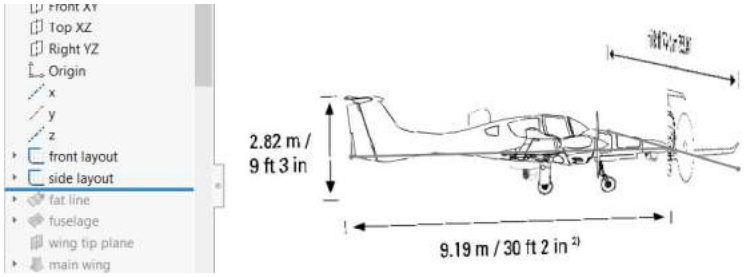
Aircraft

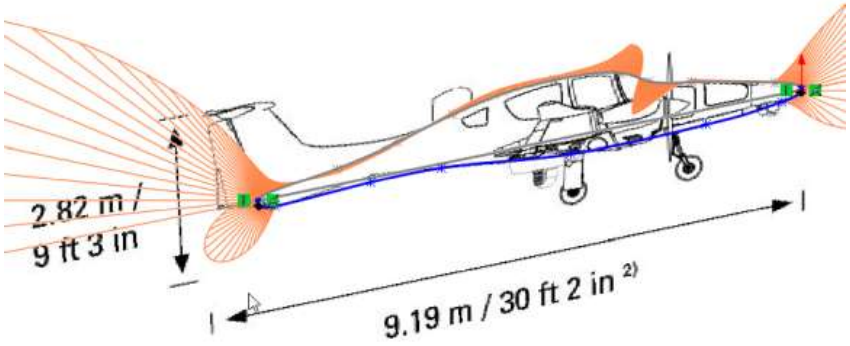
This model was inspired by a Diamond four seat two propeller plane. Very shapely design, and believe it or not, fairly easy to model. Here we will work on 3D splines, using points as a guide curve in a Fill feature, and symmetry.

We can get started with sketch pictures and trace around it to make the main part of the fuselage. For this model, I've provided the images you can use for sketch picture layouts, but in general, the internet is your friend, and you can find orthographic drawings on many manufacturer's websites. Get a decent image editor (I use Irfanview for simple stuff), and trim out the data you don't need. To download the image I used, click this link: airplane.png



Put the images on the correct planes as sketch pictures. Scale the images 1:1 so you can model accurately with the traced splines. Make sure the images are reasonable resolution so they are easy to trace over accurately.

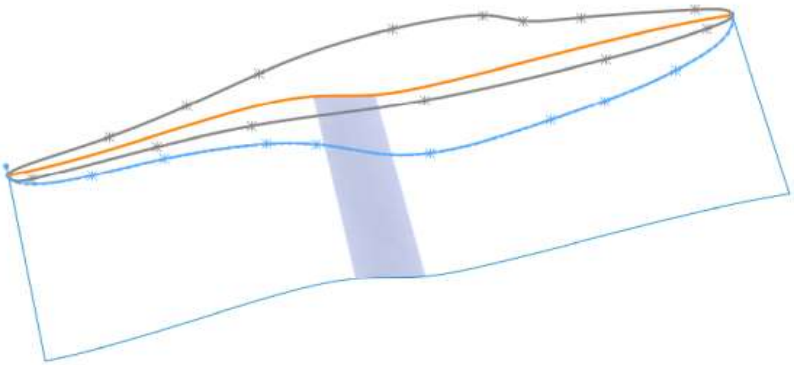
For some models you may need front and back, top and bottom, right and left. For example, an automobile needs placement for front and back lights, so you need both views. For this model, I should have added a top view, but instead I estimated the top silhouette view.



The top and bottom silhouettes of the fuselage are sketched separately on the right plane, and at the ends of the splines, the two sketches are tangent. The top spline curves down, and the bottom spline curves up. You can do this with sketch relations or with the directional handles at the ends of the splines.

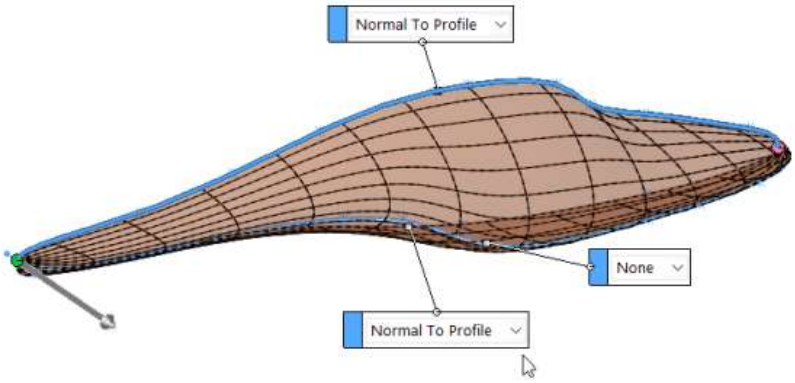
For the top and bottom sketches on the symmetry plane that's easy, but for the side profile you really need a projected curve, because it is a 3D curve. You need to sketch it from the top view and the side view, and create a projected curve. The tail end can be sloppy because it will be trimmed off and replaced by the tail. The front, however, must be perfect.

To estimate the silhouette view from the top, I drew what I called a fat line to show where the fattest part of the cross section would go from the side view, and extruded that line as a surface. Then I used the Spline On Surface to draw a 3D spline of what I thought that fat line would look like from the top. The gray lines are top and bottom at the center plane, the orange is the fat line seen from the side (extruded as a surface), and the blue is the 3D spline on surface fat line as seen from the top. So in this case, the orange spline and the extruded surface are just reference geometry to come up with the blue 3D spline.



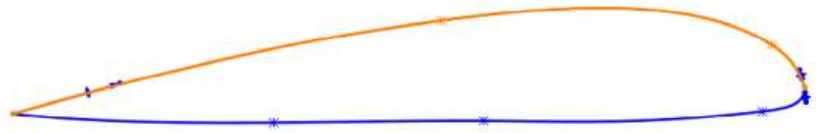
I understand that aeronautical surfaces are mathematical constructions, and what we are doing here is mainly visual. But you can apply these techniques even to more technical surfacing projects. You can drive curves mathematically (using the Equation Driven Curve), and use those curves to create technically accurate aero/hydro surfaces, and then finally the ultimate goal, manufacturable solid data.

From the 3 curves – top, bottom and 3D fat line, you can make the fuselage from a boundary surface. Just be aware that in this configuration, you're going to have two degeneracies at the ends. You can use Fill surfaces to recreate the ends with better surfaces.

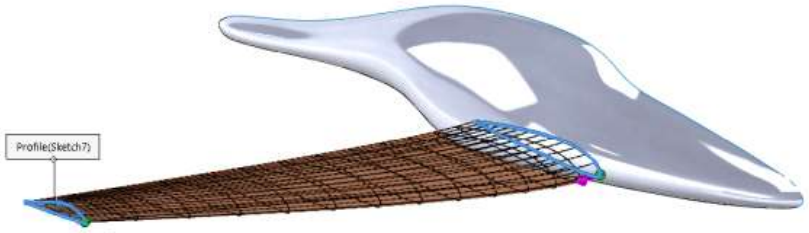


There are several ways to make the wing, depending on what kind of data you are starting from. If this will be a more technical model for you, you can create airfoil curves for various points along the wing and loft together those sections. In this case, I just have two cross sections – the symmetrical point and the wing tip. Both of my sketches are created from two splines – one on the top and one on the bottom. This can actually be tricky.

You might think to make the airfoil shape with a single spline, but when you do that, SolidWorks automatically makes the spline internally continuous, meaning that you can't get a sharp edge at the back of the airfoil. So you have to do it with two splines, set them tangent at the front, and not tangent at the rear.



I have used the Loft feature, but you could also use a boundary surface. I have used some tangency weighting at the symmetrical section to give the wing a slight curvature. Again, this exercise is more about how to do the surface modeling than about how to get the airfoil correct.

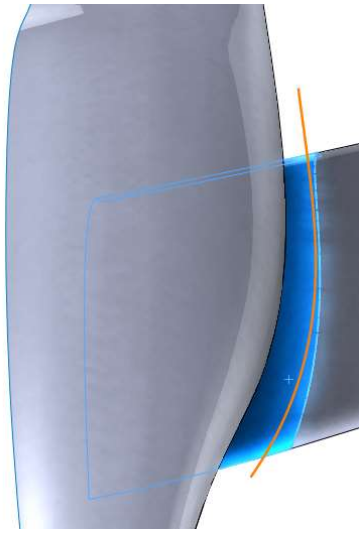


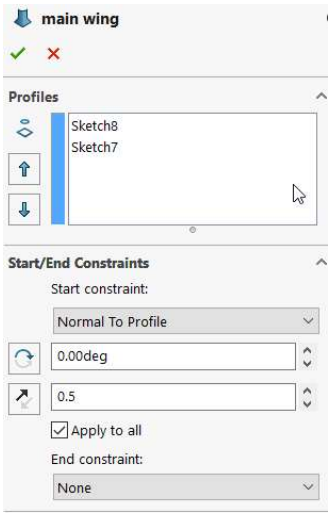
I'm trying to integrate the wing into the fuselage at the bottom to maximize the room inside the fuselage and keep the wing as stiff as possible.

After the loft for the wing, the next challenge is to blend the wing into the fuselage. You could use a big fillet to do this, but let's use something that offers a little more control.

First, let's place a split line across the

top of the wing surface, shaped as shown to the right. This will be the outer boundary of the blend between the wing and the fuselage. For reference, the nose of the plane is pointing up in this image.



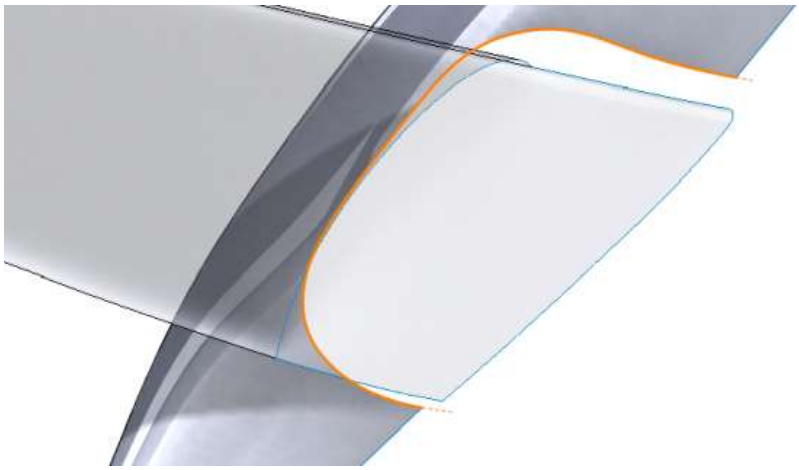


Because the two airfoil sketches of the loft were created with two sketches, the wing has a top face and a bottom face, and the split can split the top without splitting the bottom.

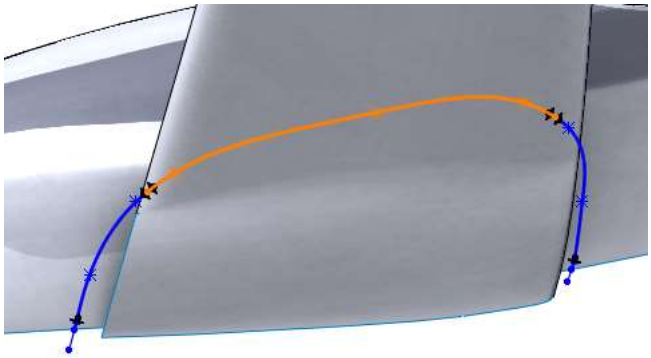
This enables you to use the Delete Face to remove the part of the top of the wing that runs into the fuselage.

> *Note: We use a split and delete face here because trimming is a body function, not a face function. Trimming will get rid of the top and bottom faces of the wing, and we want to keep the bottom face.*

Next we use a trim to make the boundary of the blend on the fuselage. This trim is created with a Spline-on-surface 3D spline as sketched shown in orange below. As long as the spline touches two edges of the surface, you can use it to trim the surface. So in the image below, the wing is transparent, the nose is up and to the right, and the 3D spline has been used to trim the fuselage. If this doesn't make sense, refer to the downloaded model.

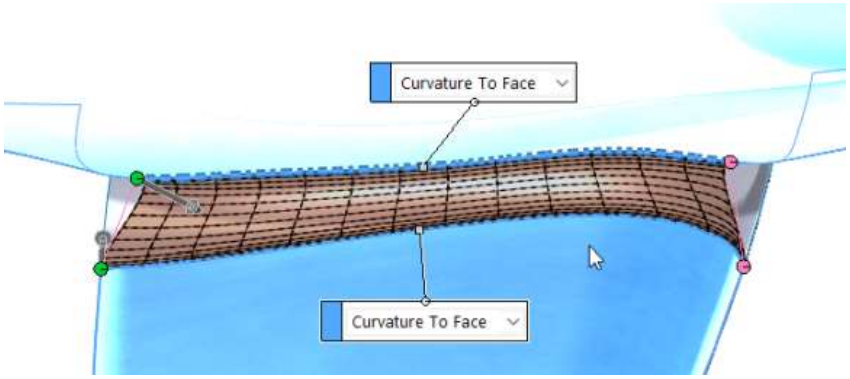


I used one trick after sketching this spline and before trimming the surface. I used Split Entities on it. You can find this at Tools > Sketch Tools > Split Entities. This in effect divides the single spline into multiple splines. It works with other sketch entities as well. I split the 3D spline twice, as shown below, so that the split will create an edge that corresponds to the edge on the wing allowing me to make a blend surface between them.



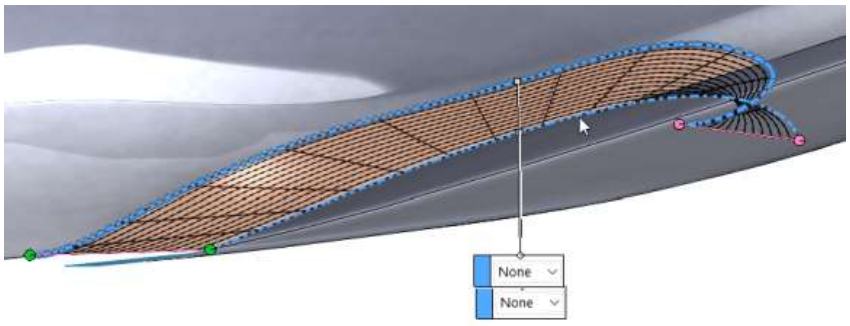
The Split Entities splits can be removed by just clicking on the point where the two splines meet and pressing Delete. The two splines will merge. If you delete both split points, you get the original single 3D spline back.

So at this point you should have the fuselage trimmed by a 3D sketch that either has or doesn't have the Split Entities splits in it. If you have the splits, you can just select the middle section of the edge created by the trim on the fuselage and loft/boundary it to the top edge of the wing, as shown below.



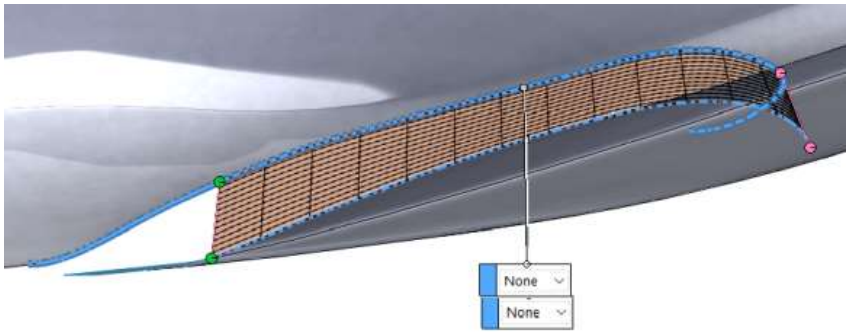
If you have not used the Split Entities, then follow these directions:

When you create a Boundary surface and select the fuselage side, it will select the entire edge. But you only want a portion of the edge. You can use the connectors to drag back the selection to only the portion you want to use. This is important because it gives you a lot of extra power and control when creating features that use connectors like the boundary and the loft features.

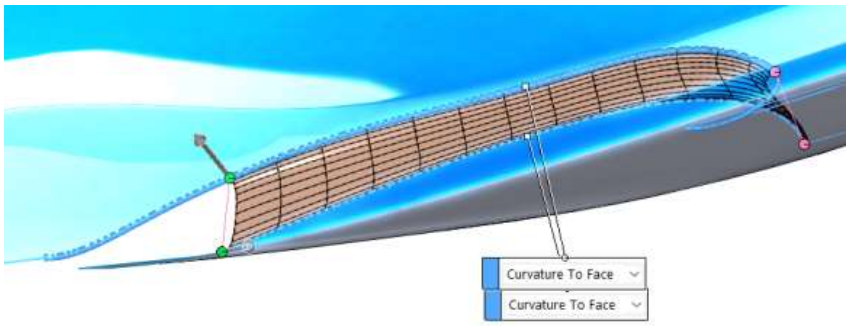


Notice in the image above, on the left side you have two small green dots, and on the right side you have two small pink dots. These are called connectors, and you can use them to straighten out lofts/boundary features, or limit the length of an edge you want to use. In this case, we want to limit the portion of the fuselage edge to use for the blend.

So do this. Drag the green dot on the fuselage to approximately the position where the Split Entities point would be – to limit the left side of the fuselage blend edge. The drag the pink dot on the fuselage edge back as well. The result should look like below.



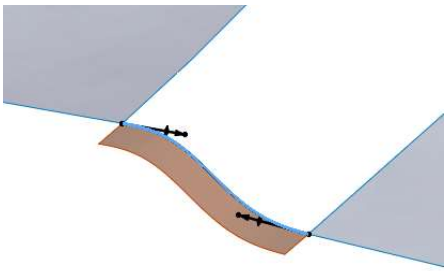
And next apply the Curvature condition to both edges. (If the tangency/curvature goes the wrong direction, use the black/white arrow symbol to flip the direction).



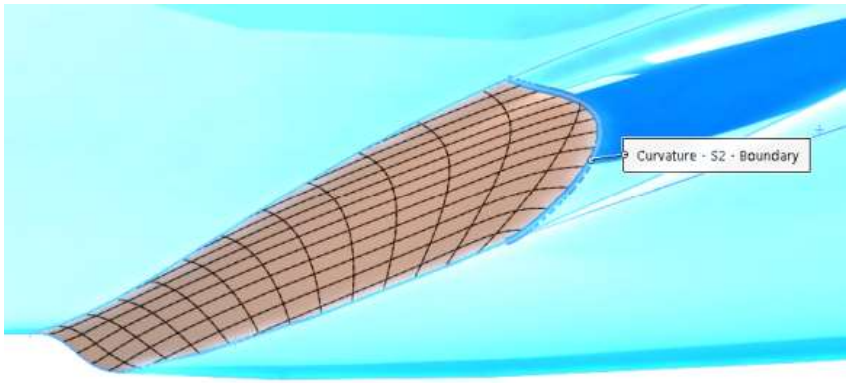
Now you might notice (if you did not use the Split Entities method) that the edge on the fuselage is still a single continuous edge. To make the rest of the blends, you need a front and back area of the fuselage edge. The way to get that is to use Knit to knit the fuselage to the blend surface. So go ahead and do that.

At this point, you should have the same result regardless of which method you used (except that one method will have the first blend surface knitted to the fuselage, and the other will just have an independent body for the first blend surface).

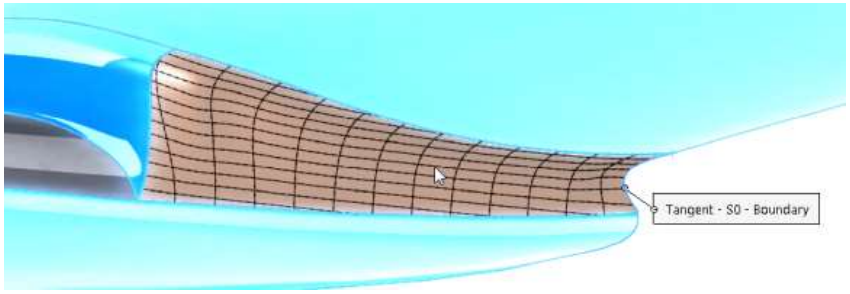
Now zoom up to the place where the trailing edge of the wing is close to the trimmed area of the fuselage. The wing should be slightly lower than the fuselage. Draw a simple two point spline to blend between the two edges, and extrude that spline a short distance as shown to the right.



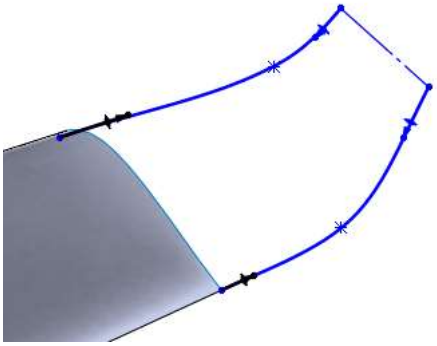
Next use a Fill surface to fill in this blend area.



You can do the same sort of procedure to fill in the blend area in the front of the wing.

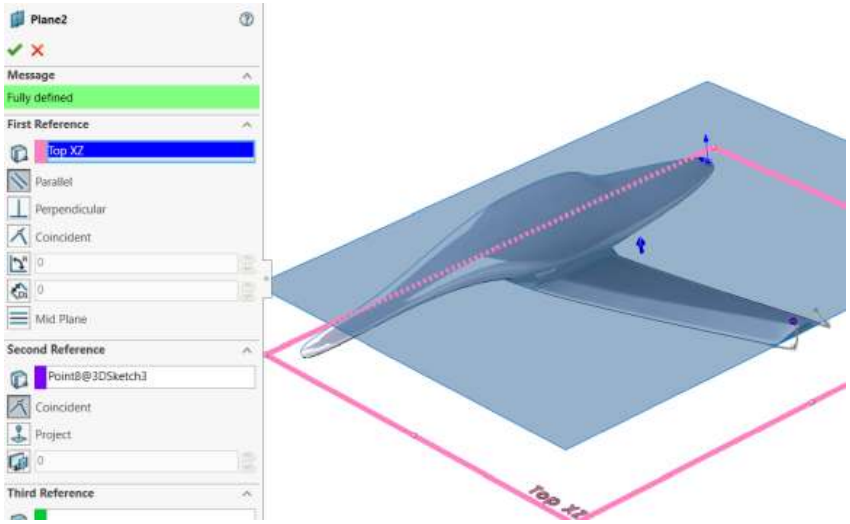


Next, at the tip of the wing, we want to create a little winglet, or curved tip for the wing. Start with a 3D sketch extending the edges of the wing in a natural-looking curvature and distance.

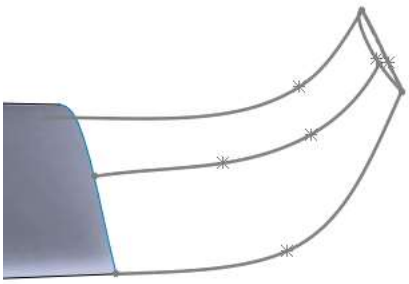


Doing this in a 3D sketch can be hard to judge, so create reference geometry and dimensions where ever you can or need to. Draw both splines in a single 3D sketch, and use the construction line to align the points along the Z axis.

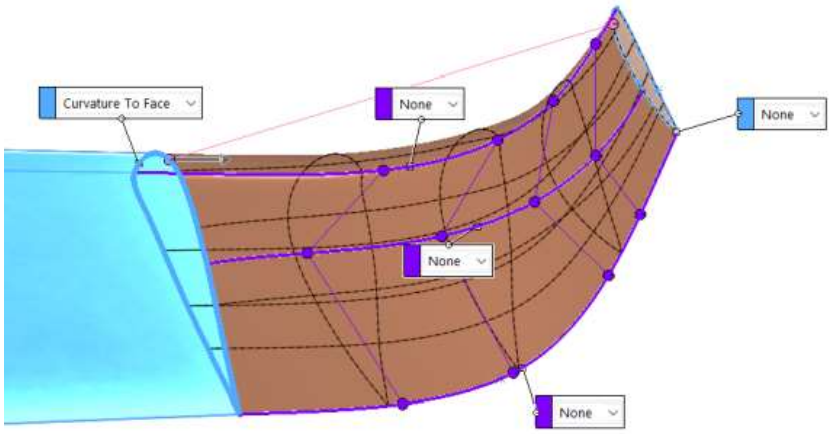
Next, create a plane parallel to the Top plane that touches both of the spline endpoints.



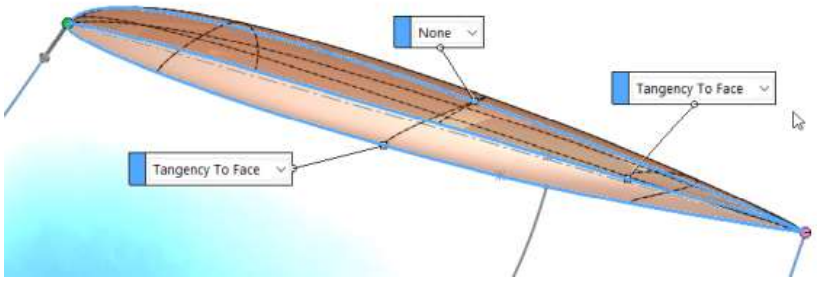
Sketch another airfoil shape on the new plane, and connect leading and trailing edges to the 3D splines. You may need to add a third 3D spline to drive the shape for the wing tip feature properly.



Create a new Boundary surface to merge the wing tip with the rest of the wing smoothly.



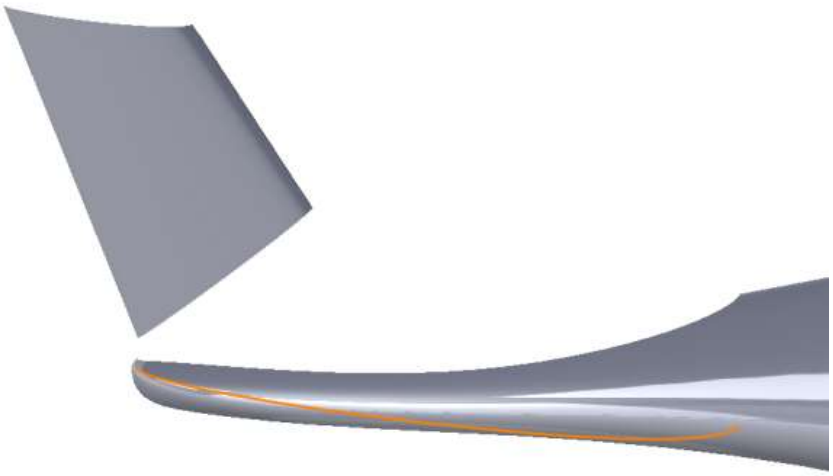
Then to cover the end of the wing tip, create a 3D spline that goes from leading edge to trailing edge and creates a little mound over the opening. Use a Boundary surface to complete the shape. Alternately, you could use a Fill surface here, and avoid another degenerate feature.



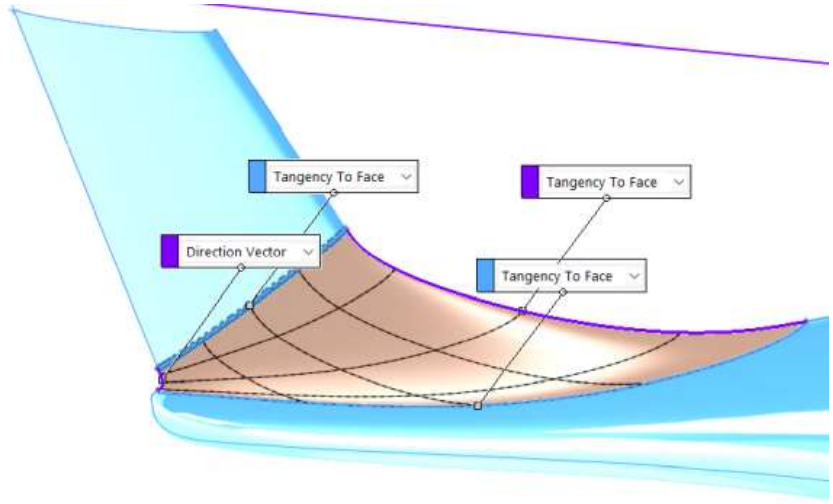
Every now and then take a step back and look at your work. This may save you some big picture editing later on, which is always the most expensive.

The next step is to attach the tail. The orange sketch below was used to trim out part of the fuselage to fit the tail. The upright tail section was created from a sketch layout, and then a couple of planes, more sketches, and a loft. At this point you should be able to

figure out how all of these work. You can refer to the downloaded part file and the movie to help get the idea of how this was done.



Connecting the two should also now be easy with a boundary surface.



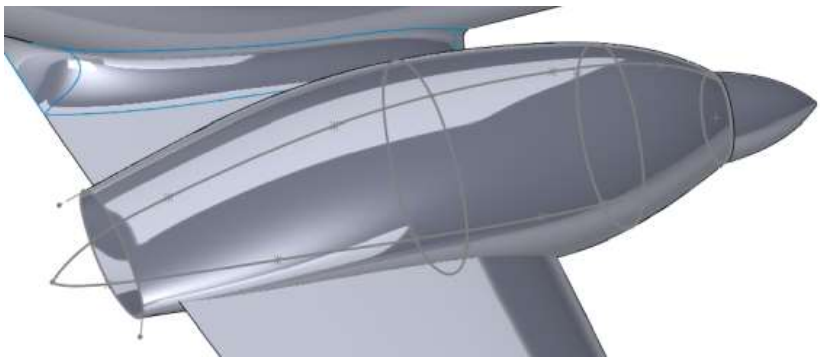
The horizontal surfaces of the tail are created just like the main wing.

Here we have a video for modeling the first half of the plane.

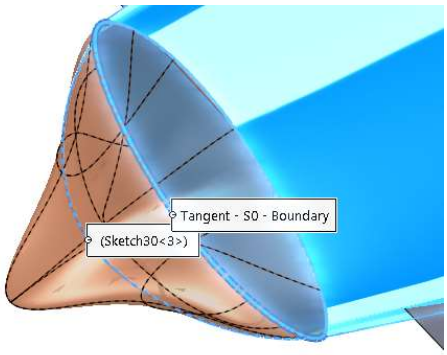
0:00 / 14:12

Next we proceed to the propeller and motor. These are located using the layout sketches and sketch pictures. I used a plane offset from the Right plane to locate the centerline of the propeller and the engine. The first feature is the propeller cone, a simple revolve.

Then the motor cowling is laid out and created with a boundary surface. The rounded off end cap remains.



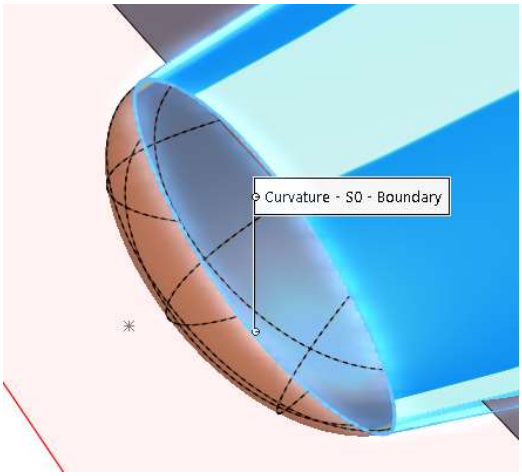
To cap off the engine cowl, since we've been making a lot of degenerate surfaces, I thought we might try to avoid that this once. So here we go with a Fill feature with a constraint curve.



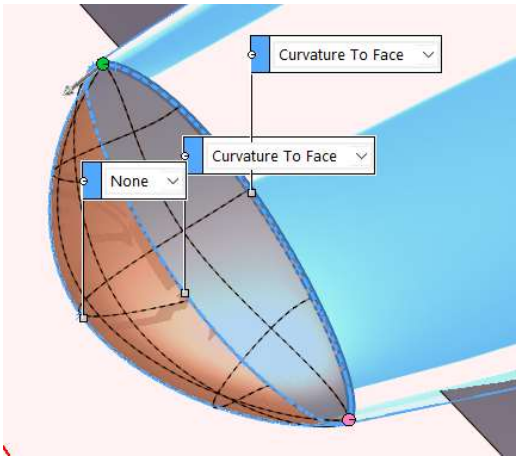
I tried the Fill surface with a 3D sketch point as the constraint, and then a 2D sketch point. Neither one worked. Without a constraint curve at all, it worked, but it didn't do what I wanted it to do.

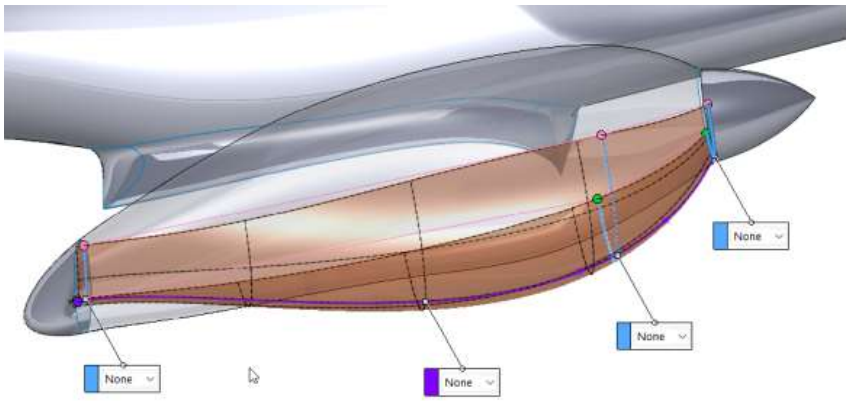
So the only thing that was left was to go back to the Boundary feature, and degenerate

geometry.

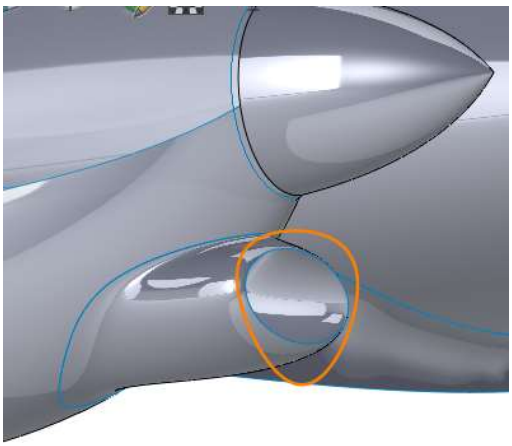


The bottom cowl for the engine is easy to make, but takes some time to set up with a few planes and sketches. This might be more complex if you had some real requirements that it had to fit into, but as we're just creating a plane for looks here, it's pretty easy. I've hidden some parts and made others transparent for visualization sake here.





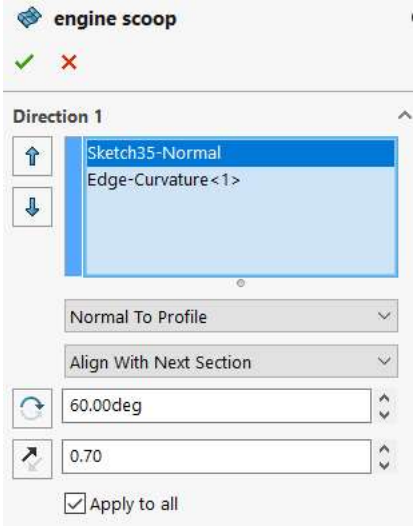
This next one is maybe a little tricky. I'll be using a setting as a part of the Boundary surface that we haven't used before.



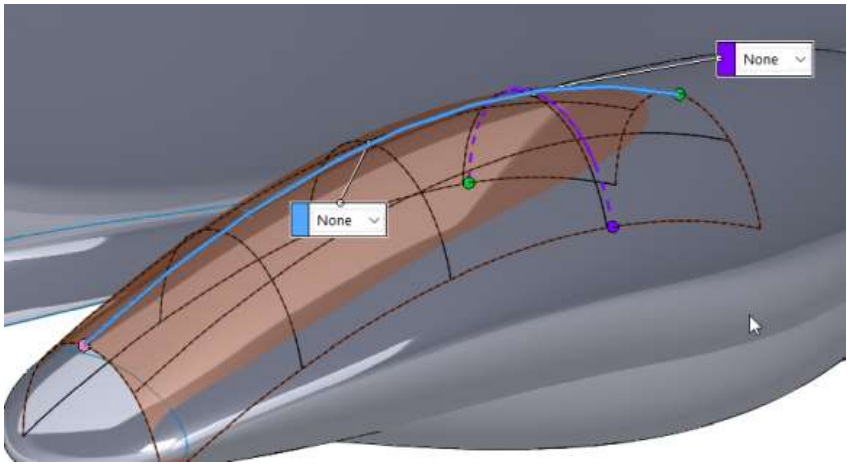
First, we start with trimming out a section of the lower cowl that we just created with a sketch.

And then create an elliptical sketch. Believe it or not, the air scoop shape is just created from one sketch and the trimmed edge. The slightly rounded shape at the opening of the air scoop is created by the Draft Angle setting for the first Direction 1 curve and the reduced tangent length or

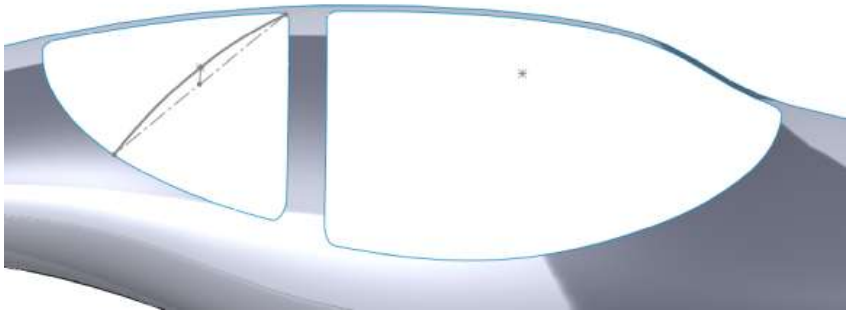
weighting. This might be an unorthodox application for these settings, but the combination is certainly effective in this situation, and useful for simplifying setup curves in many cases.



The exhaust for the engine is again another simple surface. We've spoken of Boundary sketch arrangements before, and this time we have an X, with two perpendicular curves.



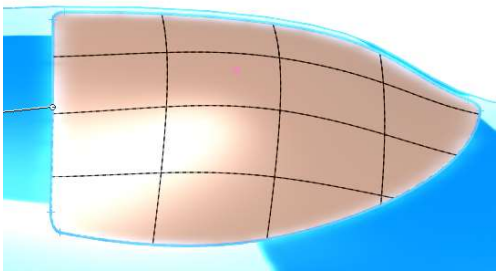
Without getting bogged down in too much detail, I want to move forward into the cockpit area. First we trim out the areas for the glass. I want to add some shape to the glass that isn't in the original fuselage shape. This may be bad for aerodynamics, but I want to show how to use some of these options with the Fill feature.



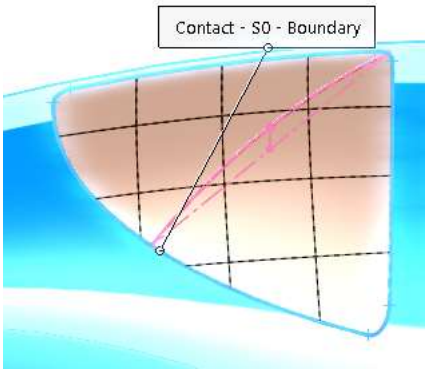
You could choose to set up these 3D sketches before you trim out the cockpit areas, or not. To get good with 3D surfaces and visualization, you have to have a good grasp on 3D sketching, even freehand 3D sketching.

In one case I just placed a point a couple of inches above where the fuselage surface would have been, approximately in the middle of the trimmed area. None of this is exactly measured and it's certainly not driven parametrically. The second option is more controlled than the first, however. Just placing that point in the front cockpit area involves rotating the view a lot. I do this with a 3D Connexion Space Pilot. Very nice device, and indispensable for 3D work.

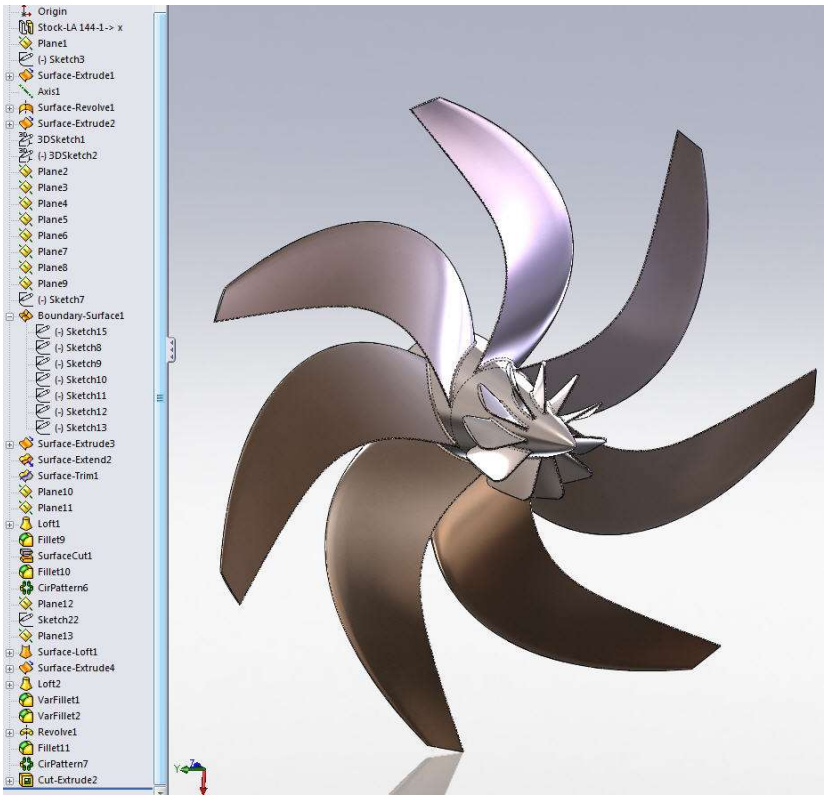
Next, you just create a Fill surface, and use that point as the Constraint Curve. It's a nice way to add a bulge to a surface.



In the back, I used a larger curve, less free form, more controlled, going all the way across. Notice that this one isn't tangent to the sides, but the bulge is more gradual, and more controlled.



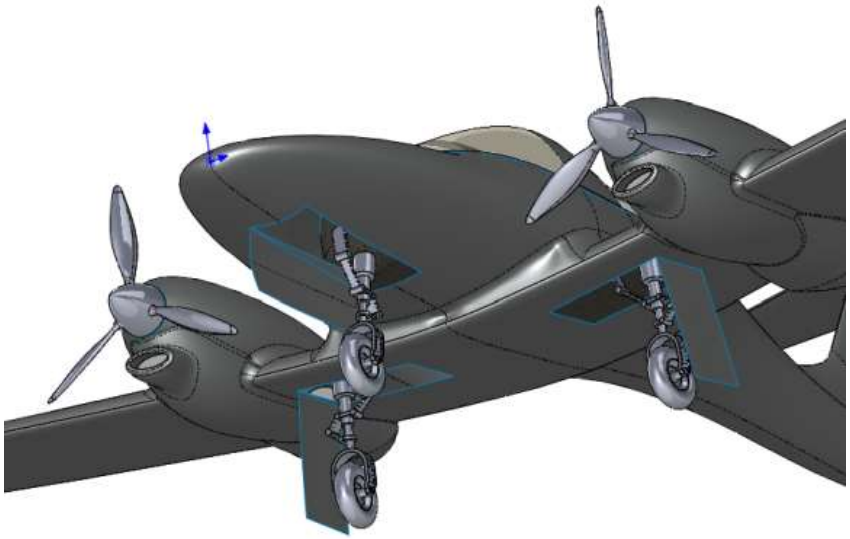
I imported some geometry for this model. The propeller was one model that I brought in from elsewhere, and the interior seats were another one. This enables you to place the geometry as a body where ever you like.



If you are looking for some tips on how to model a propeller in SolidWorks, I held a propeller modeling challenge on my blog almost a decade ago, and there are 14 models most of which you can still download and examine. Everything from the simple to the very complex.

The landing gear on the bottom is all pretty straight forward solid modeling, with some body mirroring, patterning, and positioning.

The panels covering the landing gear were slightly more difficult. The panels were first Split from the rest of the model, and then I used Move/Copy Body to rotate them into position.



Leave a comment with a link to your model or a screen capture of what you've done. If you have questions, also feel free to leave questions in the comments or email me directly.

I've also got a movie for this second part of the model, and a link if you want to download the plane model itself. plane.SLDPRT

0:00 / 15:33

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