



MP20599

3D Printing and Prototype Development with Fusion 360

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Learning Objectives

- 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 is quickly becoming an indispensable tool in this revolution, enabling designers and engineers to create and iterate their design faster than ever before. This course will step through the process of developing, printing, and iterating the design of a real product prototype. There are products used every day for a variety of purposes, from the office to the house. This course will explore the development of a unique Autodesk University badge accessory that you can take home with you. You will step through the process of designing the product, learning the different phases of the design used to create a 3D-printable final product. This session features Fusion 360.



Your AU Experts

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Introduction

Autodesk Fusion 360 software is a recent addition to Autodesk's tools 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 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)

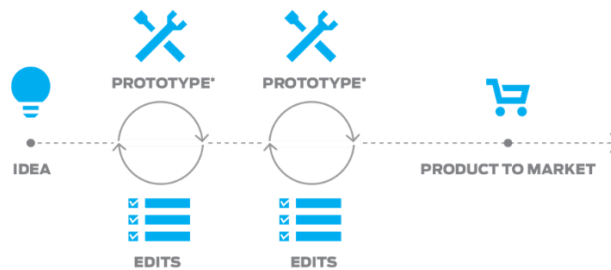
Traditional prototype creation can take days, even weeks to get a model built to specifications. Models were often made by hand from a variety of materials, like clay, paper, Styrofoam and a host of other options. These models were machined, were made on lathes, or on more modern CNC machines.

The problem is 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 underwent a dramatic change. No longer would the prototyping process be the drag on the design of a part. Instead, it would greatly enhance the process and reduce the time it took to get a part from the idea stage to the production stage.

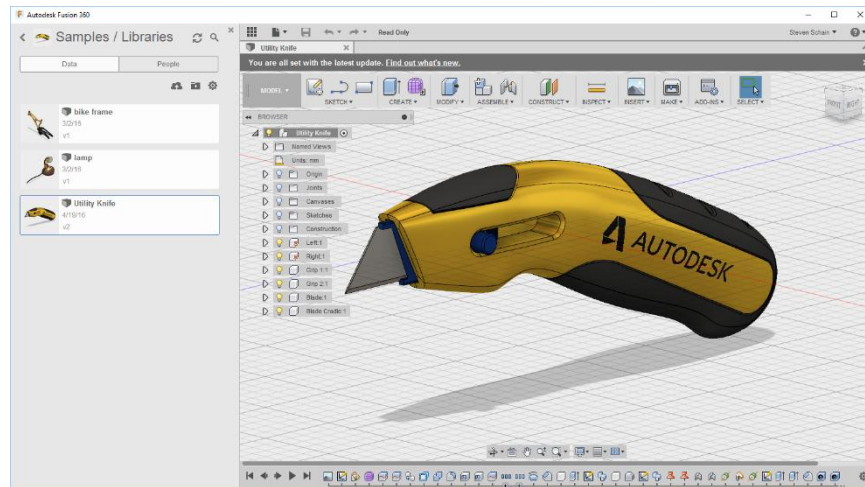
Instead of weeks to get a prototype back from being created, it now takes hours or days. Not only is the time reduced, but what once cost hundreds or thousands of dollars, now costs significantly less, even just a few dollars. The reduced time and cost allows designers and engineers to work in near real-time,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



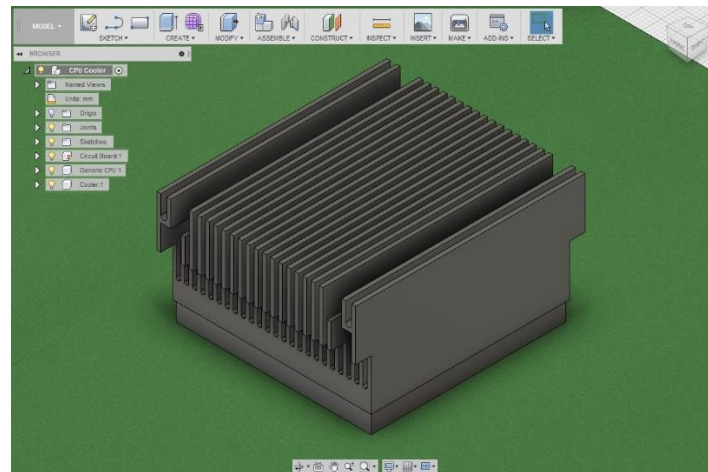
AUTODESK FUSION 360

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, 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 3D print a prototype 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.

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 costly.

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 cause you to design parts within limited parameters.

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

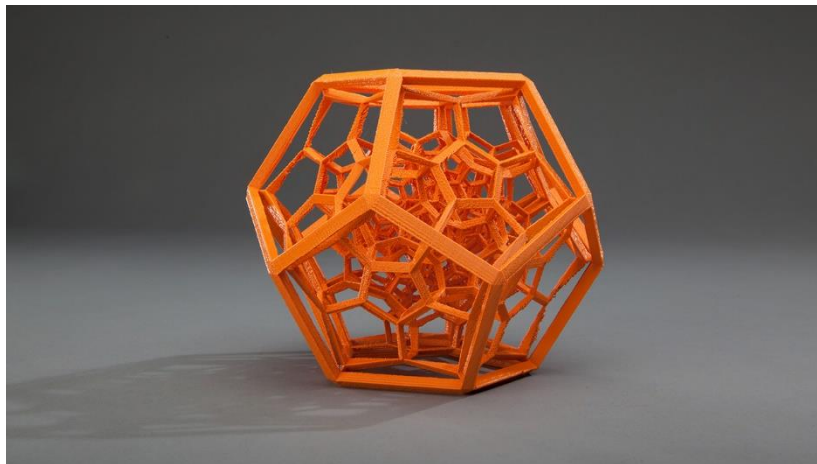


materials range from basic PLA or ABS plastic to carbon fiber and a host of high-strength metals. But it's not only the materials that make 3D printing an alternative to traditional manufacturing, the printers themselves have been steadily getting faster and more capable.

A manufacturing revolution is in progress because of 3D printers and their ever increasing capabilities. 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 run.

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

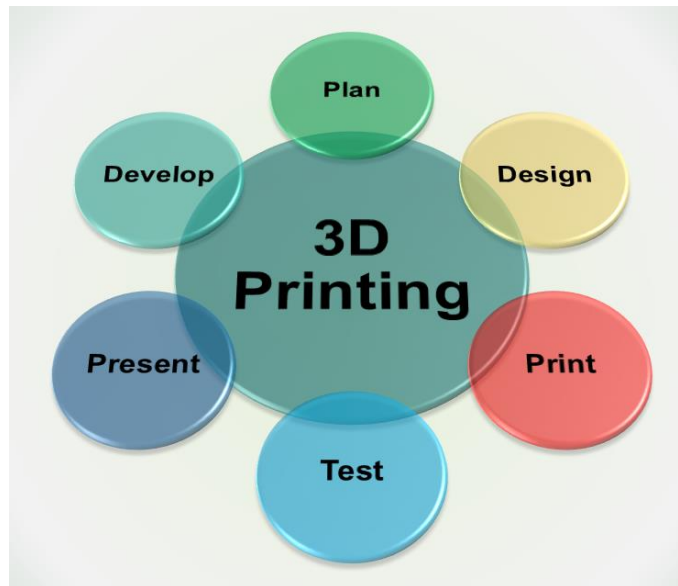


THE IMPOSSIBLE PART, COURTESY OF MAKERBOT

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. Now, there is a practical limit to the number of design iterations you can run through. That will be determined by time, budget and other issues, such as if the part needs to be put to use in the field or if it must be reviewed by others for ergonomics and other factors.

Redesign

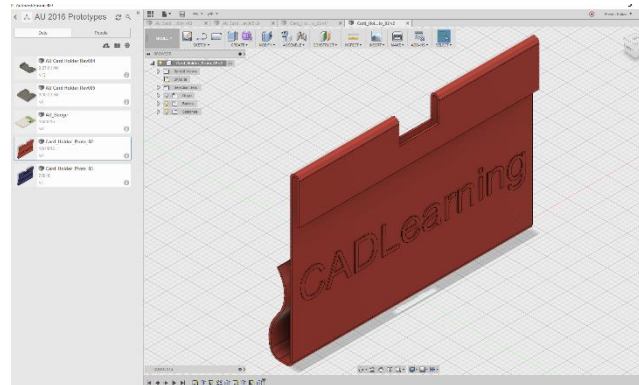
While working through the prototyping phase of the development process, you may redesign a part several times for various reasons. The part for this class is designed to be a functional add-on to the event badge. The initial prototype, printed from PLA on a MakerBot Replicator Plus 3D printer, was fit tested and evaluated for functionality.



MAKERBOT REPLICATOR PLUS, FDM 3D PRINTER

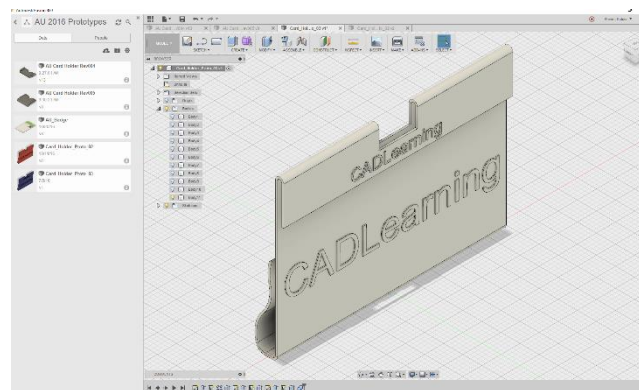


The feedback from initial fit and feature tests determined the original design was too simple and not entirely functional. So the Fusion 360 design was modified.



INITIAL BADGE ACCESSORY DESIGN, REVISION 001

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



BADGE ACCESSORY DESIGN, REVISION 002

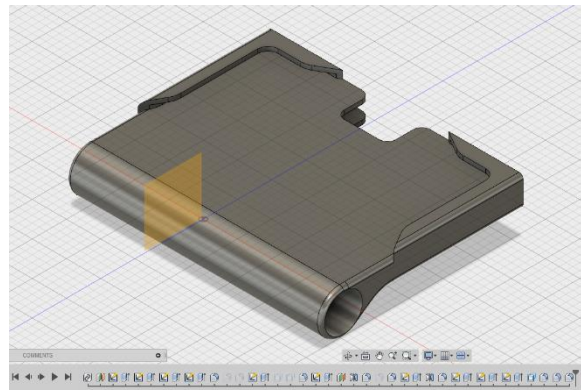
Modifying an Existing Model

When creating revisions to an existing part, you have several choices as to how you handle the file management aspect of changes. If you are using a tool like Vault, 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. Fusion 360 provides a simple project management interface to work with. But that only deals with the file itself, not the geometry changes.

When you get the feedback from your prototype evaluations, most likely there will need to be changes to the geometry, some simple and 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 errors.



FUSION INTERFACE WITH PART MODIFICATION TIMELINE.

The Project



AUTODESK UNIVERSITY 2015 BADGE, SAMPLE PEN AND 10 BUSINESS CARDS

Project Overview

This project was an idea that was developed to solve a simple problem when attending Autodesk University. The problem was to make it easy to either carry or collect business cards and be able to have a pen available when someone needed one. Part of the solution was the badge on the lanyard you get when you register. So the challenge was to create an attachment to the AU badge that accomplished the task.

From the beginning, the final production method was to be 3D printing. Because of this, the part needed to be designed with specific 3D printers in mind. The printers available were two



MakerBot Replicator Plus printers, one Replicator 5th Generation printer, one Craftbot Plus printer, and a uPrint SE Plus printer. However, the cost of printing with the uPrint made it impractical for this project, since there was to be enough parts made for each person in the class to get one, with a few extras.

To keep costs down and allow for printing the maximum number of holders, it was decided that the parts would be made from PLA or a PLA/PHA blend. With the material and printers identified, it was time to move on to the planning process.

Project Requirements

The project requirements were based on the intended use of the holder. The plan was that the attachment would be able to hold between 5 and 10 business cards, and a pen that can clip into the holder. Additionally, it needed to fit the badge easily and be comfortable to wear, light in weight and unobtrusive.

Limitations

The main limitations are size and weight. But, to make it comfortable is of the utmost importance. The other limitations come from the badge itself. Specific items on the badge cannot be covered up, such as the name and QR code especially. Plus, it cannot interfere with how the badge attaches to the lanyard. These are all considerations taken into account.

Other limitations came from the printers themselves and what their technical limitations are when printing. Besides speed, FDM 3D printers have limitations when printing parts that need to be supported. The support material, which breaks away on single nozzle printers, needs to be easy to remove.

The Design Process

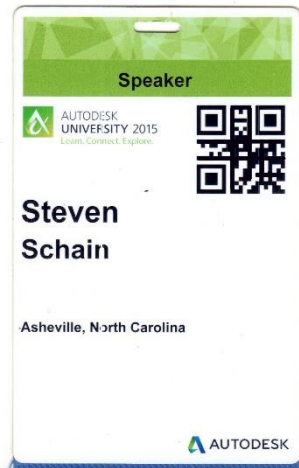
The Badge

In order to start the design process, it's a good idea to create a basic model of what the final product is going to be designed to. In this case, all that was needed was the badge. The first step is to capture reference imagery.



Capturing Reference Art

When capturing images for developing a reference model in Fusion 360, it's not critical that you take tens of photos from every angle. Just take the photos that will provide the details you need. In this case only a top view was necessary. If taken properly, reference art will make it possible to measure angles and distances.



SCANNED BADGE

Measuring the Badge

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

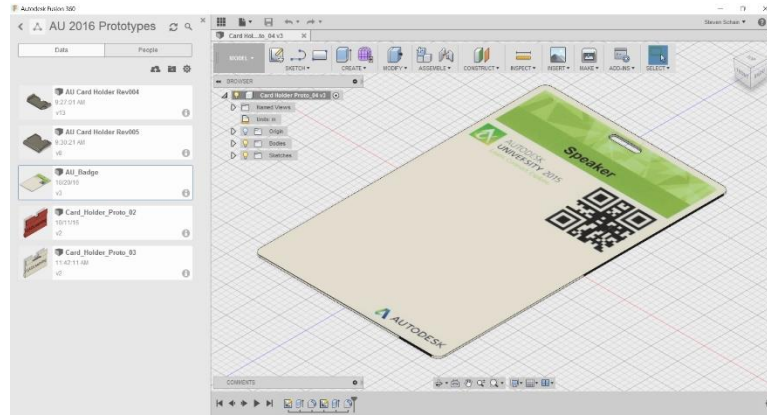


A GOOD SET OF CALIPERS CAN GO A LONG WAY.



Developing a Reference Model

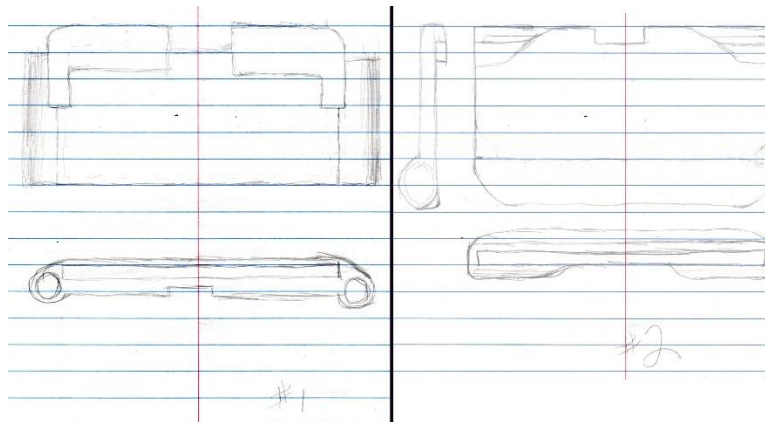
The first step was to create a reference model that could be used as the base from which to build the card holder.



AU BADGE 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.

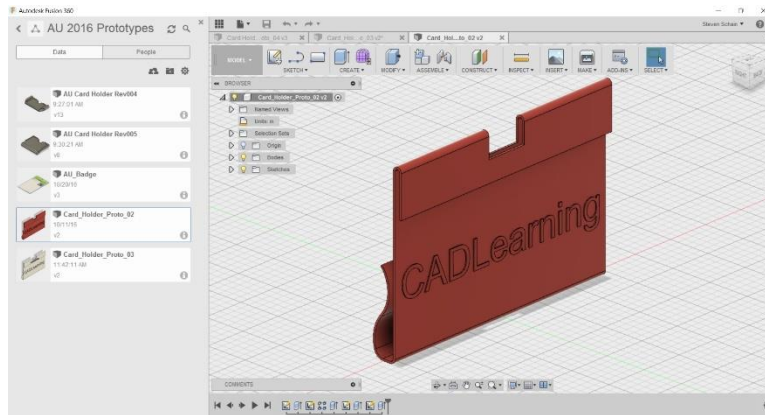


TWO SIMPLE DESIGN SKETCHES

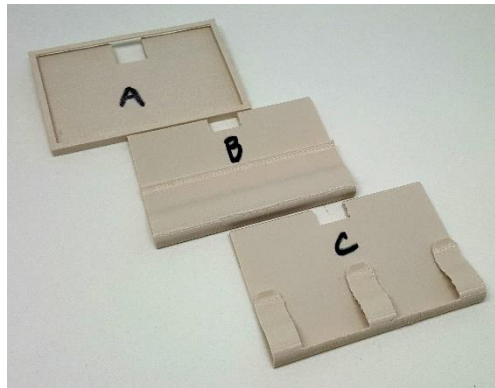


Creating the Initial Prototype

As a designer, there are times you start working in a direction with a prototype that looks like it will work. The first step is to create an initial prototype for your idea. That idea can be whatever you want it to be, it doesn't even have to be from your initial sketches. This is the part of the process where you can be creative. If the design doesn't work, it's okay; just move on.



After the design was test printed and evaluated, it was decided the finished part needed to be stronger. Since this was going to be banged around for several days, the initial design was prone to break too easily.

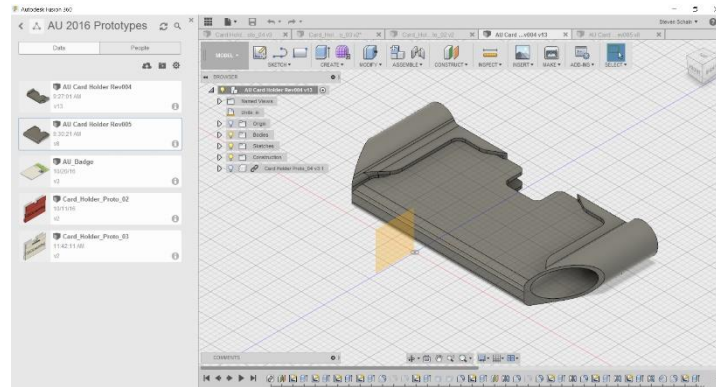


CARD HOLDER, TEST 1



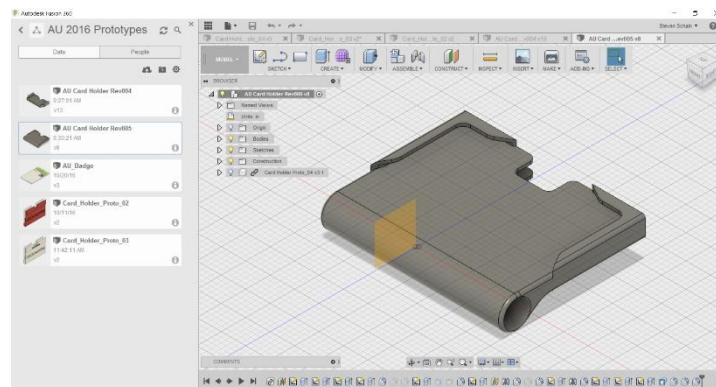
Iterating the Design

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.



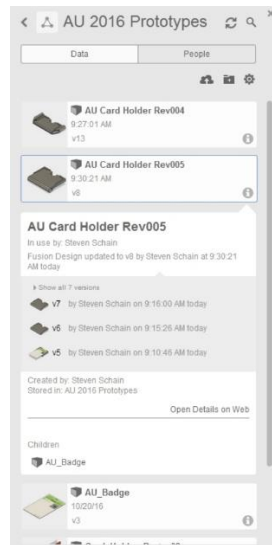
NEW DESIGN BASED ON INITIAL SKETCHES

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. Where 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 VERSION OF THE ORIGINAL DESIGN

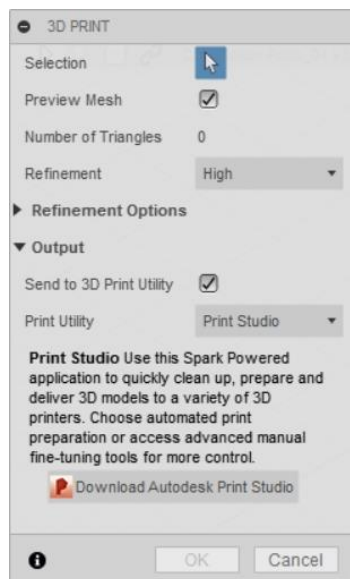
A note about Fusion 360 and design history. When you save a file in Fusion 360, you are able to name that particular saved version. This keeps a running tally of the versions of your design each time you save the file. The initial view shows you the last three revisions, however, you are able to go all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



CARD HOLDER 005 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

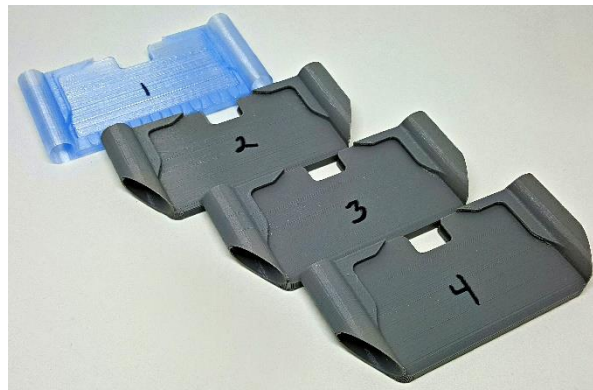
There are several options for printing models out of Fusion 360. The first is to send the file to a print utility that is installed on your computer, such as Print Studio. The default is Autodesk Print Studio, however, you can use other programs as well, like MakerBot Print. The other option is to



uncheck the Send to 3D Print Utility option and save directly to an STL file. This method is the simplest to use, since all of the 3D printers that are being used for printing the parts use their own slicer software.

3D Printing the Prototype

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 MakerBot Replicator Plus, it's MakerBot Print, and 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, PRINTED WITH PLA ON A MAKERBOT REPLICATOR PLUS.

Test Fit and Evaluation

Each iteration of card holders was 3D printed and tested to ensure that the fit was good. When interferences were found, or the fit was not correct, changes were made to the Fusion 360 model and a new print was tested.

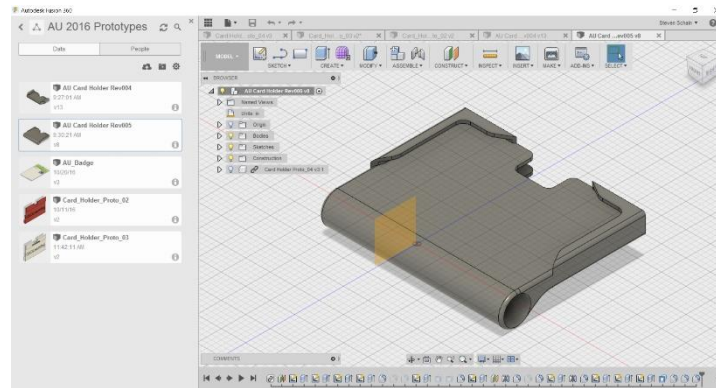


TEST FIT FOR REVISION 004 VERSION 10



Redesign

So far, the card holder has undergone several redesigns for various reasons. Some of the reasons are for the durability of the final part, others for fit and printability. Whatever the reason, Fusion 360 makes it easy to modify the design. There is one important thing to remember when making changes to a design: when you make a change that alters the geometry of the model, a sketch or modification further to the right in the timeline may no longer work and will need to be fixed.



CARD HOLDER REDESIGN

Conclusion

With the availability of 3D printers for creating low-cost prototypes and the power of Autodesk Fusion 360, you are able to 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.



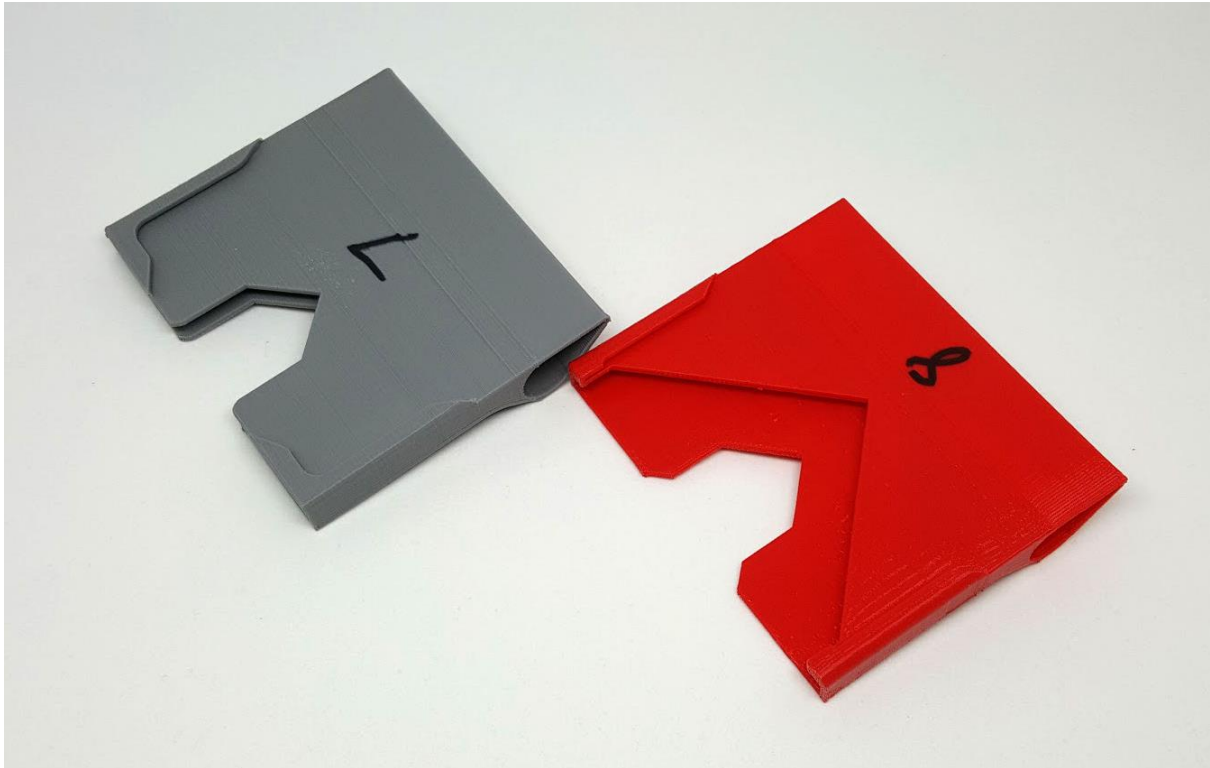
FINAL BADGE HOLDER DESIGN



Hold the Presses!!!!

Sometimes when you're working on a product you get some news late in the design process that changes a major part of the design. With this part, the design was based on the Autodesk University 2015 badge design with the clip cutout in the center of the badge. The major design change came only two weeks out from the 2016 event.

The change... The clips that hold the badge are now on either side of the badge. The problem is that there are no available measurements. The solution was to attempt to open the area behind the badge and hope the 2016 badge fits.



PROTOTYPE 7 REPRESENTS THE ORIGINAL DESIGN, 8 IS THE UPDATED DESIGN FOR THE NEW BADGE