AUTODESK UNIVERSITY 2013

Modeling for 3D Printing with Autodesk® Design Suites

Ryan Johnson – D3 Technologies

MA2711 Learn how to use Autodesk Design Suite tools for 3D printed prototypes. The class begins with an overview of several current 3D printing technologies. After reviewing how they work, you will understand why modeling details can make a difference. Building on that, we cover several modeling tips for use in Autodesk® Inventor® software that take advantage of tools such as multibody solids, motion constraints, and user parameters to facilitate adjustments for the 3D print. We also explain how to use Autodesk® 3ds Max® software to easily add coloring or imagery that can be used by full-color 3D printing technologies. At the end of the process, learn how positioning of your model can affect print and processing time or even model functionality and appearance. You will see real-world examples and 3D printed prototypes throughout the class.

Learning Objectives

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

- Identify and describe the basic classes of 3D printing technologies
- Prepare both still and moving Inventor models for 3D printing
- Apply colors or images with 3ds Max for transferring to a color 3D printer ***revised

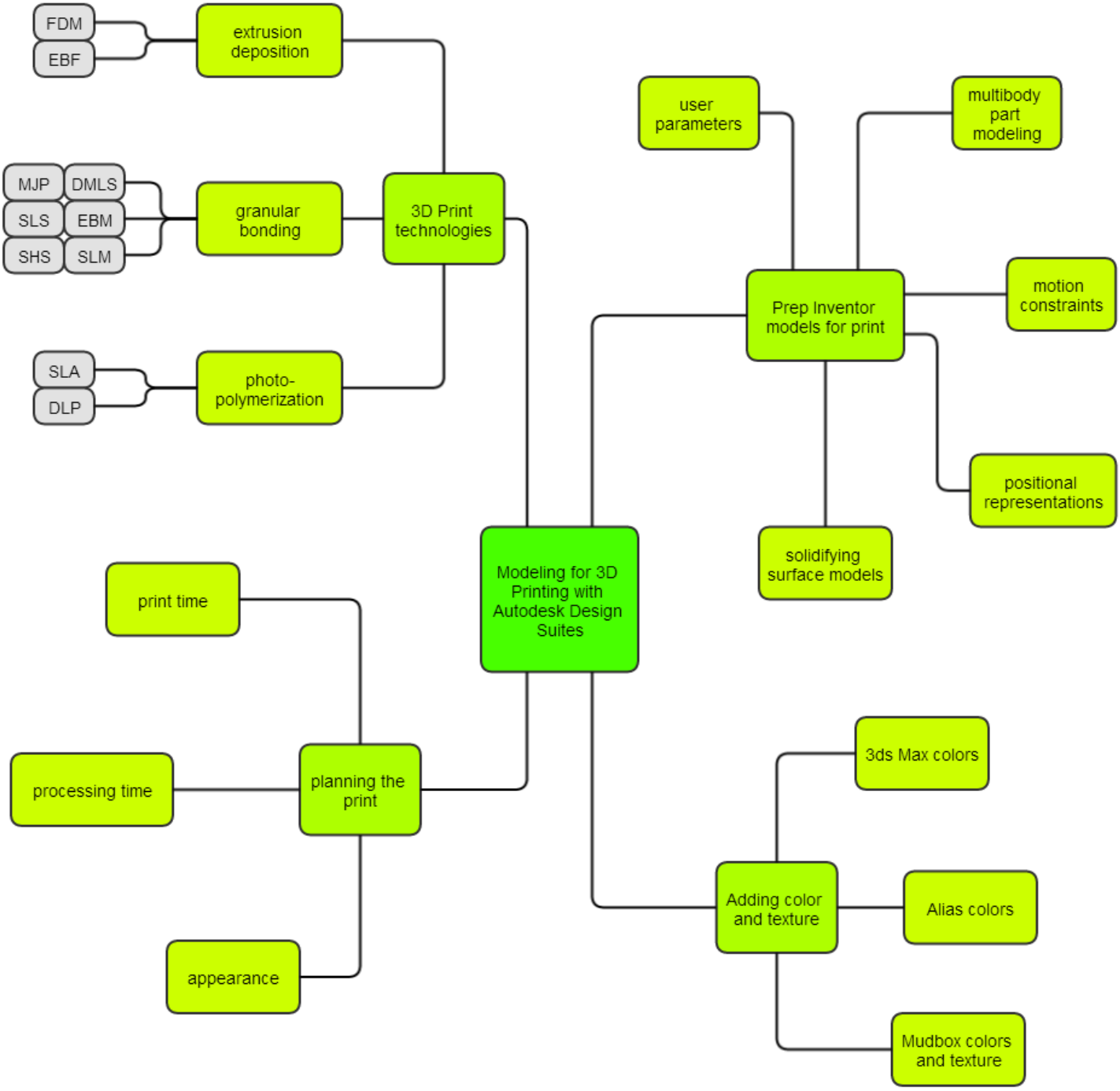
  Apply colors, images, and texture with additional Autodesk Design Suite programs
- Plan how to position models for best surface finish and efficient printing and processing

About the Speaker

Ryan is an Implementation Consultant for D3 Technologies and works with a variety of customers across the US. He specializes in Autodesk software training and consulting for the manufacturing industry and also has a background in visualization using 3ds Max and Showcase. Ryan regularly teaches for D3 Technologies, an Autodesk Authorized Training Center. He is an Autodesk Certified Professional in Inventor, AutoCAD, and 3ds Max and an Autodesk Certified Instructor.

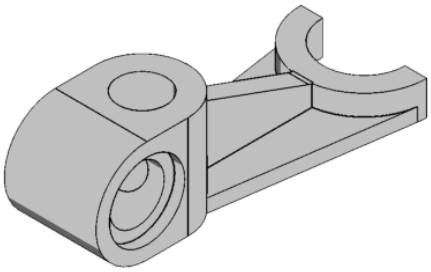
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Class Outline:



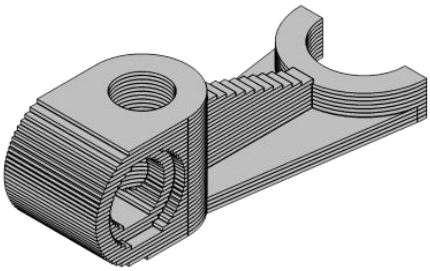
Identify and describe the basic classes of 3D printing technologies

3D printing, sometimes referred to as additive manufacturing, is the process of building a physical three-dimensional model from a digital model. The model is translated into vertical cross-sections which the 3D printer builds up successively. When the print is completed you have a physical 3D solid model.



digital model

3D printing is used commonly for prototyping of digital models. It is useful for evaluating what a design will actually feel like when held or used. Full-color 3D printing can produce very accurate models for evaluation of aesthetics. It is also commonly used for creating scaled models of large projects for evaluation or presentation in industries such as architecture and manufacturing. With new materials and processes being developed, 3D printing is starting to be used for full scale production of parts in some industries or applications. 3D printing has also been used by the entertainment industry for producing props or even characters for filming.



model divided into cross-sections

We will consider three main technologies used for 3D printing today. These are extrusion deposition, granular bonding, and photo-polymerization.

Extrusion Deposition



3D Systems Cube®



MakerBot® Replicator™ 2

How It Works:

In extrusion deposition systems a spool of filament material is typically melted and extruded through a nozzle. The extrusion head and/or the build platform move to create the 3D geometry. The material hardens upon cooling.

Limitations exist on overhanging geometry or very steep slopes because there is no separate support material used. Additional support structures or lattices can be created to support these types of geometry and are removed during post-processing.



Materials:

Extrusion deposition systems generally use spools of metal or plastic filament to create 3D geometry.

Acronyms:

FDM – fused deposition modeling

FFF – fused filament fabrication is an alternate term

EBF – electron-beam freeform fabrication



Granular Bonding



ProJet® 460 Plus



ProJet® iPro™ 9000

How It Works:

In granular bonding systems layers of powdered material (media) are bonded or fused together selectively to create 3D geometry. A layer of the media is spread across a printing bed. Areas of the media are fused using various methods. Subsequently the print bed moves down, another layer of media is spread over the bed, and the process repeats.

In this process the unfused media remains in the print bed and supports overhangs and very thin geometry. This removes the need for printing extra support structures.

The media is bonded or fused in different ways. Some systems sinter the media to fuse it using a scanning laser. Others actually melt the media on each layer to fuse it. MJP systems print a binder over the media to bond it. After the print is removed from the build bed it can be impregnated with additional materials to greatly enhance the strength.

Some MJP systems are able to print color onto the fused material. This results in very accurate full color reproductions of a 3D model.

Materials:

Granular bonding systems use a large variety of materials depending on the specific technology or system. The media that can be used includes metal and polymer powders for sintering or melting technologies. MJP systems typically use a plaster or resin powder on which a bonding agent is printed to bond each layer.

Acronyms:

MJP – multi-jet printing

SLS – selective laser sintering

SLM – selective laser melting

SHS – selective heat sintering

DMLS – direct metal laser sintering

EBM – electron beam melting



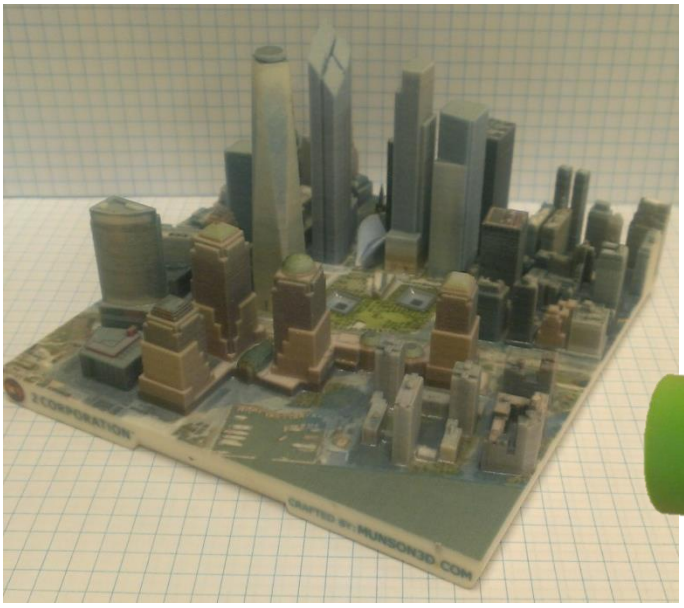






Photo-Polymerization



ProJet® 3510 HD Max



Objet Eden500V

How It Works:

In photo-polymerization systems a liquid polymer is hardened by exposure to UV or other light. Some systems use a vat of liquid with a build plate inside. After a layer is hardened by light the build bed moves down and is covered by a new layer of liquid which can then be selectively hardened. Other systems spray photopolymer materials onto the build tray in thin layers which are then cured.

Additional support materials can also be printed to support overhangs and removed in post-processing. Water-soluble support material is used by some systems and can be removed by rinsing or water-jetting. Wax with a low melting point is used by others and is easily removed by heating during post-processing.

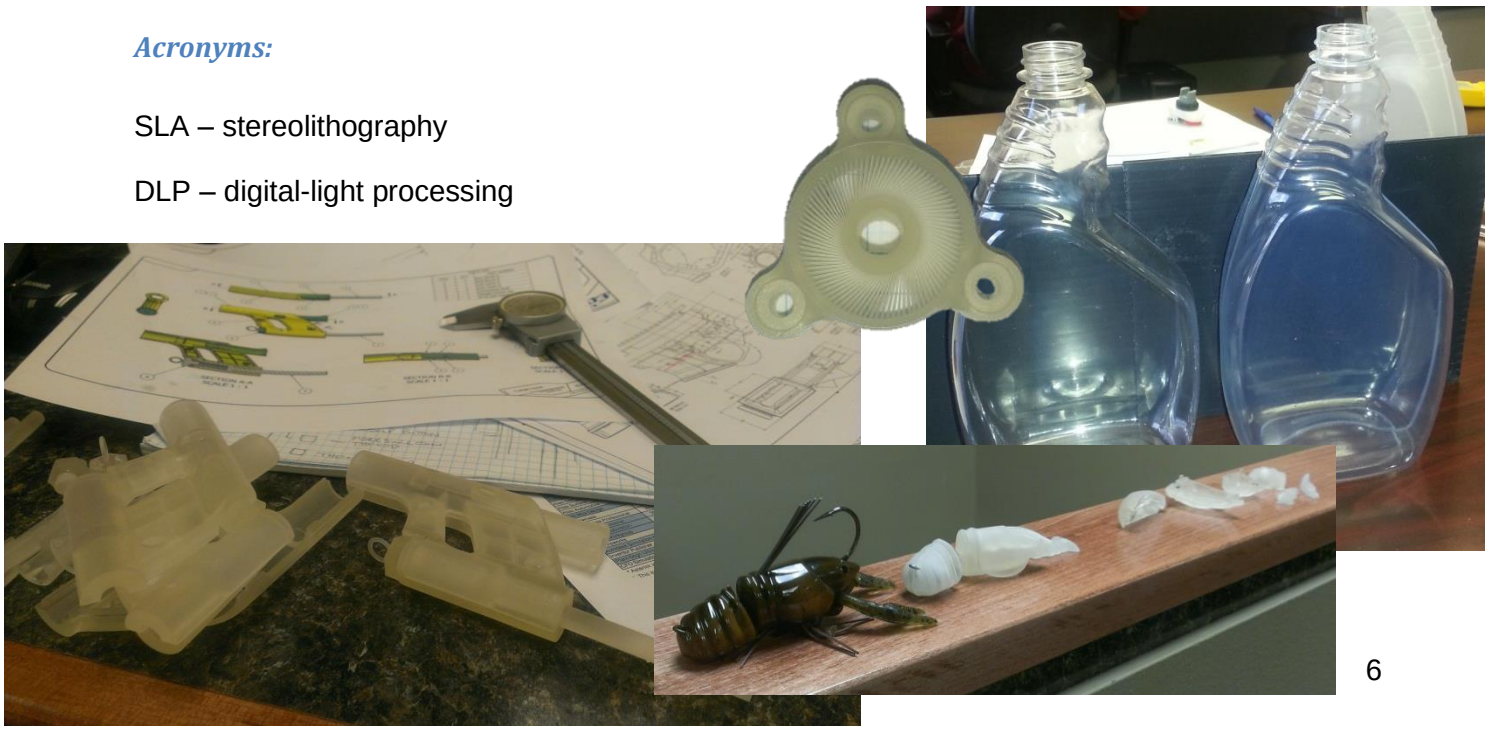
Materials:

This process requires the use of photopolymer materials. These are initially liquid or gel-like. After curing with a specific wavelength of light the material hardens to its final properties.

Acronyms:

SLA – stereolithography

DLP – digital-light processing



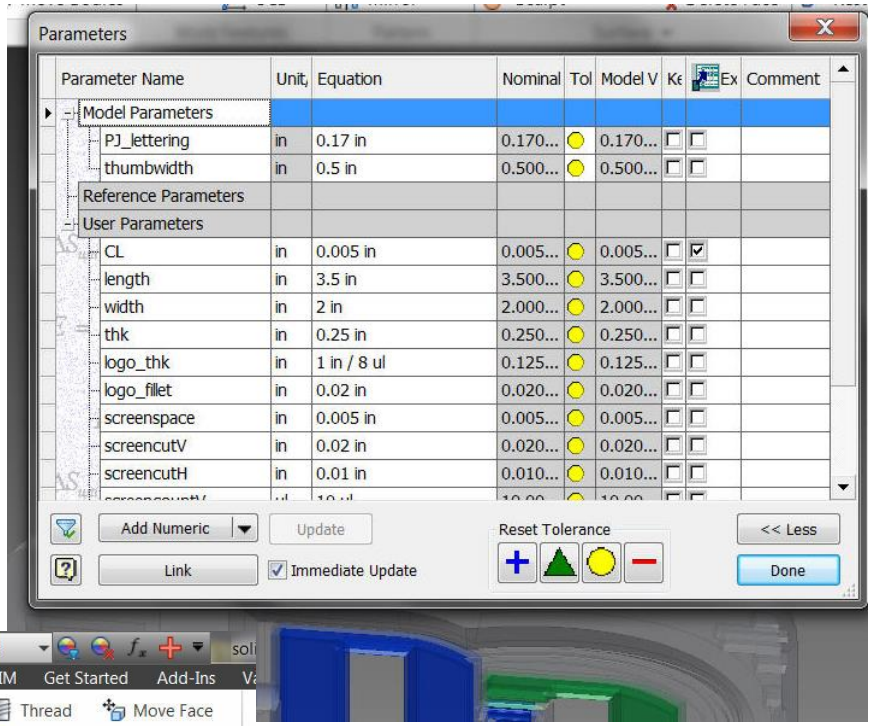
Prepare Inventor models for 3D printing

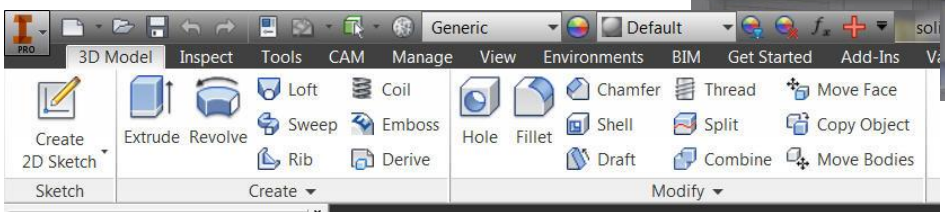
When building models in Autodesk Inventor software, there are many tools available to help prepare the models for 3D printing. In some cases these tools can be used to evaluate the geometry whether the model will be 3D printed or produced with some other process later on. We will discuss several of these tools.

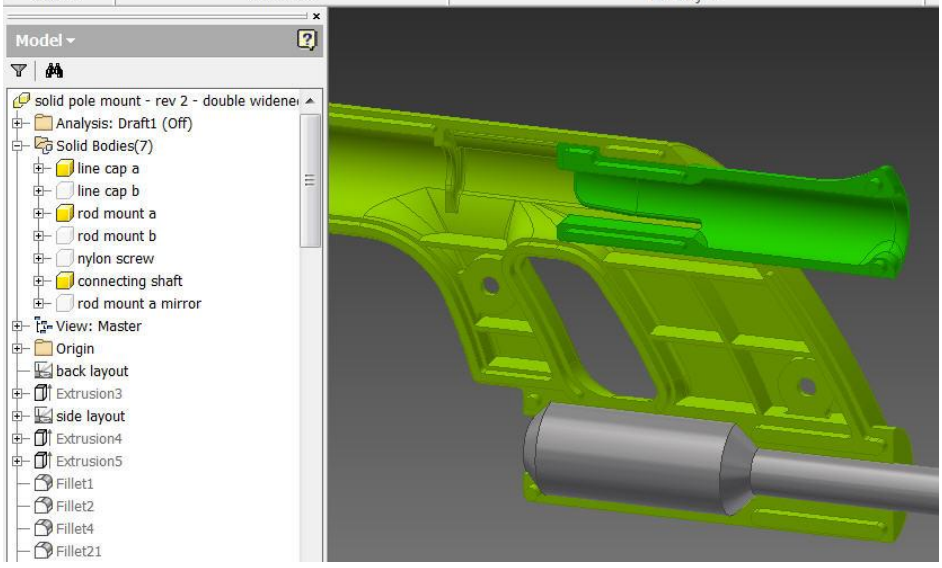
Adding user parameters

User parameters allow you to set up and pre-name parameters that will be useful when modeling. Things like clearance or separation distances can be tied to multiple features and easily identified and modified later on.

It's useful to set these up before beginning the modeling, although they can be added at any time.



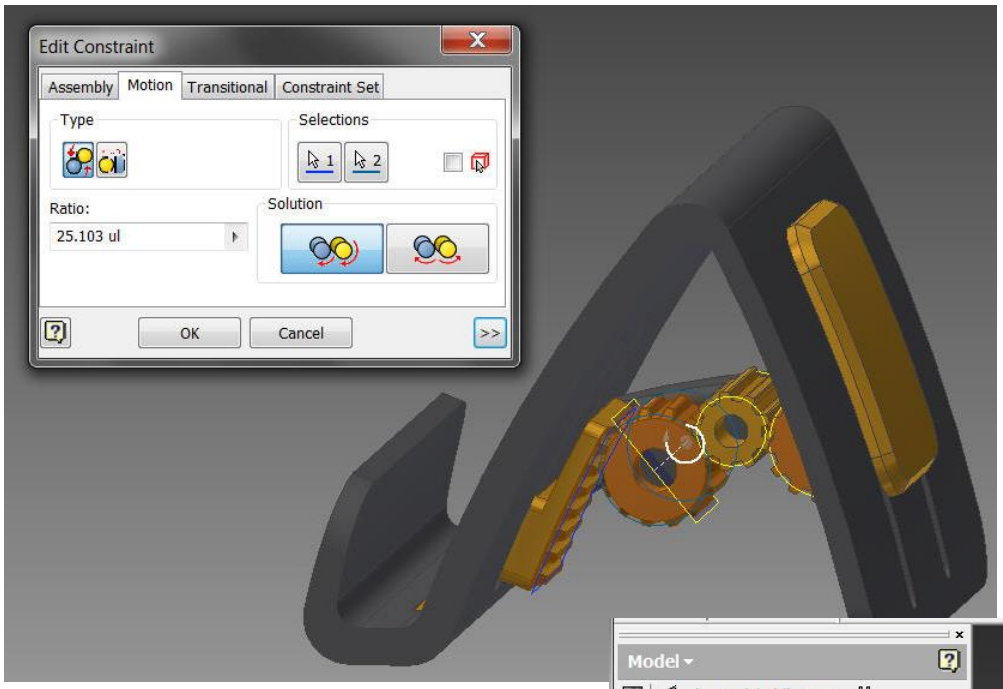




Multibody part modeling

Often multiple parts interact with each other or drive size or position of other components. Multibody part modeling is a useful way to build these parts in one file where they can be tied to each other easily.

Bodies are derived into individual part files and assembled in an assembly file after they are modeled. The Make Components tool in the Manage tab > Layout panel automates this process into a few easy clicks.

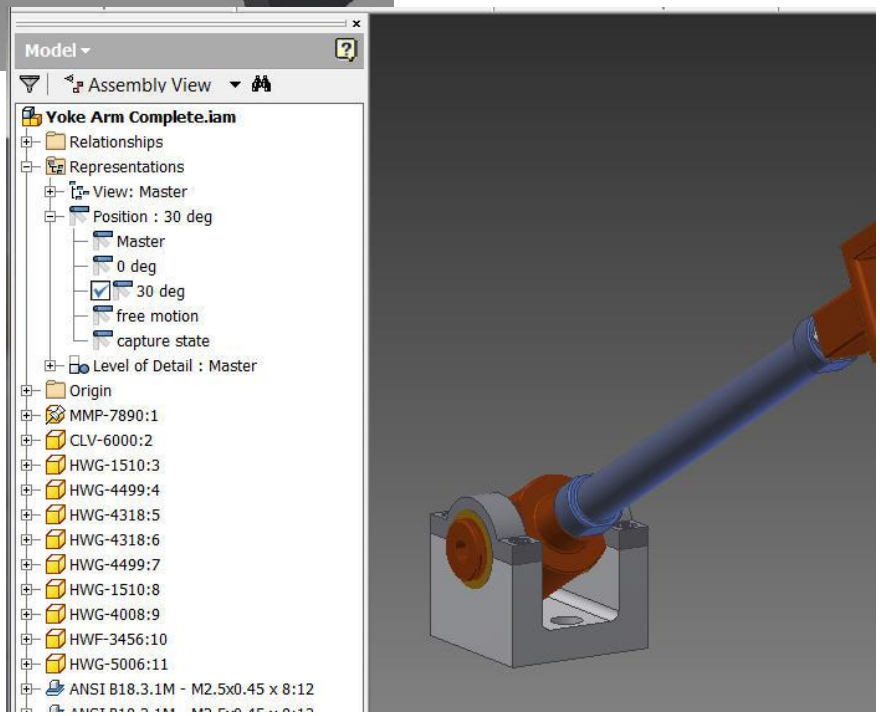


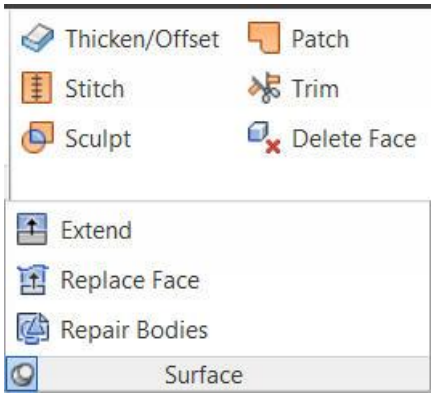
Motion constraints

Motion constraints are useful for tying parts together that affect each other's motion. This can help you to analyze how the parts will move in real life once they are printed. It may help identify areas where parts don't interact correctly.

Positional Representations

Positional representations allow you to calculate part constraints at various values and recalculate all other constraints accordingly. This may help you to find inconsistent constraints where the model may not behave properly once printed. It also assists in finding exact ranges and extents of motion.





Solidifying surface models

Most 3D printers can translate solid files effortlessly for 3D printing. If you are working with a surface model the tools in Inventor's Surface panel can help to modify geometry as needed and convert it to a solid body.

Use patches to create quick cap surfaces where edges already intersect. Create additional surfaces and use trimming tools to modify existing geometry. Use stitch tool to ensure all edges are touching and create solid bodies. Thicken is also useful for creating constant-thickness walls from existing surfaces.

~~Apply colors or images with 3ds Max for transferring to a color 3D printer~~ ***REVISED

Apply colors, images, and texture with additional Product Design Suite programs

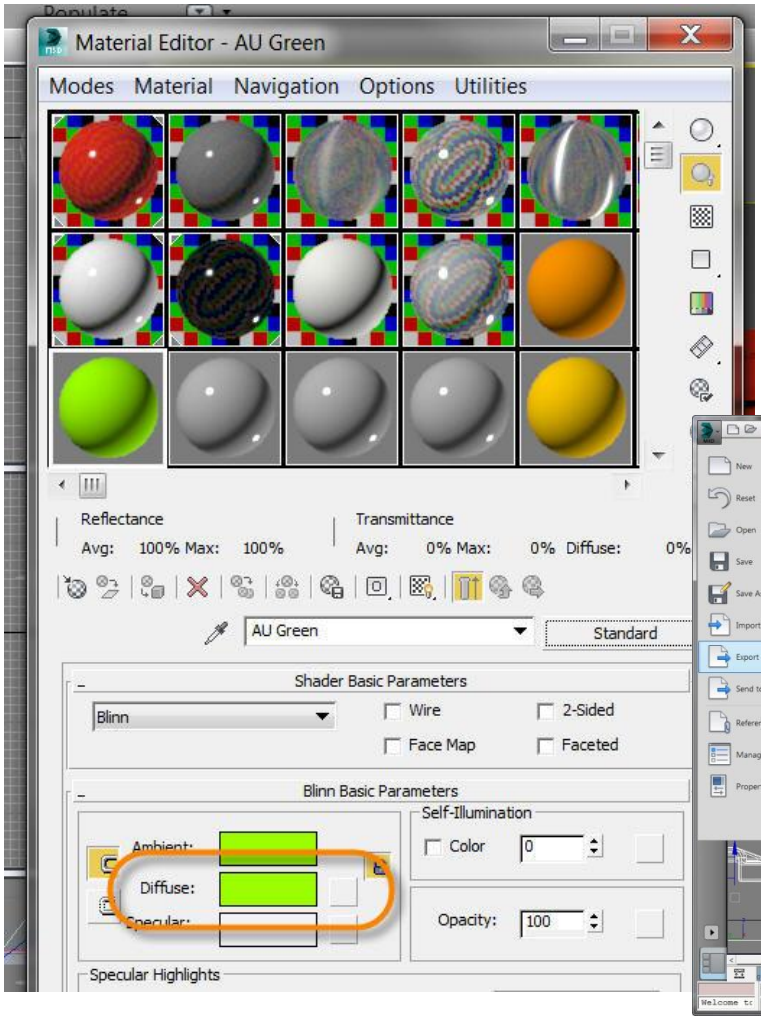
Regardless of how a model was created, it must generally be opened or imported into 3D print software that sends data to each 3D printer. Some of these programs are capable of adding color or images to model surfaces. However, it's often easier to add or translate colors on the model using programs right inside of the Autodesk Design Suites.

Colors can be added and exported for 3D printing using 3ds Max, Alias, or Mudbox. Also, physical textures can be added using Mudbox. We will discuss the process for adding and exporting colors or texture for 3d prints in each of these programs.

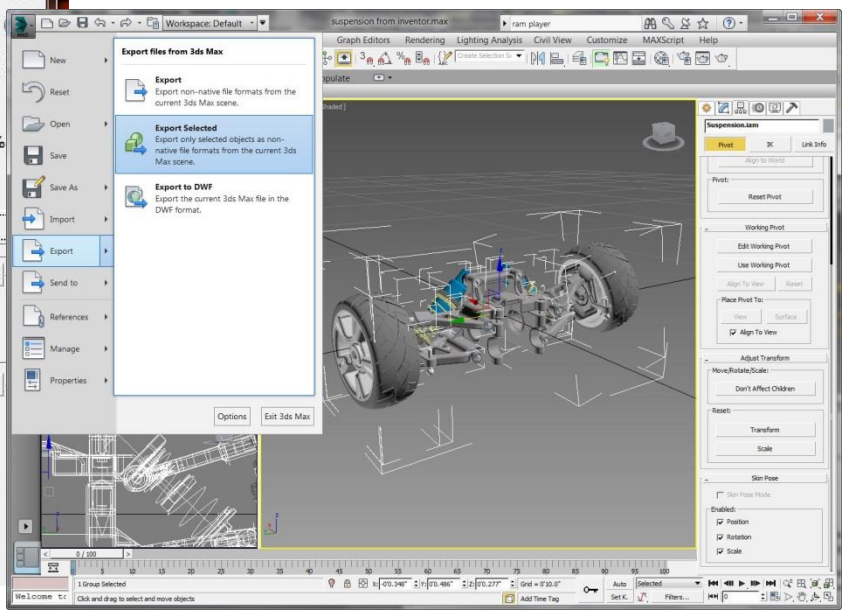
Adding colors in 3ds Max

Colors are exported according to material assignments for objects in 3ds Max. The method we will discuss requires objects to be using Standard material types. We will use the FBX file format to export models and material information that can be imported into the 3D printer software.

In 3ds Max the material's Diffuse definition is what will be transferred for the 3D print. Any image maps applied to the diffuse channel can also be exported with the FBX format and brought in to the 3d print software.



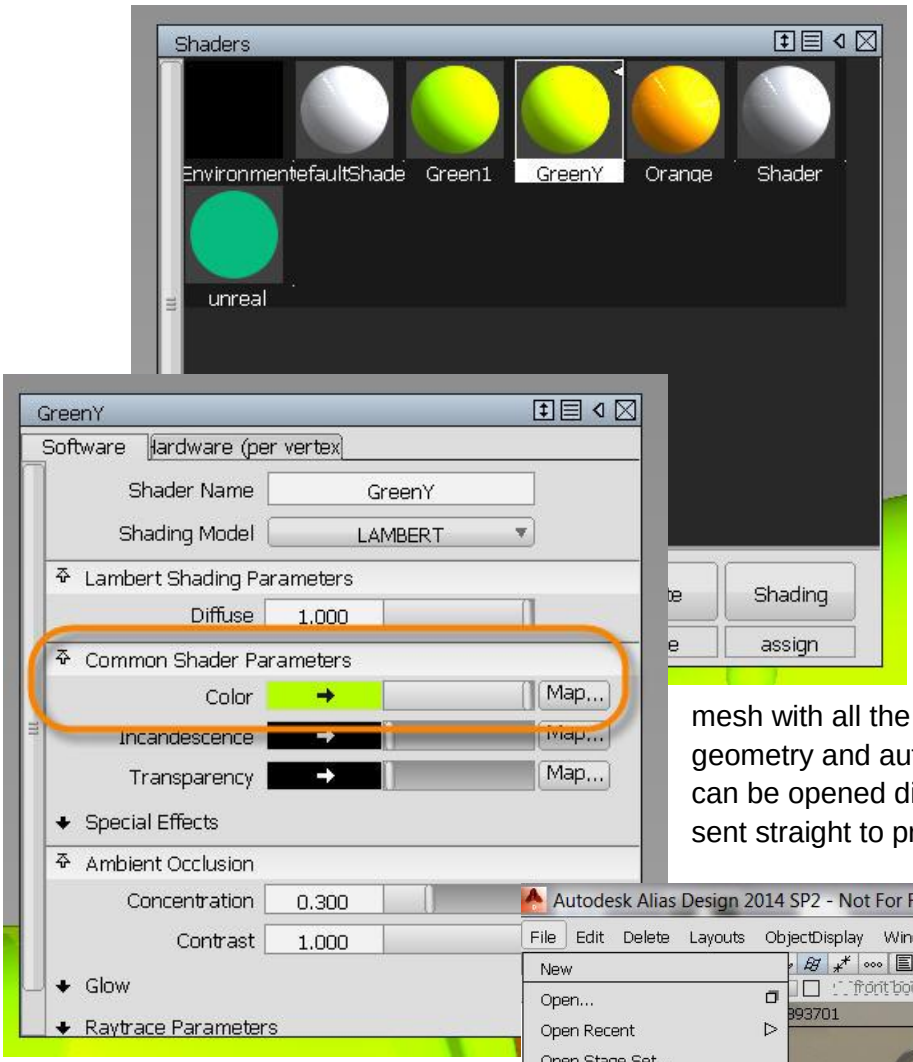
Once the objects in the scene have materials assigned to them you can export them using the FBX format. FBX files can be imported into some versions of ZPrint software to process and send to full color MJP 3D Printers.



Adding colors in Alias

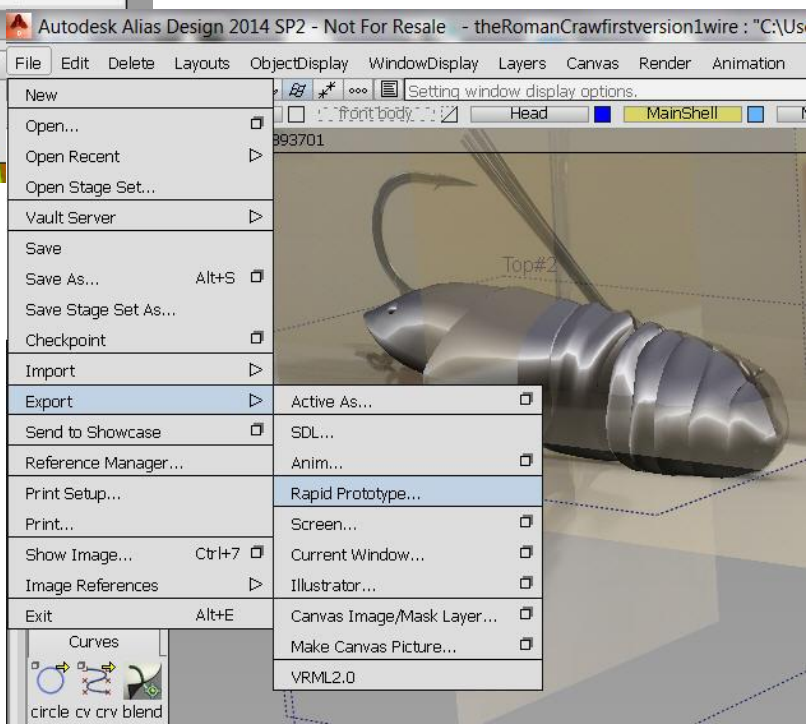
In Alias the materials assigned to objects are called shaders. As in 3ds Max, colors or images to be transferred to a 3D print are exported from Alias based on a specific shader parameter.

Every shader type has the settings rollout called “Common Shader Parameters”. The Color parameter here is what will control the printed color. The color definition or any image applied to the map field can be exported for 3D printing.



In Alias a few methods can be used for exporting a model with color data for 3D printing. As in 3ds Max, the FBX format can be used to transfer this data into 3D print software that will read it.

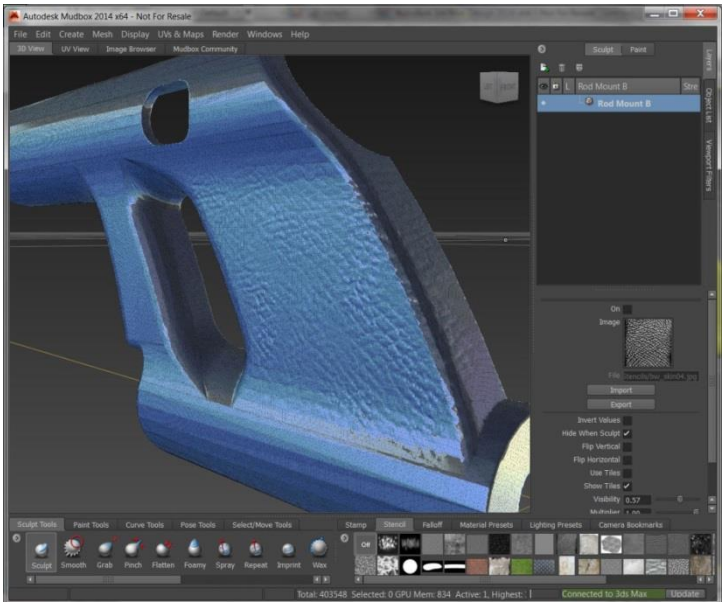
Another option when using Alias for coloring is to export directly for rapid prototyping. You can export straight to the ZPR format which is used by 3D Systems ProJet® printers. Alias will generate a mesh with all the colors assigned to the original geometry and automatically create the ZPR file which can be opened directly in the printing software and sent straight to print.



Adding color and texture in Mudbox

Models can be created in or transferred into Mudbox to add color and even realistic textures to surfaces.

For adding colors, Mudbox will behave as if you were painting or coloring straight onto a model. This is a different method than in other software where you assign colors based on surfaces, bodies, or parts.



With Mudbox, a user can also add physical texture to model surfaces for 3D printing. Although a surface may appear textured in a rendered image from 3ds Max, Alias, or Showcase, the surfaces usually do not physically contain the texture. The rendering effects used only simulate the appearance of texture. This works great for renderings, but the 3D printed part will not contain those textures when physically printed, because they are just digitally simulated by the rendering software. With Mudbox you can sculpt physical textures which can be 3D printed.

Geometry created as mesh works best in Mudbox. Although you can get geometry from programs like Inventor into Mudbox, you may be limited by how you can modify the geometry. It may require some extra work to prepare the model for sculpting in Mudbox. One possible workflow involves transferring the model to 3ds Max in order to create and fine-tune the mesh so that it will be ready for texturing in Mudbox. A good understanding of mesh modeling and geometry modification tools in 3ds Max will help prepare a good model for sculpting in Mudbox.

Geometry created from photogrammetry software such as Autodesk ReCap can be easily transferred into Mudbox for repair, sculpting, and recoloring.



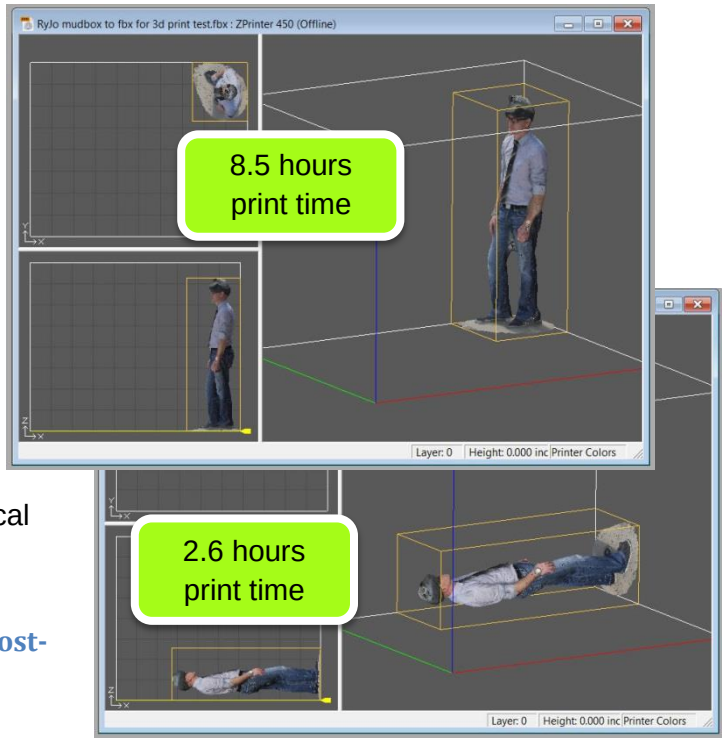
ReCap model in Mudbox and final 3D print.

Plan how to position models for best surface finish and efficient printing and processing

Just as in any production process, there are a variety of options when it comes to planning and executing the 3D print. Although you are not modifying the printed geometry itself at this stage, you can adjust positioning and orientation of the models in the print bed. This can affect print time and post-processing requirements. It can even affect the finish or appearance of the printed model. The following is a discussion of these considerations.

Positioning effect on print time

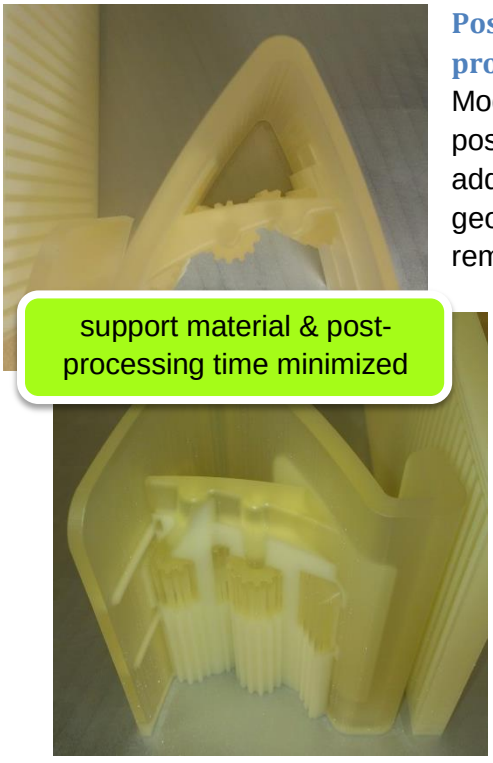
Model orientation and position in the build area can greatly affect print time. The considerations are generally different for the different print technologies.



Especially for granular bonding and photo-polymerization, more vertical build sections will generally require more time to print than the same build volume with less vertical sections. Both technologies require extra time either to spread or to cure the material on each layer. If objects to be printed can be oriented in the build bed so that they take up more horizontal space rather than vertical space, build time can generally be reduced.

Positioning effect on post-processing time

Model orientation and position can also affect the post-processing that will be needed. If additional support structures are required for overhangs or stacked geometry in extrusion deposition systems, they will have to be removed and cleaned up in post-processing.

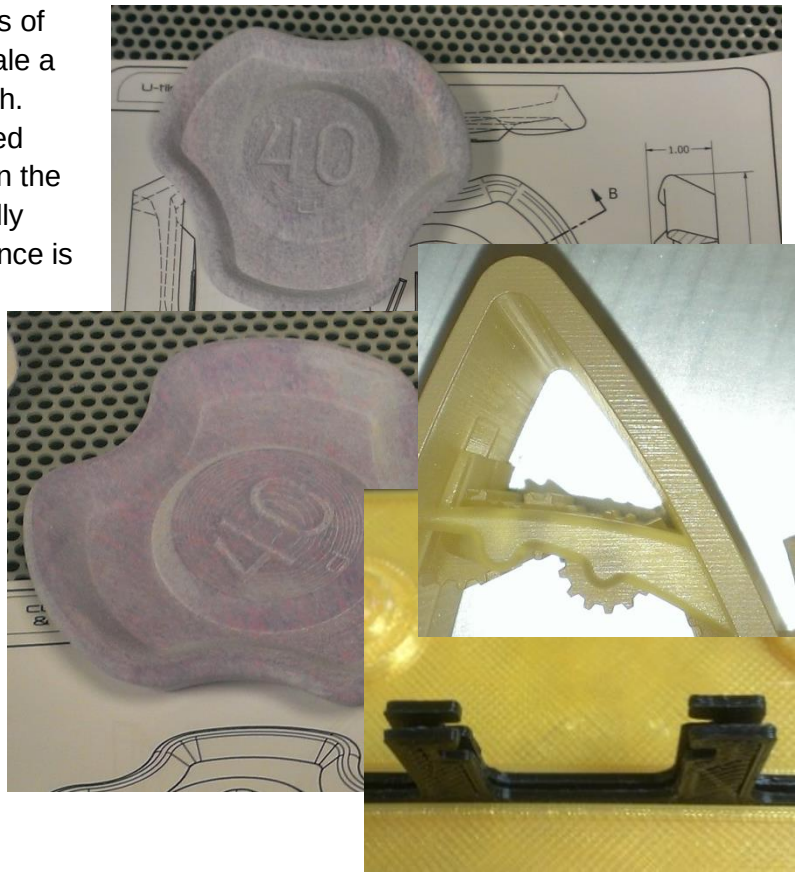


In photo-polymerization systems the support material also has to be removed. Depending on model orientation more or less support material may be required. Small reliefs or other features can sometimes be oriented so that no support material is required. This makes post-processing much easier and quicker since time doesn't have to be spent to remove support material from these areas. Orientation can even affect final print costs, since more or less support material may be required depending on model orientation.

For granular bonding systems unfused powder is simply brushed, vacuumed, or blown away, so orientation doesn't generally affect post-processing time.

Positioning effect on appearance

Because a 3D print actually consists of stacks of vertical cross-sections, at a close enough scale a surface will never really be completely smooth. Gradual curves on surfaces which are oriented horizontally will generally be more visible than the same gradual curve which is oriented vertically during printing. If very high finished appearance is required you may wish to reorient your part to minimize gradual curves around the horizontal plane.



The layer or filament size will obviously make a huge difference in final print resolution. High-end commercial printers today commonly can print at a resolution of 0.004 inch (0.1 mm) or more.

Some parts can be sanded or smoothed after being printed. This post-process can also smooth out small ledges which may be visible after the initial print and greatly improve the final look and feel of a model.

Conclusion

3D printing is an exciting industry which has been developing for many years and is rapidly expanding today. Those involved in this technology today are directly affecting its future growth and development.

Autodesk's Design Suites, among their other products and software, give users many tools to develop and prepare their models with 3D printing in mind. No doubt these capabilities and processes will continue to evolve and improve over time.