable for Casting - ALM

Same Performaces

- ***Stress***
- ***Stiffness***
- ***Mass…***



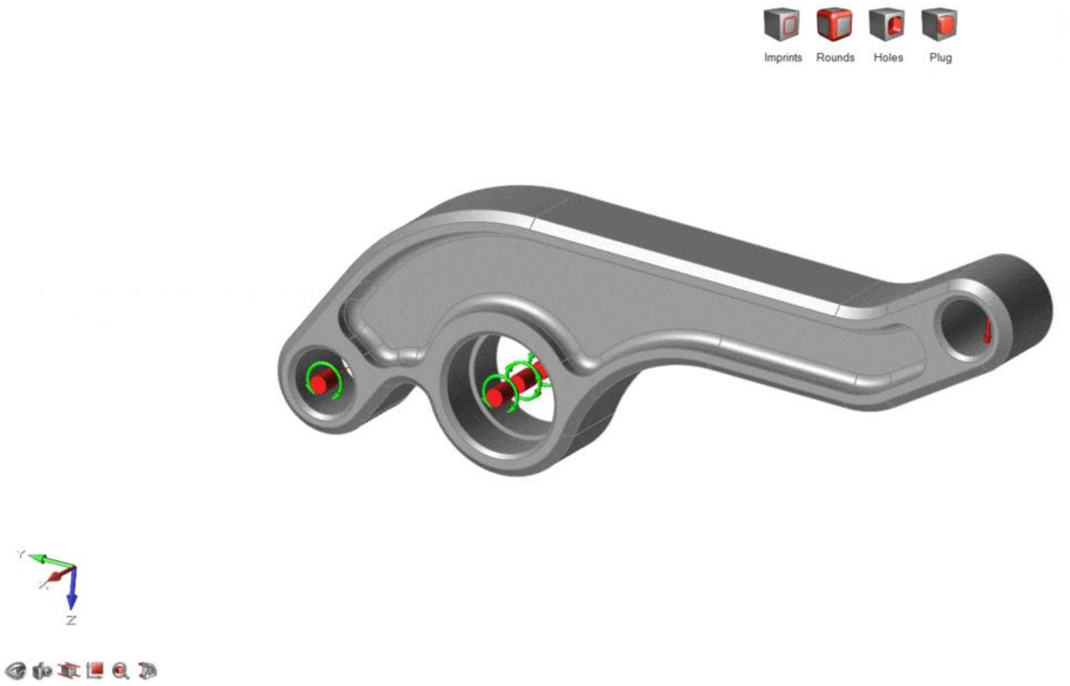
Suitable for Milling, Stamping

SHAPE THE INSPIRATION

SHAPE THE INSPIRATION – MODEL CHECK

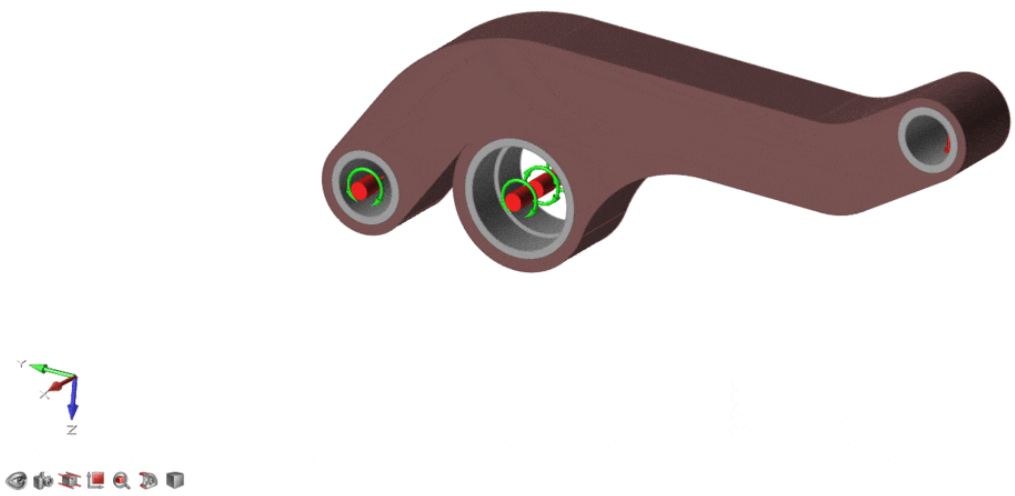
SHAPE THE INSPIRATION – MODEL PREPARATION

Model Preparation



SHAPE THE INSPIRATION – CONCEPTUAL OPTIMIZATION

Model Preparation → **Conceptual Optimization**



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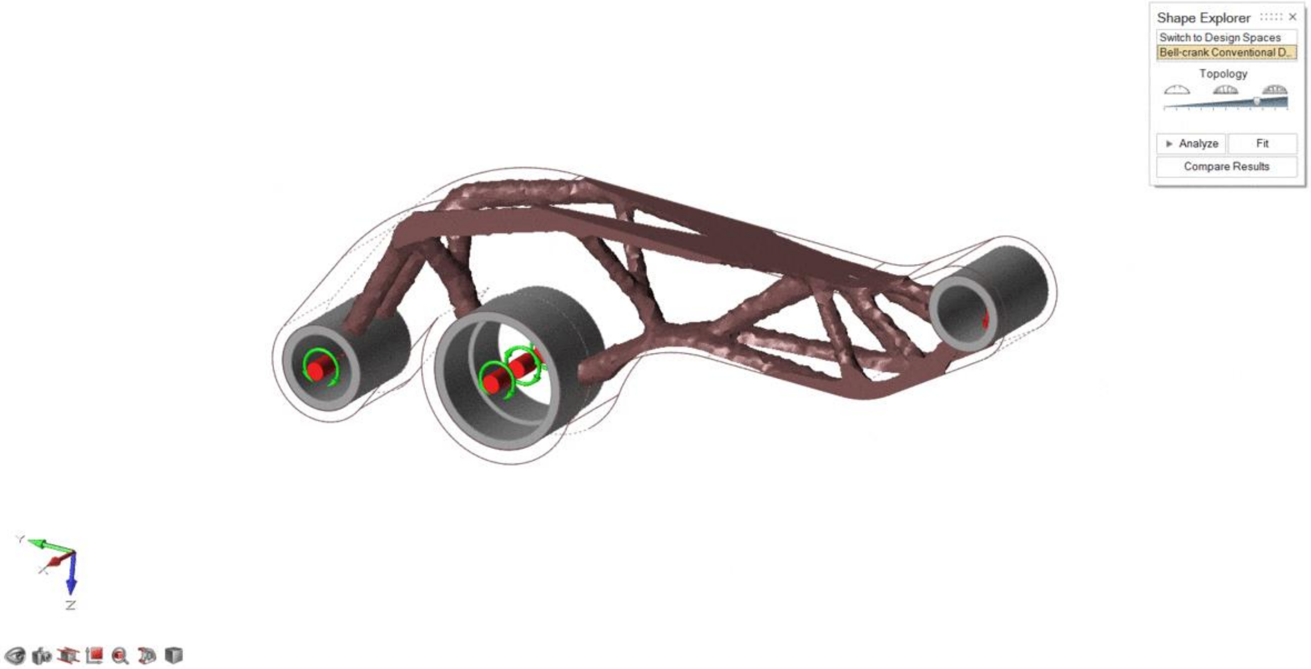
SHAPE THE INSPIRATION – CONCEPT VALIDATION

Model Preparation → Conceptual Optimization → Concept Validation



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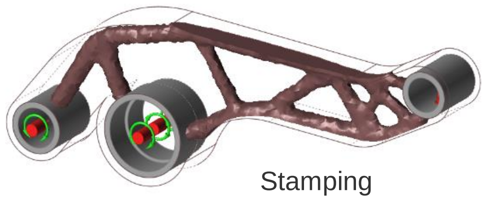
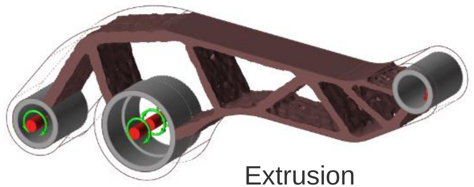
SHAPE THE INSPIRATION – CONCEPT MODIFICATION

Model Preparation → Conceptual Optimization → Concept Validation → Concept Modification



Stamping



Extrusion

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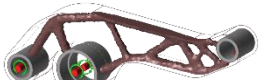
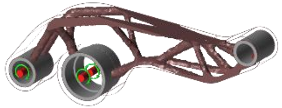
SHAPE THE INSPIRATION – COMPARE RESULTS

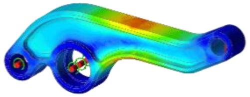
Model Preparation → **Conceptual Optimization** → **Concept Validation** → **Concept Modification** → **Compare Results**

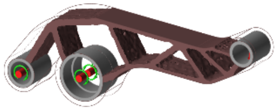


Stamping

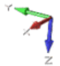


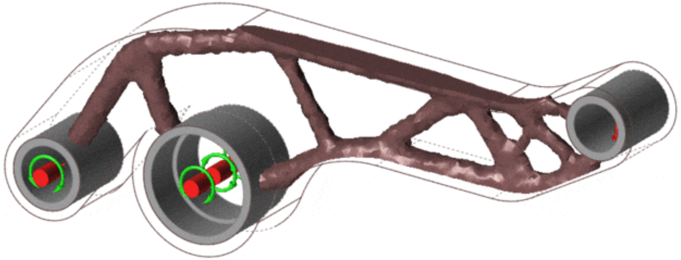
ALM





Extrusion





Compare Results

Run	Mass Total	Mass Part 1	Compliance
Bell-crank Conventional Design1 Min Mass SF 2 (5)	0.0634963 kg	0.0315688 kg	1.499388
Bell-crank Conventional Design Min Mass SF 2 (2)	0.0698871 kg	0.0379596 kg	1.748302
Bell-crank Conventional Design1 Min Mass SF 2 (6)	0.125394 kg	0.0934664 kg	9.090066

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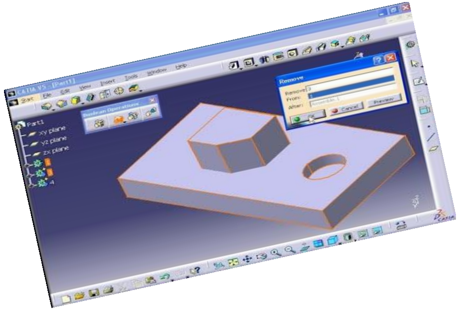
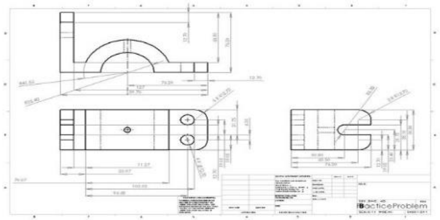
SHAPE THE INSPIRATION – CONCEPT INTERPRETATION

Model Preparation → Conceptual Optimization → Concept Validation → Concept Modification → Compare Results → **Concept Interpretation CAD**

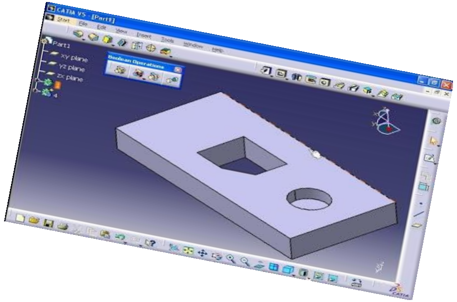
How to sketch such a complex part?

Too Complex



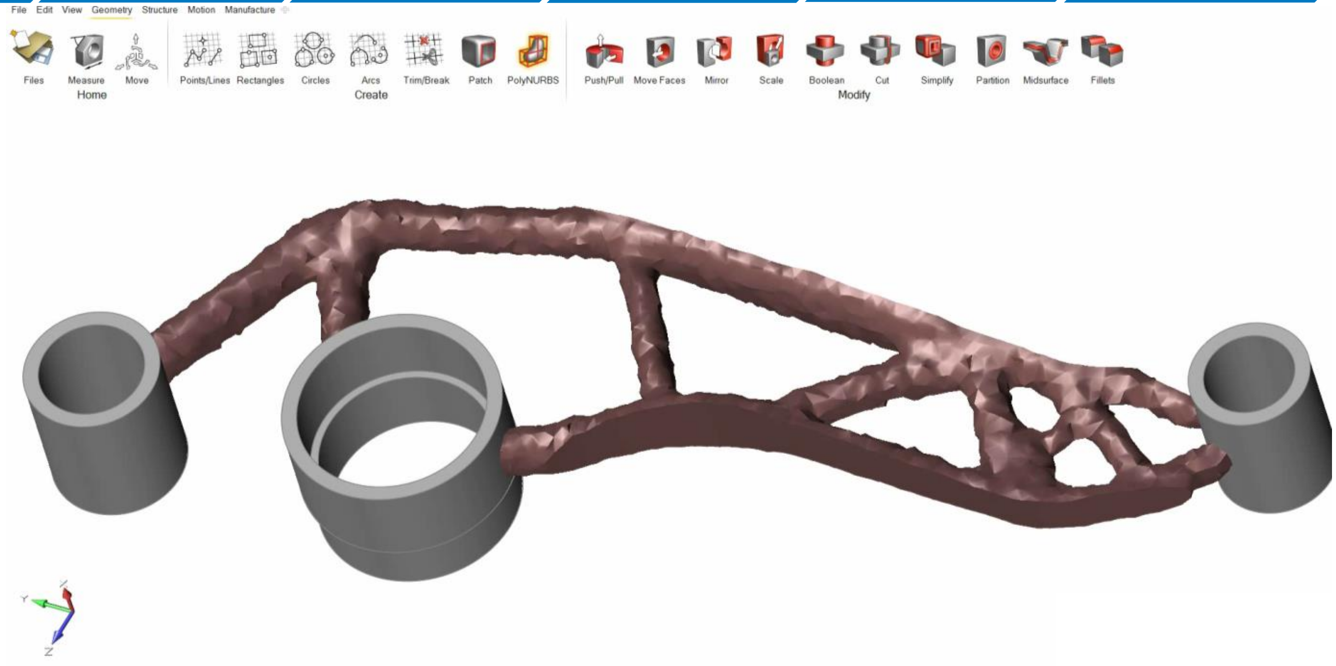


Organic shape



SHAPE THE INSPIRATION – FROM POLYNURBS TO CAD

Model Preparation → Conceptual Optimization → Concept Validation → Concept Modification → Compare Results → Concept Interpretation CAD



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SHAPE THE INSPIRATION – FINAL CAD

Model Preparation → **Conceptual Optimization** → **Concept Validation** → **Concept Modification** → **Compare Results** → **Concept Interpretation CAD** → **Final CAD**

EVOLVE

solidThinking / WHERE IDEAS TAKE SHAPE

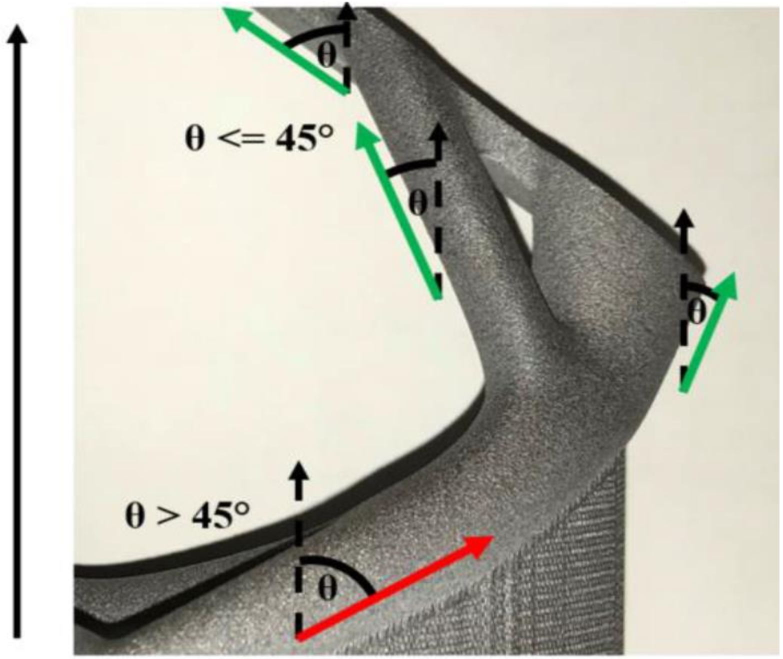
Advance geometry reconstruction via full PolyNurbs technology and many more

PROCESS EXPLORATION

IS THE ALM TECHNOLOGY LIMITLESS?

Unfortunately, the ALM products need **supports** in case of:

- Downward facing surfaces
- Angled facing surfaces
- Circular holes

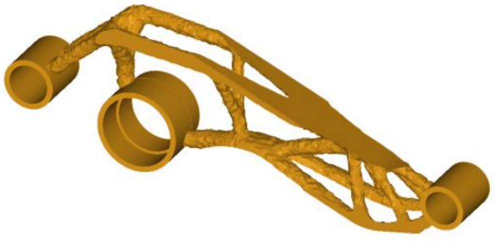


How to consider the NEW Manufacturing Constraints?

OVERHANG ANGLE CONSTRAINT

In general supports represent a problem:

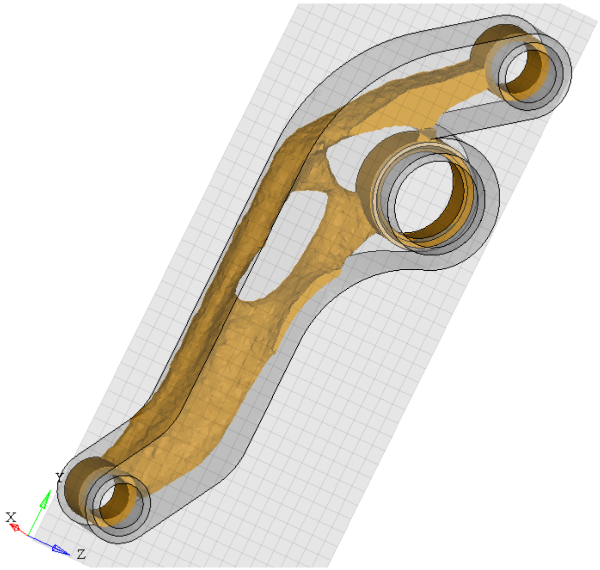
- Wasted material
- Time consuming
- Influence the surface finish
- Manual operation



Initial design "Free" No manufacturing constraint

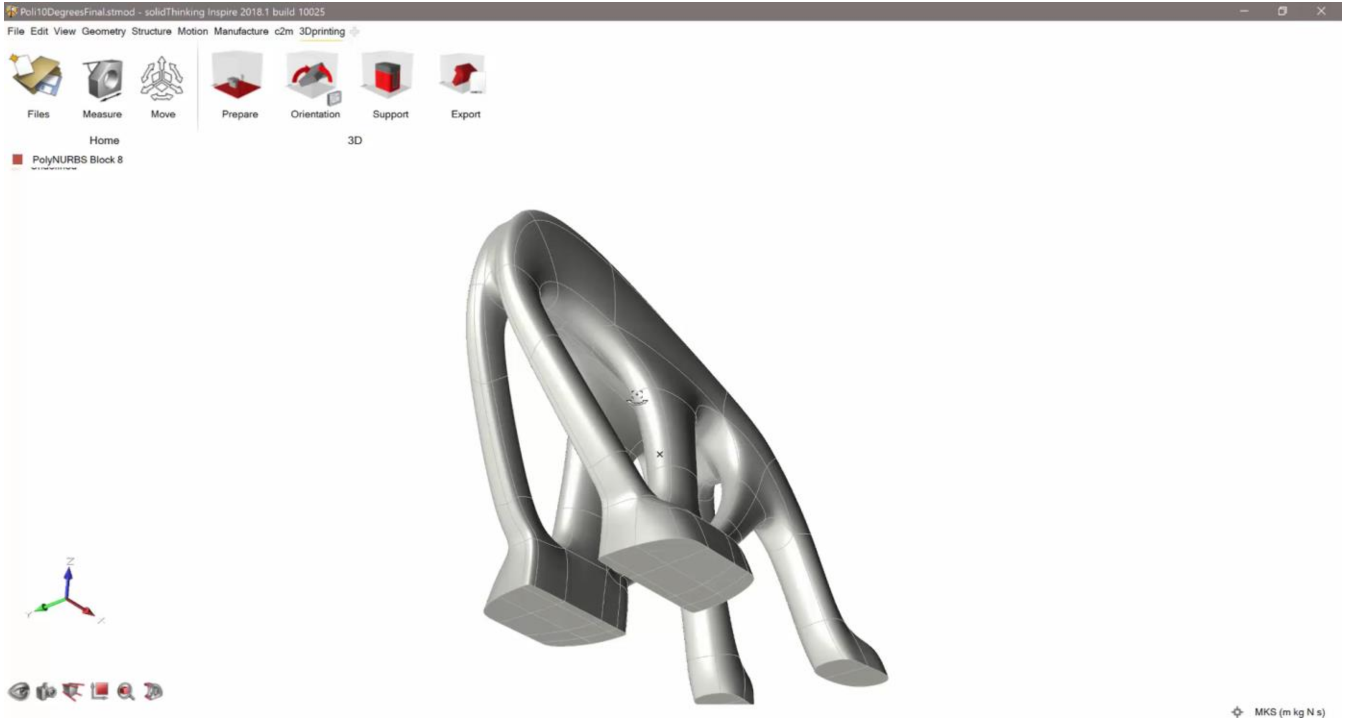
Minimise Support Structure by Overhang Angle Control
45° respect to Building Direction

Building Direction



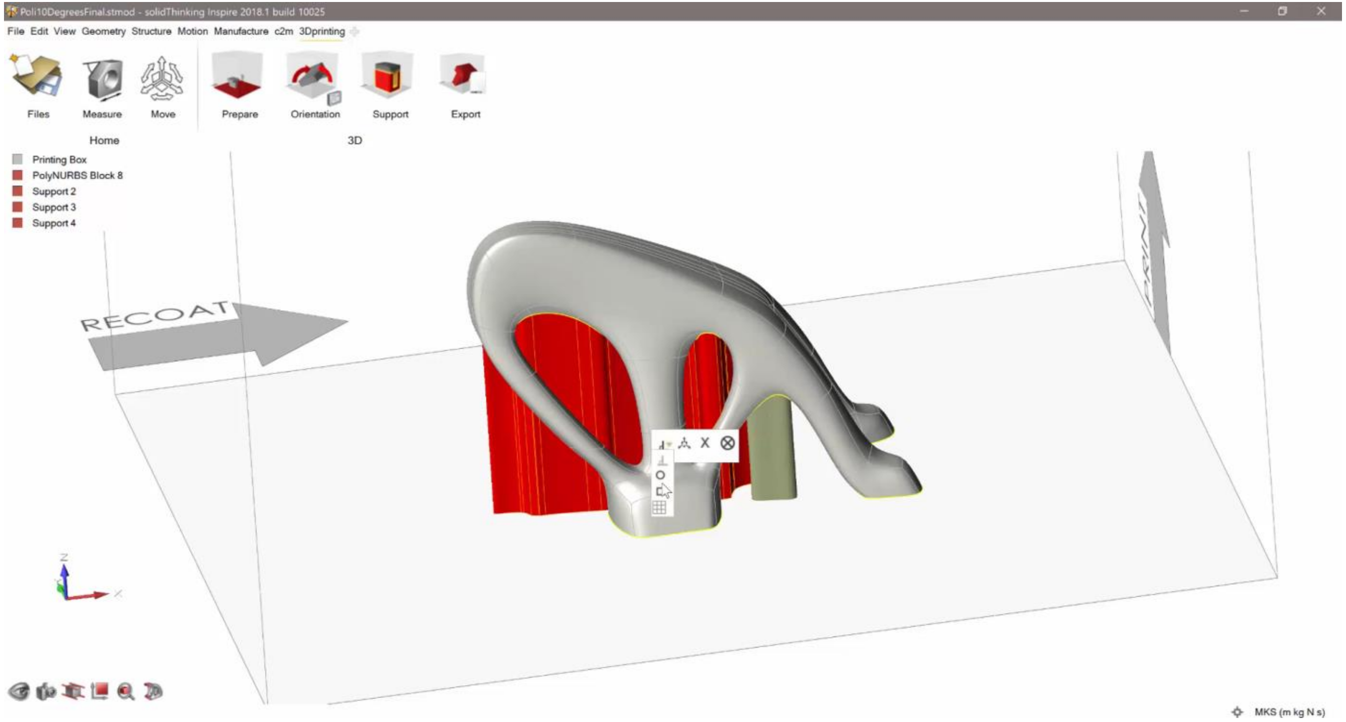
NEXT FUTURE DEVELOPMENTS

> Modify geometry in order to minimize areas that need supports



NEXT FUTURE DEVELOPMENTS

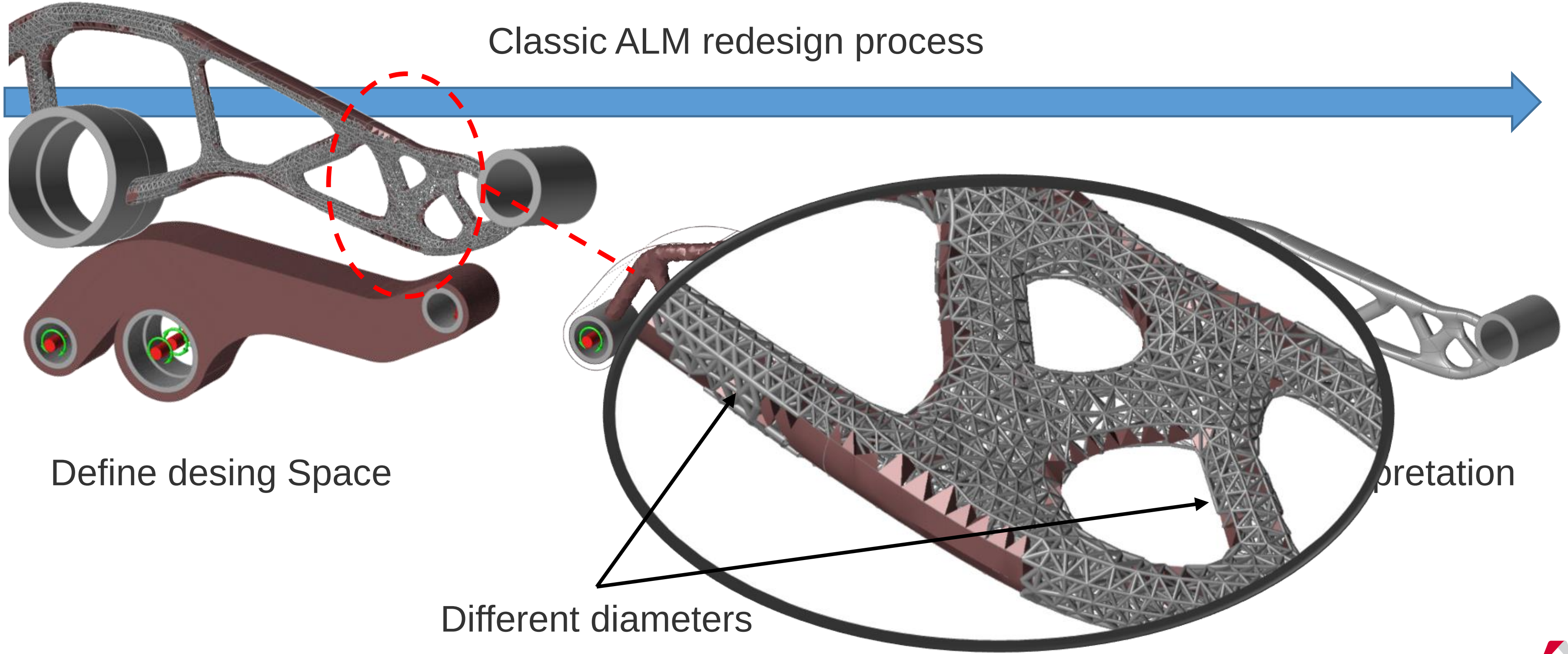
- > Modify geometry in order to minimize areas that need supports
  - > Modify supports distribution in order to minimize them



LATTICE STRUCTURES

LATTICE STRUCTURE WORKFLOW

Classic ALM redesign process



Define desing Space

pretation

Different diameters

CASE STUDIES


Altair

FROM THE PRINTER INTO SPACE

3D Printed Antenna Bracket for Sentinel-1 Satellite:

- **43% weight reduction** (from 1.626 kg to 0.936 kg)
- Increased Eigen frequency (70Hz → 90 Hz)
- Reduced number of parts, bolts, rivets, etc… decreasing checks, time and costs
- Improved static behaviour, strength, stiffness, stability

Together ahead. RUAG

DESIGN PROCESS SUMMARY

Together ahead. RUAG

Design

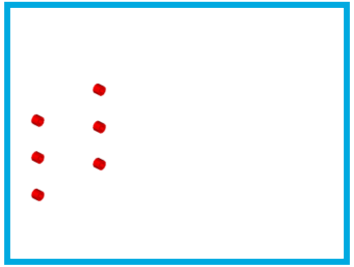
- Functional analysis
- Topology optimization
- CAD Interpretation
- Size/Shape optimization
- Detail stress analysis

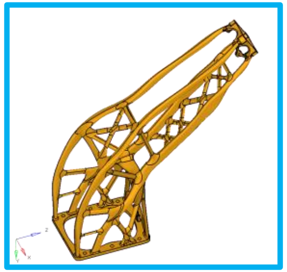
Manufacturing

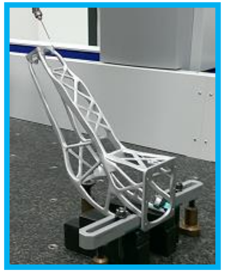
- Optimization
- Post-Processing
- Samples definition
- Process control

Verification / Testing

- Quality control
- Test definition
- Qualification testing
- Model correlation







42% Weight save

AMAZONE

voxeljet

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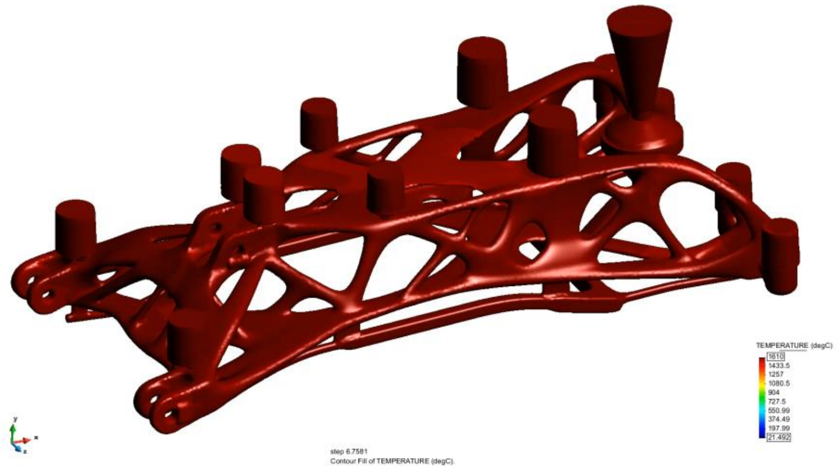
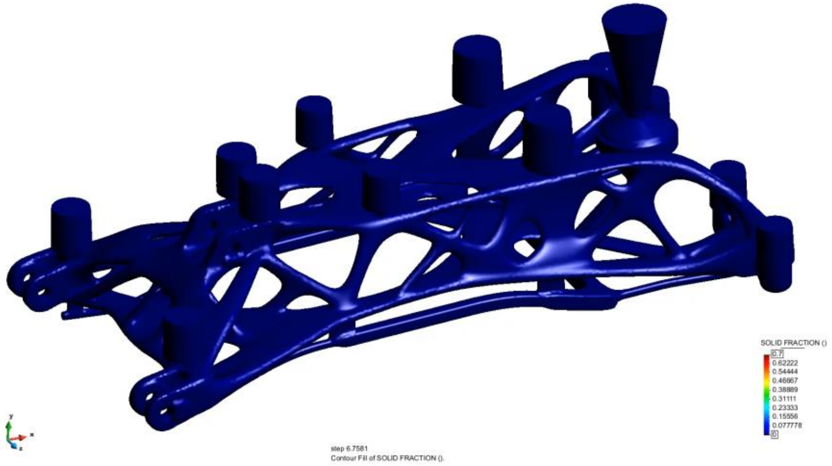
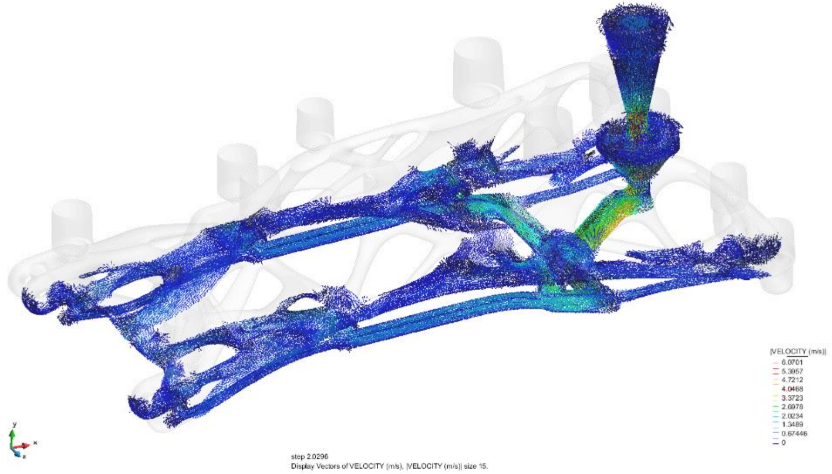
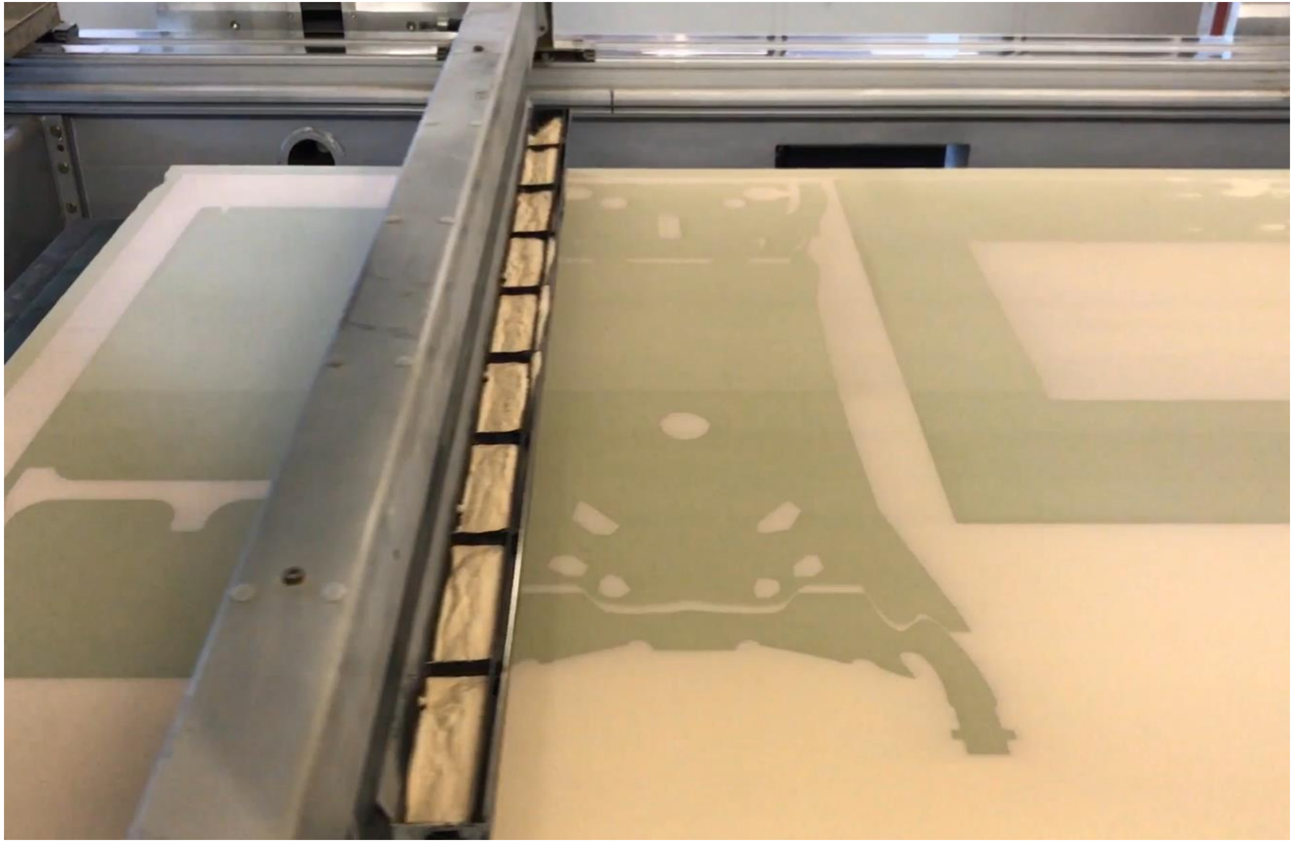
MANUFACTURING SIMULATION







SAND 3D PRINTING



DESING PROCESS SUMMARY

- **Core Design (Topology Opt)**
- **Casting Process Evaluation**
- **3D-printed core with AM**
- **Mold production**
- **Mold de-sanding**
- **Casting**
- **Final Component**

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voxeljet

CLICK2 CAST™ solidThinking

Disc Harrow bionic rocker arm

Welded construction:

- 16 Meters of welds

Optimized casted part:

- Integral part
- 35% costs reduction
- 10% weight reduction
- 250% fatigue performance

Casted part with 3D printed form:

- Same Performances
- 11% weight reduction
- 75% lead time reduction

THANK YOU FOR YOUR ATTENTION!

AMORESE@ALTAIR.COM