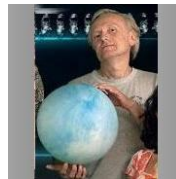


Humankind 2.0: The Technologies of the Future

8. 3D Printing

Piero Scaruffi, 2016



See <http://www.scaruffi.com/singular/human20.html>
for the full text of this discussion

Industry 4.0

- Lower technological barriers to entry
 - A distributed system of innovation: the innovation system expands to high-school kids
 - Rapid diffusion of tools and know-how through open source
 - Rapid prototyping (3D printing/ additive manufacturing)
 - Automated for-rent logistics
 - Self-marketing online

3D Printing

- ...turns digital files into real-world objects
- ...blurs the boundary between the space of data and the space of objects.



In 2012 Eric Haines created Mineways as a way to capture areas of the cube-filled, sandbox world of Minecraft and export it as a texture file and 3D model that can be used by 3D printers

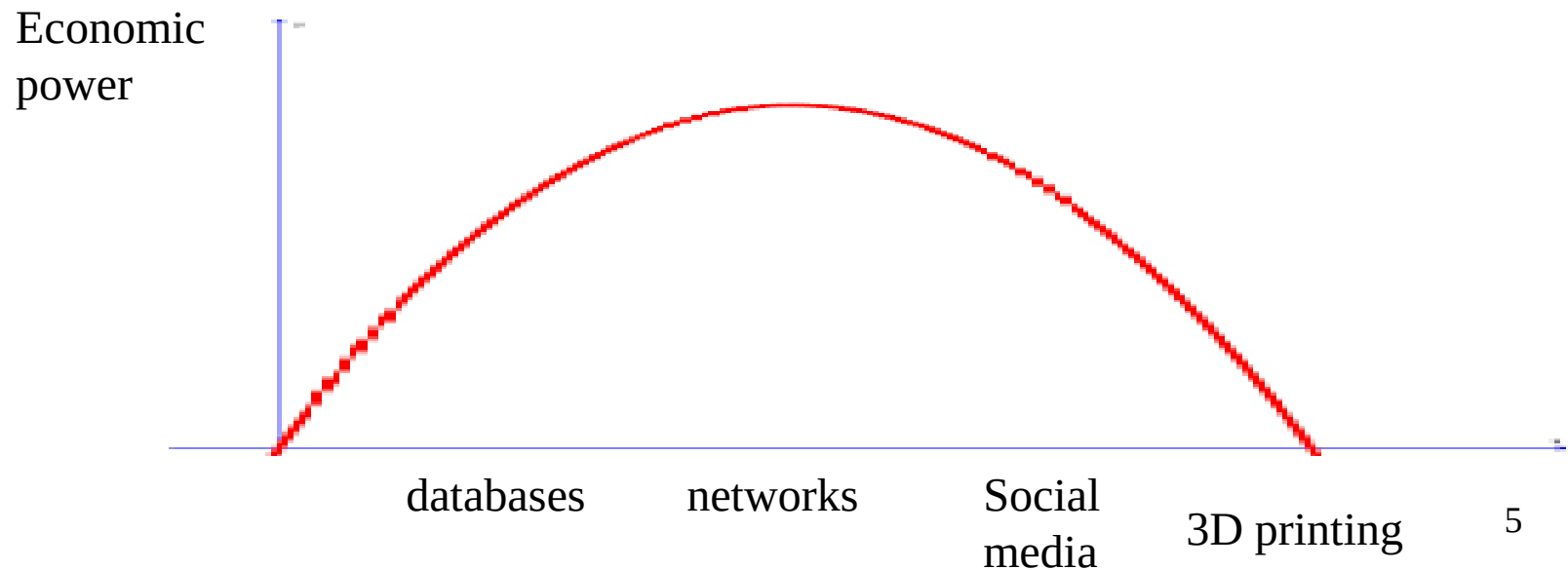
3D Printing

- When we invented databases, we turned **information** into computer data.
- When we invented computer networks, we turned **processes** into computer data.
- When we invented social media, we turned **social interaction** into computer data.
- 3D printing is turning even **objects** into computer data.
- 3D Printing converts **bits into atoms**, another step in the convergence of the digital and the physical worlds.



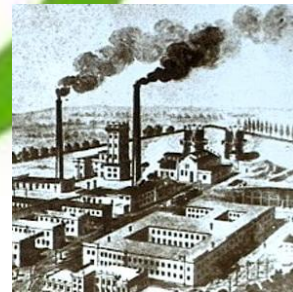
3D Printing

- Databases created computing for big corporations and networks increased the value for big corporations
- but social media shifted computing towards the people, and 3D printing shifts computing power even more towards people



Makers Movement

- Industrial revolution: from the home to the factory
- 3D Printing: from the factory back to the home
- Revival of the world of artisans: the "makers"



Democratization of Manufacturing

- Funding: crowdfunding
- Manufacturing: "on demand" 3D printing
- Logistics: robotic warehouse
- Delivery: drones
- Marketing: social media

3D Printing

- A brief history:
 - 1974: first demonstration of 3D printing
 - 1990: first commercial 3D printer
 - First medical application
 - Open-source RepRap
 - Desktop 3D printer
 - Handheld 3D printer

3D Printing

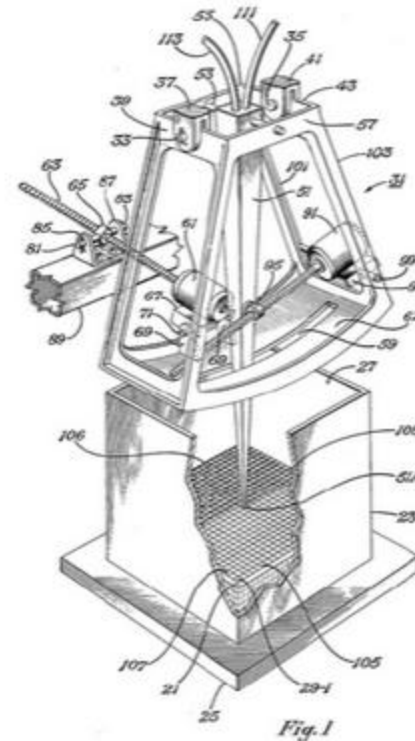
- Pioneers
 - 1974: Wyn Swainson's Formigraphic (Bay Area) demonstrates the printing of a 3D object

3D Printing

- Pioneers
 - 1979: Ross Housholder's SLS in Las Vegas

HOUSHOLDER, ROSS F.

U.S. Patent Jan. 27, 1981 Sheet 1 of 6 4,247,508

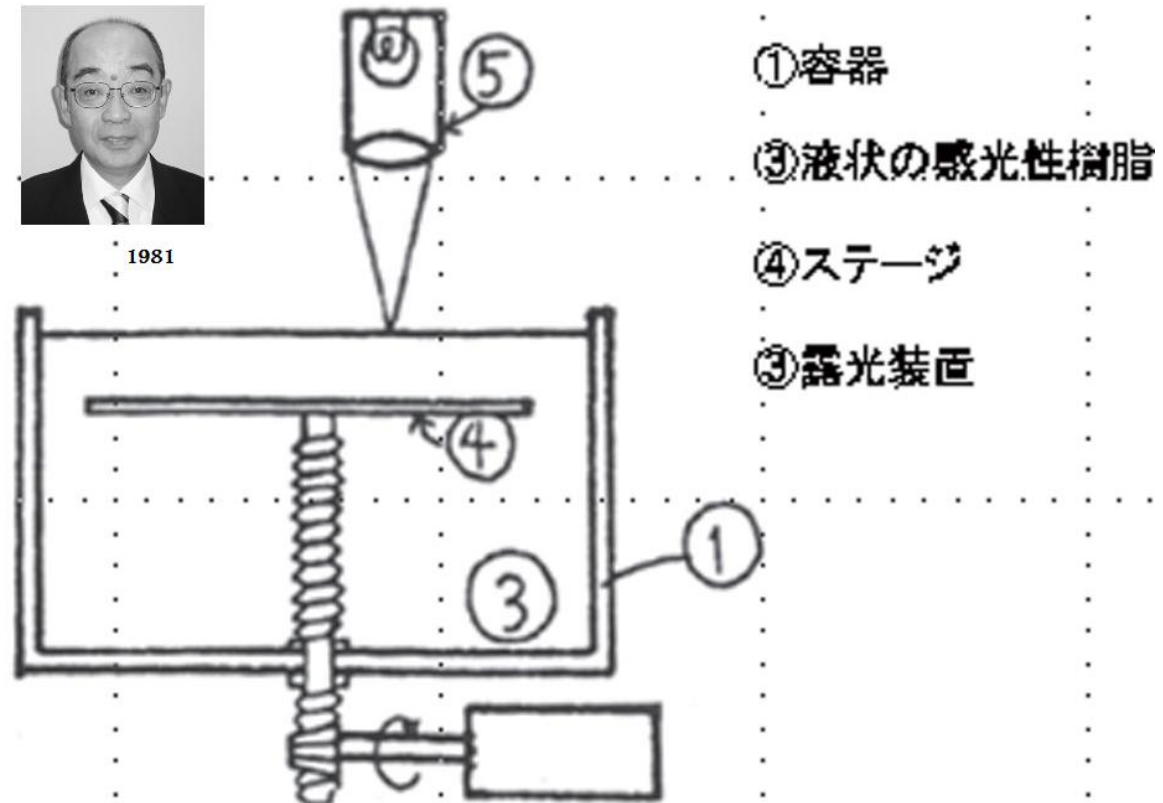


3D Printing

- Pioneers
 - 1980: Hideo Kodama in Japan



1981



3D Printing

- USA
 - 1984: Charles Hull's SLA in L.A.
 - 1986: Carl Deckard's SLS in Texas
 - 1987: Michael Feygin's LOM in L.A.
 - 1988: Frank Arcella's LAM in Pittsburgh
 - 1989: Scott Crump's FFF in Minnesota
 - 1993: Michael Cima and Emanuel Sachs's 3DP/inkjet



AeroMet



3D Printing

- Europe and Asia
 - 1984: Alain LeMéhauté's SLA (General Electric, France)
 - 1984: Yoji Marutani (OPIRI, Japan)
 - 1986: Takashi Morihara (Fujitsu, Japan)
 - 1989: DMEC's SLA (Sony, Japan)
 - 1990: CMET's SOUP (Mitsubishi, Japan)
 - 1991: Cubital's Solider 5600 (Israel)
 - 1991: EOS' SLA (Germany)



3D Printing

- *Leadership in 3D printing has come from small companies and independent inventors, not from the universities (exception: MIT)*

3D Printing

- 3D printing/ Additive manufacturing
 - Stereolithography (SLA): Charles Hull's 3D Systems (1988)
 - Fused Filament Fabrication (FFF) or Fused Deposition Modeling (FDM): Scott Crump's Stratasys (1991)
 - Laminated Object Manufacturing (LOM): Michael Feygin's Helisys/ Cubic (1991)
 - Selective Laser Sintering (SLS): Carl Deckard's DTM (1992)
 - Inkjet (3DP): Zcorp (1996)
 - Laser Additive Manufacturing (LAM): Frank Arcella's AeroMet (1997)



3DSYSTEMS



stratasys



Cubic Technologies



z corporation

Chronological development of RP/T.

By Patri K. Venuvinod, Wei Yin Ma

Year	Company/Org.	Country	RP system	Key Process
1987	3D Systems	USA	SL Apparatus SLA-1	SL
1988	NTT Data CMET	Japan	Solid Object Ultraviolet Plotter (SOUP)	SL
1989	Sony/D-MEC	Japan	Solid Creation System (SCS) based	SL
1989	MIT	USA	3D Printing	Inkjet
1990	EOS	Germany	Steros SL system	SL
1991	Stratasys	USA	FDM TM	FDM
1991	Cubital	Israel	Solid Ground Curing (SGC)*	SL
1991	Helisys	USA	Laminated Object Manufacturing (LOM)	LOM
1992	Teijin Seiki ¹	Japan	Soliform SL system based on DuPont SOMOS	SL
1992	DTM ²	USA	Selective Laser Sintering (SLS)	SLS
1993	Denken	Japan	Solid-state SL: 1 st Desktop RP system	SL
1993	Soligen1	USA	Direct Shell Production Casting (DSPC)	Inkjet
1994	Sanders ⁴	USA	ModelMaker	Inkjet
1994	Meiko	Japan	Small SL machine for jewelry	SL

3D Printing

- 3D printing/ Additive manufacturing

Classification of RP processes.

By Patri K. Venuvinod, Weiyin Ma

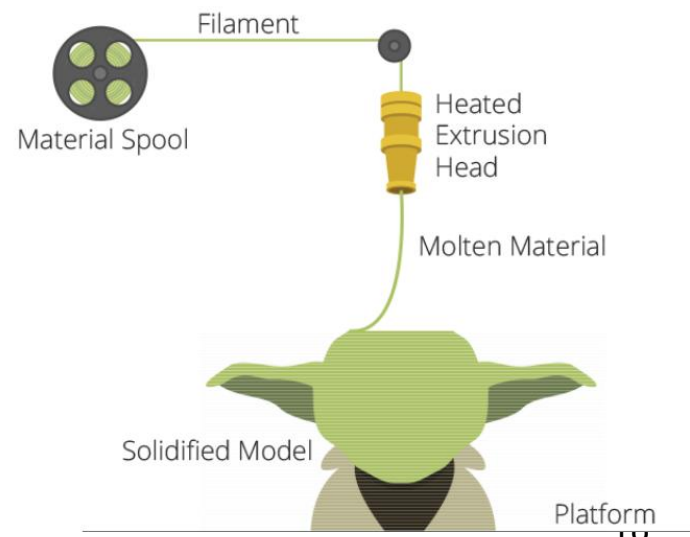
RP process	State of raw material	Kind of raw material	Chemical or physical transformation
3DP	Powder	Ceramic and wax	Adhesive bonding
FDM	Solid	Wax and polymer	Solidification
LOM	Solid	Paper	Cutting and bonding
SL	Liquid	Polymer	Photo-polymerization
SLS	Powder	Ceramic, wax and alloy	Sintering

3D Printing

- Fused Filament Fabrication (FFF) or Fused Deposition Modeling (FDM)

- All the RepRap printers
- LulzBot (Colorado, 2011),
- Zhejiang Flashforge 3D (China, 2011),
- Rostock Delta Printer (Seattle, 2012)
- Airwolf3D (San Diego, 2012),
- Oozenest (Britain, 2013),
- Zortrax (Poland, 2013),
- WASP's DeltaWASP (Italy, 2013),
- Cel's Robox (Britain, 2013),
- BeeTheFirst (Portugal, 2014),

BCN3D (Spain, 2015),
E3D's BigBox (Britain, 2016),
Skriware,
New Matter



3D Printing

- FDM

FDM: the race to the bottom			
Makerbot  Acq. by Stratasys for \$403M	Buccaneer  \$1.4M on Kickstarter	Overlord  £255k on Kickstarter	
Flux  \$1.6M on Kickstarter	Micro  \$3.4M on Kickstarter	iBox Nano  \$457k on Kickstarter	

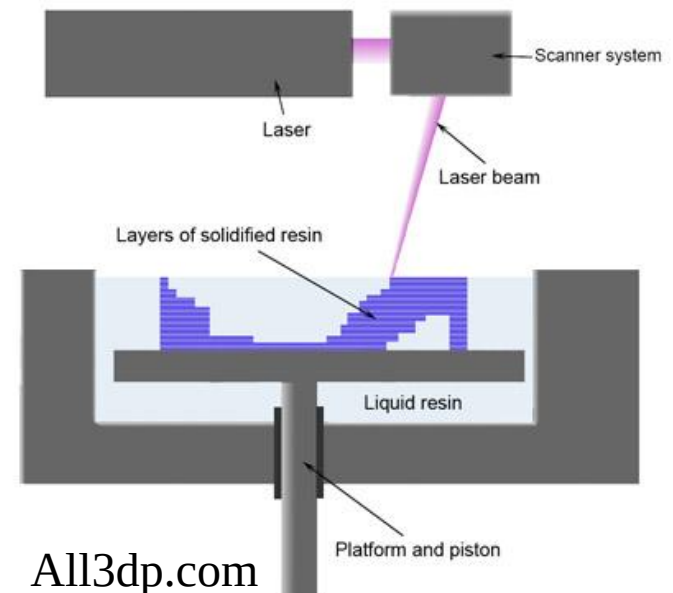
3D Printing

- 3DP/Inkjet (aka "powder and inkjet" and "Z printing")
 - 1996: Z Corp's Z402
 - 1997: Solidscape's ModelMaker
 - 2001: Objet Geometries' Quadra
 - 2008: Objet's "polyjet printing"
 - Metal (LDT/DMD/LMD)
 - 1997: Soligen's DSPC
 - 1998: Optomec's LENS
 - 1999: Ex One's ProMetal



3D Printing

- SLA
 - 1988: NTT system
 - 1991: Electro Optical Systems (EOS) of Germany introduces the STEREOS 400 system
 - Formlabs (Boston),
 - XYZ's Nobel (Taiwan),
 - Digital Wax Systems' Xfab (Italy),
 - Carbon3D's M1 (Redwood City),
 - 3D Systems' ProJet 1200



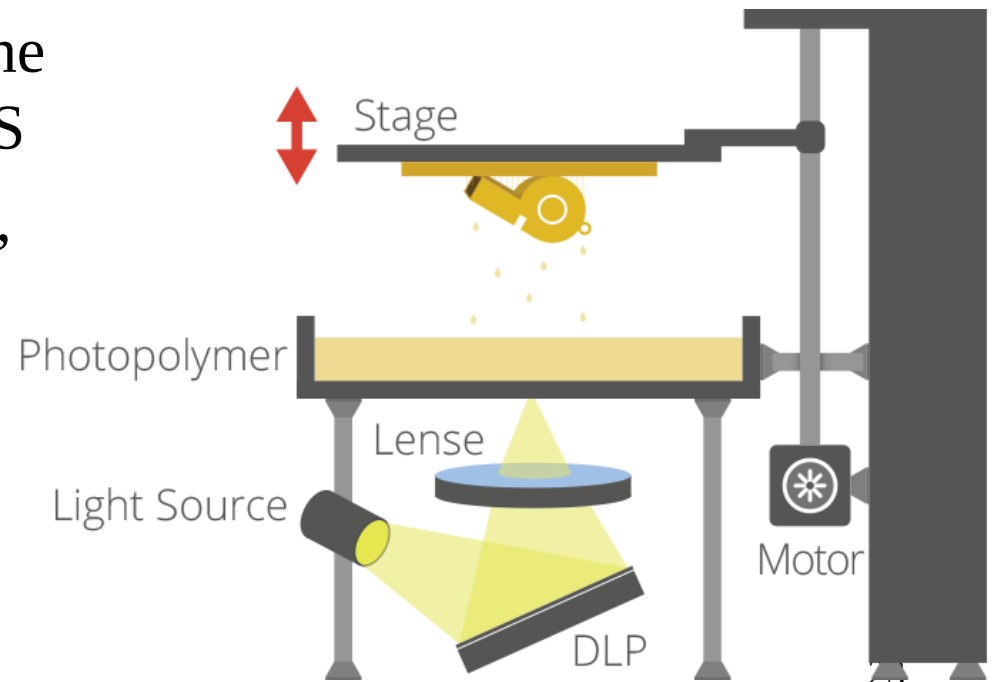
3D Printing

- DLP (like SLA but uses a DLP projector)
 - 2002: EnvisionTec Perfactory (Germany)
 - Autodesk Ember
 - B9 Creator (2012)
 - mUve (2013)
 - Uncia3D (China)
 - Morpheus (South Korea)
 - Kudo3D (San Francisco)



3D Printing

- SLS
 - 1990: DTM's Mod A
 - 1992: DTM's SinterStation
 - 1994 EOS introduces the second commercial SLS
 - Sintratec (Switzerland),
 - Norge (Britain)
 - Prodways (France)



3D Printing

- DMLS
 - 1995: SLM at the Fraunhofer Institute
 - 1995: EOS Eosint M250
 - 2004: Eosint M270

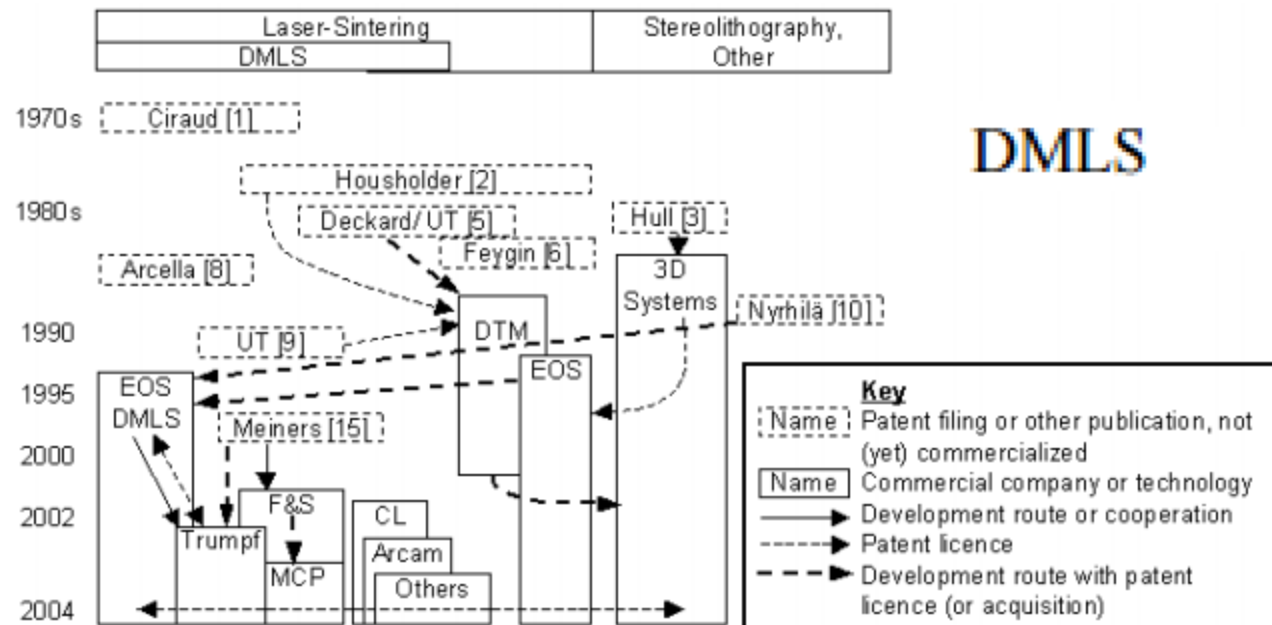


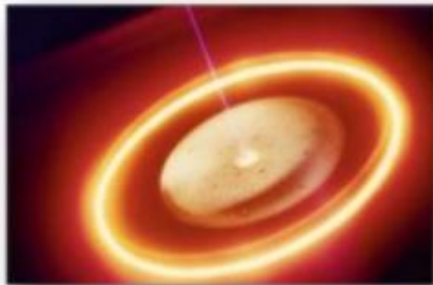
Figure 1: Summarized development and patent history of DMLS

3D Printing

- EBM and LBM

Generalities: Metal Additive Manufacturing

▪ Electron Beam Melting (EBM)



- Metallic powder deposited in a powder bed
- Electron Beam
- Vacuum
- Build temperature: 680–720°C

▪ Laser Beam Melting (LBM)



- Metallic powder deposited in a powder bed
- Laser Beam
- Argon flow along Ox direction
- Build temperature: 200°C



3D Printing

- 2000s
 - Metal
 - 2002 Arcam's EBM (Sweden)
 - 2002 POM's DMD(Michigan)
 - 2007: Accufusion's LENS (Canada)
 - 2009 Sciaky's EBDM (Chicago)
 - 2002 EnvisionTec's DLP (Germany)
 - Materialise (Belgium): 3D printing service



3D Printing

- 2000s
 - Printing electronic boards
 - Optomec's Aerosol Jet (2004)
 - Fujifilm's DMP (2009)
 - Nano Dimension (2016)



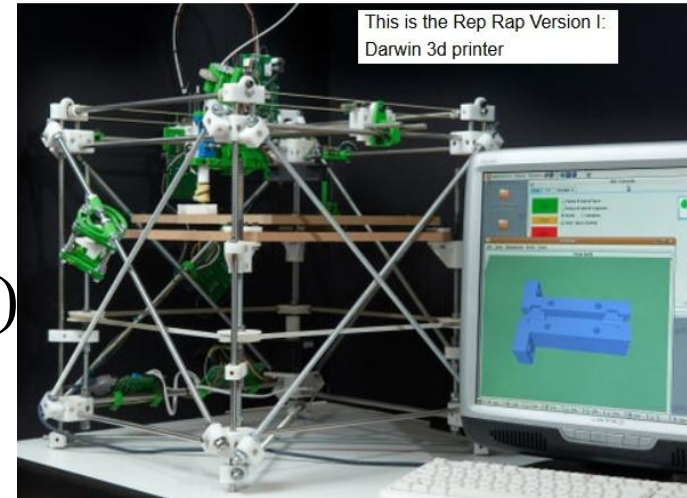
Lena Kotlar with the DragonFly 2020.



3D Printing



- RepRap
 - 2005: Adrian Bowyer's open-source RepRap project to develop a self-replicating 3D printer (Univ. of Bath)
 - 2008: Bowyer's Darwin machine builds a copy of itself
 - The first low-cost 3D printer
 - RepRap jumpstarted the open-source movement for 3D printing
 - RepRap "democratized" 3D printing



3D Printing

- RepRap
 - 2009: BitsFromBytes's DIY kit
 - 2010: BFB3000 pre-assembled
 - 2009: MakerBot's kit CupCake
 - 2012: MakerBot's Replicator



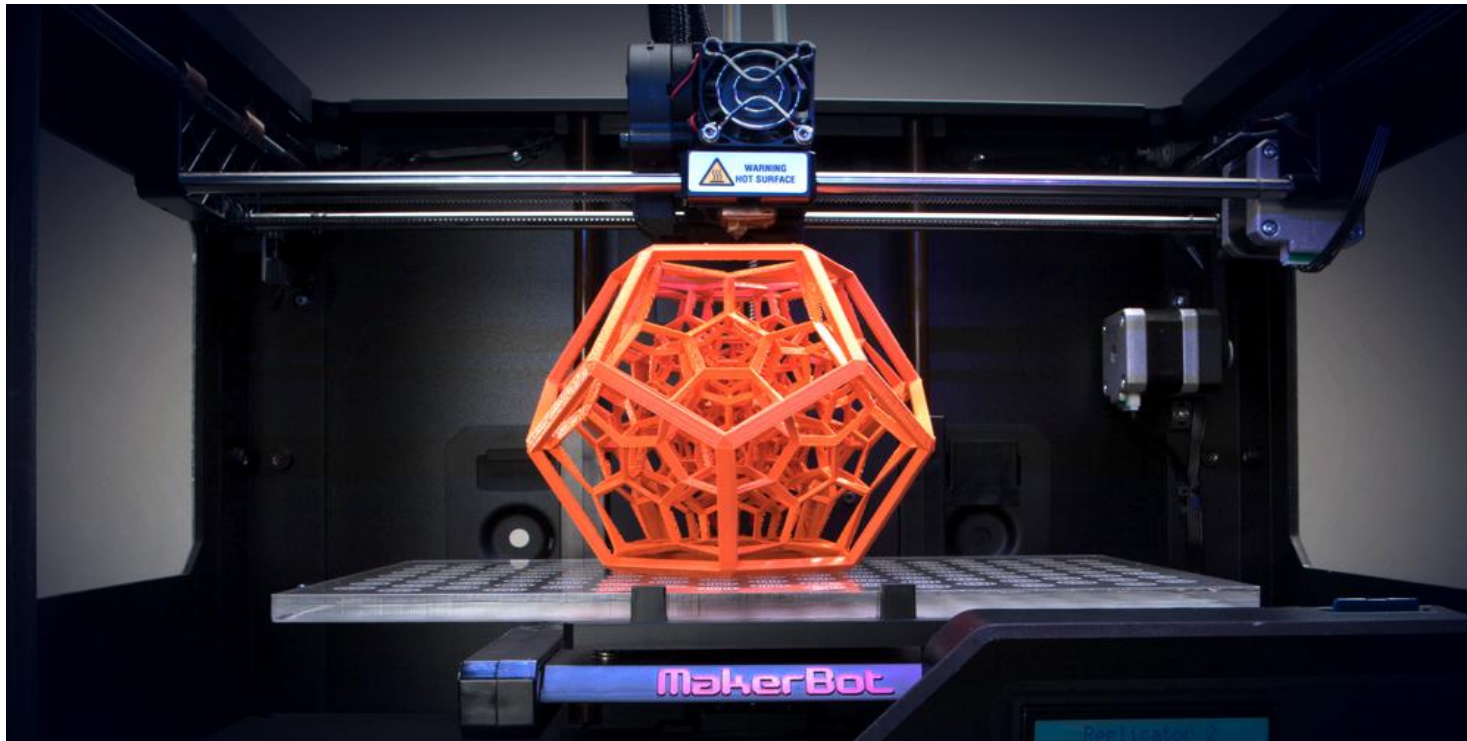
3D Printing

- The community
 - 2008: MakerBot's Thingiverse where hobbyists can share for free their 3D models
 - 2008: Shapeways launches an online marketplace for 3D models

The logo for Thingiverse, featuring the word "Thingiverse" in a blue, sans-serif font. The text is positioned on a light gray rectangular background.The logo for Shapeways, featuring the word "shapeways" in a dark gray, sans-serif font, followed by a blue star icon.

3D Printing

- MakerBot: the desktop 3D printer

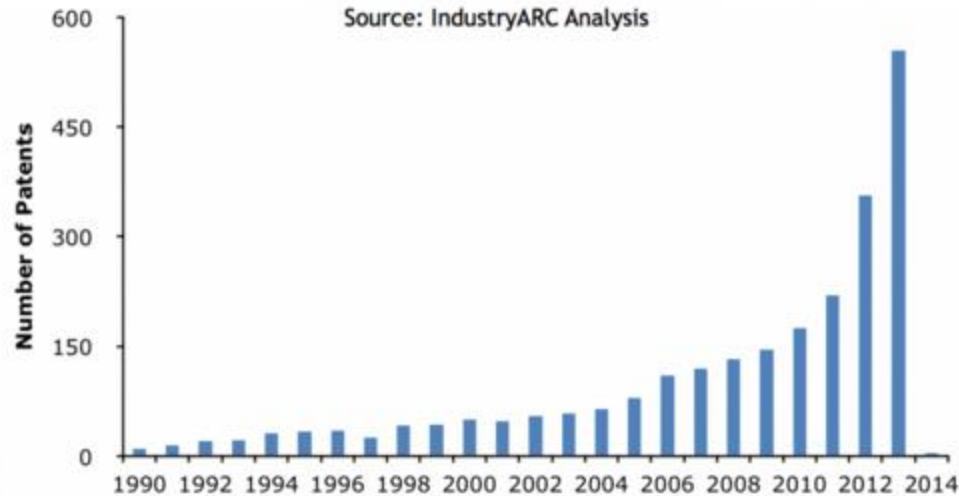


3D Printing: Why Only Now?

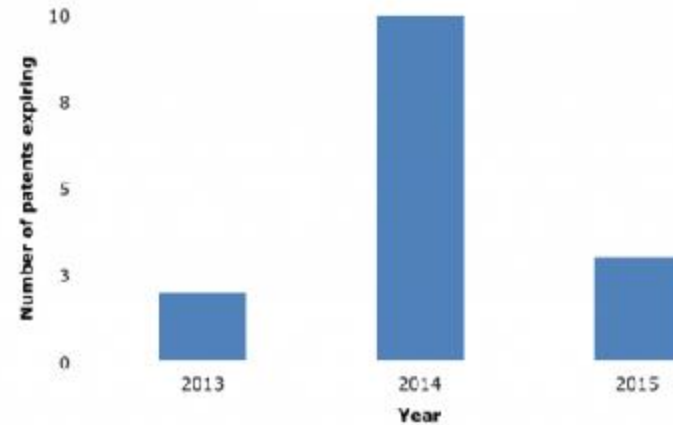
- Patents expired...

3D Printing patent publications

Source: IndustryARC Analysis



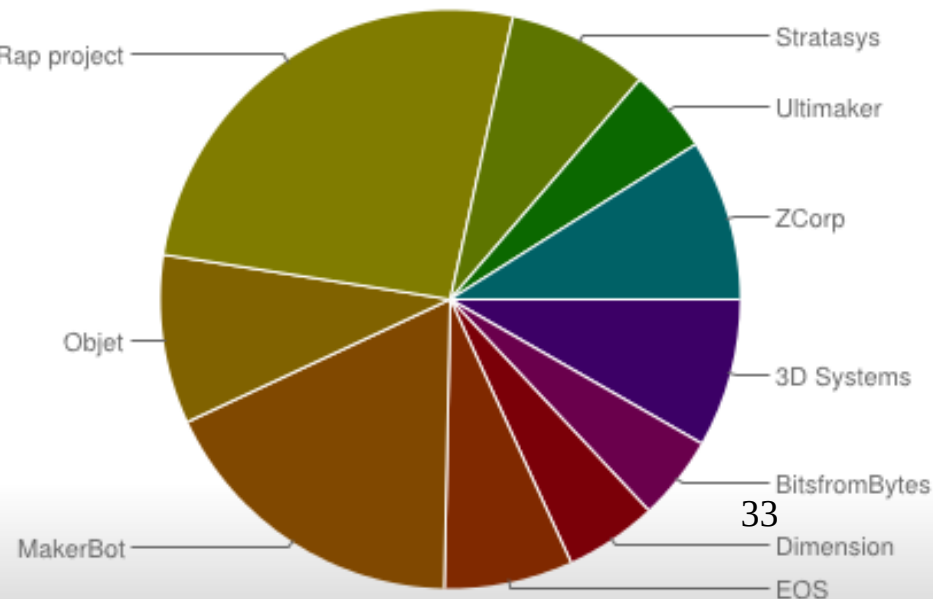
Patent Expiry



3D Printing

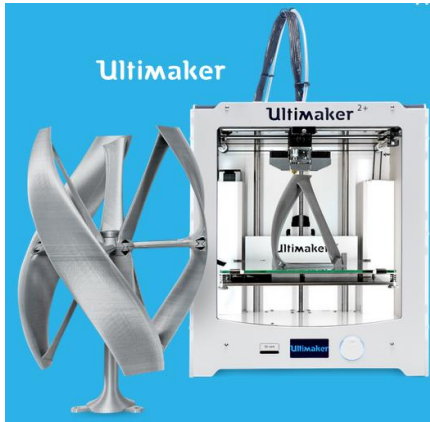
- 2010s
 - Consolidation:
 - Stratasys acquired Solidscape in 2011, Objet in 2012 and MakerBot in 2013 + providers of 3D models (The3dstudio, Freedom of Creation, MyRobotNation)
 - 3D Systems acquired BitsFromBytes in 2010 and Z Corp in 2012

Which printers (which manufacturer) have you used?



3D Printing

- 2010s
 - RepRap's influence
 - Multiplication of 3D printers
 - 2011: Printrbot (California)
 - 2011: Ultimaker, the anti-RepRap
 - 2011: Solidoodle (New York)
 - 2012: Josef Prusa's self-cloning Prusa i3.

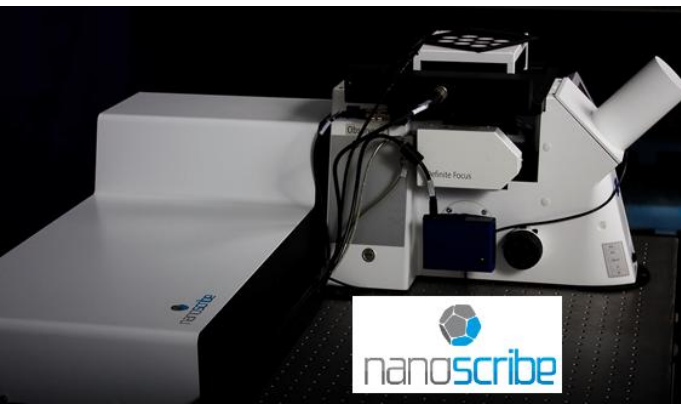


Assembled Printrbot Simple



3D Printing

- 2010s
 - 2012: Shapeways' "Factory of the Future" in New York
 - 2013: Formlabs (Boston): SLA desktop
 - 2013: Arburg's Freeformer (Germany): granules rather than filaments or powders
 - 2013: Nanoscribe (Germany): 3D printer of microstructures
 - 2014: New Matter (L.A.): FDM desktop



3D Printing

- 2010s
 - 3Doodler's 3D printing pen (San Jose, 2013)
 - OLO's smartphone-attached 3D printer (Italy, 2015)



OLO - The First Ever Smartphone 3D Printer



3D Printing

- 2010s
 - Metal
 - 2011: Fabrisonic's ultrasonic printer (Ohio)
 - 2012: Beam's EasyClad (France)
 - 2015: Xjet (Israel): inkjet metal nanotechnology
 - 2017: Toyota & GE

Dec 14, 2016 **GE takeover of AB, Concept Laser**



3D printing

- Emanuel Sachs' Desktop Metal (2015)



3D Printing

- 2010s
 - 2015: Carbon3D (North Carolina): CLIP/ SLA
 - 2015: Skriware (Poland): FDM desktop



3D Printing

- 2010s
 - 2016: LCD printers
 - Uniz 3D (San Diego)
 - Photocentric (Britain)



3D Printing

- 2010s
 - Multi-color printers
 - DreamMaker's Overlord (2014)
 - 3D Systems' CubePro (2014)
 - HP' JetFusion (2016)

HP's Jet Fusion technology.



3D Printing

- 2010s
 - Steel

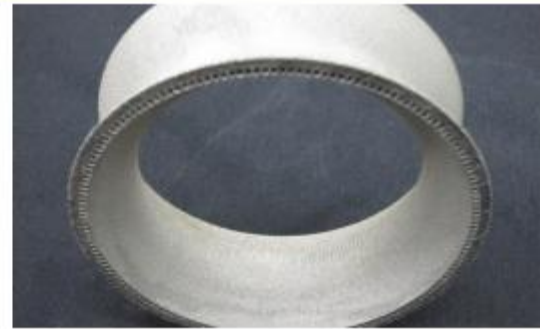
Additive manufacturing for fusion energy sciences

June 21, 2017



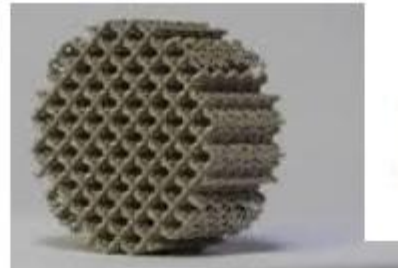
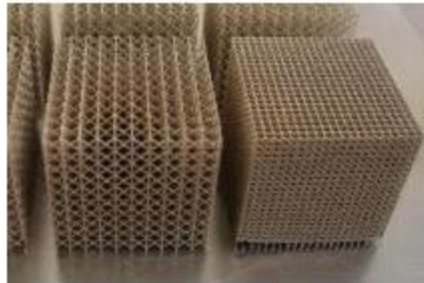
Yinmin Morris Wang

Lawrence Livermore
National Laboratory



Rocket engine

The throat of rocket engine



3D Printing

- 4D Printing
 - MIT (Skylar Tibbits), Stratasys and Autodesk (Carlos Olguin's Project Cyborg)
 - Printing materials that are both customizable and programmable
 - 3D printed object that performs an additional function, for example that self-assembles after the parts come out of the printer or that change shape to better adapt to the environment



What has been 3D-printed

2011: a small aircraft (Univ of Southampton)

2012: chocolate (Univ of Exeter)

2012: a wearable cell phone (Bryan Cera)

2013: car body (Jim Kor)

2014: a drone (Louis DeRosa)

2014: ceramics (VormVrij)

2015: ceramics (DeltaBots)



What has been 3D-printed

- 2014: electric car (Local Motors' Strati)
- 2014: ten homes (WinSun)
- 2015: a five-storey house (WASP)
- 2016: an electric motorcycle (AP Works)



What has been 3D-printed

2016: Triumphal Arch of Palmyra
Davide Quayola's antiquities



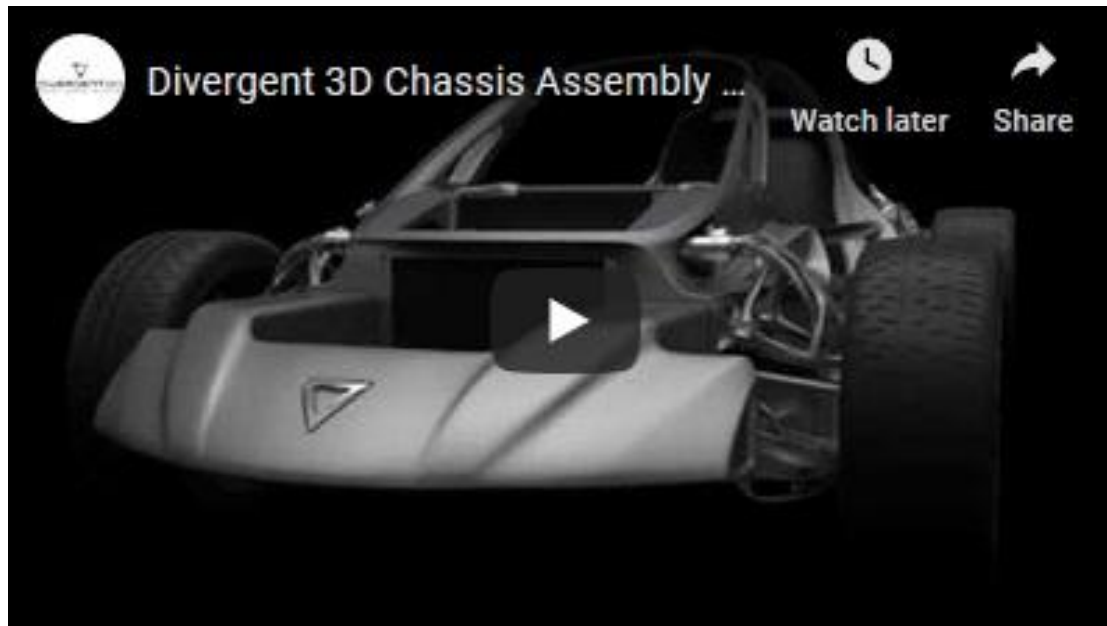
Davide Quayola creates sublime
'antiquities' carved by robots

2018



What has been 3D-printed

Divergent



What has been 3D-printed



May 4, 2013

Defense Distributed Claims To Have Produced The First Fully 3D-Printable Pistol



July 10, 2018

The files you need to make your own gun can now be legally shared online

What has been 3D-printed

MIT's giant mobile 3D printer can build a building in 14 hours, and some day it may be headed to Mars *Apr 27, 2017* **Digital Construction Platform**



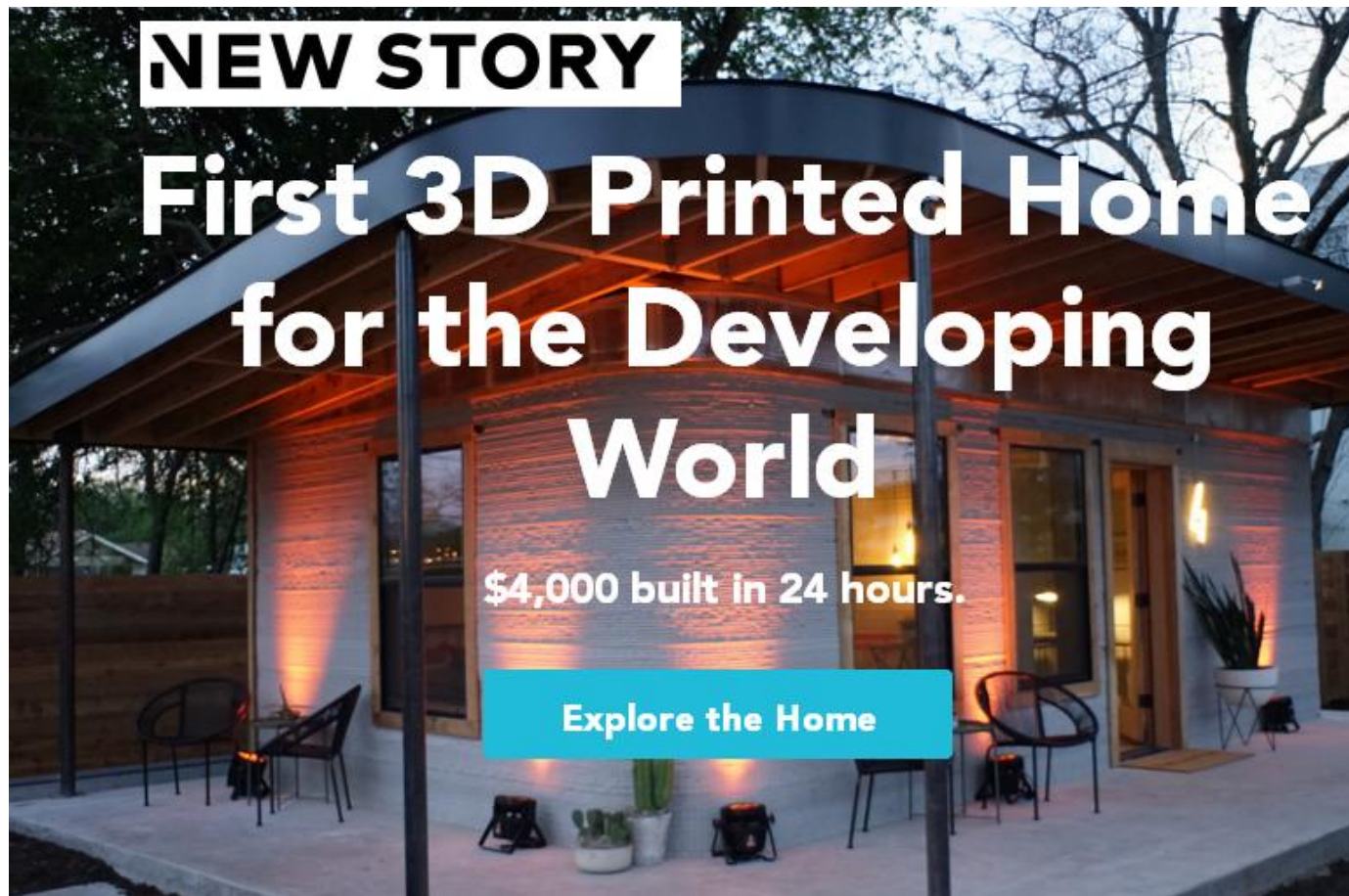
What has been 3D-printed

2017: Made in Space's Archinaut (3d printing for space stations and satellites)



What has been 3D-printed

2018: New Story charity 3D-builds homes for poor countries



3D Printing for Regenerative Medicine

2001: EnvisionTec's BioPlotter

2001: Stuart Williams' BioAssemblyTool (BAT)

2006: "Ink-jet Printing of Viable Cells" (Clemson Univ)

2007: hip (Arcam)

2008: blood vessel (Organovo/nScript)

2009: knee (Stanford Univ)



organovo

Tissue Engineering by
Self-Assembly of Cells Printed
into Topologically Defined
Structures

Article (PDF Available) in Tissue Engineering
14(3) · December 2007



Last [Gabor Forgacs](#)
at 40.41 · University of Missouri

TIME

The 50 Best Inventions of 2009

The \$20 Knee

Stanford



3D Printing for Regenerative Medicine

2010: Organovo's MMX bioprinter

2010: prosthetic limbs (Bespoke Innovations)

2012: jaw (Hasselt Univ)

2013: ear (Princeton Univ)

2014: custom prosthetic leg (William Root)

2015: nScrypr's TE series (tissue engineering)



3D Printing for Regenerative Medicine

- 3D bioprinting
 - Anthony Atala @ Wake Forest
 - Jennifer Lewis @ Univ of Illinois
 - James Yoo @ Wake Forest
 - William Root @ Pratt Inst

Doctors 3D-print 'living' body parts

16 February 2016 | Health



 Wake Forest®
School of Medicine

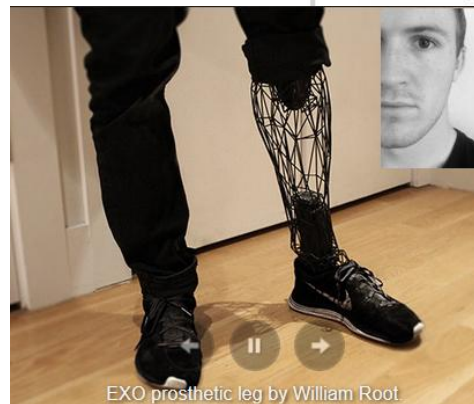


 Wake Forest®
School of Medicine



HARVARD
UNIVERSITY

WYSS INSTITUTE



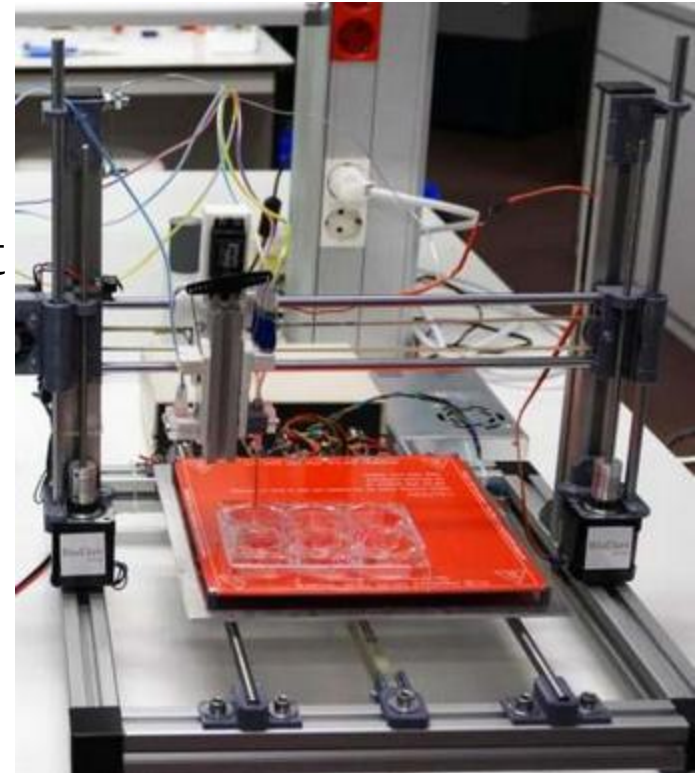
EXO prosthetic leg by William Root

3D Printing for Regenerative Medicine

- 3D bioprinting
 - 2017: Jose Luis Jorcano (Spain): a commercial 3D printer that can print human skin
 - 2015: Steven Keating 3D-prints his own brain tumor

[Apple hires Steven Keating](#) Apr 21, 2017

Apple has hired the guy who 3-D printed his own brain tumor.



3D Printing for Regenerative Medicine

- 3D bioprinting
 - Prellis



Prellis Biologics has made the production of lab-grown human organs possible.

3D Printing – 2018 Additions

- Home printer: Robo3D (San Diego), BCN3D (Spain)



3D Printing – 2018 Additions

- T3D (Taiwan): powered by the light of the smartphone

T3D uses the light from your smartphone or tablet



3D Printing – 2018 Additions

- Velo3D (Silicon Valley): high-quality metal parts
- Arevo Labs (Silicon Valley): high-performance and ultra-strong polymers



AREVO



3D Printing – 2018 Additions

- Xjet (Israel): ceramic and metal
- Snapmaker (China): also a CNC carver and laser engraver



snapmaker
Daniel Chen (Shenzhen)



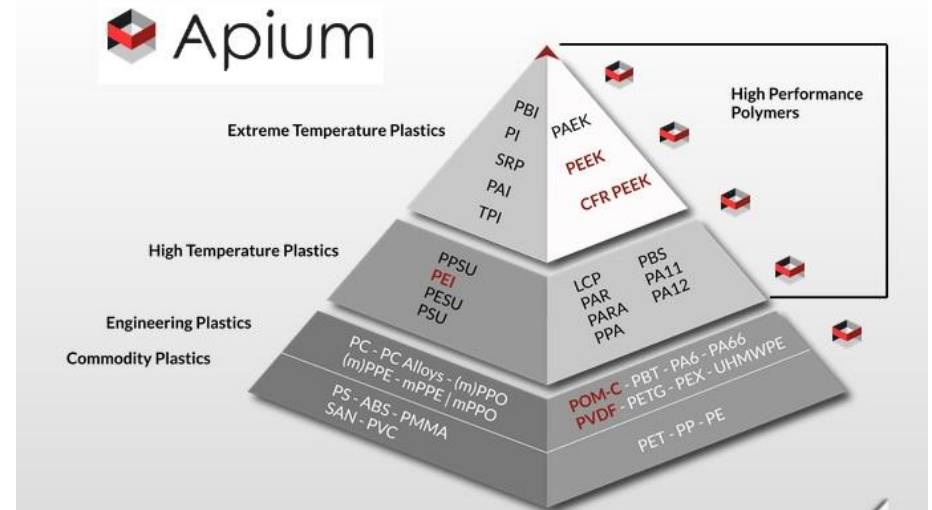
3D Printing – 2018 Additions

- Evolve (Minnesota, Stratasys spinoff)



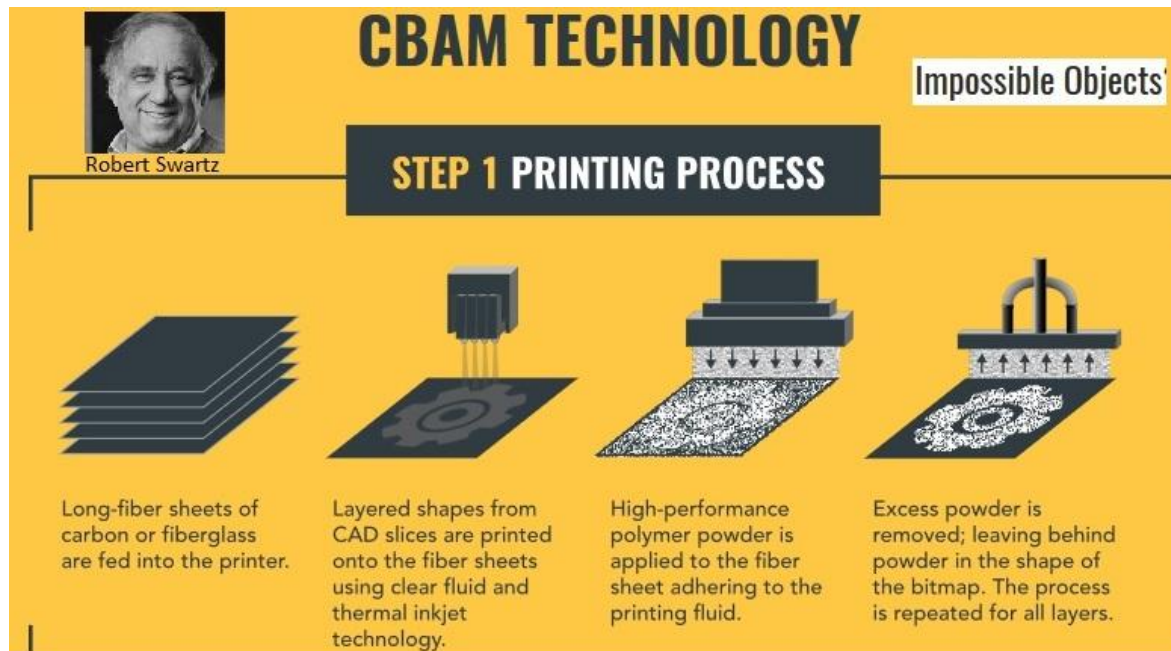
3D Printing – 2018 Additions

- Aurora (Australia): metal
- Apium (Germany): high-temperature polymers



3D Printing – 2018 Additions

- Markforged (Boston): composite parts
- Impossible Objects (Chicago): composite parts



3D Printing – 2018 Additions

- Uniz (San Diego): Medical
- SprintRay (Los Angeles): Dentistry



Makers Movement

- Makers movement
 - Bay Area known for the Do-It-Yourself (DIY) culture, eg Homebrew Computer Club
 - DIY movement in biotech
 - Maker Faire (2006)
 - Tech Shop (2006)
 - Hacker Dojo (2009)



Makers Movement

- Makers movement



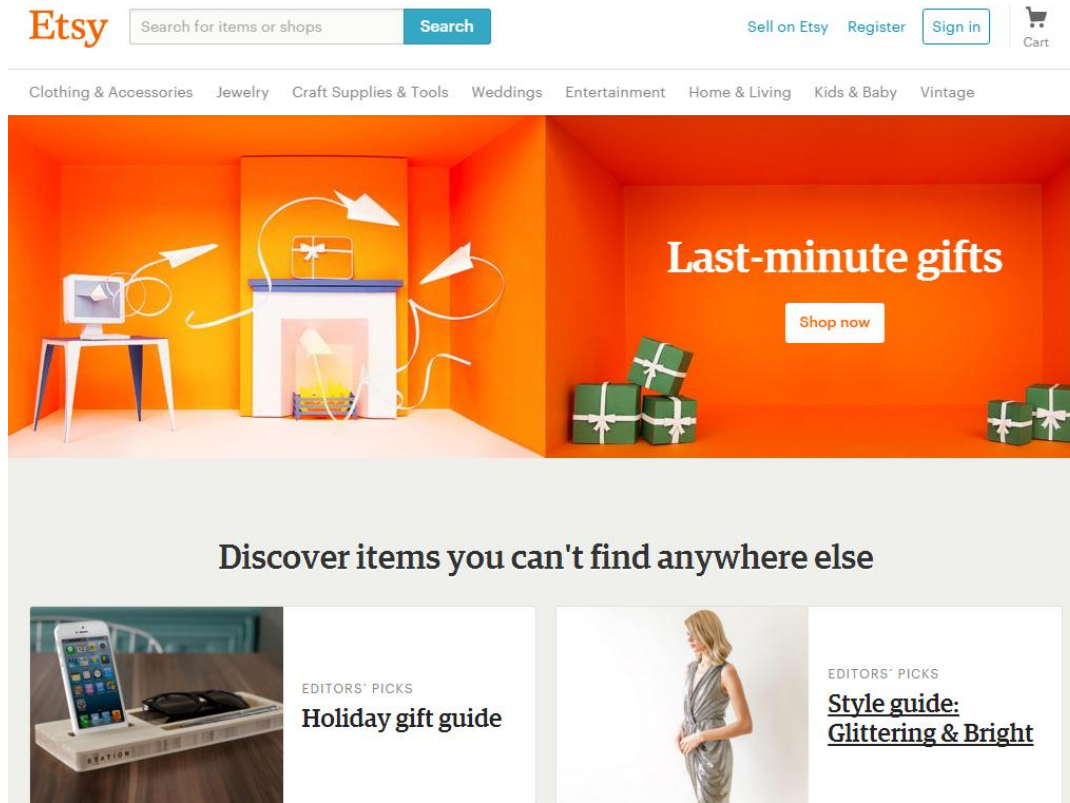
Makers Movement

- Makers movement



Makers Movement

- Marketplaces
 - Etsy, a platform to buy and sell handmade items



Makers Movement

- Marketplaces
 - Valsfer (San Francisco, 2015) connects designers and manufacturers



The other pieces...

- To build a replica of your boyfriend, you need:
 - 3D scanner to make a 3D model
 - Cloud to store 3D model
 - Editor to modify your 3D model
 - STL editor
 - Slicer
 - 3D printer

3D Scanning

- Origins
 - 1977: Laser-based 3D scanning (IRIA, France)
 - 1987: Cyberware's head scanner
 - ...
 - 1998: Cyra's Cyrax



**Process and apparatus for optically exploring
the surface of a body**

US 4146926 A

Filing date

Sep 1, 1977



3D Scanning

- Desktop scanners
 - Matter & Form's MFS1V1 (\$600)
 - NextEngine's Ultra HD (\$3,000)
 - MakerBot's 2016 Digitizer (\$800)



3D Scanning

- Handheld 3D Scanners
 - 4DDynamics' IIIDScan PrimeSense from Belgium (\$1,500)
 - Shining 3D's EinScan-S from China (\$1,300)
 - Fuel3D's Scanify from North Carolina (\$1,500)
 - Artec's Eva from Luxembourg (\$15,000)
 - Nikon's ModelMaker MMDx



ModelMaker MMDx

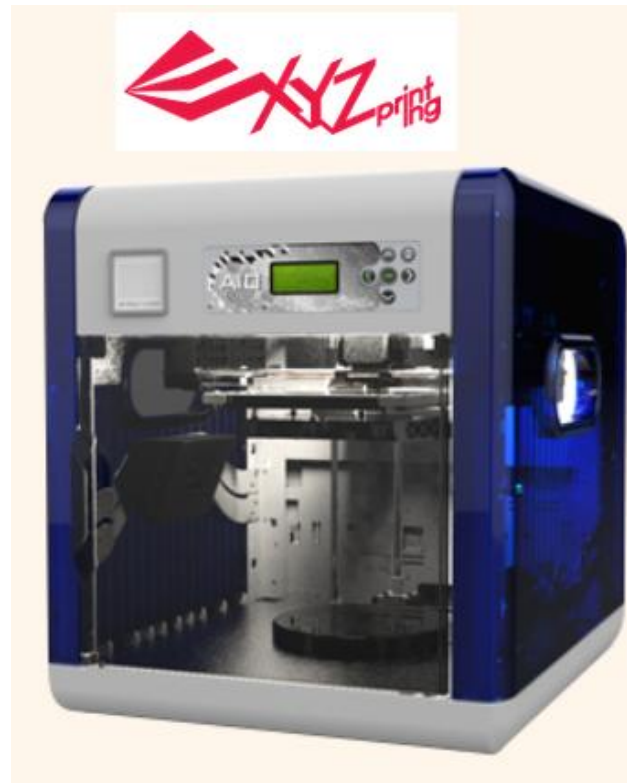
3D Scanning

- 3D scanners that attach to a smartphone or a tablet
 - 3D Systems' Cubify iSense (\$400)
 - EORA (\$330)
 - Occipital's Structure Sensor (\$400)



3D Scanning

- 3D scanning and 3D printing:
 - 2014: AIO Robotics' Zeus (\$2,500)
 - 2014: XYZPrinting's Da Vinci AiO (\$800)



3D Scanning

- The Future
 - Peachy Printer (Kickstarter in progress): \$100 printer and scanner
 - Ali Hajimiri @ Caltech: a 1-mm chip that uses a laser to scan an object
 - Ramesh Raskar @ MIT Media Lab: "Polarized 3D" for high-quality 3D cameras into smartphones

KICKSTARTER

The Peachy Printer -
The First \$100 3D Printer & Scanner!



3D Scanning

- The Future
 - "Bidirectional fabrication": pick an object from a database of 3D models, 3D-print its digital file, modify it manually, 3D-scan it, upload its new digital file, 3D-print the new digital file
 - 2015: Lancaster Univ's ReForm (Jason Alexander)



3D Design/Modeling

- Professional 3D CAD

- CATIA from Dassault (1981)
- Pro/E (later renamed Creo) from PTC (1987)
- 3D Studio from Gary (1990, now Autodesk's 3ds Max)
- LightWave3D from NewTek (1990)
- SolidWorks from Jon Hirschtick (1995, now Dassault)
- SolidEdge from Intergraph (1996, now Siemens)
- ZBrush from Pixologic (1999)
- Inventor from Autodesk (1999)
- SketchUp from Last Software (2000, now Google)



3D Design/Modeling



- Free/cheap 3D tools:
 - Open-source projects Blender (1995) and FreeCAD (2002)
 - Autodesk 123D (2009)
 - Pixologic's Sculptris (2009)
 - Kai Backman's TinkerCAD (2011, now Autodesk)



AUTODESK® 123D®



3D Design/Modeling

- The user-friendly era
 - A positive influence: the videogame Minecraft (2011)
 - 2014: Sylvain Huet's 3D Slash
 - 2014: uMake's smartphone 3D CAD
 - 2015: Autodesk's a cloud-based service Forge



3D Design/Modeling

STL editors:

- open-source MeshLab (Italy, 2005)
- Meshmixer (Canada, 2009, now Autodesk)

Slicers to convert the STL into printing instructions:

- Repetier
- Slic3r
- Ultimaker's Cura
- Simplify3D



3D Printing

- Microsoft strategy
 - Cloud Print Service
 - Printing from any device using Windows and from HoloLens
 - Shipped to your door
 - Windows 10 + Materialise's cloud + 3MF standard



3D Printing

- The 3MF Consortium:

- 3D design



- 3D printing



- Cloud



- Middleware



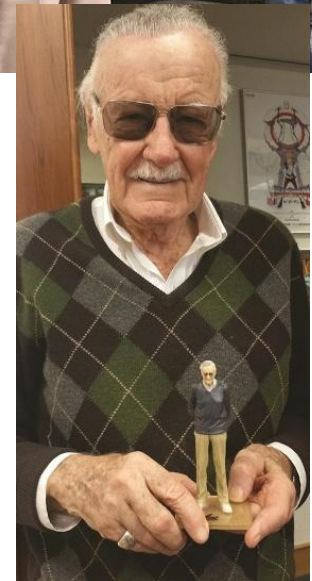
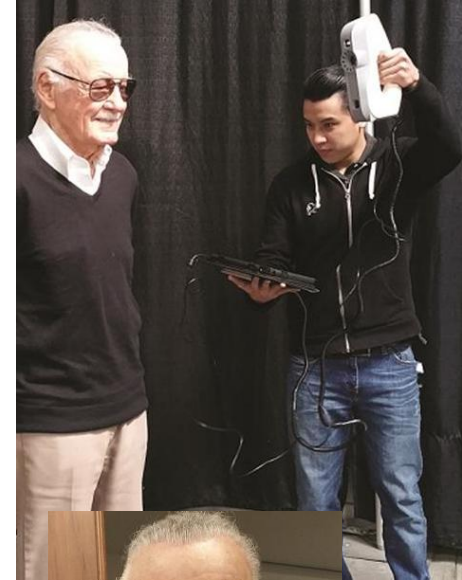
- Open Source



3D Design/Modeling

The Future

- 3D printing will become a family hobby.
- Children will modify objects, scan them, and order a 3D print.
- Schoolchildren will be asked to create objects
- Parents will 3D print objects for useful purposes in the house or simply for fun.
- You will be able to 3D-print your own jewelry, makeup and clothes.
- You will be able to scan, modify and 3D print any object that you have



3D Design/Modeling

The Future



3d model Arnold Schwarzenegger \$49.00



3d model Tom Cruise head \$56.00

cgtrader



Rihanna \$20.00



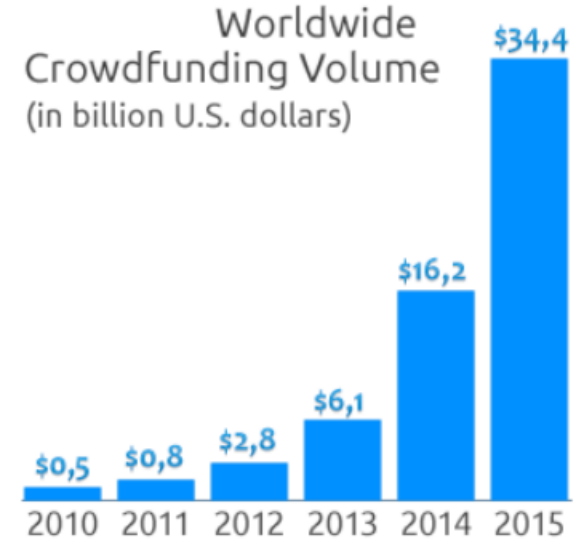
3d model Angelina Jolie head ztl \$9.00

The Factory of the 21st Century

- Lower technological obstacles to manufacturing because of 3D printing
- Making a product is becoming less costly
- The money can be found on crowdfunding websites
- Logistics: rent it from Amazon
- Marketing: social media and customer reviews

The Factory

- Crowdfunding



Crowdfunding Site 2014 Volume

gofundme \$470M

KICKSTARTER \$444M

indiegogo ???

The Factory

- Logistics
 - Amazon's colossal PHX6 fulfilment center at Phoenix (Arizona) is transformed into an automated, robot-intensive facility
 - The whole supply chain is made available to other merchants as well
 - Rapidly moving online business towards same-day delivery and mobile shopping.



The Factory

- Reinventing logistics with drones and robots



The Factory

- The new age of marketing
 - Amazon, Google, etc collect data about their customers and then steer them towards the most suitable purchases
 - This process is only partially controlled by manufacturers and retailers, no matter how much money they want to invest
 - Yelp, Trip Advisor, Amazon reviews, etc provide the most powerful form of marketing: the buyer's opinion, not the seller's opinion

The Factory

- Industry 4.0. What is changing:
 - actors
 - process
 - investors

The Factory

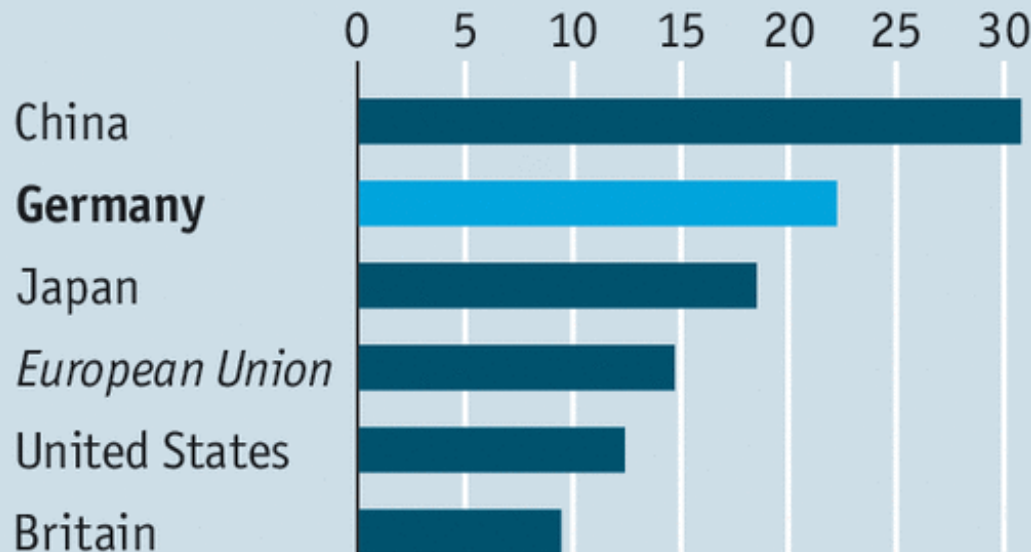
- The “time-to-market” used to be measured in years
- From prototyping to crowdfunding to manufacturing to retail to user feedback and back to prototyping in a few months

The Factory

Factory focused

1

Manufacturing as % of GDP
2014 or latest available



Source: World Bank

The Factory

- Case study: Trumpf's Axoom (Germany, 2015): an online platform to connect smart machines
- Smart machines can replace ERP/Supply Chain software
- Data generated by smart machines can be used to improve the flow and to design future machines
- Smart products made in smart factories that provide smart services
- Next opportunity: the platform for the smart (digital, Internet-connected) home



Management Science

- Transitioning into a new era:
 - Hierarchical -> Network
 - Proprietary -> Open
 - Market Economy -> Gift Economy And Sharing Economy

Management Science

- "Design for loss of control" (JP Rangaswami)
- Turn an organization into a social enterprise



Management Science

- How to prepare the next generation of leaders to deal with extremely complex and rapidly mutating systems
- Grand challenges require interdisciplinary thinking

Fashion

When 3D printing meets
wearable technology...



Fashion

- 2010: Iris van Herpen
- Borre Akkersdijk
- 2014: Francis Bitonti



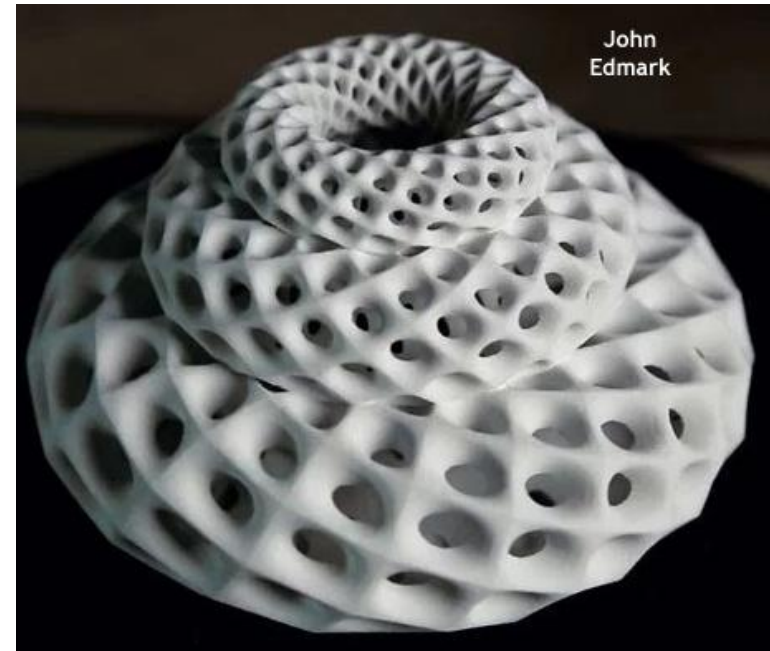
Fashion

- 2015: Julian Hakes
- 2015: Paola Tognazzi
- 2015: Behnaz Farahi
- 2015: Nasim Sehat



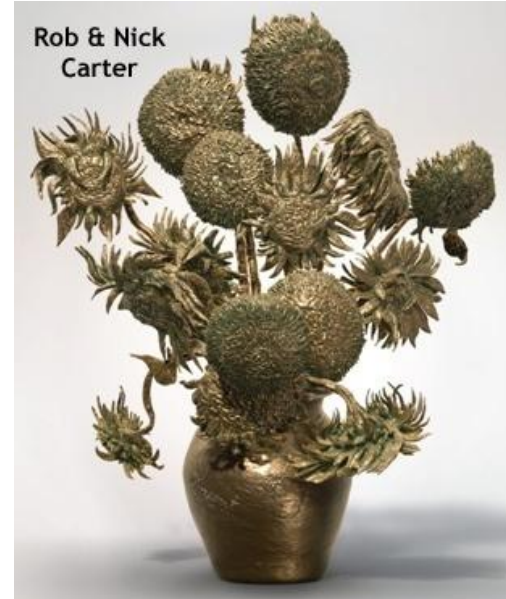
Art

- John Edmark
- Lorna Bradshaw



Art

- Rob & Nick Carter's replica of Vincent van Gogh's Sunflowers
- Ji Lee's "Mysterabbit" (2013): 10,000 tiny bunny statues hidden in random spots across the world
- Michael Hansmeyer and Benjamin Dillenburger's "Digital Grotesque", a 3D printed 16-square-meter cubic room



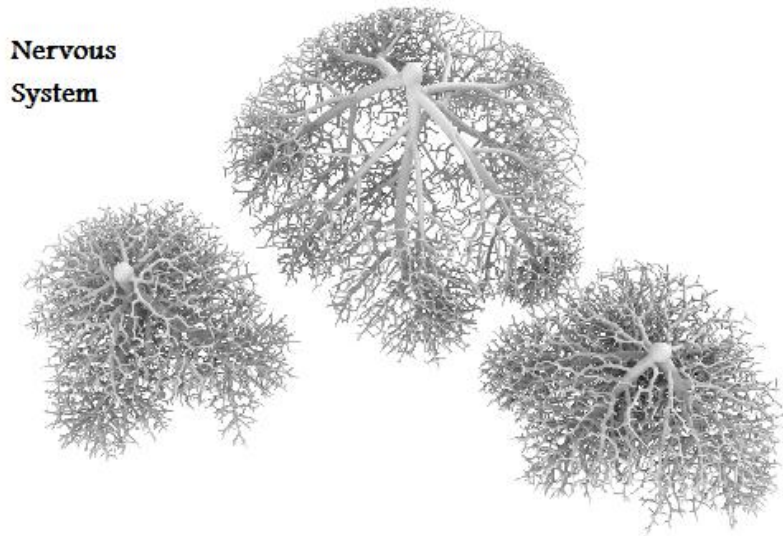
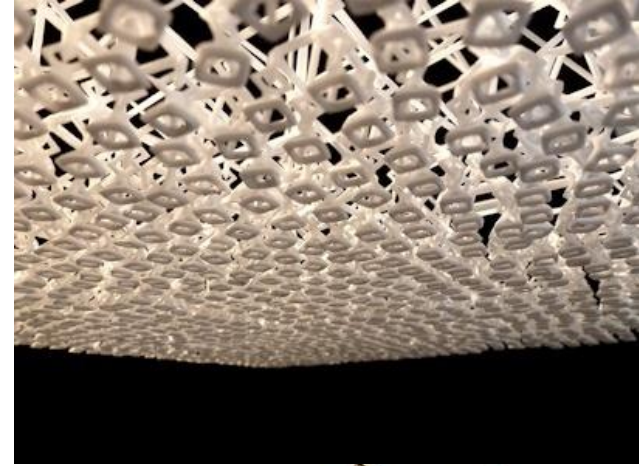
Art

Joshua Harker



Art

- Marco Mahler and Henry Segerman
- Bathsheba Grossman
- Nervous System
- Theo Jansen



Art

- Nick Ervinck
- Monika Horcicova
- Michaella Janse van Vuuren



Monika Horčicová



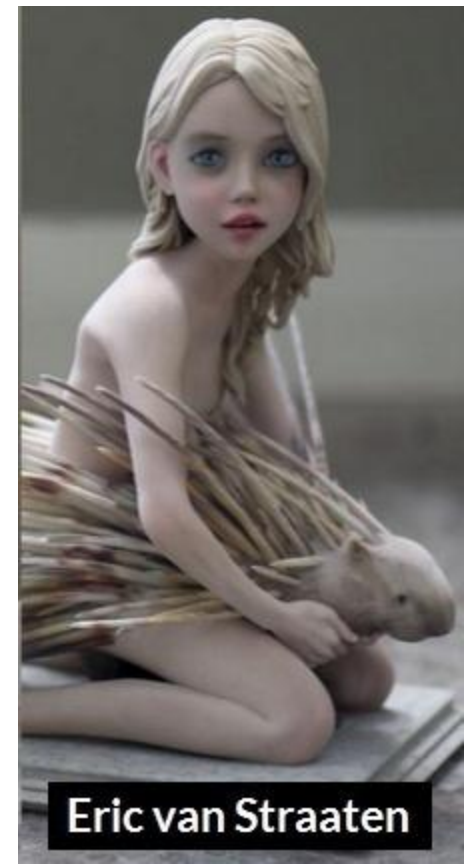
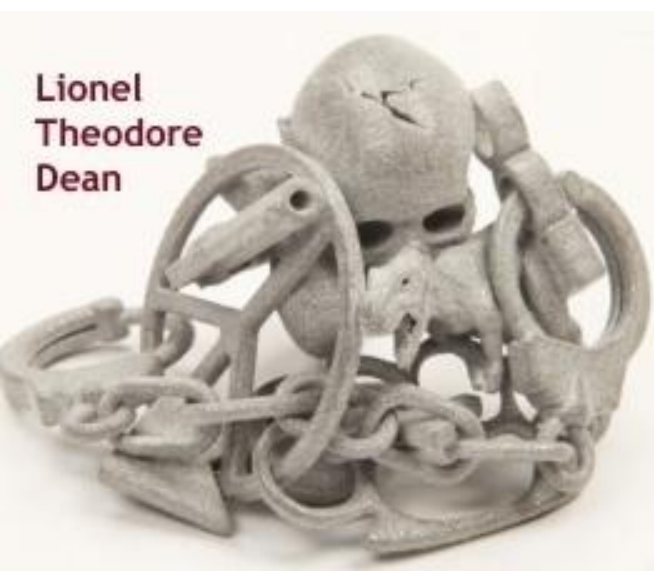
Michaella Janse
van Vuuren



Art



- Louis Pratt
- Isaie Bloch
- Lionel Theodore Dean
- Janne Kyttanen
- Eric van Straaten

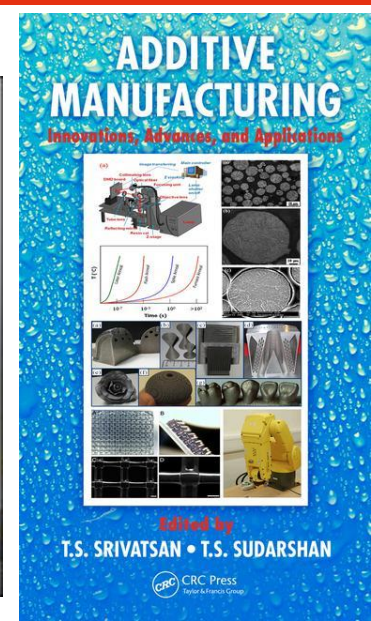
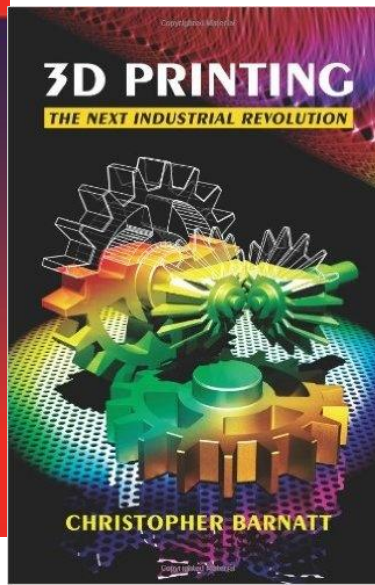
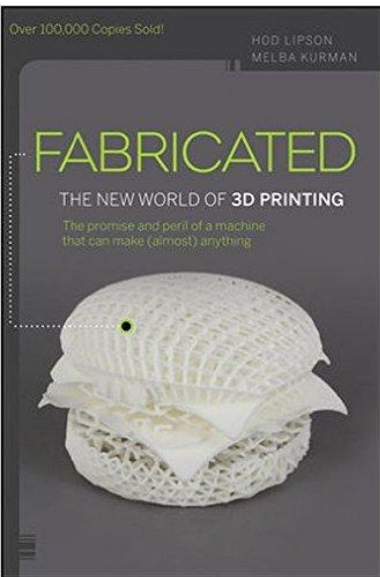
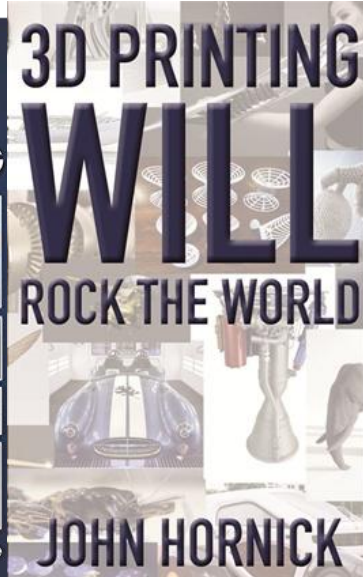
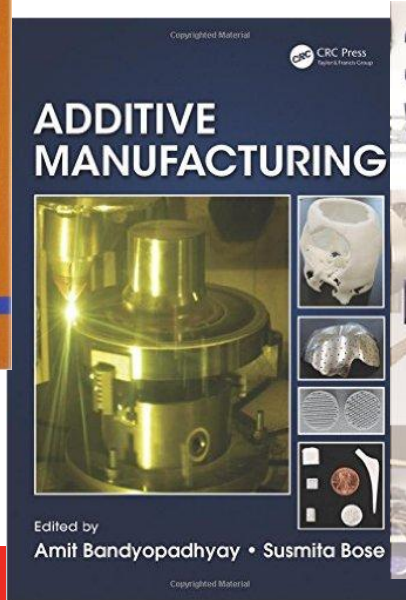
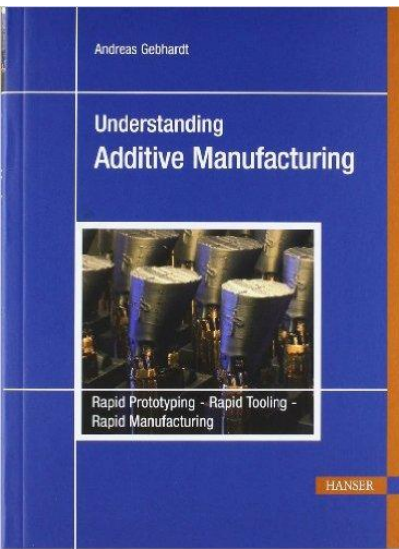


Art

- Adam Lowe's replica of King Tut's Tomb (2014)
- Morehshin Allahyari's replicas of monuments destroyed by ISIS (2015)
- Oxford Institute of Digital Archeology's replica of Palmyra's triumphal arch demolished by ISIS (2016)

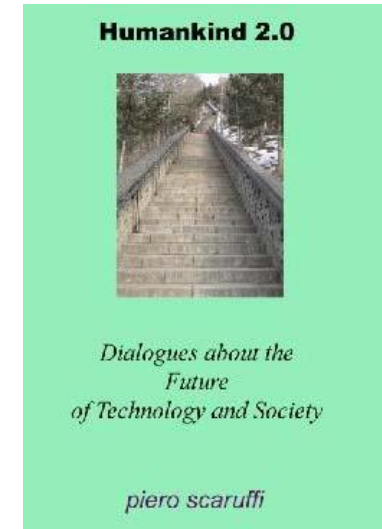
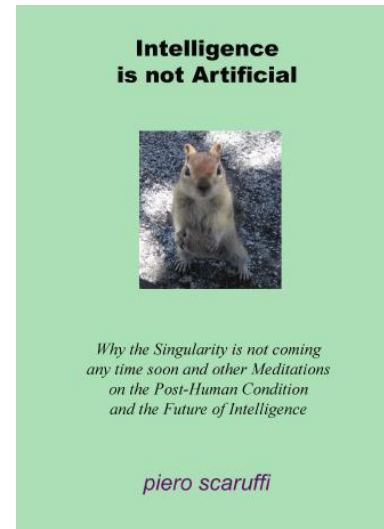
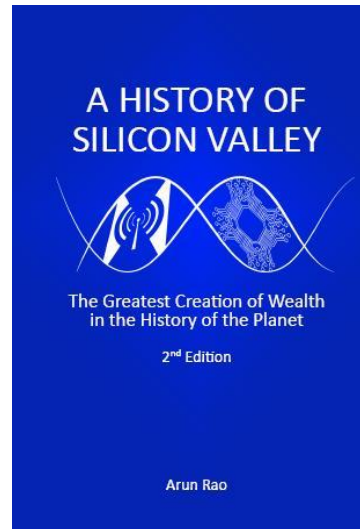


Bibliography



Contact

- www.scaruffi.com



See <http://www.scaruffi.com/singular/human20.html>
for the full text of this discussion