

# 3D PRINTING TIMELINE



museum of arts and design

Mapping significant milestones of innovation and invention, this timeline charts the advancement of 3D printing across more than three decades.



1977

## Early 3D-Printing Concepts Emerge

Wyn Kelly Swainson files a patent for “using a laser to create covalent cross-linking at the surface of a liquid monomer where the object being manufactured rested on a tray that was gradually lowered into a vat one step at a time.”

1981

## Innovators Develop Ideas for How to Fuse Materials with Lasers

Hideo Kodama of Nagoya Municipal Research Institute and Alan Herbert from 3M Company further develop concepts for linking lasers with photopolymeric solutions in liquid polymer.

1986

**C**huck Hull Patents Stereolithography and Founds 3D Systems, Inc.

Chuck Hull is granted a patent for "Apparatus for Production of Three-Dimensional Objects of Stereolithography," the first commercial rapid prototyping technology, also known as additive manufacturing or 3D printing. Hull also develops the STL file format, which allows 3D digital files to be converted into 3D-printed objects.

**C**arl R. Deckard Patents Selective Laser Sintering (SLS) Technology

Carl R. Deckard files a patent for Selective Laser Sintering, a project he began researching as an undergraduate at the University of Texas at Austin. The first SLS machine, nicknamed Betsy, fuses small particles of plastic, metal, ceramic or glass powders into solid 3D forms with a high-powered laser.

1989

**T**he First Known Artist Works with 3D-Printing Technologies

Masaki Fujihata uses stereolithography to create his computer-generated work, *Forbidden Fruits*, a golden orange, semi-translucent group of organic forms arranged in a sculptural cluster.

**S.** Scott Crump Patents Fused Deposition Modeling (FDM):

FDM, a 3D-printing technology, applies materials in a series of additive layers by mathematically slicing and orienting models. Crump also establishes Stratasys, a 3D printing and production company.

**D**rs. Hans J. Langer and Hans Steinbichler Found EOS GmbH Electro Optical Systems:

Drs. Langer and Steinbichler found EOS in Germany. They use 3D printing with Selective Laser Sintering (SLS) technology generated by data from CAD software.

1990

**W**ilfried Vancaen Founds Materialise, the First Rapid Prototyping Service Bureau:

Vancaen establishes Materialise in Belgium, concentrating on the research and development of solutions for the transfer of data to 3D printers.

1991

**H**elisys Creates Laminated Object Manufacturing (LOM):

LOM prints in 3D by using paper that is unrolled and glued layer by layer.

## Cubital Ltd Introduces Solid Ground Curing (SGC):

This technology flashes layers of printing materials with ultraviolet (UV) light to harden polymers through a series of masks created by electrostatic toner on a plate.

1993

## First Worldwide Computer Sculpture Exhibition:

Ars Mathematica, based in France, organizes the first exhibition devoted to computer sculpture at the Ecole Polytechnique in Paris; this exhibition later evolves into the "Intersculpt" biennial.

## Soligen Commercializes Direct Shell Production Casting:

The company bases its technology on the Massachusetts Institute of Technology's patent for ink jetting a liquid binder onto ceramic powder to form shells that are then used in the casting process.

1994

## Solidscape Incorporates and Introduces First 3D Wax Printing

Solidscape produces high-precision 3D printers, materials and software for the direct manufacturing of solid objects designed in CAD. The company creates the first 3D wax printer, ModelMaker.

1995

## Z Corporation Introduces Z Printers:

Z Corporation, commonly called Z Corp, produces Z Printers, which act like inkjet printers in that a head moves across a bed of powder, selectively depositing a liquid binding material in the shape of the section. The printer then spreads a fresh layer of powder across the top of the model and the process is repeated.

1997

## Materialise Introduces Next-Day 3D Printing Service:

The 24-hour service, Materialise NextDay, allows customers to order 3D-printed objects online.

## AeroMat Launches 3D Metal Printer:

AeroMat, a subsidiary of MTS Systems Corp., produces the first 3D-printed metal using Laser Additive Manufacturing (LAM), which employs high-powered lasers to fuse powdered titanium alloys.

1999

### Objet Geometries Is Founded and Introduces 3D-Printed Objects That Can Simulate Different Material Properties in One Object

Specializing in high-resolution rapid prototyping and rapid manufacturing, Objet Geometries Ltd. produces the first 3D printer that can print both hard and soft materials, and a range of hardnesses in between, that look, feel and function like the final product.

### Voxeljet Is Founded:

The company's goal is to develop new generative processes for casting and producing plastic components using 3D printing. Voxeljet focuses on large-scale production, making the molds for several automotive companies' engines.

### Scientists Create the First 3D-Printed Organ:

Scientists at the Wake Forrest Institute for Regenerative Medicine create the first 3D-printed lab-grown organ, a bladder. The bladder is made from a patient's own cells, significantly reducing the risk for rejection if implanted. (Note: This organ was not implanted; for the first working 3D-printed organ, see 2003.)

2000

### Mammoth Stereolithography Machine Allows for Large-Scale Printing:

Materialise launches the Mammoth Stereolithography machine, which has a build area of more than two meters. This enables the large-scale creation of 3D objects in one piece through the successive addition of liquid polymer hardened using a laser beam.

2002

### Fast, High-Quality 3D Objects Become Available

Envisiontec starts manufacturing their Perfactory Machine (first unveiled in 2001) that allows for the production of exceptionally large 3D parts at fast speeds without sacrificing surface quality and part accuracy. The machine eliminates the look of visible line layers and has a build volume of 500 x 600 x 400mm (20 x 24 x 16 inches).

2003

### Arcam Launches the First Commercial Electron Beam Melting (EBM) System

This system melts metal powder together, layer by layer, using an electron beam in a high-temperature vacuum.

## Other Important Developments

EOS introduces the first laser-sintered, metal-based powder machine.

Z Corp introduces the world's first commercially available multiple-color 3D printer.

The first 3D-printed working organ, a kidney, is created in China.

2005

### First Fully Articulated 3D-Printed Furniture Created

French artist Patrick Jouin creates the C1 chair, which is built as a cellular structure superimposed onto a standard chair form.

The same year, Materialise produces the first 3D-printed stool that is printed in one piece, complete with concealed hinges.

### First At-Home 3D Printers Emerge

The RepRap project, founded by Dr. Adrian Bowyer at the University of Bath, brings the world the first at-home 3D printer.

2006

### Multi-Material 3D Printer Available to the Public

The Fab@Home project, one of the first open-source DIY printing projects, brings multi-material printing to the public that is low-cost and "hackable."

### 3D-Printed Cobalt Chrome and Stainless Steel

The first laser-sintered 3D Printer, EOSINT M 270 by EOS, prints cobalt chrome and stainless steel.

2007

### Objet Upgrades 3D Printers to Include 14 Varieties of Hardness That Simulate Different Material Properties in One Object

Objet introduces the Connex series of 3D printers that enable users to combine two different materials in one print job in a variety of combinations that produce up to fourteen different levels of hardness, texture and shading, with no assembly, creating forms that range from rigid to rubber, dense to hollow and translucent to opaque.

2008

### New Matrix System Enables 3D Printing with Regular Sheets of Paper

Mcor Technologies, founded by Dr. Conor MacCormack and Fintan MacCormack, launches the New Matrix system that adheres A4 sheets of paper together using Helisys LOM technology.

## RepRap Project Releases Darwin, the First Open-Sourced 3D Printer Hardware

This spawns a huge 3D-printing maker community worldwide.

## Shapeways Starts its Online 3D Printing Service

Shapeways launches in the Netherlands as a spin-off of Royal Philips Electronics. Using this online 3D printing service, individuals can use a simplified design process made for consumers to make, buy and sell their own products that are then inexpensively printed and delivered.

## First Usable Prosthetic Created

The first usable prosthetic with all its parts, including knee, foot, and socket, is printed in one piece without any assembly required. This development leads to the creation of Bespoke Innovations, Inc. in 2010.

## User-Created Open-Source Design Flourishes

Thingiverse launches a website dedicated to sharing user-generated digital design files, providing primarily open-source hardware design licenses under the GNU General Public License (a Creative Commons License).

2009

## Laika Animation Makes First 3D-Printed Animated Movie

Laika animation studio uses 3D printing to make the "puppets" (i.e., the animated characters) for Coraline. The heads and hands are 3D printed, then painted by hand.

## 3D Printing Gets its First Standard Reference Guide

Seventy individuals from around the world meet at the ASTM International Headquarters near Philadelphia, PA, to establish ASTM Committee F42 on Additive Manufacturing Technologies. This results in the publication of the first standard terminology reference.

## MakerBot Industries Makes 3D Printing More Accessible for Individuals

MakerBot Industries is founded with an open-sourcing model, offering products that are created not with the intent to mass-produce, but rather for individuals. Printers are sold as do-it-yourself kits, requiring only minor soldering.

2010

## The Centre for Fine Print Research Is the First to 3D Print Porcelain

Based out of England, the Centre patents their system for 3D printing porcelain using the ZCorp 310 Printer.

**S**cott Summit and Kenneth Trauner Found Bespoke Innovations, Inc.:

The company creates personalized 3D-printed prosthetics.

### **O**ther Important Developments

HP signs an agreement with Stratasys and becomes the first large consumer electronics company to manufacture 3D printers.

Freshfiber is first company worldwide to exclusively use 3D printing to create consumer products.

.MGX, by Materialise, opens the first store exclusively for 3D-printed goods in Brussels.

Continuum Fashion and Shapeways create n12, the first ready-to-wear, 3D-printed and fully articulated bikini.

2011

### **F**irst 3D-Printed Animated Movie in All Color

Laika animation studio and Aardman Animations both produce 3D-printed "puppets" in full color for ParaNorman and The Pirates! Band of Misfits, respectively.

### **F**used Deposition Modeling (FDM) Patent Expires

The expiration of the FDM patent brings technology and information into the public domain that is a catalyst for creativity and open sourcing, building on the momentum created by RepRap and other open-sourcing companies.

### **P**resident Barack Obama Announces Advanced Manufacturing Process Partnership (AMP)

This national initiative, bringing together industry, universities and the federal government to invest in emerging technologies, aims to increase U.S. competitiveness in manufacturing.

### **3**D-Printed Dress "One of 50 Best Inventions"

TIME Magazine names Iris van Herpen's first-ever 3D-printed flexible dress as one of the 50 Best Inventions of the year.

### **F**irst 3D-Printed Precious Metal

Sterling silver is 3D printed for the first time by Cookson Precious Metals.

### **F**irst 3D-Printed Aircraft

Designed at the University of Southampton, the first 3D-printed aircraft is created in just seven days.

## First 3D-Printed Vehicles

HAWK University of Applied Sciences and Arts, Germany, teams with Stratasys to create the world's first one-person vehicle with a bionic form modeled after a human jaw. The Rapid Racer took 10 days, included 3,600 layers and was made from a 44 MB file.

Stratasys and Kor Ecologic Inc. co-develop the Urbee hybrid, the world's first production car ever to have its entire body, including its glass-panel prototypes, 3D printed.

The European Aeronautic Defence and Space (EADS) group in England creates the first 3D-printed bicycle, the Airbike, out of nylon that is as strong as steel or aluminum, but only 65% of the weight.

## "Desert Manufactured" 3D Printing Uses the World's Most Efficient and Abundant Energy Source, the Sun:

Raising questions about the future of manufacturing, Markus Kayser creates the Solar Sinter in the Sahara desert. This machine uses two abundant resources, silica sand and the sun, to harness the sun's energy into creating 3D-printed objects made of glass (melted and cooled silica sand).

2012

## First 3D-Printed Jaw

LayerWise builds the world's first 3D-printed jaw implant for an 83-year-old patient in the Netherlands. The implant helps promote the growth of new bone tissue.

## 3D-Printed Affordable Housing Appears on the Horizon

Dr. Behrokh Khoshnevis at the University of Southern California creates an automated construction technology, Contour Crafting, that has the potential to build an entire housing unit in one day for a quarter of the costs of manual construction methods. This technology also reduces environmental impact by creating less waste and emission pollution.

## First 3D-Printed Gun

The "Liberator" pistol is created by Cody Wilson, a Texas law student. Wilson shares his blueprints for making the gun on the Internet, causing a controversy and leads to Wilson being dubbed one of the "15 Most Dangerous People in the World" by Wired Magazine.

## 3D-Printed Candy and Gold

First 3D chocolate printer, the Choc Creator, is made commercially available.

Gold is 3D printed for the first time by Cookson Precious Metals.



## Stratasys Creates 3D-Printed “Magic Arms”

These arms, fully articulated with custom-molded parts, give a two-year-old child the use of her limbs.

## 3D Precision Engineering Meets Footwear

A Selective Laser Sintering (SLS)-crafted cleat is the first 3D-printed shoe plate designed for high-performance football athletes. Through proprietary material selection, Nike was able to prototype a fully functional plate and traction system at a fraction of the time and weight of traditional manufacturing techniques.

2013

## Planning 3D-Printed Lunar Habitations of the Future

Foster and Partners, along with several smaller firms, teams with the European Space Agency (ESA) to develop a lunar habitation using 3D-printed parts transported by rockets, as well as 3D-printed materials using the moon’s own soil. Destined for the moon’s south pole, the structures would protect inhabitants from meteorites, gamma radiation and temperature fluctuations.

## 3D Printing Saves Lives

Baby’s life is saved with a groundbreaking 3D-printed splint created at the University of Michigan. The splint, made of biological material, opened up the child’s lungs and allowed him to breathe freely.

## NASA Embraces 3D Printing

NASA announces a plan to explore the possibility of 3D printing food in space for astronauts. At the same time, the organization announces the development of a 3D printer, to be launched in 2014, which can make tools on demand, reducing the need to bring unnecessary supplies into space. NASA also successfully tests the first 3D-printed rocket fuel injector.