



# Multi Jet Fusion (MJF)

*Best Practices & Things to Keep in Mind*

- I Overview
- II General Guidelines
- III Design Concerns / Things to Consider
- IV Materials
- V Finishing / Post - Processing

# Contents

---

## Overview 1

What are the prime applications ?.....	1
What is the Digital Manufacturing Network ?.....	2

## General Guidelines 3

Maximum Build Size   Features   Cantilever.....	3
Text, Graphics and Numbers.....	4

## Design Concerns & Things to Consider 5

Warping.....	5
Parts That Assemble   Parts Printed as Assemblies.....	6
Extra-Large Parts   “Elephant Skin” .....	7

## Materials 8

Nylon PA12 / Nylon PA12 with Glass Beads / Nylon PA11.....	8
Which Nylon Should I Use ?.....	9
TPU (Thermoplastic Polyurethane).....	10

## Finishing / Post - Processing 11

BLAST Vapor Smoothing.....	11
Dyeing, Painting, Clear - Coat.....	12
Cerakote.....	13
Metallization.....	14
Hydrographics.....	15

3D printing offers the ability to produce—both rapidly and at low cost—short runs or one-of-a-kind parts. HP Multi Jet Fusion (MJF) technology offers high build quality at a much higher speed, and at the lowest cost, relative to competitive 3D printing solutions in the marketplace today.

## What are the prime applications ?

Prime applications for 3D printing include the functional and aesthetic components of machines, consumer and industrial products that are manufactured in short runs of typically less than 1000 units, highly-customized and high-value products that can be one-of-a-kind, and parts with complex internal and external 3D geometries.

Before 3D printing, parts with complex surfaces, moving elements, and internal fluid passages were assembled from subcomponents that were aligned and assembled with fasteners and/or adhesives. In conventional parts—especially those designed to handle air and liquids—joints and sealing surfaces may be points where mechanical failure and leakage occurs. But, with 3D printing, complex parts can be produced either as a single piece or from far fewer subcomponents.

3D printing has the potential to simplify design and manufacturing processes and to reduce processing time and costs. Parts can be made by 3D printing that cannot be made by other methods, and this creates many new possibilities for innovations in design, form, and function.



## What is the Digital Manufacturing Network (DMN) ?

**The Digital Manufacturing Network (DMN) is a very select group of *production-capable* suppliers of Multi Jet Fusion parts, as certified by HP.**

HP set a standard of very high quality in printed parts that DMN members must meet for solutions engineering, production capacity, consistency, quality and repeatability of prints. HP audited all partners to also verify our stability as a company.

GoProto was selected by HP as one of the first six foundation partners globally that meets the very high standards of acceptability. HP selected GoProto as a foundation partner to deliver prototype and production parts in North America due to our customer-solutions orientation, production capacity, and decades-long relationship with the HP printing family.

As one of the first service bureaus to be selected in the country, we offer leading-edge expertise, and will help you get started with this groundbreaking manufacturing process. Whether you need quick-turn prototypes or more robust production parts, GoProto is your source for all things Multi Jet Fusion.



Digital  
Manufacturing  
Network Partner



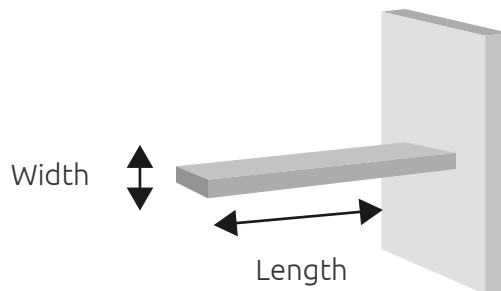
Minimum Feature Sizes	mm	inches
Hole Diameter At 1mm Thickness	.5	.020
Shaft Diameter At 10mm Height	.5	.020
Clearance At 1mm Thickness	.5	.020
Slit Between Walls	.5	.020
Gap Between Parts That Are To Be Assembled	.6	.024
Gap Between Assembly Parts	.9	.035
Gap In Lattice Structures	1	.040

Other	mm	inches
Maximum Build Size	380 x 285 x 380	14.96" x 11.15" x 14.96
Dimensional Accuracy (measured after sand blasting)	Up to 100mm: $\pm 0.2\text{mm}$ > 100mm: $\pm 0.2\%$	Up to 3.937in: $\pm 0.007\text{in}$ > 3.937in: $\pm 0.2\%$
Recommended Wall Thickness	1 - 20	.040 - .787

## Cantilever

The dimensions of a cantilever are based on the aspect ratio, determined by the length divided by the width. It is advisable to keep the aspect ratio <1.



## Text, Graphics and Numbers

Multi Jet Fusion technology excels at very high resolution for letters and drawings.



### Minimum Printable Font Size

**6 pt**

### Minimum Text Height

*(Emboss and Deboss)*  
**1mm (0.039")**

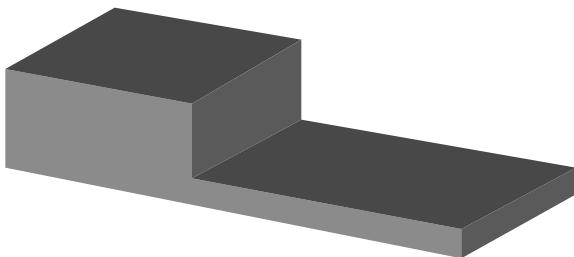
## Warping

Long and thin parts have the potential to warp. Generally, any part that has an aspect ratio higher than 10:1 is susceptible to warpage.

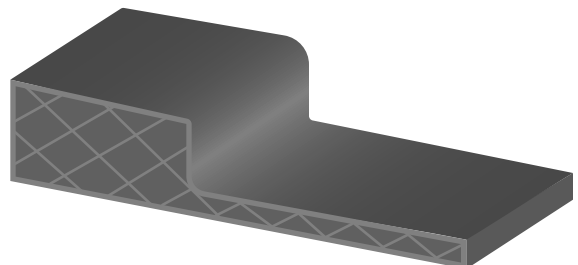
## What can you do?

- Increase the thickness of the part.
- Add ribs in the areas that may be affected.
- Replace the solid volume with a lattice structure as in the “Lighter Design” shown.
- Reduce sharp transitions, as shown in the “Smooth Transition” shown.

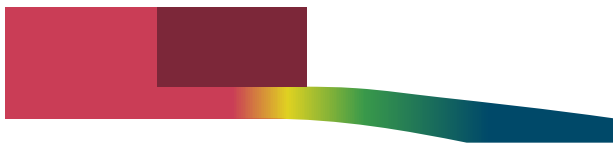
## Original Part



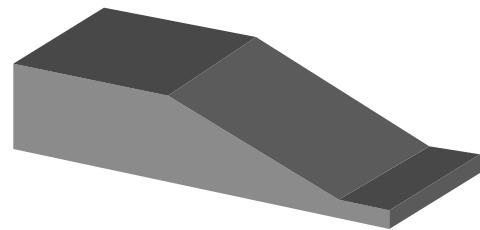
## Lighter Design



## Potential Warp



## Smooth Transition

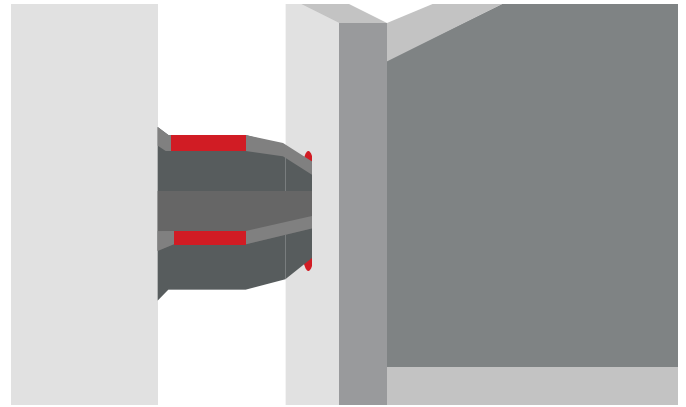
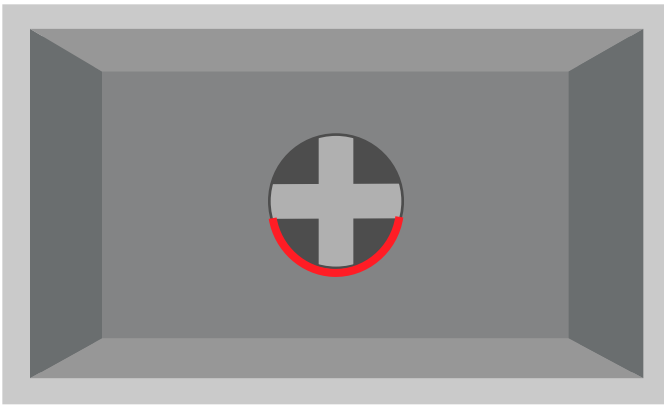


## Parts That Assemble

Sometimes a pair of parts need to fit together for the final application.

## What can you do ?

**The recommended minimum gap between the interface areas of the parts is 0.024" (0.6mm) to ensure correct assembly.**

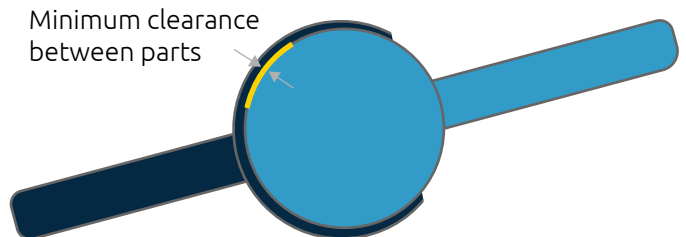
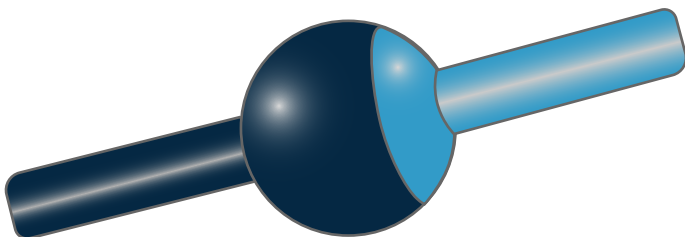


## Parts Printed as Assemblies

One key advantage of additive manufacturing is the ability to print a part as a single assembly.

## What can you do ?

**Assembly parts that are printed together should have a minimum clearance of 0.035" (0.9mm). Parts with very thick walls, above 50mm, should have a higher gap in order to ensure proper performance.**





## Extra-Large Parts

When parts are larger than the maximum build size, we can work with you to print the parts in multiple pieces and then join them together. GoProto is happy to help with this process every step of the way.



### What can you do ?

It is recommended to design interlocking features, such as shown above, as a guide to position the parts and help them bond together.

## “Elephant Skin”

“Elephant Skin” is a phenomenon where the nylon material on a part shrinks and is cured unevenly resulting in surfaces that are uneven and “pocked”. Anything thicker than 0.8” can get “Elephant Skin”.



### What can you do ?

To decrease wall thickness, it is recommended to hollow out your parts or introduce internal lattice structures.

## Nylon PA12

PA 12 is a strong, multi-purpose thermoplastic for functional prototyping and final parts. It is optimized for the MJF platform to deliver high-density parts with balanced property profiles. It is ideal for complex assemblies, housings, enclosures and connectors, and optimal for post finishing processes. PA 12 also has excellent chemical resistance to oils, greases, aliphatic hydrocarbons and alkalis.

## Nylon PA12 with Glass Beads

Glass Beads are added to Nylon PA 12 to produce stiff, functional parts. This material provides dimensional stability along with repeatability. It is ideal for applications requiring high stiffness like enclosures and houses, fixtures and tooling.

## Nylon PA11

Nylon PA11 is a material with excellent performance characteristics that mitigates many of the negatives inherent to other materials. With excellent impact and chemical resistance and an eco-friendly and bio-friendly profile, here are six reasons to consider Nylon PA11 for your project.



### ECO-FRIENDLY

PA 11 is 100% bio-based, made from castor oil.



### CHEMICAL RESISTANCE

Excellent resistance to grease, hydrocarbons, acids, bases, and salts.



### IMPACT RESISTANCE

Excellent over a wide range of temperatures; With a Shore Hardness of 80 and a EAB of 50%.



### BIOCOMPATIBLE

Meets requirements of USP Class I - VI and US FDA guidance for Intact Skin Surface Devices.



### HEAT DEFLECTION TEMP

With a HDT of 350 F, it will maintain optimal mechanical properties even in extreme environments

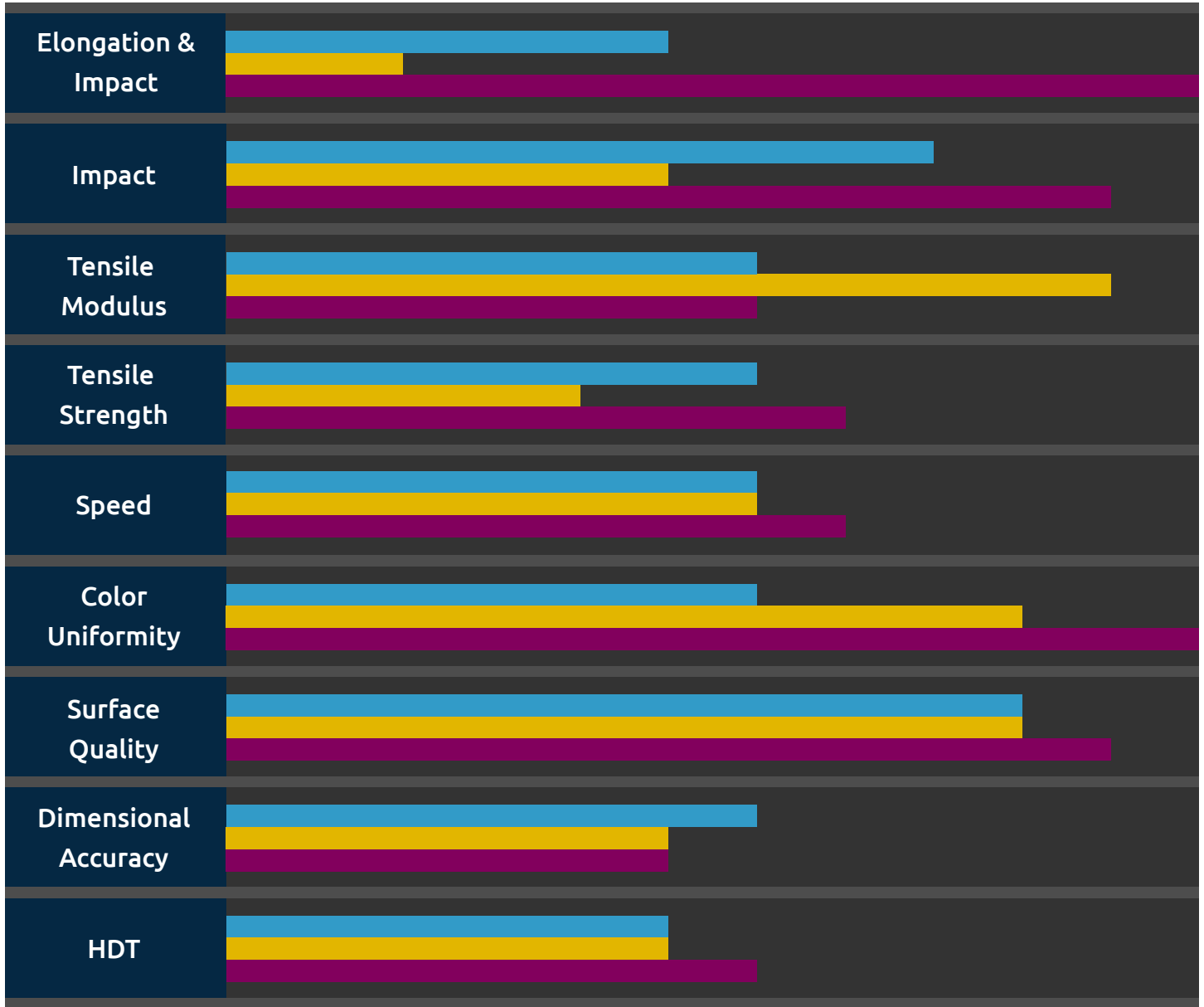


### STRONG & FLEXIBLE

Known for its optimal mechanical properties. Ideal for prostheses, insoles, sporting goods, and more.

## Which Nylon Should I Use ?

■ PA12 - Balanced    
 ■ PA12GB    
 ■ PA11 - Balanced



## TPU (Thermoplastic Polyurethane)

3D Printed elastomer parts can be used in place of traditionally molded rubber for just about any 3D printed application. And, now, with this specially optimized TPU elastomeric powder designed for HP's Multi Jet Fusion (MJF) technology, we can further accelerate the already fast processing times of MJF printers.

### TPU is valued by engineers for its...

- High Precision & Resolution
- Flexibility / High Elongation at Break
- Well- Balanced Strength Profile
- Good Shock Absorption
- High Wear and Chemical Resistance
- High Thermal Stability
- High Oil & Grease Resistance.

### Ideal Applications for 3D Printed TPU

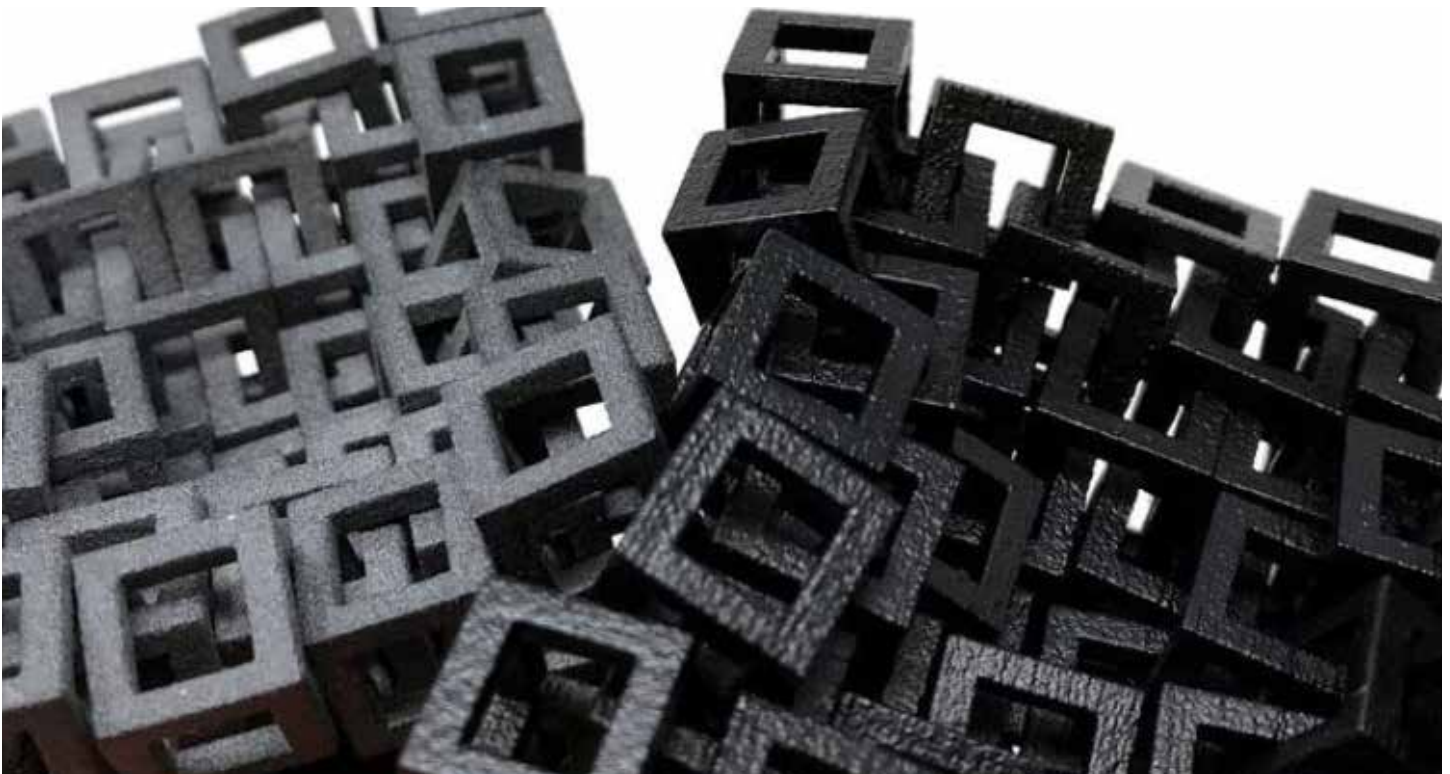
- Gaskets, Seals, Connectors & Hoses
- Lattice Design Structures
- Robotics
- Auto Instrument Panels / Shock Absorption
- Bellows & Ducting
- Isolation Dampers
- Harnesses & Fasteners
- Functional Prototypes
- Footwear & Sporting Goods
- Medical Components
- Machine Tool Arm End Effectors



## BLAST Vapor Smoothing

One of the most exciting secondary finishing techniques GoProto employs on our Multi Jet Fusion parts is BLAST Vapor Smoothing. This process uses the AMT PostPro3D smoothing machine to expose parts to a vaporized solvent gas, which reorders the surface molecules to smooth the part without dramatically affecting the dimensions ( it reduces the part dimensions by roughly .4%).

Not only does this process improve the surface finish of the parts, but tests have shown that the parts are also made more tough, elongation is improved, resistance to liquids is improved, and the part is sealed better, which provides for better surface adhesion for gasketing and suction and provides an excellent base for adding paint, Cerakote, hydrographics or clearcoat. For more details on these tests, please reach out to GoProto directly for the corresponding white paper.



*Above : BLAST Vapor Smoothing of MJF parts, before (sand blast only) and after (sand blasted, dyed and smoothed).*

## Dyeing, Painting, Clear-Coat

After printing, Multi Jet Fusion parts are a matte gray color with a light grain texture. The gray can be mottled from light to darker in color. To create an even appearance, these parts are often dyed black. This is done at an elevated temperature for a fixed period to bond the dye to the part. The parts are then rinsed and dried. GoProto can dye your parts with black dye, or other dark colors such as dark red, dark green and dark blue.

Multi Jet Fusion parts accept paint well. The light grain texture on the surface gives a mechanical bond to the primer that is applied to the parts. After primer the parts can be painted with a huge variety of colors and sheen levels from matte to gloss. However, it is important to note that gloss sheen will show the light grain texture on the printed parts.

To add durability to painted parts we often add clear coat as a final finishing coat. Clear coat can add different sheen, UV stability, impact and scratch resistance. Talk to us about what finishing steps are best for your parts.

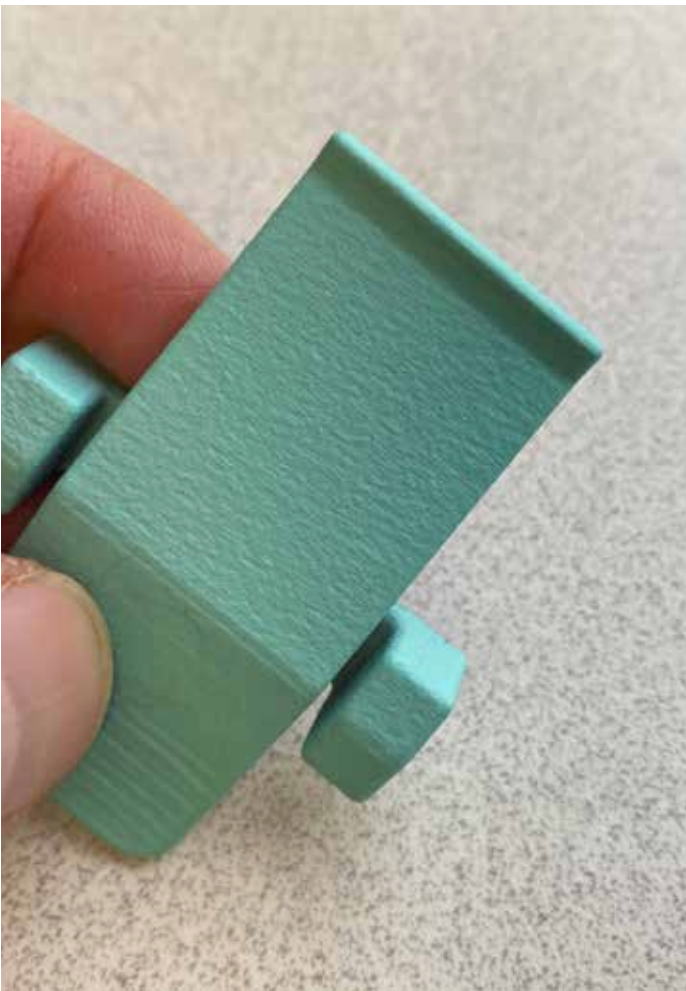


*Above : MJF parts dyed and painted various colors and sheens.*

## Cerakote

Cerakote is a name brand protective coating we apply to Multi Jet Fusion parts. It is applied as a paint which is then post-baked to cure the coating onto the parts. It is extremely durable, scratch resistant, chemical resistant, heat resistant, liquid resistant and UV resistant. It also is extremely thin at about .002".

It is possible to add a primer to the part prior to application of the Cerakote which fills in some surface roughness to give the parts a more even and "satin" appearance. Cerakote is applied while the parts are hung in commercial racks so the hanging of the parts may leave a cosmetic blemish. This requires consideration of where to hold onto the parts to minimize this effect while giving maximum line of site to the features of the part so the Cerakote can reach all surfaces.



## Metalization

Multi Jet Fusion parts are durable enough to be able to be plated with metal finishes. GoProto employs two types of metalization.

The first is cosmetic “metal” which is chrome finish to make the parts shiny and reflective. This process involves spray application of a chrome effect metal finish that is applied like paint. It’s line of site and can be masked to leave areas unfinished for assembly or fit reasons. The chrome is as durable as standard paint. This process requires extensive finishing of the MJF part to make it as smooth as possible prior to applying the finish. Design considerations with the chrome finish are very similar to paint in that not all surfaces can be reached completely if they are deep pockets, back sides of parts or undercut. The surface finish of MJF has a light texture inherent in the process. Smoothing surfaces completely is not possible, so it is critical to work with our shop to specify the cosmetic surfaces required to be highly cosmetic.

The second is functional metal which is done with electroplating. MJF electroplates very well by using copper and nickel. Plating MJF parts can make them very effective EMI/RFI shields, conductive pieces or very stiff mechanical parts. The process is not intended for highly cosmetic chrome effects. It is a functional plating meant to make the parts conductive, so they are functional for your application. Like other coating processes the parts must be held while the finish is applied. This results in visible blemish areas on the parts, so it is critical to work with our team to specify where it is acceptable to locate these blemishes on the parts.



*Left & Center : Chromed MJF parts*

*Right : Electroplated MJF part.*



## Hydrographics

Hydrographics are a cosmetic finish we apply to Multi Jet Fusion parts using graphics that are printed on a soluble sheet substrate. When the sheet is placed in water, and activator is applied, the substrate dissolves and the graphics are left on the surface of the water. The MJF part is dipped through the graphics which transfer them onto the part in a “wrap” fashion.

The graphic is relatively durable, but can be further improved by a clear topcoat that can be either glossy or matte. There is a huge range of graphics available including wood grains, carbon fiber, diamond plate, camo, metallic, leather, etc. Hydrographics add very minimal thickness, with the clear topcoat adding just 0.005”.

Careful consideration needs to be taken to avoid a “stretching” effect with grained patterns such as carbon fiber, leather or even wood grain. Also, the graphic film may not reach some pocket or “deep draw” features since the graphic becomes too thin as it stretches. However, we at GoProto have utilized this technique extensively on MJF parts and are happy to help determine the best hydrographic for your specific design.



# Let's Get This Done

GoProto is a full-service manufacturing partner, with a focus on customer service across the country. We are organized unlike any other rapid manufacturing solutions provider, with dedicated work groups in territories across the US. Each territory is staffed with an expert Business Development Manager living and working in that region, matched up with dedicated project manager experts to offer consistent and amazing service from initial consultation through production. People matter, relationships matter, and consistent expertise is critical to help you achieve your goals of speed, cost-effectiveness and the best possible process to meet your project needs.

**We know you like to win. We do too. We'll work together to make "it" happen**

## ON-SITE TRAINING

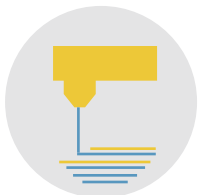
GoProto will gladly come on site for training and presentation via lunch and learns.

## DESIGN HELP SERVICES

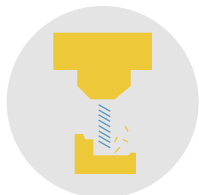
Looking for DFMA (Design for Manufacture and Assembly) guidance? We can help to ensure this process is smooth.

## WE'RE FAST AND GOOD

We understand that time is priceless and will never sacrifice our commitment to superior quality in the production of your parts.



**Additive  
Manufacturing**



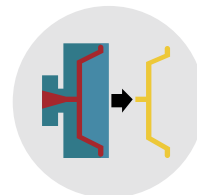
**CNC  
Machining**



**Sheet  
Metal**



**Cast  
Urethane**



**Injection  
Molding**



**Finishing**

Go to **[www.GoProto.com/GoQuote](http://www.GoProto.com/GoQuote)** to quote and order today!



[www.GoProto.com](http://www.GoProto.com)

1-888-GoProto (467-7686) | [quotes@GoProto.com](mailto:quotes@GoProto.com)