AUTODESK UNIVERSITY 2014

3D Printing: An Entrepreneur's View

Steven Schain - Spectra3D Technologies - President

CD5192 Whether it's being used in rapid prototyping and consumer products or small-run manufacturing, 3D printing has become an important part of the workflows of many hobbyists, artists, engineers, and fabrication companies. This course will look at the landscape of the 3D printing industry in order to break through the hype that surrounds it. You will discover how 3D printing is being used in the real world for both personal and professional uses. From creating art to engineering prototypes, this course will also explore the expanding use of 3D printers and their place in an enhanced design workflow. The course discusses the current state and the future implications of 3D printing in the real world.

Learning Objectives

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

- Learn the process of rapid prototyping and its applications.
- Discover real-world applications of 3D printing and how you can make use of them.
- Discover tools available that can be used to create and deploy 3D printable models.
- Look at the future of 3D printing and its growing applications in the design industries.

About the Speaker

Steven attended R.I.T.'s film/animation in 1989 & A-B Tech's Entrepreneurship in 2011. Opened Spectralight Images in 1989 to deliver 3D training and animation. Moved to Orlando, FL in 1990. As VP of Computer Animators Plus (1995) began teaching 3D at Seminole State College. With a love of art, opened Gallery 611 in 1997, and formed the Orlando Visual Artists League in 2000, president until 2004. In 1998 he became an Autodesk® training specialist, and has contributed to Autodesk's certified training material for 9 releases of 3ds Max®. He was a co-developer of Autodesk's ACI Program, and Autodesk's 3ds Max® fundamental standards. Now he develops 3ds Max / Maya training courseware for CAD Learning's online training. Spectra3D Technologies provides 3ds Max, Maya & AutoCAD training. Steven teaches classes for end users, companies, Autodesk University, & others. Past trainees: Disney, Guess, US Army, and more. In 2014 Spectra3D Technologies expanded into 3D printer sales and support offering an array of 3D printers, design services and 3D printing training.

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3D Printing: An Entrepreneur's View

What is 3D Printing / Rapid Prototyping?

Rapid prototyping is a relatively new field in the design and manufacturing industries. By utilizing rapid prototyping, companies can create models of 3D designs using a number of prototyping techniques.

(3D Print courtesy of Rapid Prototyping Services, LLC)

There are several reasons a company would use rapid prototyping.

First, a company can quickly create an iteration of a new design, which allows them to test and retest a complete finished part without the expense of manufacturing. Using this process, a company or engineer can mock up a design, test features, evaluate form and function and perform other tests, like conducting a focus group, in order to evaluate the design of a new product. Having the ability to quickly alter the design and create a new version at a low cost makes it easier for companies to create better designs.

The second application of rapid prototyping is the creation of parts that will be used in the field. For many manufacturing companies, creating parts for a short run, say 25 to 200 pieces, can be costly. If it is a standard part, such as a connecting tube with flanges that would normally be molded from ABS plastic, rapid prototyping can save thousands of dollars. With materials capable of withstanding high pressure that are also strong and flexible, parts can be made that meet very rigorous standards.

A third application of rapid prototyping is the creation of fixtures that can be used during the manufacturing process. Take, for example, an assembly line where people are installing components into a small part. An engineer can spend the time to design a tool that holds the part properly, but it still has to be made. This is where rapid prototyping can be used to deliver low cost, reusable fixtures for the assembly line. If the design of the fixture were to change, the fixture can be easily recreated and replaced with the new design.

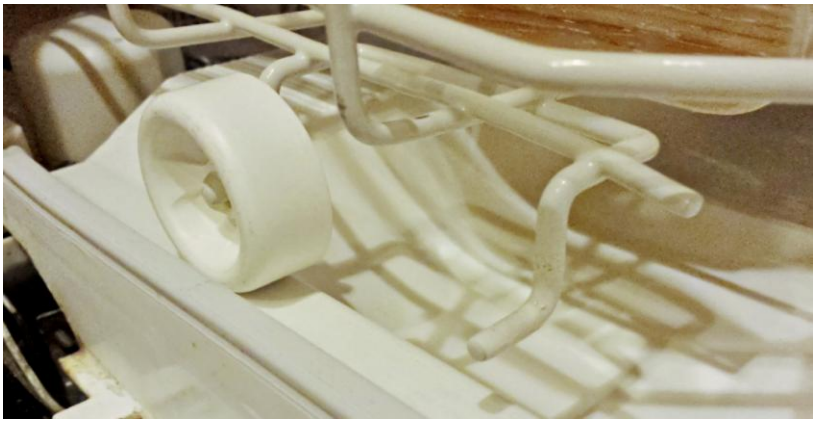
Lastly, rapid prototyping is within the reach of nearly anyone with a computer and an idea. This opens the door to a future where you can just print a replacement part for a broken toy, create your own unique model, or even design your own custom chess set.

As a process, rapid prototyping has the ability to make the job of a designer a little easier by allowing him or her to focus on the design. It also provides a way for companies to save on manufacturing costs for low quantity items and can increase productivity in many areas of the production industry.

Real-World Example

A common problem with a 3D solution

Once you have learned the basic tenets of 3D printing, opportunities for putting a 3D printer to work are constantly popping up. Take, for example, a fairly common household issue: the loss of a dishwasher wheel.

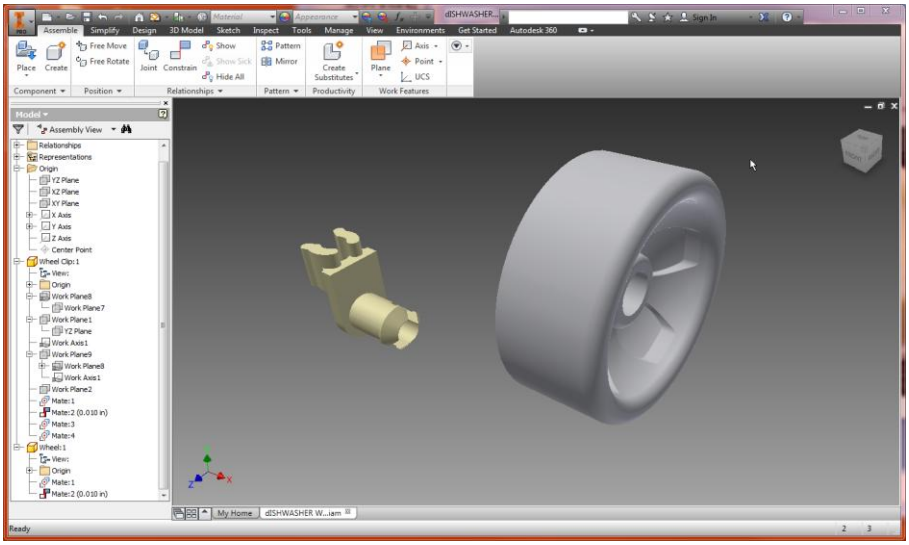


Without a 3D printer, you can shuffle through your paperwork to find the model number, contact the manufacturer, pay for the replacement part, and wait patiently for the part to arrive. If you happen to have a 3D printer, however, with some basic design skills, you can design your own replacement and have your dishwasher back to fully-functional in a matter of hours.

Designing your replacement part

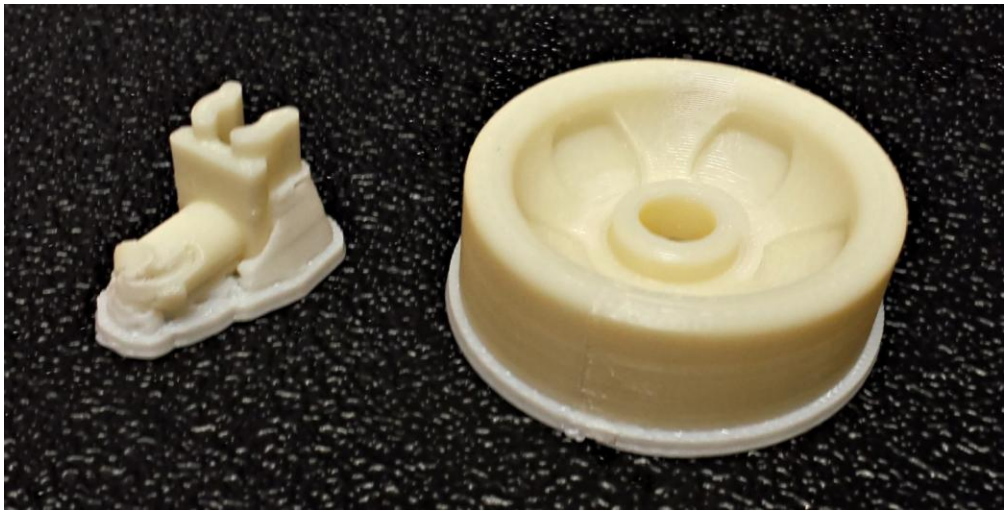
The first step when creating your dishwasher model is to make sure that you accurately recreate the dimensions of the original. Use a digital caliper to take accurate measurements.

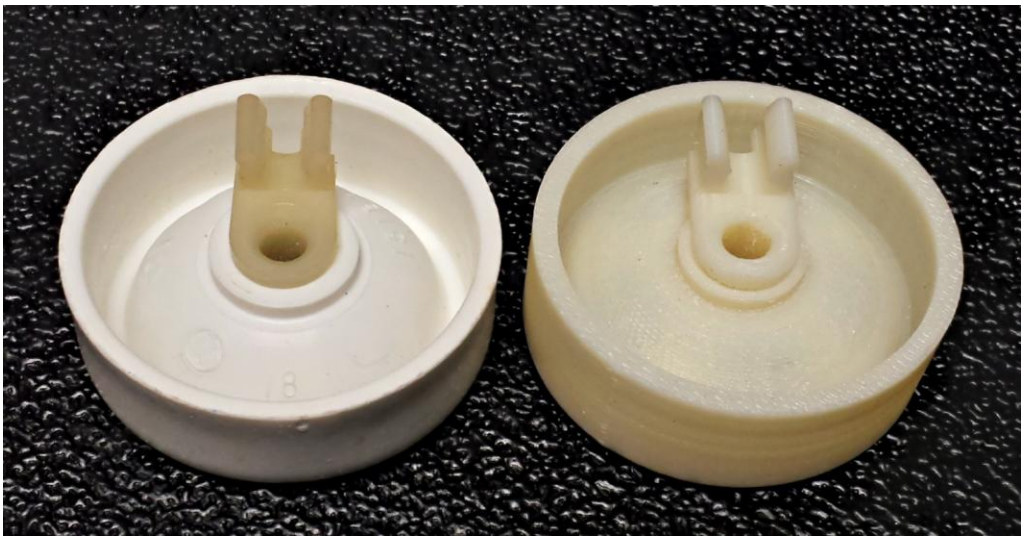
This information can be inputted into your software when creating your model. For this design, I used Inventor.

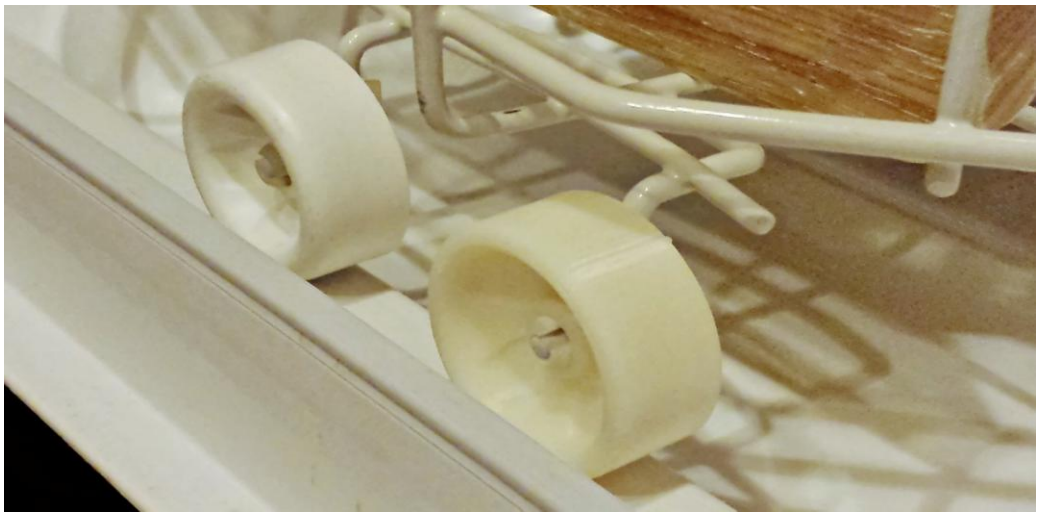


The Results

After printing, I had a tangible model that was identical to my existing wheel.







3D Printing Businesses

Printing Services

One of the more obvious ideas when considering a 3D printing business is to offer the print services themselves. As designers and the general public become more familiar with the capabilities of 3D printing, there will be more demand for 3D prints. In the initial stages, there is likely to be a large number of consumers interested in having a 3D part made without the ability to do it themselves.

Printing services can come in many forms. You may consider opening a print shop. This service would allow consumers to send you their designs and you return to them a printed part. You may also consider offering design services for those who don't have the expertise necessary to create their own parts.

Peripheral Services

Peripheral services help make a 3D printed part more usable. In some cases, businesses in the peripheral services will work to make the 3D part more durable by giving it a metallic finish, such as chrome or silver. Other services, such as painting, simply work to make the piece more aesthetically pleasing. Another example of a peripheral service is a company that takes a 3D piece and uses it to make a mold or casting.

The Cost of Business

The Printer

One of the first costs encountered when starting a 3D printing business is the cost of the printer itself. Many companies allow you to choose whether you would prefer to purchase the printer or take on a monthly lease. There are benefits and disadvantages to both options. Be sure to weigh the offers of each brand carefully before deciding which option is right for your business.

Miscellaneous

Other costs to consider before beginning your business are both the variable and fixed costs of doing business. Fixed costs include your overhead and the cost of your lease or loan. A few examples of the variable costs you will encounter include your necessary materials, the cost of your power, and the value of your time spent.

Profit!!!

Even after costs are figured in, however, there is tons of room for profit in even the most rudimentary printing business.

For a quick back of the napkin breakdown, say that your monthly lease on your printer costs you $380 per month. Material costs tend to sit around $5 per cubic inch. A reasonable estimate for how much you could charge for a printed part would start at about $75, with most parts selling for an average of $150.

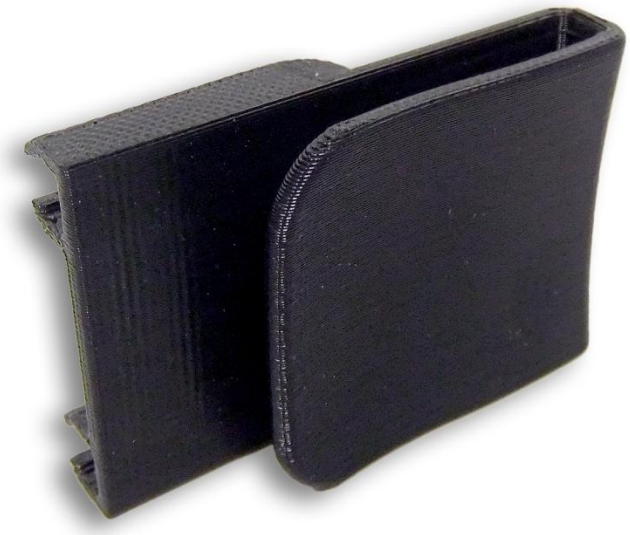
With these costs in mind, in order to break even printing parts at a price of $150 per piece, you would only need to print approximately four parts per month. Now, let's say that you were able to sell 10 prints per month at the same rate. This would net a profit of $820 per month.

Whether you would like to add printing to the list of services that you already offer or embark on a whole new venture, the potential for profits in a 3D printing business is significant.

What's it all about?

The Process of 3D Printing

The principle of rapid prototyping involves the idea that you can take a 3D model and build it using successive layers of a material. This is also known as 3D printing.



(3D Print courtesy of Rapid Prototyping Services, LLC)

First established in the early 1980's, neither the concept nor process of 3D printing has changed much over the years. What has changed, however, is both the price and the technology used for creating a 3D printed model.

The process begins with a designer, engineer or artist creating a 3D model in one of the many design programs on the market today. That model is then saved out to a format that will be used by the 3D printer, generally an STL file.

The printing process uses software specific to each printer, though they all do basically the same thing. The printing software takes the STL file data and slices it into layers that the printer is able to print.

Different printers use one of a handful of 3D printing processes. A majority of the 3D printers used in rapid manufacturing use a plastic filament that is laid down one layer at a time using a heated print head; others use ultraviolet light to cure layers of plastic resin; and some lay down a layer of fine material and an inkjet-like process that sprays a polymer to create the layer of the model. No matter which method you use, the process is generally the same.

What can you do with your model?

Printed parts can be used in a number of different applications. If you would like to test a concept or evaluate a design, a printed part is a great place to start. By creating a printed prototype, you can analyze many elements of the design and modify the part as necessary without the expense of traditional prototyping. A 3D printed part is also a great way to help you establish a new process.

With the high-quality of available materials and the high-degree of precision that many printers are capable of producing, printed parts can also be functional components. Using printed alternatives for pieces is particularly useful when you are designing a small-run of a part. Using a printer to create small parts can save design and engineering firms tons of money.

A function of a 3D print that shouldn’t be ignored is that it is simply fun to create. When 3D printing, if you can think of an idea for an invention, a piece of art, or anything else that you can dream up, you can bring it to life.

The Old Way. . .

Traditional Process

In the past, when you worked in design or product development, you went through a multi-stage process. After part development, you would have to create a part mold. The mold would then be used to create your finished product. If the part wasn't produced accurately the first time, there was often a considerable amount of cost involved in both material and time to rework the concept.

The New Way. . .

Rapid Prototype Process

Now, after creating a CAD model design, you can perform a quick model analysis and, from there, order the 3D print. If it is not correct the first time, it will take far less time and money to correct the part the second time around.

Process

With the 3D Printing workflow, there are six basic steps that you should go through before completing your design.

Plan

Although this stage is all-too-often overlooked, it is quite possibly the most important step. Taking the time to really think through your model, including how you want it to look and function, will help make the remaining five steps go much more smoothly.

Design

During this stage, you will transform your plan from a concept or a napkin sketch into a fully realized design. This will be done in the CAD software of your choice.

Print

Once you have designed your part and run any preliminary tests on your design, it is time to print. One of the most important things to keep in mind during this stage is that every printer is unique. In order to get the exact quality of print that you want, you will likely have to spend a fair amount of time becoming familiar with your system’s software and tweaking the settings to your specifications.

Test

Once your printed part or prototype is complete, it is time to begin the testing phase. Whether you are using focus groups, torture tests, or some other method, you should feel comfortable that the design you have is the design that you want.

Develop

Now that your design has gone through these carefully-orchestrated steps, it is time to put your design into development.

Uses and Applications

Commercial

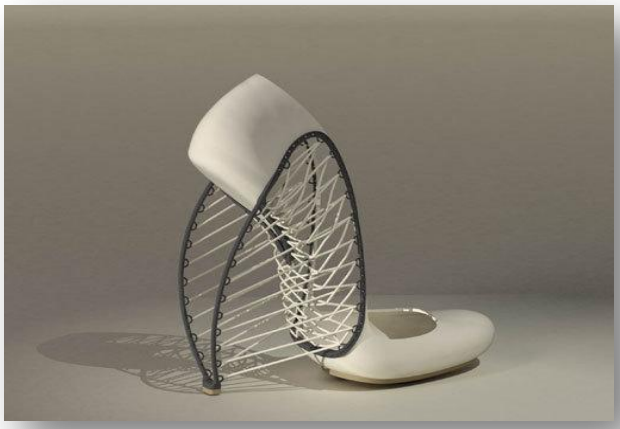
Image Courtesy of 3D Systems

Turn your concept into something more concrete that you can feel, hold, and interact with in order to get a better idea of how your design will work.

Image Courtesy of 3D Systems

End-user products from a 3D printer can range from parts, to models, and everything else in-between.

Fashion



The fashion industry has eagerly embraced the technology of 3D printing. You can find everything from small pieces of jewelry to full outfits created by a 3D printer.

Hobby and Fun

Image Courtesy of 3D Systems

If you really want to check out the creativity that 3D printing has inspired, you needn’t go any further than a quick search on a hobbyist site. With prints available for download for free or for a fee, these sites are packed with innovative design concepts.

Artistic

Image Courtesy of Voxel Studio

There are a number of amazing artists currently using 3D printing as a medium to produce works that would be difficult, if not impossible, to create before the invention of this technology.

Printer Types

Extrusion

Extrusion printers utilize basic Fused Deposition Modeling (FDM) technology in a 3D printer application. Quite simply, FDM is the additive manufacturing process that occurs through an additive principle, with each piece being constructed layer by layer.

Extrusion printers can print a few different materials, primarily ABS plastic and polycarbonate. These printers are a good option for professional use.

Granular

Granular printing is typically found in heavily industrial environments. This process requires an extremely controlled environment. During this process, a powdered material is fused together with the help of a heat source. After each layer is complete, the tray holding the materials sinks, slowly, exposing the part.

Direct Metal Laser Sintering (DMLS)

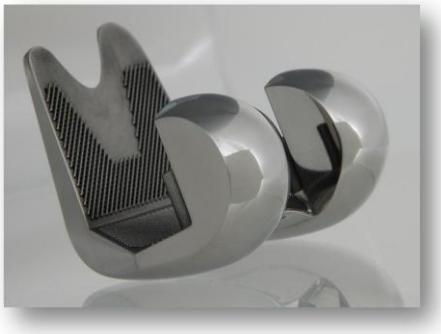


Image Courtesy of Morris Technologies

DMLS uses a high-power laser to create a solid structure out of powdered metals.

Selective Laser Sintering (SLS)

Image Courtesy of Vladimir Bulatov

Similar to DMLS, SLS also creates solid forms out of powdered materials, including metals and ceramics. DMLS and SLS differ primarily in technical details.

Powder Bed / Inkjet (PP)

Image Courtesy of Mcor Technologies

In this type of granular printing system, instead of using a laser or heat source to bind the powder together, an inkjet printhead moves across the bed of powder and adds a binding liquid to create the part.

Other

Plastic Jet Printing

Another term for Fused Deposition Modeling, Plastic Jet Printing utilizes the same techniques as an extrusion printer.

Stereolithography

This type of printer creates layers by curing a resin that is photo-reactive with a UV laser.

Laminated Object Manufacturing

Starting with materials, including paper, plastic, and metal, which are coated with an adhesive, the layers are glued together and a knife or laser is used to cut the desired shape.

The Printers

Professional / Production

Like any other technology, the advancement in process and equipment has steadily brought the cost of 3D printing down all the way to the consumer level. Companies that make 3D printers have developed a variety of printers that range in price from $500 up to more than $200,000 for industrial applications.

On the high end, Stratasys (http://www.stratasys.com) builds several lines of printers that can be used by small business providing low cost 3D printing services with prices starting at $6,000

(Image courtesy of Stratasys, Inc.)

The Mojo and uPrint SE Plus (pictured above) are two options in this category.

For more industrial applications, Stratasys' Fortus Series, which starts around $50,000, use the production-grade thermoplastics that are typically found in injection molding, CNC machining, and traditional manufacturing processes.

3D Systems (www.3dsystems.com) is another well known 3D printer company. The ProJet 1500 and 160 are nice mid-range options with good build speeds and resolutions. 3D Systems also offers professional models, such as the ProJet 5000, which can be left to print unattended for 80 hours and features a build volume of more than 21x15x11 inches.

Consumer / Hobby

The consumer can now get into the 3D printing market using one of several low end 3D printers. Two that compete head to head are the Replicator 5th Generation by Makerbot (http://www.get3dp.com) costing about $2,900, and the Cube Pro by Cubify 3D Systems (http://cubify.com), which is at approximately the same price point.

(Image courtesy of Makerbot)

Formlabs www.formlabs.com) is one of spate of relative newcomers who are offering upgraded features like multiple materials. The Form 1+, for example, puts the power of stereolithography on your desktop and can even print castable resin.

With so many options and costs coming down to acceptable prices, 3D printing is bound to be in your future in one way or another. Whether you are an engineer or designer, or just having fun, 3D printing opens the door to infinite possibilities.

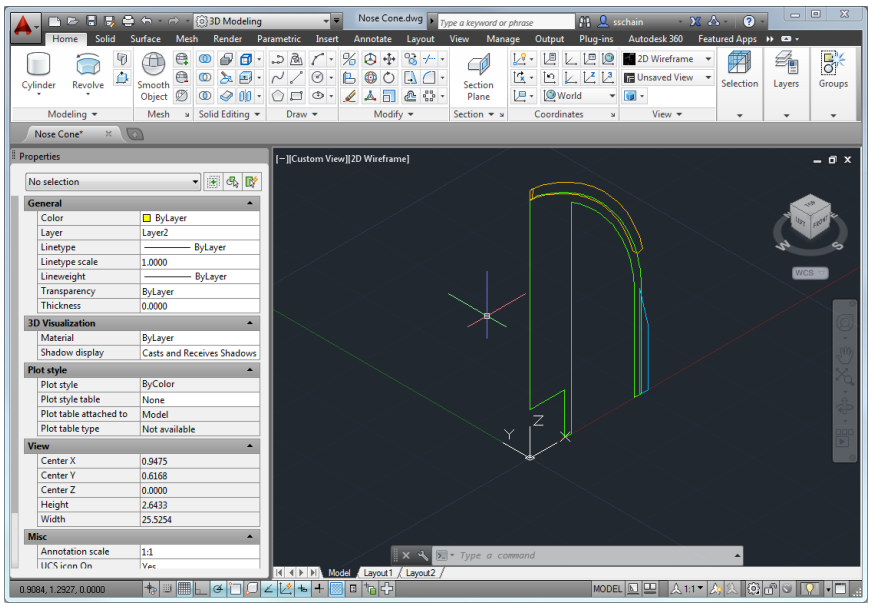
Tools for 3D Printing

Modeling for Rapid Prototyping

Basic AutoCAD Modeling

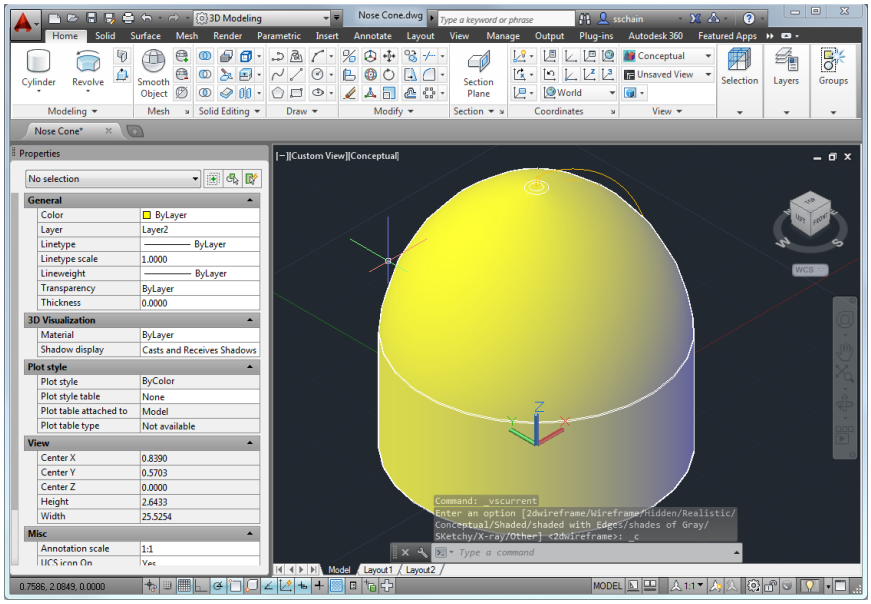
The process of creating a model that can be used for rapid prototyping can be as simple or as complex as your part requires. Here we use AutoCAD

1. Begin with the basic curves that make up each element of the design.



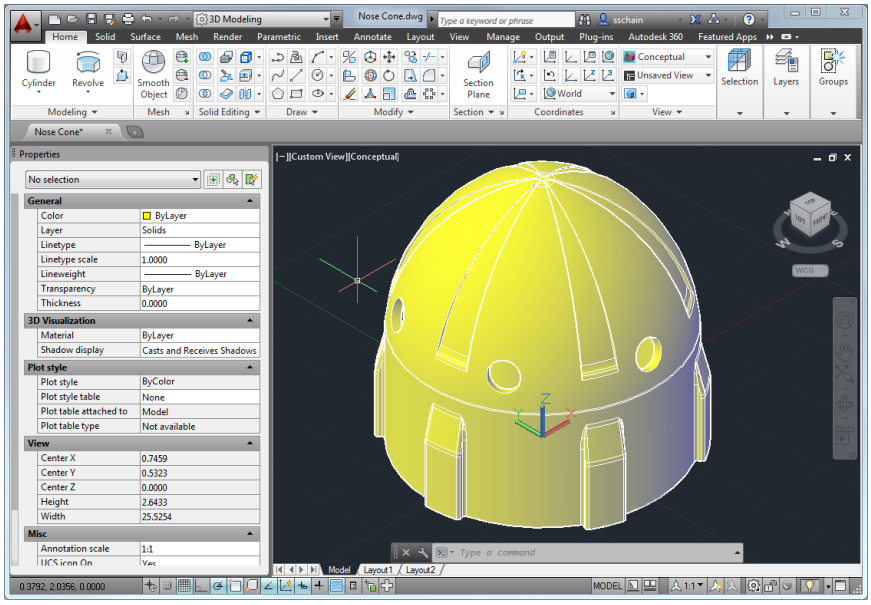
The curves represent the main body portion of the nose cone, the material to be added to the body and the material to be removed from the body.

2. Using the 3D solid modeling tools available in AutoCAD you can begin to create the solids you will need to construct the final part.



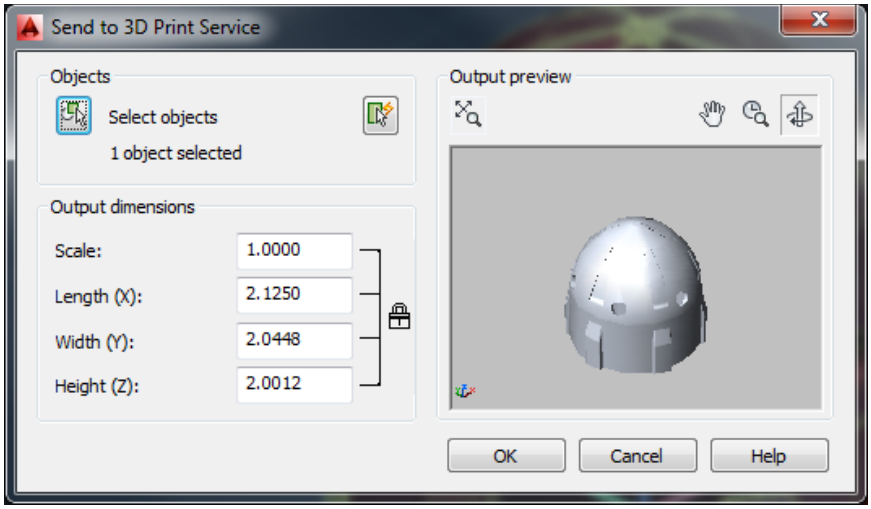
Using the Revolve tool allows you to create a solid model that represents the shape of the main body of the nose cone.

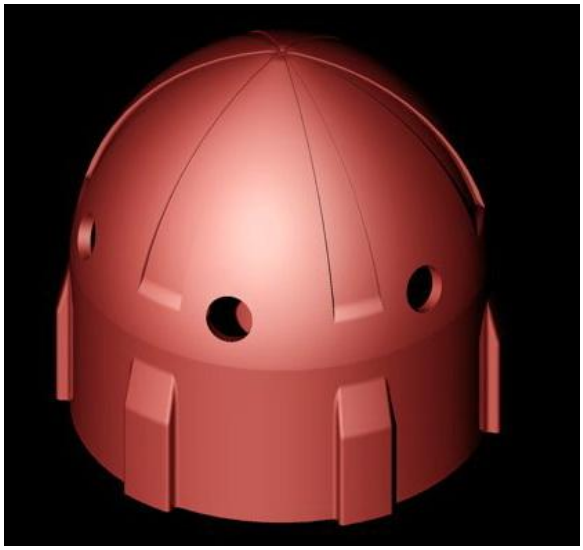
3. Creating the additional elements, then using the Boolean functions allows you to create more complex solids.



The final version of the nose cone uses boolean operations to union and subtract elements from the main body. Fillets complete the creation of the final part.

You are now ready to send the part to get 3D Printed.





AutoCAD quick rendering of the part

Other Autodesk programs that can be used to create 3D models include Inventor, Fusion 360, Revit, 3ds Max Design, InfraWorks, and Sketchbook Pro. For a free program that is great for beginners who are learning to model in 3D, Autodesk now provides a suite of apps, located at www.123dapp. These apps give you tools to help you create your STL file, build a 3D model out of foam board, or transform photographs into a printable model.

3D Printer Software

Once you have your model designed, your printer needs to be able to read it. A slicer program, such as Slic3r (www.slic3r.org) or KISSlicer (www.kisslicer.com) can take your existing model, slices it into horizontal slices, and creates the necessary toolpaths. The program will then calculate the material that it needs to extrude.

The Future. . .

The future of 3D parts is one in which pieces can be modeled on demand. Finding replacement parts will be as simple as sending the file to your printer and snapping the part into place when it is complete. This will lead to a significant reduction in inventory and a much more streamlined workflow.

Although we have already seen some medical advancement through 3D printing, as technologies continue to become more refined, there could be some major breakthroughs thanks to 3D printing.

Finally, as demand increases for items that are customized for the user, there are tons of possible markets that 3D printing could fulfill, including custom fit items and mass customization.