Geometry Creation

Capstone v9 Tutorial

Overview

1. Introduction
2. Geometry Set-up
   - Airfoil Creation
   - Geometry Set-up
3. Surface Meshing
4. Volume Meshing
   - Volume Mesh Generation
   - Mesh Inspection
   - Mesh Export

Overview

Introduction

Capstone is an HPCMP CREATE™-MG product. This tutorial was generated by the HPCMP CREATE™-AV Quality Assurance team, with specific intentions of being applied to AV-related cases, however, it could be applicable in other areas as well.

Why this Tutorial?

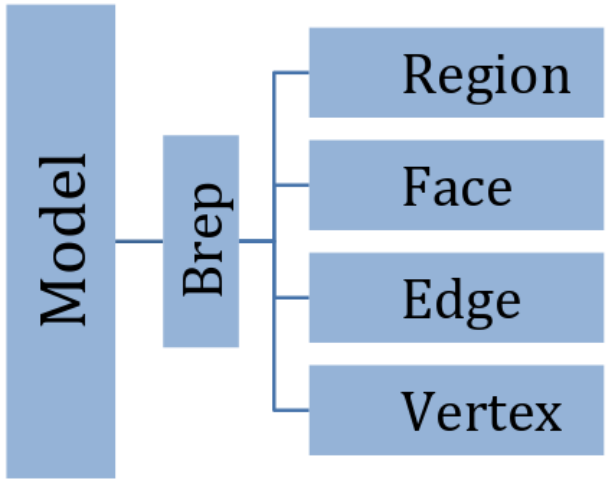
- Objectives:
  - Gain familiarity with importing text files
  - Explore basic geometry generation techniques
- Potential Applications:
  - Simple geometry creations
  - 3D Wing, Symmetry Planes

Notes Going Forward:

- **Bold Font** indicates a menu or shortcut button option
- > indicates a sub selection
- Blue text indicates options/selections inside of an operation or function
- This tutorial assumes you know some basic Capstone operations. If you need an introduction please watch the Capstone Intro Video (~15 min) **found here**

Topology Definitions

Capstone uses the following Topology model to describe geometry:



Model

- Total grouping of all Breps and meshes

Brep (Boundary Representation)

- A grouping of geometry entities

Region

- A water-tight volume defined by connecting faces where the volume mesh will be generated

Face

- Surface defined by a closed set of edges

Edge

- Curve bounded by 2 (or 1 if self looping) vertices

Vertex

- Point defined by x,y,z location

Workflow

1. Geometry Setup
   - Import or create geometry
     - Can be CAD or Discrete
   - If CAD, then "clean" to make water-tight
     - utilize the **Edit** > **Basic Cleanup** menu
   - Fluid Volume Region Creation
     - Regions are where the volume mesh will be created
     - Define the fluid volume to be solved on
2. Mesh Set-up
   - Set **Analysis**
   - Work your way down the **Attributes Tab**
     - For example, set up Global Sizing, Topos Sizing, Boundary Layers, Periodicity and any other mesh settings as desired
   - Set up both Surface and Volume mesh settings before meshing for highest mesh quality/consistency

Workflow Continued

3. Generate Meshes
   - Generate a Surface Mesh
     - Inspect the mesh (visually and/or using **Mesh** > **Mesh diagnostics** or **Detect defects and heal**) and make any necessary changes
   - Generate a Volume Mesh
     - Inspect the mesh again
       - Utilize **Mesh** > **Mesh crinkled cutplanes** to visualize the volume cells
4. Export Mesh
   - Create mesh Properties (like Patches) if desired
   - **File** > **Export Mesh**

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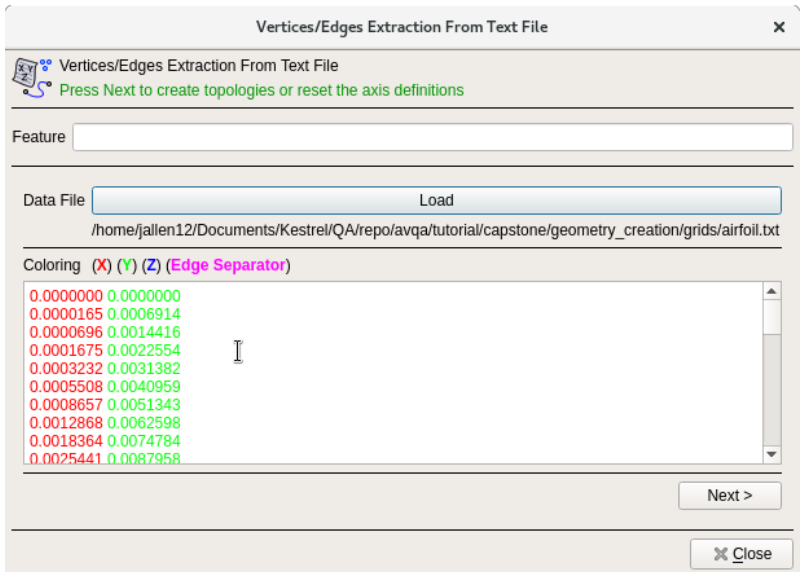
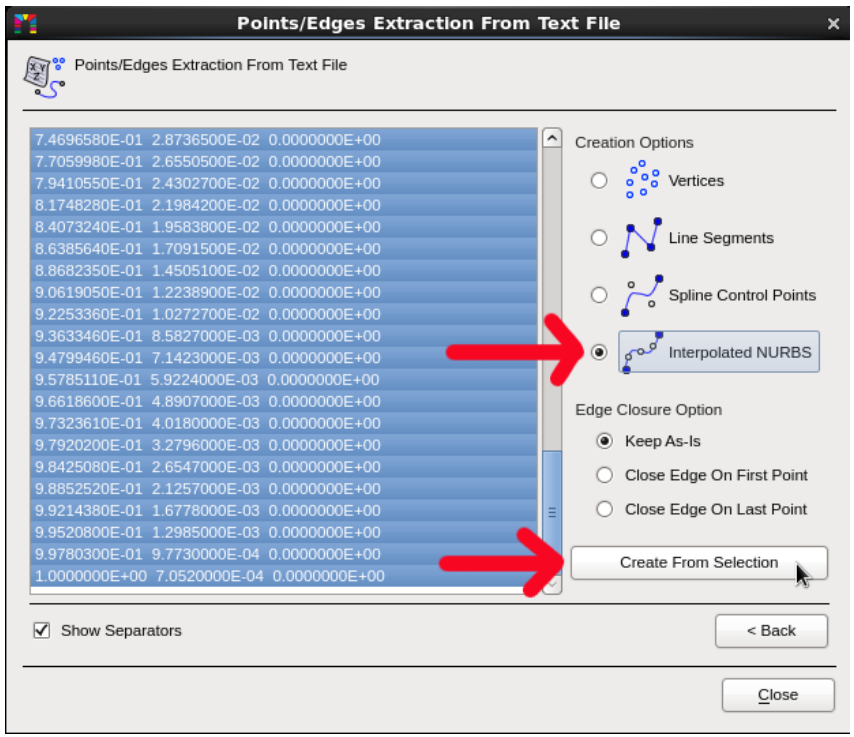
Importing Airfoil Coordinates

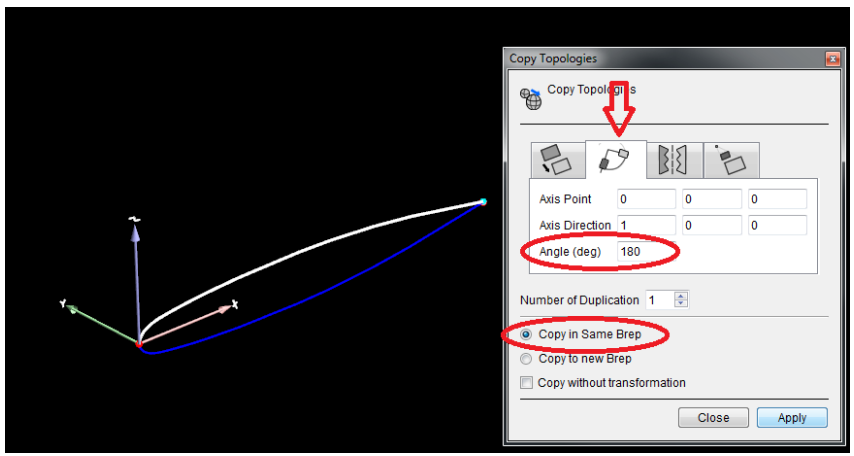
- Open Capstone and ensure you are in SMLIB mode: **Config/Help** > **Switch Geometry Kernel to SMLIB**
- **Vertices** > **Vertices/Edges Extraction From Text File** and hit Load
- Locate airfoil.txt then click Open
- Click on the left column, then right-click and select Set Column as X Coordinate
- Click on the right column, then right-click and select Set Column as Y Coordinate
- Hit Next



Airfoil creation

- Select all the coordinates by pressing and holding LMB and dragging to the bottom
- Select Interpolated NURBS and hit Create From Selection then exit the menu
- Now **Edit** > **Copy Topologies** select Rotation and Copy in Same Brep and enter 180 deg.
- Select the airfoil edge and hit Apply, then exit the menu

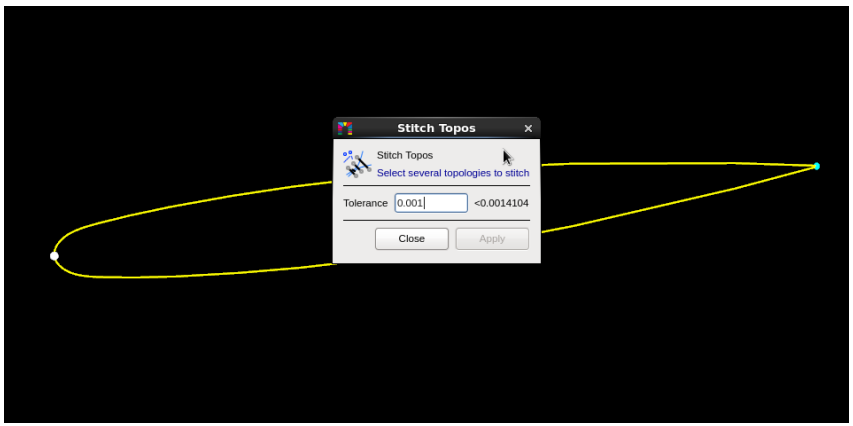


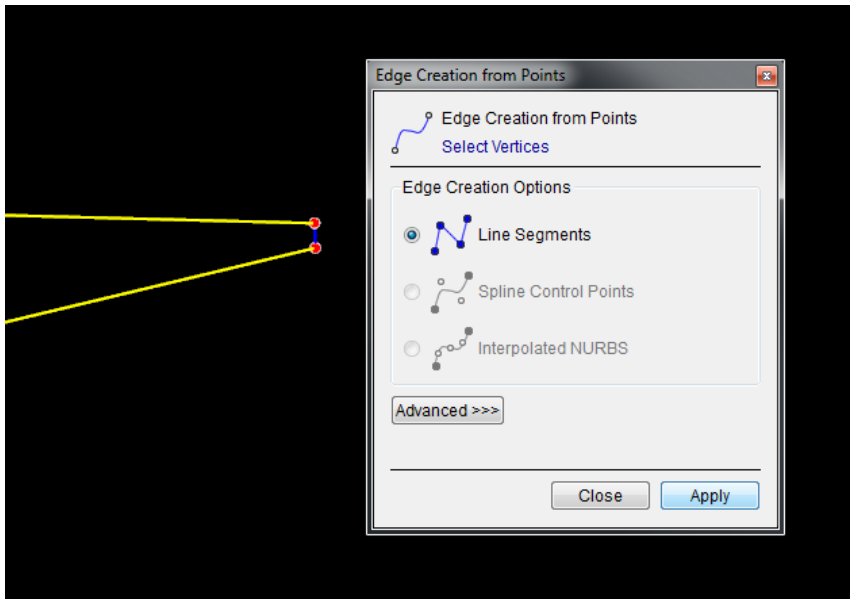


Airfoil Completion

At this point you can inspect the airfoil and notice that there are 2 vertices overlapped at the leading edge (LE) and that the trailing edge (TE) is blunt and currently not connected. Let's take care of these:

- **Edit** > **Stitch Topos**
- Select both of the LE vertices, and hit Apply
- **Edges** > **Edge Creation from Points**, select the 2 TE vertices and hit Apply



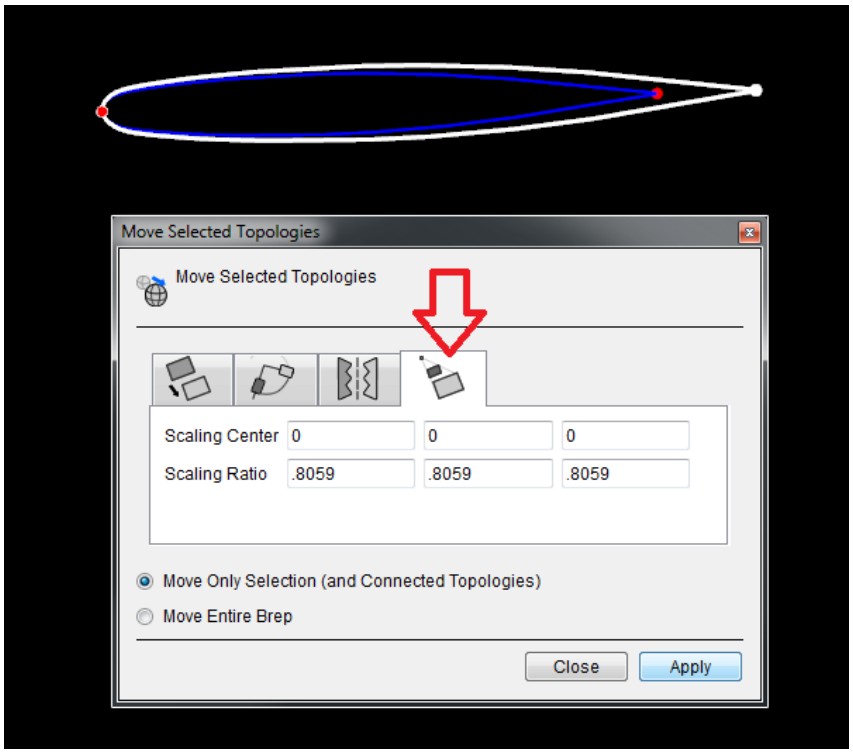


- Now is a good time to save your model. Use **File** > **Save-As Create-Native Dataset** which will save the file as NAME.cre

Scaling

The ONERA M6 wing has specific geometry, described by NASA **here**, therefore, we must now scale our airfoil and create the rest of the geometry necessary to complete the wing.

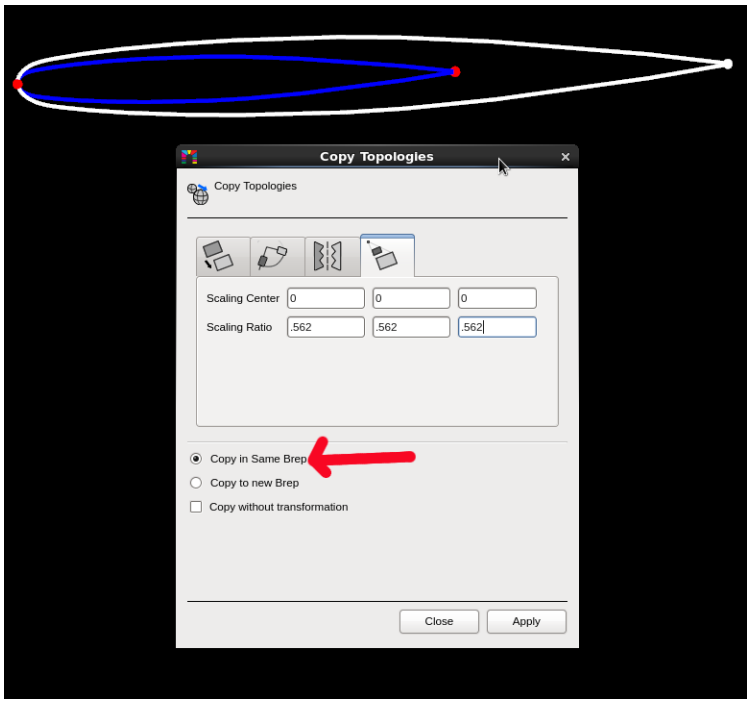
- **Edit** > **Move Selected Topologies**, select Scaling and the entire airfoil, then enter .8059 for all 3 Scaling Ratios and hit Apply

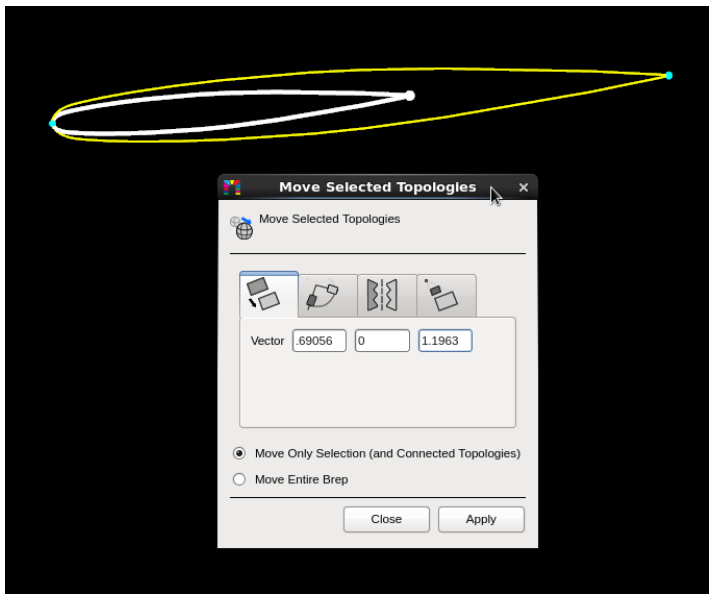


Tip Airfoil Creation

Create the tip airfoil by copying the root airfoil and scaling/moving it to be the correct size/location.

- **Edit** > **Copy Topologies**, Scaling and enter .562 for all 3 Scaling Ratios
- Select the airfoil and Copy in Same Brep, then hit Apply
- **Edit** > **Move Selected Topologies**, Translation, and enter .690656, 0, 1.1963
- Select the tip (small) airfoil and Move Only Selection, then hit Apply

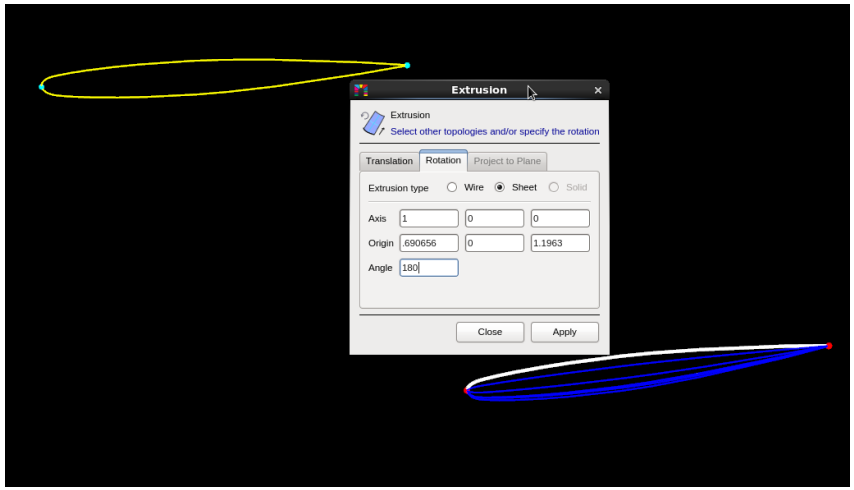




Wing Tip Creation

Now we need to cap-off the end of the wing tip with a rounded face.

- **Advanced** > **Extrusion** and select Rotation
- Set Axis to 1,0,0
- Set Origin to .690656, 0, 1.1963
- Set Angle to 180
- Select the top edge of the tip airfoil and hit Apply

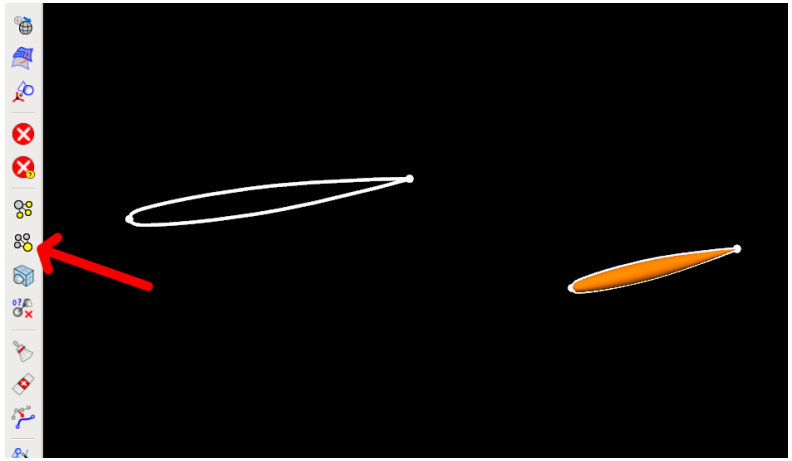


- The extrusion has created duplicate edges on the tip airfoil.
- To delete the unused tip edges, navigate to the Explorer Tab and uncheck Show Only Selection. Right-click Brep 2 and select Hide. (Edges and vertices associated with Brep 2 are now greyed out in the Explorer Tab.)
- Holding the Shift key, drag a box around the entire tip airfoil to select all of its topologies and hit **Edit** > **Delete all selected topologies**
- Lastly, hit the **Show All** button to bring the hidden geometry back

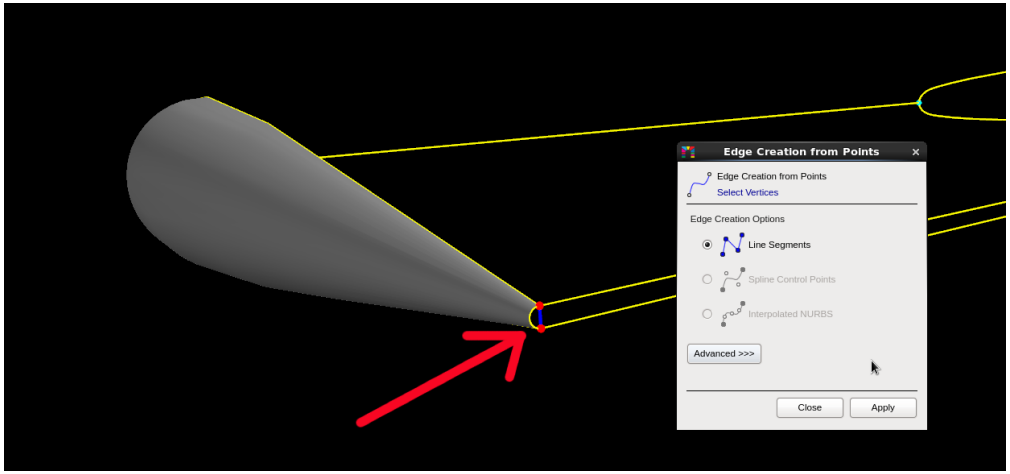
Merge Breps and Connecting Edges

The new wing tip we just created was placed into a separate Brep. We need to merge the two before we can complete the wing shape by adding the leading and trailing edges.

- Use Shift and drag the LMB to select all of the topologies
- **Breps** > **Merge the selected breps into a single brep** or hit the button shown on the right



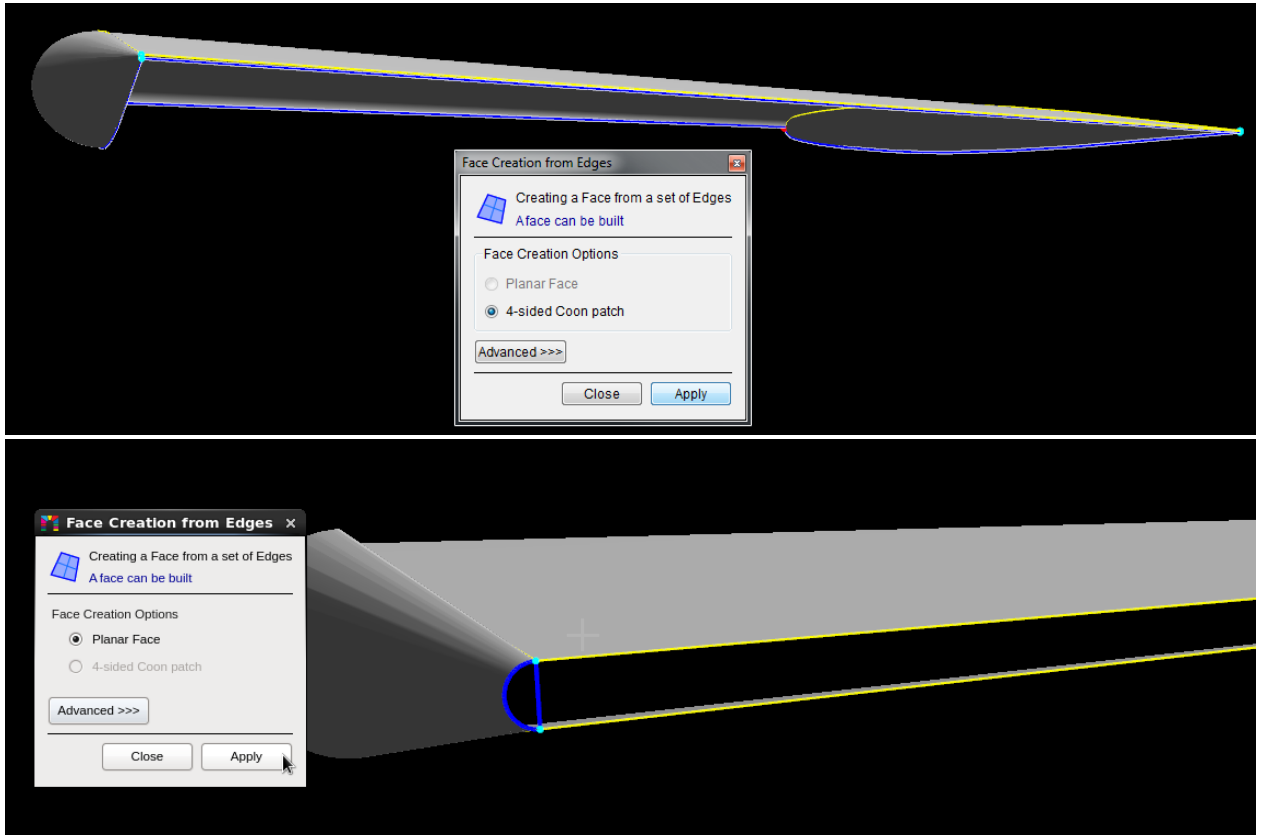
- **Edges** > **Edge Creation from Points**
- Select the 2 vertices forming the LE and hit Apply
- Repeat for the 2 TE lines
- Lastly, connect the upper and lower vertices on the wing tip with a vertical line



Wing Surface Creation

Now we can complete our wing by creating the final faces.

- **Faces** > **Face Creation from Edges** and select the 4 edges that make up the upper surface of the wing. Then hit Apply
- Repeat for the lower surface of the wing, TE, and TE-tip faces

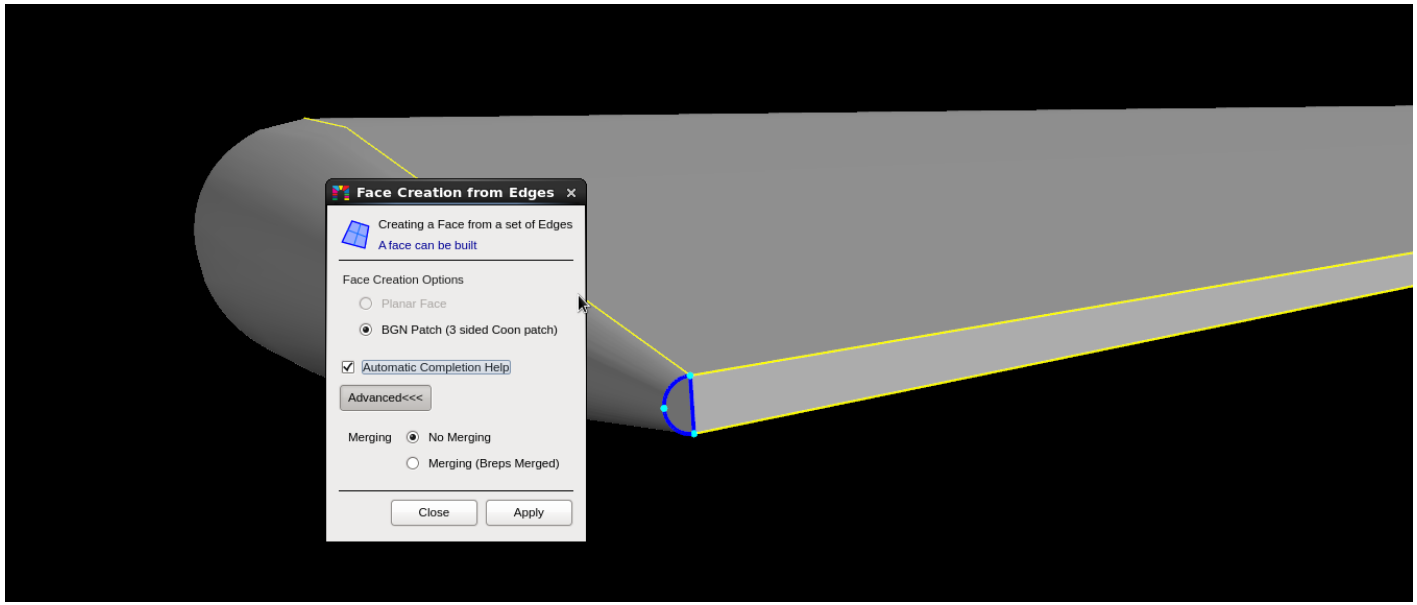


If the TE-tip face (shown above) fails or doesn't give you the option to hit apply, then check the next slide for a workaround

Planar Face Creation - Workaround

Sometimes faces will fail to create (planar or otherwise) if Capstone can't make sense of the underlying edges being used. Normally, a great workaround for this type of issue is to split the geometry edges into smaller chunks. So for a circle, rather than using 1 complete circular edge, we could split it into 4. For this example, since we only need half a circle we will split the edge in half.

- **Edges** > **Split Edge at Edge Parameter** and select the curved edge of the tip face. Split it at .5 and try creating the face using the 3 curves. This should allow the option of a BGN 3-sided Coon patch.



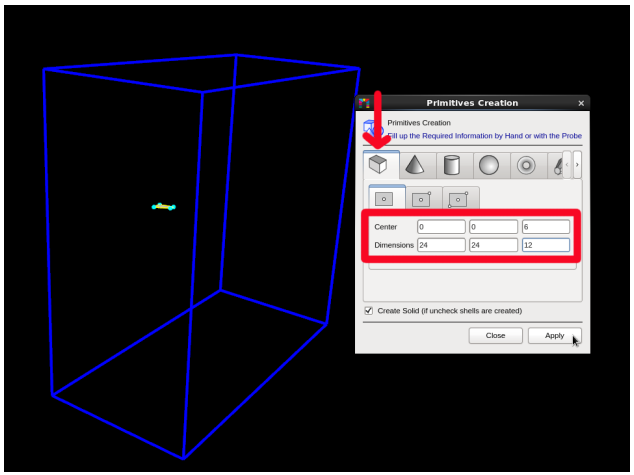
Region Creation

First, finish closing off the wing by creating a face on the root airfoil.

- **Faces** > **Face Creation from Edges** and select 1 airfoil edge at the root (it should auto-complete the rest) and hit Apply

Your wing is now complete! Save your progress. The wing is now water-tight (you can verify this by going to **Edit** > **Basic Cleanup** and looking at the Closure section) and a Region was automatically created on it. Now let's create an outer boundary box for the fluid region.

- **Solids** > **Primitives Creation** and select the Rectangular Prism option
- Set Center to 0, 0, 6
- Set Dimensions to 24, 24, 12
- Ensure Create Solid is selected and hit Apply

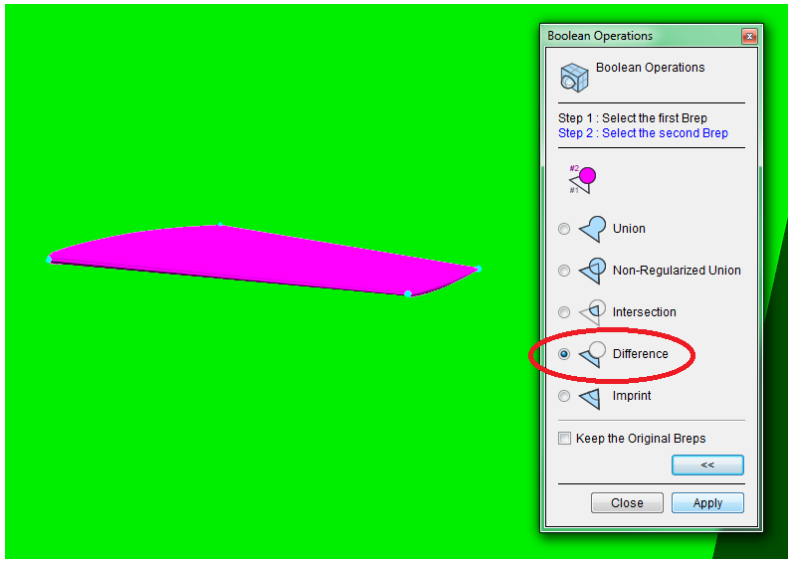


You now have 2 Breps and 2 Regions that need to be Boolean Differenced for the final fluid volume to be created.

Fluid Volume

The regions that have been created are internal to their respective geometry boundaries. Therefore, the region inside of the wing needs to be subtracted from the region inside of the box for the fluid volume region to be correct.

- **Breps** > **Boolean Operations**
- Select Difference
- Select the box then hit >>
- Note, it is important to select the box first, because Difference will subtract the second selection from the first!
- Select the wing and hit Apply



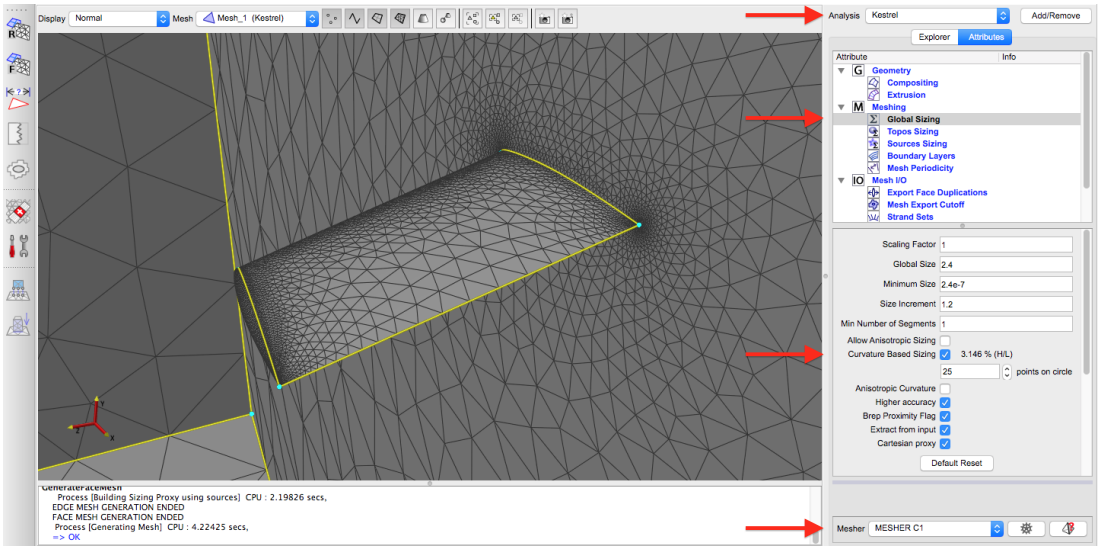
Congratulations, you have completed setting up the geometry! Save your progress.

Overview

Curvature-Based Surface Mesh

For a quick and easy surface mesh use the auto sizing and curvature-based sizing.

- Set the **Analysis** to Kestrel
- **Attributes Tab** > **Meshing** > **Global Sizing**
- Hit OK to accept the auto sizing ratio
- Check Curvature-Based Sizing and hit Apply
- Select MESHER C1 from the Mesher drop down menu at the bottom of the Attributes tab
- Select **Mesh** > **Generate Face Mesh** and the surface mesh will automatically start generating
- After mesh is complete, hit **Show tessellation**



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Volume Meshing

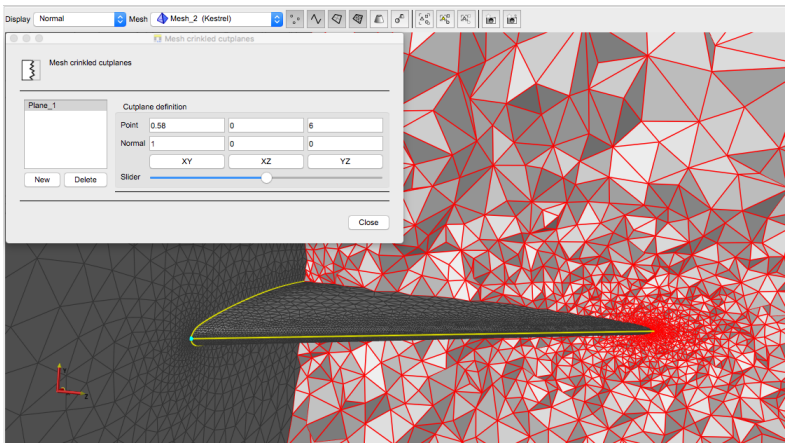
Now we are ready to complete an Euler volume mesh.

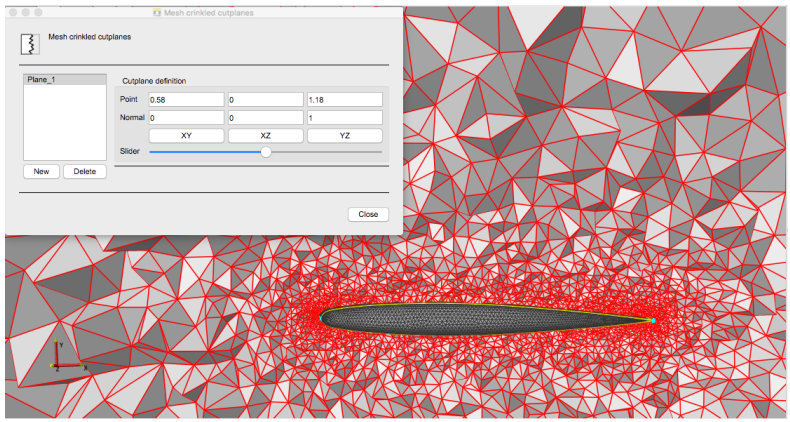
- With MESHER C1 still selected in the Mesher drop down, select **Mesh** > **Generate Region Mesh**
- The volume mesh will automatically start generating

Crinkle Cuts

After the mesh is complete, look at it!

- **Mesh** > **Mesh crinkled cutplanes**
- Set Point to .58, 0, 6 (or move the slider)
- Hit Calculate
- Play around with different views to inspect the mesh

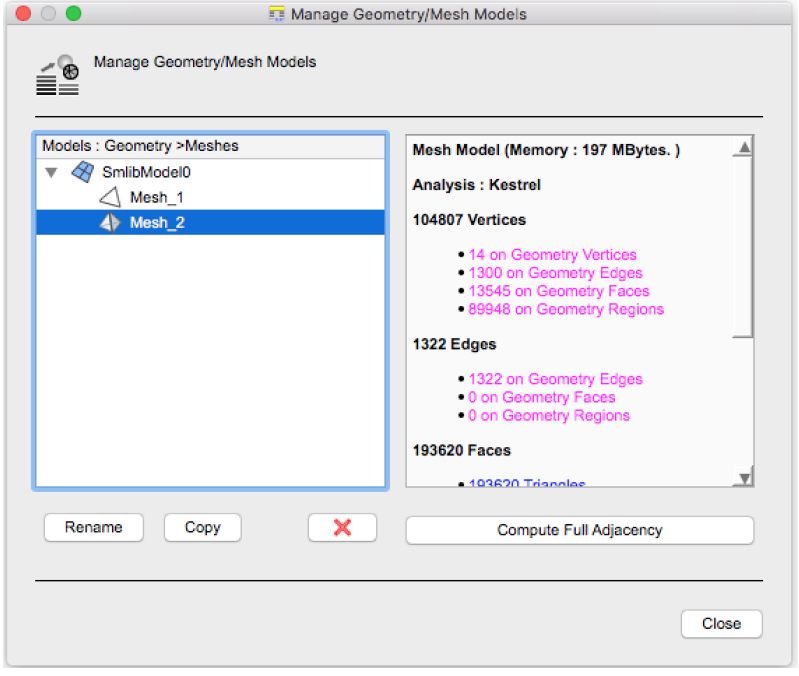




Mesh Manager

To gather data about the mesh use the Mesh Manager.

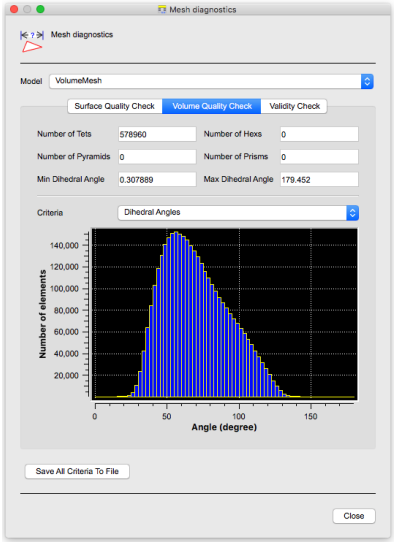
- **File > Manage Geometry/Mesh Models**
- The pyramid next to Mesh_2 indicates a volume mesh
- Highlight Mesh_2 and the right side of the menu displays the information on the number of cells
- Faces on "Geometry Faces" indicate surface cells
- Regions indicate volume cells
- Rename Mesh_2 to VolumeMesh



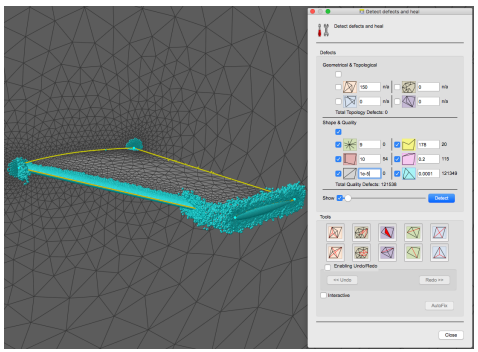
Mesh Diagnostics

Two menus that are helpful tools for diagnostics are:

- **Mesh** > **Mesh diagnostics**
- Select the Volume Quality Check tab and select VolumeMesh as your Model



- **Mesh** > **Detect defects and heal**
- Check the box under Shape & Quality
- Hit Detect
- Notice the cells are colored based on what diagnostic they failed
- If a threshold is too sensitive (like Face Area in this case) simply change the value in the white box

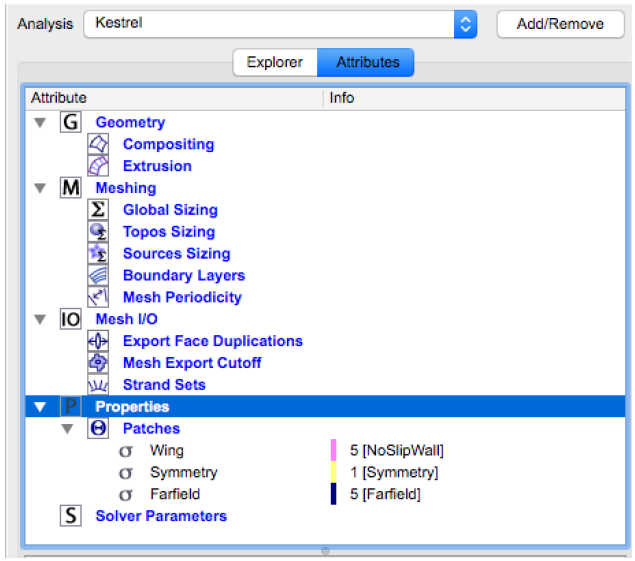


Also, keep in mind that this mesh is very coarse and setup only for the purpose of this tutorial. A much more detailed/finer mesh would be needed for CFD analysis.

Patch Creation

Now, we want to create patches for a Kestrel simulation.

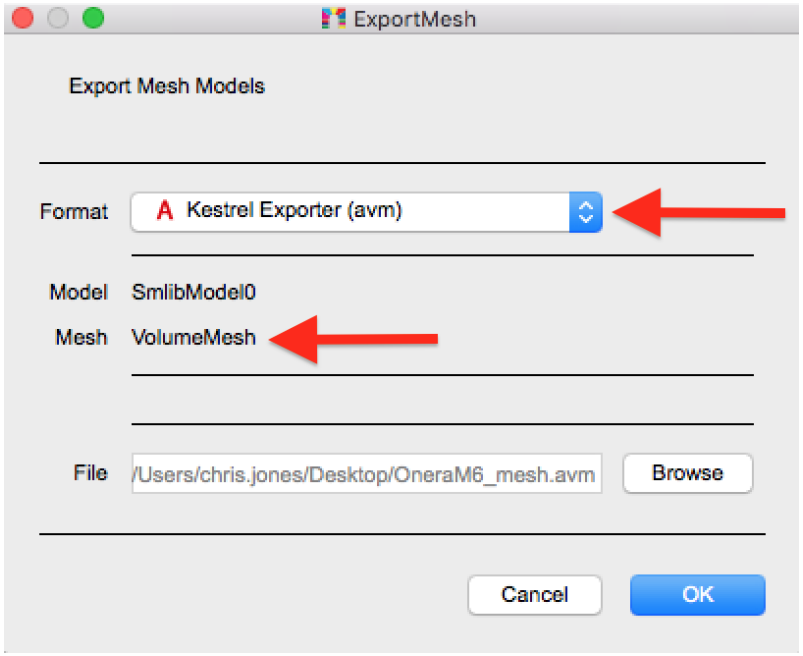
- **Attributes Tab** > **Properties** > **Patches**
- Right-click **Patches** and hit Create a new group
- Specify the patch type from the drop-down bar
- Name the patch "Wing" by typing in the text field labeled "Name"
- Select the 5 wing faces, then right-click the new "Wing" patch and hit Add Topos
- Repeat the process for the Far-field (5 faces) and Symmetry Plane (1 face)
- Note that you can select the faces first before creating a new group and the selected faces will be put into it.



Export Mesh

Now you are ready to export your mesh. Save the cre file one more time before you export the mesh.

- **File** > **Export Mesh**
- Verify the Format is set to Kestrel Exporter (avm)
- Verify the mesh is on "VolumeMesh" (If not, then exit the menu and switch to your volume mesh using the **Mesh Model drop-down** menu.)
- Browse to select a file location and name and hit OK



Conclusion

You have now completed the Capstone portion of creating your grid.

For more help relating to Capstone or other CREATE products please check out:

Capstone Website
Capstone User Online Forum
CREATE Website
CREATE-MG Quality Assurance Support
CREATE-AV Quality Assurance Support