322470

Using Generative Design and 3ds Max to explore design options and dazzle stakeholders

Brent Scannell
Autodesk

Learning Objectives

- Import existing design data into the Fusion 360 generative design workspace
- Set up design and manufacturing constraints to guide the simulation
- Set up and execute automated 3D design using Generative Design
- Import, embellish, and render the results in 3ds Max for compelling design visualization

Description

Creating technical design solutions and presenting them to stakeholders is part of the everyday life of a design engineer, and the expectation of doing more with less is rapidly becoming the status quo in industry today. This class will use a real world example to demonstrate how you can unleash the potential of Generative Design in Fusion 360 to automate the solutions exploration phase of any design. You will learn how to import existing design data, set up design and manufacturing constraints, and execute automated design creating an unlimited set of possible solutions. Next, you will learn how to leverage the flexibility and power of 3ds Max to quickly create a compelling story for your stakeholders with stunning visuals, bringing the designs to life. Design engineers, it's time to level up and maximize your potential with today's latest and greatest engineering and presentation tools.

Speaker(s)

Brent Scannell is a member of the product management team at Autodesk in the Media and Entertainment group, working specifically on the development of 3ds Max. He is responsible for representing the needs of his customers to development teams. Prior to Autodesk, Brent worked as a mechanical engineer in the aerospace sector, and served as a technical lead on a new commercial helicopter development program. His focus was on propulsion structures design, and currently has 8 patent applications in review for his work on this program, however his passion for design and manufacturing date long before the start of his professional career. Brent is a member in good standing of the Quebec Order of Professional Engineers, has a bachelor's degree in Mechanical Engineering from Concordia University (Montreal) where he specialized in Thermodynamics and Propulsion, a Technical Mech. Eng. Technology Diploma from Dawson College (Montreal) where he specialized in 3D design and automated manufacturing.

Import Existing Design Data into Fusion 360 Generative Design Workspace

Generative Design in Fusion 360 is not limited to using geometry authored natively in Fusion 360, meaning you are free to import existing CAD data. Fusion 360 supports everything from Inventor to CATIA and Solidworks files, as well as nonproprietary formats such as STEP and IGES.

Importing using the Data Panel

Ensure the data panel is visible in the Fusion 360 user interface (item 1 in the graphic below)

The "Upload" button in the Data Panel will open a dialog and allow you to browse for a local file on your machine.

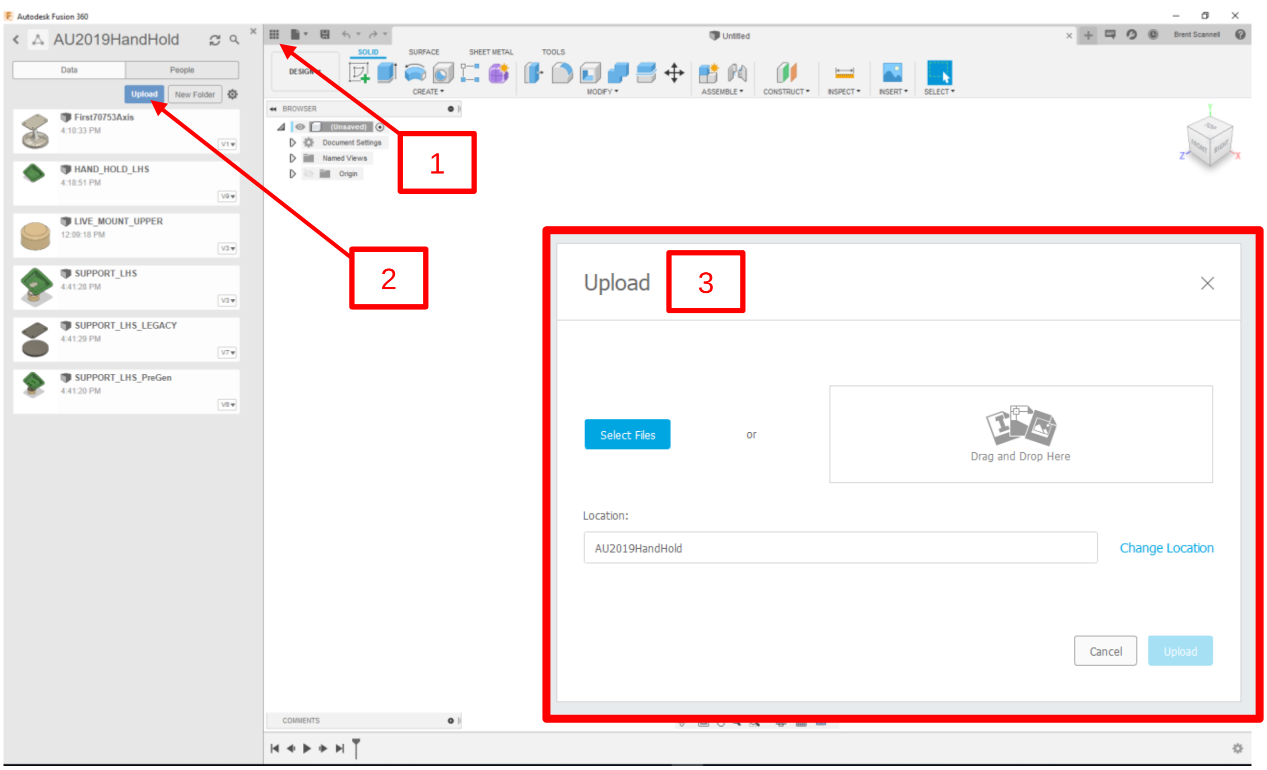


Figure 1

A new project file will appear in the Data Panel and will show a temporary thumbnail while the model is being processed and translated. Once the translation is complete, it will be available to open in the main Design workspace where it can be previewed, operated upon, or inserted into a Fusion 360 design.

To insert the imported dataset into a Fusion 360 project, right click on the imported and select “Insert into Current Design”

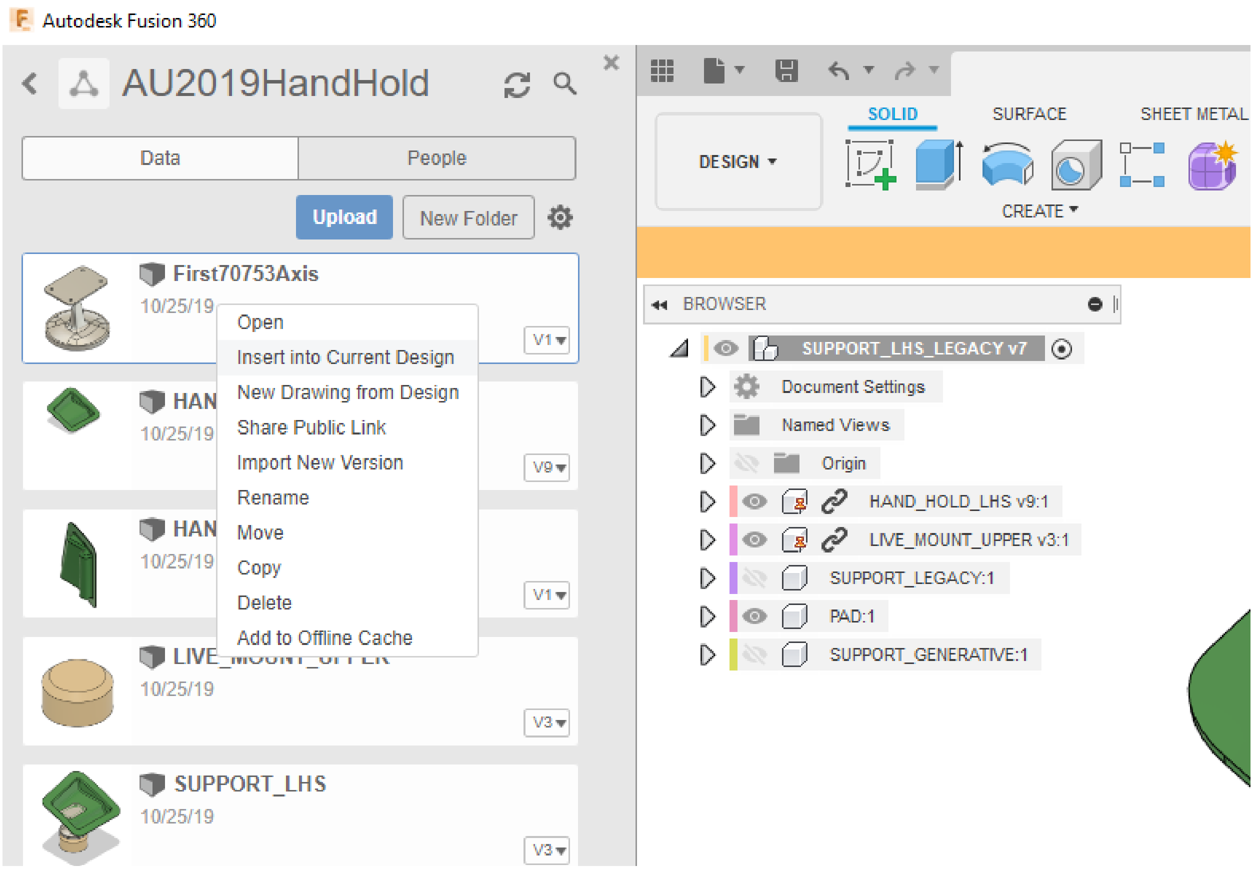


Figure 2

This will instance the selected part into the active project as a referenced child. Updates to the inserted component can be updated in the instanced location if changes are made, and this becomes a live link back to the source data. You may also apply spatial transformations to the imported model, as well use it in a rigged mechanical assembly in a joint definition.

In the example presented, I am inserting some reference models that the part that I am designing will interface with. I intend to use some geometry from the reference models to serve as a baseline to build interface geometry as a starting point for Generative Design. In this case, I have included a reference part where there is a known loading condition that must be supported, as well as some underlying grounded structure that I know will ultimately support the load from the first reference part. The part that I am designing will need to bridge the incoming load to the second reference part.

Set Up Design and Manufacturing Constraints

The Generative Design process requires some initial starting point to build geometry, which can typically be considered as the interface points of the part to be designed. In most cases, some basic hand calculations to be used to determine sizing of the interface points to support the load condition. Some typical examples include: minimum pin size in a clevis type connection, or number of fasteners and fastener diameter in a bolted connection.

Building initial interface geometry

In the Design Workspace, begin modeling the basic interface model geometry or import the geometry from an existing model/other CAD application. In the example presented, I am modeling a 4x .250” fastened connection with a .125” thickness baseplate. It is important to specify the bare minimum here while exercising some basic design best practices. It is arguable that the baseplate specified is not required as part of the minimum design criteria, however I opted to design a .125” thickness pad to accommodate some potential local punch loading that won’t be part of this design study. I will, however, present the Generative Design results in both cases.

In addition to the bolted connection interface with the first reference part, I have also modeled the second interface with the second reference part: a thin, circular rubber pad intended to transfer load to the grounded structure.

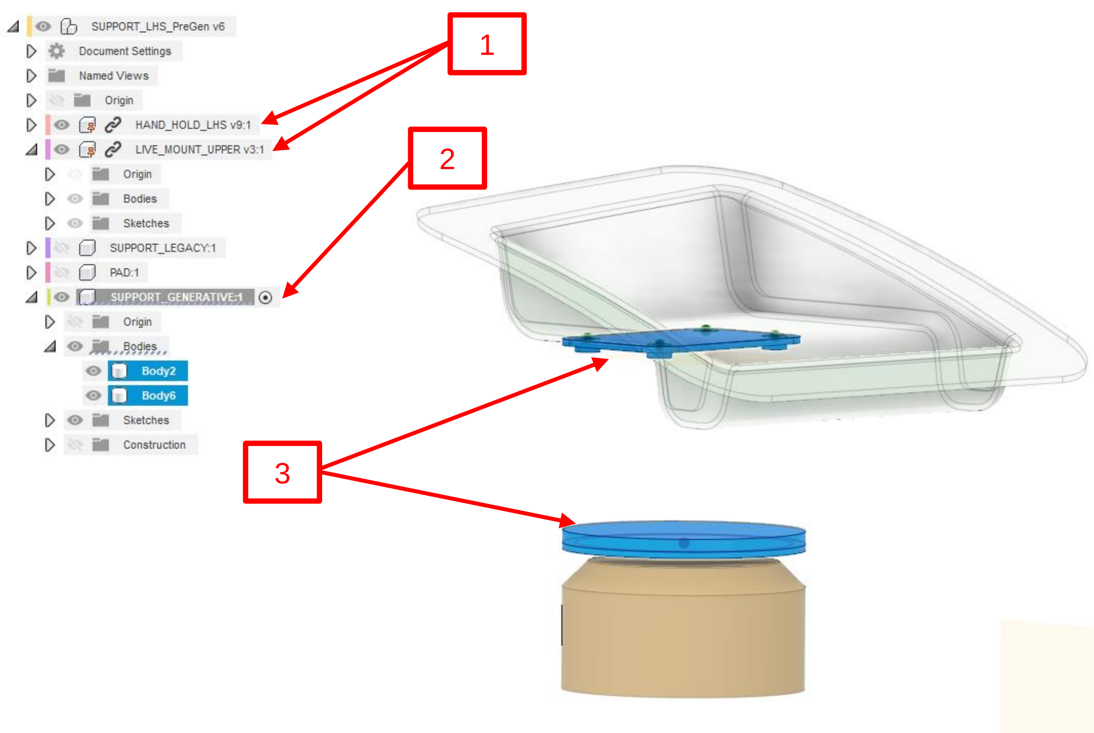


Figure 3

In Figure 3, item 1 refers to imported reference geometry, item 2 to the new design, and item 3 to the modeled interface geometry that will contact the imported reference models.

Design and assembly constraints for Generative Design

A good Generative Design should be guided by design and assembly considerations that aren't normally part of the engineering 3D model. Thankfully, the generative design workspace includes some geometry modeling tools that allow you to construct obstacles and other design considerations that will guide the Generative Design process without adding mass to the basic 3D model that we start with.

Switch to the Generative Design workspace as shown in Figure 4

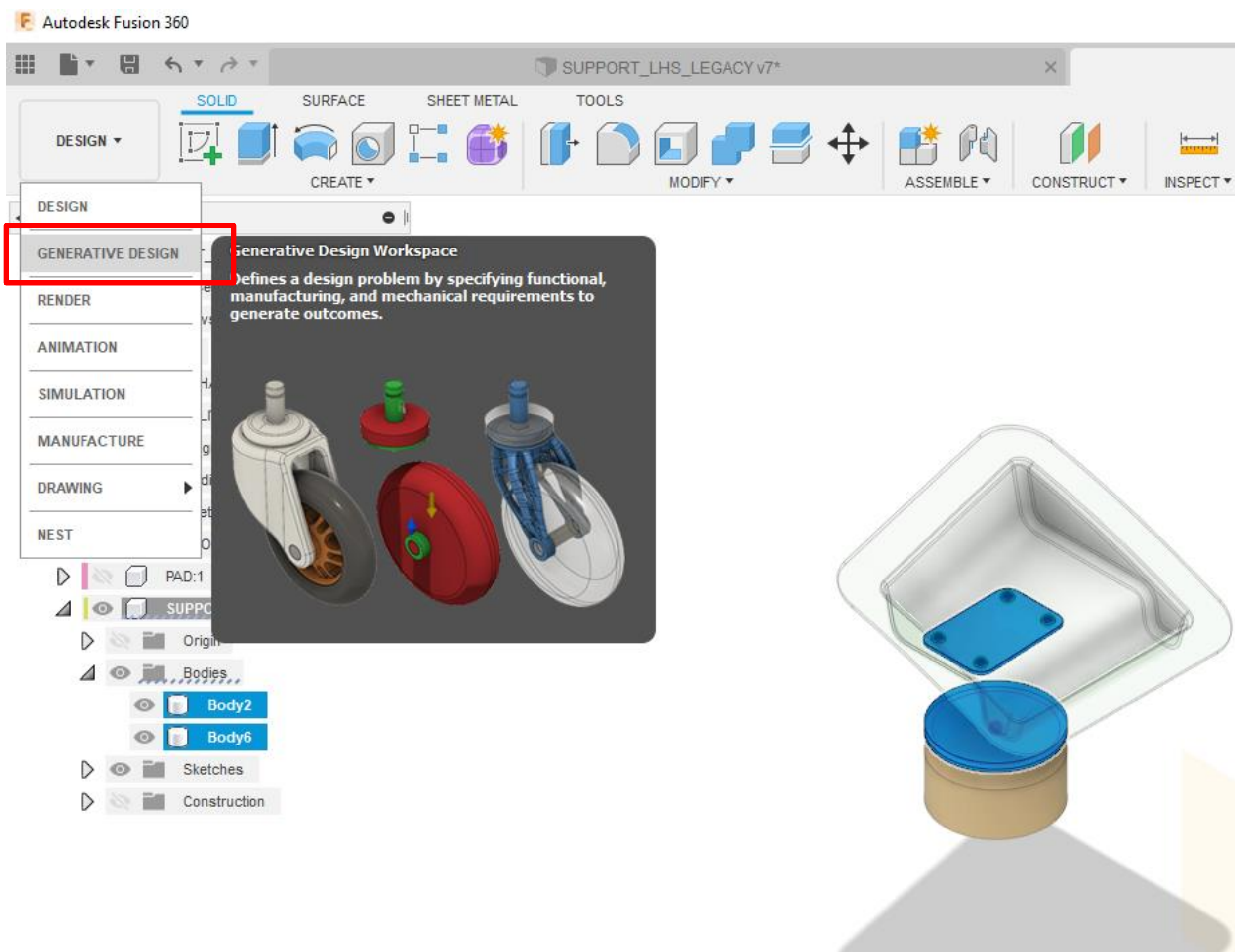


Figure 4

Generative Design works by defining both **included** geometry as well as **obstacle** geometry. In this example, the interfaces that were designed will be part of the included geometry and the obstacle geometry, if necessary, must be designed. Obstacle geometry might be existing components of the assembly, or temporary geometry that is modeled in place to represent design or assembly considerations such as clearance to fit a socket driver onto a bolt head. It is also recommended to use obstacle geometry to constrain the Generative Design simulation to the areas where you expect the design solution to reside. In this example, I have included tool clearance on the opposite side of the 4 bolt attachment interface, as well as large planar obstacles representing the unseen extents of the interfacing parts. Alternatively, I could have included the actual interfacing parts as obstacle geometry in this simulation if they were more complex and not easily represented as primitives.

The Generative Design workspace contains an **Edit Model** toolset to author temporary obstacle geometry and there are a few built in tools to create quick obstacle geometry for things like bolts and their tool clearances. In Figure 5, the red geometry represents my temporary obstacle geometry and the green geometry represents the geometry to be preserved. This is the default scheme for these geometry types.

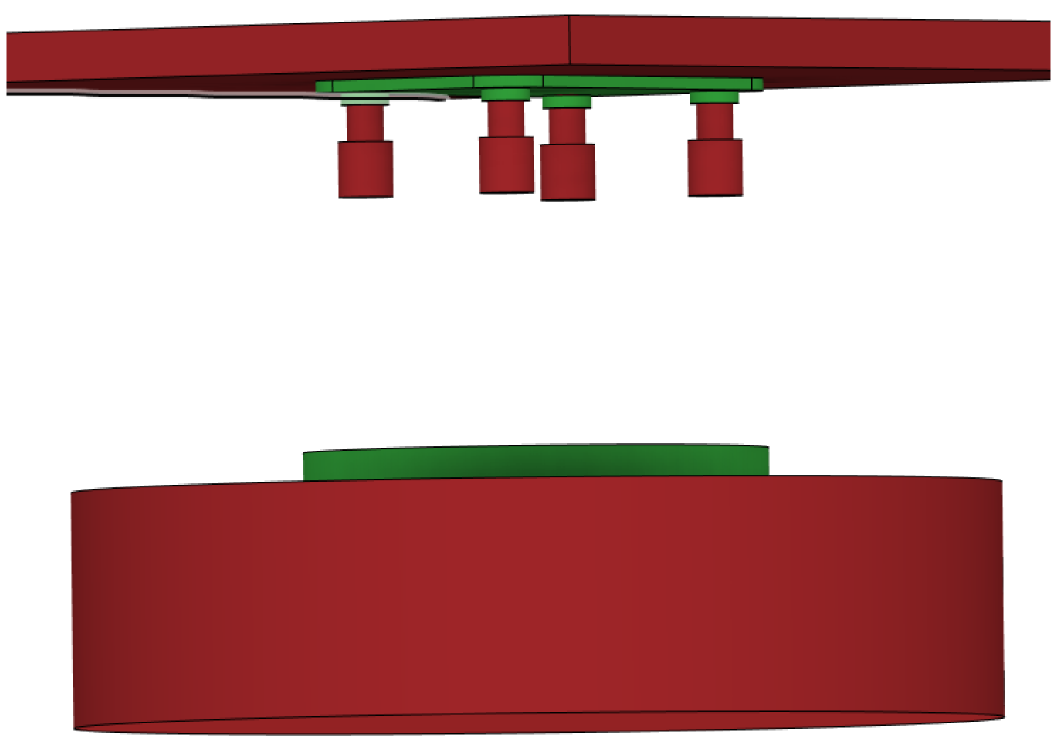


Figure 5

The Edit Model toolset contains familiar modeling tools as well as a **connector obstacle** tool which generates obstacle geometry in bolt holes, bolt/nut head geometry, as well as tool clearance in a single operation. See figure 6 for connector obstacle parameters.

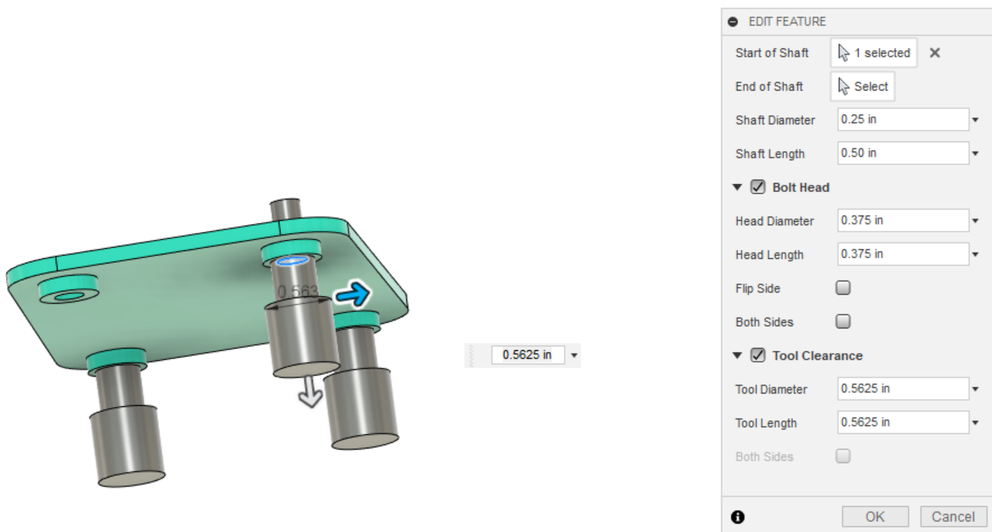


Figure 6

Setting up Load Cases

The next phase of preparing this model for Generative Design is defining the loading. In this example, I have set the interface points with the ground structure as a fixed constraint, and applied a load of 300 lbs to the top surface of my interface.

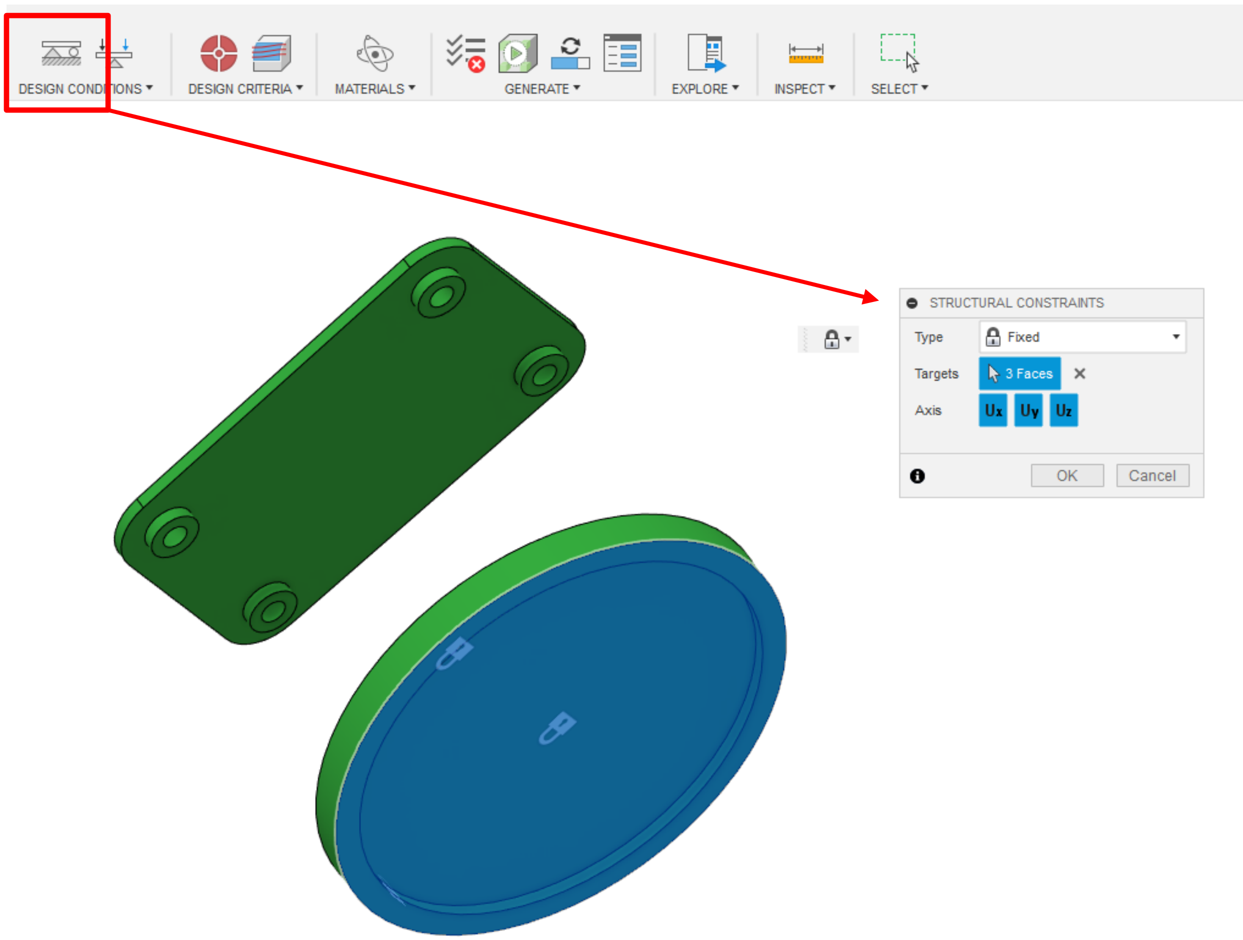
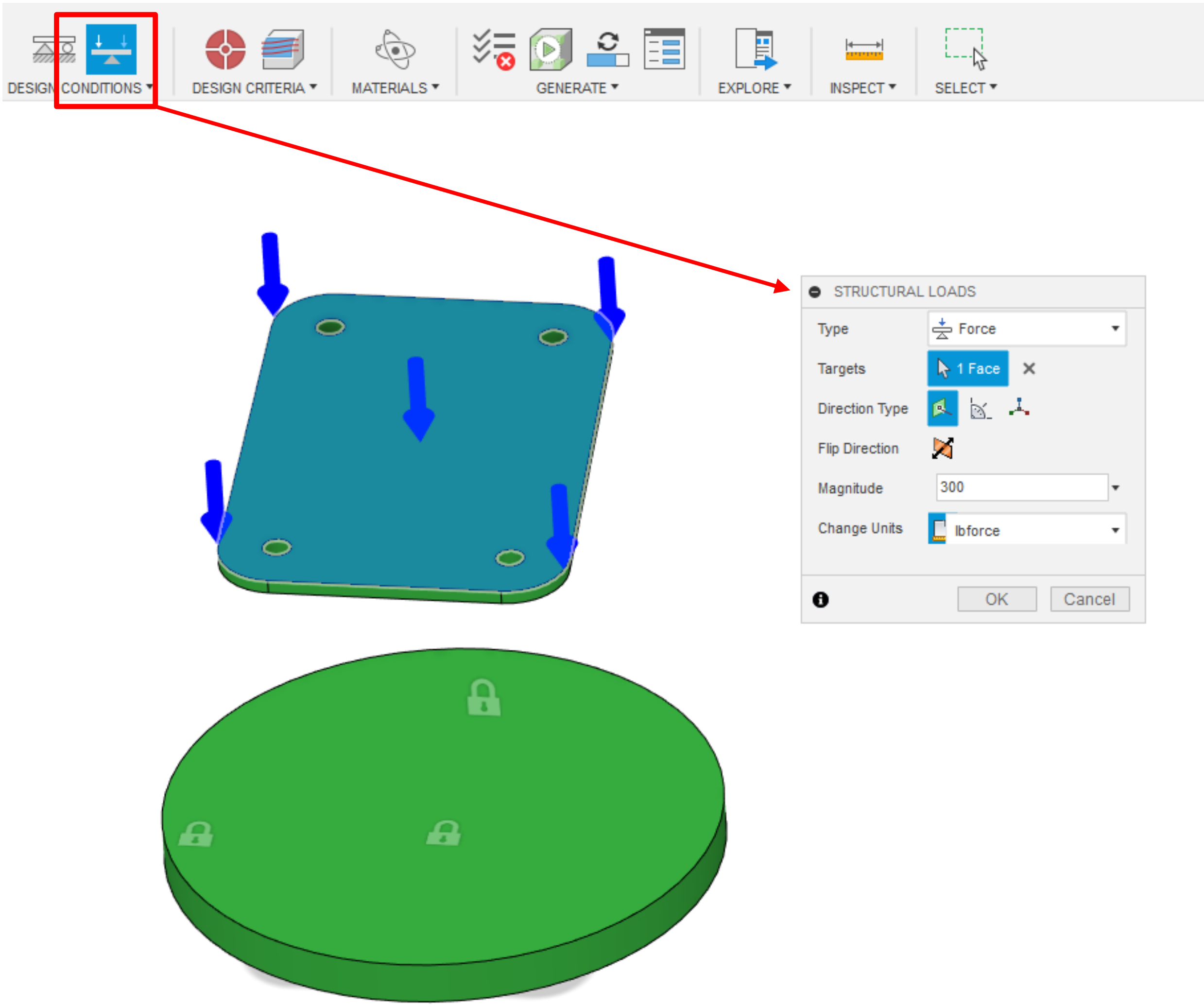


Figure 7


DESIGN CONDITIONS
DESIGN CRITERIA
MATERIALS
GENERATE
EXPLORE
INSPECT
SELECT
STRUCTURAL LOADS
Type
Force
Targets
1 Face
Direction Type
Flip Direction
Magnitude
300
Change Units
lbforce
OK
Cancel

Setting Design Objectives

This step allows you to define the objectives of the design by either minimizing mass or maximizing stiffness, along with a factory of safety target.

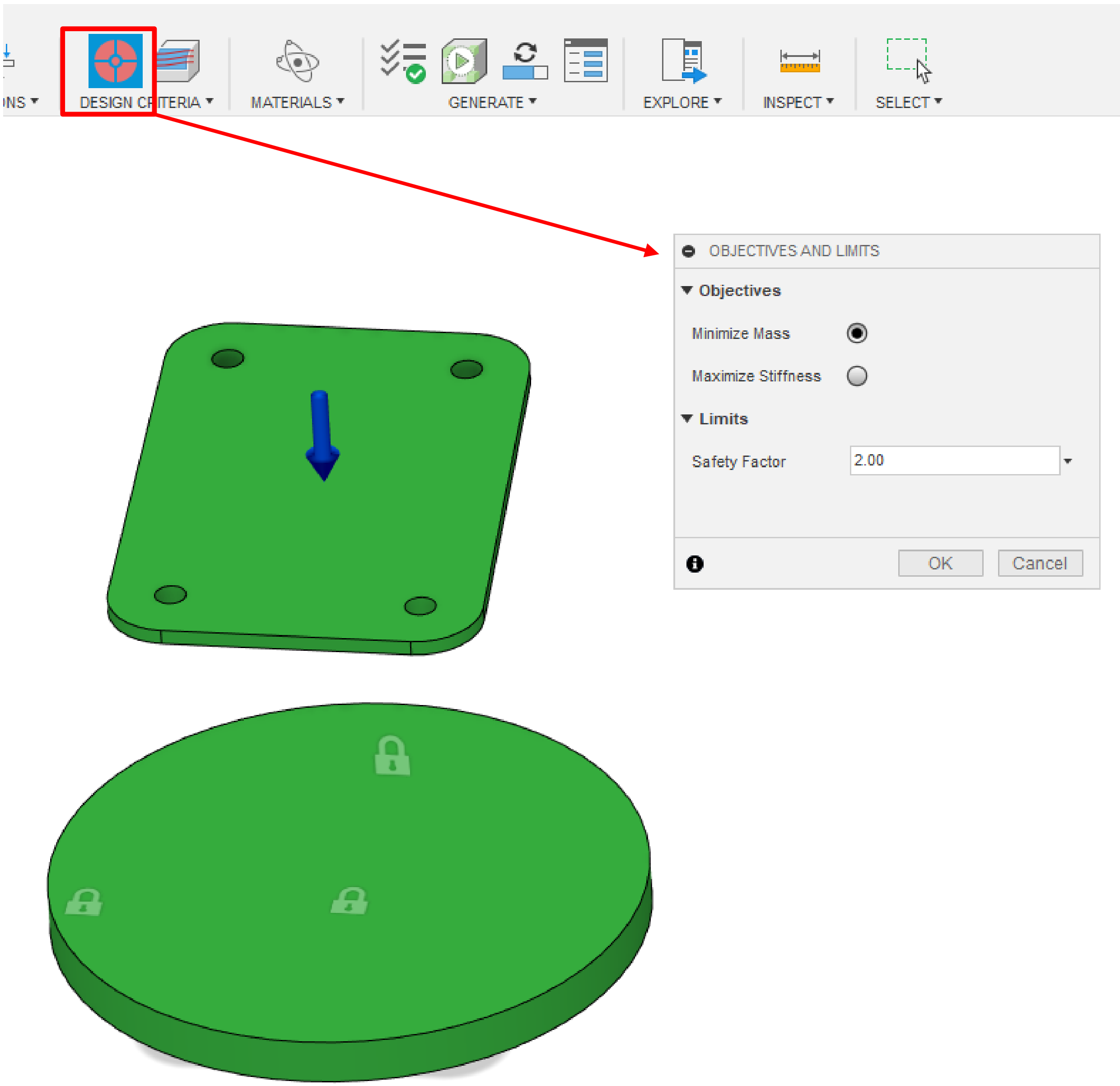


Figure 8

Setting Manufacturing Constraints

This step allows you specify which types of manufacturing processes and limitations that you'd like Generative Design to create solutions for. This includes 2, 2.5, 3, and 5-axis conventional machining as well as additive or die casting manufacturing processes. In addition to specifying the manufacturing process, you can also specify the orientation of work holding/tool direction or even multiple work holding orientations, allowing more flexibility on a 3-axis machining center, for example.

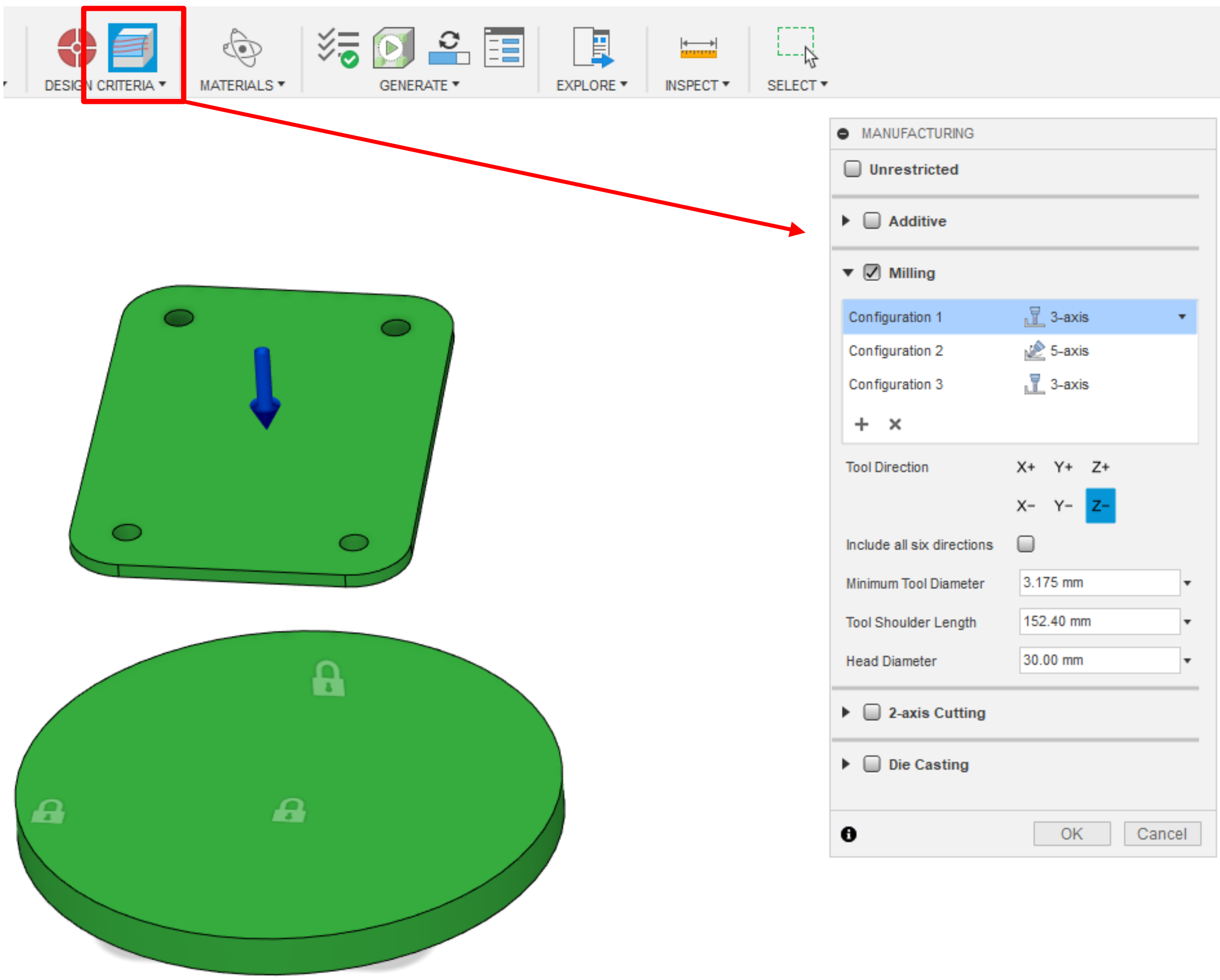


Figure 9

Selecting Materials

Generative Design currently allows you to specify 7 materials for a specific study without consuming any addition cloud credits. These materials may either be from the existing material library, or custom user defined materials, as shown in Figures 10 and 11

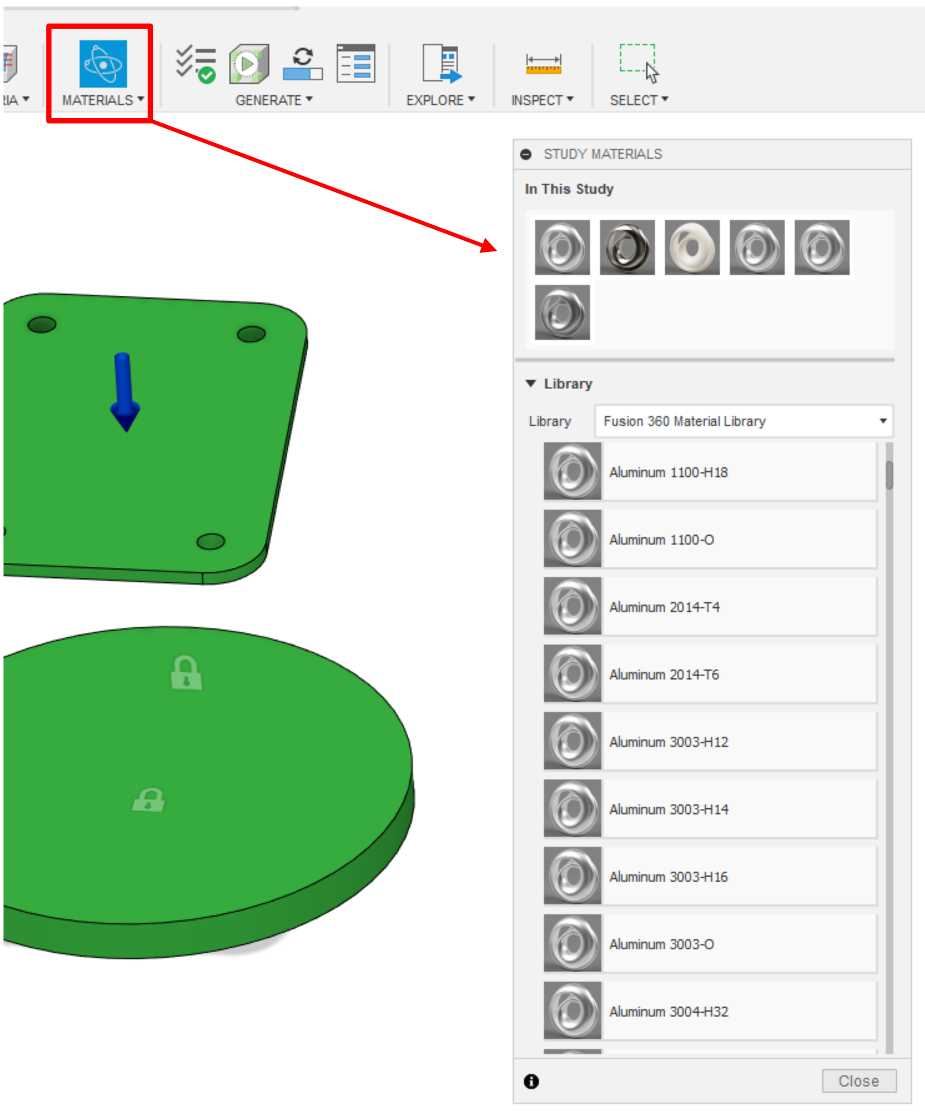


Figure 10

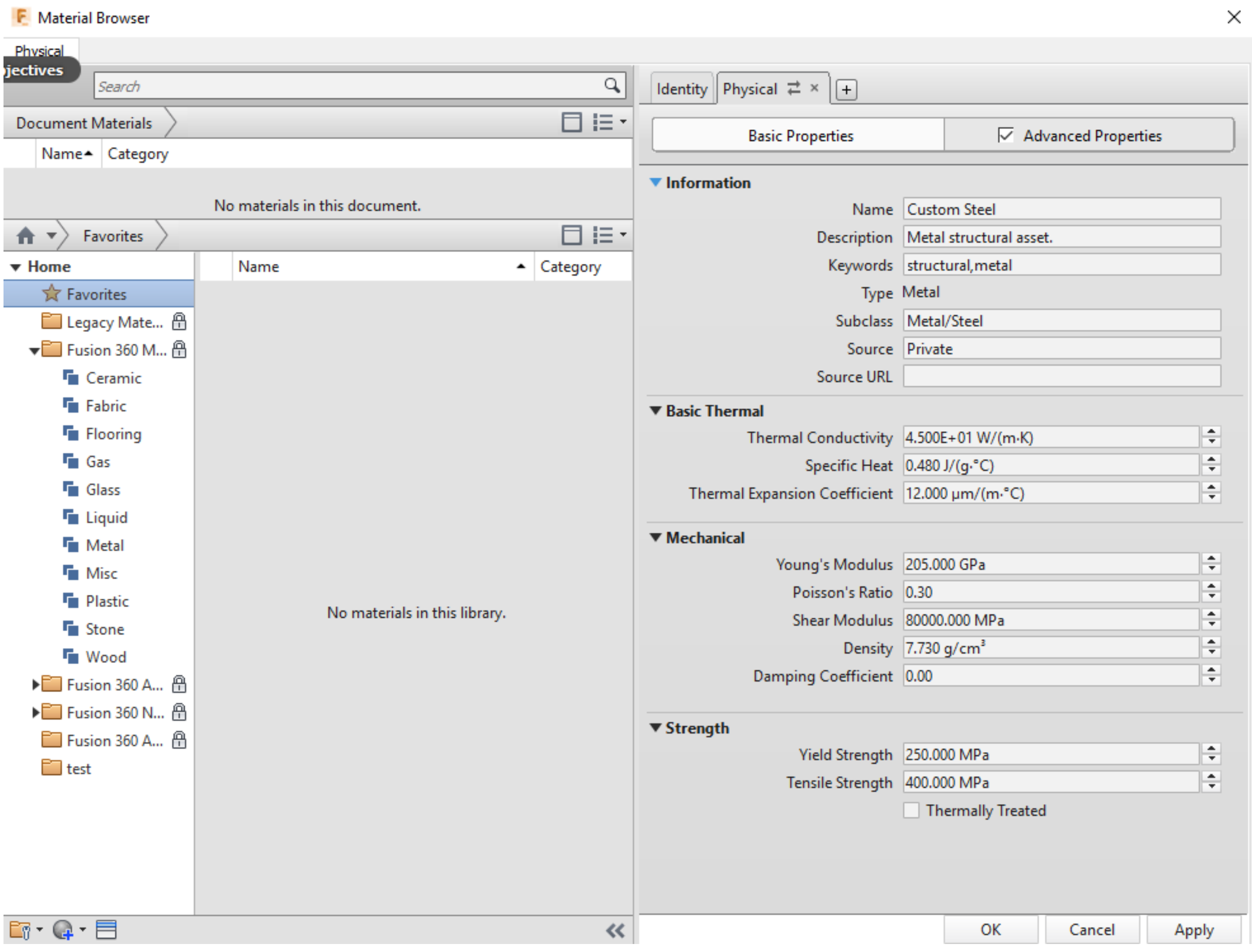

Material Browser
Physical
jectives
Search
Document Materials
Name
Category
No materials in this document.
Favorites
Home
Favorites
Legacy Mate...
Fusion 360 M...
Ceramic
Fabric
Flooring
Gas
Glass
Liquid
Metal
Misc
Plastic
Stone
Wood
Fusion 360 A...
Fusion 360 N...
Fusion 360 A...
test
Name
Category
No materials in this library.
Identity
Physical
Basic Properties
Advanced Properties
Information
Name Custom Steel
Description Metal structural asset.
Keywords structural,metal
Type Metal
Subclass Metal/Steel
Source Private
Source URL
Basic Thermal
Thermal Conductivity 4.500E+01 W/(m·K)
Specific Heat 0.480 J/(g·°C)
Thermal Expansion Coefficient 12.000 µm/(m·°C)
Mechanical
Young's Modulus 205.000 GPa
Poisson's Ratio 0.30
Shear Modulus 80000.000 MPa
Density 7.730 g/cm³
Damping Coefficient 0.00
Strength
Yield Strength 250.000 MPa
Tensile Strength 400.000 MPa
Thermally Treated
OK
Cancel
Apply

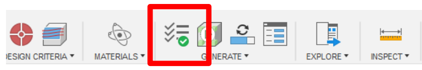
Figure 11

Using Generative Design

Now that all the geometric requirements and constraints have been defined, and the simulation objections and manufacturing considerations have been included as design parameters, we are ready to begin using the solve capability of Generative Design.

Starting a Simulation

The Fusion 360 Generative Design workspace includes a model precheck tool which can identify potential issues with the simulation before starting the job. Issues such as incomplete load case definition, missing materials, incompatible or missing model references, or other issues will be identified here.



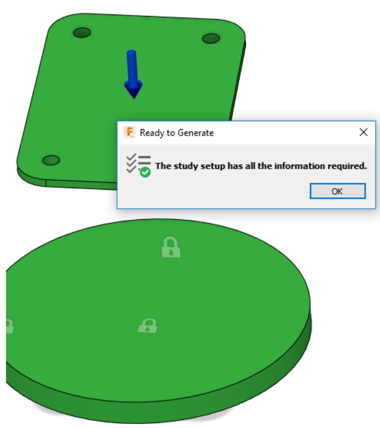


Figure 12

The Generative Design workspace also includes a **Previewer** tool which can give you a quick approximation in the viewport of what the generated geometry might look like. This is not intended to give final results; it is to help identify missing controls or obstacles. In the preview shown in Figure 13, the geometry is far from optimized however it has identified that some solutions may be delivered which include appropriate tool clearance locally to the bolt holes, however they do not extend far enough to render them accessible from outside the part boundary. Generative Design will work within the constraints that you set up, however restrictive or not they are. Additional obstacle geometry may need to be created to provide tool access to the bolt head.

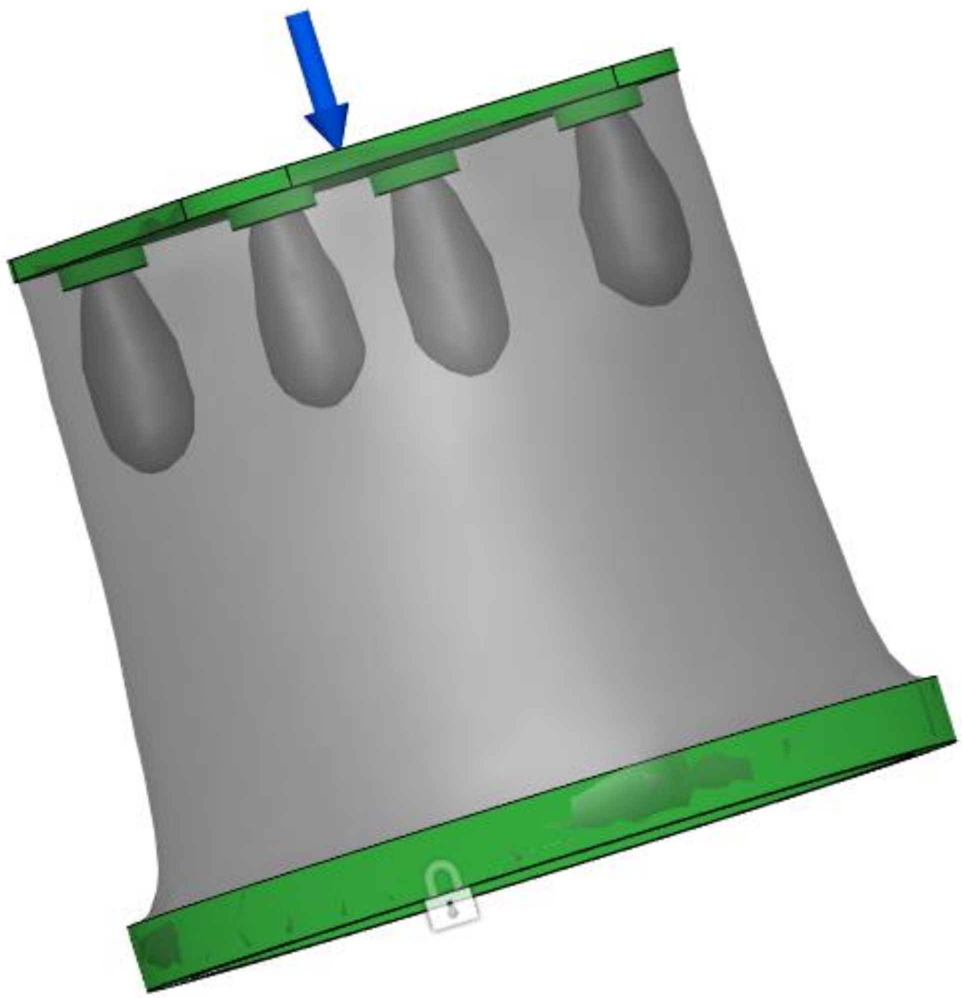


Figure 13

A new project file will appear in the Data Panel and will show a temporary thumbnail while the model is being processed and translated. Once the translation is complete, it will be available to open in the main Design workspace where it can be previewed or operated upon.

Once satisfied with the preview, clicking **Generate** will open a dialog to begin the simulation.

Reviewing Results

Generative Design allows multiple methods for reviewing the results of the simulation, including visual thumbnails, 3D previews, filtering based on properties, scatter plots, and a table view.

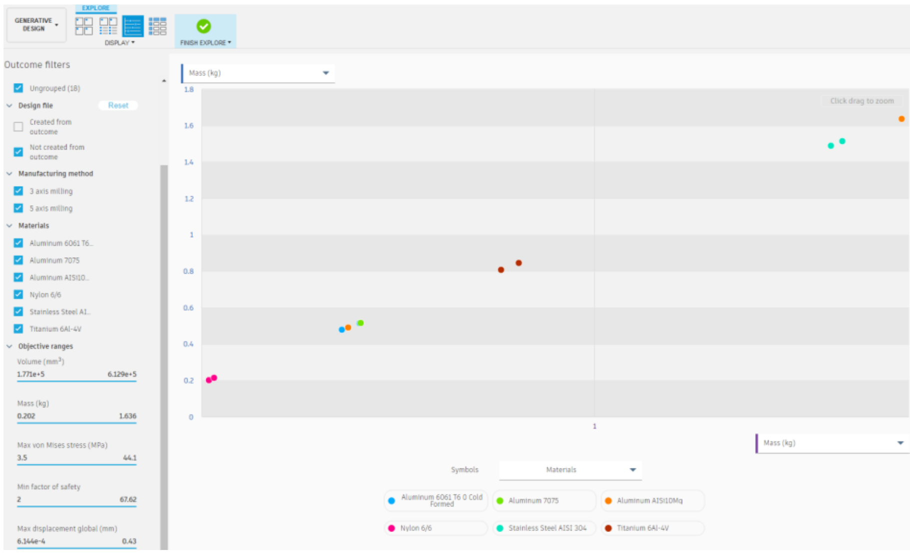


Figure 14

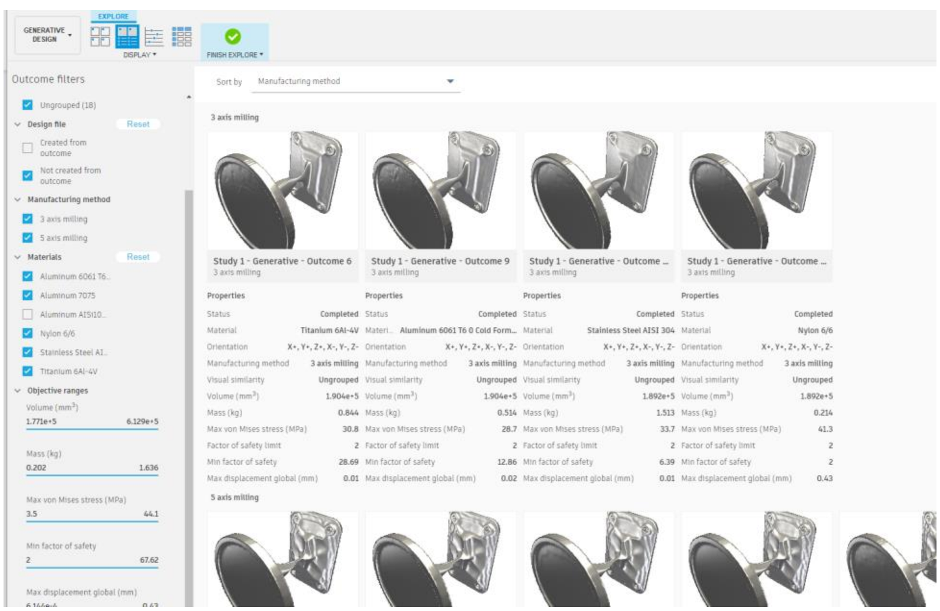


Figure 15

Using the results

One important consideration that needs to be made is that Generative Design develops solutions using Finite Element Analysis on a triangle-mesh representation of the starting geometry, and delivers results in the same mesh format. If you wish to use one of the generated results, a secondary process must also be used to convert this representation back of a CAD friendly format. In the detailed view of any single solution/outcome, the **Create New Design from Outcome** button will initiative a cloud job to convert the model to a new design component that can be inserted back into your assembly once completed. Figure 16 shows the workflow for creating a new component from an outcome, and Figure 17 shows the result back in context with the original reference models.

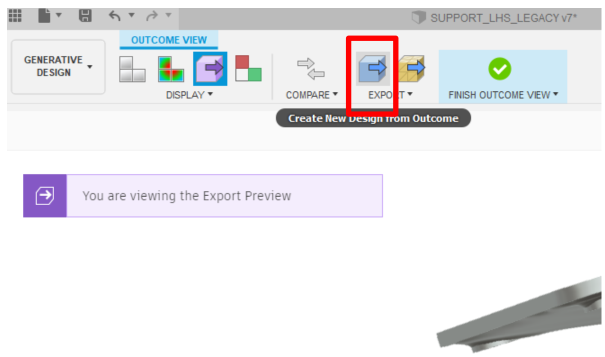


Figure 16

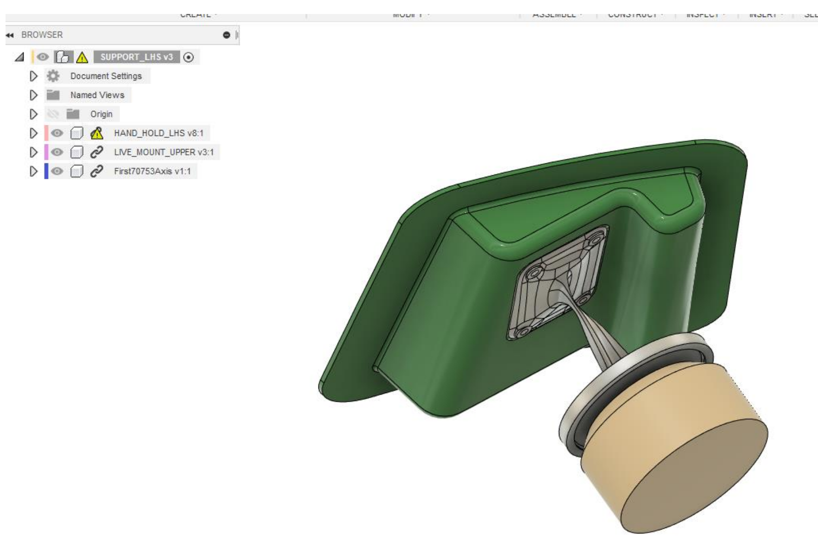


Figure 17

Using 3ds Max for Design Review Imagery

3ds Max is a professional 3D content creation tool used in games, film & tv, and for high end design visualization in architecture and product design. While many CAD applications, including Fusion 360, include capable rendering tools as part of their offering, 3ds Max excels at allowing users to go the extra mile and embellish their designs, creating stories and delivering impact to their stakeholders.

I will not attempt to summarize every capability and workflow available in 3ds Max in this handout, however I will demonstrate a few best practices and include links to get more detailed information.

Setting up 3ds Max for a Basic Product Render

Ensure that Arnold is set as the current renderer in 3ds Max. Many settings in 3ds Max are derived or inherited based on the active renderer, so setting it to Arnold ensures no wasted downstream work. To access the render settings, enter the **Rendering** menu from the main menu bar, and select **Render Setup**.

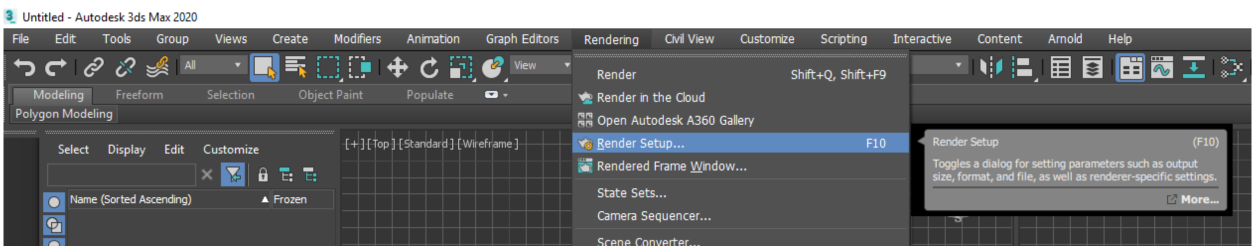


Figure 18

Select Arnold from the Renderer drop down list, then close the dialog.

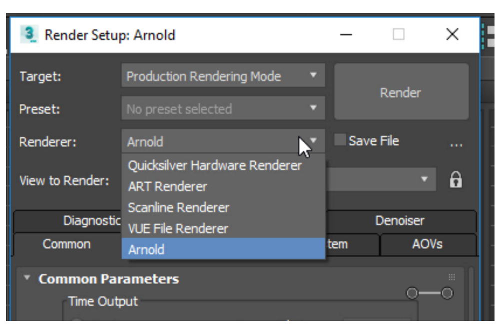


Figure 19

Next, we will set up a basic high-dynamic-range background image that will serve as a backdrop for the render as well as provide a basic set of lighting for the render. This is an optional step, however skipping this step would require you to set up light sources in the scene which will not be covered in this handout.

From the **Rendering** menu, select **Environment…**

In the dialog that opens, click the button labeled by default as **None** in the Environment Map: field, then double click on the **Bitmap** item in the Material/Map Browser dialog. The resulting dialog will allow you to select an HDR file, which may be found on many paid and free websites. Choose the default options, the perspective viewport should now show the resulting background image.

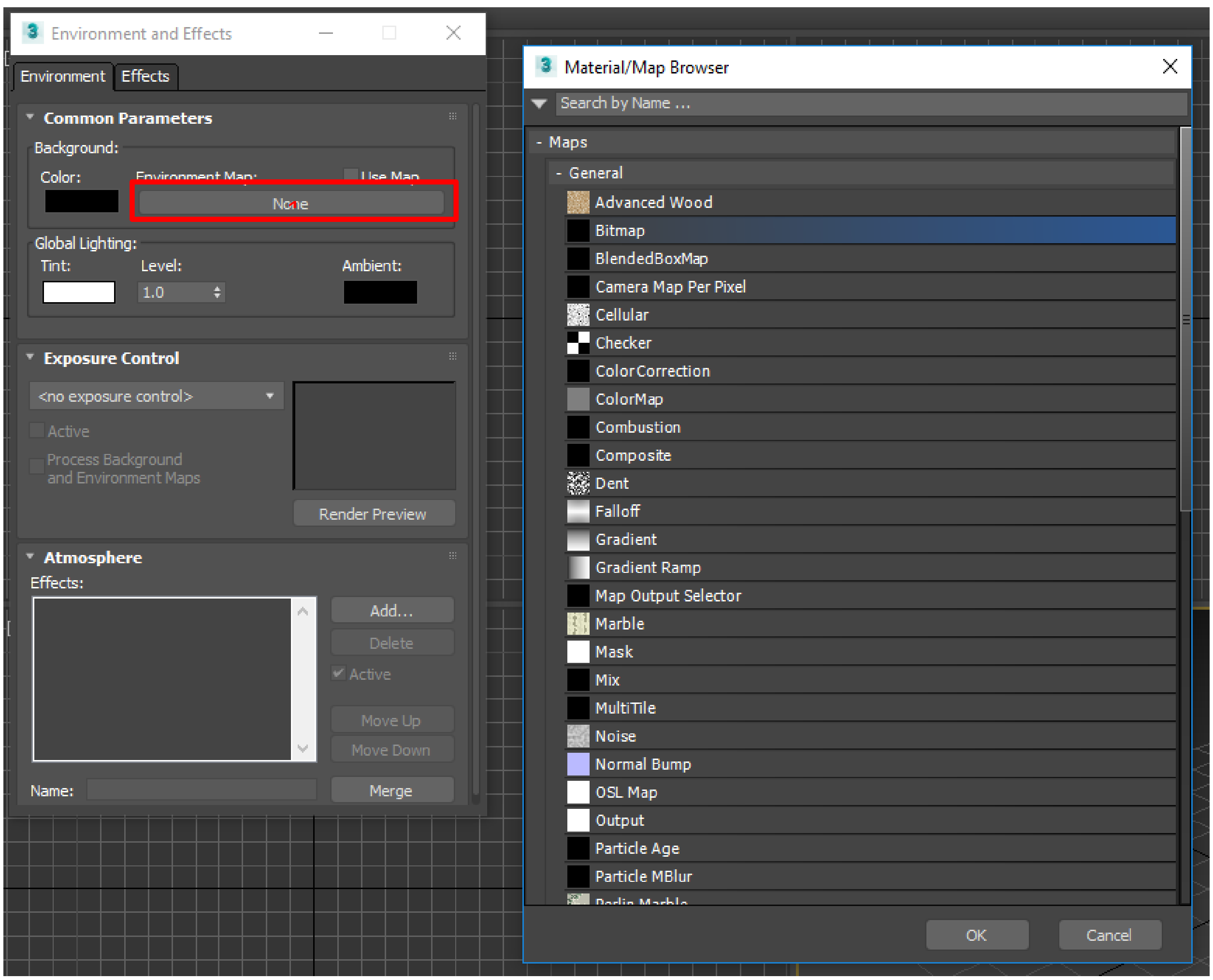


Figure 20

Getting the Model Data from Fusion 360 to 3ds Max

While there is no direct support in 3ds Max to import Fusion 360 archive files directly, there are a number of export options from Fusion 360 that can be consumed directly in 3ds Max. Some formats use a tessellation (converting solids to triangle mesh objects) mechanism built into to Fusion 360 such as OBJ, FBX, and STL. Other export solid model data directly, such as IGES and STEP. My preference is to use the STEP interchange format. Export is available from the file menu of Fusion 360:

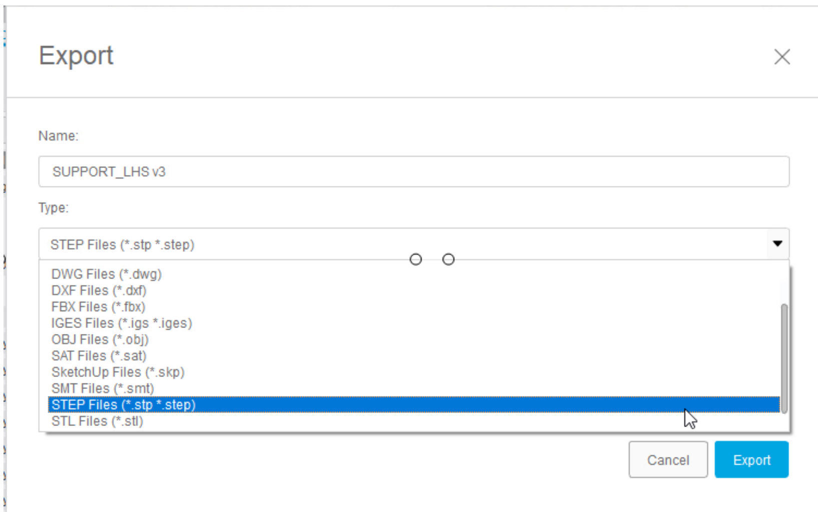


Figure 21

Once exported, we will import the model into 3ds Max via the **File** menu, and selecting the **Import->Import…** item, then choosing the exported STEP file. The import dialog will present you with a few import parameters, as shown in Figure 22.

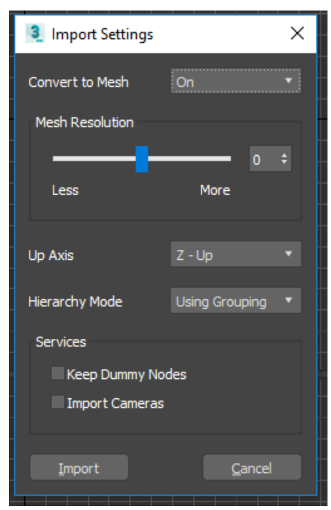


Figure 22

The convert to mesh option will convert the solid geometry to a triangle mesh using the mesh resolution control below. A higher resolution mesh will consume more resources and perform slower, but will have higher visual quality. This cannot be modified after the initial import, so a few iterations may be required to find the right setting for your needs. Opting not to convert to mesh will translate the model data into **Body Object** object types in 3ds Max, which are a hybrid between a solid body and a mesh representation.

Up Axis defines which direction the model orientation was in the source definition, and Hierarchy modes allows preservation of assembly grouping or optionally flattening the structure to a single level.

In this example, I have used the default settings of convert to mesh ON, mesh resolution setting in the 0 setting, Y as the UP axis, and using groups as a hierarchy mode. The import results can be seen in Figure 23.

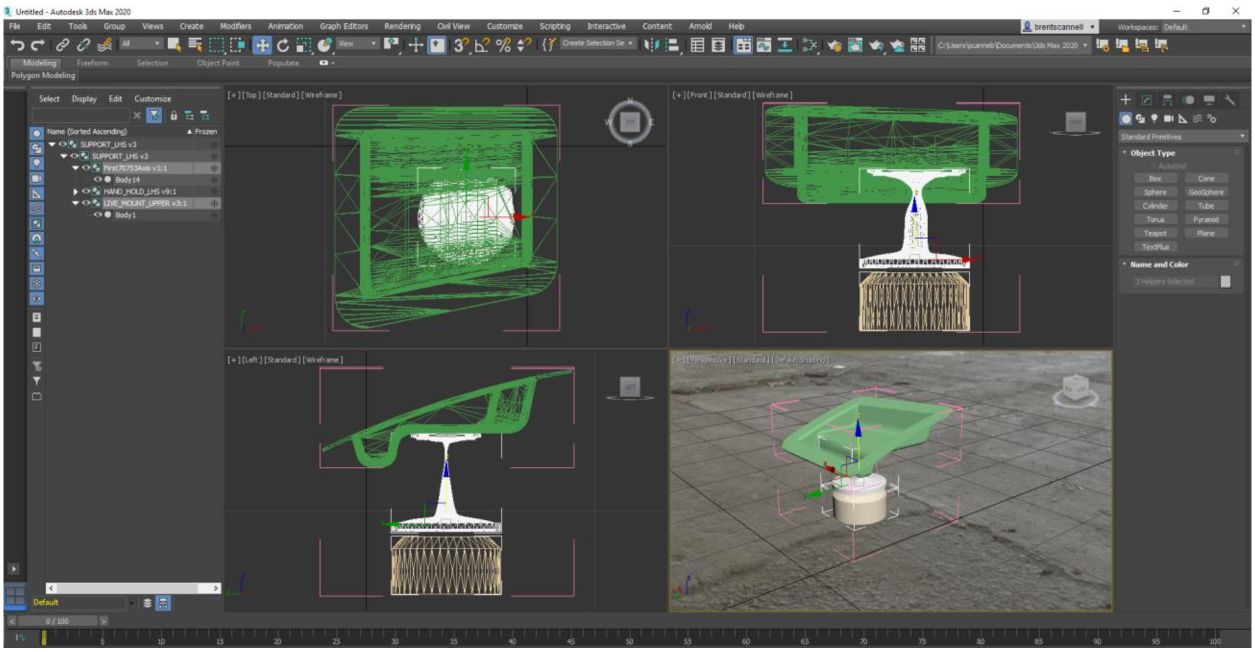


Figure 23

Applying Materials to the Imported Models

While the imported model, as shown in Figure 23, did converse some basic color info from the Fusion 360 model, these basic material definitions will not deliver the impact we are looking for in a high quality render.

3ds Max includes a shader model known as the Physical Material, which is a physically based material definition which is similar to the Appearance/Material model used in Fusion 360.

More information about Physical Materials at Autodesk can be found here:
https://github.com/Autodesk/standard-surface

To open the material editor, open the **Rendering** menu, select **Material Editor->Slate Material Editor**. By default, the material editor will only display material types that are compatible with the selected renderer. To create a first physical material, double click on **Physical Material** in the Material/Map browser on the left side of the interface, then double click once again on the Physical Material that now appears in the main part of the material editor interface.

In Figure 24, I have selected the **Patterned Copper** preset from the drop down list on the right side of the interface, which pre-populates the material parameters lower in the interfaces. All of these parameters are adjustable, and the preset is purely a starting point to get basic parameters set up for a metal type material. Again, many of these parameters are similar to the material controls in Fusion 360.

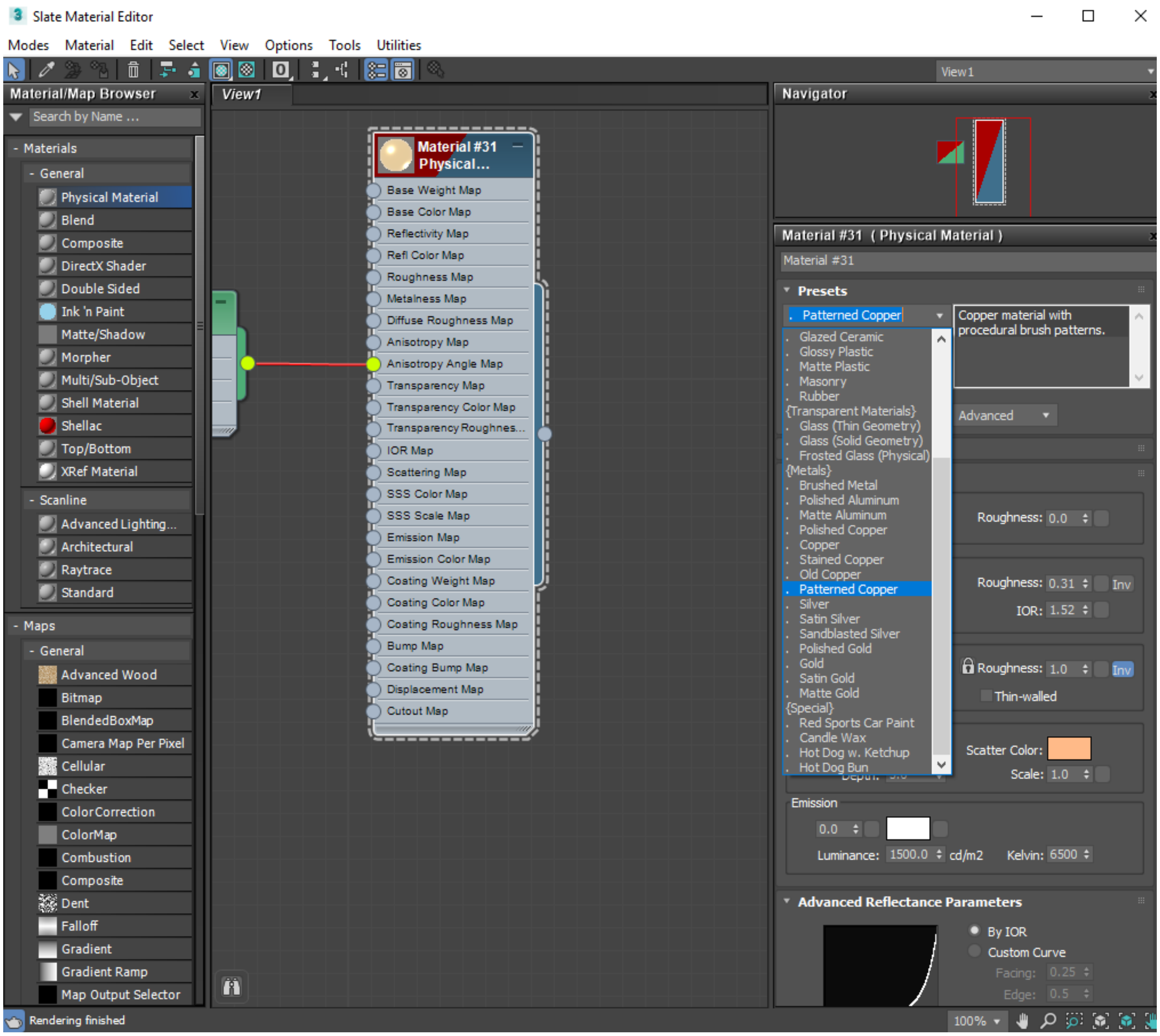


Figure 24

To assign a material to an object, select the target object in the viewport or from the scene explorer on the left side of the main 3ds Max interface, and then using the **Material** menu, select **Apply Material to Selection** as shown in Figure 25.

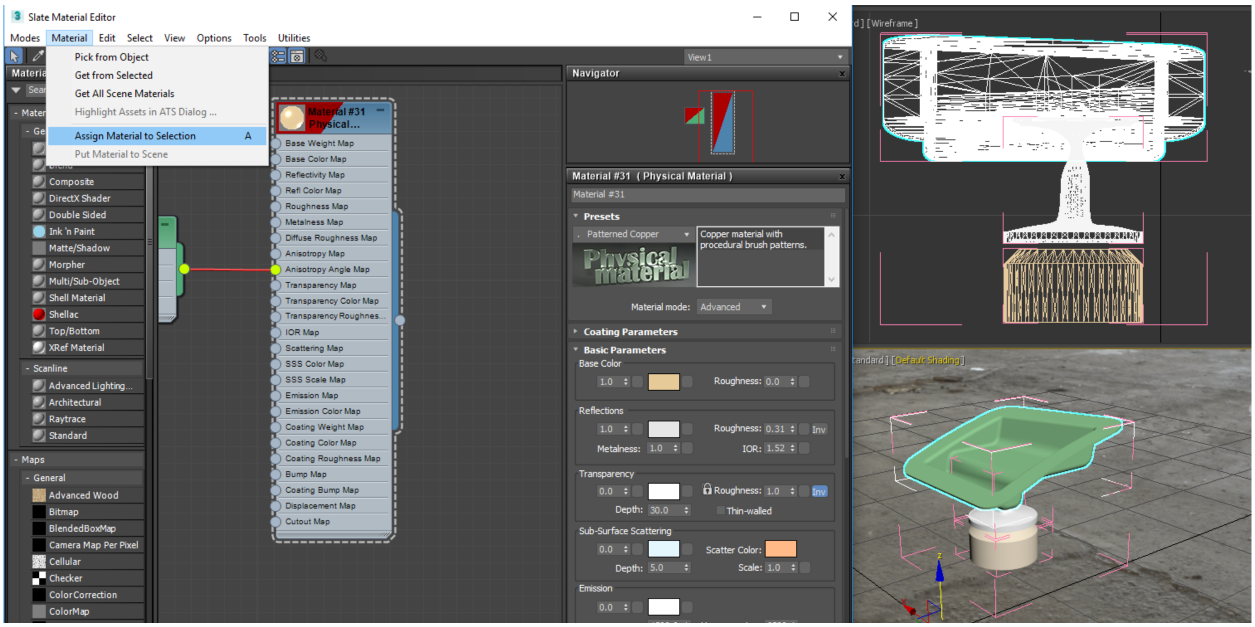


Figure 25

After all material definitions and assignments have been made, the first test render is ready to be executed. From the **Rendering** menu, select **Render Setup…** again and choose some initial options such as output resolution. Click the **Render** button to see the initial results. To save any rendered results, simply click the Save button in the rendered frame window to save out the current render.

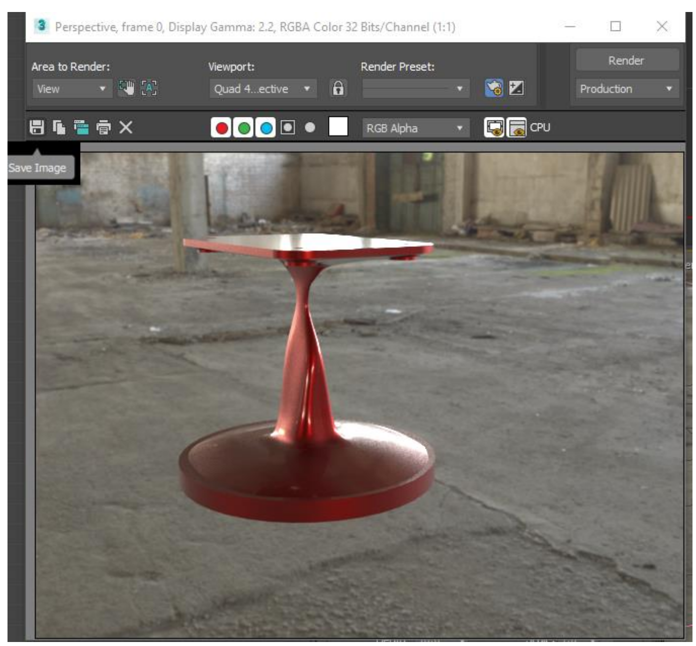


Figure 26

Accessing Detailed Information

While this section has outlined an extremely basic overview getting a rendered result in 3ds Max, there are an infinite number of possible workflows to showcase a design in 3ds Max each with their own specific nuances and learning curve. In the links below you can find more information on either the presented workflow or other workflows that could apply to a design review context.

First off a shameless plug for the Autodesk Area, a one stop shop for aggregated tutorials and featured articles. The content here is ever evolving, so check often and use the search. If there is content missing here, feel free to reach out.
https://area.autodesk.com/all/tutorials/3ds-max/

With respect to getting a quality render out of Arnold in 3ds Max, I recommend looking at some existing and future AU classes by my colleagues Bruno Landry and Jose Elizardo. They go in depth with how to do efficient noise reduction and include some tips and tricks based on their combined experiences in industry:

Unleashing the Power of Arnold in 3ds Max for Product Design and Visualization (AU 2018 Class)
https://www.autodesk.com/autodesk-university/class/Unleash-Power-Arnold-and-3ds-Max-Product-Design-Visualization-2018

3ds Max: A Case Study in Design Viz (AU 2019 Class: AE321681)

Stuck on the start screen? Not sure what that button does? Check out our forums over at
https://forums.autodesk.com/t5/3ds-max-forum/bd-p/area-b200
Not only is there a massive database of previously answered questions, but there are tons of industry experts and 3ds Max employees participating on the forums to answer any and all questions.