ANIE FEDERAZIONE

CONFINDUSTRIA

La stampa 3D: tecnologia abilitante oggi, tecnologia produttiva domani.

Dalla progettazione alla produzione.

Ferdinando Auricchio
Computational Mechanics &
Advanced Material Group
Università di Pavia

Organizzato da ANIE SERVIZI INTEGRATI

Organizzazione intervento

- **Stampa 3D o manifattura additiva**
  - Descrizione della tecnologia
  - Vantaggi e criticità
- **3D@UniPV: il nostro percorso**
  - Ambito biomedicale
  - Tema strategico di UniPV
  - Creazione di una rete di laboratori
- **Esempi applicativi di interesse industriale**
  - Impatti su concept e progettazione di nuovi prodotti
  - Casi applicativi in diversi settori
- **Forme di collaborazione 3D@UniPV-Impresa**
  - Attività di progettazione / stampa 3D
  - Creazione di un percorso dedicato 3DMetal@UniPV

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

- **Stampa 3D o manifattura additiva**
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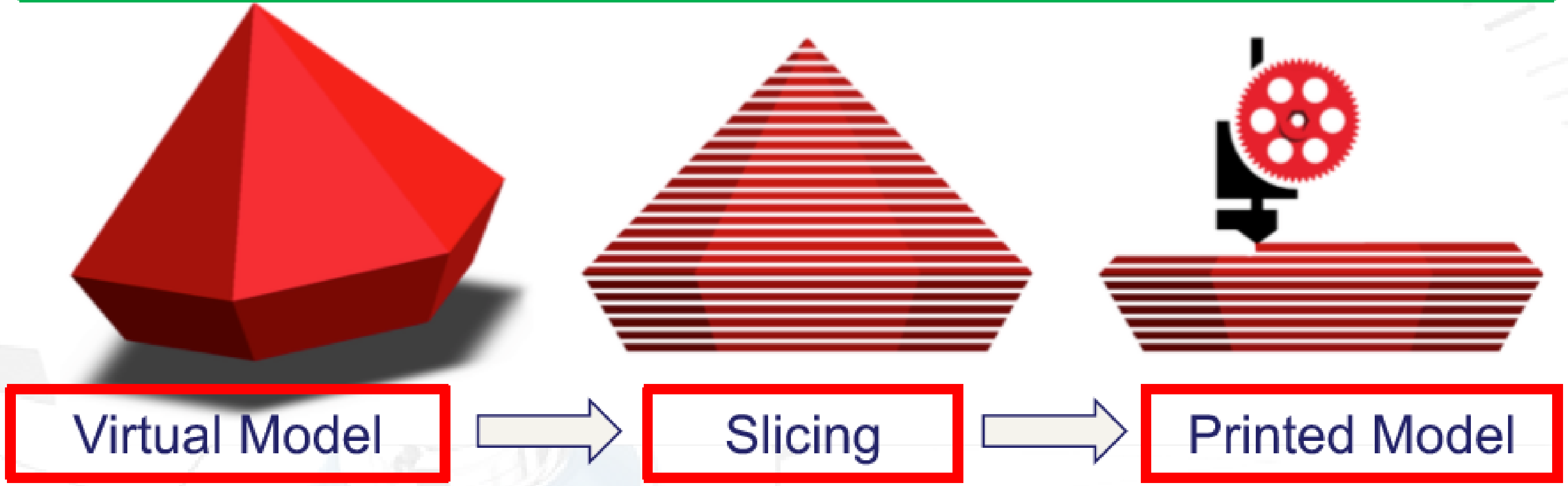
3D printing: general principles

- **3D printing** also known in general as **additive manufacturing**
- in contrast with more traditional subtractive manufacturing such as machining / milling



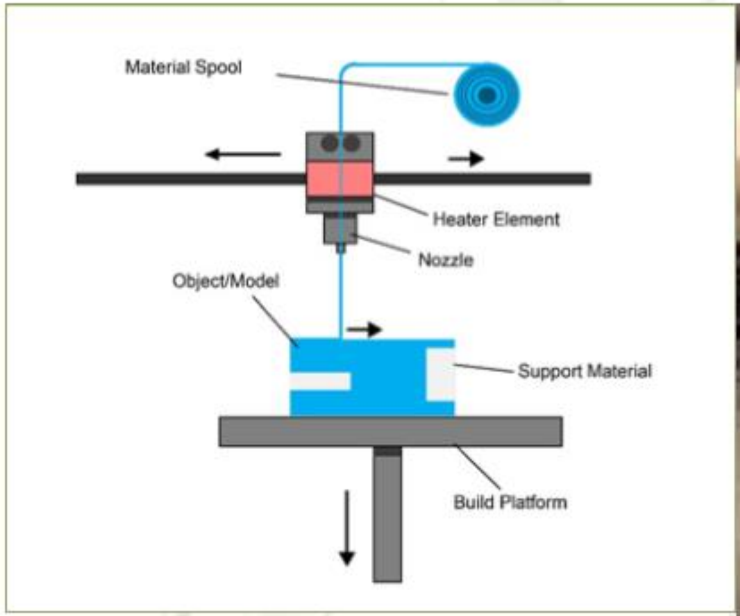
3D printing: some key-words !!

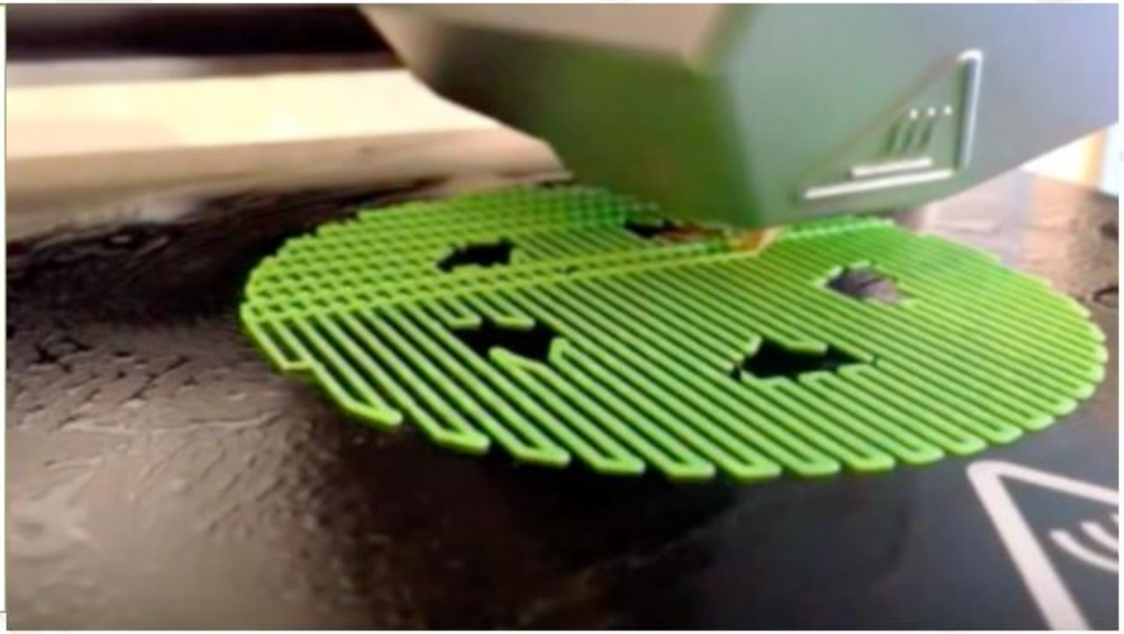
- **DEMOCRATIC TECHNOLOGY**
  - ✓ democratization of manufacturing & production
- **NATIVE DIGITAL TECHNOLOGY**
  - ✓ Technology which was born digital
- **HIGHLY MATERIAL DEPENDENT**
  - ✓ 3DP includes many different technologies due to a broad range of materials

FDM *(Fused Deposition Modeling)* uses a thermo-plastic filament, pushed through a heating chamber and extruded through a small nozzle

- Material: **thermoplastic filaments** (PLA, ABS, HIPS,TPU, TPE, PETG,Nylon, reinforced materials)
- Curing: **temperature gradient**

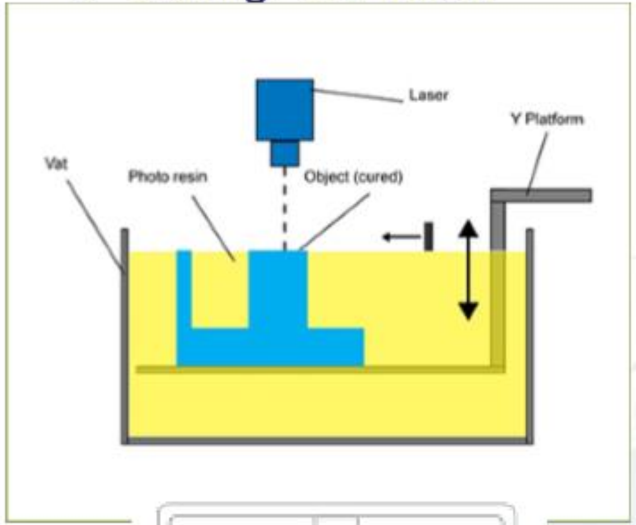
- **Inexpensive** process
- **Low resolution** with respect to other processes

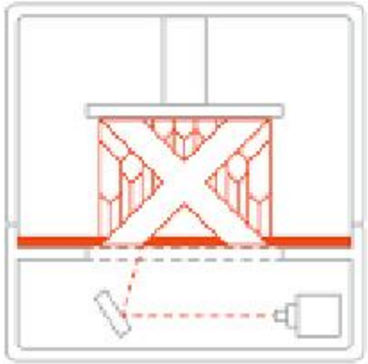




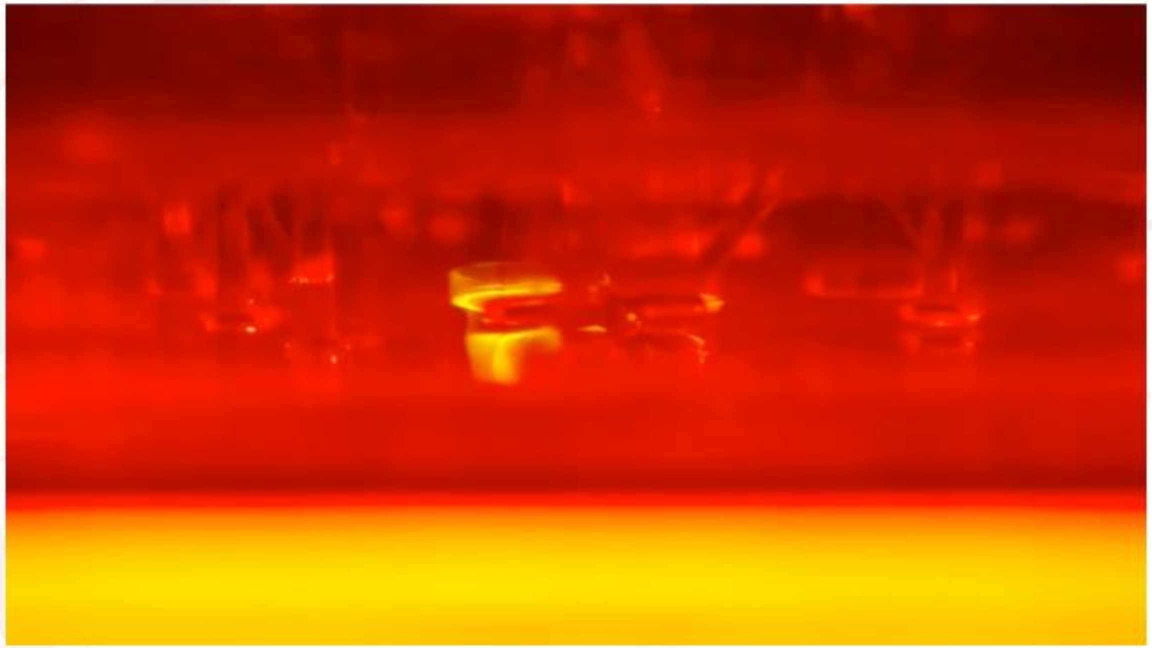
Vat – Polymerization or **SLA** (*stereolithography*) uses a container with liquid photopolymer, cured through UV laser

- Material: **photo-polymeric resins**
- Curing: **UV laser**





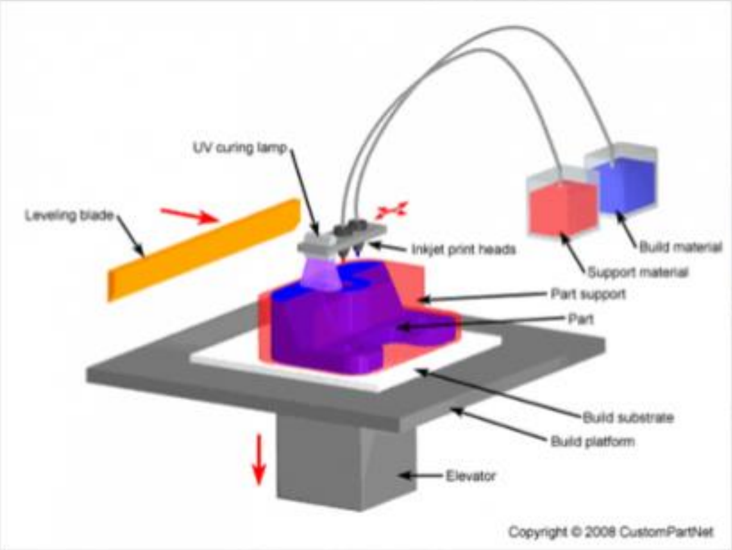
- **Quite expensive** process
- **High accuracy** and good finish
- Only one material at a time

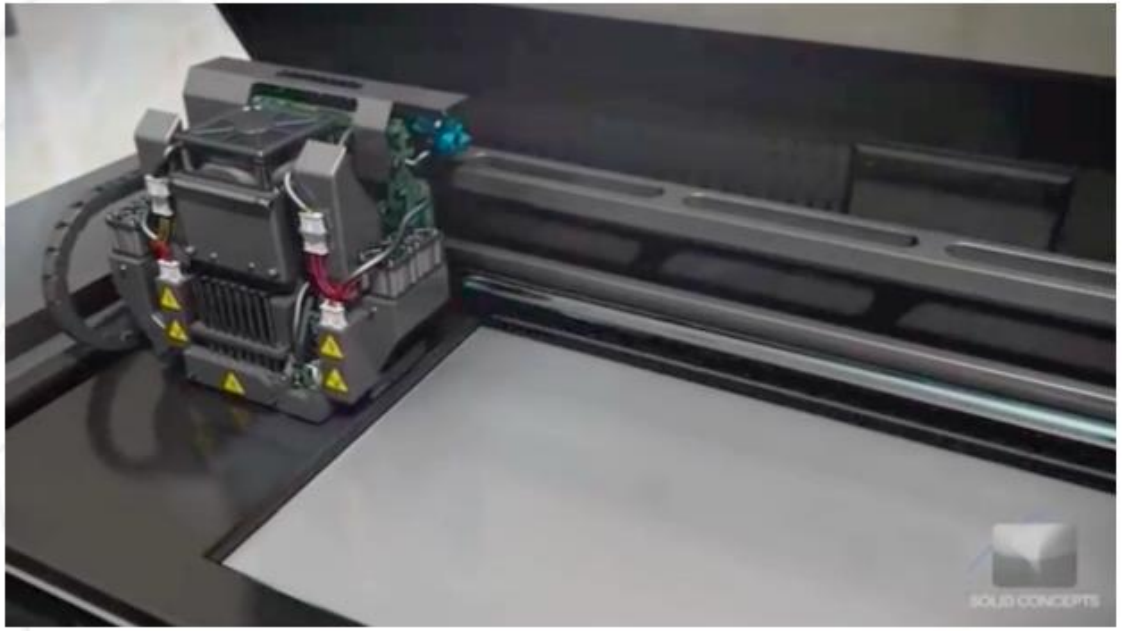


3DP technologies

Material Jetting uses photopolymers that are dropped through small nozzles

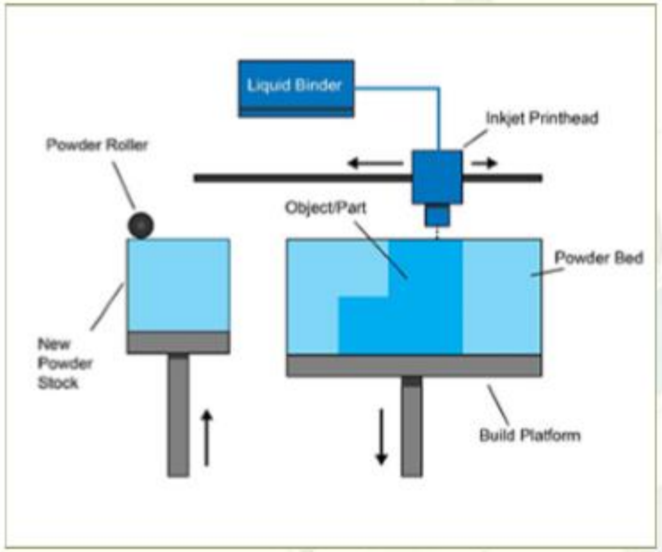
- Material: **photo-polymeric resins**
- Curing: **UV lamp**
- **Highly expensive**
- **Multiple** materials & colours with **high accuracy**

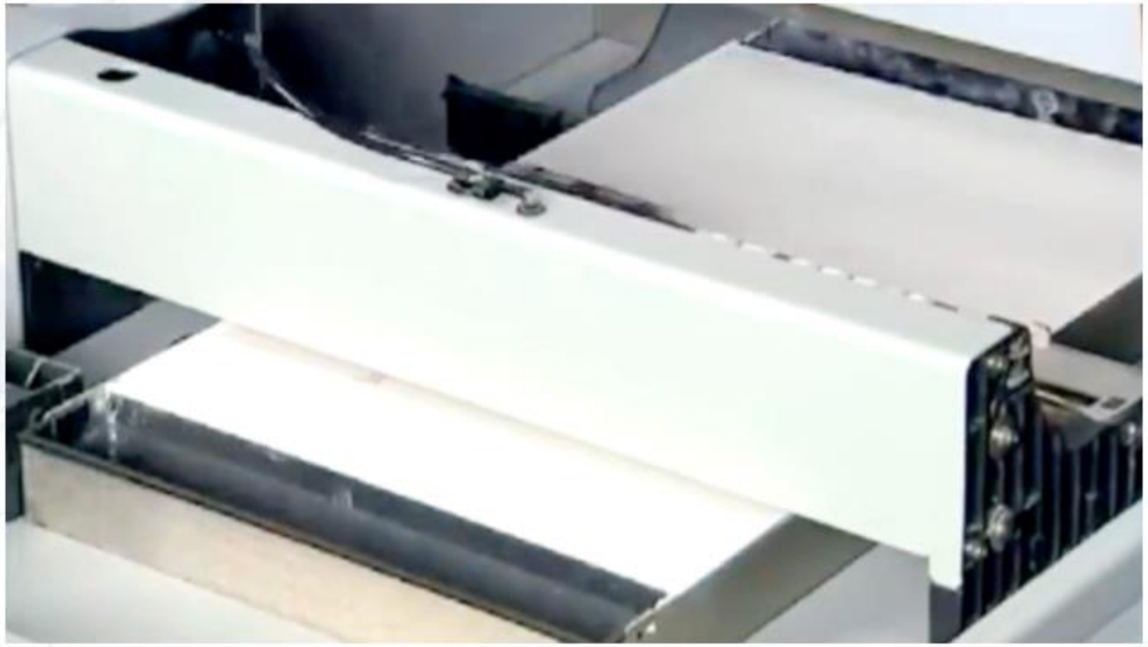




Binder Jetting employs a powder base material and a liquid binder

- Material: **chalk-like** or **plastic powder**
- Curing: **binder (glue)**
- Fast process and good finish
- Parts can be made with a wide range of **different colours** (milions)



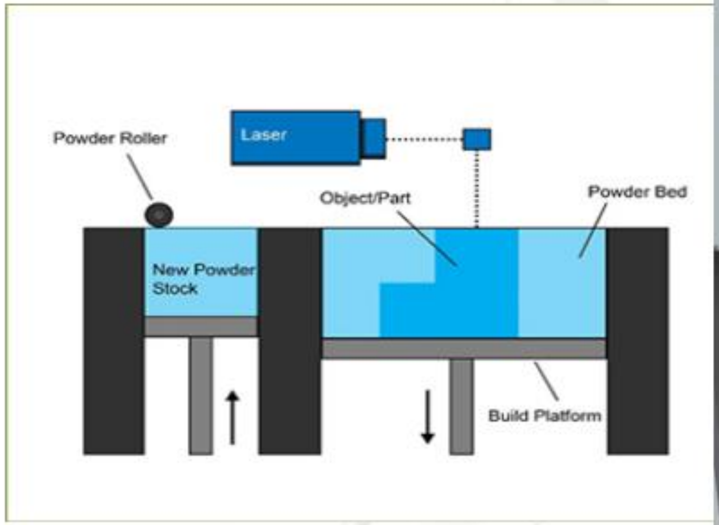


3DP technologies

Power bed fusion uses a laser source to melt powder on a printing plate

- Material: **metal alloys** (Ni, Co, Fe, Al, Steel)
- Curing: **CO_2 laser**

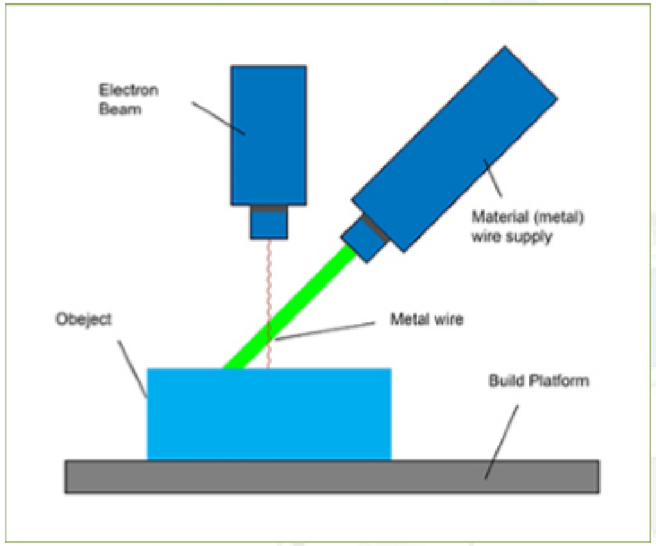
- **Expensive** process
- **Higher precision** but **lower speed** than other metal technologies
- Post-processing required



Directed energy deposition uses an electron beam source to melt powder while it is deployed

- Material: **metal alloys** (Ni, Co, Fe, Al, Steel)
- Curing: **high power electron laser beam**

- **Expensive** process
- **Lower precision** but **higher speed** than other metal technologies
- Post-processing required



Some initial considerations

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  - ✓ 3DP includes many different technologies due to a broad range of materials

3D printing: a huge interest !!

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

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A study from Wanted Analytics (reported by Forbes) [April 2014]

✓ 35% of all ads posted for engineering jobs in the last 30 days prioritize 3D printing and additive manufacturing as the most sought-after skill

AM industry grew 29% (compound annual growth rate) in 2012

AM and 3D printing industry (products and services) worldwide projected value

2015	$4 billion
2017	$6 billion
2021	$10.8 billion

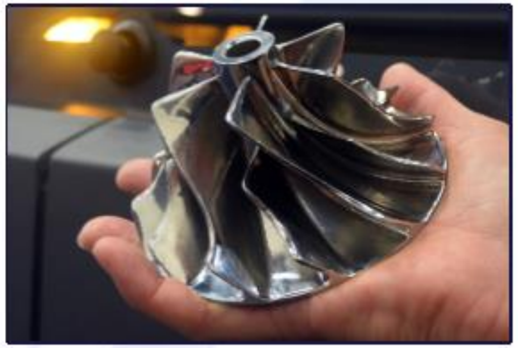
Source: Wohler's Report 2013[3]

- Global AM industry expected to grow $ 4.1 billion in revenue in 2014 & **$12.8 billion by 2018**
- Worldwide revenue to exceed $21 billion by 2020 (*Wohlers report 2015)*

A clear evident strong interest on 3DP. Why??

Prototyping vs production

3D Printing technologies → **Prototyping**



Standard technologies → **Production**

Prototyping vs production

3D Printing technologies → **Prototyping**

3D Printing technologies → **Production**

Metal 3DP: material features

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ALLOYS PROPERTIES

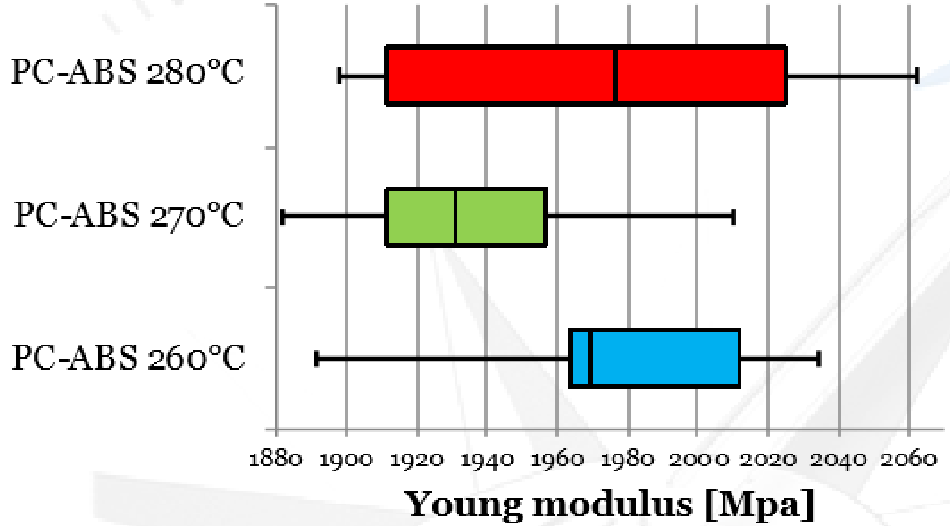
Aluminum AlSi12 — Mechanical Properties

PARAMETER	TRADITIONAL PART	3D PRINTED PART	3D PRINTED AFTER HEAT TREATMENT
Yield Strength	131 MPa	270 MPa	180 MPa
Ultimate Tensile Strength	290 MPa	480 MPa	240 MPa
Elongation at break	3,5 %	5,5 %	20 %
Hardness	80 HB	137 HB	90 HB

Data from: MatWeb MATERIAL PROPERTY DATA — 3DSYSTEMS

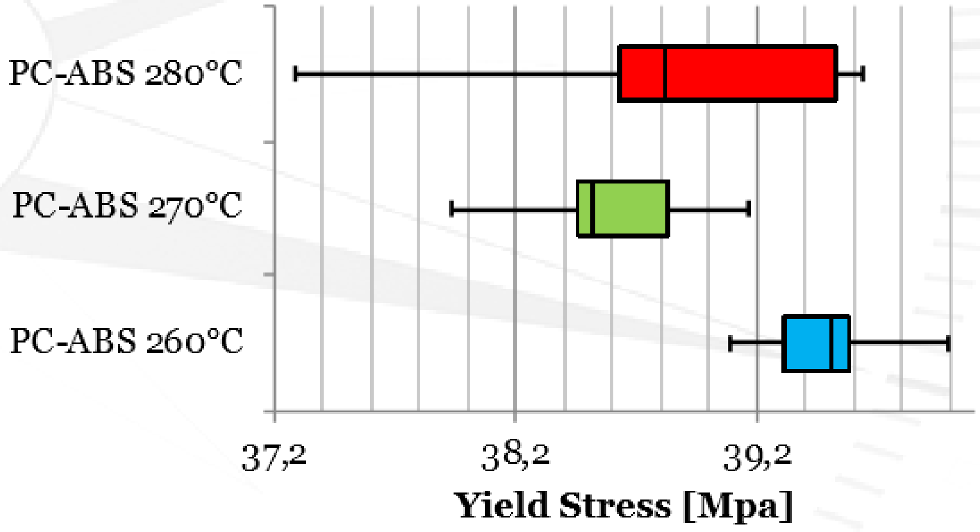
Plastic 3DP: material features

Material properties of specimens produced with FDM



Young modulus obtained from traction tests on dog bone specimens

- Investigated material: PC-ABS,
- Material extruded at different temperatures
- 5 different deposition paths has been considered for each extrusion temperature



Conclusions:

- The extrusion temperature has not a great influence on the Young modulus and the Yield stress
- Measurement uncertainty increases with the extrusion temperature

Plastic 3DP: material features

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

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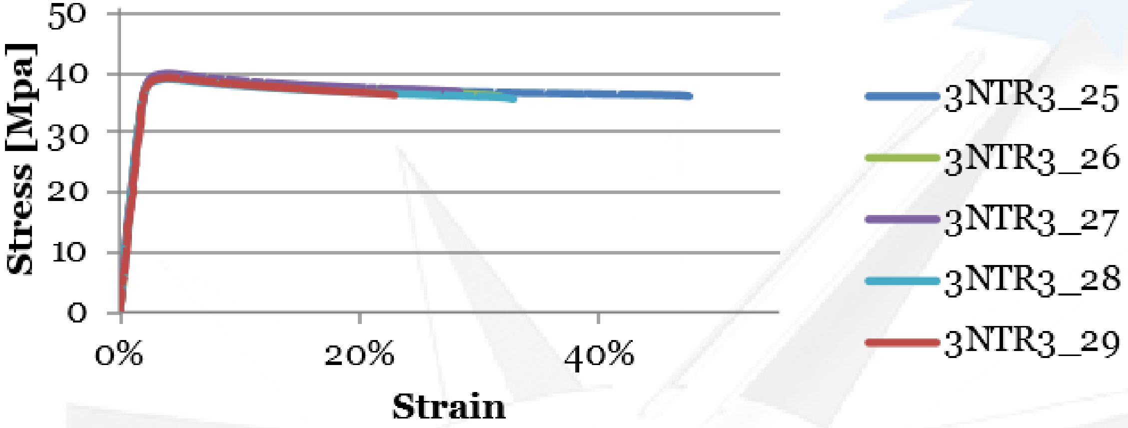
Material properties of specimens produced with FDM

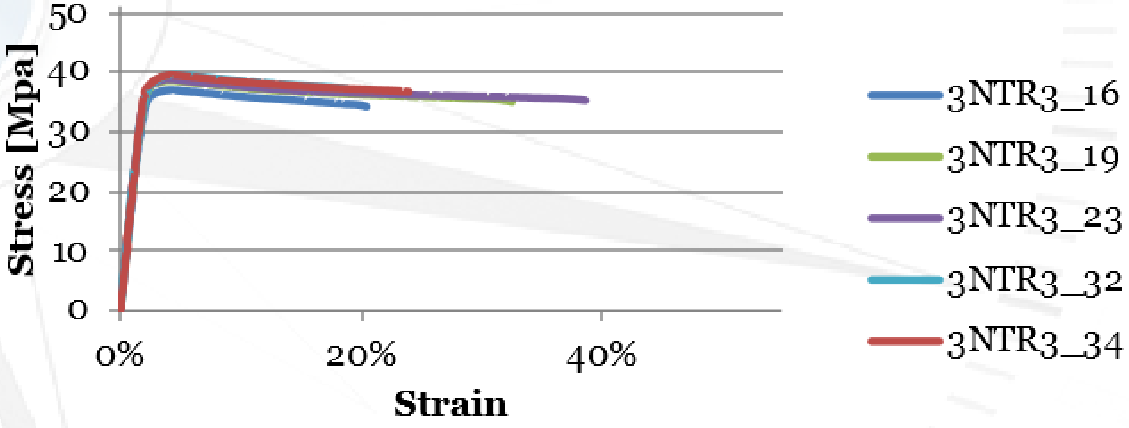
PC-ABS 260°C



Stress strain curves obtained from traction tests on dog bone specimens

- Investigated material: PC-ABS,
- Material extruded at different temperatures
- 5 different deposition paths has been considered

PC-ABS 280°C



Conclusions:

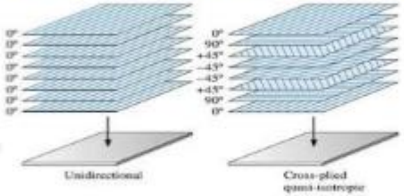
- The extrusion temperature has a great influence on the ductility of the specimens, while it has almost no influence on the yield stress
- By tuning the extrusion temperature it is possible to obtain different ductility propoerties

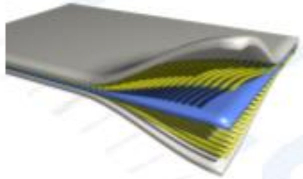
Architectured materials

MATERIALS vs STRUCTURE

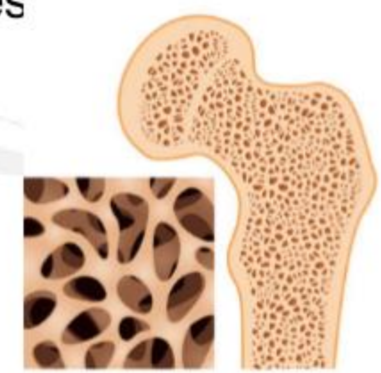
MATERIALS and STRUCTURES

Laminates / Composites





- **Inspiration by nature**: relatively small number of natural materials vs large quantity of available structures, showing wide range of properties



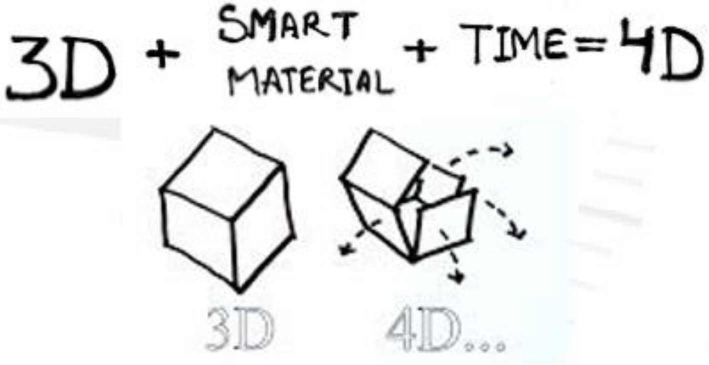
Architectured materials: combinations of two or more materials, or one material and space (pores), designed to display attributes not offered by one material alone

From 3D printing …

3D PRINTING or ADDITIVE MANUFACTURING: allows the creation of 3D objects with complex shapes

… to 4D printing

4D PRINTING: adding a new capability (transformation) to **multi-material** 3D printing



Civil engineering & 3D-printing

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3D Printing in Civil Engineering

Arnhem Station (Arup)

Modular elements

3D printed brick for the Quake Column designed by Emerging Object

Architectural purposes

Beijing studio Laboratory for Creative Design fabricated silkworm-inspired pavilion for the city's 2015 Design Week

Optimization

3D printed curve wall, University of Southern California

Stampa 3D a bordo della stazione orbitante

Portal: progetto realizzato da *Made In Space*, azienda americana nata con lo scopo di portare la manifattura additiva nello spazio: sperimentazione utile per verificare la possibilità di produrre pezzi di ricambio in orbita

http://corriereinnovazione.corriere.it/tech/2014/21-novembre-2014/stampante-3d-bordo-stazione-orbitante-230584475104.shtml

//www.futureengineers.org/

- Programma NASA utilizzato anche per promuovere i temi Stem (science, technology, engineering and math) nella scuola

3D@UniPV
Virtual Modeling and Additive Manufacturing for Advanced Materials

3D bio-printing

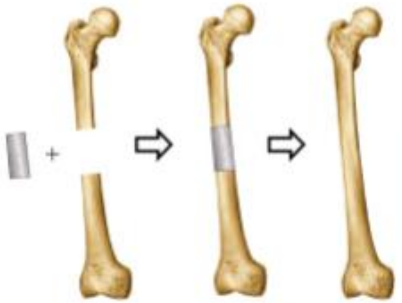

Figure: Image-based tissue engineering of human ear cartilage. Comparison of photograph (left), digitized image (middle), and tissue engineered ear cartilage after two weeks in culture.

- **Tissue engineering:** combination of cells, engineering, materials to improve or replace biological functions
- **Scaffolds:** artificial structure capable of supporting three-dimensional tissue formation on which cells are often implanted or 'seeded'. These structures are often critical

Problem: limit to which cells can penetrate 3D scaffolds

Idea: cells and scaffold maybe "printed" together

- **Bio-printing challenge: keep cells viable & functional during printing**
- Cells: extremely sensitive to various external factors, i.e., temperature and pH
- Cells: under loading, damage may result in changes in cell functions

- **2007:** First bio-printing company, Organovo, founded
- **2009:** Organovo released first commercial bioprinter (NovoGen MMX BioprinterTM)
- **2010:** Organovo demonstrated **feasibility of printing blood vessels**
- **2014:** Organovo published data on a **3D printed liver model**, 500μm thick, complete with microvasculature network, producing proteins & cholesterol

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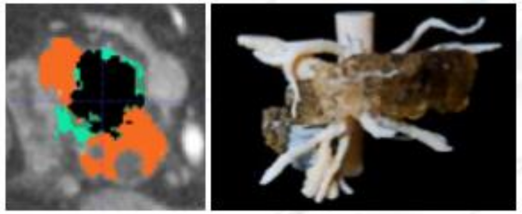
Timeline

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

2011



Master Thesis of Eng. S. Marconi: Virtual Reconstruction of Pancreatic Tumors

2013

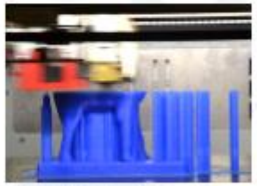
Ministero della Salute

"Pancreas Project" funded by Italian Minister of Health

2015

A Strategic Theme for UniPV

2016



PROTOLAB: First Prototyping Lab

2016

UNIVERSITIAMO by UNIPV

Crowdfunding Campain

2018

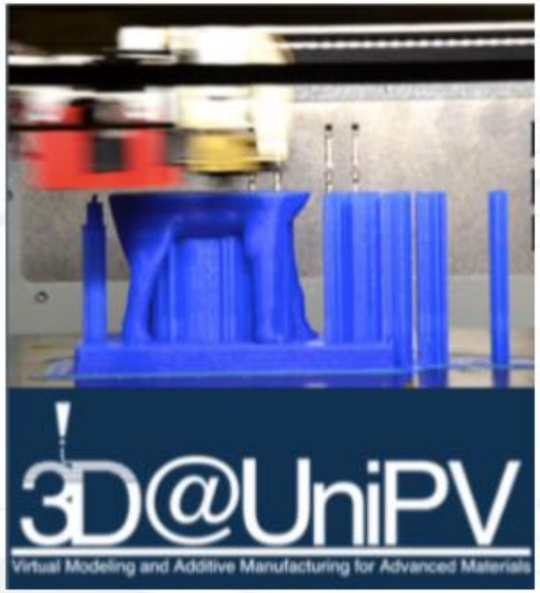
3DMetal@UniPV

2018

3D4MED

UniPV Strategic Theme

Virtual Modeling and Additive Manufacturing for Advanced Materials

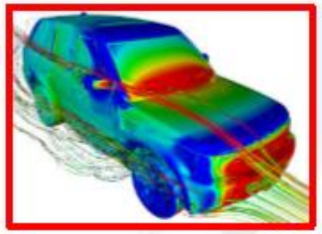


Web http://www.unipv.it/3d

3D@UniPV: university strategic theme

Modeling & Simulation

1



5 PILLARS

5

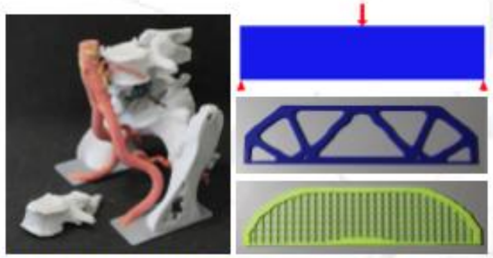
In collaboration with:
Prof. Denicolai
Prof. Hagen
(UniPV)

Socio-Economic Impact

2

In collaboration with:
Prof. Anselmi-Tamburini (UniPV)

New Materials



Many fields of applications from medical to mechanical and civil engineering app.

4

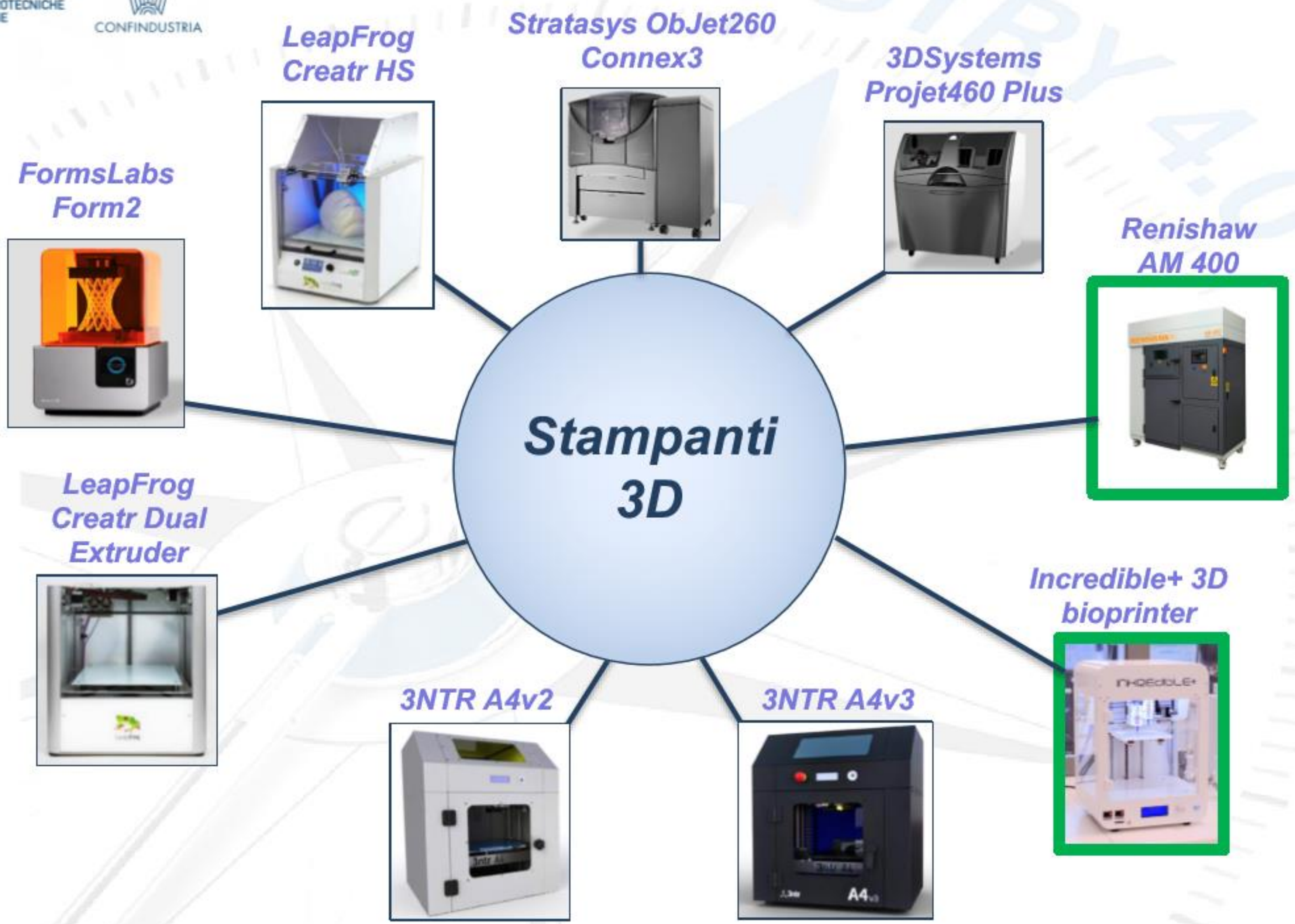
Applications

3

Manufacturing

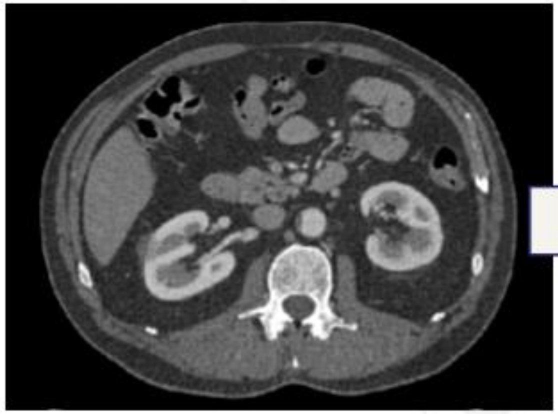
Collaboration with many companies:
7 printers (4 technologies)
1 SLM metal printer

Available 3D printers



3D4MED: How?

A **new instrument** for surgical planning, training and simulation.



MDTC Scan

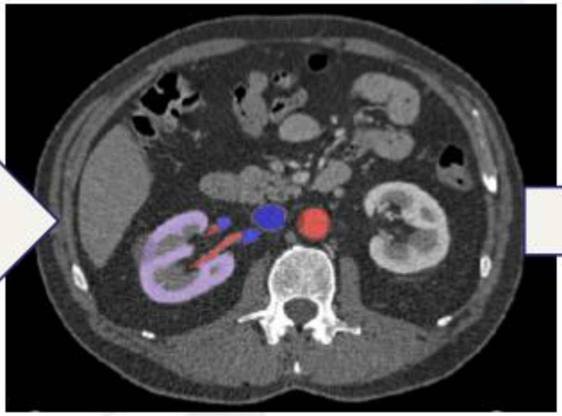
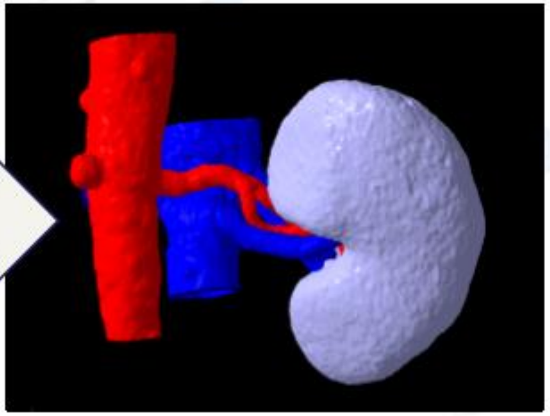


Image Segmentation



3D Virtual Model

3D Printed Model

Surgical Planning, Simulation & Training

Minimally Invasive Robotic Surgery

3D4MED: Why?

The 3D printed model **helps the surgeon** in:

Intra – operative navigation

Surgical planning

Communication with patients

Surgical training and simulation

3D4MED: To Whom?

Our 3D printed models are made for **any medical specialty**. We have several years' experience in the following areas, to date:

Abdominal Surgery

Vascular Surgery

Otolaryngology

Orthopedics

Abdominal Surgery	**> 45** clinical cases	Orthopedics	**> 10** clinical cases
Otolaryngology	**> 15** clinical cases	Vascular Surgery	**> 35** clinical cases

... but it is possible to reproduce **many others anatomical structures**!

3D4MED: the Lab

3D4MED is the **first Clinical 3D Printing Lab** in Italy
and one of the first worldwide.

It is located at the **DEA building** of **IRCCS Policlinico San Matteo** of Pavia and it has a strategic position to improve its **visibility** (to disseminate the new proposed service) and **centrality** (to facilitate the collaboration between surgeons and engineers).

DEA Building
0 floor – tower B

3D4MED Lab

3DConcrete@UniPV: a new Lab

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

Università degli Studi di Pavia

RegioneLombardia

The project purpose is to use emerging 3D printing technologies to offers a quick and cost-efficient way of building structures

- Robotic Control
- Optimized Materials
- FreeForm Architecture

Etesias: a new spin-off

In collaboration with D.Asprone & C.Menna (Federico II) & Materias

Concrete-beam 3D Printing

Federico II experiment

Vesuvio RC Beam: 3D printing

Concrete components 3D Printing

Assembly and rebars

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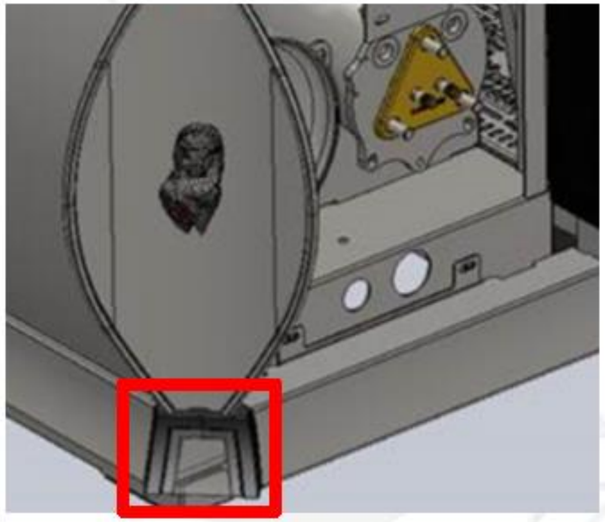
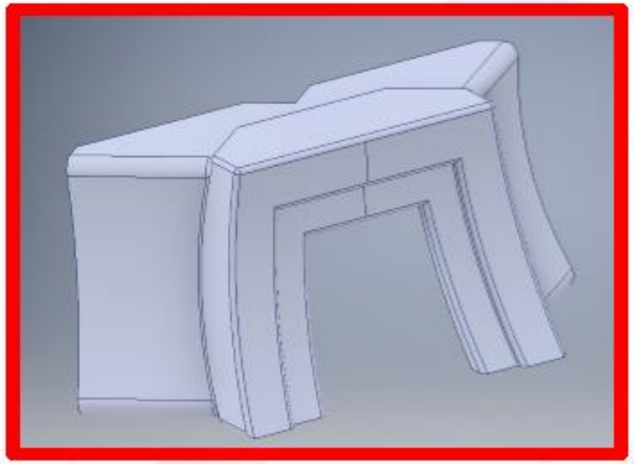
CONFINDUSTRIA

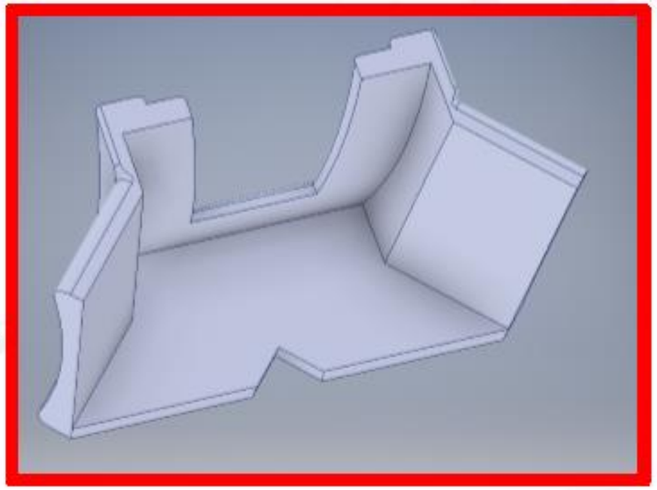
Coffee machine component - 1

Original prototype where redesigned and prepared for AM production

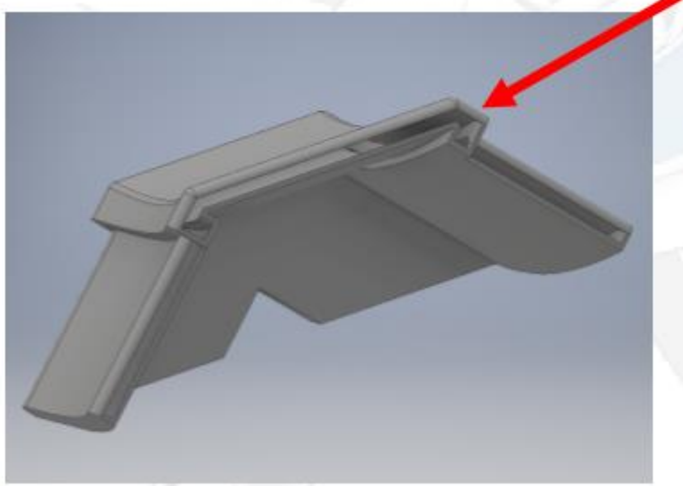




Original component in Stainless Steel

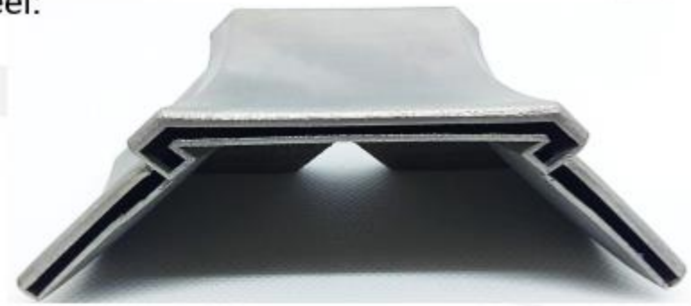


The component was **lightened** relying on exclusive features of **AM**



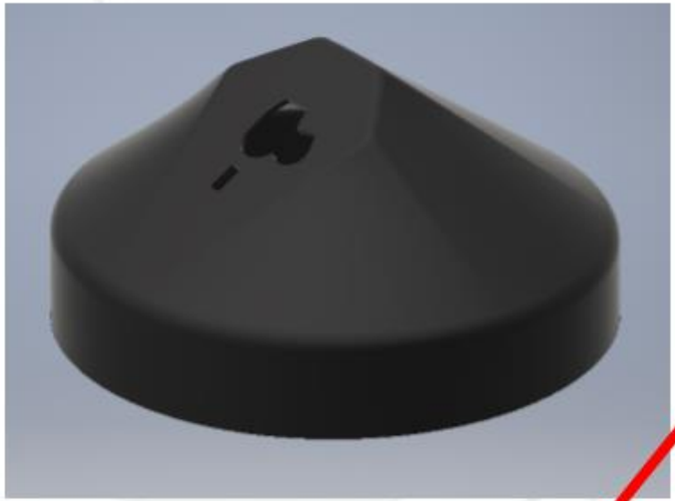
AM component in Stainless Steel:

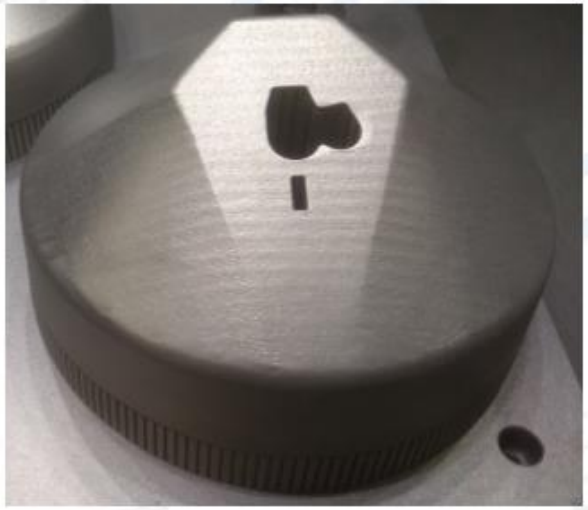
- **60% MASS REDUCTION**
- **Around 50% TIME SAVED**
- **Reduced number of post processing operations**



Coffee machine component - 2

Component designed and optimized for AM production





AM component in Stainless Steel:

- **thin skin**
- **supports** needed only **on the perimeter** of the component

AM component after **post processing operations** and after **installation on the machine**!!

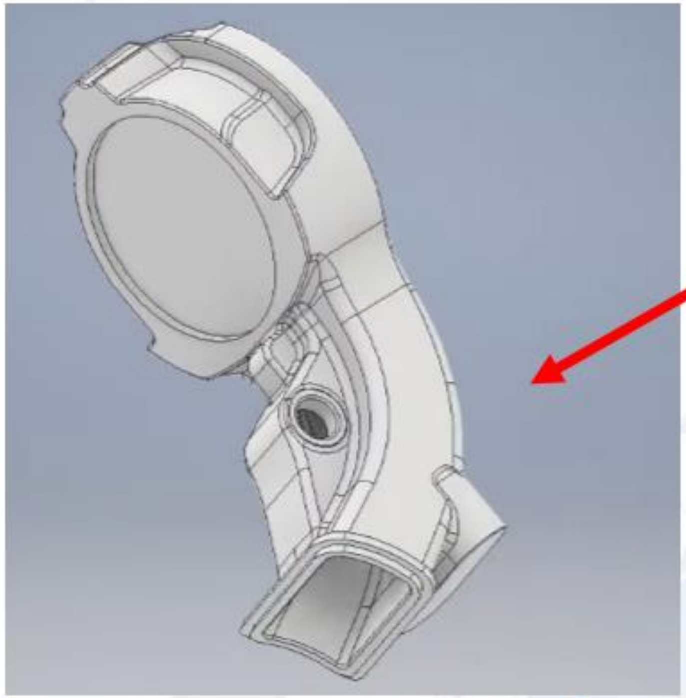
Time for producing the component:

- **Original: 8 weeks** for the final component
- **AM: 1 week** for the final component

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE
CONFINDUSTRIA

Coffee machine component - 3

Component produced with traditional processes.

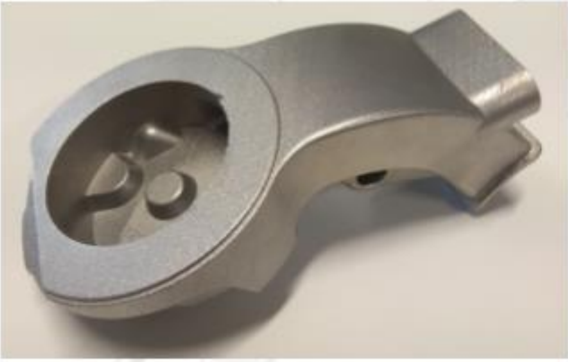


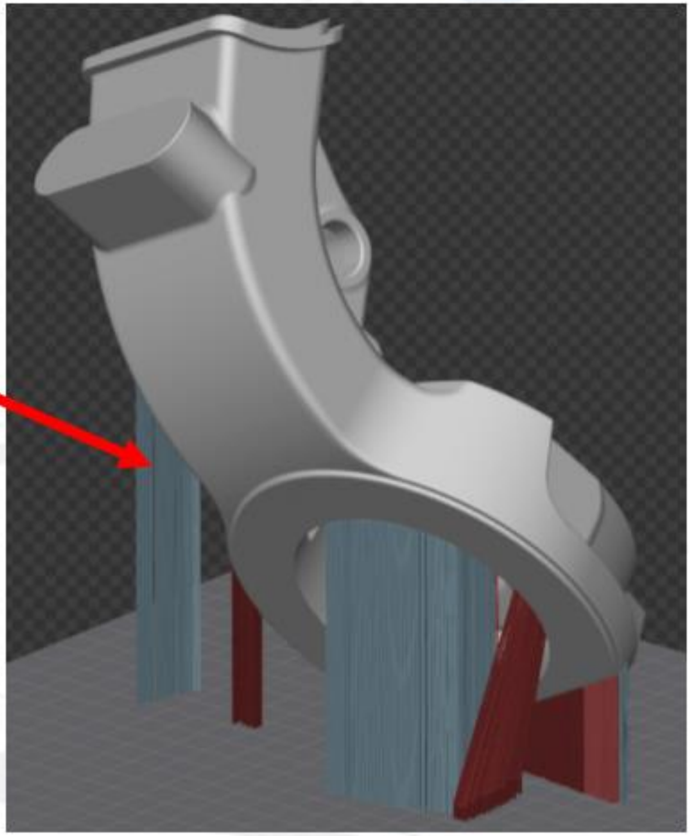
Original component in Stainless Steel:

- constituted of three parts welded together

AM component in Stainless Steel:

- constituted of **One part**
- has been oriented using a **specific algorithm** in order to **avoid internal supports**





With AM:

- **Overall production time drops from 3 weeks to 3 days**
- **Reduced numbers of post processing operations**

Coffee machine component - 4

Material: Stainless Steel.

GOAL - 1: to increase internal temperature

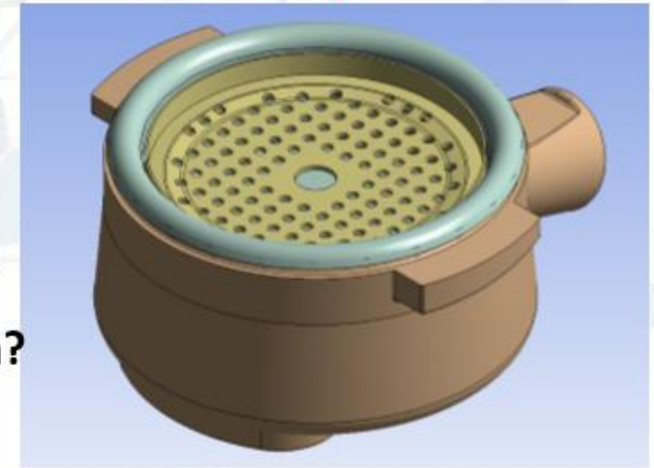
GOAL – 2: to reduce the external temperature in order to avoid accidents for the barman

Original component

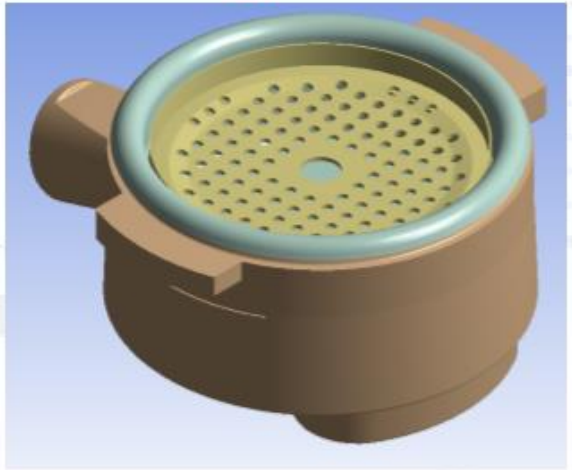
How to validate the design?

How to achieve the GOALS?:

- With **thermal shape optimization** we have developed TWO SOLUTIONS



GOAL - 1: internally warmer



GOAL - 2: externally colder

INDUSTRIAL CASE STUDIES

Coffee machine component - 4

Material: Stainless Steel.

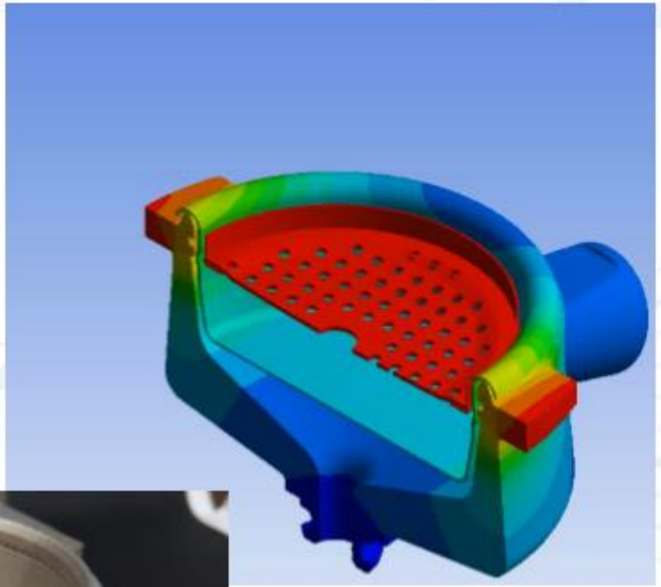
GOAL - 1: to increase internal temperature

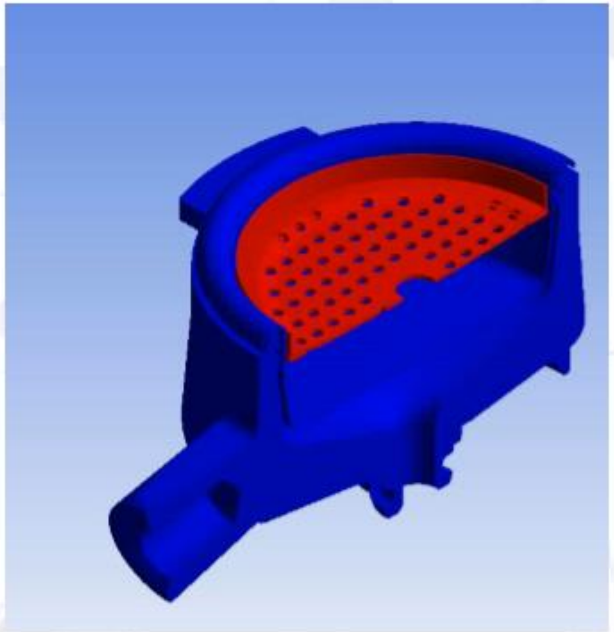
GOAL – 2: to reduce the external temperature in order to avoid accidents for the barman

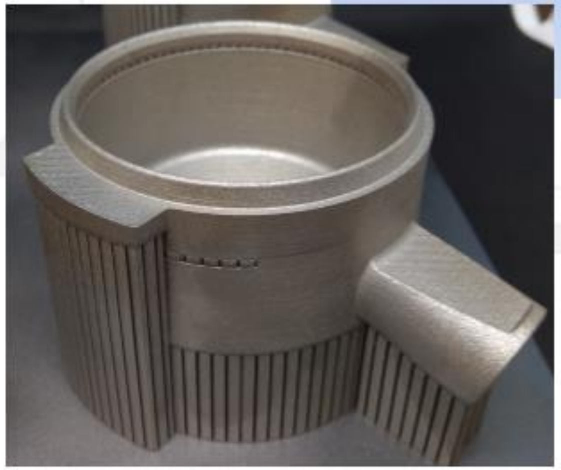
How to define optimized design?

By non-linear transient thermal simulation with FEM

ANSYS







AM component in Stainless Steel:

- **able to respect the GOALS**

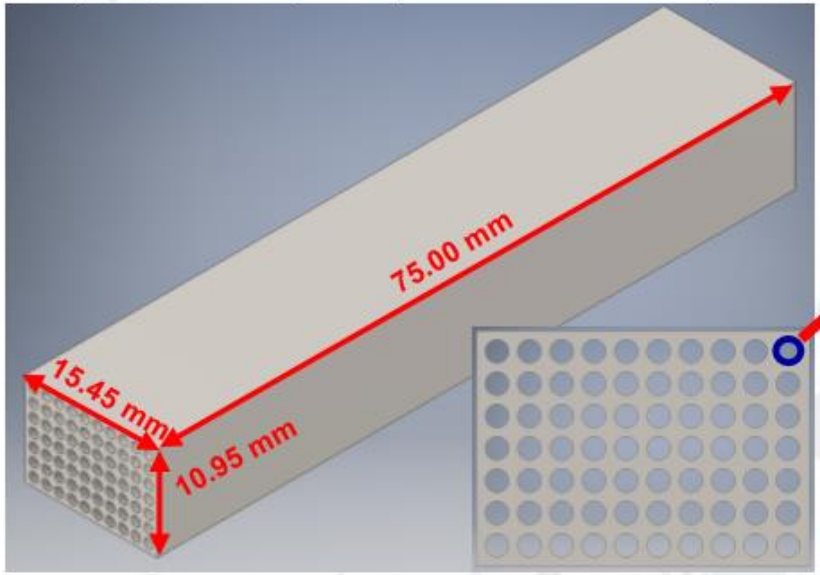
INDUSTRIAL CASE STUDIES

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

Optic fiber conveyor for nuclear applications

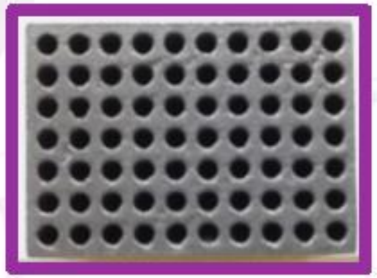
Simple geometry component almost impossible to realize with classical milling operations

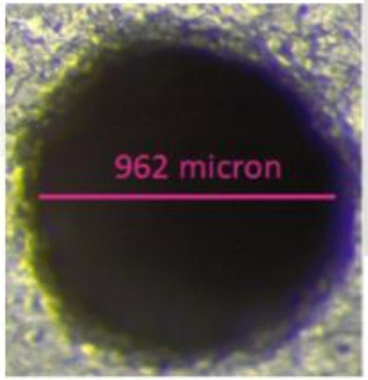


Dimensional requirements:

- Min diameter: 1.10mm
- Max diameter: 1.15 mm

1st experimental result:





How to reduce the dimensional error?:

- With numerical simulations we can predict part distortions and compensate CAD geometry

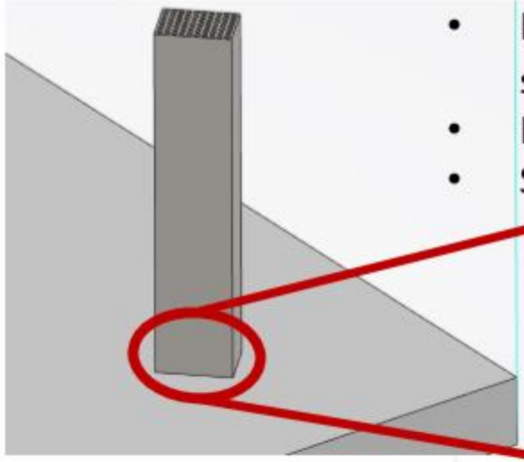
+ ABAQUS

DASSAULT SYSTEMES

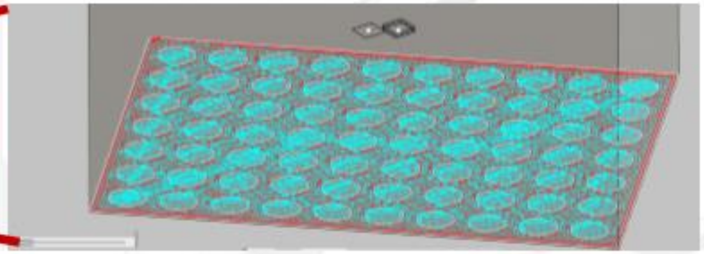
INDUSTRIAL CASE STUDIES

Optic fiber conveyor for nuclear applications

Simple geometry component almost impossible to realize with classical drilling operations

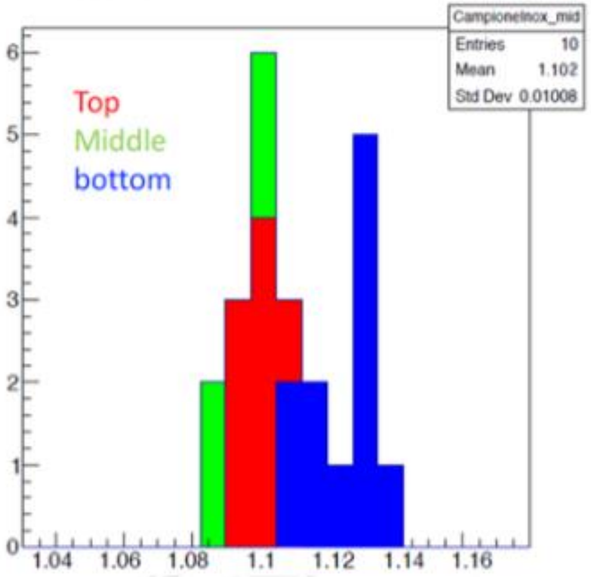


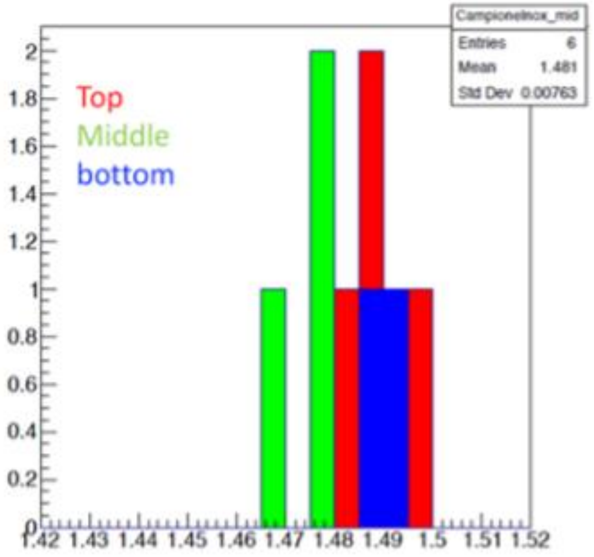
- Part orientation on build tray and supports generation were needed
- Parameter definition
- Scan path and supports generation



New dimensions:

- Medium diameter: **1.102mm** **OK**
- Distance between holes: **1.481 mm** **OK**





What about COSTS & PRODUCTION TIME?:

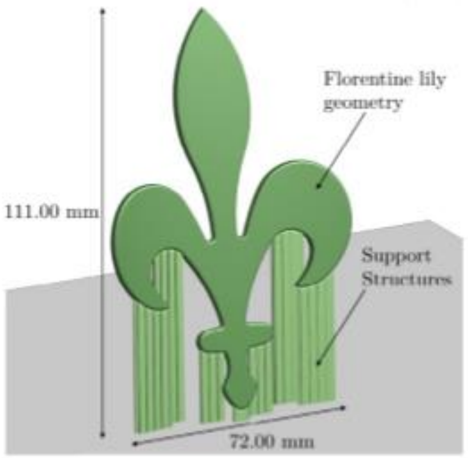
The only alternative method to produce the component is EDM:

- **AM is 8 times FASTER** than EDM
- **AM is 10 times CHEAPER** than EDM

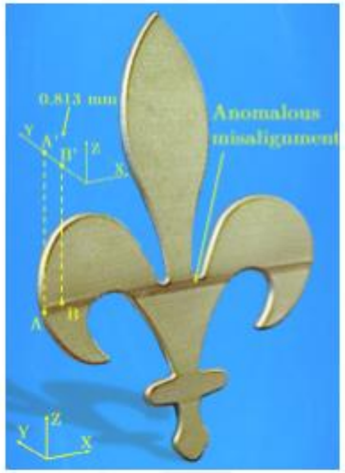
INDUSTRIAL CASE STUDIES

ANIE FEDERAZIONE — FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE — CONFINDUSTRIA

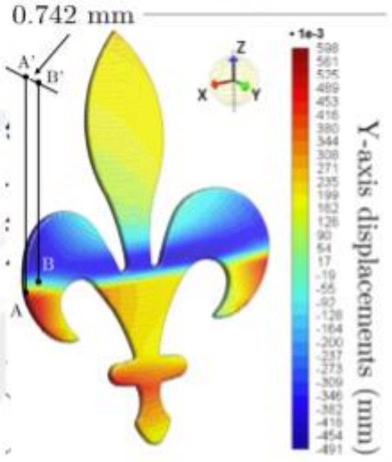
Florentine lily geometry: decorative element for coffee machines



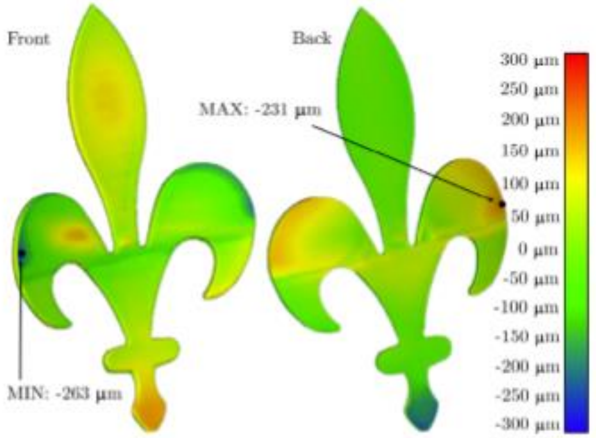
Original geometry and support structures



Printed original component

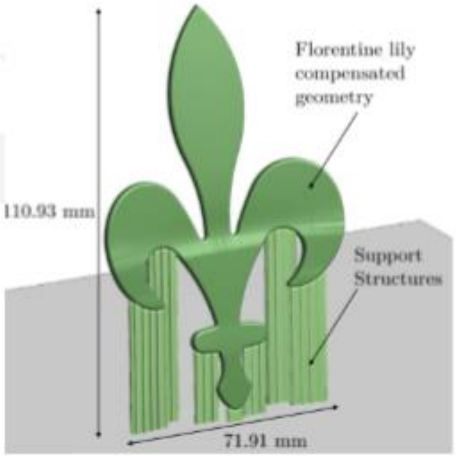


simulation results in terms of displacements

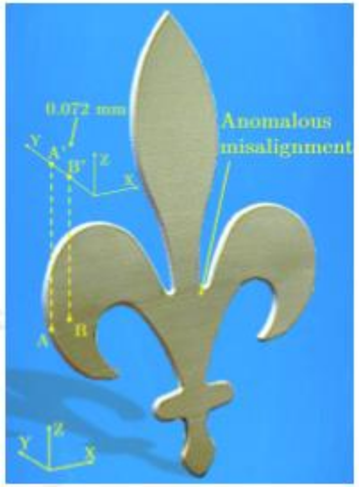


Relative displacements between numerical model and micro-CT

Idea: use numerical simulation to <u>compensate</u> original geometry



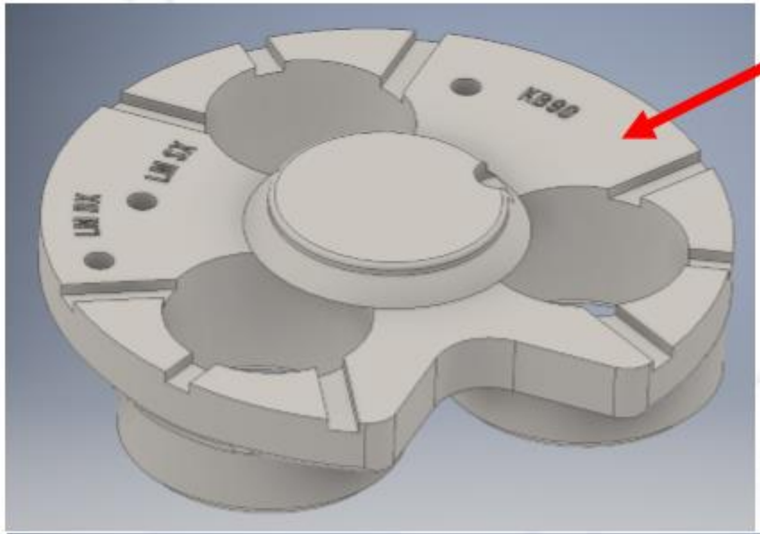
Compensated geometry



Printed compensated component

Electro welding guide

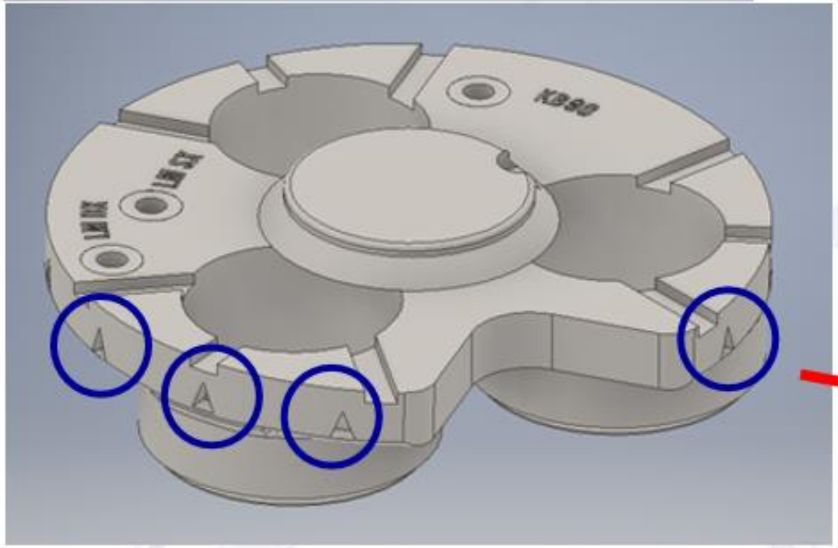
Very expensive for casting production with a small number of parts!



Original component in thermo**plastic polymer**:

- Wear problems induced by the high temperatures produced during welding process
- Need a dedicated mold to be produced
- High production costs

Production time is less than 10% of original casting by molding



AM component in Stainless Steel:

- Same weigth thanks to the **internal design**
- **No wear problems** thanks to a stiffer material
- No mold needed → **LOWER COSTS**

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

Optimized flow channel

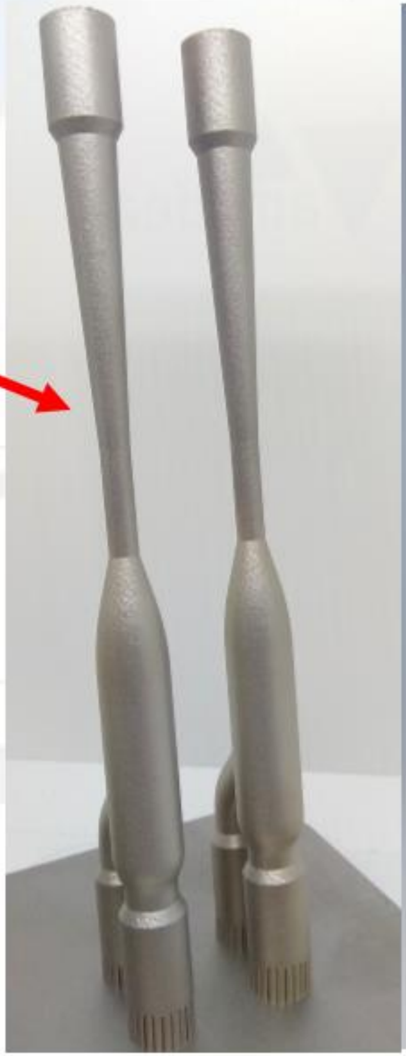
Internal channels originally realized in plastic material, then optimized for metal AM production

Original component in **plastic**:

- Higher mass
- Higher production time
- Higher cost

AM component in **Stainless Steel**:

- Same weight
- Lower production time
- Stiffer, and more resistant to internal pressure

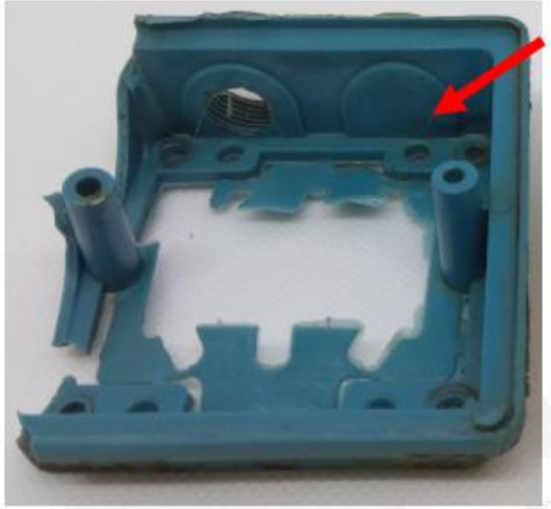


- **reduced number of supports**
- **almost no post - processing operation needed**

INDUSTRIAL CASE STUDIES

Containment box for electric component

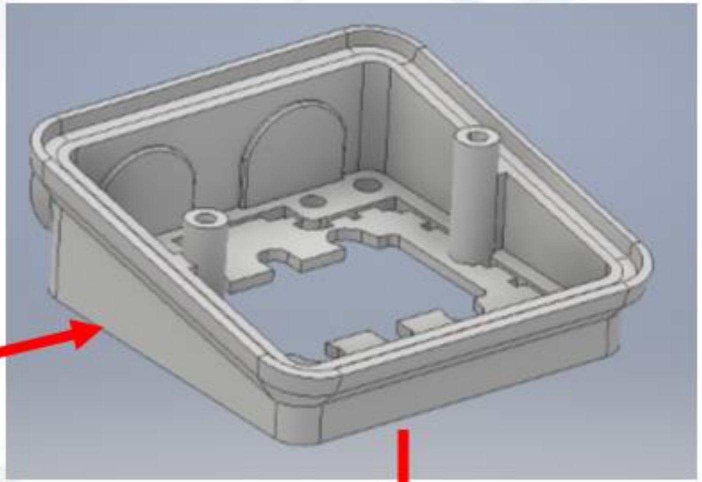
Component originally realized in plastic material, then optimized for FDM based AM production



Original component in **plastic**:

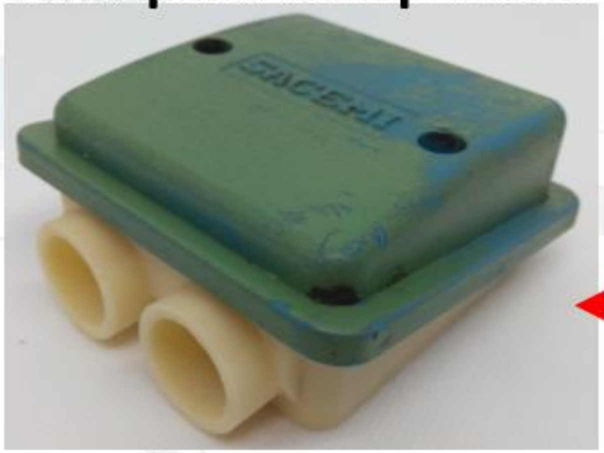
- **Out of production**!!
- Indispensable for safety reasons
- Need to change the entire engine

Plastic component redesigned for AM production with PC-ABS!!



Damaged component

Replica component

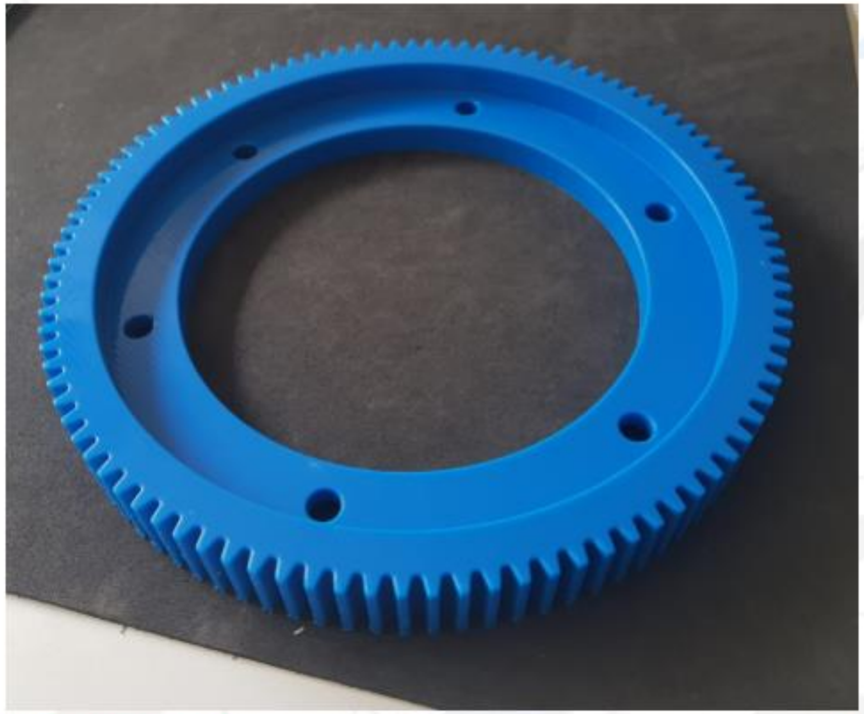


FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

Structural gear realized with PolyJet technology

Gear component for a very old compression test machine

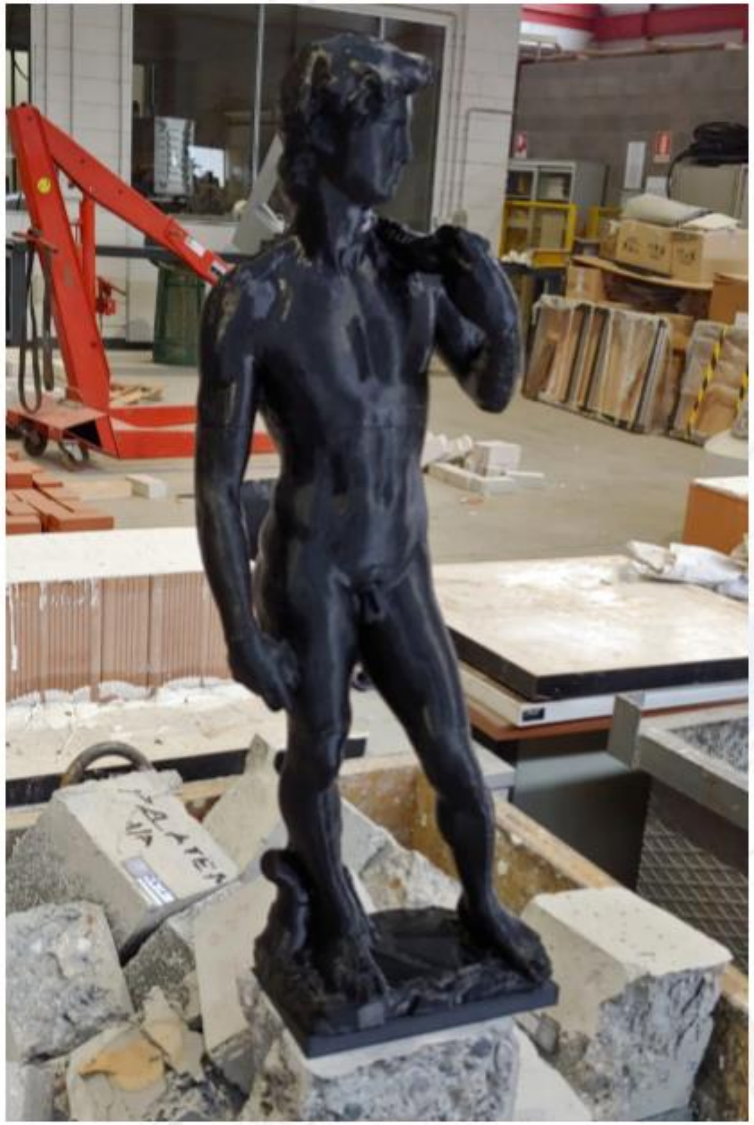


Original component in **reinforced plastic** was turned into an **AM component** realized with PolyJet technology in a **photo-polymeric resin**

- **Mass reduction: 25 %**
- Production **costs and time** down 40%
- The part was out of market, we produced it with trough a **CAD reconstruction**

INDUSTRIAL CASE STUDIES

Various components realized with FDM technology

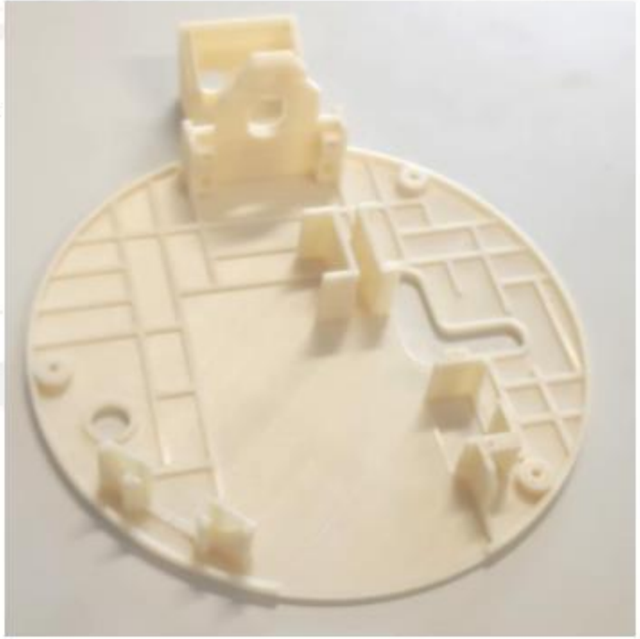


Davide di Michelangelo in **ABS plastic**:

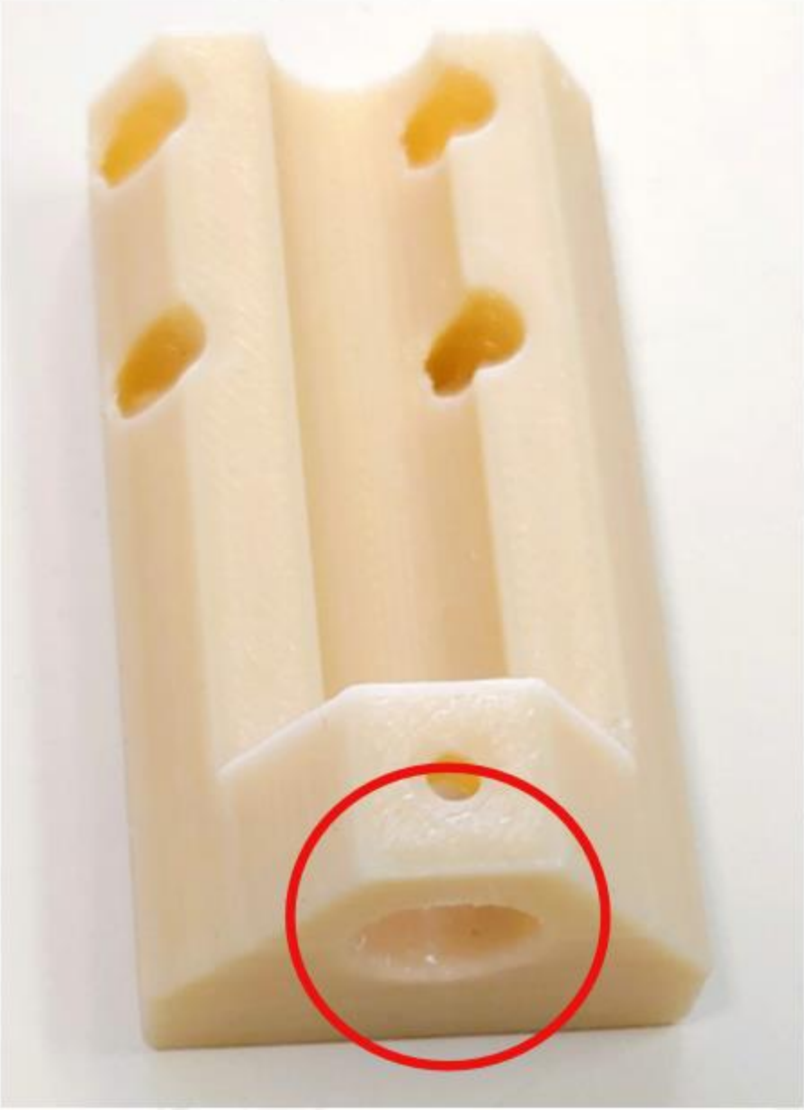
- This component was realized for testing an **anti-seismic display case** to be used in museums
- The component is **empty inside** in order to be filled with different levels of **sand used to tune the final mass of the model** and, consequently, its **seismic response**

Positioning plate for mechanical leverage in **PC - ABS plastic**:

- This component was realized for an ad-hoc application



Various components realized with FDM technology

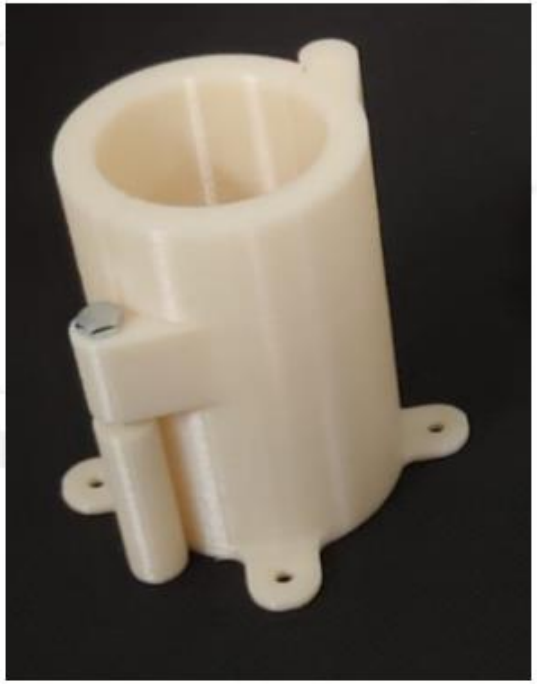


Support structure for bioprinter extruder in **PC-ABS plastic**:

- This component was realized to replace the original component realized in Aluminum
- Main challenge was to **take the red zone at a temperature as low as possible**

Mold for concrete 3D printer in **PC-ABS plastic**:

- This component is used to **realize cylindric concrete specimens** with a concrete 3D printer
- The component has been printed in two parts, then assembled



FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

Various components realized with FDM technology

Covering part for a CNC machine in **PC-ABS plastic**:

- The original component was simply reproduced with the requested tolerance

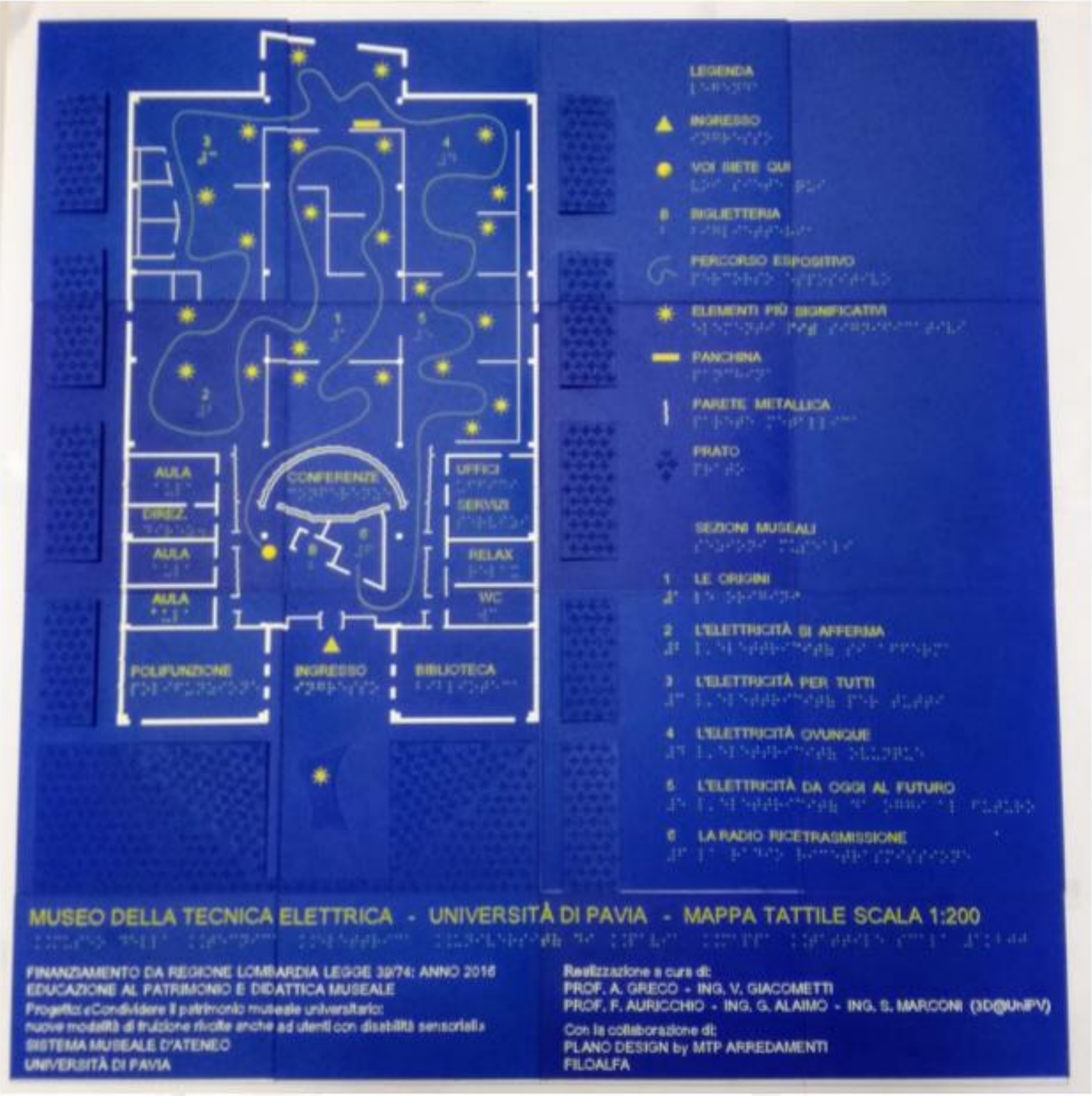
Drone buffer in **PC-ABS plastic**:

- The component was manufactured in **PC-ABS** polymer to obtain a more ductile part, more resistant to impacts

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

Various components realized with FDM technology

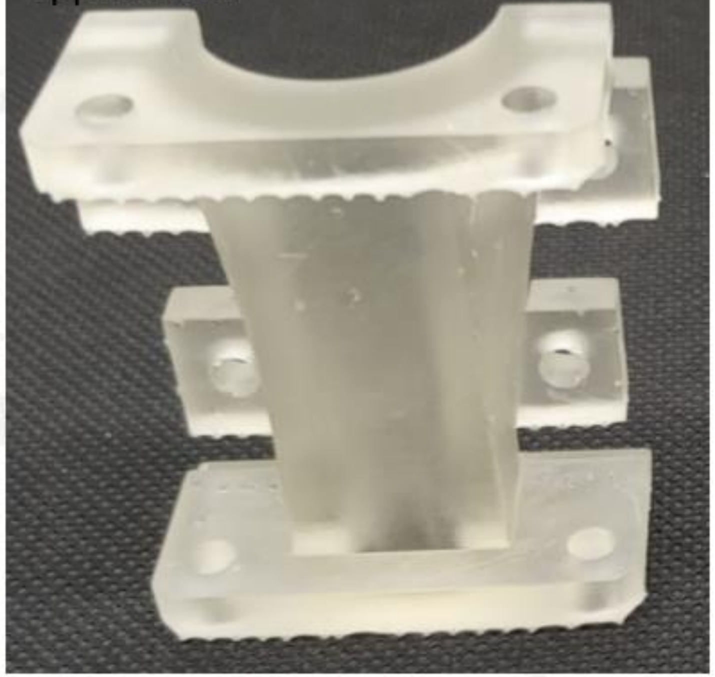


Tactile map in **ABS plastic**:

- This map was realized for the Electric Museum in Pavia

Component in **Resin**:

- The component is metalized with a copper film for microwave applications



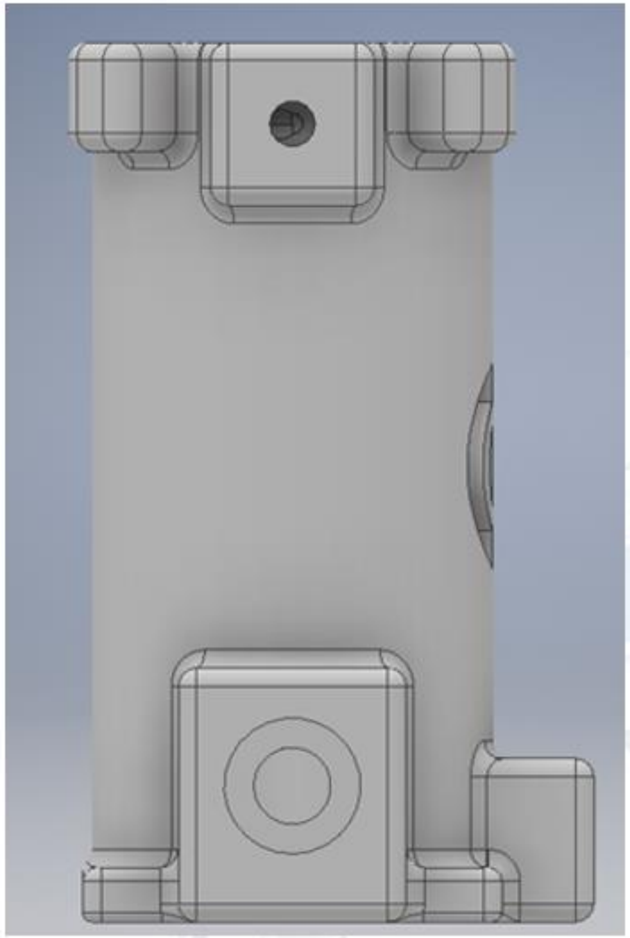
INDUSTRIAL CASE STUDIES

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE
CONFINDUSTRIA

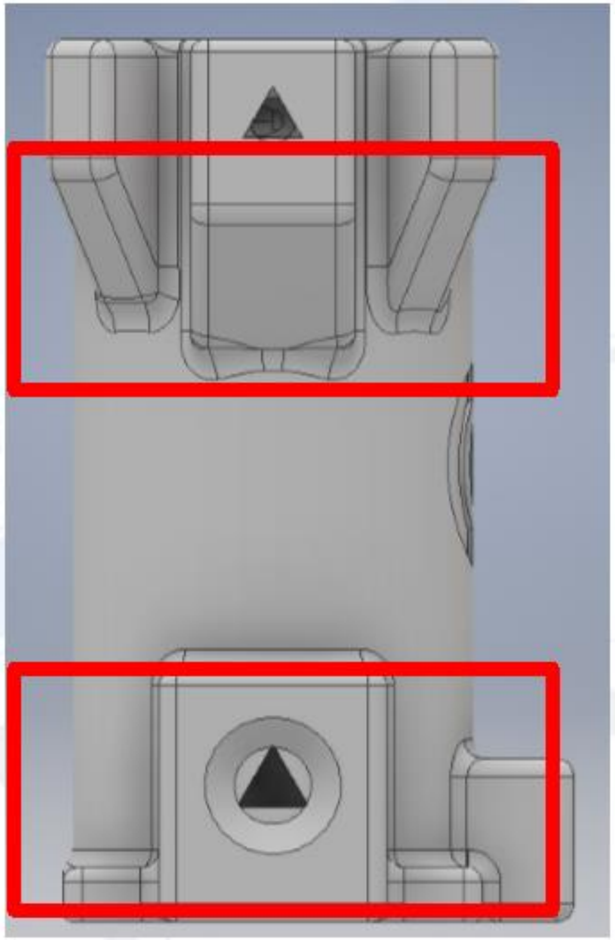
Thermo-fluid-dynamic pump component

Internal channels (not displayed) can be realized only with AM technology.

ORIGINAL MODEL



MODEL REDESIGNED FOR



3D PRINTED COMPONENT

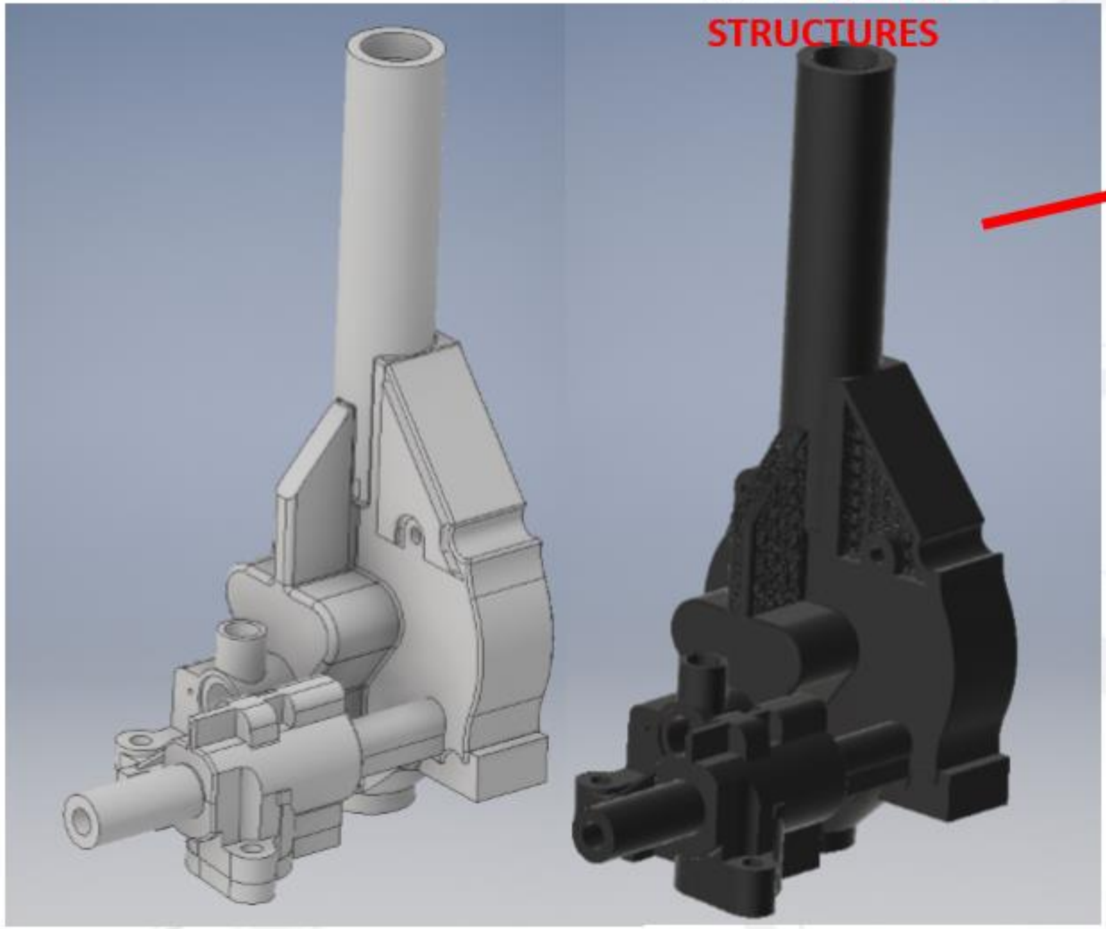
INDUSTRIAL CASE STUDIES

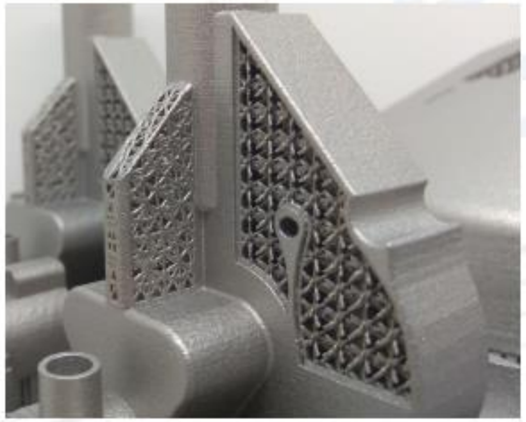
Component for alimentary industry

Component originally realized by assembling **multiple components** and lightened with usage of **lattice structures**

ORIGINAL MODEL

LIGHTWEIGHT MODEL WITH LATTICE STRUCTURES





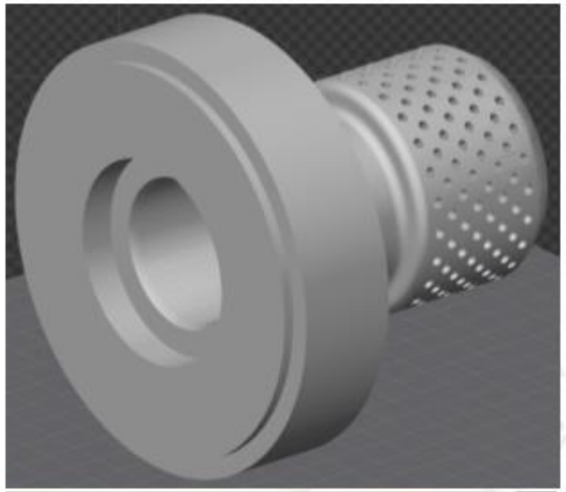
FINAL COMPONENT ASSEMBLED WITH ELECTRIC ENGINE

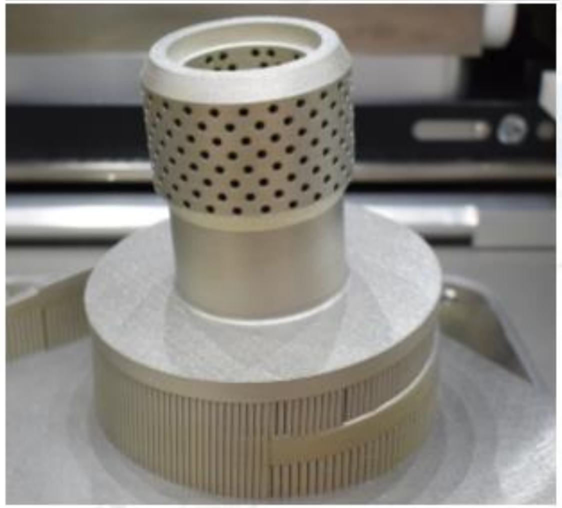
INDUSTRIAL CASE STUDIES

Component for Oil & Gas industry

Component originally realized by assembling **multiple** components was lightened with **topology optimization**

VALVITALIA GROUP





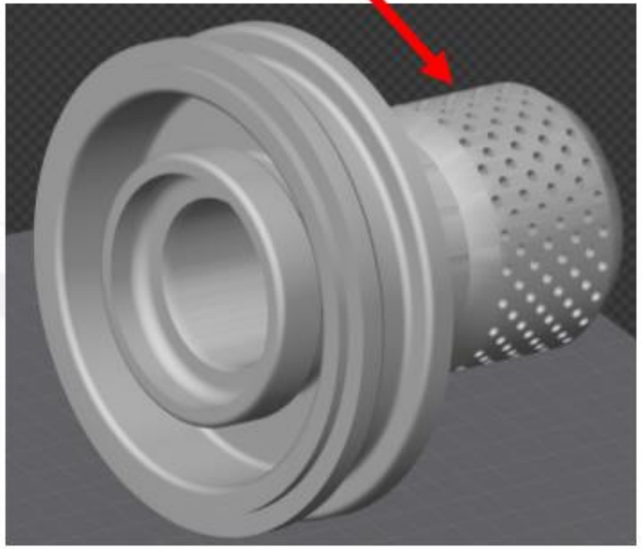
Original component in Stainless Steel

- Produced with CNC operations
- Part realized of multiple components welded together
- Production time: 7 weeks

Altair HyperWorks

AM component in Stainless Steel: **50% of the original weight**

- Produced in a single component
- Production time: 40 hours
- **Same yielding safety factor**



Organizzazione intervento

ANIE FEDERAZIONE
FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE
CONFINDUSTRIA
ANIE SERVIZI INTEGRATI

- **Stampa 3D o manifattura additiva**
  - Descrizione della tecnologia
  - Vantaggi e criticità
- **3D@UniPV: il nostro percorso**
  - Ambito biomedicale
  - Tema strategico di UniPV
  - Creazione di una rete di laboratori
- **Esempi applicativi di interesse industriale**
  - Impatti su concept e progettazione di nuovi prodotti
  - Casi applicativi in diversi settori
- **Forme di collaborazione 3D@UniPV-Impresa**
  - Attività di progettazione / stampa 3D
  - Creazione di un percorso dedicato 3DMetal@UniPV

ANIE FEDERAZIONE
FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE
CONFINDUSTRIA

ANIE SERVIZI INTEGRATI

3DMetal@UniPV

Fluid-o-Tech®
POWER THE FLOW

UNIVERSITÀ DI PAVIA

la marzocco
handmade in florence

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

3DMetal@UniPV

- Il progetto unisce mondo dell'impresa e della ricerca allo scopo di sviluppare un **percorso di crescita delle competenze nel campo della stampa 3D metallica,** tecnologia che offre grande versatilità
- Ha lo scopo di **produrre componenti metallici** di interesse dei partner industriali e di **svolgere attività di ricerca** su ottimizzazione dispositivi e simulazione del processo di manifattura additiva
- Il progetto ha 3 partner
  - **Fluid-o-Tech**: azienda leader nella progettazione e produzione di pompe volumetriche e sistemi per la gestione dei fluidi
  - **La Marzocco**: azienda leader nella produzione di macchine per il caffè
  - **Università di Pavia**

Fluid-o-Tech POWER THE FLOW

la marzocco handmade in florence

UNIVERSITÀ DI PAVIA

3DMetal@UniPV

Renishaw AM 400

- SLM metal 3D printer
- Flexible AM for professional use in a wide range of metals
- 400W optical system with a reduced beam diameter of 70 µm
- Available metal powders: Titanium, Aluminium, Cobalt chromium, Stainless steel, Nickel alloys

Principal Characteristics

Laser type:	PULSED
Laser wavelength:	1070 µm
Laser power:	400 W
Laser spot:	70 µm
Laser velocity (max):	7 m/s
Chamber volume	250x250x300 mm
Construction volume rate:	20 cm^3/h
Accuracy:	25 µm
Layer thickness:	20-100 µm
Type of gas:	ARGON
Argon consumption:	60 l/min

3DMetal@UniPV

Instrumentation for **post-processing treatments**:

- Heat treatments oven;

- Sandblasting machine;

- Machining center for finishing and removal.

Budget reporting:

➢ Project budget: 1,029,669.16 €

- Companies contracts: 257,417.29 € x 2 + IVA
- UniPV: 514,834.58 €

➢ Investments: 640,000.00 €

- 3D printer and accessories rental: 390,000 € + IVA
- Dedicated Personnel costs: 120,000 €
- Machining center: 90,000 € + IVA
- EDM Machine: 40,000 € + IVA
- Other costs: to be computed and retributed depending on the amount of printed components

NOTE: IVA is a cost for the project !!

Remark:

PARTNERSHIP AGREEMENT

Art. 4 – Riservatezza

Tutta la documentazione e le informazioni di carattere tecnico e metodologico, fornite da ciascuna parte all'altra, dovranno essere considerate da quest'ultima di carattere confidenziale.

Esse non potranno essere utilizzate per scopi diversi da quelli per i quali sono state fornite senza una preventiva autorizzazione scritta della parte che le ha comunicate.

Ciascuna parte applicherà le misure più opportune per mantenere circoscritte le informazioni e la documentazione ottenuta.

FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE

CONFINDUSTRIA

First printed parts:

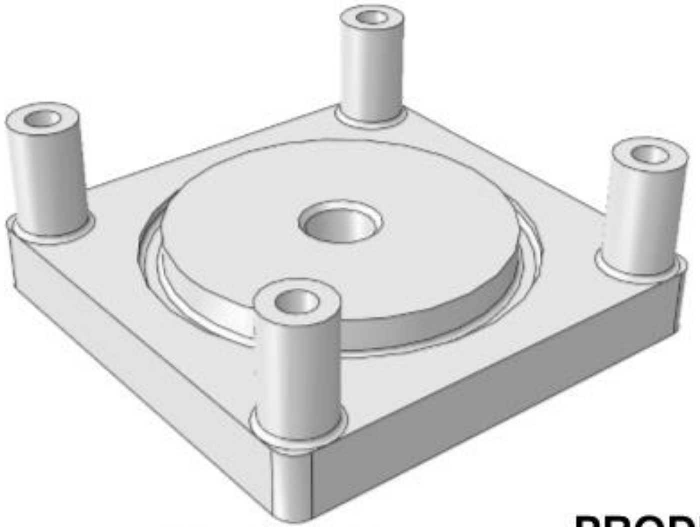
Fluid-o-Tech® POWER THE FLOW

MATERIAL COSTS*:

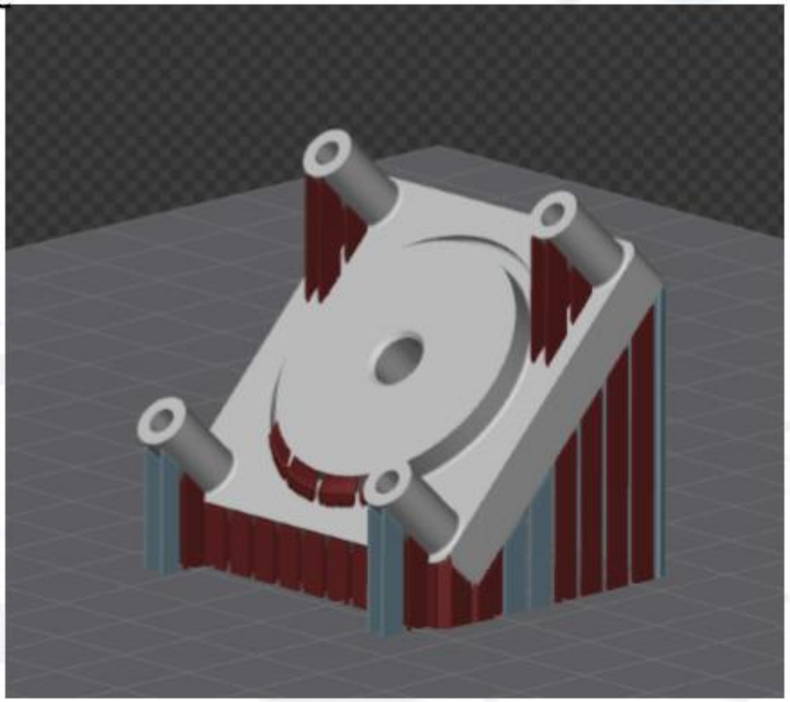
- Powder: 15.6 €
- Argon: 5.0 €

* if the printing process would include just this part

PART-2



SETUP FOR THE PRINT



PRODUCTION TIME: 5h

First printed parts:

Fluid-o-Tech®
POWER THE FLOW

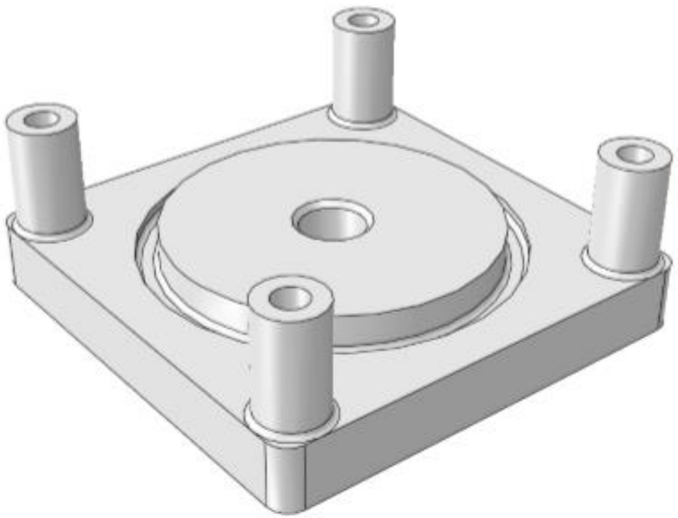
Maximum number of parts printable with a single printing process:

20

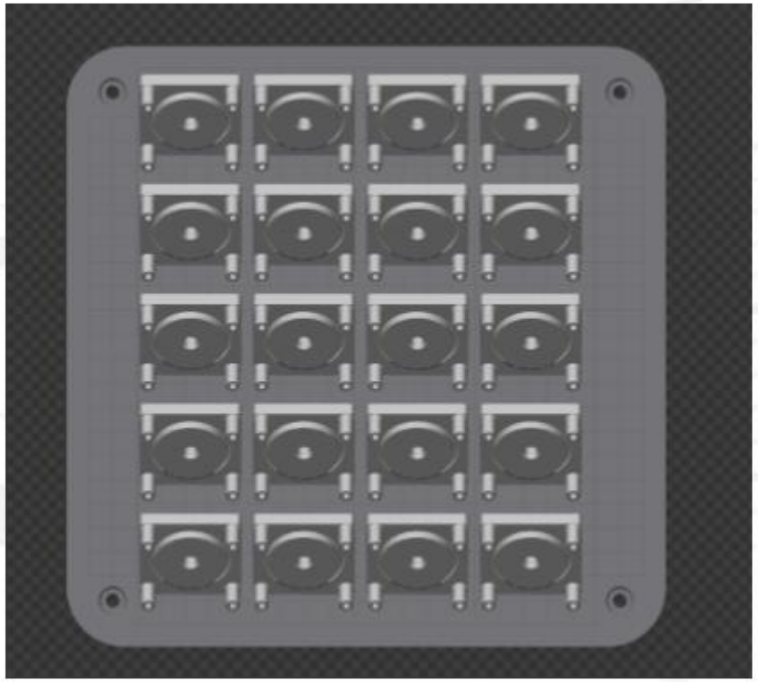
MATERIAL COSTS:

- Powder: 312.0 €
- Argon: 15.0 €

PART-2



SETUP FOR THE PRINT



PRODUCTION TIME: 42h

Software for PRINTING SETUP and SIMULATION:

QuantAM (RENISHAW apply innovation)

- Part orientation on building plate
- Material development
- Orientation of multiple components on building plate
- Laser exposition control and management

Altair HyperWorks

- Topology optimization for AM
- Weight reduction
- Stiffness maximization
- Lattice structures optimization

ANSYS

- Finite Element Simulation
- Residual stresses and displacements prediction
- Geometry compensation and STL generation

ABAQUS (Dassault Systemes)

- Finite Element Simulation
- Plugin for AM simulation
- Residual stresses and displacements prediction
- Geometry compensation and STL generation

We have signed a partnership with **CAETECH** for using commercial products dedicated for AM Simulation like **3DExperience**

CAETECH PERFORMANCE EXPERIENCE

Come approcciare il mondo stampa 3D

ANIE FEDERAZIONE — FEDERAZIONE NAZIONALE IMPRESE ELETTROTECNICHE ED ELETTRONICHE — CONFINDUSTRIA — ANIE SERVIZI INTEGRATI

- **Individuare un componente di forte interesse**
  - Componente per il quale sia necessario un miglioramento delle prestazioni o
  - Necessario un investimento in termini di tempo / risorse di progettazione / eventualmente economiche

- **Particolari vantaggi se si integrano funzioni o si ottimizza (migliorano) le prestazioni**
  - Necessario avere un "parziale" margine di azione

- **Università / laboratory di ricerca devono giocare un ruolo fondamentale**
  - Università ed aziende devo giocare insieme
  - Ricerca ha tempo e può investire in sviluppo
  - Aziende hanno competenze sul prodotto finale
  - Università può anche essere un terreno "neutrale" per la gestione di investimenti condivisi → riduzione di rischi e riduzione di impegno economico