Convegno

Mecc-iTI 4.0

Prepariamoci all'industria

Mercoledì, 7 ottobre 2015

Ore 16.30 – 19.30

Polo Meccatronica

Via Zeni 8, Rovereto (TN)

"PRINTING TECHNOLOGIES": UN VOLANO PER IL MANIFATTURIERO ITALIANO E LO "SMART MANUFACTURING

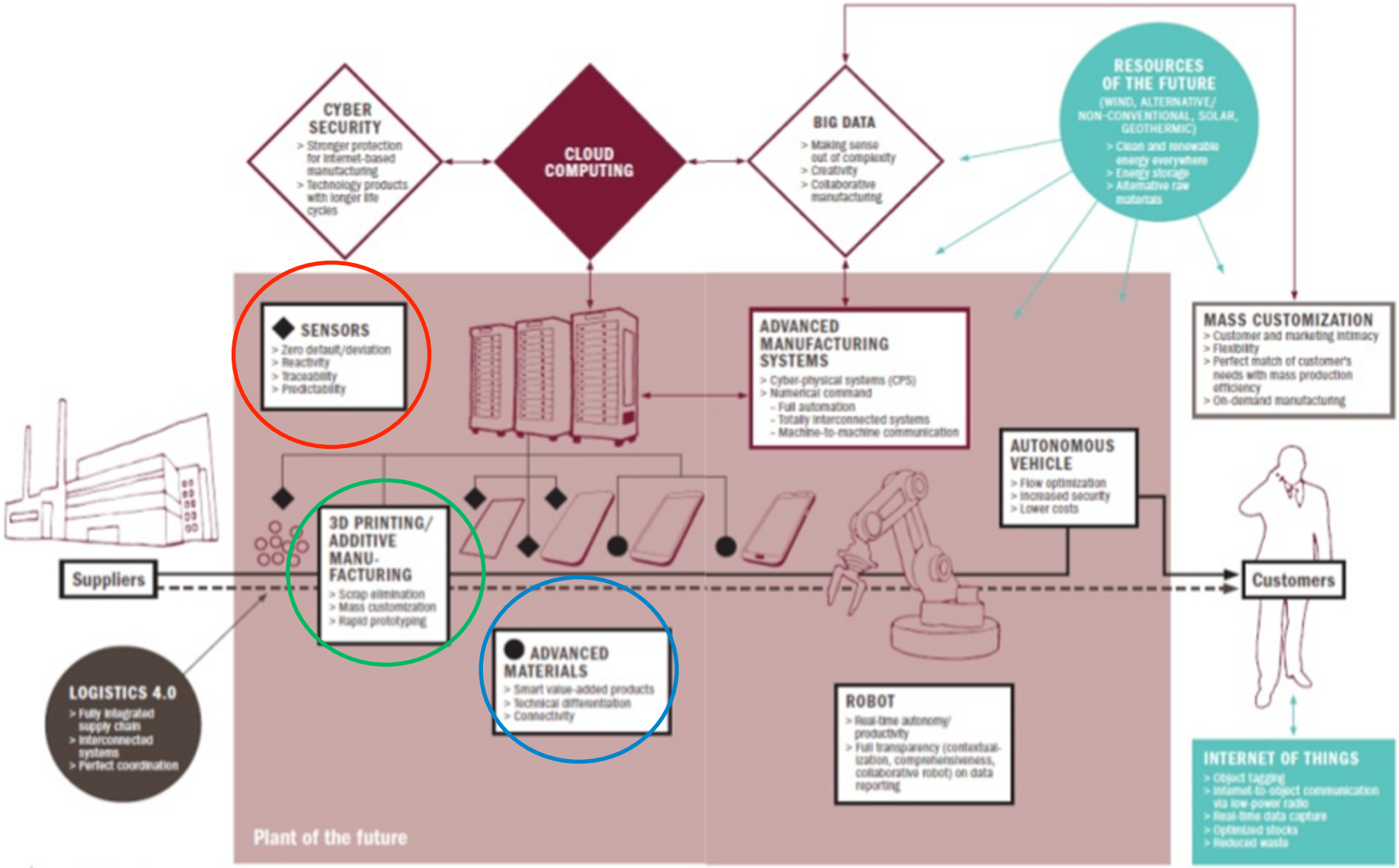
Fabrizio Pirri

Politecnico di Torino e Istituto Italiano di Tecnologia

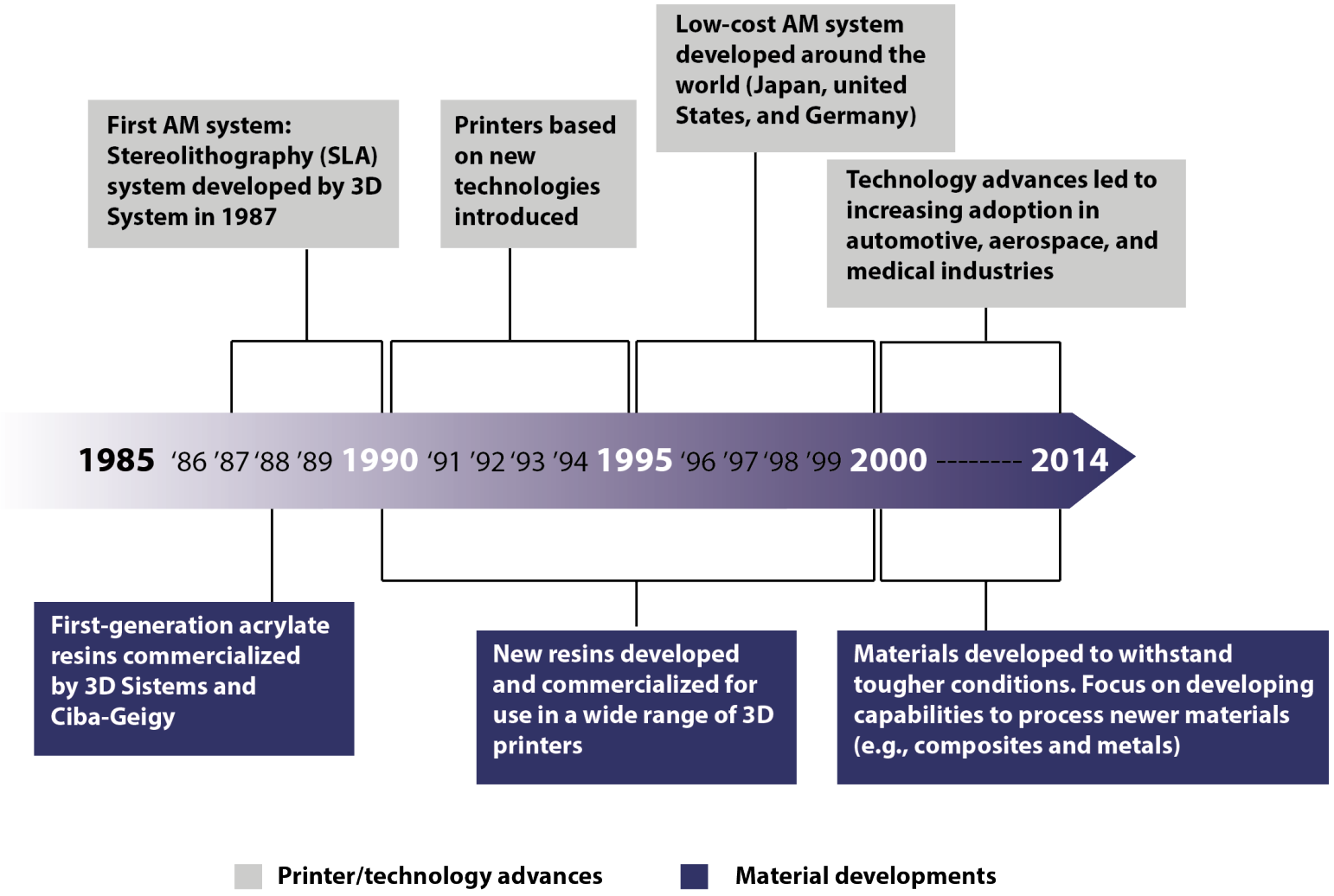
ISTITUTO ITALIANO DI TECNOLOGIA

CENTER FOR SPACE HUMAN ROBOTICS

Industry 4.0

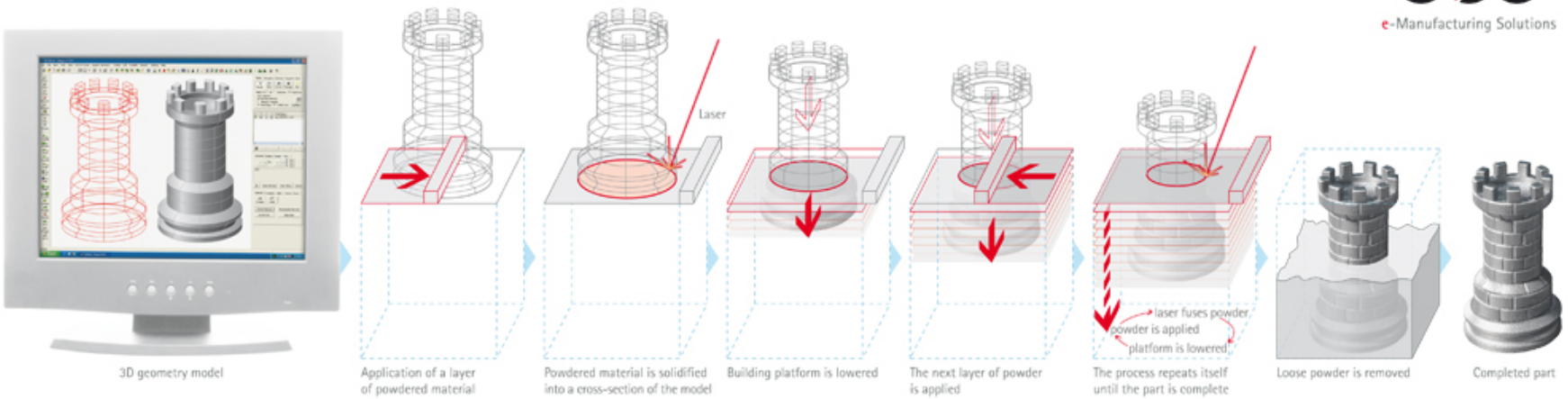

CYBER SECURITY
> Stronger protection for Internet-based manufacturing
> Technology products with longer life cycles
CLOUD COMPUTING
BIG DATA
> Making sense out of complexity
> Creativity
> Collaborative manufacturing
RESOURCES OF THE FUTURE
(WIND, ALTERNATIVE/ NON-CONVENTIONAL, SOLAR, GEOTHERMIC)
> Clean and renewable energy everywhere
> Energy storage
> Alternative raw materials
SENSORS
> Zero default/deviation
> Reactivity
> Traceability
> Predictability
ADVANCED MANUFACTURING SYSTEMS
> Cyber-physical systems (CPS)
> Numerical command
- Full automation
- Totally interconnected systems
- Machine-to-machine communication
MASS CUSTOMIZATION
> Customer and marketing intimacy
> Flexibility
> Perfect match of customer's needs with mass production efficiency
> On-demand manufacturing
AUTONOMOUS VEHICLE
> Flow optimization
> Increased security
> Lower costs
Suppliers
3D PRINTING/ ADDITIVE MANU-FACTURING
> Scrap elimination
> Mass customization
> Rapid prototyping
ADVANCED MATERIALS
> Smart value-added products
> Technical differentiation
> Connectivity
Customers
LOGISTICS 4.0
> Fully integrated supply chain
> Interconnected systems
> Perfect coordination
ROBOT
> Real-time autonomy/ productivity
> Full transparency (contextual-ization, comprehensiveness, collaborative robot) on data reporting
INTERNET OF THINGS
> Object tagging
> Internet-to-object communication via low-power radio
> Real-time data capture
> Optimized stocks
> Reduced waste
Plant of the future

Evolution of AM/3DP technologies



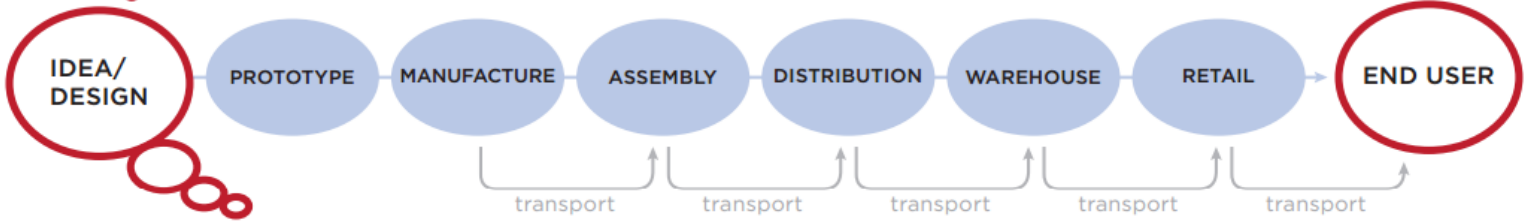
Source: Deloitte University; Wohlers Associates, Additive manufacturing and 3D printing state of the industry, 2012

General functional principle of laser-sintering



e-Manufacturing Solutions

3D PRINTING



3D printing, a new paradigm?

Unique Advantages

- Affordable customization
- Allows manufacture of more efficient designs — lighter, stronger, less assembly required
- One machine, unlimited product lines
- Very small objects (nano)
- Efficient use of raw materials (less waste)
- Pay by weight — complexity is free
- Batches of one, created on demand
- Print at point of assembly/consumption
- Manufacturing accessible to all — lower entry barriers
- New supply chain and retail opportunities

Areas of Further Development

- Printing large volumes economically
- Expanding the range of printable materials
- Reducing the cost of printable materials
- Using multiple materials in the same printer, including those for printing electronics
- Printing very large objects
- Improving durability and quality

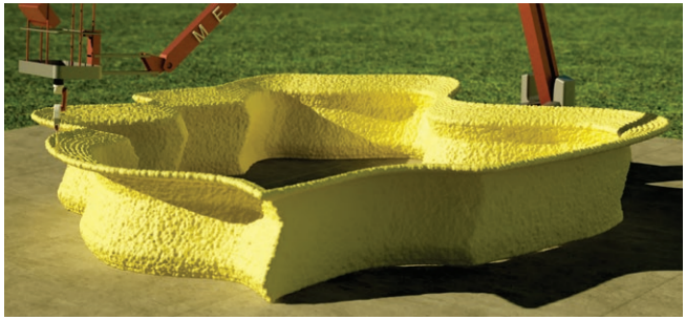
3D printing?

Estimate materials total market of over **$8B** by **2025**. In terms of market value and volume, for:

- **Photopolymers**
- **Thermoplastic filaments**
- **Thermoplastic powders**
- **Metal powders**
- **Sand and binder**
- **Plaster**

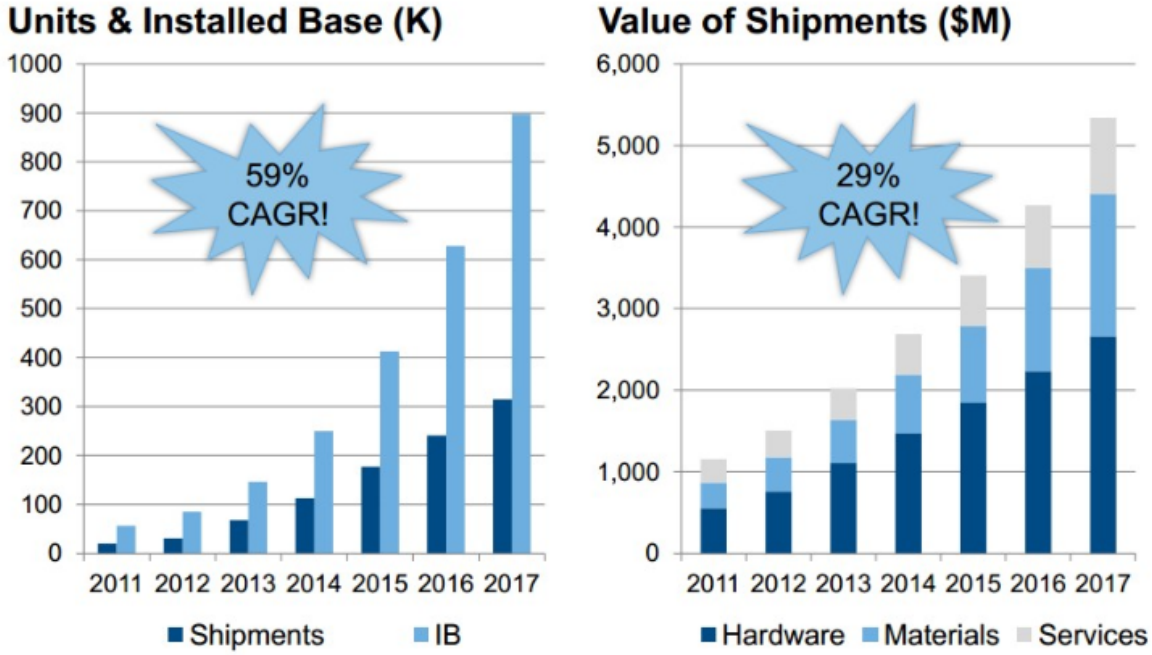
Metal Airbus wing bracket.
(Source: EADS)

Chocolate from researchers at the University of Exeter.
(Source: David Martin)



Polyurethane. (Source: Mediated Matter Group, MIT Media Lab)

WW 3D Printer Market Opportunity



*IDC Special Study – WW 3D Printer 2012-2017 Forecast and Vendor Shares, #244304, November 2013

IDC Analyze the Future

#directions14

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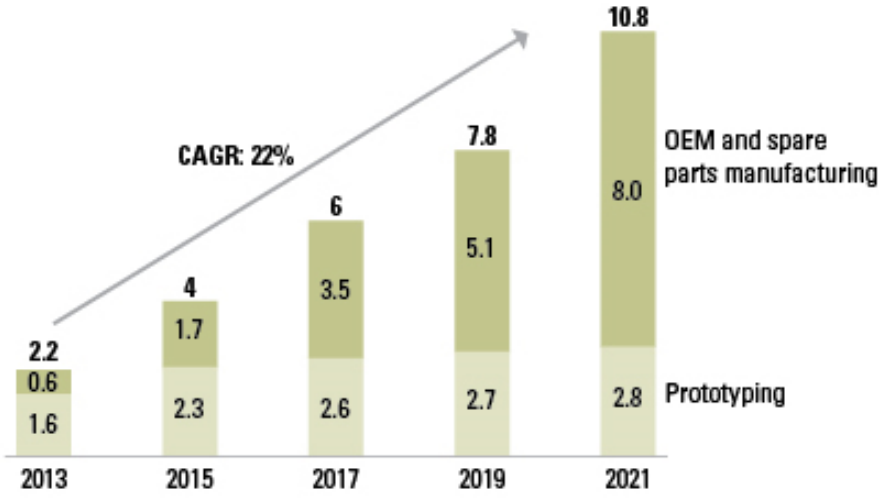
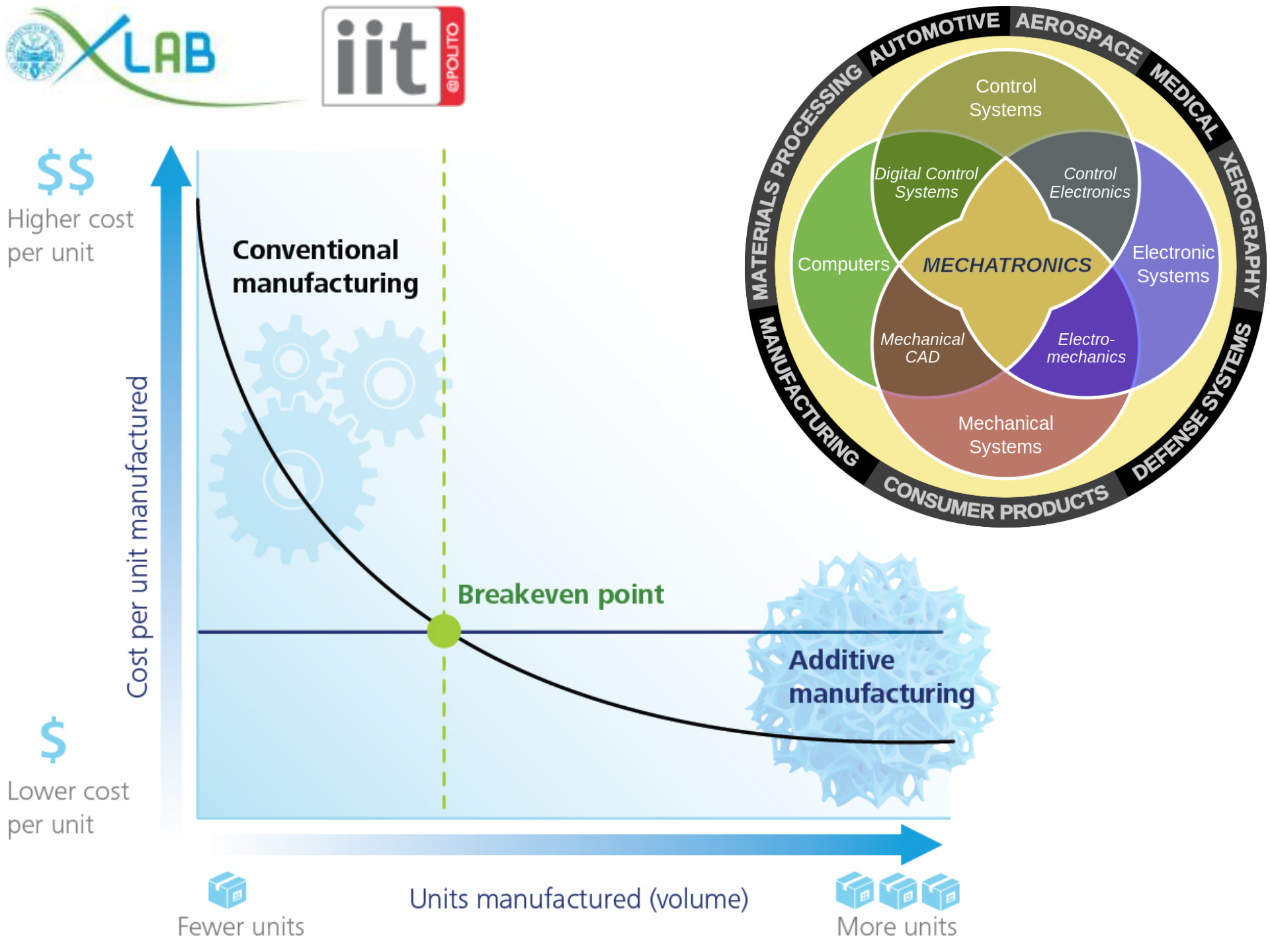
Figure 6: 3-D-Printing Market Forecast, 2013–2021 ($ billions)



Sources: Wholers Associates, AlixPartners estimates

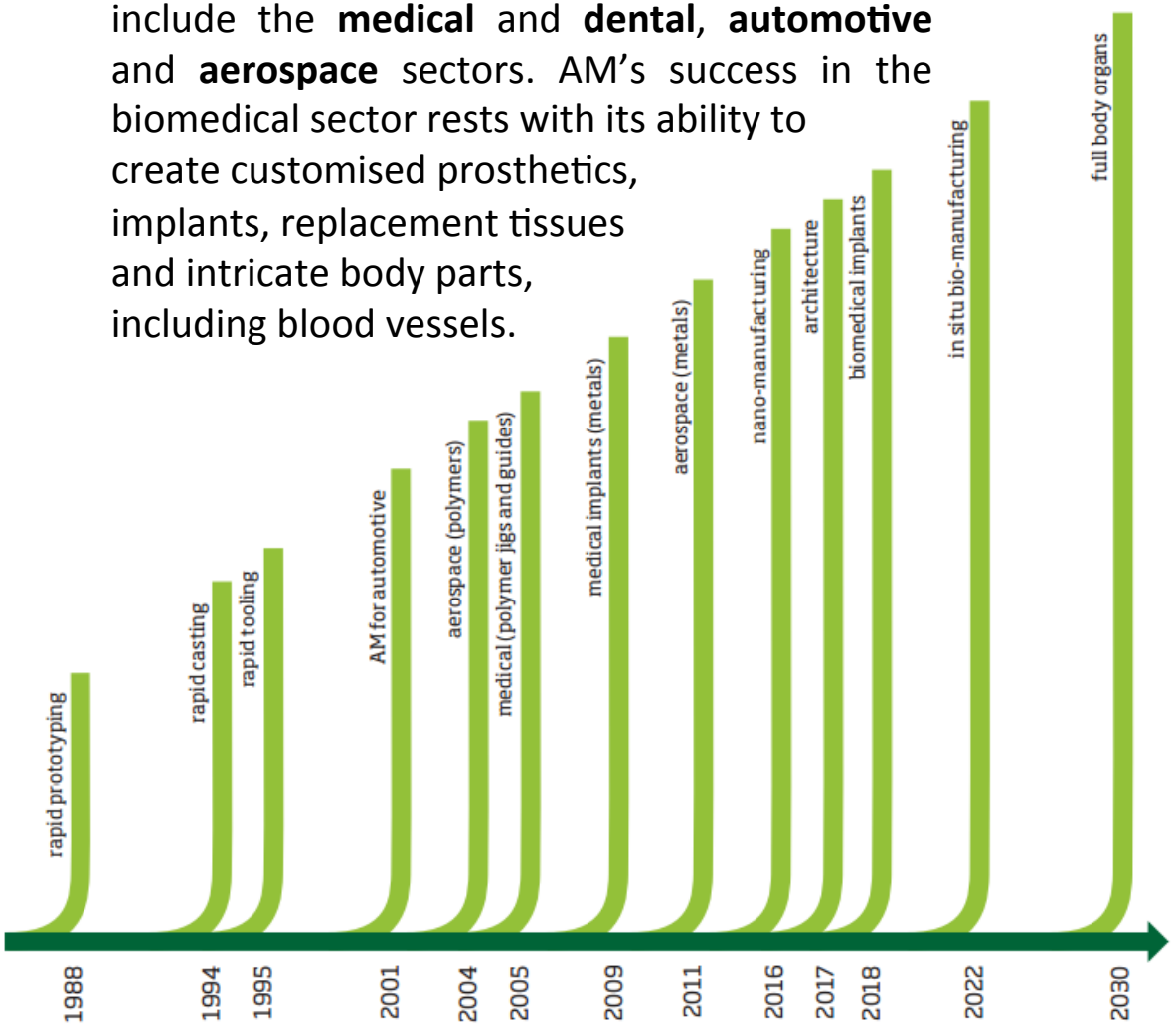

$$
Higher cost per unit
Conventional manufacturing
Cost per unit manufactured
Breakeven point
Additive manufacturing
$
Lower cost per unit
Fewer units
Units manufactured (volume)
More units
AUTOMOTIVE
AEROSPACE
MEDICAL
XEROGRAPHY
DEFENSE SYSTEMS
CONSUMER PRODUCTS
MANUFACTURING
MATERIALS PROCESSING
Control Systems
Digital Control Systems
Control Electronics
Computers
MECHATRONICS
Electronic Systems
Mechanical CAD
Electro-mechanics
Mechanical Systems

AM applications timeline

This timeline lays out past, present and potential future AM developments and applications.
(courtesy of Graham Tromans)

1988-1994	rapid prototyping
1994	rapid casting
1995	rapid tooling
2001	AM for automotive
2004	aerospace (polymers)
2005	medical (polymer jigs and guides)
2009	medical implants (metals)
2011	aerospace (metals)
2013-2016	nano-manufacturing
2013-2017	architecture
2013-2018	biomedical implants
2013-2022	in situ bio-manufacturing
2013-2032	full body organs

Three of the fastest-growing areas for AM include the **medical** and **dental**, **automotive** and **aerospace** sectors. AM's success in the biomedical sector rests with its ability to create customised prosthetics, implants, replacement tissues and intricate body parts, including blood vessels.



* TranPham METALs *

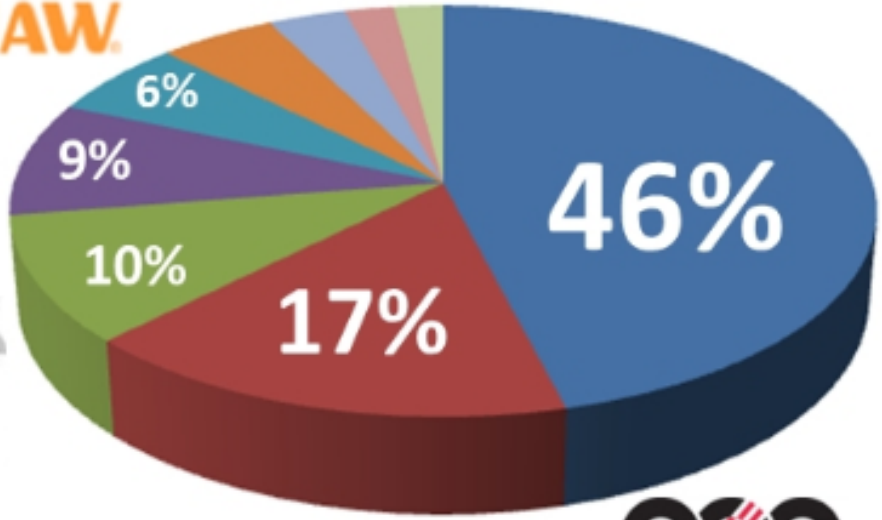
tuan@tranpham.com | @ttranpham | www.tranpham.com | 14-FEB-2013 | Ver. 1 |

CC BY ND

OPTOMEC voxeljet ExOne

RENISHAW

PHENIX SYSTEMS



- EOS | 460# | 46%
- ConceptLaser | 165# | 17%
- Arcam | 100# | 10%
- Phenix/AMT | 90# | 9%
- Renishaw/MTT/SLM | 60# | 6%
- Optomec | 50# | 5%
- VoxelJet (indirect) | 33# | 3%
- ExOne (indirect) | 21# | 2%
- Other | 21# | 2%

CAD TO METAL

Arcam AB

CONCEPTLASER

eos

XLAB

TranPham 3DprintinG

tuan@tranpham.com | @ttranpham | www.tranpham.com | 14-FEB-2013 | Ver. 1 |

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Rapid prototyping

A group of technicques able to fabricate a scale model of a device in a fast, flexible, and accurate way

Metal 3D printing

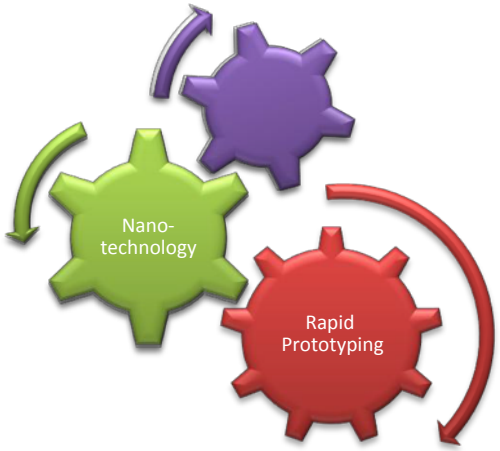
Laser/eln Pattern

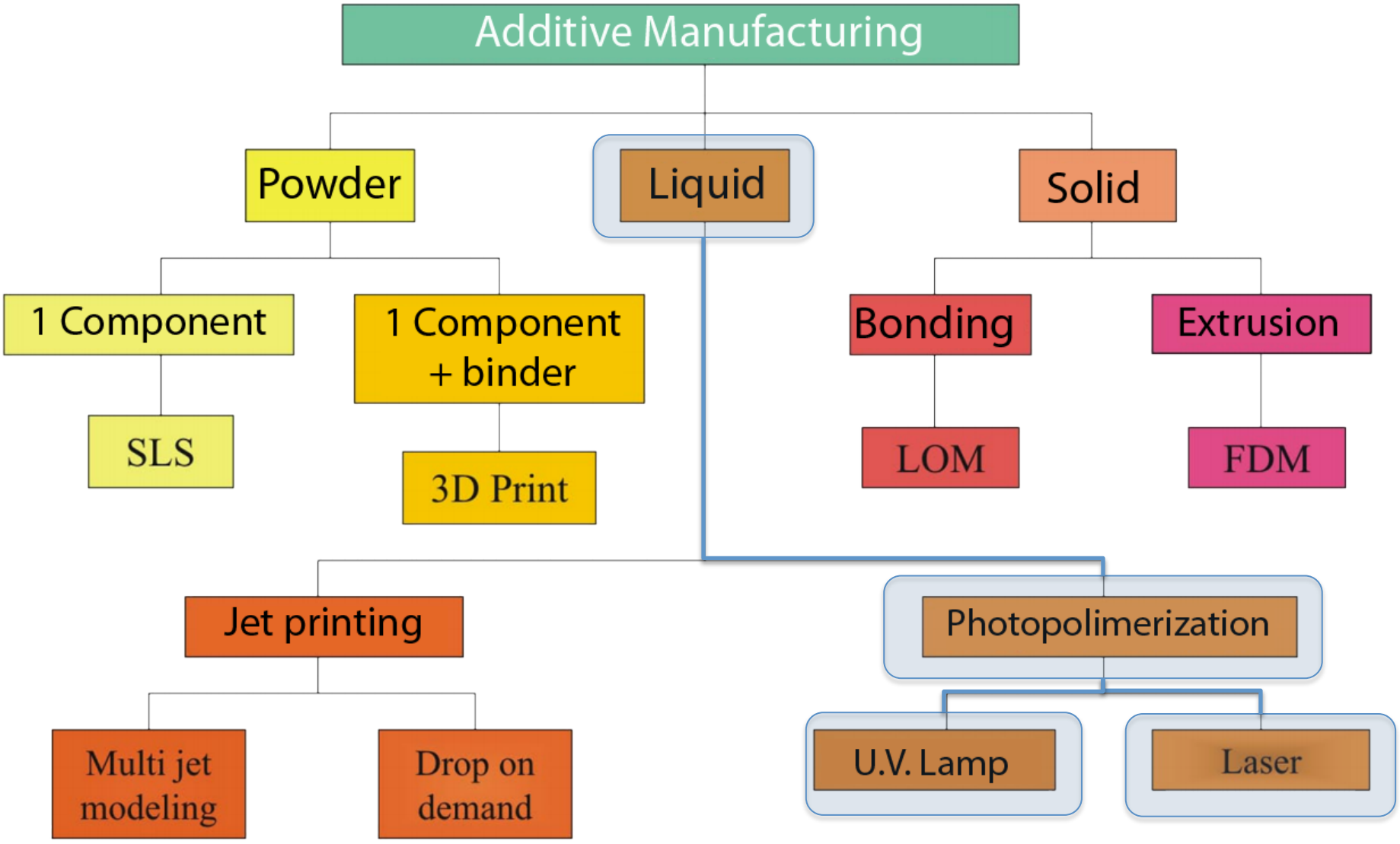
direct fabrication of metallic structures from CAD file

Polymeric 3D printing

Laser/light Pattern

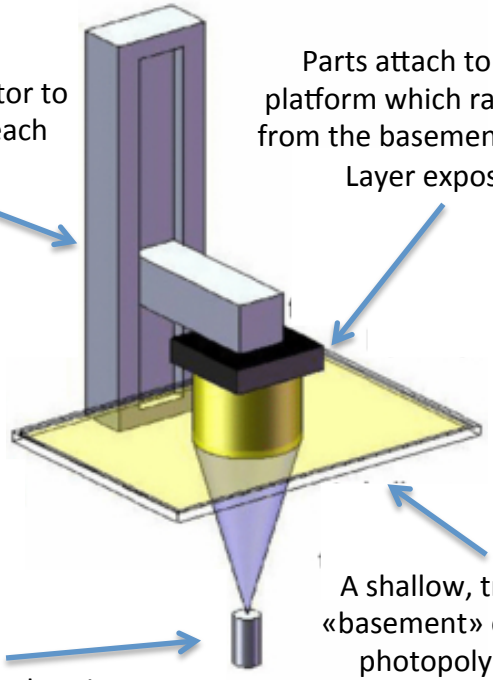
direct fabrication of polymeric structures from CAD file



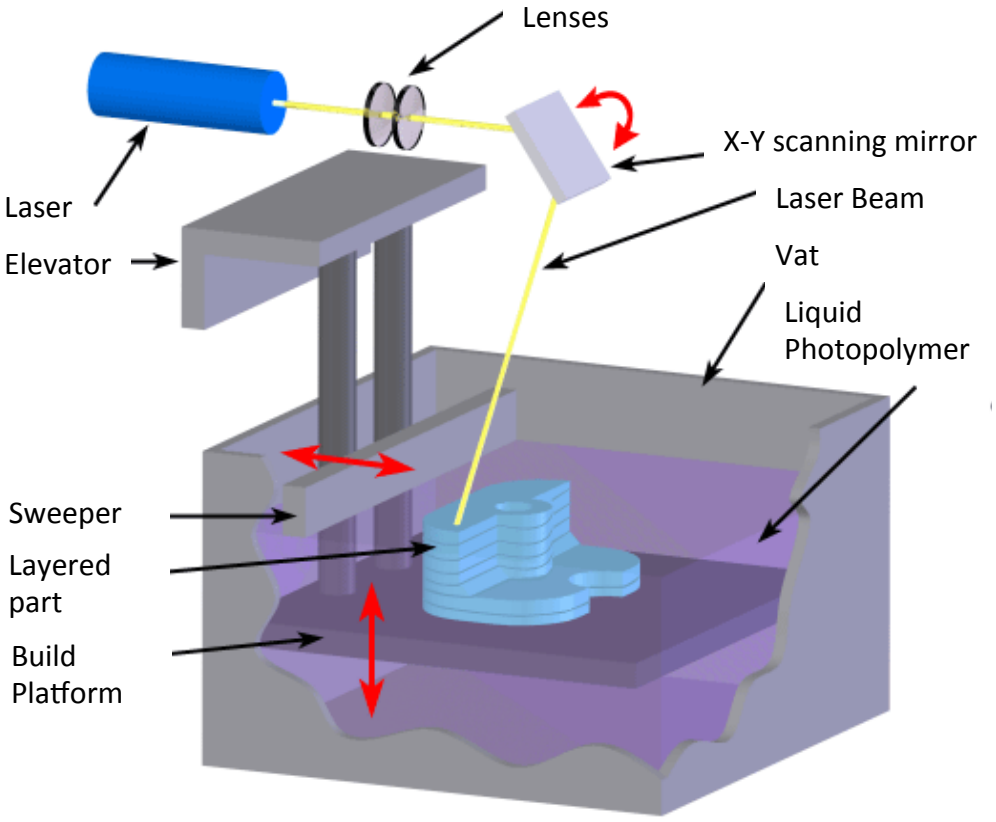

Additive Manufacturing
Powder
Liquid
Solid
1 Component
1 Component + binder
Bonding
Extrusion
SLS
3D Print
LOM
FDM
Jet printing
Photopolimerization
Multi jet modeling
Drop on demand
U.V. Lamp
Laser

3D printers of photopolymers

DLP Printer



SLA Printer



Polymeric 3D printing

3D PRINTER: OBJET30 ORTHODESK

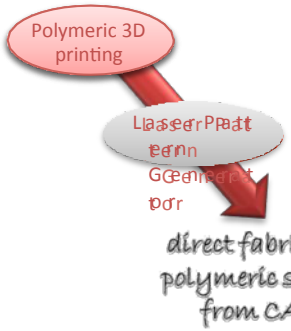
Layer Thickness (Z-axis)
Horizontal build layers down to 28-micron (0.0011 in)

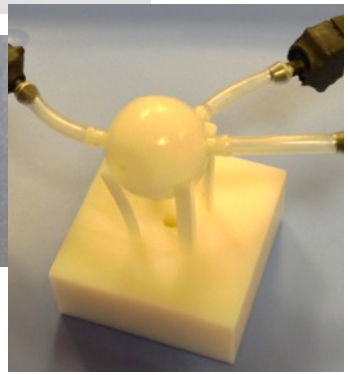
Tray Size (X×Y×Z)
300 × 200 × 150 mm
(11.81 × 7.87 × 5.9 in)

Net Build Size (X×Y×Z glossy)
294 x 192.7 x 148.6 mm
(11.58 x 7.58 x 5.85 in)

Build Resolution
X-axis: 600 dpi
Y-axis: 600 dpi
Z-axis: 900 dpi

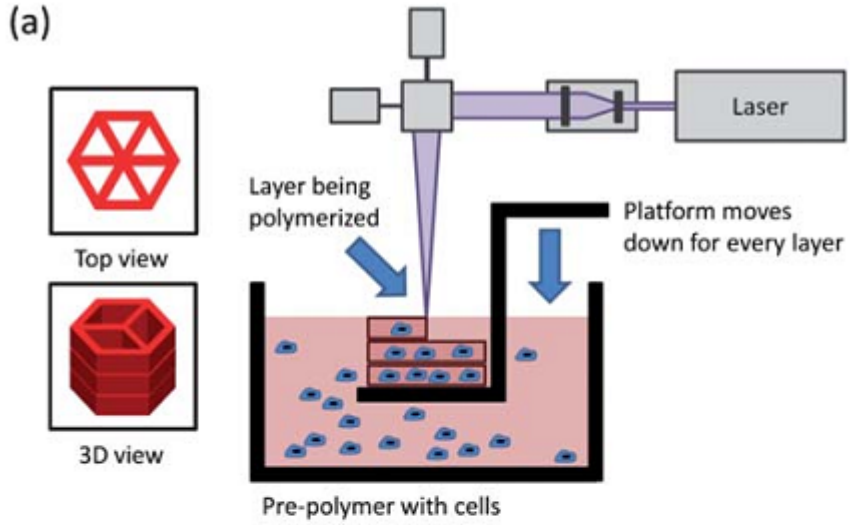
Accuracy
0.1mm (0.0039 in) (Accuracy varies according to geometry, part orientation and print size)



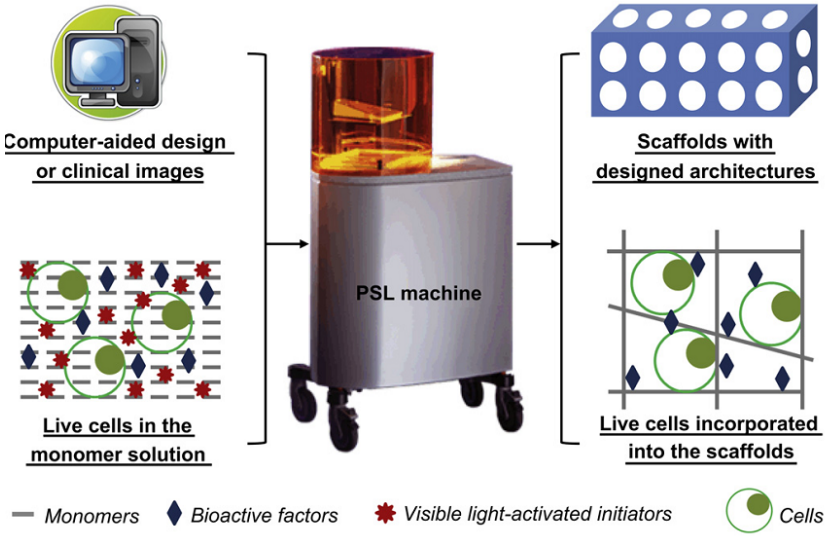


Eye bulb prototype

Scaffold Cellulari



Inglobamento di cellule nello scaffold durante la costruzione



Lab Chip. 2010, 10, 2062-2070
Biomaterials 34 (2013) 331e339

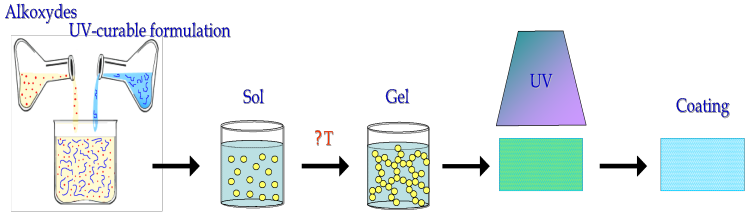
Resine + Filler (Magnetici e/o Elettrici)

Resine conduttive o Magnetiche (Filler)

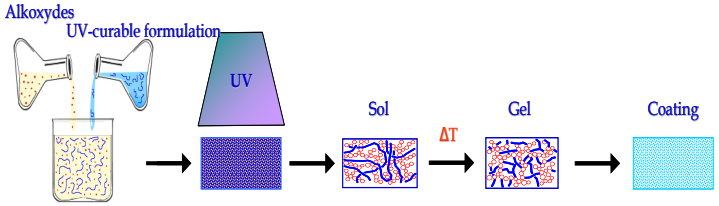
- Metalli
- Ossidi

1. Dispersione delle particelle nella matrice
2. Creazione delle particelle all'interno della matrice polimerica partendo da precursori.

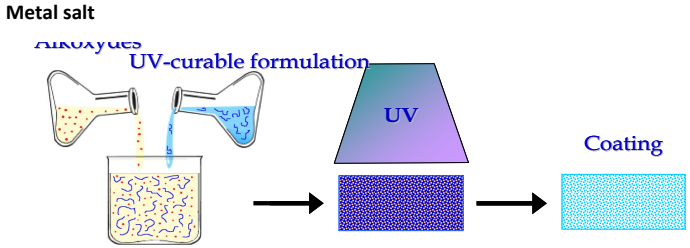
Scheme A: Bottom up preparation of photopolymerised nanocomposites:
UV-curing of the curable monomers follows the synthesis of the inorganic phase



Scheme B: Bottom up preparation of photopolymerised nanocomposites:
the synthesis of the inorganic phase follows the building of the matrix by UV-curing



Scheme C: Bottom up preparation of photopolymerised nanocomposites: the synthesis of the inorganic phase and the building of the matrix is simultaneous (by UV)

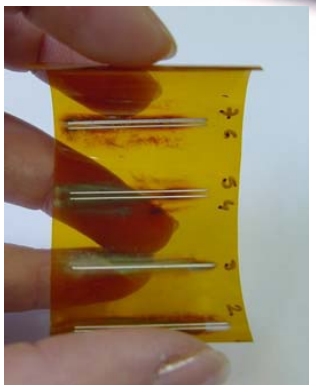


Esempi:
NPs Ag, NPs Cu, NPs Fe_3O_4

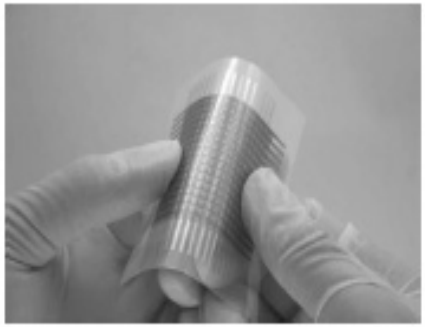
Vedere se adattabili al sistema 3D

Soft Matter **6,** 4666–4668 (2010).
Materials Letters **59,** 2484–2487 (2005).
Nanomedicine (Lond) **1,** 201–208 (2006).
Opt. Express **16,** 1174–1179 (2008).
PhD Thesis Amici Julia
PhD Thesis Rabia Nazar

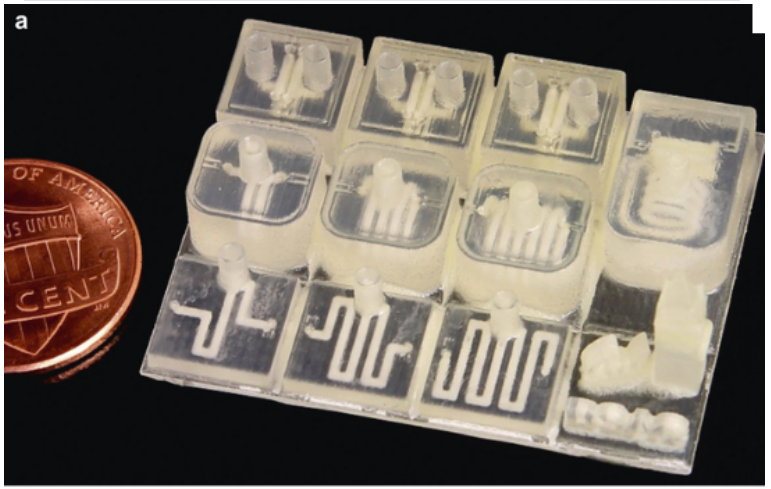
Flexible & embedded electronics

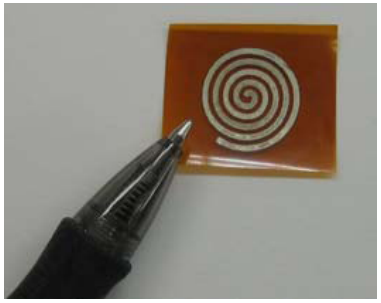


RFID

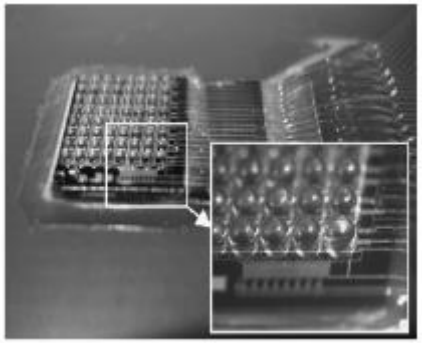


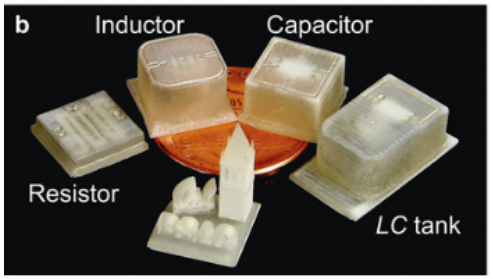
sensori

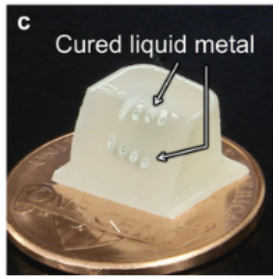




antenne



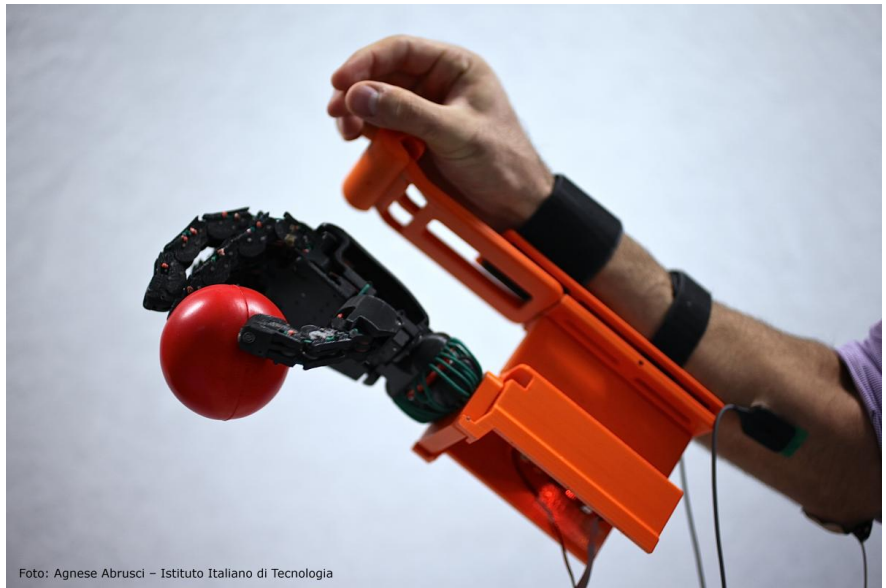




3D printed body parts - Made affortable

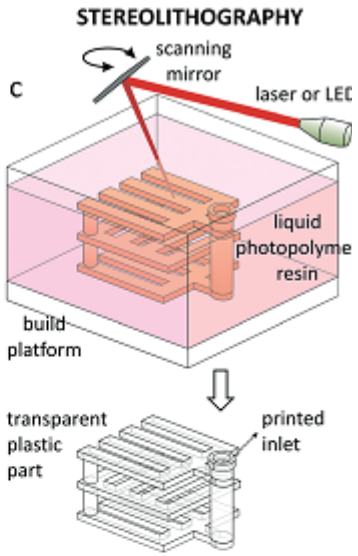
3d printed prosthetics
http://www.nytimes.com/2015/02/17/science/hand-of-a-superhero.html?_r=0

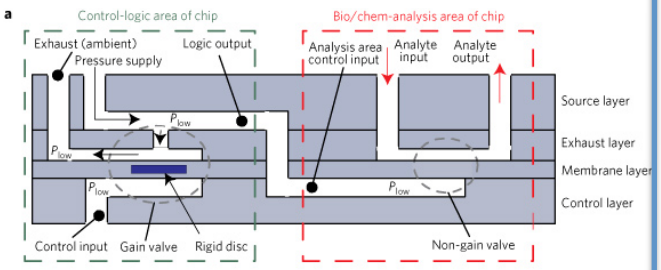
Prostethic hand
http://3dprint.com/2438/50-prosthetic-3d-printed-hand/

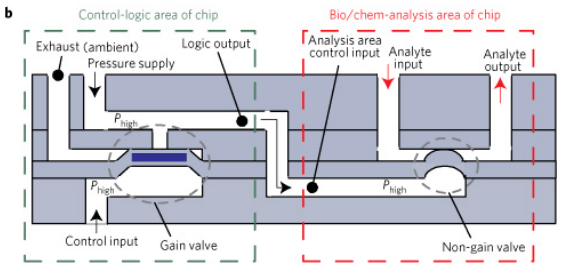


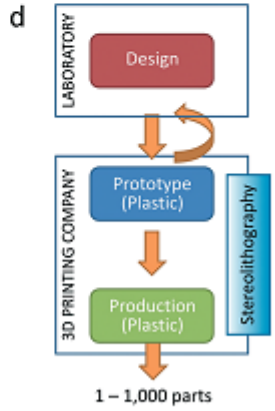
Microfluidica

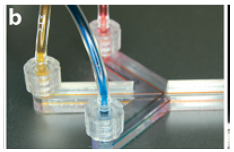
Vantaggi
Sistemi a geometrie complesse
Sistemi multistrato (valvole quake)
Integrazione di inlet e outlet

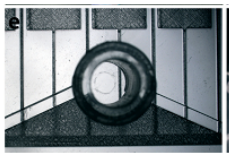


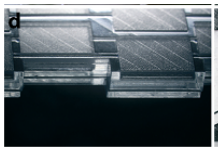








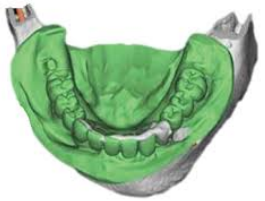




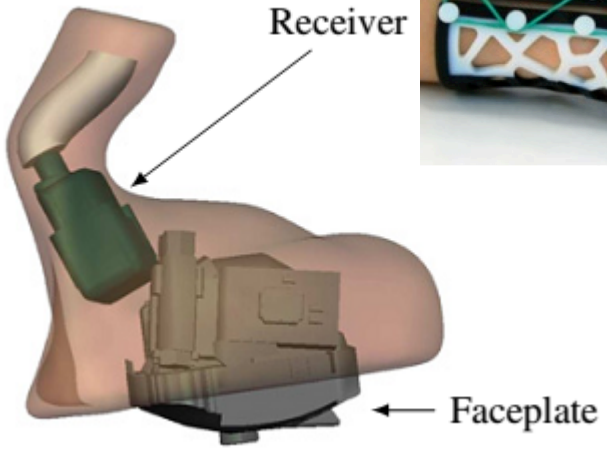
Guide Chirurgiche

Ortodonzia e ortopedia

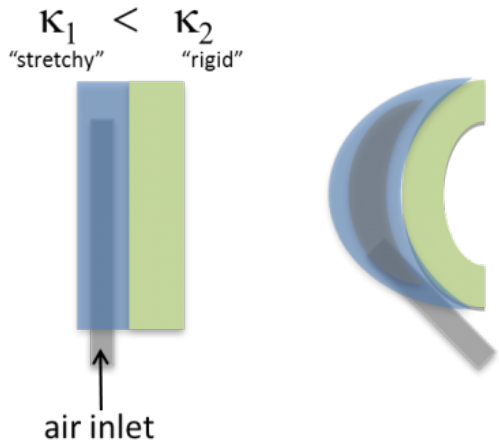
Vantaggi
Diretta custumizzazione
Utilizzo già consolidato

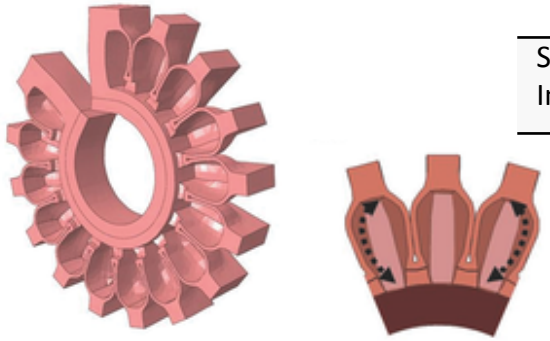


Protesi e tutori



Attuatori/Sensori

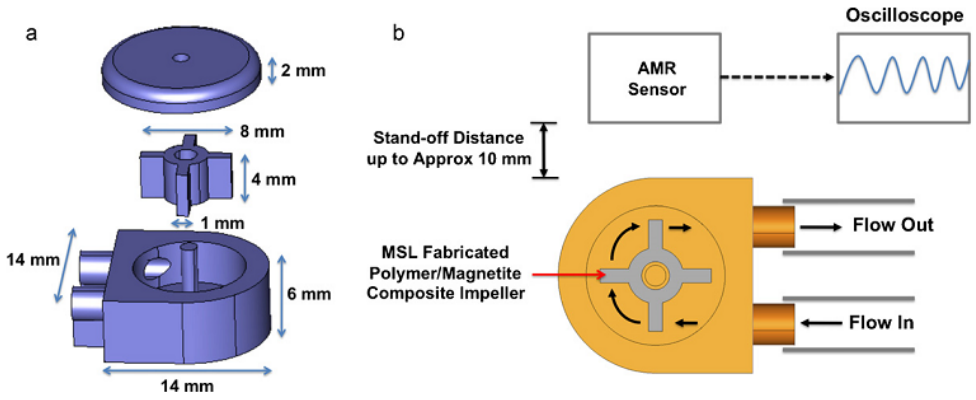


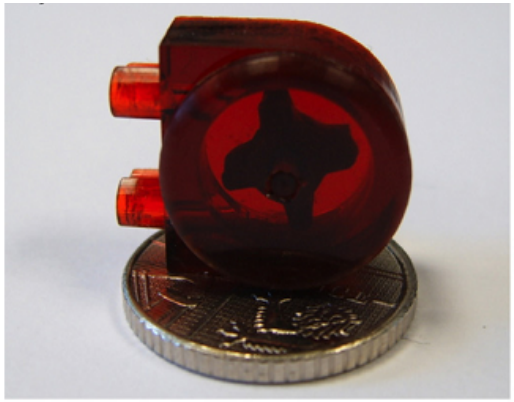


Vantaggi

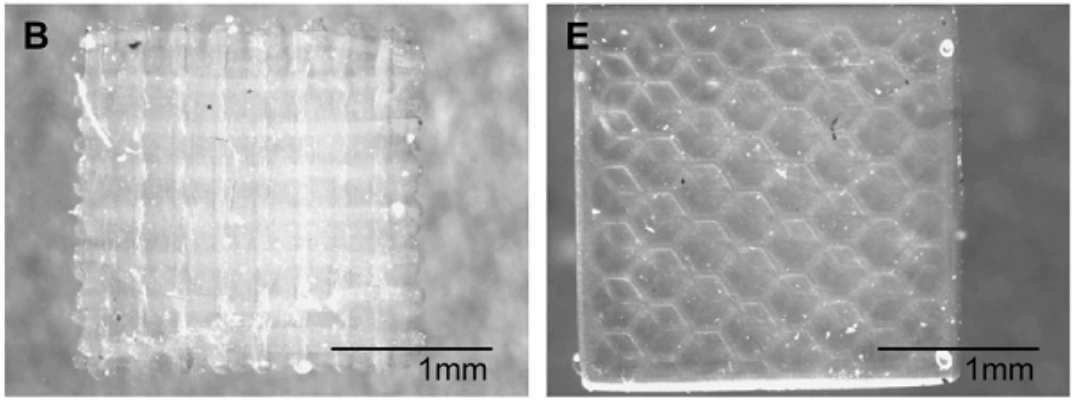
Sistemi a geometrie complesse
Incorporazione di elementi conduttivi o magnetici.

- Struttura doppio strato: uno strato flessibile ancorato ad uno strato rigido.
- Lo strato flessibile presenta una serie di camere a geometria complessa create in modo da indurre una flessione quando pressurizate.
- Cambiando la geometria, il numero e l'orietamento delle camere è possibile modulare la flessibilità del sistema.

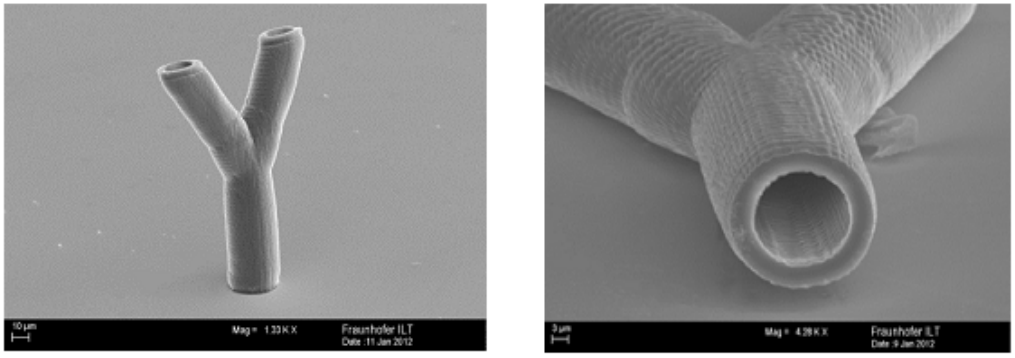




Scaffold

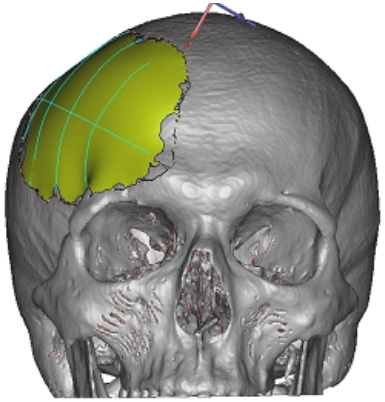


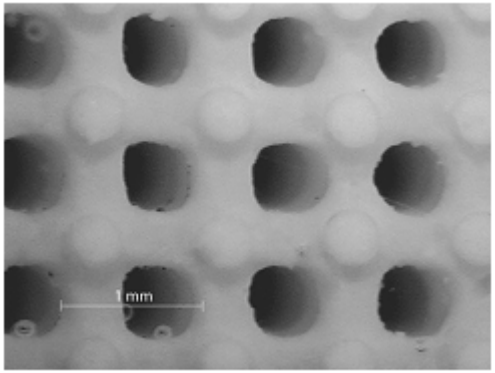
Vasi sanguini - Sistemi vascolarizzati



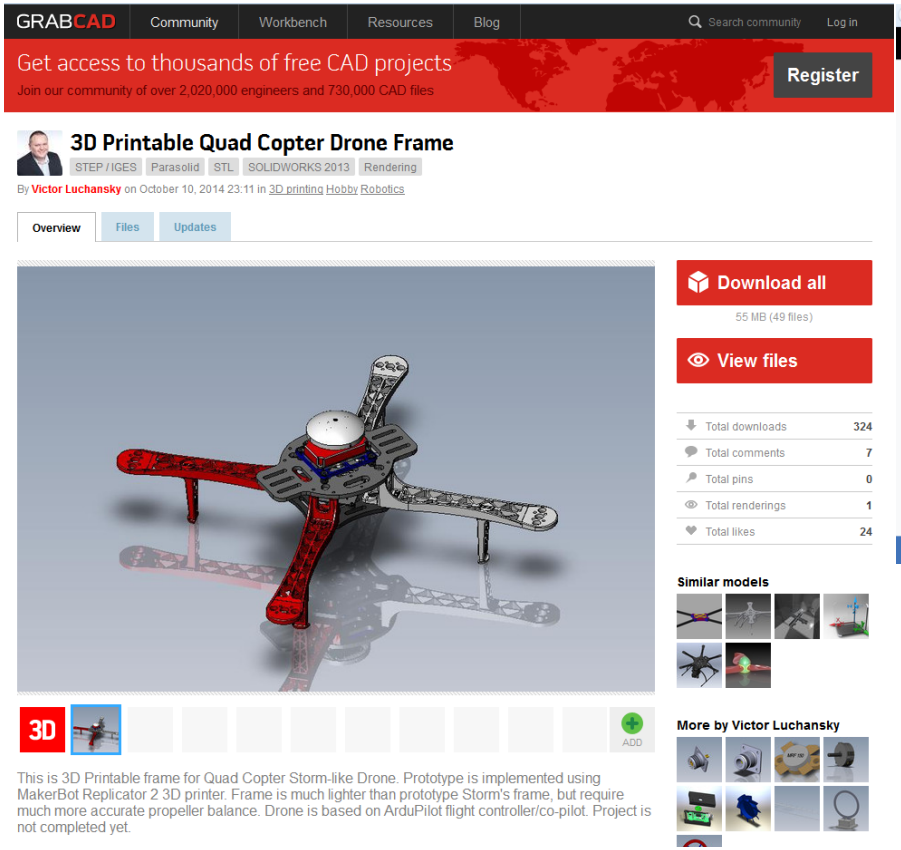
The height of the tubular structures is approximately 160 µm.
The inner diameter and wall thickness is approximately 18 µm and 3 µm.

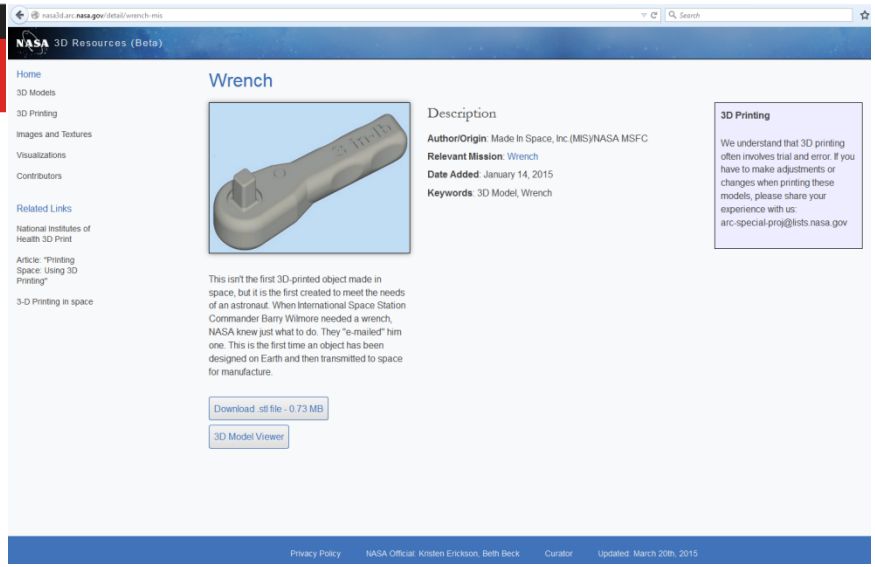
Impianti permanenti





3D printable *.STL files free to download





Nasa 'Made In Space' STL-files

http://nasa3d.arc.nasa.gov/detail/wrench-mis

Moving and funtional part from single process

Drone parts

https://grabcad.com/library/3d-printable-quad-copter-drone-frame-1

Realize your imagined build

Have you always wanted a robotic arm?

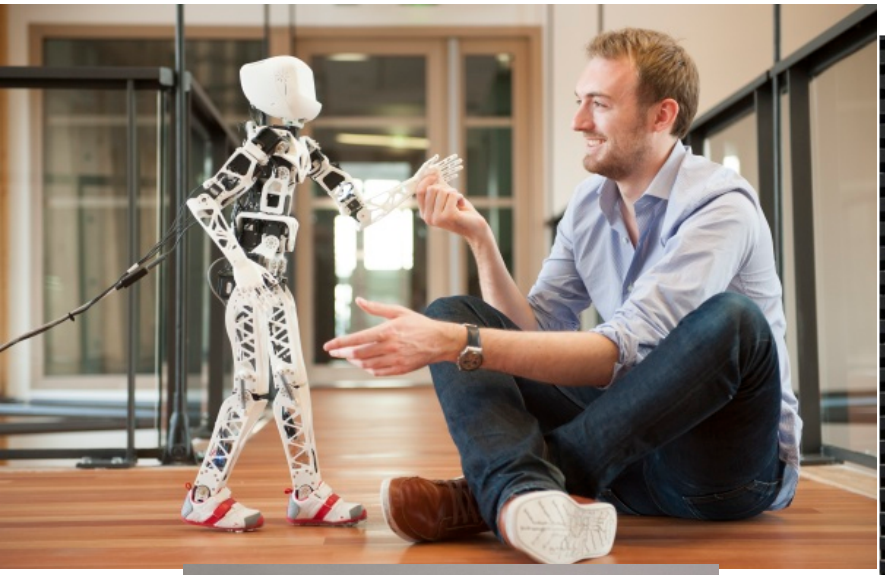
Build it yourself!

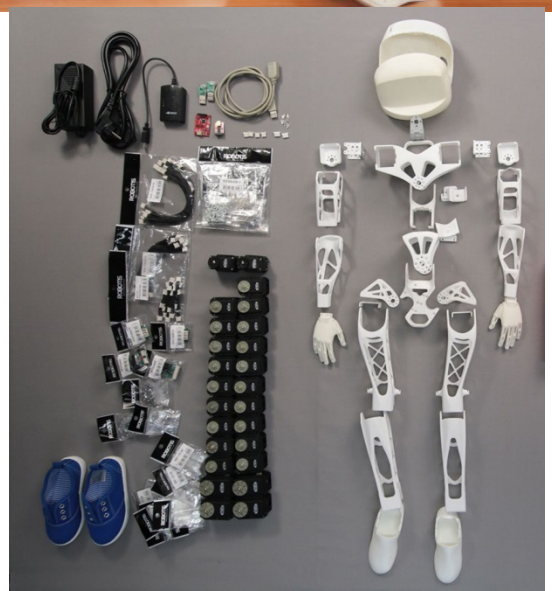
- Before you could make this with LEGO kits but with 3D printing you can build the blocks yourself.
  - Look the instructions from internet and download the *.STL files
  - Print the model
  - Add motors and electric circuits
  - Add control
  - Share your experiences for the community

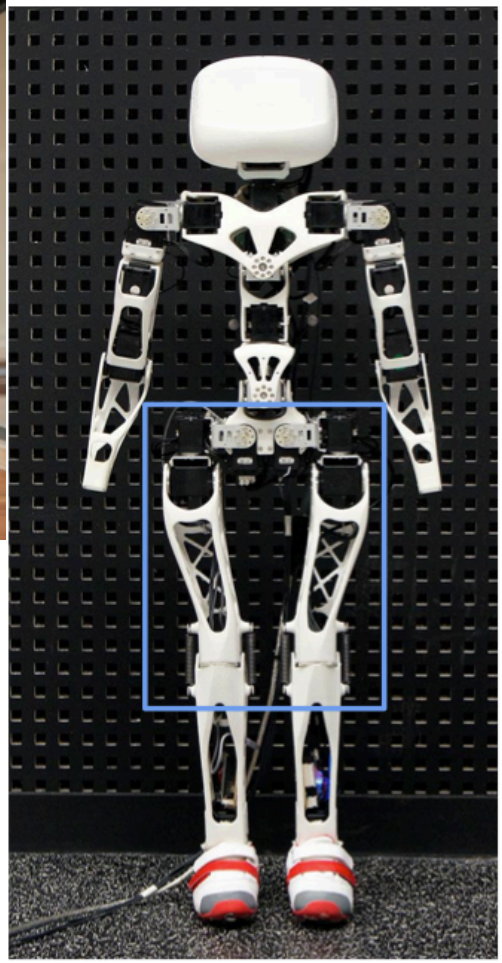
Instructions: http://www.instructables.com/id/3D-Printed-Robot-Arm/?ALLSTEPS

Manufacture tool driven by you

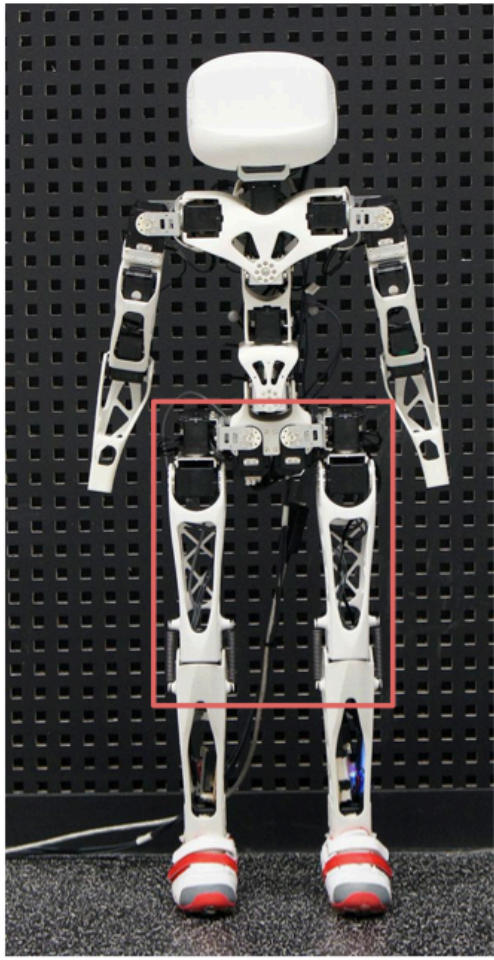
Open sourse robot project: https://www.poppy-project.org/







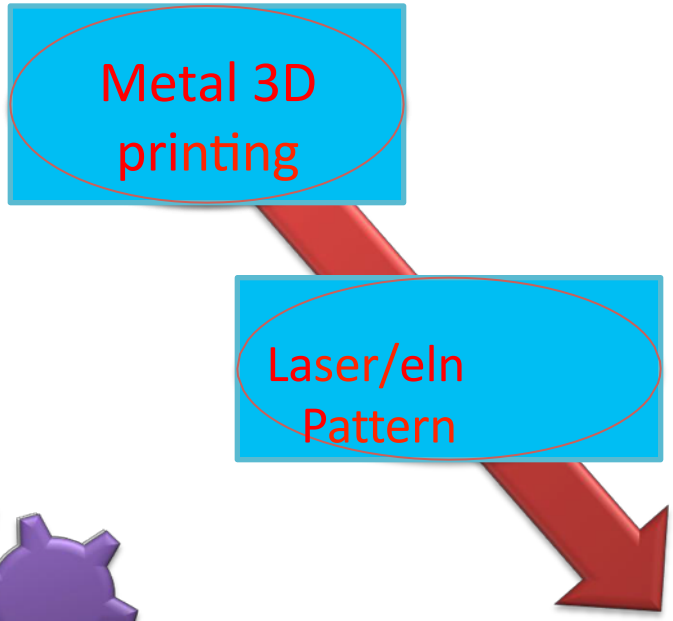
(a) bended thighs

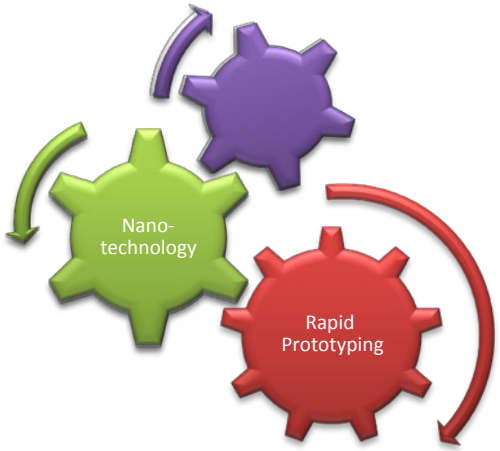


(b) straight thighs

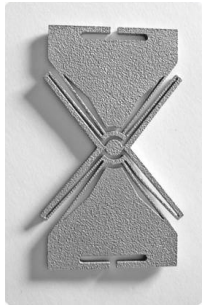
Rapid prototyping

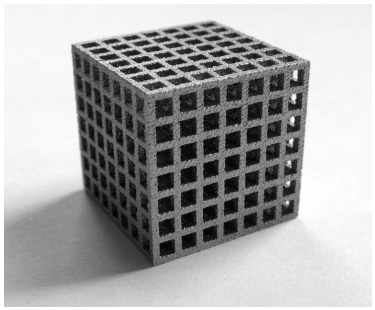
A group of technicques able to fabricate a scale model of a device in a fast, flexible, and accurate way





direct fabrication of metallic structures from CAD file

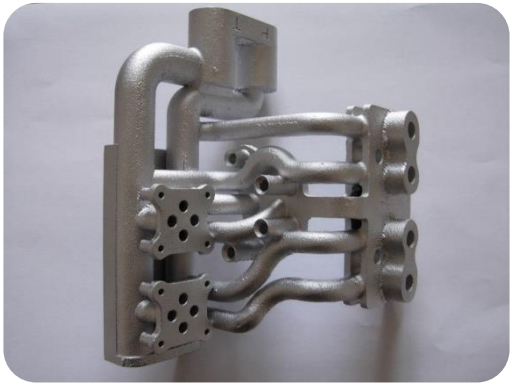




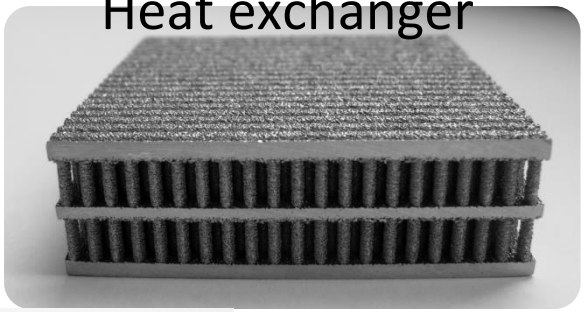
ADDITIVE MANUFACTURING

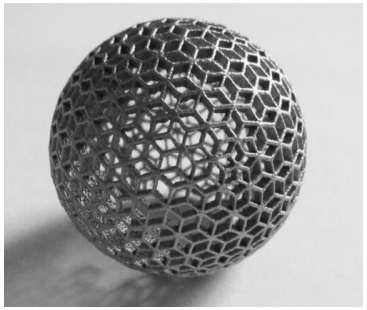
Design for manufacturing

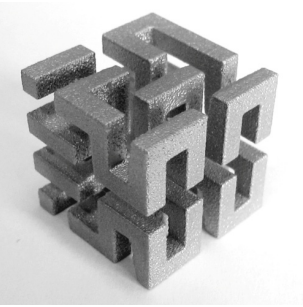
Non assembly mechanisms, lightweight bioinspired structures

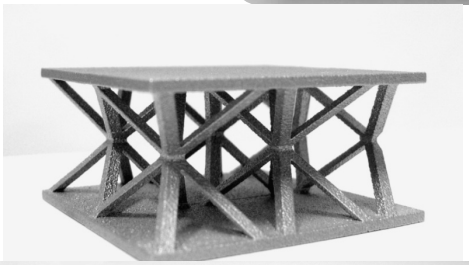


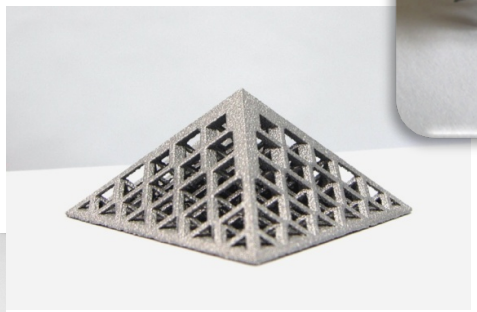
Heat exchanger

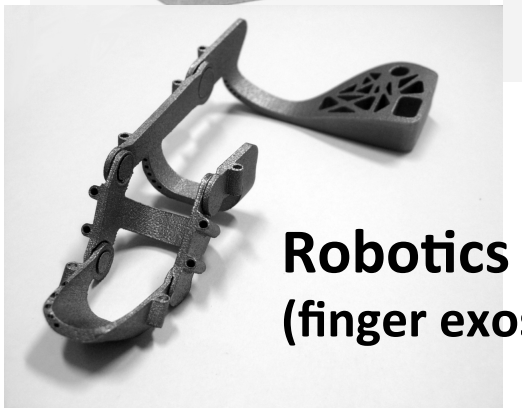












Robotics
(finger exoskeleton)

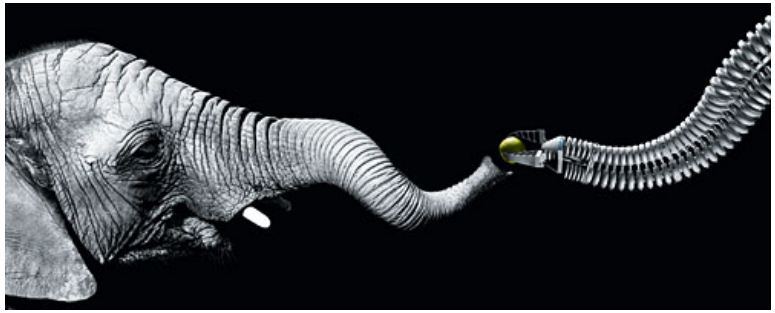
Robotic hand

Developers:
Oak Ridge National Laboratory

A lightweight, fluid-powered robotic hand that combines fluid power with additive manufacturing technologies could have application potential in robotic assembly, prosthetics, and remote handling of hazardous materials.

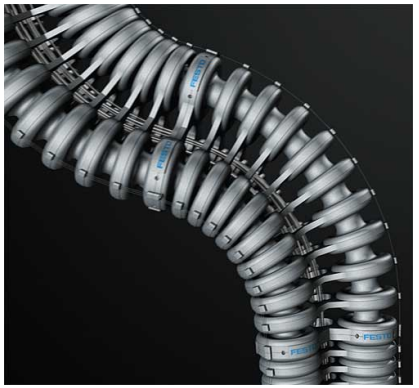
All of the fluid components (pistons, pump, motor housing, cams, fluid passages, etc.) were integrated directly with the mesh structure, significantly reducing parts, materials, weight, energy used to fuse the material, and cost. Weight is reduced by more than five times and process time by more than three times.

Industry - Handling and Robotics



Bionic Handling Assistant
Biological inspiration: Elephant trunks
Developed by: Festo Corp
(Source: Festo AG & Co.KG)

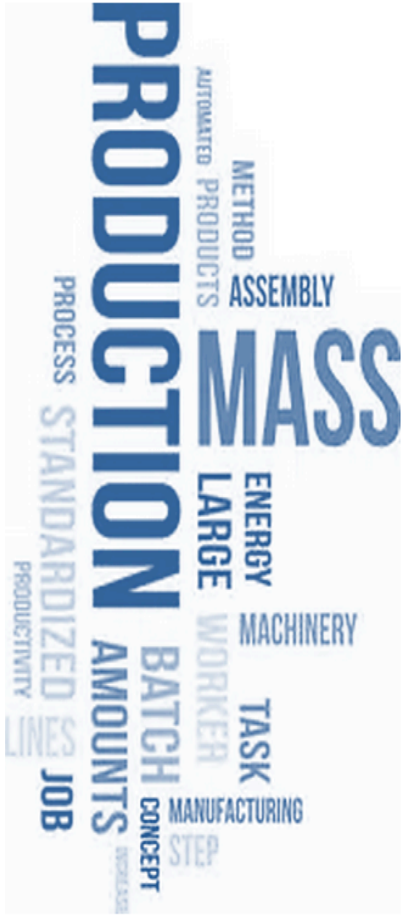
Nature has countless solutions only waiting to be analyzed by bionic science and translated into technological innovation.

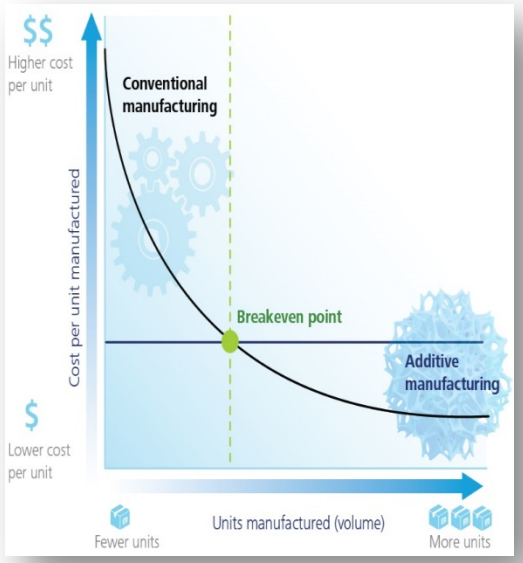


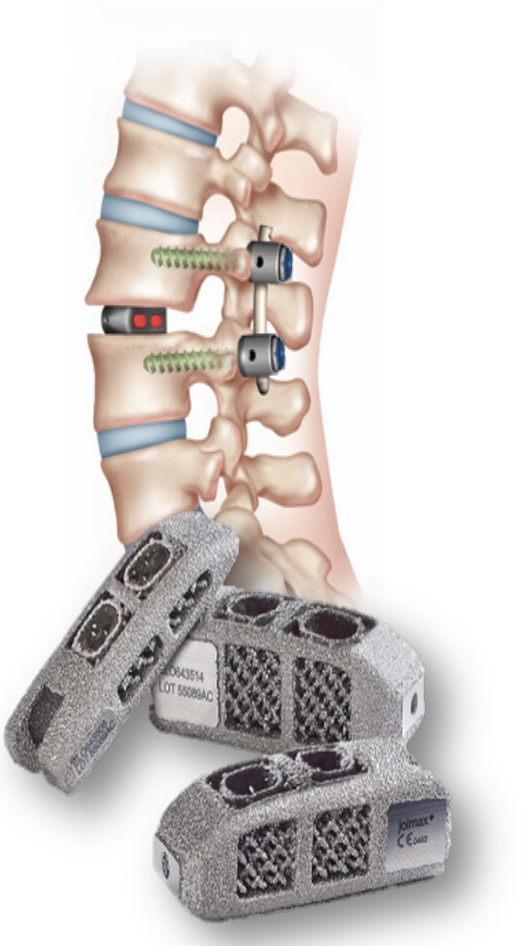
However, it is difficult to employ conventional manufacturing techniques to make use of the solutions which Mother Nature has developed in millions of years of evolution.

GE Aviation, one of the world's top aircraft engine producers, announced plans to introduce high-volume production of the fuel nozzle using additive manufacturing. The company said the $50 million project would make the Alabama plant the first to mass produce 3-D printed components for the jet propulsion industry. The company said production there will ramp up quickly over the next five years, going from **1,000 fuel nozzles manufactured annually** to more than **40,000 by 2020**.

The LEAP is the first engine equipped with 19 3D-printed fuel nozzles and parts that make it **15 percent more fuel efficient** than comparable engines built by CFM International. Source: Ge Reports

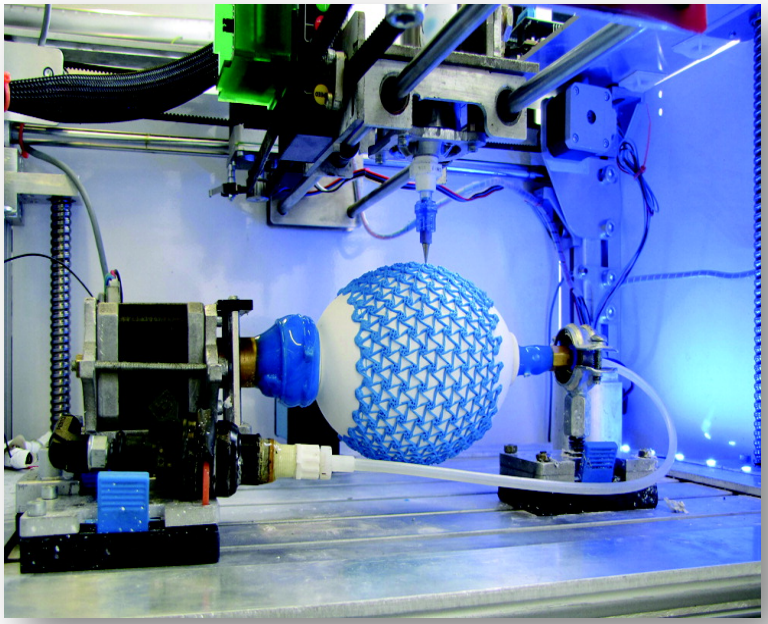






FDA is continuing to approve implant devices. The latest is a **spinal implant** from a German company called joimax, which just received 510(k) clearance from the US governmental body.

Source: 3Dprintingindustry.com

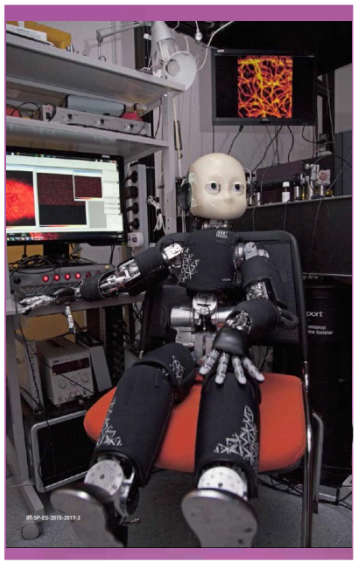


With their own version of 4D printing, Fergal B. Coulter and Anton Ianakiev are exploring the fabrication ofartificial muscle by creating a system for producing seamless tubular silicone membranes with dielectric elastomer actuators (DEA), a form of electroactive polymer that induces a change in form. Coulter and Ianakiev describe the DEAs as “essentially flexible capacitors”, sending low energy electric signals to the flexible tubular structure and causing it to change its form.

Source:Coulter Fergal B. and Ianakiev Anton. 3D Printing and Additive Manufacturing. September

Robotics @ iit

Robotic systems developed at IIT




Design structures bio-inspired

"In her (nature's) inventions,
nothing is lacking,
and nothing is superfluous"
Leonardo Da Vinci

Thanks for your attention!

Fabrizio Pirri

fabrizio.pirri@polito.it