

MFG125668

## **We Can Make Dreams Come True**

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Metso

### **Learning Objectives**

- Learn how to load projects and models into the software
- Learn how to set loads and constraints on the model
- Learn how to set objectives needed for results
- See how simple it is to run the application

### **Description**

“We are the music makers, and we are the dreamers of dreams.” Autodesk Generative Design (formerly Dreamcatcher) is Autodesk's amazing and innovative standalone application for generative design. With this revolutionary software, we can design products with the influence of nature and the power of computing. These generated designs are something you could only dream about. This instructional demo will cover basics of the Autodesk Generative Design software. We will demonstrate the steps needed to get your data loaded, constraints added and objectives set. After that, we will then show what definitions are required to process the information and how easy and informative it is to view the computed results. Sample parts will be used for the demo and shown for reference. Other topics will include subscription information, technical specifications and more. Only released Autodesk software made available to the public will be demonstrated.

### **Speaker**

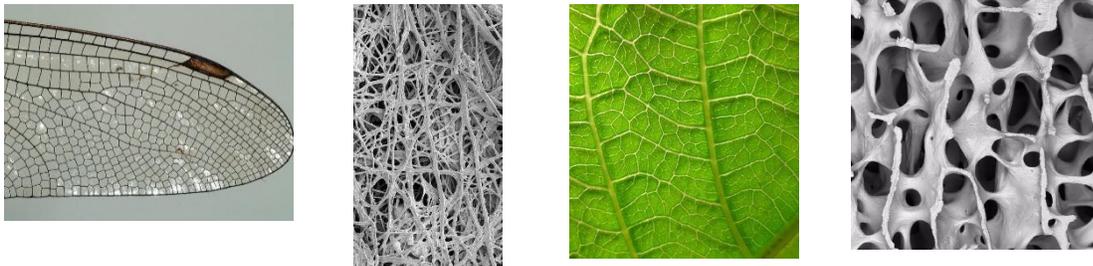
In David's busy life, his day job currently takes on the role as a Global System Specialist for Metso, a large Mining and Construction company. As part of this role, David deploys new software, supports users on Engineering applications and remains fluent on new industry trends. His past experiences in the engineering and CAD field include serving as a Mechanical Designer, CAD Drafter, Industrial Designer and Graphic Designer. After-hours, David is also the co-founder and Chief Development Officer of Dvelopd, LLP. Dvelopd provides modern technology, additive manufacturing, and mobile apps to businesses and individuals throughout the world.

## What is Generative Design?

Nature has been perfecting and adapting design for millions of years. What if we could reference nature for the basic of our design?

Autodesk Generative Design (in short, AGD) makes it possible to create designs that only nature and dreams could accomplish. Autodesk Generative Design uses organic algorithms to design structures that mimic nature.

Reference construction derived by nature include dragonfly wings, egg shells, leaf structure and bone. (shown from left to right)



More information about Autodesk Generative Design can be found here:

<https://www.autodesk.com/solutions/generative-design>

This document will walk-through steps within the AGD workflow and give you a better understanding to setup your very first generation of designs. Screenshots of the software could vary in look and describe usage different than versions available.

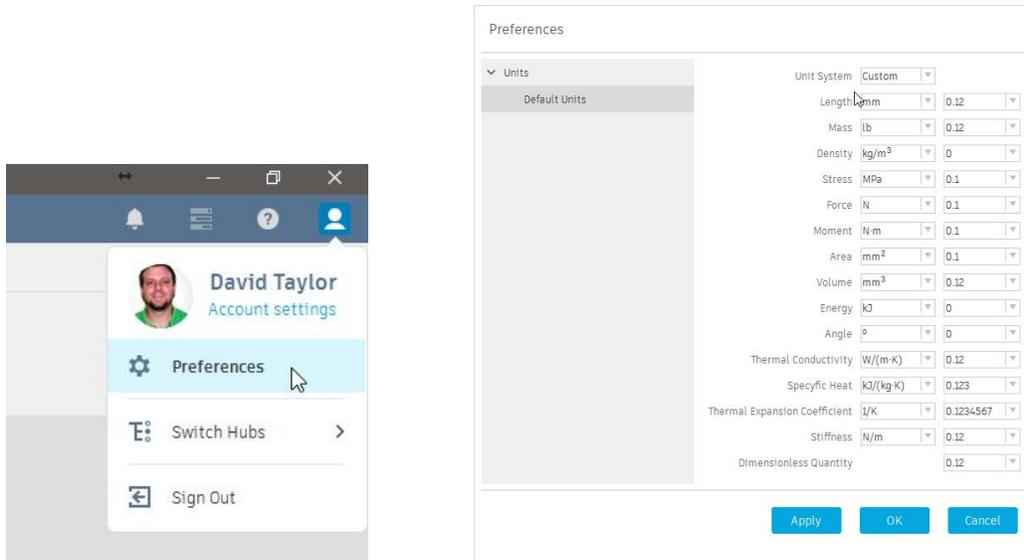
## User Interface and Workflow

Autodesk Generative Design is setup to allow for maximum ease-of-use and simplicity of workflow. The buttons are laid out so that the user can follow the process from left-to-right.

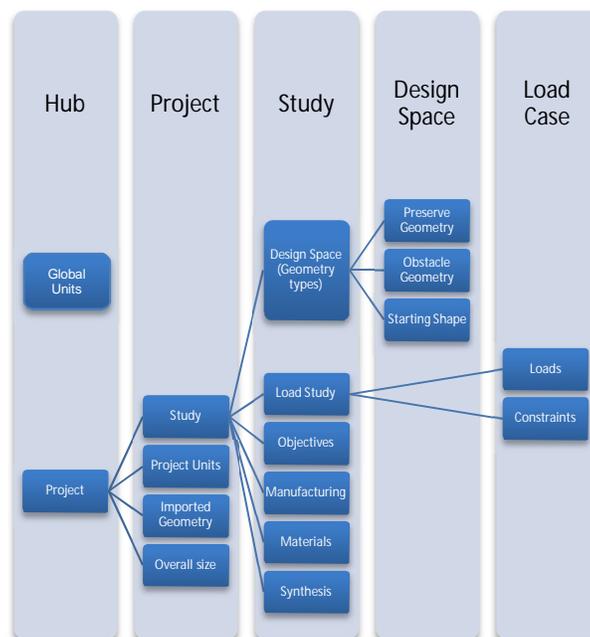
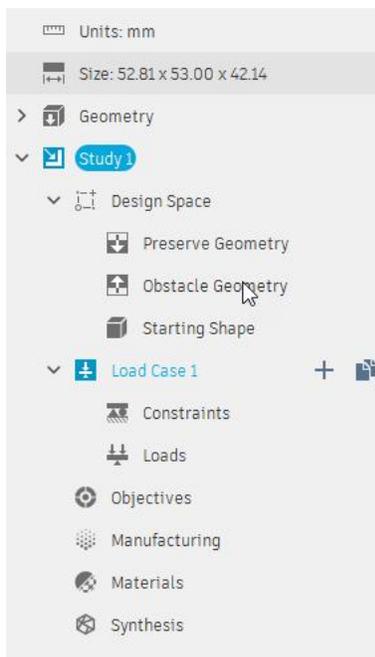


Right-click menus also allow for assigning bodies within the design space, toggling visibility and selecting objects. You can also right-click in the browser tree to edit Objectives, Materials, etc.

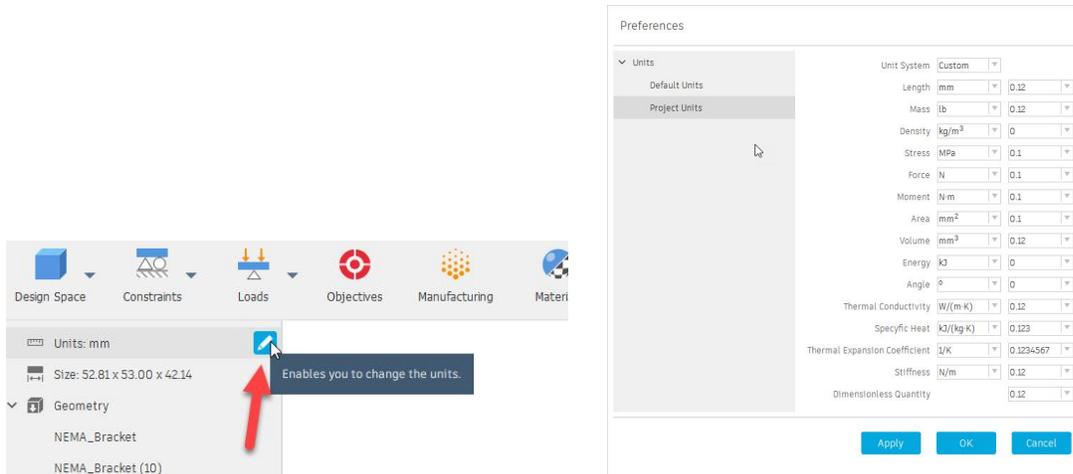
Global preferences and defaults can be found in the User Account button on the top-right of the application window. Here you can change default units for AGD.



On the left of the window is a browser tree and will display units, size of the overall geometry, geometry bodies and studies. This information is accumulated into a *Project*. Breaking down a project, we find it contains a *Study*, which holds assigned geometry types, loads and constraints as we start to work through the process. A breakdown of the workspace structure is included in the chart below. A *Hub* contains a *Project*, a *Project* contains a *Study*, etc.



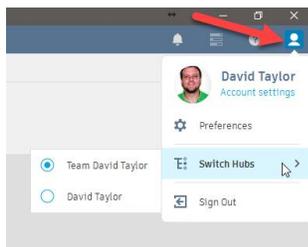
Project preferences (if you want to specify different from the global AGD preferences) can be found by clicking the pencil button next to the project units.



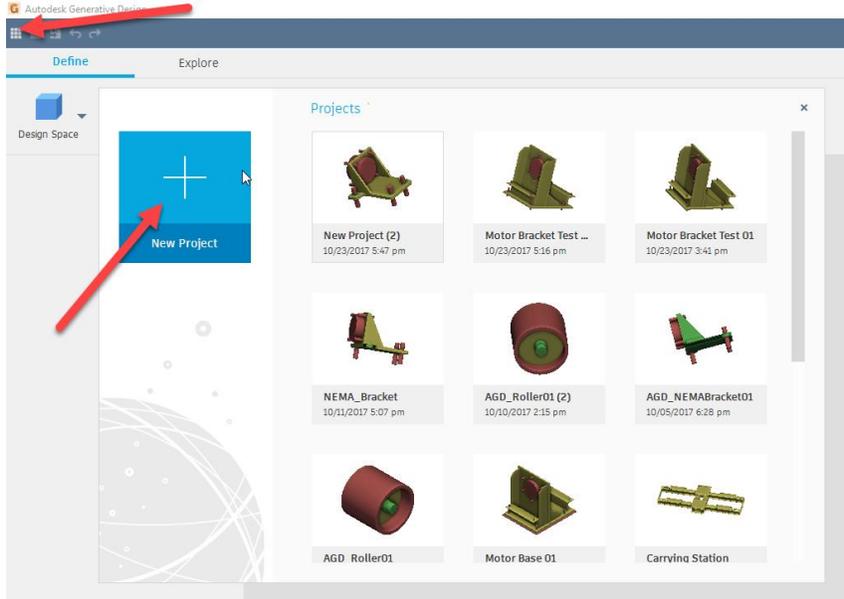
Note: The browser tree, 'Study' heading and Project preferences can only be viewed after geometry is imported.

## Define

When you are going to work with Autodesk Generative, the first thing you will need to do is sign into your A360 account (Autodesk ID). Next, select an A360 hub and location to designate your project directory. Your hubs can be found and switched within the User Account button in the top-right of the application window.

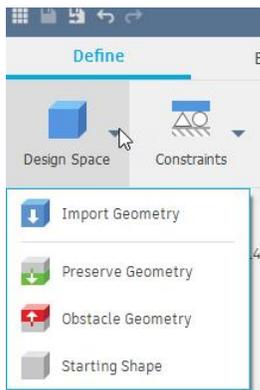


Once the hub is selected, click 'New Project' to begin the project. It is found in the 'Open' button on the top-right. The project is the 'top-level' data storage directory for your design.



## Import

When making a new project, you can start to import your geometry. Click the 'Design Space' button and click 'Import Geometry'.



The types of files to import include the following mesh & standard formats:

- ACIS files (\*.sat)
- Catia V5 files (\*.catpart)
- Initial Graphics Exchange Specification (\*.iges, \*.igs)
- Pro/ENGINEER / Catia (\*.part, \*.prt)
- STEP files (\*.step, \*.stp)
- SolidWorks part files (\*.part, \*.prt, \*.sldprt)
- Stereolithography files (\*.stl)
- Wavefront files (\*.obj)

Working with imports from Autodesk Inventor, I have discovered some tips for import of files into Autodesk Generative Design. These tips should carry over to other CAD modeling applications, but trial and error on each file you export/import is ultimately the best method.

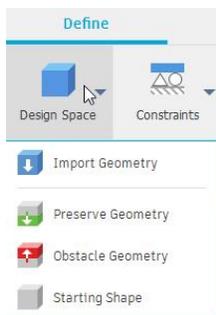
- I have found that .iges, .step/.stp, & .sat file export from Inventor will not include mesh features when imported in AGD. You will need to create a solid from the Mesh Feature within Inventor first before exporting. You can create the solid from the mesh using the free add-in for subscription users called 'Mesh Enabler.'
- .sat format will treat bodies in a part as one entity, meaning you will not be able to select each body separately in AGD.
- File types .obj & .stl export from Inventor will join solids within each other, so if you have a solid within another solid from Inventor, it will not display the solid inside anymore.
- The neutral file format .stp/.step seems to give me the best results for import, but as I recommend, the best method for finding what works for you is trial and error.

## Assigning

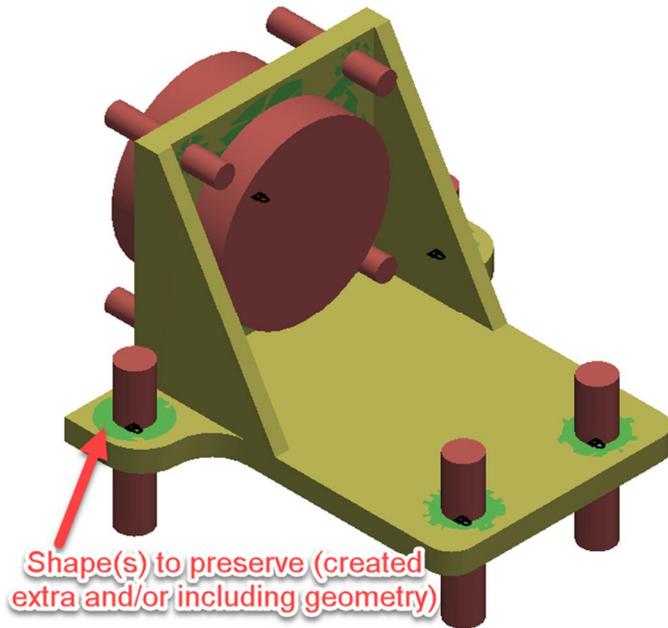
At this point, your geometry should import into the design window. You can start to assign bodies & geometry types for generation. You can right-click on the geometry in the window or use the buttons in the 'Design Space' drop-down to assign the types.

There are (3) different types of geometry types:

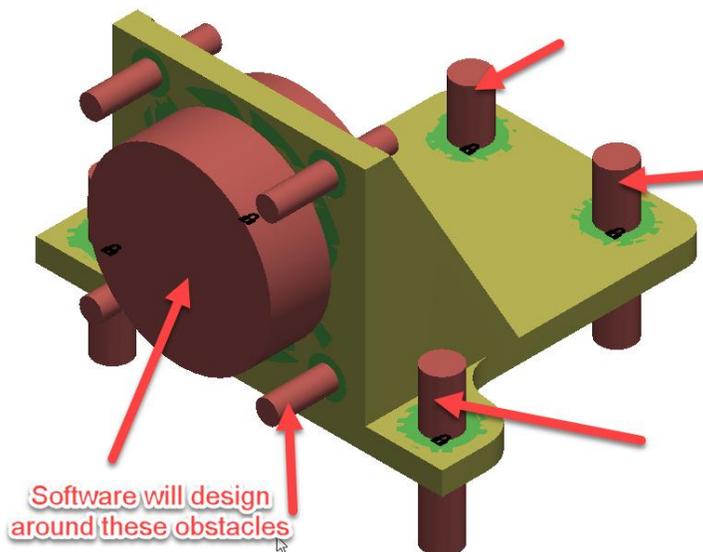
- Preserve Geometry
- Obstacle Geometry
- Starting Shape



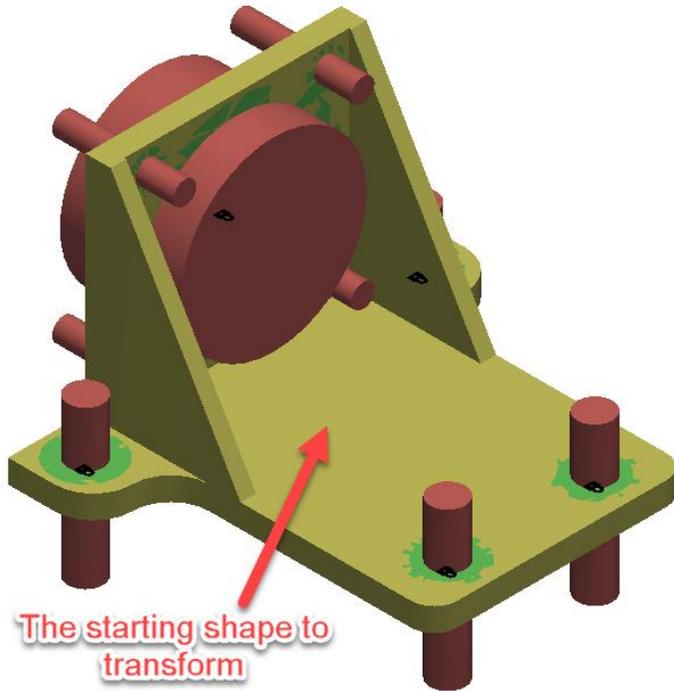
The *Preserve Geometry* type is to assign geometry in your design that you want to keep the same as YOU designed it. The selected geometry is treated as part of the final shape during the design process. You could create extra geometry/bodies in your design for assigning to preserve. As seen in the screenshot below, the green area are extra bodies I created to preserve those shapes for the final design. The bodies assigned to this type will inherit a green color.



The *Obstacle Geometry* type is geometry which you want AGD to build the optimized design around. These are also known as obstacles. I have created obstacles in the screenshot below so that the holes are not filled within the final design. The bodies assigned to this type will inherit a red color.

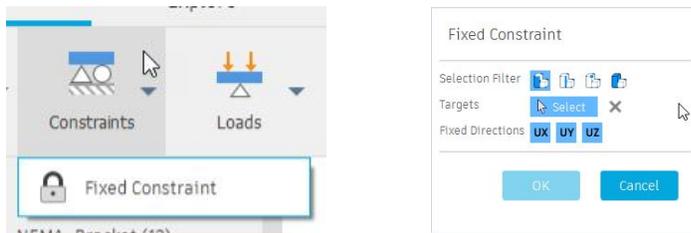


The *Starting Shape* is geometry you want AGD to recreate, optimize or build upon. This will morph into the organic shape in the end. The bodies assigned to this type will inherit a yellow color.



*Note: You must define one geometry type to at least (1) body for the generation.*

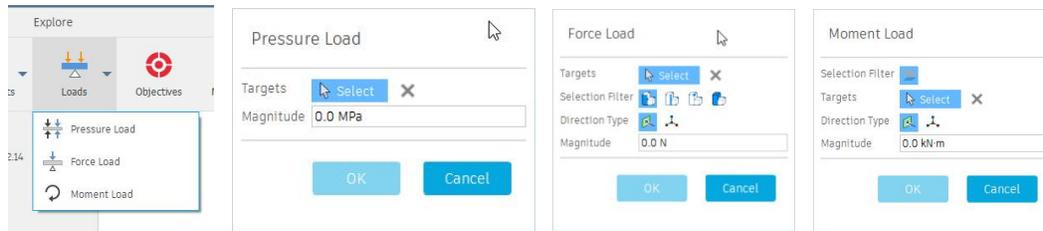
## Constraints



After assigning the geometry to body types, use the 'Constraints' button to set constraints within the design. The usage of this tool is similar to constraint functions found in other CAD platforms. You can place fixed constraints in the X, Y, and/or Z directions on bodies, faces, edges or vertices.

*Note: You must define one or multiple constraints to the geometry for the generation to be enabled.*

## Loads



There are 3 different types of Loads to assign within Autodesk Generative Design. A *Pressure Load*, a *Force Load* and a *Moment Load*.

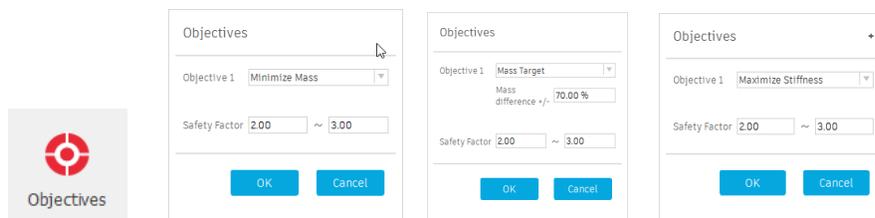
With a *Pressure Load*, you can apply a Pascal (Pa), Kilopascal (kPa), MegaPascal (MPa), Pounds per square inch (psi) or Kilograms per square inch (ksi) unit of pressure to the selected faces. This type of load applies force on both sides of an object, like squeezing it.

With a *Force Load*, you can apply forces of Newtons (N), Kilonewtons (kN), Meganewtons (MN), Pound force (lbf) or Kips (kip) to specified bodies, faces, edges or vertices. With a Force Load, you can also specify a normal load direction or a vector load (XYZ) direction. This load type applies force in one direction to an object, as in something pushing on it.

With a Moment Load, you can apply forces in units of Newton-meter (N-m), Newton-millimeter (N-mm), Kilonewton-meter (kN-m), Pound force-inch (lbf-in), Pound force-foot (lbf-ft). This load type can be applied to a flat face with a straight direction or vector direction (XYZ). A moment load is a force in a rotational manner, like a turning or twisting.

*Note: You can just type the unit after the number to enter something other than the default unit of measurement for loads. Just because you can't see it, doesn't mean you can't input it! Also, you must define one or multiple loads to the geometry for the generation to be enabled.*

## Objectives



There are (3) objectives to specify for the algorithms to focus on. Minimize Mass, Mass Target, Maximize Stiffness.

Minimize Mass allows you to specify a Safety Factor range and the software will subtract and optimize the mass of the object until it reaches the confines of the Safety Factor range.

With the Mass Target objective, you can specify a target percentage of the original design mass. You must also specify a Safety Factor range. The software will optimize the design until it reaches the percentage within the Safety Factor range.

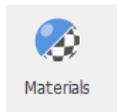
The Maximize Stiffness objective allows us to specify the Safety Factor range, but the software will find the optimum rigidity to weight ratio within the range.

## Manufacturing



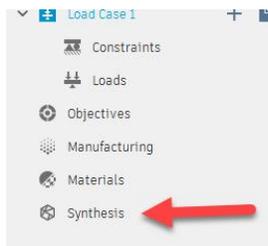
There are (2) manufacturing types. The first is *Unrestricted*, which withholds any manufacturing constraints. The software will generate shapes and designs freely. The second selection is *Additive* manufacturing, which includes additive process such as 3D printing. Within the Additive manufacturing selection, you must specify orientation of prints, overhang angles and minimum wall thickness. The AGD software already has some default input values, but you should take a look at them and modify as needed.

## Materials

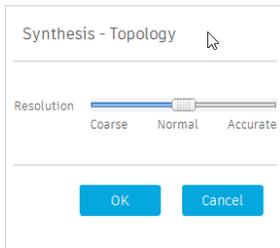


With the 'Material' button, you can select a maximum of (5) materials for the design to be made from. Click on a material to see its specification. Currently, there are several options available and gradually new materials are being added. There is currently no ability to create your own custom materials, but that functionality is being explored.

## Synthesis



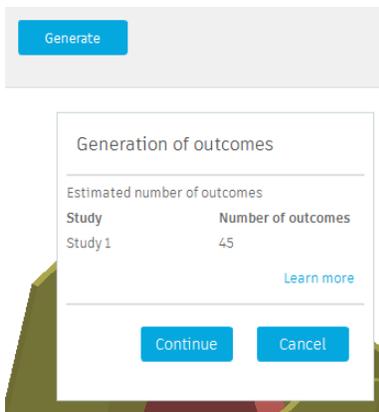
The *Synthesis* criteria does not have its own button. Instead, it is assigned within the Study by double-clicking or right-clicking to edit. A study's synthesis determines the topology accuracy in the outcome model.



There are (3) options:

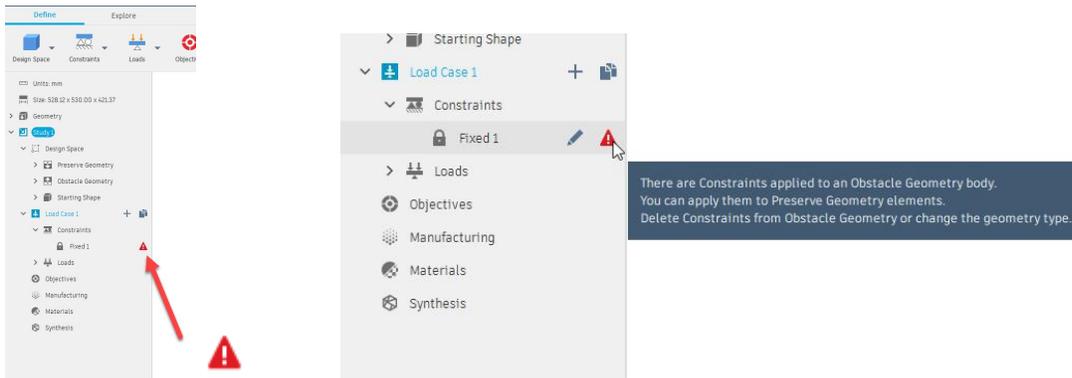
- *Coarse* reduces time for the generation, but least accurate topology for prototyping
- *Normal* optimizes outcomes
- *Accurate* is the best quality and desired for manufacturing

## Generate

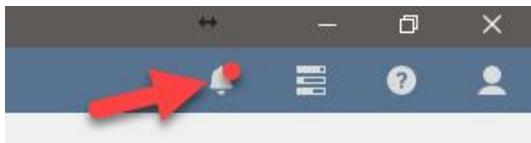


If you have progressed through the workflow, the 'Generate' button will now be enabled. It will not be enabled unless you fill out all the required steps within the Autodesk Generative Design 'Define' tab.

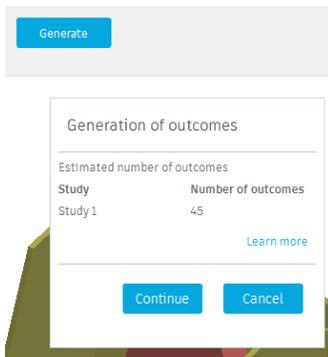
Once the 'Generate' button is clicked, the application will check all the data specified and return errors if found. If there are errors, AGD should show a red icon next to the line on the left in question. If you roll-over the error, it should describe what is wrong.



If there are cloud or other issues after clicking the Generate button, the notification popup will display.



If the data and specifications are good, then a popup will show of the number of outcomes AGD will generate.



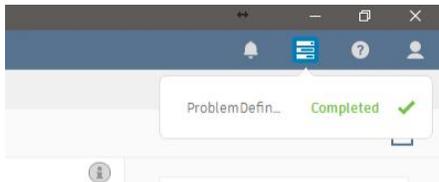
Outcome numbers are dependent on:

- How many materials selected
- Safety factor range (bigger range = more outcomes)
- Manufacturing constraints
- Synthesis resolution

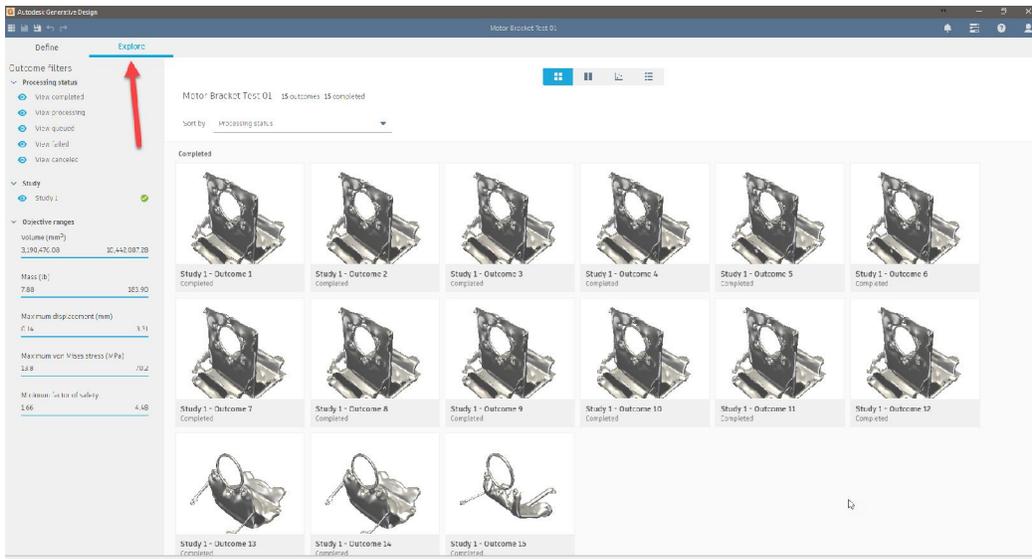
## Explore

The generation could take some time. I have found that a quick generation of 6-10 outcomes have completed within 30-45 minutes and the total study to finish within 3-4 hours. Larger outcome generations will, of course, take longer. It all depends on your criteria.

You can see progress of the generation with the status icon. This will also allow you to cancel a generation and see if there is an error.



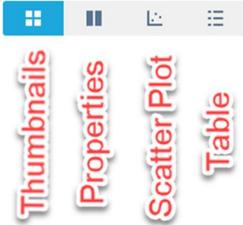
Once you start to see outcomes being generated, you can check the 'Explore' tab. This tab will display the number of outcomes described when clicking on the 'Generate' button in the last step.



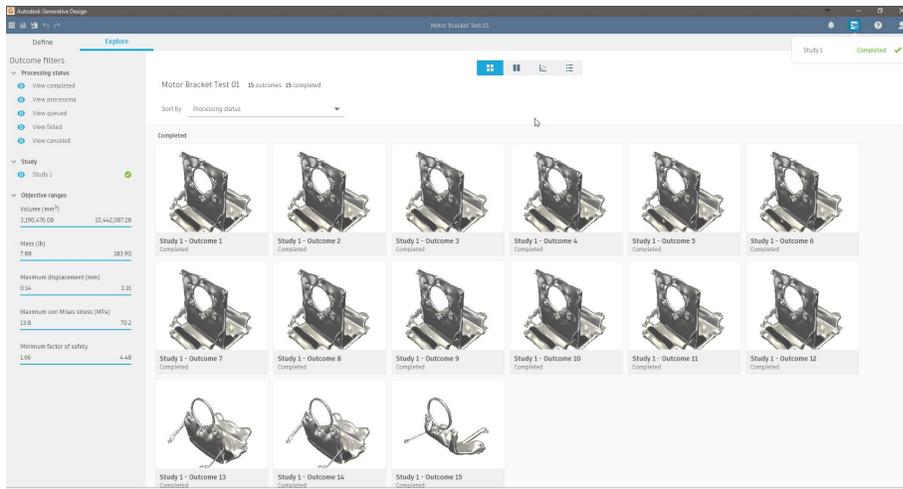
Within the explore tab, you will see 'Outcome filters' on the left, which allow for filtering by:

- Status
  - Completed, processing, queued, failed, canceled
- Study or studies
- Objective ranges
  - Volume
  - Mass
  - Max displacement (mm)
  - Max von Mises stress (MPa)
  - Minimum factor of safety

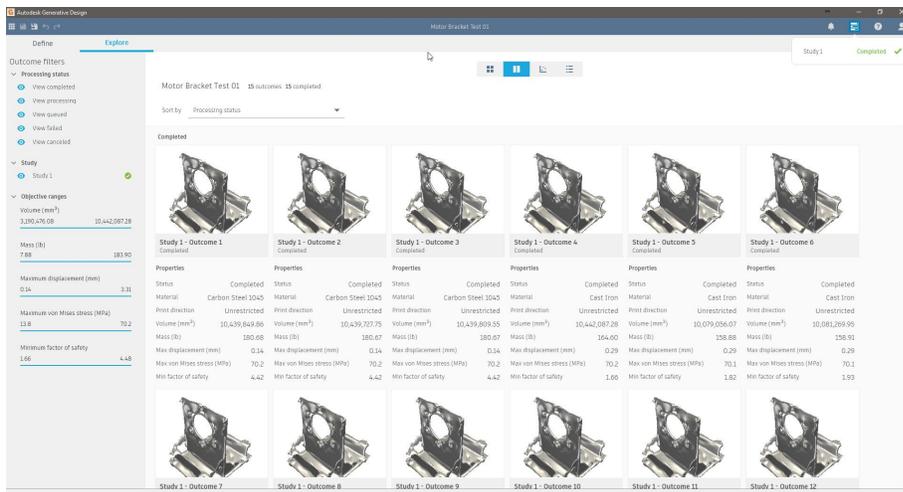
The filters bar on the left will be present and allow for filtering in every outcome display view. At the top of the view are icons which represent different outcome display views.



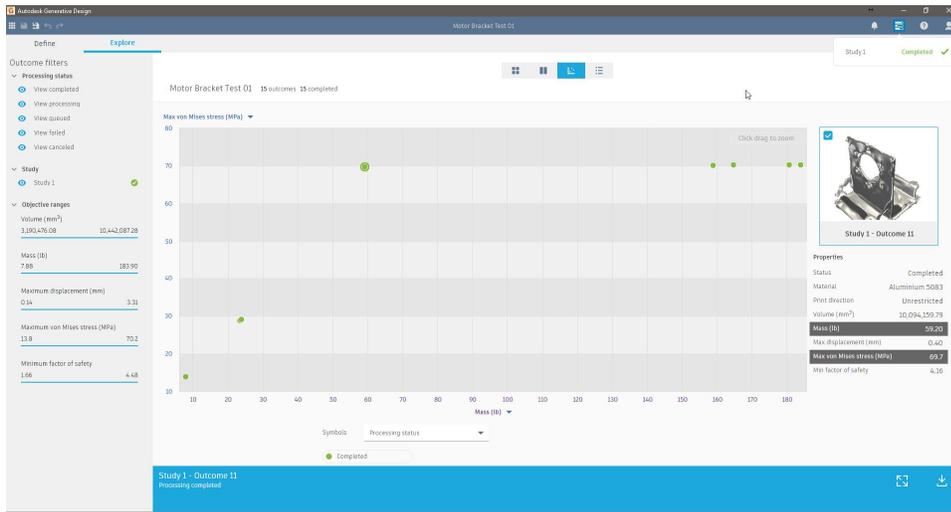
The first is *Thumbnails*, which is the simplest view and displays individual outcomes in their own thumbnail. You can single-click on the thumbnail to open the design in a 3D view. Within the 3D view, you can download the .stl file of the outcome.



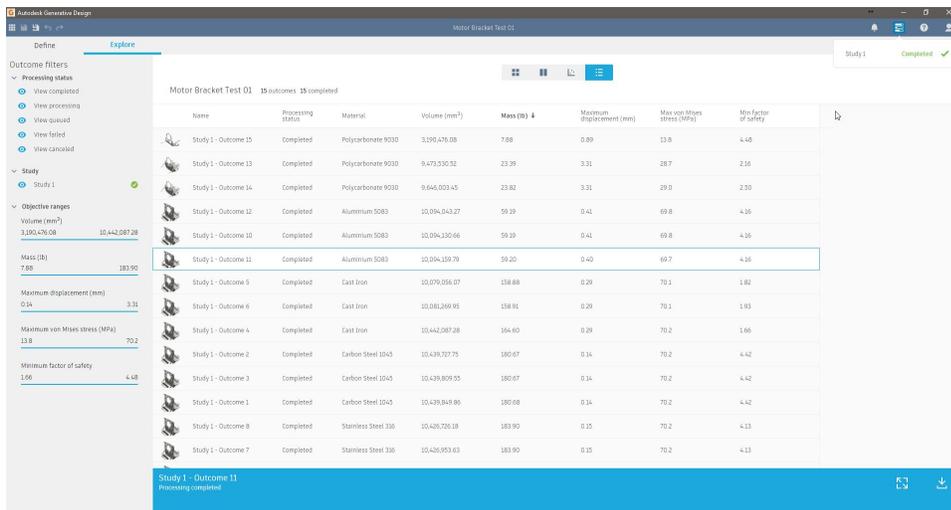
The second icon is *Properties*. In this view, the outcomes are displayed in individual thumbnails with a property section under each. You can also single-click on the outcome to open a 3D view of the design. Within the 3D view, you can download the .stl file of the outcome.



The third icon is *Scatter Plot*. In this view, each outcome resides on the plot. You can change the filter on the up (X) and right (Y) axis to view new plots. Roll-over a dot to see a quick view of the model & specification on the right. If there are multiple dots in a single area and you'd like to zoom in, click-drag over the area to zoom and the plot will scale. Single-click on a dot to see an overlay at the bottom to view the 3D model or to download the .stl file of the generation. Alternatively, you can double-click on the dot to open the 3D model.



The last icon is *Table*. This view displays all outcomes with their specifications in a table. You can click on a column header to sort by that column. Single-click on a line to see an overlay at the bottom to view the 3D model or to download the generated .stl file. Double-click on a line to open the 3D model directly.



Name	Processing Status	Material	Volume (mm <sup>3</sup> )	Mass (lb)	Maximum displacement (mm)	Max von Mises stress (MPa)	Min factor of safety
Study 1 - Outcome 15	Completed	Polycarbonate 9030	3,190,476.08	7.88	0.89	13.8	4.48
Study 1 - Outcome 13	Completed	Polycarbonate 9030	9,473,050.32	23.39	3.31	28.7	2.58
Study 1 - Outcome 14	Completed	Polycarbonate 9030	9,646,003.45	23.82	3.31	29.0	2.58
Study 1 - Outcome 12	Completed	Aluminum 5083	10,094,043.27	59.39	0.41	69.8	4.16
Study 1 - Outcome 10	Completed	Aluminum 5083	10,094,130.66	59.39	0.41	69.8	4.16
Study 1 - Outcome 11	Completed	Aluminum 5083	10,094,159.79	59.20	0.40	69.7	4.16
Study 1 - Outcome 5	Completed	Cast Iron	10,079,056.07	158.88	0.29	70.1	1.82
Study 1 - Outcome 6	Completed	Cast Iron	10,081,269.95	158.91	0.29	70.1	1.83
Study 1 - Outcome 4	Completed	Cast Iron	10,442,087.28	164.60	0.29	70.2	1.66
Study 1 - Outcome 2	Completed	Carbon Steel 1045	10,439,727.75	180.67	0.14	70.2	4.42
Study 1 - Outcome 3	Completed	Carbon Steel 1045	10,439,809.55	180.67	0.14	70.2	4.42
Study 1 - Outcome 1	Completed	Carbon Steel 1045	10,439,849.86	180.68	0.14	70.2	4.42
Study 1 - Outcome 8	Completed	Stainless Steel 316	10,426,706.18	183.90	0.15	70.2	4.13
Study 1 - Outcome 7	Completed	Stainless Steel 316	10,426,953.63	183.90	0.15	70.2	4.13

## **Extras**

### **Further learning and help**

There are further learning resources for Autodesk Generative Design. If you'd like to step through the details of the software, there is an Online Help. You can find by clicking on the question mark icon  and then 'Help' in the AGD software or at the URL:

<http://help-beta.autodesk.com/view/NETF/2017/ENU/?guid=GUID-BE07A02A-0DF8-4F3F-9C36-782D6BFC528C>

You can also visit the forums at the Autodesk Feedback Community to post questions or to show off your designs.

### **Where can I get it?**

You can get Autodesk Generative Design by invitation or by visiting the AU Idea Exchange at Autodesk University. For more information, you can contact David Milam ([david.milam@autodesk.com](mailto:david.milam@autodesk.com)).