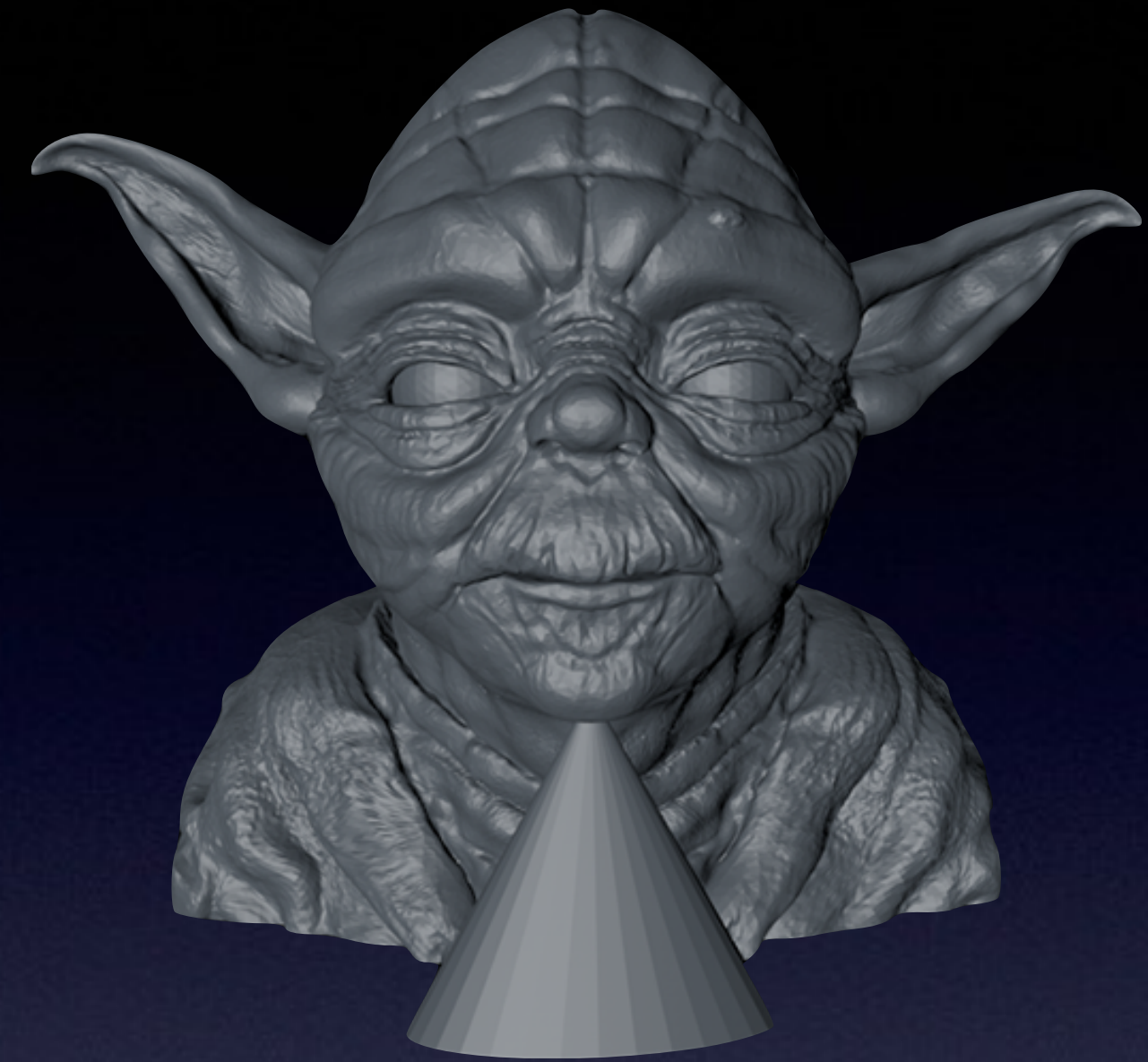



# An Introduction to **3D Printing** for Mac Admins




**Anthony Reimer**

*Head Technician, IAML*

 *AnthonyReimer*

 *jazzace*

 *jazzace*

**Rob Furr**

*Instructor, Dept. of Art*

 *rsfurr*



**UNIVERSITY OF  
CALGARY**







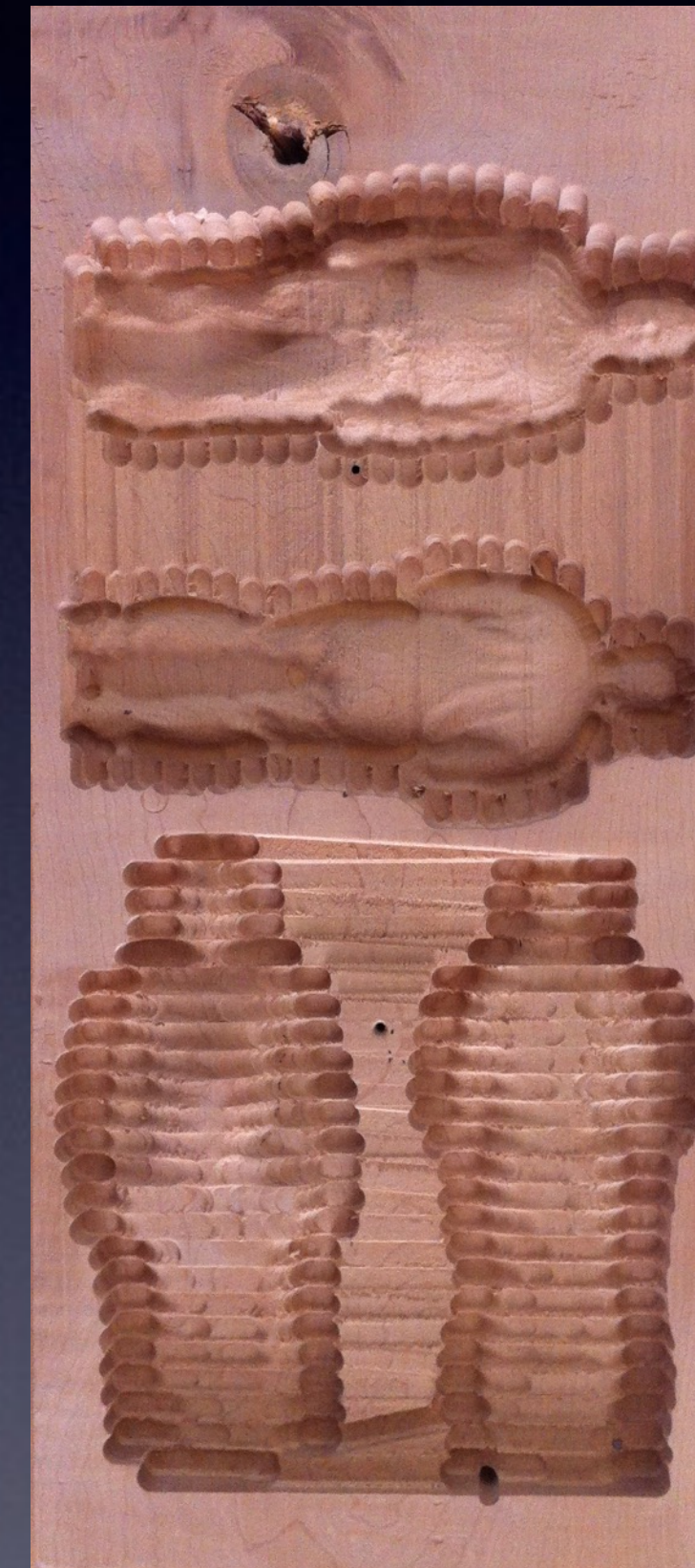
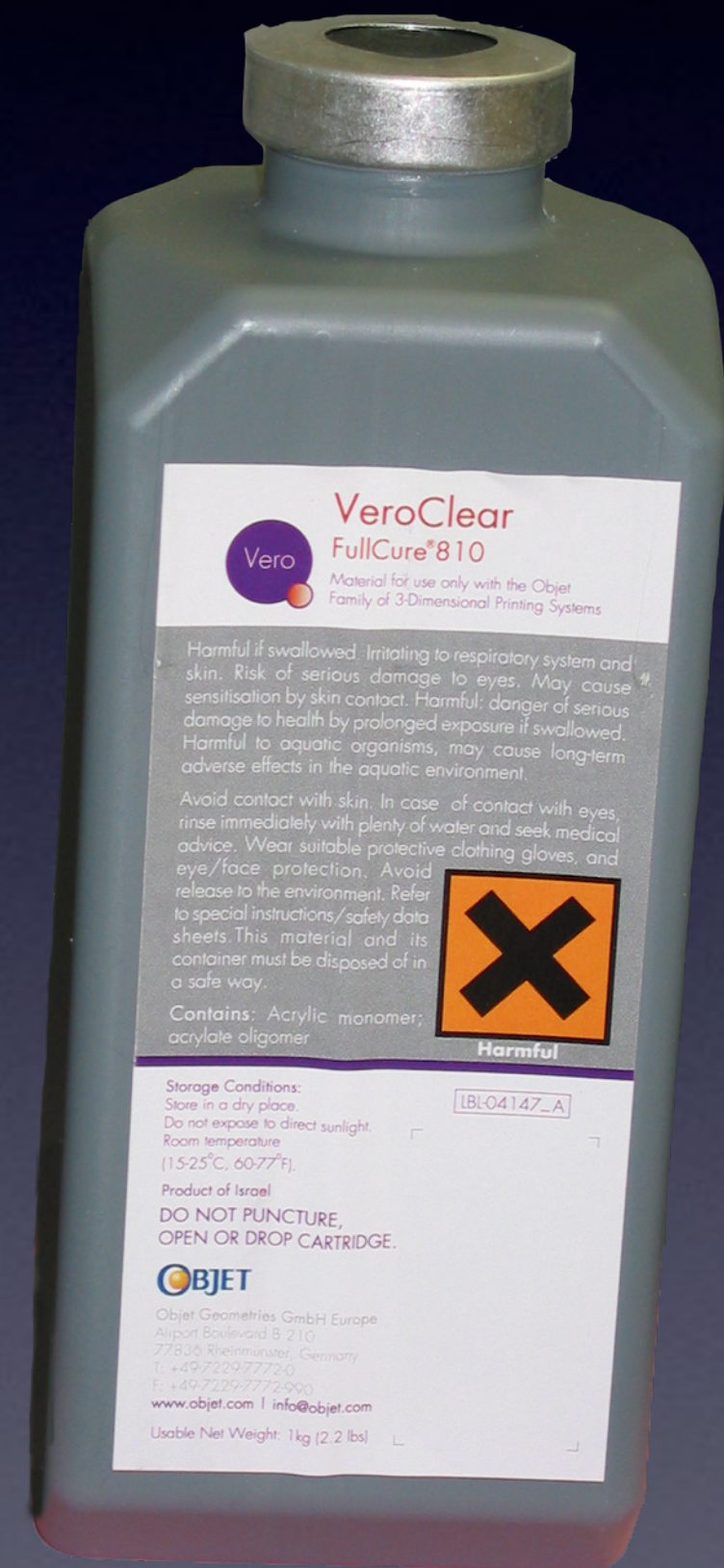
?!

# Topics

- The Output
- The Hardware
- The Software
- Models

# The Output

# Materials



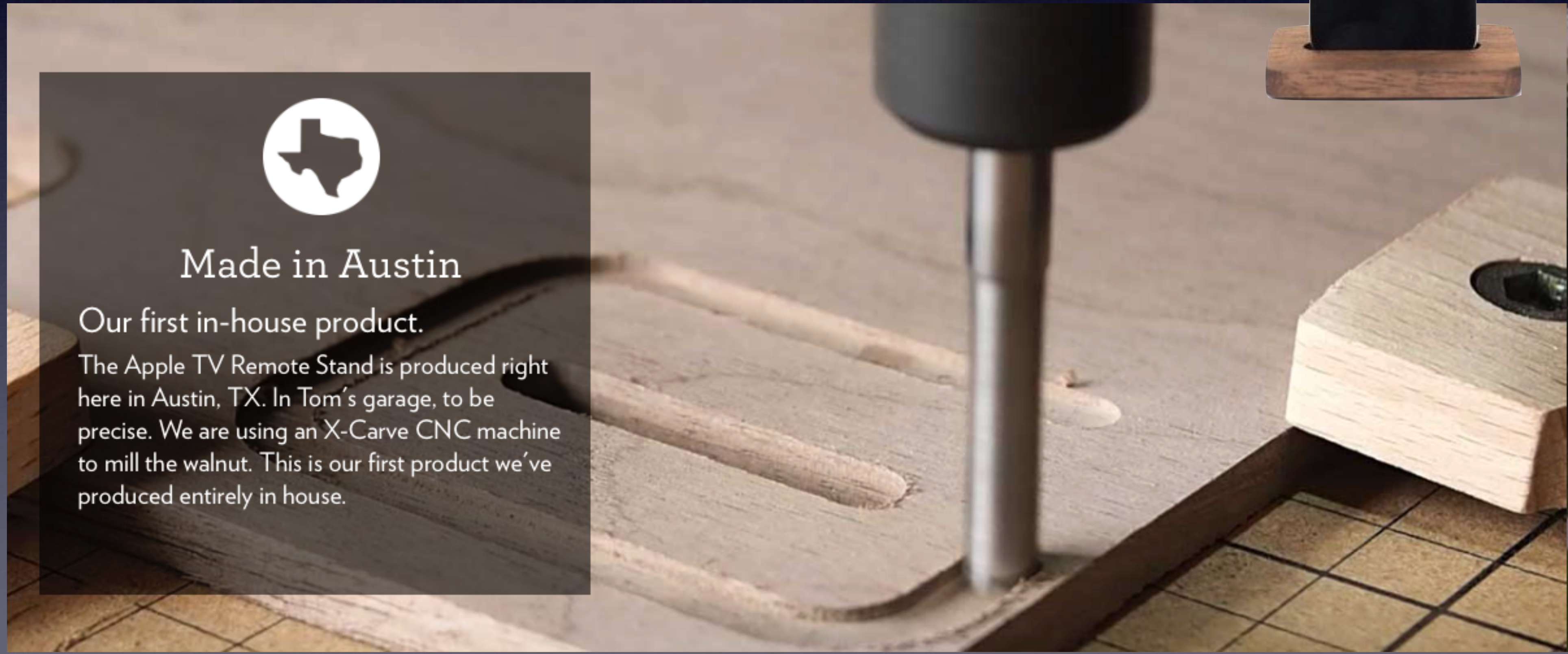




## Made in Austin

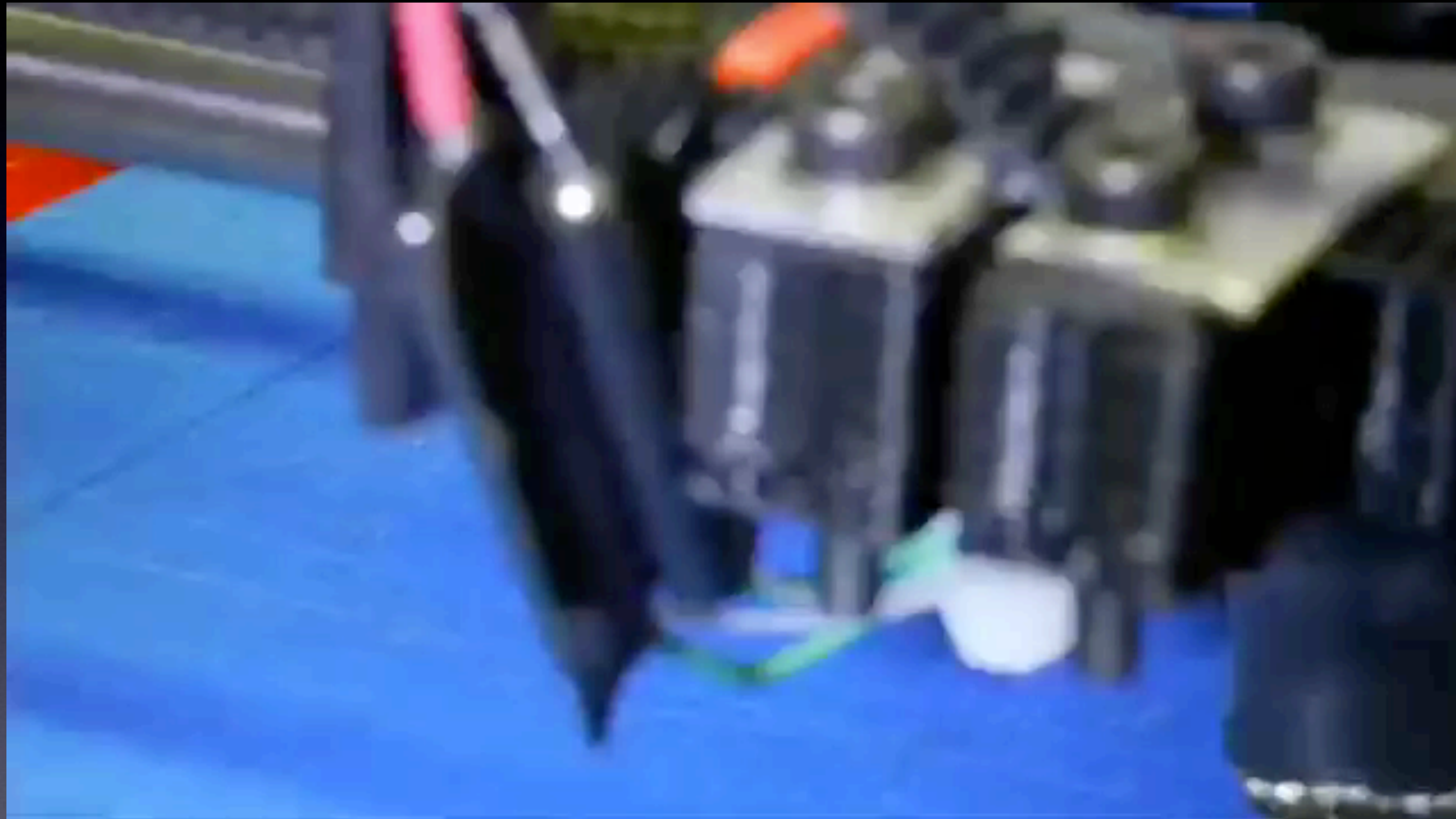
Our first in-house product.

The Apple TV Remote Stand is produced right here in Austin, TX. In Tom's garage, to be precise. We are using an X-Carve CNC machine to mill the walnut. This is our first product we've produced entirely in house.

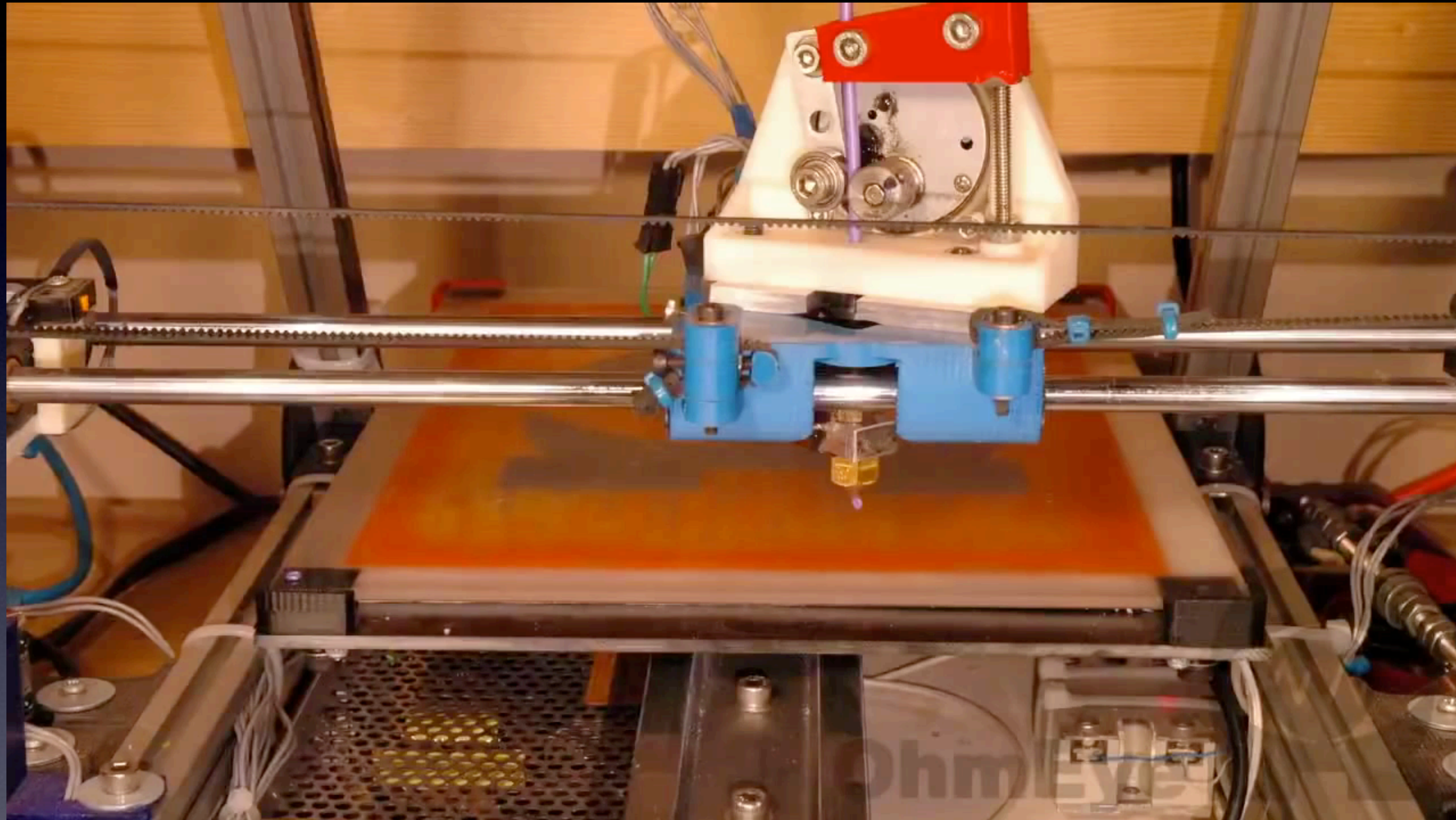


# Additive Manufacturing

- Fused Deposition Modelling / Fused Filament Fabrication
- Layers of resin exposed to light (e.g., UV)



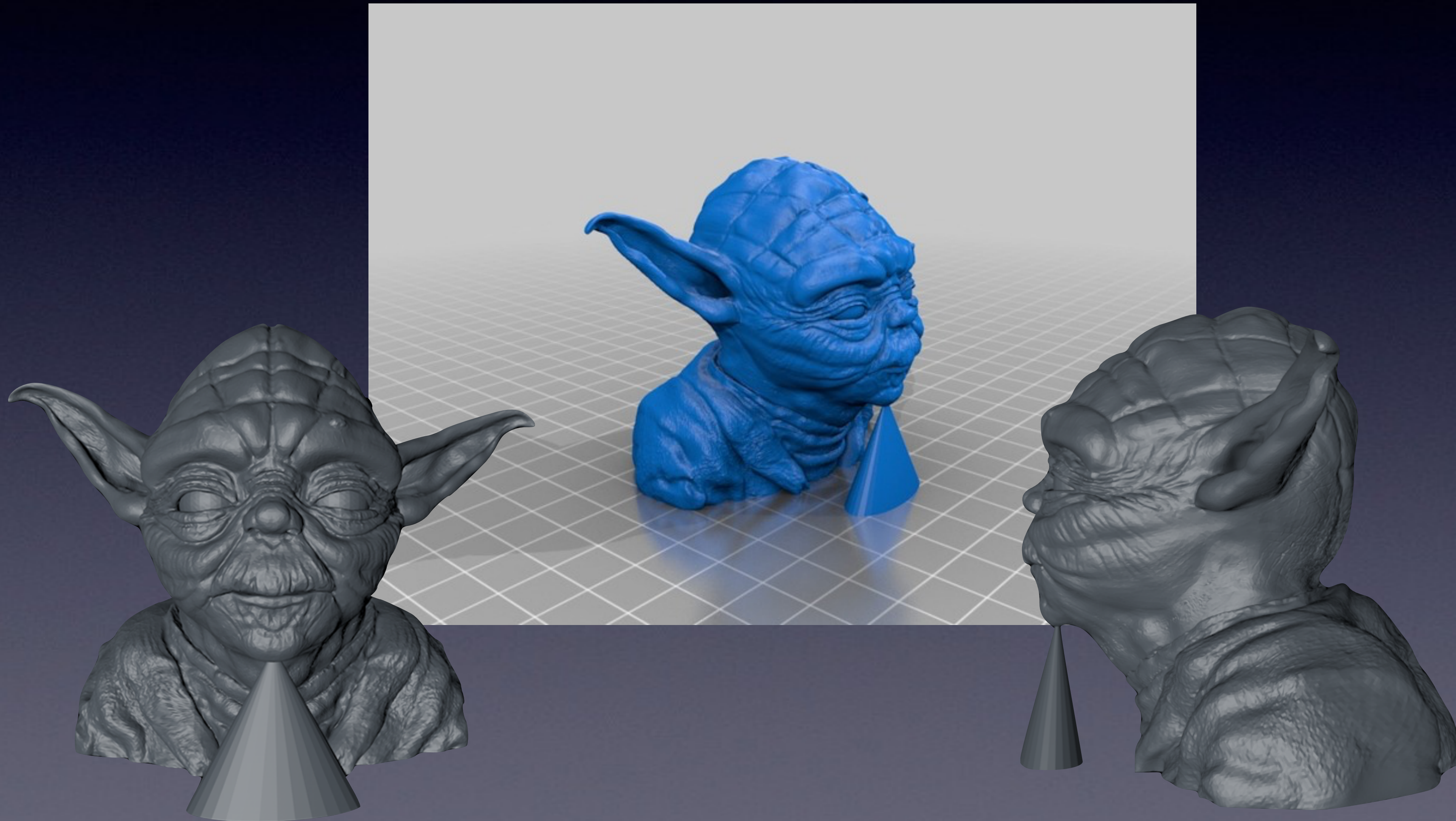
*Credit: OhmEye (Creative Commons License)*  
*<https://youtu.be/1213kMys6e8>*



*Credit: OhmEye (Creative Commons License)*  
*[https://youtu.be/NzQF7SRU\\_1E](https://youtu.be/NzQF7SRU_1E)*

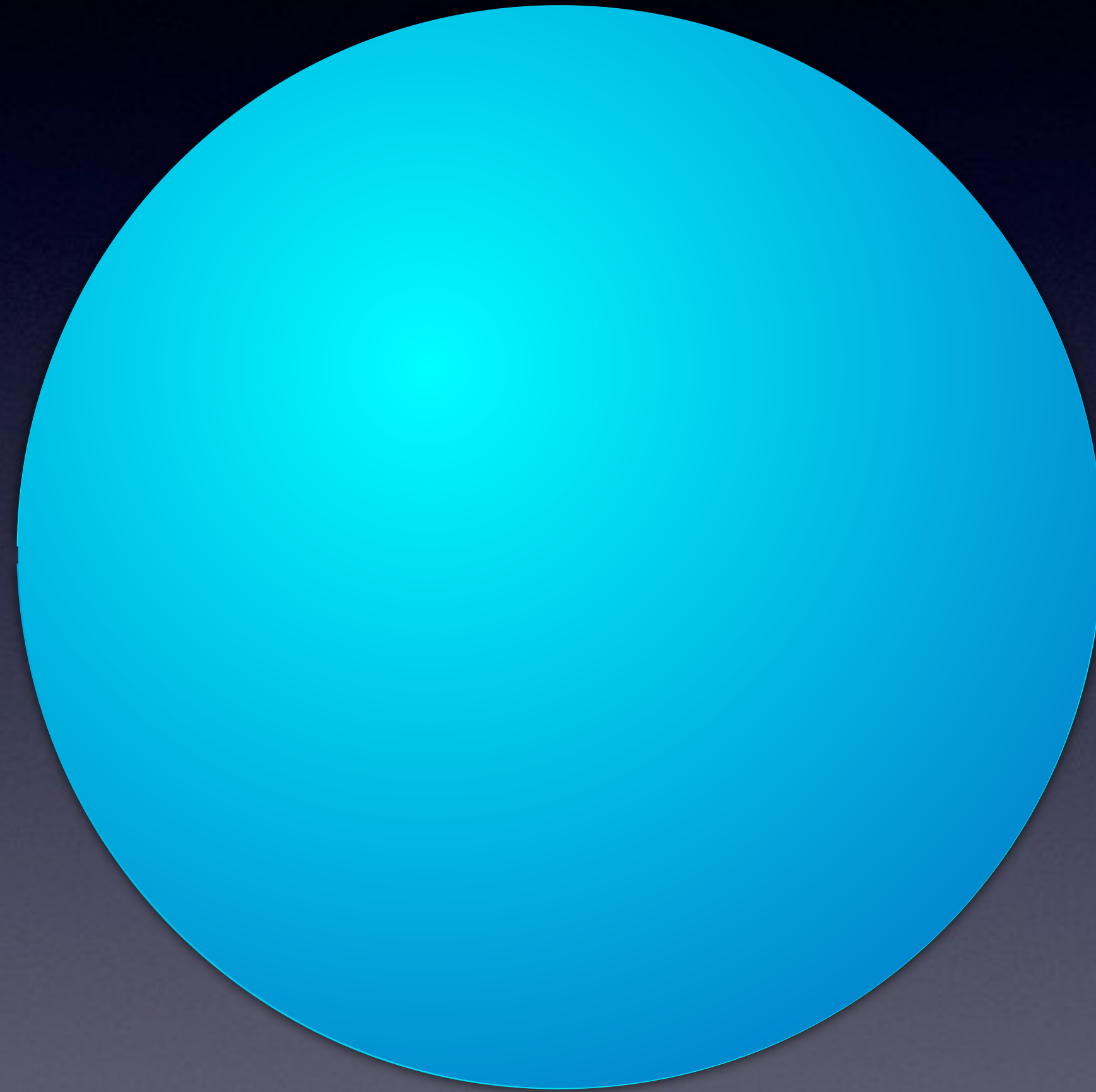


# FDM/FFF



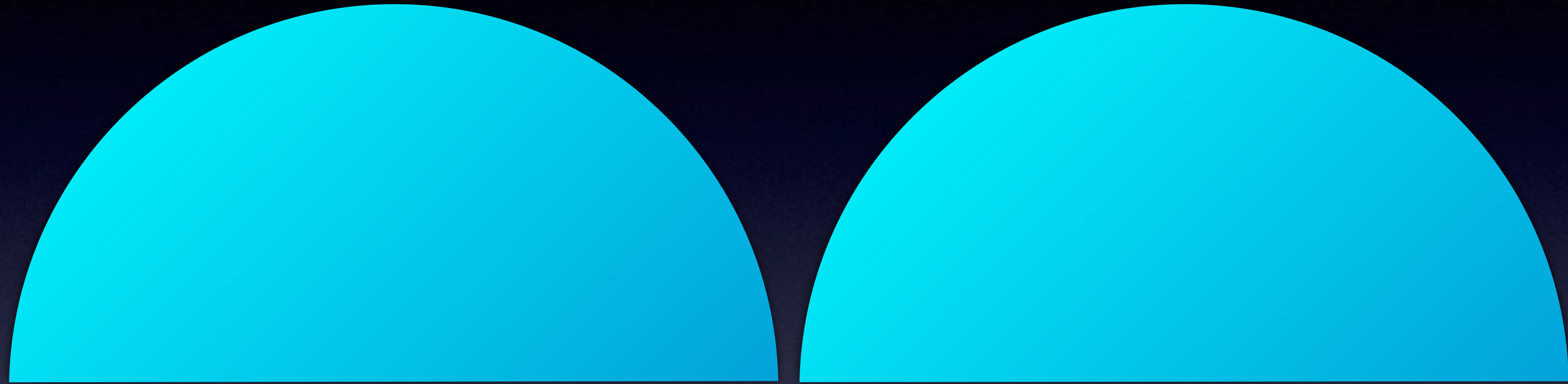


**FDM/FFF**





**FDM/FFF**





# Operations & Safety

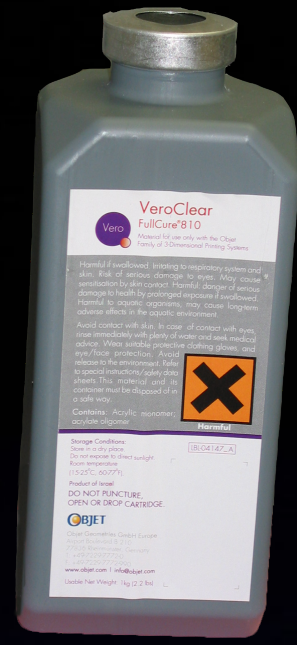






# FDM/FFF

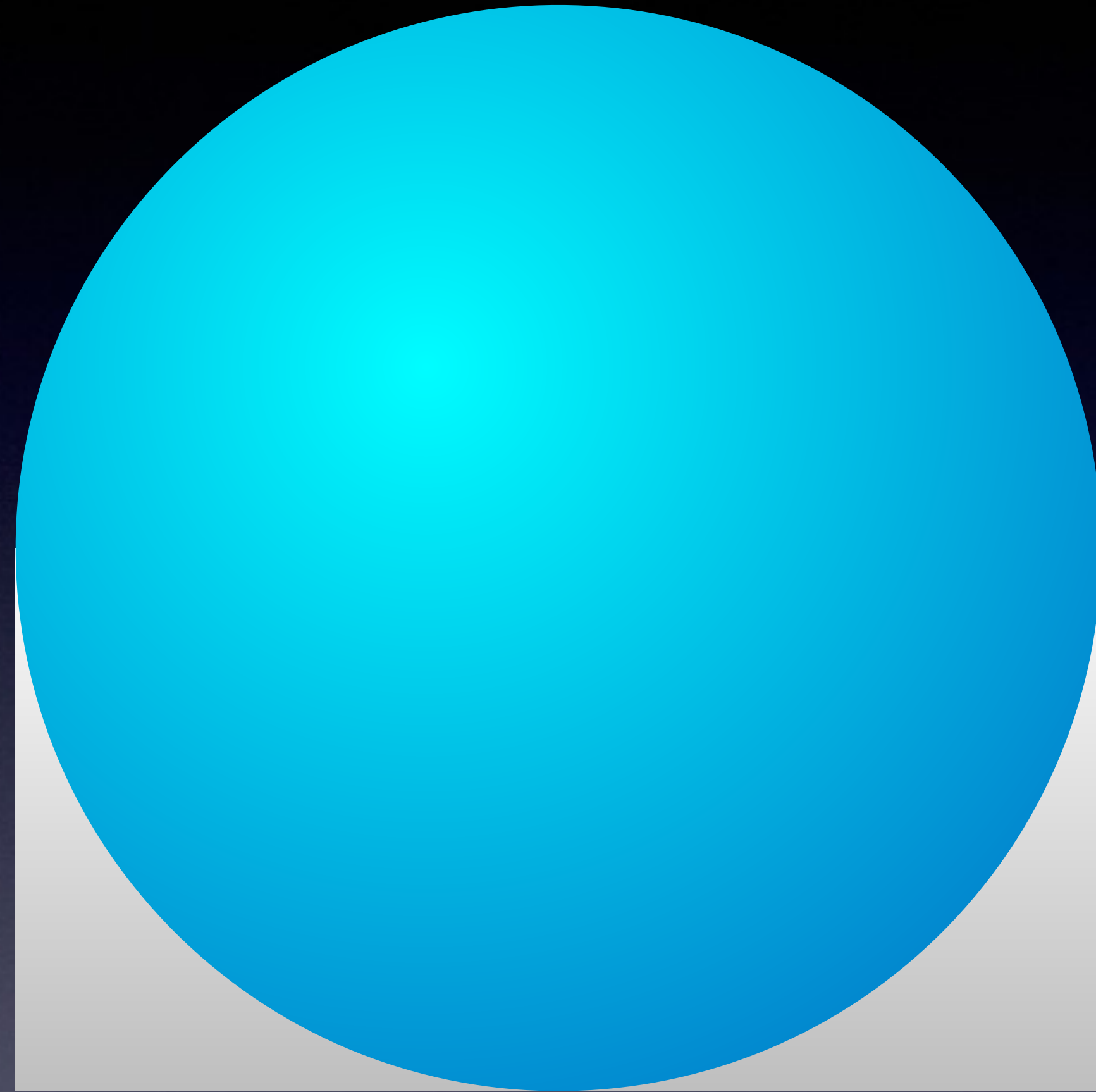
- Less expensive printers & materials
  - ▶ *Often print hollow*
- Variety of materials & colours
  - ▶ *PLA, ABS, Nylon, Wood*
- Printing angle a consideration
- Some designs can't be printed
- 100  $\mu\text{m}$  (0.1 mm) minimum thickness  
(250  $\mu\text{m}$  typical)



# Resin (PolyJet)

- Build Material
- Support Material

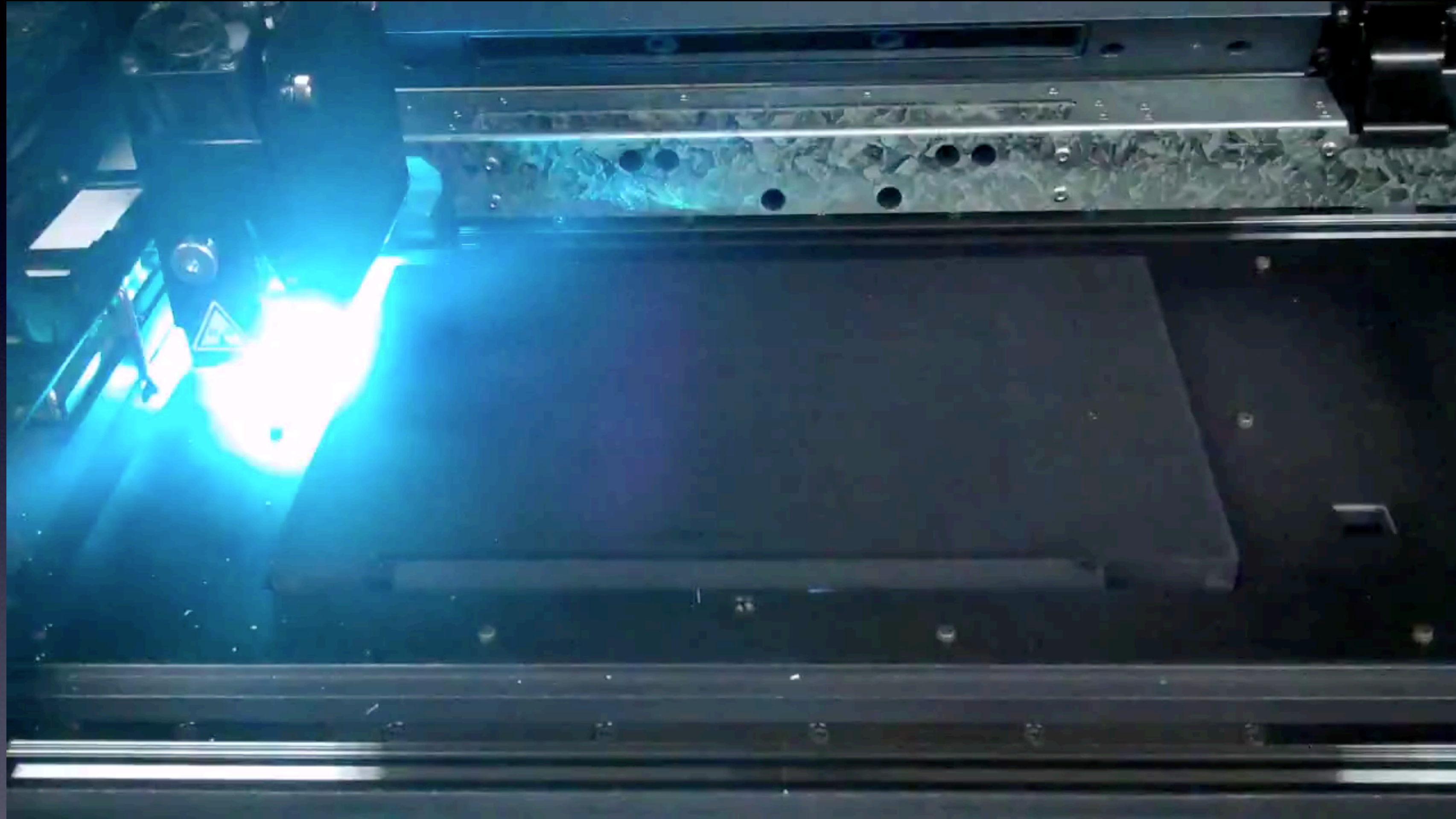
**Build Material**



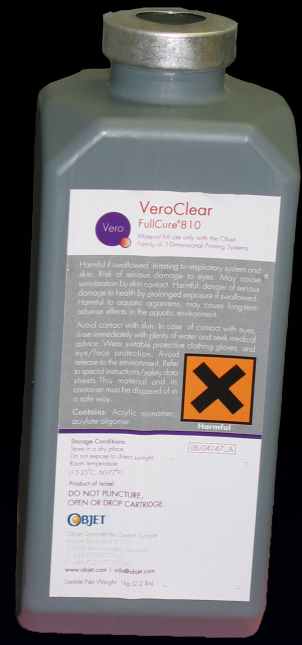
**Support Material**



*Credit: James Thornburgh (Creative Commons License)*  
*<https://youtu.be/AKca08-ggX0>*

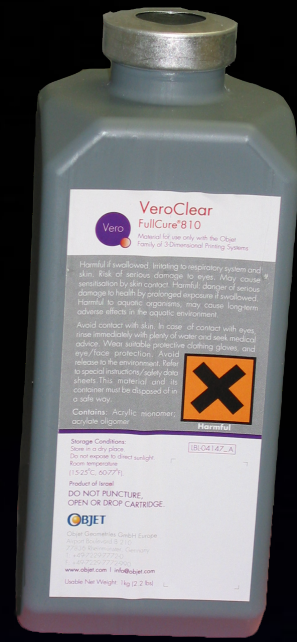


*Credit: James Thornburgh (Creative Commons License)*  
*[https://youtu.be/-rJnVPey\\_5Q](https://youtu.be/-rJnVPey_5Q)*



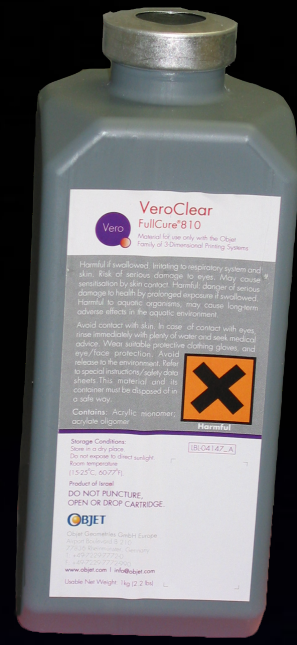
# Operations & Safety





# Resin (PolyJet)

- More expensive – proprietary
- Material variety increases with cost of printer
- No angle restrictions
  - ▶ *Solid objects*
- 28  $\mu\text{m}$  typical (0.028 mm)
- Hazardous waste
- Model cleaning required



# (Back to) The Future

- Resin Stereolithography
  - ▶ *Form 2 et al*
  - ▶ *Speed an issue*
  - ▶ *Immature technology*



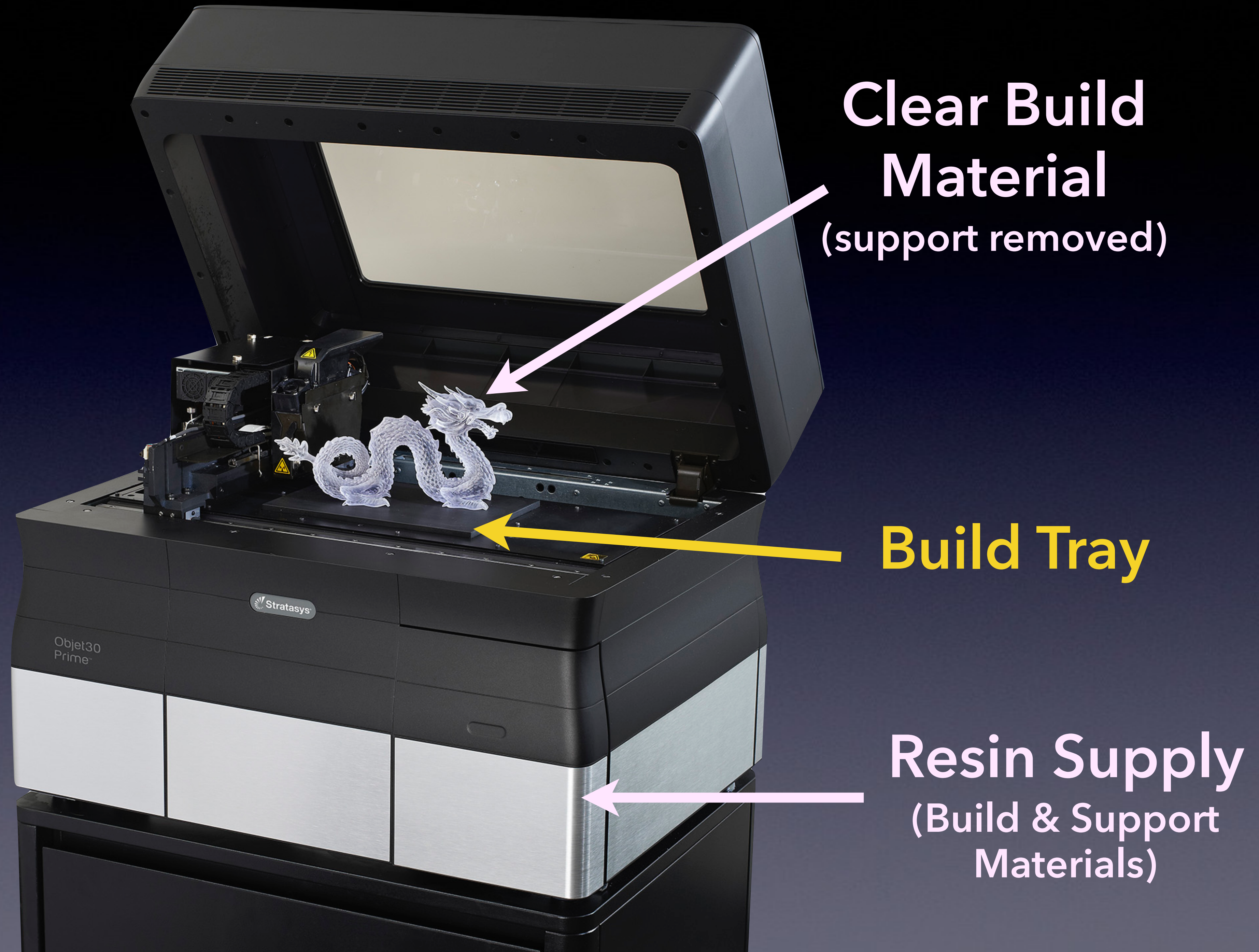
# The Hardware



Filament  
(Build Material)

Build Tray

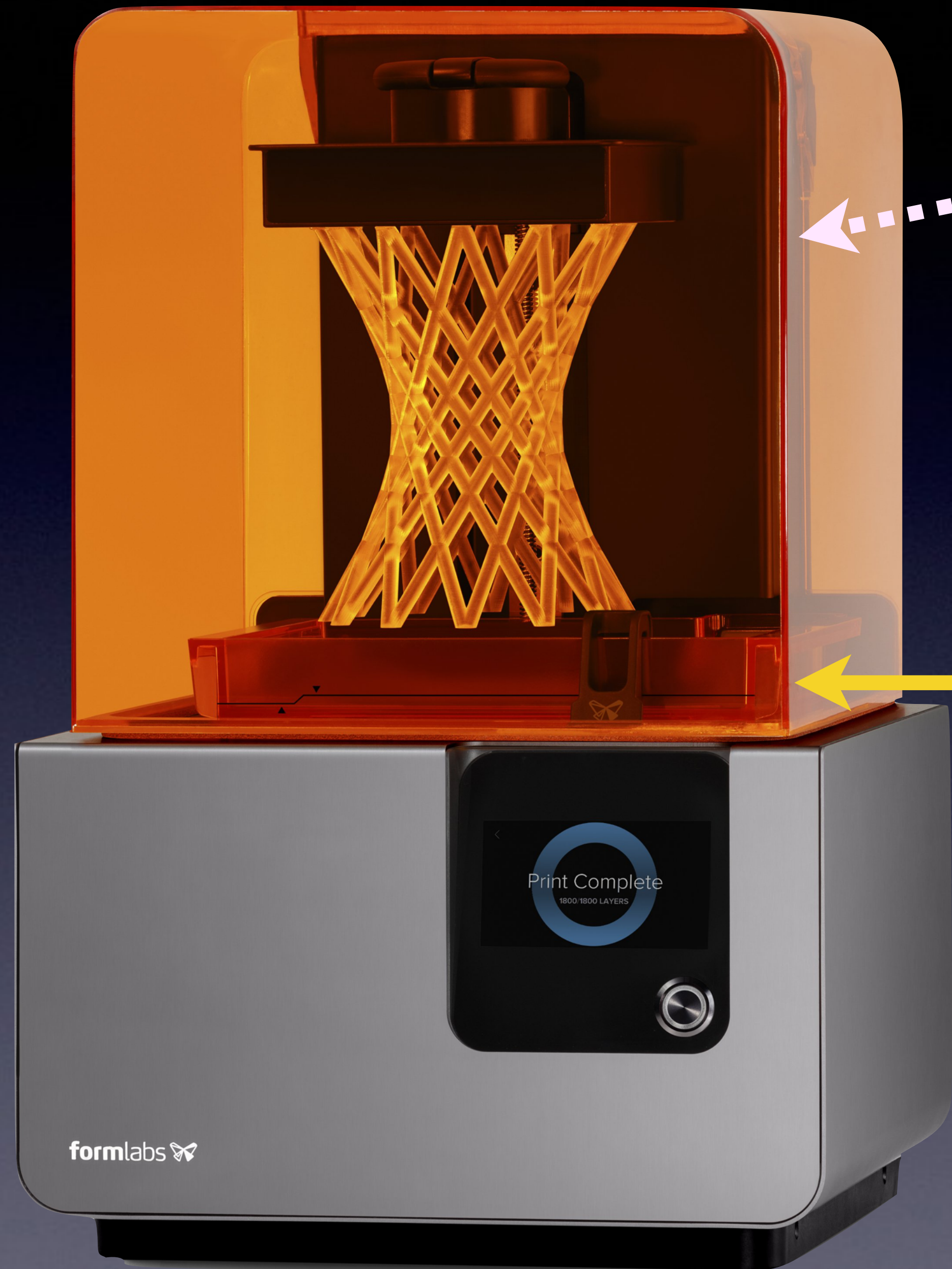




**Clear Build  
Material**  
(support removed)

**Build Tray**

**Resin Supply**  
(Build & Support  
Materials)



**Resin Cartridges**  
(Build Material)



**"Build Area"**  
(Resin Tray)



formlabs 

# Setup & Operating Considerations



# Setup & Operating Considerations



# Setup & Operating Considerations



# Setup & Operating Considerations





# Setup & Operating Considerations



# Printer Selection

- Parts or Art?
- Materials
  - ▶ *Particular materials needed*
  - ▶ *How often do you need to swap*
- Build Volume



# The Software



**.sc1**



**.zpr, .zbr**



**.ma**



**.blend**



**.c4d**



**.mud**



**.mlp**

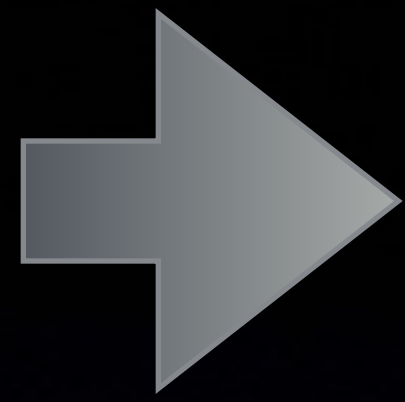


**.vwx**



**.3ds**

**.STL**  
**.OBJ**



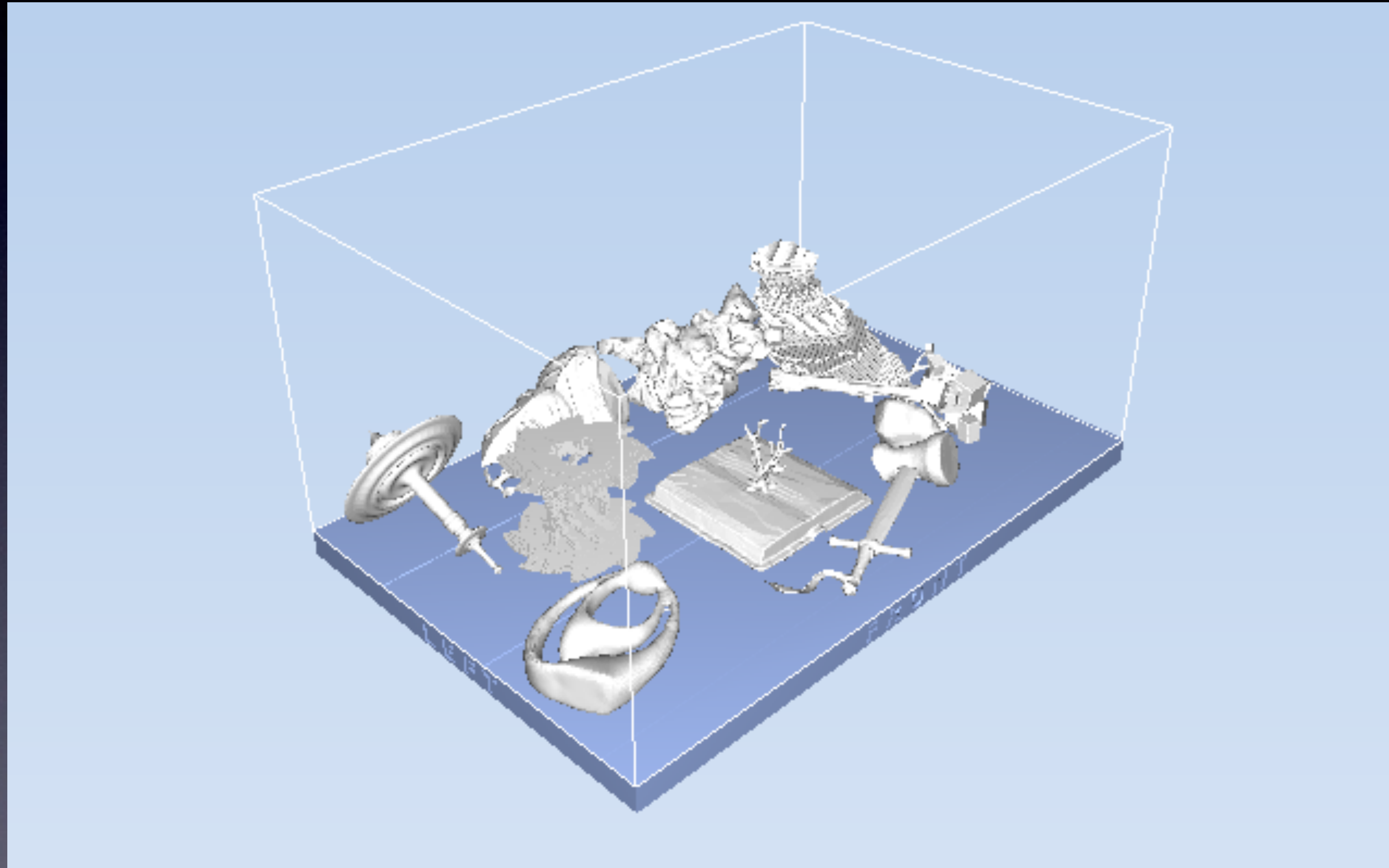
# File Conversion Tools

- The App that created it
  - ▶ *Might need to use an intermediary format*
- MeshLab
  - ▶ *meshlab.sourceforge.net*
- A commercial app with STL export
  - ▶ *e.g., Cinema4D (maxon.net)*

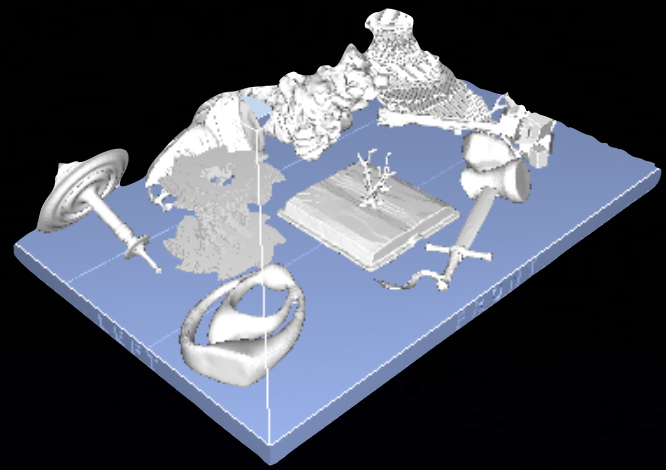
# Software & Services



# Making a Tray

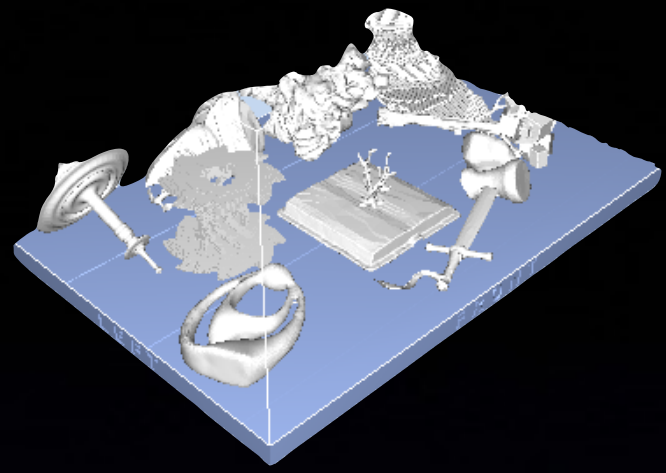






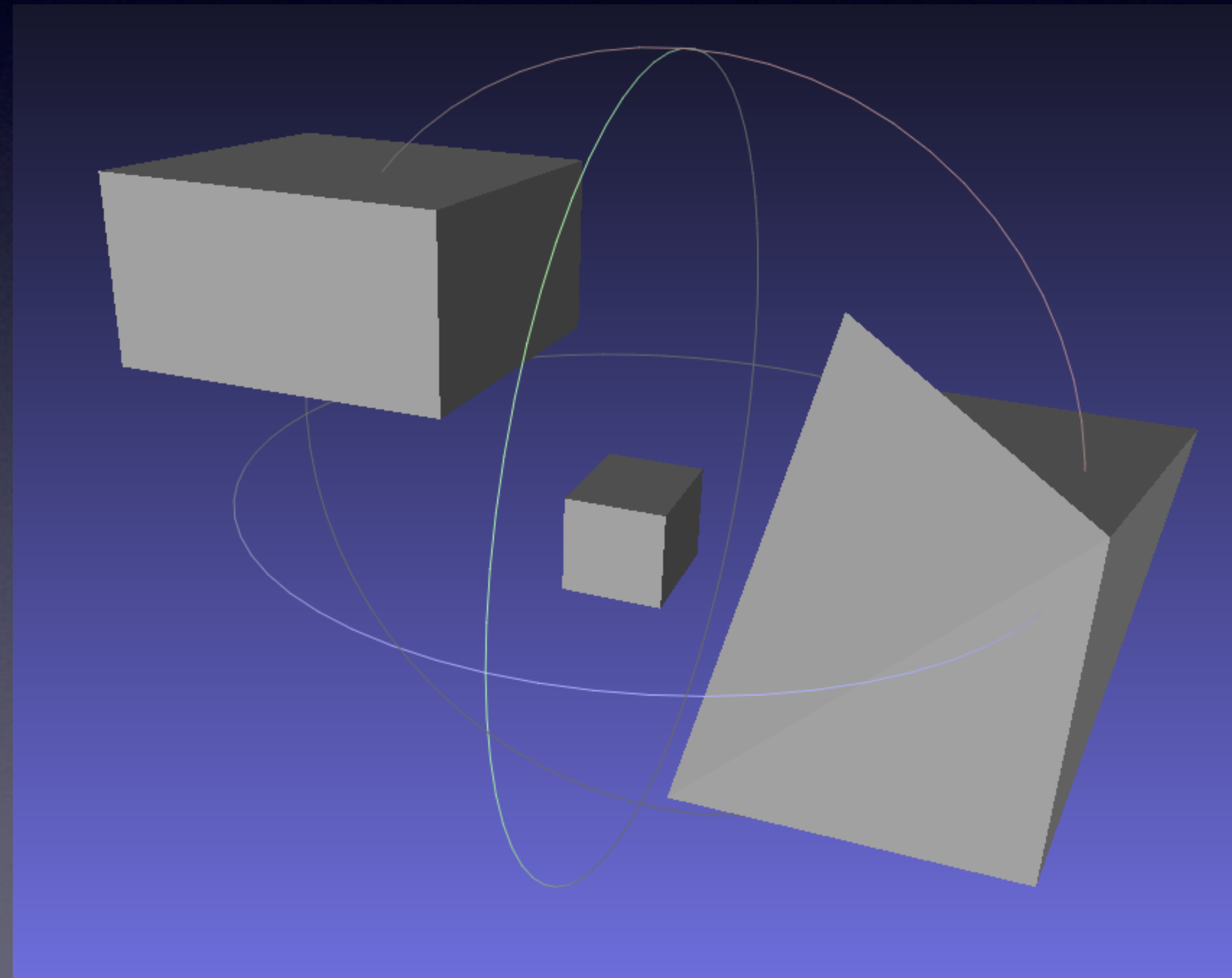
# Making a Tray

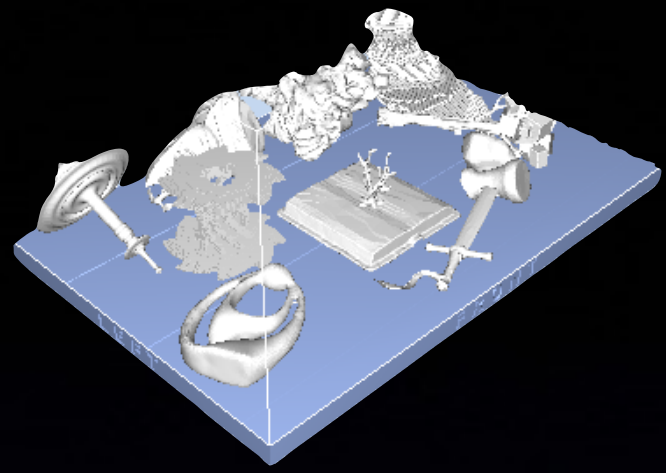
1. Collect your STL model(s)
2. Open the software (VM is OK)
3. Import each model, specifying scale units (mm or inch)
4. Adjust placement (auto or manual)
5. Verify tray
6. Estimate materials & Save Tray



# Making a Tray – Issues

2+ models in 1 STL file

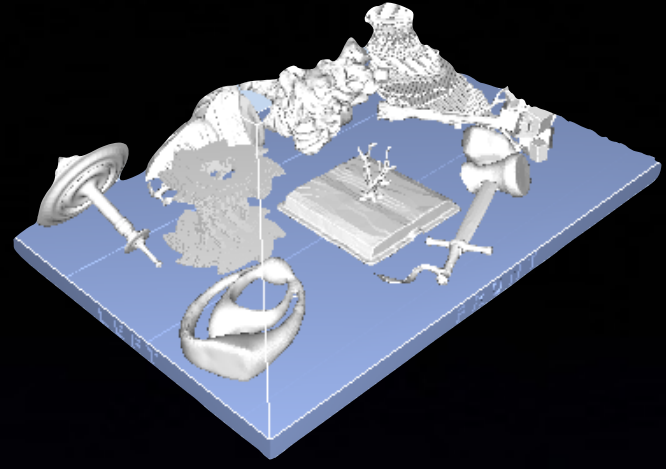




# Making a Tray – Issues

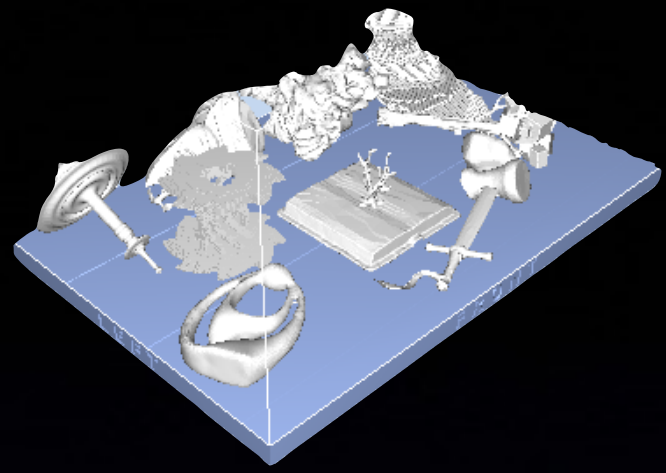
## 2+ models in 1 STL file

- User exports models separately
- Split with an app:  
NetFabb Basic (Free)
  - ▶ [www.netfabb.com/downloadcenter.php?basic=1](http://www.netfabb.com/downloadcenter.php?basic=1)



# Making a Tray – Issues

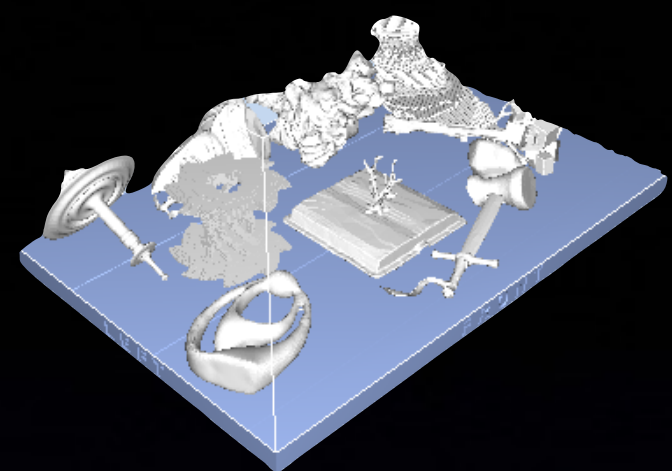
Unclosed contours, vertices, other defects



# Making a Tray – Issues

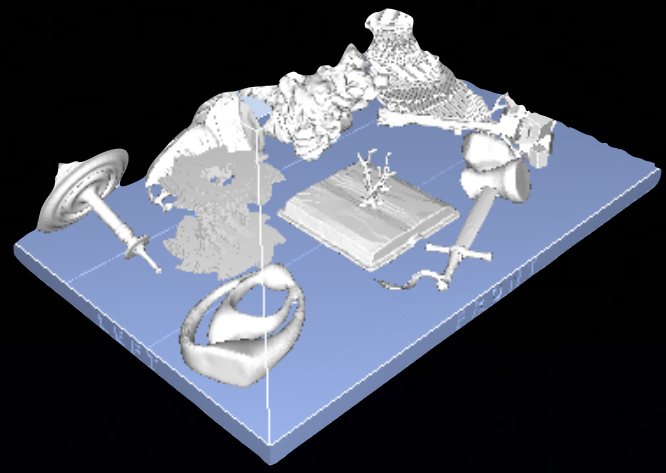
## Unclosed contours, vertices, other defects

- NetFabb Basic
- MeshLab
- NetFabb online (“cloud”) service
  - *<https://netfabb.azurewebsites.net/>*
  - *Requires (free) Microsoft account*
- NetFabb Private (“personal”)
  - *US\$300*
- NetFabb Professional (\$\$\$\$)



# Making a Tray – Issues

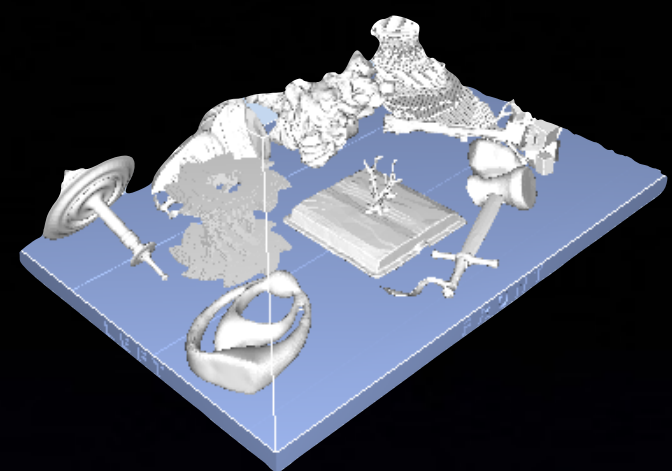
Model too large



# Making a Tray – Issues

## Model too large

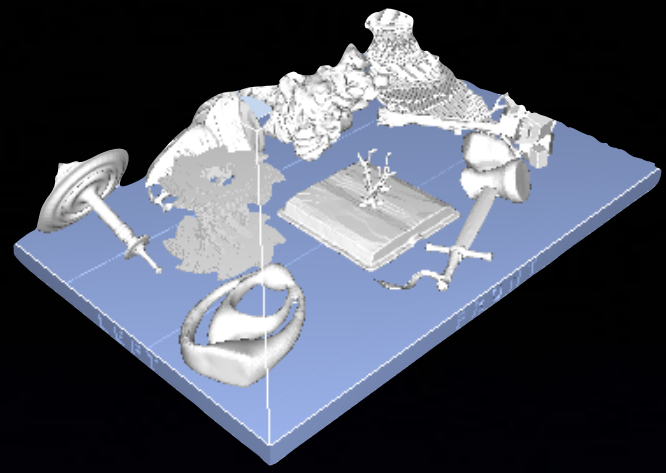
- Scale the model
  - ▶ *printer software*
  - ▶ *any design software*
- Split the Model
  - ▶ *NetFabb Basic*
- Resin: re-orient the model



# Making a Tray – Issues

Speed of Printing





# Making a Tray – Issues

## Speed of Printing

- Resin: Z-axis is slowest  
e.g., 25×50×100 mm (1×2×4"):
  - ▶ 9h when  $z=100$  mm
  - ▶ 5h when  $z=50$  mm
  - ▶ 3h when  $z=25$  mm
- Fill the tray
  - ▶ 6h for 4 copies on 1 tray when  $z=25$  mm

# Models



Free



Open Source



Open Source



# Making Models



Sculptris (Pixologic)

▶ [pixologic.com/sculptris/](http://pixologic.com/sculptris/)



Blender

▶ [www.blender.org](http://www.blender.org)

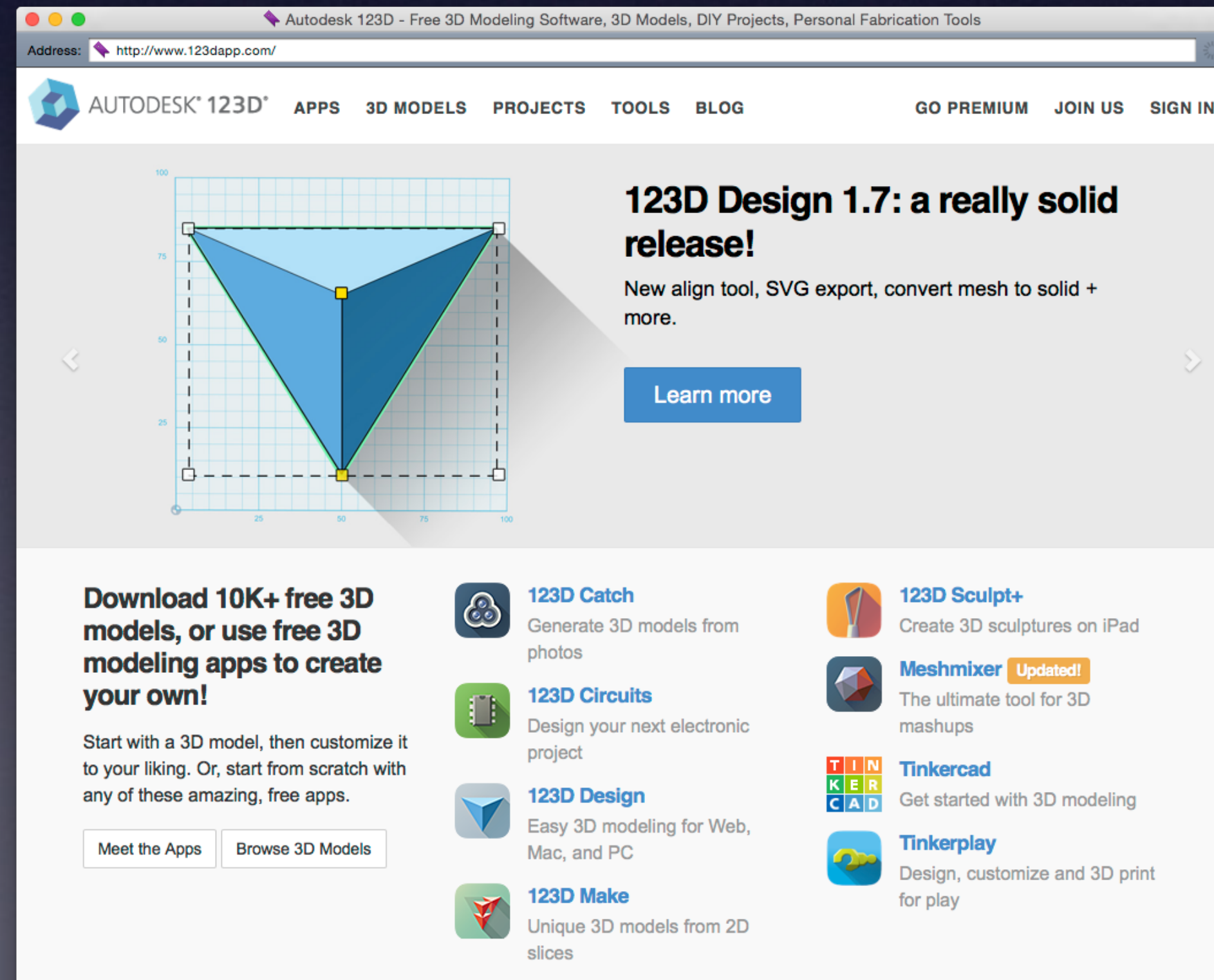


MeshLab

▶ [meshlab.sourceforge.net](http://meshlab.sourceforge.net)

# Making Models

- Autodesk 123D
  - ▶ [www.123dapp.com](http://www.123dapp.com)



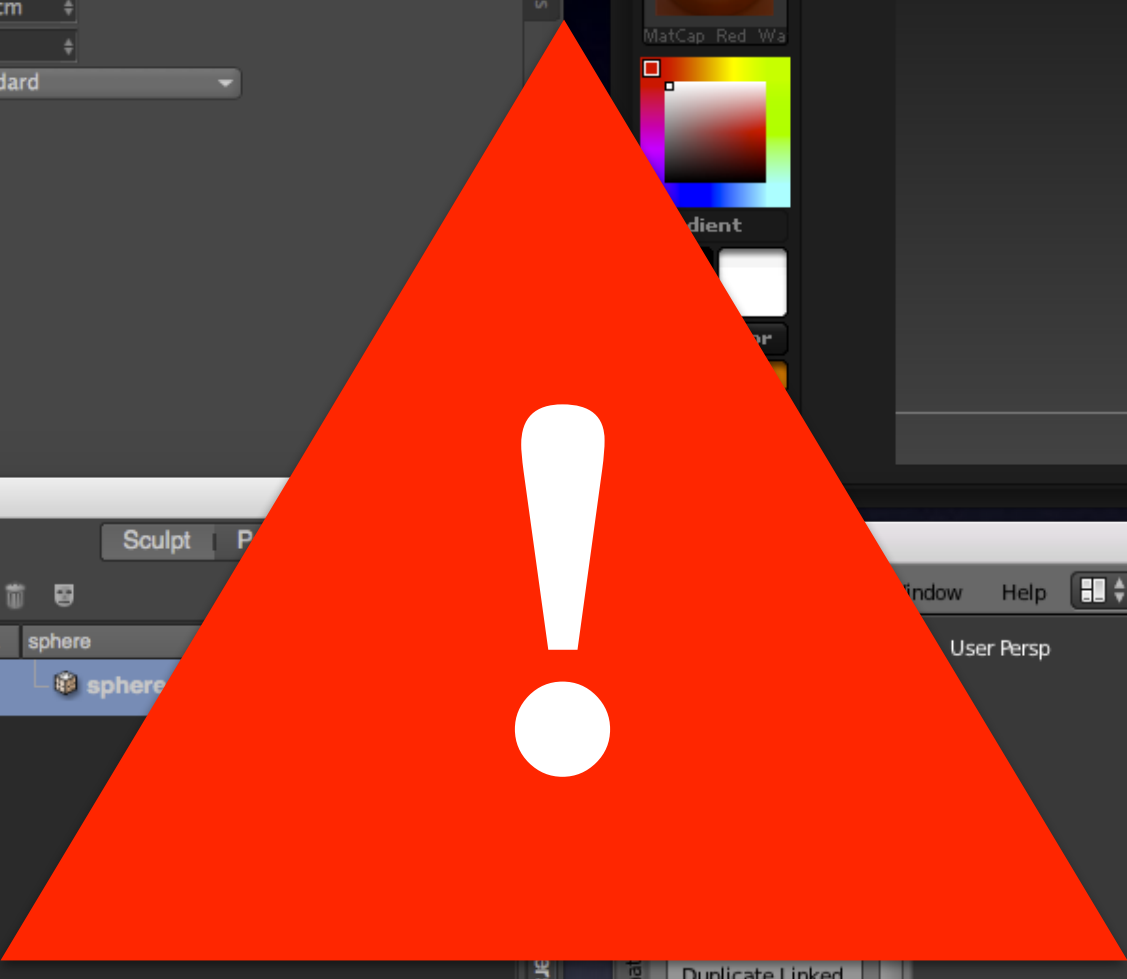
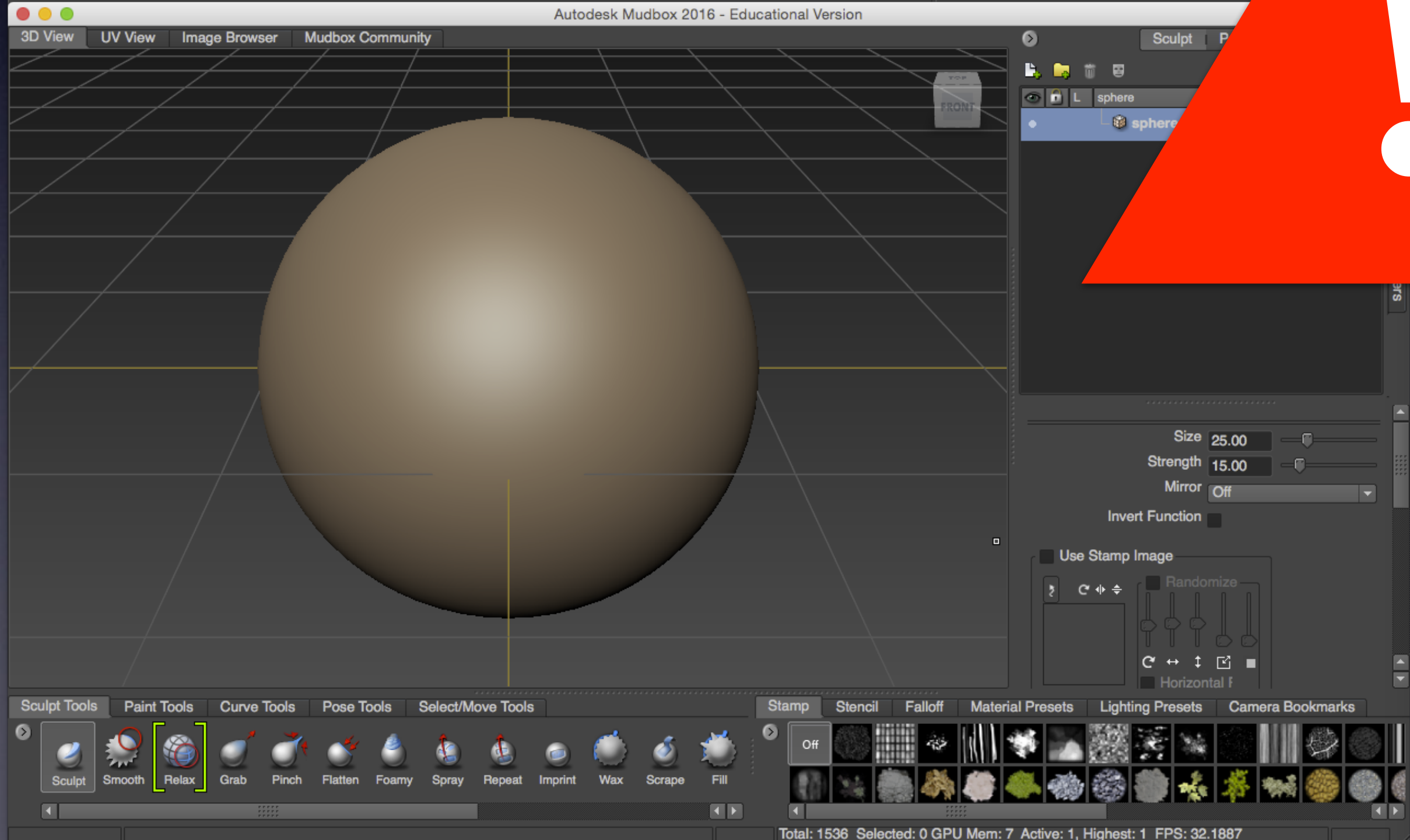
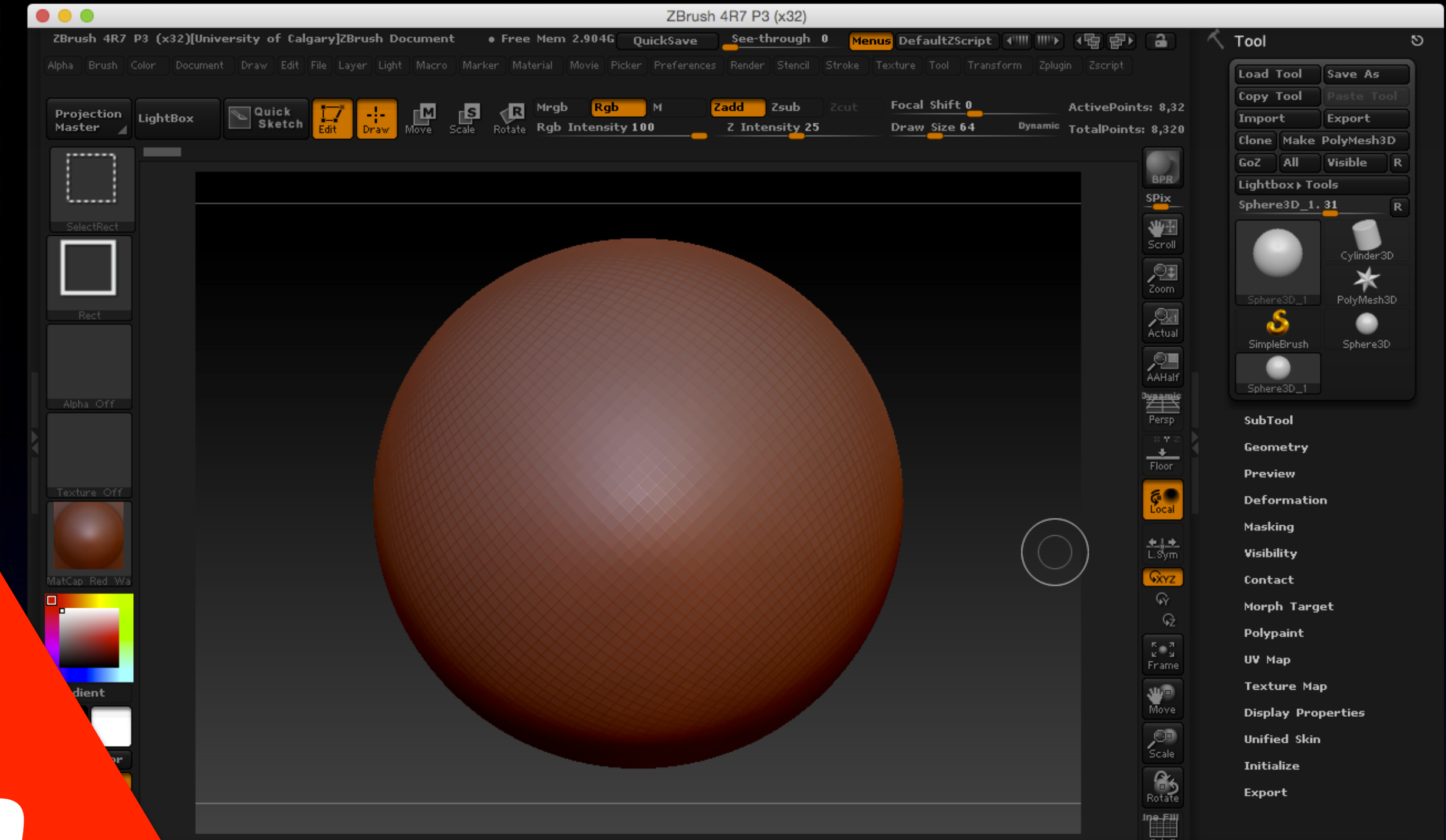
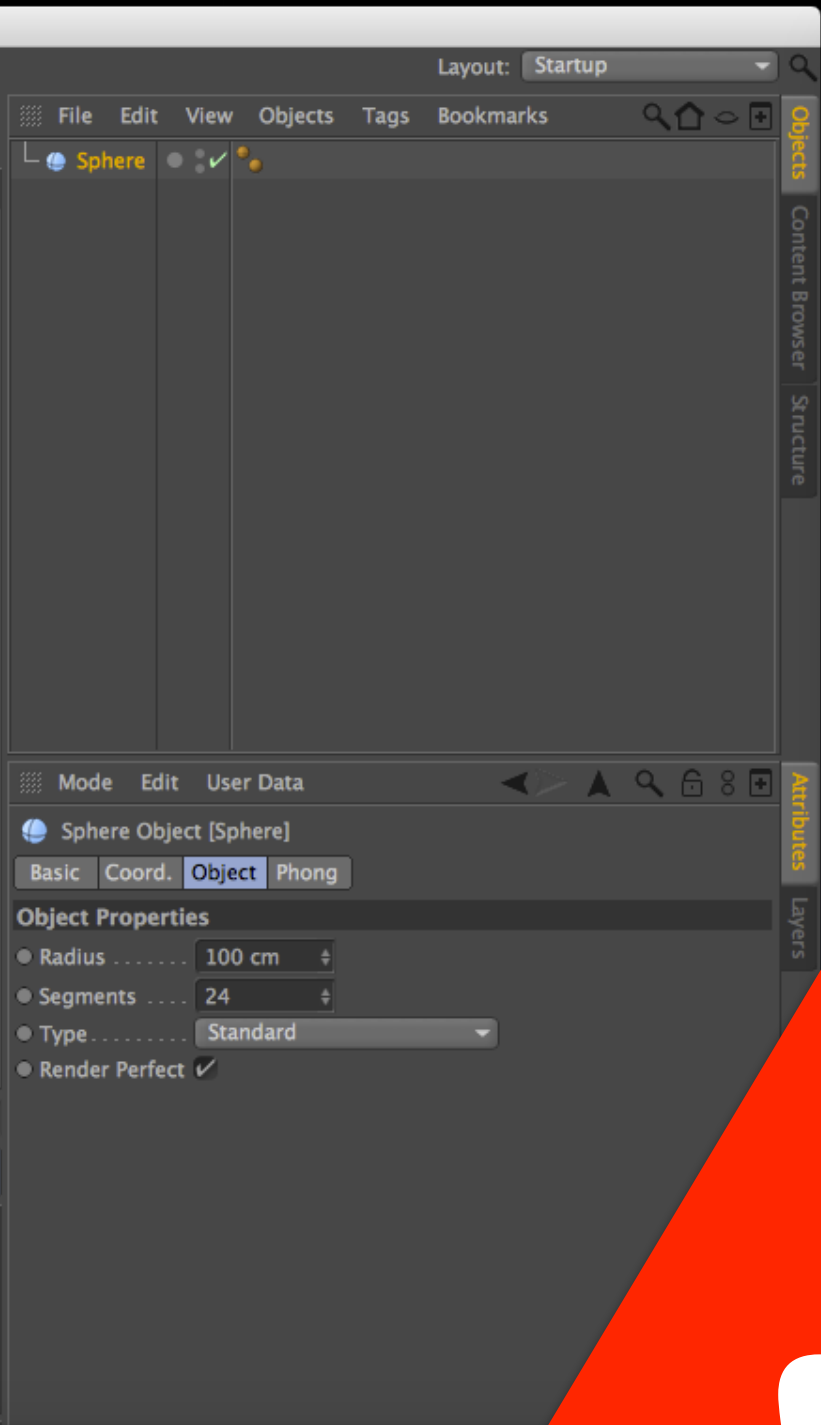
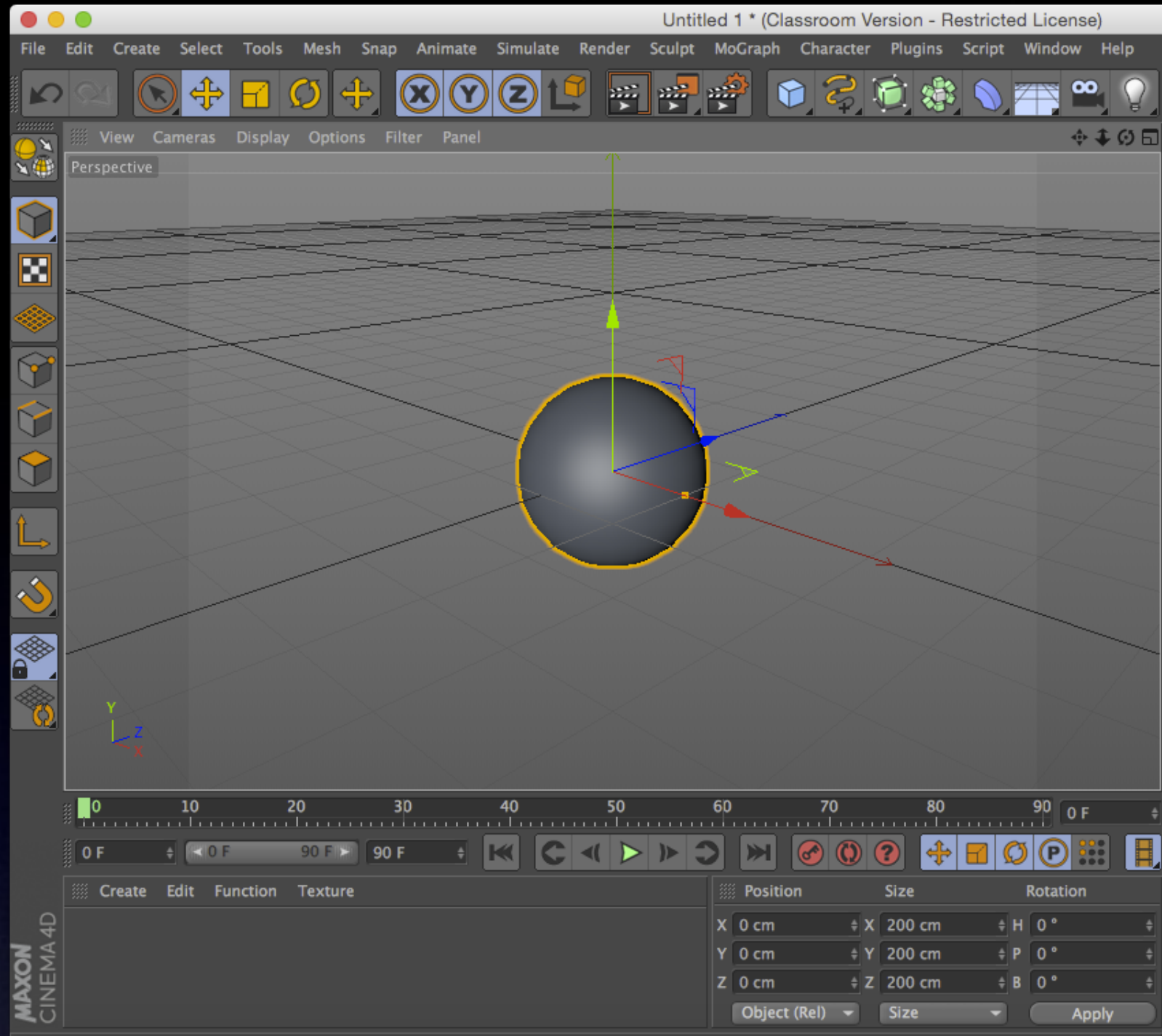
The screenshot shows the Autodesk 123D website homepage. The browser address bar displays "http://www.123dapp.com/". The navigation menu includes "AUTODESK 123D", "APPS", "3D MODELS", "PROJECTS", "TOOLS", "BLOG", "GO PREMIUM", "JOIN US", and "SIGN IN". The main banner features a 3D model of a blue pyramid on a grid, with the text "123D Design 1.7: a really solid release!" and "New align tool, SVG export, convert mesh to solid + more." Below the banner is a "Learn more" button. The lower section is titled "Download 10K+ free 3D models, or use free 3D modeling apps to create your own!" and lists several apps: 123D Catch (Generate 3D models from photos), 123D Circuits (Design your next electronic project), 123D Design (Easy 3D modeling for Web, Mac, and PC), 123D Make (Unique 3D models from 2D slices), 123D Sculpt+ (Create 3D sculptures on iPad), Meshmixer (The ultimate tool for 3D mashups), Tinkercad (Get started with 3D modeling), and Tinkerplay (Design, customize and 3D print for play). There are also buttons for "Meet the Apps" and "Browse 3D Models".

# Making Models



## SketchUp Make (Trimble Navigation)

- ▶ *[www.sketchup.com](http://www.sketchup.com)*
- ▶ *Ruby API*
- ▶ *SDK*



# 3D Scanning

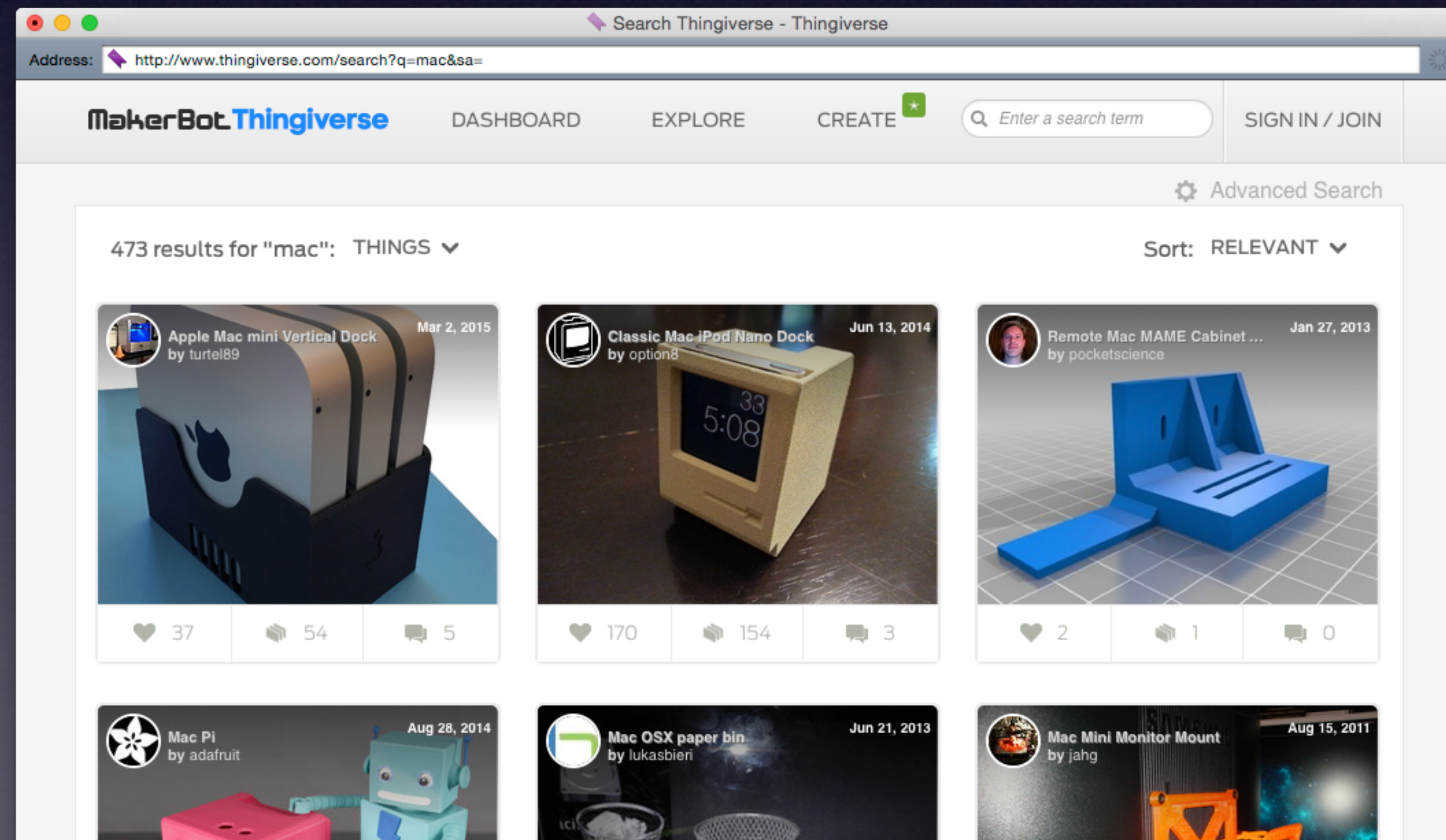
- Different Kinds, Different Sizes
- Notorious for needing model cleanup



# Community

- Thingiverse (Makerbot)

▶ [www.thingiverse.com](http://www.thingiverse.com)



# Community

- 3D Warehouse (SketchUp)

- ▶ *[3dwarehouse.sketchup.com](http://3dwarehouse.sketchup.com)*

- TurboSquid

- ▶ *[www.turbosquid.com/Search/3D-Models/free](http://www.turbosquid.com/Search/3D-Models/free)*


- ▶ *Paid royalty-free models as well*


[ucalgary.ca/iaml/help/pro/3d4ma](https://ucalgary.ca/iaml/help/pro/3d4ma)

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