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Comparing Five Industrial 3D-Printing Methods: MJF, SLS, FDM, SLA, and DLS

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Learning Objectives

- Discover unique industrial 3D printing processes and how they work.
- Learn cost drivers per process, as well as limitations.
- Discover printer "sweet spots" based on material and application.
- Discover decision factors when choosing a 3D-printing process for your project.

Description

Join Xometry's Greg Paulsen for an in-depth comparison between five major, plastic 3D printing processes. In this talk, you will learn what makes them unique, how they are used, and what to consider when choosing an additive manufacturing process. Paulsen will discuss the following industrial 3D printing methods: HP Multi Jet Fusion (MJF); selective laser sintering (SLS); fused deposition modeling (FDM); stereolithography (SLA); and carbon digital light synthesis (DLS). Whether it's cost concerns, mechanical function, performance environment, cosmetics, or output, this topic will help steer the design approach for end-use 3D-printed parts. The presentation will conclude with an open question-and-answer session

Speaker

Greg Paulsen leads the Applications Engineering team a Xometry, which handles special case projects that require attention on material selection, design-for-manufacturing, or technical engineering resources. He has used his experience to create content and educate engineers about advanced manufacturing, 3D printing, design, and quality assurance. Greg plays a vital role in vetting new technologies and materials to add to Xometry's manufacturing portfolio.

Why can Xometry talk about all these 3D printing processes?

Xometry is and on-demand manufacturing marketplace. We have partnered with over 5,000 professional manufacturers to provide 3D printing, CNC machining, sheet metal, urethane casting, and injection molding services. Xometry provides instant pricing and lead times with the upload of a 3D model and pairs work with the best supplier to hit quality, scope, and lead time.

On-demand Access to Massive Global Network   Instant Quoting & Fully Digital RFQ Process   Security, Certifications, & Quality Guaranteed

We make a TON of parts at Xometry

Xometry has an intuitive interface for configuring a manufacturing quote, allowing you to choose from over a dozen different manufacturing processes. We can run multiple parts per order, and thousands of orders in parallel without capacity issues by using our network.

Some of Xometry's services are:
- Additive: SLS, FDM, PolyJet, SLA, Carbon DLS, DMLS, HP MJF, and more.
- Subtractive: 3+ Axis Milling, Turning, EDM, Sheet Metal, and more.
- Injection Molding and Casting
- Light Assemblies and Weldments
- Full Supply Chain Service
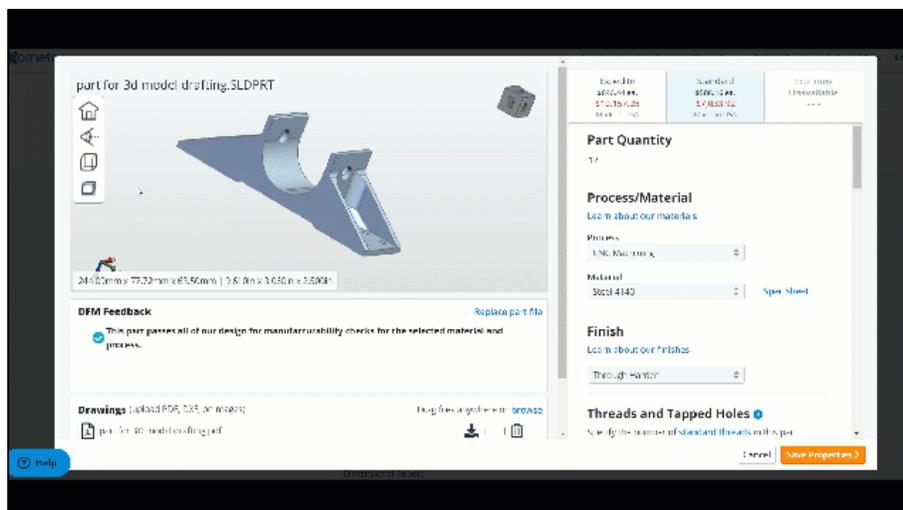
XOMETRY'S INSTANT QUOTING ENGINE LETS YOU SEE PRICING UPDATES IN REAL TIME AS YOU CHANGE PROCESSES, MATERIALS, FEATURES, FINISHES, AND INSPECTION REQUIREMENTS.

Common Themes in 3D Printing (Additive Manufacturing)

Each 3D printing process has its own unique way of making a part. However, there are some common considerations to be aware of regardless of the platform.

3D printers dictate the tolerances, not the print

- 3D printers always create a NET SHAPE of the 3D design provided.
- Each 3D printing platform has its own global tolerances and considerations. Examples of this can be found on Xometry's manufacturing standards page.
- Offsets of the 3D model may be necessary to hit tighter tolerances. This could require multiple prints depending on the requirement.

3D printing is powerful for prototyping

- 3D printing is typically faster and cheaper than traditional manufacturing routes for one-offs or low volume manufacturing.

3D printing is best used when purpose-designed

- Look for function, not cosmetics, when designing for 3D printing as an end-use production method.
- Historically, the "prettier" the parts, the less mechanical strength. For example, SLA may produce parts with a very smooth cosmetic finish, but may not be as durable or strong as parts made in SLS.

Size and detail limitations vary per platform

- Each process has its ownplatform size, detail resolution, and tolerances.
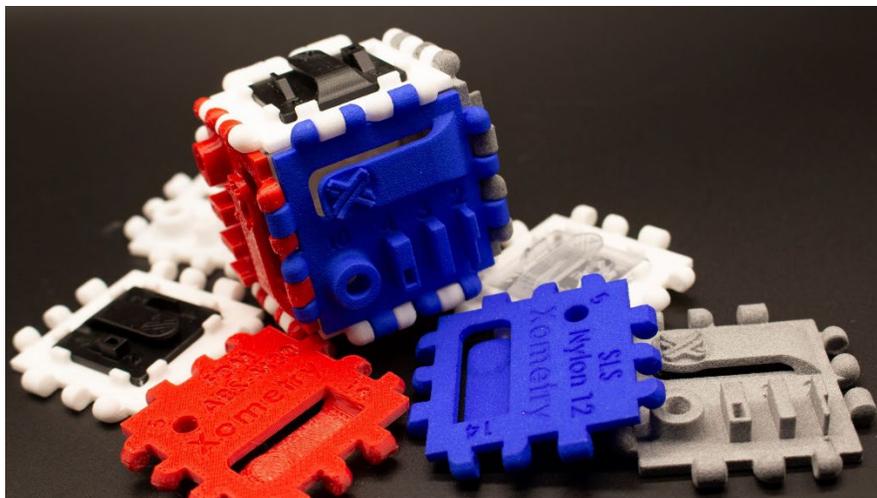
FIVE DIFFERENT 3D PRINTED PROCESSES AND SIX MATERIALS ARE REPRESENTED IN THIS IMAGE (XOMETRY SAMPLE CUBE)

Supplemental: The Complete Guide to 3D Printing.

Powder Bed Fusion: Selective Laser Sintering (SLS)
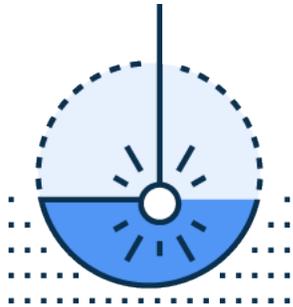
The Basics Of Selective Laser Sintering

Selective laser sintering (SLS) is a powder bed 3D printing technology that produces highly accurate and durable parts capable of being used directly in end-use, low-volume production. SLS is a newer 3D printing process that is often thought of as a cousin to the popular metal 3D printing technology direct metal laser sintering (DMLS). Both processes work by utilizing a laser to precisely fuse a bed of powder to construct a part from a 3D CAD file. SLS specializes in nylon or polyamide powder particles to create parts, while DMLS uses metal particles, and is extremely common for prototyping and low volume production.

Benefits of SLS 3D Printing

Since SLS doesn't require a support structure like most other 3D printing tech, parts can be made in greater quantities, but with less labor and material expense. Additionally, because the support structure doesn't need to be removed, there is less risk of damage to the complex internal geometries 3D manufacturing is capable of producing.
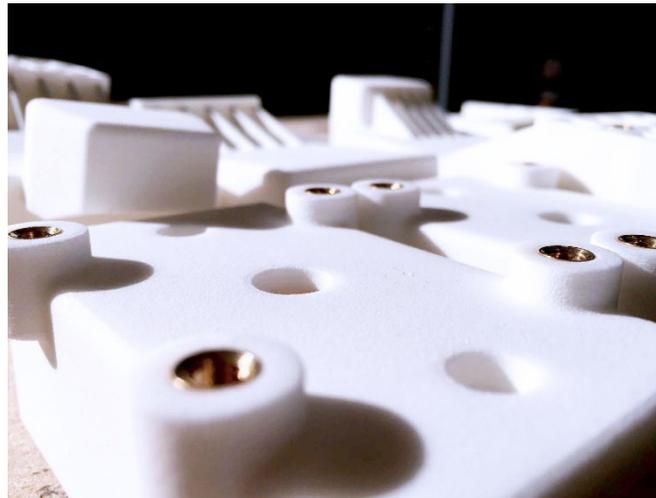

SLS NYLON PARTS WITH INSTALLED BRASS INSERTS

SLS can be useful for both rapid prototyping or low volume production of functional end-use parts. Nylon, especially, is a durable material with great impact strength, medium flexibility, and high resistance to environmental factors. SLS nylon material is also FDA approved USP Class VI/121C certified for skin contact. This combination of complexity, design flexibility, material diversity, rapid turnaround, and overall durability makes SLS an increasingly popular choice in many industries.

Powder Bed Fusion: HP Multi Jet Fusion (MJF)
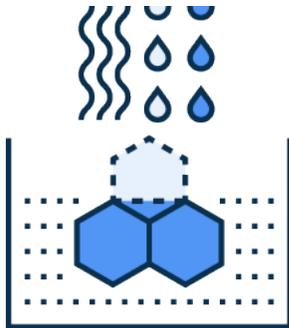
The Basics of HP MJF

[HP Multi Jet Fusion](#) is a powerful 3D printing technology that produces highly accurate and durable parts that are capable of being used directly in end-use, low-volume production, or for rapid prototyping. Since the process uses well-established 2D printing ink-jetting, it has remarkably fast layer times compared to other powder bed fusion technologies such as SLS.

Like all powder-based 3D printing processes, HP Multi Jet Fusion builds parts layer by layer, using a fusing agent and heat to set each layer before moving onto the next. In the more traditional 3D printing processes — such as SLS, FDM, or SLA — each part is imaged, layer by layer, with a single laser beam. HP's Multi Jet Fusion works a bit more like a traditional ink-jet printer with a printhead that deposits the material, and then a fusing agent, across the entire build plate in one pass, allowing for the printing of multiple parts simultaneously.

Benefits of HP MJF 3D Printing

While there are many benefits to HP Multi Jet Fusion, a few truly stand out. For starters, the standard build parameters are optimized for best density. The result is that Multi Jet Fusion parts are watertight.

HP MJF PARTS IN NATURAL (GRAY) AND DYED BLACK

If you like SLS but want to produce higher quantities for small-batch production runs, Multi Jet Fusion is the way to go. The ability to print multiple parts simultaneously across the entire build volume means you can print parts at rates up to 10X faster than SLS or other 3D printing processes. Also, Multi Jet Fusion delivers more balanced mechanical properties across the X, Y, and Z axes compared to SLS.

Comparing SLS and HP MJF

Strengths and Considerations

Common Strengths
- Freeform design (no supports)
- Scalable
- Versatile material
- Fast
- Cheap

Common Considerations
- Few material choices (mostly nylon/PA base)
- Few color choices
- Matte surface finish
- Can warp in large, broad parts or features
- Limited post processing

Choosing SLS or MJF

Part Size?
- Parts typically the size of your fist or smaller are viable for volume production.
- SLS can typically handle larger parts than HP MJF platforms

Color?
- SLS is in a white natural state, and can be dyed to different solid pigments.
- MJF parts are gray on the exterior and scratch black (black interior)
- MJF color is becoming more available but does not have the same mechanical properties as the gray MJF.

Throughput?
- Each build process can be interpreted as "overnight" so in few quantities both SLS and MJF are comparable.
- MJF has slightly faster turn around in both total build speed and post processing. This can save days or weeks in production.
- Pro tip: Get accurate lead time and pricing comparisons using Xometry's Instant Quote.

Material Choices?
- SLS has more characterized materials choices. This includes robust datasheets and historic use cases.
- MJF materials are quickly catching up using the historic success of SLS, but still may require more vetting for use in stringent applications.

Material Deposition: Fused Deposition Modeling (FDM)
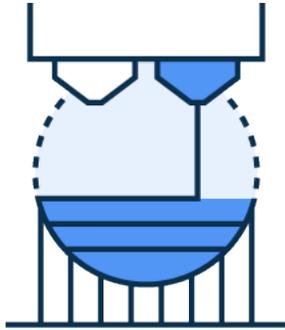
The Basics of FDM

Fused Deposition Modeling (FDM) is a 3D printing technology widely known for its speed, accuracy, and competitive cost. An FDM machine precisely extrudes melted plastic filament to create a part. FDM parts can be made in as fast as one day.

Xometry's Fused Deposition Modeling 3D printing service offers large build volumes up to 24″ x 36″ x 36″ on Stratasys Fortus platforms. FDM offers the largest variety of colors and selection of production-grade thermoplastics of any 3D printing process. Material range from general-purpose ABS or ASA to high performing polycarbonate and heat resistant ULTEM.

With Fused Deposition Modeling, a spool of the chosen feedstock is introduced to a typical fused deposition modeling system via an extruder, which regulates the feed movement of the polymer to the heater where it melts. This molten polymer is extruded through a nozzle and deposited onto the print bed, also known as the build platform. The extruder, heater, and nozzle are all contained in a printhead which is attached to a gantry above the flat build platform. This is designed to offer relatively high freedom of motion in the X and Y axes as the material is deposited.

Benefits of FDM 3D Printing

used deposition modeling (FDM) is among the most easily accessible and recognizable additive manufacturing technologies worldwide. Available to both 3D printing hobbyists and large-volume manufacturers alike, it is known for its speed and precision in generating three-dimensional polymeric structures using a choice of feedstock materials. FDM can have an adjusted infill to the part interior, creating lightweight and strong parts.

FDM JIGS USED IN VEHICLE ASSEMBLY OPERATIONS MADE WITH BLUE ABS

FDM is a cost-effective additive manufacturing process, especially for rapid prototyping or low-volume production. Since FDM prints require little post-processing and use more readily available materials, leads times from quote to print and delivery are fast.

Vat Photopolymerization: Stereolithography (SLA)
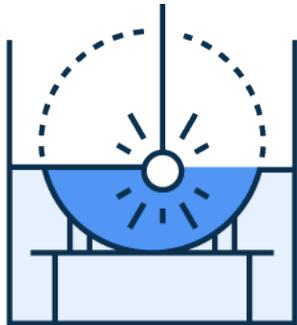
The Basics of SLA

Stereolithography (SLA) is a powerful 3D printing technology that produces extremely accurate and high-resolution parts that are capable of being used directly in end-use, low-volume production, or for rapid prototyping. Xometry offers over 15 uniquely engineered SLA materials that can enable products to be brought to the market.

SLA is an additive manufacturing process that uses ultraviolet (UV) light on a vat of liquid photopolymer resin to selectively solidify part features, building the part layer by layer. The UV light continues this process through the entire vat of resin, selectively curing and solidifying the resin to match the design of the CAD file. Structural supports are created during the pre-build setup process and manually removed after the print is completed. The parts are then washed in a solvent solution to remove uncured resin, and then receive a final post-cure in a UV light oven.

SLA offers higher resolution printing than many other 3D printing technologies, allowing customers to print parts with fine details and surface finishes. SLA 3D printing is a highly-versatile platform for making custom parts in prototype and production settings, often acting as a stand-in for injection molded parts.

SLA PARTS HAVE SMOOTH SURFACE FINISHES AND HAVE AVARIETY OF RESINS WITH DIFFERENT PROPERTIES

Benefits of SLA

SLA is a go-to choice for 3D printed models that require accurate features and a smooth surface finish. Xometry offers both standard and high-resolution options for fine detail parts, and can also print larger sized parts and products, offering up to a 29" inch build area. With the ability to produce complex features with good mechanical properties, SLA 3D prints are often used for final fit checks before moving to injection molding services.

Vat Photopolymerization: Carbon Digital Light Synthesis™ (DLS™)
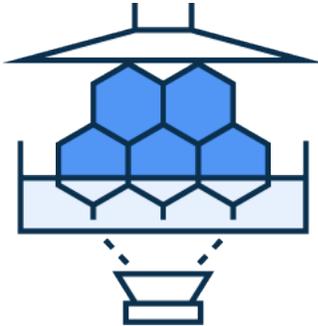
The Basics of DLS™

Carbon uses digital light projection, oxygen-permeable optics, and programmable liquid resins to produce products with end-use durability, resolution, and surface finish. This 3D printing technology is called *Digital Light Synthesis™*, or DLS for short. Another legacy term for the process is *Continuous Liquid Interface Production* (CLIP). Along with Carbon's custom liquid resins, DLS unlocks new business opportunities and product designs previously impossible, including mass customization and on-demand inventory of end-use products.

Carbon bridges, and sometimes substitutes, for processes like Urethane Casting and Injection Molding service production, because the materials are urethane-based or epoxy-based, giving excellent mechanical properties. There are even elastomer and silicone resins that outperform most additive manufactured rubber-like materials.

Benefits of DLS™

What differentiates Carbon from similar processes like Stereolithography (SLA) or PolyJet 3D prints is that the resin has a secondary thermal step which activates dormant epoxies or urethanes, making parts much stronger than UV-curing alone. Additionally, the DLS process is continuous, without stopping layer-by-layer as with most additive manufacturing. This gives the parts isotropic properties, meaning that strength is even regardless of orientation. This is a significant advantage over processes like Fused Deposition Modeling (FDM), where Z-direction features can be much weaker than similar features built in the XY-direction.

CE 221 IS AN AMBER DLS MATERIAL WITH A VERY HIGH TEMPERATURE RESISTANCE

Recap: 5 3D Printing Methods: SLS, MJF, FDM, SLA, and DLS

MJF and SLS

- The 90% tool - getting you a general purpose, useful outcome

- Cheap and scalable

- No supports = most design freedom

- MJF may price slightly better than SLS in quantity

- SLS materials are characterized well due to decades of use, but MJF is catching up!

FDM

- Higher variety of real thermoplastics

- Great for bulkier designs--think designing for machining

- Big or broad parts

SLA

- Smoothest surface finish of all processes

- Great detail resolution

- Parts are not as durable as SLS, FDM, or DLS

- Clear parts are available with light post processing

DLS

- Awesome material properties + surface finish balance

- Good for rigid and elastomers

- Small build is best for narrow parts under 3"

- High setup favors minimum lot sizes

- Great sub for urethane casting on smaller parts

Resources at Xometry

Follow the links below to learn more

- [Instant online pricing and lead times](#)

- [8 industrial 3D printing processes](#)

- [CNC machining](#)

- [Sheet metal](#)

- [Urethane Casting](#)

- [Injection Molding](#)

- [Free Design Guides](#)

- [Webinars and Engineering Challenge Videos](#)

- [Chat with an engineer](#)

THANK YOU!

Let's keep the conversation going!

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