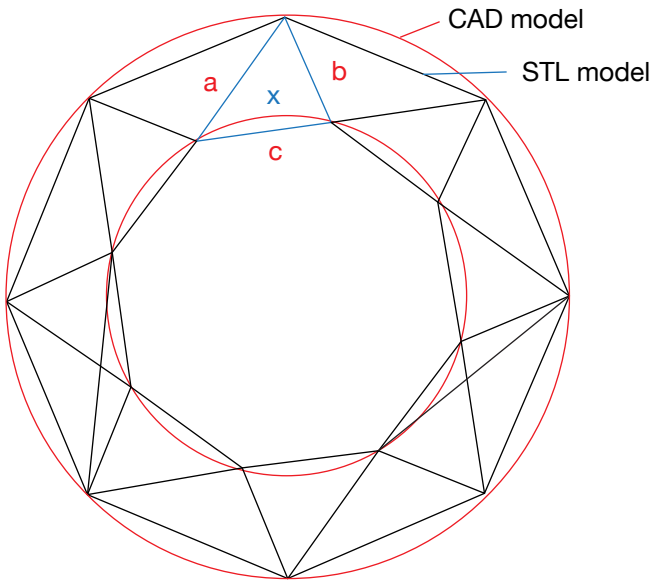
FATHOM

STL FILES—UNDERSTANDING THE 3D PRINTING FILE TYPE



Introduction

To get the best quality 3d prints for your project, it is important to understand the most commonly used 3D printing file format—the STL. This file format is a mesh approximation of the geometry that is generated in a solid or surface modeling software. Design for additive manufacturing (DFAM) techniques, such as topology optimization and lattice structure design, both output STL meshes—so working with this file type is becoming increasingly important for designers and engineers.

What Is An STL?

An STL file is made up of triangles which approximate a surface. The file consists of faces defined by three vertices and a normal direction for each face. To 3D print an STL file, the mesh must be closed (or watertight), meaning all edges of the triangles align with another and all of the normal directions are matching.

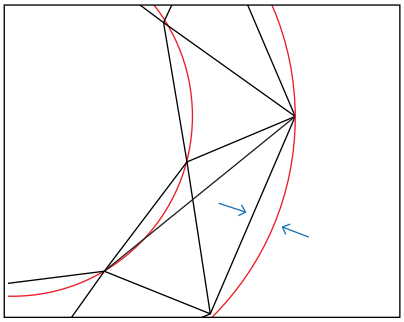
Why Do We Use STLs?

With many different 3D CAD programs, various types of 3D printing processes and multiple equipment manufacturers to consider, having a universal file type creates a common ground throughout the industry. Before 3D printing, a 3D CAD file needs to be processed and sliced into contours. Doing this with a boundary represented (BREP) file that is generated from solid and surface modeling is heavy on computing time. An STL file is much faster to slice into contours.

Exporting An STL

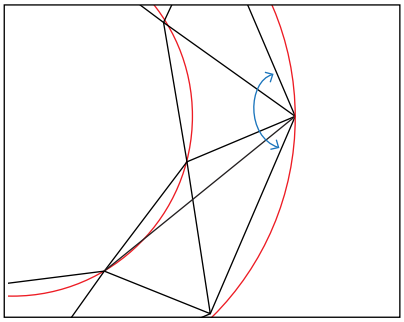
The number of triangles used to approximate a surface will determine the resolution and size of an STL file. A low resolution STL file will have facets that may appear in a 3D print of the model. A very high resolution STL may create an excessively large file that is difficult for 3D printing software to process. Balance between a resolution required for 3D printing and what is a manageable file size.

To control STL file resolution, 3D CAD packages will have different options for export. Below are some common options. Some 3D CAD packages will have one, a couple, all, or even more settings to work with. The most common setting is distance deviation. A recommended starting place for this value is 0.01mm, but sometimes it can be a trial and error type of process to achieve a good balance between file size and resolution.



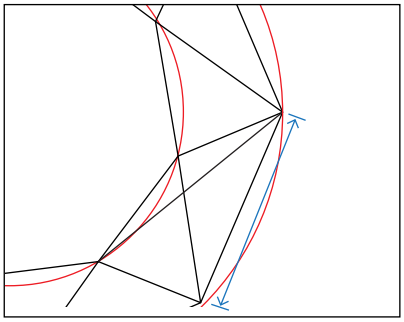
DISTANCE DEVIATION //

Maximum distance from the midpoint of a triangle edge to the model surface—the smaller the distance, the higher file resolution.



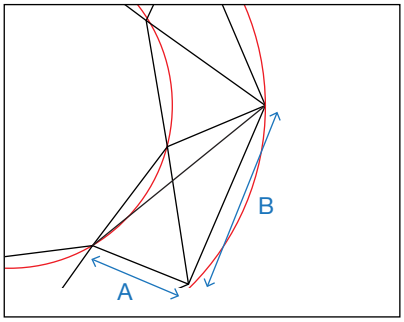
ANGLE RESOLUTION //

Maximum angle between triangle normals—lower angle resolution will result in a higher resolution file.



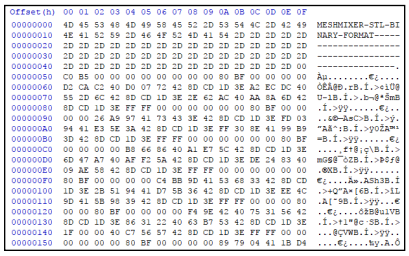
EDGE LENGTH //

Maximum triangle edge length. Some programs allow for a minimum too. Manipulating this setting will prevent long and thin triangles from being created that make editing a mesh difficult. It is not a setting that needs to be worried about for 3D printability but will be a concern for mesh editing.



ASPECT RATIO //

Maximum allowable ratio of two sides of a triangle. Will also prevent narrow and long triangles. Lower ratios will create triangles that are closer to equilateral. This setting also helps with mesh editing and will not affect the printability of the file.



Offset(h)	00	01	02	03	04	05	06	07	08	09	0A	0B	0C	0D	0E	0F	
00000000	4D	45	53	48	4D	49	58	45	52	2D	53	54	4C	2D	42	49	MESHMIXER-STL-BI
00000010	4E	41	52	59	2D	46	4F	52	4D	41	54	2D	2D	2D	2D	2D	NARY-FORMAT-----
00000020	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	----------
00000030	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	----------
00000040	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	2D	00	----------.
00000050	C0	B5	00	00	00	00	00	00	00	80	BF	00	00	00	00	00	Àµ.....€¿....
00000060	D2	CA	C2	40	D0	07	72	42	8D	CD	1D	3E	A2	EC	DC	40	ÒÊÂ@Ð.rB.Í.>¢ìÜ@
00000070	55	2D	6C	42	8D	CD	1D	3E	2F	42	AC	40	AA	8A	8D	42	U-lB.Í.>./B¬@ª.B
00000080	8D	CD	1D	3E	FF	FF	00	00	00	00	00	00	80	BF	00	00	.Í.>ÿÿ.....€¿..
00000090	00	00	26	A9	97	41	73	43	3E	42	8D	CD	1D	3E	FD	03	..&©-AsC>B.Í.>ý.
000000A0	94	41	E3	5E	3A	42	8D	CD	1D	3E	FF	30	8E	41	99	B9	"Aã^:B.Í.>ÿ0ŽA™¹
000000B0	3D	42	8D	CD	1D	3E	FF	FF	00	00	00	00	00	80	BF	00	=B.Í.>ÿÿ.....€¿.
000000C0	00	00	00	00	B8	66	86	40	A1	E7	5C	42	8D	CD	1D	3E	.....f†@¡ç\B.Í.>
000000D0	6D	47	A7	40	AF	F2	5A	42	8D	CD	1D	3E	DE	24	83	40	mG§@¯òZB.Í.>Þ$ƒ@
000000E0	09	AE	58	42	8D	CD	1D	3E	FF	FF	00	00	00	00	00	00	.®XB.Í.>ÿÿ.....
000000F0	80	BF	00	00	00	00	C4	BB	9D	41	53	68	33	42	8D	CD	€¿....Ä».ASh3B.Í
00000100	1D	3E	2B	51	94	41	D7	5B	36	42	8D	CD	1D	3E	EE	4C	.>+Q"A×[6B.Í.>îL
00000110	9D	41	5B	98	39	42	8D	CD	1D	3E	FF	FF	00	00	00	80	.A[˜9B.Í.>ÿÿ...€
00000120	00	00	80	BF	00	00	00	00	F4	9E	42	40	75	31	56	42	..€¿....ôžB@u1VB
00000130	8D	CD	1D	3E	86	31	22	40	63	B7	53	42	8D	CD	1D	3E	.Í.>†1"@c·SB.Í.>
00000140	1F	00	00	40	C7	56	57	42	8D	CD	1D	3E	FF	FF	00	00	...@ÇVWB.Í.>ÿÿ..
00000150	00	00	00	00	80	BF	00	00	00	00	89	79	04	41	1B	D4	....€¿....‰y.A.Ô

ACSII VERSUS BINARY //

Some software gives a user the option to export either an ASCII or binary STL. The only difference between the two is ASCII is written in plain text while binary is compressed to reduce file size. The only reason you would want to export as ASCII is to read what it has exported or do some kind of operation on the file in plain text.

Why Can STLs Be Difficult To Work With?

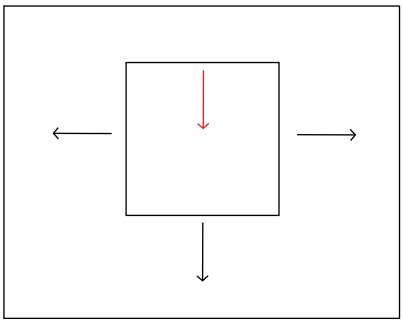
Once an STL is created, you cannot go back and create a higher resolution file from that STL. Some STL editing software will let you smooth out a file to remove faceting that may show up on a 3D print, but that process will not bring you closer to actual 3D CAD that the STL is approximating.

After an STL is created, the only way to edit a file is to manipulate the triangles created in the mesh. You are unable to extrude, loft, sweep, or perform most functions that you are used to using in solid and surface modeling software. Some simple operations such as Booleans or cuts can be performed.

The STL file type only stores information about the vertices and normal directions of the mesh triangles. The units of the model are not transferred with the STL, so this information will need to be communicated to others who will work with the file to avoid confusion.

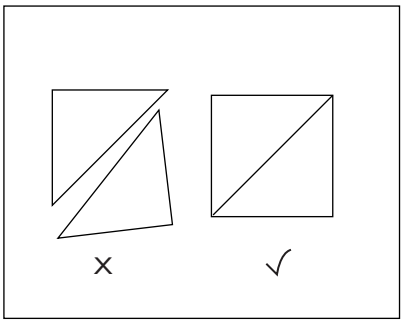
Potential STL Errors

Every design program has a different method of converting files to STLs and some are more successful than others. There are STL editing and fixing software to help correct issues that may come up. Below is a list of common errors



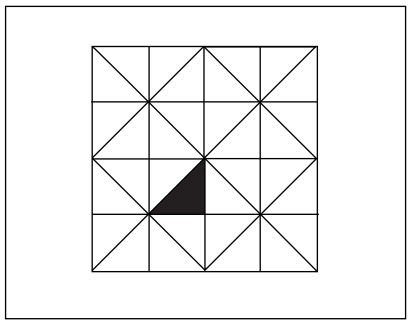
INVERTED NORMAL //

A triangle's normal is flipped the wrong way, creating an open mesh. Because of this, slicing software will be unable to create contours for printing. STL editing software will enable you to flip the direction of the normal to correct this issue.



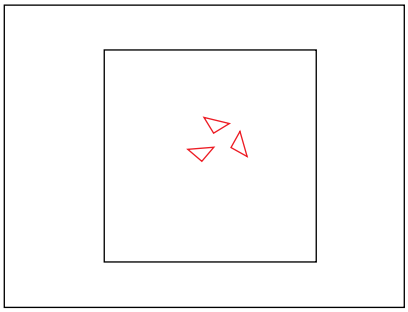
BAD EDGES //

Edges of triangles are not adjacent to another triangle edge. This also creates an open mesh. Many times bad edges that are very close to one another may be stitched together to close the mesh.



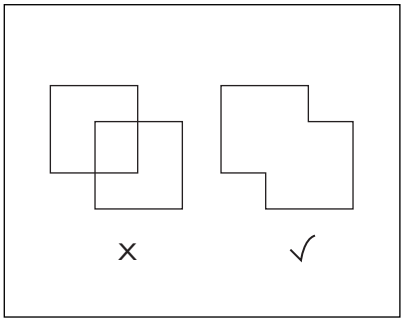
HOLES //

Missing triangles from a region prevents a closed mesh. Sometimes this is an easy fix within the STL—other times, an edit or re-export of the original 3D CAD file may be needed.



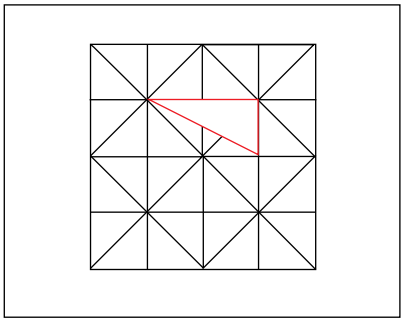
NOISE SHELLS //

Sometimes very small, unwanted meshes are created in error during an STL export—for cleaner contours generated from slicing, these noise shells should be deleted.



MULTIPLE SHELLS //

While there are some instances where you would want multiple shells, for the most part you want your STL to made of one shell body for printing.



OVERLAPPING & INTERSECTING TRIANGLES //

Having overlapping and/or intersecting triangles may produce a section with areas too small to print, or if intersecting it may create a section that overlaps itself.

To get a good quality 3D print, you need to start with a good STL. A good STL has a closed, watertight mesh with no overlapping or intersecting triangles. The file should have enough triangles to not show the faceting on the 3D print, but not so many triangles that the file is too heavy to process. If you will be manipulating the STL and not just using the STL for 3D printing, you will want a mesh without long and thin triangles to make editing easier.