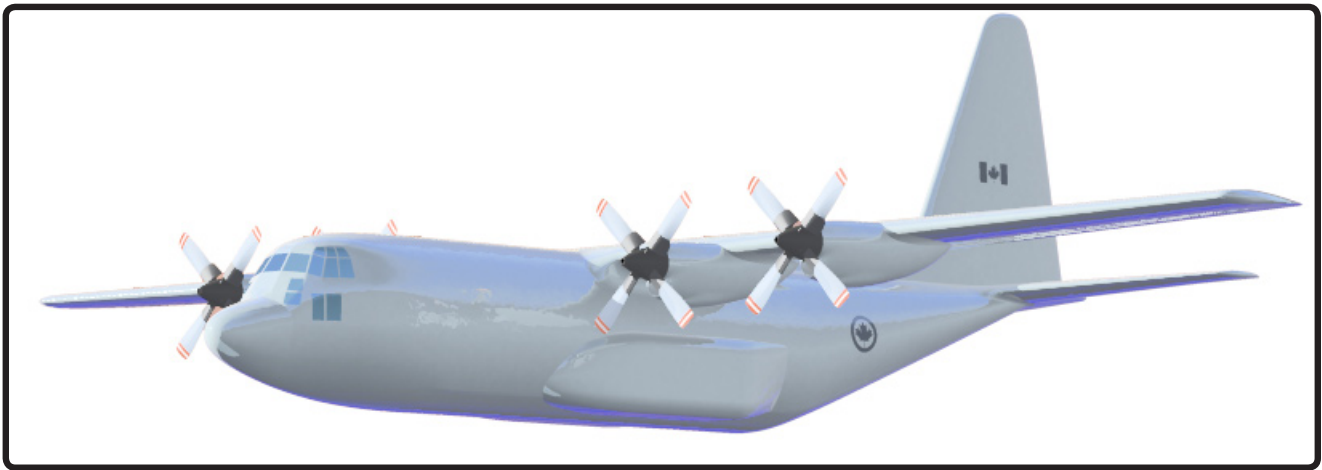


Form vs. Shape 2

James Carruthers



Advanced 3D Modeling with
Rhinoceros®
NURBS modeling for Windows

Version 4 Edition
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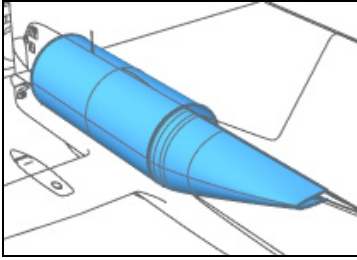
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Introduction

What we'll be creating here is a C-130 Hercules or 'Herk' (not Herc,) loosely an 'H' model. The level of detail isn't extremely high, it's just a 'shell' of the outer form. Now that this a tutorial about NRUBS surface modeling, not aircraft design, this will-not fly! The focus here is on complex, high-quality freeform surfacing, we will try not to dwell on details that are merely time-consuming.

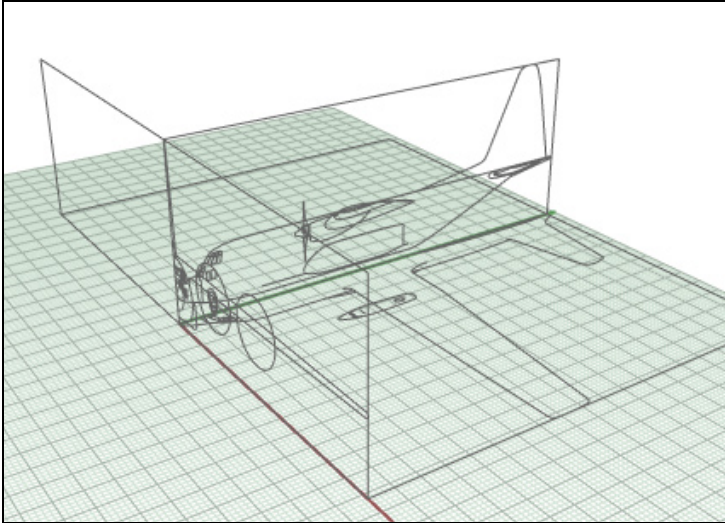
This is an "advanced" tutorial. It is designed to be easy to follow, but the emphasis here is on what NURBS and Rhinoceros can do, not necessarily how to execute every command prompt-by-prompt. Commands are referred to by the name used for typed entry and are ***Highlighted***.

Included with this tutorial are a [Printable PDF version](#), as well as 3D models from the completion of each section.



Fuselage 1

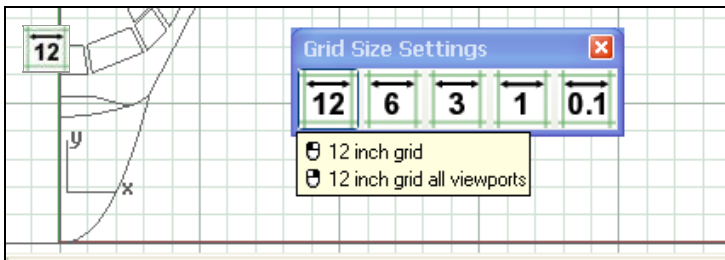
Main Fuselage Section



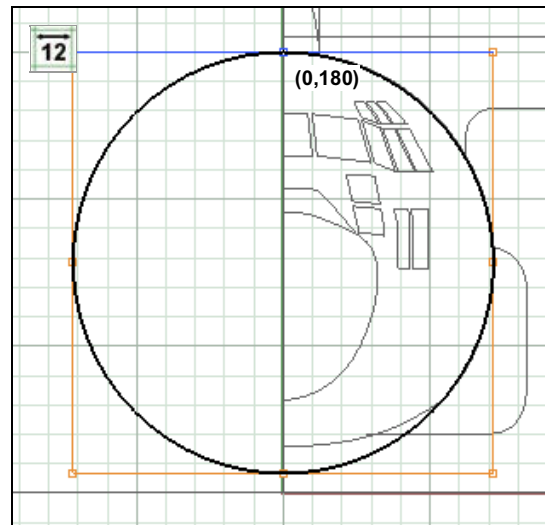
1. Start a **New** file. This model was designed with these Units settings:

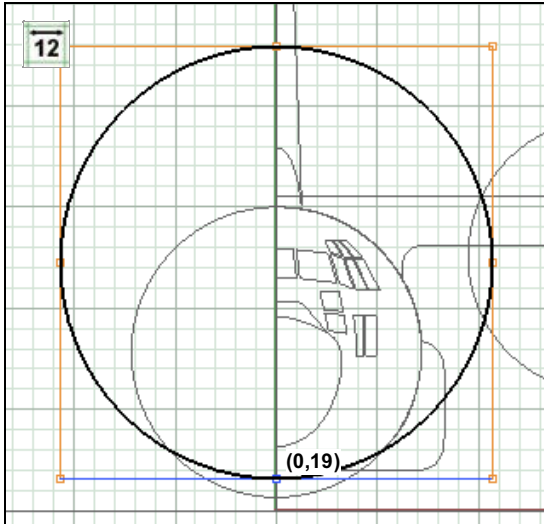
Model Units: Inches
Absolute Tolerance: 0.001
Angle Tolerance: 0.1

The original distribution included a file with some background geometry, and a custom toolbar file with shortcuts for different grid sizes. You can email a request for the files if needed.



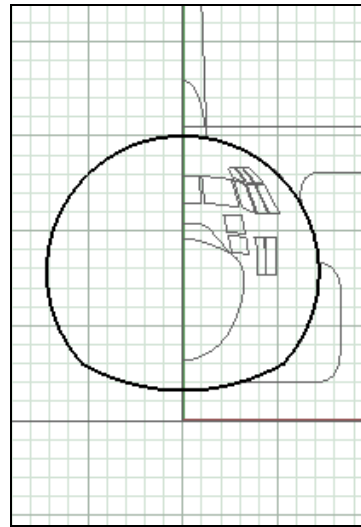
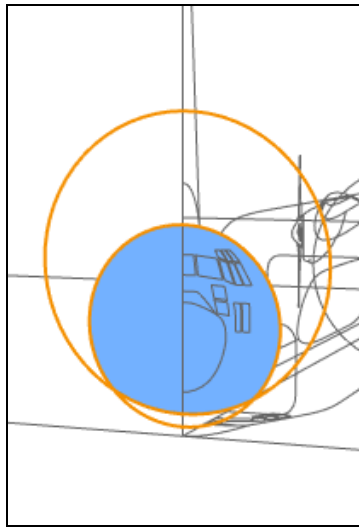
3. We'll begin with the main straight fuselage section. It's a combination of two circles. In the Front view draw a **Circle** using the **2Point** (diameter) option. Locate the first point at the top of the fuselage, 180 units up from the origin, then enter a value of **172** to set the diameter and pick the bottom point.





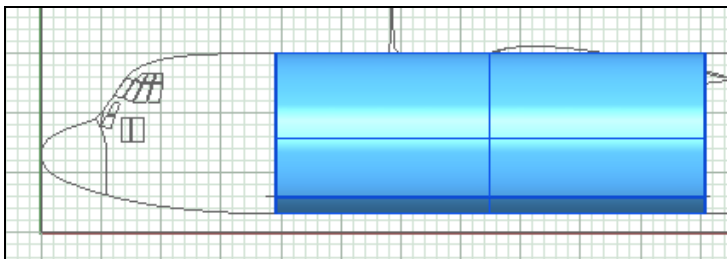
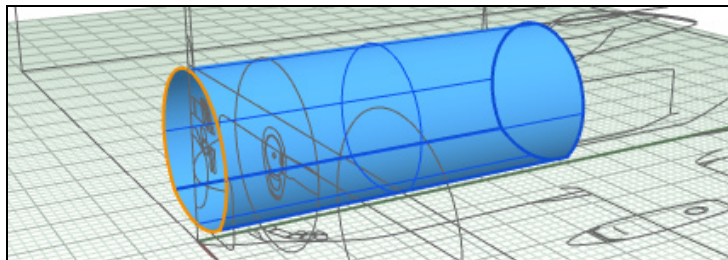
4. Draw a second **Circle** the same way, placing the first point at the bottom of the fuselage, 19 units up from the origin. Make it's diameter **256**.

5. Combine the circles using **CurveBoolean**. At the *Click inside regions to keep* prompt, pick inside the common area of the the two circles. Set *DeleteInput* to **All**.



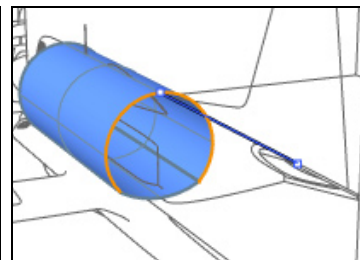
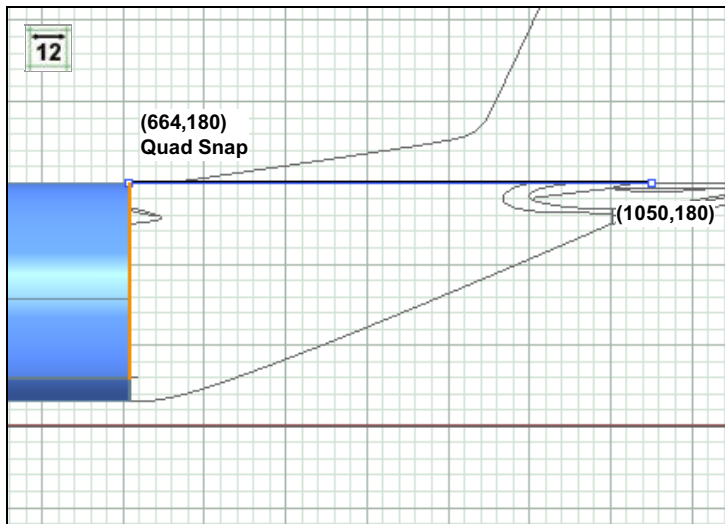
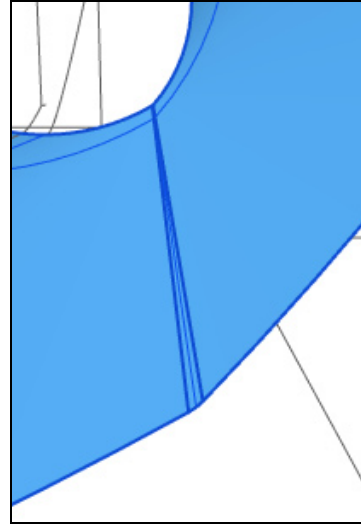
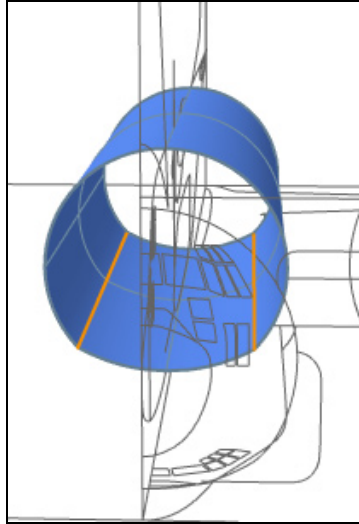
6. **ExtrudeCrv** the fuse section a distance of **429** units.

7. You can **Delete** the fuse section curve.

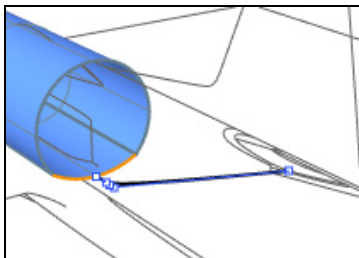


8. **Move** the fuselage back by **235** units.

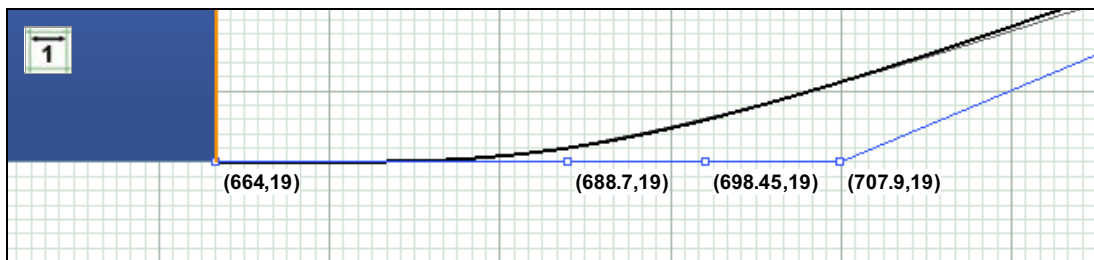
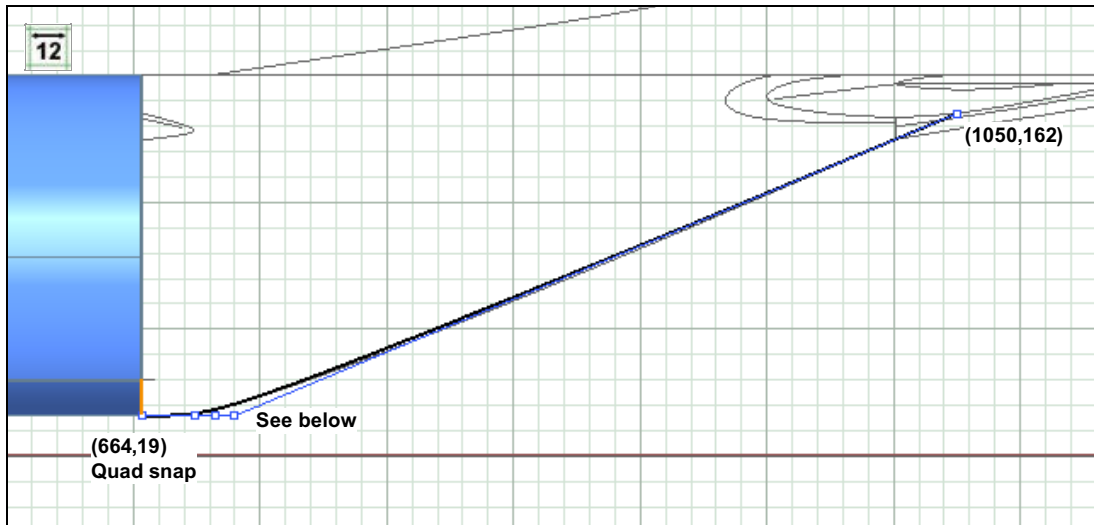
9. FilletEdge the seams between the surfaces of the fuselage with a radius of **1.5**. The default *RailType* of **RollingBall** is what we want.



10. Starting on the aft fuselage, use the **Quad** Osnap to draw a **Line** starting from the top edge of the main fuse and extending back **386** units.

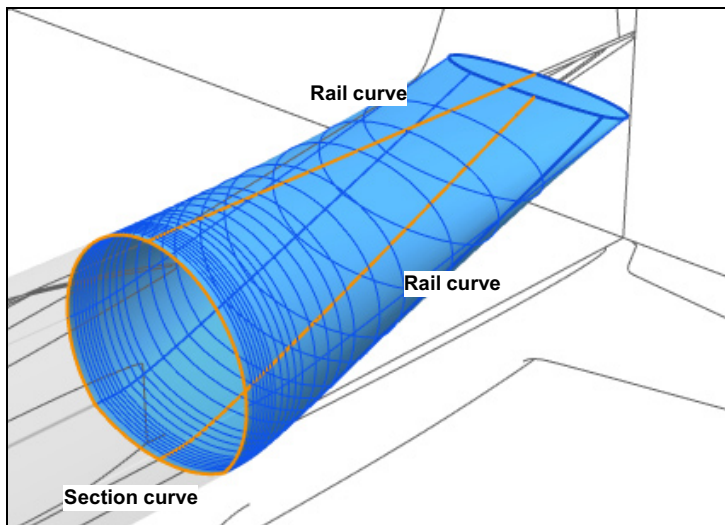
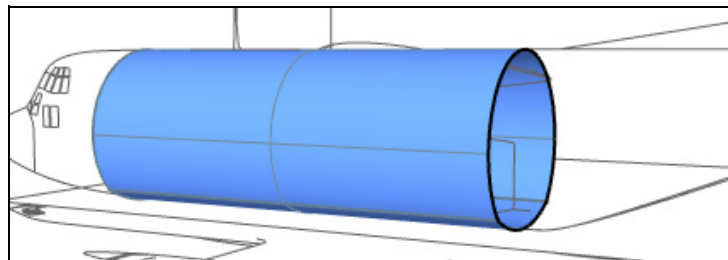


11. Draw a **Curve** starting from the bottom of the fuselage. Use the **Quad** Osnap to snap it to the fuse. It's Degree is 4, since it has 5 points, so set the *Degree* setting to **4** or more. I typically leave it set at **5**.



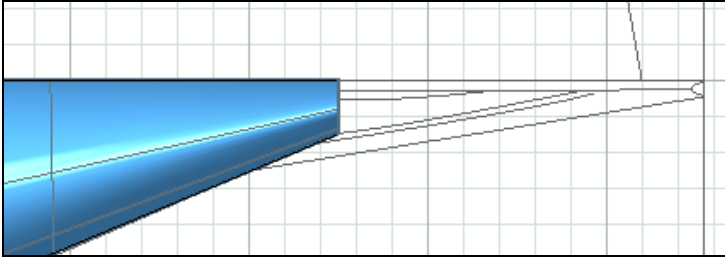
12. Run **DupEdge** and select all the edges around the back end of the main fuselage.

13. **Join** up the extracted curves.



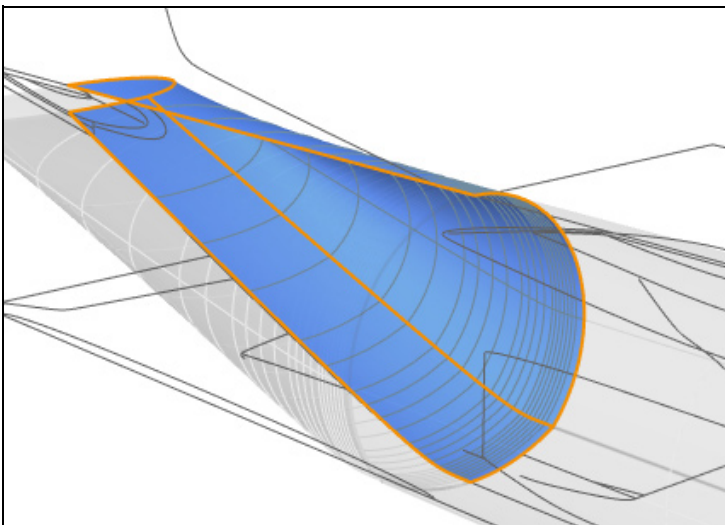
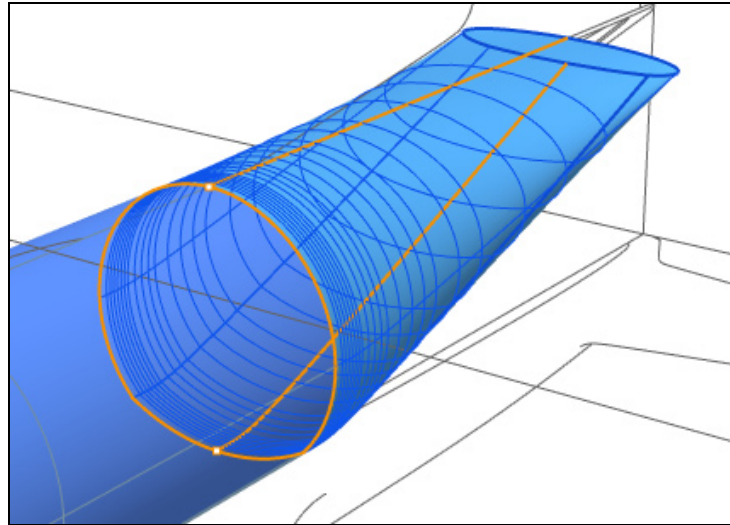
14. Run **Sweep2**, using the drawn curves as the rails and the copied edge curve as the section. Set the *Do not simplify* option and specify *Maintain Height*.

15. You can **Delete** the input curves.

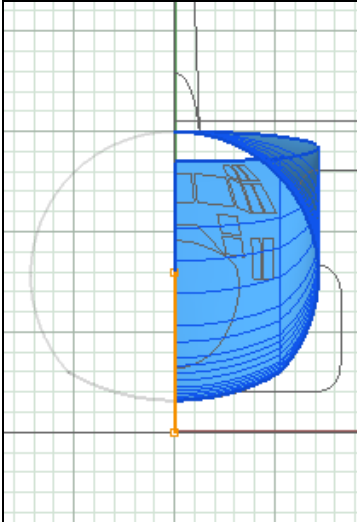


You will note that our aft fuselage surface extends slightly into the tail. That is on purpose. It's easier to trim objects back later on than to extend them if they turn out too short

16. The editing we'll be doing now is simpler if we just work on half the aft fuse, so run **Split** using the **Isocurve** option, and with **Shrink** set to **Yes**. Split the fuselage in half, using the **Quad** Osnap to snap to the top and bottom of the main fuselage.

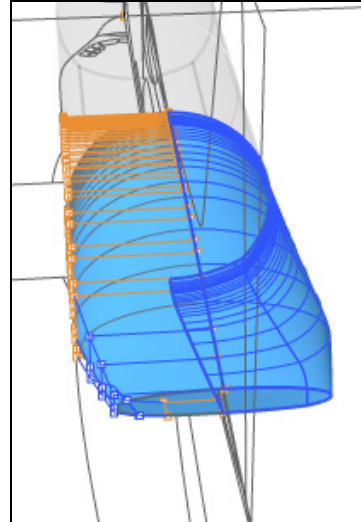


17. It is likely that the split will produce three surfaces, as the seam of the aft fuselage was placed at the seam between the sections of the main fuse. **Delete** the half in two surfaces.



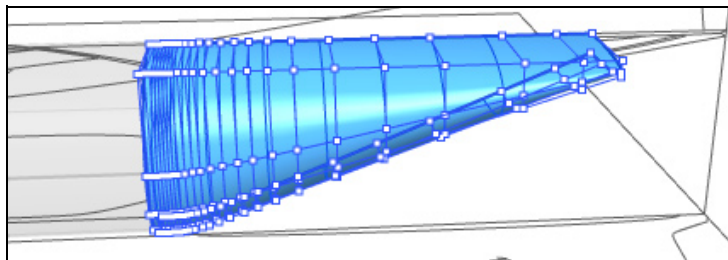
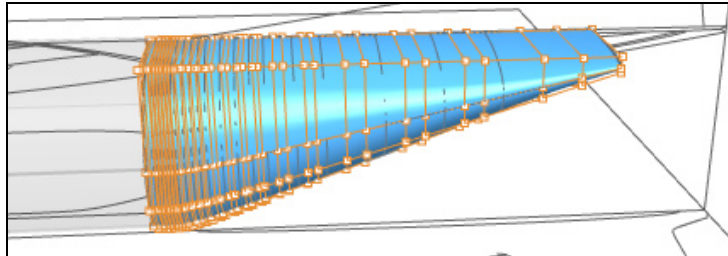
18. If the remaining half is on the right side of the aircraft (from the pilot's point of view,) switch it over to the left using **Mirror** with **Copy** set to **No**.

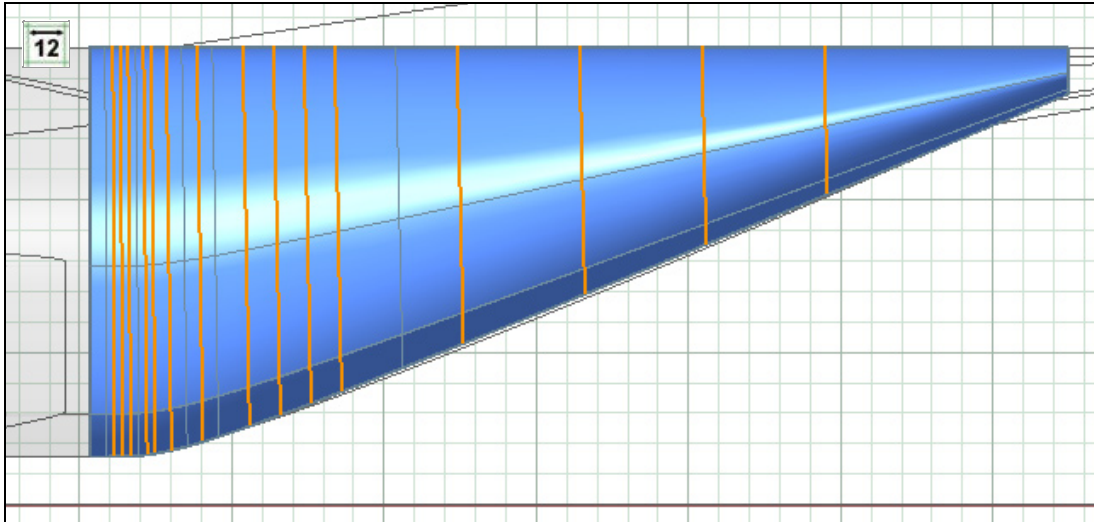
It is possible to work on both halves at once using construction history. Simply run **Mirror** with **History** enabled via the status bar button. To keep the screen shots clearer, in this tutorial objects will simply be mirrored after construction.



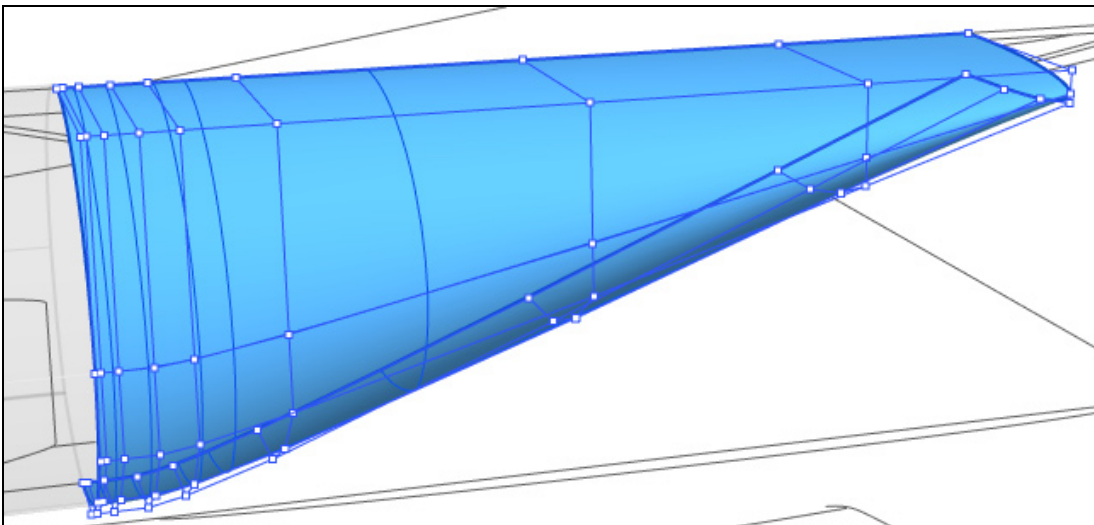
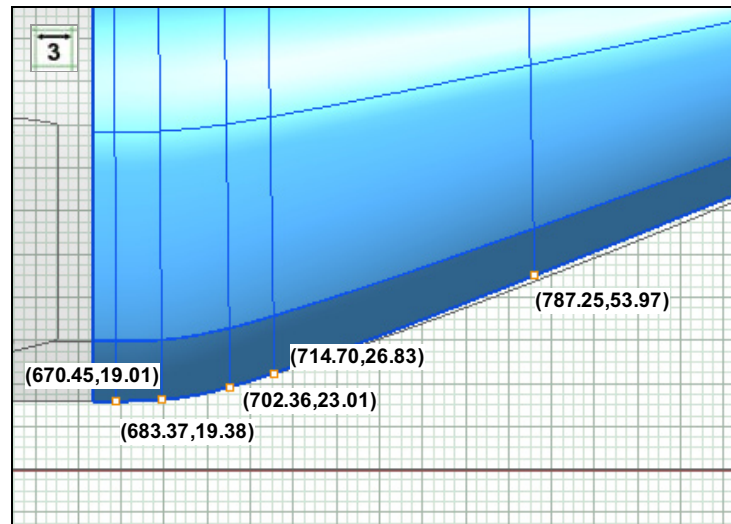
19. Now we're going to simplify the aft surface for point-editing. Run **RemoveMultiKnotSrf** on it.

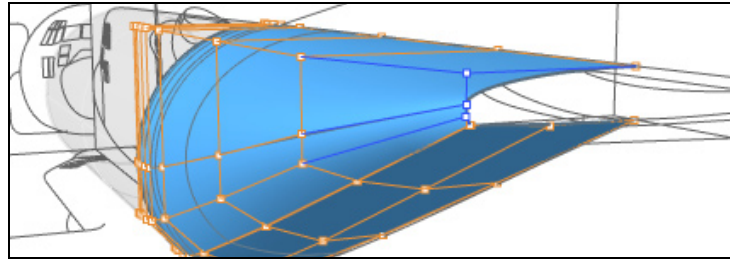
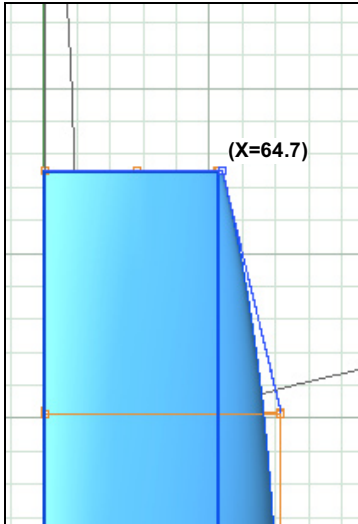
Sweep2 normally creates surfaces where knots are stacked on top of the other, **RemoveMultiKnotSrf** removes the duplicates. You'll notice that removing these knots and reducing the point count doesn't appear to change the surface, but it does slightly.



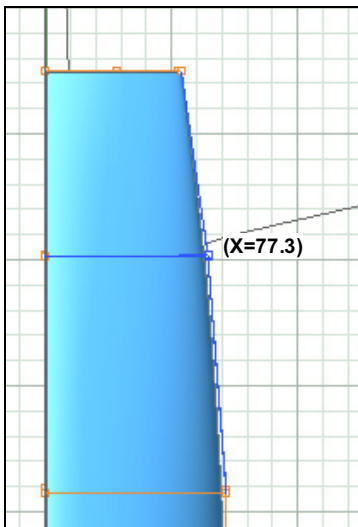


20. Remove knots along the length of the surface with **RemoveKnot**. Remove most of them, until there are only 5 left (aside from the start and end.) The coordinates at Right were taken from the end points of the knots to keep. Your surface may not be absolutely identical, but it should be very close, and the control point structure will look like below.

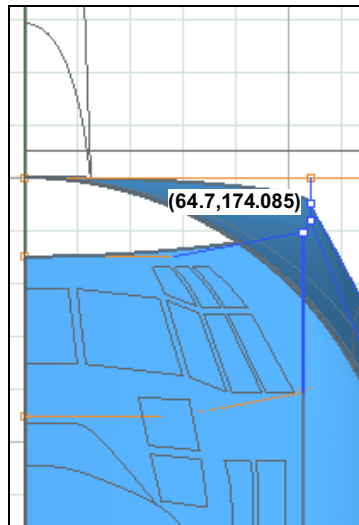
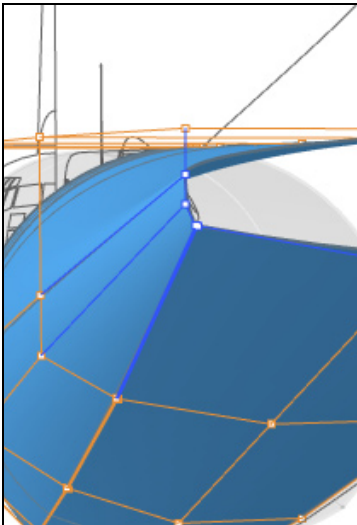
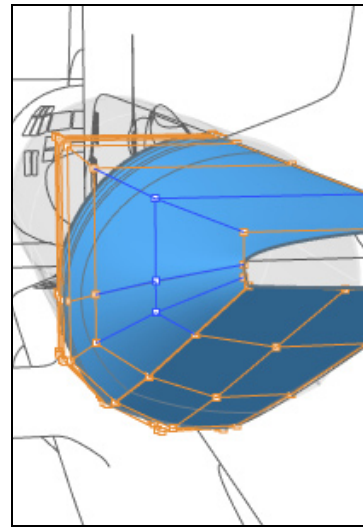




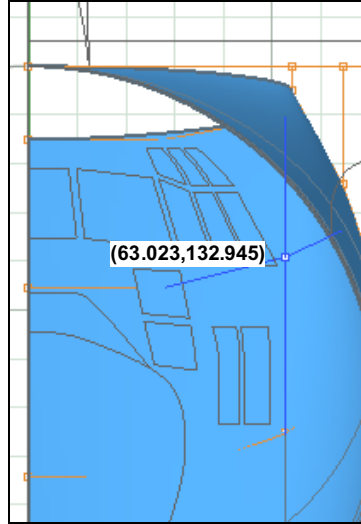
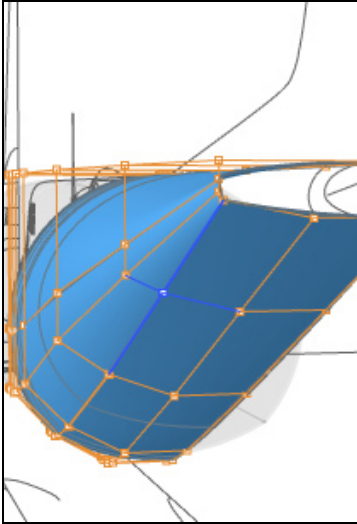
21. To start tapering the fuselage, select three points on the end of the aft fuse and move them in by **21.3** units. Use the **Move** command or point-nudging. The coordinates at left are of a representative point, after moving.



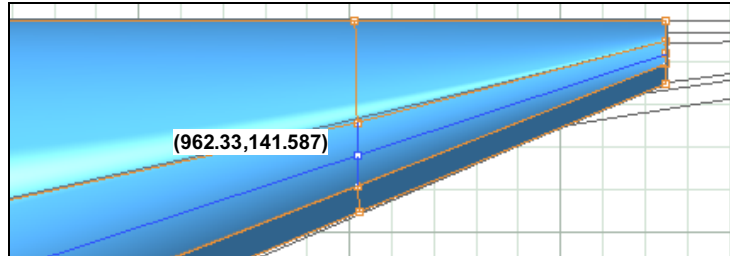
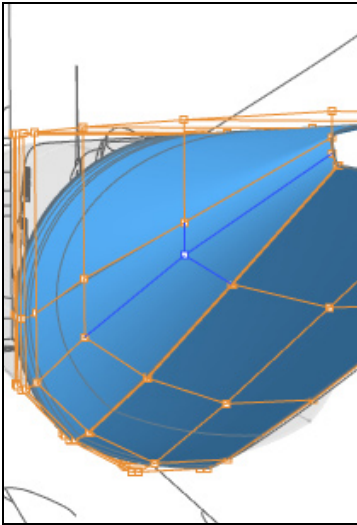
22. Move down a row, in my case **PrevU** worked so yours should be the same, and move three points in by **8.7** units.



23. Go back to the end row of points, select these five—there are three tightly packed about the seam between the fuse sections—and move them up by **3.7** units.

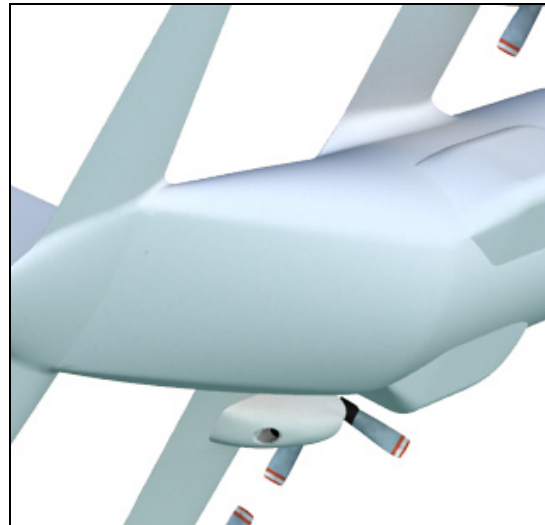


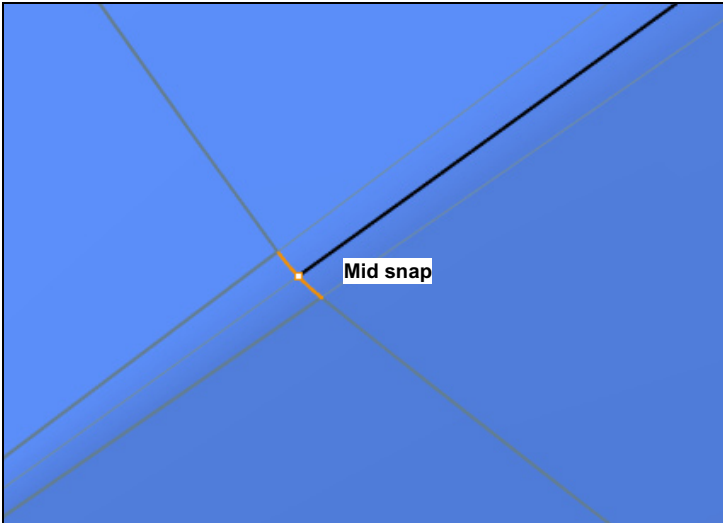
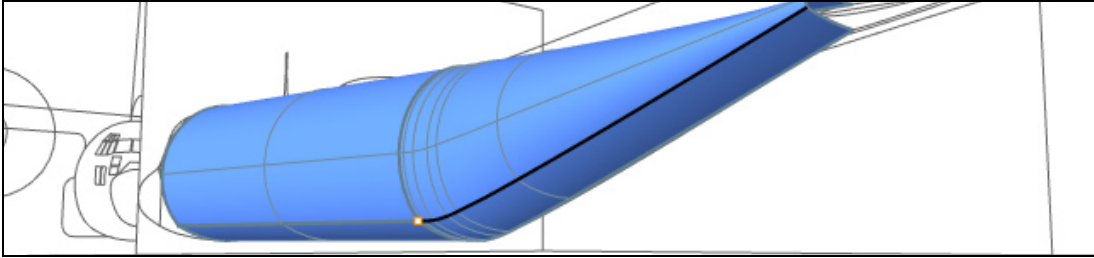
24. Select the three tightly grouped points in the next row and adjust them up by **1.8** units.



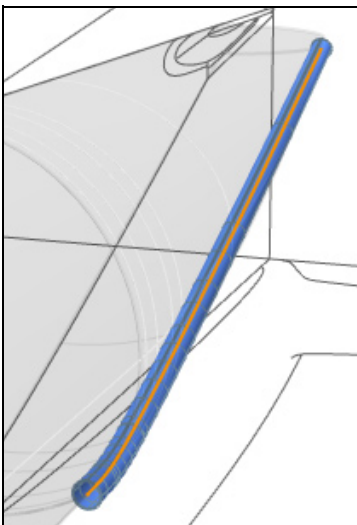
25. Pick the next point up from those three and move it up **2** units.

The sharp crease between the two circles that make up the main fuselage section is not so visible on the aft fuselage here, so we'll soften it up.



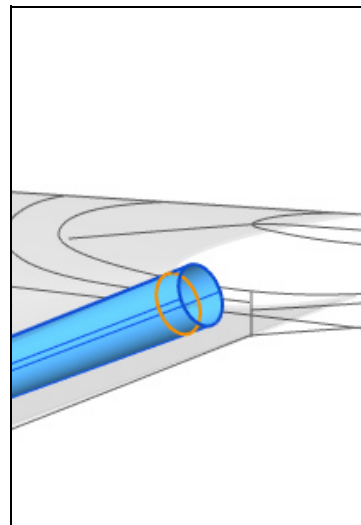


26. Use **ExtractIsocurve** to grab a curve along the aft fuselage, at the midpoint of the fillet between the main fuse section, with the **Mid** Osnap.

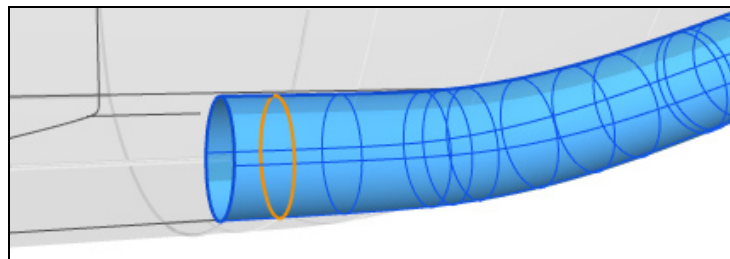


27. Build a **Pipe** around the extracted curve with a constant **Radius** of **6** units.

28. Run **ExtendSrf** with the **Type** set to **Smooth**, and extend the back end of the pipe with an **Extension factor** of **5**.

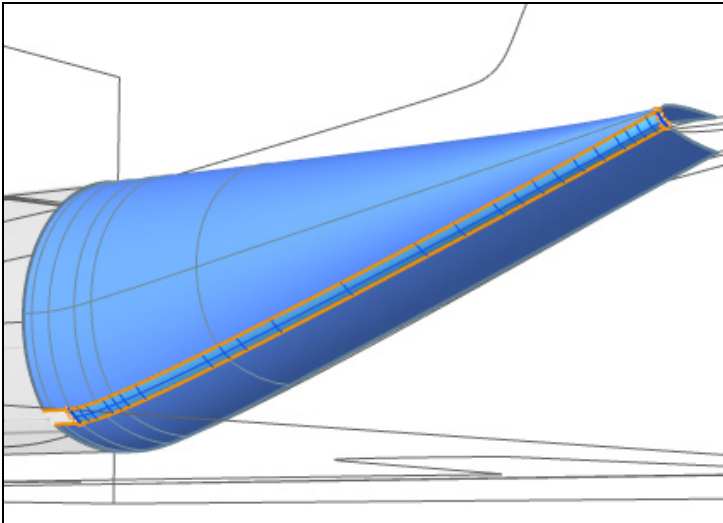
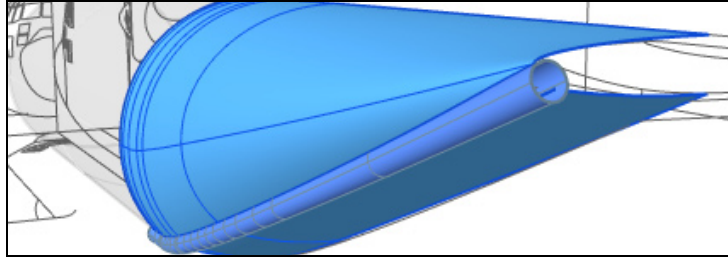


29. It will be necessary to repeat the **ExtendSrf** procedure on the front end of the pipe.



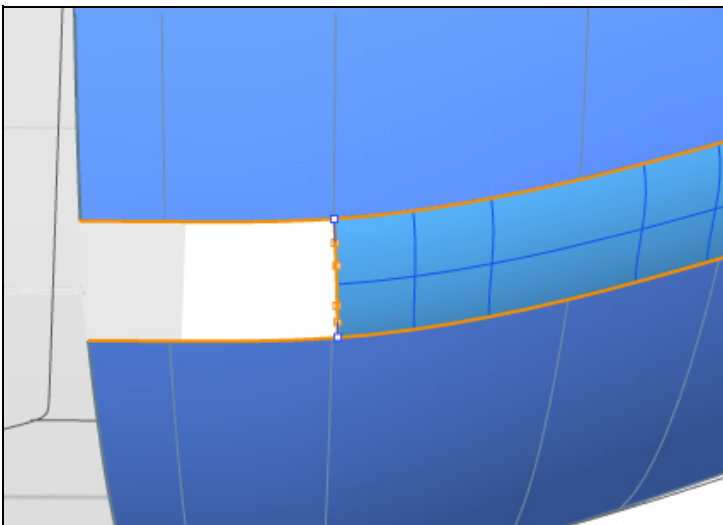
30. Trim a gap out of the aft fuselage using the pipe.

31. Delete the pipe and the curve used to make it.

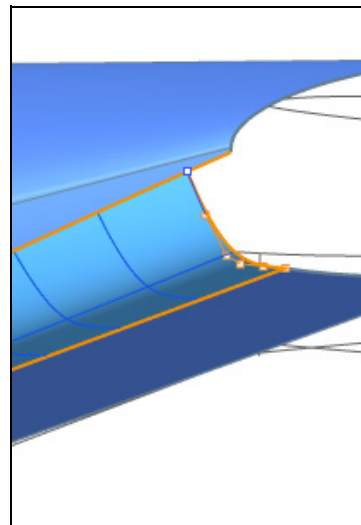


32. Build a *BlendSrf* between the fuse pieces. We want to leave a gap at the front to build a transition surface, which you can do inside the command by simply grabbing the end points of the blend surface and dragging them.

Unless otherwise noted in this tutorial specify **G2 Continuity** on both edges in **BlendSrf** operations, and leave or set the **Blend bulge** at it's default value of **1.0**.

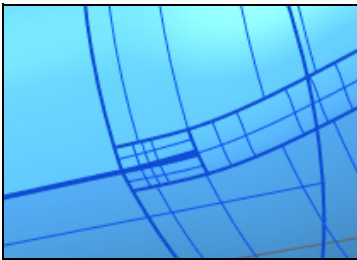
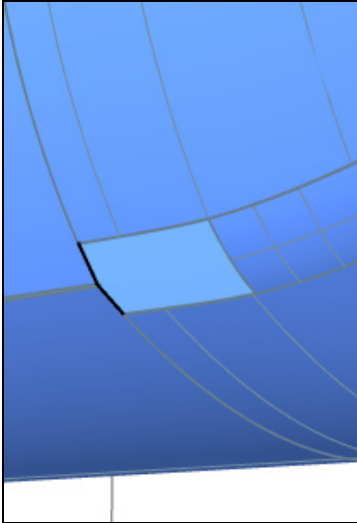
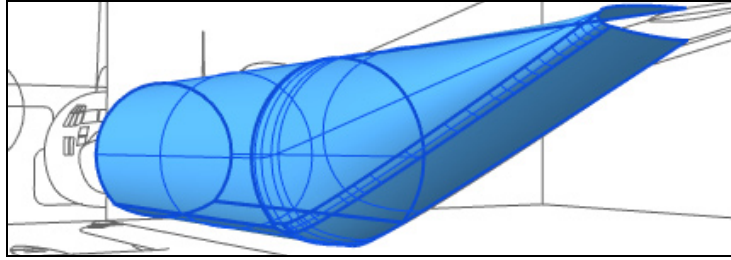


At the front, move the edges of the blend back until approximately the second isocurve. Note that one side was placed at the line while the other was placed to make the section straight.



At the other end, adjust one side of the blend to straighten out the section.

33. Join up the fuselage surfaces.

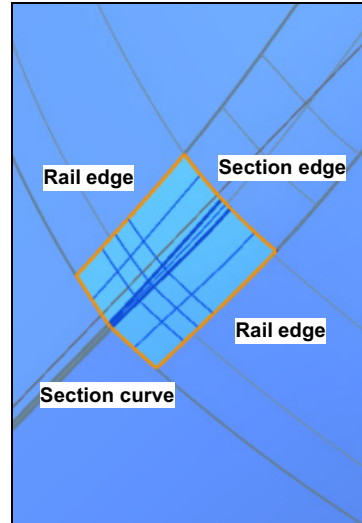


34. To make the transition surface, first **DupEdge** three edge curves from the main fuse.

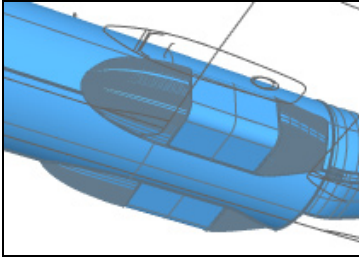
35. Join up the curves.

36. Fill in the hole using **Sweep2**. Set **Simplify** to **Do not simplify**. It's not necessary to specify continuity options to get a surface that's adequately smoothly connected to all the edges.

37. Delete the edge curve.

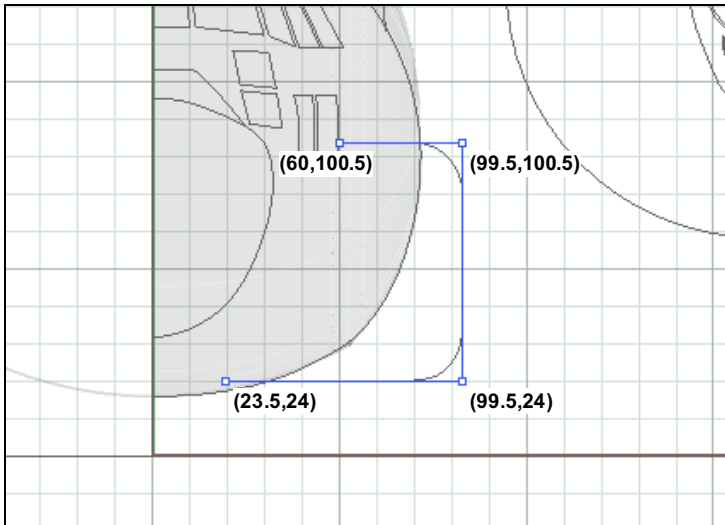


38. Join the swept surface to the fuse.



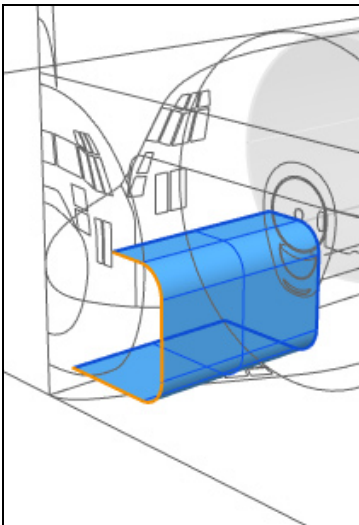
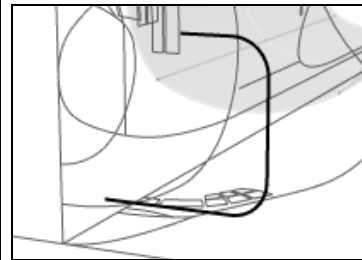
Fuselage 2

Side Pods



1. Draw a **PolyLine** in the Front view.

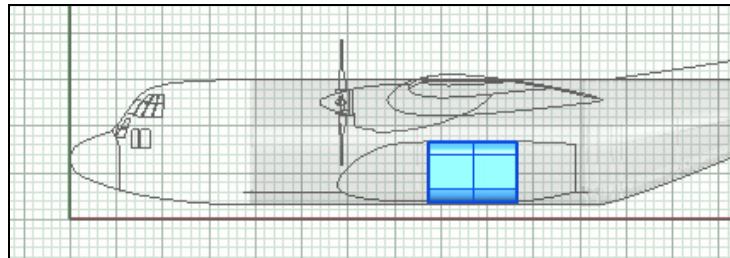
2. **Fillet** the corners of the polyline with a **Radius** of **16**. Set the **Join** and **Trim** options to **Yes**.



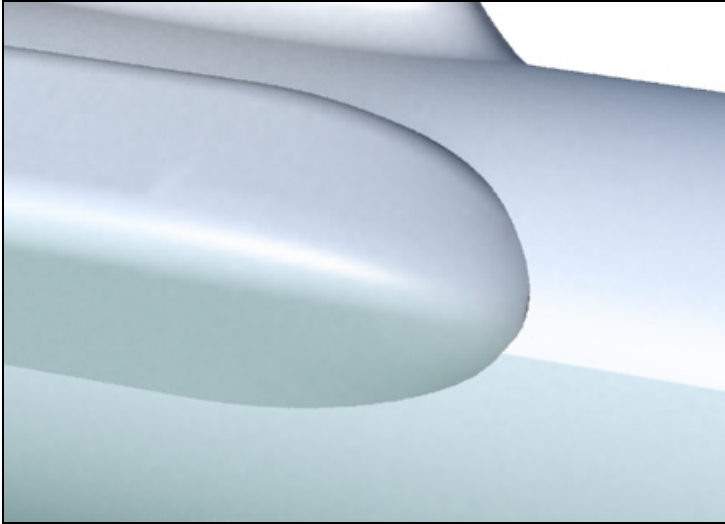
3. **Extrude** the polyline by **114** units.

4. **Delete** the curve.

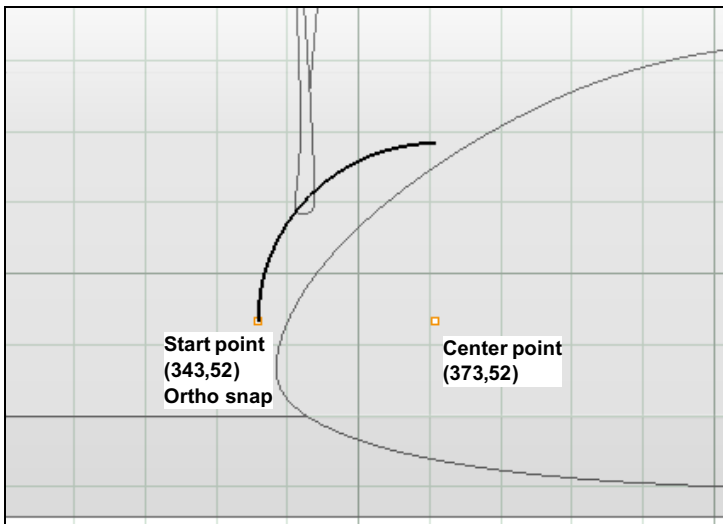
5. **Move** the extruded surface back by **464.5** units.



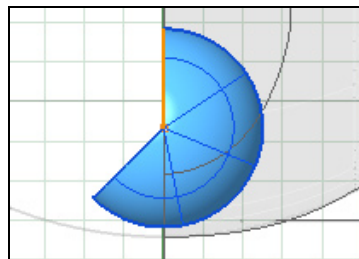
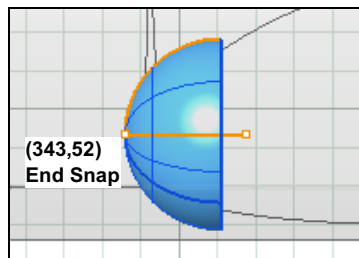
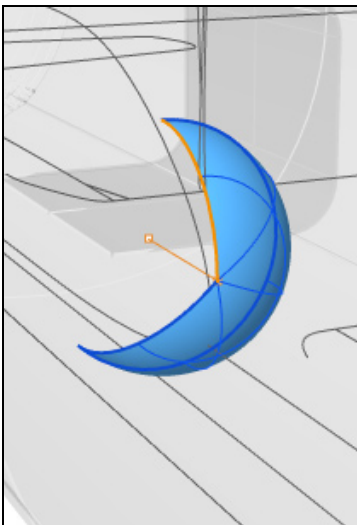
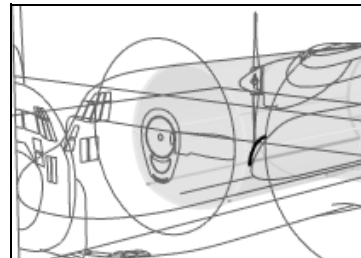
As you may notice my general preference is to create objects, the starting points for them anyway, using the default construction planes and then move them into place, rather than creating custom construction planes. I prefer to not have to think about managing things in the model that aren't actual geometry.



The front area of the side pod transitions from what seems to be the rounded-off rectangle of the main section to the tip which seems to be more or less spherical, if you imagine it continuing inside the fuselage. So, we're going to make a sphere—part of one anyway—then deform it to match up to the main section.



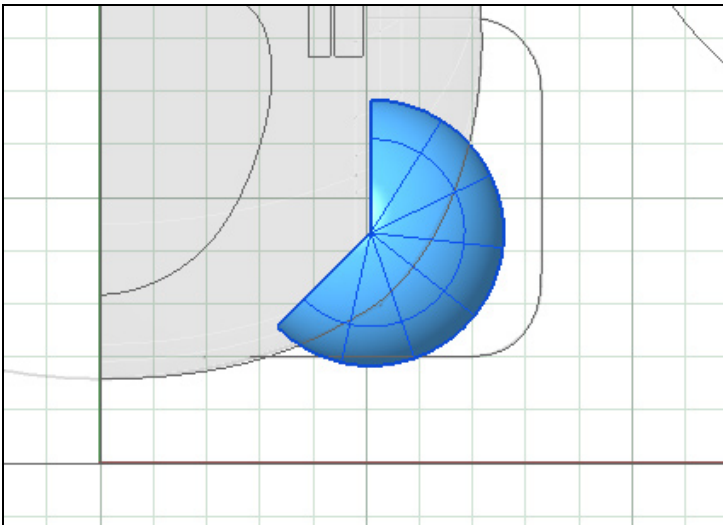
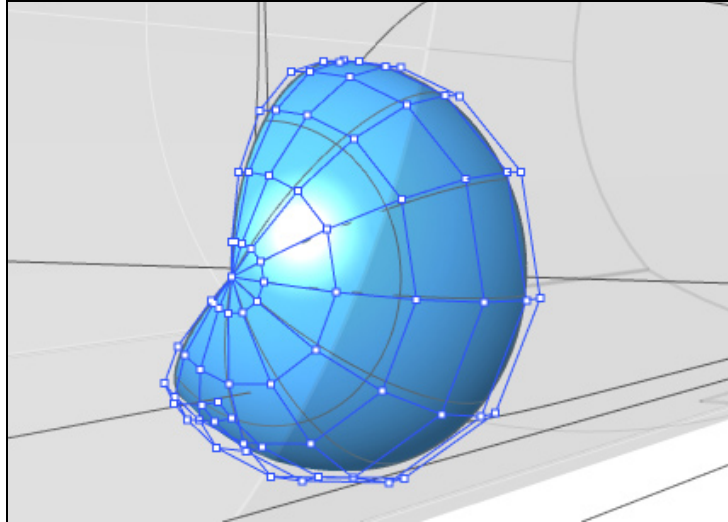
6. In the Right view, draw an **Arc**. Place the center point, enter a distance of **30** and hold down the **SHIFT** key to activate the **Ortho** snap and place the start point. Then, enter a value of **-90** degrees for the angle.



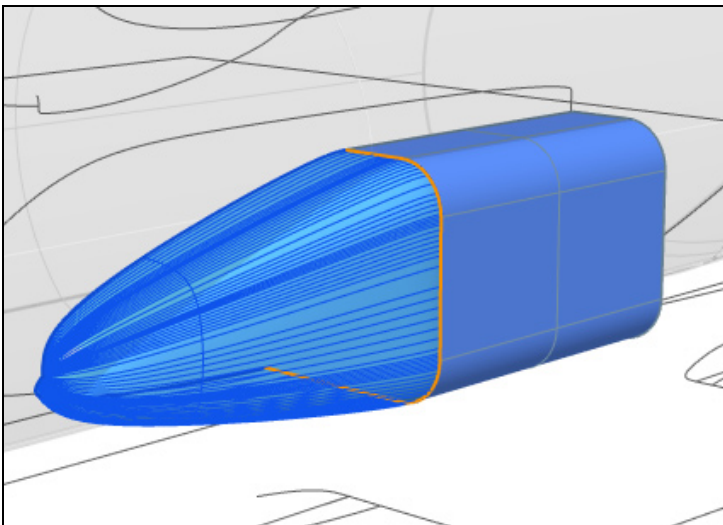
7. **Revolve** the arc. Start the Revolve axis at the the **End** of the arc, and extend a line straight back.

Set the **Start angle** to **0** **Revolution angle** to **225**. Make sure **Deformable** is set to **No** and you can set **DeleteInput** to **Yes** to delete the arc.

8. Run **Rebuild** on the partial sphere. Raise the Degree in both directions to **5**, and set the Point count around the revolve to **12** (from 9) and along the arc to **7** (from 3.) There are *Deformable* options in both the **Arc** and **Revolve** commands to accomplish the same task. They use a little different method and produce a different control point structure, but the choice was simply based on this way being clearer to illustrate.

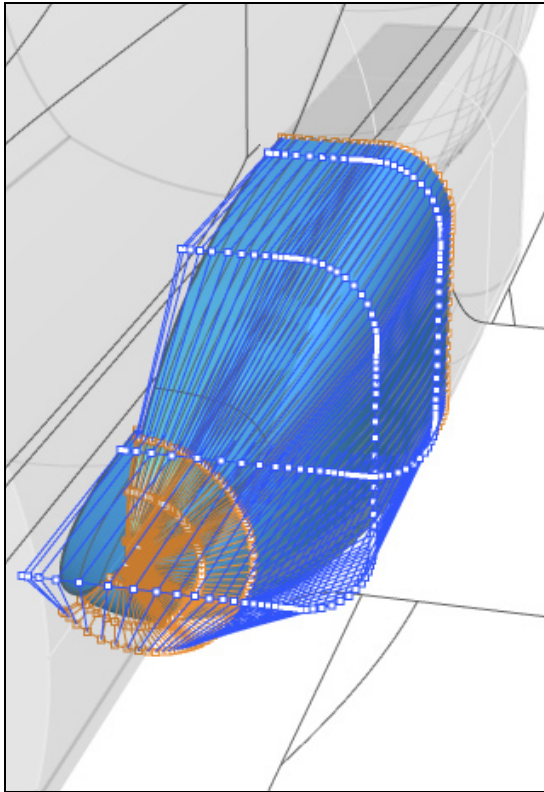


9. **Move** the surface **61** units to the right in the Front view.

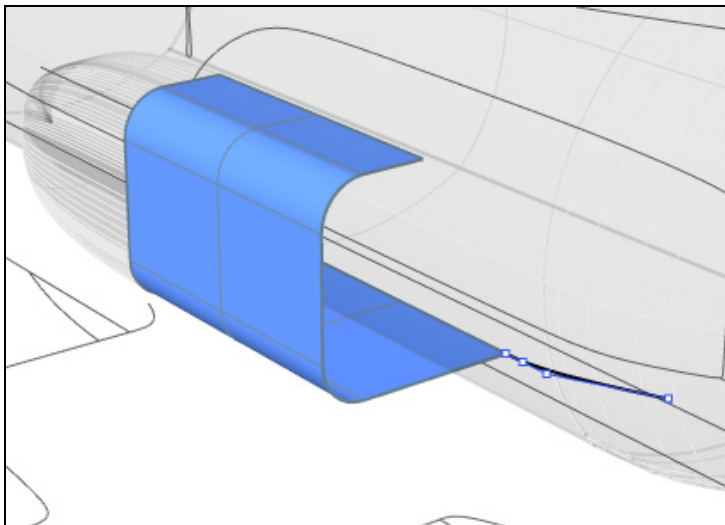
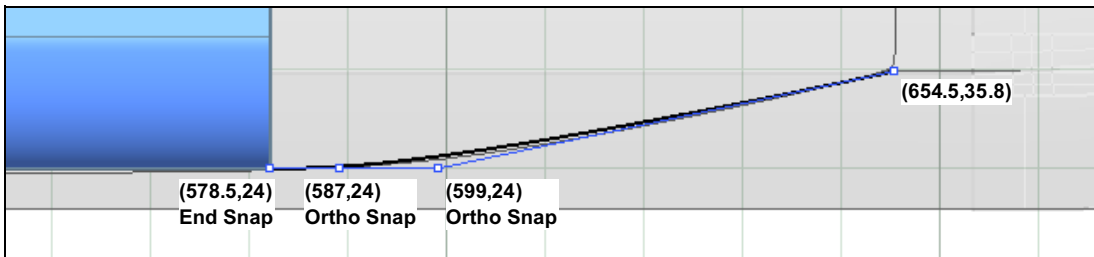
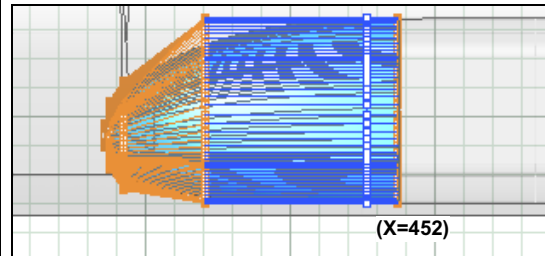
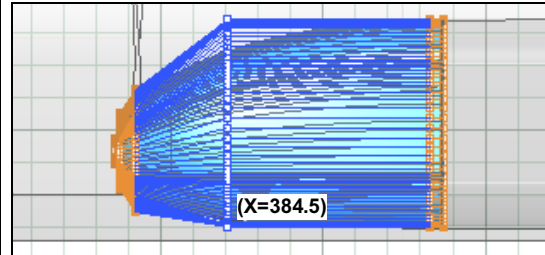


10. **MatchSrf** to the main side pod section. Specify **Curvature Continuity**, turn on *Refine match*, other options off, and leave the *Isocurve direction adjustment* at **Automatic**.

Aligning the Degree 5 freeform surface we have here to one made up of lines and arcs (Degree 2) requires a lot of control points because higher-degree surfaces can't "exactly" represent such shapes, only an approximation to within a tolerance.



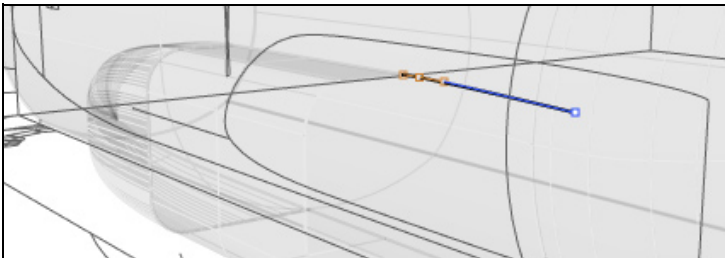
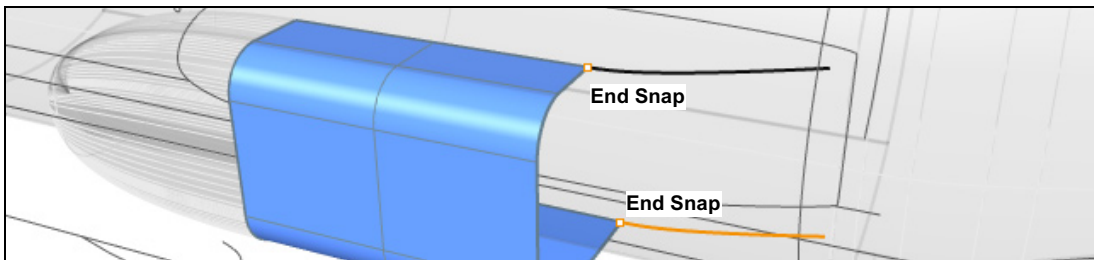
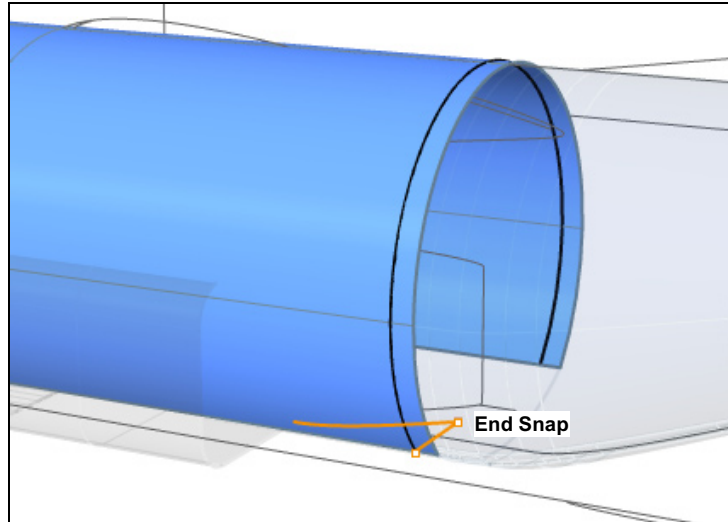
11. Now we'll adjust the 2nd and 3rd rows of points. Move the second row forward by about **7.79** units and the third forward by about **65.86**. The **SetPt** command is useful for this, just check the Set X checkbox, choose **Align to Cplane**, and in the Right view enter a value of **452,0** to set the second row of points, for example.



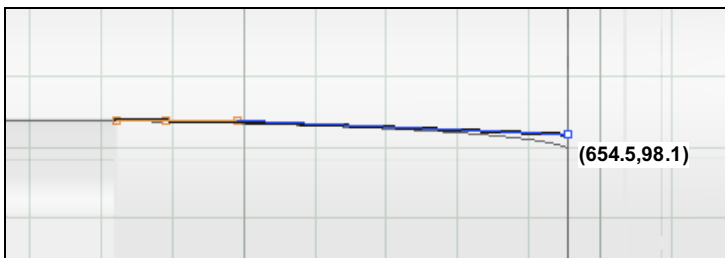
12. To start the back part of the side pod, Draw a **Curve** in the Right view, starting by snapping to the **End** of the main pod.

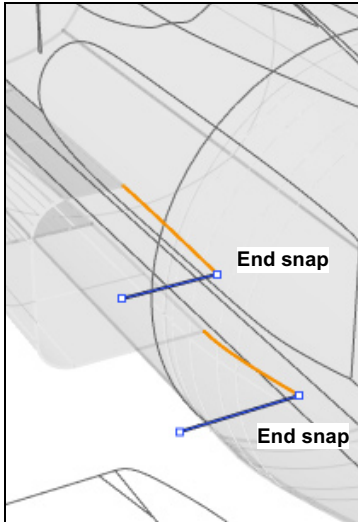
13. Using **ExtractIsocurve** , extract a curve from the main fuselage section, snapping to the **End** of the curve we just made.

14. Make a **Copy** of the curve we just drew, Snapping to the **End** near the side pod surface for the **Point to copy from**, and placing the copy at the top edge of the side pod surface again using the **End** snap.



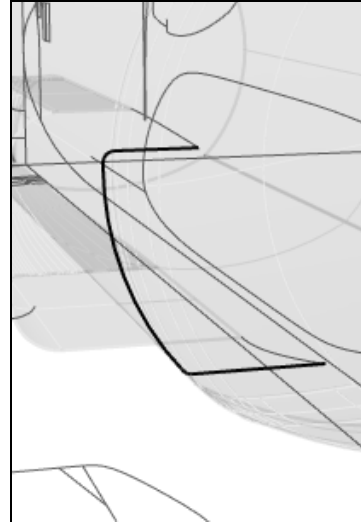
15. Turn on the control points for the upper curve copy and move it's end down by **14.2** units.



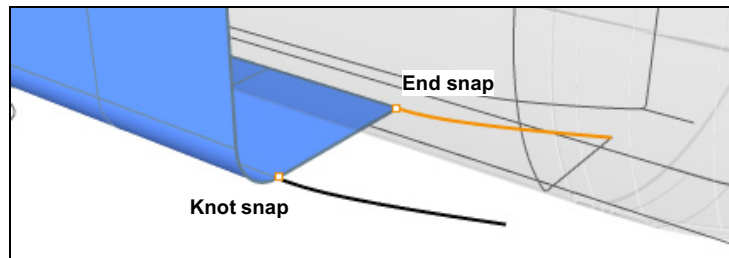


16. Draw a **Line** extending straight out from the **End** of each of the curves. The distance is not important, since you're going to....

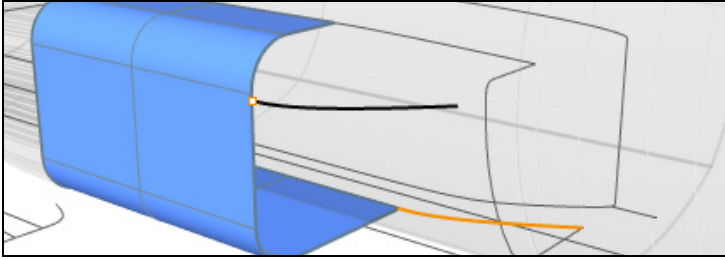
17. Take each of the lines and **Fillet** it with the curve extracted from the fuselage. Use a **Radius** of **3** and set the **Join** and **Trim** options to **Yes**.



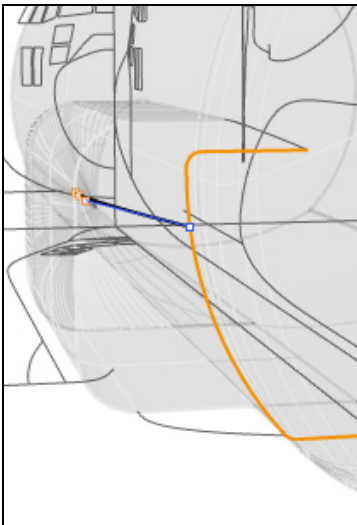
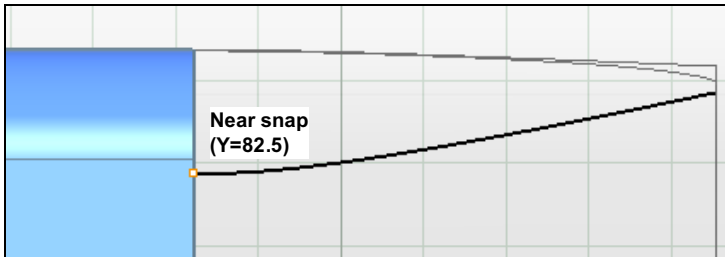
18. We're going to make two more copies of the lower curve. For the first, **Copy** from the **End** of the curve to the edge of the lower fillet on the side pod, using the **Knot** Osnap.



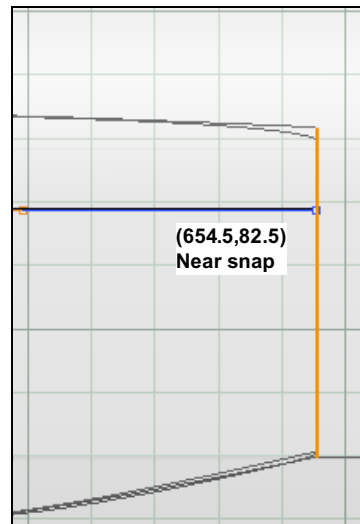
19. Turn on the new curve's control points and move its end point onto the filleted curve along the fuselage, snapping it to the upper **End** of the lower fillet.



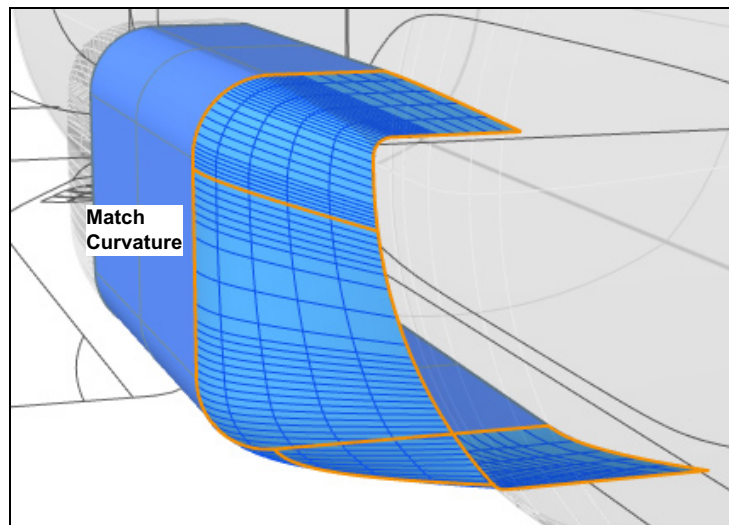
20. Make one more **Copy** of the lower curve. Use the **Near** Osnap to place it slightly below the upper fillet on the main side pod section.

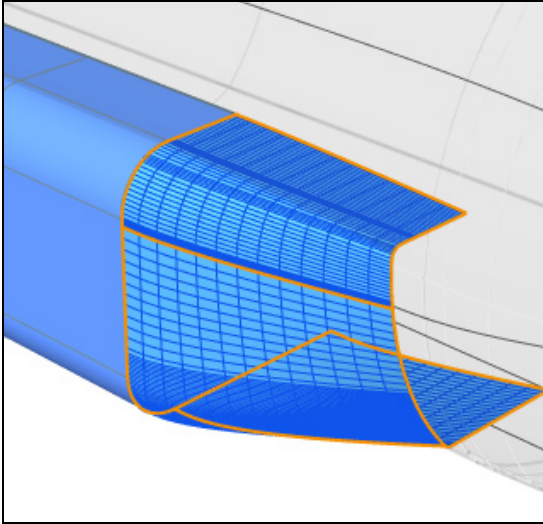


21. Adjust the end point of this curve by moving it onto the fuselage curve using the **Near** Osnap. Try to keep the curve more or less horizontal.



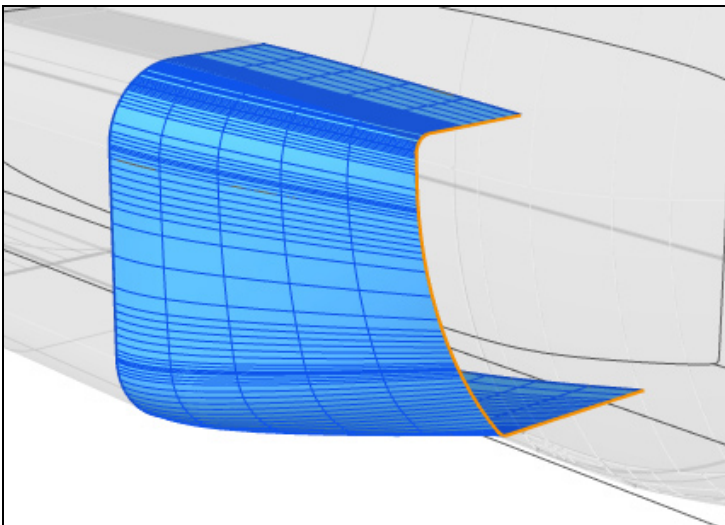
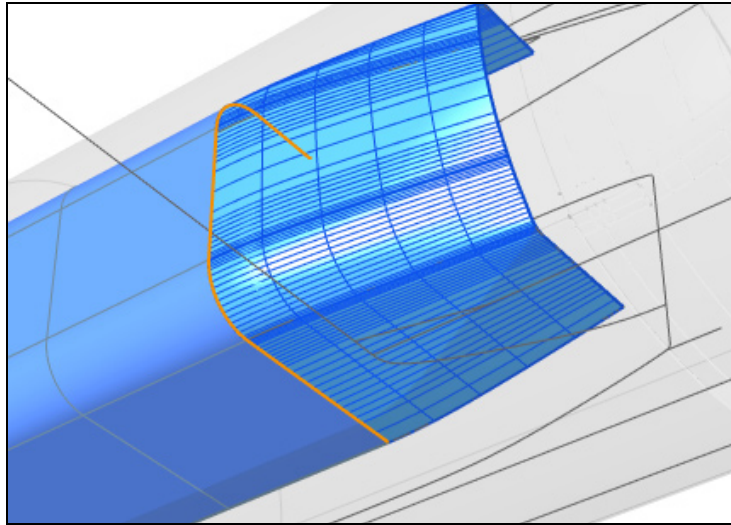
22. Build a **NetworkSrf** using the back edge of the main side pod surface and the collection of curves we just made. Specify tolerances of **0.1** for **Edge curves**, **Interior Curves**, and **Angle**. For the Edge matching, specify **Curvature** for the surface edge and **Position** for the others.





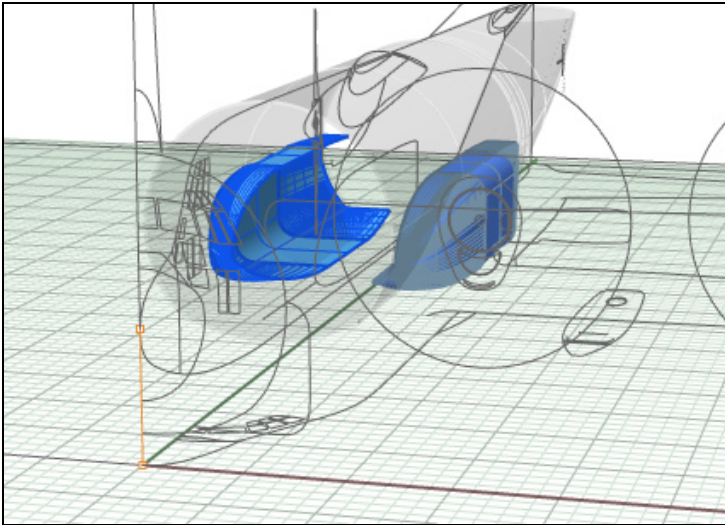
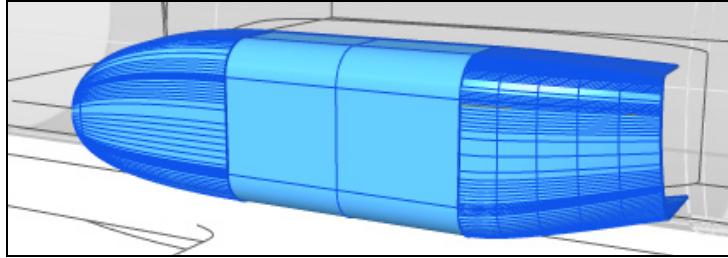
So why specify a tolerance of 0.1 when we're aiming for a global tolerance 0.001? In this situation, trying that resulted in a surface that was massively "heavier" but still wouldn't join to the main surface. As we will encounter again, network surfaces sometimes need some "hand tuning," so to speak, when trying to achieve high surface quality and accuracy.

23. MatchSrf the network surface to the main side pod surface. Specify **Tangency Continuity**, and turn on the *Refine match* and *Match edges by closest points* options, leaving *Isocurve direction adjustment* at **Automatic**.



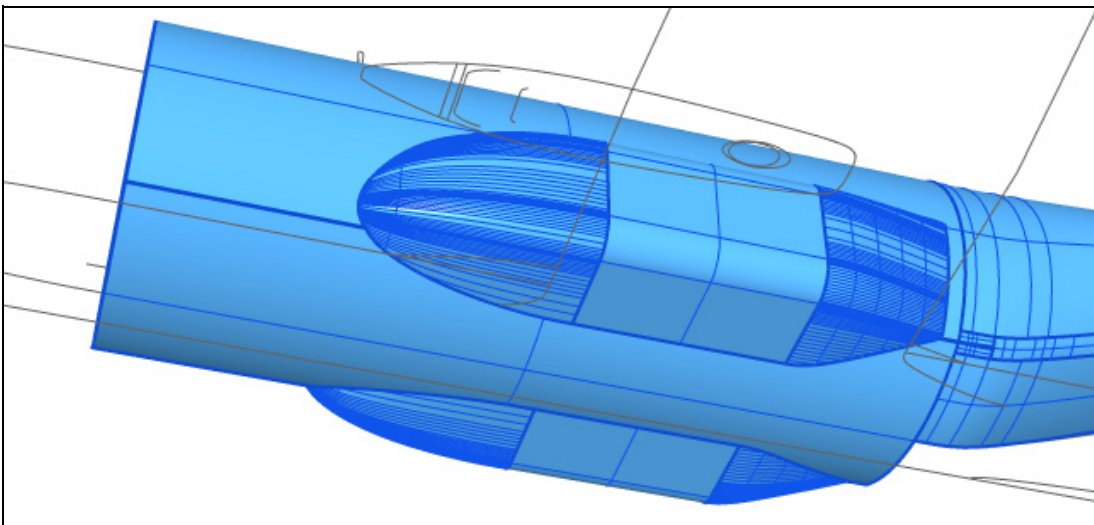
24. Because of the tolerance in the network it's necessary to repeat the **MatchSrf** at the other end. Match the surface to the curve we made to define the edge. Turn on the *Refine match* and *Match edges by closest points* options.

25. Join the three surfaces that form the side pod.



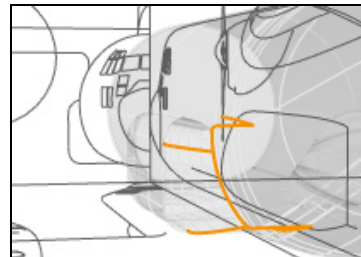
26. Mirror the side pod along the world Y axis.

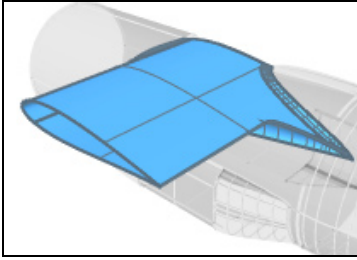
27. Use Boolean2Objects twice to union the side pods to the fuselage. This command cycles through all possible boolean combinations, so that you don't have to use **Dir** to check which way is "out" on your objects and flip the normals to get what you want.



28. Select all our construction curves with **SelCrv** and **Delete** them.

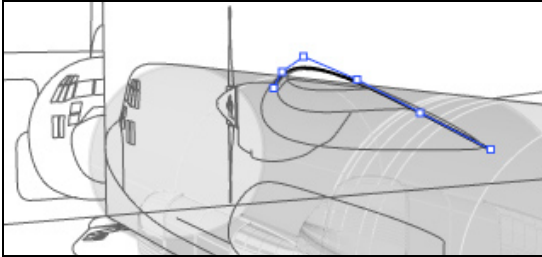
29. Make sure to Save your work.



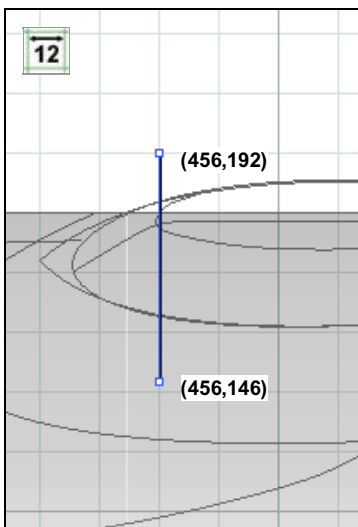
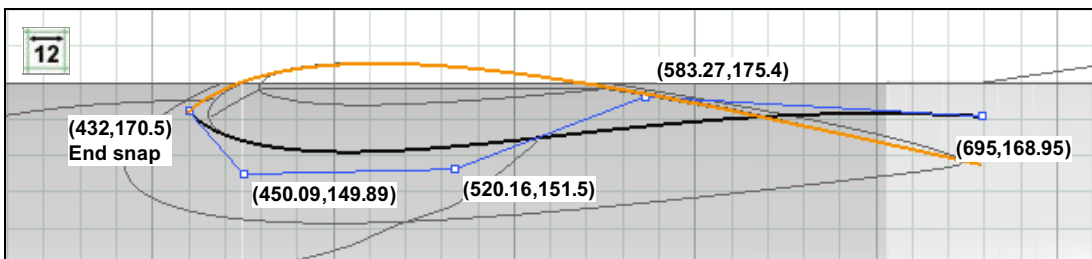
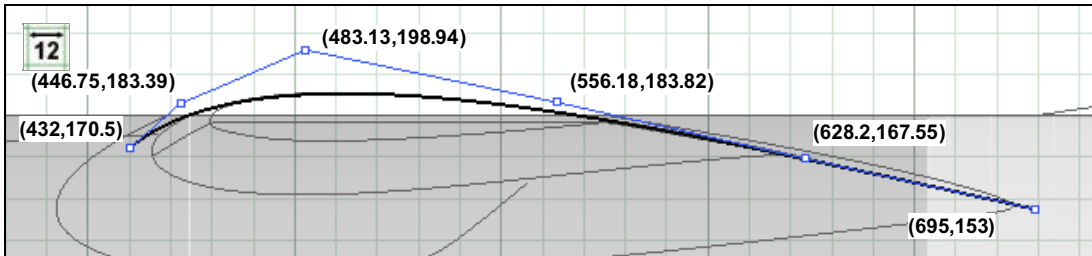


Wing 1

Main section and fillet

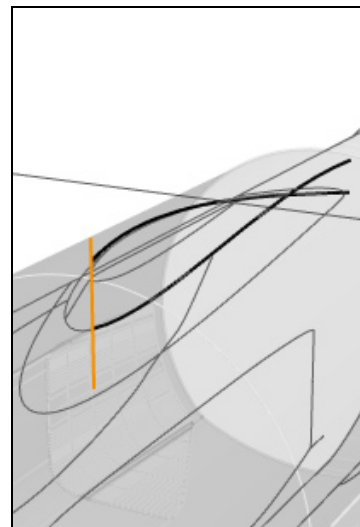


1. In the Right view, draw a **Curve** of **Degree 5** for the top of the wing root section.
2. Draw another **Curve** for the bottom of the wing.

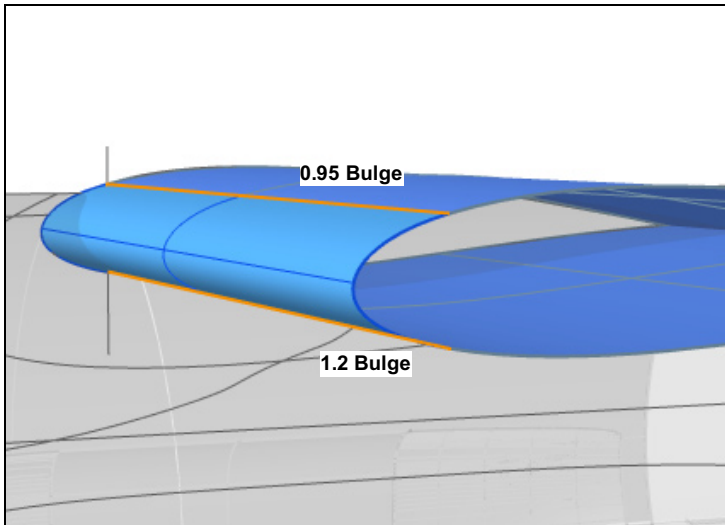
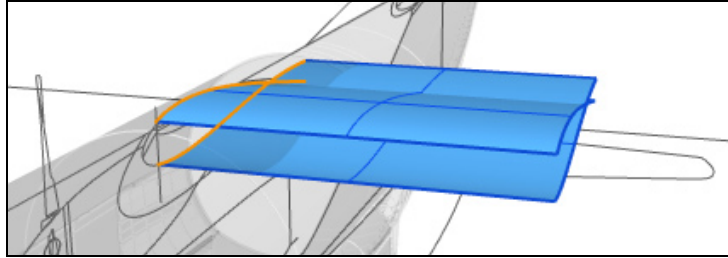


3. Draw a **Line** in the Right view.

4. **Trim** the wing root section curves with the line.



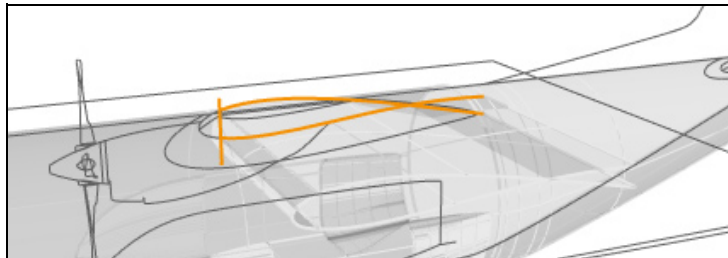
5. Select both wing section curves and **Extrude** them **216** units.



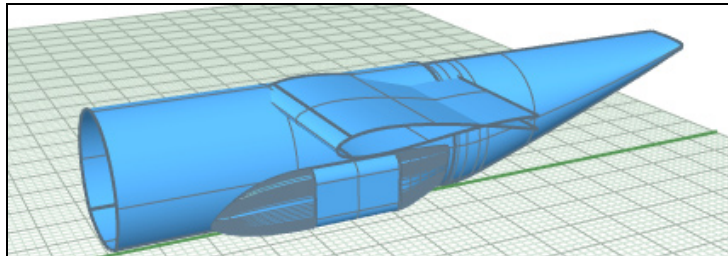
6. **BlendSrf** between the surfaces to make the leading edge. Specify the blend bulge as shown.

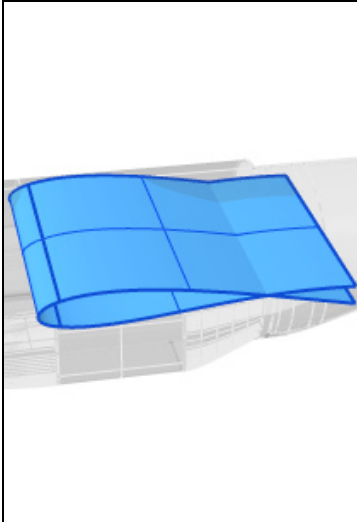
Those bulge values are factors based on the particulars of the edges being blended, they don't represent some predictable dimension.

7. The upcoming steps involve adding several curves in this area, so to keep things clear **SeI Crv** the ones made so far and **Delete** them.



8. For the same reason, go to or open up the the **Layer** panel and hide the "Ref Drawings" set of layers.

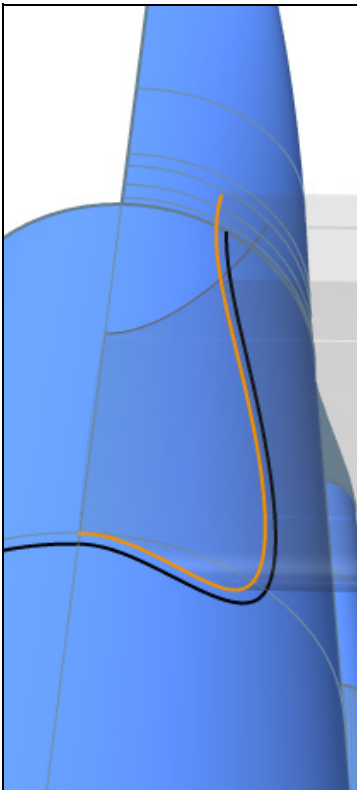
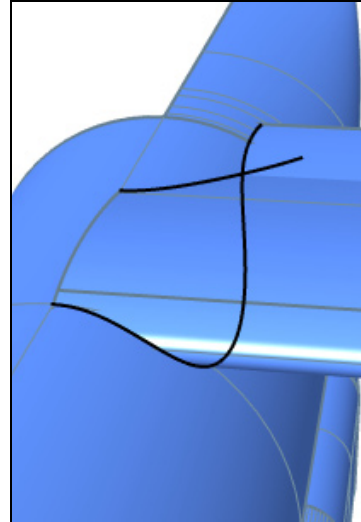




9. For now, **Join** up the three wing surfaces.

10. Intersect the wing surfaces with the fuselage. The result will be two curves.

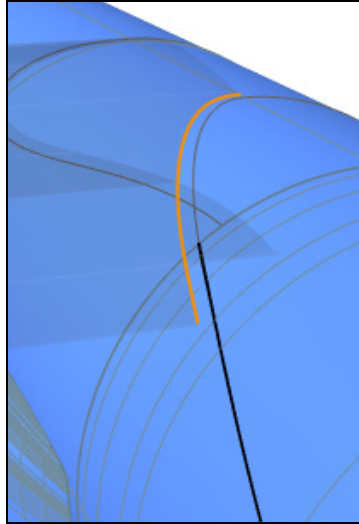
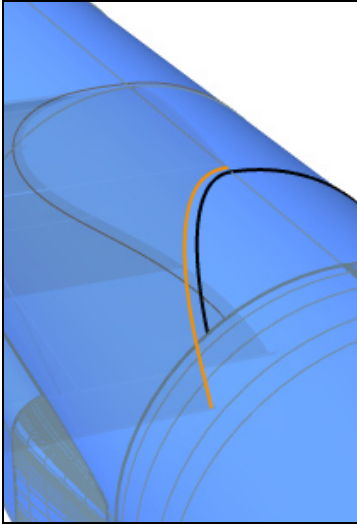
11. Explode the wing surfaces.



12. Select the lower intersection curve and run **OffsetCrvOnSrf**. Select the main fuselage surface as the **Base surface** and offset it a distance of **5** units. It may be necessary to use the **Flip** option to get it to offset towards the 'outside.'

13. Delete the intersection curve we just offset.

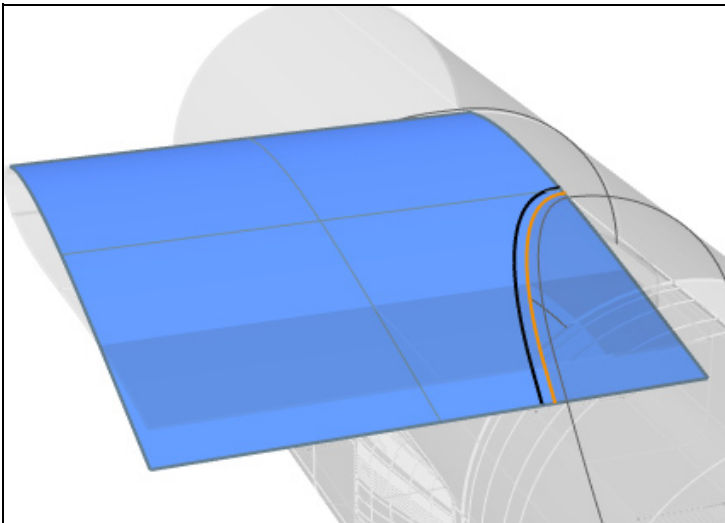
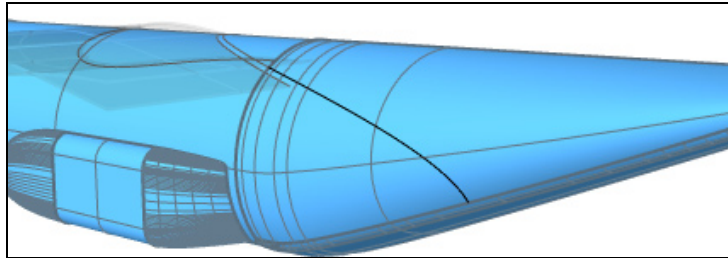
What was the point of making a curve like this? Obviously it doesn't follow the edge of the wing "fillet," except maybe right at the centerline of the fuselage. This is being done just to help figure out how things should be trimmed out to make this fairly elaborate blend.



14. Now move on to the upper intersection curve, using **OffsetCrvOnSrf** again. Again select the main fuselage surface as the *Base surface* and offset it **5** units.

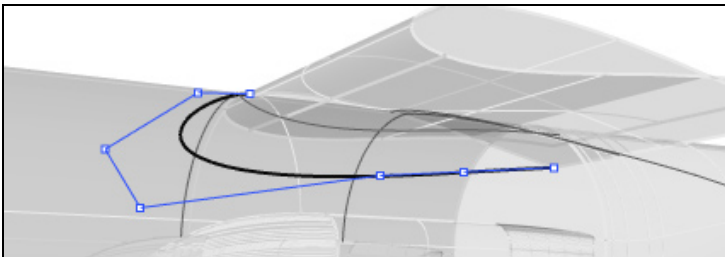
15. **OffsetCrvOnSrf** one more time, same distance, but on the aft fuselage surface. This was still faster than making a pipe, intersecting, then deleting the extraneous curve.

You will have noticed how **OffsetCrvOnSrf** extends the offset curves to the edges of the base surface.

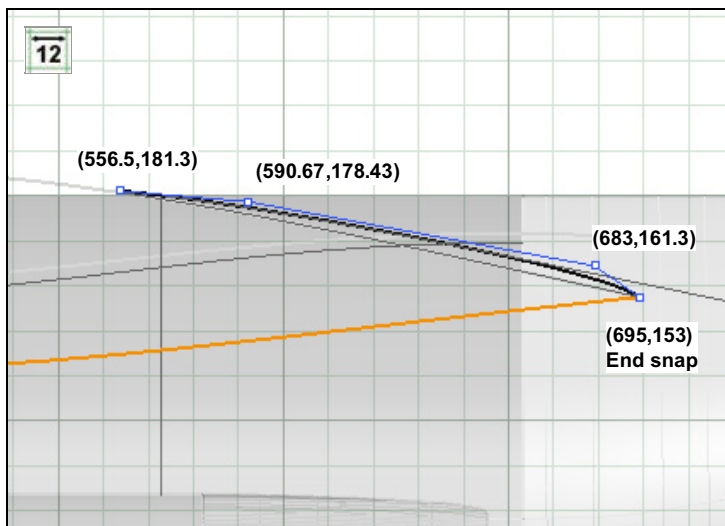
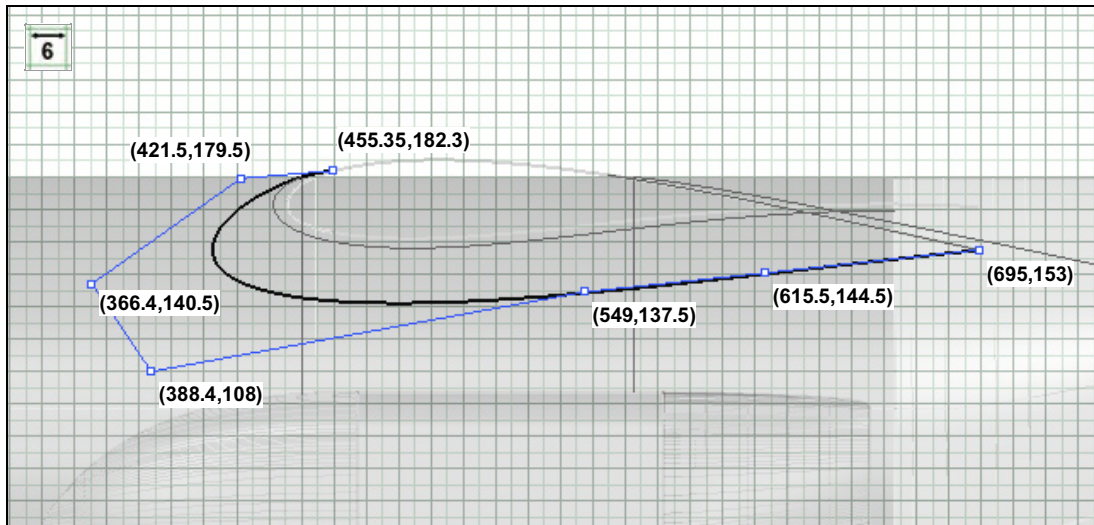


16. Run **OffsetCrvOnSrf** on our intersection curve yet again. This time select the upper wing surface as the *Base surface* and offset it the same **5** units, outwards.

17. **Delete** the intersection curve we've been offsetting.



18. Make a **Curve** of **Degree 6** that will be used to slice the fuselage.

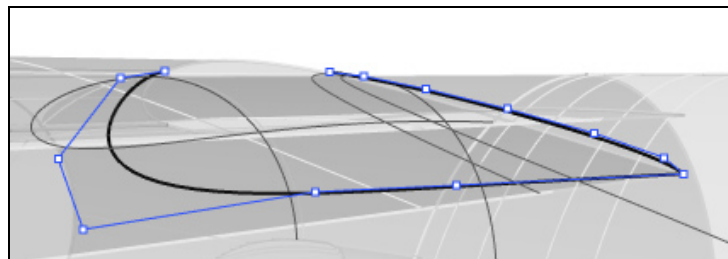
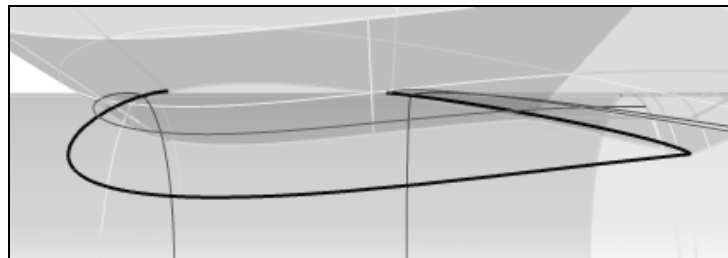


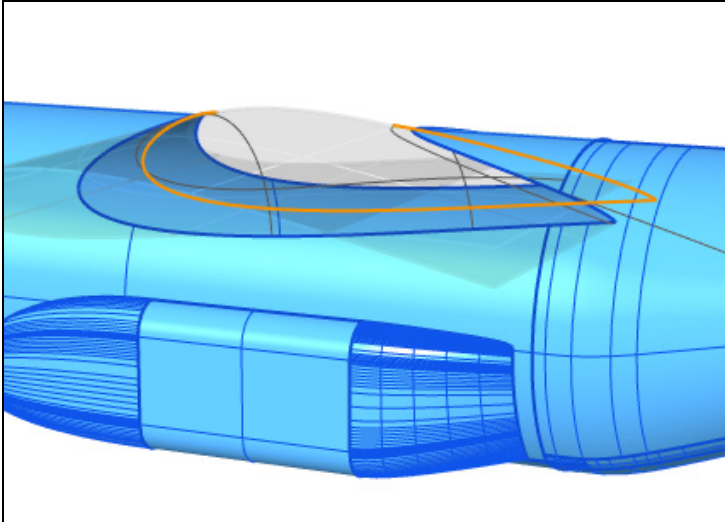
19. Draw another smaller *Curve*, snapping to the *End* of the previous one.

The curves we made on the fuselage were used as a guide for drawing these two.

20. *Join* the two curves we just drew.

If you turn on the control points you'll see that the smaller curve has had three added. When you join curves the pieces get raised to the same degree as the highest degree segment.

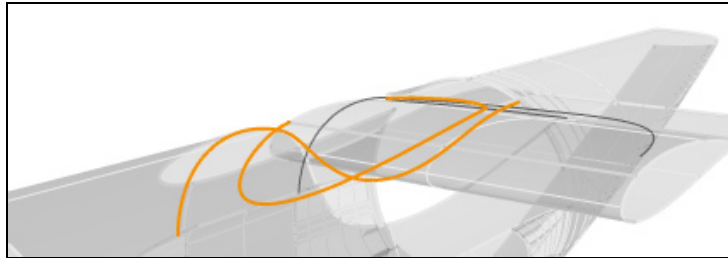




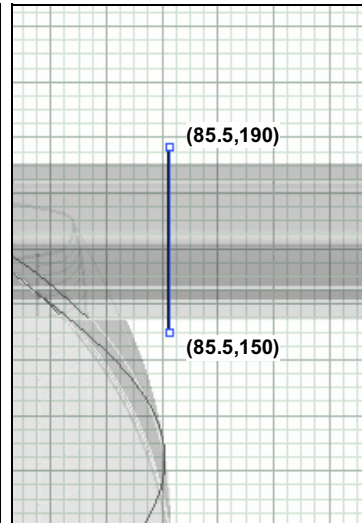
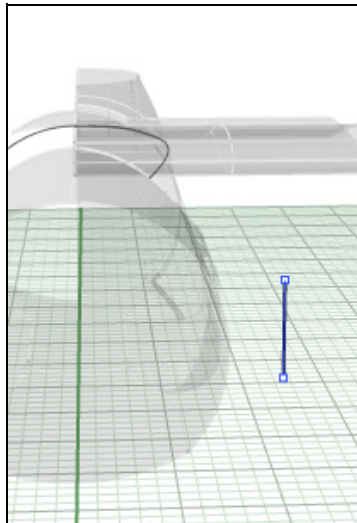
21. Trim the fuselage with the new curve.

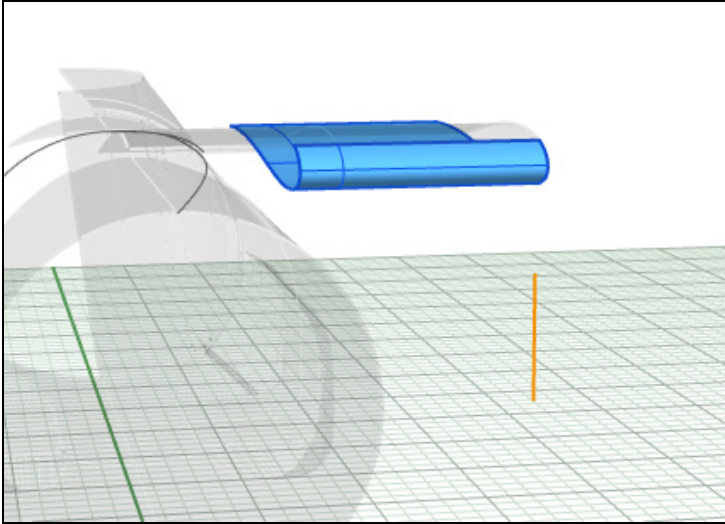
22. Delete the trim curve.

23. Delete the trim curve as well as the offset lower intersection curve.



24. Draw a Line in the Front view.

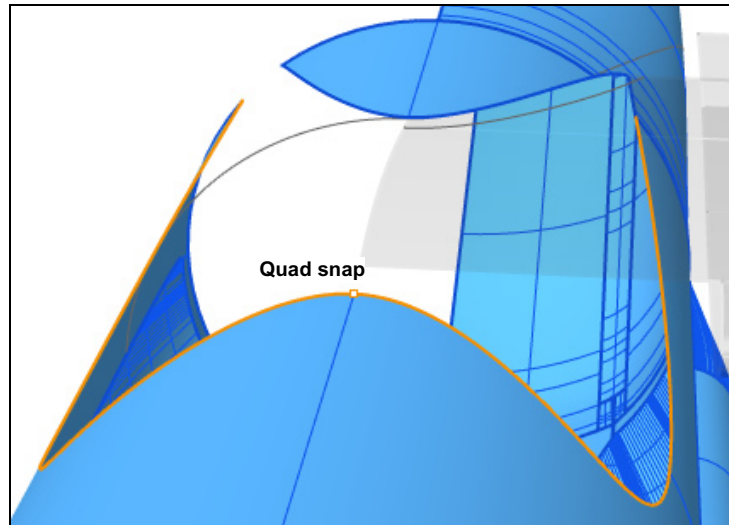


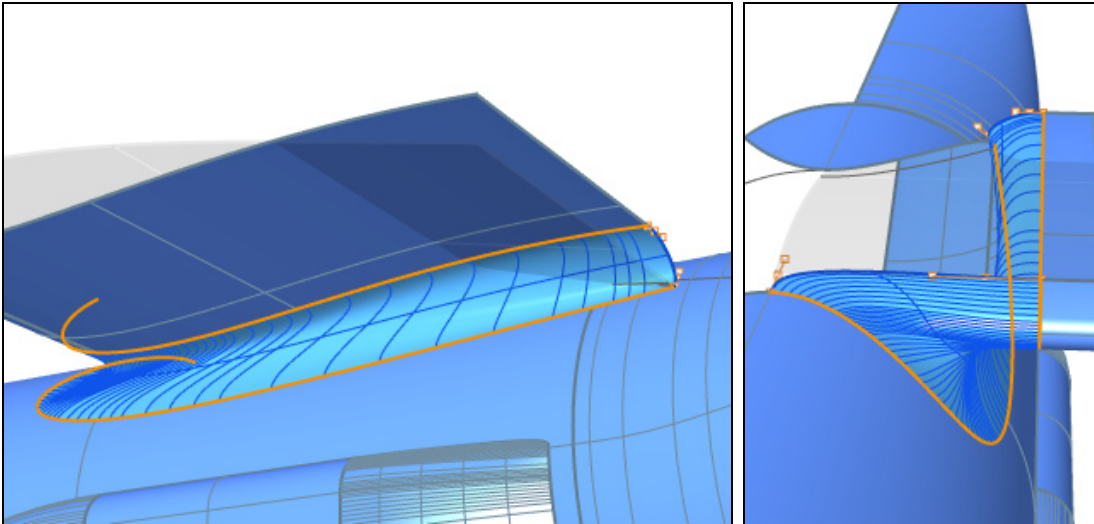


25. From the Front view, use that line to **Trim** off the inside of the lower and leading edge wing surfaces.

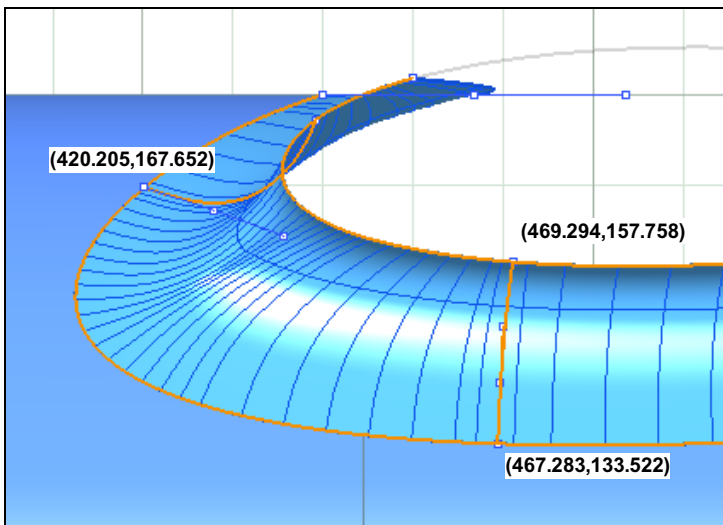
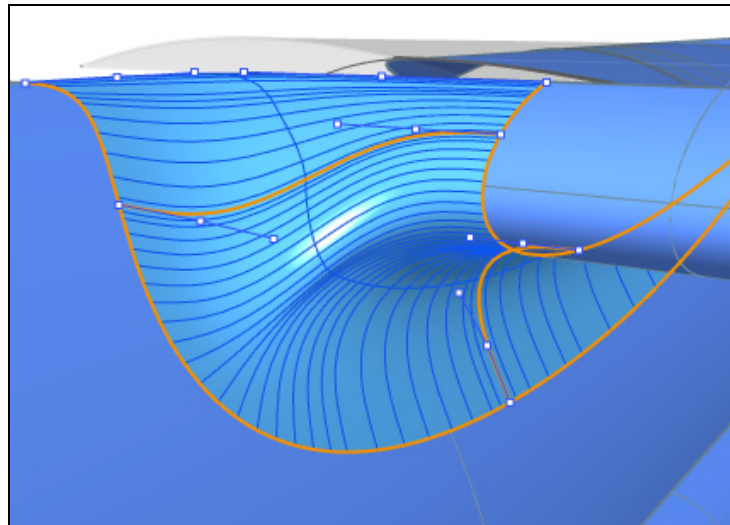
26. **Delete** the trimming line.

27. While not strictly necessary, it's a little more convenient to run **SplitEdge** on the opening trimmed out of the fuselage, using the **Quad** Osnap to split it at the centerline.



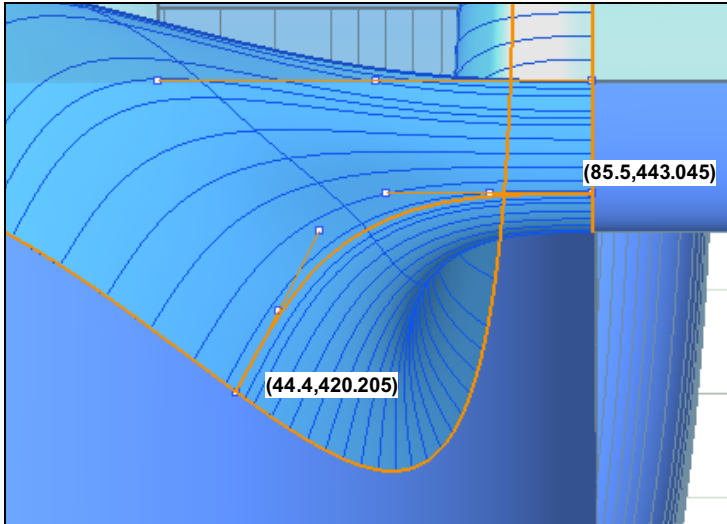


28. Start the **BlendSrf** command, and blend between the fuselage and the lower and leading edge wing surfaces. If you turn on the *Preview* option in the blend bulge dialog, you can see we need to do some tweaking, so don't exit the command yet.

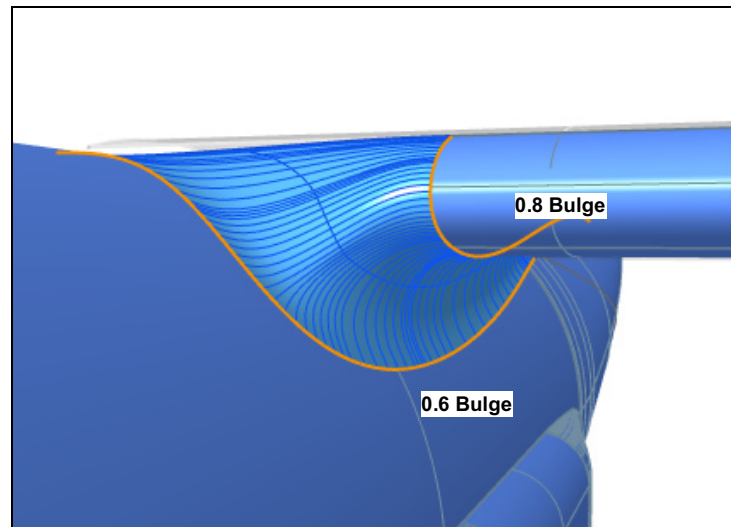


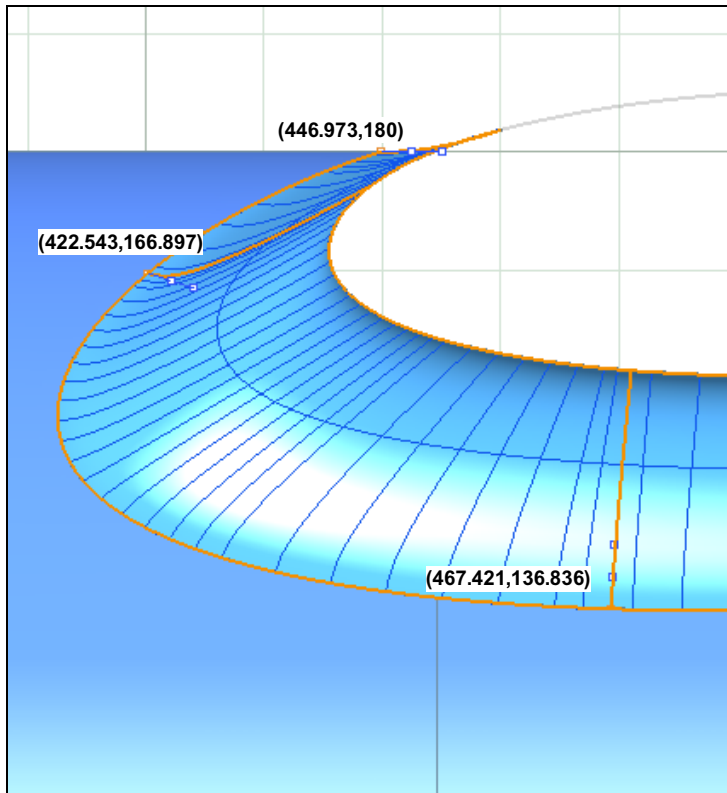
29. With the **AddShapes** option, add two guide sections to the blend around the leading edge.

Triple-digit accuracy in placing these sections is not essential or practical, the coordinates are provided for your information. You can adjust them after adding, by dragging the end points.

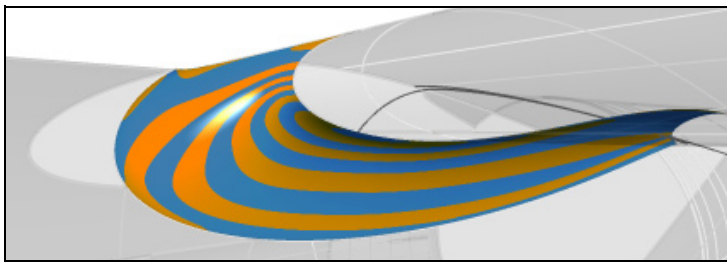
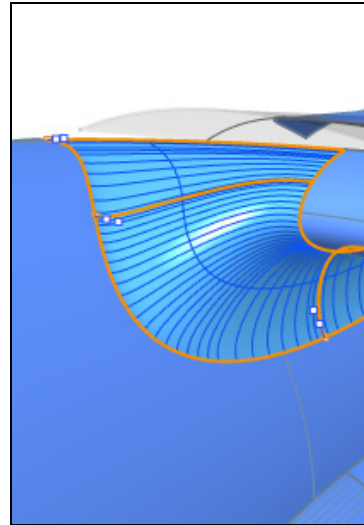


30. Now adjust the "global" *Blend bulge* settings. If you were to change these after editing individual sections as in the next step, the sections would be "reset."



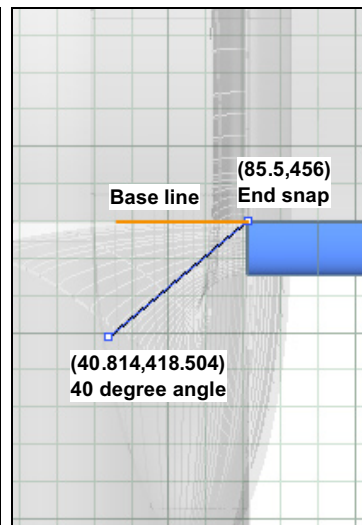
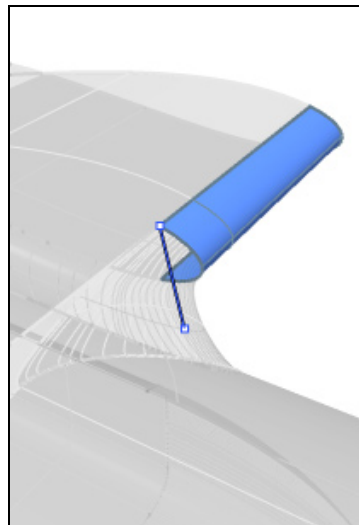


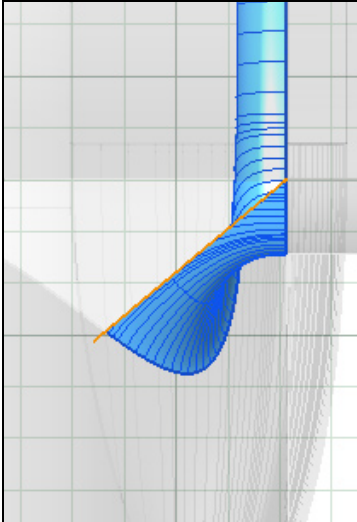
31. Finally, tweak the bulginess of the two added sections and the end. Adjust them by moving the second point, the third will be modified automatically.



The result should look very smooth under **Zebra** analysis.

32. Obviously, we're not quite done with this. Draw a **Line** in the Top view. I used the **Angled** option, drawing the base line starting at the upper **End** of the leading edge surface, then entering an angle of **40** degrees.

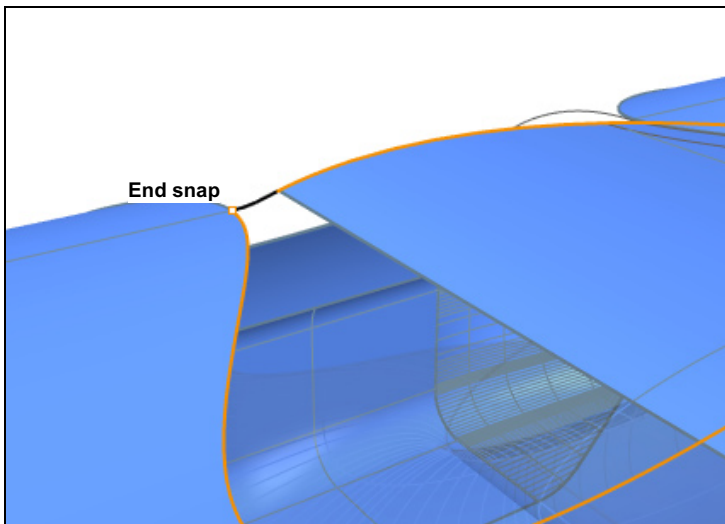
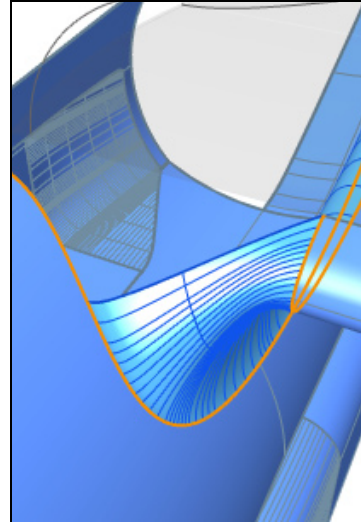




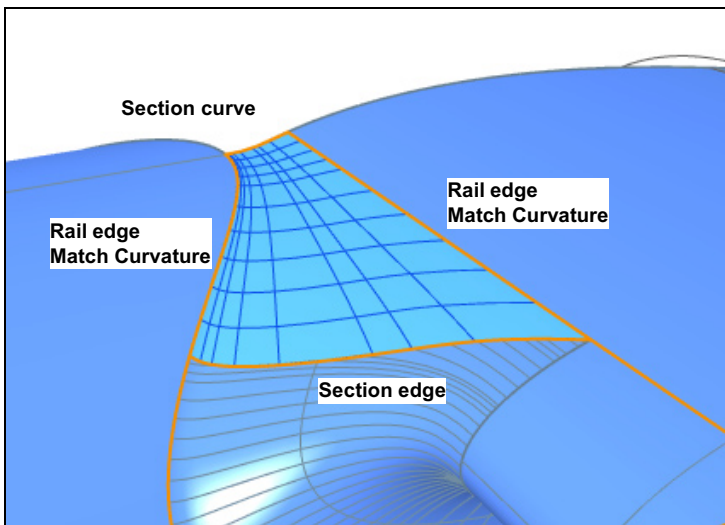
33. Trim the blend surface.

34. Delete the line.

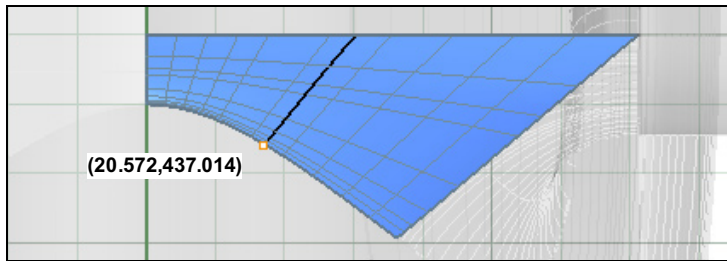
As illustrated at right, it was possible when building the blend surface to adjust it to avoid this trimming step, but having the 'extra' surface helped with figuring out what the blend should look like.



35. Create a *Blend* curve with *Curvature Continuity* between the fuselage and the upper wing surface. You'll have to use the *Perpendicular* option, then snap to the *End* of the blend cutout on the fuselage.

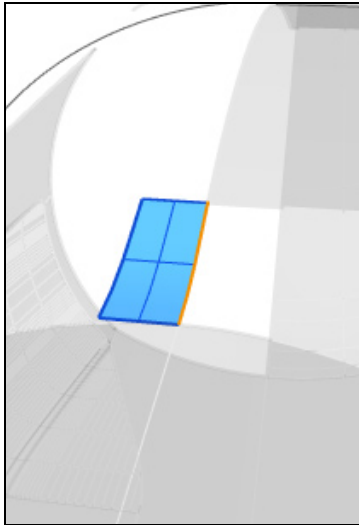


36. Sweep2 between the wing and the fuselage. Under the cross-section curve options, specify *Refit within 0.01* units, simplifying it slightly. Leave the other settings off and match **Curvature** to each rail.



37. Extract a curve from the sweep using **ExtractIsocurve**.

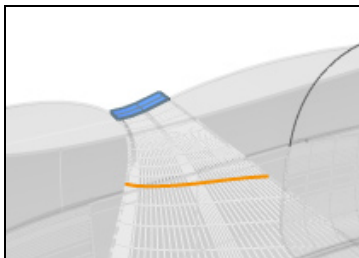
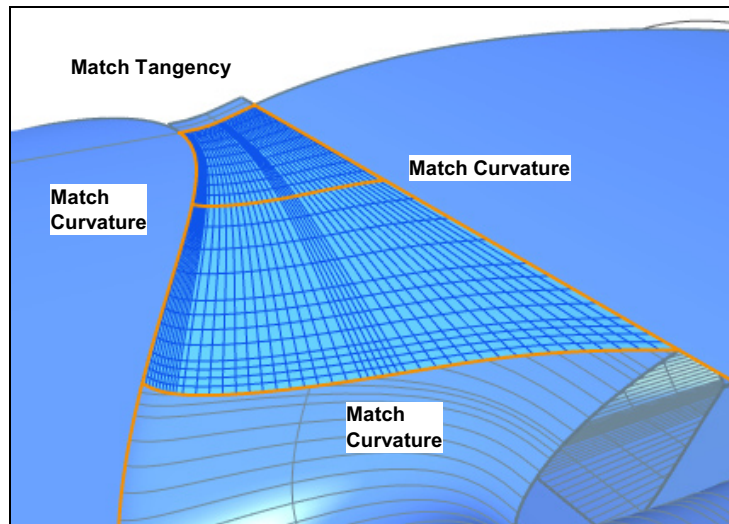
38. **Delete** the sweep.



39. **ExtrudeCrv** the small blend curve between the fuse and the upper wing surface a few units.

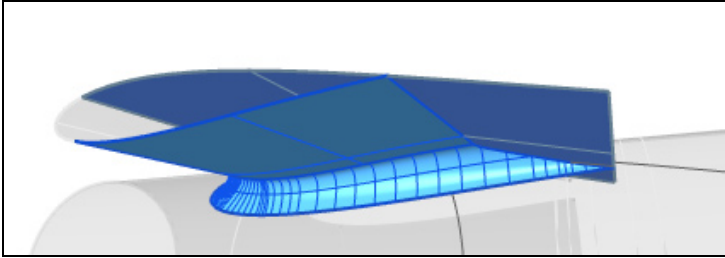
40. **Delete** the curve.

41. Build a final **NetworkSrf**. Specify Tolerances of **0.001** for *Edge curves*, and leave *Interior Curves* and *Angle* at **0.1**.

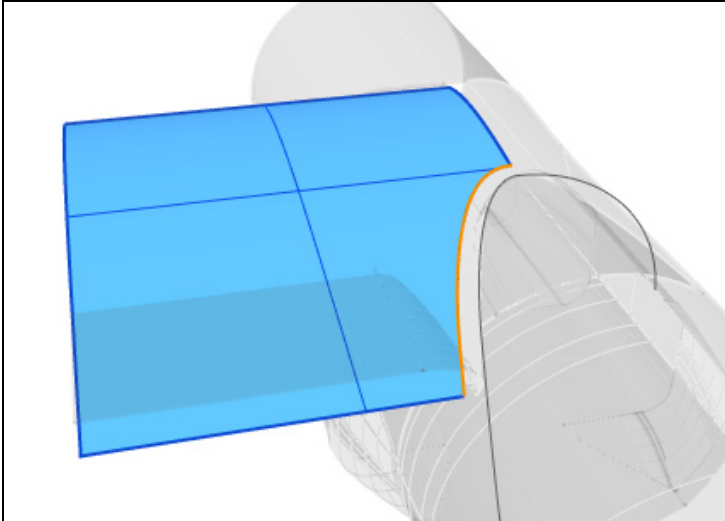


42. **Delete** the small extruded blend and the section we extracted from the sweep.

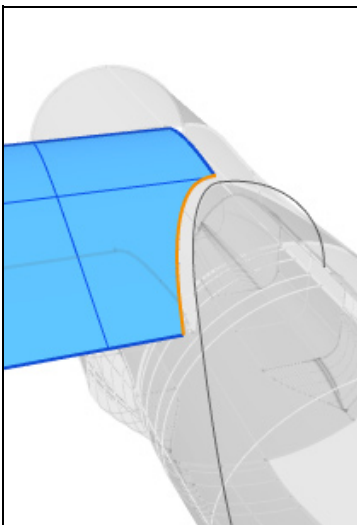




43. Moving on, use the upper wing surface to **Trim** off the lower wing surface and blend.

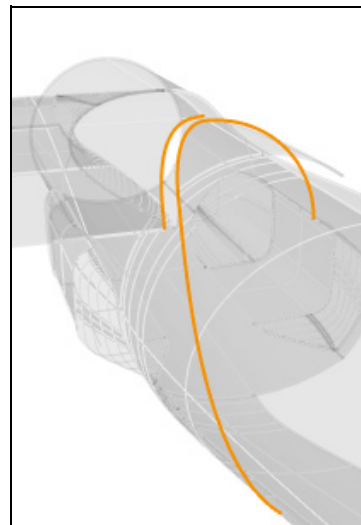


44. Select the curve offset on the upper wing surface and use it to **Trim** the upper wing.

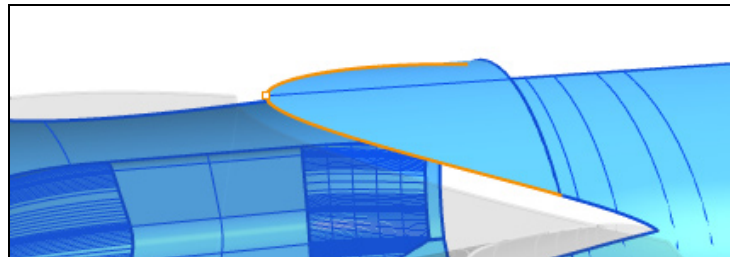


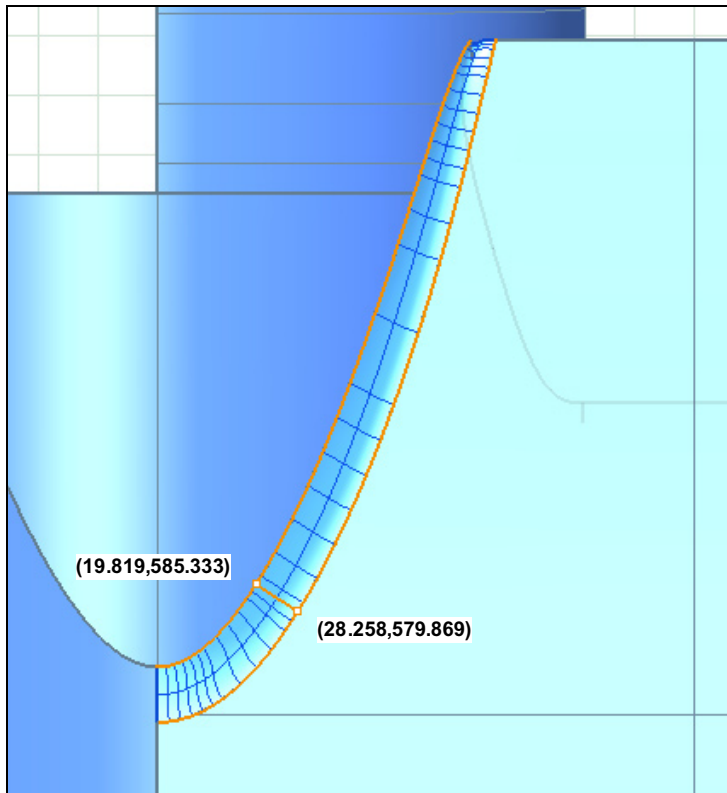
45. Select the curve offset on the upper wing surface and use it to **Trim** the upper wing.

46. **Delete** the trim curve we just used and the curves offset onto the fuselage.



47. As we did with the front edge, use **SplitEdge** with the **Quad** osnap to split the fuselage edge at the centerline.

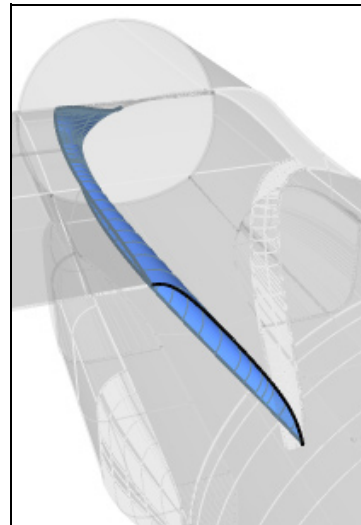
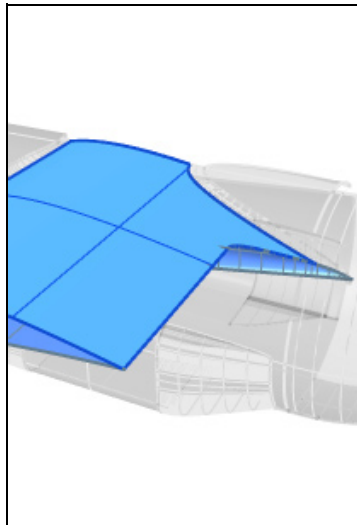




48. *BlendSrf* between the top wing surface and the fuselage. Add one guide section and set the *Blend bulge* to **1.0** for both edges.

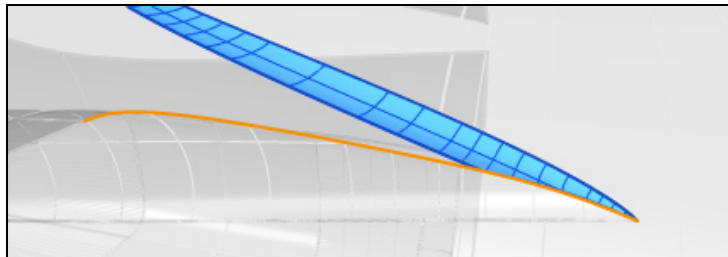
49. Use the lower wing surface and blend to ***Trim*** the excess off the back of the upper wing surface.

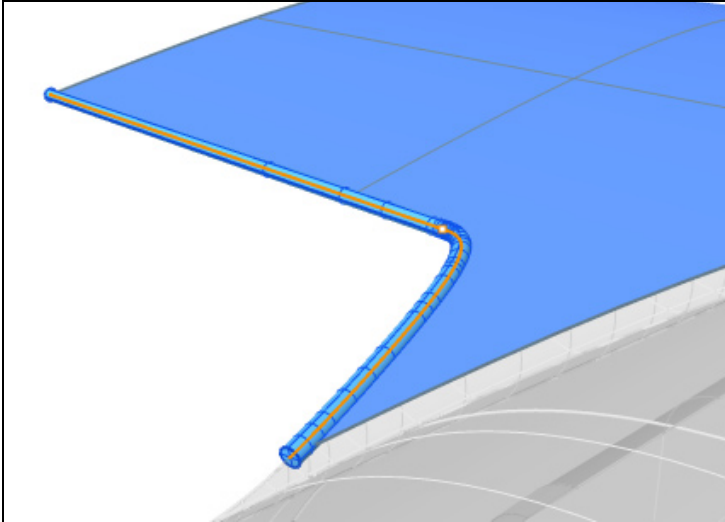
50. Extract a curve from the trimmed back edge of the wing blend with ***DupEdge***.



51. Use the duplicated curve to ***Trim*** off the upper smaller wing blend. Do this in the Top or Perspective view.

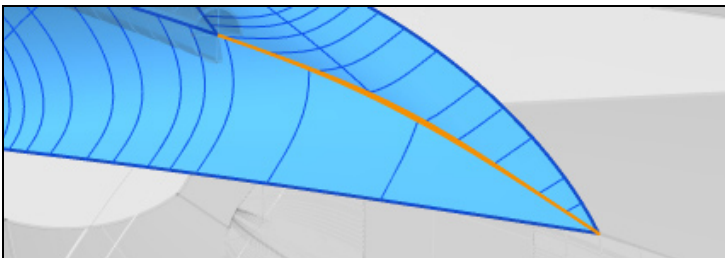
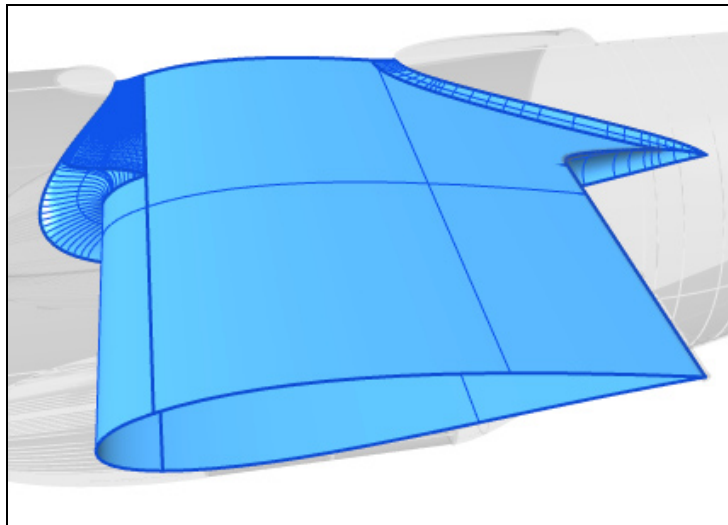
52. *Delete* the trim curve.



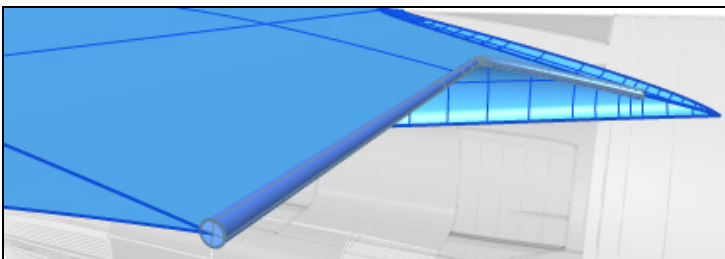


53. Build a **Pipe** with a constant **Radius** of **1.5** along the back edge of the upper wing surface. The **ChainEdges** option lets you pick the two edges that form the curve to place the pipe around. Set the **Cap** option to **Flat**.

54. **Join** up the 6 surfaces that make up the wing so far.

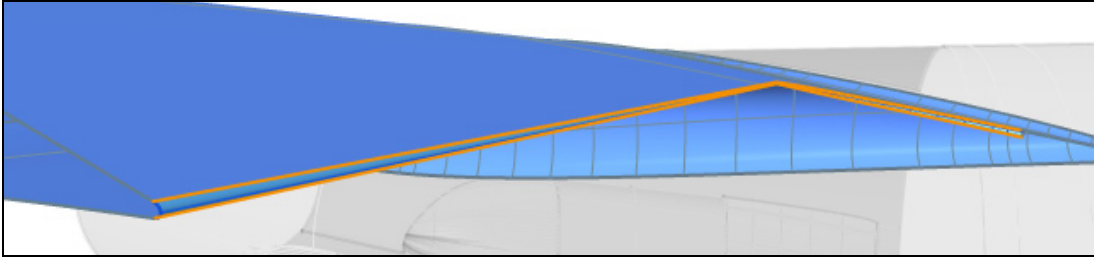


Everything should join up cleanly except for the two blend surfaces at the rear.



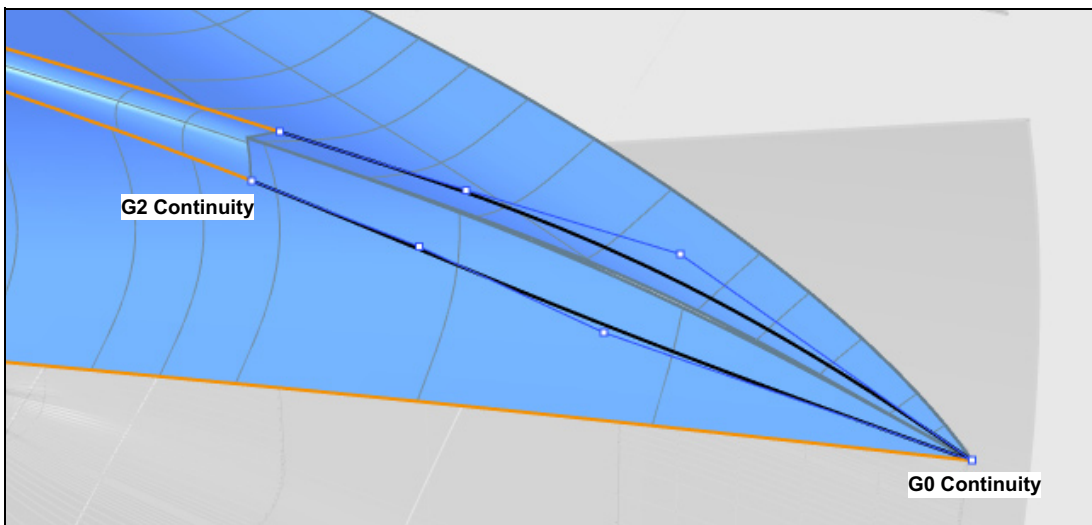
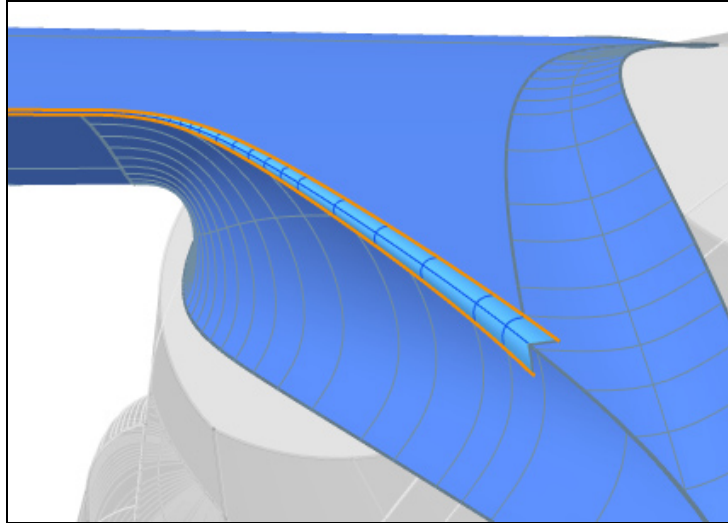
55. **Split** the wing polysurface with the pipe.

56. **Delete** the pipe and slim piece split away from the trailing edge of the wing.

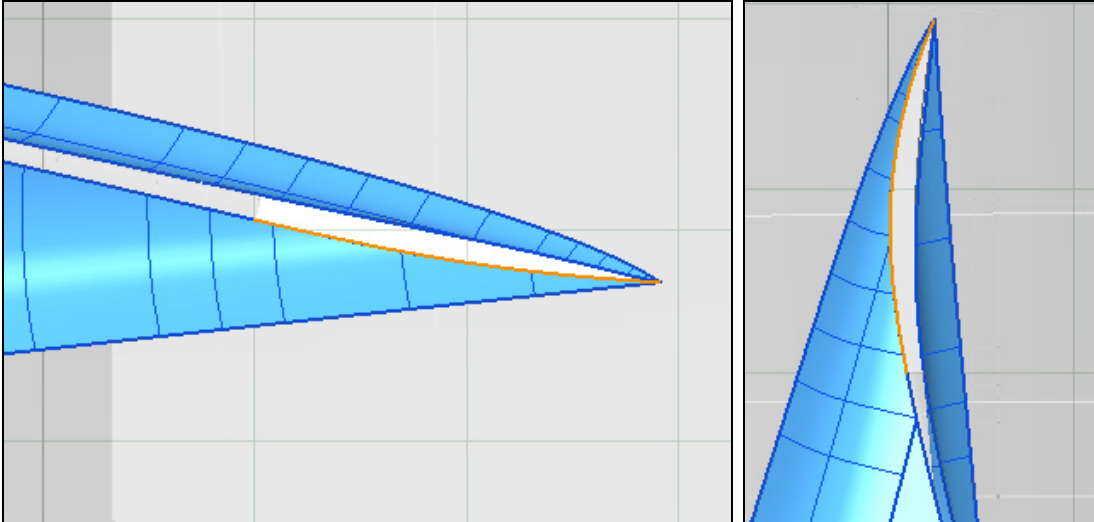


57. BlendSrf between the edges we just trimmed away. Specify a *Blend bulge* of **1.0**.

The **BlendEdge** command can do much the same thing we did here, but it's not quite able to handle where the two blends come together and would need more cleanup than we're going to do here.



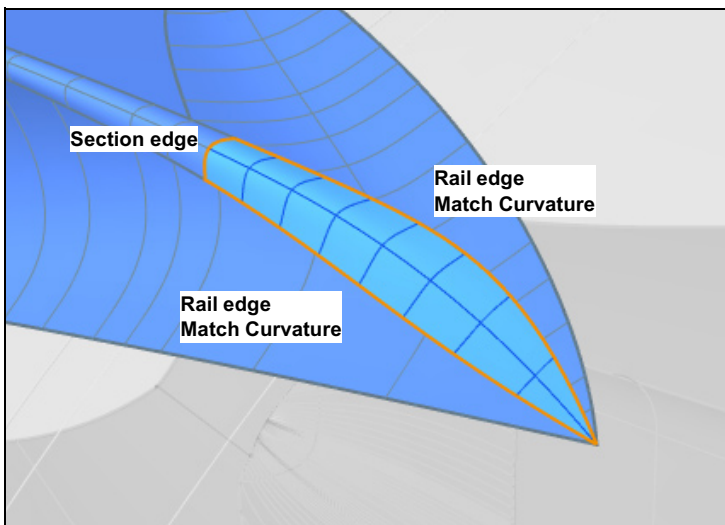
58. Use the **BlendCrv** command twice to create two lines extending from the trailing edge blend to the corner of the wing blends. Specify **G2** continuity from the end of the trailing edge blend, and **G0** at the other end. It doesn't matter which of the four edges that meet at this one corner you use, though it's probably best to be consistent.



59. From the Right view, **Trim** off the lower wing blend with the lower blend curve.

60. From the Top view, use the other blend curve to **Trim** the upper wing blend surface.

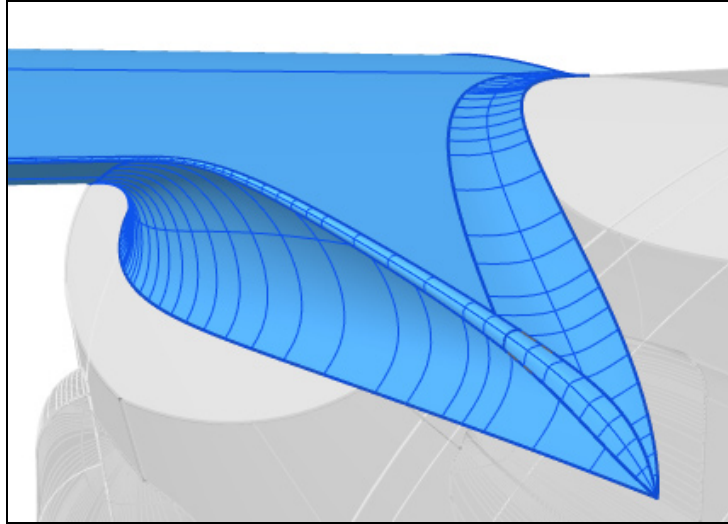
61. **Delete** the blend curves.

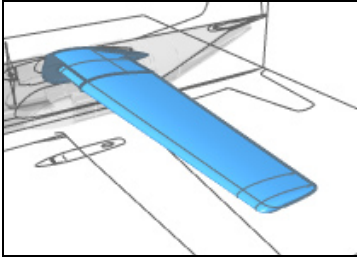


62. Fill in the hole with a **Sweep2** surface, specifying **Curvature** matching for each edge and *Do not simplify* for the cross-section curve options.

63. Join the trailing edge blend and the sweep to the wing polysurface.

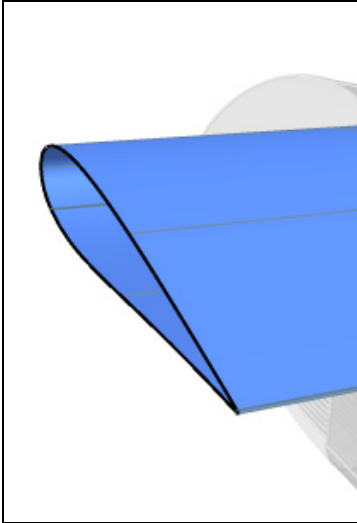
You have to exercise care in an area like this corner where several surfaces come together at a point (I prefer to avoid 'singularities' like at the end of the sweep to begin with,) especially with the way the wing blends are trimmed. You have to be precise or tiny extra edges will appear when you join things up.





Wing 2

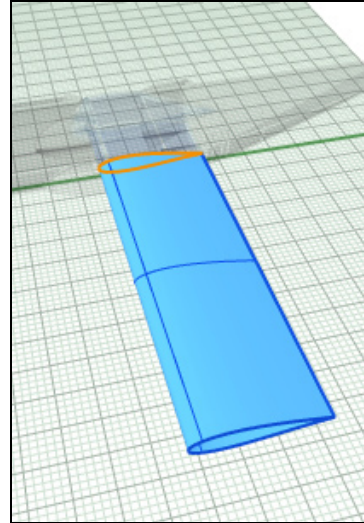
Outer wing



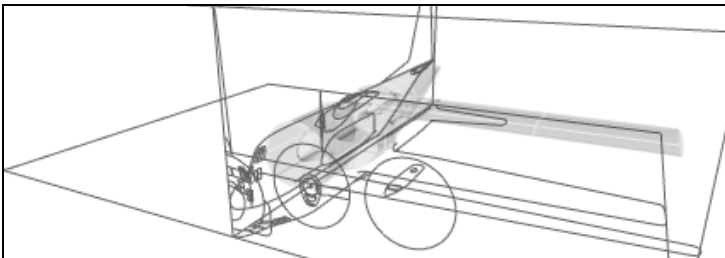
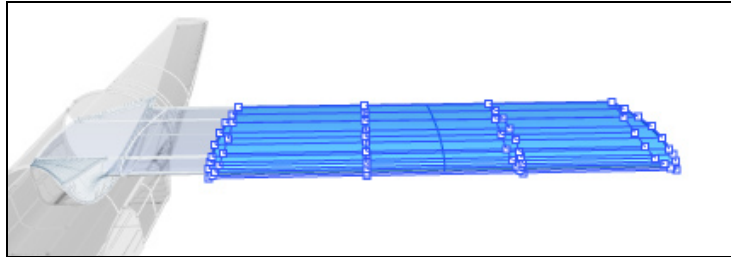
1. With **DupEdge**, extract all around the end of the outer wing section.

2. **Join** up the curves.

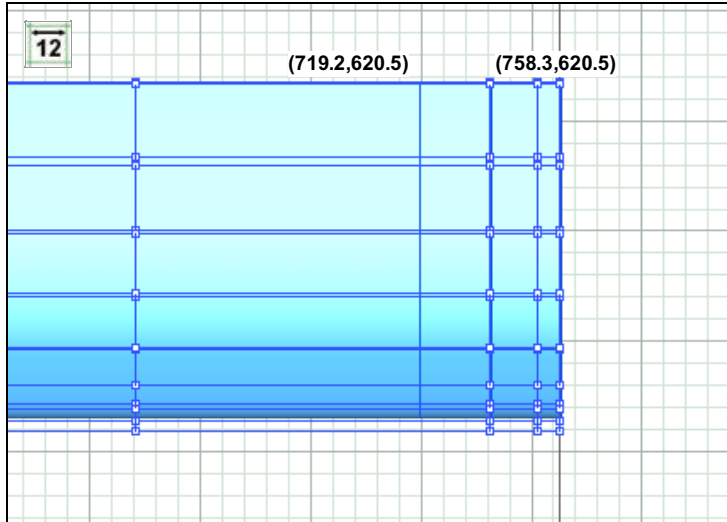
3. **ExtrudeCrv** the wing section by **579.5** units. Set **DeleteInput** to **Yes**.



4. Raise the degree of the wing along it's length to **3** from **1** with **ChangeDegree**. Leave the other direction at **5**.

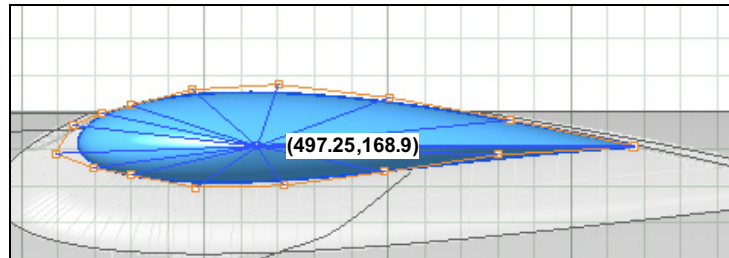
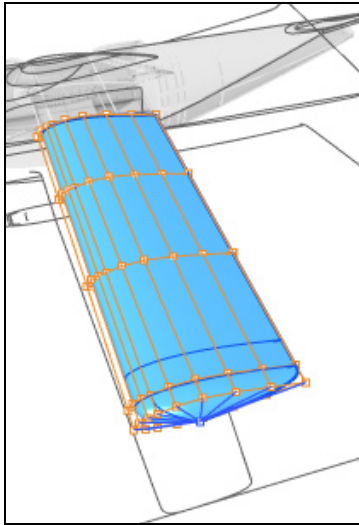


5. You can turn the reference drawings back on in the **Layer** panel.



6. Use **InsertKnot** to add a couple rows of control points near the end of the wing. The positioning isn't important, they'll be modified later.

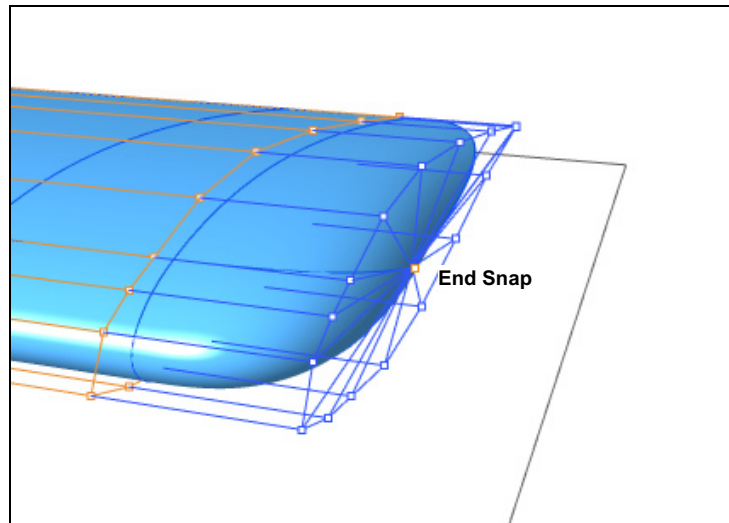
While adding a knot adds a row of control points, where you pick is not where they wind up, it is a little indirect. The **InsertControlPoint** command does place the points where you pick, but that changes the shape of the surface.

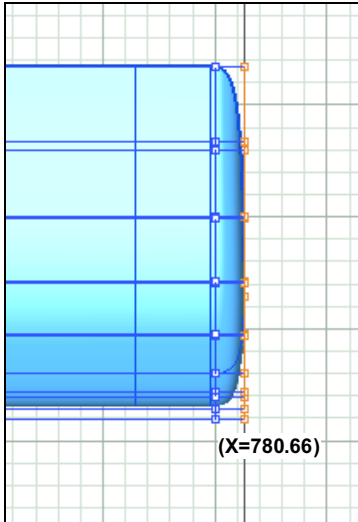


7. Use **SetPt** to collapse the last row of points into one. Use **SetY** and **SetZ** with the *Align to World* option, then place a point in the Right view.

8. Use **SetPt** again to align the second row of points with the end point. This time use **SetX** with the *Align to World* option and snap to the **End** point.

This is the simplest way to smoothly "close" a shape. If the end and second row of points are in the same plane, the tip will technically be smooth. It will suffice here, but other approaches can provide finer control and better surface quality.



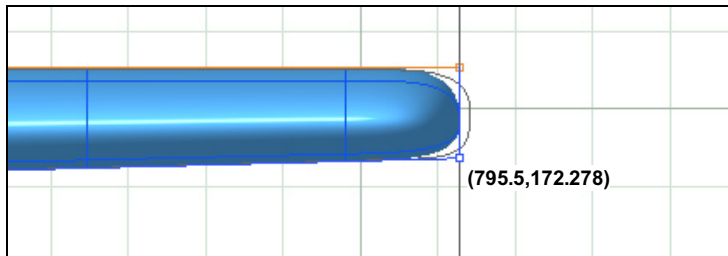
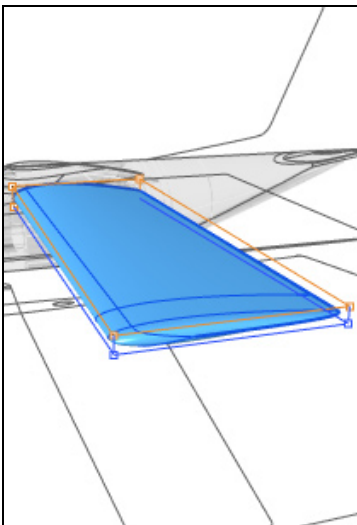
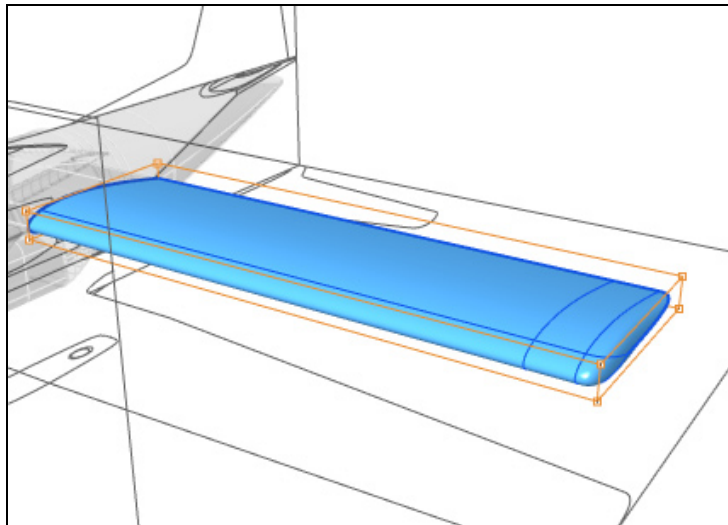


9. Select the third row of points and move them. You could use **SetPt** again for this, or just drag or nudge.

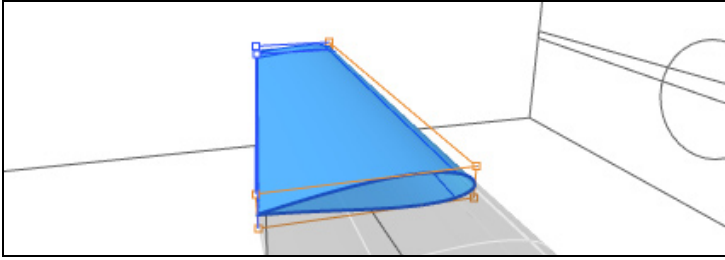
10. Grab the next row of points and slide them out.

Now the wing needs to be tapered, we'll use a new deformation tool for that.

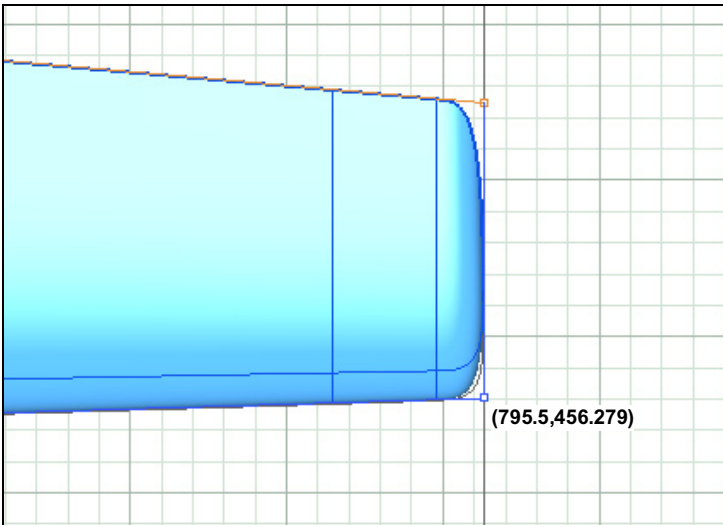
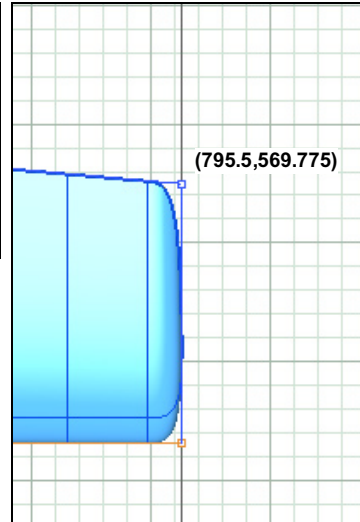
11. Select the wing surface and run **CageEdit**. Set **PreserveStructure** to **Yes**. At the **Select control object** prompt pick **BoundingBox**, Pick **World** for the **Coordinate** system, and at the **Cage points** prompt enter values of **2** for the number of points in each axis: **XPointCount**, **YPointCount**, and **ZPointCount**. Finally, select **Global** for the **Region** to edit. There are a lot of settings, but you can click through the defaults for most of them usually.



12. We now have a simple control point "cage" that can be used to modify this surface. Select the lower outside row of points and move them up by about **15.09** units.

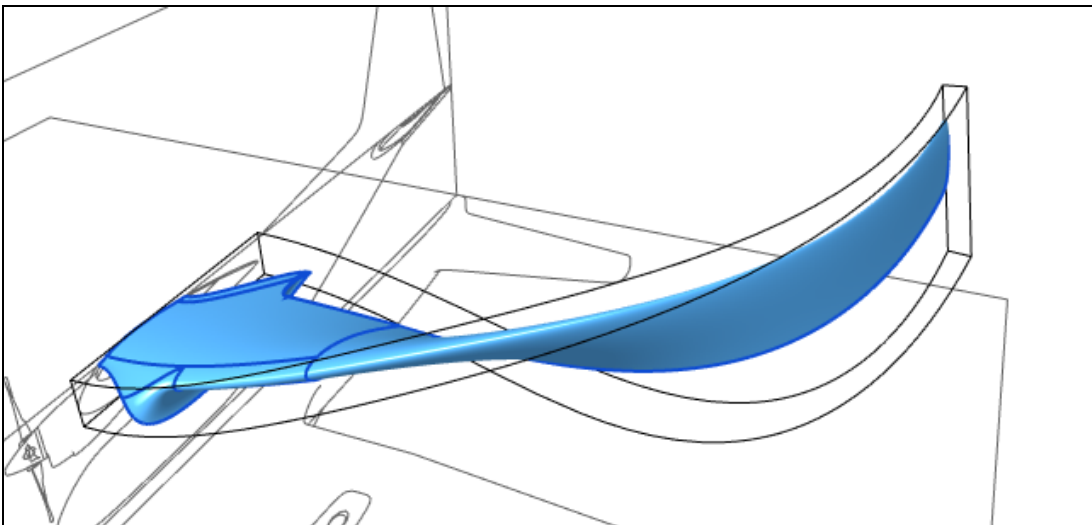


13. Move the rear outer column of points forward by **51** units.



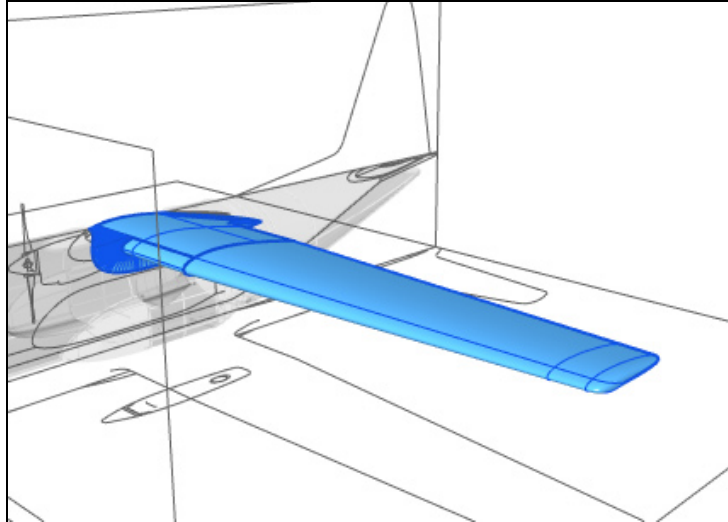
14. Finally, move the front outer column of points back by **17.7** units.

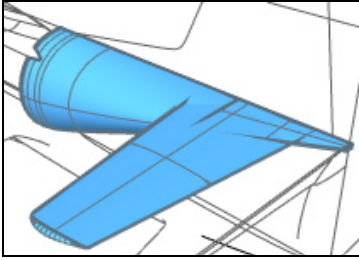
This was a very simple example of using Rhino's Universal Deformation Technology. **CageEdit** works on polysurfaces as well as surfaces, and can be made to do some "interesting" things.



15. Turn off the control points for the control cage and **Delete** it.

16. Join the outer wing to the inner.





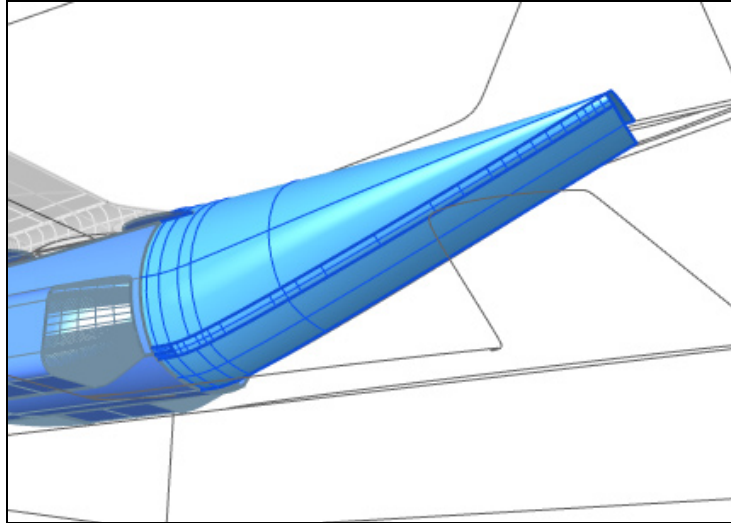
Empennage 1

Horizontal tail

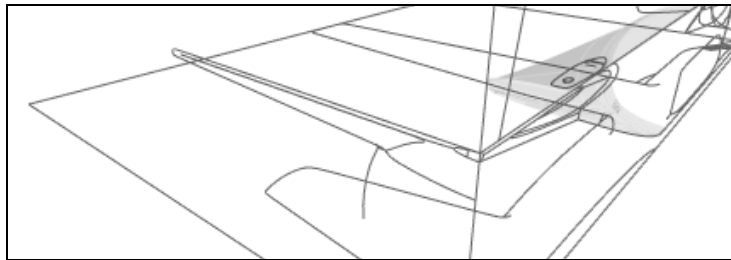
1. **ExtractSrf** the aft fuselage surfaces from the main body.

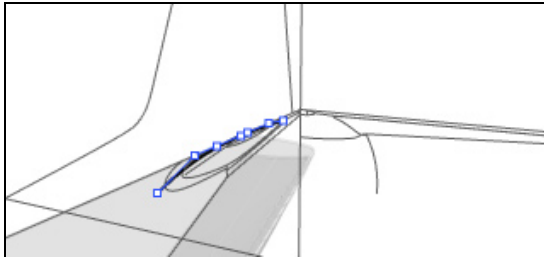
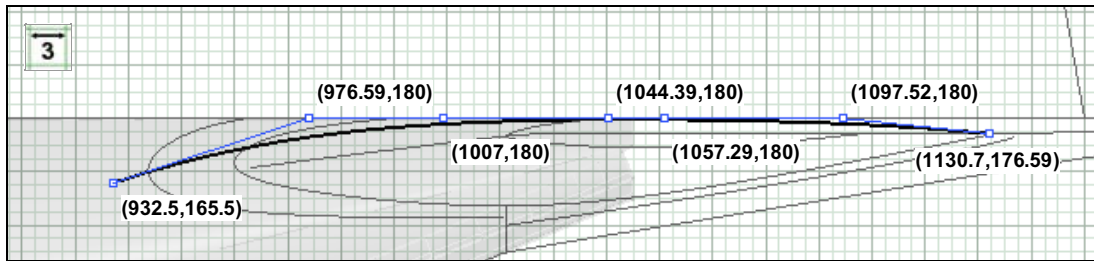
2. **Join** up the extracted surfaces.

3. Hide the rest of the model by running **Invert** then **Hide**.



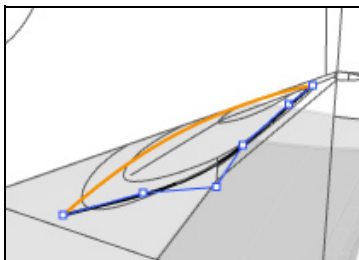
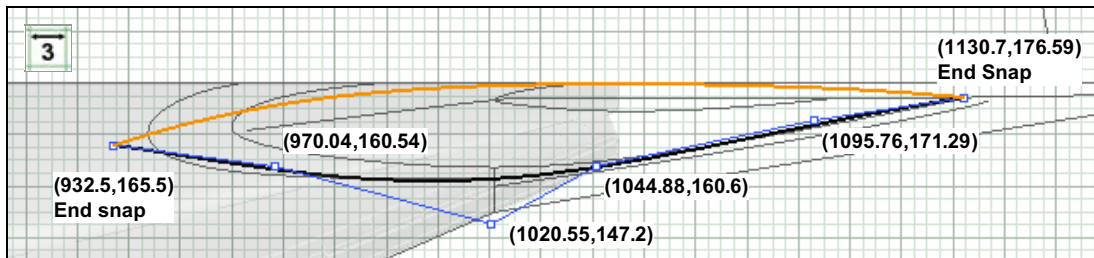
4. Go to the **Layer** panel and make the "Tail Drawing" layer visible, but leave it locked.





5. Draw a **Curve** of **Degree 5** for the upper part of the root section of the stabilizer.

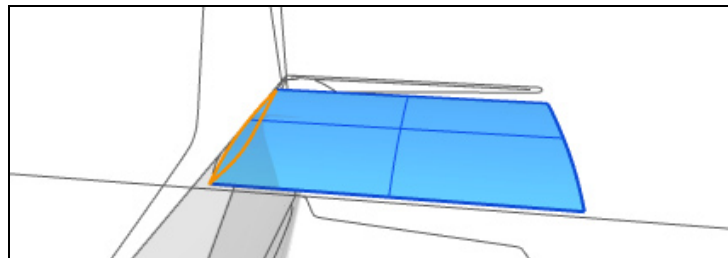
6. Draw another **Curve** for the lower part, snapping to the ends of the first.



As you use higher degree curves they get smoother, each control point has a more subtle, gentle, spread-out influence over the curve. Beyond Degree 5 the added 'smoothness' is fairly academic and at very high degrees (you can go up to 11) the influence of control points becomes so subtle the relationship between the control point structure and the shape of the curve can cease to make sense.

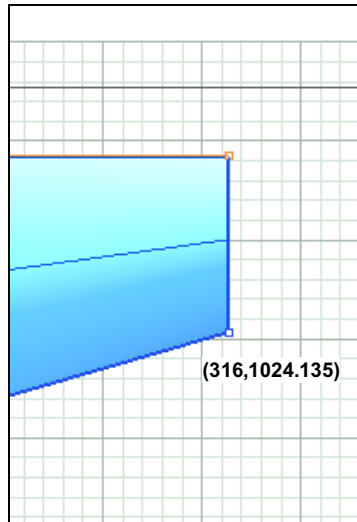
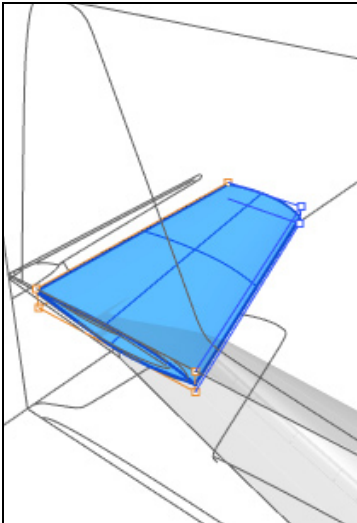
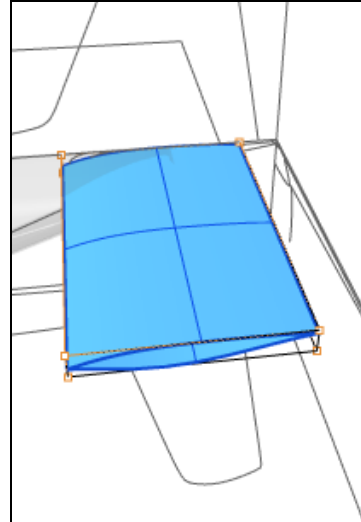
7. **ExtrudeCrv** the root curves a distance of **316** units.

8. You can **Delete** the input curves.

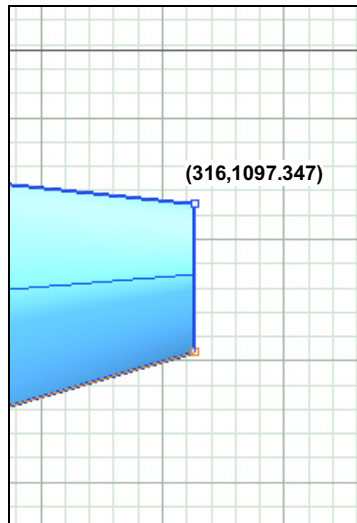
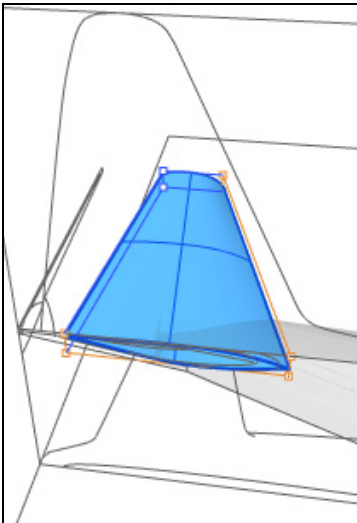


9. We're going to start editing the stabilizer the way we finished editing the wing, with a simple deformation cage. Run **CageEdit** on both surfaces together and set the same options, which you won't have to reset all of these.

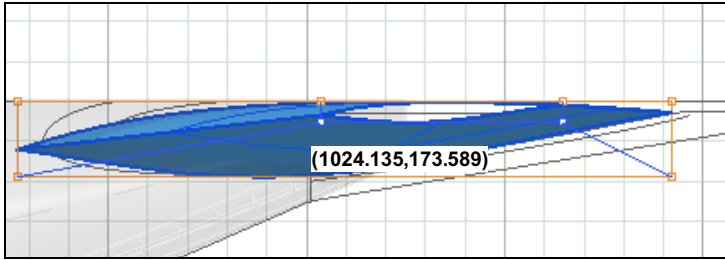
Set *PreserveStructure* to **Yes**. At the *Select control object* prompt pick **BoundingBox**, Pick **World** for the *Coordinate system*, and at the Cage points prompt enter values of **2** for the number of points in each axis: *XPointCount*, *YPointCount*, and *ZPointCount*. Finally, select **Global** for the *Region to edit*.



10. Select the front outer column of cage points and move them back **91.64** units.

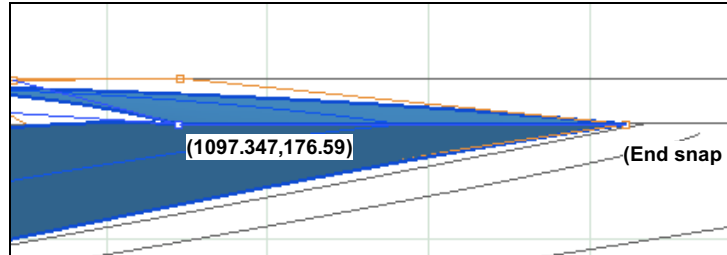


11. Select the aft outer column of cage points and move them forward **33.35** units.

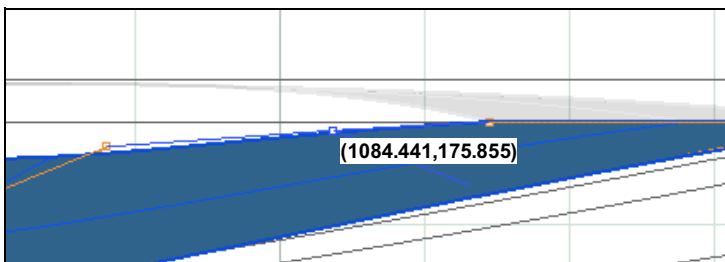


12. Select the lower outer row of points and move them up **16.37** units.

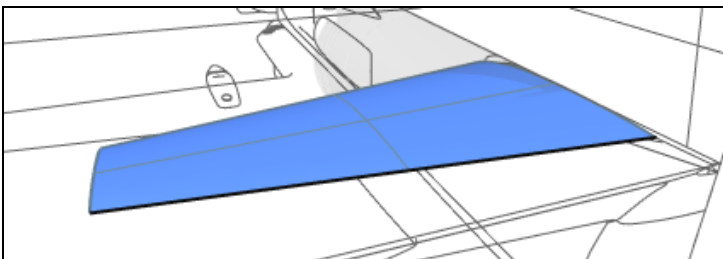
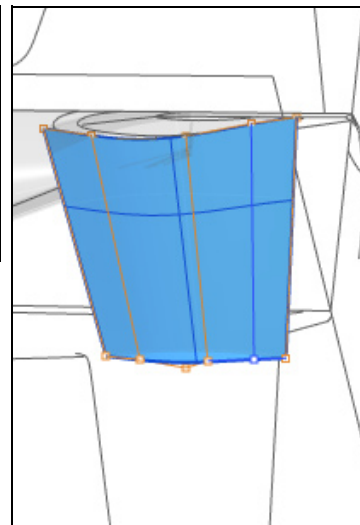
13. **Delete** the control cage object.



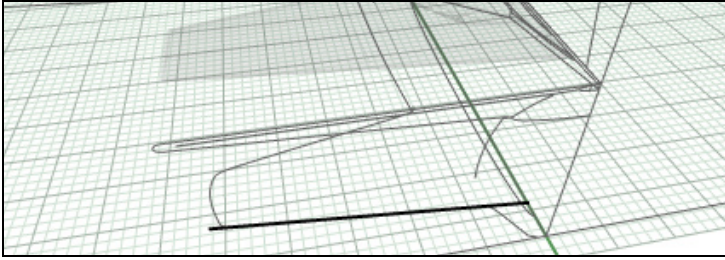
14. We want the trailing edge of the stabilizer to be flat, so use **SetPt** with **SetZ** and **Align to World** to align the outer rear end points of the surfaces with the inner **End** point.



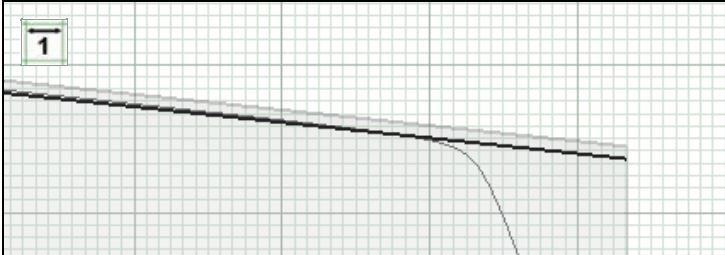
15. Move the second-from-rear point down by **1.6** units.



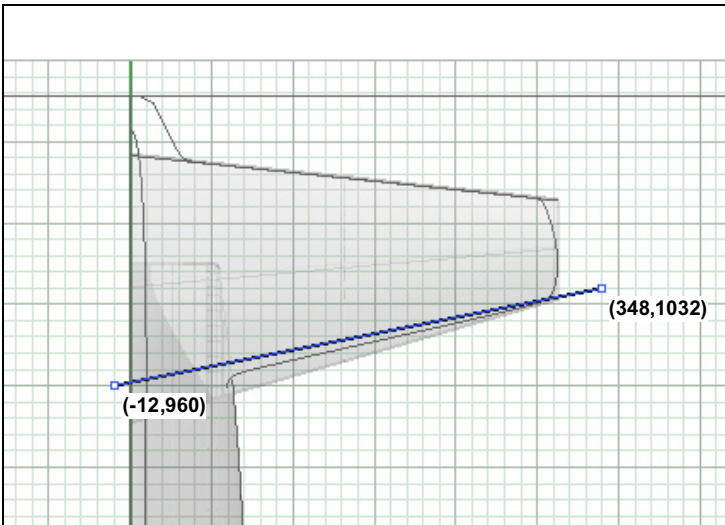
16. Extract a line from the trailing edge of the stabilizer with **DupEdge**.



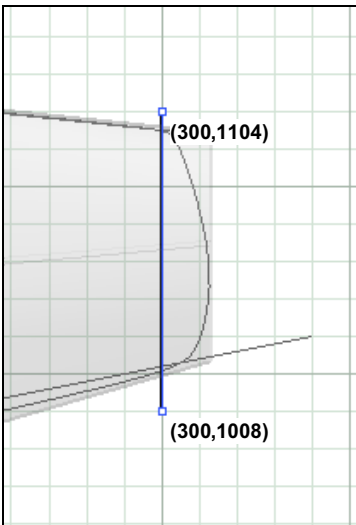
17. Move it down to the construction plane using **ProjectToPlane**. At the *Delete input objects?* prompt select **Yes**.



18. Nudge the line forward by **1** unit.



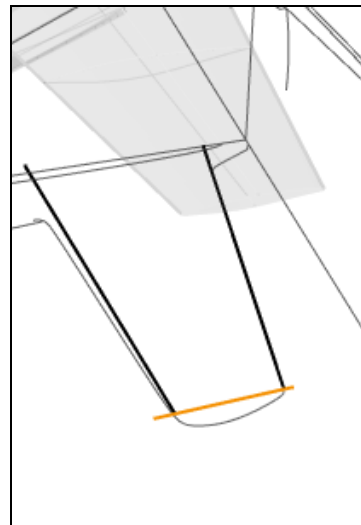
19. Draw a new **Line** near the leading edge.

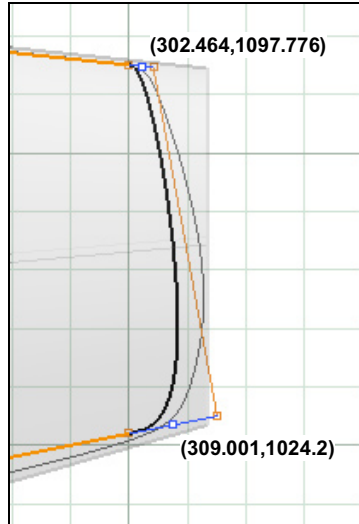
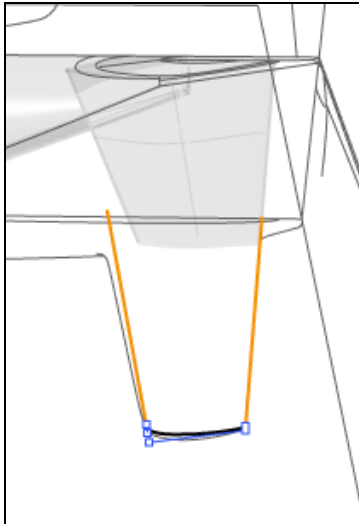


20. Draw one more **Line**, then...

21. Use it to **Trim** off the other lines.

22. **Delete** it.

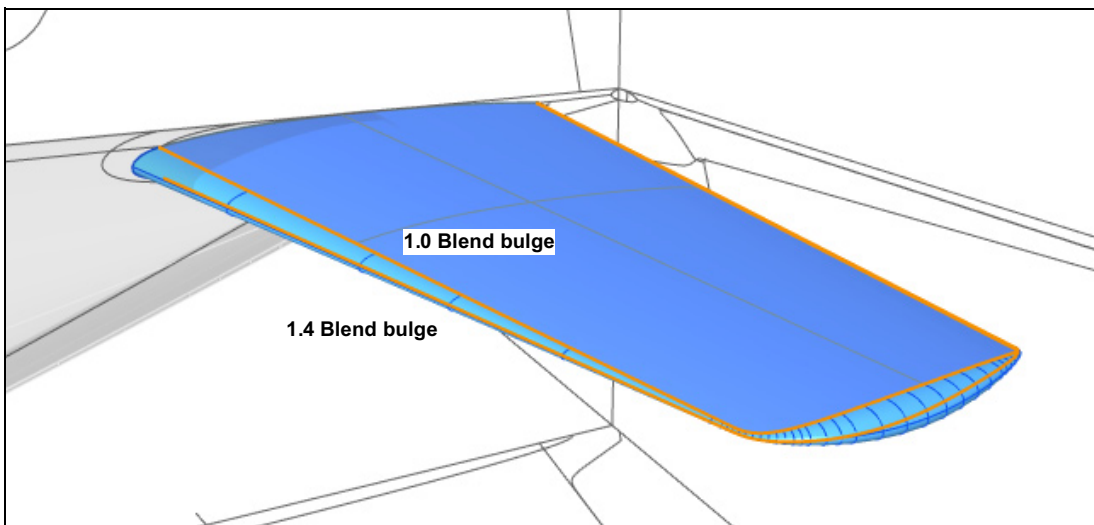
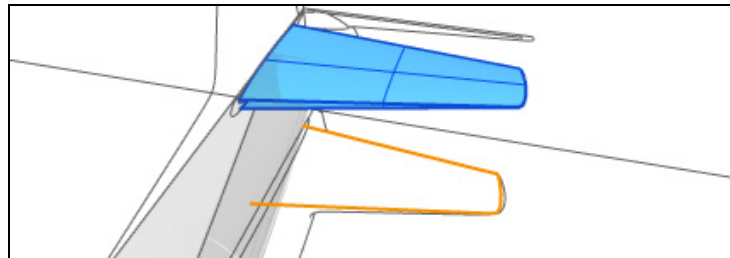




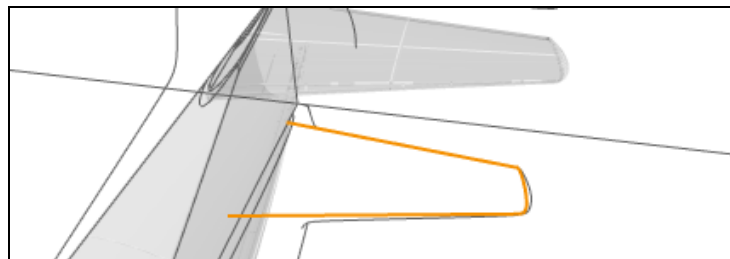
23. *BlendCrv* between the lines. Specify **G2 Continuity** for each end, and move the second points as shown to adjust the bulginess.

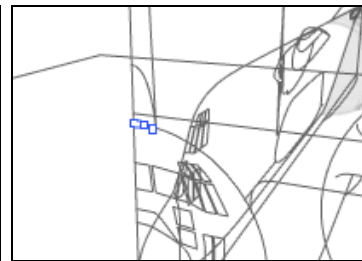
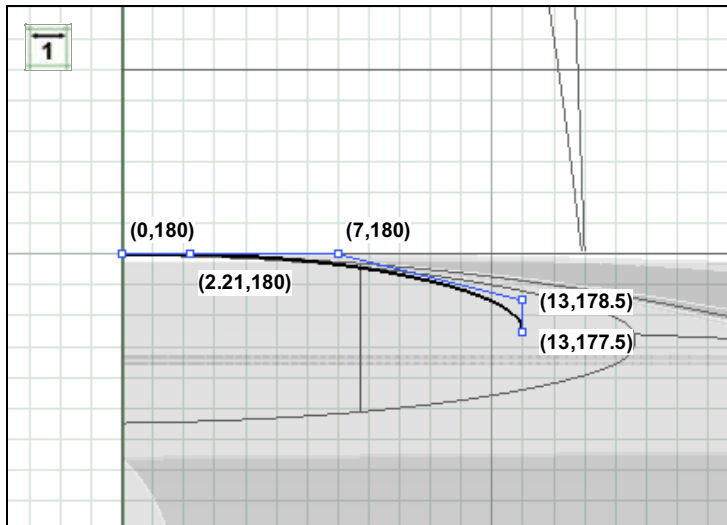
24. Select the blend curve and lines and **Trim** off the stabilizer surfaces.

25. *BlendSrf* between the stabilizer surfaces. Use a **Blend bulge** of **1** for the upper edge, **1.4** for the lower.



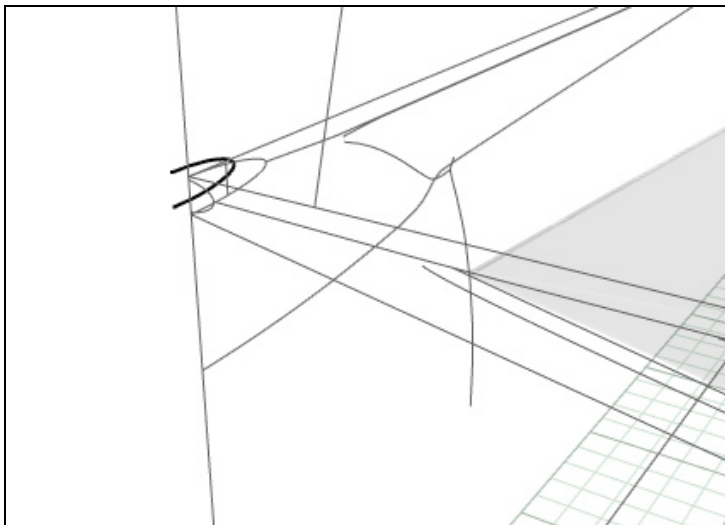
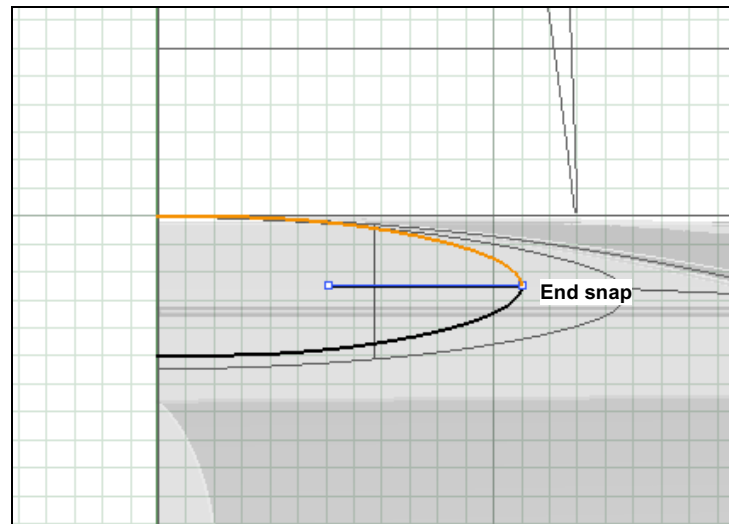
26. *Delete* the curves we used to trim the stabilizers.





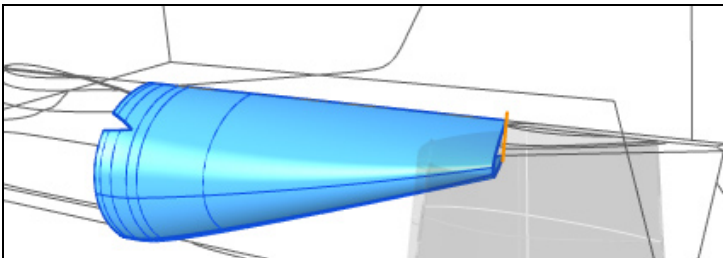
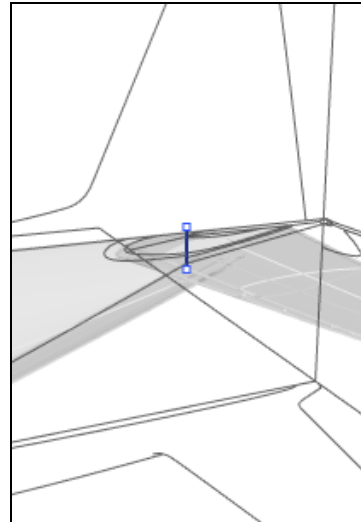
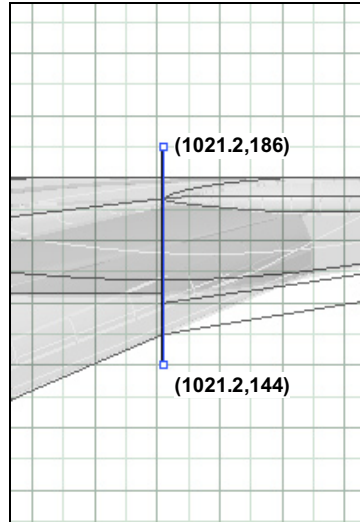
27. Draw a *Curve* of Degree 3 in the Front view.

28. *Mirror* this curve about it's **End** in the Front view.



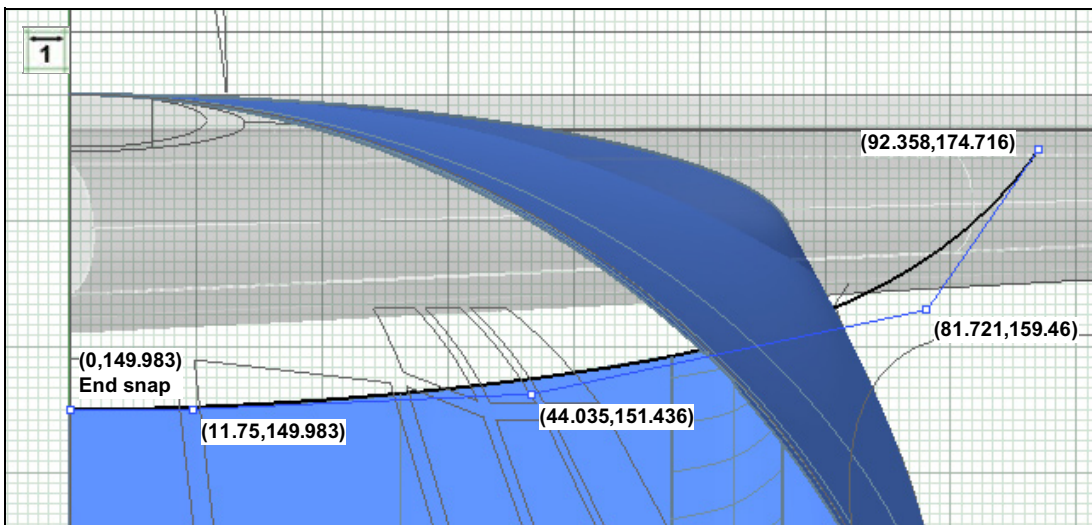
29. *Move* the two curves back by **1176** units, which places them a little past the end the plane. These curves will be used for the end of what we'll call the 'tail cone,' even though it's not terribly 'conic.'

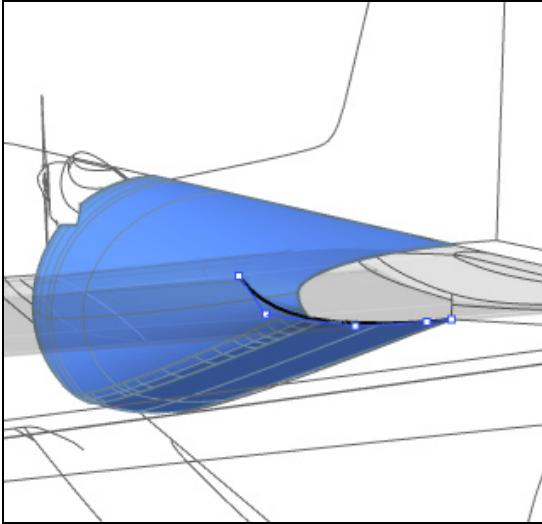
30. To start the front end of the tail cone, Draw a **Line** in the Right view.



31. Use the line to **Trim** off the aft fuselage.

32. **Delete** the line.



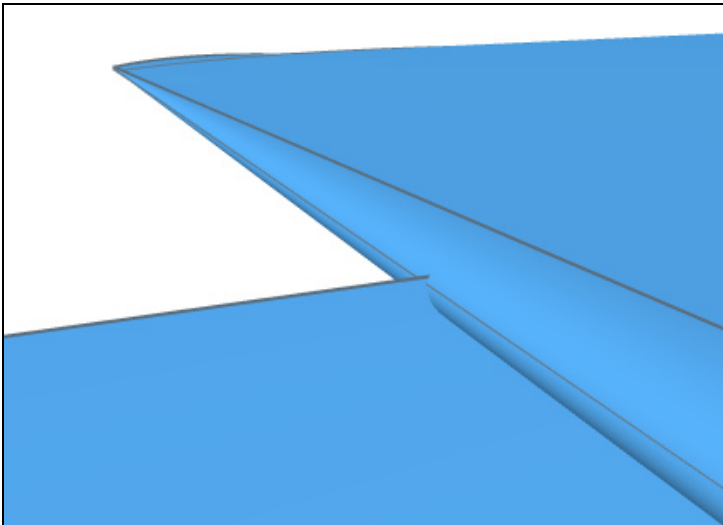
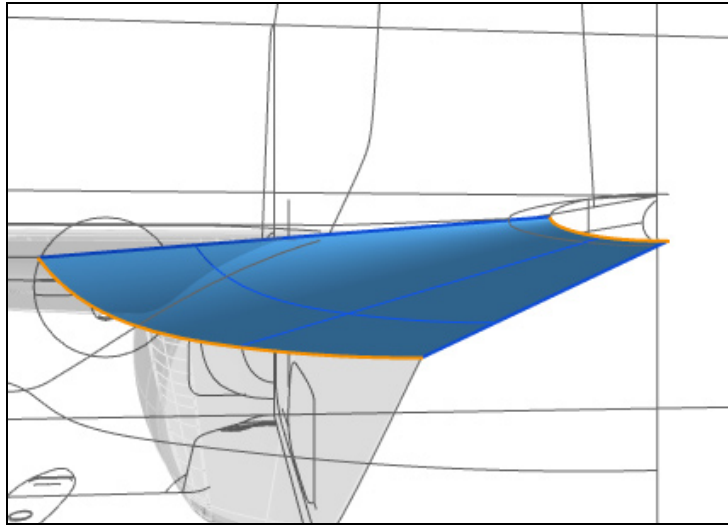


33. Draw a *Degree 3 Curve* for the lower front edge of the tail cone. Place its start point by snapping to the **End** of the aft fuse. Now if you enter the coordinates shown without adding the Z value of 1021.2, they won't be kept on the same plane as the first point, they'll be on the construction plane, so you can place them freehand—which should be adequate—use the Ortho snap to place the second point—or use **ProjectOsnap** (the button marked "Project" in the snap panel) to draw the whole curve on the construction plane, then **Move** it back.

This doesn't follow the edge of the fuse extremely closely but that's actually not unlike the actual aircraft!

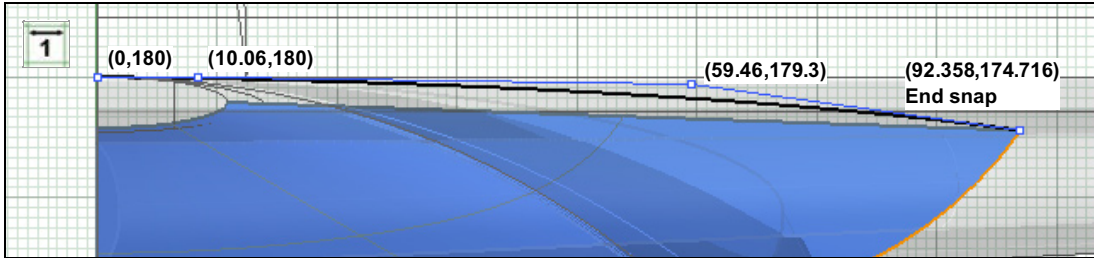
34. **Loft** between the curve we just made and the lower, aft tail cone edge curve. Before running the command, click the "Record History" button on the task bar.

Take a look at how the lofted surface intersects the trailing edge of the stabilizer. It should cross somewhere around the middle of the small blend surface. If it's not, you can adjust the end point of the front curve and the surface will update automatically.

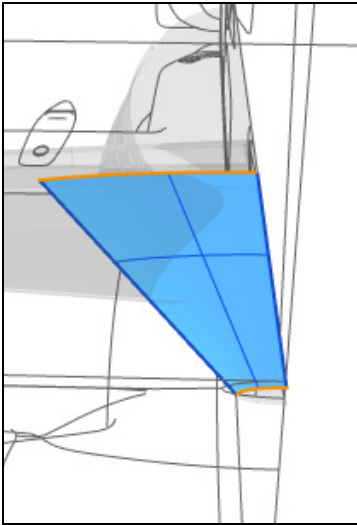
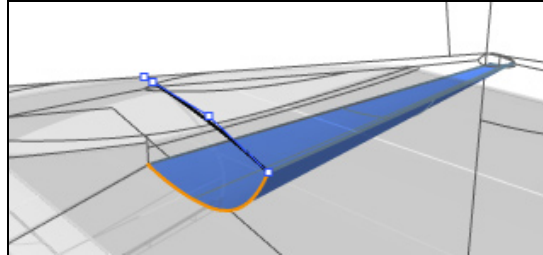


This is, of course, a fairly trivial example of using Command History since it's pretty simple to just point-edit the surface.

35. At any rate, when satisfied with the surface **Delete** the curves used to make it.



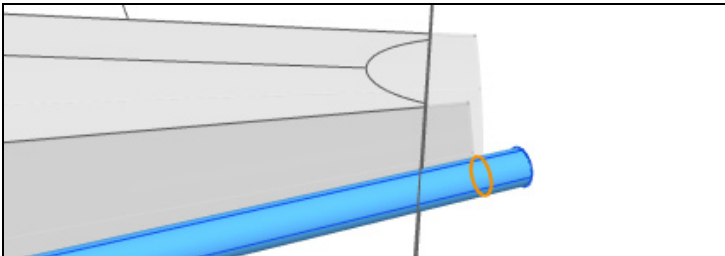
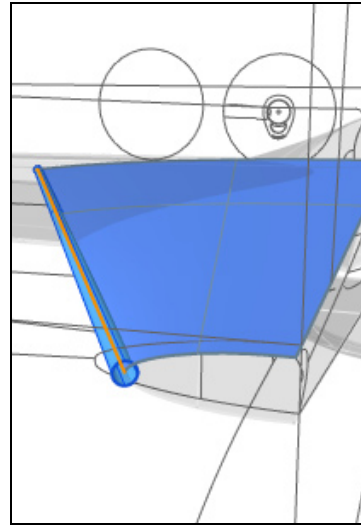
36. Draw another *Degree 3 Curve* for the lower front edge of the tail cone. There's a similar issue trying to draw it as with the lower curve. If you "freeform" it, after use **SetPt** to make sure the inner points are at a height of 180 units.



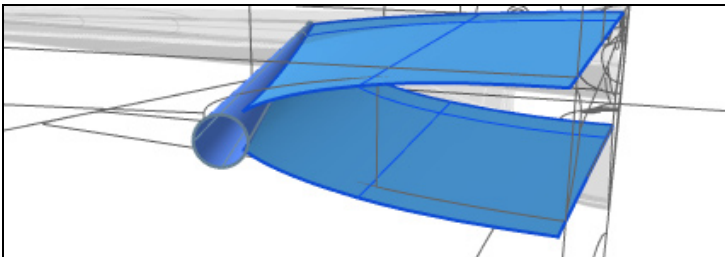
37. **Loft** between the curve we just drew and the upper upper aft tail cone curve.

38. **Delete** the input curves.

39. Build an open *Pipe* with a *Radius* of **1** along the edge of one of the tail cone surfaces.

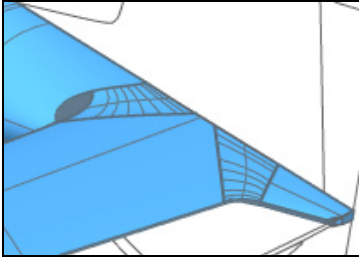


40. Use **ExtendSrf** with the *Smooth* option on the aft end of the pipe, with a factor of at least **1**.



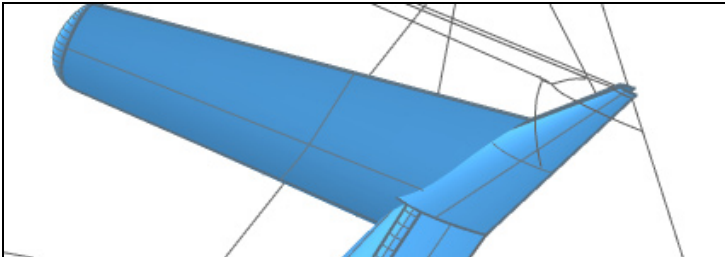
41. **Trim** off the two tail cone surfaces with the pipe.

42. **Delete** the pipe.



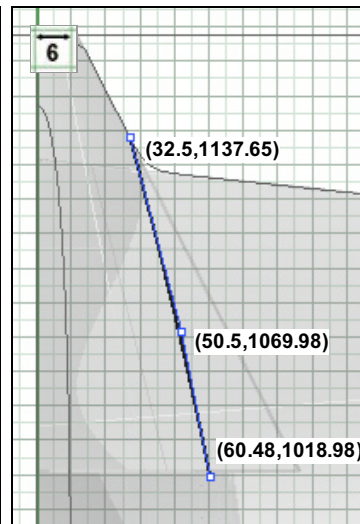
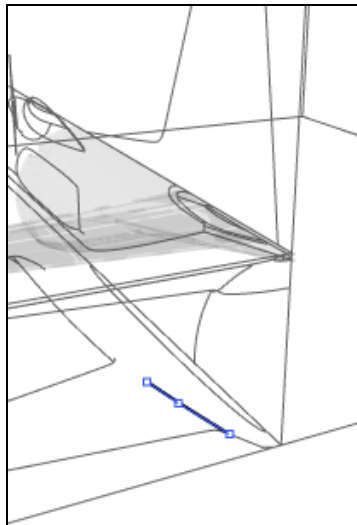
Empennage 2

Blending



We now have these three rather disjoint shapes that need to be blended together.

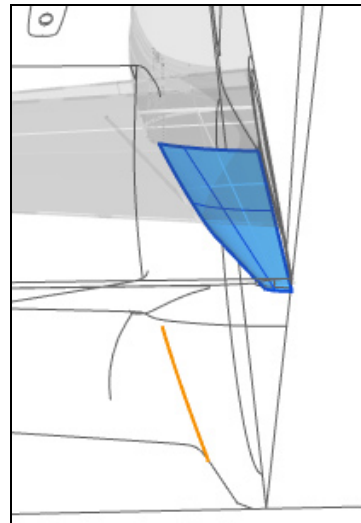
1. Create a **Curve** in the Top view.

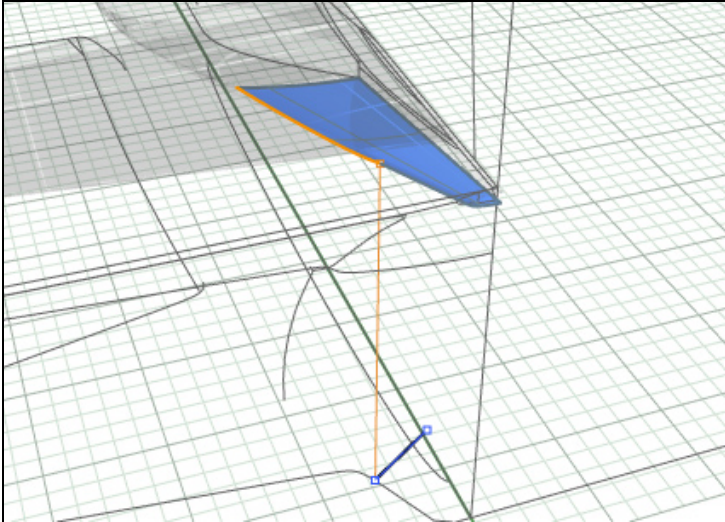


2. **Trim** off the lower tail cone surface using the curve.

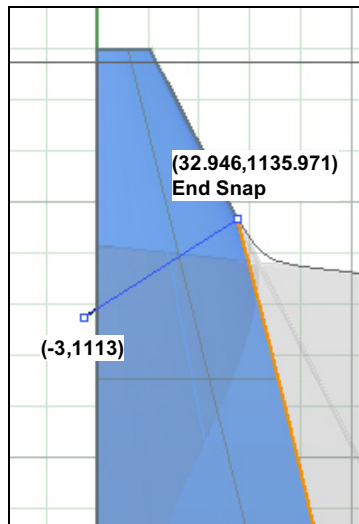
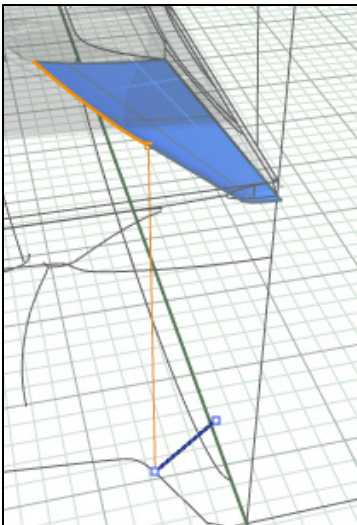
3. **Delete** the Curve.

This deleting of construction geometry as soon as possible is only to keep the screen shots clean and simplify instructions about what curve to use for what operation, it is not recommended practice in the 'real world.'



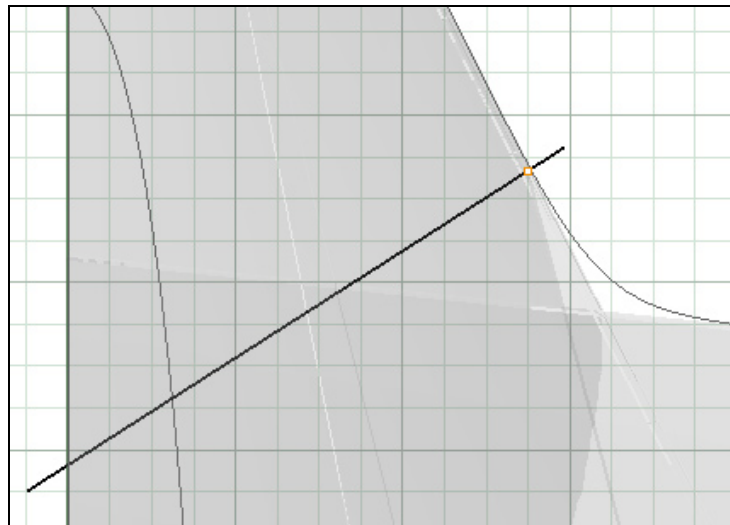


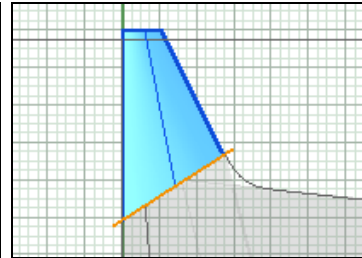
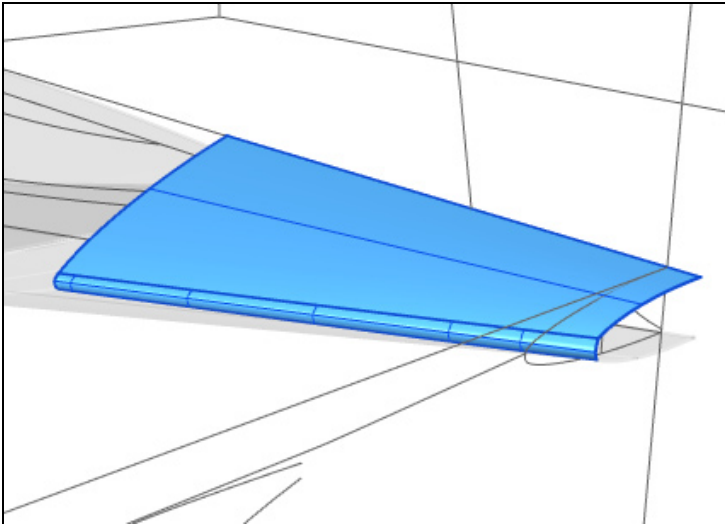
4. Draw a **Line**, extending from the **End** of the edge that we just trimmed off the lower tail cone surface.



5. Draw a **Line**, extending from the **End** of the edge that we just trimmed off the lower tail cone surface. It's not necessary, but enable **ProjectOsnap** to place it on the construction plane.

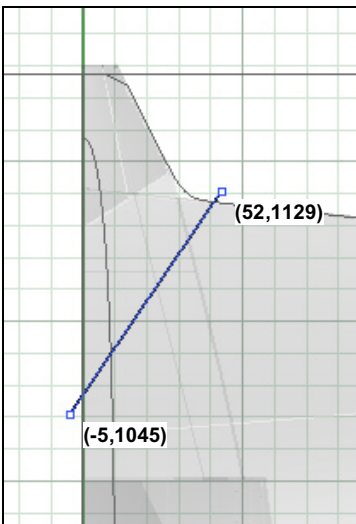
6. It's necessary to **Extend** the line a little bit. Press Enter at the first prompt for dynamic extend, Set **Type** to **Line**, then enter an extension distance of a few units.





7. Use the line to **Trim** off the upper tail cone surface and the blend between the tail cone surfaces.

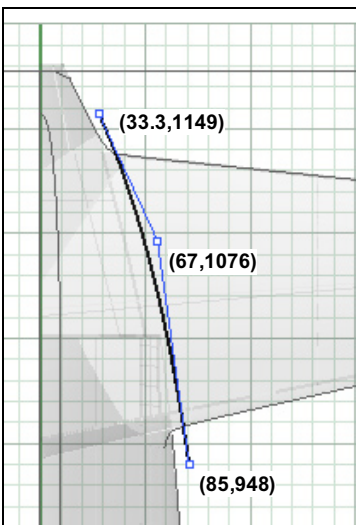
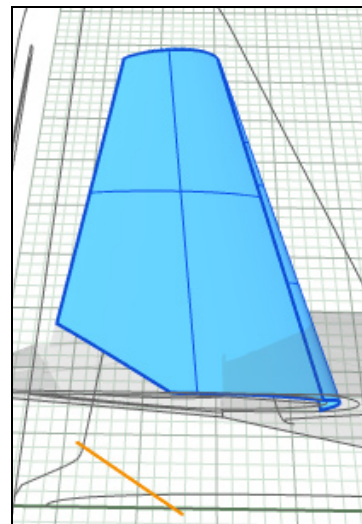
8. As usual, **Delete** the line.



9. Draw a **Line** in the Top view.

10. Use it to **Trim** off the upper stabilizer surface and the stabilizer edge blend.

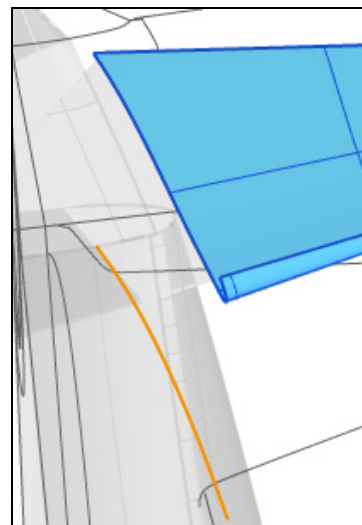
11. **Delete** the line.

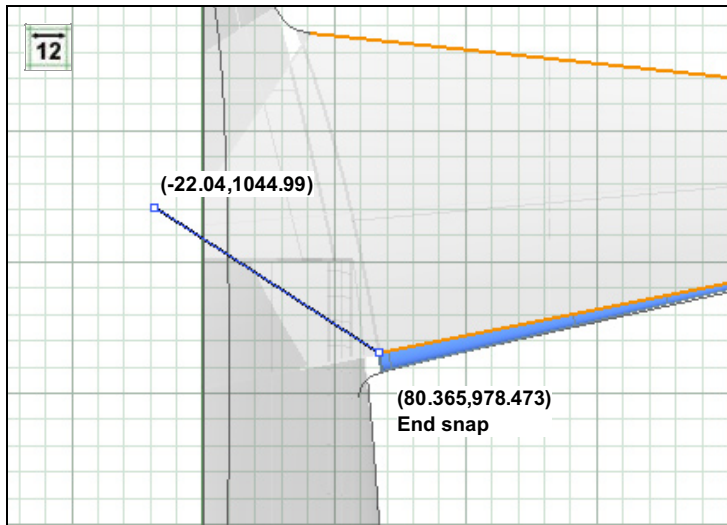


12. Draw a **Curve** in the Top view.

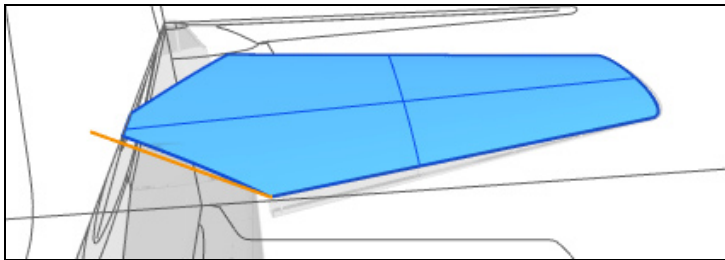
13. Use it to **Trim** off the lower stabilizer surface and the front piece of the stabilizer edge blend.

14. **Delete** the curve.





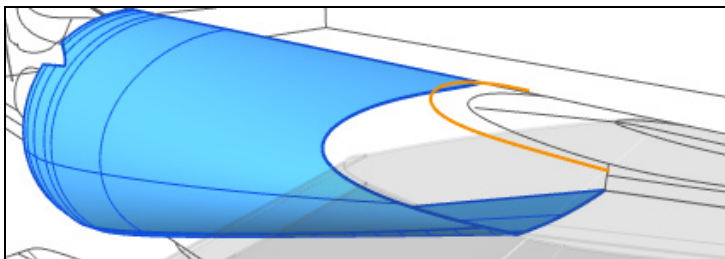
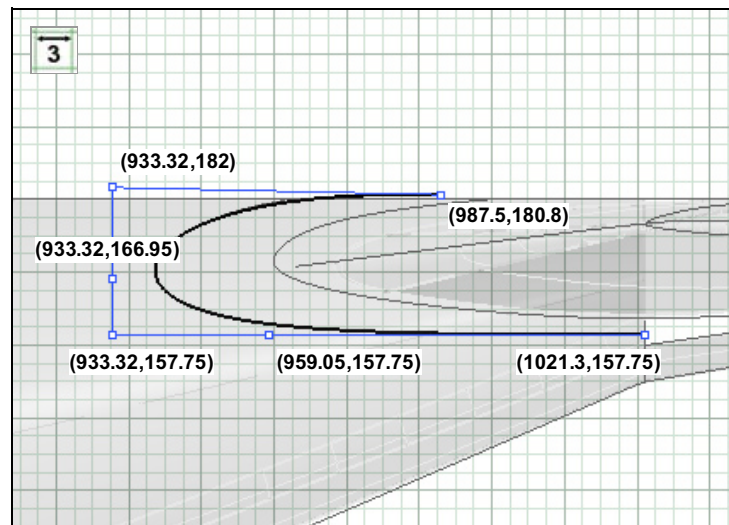
15. Use the **End** of the edge trimmed off the stabilizer blend as the starting point for another **Line**.



16. Use the line to **Trim** the upper stabilizer surface.

17. **Delete** the line.

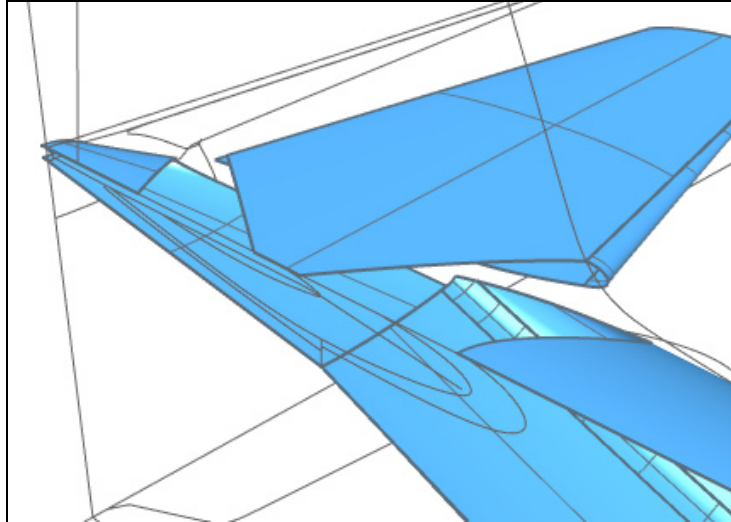
18. Draw a **Degree 5 Curve** in the Right view.



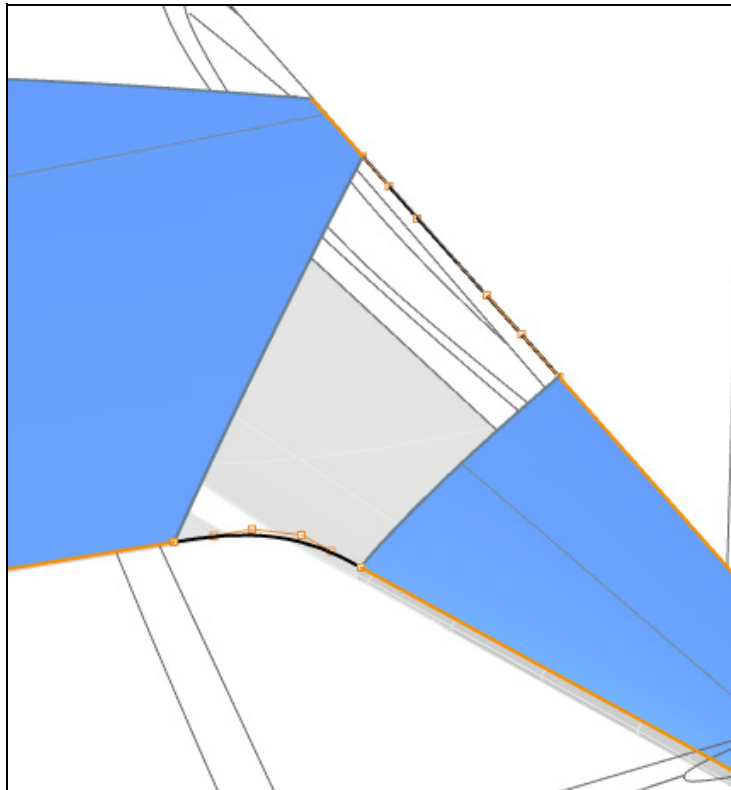
19. Use it to **Trim** the aft fuselage.

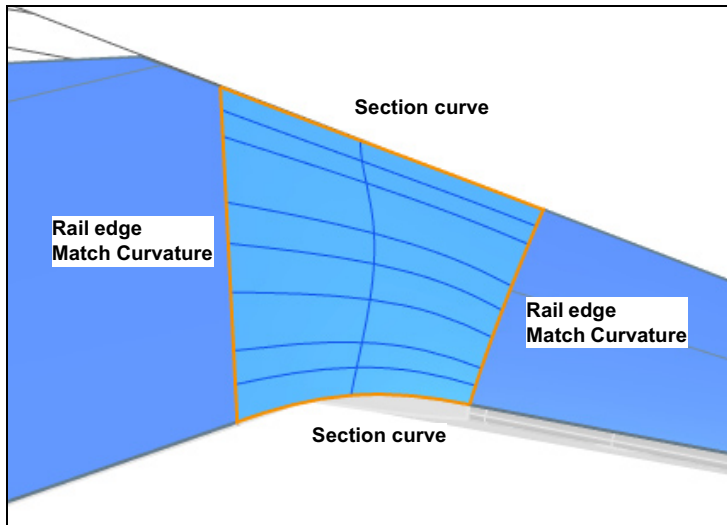
20. **Delete** the curve.

Now we'll start building transition surfaces between these objects.



21. Create two **BlendCrv** curves between the edges of the upper stabilizer surface and the upper tail cone surface. Specify **G2** continuity on each end, and the default curves should be fine.

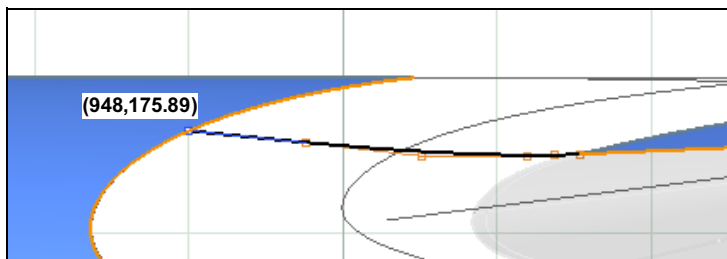
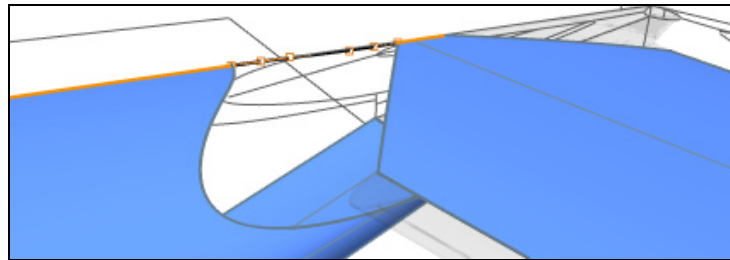




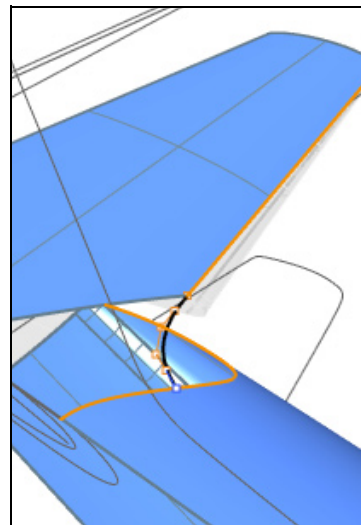
22. Sweep2 with **Curvature** continuity between the stabilizer and tail cone. Use the *Preserve first* and last shape options.

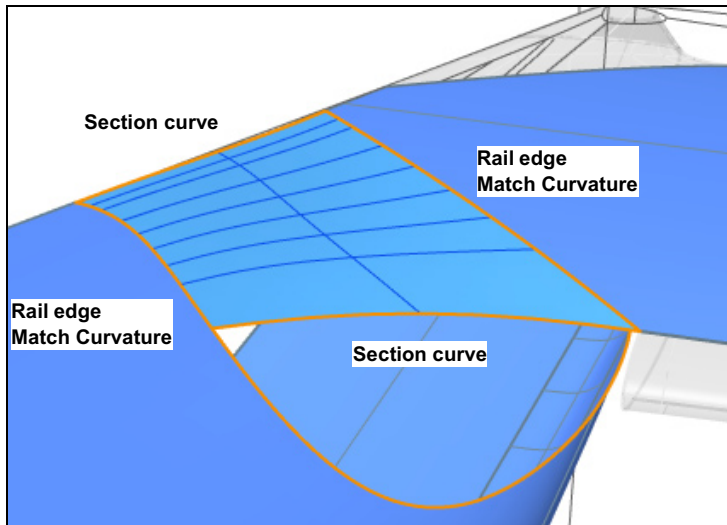
23. Delete the section curves.

24. Build a **BlendCrv** between the inside edge of the fuselage and the upper stabilizer surface. Specify **G2** continuity on each end.



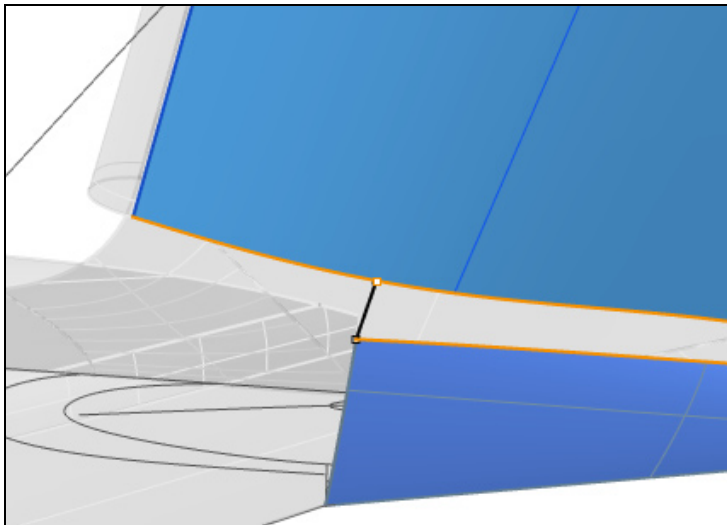
25. Create another **BlendCrv** from the stabilizer to the cutout in the fuse. Use the default **Curve** option and pick the edge of the stabilizer, then use the **Edge** option to place the other end perpendicular the fuselage edge. After adjusting the placement of the end point, you may want to "reset" the curve bulginess by going into the continuity settings and re-specifying them.



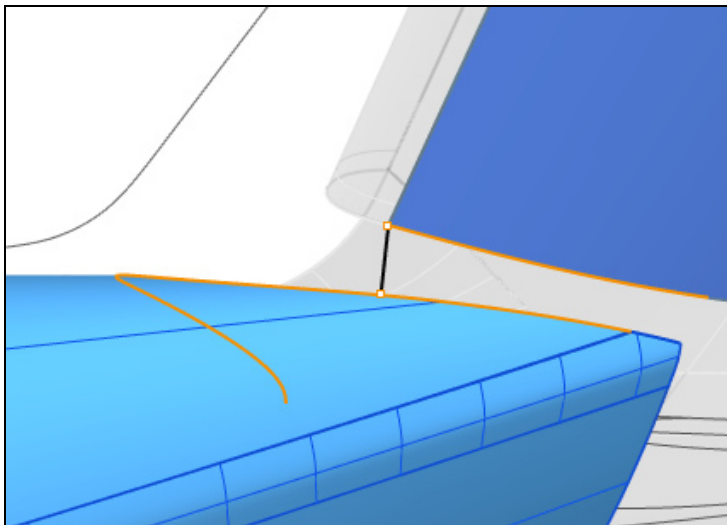


26. Sweep2 with **Curvature** continuity between the stabilizer and fuselage, as we did further back. Use the *Preserve first* and last shape options.

27. Delete the blend curves.



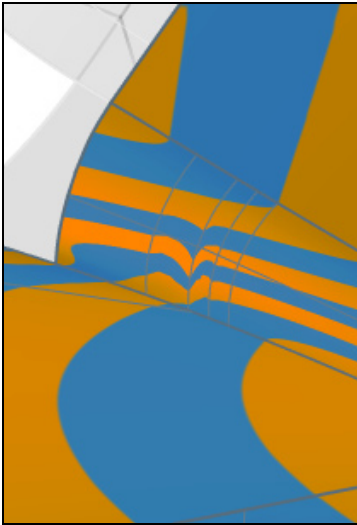
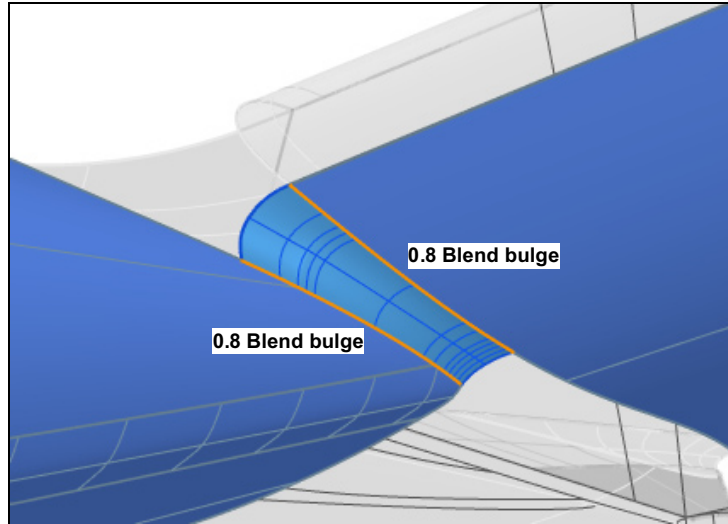
28. Use SplitEdge on the lower stabilizer surface. Split the edge by snapping to the **End** of the bottom of the tail cone.



29. Now run SplitEdge on the edge of the fuselage, splitting to the **End** of the lower stabilizer surface.

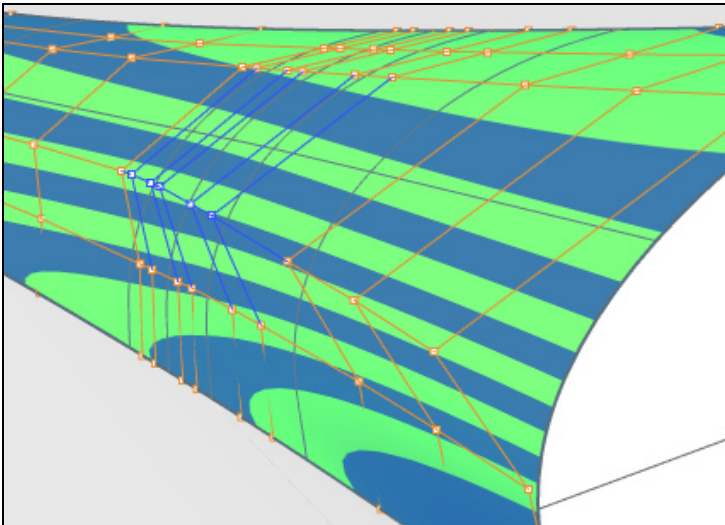
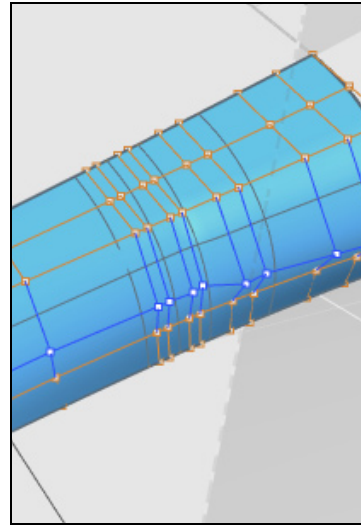
Of course this splitting of edges is not necessary to get the blend to cover part of an edge, but it's more convenient in this case.

30. BlendSrf between the aft fuse and the lower stabilizer surface. Specify *Blend bulge* values of **0.8** for both sides.



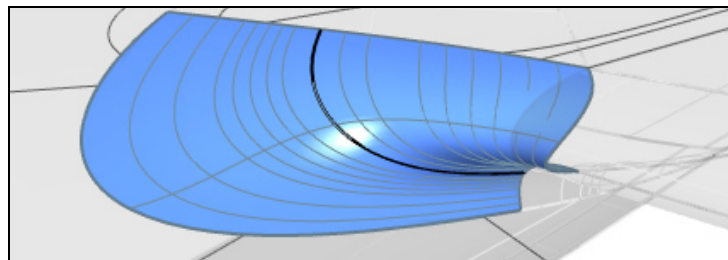
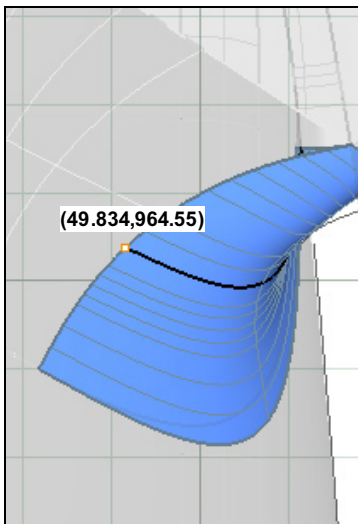
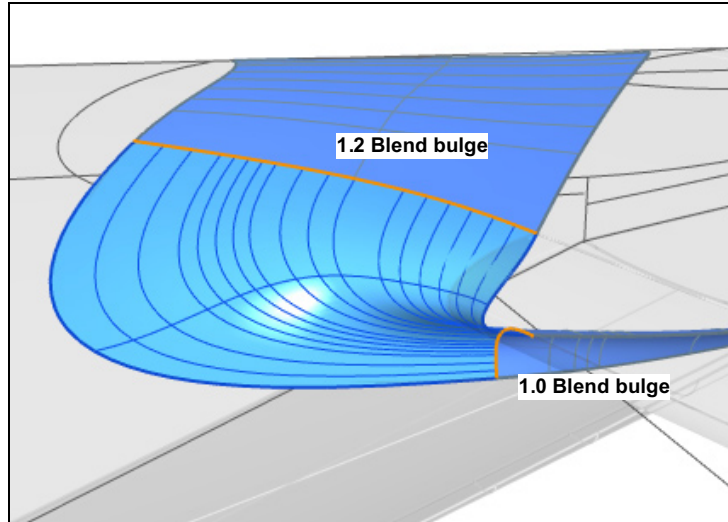
Looking at the blend surface, there is a small flaw evident. If you turn the control points on, you can see that a few points in the third row from the bottom are 'out of whack.'

This is the result of the aft fuselage section being based on a precise circle. As has been pointed out, Degree 2 surfaces like that aren't as 'smooth' as higher Degree surfaces, and the blend surface cuts across the seam between the halves of the original circle.



31. Thankfully, it's relatively easy to fix with a little point-editing. Having the **Zebra** command active while editing helps. This isn't an important area and won't impact anything else, so I'll not give detailed instructions. It should only be necessary to move 4 or 5 points in the Top view, and don't change any of the first three columns of points.

32. BlendSrf between the the blend we just made and the swept surface between the fuselage and the upper stabilizer surface.



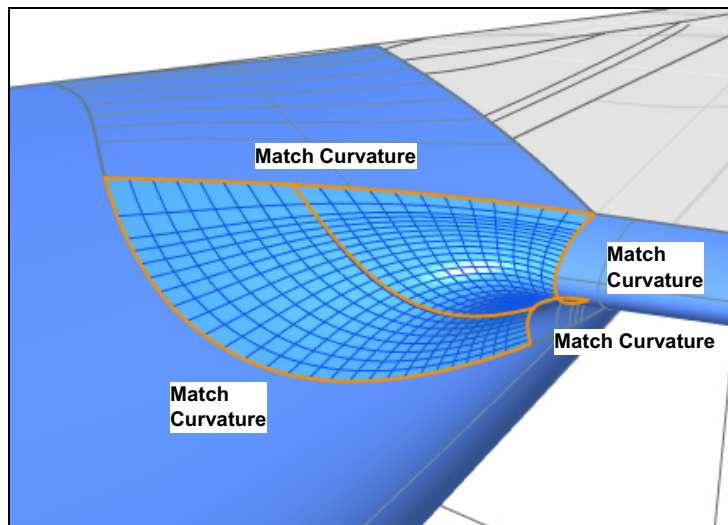
33. Grab a curve from a bit ahead of the center of the the blend with **ExtractIsocurve**. We could have used **BlendCrv**, but this helped visualize what curve to pick.

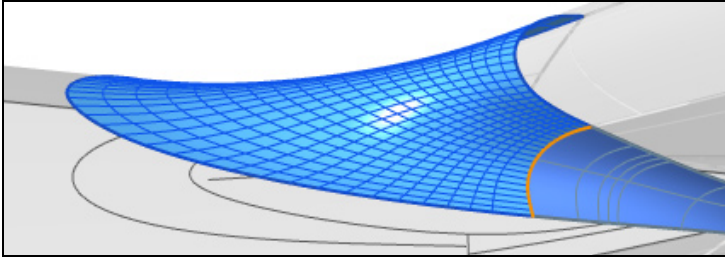
34. Delete the blend surface.

35. Fill in the hole with a **NetworkSrf**. Using a tight tolerance gave a very 'heavy' surface with some odd effects, so set all the Tolerances to **0.1**.

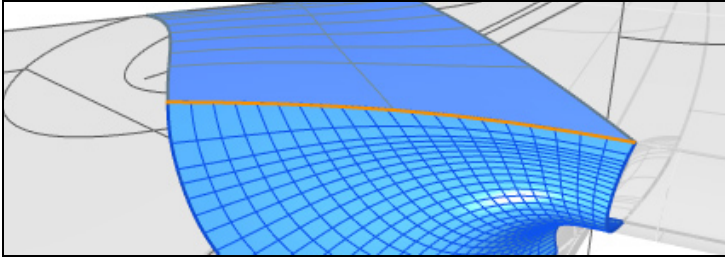
36. Delete the curve extracted from the initial blend.

Using a loose **Edge curve** tolerance but keeping a tight **Angle** tolerance like this, and specifying **Curvature** continuity, gives us a surface that's G2 to the adjacent edges...but not quite G0, they don't touch.

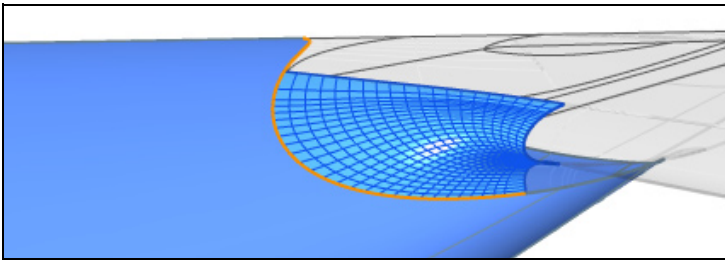
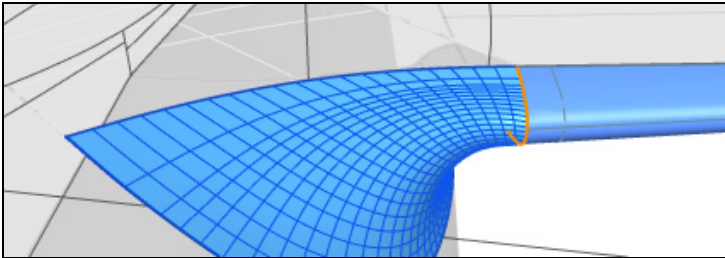




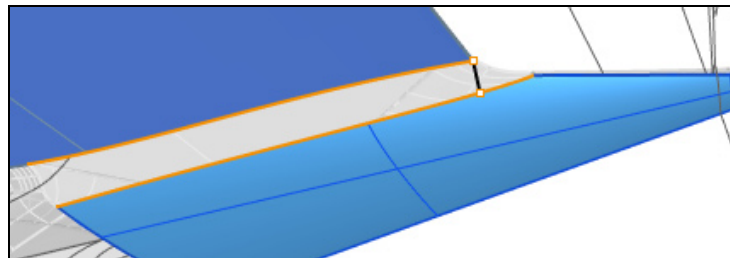
37. MatchSrf each edge of the network in turn. The sequence was determined by trial-and-error to minimize the number of knots added to the surface and the chance of adjacent edges getting pulled apart. Use the same settings for them all.

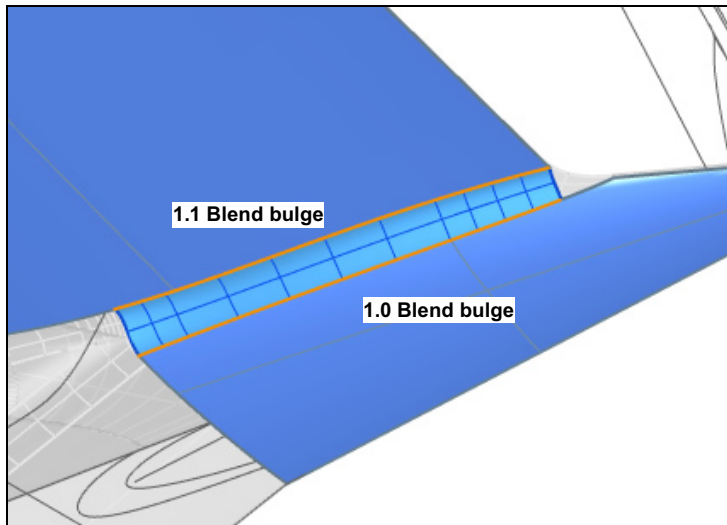


Specify **Curvature Continuity**, turn on *Refine match* and *Match edges by closest points*, and for the *Isocurve direction adjustment* specify **Preserve Isocurve direction**.



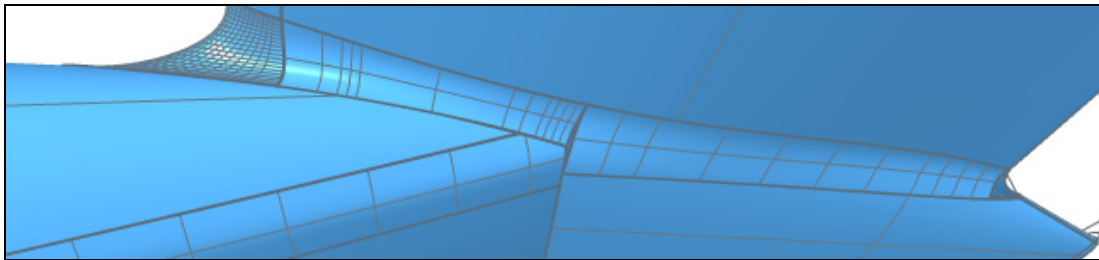
38. Now move back and run **SplitEdge** on the lower tail cone surface, snapping to the **End** of the lower stabilizer surface.



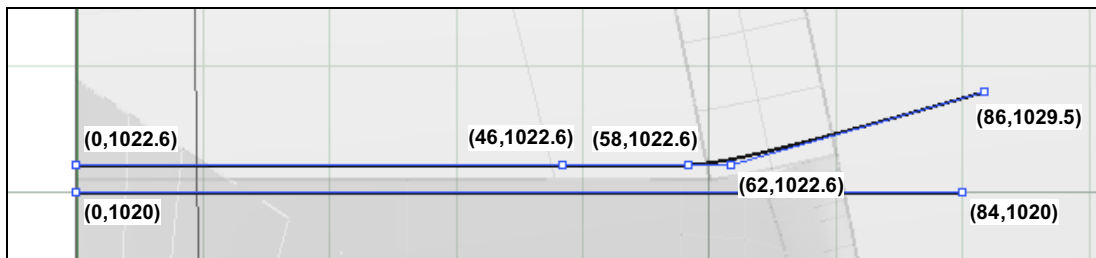
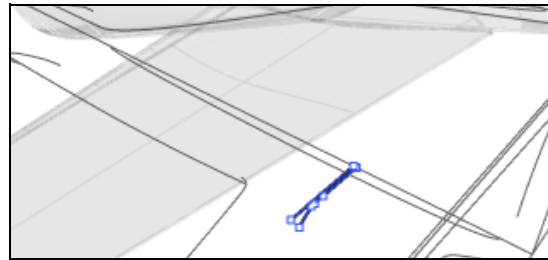


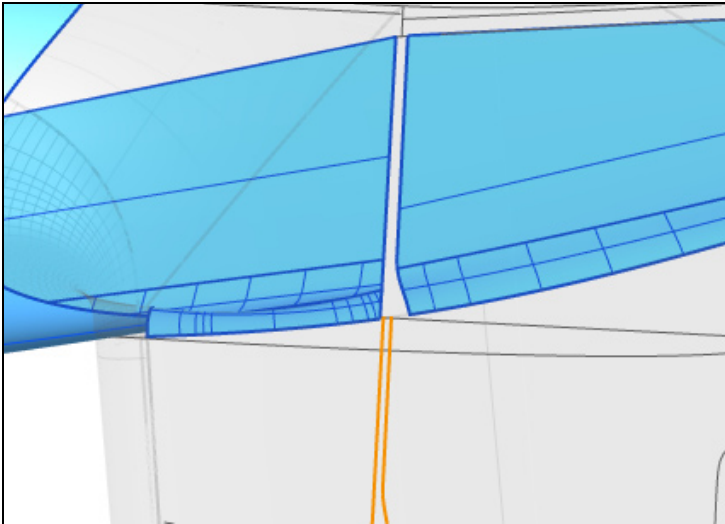
39. BlendSrf between the lower stabilizer surface and the lower tail cone surface. Specify a *Blend bulge* of **1.1** for the upper edge, **1.0** for the lower

The surfaces don't come together very well between the fuselage and tail cone. This is consistent with the plane, I've seen a gap in the sheet metal in this area! It was a useful discovery about how to model the tail, it wasn't turning out smooth because it isn't. We won't "fix" it, just fill in the gap.



40. Draw a *Line* in the Top view, then a ***Curve*** of *Degree 3*.

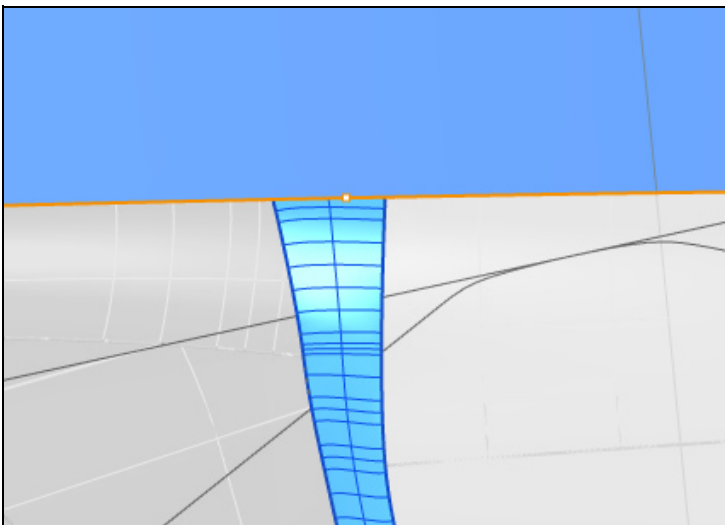




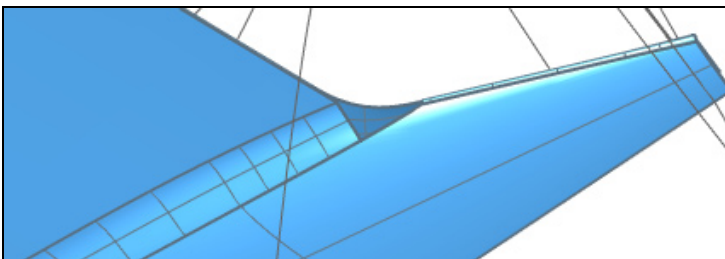
41. Use the line and curve to **Trim** out a gap between the fuse and the tail cone.

42. Delete the trimming curves.

43. Fill in the gap with **BlendSrf**.

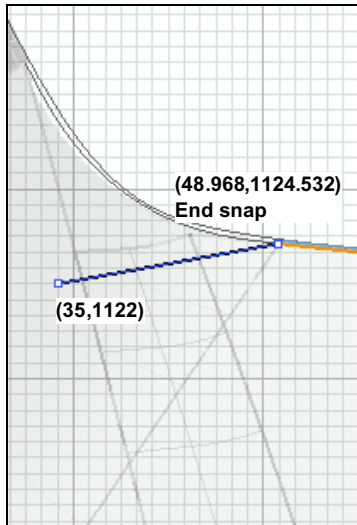
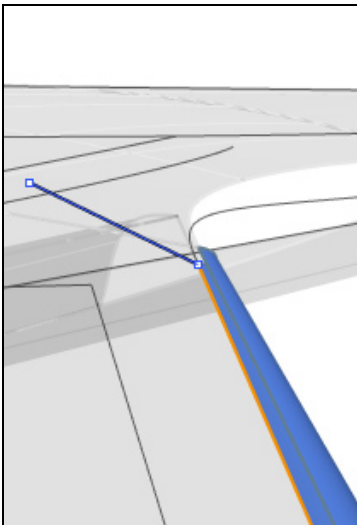
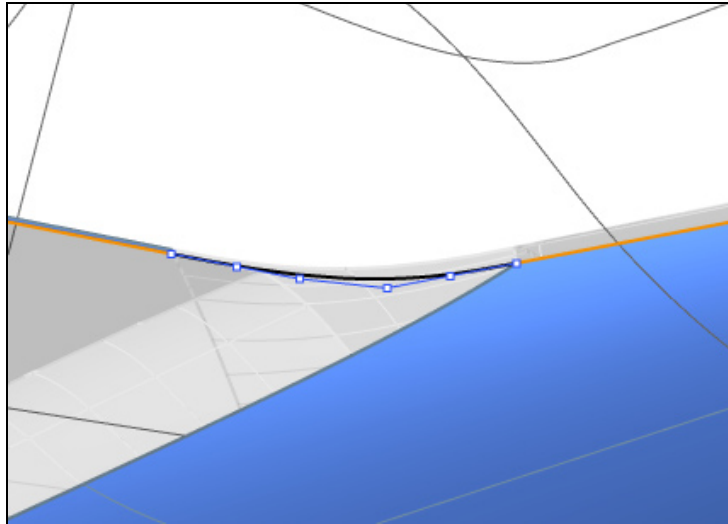
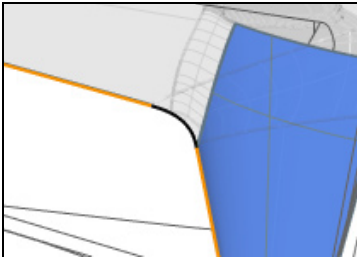


44. MatchSrf the end of the blend surface to the lower stabilizer surface. The edge of the stabilizer was split earlier, so use the *ChainEdges* option to pick both edges. Specify **Tangency Continuity**, enable *Refine Match* and *Match edges by closest points*, and set *Isocurve direction adjustment* to **Preserve Isocurve Direction**.

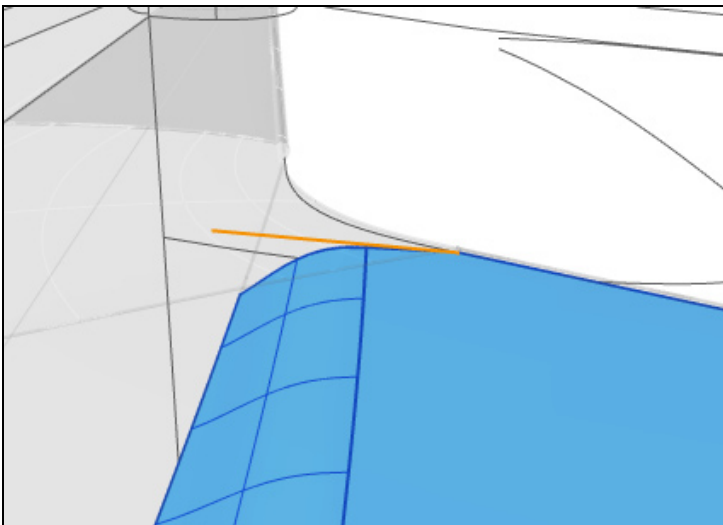


The remaining major task on the horizontal tail(the whole tail, really,)is this very smoothly closing up this opening at the back.

45. BlendCrv between the edge of the lower tail cone surface and the lower edge of the stabilizer edge blend.



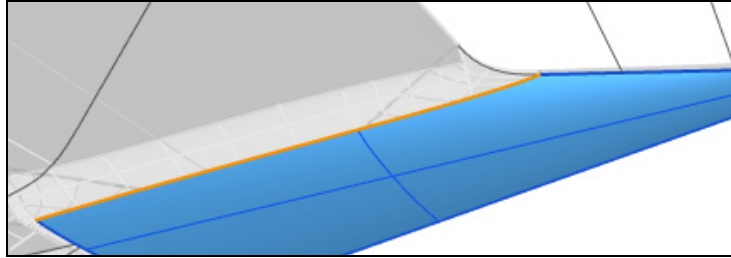
46. Draw a *Line* in the top view, snapping to the ***End*** of the bottom edge of the stabilizer edge blend.



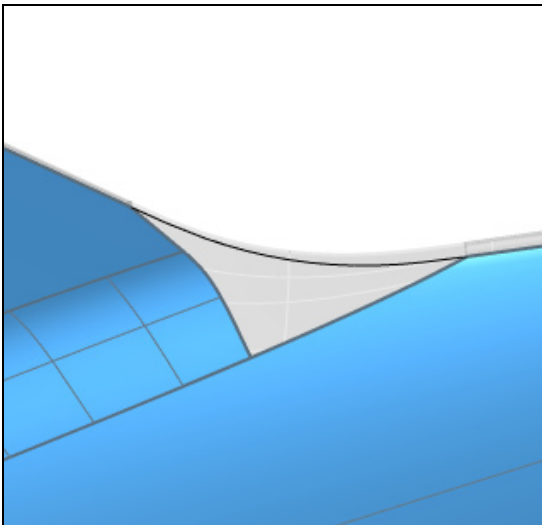
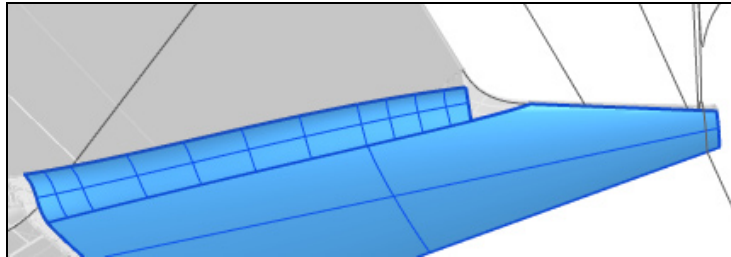
47. Use the line in the Top view to *Trim* a small piece off the lower stabilizer surface and the blend surface.

48. *Delete* the line.

49. This edge on the lower tail cone surface had been split to make the blend. Use **MergeEdge** to combine the two edges back into one.

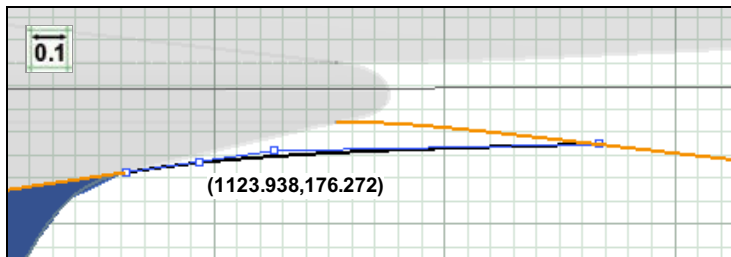
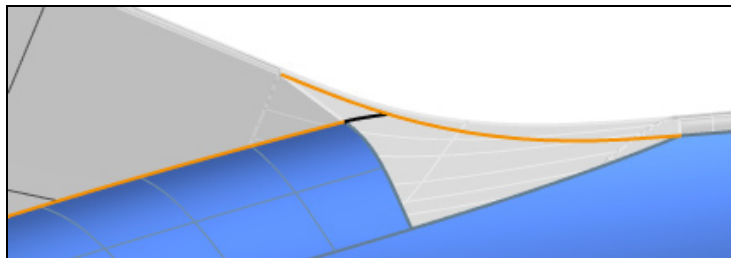
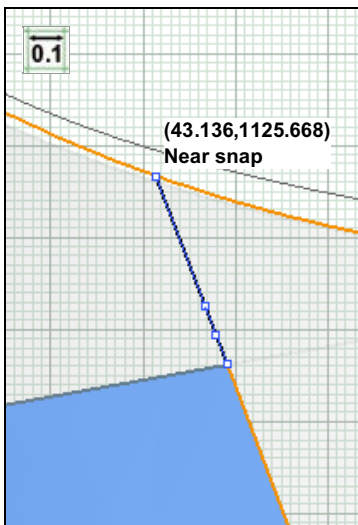


50. Join the blend surface to the tail cone surface.

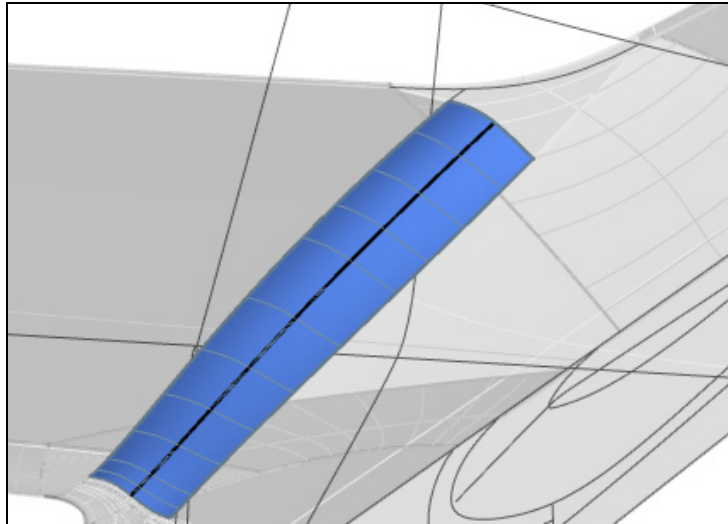
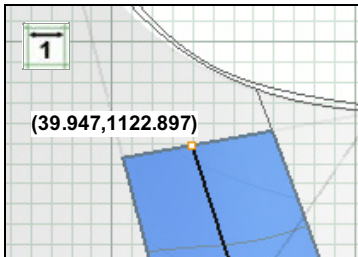


Now we need to fill in this area. We're going to use **BlendCrv** to make three section curves. I prefer to make the bare minimum curves needed to get a surface then work with it, but in this case the triangular shape with a singularity complicates that and it's not a very important area I'd want to spend much time tweaking.

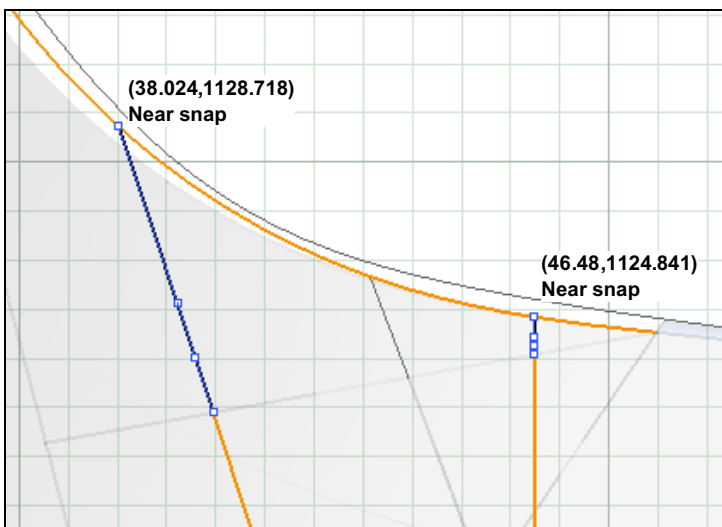
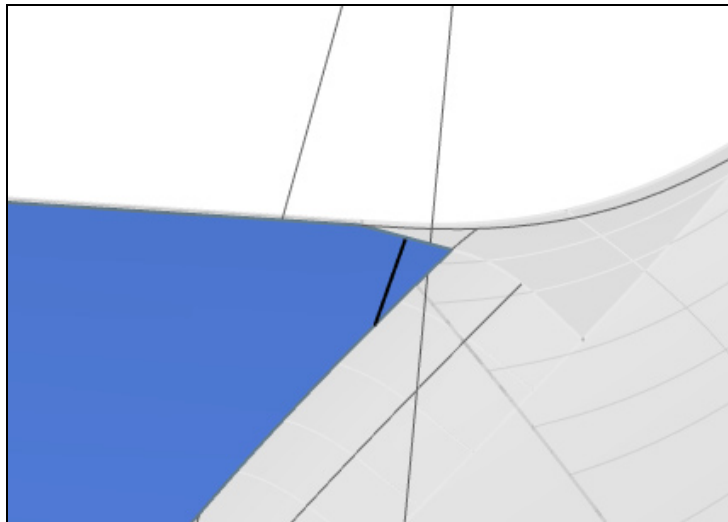
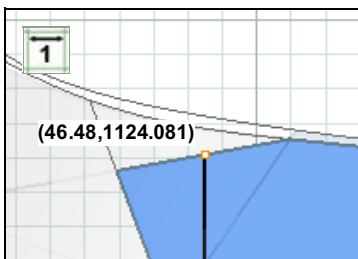
51. To make the first section, **BlendCrv** from the edge of the blend surface and use the **Point** option to place the other end on the blend curve using the **Near** Osnap. Adjust the bulginess of the curve by moving the second point. The numbers are for illustration, that the overall appearance is similar is more important.



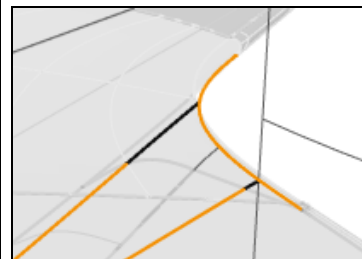
52. Use **ExtractIsocurve** to get a curve from the blend, at about the middle, coinciding with the isocurve.

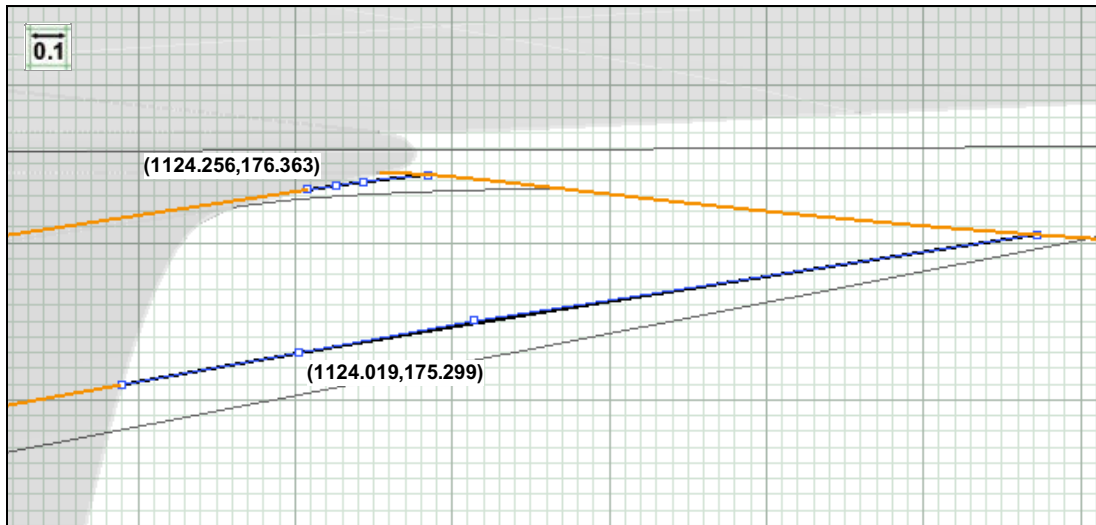


53. **ExtractIsocurve** again, extracting a curve from the lower stabilizer surface.

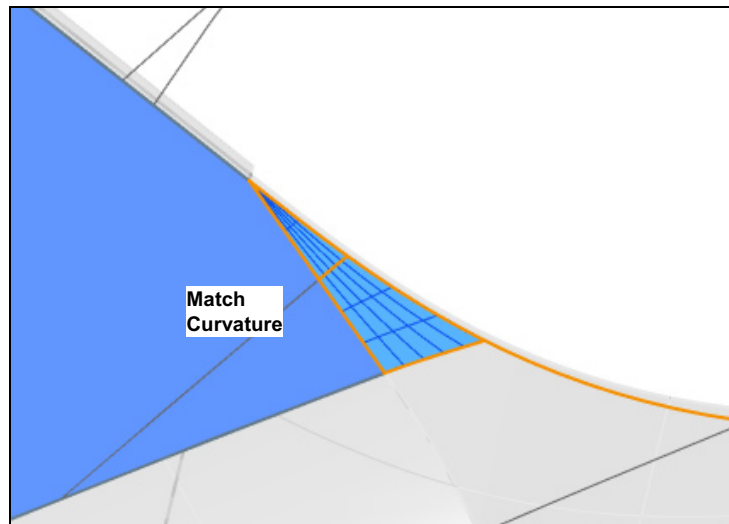


54. Use the extracted curves to make two more curves using **BlendCrv**, in the same manner as the first.

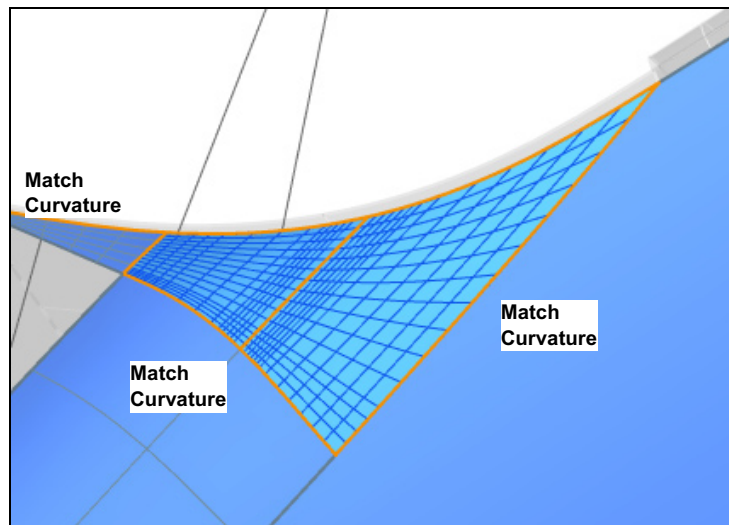


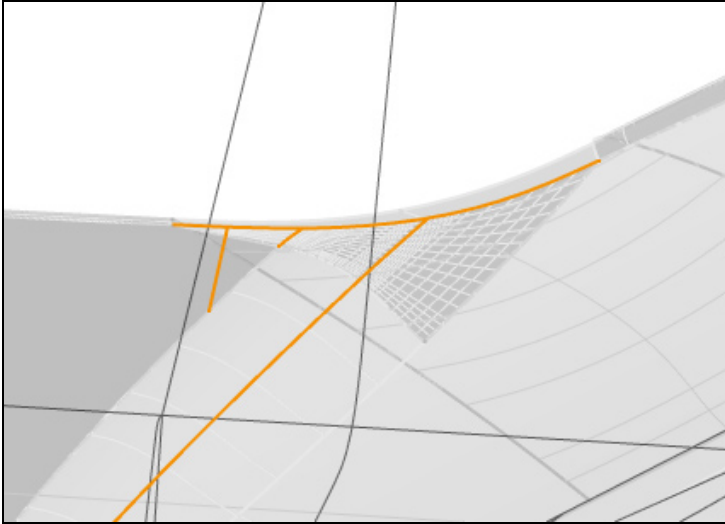


55. We'll use two **NetworkSrf** surfaces to fill this in. Specify a tolerance of **0.001** for **Edge curves**, and **Curvature** continuity along the edge of the lower stabilizer surface.



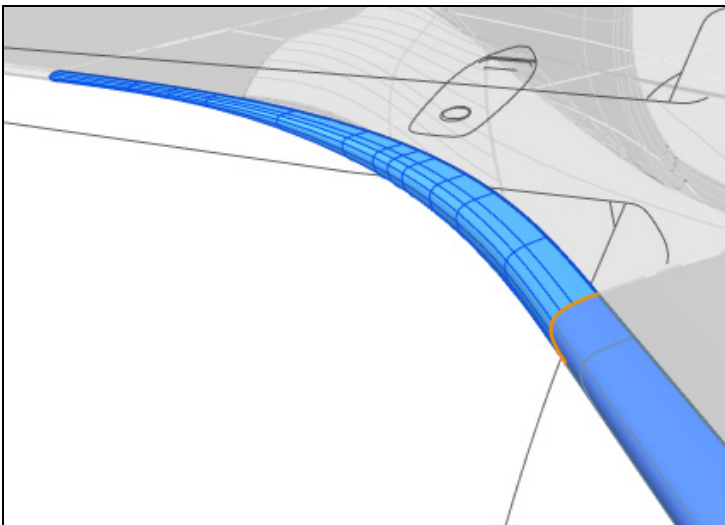
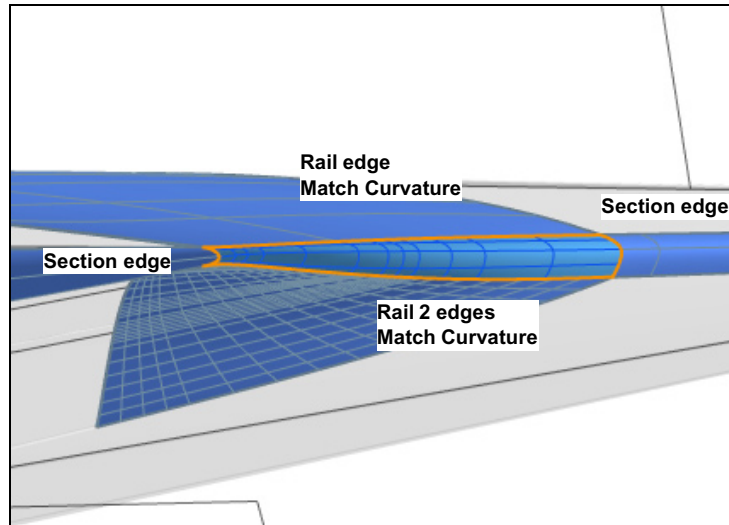
56. For the second, use the same settings and match with **Curvature** to the first surface.



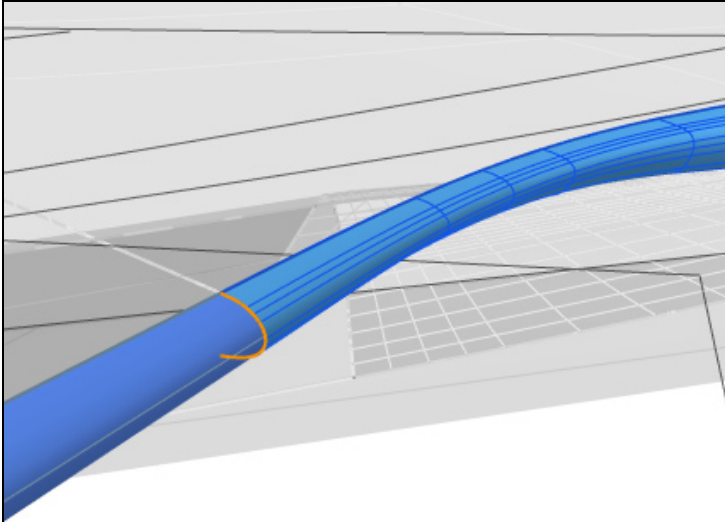


57. Delete all the curves used in making these surfaces.

58. Now fill in the remaining gap with a **Sweep2** surface. Use the **ChainEdges** option to select the edges of both the surfaces we just made. Specify **Rebuild with 7 control points**. **Curvature** continuity along both rails, and use the **Preserve first** and **last shape** options.

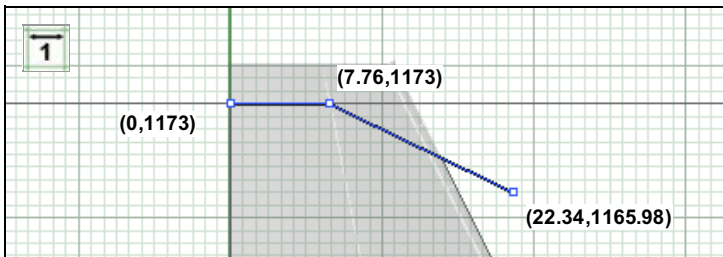
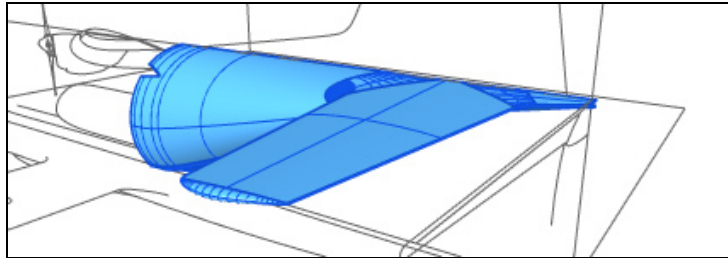


59. MatchSrf the sweep surface to the tail cone blend. Specify **Tangency Continuity**, turn on **Refine match** and **Match edges by closest points**, and for the **Isocurve direction adjustment** specify **Preserve Isocurve direction**.

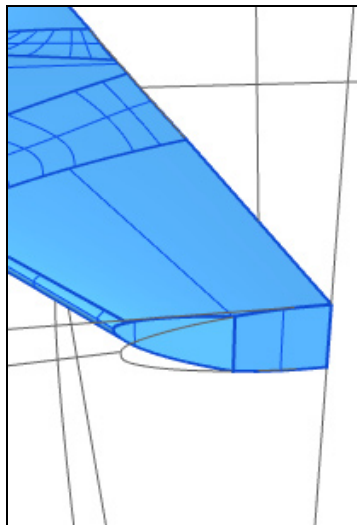
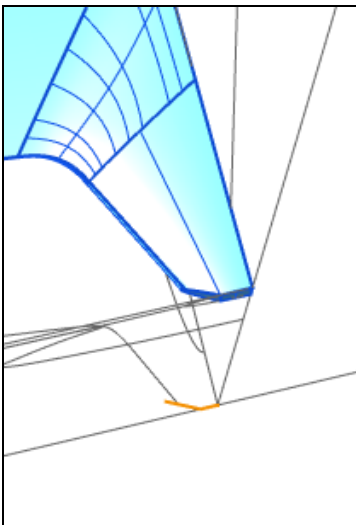


60. Repeat the **MatchSrf** at the other end of the sweep. Use the same options.

61. **Join** all the empennage surfaces and polysurfaces into one.

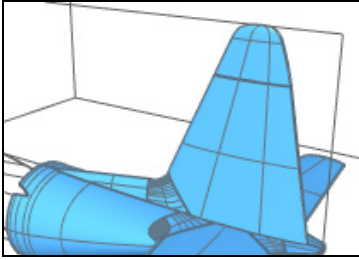


62. To finish off the tip of the tail cone, draw a **PolyLine** in the Top view.



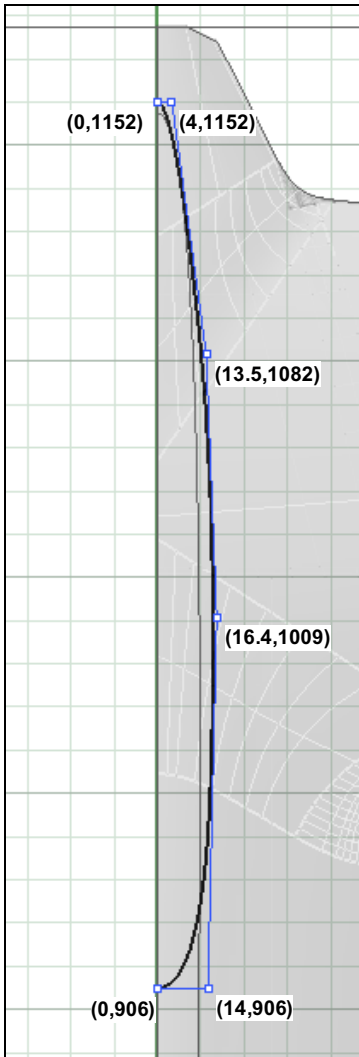
63. Use the **WireCut** command to trim and close off the tail cone in one operation with the polyline.

64. **Delete** the polyline.

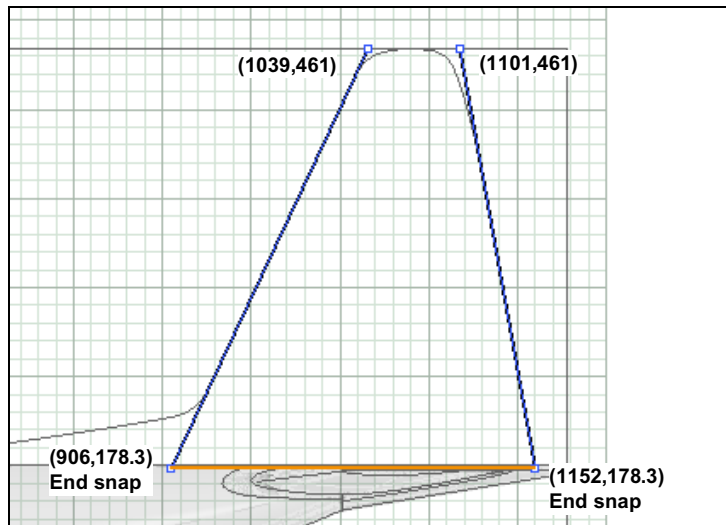
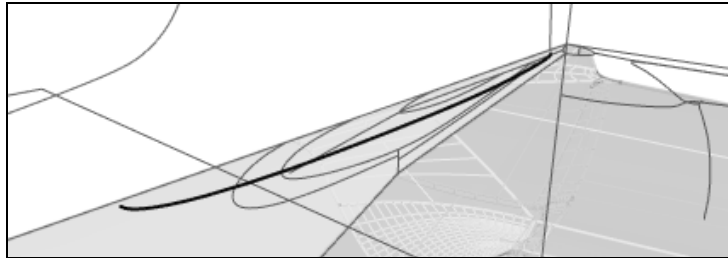


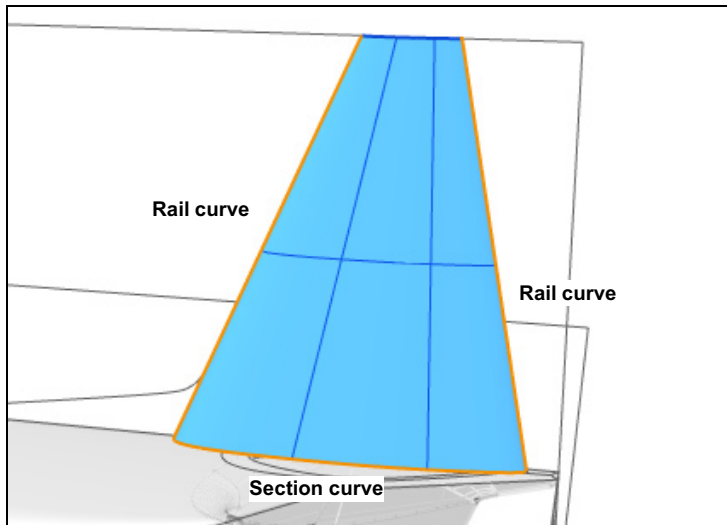
Empennage 3

Vertical tail



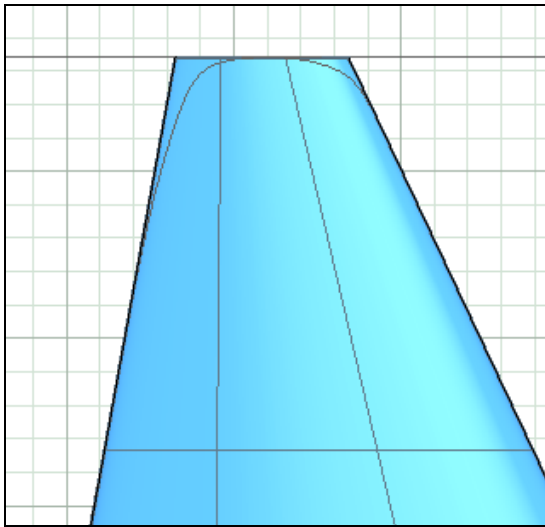
1. To begin the vertical tail, in the Top view draw a **Curve of Degree 3**.
2. **Move** the curve up by **178.3** units.
3. Create two **Line** objects, starting at each **End** of the section curve.





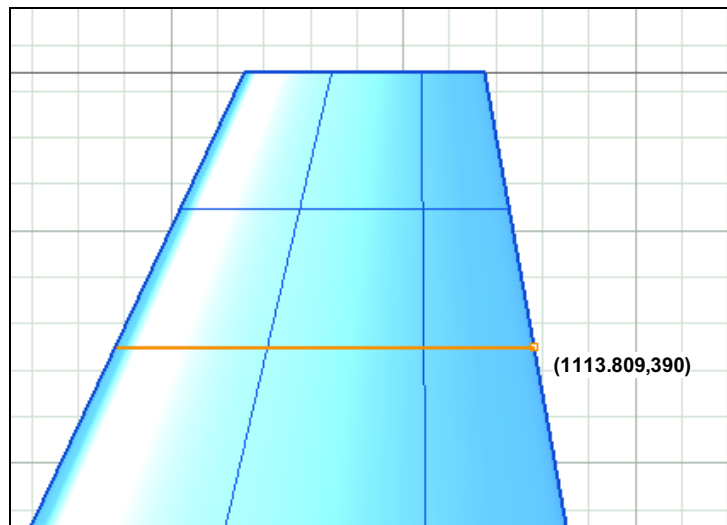
4. Build a **Sweep2** surface with the lines and curve. Make sure to set the Cross-section curve options back to **Do Not Simplify** after our last use of it. Don't use any other options.

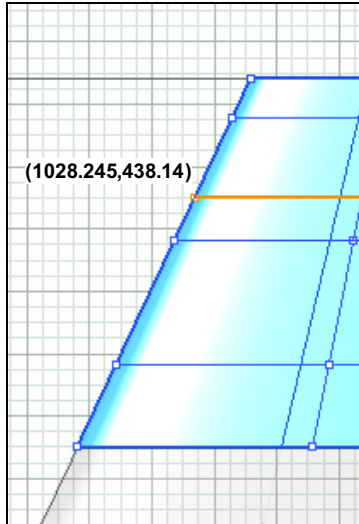
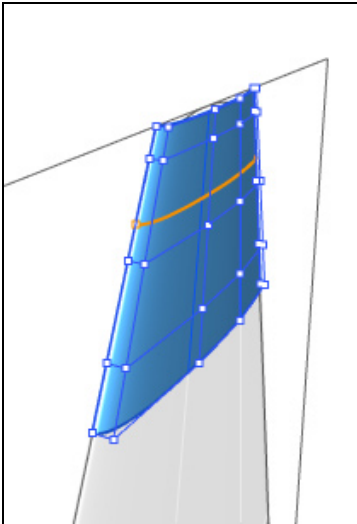
5. **Delete** the curve and lines.



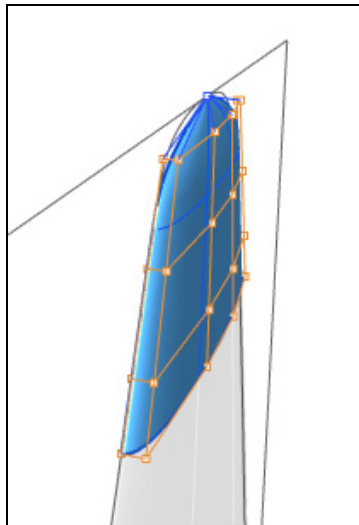
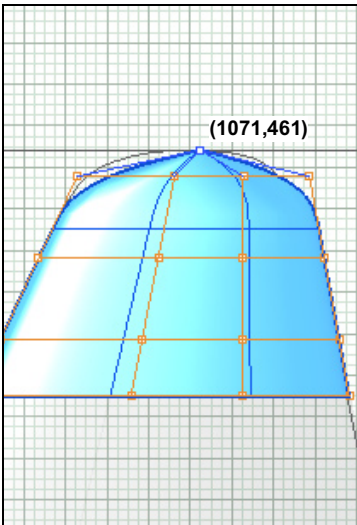
According to our reference materials, looking from the Left view here, the trailing edge of the tail takes a little turn near the top, it's not so deep. This detail was left out of the rail curve because a swept surface is scaled according to the relative distance between the rails, so as it went around that bend the thickness of the tail would be reduced—or more accurately, the rate at which it's reducing would change. That doesn't correspond to the actual tail.

6. Run **Split** on the sweep, using the **Isocurve** option with **Shrink** set to **Yes**.

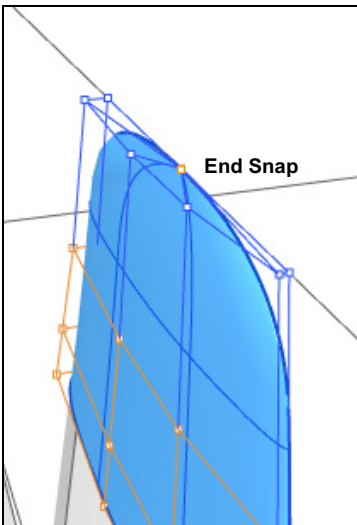




7. Use **InsertKnot** to add one knot to the supper piece of the tail.

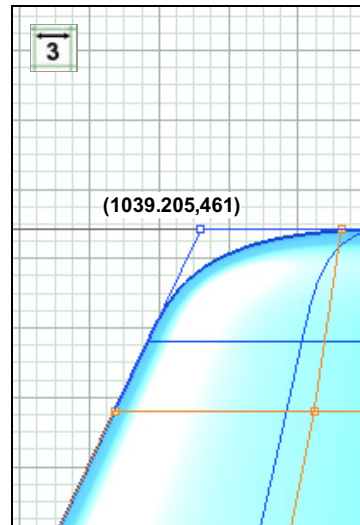


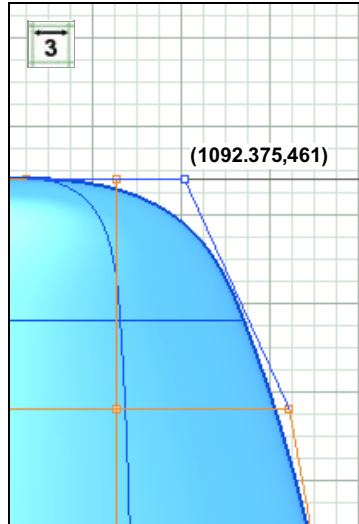
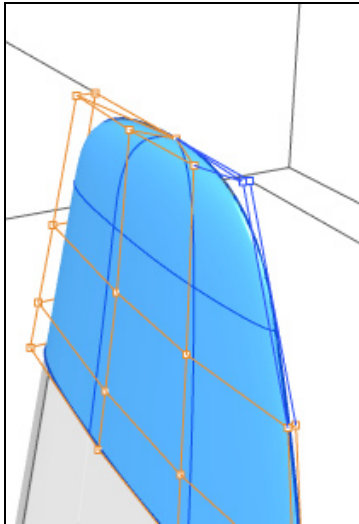
8. Select the top row of points on the smaller surface and use **SetPt** to collapse them to one. Select all three axes.



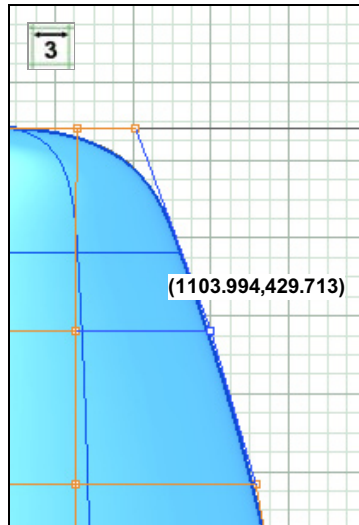
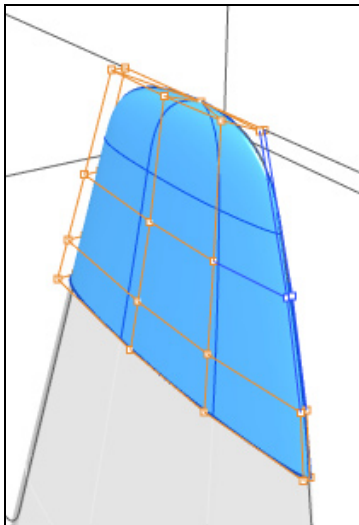
9. Use **SetPt** again, use **SetZ** with the **Align to World** option and snap to the **End** point, to 'smooth out' the top of the tail as we did with the wings.

10. Tweak the leading edge by selecting the front two points and moving them back **3.79** units.

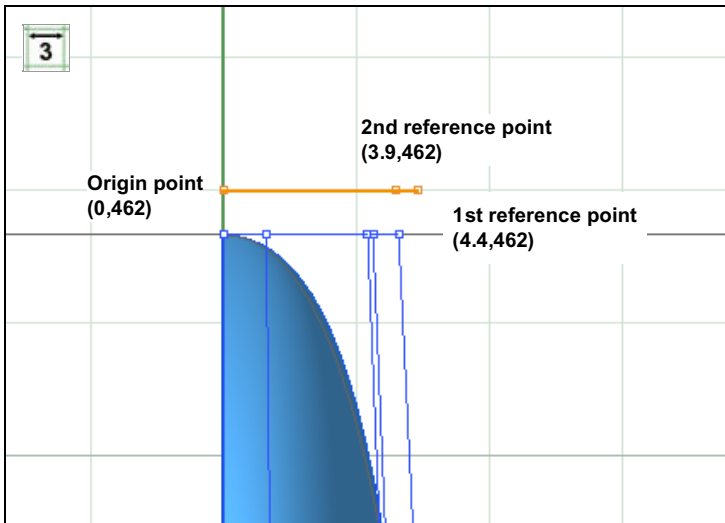




11. Select two points at the trailing edge and move them forward **10** units.



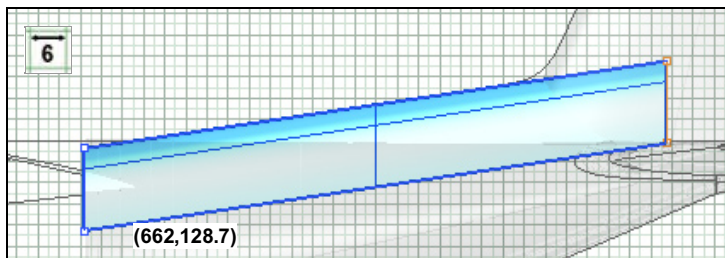
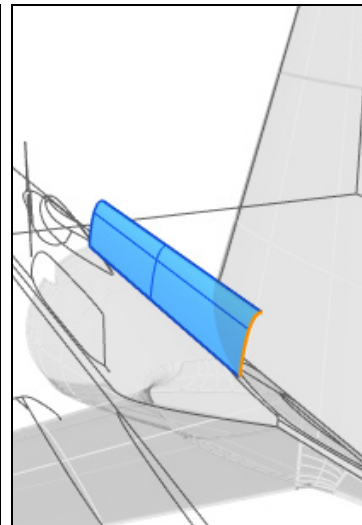
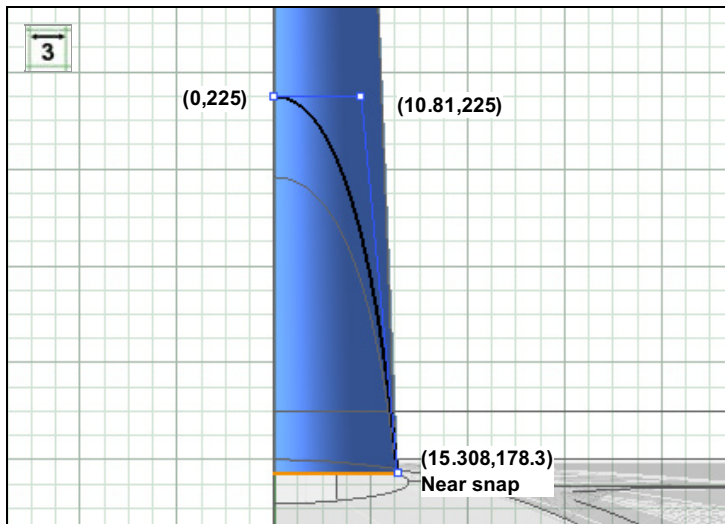
12. Select the next two points below the previous and move them forward **2.65** units.



13. Select the top points and use **Scale 1D** to 'squash' them a little bit. Where you place the origin and reference points vertically doesn't matter, but when typing the location of the reference points you do have to enter coordinates, if you just enter the distance "4.4" from the origin point, the command assumes that's the scale factor you want.

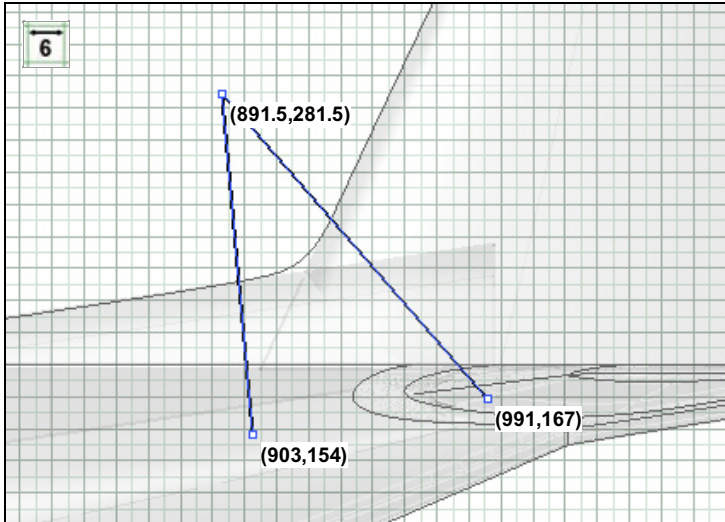
14. Draw a **Curve**, using the **Near** osnap to start it along the edge of the tail, then place the next points freehand using the **Planar** snap. To align the third point with the centerline and vertically with the second point, turn on the grid snap by clicking the button in the status bar and hold SHIFT to activate the Ortho snap.

15. **ExtrudeCrv** the curve forward by entering value of - **331** units.



16. **Delete** the curve.

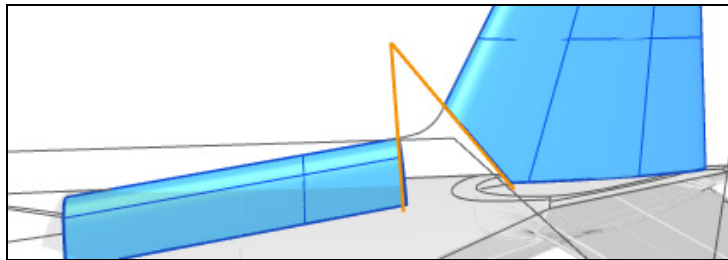
17. Select the forward control points on the fairing surface and **Move** them down by **49.6** units.



18. Draw a **PolyLine** in the Right view.

19. **Trim** off the vertical tail and fairing surfaces with the polyline.

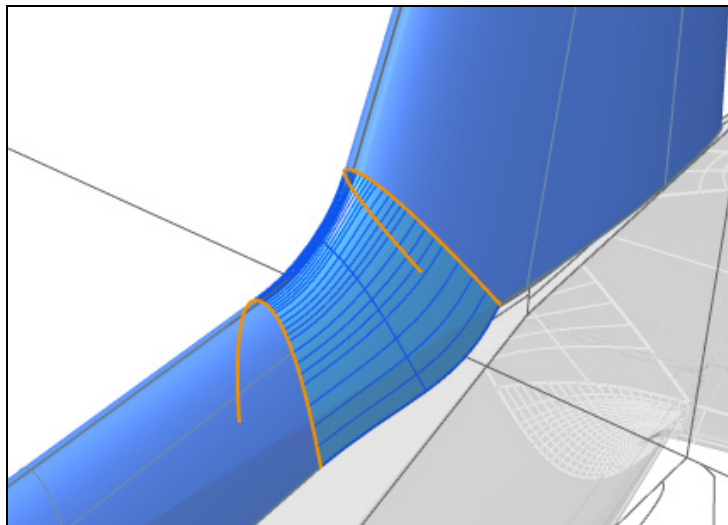
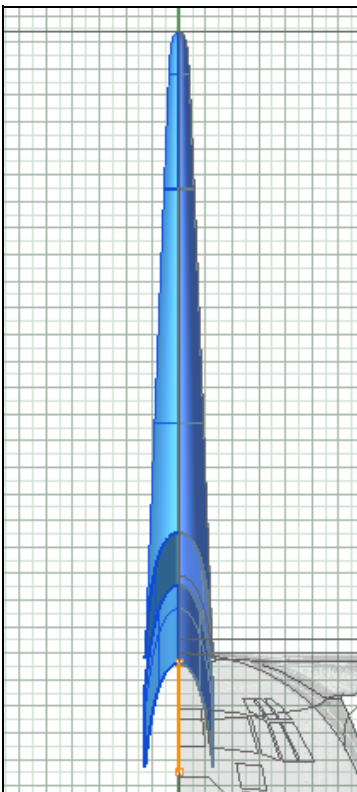
20. **Delete** the polyline.

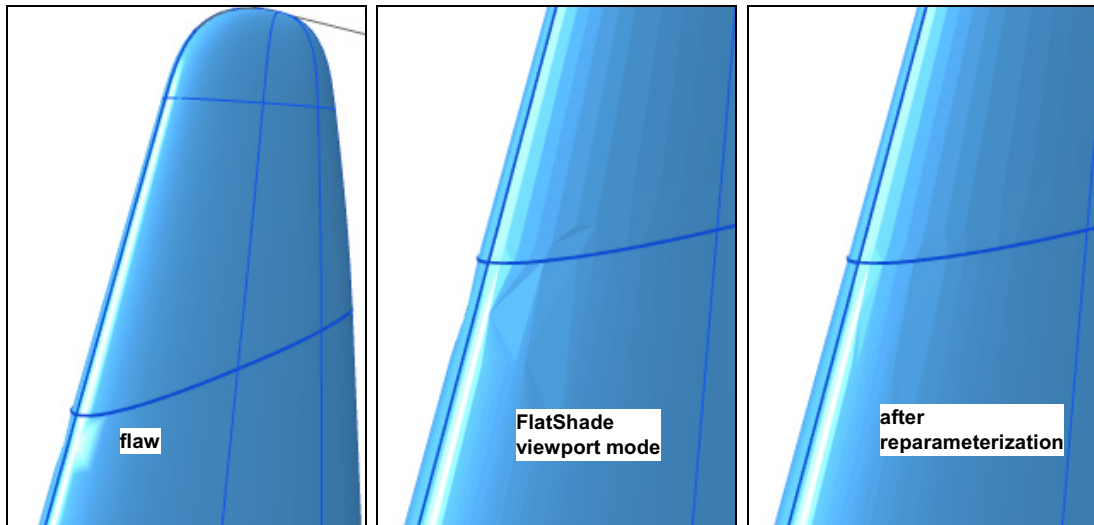


21. **Mirror** the tail surfaces about the World Y axis.

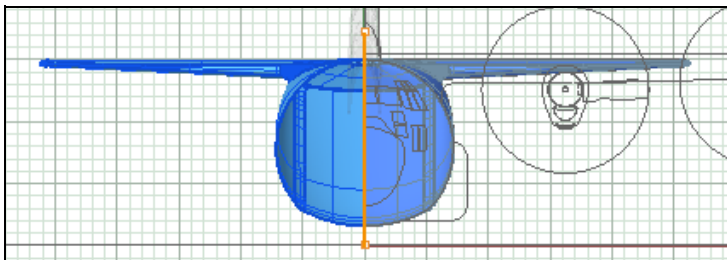
22. **BlendSrf** between the tail and the fairing. Use the default **1.0 Blend bulge**. This was done after mirroring the tail to get a nicer blend surface at the centerline.

23. **Join** all the vertical tail surfaces.





You may notice a flaw where the split pieces of the vertical tail meet, the meshes of the adjacent surfaces are aligned haphazardly. This error is caused by the 'parameterization' of the surfaces. For example, if you created a rectangular surface measuring 5 by 5 units, the parameterization would be 5 in the U and V directions. If you then scaled it to measure 100 by 10, those 'internal' values would not change, the parameterization would stay 5 by 5. This is irrelevant to your work, except that those values are used in the meshing process and if they are "out of whack" then these problems can result. This can be ameliorated by using the **Reparameterize** command with the *Automatic* option, which 'normalizes' surfaces, changing the parameterization to 1 by 1.

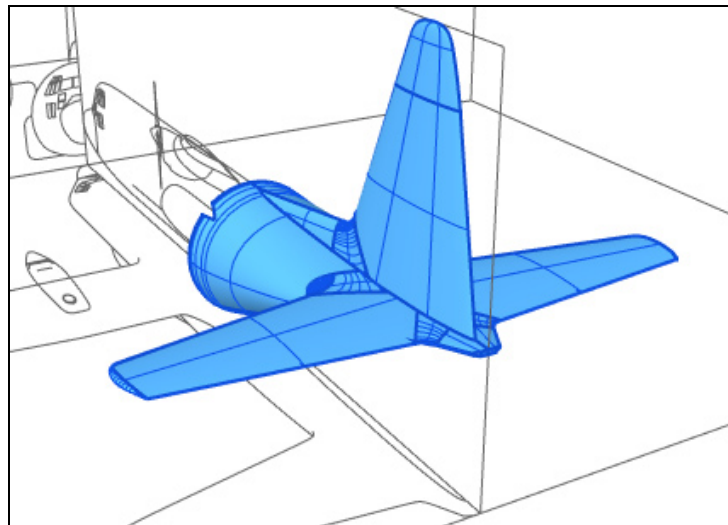


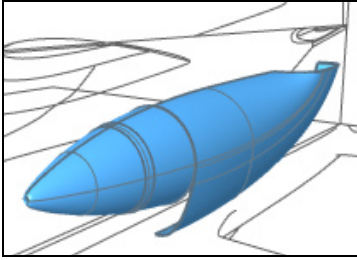
24. Mirror the horizontal tail/aft fuselage polysurface.

25. Join the tail halves.

26. Assemble the two pieces of the tail using **Boolean2Objects**.

27. In the Layer palette, turn off the 'Tail Drawing' layer.

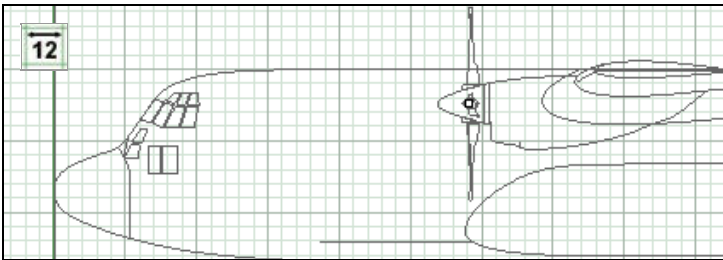
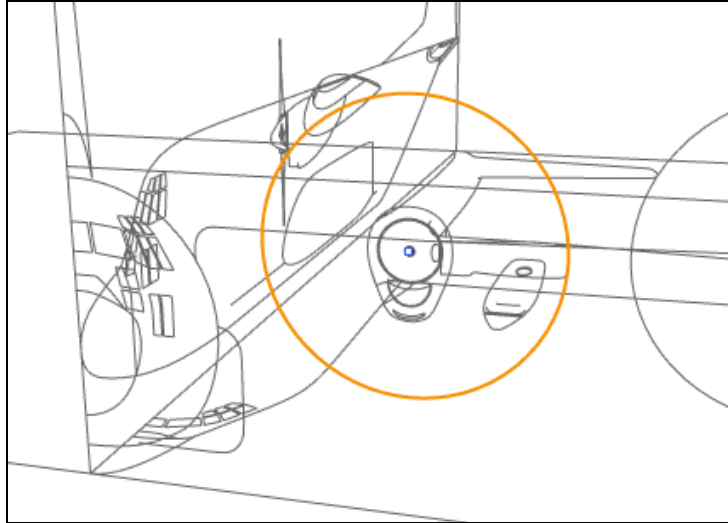




Engines 1

Main shroud

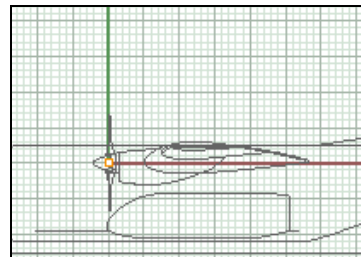
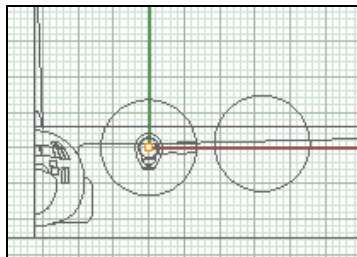
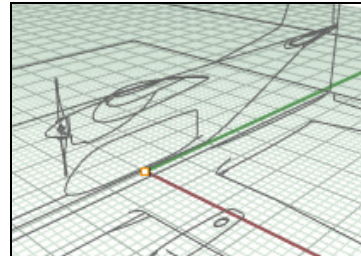
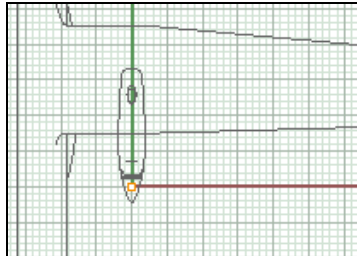
1. **Hide** the rest of the model.
2. In the **Layer** panel, temporarily unlock the "Front Drawing" layer.
3. Create a **Point** object, snapping to the **Center** of the reference circle for the inboard propeller.
4. Re-lock the "Front Drawing" layer.

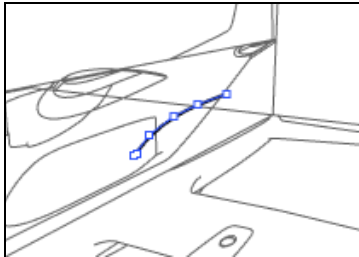
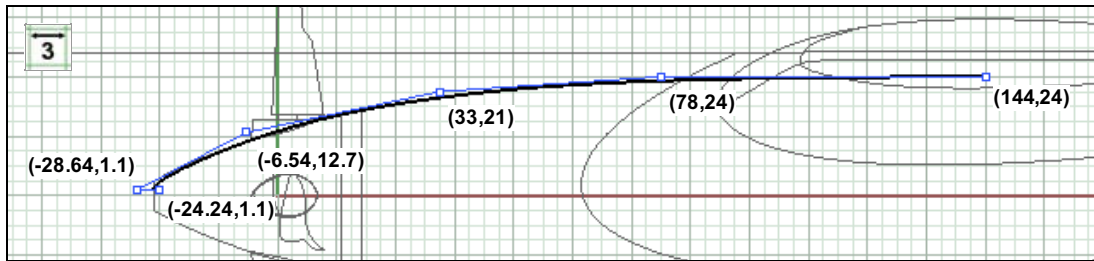


5. Move the point aft **349** units.

6. Start the **CPlane** command, set the **All** option to **Yes**, and snap to the **Point** in any view to place the origin of a new set of construction planes.

7. **Delete** the point.

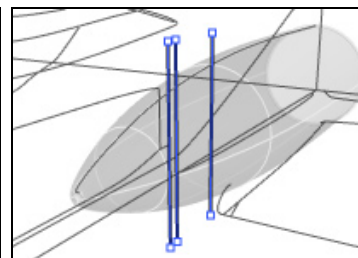
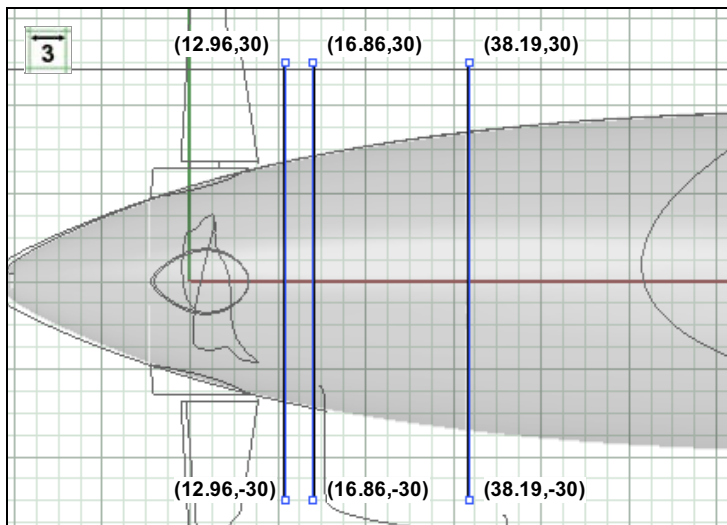
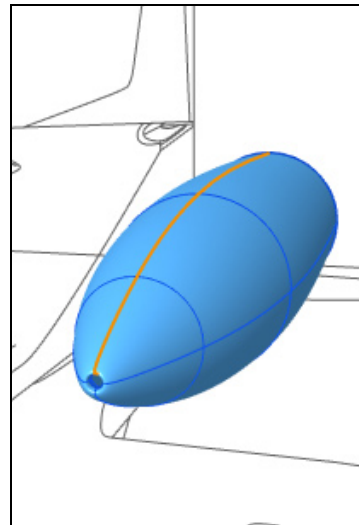
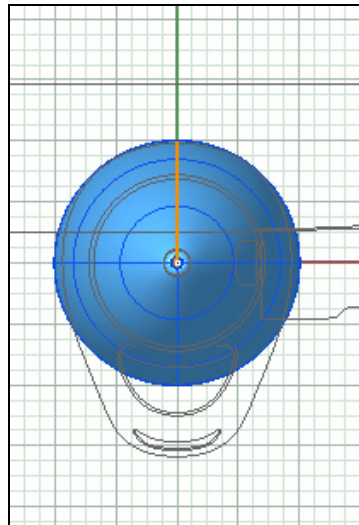




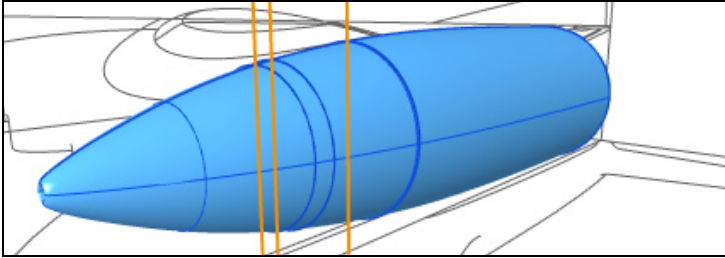
8. Draw a profile **Curve** of Degree 3 in the Right view.

9. **Revolve** the curve around the origin of our custom CPlane.

10. **Delete** the curve we revolved.

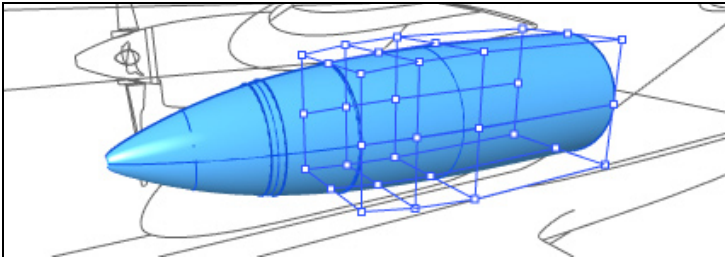


11. Draw three **Line** objects in the Right view.



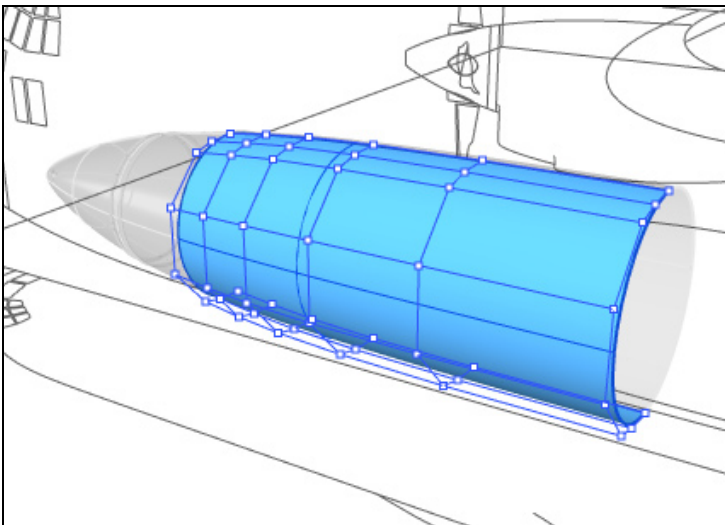
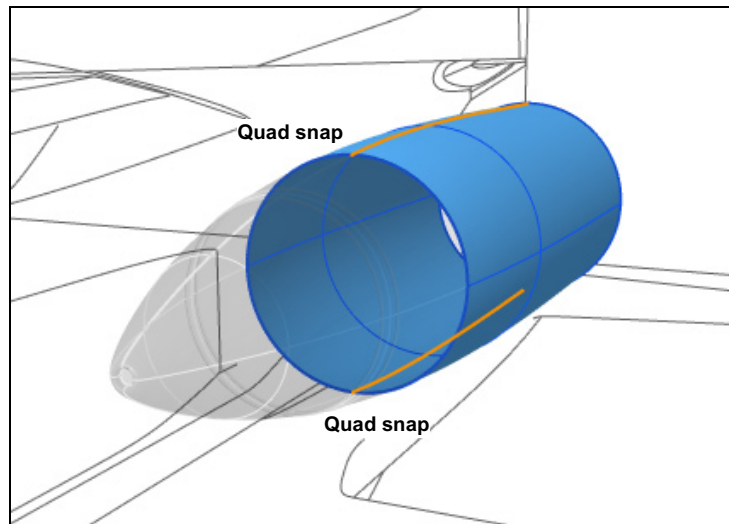
12. Use those lines to **Split** the surface into 4 pieces.

13. **Delete** the lines.

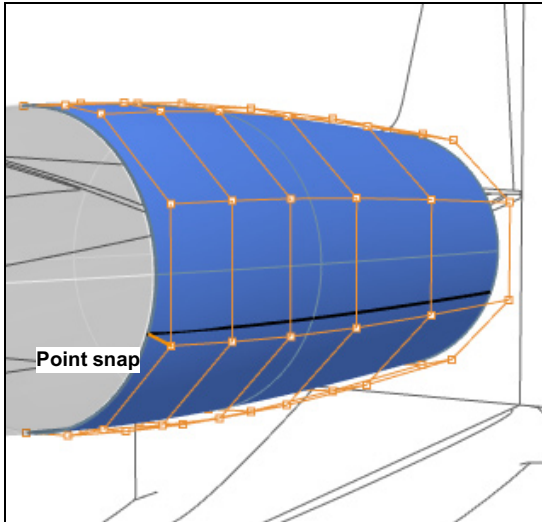


14. Select the surfaces and run **ShrinkTrimmedSrf** on them. The points were turned on for the larger surface here to show how the surface is 'shrunk' to remove the trimmed-away area.

15. Use **Split** again, this time with the **Isocurve** option, and with the **Shrink** option set to **Yes**, to cut the largest piece of the revolve in half vertically using the **Quad** Osnap.

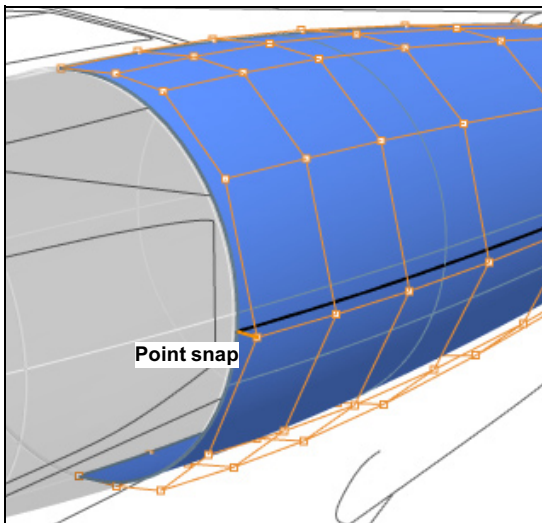
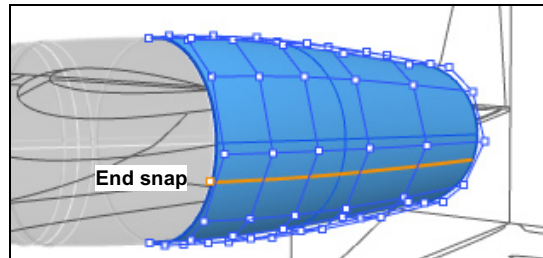


16. Since a straight revolved surface can't be point-edited smoothly, select the outer half of the larger surface and use **ChangeDegree** to raise it's Degree to **5** in both directions, with the **Deformable** option set to **Yes**.



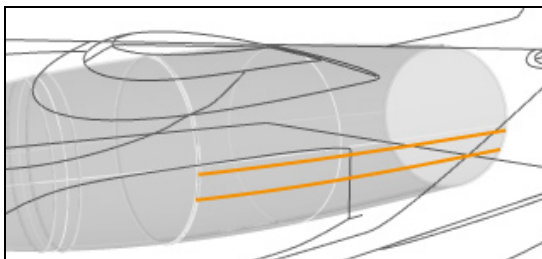
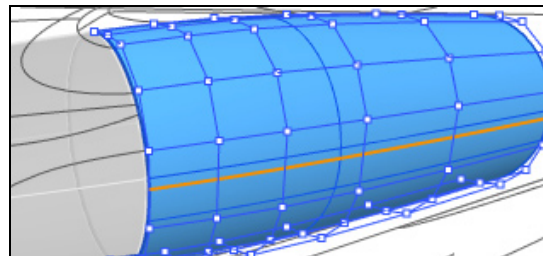
17. We want to add two rows of control points to this surface in a predictable location. Well, where they are is not so important as that your model match this precisely, so to help run **ExtractIsocurve** on the surface, snapping to a **Point** on the control point cage.

18. Run **InsertKnot** on the surface, adding one knot, snapping to the **End** of the curve we extracted.

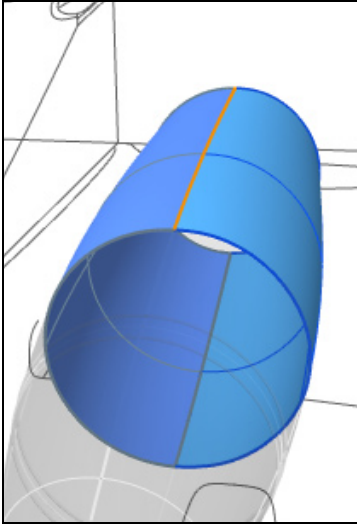


19. Repeat the **ExtractIsocurve** procedure, snapping to the control **Point**.

20. Run **InsertKnot** on the surface again, adding one knot snapping to the **End** of the Extracted curve.

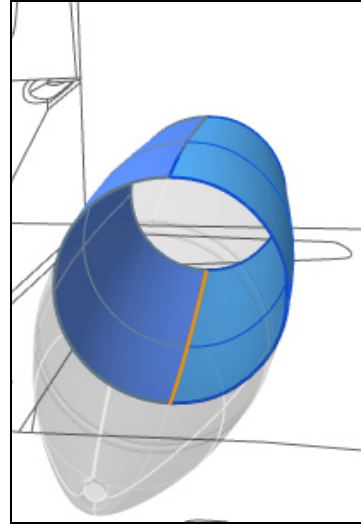


21. Delete the extracted curves.

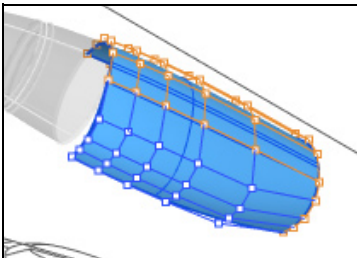
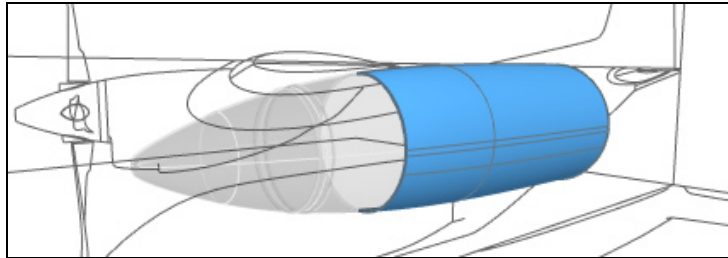


22. The reason we kept the right half of this surface around was this step. **ChangeDegree** will not try to maintain edge continuity, so **MatchSrf** each edge of the modified surface back to the unmodified. Specify **Tangency Continuity**, and none of the other settings should have any effect but enable **Match edges by closest points** just in case.

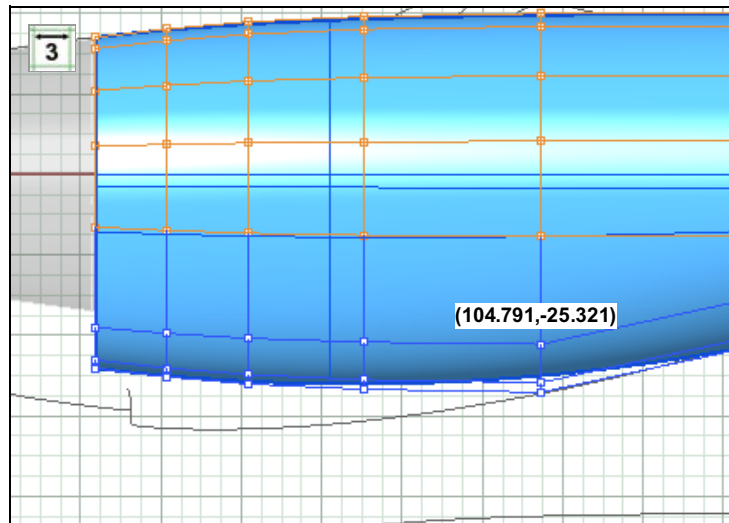
23. **Delete** the right surface.

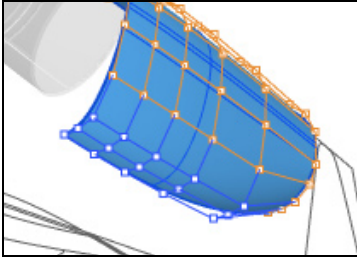


We'll now do some fairly extensive point-editing on this surface to form the main part of the engine shroud.

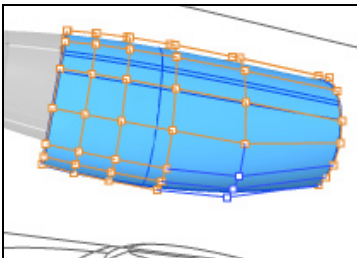
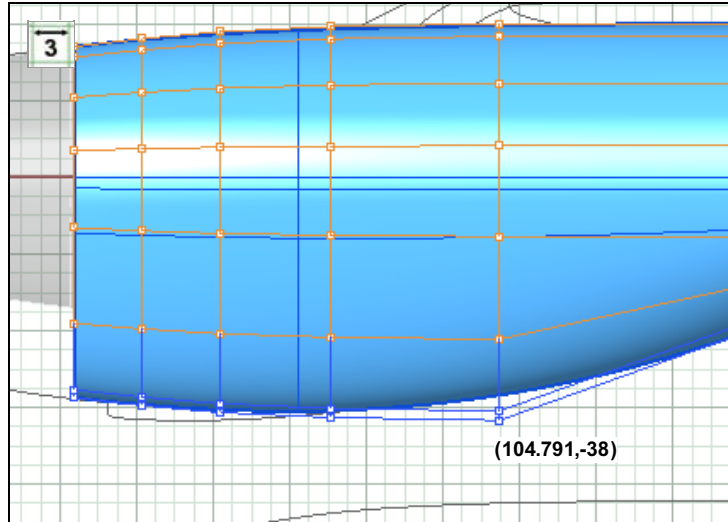


24. Select 20 points on the first 5 columns and move them down by **8.5** units.

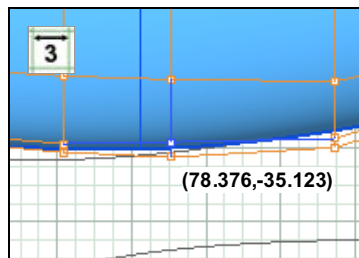
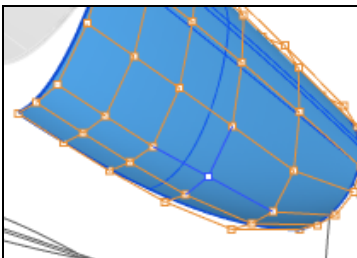
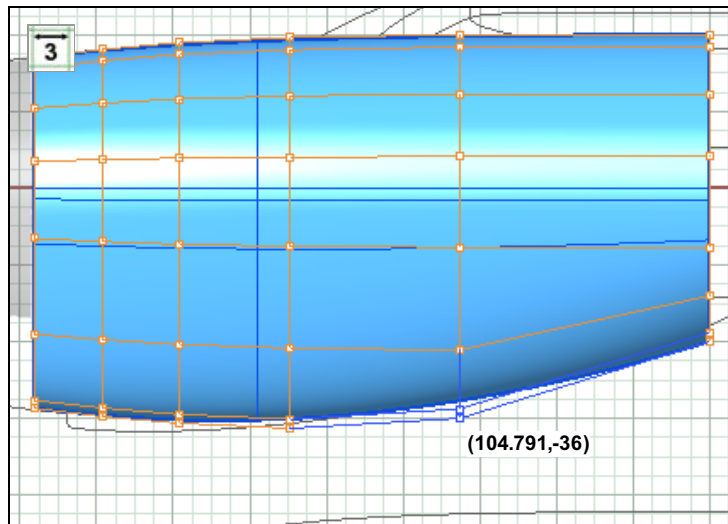




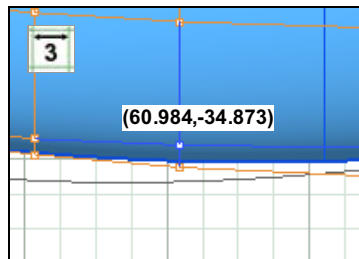
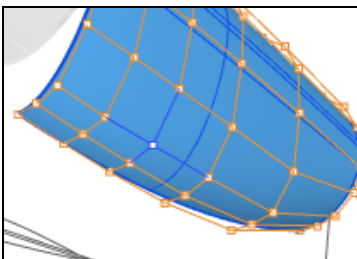
25. Select 15 points and move them down an additional **5.5** units.



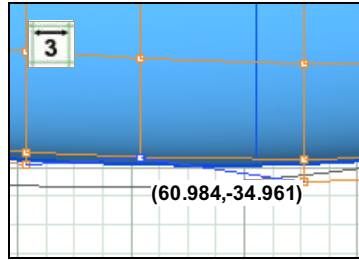
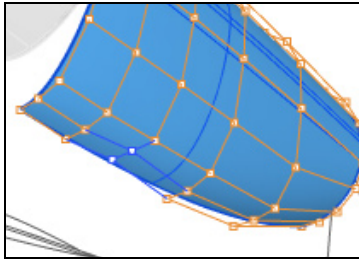
26. Now move a couple of the points we just moved back up by **2** units.



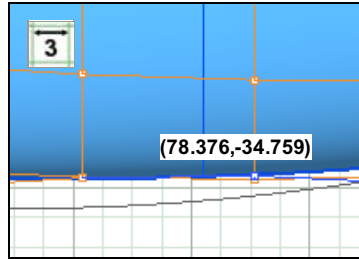
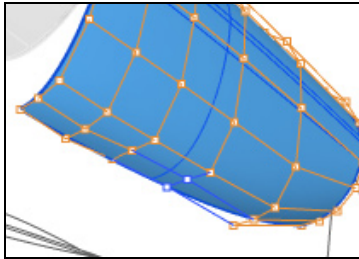
27. Move this point up **1** unit.



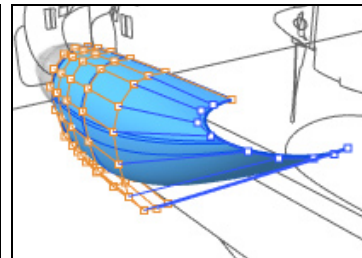
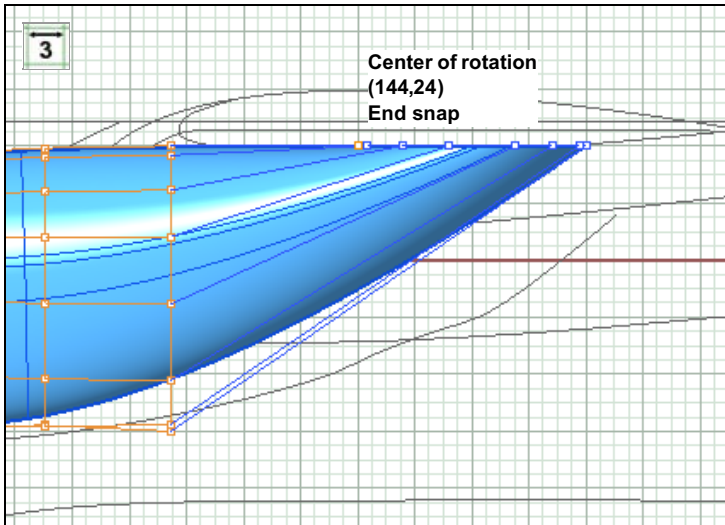
28. Move this point up by **0.5**.



29. Move two points up by 1.8.

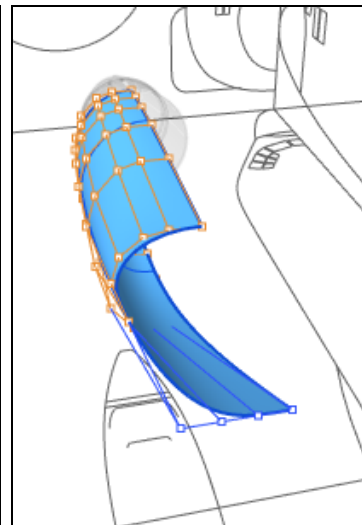
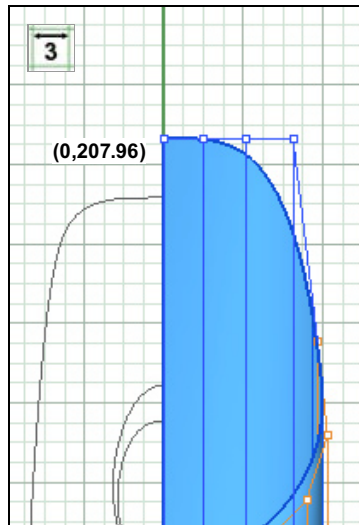


30. And move these up by 2.8.

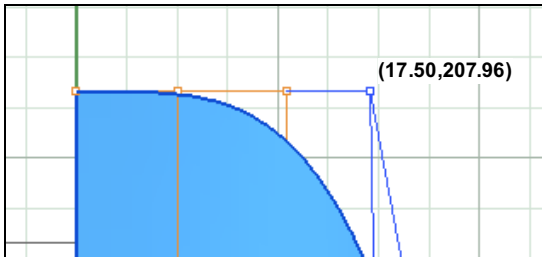
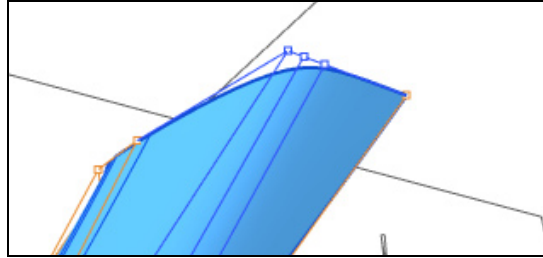


31. Select the last column of points and **Rotate** them 90 degrees. Use the upper **End** point for the *Center of rotation*.

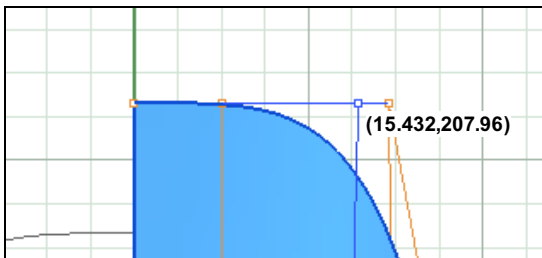
32. Use **SetPt** to align these four points with a Y value of 207.96.



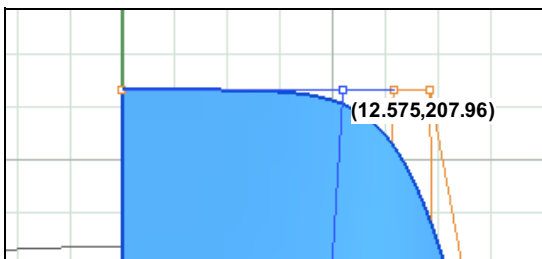
Zero in on the points we just aligned and tweak them:



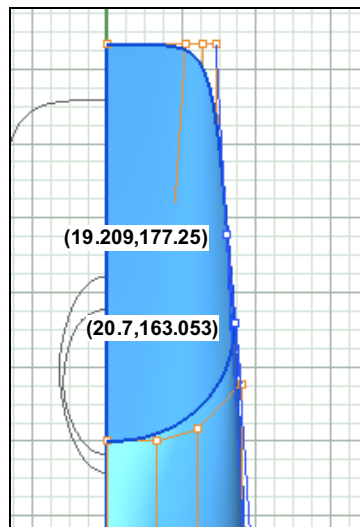
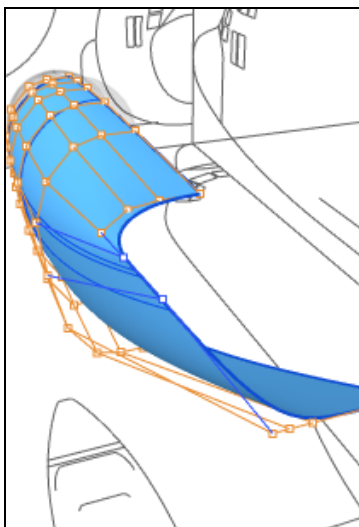
33. Move the outermost point in by **2** units.



34. Move the third point out by **2.95** units.

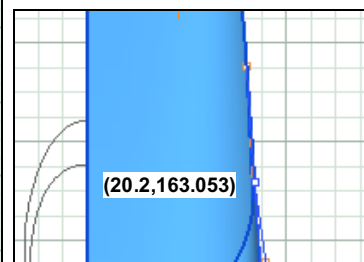


35. Move the second point out by **6.51** units.

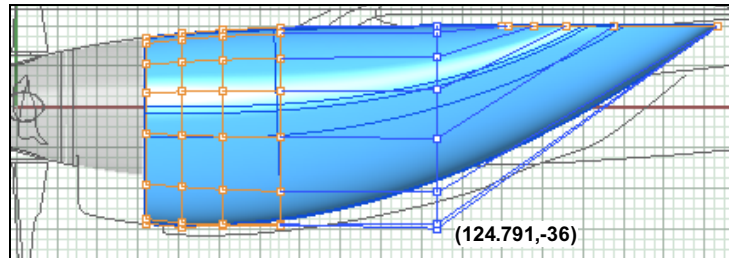
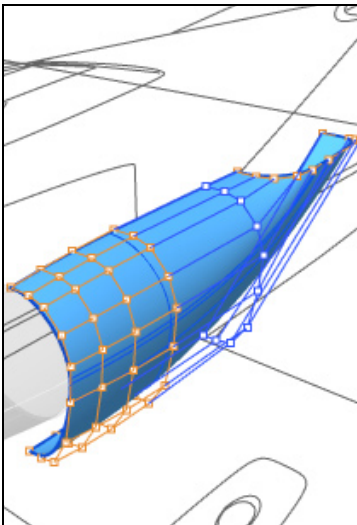
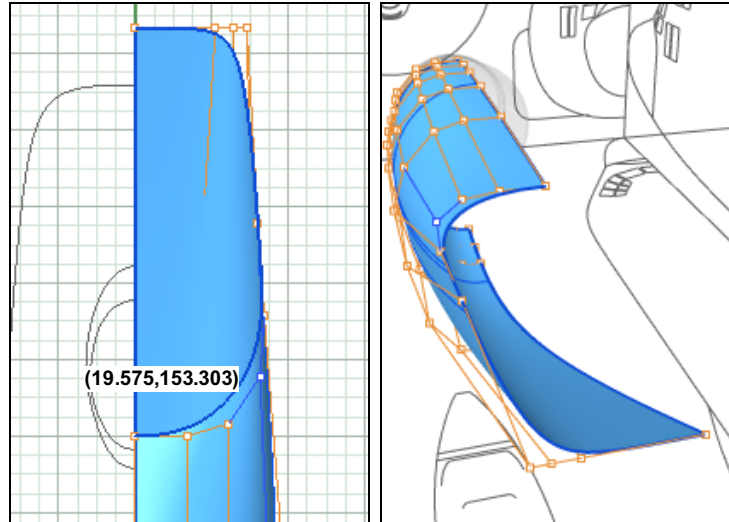


36. Select these two points and move them in by **4** units.

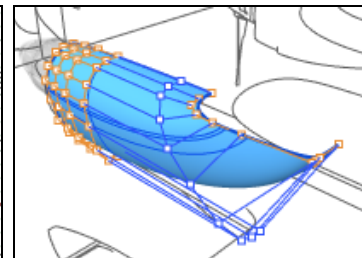
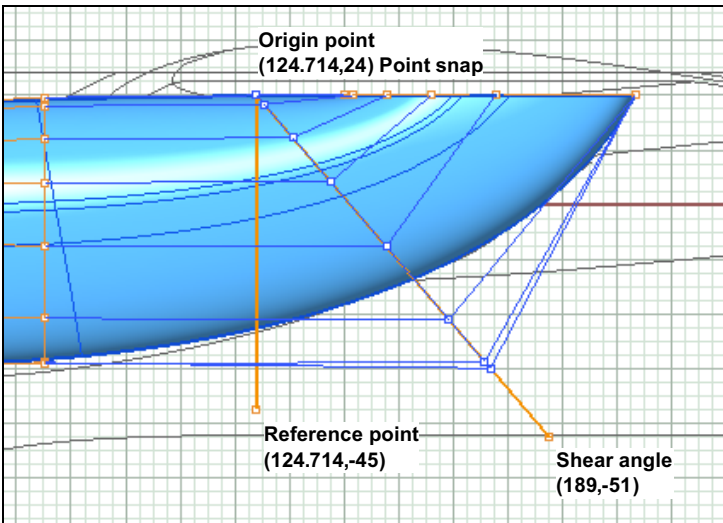
37. Move the forward point of these two in an additional **0.5** units.



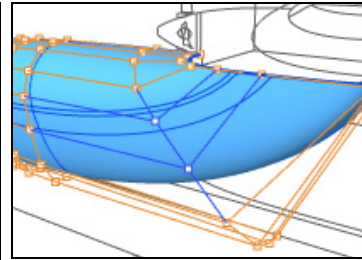
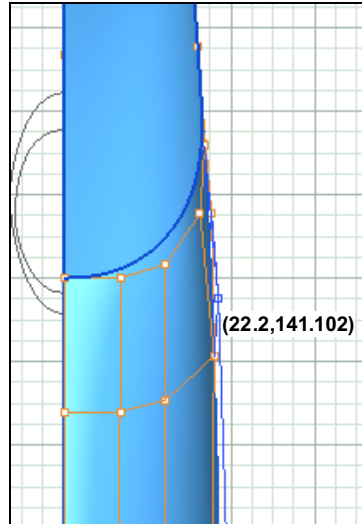
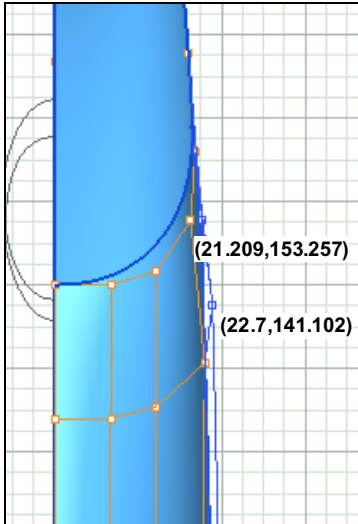
38. Move to the next point and nudge it in by **2** units.



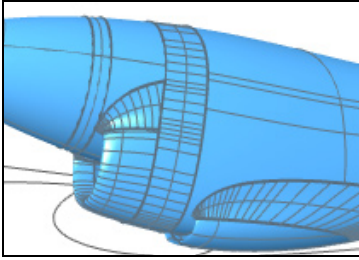
39. Select the next whole column of points and move it back **20** units.



40. Shear the points we just moved.

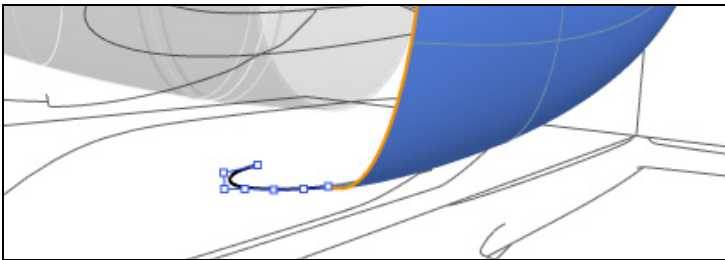
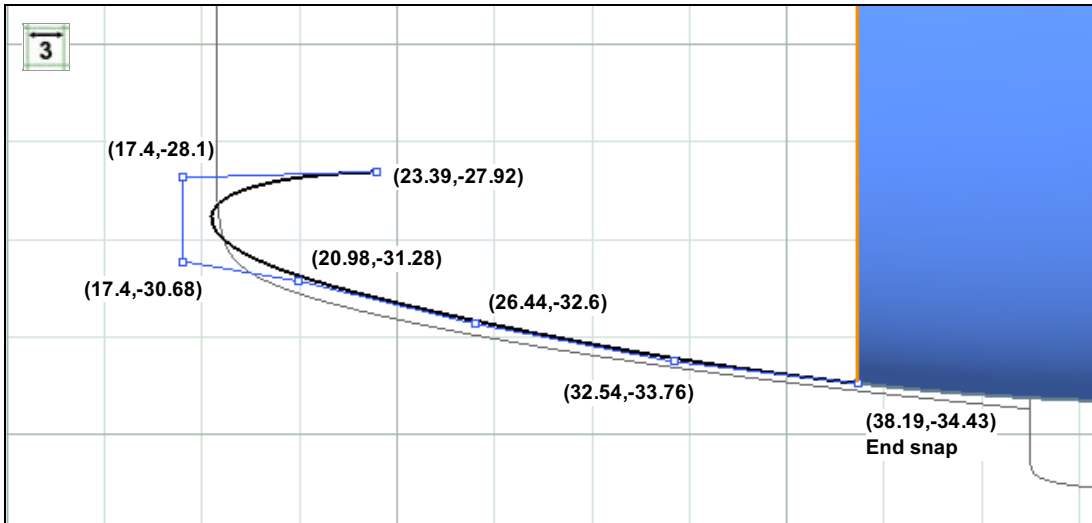


41. Adjust two of the points we just sheared. Move them in by **2** units, then move the more forward point in an additional **0.5**.

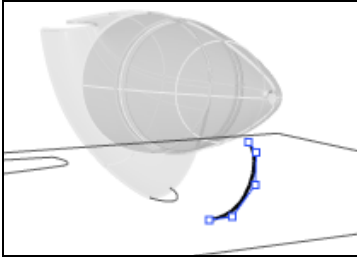


Engines 2

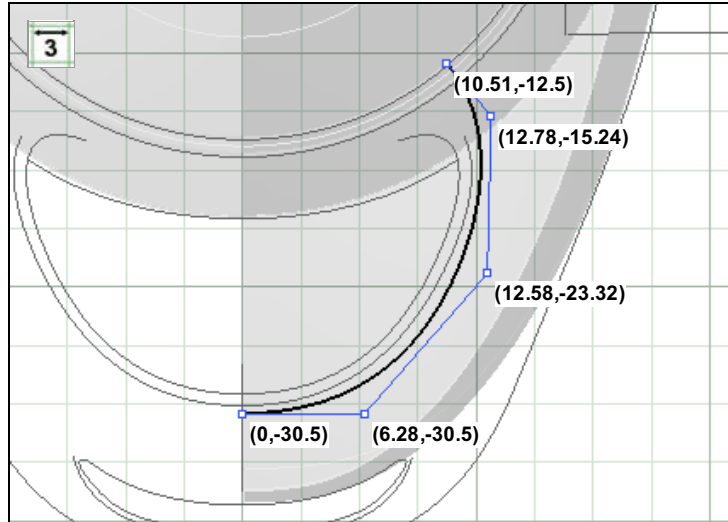
Intakes



1. Draw a *Degree 5 Curve* for the profile of the intake, snapping to the **End** of the main shroud surface.

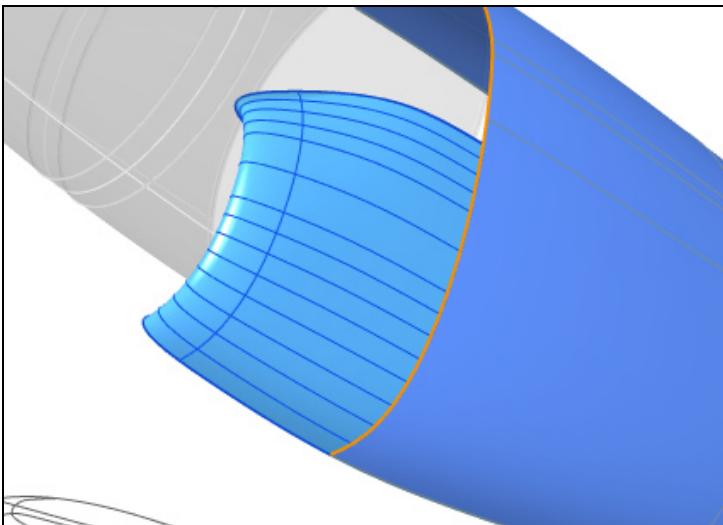
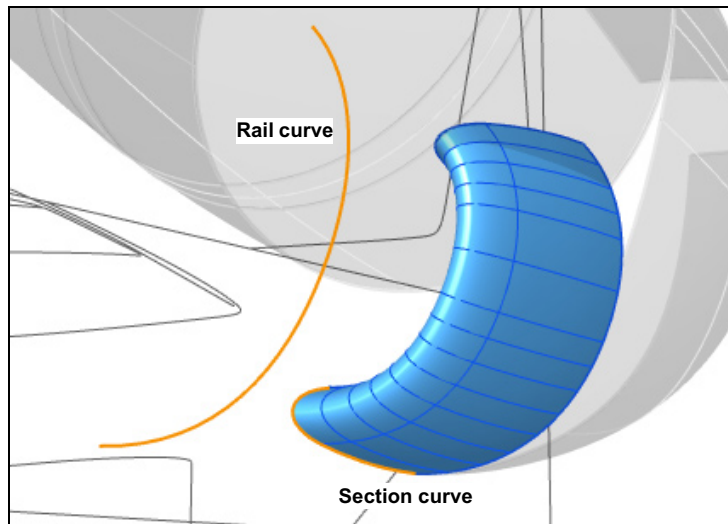


2. Draw a Degree 3 Curve in the Front view.

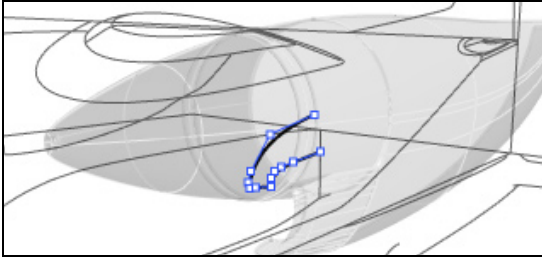


3. Use the last curve as the rail and the profile curve as the section for a **Sweep1** surface. Set the **Style** to **Freeform**, set **Do not simplify** in the Cross-section curve options, and the other settings are not applicable.

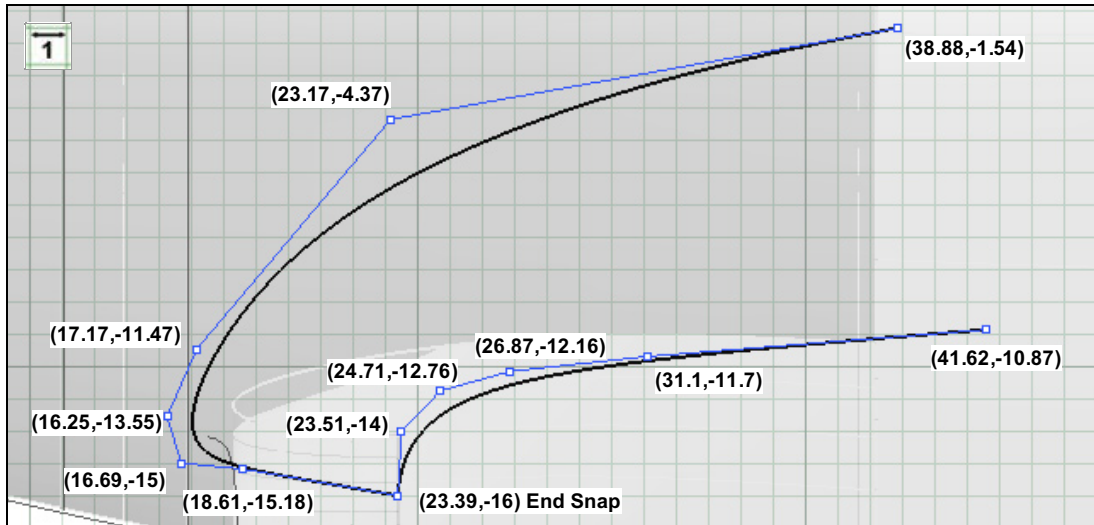
4. Delete the input curves for the sweep.



5. MatchSrf the intake to the shroud. Specify **Curvature Continuity**, enable **Refine match** and **Match edges by closest points**, and set the **Isocurve direction adjustment** to **Automatic**.

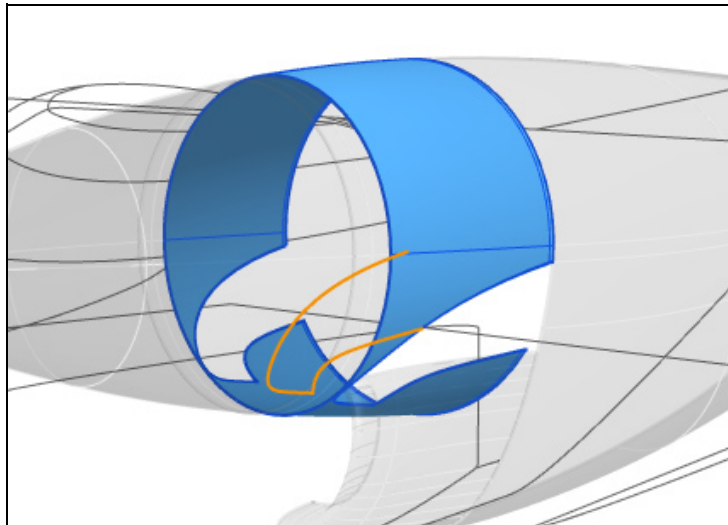


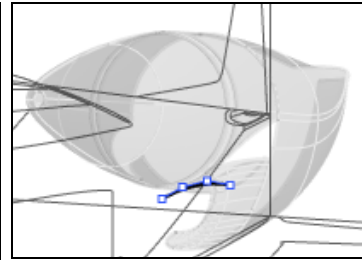
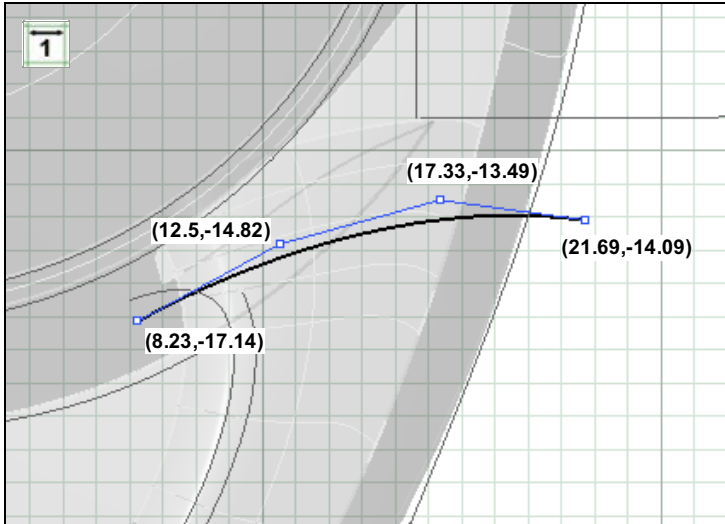
6. Draw two **Degree 5 Curves** in the Right view. snap to the to the **End** of one to place the end of the other.



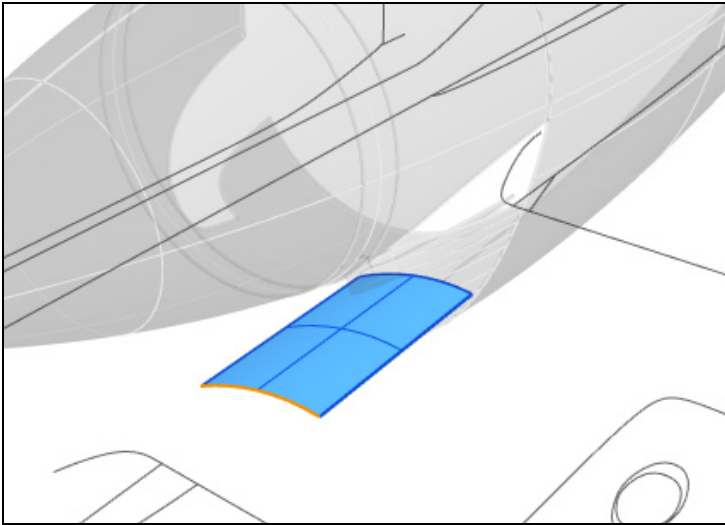
7. Use the curves to **Trim** out the unmodified piece of the shroud.

8. **Delete** the curves.



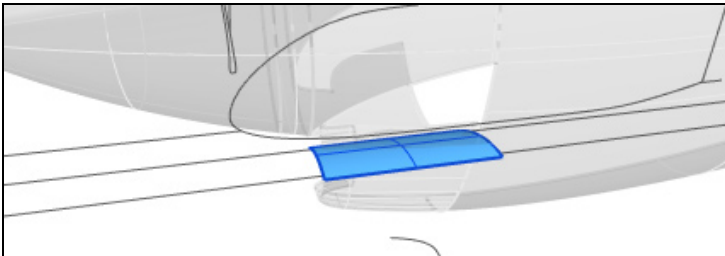


9. Draw a new **Curve** in the Front view.



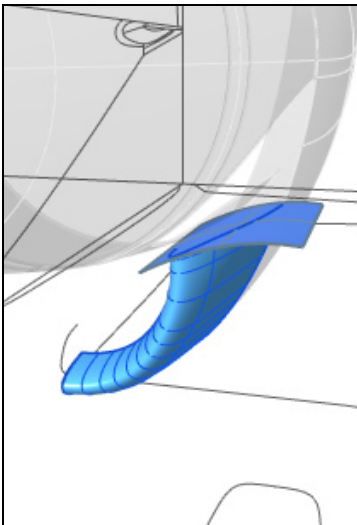
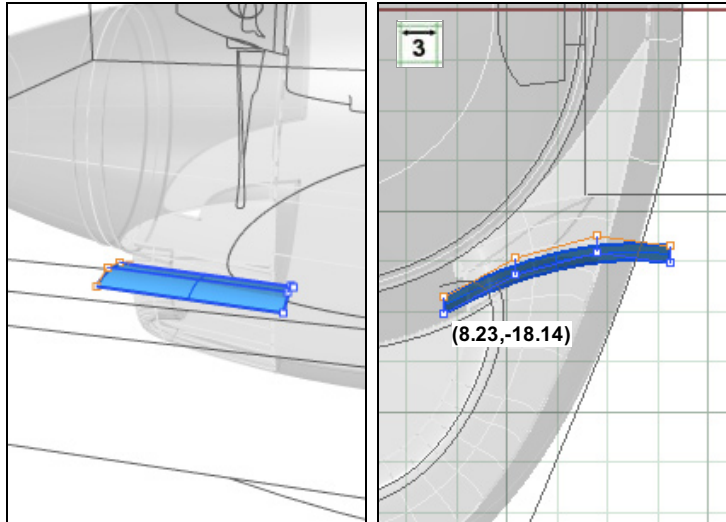
10. ExtrudeCrv it a distance of **23** units.

11. Delete the input curve.



12. Move the extruded surface back by **17** units.

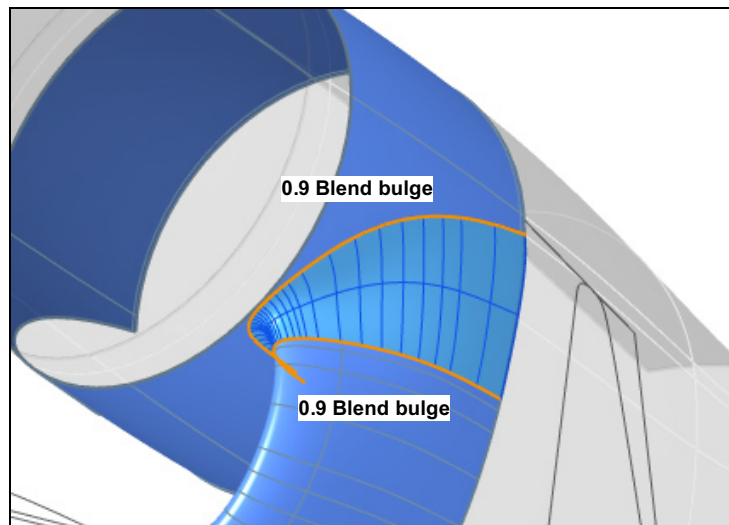
13. Select the back row of points on the surface and move them down by **1** unit.

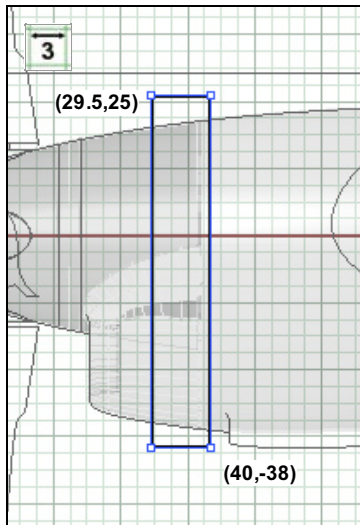


14. Trim that surface to trim off the intake surface.

15. Delete the trimming surface.

16. BlendSrf between the intake and the shroud piece. The blend should turn out okay without specifying any guide sections, and set the *Blend bulge* to **0.9** on both edges.

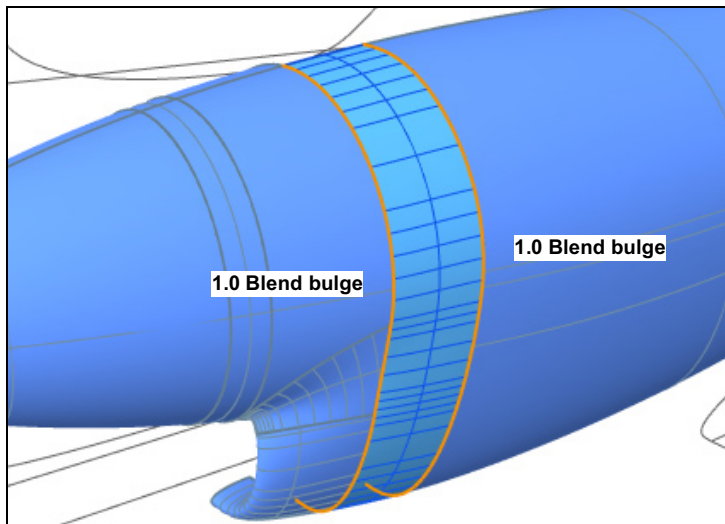
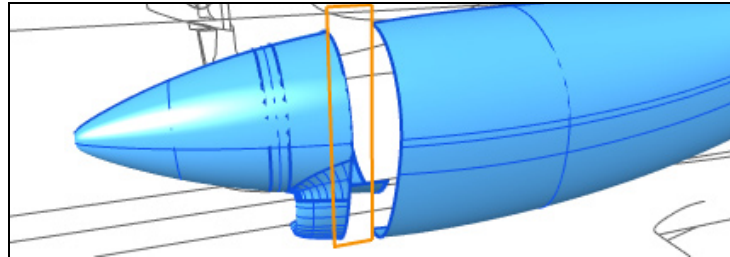




17. Draw a **Rectangle** in the Right view.

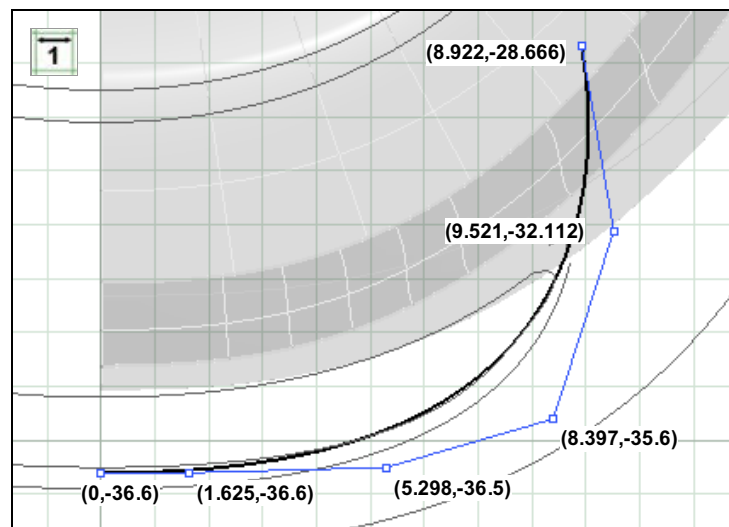
18. Use it to **Trim** off the intake and blend surfaces, the main shroud surface, and the upper part of the smaller shroud surface.

19. **Delete** the rectangle.

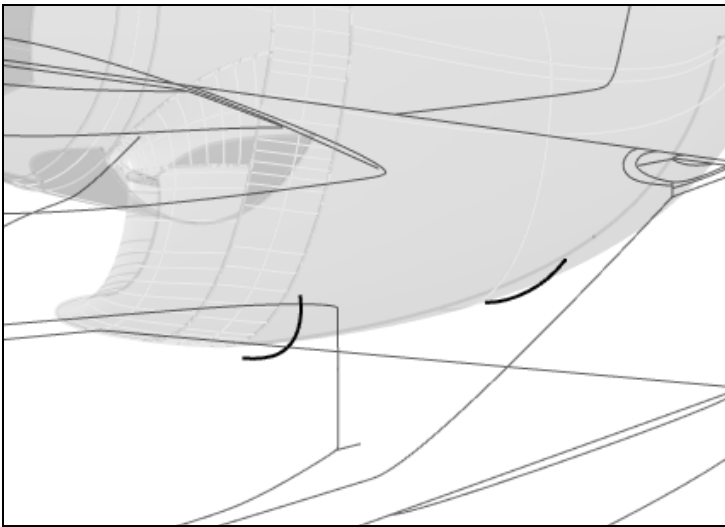
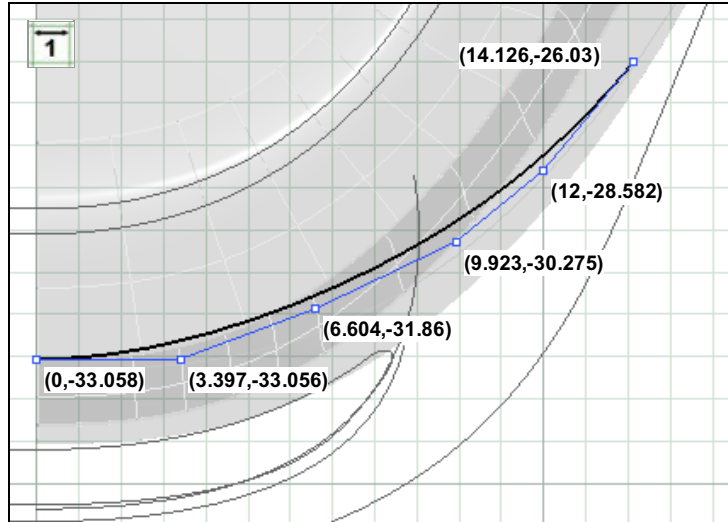


20. Create a **BlendSrf**. The idea here was that we needed to align the blend surface with the main shroud surface, as well as align the Degree 5 main shroud surface with the smaller Degree 2 piece, this is a simple way of smoothly doing both.

21. To begin the smaller intake(probably "vent" is a more accurate term) on the bottom, draw a **Degree 5 Curve** in the Front view.

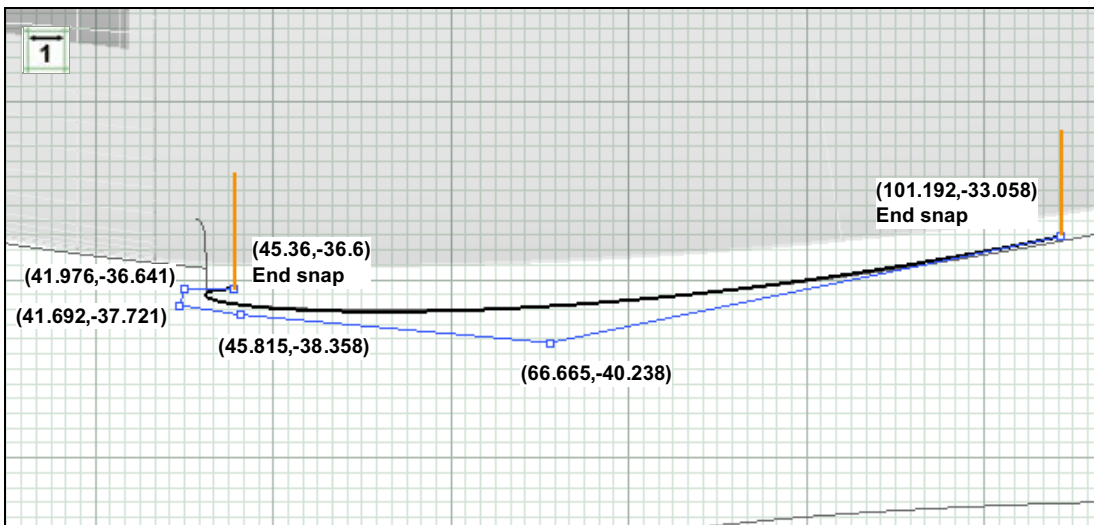
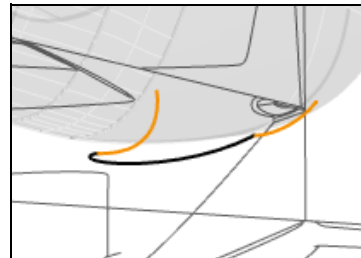


22. Draw another **Curve** in the Front view.



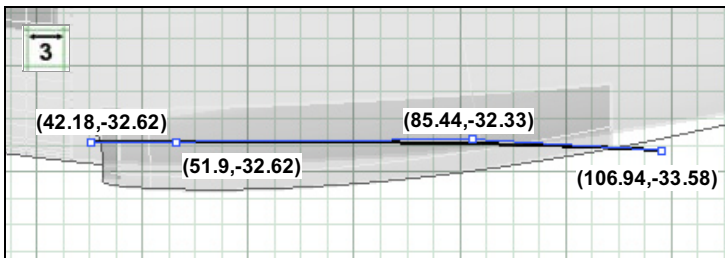
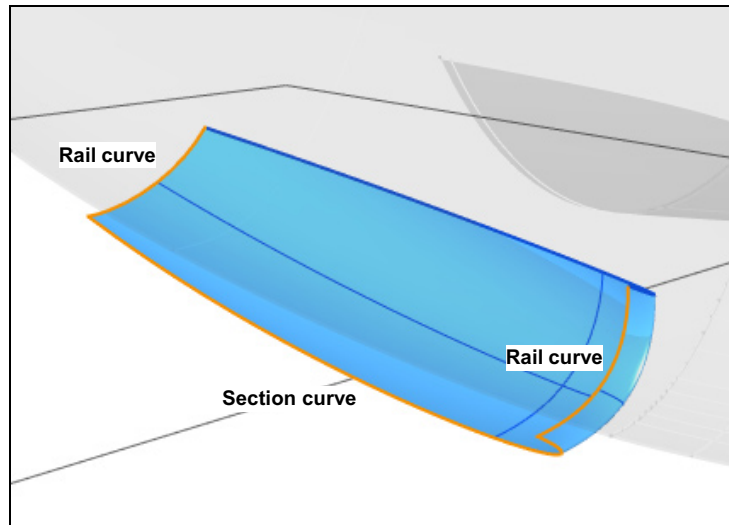
23. Move the curves aft. Move the first back by **45.36** units, the second by **101.192**.

24. Draw another **Curve**, in the Right view, snapping the **End** points of the previous curves at each end.

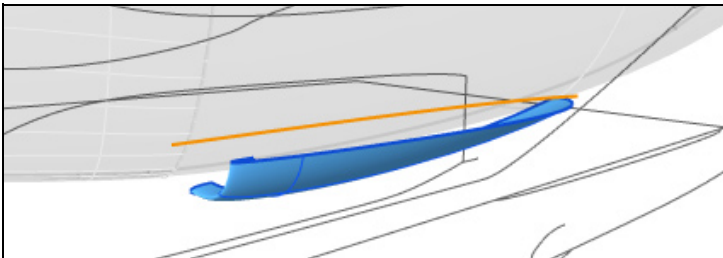


25. With three curves, make a **Sweep2** surface. Select the **Simple Sweep** option, which overrides the other settings. It's only available in certain cases where your curves are drawn uniformly. The result is a surface that isn't "fitted" to the rail curves, but actually uses their structure directly.

26. Delete the input curves.

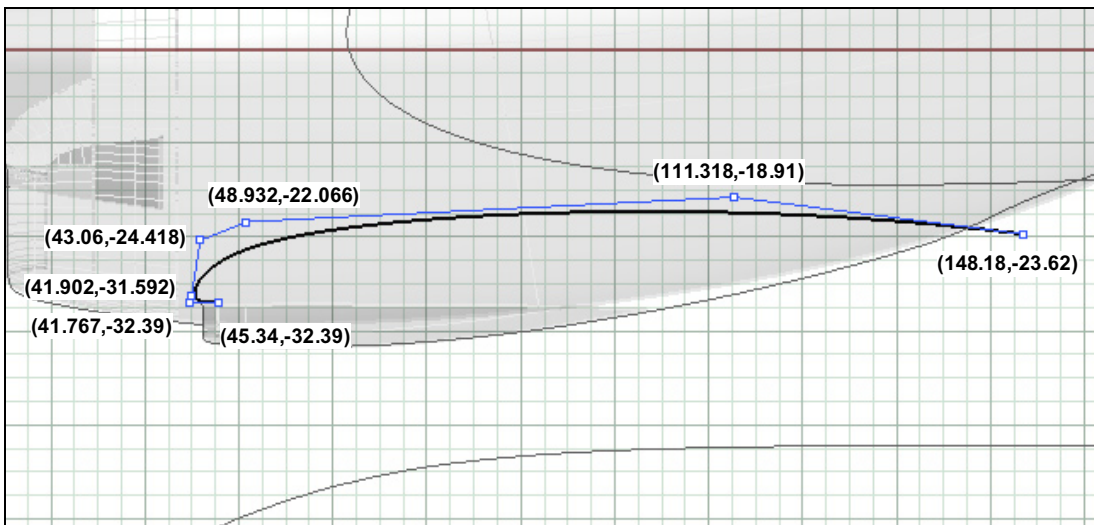


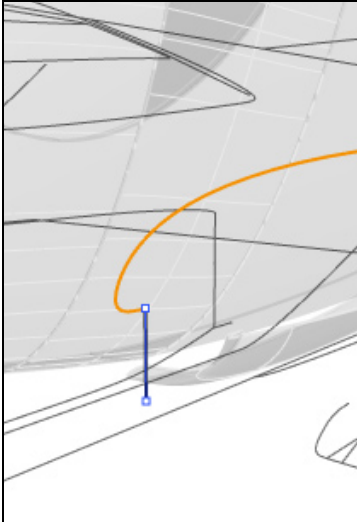
27. Draw a **Curve** in the Right view.



28. Trim off the vent surface with the curve.

29. Delete the curve.



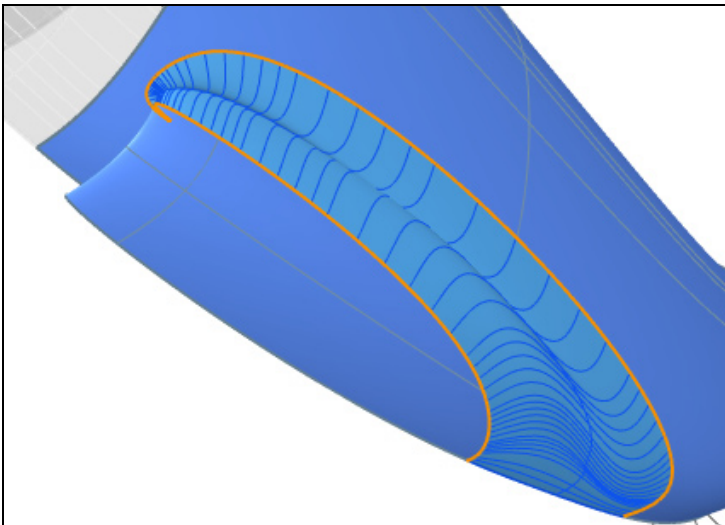
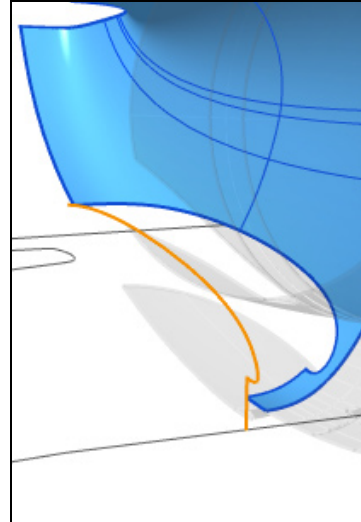


30. Draw a new **Curve** of **Degree 5** in the Right view.

31. Draw a **Line**, extending straight down from the front **End** of the curve by 6 or 7 units.

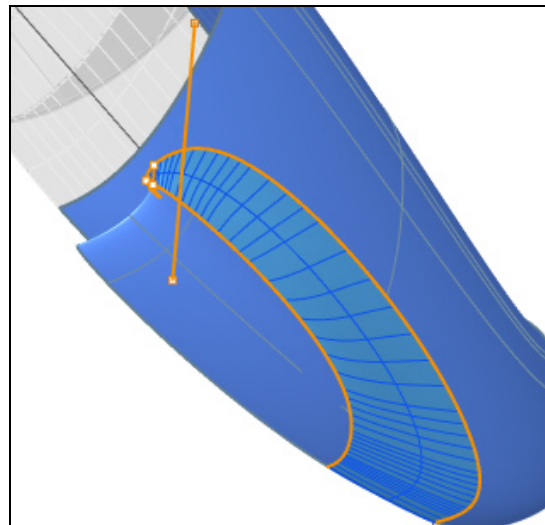
32. **Trim** off the main shroud surface using the curve and line.

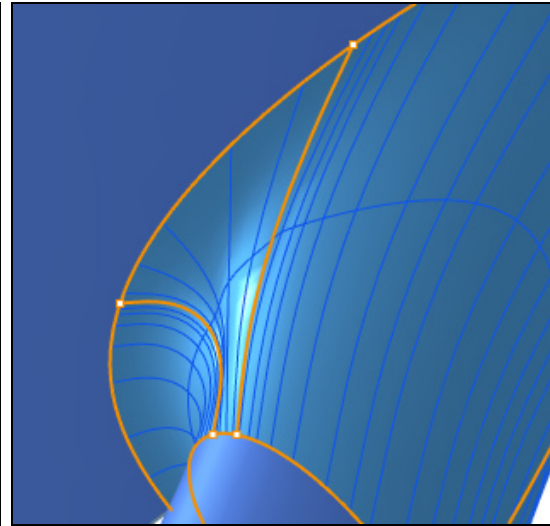
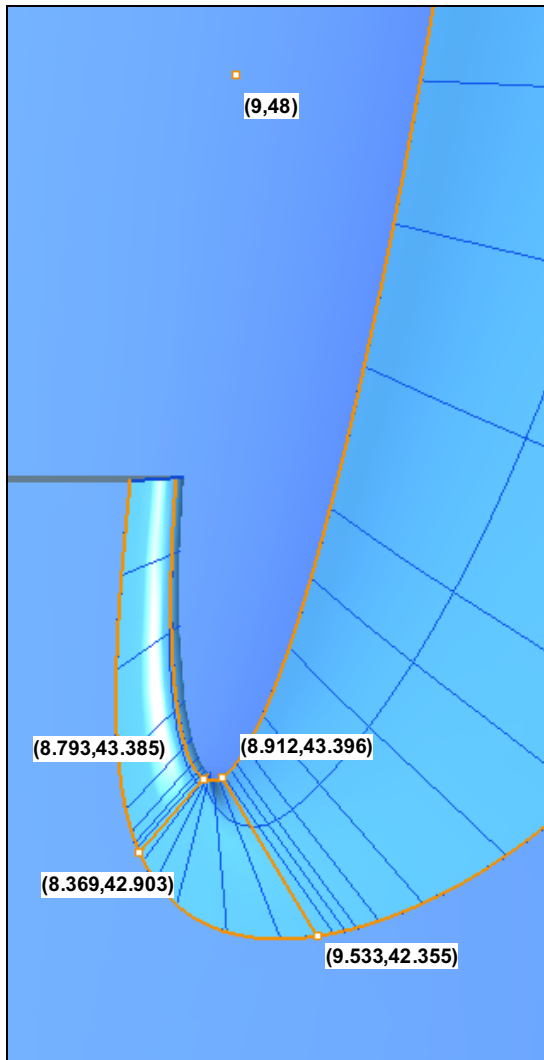
33. **Delete** the trimming curves.



This is going to be a more elaborate blending task than with the intake. One simple **BlendSrf** isn't going to work.

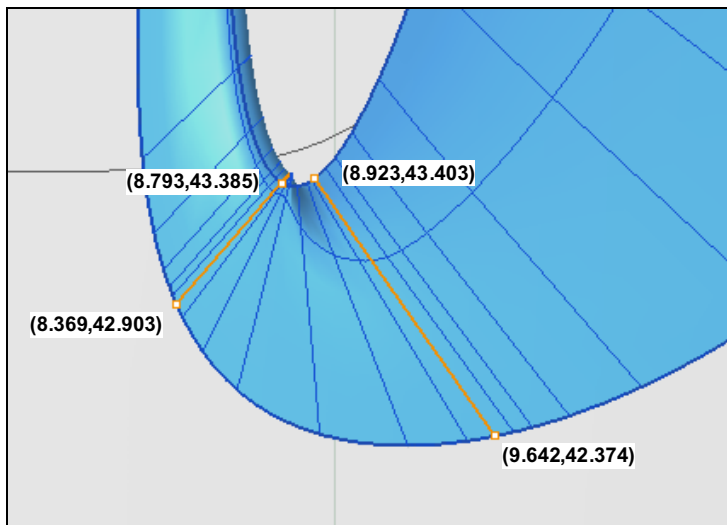
34. To address the waviness in the larger part of the blend, use the **PlanarSections** option, which insofar as is possible orients the sections of the blend parallel to the line it prompts you to input. Make a vertical line starting at the point shown. Use the default **10 Blend bulge** and specify two guide sections at the front.





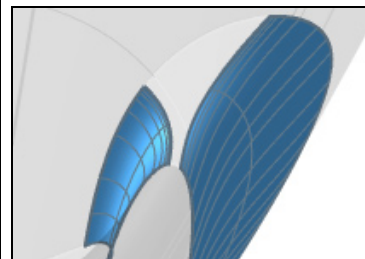
The blend is 'crumpling' in this area, adding more sections to try to control it is excessively fiddly and the *PlanarSections* option disables adjusting the angle of the guide sections. So, we'll have to fix this another way.

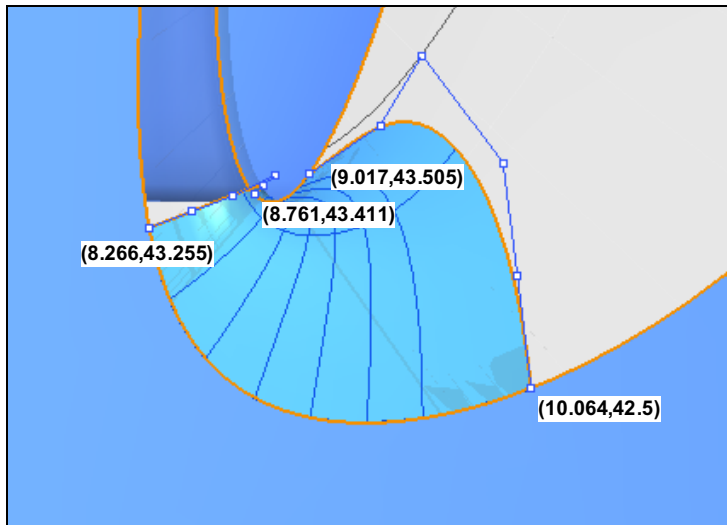
This corner is tricky because this blending is not unlike like filleting a simple solid, and when doing that you need to progress from the largest fillets to the smallest to avoid hassles. In this situation, the leading edge of the vent opening is the smallest area of curvature.



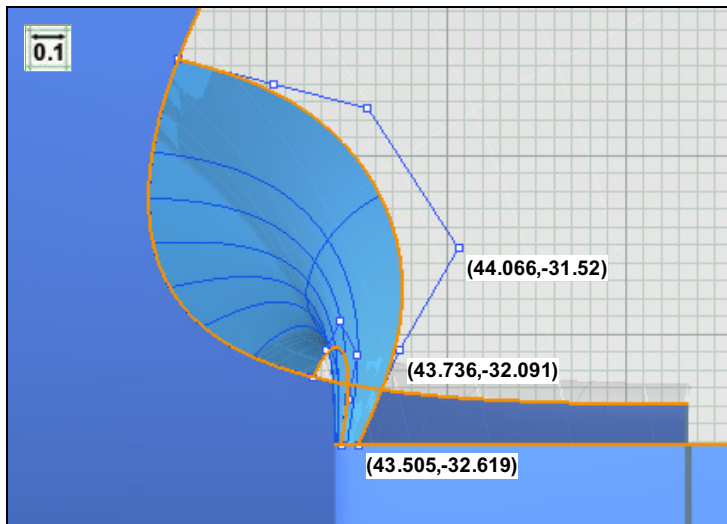
35. Remove the crinkled section of the blend with *Split* and the *Isocurve* option.

36. Delete the small piece of the blend.

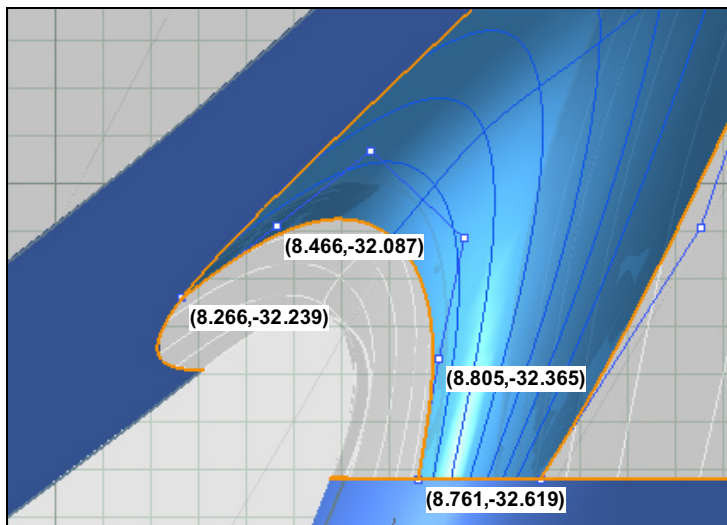




37. Make another **BlendSrf**. This time don't use the **PlanarSections** option and move the end sections so that it's only around the front edge of the vent surface. Just click on the **Blend bulge** sliders to 'reset' the bulginess after moving the sections.

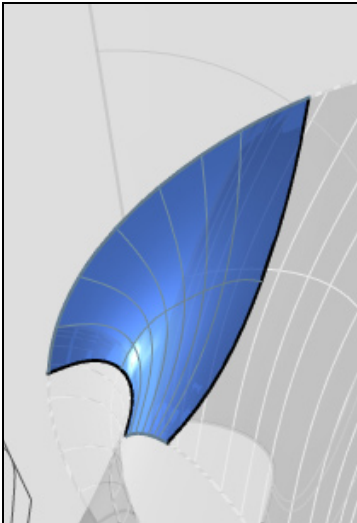
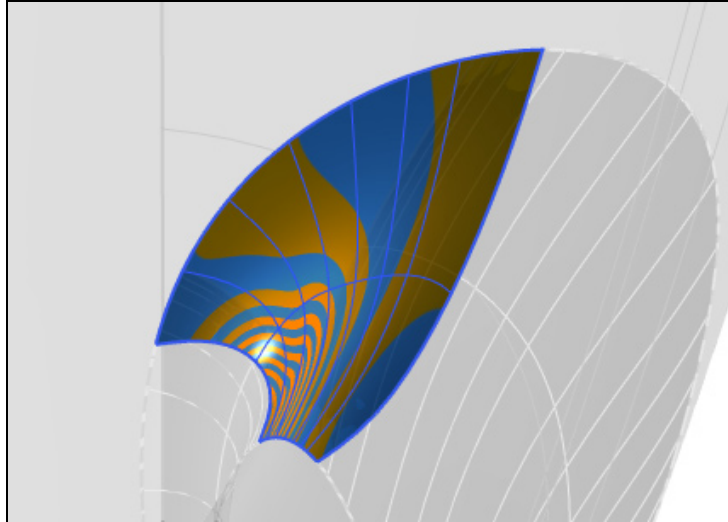


Hold down the ALT key to adjust the angle of the lower edge of the outer section.



On the inside edge, slightly modify the bulginess by moving the second points.

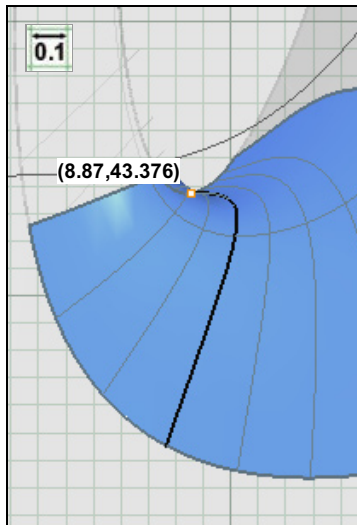
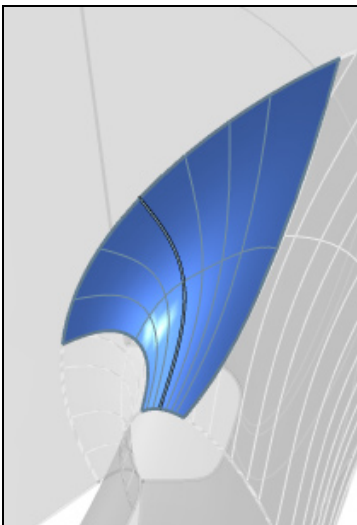
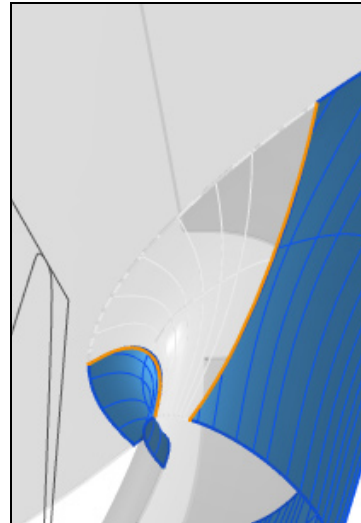
While it is possible with more fine tweaking of the blend, the surface will not be completely free of unwanted waviness, but that's alright, this is only an intermediate surface.



38. Extract the inner and outer edges of the blend with **DupEdge**.

39. In the Perspective view, **Trim** the pieces of the first blend surface with the curves. Differently from the other views where trim curves get extruded perpendicular to the CPlane, in the Perspective view what happens is the same as using the **Pull** command to 'suck' the curve onto the surface.

40. **Delete** the trim curves.

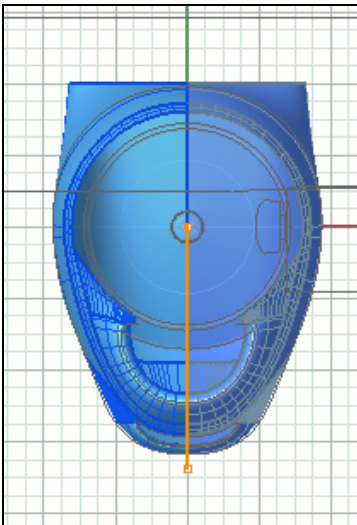
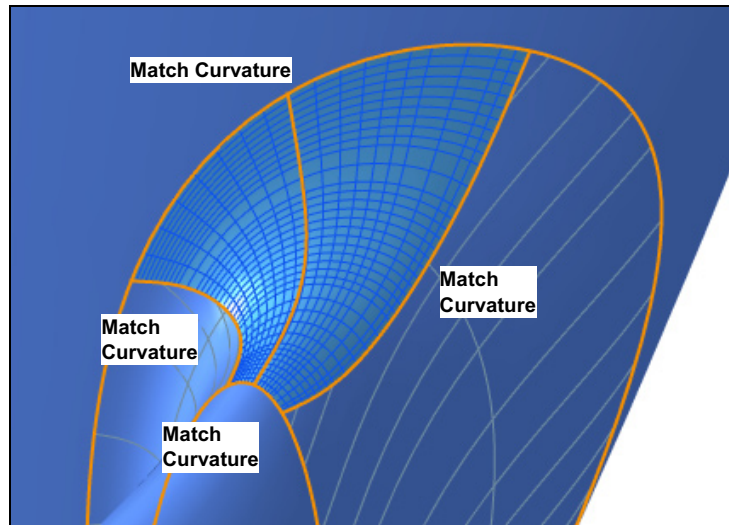


41. **ExtractIsocurve** from the blend surface.

42. **Delete** the blend surface.

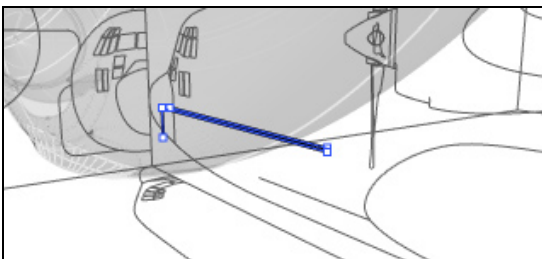
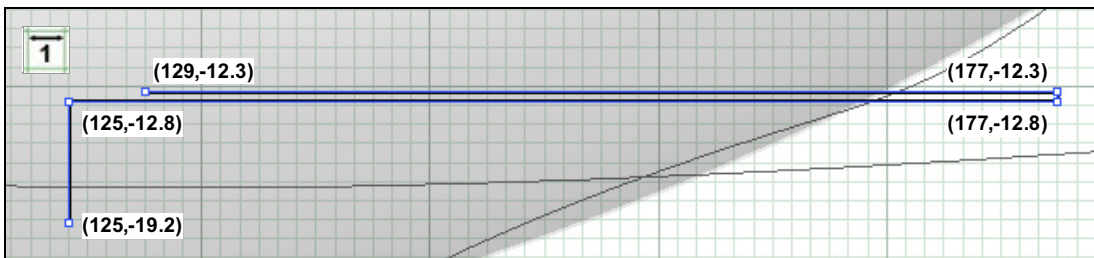
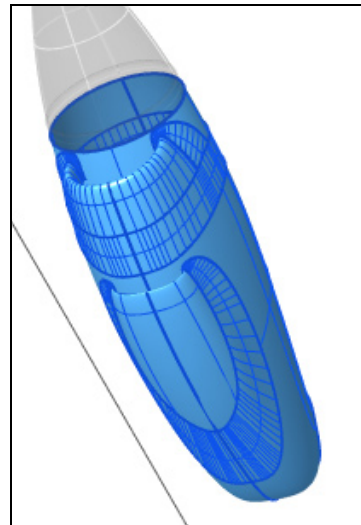
43. Fill in the hole with **NetworkSrf**. Specify a tolerance of **0.001** for **Edge curves** and **Curvature Continuity** for each edge.

44. Delete the curve.



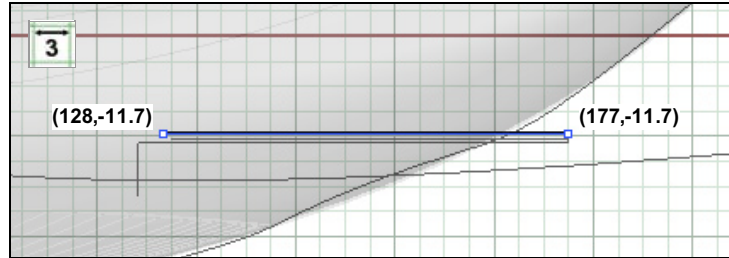
45. Mirror the engine surfaces.

46. Join them up.

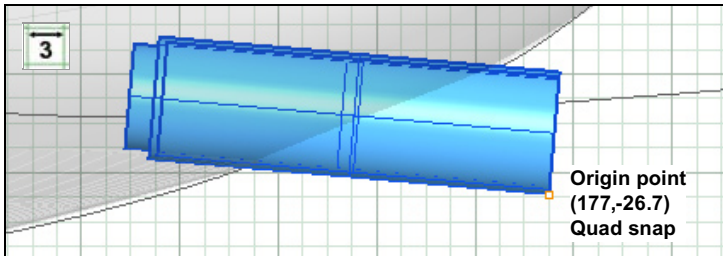
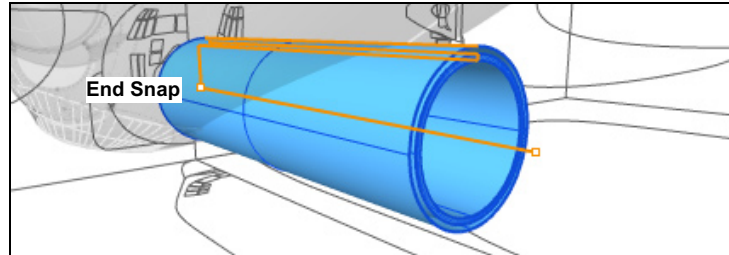


47. Next we'll add some simple geometry to indicate the exhaust pipe. Draw a **PolyLine** in the Right view for the section of the exhaust pipe.

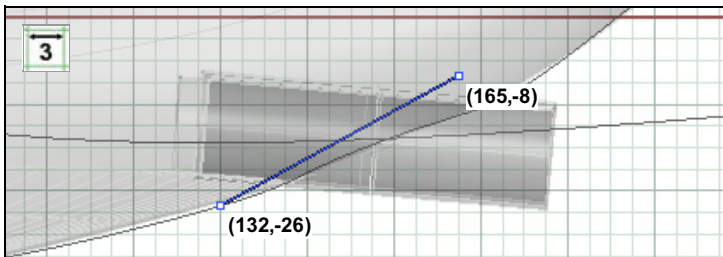
48. Draw a **Line** above the polyline. This is for the opening in the engine shroud.



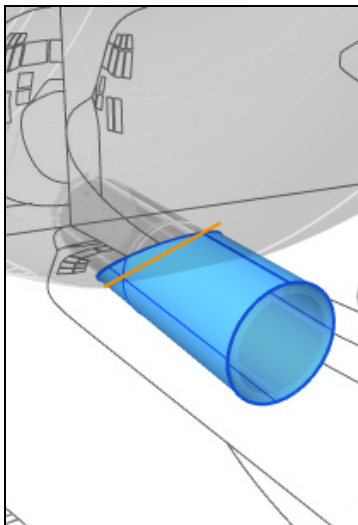
49. **Revolve** the line and polyline. Set *DeleteInput* to **Yes** to remove the lines.



50. **Rotate** the revolved objects by -5 degrees in the Right view.



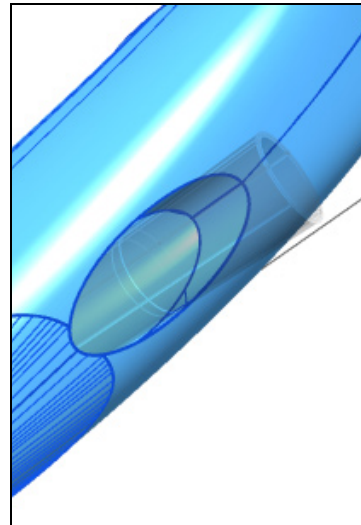
51. Draw a **Line**.

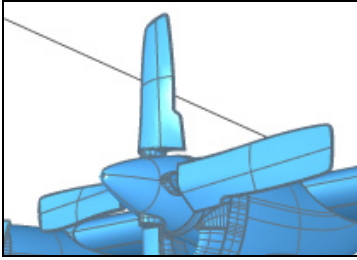


52. **Trim** off the forward part of the outer cylinder using the line.

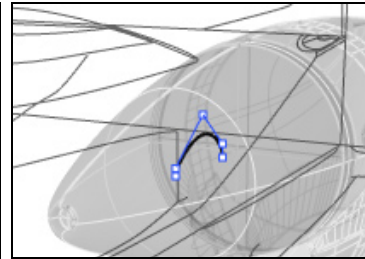
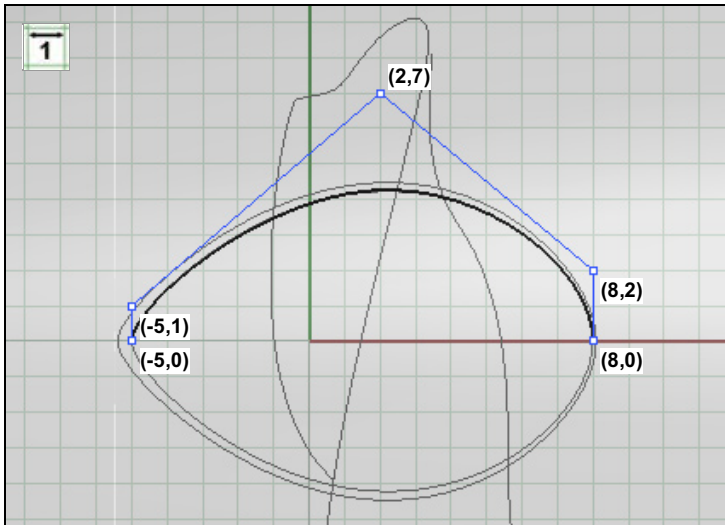
53. **Delete** the line.

54. Run **Boolean2Objects**, selecting the outer cylinder and the shroud. Cycle through the options until you get the shroud with a hole in it, with a small lip from what's left of the cylinder.

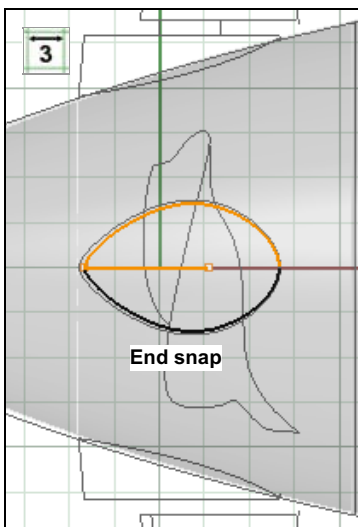




Engines 3 Propellers



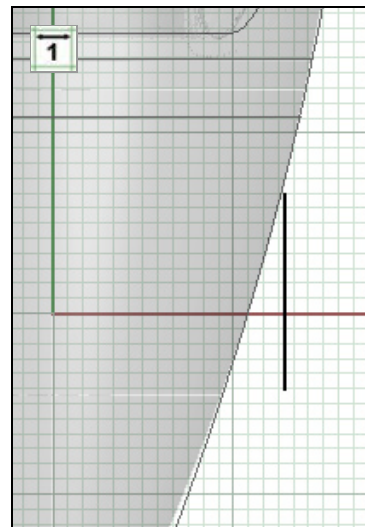
1. Begin the propeller mount by drawing a *Degree 3 Curve* in the Right view.

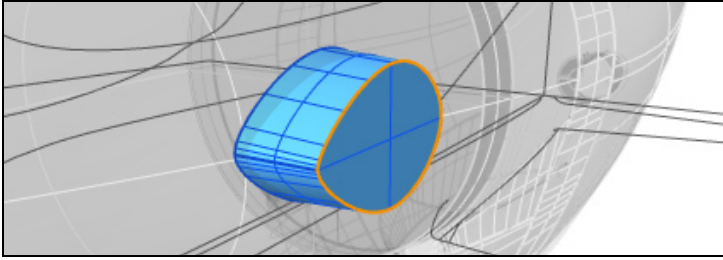


2. *Mirror* the curve about it's *End*.

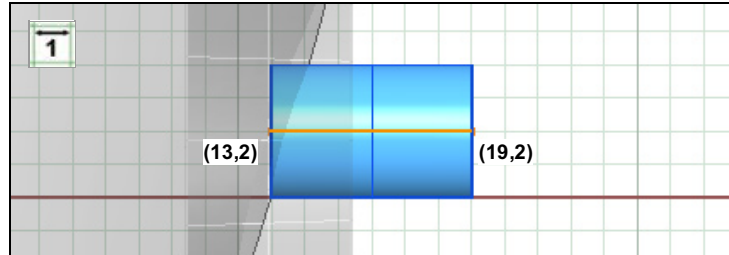
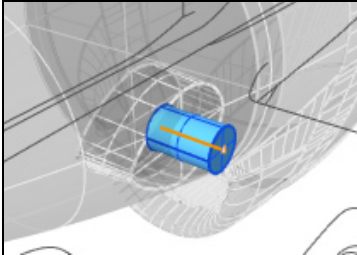
3. *Join* the curves.

4. *Move* the joined curve out by **15.4** units. Make sure they don't intersect the spinner surface.



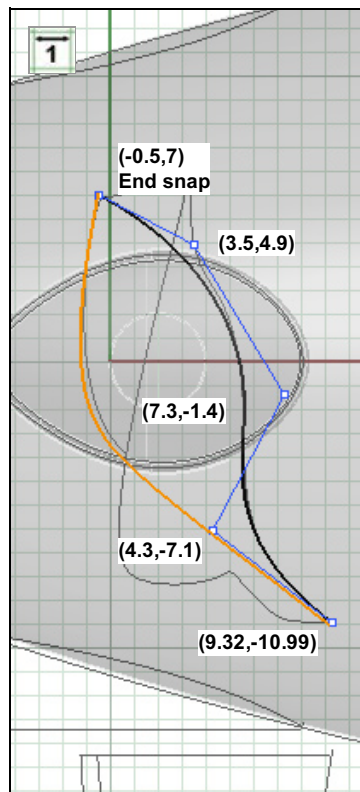
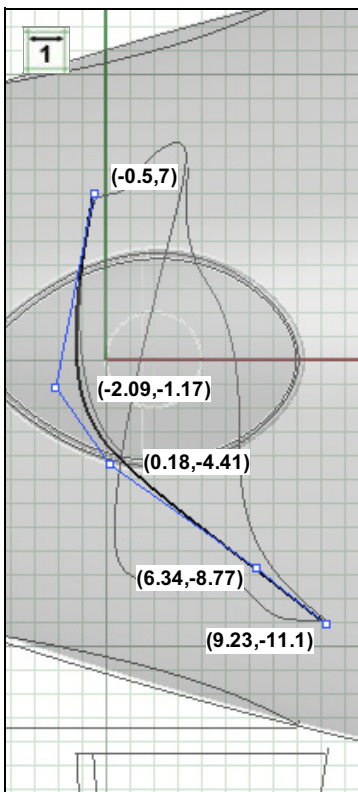
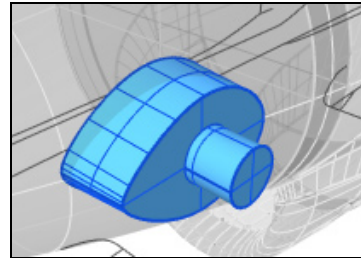


5. Make a solid using **ExtrudeCrvTapered**. Extrude a *Distance* of **-5** units, set the *DraftAngle* to **5**, and use the *Cap* and *DeleteInput* options.



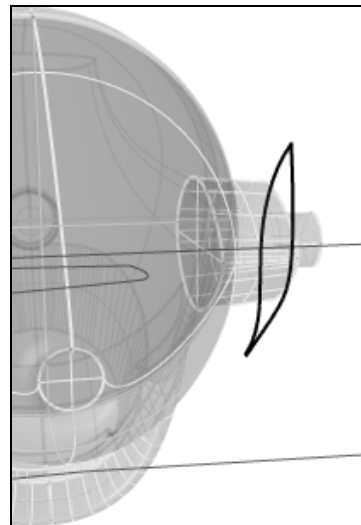
6. Draw a small **Cylinder** in the Top view with a *Radius* of **2** units. Set the *DirectionConstraint* option to **None**.

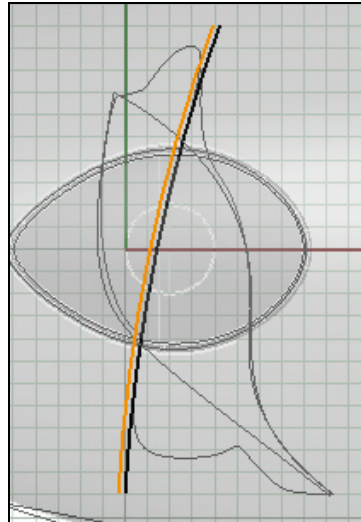
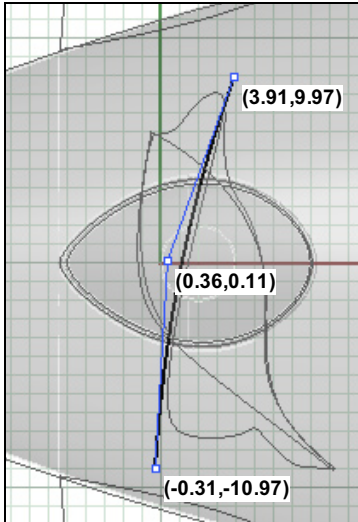
7. **BooleanUnion** the cylinder to the propeller mount.



8. Draw two **Degree 3 Curves** for the section of the propeller. Note that they only touch at the top end.

9. **Move** the curves out by **16.4** units.

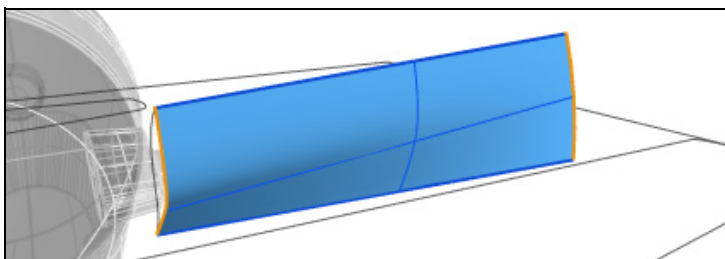
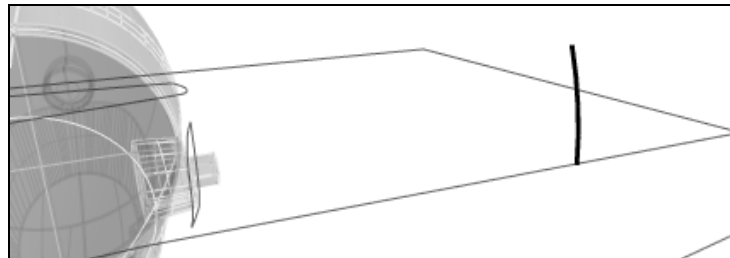




10. Draw another **Curve**, for the section of the propeller at the outside.

11. Make a **Copy** of it, placing the copy **0.3** units aft of the original. Obviously this is not going to be an extremely accurate representation of the airfoil of the propellers.

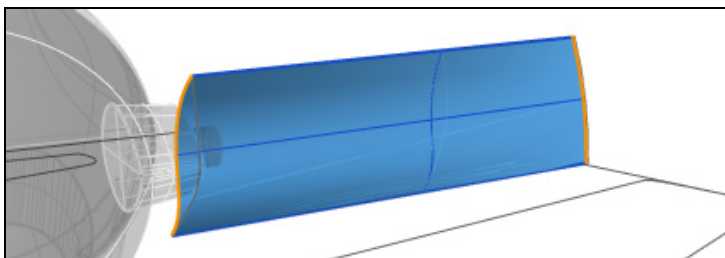
12. Move the two curves we just made out by **82.5** units.



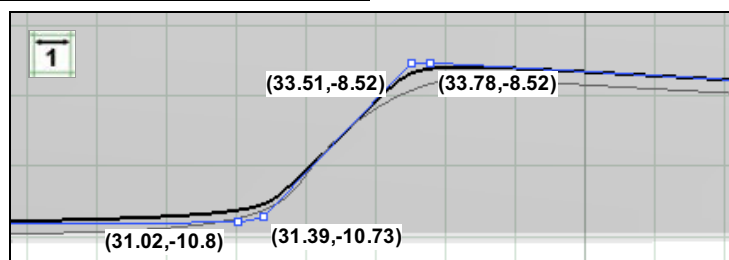
13. **Loft** between the front curves. Set the **Style** to **Normal** and specify **Do not simplify**.

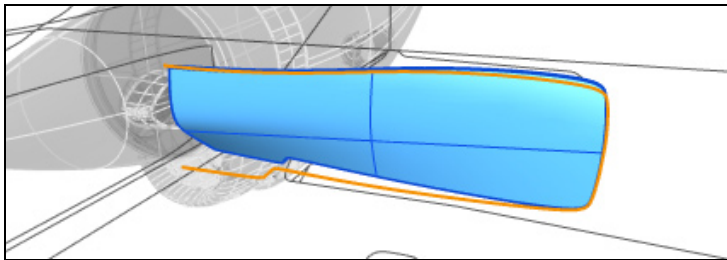
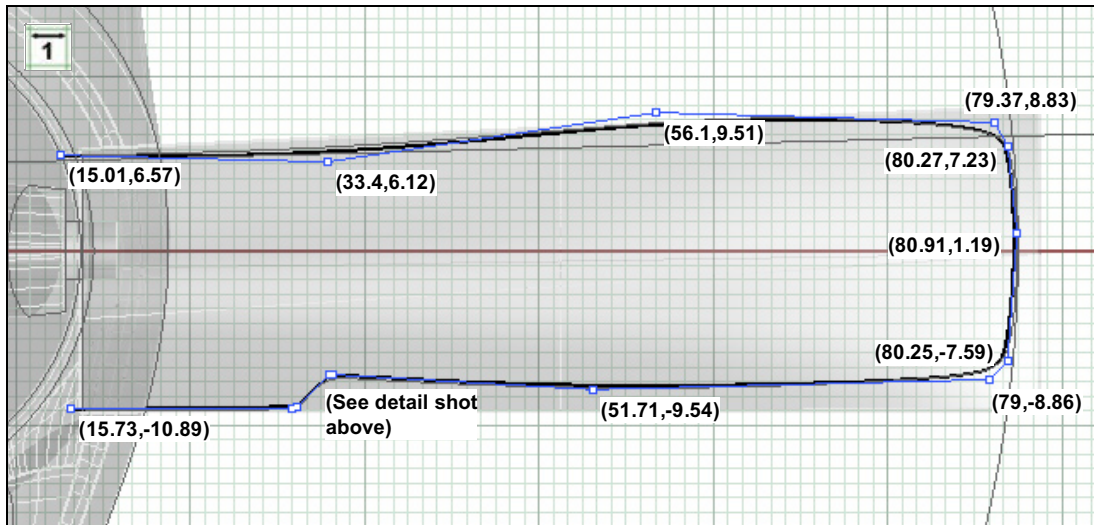
14. **Loft** between the back curves.

15. **Delete** the curves.



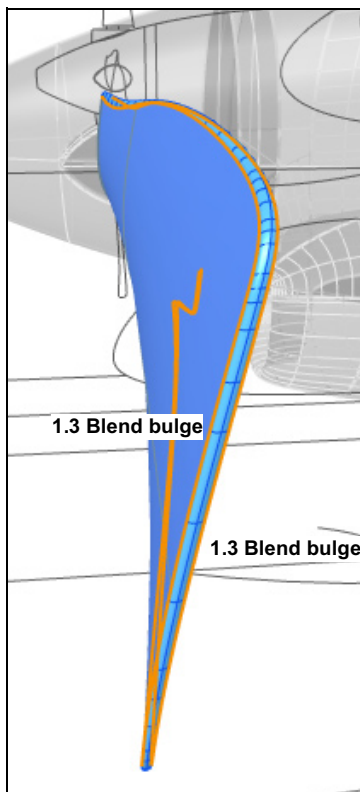
16. In the Front view, draw **Degree 3 Curve**.





17. Trim off the propeller surfaces.

18. Delete the curve.

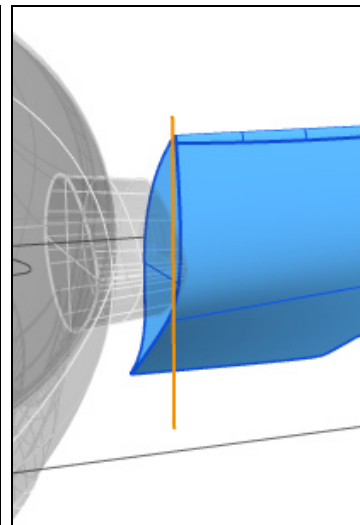
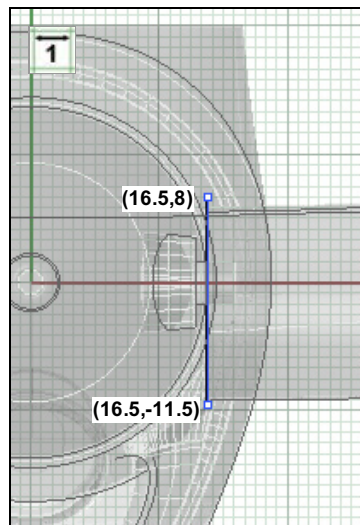


19. BlendSrf between the propeller surfaces.

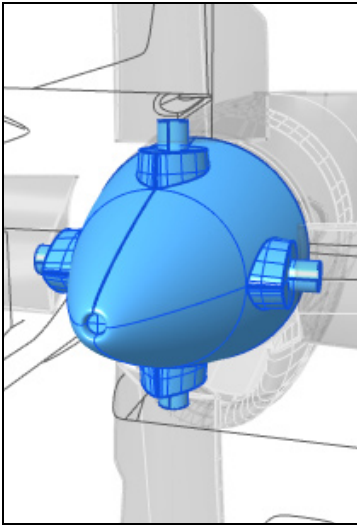
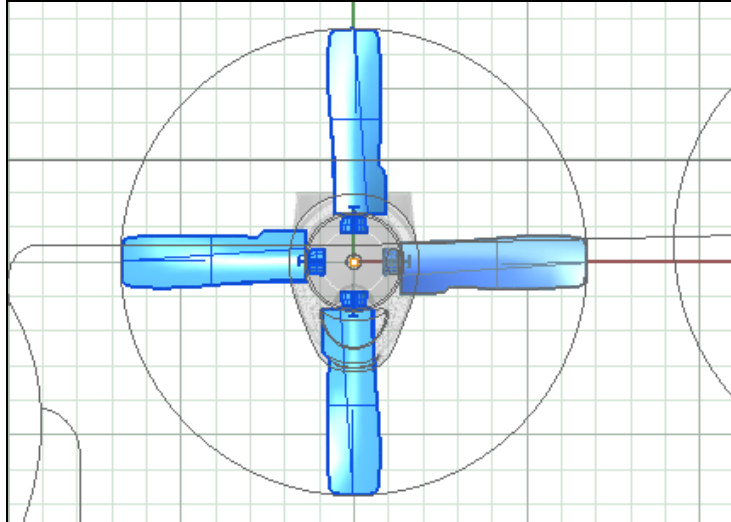
20. Join the propeller surfaces and blend.

21. To finish off the propeller, draw a **Line** in the Front view.

22. With the **WireCut** command, use the line to square off and close up the propeller.

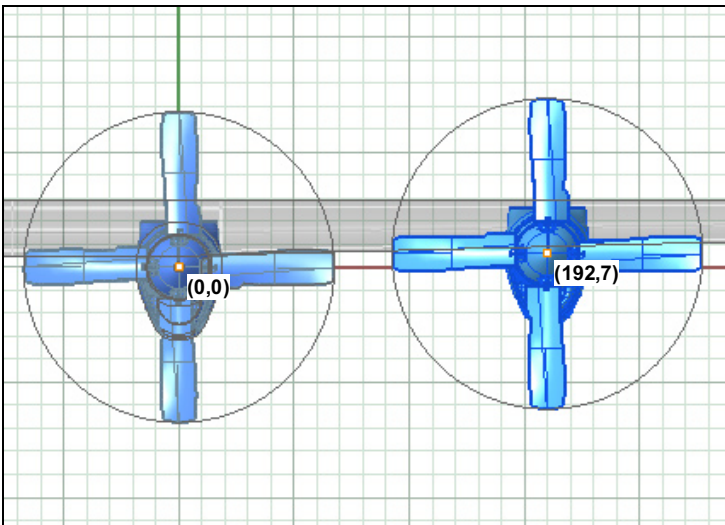
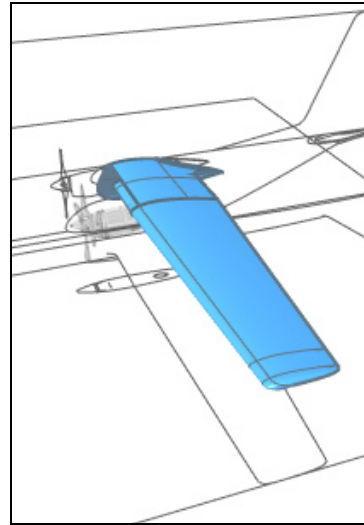


23. Make 3 copies of the propeller and mount objects around the origin with **ArrayPolar**.



24. **BooleanUnion** the spinner and propeller mount objects. The propellers are being kept separate for rendering purposes.

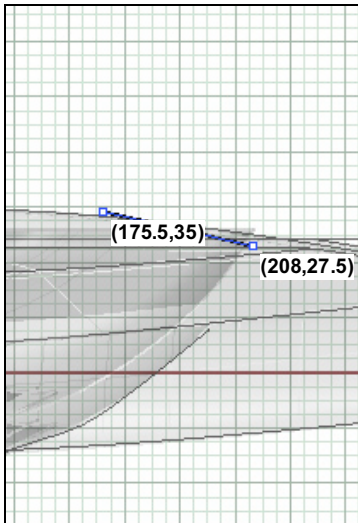
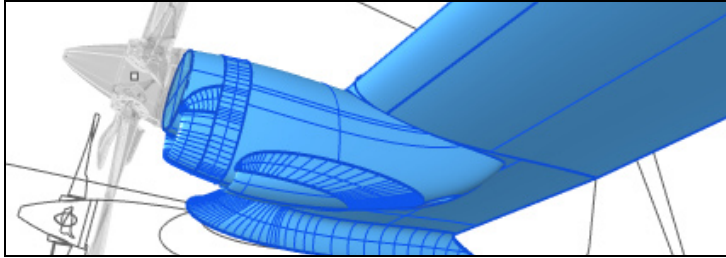
25. With **ShowSelected**, un hide the wing polysurface.



26. Make a **Copy** of the engine and propellers.

27. BooleanUnion the inboard engine to the wing.

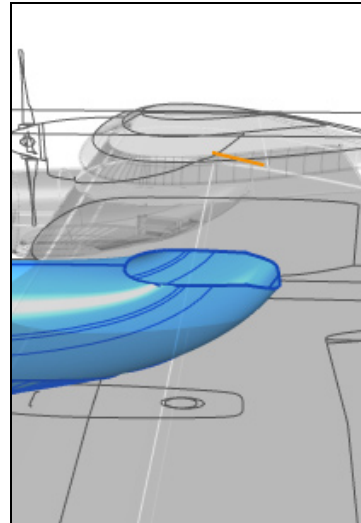
The outboard engine pokes through the wing a bit, so we have to trim it off.



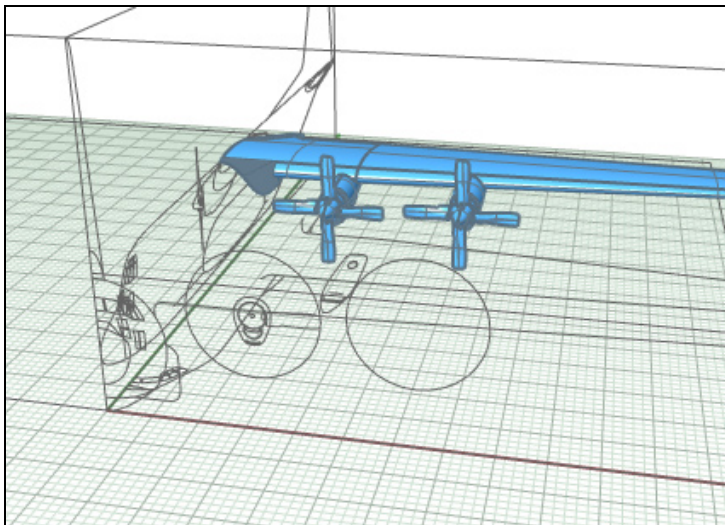
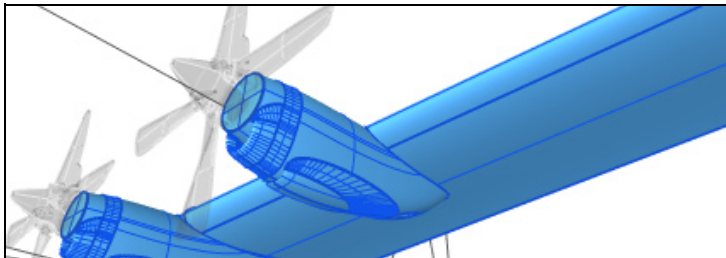
28. Draw a *Line* in the Right view.

29. Trim a small notch off the outboard engine.

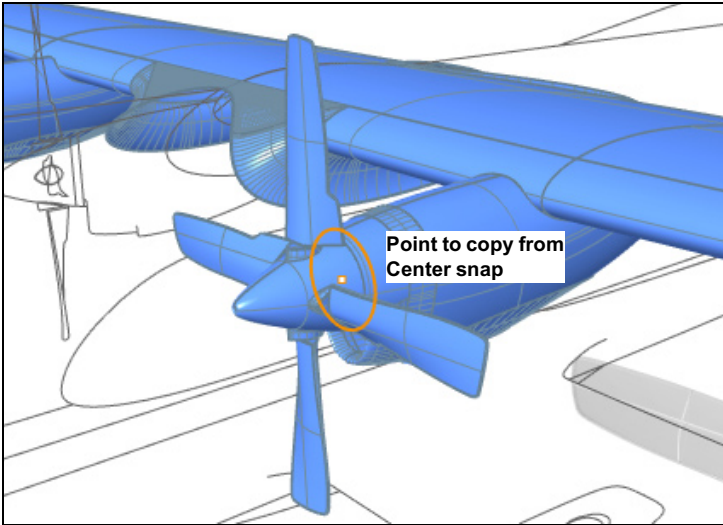
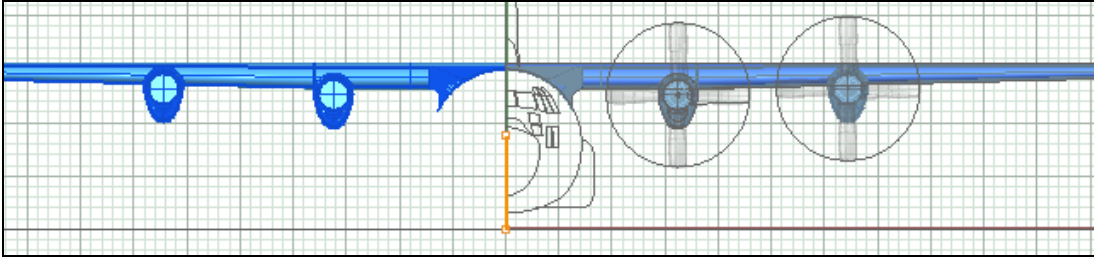
30. Delete the line.



31. BooleanUnion the outboard engine to the wing.

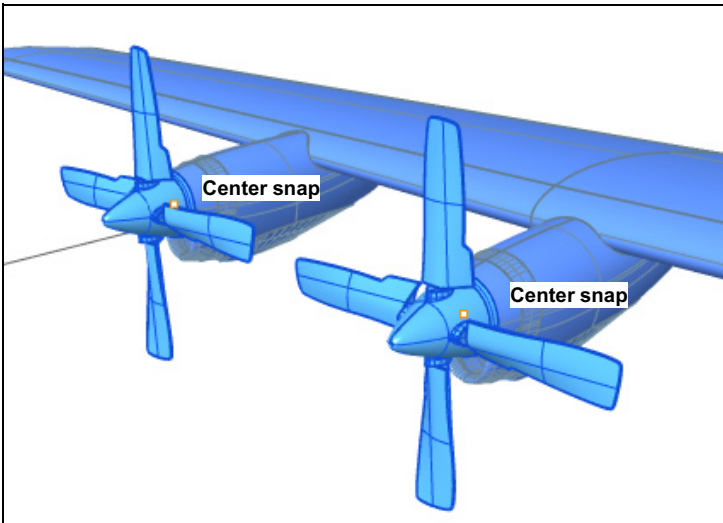


32. Now we want to reset the construction planes back to their defaults. The quickest way is simply to run **4View twice.**

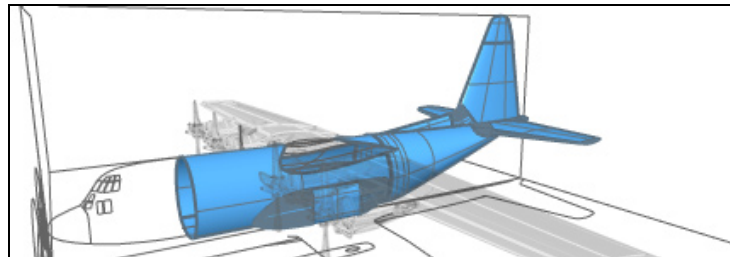


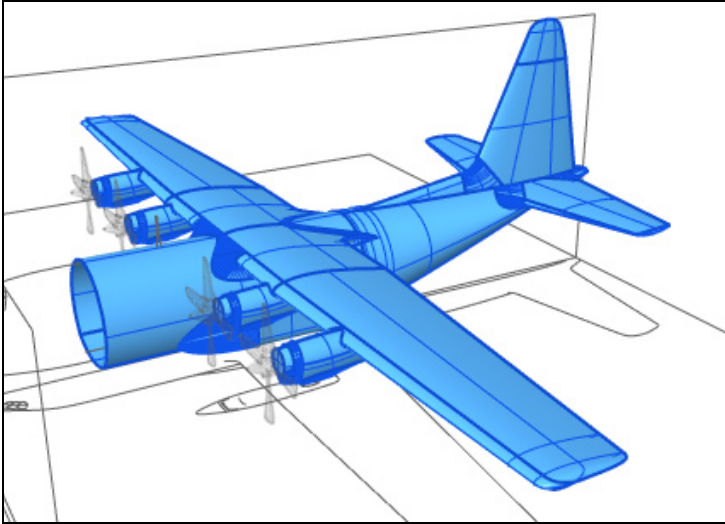
33. Mirror the wing/engine polysurface and the exhaust pipes about the origin.

34. Copy the propeller and spinner objects to the other side, snapping to the **Center** of the from edge of the engine.

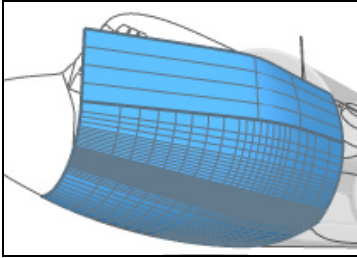


35. Show the fuselage and empennage.





36. *Join* the empennage and wings to the main fuselage.



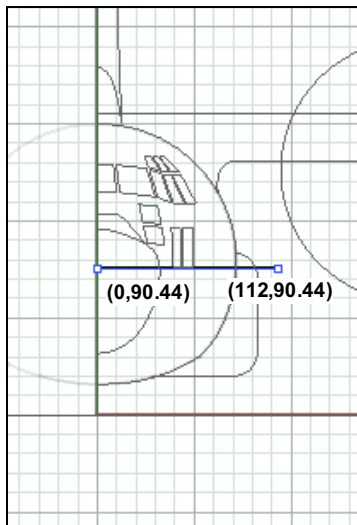
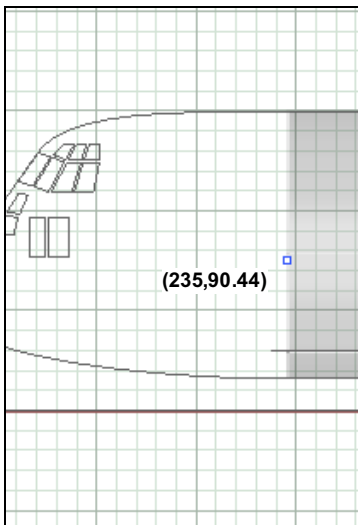
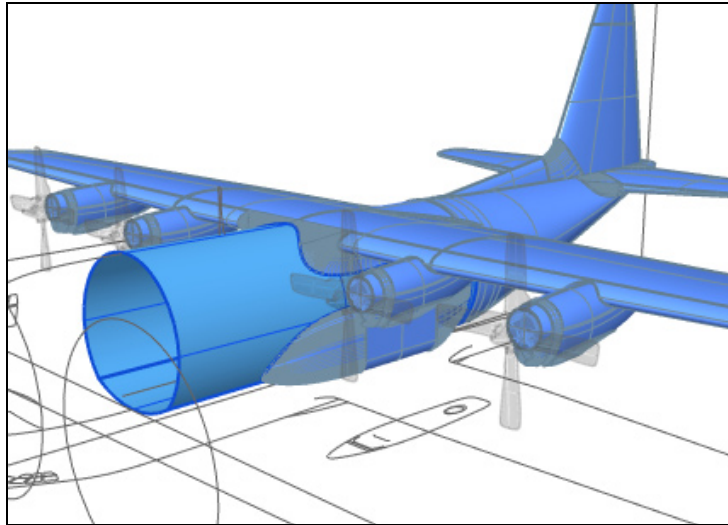
Nose 1

Lower surface

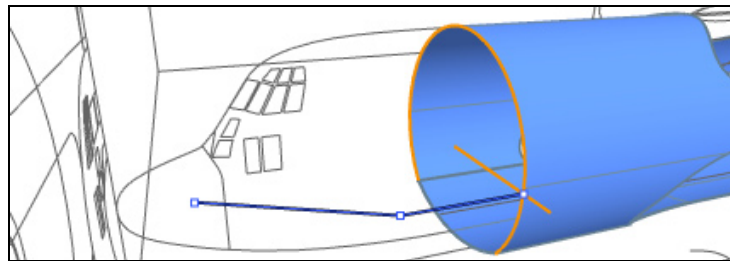
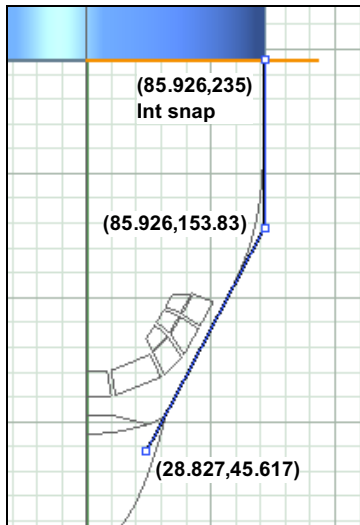
1. **ExtractSrf** the surfaces of the main fuselage section.

2. **Join** up the extracted surfaces.

3. Hide the rest of the model by running **Invert** then **Hide**.

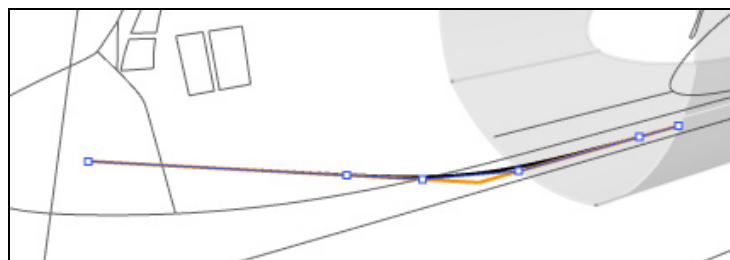
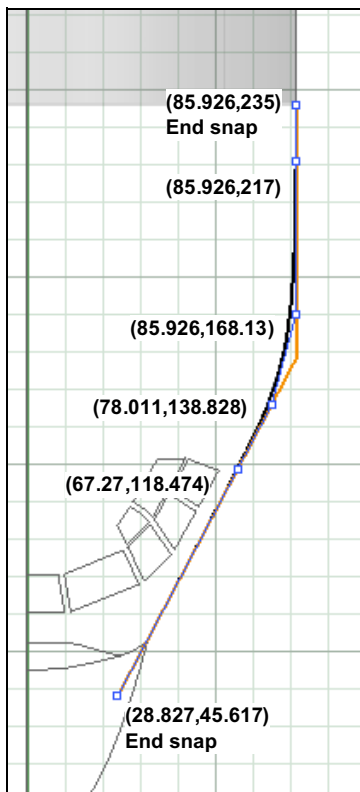


4. Draw a **Line**. Start it in Right view, placing it aligned with the end of the main fuse, then place the second point out beyond the fuse.



5. Use that line, with the **Int** Osnap(intersecting with the edge of the fuselage,) to place the first point of this **Polyline**. Place the second point aligned with the first using **Ortho** mode.

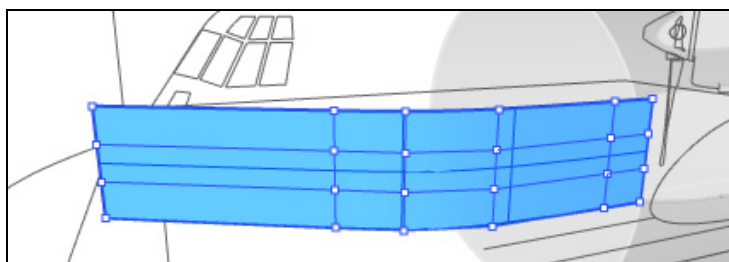
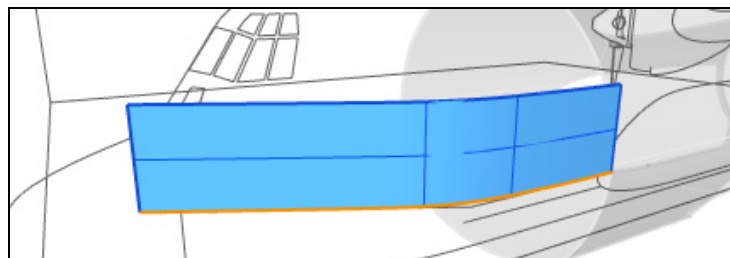
6. **Delete** the first line.



7. Add **Near** and **End** to your active Osnaps. Draw a **Degree 3 Curve**, snapping to the ends and along the polyline.

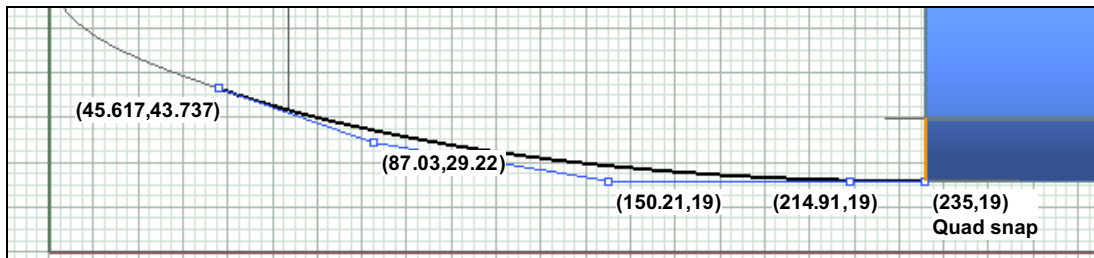
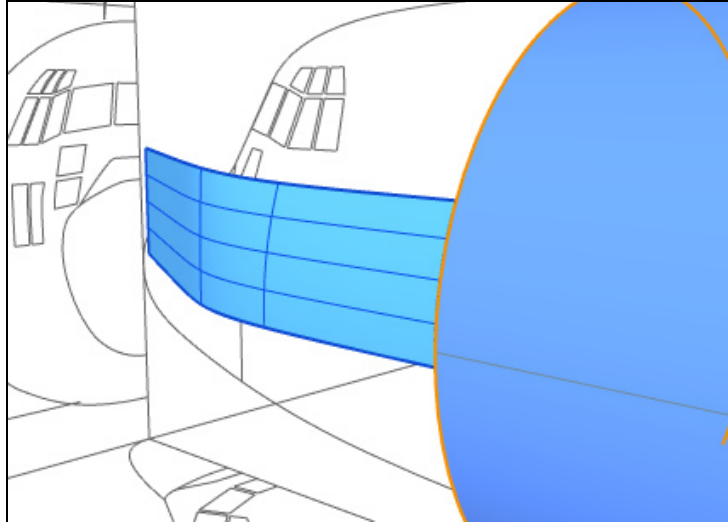
8. **ExtrudeCrv** the curve up by **40** units.

9. **Delete** the curve and the polyline.



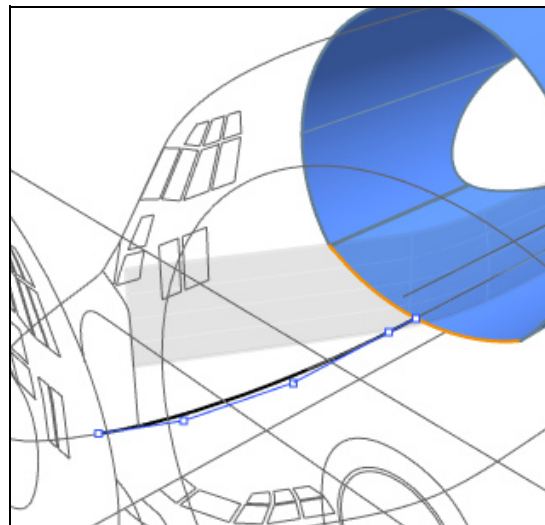
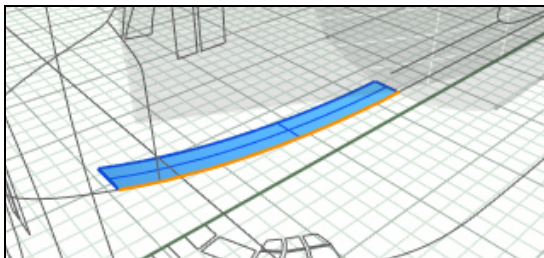
10. Use **ChangeDegree** to raise the degree of the surface along the direction of extrusion from **1** to **3**.

11. MatchSrf the extruded surface to the fuselage. Specify **Curvature Continuity**. Use the **Refine match** and **Match edges by closes points** options, and leave the **Isocurve direction adjustment** at **Automatic**.

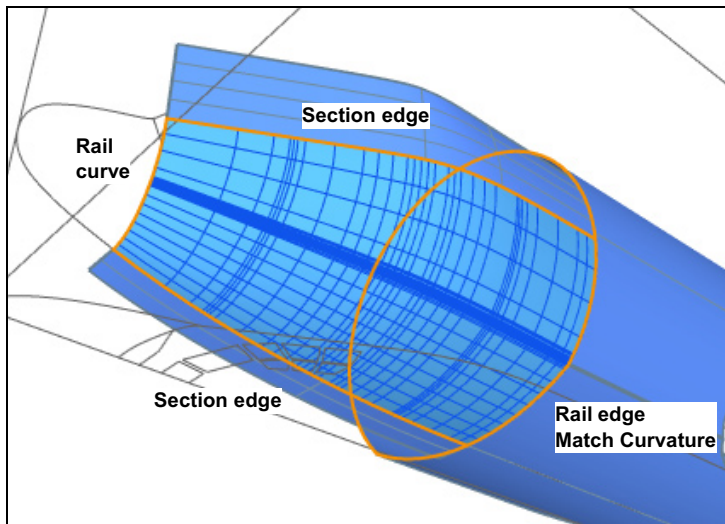
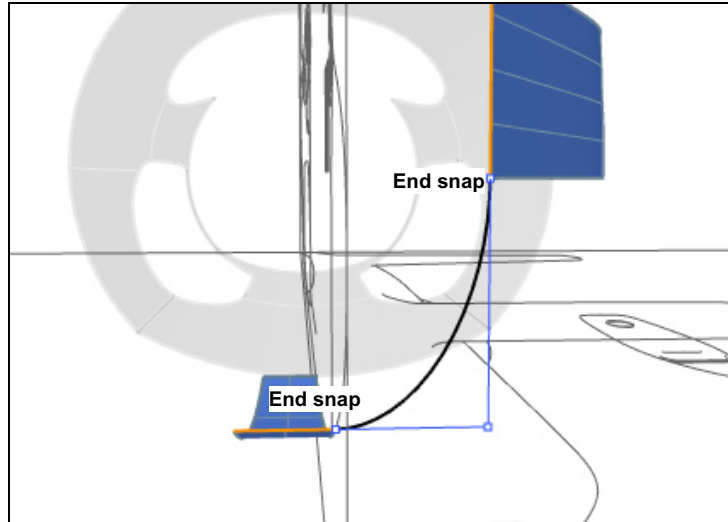


12. In the Right view draw a **Curve**, using the **Quad** Osnap to start from the bottom of the fuselage. Set the **Degree** setting back to **5**, though this curve will actually have a Degree of 4.

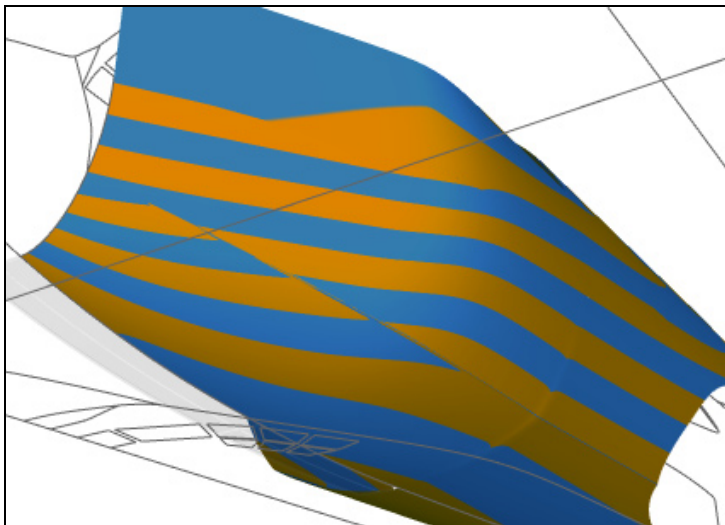
13. ExtrudeCrv the curve a few units, and then **Delete** the curve.



14. Make a **Conic** curve between the front edges of the side and lower surfaces we just made. Specify the **Tangency** option and use the **End** snap to place each end of the curve, then enter a rho value of **0.4**.



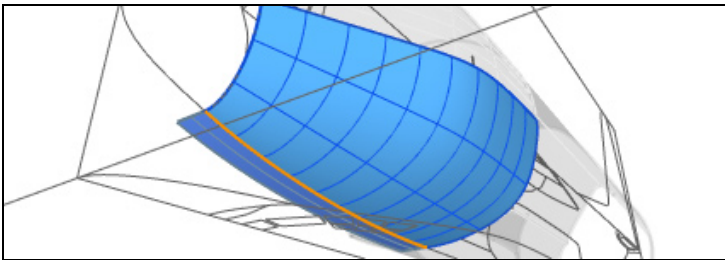
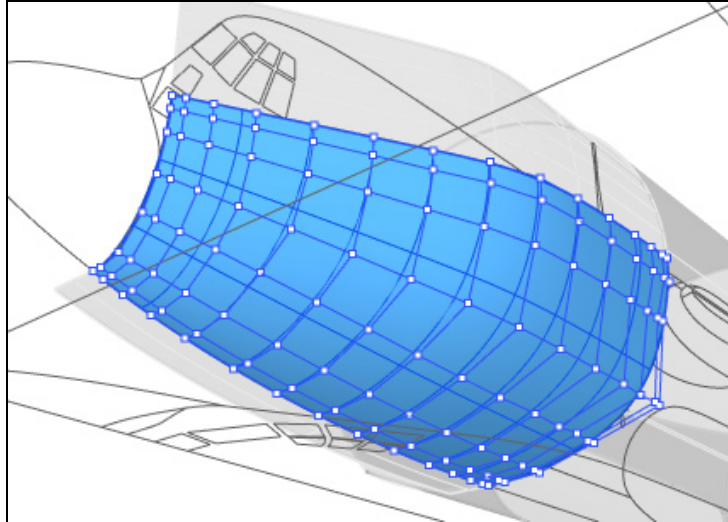
15. Create a surface with **Sweep2**. Use the **ChainEdges** option, **AutoChain** is helpful too, to select the three edges on the fuselage for the one rail. Use **Refit within 0.001** inches to keep the surface orderly. Do not use the other options, just specify **Curvature** continuity along the fuselage.



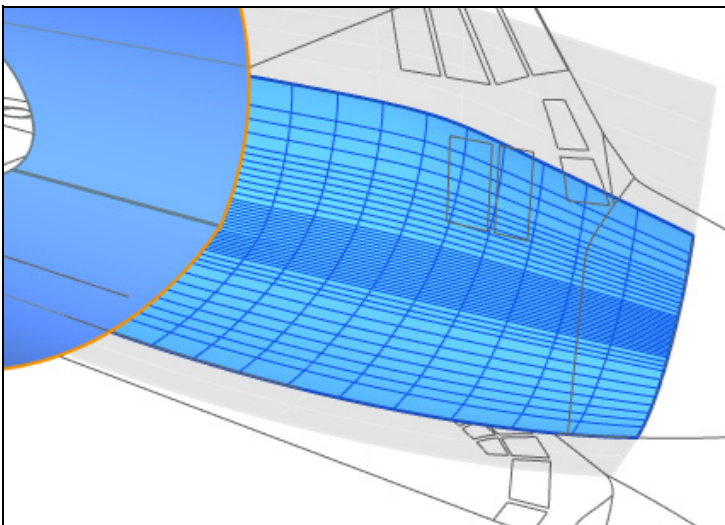
The overall shape is basically what we want, but there's a little trouble with the crease from the fuse.

16. Simplify the surface with **Rebuild**. Set the *Degree* to **5** in both directions and set the *Point count* to **15** along the length, and **8** along the height or width.

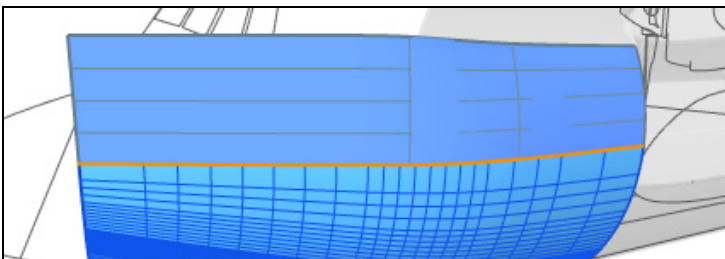
Now we'll match the surface back up to the adjacent edges.



17. MatchSrf to the bottom profile surface. Set the *Continuity* to **Tangency**, only turn on *Match edges by closest points*, and set the *Isocurve direction adjustment* to **Automatic**.

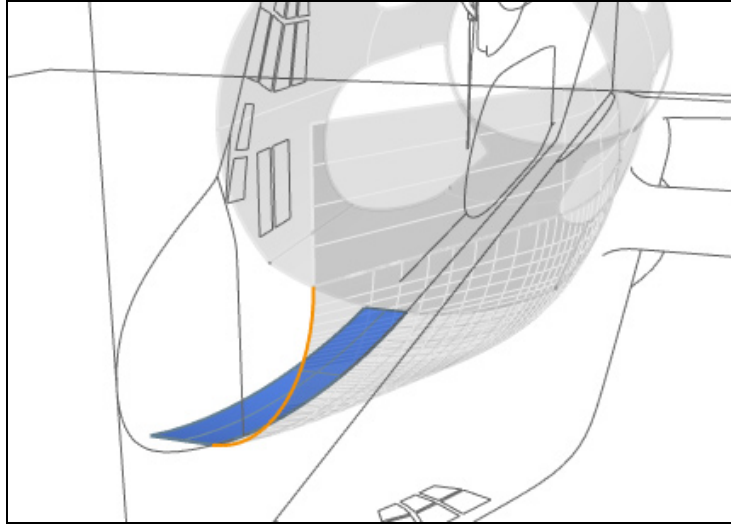


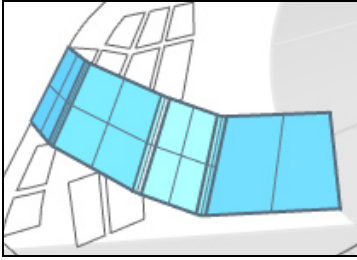
18. MatchSrf to the fuselage, using the *ChainEdges* option to select all the edges. This time set the *Continuity* to **Curvature** and add *Refine match* to the options.



19. MatchSrf one more time, with the upper edge, with **Tangency Continuity**, the other options the same as the previous match.

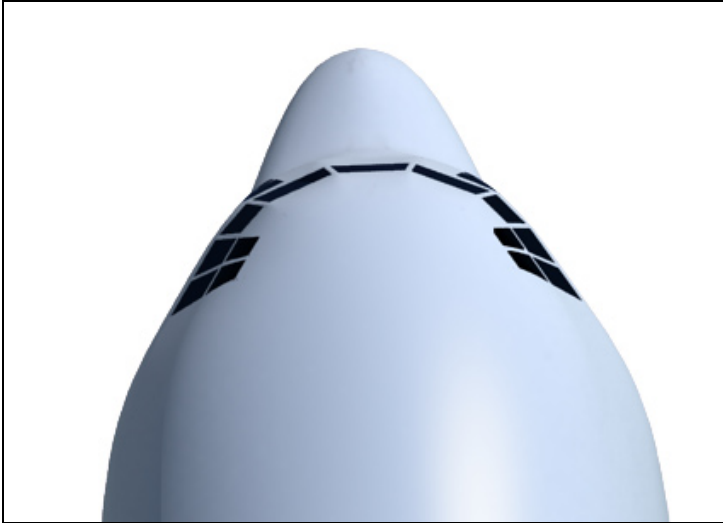
20. Delete the lower profile surface and the conic curve up front.





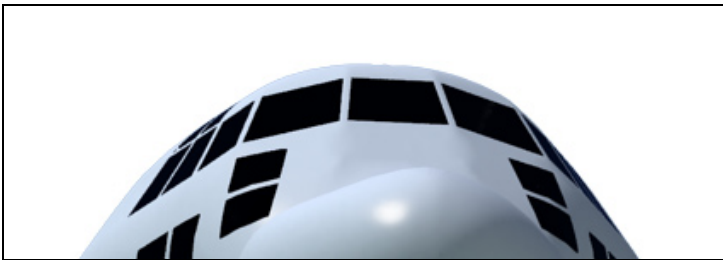
Nose 2

Windscreens

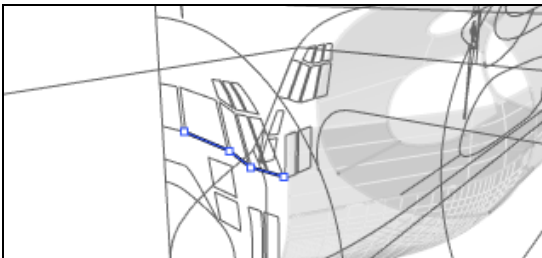


Now we'll make the main windscreens, then work on 'filling in the gaps' between them and the rest of the nose and fuselage.

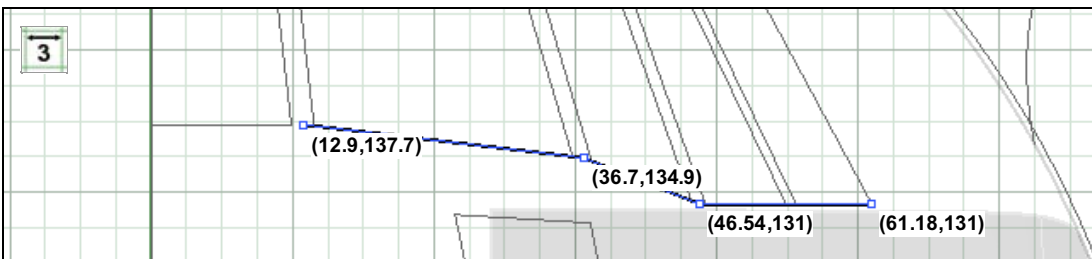
The trick with trying to figure out how to approach this was that these windows are obviously flat and ensuring they actually stay planar as they're edited on these angles requires some care, especially as I was uncertain of any of the measurements here.

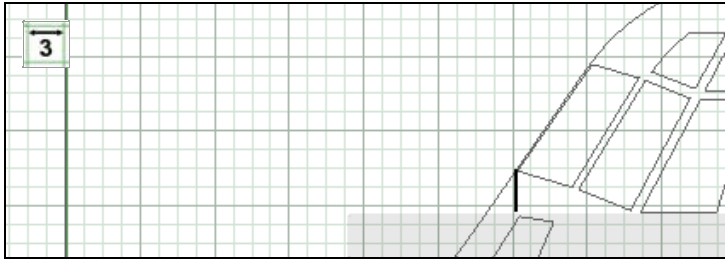


The angling of the windscreens did offer a clue to a way around this problem. Triangular surfaces are inherently flat.

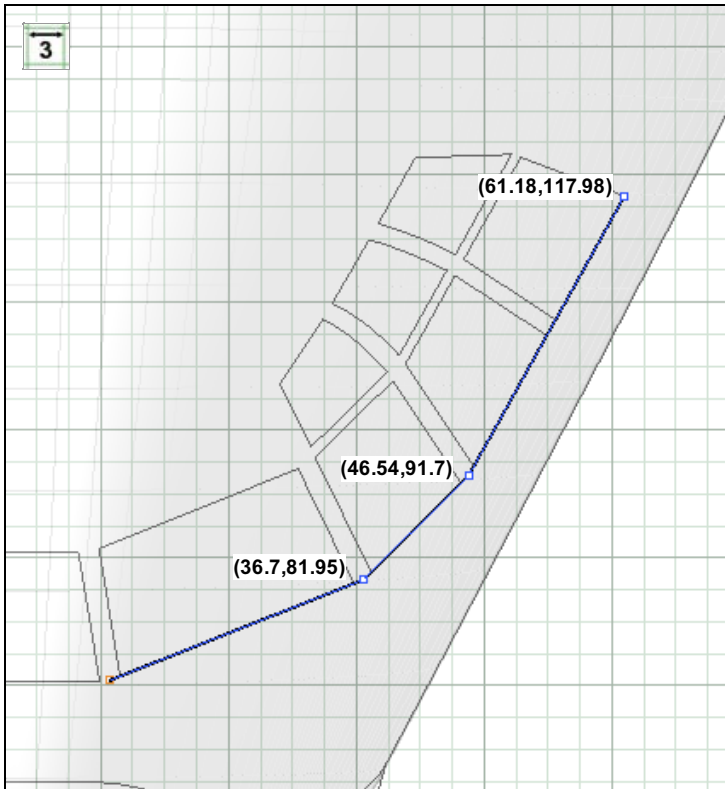


1. Draw a **PolyLine** in the Front view.



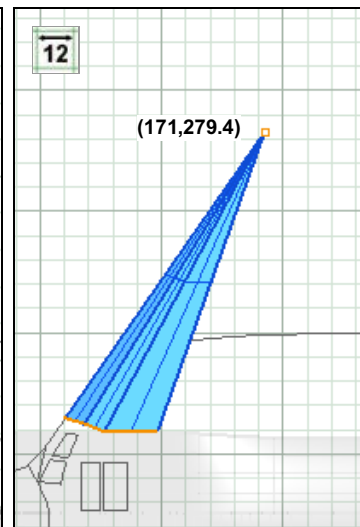
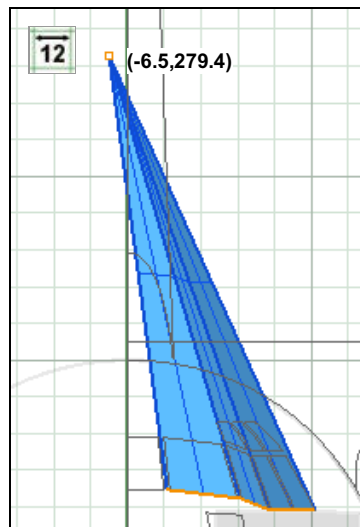
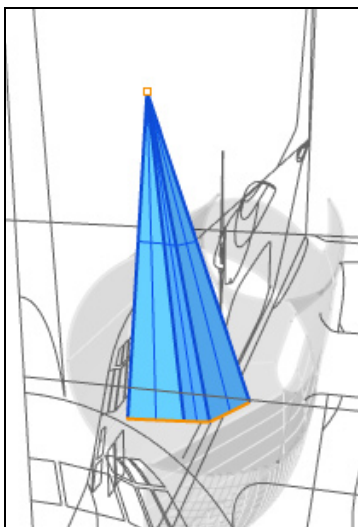


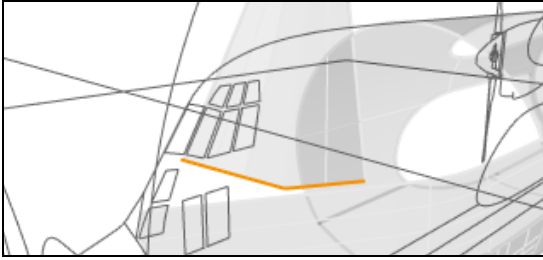
2. Move the polyline back by **72.5** units.



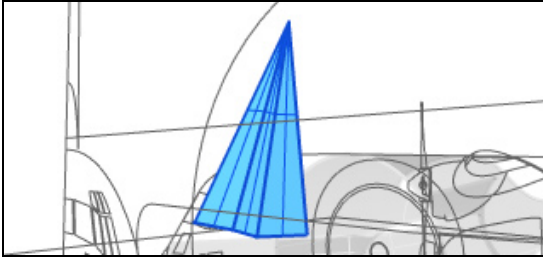
3. Move three points on the polyline back to align with the top view of the windcreens. Move the first point from the left back by **9.45** units, the second by **19.2**, and the outer point by **45.48**.

4. Select the polyline and create a polysurface with **ExtrudeCrvToPoint**. For the Point to extrude to, enter world coordinates using the notation of **w-6.5,171,279.4**.



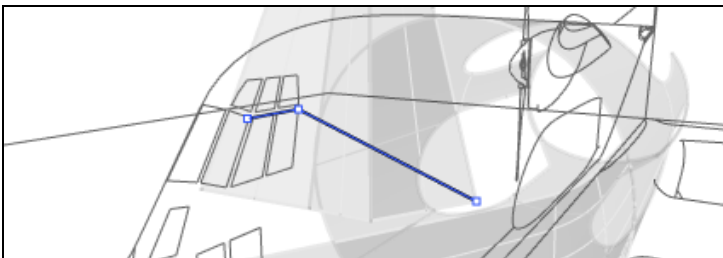
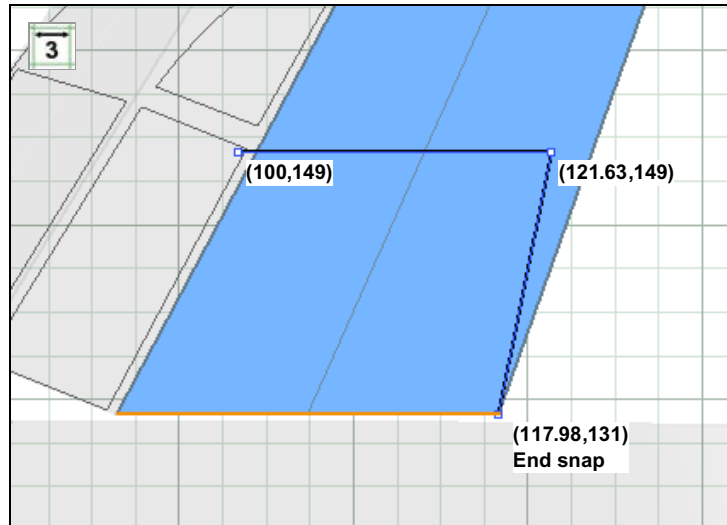


5. **Delete** the polyline.



6. **Explode** the windscreen polysurface.

7. Draw a **PolyLine** in the Right view around the two aft windscreens, which we are going to assume lie in the same plane. Snap to the corner of the windscreen surface with the **End** snap.



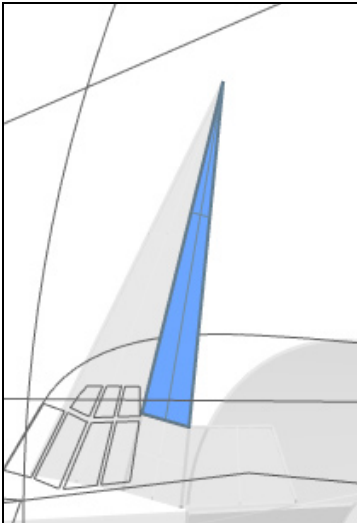
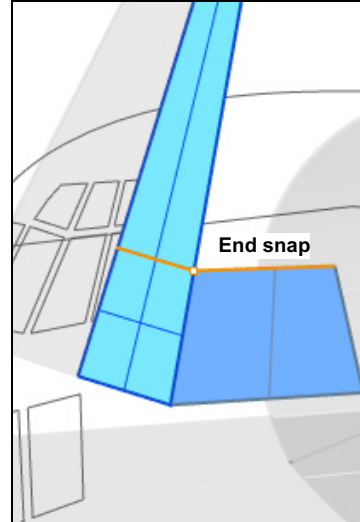
Your polyline will probably look like this, that's not a problem.



8. Trim off the aft windscreen surface in the Right view.

9. Delete the polyline.

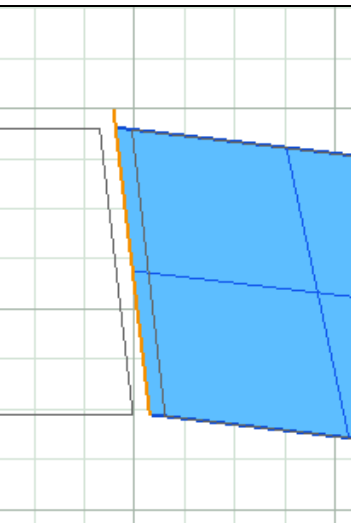
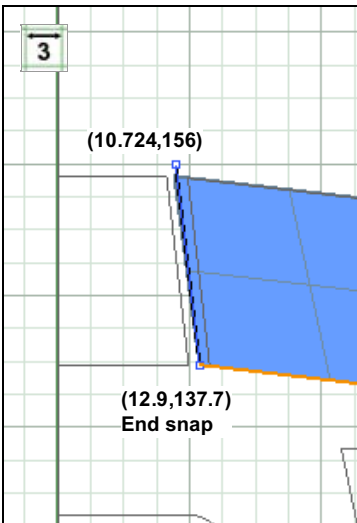
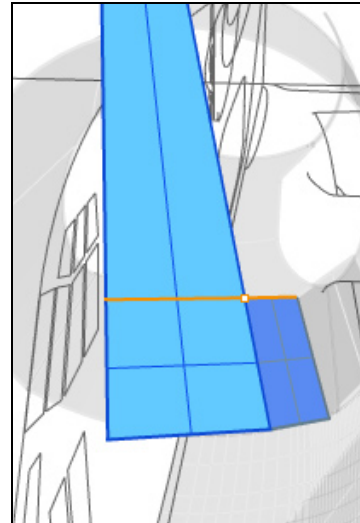
10. Split the adjacent surface using the *Isocurve* option, snapping to the **End** of the edge of the side windcreens. Set *Shrink* to **Yes**.



11. Delete the upper piece of the split surface.

12. Repeat the Split by *Isocurve* procedure with the next windscreen surface.

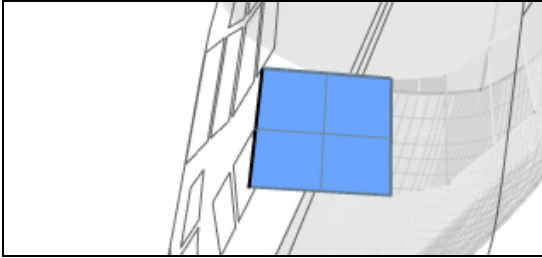
13. Again, Delete the upper piece of the split surface.



14. Draw a Line in the Front view to tweak the edge of the inner windscreen.

15. Trim off the surface with the line.

16. Delete the line.



17. DupEdge the inside edge of the forward windshield.

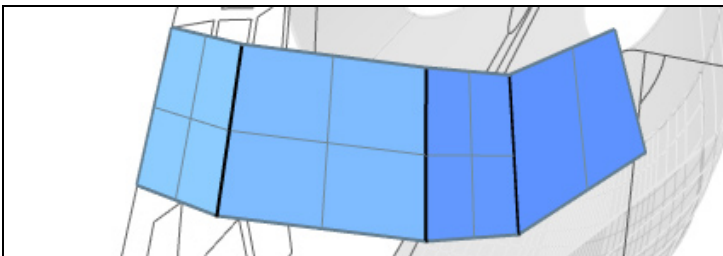
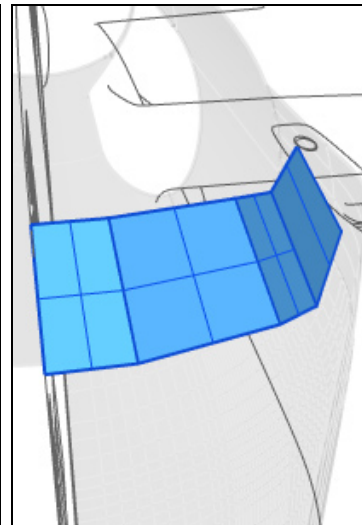
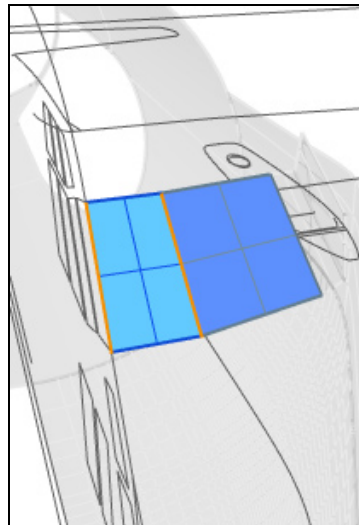


18. In the Right view, use **ProjectToPlane** to project this curve onto the construction plane. At the *Delete input objects?* prompt, say **Yes**.

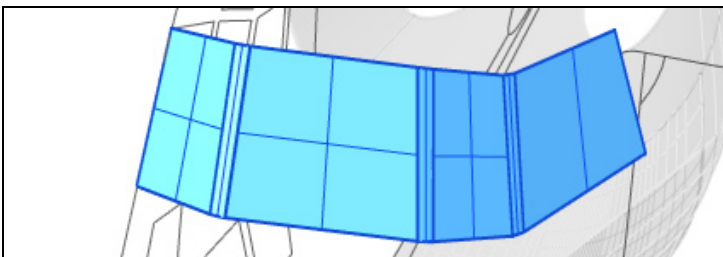
19. Loft from the projected line to the windscreen edge.

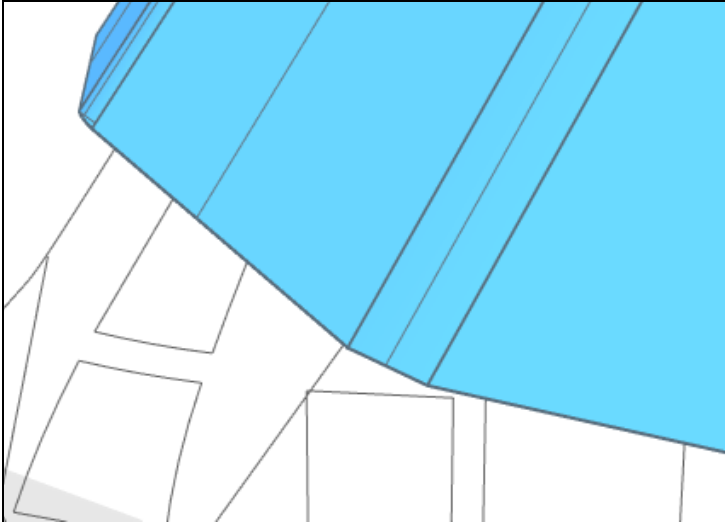
20. Delete the projected line.

21. Join the 4 windscreen surfaces.



22. FilletEdge three edges of the windscreen polysurface. Set the *Radius* to **1** and the *RailType* to **DistFromEdge**, which creates a result similar to if we built a **Pipe** along the edges and trimmed and blended them.

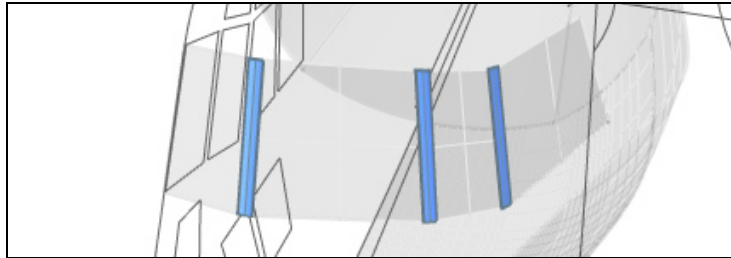




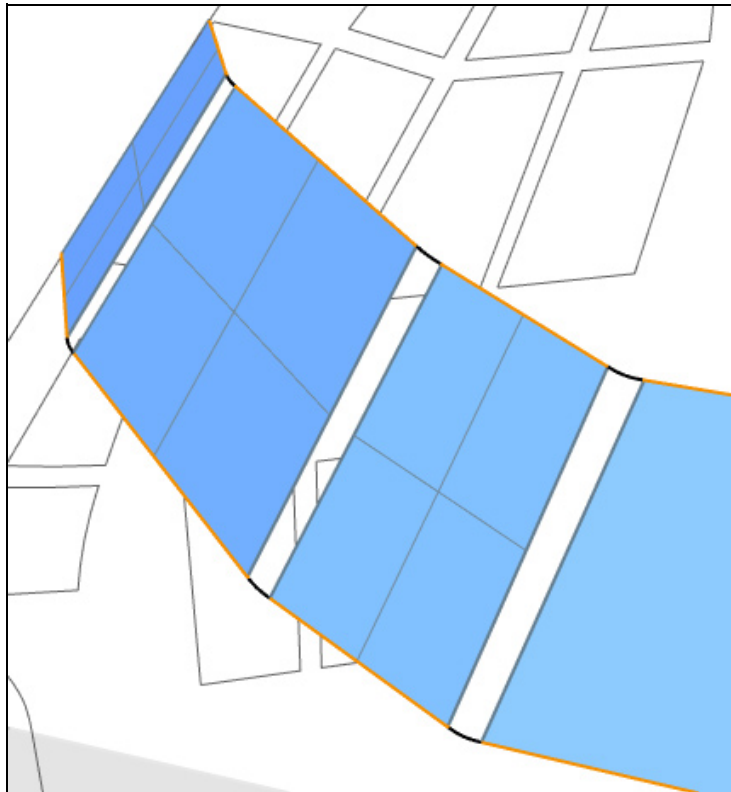
There is an issue here in that we want the top and bottom edges of the windscreen object to form a single 'smooth' curve. We could modify the fillet surfaces, but The most straightforward way to remedy this is to replace them.

23. Explode the windscreen object.

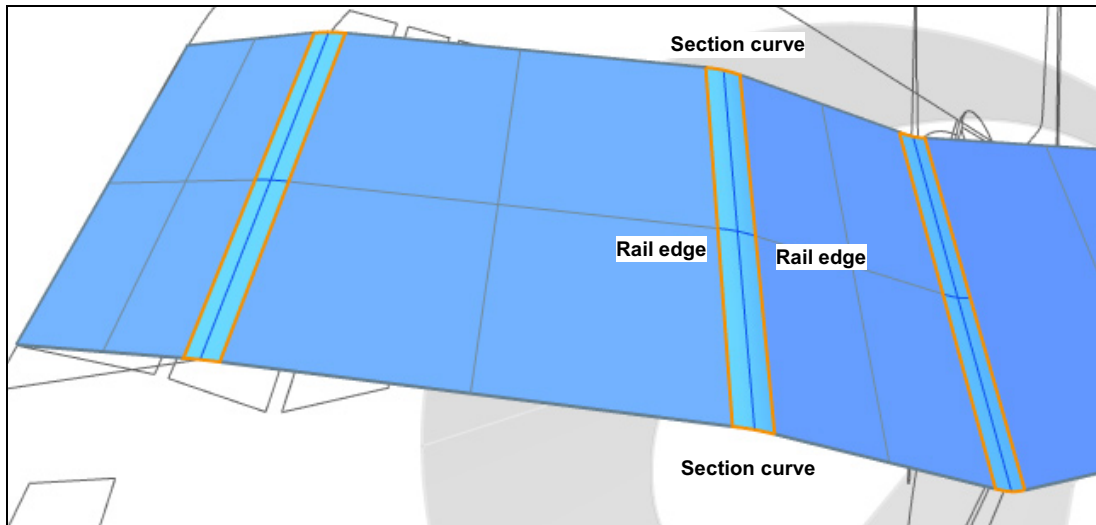
24. Delete the fillet surfaces.



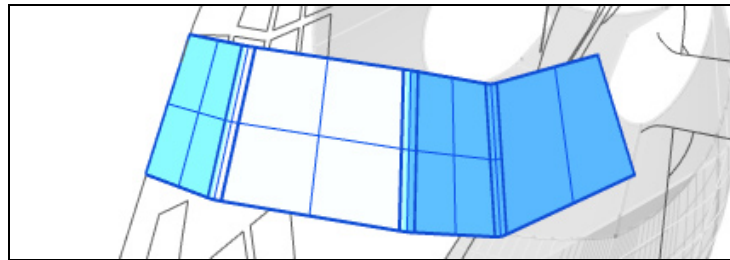
25. Create six **Blend** curves with **Curvature Continuity** bridging the top and bottom edges of the windscreen surfaces. **Blend** is an older command, it doesn't have all the options of **BlendCrv**, but in this case it saves a click each time.



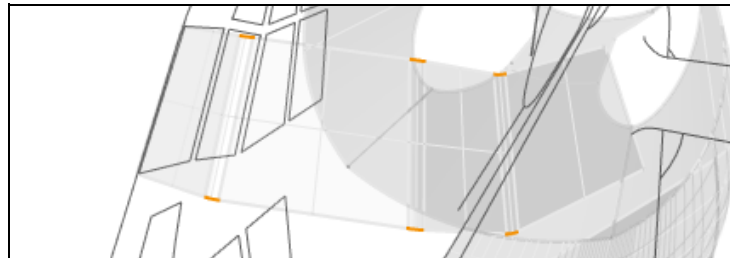
26. Fill in each gap using **Sweep2**. Specify **Do not simplify** for the *Cross-section curve options*, the continuity options will have no effect here.

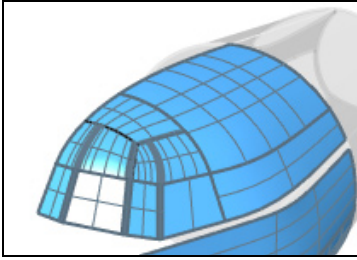


27. Join up the surfaces.



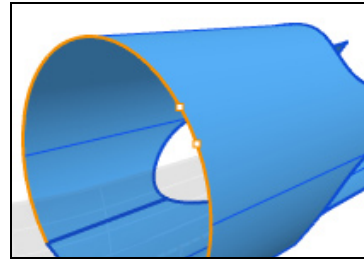
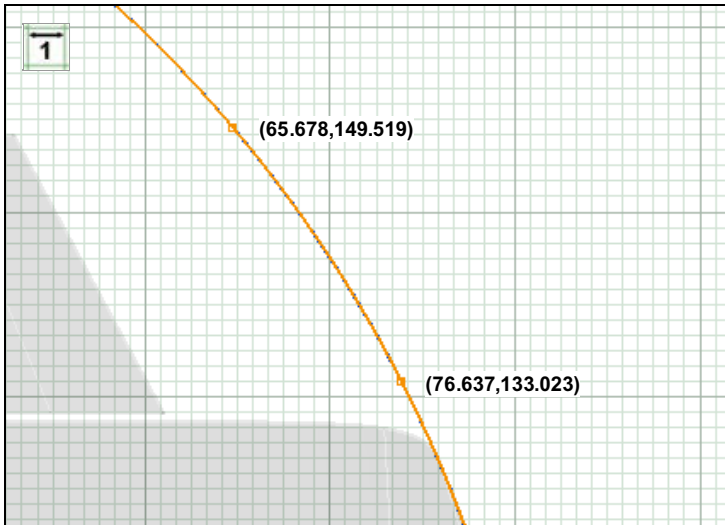
28. Delete the six little blend curves.





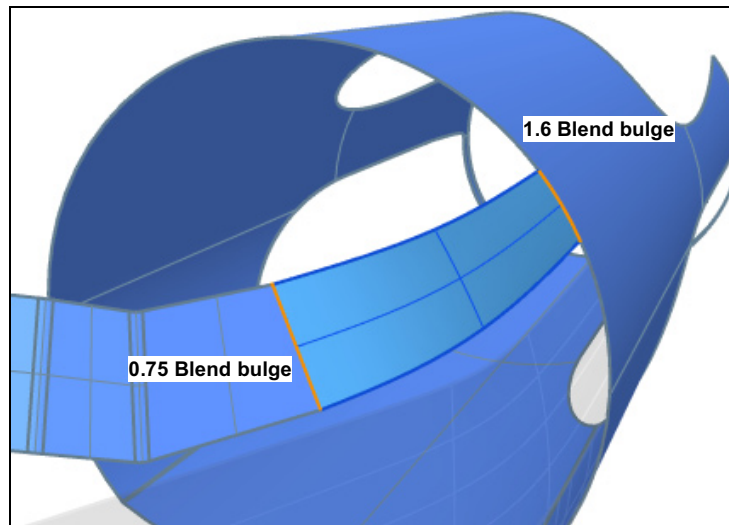
Nose 3

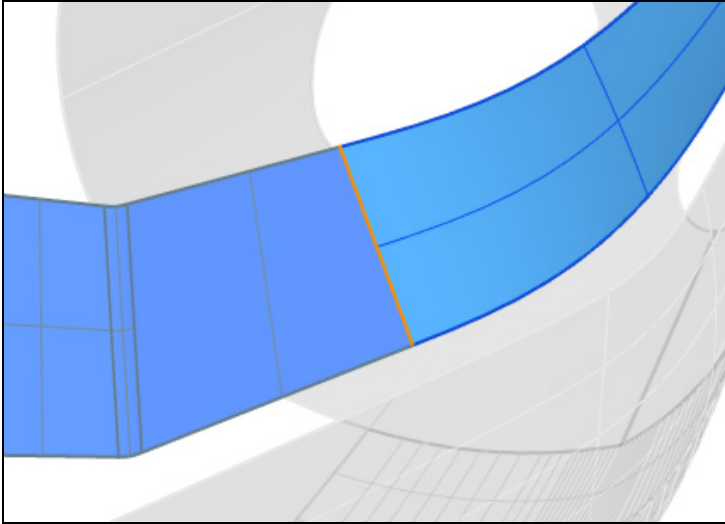
Upper section



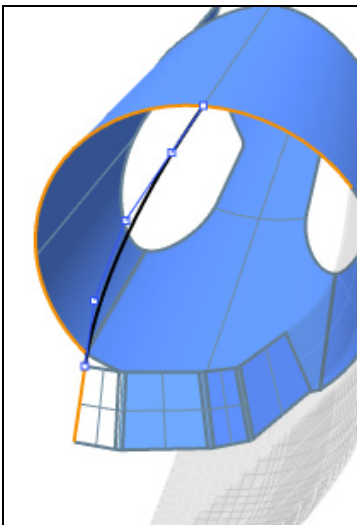
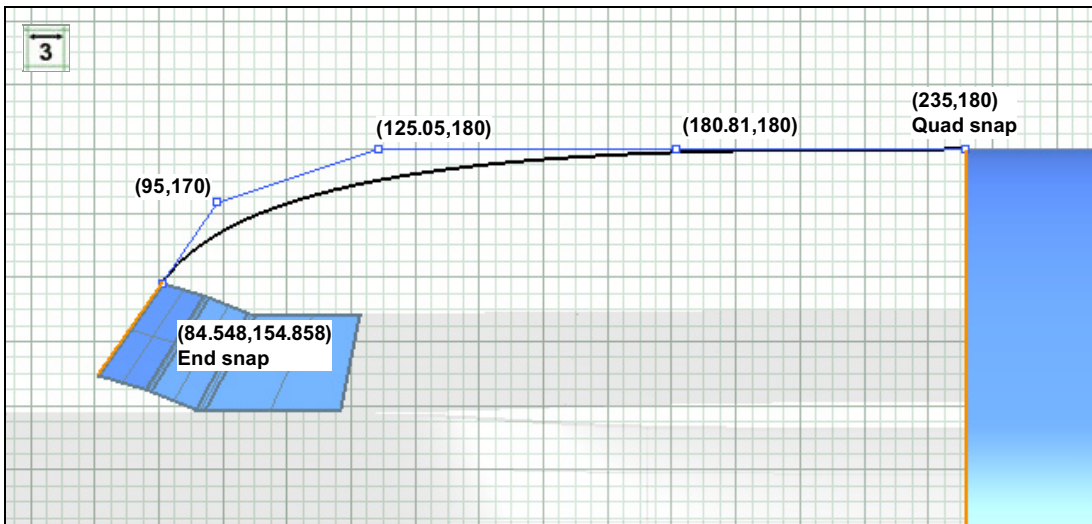
1. Use **SplitEdge** on the forward edge of the main fuselage, splitting it in two places.

2. **BlendSrf** between the windshield and the small edge split out of the fuselage. Use a **Blend bulge** of **1.6** along the fuselage and **0.75** at the windscreen. Take a close look to ensure that the blend doesn't bulge too much at the windscreen, beyond the diameter of the fuselage.



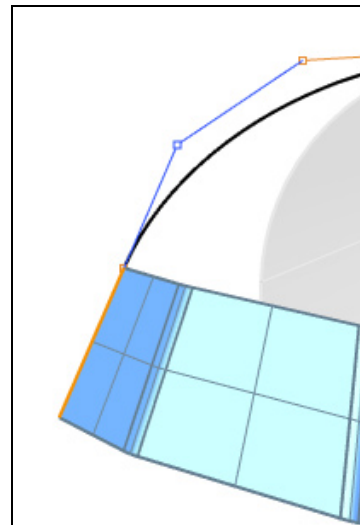


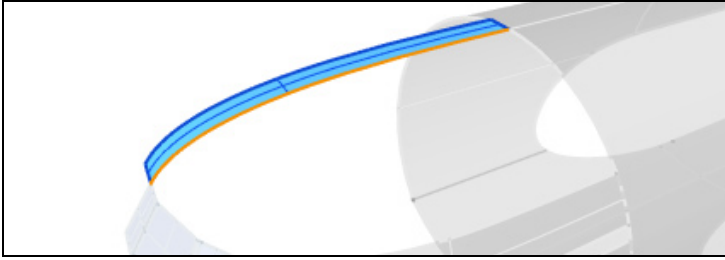
3. Tweak the blend by actually running **MatchSrf** on it. Specify **Tangency Continuity**, enable *Match edges by closest points*, and—this what this step is about—set the *Isocurve direction adjustment* to **Match target isocurve direction**. This has aligned the top and bottom edges of the blend with the edges of the windscreen.



4. Draw a **Curve of Degree 5** (the result will actually be **4**) in the **Right** view, snapping to the **End** of the edge of the windscreen and using the **Quad** osnap to snap to the centerline of the fuse.

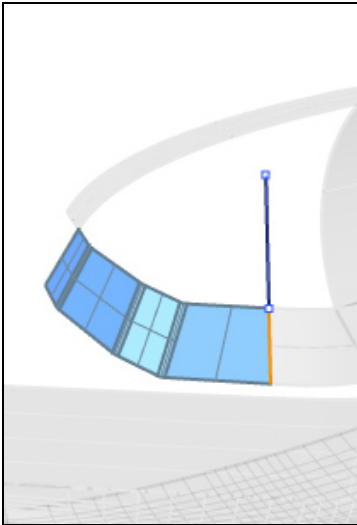
5. **Match** the curve to the edge of the windscreen. Specify **Tangency Continuity**, set *Preserve other end* to **None**, and turn off the other options.



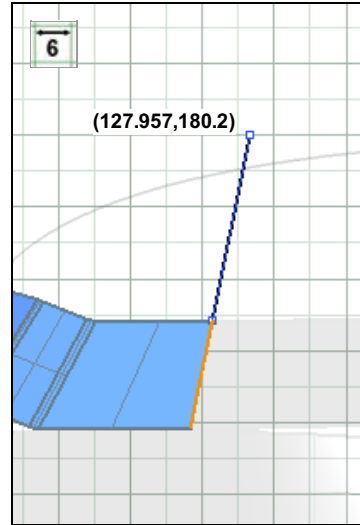


6. *ExtrudeCrv* the profile curve a few units.

7. *Delete* the curve.

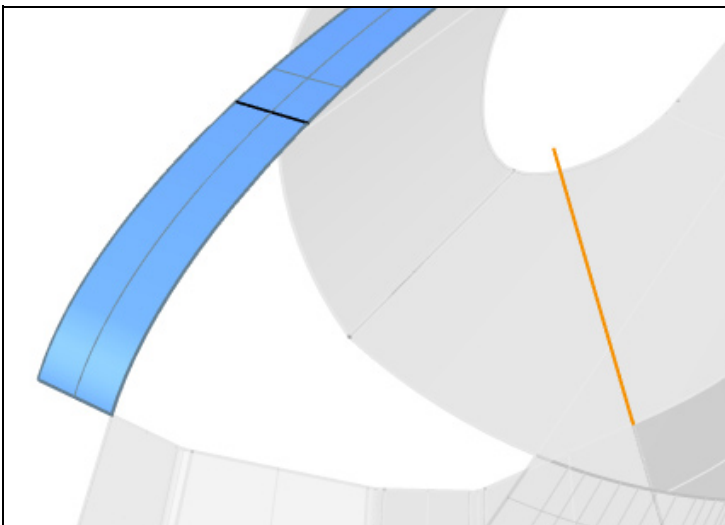


8. Draw a *Line* using the *Extension* option. At the *Select curve* prompt, pick the aft edge of the windscreen object. Then, place the end point of the line above the upper profile surface from the Right view.

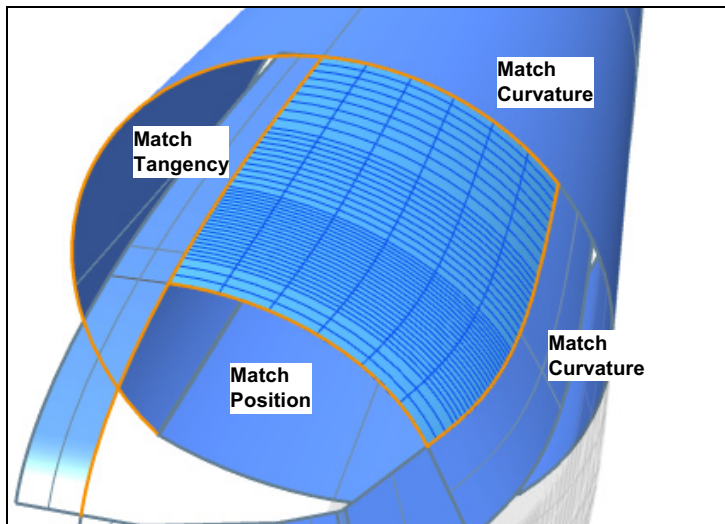
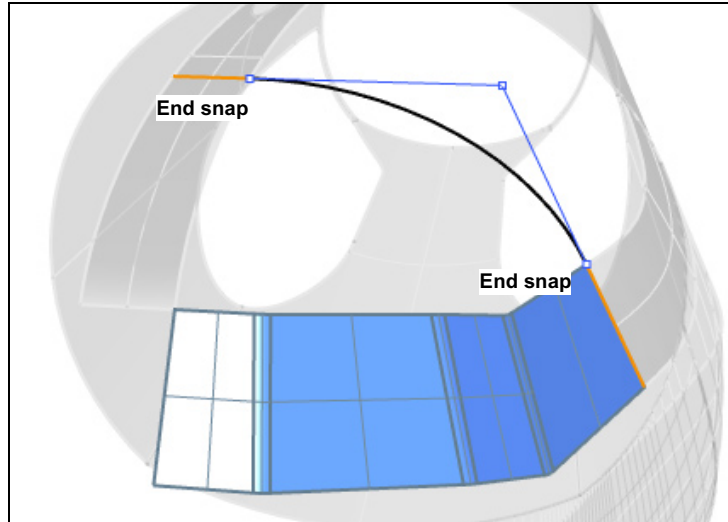


9. From the Right view, *Project* the line onto the profile surface.

10. *Delete* the line.

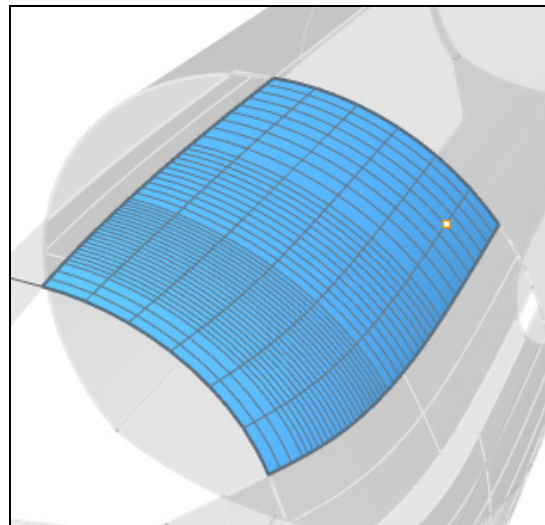


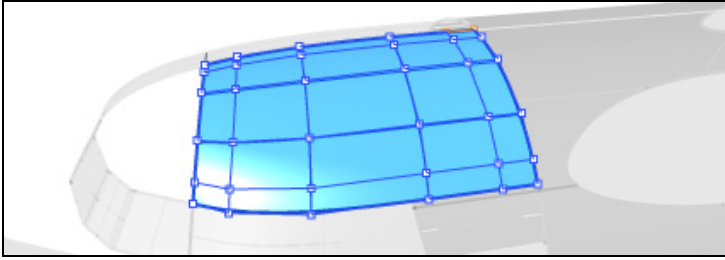
11. Make a **Conic** curve between the aft edge of the windscreen and the projected line we just made. Specify the **Tangency** option for each end and use the **End snap** to place each end of the curve, then enter a rho value of **0.45**.



12. Now build a surface between these curves and edges using **NetworkSrf**. Specify a tolerance of **0.001** for **Edge curves**, and set the continuity as shown.

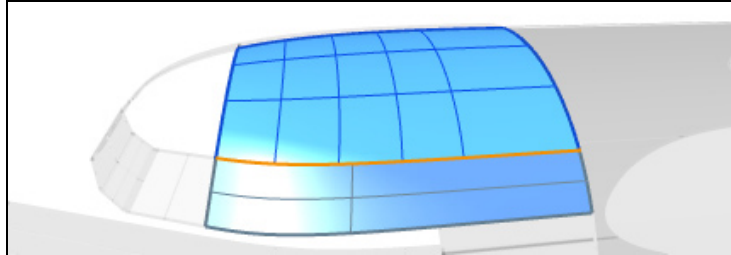
The quality of this surface is pretty good, except for one problem. If you were to zoom in extremely close in a Front view, you would see that in the general vicinity of the point at right, it bulges out beyond the main fuselage. It's incredibly slight, about 0.020 units, but for this exercise we'll fix it with the same procedure we used on the lower half of the nose.



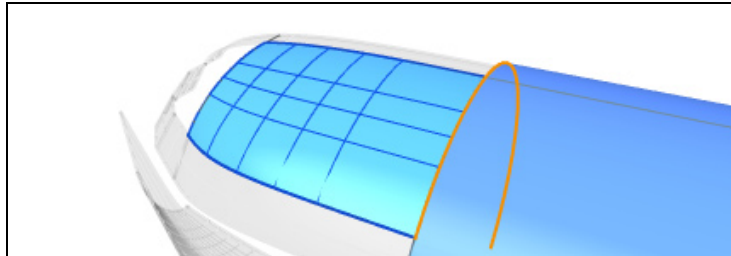


13. *Rebuild* the surface with **6** points and a *Degree* of **3** in each direction.

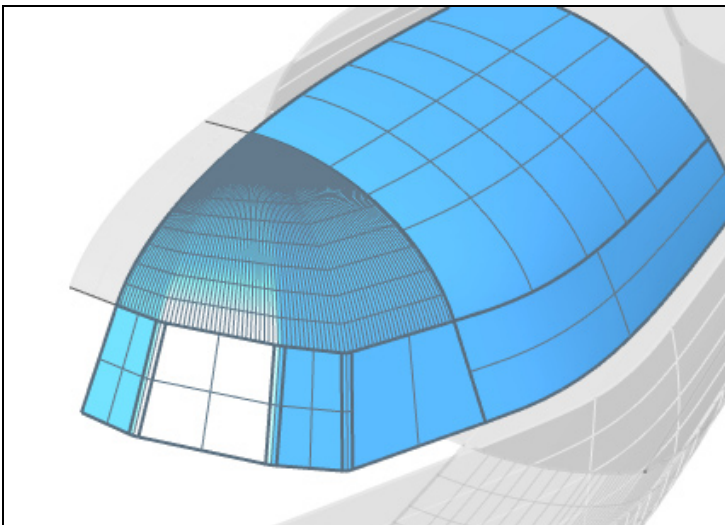
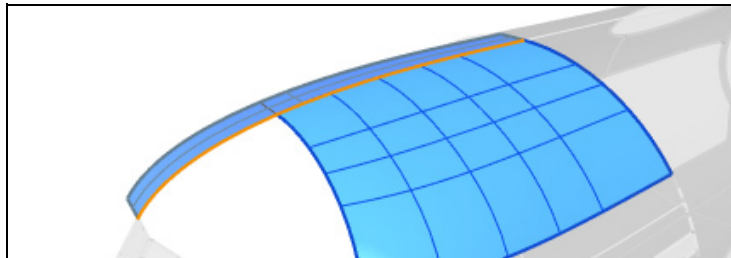
14. *MatchSrf* the bottom edge. Specify **Tangency Continuity**, turn on *Refine match* and *Match edges by closest points*, and set the *Isocurve direction adjustment* to **Automatic**.



15. *MatchSrf* again, to the fuselage, this time with **Curvature Continuity** and the rest of the settings the same.

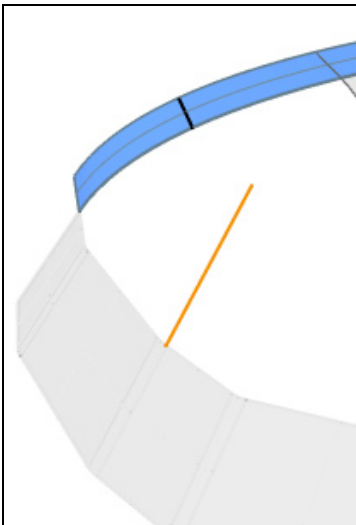
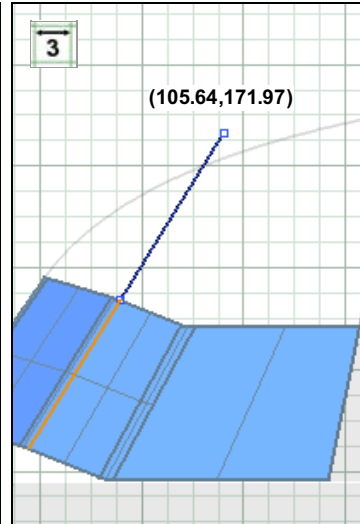
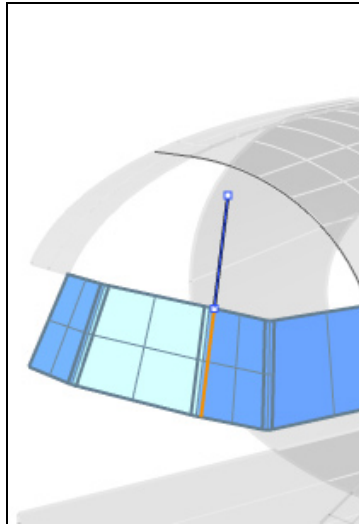


16. *MatchSrf* one more time, with **Tangency Continuity**.



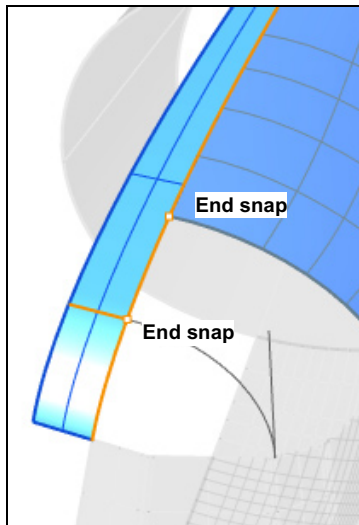
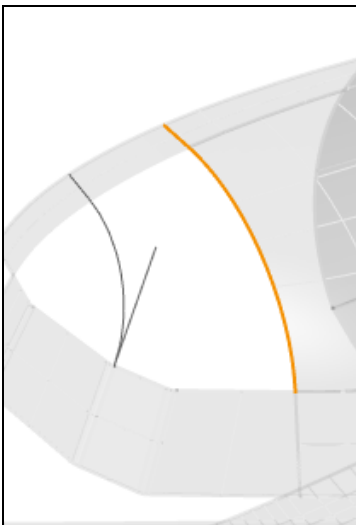
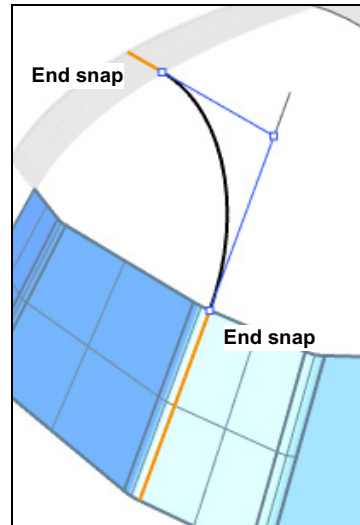
We want to create a very smooth transition to the flat windscreens, mindful of the structure around them. This might seem like logical place to fill in with something like a triangular **NetworkSrf**, like this quick example here, but it would be extremely difficult to make the singularity at the peak totally unnoticeable.

17. Like we did earlier, a **Line** using the *Extension* option, extending the line up from and edge of the windscreen object, to a point above the upper profile surface.



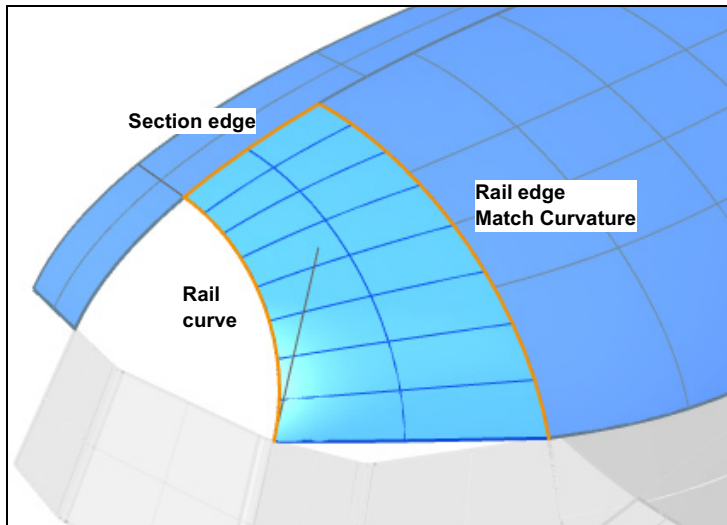
18. Project the line onto the side profile surface from the Right view. Do not delete the extension line just yet.

19. Again as before, create a **Conic** curve using the *Tangent* option at each end, with a rho value of **0.45**.

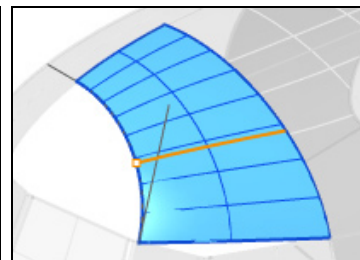
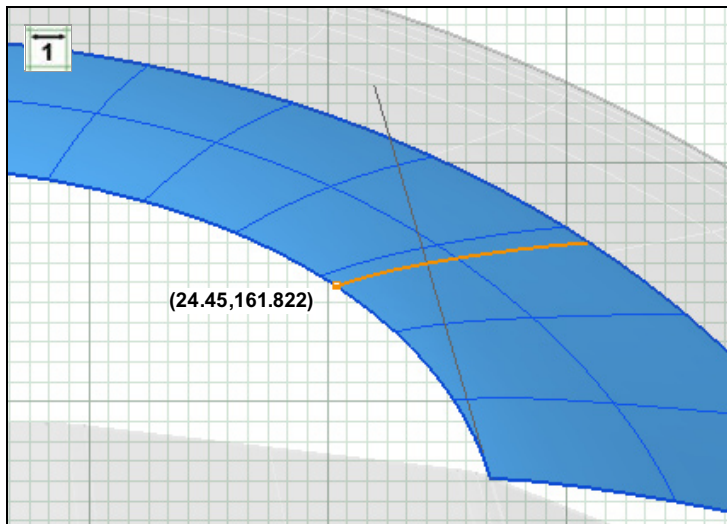


20. Next a little cleanup, **Delete** the first conic and projected line we made off the edge of the windscreen.

21. Use **SplitEdge** on the side profile surface, splitting in two places, snapping to the **End** of the upper surface and the projected line.

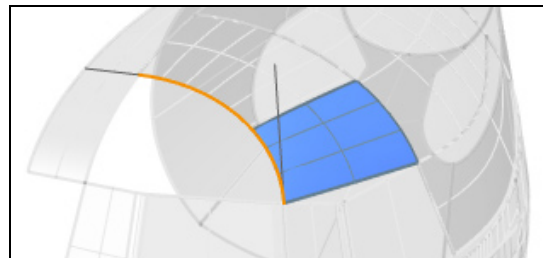


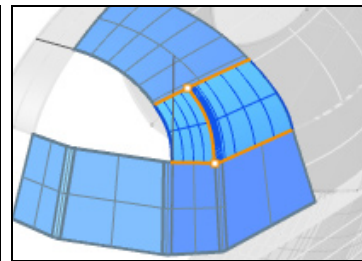
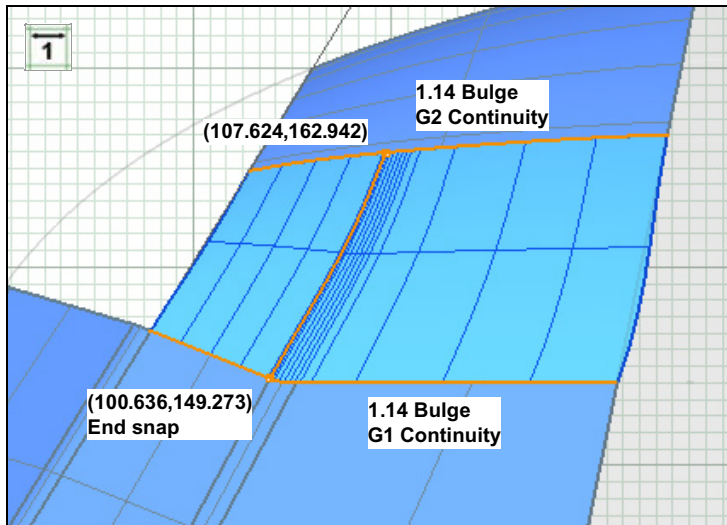
22. Build a **Sweep2** surface, using the edge of the profile surface as the section.



23. Use **Split** by **Isocurve** to slice the swept little more than 1/3rd of the way up.

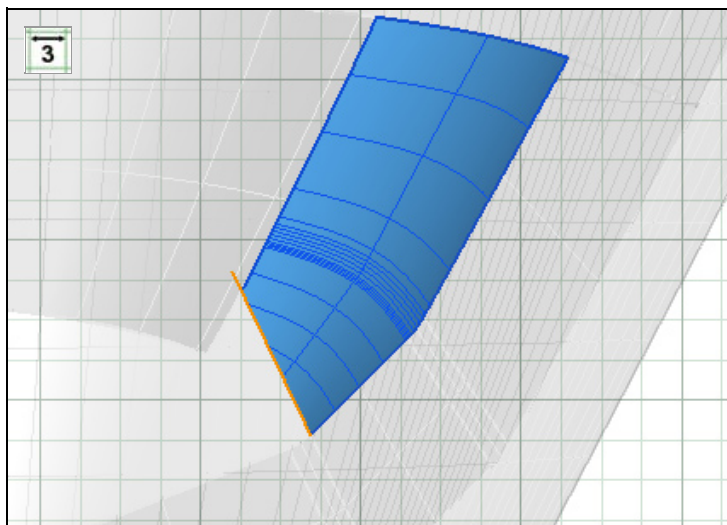
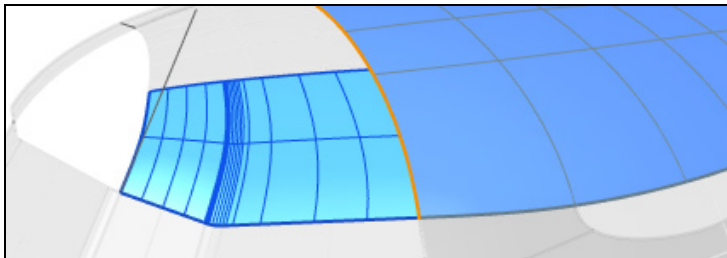
24. **Delete** the smaller piece of the split sweep and the conic curve used to make the sweep.





25. BlendSrf from the edge of the sweep to the windscreen. Add one guide section, set the *Blend bulge* to **1.14** for both sides, and set the continuity as shown.

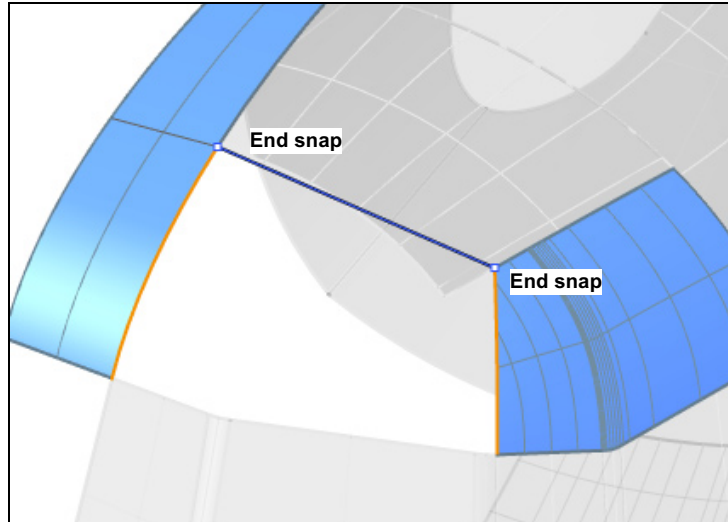
26. Align the blend surface to the upper surface with **MatchSrf**. Specify **Tangency Continuity**, turn on *Refine match* and *Match edges by closest points*, and set the *Isocurve direction adjustment* to **Preserve isocurve direction**.



27. Trim the blend in the Top view using the line extended from the windscreen edge.

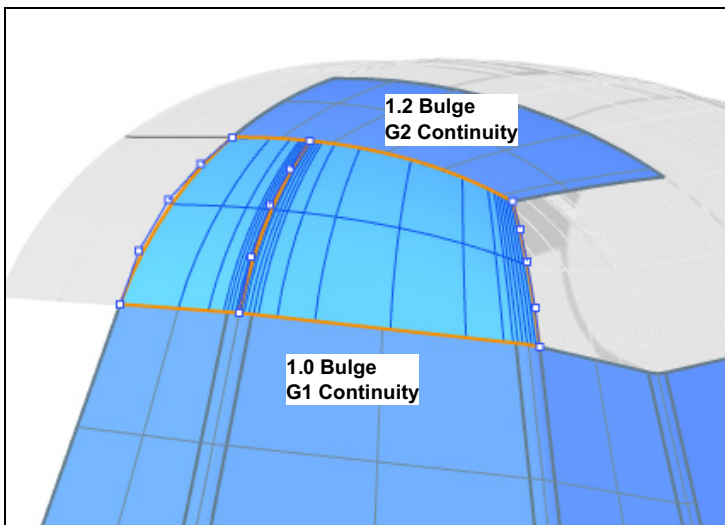
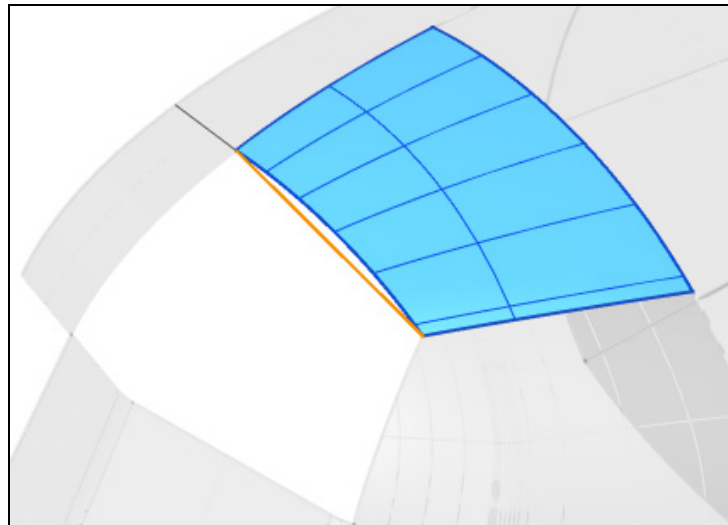
28. Delete the line.

29. Now draw a **Line**, between the **End** of the edge trimmed off the blend surface and the **End** of...well one of the edges or curves that converge at the end of the swept surface.

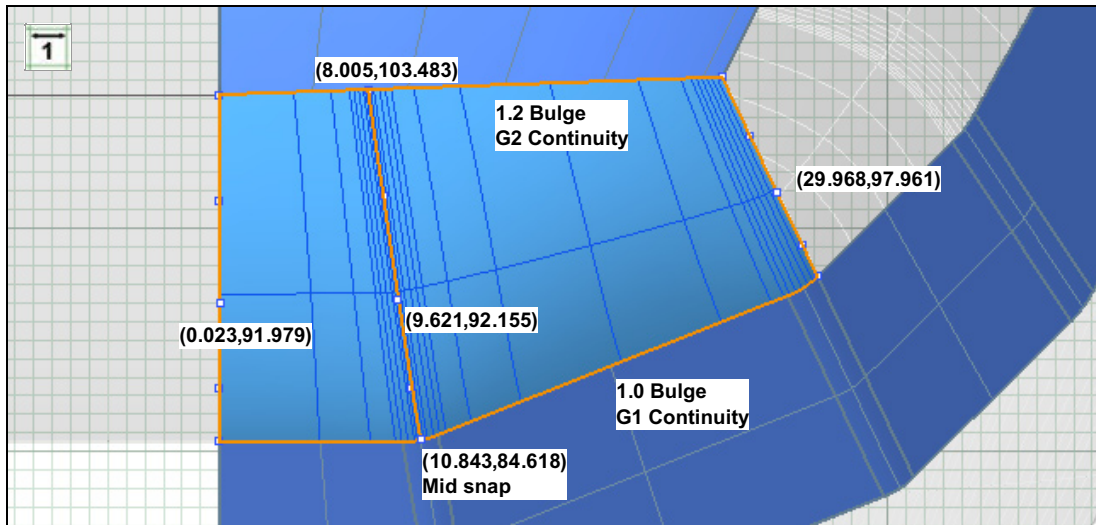


30. From the Top view, **Trim** off the sweep using the line.

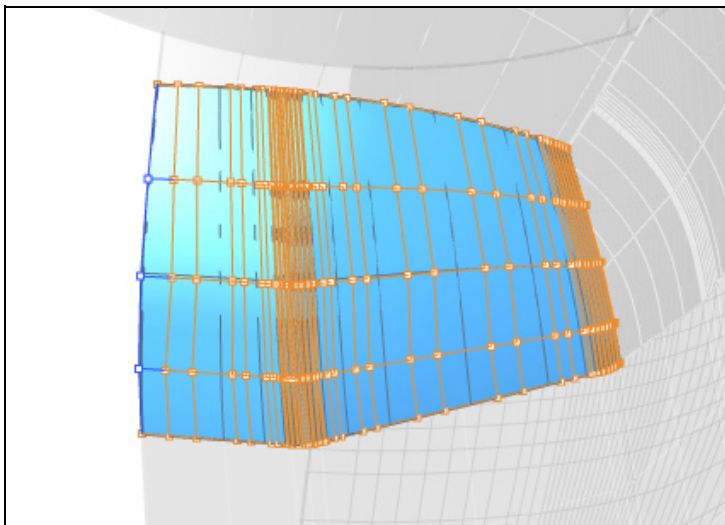
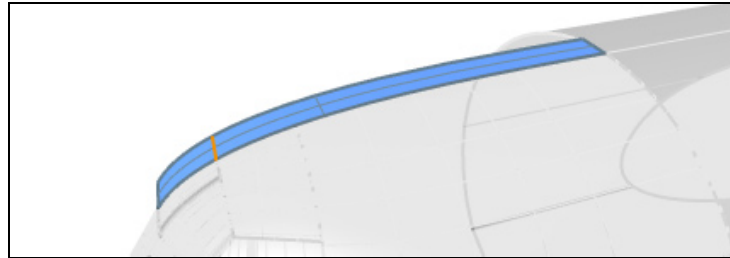
31. **Delete** the line.



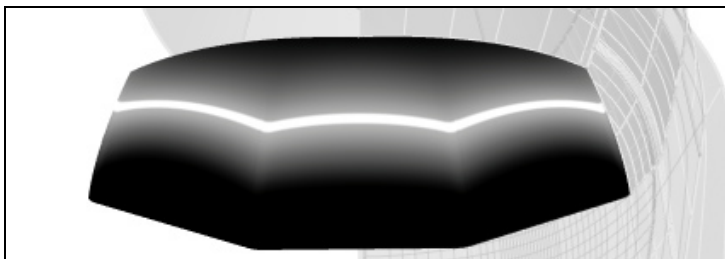
32. **BlendSrf** between the sweep and the edges of the windcreens. Add one guide section, snapping to the **Mid** point of the fillet between the first and second windcreens. Set the continuity and bulginess as shown. Hold the ALT key then pick the third points on the ends and section to adjust their angle to make them straight, as well as you can by eye, we'll fix them precisely next.



33. Delete the side profile surface and the small line on it.



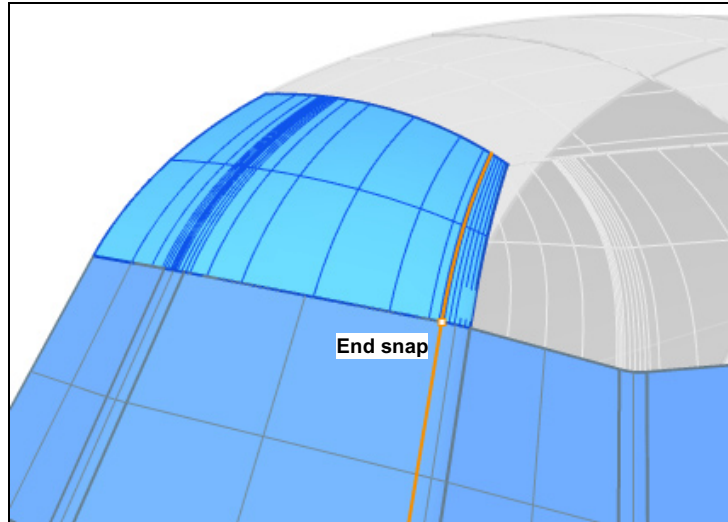
34. Use *SetPt* with *SetX* and *Align to World* to align the points on the inner edge of the blend with the centerline, at the *Location for points* prompt simply enter **0**. We're not actually using the **Symmetry** command or matching because it should be within tolerance as-is.



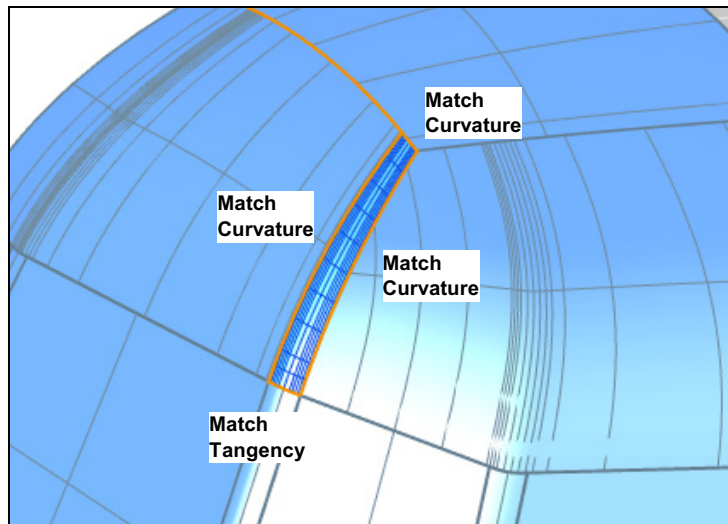
If we **Mirror** it and look at it using **Emap**—the "fluorescent tube" map could be considered the most likely to highlight tiny flaws—it indeed would seem to be reasonably tangent.

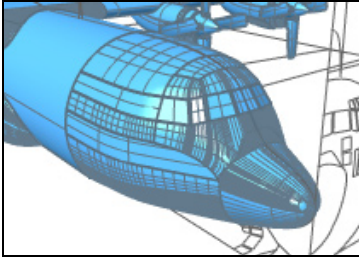
35. At the other end of the blend, run **Split** on the surface with the **Isocurve** option, splitting it at the edge of the windscreen corner fillet.

36. **Delete** the small piece of the split blend.



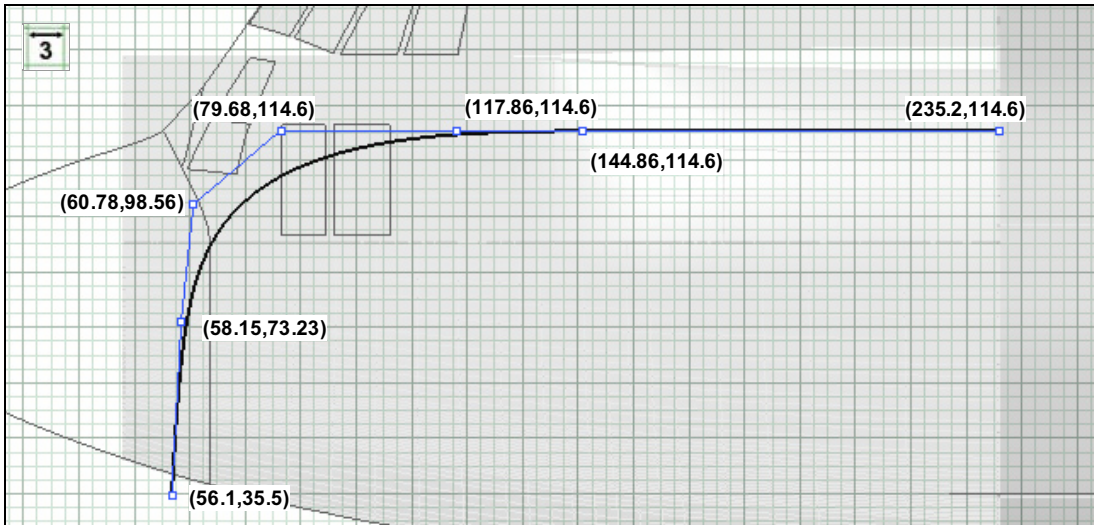
37. Fill in the hole with a **NetworkSrf**. Set the edge tolerance to **0.001**.



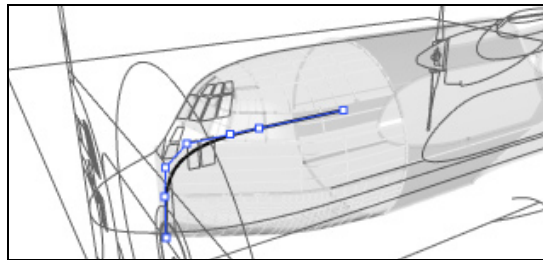


Nose 4

Nose and radome

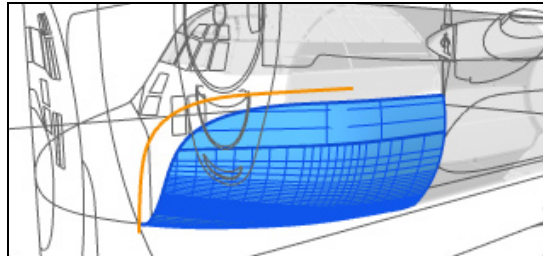


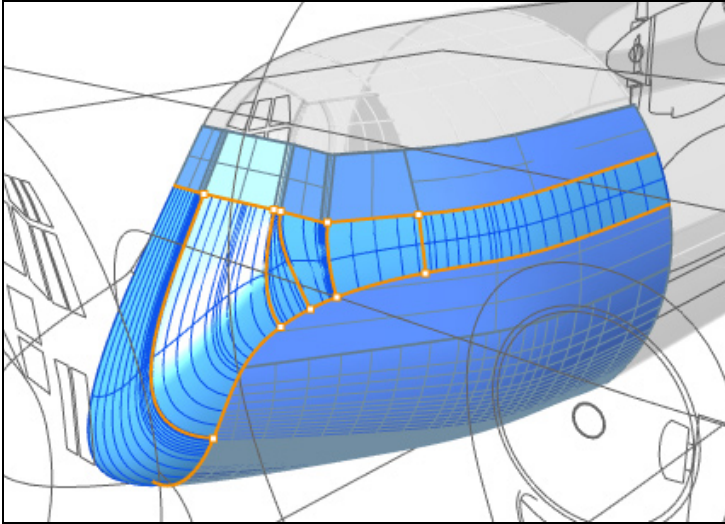
1. Draw a **Degree 5 Curve** in the Right view.



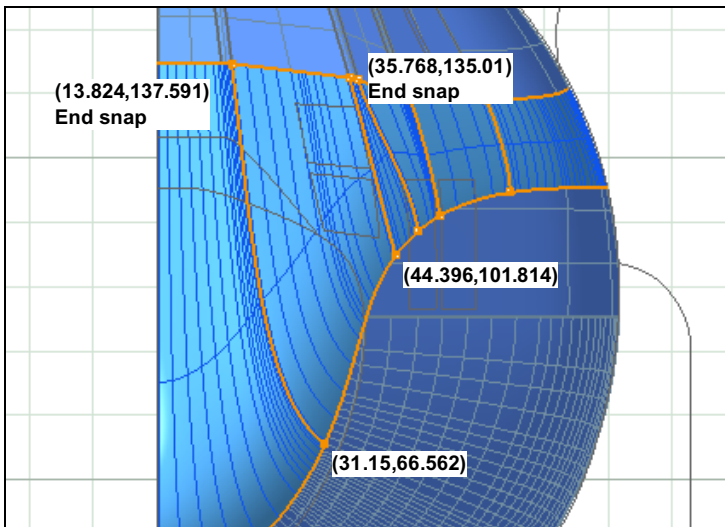
2. **Trim** off the side and lower surfaces with the curve.

3. **Delete** the curve.

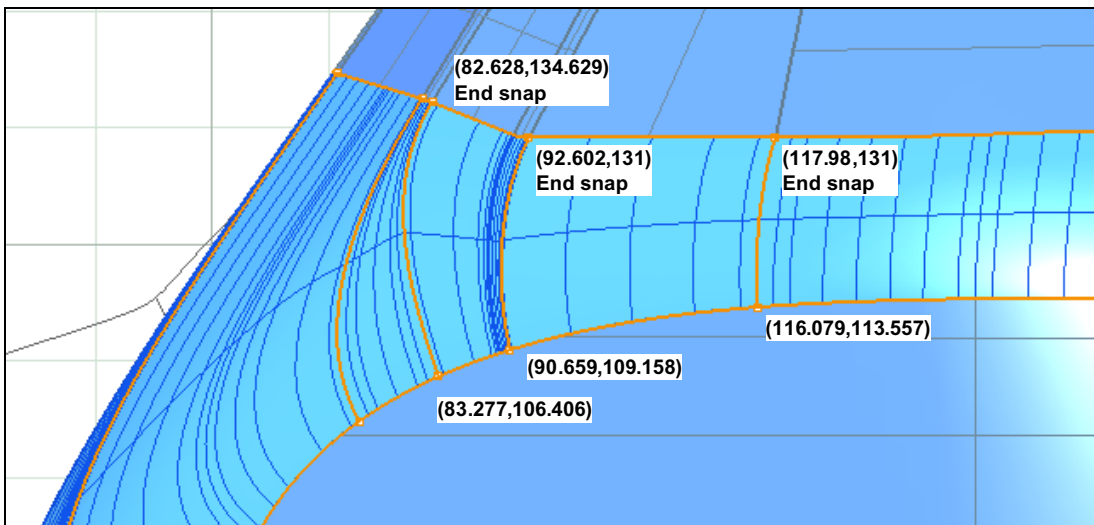




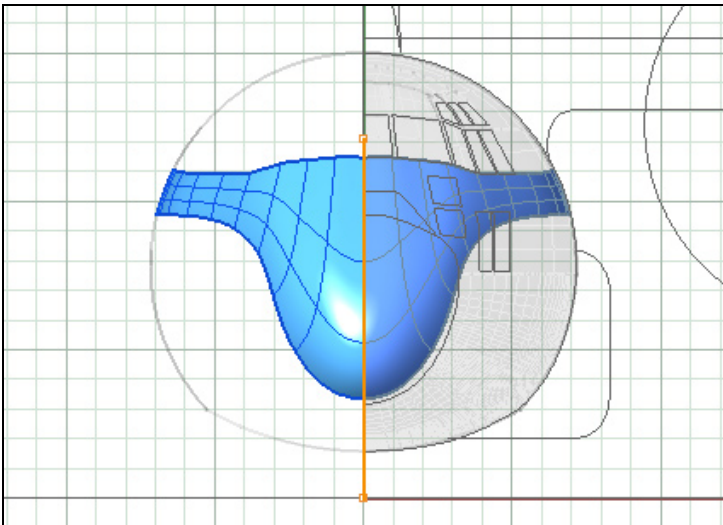
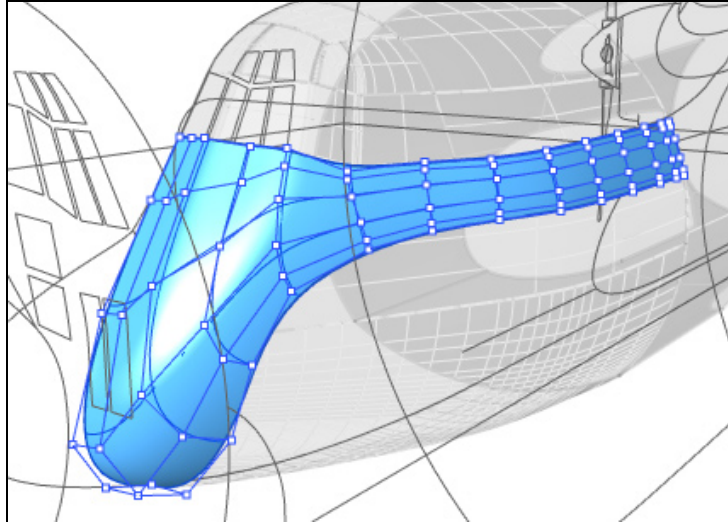
4. BlendSrf between the upper and lower nose surfaces. Use the AutoChain option to speed up picking all the edges and specify **G1** continuity on both edges and use the default **1.0 Blend bulge**. Place 5 guide sections to control it.



Now after all that placing of sections, the result definitely needs to be smoothed out. We'll use the same procedure we've used elsewhere. It can seem tedious, but compared trying to point-edit this or come up with a magic set of curves that will make a nice sweep or network, it's pretty easy.

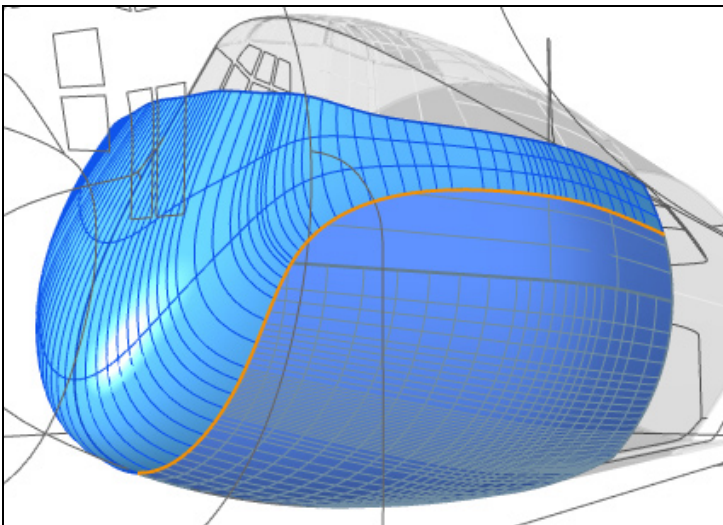


5. Rebuild the blend surface. Set the *Degree* to **3** in both directions and the point count to **6** along the height and **14** along the length.

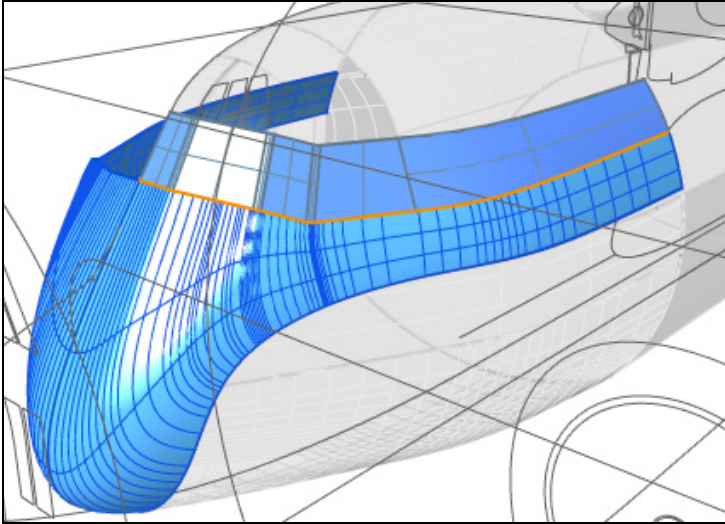


6. Temporarily turn on construction history by clicking the Record History button on the status bar.

7. Make a mirrored copy of the simplified blend surface about the centerline using the **Symmetry** command. This will help keep this edge in line as we fix the other edges.



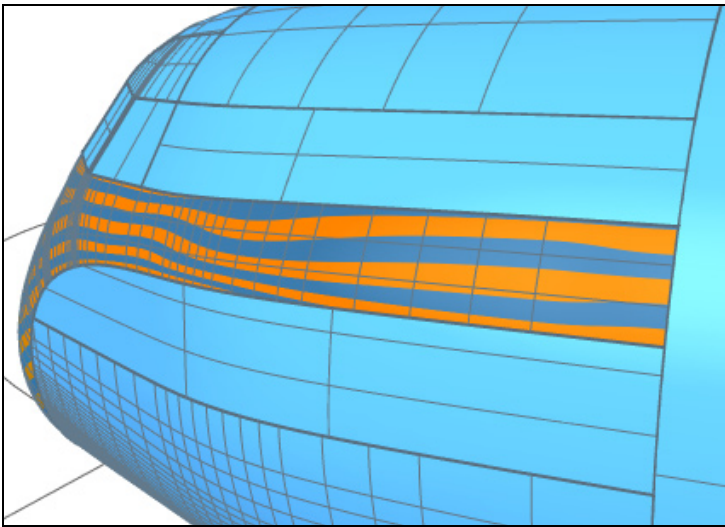
8. MatchSrf to the lower nose surfaces. Use the *ChainEdges* option to select the two edges, specify **Tangency Continuity**, *Refine match*, *Match edges by closest points*, and **Automatic** for the *Isocurve direction adjustment*. Note that the Symmetry copy has been updated.



9. Repeat the **MatchSrf**, with the same settings, on the upper edge.

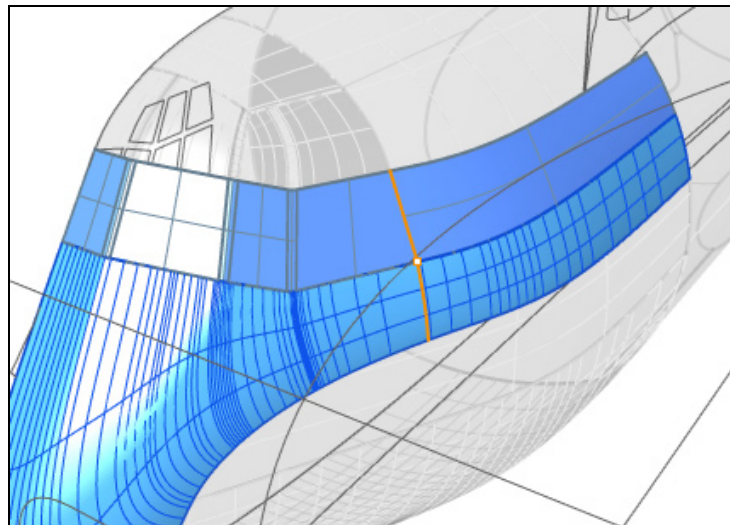
10. Delete the Symmetry copy of the modified blend.

What we've basically made here is the so-called "Roman nose" of the very first C-130s, onto which the radome was added. When imagining how to model an object like this, looking at how it was actually made is not a bad place to start.

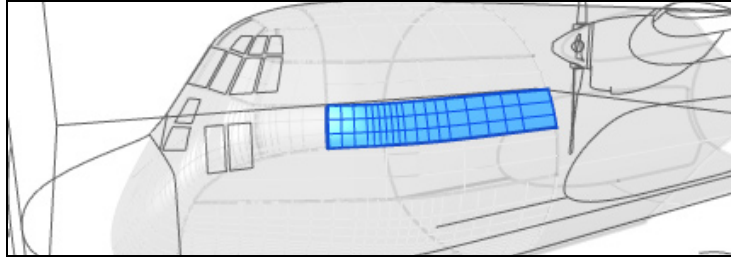


11. The surface quality here mostly looks adequate, but aft of the windcreens there's some unexpected(unlike on the rest of the surface) 'waviness' in the **Zebra** display. We'll remove that area and replace it with a hopefully 'crisper' surface.

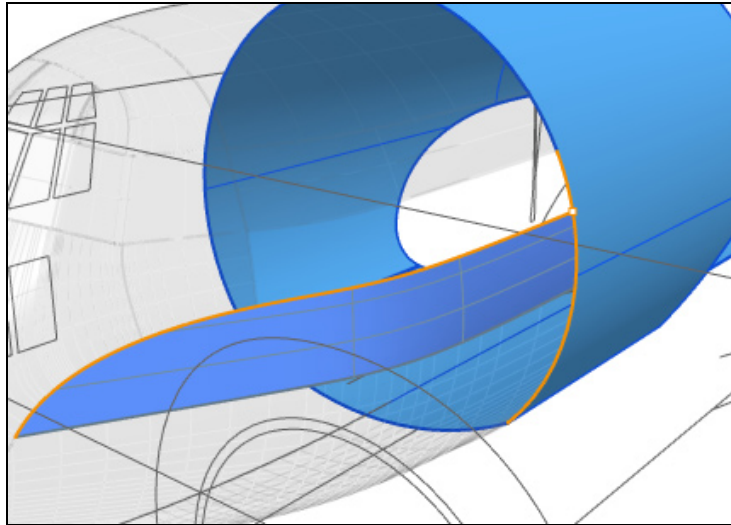
12. Split the blend with the **Isocurve** option. Snap to the **End** of the aft windscreen surface.



13. Delete the aft piece of the blend.

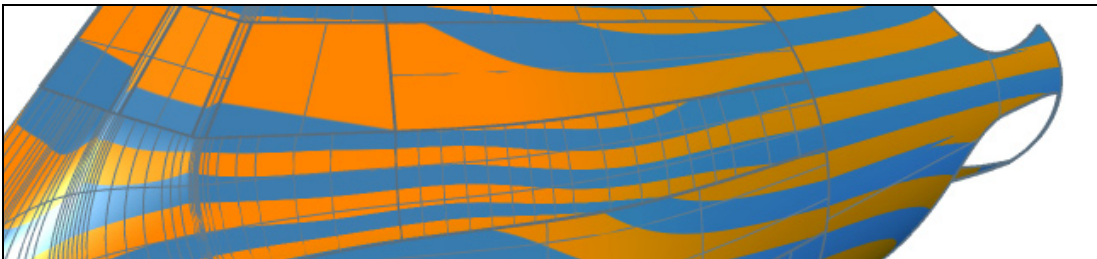
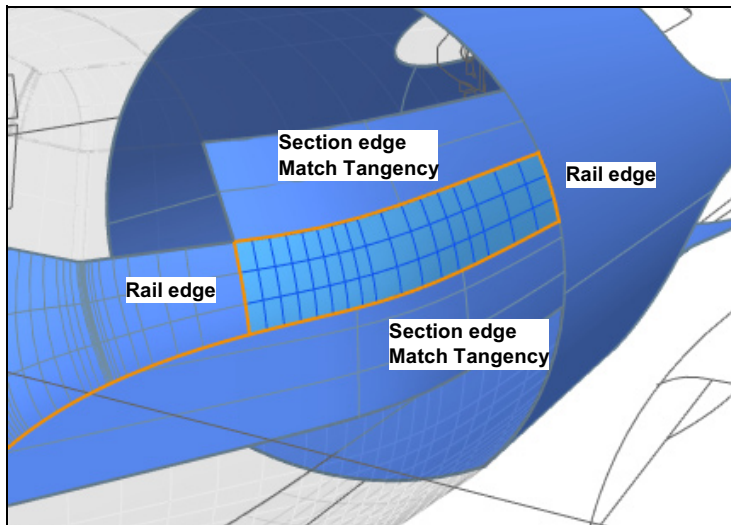


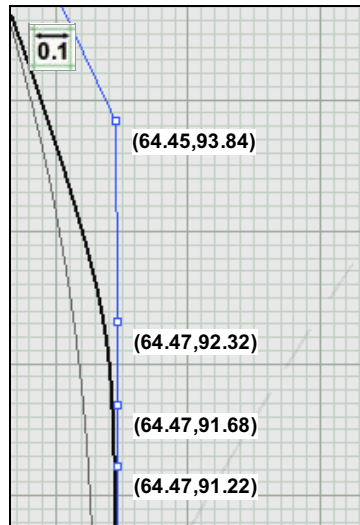
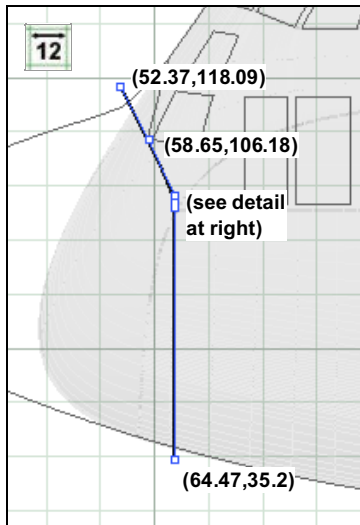
14. To give us a curve to sweep, run **SplitEdge** on the main fuselage surface, snapping to the **End** of the lower side surface.



15. Fill in the opening using **Sweep2**. Match **Tangency** to the rails, enable Preserve first shape and Preserve Last shape, and specify **Rebuild with 6 control points**.

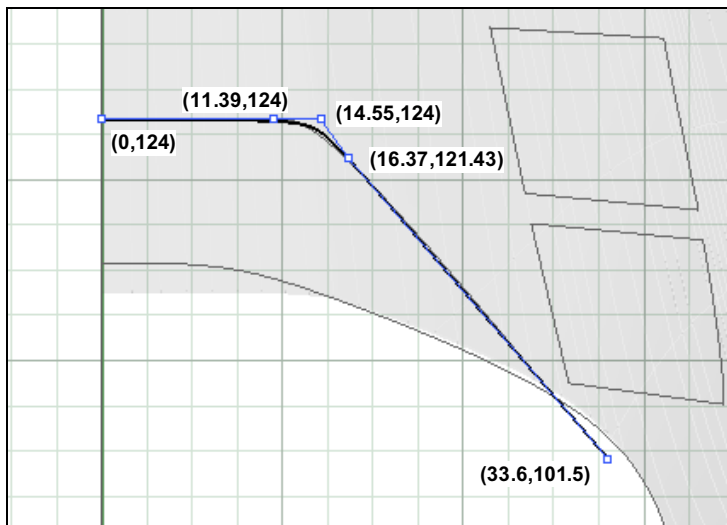
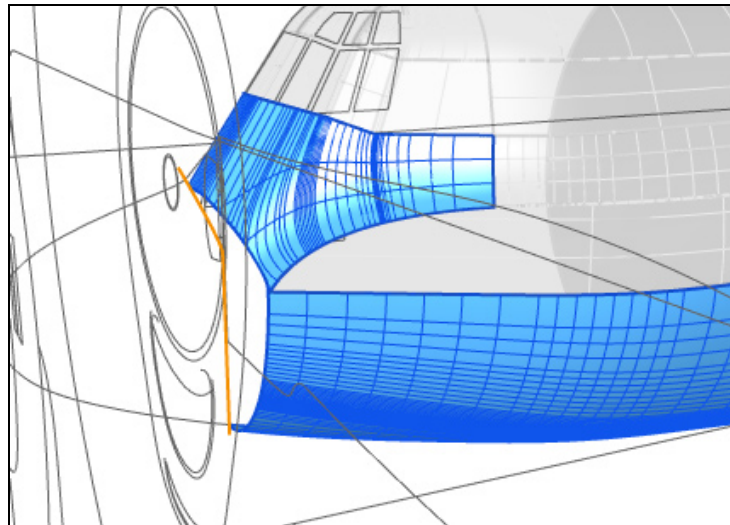
With any luck, if the surrounding surfaces have been made precisely, the ends of the sweep, which are not controlled by the alignment options inside **Sweep2**, will appear acceptably smooth without any further adjustment.



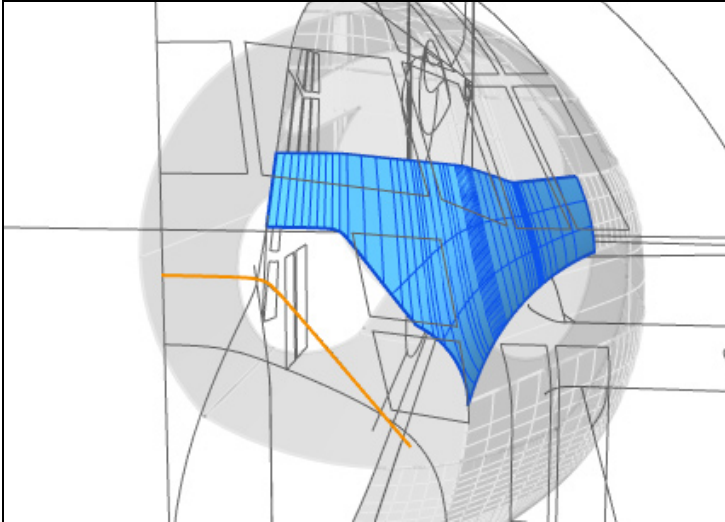


16. Draw a **Curve** of **Degree 5** in the Right view for the edge of the radome.

17. Use the curve to **Trim** off the nose. Don't delete the trimming curve just yet.



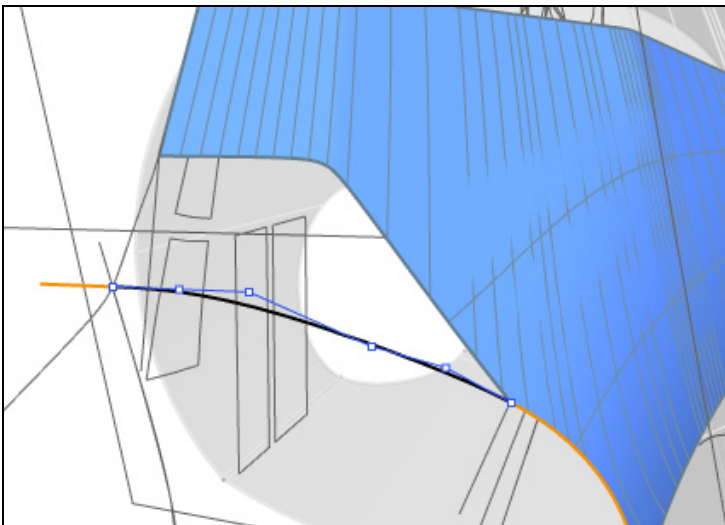
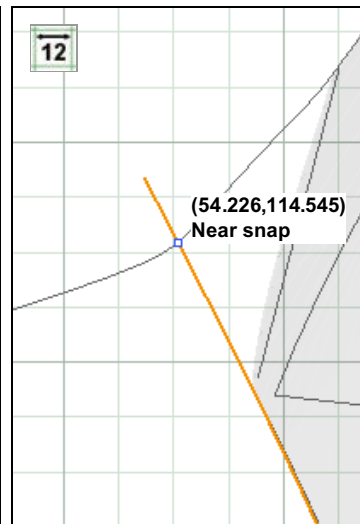
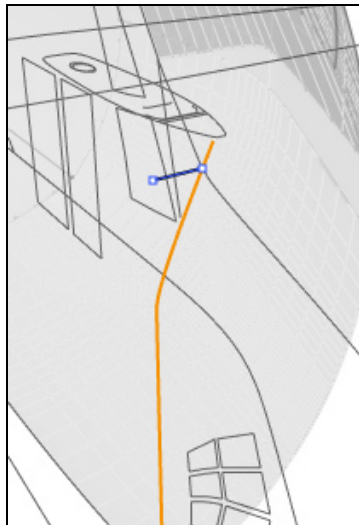
18. Draw a **Curve** of **Degree 3** in the Front view. This is for the edge of a small fairing between the radome and the nose.



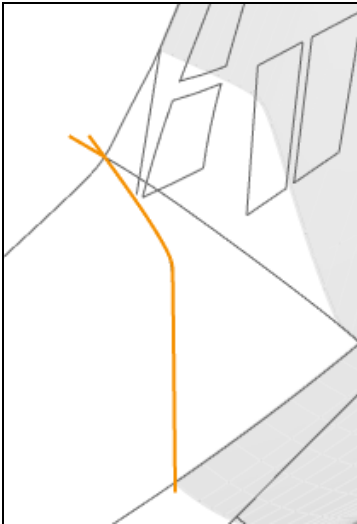
19. Trim the nose with the curve.

20. Delete the curve.

21. Draw a Line, using the **Near** Osnap to place its start point on the curve we drew for the edge of the radome, then use the **Ortho** snap to extend it a short distance to the (pilot's) right, away from the side we've been constructing everything on.

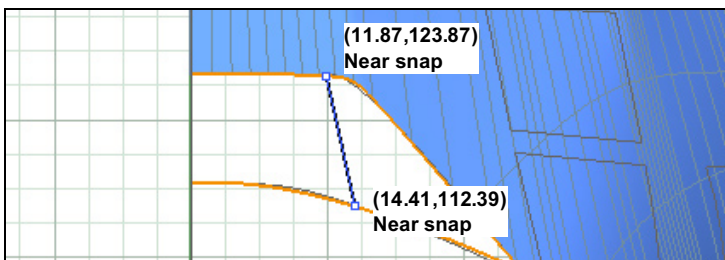
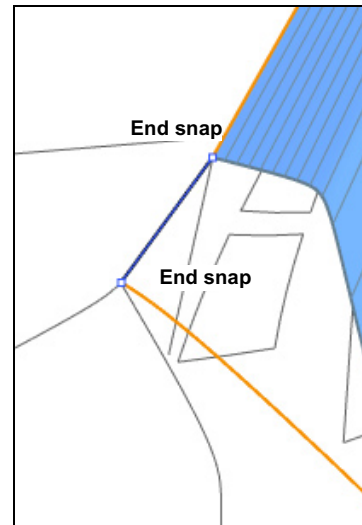


22. BlendCrv with G2 continuity between the line we just drew and the edge of the blend.

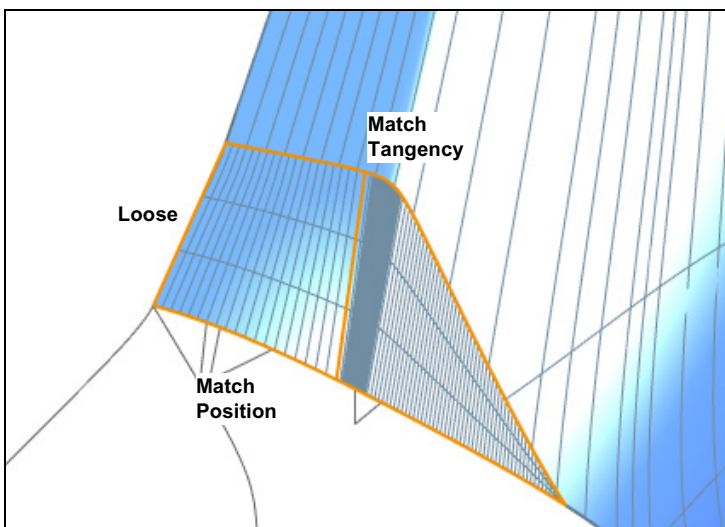
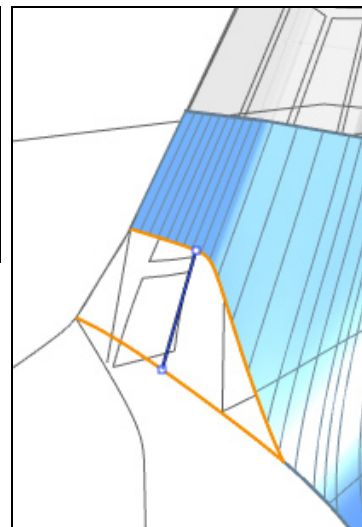


23. Delete the small line and the curve used to trim off the nose.

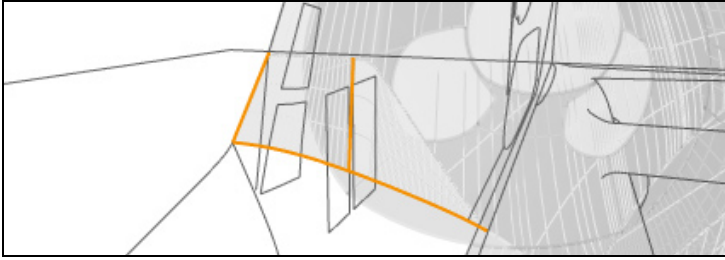
24. Draw a *Line*, between the edge of the blend surface and the blend curve, snapping to the **End** of each.



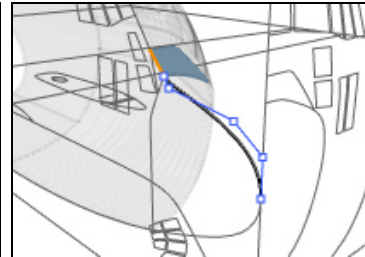
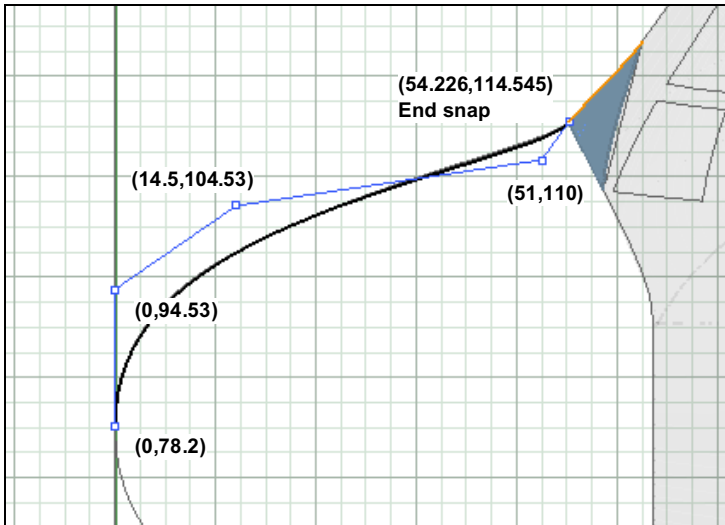
25. Draw another *Line* between the blend curve and the edge of the nose, using the **Near** Osnap.



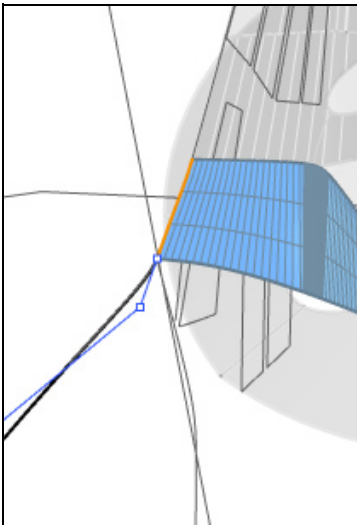
26. Build a small fairing between the nose and the radome with **NetworkSrf**. It's necessary to set the edge tolerance to **0.0001** to get the result to join to the nose. Note the use of the **Loose** matching(well, not-matching)option on the inside edge.



27. Delete the blend curve and lines used to make the fairing.

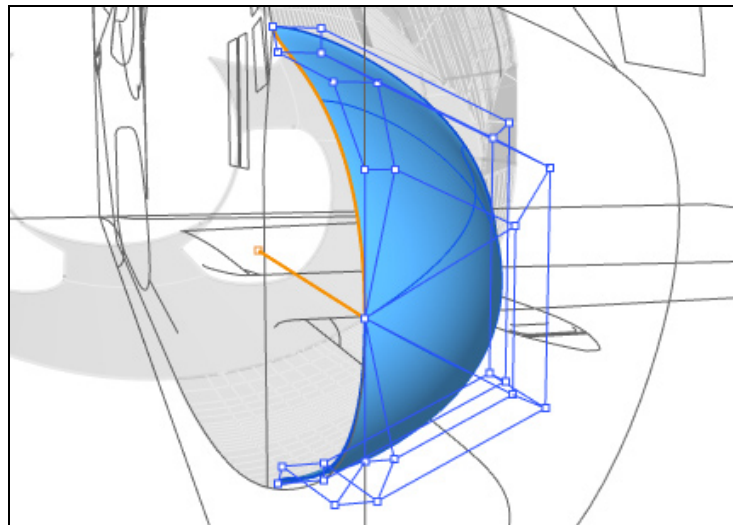


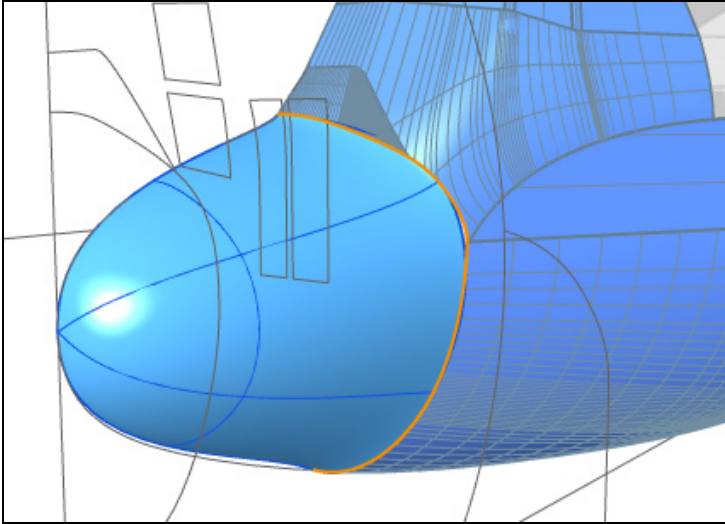
28. Build a *Curve* of Degree 5 following the top profile of the radome.



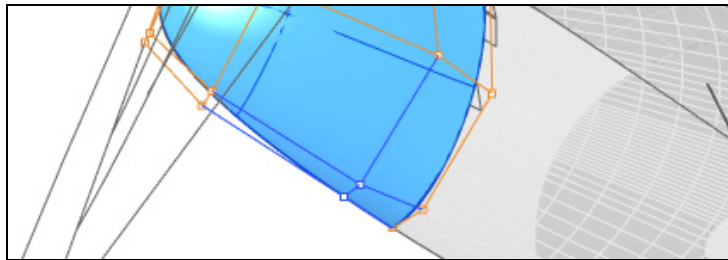
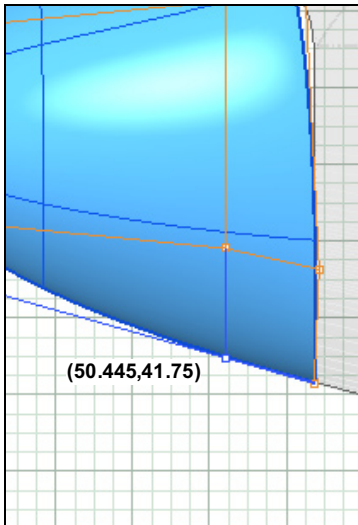
29. Match the curve to the edge of the fairing. Specify **Tangency Continuity**, set *Preserve other end* to **None**, and turn off the other options.

30. Revolve the profile curve about its **End**. Set the *Start angle* to **0** and the *Revolution angle* to **180**. Use the *Deformable* and *DeleteInput* options, and set the *DeformablePointCount* to **6**.

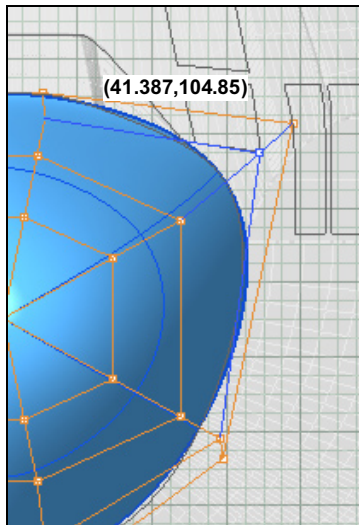
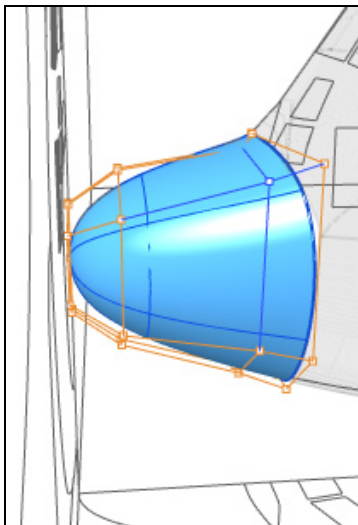




31. MatchSrf the radome to the nose, which will of course require the *ChainEdges* option, but with *Refine match* off so that it doesn't add any control points, we'll tweak it before 'nailing it down.' Set the *Continuity* to **Position**, turn on *Match edges by closest points*, and set *Isocurve direction adjustment* to **Automatic**.



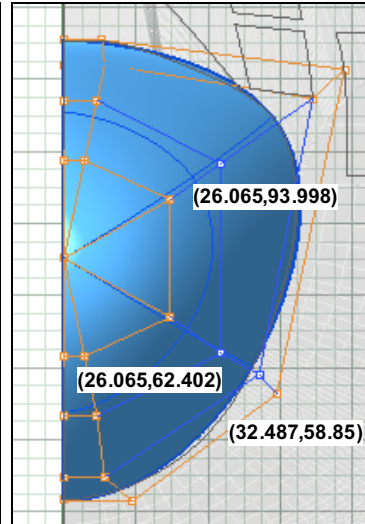
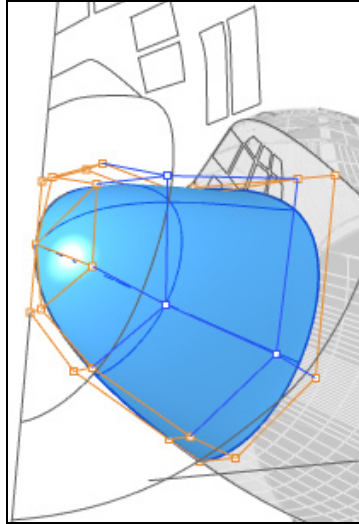
32. Select these two points on the radome and move them down by **4.2** units.



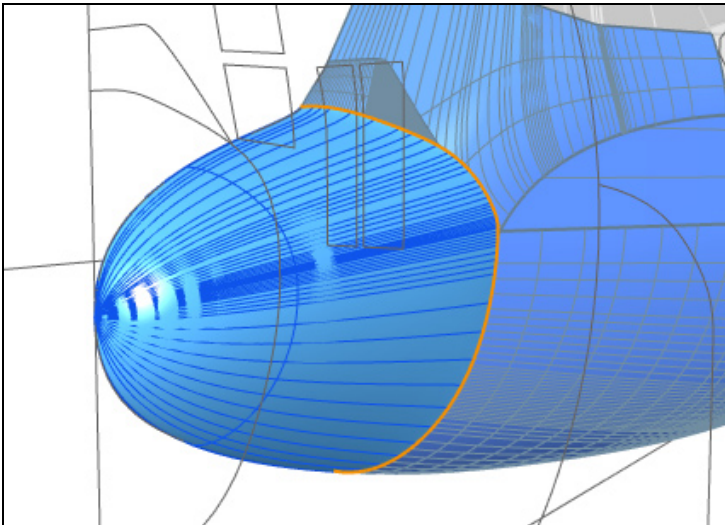
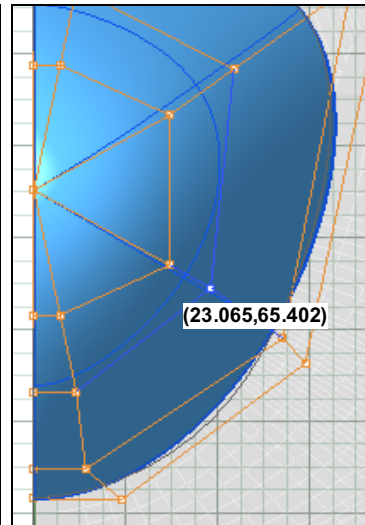
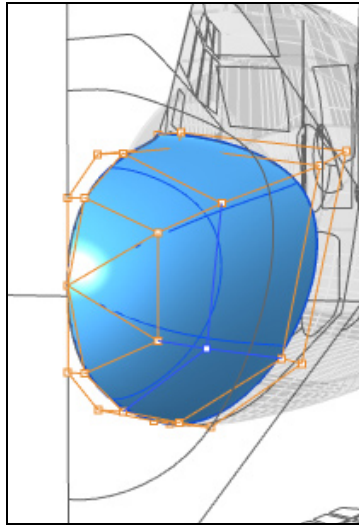
33. Move this point up by **7.3** units and out by **6.4**.

next point in by 3 and up by 3 units.

34. Select three points and move them towards the inside by **2.5** units.

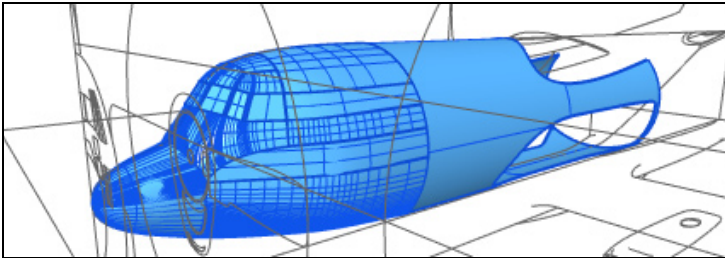
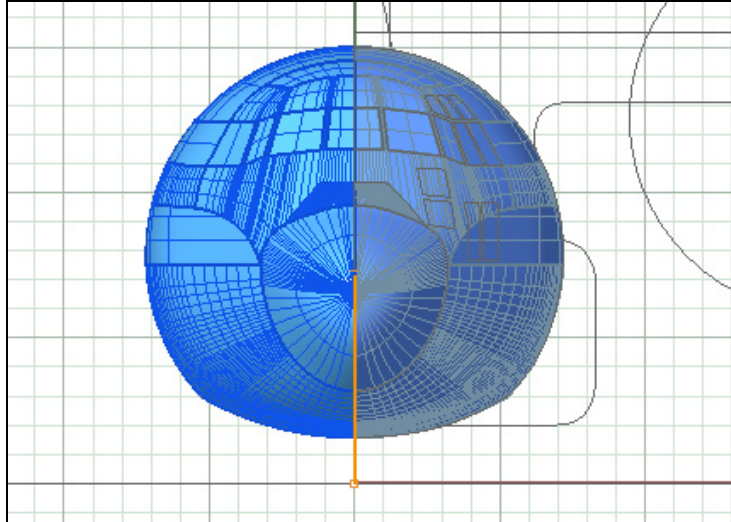


35. Pick this point and move it in an additional **3** units and up by **3**.



36. MatchSrf the radome to the nose again. Set the *Continuity* to **Position**, turn on *Match edges by closest points* and *Refine match*, and set *Isocurve direction adjustment* to **Automatic**.

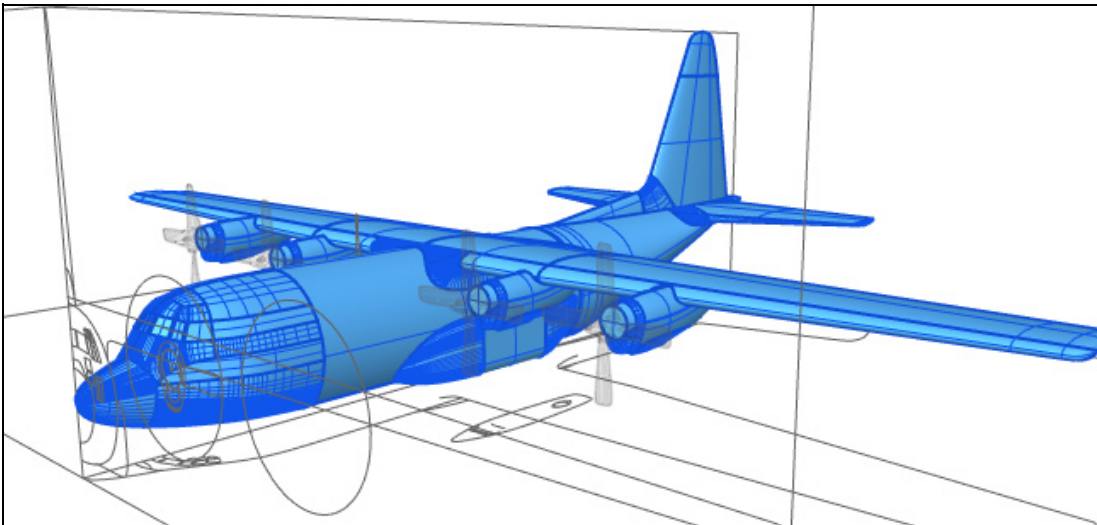
37. Mirror the nose.



38. Join up the nose and fuselage objects.

39. Show the rest of the model.

40. Join everything up.



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