L’OTTIMIZZAZIONE TOPOLOGICA, ELEMENTO ESSENZIALE NELLA PROGETTAZIONE DI COMPONENTI REALIZZATI IN ALM

Giulio Turinetti, Mar 10 2016

Altair

Fields of application

Automotive

Rapid prototyping, Tooling, first experiments with mold making for metal casting

Aerospace

Rapid prototyping,

Airducts in plastic in operation since a while, spare parts

first flight-critical production parts in metal in the air

Medical:

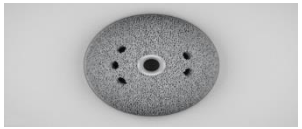
Dental, implants

Turbomachinery:

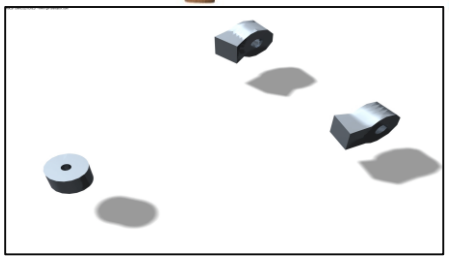
blade Cooling, fuel nozzles, Heat exchangers

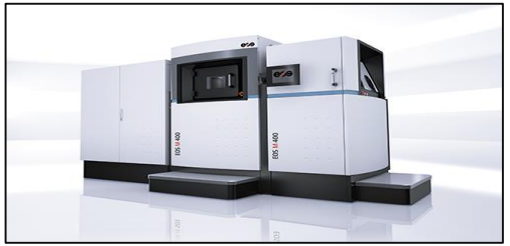
General:

Jewelry, Art, consumer products, Edutainment, Modelling



The ALM Process – 3 Main elements





Metallic Powders

- Final material strenght
- External roughness
- Chemical properties

Topology Optimization

- Load path based design
- Minimun material
- Designed by performances

3D printing Machines

- Production time
- Process controls
- Hybrid capabilities

How to get an added value from 3D printing

Complexity for free!

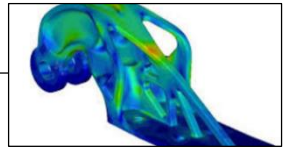
How to convert the freedom into performance?

Complementary Technologies

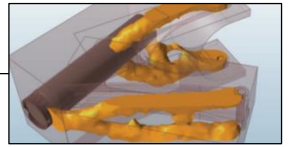
Altair

AM + **Topology Optimization**

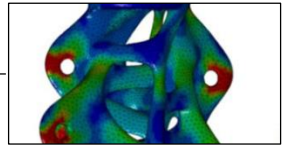
Geometric Freedom

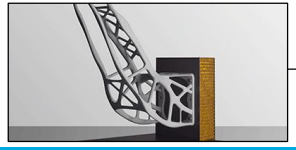


Injects Innovation



Design Individuality



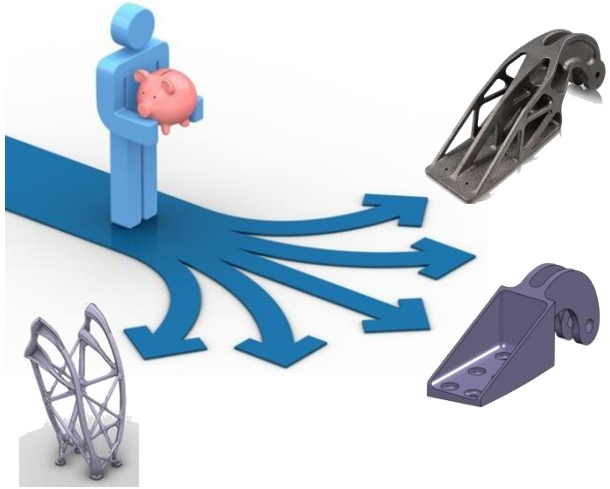


Accelerated Product Development

Why Topology Optimization?

ALM offers a broad range of possibilities in shape design

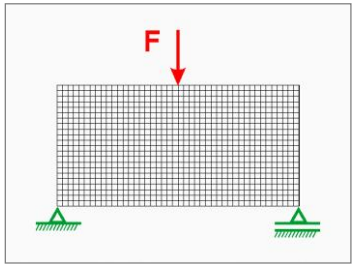
How can a designer come up with the best possible shape?



Helping to choose thecnology, Traditional Vs. ALM

In ALM reducing the volume parts means saving time

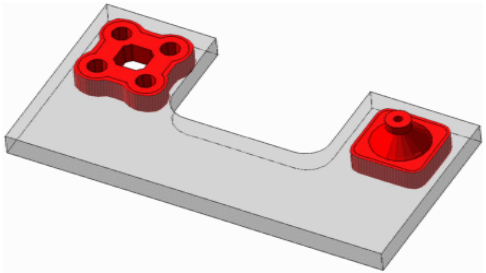
Topology Optimization



Topology optimization is a mathematical approach that optimizes material layout within a given design space under given operating conditions.

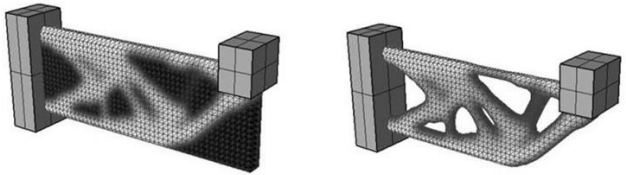
IDENTIFING THE LOAD PATHS

CHOOSE THE BEST MASS DISTRIBUTION

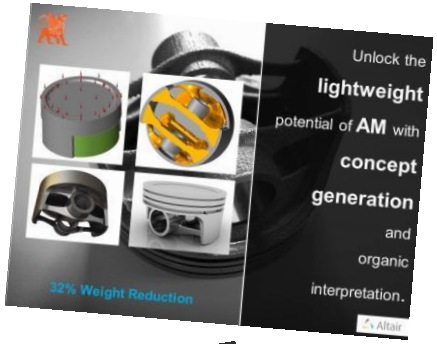


Altair Topology Optimization is OptiStruct

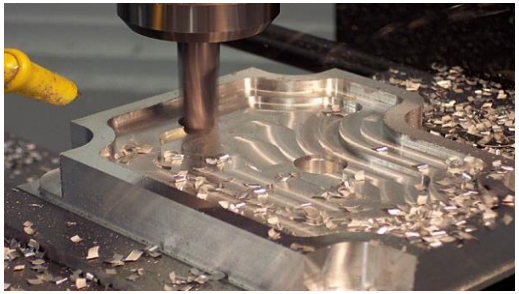
Altair is the premier provider of design optimization software, driving design processes of leading manufacturers for over 20 years



Not just an exercise



Classical Manufacturing methods



Milling

Extrusion

Casting

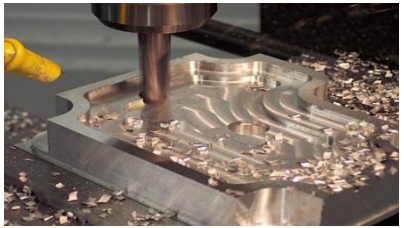
Metal Forming

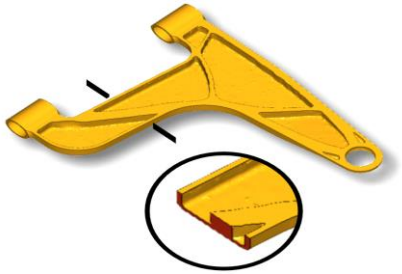
Injection Molding

Optistruct Classical Manufacturing Constraints

Altair

Draw direction

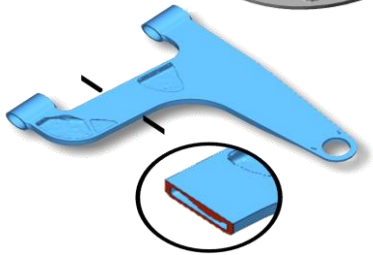




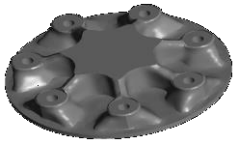
Extrusion

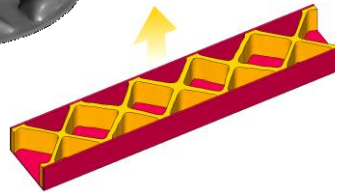
Free / no Holes

Max member dimension



Min member

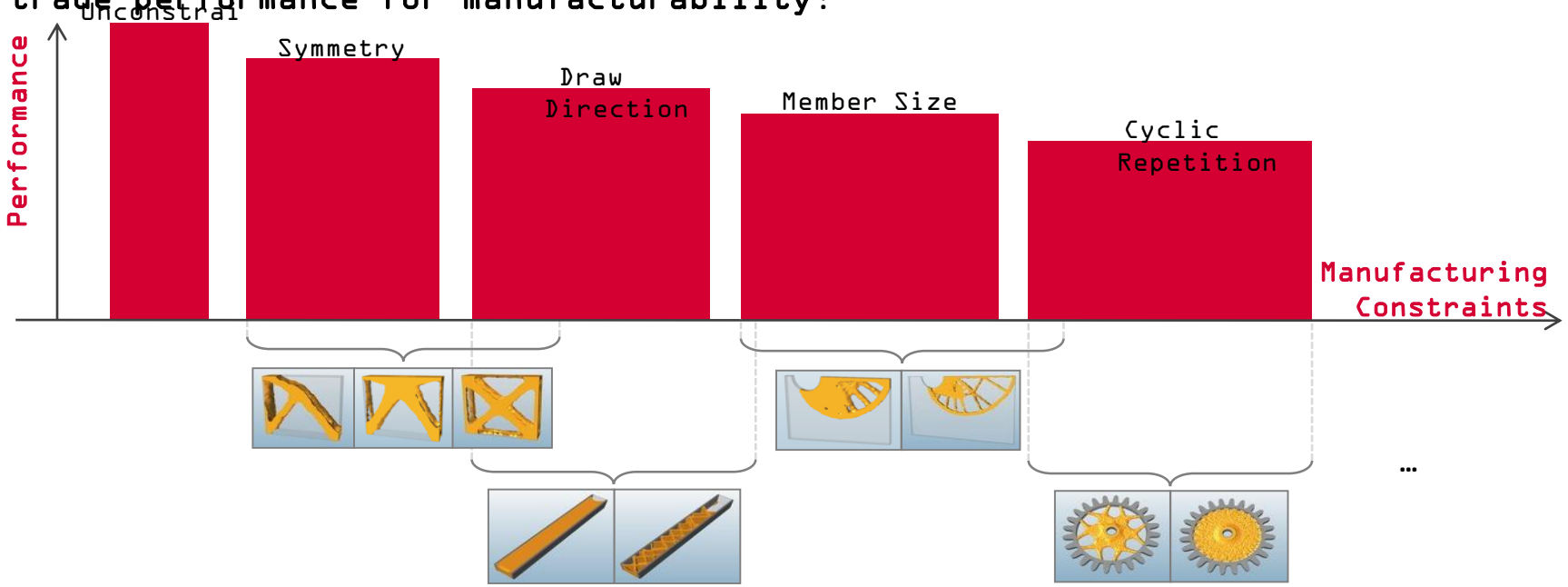




Draw + Member

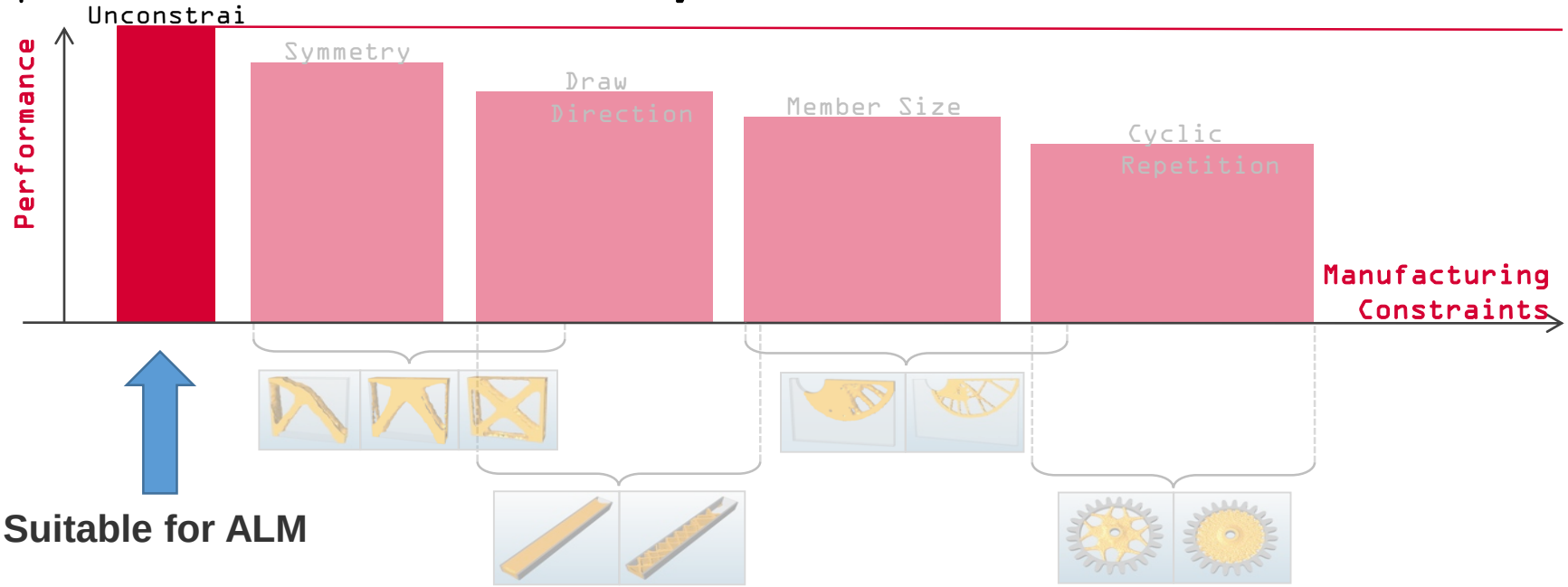
Technology symbiosis

Topology optimization provides the most efficient structure for a given load situation, but for traditional manufacturing designers always have to **trade performance for manufacturability!**



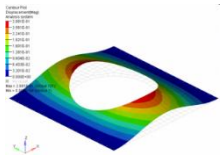
Technology symbiosis

Topology optimization provides the most efficient structure for a given load situation, with added manufacturing designers **no more** have to **trade performance for manufacturability**

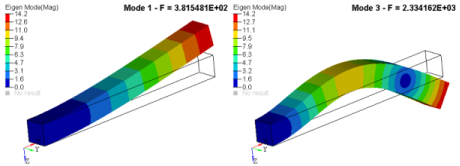


Optimization - Advanced features

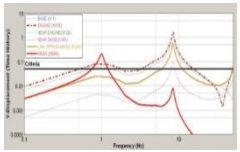
Different Physics in a single analysis



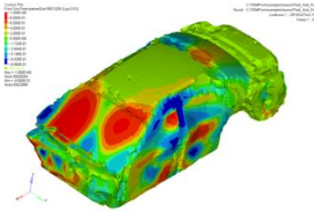
Static



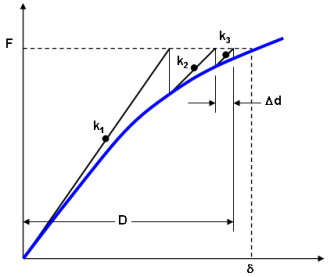
Modal

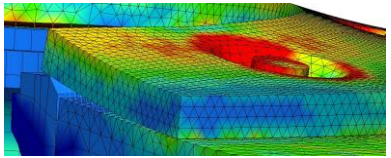


FRF

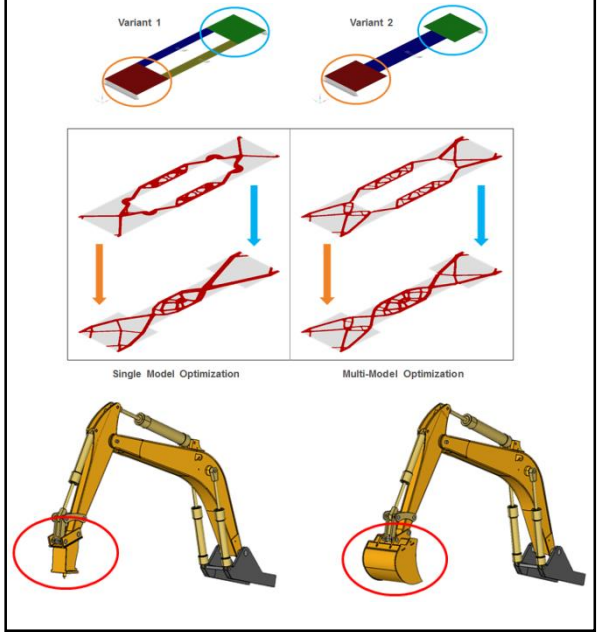


Non- Linear Optimization





Multi-model Optimization

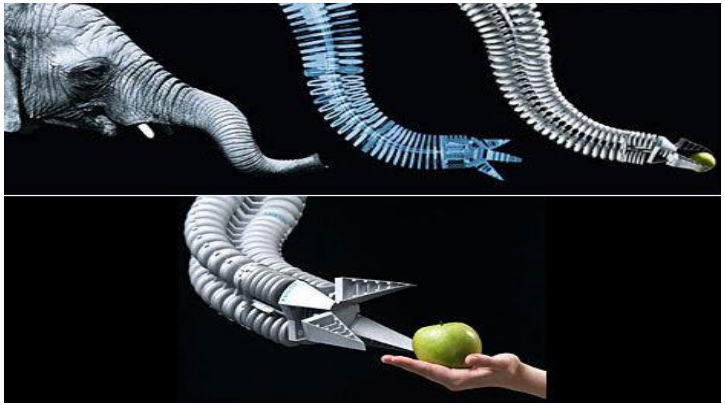


The Additive Manufacturing Design Challenge

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

picture by courtesy of Laser Zentrum Nord

Inspiration by Nature

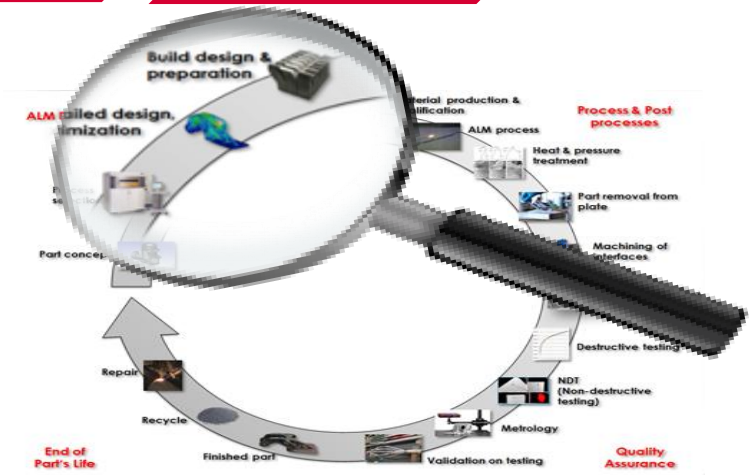


Process chain

How does the digital process chain look like at the moment

... → **CAD** → **Slicing & adding supports** (i.e. Magics) → **Job prep. system ind.** → **Building** → ...

Where to get the structural inspiration?

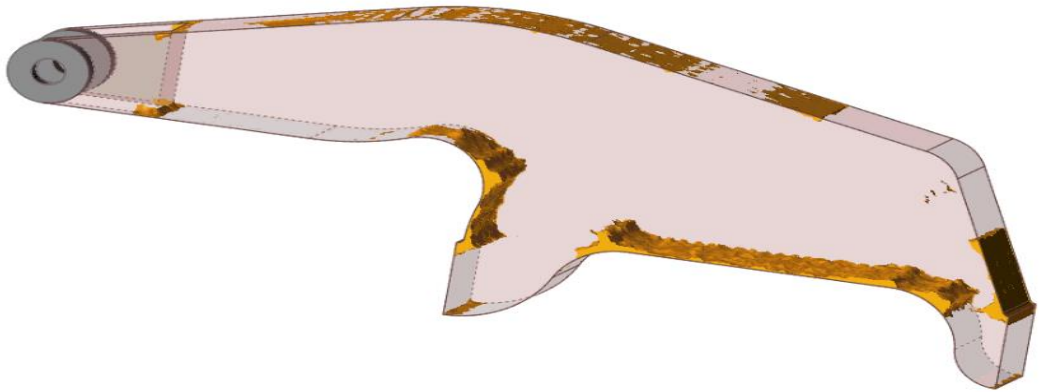


For Design Engineers

Altair

INSPIRE
solidThinking®

helps design products:



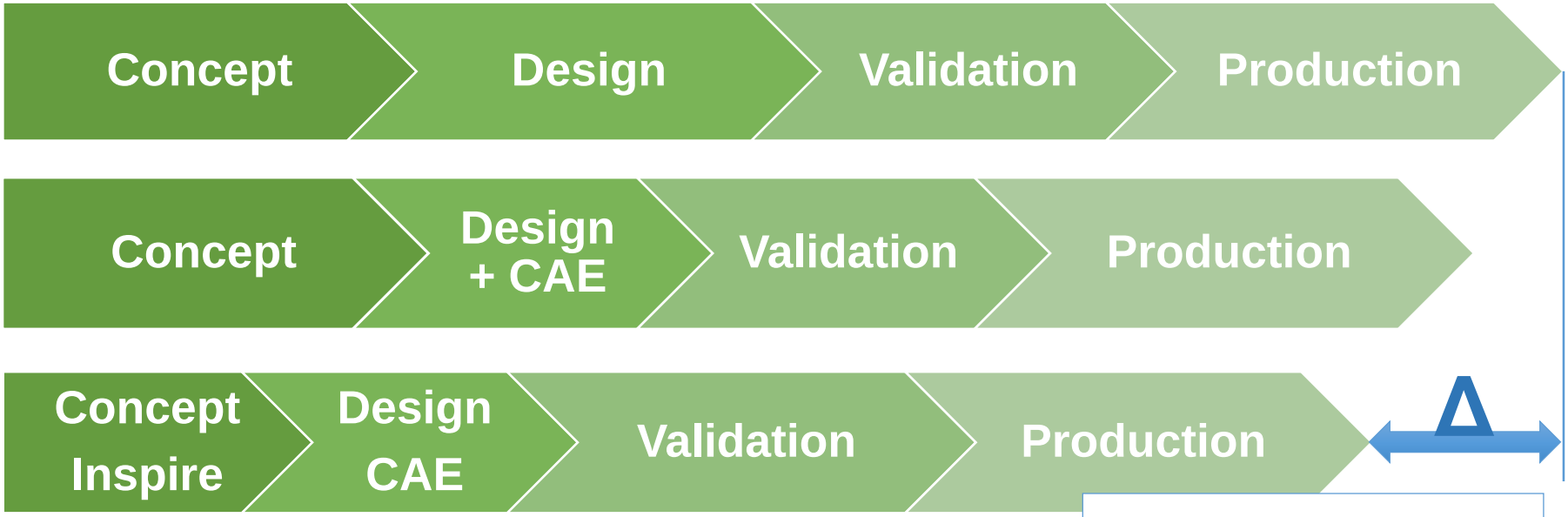
Faster

Smarter

Lighter

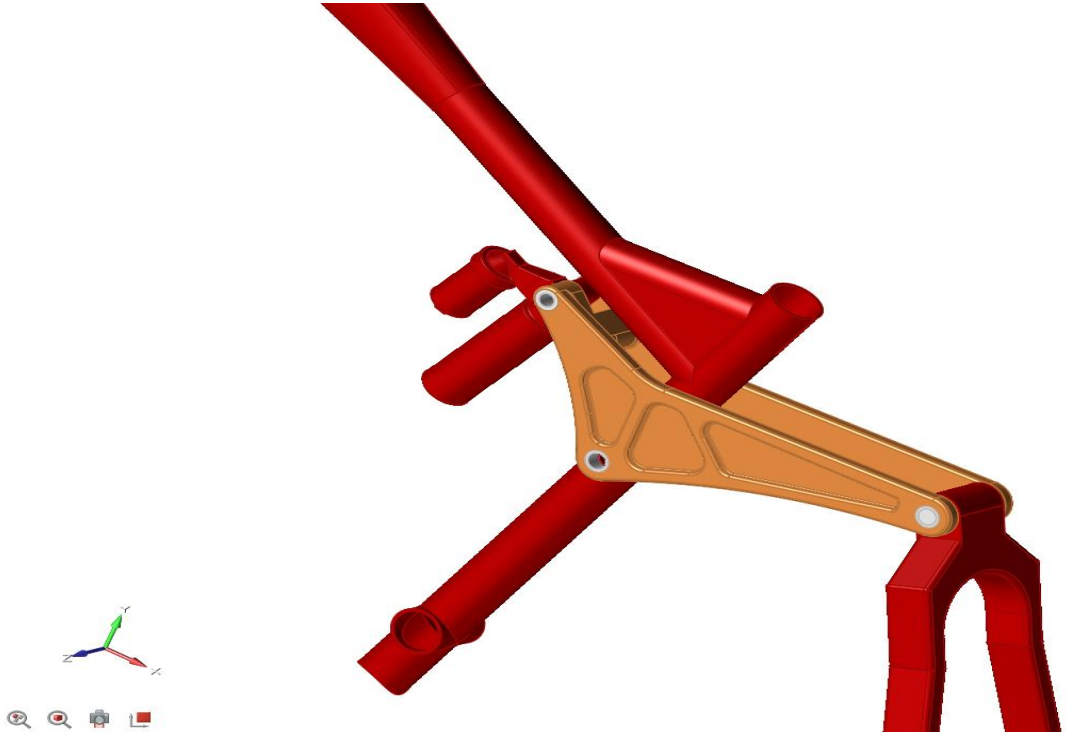
Never too soon to optimize

Altair



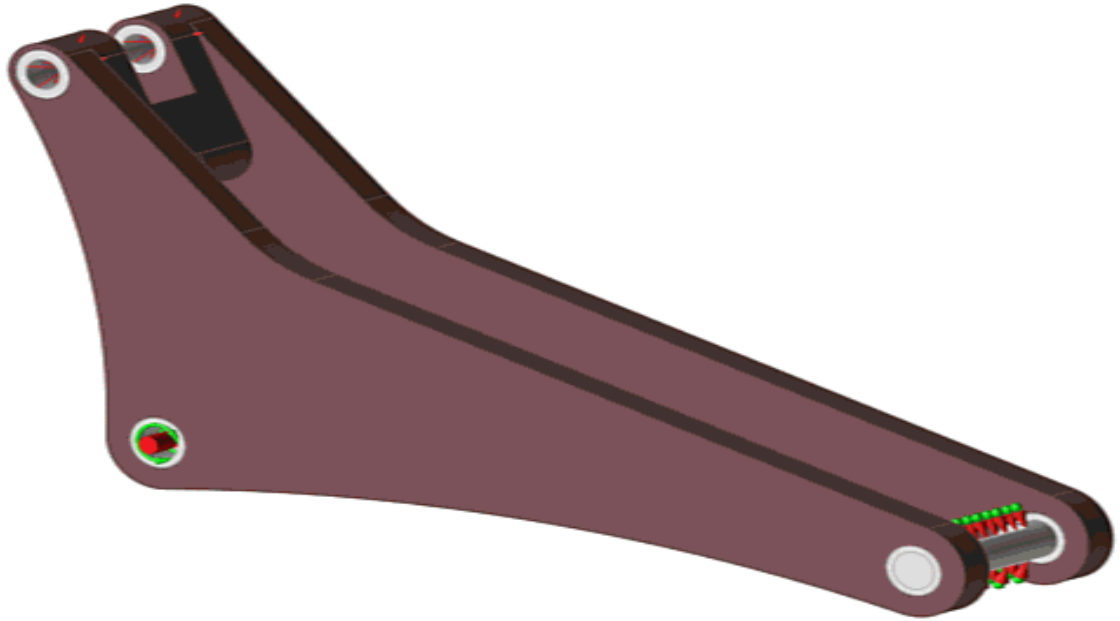
- ✓ Weight saving
- ✓ Time saving
- ✓ Cost saving

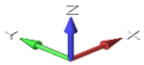
Start with original CAD design



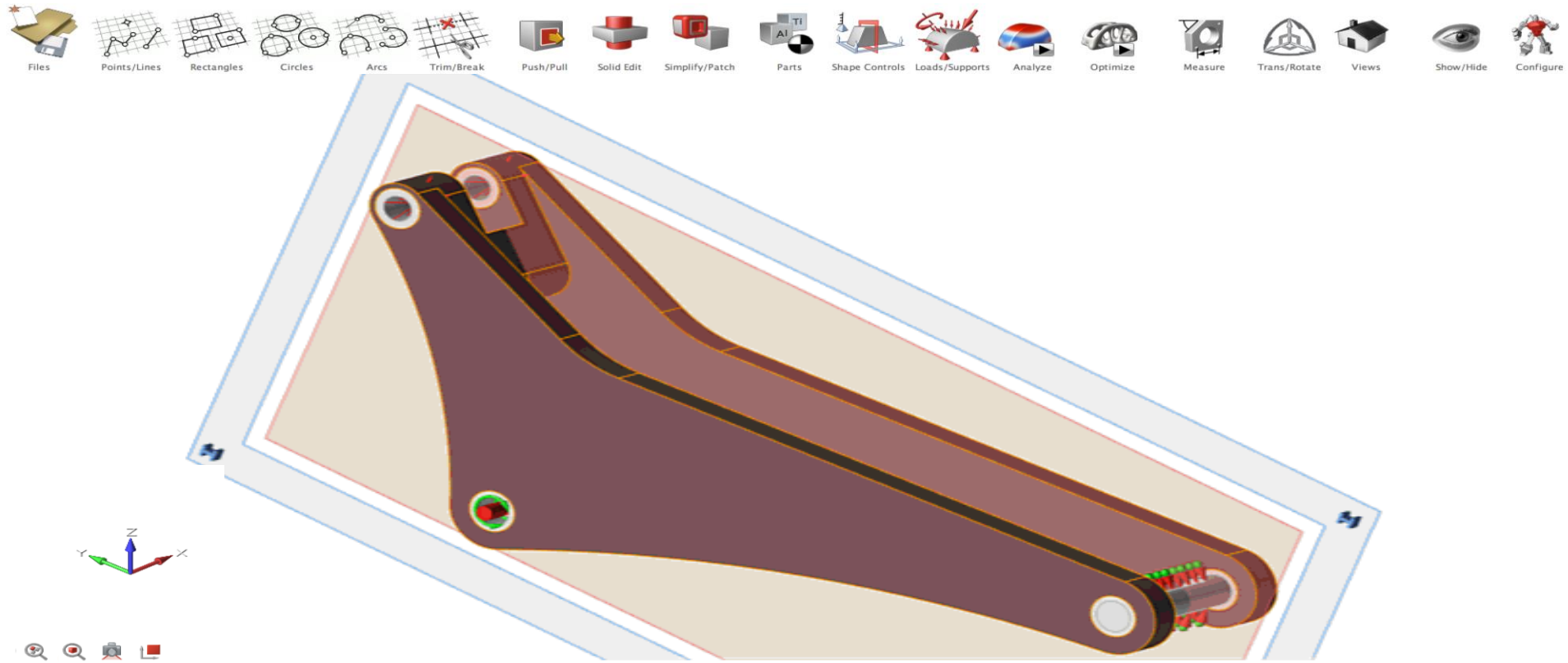
Create Package Space and Load Cases

Inspire Concept Shape

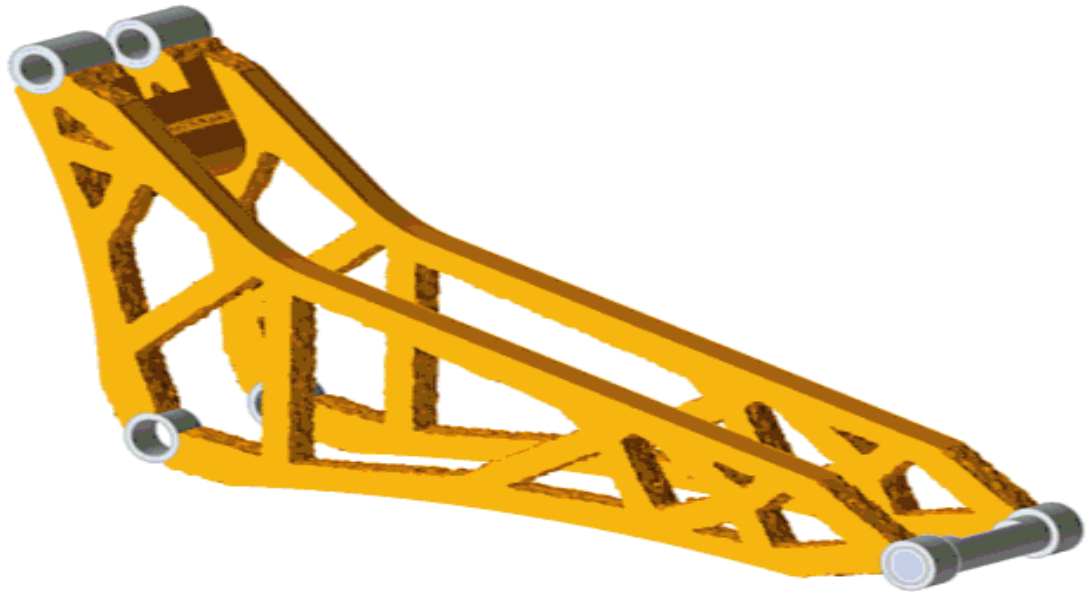


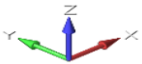


Explore Different Designs / Shapes

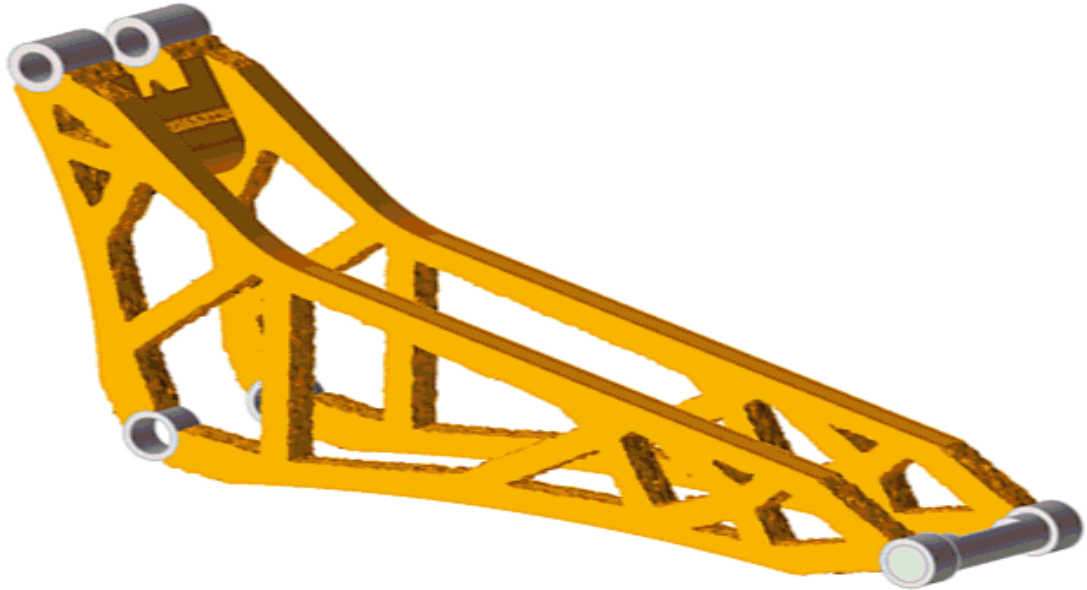


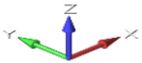
Validate Inspire Concept Shape / Proposal





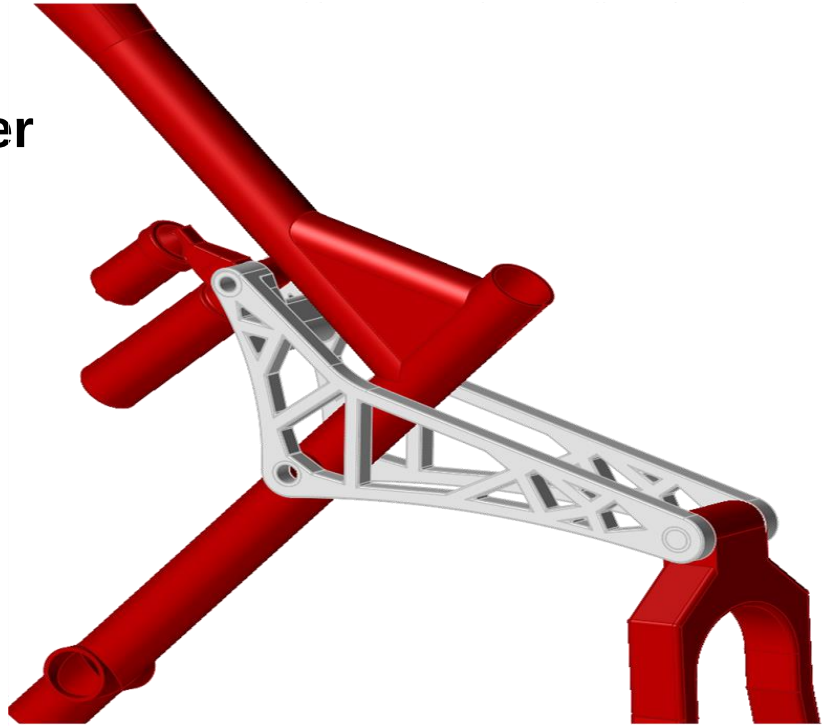
Inspire Results back into CAD





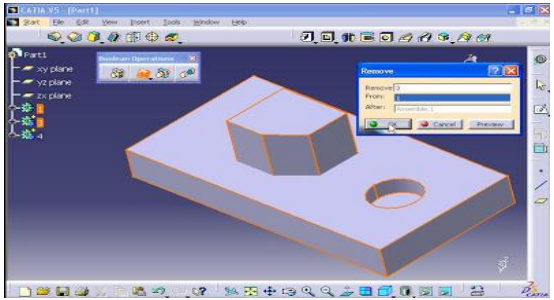
Original Design vs. Inspire Design

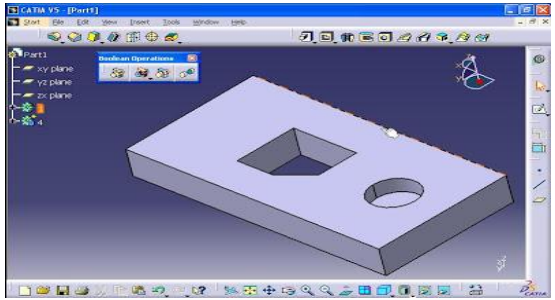
New Design: 25% Lighter

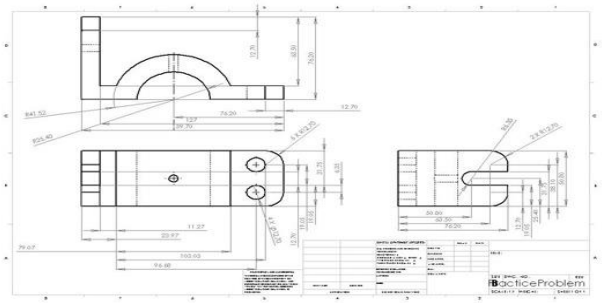


How can the engineer draw it in a CAD system?

Conventional CAD systems rely on boolean operations of simple geometric entities







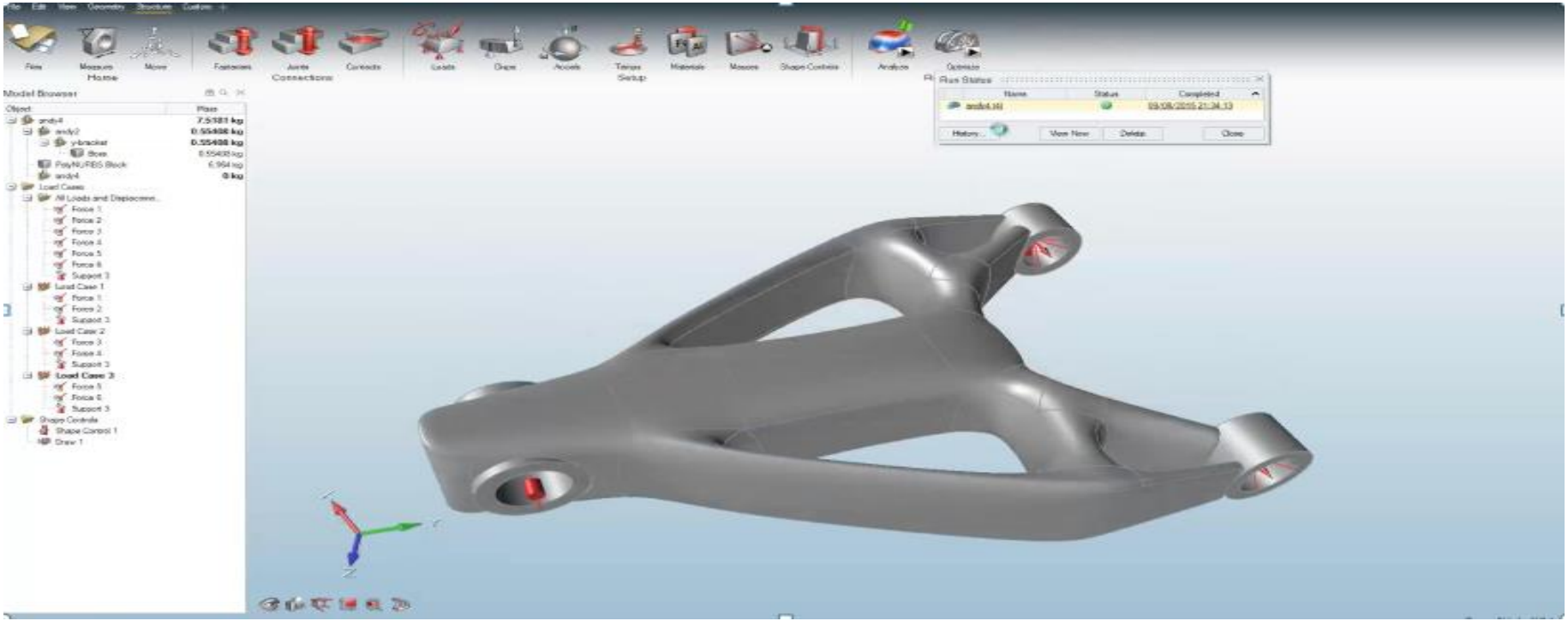
Too Complex

Organic shape

How can the engineer draw it in a CAD system?

So “drafting” something like this
can take weeks with a conventional system:

Nurbify – Evolve technology



Topology Optimization Workflow from Altair to Materialise

Altair

Altair

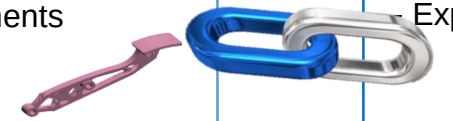
Materialise

Design Space Preparation

- CAD assembly
- CAD to FEM export
- Indicate Loads on part

Topology Optimization

- Mesh Optimization
- Linear stresses
- Design requirements



Optistruct
Inspire

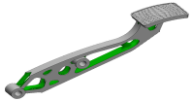
Altair | HyperWorks

Design for AM

- STL Cleanup

Based on **Digital CAD** (STL)

- Lattice design
- Export to FEA/CAD



3-matic[STL]

Altair
Partner Alliance

AM production

- CAM software for 3D printing

Supports

- Positioning
- Platform validation
- Scan profiles

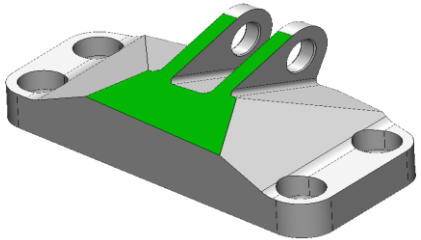
Magics RP

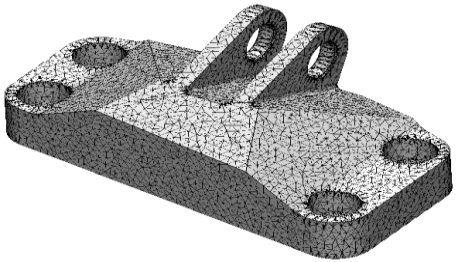
[not in APA]

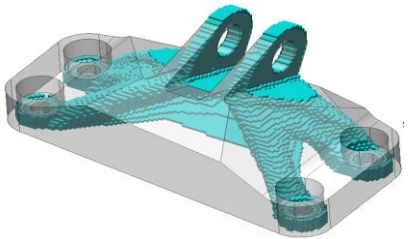
Design flow for Topology Optimization

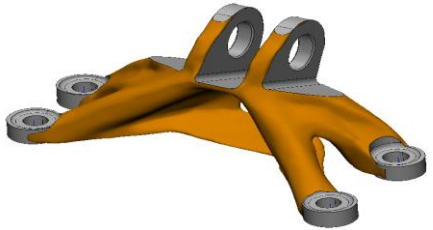
Materialise Altair

Design Space → FEM Model → Topology optimizaton → **3-maticSTL**









- *Designed in CAD*
- *Fits in assembly*
- *Loads are known*

- *FE Model*
- *Apply loads*

- *Optimize*

- ***STL Studio***
- *FEA check*
- *owards AM*

Topology Optimization software

Post-process

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Is ALM technology Limitless?

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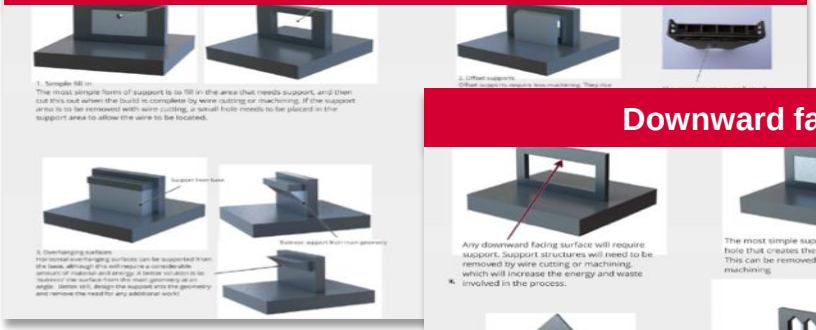
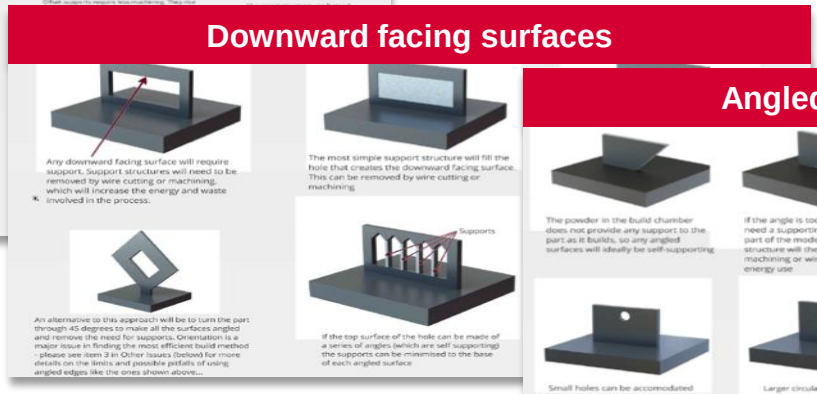
Types of support



Downward facing surfaces



Angled surfaces and holes

How to consider the NEW Manufacturing Constraints?

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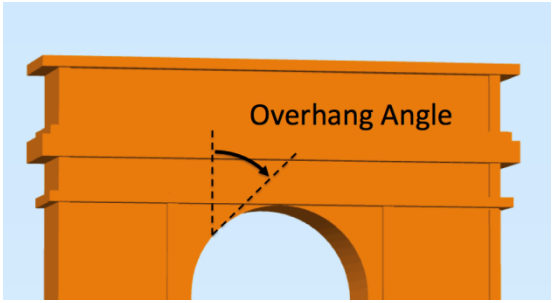
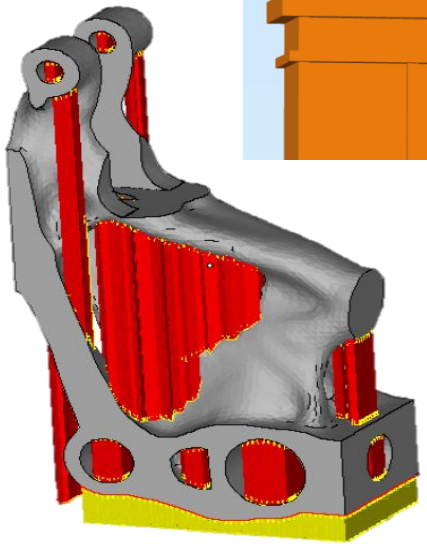
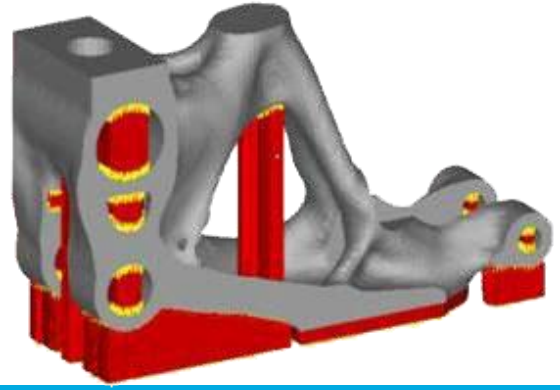
Minimise Support Structure by Overhang Angle Control







How to reduce support structures

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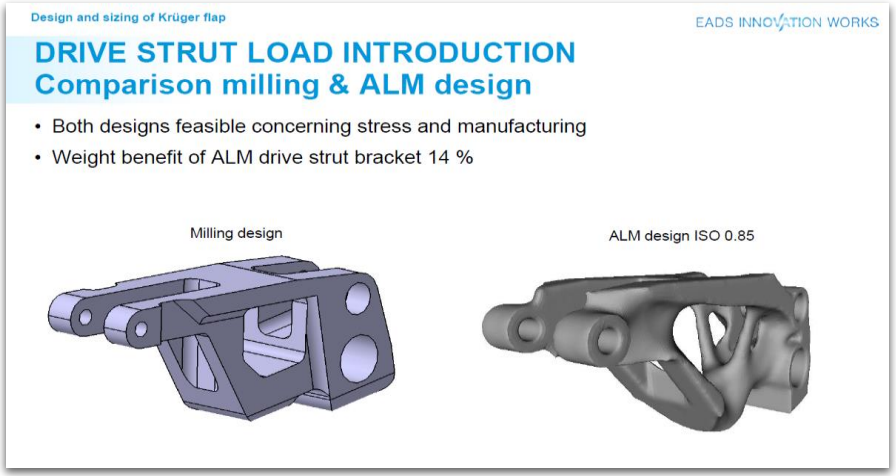
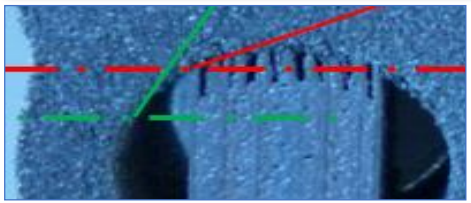
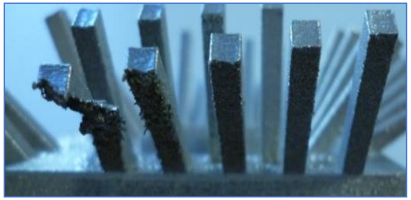
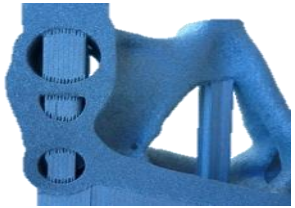
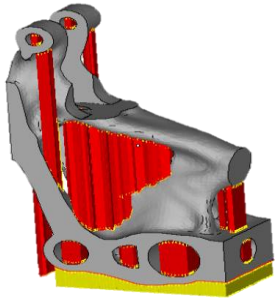
We are working on it!

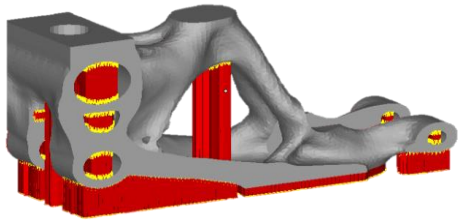


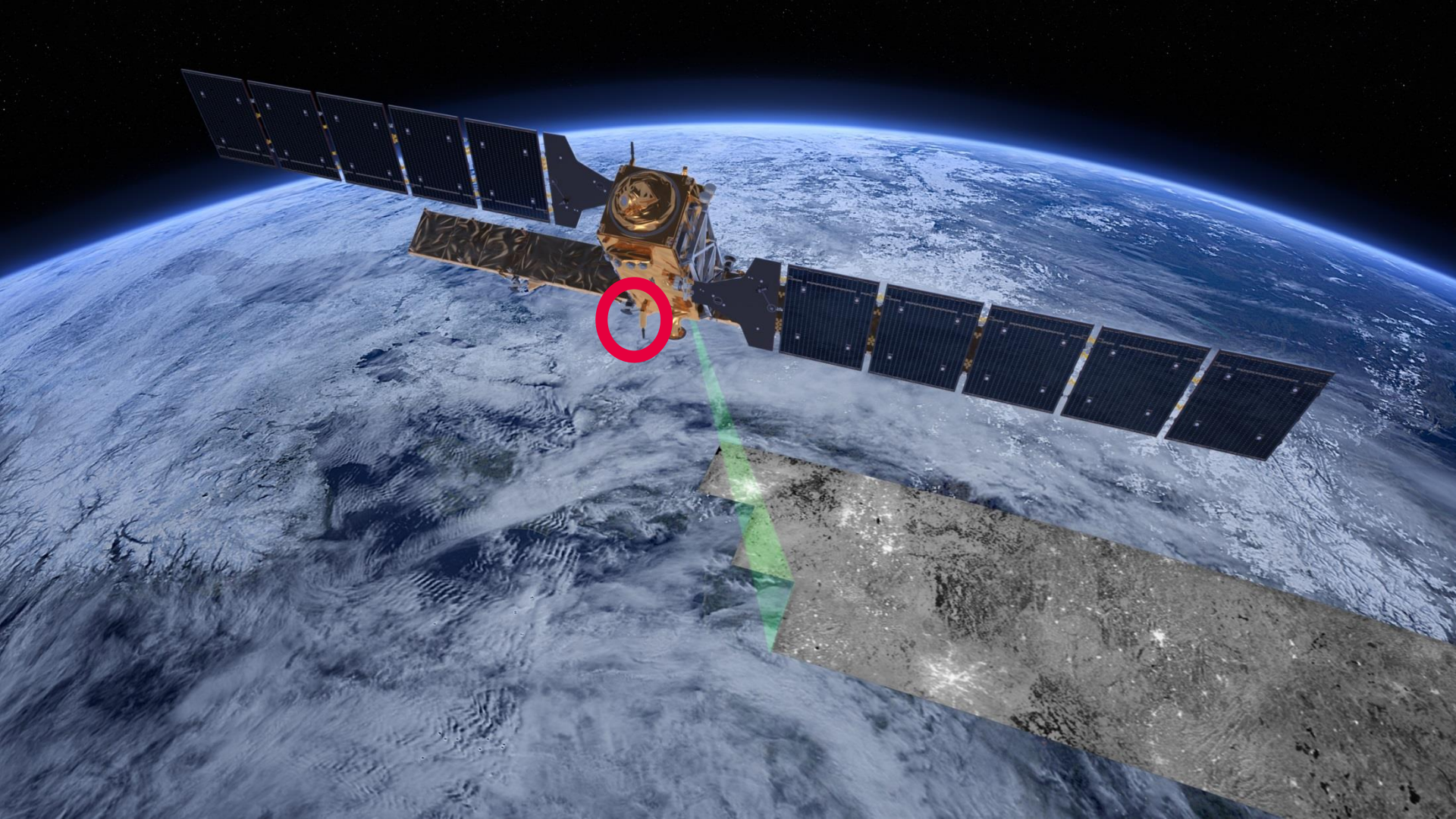










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From the Printer into Space

3D Printed Antenna Bracket for Sentinel-1 Satellite:

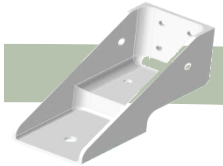
- **43% weight reduction** (from 1.626 kg to 0.936 kg)
- Increased Eigen frequency (70Hz → 90 Hz)
- Improved static behaviour, strength, stiffness, stability

Together ahead. RUAG

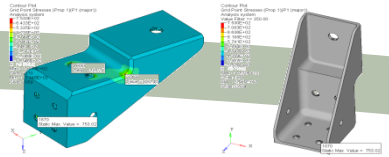
eos

Optimization Aided Design - Process

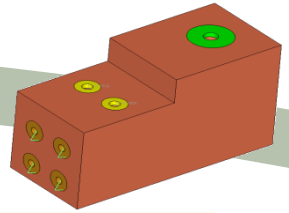
Courtesy of Thales Alenia Space



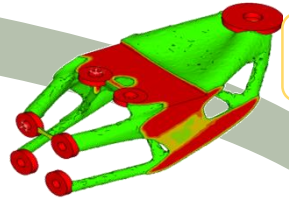
Orginal CAD model



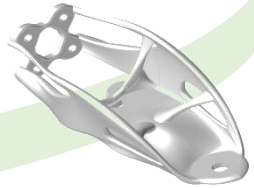
Orginal bracket Analysis



Topology Optimization Setup



Design Interpretation



New CAD Design

Mass Reduction more than 20 %

New Final CAD

Design/Analysis loop

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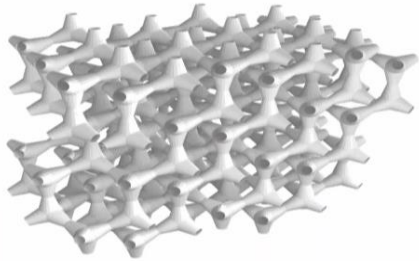
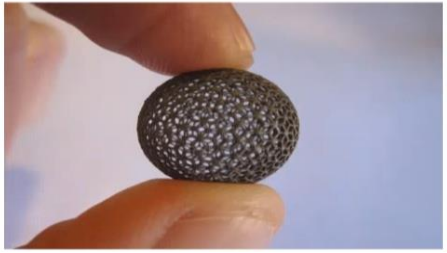
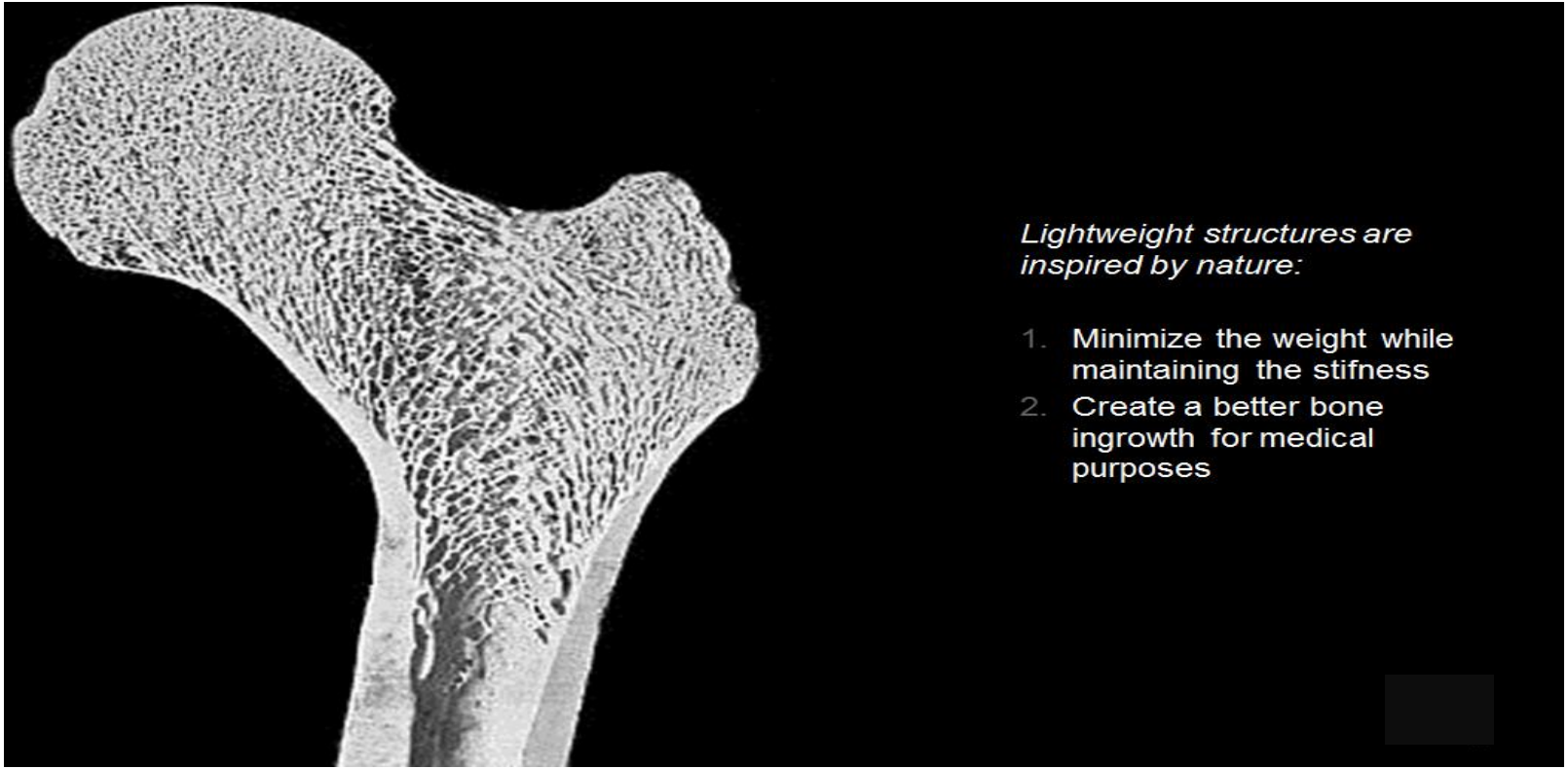
Topology optimized structures are pretty good, but lattice structures could be even better



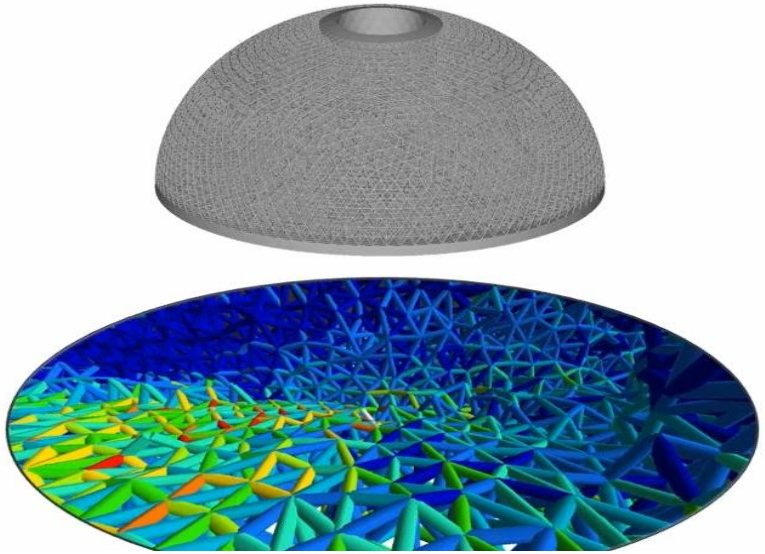


Lattice structure : Example

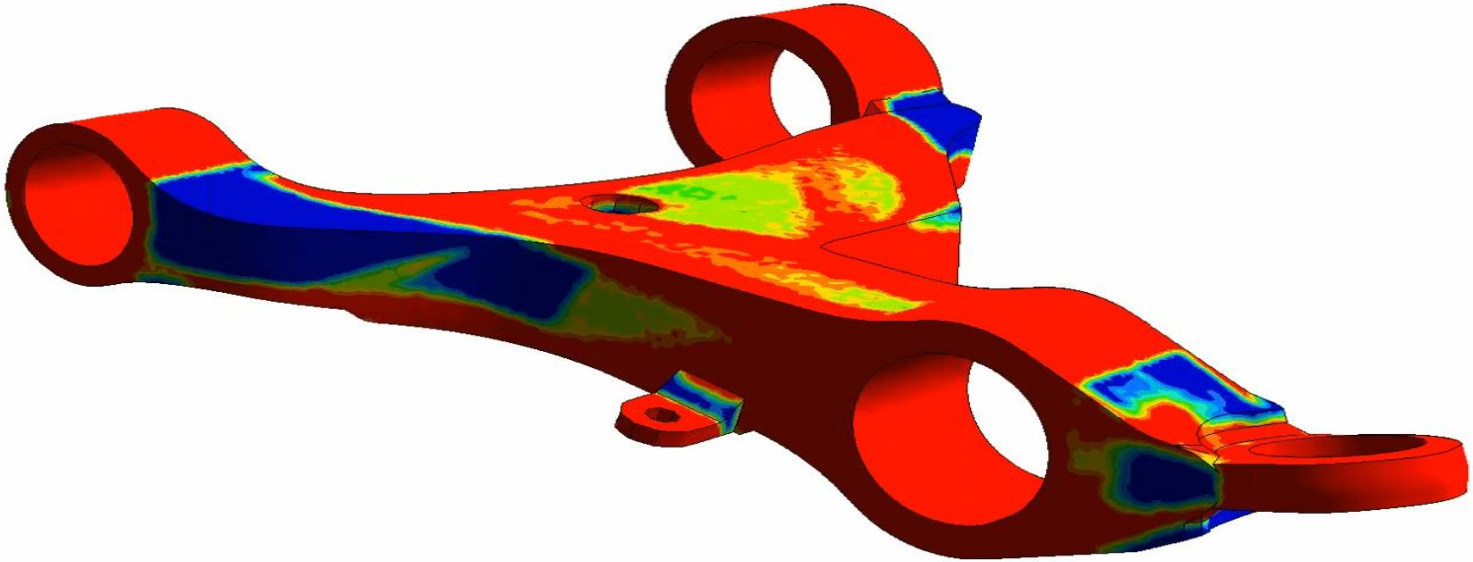


Lattice structure Design Characteristics

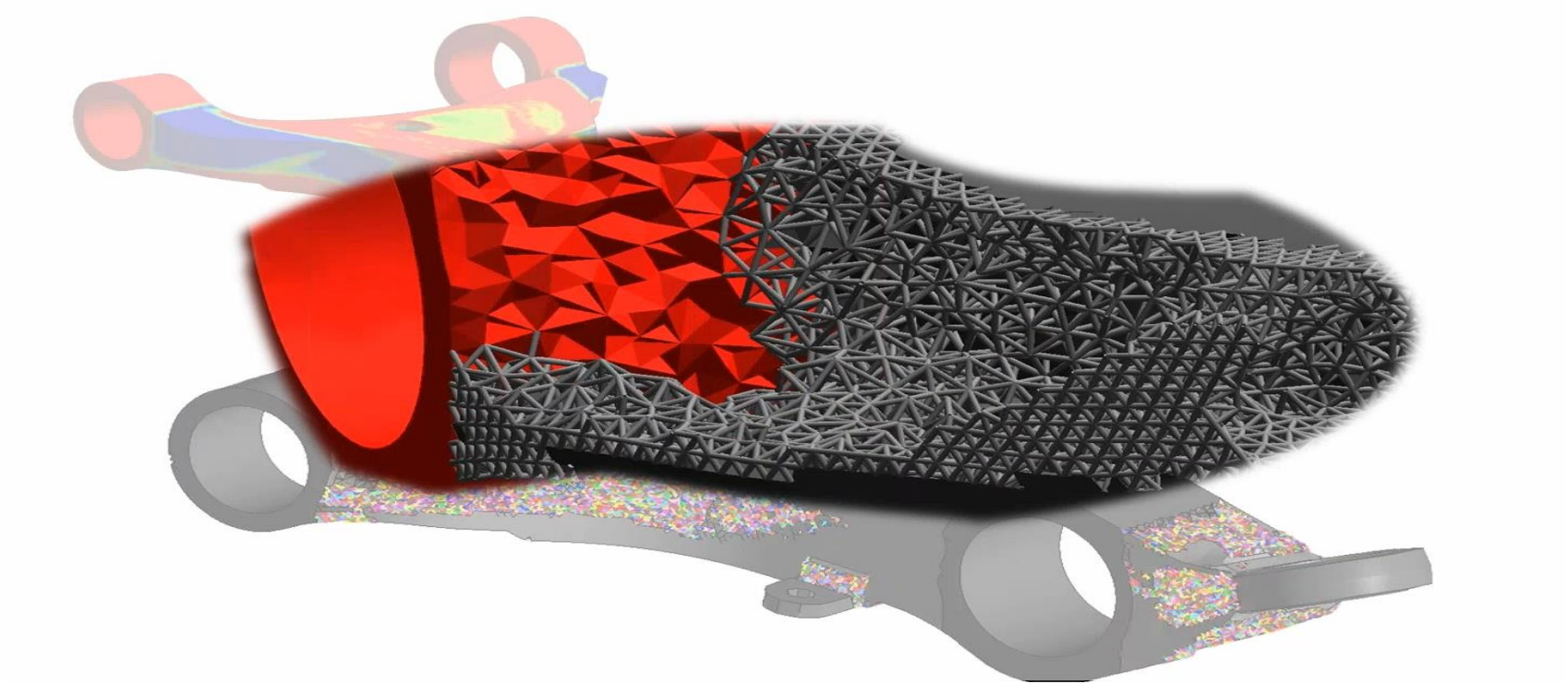
- **Usually less stiff when compared to free topology based structures**
- **Can be stiffer when topology is used with manufacturing constraints**
- **Better performance for stability, thermal behavior, vibrations, etc.**
- **Specialized applications such as biomedical, e.g. implants**



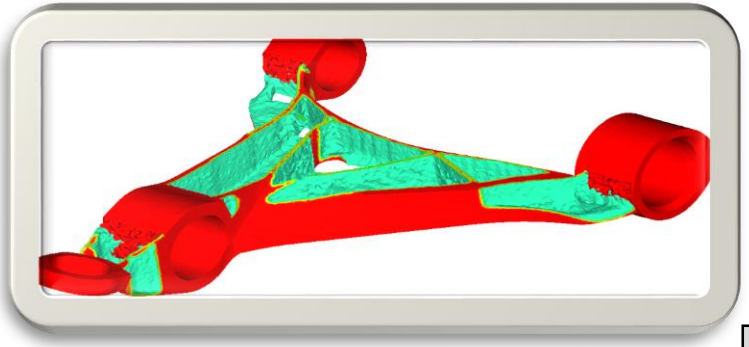
Control Arm – Concept Design (Phase 1)

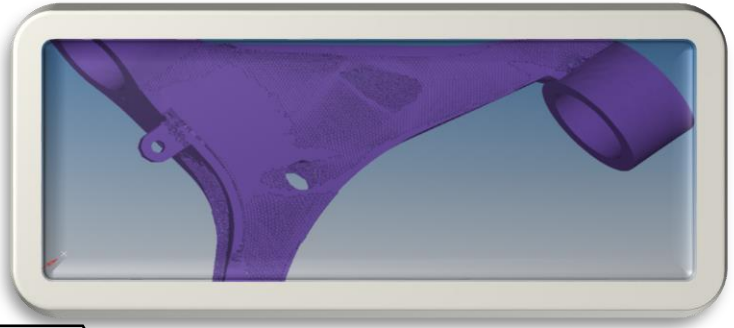


Control Arm – Concept Design to Lattice Design



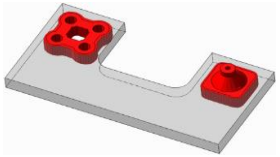
Demouldable Design vs. Lattice Structure





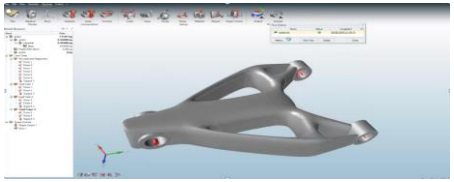
3% Stiffer

Summary

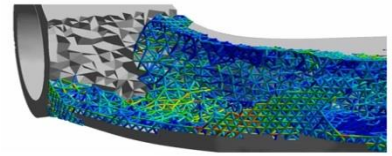


Topology Optimization is the technology behind the scene

Inspire is the easy to use software to take shape inspiration



Nurbify can easy draw organic shapes



Lattice can even improve the design

Altair Vision - Not a traditional Optimization tool

Optimization Driven Design

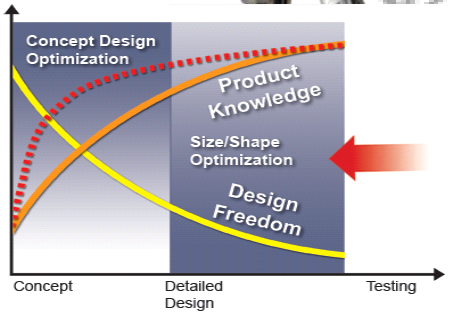
Help to think different

Version-1

n-2

Version-3

Help to make decision



Suggest the best shape from the beginning

Not just to improving design

Awards

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DesignNews

GOLDEN MOUSETRAP AWARDS 2013 WINNER

Design Tools: Hardware & Software
CAD/PDM/PLM Software

INSPIRE
solidThinking

A' INFORMATION TECHNOLOGIES DESIGN AWARD

2014
A'DESIGN AWARD
WINNER

architosh
BEST
of show
2014
Innovation
AIA National

Materialise

SLOT CAR CHAMPIONSHIP
RAPID 2014

Thank you for your attention!