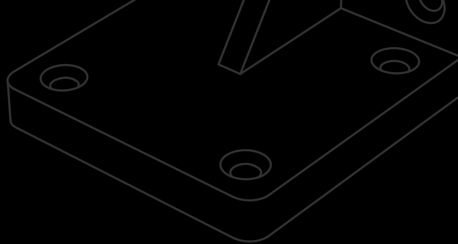
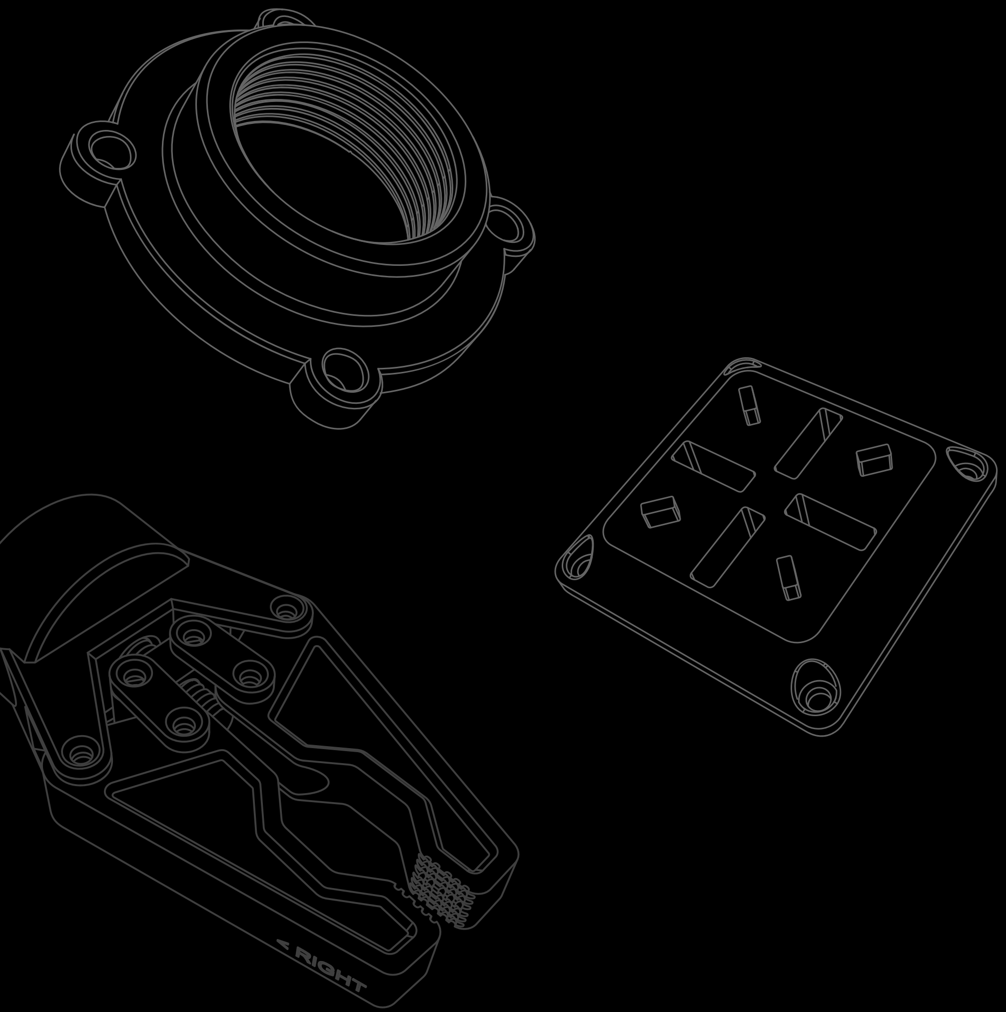
MakerBot

# THE 2021 CARBON FIBER 3D PRINTING APPLICATIONS GUIDE



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If you're new to 3D printing, you're probably discovering the range of materials that are available. One of the most exciting material groups are composites, which include carbon fiber, a highly versatile material. But what can you actually do with 3D-printed carbon fiber composites and when should you use them? This guide is designed to help answer that question.

## Introduction

Carbon fiber was first used by Thomas Edison in the late 19th century for use as filament in early lightbulbs. In the late 1950's, The Union Carbide Corporation first realized the strength benefits that could be achieved through further processing techniques. Over the next 50 years, manufacturing techniques advanced further, and today carbon fiber has become ubiquitous with high performance products from race cars to airplanes. Now, with the advances in composites and convenience of 3D printing, carbon fiber is more accessible to more people, for more applications, than ever before.

# Making Carbon Fiber Accessible Through 3D Printing

## TRADITIONAL CARBON FIBER VS. COMPOSITE BLENDS

When you think of carbon fiber, the first thing that likely comes to mind is some type of exotic race car, sporting good, or aircraft part - easily identified by the graphite black crossweave pattern that is both incredibly strong and lightweight. The process of creating parts using the carbon fiber layup or weave process produces incredible results, but can also be cost and labor prohibitive due to the many steps required to produce a part.

Enter carbon fiber composite blends. In composite blends, carbon fiber goes through the process of chopping and mixing with a base resin or polymer. The result is a material that is easier to turn into parts (you can use techniques like injection molding, machining, and 3D printing). Another added benefit of compositing carbon fiber is the ability to introduce additional properties through the use of a variety of base polymers (nylon, for example, can add a level of impact strength to reduce the brittleness of carbon fiber).

## COMPOSITES MANUFACTURING TECHNIQUES

While composites already bring a certain accessibility to carbon fiber by opening up the material to mass production techniques, 3D printing enables the use of carbon fiber for low volume and low effort parts. With 3D printing, you can easily make a single tool that will be used for one specific application by one user. You can also go through an iterative process by which that tool continues to be improved upon as new insights or requests come in. Thus, a part such as a fixture or jig that would seem crazy to produce out of carbon fiber in a traditional sense, becomes entirely plausible and possibly the most logical choice for that application through the use of 3D printing.

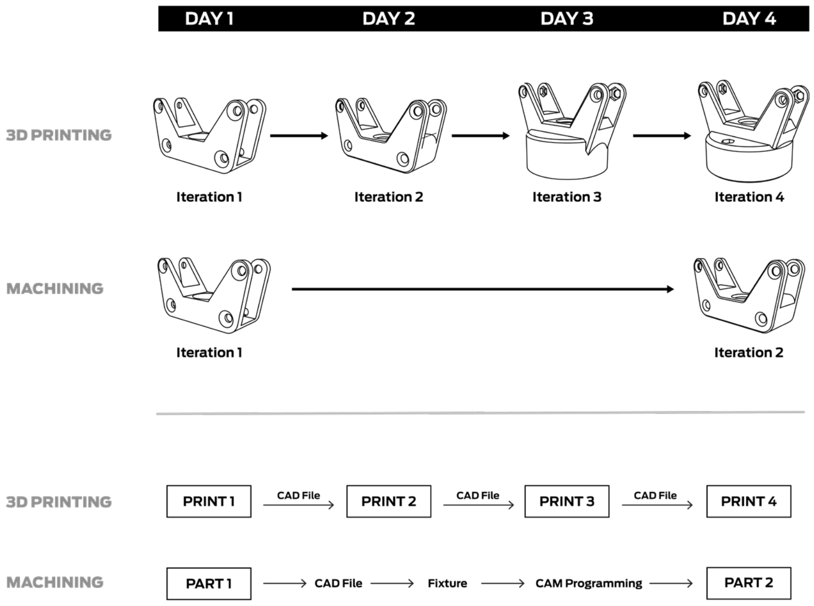
To understand why, you need to understand the basic benefits of 3D printing over other manufacturing processes. With an FDM 3D printer, you just need a spool of material and a 3D design file. Start the print, and in a few hours you'll have the completed part. By contrast, an injection mold process requires the design and manufacture of the mold ahead of time. Similarly in machining, the setup requires fixtures to be set up, a CAM program to be created, and possibly multiple manipulations of the part by an operator throughout the machining process. In a nutshell, 3D printing requires very little setup or monitoring during the manufacturing process making it a fairly simple, automated process.

# Identifying Opportunities - When Does 3D Printing Make Sense?

Before you dive in, buy a 3D printer, and start replacing all of your parts and processes, it is important to understand where 3D printing carbon fiber composites makes sense. Just like any technology there are pros and cons to 3D printing, and if you are going to be using this for a business application, you want to ensure there is a real return on your investment.

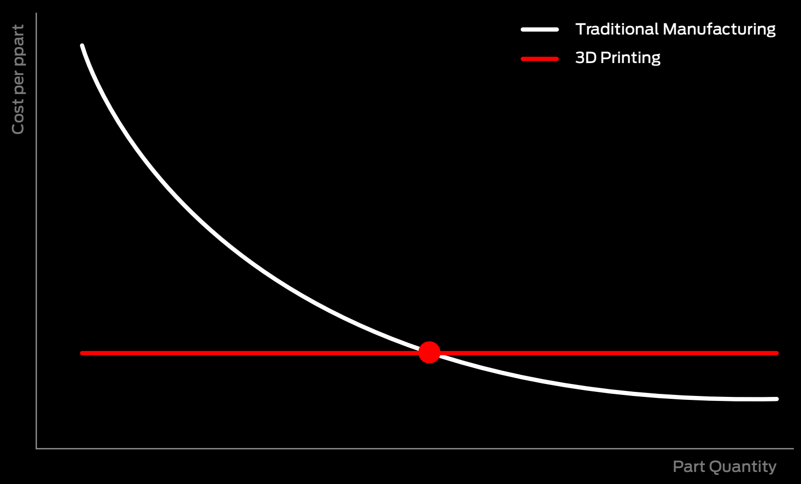
## TIME - ITERATIONS, ONE-OFFS

One major benefit from 3D printing, as mentioned above, is the ease of setup compared to both injection molding and machining which can result in a huge time advantage. Going from design directly to starting the print job, without the extra setup, means that individual parts need significantly less labor time devoted. That time advantage is further multiplied if you continue development on the part to improve it through multiple iterations.




## COST PER PART - VOLUME

In the context of high volume, extra setup steps in injection molding and machining make more sense. The time you spend setting up will pay off when you use the machine fixtures or the injection mold to mass produce large quantities of parts because the processes themselves are relatively quick and inexpensive. Thus, we must look at the part volume required. If large volumes are your goal, then more traditional means of production are likely going to make more sense. However, if low volume is your goal - as may be the case with prototypes, custom/highly specialized tools, or replacement parts - 3D printing is almost always going to make the most sense from a cost standpoint.



**SPEC REQUIREMENTS (ie. tensile strength)**

When considering material and manufacturing processes, you'll need to understand the properties required for your specific application. What stresses and strains will the part undergo? What type of temperature thresholds will the part need to withstand? Will the part be exposed to moisture or chemicals?

Certain parts may require the structural strength of steel. But just because a part is currently made out of metal does not mean it NEEDS to be made out of metal. In fact many parts are made out of metal simply because metal is the material that has been readily available and the tools that have been available in the shop are able to make that part.

Understanding the following property requirements of your part can make your exploration of 3D printing much easier to fully comprehend.

- Load
- Stiffness
- Durability
- Heat Deflection
- Special properties
  — ESD - Resistance to electrostatic discharge
  — Flame retardance
  — Chemical resistance
  — Electrical conductivity

# Example Carbon Fiber 3D Printing Applications

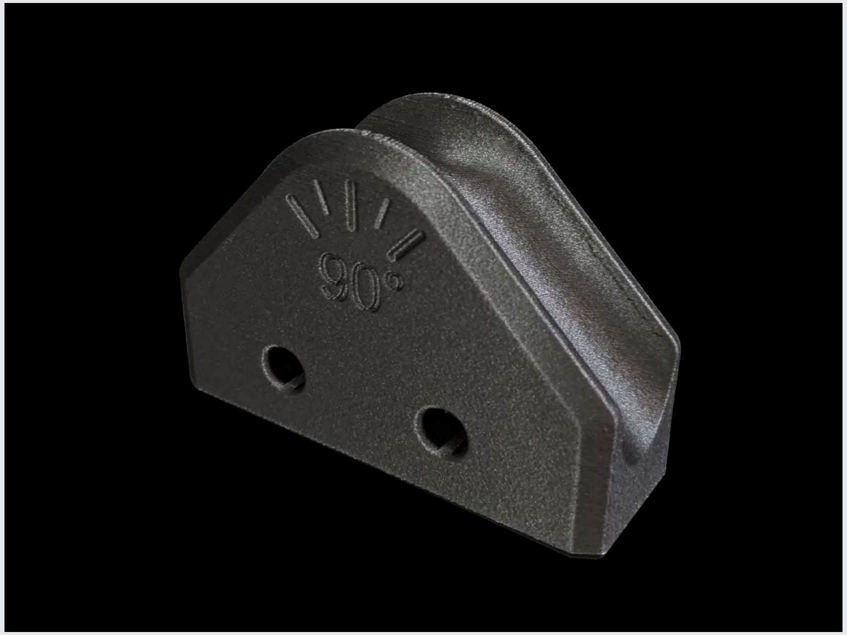


## WELDING FIXTURE

Welding often requires custom fixtures that hold the pieces together in advance of the welding process. These fixtures can be easily designed in CAD and 3D printed to minimize labor time while ensuring a tight tolerance fit. Nylon 6/66 carbon fiber is an ideal choice for this application thanks to it's high heat deflection temperature and rigidity.

## BENDING DIE

Bending dies are used in conjunction with a hydraulic press to shape and form metal parts. Depending on the job or facility, these parts may benefit from 3D printing for quick customization from one job to the next. Carbon fiber composite is a great material option thanks to its rigidity - it will hold its form under more pressure than many other polymers.



# Example Carbon Fiber 3D Printing Applications

## END-OF-ARM TOOLING

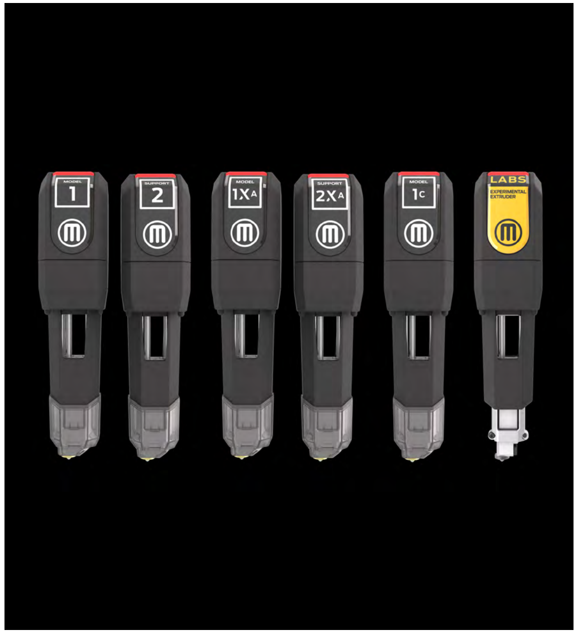
When it comes to manufacturing automation, robotic arms are becoming ubiquitous as a tool for streamlining mundane tasks with unparalleled precision. End effector tools can come in all shapes and sizes, so the ability to 3D print these makes the possible applications nearly endless. The payload of the robotic arm is limited so reducing the weight of the tool through 3D printing with carbon fiber composite can help quite a bit. This leaves the robot arm with the ability for increased payload, speed, and/or maneuverability.

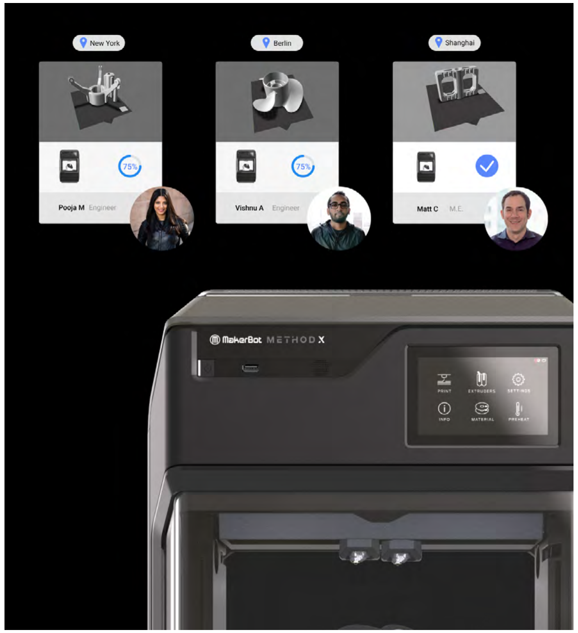
## ALIGNMENT TOOL

Alignment tools or gauges are used for quickly measuring during the manufacturing or assembly process. The rigidity of carbon fiber composite makes it a perfect material as it ensures the part won't flex or compress during measurement which could result in incorrect tolerances and inconsistent assemblies.

# MakerBot METHOD Carbon Fiber Edition

## UNIQUE FEATURES




### CIRCULATING HEATED CHAMBER

Many desktop 3D printers use heated build plates to try and regulate their environment and prevent warping on the print bed. This improves adhesion to the build plate for the first layer and... that's about it. METHOD uses the patented Circulating Heated Chamber to rapidly warm the entire build chamber up to 110ºC, providing optimal print conditions from the first layer to the last. The result is a degree of dimensional accuracy typically reserved for industrial 3D printers (±0.007 in), at the base layer and everywhere else.

### COMPOSITE EXTRUDER + MODULAR EXTRUDER PLATFORM + SUPPORT EXTRUDER

The 1C Composite Extruder for METHOD conveniently comes included with the METHOD and METHOD X Carbon Fiber Editions. This extruder has been optimized with hardened parts to print abrasive composites longer. With METHOD's modular extruder platform, you can switch between different extruders in seconds without the need for tools, giving you flexibility to jump between material groups and applications.

### CLOUDPRINT COLLABORATION

Included with all MakerBot 3D printers is the ability to use MakerBot CloudPrint™ - MakerBot's cloud-based 3D printing and collaboration tool. With MakerBot CloudPrint you can access your MakerBot 3D printers remotely from anywhere, set up workspaces and give your teammates access to use your printers, and unleash the full power of the METHOD platform.

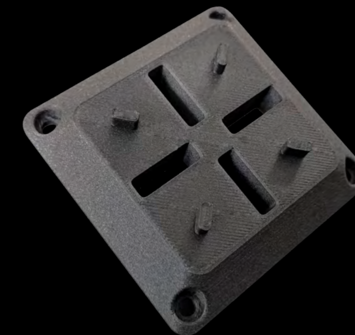
# MAKERBOT CARBON FIBER COMPOSITES

## NYLON CARBON FIBER (NYLON 6/66 BLEND)

Nylon 6 carbon fiber has the strength and lightweight benefits of other carbon fiber composites. The main thing about nylon 6 that sets it apart from others in that category is its ability to withstand higher temperatures. The heat deflection temperature is significantly higher than many of the popular base polymers. In the case of MakerBot Nylon Carbon Fiber, the HDT is 100ºC higher than that of ABS and 93ºC higher than regular nylon 6.

**PIPE FITTING BRACKET**

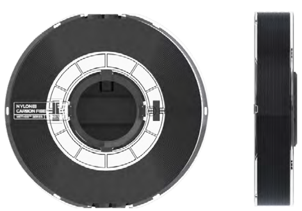
**Print Time:** 4h 44m
**Material:** Nylon Carbon Fiber
**Support:** SR-30



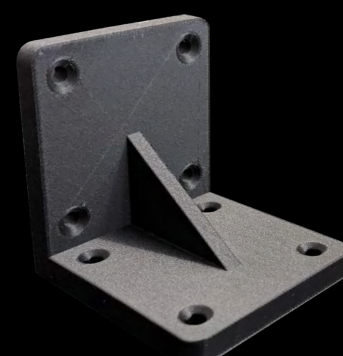
**POSITIONING FIXTURE**

**Print Time:** 7 h 51m
**Material:** Nylon Carbon Fiber
**Support:** SR-30

## NYLON 12 CARBON FIBER



Much like nylon 6 carbon fiber, the nylon 12 variant has the benefits of strength, stiffness, and lightweight. Unlike nylon 6, nylon 12 has a better resistance to moisture uptake, making it somewhat easier to print and giving the printed part a cleaner final appearance without the need for post-processing. One drawback of nylon 12 compared to nylon 6 is that it will generally have a lower HDT - so you really just need to weigh what is most important for your specific application.

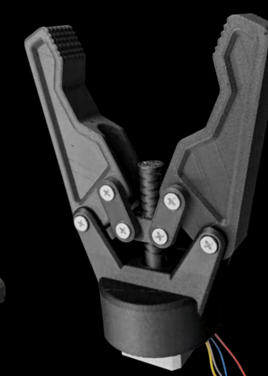


**RECTANGULAR BRACKET**

**Print Time:** 5h 7m
**Material:** Nylon 12 Carbon Fiber
**Support:** SR-30

**PIPE WELDING FIXTURE**

**Print Time:** 8h 40m
**Material:** Nylon 12 Carbon Fiber
**Support:** SR-30



**ROBOTIC GRIPPER ASSEMBLY**

**Print Time:** 17h 23m
**Material:** Nylon 12 Carbon Fiber
**Support:** SR-30

## THIRD-PARTY COMPOSITES WITH MAKERBOT LABS

With the new MakerBot LABS GEN 2 Experimental Extruder, you can print composites and polymers from third-party suppliers with extra longevity. Here are a few composite materials that have gone through the extended verification process of MakerBot LABS for METHOD, and we are continuing to add more materials to the platform.

### KIMYA ABS CARBON FIBER

Kimya ABS Carbon 3D filament provides a similar finish to ABS but with carbon fiber reinforcement for added strength and rigidity.  This filament is highly valued by manufacturers of drones and by modeling aficionados. It is also used to make tools.

### KIMYA PETG CARBON

Kimya PETG Carbon 3D filament provides the chemical resistance benefits of PETG but with added strength and rigidity from the addition of carbon fibers. Thanks to its rigidity, the PETG Carbon is highly valued in the production of special parts, notably in the paramedical and automotive fields.

### JABIL PETG ESD

Jabil PETG ESD is an Electrostatic Dissipative (ESD) product for printing parts that require protection from electrostatic discharge. This product combines the benefits of PETG - most notably chemical resistance - with the addition of ESD for use with sensitive electronics.

### KIMYA ABS ESD

Kimya ABS-ESD 3D filament is an Acrylonitrile Butadiene Styrene to which an additive has been added to give it Electro Static Discharge properties: this material protects against electrostatic discharge. It also provides good impact resistance. It is a lightweight and rigid material that is also easy to print. It is ideal for applications requiring protection against electrostatic discharge.

### KIMYA ABS KEVLAR

Acrylonitrile Butadiene Styrene Kevlar (ABS Kevlar) is a composite filament enriched in aramid fibers. It offers properties that are superior to a standard ABS. It provides the printed parts with increased resistance to abrasion and impact. It is used for finished parts and tools.

### KIMYA ABS EC

Kimya ABS-EC 3D filament is a combination of ABS and electrically active additives: carbon nanotubes. ABS-EC is resistant to impact, heat and ageing. It is used in the automotive and electronics industries.


METHOD
CARBON FIBER EDITION
Replace metal parts with 3D printed Carbon Fiber on METHOD
MakerBot METHOD X
WWW.MAKERBOT.COM/CARBON