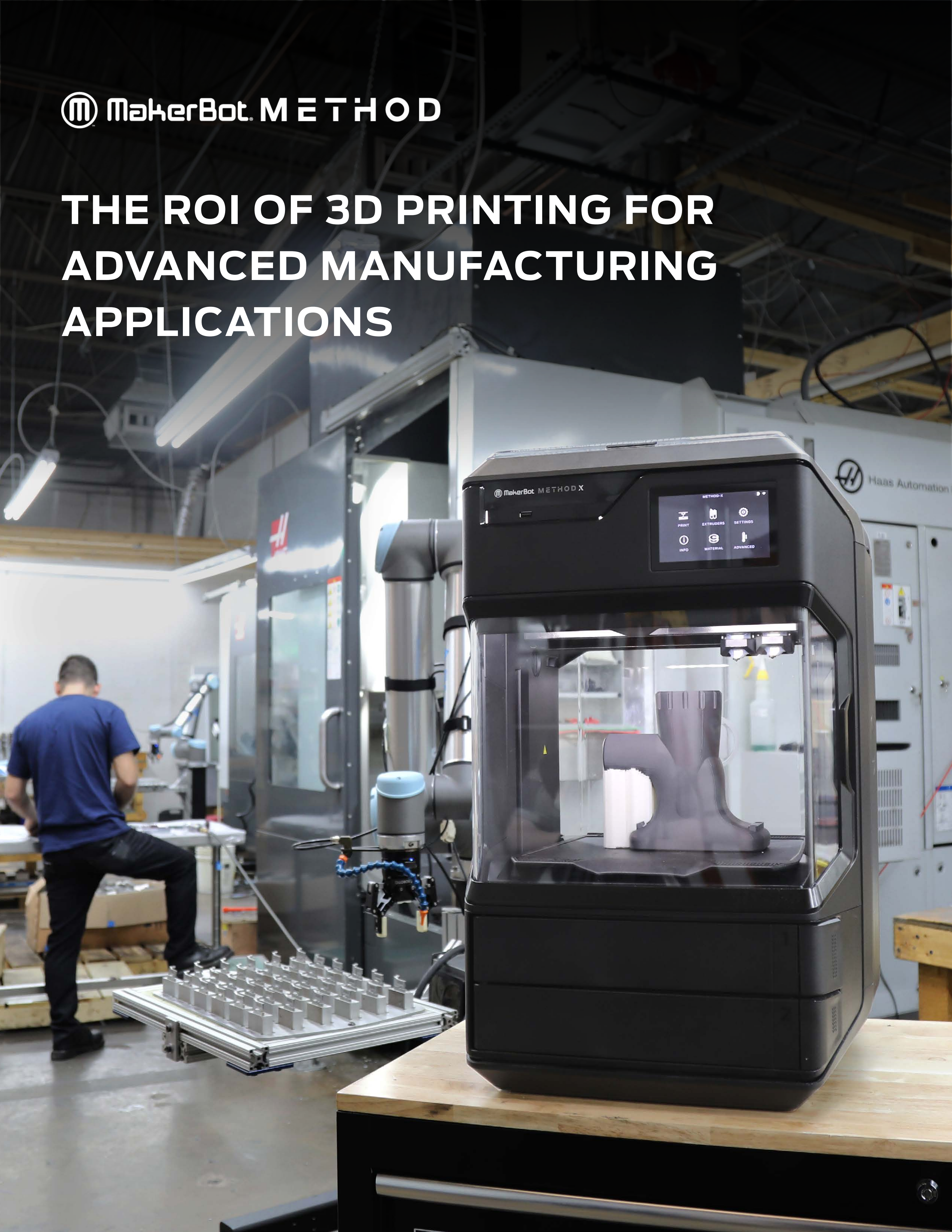
MakerBot METHOD

THE ROI OF 3D PRINTING FOR ADVANCED MANUFACTURING APPLICATIONS



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INTRODUCTION

Product designers, engineers, and manufacturing professionals are no longer limited by 3D printers that are too big, unsuitable, and cost-prohibitive for an office environment.

Today, affordable, office-friendly desktop 3D printing machines are enabling design and manufacturing professionals to create on-demand, high-quality prototypes, manufacturing tools, and end-use parts—be it in the office or on the factory floor.

Desktop 3D printers have become highly attractive to many of these professionals because of their low cost to purchase and run when compared to other technologies such as injection molding or CNC machining.

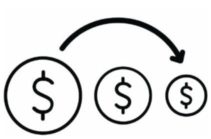
The reliability and ease of use of a high-quality professional 3D printer saves businesses money by maximizing uptime and yielding higher print success rates, while being easy to use reduces the time spent in operation, maintenance, and training.

Before investing in a 3D printer, it is important to calculate the costs involved as well as answer certain key questions:

- How does desktop 3D printing compare to your current costs?
- How many 3D printers do you need?
- How long before savings bring a complete return on investment?
- Besides the cost of the machine, are their additional costs such as installation and training?
- Aside from the machine, what accessories and tools are required to create final parts?
- What are the maintenance needs and costs of the machine within the normal range of activity? How does it change if production levels rise?

Let's take a deeper look at how to calculate these costs and potential savings, as well as a case study of one business that turned from outsourcing their 3D prints to relying on cost-effective desktop 3D printing for turning their designs into reality - in days, not weeks - and creating parts that are reliable and can withstand extreme weather conditions.

REASONS TO INVEST IN 3D PRINTERS



1 COST SAVINGS

Choosing to buy your own in-house 3D printers requires careful analysis and comparison of the costs involved. For instance, if you require 3D printing only occasionally outsourcing is recommended. You pay a single price for the service and without the need for an upfront investment, the costs are regular and predictable. With in-house 3D printing, factors such as labor and running costs must be taken into account.

However, the main downsides of outsourcing are cost and lead time. Outsourced parts can take multiple days or even weeks to arrive. When your production demands for 3D printing grow, outsourcing quickly becomes expensive.

When you need parts quickly and depending on the number of parts and printing volume, an investment in desktop 3D printers can reach the break-even point within months.

A desktop FDM (Fused Deposition Modeling) 3D printer is an especially economical option when compared to other solutions and technologies like selective laser sintering (SLS) or a large industrial printer. And the software for controlling the printer is often free of charge.

FDM does not require any special facilities, tools, or accessories which keeps installation costs to a minimum. It is a clean, quiet process where the machine can be placed at the end of a desk or grouped together in a workspace.

With desktop machines you pay for the capacity your business needs and scale production by adding extra units as demand grows without needing to make a significant investment in a large-format 3D printer. Using multiple 3D printers, you also get the flexibility to print parts in different materials simultaneously.

2 QUALITY

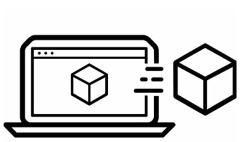
Another thing to consider is how well desktop 3D printing works as a prototyping or manufacturing solution. Will it do what you need it do?

You must look at what materials 3D printers are compatible with and the quality of the parts they produce.

Both of these factors vary widely depending on the machine. A high-quality, professional 3D printer should work with a wide range of materials with different properties such as strength, flexibility, heat or chemical resistance.

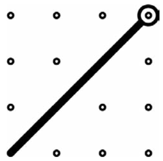
Professional-grade 3D printers can provide accuracy and part strength suitable for such applications as visual prototyping, functional prototyping, manufacturing aids, and other end-use parts.

Printer specifications should be compared and it is also a good idea to look at customer case studies from 3D printer manufacturers to see if their customers are able to achieve the kind of results you need.



3 AVAILABILITY

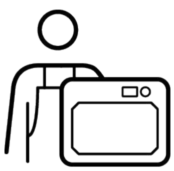
Another benefit of an in-house 3D printer is that it is always available for on-demand production. Creating customized jigs, fixtures, or parts reduces ordering costs in a manufacturing facility while on-demand in-house production reduces the need for maintaining a large inventory, eliminating storage costs.



4 EFFICIENCY

In-house 3D printing's biggest benefit for businesses is its speed and efficiency in the design process. There is no need for the waiting involved when design iterations are outsourced and delivered. Instead, designers see the latest version of their product in hours, not days or weeks, allowing more iterations in a shorter span of time.

This all results in a competitive edge for your business, because of less costly product development, a refined design, and faster time to market.



5 TRAINING

A professional-grade 3D printer presents a relatively simple user experience. 3D designs are easily sent to the printer, possibly with a few minor adjustments using the print preparation software for your machine.

No specialized operator is required. Generally, designers who are proficient with 3D modeling software can develop 3D printing models with no problem. Therefore, the investment in user training is minimal and sometimes not necessary at all.

CALCULATING ROI

1 COST PER PART

The first thing to keep in mind when comparing the investment in 3D printers to outsourcing is calculating the cost per part. With outsourcing you simply need to determine your average cost per outsourced part.

For in-house 3D printing calculating the cost per part involves accounting for the costs of equipment ownership, materials, and labor.

2 EQUIPMENT OWNERSHIP

costs are comprised of the investment in machines, service contracts, installation, and maintenance. These fixed costs are incurred regardless of whether a machine is idle or produces dozens of parts per week.

Another point to think about is how many 3D printers you need to invest in. A typical FDM 3D printer can handle one to two print jobs per day, based on the average needs of a professional user. Your print times may be shorter or longer depending on whether you are printing very small objects or large parts that take up most of the printer's build area. Smaller parts can be printed together in one job.

If you are printing more than 10 parts per week, you may need multiple printers to meet capacity. Of course, the initial investment will be higher, but with efficient management multiple printers will greatly increase capacity and throughput.

Add up all of the forecasted fixed costs of equipment ownership over the lifetime of the machine and divide by the total number of parts it is expected to produce. The higher the productivity and utilization of the machine the lower the equipment ownership cost on a per-part basis.

3 MATERIAL COSTS

are dependent on the number of parts being produced. It is measured by first clarifying the exact materials needed to create the parts, then calculating the amount of material required to produce a single part and multiplying by the cost of the material. Waste should be figured in as well.

4 LABOR COSTS

with desktop 3D printers are much less than with traditional manufacturing methods where regular maintenance or changing materials require a skilled operator. Desktop 3D printer labor costs mainly involve post-processing workflows such as cleaning parts and removing supports or excess material.

Below is an example of savings of in-house 3D printing compared to outsourcing. Hardware cost is one MakerBot METHOD, excluding tax.

UPFRONT COSTS	IN-HOUSE 3D PRINTING	OUTSOURCED 3D PRINTING
Hardware & software	$4,999	$0
Training (optional)	$0	$0
PER-PRINT COSTS		
Cost per print (average)	$10	$200
20 prints	$5,199	$4,000
50 prints	$5,499	$10,000
80 prints	$5,799	$16,000

CONSIDERATIONS BEYOND DIRECT COSTS

Investment, materials, and labor costs are relatively straightforward to calculate. You also need to consider indirect costs and factors that are harder to quantify but still affect your business.

1 TIME SAVINGS:

3D printing simplifies traditional prototyping and production workflows allowing you to bring products to market months faster or cut lead time for your products by days and weeks. You save time and outpace the competition.

2 BETTER RESULTS:

3D printing allows you to create more iterations and find what works and what does not faster, achieving better end products. Finding and fixing design flaws early in the process helps avoid costly design revisions and tooling changes in production.

3 COMMUNICATION:

High-quality prototypes and parts allow you to better communicate with clients, suppliers, and other stakeholders, avoiding confusion and costly mistakes.

4 IP PROTECTION:

If you work with sensitive information, creating parts in-house means you do not have to give away intellectual property (IP) to third parties, reducing the risks of leaks or IP theft.

Comparison of Additive and Subtractive Manufacturing Processes

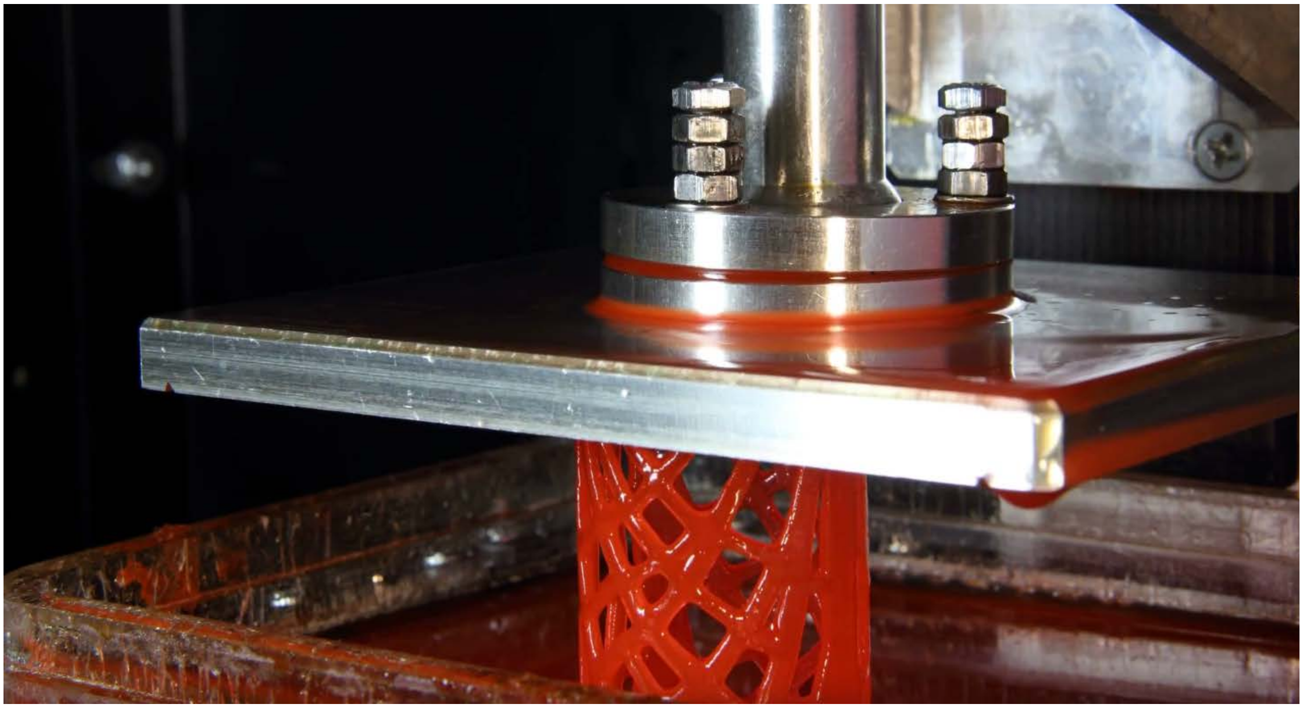
FDM (FUSED DEPOSITION MODELING)

Material filament is fed through the printer's nozzle onto the build plate, building up the object layer by layer.

COST ADVANTAGES:	COST DISADVANTAGES:
• Desktop FDM printers are affordable compared to other 3D printer types • They are a scalable solution because of the affordable hardware costs • They offer a wide variety of low-cost materials • They require minimal post-processing of prints compared to other types of 3D printers	• Manual post-processing is sometimes needed, such as removing supports from certain types of prints • Not every printer manufacturer offers an open filament system, resulting in having to use that manufacturers proprietary materials

SLA (STEREOLITHOGRAPHY)

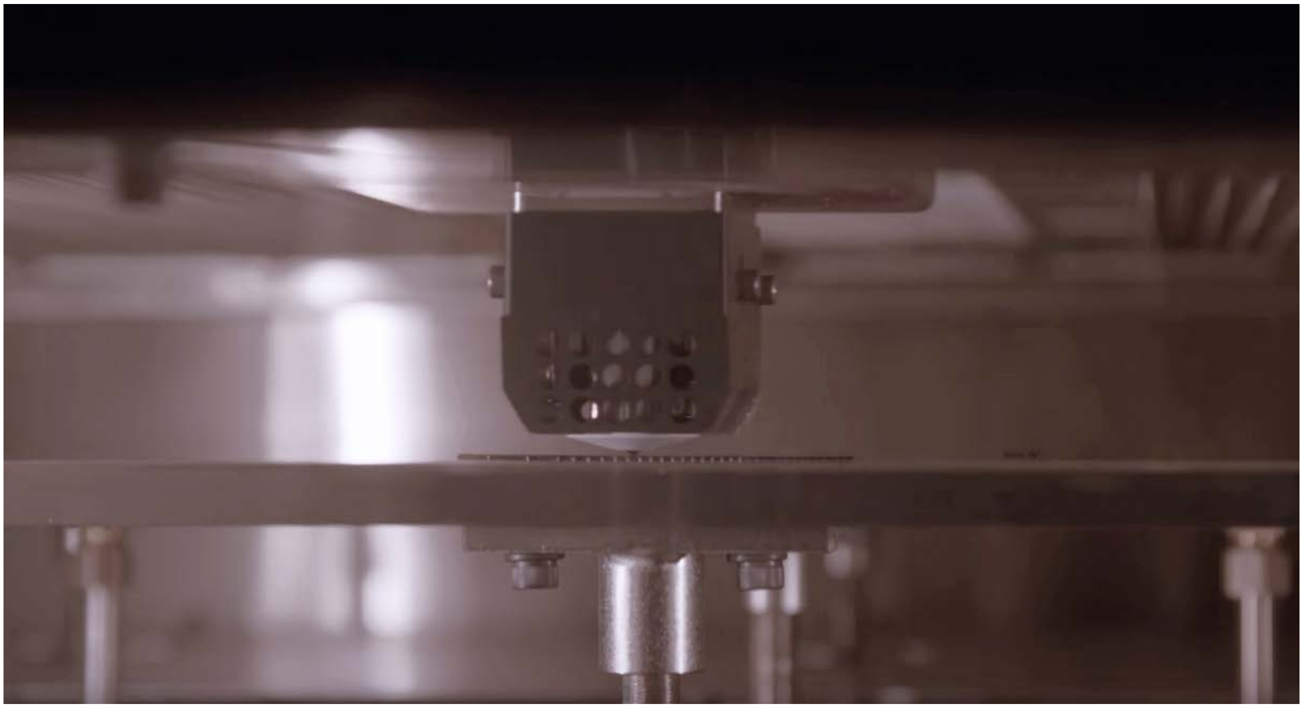
Photopolymer is selectively cured by a laser, building up an object layer by layer.



COST ADVANTAGES:	COST DISADVANTAGES:
• Desktop SLA printers are affordable compared to other 3D printer types • They are a scalable solution because of the affordable hardware costs	• Materials are more expensive and have a shorter shelf life than FDM filament • They require buying and storing several consumables such as pigments, resin tanks, build platforms, and cleaning fluid which all need replacing regularly • Time-consuming, manual post-processing such as washing, curing, and support removal is needed for every print • Lower throughput capacity because of small build volume on desktop machines

SLS (SELECTIVE LASER SINTERING)

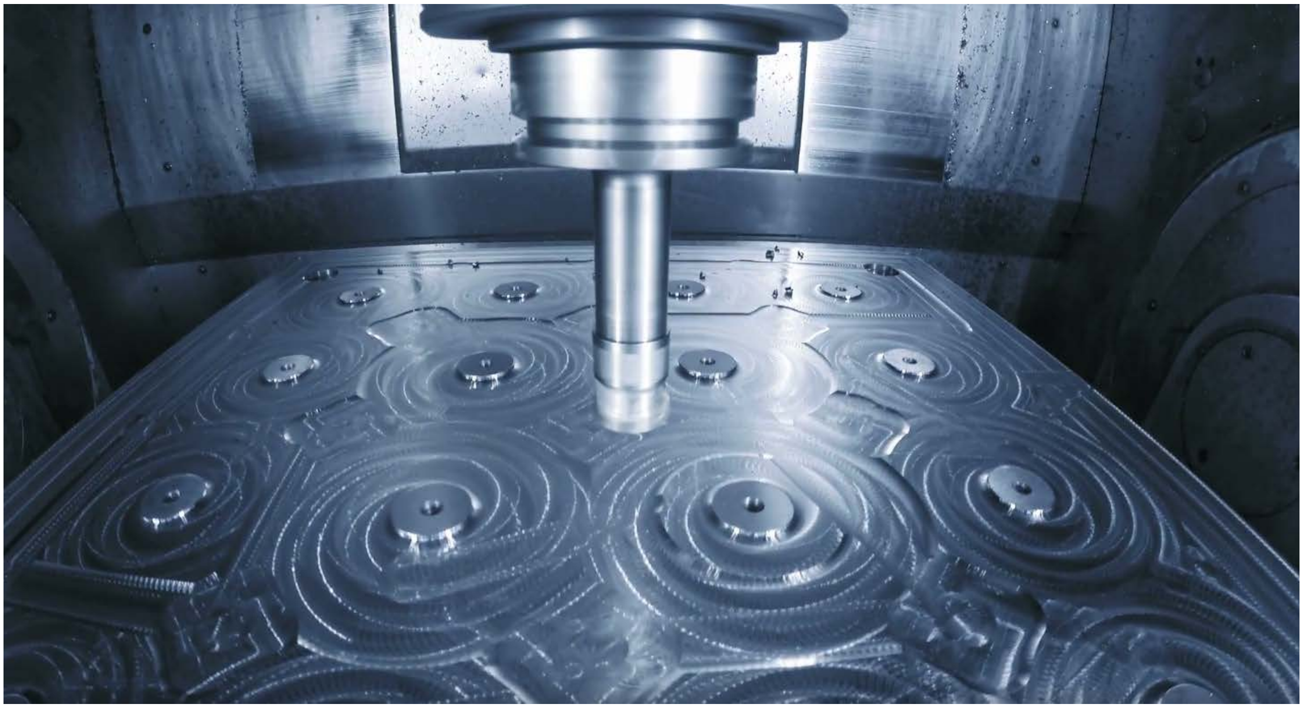
Powder particles are fused together by a heat source, forming a solid object layer by layer.



COST ADVANTAGES:	COST DISADVANTAGES:
• Cost effective when the build chamber is densely packed with parts • Support material is not needed	• When build chamber is not densely packed SLS is not economical and waiting to fill the chamber results in long lead times • Hardware is more expensive than FDM or SLA and requires more space • Needs post-processing and powder recycling stations, adding extra costs

CNC (COMPUTER NUMERICAL CONTROL)

involves a computer-controlled machine cutting away from a block of material.



COST ADVANTAGES:	COST DISADVANTAGES:
• Offers a variety of materials and surface finishes and is therefore versatile • If high precision and repeatability are needed this is an efficient option	• High initial investment, CNC machines cost tens of thousands of dollars - or more • Machine setup and axis reorientation are time-consuming • Because machinery is complex, it requires training and a dedicated operator • Because it is a subtractive process, a large amount of material is cut away and wasted

INJECTION MOLDING

Molten material is fed into a mold, setting in the shape of the required part.

COST ADVANTAGES:	COST DISADVANTAGES:
• After initial setup, process is highly automated • Fast production times • Cost effective for high-volume production runs	• Complex equipment requires very high capital investment • Tooling needed for each production run results in high setup costs • Not cost effective for low-volume production runs

USER APPLICATIONS

The New Performance Standard

1 **PNEUMATIC PUMP**
Functional Prototypes

2 **EOA ROBOTIC SANDER**
Manufacturing Tools

3 **ELECTRONICS HOUSING**
End-Use Parts

The quality of additive manufacturing systems used to be measured primarily on resolution (layer height) and surface quality—both of which factored into the finished appearance of cosmetic models.

As modern business needs have pivoted towards more demanding functional applications, additive systems that produce printed parts with accuracy—and can do so repeatedly—are becoming the new performance standard for design and manufacturing engineers.

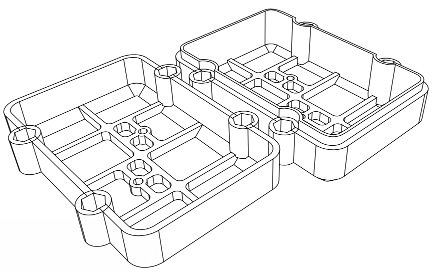
Understanding the value of dimensional accuracy and industrial reliability over resolution is key when it comes to choosing the right 3D printer for your business needs—particularly as time to market has become a new benchmark of business success. Without total printer ecosystem control, achieving accuracy and repeatability with ABS prints is near impossible.

MAKERBOT REAL ABS USER APPLICATION

End-Use Parts

EXAMPLE: ELECTRONICS HOUSING

3D printed end-use parts are typically used for low-volume production runs and custom parts, such as internal components of electronics devices. 3D printing these plastic parts provides greater design freedom than traditional manufacturing process while saving time and money.



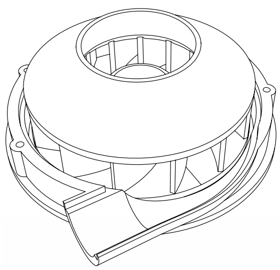
Material	Supports	Print Time
ABS	**SR-30**	**12h 30m**

MAKERBOT REAL ABS USER APPLICATION

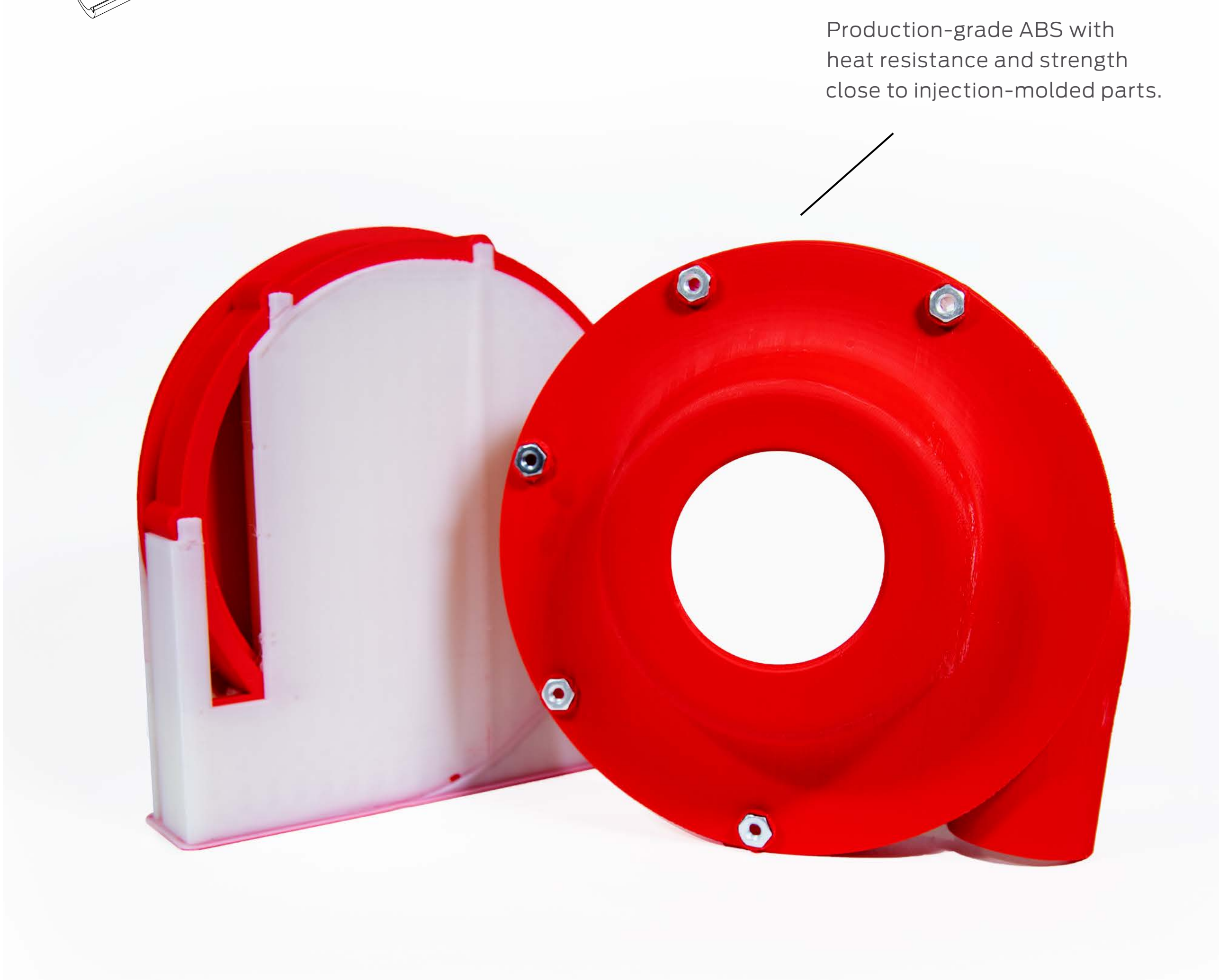
Functional Prototypes

EXAMPLE: FUNCTIONAL PUMP ASSEMBLY PROTOTYPE

Functional and fit prototypes are used in product design and engineering processes to test part fit, functionality, and form to reduce design risks and costly errors found later in the production cycle. These prototypes are most useful when they look and perform as close to the finished intended part design.



Material	Supports	Print Time
ABS	**SR-30**	**46h 30m**

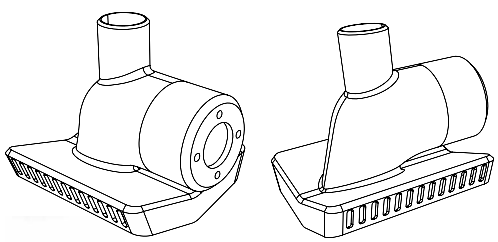


MAKERBOT REAL ABS USER APPLICATION

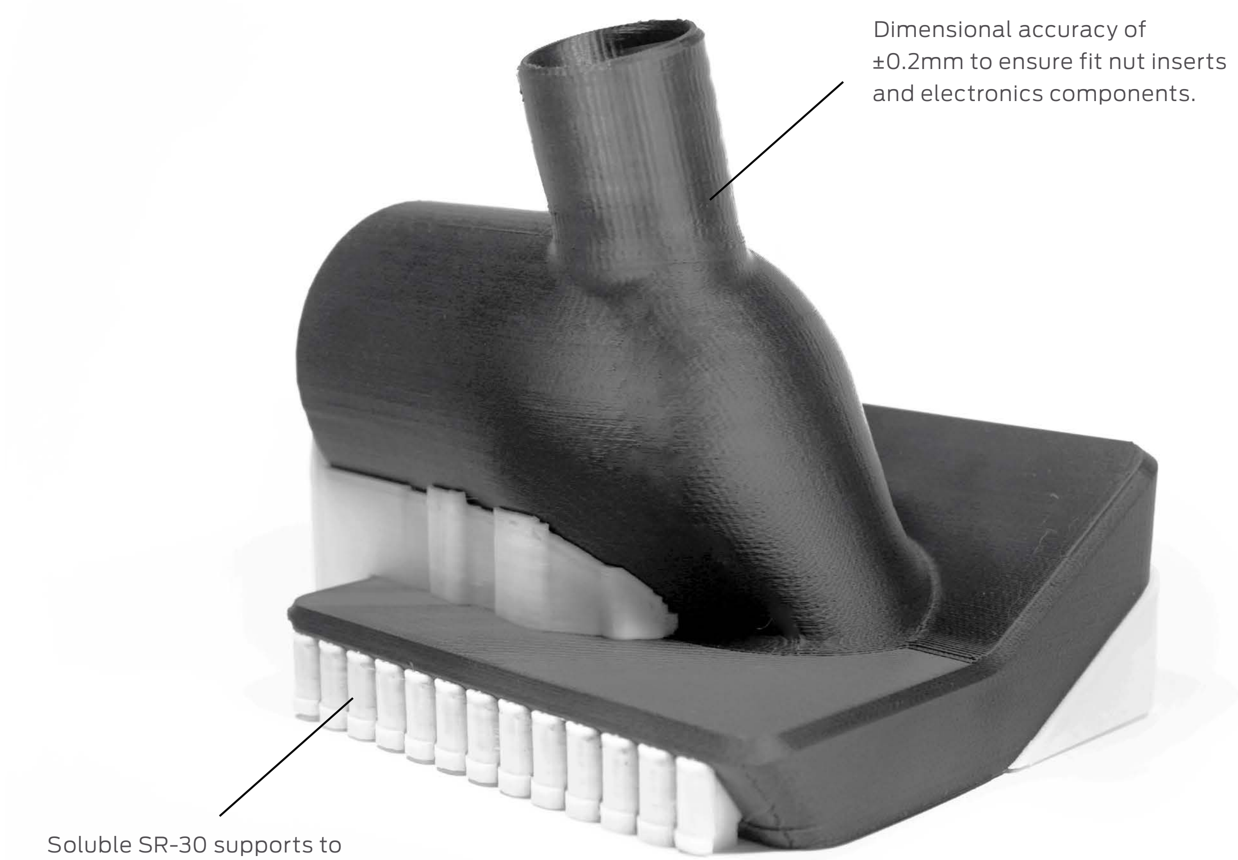
Manufacturing Tools

EXAMPLE: DUAL SANDER FOR MANUFACTURING ARM

Manufacturing tools are used to assist in the manufacturing and assembly of products by holding, protecting, guiding, and measuring parts. There are many different types of manufacturing tools including robot end-effectors, jigs & fixtures, visual gauges, molding patterns, and more. Having proper manufacturing tools that are customized to meet the needs of each part can directly impact the product quality and manufacturing costs during the assembly process.



Material	Supports	Print Time
ABS	**SR-30**	**66h 15m**



Dimensional accuracy of ±0.2mm to ensure fit nut inserts and electronics components.

Soluble SR-30 supports to print large overhangs and with superior surface finish.

CASE STUDY: All Axis Robotics

All Axis Robotics is a Dallas, Texas-based machine shop and a leader in turnkey custom robot solutions for other machine shops and manufacturing facilities in need of automated machine tending. Customers enlist the expertise of All Axis Robotics' mechanical and manufacturing engineers to streamline their manufacturing operations with robotic arms and custom end-effectors including those for CNC machine tending, automated part sanding, and brake press machine tending, among others.

The engineering team at All Axis uses 3D printing to produce custom tooling parts—reducing lead times from months to hours for their bespoke robot end-effector designs. This ability to create custom solutions for customers—combined with rapid turnaround times—has helped All Axis gain a competitive advantage against competitors as more manufacturing facilities upgrade new and legacy equipment to meet the increasing demands of industry 4.0 and the modern global marketplace.

This custom part sander was designed and manufactured in-house by All Axis engineers in under two weeks using a Makerbot METHOD X 3D printer using strong and durable real ABS material. The robot sander automates the time-consuming manual aluminum sanding operation, helping a machine shop to run more efficiently by freeing up personnel for other tasks. It features two sides with different grid sand pads as well as a connection for a vacuum to remove debris.

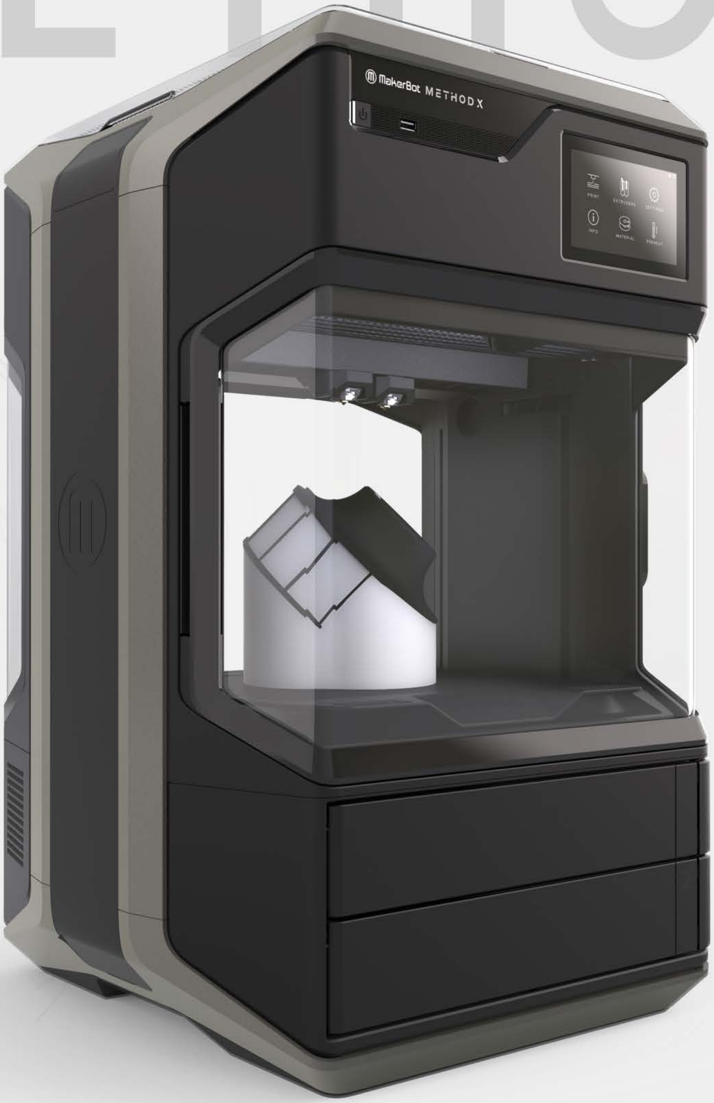
By producing the part with an in-house METHOD 3D printer, the team was able to eliminate undesirable factors typical of traditional manufacturing processes, including expensive machinist time and material costs. And by approaching the part design through the lens of freeform additive manufacturing, the engineers were able to 3D model the part quickly without having to account for complex assembly considerations typical of traditional manufacturing processes. The ability to print with soluble SR-30 supports allowed the engineers to design the sander as one complex part, which would've been impossible to machine. METHOD's dimensional accuracy ensured that the part mated perfectly with the robot arm

KEY TAKEAWAYS

- Tooling for robotic arms requires tight tolerances and hole cylindricity for optimal fit and function. The All Axis team was able to create functional, durable tooling on METHOD X with a dimensional accuracy of ± 0.007 in (±0.2 mm).
- Large overhangs, carve-outs, and other complex part features are near-impossible to machine. Stratasys® SR-30 soluble support material enabled the All Axis team to print complex parts with ease.
- Durable tooling is required to withstand the rigorous conditions of the machine shop. The All Axis team was able to create their part on METHOD X with production-grade ABS printed in a 100C heated chamber for maximum dimensional accuracy and durability.

MakerBot

METHOD



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