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# Design for Additive Manufacturing Metal & Multi-Jet Fusion (MJF)

20 Dec 2021

## Fusion 360 Generative Design Workshop

03/11/2021

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## 1. What is Generative Design

- Generative design - create parts that would otherwise be too difficult or costly to justify with traditional manufacturing methods.
- Software tools to create highly-optimized parts backed by complex computational simulations.
- Built to withstand specific loads and user-defined constraints.
- Generate parts only put material where it's needed, resulting in parts that are as much lighter - yet equally strong - than conventional designs.



Engine Mount



Skateboard Truck

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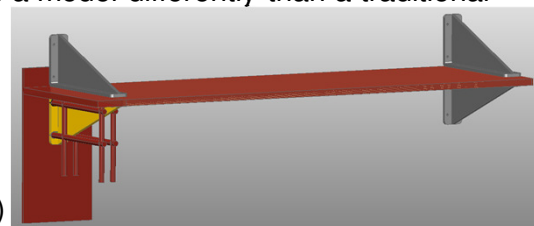
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## 2. Generative Design - Terminology

- Generative design requires that we approach a model differently than a traditional design.
- Information to be provided:
  - Initial shape of design (Starting shape)
  - what materials we want (PA12, SS316L)
  - how the part interacts with its surroundings (Loading & Constraint)
  - what geometry it must keep (Preserve geometry)
  - what geometry it must avoid (Obstacle geometry)
  - Design objectives (Minimize mass, Factor of safety, etc.)
  - Manufacturing method (3D printing)
- Once software has all the parameters, it can go to evaluating large number of possible cases and presenting us with best options.



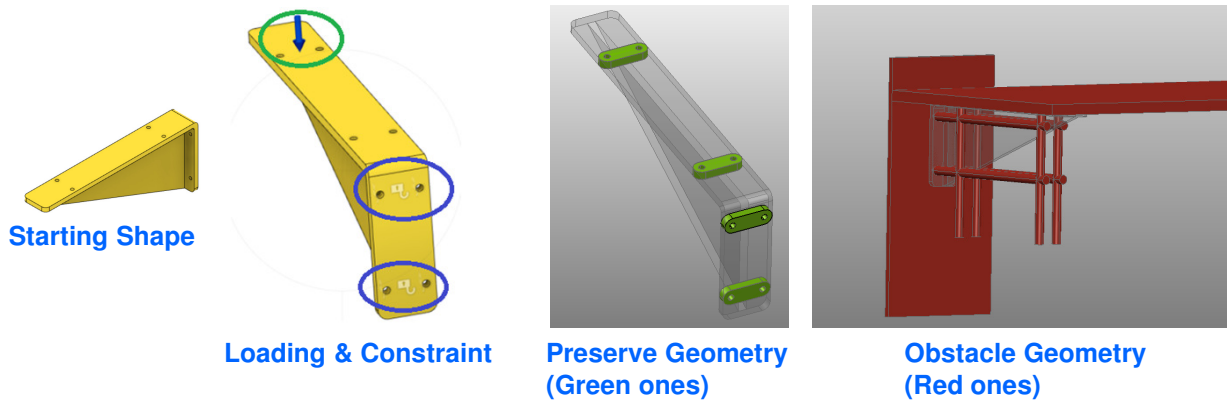
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## 2. Generative Design - Terminology



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## 2. Generative Design - Terminology

- Preserve geometry: what geometry needs to stay behind
  - These will be things like bushings or areas for mounting to other components in an assembly.
  - This geometry also gets utilized to apply any loads or constraints that drive the design.
- Obstacle geometry: what geometry needs to avoid
  - Geometry needs to be created for the shelf and for the hardware connecting the bracket to the shelf.
  - Tools used to install or remove the fasteners cannot be blocked by the Generative Design results.
  - Not only will the hardware itself be represented, but areas for the installation tools will also be modeled.

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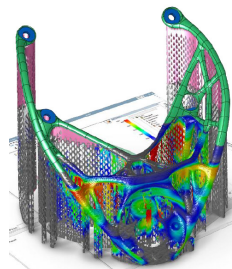
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### Metal 3D Printer

### 3. Printer Specification

- Build volume: 100 x 100 x 80 mm
- $\pm 0.2\%$  with  $\pm 0.05$  mm minimum
- Wall thicknesses down to 0.15 mm
- Needs to have support



LaserForm 316L (B)



LaserForm 17-4PH (B)



DMP Flex 100

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### Nylon 3D Printer

### 3. Printer Specification

- Build volume: 332 x 190 x 248 mm
- $\pm 0.3\%$  with  $\pm 0.2$  mm minimum
- Wall thicknesses down to 0.6 mm
- Self-supporting nature
  - Freedom to print complex and intricate geometries
  - Enables to print assemblies in single, continuous pieces



Jet Fusion 540

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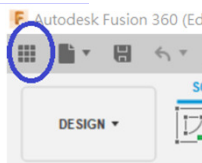


**Import Data**

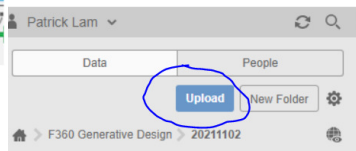
**4. Fusion 360 with Generative Design - Workflow**

- To use online Fusion 360:
  - <https://fusion.online.autodesk.com>.

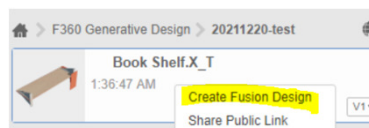
- Data uploading
  - Show the Data Panel



- After creating your folder, then Upload the X\_T file



- Right click the uploaded file and select "Create Fusion Design" to create a Fusion360 model



- Double click the created Fusion 360 model at Data Panel to open it



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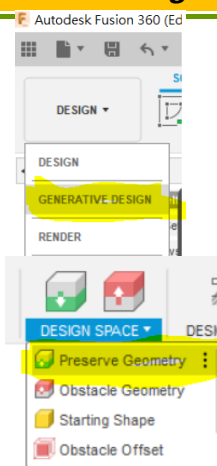
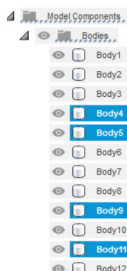
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**Preserve Geometry**

**4. Fusion 360 with Generative Design - Workflow**

- Change Workspace to "Generative Design"
- Click "Create Study"
- Define Preserve Geometry
  - Ribbon "DESIGN SPACE" > "Preserve Geometry"
  - Select preserve geometry by selecting Body4, Body5, Body9 and Body11 from "Model Components" > "Bodies"



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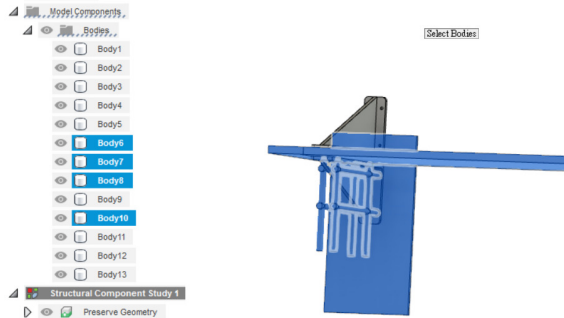
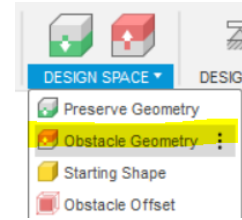




**Obstacle Geometry**

**4. Fusion 360 with Generative Design - Workflow**

- Define Obstacle Geometry
  - Ribbon “DESIGN SPACE” > “Obstacle Geometry”
  - Select obstacle geometry by selecting Body6, Body7, Body8 and Body10 from “Model Components” > “Bodies”



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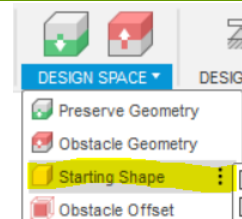
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**Starting Shape**

**4. Fusion 360 with Generative Design - Workflow**

- Define Starting Shape
  - Ribbon “DESIGN SPACE” > “Starting Shape”
  - Select starting shape by selecting Body13 from “Model Components” > “Bodies”



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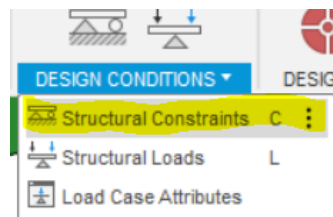
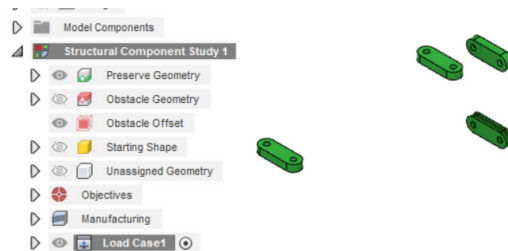




**Constraints**

**4. Fusion 360 with Generative Design - Workflow**

- Define the constraints on preserve geometry
  - Click the “eye” of the Obstacle Geometry, Starting Shape and Unassigned Geometry, so that they are invisible.
    - Only Preserve Geometry is visible.
  - Ribbon “DESIGN CONDITIONS” > “Structural Constraints”



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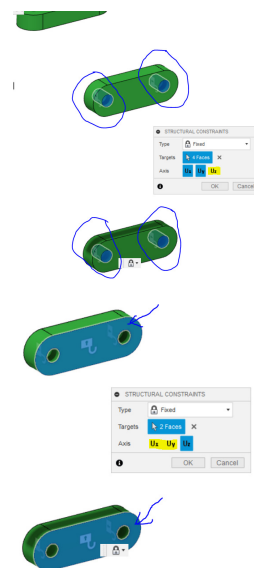
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**Constraints**

**4. Fusion 360 with Generative Design - Workflow**

- Click to select the 4 cylindrical surfaces of the holes for the fasteners to passing through the bracket into the wall.
  - Type = Fixed
  - Deactivate “Uz”
    - => only fixes in X and Y axes.
  - Click “OK”
- Click to select the 2 back faces of the vertical preserve geometry, which will contact the wall.
  - Type = Fixed
  - Only activate “Uz”
  - Click “OK”



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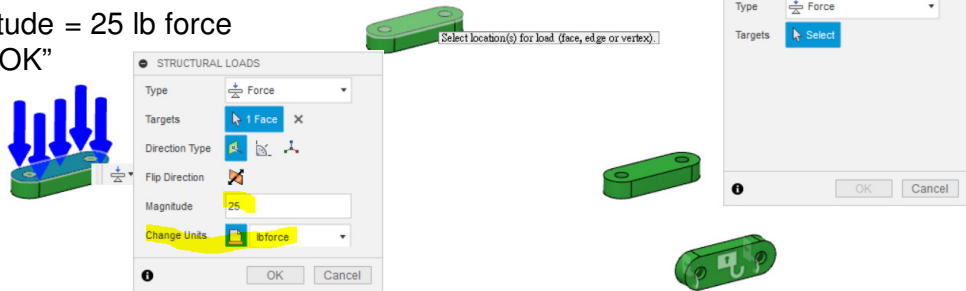




**Loading**

**4. Fusion 360 with Generative Design - Workflow**

- Define the loading on preserve geometry
  - Ribbon “DESIGN CONDITIONS” > “Structural Loads”
  - Type = “Force”
  - Select the top face of horizontal preserve geometry that is furthest away from the wall.
  - Magnitude = 25 lb force
  - Click “OK”



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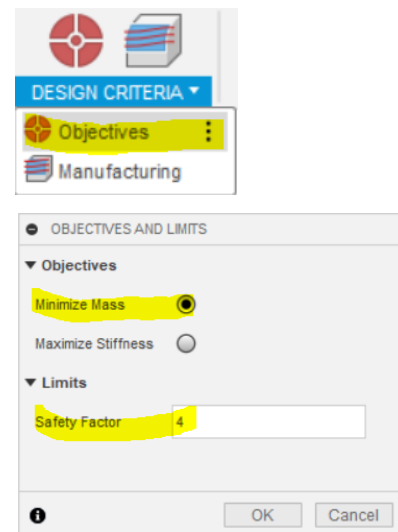
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**Design Objectives**

**4. Fusion 360 with Generative Design - Workflow**

- Define the design objectives
  - Ribbon “DESIGN CRITERIA” > “Objectives”
  - Check ON “Minimize Mass”
  - Safety Factor = 4
  - Click “OK”



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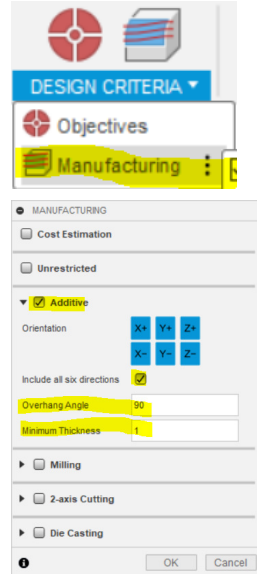
**Manufacturing Method**

**4. Fusion 360 with Generative Design - Workflow**

- Define the manufacturing method
  - Ribbon “DESIGN CRITERIA” > “Manufacturing”
  - Check ON “Additive” only
  - Check ON “Include all six directions”
    - To get more design alternatives

(Assuming using MJF540 for 3d printing)

- Overhang Angle = 90
- Minimum Thickness = 1
- Click “OK”



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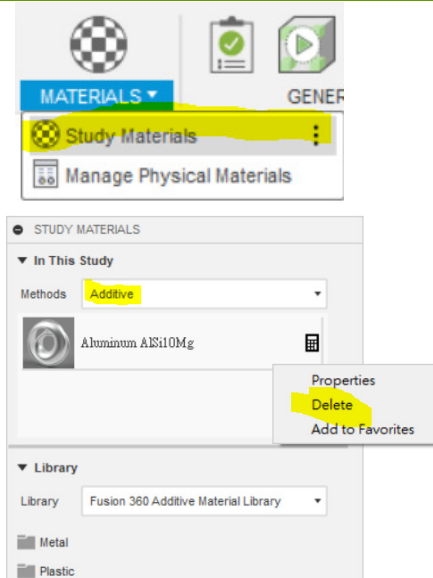
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**Materials**

**4. Fusion 360 with Generative Design - Workflow**

- Define the materials
  - Ribbon “Materials” > “Study Materials”
  - Methods = “Additive”
  - If there is any materials in this study, then:
    - Right click > Select “Delete”



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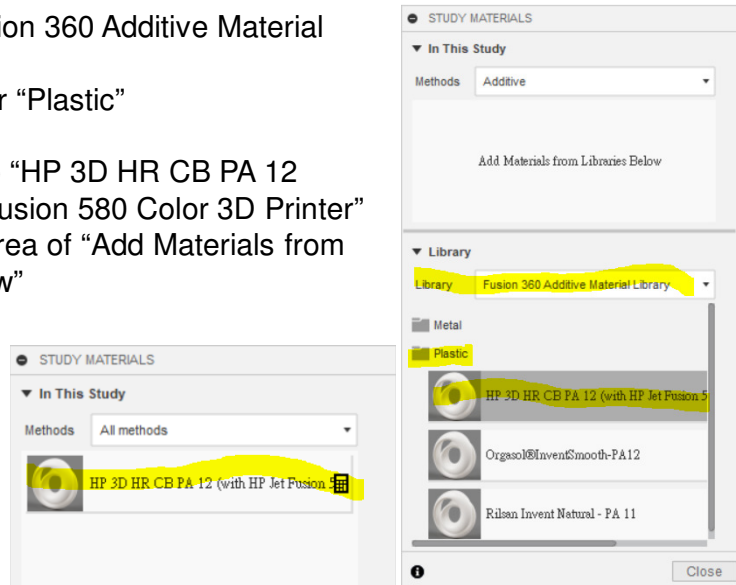




**Materials**

**4. Fusion 360 with Generative Design - Workflow**

- Library = “Fusion 360 Additive Material Library”
- Click the folder “Plastic”
- Drag and drop “HP 3D HR CB PA 12 (with HP Jet Fusion 580 Color 3D Printer)” to the upper area of “Add Materials from Libraries Below”
- Click “Close”



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**Generate Designs**

**4. Fusion 360 with Generative Design - Workflow**

- Generate designs: Pre-Check > Previewer > Generate

**Pre-check**  
Checks the active generative study to ensure the setup meets the requirements to generate outcomes. The icon changes color according to the study status.

**Red**  
You can't generate outcomes because the study setup doesn't meet some requirements. For example, there is less than the minimum number of preserve geometries or a material is missing.

**Yellow**  
You can generate outcomes, but there are potential issues with the study. For example, a preserve, obstacle, or starting shape body is missing, but the study includes the minimum number of preserve geometries.

**Green**  
The study setup meets the requirements.

**Previewer**  
Generates an outcome preview based on the study setup before you run a job.

Use Previewer to see how the setup affects outcomes. Then adjust the setup, if needed. Previewer ignores manufacturing and material settings. It generates the preview after Pre-check verifies that the study is ready to generate.

**Generate**  
Generates outcomes that satisfy the design requirements specified in the generative study.

You can select one or more studies in your design. Track the processing status in the Job Status dialog.

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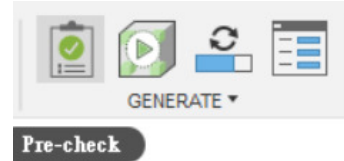




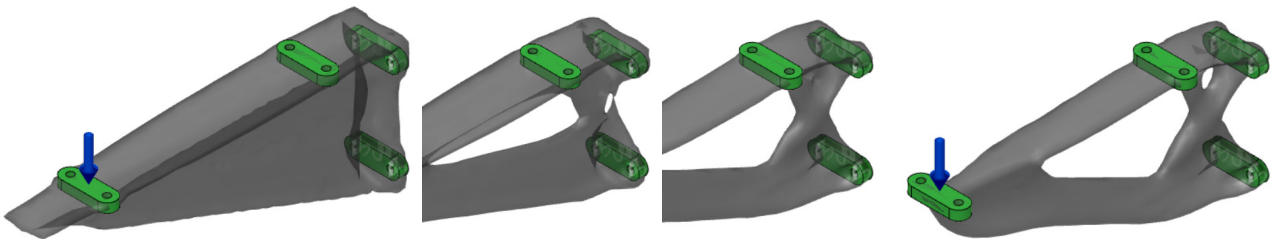
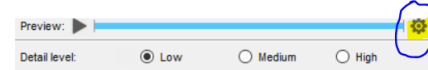
**Generate Designs**

**4. Fusion 360 with Generative Design - Workflow**

- Generate designs > Pre-check
  - Ribbon "GENERATE" > "Pre-check"
  - A "green" tick => everything OK



- Generate designs > Previewer
  - Ribbon "GENERATE" > "Previewer"
  - Drag the slider to preview outcomes



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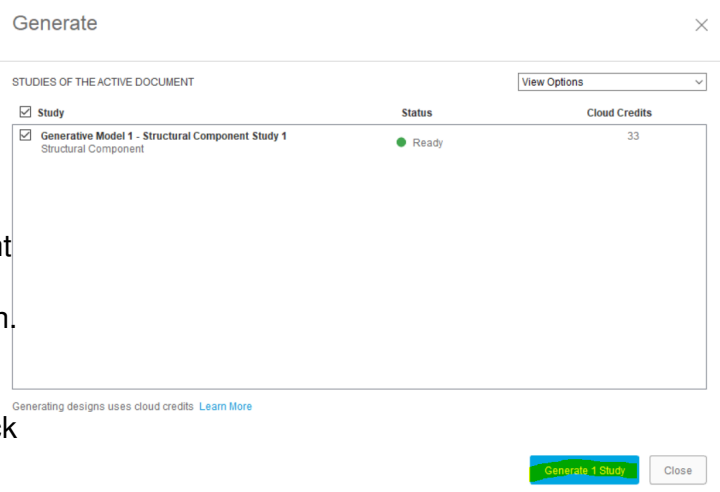
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**Generate Designs**

**4. Fusion 360 with Generative Design - Workflow**

- Generate designs > Generate
  - Ribbon "GENERATE" > "Generate"
  - Check ON the related Study
  - Click the "Generate 1 Study" button
- The analysis study is then sent to the cloud.
- "Job Status" dialogue is shown.
- Can exit Fusion 360.
- Enter Fusion 360 later to check the generated designs.



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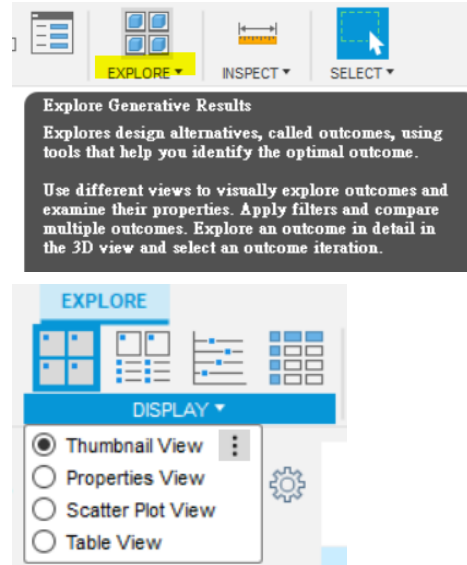
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**Explore Generative Results**

**4. Fusion 360 with Generative Design - Workflow**

- Ribbon “EXPLORE”
- Select the various display modes:
  - Thumbnail View
  - Properties View
  - Scatter Plot View
  - Table View



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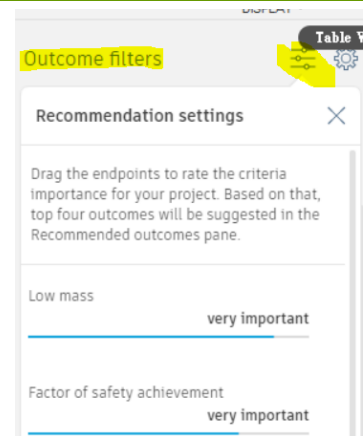
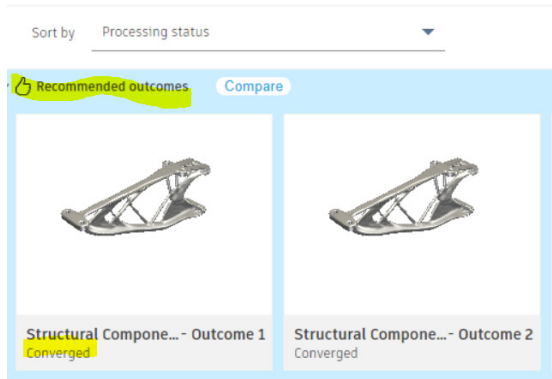
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**Explore Generative Results**

**4. Fusion 360 with Generative Design - Workflow**

- Click “Recommendation settings” button to fine-tune the displayed results
- Explore the recommended outcome by clicking one of the converged result



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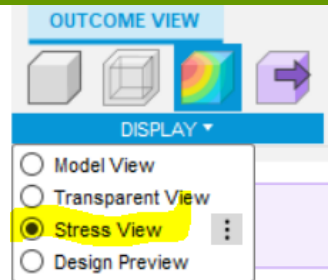




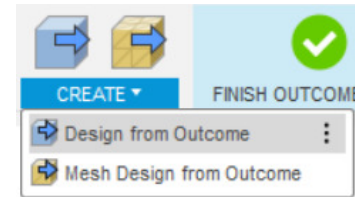
**Explore Generative Results**

**4. Fusion 360 with Generative Design - Workflow**

- Select the “Stress View” to check the stress level of the result.



- To export the outcome:
  - Select “Design from Outcome”
    - Create editable CAD model
  - Select “Mesh Design from Outcome”
    - Create mesh file for 3d printing



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