Quad Drone Frame Generative Design

Source:
Autodesk User Manual
https://www.youtube.com/watch?v=c48wejg4o8Y
KPR Institute of Engineering and Technology
Makerspace Techno Engineers

Generative design

- **Generative design is a computer aided design (CAD) process that uses generative algorithms to produce a range of possible solutions for a given problem.**
- **The generative design process starts with a set of design criteria and objectives, which are then fed into generative algorithms.**
- **The generative algorithms generate a set of possible solutions for the criteria.**
- **AI can be used to identify the ‘optimal’ design from the generated solutions.**

Generative design requirements

Geometry types to bodies to include them in the generative design process.

- Preserve geometry: Bodies to incorporate them in the final shape of the design.
- Obstacle geometry: Bodies that to be excluded from the final shape.

Design conditions: Constraints and loads that are applied to the generative model.

- Structural constraints: Use constraints to define how the design interacts with the objects not included in the model.
- Constraints are applied to the model to prevent it from moving in response to applied loads.
- At least one constraint to a preserve geometry body.
- Fixed: Prevents movement in selected directions. By default, all three global directions are constrained.

Generative design requirements

Structural loads: Use loads to define the external forces that cause the design to work.

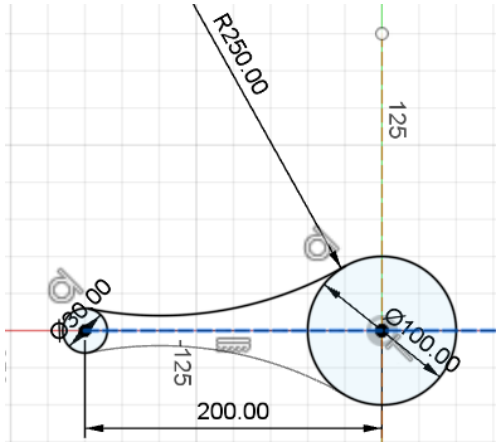
- Apply loads to the preserve geometry. It is displayed in green on the canvas.
- A load and constraint can't be on the same face, edge, or vertex.
- Force: Apply a point load to simulate the action of this load on the model.

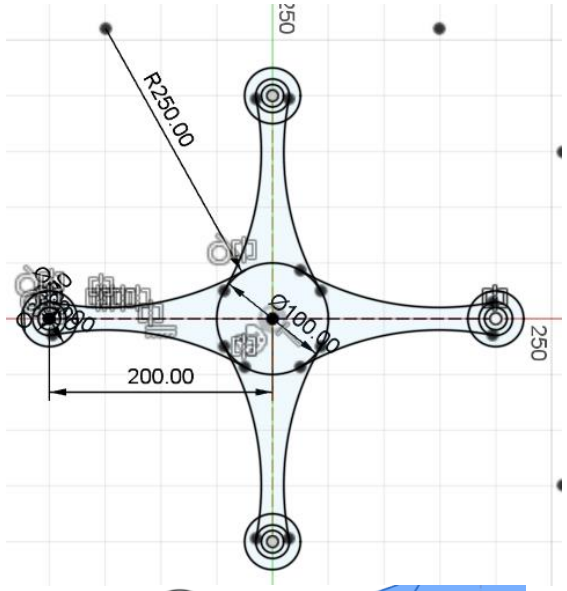
The selection of materials is a very important part of the design requirements in a generative study.

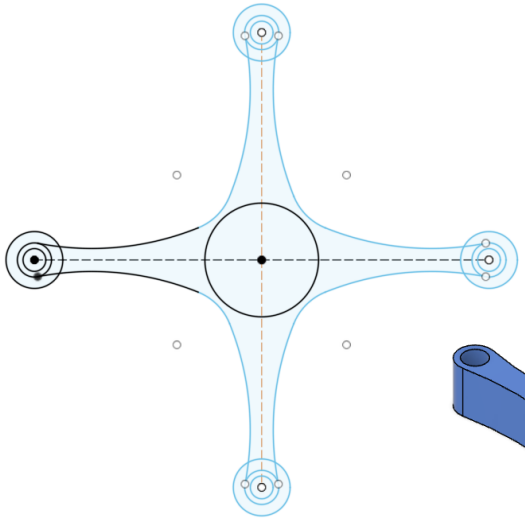
- The Yield Strength value of the material is used to calculate the Safety Factor.
- The Poisson’s ratio and Young’s Modulus of the material are the main values used to solve the linear stress problems when generating outcomes.
- The material density is used to calculate the outcome mass when a gravity load and/or frequency constraints are applied.
- The material density must be different from zero for gravity to affect the outcome.

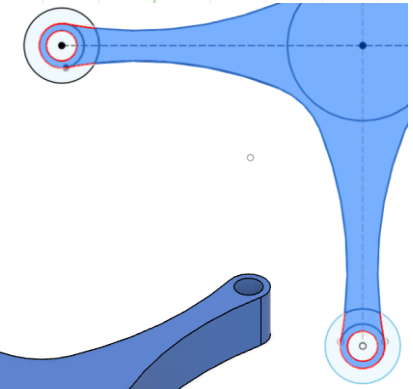
Drone frame generative design

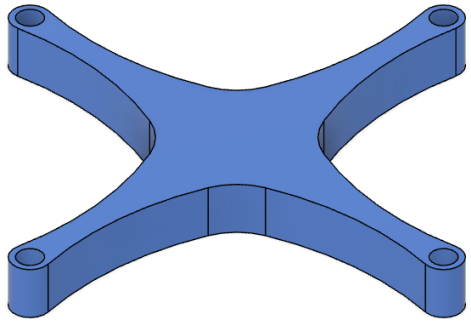
- **Sketch on top plane**
- **400 mm construction lines: Through origin perpendicular to each other.**
- **Circles of 100 (origin), 30 D. along the –X-axis 200 apart.**
- **3 points arc of 250mm R touching the two circles tangentially.**
- **Mirror of the arc about the center line.**
- **Circles of 20, 50 mm concentric to 30mm circle.**
- **4 circular pattern of the 3 concentric circles & the arcs connecting the 30mm and 100mm circles about the center of 100 mm circle.**
- **Trim the intersecting line portion making contact with the 100mm circle and use 50 mm fillet to smoothen the sharp line intersections.**
- **Extrude symmetrically by 20 mm excluding the concentric inner and outer 4 sets of circles as new body.**





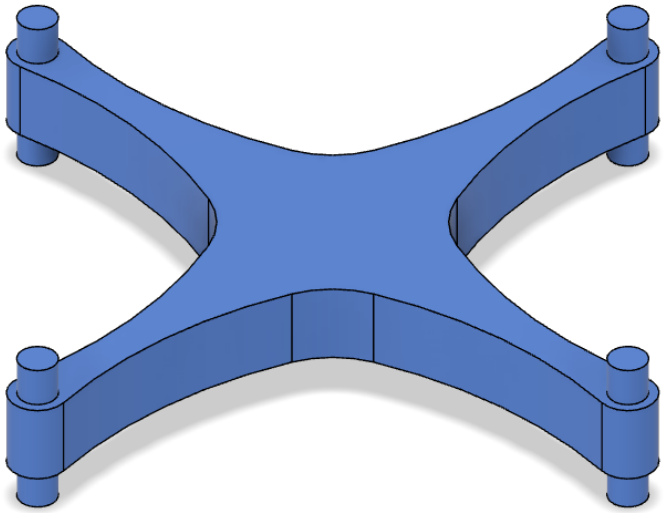


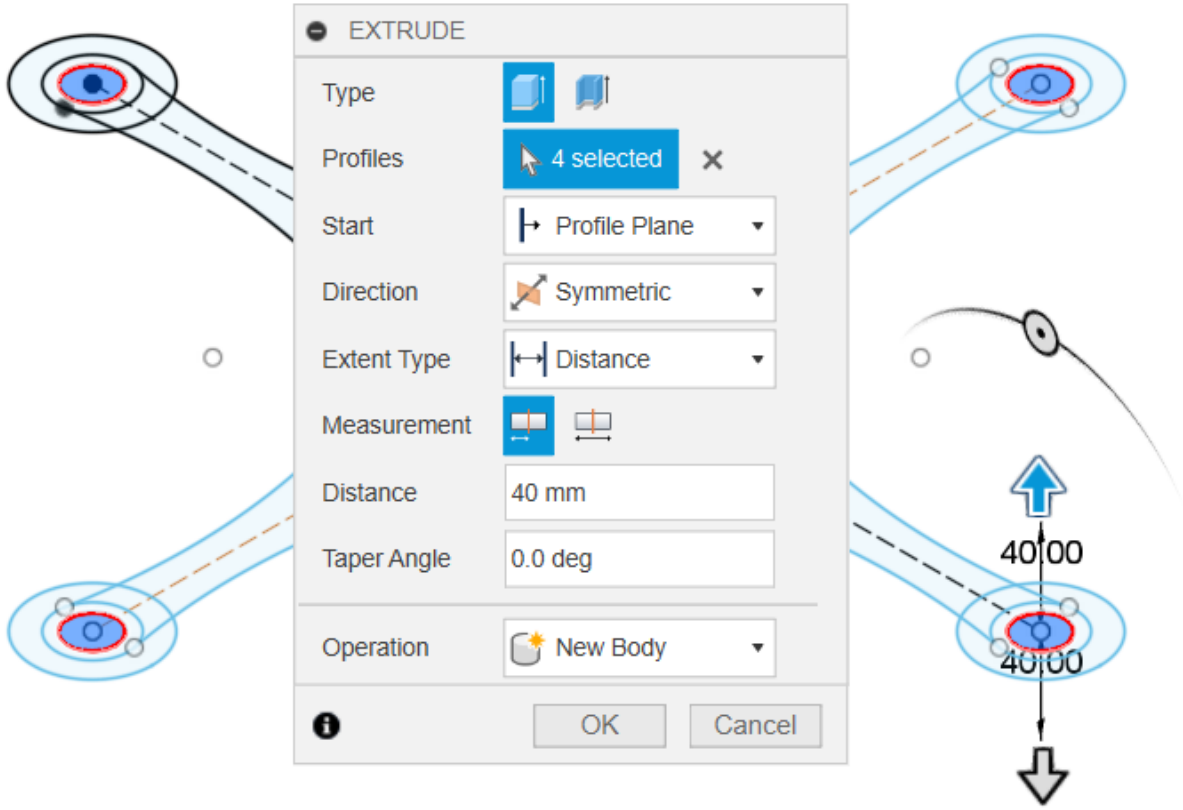




Drone frame generative design

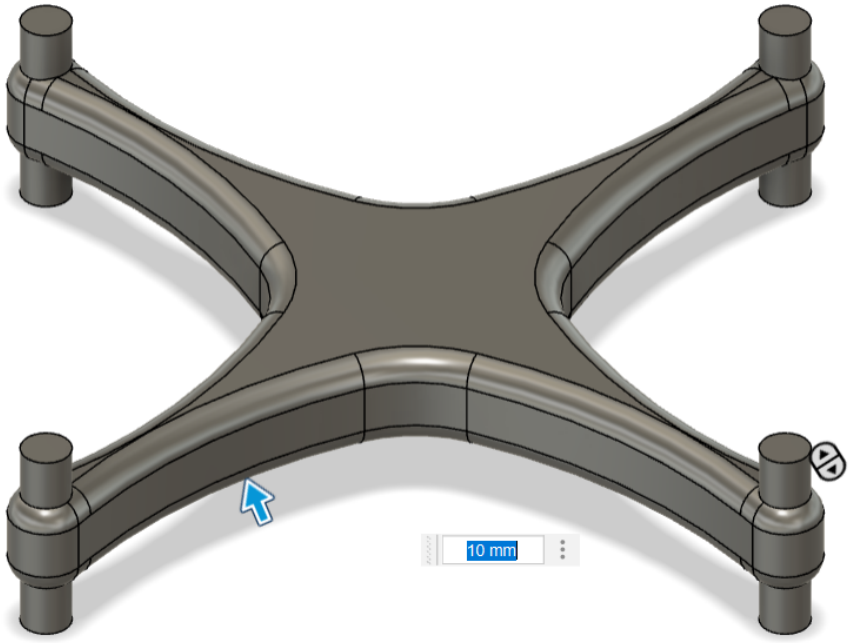
- **Activate the sketch.**
- **Extrude the 4 inner circles symmetrically to 40 mm, operation as new body.**

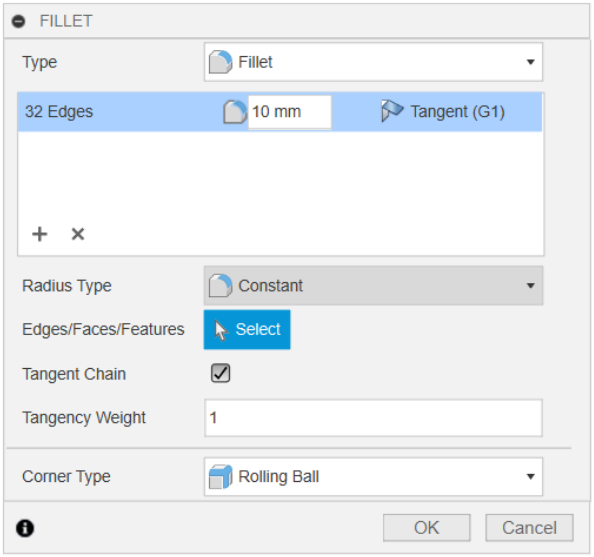


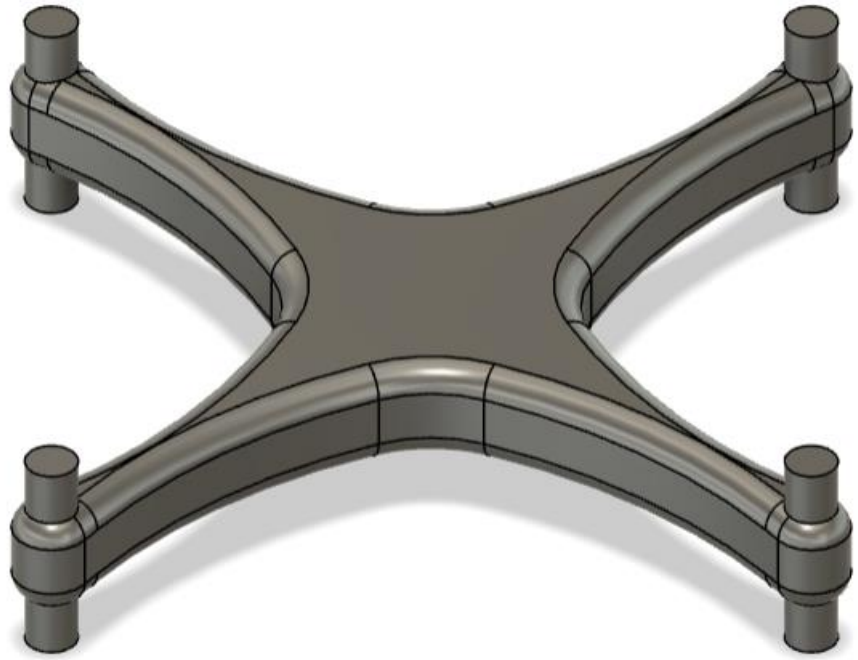


Drone frame generative design

Fillet, select 32 edges and 5 mm radius to smoothen the edges

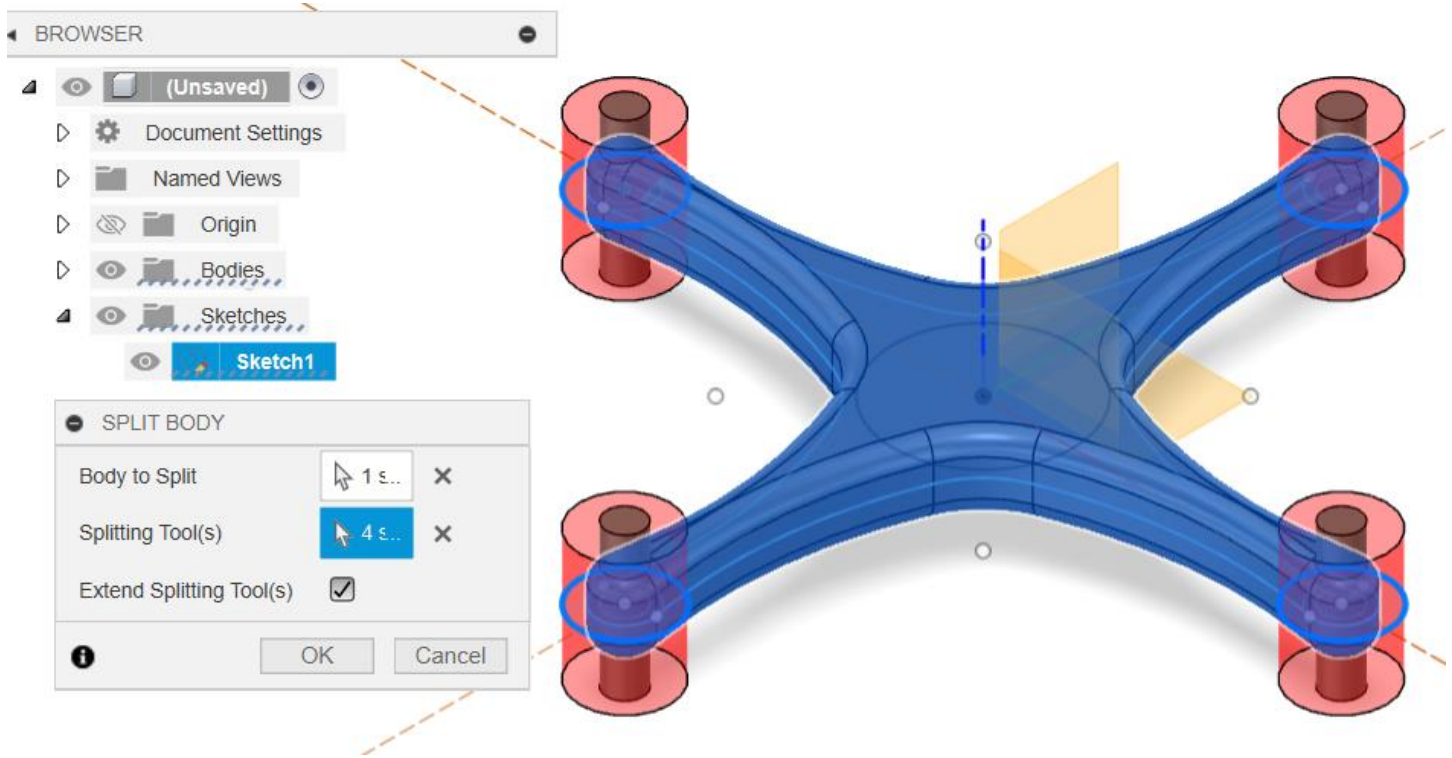


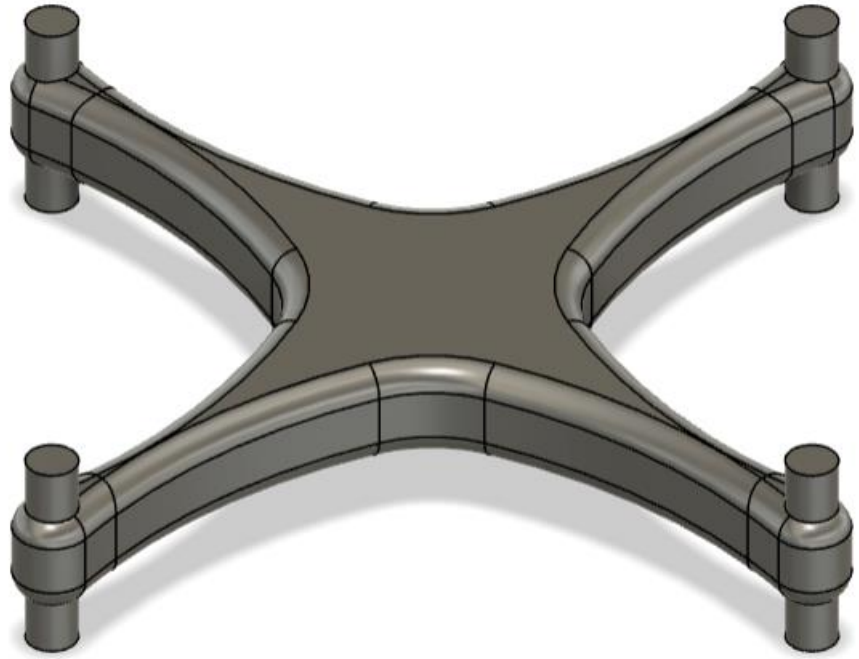




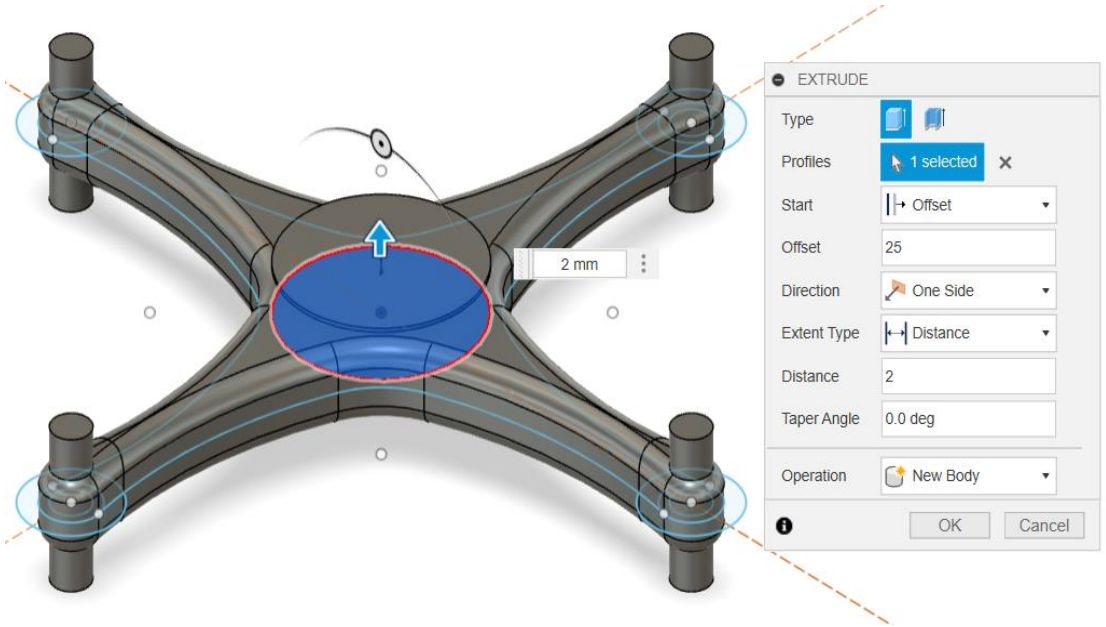
Drone frame generative design

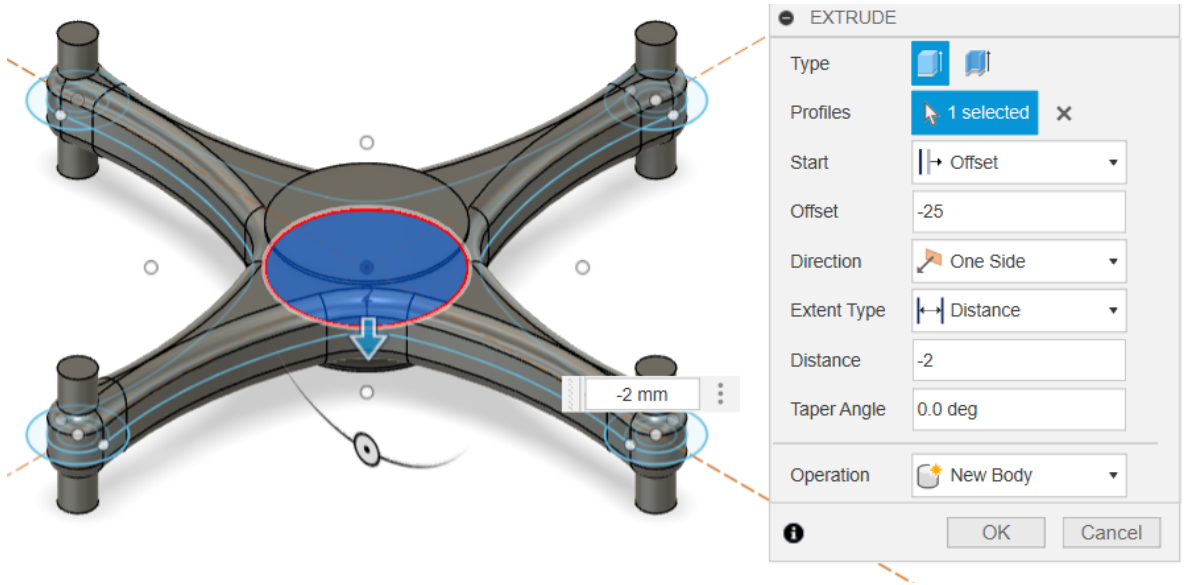
Use split body tool. Select main body to split. Select 4 outer circles as splitting tools. Extend splitting tool.

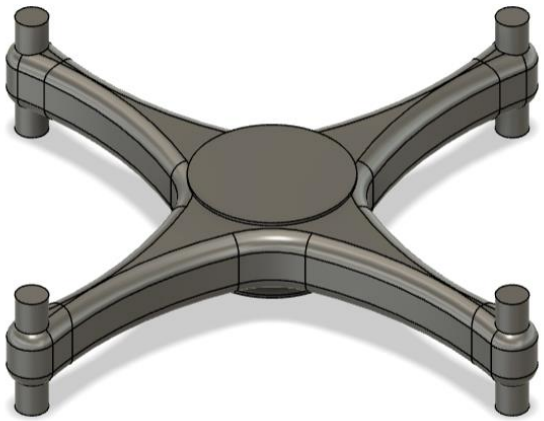




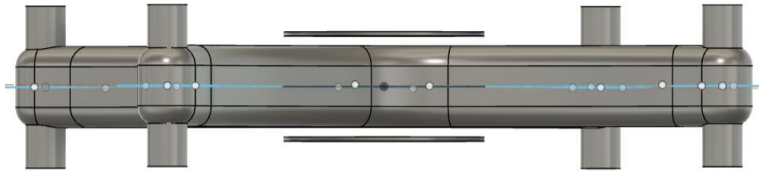
Drone frame generative design







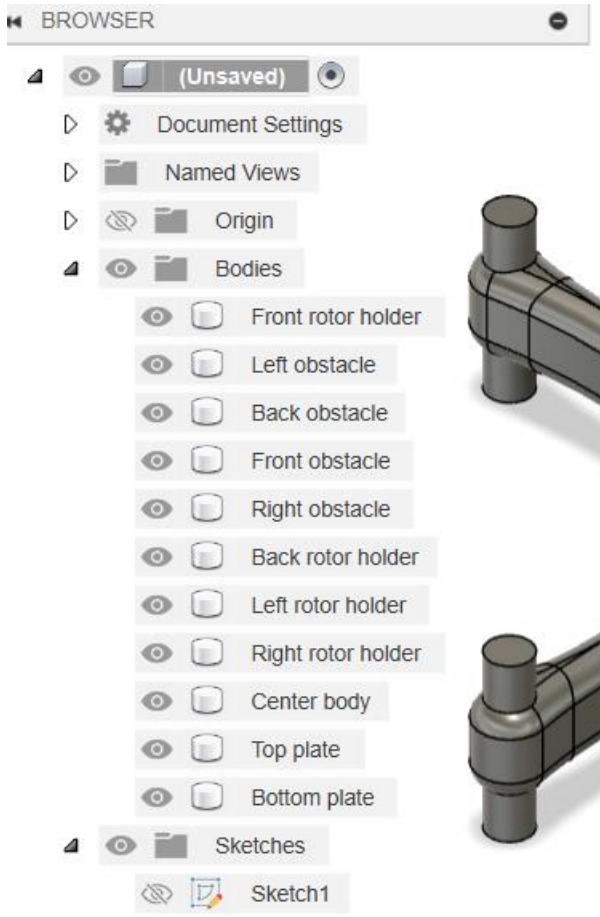
Extrude center circle twice.
Offset by 25 and -25 mm.
Thickness of 2 and -2 mm.
Operation: New Body

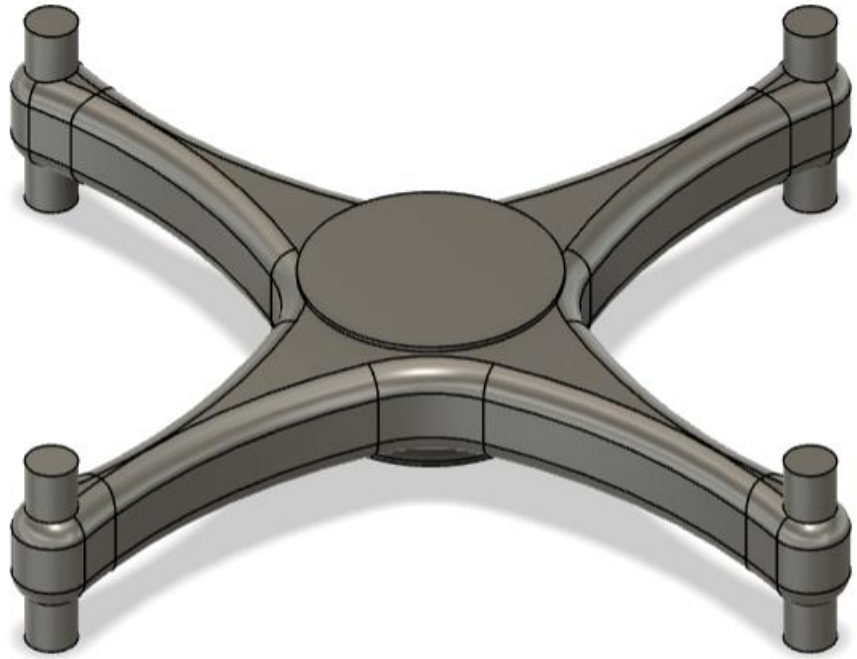


Drone frame generative design

Rename the bodies as

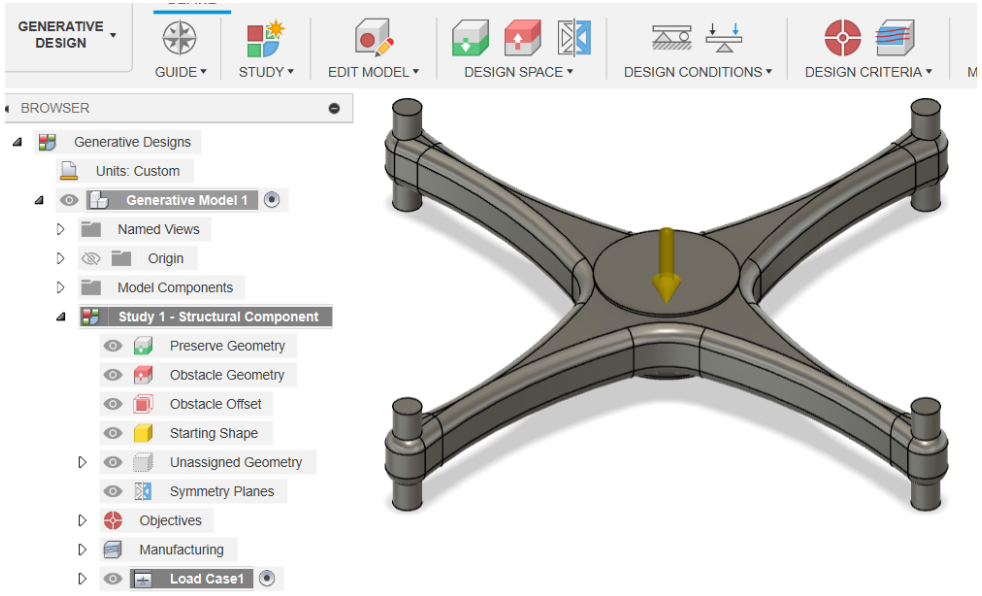
1. **Front rotor holder**
2. **Left rotor holder**
3. **Right rotor holder**
4. **Back rotor holder**
5. **Front obstacle**
6. **Left obstacle**
7. **Right obstacle**
8. **Back obstacle**
9. **Center body**
10. **Top plate**
11. **Bottom plate**

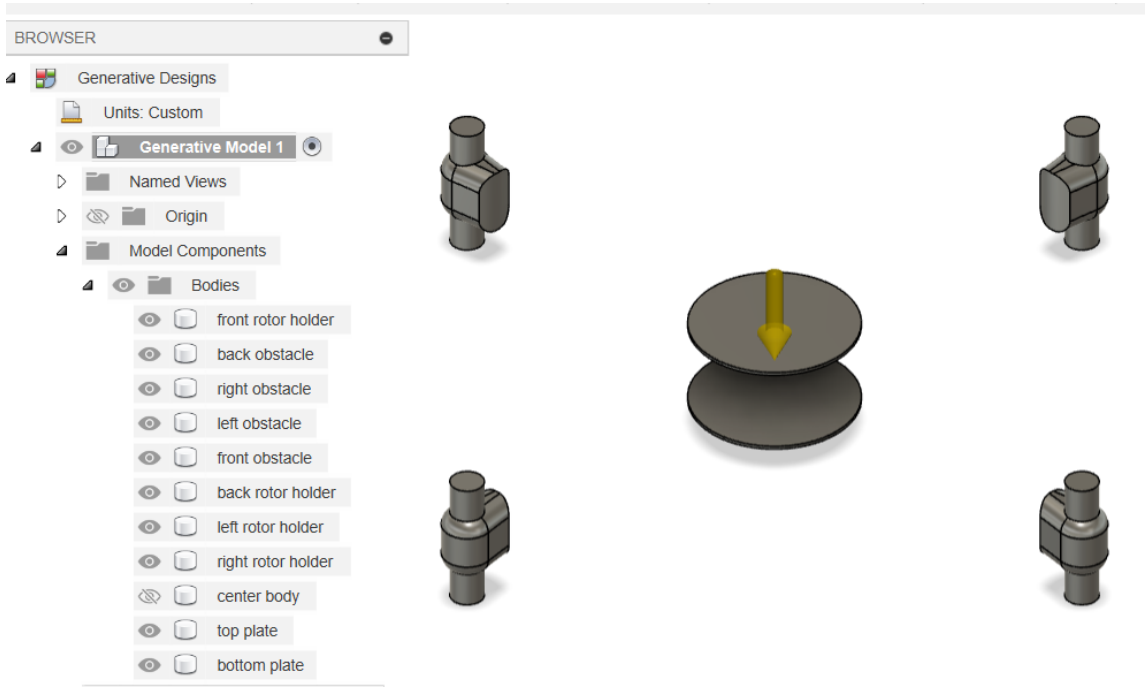




Drone frame generative design

From the Design drop down menu
Select generative design





Expand model components
From bodies inactivate center body

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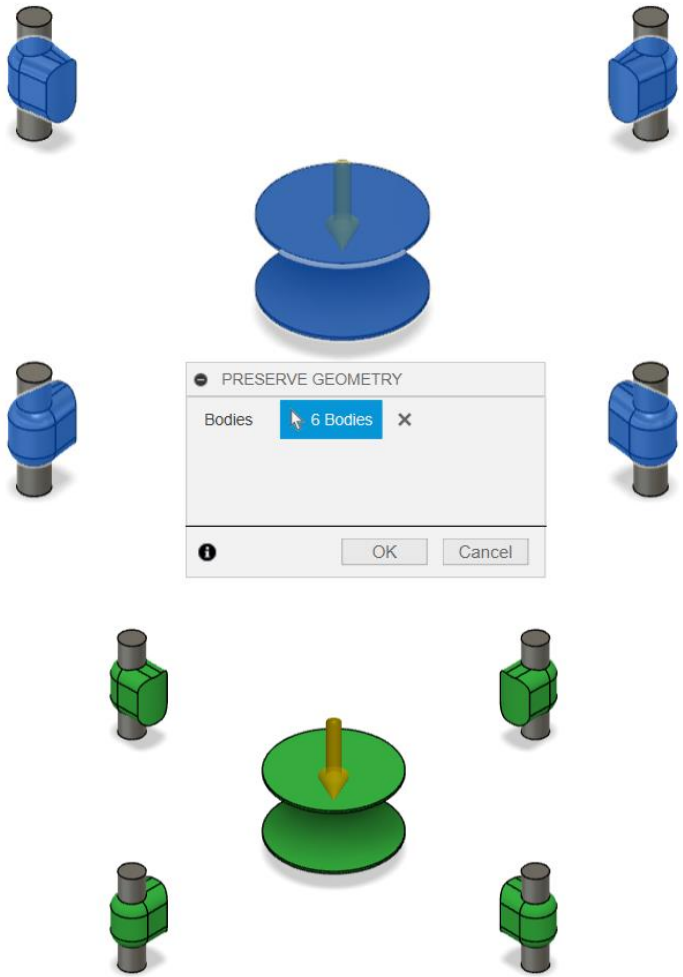
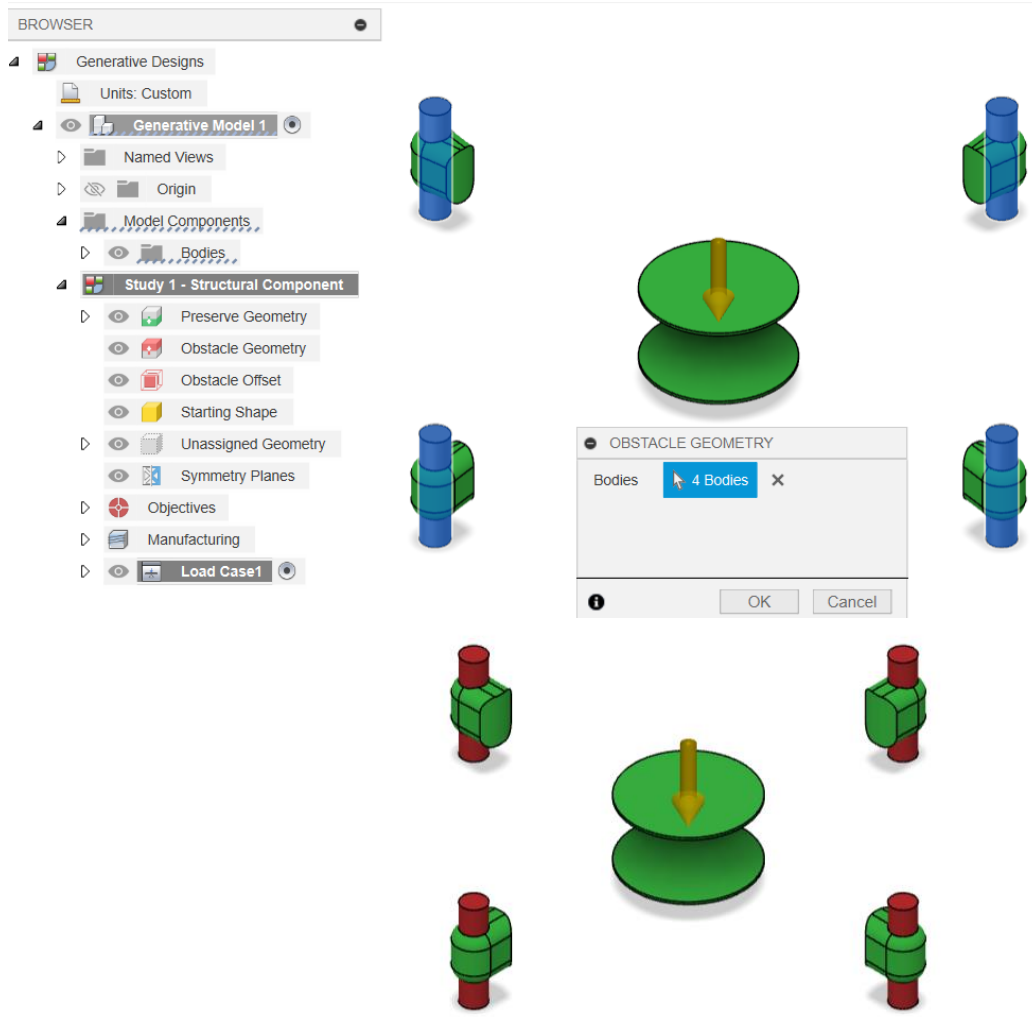
Select preserve geometry
Select rotor holders, top & bottom plates



Select obstacle geometry
Select 4 rotors as obstacle bodies



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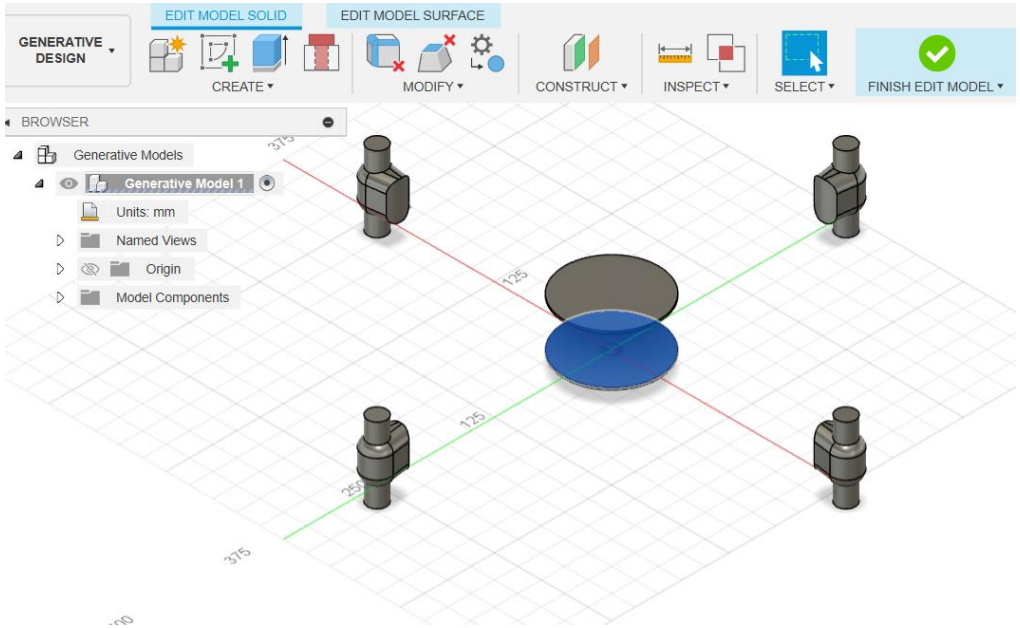

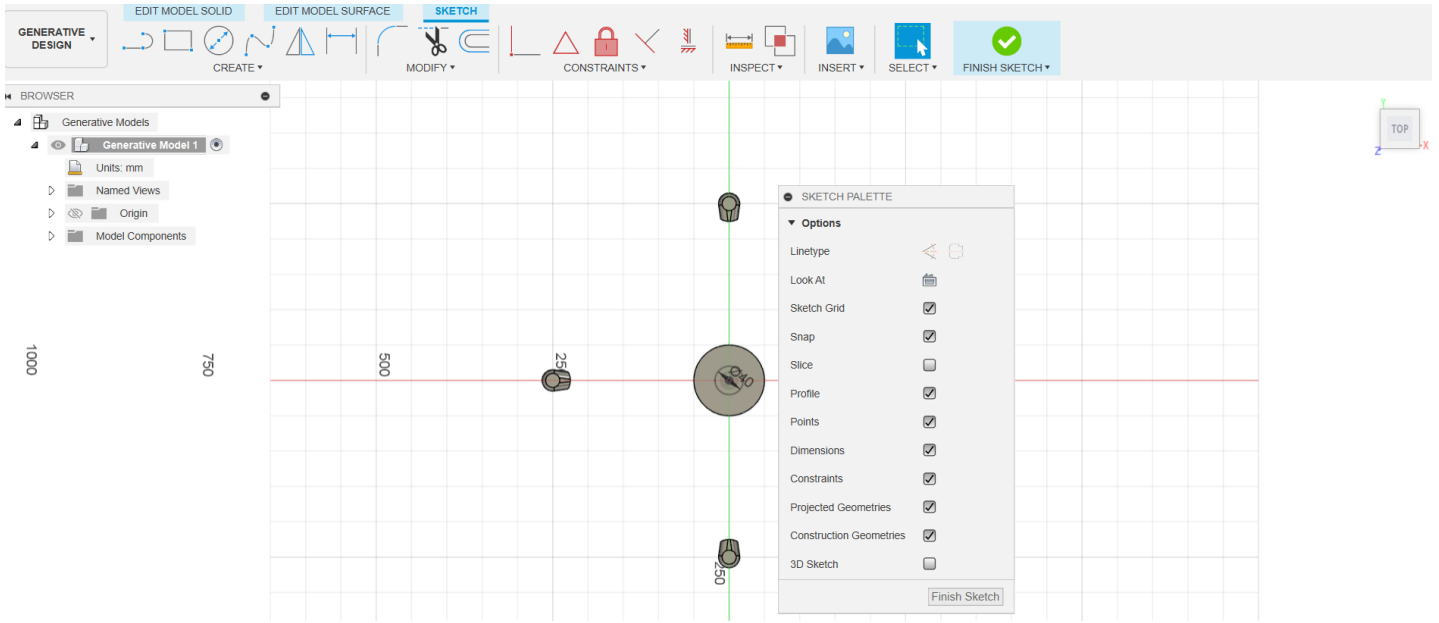

Edit model, edit model solid.
Create sketch on top face of bottom plate.

Create circle of 40mm dia.

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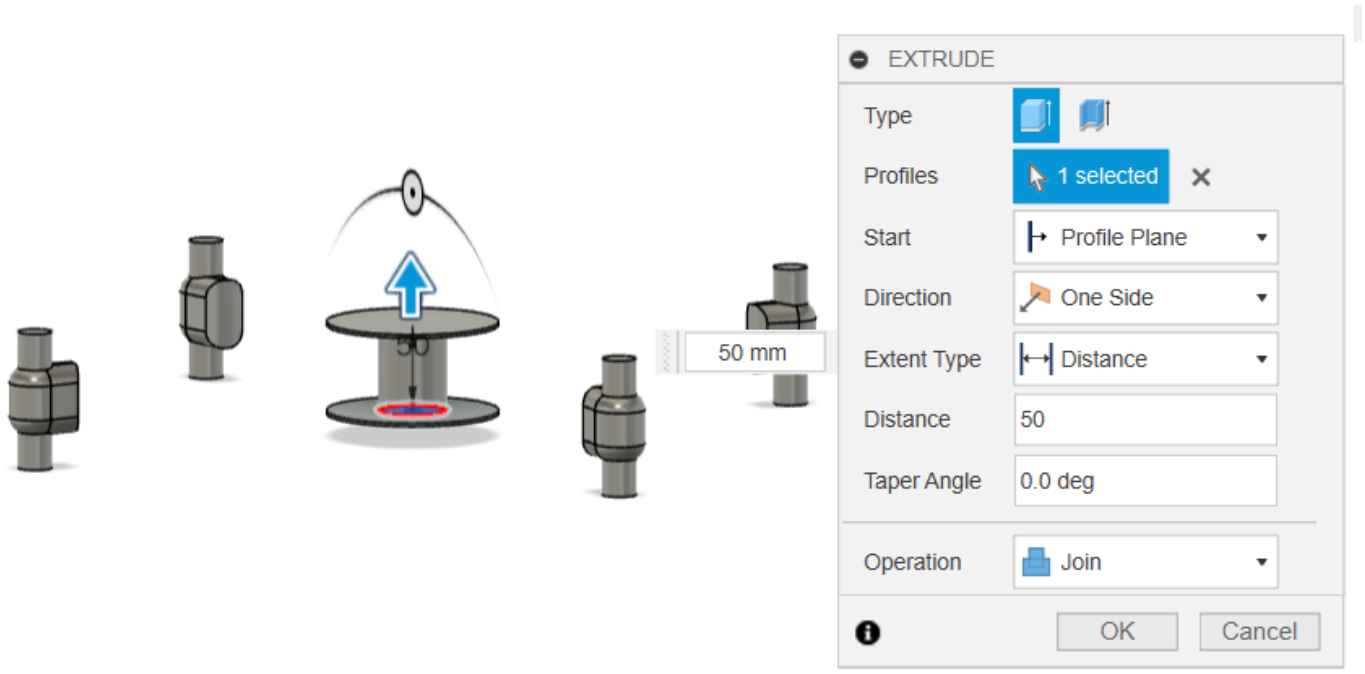
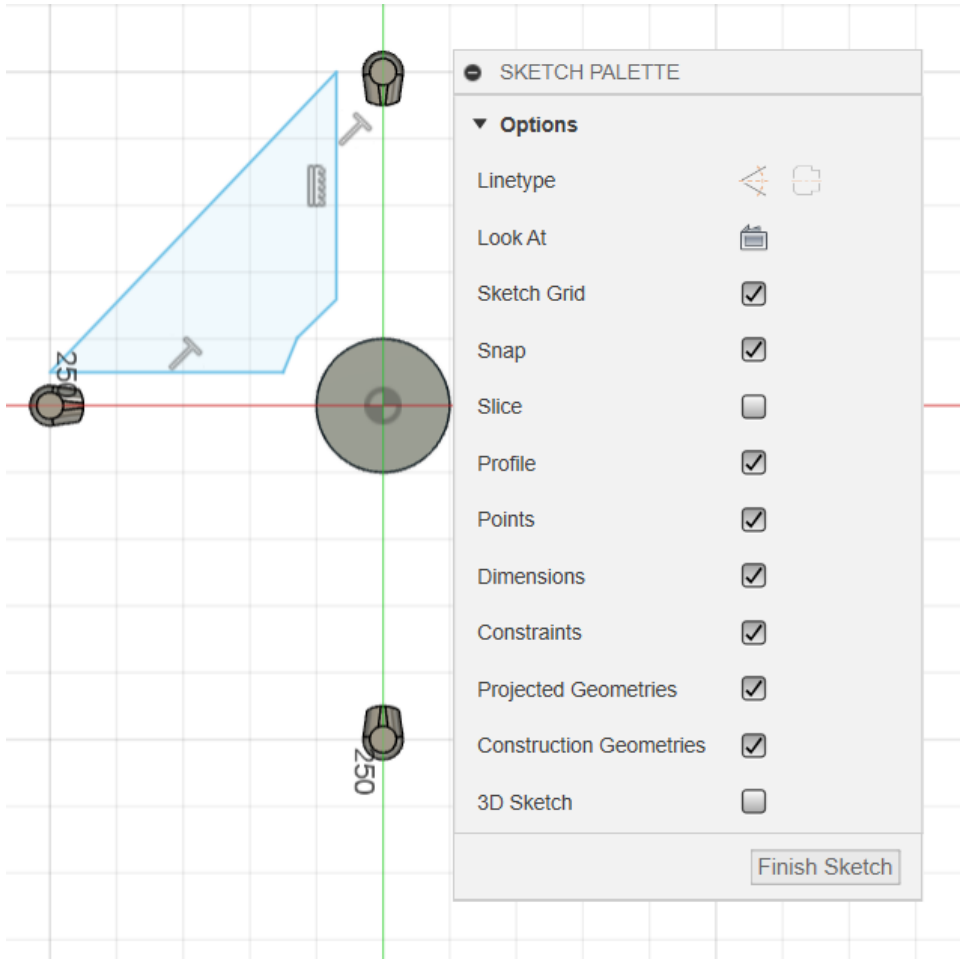
Extrude the circle by 50mm as join operation





Create sketch on the top plane as shown

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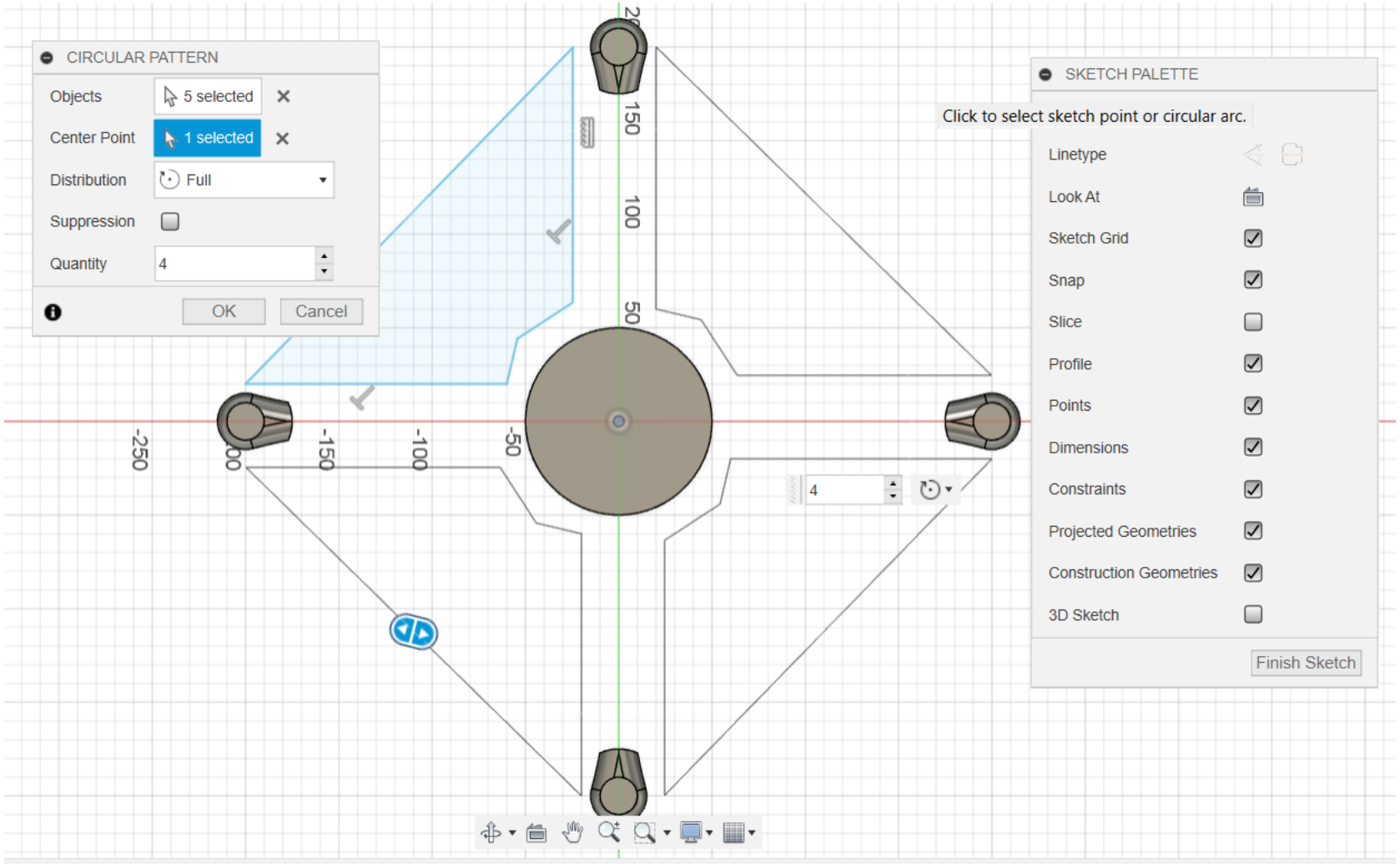
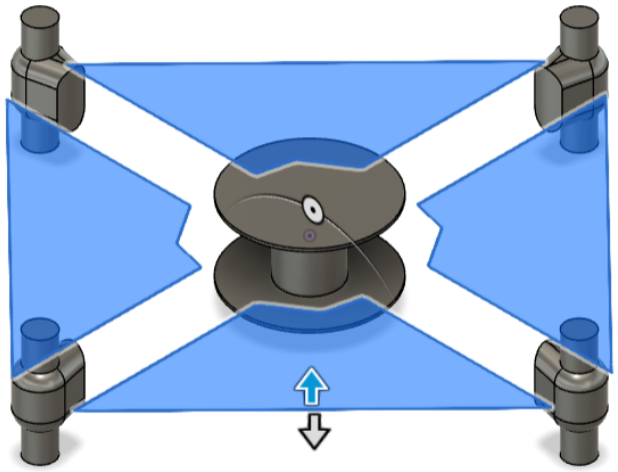
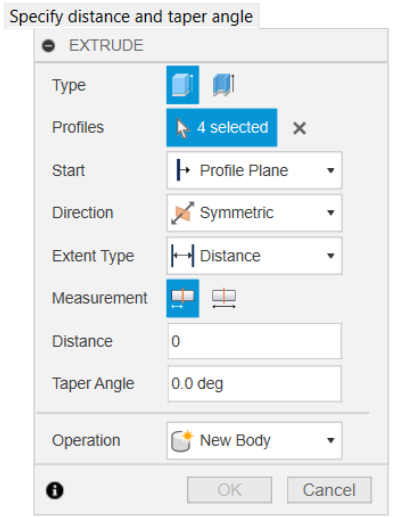
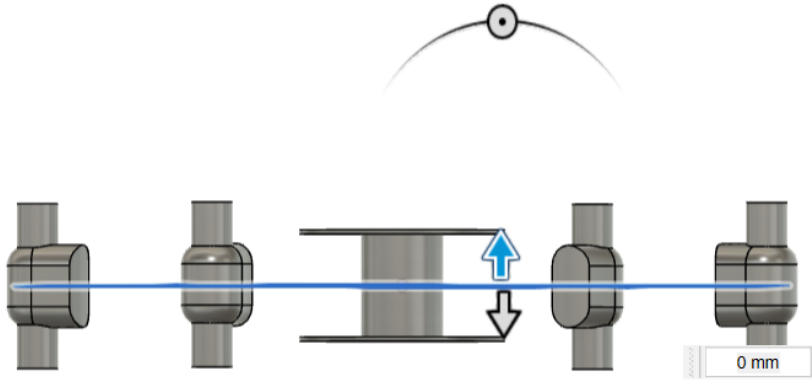
Create 4 circular pattern of the sketch about the center

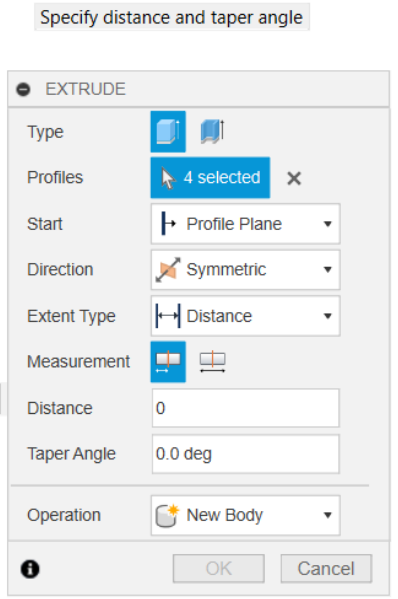


Drone frame generative design









Extrude the four sketches symmetrically

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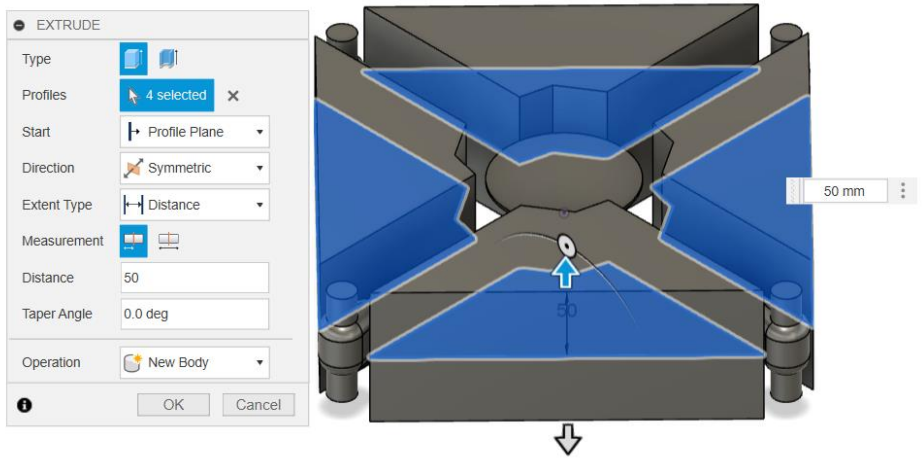
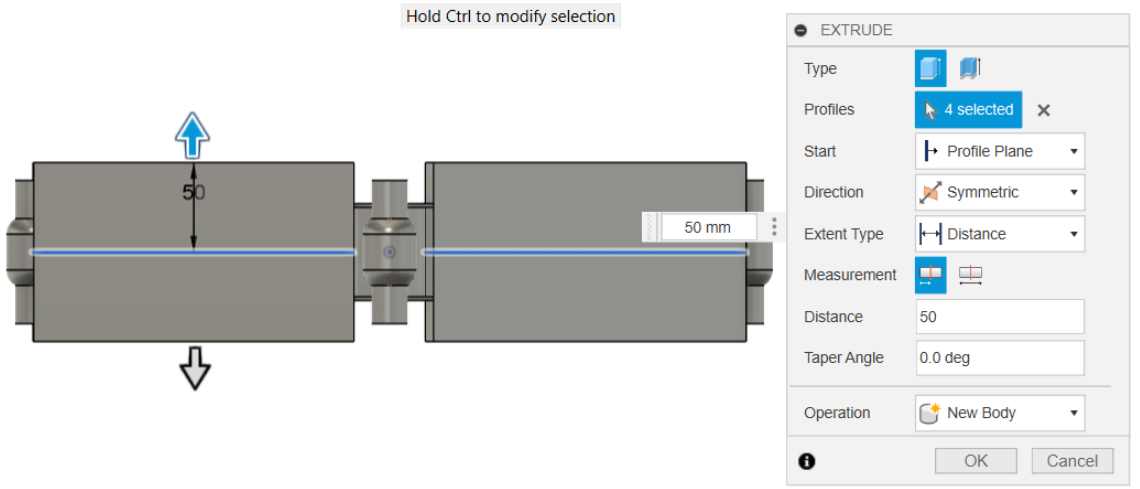
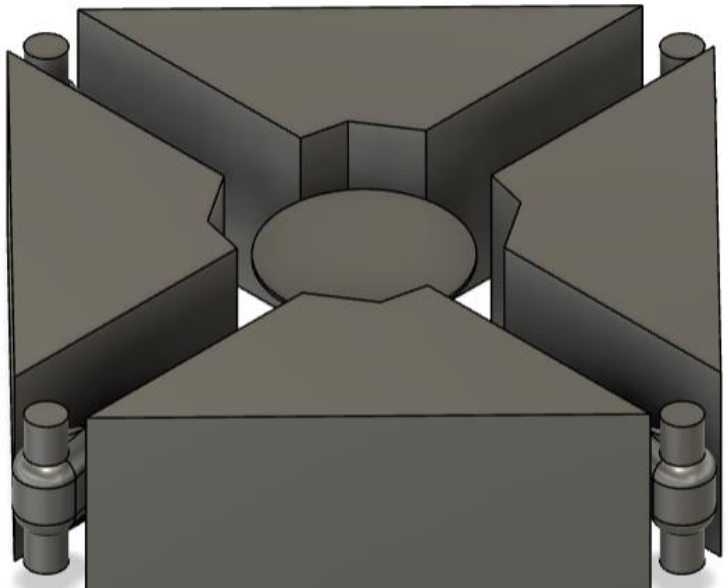
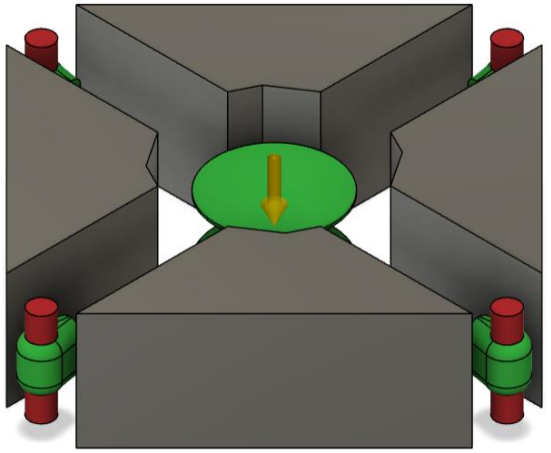




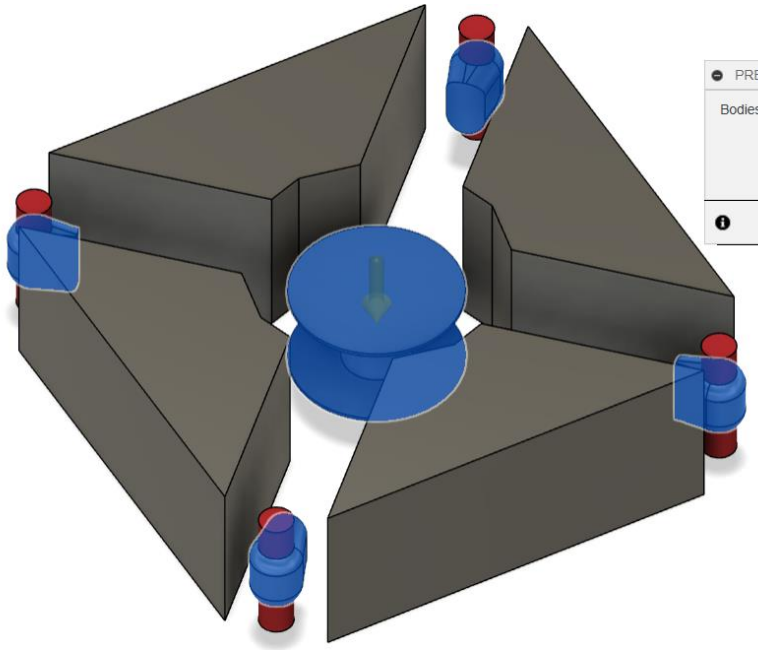
Extrude the four sketches symmetrically 50 mm
Select the operation as new body
Finish edit model

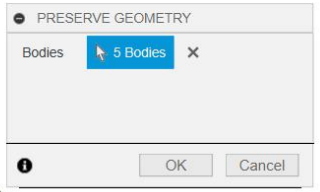


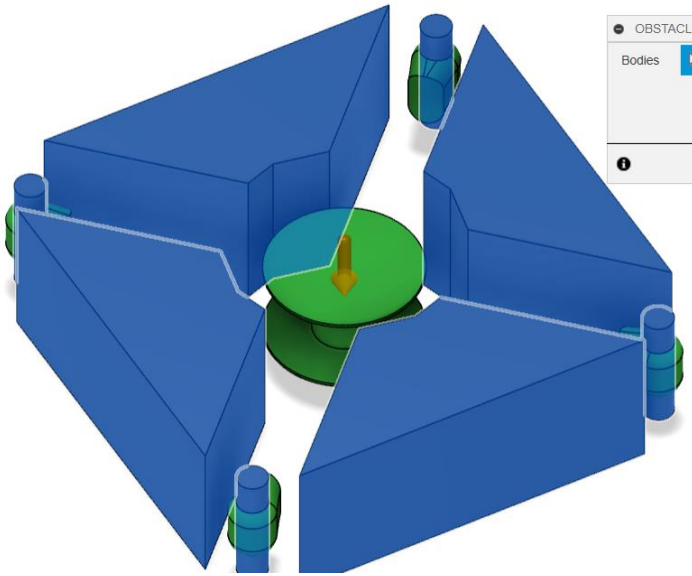


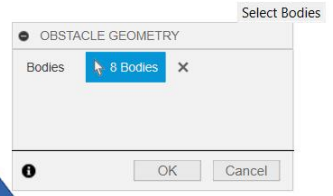
Drone frame generative design

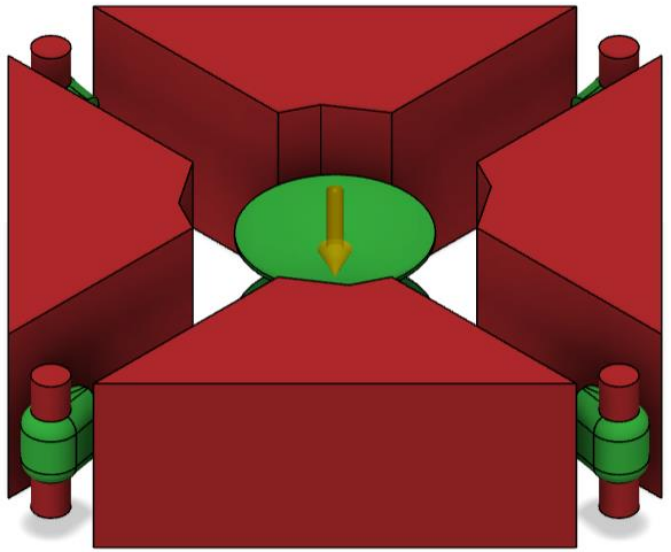
Preserve the geometry bodies the same







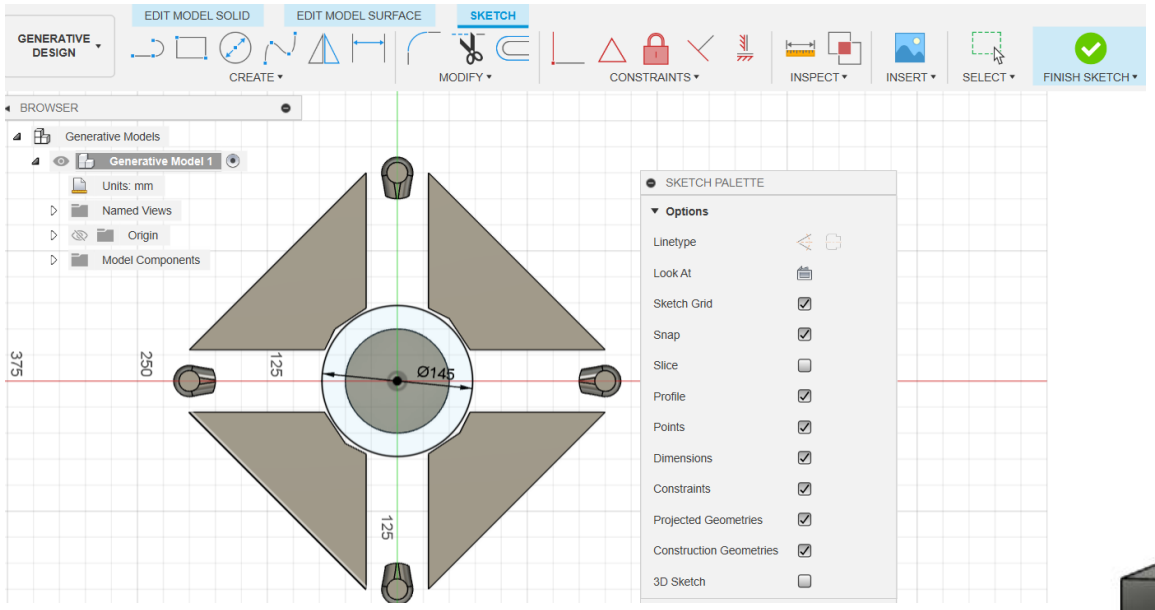


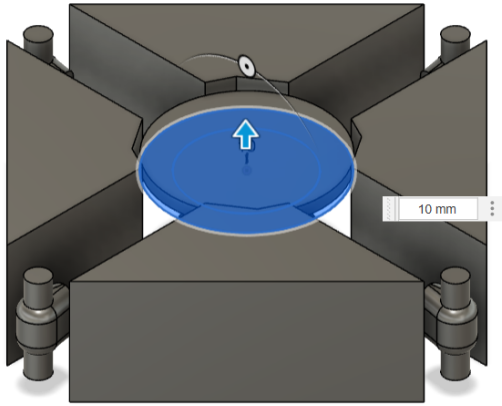


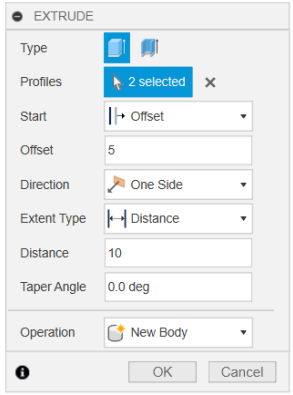
4 new bodies as obstacle geometry, 8 in total

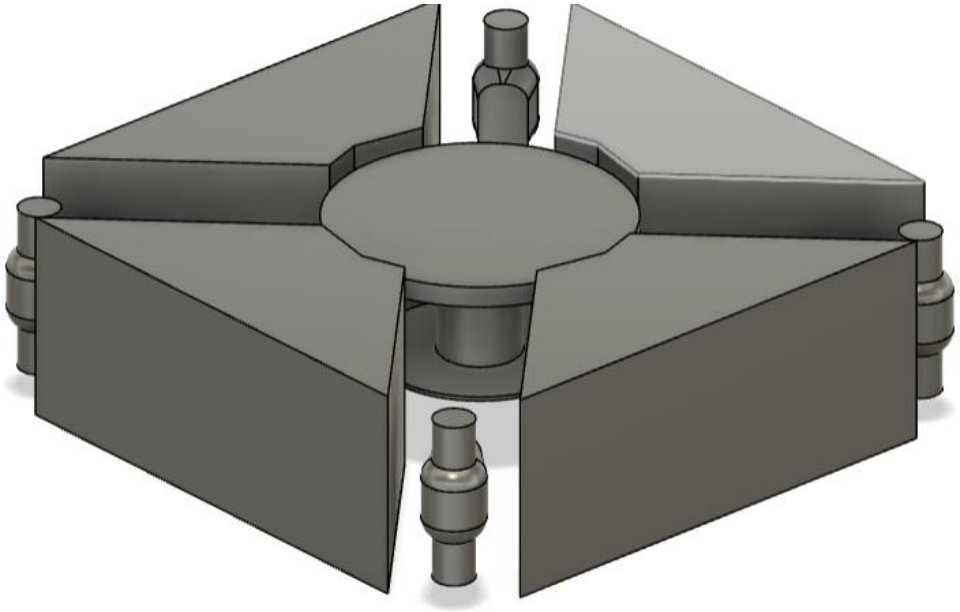
Drone frame generative design

Extrude the two circle 145 and 100mm
Offset 5mm, distance 10 mm as new body









Edit the model
On the face (top plane) of the 100 mm circle
Sketch approx. 150mm circle.

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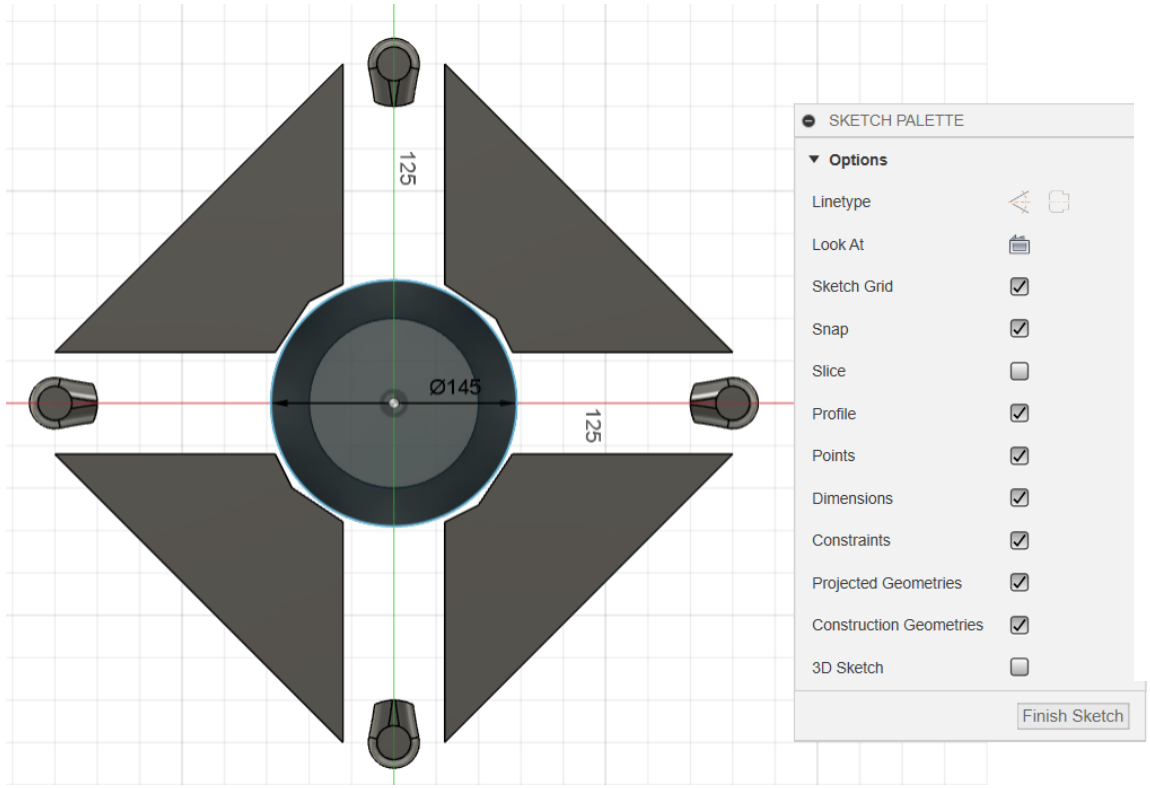
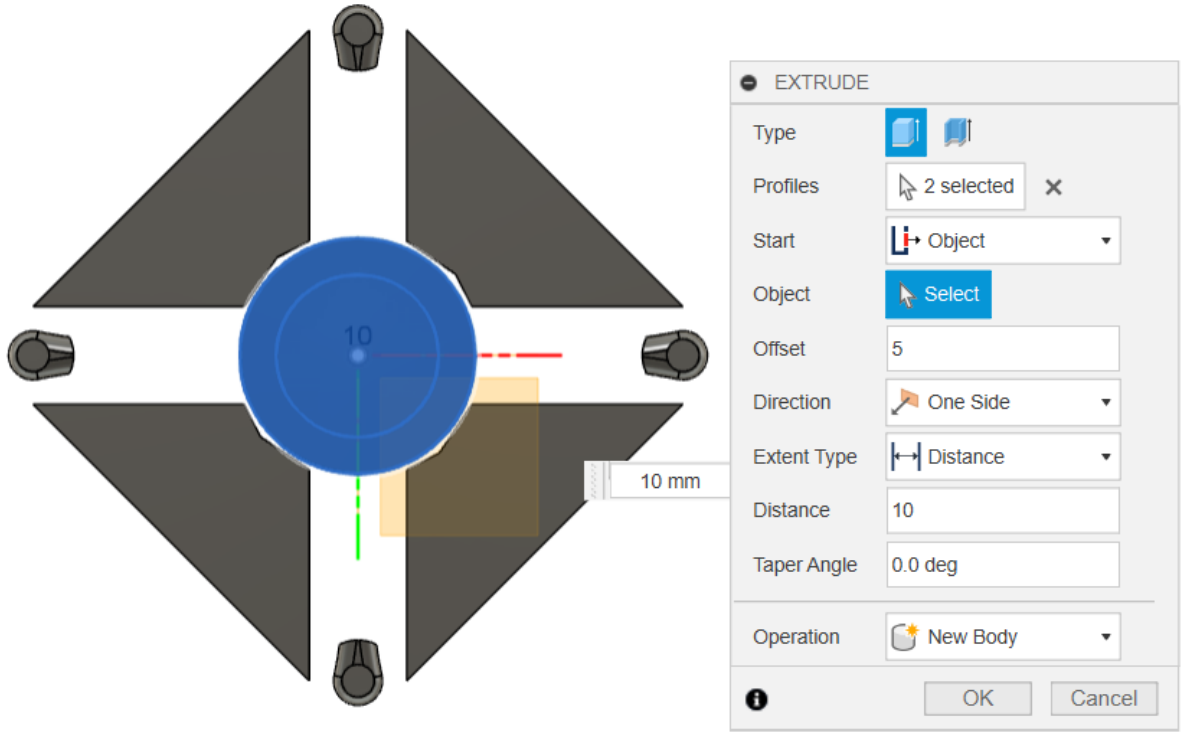
Repeat the create sketch and extrusion from the bottom circle face as new body.





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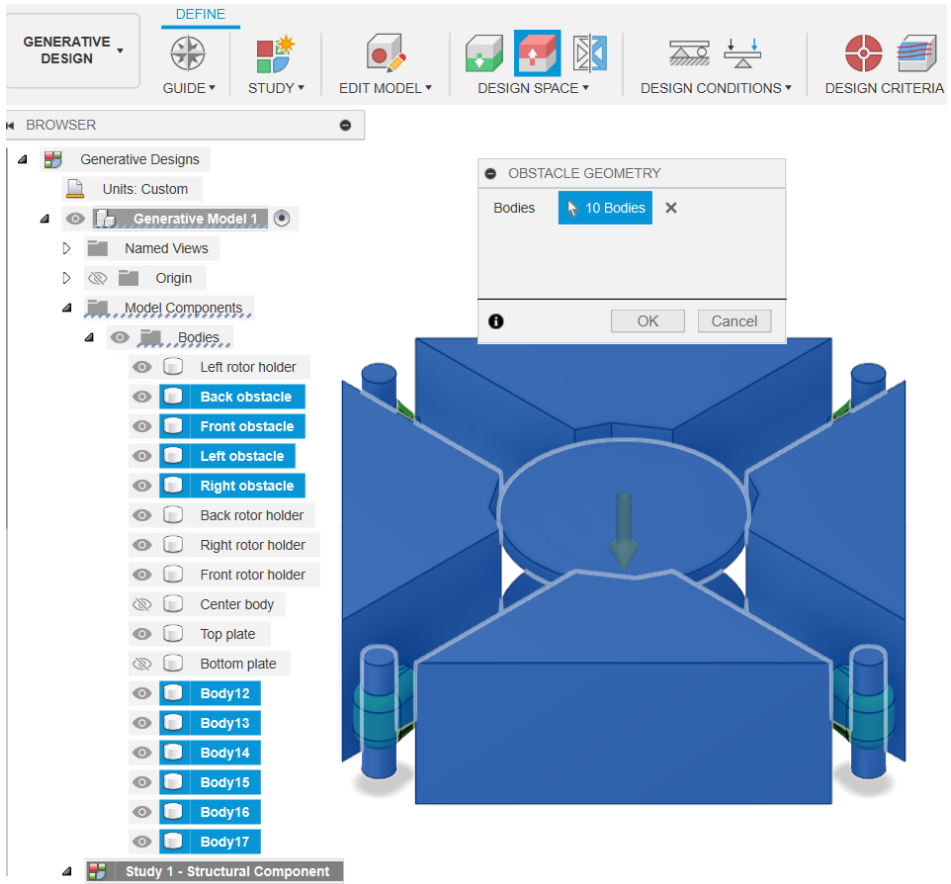
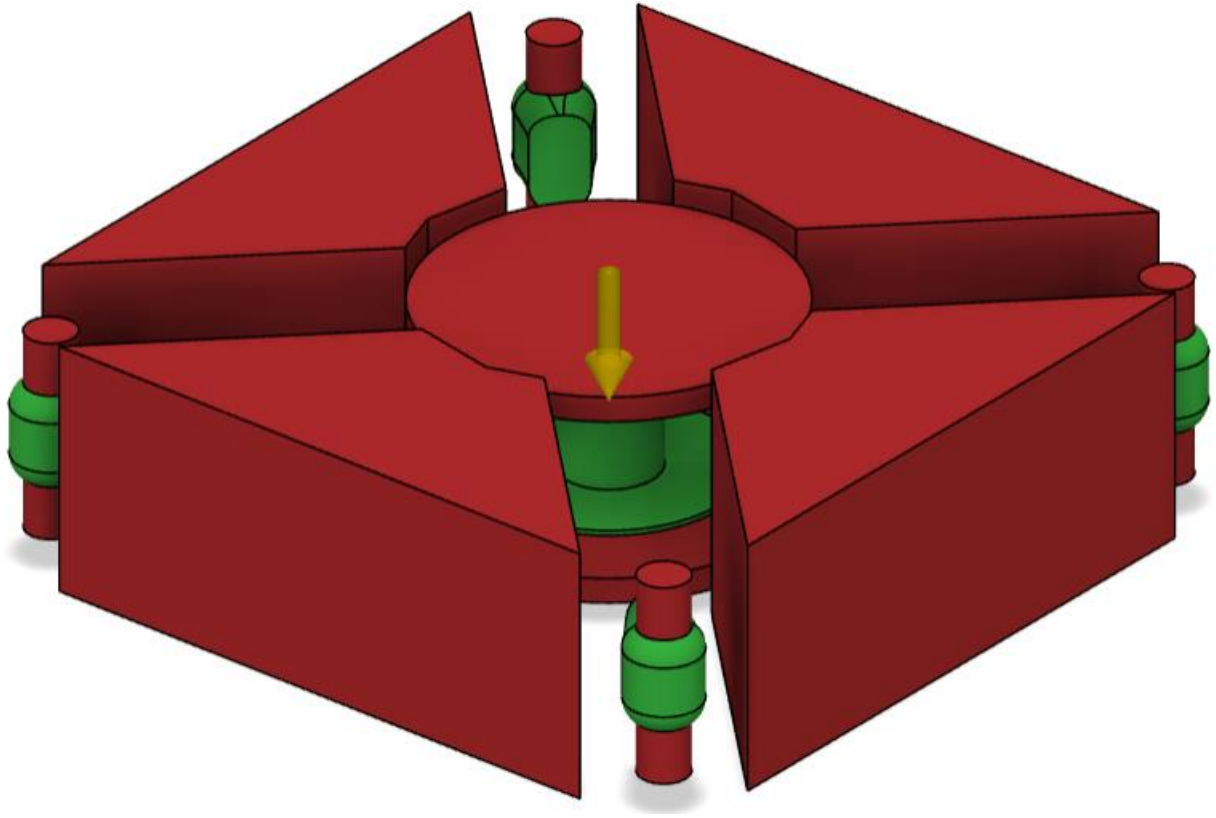
Finish edit model

Add the two circular bodies as obstacle geometry

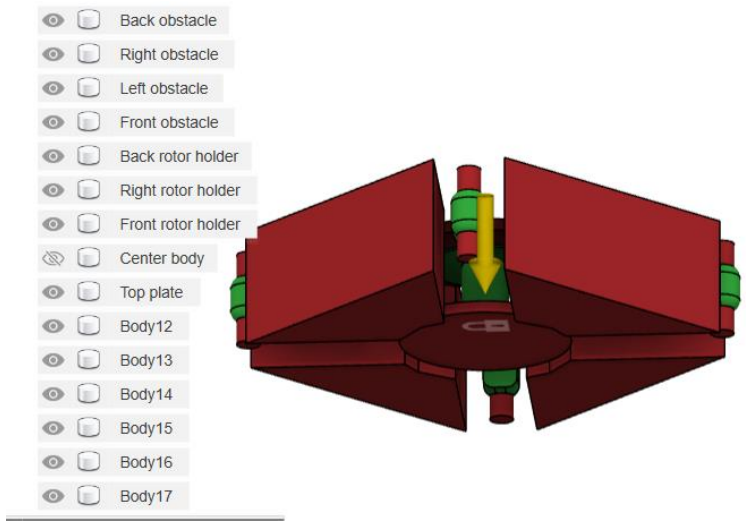


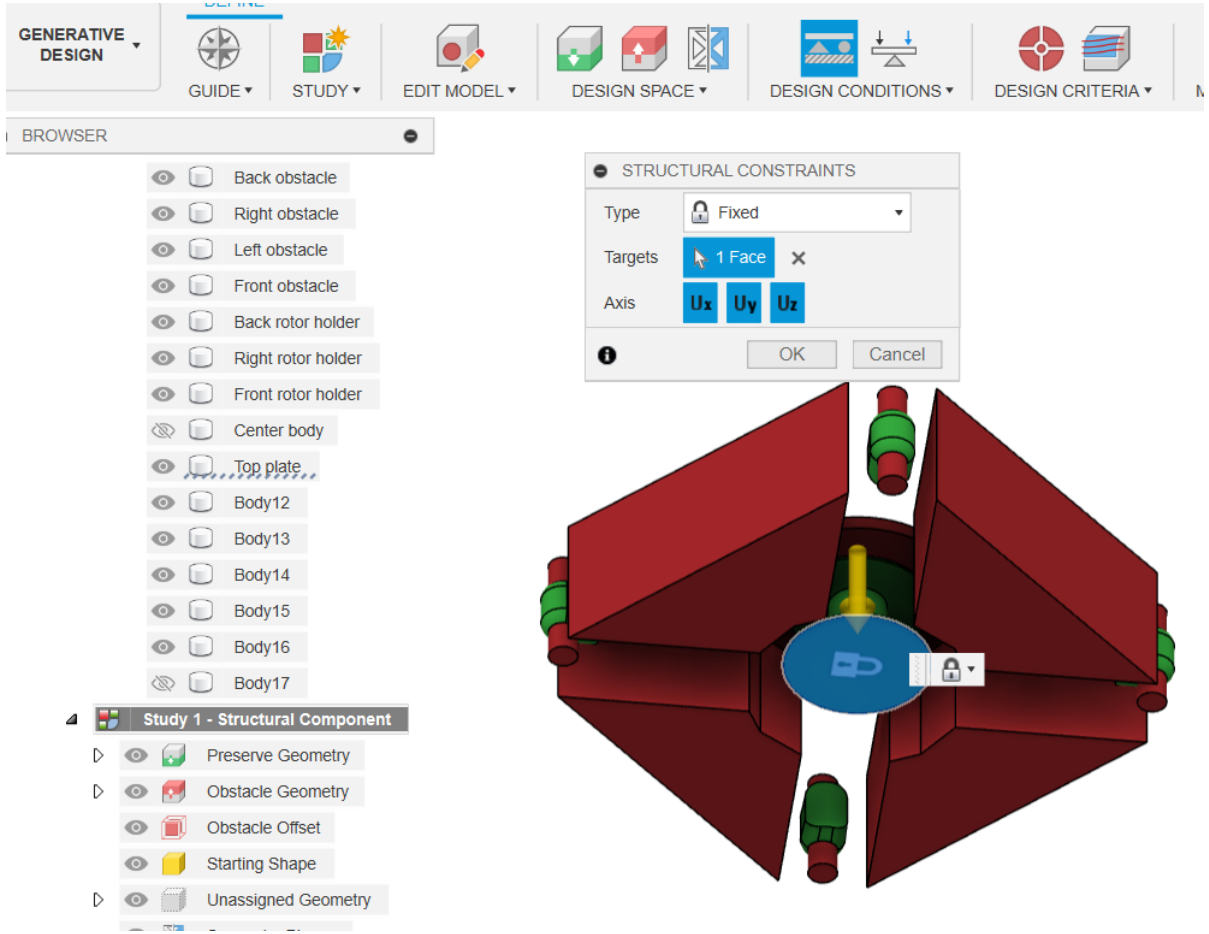


Drone frame generative design

Select structural constraint from design conditions.
Inactivate body17 (bottom circular obstruction)
Select the bottom plate face as fixed constraint.

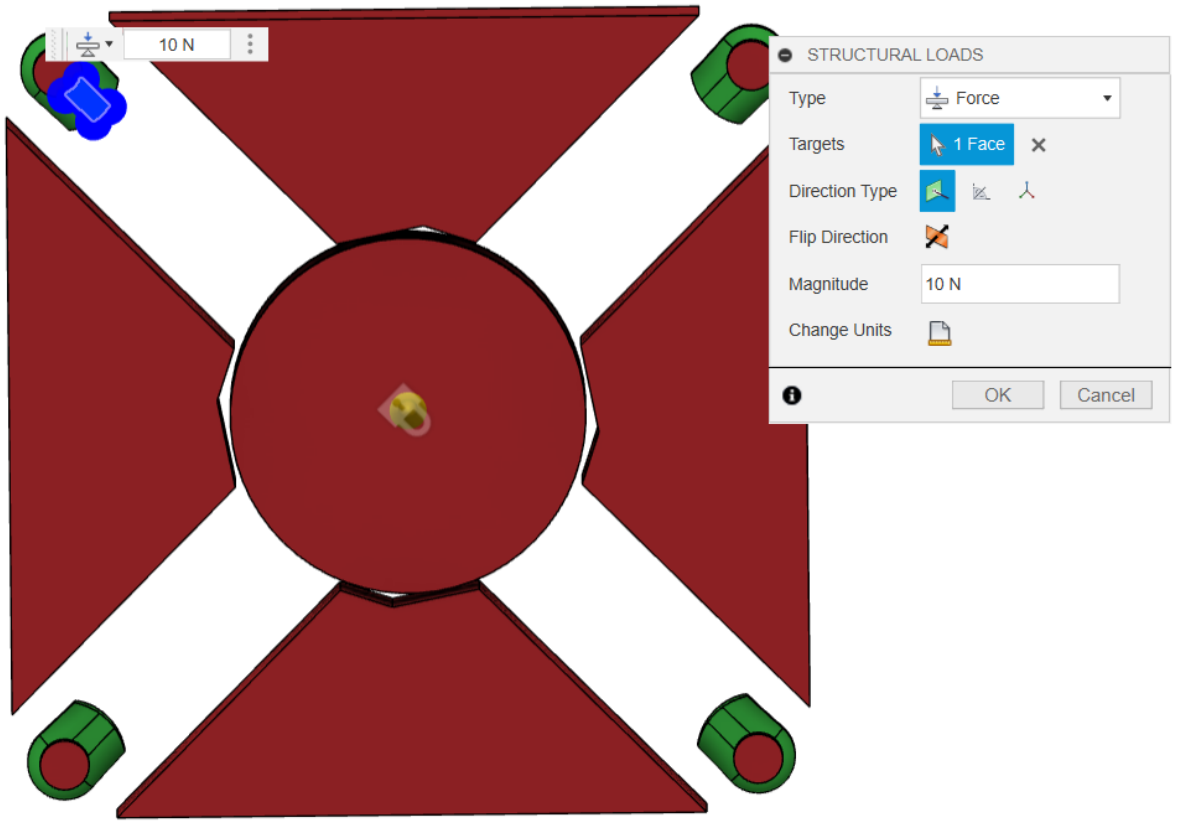
Activate all bodies except center body.

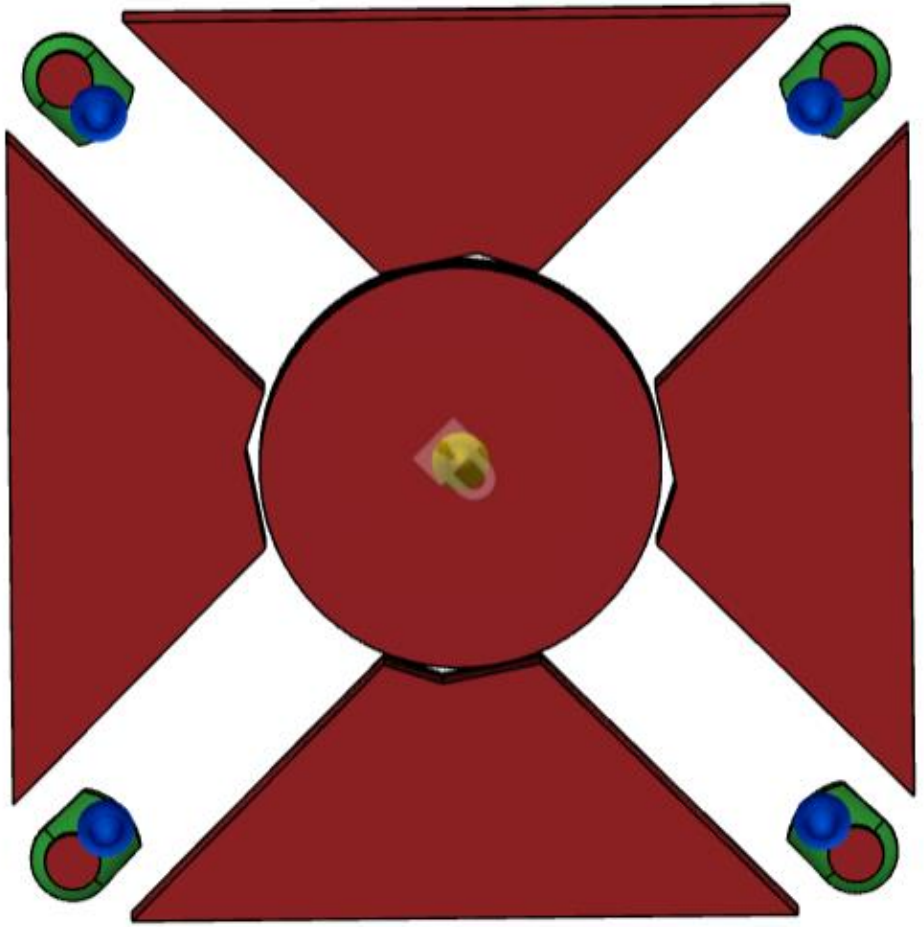




Drone frame generative design

Select bottom face of the rotor holder for structural loads.
Select 10 N as the force.
Repeat the same for the other 3 rotor holder face.



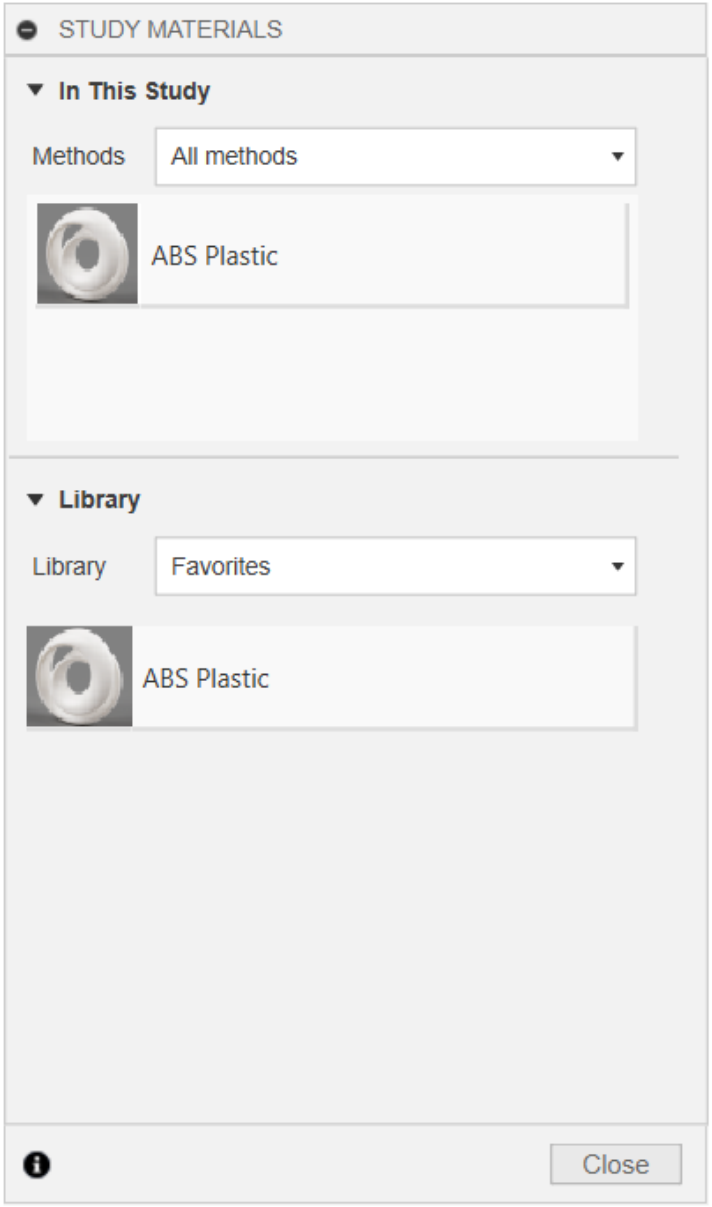


Drone frame generative design

Select study materials from the drop down of materials.

Materials from available material library can be added to the favorites library.

Click on the materials from favorites/material library and drag it into the in this study section.

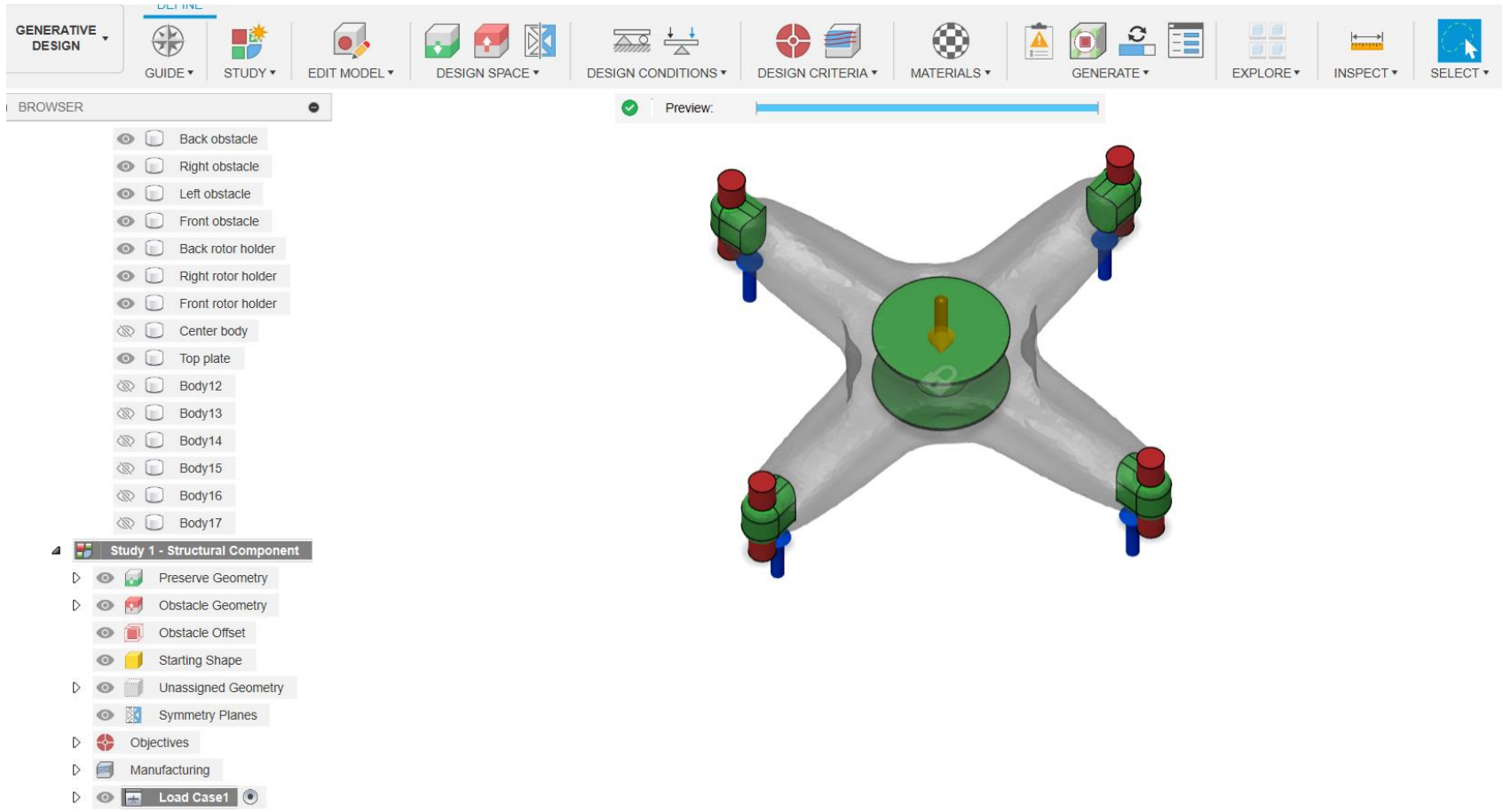


Drone frame generative design

Run the previewer from Generate menu

Preview from the generate shows the geometry

By inactivating body12-17

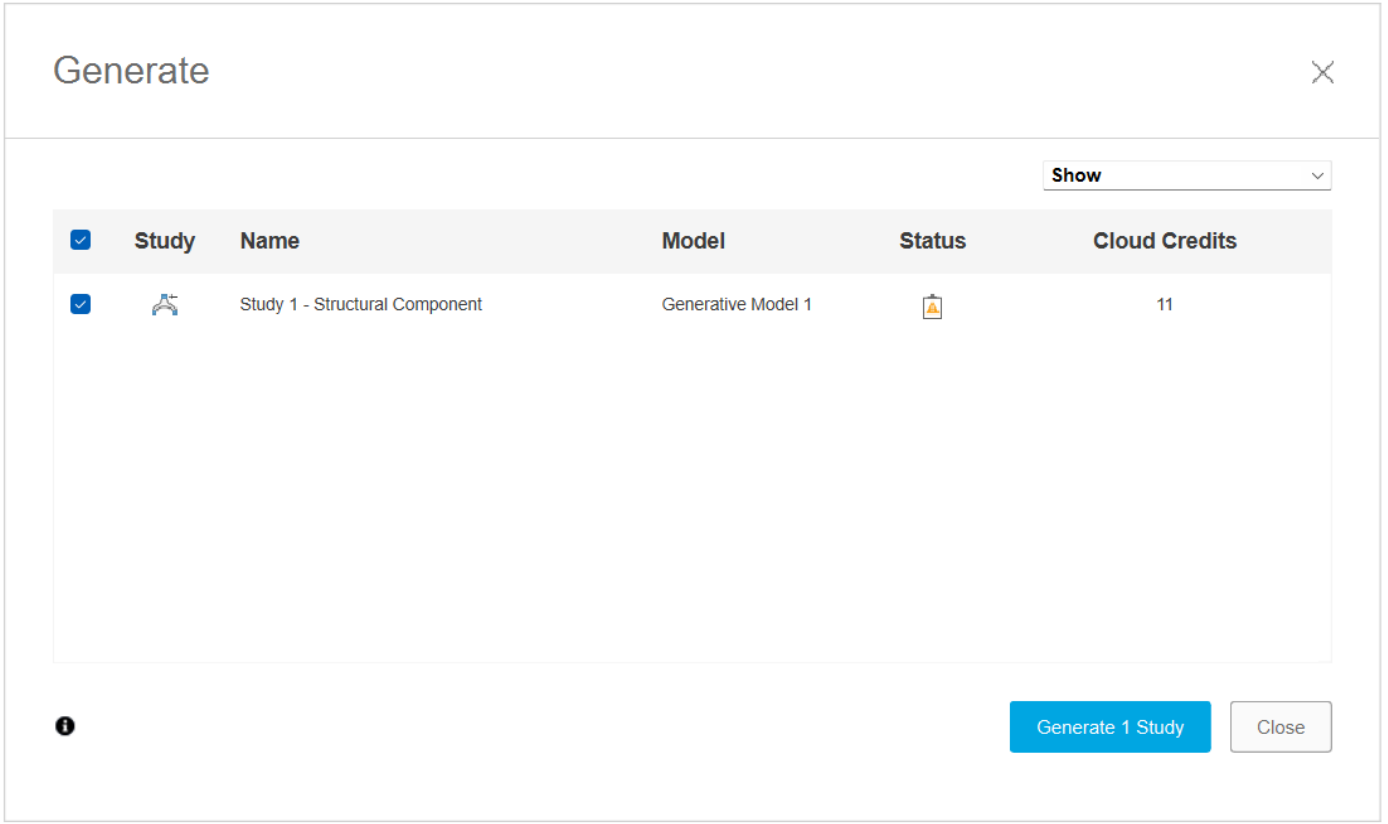


Drone frame generative design

Stop previewer and activate all the bodies except center body

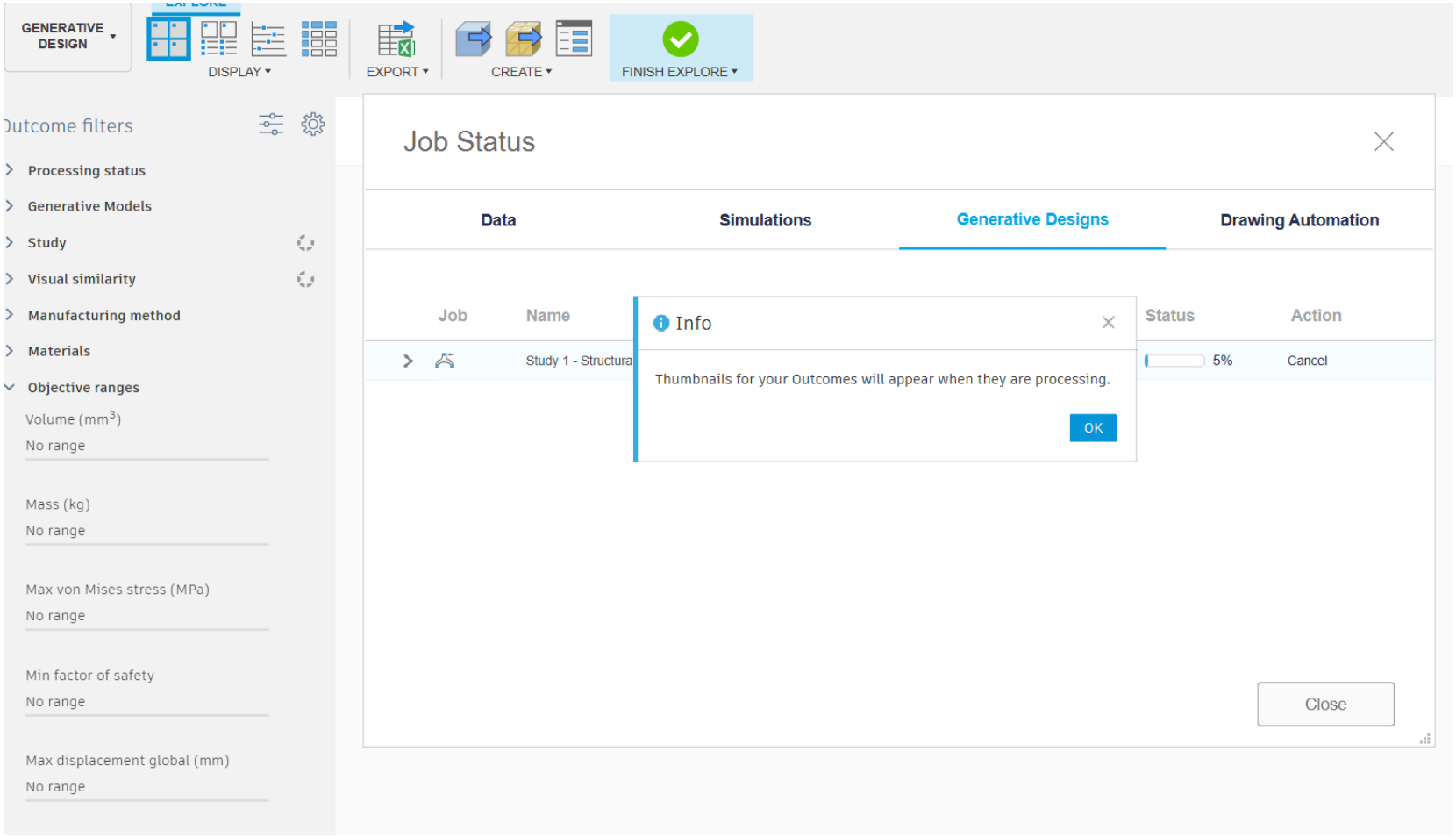
Generate shows the details the study

Click on the generate 1 study



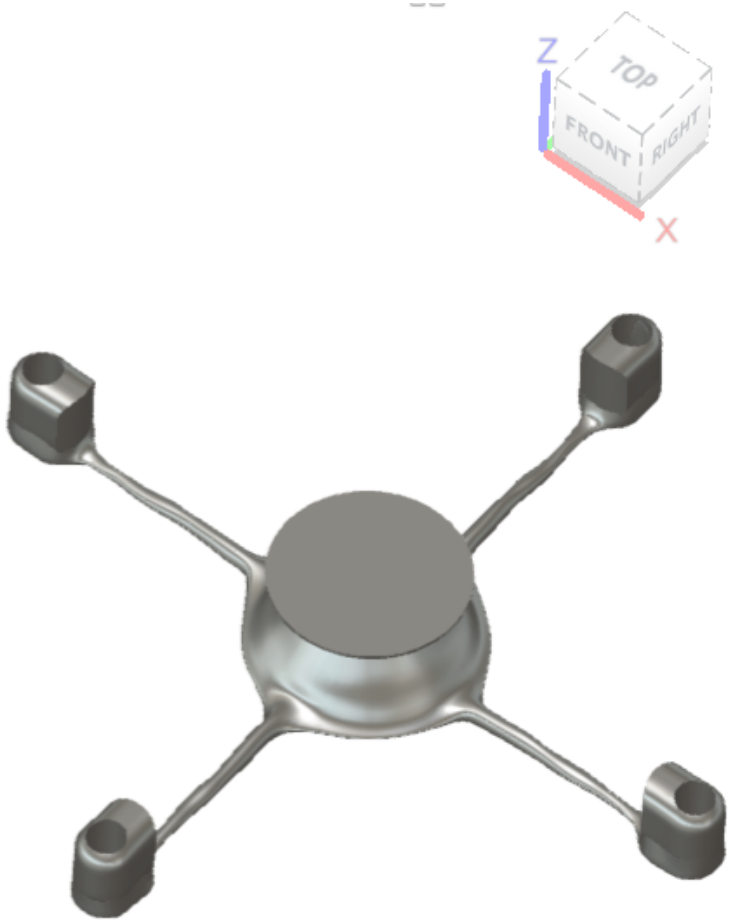
Drone frame generative design

Progress window of the design process



Drone frame generative design

Design study outcome 1



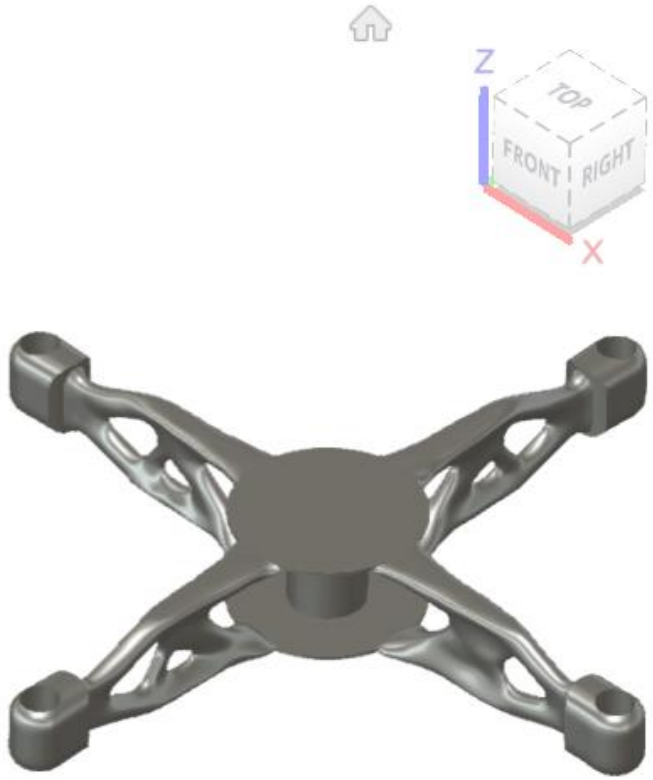
Study 1 - Structur... - Outcome 1
Iteration 33 (final)

Properties

Status	**Converged**
Material	**Aluminum 6061**
Orientation	**Z-**
Manufacturing method	**3 axis milling**
Visual similarity	**Ungrouped**
Volume (mm^3)	**459,393**
Mass (kg)	**1**
Max von Mises stress (MPa)	**8**
Factor of safety limit	**2**
Min factor of safety	**33**
Max displacement global (mm)	**1**

Drone frame generative design

Design study outcome 2



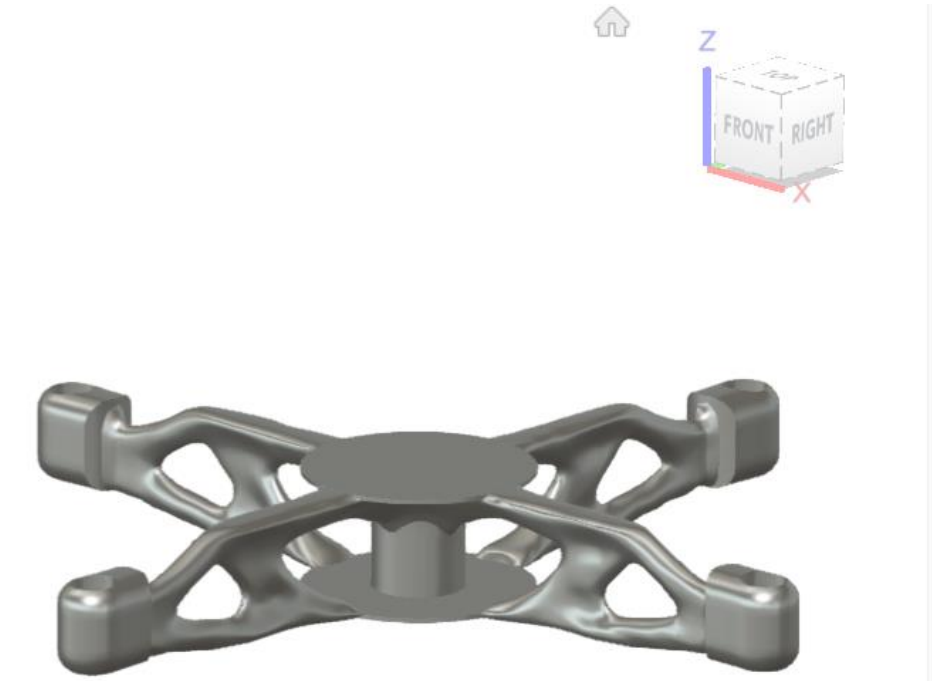
Study 1 - Structur... - Outcome 2
Iteration 32 (final)

Properties

Status	**Converged**
Material	**Aluminum AlSi10Mg**
Orientation	-
Manufacturing method	**Unrestricted**
Visual similarity	**Ungrouped**
Volume (mm^3)	**396,214**
Mass (kg)	**1**
Max von Mises stress (MPa)	**0**
Factor of safety limit	**2**
Min factor of safety	**1,205**
Max displacement global (mm)	**0**

Drone frame generative design

Design study outcome 3



Study 1 - Structur... - Outcome 3
Iteration 32 (final)

Properties

Status	**Converged**
Material	**Aluminum AlSi10Mg**
Orientation	**Z+**
Manufacturing method	**Additive**
Visual similarity	**Ungrouped**
Volume (mm^3)	**392,738**
Mass (kg)	**1**
Max von Mises stress (MPa)	**0**
Factor of safety limit	**2**
Min factor of safety	**1,081**
Max displacement global (mm)	**0**

Fusion Simulation

Fusion Simulation is a validation tool that uses finite element analysis (FEA) to help you understand how a design performs under certain conditions.

Simulation workspace help to:

Evaluate the effects of structural or thermal loads.

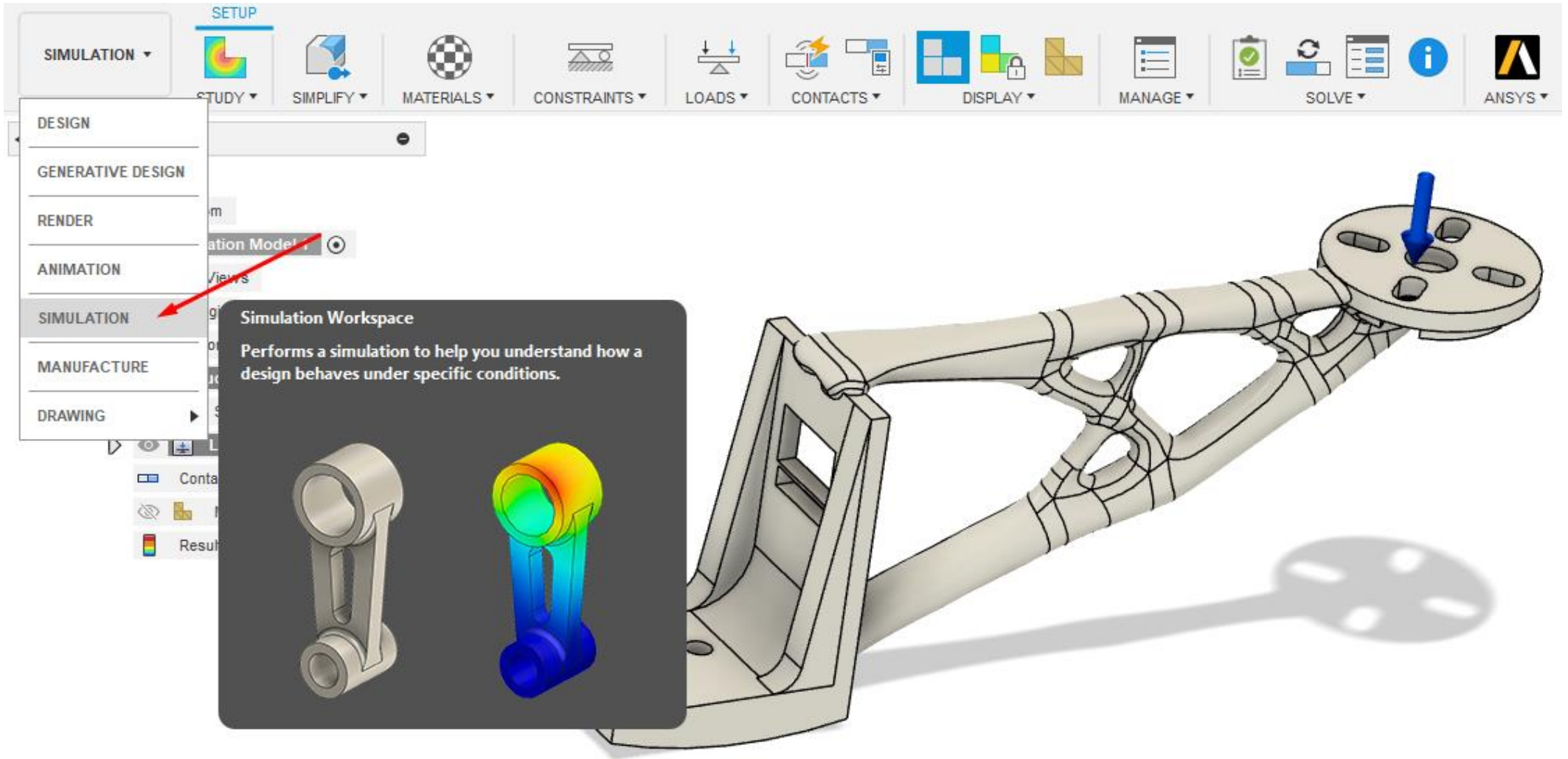
- **Is the design strong enough to withstand the expected loads or vibrations?**
- **Can it withstand stresses induced by temperature gradients in addition to stresses associated with static or transient mechanical loads?**
- **Does it fail under heavy load?**
- **Does it overheat?**
- **Is it prone to resonance?**
- **Is the operating temperature acceptable?**
- **Will long and slender structures fail due to geometric instability (buckling) when subjected to compressive loads?**
- **Can it survive being dropped onto a hard object or the impact from a projectile?**

Fusion Simulation

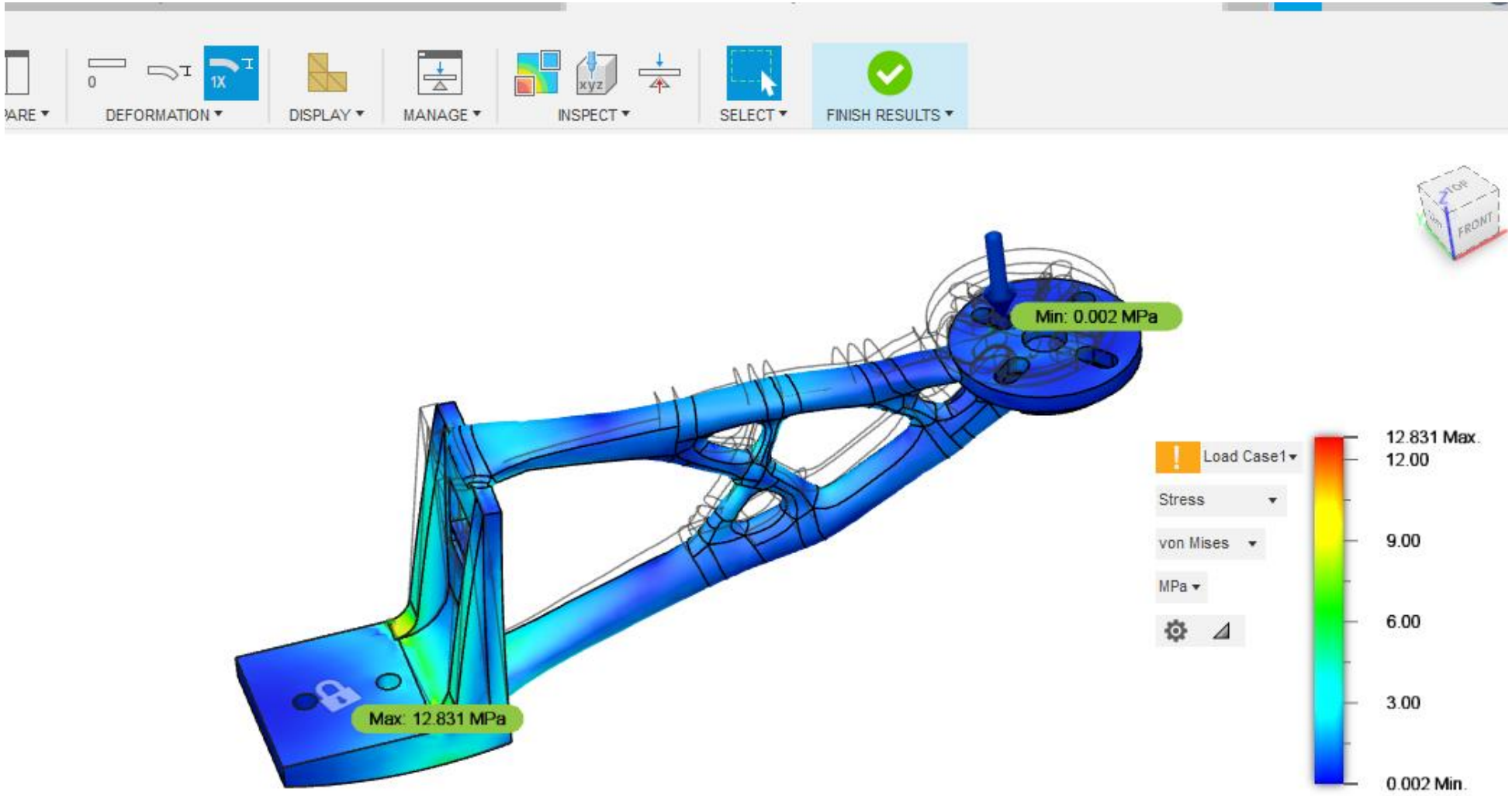
Simulation workspace help you to:

- **Compare the effects of different materials and different conditions (such as loads and constraints).**
- **Analyze the behavior of design variations.**
- **Optimize the geometry of your parts to minimize their weight.**
  Does it use too much material, or can I substitute a different material?
- **Ensure that you are not overdesigning or under designing your parts.**
  If the design works correctly, is it overdesigned? Can I better achieve the design goal by changing the geometry?
- **Gain valuable insight at an early stage when the cost of redesign is small.**
- **Alter the mass and geometry of an object to change its natural vibration frequencies, avoiding the frequencies of operating loads to prevent resonance.**

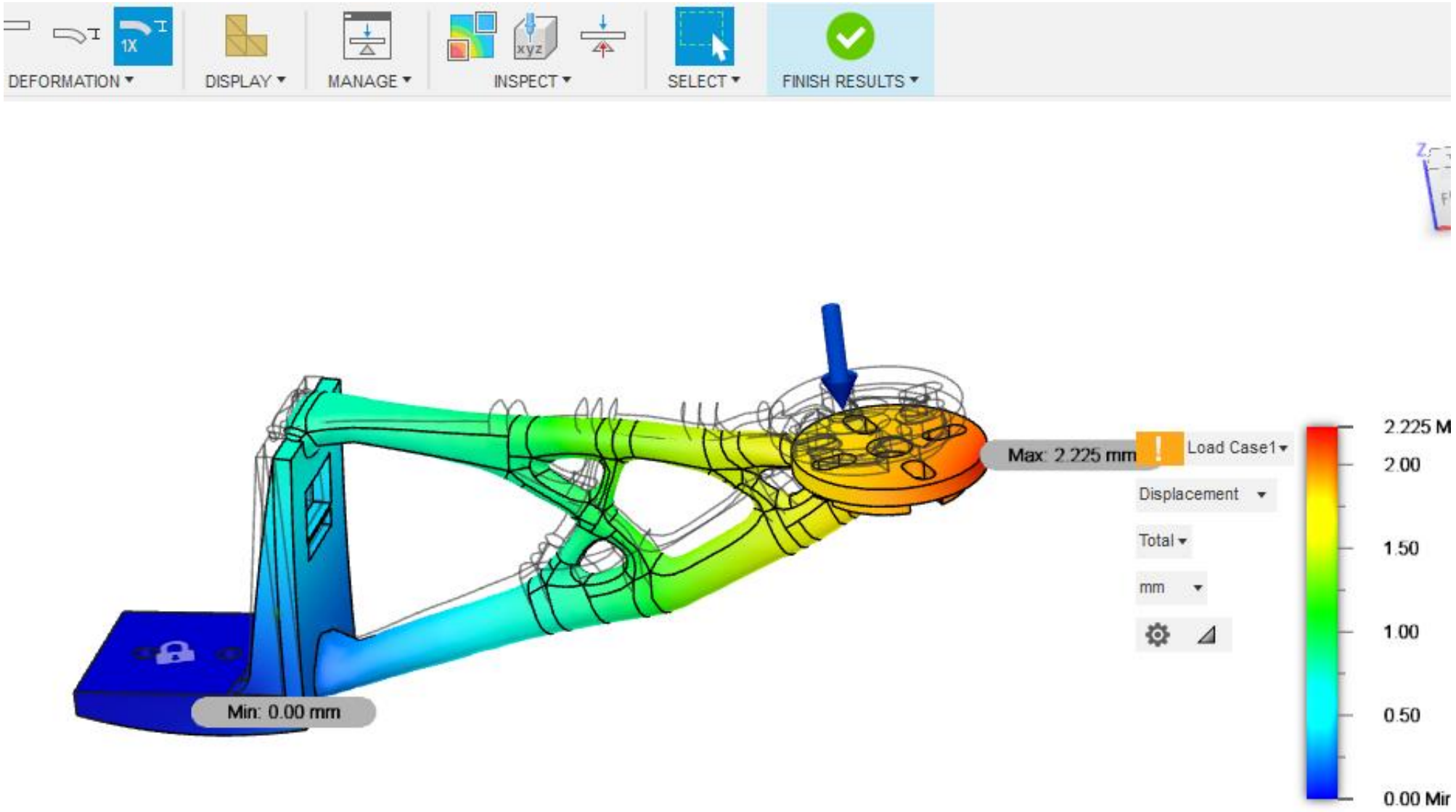
Fusion Simulation



Fusion Simulation



Fusion Simulation



Thank you