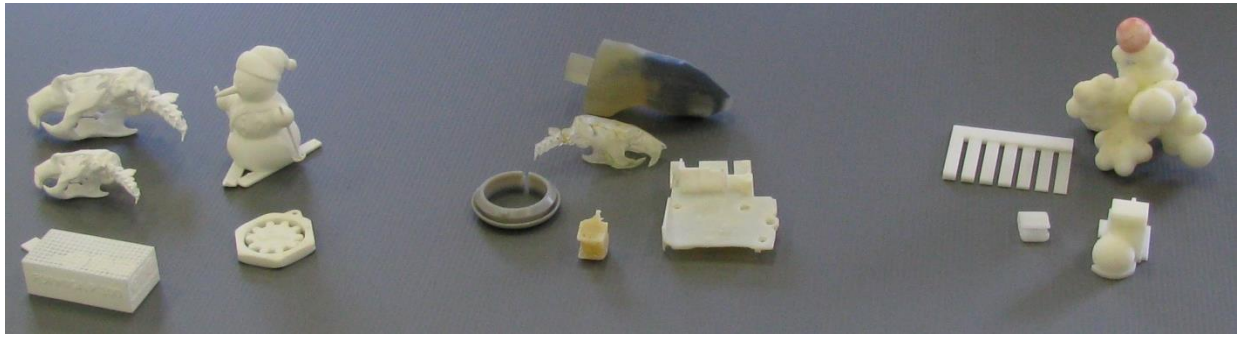
ESIPAP European School of Instrumentation in Particle and Astroparticle Physics

Additive Manufacturing

Thinking about innovation

Feedback on implementation on Additive Manufacturing
For designing and manufacturing of definitive mechanical parts, since 1995
When could I use additive manufacturing ? Where could we find some informations ? Who could help ?



Enigmass

IPHC Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

cnrs IN2P3 Les deux infinis

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Summary

1- two complementary aproaches
specific contexts

2- main additive manufacturing technics in use
processes, machine manufacturers, partners, …

3- achievement example
geometrical optimization in an IPHC project,
some research and development examples in several domains

4- some 3D printers

5- conclusion

Annex : complementary informations

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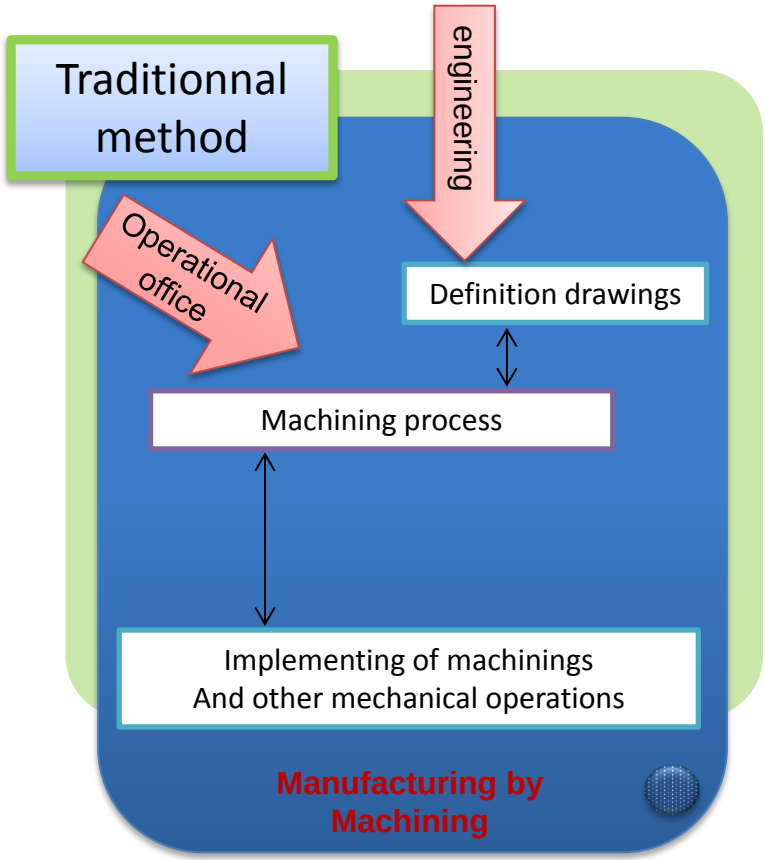
1- two complementary aproaches

specific contexts

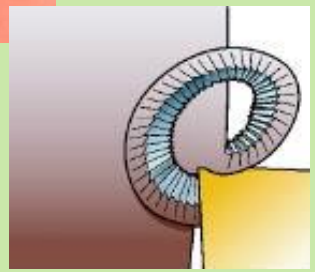
1- two complementary approaches



Metal cutting

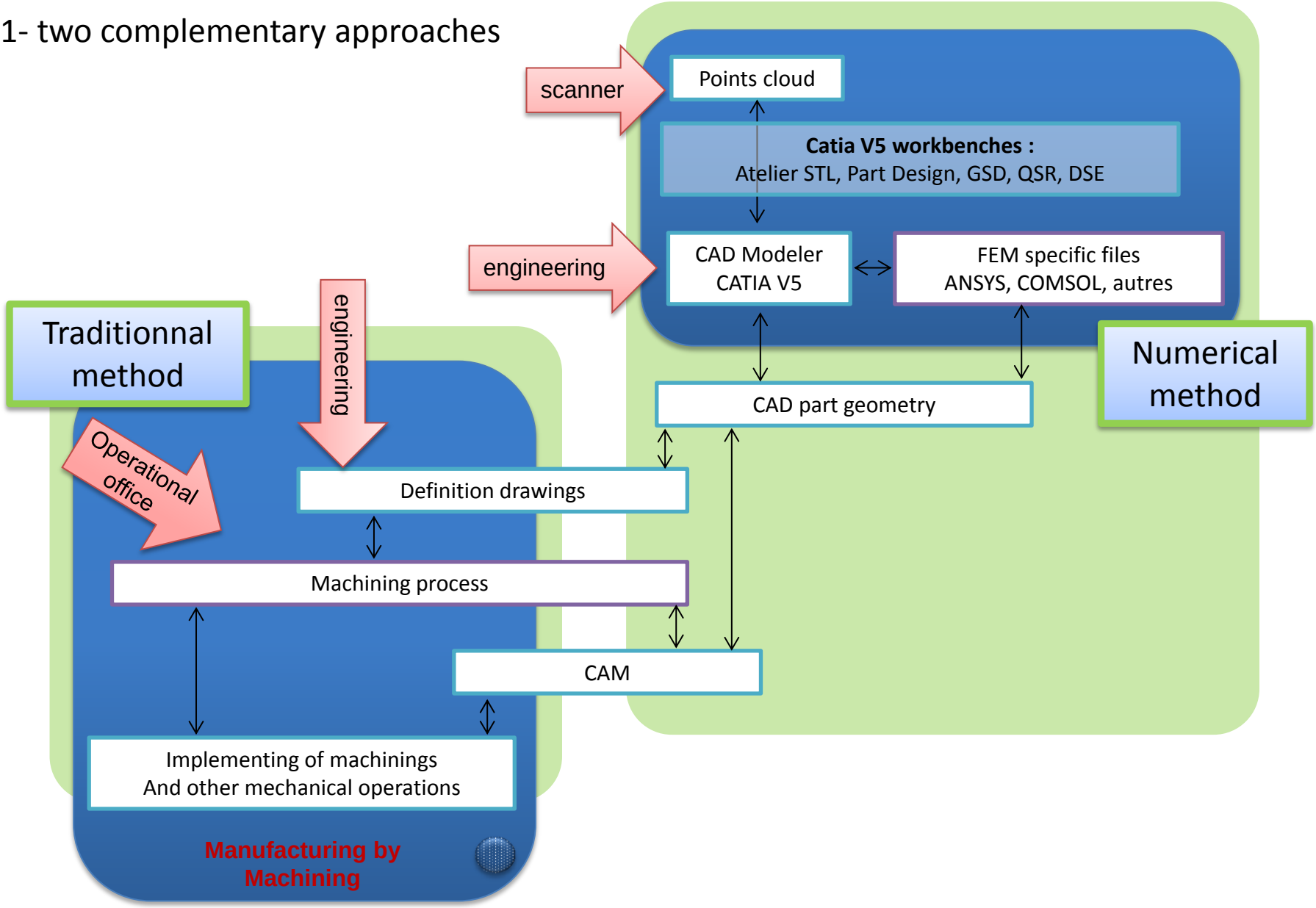
elasticity,
plasticity
rupture,
Strain

Machine chip

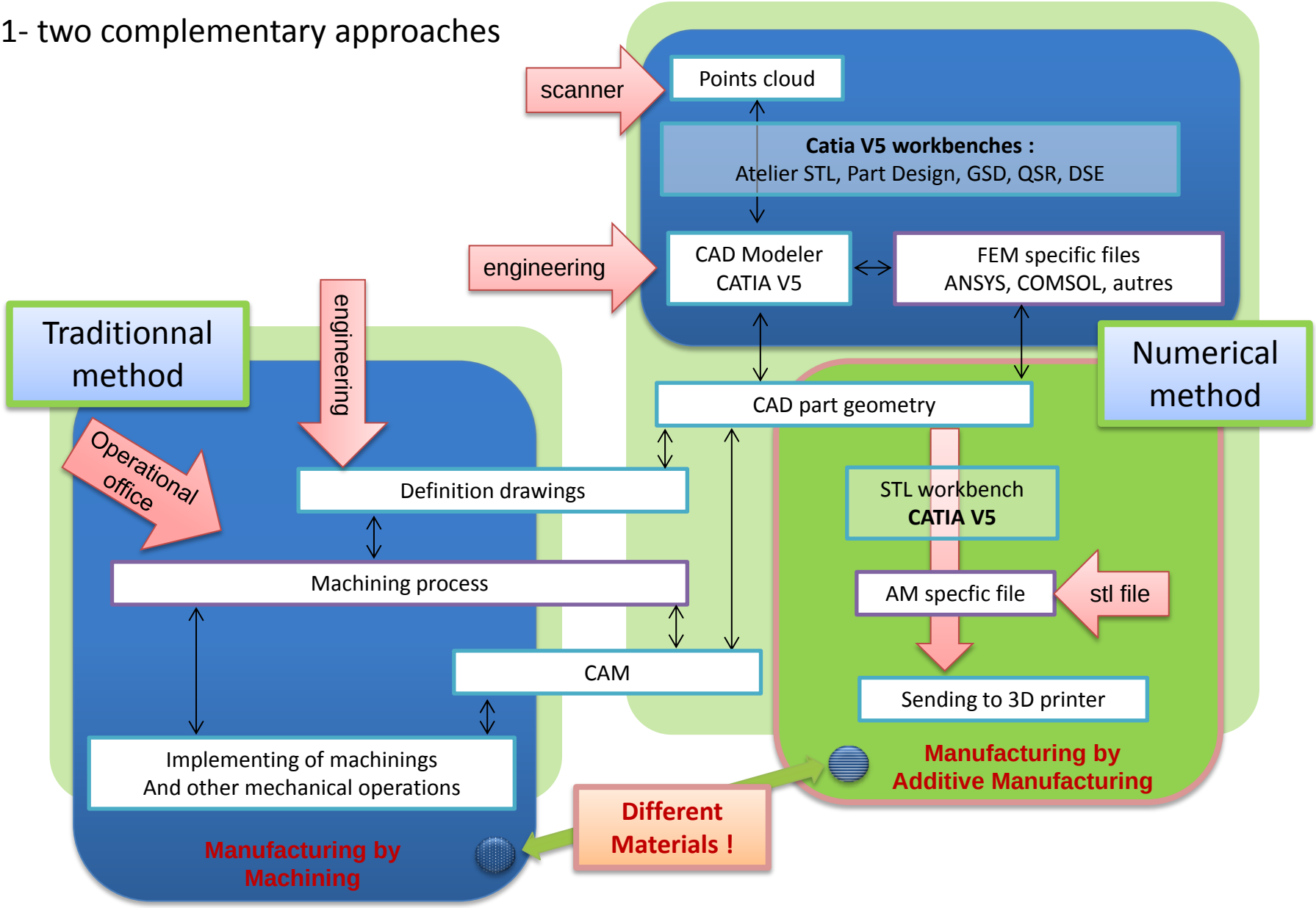


Source : http://www.sandvik.coromant.com/

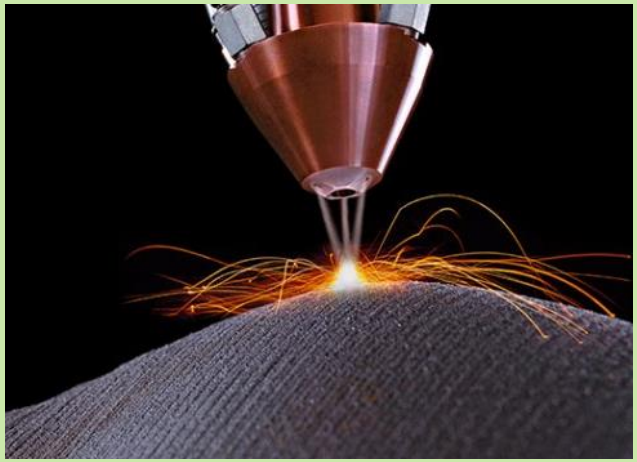
1- two complementary approaches



1- two complementary approaches



1- two complementary approaches



Powder and laser…
Direct manufacturing

scanner

engineering

Points cloud

Catia V5 workbenches :
Used workbenches : STL, Part Design, GSD, QSR, DSE

CAD Modeler
CATIA V5

FEM specific files
ANSYS, COMSOL, other

Numerical method

CAD part geometry

STL workbench
CATIA V5

AM specfic file

stl file

Sending to 3D printer

Manufacturing by Additive Manufacturing

1- two complementary approaches : numerical method

DSE

Points cloud
in **CATIA V5 environment**…

collaboration UdS LPODECK CNRS IPHC

Importation
Filtration
Reparation

QSR

Automatic
Surface construction

Part Design

solid

Analysis
and Simulation

Exportation
Simulation

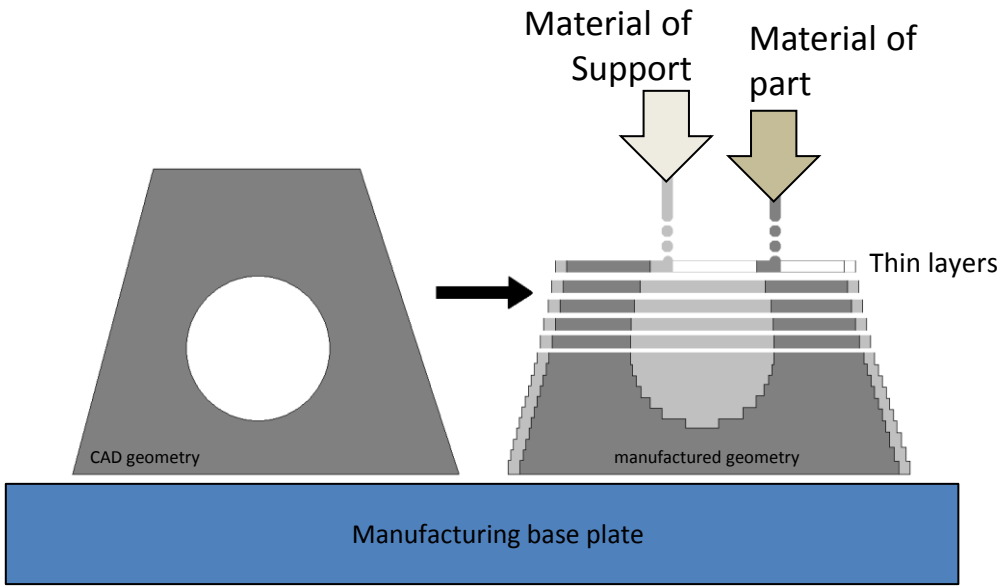
1- two complementary approaches : numerical method

Base principle

Additive Manufacturing (AM) is defined by ASTM norm under the name 'Fast Manufacturing'

'3D printing' is the common name to describe all the process which use AM.

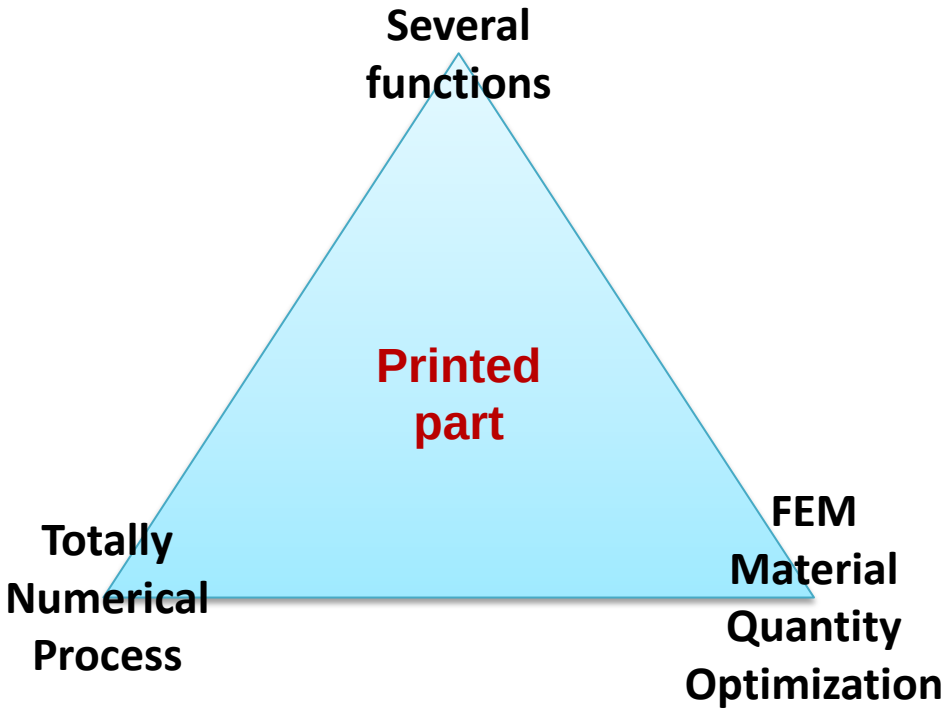
Invention of stereolithography begins in 1980's, in a chemical school in Nancy (France).
Industrialisation begins in 1986 in USA by 3D Systems society.



Material of support : specific resin or fine mechanical structure
needed by supporting part during manufacturing process
Material of part (anisotropical material) : plastic, metallic ou composite

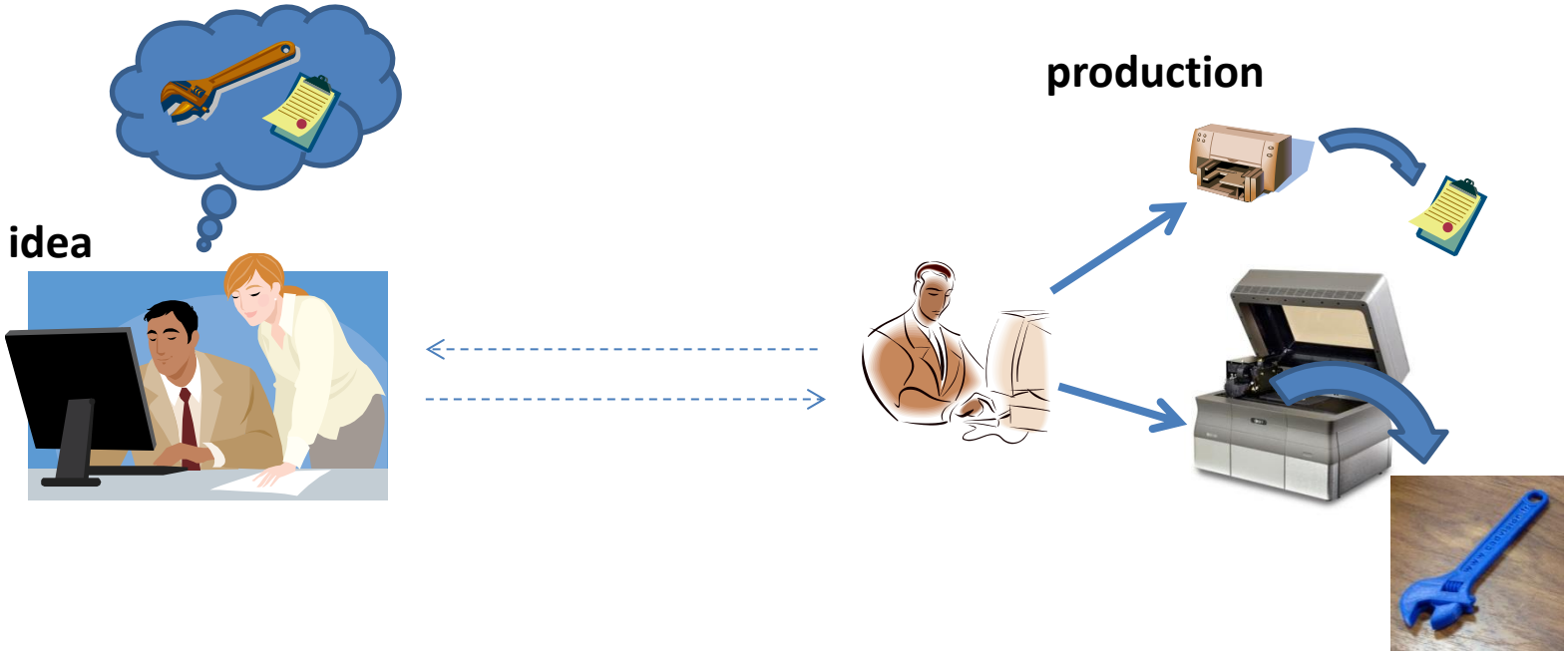
1- two complementary approaches : numerical method

a revolution …



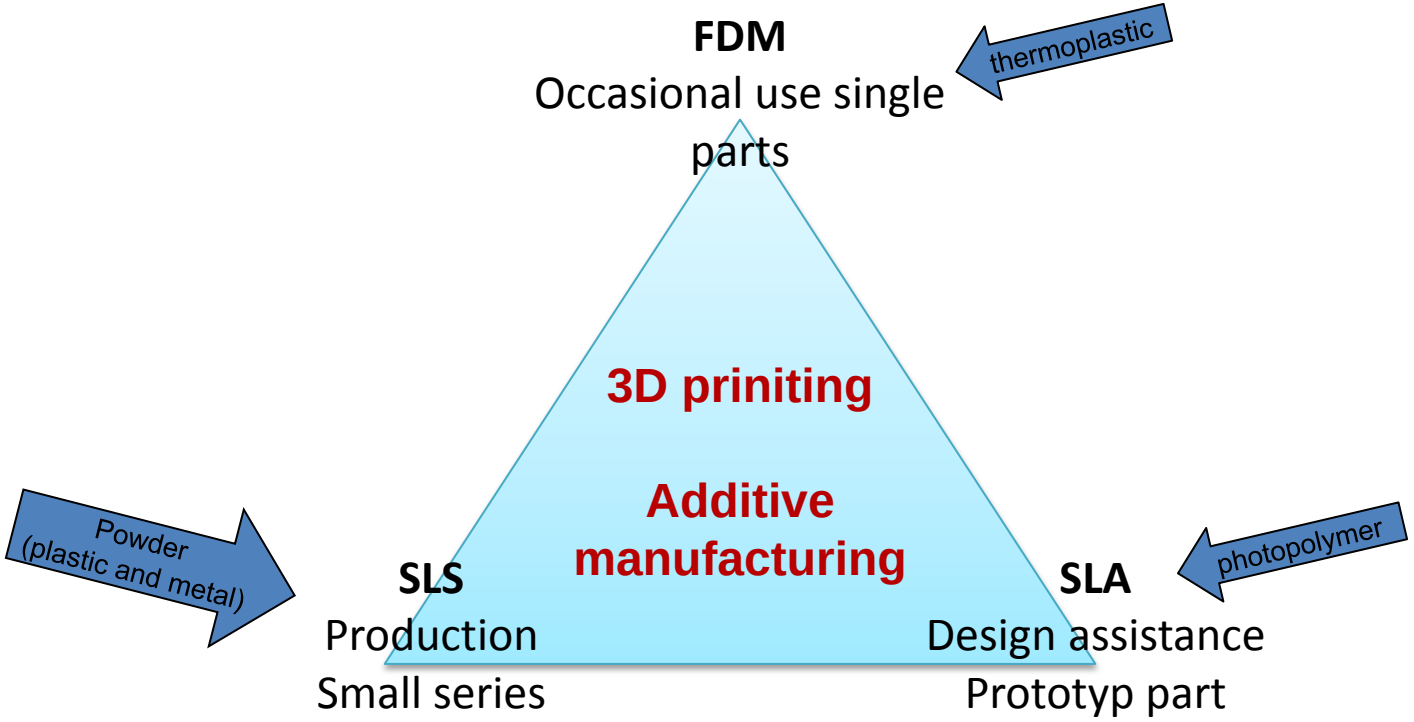
1- two complementary approaches : numerical method

a revolution …



1- two complementary approaches : numerical method

Main existing printing processes …

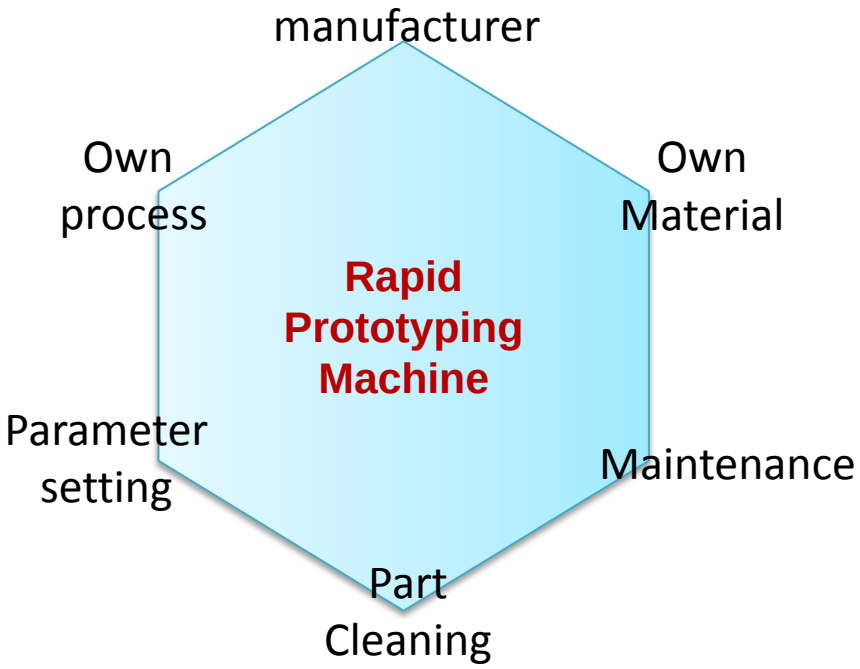


FDM = Fused Deposition Modeling
SLS = Selective Laser Sintering / DMLS = Direct Metal Laser Sintering
SLA = stereolithography

-> http://fr.wikipedia.org/wiki/Impression_tridimensionnelle
http://en.wikipedia.org/wiki/3d_printing

1- two complementary approaches : numerical method

Inseparable…



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2- main additive manufacturing technics in use

processes, machine manufacturers, partners, …

Main : industrial use, make durable and accurate parts, with well known material

2- Main direct fabrication technics in use

Sources : http://www.industrie-techno.com/sept-facons-de-fabriquer-en-3d.23174
http://en.wikipedia.org/wiki/Cladding_(metalworking)

Several additive manufacturing processes :

1- **fdm process** : thermoplastic

2- **Objets 3D printers** (Objet.com) : thin layers (less than 30 µm)
Remove with spatule, remove support material with water jet
Clear the tray with spray
Build tray is ready for the next model

3- **voxeljet** (voxeljet.com)
Pouder and binder jet
Parts complete curing after 24 h standing
Make vax parts
Layer thickness 0,006 inch
Depoudering station to remove the pouder by hand to prevent damage
Final curing process : low temperature for 5 h
When curing is complete, remaining excess pouder is removed with low pressure air jet
Final step : quick dip in vax to seal the part
A heater can as used to remove the excess vax from the surface

4- **stratoconception**
Cutting parts in thin hard or soft plates (foam, wood, plastic, metal, …)
Stack the pieces to construct the whole geometry

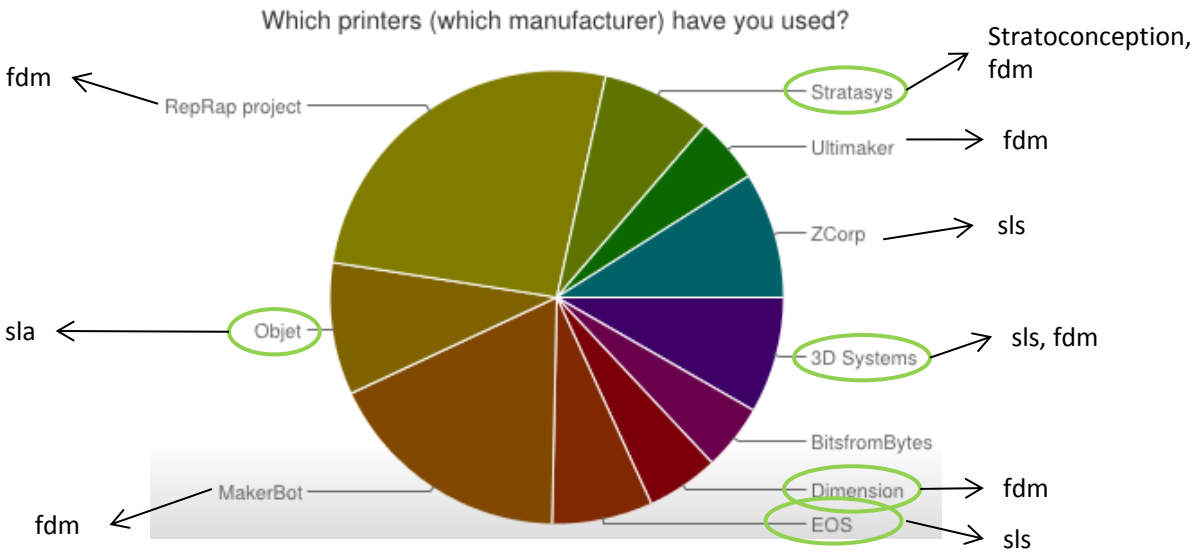
5- **stereolithography** (materialise.com)
Pieces are produced in liquid polymer, with a same material builded supporting structure.
The polymer is solidified layer by layer : during the process, the pieces supporting tray go down in the polymer.

6- **polyshape process** :
Pouder layers with selective laser melting, layer by layer
The support, the pouder and the pieces are cooled before cleaning

7- **CLADDING :**
Metal powder projection and melting by laser : the melted powder consolidates and form the part on a substrate layer by layer.

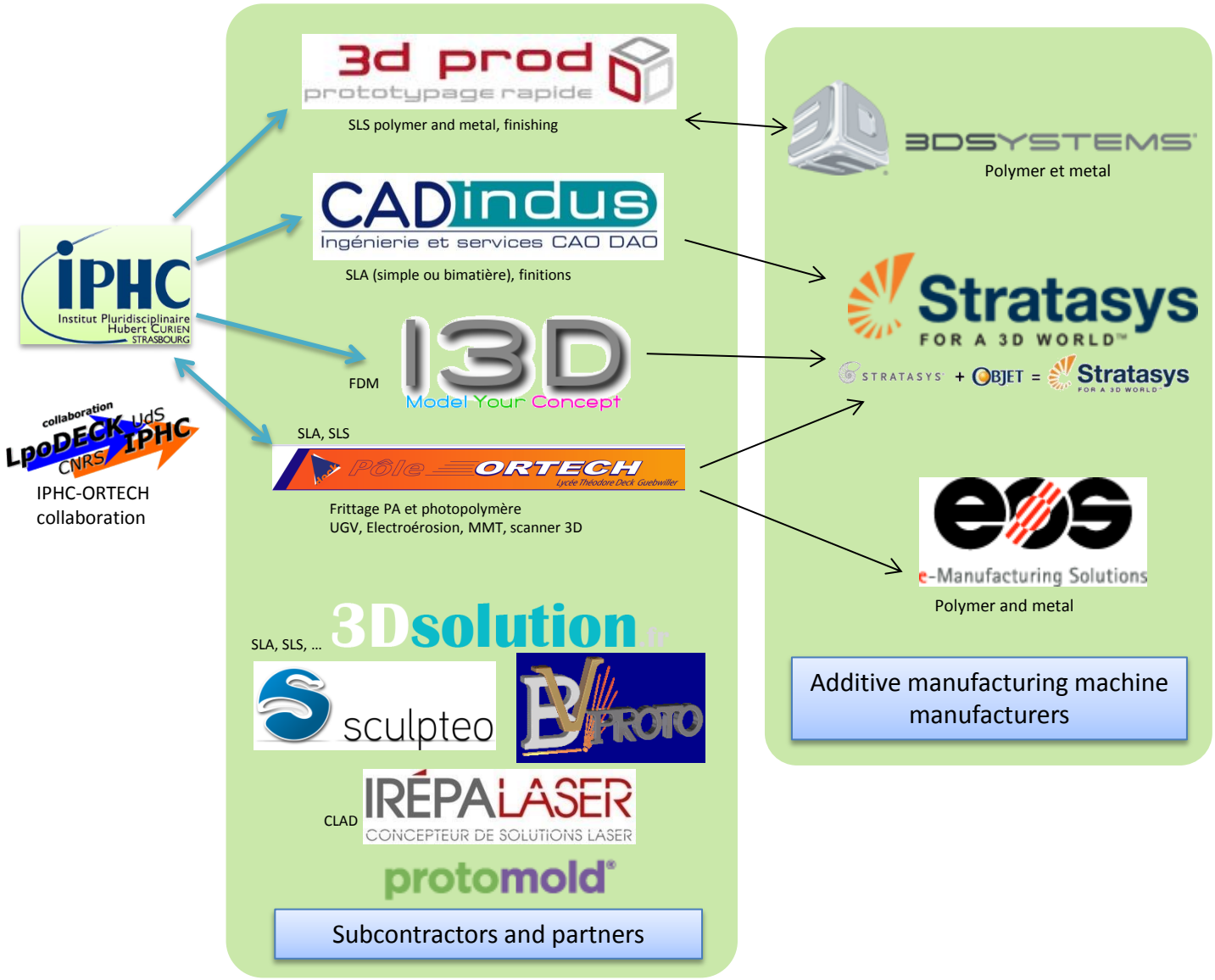
2- Main direct fabrication technics in use

Several machine manufacturers …



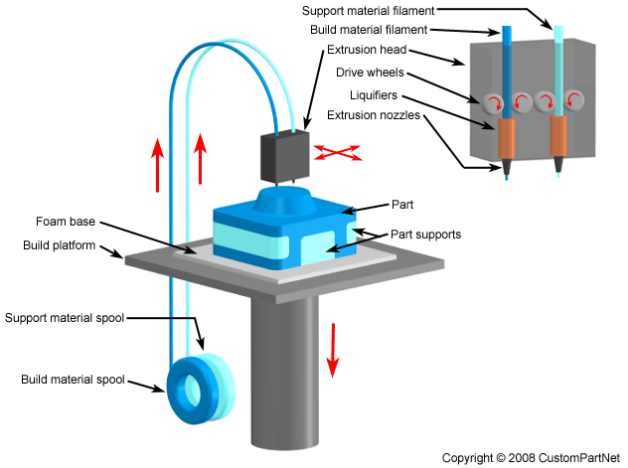
source : http://reprap.org/

2- Main direct fabrication technics in use



Fused Deposition Molding at CEMES laboratory (CNRS, Toulouse)

machines DIMENSION et Stratoconcept (manufacturer : STRATASYS)



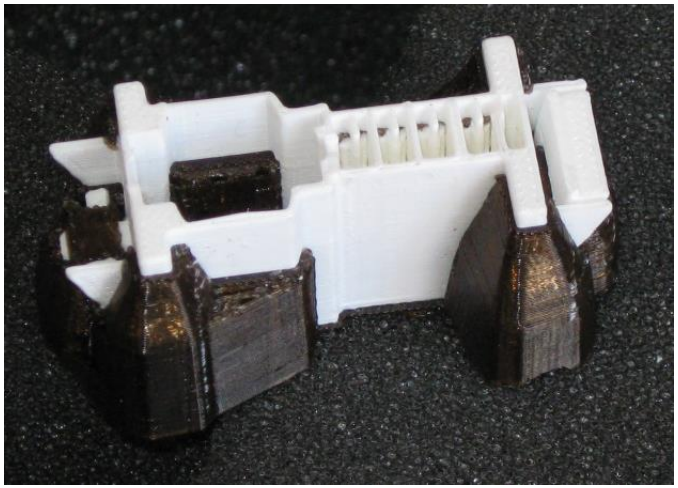
Soluble resin and part material (ABS) are deposed together .

L'I3D du CEMES propose un parc de machines mutualisées…

http://www.i3d.cemes.fr/

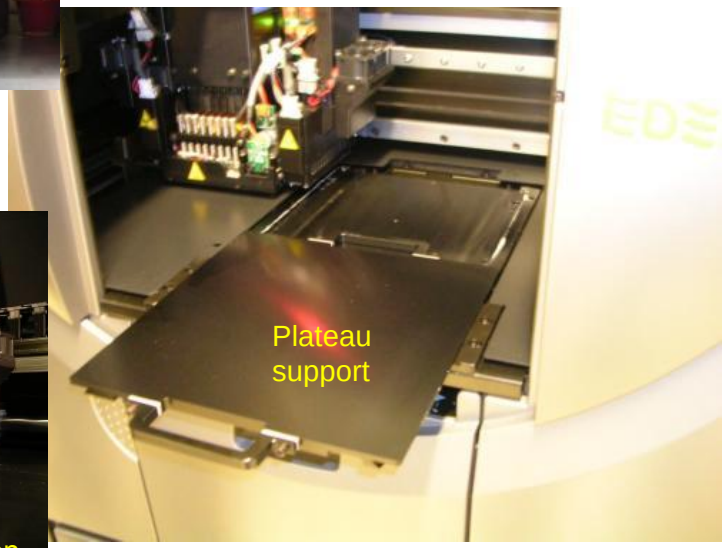
Fused Deposition Molding

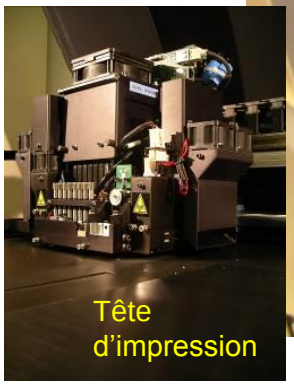
What come out of printer ?



Cleaning by immersion : support material is soluble
! two different materials

Photopolymer UV curing with CADINDUS Society (in Mulhouse) and pôle ORTECH from LpoDeck (in Guebwiller)





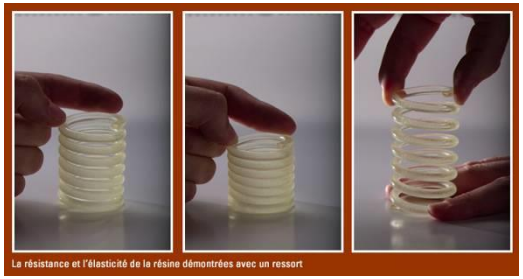
EDEN machine
by OBJET Society

Photos INTERNET (Société OBJET)

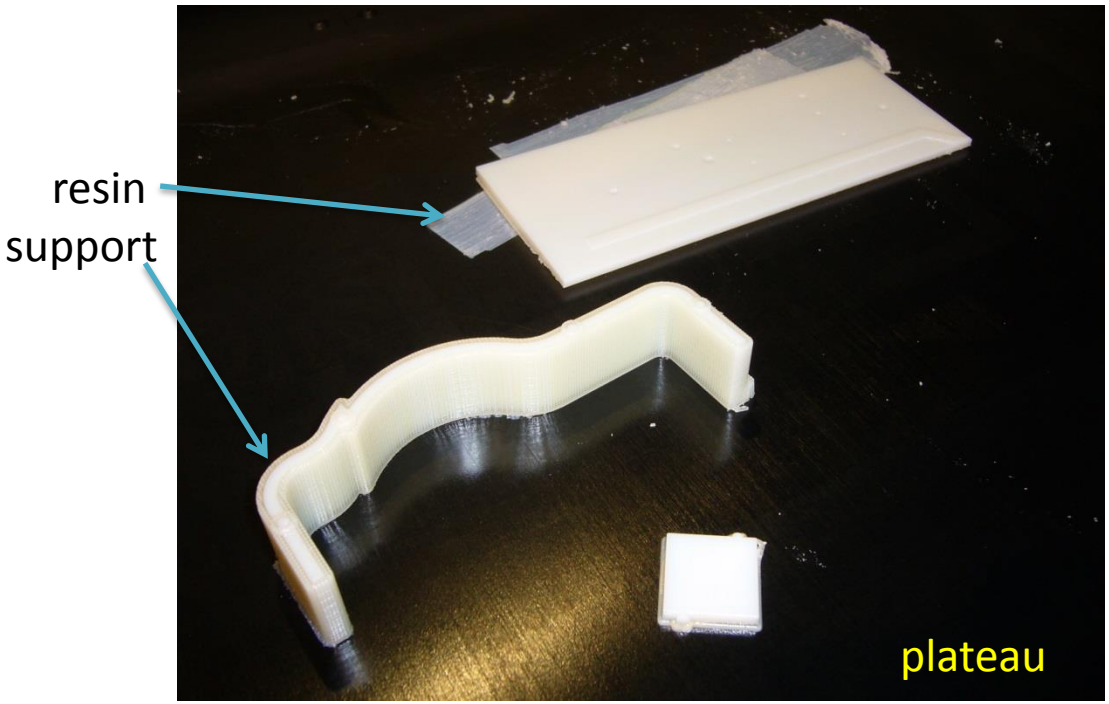
Bimaterial production
(with CONNEX 500)

Unremovable parts : bearing

spring

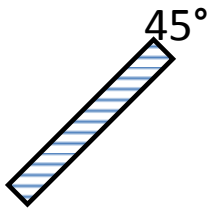


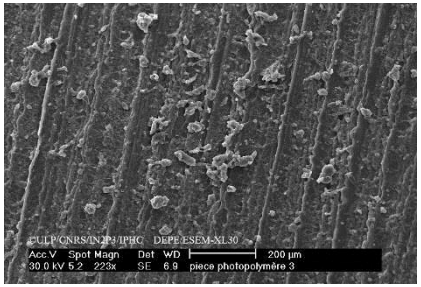
Photopolymer UV curing

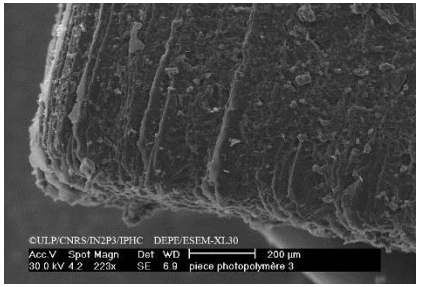


Cleaning : water jet and scraper
! resin support and part : same chemical base

3D printing with EDEN 330, viewed by electron microscope ESEM (IPHC)

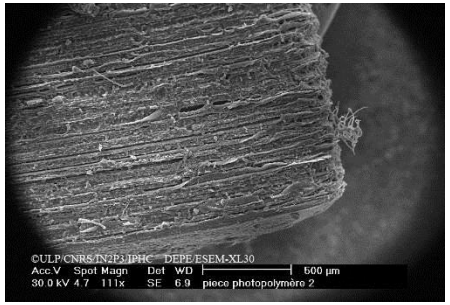


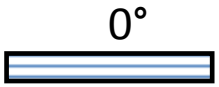


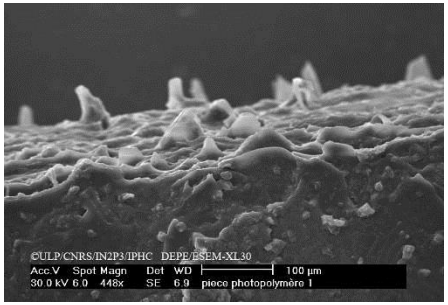


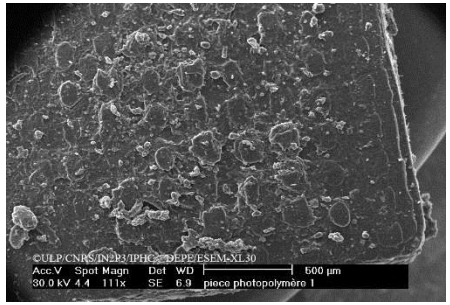
Sample fabrication
10mm x 10mm x 1mm

Layers thickness : 16µm







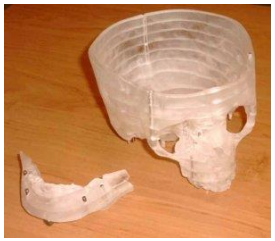


©IPHC / DEPE / ESEM : Environnemental Scanning Electron Microscope
Source : http://en.wikipedia.org/wiki/Environmental_scanning_electron_microscope

2- Main direct fabrication technics in use

Stratoconception (hybrid principle : stack of machined plates or cutted sheets : glued, welded or screwed together)

Using of traditionnal machining technics



Stratoconception original patent

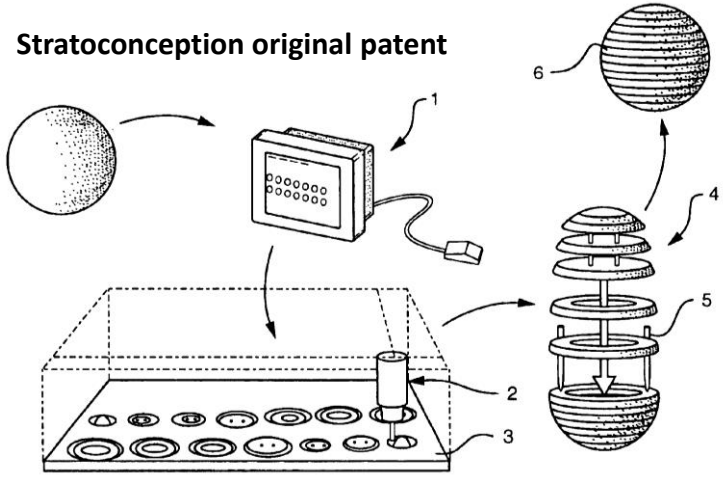


Image Source : http://www.freepatentsonline.com/6745446.html

Selective laser sintering (sls)

PA parts production at LpoDECK and 3DPROD (Vosges, Alsace)

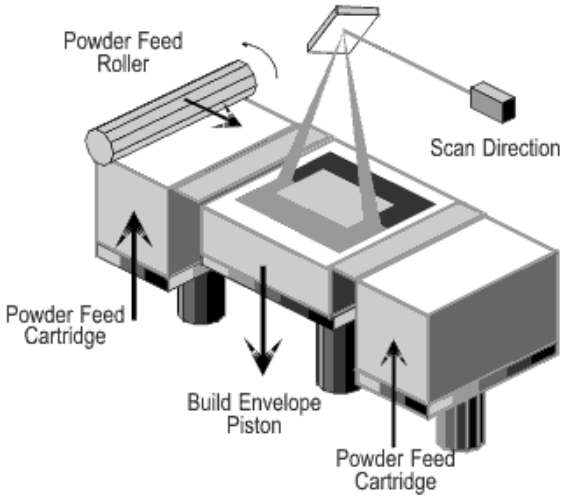
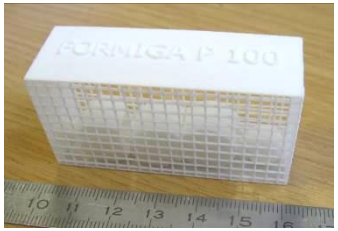


Image source : http://3dprinting.com/

EOS sample



Ensemble indémontable
Couches d'épaisseur 0.1mm

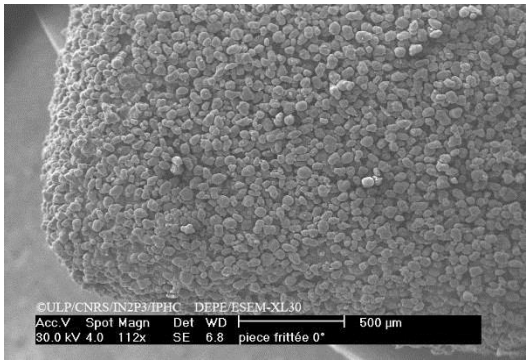
EOS Formiga P100 : Polyamid (PA) printing

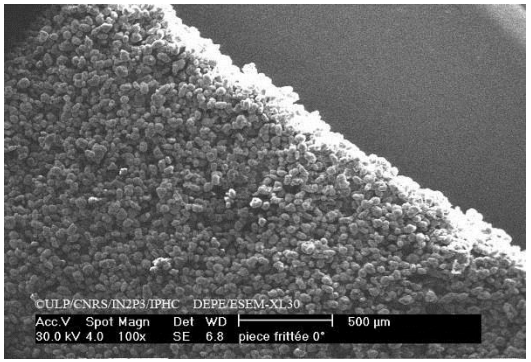
metal or ceramic possible on other machine

3D printing with EOS FORMIGA 100, viewed under ESEM (IPHC)

Grains size less than 100 µm

Partially melted on surface





©IPHC / DEPE / ESEM : Environnemental Scanning Electron Microscope

Direct Metal laser sintering (DMLS)

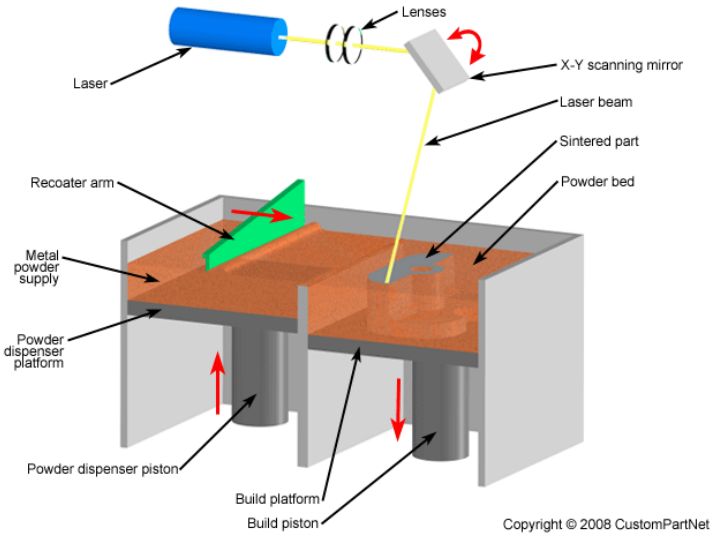
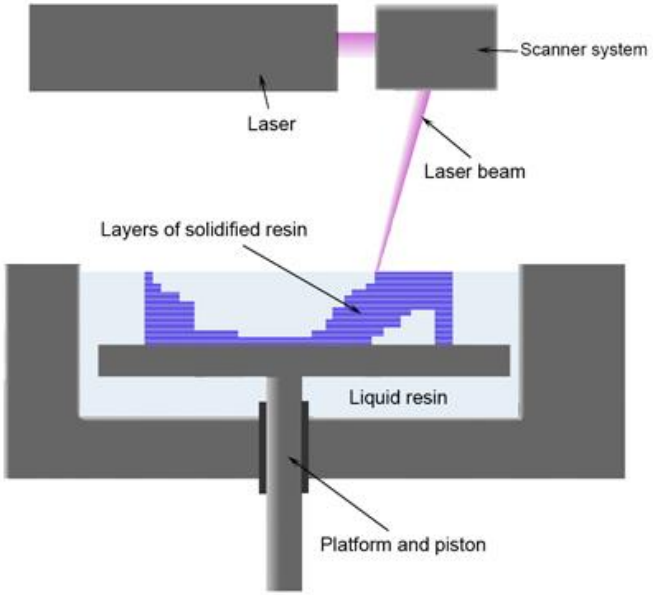


Image source : http://www.custompartnet.com/wu/direct-metal-laser-sintering/

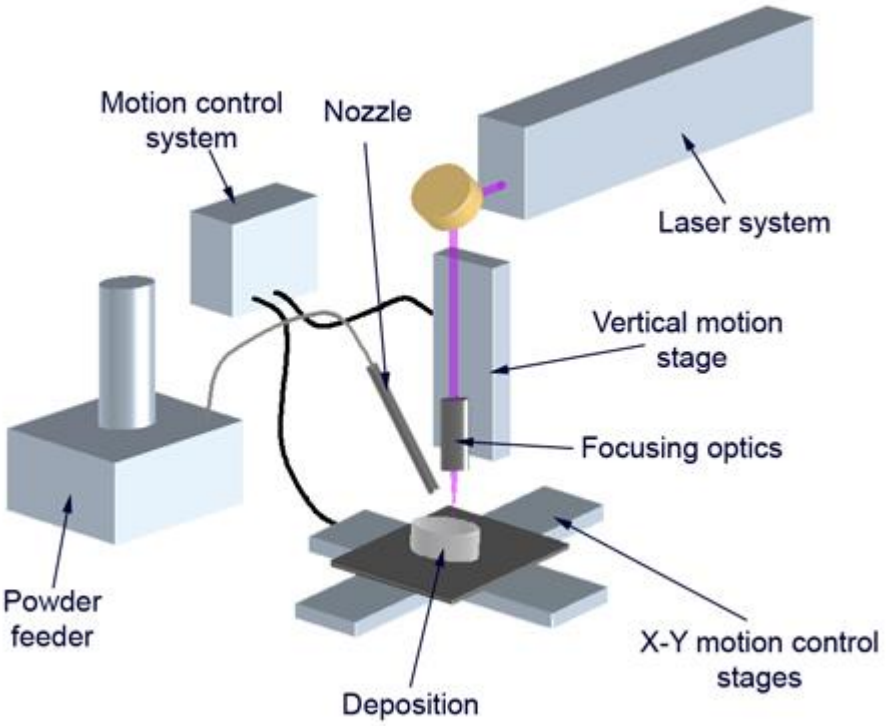
Stereolithography (SLA)

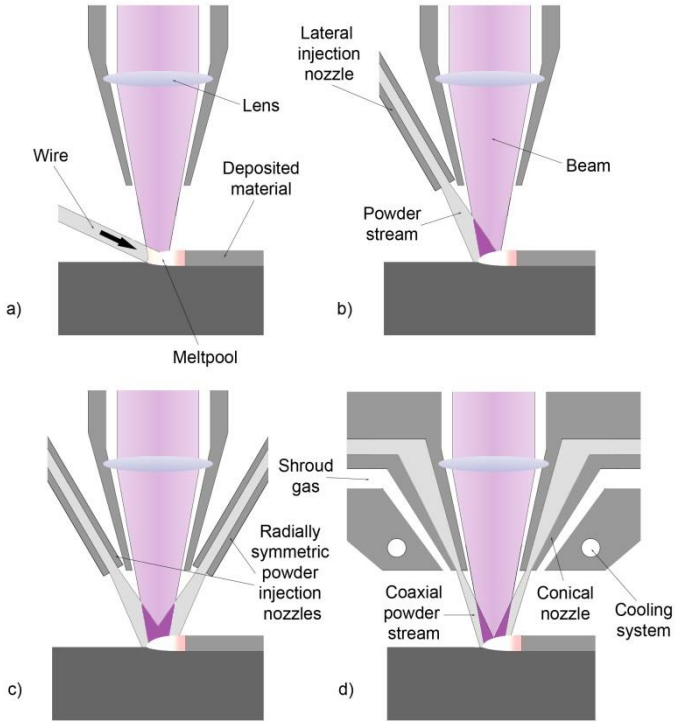
Photo-solidification : 3D printing patent (1986)
Using of a vat of liquid ultraviolet curable photopolymer and ultraviolet laser



Source : http://en.wikipedia.org/wiki/Stereolithography

Laser cladding (CLAD)





Source : http://en.wikipedia.org/wiki/Cladding_(metalworking)

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http://www.iphc.cnrs.fr/

3- achievement examples

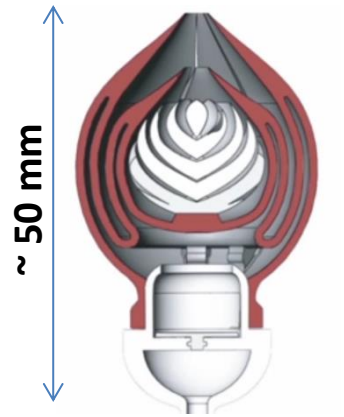
geometrical optimization in an IPHC project,
Quick overview of
some research and development examples in several domains

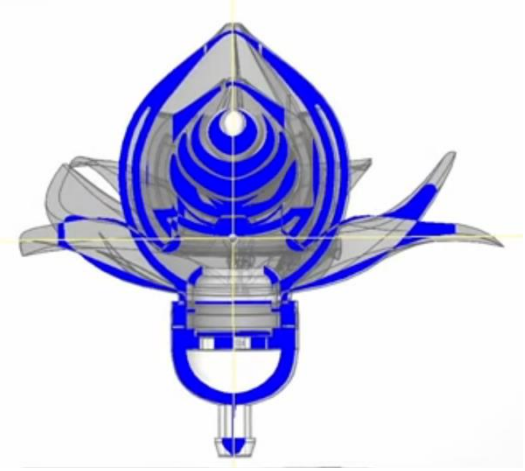
Techno flower

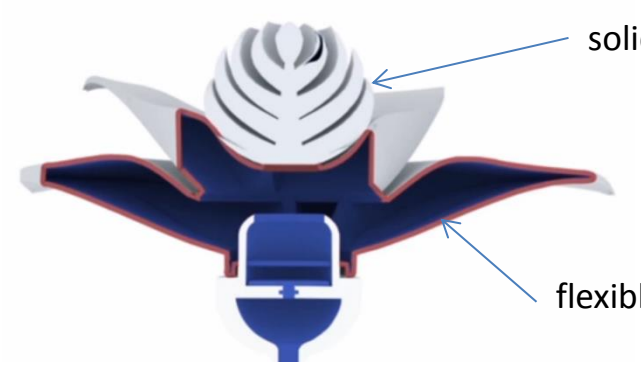
Printed by OBJET connex

multimaterial 3D printing

Inflatable structure

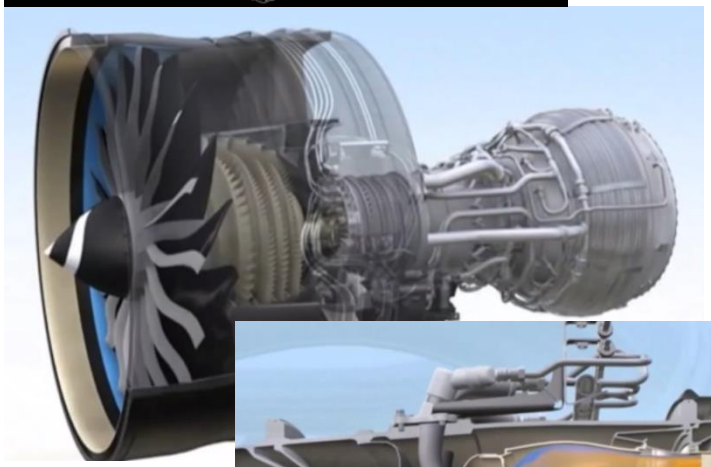


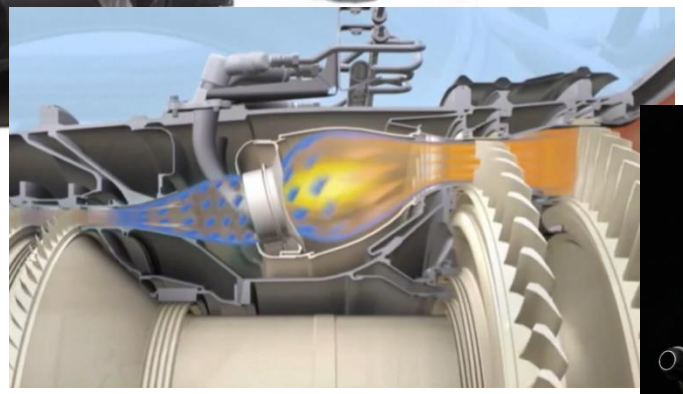




Source : http://www.industrie-techno.com/fleurs-de-techno.27541

Leap Fuel Nozzle





Aviation développement :
Problem of nozzle cooking with carbon deposition
Spray fuel into combuster

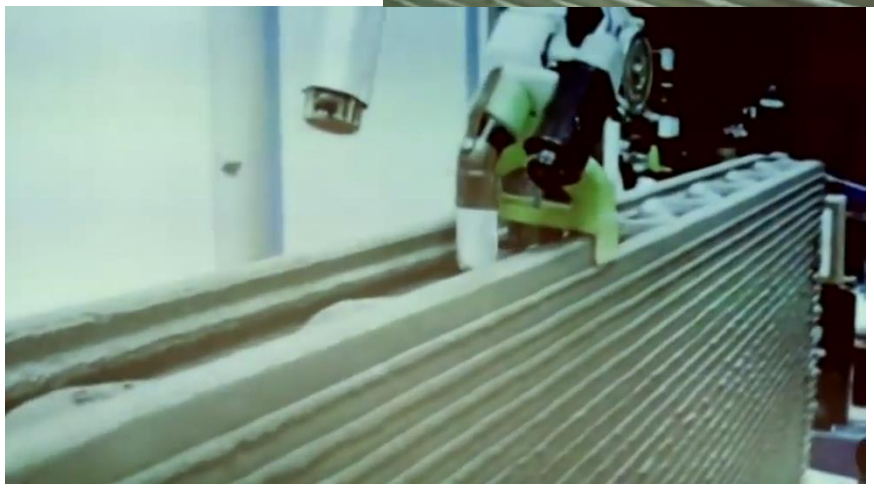
The temperature increases up to 3000°C

Efficiency
engine durability (X5)
18 parts in one single piece
Weight -25%
Better than casting, machining, welding,…
Production speed x20

Source : http://www.youtube.com/watch?v=l0SXlkrmzyw

Building 3D printing – concrete masonry unit -1-

Contourcrafting.org

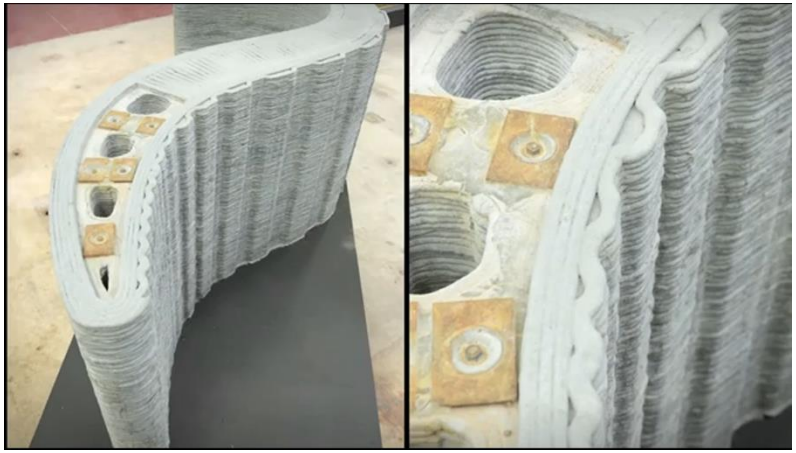


Extrusion of
high performance concrete
Strength : 3 000 to 10 000 psi

NASA developpement

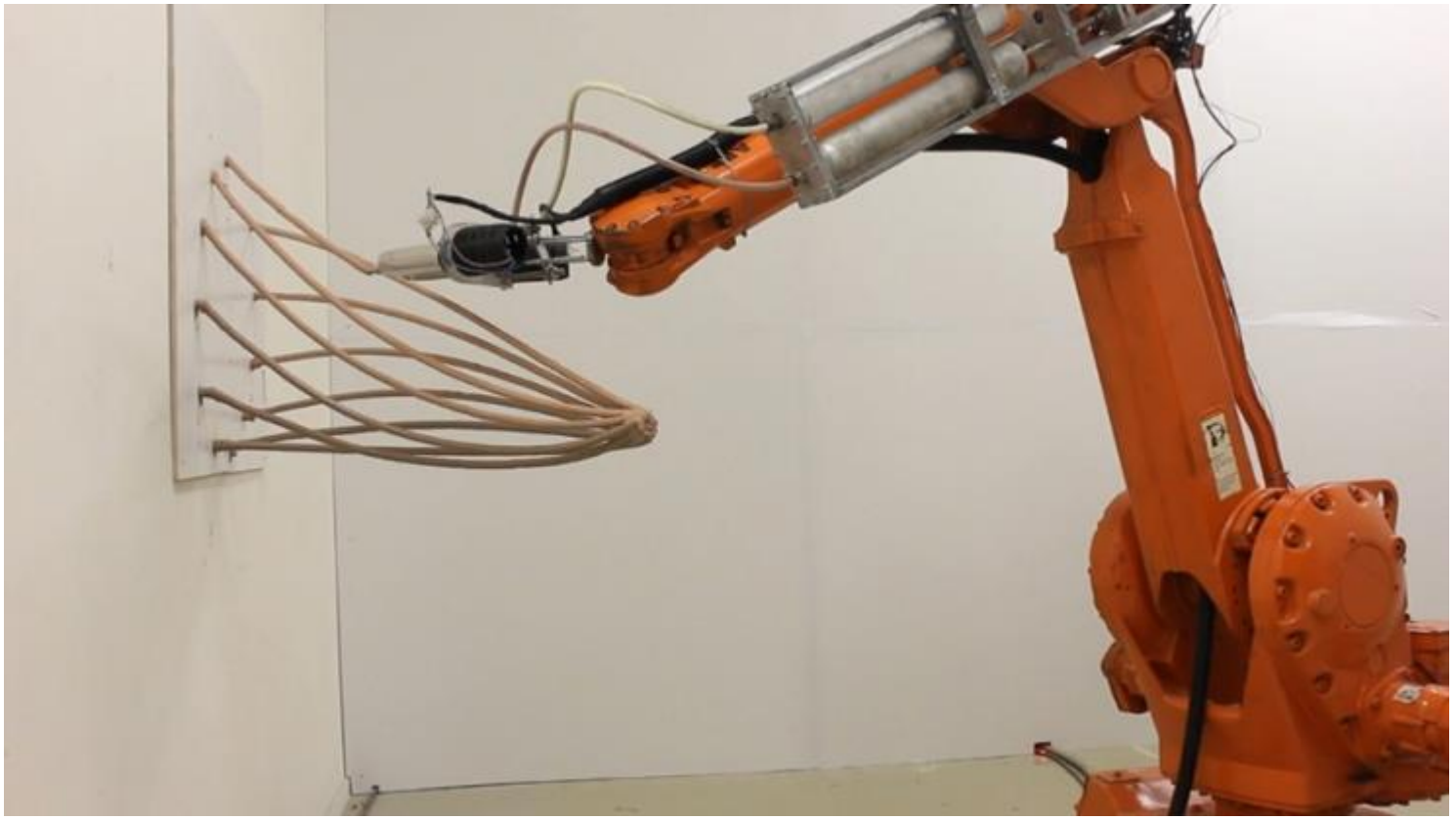
Source : https://www.youtube.com/watch?v=ehnzfGP6sq4&list=PLwZuNacIKo6a3C1tavZ5hnS2WABYSGbJv
http://www.contourcrafting.org/

Building 3D printing – concrete masonry unit -2-



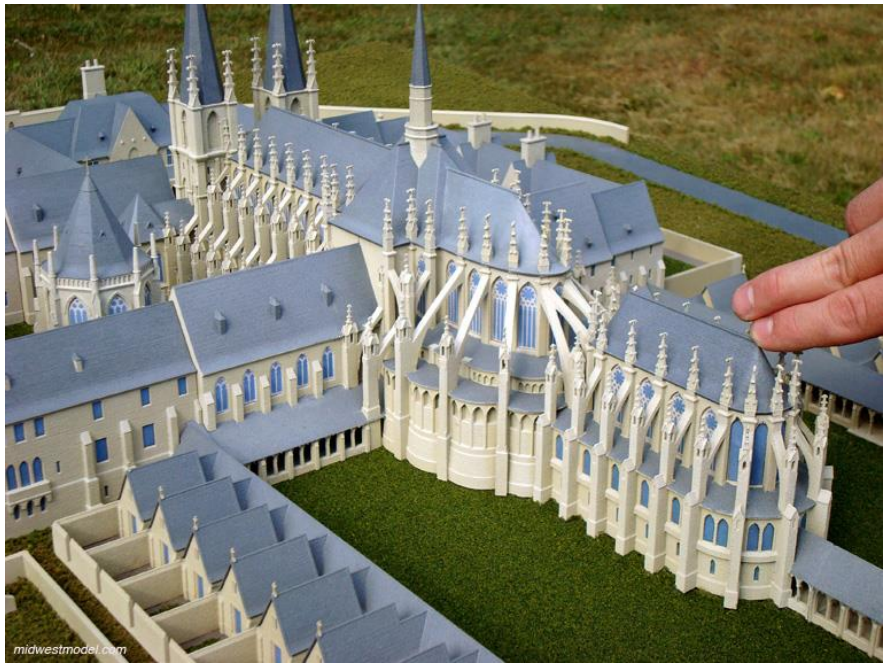
Source : https://www.youtube.com/watch?v=EfbhdZKPHro&list=PLwZuNaclKo6a3C1tavZ5hnS2WABYSGbJv

Robot 3D printing

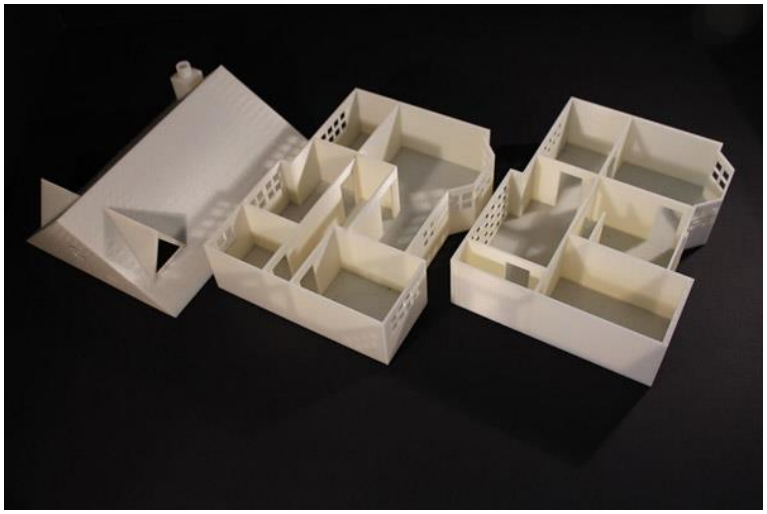


Source : http://www.dvice.com/2013-5-22/mataerial-anti-gravity-3d-printer

Architecture

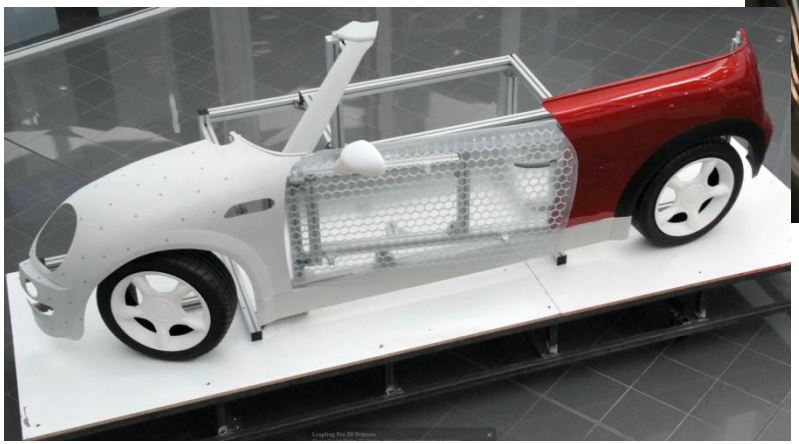


Source : http://www.midwestmodel.com/pagesroot/pages/ProjectDetails.aspx?ProjectId=339&DetailsType=ATOZ



Source : http://www.hp3dprinting.co.uk/applications.htm

Automobile Design

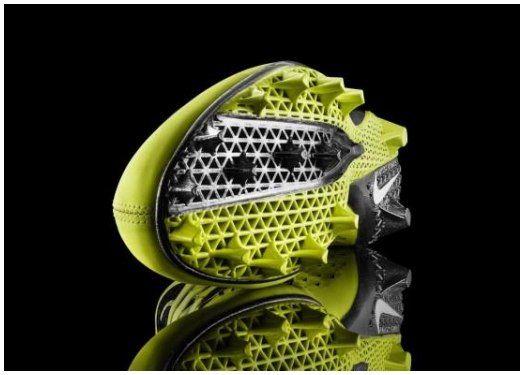


First Asian 3D Print Fashion Show

2013
First fashion meeting with 3D printed wears, organized by Materialise, belgian company.

Source : http://www.numerama.com/magazine/26298-un-defile-de-mode-pour-l-impression-3d.html

Nike Debuts First 3D-Printed Football Cleat



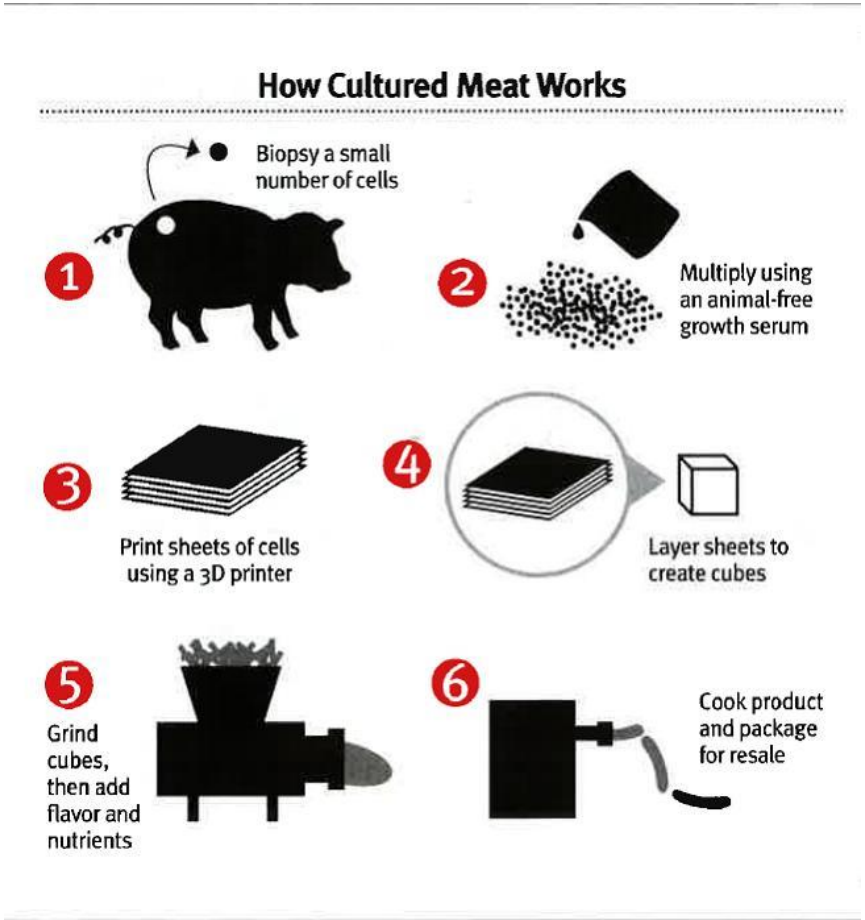
Source : http://mashable.com/2013/02/27/nike-3d-printed-cleat/

Edible prints

Although these ideas are only being experimented in labs for now, it's thrilling to know that these innovations might be very soon a part of our daily consumption.

Source : http://blsciblogs.baruch.cuny.edu/yomara89/?p=7

Meat 3D printing



Source : http://veganvine.blogspot.fr/

Source : http://veganvine.blogspot.fr/2013/08/you-can-take-meat-out-of-animal-but-you.html

Source : http://www.peta.org/issues/animals-used-for-food/meat-wastes-natural-resources/

MADE IN 3D challenge - 2011

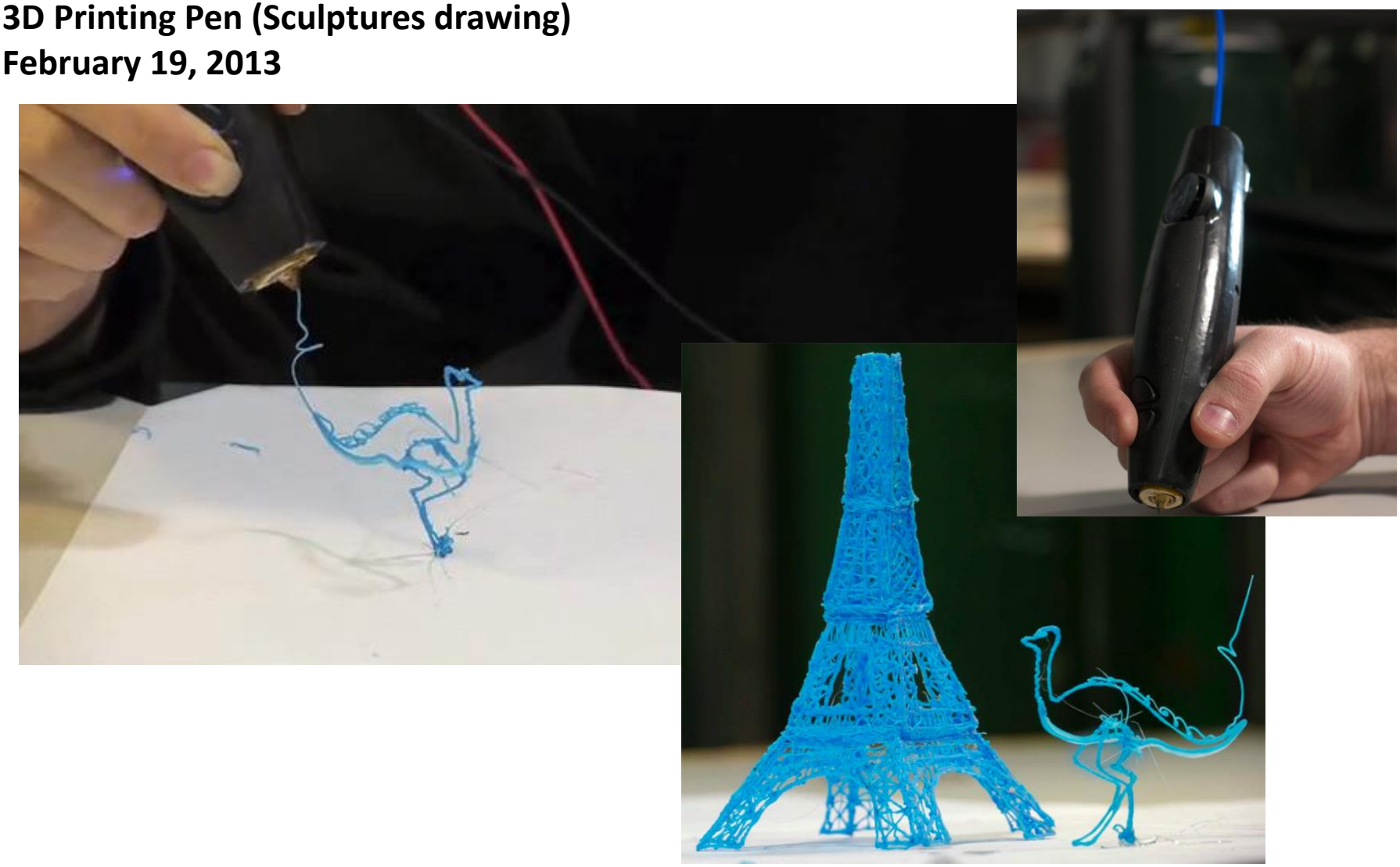
This strange parts supports an Iphone and emplifys sound coming out the phone.

To make a 3D ready printing design is the main goal.

This part is called the ‘Mush’ and was designed with CATIA V5 by a young designer .

Source : http://blogs.cotemaison.fr/archiboom/2011/06/26/made-in-3d-%E2%80%93-design-et-impression-3d/
http://www.3dvia.com/blog/made-in-3d-challenge/

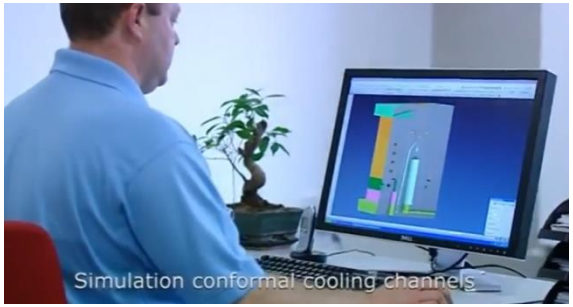
3D Printing Pen (Sculptures drawing)
February 19, 2013

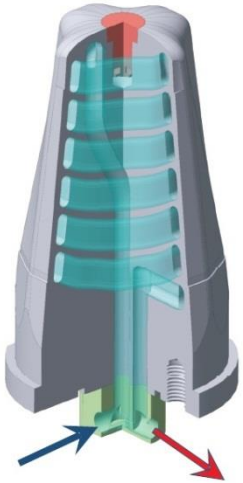


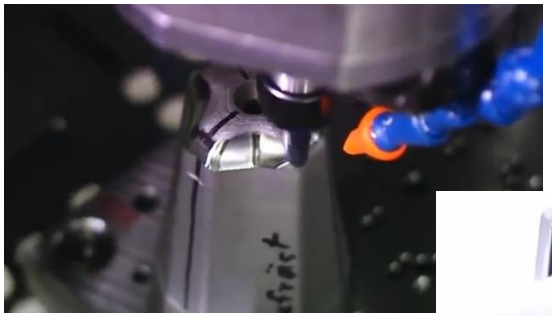
http://www.thisiscolossal.com/2013/02/the-worlds-first-3d-printing-pen-that-lets-you-draw-sculptures-in-real-time/

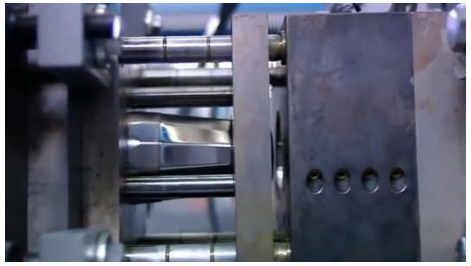
Numerical method

CAD – DMLS – PLASTIC INJECTION





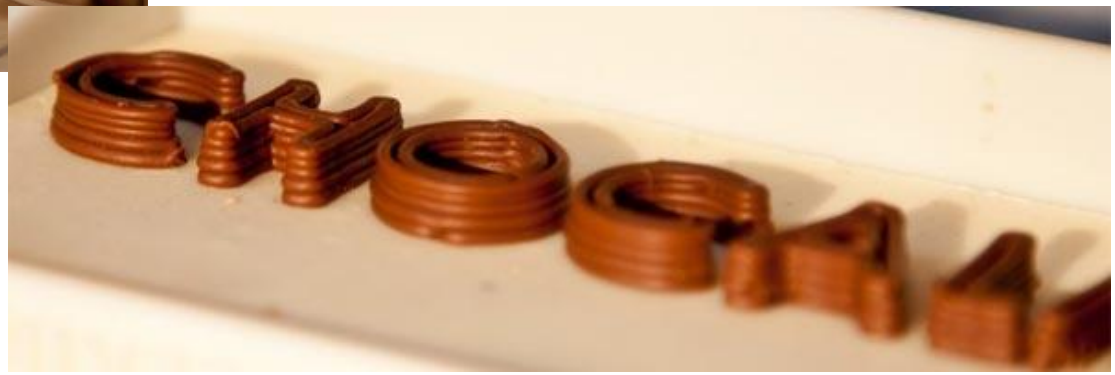




A kid drawing converted into 3D part

Source : http://journalmetro.com/dossiers/la-liste-du-lundi/338524/objets-3d/

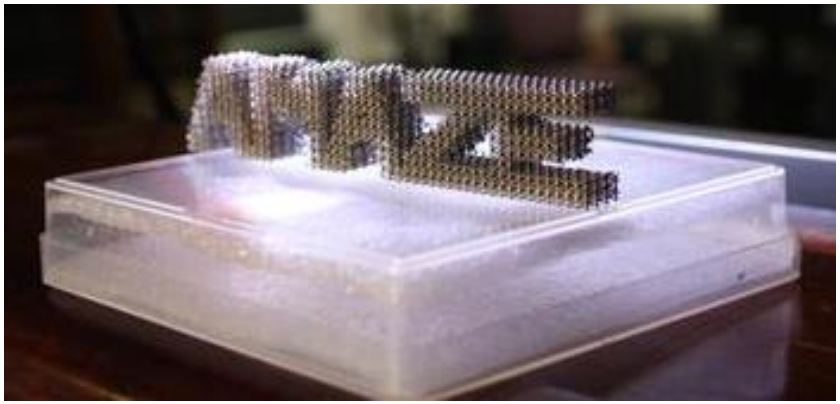
Chocolate 3D printing



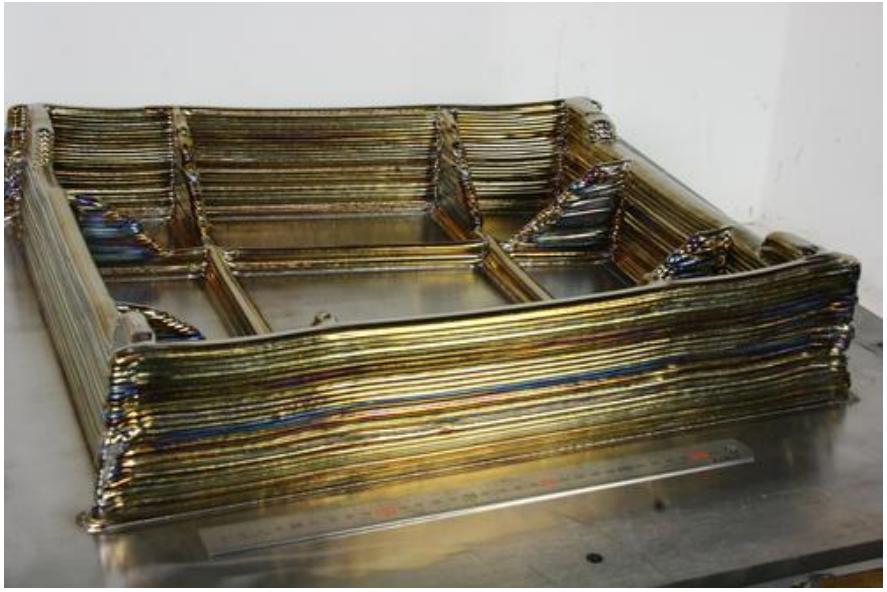
Source : http://www.lesimprimantes3d.fr/limprimante-3d-fabrique-chocolat/

ESA : 3D Printing Metals on earth and in Space

The AMAZE project team printed its logo in titanium as an intricate net shaped to millimeter-level precision to demonstrate what metal 3D printing can do. The project is working with materials that can withstand temperatures up to 3500 °C and involves 28 industrial and educational partners across Europe.
(Source: ESA-N. Vicente)

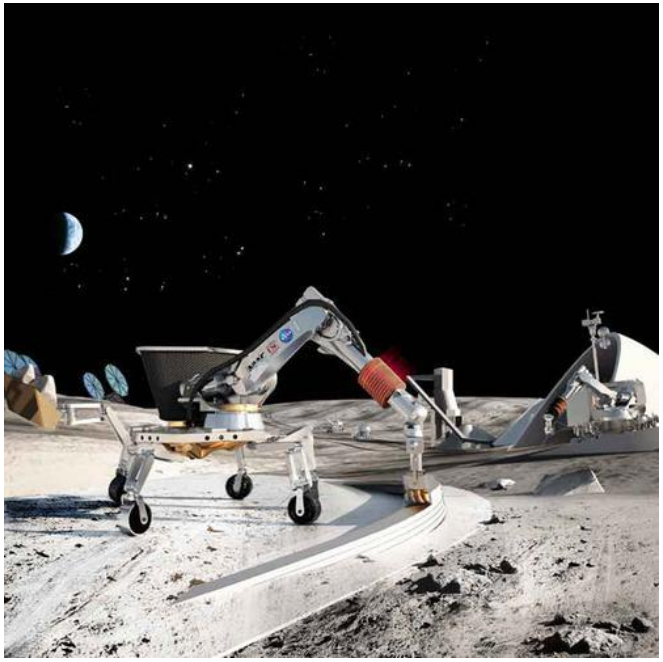


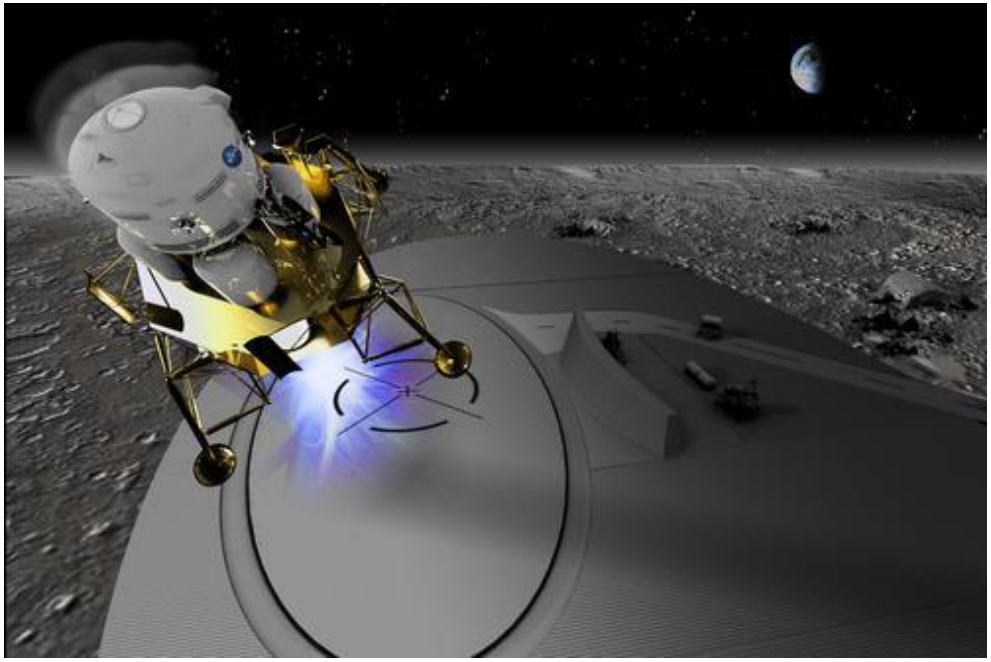
Titanium 3D printing



Source 2013 : http://www.esa.int/Our_Activities/Human_Spaceflight/Research/3D_printing_for_space_the_additive_revolution

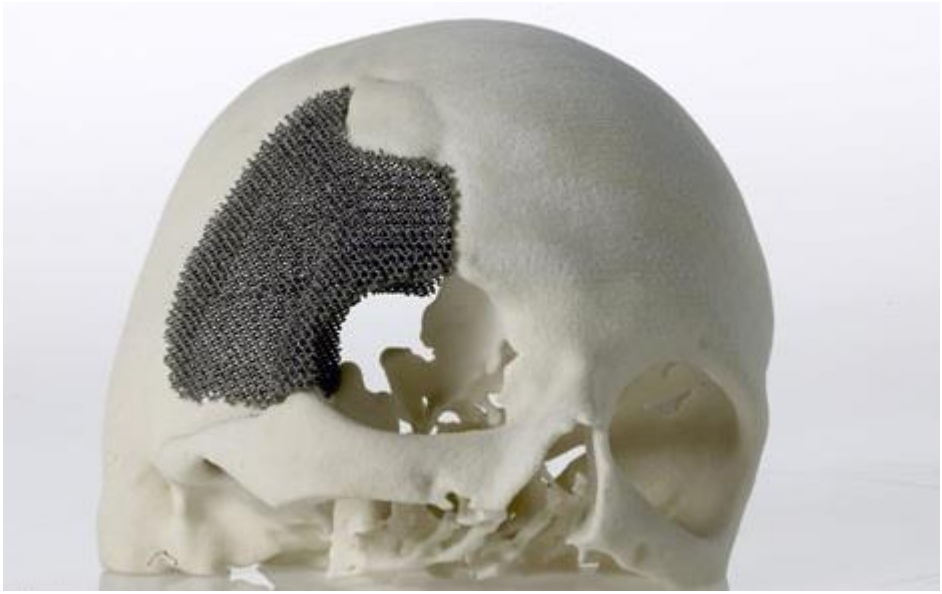
NASA : 3D Printing Metals on earth and in Space





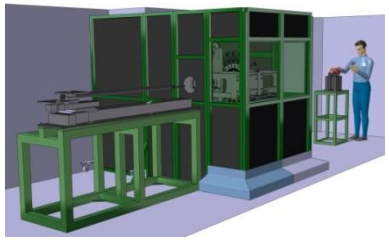
NASA-funded research by University of Southern California professors Behrokh Khoshnevis, Madhu Thangavelu, Neil Leach, and Anders Carlson is exploring how structures on the moon can made using the Contour Crafting robot. Under NASA's Innovative Advanced Concepts program, the researchers aim to develop methods for creating infrastructure, such as roads and landing pads, to support human settlement on the moon. The technology can create structures *in situ* from local materials, which is especially important for long-term, continuously expanding operations on the moon. For example, the team is exploring a nozzle system that heats lunar soil into a cement-like paste. In this visualization by Behnaz Farahi and Connor Wingfield, a lander descends on a pad fabricated by the Contour Crafting robot.
(Source: University of Southern California/Contour Crafting)

Implants



Source : http://www.treehugger.com/green-architecture/heavy-metal-meets-downloadable-designs-3d-printing-from-cad-to-metal.html

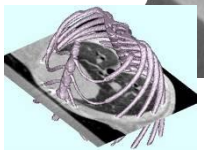
Numerical method at IPHC

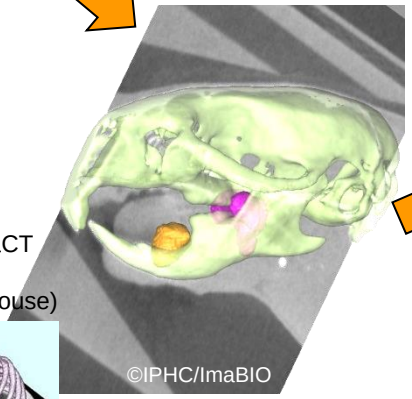


Imaging System AMISSA at IPHC
(ImaBio Group)

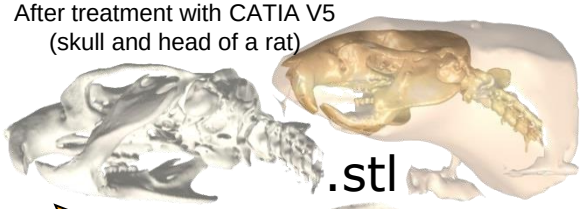
Rat or mouse

3D images superposition
Acquisition by µTEMP and µCT
(skeleton, flesh
and localisation of cancer in mouse)



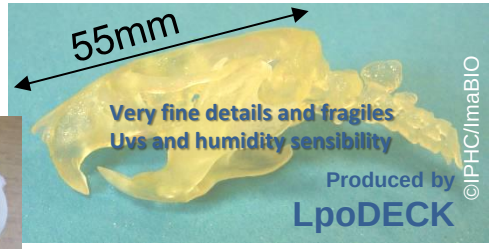


3D Images
After treatment with CATIA V5
(skull and head of a rat)



Not well cleaned part

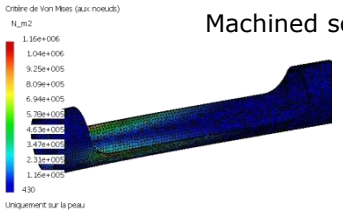
Impression 3D

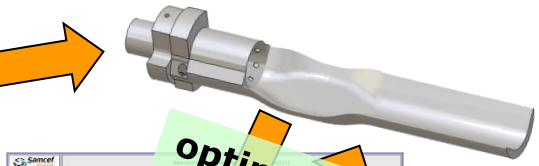


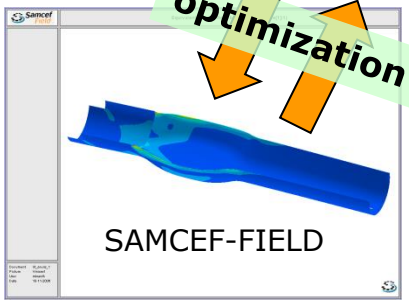
Fabrication of rat skull

- Mouse supporting during scanning time

Machined solution



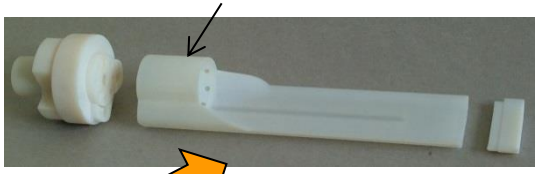


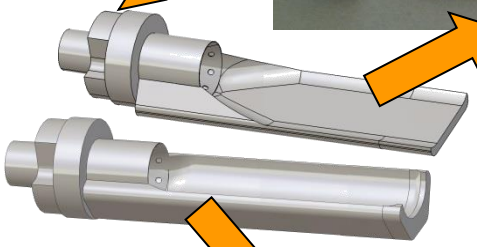


Shell FEM Model

CATIA V5

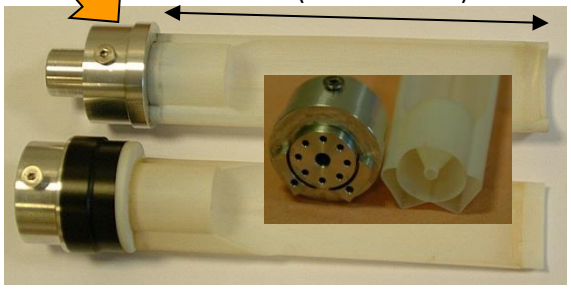
Bed first generation
End-peace ϕ 30 mm





Rapid prototyping
Photopolymer

18 cm (thick. 0.4mm)

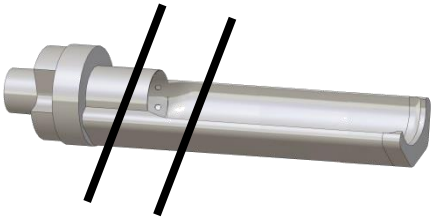


Technics Association

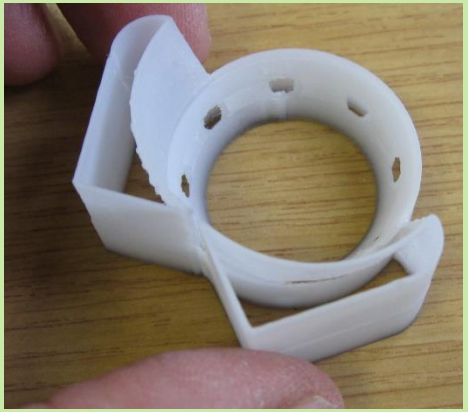
Requests :
-General Anesthesia
-Mechanical supporting of mouse (40 gr)
-Material optimization around the mouse
-Possibility of hot air circulation

Produced by CADindus Ingénierie et services CAO DAO

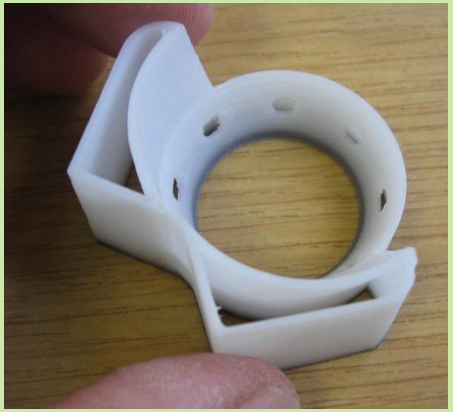
FDM on STRATASYS/DIMENSION (at CEMES Toulouse) :
ABS thread / layer thickness = 0,254 mm

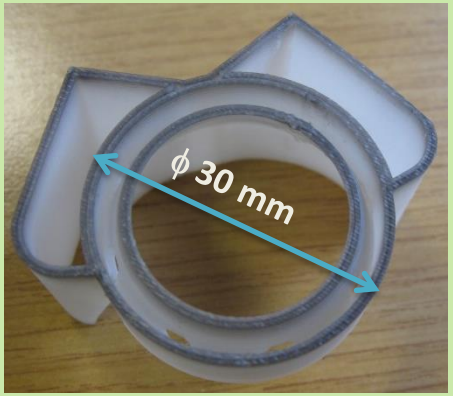


Paroi ép. 1 fil



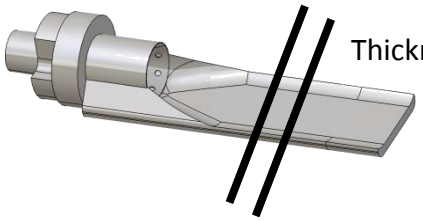
Paroi ép. 2 fil





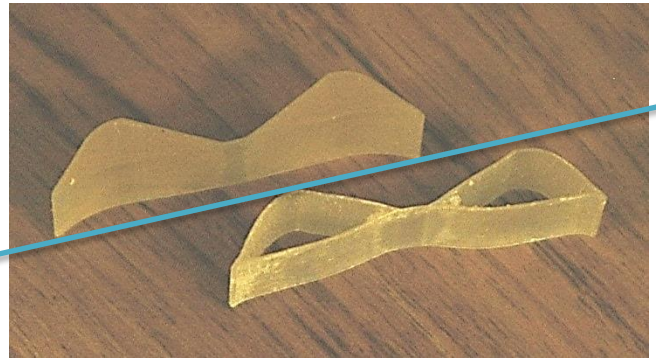
Photopolymer support by OBJET 250

Material evolution, in water immersed part and leave in sun shine



Thickness wall = 0,4 mm

Unused part

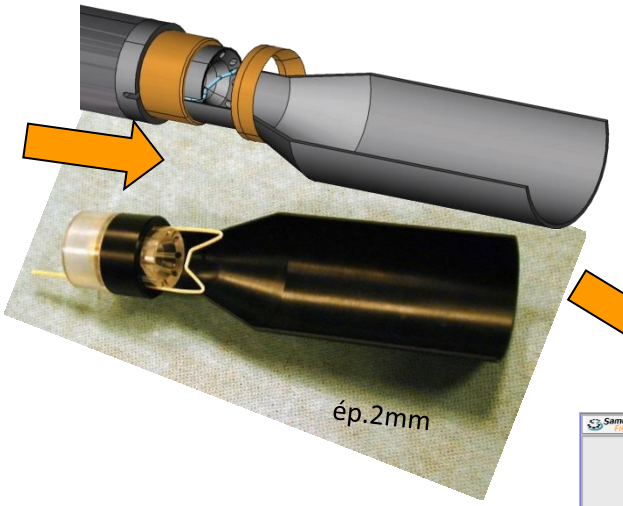


Totally removed supporting resin
Total in water immersion
UV ray exposition

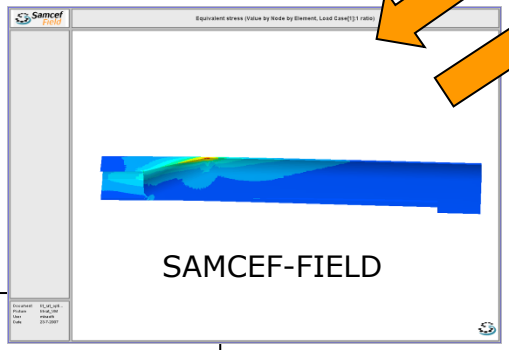
After 3 days :
- Deformation
- hardening

Produced by
CADindus
Ingénierie et services CAO DAO

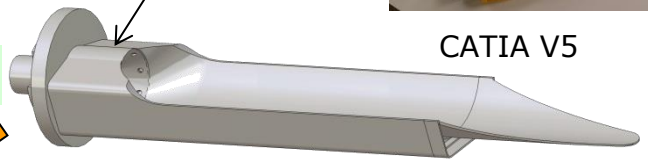
Rat supporting during scanning time



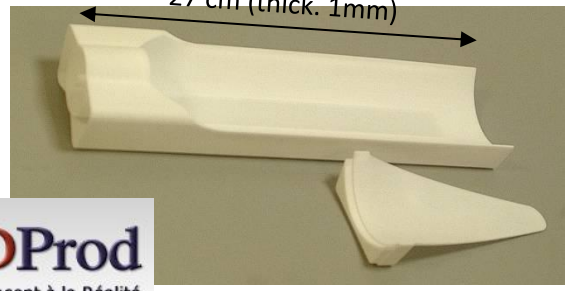
optimization



End-peace ϕ 40 mm



PA SLS



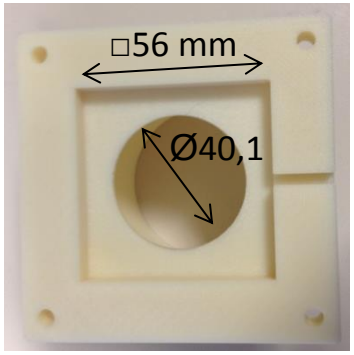
Produced by

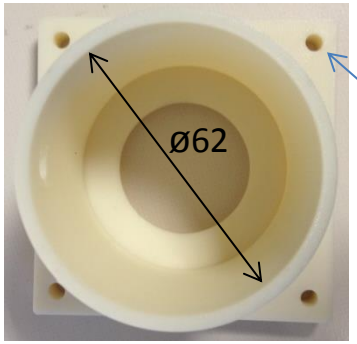
3DProd
Du Concept à la Réalité

Requests :
-General Anesthesia
-Mechanical supporting of rat (800 gr)
-Material optimization around the mouse
-Possibility of hot air circulation

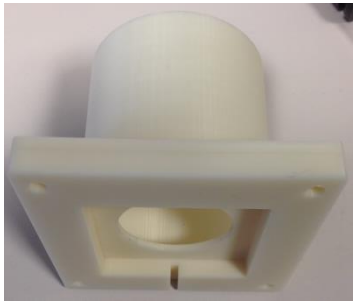
CADVISION / IPHC manufacturing test
Mesurements on fdm produced part
on Fortus 250 Stratasys machine, with layer thickeness of 0,178 mm

IPHC contact IPHC : Christophe Ruescas, christophe.ruescas@iphc.cnrs.fr / Marc Krauth, marc.krauth@iphc.cnrs.fr



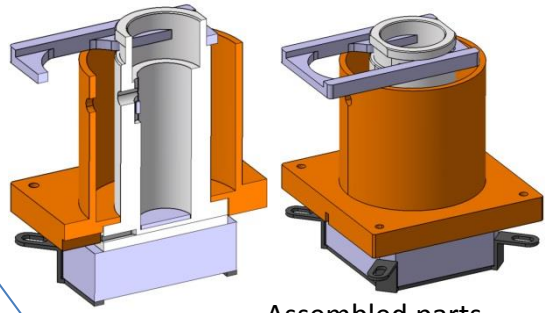


Some theoretical values



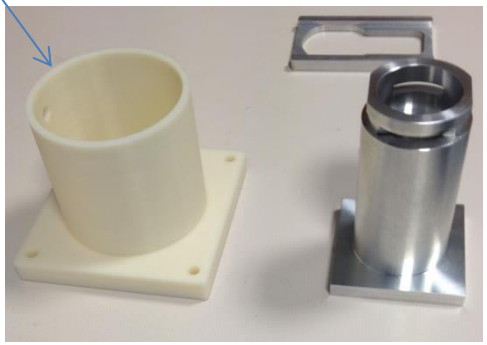
Hole ø 5 mm

ABS fdm part



Assembled parts

Height 73 mm
Thickness plate 12 mm
Cylindrical part thickness 4 mm



Differencies between several numerical dimensions and real produced dimensions are contained between 0,04 and 0,2 mm .

Part produced by Cadvision
Contact : Stefka BARZAKOVA / stefka@cadvision.fr

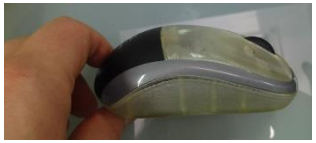
Photos : ©IPHC.cnrs.fr

Décembre 2013

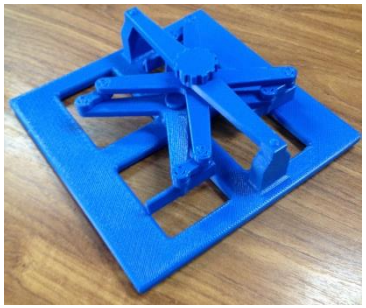
Some samples

http://www.cadvision.fr/
stefka@cadvision.fr

Photopolymer



Thermoplastic



http://www.stratasys.com/

www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

4- some 3D printers

ESIPAP European School of Instrumentation in Particle and Astroparticle Physics

4- some 3D printers

http://www.u-print.fr/

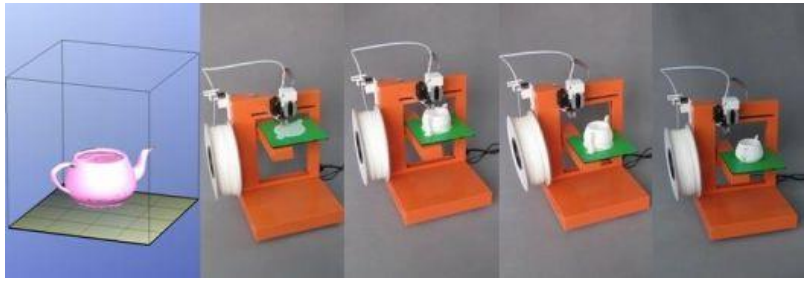
Stratasys uPrint SE

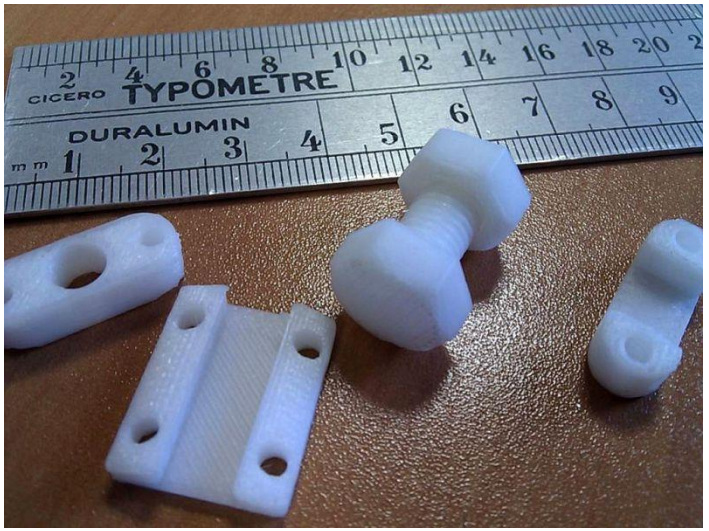
ABSPlus thermoplastic thread
With resin support
Layers thickness between 0,12 and 0,25 mm
Geometrical precision ~0,2 mm
Production 3D array 152 x 203 x 152 mm
<20 k€

4- some 3D printers

http://modeler3d.fr/

2013 UP MINI 3D PRINTER
ABS withe thread
layers 0,15 to 0,40 mm
3D array : 140 x 140 x 135 mm
~3k€





4- some 3D printers

http://fr.objet.com/

Objet30 Pro
3D array : 294 x 192 x 148.6 mm
Layers thickness 28 microns
Layers thickness 16 microns with VeroClear material
Resolution: 600 x 600 x 900 dpi
Precision about 0.1 mm
7 different photopolymers (indépendant prinitings)
With resin support material
~20k€

EDEN 260 at Pôle ORTECH (Lycée Théodore Deck, in Guebwiller, France)

http://www.lyceedeck.fr/poleortech/equip_eden.html

59

4- some 3D printers

http://www.eos.info/en

FORMIGA P100
sls PA 100µm
~200 k€
Maintenance ~2-4k€/an

FORMIGA P100 at Pôle ORTECH (Lycée Théodore Deck, in Guebwiller, France)

http://www.lyceedeck.fr/poleortech/equip_eos.html

60

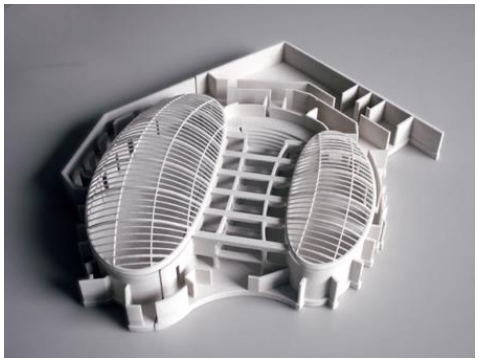
Powder and binder jet

http://www.zcorp.com/

ZPRINTER 150 by ZCORP
monochrom (white)
Resolution : 300 x 450 dpi
minimal size : 0,4 mm
vertcal creation speed : 20 mm/heure
fabrication maximal size : 236 x 185 x 127 mm
layer thickness 0,1 mm

Zprinter 150
Monochrom voxeljet ~15k€

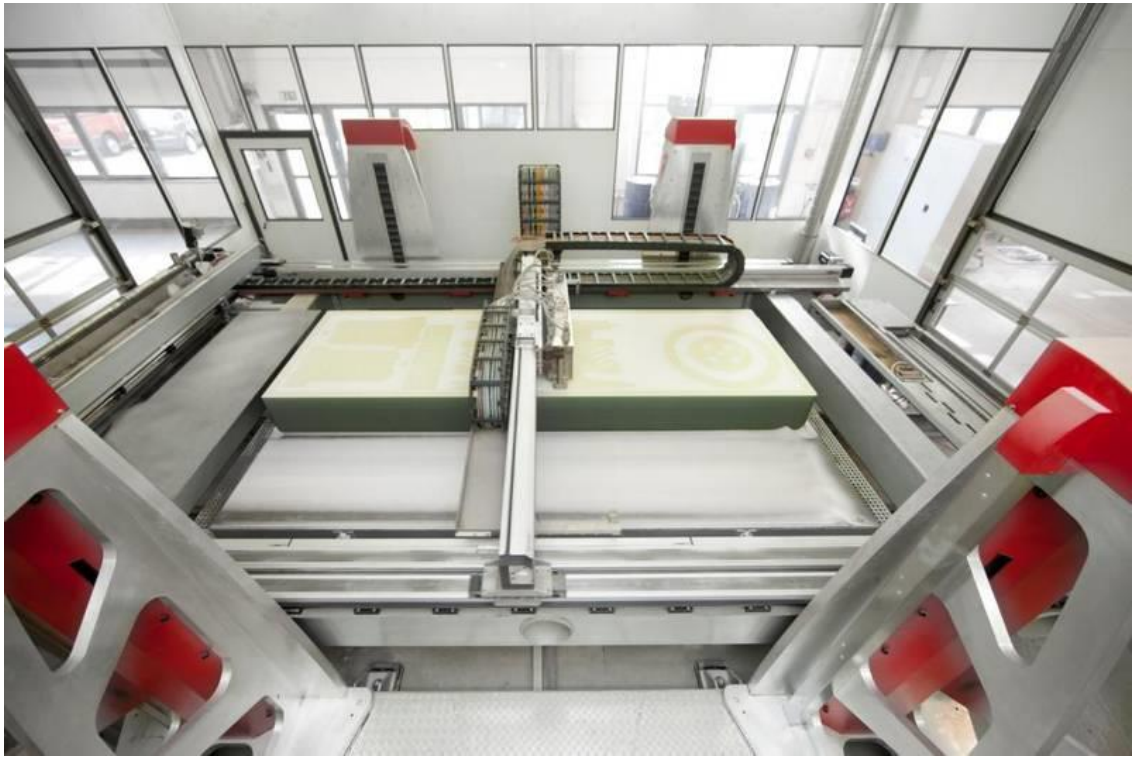
Zprinter 250
Polychrom voxeljet ~25k€



VOXELJET

PMMA or SAND
Print resolution x, y 600 dpi
Layer thickness 120/300 µm
Build speed 15,4 mm/h (=123 l/h)

build space : **4000 x 2000 x 1000 millimetres**



voxeljet

Source : http://www.voxeljet.de/en/systems/vx4000/

3Z MAX printer by SolidScape

Precision and High quality wax printing

For lost wax casting

http://www.multistation.com/3Z-MAX

www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

5- Materials

Several possible materials used in 3D printing industry

Several materials by STRATASYS

Stratasys fdm production possibilities :

ABSplus-P430, ABSi, ABS-E SD7, ABS-M30, ABS-M30i, PC-ABS, PC-ISO, PC, Nylon 12, ULTEM-9085, PPSF PPSU

Source : http://www.stratasys.com/materials/fdm/compare-fdm-materials

Stratasys Polyjet plastic production possibilities :

Vero, Translucent Rigid, High Temp, Durus, Digital ABS, Digital ABS2, Tango (Rubber-Like / Flexible), Performance Digital, Rubber-Like Digital, Biocompatible

Material Mimic : Polypropylene – PP, High-Density Polypropylene – HDPE (PEHD), Polystyren – PS, Poly Methyl Methacrylate – PMMA (plexiglas), Polycarbonates – PC, Acrylonitrile Butadiene Styrene – ABS, High-Impact Polystyrene – HIPS, Styrene-Based Thermoplastic Elastomers, Ethylene Propylene Diene Monomer M-class – EPDM Rubber,

Source : http://www.stratasys.com/materials/polyjet/compare-polyjet-materials

http://www.stratasys.com/

Several materials by EOS

EOS SLS plastic production possibilities :

Alumide (polyamide alumium filled), CarbonMide (polyamide carbon fiber-reinforced), PEEK HP3 (PEEK, polyaryletherketone), PA 1101 (PA11), PA 2015 (PA12), PA 2200, PA 3200, PrimeCAST 101 (PS, polystyrene),

Source : data sheet on
http://eos.materialdatacenter.com/eo/standard/main/ds

EOS DMLS metal production possibilities :

Aluminium AlSi10Mg, CobaltChrome MP1, CobaltChrome SP2, MaragingSteel MS1, NickelAlloy IN625, NickelAlloy IN718, StainlessSteel GP1, StainlessSteel PH1, Titanium Ti64

Source : http://www.moulds.asia/whats-new/
dmls-direct-metal-laser-sintering/

http://www.eos.info/

Several materials by 3D SYTEMS

3D Systems SLA plastic production possibilities : Accura series

Accura 25, 55, 60, 48HTR, ABS Black (SL 7820), ABS white (SL 7810), Amethyst, Bluestone, Casto, Casto Free (SL 7800), CeraMAX Composite, ClearVue, ClearVue Free, e-Stone, Peak, Sapphire, SL 7840, Xtreme, Xtreme White 200

3D Systems SLS plastic production possibilities : CastForm PS and Duraform series
Duraform EX Black, EX Natural, Flex, FR100, GF, HST Composite, PA, ProX

Source : data sheet on
http://www.3dsystems.com/materials/production

3D Printer plastic production possibilities : VisiJet series (27 different materials)

Source : ttp://www.3dsystems.com/materials/professional

DMS metal production possibilities :

17-7 PH, Aluminium, Berylium Copper, Brass, Carbon Steel, Copper, Nickel Alloys, Phosphor Bronze, Spring Steel, Stainless Steel, Titanium
Also some finishes : anodized, Heat Treated, Laser Welded, Painted, Powder Coated, …

Source : http://www.3dsystems.com/quickparts/production/quick-sheet-metal

http://www.3dsystems.com/

Material today in use

Plastics or 'plastic like'
ABS Acrylonitrile Butadiene Styrene
PLA
Polyjet Resin
PMMA
PA
PEEK
PSU
Multicolor or not
…

Other
Ceramic
Sand
Wax
Alumid

Metals
Aluminium
Titanium
Maraging steel
Stainless steel
Cr-Co alloy
Aluminium alloy
Gold, silver

www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

6- Conclusion

ESIPAP European School of Instrumentation in Particle and Astroparticle Physics

5- Conclusion

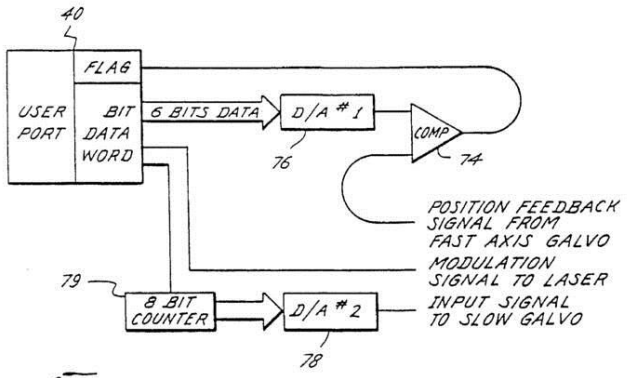


Fig. 3

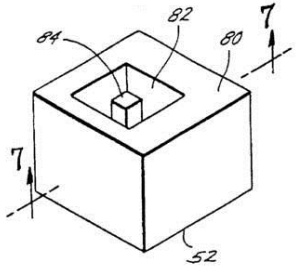


Fig. 4

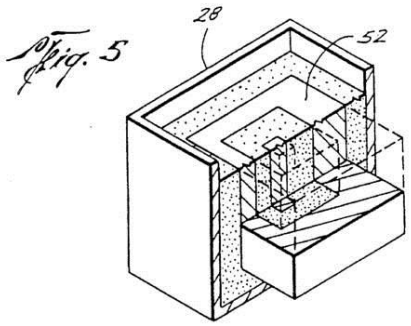


Fig. 5

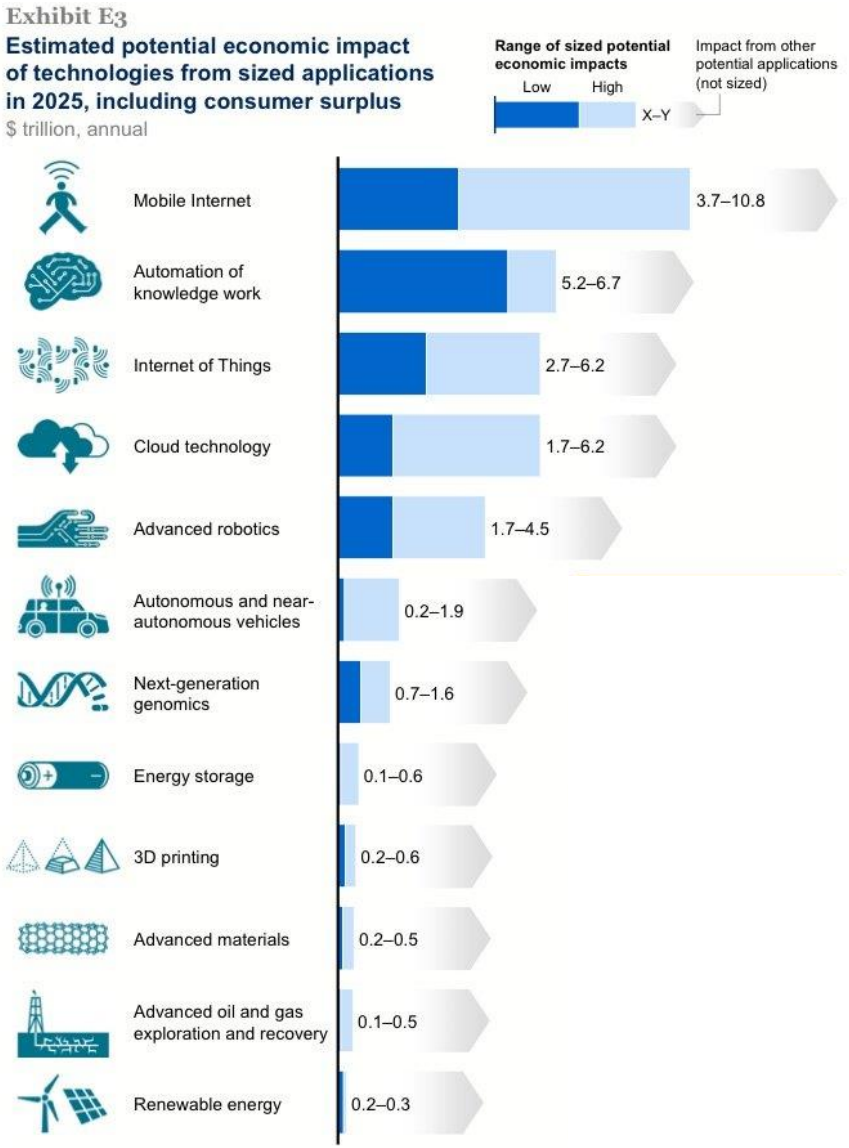
Fdm patent is already expired (in 2009)

Key 3D printing patent expired 28th of January 2014

Apparatus for producing parts by selective sintering
US 5597589 A
Abstract :
An apparatus for selectively sintering a layer of powder to produce a part made from a plurality of sintered layers. The apparatus includes a computer controlling a laser to direct the laser energy onto the powder to produce a sintered mass. The computer either determines or is programmed with the boundaries of the desired cross-sectional regions of the part. For each cross-section, the aim of the laser beam is scanned over a layer of powder and the beam is switched on to sinter only the powder within the boundaries of the cross-section. Powder is applied and successive layers sintered until a completed part is formed. Preferably, the powder dispensing mechanism includes a drum which is moved horizontally across the target area and counter-rotated to smooth and distribute the powder in an even layer across the target area. A downdraft system provides controlled temperature air flow through the target area to moderate powder temperature during sintering.

Even it's a little different, but
3D printing using pouder will explode in 2014
More possible materials !

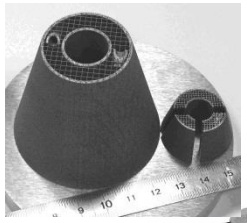
5- Conclusion



Source : http://www.3ders.org/articles/20130529-mckinsey-report-12-disruptive-technologies-by-2025-3d-printing-included.html

5- Conclusion

Possibilities for innovation in physics developpements



Including 3D wire screen (filter),
Cooling channels,
Volume optimisation

Without assembling
or
Assembling by glueing, bolting, screwing, …

Multifunctionnal parts

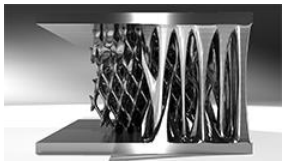
Where are the limits ?

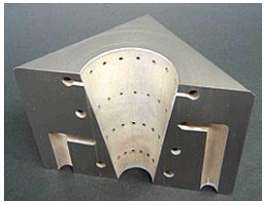
Geometries

Additive Manufacturing Machine

New materials

Plastics,
Metals,
Composites





integration
In existing manufacturing process

DMLS
Direct
Metal
Laser
Sintering

Some benchmarks :
- Service society : Specialized in additive manufacturing
- Possible plastics : ABS, PLA, PC, PA, Plastique ceramic charged, fibres or aluminium alloy charged,…
- Possible metals : 316L, Ti64, TA6V, maraging steel, CR-CO, Bronze, Inconel, Nickel alloy, aluminium alloy, ceramics, …

5- Conclusion

Be carefull about copyright !

Where is the limit of 3D printing ?

A lot of leaders : each in his domain …

5- Conclusion : questions …

When will I use 3D printing technology ?

What have I to do with it ? What can I do with it ?

Just think, calculate and print …

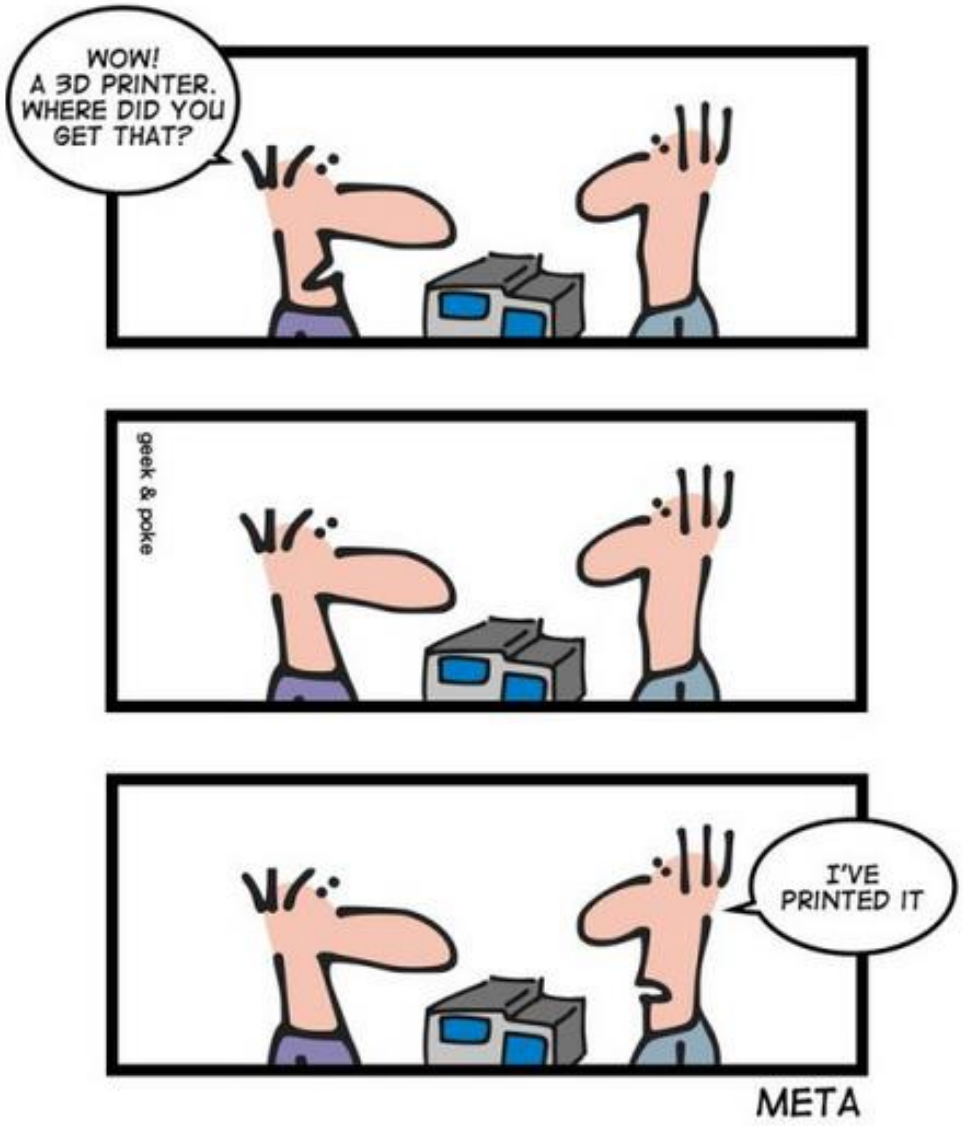
Source : http://www.dezeen.com/2013/02/13/protohouse-2-3d-printed-house-by-softkill-design/

Innovation : ears and guns produced by 3D printing
Some steps were forgotten …

and printing something between ears ?

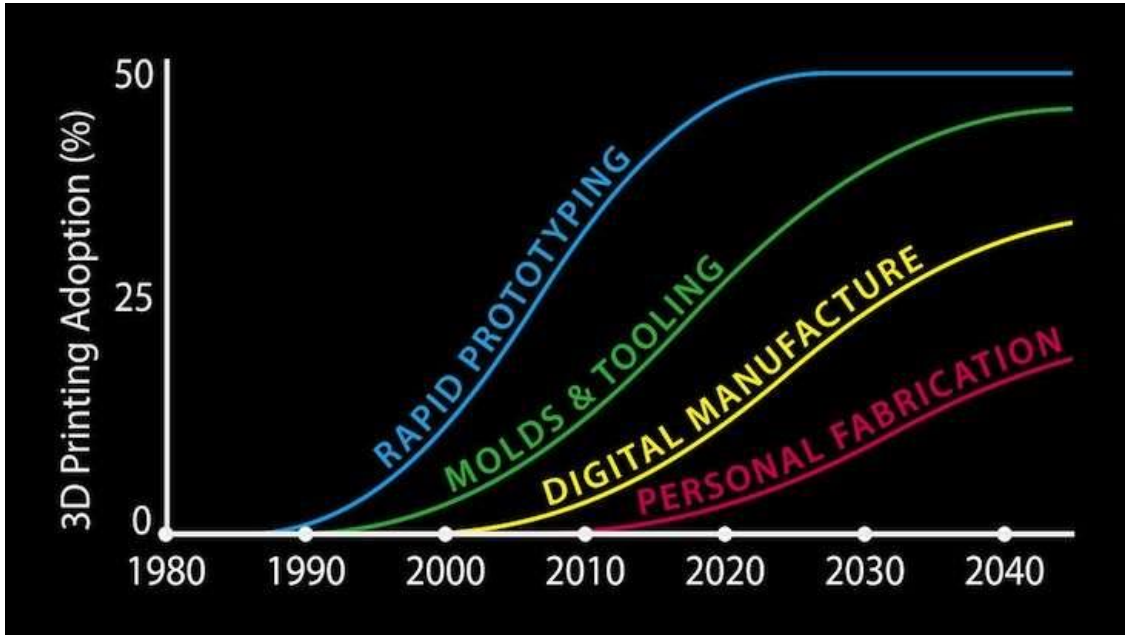
Source : http://www.clubic.com/diaporama/photo-la-semaine-de-flock-enleve-les-bigoudis-de-l-actu-61890/

5- Conclusion



Source : http://textually.org/3DPrinting/2012/12/031489.htm

5- Conclusion



Source : http://www.3dprinter.net/3d-printing-the-business-opportunities

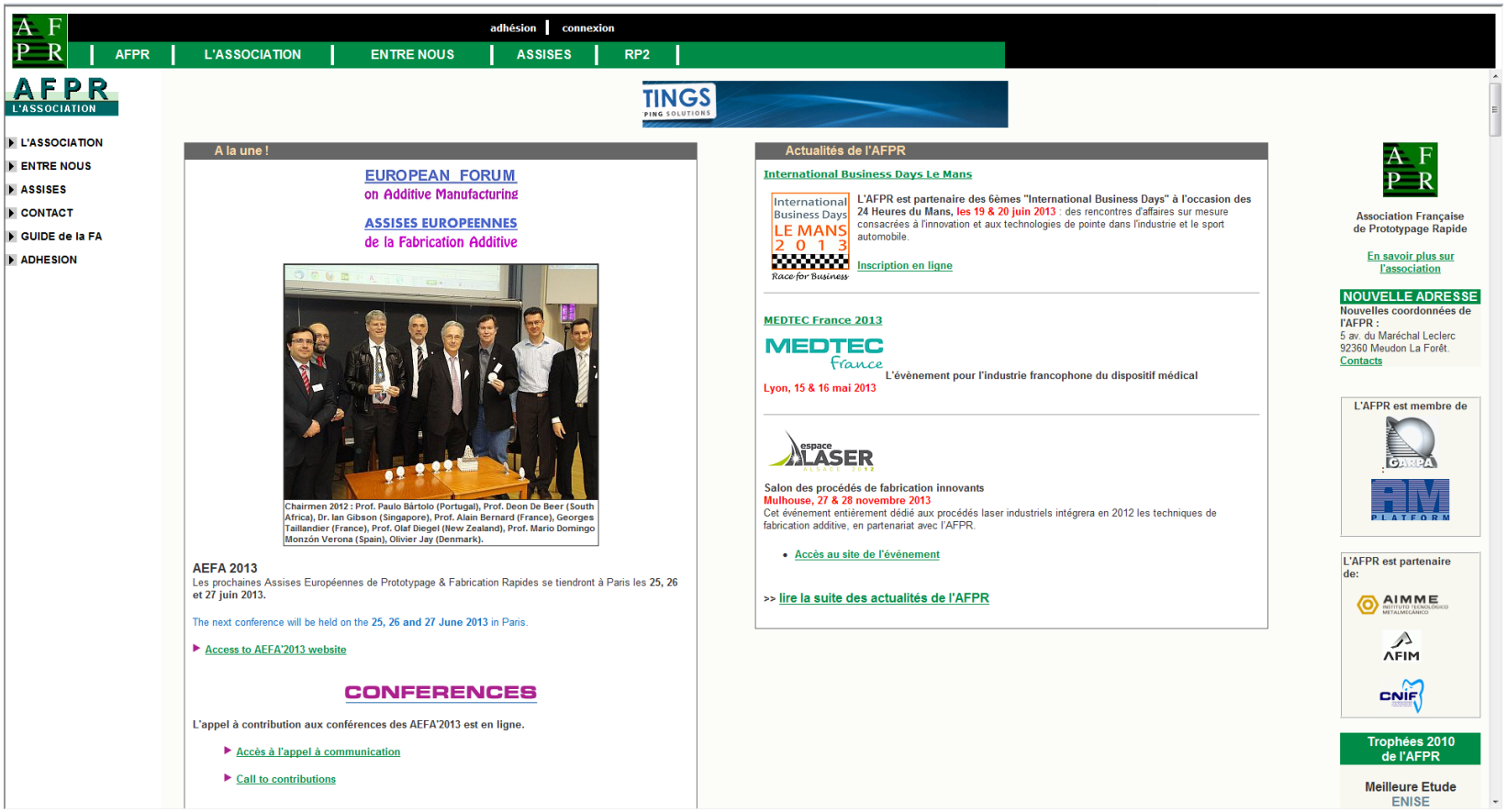
www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

Annex

Association Française de Prototypage Rapide :
http://www.afpr.asso.fr/

Assises Européennes de Prototypage Rapide :
http://code80.net/afpr/aepr/



National Additive Manufacturing Innovation Institute : SOURCE : http:/namii.org/resources/presentations/

NATIONAL NAMII ADDITIVE MANUFACTURING INNOVATION INSTITUTE

Hub AM Equipment Entrusted To Date

Equipment	Manufacturer	Model
Fused Deposition Modeling	Stratasys	Fortus 400MC
Selective Laser Melting	Renishaw	AM 250
Bonded Plaster	Z-Corp	Z-Printer 310
Selective Laser Sintering	3D Systems	SLS sPro 60
Wax Depositon	3D Systems	Thermojet
Bonded Refractory Material	ExOne	M-Lab
Material Extrusion (3D Printer)	3D Systems	Cube
Direct Metal Deposition	POM	Synergy 5
Material Extrusion (3D Printer)	3DCAD Printer	Hyrel
Plunge / "Dry" EDM	Sodick (w/ POM Upgrades)	AQ55L

Ancillary/support equipment: CNC milling machine, ovens, chillers, etc.

Distribution A: Cleared for Public Release # 88ABW-2012-5792

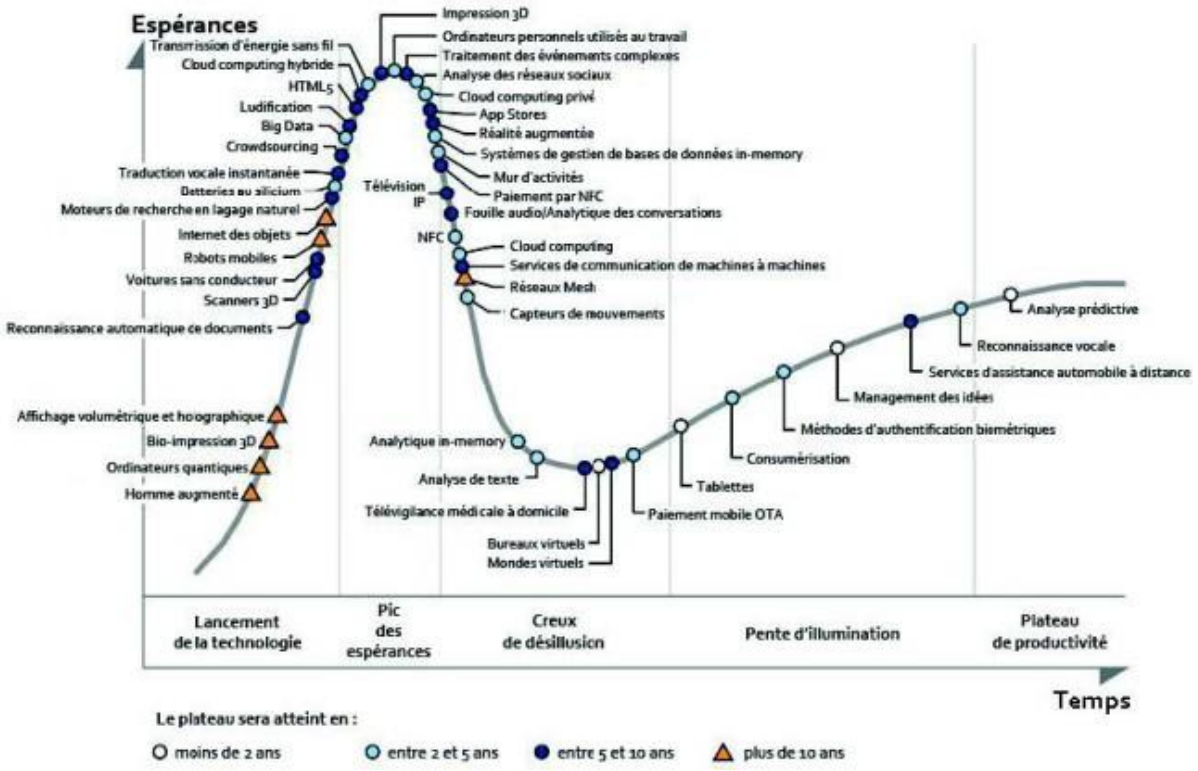
77 membres de 15 Etats

Aux Etats Unis…

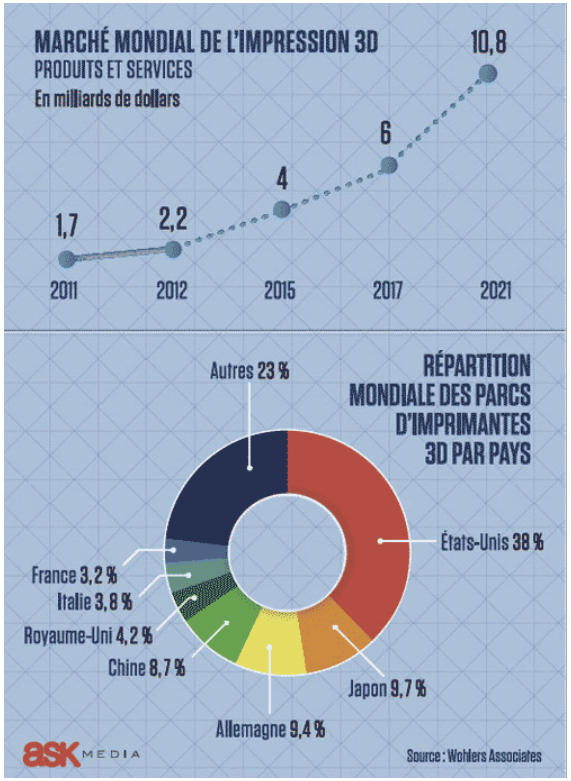
SOURCE : The Shapeways Blog : 3D Printing News & Innovation – 8-2012

2012 - développement des techniques

2013 - début des mises en application

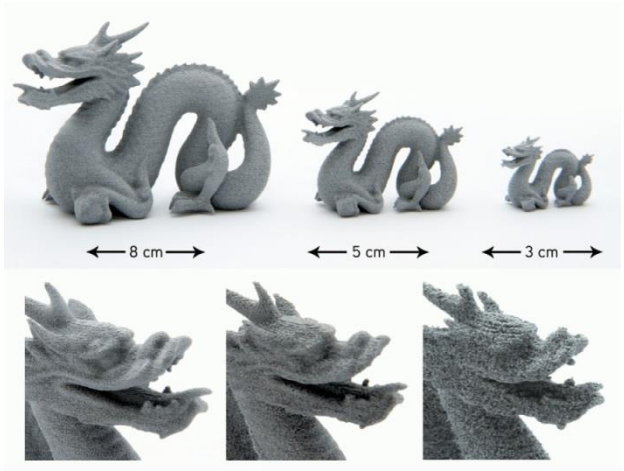


Source : http://alternatives.blog.lemonde.fr/2013/07/22/limpression-3d-livre-mathilde-berchon/

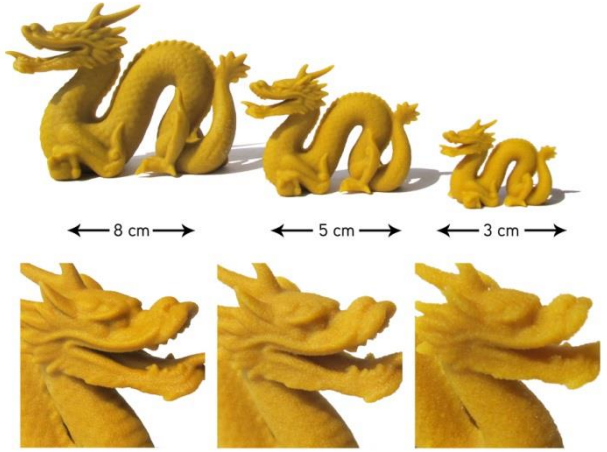


SOURCE :
http://fortune.fdesouche.com/311407-imprimantes-3d-ces-petites-machines-qui-vont-beaucoup-changer-le-monde

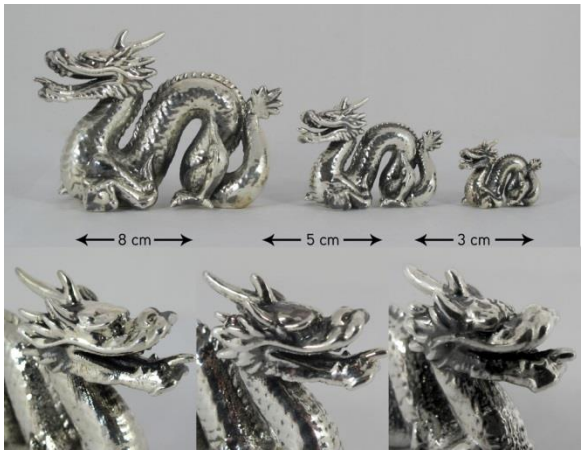
sculpteo



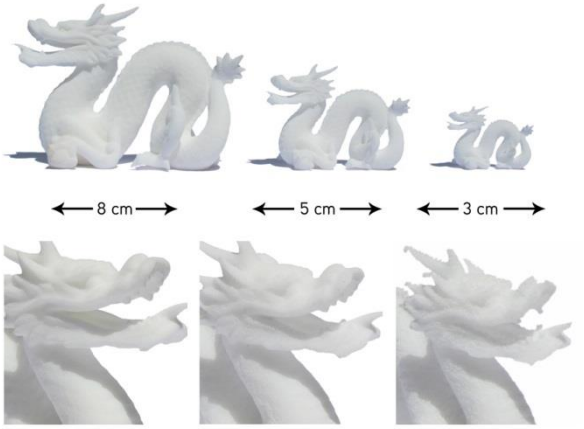
alumide



zcorp



argent



eos

Source des images : http://www.sculpteo.com/fr/help/

3D printer prices

	 Rapide One	 Replicator 2	 Cube X
Price	$2499	$2799	$2799
Build Volume	170x170x170mm	250x160x150mm	275x265x240mm
Layer Resolution	100um	100um	100um
Material	PLA/ABS/PVA/Nylon	1.75mm PLA	PLA/ABS
Nozzle Diameter	0.4mm	0.4mm	0.4mm
Maximum Print Temp	350C	230C	280C
Dimensions	532x449x345mm	490x420x531mm	515x515x598mm
Chassis	Aircraft Grade Aluminum (CNC)	Powder Coated Steel	Steel
Body	Aluminum & Plexiglas	PVC Panels	Acrylic
Body Type	Fully Enclosed	Open	Open
Body Style	Designer	Box	Box
Build Platform	Heated Aluminum	Heated Aluminum	Heated Aluminum
XYZ Actuation	Water Resistant Bronze	Water Resistant Bronze	Liniar Bearings
Connectivity	USB, SD Card	USB, SD Card	USB
Operating System	Windows (7+) Mac OS X (10.6+) Linux (Ubuntu 12.04+)	Windows (7+) Mac OS X (10.6+) Linux (Ubuntu 12.04+)	Windows (7+)

Timeline for the Rapide One Project

rapide 3D

	Early 2012 Research & Development	**Mid 2012** Alpha Design	**Late 2012** Alpha Testing
March 2013 Completed R&D	**April 2013** Proof of Concept Design	**August 2013** Prototype Testing and Evaluation	**October 2013** Pre Indiegogo Preparation
December 2013 Indiegogo Campaign	**January 2014** Tooling and Mold Production	**Feb – Mar 2014** Mass Production / Shipping	.....

Source 2012 : http://www.indiegogo.com/projects/rapide-one-affordable-professional-desktop-3d-printer-by-rapide-3d

3D printer prices

Source : Industrie et Technologies – May 2010

Marque	Multi station	Solido	3D Systems		Zcorporation		Stratasys		Solid scape	Objet
Nom	Extru 3D plastique	SD3000 Pro	V-Flash	Projet 3000 Dentaire	Zprinter 350	Zprinter 650	uPrint	Dimensio n	3D cire	Alaris 30
Taille Objet	60 x 60 x 80 x cm	46 x 77 x 42 cm	66 x 69 x 79 cm	73 x 125 x 150 cm	20 x 25 x 20 cm	25 x 38 x 20 cm	63 x 66 x 78 cm	NC	55 x 49 x 40 cm	82 x 62 x 59 cm
Résolution	400 µm	100 µm	220 µm	328 x 606 dpi	450 x 300 dpi	600 x 540 dpi	200 µm	100 µm	76 µm	600 x 900 dpi
Consomm able	ABS	PVC	FTI230	Bimatériau Support/ré sine	Poudre + liant	Poudre + liant	Bobine ABS	Cartouche ABS	Cire spécifique	VeroWhite
Principe	Extrusion fil plastique	Plastic sheet lamination	Type stéréolitho graphie	Ajout de couches	Jet d'encre couleur sur poudre	Jet d'encre couleur sur poudre	Fused Deposition Modeling	Fused Deposition Modeling	Dépôt de couches cire	Dépôt résine photopoly mère
Prix	1 000 €	7 950 €	9 900 €	70 000 €	22 000 €	50 000 €	11 999 €	15 300 €	31 900 €	34 500 €
Les plus	La moins chère	Faible coût impressio n	Prix peu élevé et simplicité	Wax up dentaire en continue	Proto couleur, faible coût impression (0.1 €/cm³)	Idem Z350 avec bac impressio n plus grand	Technolog ie nid d'abeille, moins de matériau	idem	Haute précision	Qualité impressio n 28 µm
Les moins		Pas de détails très fins			Opacité des pièces	Opacité des pièces	Plateau impressio n petit	Que de l'ABS		

Comparatif Imprimantes 3D du marché - Source : Industrie et Technologies - Mai 2010

SOURCE : http://p1.storage.canalblog.com/16/54/447324/54635666.png

http://souspression.canalblog.com/archives/2010/06/28/18432637.html

www.cnrs.fr
IN2P3
http://institut.in2p3.fr/

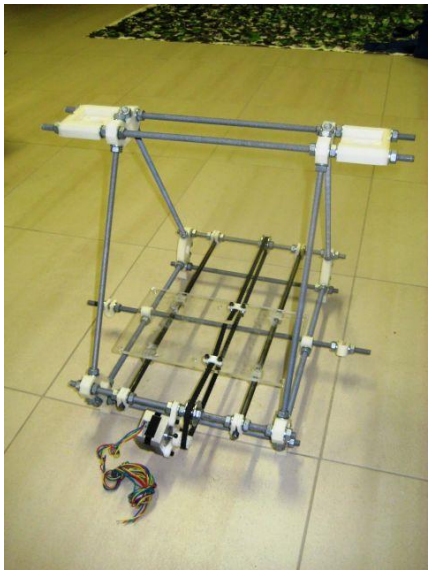
IPHC Institut Pluridisciplinaire Hubert Curien STRASBOURG
http://www.iphc.cnrs.fr/

Annex

fdm 3D printers

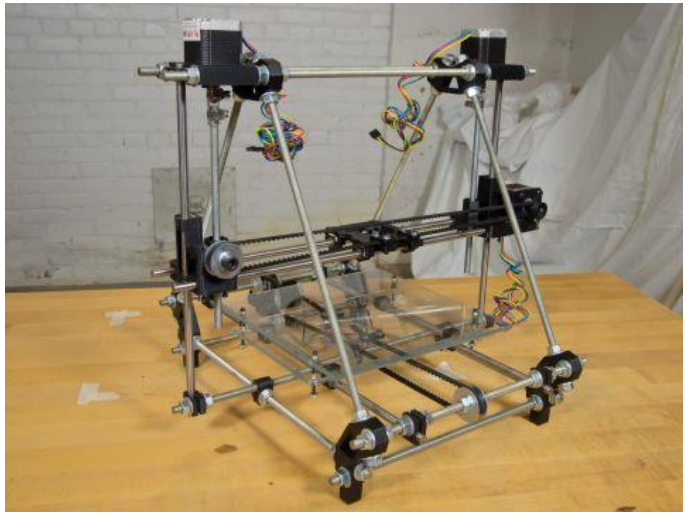
Building Your Own 3D Printer

Frame



Y-axis and bushings

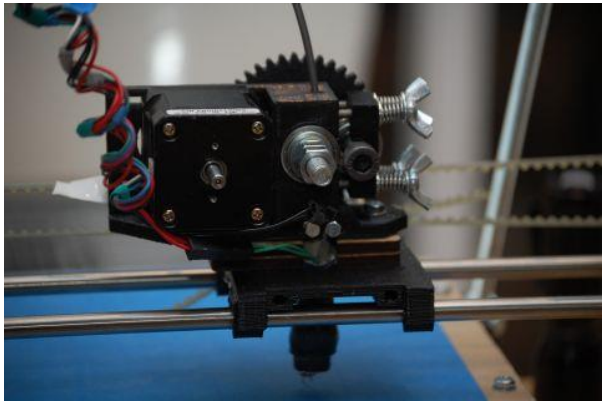
Z-axis and Y-axis

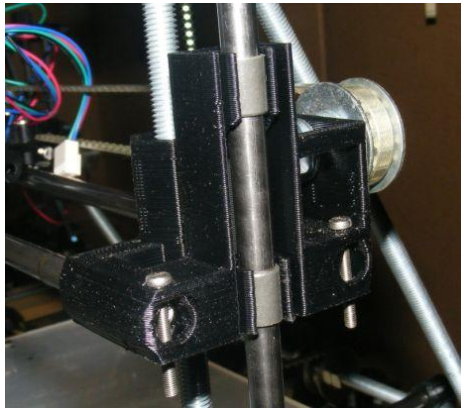


Source : http://reprapbook.appspot.com/

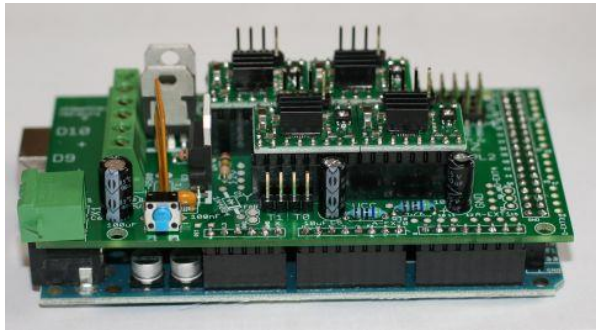
Building Your Own 3D Printer

Extruder

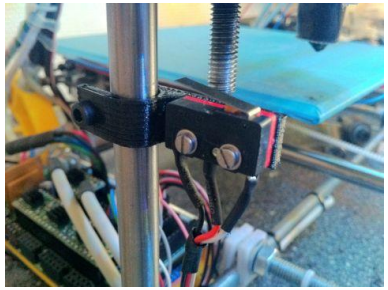




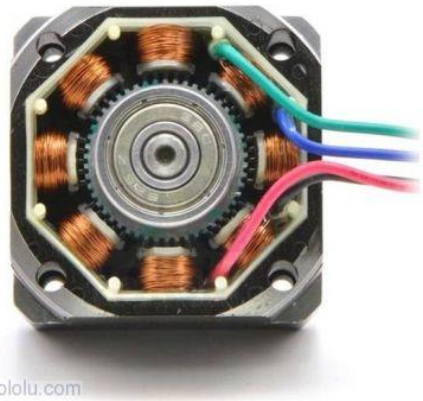
Electronics



End stops

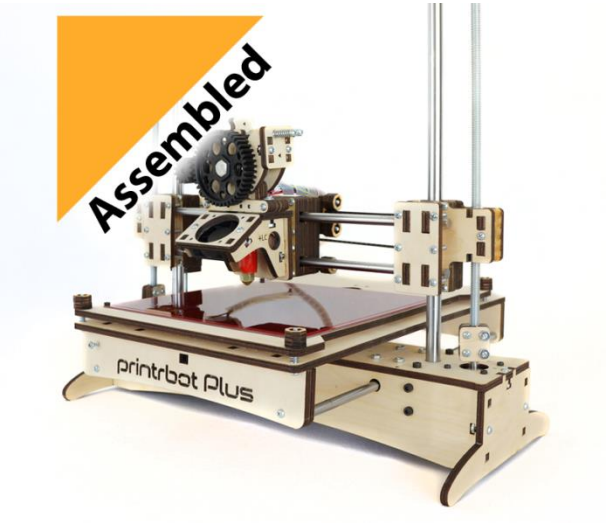


Stepper motors



Source : http://reprapbook.appspot.com/

http://printrbot.com/product-category/assembled-printrbots/

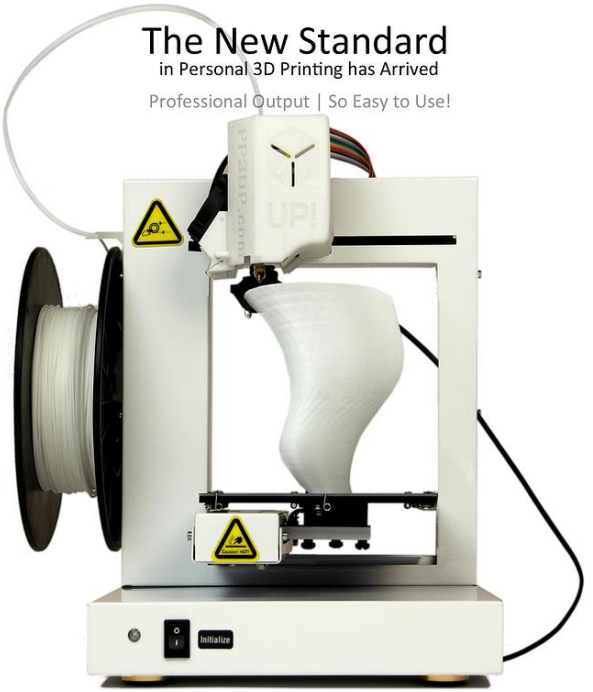


http://www.ultimaker.com/

Fdm ABS
3D array : 21 x 21 x 20,5 cm
~2k€
32€/reel of thread

http://www.up3dusa.com/

UP Plus 2
Fdm ABS
3D array : 14 x 14 x 12,5 cm
Precision between 0,15 and 0,4 mm
<2k€



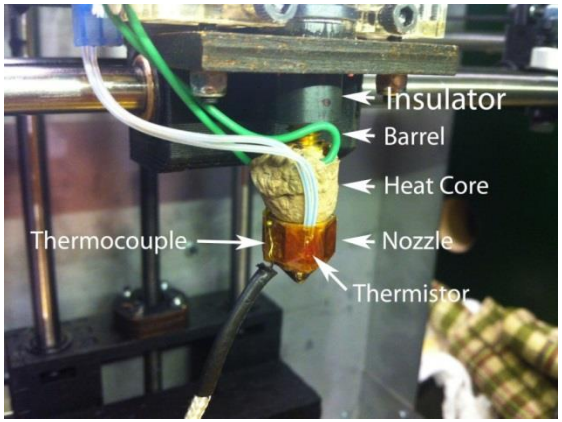
http://www.cubify.fr/

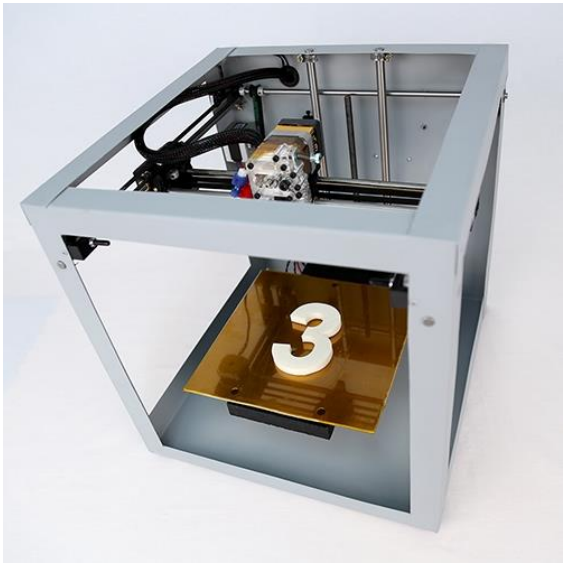
Cube 3D
Fdm ABS
Layer thickness 0,25 mm
3D array 14 x 14 x 14 cm

<2k€

http://www.solidoodle.com/

Solidoodle
Fdm ABS diam. 1,75 mm
Resolution : nozzle diam. 0,35 mm
Layer thickness from 0,1 mm to 0,3 mm
3D array ~8'' x 8'' x 8''
~2 k€





http://www.solidoodle.com/

SOLIDOODLE 3
3D array : ~150 x 150 x 150 mm
Fdm ABS thread diam. 1.75mm
nozzle diam. 0,35 mm

<1k€

http://www.numerama.com/magazine/22485-solidoodle-une-imprimante-3d-a-moins-de-400-euros.html

http://www.a4.fr/

EASY 120
Fdm ABS
thread diam. 1,75 mm
Resolution : 0,15 to 0,4 mm
3D array : 140 x 140 x 135 mm
Printing software : UP
~2 k€