Modeled in Rhinoceros by Michael Philbrick

Modeling a Tank

By Michael Philbrick

Warning: This tutorial involves the creation of a somewhat large, complex model. A minimum system of 256 Megabytes of RAM is recommended to comfortably complete the project.

Body

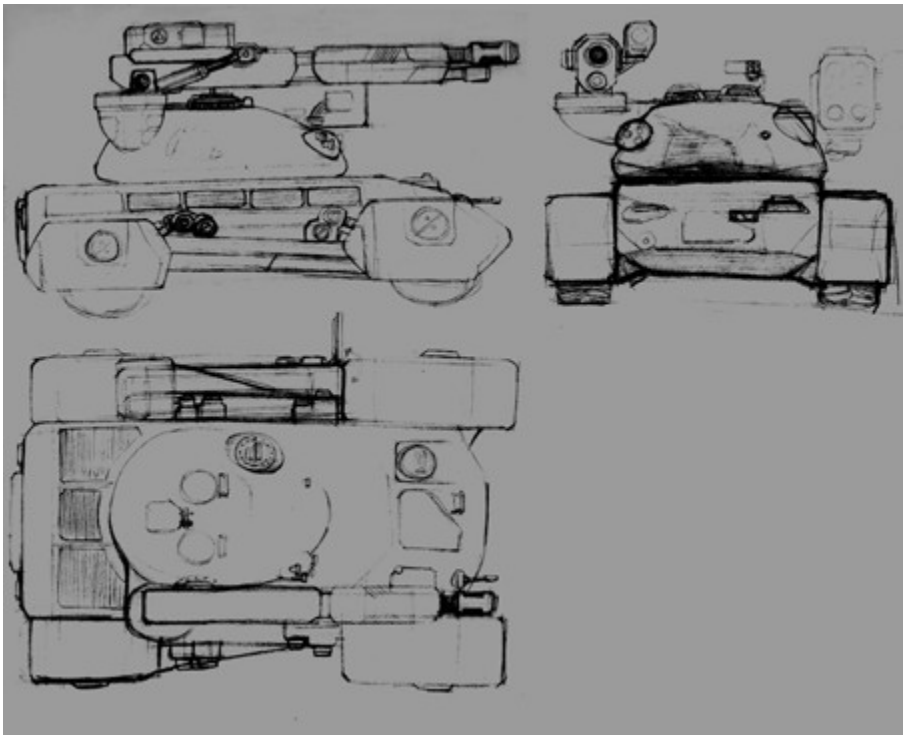
Open lunar/body_curves.3dm and save it out as body.3dm on your local hard drive in a new subdirectory called tank.

What you have here is the PolyLines that form the body of the tank. The lines are based on the background sketch shown below.

Select all the PolyLines and hit **Loft** and use the 'Straight sections' and 'Do not simplify' options.

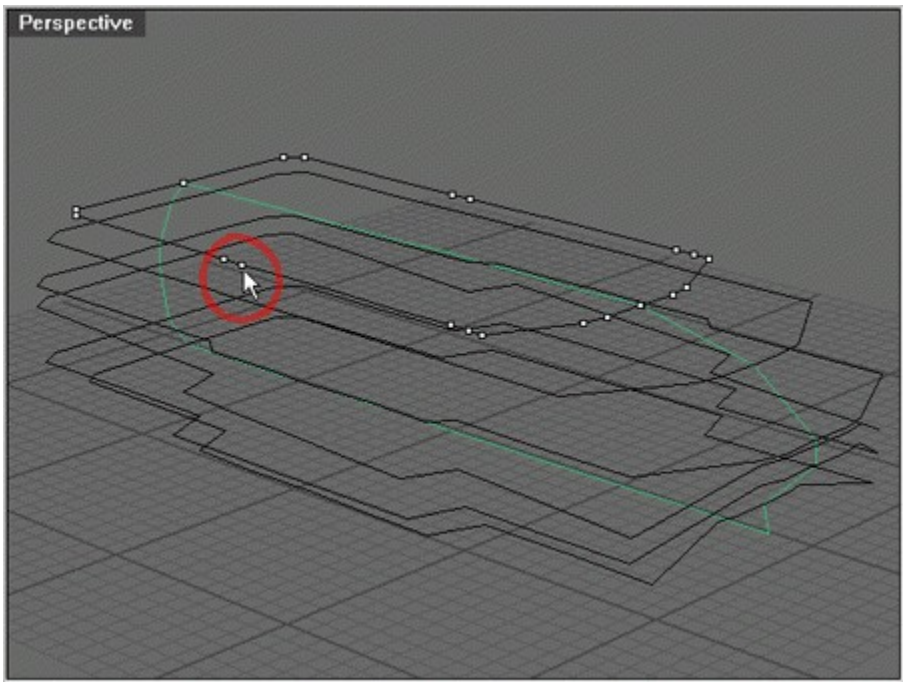
Overview: So basically what you see are PolyLines that where made in the top view. They were placed at the right height in the front view. In the top view, edit points were adjusted to fit the background body shape. The background used is shown below. Some other sketches by my friend Steve Pak are in the Tank/background directory on the CD-ROM.

After one line looks about right I then used **Copy** '**I**nPlace' and dragged and edited that PolyLine keeping the same amount of points in the curve. If you select all the curves and hit **What** you will see that they all have 24 segments. One thing you should note is that sometimes the edit points are used in the 6 curves to denote change in the shape of the body and sometimes they do not. The reason for points on the curves that do not denote change is they keep the surface in order from the top to the bottom.



Optional: If you would like to see what I mean you can delete or hide the surface and select the top curve, hit

EditPtOn and hit **RemoveKnot** and remove the 2 knots shown circled below. Then repeat step one and you'll see that even though the points didn't change the appearance of the curve, they did maintain the surface.



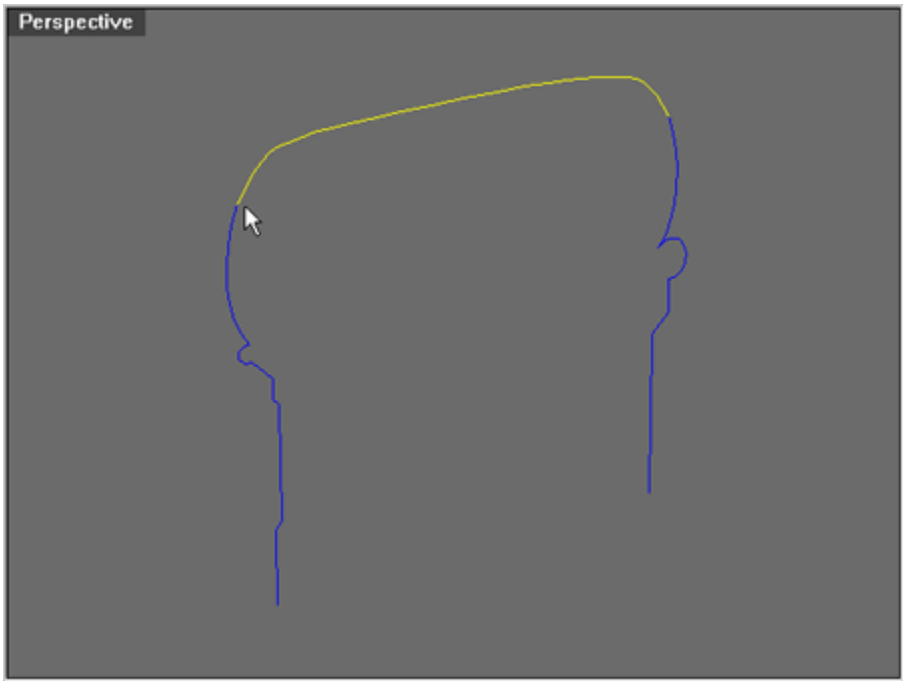
Technoid Notes: about surface construction: How the points are placed in the curves effects how all loft surfaces are constructed. This is also why the rebuild option in the 'Loft dialog box' is such an important option. What 'Rebuild' does is space the points evenly on the construction curves and gives the the construction curves a equal number of points and the option of lining up where the curves start so that the surface does not have twists and bunch up in undesirable areas. In the above situation though the Rebuild option wouldn't be a desirable option because it would require to many points to maintain the rectangularity of the object, Rebuild is mostly used for organic shapes. So what is called for, to create inexpensive rectangular geometry, is to manually orient the points and use the 'Straight sections' option.

Select the surface and hit **Cap**, which will put a cap on the top of the tank.

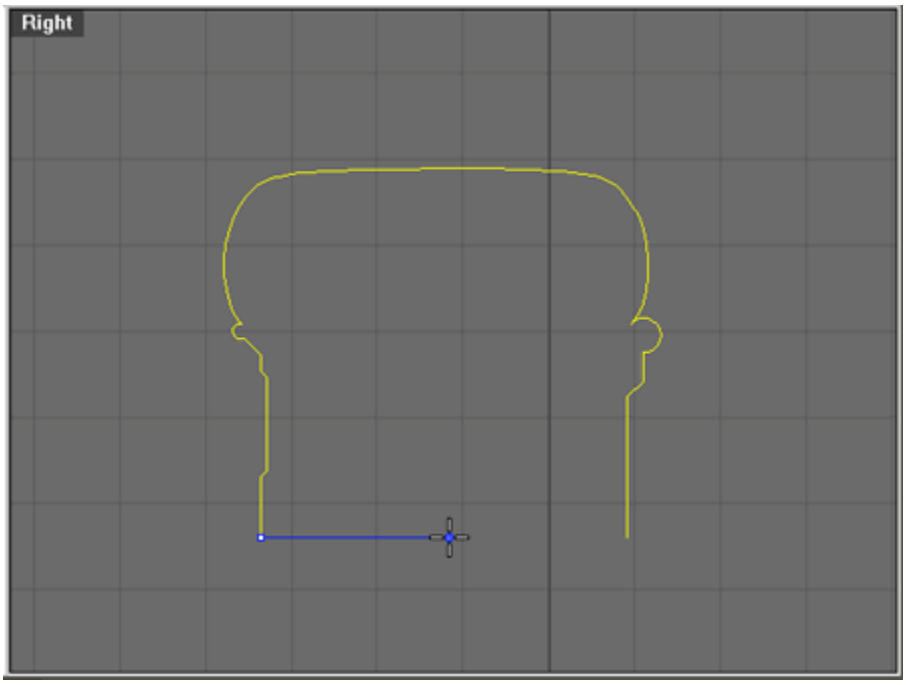
Save the body.3dm file.

Wheels and Tires
Open file wheel_curves.3dm and save it out as wheel.3dm on your local hard drive in your subdirectory called tank.

Explanation of curves: These curves are comprised of some PolyLines and Arcs that are joined with the intention of creating the tire and wheel with a **Revolve**. Not too much to add about these construction curves except that the curve that forms the tread part of the curve has been split and rejoined so that after the revolve the 'PolySurface' (more than 1 surface joined together) created will have a surface that creates a tread surface and 2 sidewall surfaces as shown below.



From the right view and with 'End' osnap on select the curve and hit **Revolve** and snap to the lower part of the curve and with shift held down (for temporary **Ortho**) drag to the right and click to bring up the 'Revolve Options' dialog box and use the 'Exact' option.



Turn on the 'tread curves' layer and from the top view hit zoom extents. Hit **ExtractSrf** and select the 'tread' part of the tire surface.

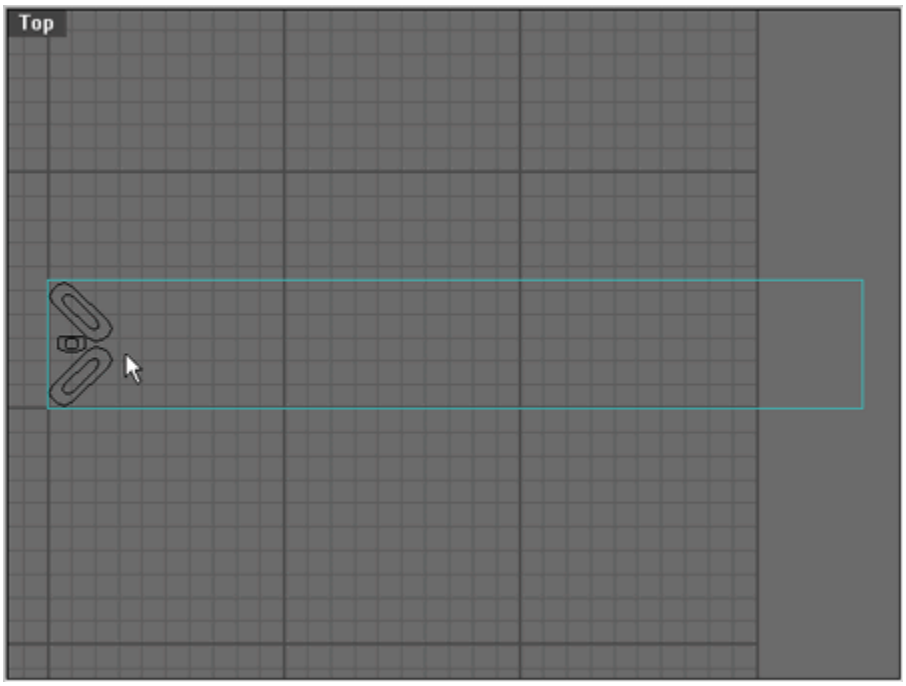
Select the 'tread' surface and hit **CreateUVCrv**. This creates a rectangle that is a representation of the U and V borders of the surface (reference). Sometimes this will have strange results like with a long skinny rectangle or in this case it's placed differently.

Hit **Undo**.

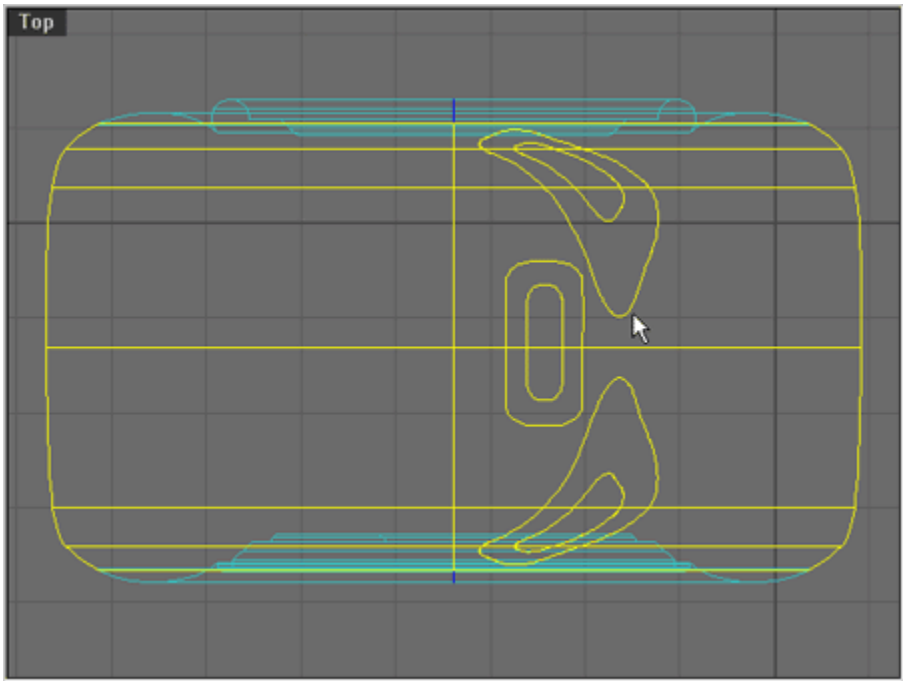
Select everything **SelAll** and hit **Improve**. This will reparameterize the values of the objects so that their U V domain sizes are roughly the same size as the 3d geometry of the objects.

Select the 'tread' and hit **CreateUVCrv** Curve/From Objects/2-D Utilities/Create UV Curves.

Zoom window around the 'tread' and U V curves shown below.



Select the rectangle and the curves from the tread layer and hit **ApplyCrv** and select the tread surface. This will map the curves onto the tread surface as shown below.



Hide the 'tread' curves layer.

Optional: We don't need the UV rectangle that was mapped to the tread anymore so to keep the

workspace uncluttered select all the UV rectangle curves (not the oval tread curves) and **Delete** them.

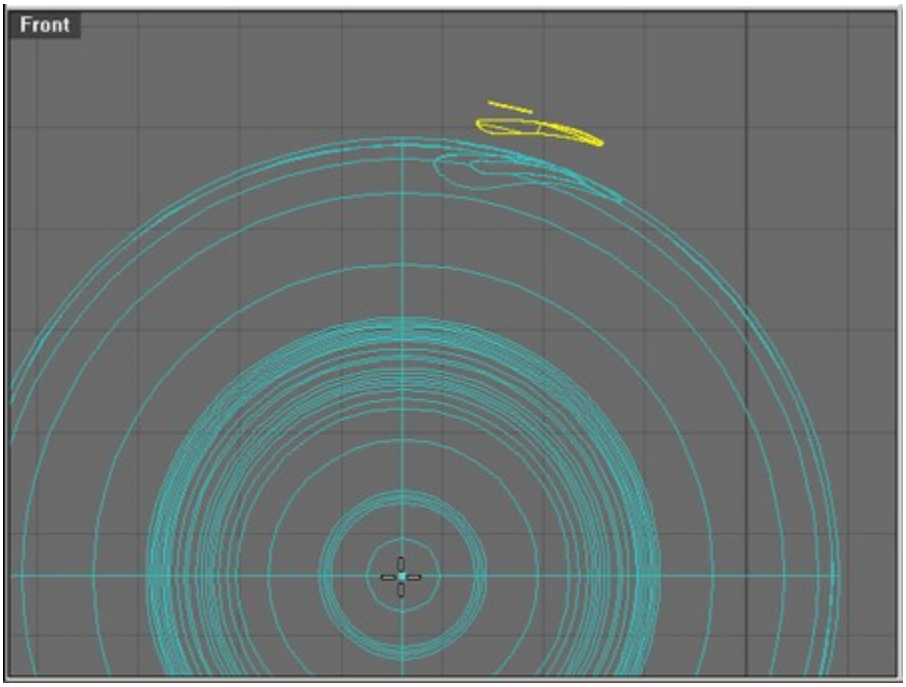
Select the new applied curves and hit **Rebuild** and use **14** points.

From the top view and hit **Split** and select the tread surface as the surface to split and select the 3 inner curves that were mapped to the tread surface as the trim curves.

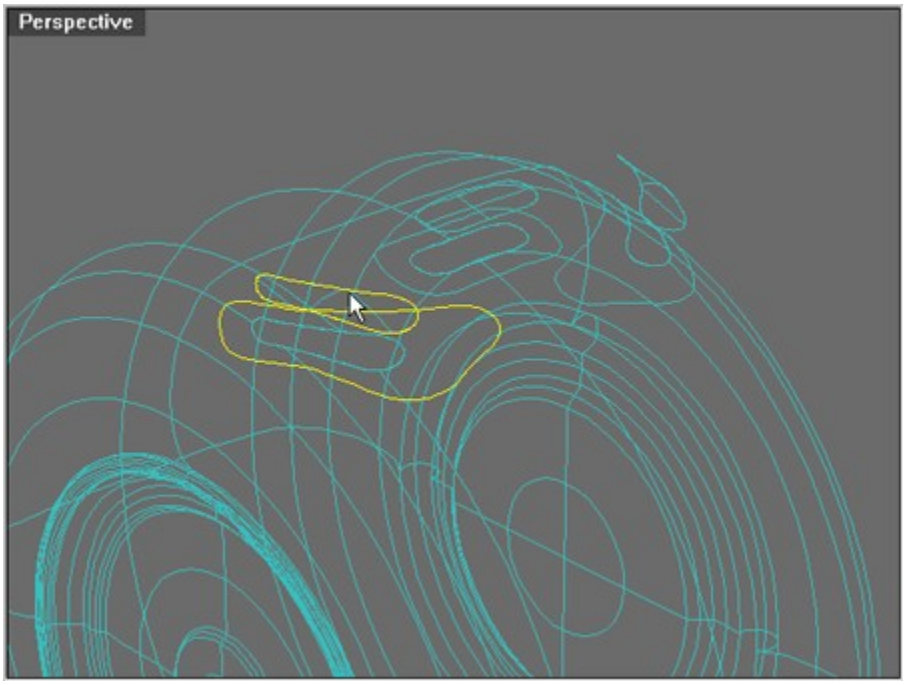
Select the split surfaces at the bottom of the tire and hit **Delete**. From the perspective view hit **Untrim** and click on the 3 trimmed edges at the bottom of the tire.

Select the 3 surfaces at the top of the tire created from splitting and hit **ShrinkTrimmedSrf**. If you want to see what ShrinkTrimmedSrf does, turn on the control Points **PtOn** for the 3 surfaces before and after using ShrinkTrimmedSrf.

From the front view and with the 3 surfaces still selected hit **Scale2D** and with 'End' osnap on, place the origin point in the center of the wheel and for the Scale factor type in **1.1**. Result shown below.



Hit **Loft** with the '**A**utomatic' option and in the perspective view and select the curves highlighted below. Use the 'Normal' option and refit to within **.5** units option.



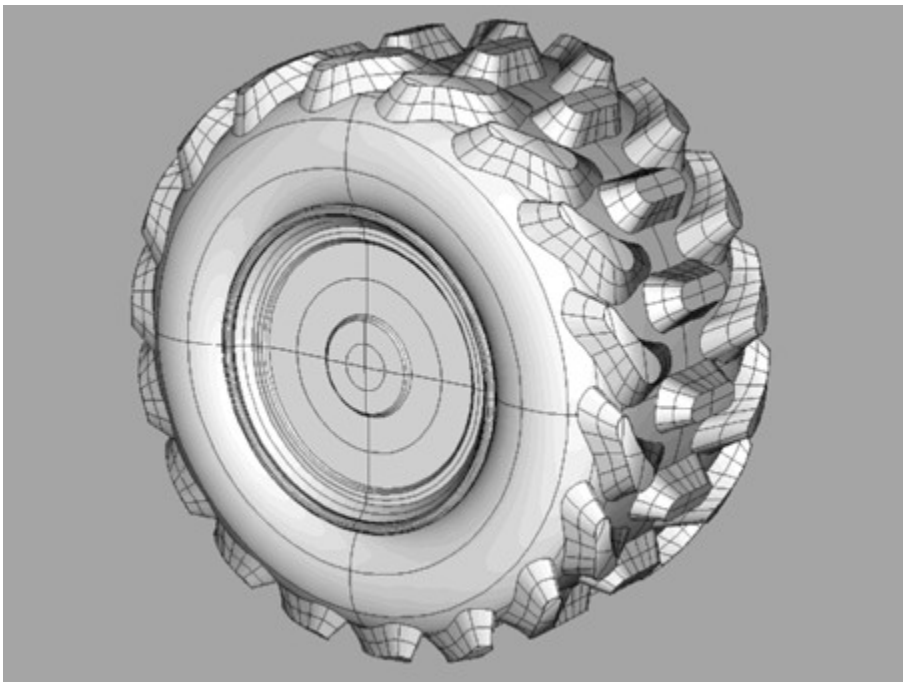
Loft as in the previous step on the other 2 treads.

Hit select all curves **SelCrv** and **Delete** them or **ChangeLayer** them to the 'tread curves' layer.

Hit **Join** and click on one of the tread sides and then the tread top surface and hit enter to complete the command. Repeat with the other 2 treads. If the surfaces won't join go to Options/Units and raise the 'absolute tolerance' to **.6** and try again.

Hit **Dir** and select one of the threads to make sure the normals are facing out and flip if necessary.

Select the tread Polysurfaces and hit **Array** and in the front view select the center of the wheel as the center of array and type in **18** when prompted for 'Number of elements.' Result shown below.



Turn on layer 'bolt curves.'

Select the 6 sided shape and hit **Extrude** '**C**ap=Yes' and extend it back so that the bolt extends through the wheel so that it will show on the opposite side or type in **230**.

Select the resulting surface and hit **Array** and use the center of the wheel as the center of array and type in **8** for 'Number of elements.'

Select everything **SelAll** and hit **JoinSrf** and save the file as wheel.3dm

Open the fender_curves.3dm file and save it out as fender.3dm on your local hard drive in your subdirectory called tank.

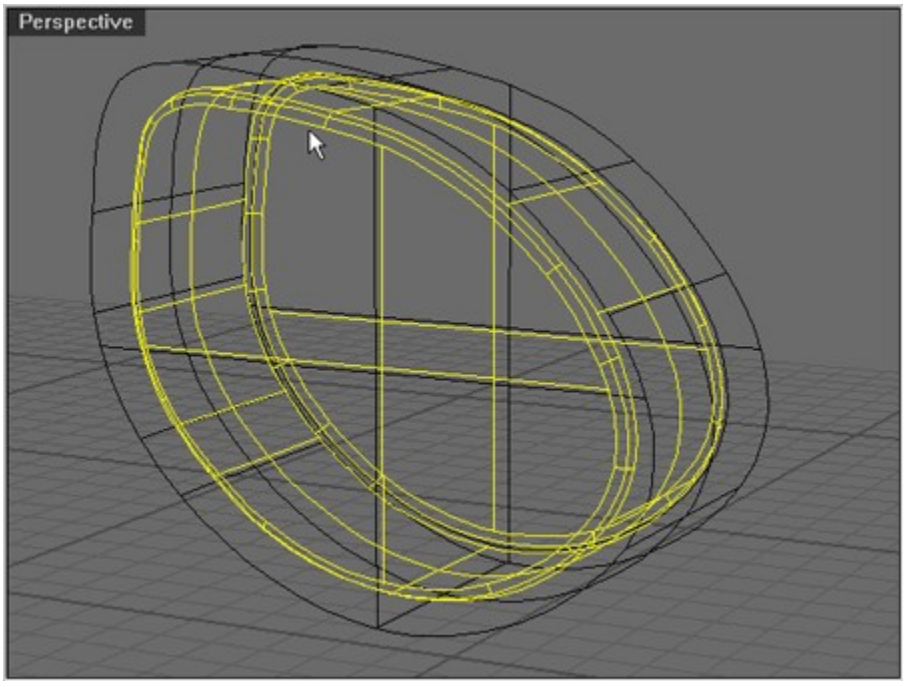
Explanation of curves: What you have here are 2 oval curves that will create the fenders and 2 other curves on the 'trim curves' layer are for trimming after. The inner oval curve was made with the tire in the scene and a curve drawn around it. **Offset** was then used a distance of **25**. Unfortunately this creates a curve with too many points in it so **Copy** '**I**nPlace' was used on the outer curve and Scale2D was used to be close to the same size as the offset curve.

Select the 2 oval curves and hit **PlanarSrf**.

Select the smaller **PlanarSrf** and with the front view active hit **ExtrudeSrf** and type in **250**.

Select the larger **PlanarSrf** and with the front view active hit enter to execute the **ExtrudeSrf** command again and type in **300**.

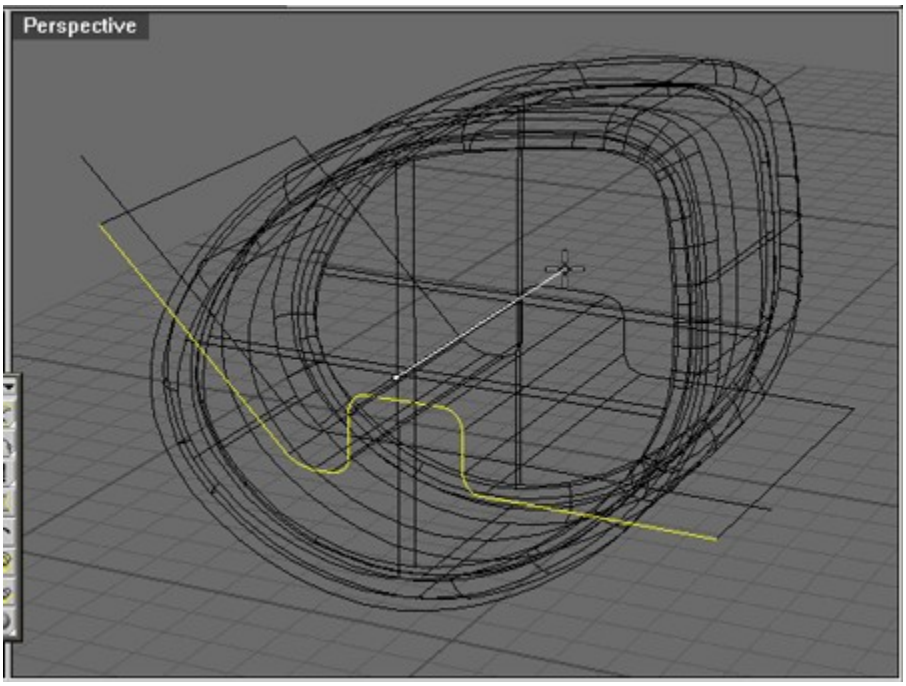
Hit **FilletEdge** and give the inner surface a '**R**adius' of **15**. Result shown below.



Hit **FilletEdge** and give the outer surface a '**R**adius' of **35**.

Turn on the 'trim curves' layer.

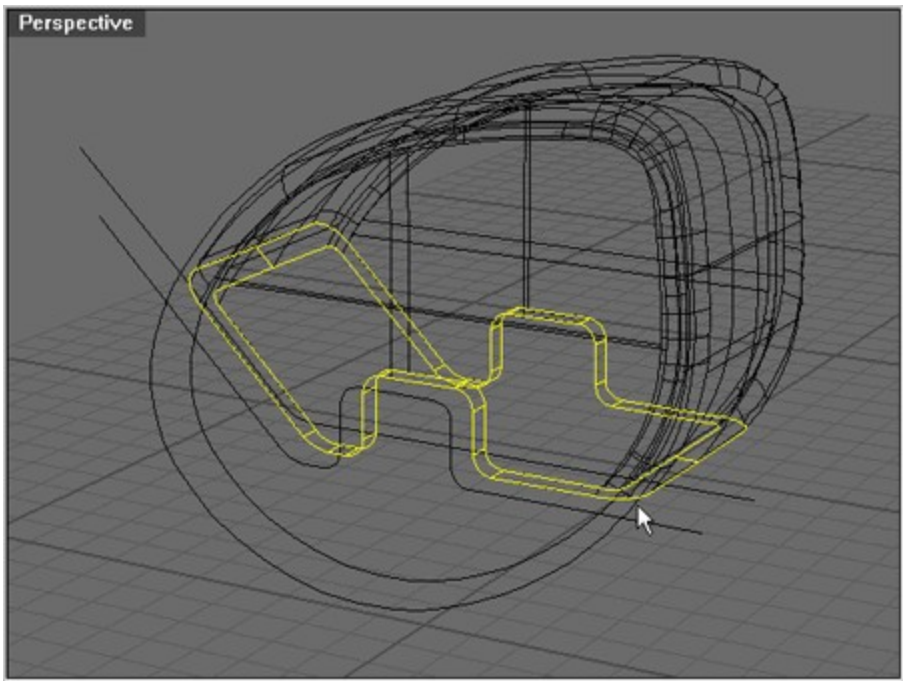
Select the lower trim curve and with the front view active. **Extrude** the curve through the fender. Shown in progress below.



Split the inner and outer fender with the trim surface and **Delete** the lower parts of the fenders.

> **Note:** You can split curves and surfaces with curves, surfaces and polysurfaces. Polysurfaces can only be split with surfaces and polysurfaces.

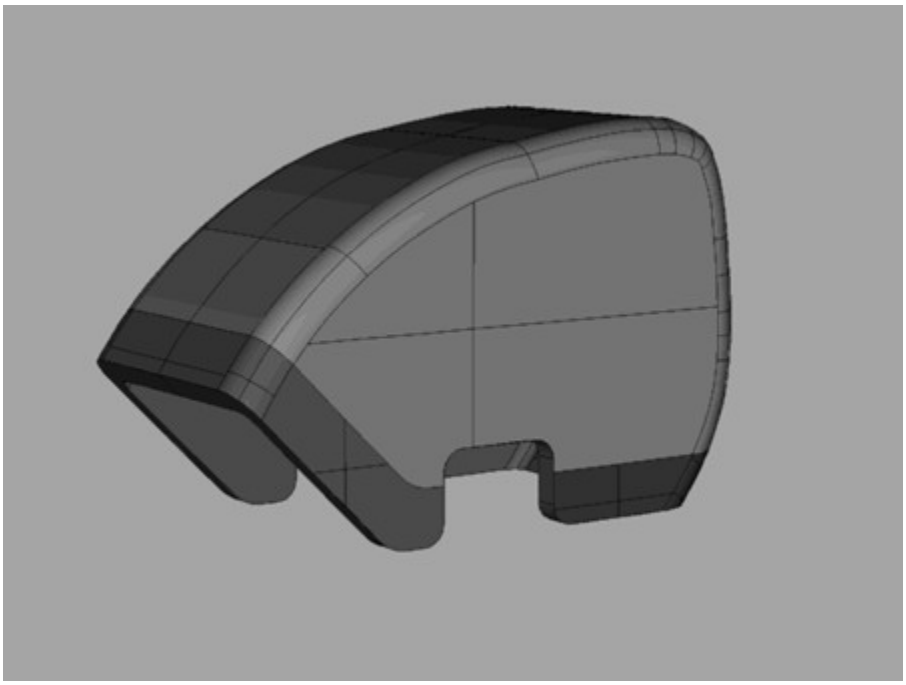
Split the trim surface with the inner and outer fender keeping the piece of trim surface that lies between them. Result shown below.



Select the upper trim curve and with the front view **Extrude** the curve through the fender.

Split the outer fender with the trim surface but do not Delete the split off part. This was only done so that we

could apply a different color or texture to the skirt part of the fender. As shown below.



> **Note:** There are other ways this fender could have been made like using RailRev but this geometry is less expensive and cleaner.

Hide the 'trim curves' layer.

Window Select all the surfaces **SelSrf, SelPolysrf** and hit **Explode** and then hit **ShrinkTrimmedSrf**.

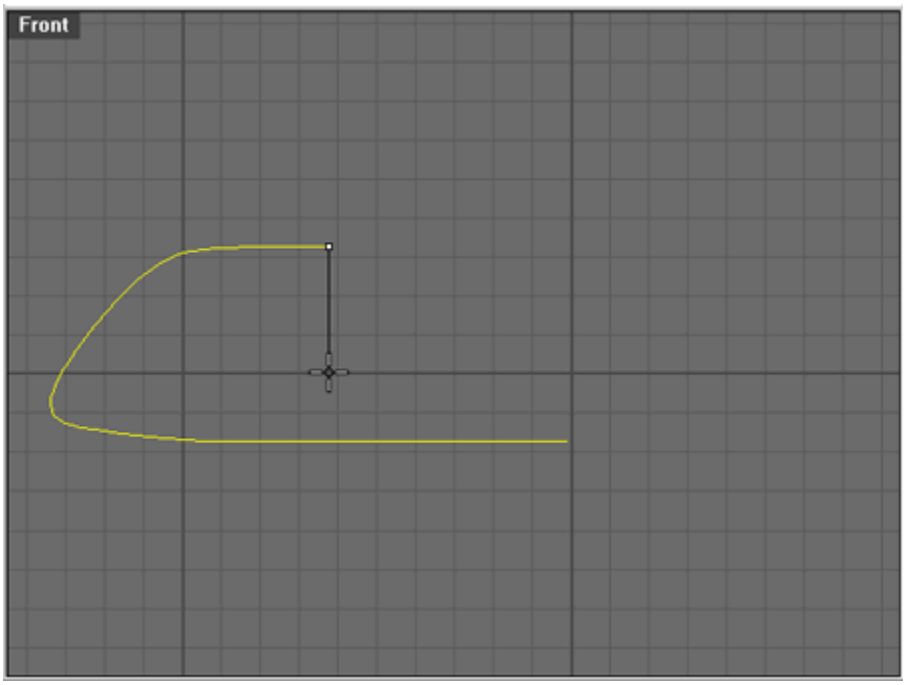
Unselect the top outside surface of the fender and **JoinSrf** with the rest of the objects are still selected.

Save out the file as fender.3dm.Open turret_curves.3dm file and save it out as turret.3dm on your local hard drive in your subdirectory called tank.

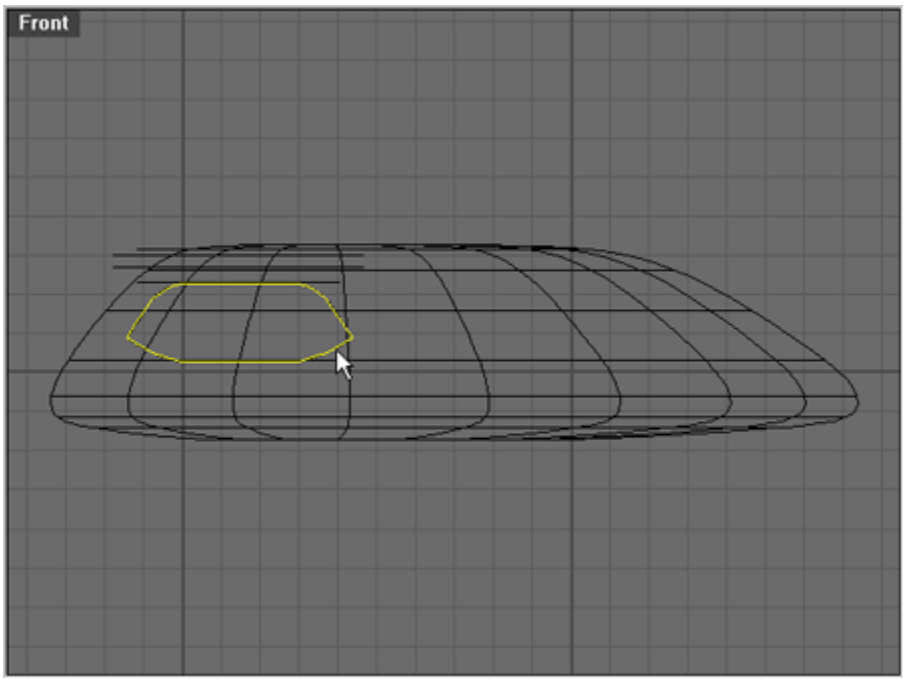
Explanation of curves: What we have here are 2 curves that are for a **RailRev**. One is the profile curve and the oval curve is the rail curve that the 'profile curve' will sweep around. So there's not much to mention about the creation of the construction curves except that if you select the profile curve and turn on the control points you will find that the last 3 points on the top are inline with each other. This is so that when they are sweep around to create the turret the top of the turret will be flat and smooth.

Hit **RailRev** and select the open curve as the 'profile curve' and the oval curve as the 'path curve.'

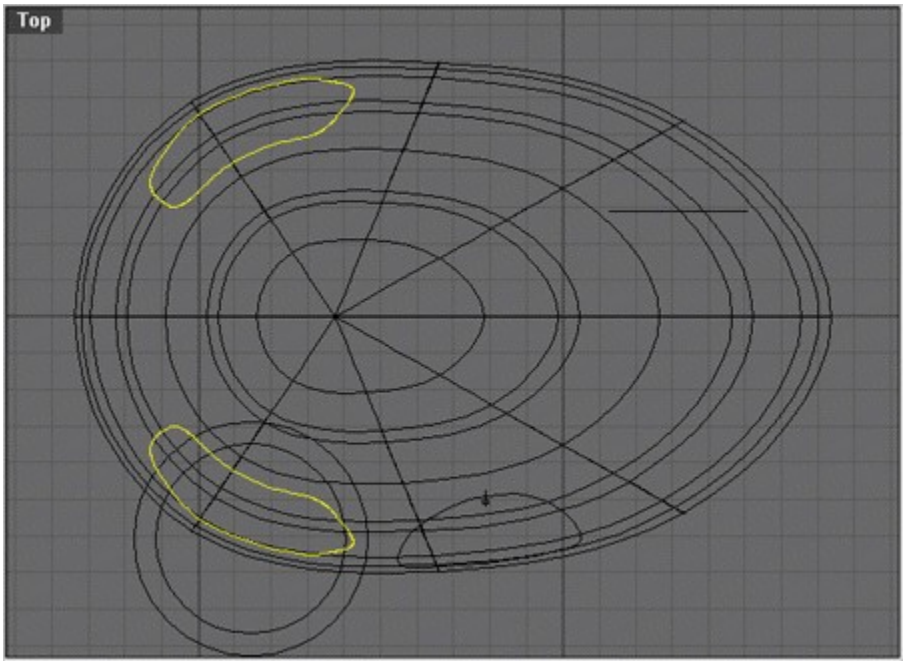
With 'End' osnap on, select the top end of the open curve and with the shift key down, for temporary **Ortho**, drag a axis down. Shown in progress below.



Turn on the 'cannon mount curves' layer. From the front view select the curve shown below and hit **Project** and select the turret when prompted 'Select surfaces or polysurfaces to project onto:'



Select just the upper curve of the 2 curves selected in the top view and delete it.

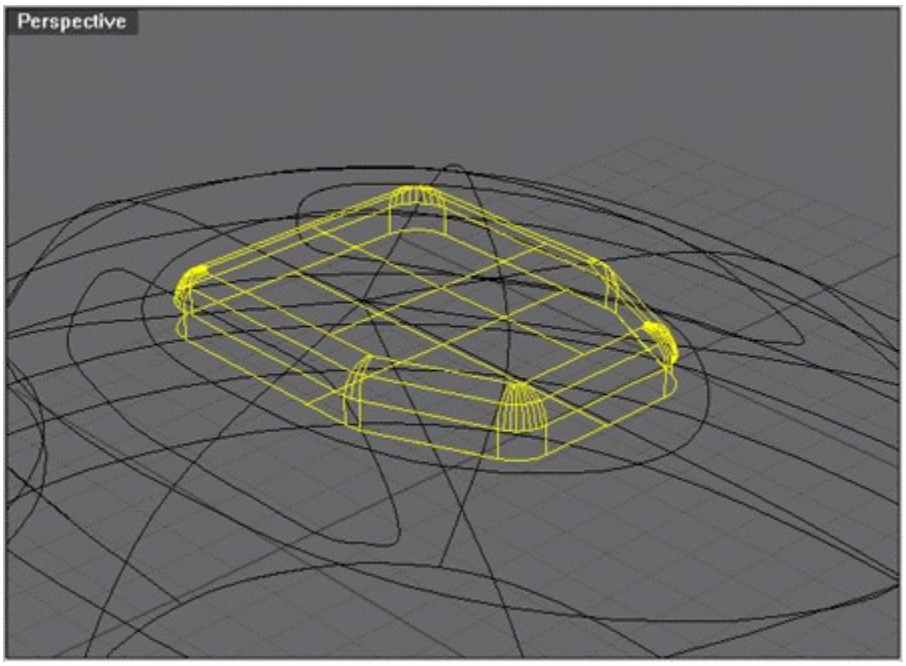


Select all the cannon mount and the projected curve except the curve inside the turret and hit **Loft** and use the 'Straight sections' and 'Rebuild with 12 points' options.

Select the new cannon mount surface and hit **Cap**.

Turn on the 'hatch curve' layer. Select the hatch curve and hit **Extrude** '**C**ap=Yes' and give it a **30** unit height.

Hit **FilletEdge** and give the top edges of the hatch a fillet '**R**adius' of **15**. Result shown below.

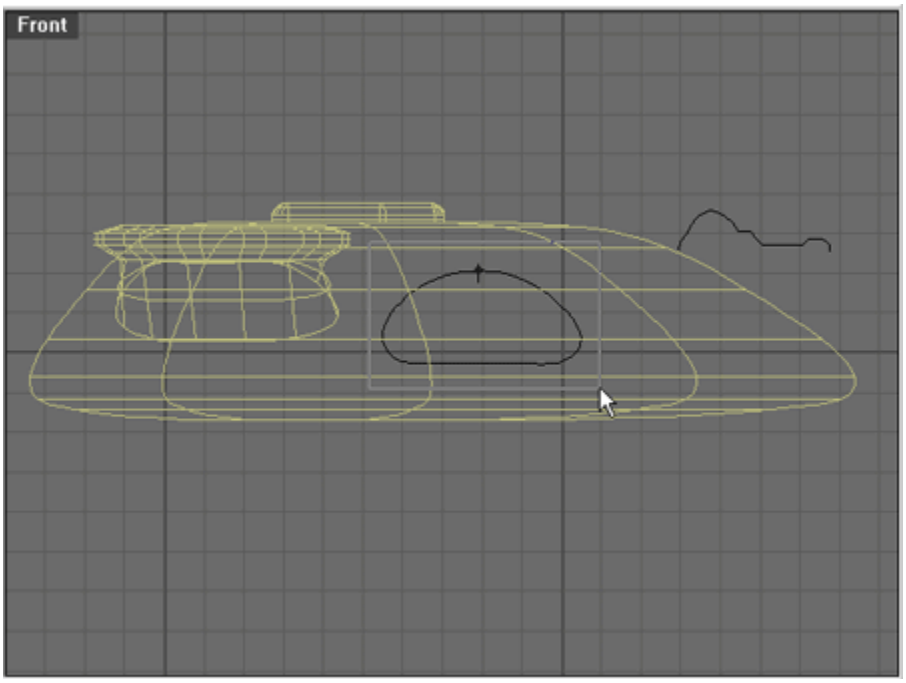


Hit **Explode** with the hatch selected and **Delete** the bottom surface. **JoinSrf** the hatch.

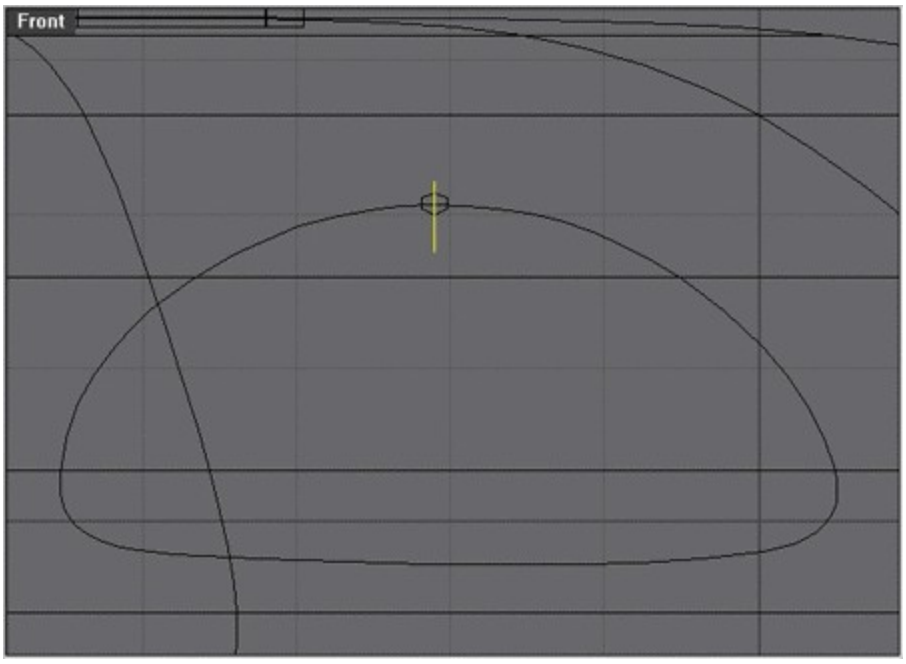
> **Note:** You can leave the bottom face on the hatch and **UnionBoolean** it to the turret but although you won't see any extra geometry it will in fact create more geometry when turned into a mesh. I

don't recommend using **UnionBoolean.**

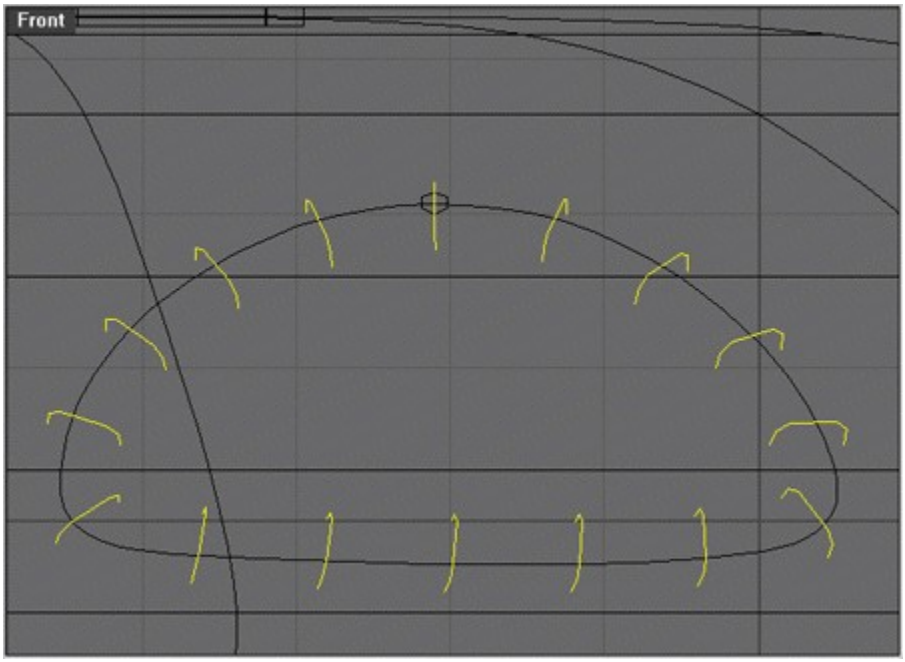
Turn off all of the curve layers and turn on the 'turret detail curves' layer and zoom in on the area shown below.



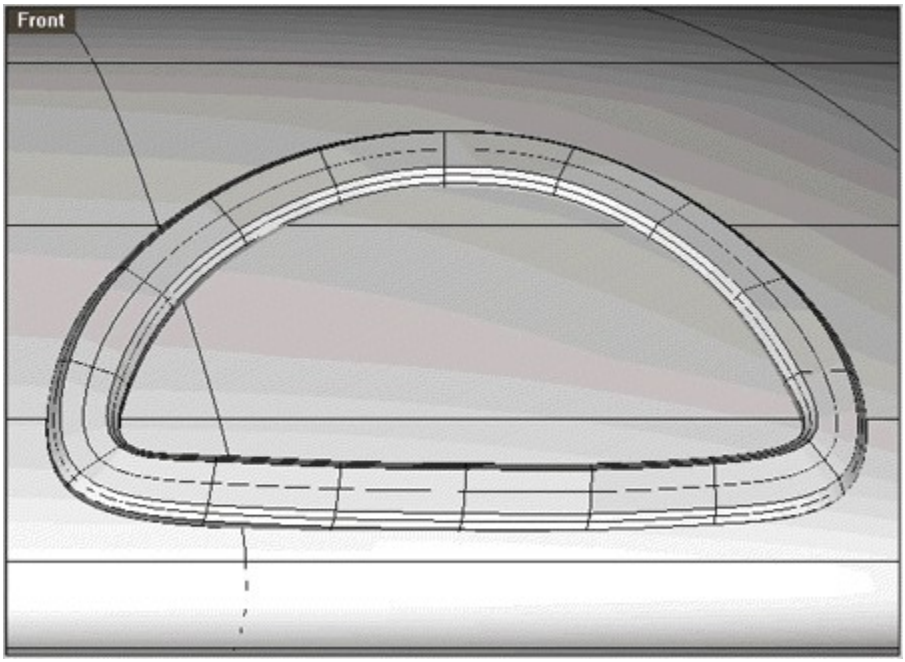
These are 3 curves to create a side hatch that's bolted to the turret. Select the vertical line shown below and hit **ArrayCrv** and when prompted to 'Select path curve:' select the oval curve. In the 'Array Along Curve Options' dialog box use 'Number of items' **16** and for Style use 'Freeform.' Before doing anything else hit **Delete** to get rid of the original curve so you don't have 2 curves right on top of each other.



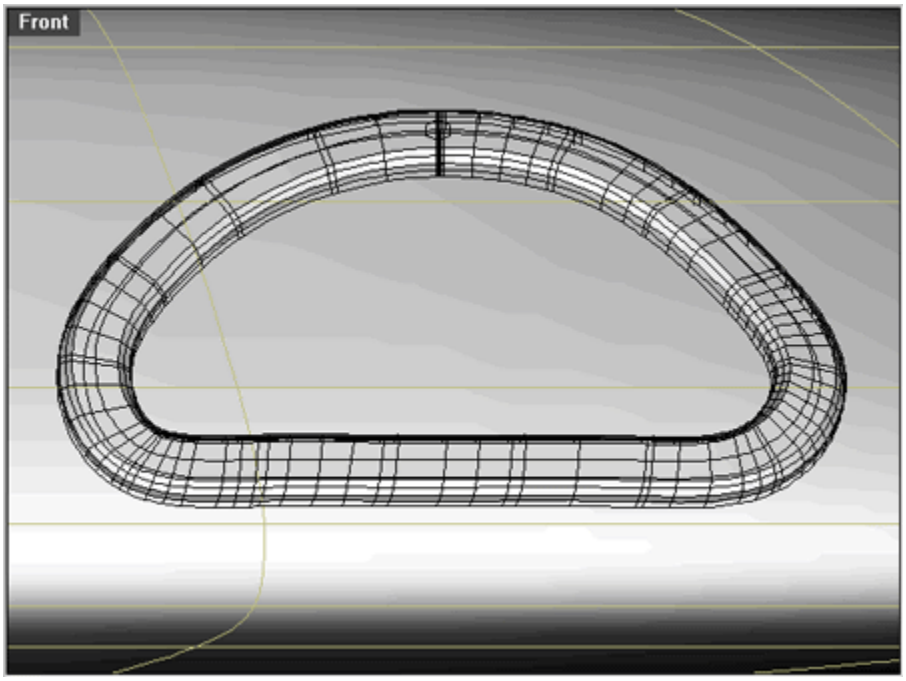
Select the curves shown below and hit **Loft** using the 'Normal' style, 'Closed loft' and "Do not simplify" options. Hit **Delete** to get rid of the unwanted construction curves.



The **Sweep1** command could have saved some steps and just selected one of the 'cross-section curves' and sweeping around the oval as the 'rail curve' but that would have created some extra geometry. The difference is shown below.

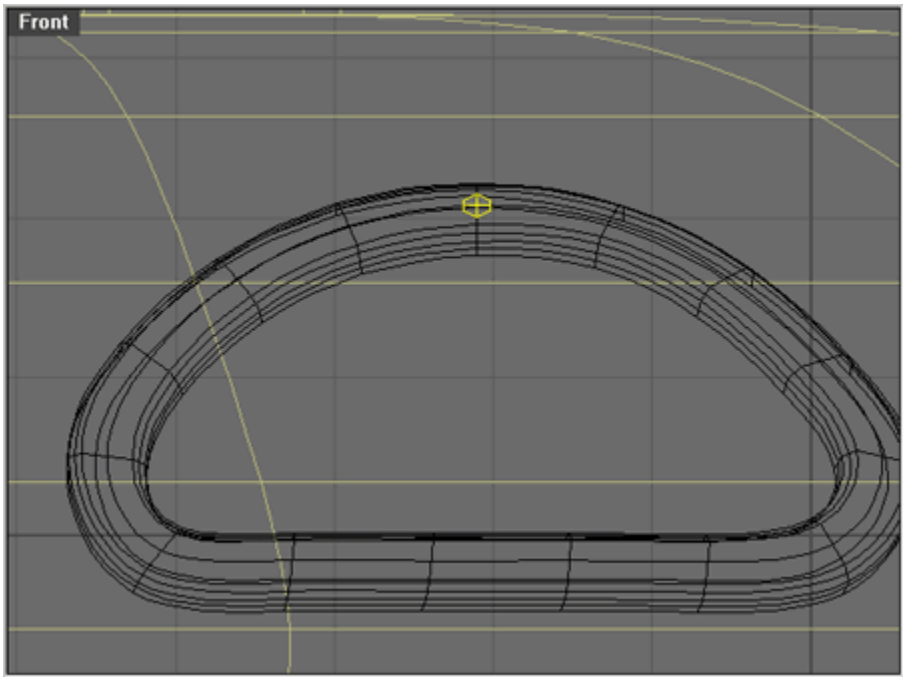


Loft (above)

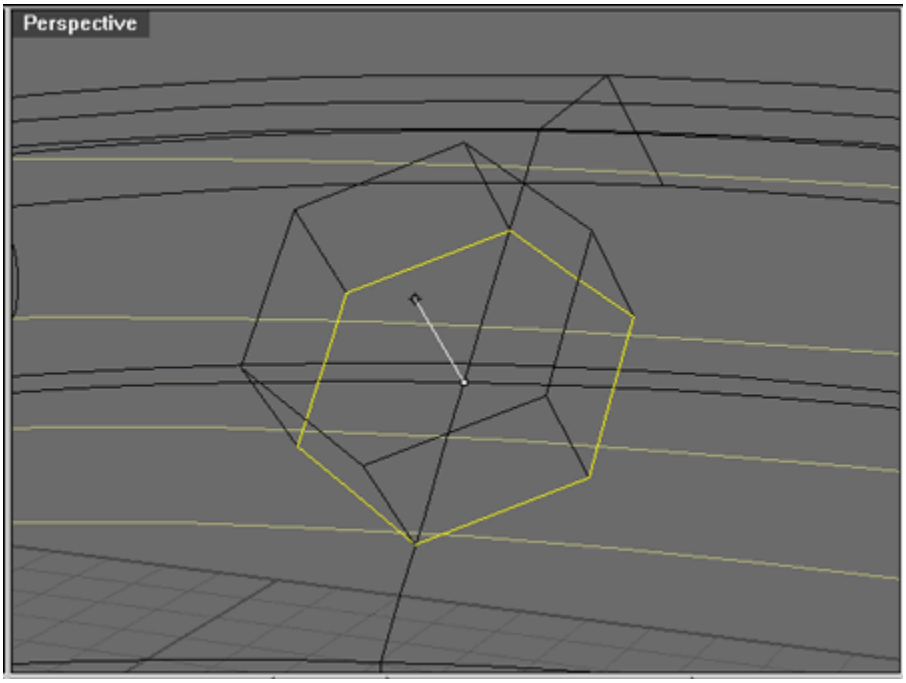


Sweep1

Zoom in on the Hexagon shown below from the perspective view. This is going to be a bolt that is going to be arrayed around the flange we just made but it needs to be Extruded first. The nice thing about Extrude is that it has some intelligence built in so that even if the object is rotated it will extrude straight out from the face of a planar curve.

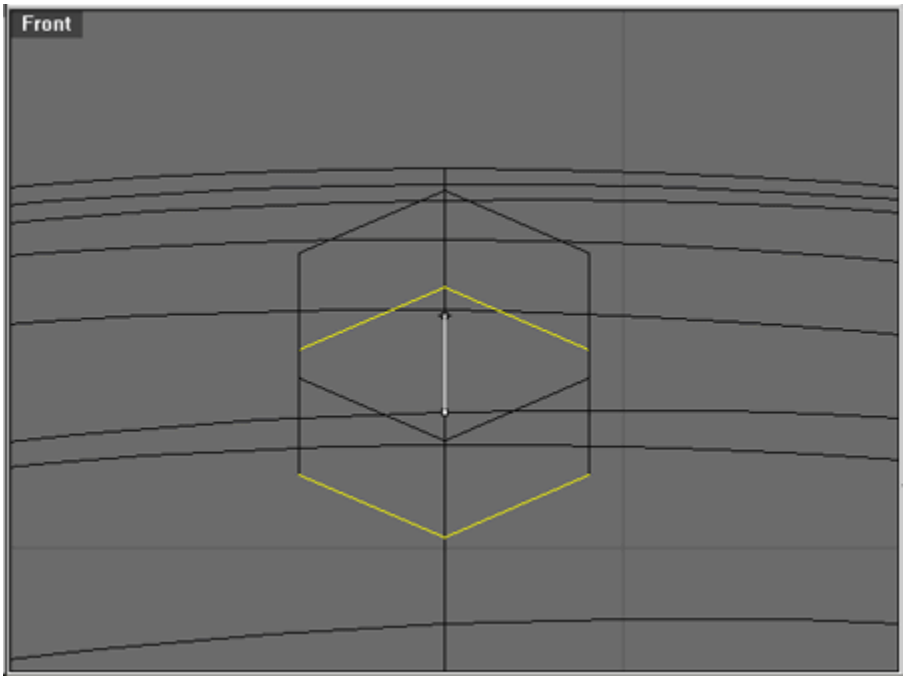


Hit **Extrude** and drag the extrusion out a bit or type in **-4**.

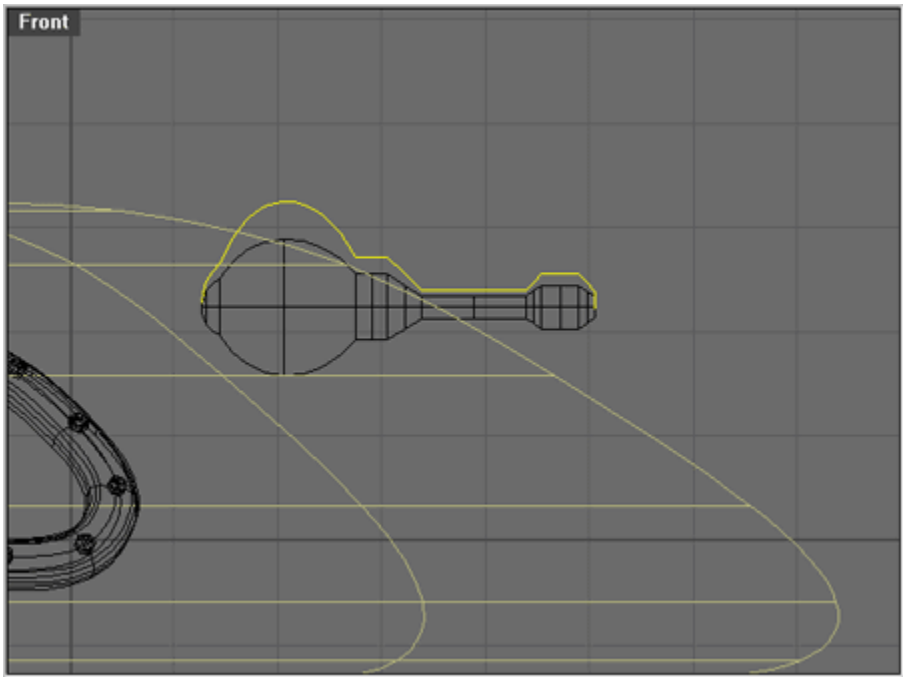


Explode the bolt head and **Delete** the hidden surface and hide or delete the hex curve and then select the bolt head and hit **JoinSrf**. Remember: if it can't be seen, eliminate it.

Hit **ArrayCrv** with the bolt head selected and select the oval path that you used before when making the Loft surface and give it **15** elements.



Ok, just one more detail and that is a small curve for some sort of gun. Which is simple to do. Just select the curve and **Revolve** it with 'End' osnap on and revolve it by snapping on the right end of the curve and with the shift key down, for temporary **Ortho**, drag a axis to the right. Use the 'Deformable' option with **4** points option.



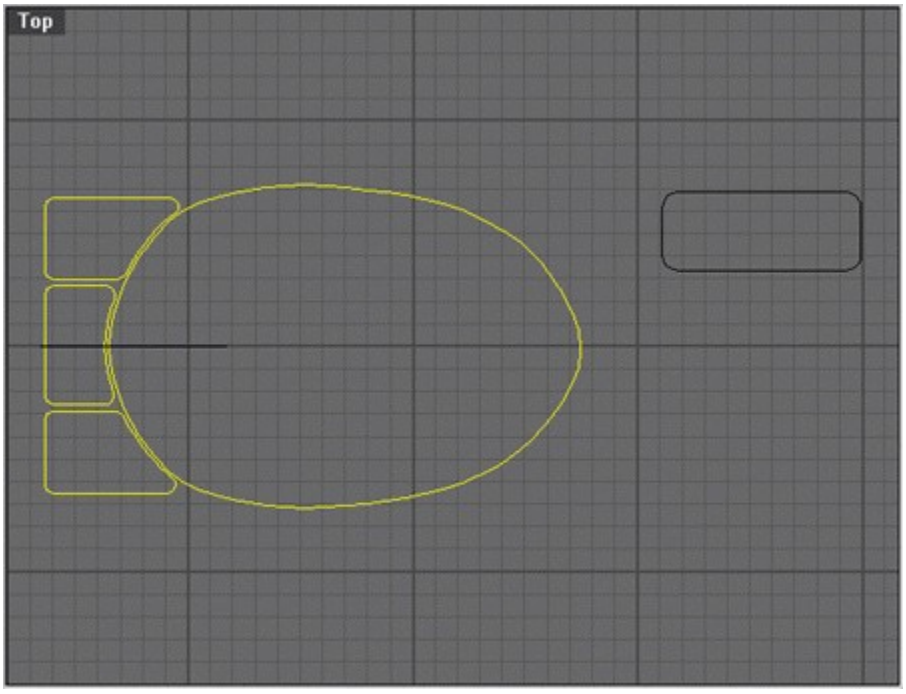
Select the resulting surface and **Scale1D** it with the origin point being near the center of the object and flatten it to about a scale of **.6**, which can be typed in when asked for the scale factor.

And that's it. Hide the curve layers and save the file.**Body Detail**

Overview: To make the tank look cool we need much more detail and one way to do it is to use adaptable parts so that with a few curves you can mix and match and reuse them in different ways to make new parts. Another thing you can do is use booleans to make the job easier. One thing most tanks have is a lot of vents on them.

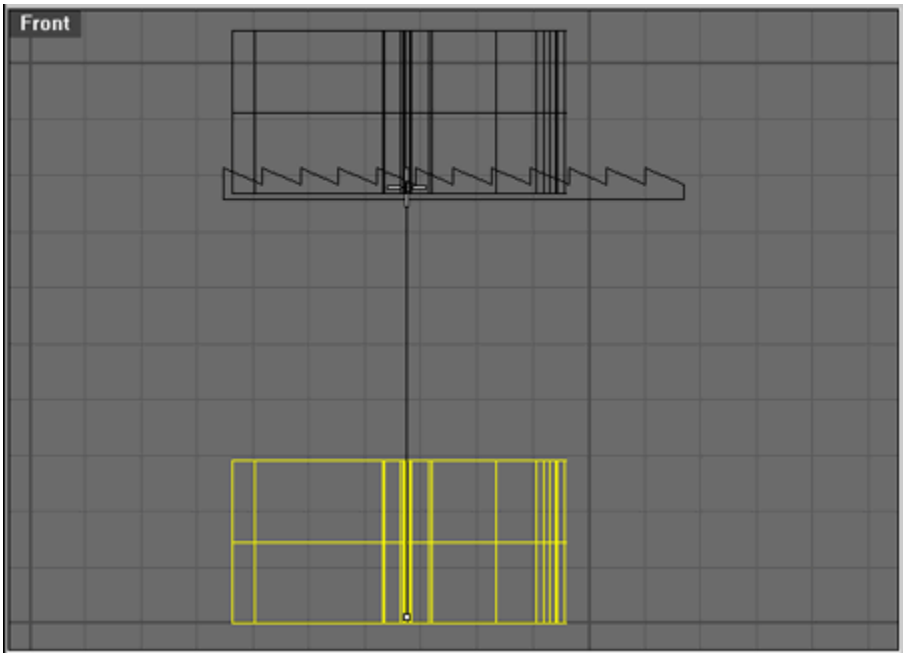
Open detail_curves.3dm file and save it out as detail.3dm on your local hard drive in your subdirectory called tank.

Explanation of curves: The large oval in the top view is a curve created using the **Silhouette** command. The Silhouette is a curve that outlines the most outward edge of an object from any view that is active. In this case it's the Silhouette of the turret from the top view. I wanted this curve so that I knew where to put the vents that are right behind the turret. The 3 rounded rectangles on the left are for the vents to be booleaned out and the rounded rectangle in the upper right is for a flat Boolean to be taken out of the tank body to make room for a sensor thingy.

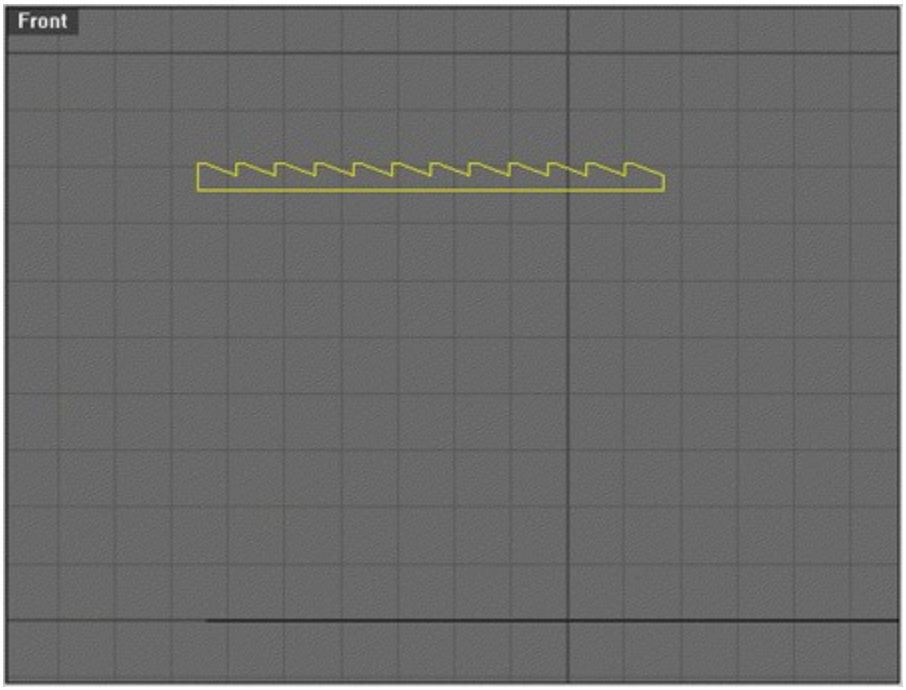


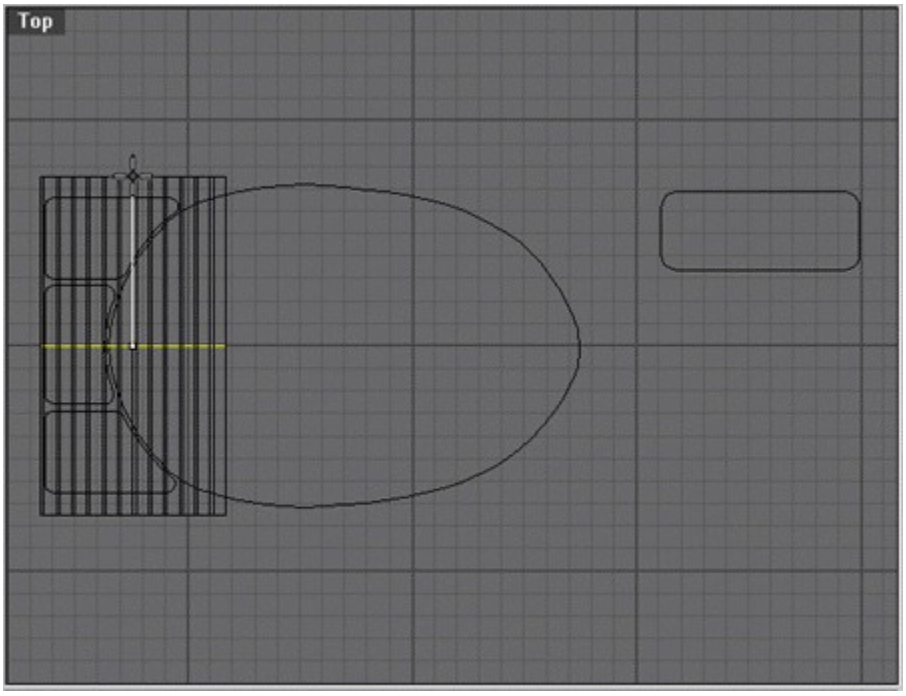
Select the 3 vent outline curves and hit **Extrude** '**C**ap=Yes' and give them about a 3 grid height in the front view.

From the front view select the three new polysurfaces and move them up so that the bottoms of the new rectangles are just above the bottom of the vent curve. Shown in progress below.



Select the vent curve from the front view and hit **Extrude,** use the '**B**othSides' option, and extrude the curve beyond the height of the 3 polysurfaces shown in progress from the top view, in the second image below.

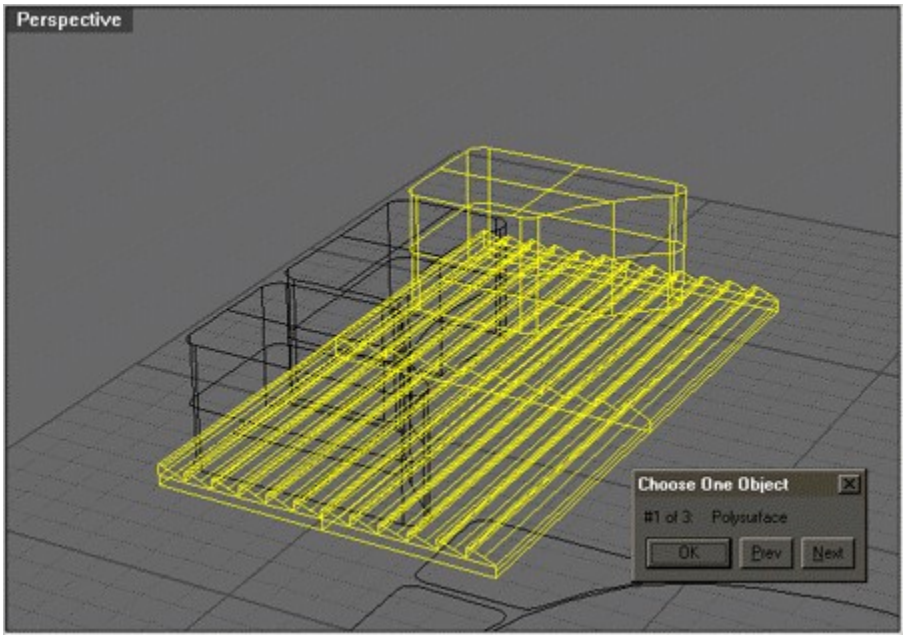




Copy '**I**nPlace' the new vent surface 2 times.

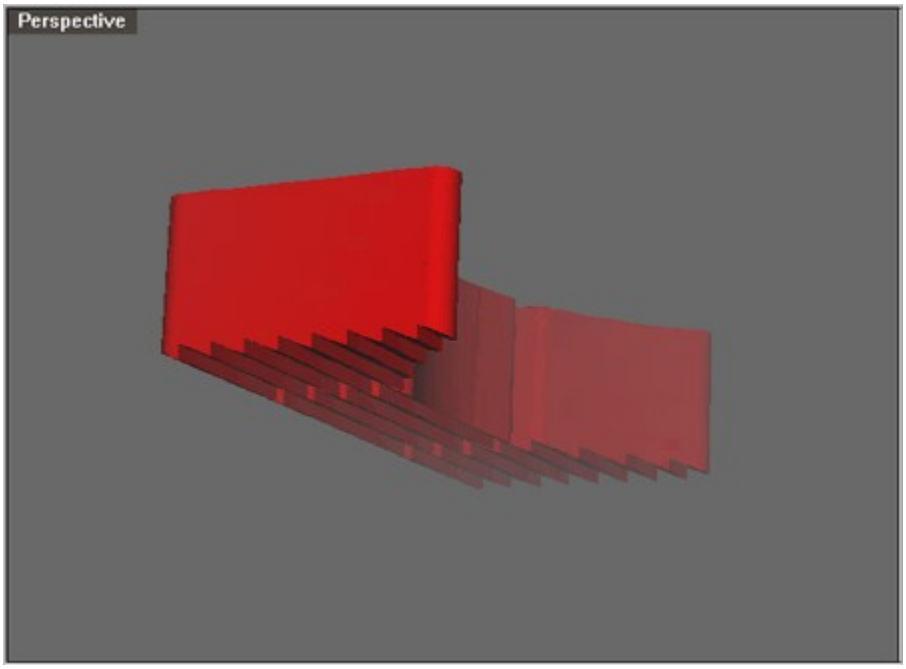
Hit **BooleanDiffence** and select the far vent outline object and then select one the copied vent objects as the object to subtract. It doesn't matter which one. Shown in progress below.

> **Note:** With all boolean operations it is wise to check the direction (**Dir**) of the normals of the surfaces. The reason for this is bacause BooleanUnion, BooleanDifference, and BooleanIntersection all conduct their operations according to the surface normals. For instance if you had 2 spheres with both surfaces with there normals facing outwards then they would behave as their respective icons would suggest. but if one of the spheres had it's surface normals face inwards (indicated by the arrows when using **Dir)** then the results of BooleanUnion would act like a BooleanDifference.



Repeat the above step selecting the middle vent outline object first and then again one of the vent objects as the object to subtract.

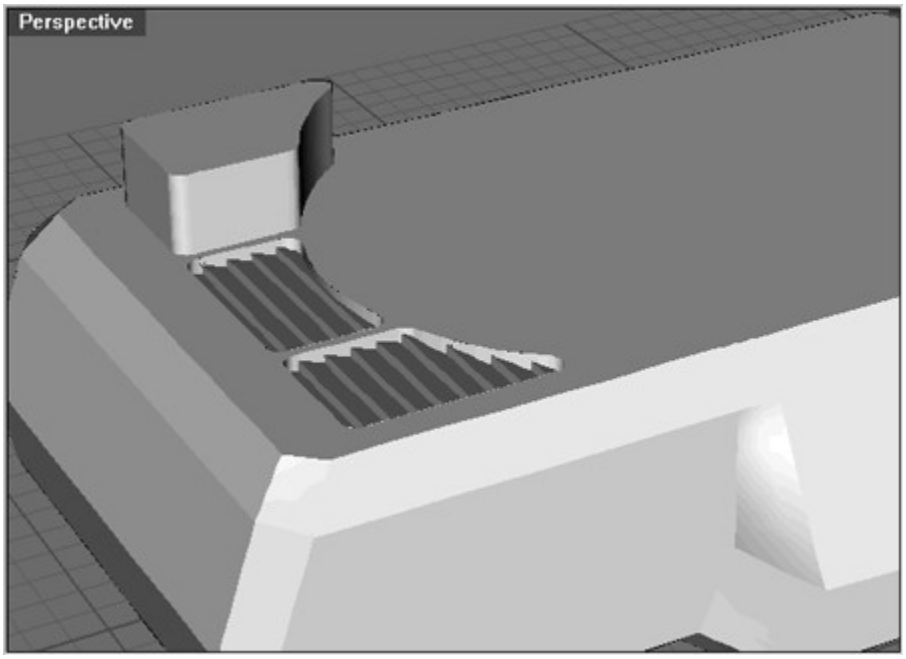
Repeat the above step on the last vent outline object. Result shown below.



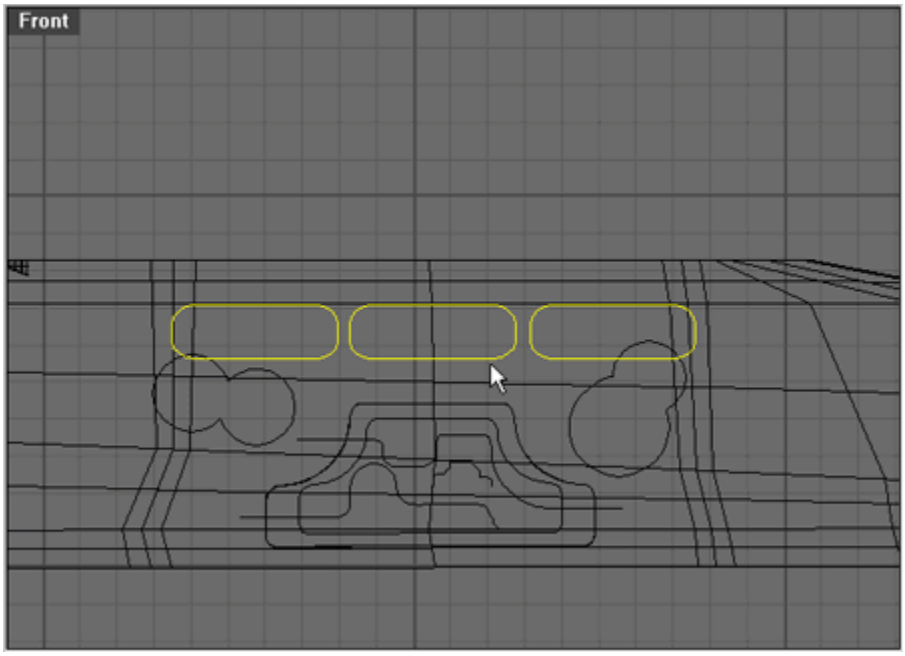
Save your file (as detail.3dm) and open the body.3dm file and select the body surface and hit **Export Clipboard** and re-open the details.3dm file and hit **Import Clipboard**. If you don't have a Export Clipboard icon or a Import Clipboard icon see the Option page below.

Option page: To build a toolbar button

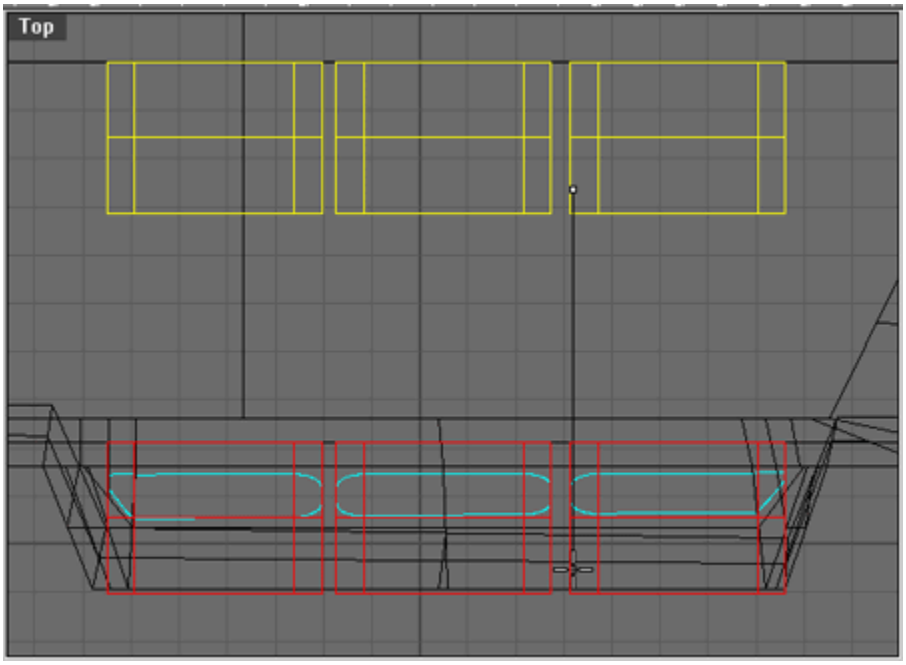
BooleanDifference the 3 vent objects from the body selecting the body first to get the results shown below.



Turn on the 'side bool curves' layer. From the front view select the 3 rounded rectangles shown below and **Project** them to the sides of the tank body and **Delete** the curves from the far side.



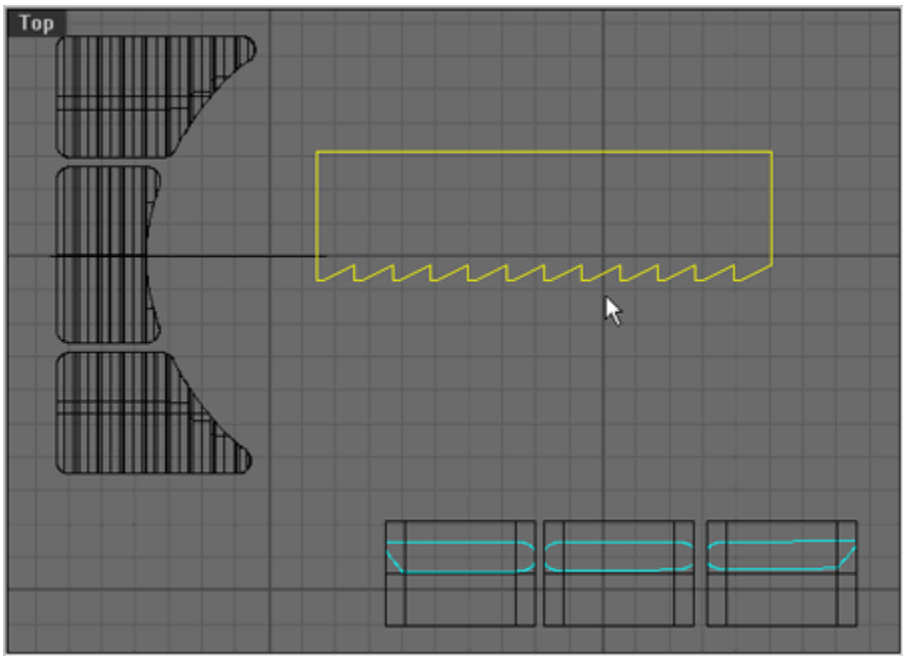
From the front view **Extrude** the 3 original curves about **3** grid lengths and then drag them to go through the side of the tank. Shown in progress below.



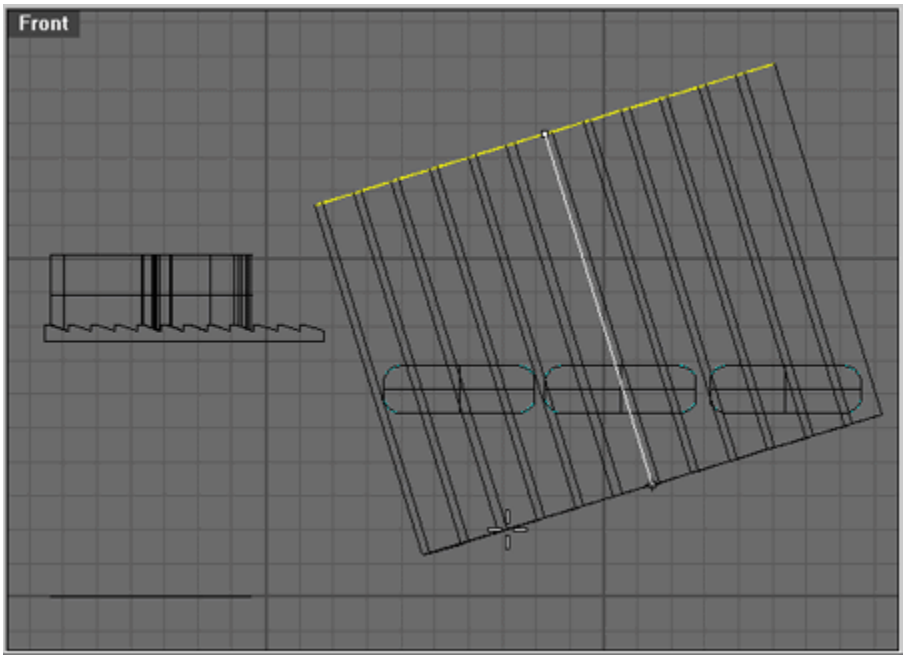
Note: the reason we made some surface objects (shown in red) to split the side of the tank is because the tank body is make up of polysurfaces and we need a Surface to split a PolySurface, Curves won't do it.

I changed the layer colors to show the relationship between the side curves (light blue) and extrusion surfaces (red).

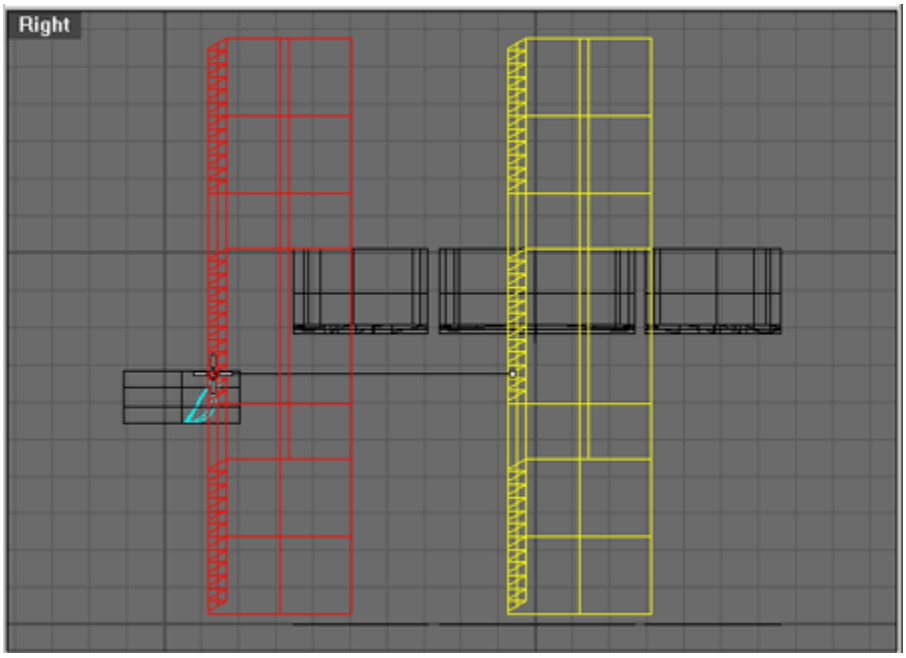
Hide the body.



Extrude the curve shown above and drag the extrusion to a distance shown below.



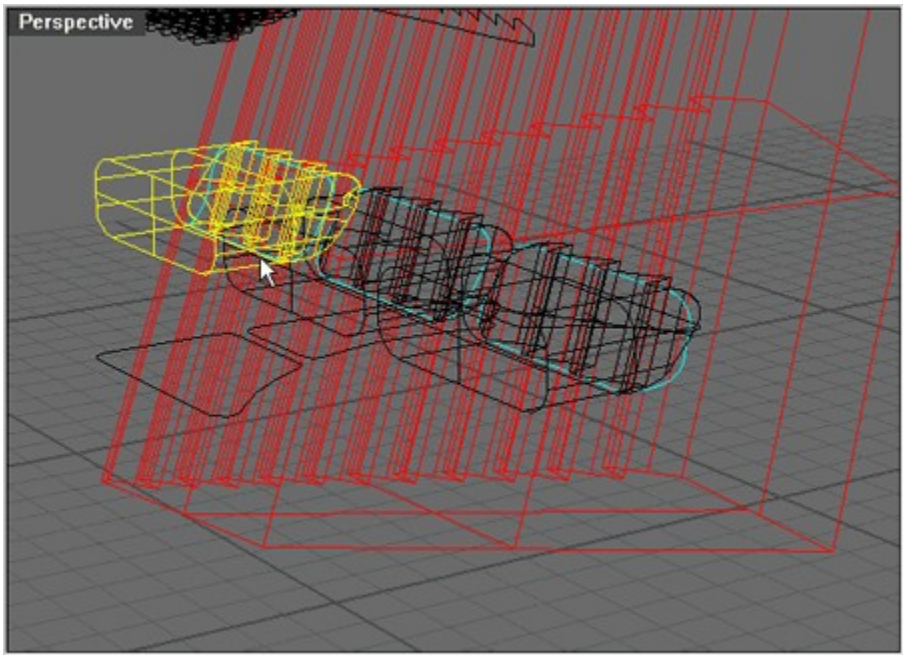
From the right side view select the Extrude object and drag to the left as shown below.



Rotate the surface clockwise to align it to the projected side curves (it's about a 20-degree rotation).

With the object still selected, **Copy** '**I**nplace' 2 times which will give us a total of 3 objects to BooleanDifference away.

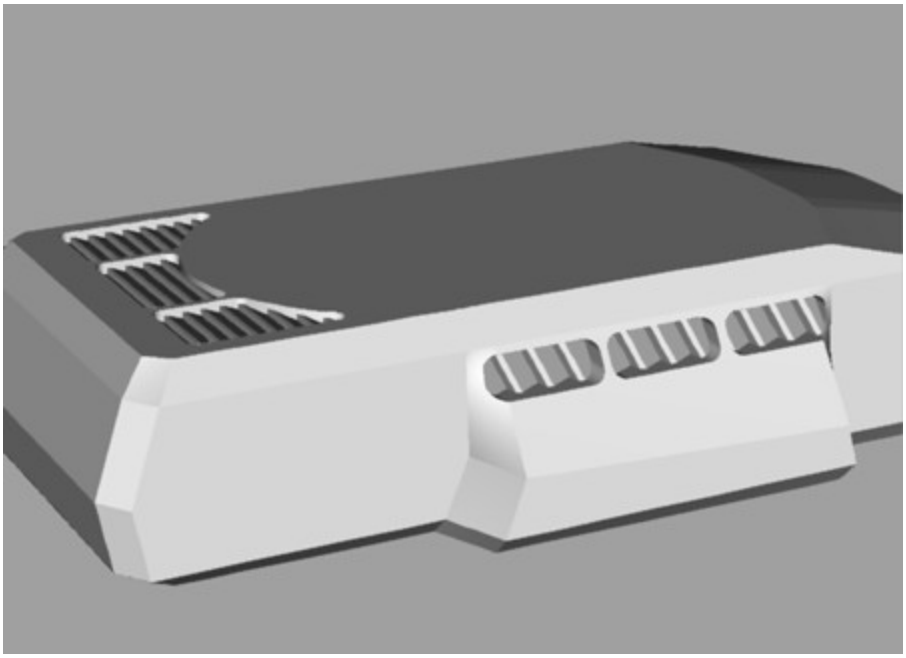
BooleanDifference the red objects from the Extruded side objects as shown in progress below.



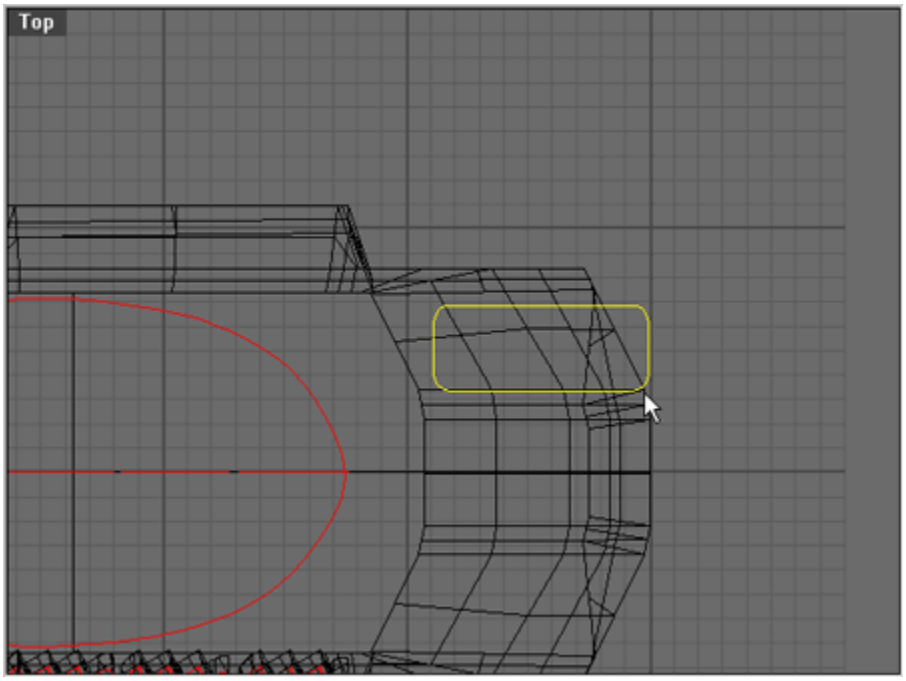
Turn off the 'side bool curves' layer and hit **Show** to unhide the body.

With the side bool objects still selected drag them in the top view about **35** units up so that they intersect deeper into the side of the tank.

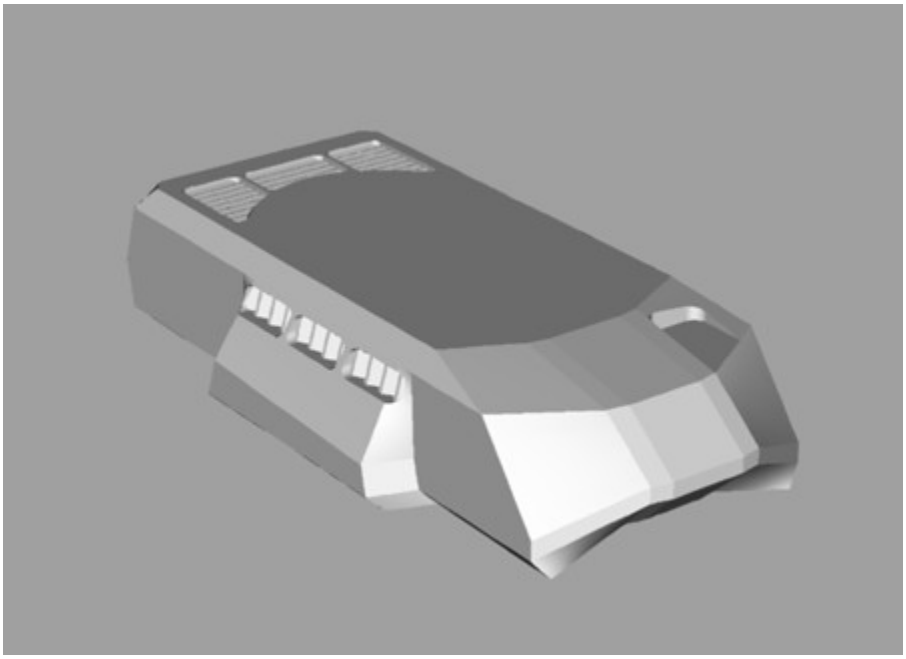
BooleanDifference the side bool objects from the tank side. If you plan on showing the far side of the tank you can **Mirror** the objects over to the far side before booleaning the near side. But if you're not sure right now create a layer and copy the side bool objects and **ChangeLayer** them that hidden layer. For this exercise we're just doing a still image with the far side hidden.



Select the curve shown below.

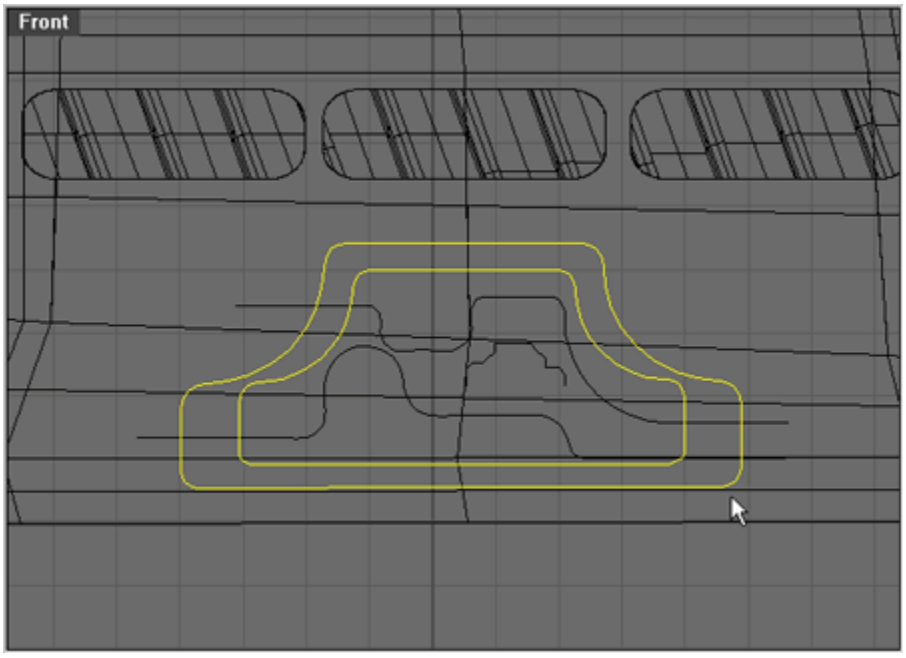


Extrude it up about **2** grid lengths and **BooleanDifference** it from the tank body to get the result shown below.

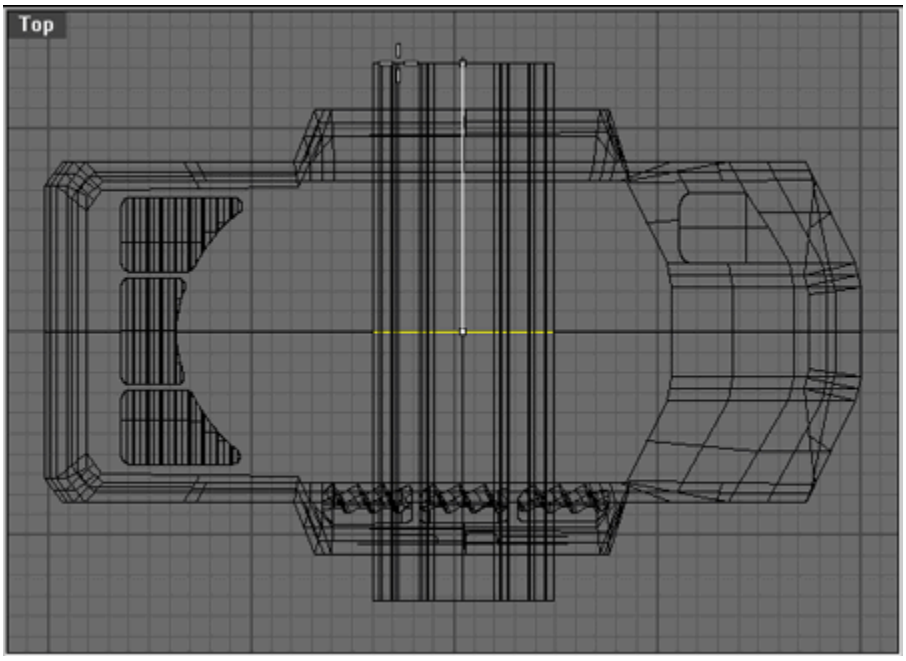


Turn on the 'mech detail curves' layer and turn off the 'body boolean curves' layer.

Select the curves shown below.



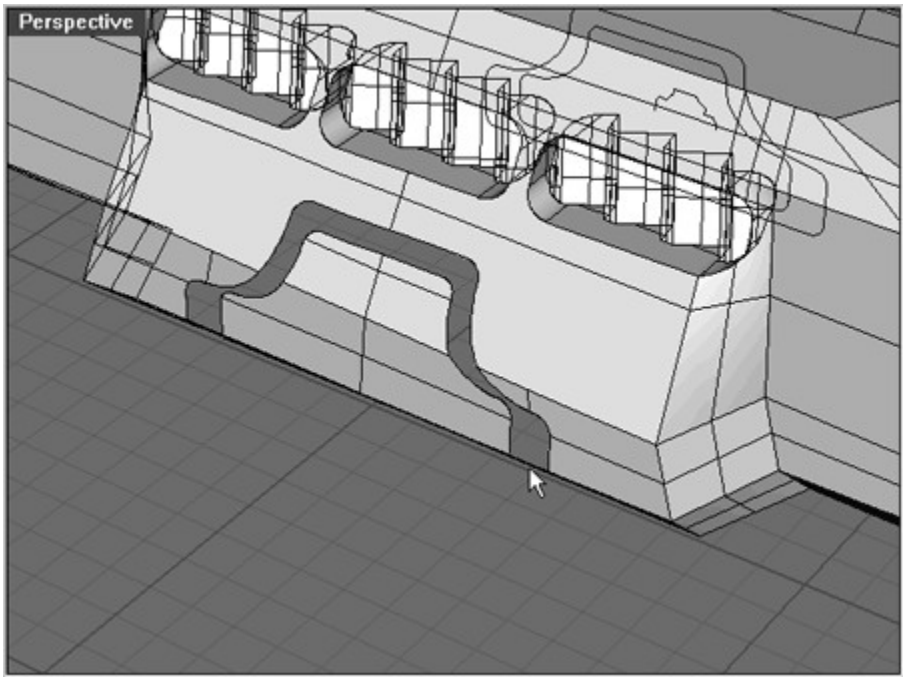
Extrude 'Cap=Yes' the curves beyond the sides of the tank as shown below.



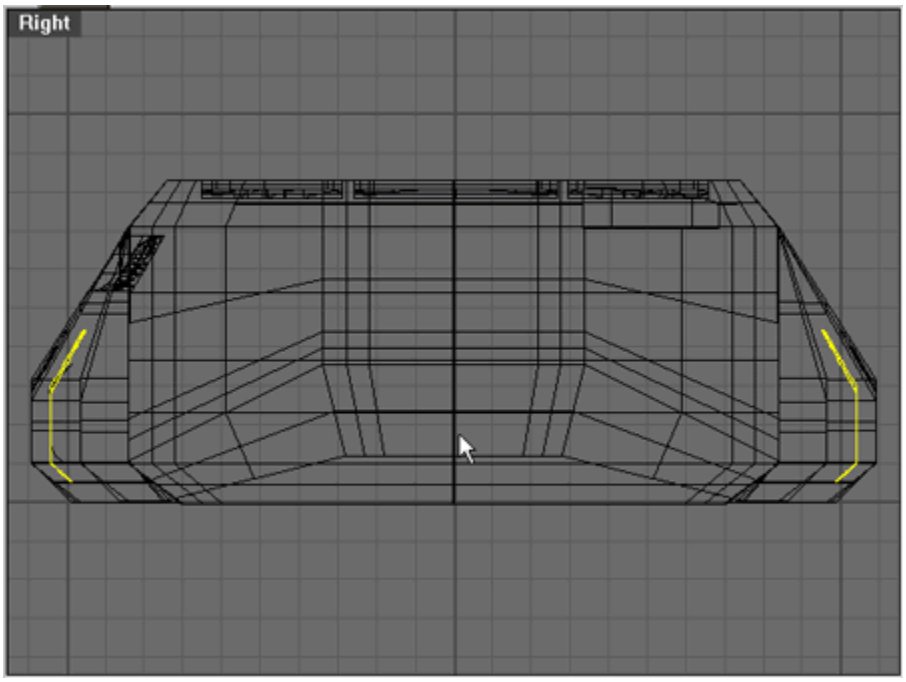
Note: When the curves are planar and you have 2 curves, one inside the other then the extrusion will be tubular in nature.

Hit **Split** and select the tank body and then the extrusion surface as the cutting edge.

Delete the extrusion and the part of the tank that the extrusion surface passed through. Result shown below.

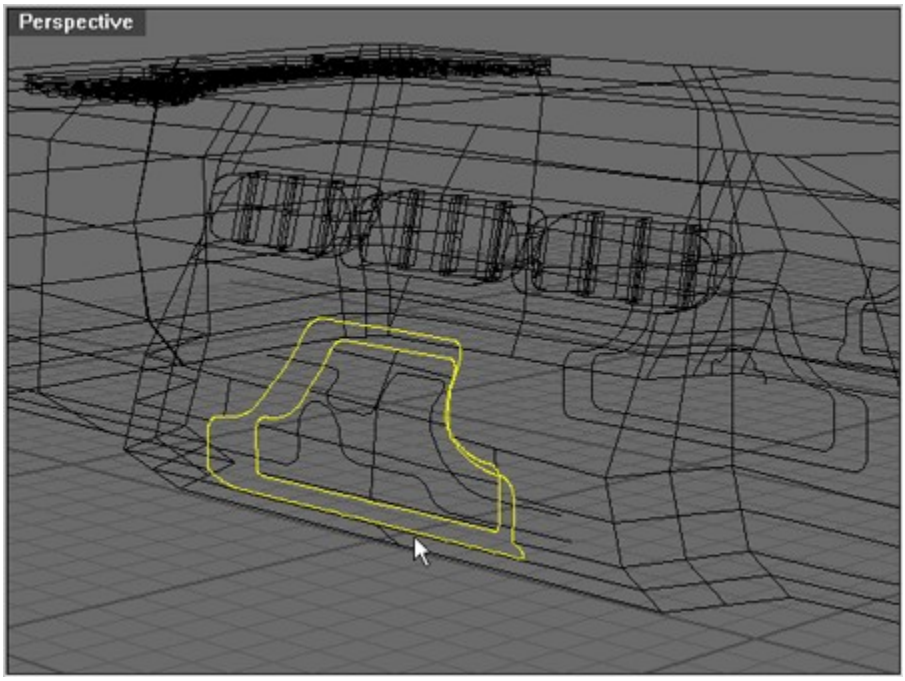


Turn off the 'mech details' layer. Select the 2 center parts of the split and from the right side view. **Scale1D** them in towards the center about a scale factor of **.95** which you can type in when prompted for scale factor as shown below.

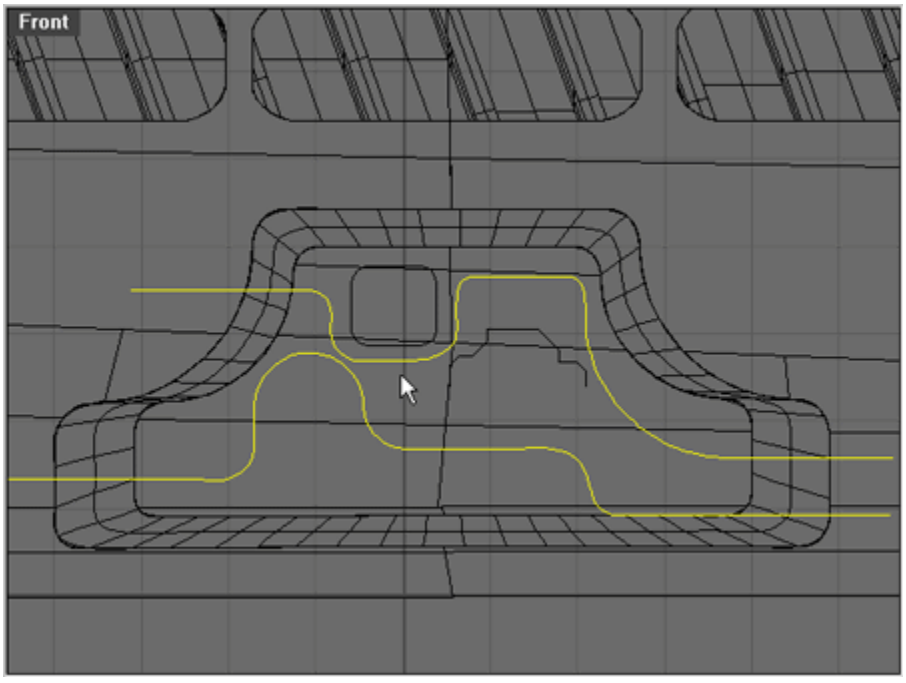


Select the tank and the 2 split out parts and hit **DupBorder**.

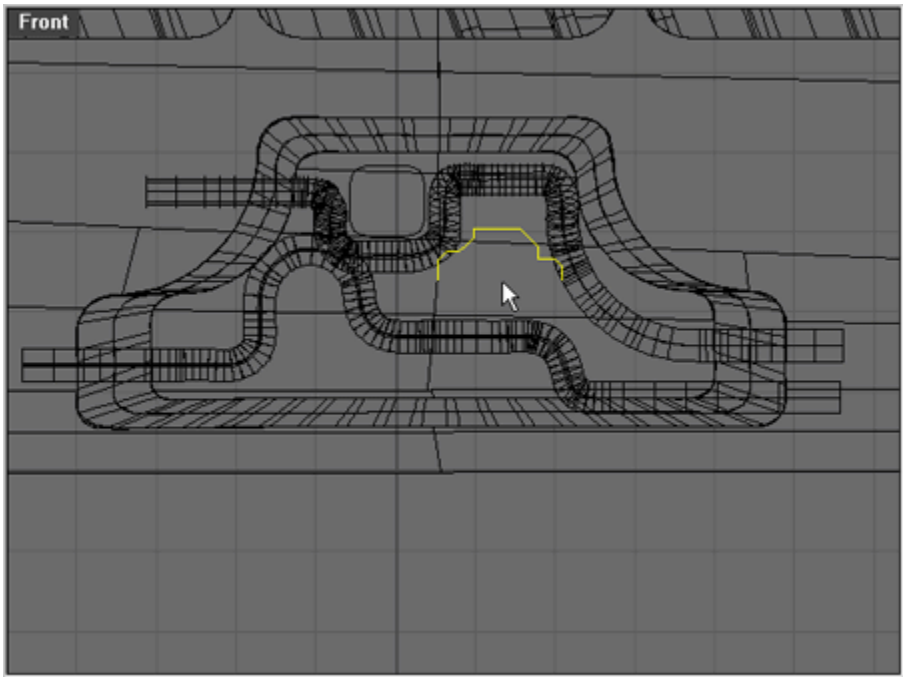
Select the DupBorders that connect the inner split out piece to the tank split edges as shown below and hit **Loft** with the '**A**utomatic' option and use the 'Normal' style and 'Rebuild with 50 points' options.



Technoid Notes: In the Loft dialog box the 'Straight sections' option could have been used and then the geometry of the body and the flange just added would **JoinSrf** together which would mean that seams would be eliminated when rendering. In this case either way is fine. If you 'Rebuild' a curve from a surface edge then the resulting surfaces will probably not join together. On the other hand, if the option 'Straight sections' is used and the surface is exploded it will probably break up into splinter pieces but a rebuild surface will not, which could be a big advantage when you are applying materials.Turn on the 'mech details' layer. Use the **Pipe** '**C**ap=No' command on the 2 curves shown below with a '**D**iameter' of **10**. Capping pipes creates a lot of geometry when meshed in Rhino.

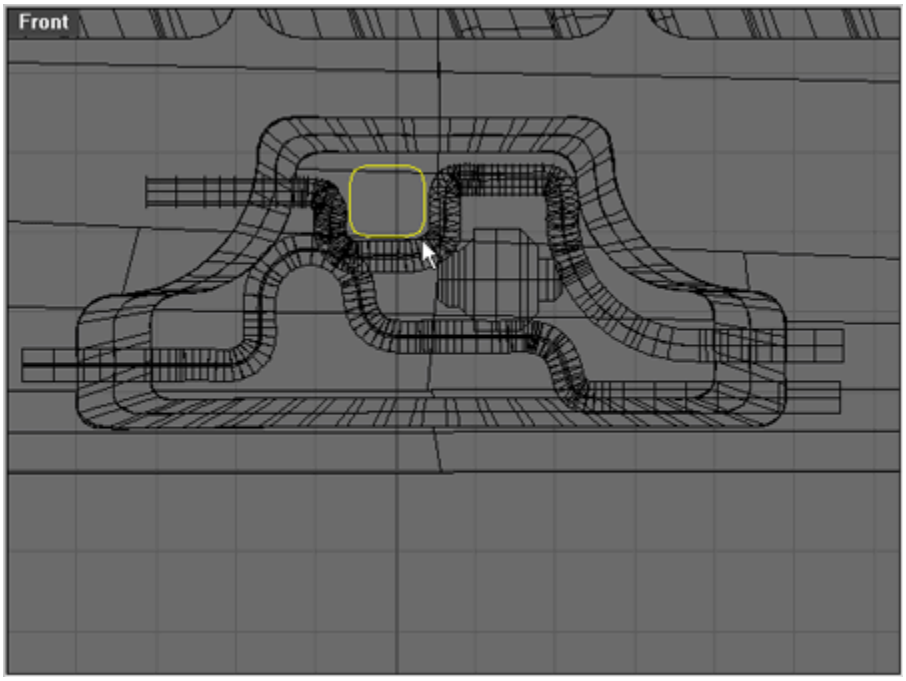


Select the curve shown below and hit **Revolve** and with 'End' osnap active revolve the curve with the axis being from one of the ends of the curve and with the shift key down, for temporary **Ortho**, drag a axis to the right and use the 'Exact' option

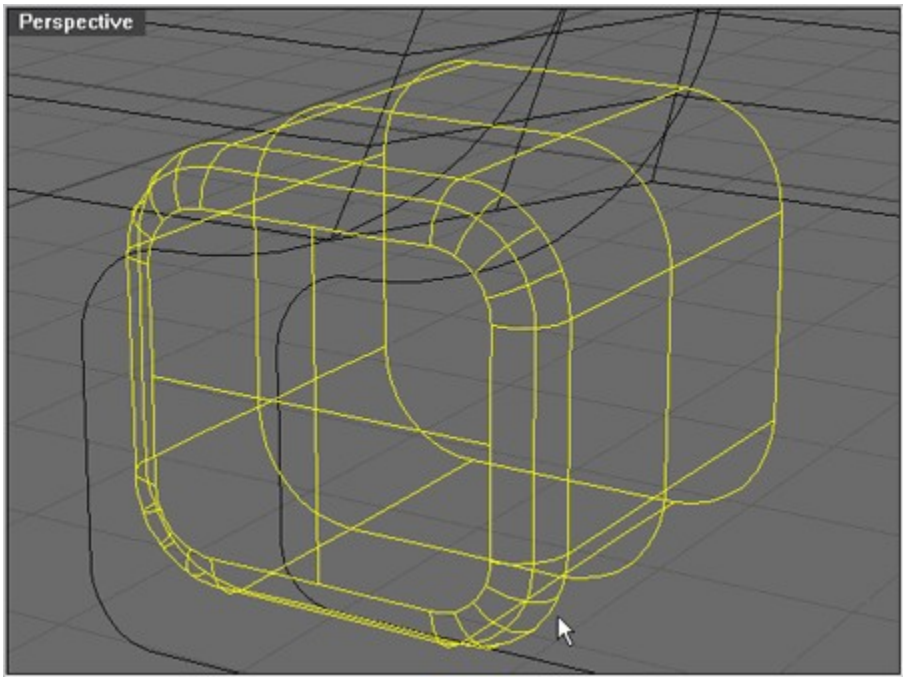


Drag the new object down from the top view so that it is half way through the tank side.

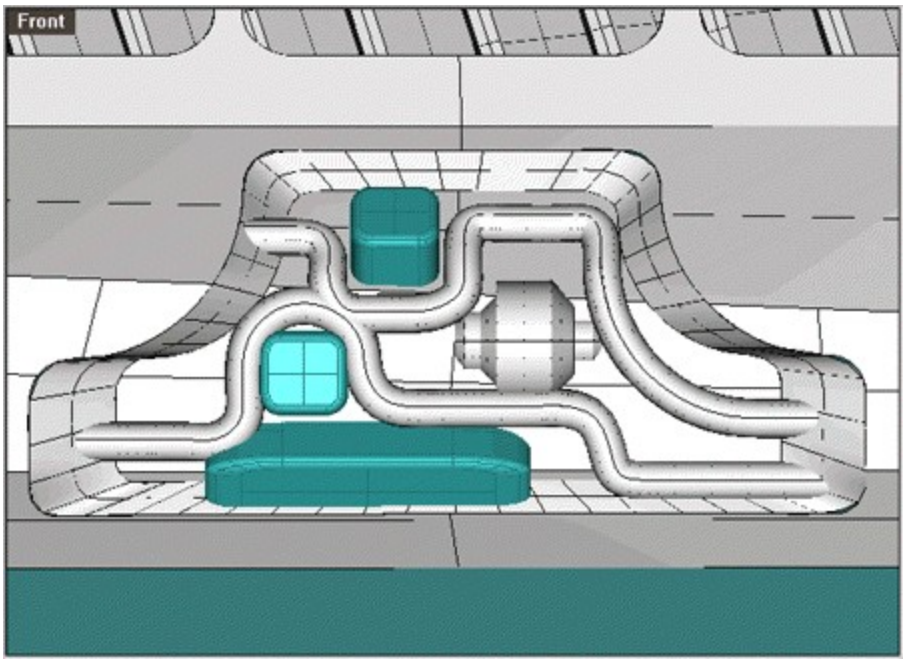
Select the curve shown below and in the front view hit **Extrude** and extrude it a distance of about 1 grid length. In the top view drag it down a few grids and hit **Explode** and **Delete** the back face of the object. Select the faces of the box and hit **JoinSrf**.



Hit **FilletEdge** '**R**adius' of **5** and select the front edge of the box as shown below.

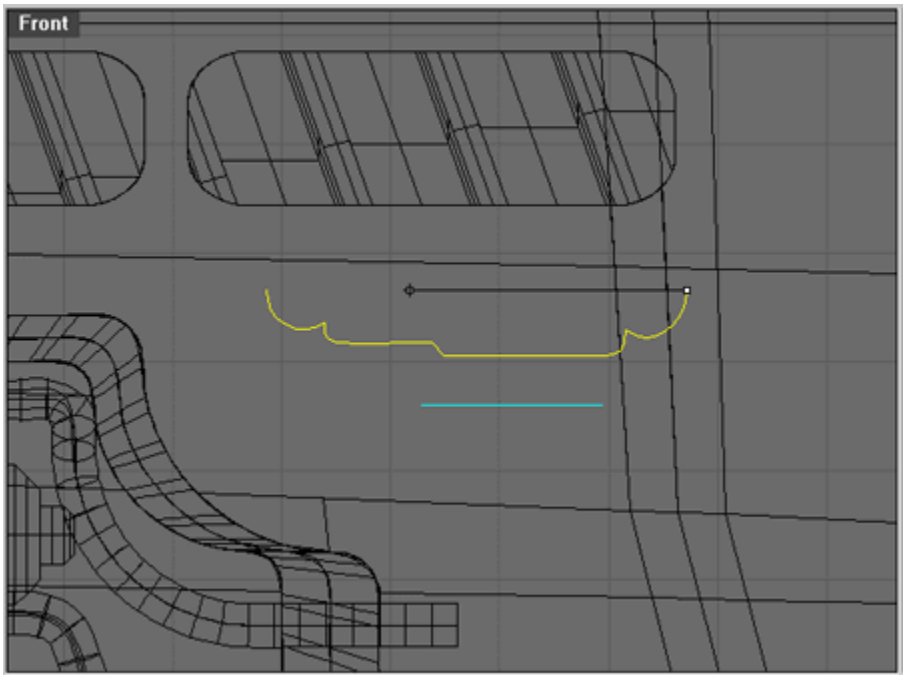


Drag the filleted box out to the side and drag, **Copy**, **Rotate** and **Scale** the copies to get them to fill in that area, indicated by the blue objects shown below.

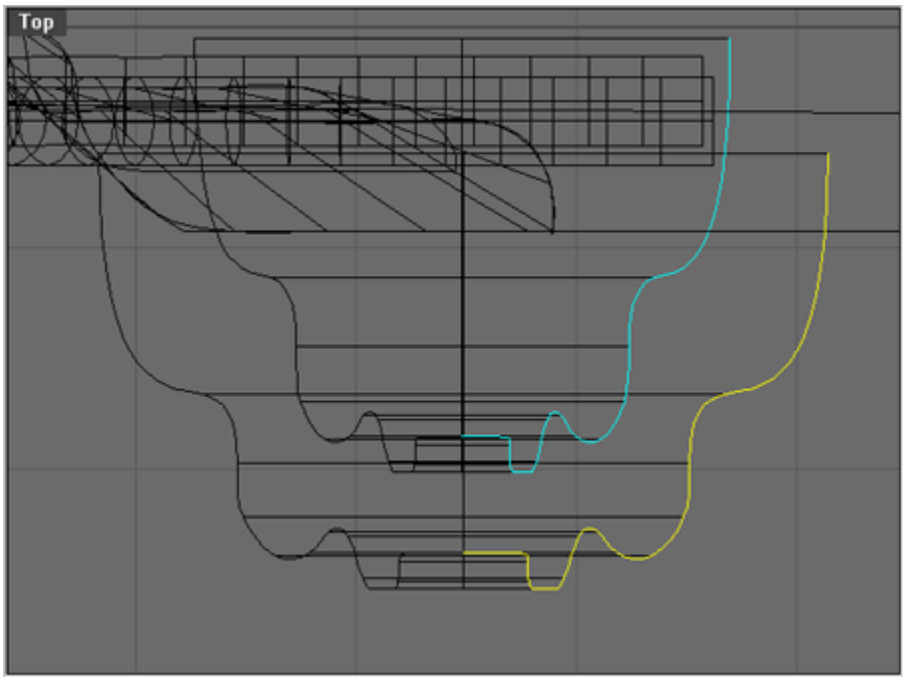


Turn on the 'hydraulic curves' layer and turn off the 'mech detail curves' layer.

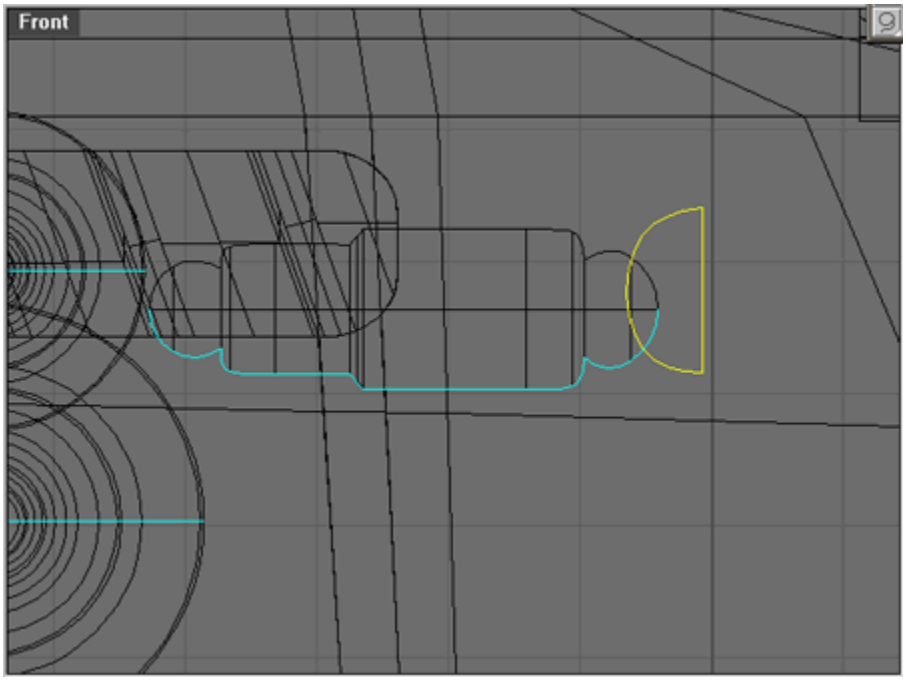
Select the curve shown and revolve it by snapping to the end of the curve and dragging horizontally with the shift key down to keep the axis **Ortho** as shown below.



From the top view select the curves shown below and **Revolve** them. 'End' osnap to the left end of the curves and use a vertical axis relative to the view.

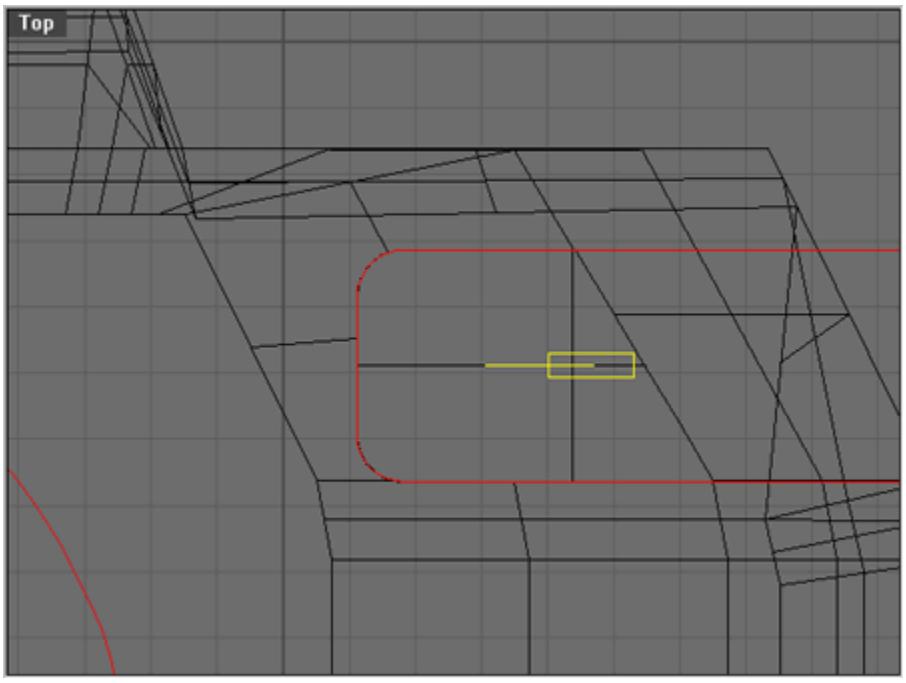


Select the curve highlighted below and from the front view and **Extrude** 'Cap=Yes' it a distance of **110**.

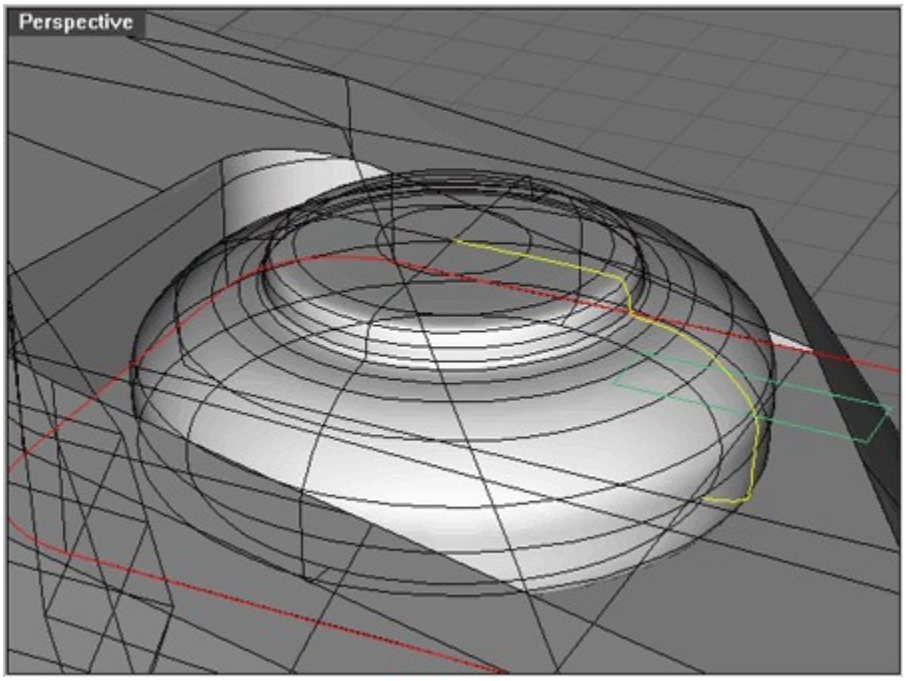


Note: Some of these objects will be needed to be dragged and rotated when the fender file is merged.

Zoom in on the curves shown highlighted below.

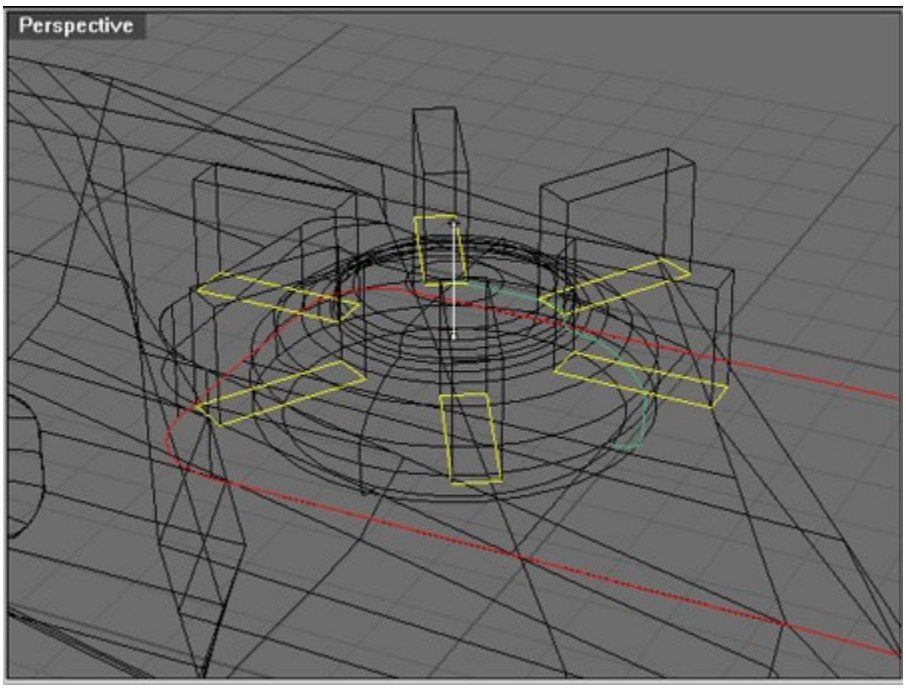


From the front view select the curve shown highlighted below and hit **Revolve** and with the 'End' osnap on, draw a vertical axis from the left side end of the curve.

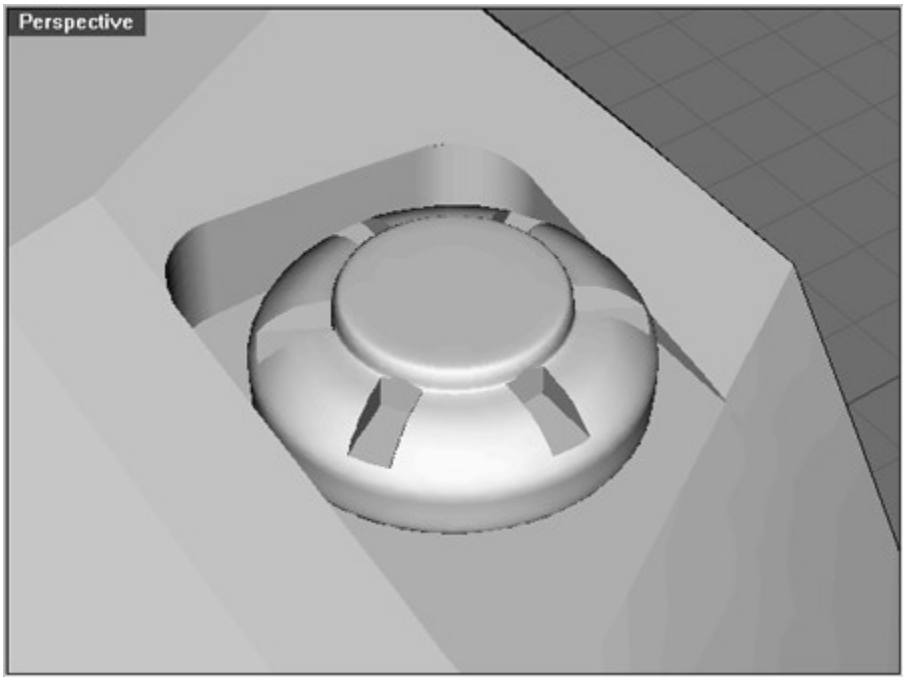


Select the rectangle shown in image at top of page, hit **Array** and in the top view and with 'End' osnap still on, snap to the center of the revolved curve when prompted for the 'Center of Axis' and for 'Number of Elements' enter **6**

Select the 6 rectangles created from **Array** and hit **Extrude** 'Cap=Yes' and type in **30** or just drag the extrusion above the revolved object. You can **Extrude** these rectangles from any view as shown below.

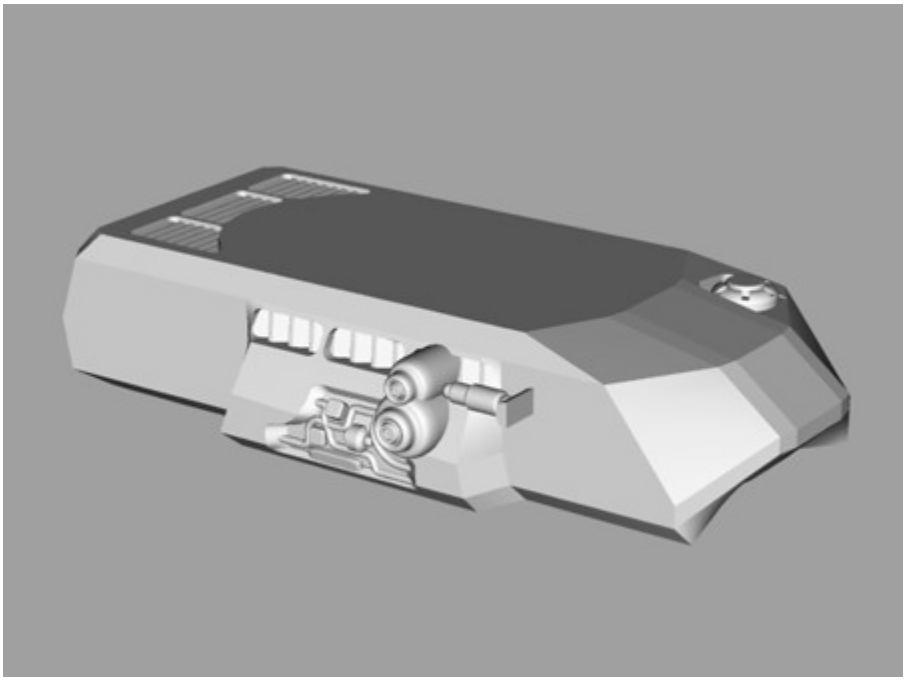


Hit **BooleanDifference** and subtract the 6 boxes from the revolved object. When prompted to 'Select surface or polysurface to subtract:,' select the revolved surface and then one of the boxes and then hit enter and hit enter again to repeat for the next box. The result shown below.



And that's it for the body details.

Save out the file but leave it open.



Assembly
Overview: Ok it's time to start putting things together and do some clean up to keep things as simple as possible.

If the details file is still open save it out and then hit **SelSrf** and **SelPolySrf** and then hit **Export Clipboard** and save it out.

Create a file and save it as 'assembly.3dm.' Hit **Import Clipboard** and leave the objects selected and create a new layer called 'body' and hit **ChangeLayer** the selected objects to that layer. Save the assembly file.

Open 'wheel.3dm' hit **SelCrv** and **SelPolySrf**. And then hit **Export ClipBoard**.

Open the 'assembly.3dm' file and hit **Import Clipboard** and create a layer called 'wheels' and **ChangeLayer** the selected wheel to the layer. Save out the assembly file.

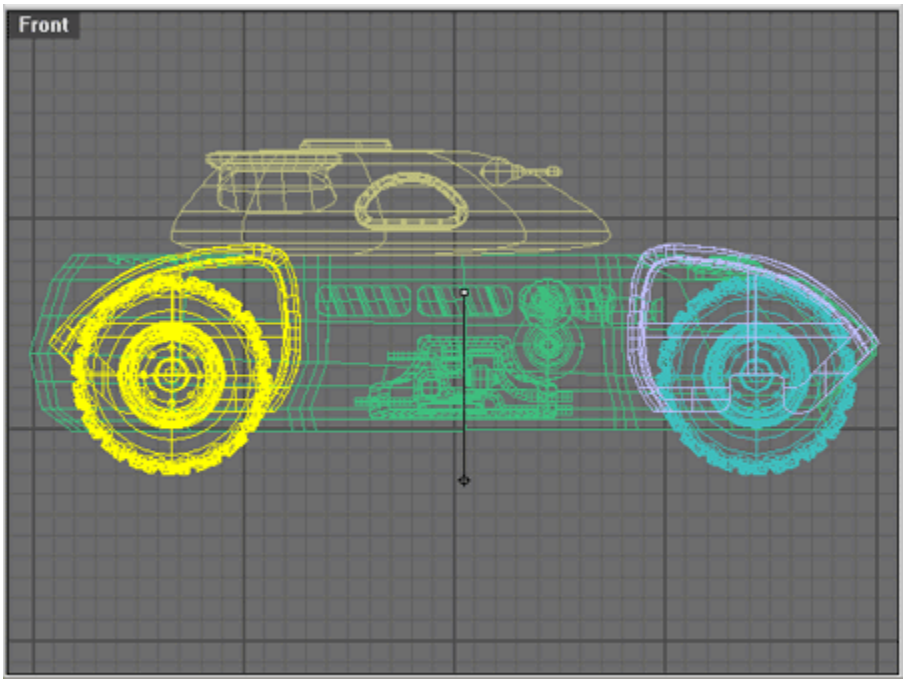
Open 'fender.3dm' and hit **SelCrv** and **SelPolySrf** . Then hit **Export Clipboard**.

Open the 'assembly.3dm' file and hit **Import Clipboard** and create a layer called "fender" and **ChangeLayer** the selected fender to that layer. Save out the assembly file.

Open 'turret.3dm' and hit **SelCrv** and **SelPolySrf** . Then hit **Export Clipboard**.

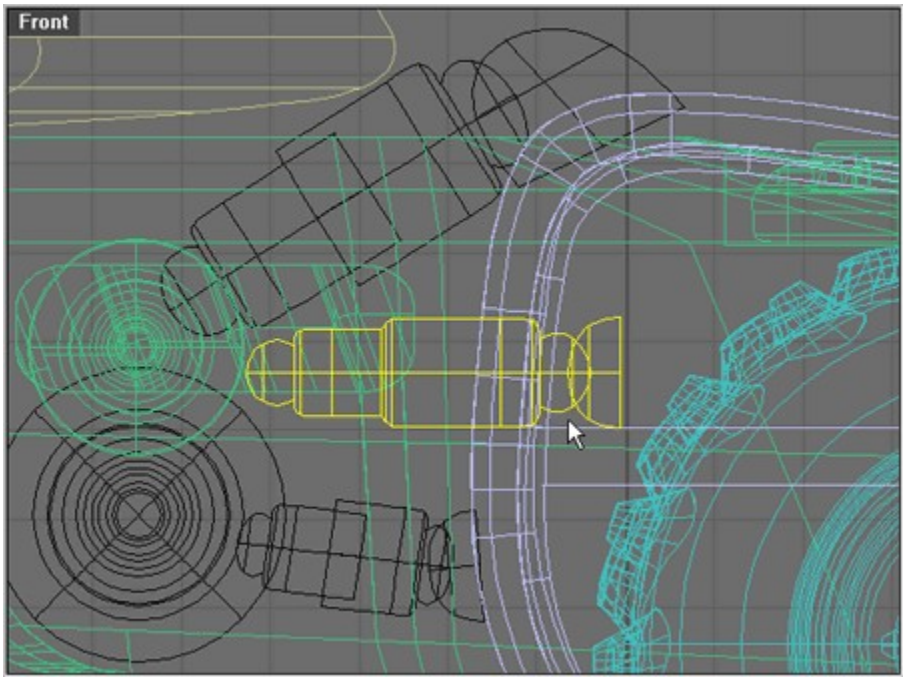
Open the 'assembly.3dm' file and hit **Import Clipboard** and create a layer called 'turret' and **ChangeLayer** the selected fender to that layer. Save out the assembly file.

SelLayer the 'wheel' and 'fender' layers and in the front view **Mirror** them over to the right. Shown in progress below.

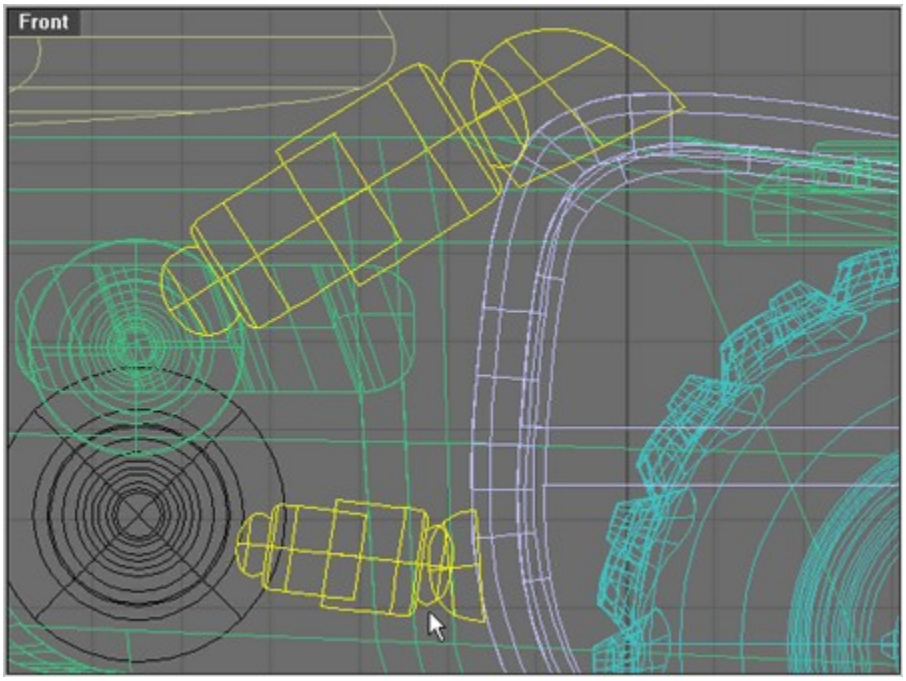


Zoom in to the center of the front view to get the hydraulics lined up to the fender as follows.

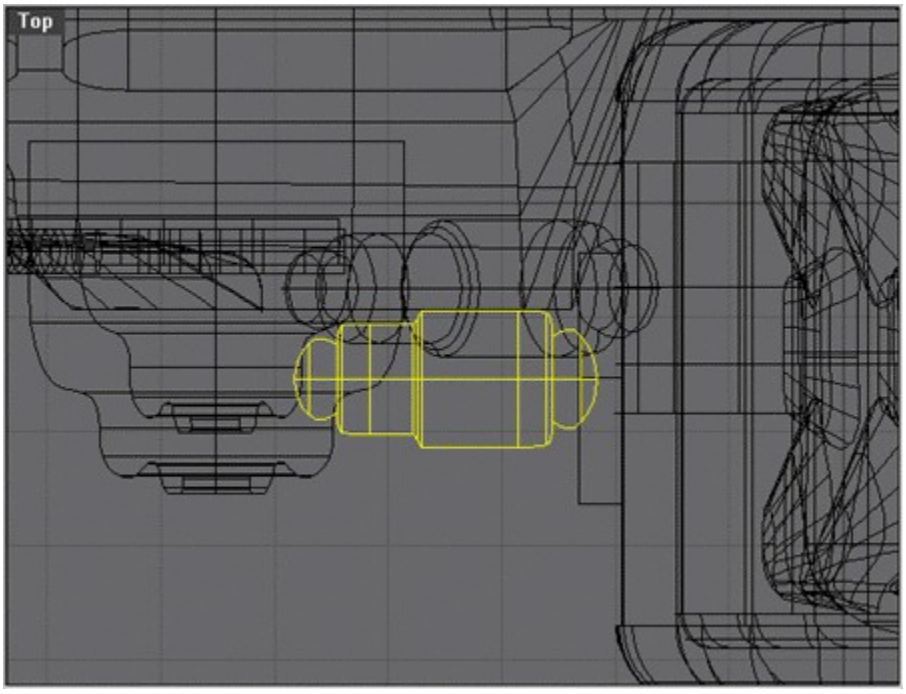
Select the hydraulic and the hinge for it.



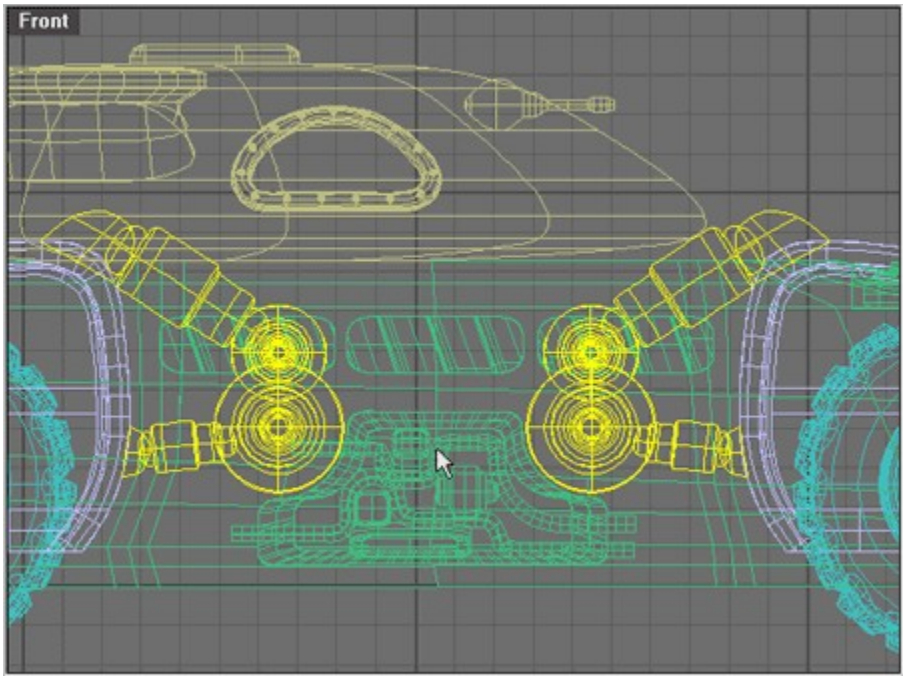
Drag, **Copy**, **Scale** and **Rotate** them to the positions shown below



In the top view select the lower hydraulic and hinge and drag it down about **2** grids.



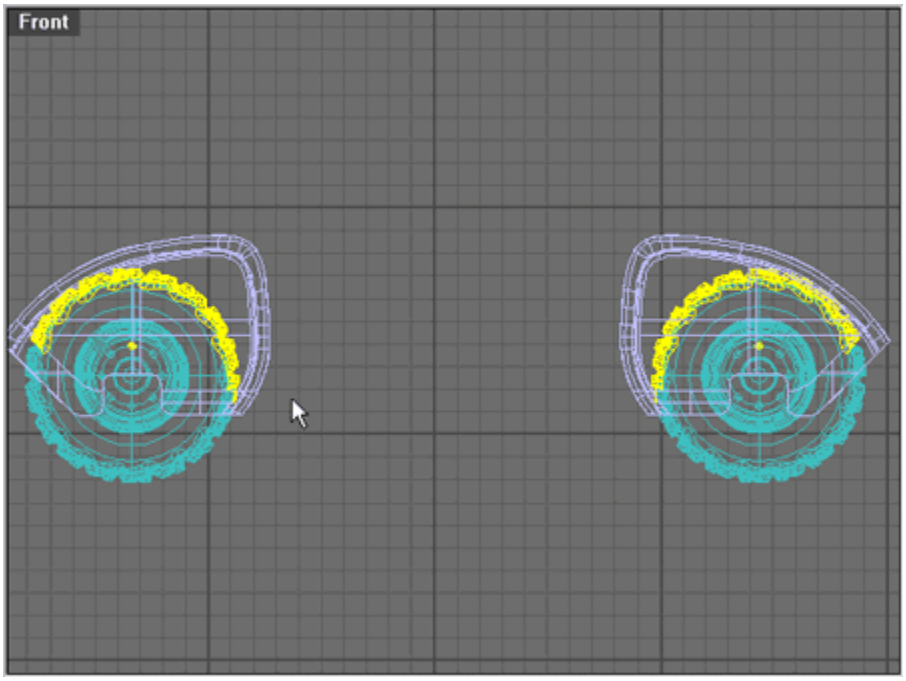
Select all the hydraulic's and **Mirror** it over to the back fender. Result shown below.



Now if the plan is to just do a still image, and for this exercise it is.. we don't need those expensive treads.

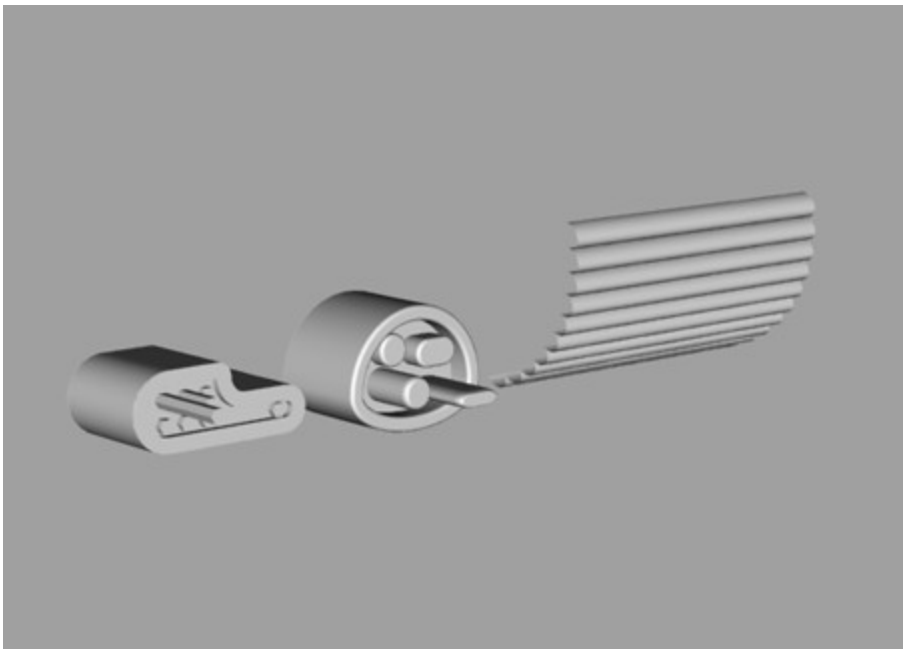
Hide all the layers except the 'wheel' and 'fender' layers.

Select the tread that is hidden by the fender and **Delete** them. On the other hand, if the plan is to do some animation the treads shouldn't be deleted .



Turn the other layers back on and save out the file.

Thingers

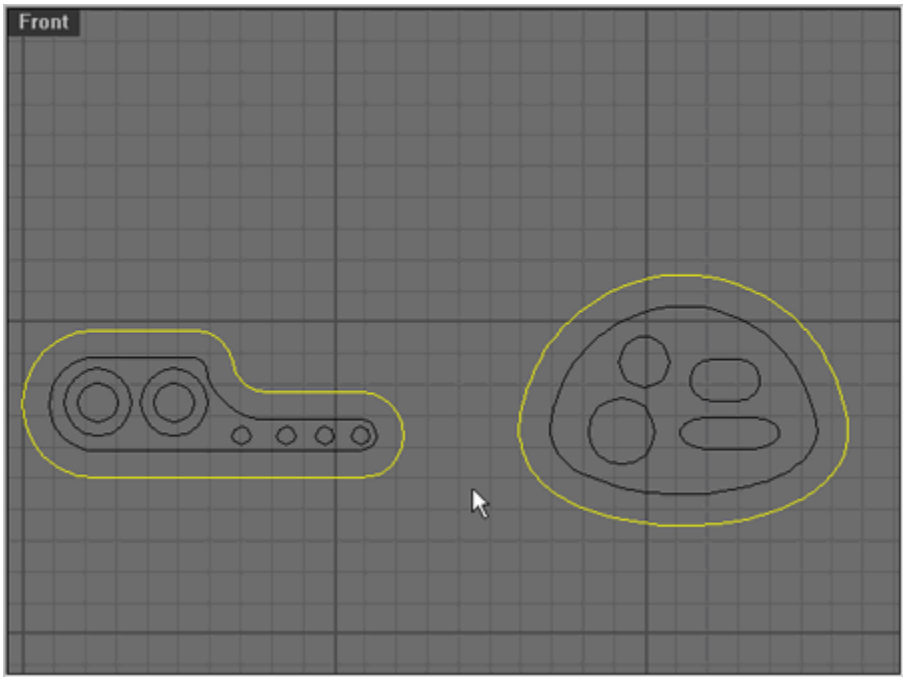


Open the thinger_curves.3dm file and save it out as thingers.3dm on your local hard drive in your subdirectory called 'tank'.

Explanation of curves: What you have here are some curves that we can **Extrude** and **Filletedge** but we also want to make them solids so that boolean could be used in a variety of ways. The nice thing about booleans is that you can add them in one place and then subtract them from someplace else for a completely different effect.

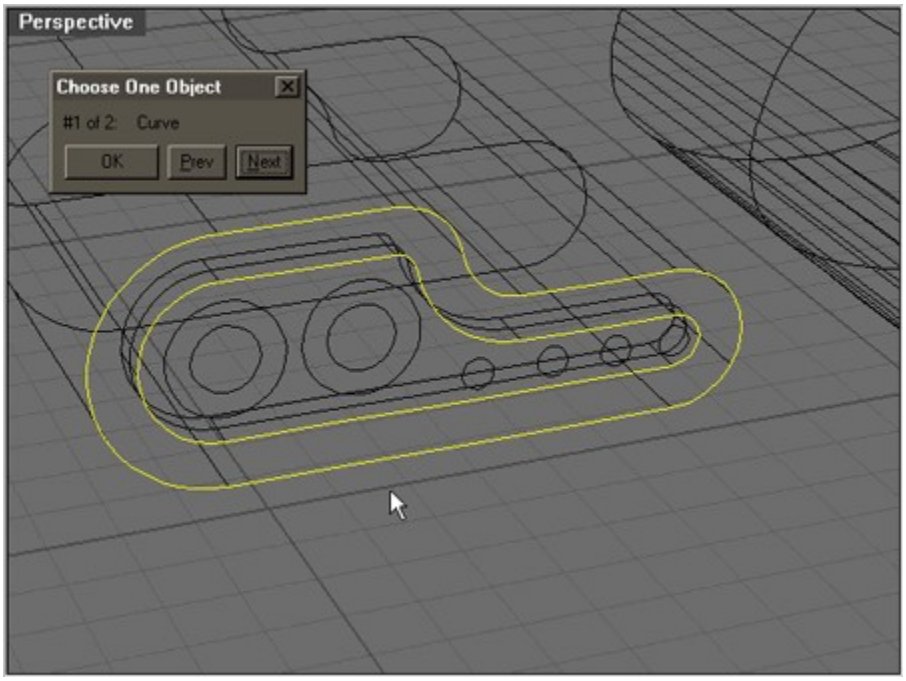
Select the curves shown below and **Extrude** '**C**ap=No' a distance of **330**.

Note: We're going to both of the objects at the same time when we can.



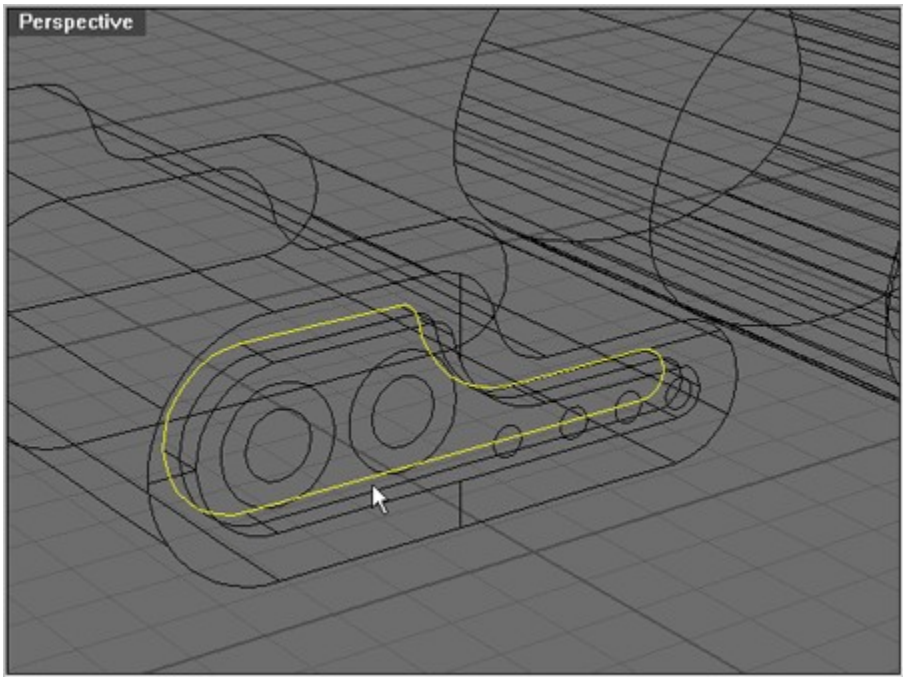
Ok select the 2 curves just inside the last 2 and **Extrude** them back about **1** grid.

Hit **PlanarSrf** and select the front edge of the outer surface when prompted to 'Select planar curves to build surface:' and then select the front edge of the inner surface. When the 'Choose One Object' dialog prompt pops up hit OK(in this case it doesn't matter.) Hit enter to complete the command. Shown in progress below.

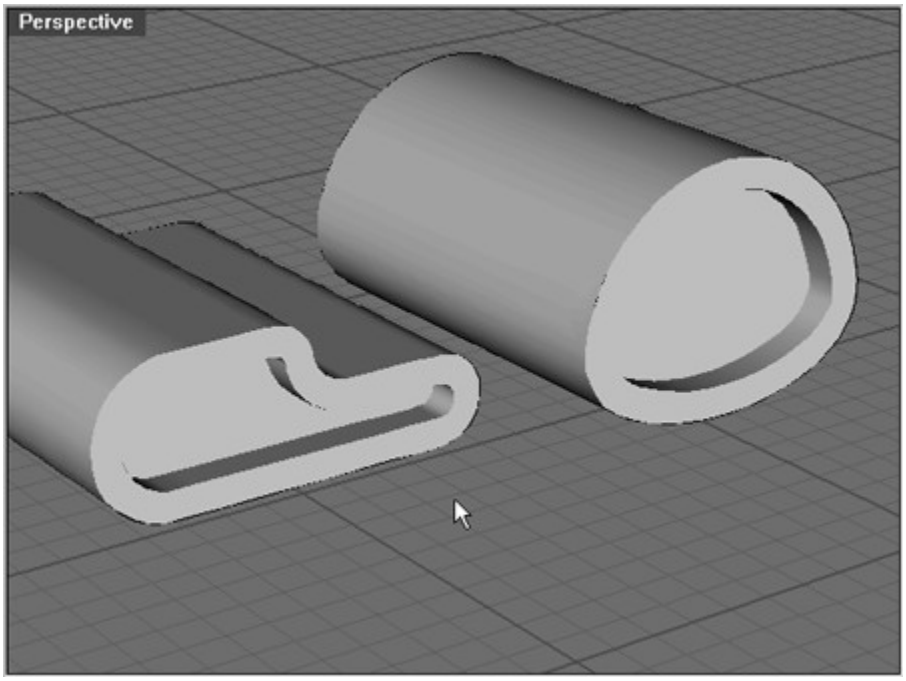


Do the same with the other object to the right.

Hit **PlanarSrf** again and select the back edge of the inner surface and hit enter to complete the command. Shown in progress below.

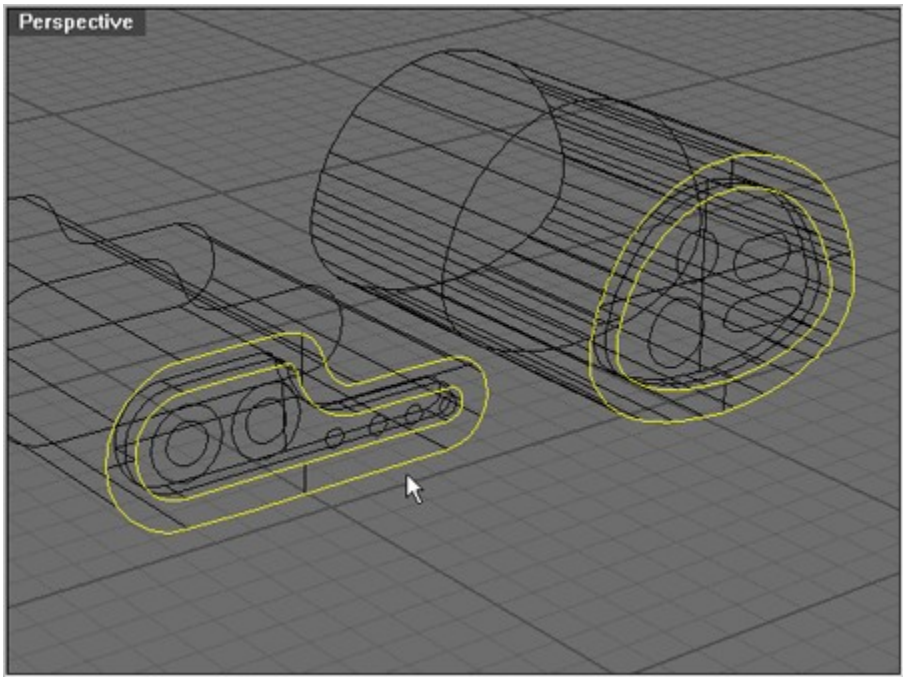


Do the same with the other object. So to get the results shown below.



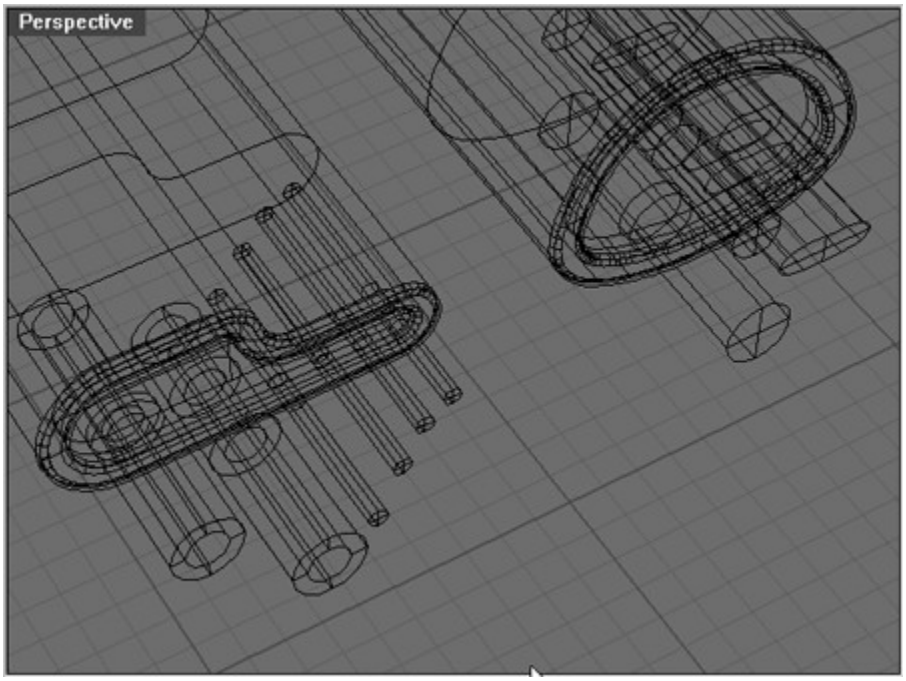
Hit **SelSrf** and then hit **JoinSrf**.

Hit **FilletEdge** with a '**R**adius' of **4** and select the edges shown below. If you get some errors about the fillets don't worry about it as long as they look Ok. But if they do look messed up **Explode** them and use **FilletSrf** instead.



Well, all we need to do now is **Extrude** the other curves at different lengths and move them so they intersect the bases and then **BooleanDifference** them so that they create a solid. Select all the inner curves that we haven't used yet and hit **Extrude** '**C**ap=Yes' and drag the extrusion about **9** grids.

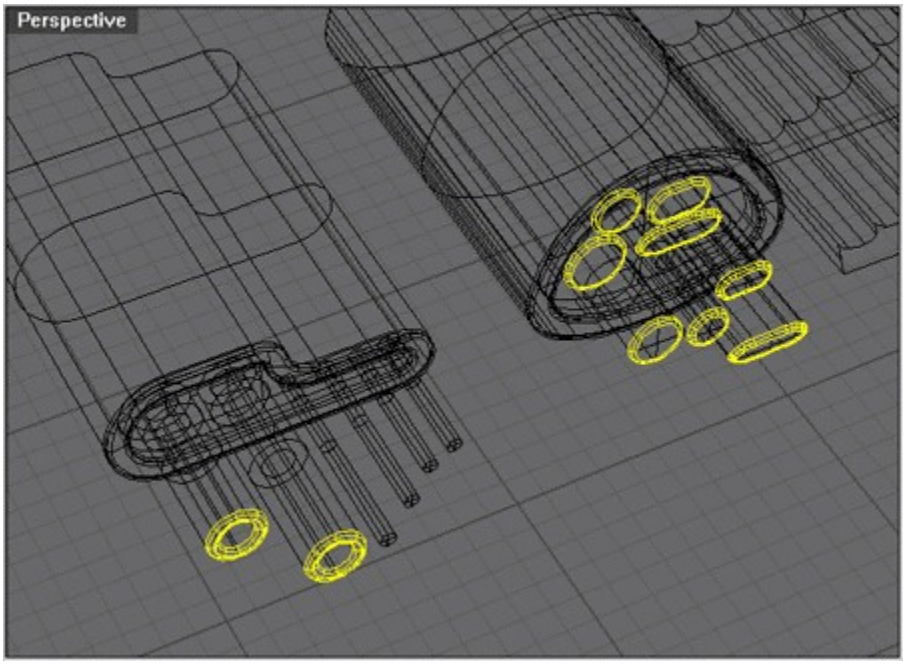
Select all the extrusions and drag them back at least **1** grid so they all intersect the 'bases' and then grab individual extrusions and move them so they are at random distances. Similar to what's shown below.



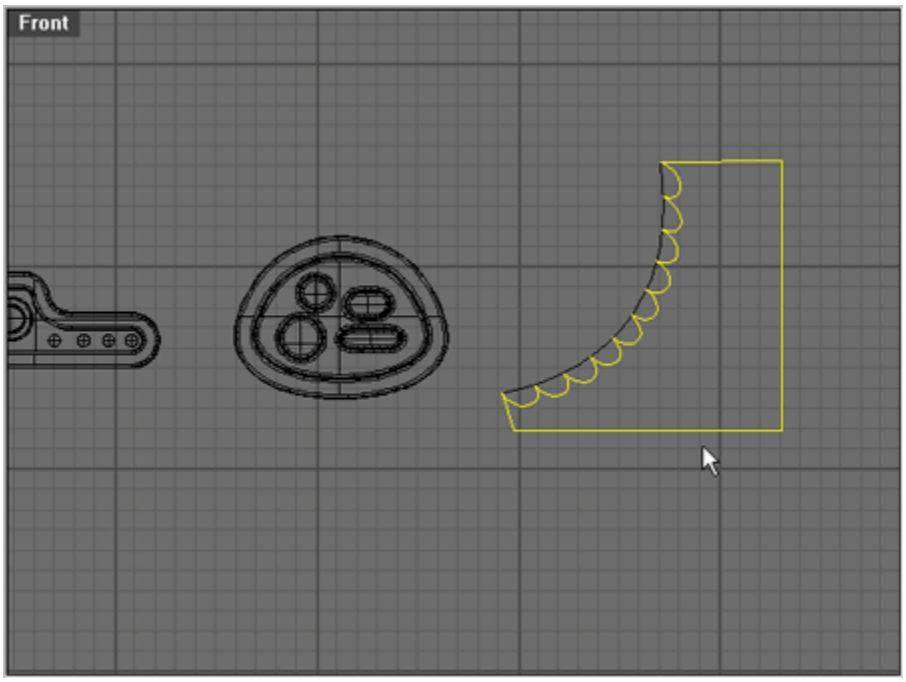
BooleanDifference the base object to the extrusion objects.

So we have 2 joined up objects and the extrusion parts need filleting.

Filletedge the ends of the extrusion objects shown selected below with a '**R**adius' of **4**.

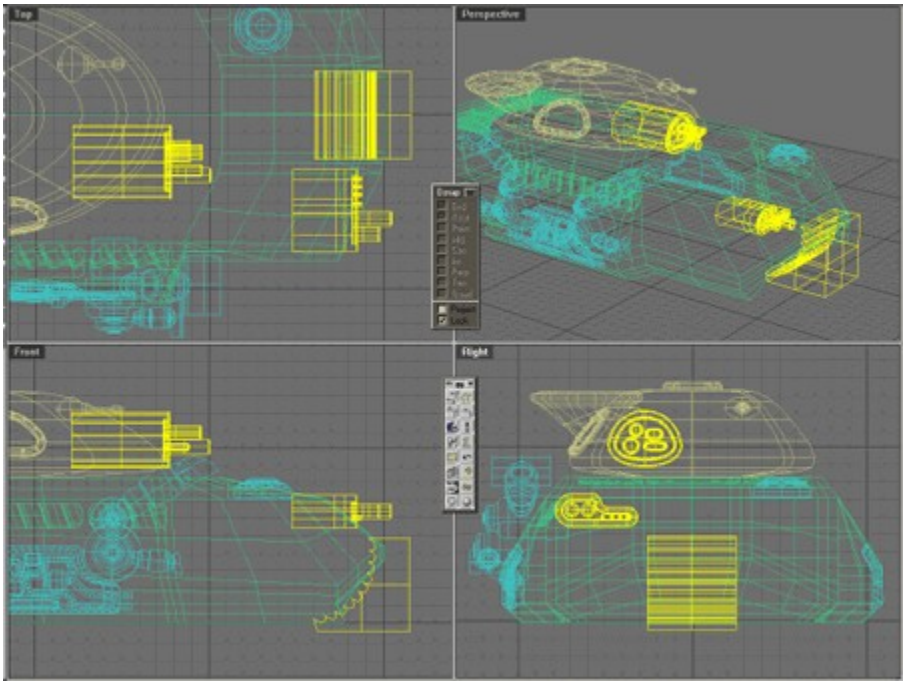


Select the curve shown highlighted below and hit **Extrude** '**C**ap=Yes' a distance of **260**.



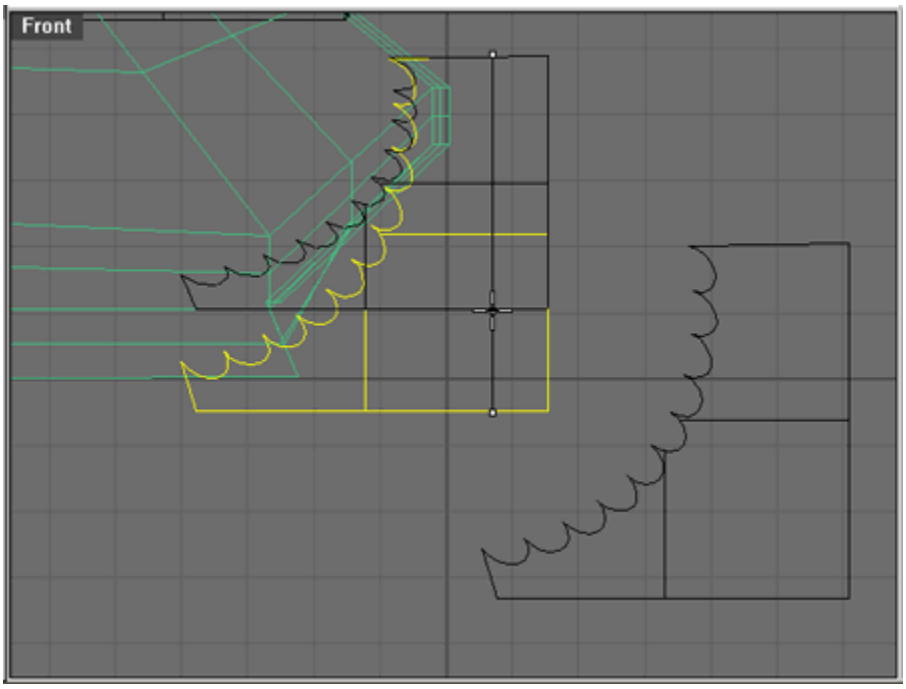
Save out the thinger.3dm file and hit **SelSrf**, **SelPolySrf** and **Export Clipboard**.Open 'assembly.3dm' and hit **Import Clipboad** and create a layer called 'thingers' and **ChangeLayer** the selected objects to that layer.

Drag and **Rotate** the thingers objects to the approximate locations shown below.



Copy the grill and drag it aside and zoom in on the grill area.

Scale1D the grill as shown below. It's scaled from the top with a factor of **.7** with temporary **Ortho** on. The object of this scaling is to have the grill completely within the body surface.

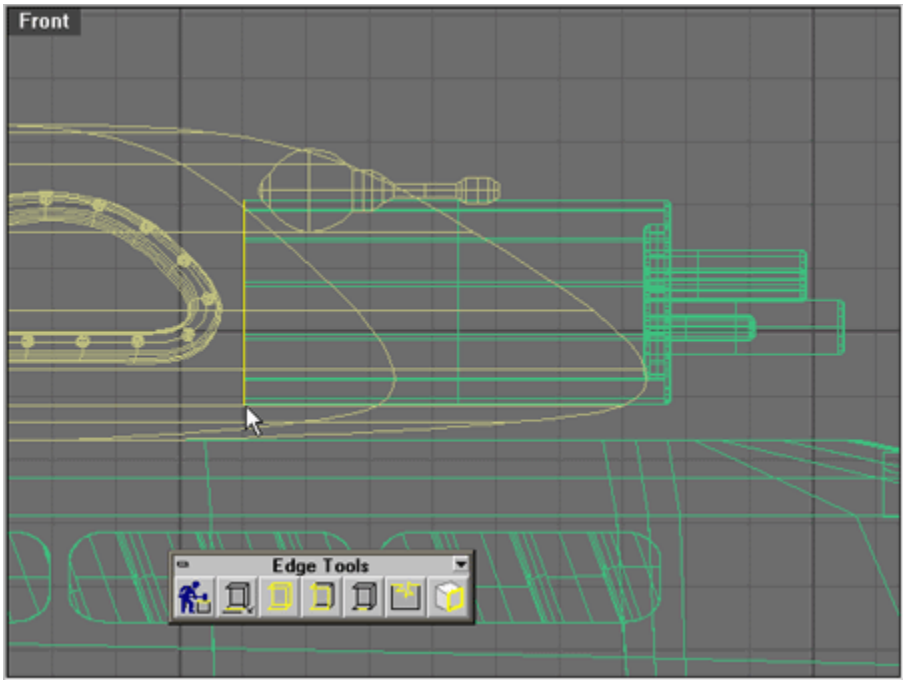


Hit **BooleanDifference** and select the body and then the grill to subtract it from the body. If it doesn't subtract just make sure the grill is completely within the boundaries of the body.

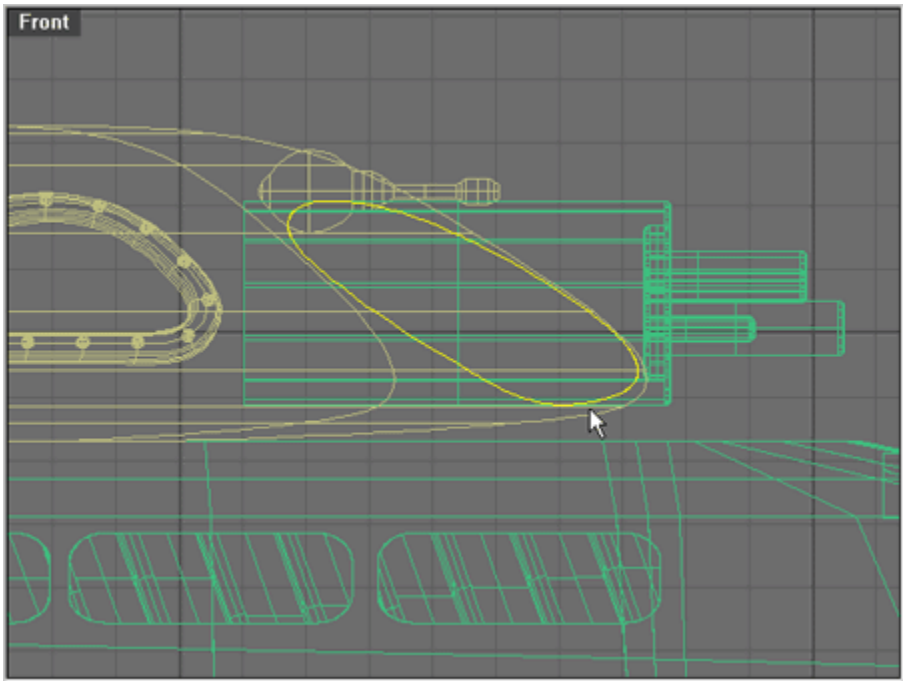
Drag, **Rotate** and **Mirror** the second grill to subtract it from the back of the body.

Select the turret sensor and drag it back into the turret further. The outer surface of the sensor needs to cleanly **Intersect** with the turret.

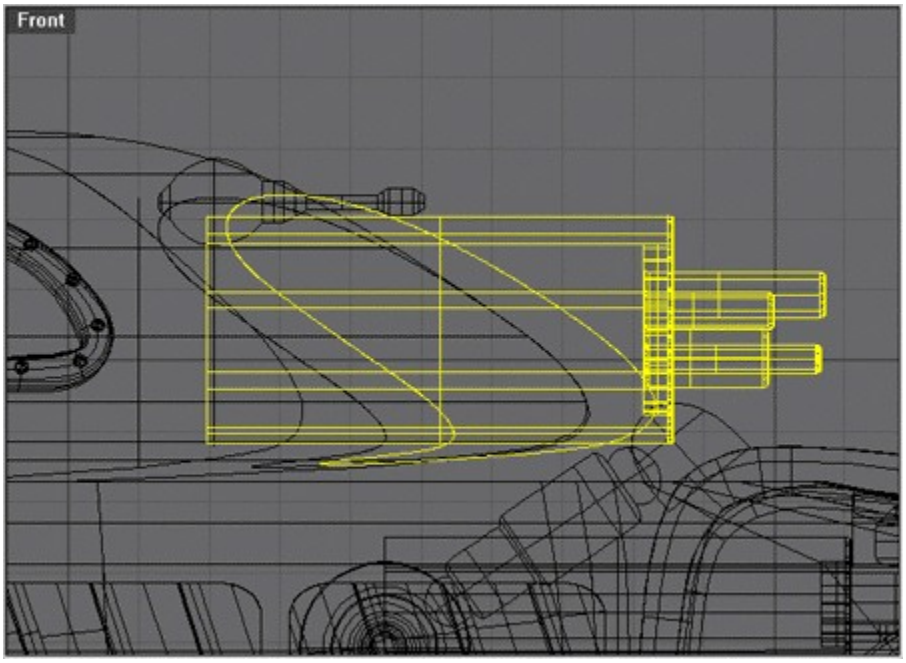
Hit **Dupedge** and select the back edge of the sensor shown below.



Hit **Intersect** and select the turret and the sensor. Result shown below.



Select the sensor and the intersect curve and **Ortho** drag them to the right about **1** grid. Result shown below.



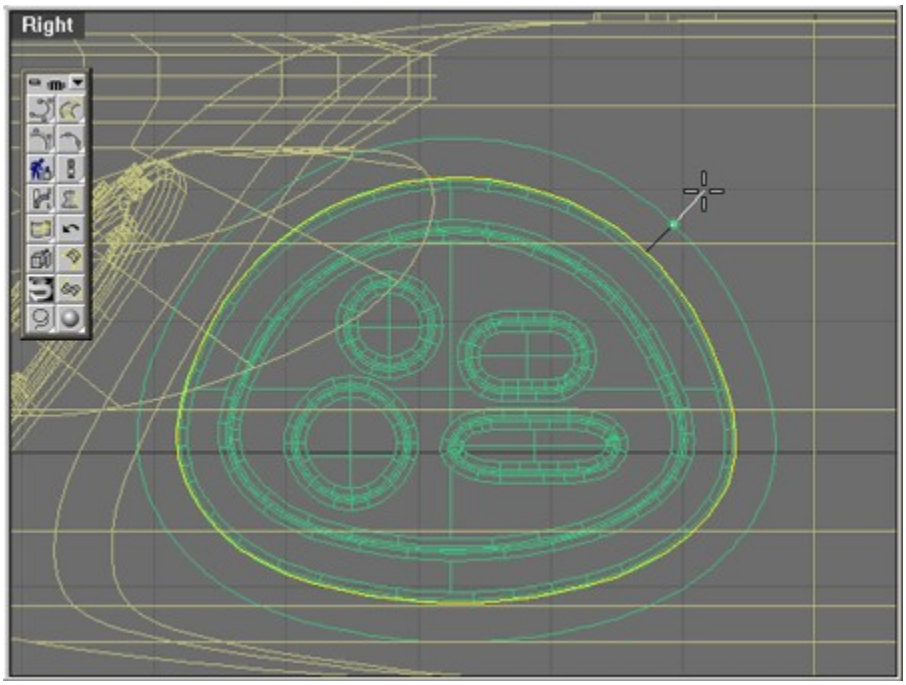
Hit **ExtractSrf** and select the surface that the 'Intersect' curve lies on.

Hit **Split** and select the extracted surface as the 'surface to split' and the Intersect curve as the 'cutting object.'

Select the trimmed surface and the sensor and hit **JoinSrf**.

In the front view select the dupedge curve that was made several steps back.

In the right view and hit **Offset** a '**D**istance' of **15**. And select outside the curve when prompted for side to offset. Shown in progress below.

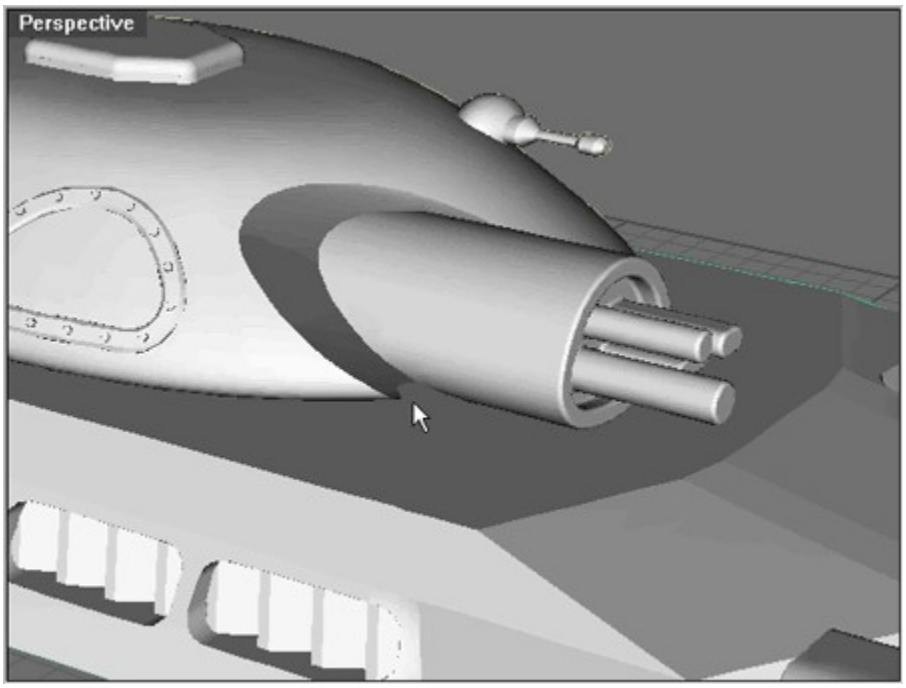


Select the new offset curve and hit **Project** and select the turret when prompted: 'Select surfaces or polysurfaces to project onto: '

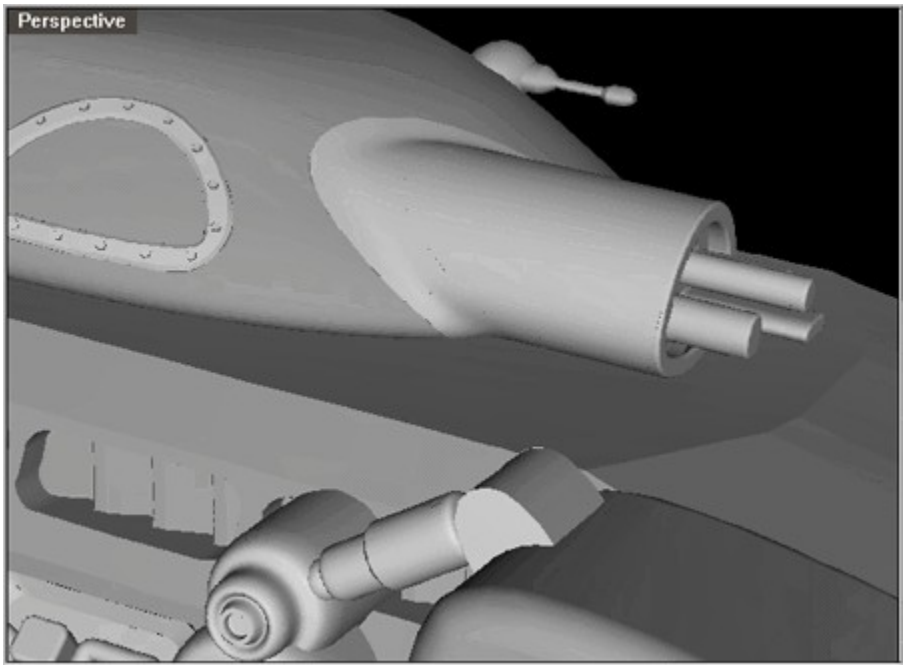
Delete the curve that is projected onto the back of the turret.

Split the turret with the projected curve at the front of the turret.

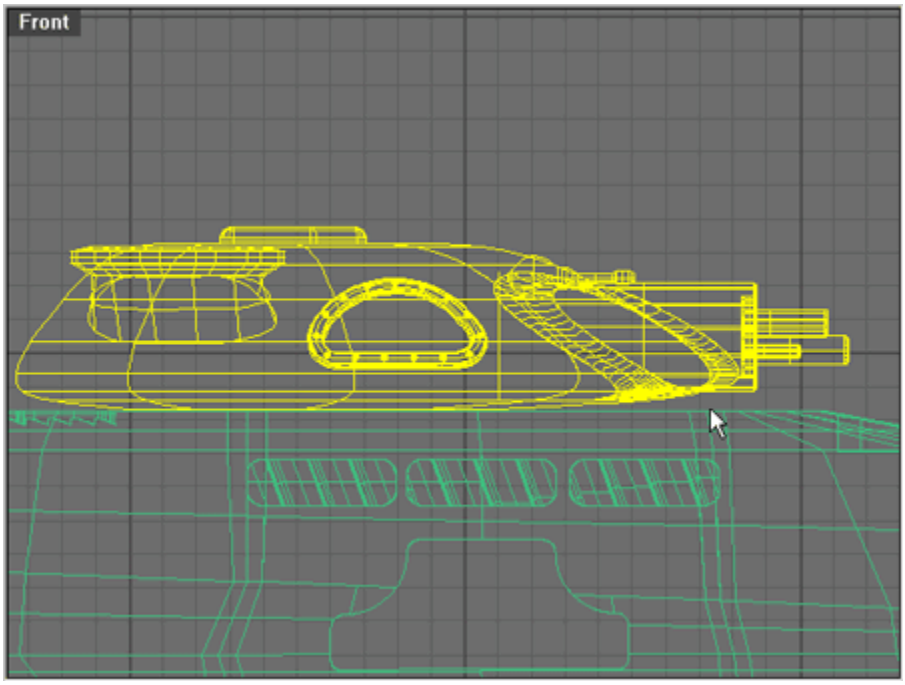
Delete the split object and the curve used to create the split and you should have the result shown below.



Hit **BlendSrf** and select the edge of the turret and the edge of the sensor. What you will find out is that the edge of the sensor surface is split in half. What you need to do is escape from the **BlendSrf** command and then use the **MergeEdge** command on the back edge of the sensor. Hit **BlendSrf** and change the '**D**egree' option to '**Q**uintic' and from the right view drag the seam points to the top of the sensor. If the **BlendSrf** doesn't work change the absolute tolerances to **.1** or more. Result shown below.



With the surfaces unjoined the seams where the surfaces meet will show when rendered. Select all the turret parts shown highlighted below and hit **JoinSrf**. Rhino will only join surface parts that are capable of being joined.



Select all the same objects and **ChangeLayer** them to the turret layer.

This sensor will be easier to deal with using a Loft instead of a Blend. The reason a blend would be difficult with the tank body is because it is very much a PolySurf, in other words it is made of many surfaces and it's difficult to blend 2 or more surfaces to one single surface.

Besides using a Loft instead of a Blend this is very similar to the process used for the previous sensor.

DupEdge the back of the lower sensor.

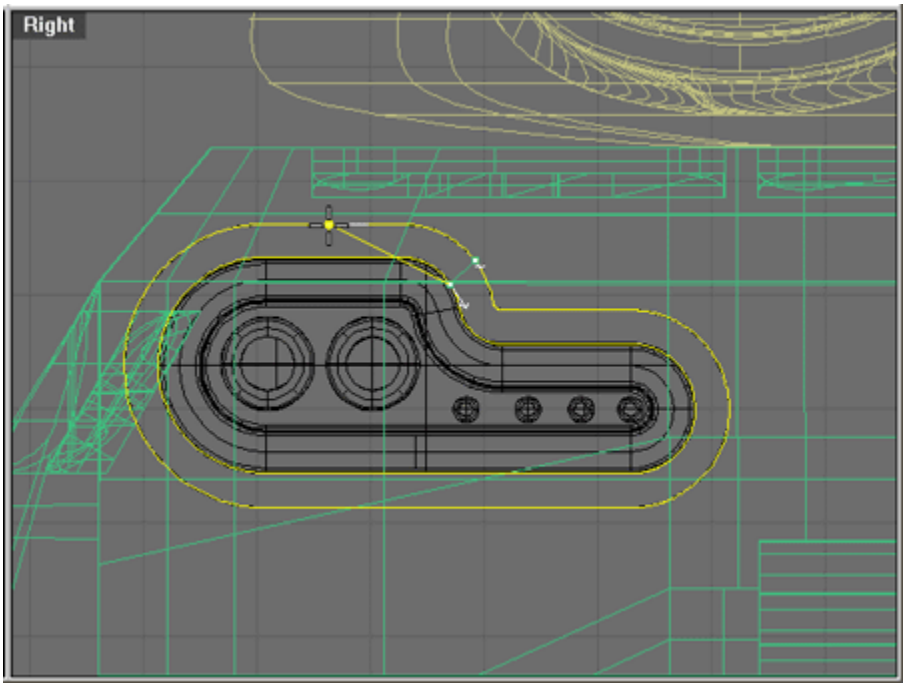
In the right view **Offset** the dupedge a '**D**istance' of **15** units. The image below shows the outer offset curve highlighted.

Project the offset curve from the right view onto the tank body. While the new projected curve is still selected hit **Join**. De-select just the curve projected to the front of the body and hit **Delete**, to get rid of the curve projected to the back of the body.

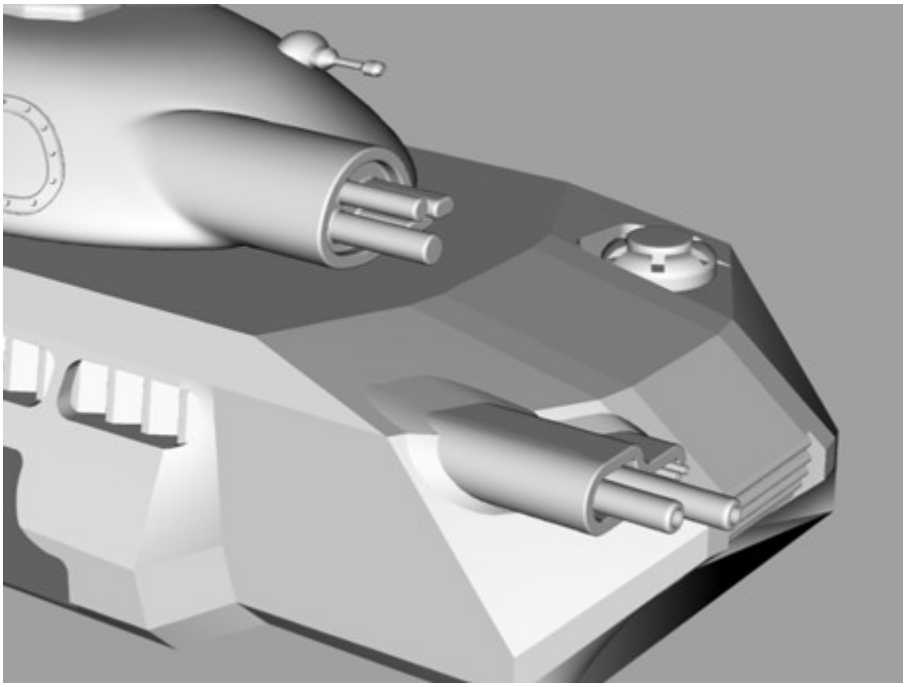
Hit **Intersect** and select the body and the sensor and in the front view drag the sensor, with the intersection curve, to the right about **½** grid.

Select the projected curve and the intersect curve and hit **Loft**.

It is necessary to move the 'seams' of the 2 curves for the loft to work correctly. Drag each of the 'seams' to the top middle of the curve as indicated by the crosshair's below.



Use the 'Straight section' and 'Refit to within .01' options. Result shown below.

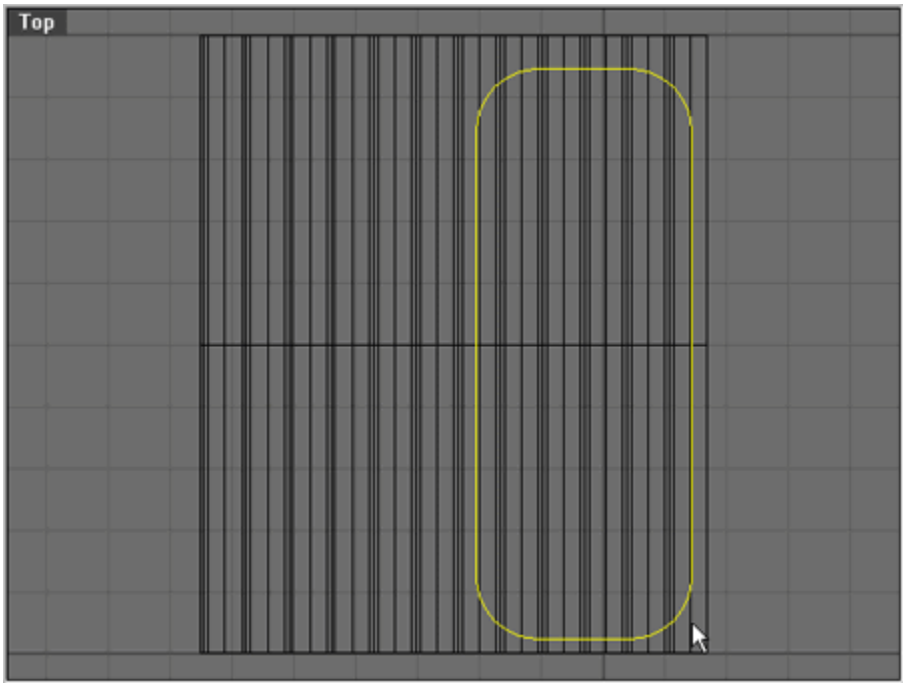


Save out your file and open the 'detail.3dm' file from your local harddrive.

Select the sawtooth curve and hit **Extrude.** Drag the Extrusion about **10** grids.

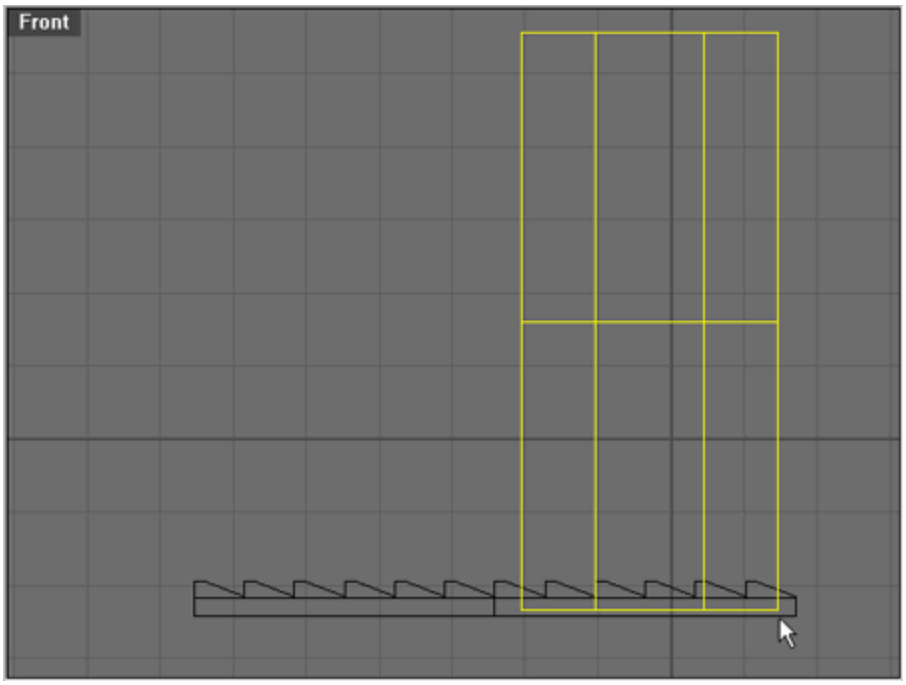
From the top view hit **Rectangle** and use the '**R**ounded' option.

Drag a rectangle similar to the one shown below.



Select the rectangle and **Extrude** '**C**ap=Yes' it about **8** grids up in the front view.

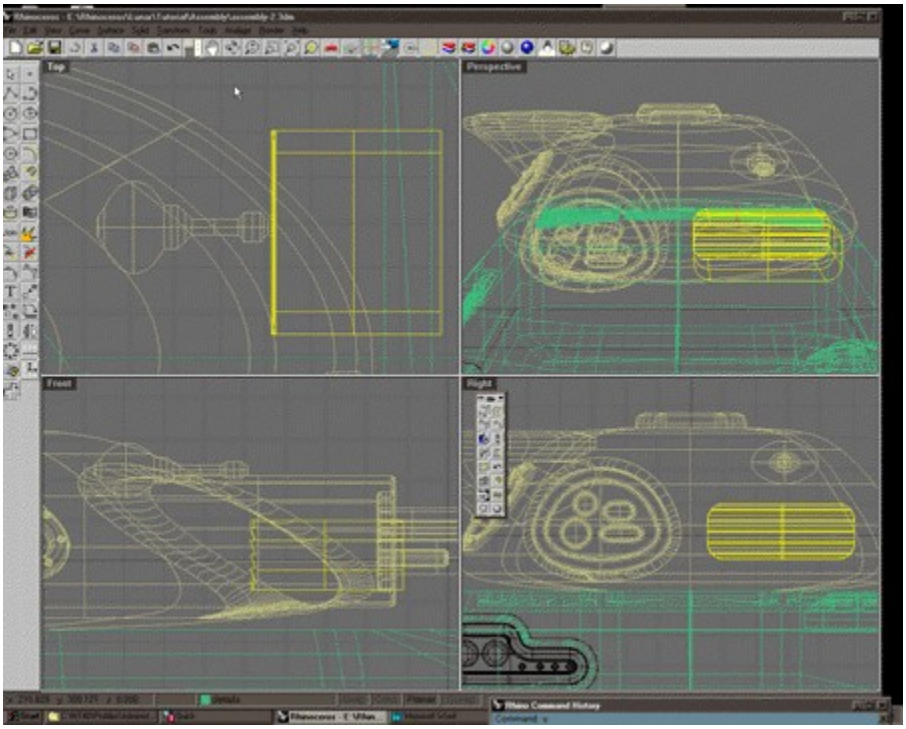
Drag the extrusion up so it can be booleaned by the sawtooth surface.



BooleanDifference the sawtooth from the rounded extrusion by picking the rounded extrusion first and then the sawtooth.

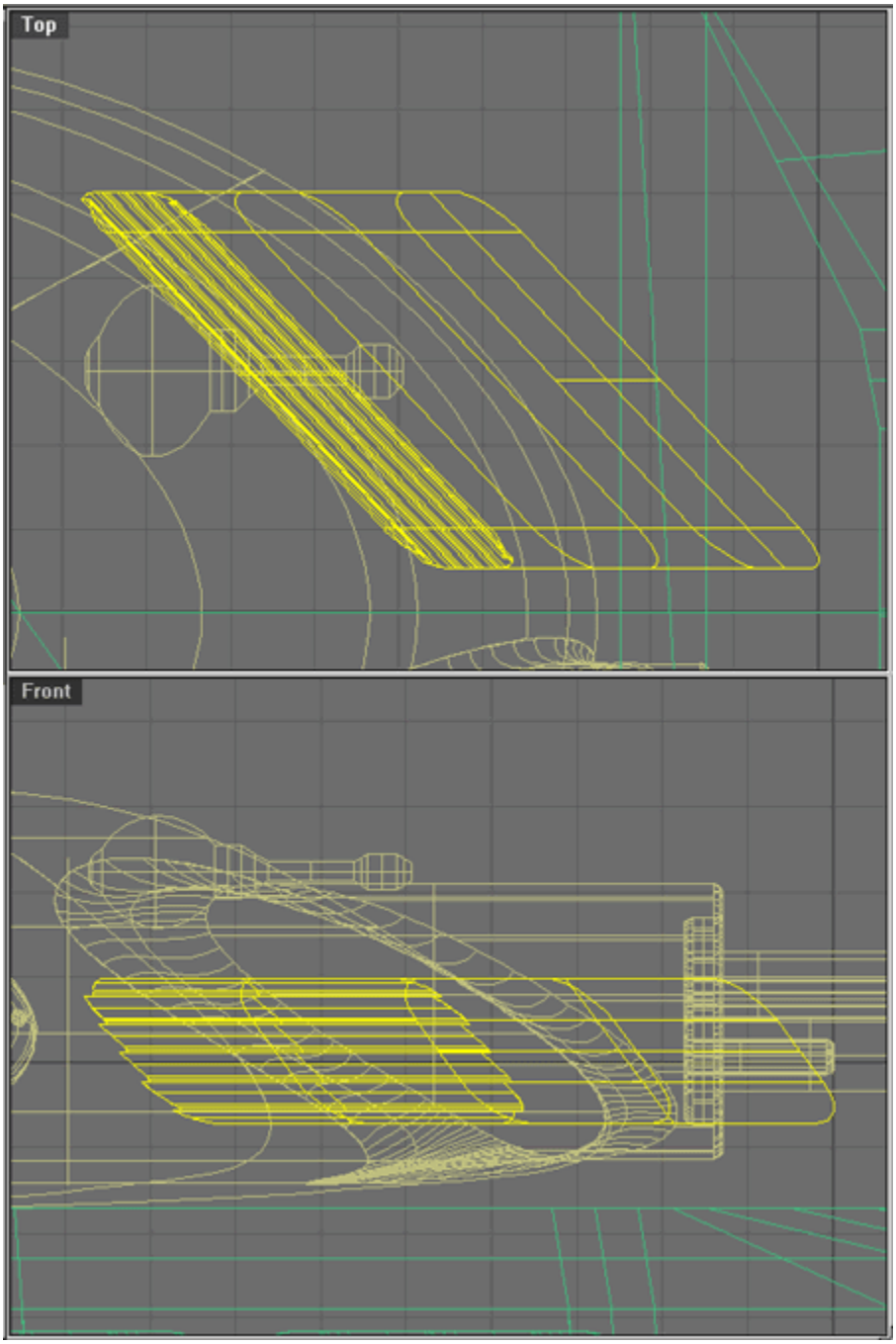
Save the 'detail.3dm' file and select the new booleaned part and hit **Export Clipboard**.Open the assembly.3dm file and hit **Import Clipboard**.

Drag, **Scale**, and **Rotate** the object to how its placed below. Note that in the front view the teeth of the vent are pointing up.



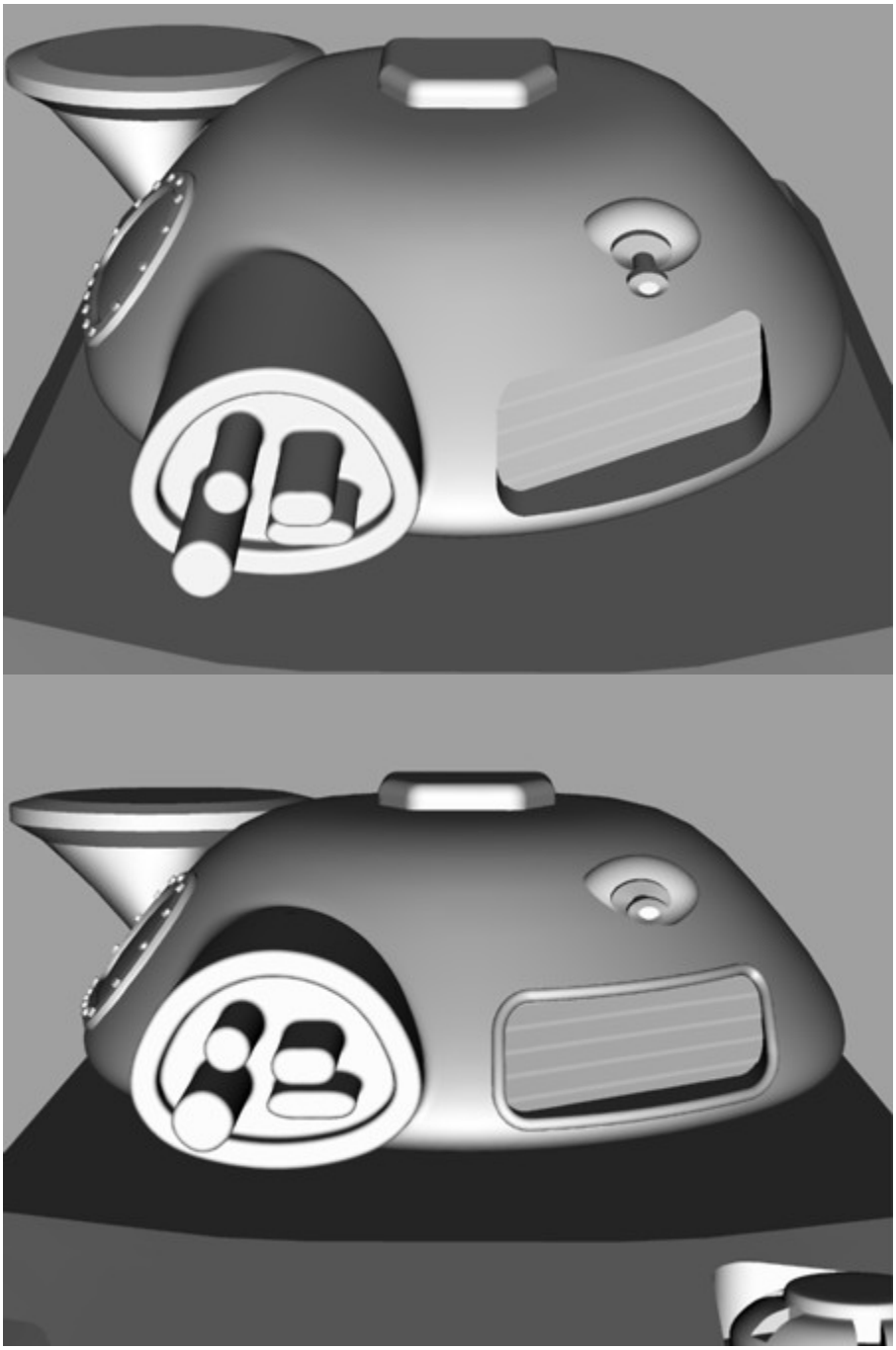
Use **Shear** in the top and front view to get the faces of the surfaces to align with the turret surface better, as shown below.

> **Note: Shear, Taper** and **Bend** can be a bit confusing sometimes. The thing to remember is that the first point you place is going to be the place that isn't going to move. I made some icons for myself that are kind of instructional in the default-2.ws or dakind.ws shown below.



You have to place the boolean object kind of deep into the turret so that you have a nice clean trim line.

Hit **Pipe** and select the outer edge of the boolean and give it a '**D**iameter' of **5** . Before and after shots shown below.

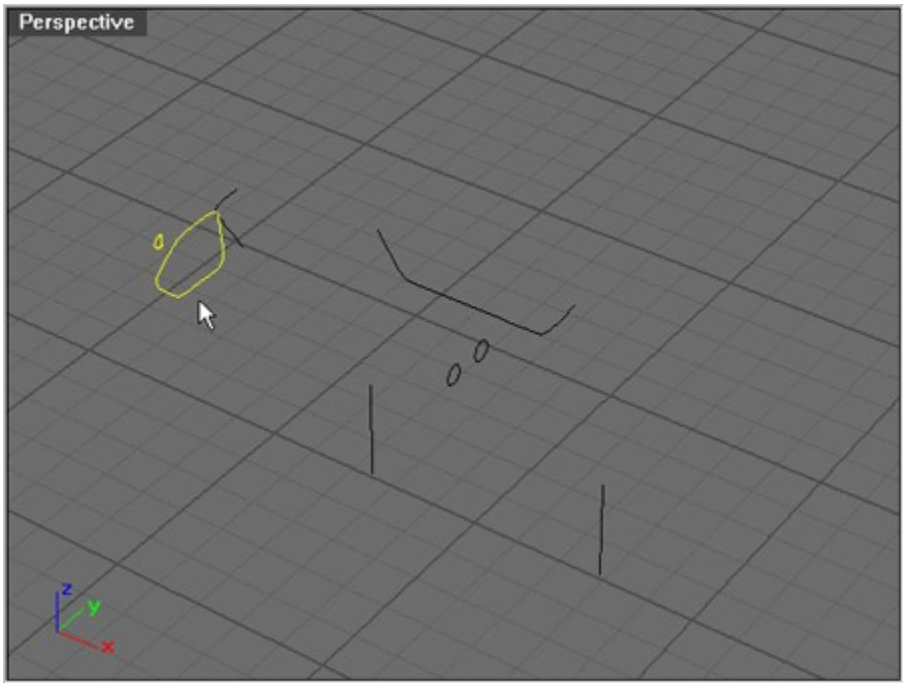


And that's it for details. Don't forget to save out.

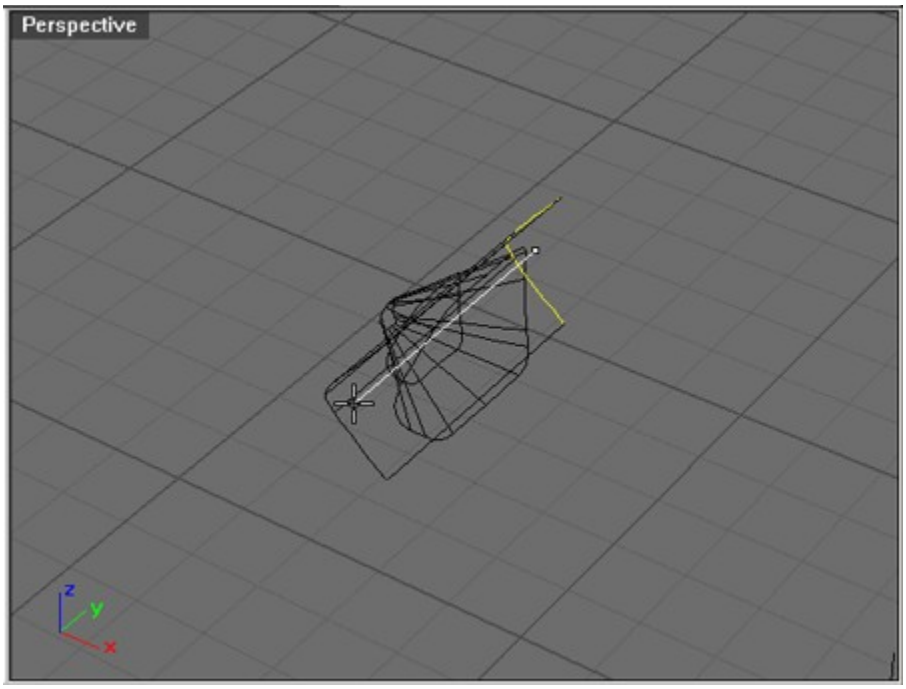
Cannon

Open the file cannon_curves.3dm and save it out as cannon.3dm in your tank directory.

Select the 2 curves show below and hit **Loft** using the 'Normal' style and 'Do not simplify' options.

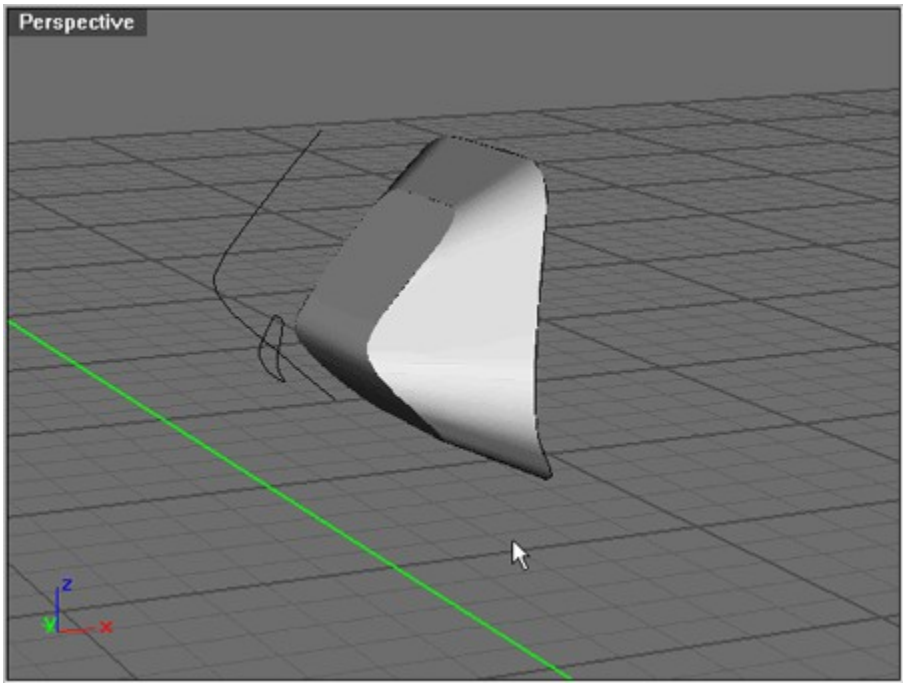


In the front view select the curve highlighted below and **Extrude** it enough to pass through the lofted object, shown in progress.

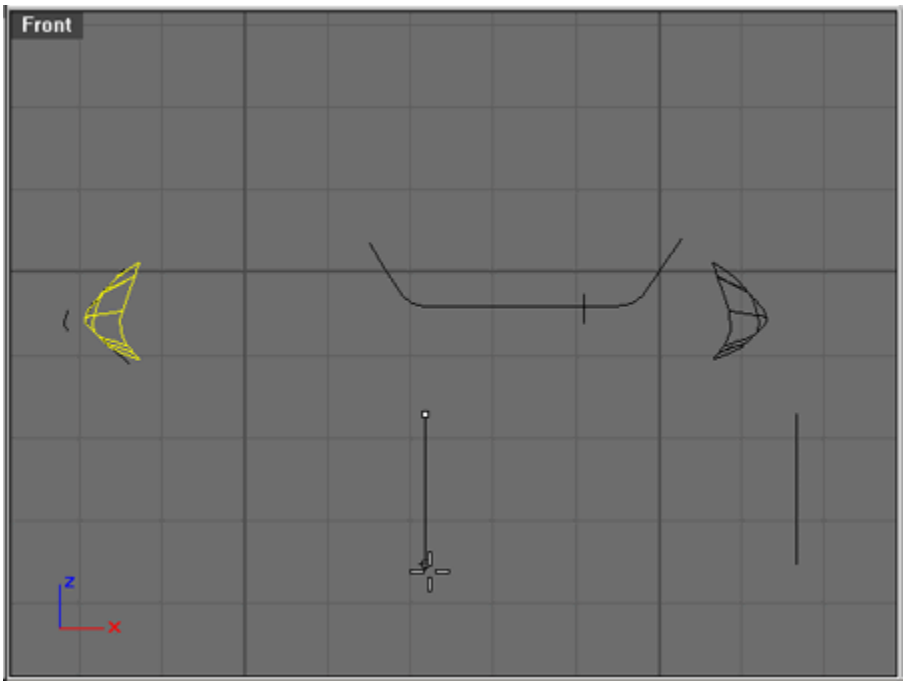


Split the lofted object with the extrusion object as the 'cutting object' and **Delete** the smaller left most part of the split.

Split the extrusion with the lofted object and **Delete** the outer part of the split to get the results shown below.

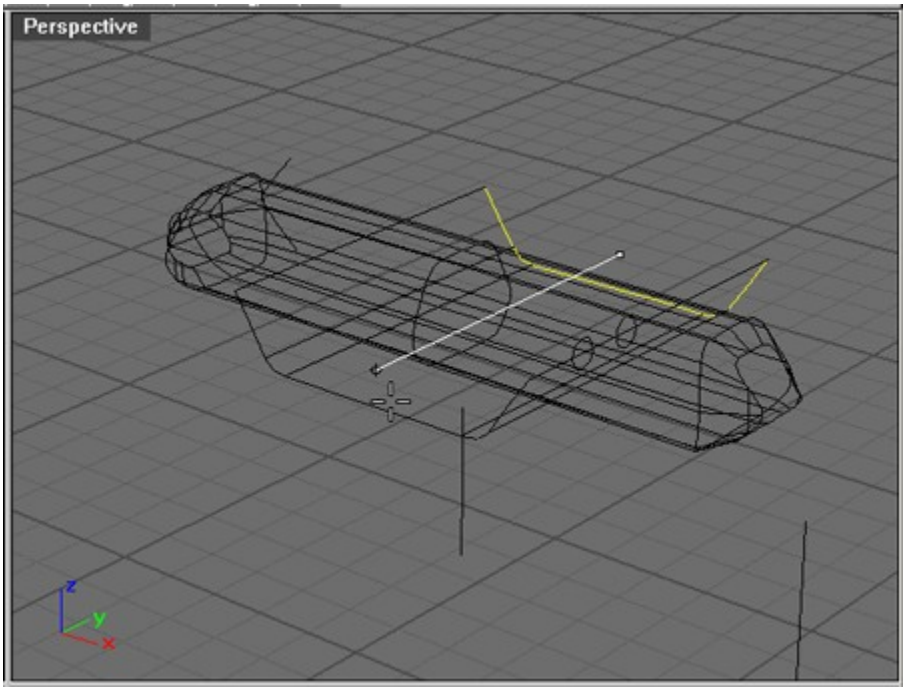


Select the lofted object and hit **Mirror** and use the 'guide curve' as the axis (you can use 'End' osnap if you want to be precise). Shown in progress below.



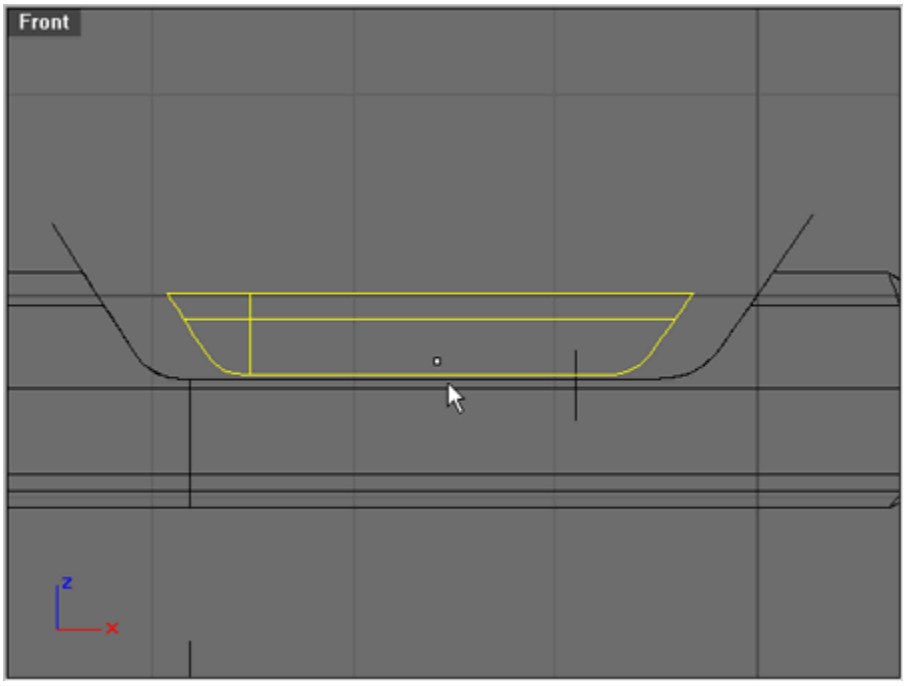
Hit **Loft** '**A**utomatic' and select the surface edges of the 2 loft objects to connect them up. Click Ok to except the last settings for Loft.

Select the curve shown highlighted below and **Extrude** it out to pass through the lofted object, shown in progress.

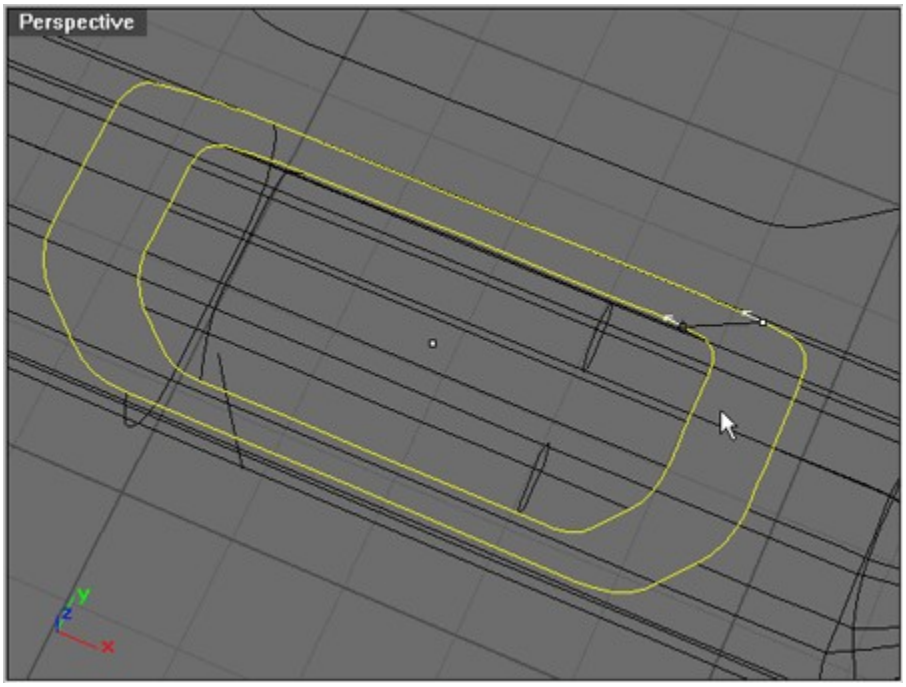


Split the extrude object from the loft object but don't delete it.

Hit **Scale** and with the 'Point' osnap active snap to the point (pointed at by the cursor below) for the origin point, and type in **.76** for the scale factor.

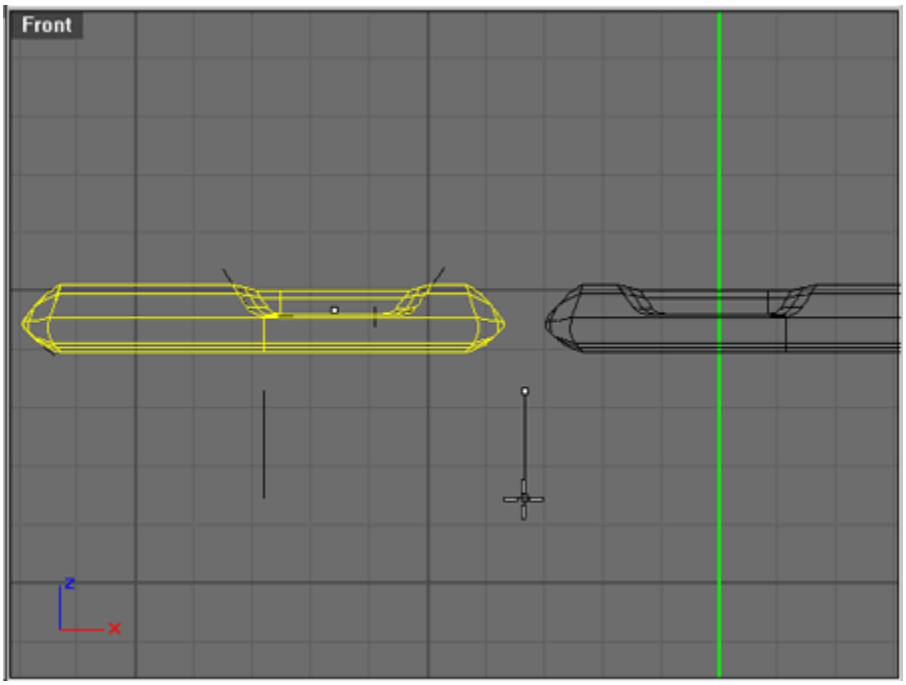


Hit **Loft** and select the 2 edges of the split to connect the split out part with the main body. Shown in progress below.

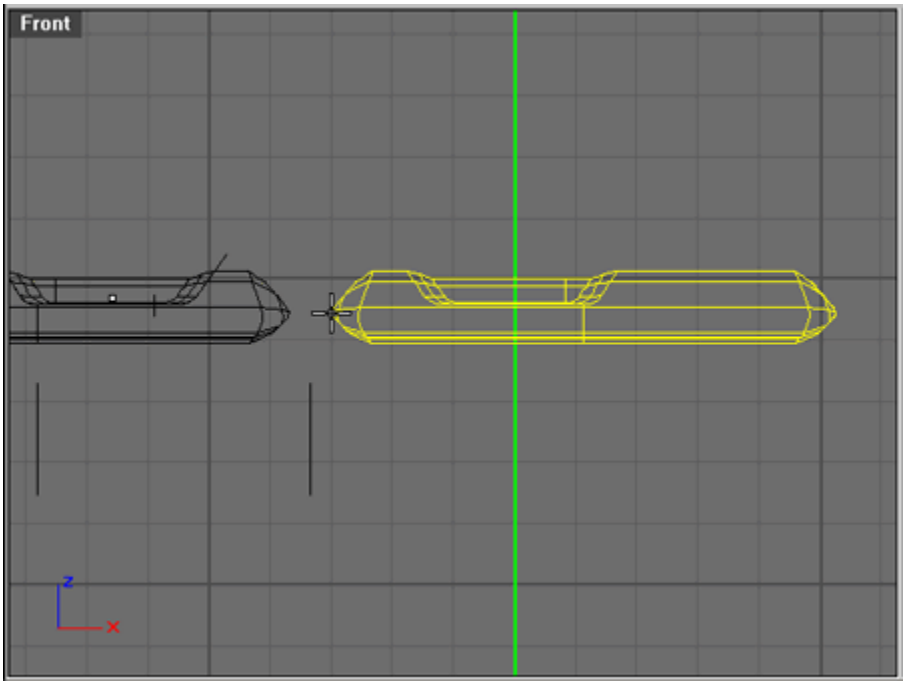


Hit **SelSrf** and **JoinSrf**.

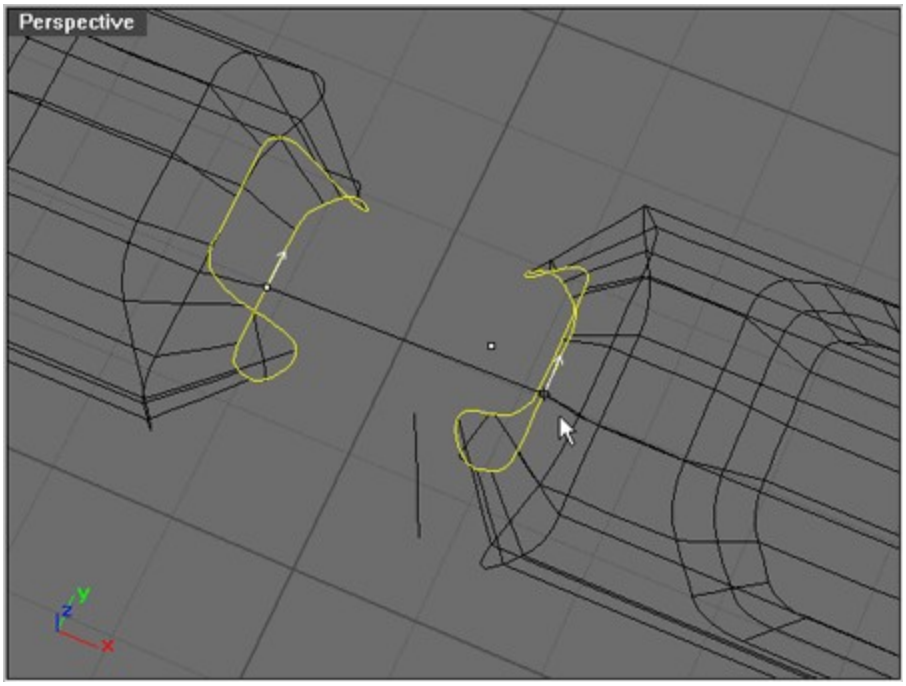
Select the new PolySurface and hit **Mirror** and use the guide curve as the axis. Shown in progress below.



Hit **Scale2D** from the front view and select the point indicated by the crosshairs as the origin point and type in **.76** for the scale factor.



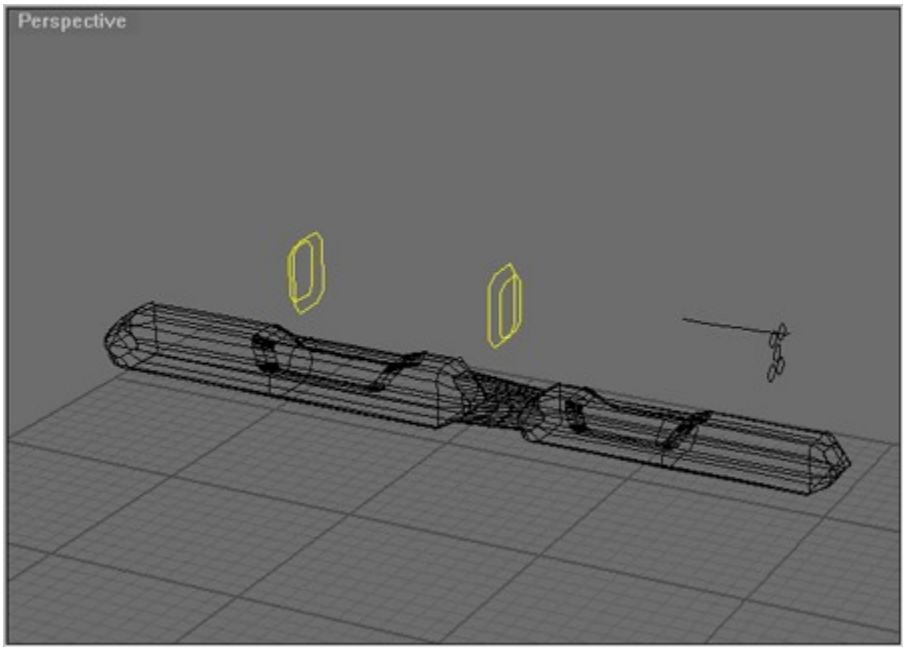
Hit **Loft** and select the surface edges to connect the front and back parts of the cannon. Shown in progress below.



Hit **SelSrf**, **SelPolySrf** and **JoinSrf**.**Missle Launcher**

Turn off all the layers and turn on the 'missile curves' layer and make it current.

Select the curves shown and hit **Loft** and use the 'Straight sections' style and "Do not simplify" options.

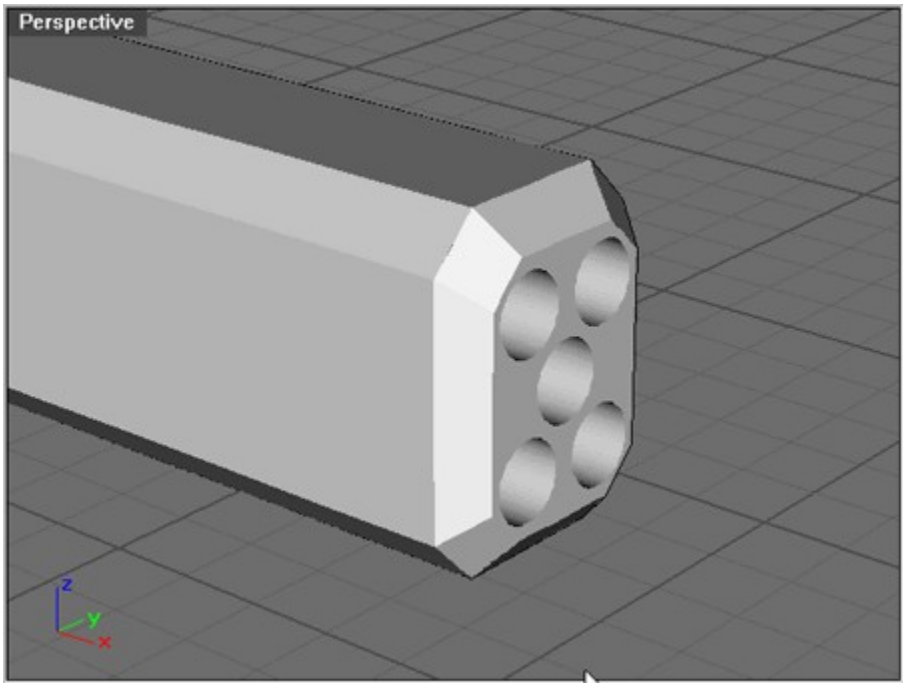


Select the loft object and hit or type **Cap**.

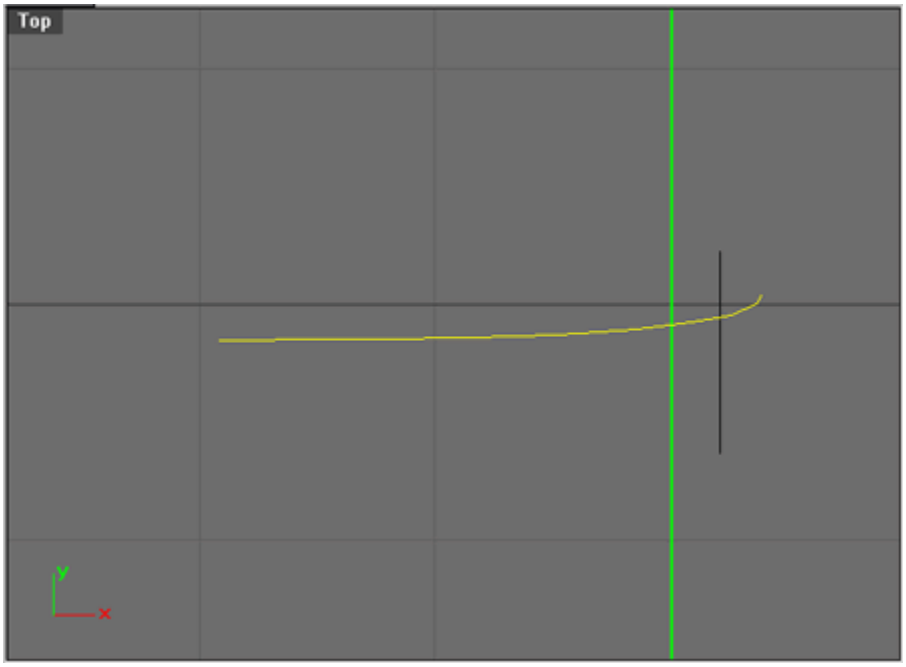
In the right or top view select the 5 circles and hit **Extrude** '**C**ap=Yes' and drag the extrusion about **2** grids.

Select the extrusions (not the curves) and drag them over to the missile box. Hit **BooleanDifference** and select the box and then one of the pipes and repeat to boolean the rest of the pipes.

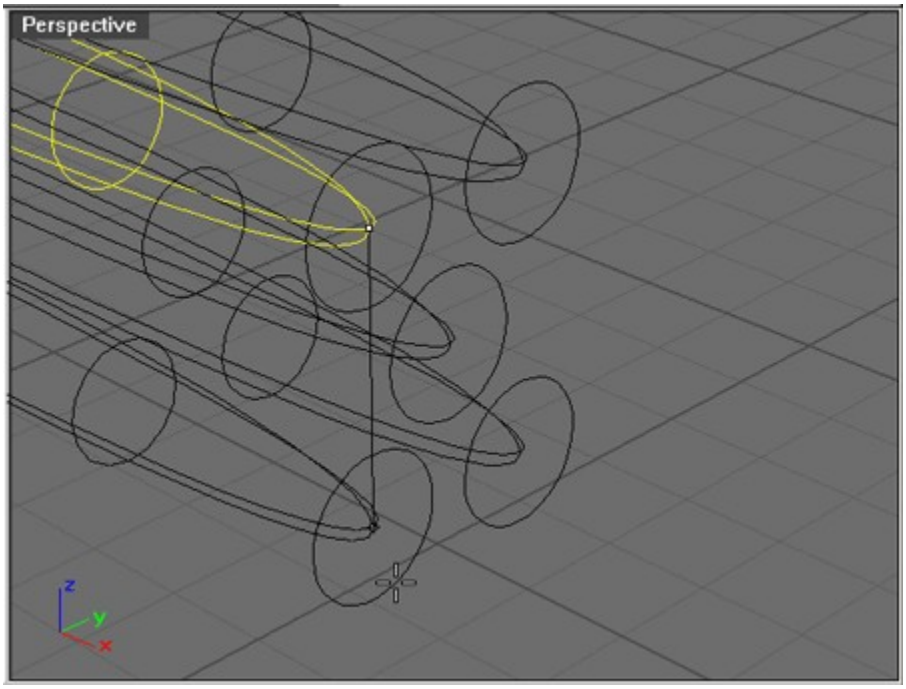
> **Note:** If the boolean doesn't subtract the pipe and the box is subtracted instead, hit **Undo** and select the box, hit **Dir** and '**F**lipNormal' and try again to get the results shown below.



From the top view and with 'End' osnap on, select the curve shown below and hit **Revolve**. Snap to the right end of the curve and drag to the left with shift held down to create the axis.



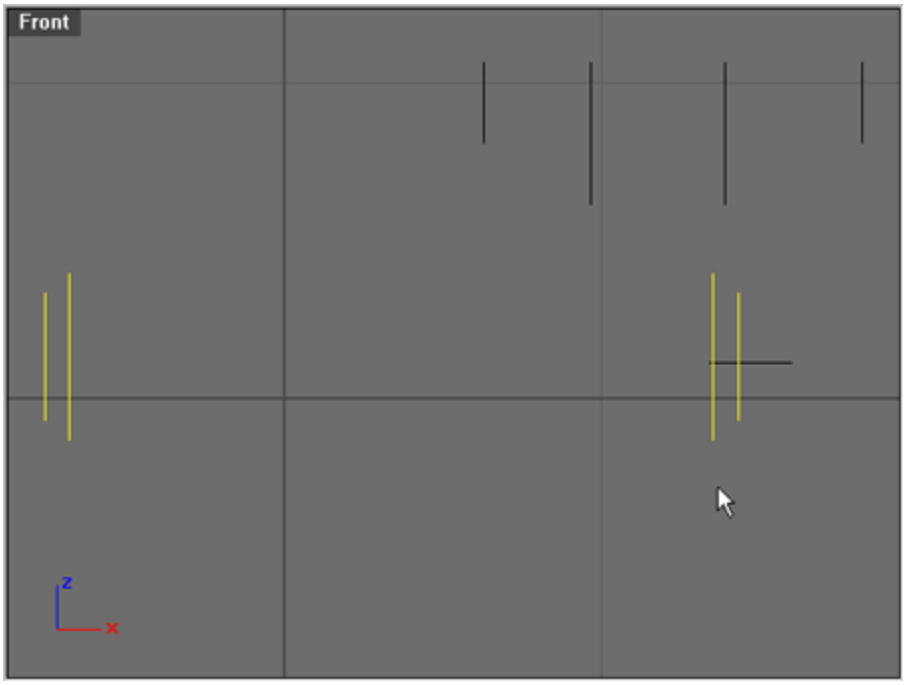
In the perspective view hit **Copy** and with 'End' and 'Center' osnap on select the tip of the missile and then hover the cursor over one of the circles so that the 'Center' osnap comes into play and left click. With the **Copy** command still active repeat this action on the other circles to get the result shown below.



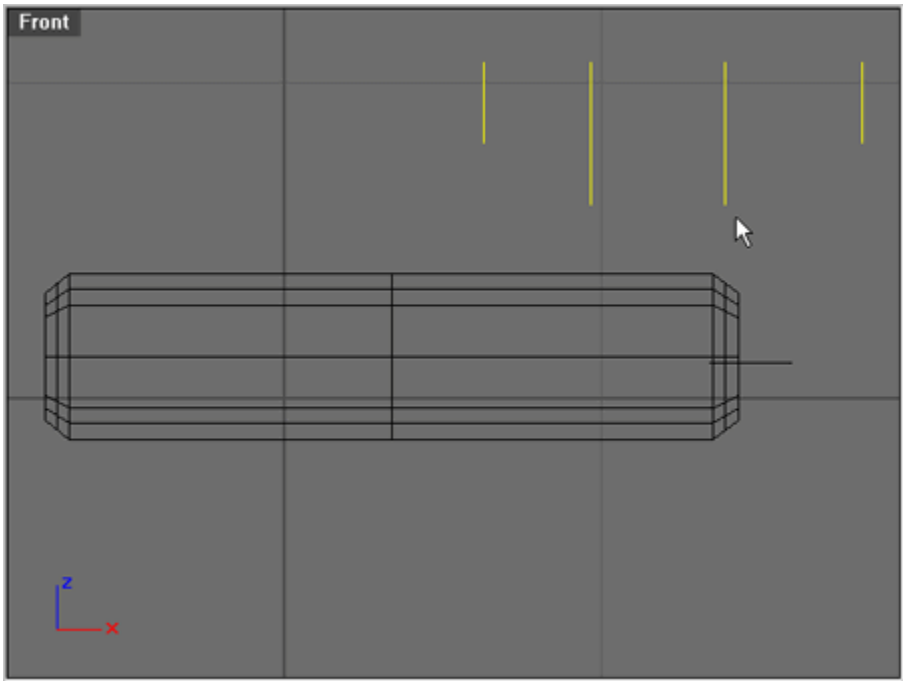
Select the new missiles and drag them back into the launcher.

Make the 'radar' layer current and hide any other layers.

Select the curves shown below and hit **Loft** and use the 'Straight sections" style and 'Do not simplify' options.



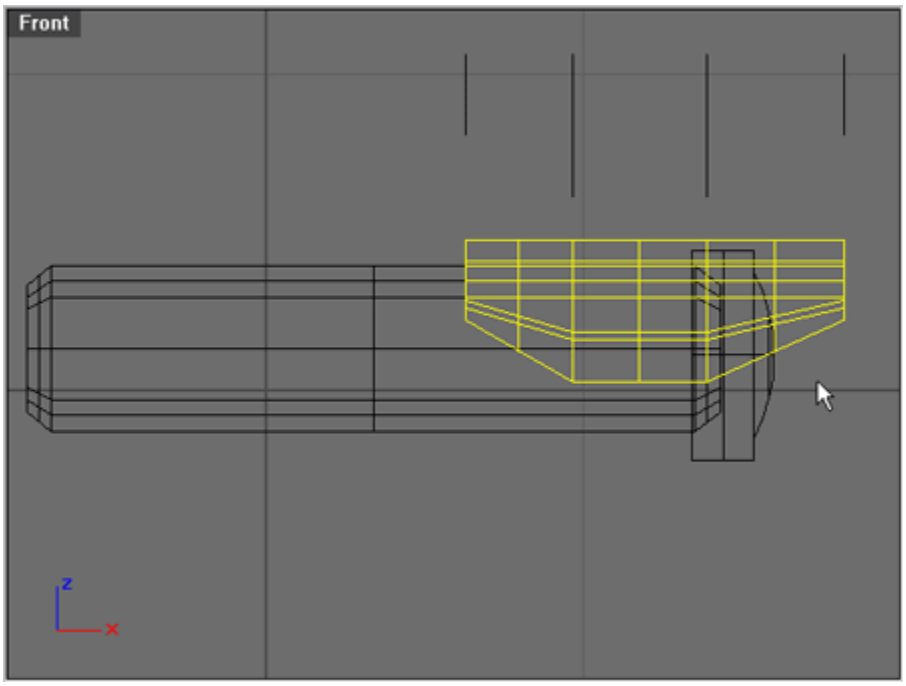
Select the curves shown below and hit **Loft** and hit Ok and then hit **Cap**.



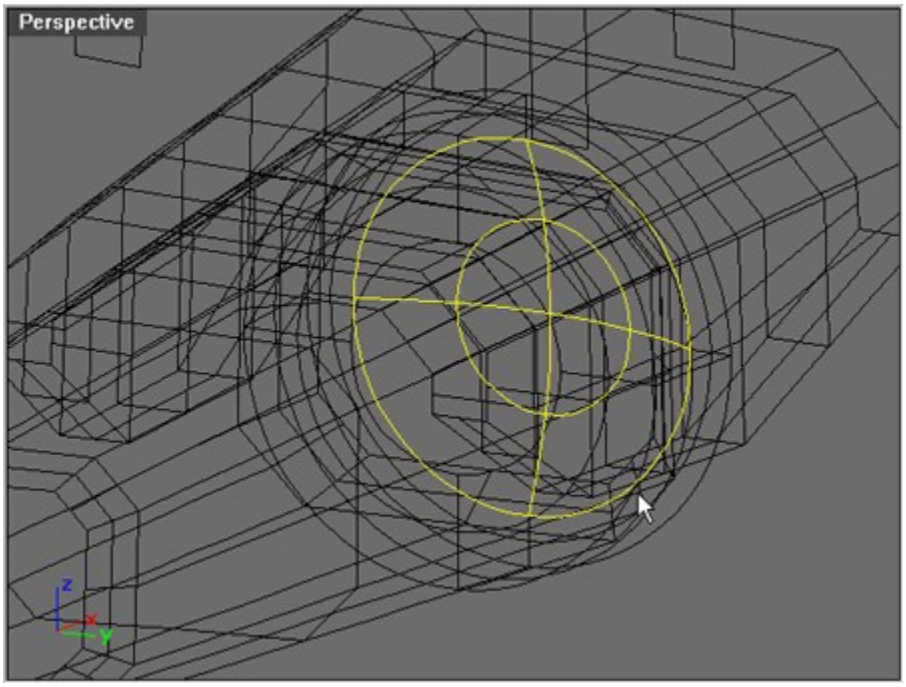
In the top view select the curve shown below and hit **Revolve** and with the 'End' osnap on select the lower end and drag a axis to the left or right with shift down, (shown in progress below,) click and except the default settings and hit Ok.

Select the visor for the sensor in the front view and with the 'End' osnap off, drag it down over the sensor shown below. Be sure to drag it down far enough down to completely intersect the sensor so that you can be booleaned together later.

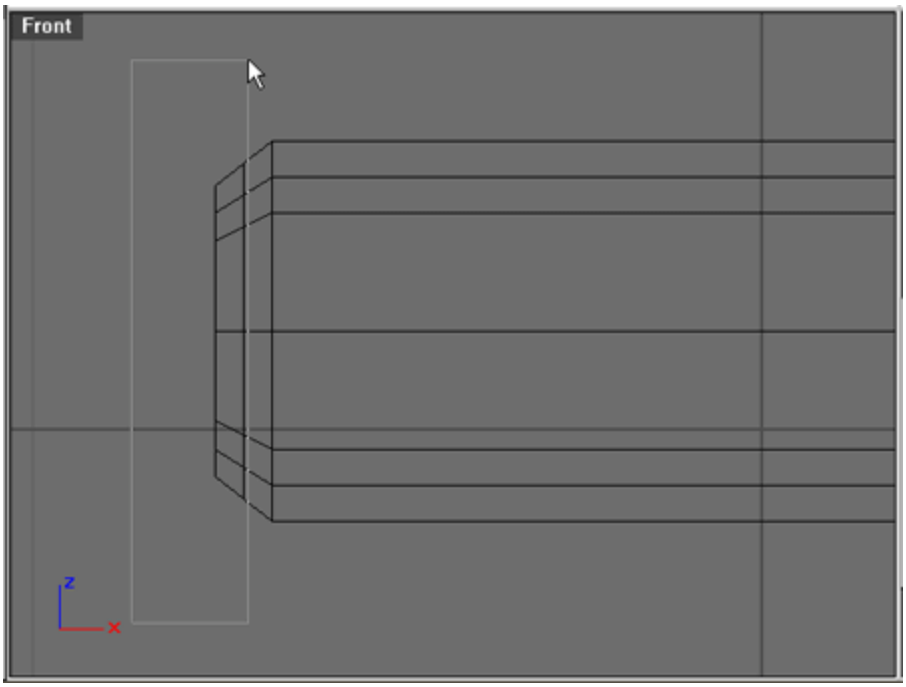
Optional: Copy the visor, drag and **Scale** it to go over the missle launcher as well.



ExtractSrf the lens part of the sensor. The reason to use ExtractSrf on the lens is because it will recieve a different material. Shown highlighted below is the lens face extracted from the PolySurface.

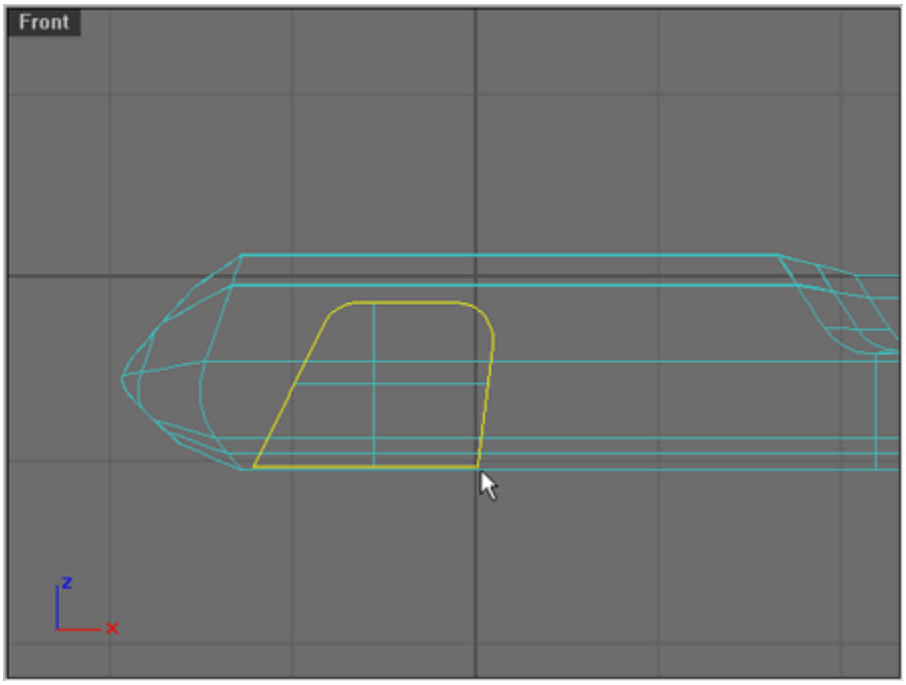


Hit **PlanarSrf** and in the front view drag a window around the end of the sensor box to select the end edges. The window selection is shown below.

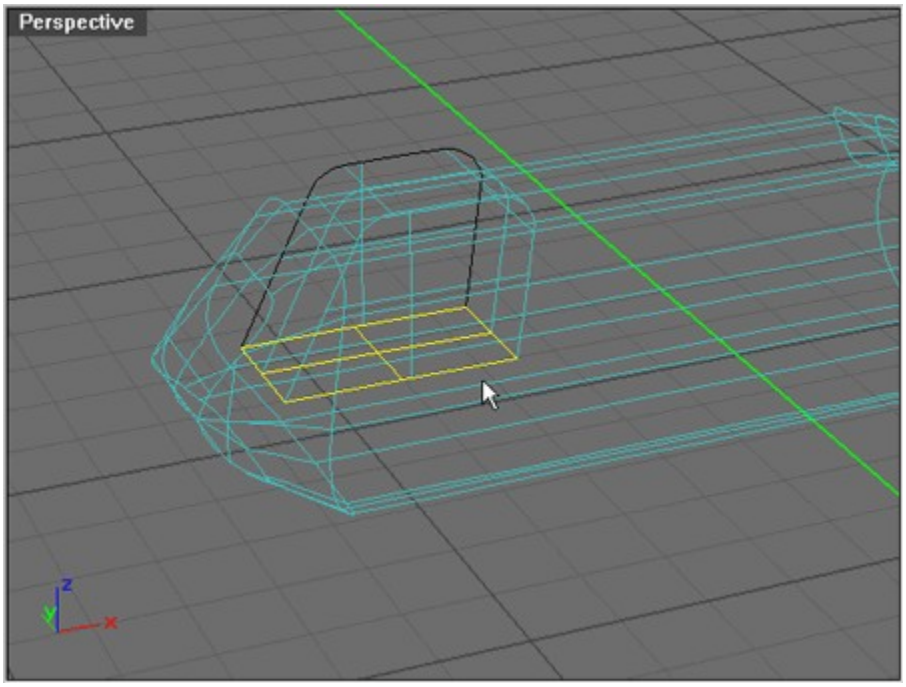


Turn on the 'hinge curve' layer.

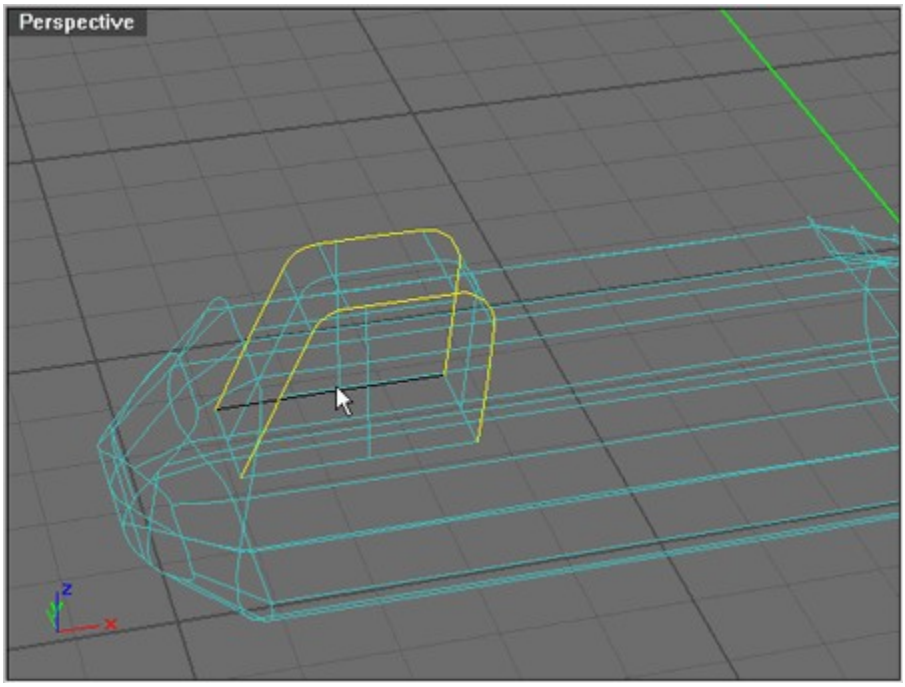
Select the curve shown below and hit **Extrude** '**C**ap=Yes' a '**D**istance' of **-65**.



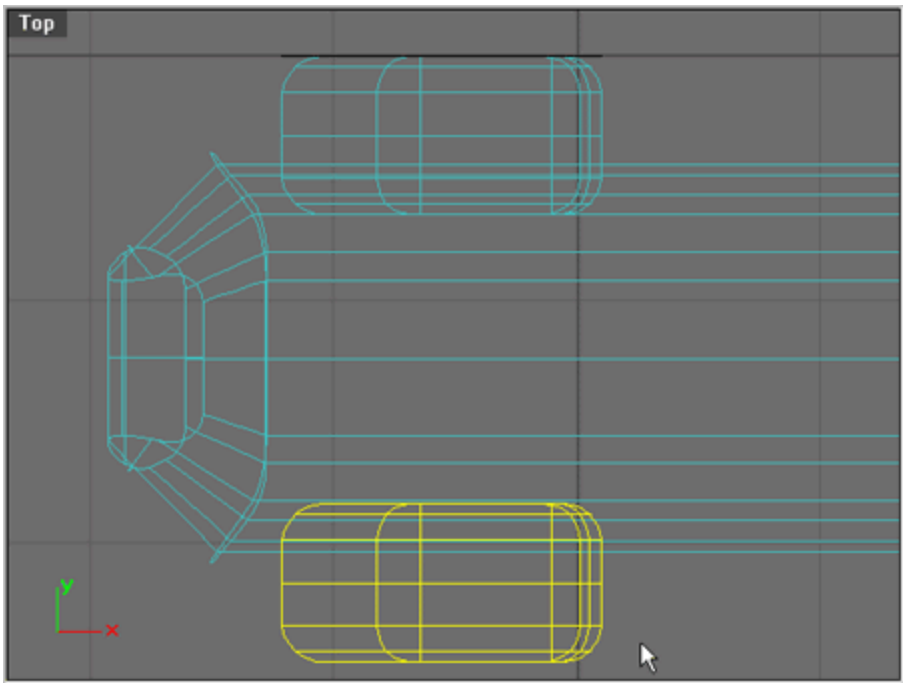
Hit **ExtractSrf** and **Delete** the bottom face of the extrusion shown below.



Hit **FilletEdge** and select the 2 edges shown below with a '**R**adius' of **15**.



From the top view select the hinge and either copy it and drag it across to the other side of the cannon or **Mirror** it.



Hooray! That's it for creating geometry. We still need to copy or mirror and assemble few things but it's just clean up from here on out.

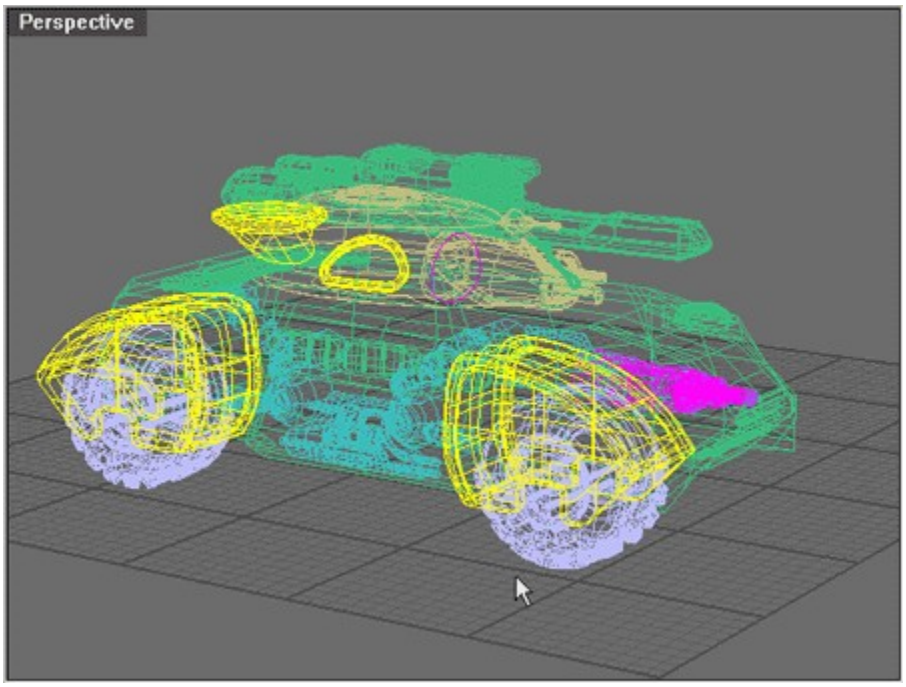
Turn on all the layers and hit **SelSrf** and **SelPolySrf** and then hit the **Export ClipBoard** icon.

Save out the file.

Open the 'assembly.3dm' file and right **Import Clipboard**.

Make a new layer called 'cannon' and **ChangeLayer** the imported objects to that layer.

Hooray again. Well almost, all you need to do is mirror the wheels and fenders across to the other side (use **SelLayer**). Actually you only need the front wheel and fender. Optionally you can give the objects some different materials. Even if you plan to **Export** the model into another program to do the final material assignment and render I think it's a good idea to assign simple color materials in Rhino because it's fast and easy and you can rough it in and get a basic color composition as well as keep things better organized. Also I would uncheck 'Render backfaces' in the 'Render' options and see if any normals need to be flipped. The surfaces I found that needed to be flipped using the **Dir** command are highlighted below.



Another thing that is a good thing to do is make an icon and paste these commands into it " SelAll SimplifyCrv Improve SelNone " without the quotes. See the Options page for more information on customizing icons. This will **Simplify** curves where possible and reparameterize the surfaces, which means that any texture maps you apply to the surfaces will basically give expected results. Don't forget to save out.