INTRO TO 3D PRINTING

CSE 590 Ubiquitous Computing | Lecture 9 | May 24

Jon Froehlich • Liang He (TA)

DESIGN USE BUILD

MAKEABILITY LAB

PAUL G. ALLEN SCHOOL OF COMPUTER SCIENCE & ENGINEERING

UNIVERSITY of WASHINGTON

SCHEDULE TODAY: 6:30-9:20

06:30-06:50: Discussion of required reading led by Alex Viktorov

06:50-06:55: Optional reading discussion led by Mark Markaryan (link)

06:55-07:00: Introduce A5: Fabrication Assignment

07:00-08:00: Introduction to 3D Printing

08:00-08:05: Break

08:05-08:15: A4 Show-and-Tell (post video to Canvas chat interface)

08:15-09:20: In-Class 3D-Printing Exercises with Autodesk Fusion 360

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ASSIGNMENT

A5: FABRICATION

In this assignment, you will extend your A4 project by designing and fabricating (1) a 3D-printed stand for the servo motor and (2) a 3D-printed motor attachment for the ultrasonic sensor.

- **The 3D-printed stand** should provide sufficient support such that when the servo is activated, the gearbox does not move. You may make a free-standing structure (e.g., a stand for a table) or an attachment (e.g., an attachment for the Honor7X).
- **The 3D-printed attachment** for the ultrasonic sensor should either plug directly into the servo's gear peg or onto a propeller and should robustly hold the sensor.

Though not required, we strongly encourage you to use Autodesk Fusion 360 for this assignment (this is what we will be using for in-class exercises and will be able to support on the Discussion forums). Alternative CAD programs include Blendr, Sketchup, Onshape, Tinkercad, and Rhino. If you are confident and experienced with one of these tools and would prefer to use it for this assignment, you can do so.

The **midpoint checkin** includes submitting draft CAD models of both the stand and ultrasonic attachment.

For the deliverables, you will turn in a video demo, your CAD files (both the raw CAD files and the STLs), pictures of your 3D prints (both failures and successes), and a brief report reflecting on learnings.

ASSIGNMENT

A5: PARTS & DELIVERABLES

Parts

As with writing code, you are welcome to explore and view as many examples as you would like online (*e.g.*, via YouTube demos, Thingiverse); however, unlike code, if you download an STL file (and not the raw CAD file), then this is more difficult to work with and modify (it can be done but it's not super straightforward--see this video from Autodesk about importing STL meshes into Fusion 360).

- [5.5 pts] **3D-printed servo stand**: The 3D-printed stand should: (i) be sufficiently robust such that the servo base unit does not move during actuations; (ii) tightly hold the servo base; (iii) be designed to lay flat on a surface (*e.g.*, table) or attach to some other object (*e.g.*, top of smartphone, light fixture).

- [5.5 pts] **3D-printed servo attachment:** The 3D-printed servo attachment should: (i) robustly attach the ultrasonic senor directly to the servo peg or a propeller; (ii) not negatively impact the wiring.

- [3 pts] **Creative feature:** Add in an additional creative feature to the IoT design. This is wildly open-ended--you can add in a new feature via Android, Arduino + new circuit, or some new physical form. If you decide to 3D-print something for your creative feature, please make sure you prioritize the core parts of this assignment before printing optional parts.

Deliverables

- [2 pts] Your **CAD** model (either a github link or zipped and uploaded to Canvas). Any part of your model that is informed by or copied from the Internet (or other sources) **must** be properly attributed in your report. If you hosted your model on github (or some other online repo), please include a link to it in your report.

- [2 pts] A brief, **1-page report** that: (i) provides an overview of your design along with key measurements; (ii) describes your creative feature; (iii) enumerates key struggles and challenges; (v) reflects on what you learned. You should include as many images as you want (at least one) that helps explain your design. Images are free. You need not write in prose (you can bullet point the entire report). Please use headers to clearly separate the four sections of your report.

- [2 pts] A brief (2 mins or less) **video overview of your design** posted to YouTube, Vimeo, or some other cloud service (we will not accept uploaded mp4s directly to Canvas). The video should simply demonstrate the two 3D-prints integrated into a working version of A4 + a demonstration of your creative feature. This can and should be super casual, no editing is necessary. The video can be unlisted or public (your choice). Please include a link to this video in your report.

ASSIGNMENT

A5: WHERE TO PRINT?

We strongly encourage you to get started on this assignment right away as 3D-printing often requires multiple iterations and the 3D-printers themselves are a constrained resource. We recommend the following places for 3D-printing:

- **UW Co-motion MakerSpace:** Most of you received the training to use the UW Co-Motion MakerSpace. The hours are: Sunday-Monday, 2PM-8PM. Note, however, that the MakerSpace is closed this holiday weekend (both Sunday and Monday). 3D prints are charged $0.05/gram. The fulltime staff is quite knowledgeable and helpful.
- **UW Area 01:** Area 01 is open to any student (a use fee of $25 applies and you must receive on-site training to use the 3D-printer). Hours: open 7-days a week 1-8PM.
- **UW GIX MakerSpace:** This MakerSpace is on the eastside in Bellevue's Spring District. We received special permission to use this space. Hours: Mon & Thurs 2-6PM and Sat 12-4PM. 3D prints are charged $0.08/gram.
- **MakerSpace of your own choosing:** Many of you have contacted me about MakerSpaces at your workplace--please feel free to use them (with company permission, of course).

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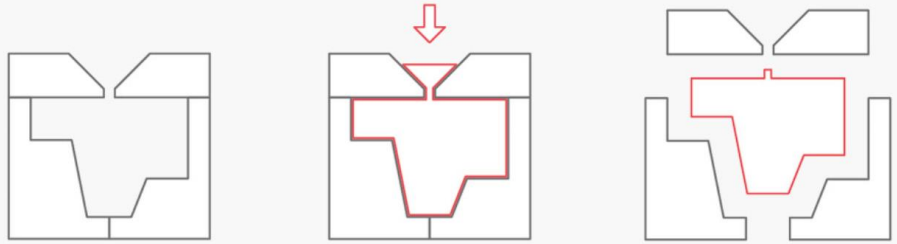
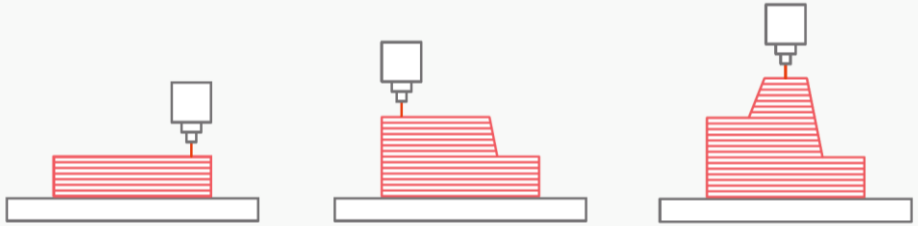
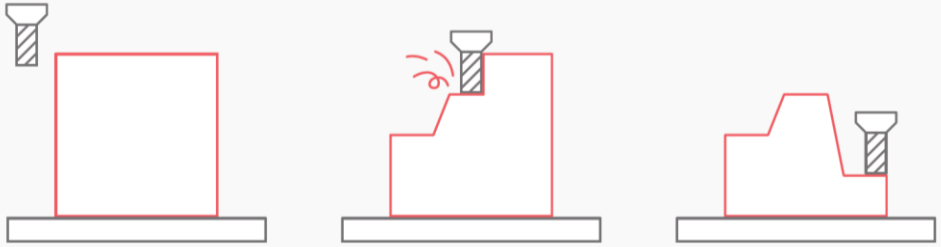
MANUFACTURING TECHNIQUES



Formative manufacturing: best suited for high-volume production of the same part, requiring a large initial investment in tooling (molds) but then being able to produce parts quickly and at a very low unit price.



Additive manufacturing: best suited for low-volume, complex designs that other methods are unable to produce or when a unique, one-off rapid prototype is required.



Subtractive manufacturing: lies in between formative and additive, being best suited for parts with relatively simple geometries, produced at low-to-mid volumes, and where materials like wood or metal are necessary

Source: Redwood *et al.*, The 3d Printing Handbook, 2017

SUBTRACTIVE MANUFACTURING

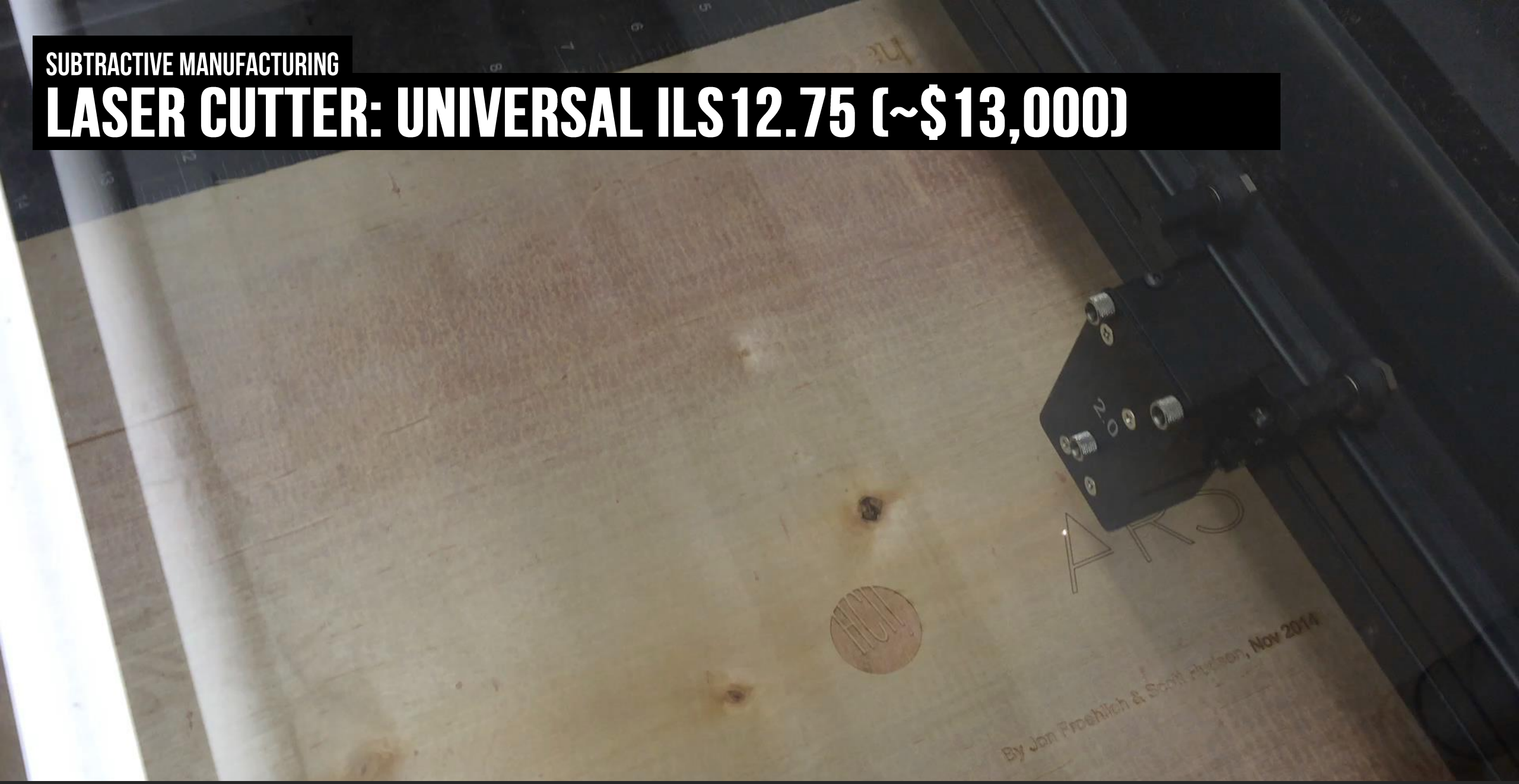
CNC MILL: THE SHOPBOT DESKTOP (~$7,000)

Source: Jon Froehlich

WARNING
BITS SPINNING AT
HIGH SPEED CAN
SHATTER OR START
FIRE
WARNING

SUBTRACTIVE MANUFACTURING

LASER CUTTER: UNIVERSAL ILS12.75 (~$13,000)



Source: Jon Froehlich

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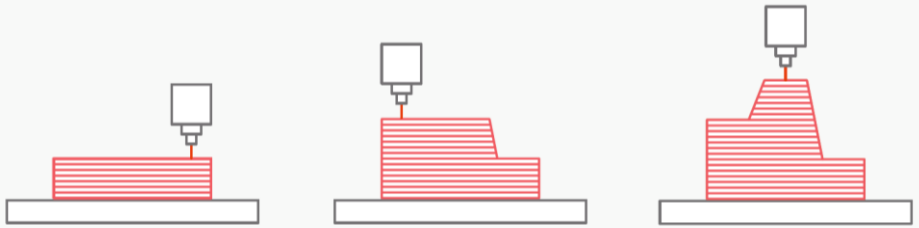

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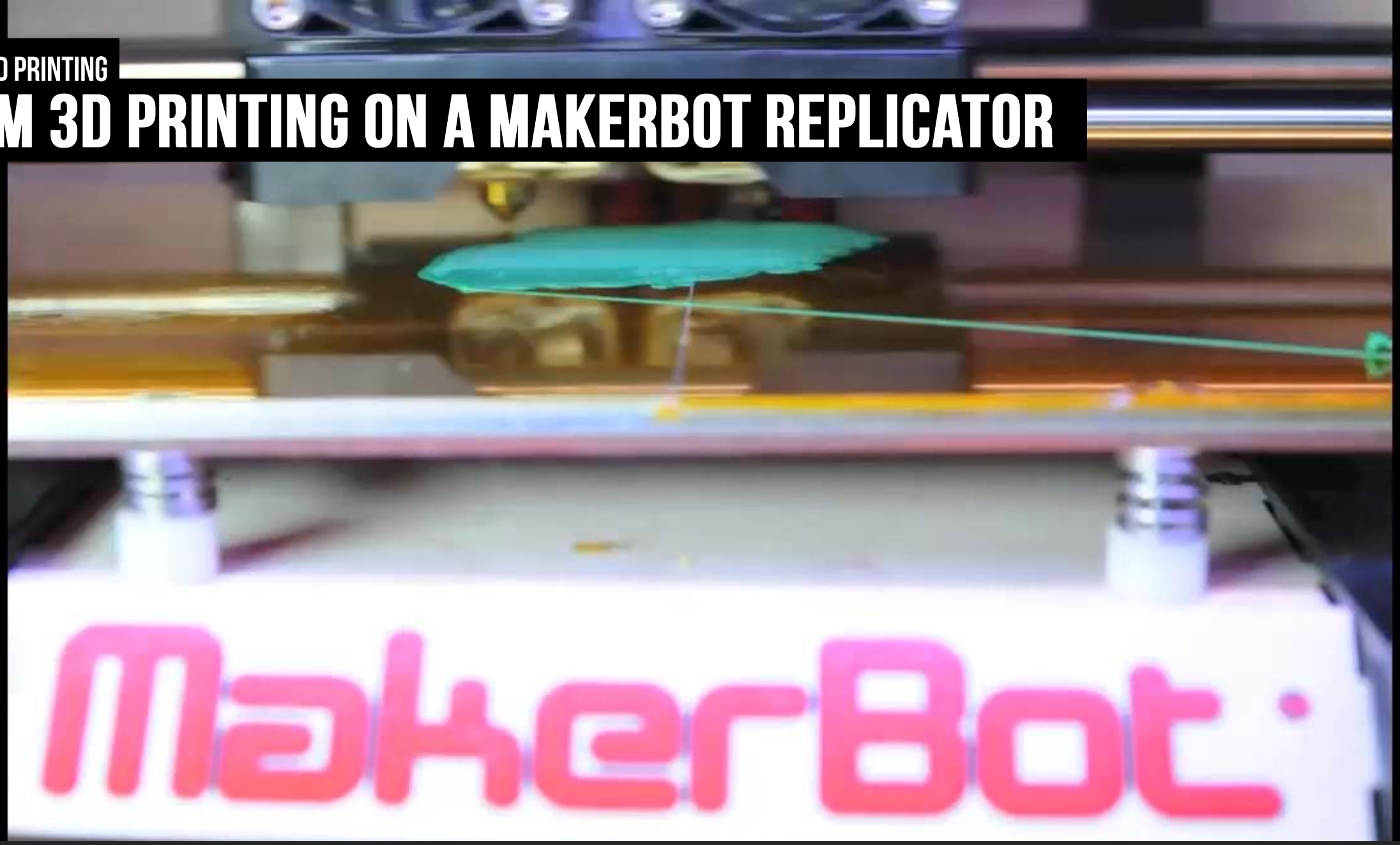
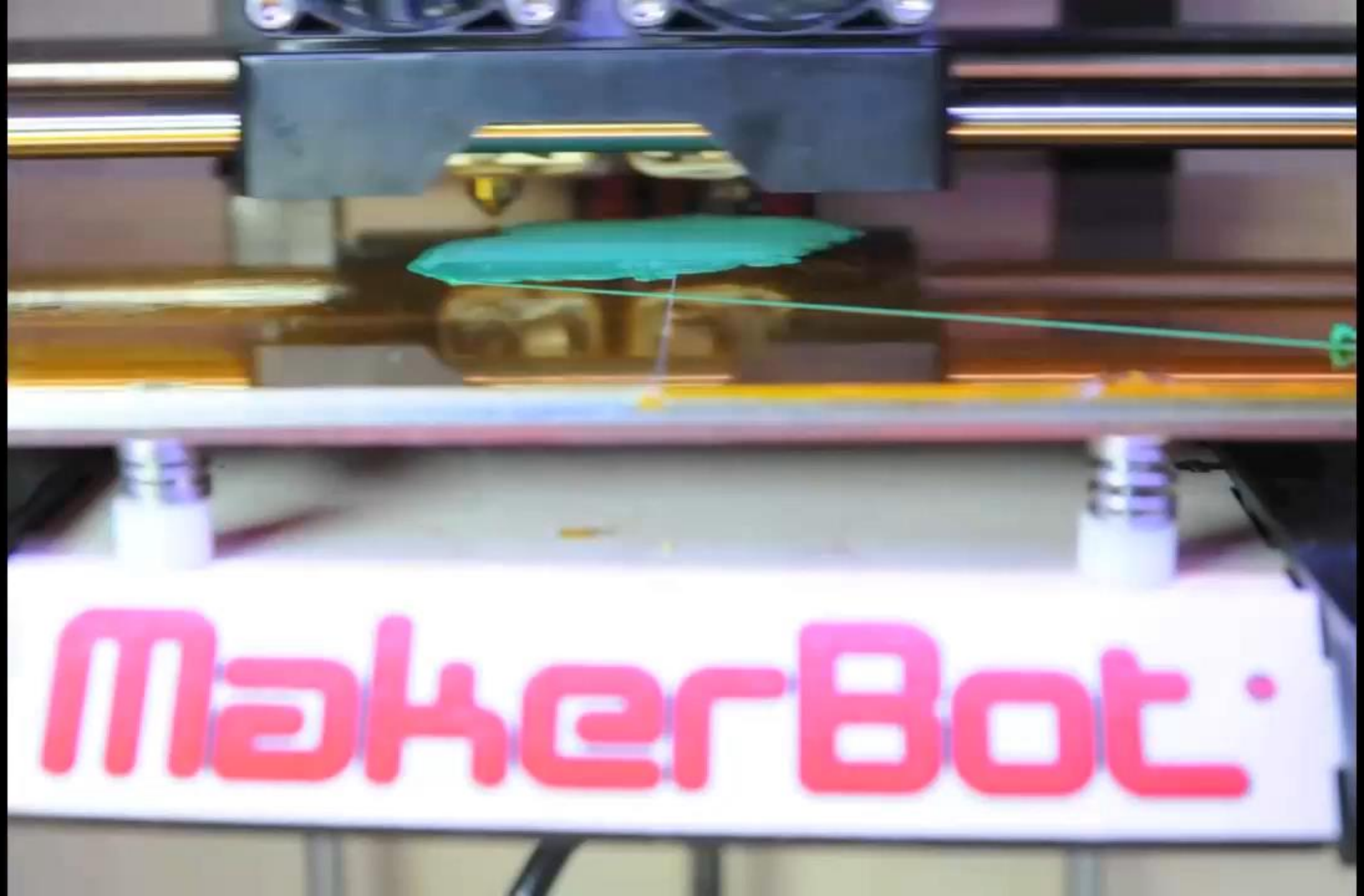
FDM 3D PRINTING

FDM 3D PRINTING ON A MAKERBOT REPLICATOR



Source: https://youtu.be/8_vloWVgf0o; Edited by Jon Froehlich


MakerBot

1987

The first commercial 3D printer
SLA-1 printer by 3D Systems Inc.
Invented by Charles Hull

Slide based on Huaishu Peng's job talk;

1992

The first commercial FDM printer
3D Modeler by Stratasys, Inc.
Invented by Scott & Lisa Crump

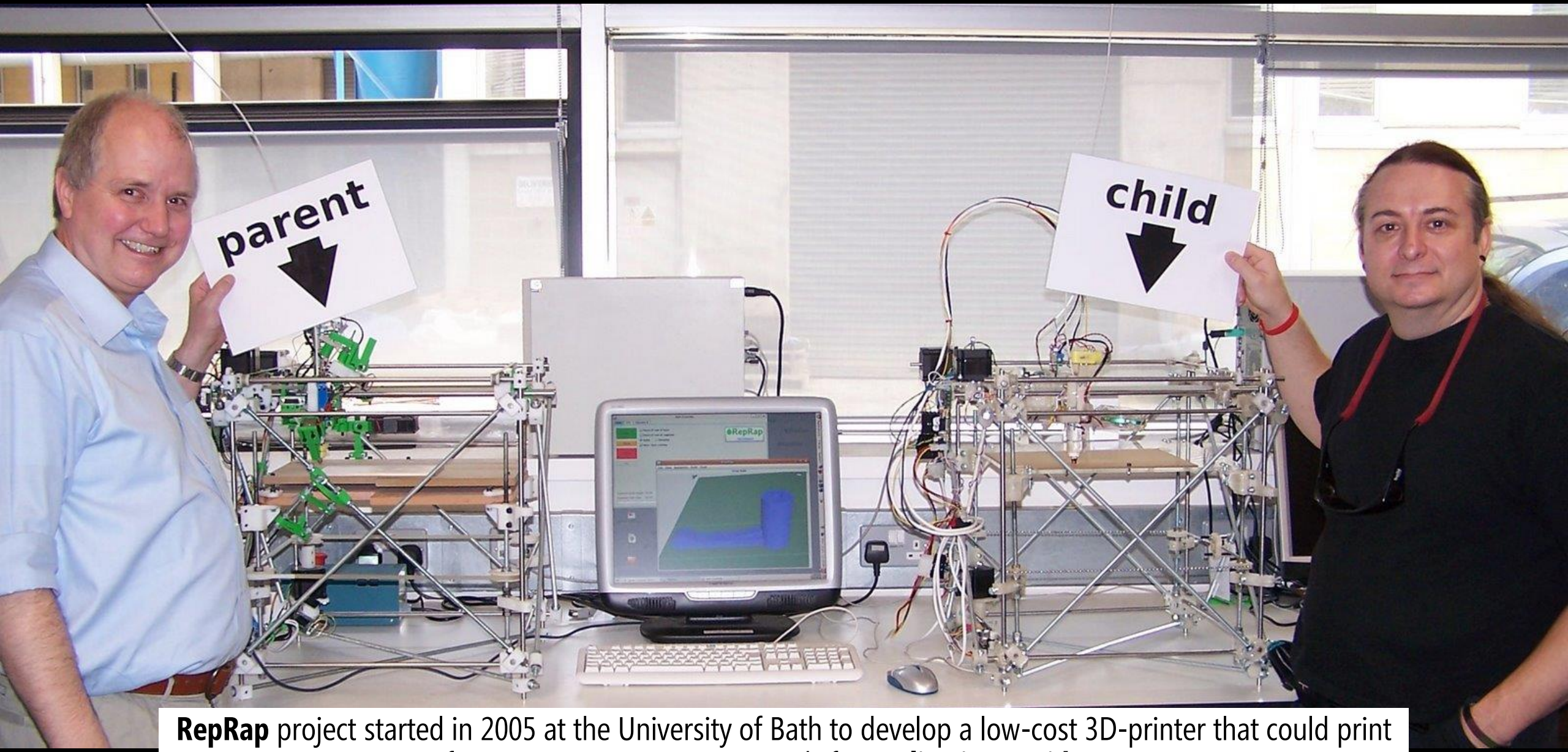
Source: https://en.wikipedia.org/wiki/Stratasys

1992

The first commercial FDM printer
3D Modeler by Stratasys, Inc.
Invented by Scott & Lisa Crump

"The idea for the technology came to Crump in 1988 when he decided to make a **toy frog for his young daughter using a glue gun loaded with a mixture of polyethylene and candle wax**. He thought of creating the shape layer by layer and of a way to automate the process. In April 1992, Stratasys sold its first product, the 3D Modeler."

Source: https://en.wikipedia.org/wiki/Stratasys



RepRap project started in 2005 at the University of Bath to develop a low-cost 3D-printer that could print most of its components. RepRap stands for **replicating rapid prototype**.

MakerBot founded in **2009** by Adam Mayer, Zach “Hoeken” Smith, and Bre Pettis to build on **RepRap project**.

How expiring patents are ushering in the next generation of 3D printing

Filemon Schoffer May 15, 2016

Comment

The year 2016 is quickly shaping up to be one of the hottest years on record for 3D printing innovations. Although there is still a lot of hype surrounding 3D printing and how it may or may not be the next industrial revolution, one thing is for certain: the cost of printing will continue to drop while the quality of 3D prints continues to rise.

This development can be traced to advanced 3D printing technologies becoming accessible due to the expiration of key patents on pre-existing industrial printing processes.

These expiring patents — many of which were issued just before the turn of the century and are reaching the end of their lifespan — are releasing the monopolistic control over processes that have long been held by the original pioneers of the 3D printing industry.

For example, when the Fused Deposition Modeling (FDM) printing process patent expired in 2009, prices for FDM printers dropped from over $10,000 to less than $1,000, and a new crop of consumer-friendly 3D printer manufacturers, like MakerBot and Ultimaker, paved the way for accessible 3D printing.

The next generation of additive manufacturing technologies are making their way down from the industrial market to desktops of consumers and retailers much like FDM did. Among these include patents for three specific 3D printing technologies: liquid-based, powder-based and metal-based printing processes.

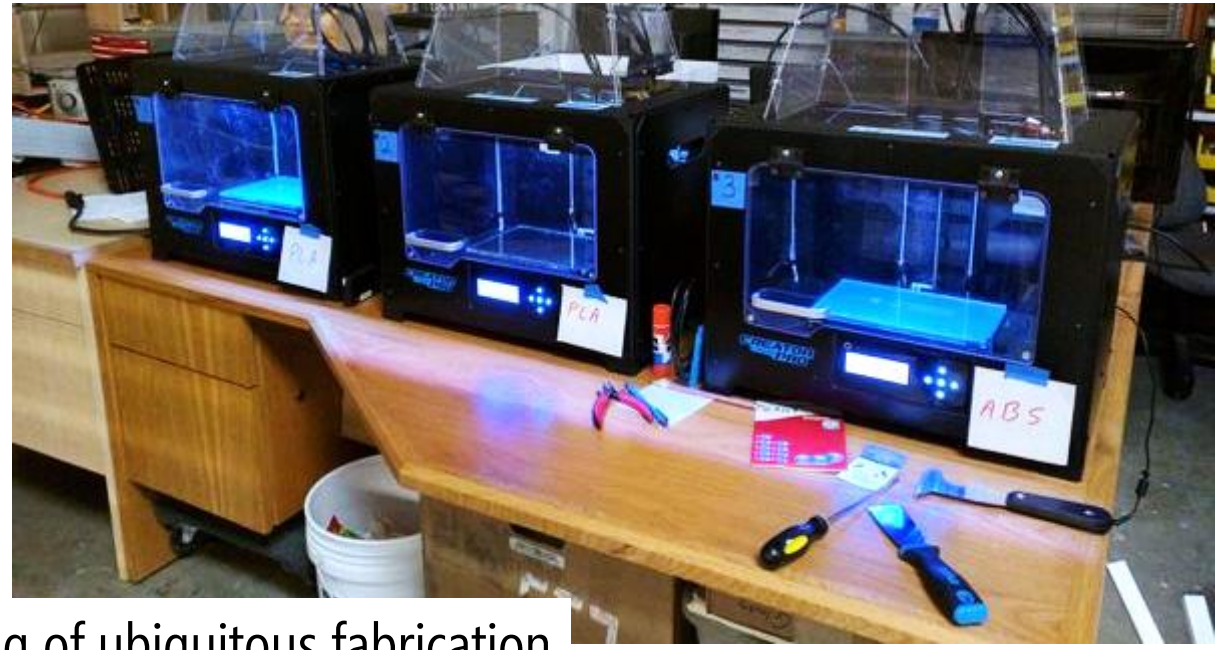
Liquid-Based Technology

Filemon Schoffer
Contributor

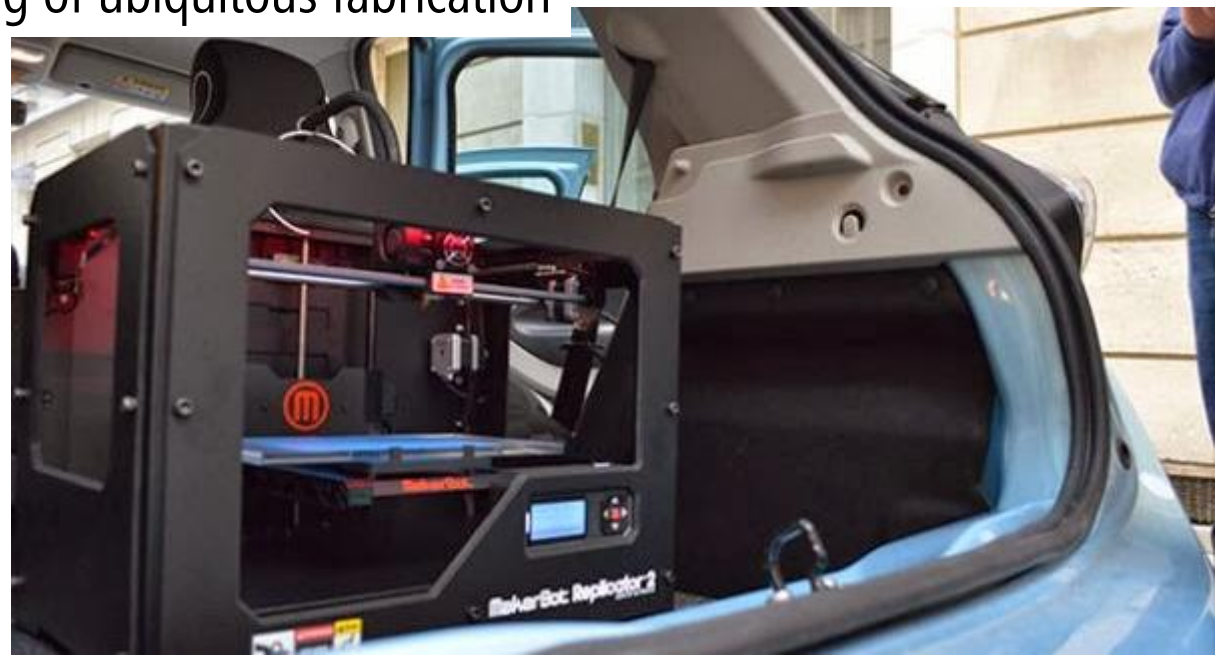
Filemon Schoffer is the head of community at 3D Hubs.

More posts by this contributor

- 3D printing technologies explained
- Metal 3D printing takes flight



2009 marked the beginning of ubiquitous fabrication

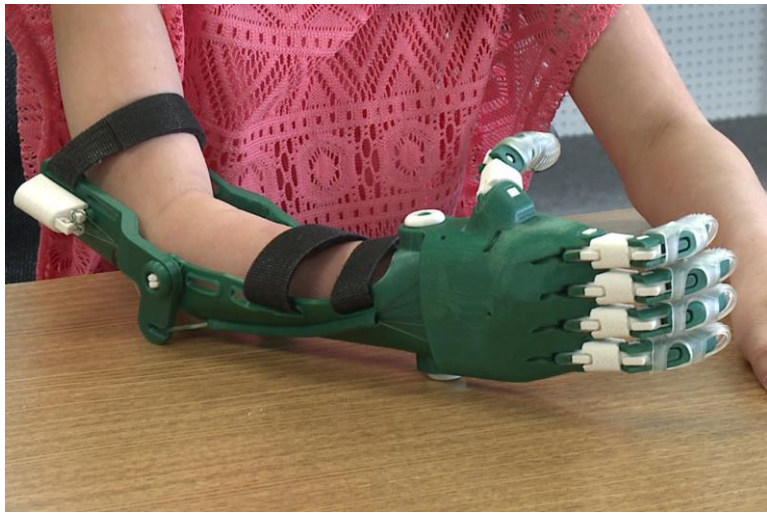


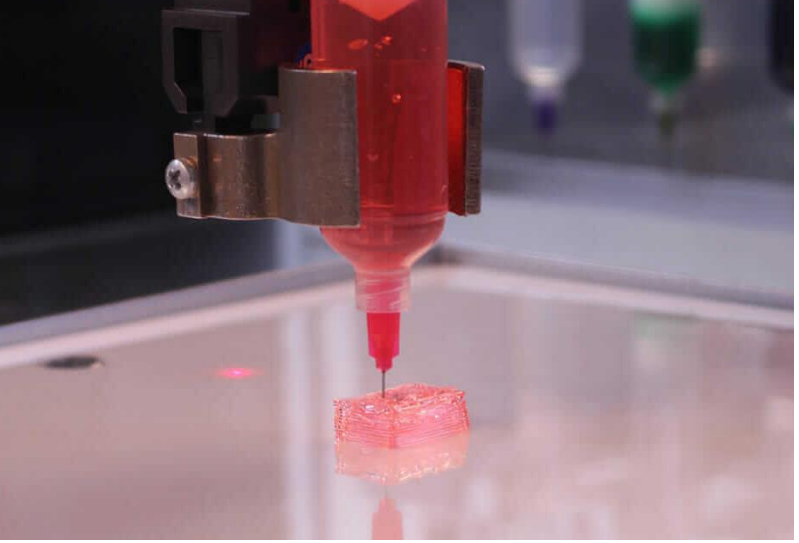
Slide based on Huaishu Peng's job talk;

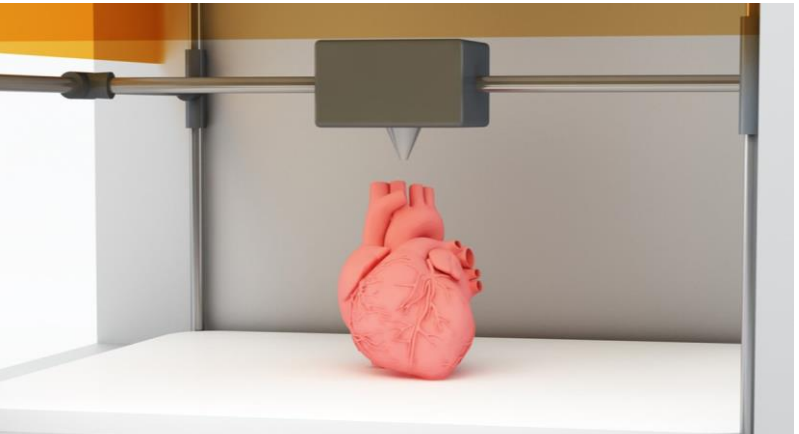
By **2012**

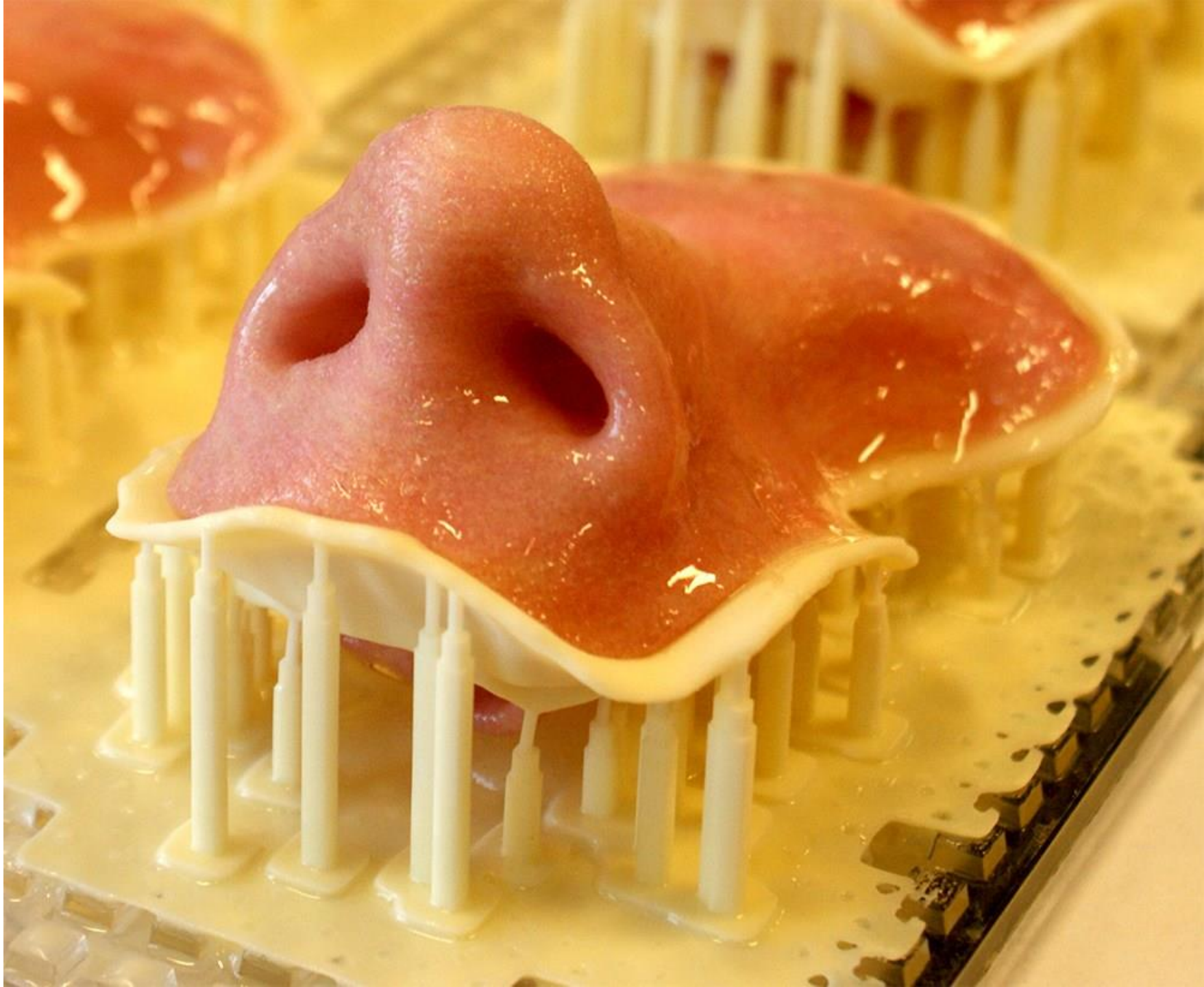
We reached the peak
of the “hype cycle”

54
LGND









LEUPOLD

By **2016**

The peak was over & a more realistic attitude set in

WIRED

The 3D Printing Revolution That Wasn't

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THE RISE AND FALL OF THE EVERYMAN TYCOON

ANDREW ZALESKI BACKCHANNEL 12.01.16 12:00 AM

THE 3D PRINTING REVOLUTION THAT WASN'T

SHARE

13

MAKERBOT MADE A BOLD BET THAT 3D PRINTERS WOULD BECOME AS COMMON AS MICROWAVES. JUST ONE PROBLEM: NO ONE ELSE SHARED THAT DREAM.

It was October 2009 when Bre Pettis — his unmistakable sideburns and dark-rimmed rectangular glasses framing his face — took the stage at Ignite NYC, threw his hand in the air, and shouted "Hooray!" two times. A PowerPoint slide lit up behind him, revealing a photo of a hollow wood box crisscrossed with wiring. Bouncing up and down, his profuse mop of graying hair flopping about, Pettis began: "I'm going to talk about MakerBot and the future and an industrial revolution that we're beginning — that's begun." A former art teacher, Pettis had emerged as a key character in the growing maker movement of the late 2000s, a worldwide community of tinkerers who holed away in makeshift workshops and hackerspaces, equally at home with tools like old-school lathes and contemporary laser cutters. Pettis had begun his ascent in 2006, producing weekly videos for *MAKE* magazine—the maker movement's Bible—that featured him navigating goofy

MAYBELLINE NEW YORK

SHARE
13

Brooklyn, lay off even more workers, and move all manufacturing to a contractor in China, even as the company celebrated the sale of its 100,000th 3D printer. Analysis of those same annual reports published by Stratasys shows that MakerBot sold a paltry 1,421 printers through the first three months of 2016.

"In 2014, MakerBot was convinced there was a consumer market ripe and ready. In 2015, we realized the consumer market is not where we thought it was," Jaglom told me the day MakerBot announced it was closing its Brooklyn factory.

Here's the thing about 3D printing: It's not as revolutionary as it was made out to be, at least not yet. Big companies, like General Electric and Ford, experiment with 3D printing and even use it to produce some parts. GE this year even spent $1.4 billion to acquire two 3D printing companies. But 3D printing technology still isn't reliable enough, fast enough, or cheap enough to supplant injection molding or traditional, subtractive manufacturing processes.

It's also not a simple process. If you want to print out original pieces, you need to know how to do 3D design, which admittedly has become much simpler thanks to online software like TinkerCAD. But an extruder head might become jammed during printing. The print bed might warp. The finished print might be crooked, which means you have to re-orient the part for printing. "There's a ton of work involved. It's not a thing where you can push a button and get what you were imagining," says Rockhold.

During the heady days of 3D printing, these weren't questions that were ignored so much as problems to be solved at a later date. What's happening now is what Jaglom calls the "de-hyping" of the industry, as the public perception of 3D printing finally catches up to reality. Stratasys' stock price took a tumble, from an all-time high of $136 in January 2014 to $25 in October 2015, when MakerBot announced its second round of layoffs.

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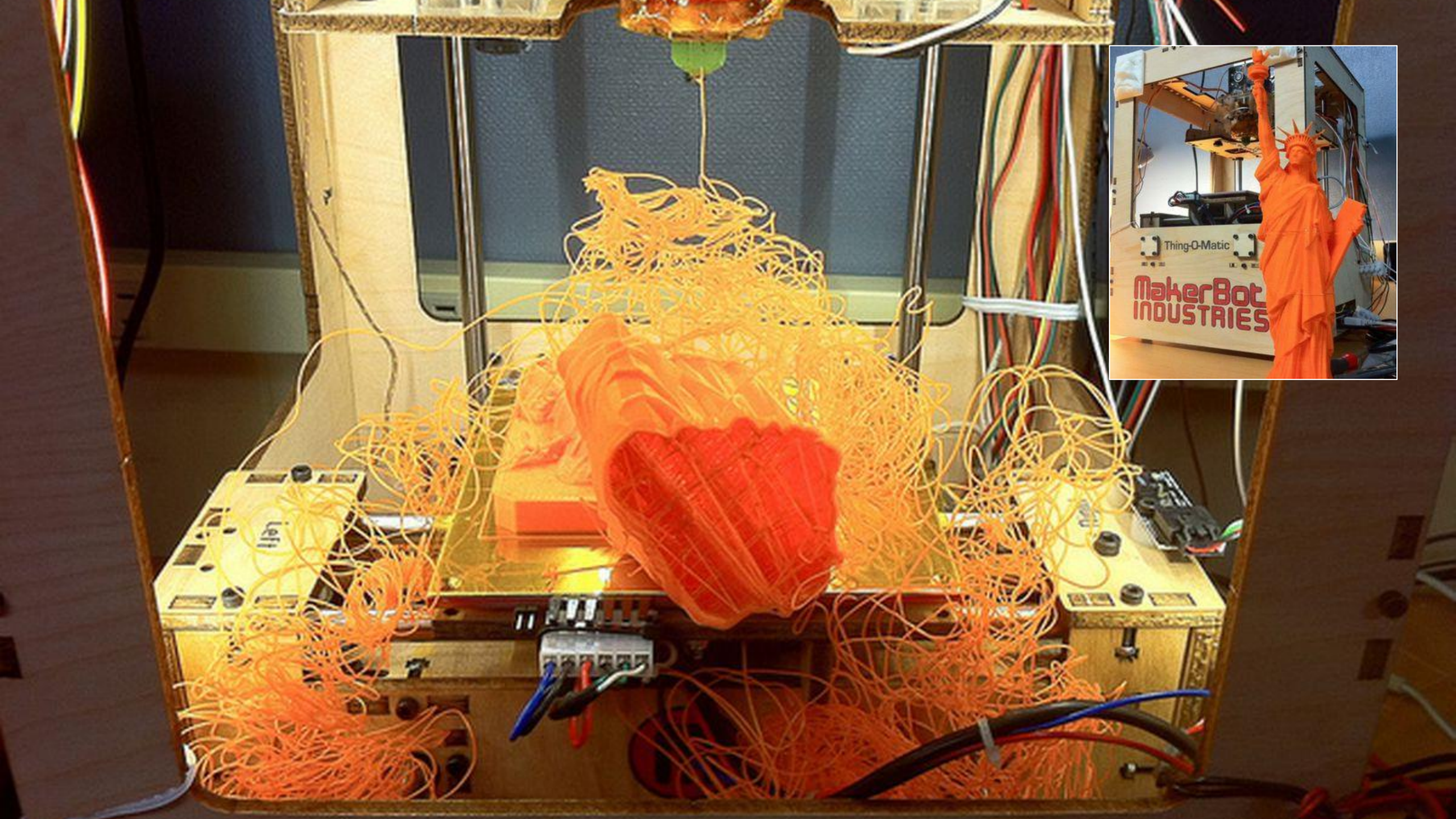
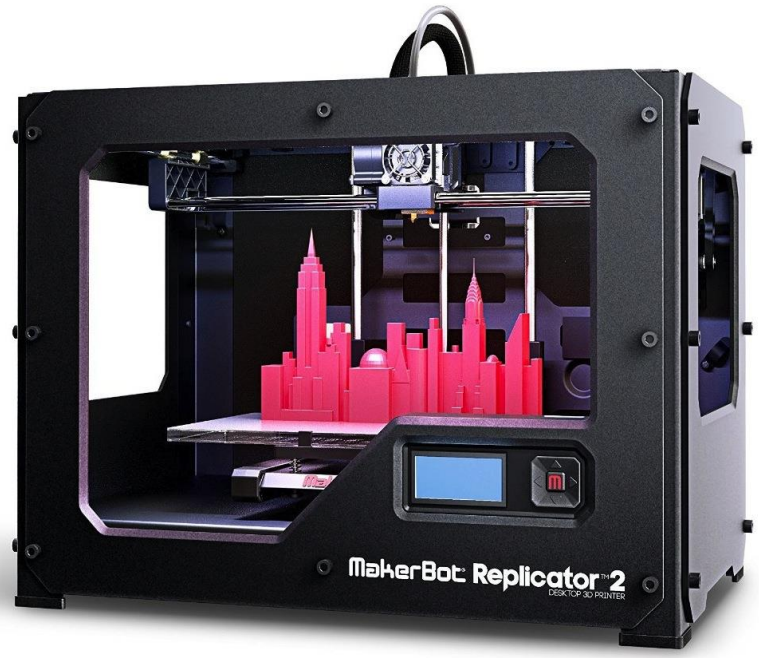
Source: https://www.wired.com/2016/12/the-3d-printing-revolution-that-wasnt/


Thing-O-Matic
MakerBot
INDUSTRIES

5-Year View

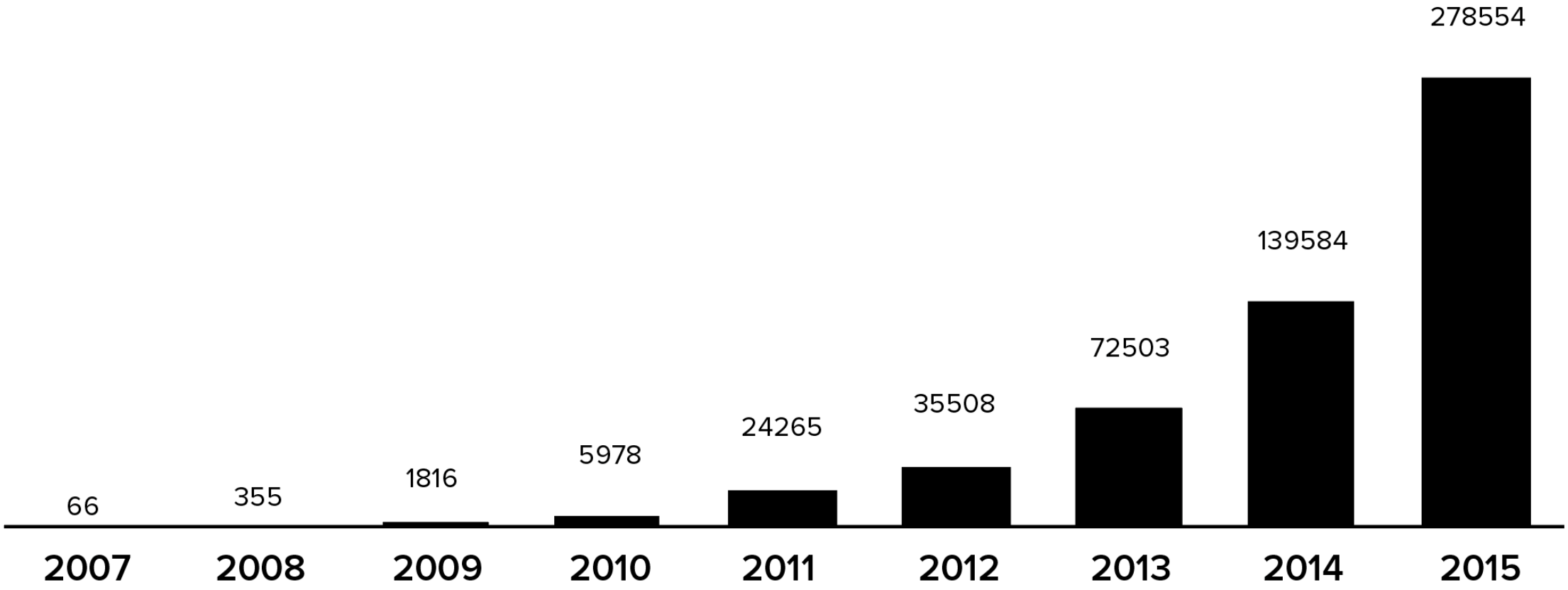
!=


MakerBot Replicator 2
DESKTOP 3D PRINTER

BACKGROUND

CONSUMER-GRADE 3D PRINTERS SOLD IN 2015

Printers all < $5000 sold globally per year



Source: https://www.3dhubs.com/knowledge-base/advantages-3d-printing; Original source: Wohlers Report, 2015

WHY 3D PRINT?

Speed. Designers can build, print, solicit feedback, & iterate on ideas quickly. 3D-printing allows the designer and other stakeholders to get a tangible, physical experience of a design.

Iteration. Digital models can be easily tweaked & reprinted.

Cost. Cost at low-volumes (*i.e.*, one-offs) is quite competitive compared to alternatives. Injection molding, for example, requires expensive mold-making equipment and each mold is expensive to produce. 3D-printers themselves are far cheaper than formative and subtractive machines.

Personalization. Certain industries (*e.g.*, dental, prosthetics) can use high-grade 3D-printers to quickly produce personalized devices for each patient (user)

Complex geometries. 3D-printers can create physical forms with complex geometries that would be impossible or very difficult using other manufacturing processes.

Source: Redwood *et al.*, The 3d Printing Handbook, 2017; https://www.3dhubs.com/knowledge-base/advantages-3d-printing

WHY 3D PRINT?

MAKE THINGS NOT POSSIBLE WITH OTHER APPROACHES

Source: https://youtu.be/qBHg1xhANxU; Edited by Jon Froehlich

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Ease of access. Unlike injection molding or even subtractive processes like CNC mills or laser cutters, 3D-printers are relatively cheap to buy and operate. Many public libraries and other community spaces provide access as well.

Sustainability. Subtractive methods remove significant amounts of material that is not used, resulting in high waste volumes. 3D-printable ABS plastic can be recycled & PLA is compostable. Check with local recycling/compost centers.

Source: Redwood *et al.*, The 3d Printing Handbook, 2017; https://www.3dhubs.com/knowledge-base/advantages-3d-printing

BACKGROUND

WHICH PRINTER?

Digital Manufacturing Trends

Q2 2018

3D Hubs Digital Manufacturing Trends is a quarterly update using data from 6,000 active international suppliers, who create more than 200,000 parts each quarter. It's the only industry report based on hard numbers and the most extensive overview of the latest trends in technologies such as 3D printing, CNC machining and more.

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Desktop

Highest Rated Desktop Printers

Insights

Another quarter another desktop printer tops the Print Quality Ratings with the Ultimaker 2+ moving from #2 to #1. Although the Ultimaker 2+ was launched back in 2016 its has become a respected workhorse in its field with a rating of 4.86.

Prusa Research sees three machines in the Top 10 with the MK2S taking #2, MK2 at #4 and the new MK3 continuing its respected pedigree at #7. What's even more impressive is that the MK2 sits at #4 with the most reviews of all the machines featured. Ultimaker has matched the feat with the 2+, 2 and 3 all making the Top 10, showing 2 manufacturers increasing their market share. That being said, the Form 2 remains the only SLA machine to be featured in the Top 10 since 2017.

#	Printer Model	Technology	Reviews	Print Quality Rating
1	Ultimaker 2+	FDM	226	4.86
2	Original Prusa i3 MK2S	FDM	413	4.84
3	Form 2	SLA	725	4.83
4	Original Prusa i3 MK2	FDM	931	4.83
5	Zortrax M200	FDM	293	4.81
6	Flashforge Creator Pro	FDM	414	4.81
7	Original Prusa i3 MK3	FDM	165	4.79
8	Ultimaker 3	FDM	182	4.77
9	Ultimaker 2	FDM	249	4.76
10	Creality CR-10	FDM	219	4.75

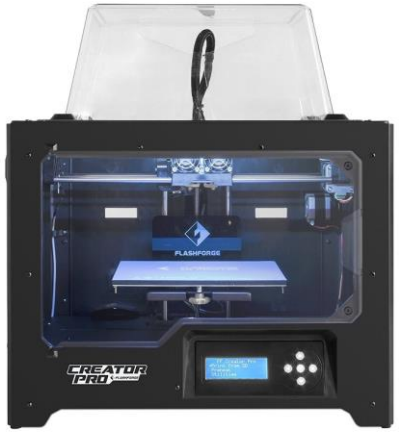
Source: https://www.3dhubs.com/trends

Ultimaker 2+ ($2499)

Build volume: 223 x 223 x 205 mm
Layer resolution (0.4mm nozzle): 200-20 micron
Heated build plate, swappable nozzles,
print from SD card

FlashForge Creator Pro ($899)

Build volume: 227 x 148 x 150 mm
Layer resolution (0.4mm nozzle): 500-100 micron
Dual extrusion, build plate not heated,
print from SD card



Ultimaker 3 ($3495)

Build volume: 215 x 215 x 200 mm
Layer resolution (0.4mm nozzle): 200-20 micron
Dual extrusion, heated build plate, swappable
nozzles, Wi-Fi

Desktop

Highest Rated Desktop Printers

Insights

Another quarter another desktop printer tops the Print Quality Ratings with the Ultimaker 2+ moving from #2 to #1. Although the Ultimaker 2+ was launched back in 2016 its has become a respected workhorse in its field with a rating of 4.86.

Prusa Research sees three machines in the Top 10 with the MK2S taking #2, MK2 at #4 and the new MK3 continuing its respected pedigree at #7. What's even more impressive is that the MK2 sits at #4 with the most reviews of all the machines featured. Ultimaker has matched the feat with the 2+, 2 and 3 all making the Top 10, showing 2 manufacturers increasing their market share. That being said, the Form 2 remains the only SLA machine to be featured in the Top 10 since 2017.

#	Printer Model	Technology	Reviews	Print Quality Rating
1	Ultimaker 2+	FDM	226	4.86
2	Original Prusa i3 MK2S	FDM	413	4.84
3	Form 2	SLA	725	4.83
4	Original Prusa i3 MK2	FDM	931	4.83
5	Zortrax M200	FDM	293	4.81
6	Flashforge Creator Pro	FDM	414	4.81
7	Original Prusa i3 MK3	FDM	165	4.79
8	Ultimaker 3	FDM	182	4.77
9	Ultimaker 2	FDM	249	4.76
10	Creality CR-10	FDM	219	4.75

Tronxy X1 Desktop 3D Printer - GUN METAL US PLUG

Support SD Card Off-line Printing + LCD Display + High Precision 0.1 - 0.4mm

Brand: Tronxy 4.73 (30 Customer Reviews) | Ask a question

Price: **$149.71**

Warehouse Options: China

Dispatch: Ship between: May 28 - May 31

QTY: 1 in stock

color: Gun Metal

size: US Plug | UK Plug | EU Plug | AU Plug

Shipping Cost: $2.85 to United States Via Standard Shipping

Buy Now | Add to Cart | Add to Favorites (401)

MONEY BACK | McAfee SECURE | PayPal | Tax Info | Price Protection | Price Disclaimer

LUSJi
4.8/5.0

Favorites

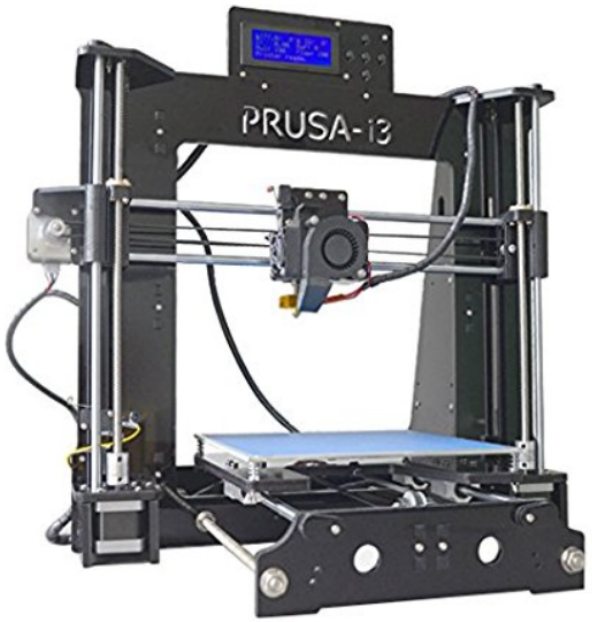
Visit Store

Description | Product FAQ | Customers Reviews | Shipping & Payment | Wholesale Inquiry

Disclaimer:

- Please read and follow the user manual carefully before you assemble or operate the 3D printer.
- Modification and customization of the 3D printer are strictly forbidden. We will take no responsibility for any problems resulting from modifications.
- Always use the correct AC voltage for your region.
- Please do not place the 3D printer near flammable / combustible materials, or any heat sources.

NEW & INTERESTING FINDS ON AMAZON EXPLORE



Roll over image to zoom in

Tronxy

Upgraded P802D Desktop DIY 3D Printer Kits by TRONXY | High Precision Acrylic Frame Prusa i3 Printer with LCD Screen -Support 1.75mm ABS/PLA/HIPS/PC/Wood Filament -Printing Size 220x220x180mm

Be the first to review this item

Price: $209.99 & **FREE Shipping**

In Stock.

Get it as soon as June 1 - 8 when you choose **Standard Shipping** at checkout.
Ships from and sold by Blackpoolfa.

New (2) from $209.99 & FREE shipping.

Specifications for this item

Part Number	ZB348700
Number of Items	1
Brand Name	TRONXY
EAN	0611890416606
UPC	611890416606

See more product details

Share

Qty: 1

$209.99 + Free Shipping
In Stock. Sold by **Blackpoolfa**

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Deliver to Jon - SEATTLE 98105

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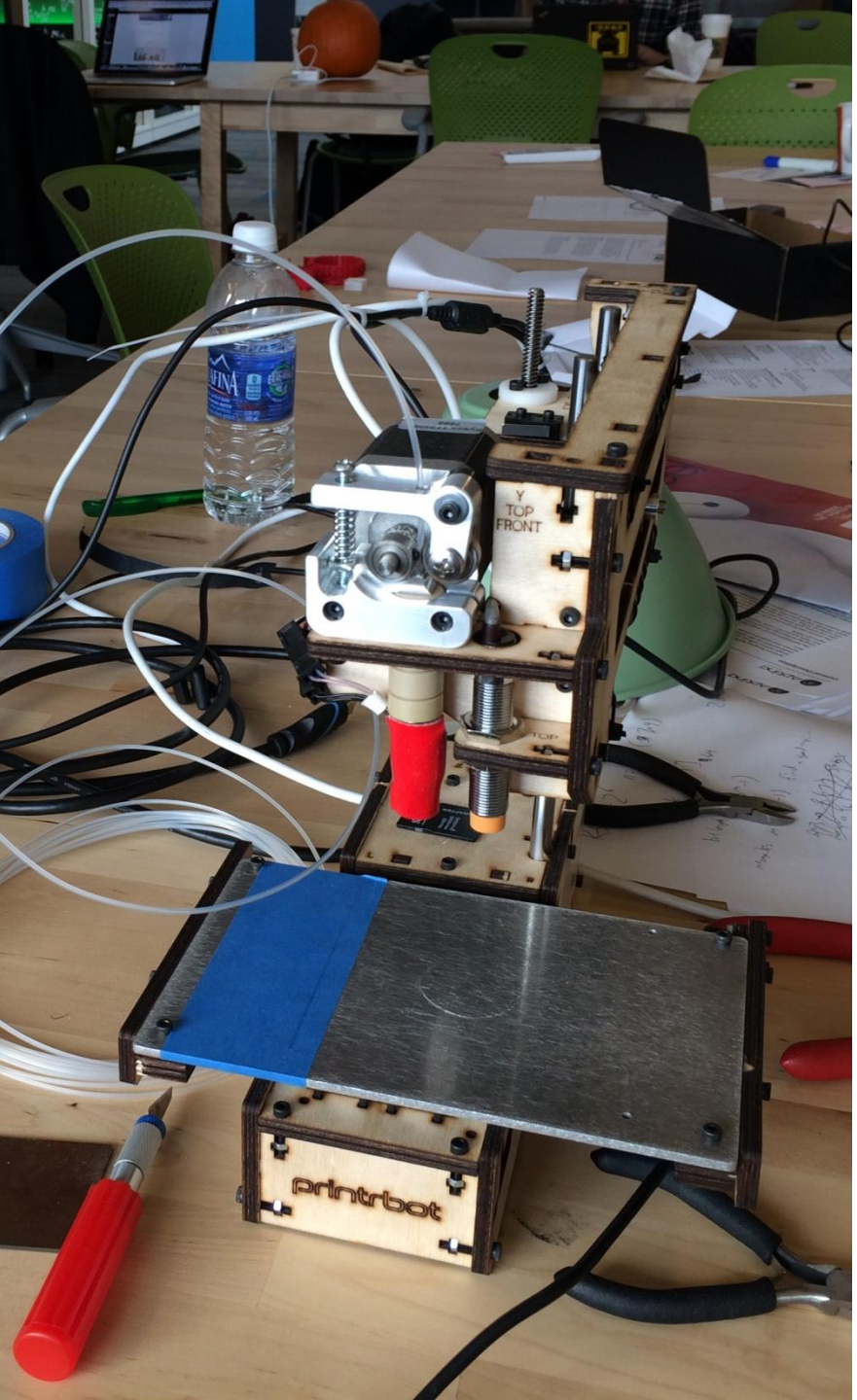
$214.99 Add to Cart
+ Free Shipping
Sold by: Coldcedar

New (2) from $209.99 & FREE shipping.

Have one to sell? Sell on Amazon


Y
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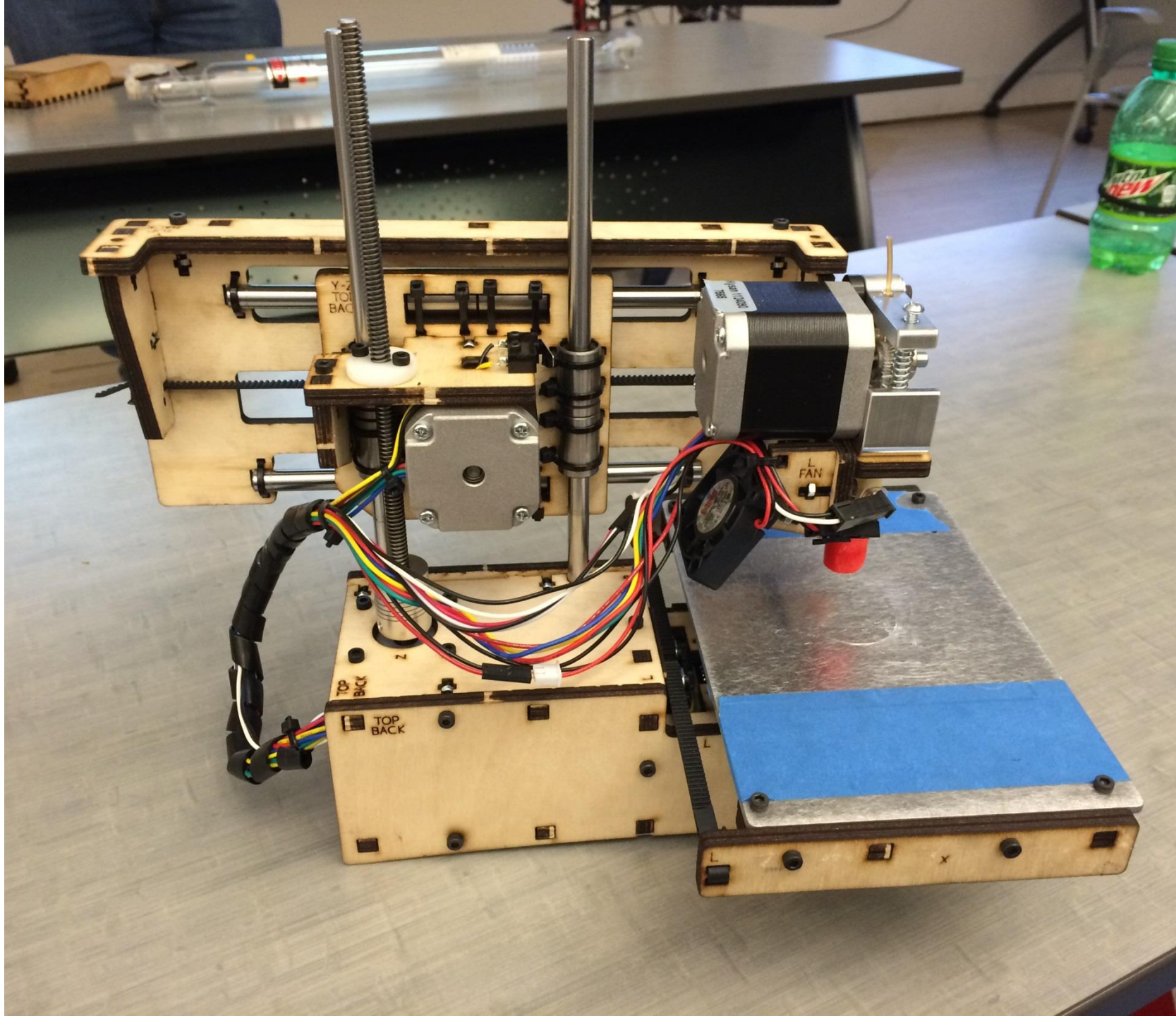
L
FAN
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BACK
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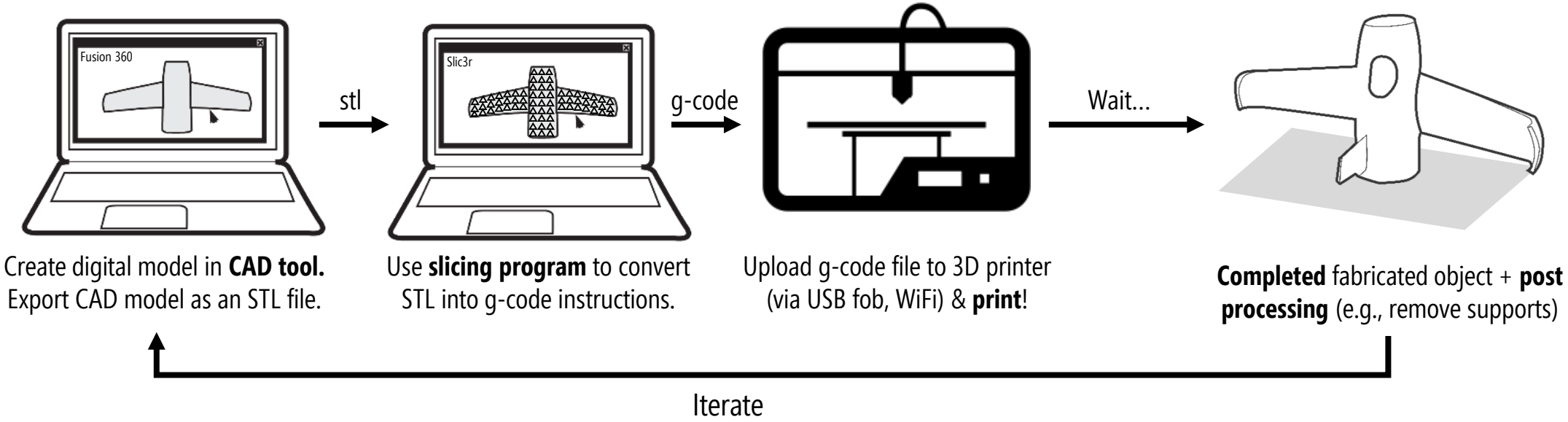
BACK

2015

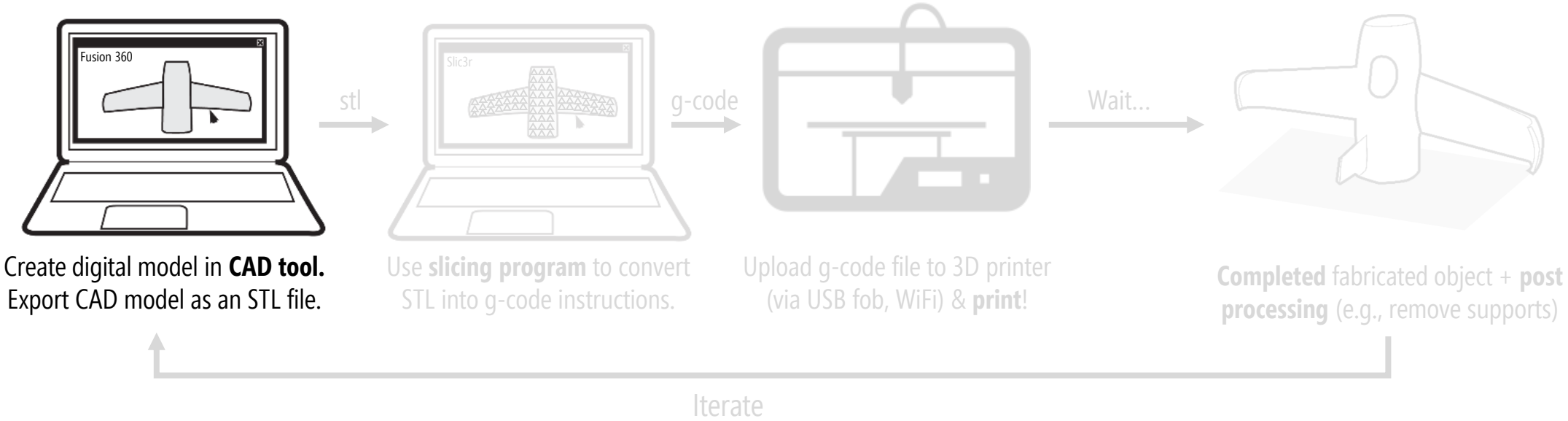
Stratasys Objet 500 Connex 3
16-micron. Works with 140 materials.
Multicolor. Cost: $330,000

ADDITIVE MANUFACTURING PROCESS



Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

ADDITIVE MANUFACTURING PROCESS



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STEP 1: CAD MODELING

COMMON CAD TOOLS IN INDUSTRY

Software	Description	Common File Type
SOLIDWORKS	**Solidworks** - Industry standard engineering software used for part and assembly modeling, includes simulation features as well as drawing and assembly tools.	.sldprt .sldasmsldrw
AUTODESK AUTOCAD	**AutoCAD** - Autodesk AutoCAD, a software package for 2D and 3D CAD, has been used since 1982! AutoCAD is used across a wide range of industries, by architects, project managers, engineers, graphic designers, and many other professionals.	.dwt .dwg
AUTODESK INVENTOR	**Inventor** - Inventor has very similar features to Solidworks, with professional 3D mechanical design, drawing tools, and product simulation tools.	.ipt .iam .idw
AUTODESK FUSION 360	**Fusion 360** - Autodesk Fusion 360 is gaining a lot of popularity with engineers and designers. It is similar to Solidworks, with the addition of integrated manufacturing tools and sculpting tools. It is also available for free for students, enthusiasts, hobbyists, and startups.	.f3d
SketchUp	**Sketchup** - Entry level software which is easy to use but with basic features. Mainly used for applications such as architectural models & interior design.	.skp
Solid Edge.	**Solid Edge** - Solid Edge provides solid modeling, assembly modelling and 2D orthographic view functionality for mechanical designers. Solid Edge is a direct competitor to SolidWorks, PTC Creo, and Autodesk Inventor.	.prt .asm

Software	Description	Common File Type
ptc	**Creo** - PTC Creo is a suite of design software with a focus on product design for discrete manufacturers. The suite consists of apps, each delivering a distinct set of capabilities within product development.	.prt .asm
Onshape	**Onshape** - Onshape is a full internet based CAD software package. It makes extensive use of cloud computing, with compute-intensive processing and rendering performed on Internet-based servers.	Cloud Only
Rhinoceros	**Rhino** - Multi-use, free form surface modeler for engineering, architecture and jewelry design.	.3dm
ZBRUSH	**ZBrush** - ZBrush is a digital sculpting tool that combines 3D/2.5D modeling, texturing and painting. The main difference between ZBrush and more traditional modeling packages is that it is more akin to sculpting.	.obj
AUTODESK 3DS MAX	**3ds Max** - Autodesk 3ds Max is a professional 3D computer graphics program for making 3D animations, models, games and images.	.3ds .max

Source: https://www.3dhubs.com/knowledge-base/3d-modeling-cad-software

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AUTODESK INVENTOR	**Inventor** - Inventor has very similar features to Solidworks, with professional 3D mechanical design, drawing tools, and product simulation tools.	.ipt .iam .idw
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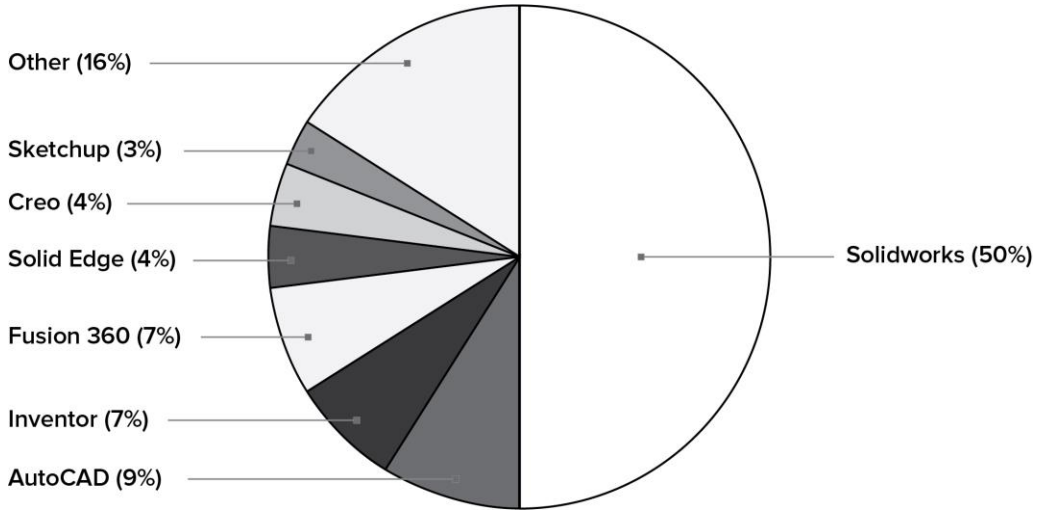
There is also Tinkercad, OpenSCAD, Blendr, Beetleblocks, CraftML, etc…

Source: https://www.3dhubs.com/knowledge-base/3d-modeling-cad-software

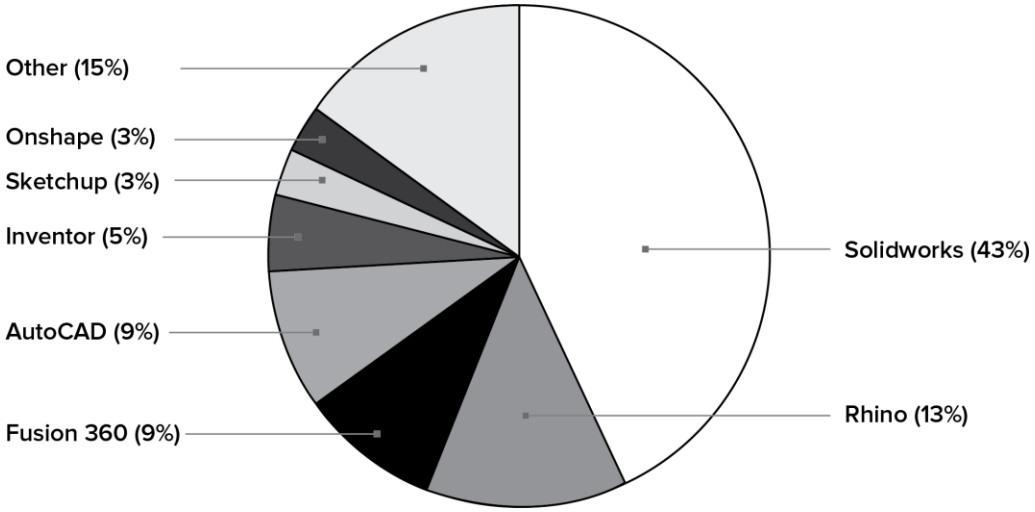
STEP 1: CAD MODELING

COMMON CAD TOOLS IN INDUSTRY

3D Hubs survey of 750 designers and engineers



CAD Software Used by Engineers



CAD Software Used by Designers

Source: https://www.3dhubs.com/knowledge-base/3d-modeling-cad-software

STEP 1: CAD MODELING

WHICH TOOL TO LEARN? WHICH TO TEACH?

Jon Froehlich
February 23 ·

Fabrication folks: I have previously taught a simple 3D fabrication module in my "Maker" grad course, which covers basic CAD modeling, physical world measurement (e.g., using calipers), and 3D printing. I initially used Tinkercad and then switched to Autodesk 123D; however, the latter is no longer offered. This quarter, Jennifer Mankoff and I decided to use Autodesk Fusion 360 (free to students) for a Masters in HCI+Design course; however, some students pushed back pretty hard because of the complexity (and, admittedly, I found 360 pretty hard to use as well). So, I'm at a crossroads: what should I use for teaching and therefore invest heavily in learning myself? From my research, talking to students, and talking to my grad student Liang He (a fab expert), it seems like the best two choices might be Fusion 360 or Rhinoceros (the latter *feels* easier to learn and Liang is strongly advocating for it). I will likely be adapting any teaching modules to the undergrad level as well. Thanks all for the thoughts/ideas.

CC Bjoern Hartmann Eric Paulos Stefanie Mueller Huaishu Peng

Like Comment Share

Bjoern Hartmann We use Fusion 360 and I ask Autodesk folks to come in and teach a two-session tutorial on it (4 hrs total).
Like · Reply · 12w

Huaishu Peng Our class used Autodesk Inventor but recently switched to Fusion 360. Along the similar line of parametric tool Onshape is also free for student and it's all browser based so nothing too much to install (I think the founder is from Solidworks). Rhino is quite popular among Architecture students but not so much for Engineering students.
Like · Reply · 12w 2

Daniel Ashbrook I use 360 in my prototyping class for HCI-MS students. I spent quite a lot of time finding the best tutorials I could as they're a non-technical bunch by and large. They didn't have many problems. Feel free to borrow: http://fetlab.rit.edu/720/assignments/3d_printing.html

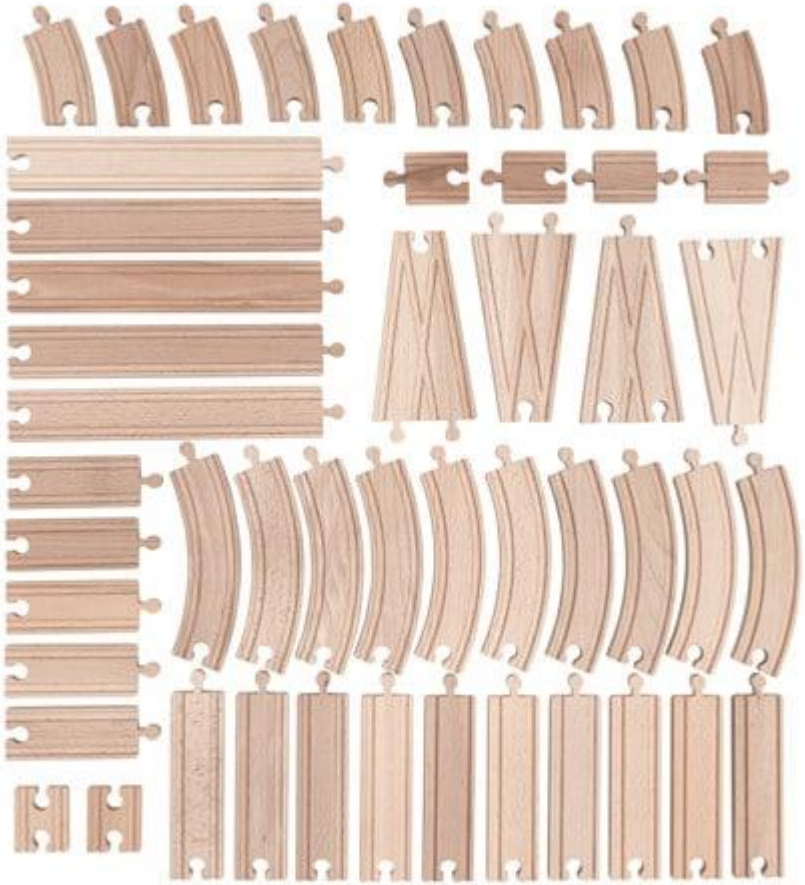
Eric Paulos Fusion 360...even our architecture students who come in already knowing rhino convert when they see it...I only show them the basics and we offer other support courses for it...I don't expect them to use all of it...even my 11 year old uses Fusion 360
Like · Reply · 11w 1

STEP 1: CAD MODELING

WE WILL USE AUTODESK FUSION 360

STEP 1: CAD MODELING

EXAMPLE: TRAIN TRACKS



STEP 0: MEASUREMENT

MEASURING!

D:\Dropbox\3DPrinting\JonTrainTracks\Notes.txt - Notepad++

File Edit Search View Encoding Language Settings Tools Macro Run Plugins Window ?

Notes.txt

```
Ikea Straight Train Track
Width: 39.29mm
Total Length: 160mm
Total length minus connector: 145mm (or more like 145.15mm on caliper)
Depth: 12.03mm

For the track trough itself:
Track starts at: 4.37mm into the width
Track is: 5.90mm wide
From bottom to beginning of trough: 9mm
Trough depth: 3mm

The connector:
Straight part is 5.25mm wide
Is 6mm long
Circle is 11.14mm in diameter (5.57 in radius)

Ikea Curved Train Track
Width: 40mm

Female connector
6.46 width inner chamber
12.56 diameter (6.28mm)
4.17 inner length
```

Normal text file | length : 1,138 | lines : 35 | Ln : 34 | Col : 42 | Sel : 0 | 0 | Windows (CR LF) | UTF-8 | IN

STEP 1: CAD MODELING

CREATING CUSTOM TRAIN TRACKS

Source: Jon Froehlich

Autodesk Fusion 360

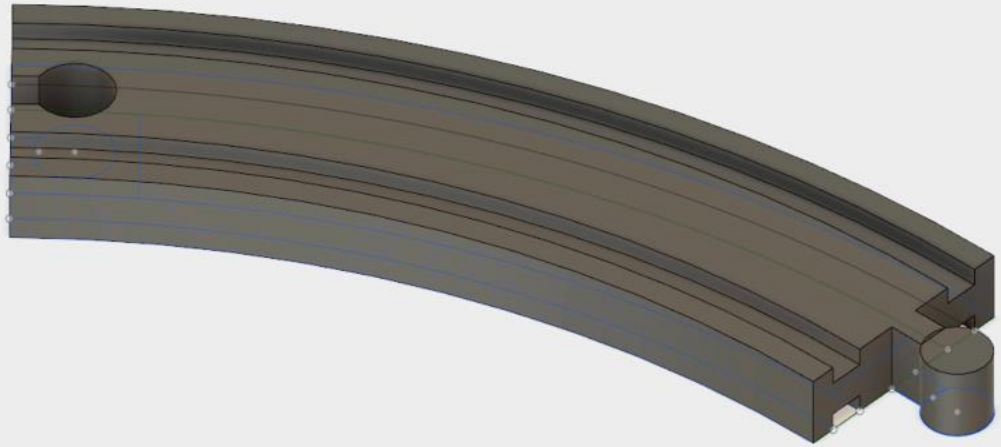
Ikea Curv...Track v9*

MODEL

SKETCH CREATE MODIFY ASSEMBLE CONSTRUCT INSPECT INSERT MAKE ADD-INS SELECT

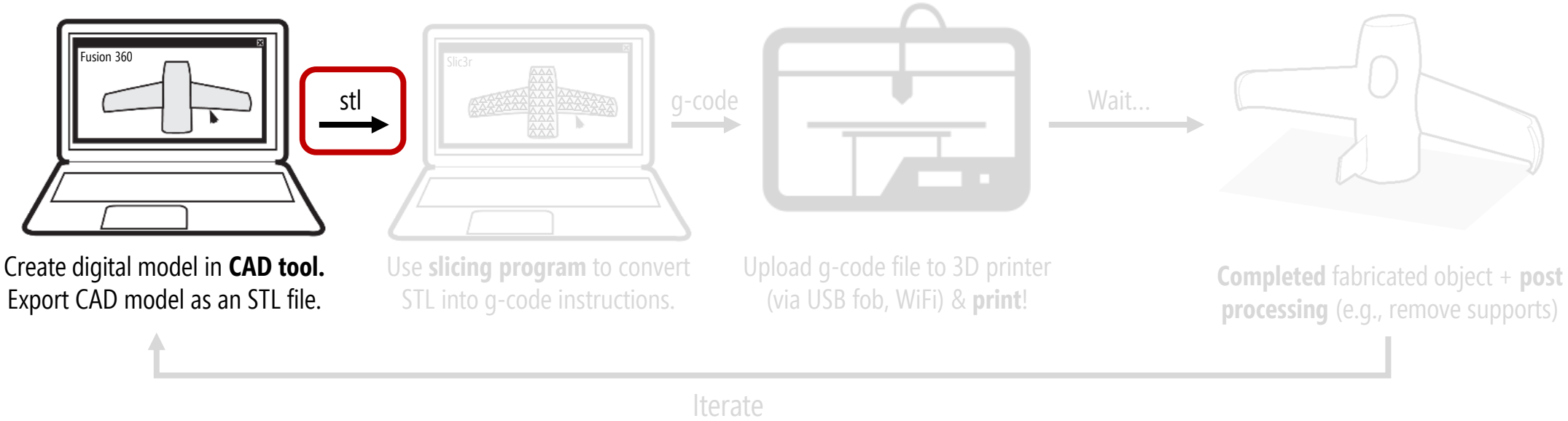
BROWSER

- Ikea Curved Train Track v9
  - Document Settings
  - Named Views
  - Origin
  - Bodies
    - Track
  - Canvases
    - IMG_3488
  - Sketches
    - Sketch1
    - Sketch2



COMMENTS

ADDITIVE MANUFACTURING PROCESS

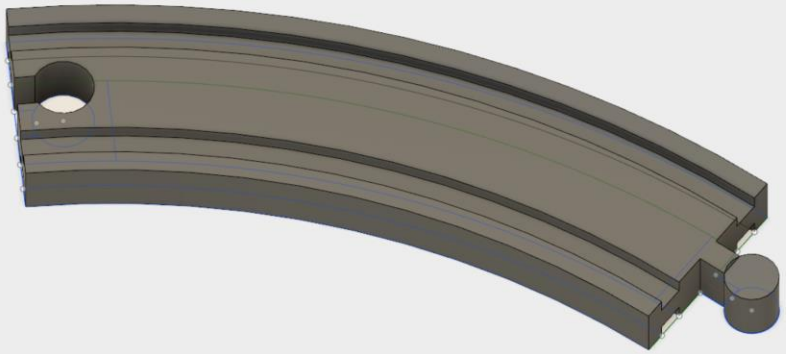


Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

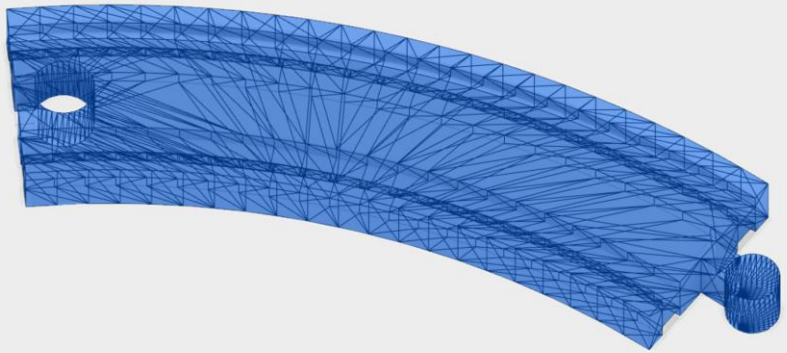
STEP 2: EXPORT TO STL FILE

EXPORT CAD MODEL AS STL (TRIANGLE MESH)

The STL (Standard Triangle Language) is the industry standard file type for 3D printing. It uses linked triangles to represent the geometry of the solid model (aka a triangle mesh). All modern CAD tools allow you to export their native file format into STL.



Raw CAD Model



Converted to STL

See also: https://www.3dhubs.com/knowledge-base/3d-printing-stl-files-step-step-guide

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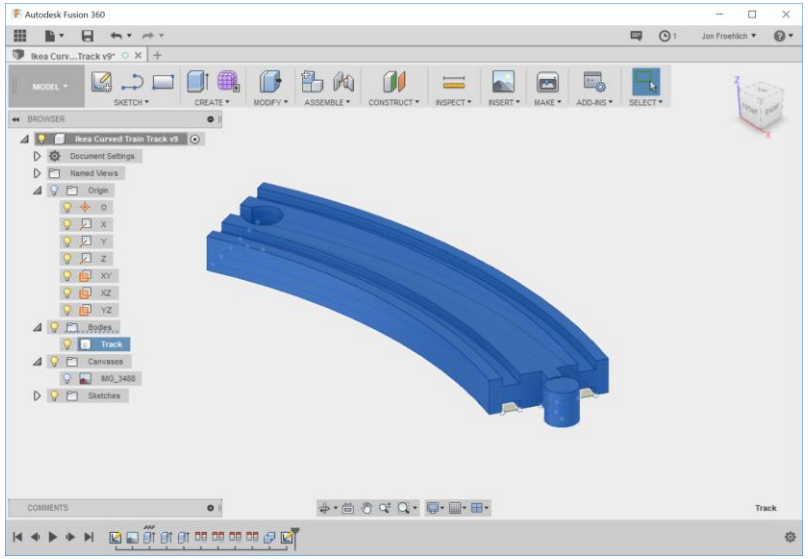
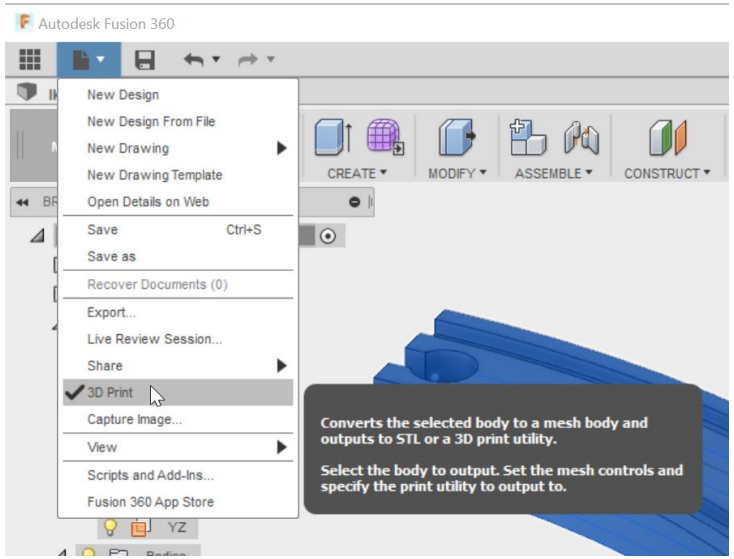
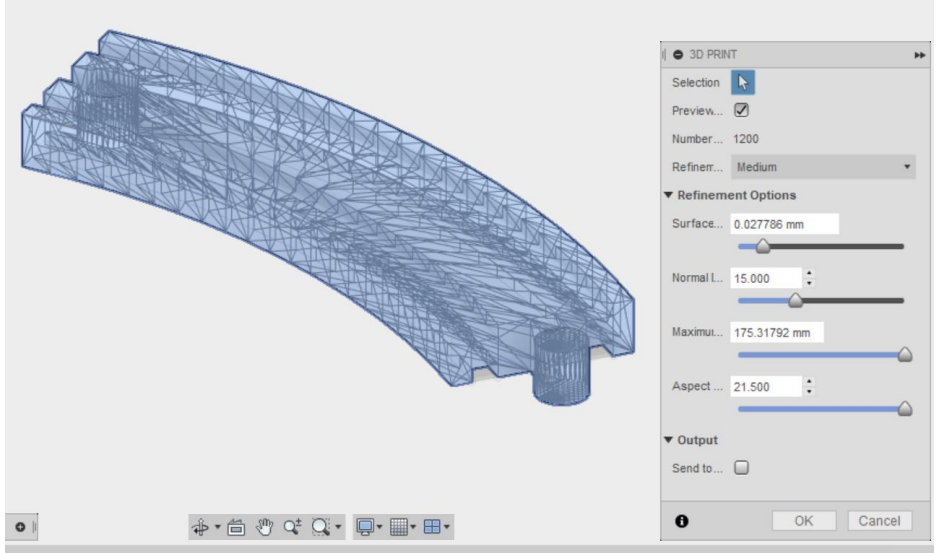


CAD Model in Fusion 360



Select File -> 3D Print

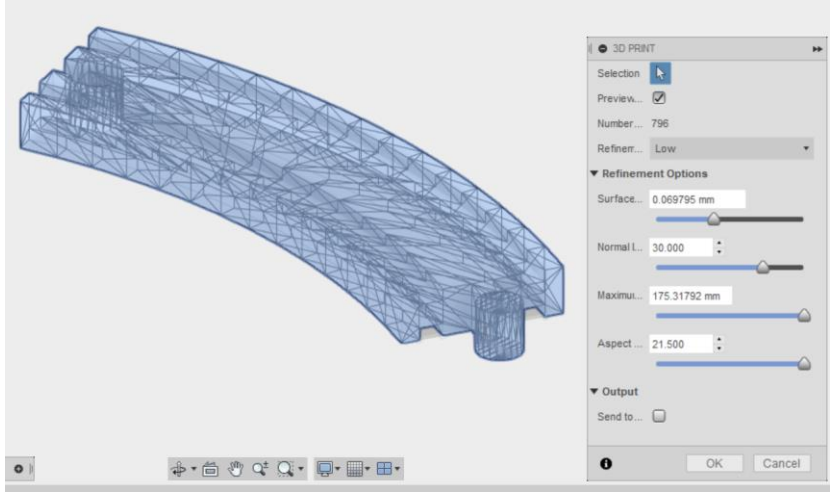


3D Print dialog allows you to customize export

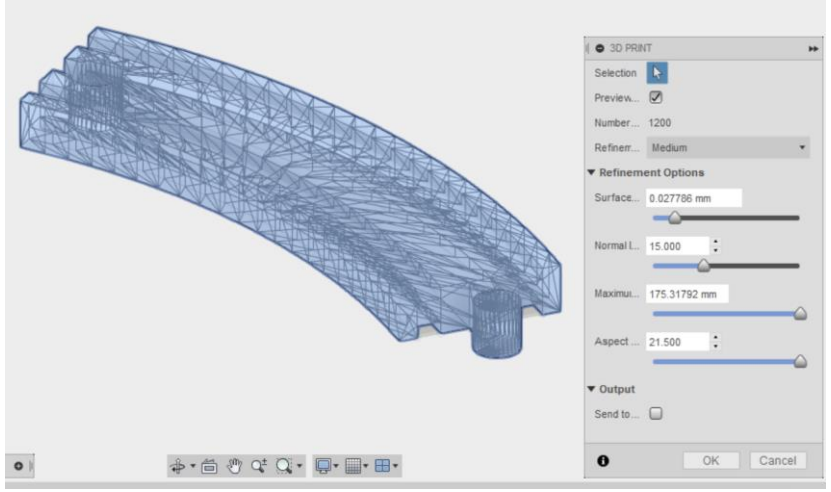
See also: https://www.3dhubs.com/knowledge-base/3d-printing-stl-files-step-step-guide

STEP 2: EXPORT TO STL FILE

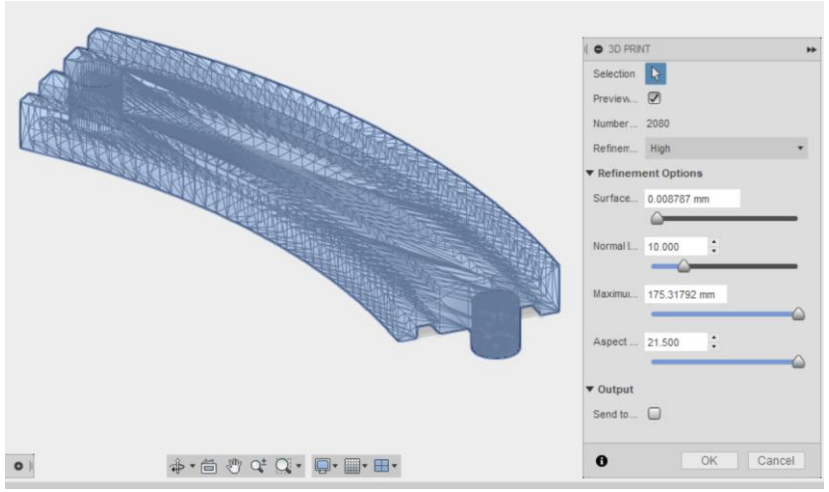
CONFIGURING EXPORT RESOLUTION (# OF TRIANGLES)



Export Quality: Low
Number of triangles: 796



Export Quality: Medium
Number of triangles: 1200



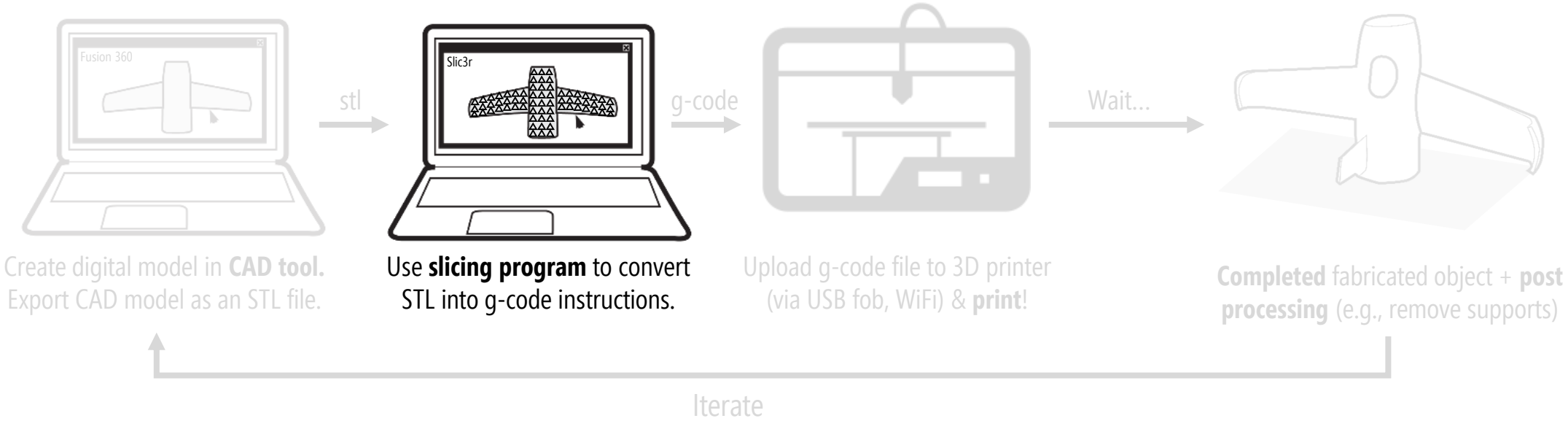
Export Quality: High
Number of triangles: 2080

Number of triangles

Typically the default export quality is fine. If you export at too low of resolution, the model will have visible triangles on its surface when printed. Increasing the resolution too much (*e.g.,* beyond capabilities of printer) will just lead to file bloat and print difficulties.

See also: https://www.3dhubs.com/knowledge-base/3d-printing-stl-files-step-step-guide

ADDITIVE MANUFACTURING PROCESS

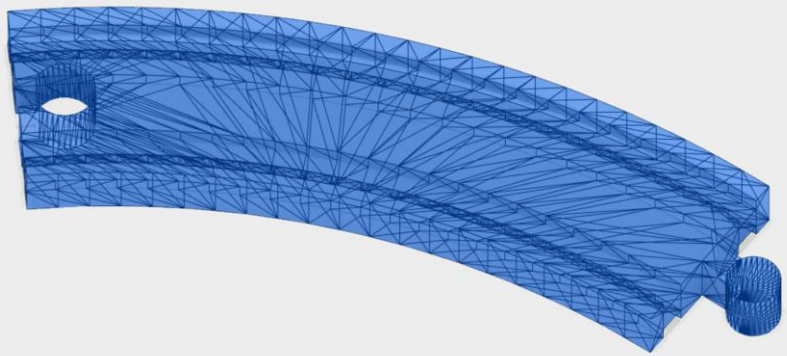


Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

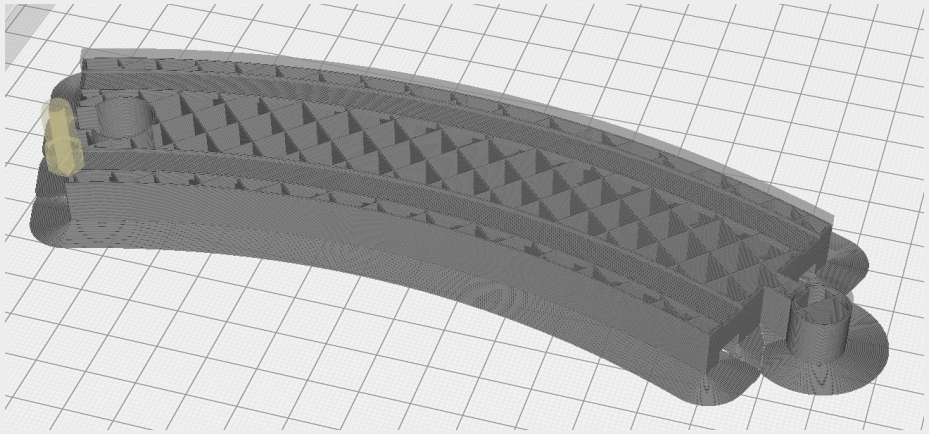
STEP 3: SLICING & GENERATING G-CODE

SLICERS CONVERT STLS INTO PRINTER INSTRUCTIONS

While STL is an industry standard file type for geometrical models, this needs to be converted into printing instructions your 3D printer can understand (g-code). Slicers cut the model into horizontal slices (layers), generate toolpaths to fill them, and calculate the amount of material to be extruded.



Load STL file into slicing program



Slicer will create g-code (toolpath) instructions for printer

STEP 3: SLICING & GENERATING G-CODE

JUST LIKE CAD TOOLS, LOTS OF DIFFERENT SLICERS

Software	User	Price	OS
3DPrinterOS	Beginners, Advanced Users	Freemium	Browser, Windows, Mac
Astroprint	Beginners, Advanced Users	Freemium	Browser, Raspberry Pi, pcDuino
Craftware	Beginners, Advanced Users	Free	Windows, Mac
Cura	Beginners, Advanced Users	Free	Windows, Mac, Linux
IceSL	Advanced Users	Free	Windows, Linux
KISSlicer	Beginners, Advanced Users	Free/$35	Windows, Mac, Linux, Raspberry Pie
MakerBot Print	Beginners	Free	Windows, Mac
MatterControl	Beginners, Advanced Users	Free	Windows, Mac, Linux
Netfabb Standard	Intermediate Users, Advanced Users	$1,000 to $4,300 (annual subscription)	Windows

Software	User	Price	OS
OctoPrint	Intermediate Users, Advanced Users	Free	Raspberry Pi, Windows, Mac Linux
Repetier	Intermediate Users, Advanced Users	Free	Windows, Mac, Linux
SelfCAD	Beginner, Advanced Users	Free trial, $9.99/month	Browser
Simplify3D	Beginners, Advanced Users	$150	Windows, Mac
Slic3r	Advanced Users, Professional Users	Free	Windows, Mac, Linux
SliceCrafter	Advanced Users	Free	Browser
Tinkerine Suite	Beginners	Free	Windows, Mac
Z-Suite	Beginners	Free	Windows, Mac

https://all3dp.com/1/best-3d-slicer-software-3d-printer/

STEP 3: SLICING & GENERATING G-CODE

ONE OF THE MOST POPULAR: ULTIMAKER CURA

Ultimaker Cura software

Ultimaker Cura prepares your model for 3D printing. Optimized, expert-tested profiles for 3D printers and materials mean you can start printing reliably in no time. And with industry-standard software integration, you can streamline your workflow for maximum efficiency.

Windows
Ultimaker Cura 3.3.1
(64 bit)

Download for free

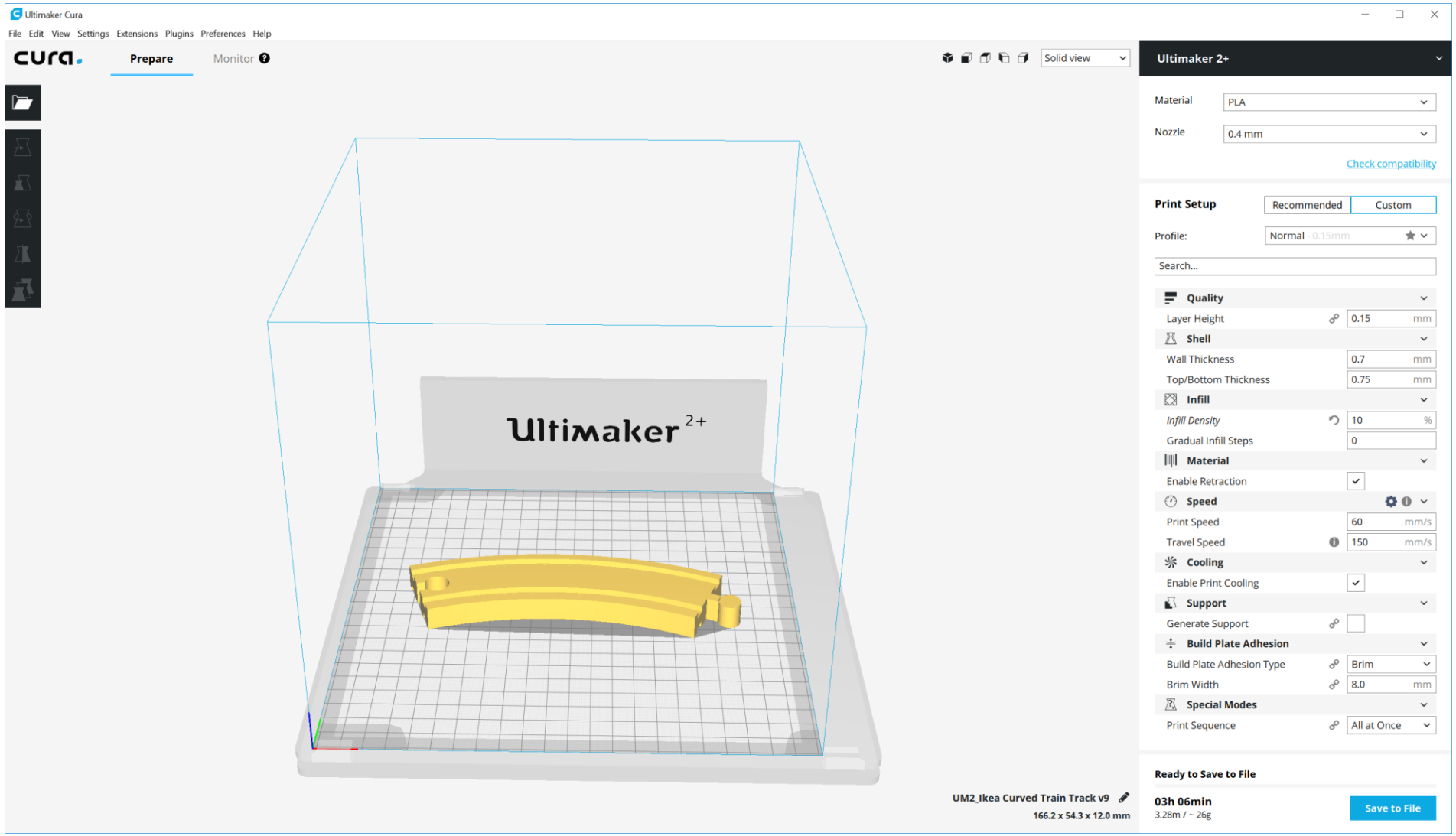
View the Ultimaker Cura manual

View all versions

Release notes

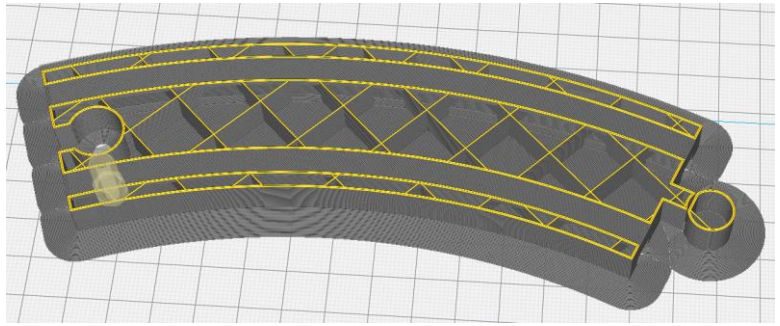
STEP 3: SLICING & GENERATING G-CODE

ULTIMAKER CURA

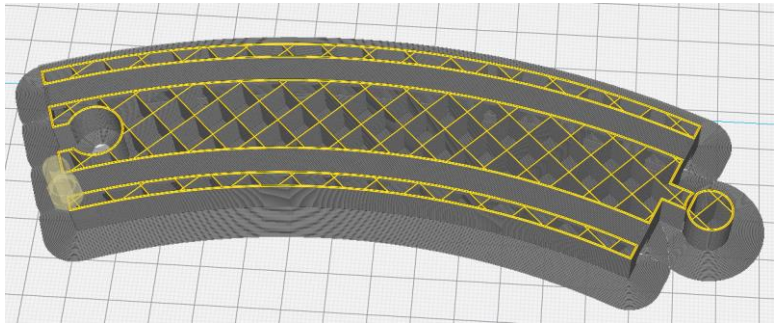


Common slicer settings (some are machine dependent)

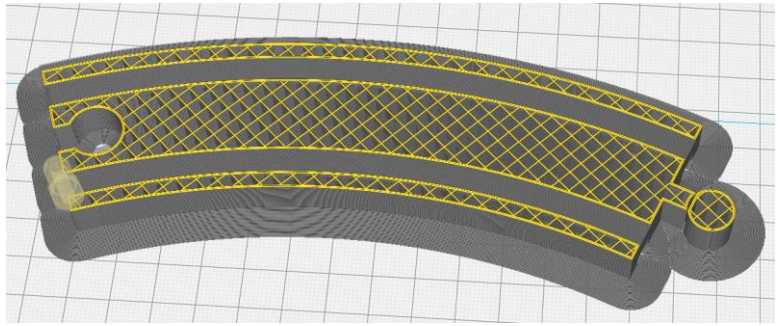
EXAMPLE SLICER SETTINGS: INFILL



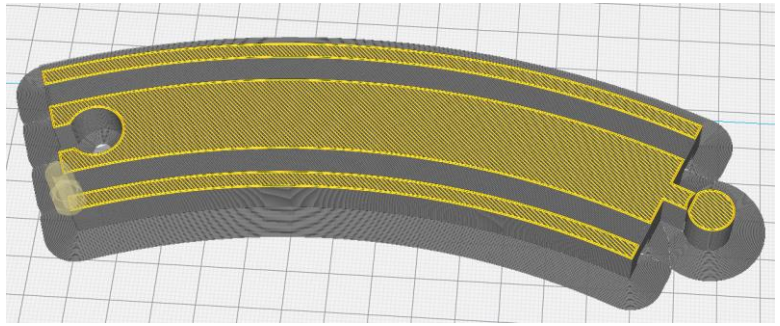
Infill Density: 5%
Estimated print time: 2h 53min
Estimated filament: 2.92 m / ~23g



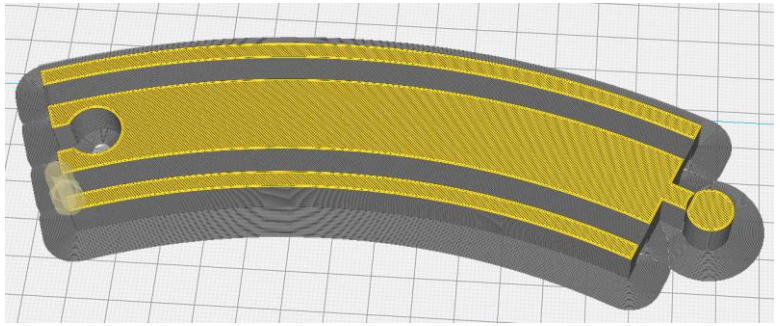
Infill Density: 10%
Estimated print time: 3h 06min
Estimated filament: 3.28 m / ~26g



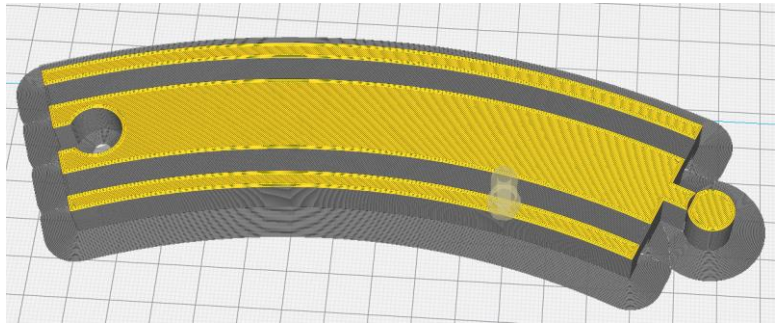
Infill Density: 25%
Estimated print time: 3h 35min
Estimated filament: 3.99 m / ~32g



Infill Density: 50%
Estimated print time: 4h 58min
Estimated filament: 6.13 m / ~48g

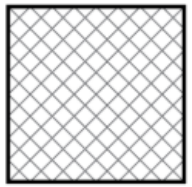
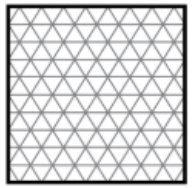


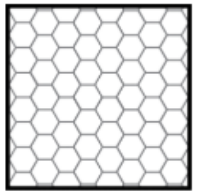
Infill Density: 70%
Estimated print time: 4h 58min
Estimated filament: 6.13 m / ~48g



Infill Density: 100%
Estimated print time: 10h 53min
Estimated filament: 9.65 m / ~76g

SLICER SETTINGS: INFILL GEOMETRY

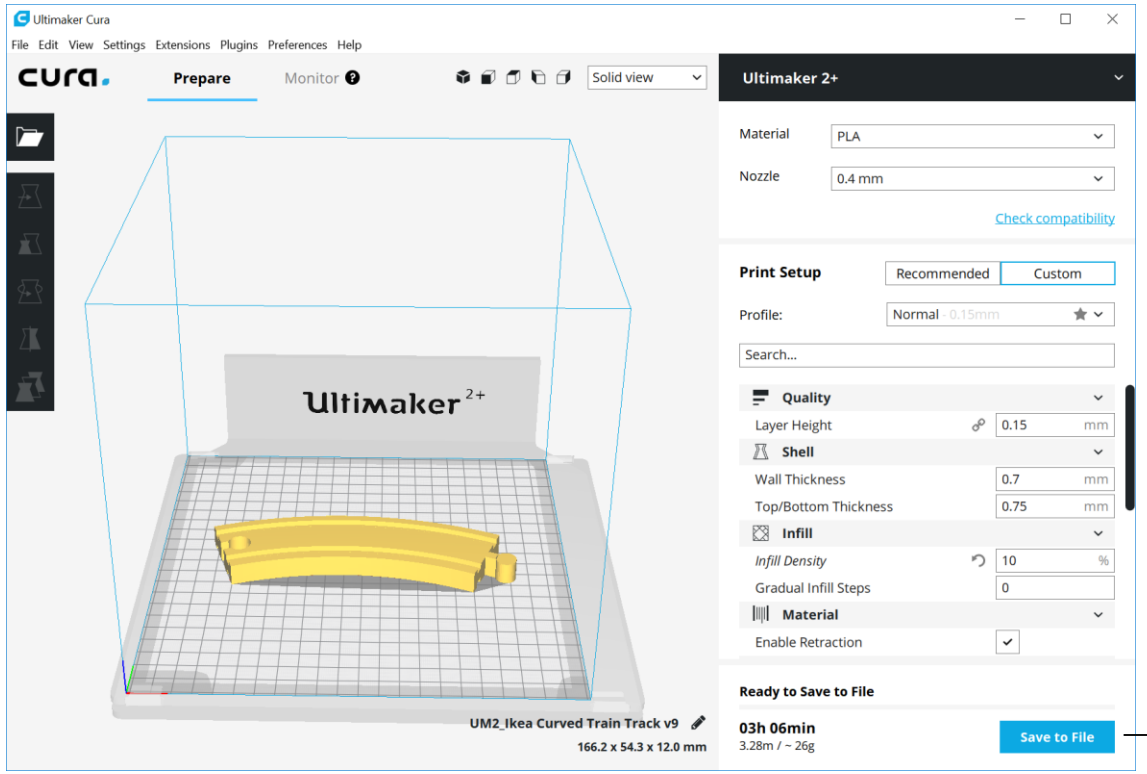
Infill geometry	Description
	**Rectangular** - Standard infill pattern for FDM prints. Has strength in all directions and is reasonably fast to print. Requires the printer to do the least amount of bridging across the infill pattern.
	**Triangular or diagonal** - Used when strength is needed in the direction of the walls. Triangles take a little longer to print.

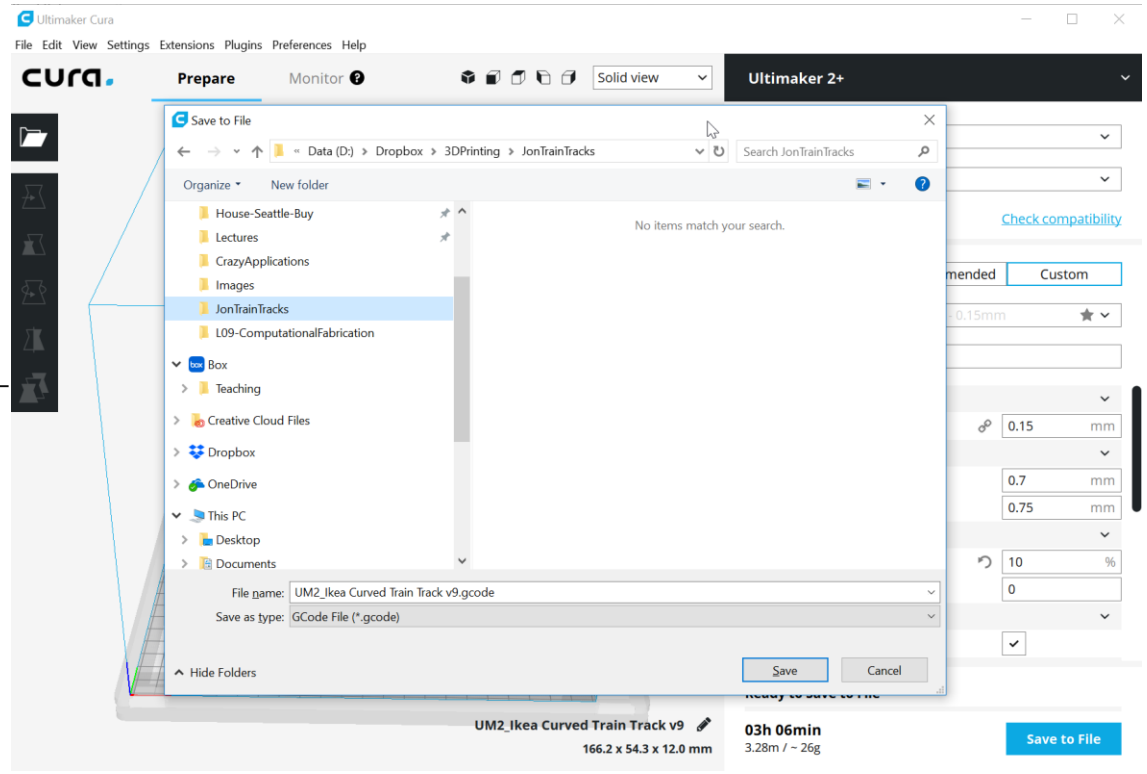
Infill geometry	Description
	Wiggle - Allows the model to be soft, to twist, or to compress. Can be a good choice particularly with a soft rubbery material or softer nylon.
	**Honeycomb** - Popular infill. It is quick to print and is very strong, providing strength in all directions.

Source: https://www.3dhubs.com/knowledge-base/selecting-optimal-shell-and-infill-parameters-fdm-3d-printing

STEP 3 & GENERATING G-CODE

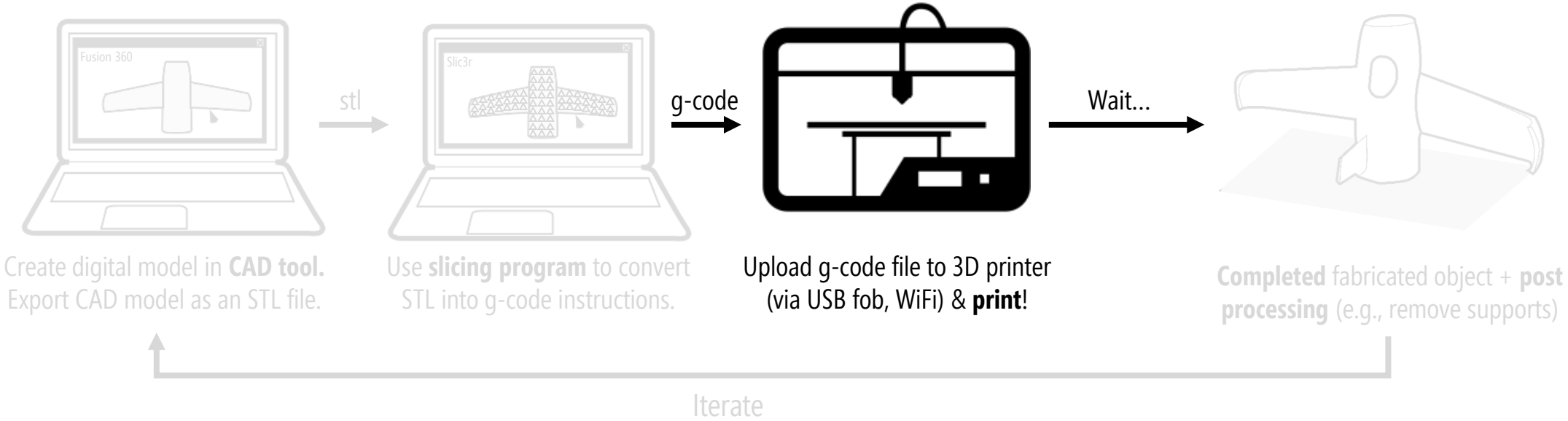
SLICER SAVE TO FILE: GCODE





Source: https://www.3dhubs.com/knowledge-base/selecting-optimal-shell-and-infill-parameters-fdm-3d-printing

ADDITIVE MANUFACTURING PROCESS



Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

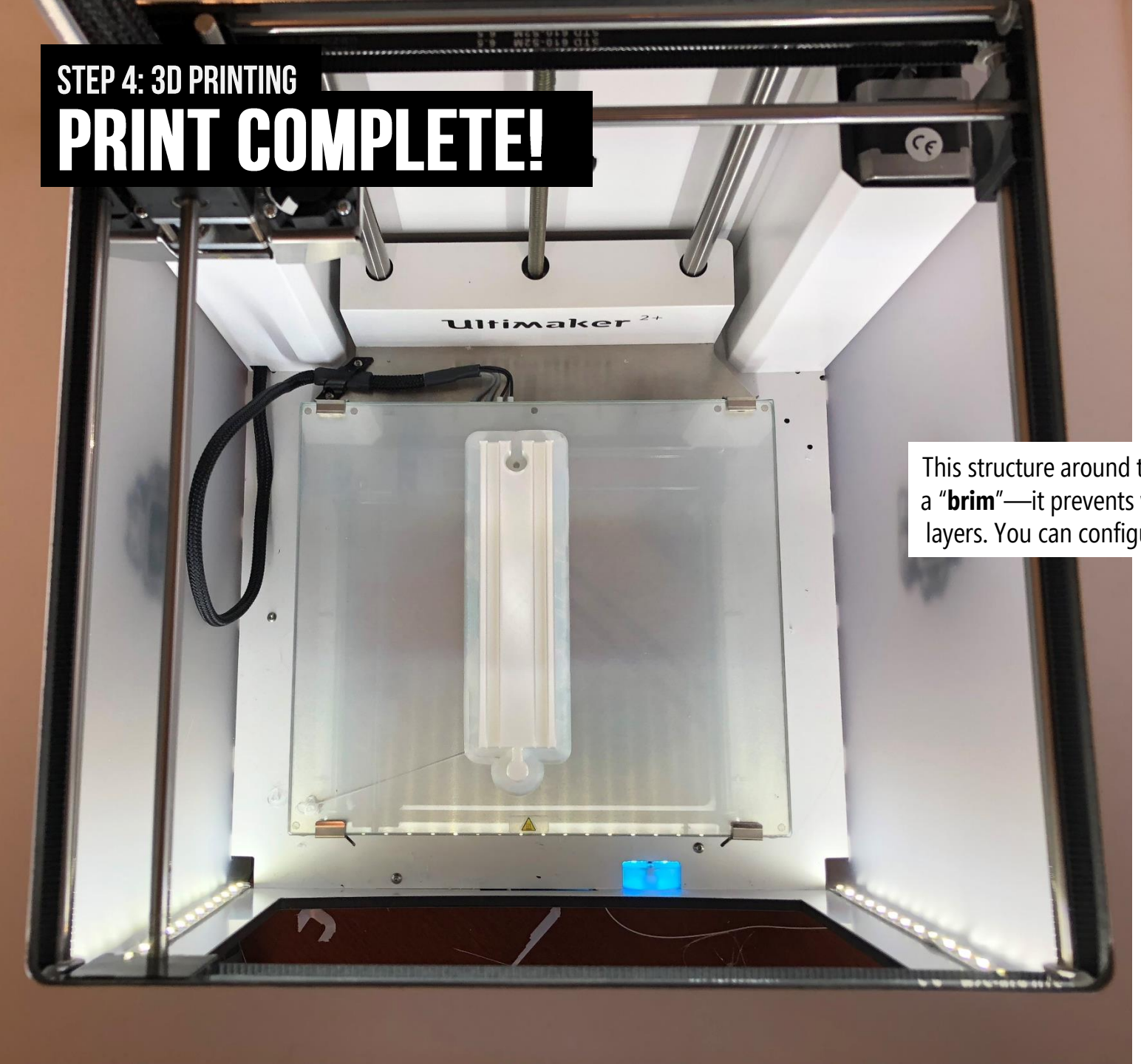
STEP 4: 3D PRINTING

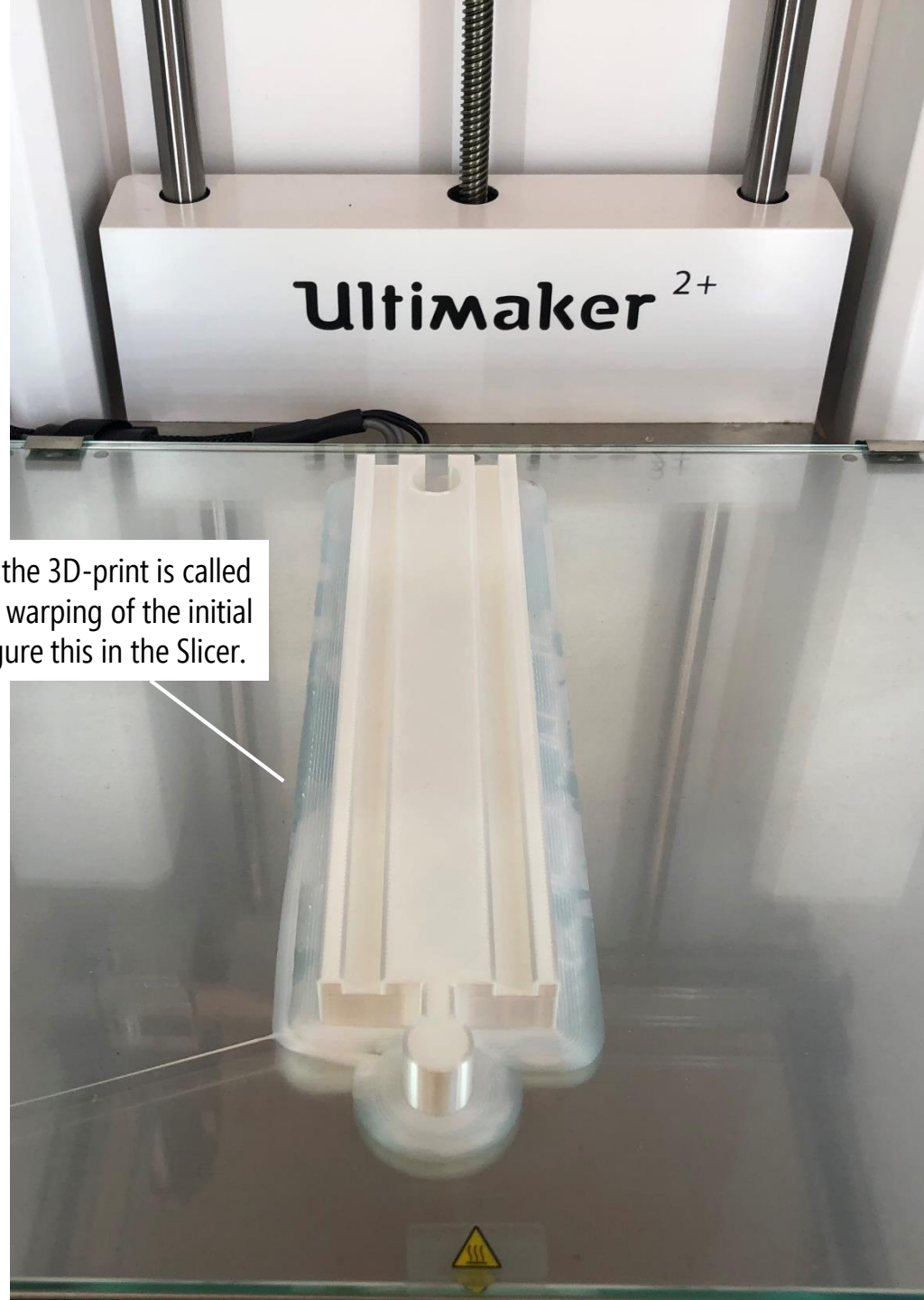
PRINTING ON AN ULTIMAKER 2+

Source: Jon Froehlich

STEP 4: 3D PRINTING

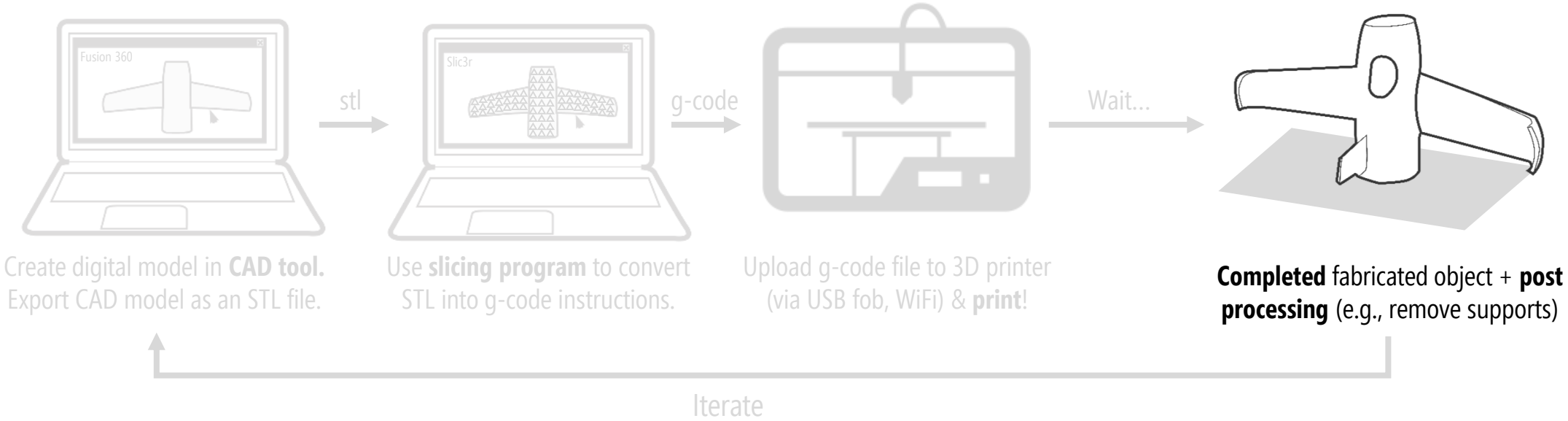
PRINT COMPLETE!





This structure around the 3D-print is called a "**brim**"—it prevents warping of the initial layers. You can configure this in the Slicer.

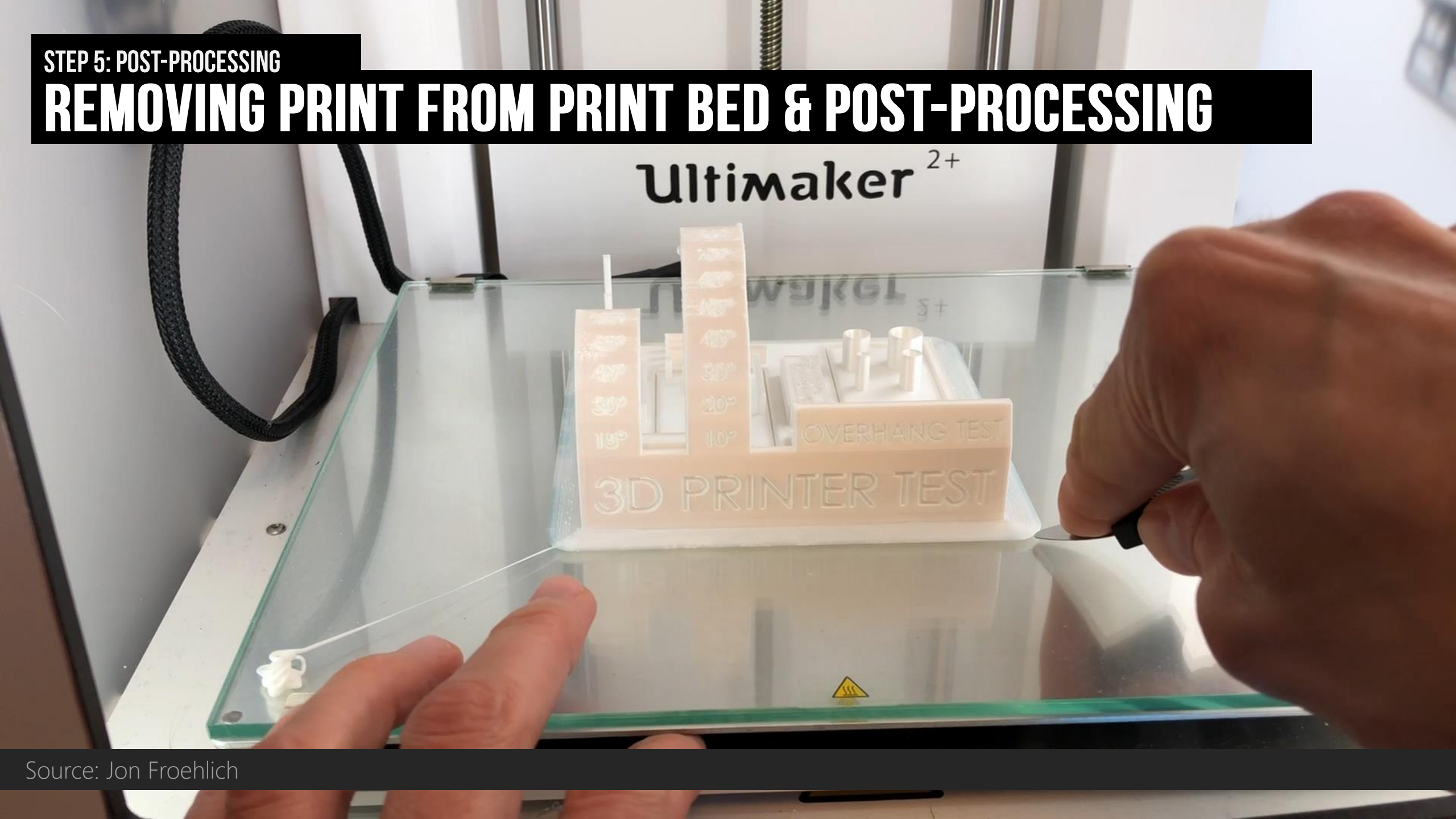
ADDITIVE MANUFACTURING PROCESS



Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

STEP 5: POST-PROCESSING

REMOVING PRINT FROM PRINT BED & POST-PROCESSING



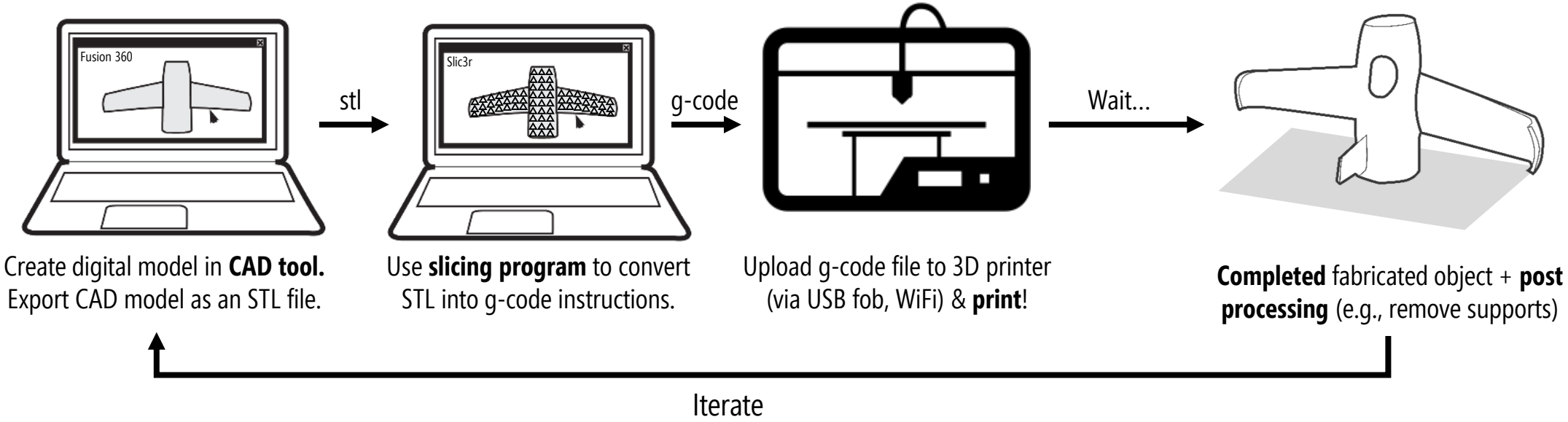
Source: Jon Froehlich

Ultimaker 2+
OVERHANG TEST
3D PRINTER TEST

STEP 6: TEST YOUR DESIGNS! ☺

TEST AND ITERATE ON YOUR DESIGNS

ANY QUESTIONS ABOUT THIS?



Slide based on Huaishu Peng's job talk; See also: https://www.3dhubs.com/knowledge-base/additive-manufacturing-process

3D-PRINTING CONSIDERATIONS

Overhangs

Cracking & warping

Part orientation

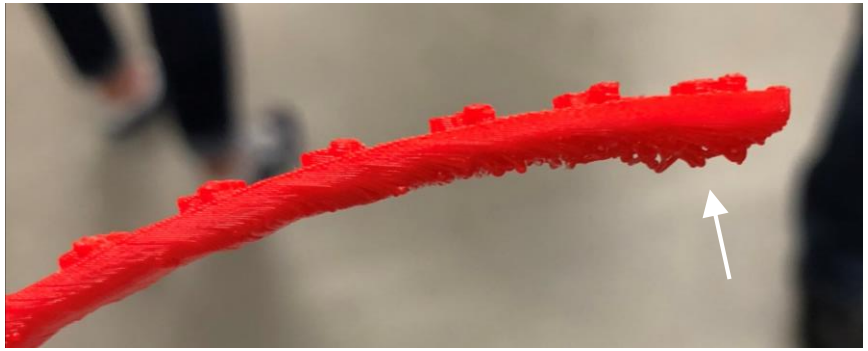
Cost

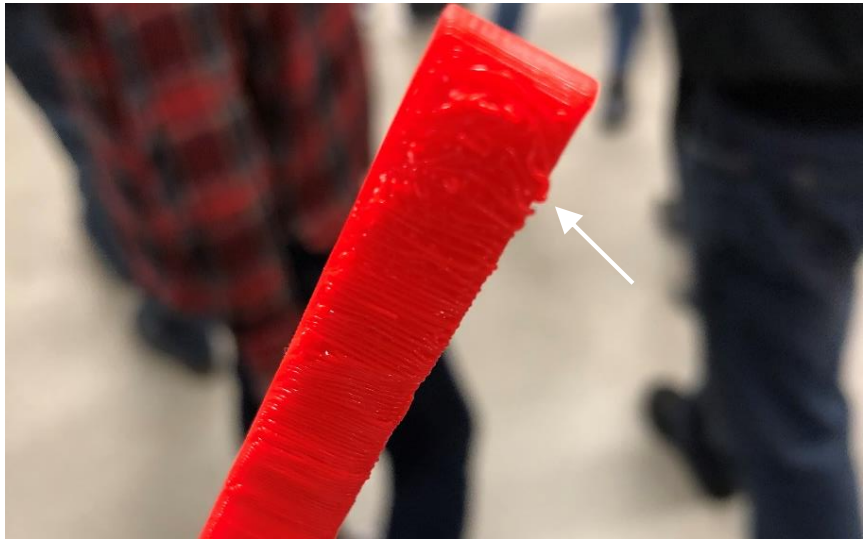
Materials

3D-PRINTING CONSIDERATIONS

OVERHANGS

3D-printing builds parts layer-by-layer. Material cannot be deposited into thin air, so every layer must be printed on some underlying layer. The maximum angle for FDM printing without an overhang is 45 degrees (as the pictures below demonstrate; see also parts passed around in class).

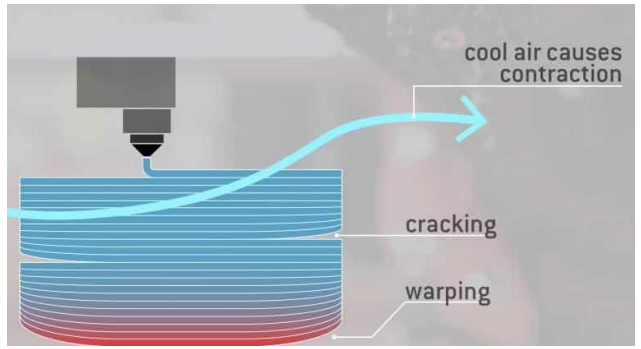


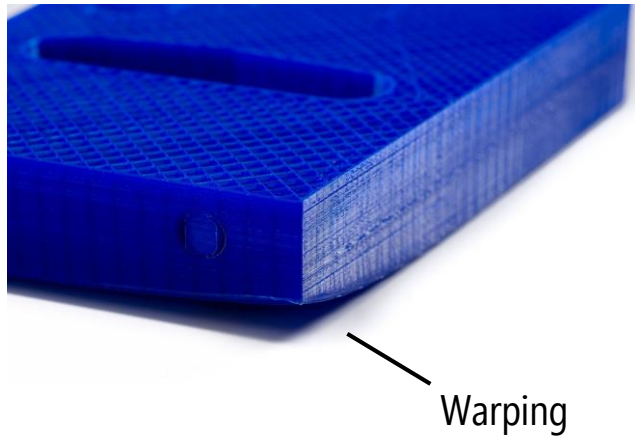


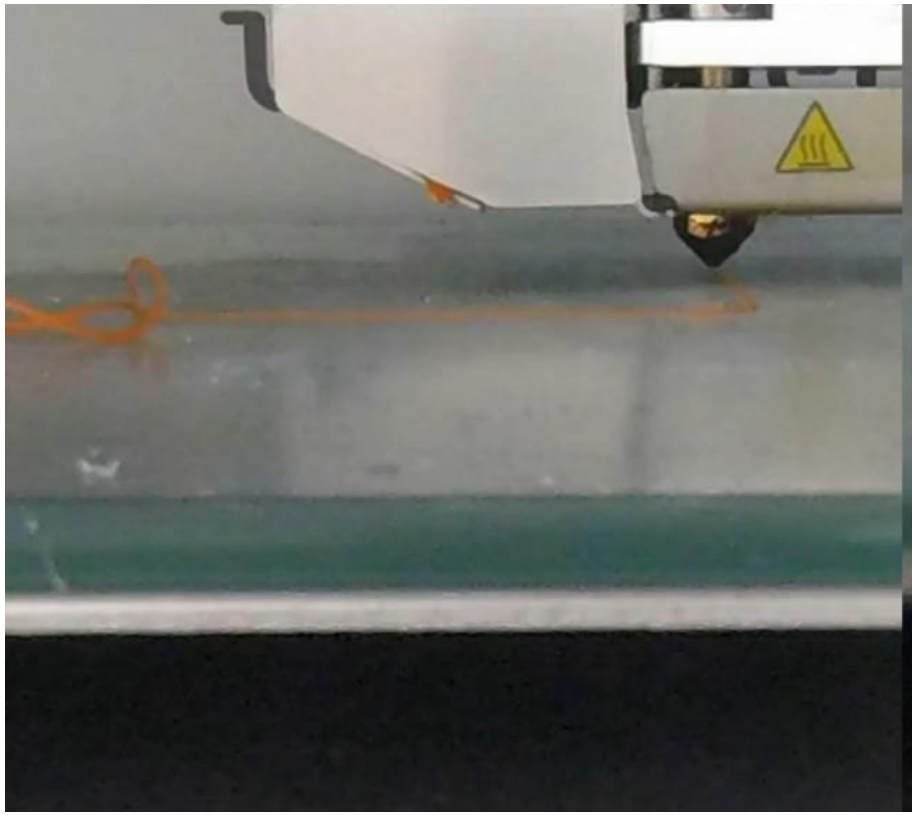
Images by Jon Froehlich; See: https://www.3dhubs.com/knowledge-base/key-design-considerations-3d-printing

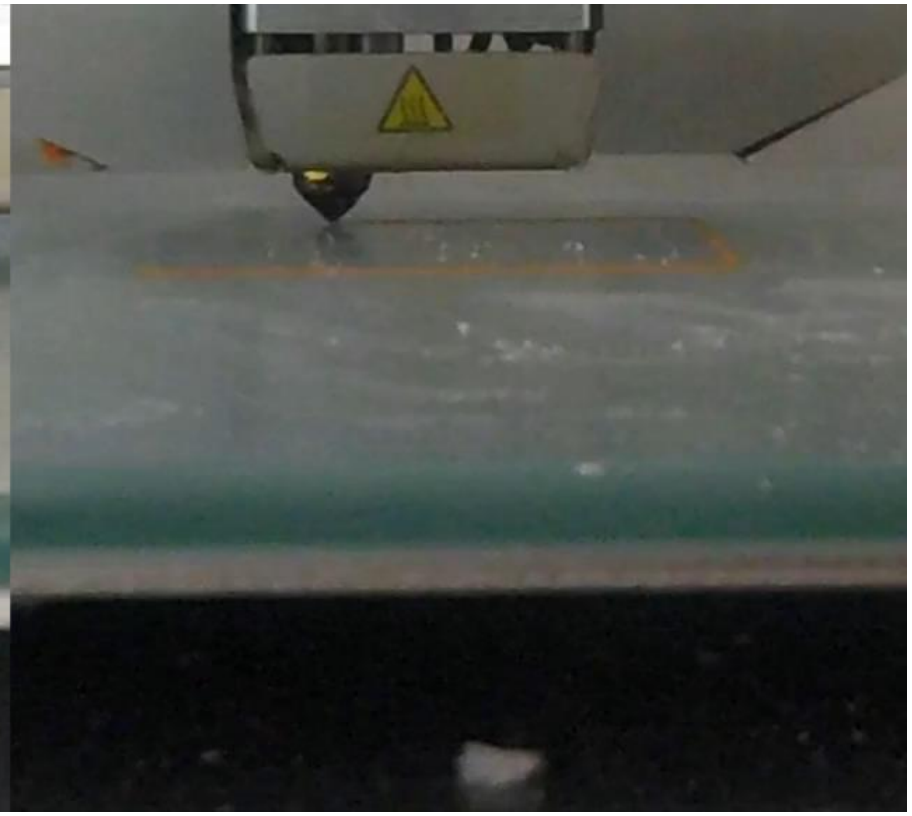
CRACKING & WARPING

Cracking and warping is caused by the shrinking of material as it is cooled. To avoid warping, try a different filament material or controlling environmental conditions. Large, flat surfaces can be especially prone to warping. Make sure the first layers properly adhere to print bed.





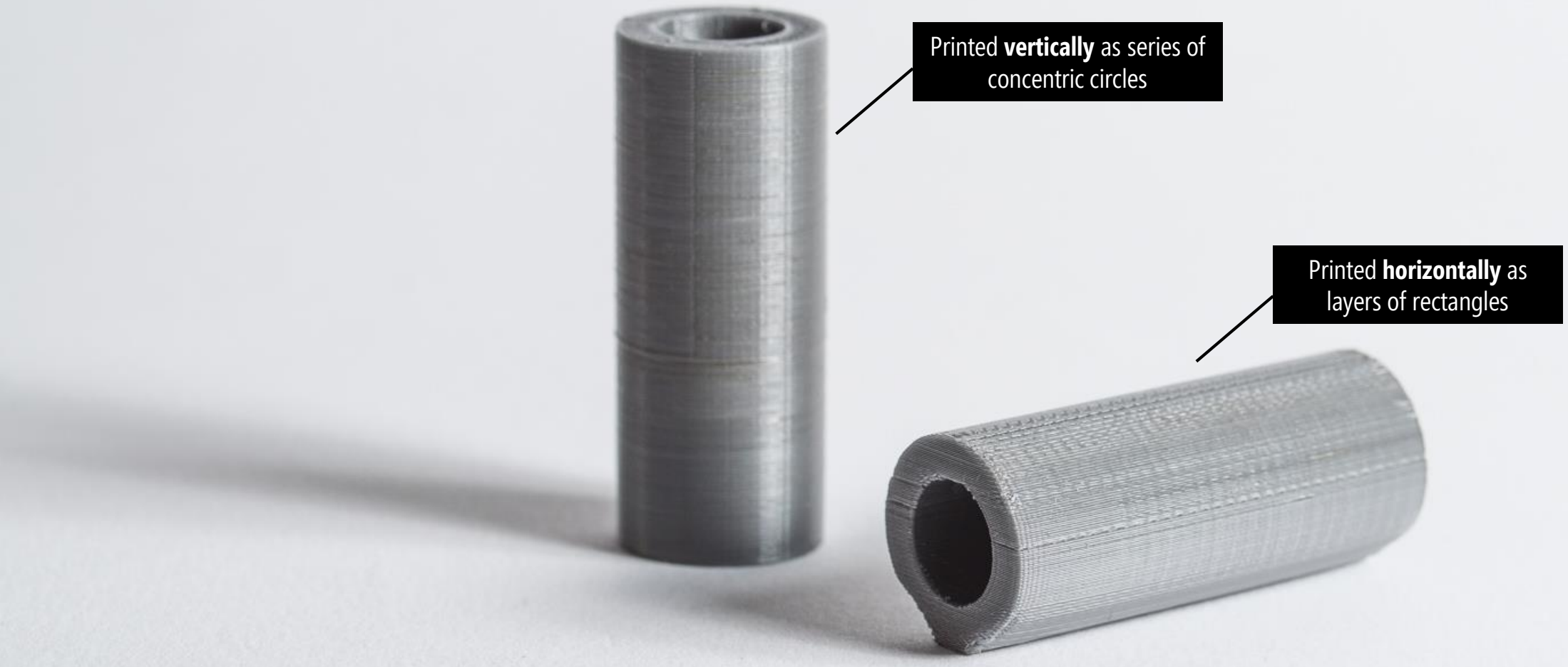




Source: https://www.3dhubs.com/knowledge-base/key-design-considerations-3d-printing; https://box3d.eu/warping-cracking-closed-environment-3d-printers/

3D-PRINTING CONSIDERATIONS

PART ORIENTATION



https://www.3dhubs.com/knowledge-base/how-does-part-orientation-affect-3d-print

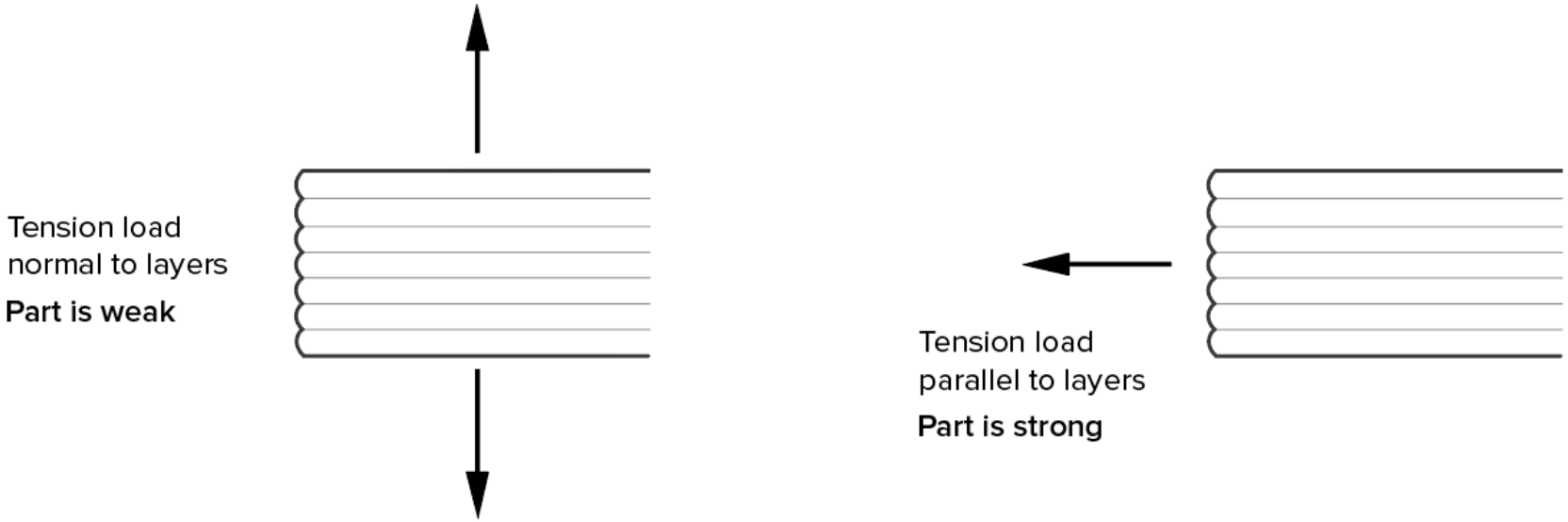
PART ORIENTATION HAS A SIGNIFICANT IMPACT

Part accuracy & aesthetic. As shown on the previous slide, orientation can affect part accuracy and aesthetic

Print time. Orientation can also impact print time. At 0.1mm layer height, for example, the horizontal cylinder will be printed with ~100 layers vs. the vertical at 300 layers.

Part strength. FDM parts are much more likely to delaminate and fracture with tension in the Z-direction (*i.e.*, pulling at the layers). Parts are much stronger in the XY direction.

https://www.3dhubs.com/knowledge-base/how-does-part-orientation-affect-3d-print



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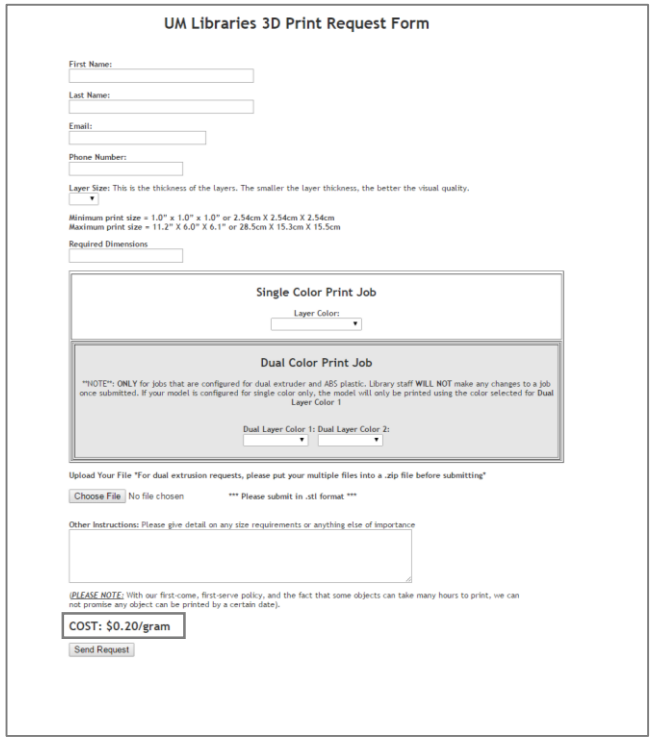
Part strength. FDM parts are much more likely to delaminate and fracture with tension in the Z-direction (*i.e.*, pulling at the layers). Parts are much stronger in the XY direction.

Support structure. It's often worth selecting a print orientation that minimizes support structures (to save money, time, and aesthetics).

https://www.3dhubs.com/knowledge-base/how-does-part-orientation-affect-3d-print

3D PRINTING CONSIDERATIONS

COSTS: FILAMENT



UM Libraries 3D Print Request Form

First Name:

Last Name:

Email:

Phone Number:

Layer Size: This is the thickness of the layers. The smaller the layer thickness, the better the visual quality.

Minimum print size = 1.0" x 1.0" x 1.0" or 2.54cm X 2.54cm X 2.54cm
Maximum print size = 11.2" X 6.0" X 6.1" or 28.5cm X 15.3cm X 15.5cm

Required Dimensions

Single Color Print Job

Layer Color:

Dual Color Print Job

NOTE: ONLY for jobs that are configured for dual extruder and ABS plastic. Library staff WILL NOT make any changes to a job once submitted. If your model is configured for single color only, the model will only be printed using the color selected for Dual Layer Color 1

Dual Layer Color 1: Dual Layer Color 2:

Upload Your File *For dual extrusion requests, please put your multiple files into a .zip file before submitting*

Choose File No file chosen *** Please submit in .stl format ***

Other Instructions: Please give detail on any size requirements or anything else of importance

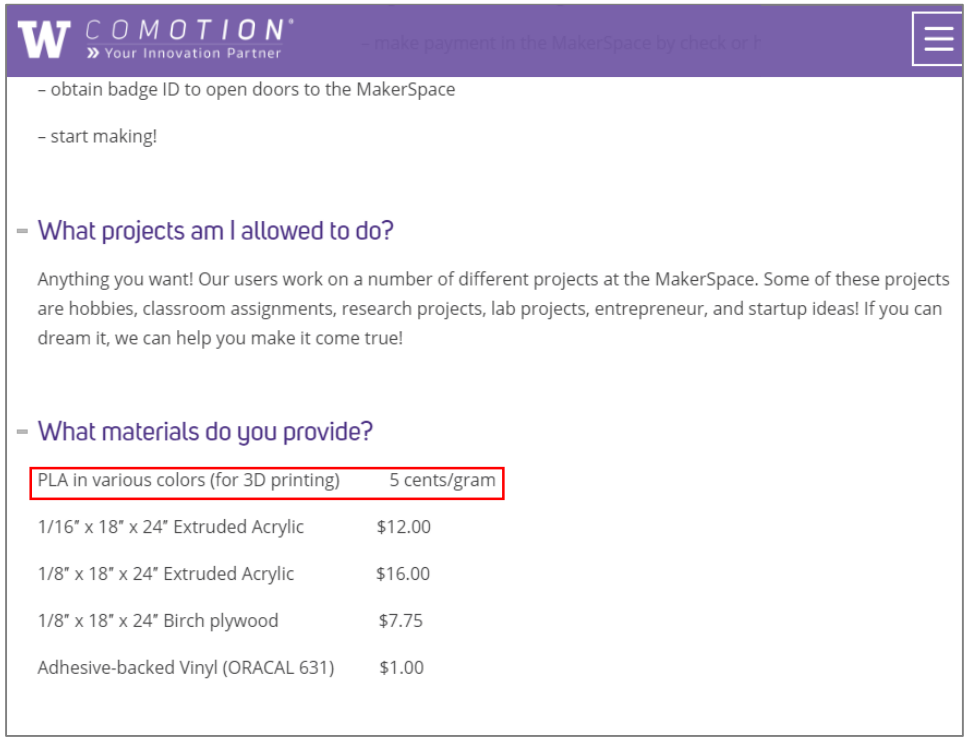
(PLEASE NOTE: With our first-come, first-serve policy, and the fact that some objects can take many hours to print, we can not promise any object can be printed by a certain date).

COST: $0.20/gram

Send Request

UMD Library System

$0.20/g



W COMOTION
» Your Innovation Partner

– obtain badge ID to open doors to the MakerSpace

– start making!

What projects am I allowed to do?

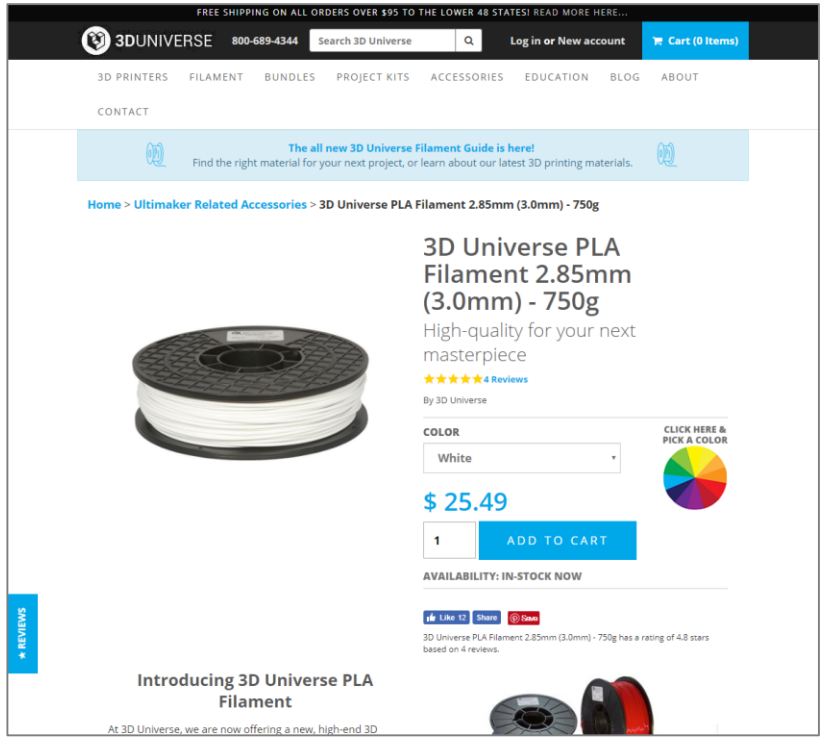
Anything you want! Our users work on a number of different projects at the MakerSpace. Some of these projects are hobbies, classroom assignments, research projects, lab projects, entrepreneur, and startup ideas! If you can dream it, we can help you make it come true!

What materials do you provide?

PLA in various colors (for 3D printing)	5 cents/gram
1/16" x 18" x 24" Extruded Acrylic	$12.00
1/8" x 18" x 24" Extruded Acrylic	$16.00
1/8" x 18" x 24" Birch plywood	$7.75
Adhesive-backed Vinyl (ORACAL 631)	$1.00

UW Co-Motion MakerSpace

$0.05/g



FREE SHIPPING ON ALL ORDERS OVER $95 TO THE LOWER 48 STATES! READ MORE HERE...

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3D PRINTERS FILAMENT BUNDLES PROJECT KITS ACCESSORIES EDUCATION BLOG ABOUT CONTACT

The all new 3D Universe Filament Guide is here!
Find the right material for your next project, or learn about our latest 3D printing materials.

Home > Ultimaker Related Accessories > 3D Universe PLA Filament 2.85mm (3.0mm) - 750g

3D Universe PLA Filament 2.85mm (3.0mm) - 750g

High-quality for your next masterpiece

4 Reviews

By 3D Universe

COLOR

White

CLICK HERE & PICK A COLOR

$ 25.49

1 ADD TO CART

AVAILABILITY: IN-STOCK NOW

Like 12 Share Save

3D Universe PLA Filament 2.85mm (3.0mm) - 750g has a rating of 4.8 stars based on 4 reviews.

REVIEWS

Introducing 3D Universe PLA Filament

At 3D Universe, we are now offering a new, high-end 3D

Filament Roll Price

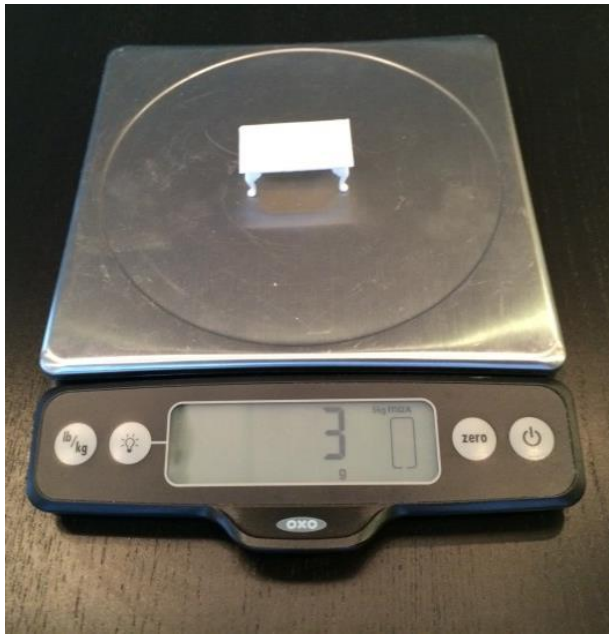
$25.49 for 750g ($0.034/g)

3D PRINTING CONSIDERATIONS

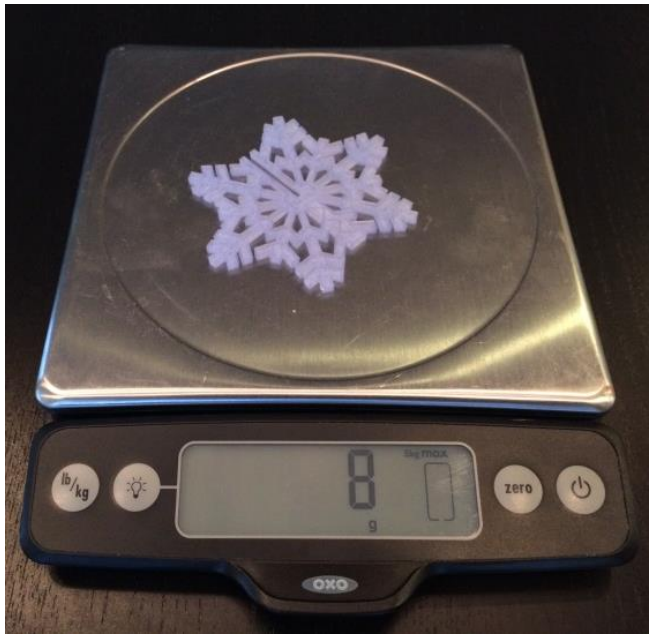
COSTS*

*Does not include the cost of energy to operate the machine.

2 Interlinked Chains: 2 grams
3.4c/g: $0.07 (raw cost: $25.49 for 750g spool)
5c/g: $0.10 (UW Co-motion MakerSpace price)
20c/g: $0.40 (UMD MakerSpace price)



1 Small Doll House Table: 3 grams
3.4c/g: $0.10
5c/g: $0.15
20c/g: $0.60



1 Snowflake: 8 grams
3.4c/g: $0.27
5c/g: $0.40
20c/g: $1.60

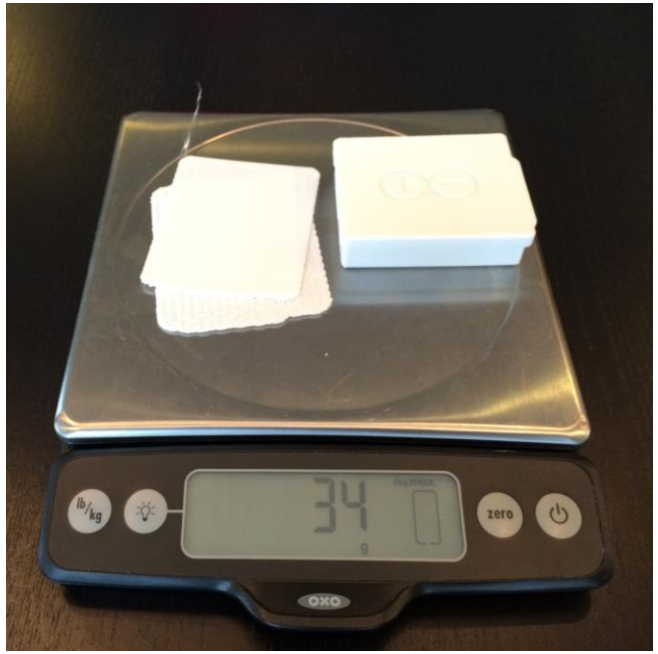
Arduino Uno Case: 22 grams
3.4c/g: $0.75
5c/g: $1.10
20c/g: $4.40

Images by Jon Froehlich

COSTS: INCLUDING RAFTS & SUPPORT

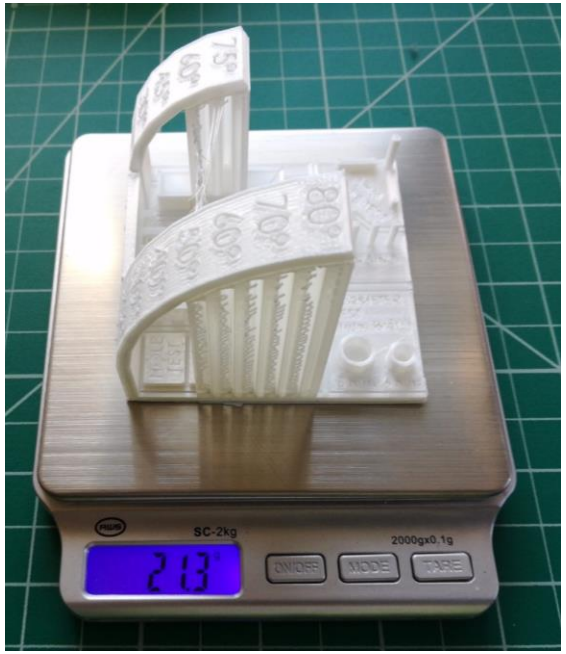
Now we include the cost of rafts (which print beneath the model) and supports (which support overhangs)

Arduino Uno Case (No Raft): 22 grams
3.4c/g: $0.75
5c/g: $1.10
20c/g: $4.40



Arduino Uno Case (With Raft): 34 grams
3.4c/g: $1.16
5c/g: $1.70
20c/g: $6.80

3D Test Object (No Support): 14.9 g
3.4c/g: $0.51
5c/g: $0.75
20c/g: $2.98



3D Test Object (With Support): 21.3 g
3.4c/g: $0.72
5c/g: $1.07
20c/g: $4.26

Images by Jon Froehlich

3D PRINTING CONSIDERATIONS

FILAMENT MATERIAL

Digital Manufacturing Trends

Q2 2018

3D Hubs Digital Manufacturing Trends is a quarterly update using data from 6,000 active international suppliers, who create more than 200,000 parts each quarter. It's the only industry report based on hard numbers and the most extensive overview of the latest trends in technologies such as 3D printing, CNC machining and more.

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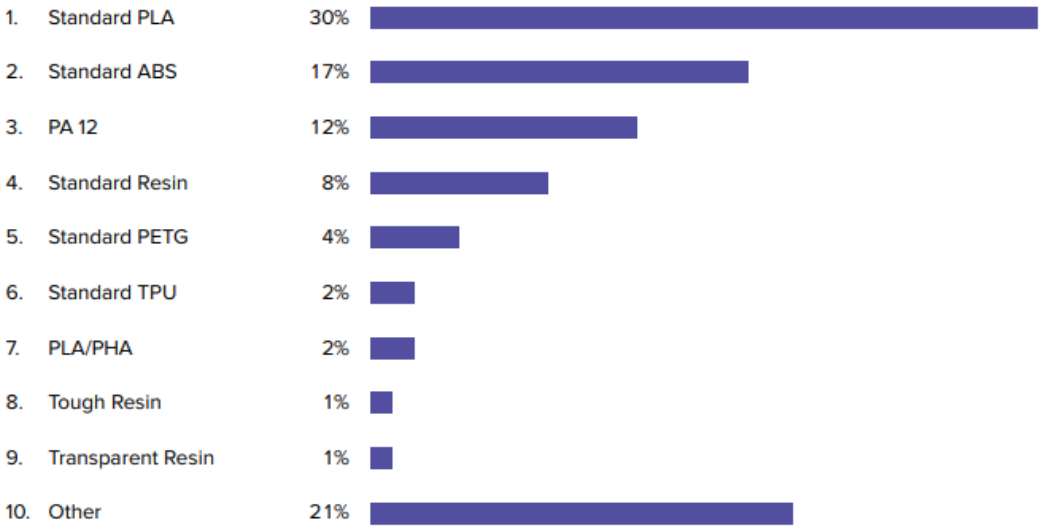
Tech & Materials

Most Used Materials

Insights

In Q2 the variety of materials has been simplified with the introduction of a "Standard", meaning that suppliers list their materials with a generic term to encompass all variants. Branded PLA's would sometimes appear independently this way you can get a truer portrayal of the most used materials.

Standard PLA comes in at #1 with a drop of 4% since Q1 with 30% of the material pie, Standard ABS at #2 increases to 17% still way off top spot. The race between SLA/DLP and SLS continues on a material level as PA 12 (the most popular SLS material) with 12% has overtaken Standard Resin (the most popular SLA/DLP material), with 8%. That being said Transparent and Tough Resin both SLA/DLP materials have entered the list for the first time at #8 and #9 respectively.



Source: https://www.3dhubs.com/trends

WHAT LEGO® BRICKS ARE MADE FROM

SEARCH For example: Technic or Subscribe

Back to all Help Topics

It's great that you want to learn more about the material from which we make our LEGO® and DUPLO® toys!

The current materials we use have been carefully chosen to make sure we can provide the best play experience for children and, most importantly, high quality and safe toys. Most LEGO® pieces are made from a high-quality plastic called ABS. It provides the unique connective grip, high gloss, and the color stability our LEGO® bricks are known for. It meets a long list of safety, durability and quality rules and we've been using it ever since 1963! ABS plastic is also commonly used to make plastic telephones, computers and car interiors.

Although elastic parts are quite rare in our sets, we do use some red, white, and blue silicone parts, and our vehicles have soft tires. These consist of a material called SBS or SEBS, commonly found in vehicle mud guards and shoe soles.

We work hard to make sure children can play safely and enjoy our products. That's why all LEGO® toys are tested by independent laboratories and meet or exceed all toy safety laws in the 140 countries where they are sold. You can find out more about how we make LEGO® toys as safe as possible here.

POPULAR ARTICLES

- Identifying LEGO® set and part numbers
- Buying individual LEGO® parts
- How to download building instructions online
- New sets with missing parts
- Replace missing or damaged building instructions
- Creating your own minifigure
- Replacing or buying minifigures
- Replacing stickers
- Product feedback survey in building instructions
- Digital building instructions for older sets

Was this information helpful?

Yes No

Didn't find what you need? Contact us! →

FILAMENT MATERIAL: ABS VS. PLA

Both are **thermoplastics**, meaning that they enter a soft, moldable state when heated and return to a solid when cooled.

ABS (Acrylonitrile Butadiene Styrene) is a common thermoplastic used in injection modling industry. Used in LEGO, electronic housings, and automotive bumper parts.

PLA (Polylactic Acid) is a biodegradable thermoplastic derived from corn startch or sugarcane. It is one of the most popular bioplastics used in everything from plastic cups to medical implants.

Properties*	ABS	PLA
Tensile Strength**	27 MPa	37 MPa
Elongation	3.5 - 50%	6%
Flexural Modulus	2.1 - 7.6 GPa	4 GPa
Density	1.0 - 1.4 g/cm^3	1.3 g/cm^3
Melting Point	N/A (amorphous)	173 °C
Biodegradable	No	Yes, under the correct conditions
Glass Transition Temperature	105 °C	60 °C
Spool Price*** (1kg, 1.75mm, black)	$USD 21.99	$USD 22.99
Common Products	LEGO, electronic housings	Cups, plastic bags, cutlery

*Sourced from MakeItFrom
**Sourced from Optimatter for a test specimen with 100% infill, 0.2mm layer height printed in a linear pattern
*** Sourced from Amazon ABS & PLA

Source: https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference

	ABS	PLA
Part Accuracy **Generally, the tolerances and accuracy of FDM printed components are largely driven by printer type, calibration, and model complexity.**	Print details down to 0.8mm. For interlocking parts, a tolerance of 0.5mm is recommended. Minimum wall thickness is 1-2mm.	Same as ABS; however, due to its lower printing temperature, PLA is less likely to warp

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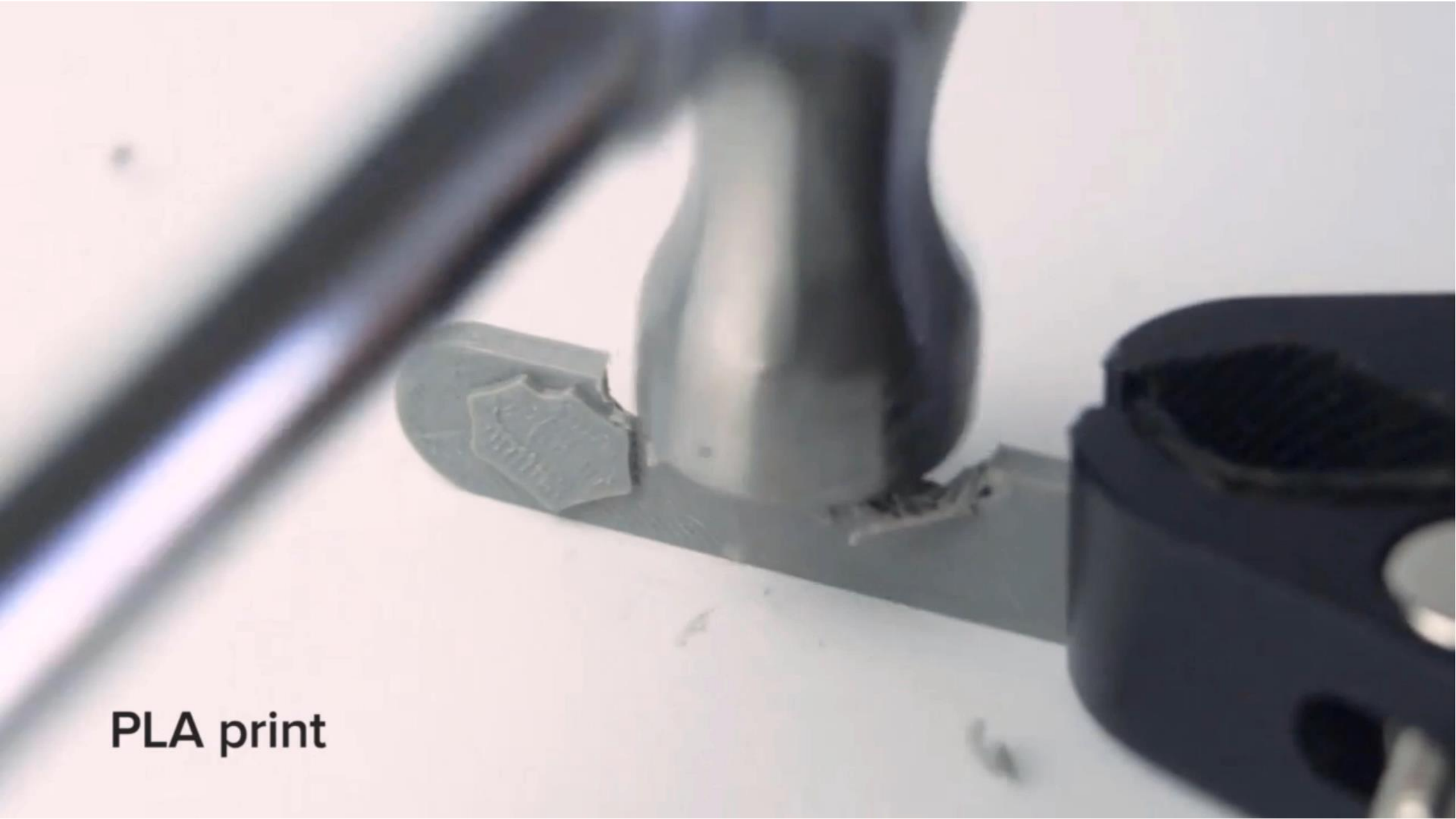
Strength **Both ABS and PLA have similar tensile strengths, which is highly impacted by print orientation.**	Better ductility under tensile stress, more flex strength	

Source: https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference

3D PRINTING CONSIDERATIONS

ABS VS. PLA IMPACT STRENGTH

Source: https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference; Edited by Jon Froehlich


PLA print

	ABS	PLA
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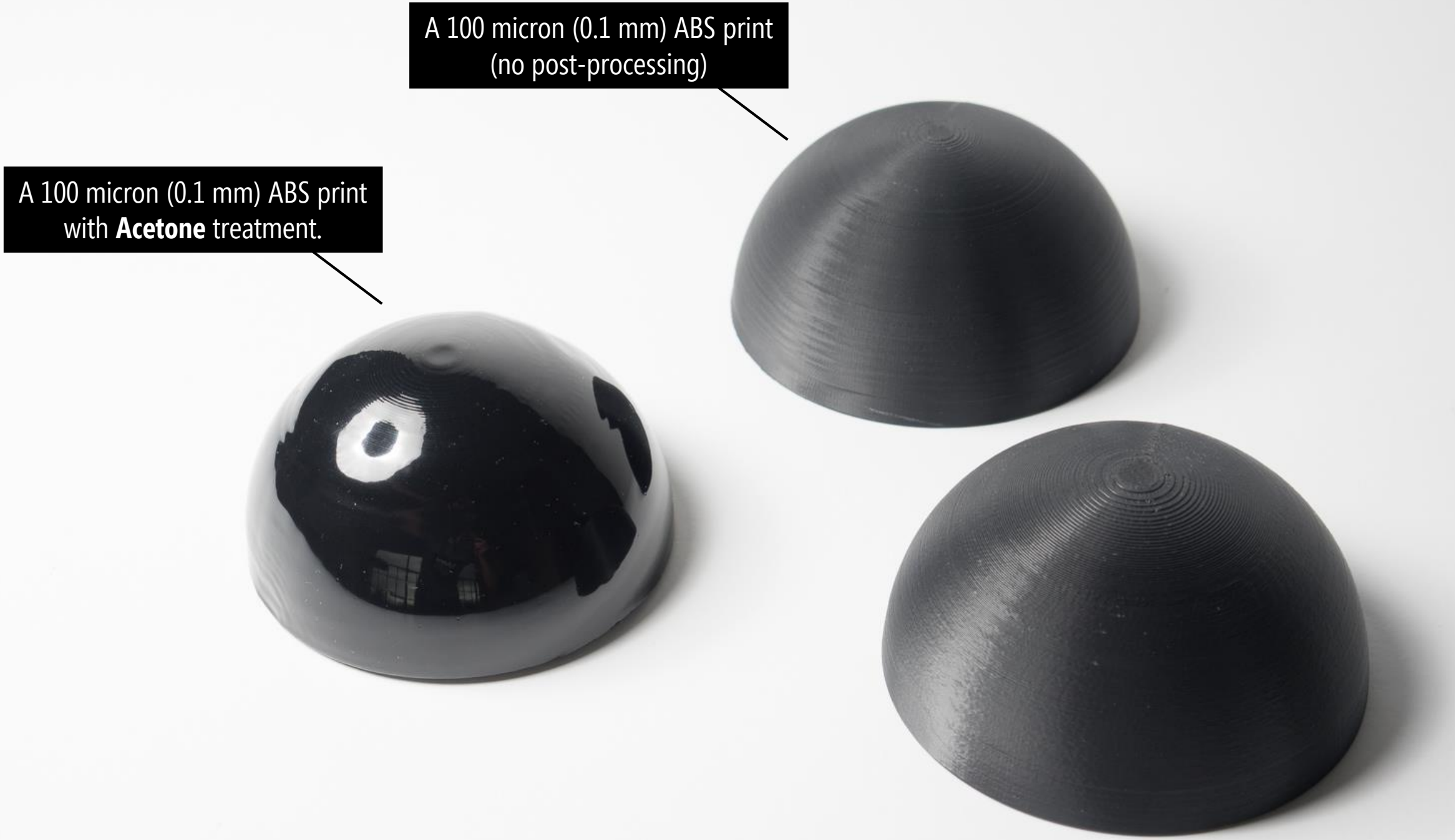
Surface Finish **For both ABS and PLA, layers will be visible. ABS typically prints in a matt finish while PLA is often glossier.**	ABS can be easily sanded and is often machined (*e.g.,* drilled) after printing. Can also use acetone for smooth finish.	PLA can also be sanded and machined but greater care is required.

Source: https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference


A 100 micron (0.1 mm) ABS print
(no post-processing)
A 100 micron (0.1 mm) ABS print
with **Acetone** treatment.

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Heat Resistance **This refers to post-printing heat resistance.**	For high temperature applications, ABS (glass transition temperature of 105°C or 221°F) is more suitable than PLA (glass transition temperature of 60°C or 140°F).	PLA can rapidly lose its structural integrity and can begin to droop and deform, particularly if under load, as it approaches 60°C.

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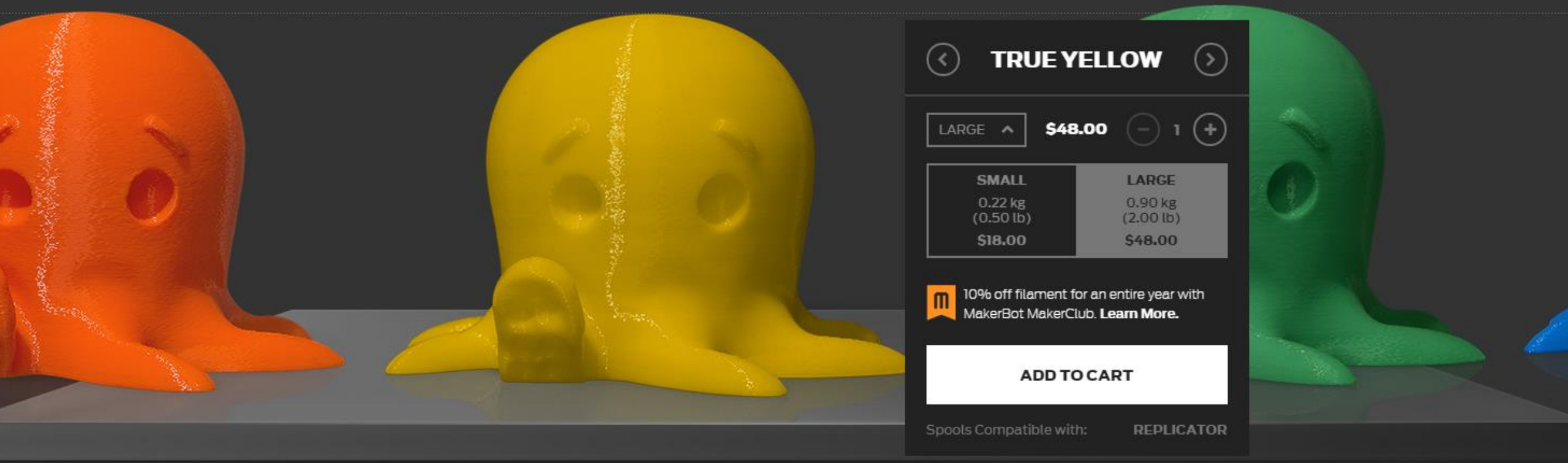
Biodegradability **This refers to post-printing heat resistance.**	ABS is not biodegradable; however, it is recyclable. Check with your recycling center.	PLA is derived from renewable resources such as corn starch or sugarcane. It will biodegrade in industrial composters in 50 days (or 48 months in water)

Source: https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference

MAKERBOT
PLA FILAMENT

GALLERY | LIST



TRUE YELLOW

LARGE **$48.00** 1

SMALL	LARGE
0.22 kg (0.50 lb)	0.90 kg (2.00 lb)
$18.00	$48.00

10% off filament for an entire year with MakerBot MakerClub. **Learn More.**

ADD TO CART

Spools Compatible with: **REPLICATOR**

TRUE COLOR

SPECIALTY

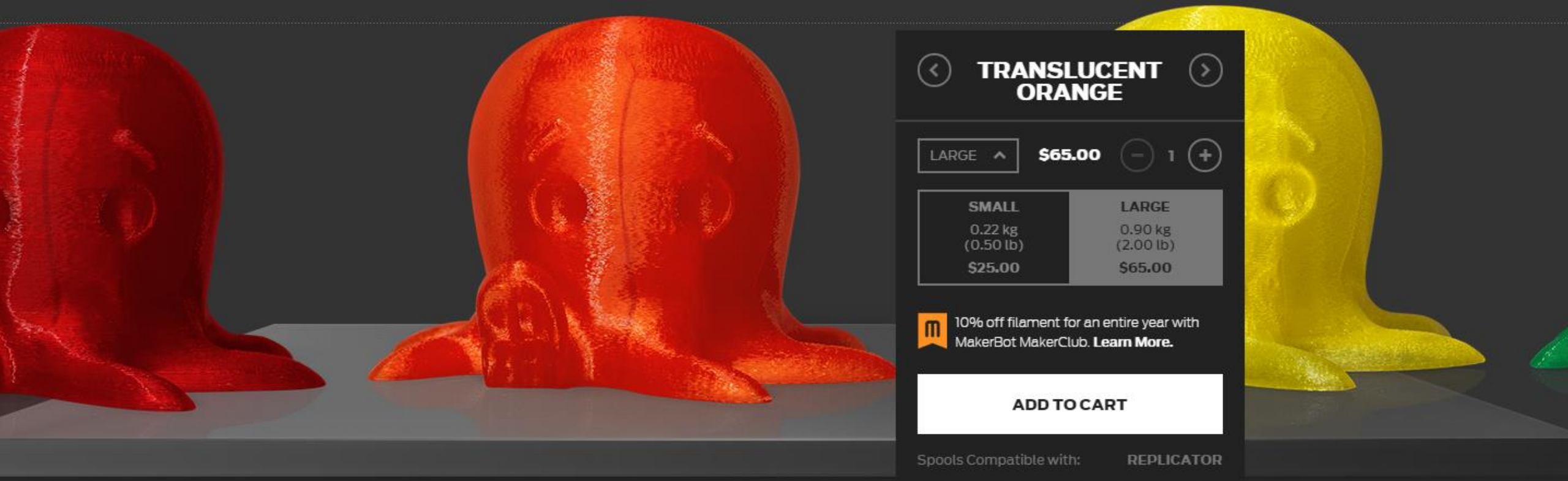
LIMITED

ALSO AVAILABLE

MAKERBOT BUILD TAPE
For the MakerBot Replicator

MAKERBOT
PLA FILAMENT

GALLERY | LIST



TRANSLUCENT ORANGE

LARGE **$65.00** 1

SMALL	LARGE
0.22 kg (0.50 lb)	0.90 kg (2.00 lb)
$25.00	$65.00

10% off filament for an entire year with MakerBot MakerClub. **Learn More.**

ADD TO CART

Spools Compatible with: REPLICATOR

TRUE COLOR

SPECIALTY

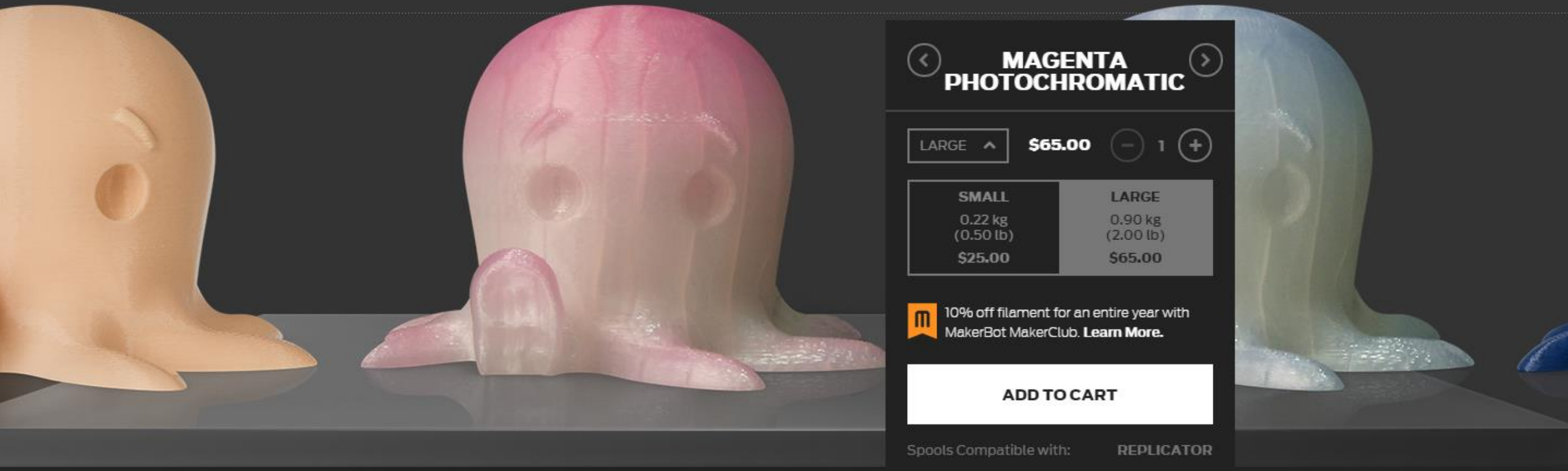
LIMITED

ALSO AVAILABLE

MAKERBOT BUILD TAPE
For the MakerBot Replicator

MAKERBOT PLA FILAMENT

GALLERY | LIST



MAGENTA PHOTOCHROMATIC

LARGE

$65.00

1

SMALL	LARGE
0.22 kg (0.50 lb)	0.90 kg (2.00 lb)
$25.00	$65.00

10% off filament for an entire year with MakerBot MakerClub. **Learn More.**

ADD TO CART

Spools Compatible with: **REPLICATOR**

TRUE COLOR

SPECIALTY

LIMITED

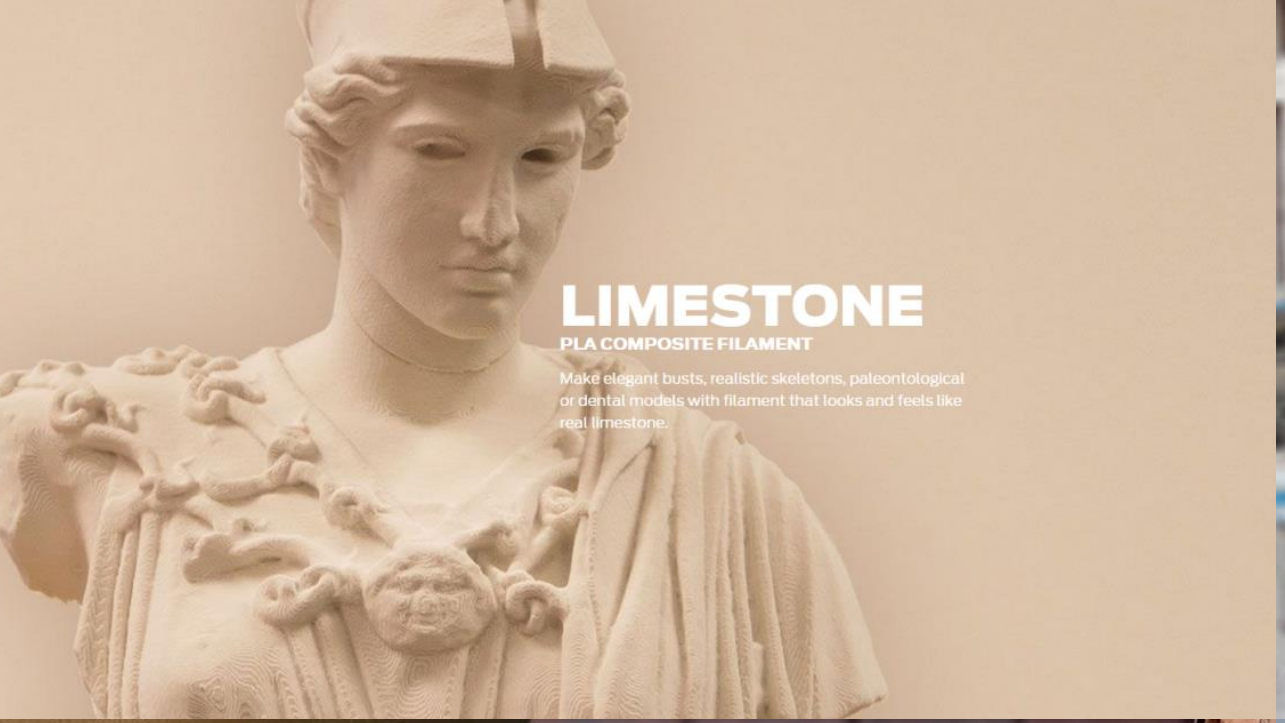
ALSO AVAILABLE

MAKERBOT BUILD TAPE
For the MakerBot Replicator

FILAMENT MATERIALS

FUSE3D WOOD COMPOSITE ON MAKERBOT REPLICATOR 2

Source: https://youtu.be/d1L3RD54Rp8



LIMESTONE

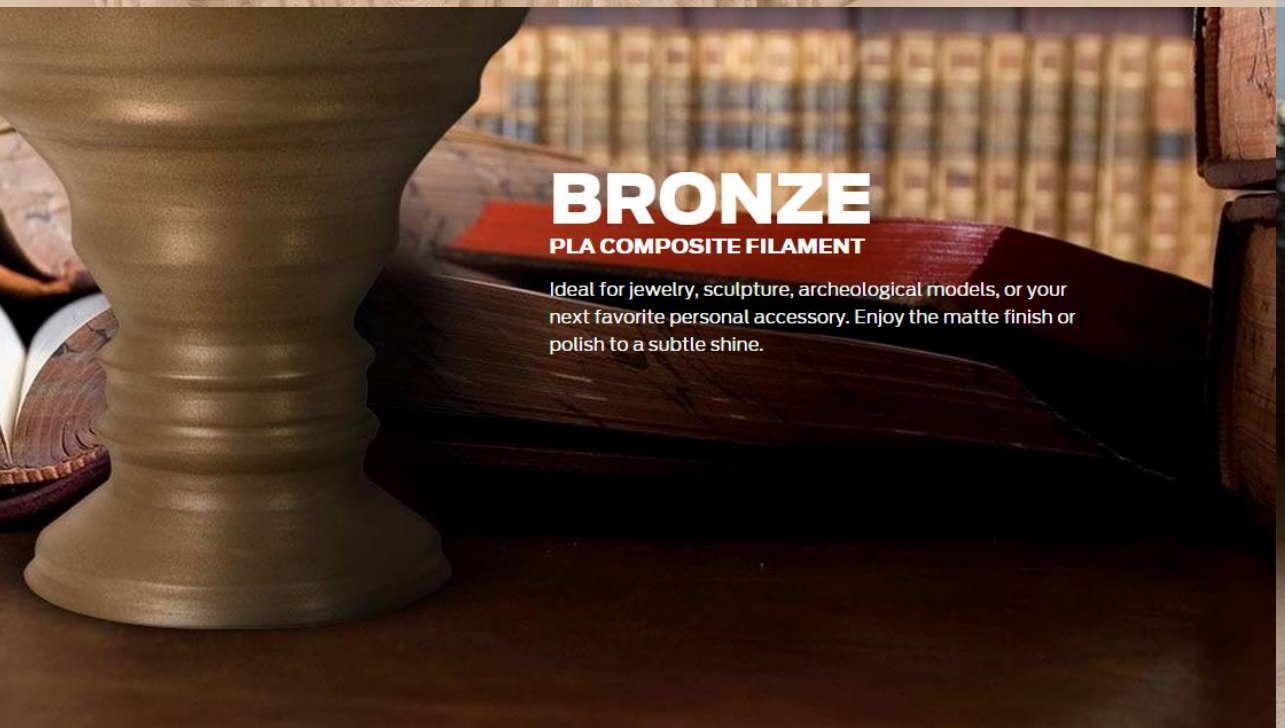
PLA COMPOSITE FILAMENT

Make elegant busts, realistic skeletons, paleontological or dental models with filament that looks and feels like real limestone.

MAPLE

PLA COMPOSITE FILAMENT

3D print decorative bowls, furniture prototypes, model handles, and more. Sand, stain, oil, or polish to replicate the look and feel of your favorite wood.



BRONZE

PLA COMPOSITE FILAMENT

Ideal for jewelry, sculpture, archeological models, or your next favorite personal accessory. Enjoy the matte finish or polish to a subtle shine.

IRON

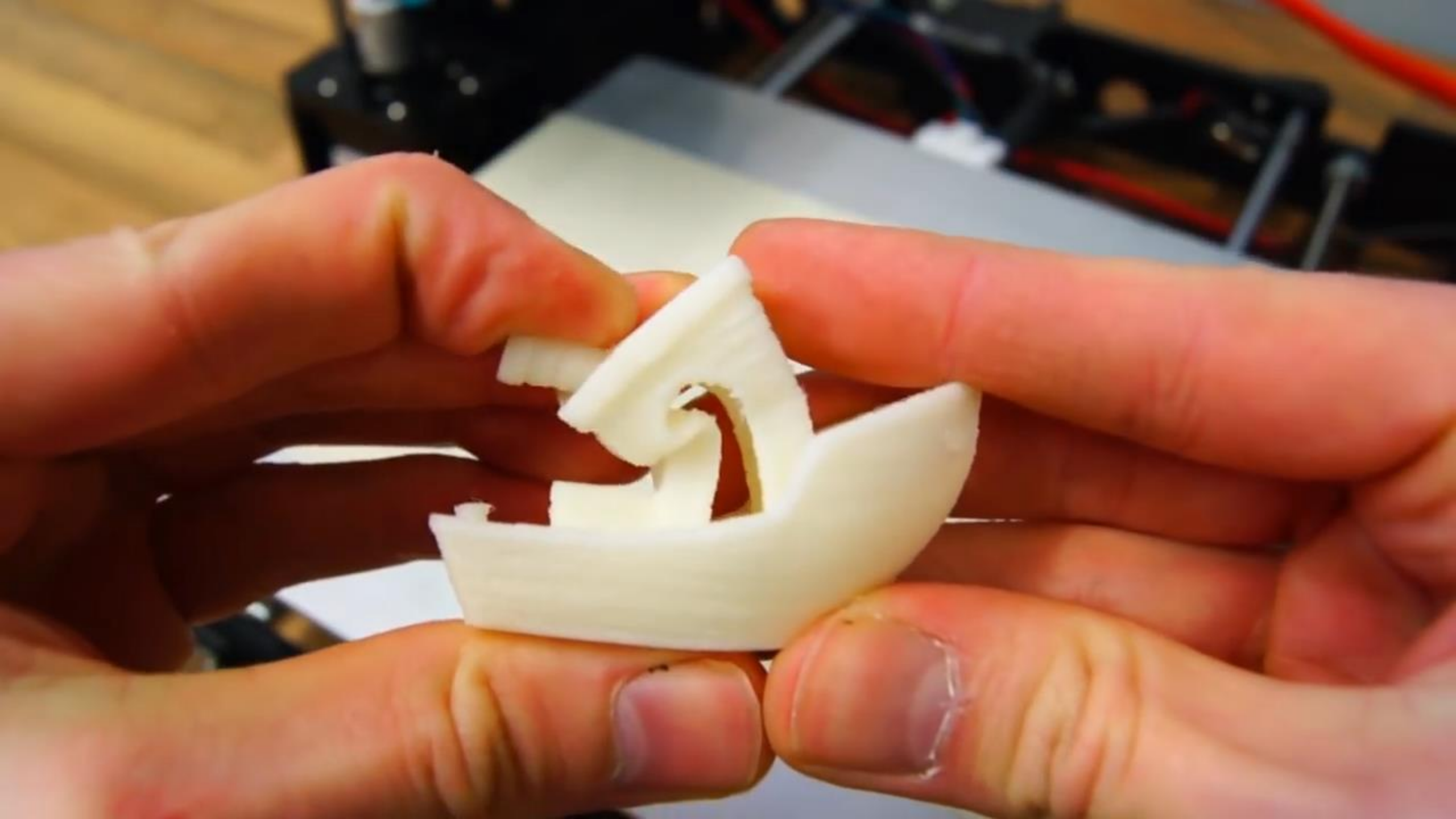
PLA COMPOSITE FILAMENT

Make prototypes of metal parts, crafts, tools, or mechanical models that you can magnetize and polish to a smooth finish.

FILAMENT MATERIALS

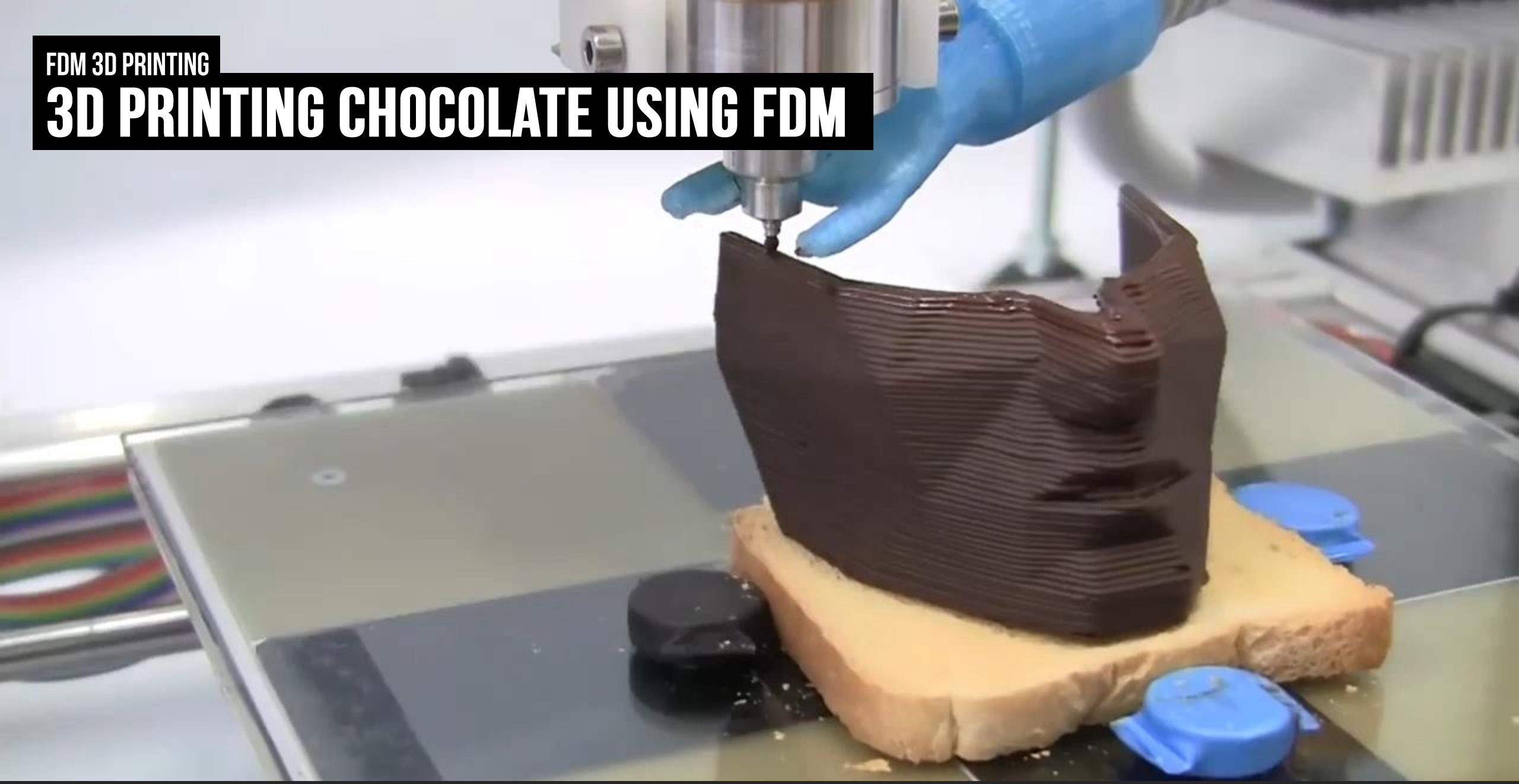
FLEXIBLE 3D PRINTS WITH ESUN ELASTIC & TAULMAN PCTPE

Source: https://youtu.be/lMu_XNEohjw

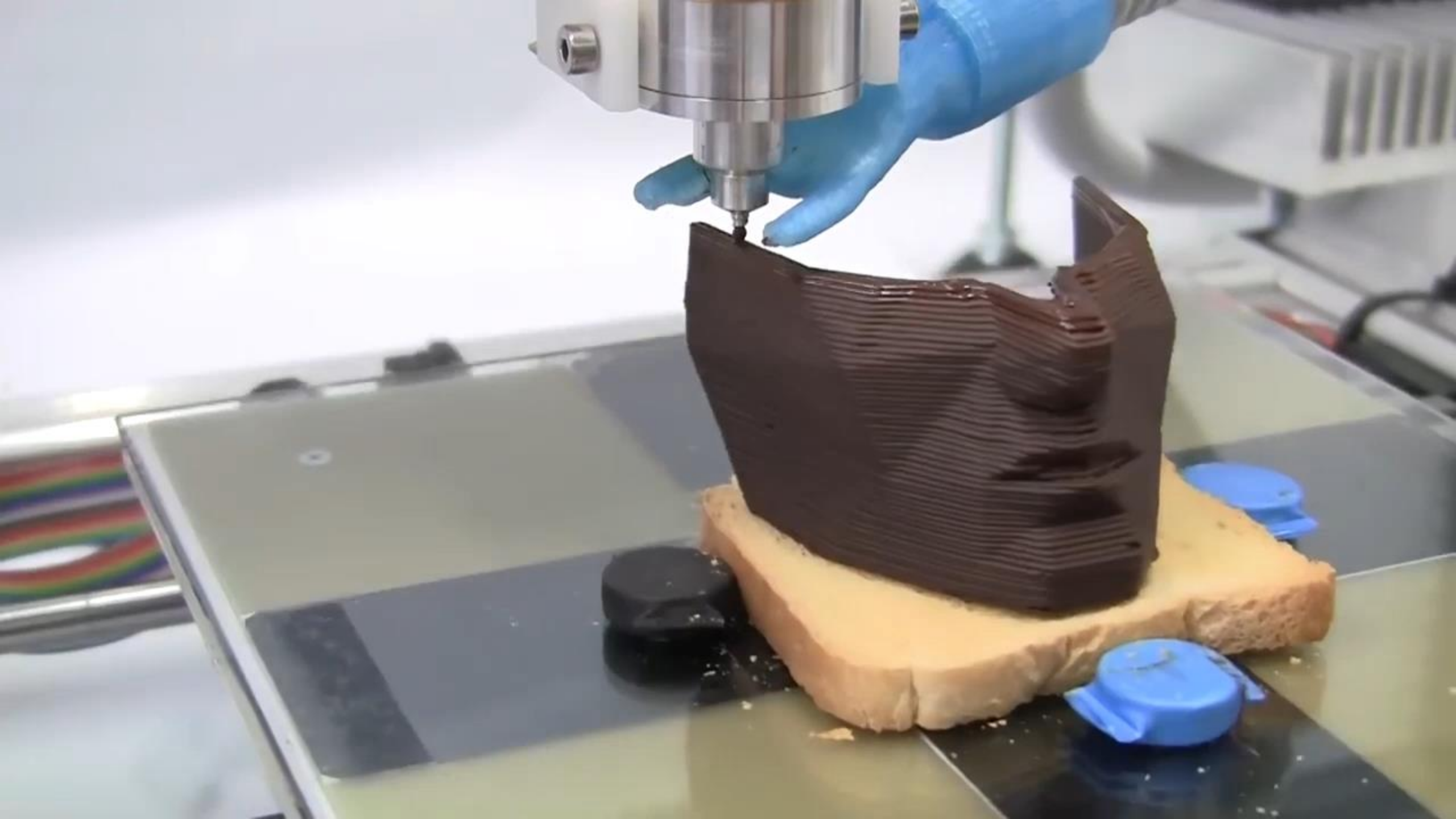


FDM 3D PRINTING

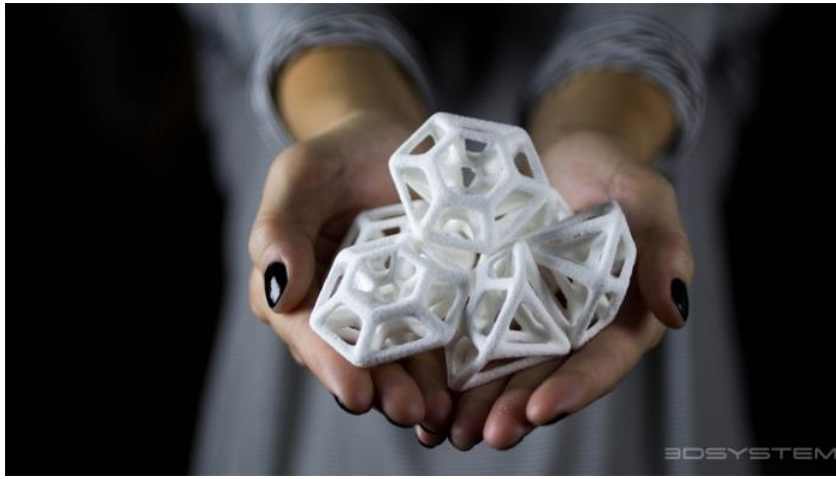
3D PRINTING CHOCOLATE USING FDM

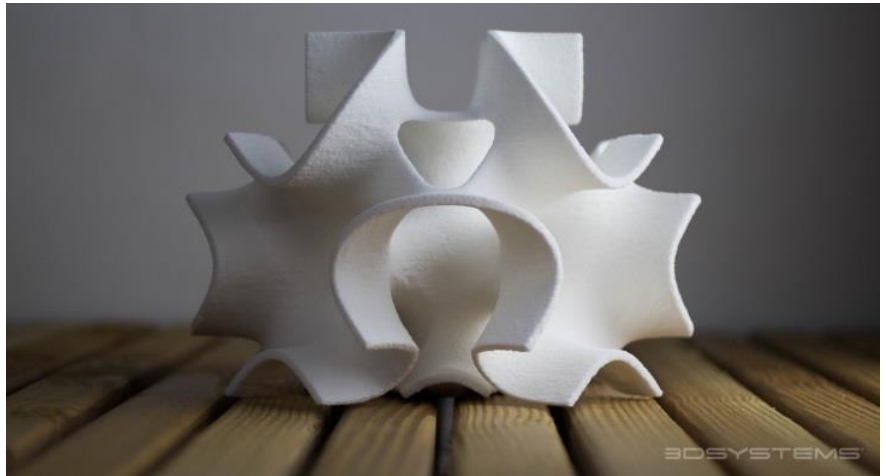


Source: https://youtu.be/MKQlys-z7SM; Edited by Jon Froehlich



http://the-sugar-lab.com/ChefJet





FDM 3D PRINTING

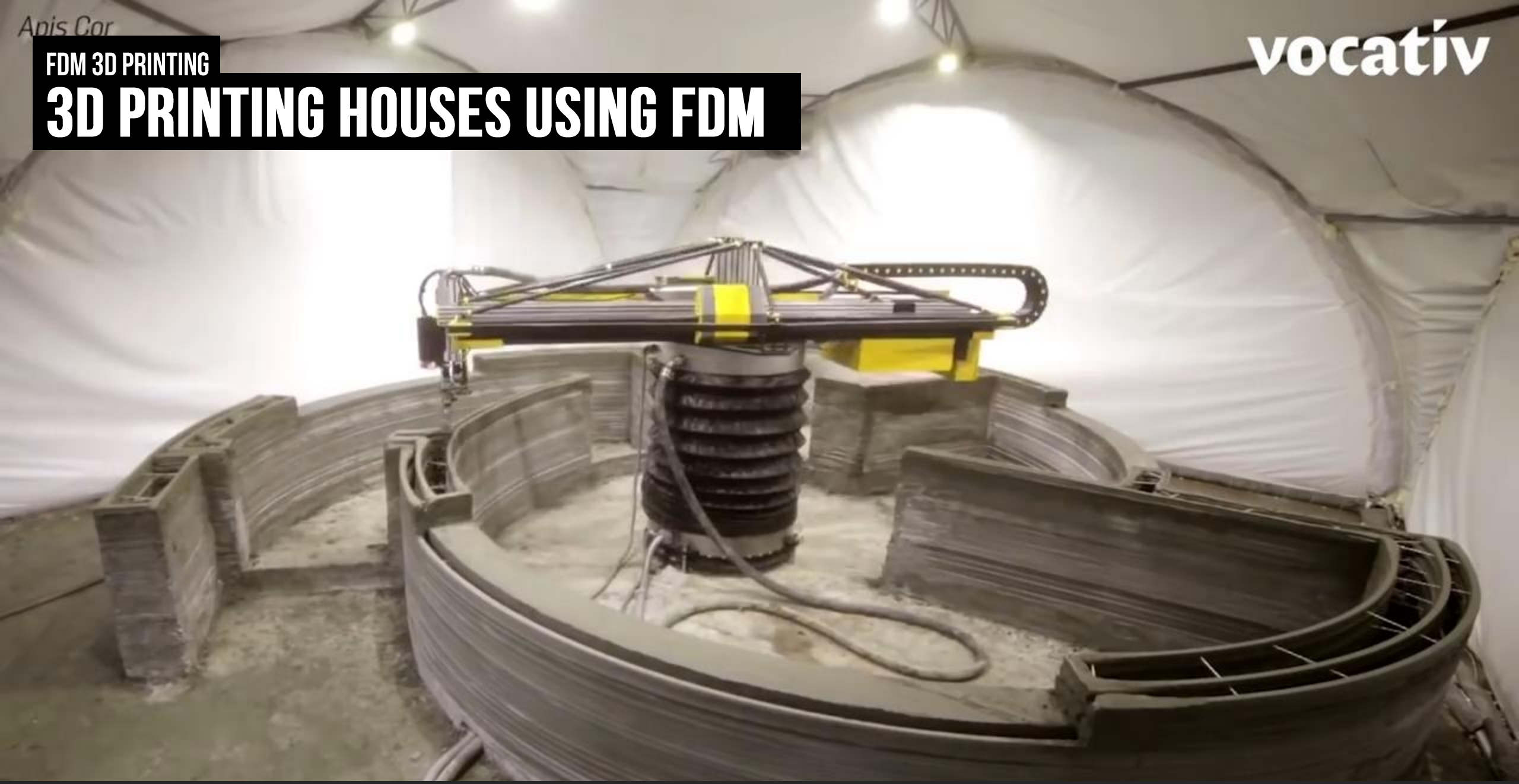
3D PRINTING PANCAKES USING FDM

Source: https://youtu.be/6rEHNGPibb0; Company: Pancake Bot

WARNING
PancakeBot™
JerryRigEverything

FDM 3D PRINTING

3D PRINTING HOUSES USING FDM



Source: https://youtu.be/GUdnrtnjT5Q; Company: Apis Cor

Apis Cor
vocativ

FDM 3D PRINTING

3D PRINTING CARS USING FDM

Source: https://youtu.be/iT9A0pBBL2A; Company: Local Motors

FDM 3D PRINTING

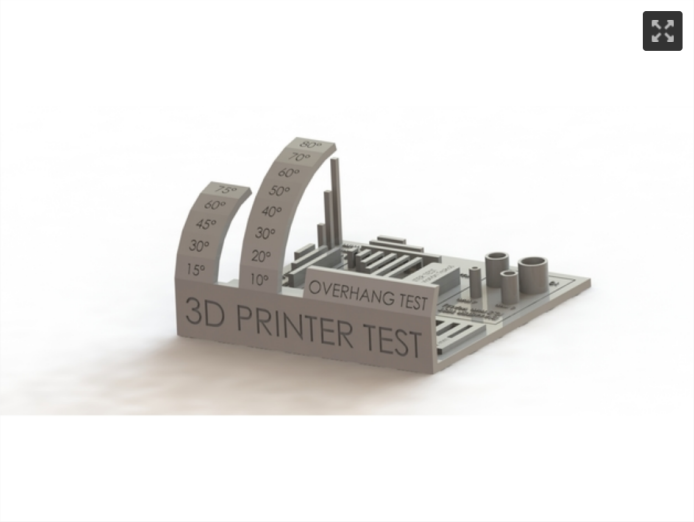
3D PRINTED MODULAR NITE LIGHT WITH LEGO ATTACHMENTS

Designer: Jon Froehlich (Based on design by my former student Philip Dasler)

Google

All In One 3D Printer test

by majda107, published Nov 19, 2017



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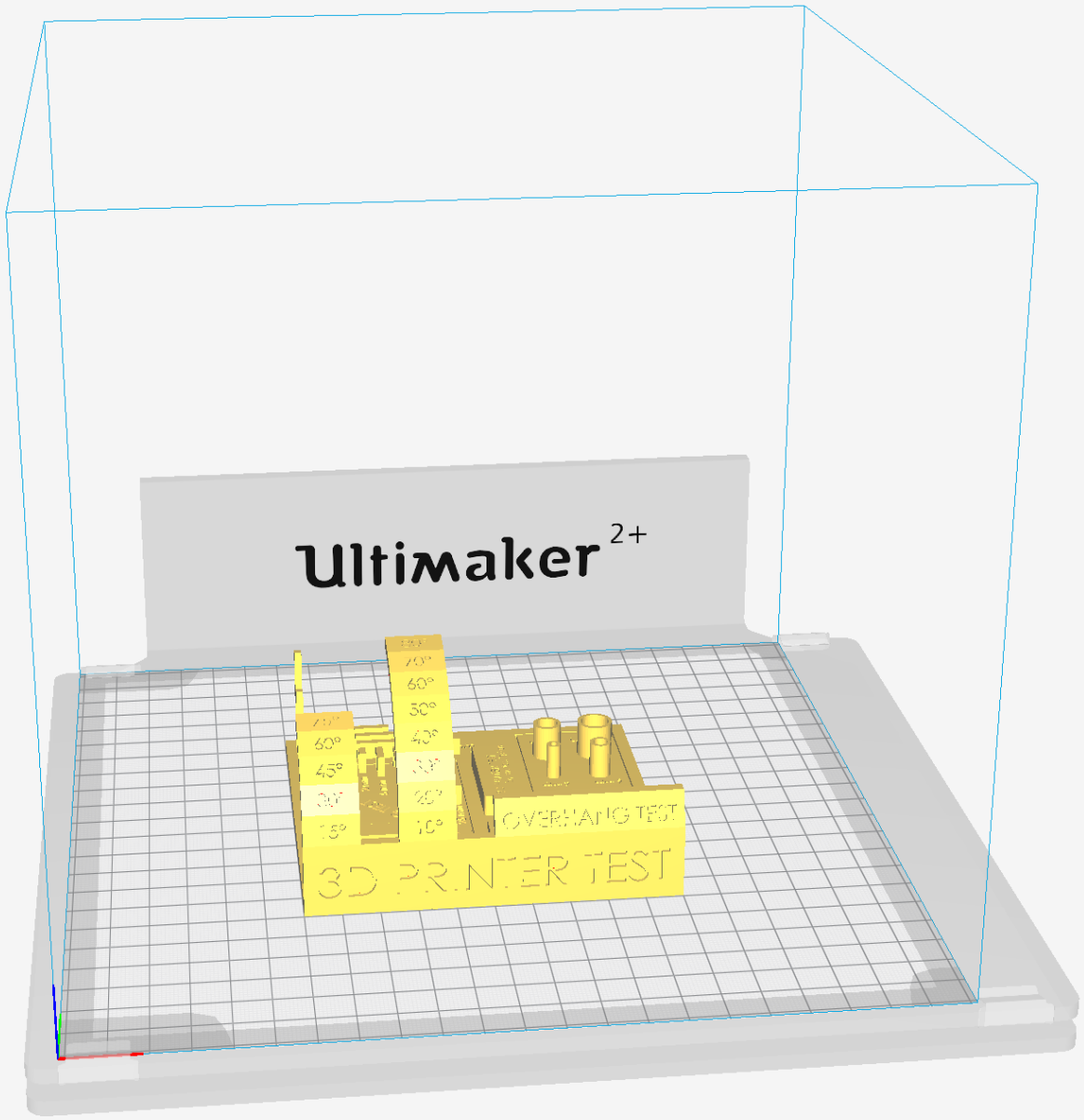
cura.

Prepare

Monitor

Solid view



Ultimaker 2+

Material: PLA

Nozzle: 0.4 mm

Check compatibility

Print Setup Recommended | Custom

Layer Height 0.06 0.1 0.15

Print Speed Slower Faster

Infill 100%

Enable gradual

Generate Support

Build Plate Adhesion

Need help improving your prints?
Read the Ultimaker Troubleshooting Guides

Ready to Save to Removable Drive