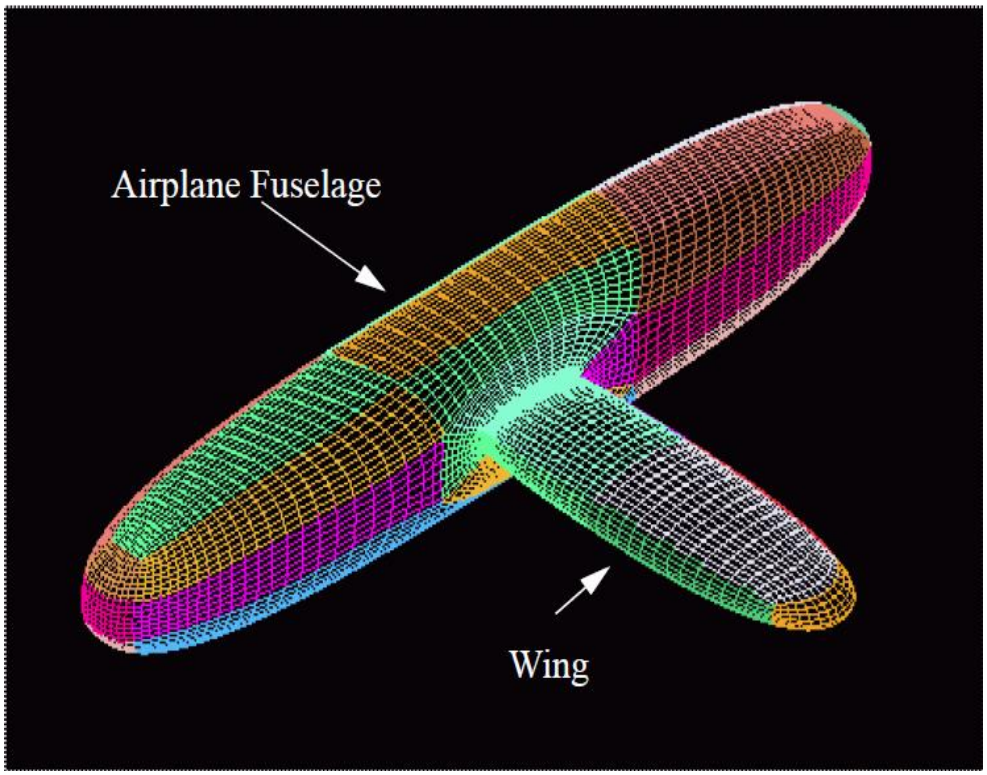
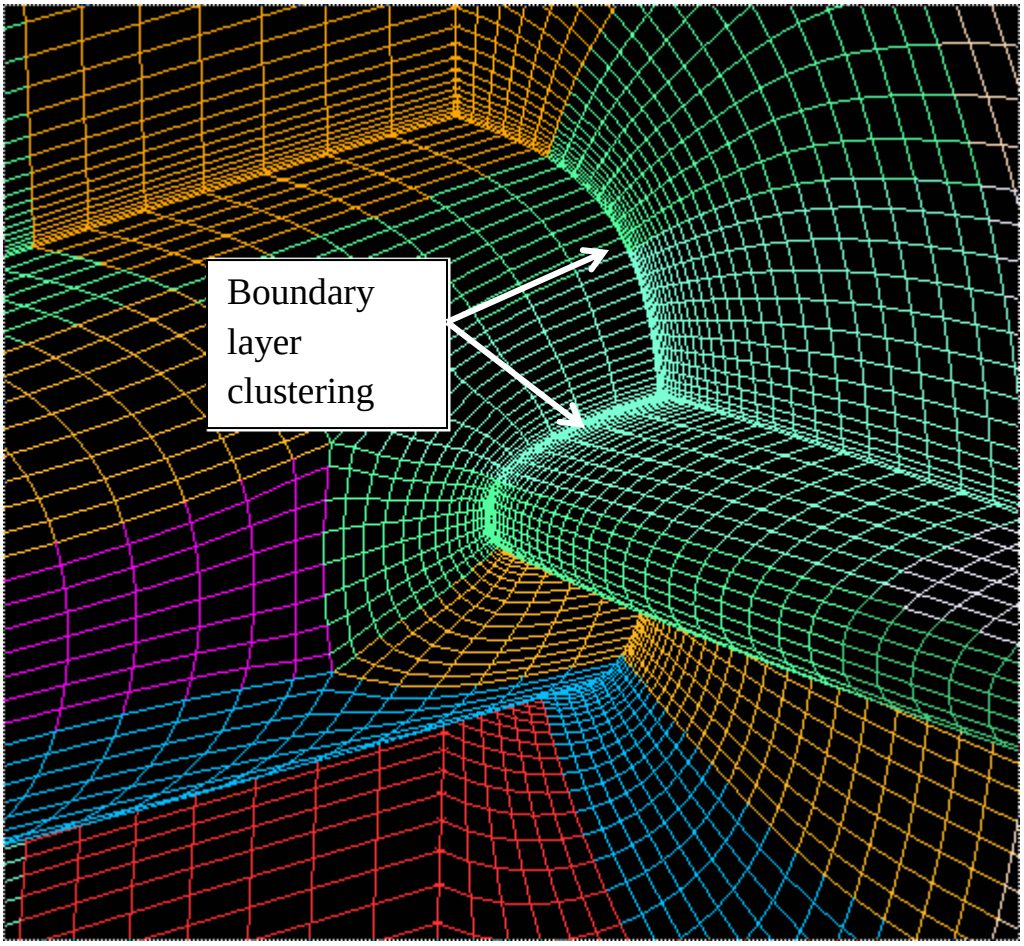
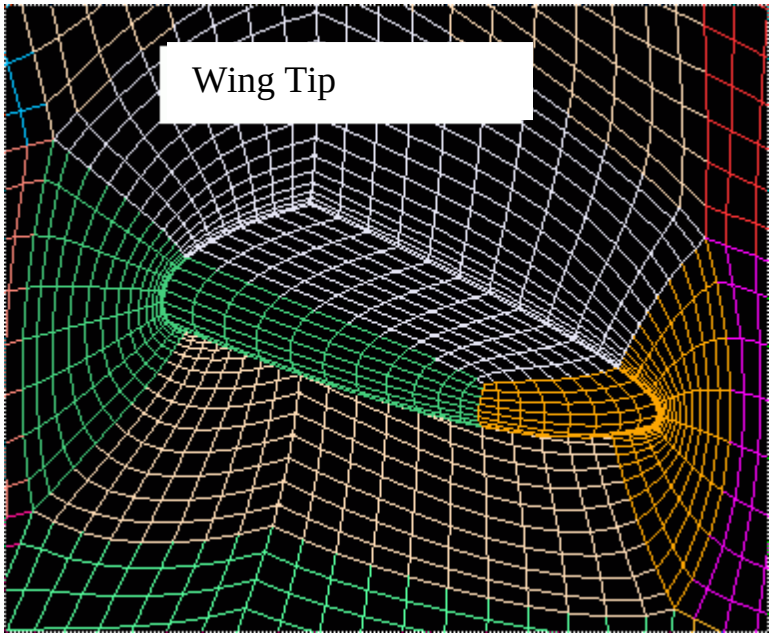
Tutorial 2.2

In this case we will learn how to make a mesh with two intersecting surfaces in 3D. Boundary layer clustering, important for capturing the details of the fluid close to the surface of the geometry, will also be covered.

What You Will Create




Boundary
layer
clustering

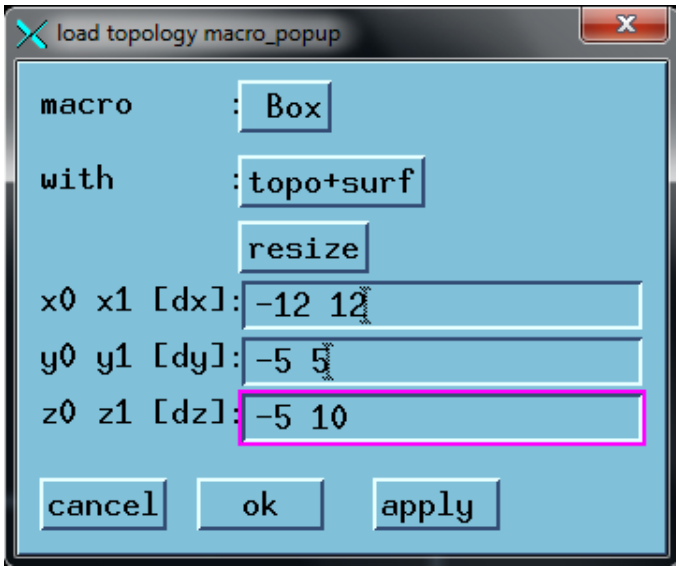

Wing Tip

What You Will Learn

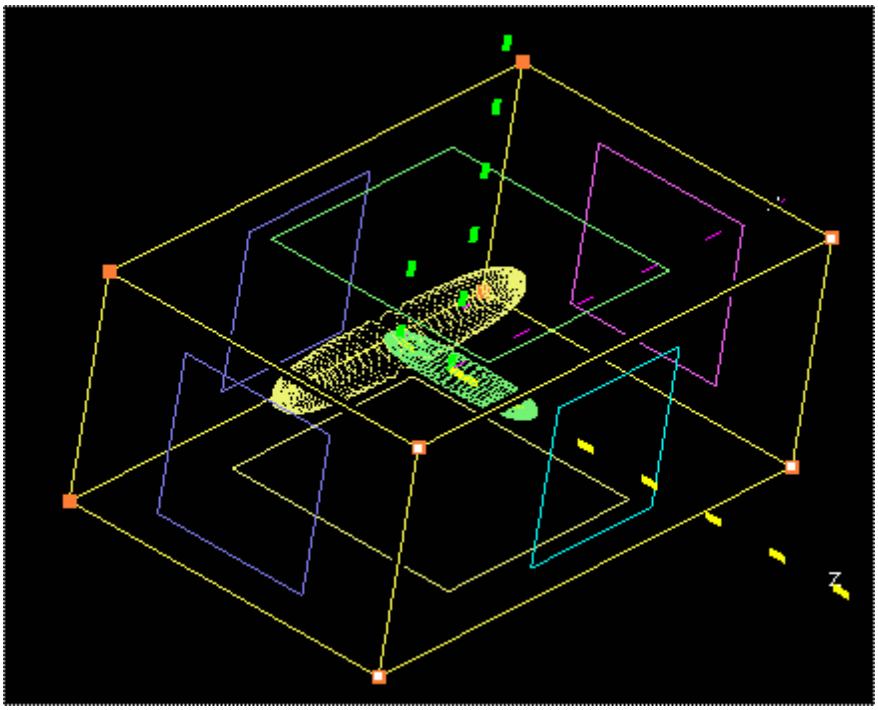
- Displaying and using topology groups to make the wrap and assign surfaces.
- Advanced surface display modes
- An introduction to topology faces exclusion for geometry with intersecting surfaces.
- An introduction to modifying the grid density to refine the mesh.
- An introduction to boundary layer clustering

Step 1 Creating the Wind Tunnel

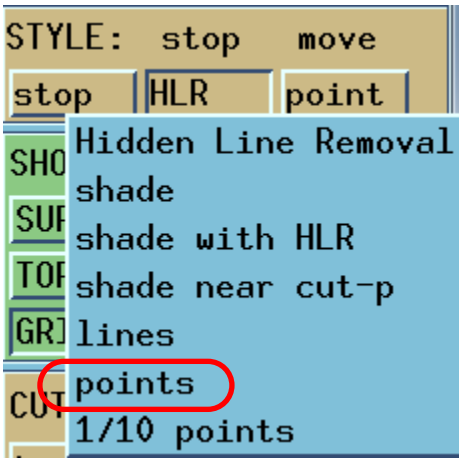
In many external flow calculations a rectangular box is created around the geometry to simulate wind tunnel conditions. In **GridPro**, the user only needs to import the geometry because the walls of the tunnel, as was learned in **Tutorial 1**, can be created internally. Open up the model by using the left mouse button and double clicking on the **Tutorial_2.2.fra** file. Turn off the Cut-Plane and go to the topo pull down menu and click on the read MACRO button. Make a **box** with **topology + surface** as in the dialogue box below. Do not resize the dimensions.



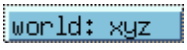
Press ok and the wind tunnel around the geometry should look like the picture below.



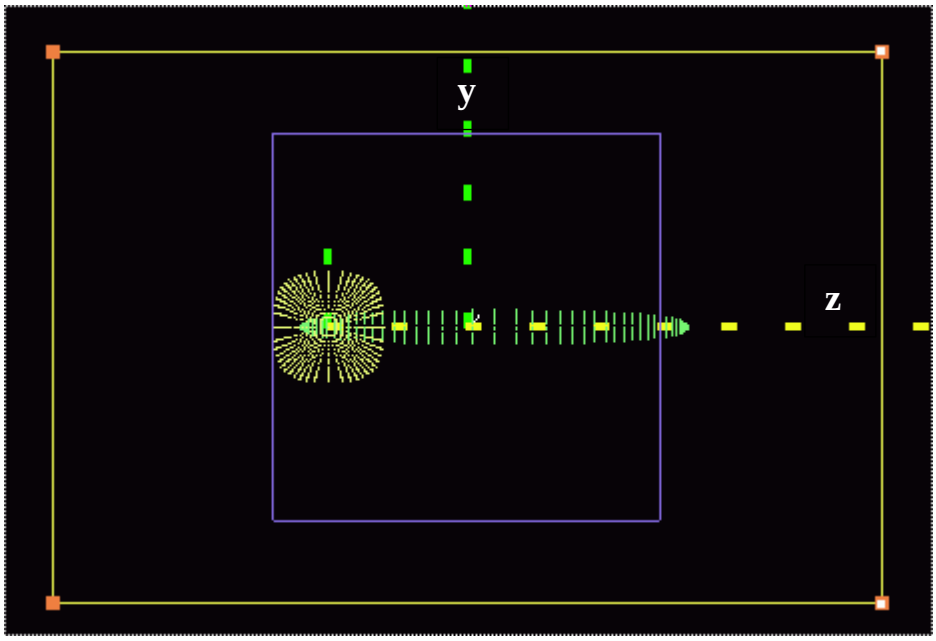
Reduce some of the screen clutter by making sure that the geometry is displayed as points. Go to the **STYLE** sub-command panel and click on **points**



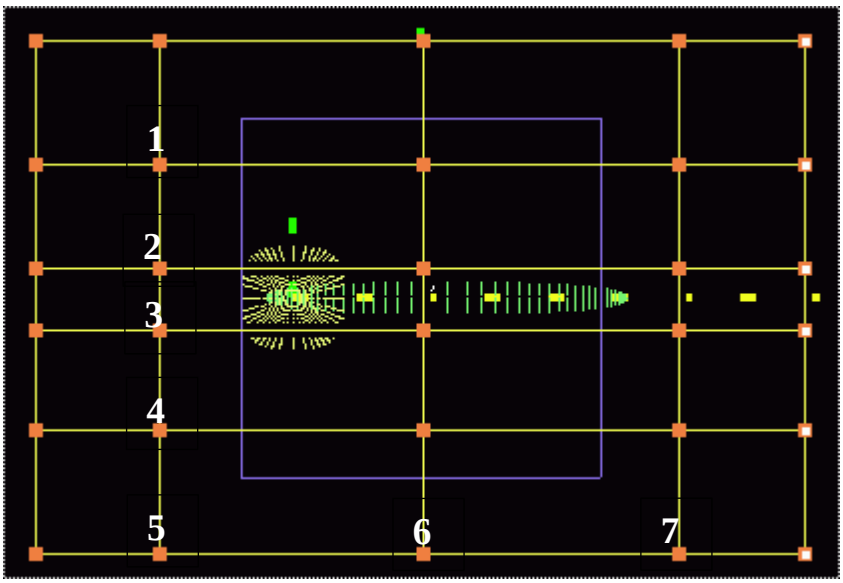
Step 2 Creating the Inner Topology

Snap the grid to the YZ plane by going to the snap function in the **ROTATE** sub-command panel and selecting  . The geometry should be aligned along the plane as

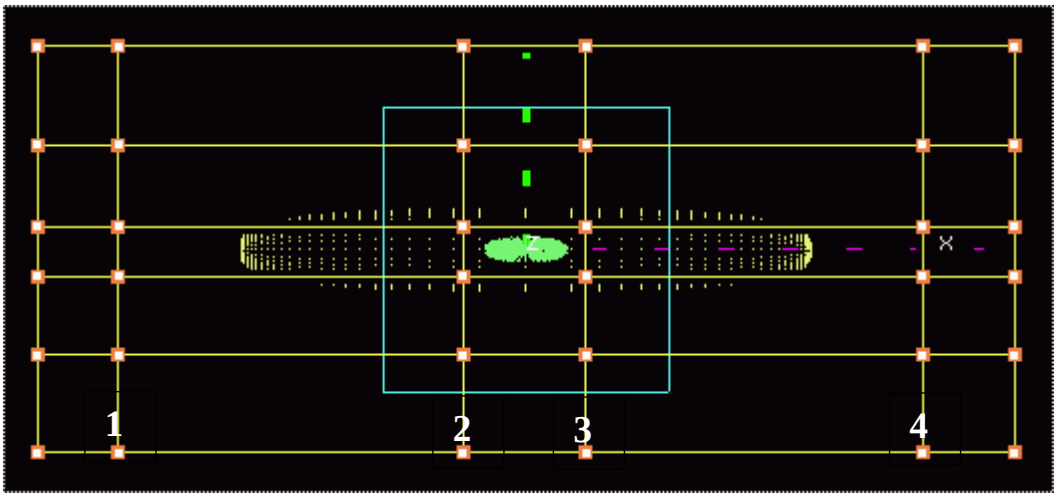
in the picture below. Again, if you snap to another plane rotate the geometry close to the YZ plane and snap again.



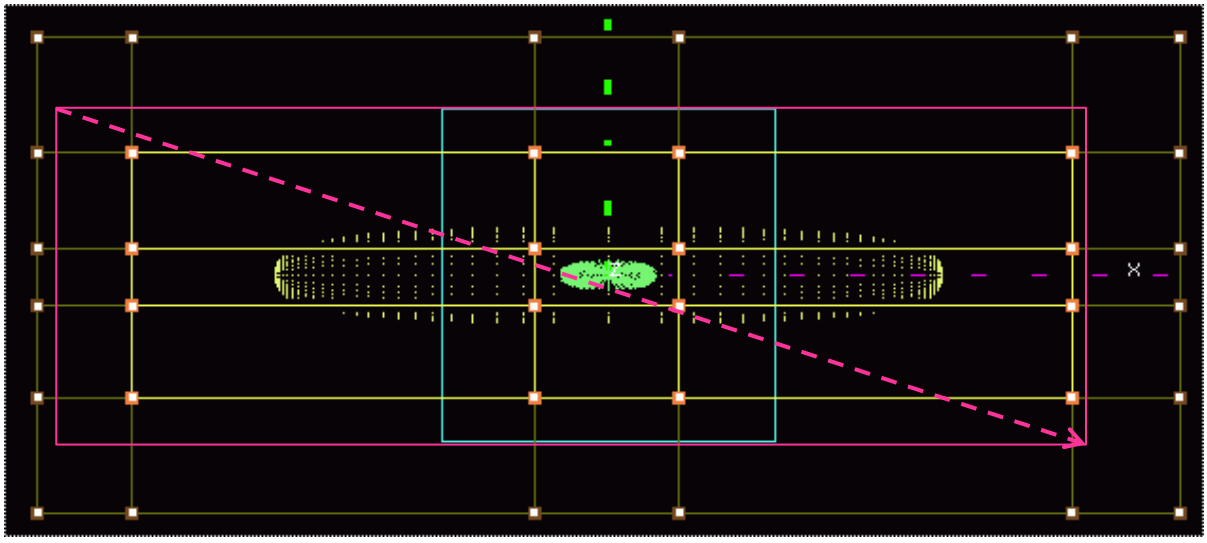
The geometry along the YZ plane is similar to the 2D geometry in **Part I**. We can therefore apply similar principles for the topology creation in 3D. Create the inner topology by inserting **Topology Sheets**, as in the picture below, by holding down  and using the cursor to click on the outer edges.



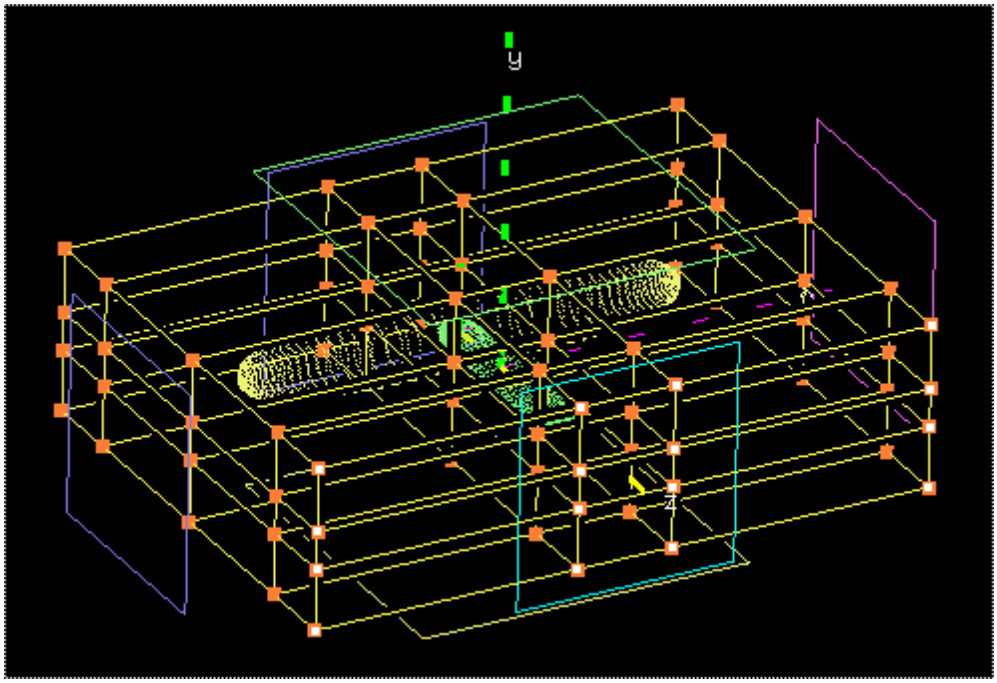
Now, snap the grid to the YX plane and insert **Topology Sheets** to the far left and right of the airplane fuselage and to the left and right of the wing.



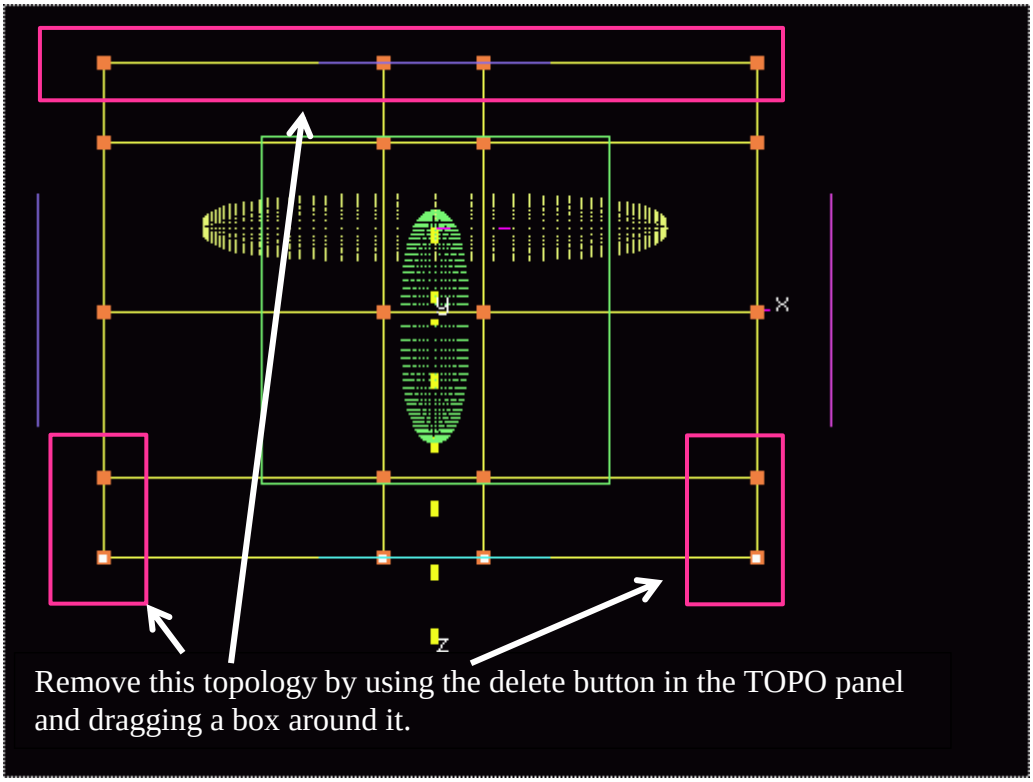
We would like to wrap the inner topology so let's group it and look at its relationship with the geometry. Go to the **TOPO** sub-command menu and insert the inner topology in **Group 2** as shown in the picture below.



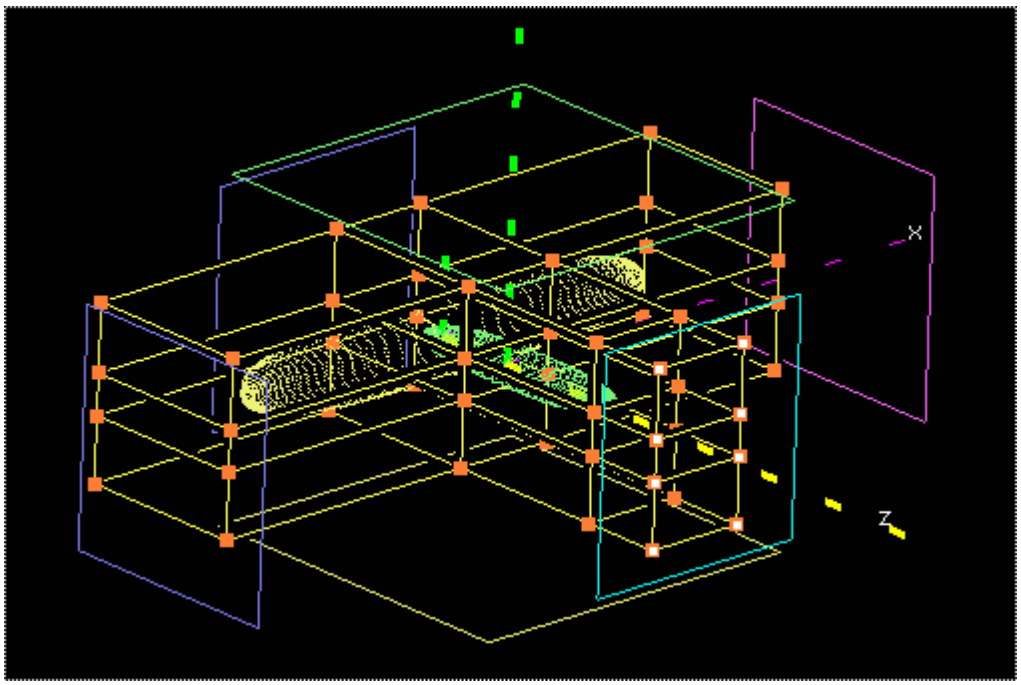
Rotate the geometry and topology so that all of it can be seen in a 3D isometric view.



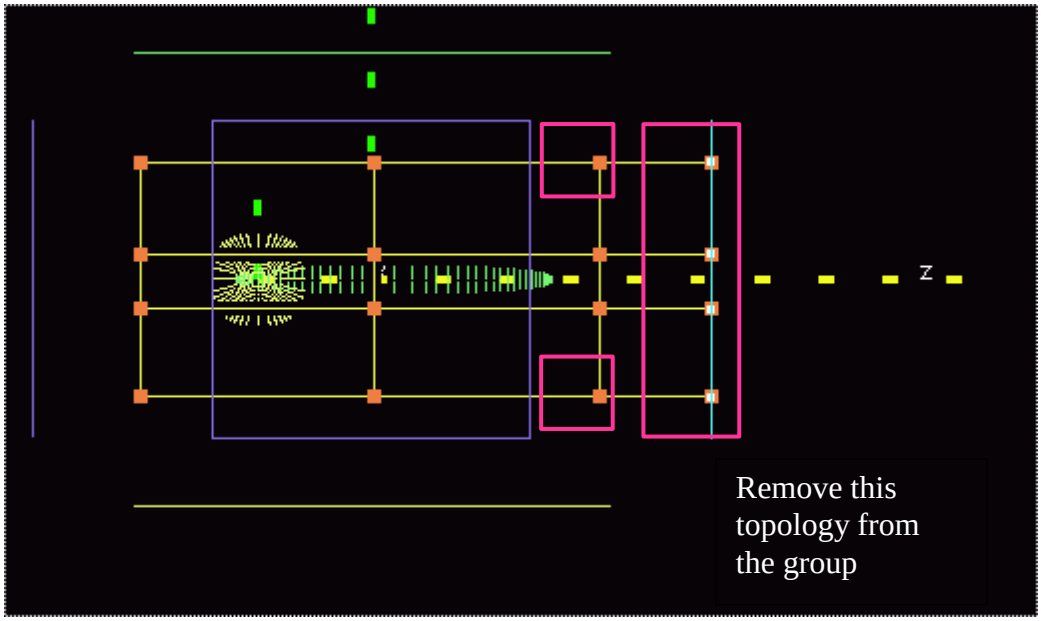
Display the contents of **Group 2** by going to the **TOPO** menu and clicking on the **Display All**  button to scroll to the **Display Group**  mode. Since it is necessary to wrap only the inner topology, let's remove the outer topology by snapping the grid onto the XZ plane so we can see a top view of the model. Remove the topology from **Group 2** by clicking on the  button in the **TOPO** sub-command and right clicking while dragging a box around the topology that you want to remove (make sure the Group 2 button remains on).



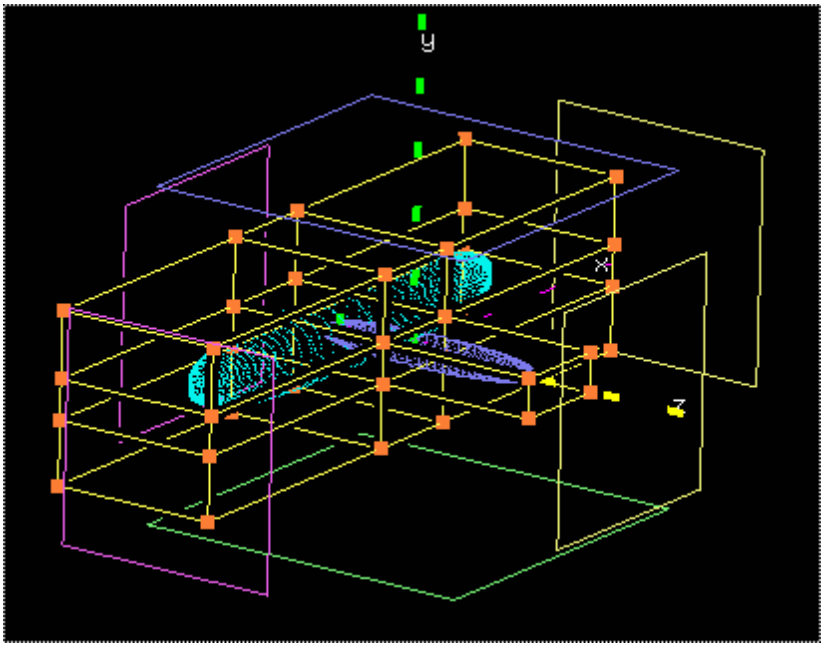
Now, let's look at what we have. Rotate the model so that you can see the entire topology as in the picture below.



The top, bottom and right portion of the topology around the wing is unneeded so let's also remove it from the group using the same procedure as above, but this time; snap the grid on the YZ plane.



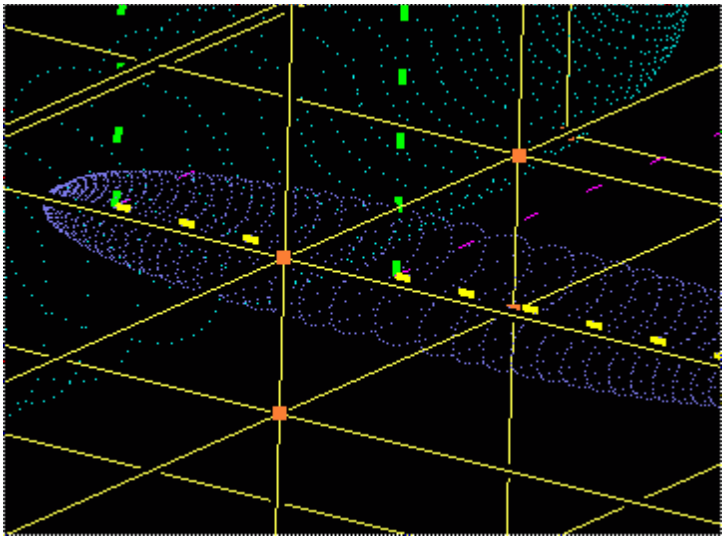
The topology should now look like the picture below.



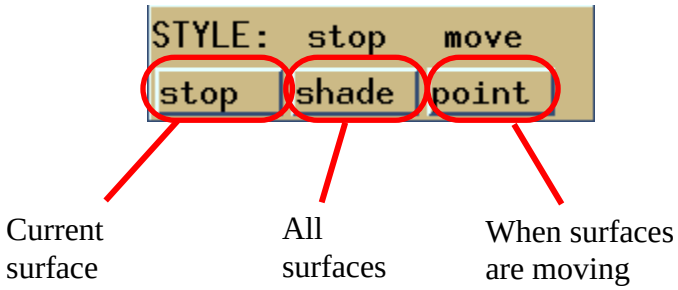
Another more quick method could have been used to create the inner topology. For reasons of understanding **Grid Pro** concepts this method was chosen. In a later tutorial we will cover ways to develop a topology creation strategy.

Step 3 Introduction to Advanced Surface Displaying

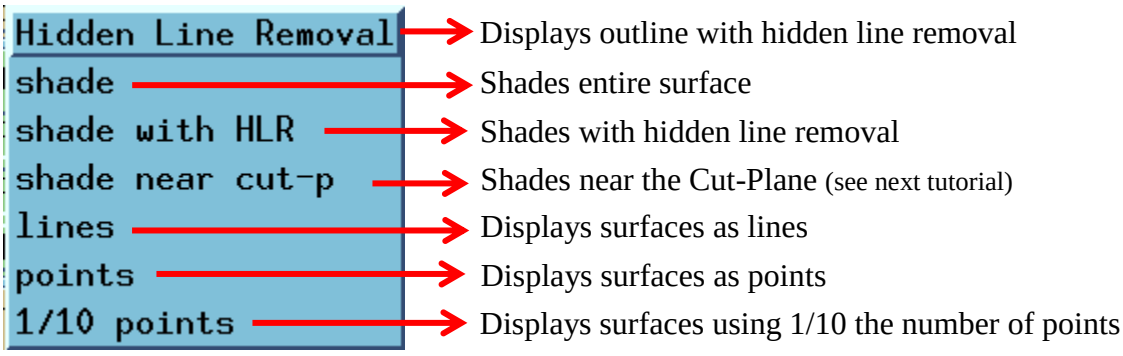
While using **Grid Pro,** many cases will arise when you need to use the advanced display functions to create and edit topology. Our topology is almost ready to be wrapped except some of the topology edges are intersecting the fuselage. Zoom-in on the fuselage/ wing intersection and let's have a look.



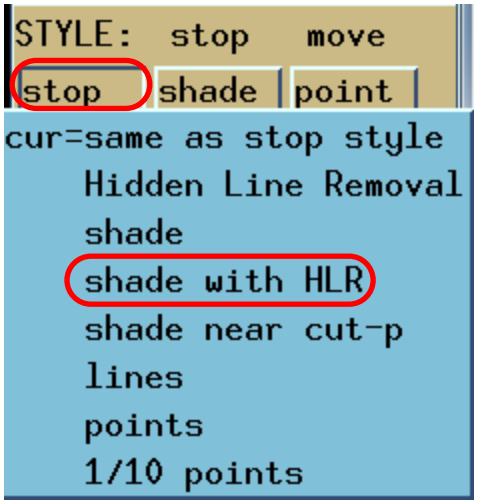
The view is a bit crowded and hard to see. This problem can be corrected by using advanced display functions on the **STYLE** subcommand panel. Three modes of displaying are available including the display options for the current surface, display options for all surfaces, and display options for all surfaces when they are moving on the work plane. The panel and each of its display options are explained below



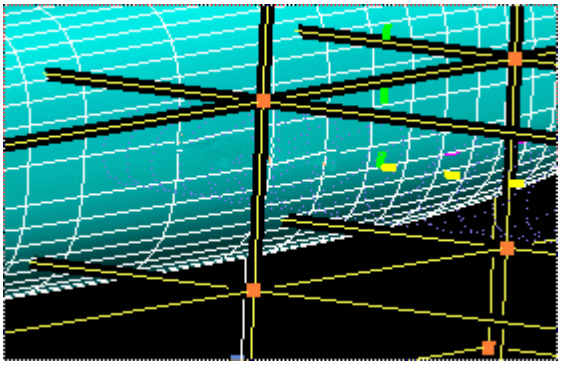
The user has the option of choosing among many display options:



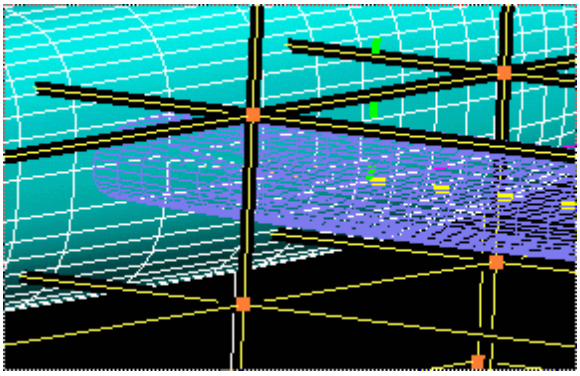
Make the fuselage easier to see by ensuring that it is the current surface and is displayed in light blue, and then go to the **Display Current Surface** menu and turn on shade with hidden line removal.



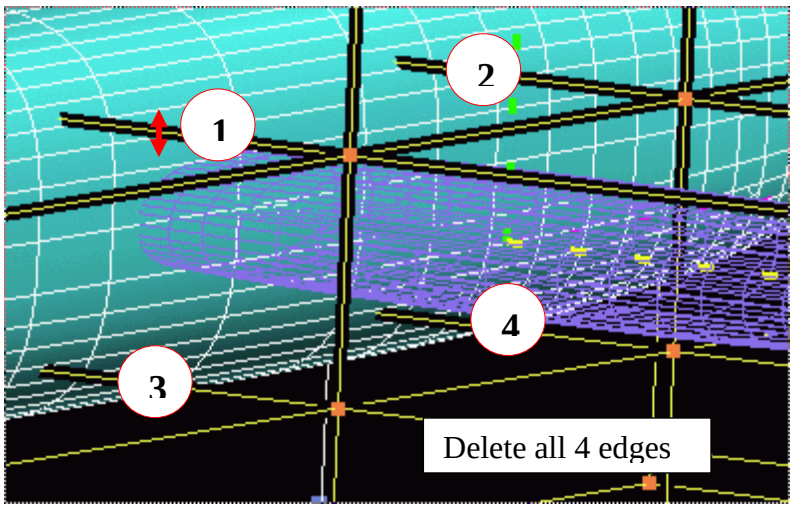
Rotate the surfaces so you can get a good view of the fuselage/wing intersection as in the picture below.



The edges crossing the fuselage can now be clearly seen. If you would like to see the wing more clearly, turn on the **lines** or **shade** option in the **Display all Surfaces** menu as in the picture below.



Now let's remove the edges crossing the fuselage by holding down  on the keyboard and left clicking the mouse button on all 4 edges.



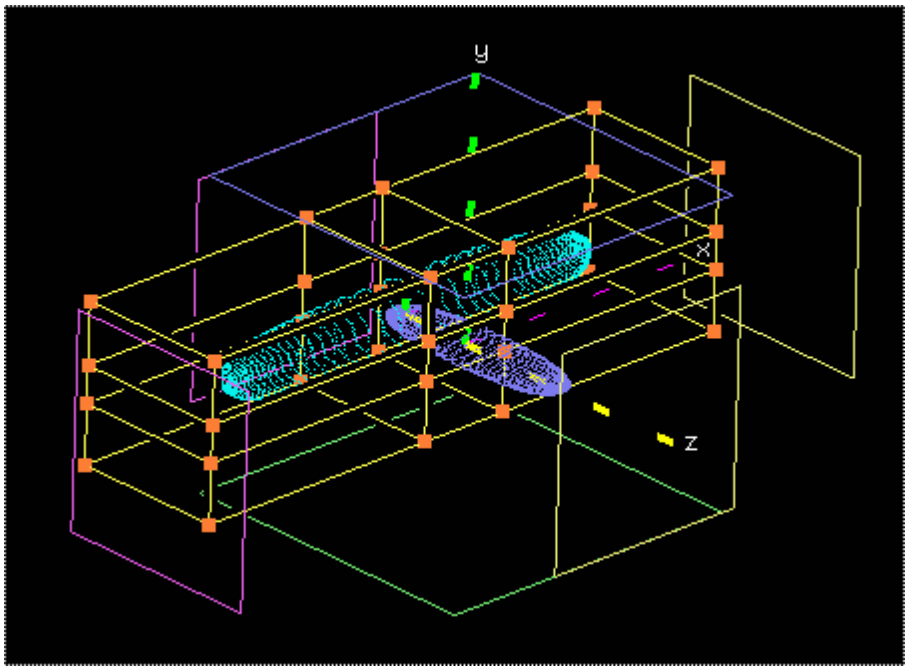
We are now ready to make the wrap.

Step 4 Creating the Wrap and Assigning the Surfaces

The Fuselage

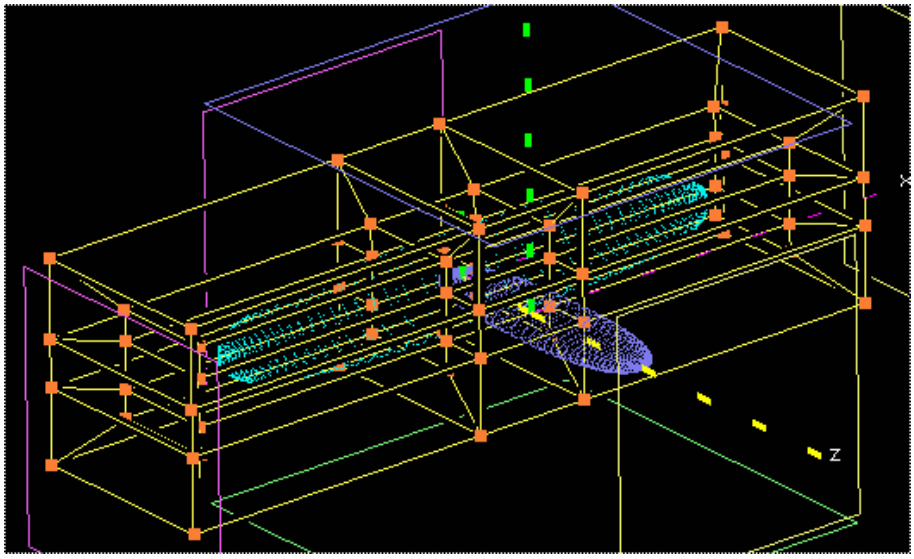
As in the 2D case, the wrap is created in two steps. The first wrap will be created around the fuselage and the second wrap around the wing. Start by switching all of the surfaces to points

and by removing the topology around the wing from **Group 2** so that only the topology around the fuselage remains.

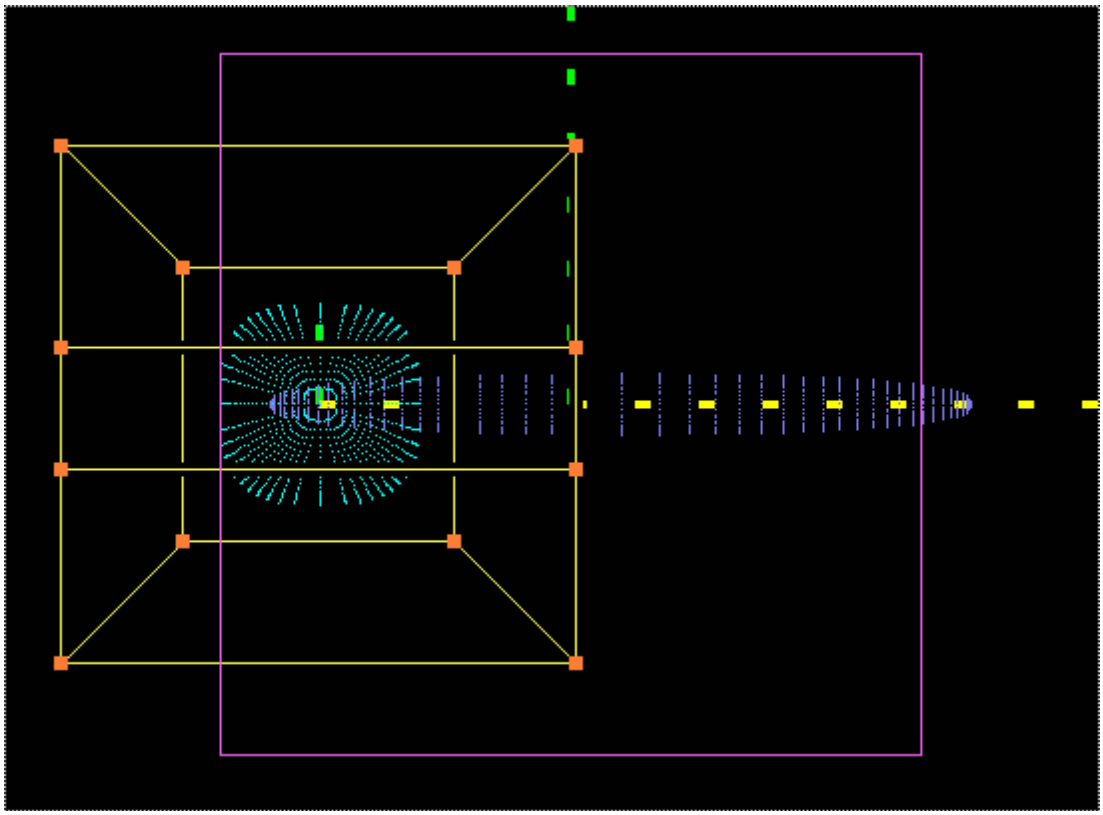


Create a wrap that is 10% smaller and rotate the image around to make sure that it doesn't wrap inside the surface. It must remain outside of the fuselage. If the wrap is too large, go to the **UNREDO** sub-command panel and scroll the wrap back using the 

button. The wrap around the fuselage should look like the picture below.

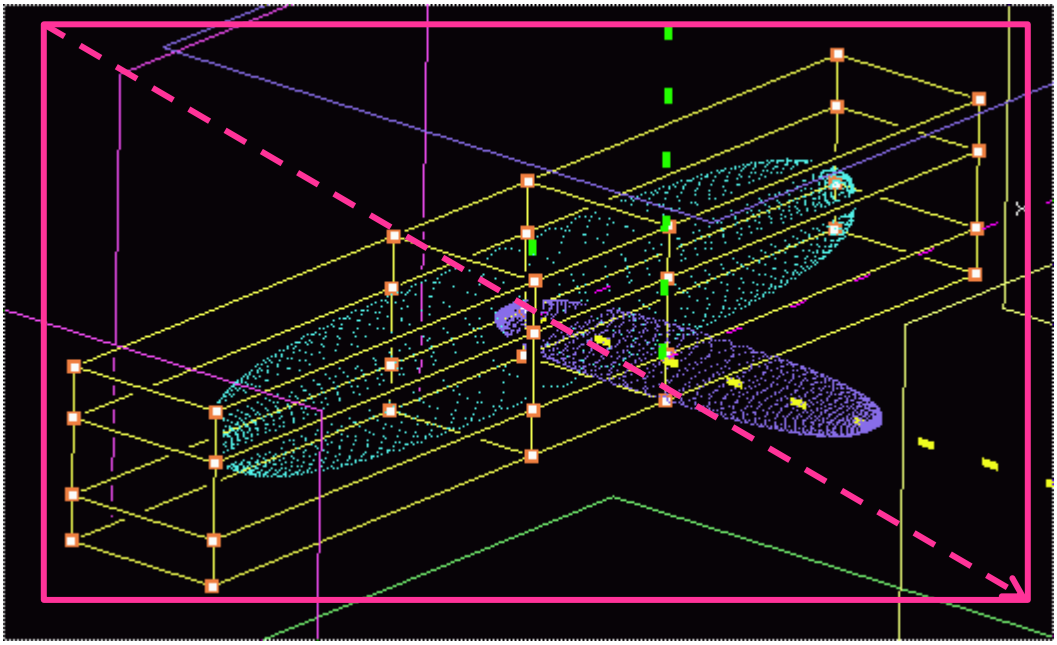


Snap the grid to the YZ plane to look at the wrap from a side view.



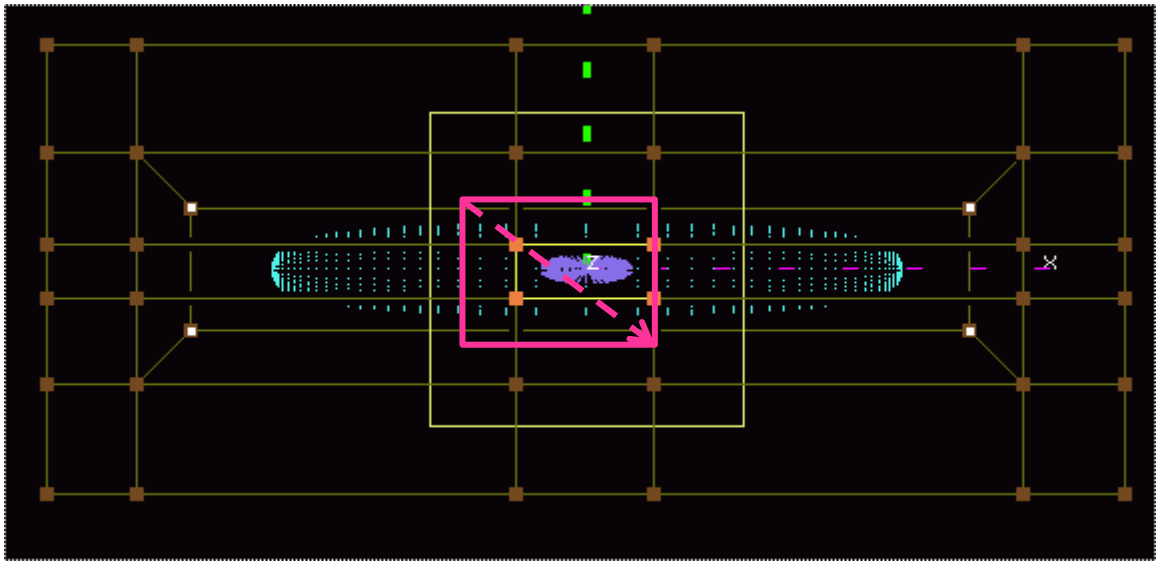
Notice from the side view that it looks very much like the 2D Case in **Part I**. Now that the wrap is created, let's assign the corners of the wrap to the surface. Make sure that the current surface is the fuselage and is displayed in light blue. Go to the **TOPO** sub-command panel and click on the **Current Wrap** button to display only the wrap.

Assign the surfaces by right clicking on the mouse button and creating a purple box around the corners as in the picture below.

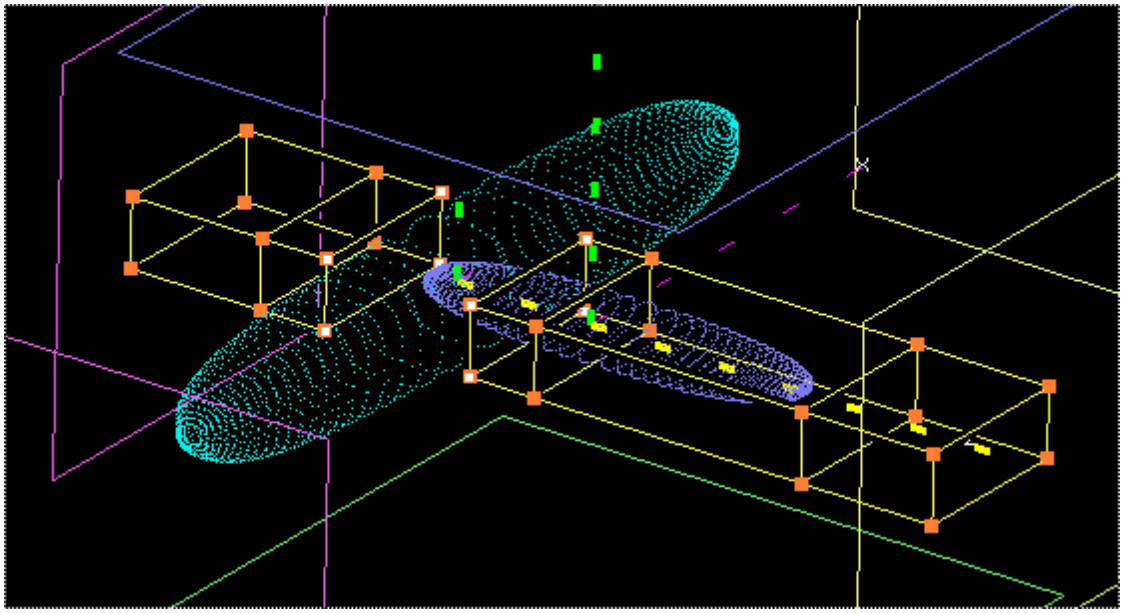


The Wing

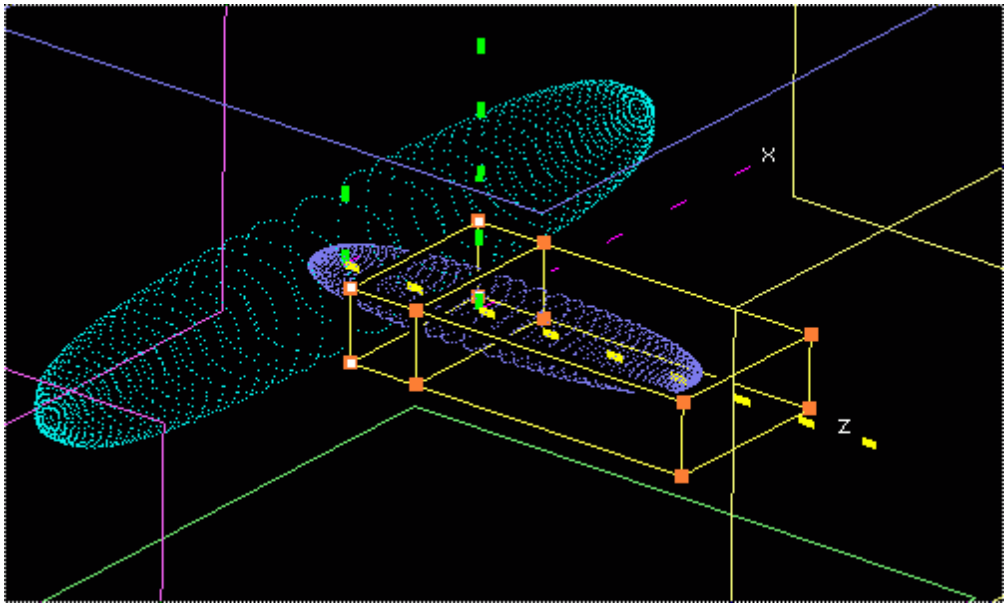
To create the wrap around the wing, snap the grid to the YX plane to see the front view and add the inner topology around the wing to **Group 3**.



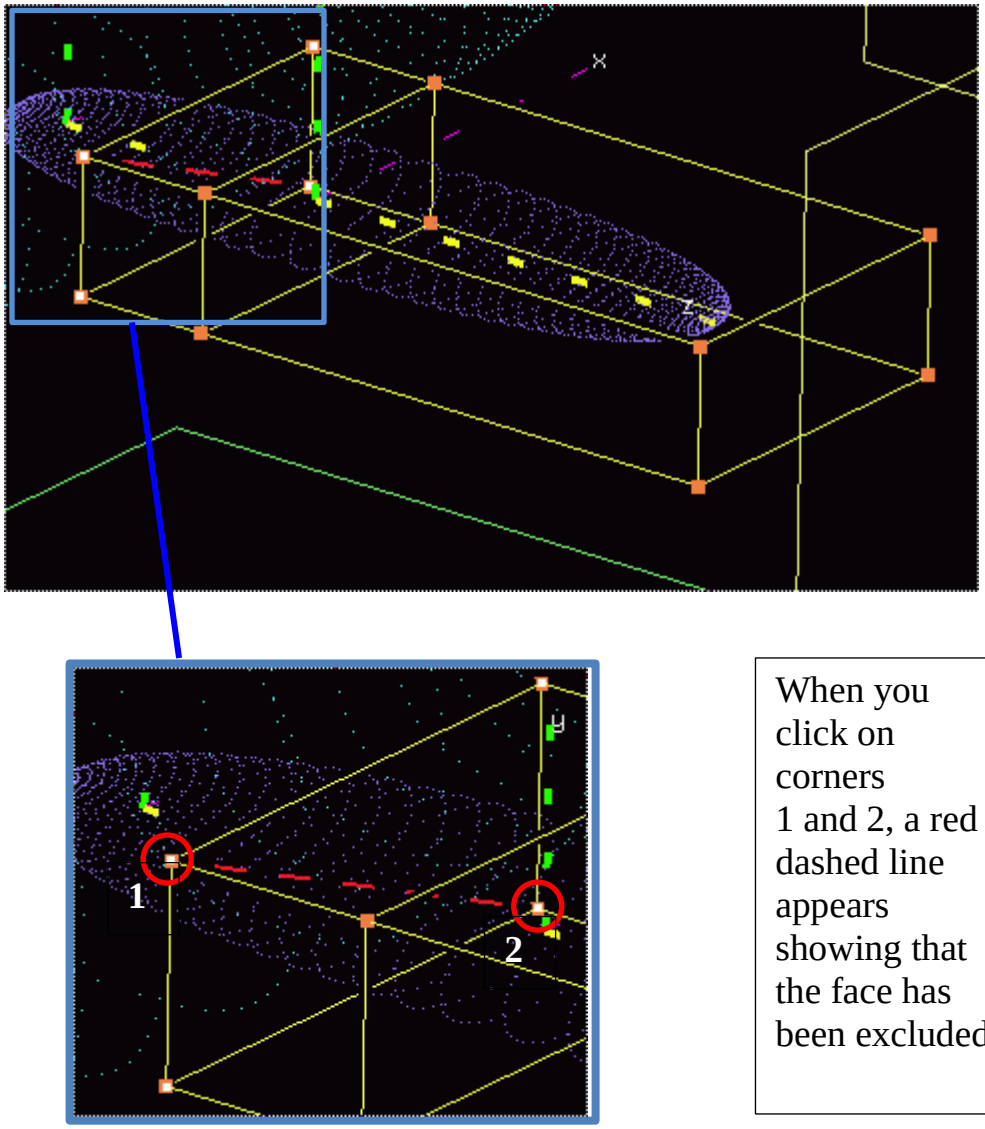
Rotate the geometry so to see the topology in an isometric view as in the picture below.



Notice that four more corners close to the fuselage/wing intersection have been created by wrapping the fuselage. Since only the inner topology around the wing is of interest, remove the unneeded topology from **Group 3** as in the picture below.



In order to create a proper wrap in **Grid Pro,** sometimes faces need to be excluded from the topology. A face is defined as four corners connected by edges. In this case the topology face intersecting the wing and fuselage must be excluded. Hold down  on the keyboard and click on the two corners of the face as shown in the picture below.

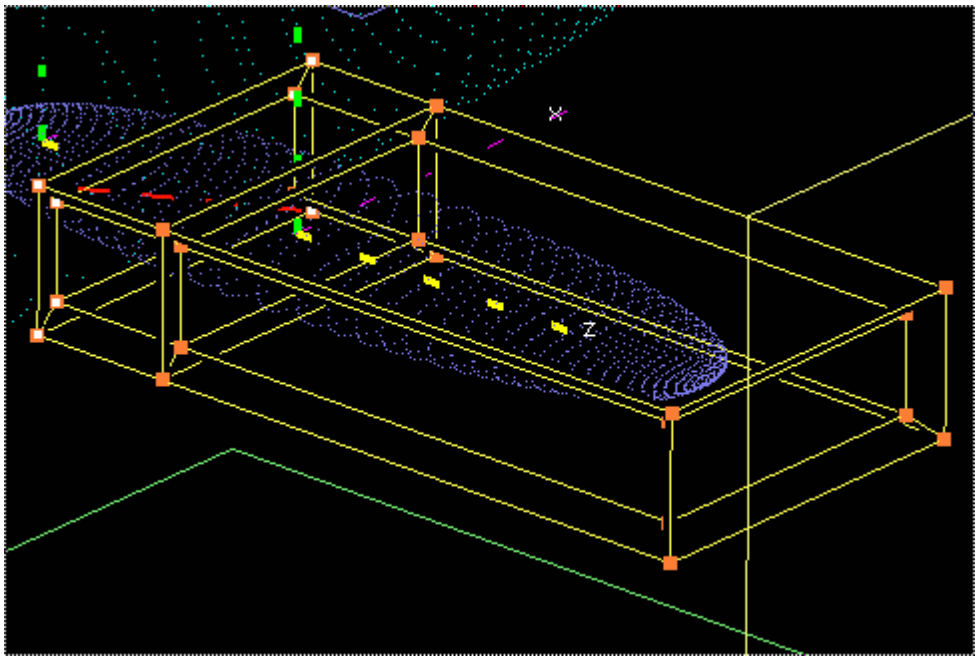


When you click on corners 1 and 2, a red dashed line appears showing that the face has been excluded.

Face Exclusion

In **Grid Pro** it is assumed that topology with 8 corners and 12 edges is a volume with 6 faces. Since we cannot wrap a volume that is adjacent to another volume, the intersecting topology surface must be removed to tell the code to wrap a quad surface instead of a closed volume. By removing one face, the other faces in the volume are also deleted and the topology around the wing behaves like one empty channel.

Now that the inner topology around the wing is complete wrap it 5% smaller. Notice that the wrap on the excluded face remains planner while the other part of the wrap shrinks at a 45 degree angle.

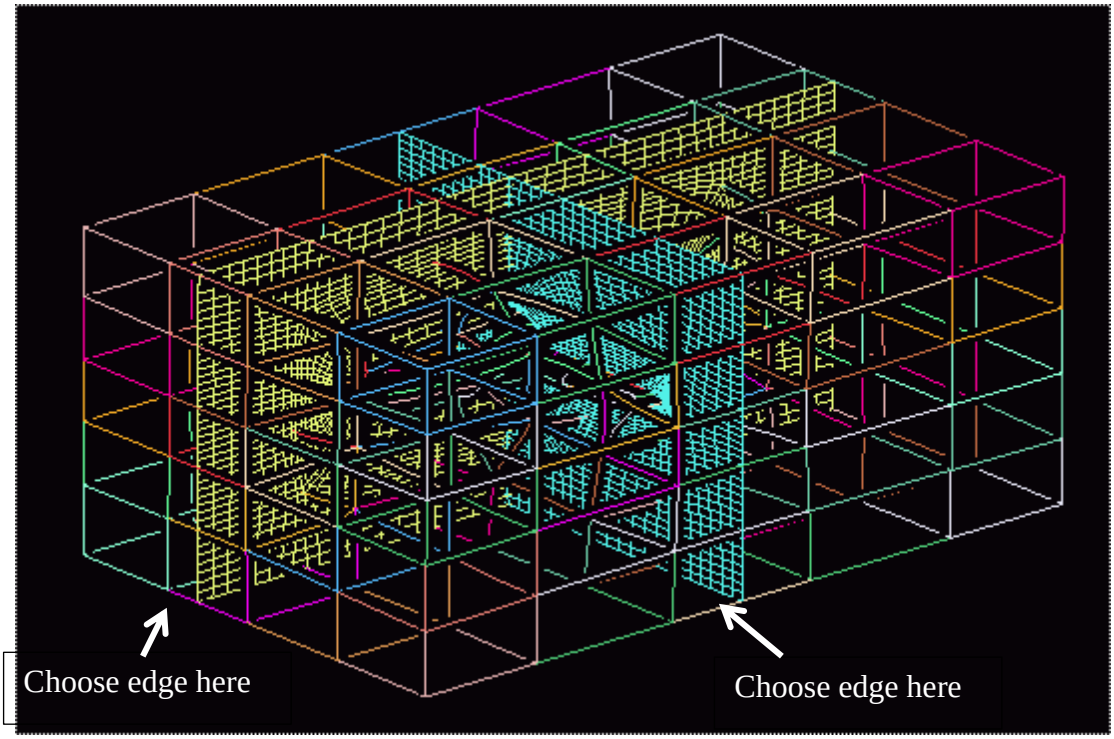


Assign the wrap to the wing the same way as the fuselage. Once the topology on the wing surface has been assigned it will be complete. Due to inheritance, the topology on the walls has already been assigned.

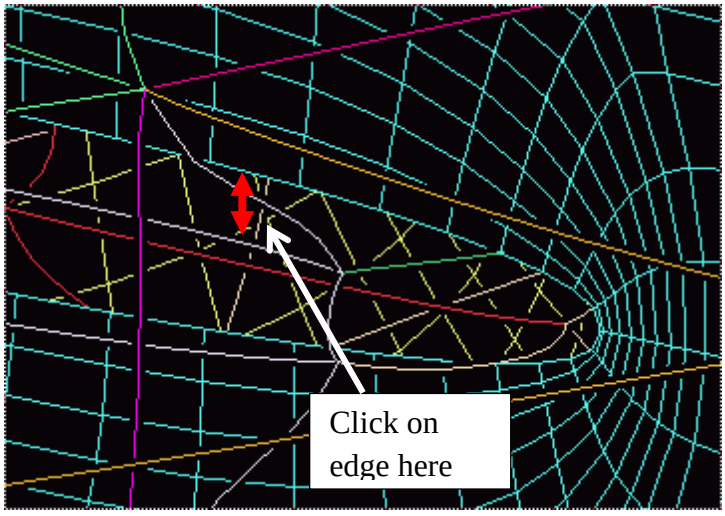
Step 5 Introduction to Grid Density

The topology is complete and the surfaces have been assigned. Go to the **topo** sub-menu on the top to start the gridding process. Wait a few minutes and load and view the grid. Make a couple of **Grid Sheets** along the fuselage and the wing by left clicking on the 

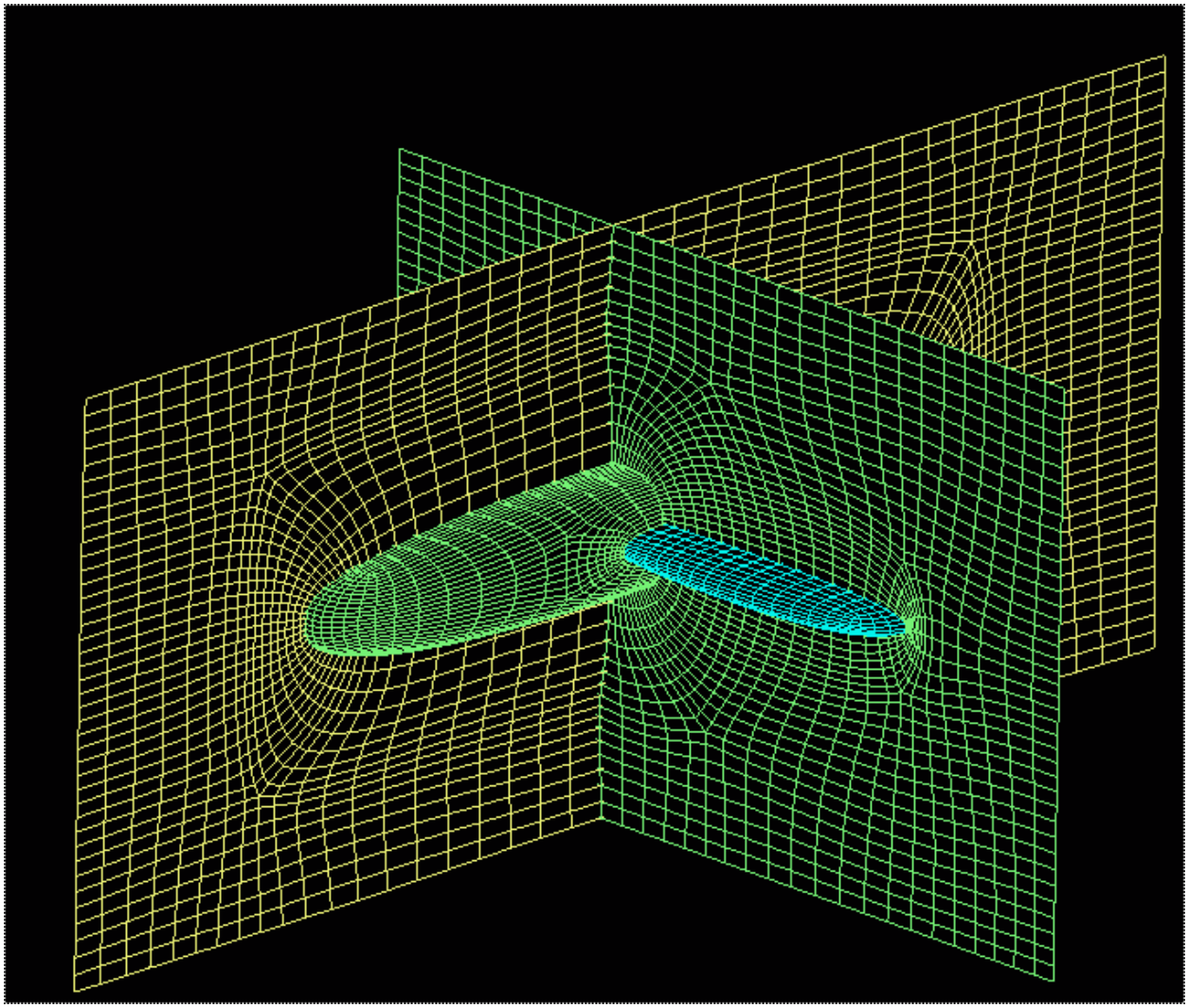
button in the **MAKE SHEET** sub-command panel and the block edges as in the picture below.



Make a sheet in which you can view the grid on the surface of the wing. Zoom-in on the wing tip and choose the block edge that is wrapped onto the surface as in the picture below.

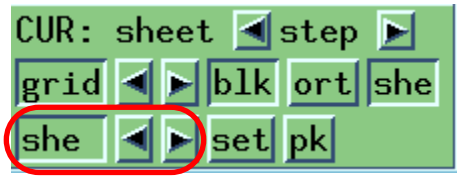


Do the same for the fuselage such that a total of four sheets are made. To get a better view of the sheets turn off the **Block Edges** in the **CUR** sub-command panel.

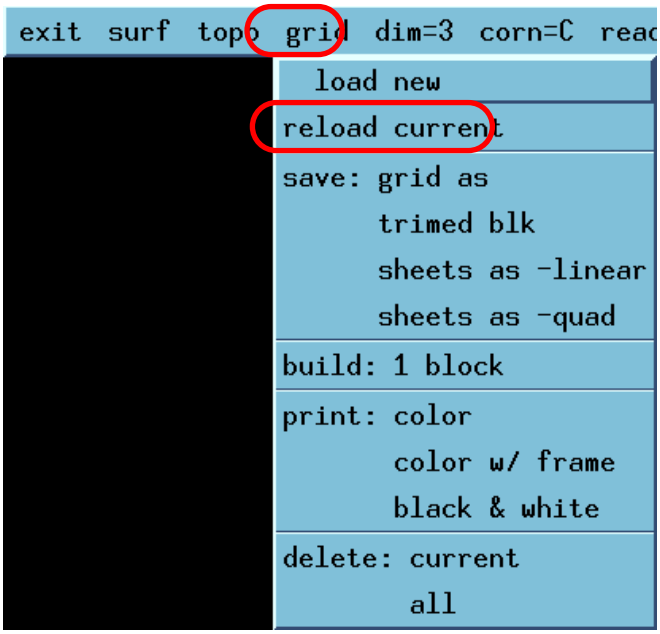


The sheet can be scrolled through the volume to highlight the important features of the grid. Go to the **CUR** sub-command panel and click on the 

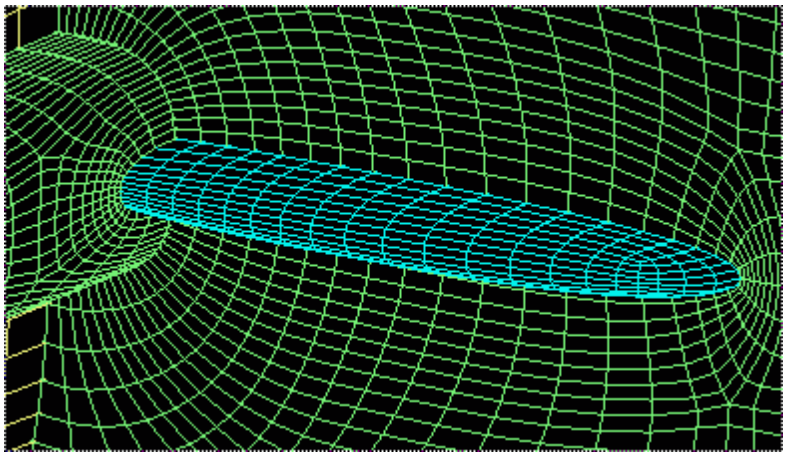
buttons to scroll. You can also choose the current sheet by scrolling through the **Current Sheet** buttons. The sheet highlighted in light blue is the current sheet.



Continue to reload the current grid every few minutes by going to the **grid** sub-menu and choosing **reload current**. Notice that every time you reload, the grid improves with each successive dump to the **blk.tmp** file.

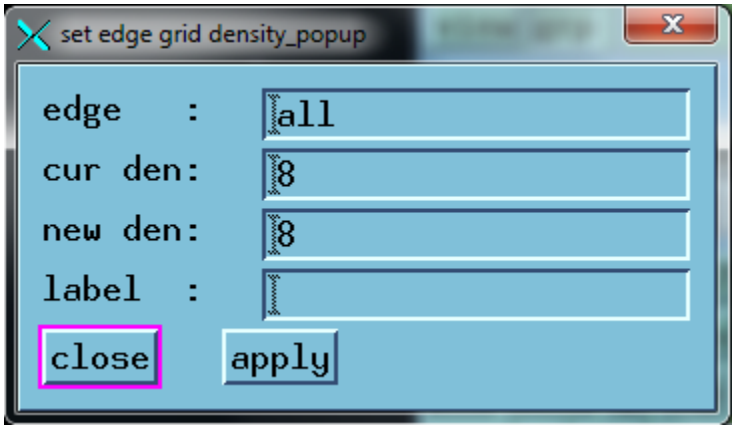


Zoom in on the wing and notice that the grid is somewhat course.

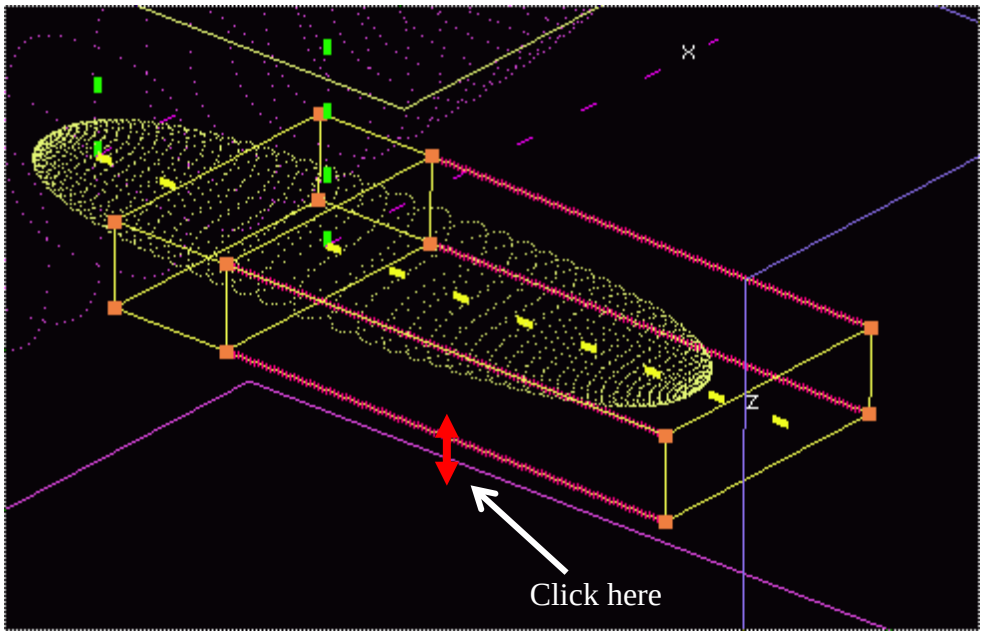


Let's increase the density so to make a finer grid. A significant advantage of using **GridPro** is that the grid density can be changed interactively while the calculation continues to converge. Change the density along the wing by going back to the **Topology Builder** and left clicking on the 

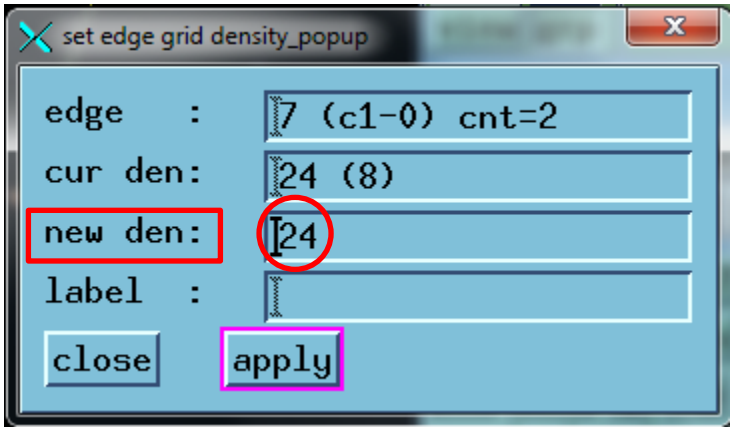
button, a dialogue box appears



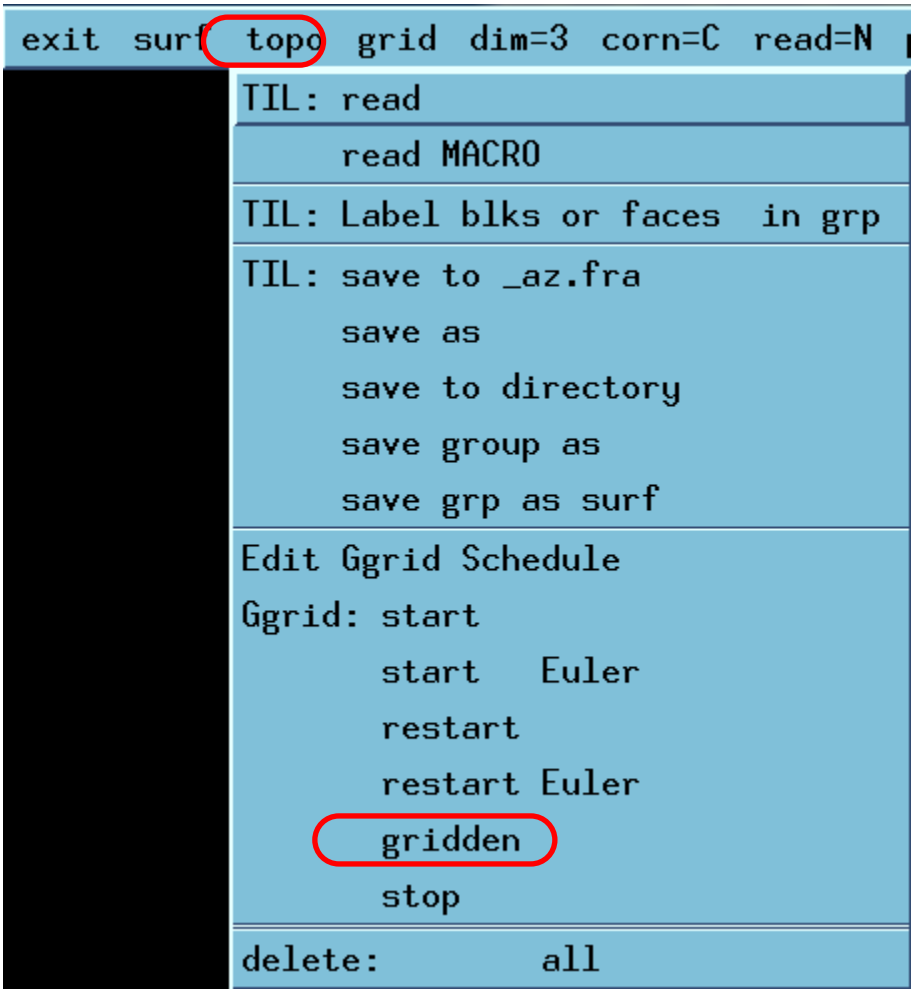
Click on the **Group 3** button in the **TOPO** sub-command panel to display the topology and place the cursor over the edge and click with the left mouse button as in the picture below.



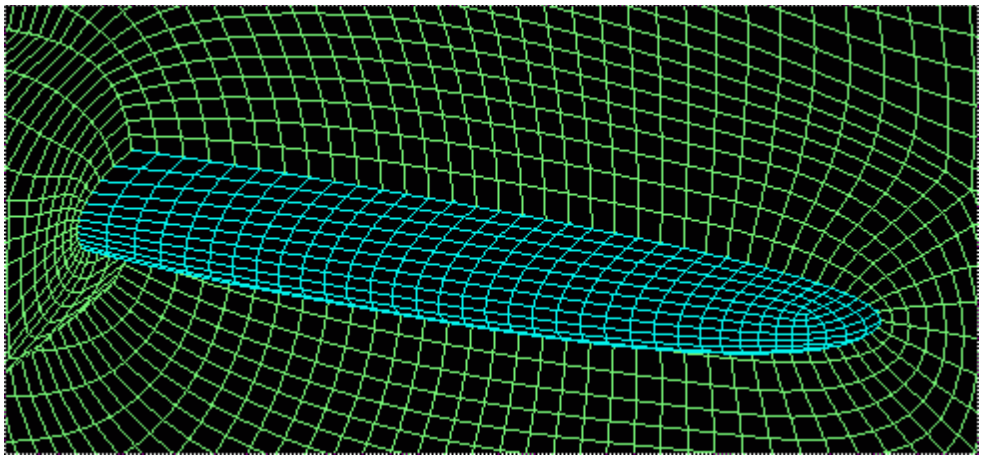
The pop-up box immediately registers the default density of 8. Choose a new density of 24, click on apply and close the pop up box.



Go to the **topo** sub-menu at the top and load the new settings by clicking on **gridden.**

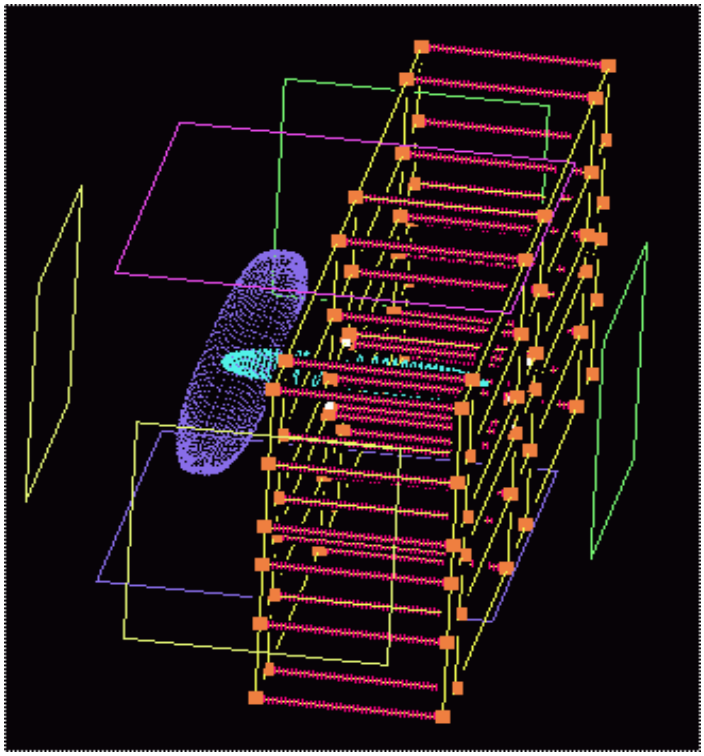


Reload the current grid and look at the mesh. Notice the difference in mesh density.



Grid Density

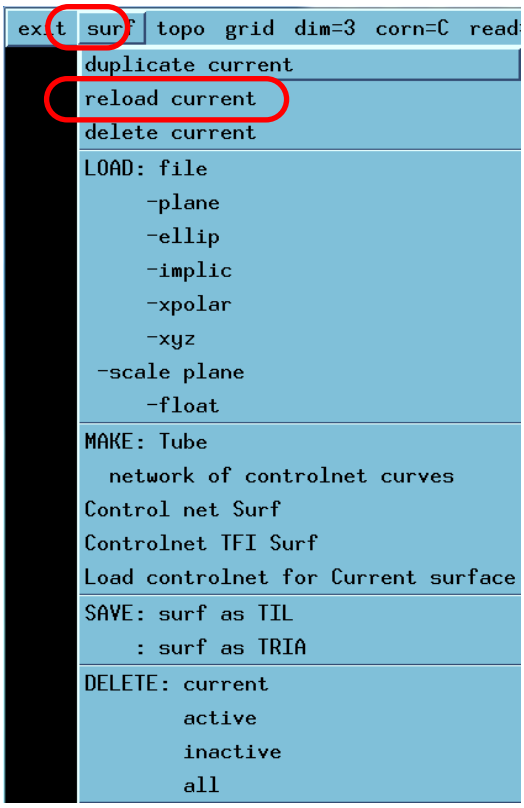
In **GridPro** the grid density can always be changed while the calculation continues. The density can also be changed after the calculation has stopped and the grid restarted using the "***topo → restart"*** command. The density does not need to be changed only on the wrap as shown above. Any edge that is parallel to a plane passing perpendicular to the wing could have been used as shown in the picture below.



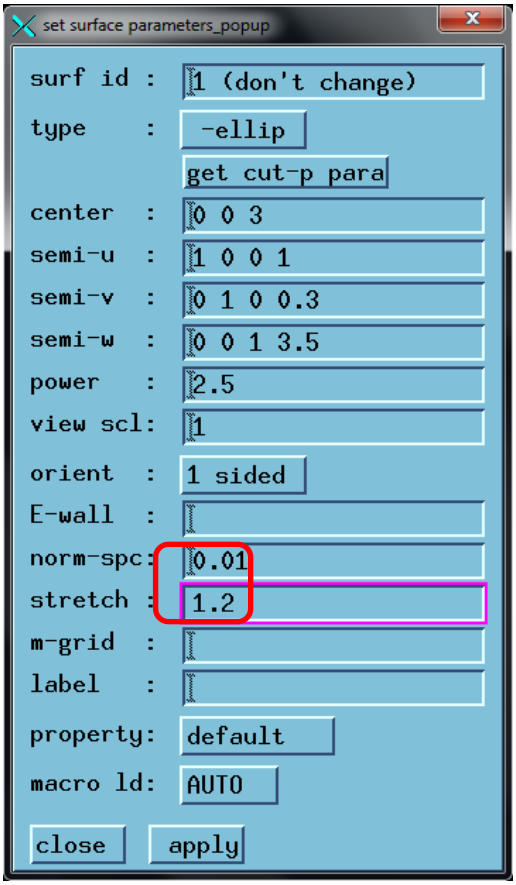
The density along all of these topology edges has been changed to 24. Any one of these edges could have been used to change the density.

Step 6 Introduction to Boundary Layer Clustering

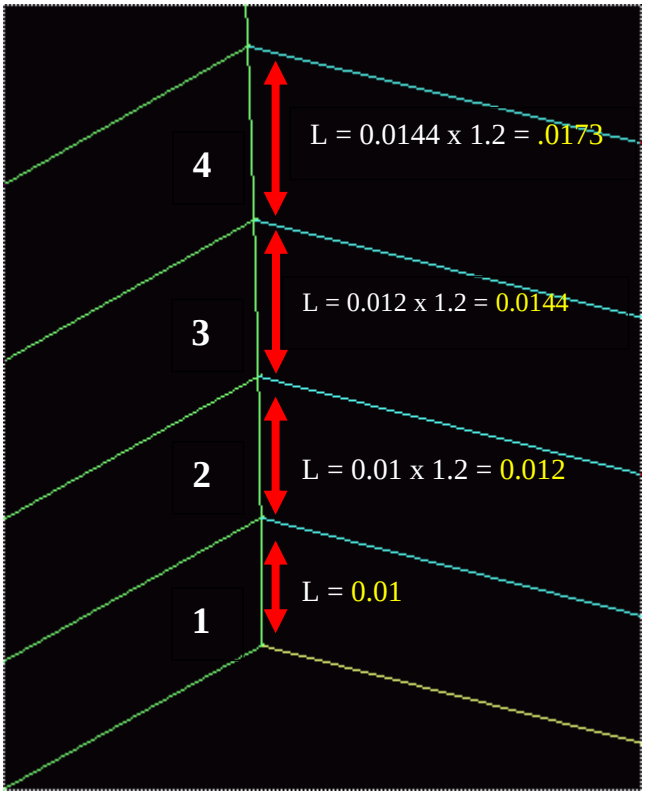
Clustering is extremely useful for capturing the details of a boundary layer. As an example, let's cluster the boundary layer on the wing. While the calculation continues to run, stay in the **Topology Builder** and choose the wing as the current surface by making sure it is highlighted in light blue. Go to the **surf** pull-down menu and choose **reload current**.



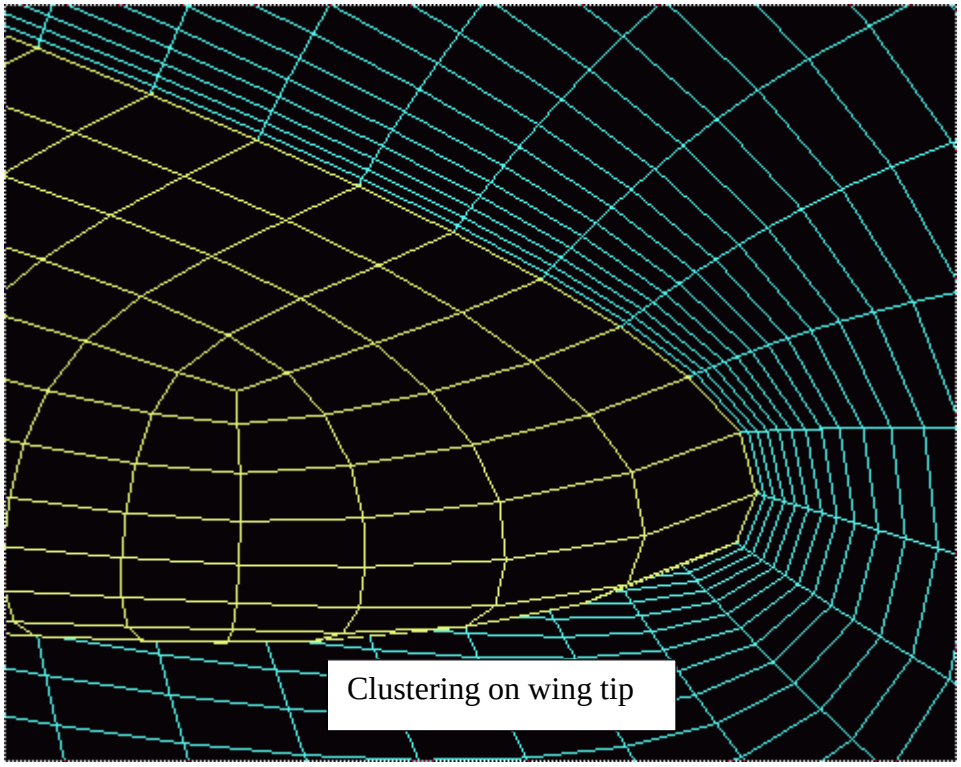
A **set surface parameters** dialogue menu will appear



In the process of clustering the length and rate of growth is determined by the normal spacing and the stretch. The normal spacing determines the length of the original cell on the surface, and the stretch determines how the original cell will grow off of the surface. For example, if a spacing of 0.01 is chosen, the original cells whose faces lie on the surface will have a length of 0.01. The second set of cells will have a length that is 1.2 times the length of the original cells, and the third set of cells will have a length 1.2 times that of he second set of cells, and so on. See the picture below.



Put in a **normal spacing of 0.01** and **stretch of 1.2**, hit apply and close the dialogue box. To activate the new settings go to the **topo** menu and click on **gridden**, wait a few minutes and go back to the **grid viewer.** The sheets you made previously should still be in place and you can view them by **reloading the current** mesh. Zoom in on the wing tip, it should look like the picture below. **Note** - you must wait until the code dumps the new mesh to view the clustering.


Clustering on wing tip