MakerBot.

THE COMPLETE GUIDE TO 3D PRINTING IN THE AUTOMOTIVE INDUSTRY

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Introduction to 3D Printing in the Automotive Industry

The Automotive industry has been using additive manufacturing since its inception. As the industry continues to rapidly change and progress, new technologies, materials, and platforms are becoming available for more applications than ever before.

At first, automotive companies adopted large, centralized 3D printers. These machines were expensive to procure and operate. Getting a printed part was only accessible to select departments, and even those departments needed to make a strong budget case to get a part printed.

Fast forward to the 2010s and cheap desktop 3D printers began to appear as a quick and dirty workaround for the average engineer. These printers were more accessible, but limited by capability (accuracy, part-strength, material options).

Today, there is a new breed of powerful, networked professional desktop 3D printers that can print strong and accurate parts in a range of engineering materials with the flexibility of networked scalability - meaning a single engineer can benefit from easy access, while a large business can also easily manage a fleet of these manufacturing machines.

THE EVOLUTION OF 3D PRINTING TECHNOLOGY IN AUTOMOTIVE

This evolution of 3D printers has led to a democratization at all levels of the automotive industry, from design and optimization, to the manufacturing and assembly floor, to usable on-car parts. While the industry still uses large, centralized industrial systems - which are more powerful than the early systems - for this guide we'll focus on the scalable, accessible solutions provided by new-aged networkable professional 3D printers such as the MakerBot METHOD. We'll follow this type of solution across all three major applications within the automotive industry - design prototyping, manufacturing tools, and low volume production parts.

Centralized industrial 3D Printer

↓

Siloed Cheap Desktop 3D Printer

↓

Scaleable Professional 3D Printer Platform

Prototypes for Ideation and Design

Every car, truck, or other vehicle begins with an idea. This concept goes through many phases from initial sketch, to scale model, to prototype, and eventually into production. The ideation and design process is extremely important because it allows designers to take liberties and be creative, test audiences, and push the boundaries of what has been done before. It also allows the engineers a chance to test parts for form, fit, and function before they make their way into the expensive tooling phase. 3D printers have become extremely valuable tools for enabling quick, easy, and low-cost prototyping.

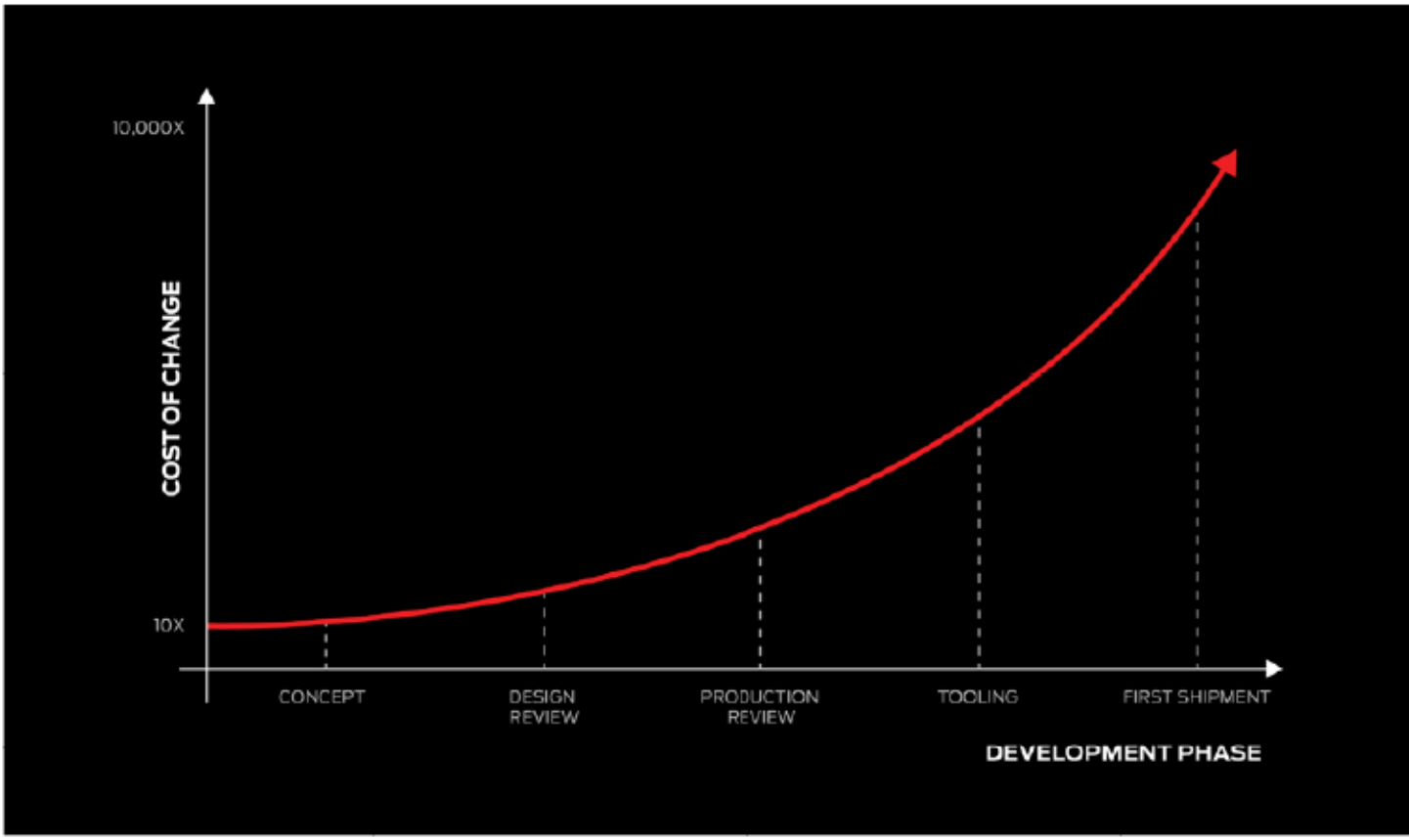
If a picture is worth a thousand words,
then an object is worth a thousand pictures.

WHY IS IT IMPORTANT TO PROTOTYPE?

Prototypes are extremely valuable tools for testing ideas and conveying information to others. For a major automotive OEM that will be manufacturing tens of thousands of vehicles, getting a design right before going to production reduces the risk of mistakes making it into production.

According to the NHTSA, the number of automobile recalls have been steadily increasing over the past 20 years resulting in billions of dollars in losses for the affected companies as well as agitation and loss of trust from customers. Due to the increase in modularity and the variety of suppliers, it is important to completely understand how everything fits and works together.

In short, while design flaws will always exist in any new product, it is essential that they are caught as early in the process as possible to minimize cost. Prototyping is essential for early validation and minimizing risk of recall.



WHY SHOULD YOU USE A 3D PRINTER FOR DESIGN PROTOTYPING?

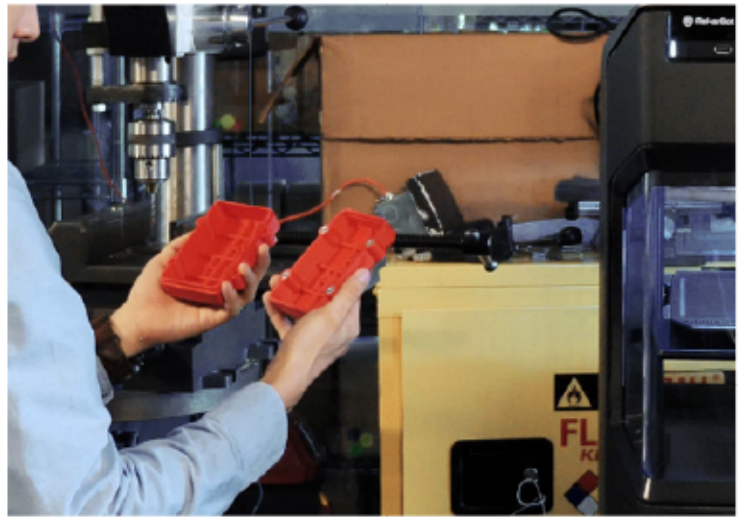
While there are many ways to make a prototype - cutting and carving in wood, sculpting in clay, machining from metal - 3D printing provides many specific benefits for prototyping in the automotive industry.

Direct link to digital CAD and other digital tools

It's no secret that nearly all automotive designers and engineers use CAD at various stages of design. You can quickly iterate on a design in CAD and print another part with very little effort. Using digital tools like MakerBot CloudPrint, you can start and manage your print jobs easily. 3D printing allows you to quickly take the part file you are working on and create it to spec.

Automation - minimal skill required and highly repeatable

Unlike many prototyping tools - 3D printing is highly automated. Obviously clay and wood models require an extensive amount of hands-on craftsmanship and attention, but even CNCs require extensive setup in CAM programming and custom fixturing. 3D printers are pretty much ready to create any shape with just the push of a button and require little to no attention from start to finish.

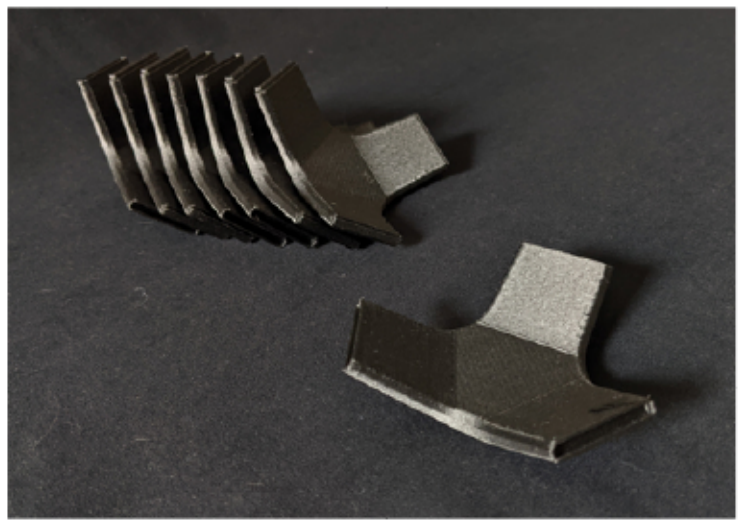


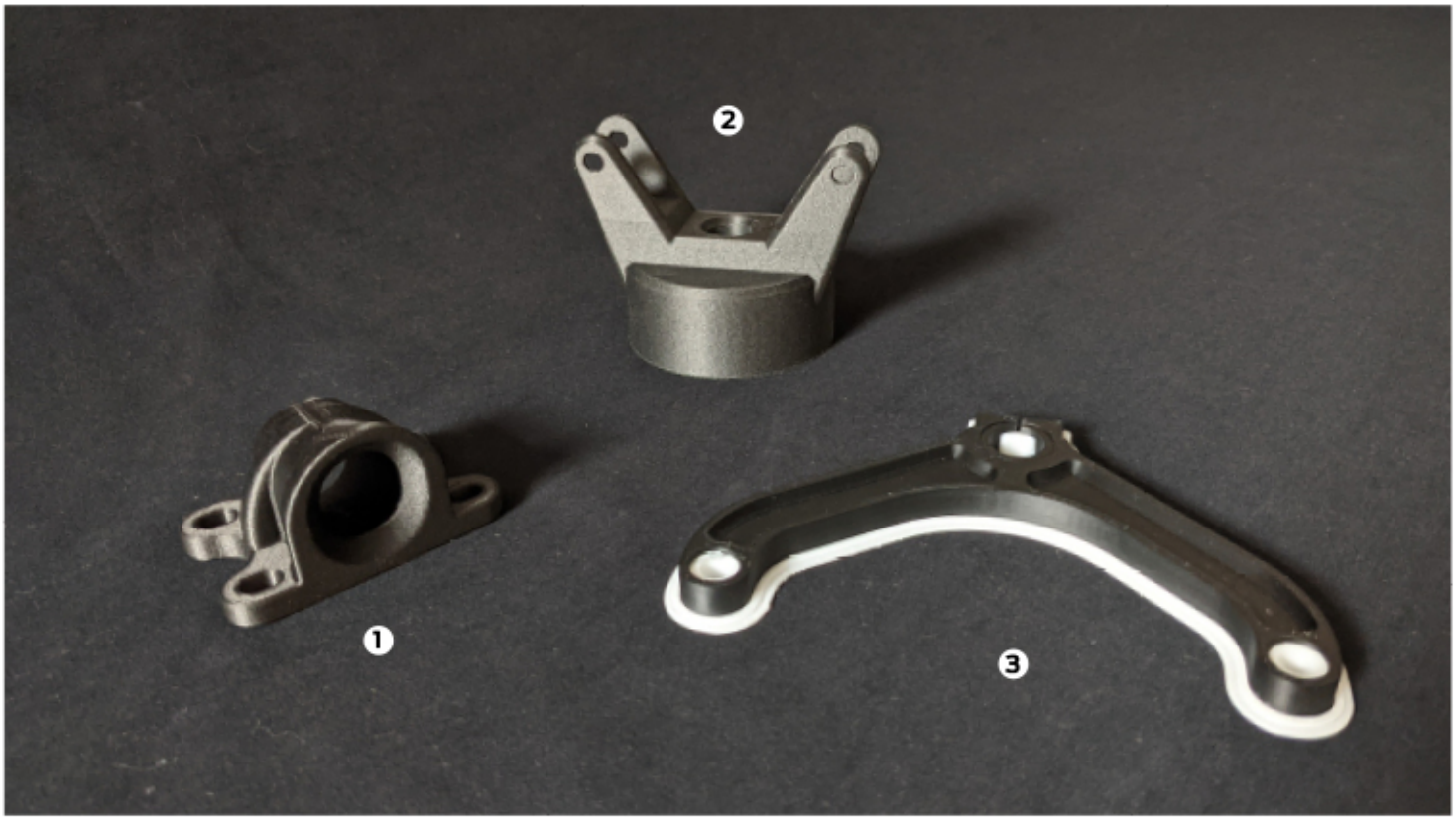
Material variety

3D printing materials are ever evolving. While there are many different technologies that specialize in materials from resins to metals - professional FDM machines like the MakerBot METHOD series allow for printing in 25+ metals, composites, and polymers. In the design and testing phase, this allows engineers to prototype in materials similar to those that will be used in final production such as PC-ABS, ASA, and PC.

Low cost

Up front costs vary from printer to printer, but for the new age of networkable professional desktop 3D printers you can expect to spend $5,000 - $10,000. Materials are also relatively affordable. All in all, the cost of creating a part can be 1/10th that of more traditional prototyping methods when factoring in labor time.





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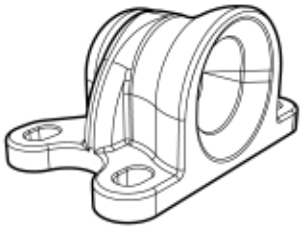

TAILGATE SOCKET

Material: Nylon Carbon Fiber

The tailgate socket is a multipart assembly component which requires tight tolerances. By prototyping the various components that fit together the engineers at Prodrive are able to test their design in the garage before they install a finished part. In this case they identified a flaw in the design but they were quickly able to modify their CAD file and print a new one which they had in hand the next day and worked perfectly.

2

END EFFECTOR MOUNT

Material: Nylon 12 Carbon Fiber

When setting up robotic arms on an assembly line, in a machine shop, or elsewhere, it is important to have the right end effectors. 3D printing allows for the design of custom end effectors that perfectly meet your application (and that might not exist from a supplier). While the final parts might be considered shop tools, the design and prototyping phase is the same as any other product. In this case the mount needs to fit securely onto the arm but also connect to interchangeable tools. Nylon Carbon Fiber provides a strong a lightweight material that lessens the tools impact on total payload budget.

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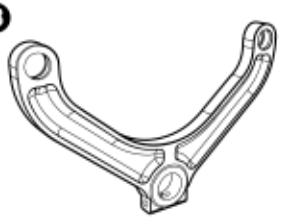


WISHBONE

Material: ABS

The wishbone is a common component found in a suspension assembly. While functionally this part is unlikely to be printed, for form and fit testing, 3D printing is a feasible option. ABS while being a great production material is also very good for prototyping. Not only is it affordable, but the parts come out with a high level of dimensional accuracy and surface finish when printed on a printer equipped with a heated build chamber - such as the METHOD X.

Manufacturing with On-Demand Tools

The assembly line floor of a manufacturing plant should be a well-oiled machine with various sub-assemblies coming together with the chassis. While the initial setup of the line is crucial for success, the job does not end once the line is turned on. The job of the manufacturing engineer is to constantly improve the process over the life of the line. Changes can come in the form of new, more ergonomic or efficient tools, inspection gauges, organizers, and various jigs and fixtures. 3D printers are becoming critical for the design, production, and replacement of tools - essentially providing tools on-demand.

> The way humans make and use tools is perhaps what sets our species apart more than anything else.

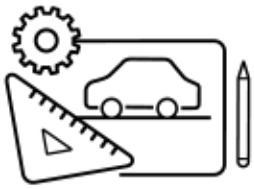
WHAT ARE MANUFACTURING TOOLS AND WHY SHOULD YOU USE THEM?

When we talk about manufacturing tools in the context of this article, we're not talking about machined molds that will be used to churn out thousands of parts. Instead we're referring to very specialized devices that serve to make the technicians, engineers, and robots on the line more effective.

Almost all manufacturing engineers in the automotive space understand the value of customized tools, jigs, and fixtures. They allow for increased speed and efficiency by making the assembly line workers' job easier and more repeatable. Like prototypes, they also reduce risk of defective vehicles making it to customers; however, rather than preventing a flawed design from getting through, manufacturing tools reduce the likelihood of mistakes or inconsistencies occurring during production.

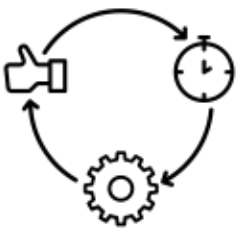
WHY SHOULD YOU USE A 3D PRINTER FOR MANUFACTURING TOOLS?

In an environment like an automotive assembly plant, there will be a bevy of tools at the disposal of the manufacturing engineers. 3D printers are valuable mini manufacturing plants that can sit in the immediate vicinity of the team and provide unparalleled access.



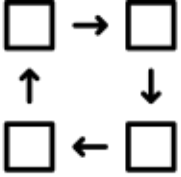
Accessibility on the floor

3D printers are powerful tools that take most of the physical work out of creating tools. The newer breed of powerful and easy-to-use desktop 3D printers have a reasonable footprint and can be placed in an office or right on the floor alongside the line, making them easy for engineers to access. Compared to CNC machines, they are extremely user-friendly meaning that anyone can print a part with little training. They also do not require overly specialized areas with industrial ventilation or dust collection.



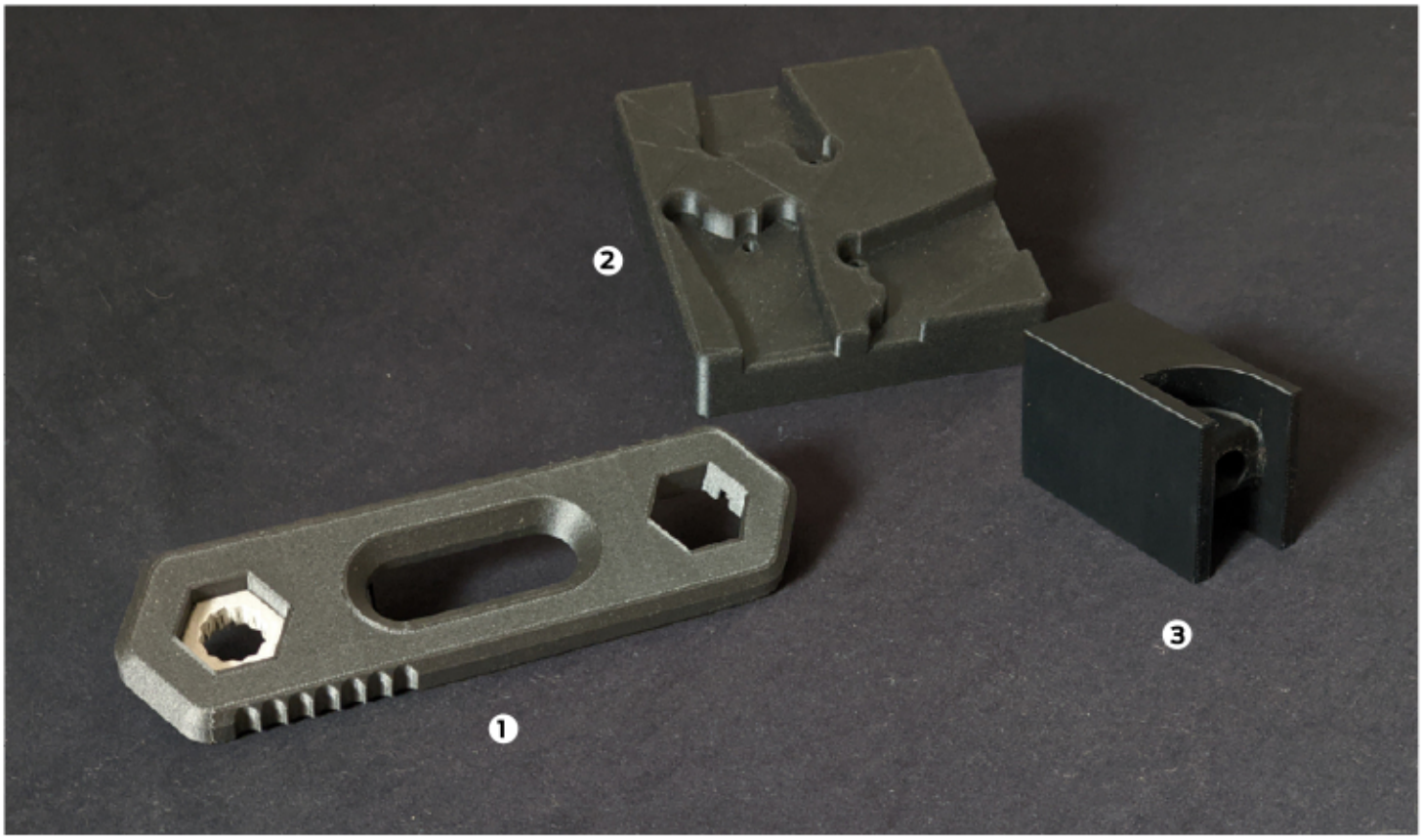
Unlimited replacements

The idea of the digital inventory is only starting to catch on, but it allows a manufacturing engineer on the plant floor to have an infinite library of parts at hand without the need for a full warehouse. The 3D printer allows for the files to be printed as needed. Certain parts - a nozzle used to apply window sealant for example - could be printed in a batch of 20 in a single print. All that is physically required is a 3D printer, a variety of material options, and a computer.



On-the-fly improvement and optimization

Just like with iterative design through prototyping, when using 3D printers to produce on-demand manufacturing tools, you can iterate and optimize your tools. Maybe you've gotten feedback that a certain jig is unwieldy and could use a handle to hold it in place. No problem - just jump into the CAD file, design in a handle, and print the new version all within a day. This easy optimization also applies to spec changes or new models, allowing you to set up a new line faster and easily adapt to any changes that come your way.



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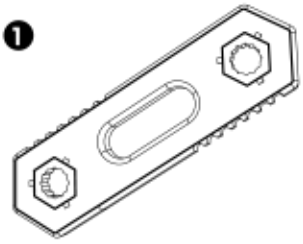

15MM HEX WRENCH

Material: Nylon 12 Carbon Fiber, BASF Ultrafuse 316L

In order to maximize the benefits from both materials, the interfacing component of this wrench is printed in 316L Stainless steel while the main body of the assembly is printed in Nylon 12 Carbon Fiber. This results in a strong and lightweight tool.

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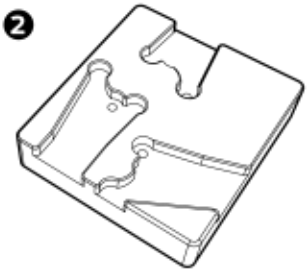

KEVLAR PUNCHER GUIDE

Material: ABS

This jig enabled the engineering team to position and press fit a small production run of metal assemblies on the factory floor. ABS Kevlar 3D filament is a composite filament enriched in aramid fibers - the same fibers used in bullet-proof vests. It offers strength and durability properties that are superior to a standard ABS.

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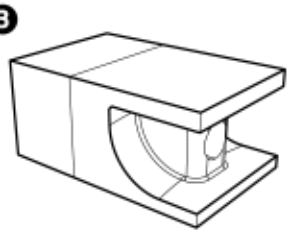


DUAL CURVATURE DRILL GUIDE

Material: ABS Kevlar

This particular fixture was developed in order to properly position a blind hole on a curved component. The complex geometry of the part requires a secure guide for the operator in order to successfully locate and execute the operation. This guide simplified the drilling process and improved the accuracy too.

Low-Volume Performance Parts

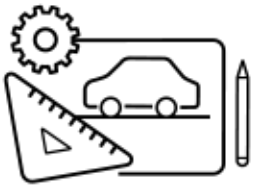
Automotive manufacturing is not just about the large scale production lines of OEMs. High-end companies from Ferrari to McLaren to Arash Motor Company produce many (or all) of their models at low volumes. Motorsports teams spend millions of dollars producing just a handful of cars each year. Similarly, there are countless custom car, motorcycle, RV, work van companies that take an existing chassis and modify it to fit the custom needs of a specific customer. What do these types of businesses have in common? You guessed it - low volumes. 3D printers provide a unique advantage of low-volume, precision, and performance parts - all at a relatively low cost.

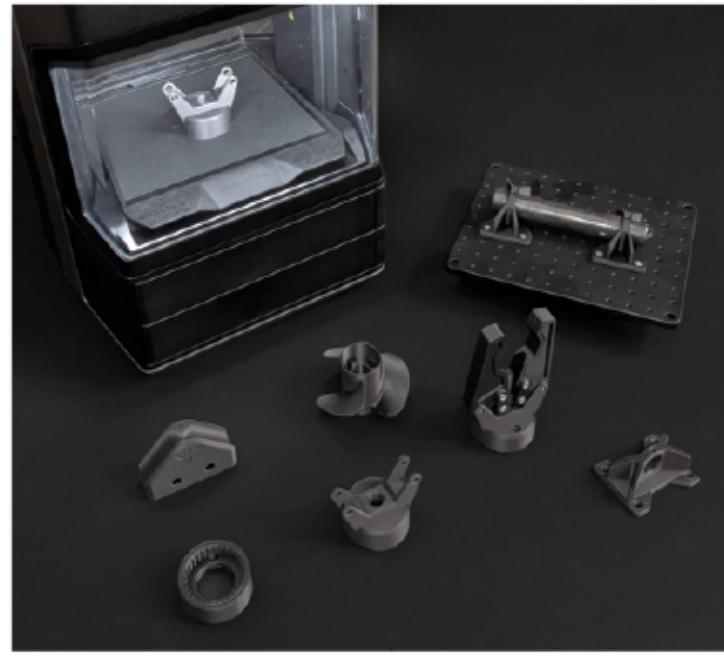
WHAT ARE LOW-VOLUME PARTS?

Low-volume production parts can really be anything that ends up on the vehicle. In the case of the bespoke auto company, the entire assembly from chassis to the shifter knob might qualify as low-volume car parts. In motorsports, you might see ductwork, bottle holders, or sensor mounts. And in the aftermarket world, brackets or replacement parts could qualify. In these cases, really anything that is relatively low volume - something like 1-20 parts - would qualify.

WHY SHOULD YOU USE A 3D PRINTER FOR LOW-VOLUME PARTS?

3D printers are not the only tools that will likely be used to produce parts for low-volume manufacturers, but they are an integral technology that should be in every shop's stable.





Variety of production-grade materials

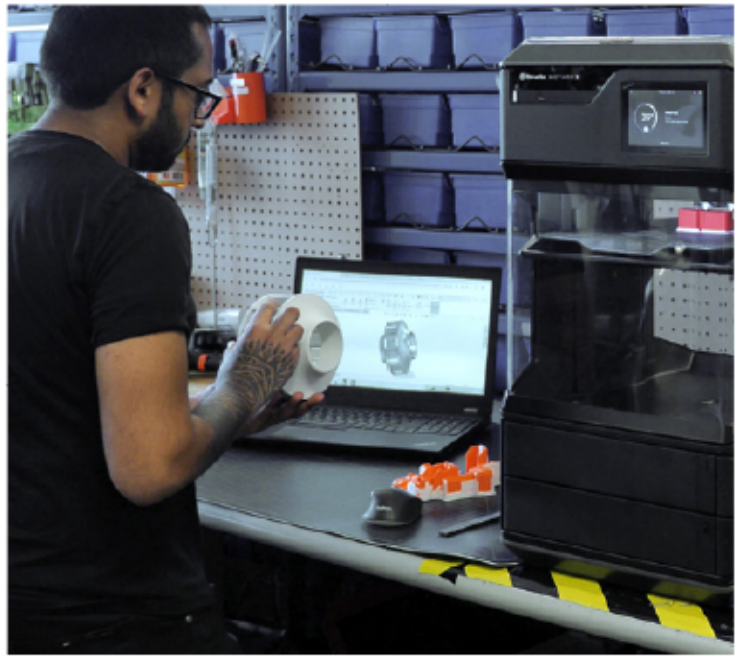
When a part ends up on a vehicle, the material it is manufactured in is essential. Exposure to high temperatures, stresses, UV rays, and moisture can all affect the performance and lifetime of the part. With today's 3D printing technology, you can choose from a range of polymers, composites, and even metals. One major benefit of using 3D printing is the ability to use more polymers and composites in final parts, allowing for lighter weight parts. Nylon Carbon Fiber is one specific material example that is bringing the benefits of carbon fiber to even more applications because of its ease of use with a 3D printer - compared to the traditional carbon fiber layup process. Other materials such as ASA and PC - both popular in the automotive industry - can be used on some of the higher end professional desktop 3D printers like MakerBot METHOD.

Complex geometries (reduced component numbers = weight savings)

The problem with traditional subtractive manufacturing techniques or molding is that you are limited by geometries. Cutter bits need to be able to access the areas where material needs to be removed. 3D printing doesn't have this same limitation. Because the part is being built from the ground up, cavities and other internal components can be printed in a single go. This reduces the need for extra components and fasteners that would traditionally be used in an assembly. The assembly essentially can become a single part.

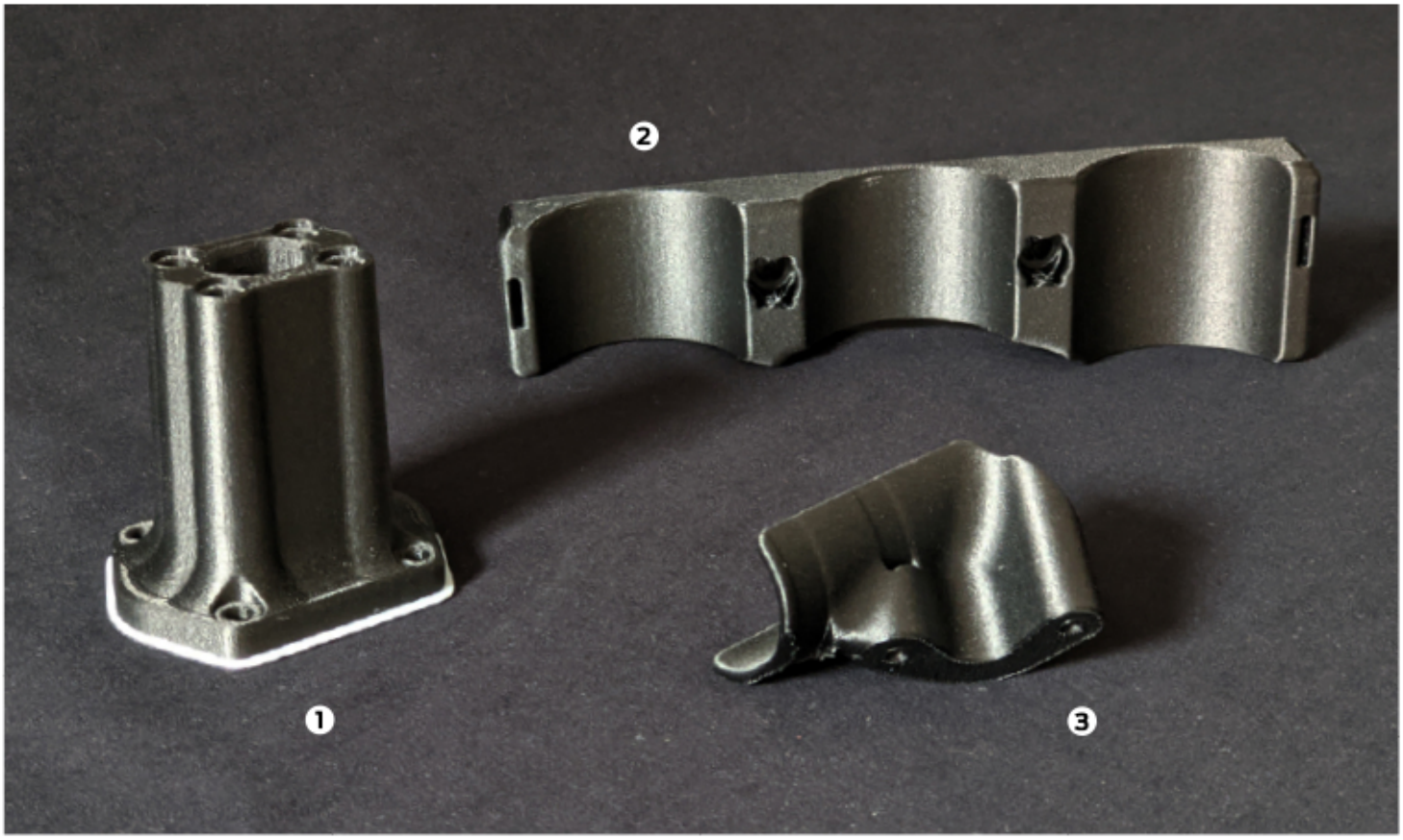
Finished look is easy to achieve

When making low-volume parts, metal is often one of the best mediums due to the relative ease of working with it. In certain cases this works really well, but these parts can also come out without the "finished" look - for example comparing bent and welded metal vs. an injection molded or stamped part. 3D printers can produce a part that has the same CAD design and look of an injection molded part but with the flexibility to produce it affordably in very low volumes.



Agile design, testing, and manufacturing all at once

This one is kind of an all-encompassing benefit. Because automotive companies who use 3D printing for end-use parts also typically go through the design process, testing, and assembly, they stand to benefit from everything in the previous two sections. 3D printers can be used early in initial design prototyping, then they can be used again during testing. Once the design is finalized, production parts can then be printed, and if necessary, assembly fixtures and other manufacturing aids can be printed. In this example, hardware improvements can immediately be implemented in production for future versions.



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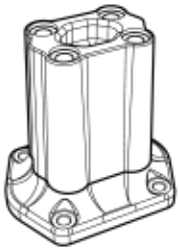

SPRINKLER SYSTEM

Material: Nylon Carbon Fiber

In motorsports, the most important features of the cars are the safety features. With the Hunter rally car, the team at Prodrive needed to create a mount for the sprinkler system in the cockpit that would allow for optimal positioning of the nozzles while also giving a "finished" look. They were able to design a custom mounting bracket and then print the final part in nylon carbon fiber in just a day.

2

RESERVOIR BRACKE

Material: Nylon Carbon Fiber

Mounting brackets are crucial for all types of elements within a vehicle. The Prodrive team 3D printed dozens of mounting brackets for sensors, but one particularly interesting print was a bracket for their hydraulic reservoirs. During the course of the 13 day Dakar Rally, one such bracket broke - requiring them to print a replacement overnight and mount it in time for the start of the stage the next day. This specific part was bolted to the exterior floor on the side of the car meaning it had to hold up to extreme conditions and punishment throughout the remainder of the race while keeping vital elements - the hydraulic reservoirs - in place.

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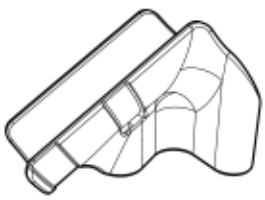


SUSPENSION BRACKET

Material: Nylon Carbon Fiber

While the suspension itself is made of metal, the bracket that kept the suspension aligned on the Hunter Rally car was 3D printed in nylon carbon fiber on the MakerBot METHOD X - enabling a quick and cost effective production of a custom, lightweight part. Another example of a part that needed to withstand extreme punishment over the course of the 13 day Dakar Rally.

How to implement 3D printing in the Automotive Industry

STEP 1
Identify your applications

First thing's first: do you have a viable application for purchasing a 3D printer? We already identified the three main applications of the automotive industry where 3D printers are clearly beneficial in prototyping, manufacturing tools, and low-volume production parts. Do you have a clear job in mind? It's best to identify a job you are currently doing, or would like to be doing.

STEP 2
Material needs

Are there certain materials you currently use that you would like to 3D print with? Are there materials you would like to start using that you don't currently have access to with your existing process? ASA, PC, Nylon, and Nylon Carbon Fiber are a few common materials used within automotive that are available with the METHOD Series.

STEP 3
Identify you team

What is the makeup of the team that will be using 3D printing? Are you a single user who is looking to try the technology for the first time? Do you have a small team of people who would be the primary users? Perhaps you are looking to implement 3D printing across the organization.

STEP 4
Calculate ROI

ROI is always important when investing in a new technology. Luckily with 3D printing it's fairly straightforward. You just need to take the jobs you do right now and break them down into the basic elements like cost (materials, labor) and time (to receive part). The MakerBot METHOD ROI Calculator provides you with a better idea of cost and time savings with 3D printing. You can also determine this for your exact application by figuring out how many jobs you do on an annual basis and what that costs. Typically, outsourcing is fairly expensive by job so most companies limit the number of jobs they can do to stay on budget. 3D printers take very little labor time which is another huge cost saver.

STEP 5
Identify budget

Once you've identified ROI, you're ready to create a budget for a 3D printer. A good networked professional desktop 3D printer like the MakerBot METHOD will range from $4000 - $8,000 depending on add ons. If you have a large team or organization who will be using the technology, you'll want to consider multiple machines to increase throughput. A single project may warrant the budgeting of a printer, but it's also not uncommon to use normal operational budgets, end of year funds, or even one-time p-cards to obtain a 3D printer.

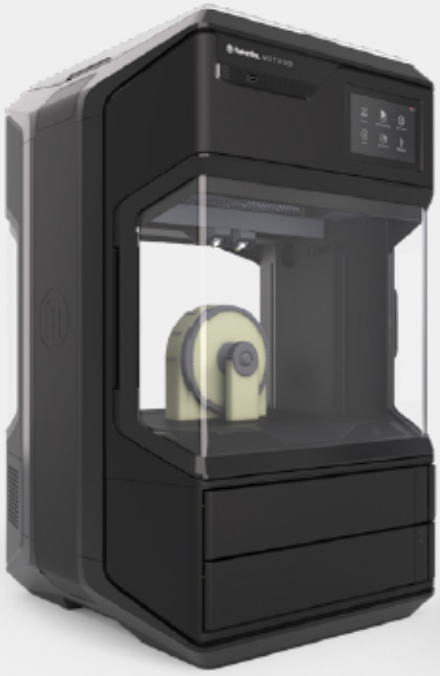
STEP 6
Talk to an expert

There are a variety of options for 3D printers and you probably have many questions. Talk to someone who works with automotive customers on a daily basis and understands your application and 3D printing. A MakerBot sales representative is always available to help determine if the technology is right for you, help you choose the best solution, and provide a quote for your 3D printing needs.

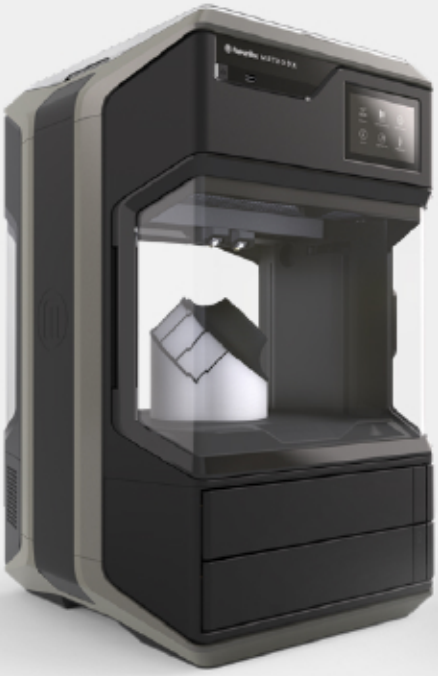
MakerBot

METHOD

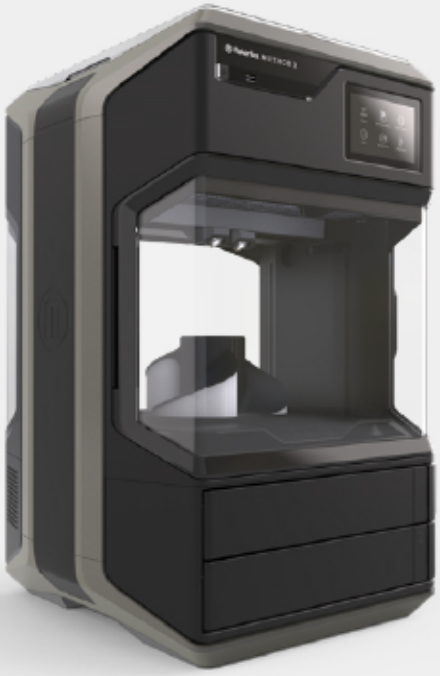
Industrial 3D Printing for Every Engineer



METHOD



METHOD X



METHOD X
CARBON FIBER EDITION

Print all the materials in this guide and more on METHOD

MAKERBOT.COM/METHOD/

POLYMERS

COMPOSITES

METAL

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