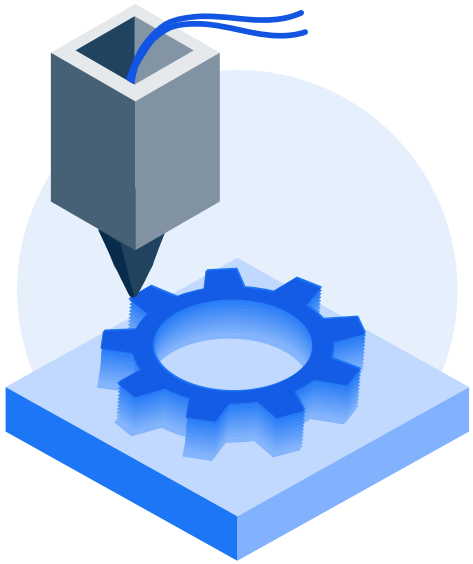


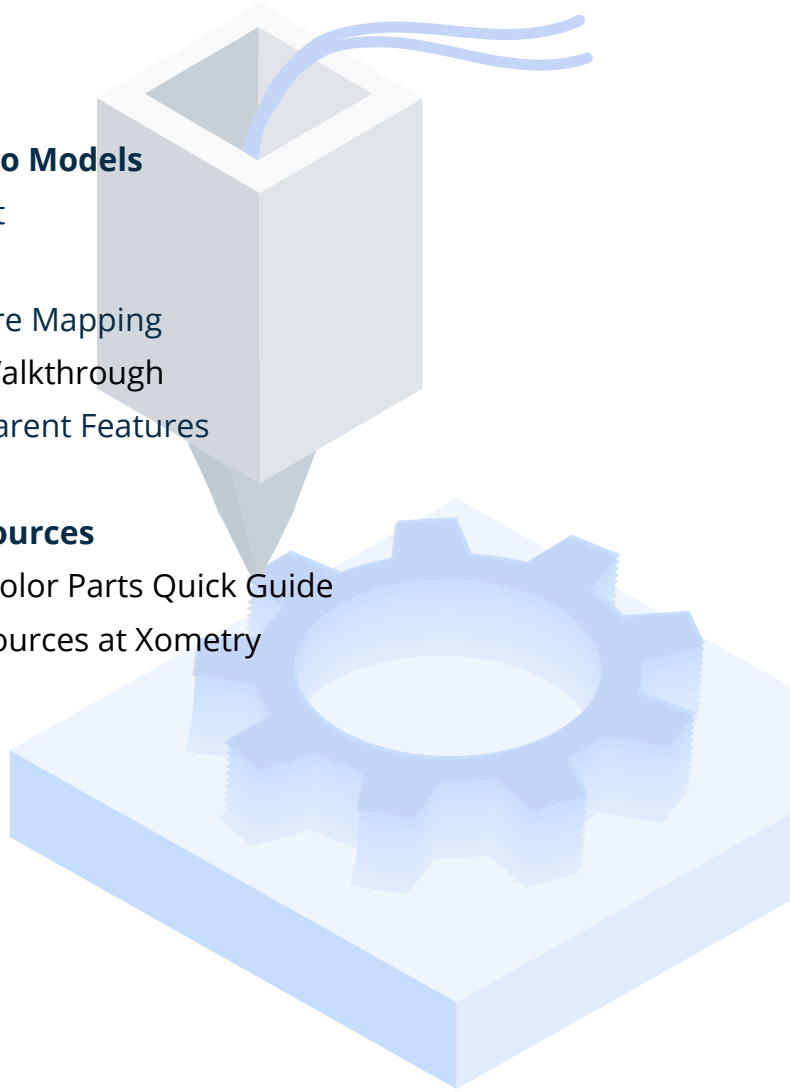
DESIGN GUIDE

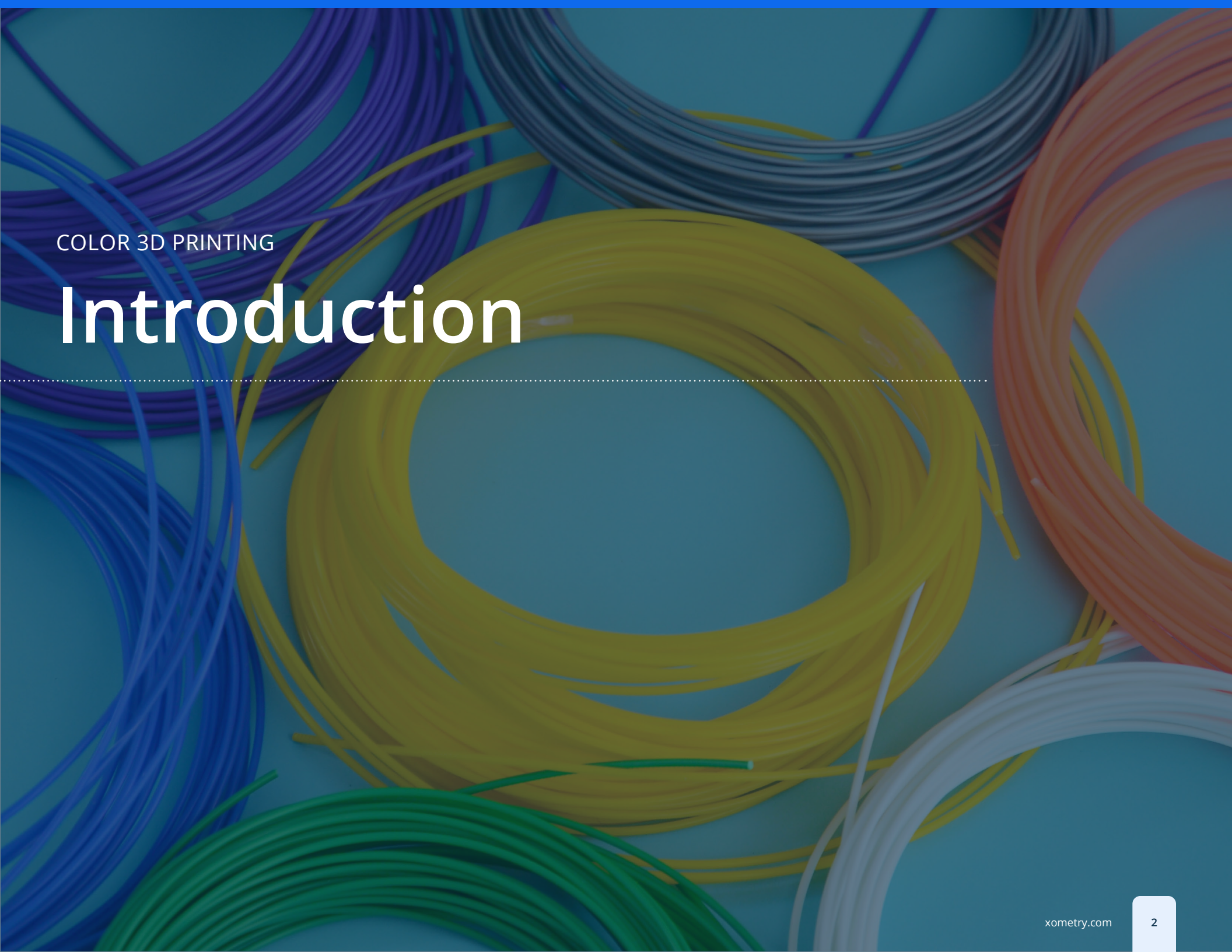
Color 3D Printing

Xometry

WHERE **BIG IDEAS** ARE **BUILT**

Table of Contents





COLOR 3D PRINTING

Introduction

Introduction

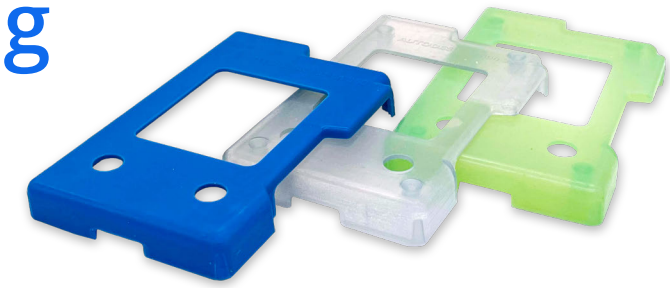
What is Color 3D Printing?

In the past, when it came to 3D printing in color, users were limited to printing materials in a set color or had to resort to post-processes, such as painting, to add color variety to their prints. Over the years, printing technology has advanced, and it's now possible to print in hundreds of thousands of colors and replicate patterns, textures, and transparency within a single print.

Throughout this guide, we will cover the different methods, technologies, and design techniques related to color 3D printing so you can get the most out of the current generation of machines and get spectacular-looking colored prints.

Introduction

Applications of Color 3D Printing



The ability to print in full color opens the door to various uses and applications across many industries. Users can print models with accurate colors, patterns, and textures in great detail. From engineers and product designers to artists and architects, each can utilize modern color 3D printing to their advantage. Below are just some examples of where this technology is applied.

Rapid Prototyping

Functional prototypes can be printed in the exact colors of their final design, offering designers even more insight into improving their products. Color prototyping can reveal cosmetic issues and strengths without needing painting or other post-processing steps, buying users more time and a better result. Also, key areas of a prototype can be colored to highlight their functionality or important features within a design.

Education & Medical Models

Models for classrooms and doctor's offices can be fabricated in full, accurate color with minimal post-processing necessary. Complex, organic geometries can also be made transparent so that bones, veins, or other internal structures can shine through the print without needing removal and coloring.

Architectural

Architectural models can be further improved with real color mapping, allowing stakeholders to better grasp the architect's vision. With amazing color accuracy, color 3D printed models will show designers what their color choices will look like without the lengthy painting process, allowing them to make faster revisions.

Geospatial Modeling

Terrain and other geospatial maps printed in full color provide a scaled 3D look at peaks, valleys, and geographic formations in a landscape. Both analysts and students benefit from accurate color matching to elevation differences, temperature or pressure gradients, or any other geospatial feature that can be superimposed onto 3D printed geography.

Artwork

The ability to produce full-color parts saves an immense amount of time for artistic endeavors, where priming, painting, and protecting take valuable time away from the creative process. Artists can save time by printing in full color, using this time to focus on innovating and refining their artistic visions.

COLOR 3D PRINTING

Printing Categories & Processes

Color 3D Printing Categories

Color 3D printing breaks down into categories based on how the machine applies colors during printing. Due to technological differences, some printers create a full spectrum of color that prints simultaneously for highly detailed results. In contrast, others rely on mixing and blending raw materials of different colors. Each process's approach and subsequent category largely depend on the printing technology and materials.

Full-Color Printing

Machines that can create thousands of colors and apply them in a single print to create photorealistic results are considered full-color. These types of printers often utilize printheads to jet tiny droplets of pigmented material or binding agents, similar to how 2D inkjet printers deposit ink to create colorful images. This approach also allows some processes, such as PolyJet, to apply materials with different properties in a single print. When it comes to overall color fidelity and detail, full-color printing is at the top.

Multi-Color Printing

Not to be confused with full-color, multi-color printing generally involves mixing, blending, or swapping between multiple colored raw materials while printing. This approach is more common with filament-based processes like fused deposition modeling (FDM). For instance, a printer with multiple extruders can deposit a different color for each extruder. It is also possible to splice and fuse other colored filaments into a single filament with special devices designed for single-extruder machines. While typically an inexpensive way to produce colored prints, this method is much more limited, can be slow, and may not be suitable for prints requiring precise color placement or realistic color details.

Post-Process Coloring

For some processes and materials, color options are limited or nonexistent. Post-processing can come in handy in this case. For example, selective laser sintering (SLS) printers typically make parts from white nylon, but Xometry can dye them in various colors. Painting is also a viable option to create customized colors and fine details; however, this can be a very time-consuming process depending on the needs and is not considered a scaleable solution.

Color 3D Printing Processes

Now that we understand that there are different ways to achieve color in 3D printing, let's take a deeper look at some of the most commonly utilized processes for creating colorful prints. When determining which is best for your application, consider the pros and cons of each 3D printing process.

PolyJet

PolyJet™ is a type of multi-jetting printing process that uses layers of deposited material (typically photopolymer resin) up to 16 microns thick to build a 3D part. A print head containing several colors/material chambers and a UV light source will deposit one layer, solidify it in one pass of the print head, and then repeat the process until the part is complete. PolyJet™ printing is an incredibly powerful tool that allows direct full-color printing and multi-material prints that can save vast amounts of manufacturing and assembly time. Hundreds of thousands of colors are possible on PolyJet™ machines with some of the highest layer resolutions available, and PolyJet™ is the only process that can print full-color transparent parts.

PolyJet is Xometrys primary full-color printing process, learn more about our PolyJet capabilities.

Color print made with PolyJet

Pros

- High resolution and high detail prints
- Capable of producing hundreds of thousands of colors
- Capable of printing transparent parts
- Can simultaneously print in multiple materials
- Fast printing speeds and lower lead times for parts

Cons

- Parts lack toughness and typically not suitable for rugged or functional testing and not intended for long-term use
- Materials are susceptible to heat and UV degradation
- Can be a relatively high-cost process
- Color zones may require additional setup for the process

Color 3D Printing Processes

FDM

Fused deposition modeling (FDM) printers offer various color options and printing methods to achieve multi-color 3D prints. FDM 3D printing works by extruding a melted plastic filament onto a build plate, patterning the shape of the part on a layer-by-layer basis. In single-nozzle systems, multi-color 3D printing requires filament swaps between transitions. There are splicing modules that manage and mix multiple filaments before they enter the extruder, offering both multi-material and multi-color printing for standard single extruder printers. Certain single extruder FDM printers also implement clear filament dyed with CMYK ink cartridges during printing to provide the full-color spectrum with a single material. In multi-nozzle FDM printers, these filaments can be printed independently of one another through dual extruders, producing 2+ different colors throughout the print and their blended color profile.

Assembly of color prints made using FDM

Xometry utilizes industrial-grade FDM machines with single-color printing capability. We offer various color options with our ABS and ASA materials. Learn more about our FDM capabilities.

Pros

- Large build volumes up to 24” x 36” x 36”
- Wide range of materials to choose from
- Can be suitable for functional prototypes and some end-use applications

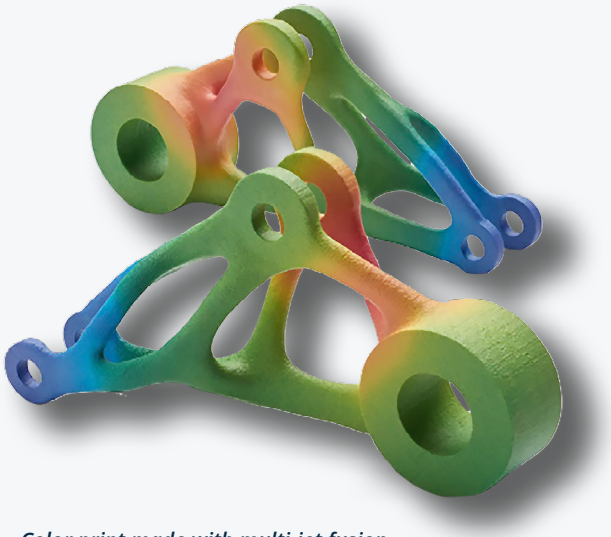
Cons

- Relatively low printing resolution with pronounced layer lines on parts
- Limited color range; generally cannot match specific tones
- Struggles with highly detailed or intricate features and tiny parts
- Requires support structures during printing; susceptible to more print errors

Color 3D Printing Processes

Multi-Jet Fusion

Developed and patented by Hewlett-Packard (HP), Multi-Jet Fusion (MJF) 3D printers use a multi-agent material jetting process where an inkjet array sprays fusing and detailing agents onto a powder bed of thermoplastic. As the layers deposit, a heating element fuses the part shape, and then a roller places a new layer of powder so the process can repeat until the part completes. Multi-Jet Fusion machines use proprietary blends of PA (nylon), PP, TPA, and TPU, all patented combinations by HP, to ensure ideal results. HP has a variant of their machine capable of applying color tones to the part; however, most installed platforms provide gray or white parts. Manufacturers can pigment MJF prints by dyeing them.



Color print made with multi-jet fusion

Xometry's manufacturing network uses current-generation HP MJF machines, which do not offer color printing. Learn more about our HP MJF capabilities.

Pros

- High productivity; suitable for batch production runs
- Creates strong, durable parts suitable for end-use applications
- Relatively low-cost process

Cons

- White will appear off-white
- Surfaces are rougher than photopolymer-based processes like PolyJet
- No transparent or translucent options
- Full-color multi-jet fusion machines were discontinued in 2021 meaning this option will become harder to source as time goes on
- Requires support structures during printing; susceptible to more print errors

Color 3D Printing Processes

Color Binder Jetting

Also found as colorjet printing, binder-jetting printers selectively spray colored binder material in the shape of each layer over a core material (typically a sandstone material for full-color prints) spread over a build plate, thereby solidifying it. The following material layer deposits and the process repeats until the part is complete. Binder-jetting printers can achieve direct color results without heating or curing steps; however, post-processing is more critical for binder-jetting prints. Binder jetting offers impressive pixel-to-pixel color control and can provide full CMYK for direct color prints.

Xometry offers metal binder-jetting to create durable metal parts. Learn more about our binder jetting capabilities.

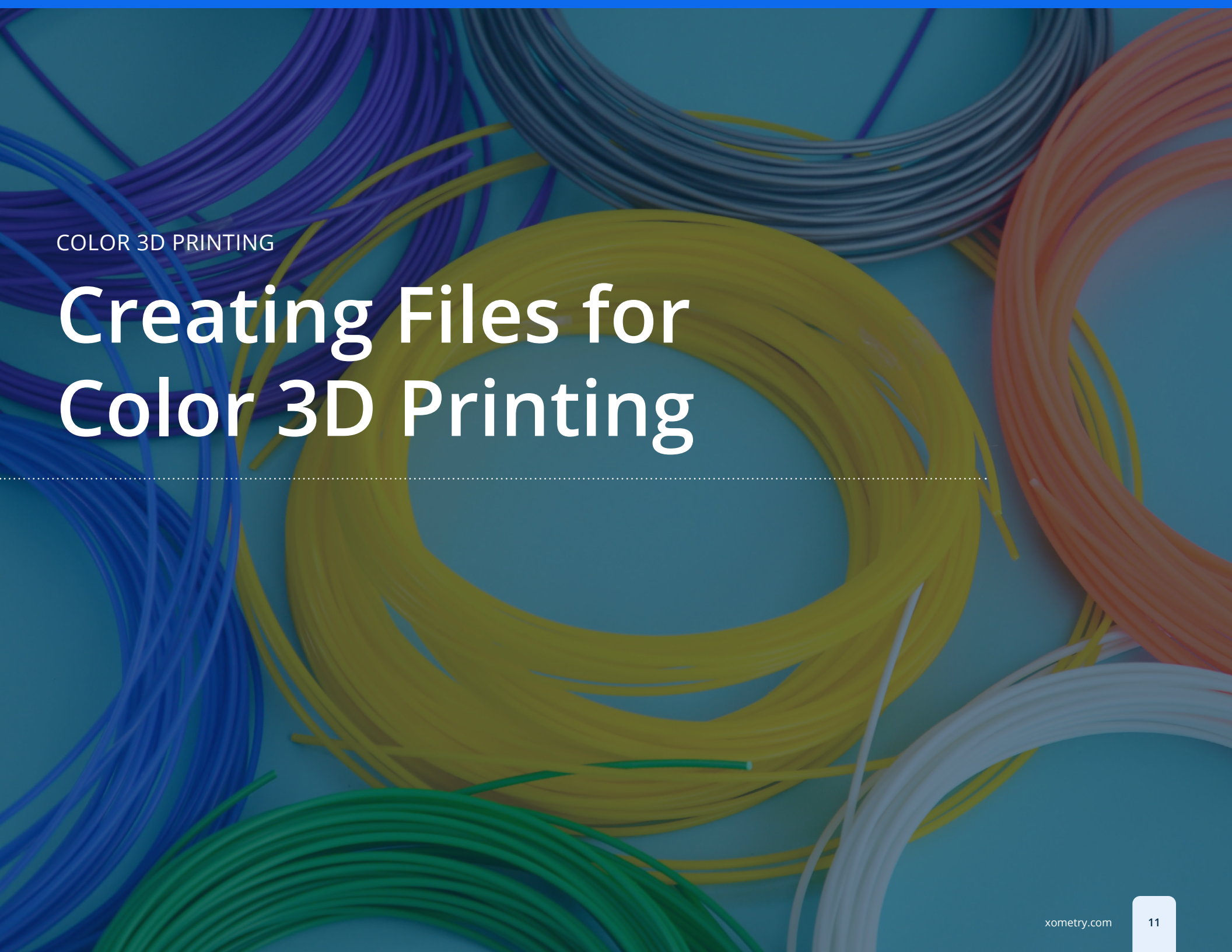
Color print made with colorjetting.
Image courtesy of 3D Systems

Pros

- Full-CMYK color range
- Large build volume; able to produce many parts at once
- Sandstone prints do not require heat or curing steps, allowing for dimensionally stable printing

Cons

- Being made from a porous and brittle material, full-color binder-jet prints are relatively fragile
- Not suitable for rugged or end-use applications
- No transparent or translucent options



COLOR 3D PRINTING

Creating Files for Color 3D Printing

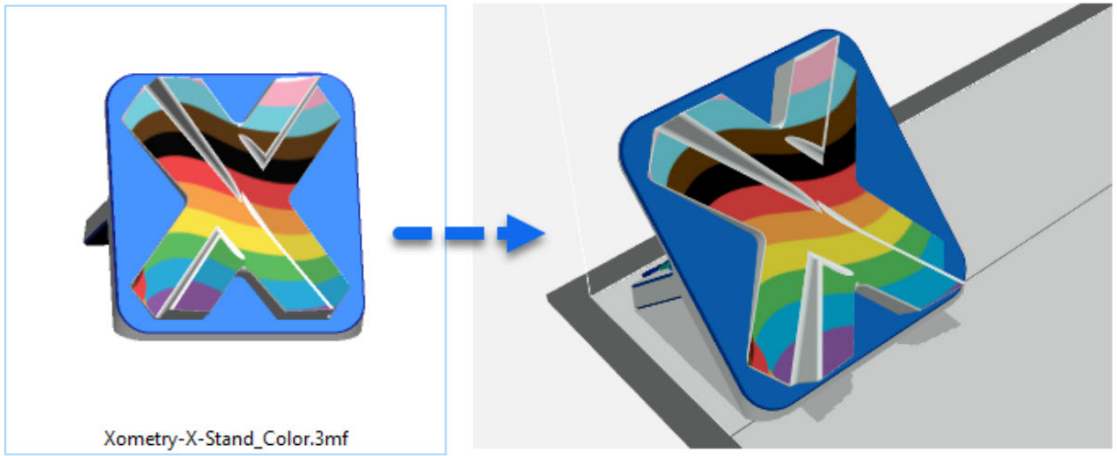
File Formats

Exporting your files in the appropriate format is crucial to print your full-color designs successfully. Many standard file types used for 3D printing, such as STL, do not retain texture, scale, or color data. STL files loaded into printing software will come through as plain, colorless files. Several native and STP file formats store this information; however, they are primarily meant to be used solely within the original design software and should be converted to a format that can be interpreted by 3D printing software.

In the section below, you will find our top picks for the best formats for full-color printing, as well as information about each so you can decide what is best for you.

3D Manufacturing Format (.3MF)

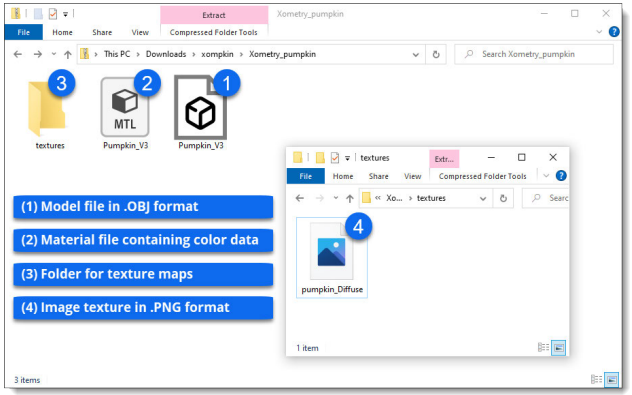
The 3MF format is relatively new compared to other 3D file formats, but it is quickly becoming one of the go-to options for 3D printing. There is a good reason for its growing popularity-- 3MF encompasses information about materials, colors, textures, support structures, dimensions, and more, all within a single file. 3MF files typically are smaller file sizes than STL without compromising resolution. We recommend using 3MF as it is natively supported in the Xometry Instant Quoting Engine® and due to its “drag and drop” simplicity.



File Formats

Wavefront OBJ (.OBJ)

OBJ is well-adopted and widely supported among CAD and 3D design software. These files define objects by their vertex positions and UV texture coordinates. Unlike 3MF, Wavefront OBJ files do not store the material and texture information inside a single file; instead, they rely on material libraries and companion files to complete the job. They cannot also store unit information that defines exact dimensions. For full-color 3D printing, this can lead to issues such as colors and textures not coming through properly or parts coming in at incorrect sizes. When using OBJ, the associated companion files (e.g., material files, images for textures, etc.) must be in the same directory or folder as the OBJ itself.



Example of OBJ and supporting files

Pro Tip:
The best way to provide an OBJ to a manufacturer for full-color printing is to put all the necessary files in a folder, then compress the folder into an archive (e.g., a .zip file), which can be uploaded or emailed.

Virtual Reality Modeling Language (.wrl)

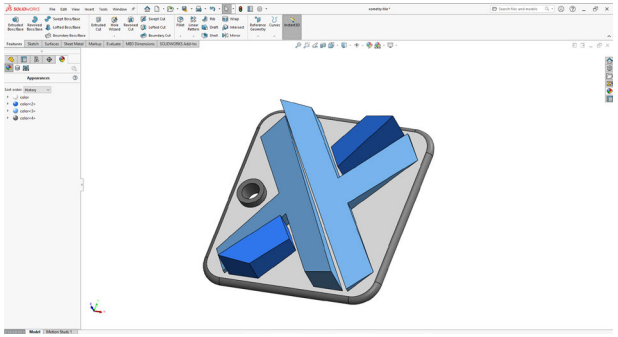
Also known as VRML files, this graphical/virtual modeling format can visualize 3D objects, figures, and environments. VRML can represent polygonal meshes, surface colors, texture information, and transparency, making it useful for color 3D printing. When using image textures for color assignment, VRML files reference a separate texture file in the same directory, similar to OBJ files.

Pro Tip:
Creating a reference drawing or image showing what the object is supposed to look like can be helpful for print operators in the event they need to repair a file manually. They do this using build preparation software which allows colors and textures to be assigned to bodies or surfaces manually; however, the files generated this way are not easily transferable to other platforms and put an additional burden on the operator.

Methods for Creating Color Models

3D CAD & Design Software

3D CAD and free-form modeling design software offer the most versatility for creating digital designs suitable for printing. Computer-aided design software such as SOLIDWORKS and Autodesk Fusion 360 utilize parametric modeling techniques to develop precisely dimensioned models. This makes them a common choice for engineers and product designers who must ensure their models have exact specifications. Typically, modeling software enables you to change the design's appearance using colors and textures that the software retains for printing when you export the file in an appropriate format.

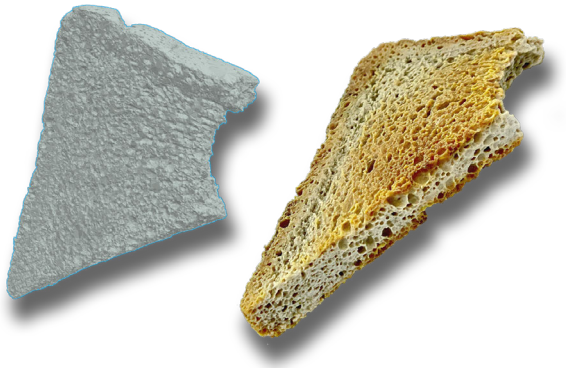


A part within SOLIDWORKS

Polygonal modeling software such as Blender and ZBrush rely more heavily on freeform tools to shape and sculpt models from polygonal meshes. This type of software excels at creating organic geometries and characters. Additionally, they often have very in-depth coloring, and texture mapping features allowing users to control appearances precisely.

3D Scanning

The process of digitizing real-world objects or environments into a three-dimensional file using a 3D scanner is known as 3D scanning. The process works by scanning objects at all possible angles with scanning equipment. Most scanners use a combination of lasers and sensors to measure the surface of and object and create a point cloud that generates polygonal 3D meshes. With scanning, it's possible to make highly detailed and accurate models of existing things. When paired with full-color 3D printing, this is an excellent process for creating life-like replicas or miniature models. For example, one could 3D scan a one-of-a-kind historical artifact, then 3D print copies of it to distribute to museums worldwide for display and educational purposes. As a less practical example, you could also use this process to fool friends and colleagues with fake food, as we've done with the piece of toast shown to the right.



A 3D scanned piece of toast printed using PolyJet

Methods for Creating Color Models

While 3D scanning allows you to create highly detailed objects relatively quickly, it does have its limitations. The primary is that you are limited to only scanning real-world objects; non-existent items must be created manually with 3D design software. Since scanning requires you to move around an object physically, it is unsuitable for replicating substantial objects (e.g., statues and buildings). Bright lighting conditions and shiny or reflective objects can also pose issues for scanners and may require coating surfaces to create a clean scan. Finally, most 3D scanned models need manual touch-up work with modeling software to join two halves of an object together or remove file errors that made their way into the scan data.

Photogrammetry

Like 3D scanning, photogrammetry is a method to create 3D models from actual objects. Instead of scanning and measuring an object with light sources, photogrammetry relies on gathering data from photographs. The process works by taking photos at various angles and loading the images into photogrammetry software that uses specially designed algorithms and math to align the photos, create plot points and calculate distances to form a point cloud. Similar to scanning, software constructs polygonal meshes from scanned point clouds. Photogrammetry is much more accessible, as you only require a camera to take photos and software designed for the task. Some applications, such as Polycam, allow you to perform photogrammetry right from a smartphone or tablet.

This technique also makes it possible to create models and capture textures of much larger objects. For example, you can theoretically digitize entire buildings or city blocks using aerial imagery from planes or drones, given you have enough photographic data. That said, photogrammetry shares many pain points around lighting conditions and reflections as 3D scanning. Since it relies on images and software to approximate distances, photogrammetry is generally less accurate than 3D scanning and is more prone to geometric errors. Like scanning, additional manual touch-up work is often required with the models before they are suitable for printing.

Example of a scan made using photogrammetry

COLOR 3D PRINTING

Adding Color to Models

Adding Color to Models

Designers can use several techniques to directly assign colors in a 3D model for full-color 3D printing. Your specific use case will determine the best and most efficient choice. In most cases, coloration can be done directly in the software you used to create your model; be sure to look for appearance or material features within your program. We'll take a closer look at a few coloring techniques below.

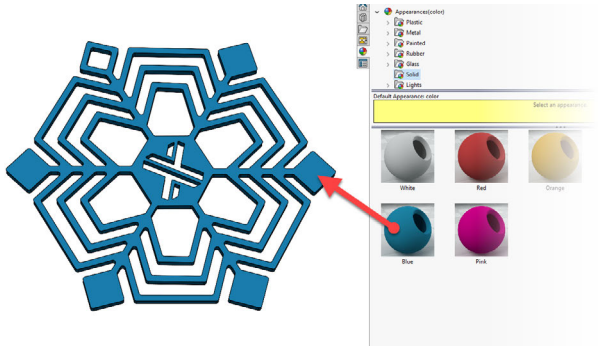
Color by Object

This method is best for making your entire object one solid color—making parts specific colors can help differentiate part configurations, aid in assemblies, or for aesthetical purposes. Solid-colored models work well with either full-color or multi-color types of printing. However, if you are looking for a custom color or as close to a color match as possible, full-color technology, such as PolyJet, is still the best option. In your design software's material or appearance menus, apply the desired color to your entire object.

Pro Tip:
With PolyJet, we can manually assign colors to entire objects with our build software. You can upload any accepted 3D file, select the "Other" color option during quoting for PolyJet and provide the hex number or RGB value of the color you'd like us to print it in.

Color by Face

Assigning color by face means selecting a particular triangle, face, group of polygons, or feature in your design software and giving it a specific color. Coloring by face is an excellent technique for giving embossed or engraved text contrast and giving features unique colors on the same object. The selection method may vary depending on your design software. Still, the core idea is to select specific areas of your model instead of the entire thing and assign a color or material to each.



Example of assigning color by objects

Example of assigning color by faces and features

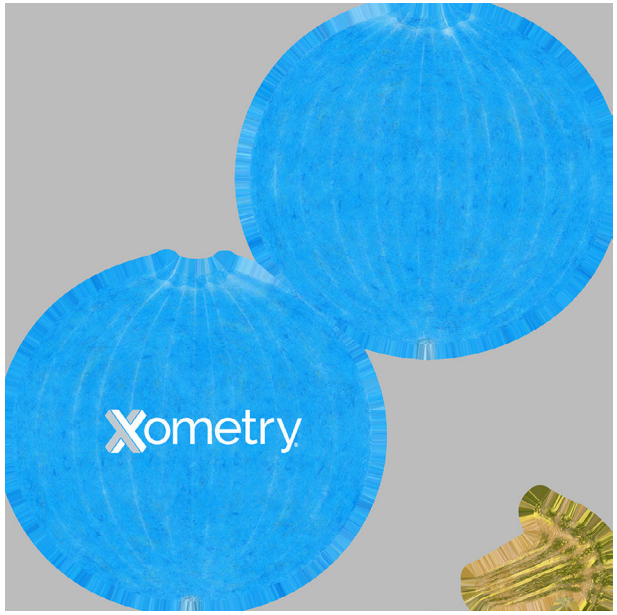
Adding Color to Models

Color by Texture Mapping

Applying a texture map to an object is the best way to create highly detailed and realistic colored prints. However, it can also be one of the most challenging techniques and could require learning additional skills to utilize it to its highest potential. Texture mapping requires a 2D image or graphic applied or overlayed on top of the 3D model to alter its appearance. Textures can allow you to overlay logos and text on your parts or even mimic the look of other materials, such as wood grains, textiles, and more. The level of detail makes texturing excellent for producing miniatures, art replicas, and product prototypes that look real.

An object's UV coordinates relate the information in the texture map to corresponding mesh coordinates, dictating how a texture is applied. Taking your object's 3D mesh and flattening it into a 2D map is called "UV Mapping" or "Unwrapping" a model. Some design software has UV mapping capabilities built-in; otherwise, you may need to use separate software dedicated to texturing to UV unwrap and wrap a model properly. If you are new to texture mapping, we recommend searching for online resources, such as UV mapping tutorials specific to your design software.

Pro Tip:
A good way to ensure your textures are correctly applied and will come through is to open your printing file (e.g., 3MF) in Microsoft's 3D Viewer, a program that comes pre-installed with Windows 10 and later.



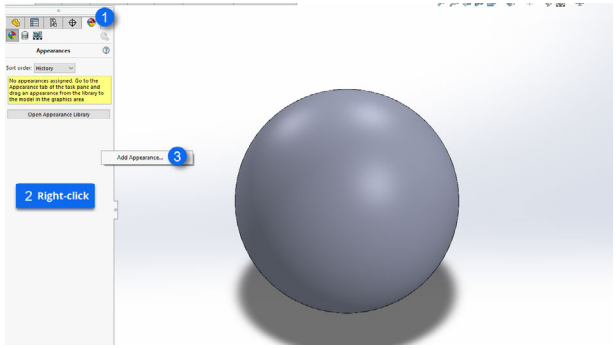
UV texture map of a blue Xometry pumpkin

Full-color prints using texture mapping

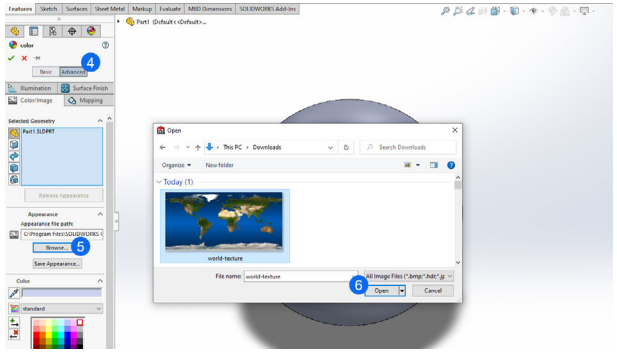
Adding Color to Models

Texturing Walkthrough

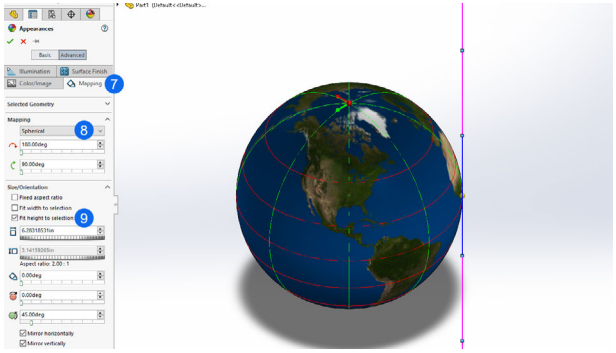
We'll go through a basic example of texturing a part. In this case, we are working within SOLIDWORKS, and our goal is to texture a sphere with a world map, making it appear like a globe. We'll start by going into the "DisplayManager" (1) and right-clicking in the area under appearances (2), and selecting the "Add Appearance..." option (3).



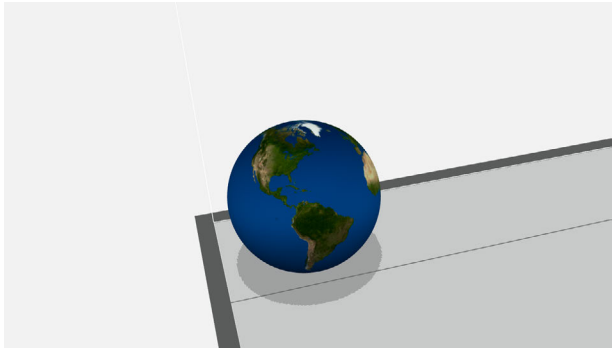
At the top of the appearance pane, make sure "Advanced" is toggled (4), so we can see all the appearance settings. In the selected geometry section, we can choose specific faces or features to apply the texture, although we will stick with the whole part in this case. Next, we click on "Browse..." under the "Appearance File Path" section (5). From the file browser that opens, navigate to and open your texture (6). Our example will use a world map image as the texture.



At first, the texture may not look right, but that's okay. We can adjust the texture mapping options by clicking the "Mapping" tab (7). We selected "Spherical" (8) as the mapping type for our example part since this best fits our parts' geometry. From here, you may need to experiment with the "Size/Orientation" options (9) to get the map to fit best to your part. We checked the boxes for fit to width and height and the mirroring checkboxes to get our texture to look correct.



Now that our part has a texture map applied, we can export it as a 3MF file, and it will be ready for printing! Here is how the 3MF file looks loaded into our printing software.

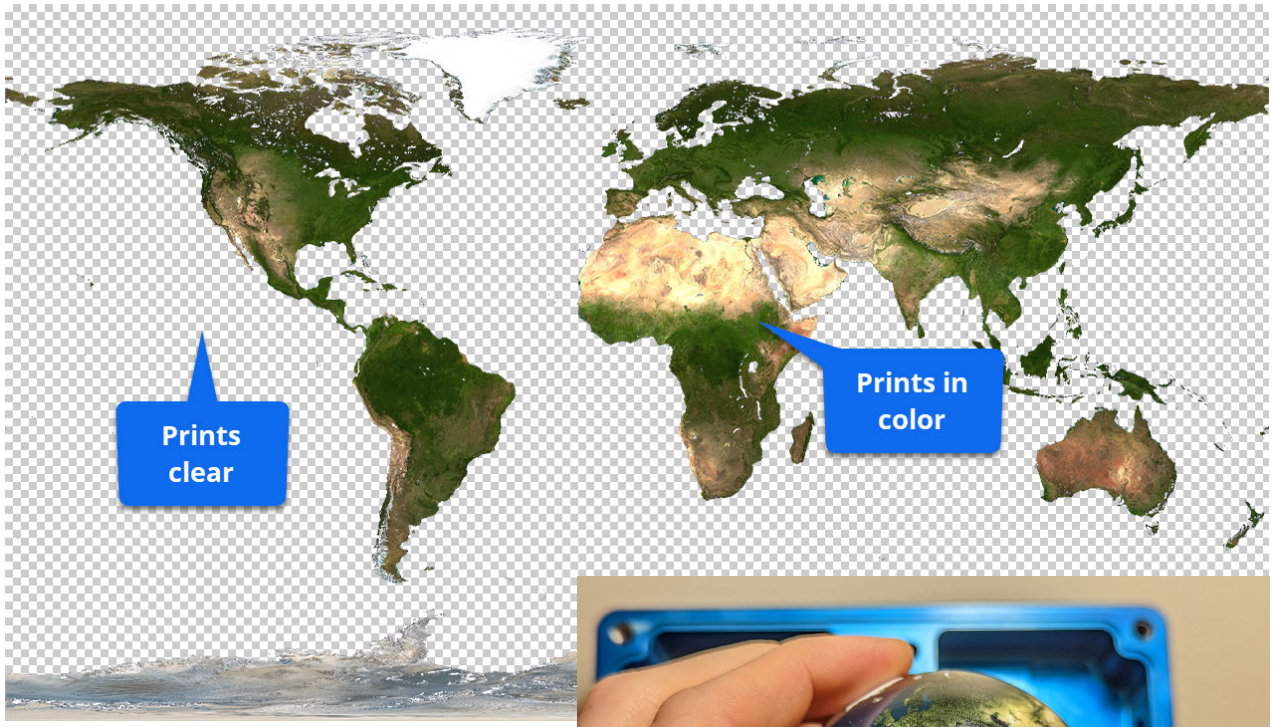


Adding Color to Models

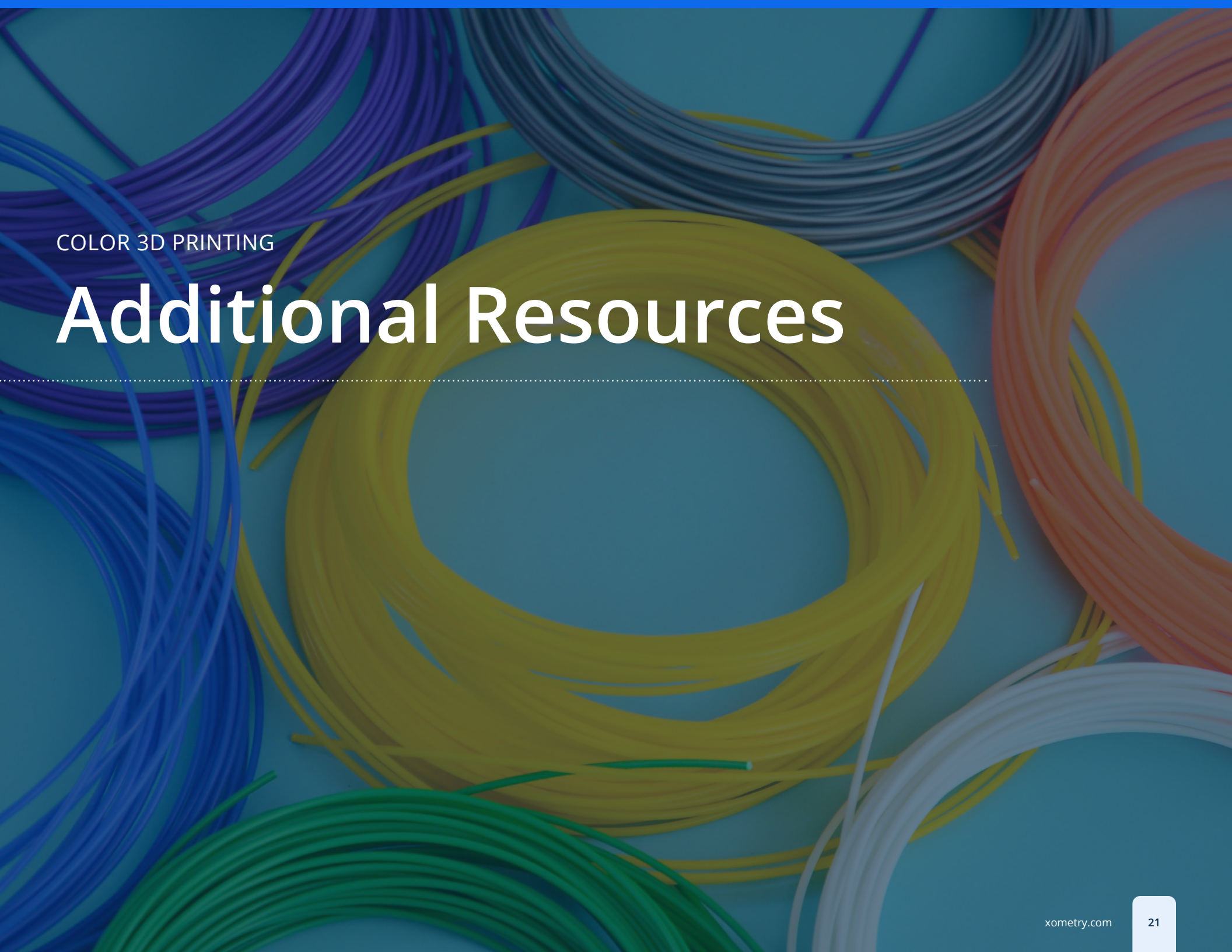
Adding Transparent Features

At Xometry, we utilize the latest PolyJet machines for printing full-color parts. As mentioned, this type of printer can also print in transparent or translucent materials. From the printing software, we can specify color and whether or not we want the core material to be opaque or transparent. Printing a single part with both opaque and transparent regions is also possible. Again, texture mapping will prove helpful in achieving this effect. Using our globe example from earlier, we can replace the blue ocean regions in our texture with a transparency layer instead.

When loaded into the printer's software, we can specify transparent areas of the texture to print in the clear core material and the non-transparent regions to print opaque in the colors shown. Here is how the result looks after printing, polishing, and applying a clear coat.



Additional Resources



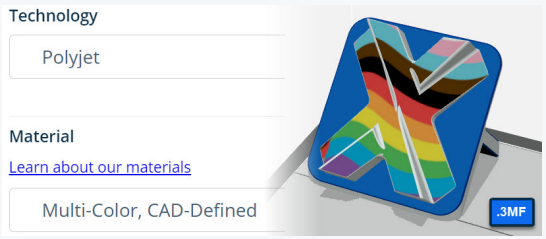
Resources

Ordering Full Color Parts Quick Guide

Ordering full-color parts with Xometry is quick and easy! You can start by going to our quoting dashboard and uploading your 3D CAD files. If you have a file type that isn't accepted, please contact us at support@xometry.com for assistance. Follow one of the methods below to quote and order your full-color prints.

Method 1: CAD-Defined

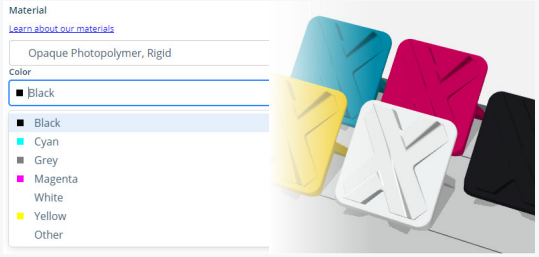
1. Assign colors or texture directly to your model within your design software.
2. Export the file as 3MF.
3. Upload your file to the Xometry Instant Quoting Engine and select "PolyJet" under the Plastic 3D printing processes.
4. Select "Multi-Color, CAD Defined" material.



Method 2: Color drop-down

Note: *This method will apply the chosen color to the entire part.*

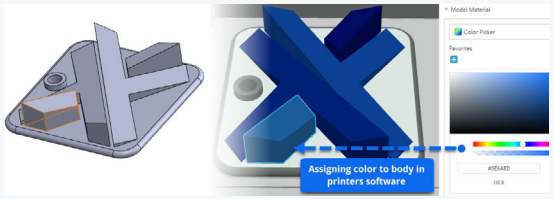
1. Upload any supported 3D CAD file and select "PolyJet" as the manufacturing process.
2. Select "Opaque Photopolymer, Rigid" as the material.
3. Under the color drop-down menu select your desired color.
4. If you want a color that isn't listed, select "Other" and write the color in the space provided using an RBG or hex color code.



Method 3: Multi Material

Note: *Color will be assigned per shell or body.*

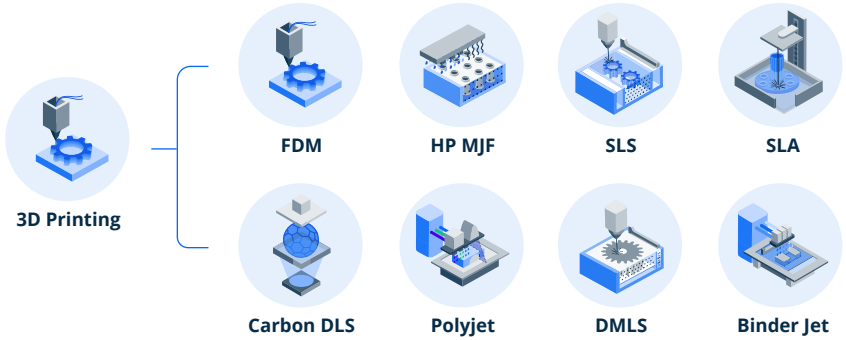
1. Create your design with multiple bodies, where each body is to have a color assignment.
2. Export as a single file and upload to the Xometry Instant Quoting Engine.
3. Select "PolyJet" as the manufacturing process and "Multi Material, Digital Overmold" as the material.
4. Attach a drawing or image to the parts "Drawing and Files" section that has instructions for the operator to follow for color and material assignments. The "Notes" section can also be used for further clarification. Colors should be provided in RGB or hex color codes.



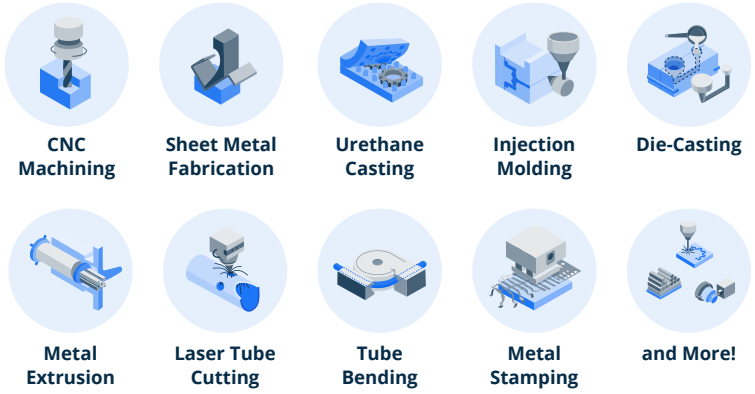
Additional Resources at Xometry

Online Instant Quoting

- **Web:** Upload your CAD file at xometry.com/quoting/home/
- **Accepted file types:** STEP (.step, .stp), SOLIDWORKS (.sldprt), Mesh (.stl), Parasolid (.x_t, .x_b), DXF (.dxf), Autodesk Inventor (.ipt), Dassault Systems (.3dxml, .catpart), PTC, Siemens (.prt), ACIS (.sat), JT (.jt)
- **3D Printing Capabilities:**



- **Other Capabilities:**



Other Sheet Cutting Resources

- Color 3D Printing Service
- All 3D Printing Services
- Achieving Clarity With PolyJet
- Full Color Printing Best Practices
- Multi-Material Printing

Live Support

- **Hours:** M-F 8AM-10PM EST, Sat.-Sun. 9AM - 5PM EST
- **Email:** support@xometry.com
- **Phone:** (240) 252-1138