THE DESKTOP 3D PRINTING REVOLUTION AND THE SOFTWARE BEHIND IT
Space Station's 3D Printer Makes Wrench From 'Beamed Up' Design
FROM THE HEADLINES

Cody Wilson, 3D Printed a Gun and Posted Instructions Online

Credit: www.telegraph.co.uk
STRATEGIC ADVANTAGE FOR FEETZ

Affordable Manufacturing of Custom Parts

Smart phone + 3D printer = Personalized Shoes
APPLICATIONS: MEDICAL

Custom fitted orthopedic devices can cost over $500, but new AM printed casts can cost approximately ~$200

3DMedScan creates AmphibianSkin, a new medical device that is designed to be lightweight and breathable while also providing structural strength.
APPLICATIONS: AEROSPACE

3D printing airplane engines...

Each Leap engine will contain 19 metal 3D-printed fuel nozzles. The part is lighter and more durable than traditional parts.
STRATEGIC ADVANTAGE FOR AIRWOLF 3D

Faster Product Development Cycle

“Since we 3D print many plastic components on the Airwolf 3D printers we can quickly make modifications and improvements then implement changes the very next day.”
APPLICATIONS: FASHION

Entirely 3D printed dress, accessories and shoes

ABS, Wolfbend TPU, and TPE

Designed to be a perfect fit for Sandy’s body.

Total Material Cost = $78
APPLICATIONS: EDUCATION

Huntington Beach High School teacher Kevin Crossett helps his students apply mathematics and science to real-life projects. Creating remote control cars, designing houses and researching methods to improve on designs. Students 3D print parts for projects.

Source: Orange County Register
THE INDUSTRY IS A FAST-MOVING SPACE

How did we get here?
THE REPRAP MOVEMENT

Founded in 2005 by Dr. Adrian Bowyer, a Senior Lecturer in mechanical engineering at the University of Bath

British initiative to develop a 3D printer that can print most of its own components and be a low-cost 3D printer

All of the designs produced by the project are released under a free software license, the GNU General Public License.
Additive Manufacturing Process Flow

1. CAD-Based 3D Model
2. .STL File
3. Sliced Layers
4. AM System
5. End-Part Finishing

Final Product
Examples of Computer Aided Drafting Software:

- TinkerCAD
- DS SOLIDWORKS
- SketchUp
- Autodesk Fusion 360
TinkerCad

Website: tinkercad.com

Cost: free

Ease of Use: easiest

Description: On the cloud

Great for beginners

Develop spatial reasoning

OC Maker Challenge
TinkerCAD
SketchUp

Website: sketchup.com

Cost: Free for students, enthusiasts, hobbyists (or $695 for Pro version)

Ease of Use: moderate

Description: Start by drawing lines and shapes. Push and pull surfaces to turn them into 3D forms. Stretch, copy, rotate and paint to make anything you like. Good for high school students and professionals.
SketchUp
Fusion 360

Website: "autodesk.com/products/fusion-360"

Cost: Free for students, enthusiasts, hobbyists, and startups (or $25/month)

Ease of Use: fairly easy to learn

Description: 3D CAD, CAM, and CAE tool.

Connects the entire product development process in a single cloud-based platform.

Good for high school students and professionals.
Fusion 360
SolidWorks

Website: solidworks.com

Cost: $4,000 to $10,000 per seat (est.)

Ease of Use: difficult

Description: 3D design solutions that offer powerful simulation and design validation, as well as ECAD/MCAD collaboration, reverse engineering, and advanced wire and pipe routing functionality. Good for professional engineers.
SolidWorks
STL File

All of these export your model as an “STL” file

STL (STereoLithography) is a file format native to the stereolithography CAD software created by 3D Systems
STL File

- Describes only the surface geometry of a three-dimensional object.

- Without any representation of color, texture or other common CAD model attributes.

- The STL format specifies both ASCII and binary representations. Binary is more common, since they are more compact.
STL File

Two concentric circles, representing a CAD model of a doughnut shape, and a series of triangles approximating the doughnut, representing how STL modeling works.
Slicers

The STL is “sliced into layers”

STL

Slicing Engines

Astroprint®

Slic3r

G-code generator for 3D printers

Cura

gCode
Open Source Slicing - Piece 1

- ReplicatorG
  - Created in 2010 by Makerbot co-founders and open source community
  - Used for MakerBot Replicator, Thing-O-Matic, CupCake CNC, RepRap machine

- Slic3r
  - Created in 2011 by Alessandro Ranellucci
  - First widely adopted Slicer for RepRaps
  - Compatible with all open source 3D printers – exports as “gcode”

- Cura
  - Created in 2011 by Ultimaker in the Netherlands
  - Optimized for Ultimaker printers and others using Bowden tubes
  - Incorporated in Astroprint
What is a slicer?

- Converts a digital 3D model into printing instructions for the 3D printer.
- Cuts the model into horizontal slices (layers)
- Sets temperatures for head and bed and speeds for extrusion
- Generates toolpaths to fill layers and calculates the amount of material to be extruded.
Slicers - example

[3D model of a 3D printed object with an interface for selecting printer, material, and print quality.]
Open source Printer Control – Piece 2

- Pronterface - 2011

- Repetier Host - 2011
Gcode
Open source Firmware – piece 3

**Makerbot**
Replicator and prior firmware – open source until Gen5 (2014)

**Marlin**
Developed in 2012
Derived from Sprinter (2011)
Powers most modern reprap and compatible machines

**Smoothieware**
32 bit, machines move “smooth”
Smaller number of developers
Needs further revisions to compete with features of Marlin
Additive Manufacturing

- Each layer of plastic is deposited on top of the previous layer
- The warm plastic bonds to the prior layer
- With each layer, an object slowly materializes
PUTTING IT IN PERSPECTIVE

Still a very small industry

3D Systems Revenue = $.66B

Stratasys Revenue = $.70B

HP Revenue (combined) = $127B
According to Wohlers Report 2014, the worldwide 3D printing industry is now expected to grow from $3.07B in revenue in 2013 to $12.8B by 2018, and exceed $21B in worldwide revenue by 2020. Wohlers Report 2013 had forecast the industry would grow to become a $10.8B industry by 2021.
Which Companies Use 3D Printers?

A Sampling of Airwolf 3D Customers
Where to now?