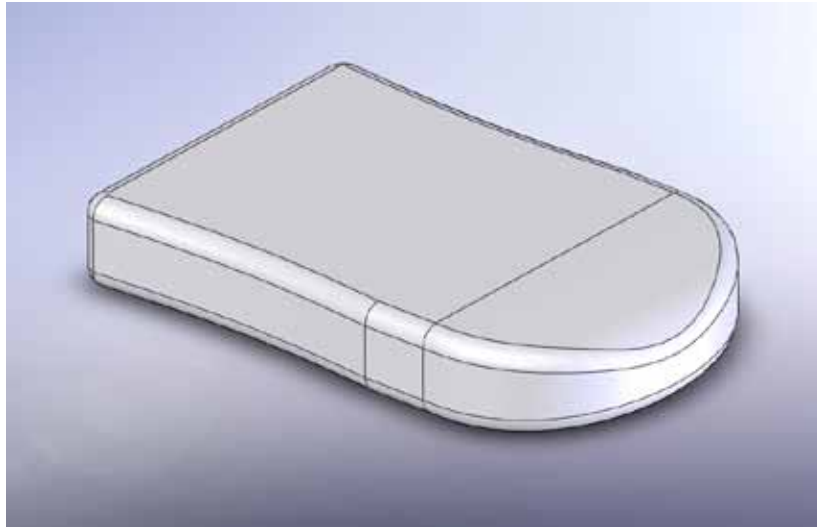# Rapid Prototyping Output

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Rapid prototyping is the automatic construction of physical objects using solid freeform fabrication. The first techniques for rapid prototyping became available in the late 1980s and were used to produce models and prototype parts. Designers benefit from being able to build digital representations of objects using 3D modeling software. Rapid prototyping allows the data to be sent to a 3D printer where the object is built.

Here in the College of Architecture at Georgia Tech, we have access to two types of 3D printers. Both are capable of printing an object up to 8"x8"x8". We have a Fused Deposition Modeler (FDM) that uses a small printing head to emit a thin bead of ABS, a common thermoplastic. We also have a Z Corp 3D printer that precisely applies a liquid binder to a powder starch one layer at a time.

Some text taken from Wikipedia

Rapid Prototyping Output

With additive fabrication, the machine reads in data from a CAD file and lays down successive layers or beads of liquid, powder, or sheet material, and in this way builds up the model from a series of cross sections. These layers, which correspond to the virtual cross section from the CAD model, are joined together or fused automatically to create the final shape. Additive fabrication is great because of its ability to create almost any shape or geometric feature.

The standard data interface between CAD software and the 3D printing machines is the STL file format. An STL file approximates the shape of a part or assembly using numerous triangular facets. An file comprised of smaller facets will produce a higher quality surface, but it will be a larger file.

Sometimes rapid prototyping is not rapid. Construction of a model with contemporary methods can take from several hours to a couple days, depending on the method used and the size and complexity of the model. Additive systems for rapid prototyping can typically produce models in a few hours, although it can vary widely depending on the type of machine being used and the size and number of models being produced simultaneously.

The STL file comprised of numerous triangles

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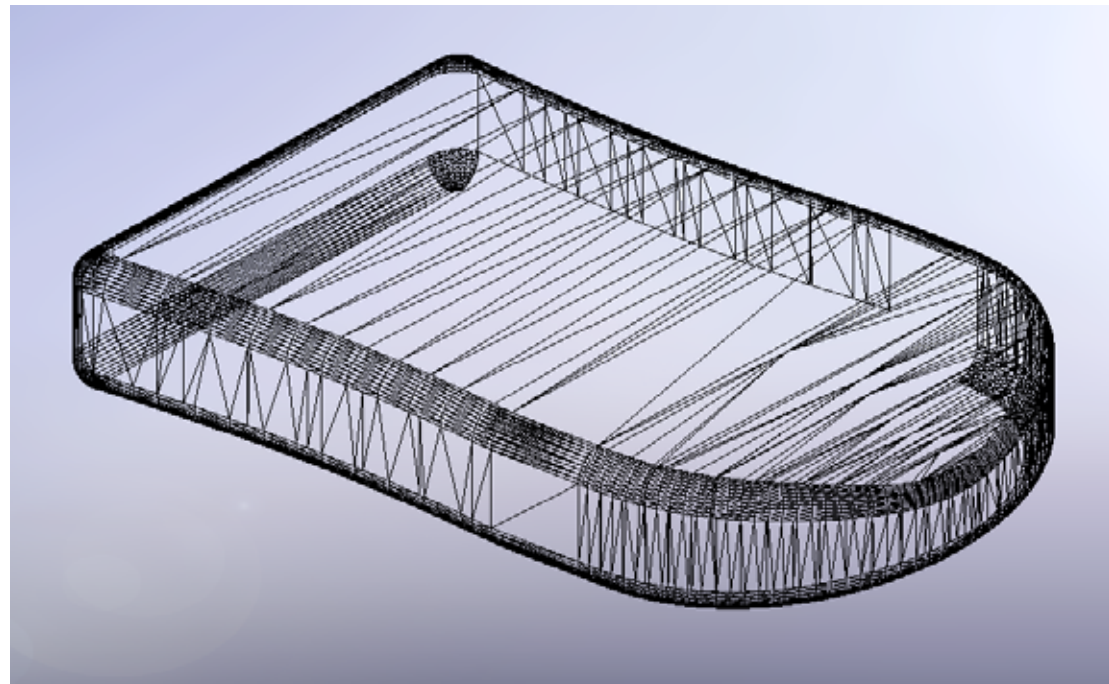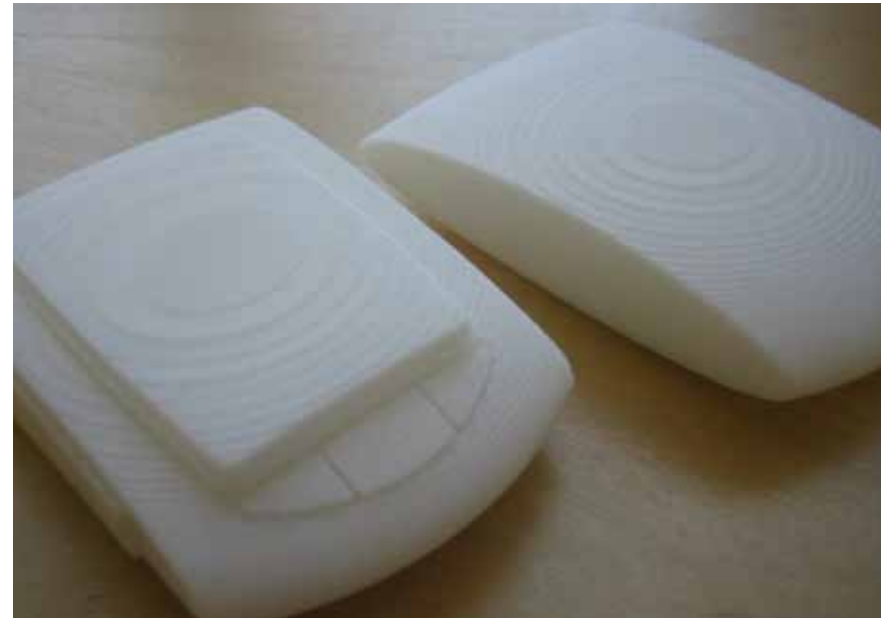
Rapid Prototyping Output
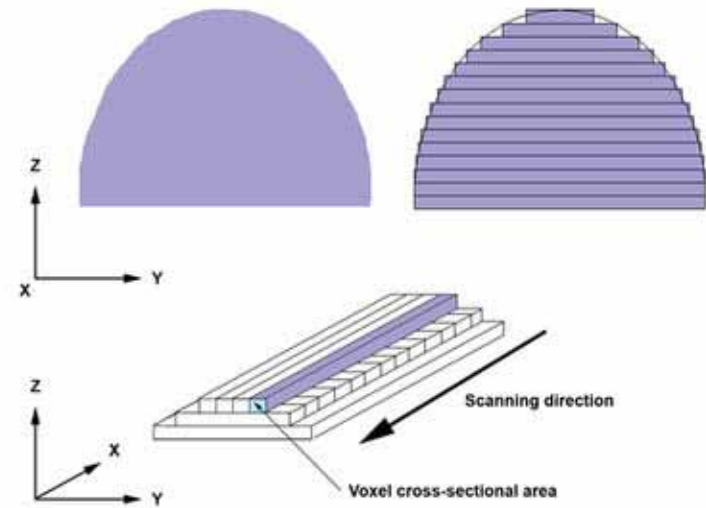
A voxel is a volumetric pixel, the smallest unit the 3D printer can create.

It is important to consider how 3D printers work so that you can have appropriate expectations and you can optimize your results. The machines reduce parts into a series of cross sections for construction. This means that curved surfaces will be resolved into a stack of flat planes. Think about this when you orient your object before exporting the file to go to the 3D printer. Also, the machines build from the bottom up, one layer at a time. This means that a part oriented so that is it lying down will be finished hours before one that is standing tall. There is one more issue to consider. When printing multiple parts that are designed to fit together, be sure to orient them all in the same direction. This will ensure that any deviations in the cross sections will be consistent and the parts will fit.

Slow

Fast

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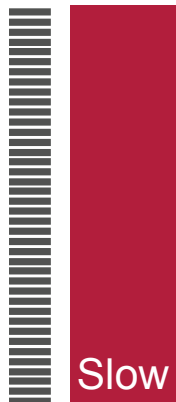
Rapid Prototyping Output

Cost/Time Comparison

To give you a sense of how certain decisions impact the 3D printing process we gathered the following data for this object on the FDM machine:

Inputs		Outputs	
Orientation	Fill Type	**Print Time**	Co$$$t
Flat	Solid	4:50 hrs	$31.62
Flat	Hollow	3:23 hrs	$16.45
On Edge	Hollow	4:46 hrs	$16.67

You can see that orienting a hollow object like this on its side adds about as much time as making it solid. And that making an object like this hollow will save you half the cost over printing it solid.

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The FDM machine in the COA shop can make objects that are durable and long lasting. The ABS that the machine uses is off-white and it can be sanded and painted. The FDM machine is more expensive per cubic inch than the Z Corp machine.

The machine reads STL files. Once the file has been imported into the controller software you can set the STL scale size and fill types. The fill types control how solid parts' interiors are. Selecting "Sparse" will make the part's interior have a mix of voids and internal structure, whereas "Solid" will make a truly solid part. Obviously, a "Solid" part will cost more, take longer to print, be heavier and be more robust.
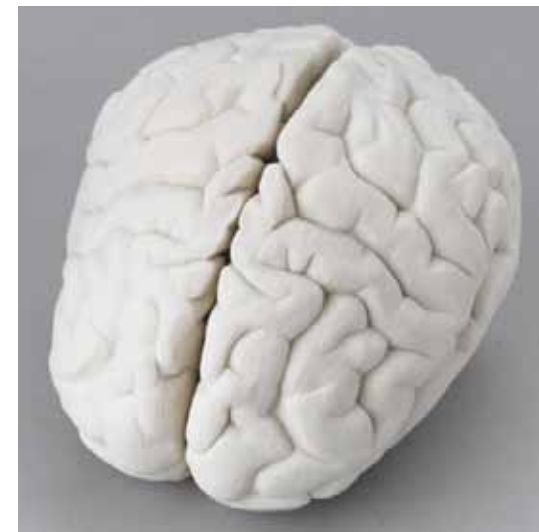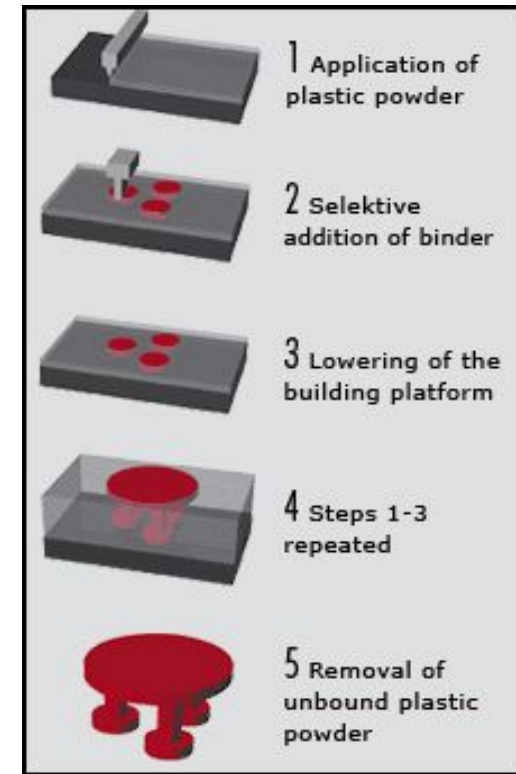
Using the controller software you can reorient your model to reduce the printing time. Also note that the bonds within the plastic are strongest horizontally and weakest vertically. So if your part has a narrow section, orient accordingly.
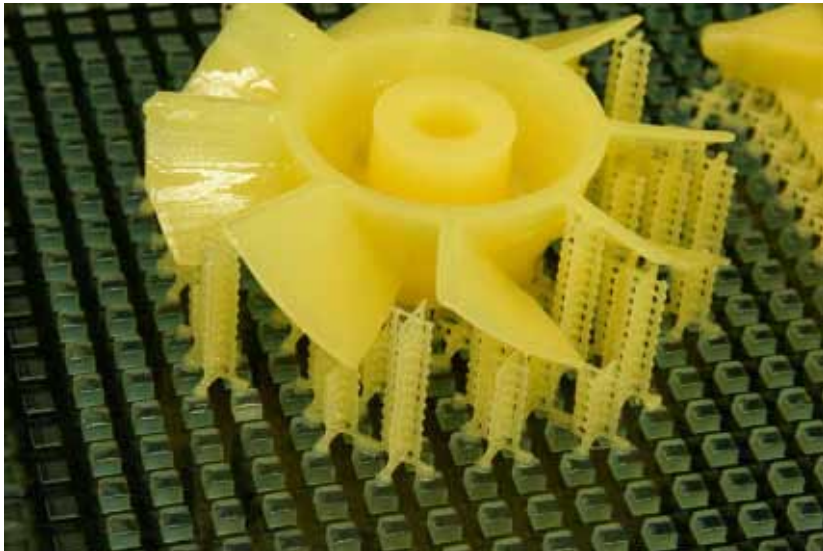
Once your part has finished printing, you will snap it off the base plate and begin removing the scaffolding. The FDM machine runs at a high temp (around 300 degrees). This means that without scaffolding, your part would droop as it was being made inside the machine. The scaffolding material is emitted from the machine head just like the plastic, but the scaffolding dissolves away using a strong base. The machine builds it strategically to support your part during construction. To remove it, simply place your part in the warm alkaline bath in the shop. For most parts, the scaffolding will be gone in several hours.

A part shown with scaffolding support structures

prepared by Gabe Landes for T. Purdy

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Rapid Prototyping Output

1 Application of plastic powder

2 Selektive addition of binder

3 Lowering of the building platform

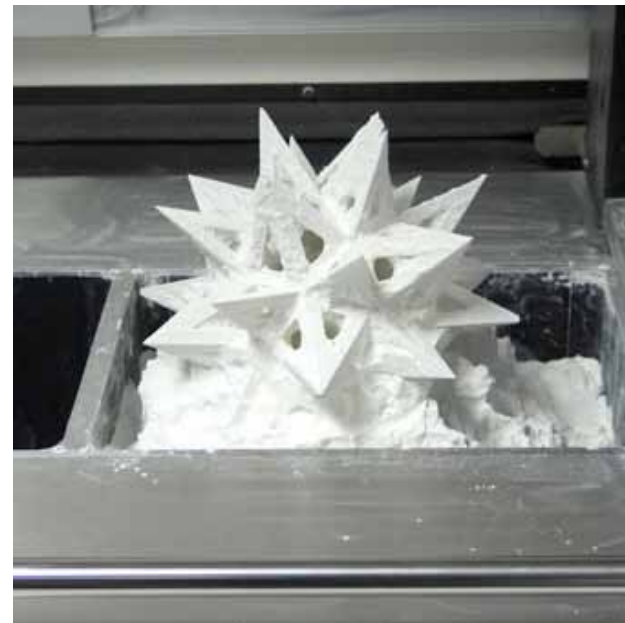4 Steps 1-3 repeated

5 Removal of unbound plastic powder

The Z Corp 3D printer is cheaper and faster than the FDM machine, but the parts from the Z Corp printer are fragile if left untreated.

The printer builds each model layer by layer, starting at the base. For every pass, a thin layer of powder is spread over the entire building area. Then, a print head similar to that of an inkjet printer prints a layer of binder onto the powder plane. The binder bonds with the powder to create a solid layer of your object. You can think of the complete model as a stack of 2D images that were printed onto the powder. When the process is finally finished with the top layer, the model will be completely enclosed in a matrix of powder that must be removed during the excavation process.

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To excavate, you must scoop and vacuum away the powder matrix to reveal the model. After the model is removed from the printer, it is recommended that you blast your model with a fine stream of air in the de-powdering station. This process removes more loose powder, especially powder in holes or crevices. The last step, which is highly recommended, is to infiltrate your model with resin. This provides necessary structural integrity for the model; without infiltration the model is very easily chipped, scratched, and cracked. The shop has a bottle full of a dilute solution of cyanoacrylate for this purpose.

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Rapid Prototyping Output

SolidWorks has a feature that allows you to send your final digital model directly to a Rapid Prototyping Service. These services can get parts to you in as little as one day. They use many different types of 3D printing technologies depending on your needs. And they can take your approved prototype and do a complete run of high quality manufacturing grade injection molded parts. To access these services from within SolidWorks go to the **File menu>3D Printing>Online Service**.

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Rapid Prototyping Output

If you want to print in the COA, you must save your finished part as an STL file. To do this go to the **File menu** and select **Save As**. This will open a dialog box. Under the **Save as type** drop-down menu, select **STL**. This creates an **Options** button in the dialog box. Press this button to open another dialog box. In this window you can preview the mesh by check-ing the **Preview** check box. You can also change the mesh resolution from **Coarse** to **Fine** to **Custom**. The resolution adjusts how many polygons your mesh is comprised of. The finer the resolution the more smooth your curves will be. Just keep in mind your part's smoothness will be limited by the thickness of each cross section the printer builds. Once your STL file is on a jump drive, take it down to the COA shop for printing.
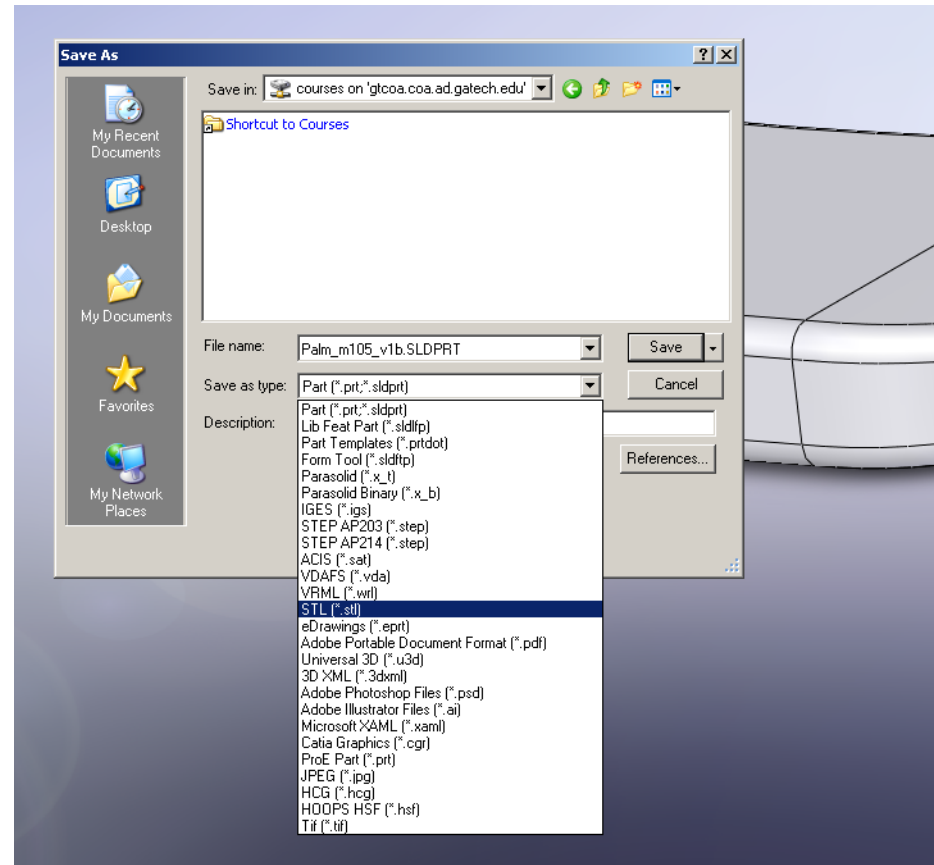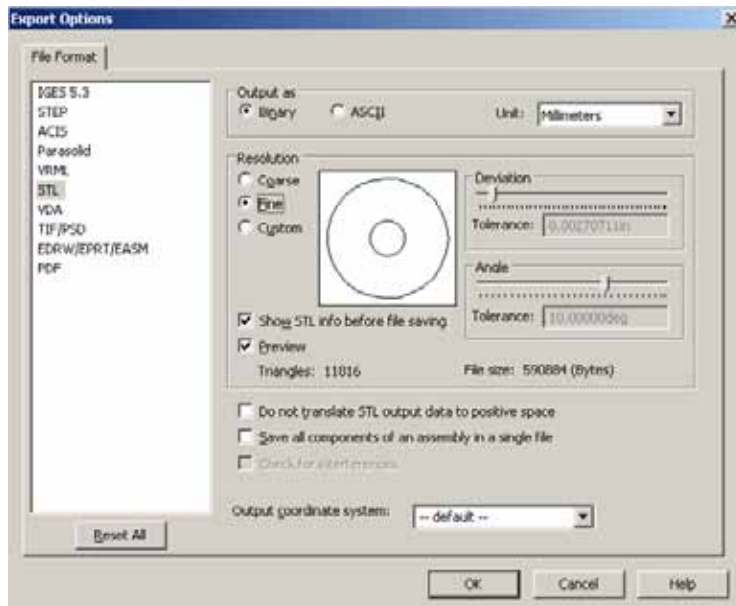
Saving as an STL file in SolidWorks

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