Design the Difference

Liberare il potenziale dell'Additive Manufacturing con nuove tecniche di progettazione

Ing. Giulio Turinetti 25 September 2017

Altair

Altair Numbers

Founded 1985

Headquarted in Troy, MI US

48 offices

in 22 countries

$323M

2016 Billings

50+

ISV partners under our unique, patented licensing model

2500+

Engineers, scientists and creative thinkers

5000+

Customer Installations globally

60,000+

Users

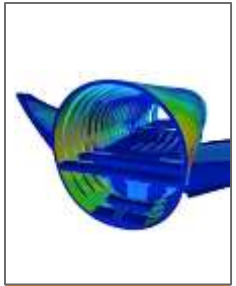
Our Vision

To radically change the way organizations **design products** and **make decisions**

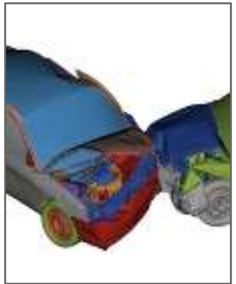
5,000 customers installations worldwide

Automotive	Aerospace	Heavy Equipment	Government
Ford, TOYOTA, CHRYSLER, 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, 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

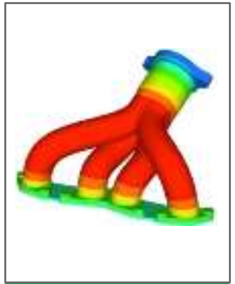
Altair Solver Technology



Structural Analysis



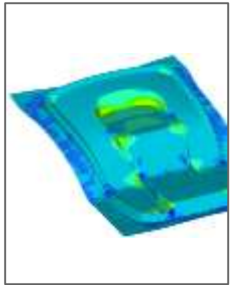
Crash, Safety, Impact & Blast



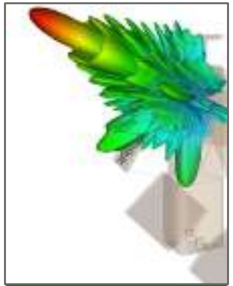
Thermal Analysis

Fluid Dynamics

Systems Simulation



Manufacturing Simulation

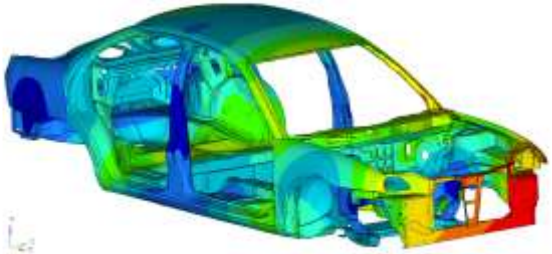


Electro-Magnetics

Multiphysics Simulation and Optimization

Mechanical

OptiStruct: Strength, Stiffness, Durability

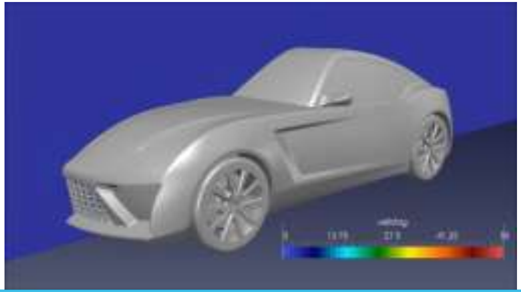


OptiStruct: Vibrations, Acoustics

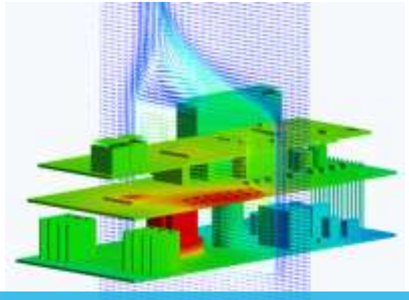
RADIOSS: Crashworthiness, Impact, Blast

MotionSolve: Mechanical Systems

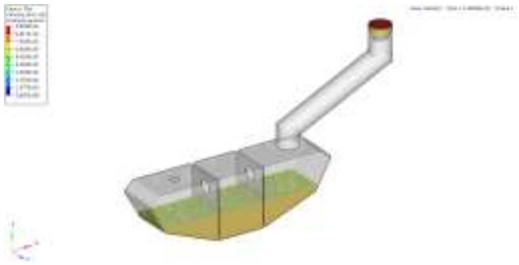
Fluid flow and Thermal



ultraFluidX: Aerodynamics



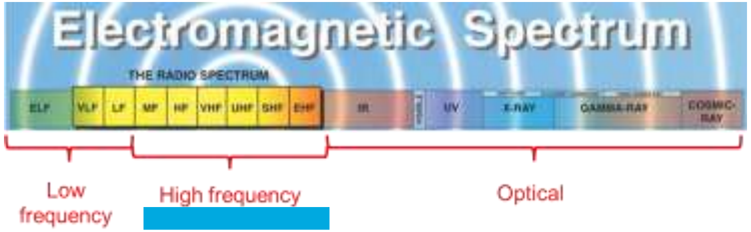
AcuSolve: Thermal Analysis



AcuSolve: Tank Filling

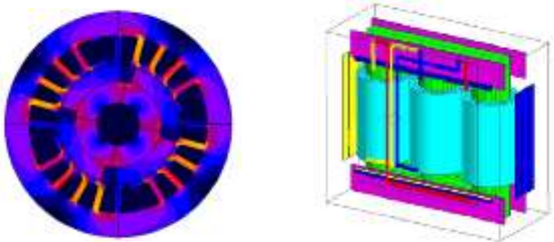
nanoFluidX: Gear and Engine Oiling

Electromagnetics

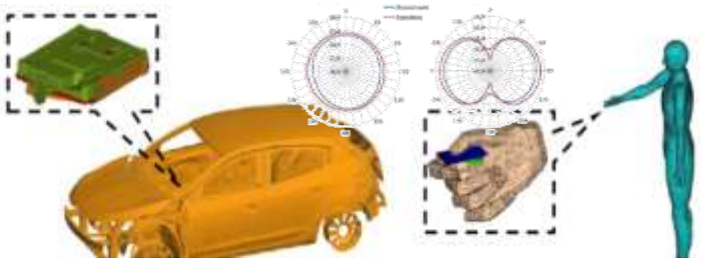


Flux FEKO

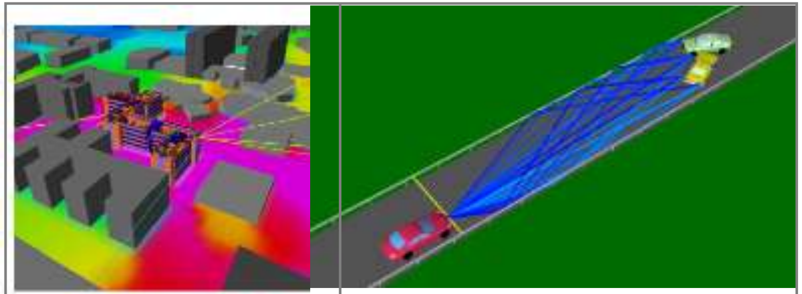
Electro-magnetic Spectrum



Flux: Motors, Transformers



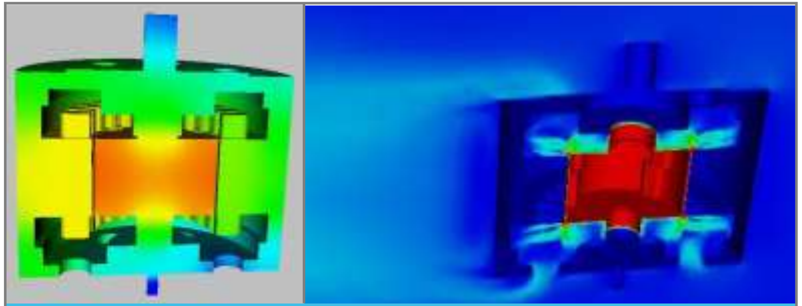
FEKO: Antennas, EMC

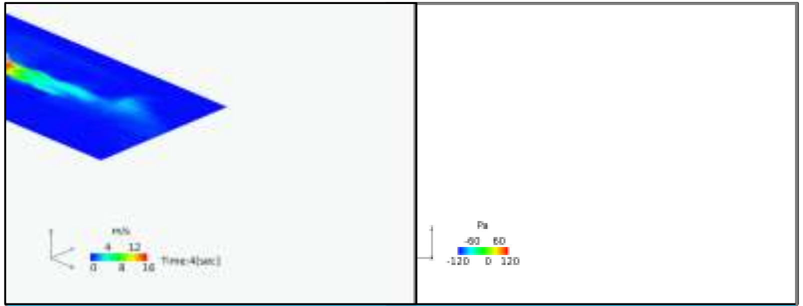


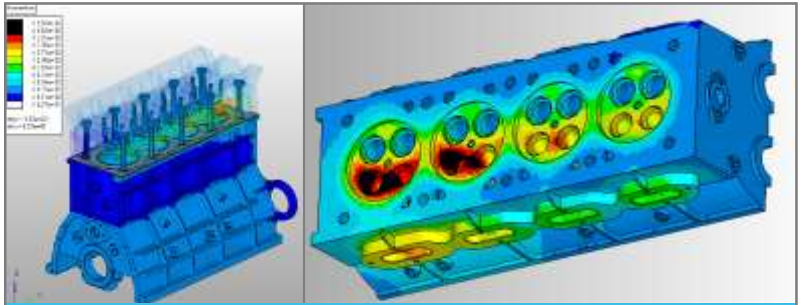
WinProp: Wave Propagation

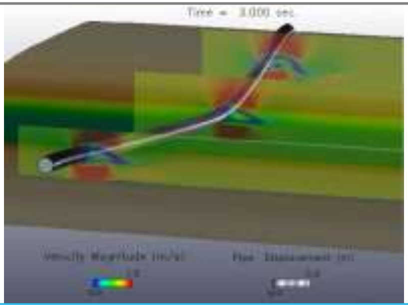
Altair

Multi-Physics


Electromagnetic-Thermal


Fluid-Multi-body


Thermal-Structure


Fluid-Structure

ALM Process

Main elements of ALM Technology

Design for Additive Manufacturing

Metallic Powders

AM Machines

How to get benefits

Slow Process

Very **expensive** Powders

Massive parts have huge **distorsion**

Huge **ratio** between material and void

Complexity is for free

Lattice is allowed

Mass reduction has a big impact on the whole result

To get most benefit we need to think complex shapes

Shape the Inspiration

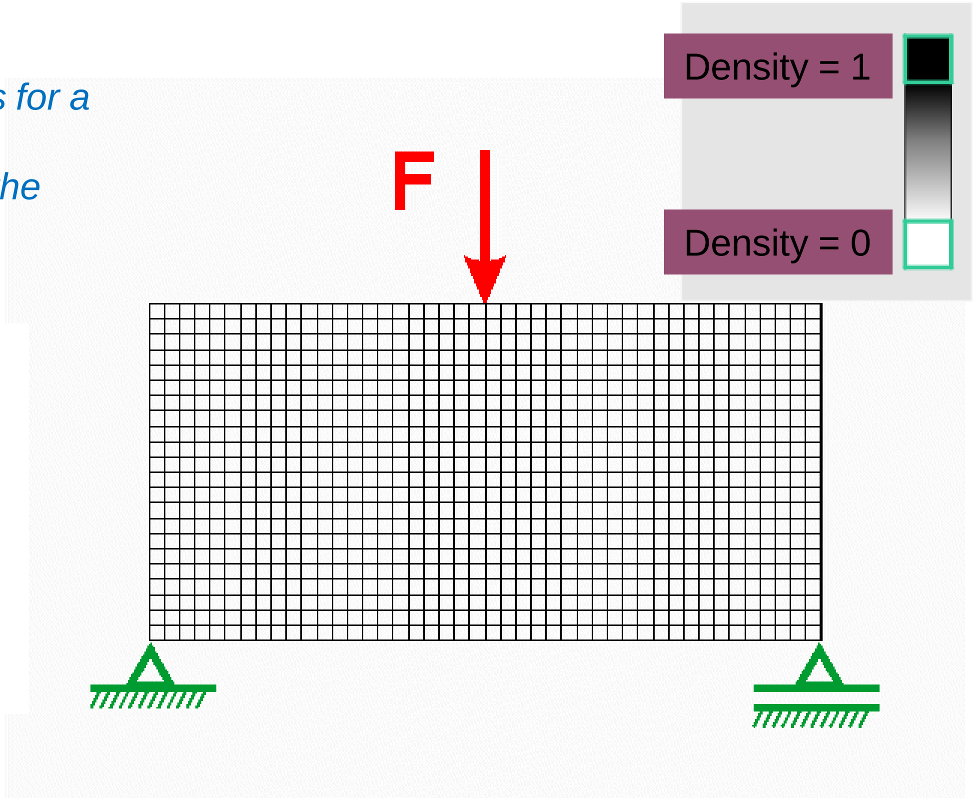
The Additive Manufacturing Design Challenge

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

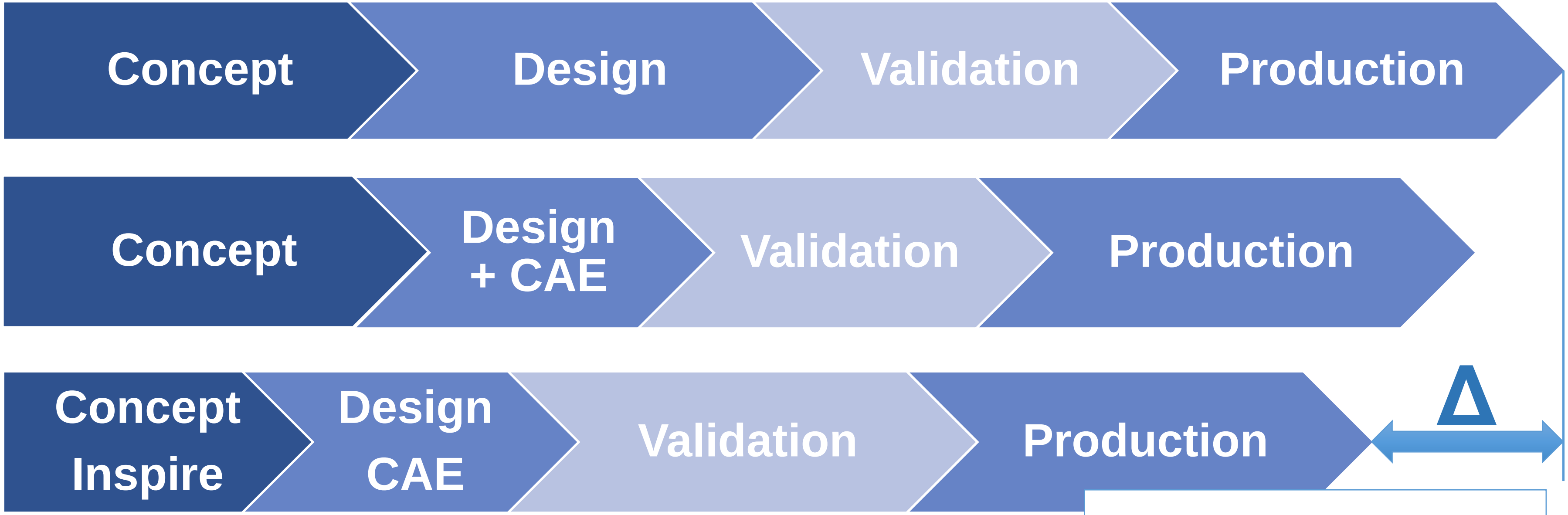
picture by courtesy of Laser Zentrum Nord

Topology Optimization

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



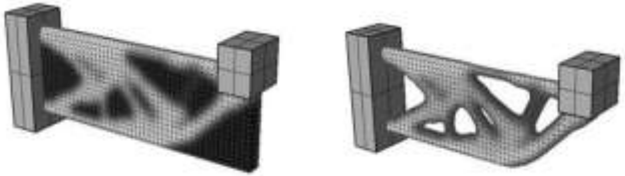
Never too soon to optimize



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

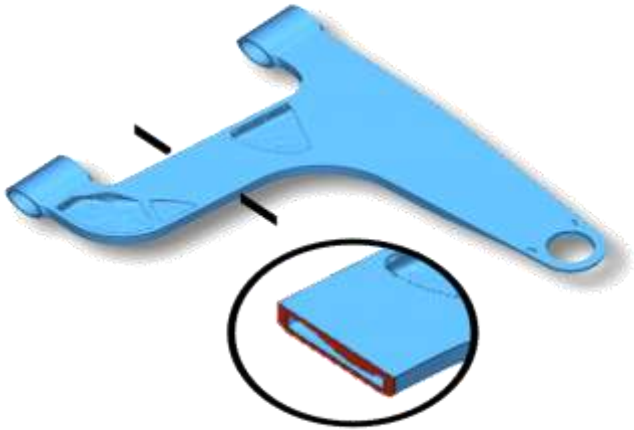
Altair Topology Optimization is OptiStruct

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



Not just an exercise

Make the design Manufacturable

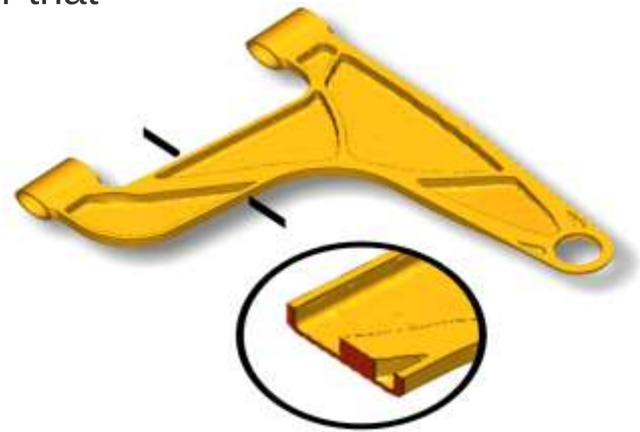


Introducing Manufacturing constraints the final desing has more doable shape for that manufacturing technology,
But with the

Same Performaces

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

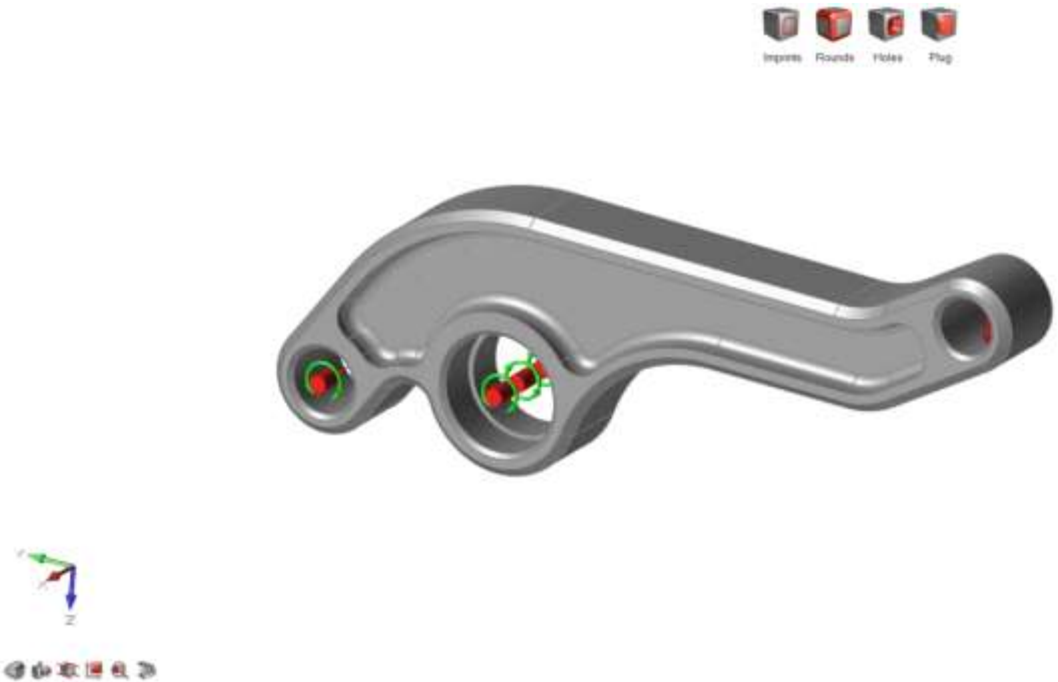
Suitable for Casting - ALM



Suitable for Milling, Stamping

Shape the Inspiration

Model Preparation



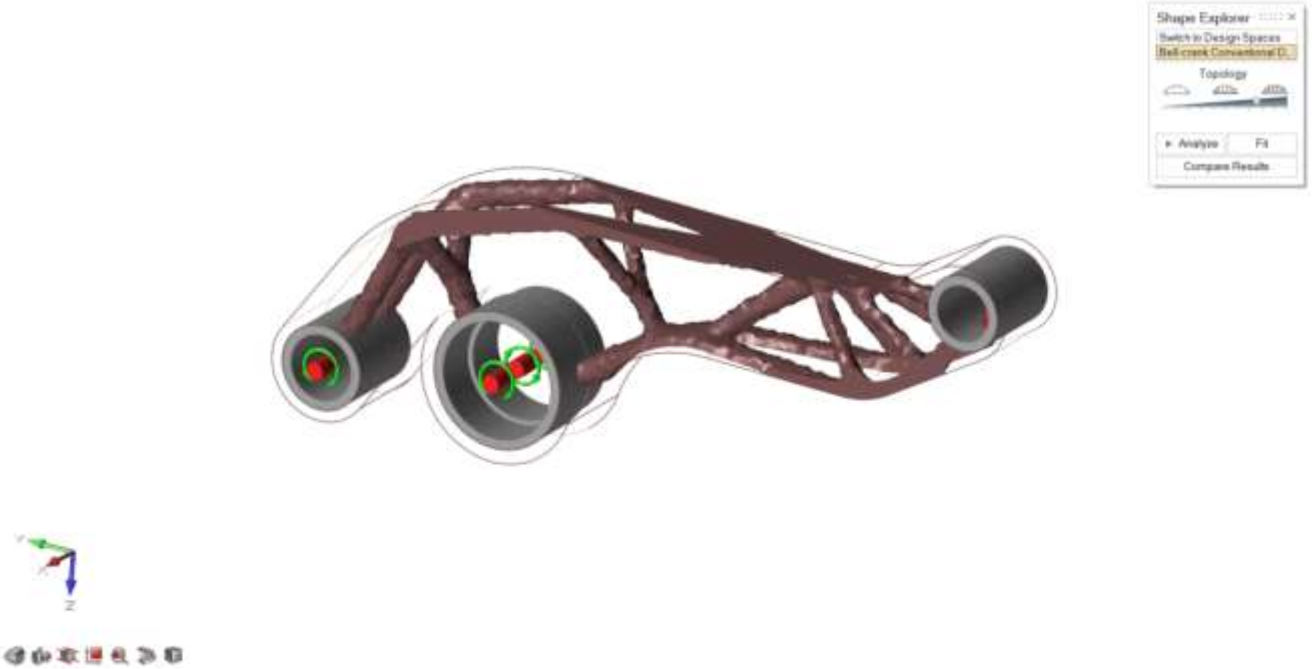
Shape the Inspiration

Model Preparation → Conceptual Optimization

INSPIRE
solidThinking

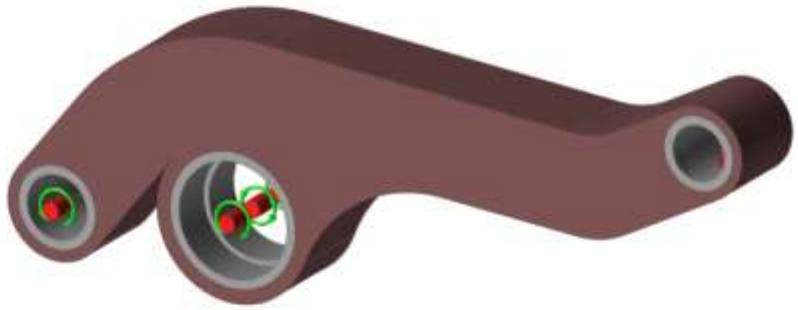
Shape the Inspiration

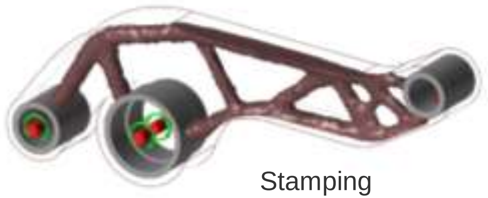
Model Preparation → Conceptual Optimization → Concept Validation



Shape the Inspiration

Model Preparation → Conceptual Optimization → Concept Validation → Concept Modification





Stamping

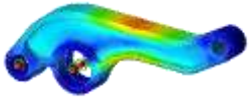
Extrusion

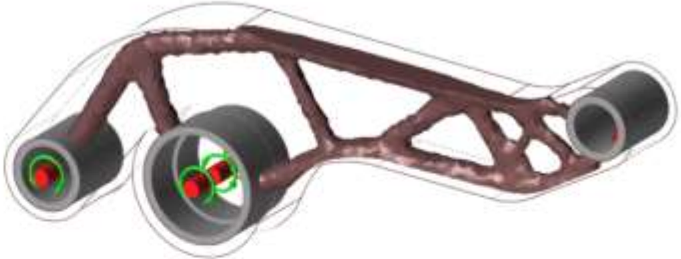
Shape the Inspiration

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	1.499368
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	8.080066

INSPIRE solidThinking

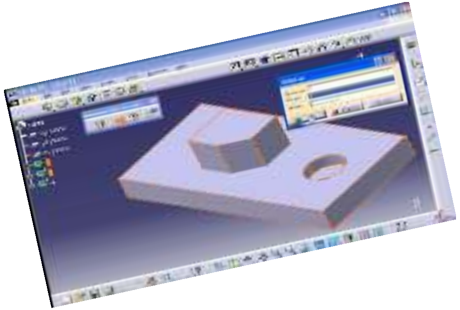
Shape the Inspiration

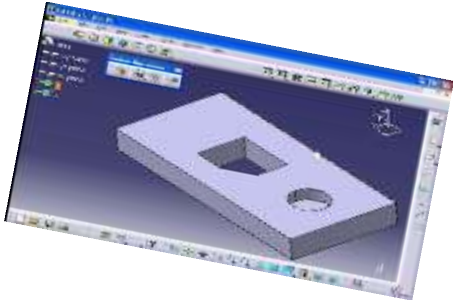
Model Preparation → Conceptual Optimization → Concept Validation → Concept Modification → Compare Results → **Concept Interpretation CAD**

How to sketch such a complex part?

Too Complex

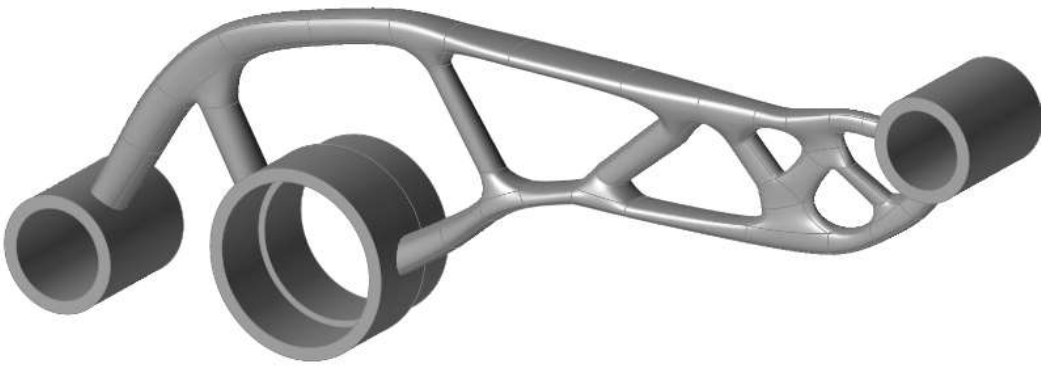
Organic shape





Shape the Inspiration

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



INSPIRE solidThinking

Shape the Inspiration

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

EVOLVE

solidThinking / WHERE IDEAS TAKE SHAPE

Advance geometry recontruction via full PolyNurbs technology and many more

Process Exploration

Is the ALM technology Limitless?

How to consider the NEW Manufacturing Constraints?

Overhang angle Constraint

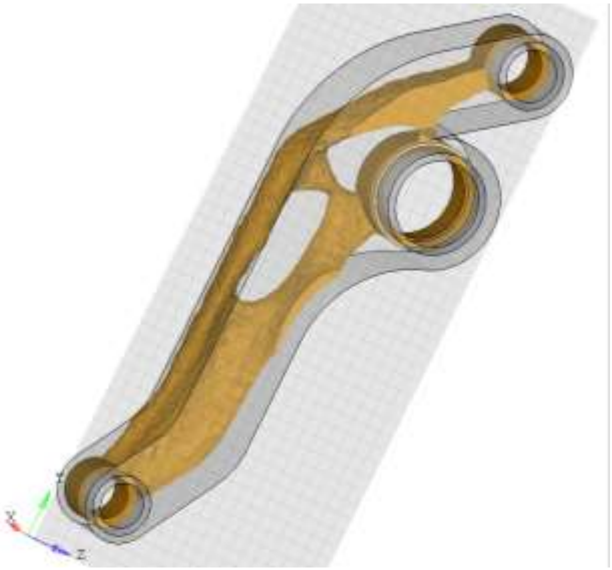
In general supports represent a problem:

- 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



Expansion to third party software

Altair's business model allows for programs such as the Altair Partner Alliance (APA)

Third Party Organizations' products are included under the Altair licensing for seamless access by customers

No additional costs for customers

92% of customers who have access to APA have downloaded an APA product

600 companies downloaded a product they'd never tried before just in 2016

Process Exploration via APA softwares

In ALM process simulation Altair can offer different softwares to manage model recontruction and process simulation.

Materialise	GEONX	additiveworks
Fast and advanced geometry reconstruction starting from STL	Process simulation (Meso and Macro scale)	Process simulation (Macro scale) with Inherent Strain Approach

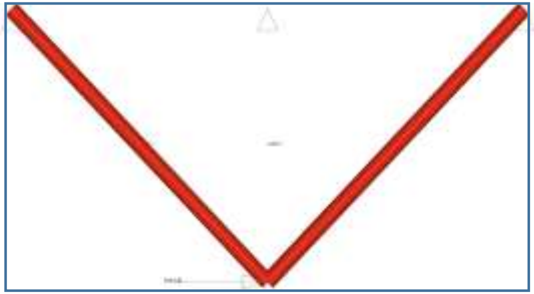
Robust Design

Fail Safe

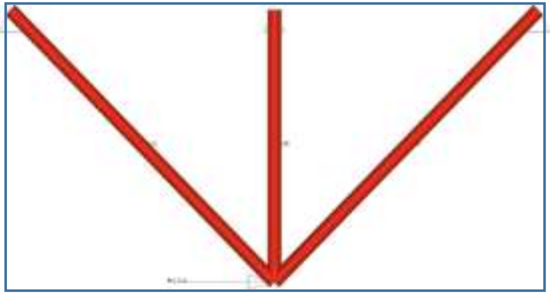
- A fail safe design is one that in an event of failure, responds or results in a way that will cause no or minimum harm

- Fail-safe structure must support 80-100% limit loads without catastrophic failure (*Airframe structural design by Michael NIU*)

Not failsafe

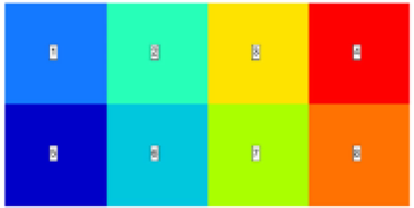


Failsafe

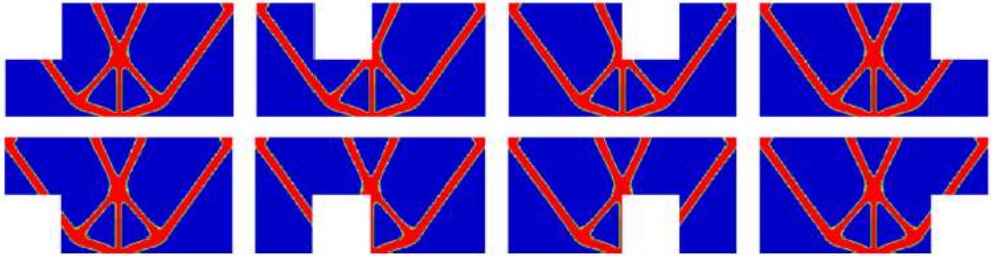


Delta airlines flight 1288, the aircraft suffered an engine explosion however the rest of the plane remained controllable and the most passengers survived unharmed.

Fail Safe Optimization



Setting damage Zones in all the design space



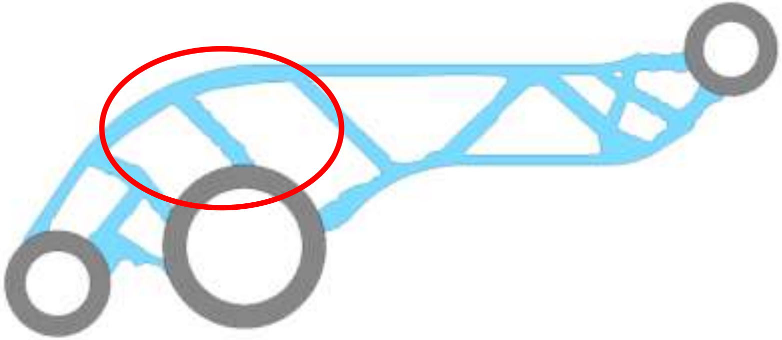
Create several models with defects.
Each variation has to fits the topology optimization requests

Final results is the Optimal compromise amongs all the defected variations
Redundant load-path

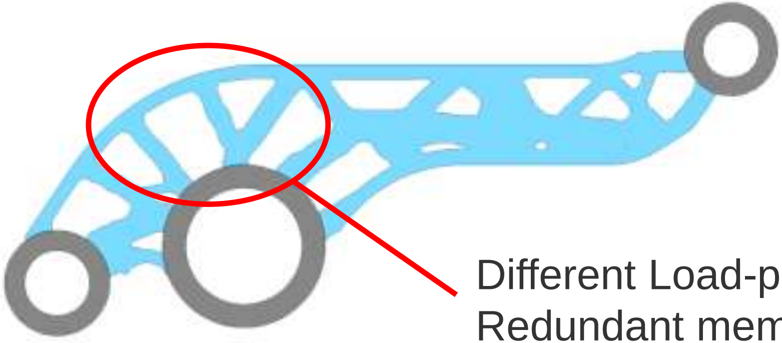
Fail Safe Optimization

Introducing «Defect zones» inside the Design space

Classic Topology Optimization

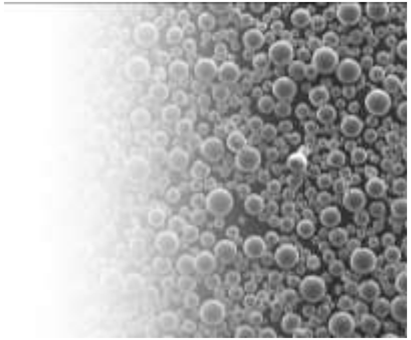


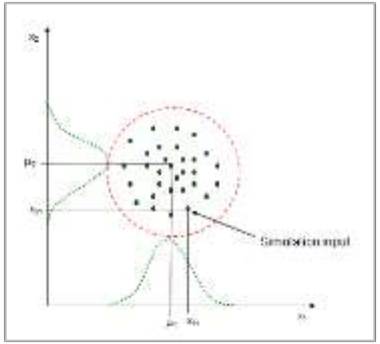
Fail Safe Optimization



Different Load-paths
Redundant members

Robust Design – Topology Optimization (RBTO)



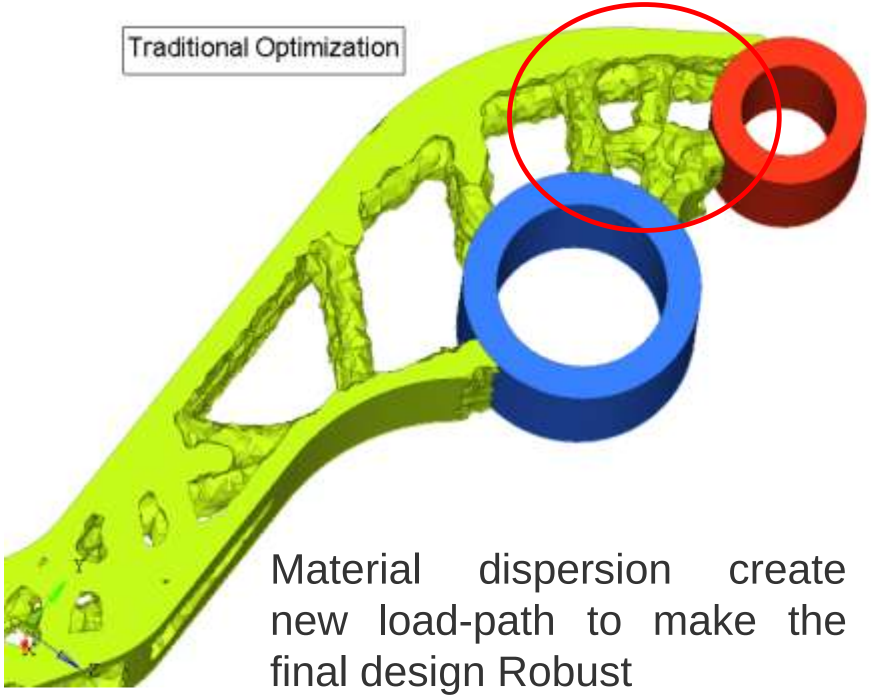


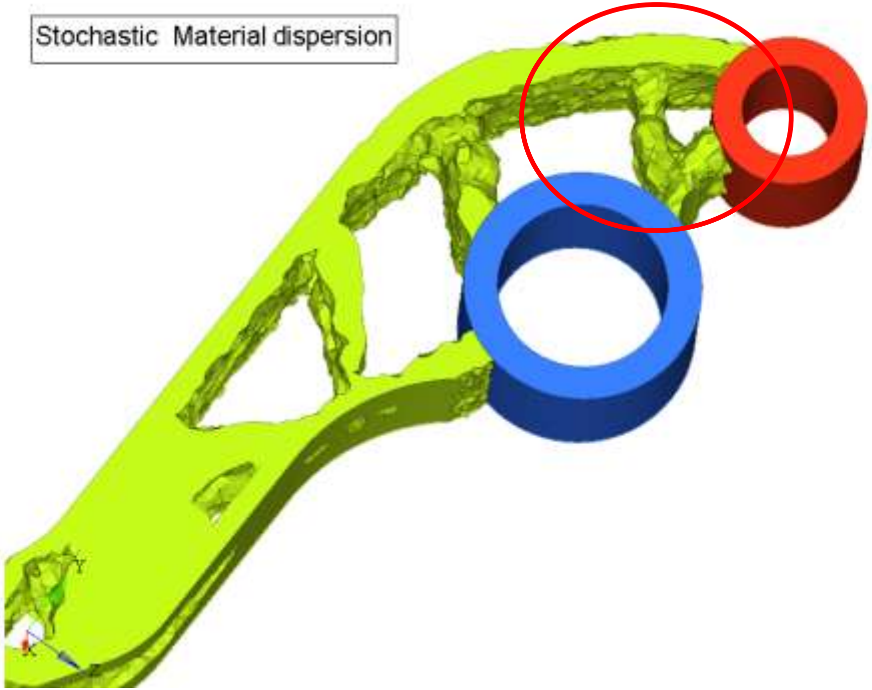
Due to manufacturing process we introduce a set of variable parameters like:

- UTS of the material
- Young Modulus
- Orthotropy (before Heat treatment)

We need to switch to deterministic approach to Stochastic approach since the very beginning as Topology Optimization

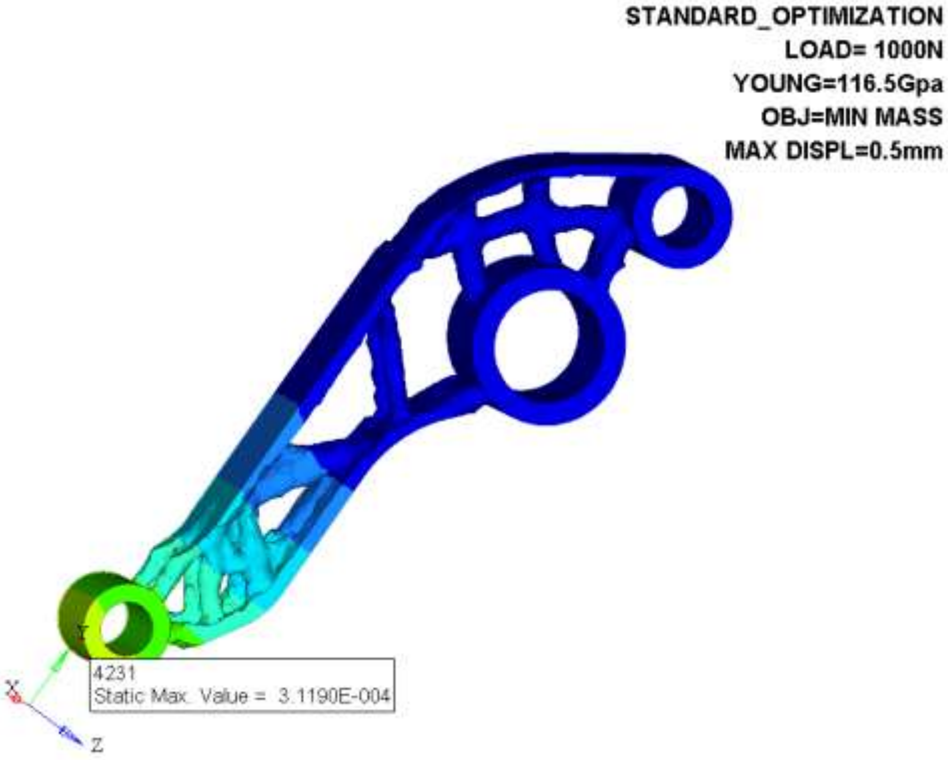
Robust Design – Topology Optimization (RBTO)

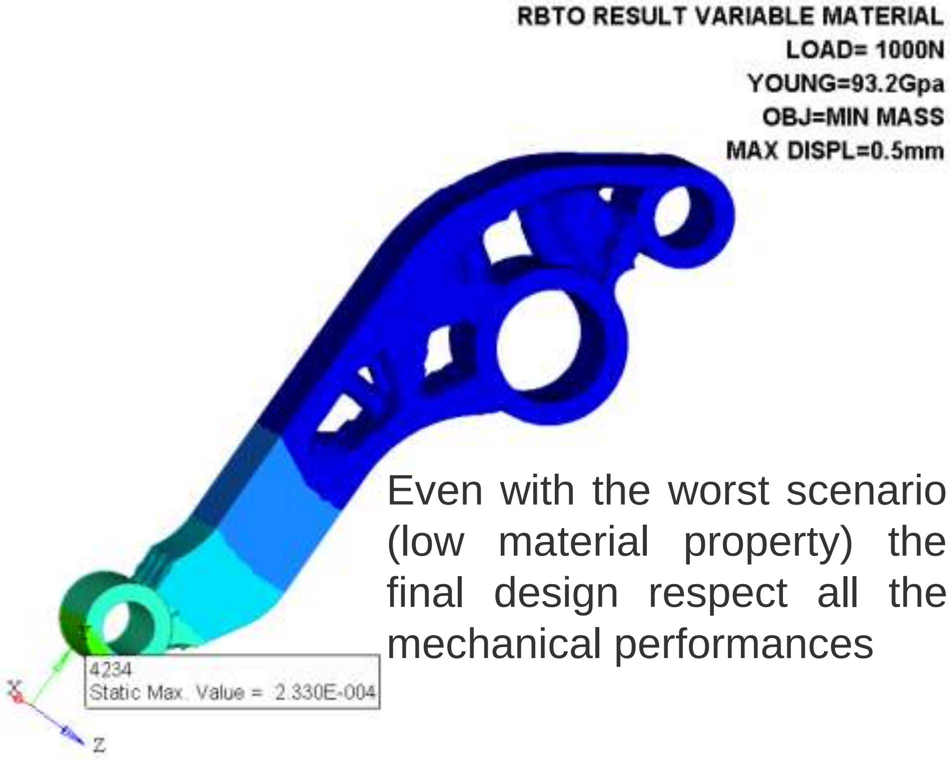




Material dispersion create new load-path to make the final design Robust

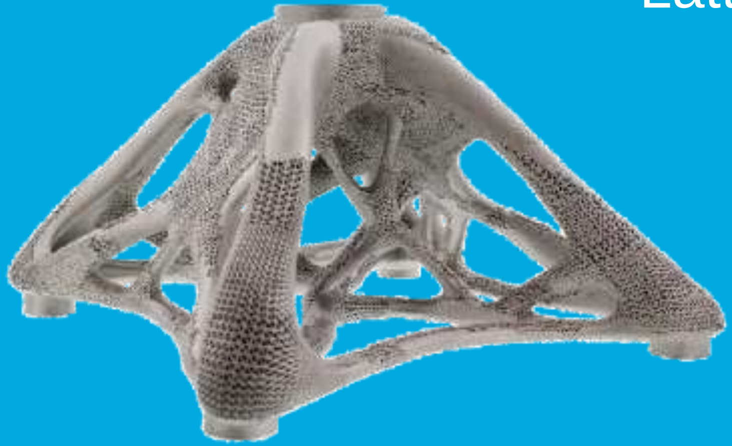
Robust Design – Validation



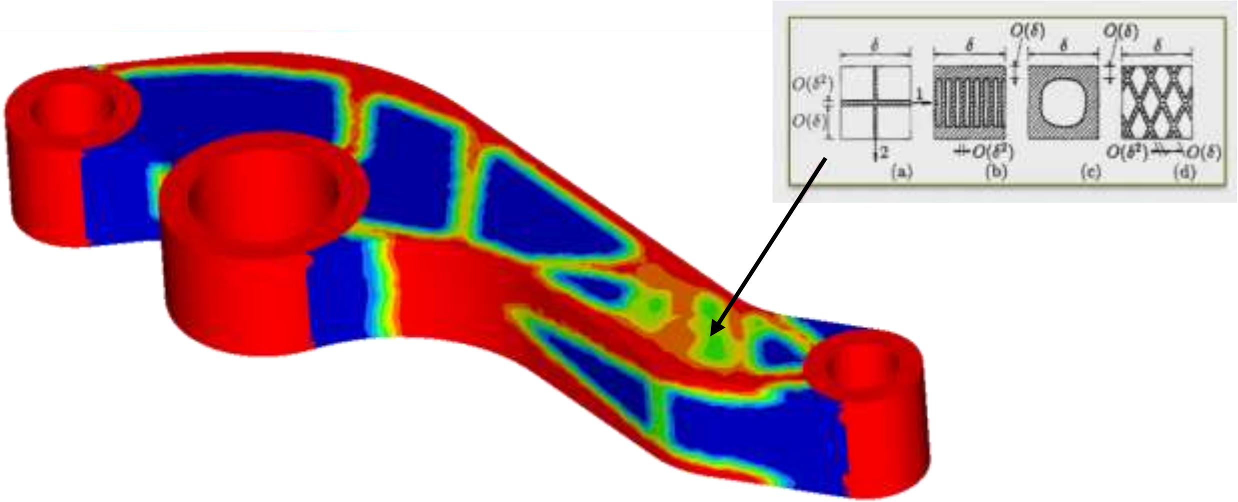


Even with the worst scenario (low material property) the final design respect all the mechanical performances

Lattice Structures



Lattice structures are natural from Topology results

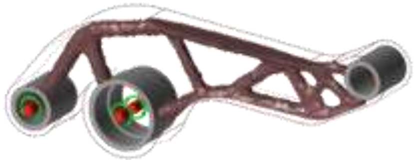


Void ⟷ Lattice ⟷ Solid

Lattice Structure Workflow

Classic ALM redesign process

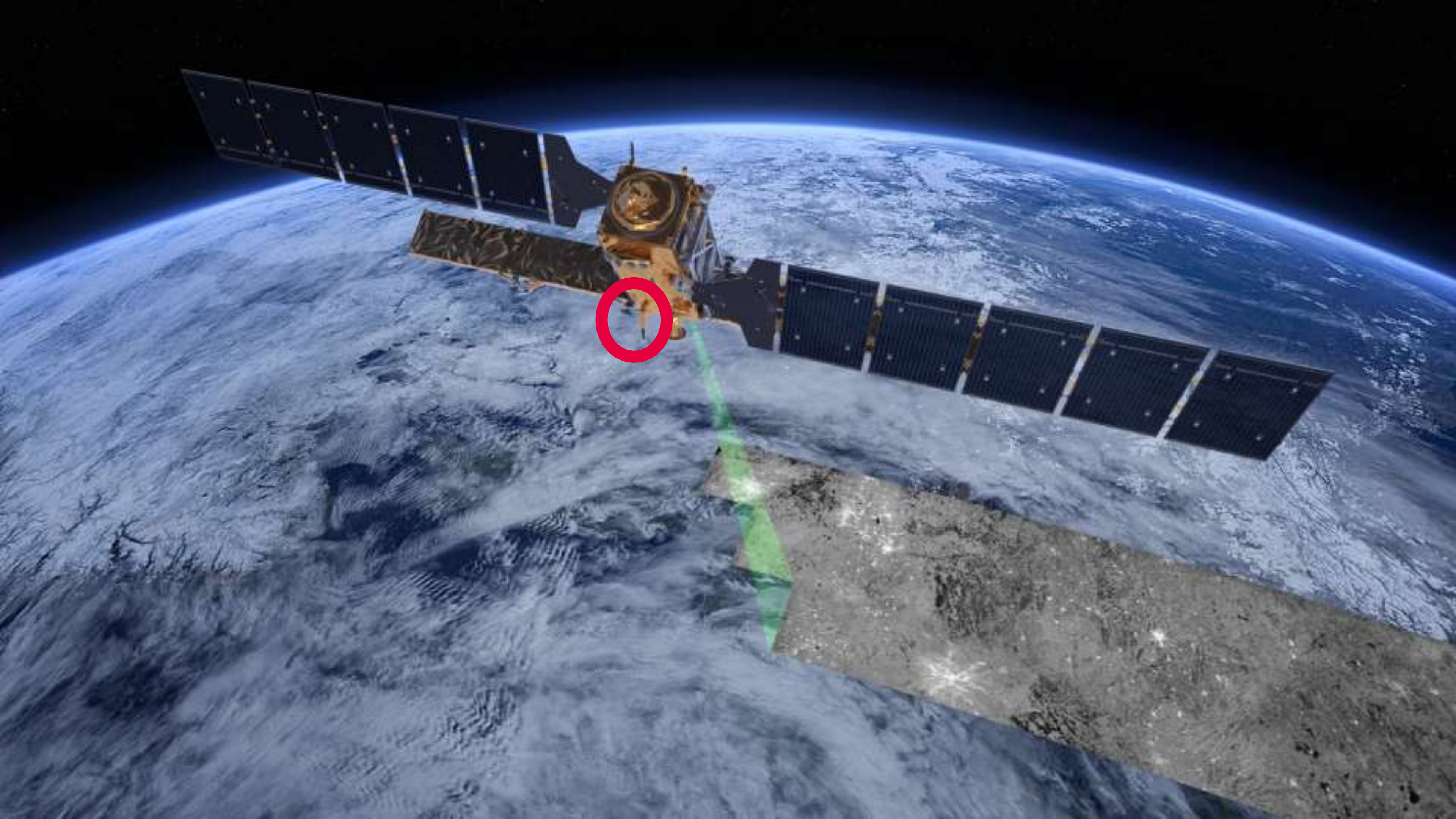
Define desing Space



Topology Results

Geometry Interpretation

How all of this becomes REAL



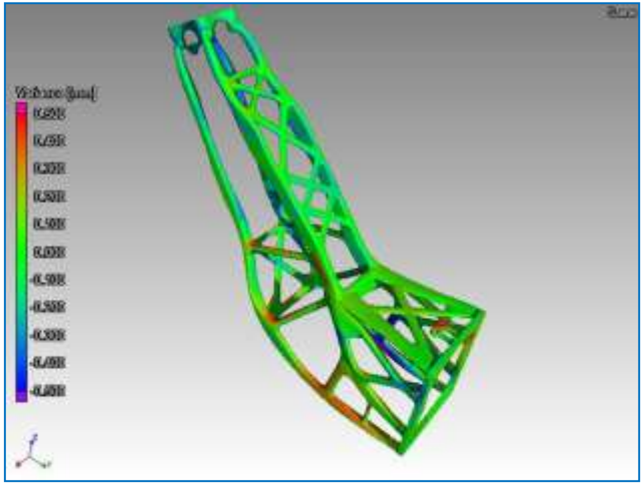
From the Printer into Space

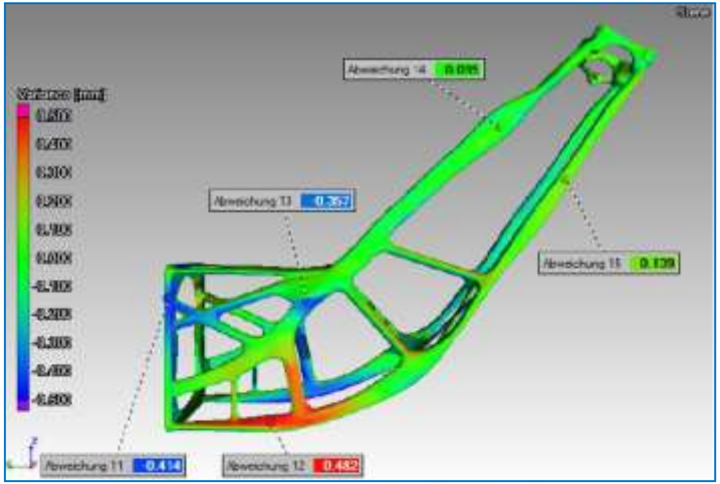
3D Printed Antenna Bracket for Sentinel-1 Satellite:

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

Verification

- Comparison of CAD model with physical model through Computer Tomography.
- Scan resolution of 320 µm





Design process summary

Together ahead. RUAG

Design

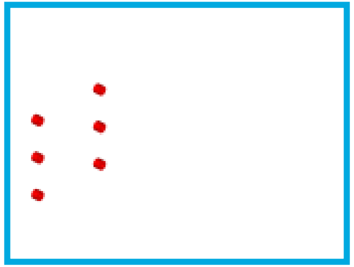
- Functional analysis
- Topology optimization
- CAD Interpretation
- Size/Shape optimization
- Detail stress analysis

Manufacturing

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

Verification / Testing

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



42% Weight save

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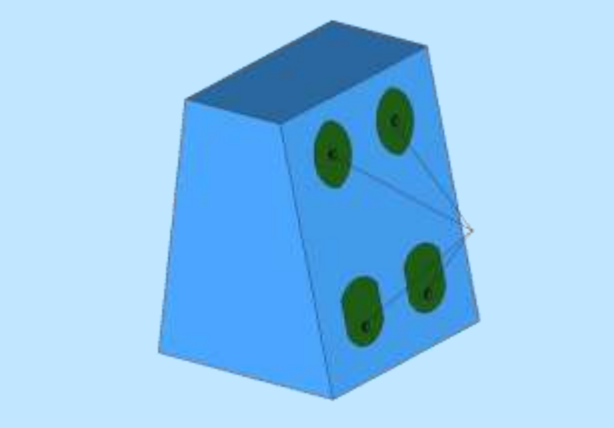
Camera bracket – Optimization model and problem definition

BAE SYSTEMS
INSPIRED WORK



- Material: **Titanium**
- Package Space Defined by Airframe Compartment
- Non-Design Regions to Accommodate Fixings
- Loading and Boundary Conditions Consistent with Baseline
  - Lateral
  - Longitudinal
  - Modal

Objective	**Minimise Mass**
Constraints	**First Mode Natural Frequency** **Longitudinal Displacement** **Lateral Displacement**

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Design process summary