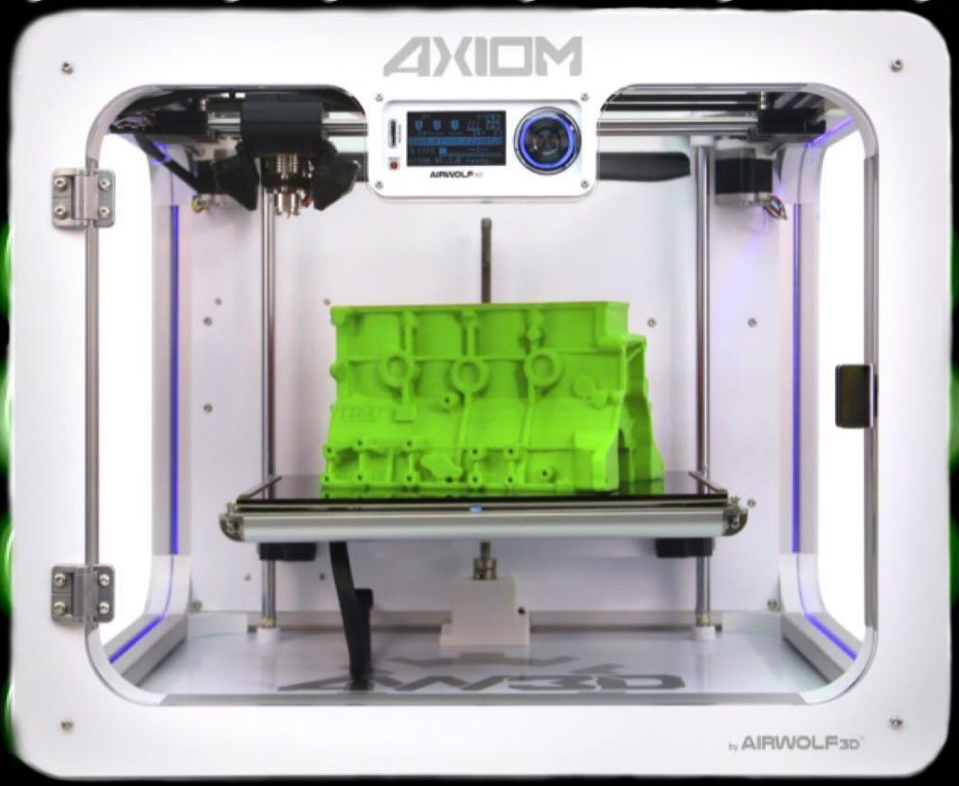
Erick Wolf
Founder of Airwolf 3D

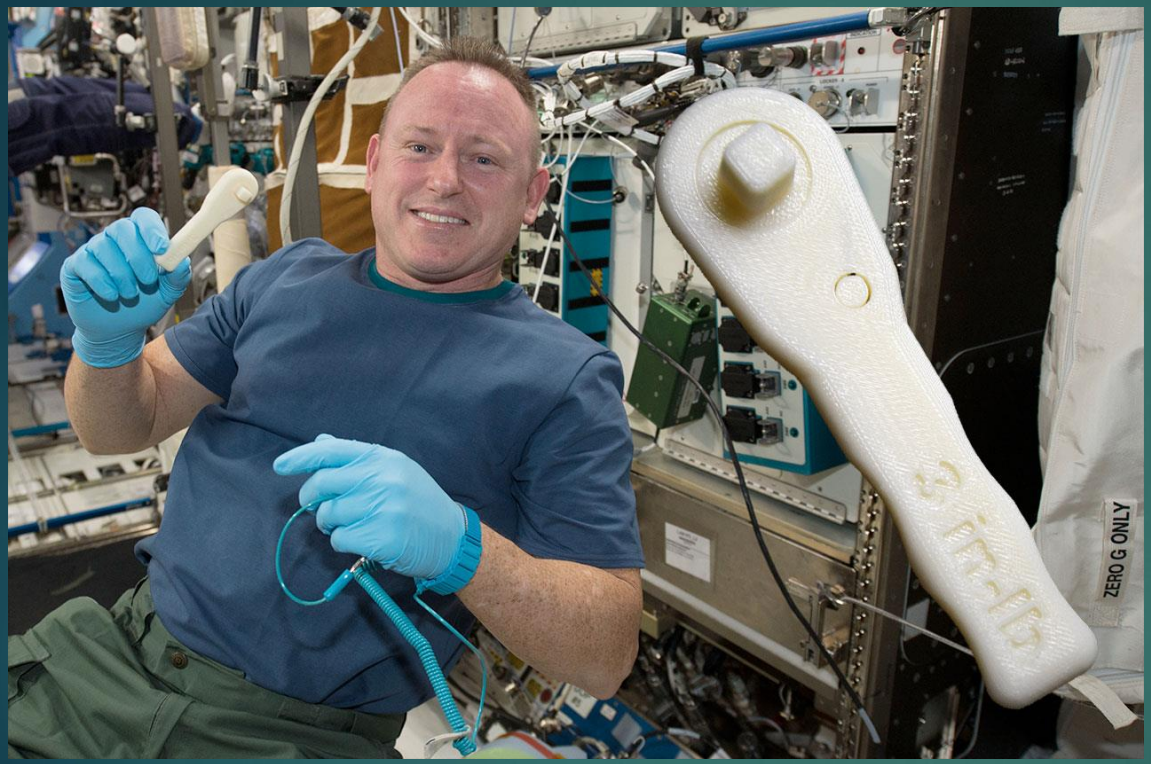
AIRWOLF 3D

THE DESKTOP 3D PRINTING REVOLUTION AND THE SOFTWARE BEHIND IT



Orange County Professional Chapter
of the Association for Computing Machinery

FAR-REACHING IMPLICATIONS



Space Station's 3D Printer Makes Wrench From 'Beamed Up' Design

FROM THE HEADLINES

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

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

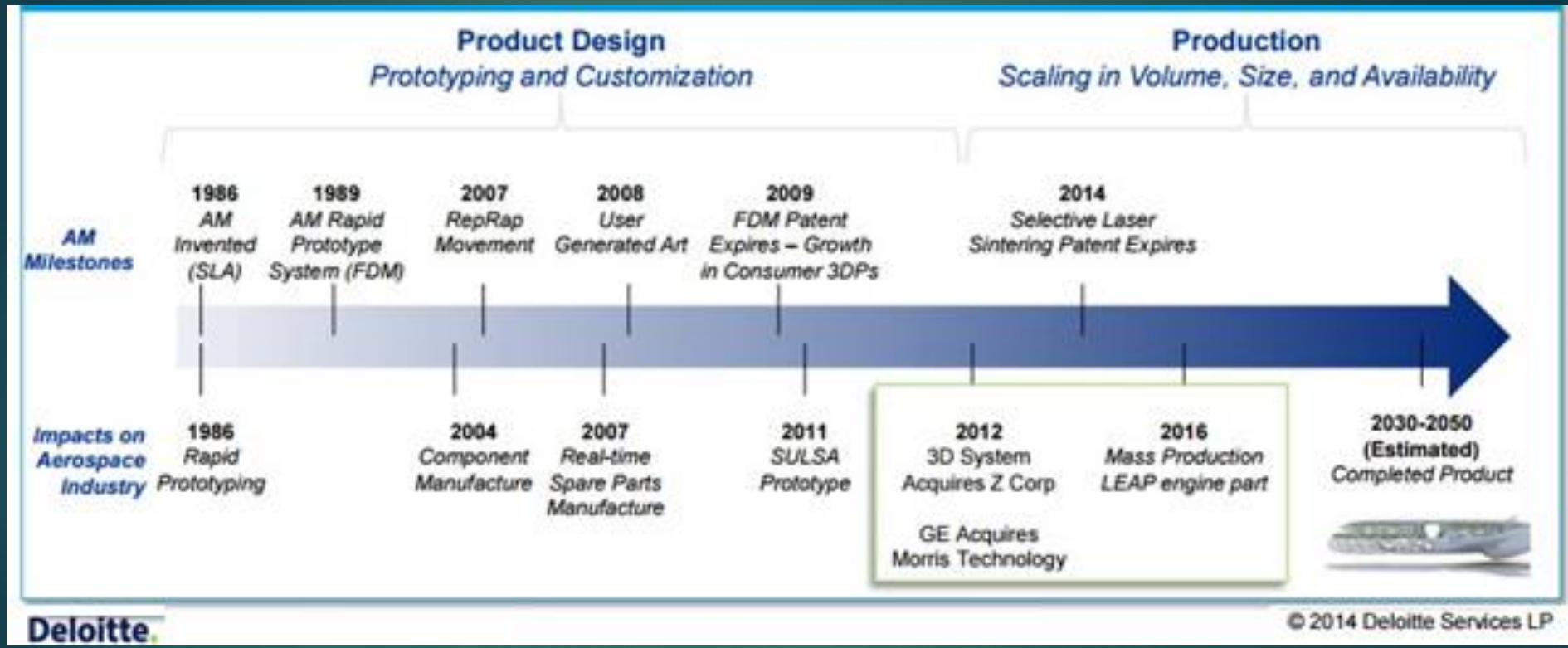
Huntington Beach High School teacher Kevin Crossett helps his students apply mathematics and science to real-life projects

Creating remote control cars, designing houses and researching methods to improve on designs.

Students 3D print parts for projects.

THE INDUSTRY IS A FAST-MOVING SPACE

How did we get here?



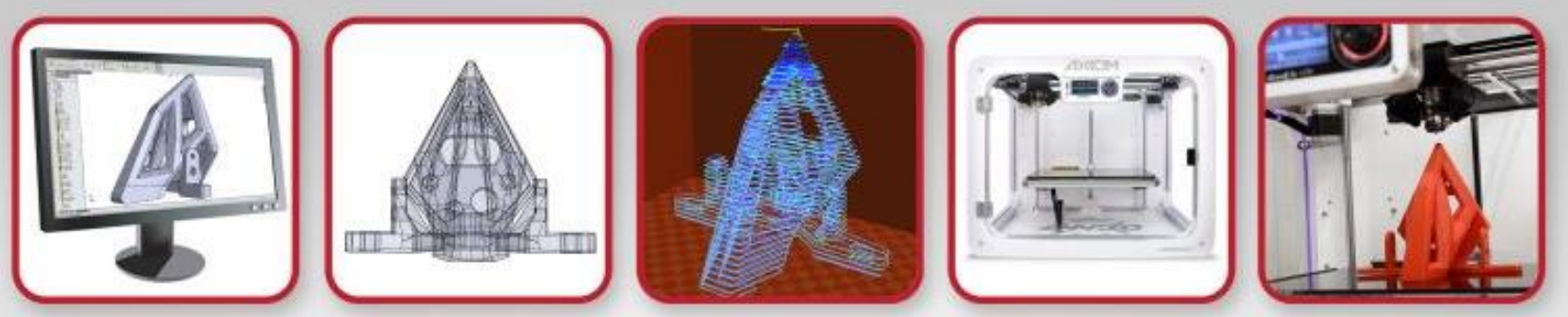
THE REPRAP MOVEMENT

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

AIRWOLF 3D

CAD

Examples of Computer Aided Drafting Software:

TinkerCad

Website: tinkercad.com

Cost: free

Ease of Use: easiest

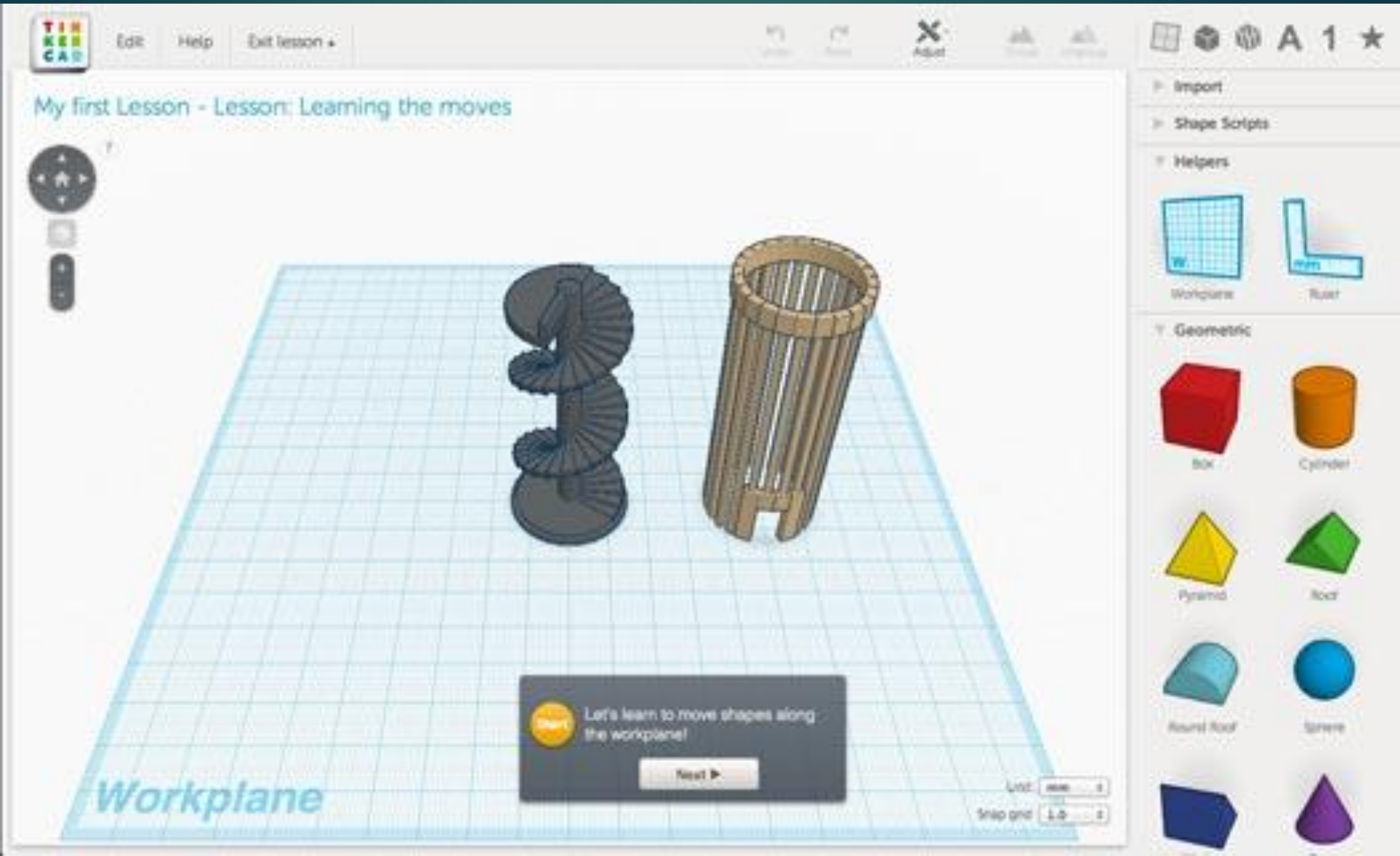
Description: On the **cloud**

Great for **beginners**

Develop **spatial reasoning**

OC Maker Challenge

TinkerCad


Edit
Help
Exit lesson
Adjust
My first Lesson - Lesson: Learning the moves
Let's learn to move shapes along the workplane!
Next
Workplane
Import
Shape Scripts
Helpers
Workplane
Ruler
Geometric
Box
Cylinder
Pyramid
Roof
Round Roof
Sphere

SketchUp

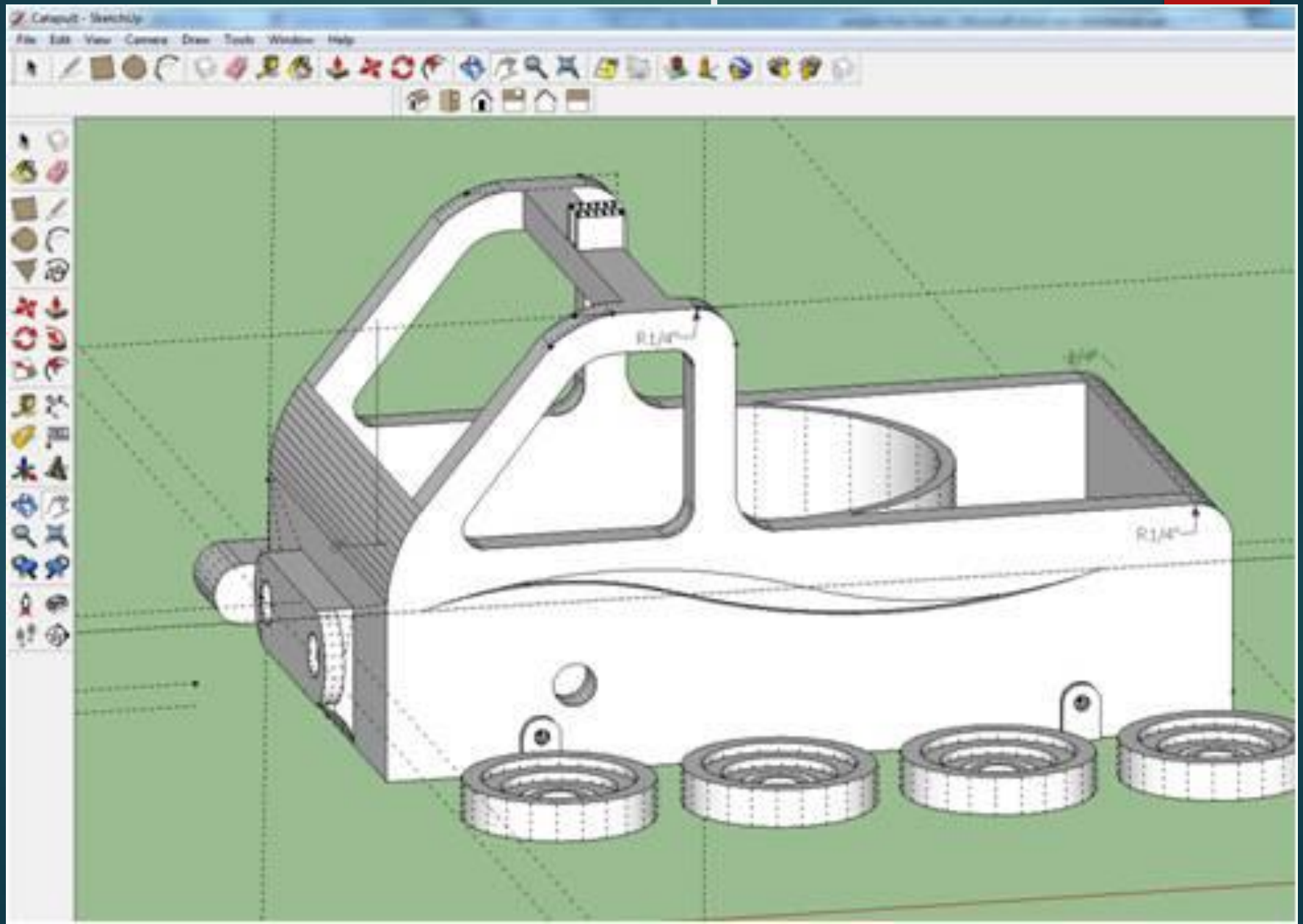
Website: sketchup.com

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)

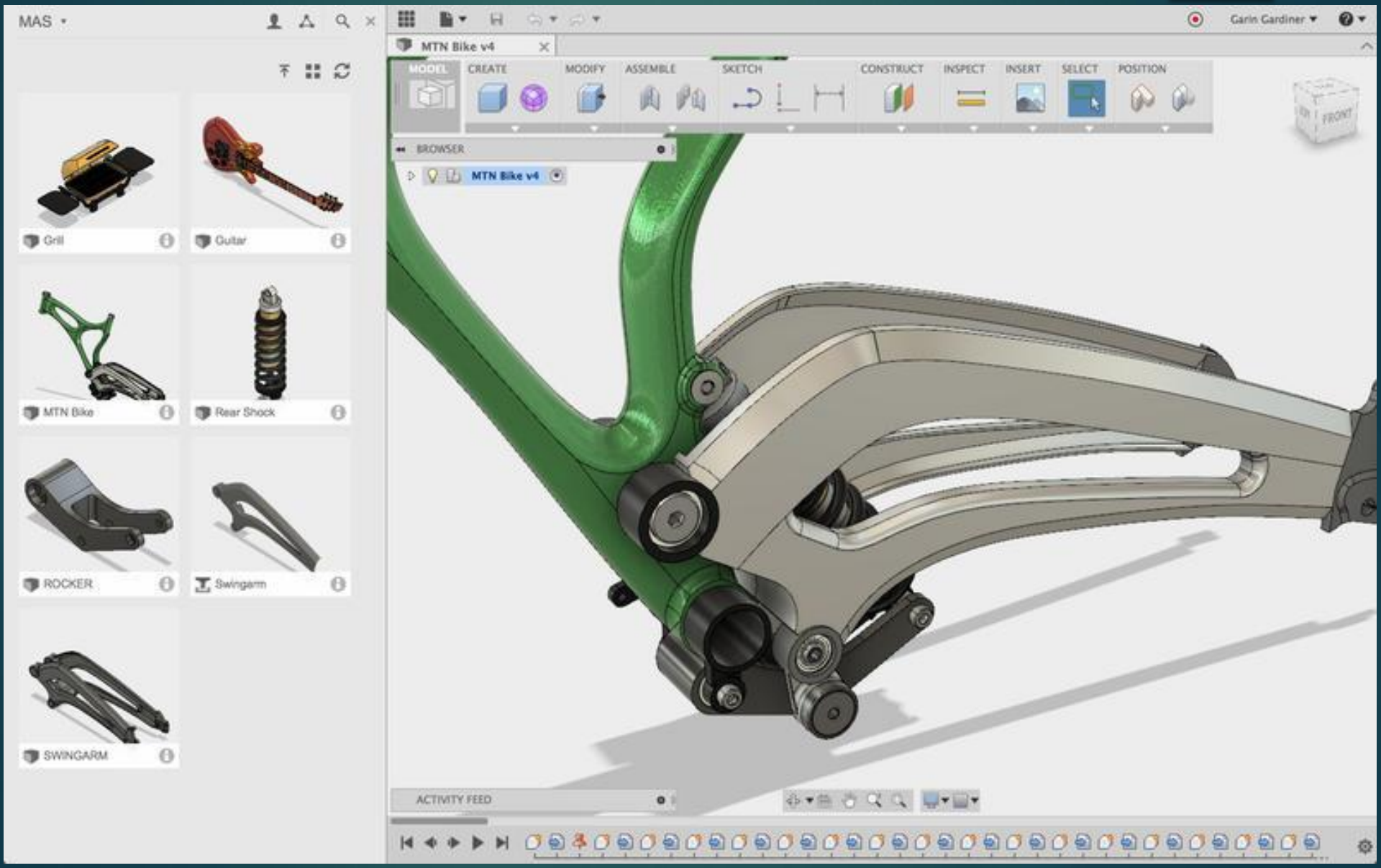
Ease of Use: fairly easy to learn

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


MAS
Grill
Guitar
MTN Bike
Rear Shock
ROCKER
Swingarm
SWINGARM
MTN Bike v4
Garin Gardiner
MODEL
CREATE
MODIFY
ASSEMBLE
SKETCH
CONSTRUCT
INSPECT
INSERT
SELECT
POSITION
BROWSER
MTN Bike v4
FRONT
ACTIVITY FEED

SolidWorks

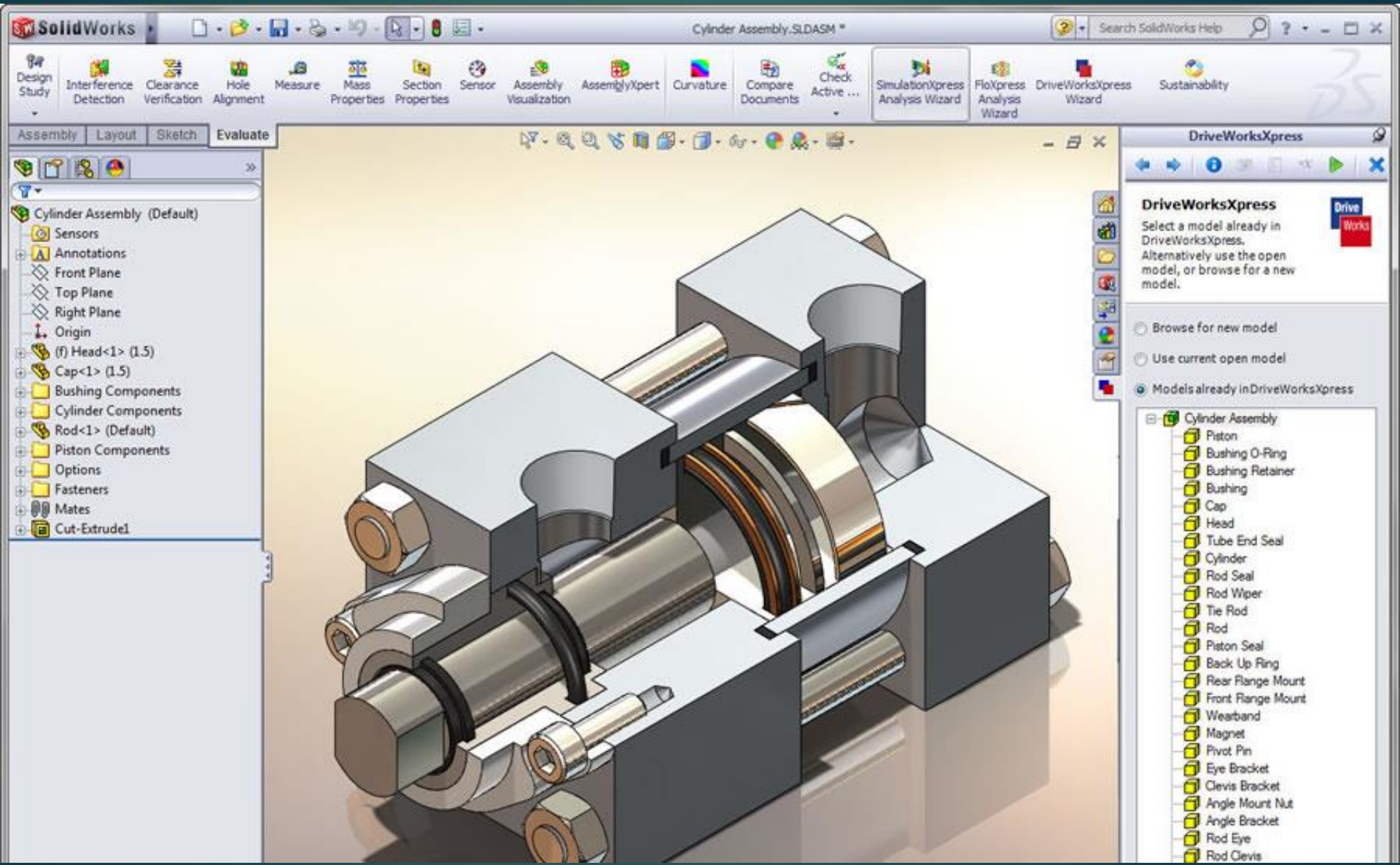
Website: solidworks.com

Cost: $4,000 to $10,00 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


SolidWorks
Cylinder Assembly.SLDASM *
Search SolidWorks Help
Design Study
Interference Detection
Clearance Verification
Hole Alignment
Measure
Mass Properties
Section Properties
Sensor
Assembly Visualization
AssemblyXpert
Curvature
Compare Documents
Check Active ...
SimulationXpress Analysis Wizard
FloXpress Analysis Wizard
DriveWorksXpress Wizard
Sustainability
Assembly
Layout
Sketch
Evaluate
Cylinder Assembly (Default)
Sensors
Annotations
Front Plane
Top Plane
Right Plane
Origin
(f) Head<1> (1.5)
Cap<1> (1.5)
Bushing Components
Cylinder Components
Rod<1> (Default)
Piston Components
Options
Fasteners
Mates
Cut-Extrude1
DriveWorksXpress
DriveWorksXpress
Select a model already in DriveWorksXpress. Alternatively use the open model, or browse for a new model.
Browse for new model
Use current open model
Models already in DriveWorksXpress
Cylinder Assembly
Piston
Bushing O-Ring
Bushing Retainer
Bushing
Cap
Head
Tube End Seal
Cylinder
Rod Seal
Rod Wiper
Tie Rod
Rod
Piston Seal
Back Up Ring
Rear Flange Mount
Front Flange Mount
Wearband
Magnet
Pivot Pin
Eye Bracket
Clevis Bracket
Angle Mount Nut
Angle Bracket
Rod Eye
Rod Clevis

STL File

All of these export your model as an "**STL**" file

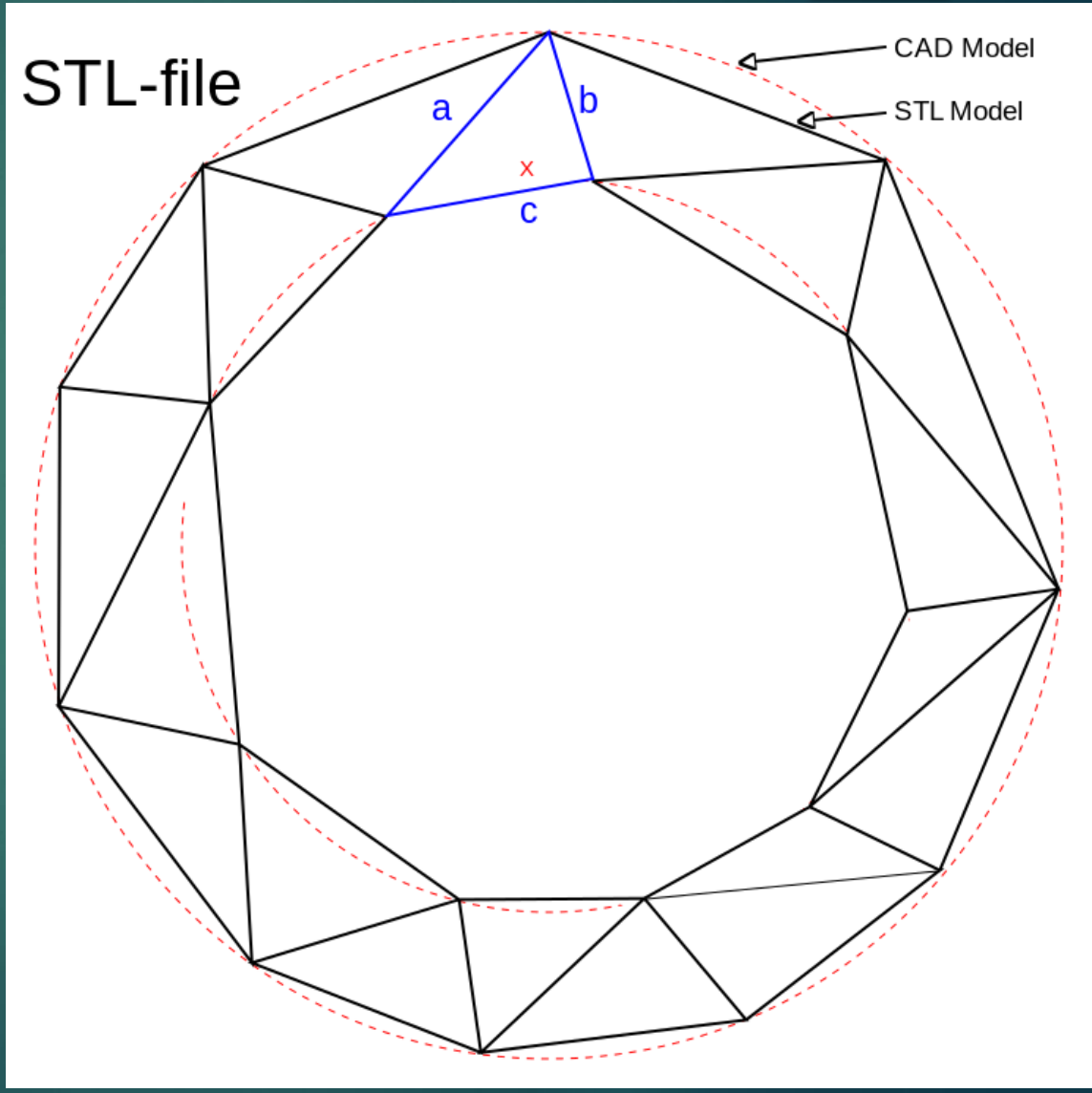
STL (STereoLithography) is a file format native to the stereolithography CAD software created by 3D Systems

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 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®

Cura

gCode

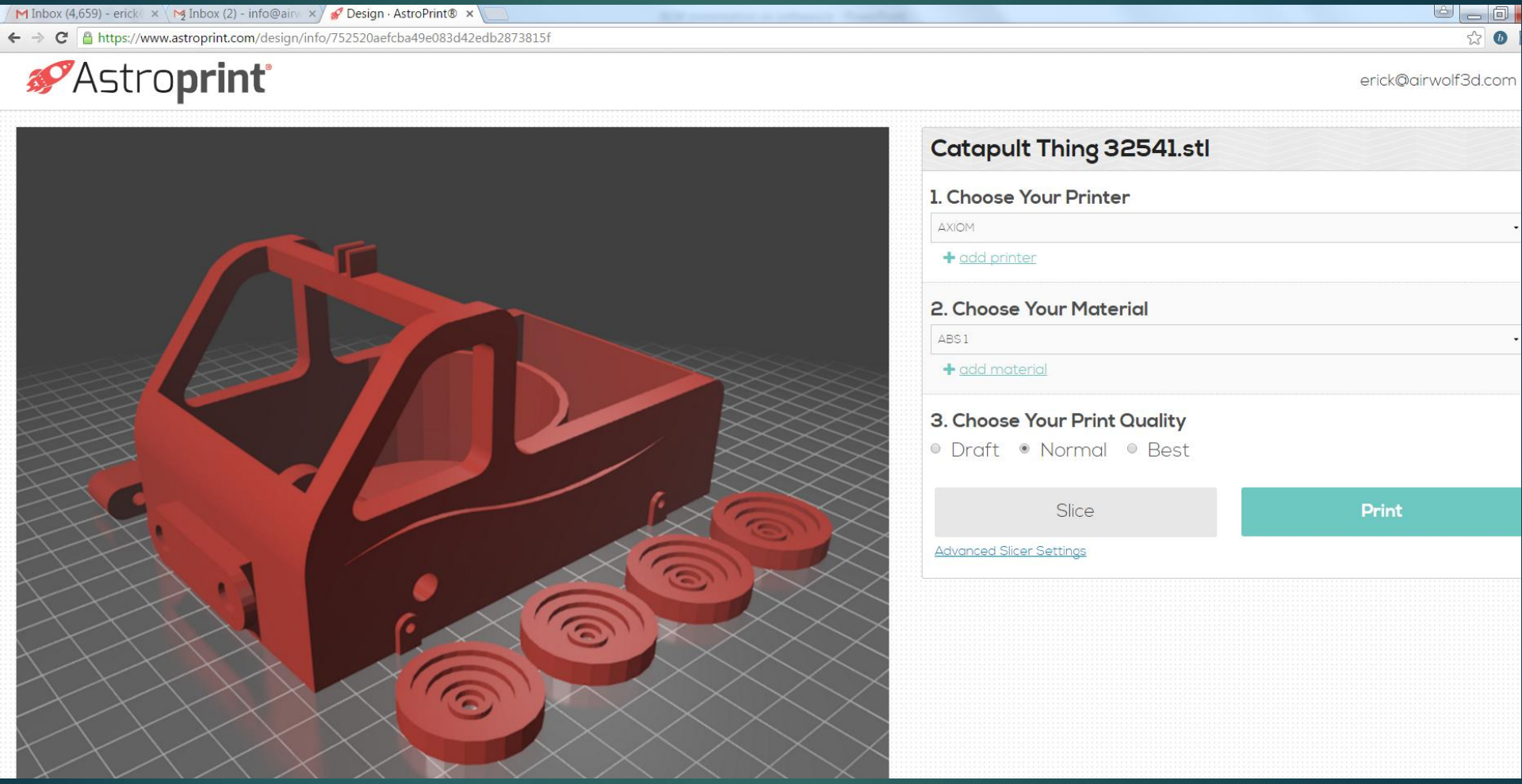
Open Source Slicing - Piece 1

- 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?

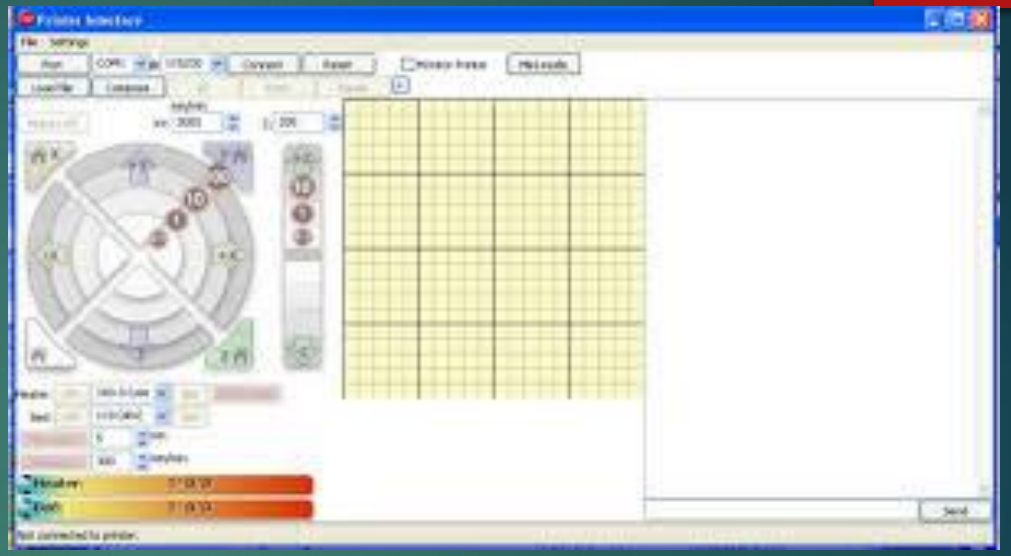
- Converts a digital 3D model into printing instructions for the 3D printer.
- Cuts the model into horizontal slices (layers)
- Sets temperatures for head and bed and speeds for extrusion
- Generates toolpaths to fill layers and calculates the amount of material to be extruded.

Slicers - example

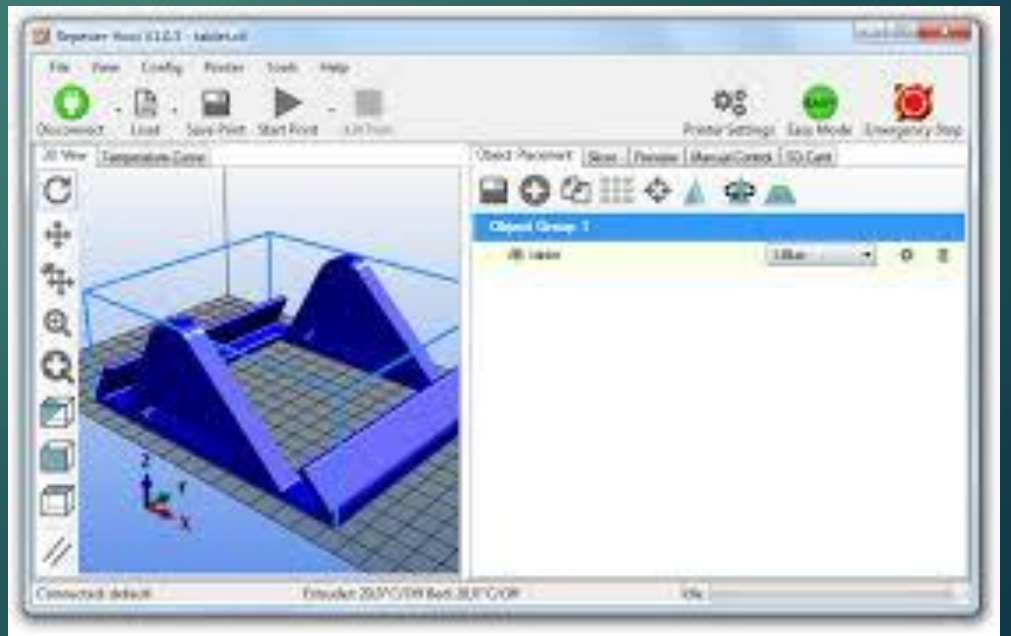


Open source Printer Control – Piece 2

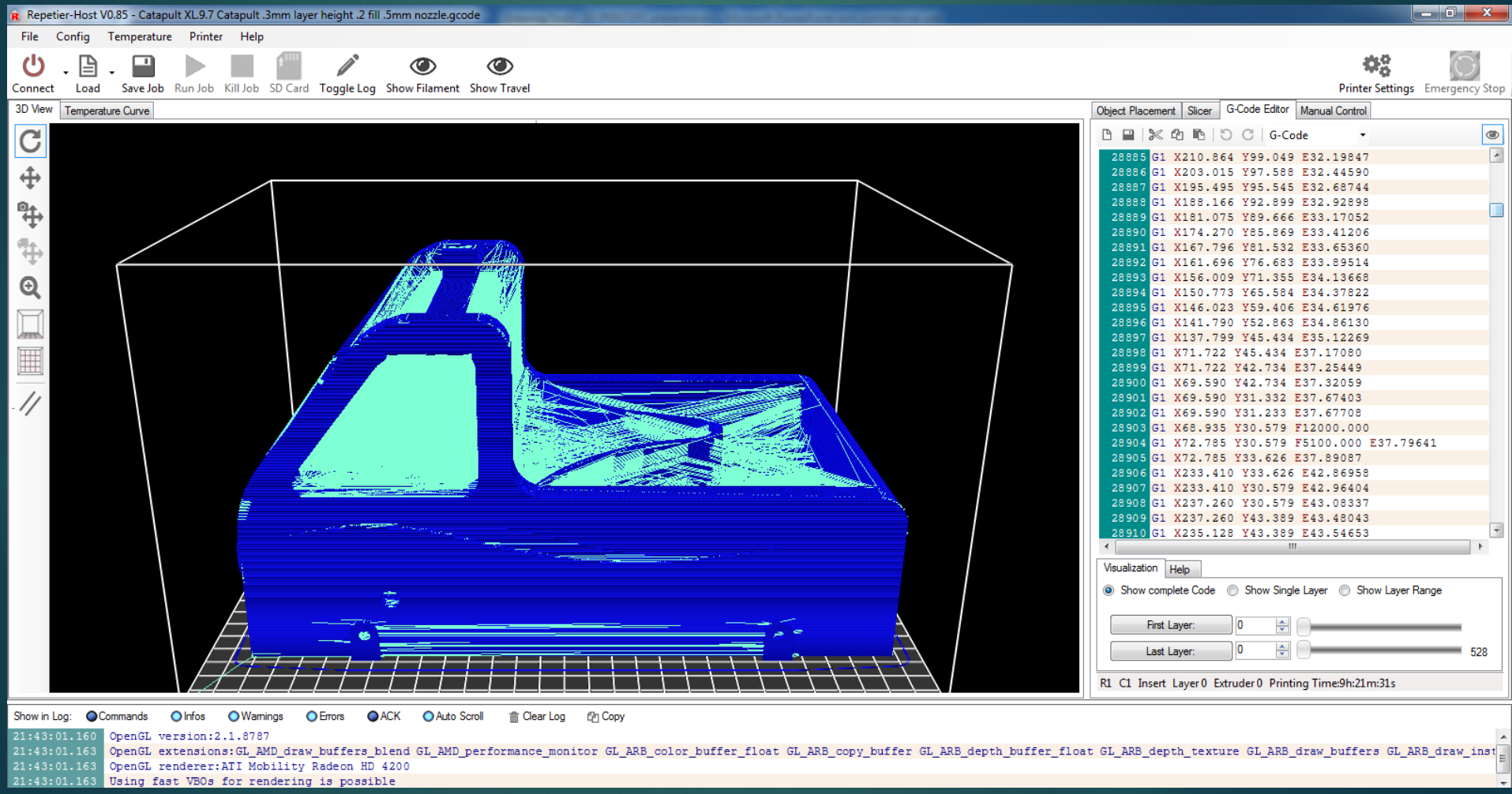
- Pronterface - 2011



- Repetier Host - 2011



Gcode


Repetier-Host V0.85 - Catapult XL.9.7 Catapult .3mm layer height .2 fill .5mm nozzle.gcode
File
Config
Temperature
Printer
Help
Connect
Load
Save Job
Run Job
Kill Job
SD Card
Toggle Log
Show Filament
Show Travel
Printer Settings
Emergency Stop
3D View
Temperature Curve
Object Placement
Slicer
G-Code Editor
Manual Control
G-Code
28885 G1 X210.864 Y99.049 E32.19847
28886 G1 X203.015 Y97.588 E32.44590
28887 G1 X195.495 Y95.545 E32.68744
28888 G1 X188.166 Y92.899 E32.92898
28889 G1 X181.075 Y89.666 E33.17052
28890 G1 X174.270 Y85.869 E33.41206
28891 G1 X167.796 Y81.532 E33.65360
28892 G1 X161.696 Y76.683 E33.89514
28893 G1 X156.009 Y71.355 E34.13668
28894 G1 X150.773 Y65.584 E34.37822
28895 G1 X146.023 Y59.406 E34.61976
28896 G1 X141.790 Y52.863 E34.86130
28897 G1 X137.799 Y45.434 E35.12269
28898 G1 X71.722 Y45.434 E37.17080
28899 G1 X71.722 Y42.734 E37.25449
28900 G1 X69.590 Y42.734 E37.32059
28901 G1 X69.590 Y31.332 E37.67403
28902 G1 X69.590 Y31.233 E37.67708
28903 G1 X68.935 Y30.579 F12000.000
28904 G1 X72.785 Y30.579 F5100.000 E37.79641
28905 G1 X72.785 Y33.626 E37.89087
28906 G1 X233.410 Y33.626 E42.86958
28907 G1 X233.410 Y30.579 E42.96404
28908 G1 X237.260 Y30.579 E43.08337
28909 G1 X237.260 Y43.389 E43.48043
28910 G1 X235.128 Y43.389 E43.54653
Visualization
Help
Show complete Code
Show Single Layer
Show Layer Range
First Layer:
Last Layer:
528
R1 C1 Insert Layer 0 Extruder 0 Printing Time:9h:21m:31s
Show in Log:
Commands
Infos
Warnings
Errors
ACK
Auto Scroll
Clear Log
Copy
21:43:01.160 OpenGL version:2.1.8787
21:43:01.163 OpenGL extensions:GL_AMD_draw_buffers_blend GL_AMD_performance_monitor GL_ARB_color_buffer_float GL_ARB_copy_buffer GL_ARB_depth_buffer_float GL_ARB_depth_texture GL_ARB_draw_buffers GL_ARB_draw_inst
21:43:01.163 OpenGL renderer:ATI Mobility Radeon HD 4200
21:43:01.163 Using fast VBOs for rendering is possible

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

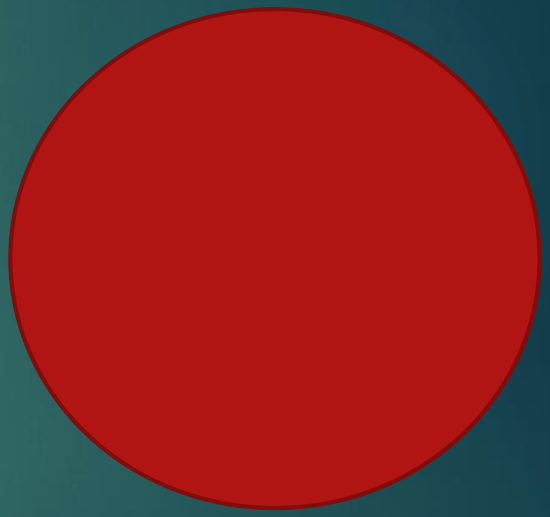
Additive Manufacturing

- 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

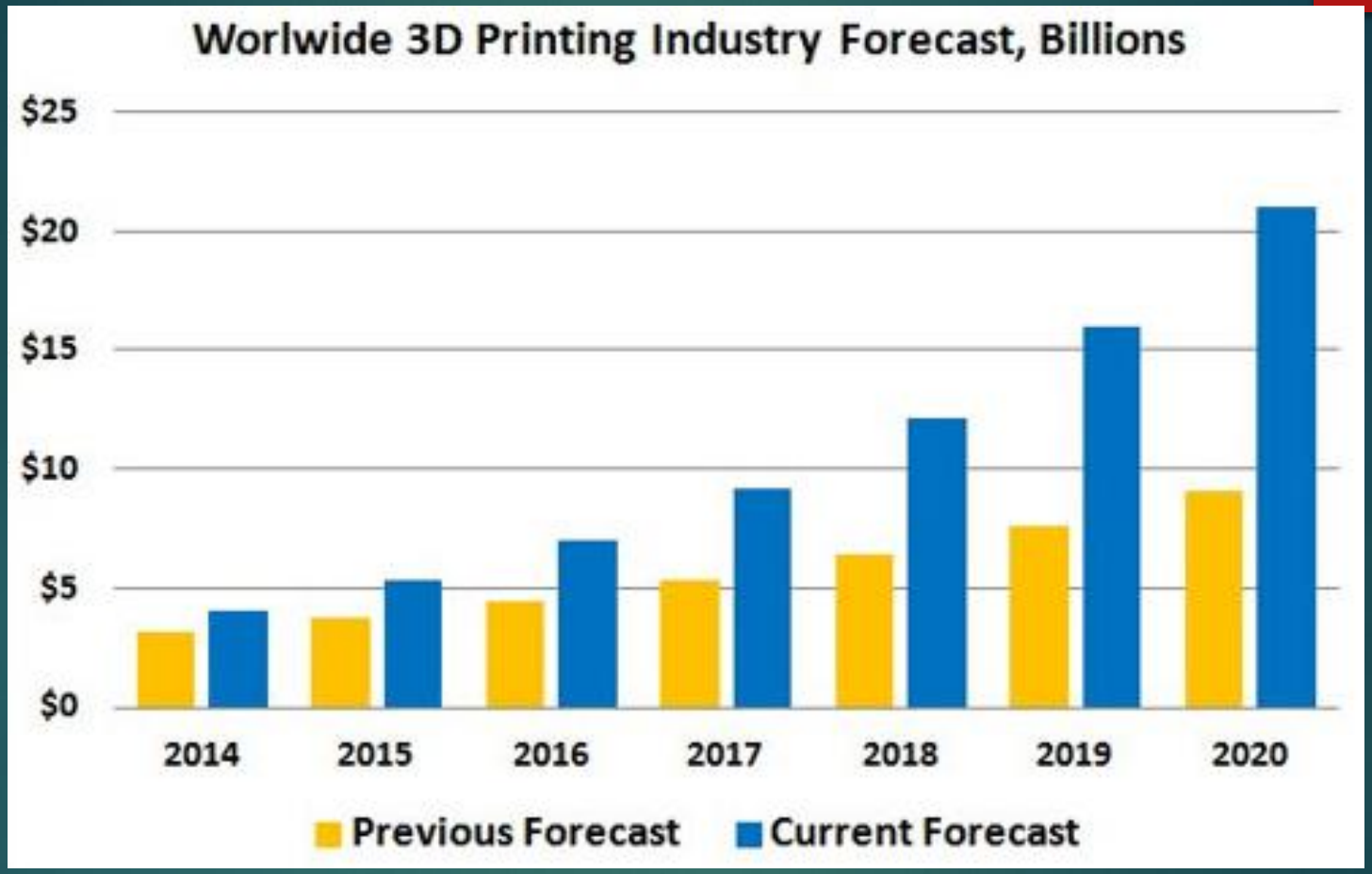
3D Systems Revenue = $.66B



HP Revenue (combined) = $127B

Stratasys Revenue = $.70B

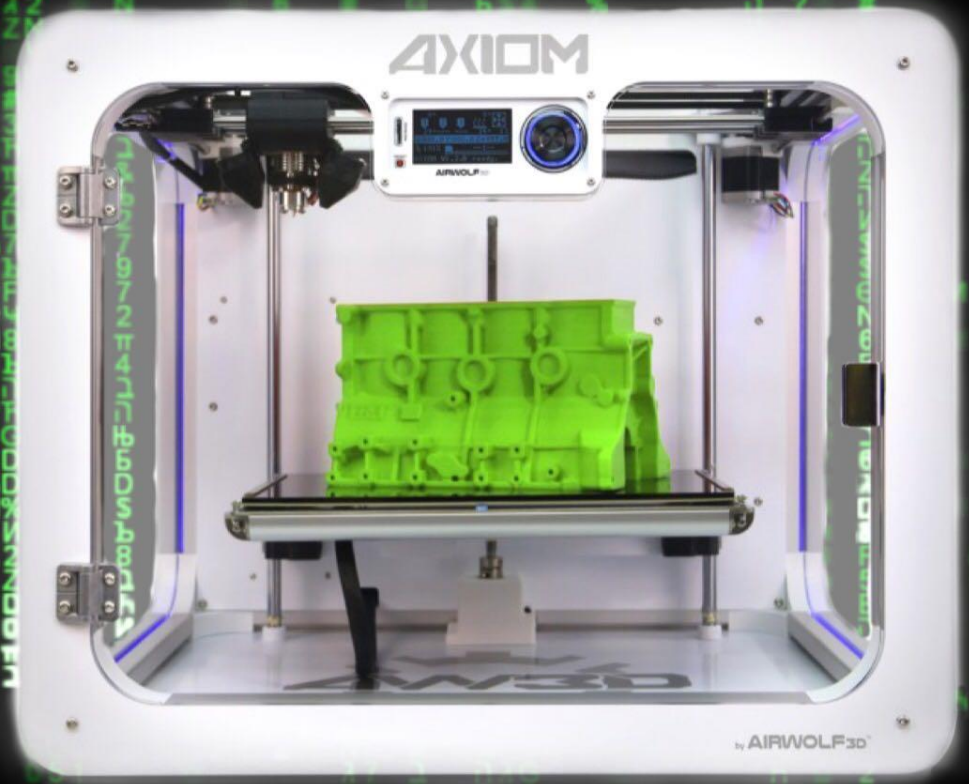
FASTER THAN THE EXPERTS PREDICTED



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?

AIRWOLF3D

Questions?

Costa Mesa, CA

info@airwolf3d.com

www.airwolf3d.com