SAND2021-15306 TR

Mass Properties Tutorial

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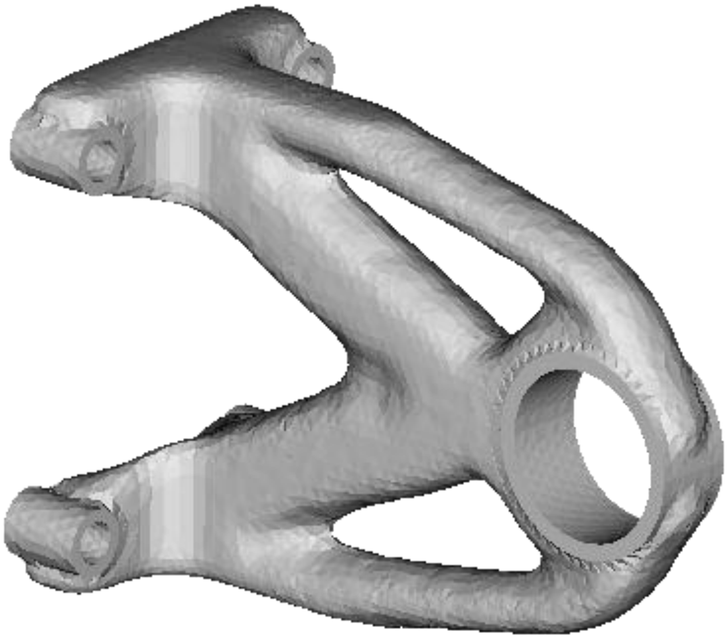
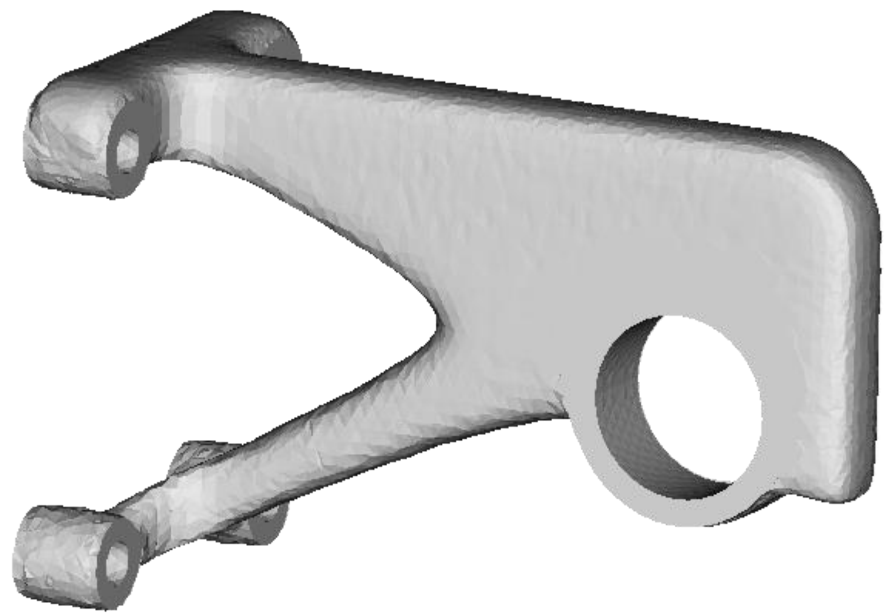
Problem Description

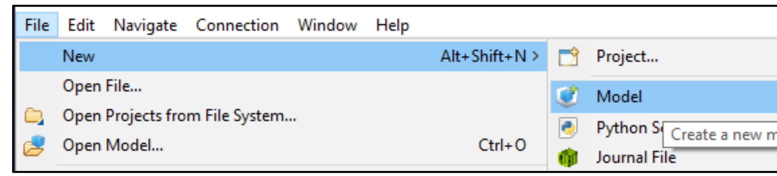
In this tutorial we will demonstrate the feature for constraining Plato designs to have user-specified mass properties. We will design a bracket for stiffness, constrain the center of gravity to be a user-specified value and see how it affects the maximum displacement of the design.

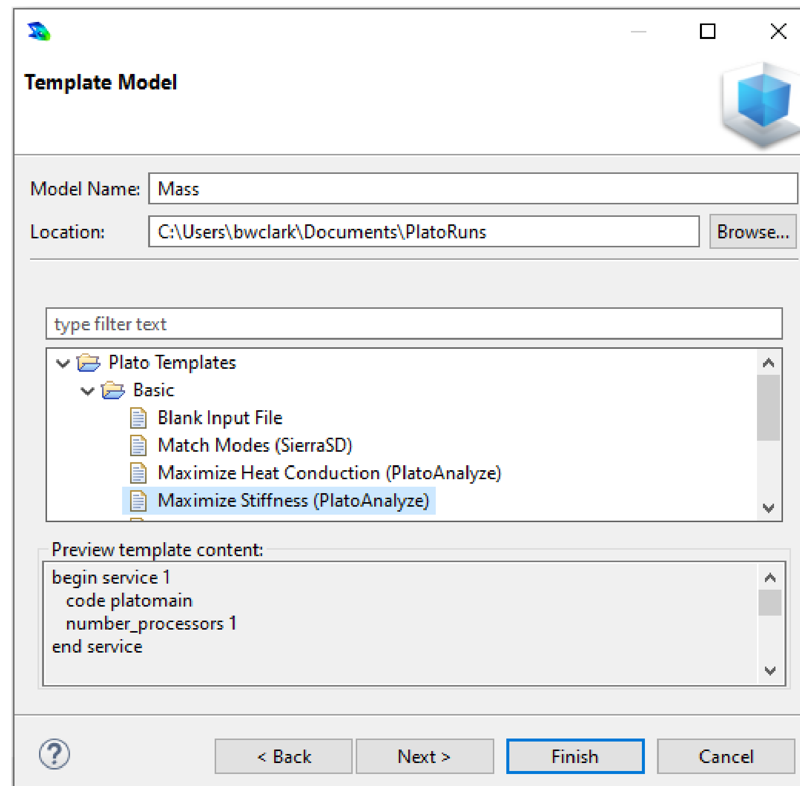




Create a New Model

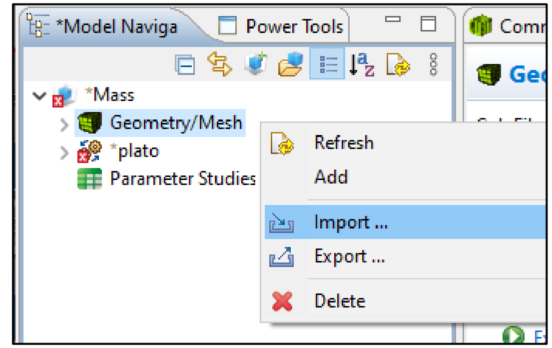
- Choose **File->New->Model** in the menu
- Choose **New Model** then **Next**
- Choose **Create From Template** then **Next**
- Enter **Mass** as the **Model Name**
- Choose the **Plato Templates->Basic->Maximize Stiffness (PlatoAnalyze)** template and then **Finish**

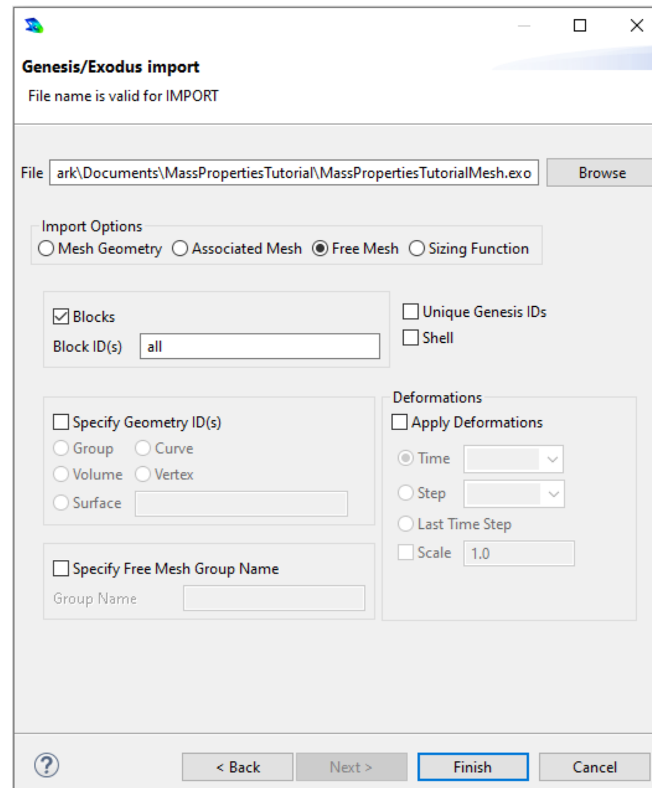


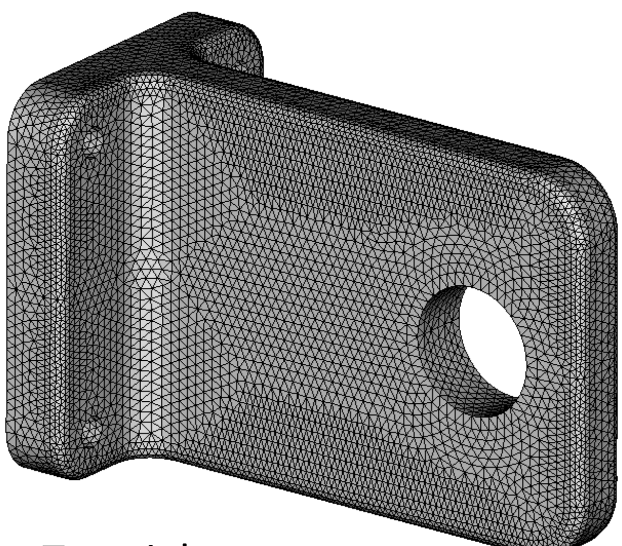


Import the Design Domain Mesh

- Right-click on “**Geometry/Mesh**” in the tree and choose “**Import…**”.
- Choose “**GENESIS**” as the file type and choose “**Next**”.
- Browse for the file called “**MassPropertiesTutorialMesh.exo**”, choose the “**Free Mesh**” option, and then choose “**Finish**”.

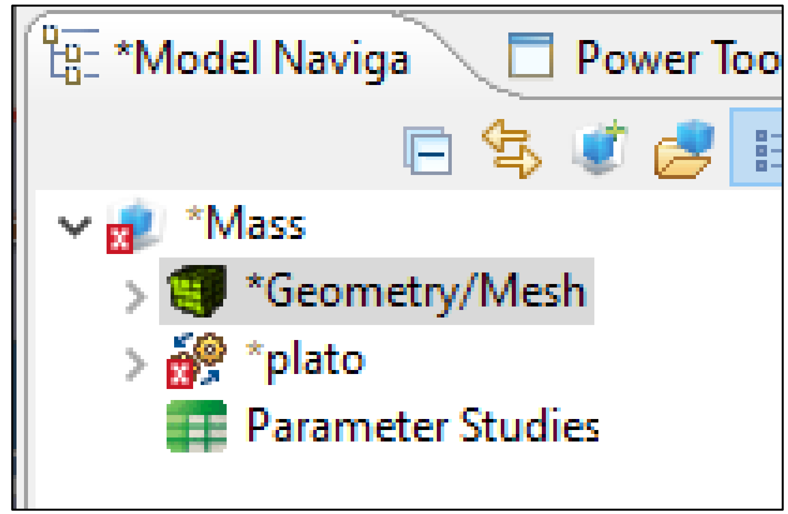


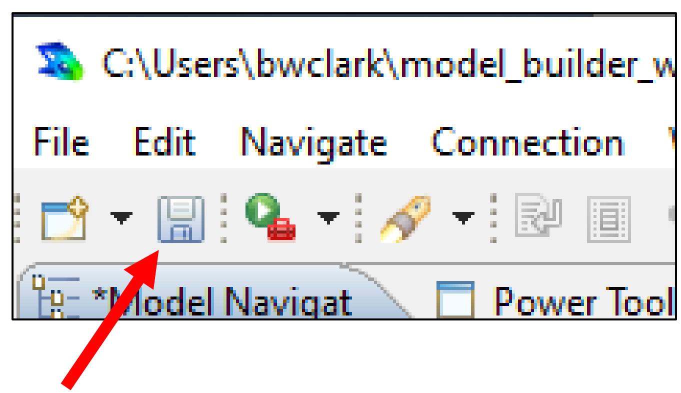




Save the Geometry/Mesh

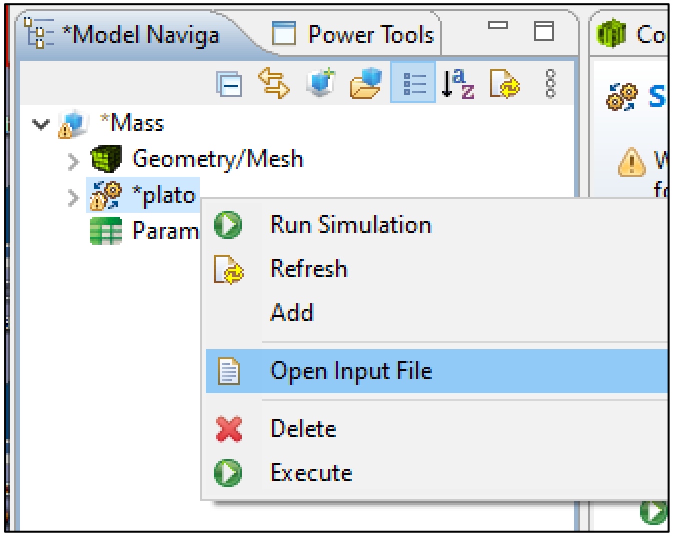
- Click on the "Geometry/Mesh" node in the tree and then click the Save icon in the toolbar.

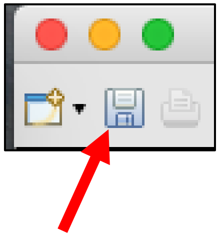




Load the Pre-defined Input Deck

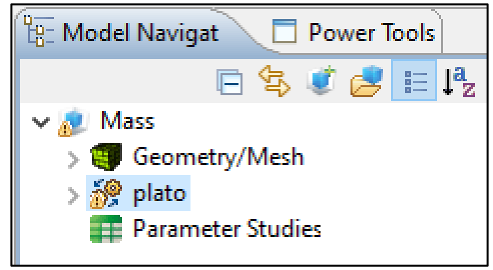
- Right-click on the "**plato**" node in the tree and choose "**Open Input File**". This will open a text editor showing the current input file for this model. We will be replacing all of the text in the default input deck with that in the file called "**MassPropertiesTutorialInputDeck.i**".
- Open "**MassPropertiesTutorialInputDeck.i**" in a text editor of your choice and copy and paste its contents into the input deck editor in Plato replacing the text that was there.
- Then click on the "**Save**" icon in the toolbar to save the model.

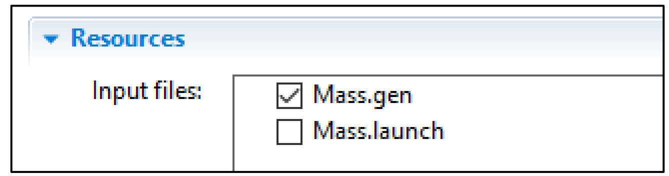


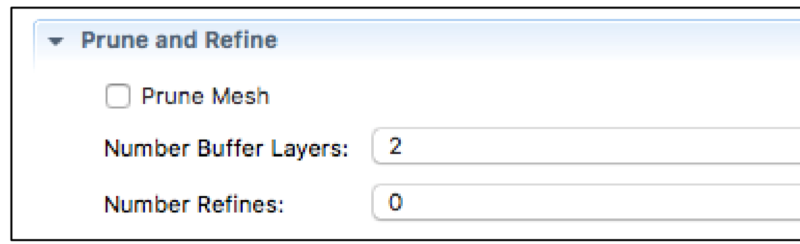


Run the Optimization

- Click on the **plato** node in the tree to bring up the job submission panel in the **Settings** view
- Choose **Plato** as the code and then choose the machine and execution template you want to use





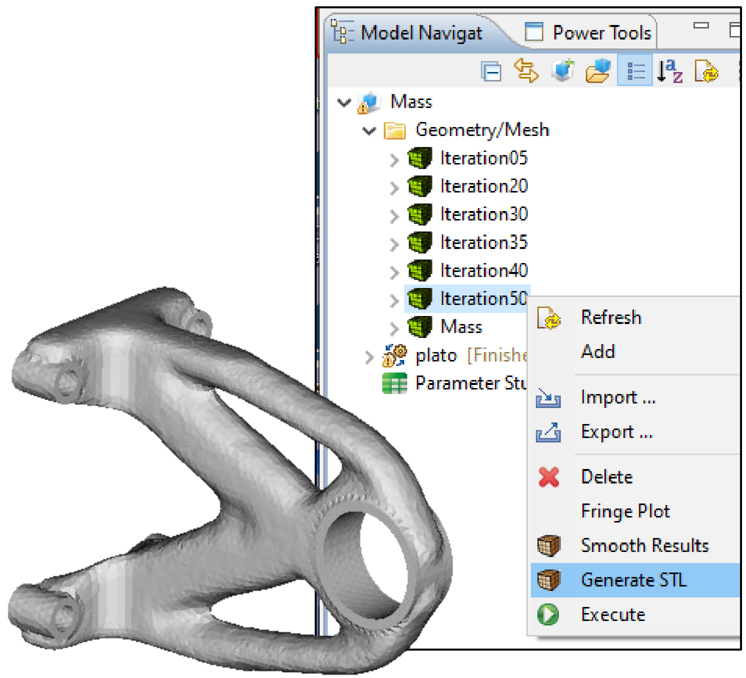


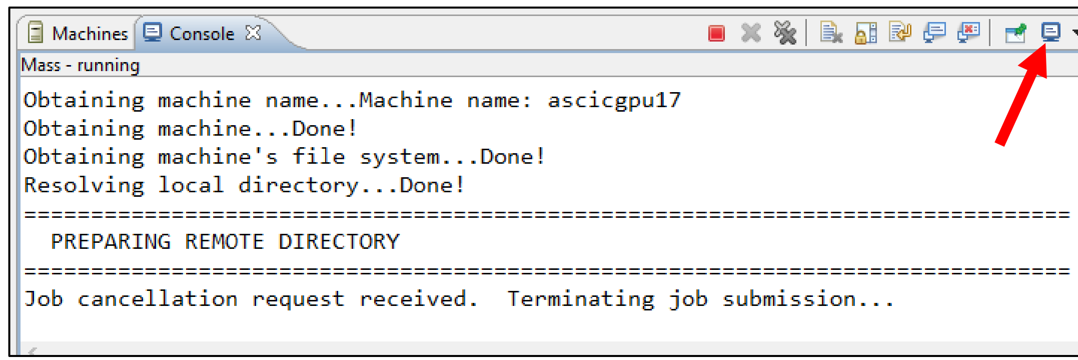
- In the **Resources** area make sure **Mass.gen** is checked so that this file gets pushed to the working directory.
- In the **Prune and Refine** area make sure **Prune Mesh** is unchecked and **Number Refines** is **0**. For this first run we won't be doing any pruning or refining.
- Choose any other preferences and launch the job by clicking on **Submit Simulation Job** toward the top of the panel

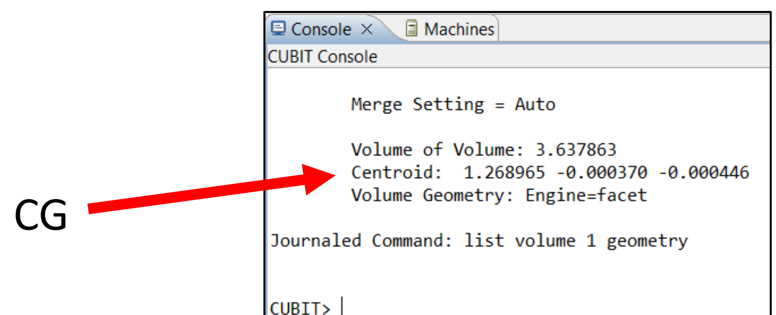
Initial Result

After 50 iterations you should have a result that looks like the one below. This initial run did not have the center of gravity (CG) constrained to be a specific value. To measure the CG we will first create an STL version of the result and then list its mass properties.

- Expand the “Geometry/Mesh” node in the tree to show all of the results from this initial run.
- Right click on the last one and choose “Generate STL”.
- In the CUBIT console type “list volume 1 geometry”. Toward the end of the output you will see some mass properties. Note: to get to the CUBIT console click on the icon in the Console toolbar (below) until it cycles back to the CUBIT console. This initial result has a center of gravity of about 1.27, 0.0, 0.0.

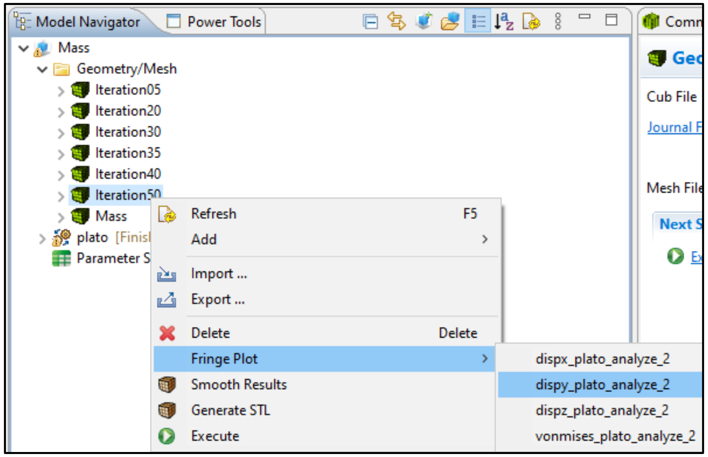


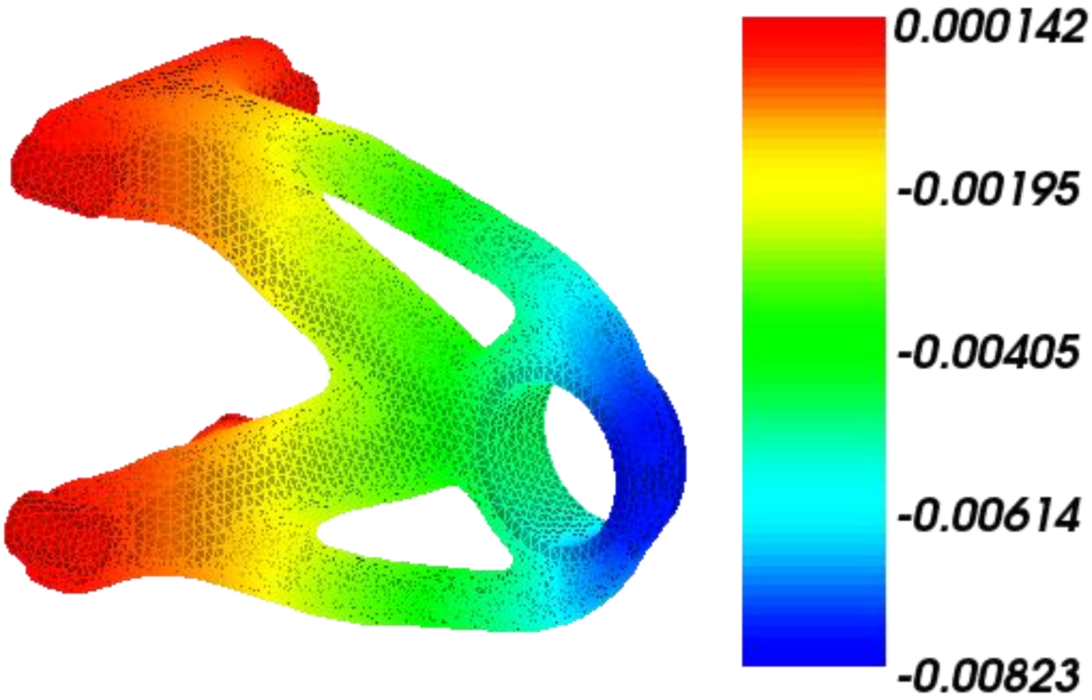




Max Displacement in Y

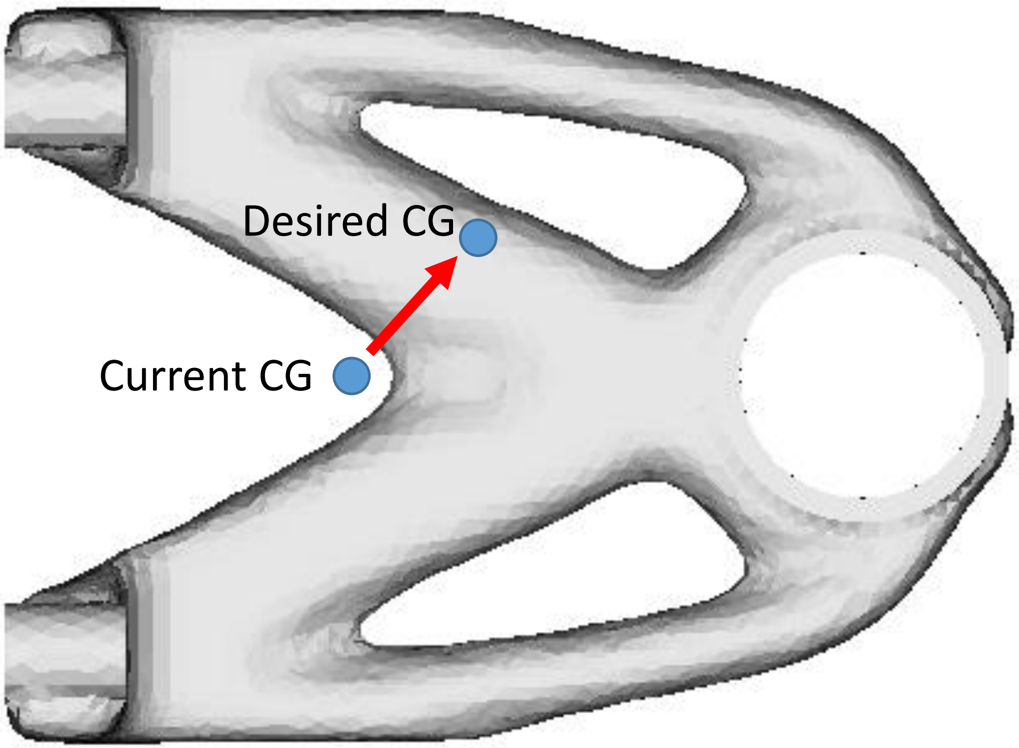
- View the max y displacement by right clicking on the last result in the "**Geometry/Mesh**" folder and choosing "**Fringe Plot->dispy_plato_analyze_2**". For this design the max displacement in y is -0.00823.





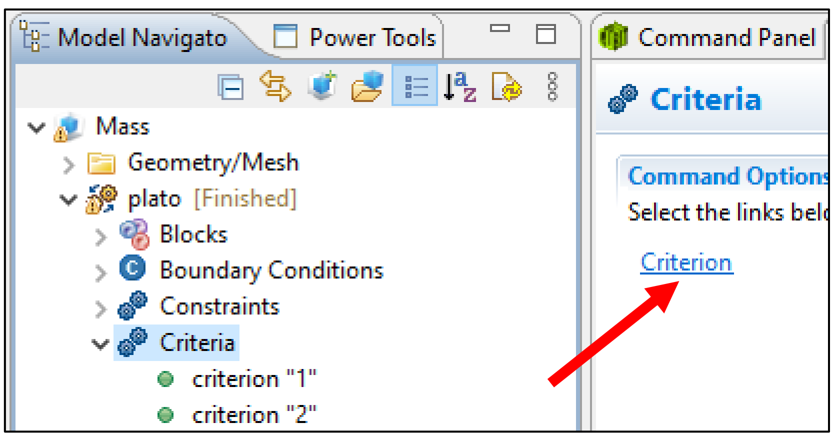
Re-run with a CG Constraint

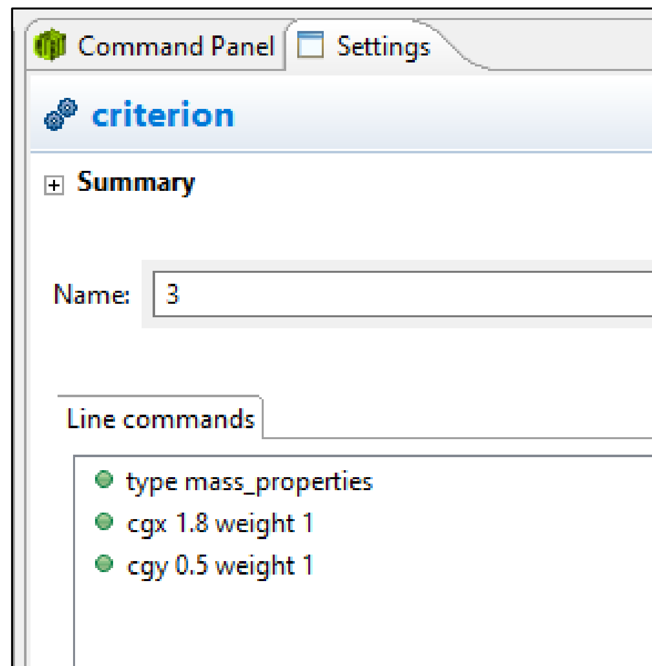
Now we will pretend there is a requirement to have the CG located at 1.8, 0.5, 0.0 and will rerun Plato with this constraint. We will actually enforce the desired CG by adding an additional sub-objective to the problem. You can also add it as an actual constraint but this problem converges more quickly with it enforced as part of the objective.



Create CG Criterion

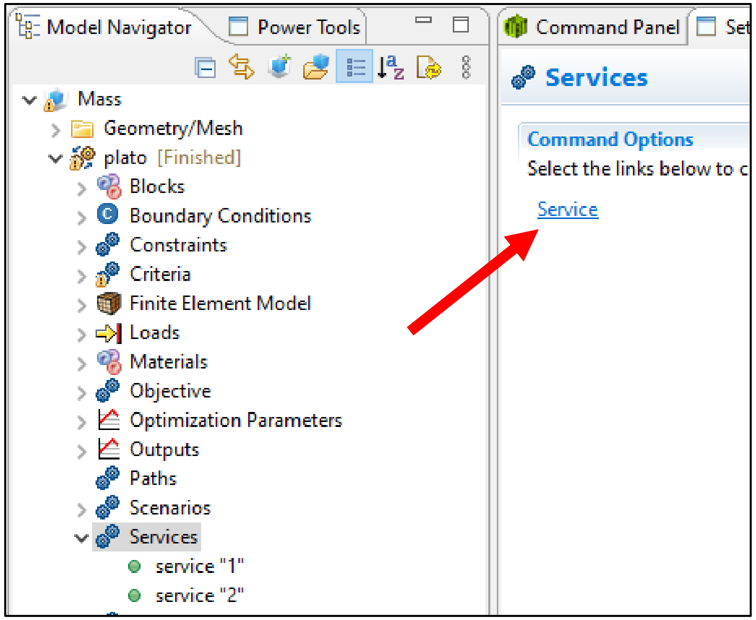
- Click on the “**Criteria**” node in the tree and then in the Settings panel choose “**Criterion**” to create a new criterion.
- Set the “**id**” to “**3**”, “**type**” to “**mass_properties**”, and add criterion parameters as shown below to set the CG x and y to “**1.8**” and “**0.5**” respectively.
- Note: To add a parameter right-click anywhere in the “**Line commands**” pane and choose “**Add…**”.

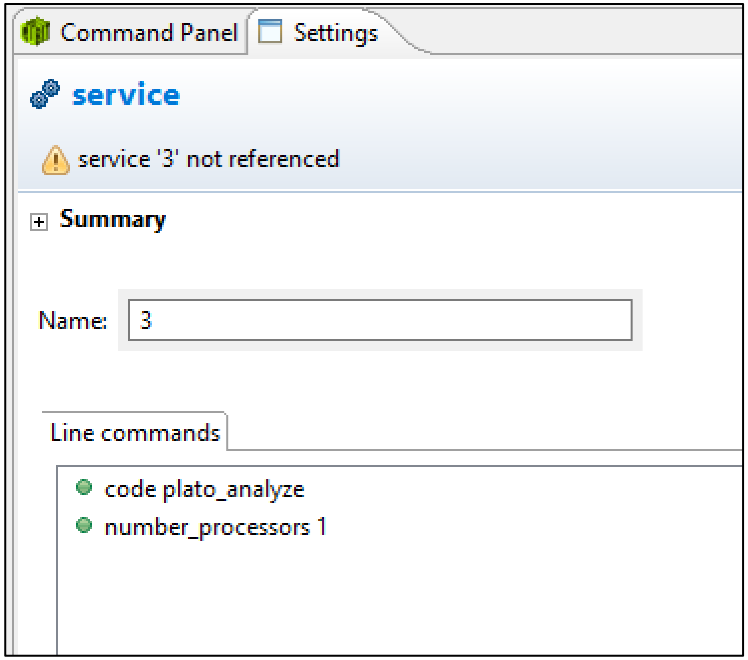




Add a New Service

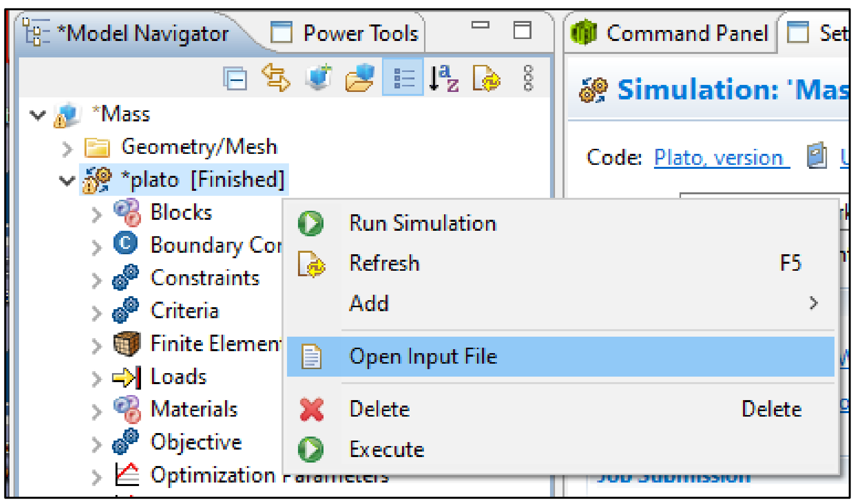
- Click on the "**Services**" node in the tree and then in the Settings panel choose "**Service**" to create a new service.
- Set the "id" to "3" and add service parameters as shown below.





Update the Objective

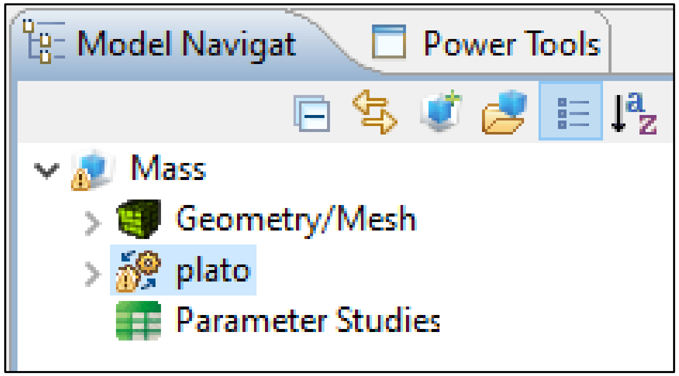
- Right-click on the “**plato**” node in the tree and choose “**Open Input File**” to open the input deck in a text editor.
- Find the “**objective**” definition and update it to look like that below. This will tell Plato to evaluate the objective by evaluating criterion 1 (mechanical_compliance) and then criterion 3 (mass_properties) and then do a weighted sum using a weight of 1 for mechanical_compliance and 10,000 for mass_properties. We have to weight the mass_properties sub-objective heavily to make sure the CG constraint is enforced.




```
begin objective
  type weighted_sum
  criteria 1 3
  services 2 3
  scenarios 1 1
  weights 1 10000
end objective
```

Re-run the Optimization

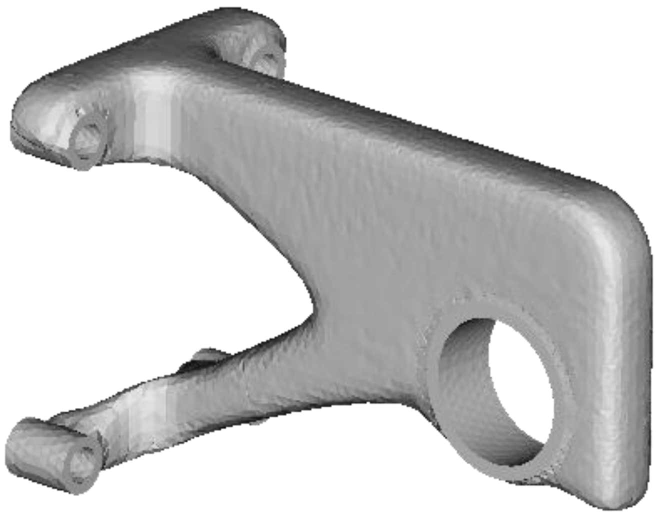
- Click on the **plato** node in the tree to bring up the job submission panel in the **Settings** view
- Launch the job by clicking on **Submit Simulation Job** toward the top of the panel

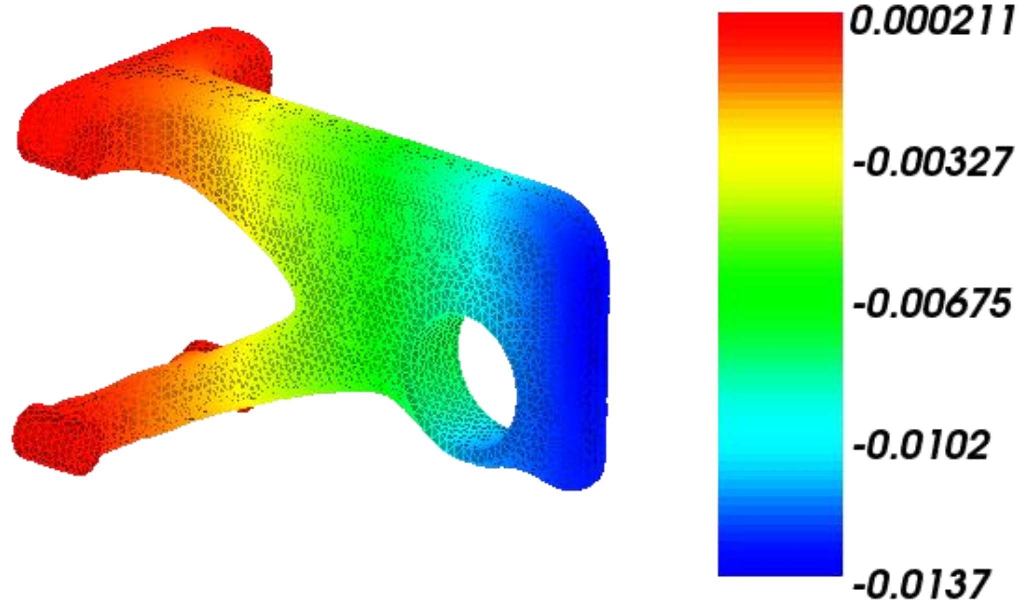


CG-constrained Results

After 50 iterations you should have a result that looks like the one below. The CG was not exactly enforced. This is due to mesh discretization error as well as density values not being completely 0 or 1. However, it is pretty good. Mesh refinement and running the optimization longer can improve the enforcement of the CG.

Also note that because we forced a constraint on the design we did not reach the same performance level as far as how stiff the design is. In the new design the max y displacement is larger than the previous design.





Desired CG: 1.8, 0.5, 0
Achieved CG: 1.84, 0.53, 0

Previous Max Y Disp: -0.00823
Current Max Y Disp: -0.0137