

CP124007

3D Printing and Prototype Development with Fusion 360

Steven Schain – Post Production Supervisor / M & E Content Producer

Jerry Berns – Manufacturing Content Manager

4D Technologies

Learning Objectives

At the end of this class, you will be able to:

- Understand where Fusion 360 fits into the prototype development process
- See how 3D printing can accelerate the design review process
- Learn how to use Fusion 360 to continuously modify a model, saving time on redesigning a part
- Identify the differences between design for manufacture and design for 3D print

Description

3D printing has revolutionized the design and manufacturing production workflow, making the creation of design prototypes as easy as pushing a button. Fusion 360 software has become an indispensable tool in this revolution, letting designers and engineers create and iterate their designs faster than ever before. This course will step through the process of developing, printing, and iterating the design of a real product prototype—learning the different phases of the design used to create a 3D-printable final product. Fusion 360 and Print Studio are used every day for a variety of purposes, from the office, to the house, to production and marketing. This course will explore the creation of a unique spinner toy that you can assemble, personalize, and take home with you. This session will feature Fusion 360, Print Studio, and a live 3D printing demonstration.



Your AU Experts

Steven Schain is the post-production supervisor for all CADLearning products from 4D Technologies, as well as the content development manager of CADLearning's Media & Entertainment products for Autodesk, Inc. software, including 3ds Max and Maya. In 1998, Autodesk recognized Steven as one of only 16 Autodesk Training specialists worldwide. He has since contributed to Autodesk's certified courseware for 9 releases of 3ds Max, was a co-developer of Autodesk's ACI Program and 3ds Max's fundamental standards, and is currently an Autodesk Certified Instructor. As a premier Autodesk trainer, he has continued teaching end users, companies, and many others, including The Walt Disney Company, Guess, and the United States Army. As a 7-year veteran of Autodesk University, Steven has taught classes ranging from creating particle fountains in 3ds Max, to classes on 3D printing and entrepreneurship.

sschain@cadlearning.com

Jerry Berns is the manufacturing content manager for all CADLearning manufacturing products from 4D Technologies, developing on-demand learning material for Autodesk, Inc., software users, including Inventor software and Fusion 360 software. An Inventor Certified Professional and Autodesk Certified Instructor, he has amassed a wealth of expertise at engineering firms and Autodesk value added resellers (VARs) in the implementation, use, and support of Autodesk products since 1985. Jerry has worked at a number of Autodesk Resellers, working with hundreds of clients, including several Fortune 100 companies. Since 2006, Jerry has presented several times at Autodesk University, earning a Top Rated Speaker award in 2013.

jberns@cadlearning.com

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Introduction

Autodesk Fusion 360 software is an Autodesk product for the creation of a wide range of manufactured parts. From consumer products to industrial tooling, to assembly line fixtures, 3D design has been an integral part of reducing the overall time from concept to completion. With the introduction of 3D printing in the mid-1980s, the process of developing real parts from 3D CAD models became less expensive with shorter delivery times. This change was quickly recognized by designers as a way to get their prototypes back in their hands for testing sooner and at a lower cost than by outsourcing to a machine shop, or by trying to make a simplified model in-house. Soon, 3D printing would revolutionize the prototyping process altogether.

Overview of the Prototype Development Process

Design and prototyping is an age-old process that remained largely unchanged through the industrial revolution. The essence of prototyping begins with an idea. That idea can be a product, part or complete system. No matter what it is, the stage between the idea and the actual prototype has been the weak link in most development cycles.

There are several reasons to create a prototype. Whether you are creating a functional prototype, creating one to capture user experience, developing a visual model, or a proof of concept, the process involves a physical model. That model begins as a concept, then must be made in some form to meet the requirements of the designer. These are not meant to be the production-ready parts, but they do represent a physical version of the idea.

Traditional Prototyping



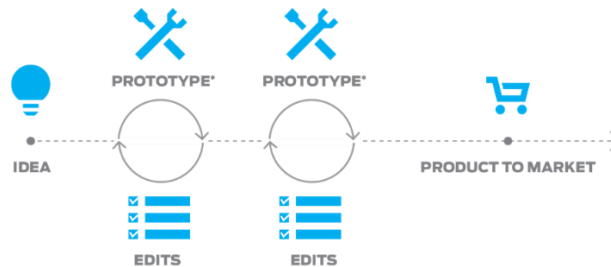
TRADITIONAL PROTOTYPE PROCESS. (IMAGE COURTESY OF MAKERBOT)

Traditional prototype creation can take days, even weeks to get a model built to specifications. Models were often made by hand from a variety of materials, like clay, paper, Styrofoam and a host of other options. These models were machined, were made on lathes, or on more modern CNC machines.

The problem is that the design process has to slow down to accommodate the prototype creation process, often leaving little time or money for redesigns and modifications. Cost is another issue that traditionally has limited the number of prototypes that can be created. Machining a part can cost hundreds, if not thousands of dollars.

Once the prototype is created, it can be tested and reviewed, then compared to the desired result. Edits and changes are then incorporated into the design, and the process is started all over again, taking more time and financial resources. With the traditional method of prototype development, many products get to market with flaws or design elements that are undesirable, or worse, cause the failure of a product after it has been brought to market and sold to customers.

Real-Time Prototyping (3D Printing)



REAL-TIME PROTOTYPE PROCESS. (IMAGE COURTESY OF MAKERBOT)

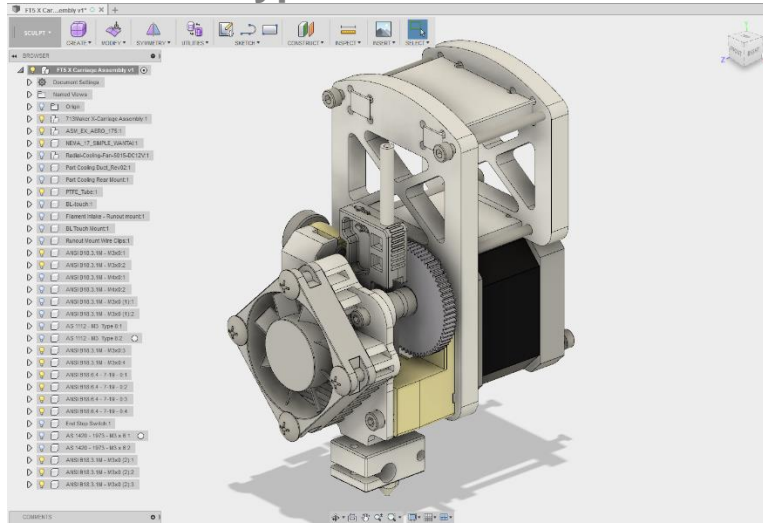
With the introduction of 3D printing into the design and engineering workplace, the prototyping process has undergone a dramatic change. No longer is the prototyping process the drag on the design of a part. Instead, it greatly enhances the process and reduces the time it takes to get a part from the idea stage to the production stage.

Instead of weeks to get a prototype back from being created, it now takes hours or days. Not only is the time reduced, but what once cost hundreds or thousands of dollars, now costs significantly less, even just a few dollars. The reduced time and cost allows designers and engineers to work in near real-time, with the design and prototyping functions happening at nearly the same time.

Real-time prototyping, with only a few hours separating the design from the prototype, is radically changing how designers and engineers work from day to day. With 3D printing, which is often located at or near a working design area, a product that in the past may have undergone two or three prototypes can now have a dozen or more prototypes created.

The increase in the number of prototypes and the reduction in cost have given designers and engineers a newfound freedom. Combined with the power of Autodesk Fusion 360, and its powerful features, you are free to create better, more tested designs than ever before.

Fusion 360 in the Prototype Process

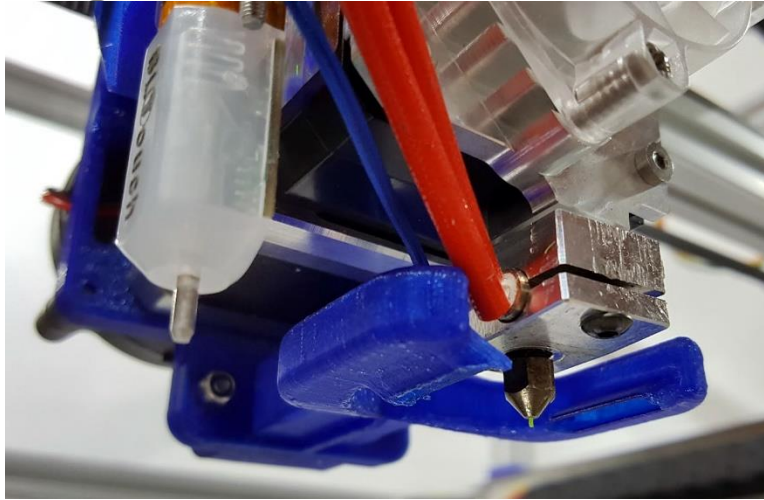


AUTODESK FUSION 360

Computer-assisted design has been evolving for more than half a century. Today's Autodesk Fusion 360 software, while building on those early CAD programs, is a highly advanced design and engineering tool. Fusion 360 can be used through all stages of the design process, from simple massing and form studies, to detailed simulation and analysis. It can even ready a part using CAM tools. Its advanced functions allow you to perform the entire engineering and virtual prototyping process in one software package.

While the advanced functions of Fusion 360 are extremely useful in the overall engineering process, it is in conjunction with 3D printing where Fusion 360 shines for rapid prototyping. Additionally, the ability to perform kinematic simulation and finite element analysis can ensure your parts will perform properly, but keep in mind that they do not replace a physical part.

Aspects of Design



FUSION 360 CPU COOLER

One aspect of design creation is the idea of form versus function. A digital model can be rendered to make beautiful 3D images that look real. Kinematic simulation can show you if an assembly will work through a series of parameters; and finite element analysis can tell you if the material you are using for manufacturing will withstand the forces that are applied. But, none of this replaces a physical model.

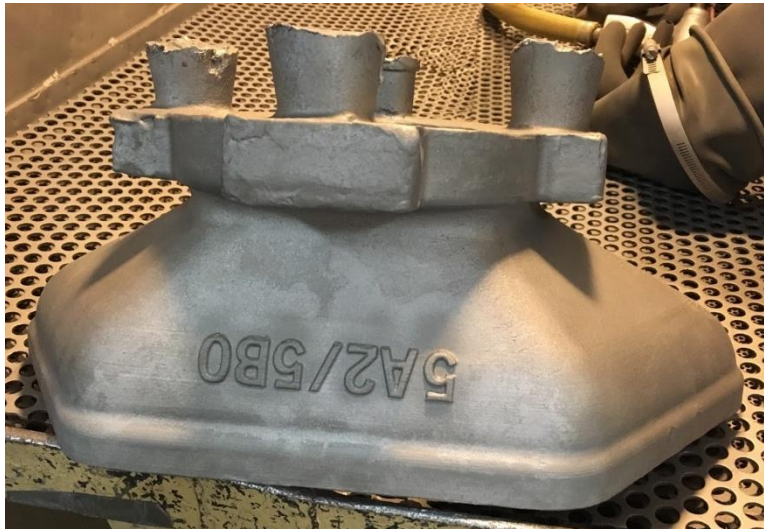
The ability to generate a 3d printable file, or STL, is not a unique capability. It's the combination of Fusion's modeling tools and a 3D printer that create a powerful one-two punch for the engineer and designer. One: design the part. Two: 3D print it and evaluate your design. Now you have the ability to touch the part, assemble multiple parts, and even create fully functioning prototypes from the 3D printed models.

Designing for Manufacturing vs. 3D Printing

A question often asked is, what's the difference between designing a part for manufacturing and designing a part for 3D printing?

While manufacturing is a low-cost way to make a large number of parts, for low-run production, it can often be cost-prohibitive. Manufacturing parts offers a way to mass produce parts that meet specific standards for material properties, tolerance and strength. And, even though the need for tooling, molds, and more, is costly, it is still the best way to make a million widgets with a low cost per part. The drawback is that the design is locked in. Changing the design mid production can be both time-consuming and expensive.

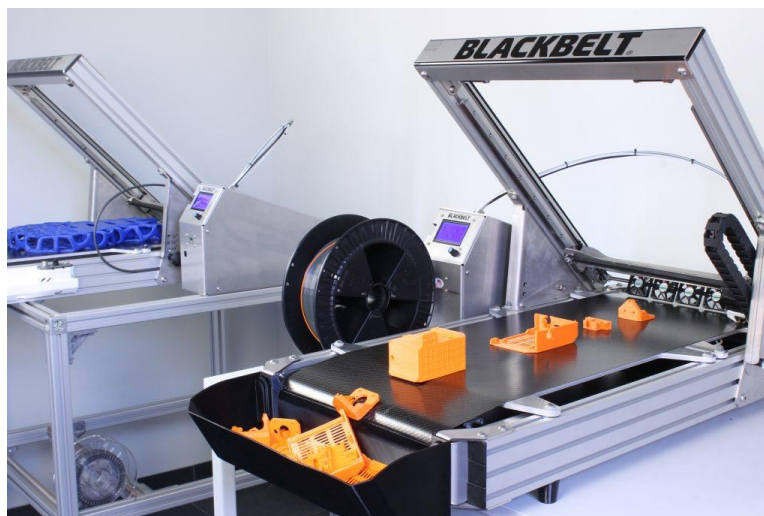
When it comes to the design of a part for manufacture, the part must be able to be manufactured. Mass producing a part can be performed in a variety of ways, from molding and casting to machining and stamping. The one thing all these processes have in common is that the parts designed for each of them must fit a specific set of criteria for the process. When designing these parts, there are certain things that just can't be done. And, depending on what manufacturing process you use, those issues will require you to design parts within limited parameters.



PART CREATED USING INVESTMENT CASTING. (SPECTRA3D TECHNOLOGIES)

3D printing, on the other hand, has come a long way since the early days of Charles Hull's SLA printer. 3D printers are able to build parts using an ever-increasing number of materials. Those materials range from basic PLA or ABS plastic to carbon fiber and a host of high-strength metals. But it's not only the materials that make 3D printing an alternative to traditional manufacturing, the printers themselves have been steadily getting faster and more capable.

The manufacturing revolution we are experiencing is because of 3D printers and their ever-increasing capabilities. For example, printers are now able to create parts with unlimited length using a continuous printing method. Full-color printing has made it to the desktop; and multi-axis 3d printers are changing the way parts are produced.



BLACKBELT 3D PRINTER, CONTINUOUS PRINTING. (BLACKBELT 3D)

Along with increased capabilities, the cost of printers and materials has dropped significantly in the last 5 years. Now, one person working from their house can be a mini manufacturing company, taking orders and printing small run parts as effectively as large manufacturing firms.

3D printers also create a more flexible manufacturing environment, enabling designs to be easily changed and lowering costs for short runs.

Because 3D printing can create nearly any part, no matter how complex, designing for 3D printing frees you from the limitations of traditional manufacturing processes. However, when designing for 3D printing, you're not completely free to create anything your imagination can come up with. While the rules of design are much more relaxed, there are still limitations. And, like traditional manufacturing, those limitations will depend on the 3D printing process. Even with these limitations, 3D printing opens doors for designers and frees them from the restrictions of the past.

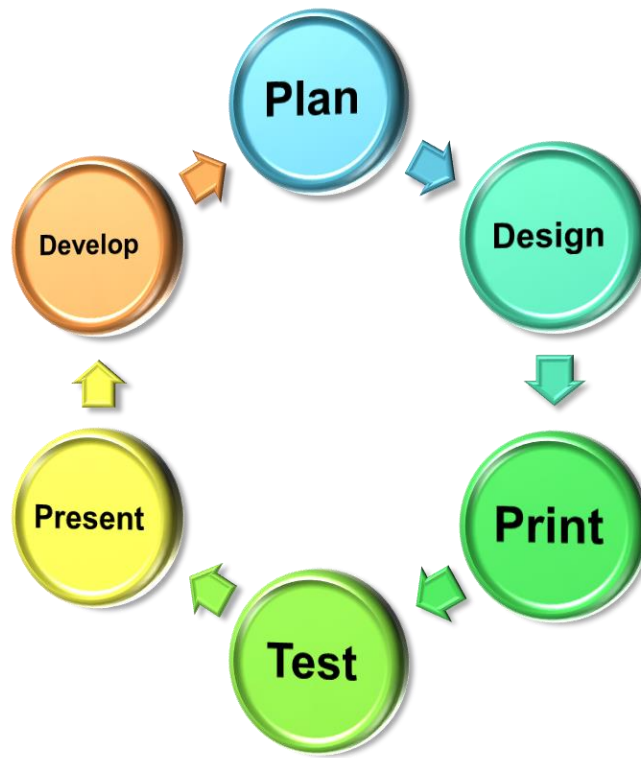
Printing an Impossible Part



THE IMPOSSIBLE PART, COURTESY OF MAKERBOT

While 3D printers have started to take hold in the manufacturing space, they have one capability that no manufacturer has. They have the ability to 3D print models that would be impossible to manufacture using any traditional techniques. Since Fusion 360 doesn't limit you to modeling only specific types of models, you are free to experiment. You can even print complete working assemblies in one print, no assembly required.

3D Printing and the Prototype Process



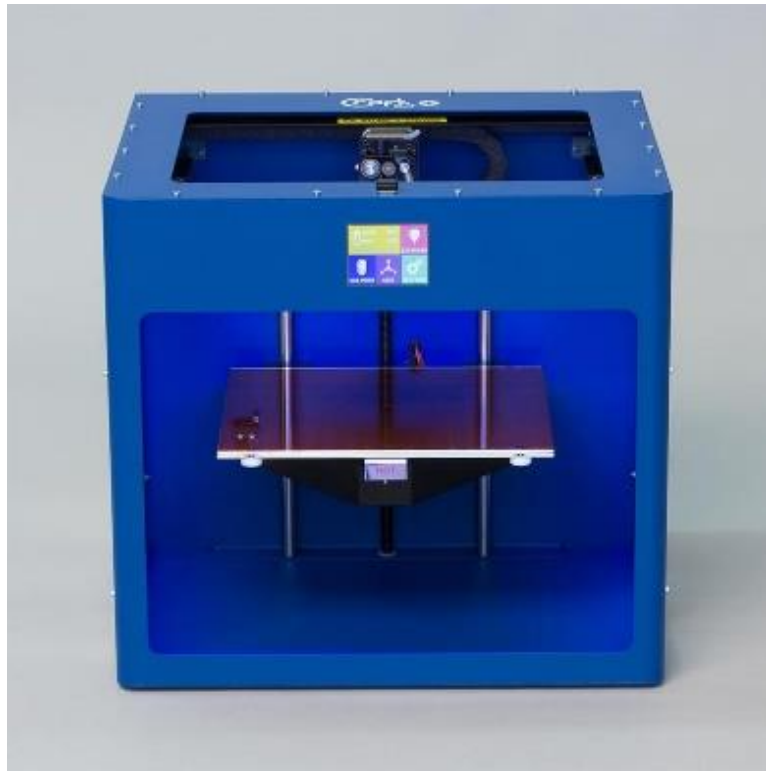
THE 3D PRINTING PRODUCTION CYCLE

The process of developing a prototype is a critical step in the development of a product. Whether it's a product for manufacturing, or a one-off part for a project, prototyping is a step that should not be overlooked. Today, everyone can get access to a 3D printer. If there is not one in your office, you can find one online through websites like 3D Hubs (www.3dhubs.com).

The 3D printing based approach to prototyping is to create as many design iterations as is needed to develop the design and perfect the product. However, there is a practical limit to the number of design iterations you can run through. These limitations will be determined by time, budget, field testing, and review by stakeholders.

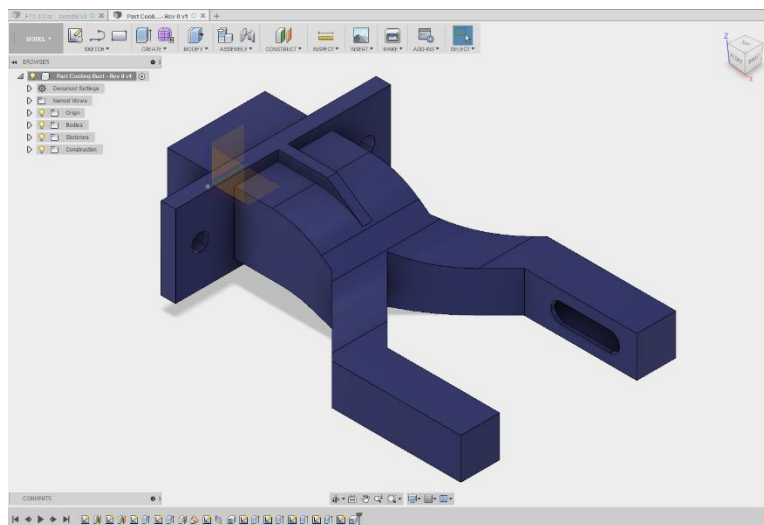
Redesign

While working through the prototyping phase of the development process, you may redesign a part several times for various reasons. The part for this class is designed to be a functional add-on to a Folgertech FT-5 3D Printer kit. The initial prototype, printed from PETG on a Craftbot Plus 3D printer, was fit tested and evaluated for functionality.



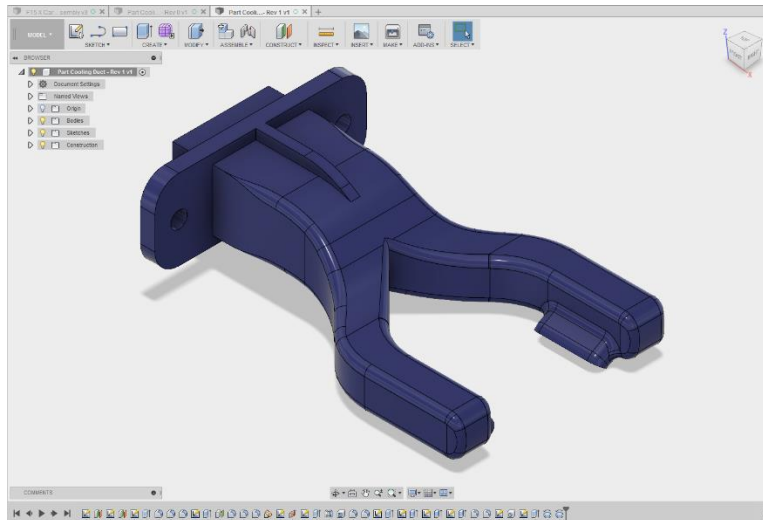
CRAFTBOT PLUS, FDM 3D PRINTER

The feedback from initial fit and feature tests determined the original design was too simple and not entirely functional. So, the Fusion 360 design was modified.



INITIAL PART COOLER DESIGN, REVISION 001

After some rework, a second prototype was 3D printed using the same Craftbot 3D printer. While the design was a little different, it still lacked the desired functionality. There's more work to do on this part yet!



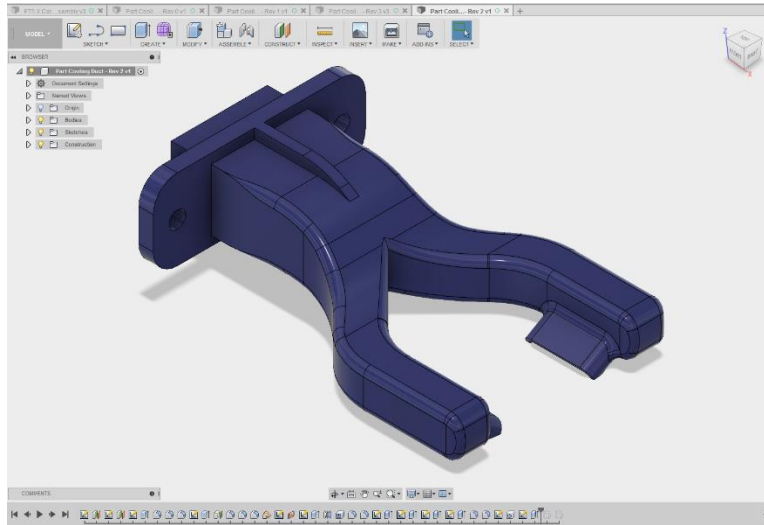
PART COOLER DESIGN, REVISION 002

Modifying an Existing Model

When creating revisions to an existing part, you have several choices as to how you handle the file management for each of the revised files. If you are using a tool like Vault with AutoCAD or Inventor, tracking the revision of the part file is handled by Vault. If you don't use Vault or some other management tool, you can use a simple file naming convention that works for your project. Since it currently does not work with Vault, Fusion 360 provides a simple project management interface. You are able to access previous versions of a part; however, it does not provide revision control or tracking. If you need PLM (Product Lifecycle Management) you should consider researching Autodesk Fusion Lifecycle (<http://www.autodeskfusionlifecycle.com>) to see if integrating it will work with your Fusion 360 file needs.

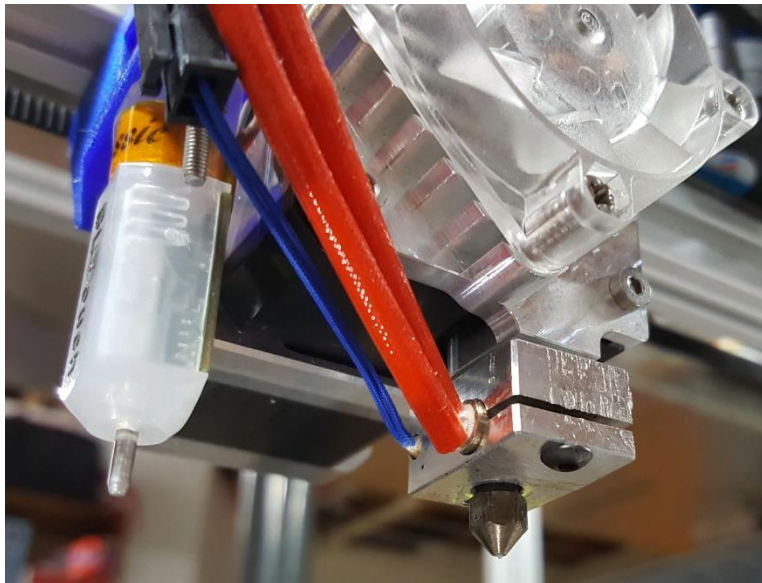
When you get the feedback from your prototype evaluations, most likely there will need to be changes to the geometry, some simple or some dramatic. This is where you have a few choices. One, you can start from a base model and rebuild it from scratch—a time-consuming process, but often times necessary. Or two, you can use the existing model and use the tools available to modify the part as needed. For most designers, this is the preferred method. However, it's not without its drawbacks.

Modifying an existing model can have some unintended consequences. When running back through the timeline in Fusion and modifying features, changes made earlier in the timeline can cause modeling errors or even just break a feature altogether. By carefully modifying features, using the direct edit feature and adding additional features, you can make changes quickly and without causing unintended errors.



FUSION INTERFACE WITH PART MODIFICATION TIMELINE.

The Project



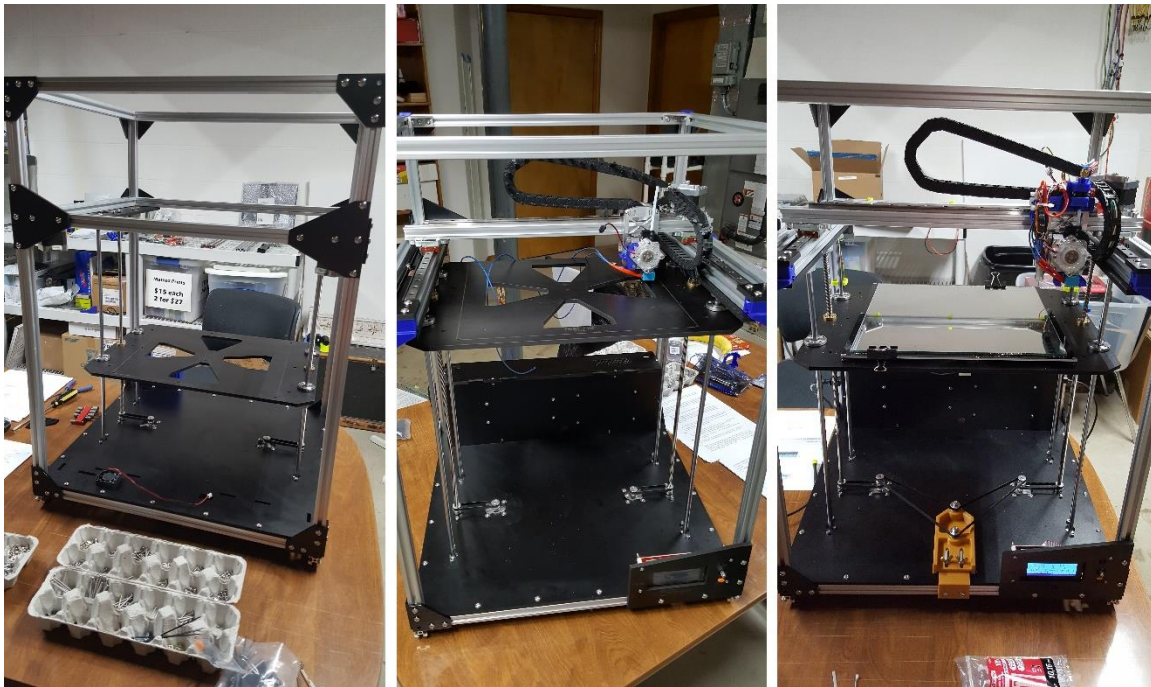
FOLGERTECH FT-5 PRINTER WITHOUT PART COOLING FAN

Project Overview

This project was an idea that was developed to solve a problem when working with certain materials like PLA, that require extra cooling while printing. The 3D printer is a Folgertech FT-5 kit, that requires the user to assemble it from scratch. During assembly, the FT-5 stock print head was upgraded to an E3D Titan Aero, compact print head, along with a 713Maker.com aluminum X carriage. After looking at several part cooling fan/duct models available online, none fit the specific needs of the upgraded printer configuration. The free models either didn't fit or function properly, so a custom solution was needed.



FOLGERTECH FT-5 PRINTER PARTS READY TO BE ASSEMBLED



FOLGERTECH FT-5 ASSEMBLY.

From the beginning, the final production method was to be 3D printing. Because of this, the part needed to be designed with that in mind. Elements like overhangs, fillets, interior spaces, print orientation, and the need for support all needed to be considered.

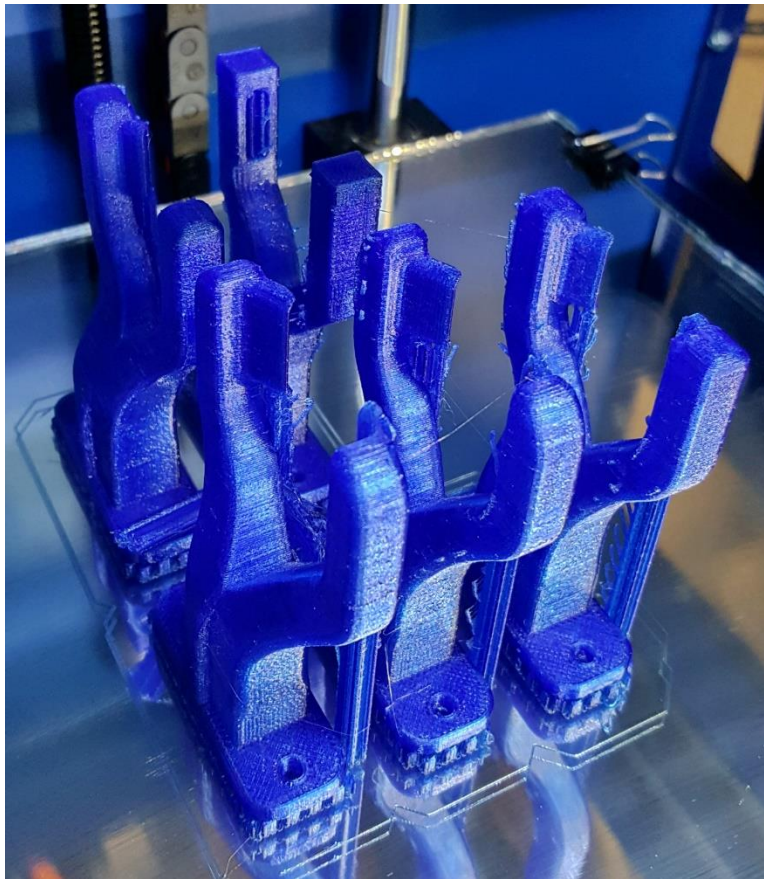
Project Requirements

The project requirements were based on the intended use and mounting of the part cooler. The primary requirement was to provide sufficient cooling of printed material, without cooling the print head itself. A second requirement was the cooling device could not interfere with the movement of the print head. A third, is that it must remain clear of the part being printed.

Limitations

The main limitations are size, mounting, and fan type. The fan type selected was a centrifugal fan, due to its compact size and airflow volume. The size of the cooler and ducting needed to fit within a specific size envelope. Too far to one side or the other could potentially interfere with the motion of the print head.

Other limitations come from the Craftbot printer itself. Because it is an FDM, single nozzle printer, supports are printed along with the part, and should be easily removeable.



PRINTED PART COOLER SAMPLES BEFORE CLEANUP. PRINTED ON THE CRAFTBOT PLUS 3D PRINTER.

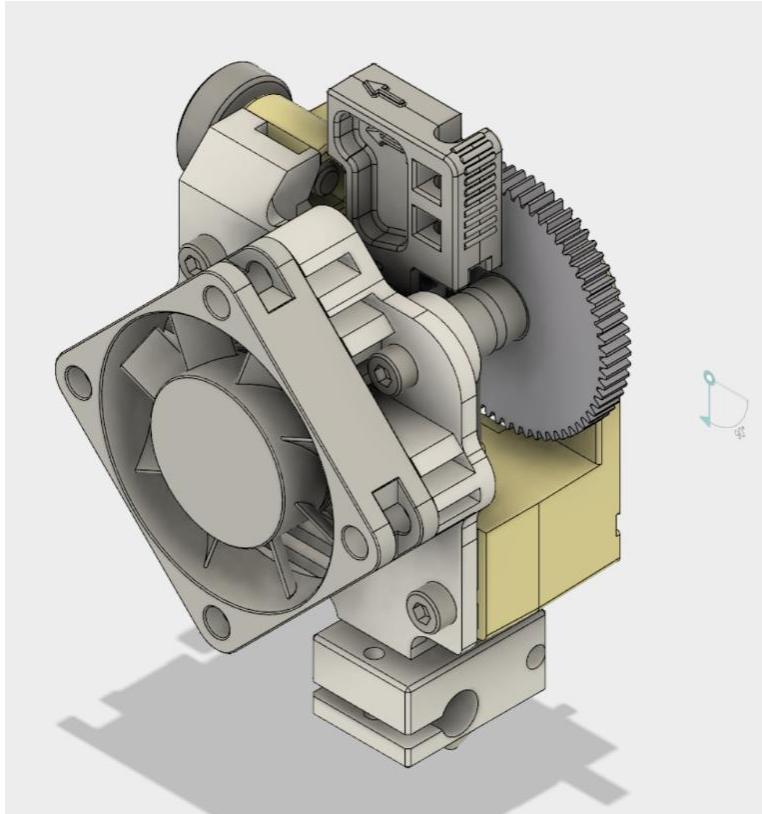
The Design Process

Mounting Bracket and Duct

When starting the design process, it's a good idea to create a detailed model, or have precise measurements of what the final part is going to be attached to. In this case, what was needed was a detailed assembly of the print head. The first steps are to gather and model the needed parts for the print head assembly.

Building the Print Head Assembly

Assembling the print head required finding or modeling the components. Whenever possible, it's easier to find premade parts online, either through manufacturer sites or community sites like GrabCAD. Even though you get the parts, you still need to measure and verify the CAD files are accurate. Parts that cannot be obtained need to be created. Again, accurate measurements are critical to the success of the overall design.



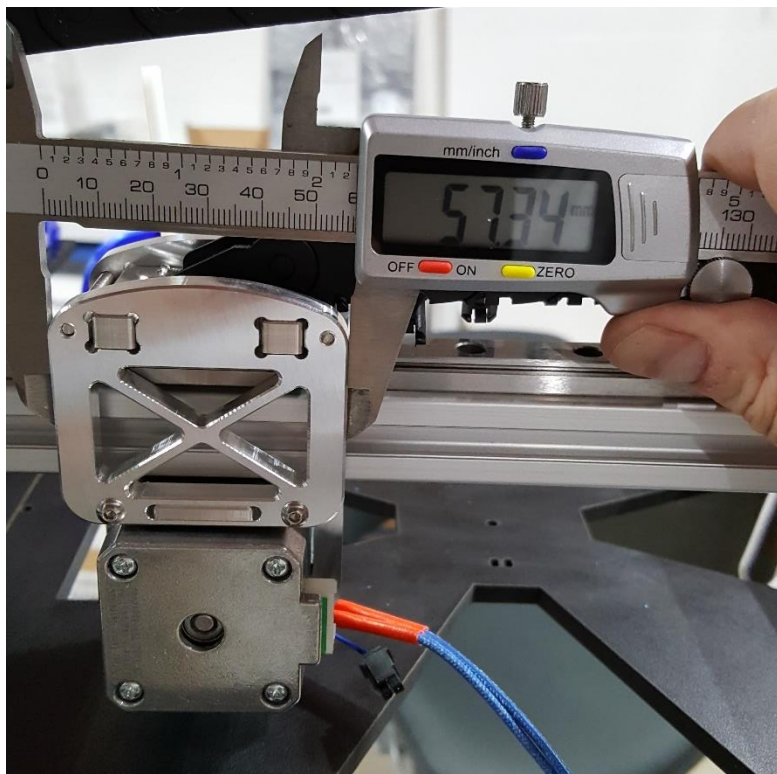
CAD MODEL OF THE E3D TITAN AERO PRINT HEAD ASSEMBLY. (COURTESY E3D)

Measuring the Assembly

While reference photos are very useful for making rough measurements and roughing in distances, to acquire the most accurate dimensions, it's best to use a set of calipers.



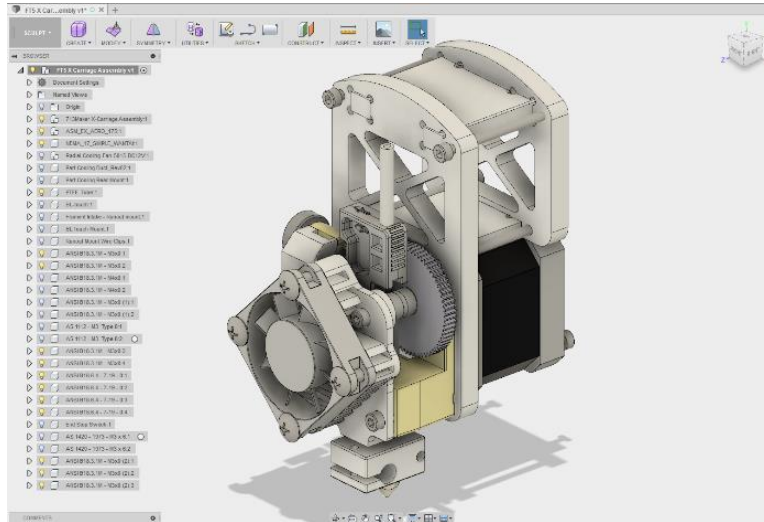
A GOOD SET OF CALIPERS CAN GO A LONG WAY.



TAKING MEASUREMENTS

Developing a Reference Model

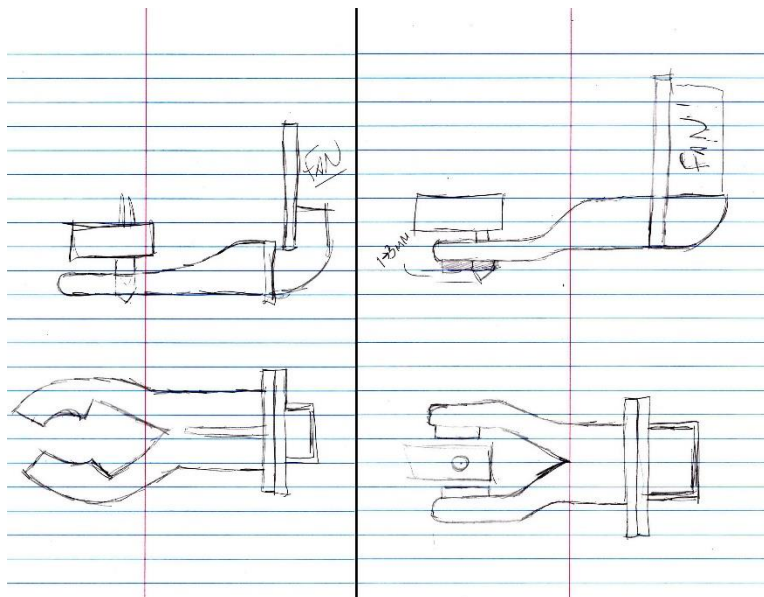
The next step was to create a reference model that could be used as the base from which to build the bracket and duct.



PRINT HEAD ASSEMBLY REFERENCE MODEL

Getting Ideas

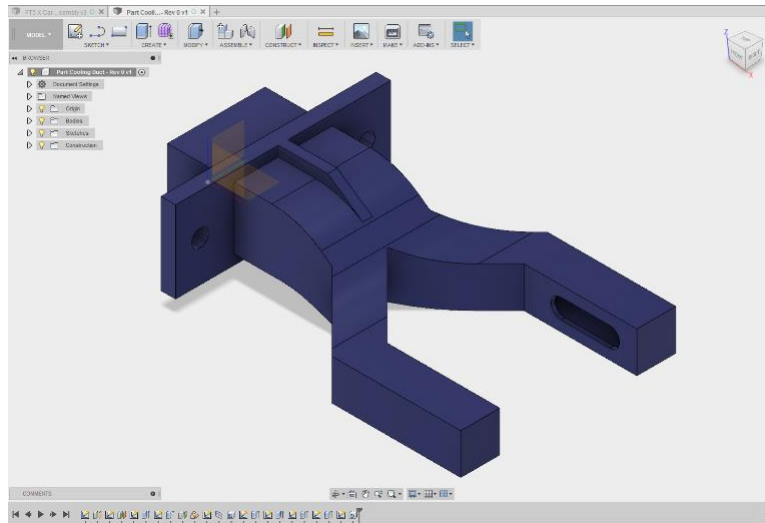
While this is the first step in the overall design process, it's important to take some time to develop your ideas. One of the best ways to do that is to use a pencil and paper for your initial sketches. When creating your sketches, quality is not important, as at this stage, you want to just get your ideas out. Then, you can add details later.



TWO SIMPLE DESIGN SKETCHES

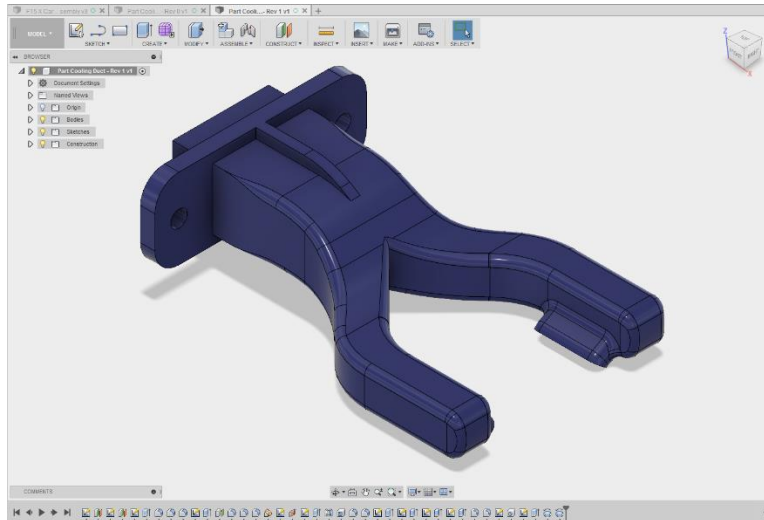
Creating the Initial Prototype

As a designer, the most satisfying and rewarding times are when you start working to create an initial prototype for your idea. Once you have a sketch or two and some known dimensions, you can determine the best approach you will use to develop the model. Creating rough models can help with this process, and it is at this time that you can be free to experiment with the methods you are using. If the design doesn't work, it's okay; just move on and begin again. The important thing is not to take a lot of time to create the initial model.

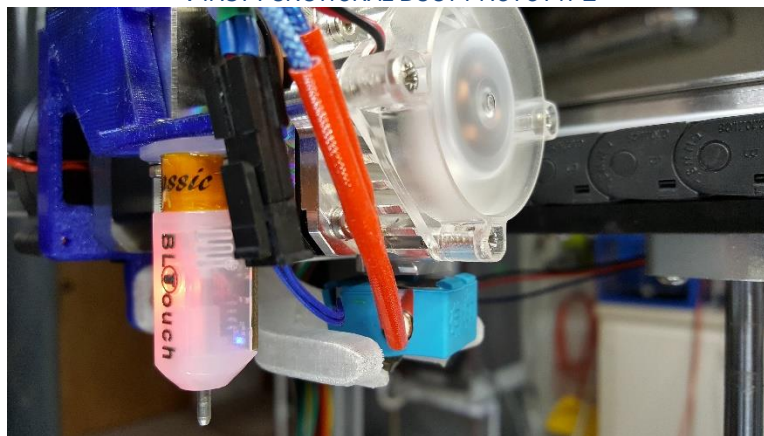


A SIMPLIFIED VERSION OF THE FINAL DESIGN

Once an initial version for the design is decided on, it's time to create the first prototype. With the first prototype complete, the model is exported, test printed, and evaluated. After fitting the parts and ensuring they fit correctly, a part was printed to test airflow and functionality. Based on the first test, it was determined the outlet ports needed to be adjusted so the nozzle wouldn't get cooled along with the printed part.



FIRST FUNCTIONAL DUCT PROTOTYPE

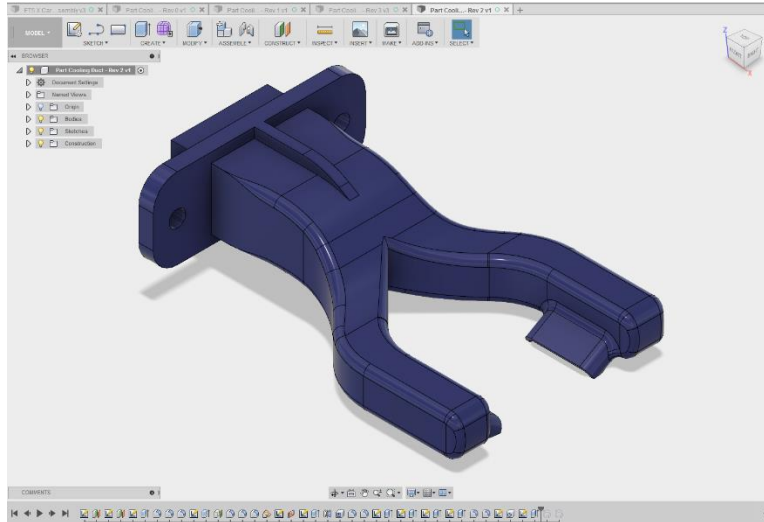


FIRST DUCT PROTOTYPE, TEST FITTING AND EVALUATION

Iterating the Design

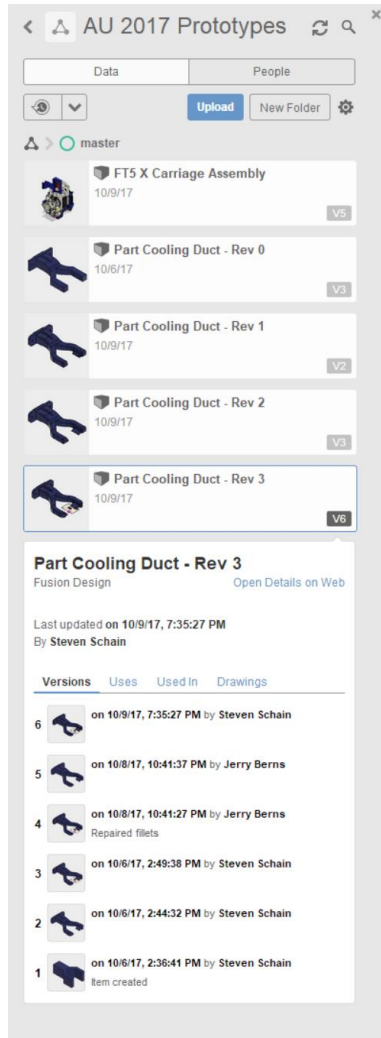
With the initial design ideas printed and tested, it was time to make changes. The changes can be simple, or the entire idea can be scrapped and a new design can be created. Depending on how different the designs are, you may want to just start from a new design file.

Other design changes can be done without creating a new file. One of the great features of Fusion 360 is the ability to go back through the construction history of your design and make changes. Some of those changes may just be changing the size of a sketch element, whereas other changes will alter the design significantly. When this happens, it's a good idea to save the design as a new file.



A NEW VARIATION OF THE ORIGINAL DESIGN WITH EXTENDED OUTLET PORTS

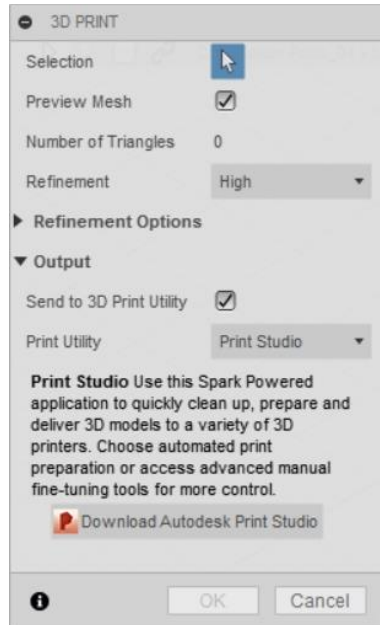
A note about Fusion 360 and design history. When you save a file in Fusion 360, you can name that particular saved version. This keeps a running tally of the versions of your design each time you save the file. The initial view shows you the last three revisions; however, you can go all the way back to the first version if you need to.



PART COOLING DUCT REV 3 INFO PANEL

Exporting the Models

Once the initial design was to a point where it was ready for initial testing, the parts were ready to be printed for fit testing. Fusion 360 provides several methods of getting a part out to a 3D printer. When you choose the 3D Print option from the Save menu, you are presented with the 3D PRINT dialog.

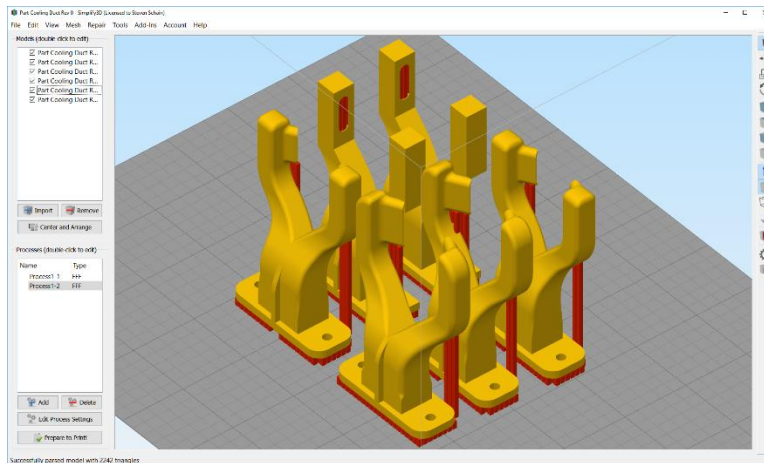


3D PRINT DIALOG

There are several options for printing models out of Fusion 360. The first is to send the file to a print utility that is installed on your computer, such as Print Studio. The default is Autodesk Print Studio, however, you can use other programs as well, like MakerBot Print. The other option is to uncheck the Send to 3D Print Utility option and save directly to an STL file. This method is the simplest to use, since all the 3D printers that are being used for printing the parts use their own slicer software.

3D Printing the Prototypes

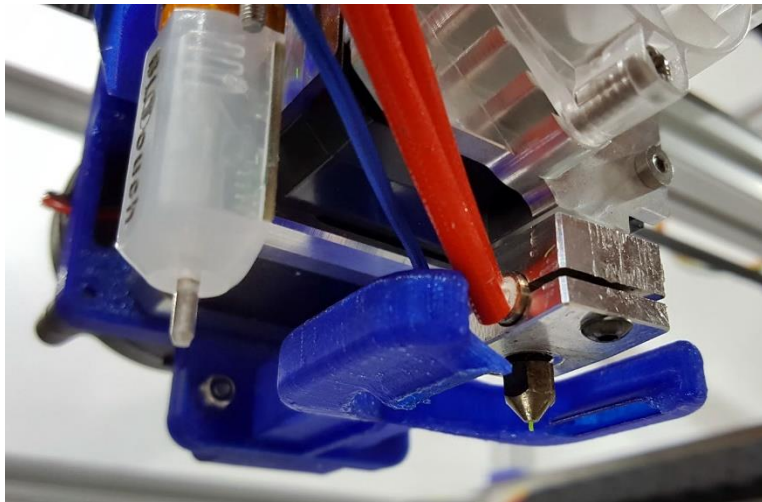
Once the design is at a point where you want to print the current version, you're ready for printing. The next step is to take the STL file into the slicing program needed for the chosen printer. For the Craftbot Plus, it's Simplify 3D. The slicing program prepares the STL file and generates a file that can be used directly with the 3D printer.



MULTIPLE ITERATIONS OF THE DUCT IN SIMPLIFY3D.

Fitting and Evaluating the Final Design

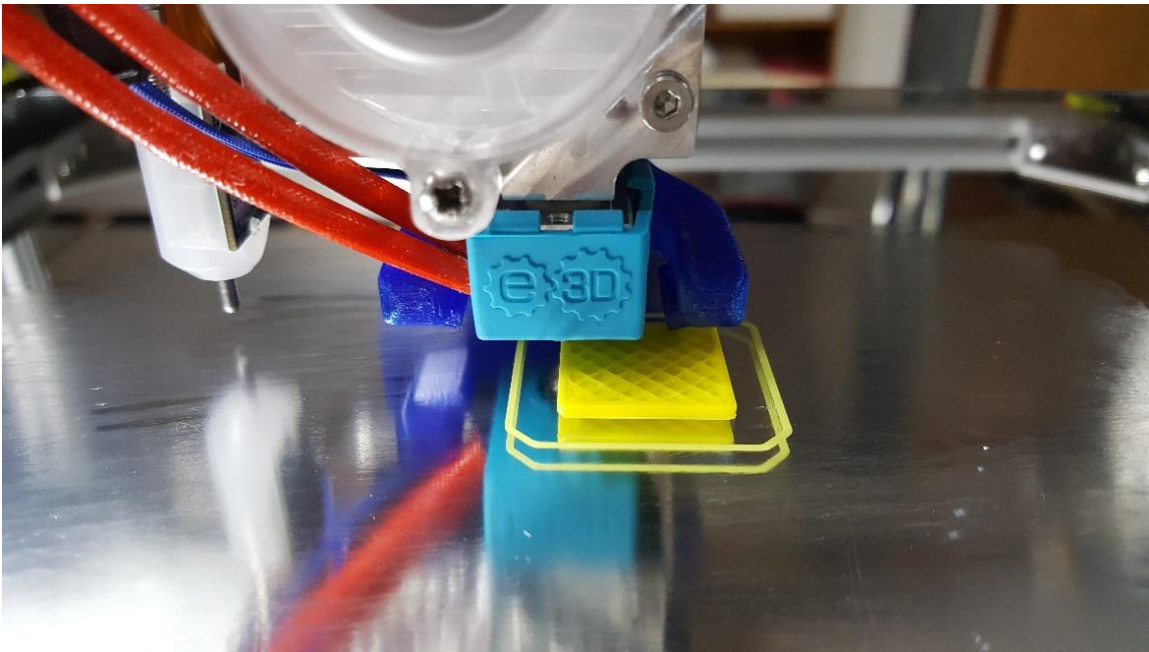
Each iteration of the part cooling duct was 3D printed and tested to ensure that the fit was good, and cooled properly. Once a final design is accepted, the part is then permanently installed and put to use.



FINAL DESIGN OF THE PART COOLING DUCT

Conclusion

With the availability of 3D printers for creating low-cost prototypes and the power of Autodesk Fusion 360, you can create designs with a freedom like never before. The prototyping process has changed from a linear series of tasks, where time and cost were major factors; to parallel functions with the redesign process incorporated. You can iterate a design faster than ever before and make those changes easier than ever before with the power of Autodesk Fusion 360.



PART COOLING DUCT INSTALLED AND FUNCTIONING

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