

3D Printing Scale Replica's How It's Done

Presented by CatzPaw Innovations, LLC



Link to Presentation Handout: www.catzpaw.com
Click "3D Printing Scale Replicas Presentation Handout"
located in the lower right hand corner under "Gallery."

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Introduction to CatzPaw

- CatzPaw is a small woman owned business dedicated to designing and 3D printing scale model replica's of just about anything.
- We are a creative and technology savvy duo, with over 45 years of experience in the technology industry.
- We do it all: design, create, 3D print, package, ship, and more.
- Just two female entrepreneurs who accidentally started and now own and operate a small business in Locust Grove, Georgia; USA.



Things That We 3D Print

Scenic Details

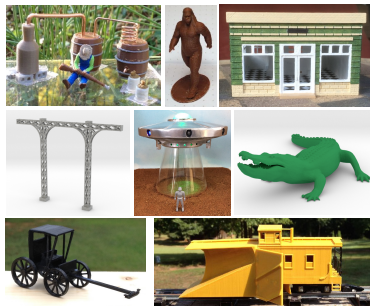
Animals & Birds

Figures

Small Buildings

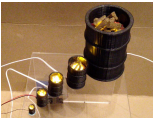
Vehicles

And more...



Flickering

- Campfires
- Burn Barrels
- BBQ Grills



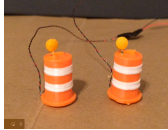
Illuminated

- Gas Pumps
- Ghosts
- Buildings



Flashing

- Traffic Barrels
- UFO's



Animated - the InvisaTrax System

Coming Soon



Where Things We Make Are Found

Model Railroad layouts

Farm Toy displays

Slot car layouts

Die cast dioramas

Historical dioramas

School projects

Any place a scale model is needed



Don Bizzozero's Model Railroad



Jason Young's Die cast Diorama





American Flyer Circus Train
Stop Motion Video by Tom Barker



Model Railroad Layout
by Pete Silcox



Model Railroad Layout
by Jimmie Walters



Award Winning Farm Display
by Christopher Steeb

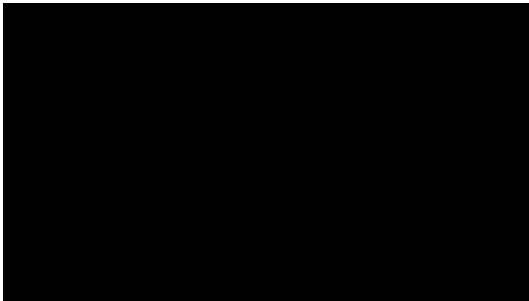


Civil War Diorama on Display in Cuthbert, GA
Created by Jimmy Bradley



Importance of Scale Replica's

Civil War Diorama Cuthbert, GA Courtesy of Jimmy Bradley



The Impact on Scale Modeling

A multitude of unique items becoming available.



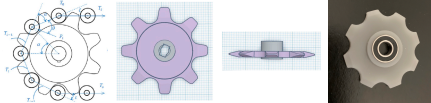
Custom items can be made according to individual needs.



The ability to create and print replacement parts for broken or missing pieces for out-of-production models.

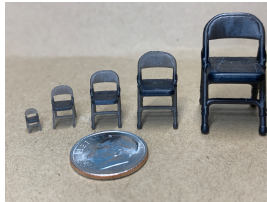


Prototypes, for testing, can be created quickly and cost effectively.



Scalability - Items designed in one scale (S - 1:64) can be reduced or enlarged to other scales: Z - 220, N - 1:160, HO - 1:87, O - 1:48, & G - 1:22.5, or any size in between.

Products can be produced on demand; no need to carry inventory. You can print only the number of items needed.



3D Printing Technology

What is 3D Printing?

3D printing, or additive manufacturing, is a process of making three dimensional objects from a digital file.

The 3D printing process creates an item by laying down successive layers of material until the object is created. Each of these layers can be seen as a thinly sliced cross-section of the object.

3D printing enables you to produce complex shapes using less material than traditional manufacturing methods. These include: milling/machining which grinds away excess material leaving just the desired object or creating a master and then casting duplicates from molds.



Benefits of 3D Printing

- Unlimited creativity: some say "if it can be drawn in a 3D computer program, it can be 3D printed."
- 3D printing is a tool-less process that reduces costs and lead times. Whereas milling and mold making both require specialized tools and die making before a part can be manufactured.
- Complex objects can be designed as a single piece or multiple pieces that can be assembled later.
- The use of ABS, nylon, and carbon infused filaments can yield lighter and stronger objects versus traditional resin castings which are heavy and fragile.
- Use of specialized resins can meet specific needs for strength, durability, and flexibility of an object.



Types of 3D Printers

Fused Deposition Modeling (FDM) - typically prints at 0.2 mm (200 microns) and can go as low as 0.1mm (100 micron) layer thickness. The average cost is \$200 - \$3,000.

Digital Light Projection (DLP) - prints at 0.05 mm (50 microns) and can go as low as at a 0.01mm (10 micron) layer thickness. The average cost is \$200 - \$2,000.

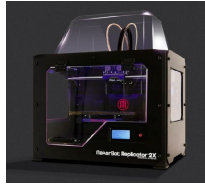
Material Jetting or Multi-Jet - Multi-jet printers can print in layer thicknesses ranging from 10 microns to 32 microns and are used by larger 3D printing services. The cost starts at \$45,000 and goes up from there.



Filament Based Printers Used by CatzPaw

Fused Deposition Modeling
(FDM) Printers

- MakerBot Replicator Dual & Replicator 2x (x2)
- Wanhao Duplicator 4S
 - All four have dual print heads; providing the ability to print objects in two colors.



Filaments

- ABS Plastic in multiple colors. Sourced from various US based manufacturers.
- Other Filaments include: PLA, HIPS, PETG, Nylon, and a host of others.

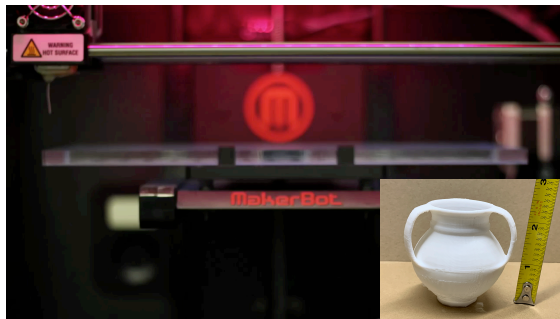
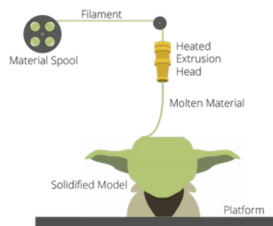


How FDM Printing Works

The FDM 3D printing process works by melting plastic filament which is deposited a layer at a time through a heated extruder onto a movable build platform.

Each layer hardens as it is deposited and bonds to the previous layer.

For complex shapes, support material is added to overhangs and must be removed during post-processing.



This object took two and half (2.5) hours to print!

Object Height (59.6mm) ÷ Print Layer Height (0.2mm) = Number of Layers (298)
Print Time = (Travel Distance x Travel Time per layer) x Number of Layers



Resin Based Printers Used by CatzPaw

Digital Light Projection
(DLP) Printers

- AnyCubic Photon (x4)

Resins

- HERO Tough in 10+ various colors, Standard, Fast+, Hard, BLUEprint ENG, and Gasket resins. All sourced from 3D Resin Solutions, Inc.
A US based manufacturer of resins.
(3dresolutions.com)

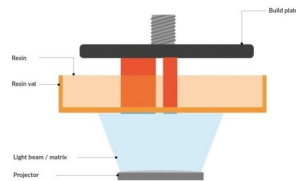


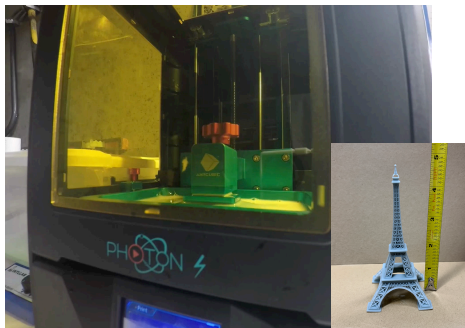
How DLP Resin Printing Works

The DLP Resin printing process works by exposing a thin layer of resin to UV light. The build plate is raised and lowered in and out of the vat of resin during the process.

Each layer of resin hardens as it is exposed by UV light and bonds to the previous layer.

For complex shapes, support material is added to overhangs and islands (areas that aren't attached to the model yet) which must be removed during post-processing.





This object took 7 hours 45 minutes to print!

Object Height (120.9mm) ÷ Print Layer Height (0.05mm) = Number of Layers (2418)
Print Time = (Exposure Time + Lift Time + Retract Time per layer) x Number of Layers



Multi-Jet Printing Outsourced to Shapeways

Materials selected for Shapeways printed products include:

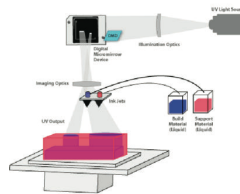
- “Smoothest Fine Detail Plastic” also known as Frosted Detail Plastic.
UV cured acrylic polymer offering high resolution, prints at 16 micron layer height, relatively brittle.
- Versatile Plastic in various colors.
Uses nylon powder sintered (melted) with a laser, solidifying the powder layer by layer. When thin, it's flexible when thick, it's strong.



How Multi-Jet Printing Works

Multi-Jet printing ejects tiny droplets of a photopolymer resin in the shape of the first layer. A UV lamp attached to the print head cures the polymer and locks the shape of the layer in place. The build platform then steps down one layer thickness and repeats the process until the part is complete.

The Multi-jet printer uses a separate, meltable material for support; typically wax. The wax support is melted away in an oven during the post-processing phase.



MultiJet Printing by Shapeways



3D Printing Pen

3D Printing Pen

- Utilizes FDM technology
- Plastic Filament (same as used in the FDM printers)
- Cost of a 3D Printing Pen: \$50 - \$150



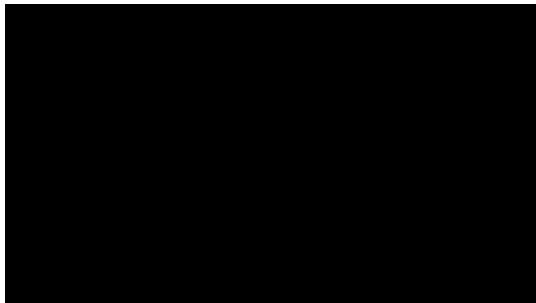
How 3D Pen Printing Works

3D Pen Printers work like FDM printers extruding filament through a heated nozzle. However, they are controlled neither by a computer nor software but guided instead by your hand. Most 3D printing pens are powered by batteries.

The filament is inserted into the pen, where it's heated to the point of melting and extruded.

As the molten filament leaves the pen, it's rapidly cooled by the air around it. You can draw desired objects on any surface or in thin air. If you're familiar with hot glue guns, hot 3D pens work in a similar way.



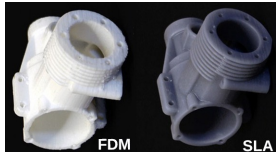


Video courtesy of MakeAnything.



FDM and Resin Prints Compared

| | FDM Printer | Resin Printer |
|-----------------------------|--|--|
| Resolution | | |
| Accuracy Dimensional | | |
| Accuracy Detail | | |
| Surface Finish | | |
| Part Strength | | |
| Complex Design | | |
| Ease of Use | | |
| Applications | Large light weight items with minimal detail, proof of concept | Small detail items, molds for casting, jewelry, dental, functional prototype |
| Material Costs | \$20 - 50 per 1 kg roll | \$20 - 60 per 1 kg bottle |
| Environment | Temperature regulated, humidity control, ventilated | Temperature regulated, humidity control, ventilated, UV light blocked |
| Ancillary Equipment | Support removal, finishing tools | Wash & cure stations, support removal, finishing tools |
| Pros | Fast, Low Cost Machines & Materials | Great Detail, Smooth Surface Finish, Low Cost Machines |
| Cons | Low Accuracy, Low Details, Rough Surface | Extra clean-up required, sensitive to UV light exposure |



FDM

SLA



The Cost of 3D Printing

Cost of Printing = Material Costs (resin/filament, consumables [gloves, masks, rags, acetone, FEP, IPA, kapton tape]) + **Manpower Costs** (print preparation, printer operation, post processing) + **3D Printer Operation and Upkeep Costs** (electricity, cost of printer, cost of printer parts [nozzles, belts, build platforms, vats, screens], **print time**) + **Post-Processing Operation Costs** (tools/machines to clean a print, smooth a print, and glues/adhesives to assemble a print)

Print times are based on the layer thickness selected, the height of the model, as well as travel speed and distance. For resin printers the exposure time per layer used and lift and retraction times also play a factor.

FDM printers take longer to print when multiple items are on the build plate.

Resin printers can print one or multiple items in the same amount of time.

Most print services base their pricing on: Material selected, Finish selected, Model Volume, Machine Space, Support Structure, Parts Bounds Volume, and Part Count.



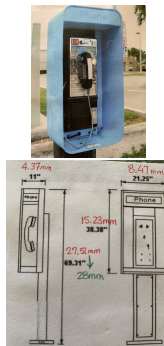
From Concept To Print

First - the spark of inspiration:
an idea we have or a request
from a customer.

Second - research: obtain as many
details/measurements/photos/drawings
as possible. Our items are true to scale
and as realistic as possible.

During this stage we verify that our new
product will be unique and not infringe on
anyone else's copyright or trademark.

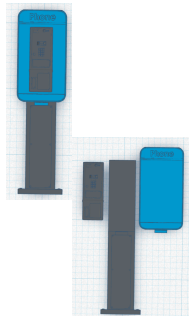
Third - the original item's measurements
are scaled and if necessary, traditional
mechanical drawings are created.



Fourth - the prototype design: the
object is recreated in a 3D computer
aided design (CAD) program.

Once the object is created in the
3D program, it needs to be refined
and made printable.

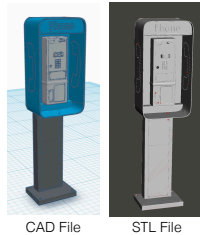
- For two or more colors in a print,
the object is separated into
multiple objects, one for each
color. Each separate 3D file is
printed in the desired color.



Fifth - file conversion: the file is converted from the CAD program's native file format (obj, 3ds, etc.) to a format that the slicing and printer software understands an STL file.

- STL - Standard Tessellation Language

- An STL file describes only the surface geometry of a three-dimensional object without any representation of color, texture or any other attributes.

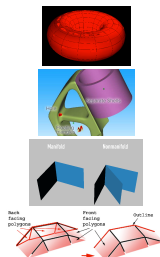


CAD File

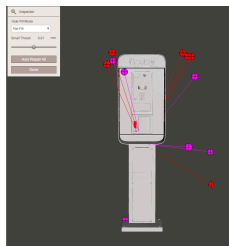
STL File

Sixth - checking for printability: not all STL files are printable; even if they look good in the CAD program and the STL viewer. To be printable, a model must be:

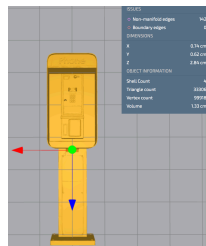
- Watertight - have no holes in the mesh; if you poured water into it, none would leak out.
- Solid - the model must be one solid piece with no surface intersections or separate shells.
- Manifold - each edge must connect to exactly two faces (non-manifold edges connect to three or more).
- Made from Front-Facing Polygons - the normals (fronts) must face out, cannot overlap or have overlapping vertices.



The STL file is opened in a utility program that is capable of checking for issues and correcting those issues, either automatically or manually.



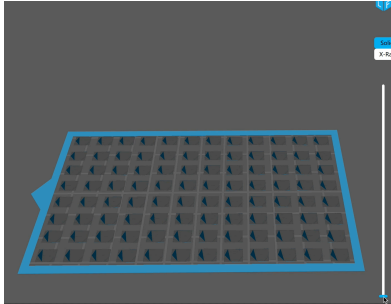
MeshMixer



MakePrintable

Seventh - slicing: once we know the STL file is printable, it then needs to be sliced into the layers that will be printed.

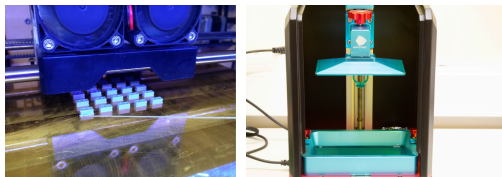
- For FDM prints we use 0.2mm layer thickness.
- For resin prints we use 0.05mm layer thickness.
- The thinner the layer the greater the detail and the longer the print time.
- The quality of a print is also determined by the material used and the software that performs the slicing. There are several slicing programs available, each having their own strengths and weaknesses.



Slicing creates the instruction set to be used by the printer, whether FDM or resin, to create each layer of the object. This file is referred to as machine code or gcode and is specific to each printer.



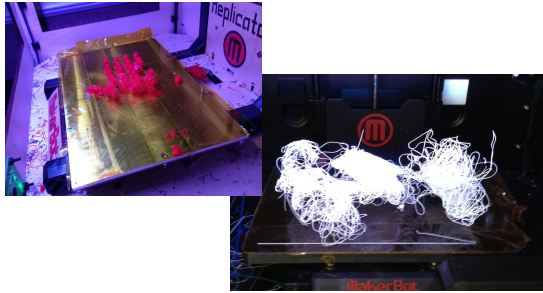
Finally We Print the Object



Unfortunately the process does not end here. It is rare that an object prints successfully the first time.



**Sometimes no matter what
we do, we get this...**



And also this...



Which Means...

1. We go back to the original 3D CAD file and tweak the design of the object itself.
2. We modify the revised CAD file for printability; creating separate objects and files as necessary.
3. We export and convert the CAD file to an STL file; which is then checked for printability and repaired if necessary.
4. We slice the new file and print. Hoping for the best.

We repeat this process until we successfully print an item.

We print at least five (5) iterations of each item to make sure it is stable and reproducible. Just because it prints once, doesn't mean it will print successfully a second, or third time.



After Printing: Post-Processing

Resin prints require additional post-processing steps that include uncured resin removal using Isopropyl Alcohol (IPA) and curing under a 405nm UV Light.

There are Wash & Cure stations available or you can use your own combination of UltraSonic Cleaner and UV Lights.



Support Removal: building any object by layers requires support structures for overhanging geometries and islands.

Supports are removed manually by snapping and/or cutting them off the part.



This process can be slow and sometimes painful. And in extreme cases can require a trip to the Urgent Care Facility.



Some objects need extra finishing steps. Whether filling gaps, fixing scarring caused by support removal, layer line smoothing, glueing multipart objects together, or painting.

- **Filling Gaps:** use a 3D printing pen, ABS slurry (ABS filament dissolved in Acetone), resin cured with a UV flashlight.
- **Cutting:** hobby knife, scalpel, jeweler's saw, hot knife.
- **Sanding:** hand sand with a fine grain sand paper or use an electric sander. Be sure to wear a face mask!
- **Smoothing:** melting with a Hot Knife or 3D Print Finishing Tool, ABS Slurry, thin layer of resin cured with UV flashlight.



MicroLux® Micro Sander



<http://www.modif3dpro.com>



- **Glueing:** Super glue, also referred to as cyanoacrylate glue, or CA glue, works on a variety of materials, including ABS, PLA, PETG filaments and most resins.

Resin can also be used to bind printed parts together, again using a UV flashlight to cure the resin. When working with resin be sure to use nitrile gloves.

- **Painting:** most 3D printed items work best with acrylic based paints. Models can be painted with or without a primer coat. Once the model is painted it can also be sealed with a clear top coat.



Software Used and Useful Links

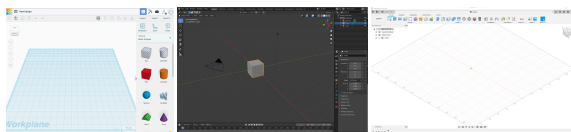


Mechanical Design

TinkerCad (<https://www.tinkercad.com>)

Blender (<https://www.blender.org>)

Fusion360 (<https://www.autodesk.com/products/fusion-360/free-trial>)



Organic Design

Daz3D (<https://www.daz3d.com>)

Poser (<https://www.posersoftware.com>)

ZBrush (<http://zbrushcore.com>)

Blender (<https://www.blender.org>)



Modifying & Repairing

Meshmixer (<https://www.meshmixer.com>)

Meshlab (<https://www.meshlab.net>)

Netfabb Online (<https://service.netfabb.com/login.php>)

MakePrintable (<https://makeprintable.com/dashboard>)

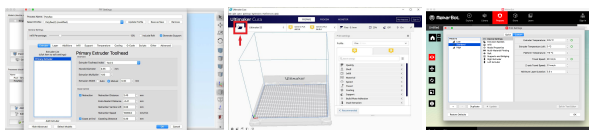


Slicing FDM

Simplify3D (<https://www.simplify3d.com>)

Cura 3D (<https://ultimaker.com/software/ultimaker-cura>)

MakerBot Print (<https://www.makerbot.com/3d-printers/apps/makerbot-print/download/>)



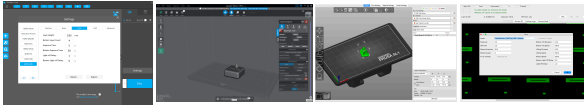
Slicing Resin

ChituBox (<https://www.chitubox.com/en>)

Lychee (<https://mango3d.io/downloads/>)

Prusa Slicer (<https://www.prusa3d.com/prusaslicer/>)

PhotonValidator (<https://github.com/Photonsters/PhotonFileValidator>)



What if I can't draw?

Most Popular Sites to Download Files to Print

<https://www.thingiverse.com>

<https://cults3d.com>

<https://www.myminifactory.com>

<https://www.cgtrader.com>

<https://www.turbosquid.com>

<https://www.shapeways.com>

Note: you may still need to repair files that have been downloaded; they are not necessarily printable.



Can I sell 3D prints of the files I have downloaded?

The short answer is: **No**.

Most all creations published and shared on websites are exclusively reserved for private and personal use. It means not selling the model or any derivative of the model for economic or financial gain. For example, you cannot sell the digital model, a derivative or adaptation of that model, nor can you sell prints of the model or make trade of it.

There are exceptions, 3D models with a *Creative Commons License* stating *Commercial Use* are allowed for sale.

The best thing to do if you want to sell a printed version of a 3D file is to ask the designer directly to see if they will give you permission. Be sure to get that permission in writing.



I don't have a printer.
But I designed an item, where can I get it printed?

Most Popular 3D Printing Service Providers

<https://www.shapeways.com>

<https://i.materialise.com/en>

<https://www.sculpteo.com/en/>

<https://www.xometry.com>

<https://www.hubs.com>



NMRA Partnership Program

See NMRA Website for Discount Code



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