ENG-A1009 – starting at 9:15
Practical Work Training with 3D Printers

Slides Version: 13.11.2023 modified by S Siddharth Kumar

Schedule – 13.11.2023

9:15 – 12:00 LECTURE Brief background on 3D printing and different technologies > closer look at material extrusion, digital and physical workflow, design guidelines & resources to help you achieve your printing needs and visions

Digital steps: Cura demo

PRACTICAL SESSION:

Session 1 will be held on Monday, 13.11 from 15:00 to 16:30.
Session 2 will be held on Tuesday, 14.11 from 10:00 to 11:30.
Session 3 will be held on Tuesday, 14.11 from 13:00 to 14.30.
Session 4 will be held on Wednesday, 15.11 from 10.00 to 11.30.
Session 5 will be held on Wednesday, 15.11 from 13.00 to 14.30.

@ADDLab: Ultimakers in practice, starting a print, filament change, bed leveling, troubleshooting problems

Learning goals & outcomes

- A “surface-scrape” introduction to the world of 3D printing
- What is 3D printing – what could *you* do with it – what are the possibilities?
- Digital and physical steps of 3D printing
- Hands-on use of the Cura slicing software and Ultimaker 3D printers

For 1 ECTS credit : Small assignment given at the end of the lecture

NOTE: The access to an online calendar to schedule the ADDLAB 3D printers for personal projects **is ONLY given to those who have gained 1 ECTS**.

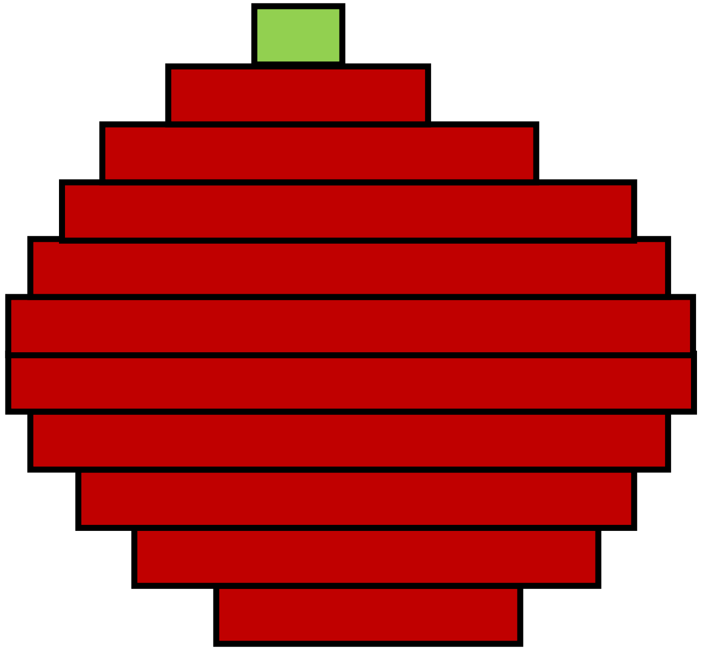
What is 3D printing and what to do with it?

3D printing ~ Additive Manufacturing

*"Additive manufacturing is **a process of joining materials** to make parts from **3D model data**, usually **layer upon layer**, as opposed to subtractive and formative manufacturing methodologies."*

ISO/ASTM 52900(en)
Additive manufacturing — General principles — Terminology

3D printing ~ Additive Manufacturing (AM)



https://commons.wikimedia.org/wiki/File:Bright_red_tomato_and_cross_section02.jpg

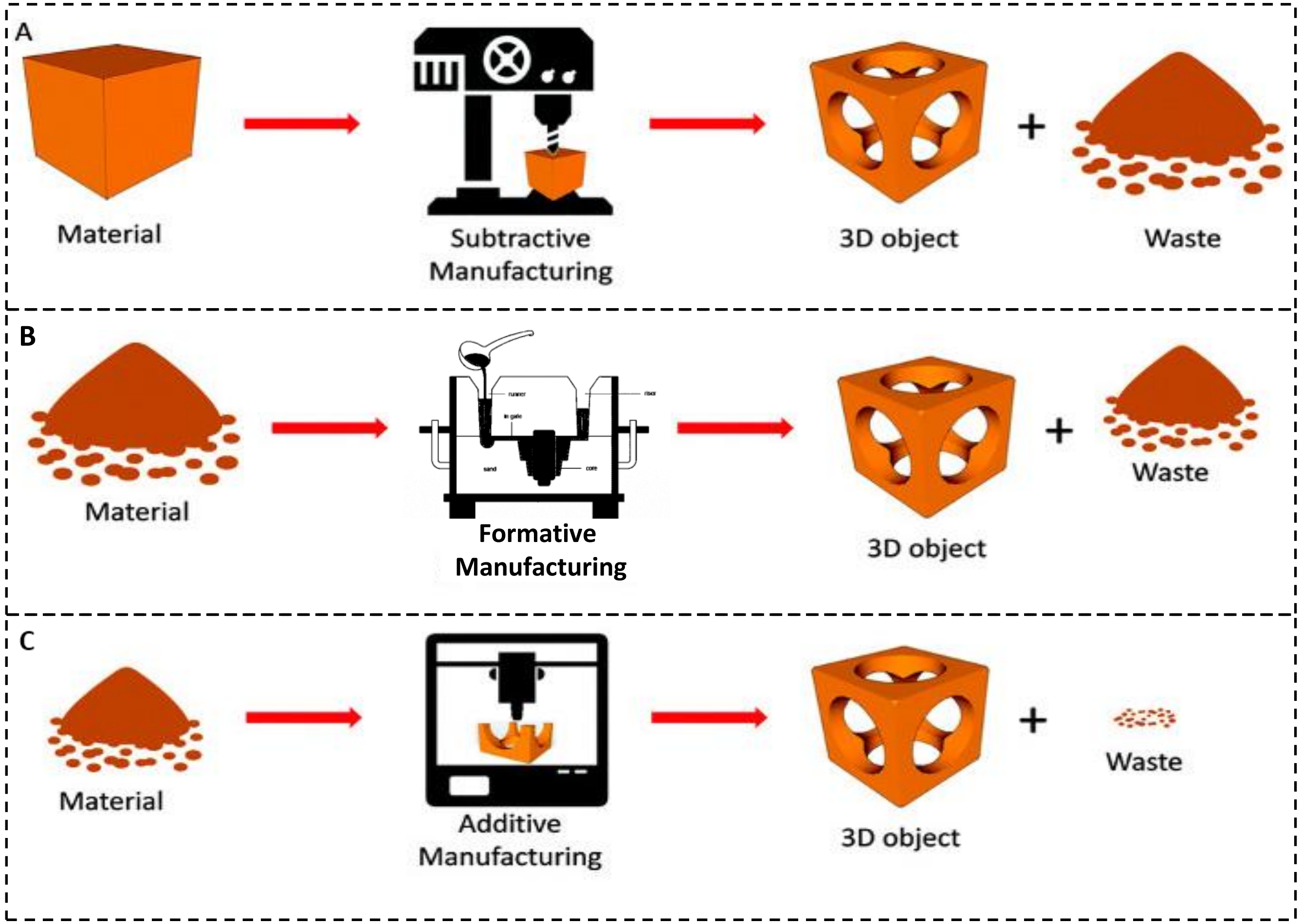
Manufacturing methodologies

Conventional

Subtractive Manufacturing

Formative Manufacturing

Additive Manufacturing



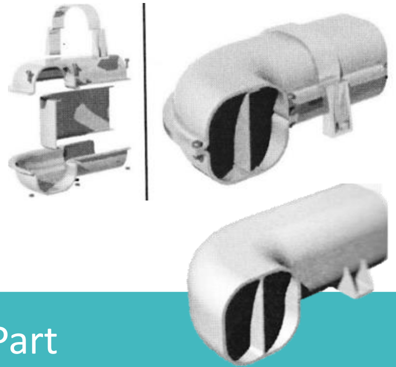
Aalto University
School of Engineering

Adapted from https://www.3dnatives.com/en/3d-printing-vs-cnc-160320184/

Advantages of 3D Printing

Design freedom

Customization



Part consolidation

Instant assemblies

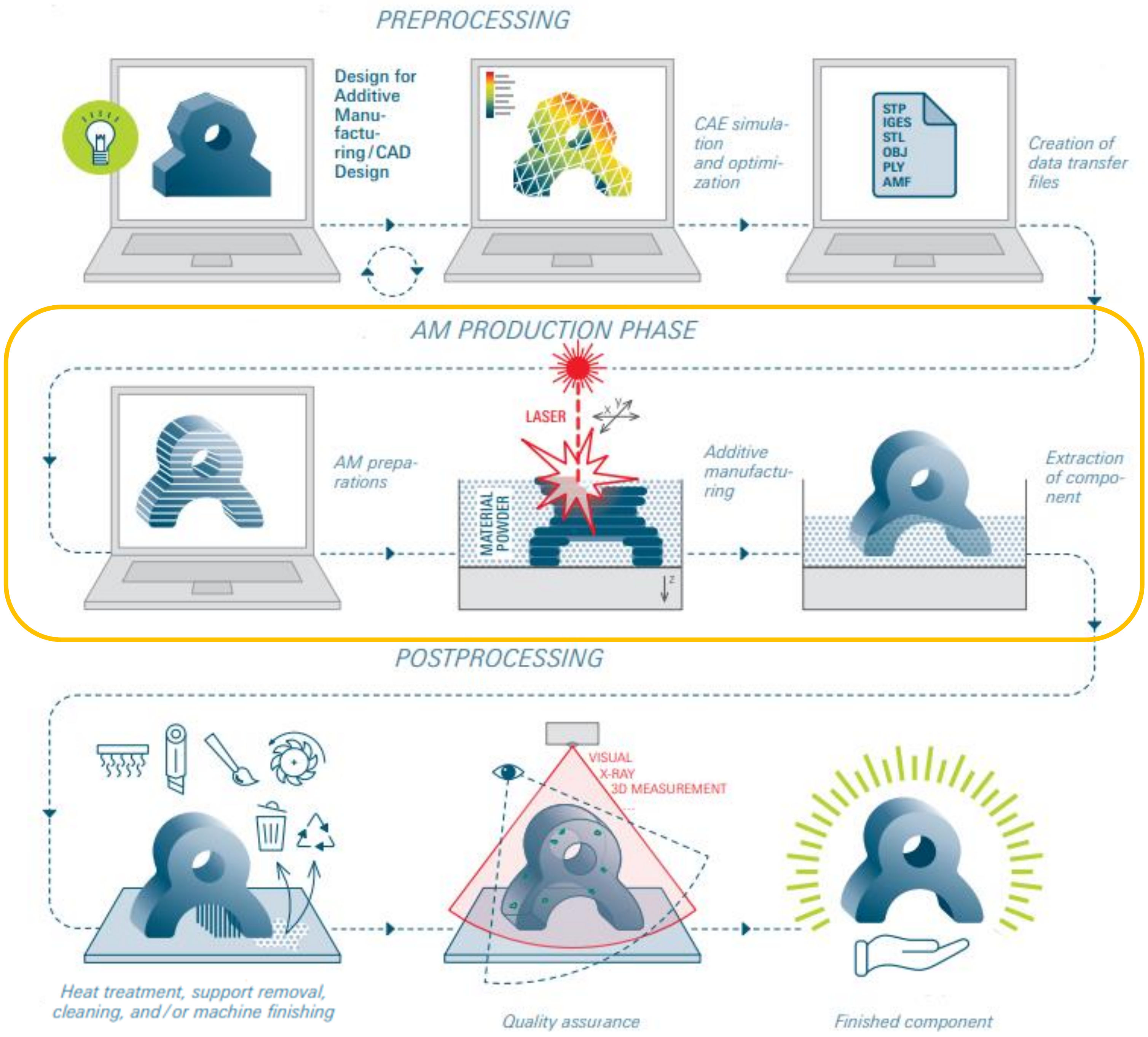
Sustainable production

Faster manufacturing cycles

Lightweighting

On-demand manufacturing

3D printing – digital to physical

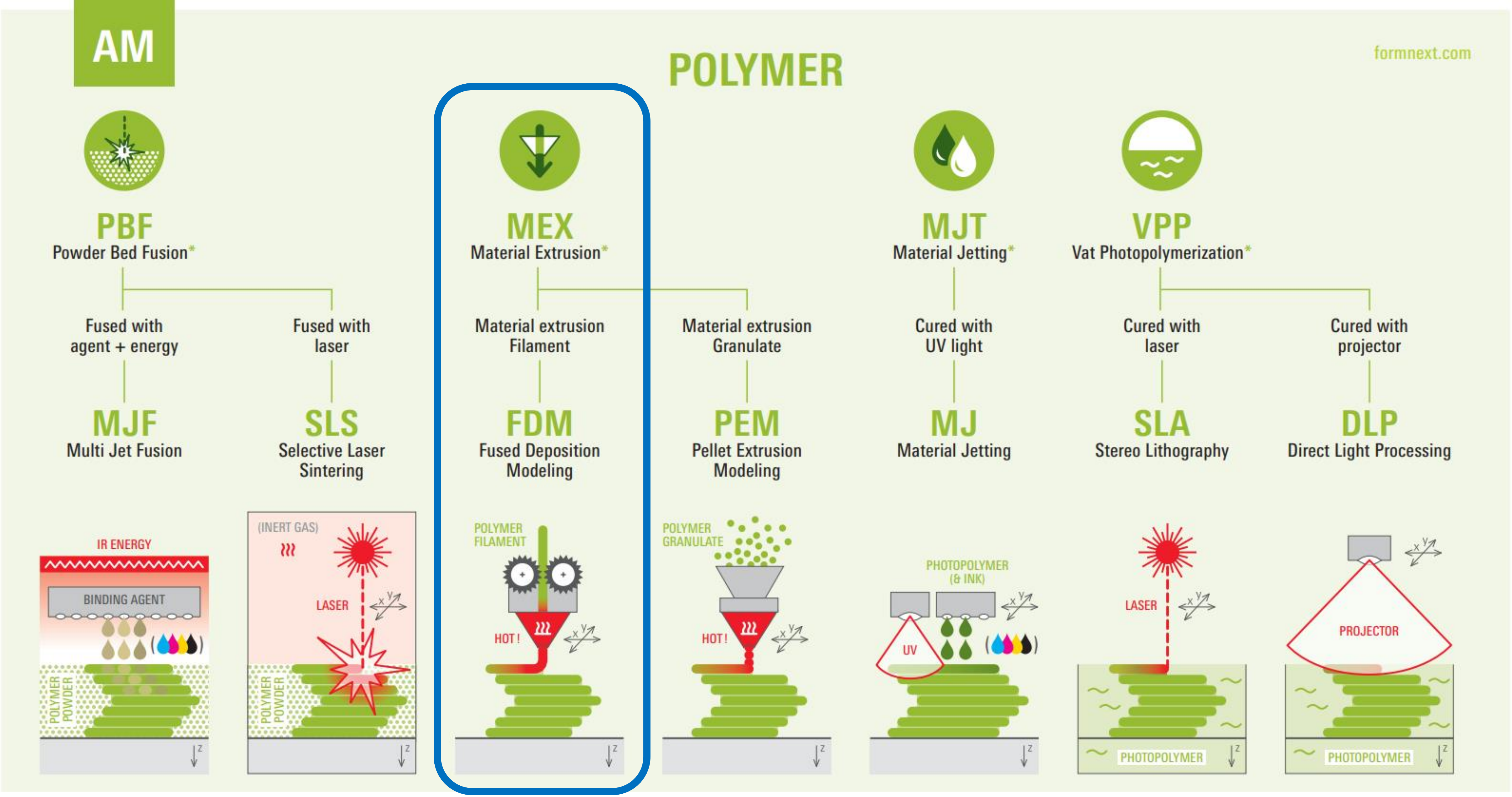


"Formnext 2022 – AM Field Guide Compact"

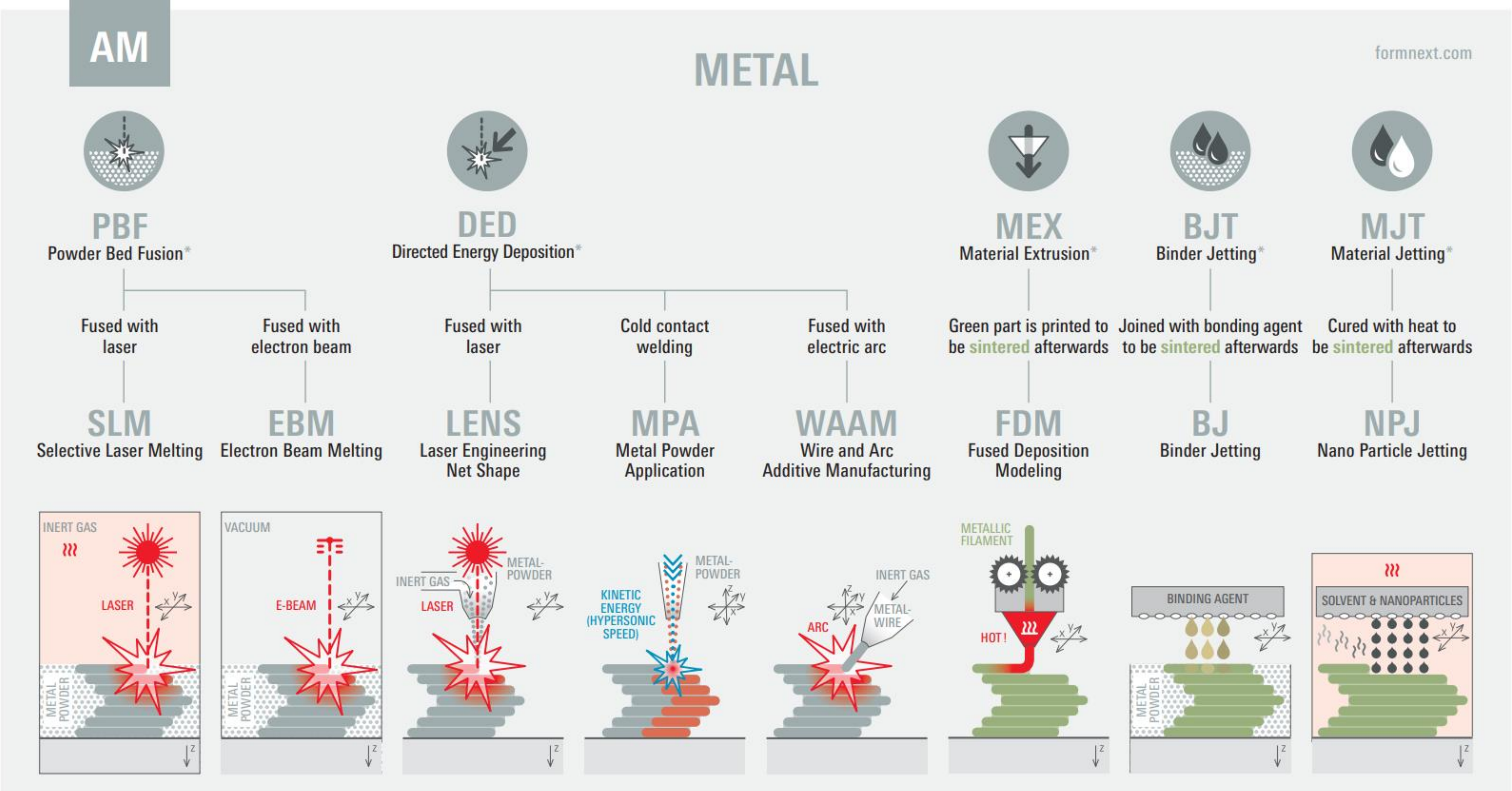
ADDITIVE MANUFACTURING TECHNOLOGIES

3D HUBS

https://www.3dhubs.com/get/am-technologies/



"Formnext 2022 – AM Field Guide Compact"



”Formnext 2022 – AM Field Guide Compact”

AM

formnext.com

OTHER MATERIALS

MEX
Material Extrusion*

Material extrusion
COMPOSITE

CFF
Continuous Filament Fabrication

Paste Extrusion
ANY PASTY MATERIAL

PEM
Paste Extrusion Modeling

BJT
Binder Jetting*

Joined with bonding agent
SAND OR GYPSUM

BJ
Binder Jetting

MJT
Material Jetting*

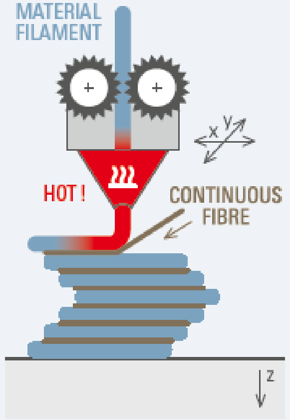
Microdosed
WAX

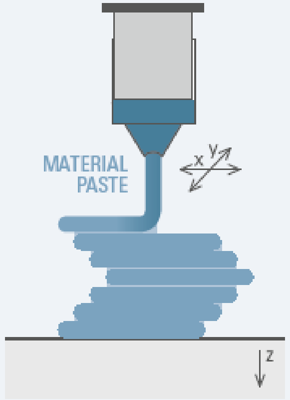
DOD
Drop on Demand

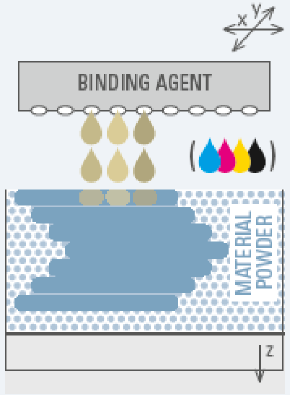
SHL
Sheet Lamination*

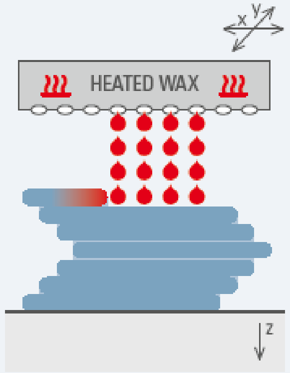
Laminated
COMPOSITE OR PAPER

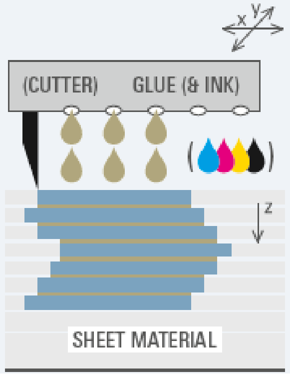
SDL / LOM
Selective Deposition Lamination / Laminated Object Manufacturing











"Formnext 2022 – AM Field Guide Compact"

Photopolymerization

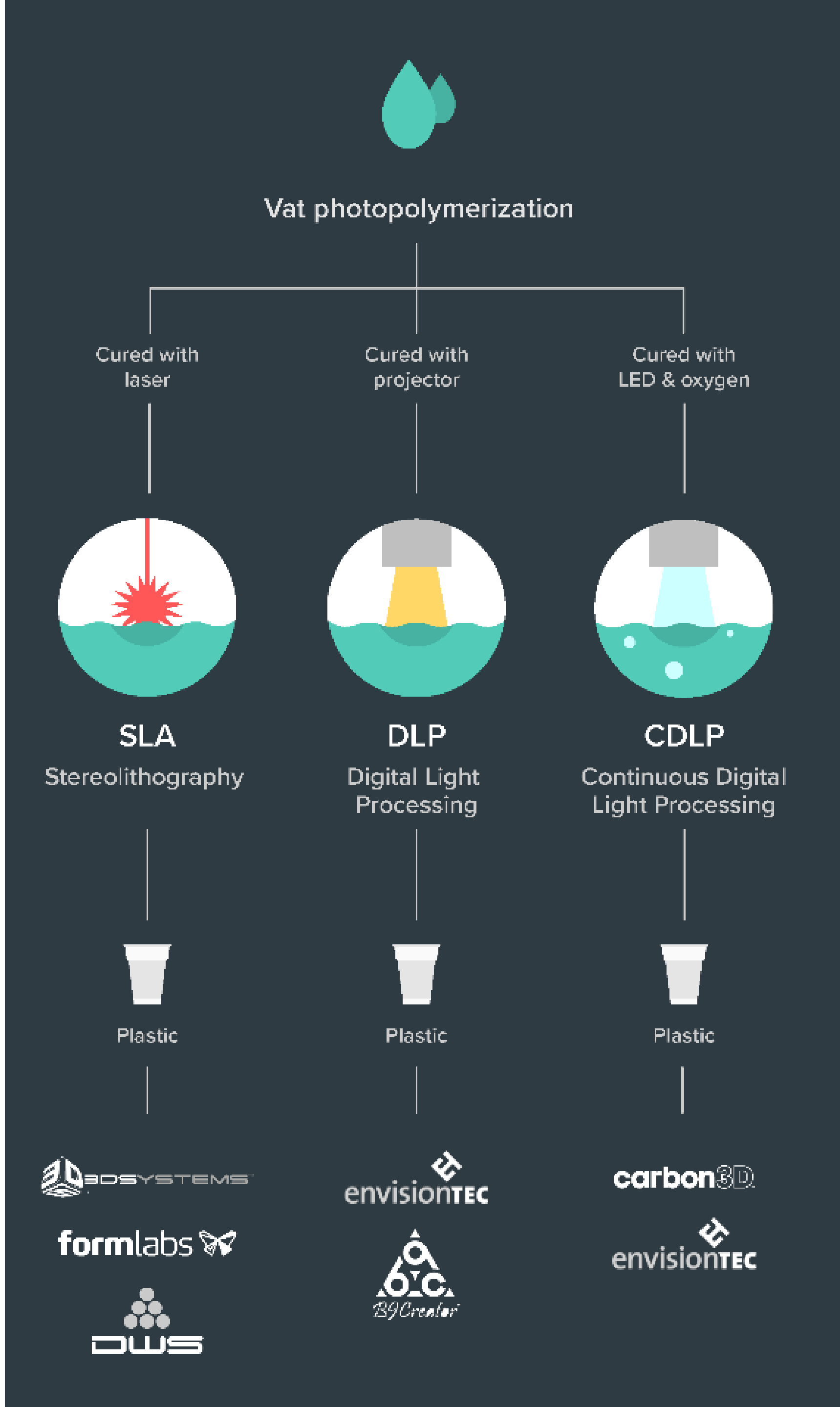
[Video 01]

Liquid photopolymers solidified with UV-light

The first 3D Printing technology (~1984)

Mostly used for prototyping and investment casting

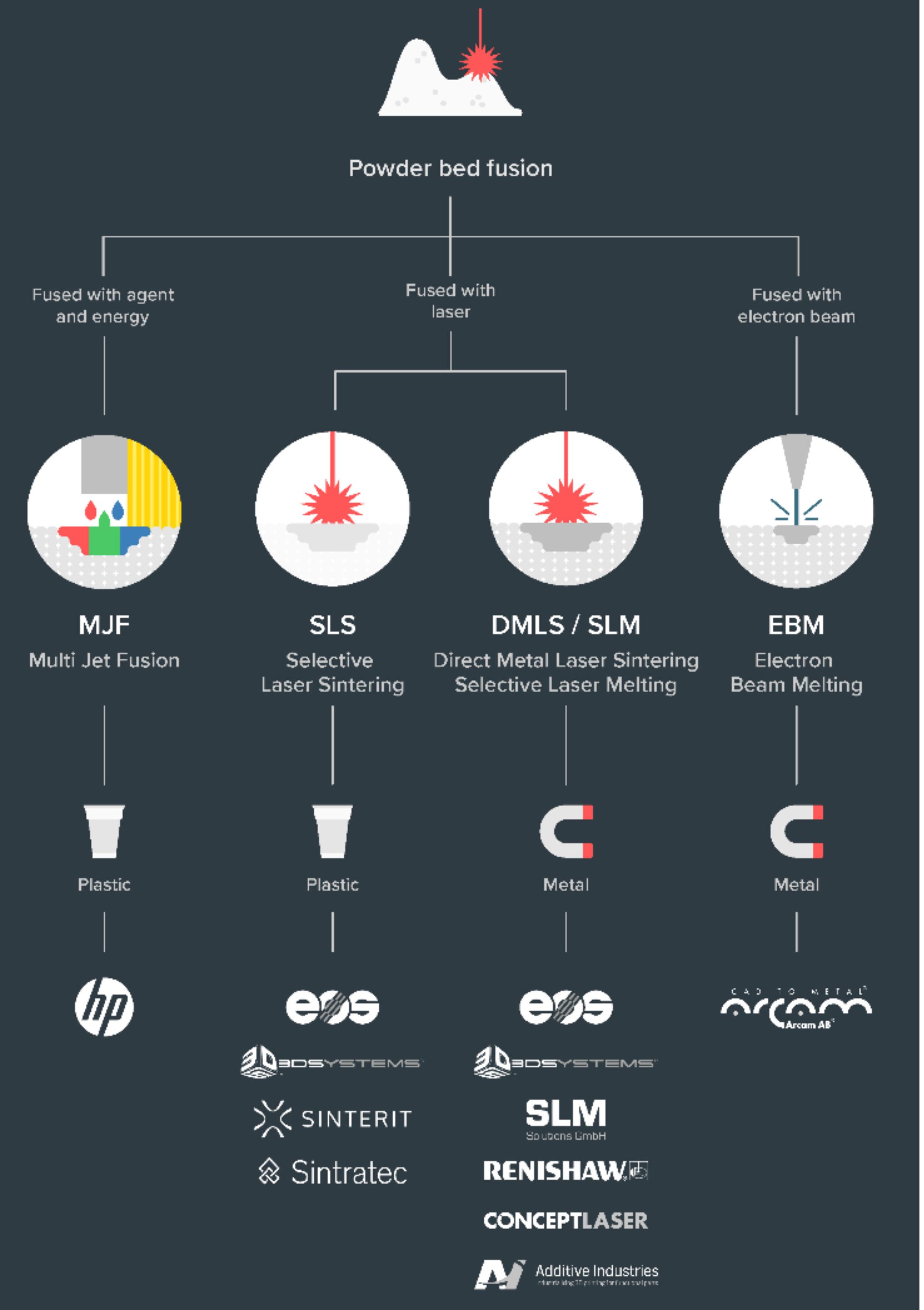
Often poor mechanical properties and parts may degrade in prolonged UV light without protective coating



https://www.3dhubs.com/get/am-technologies/

First Commercially Successful Stereolithography Machine, Model SLA-1, 1987,
Chuck Hull – 3D Systems

https://www.thehenryford.org/collections-and-research/digital-collections/artifact/242212/#slide=gs-249773



Powder Bed Fusion

Video_02

For plastics (MJF / SLS) and metals (DMLS / SLM / EBM)

Material in powder format

High-power, focused laser melts material layer-by-layer

Industrialized technology, end-use products

Parts have good mechanical properties

EOS M290 – behold!

http://cam.usc.edu/references/Machines/EOS_M290_DMLS_3D_Printer.pdf

Material Jetting

Or Polyjet, video_03

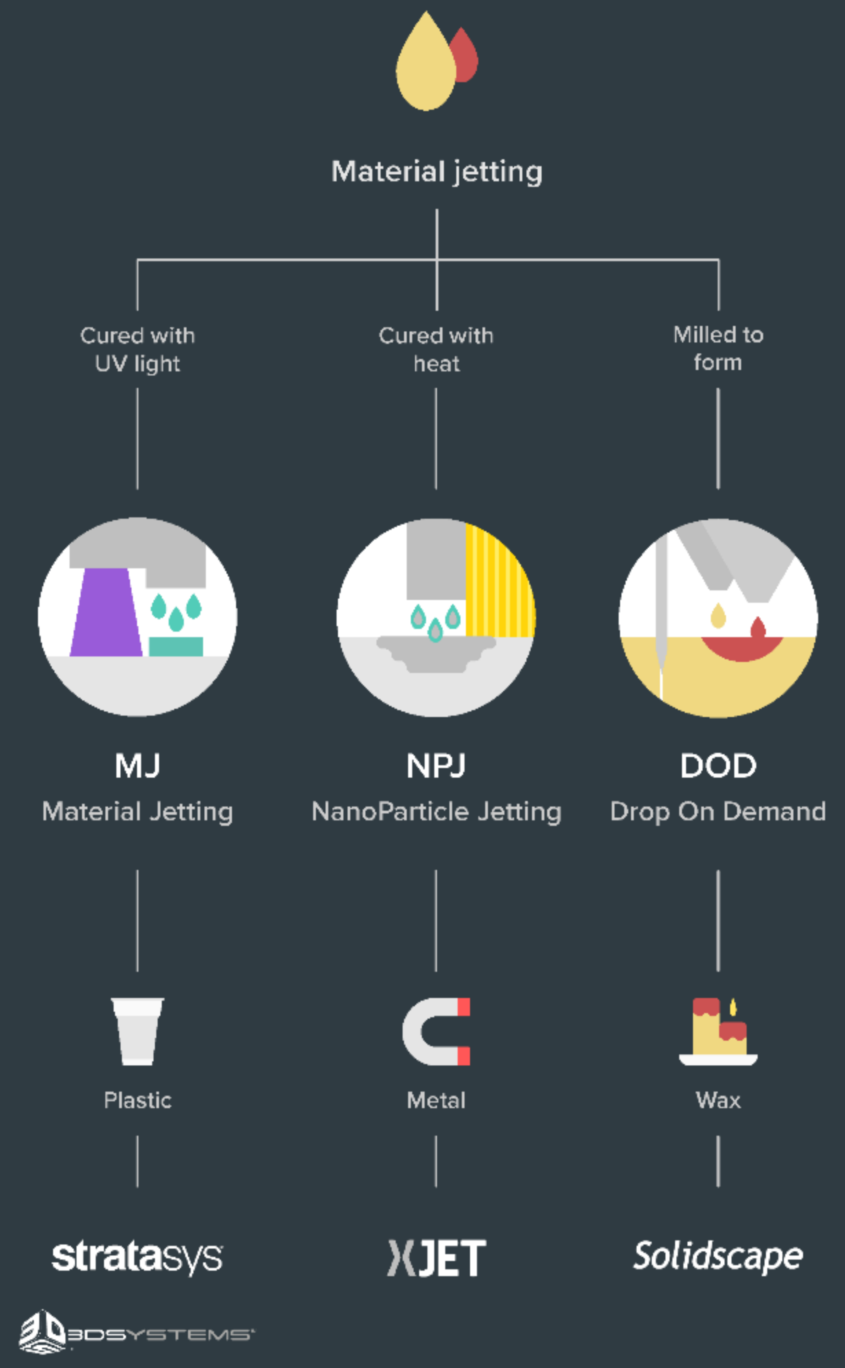
A cousin to photopolymerization : inkjet (2D printing tech) heads are used to drop small photopolymer droplets on the build platform which are then cured with a passing UV-light

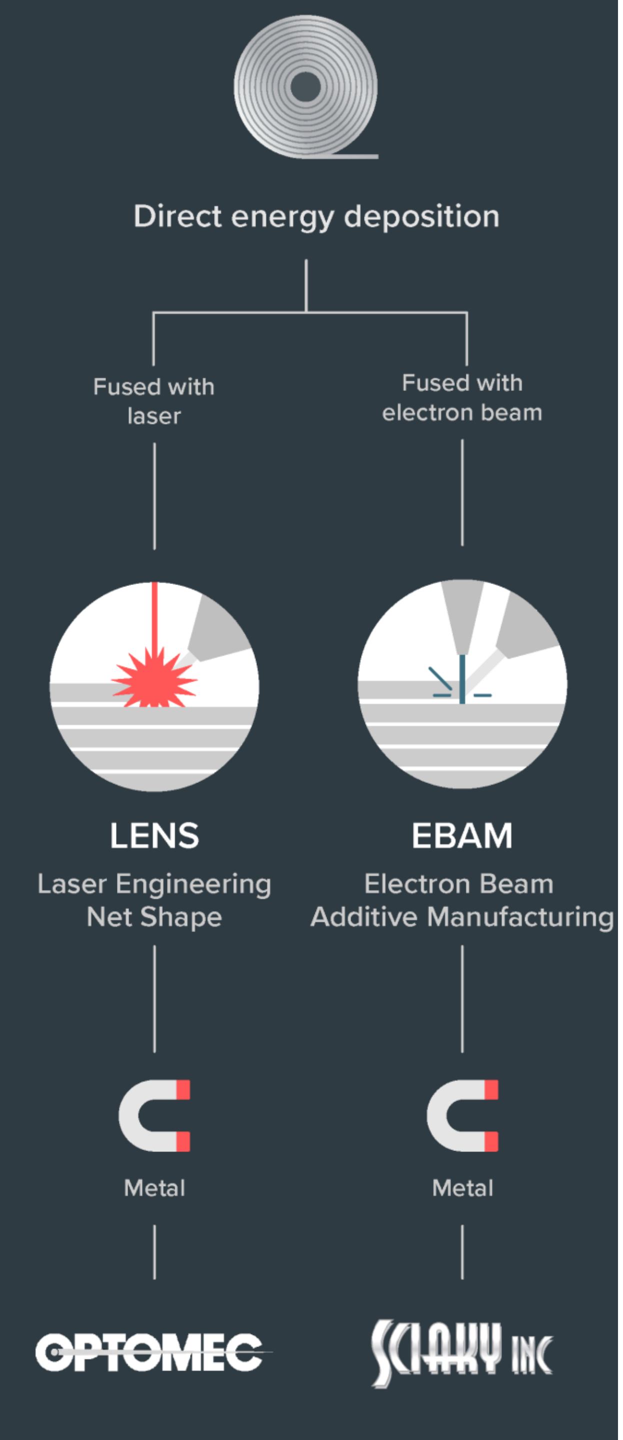
Multi-material possibilities

Very good resolution and fine features

Again, poor mechanical properties and parts degrade with UV

Used for prototyping, medical models, and research





Directed Energy Deposition (DED)

video_04

Powder or wire fed and melted with a laser, electron beam or a plasma arc

Poor surface finish, machining often required

Large components

Repairs of broken parts

So.., what to do with all of this ? video_05

Simple, (sometimes) useful everyday objects

Shoe Support

Shoe Support (Source: Mickapouel, via Thingiverse)

Self-Watering Planter

Houseplants dying from neglect? NEVER AGAIN. Pr
plant waterer, and your conscience will remain clea
for kitchen herbs, where you can make them last up
re-potting in this natty device.

Who made it: Parallel Goods

Where to download it: Cults3D

Toothpaste Tube Squeezer

Squeeze every last drop of toothpaste from the tube with th
tube squeezer. It prints in three separate parts, and is wide e
accommodate most tubes on the market. Not only a cool th
but also something to keep your breath minty fresh.

Who made it: Justin Otten

Where to download it: Thingiverse

Bottle Opener and Cap Gun

Bottle Opener and Cap Gun (Source: 3Deddy, via Thingiverse)

https://all3dp.com/1/useful-cool-things-3d-print-ideas-3d-printer-projects-stuff/

Need a custom tool onboard the International Space Station?

Yes.

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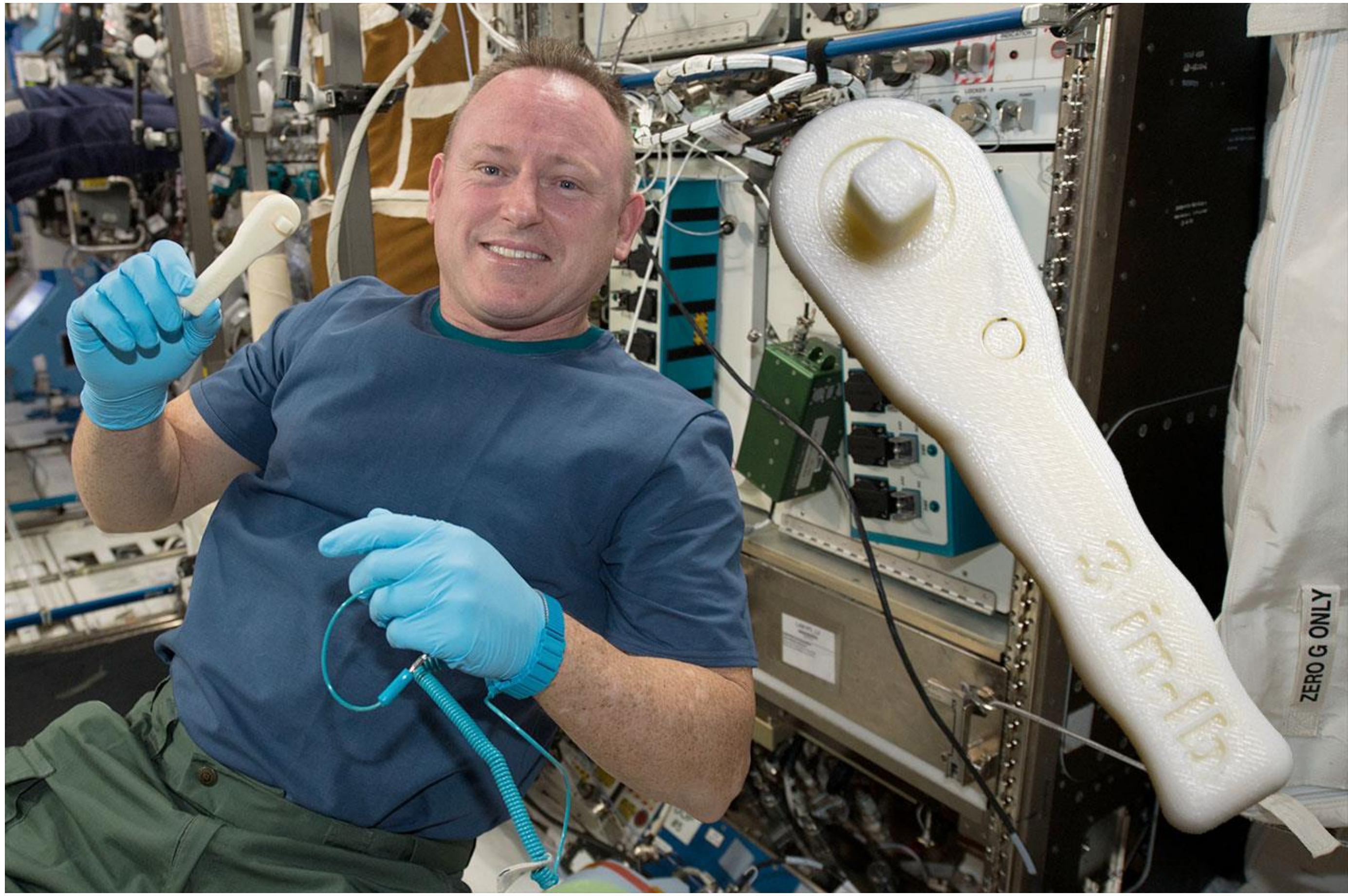
Let me fire up the *Refabricator.*

NASA Artemis program is building habitats on the Moon and later on Mars.

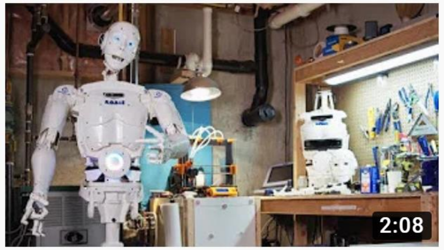
Decreasing Earth-dependance on manufacturing assets in space.



https://blog.grabcad.com/blog/2019/02/26/sending-3d-printed-parts-and-3d-printers-into-orbit/

https://scognito.wordpress.com/category/inmoov/

DIY Robotics, video_06

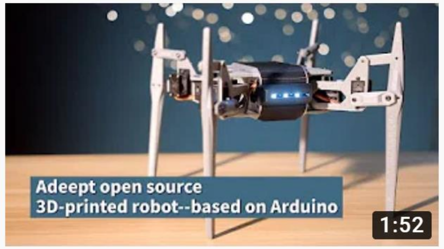


3D Printed Life-Size InMoov Robot

Jukebooth • 2.4K views • 8 months ago

Matt Edminster and Billy Ramey, two New England guys, bought a **3D printer** 3 years ago and what started as a hobby became a ...

4K



Adeept open source 3D printed robot based on Arduino

Adeept Studio • 616 views • 4 months ago

Adeept open source **3D printed robot** based on Arduino. Welcome to the website: www.adeept.com.

3D Printed Delta Robot (Arduino Controlled) 2019

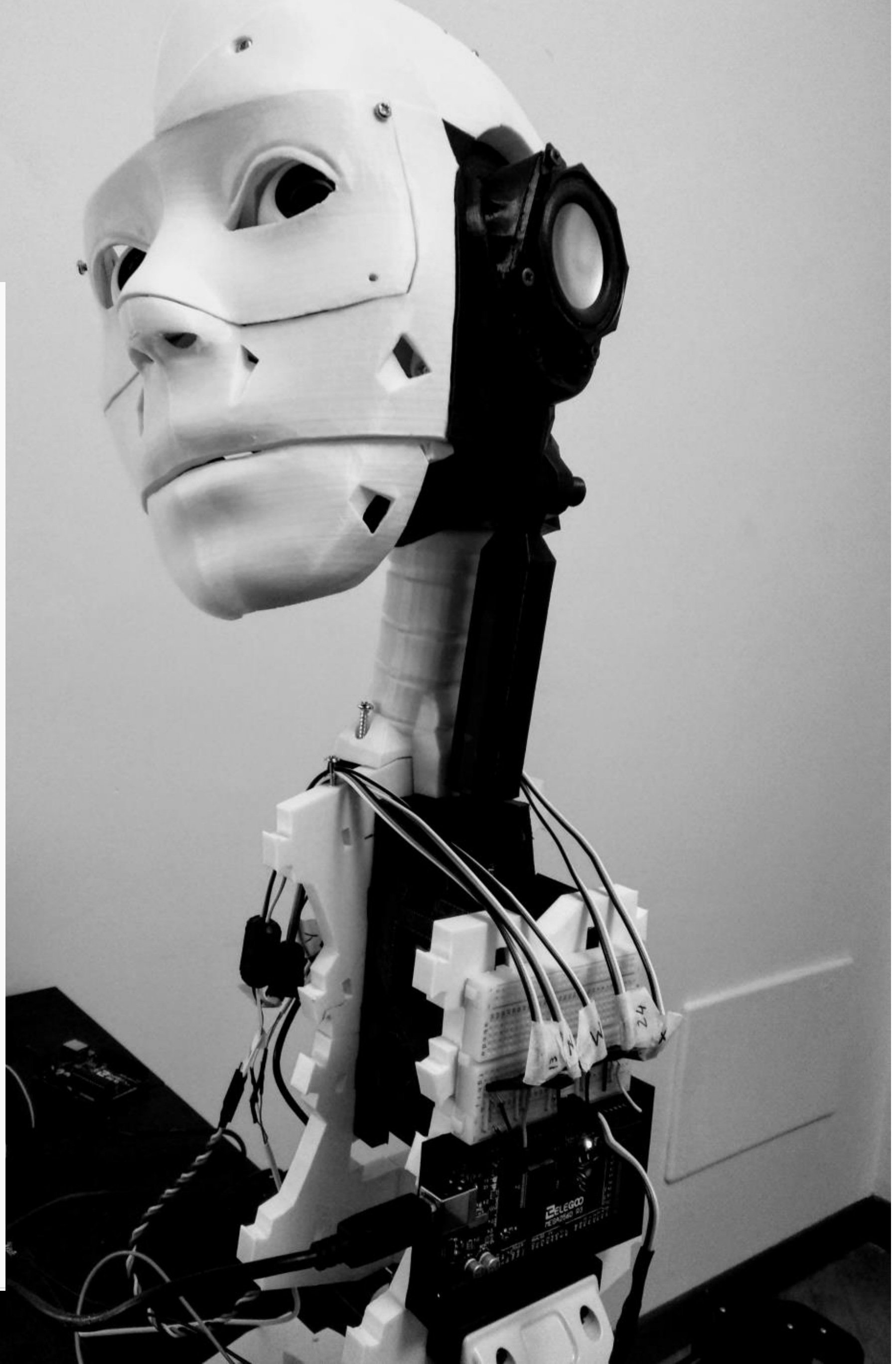
isaac879 • 57K views • 9 months ago

If you enjoyed the video please leave a like and consider subscribing for more. I have always loved how delta **robots** move and ...

3D printed RC FPV tank rover

Brian Brocken • 12K views • 9 months ago

I designed the tank in a way that it can be almost completely **3D-printed**. It's of course inevitable to truely completely **3D print** the ...

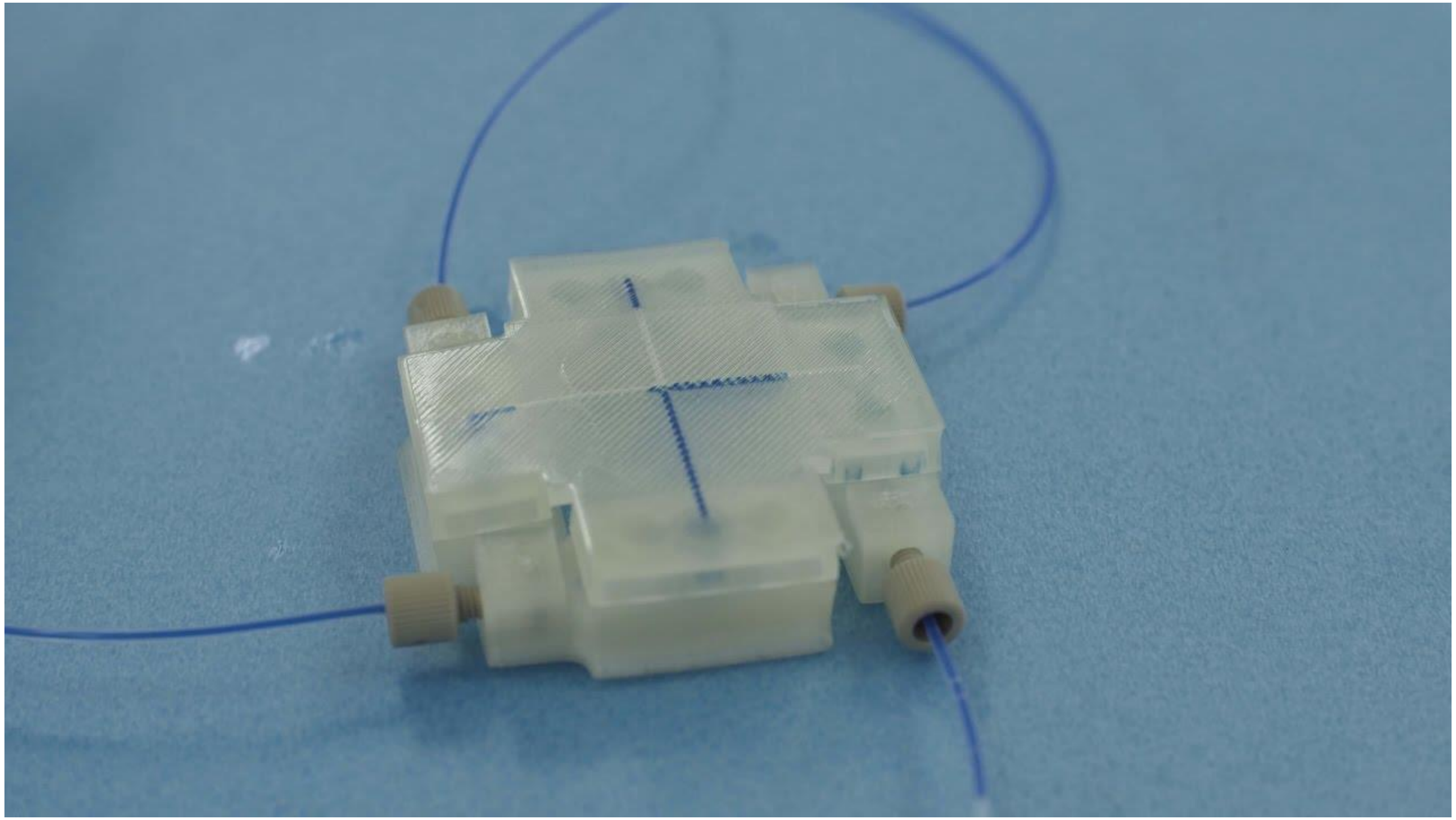


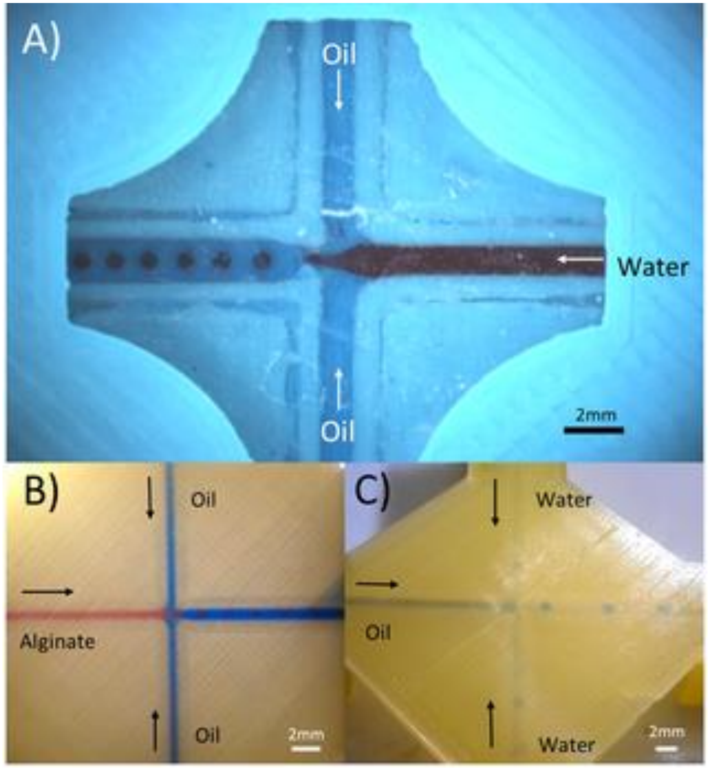
YouTube : some search results for “3d printed robot” published last year (2020)

Volkswagen : video_07
Jigs and fixtures to help assemble cars

- https://www.tctmagazine.com/can-you-jig-it-volkswagen-ultimaker-3d-printing/

Microfluidic devices with an Ultimaker





https://ultimaker.com/learn/cardiff-university-accessible-3d-printed-microfluidic-devices

Morgan, A. J., San Jose, L. H., Jamieson, W. D., Wymant, J. M., Song, B., Stephens, P., ... & Castell, O. K. (2016). Simple and versatile 3D printed microfluidics using fused filament fabrication. *PloS one*, *11*(4).

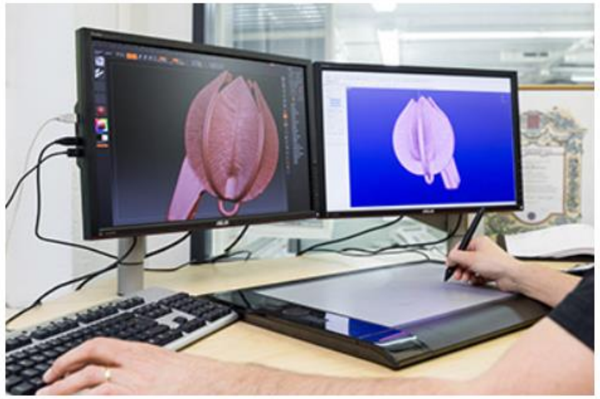
Adidas

- https://3dprintingindustry.com/news/adidas-to-release-a-new-version-of-3d-printed-shoe-alphaedge-4d-155578/

MX3D Smart Bridge

World's first 3D-printed steel pedestrian bridge.

Kalevala Koru – jewellery with 3D Printing

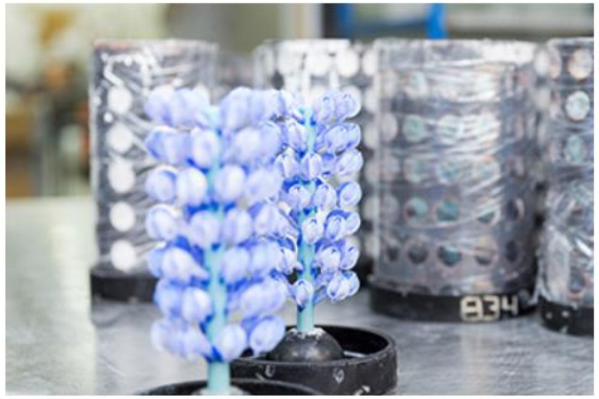


Also this can be a goldsmith's tool. The 3D model of the Snow Flower is being prepared using the drawing pad and the computer.

Snow Flowers printed in blue wax with a 3D printer.

Some of the wax models are still created traditionally by hand. Hot wax is injected inside a rubber mold and the solidified wax model is carefully removed from the mold.

The wax flowers are ready for the next stage.

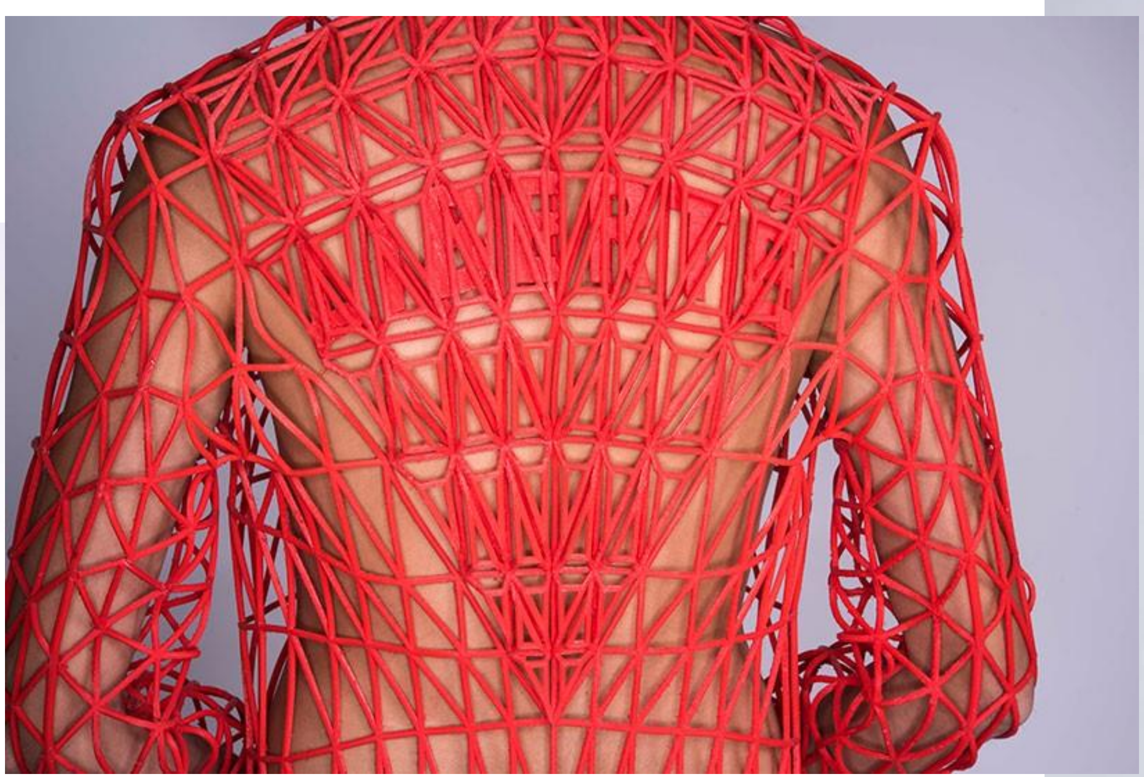


The wax models are attached to a wax pole forming tree-like structures. The trees are placed inside a cylinder which is then cast with plaster. Numbers on the cylinders mark the different treatments each cylinder receives depending on the jewelry model that is being produced.

The wax has been melted off from the cylinder and replaced with molten metal.

https://www.kalevalakoru.fi/en/story/handmade-in-finland

3D Printing in Fashion



Danit Peleg

https://3dprintingindustry.com/news/3d-printing-wins-big-at-the-oscars-with-black-panther-and-materialise-149884/

Glass / Ceramics / Concrete 3D printing

Neri Oxman

Ashish Mohite

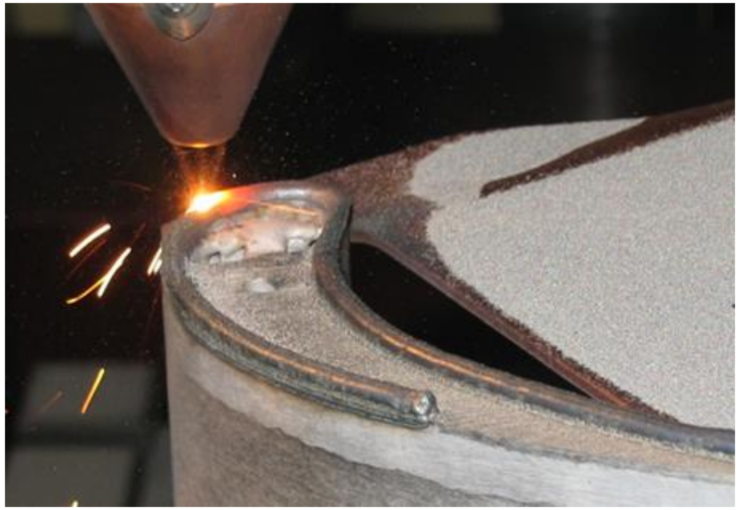
Company 'Concreative'

http://www.globalconstructionreview.com/markets/vinci-sets-factory-3d-printed-elements-dubai/

3D printed house in Dubai

Eco-sustainable 3D printed house (local and recycled materials) - Tecla, 3D printed by WASP
https://www.youtube.com/watch?v=w9sXqxccRPM&t=12s

Repair of blades



Repairing blades of different kinds is a common application of DED. The worn tips are regrown and machined to shape.

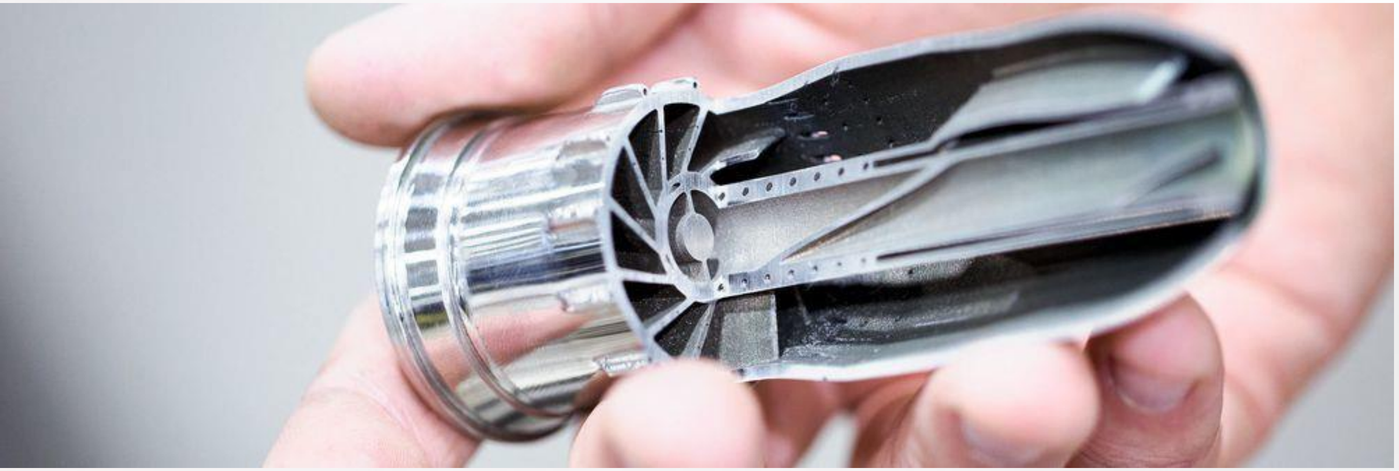
Sources: https://www.oerlikon.com/metco/en/products-services/coating-services/coating-services-laser-cladding/component-manufacturing-and-repair//

LEAP fuel nozzle

Part Consolidation - previously almost 20 parts welded together, now 1 single part : 3D printed, machined, and heat treated. Already 30 000+ made.

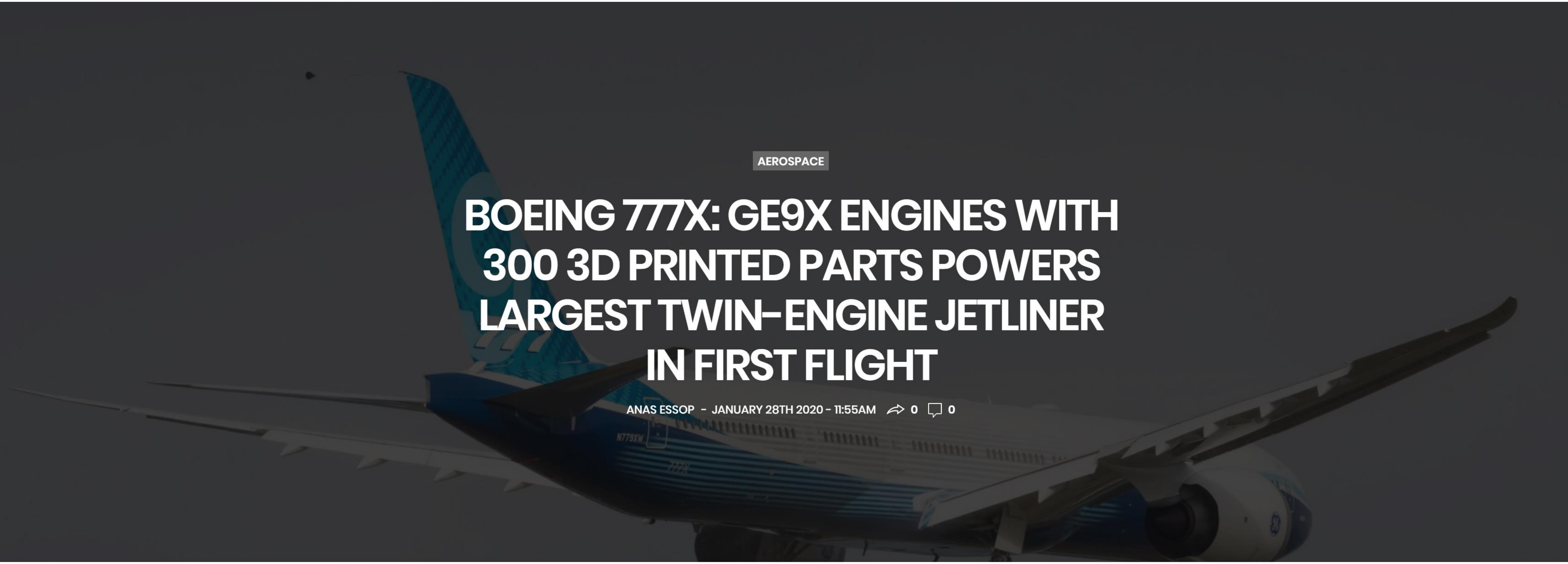
https://www.geaviation.com/commercial/engines/ge9x-commercial-aircraft-engine

https://www.ge.com/reports/heirs-gutenberg-ge-adding-next-chapter-3d-printing-push-germany/



https://www.ge.com/reports/all-the-print-thats-fit-to-pitt-new-additive-technology-center-opens-near-steel-town/

Jet Engine Parts

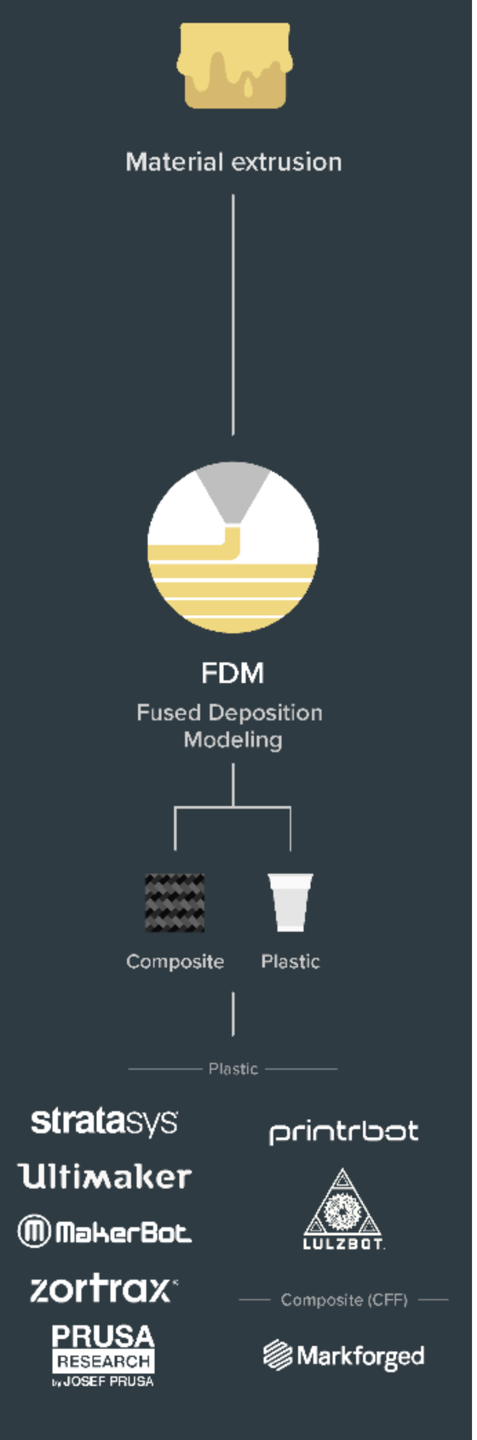


3D Printing Industry. Anas Essop. 2020. Boeing 777X: GE9X Engines with 300 3D Printed Parts Powers Largest Twin-Engine Jetliner in First Flight. Available at: https://www.3dnatives.com/en/boeing-777x-300-3d-printed-parts-290120205/ Accessed 14.11.2022

Was there a break already?

Remember to register for practical sessions!

Material extrusion | The printers you will use today

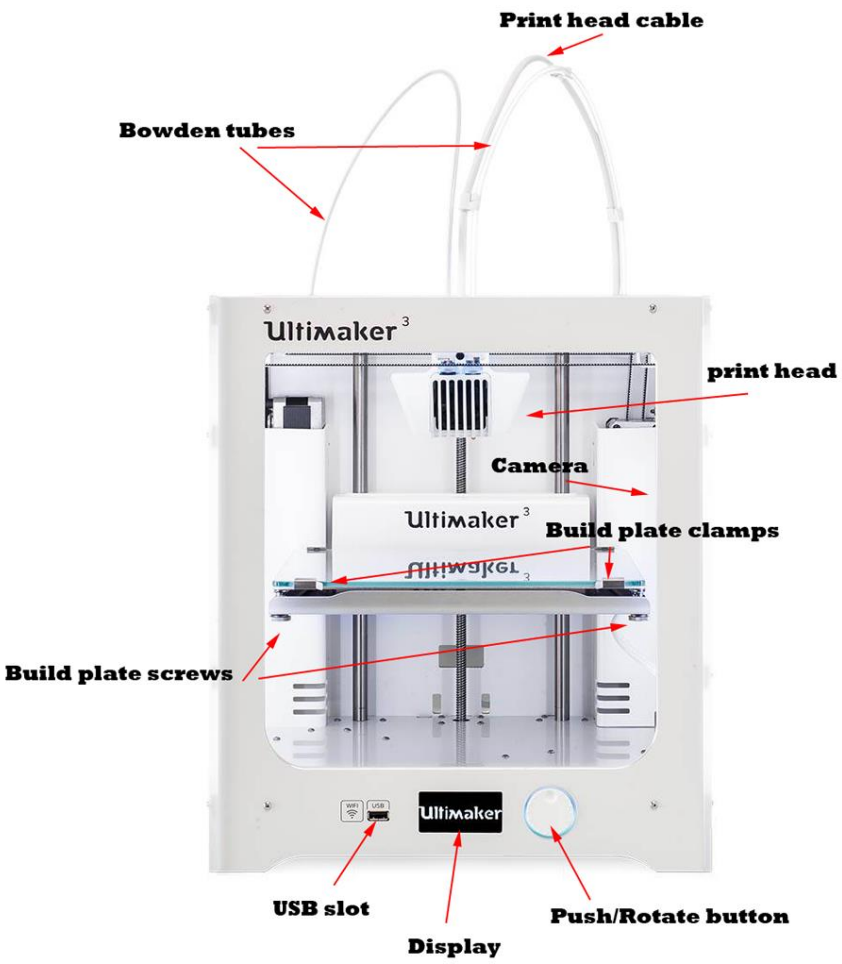


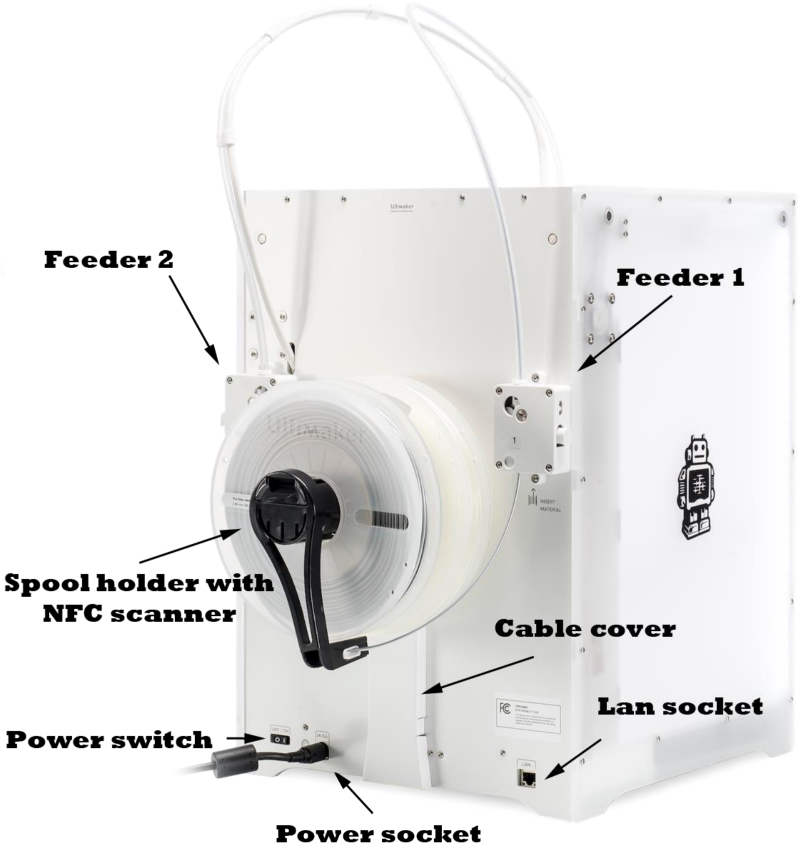
Material Extrusion (FDM)

https://www.3dhubs.com/get/am-technologies/

Material Extrusion (FDM) – video_09 1, video_09 2

Ultimaker – what is what





Ultimaker 3:
https://ultimaker.com/en/resources/45871-anatomy-of-an-ultimaker-3

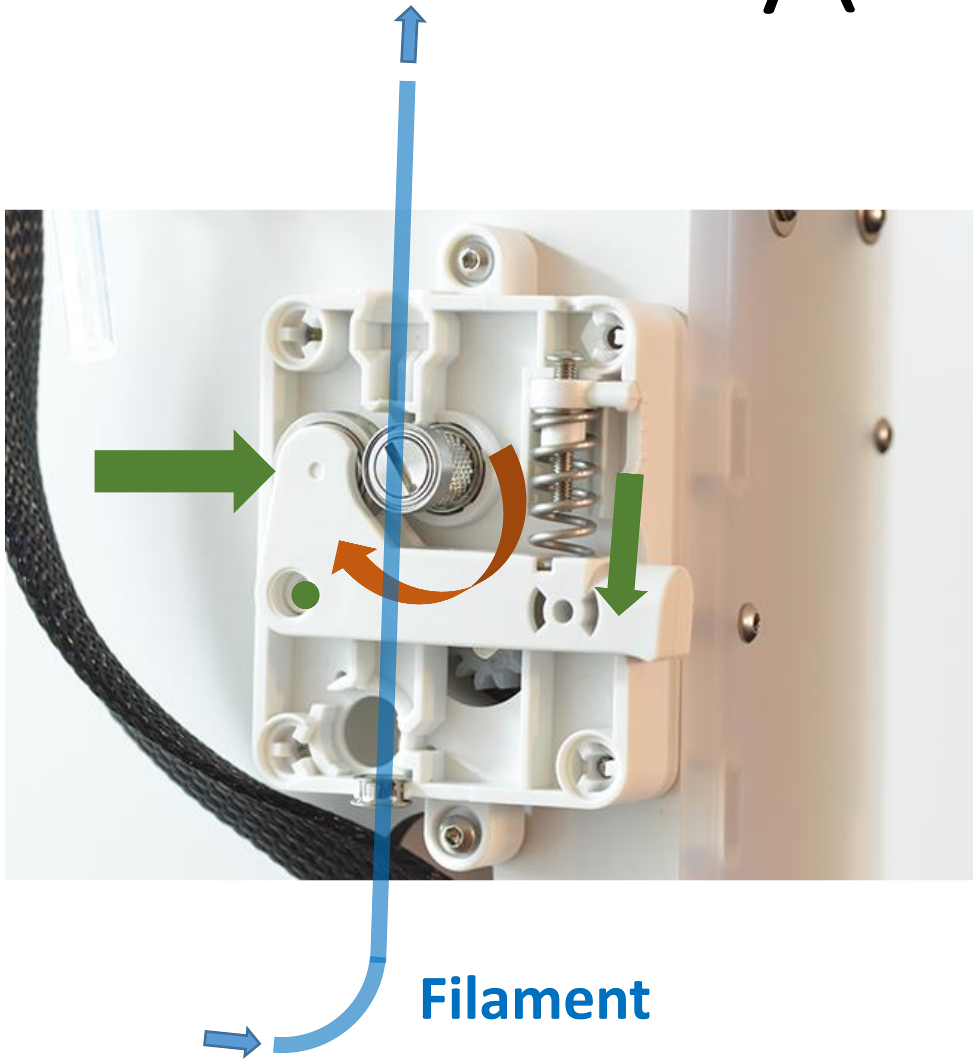
Ultimaker 2:
https://ultimaker.com/en/resources/22131-anatomy-of-an-ultimaker-2

Material Extrusion Systems

Main differences:

- Movement of the extruder, the build plate or both: *Cartesian or polar coordinates, delta arrangement or with an industrial robot*
- *Extruder type; filament-, plunger- and screw-based*
- *Bowden* or *Direct* extruder
- *Open* or *Closed* build volume
- No heating, Heated build plate and/or heated build volume
- Higher temperature nozzles for more exotic materials (like PEEK, ULTEM, PPSU)

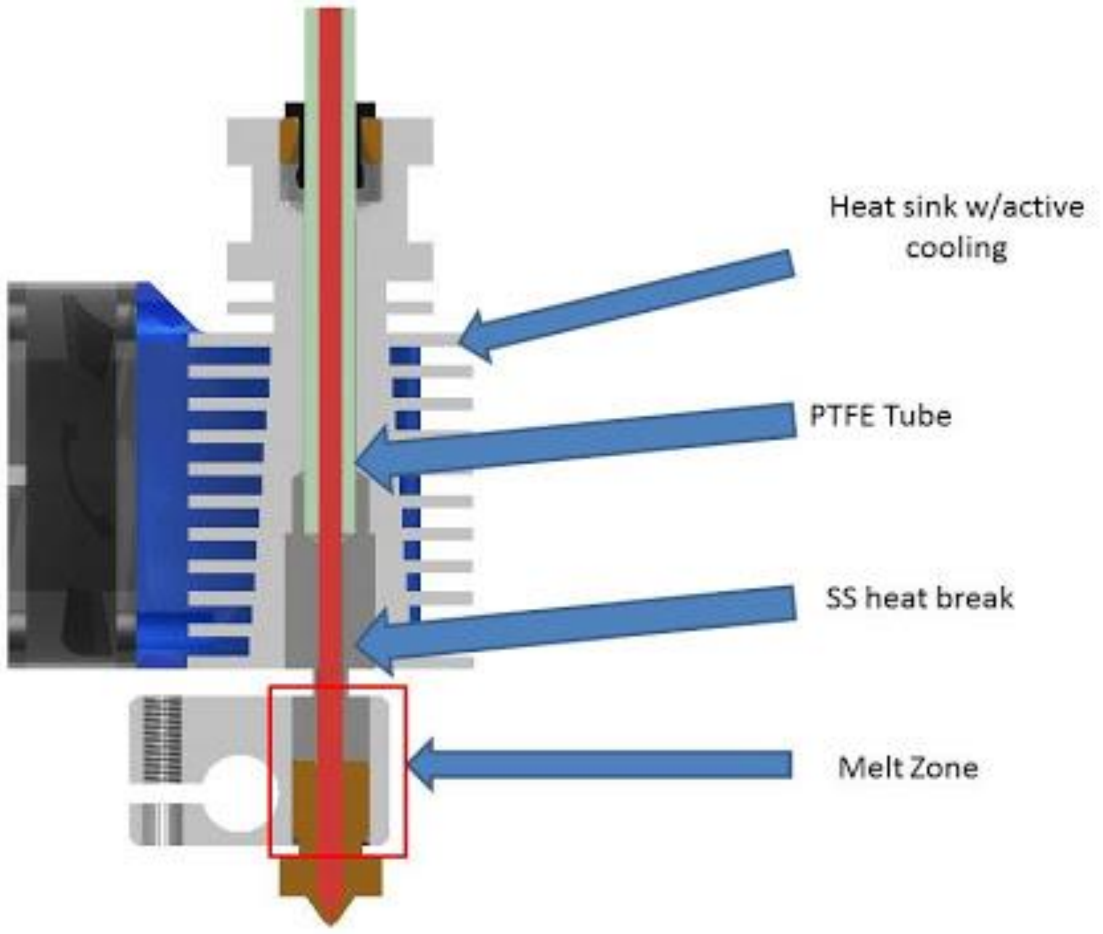
Feeder assembly (bowden)



Stepper motor (geared) rotates feeder screw
Spring loaded arm + bearing compresses filament against the feeder screw to move it towards the extruder

! Please do not adjust or open the Feeder boxes yourself. In case of a problem, ask the ADDLAB staff to do it !

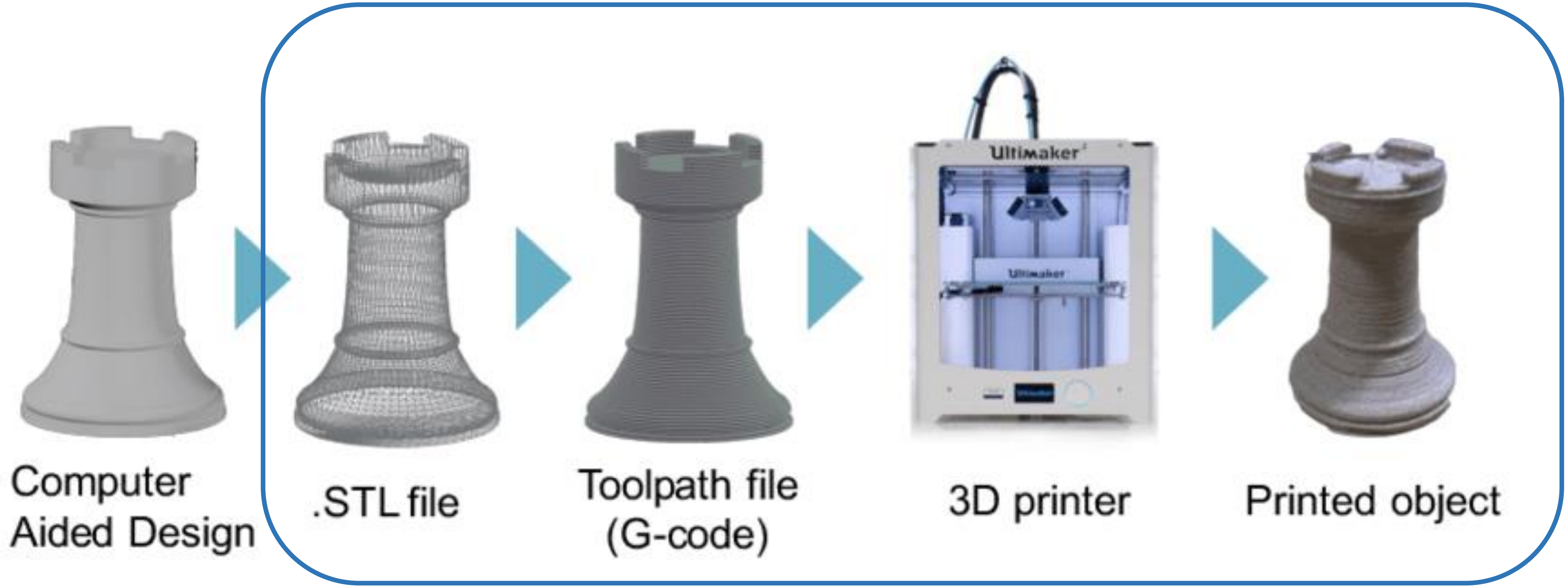
Extruder assembly (example)



https://www.matterhackers.com/articles/how-to-clear-and-prevent-jams

Digital workflow, software & design

3D printing – digital to physical

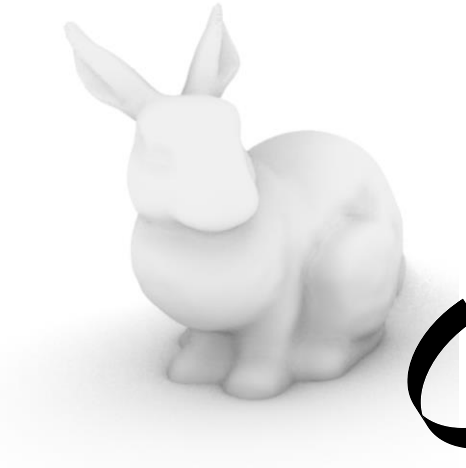


CAD model or scan, 3D

Cura slicing software, 2D slices out of 3D

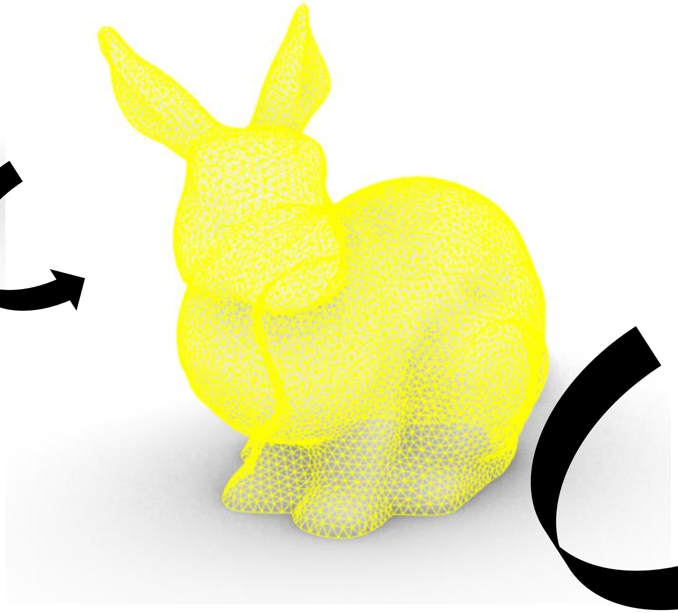
Image source: Gao, Yang & Li, Borui & Wang, Wei & Xu, Wenyao & Zhou, Chi & Jin, Zhanpeng. (2018). Watching and Safeguarding Your 3D Printer: Online Process Monitoring Against Cyber-Physical Attacks. Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies. 2. 1-27. 10.1145/3264918.

From 3D model to printable file



1. Original 3D model

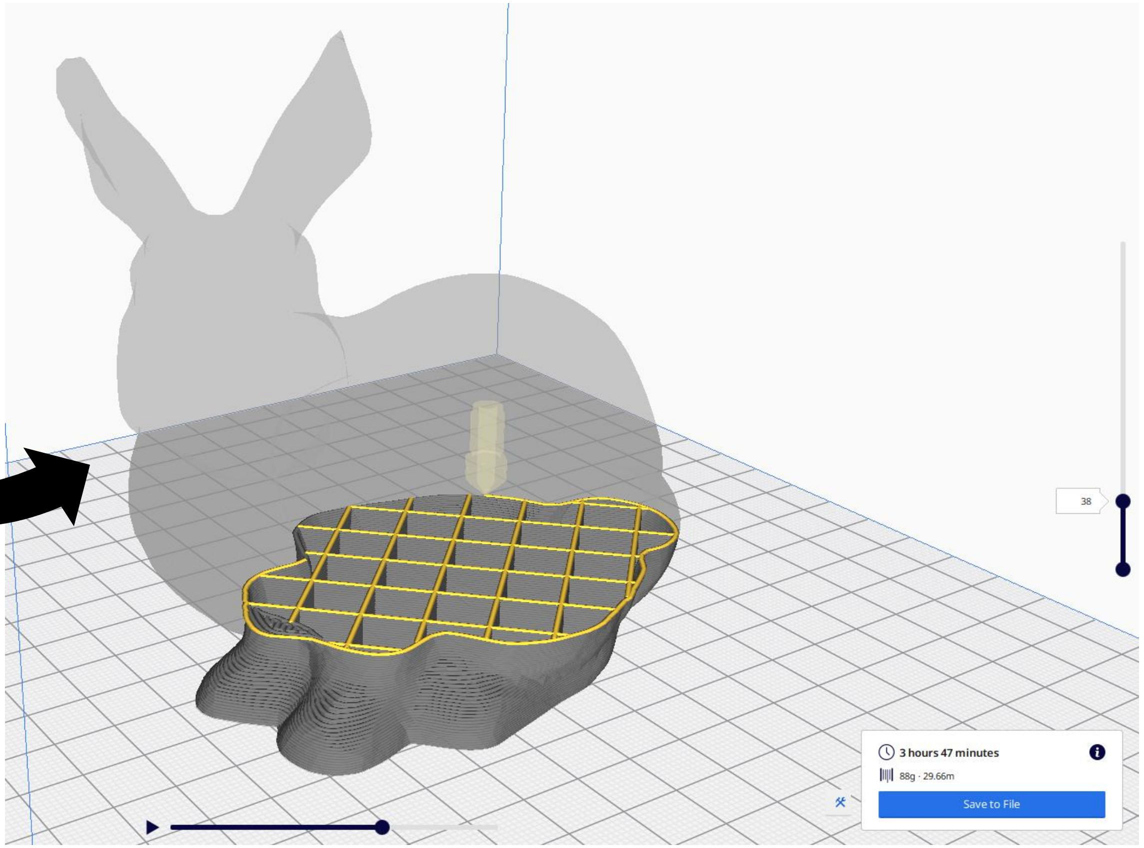
File format examples:
.OBJ, .STEP, .IGES, .PRT,
.SLDPRT, …



2. STL conversion
Standard **T**riangle/ **T**essellation **L**anguage

Current industry standard
for 3D printing

3. Sliced to 2D layers and G-code created
Layer thickness-, nozzle / bed temperature-,
infill-, support-, etc. .. settings



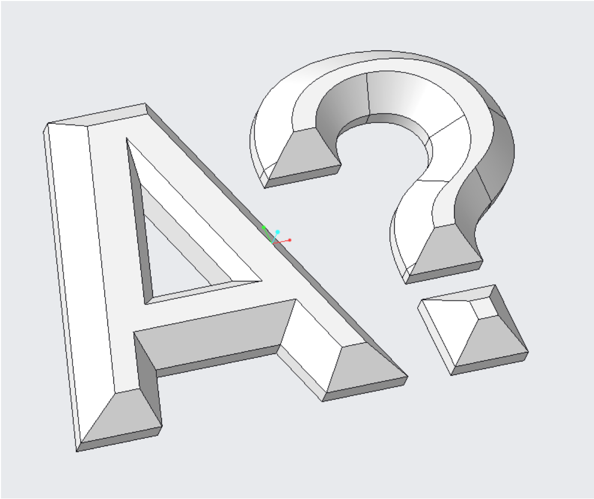
STL conversion (3D model to .stl)

STL (**S**tandard **T**essellation **L**anguage) https://en.wikipedia.org/wiki/STL_(file_format)

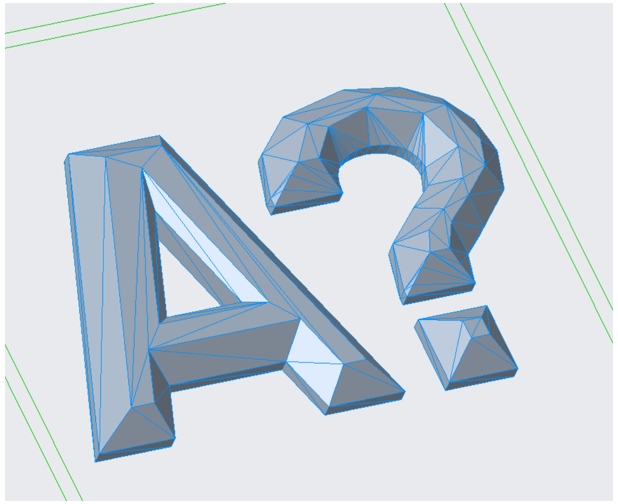
Approximates a surface of a solid 3D model by dividing it into triangles and normal vectors

Is the most common file format that the slicing software understands

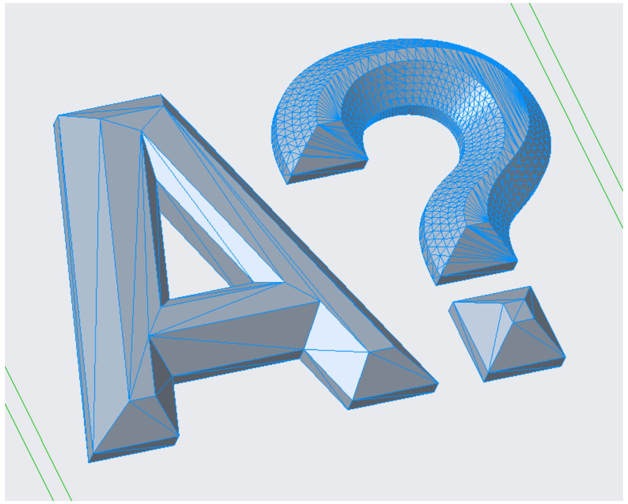
Supported by almost all 3D modeling software



3D model (Creo .prt), **143 KB**

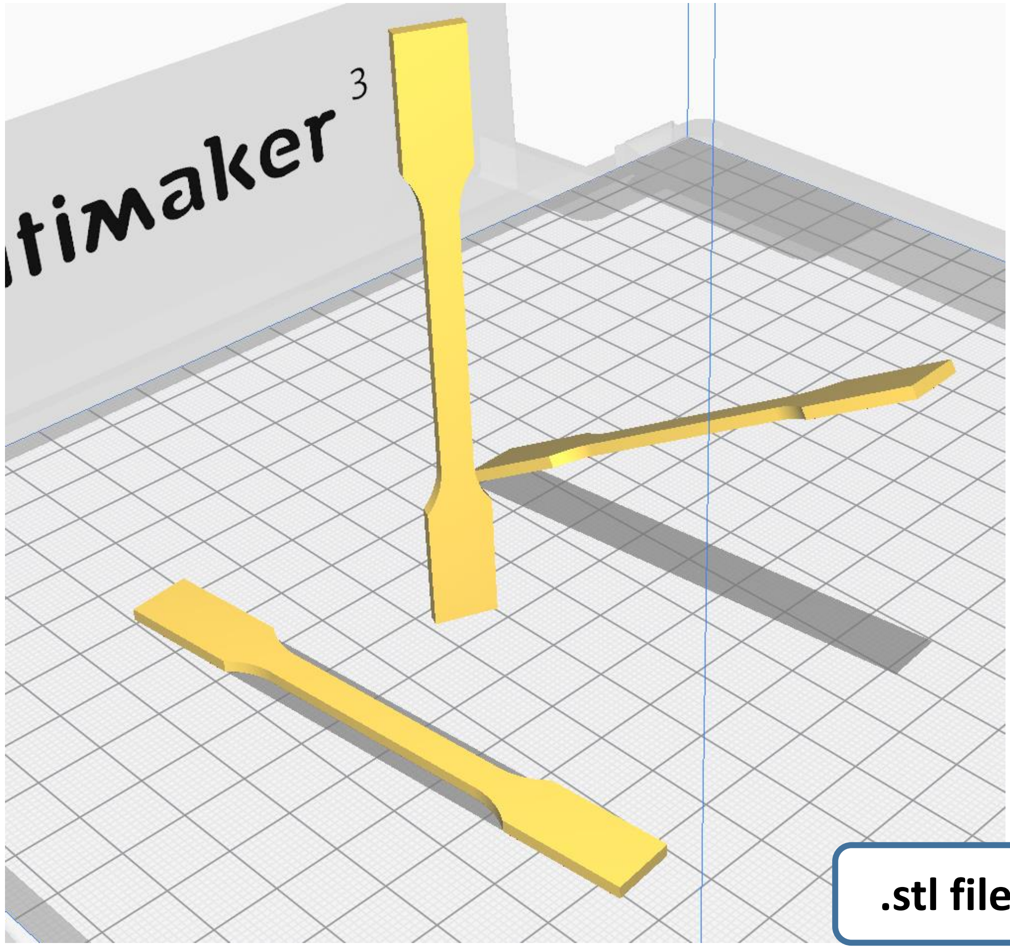


.stl coarse settings, **14 KB**

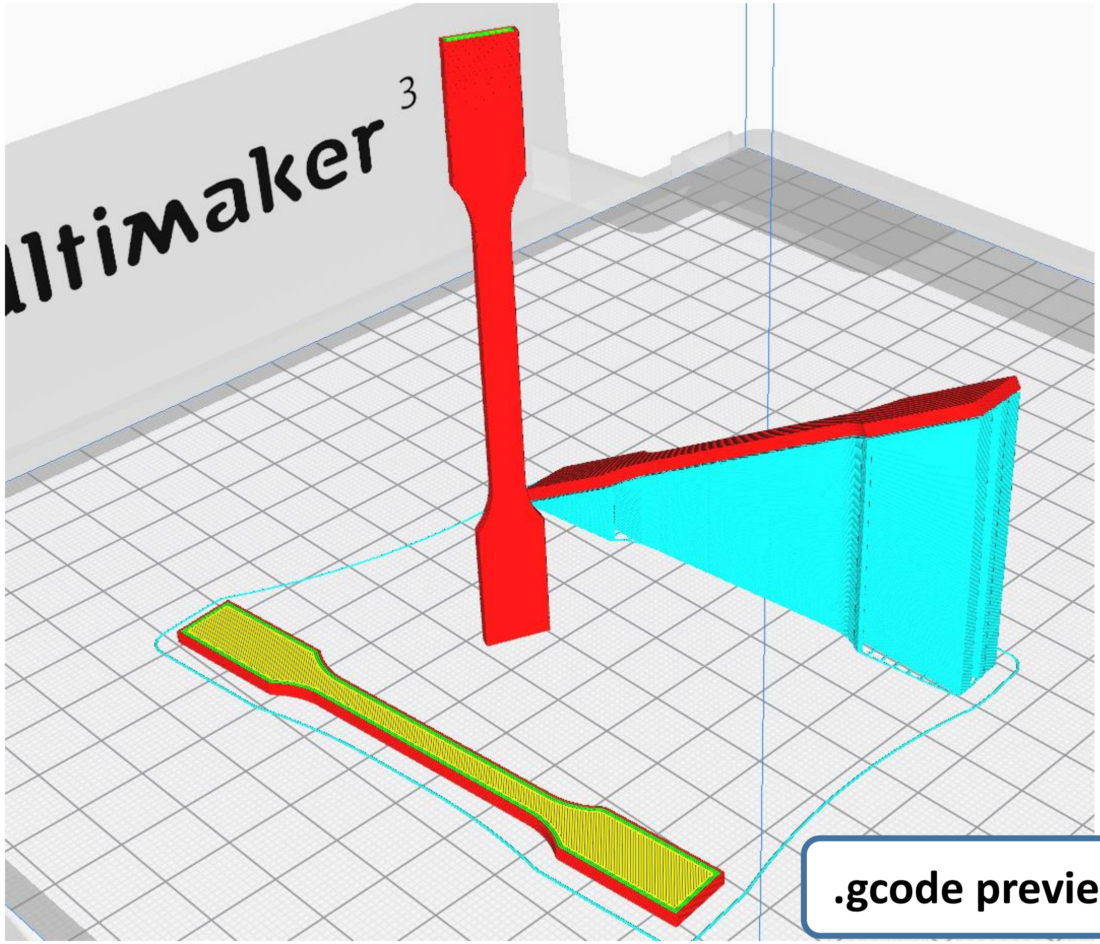


.stl fine settings, **96 KB**

Build orientation, overhangs, support structure



.stl files

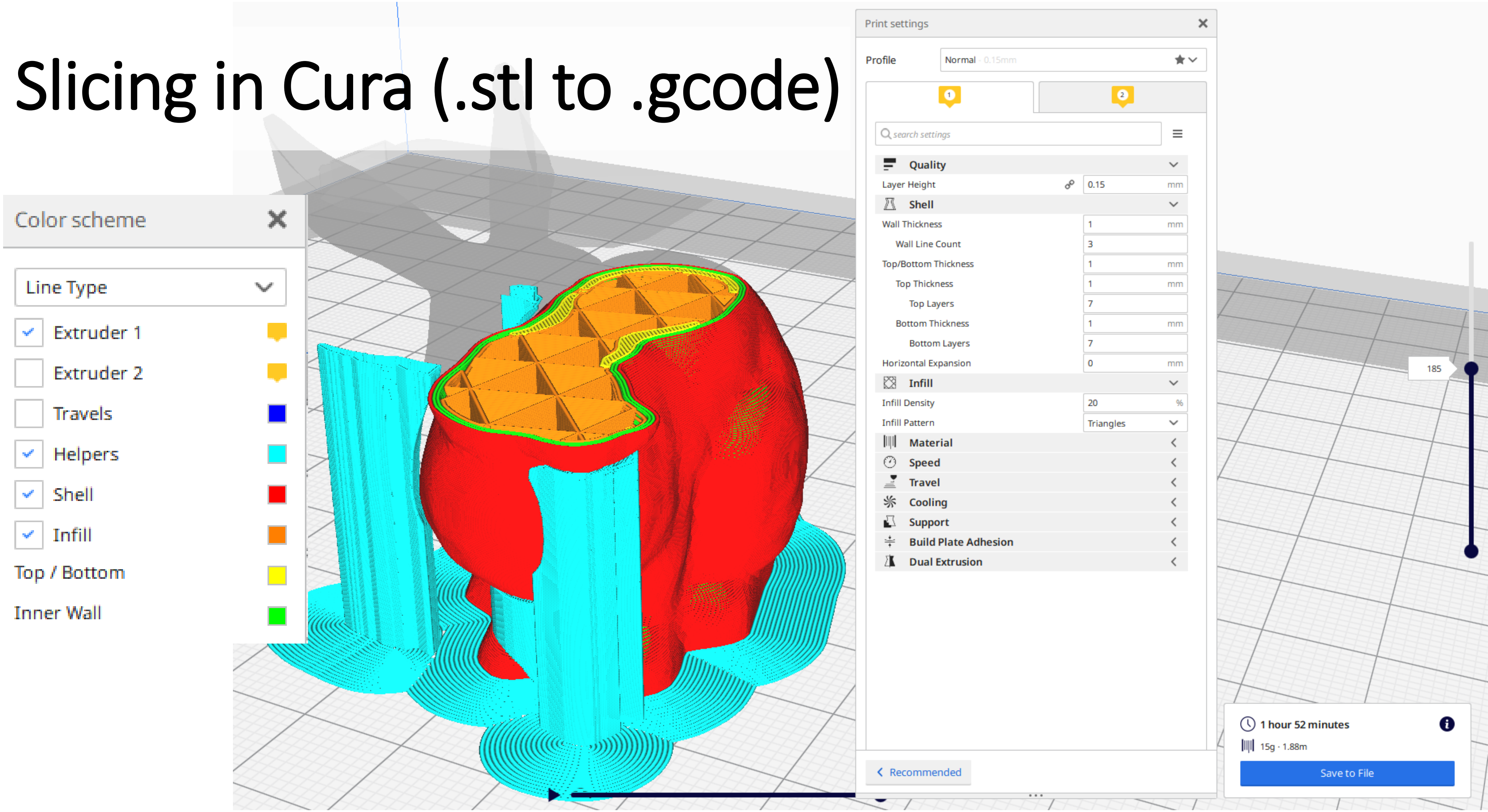


.gcode preview

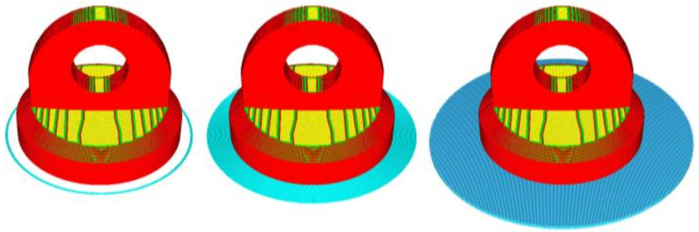
.STL files brought into Cura, different build orientations

Slicing operation and support generation

Slicing in Cura (.stl to .gcode)



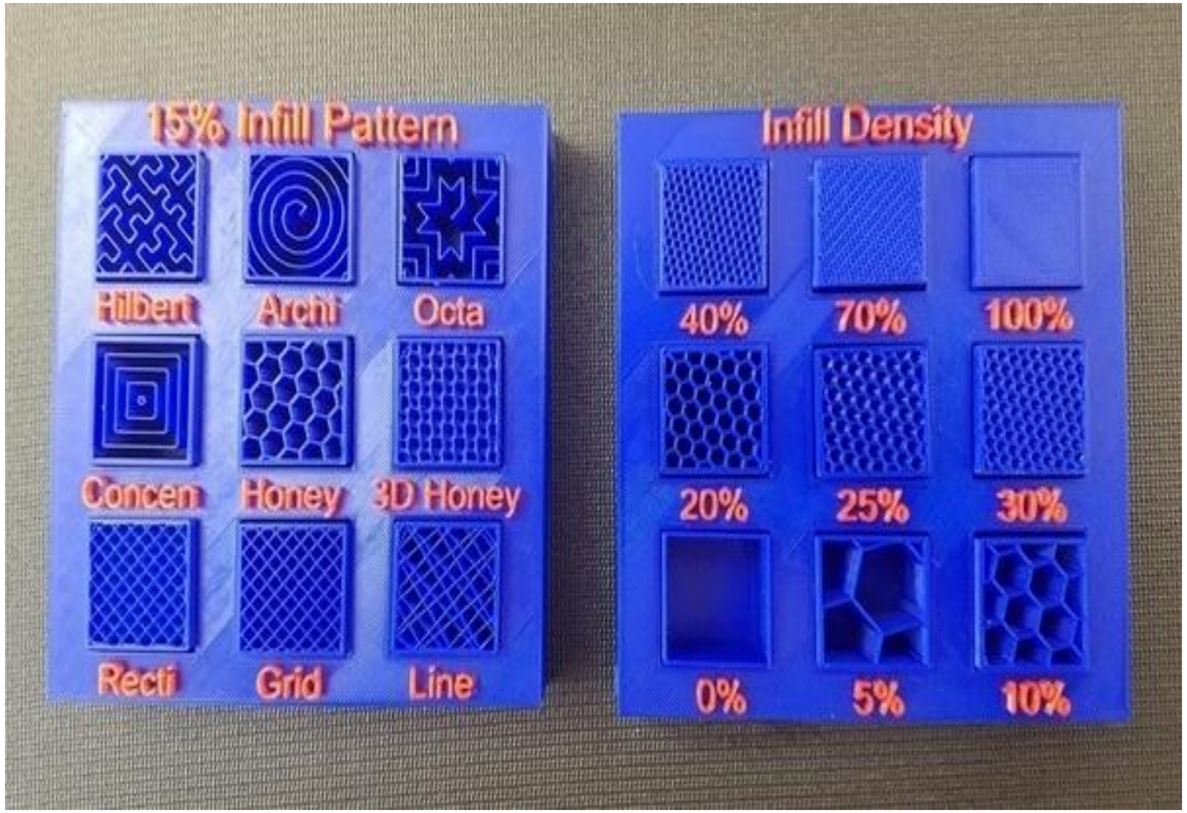
Adhesion, Layers and Infill



Skirt Brim Raft

Quality (layer-height difference)

Layer height:	0.06mm	0.1mm	0.2mm
Approx print time:	30mins	18mins	9mins



G-code – commands for the printer

```
G0 X12              ; move to 12mm on the X axis
G0 F1500            ; Set the feedrate to 1500mm/minute
G1 X90.6 Y13.8 E22.4 ; Move to 90.6mm on the X axis and 13.8mm on the Y axis while extruding 22.4mm of material
```

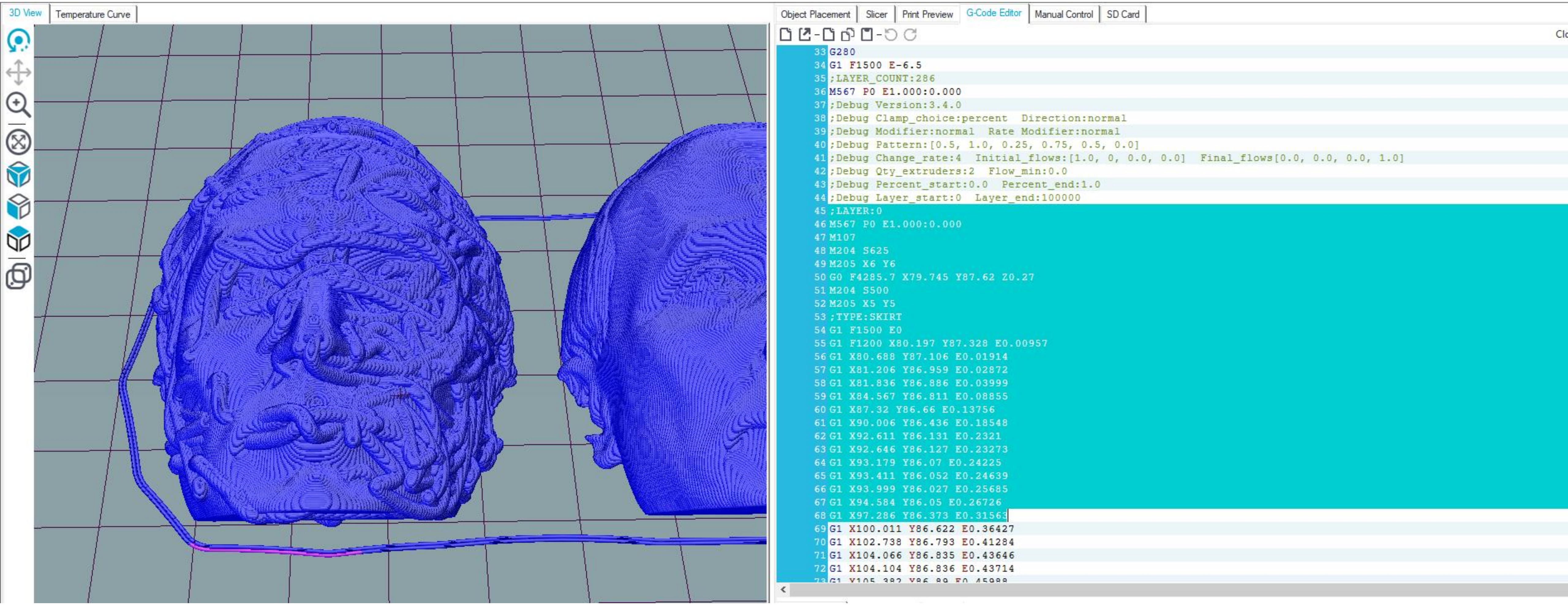
Some example G-code commands (RepRap):

G0 – rapid move
G1 – linear move
G28 – move to Origin (Home)

M109 – Set extruder temperature
M204 – Set default acceleration
… etc. refer to https://reprap.org/wiki/G-code

If you want to learn more about G-code and different "flavours": https://all3dp.com/g-code-tutorial-3d-printer-gcode-commands/, https://ultimaker.com/en/resources/20996-gcode-flavours-reprap-vs-ultigcode, https://reprap.org/wiki/G-code , https://marlinfw.org/meta/gcode/

G-code – commands for the printer



Those who are interested to better visualize, understand, and edit G-code, Repetier-Host: https://www.repetier.com/ (free)

Cura demo:

Software Overview &
preparing an .STL file for printing

Where to get 3D models?

The Internet is full of printable 3D files: maker communities, databases, 3D model shops: Google “3d models for printing” → **Thingiverse, Cults, Pinshape, GrabCAD, MyMiniFactory…** https://reprap.org/wiki/Printable_part_sources

- 3D scan an existing geometry for 3D printing

- 3D model your own parts
  - Ask a friend to 3D model for you
    - Pay a friend to 3D model ..
      - Pay a company to 3D model ..

3D Scanning for a printable model, video_10

https://formlabs.com/eu/blog/how-to-use-3d-scanning-and-3d-printing-for-reverse-engineering/

3D Modeling Software

BEGINNERS

TinkerCAD (free) - https://www.tinkercad.com/

Meshmixer (3D Sculpting and mesh modifications, free, being replaced by Fusion 360) - http://www.meshmixer.com/

FreeCAD - https://www.freecadweb.org/downloads.php

Autodesk Fusion 360 (free license for students and makers) - https://www.autodesk.com/campaigns/fusion-360-for-hobbyists

Onshape (cloud-based CAD) - https://www.onshape.com/education-plan

Solidworks, Creo, Siemens NX (Aalto student licence) - https://download.aalto.fi/student/

Blender (free, from mesh-based modeling to producing an animation movie) - https://www.blender.org/download/

Rhinoceros (Installed in some ARTS computer classes, Grasshopper included for algorithmic design)

ADVANCED

Autodesk Netfabb, **Altair Inspire** (Lattice design and topology optimization, student licenses available on request)

Options for programmatic 3D modeling: **OpenSCAD, ImplicitCAD, Matlab, etc.**

https://www.3dhubs.com/knowledge-base/key-design-considerations-3d-printing/#process-specific-guidelines

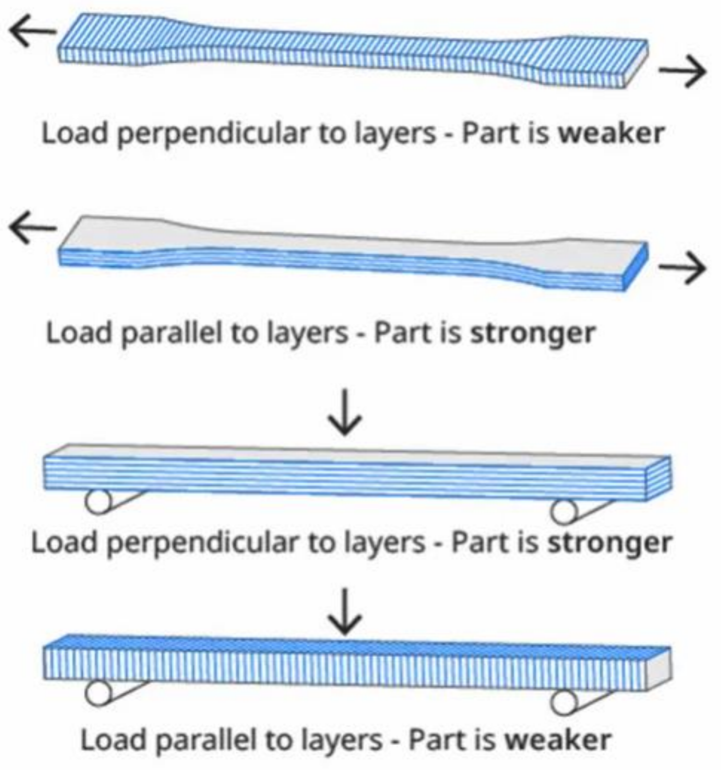
DESIGN RULES FOR 3D PRINTING

3D HUBS

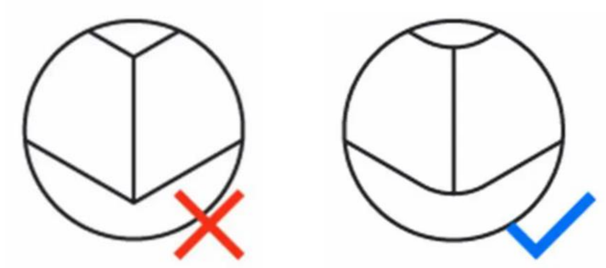
	Supported Walls	Unsupported Walls	Support & Overhangs	Embossed & Engraved Details	Horizontal Bridges	Holes	Connecting /Moving Parts	Escape Holes	Minimum Features	Pin Diameter	Tolerance
	Walls that are connected to the rest of the print on at least two sides.	Unsupported walls are connected to the rest of the print on less than two sides.	The maximum angle a wall can be printed at without requiring support.	Features on the model that are raised or recessed below the model surface.	The span a technology can print without the need for support.	The minimum diameter a technology can successfully print a hole.	The recommended clearance between two moving or connecting parts.	The minimum diameter of escape holes to allow for the removal of build material.	The recommended minimum size of a feature to ensure it will not fail to print.	The minimum diameter a pin can be printed at.	The expected tolerance (dimensional accuracy) of a specific technology.
											
Fused Deposition Modeling	0.8 mm	0.8 mm	45°	0.6 mm wide & 2 mm high	10 mm	Ø2 mm	0.5 mm		2 mm	3 mm	±0.5% (lower limit ±0.5 mm)
Stereo-lithography	0.5 mm	1 mm	support always required	0.4 mm wide & high		Ø0.5 mm	0.5 mm	4 mm	0.2 mm	0.5 mm	±0.5% (lower limit ±0.15 mm)
Selective Laser Sintering	0.7 mm			1 mm wide & high		Ø1.5 mm	0.3 mm for moving parts & 0.1 mm for connections	5 mm	0.8 mm	0.8 mm	±0.3% (lower limit ±0.3 mm)
Material Jetting	1 mm	1 mm	support always required	0.5 mm wide & high		Ø0.5 mm	0.2 mm		0.5 mm	0.5 mm	±0.1 mm
Binder Jetting	2 mm	3 mm		0.5 mm wide & high		Ø1.5 mm		5 mm	2 mm	2 mm	±0.2 mm for metal & ±0.3 mm for sand
Direct Metal Laser Sintering	0.4 mm	0.5 mm	support always required	0.1 mm wide & high	2 mm	Ø1.5 mm		5 mm	0.6 mm	1 mm	±0.1 mm

DFAM

- Anisotropy

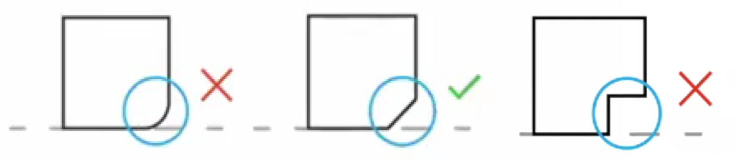


- Avoid sharp corners

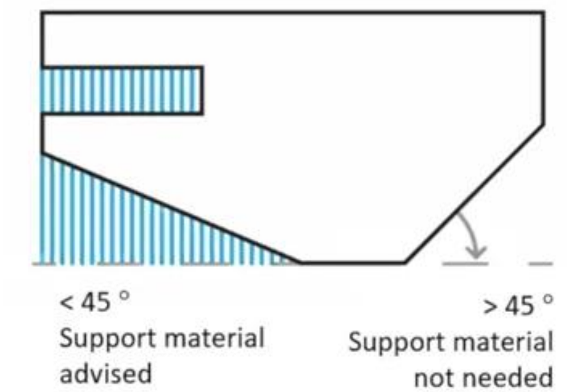


- Tolerances

- Avoid fillets at base



- Supports



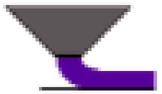
https://ultimaker.com/learn/design-for-fff-3d-printing

“Just press play and pick the finished part later”

aka 3D Printing Troubleshooting :

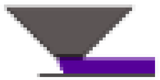
Nozzle Height & Build Plate Adhesion

Too High



Too much distance will cause the filament to extrude into the air. This is wil not stick to the bed.

Perfect



The tip of the nozzle is adding slight pressure to the top of the filament, greatly increasing how much filament is securely sticking to the bed and subsequent layers.

Too Low

The filament is not flowing properly, which can cause retrograde extrusion. Layers are predominantly choppy and short. Continued printing in this manner will likely cause a jam.

https://www.matterhackers.com/articles/how-to-clear-and-prevent-jams

Under- / over extrusion

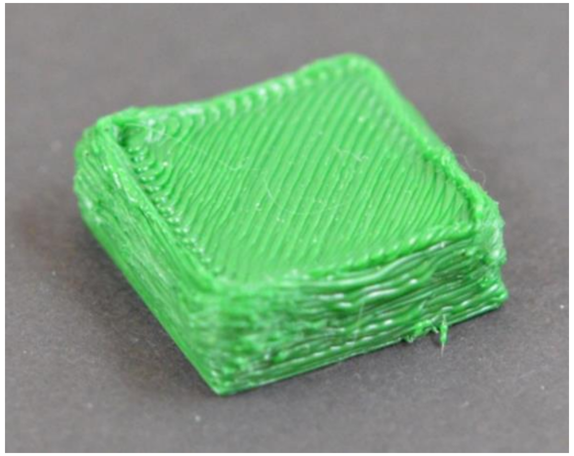
Not enough / too much material flow

Good material flow is a balance between nozzle diameter, print speed, temperature, and material flow rate

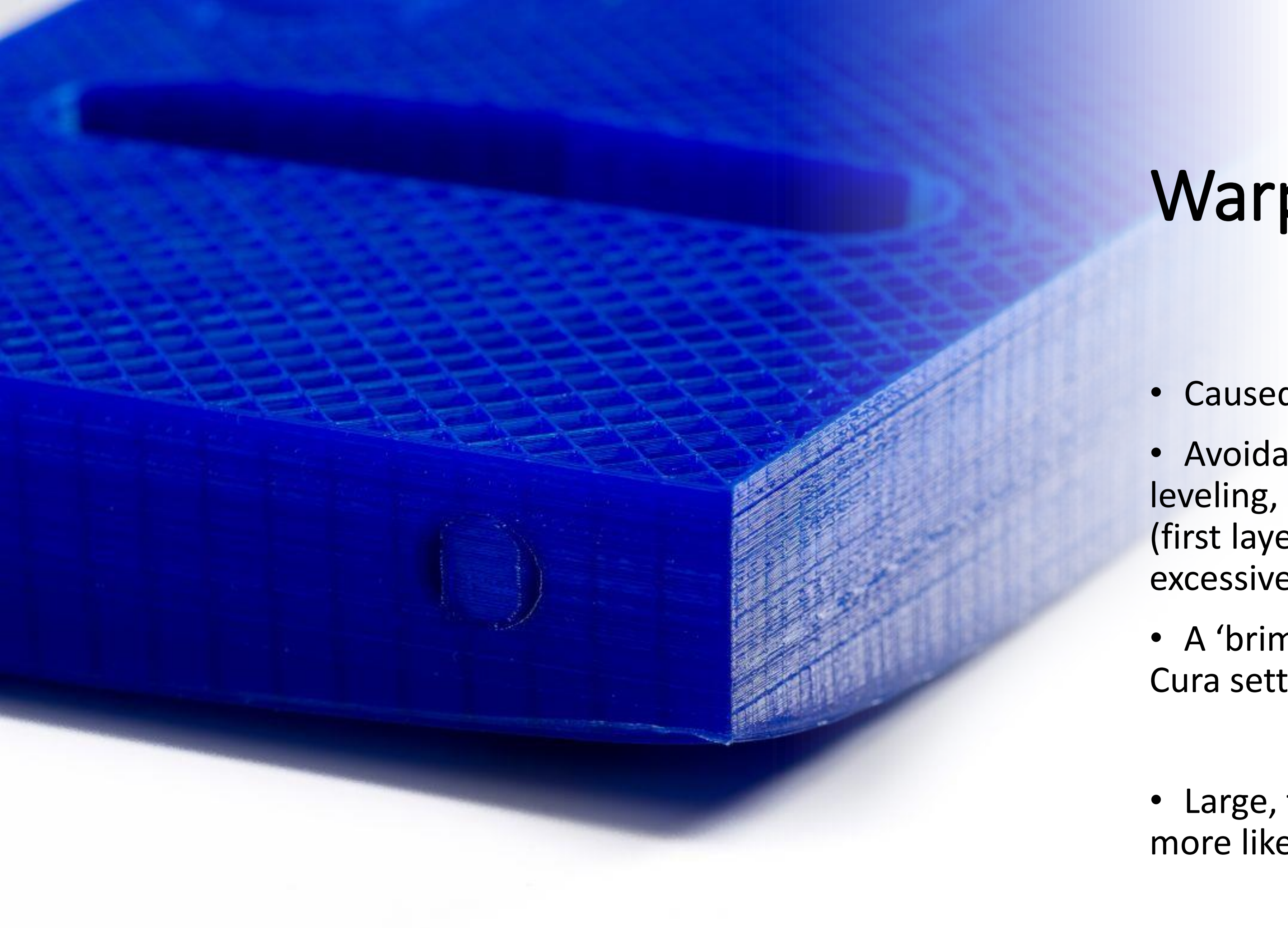
> double-check the Cura settings

Might be caused by feeder issues, or a clogged hot-end

> Use another Ultimaker and report a problem to the ADDLAB staff



https://ultimaker.com/en/resources/21477-how-to-fix-under-extrusion



Warping

- Caused by material shrinkage
- Avoidable with good build plate leveling, adhesion to the plate (first layers), and proper but not excessive cooling.
- A ‘brim’ or a ‘raft’ can help (See Cura settings)

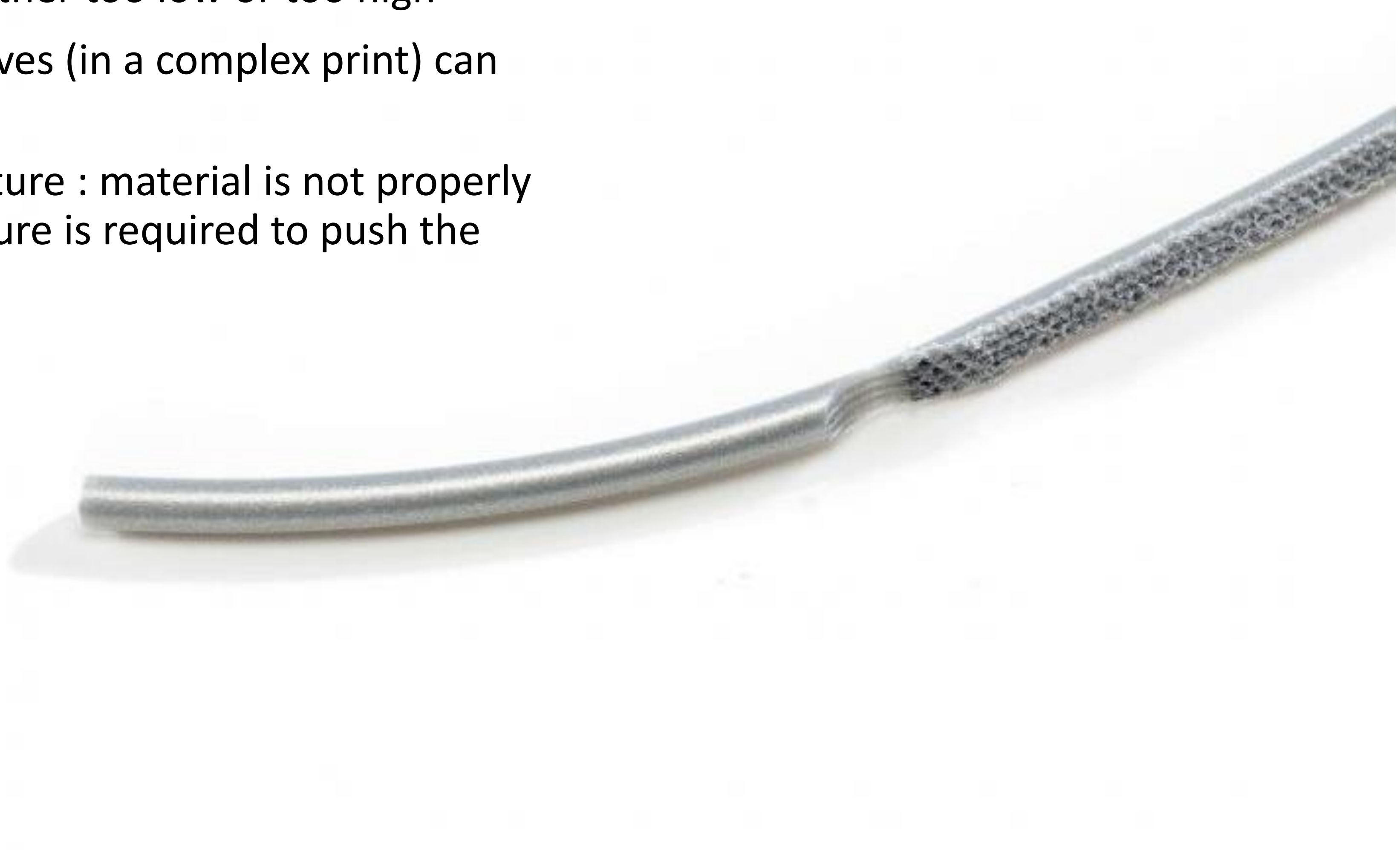
- Large, flat 3D designs will warp more likely !

Filament skipping or grinding

Feeder spring tension either too low or too high

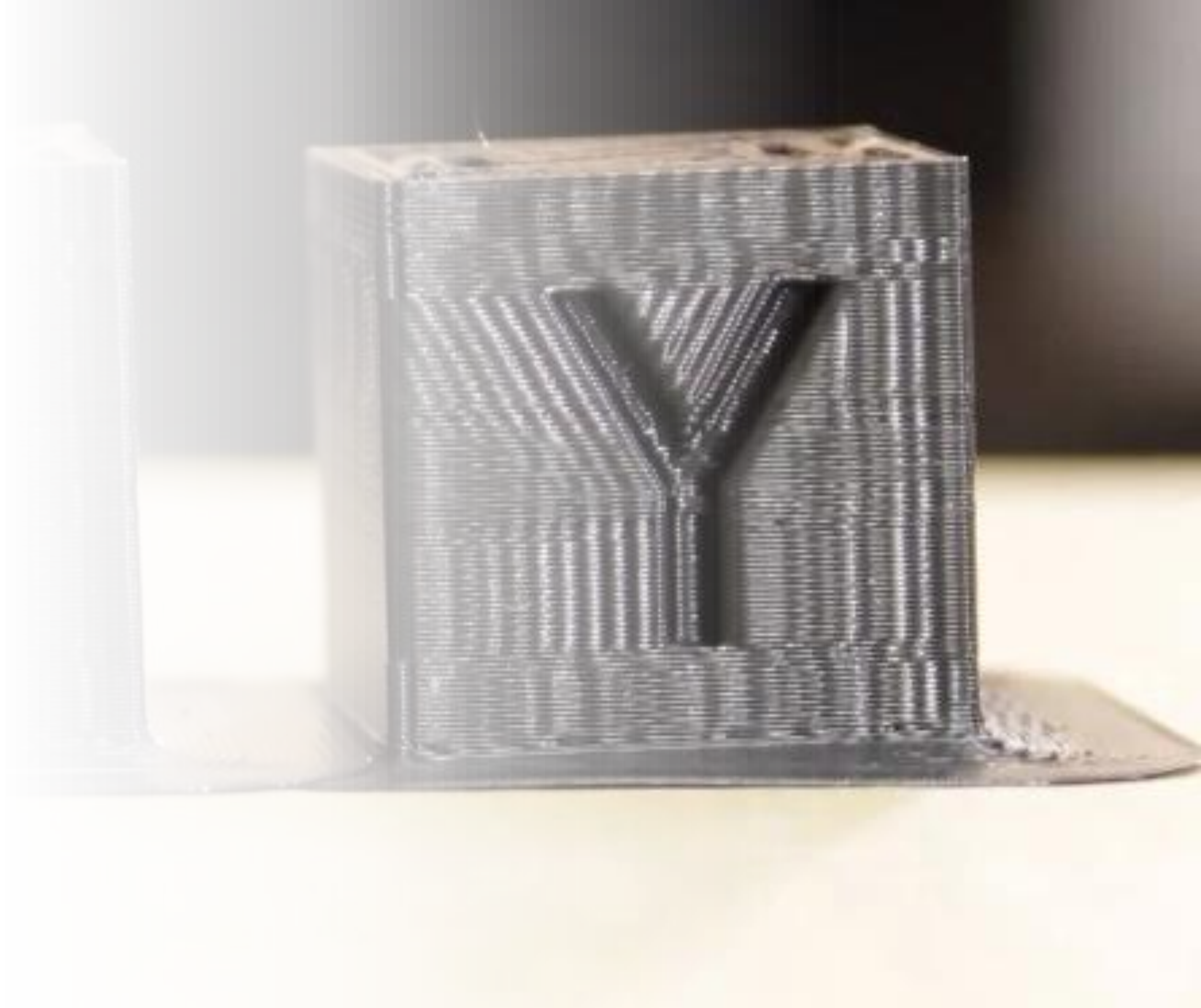
Too many retraction moves (in a complex print) can cause grinding

Too low nozzle temperature : material is not properly melted, and more pressure is required to push the filament => grinding



Ghosting/Ringing

- visual waves or rippling on the print surface
- Problem - Vibrations and speed
- Reduce the speed
- And oil the bearings



Stringing

- Caused by material leaking during print head travel movements
- Affected by printing temperature (more strings with higher temperature), print speed (+ travel speed) and ‘retraction’ settings
- ‘Retraction’ means a small recoil, or counter movement. The extruder will drive filament back to prevent leaking.

https://ultimaker.com/en/resources/19504-how-to-fix-stringing

Cracking

- layer will not stick to the previous layer
- happens when the top layers begin to cool faster and there is less adhesion between the individual layers
- Change material
- Reduce layer height

Online help

https://community.ultimaker.com/

https://rigid.ink/pages/ultimate-troubleshooting-guide

YouTube tutorials

ADDLAB and 3D Printers

Booking the Ultimakers

After the workshop, you will be given access to “ADD DMF Google Calendar” to check which printers are available and make reservations.

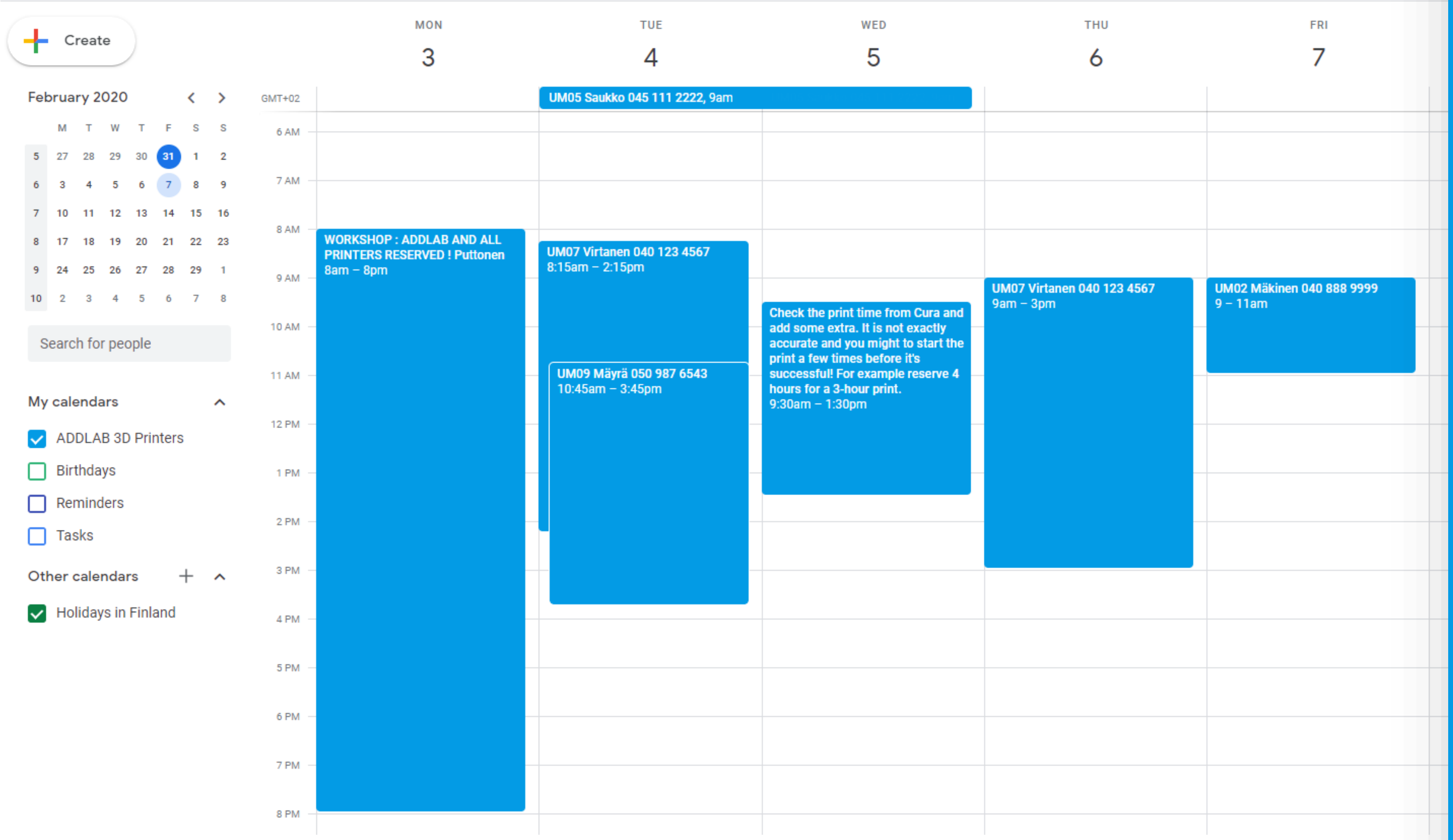
Write (clearly) your email in the participation list, I will send a link to join the calendar.

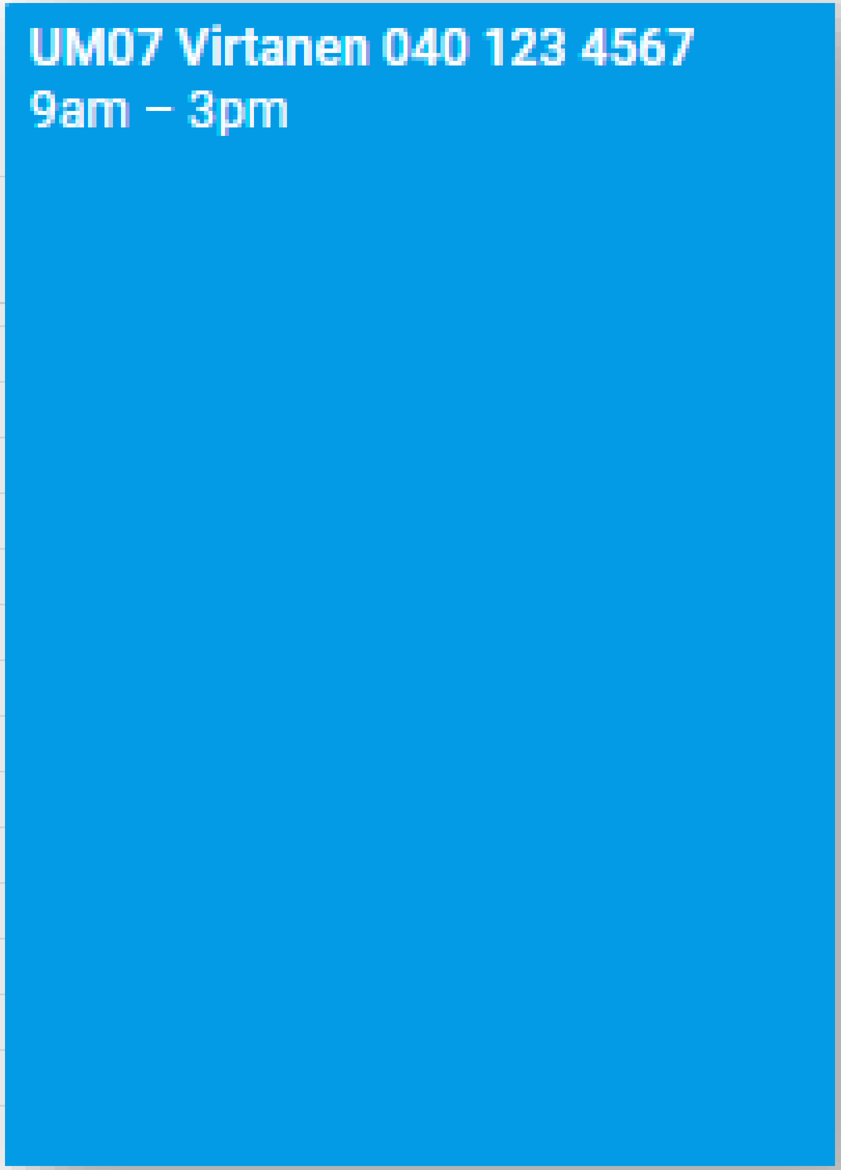
To reserve a printer for a time slot, simply add an entry in the “ADD DMF Google Calendar” *(not in your personal Google Calendar)* with:

The printer number, your name, your phone number:

Example: **UM22_Bond_James_040xxxxxxx**

Booking the Ultimakers





ADDLAB - code of conduct

https://www.picpedia.org/post-it-note/c/code-of-conduct.html

- Treat everyone and everything respectfully :)
- Don’t make a mess. Clean your workspace before you leave
- Return all tools to their own places
- **Report broken things**
- Ask and give help
- Minimize the amount of new plastic waste to the world

Learn more about 3D Printing

- Go to **ADDLAB**, 3D print more, and learn by doing
- MEC-7006 Advanced Manufacturing course (5 credits), organized every Spring
- https://ultimaker.com/en/resources/education/getting-started-with-an-ultimaker
- https://www.youtube.com/user/Ultimaker3D/videos and numerous other info / tutorial videos on YouTube
- **Redwood, B., Schffer, F., & Garret, B. (2017).** *The 3D printing handbook: technologies, design and applications*. 3D Hubs.

Scientific sources:

- **Gibson, I., Rosen, D. W., & Stucker, B., Khorasani, M. (2021).** *Additive manufacturing technologies*. New York: Springer.
- **Ngo, T. D., Kashani, A., Imbalzano, G., Nguyen, K. T., & Hui, D. (2018).** Additive manufacturing (3D printing): A review of materials, methods, applications and challenges. *Composites Part B: Engineering*, *143*, 172-196.12-224.
- **DebRoy, T., Wei, H. L., Zuback, J. S., Mukherjee, T., Elmer, J. W., Milewski, J. O., ... & Zhang, W. (2018).** Additive manufacturing of metallic components–process, structure and properties. *Progress in Materials Science*, *92*, 1
- https://scholar.google.com/ and search ‘additive manufacturing’

Assignment

Assignment (1 credit)

Please note:
The part that needs to be printed for the assignment **must be different** from what you print for the workshop session.

Reserve an ADDLab 3D printer with the “ADD DMF Google Calendar”, 3D print a part of your selection, and prepare **a short report** (max 1-2 pages) including:

- **A screenshot of the part from the Cura slicer software** (in the Cura *Preview mode*) with the print orientation and main print parameters visible + **a picture of the finished 3D-printed part**

1. Description of the part and its function
2. What difficulties or problems did you face while 3D printing? How did you solve them?
3. How could you reduce the printing time of your part (e.g., via adjusting Cura parameters, print orientation, or modifying the 3D design of the part)?
4. How could you maximize the quality and surface finish of your part (e.g., via adjusting Cura parameters, print orientation, or modifying the 3D design of the part)?

- Add the report to the Assignment submission tab on MyCourses, title:*“ENG-A1009 Assignment_your name”* – **deadline Fri 30.11.2023.**
- For any queries, write to ssiddharth.kumar@aalto.fi.

See you at ADDLab !

K4 building seafront

Access from Sähkömiehentie 4 J
Corridor to the end and U-turn – voilà !

https://www.aalto.fi/en/locations/addlab-hourslocation?check_logged_in=1