



AUTODESK UNIVERSITY

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Families In Motion: New and Exciting Methods that Make Your Revit Families Move

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Learning Objectives

- Learn new methods to apply rotation parameters to masses and adaptive component families
- Learn new methods to apply rotation parameters to traditional families
- Learn how to create multiple joints that move together in Revit Families in 2D planes
- Learn how to create multiple joints that move together in Revit Families in 3D "Ball" Joints

Description

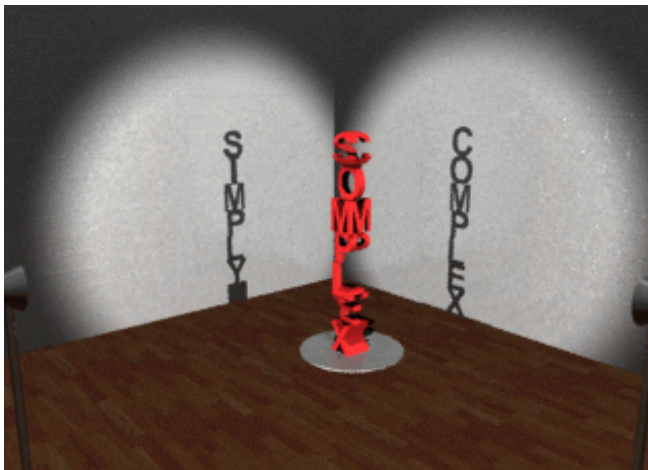
Have you ever built a family in Revit software and needed to create rotation and dimensional parameters because there were multiple moving parts? This class will show you how to create parameters within the Revit software massing, adaptive component, and traditional Family Editors so your families can move. Just some of the examples we will show include folding-door rotation, articulating booms on cranes, and swinging roof davits. Forget what you've learned about how to apply rotation and dimensional parameters to Revit software families. This lecture will show new and exciting methods that could be applied to most Revit families. There will even be a portion of the lecture dedicated to simulating ball joint movement. The class is sure to be fun, exciting, and fresh.

About The Speaker



Marcello is the BIM Director at John A. Martin & Associates Structural Engineers in Los Angeles, CA. He has been using Autodesk products for over 15 years including AutoCAD, 3ds Max, and Revit. Marcello is heavily devoted to helping advance the use and knowledge of BIM solutions within the AEC community. He is well known for modeling elements and creating workflows that others have thought not possible. He also frequently presents at Autodesk University and at The Revit

Technology Conference where he has been voted the top rated speaker three years in a row at both conferences. He has worked on many well-known projects in the past including the Walt Disney Concert Hall in Los Angeles, CA, the Stata Center at MIT, and the Tom Bradley International Terminal Expansion at LAX. Marcello received B.S. and M.S. degrees in Civil Engineering and is a licensed Civil and Structural Engineer.

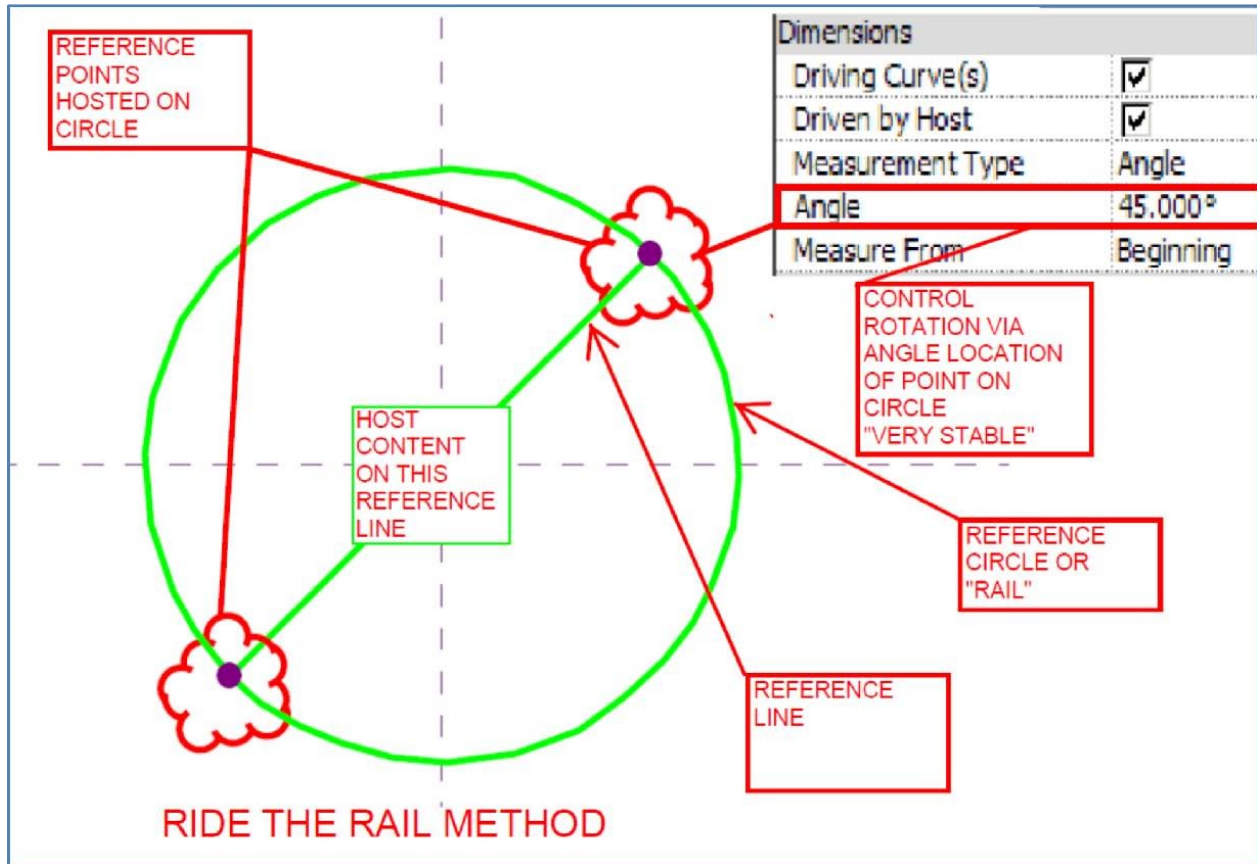


Read more of Marcello's work at [Simply Complex](#), a blog dedicated to modeling and documenting complex geometry in the AEC industry using Autodesk products. You can also email Marcello (marcellojs@hotmail.com) or follow him on [Twitter](#).

Introduction: Lifts



I built this construction lift family to help understand how a virtual lift would "fit" inside of a particular building. This lift was built per manufacture specifications. Follow the steps below to make this lift family movable!



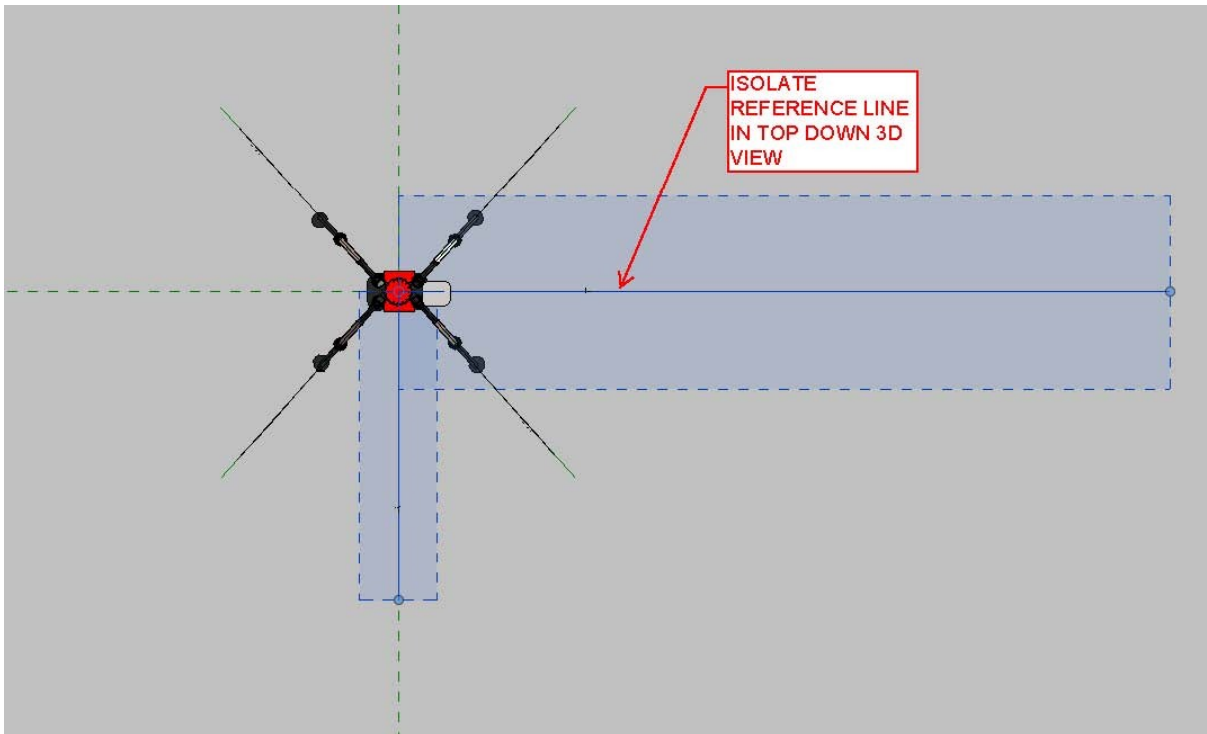
You will be making the lift family movable by hosting points onto circles. This is known as "ride the rail" method. As shown above in the rotation rig, the Ride the Rail method does not use the angular dimension to control the angle of the hosting reference line. It uses the power of the reference point to "ride" the "rail" of the circle or curve to control the angle

PART 1

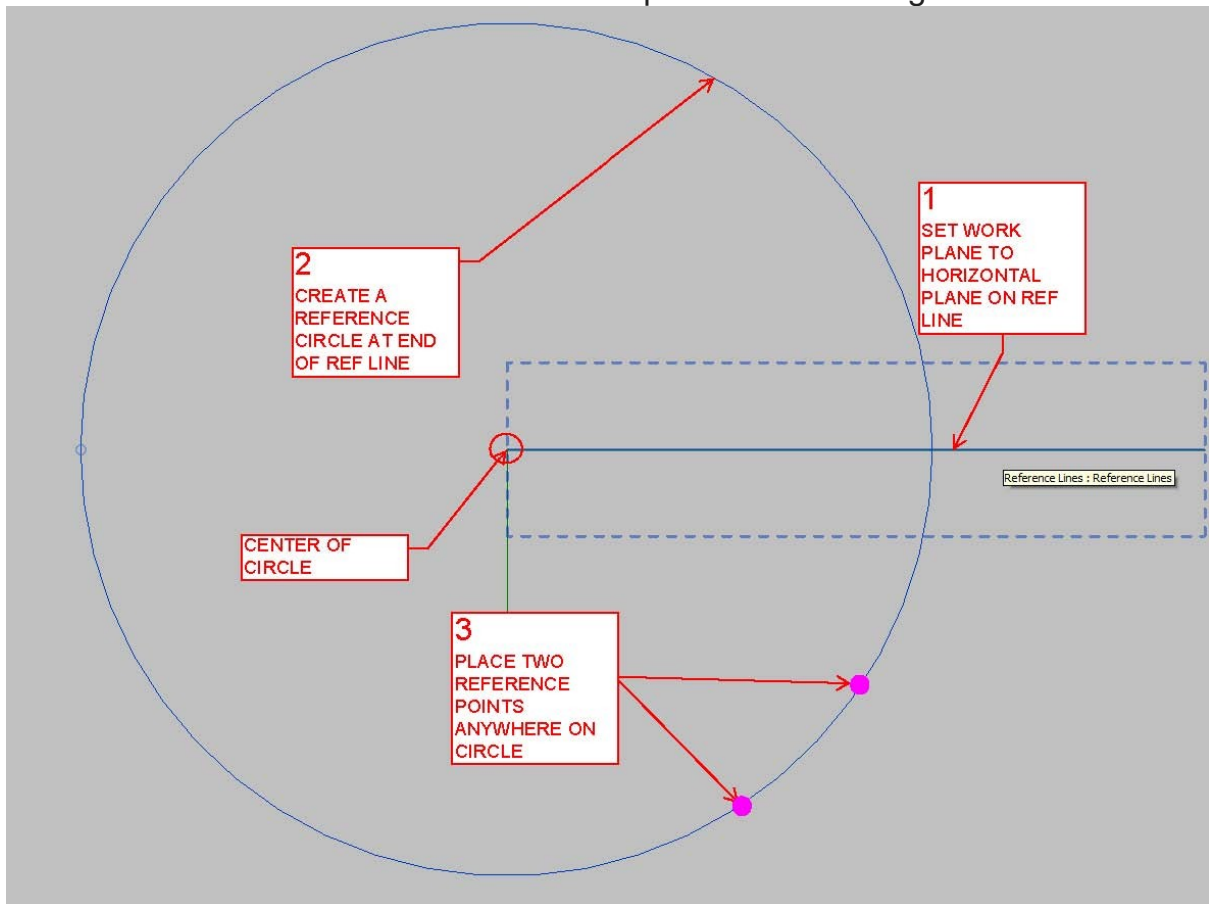
Creating Base Rotation Rig

This portion of the exercise is only to introduce the concept of creating a rotation rig with points.

1. Open the file that has the bottom family EX_1_LIFT_START.RFA as shown in the figure below.

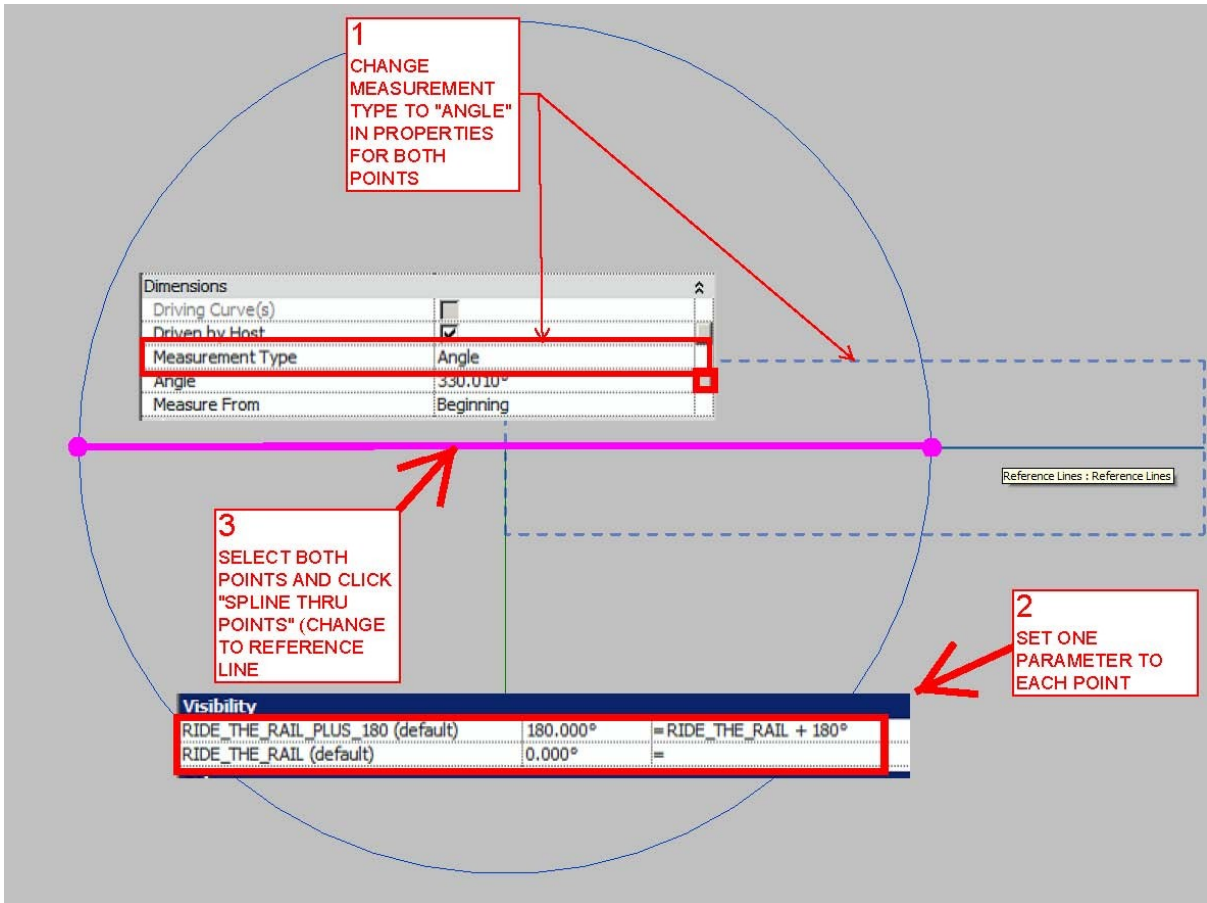


2. Create the Reference line as shown in in top down view the figure below.



3. Set the work plane of the isolated reference line.
4. Create a reference circle at the end of the isolated ref line.
5. Place two points anywhere on the circle.
6. Change the measurement type to "angle" in the properties for both points.
7. Create the following parameters to the first point "RIDE THE RAIL."
8. Create the following parameters to the first point "RIDE THE RAIL PLUS 180."
9. Select both points and click "spline thru points" and change new line to "reference line" (this is the new hosting reference line).

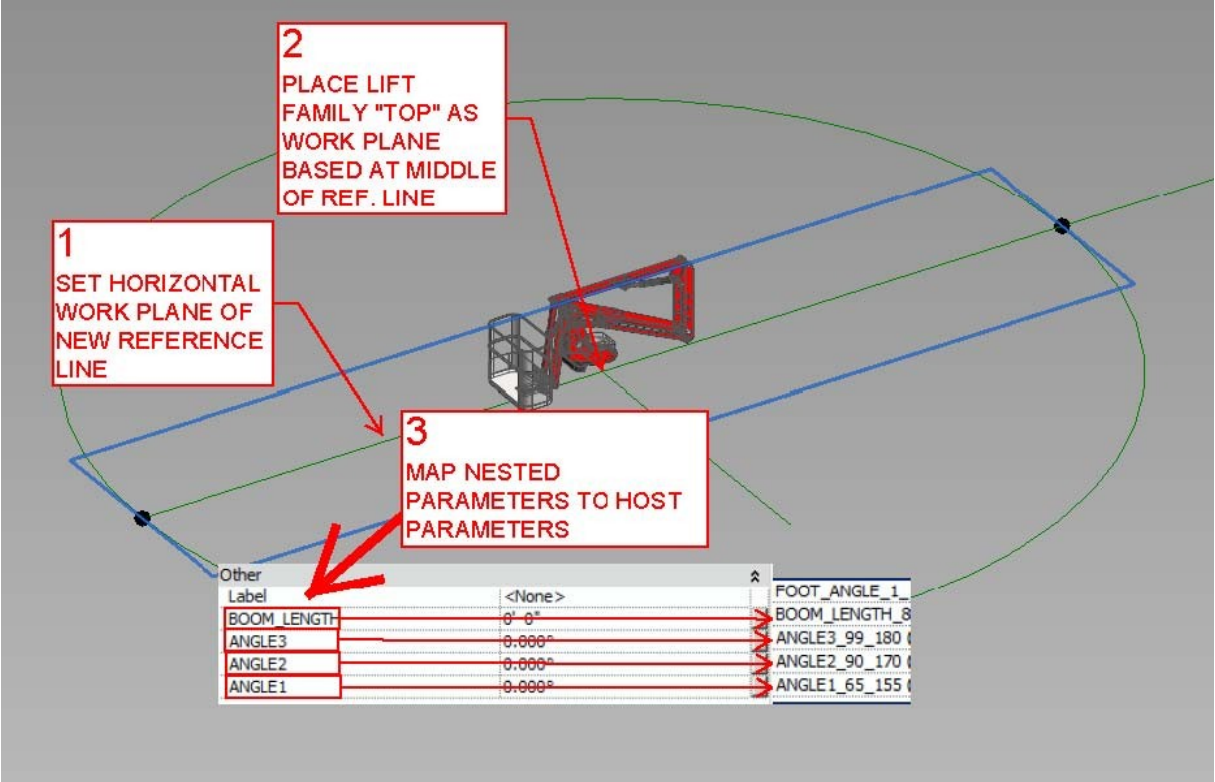
10. Congratulations! The Ride the Rail rotation rig is complete as shown in the figure below.



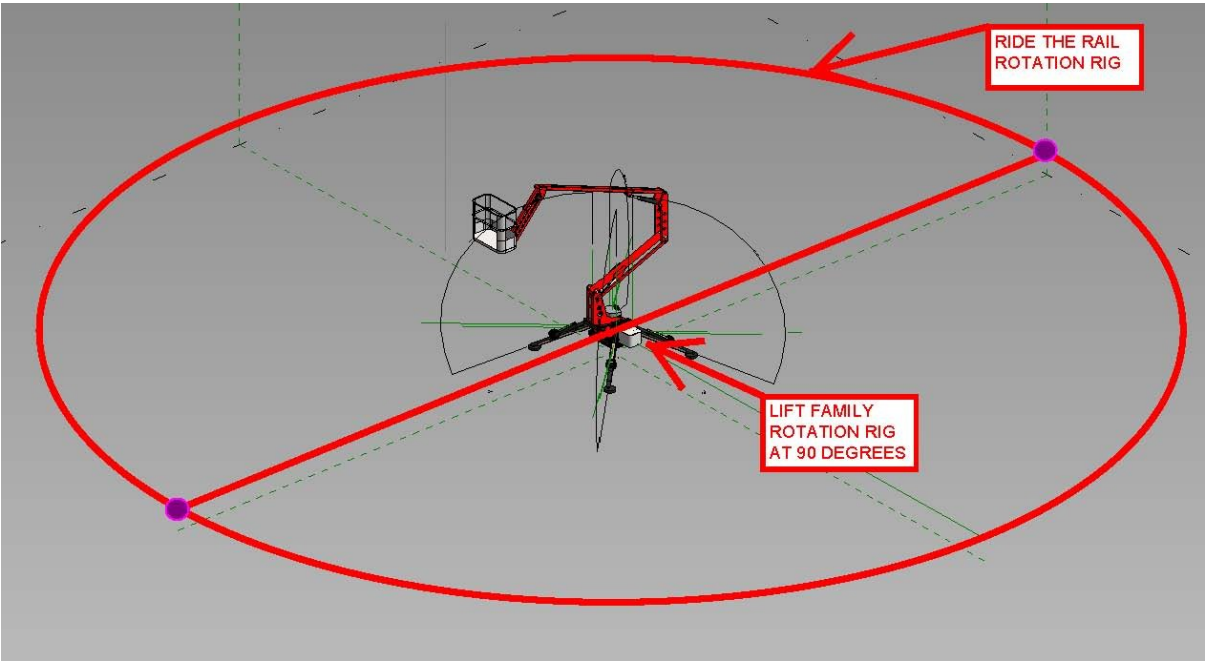
11. Set the Horizontal work plane of the new reference line.

12. Place the nested lift family "EX_1_LIFT_TOP_02.RFA" as work plane based at the middle of the reference line.

13. Map the nested lift family parameters to the host family as shown below.



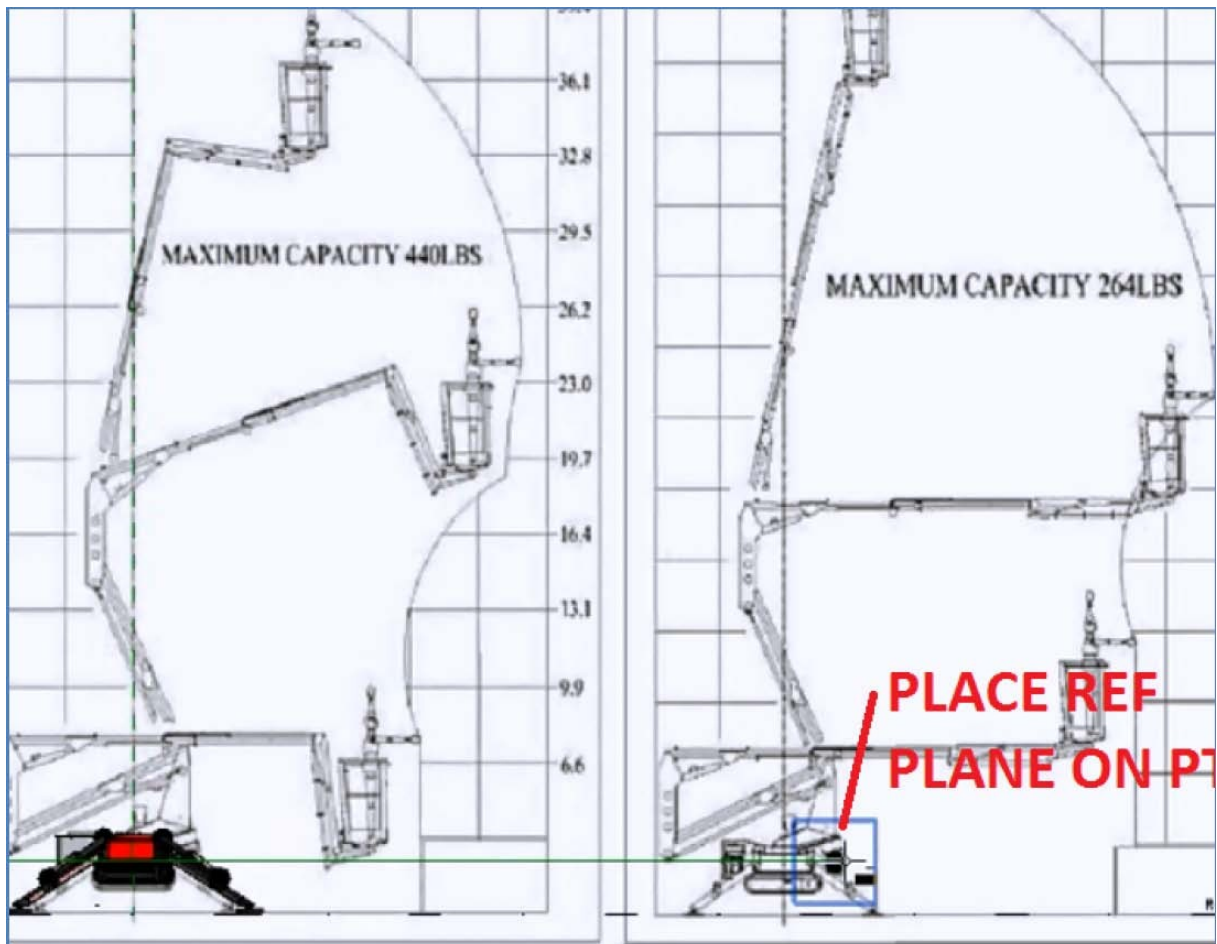
14. Flex and enjoy. Take this family with you and practice! What other rotation angles could be applied to this Ride the Rail rig?



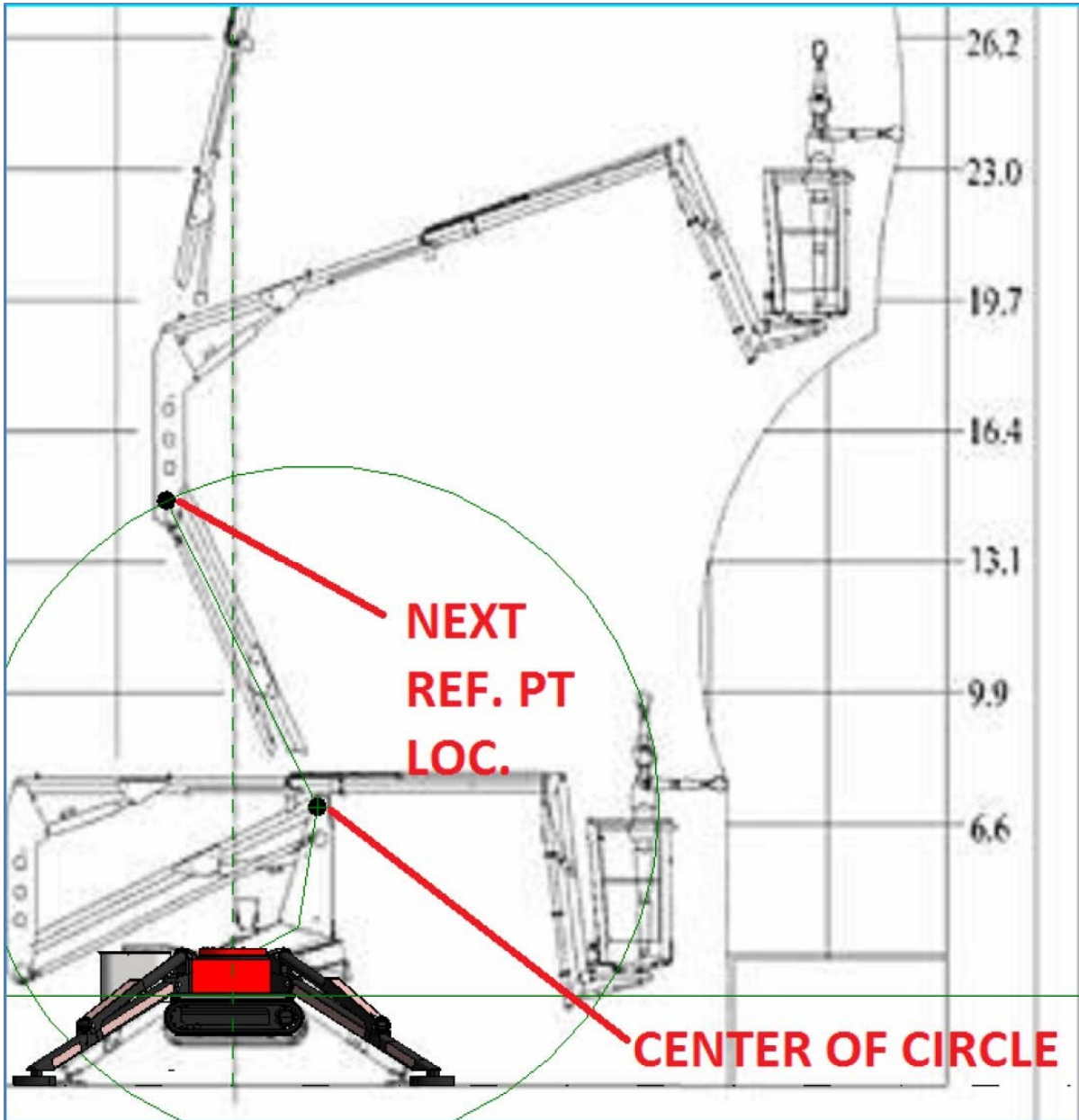
PART 2

Creating Elevated Rotation Rigs

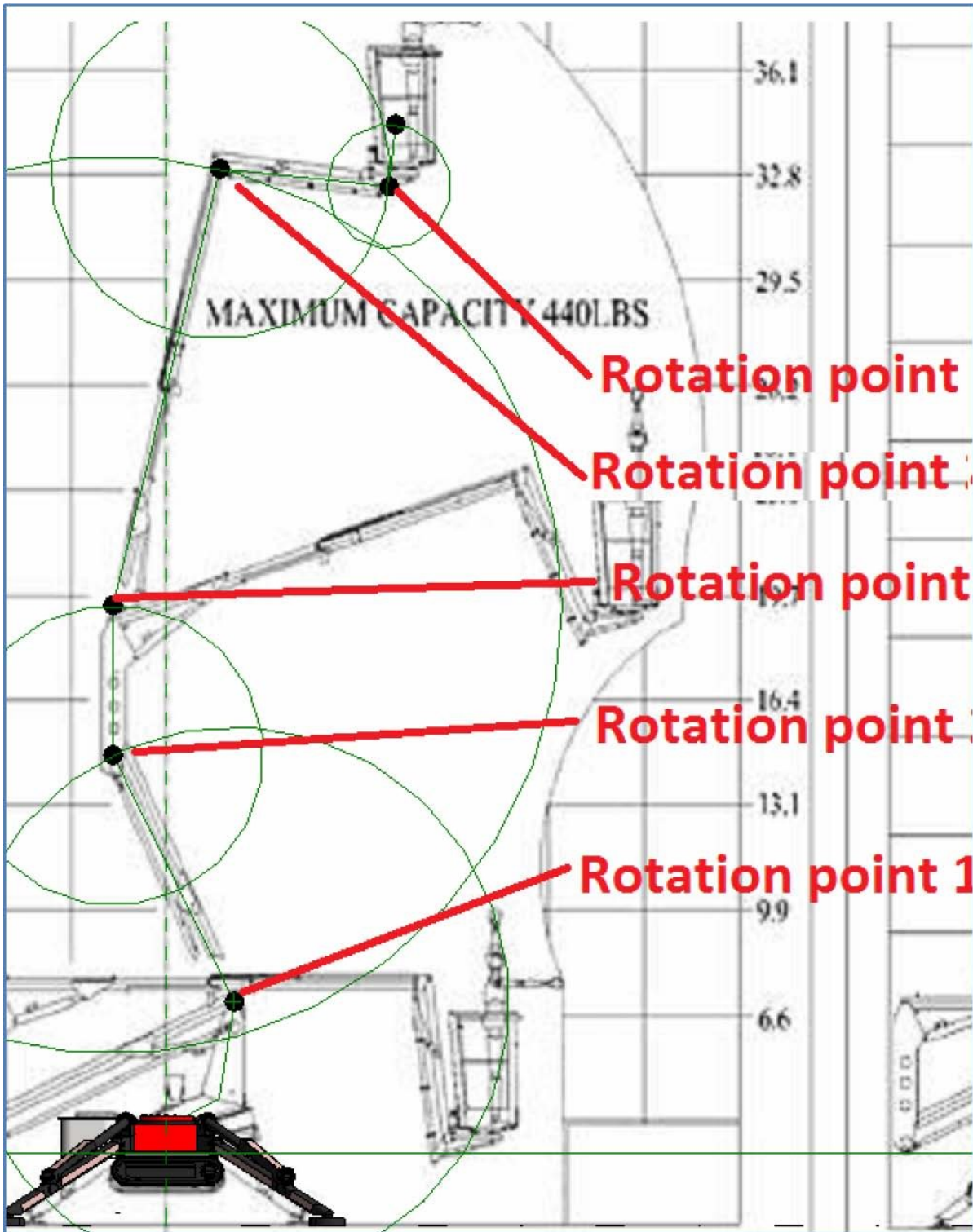
1. Open the files titled EX_1_LIFT_START.rfa
2. First hide the top part of the lift family then set reference plane to the reference point's plane that is parallel to the screen of the computer. Note that in Revit 2016 if the reference plane of the base reference line was used instead of the point, the boom element would be off in the distance.



3. Draw a reference circle whose center is on the first center of rotation. Then draw a circle where the radius as large as the next closest rotation point as shown in the figure below.

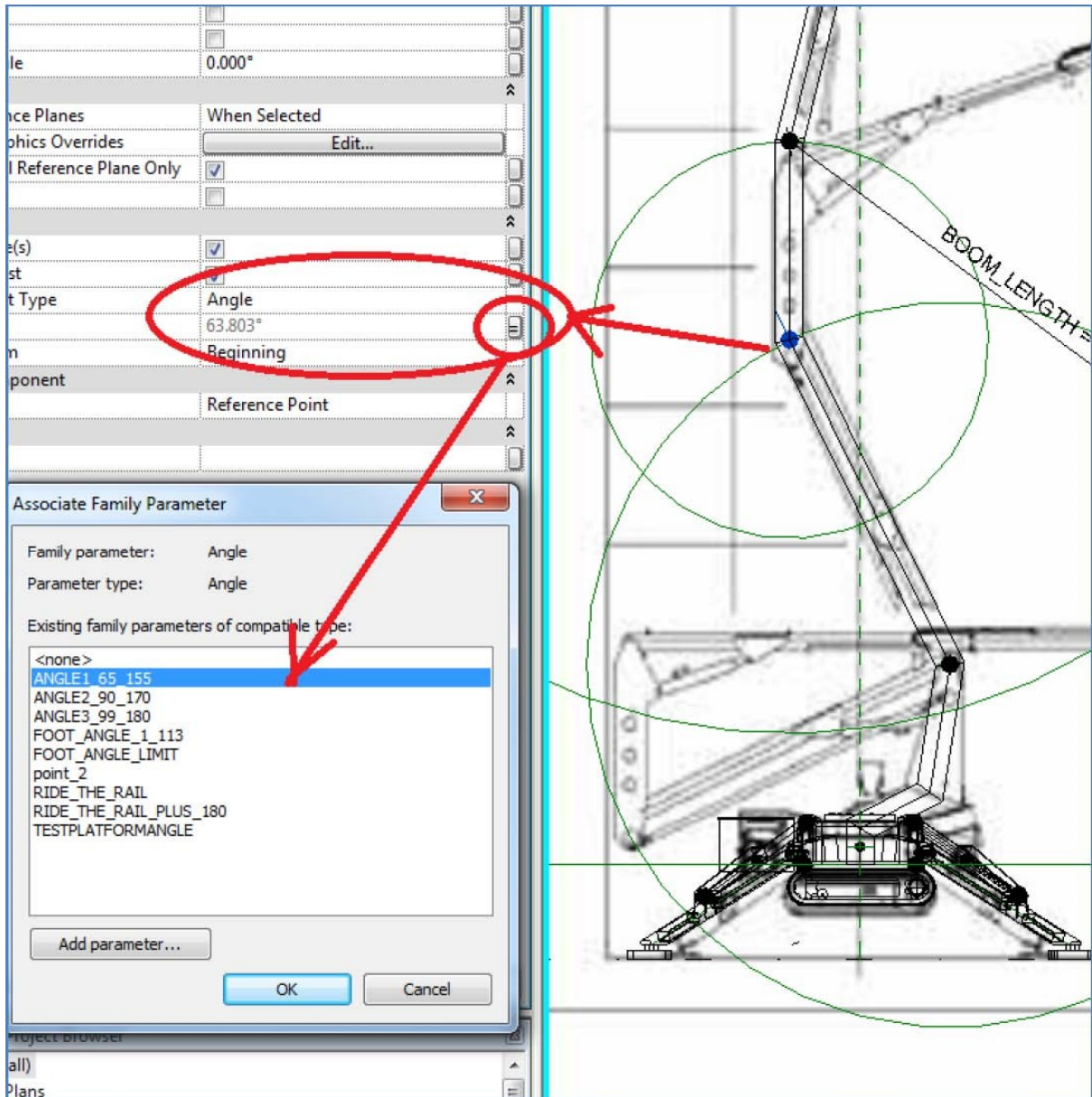


4. Continue to draw circles at each node as shown in the previous step until all the joint locations have nodes with reference. if you are not finished just simply open EX_1_LIFT_MID.RFA to catch up!

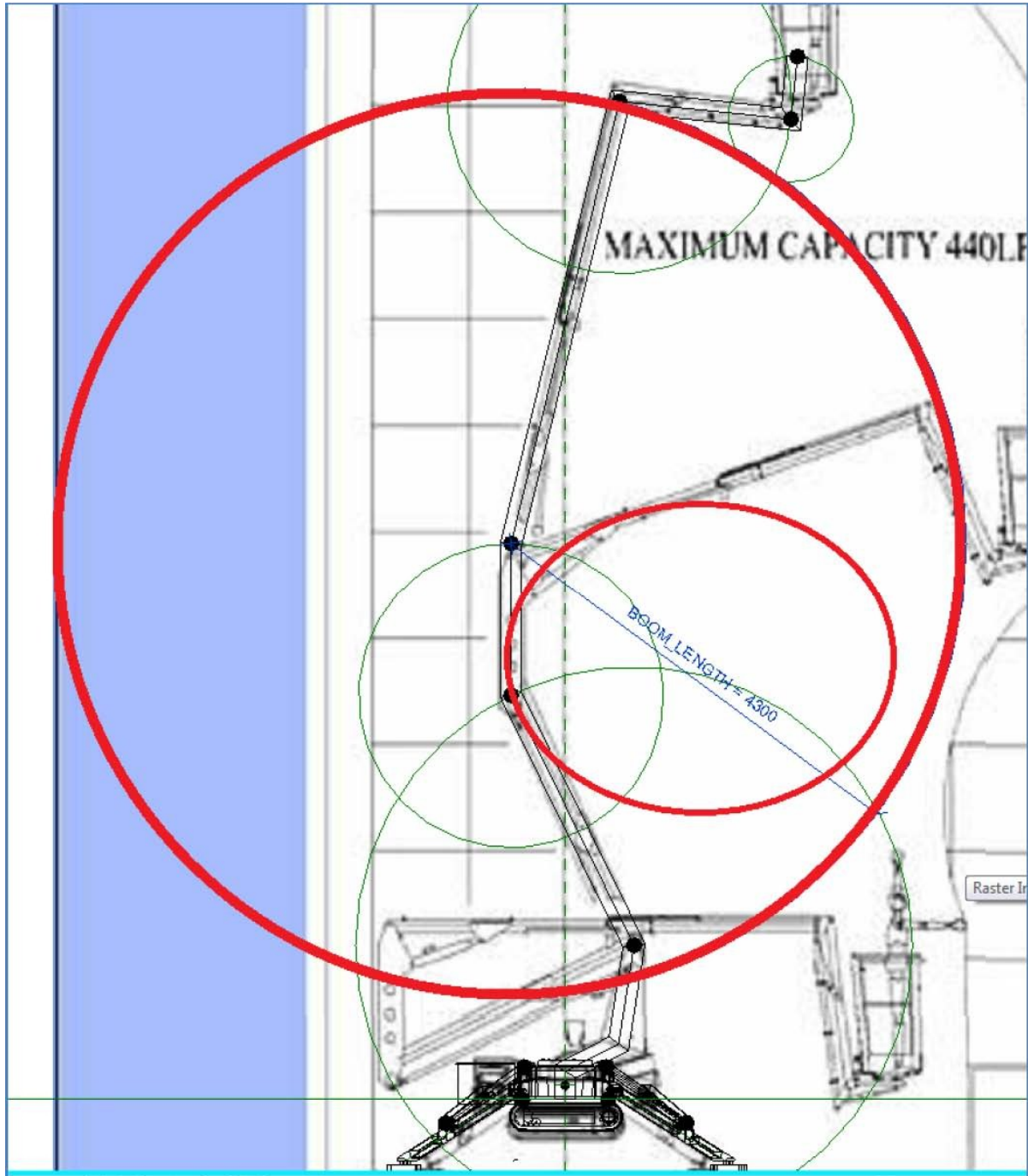


5. Now flex your nodes to the next position as shown in the figure above. If you are not finished simply open EX_1_LIFT_FINAL.RFA to catch up!
6. We will not be adding angle parameters however you should do this to control the joints once this family is placed in the project environment.

7. To add an angle parameter to each swing rig select the hosted node on the circle and change the measurement type to angle and assign or create an angle parameter as shown in the figure below.



- To add length parameter, do not use an aligned dimension. Take advantage of the rotational rigs that were just created. Since each segment of "arm" spans from hosted nod to hosted node then to make the "arm" longer just make the radius of the circle a parameter as shown in the figure below



1. Since this is a piece of construction equipment then there will need to be some limits on the parameters that were just assigned. These booms are not allowed to move past a certain point as shown in the specifications. Therefore, it is important to add some sort of limitations to the parameters. There are two ways to do this. The method, that is controlled by equations and the method that is controlled by the arc length of the circle

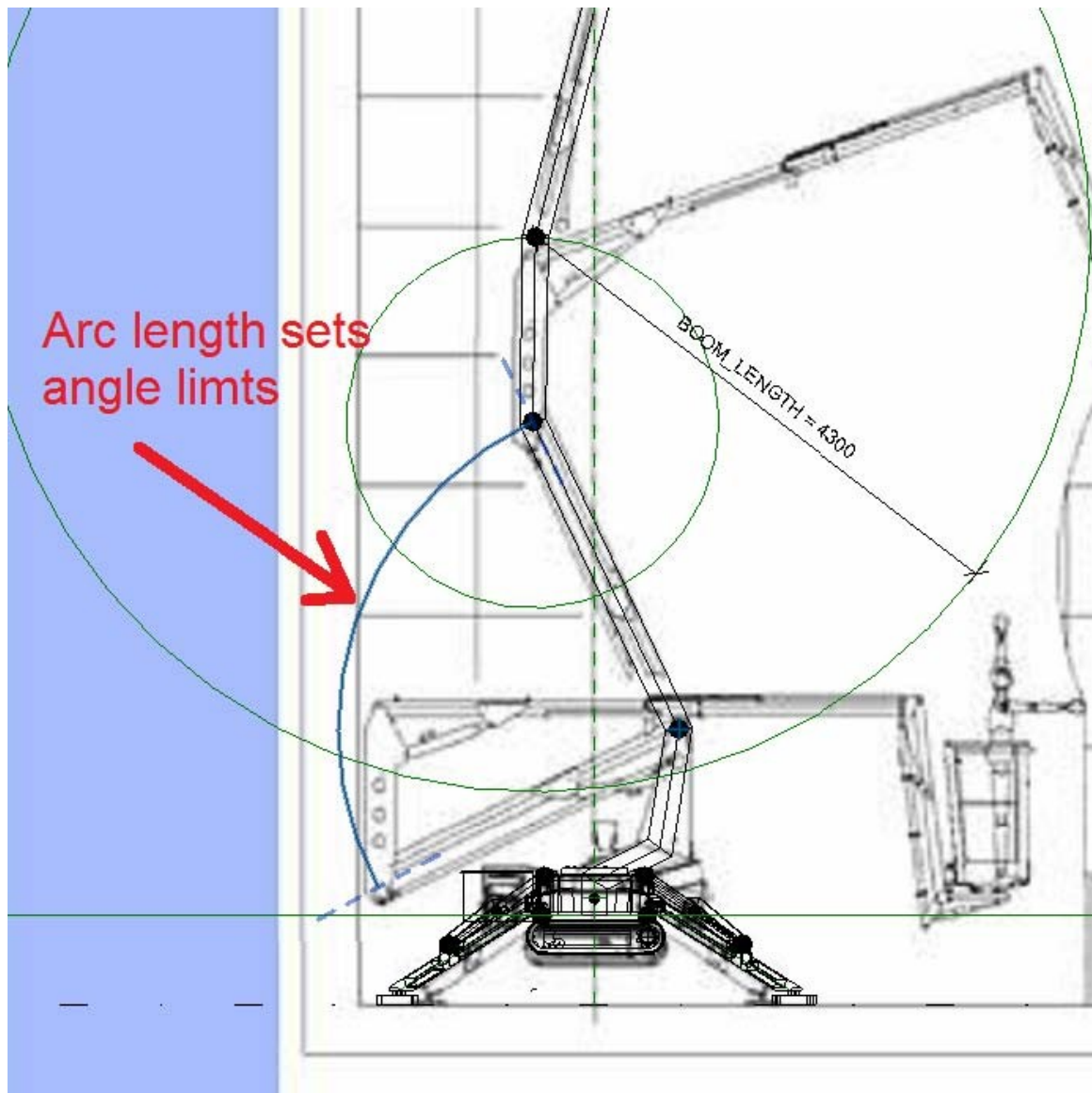
A. Limits by Equation: To replace the recently assigned parameters with a new parameter, I typically use the name "limit" in the name. Then in the equation of the parameter list the following limits as shown below.

The image shows a CAD software interface with a parameter table and a 3D model of a boom. The parameter table is as follows:

Dimensions		
point_2 (default)	296.197°	= 360° - ANGLE1
end_point_offset (default)	2438.4	= 2438.4 mm
TRIGGER_ANGLE (default)	0.000°	= 0°
ANGLE_1_LIMIT (default)	63.803°	= if(ANGLE1 < -30°, 330°, if(ANGLE1 > 67°, 67°, ANGLE1))
Visibility		
Other		
FOOT_ANGLE_1_113 (default)	113.000°	=
BOOM_LENGTH (default)	4300.0	=
ANGLE3 (default)	352.173°	=
ANGLE2 (default)	27.283°	=
ANGLE1 (default)	63.803°	=
Identity Data		
Assembly Code		=
Keywords		=

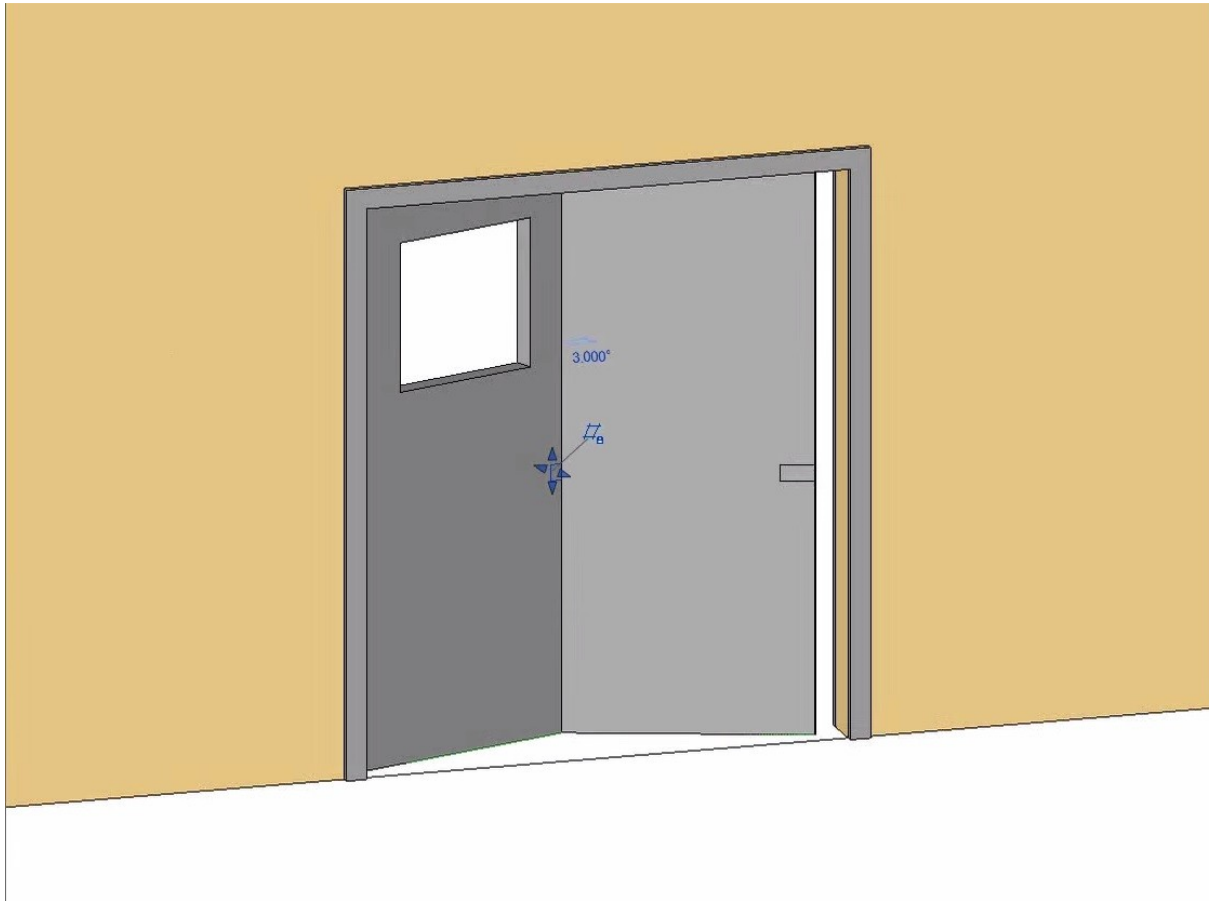
The 3D model below shows a boom with a length of 4300 mm. Red arrows and text indicate the maximum angle of 67° and the minimum angle of -30°. The current angle is shown as 63.803°.

B. Limits by Arc Length: Use the "break" command and click twice on the reference circle. Take the ends of the reference circle and place each of them at the true limits of the angle, arm swing, limits as shown below. Presto! Instant angle limits! Repeat for all reference circles. If you are not finished just open EX_1_LIFT_LIMITS_FINAL.RFA to catch up!

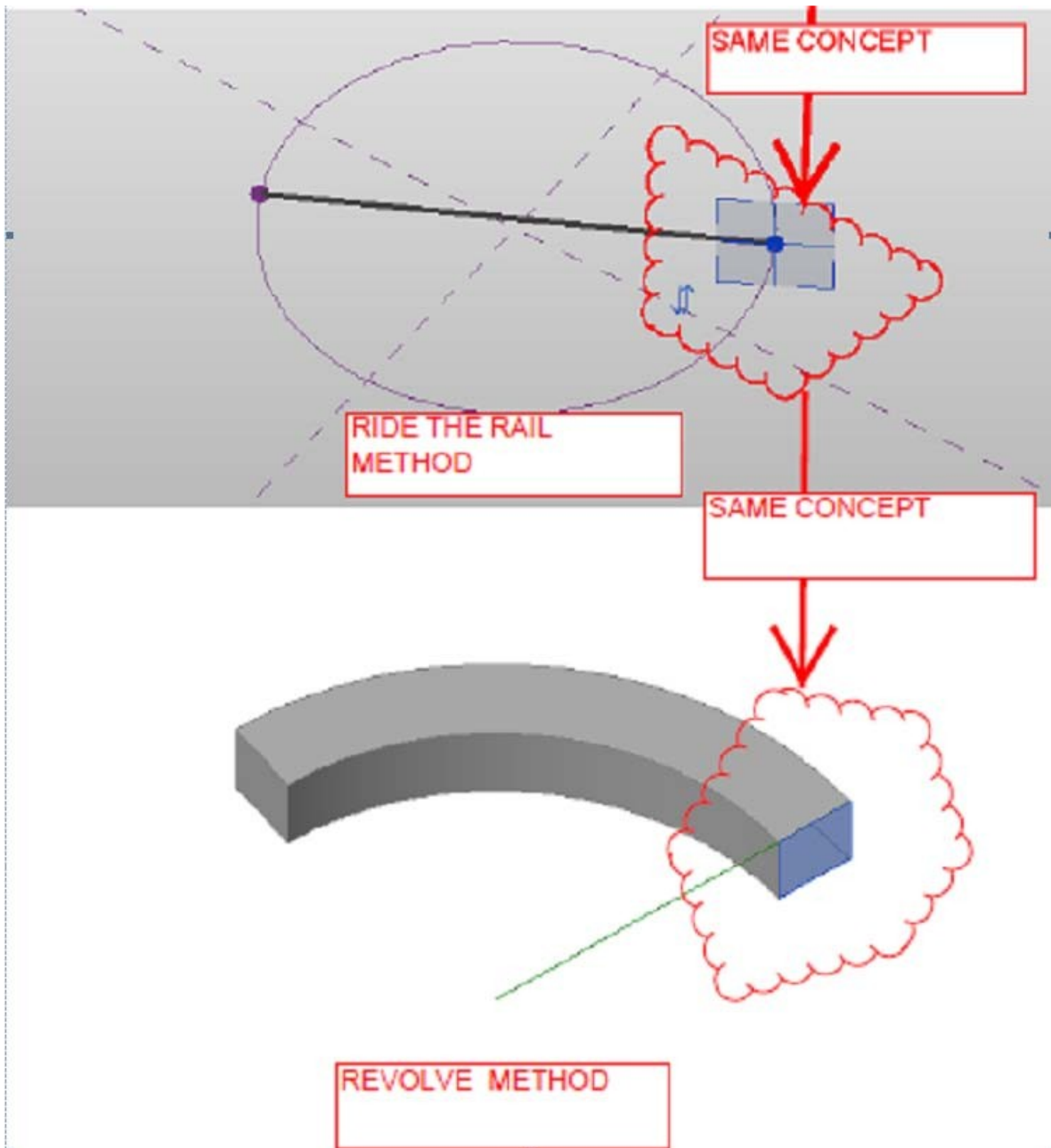


One final exercise to test how the lift works simply open EX_1_LIFT_REACH_FINAL.RFA and select only the nodes and try to get the lift to reach the "window" in the family.

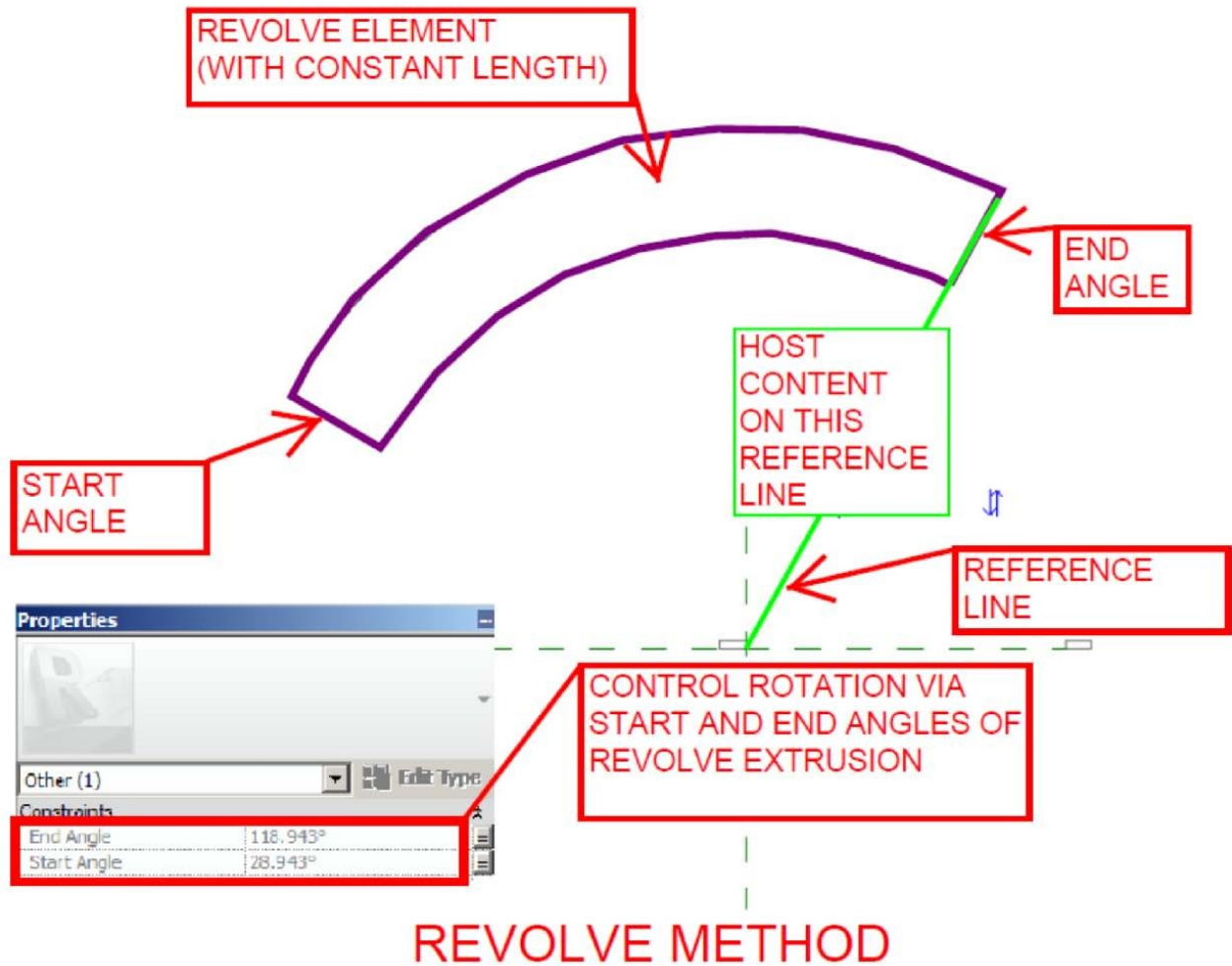
Introduction: Folding Doors



In this exercise we will be creating a custom bi-folding door family, as shown above, within the classical family editor using the "revolve" method to create a rotation rig to which we will be placing each door panel on. Let's get started!



It was this fundamental concept that had me realize that the Revolve element (which is one of the four forms that could be created in the classic family editor) could have a constant angle value and have its start and end angles move together. This would allow the arc angle to never be zero. As shown above the end of the revolve element could be defined as a work plane similar to the point on Ride the Rail method.

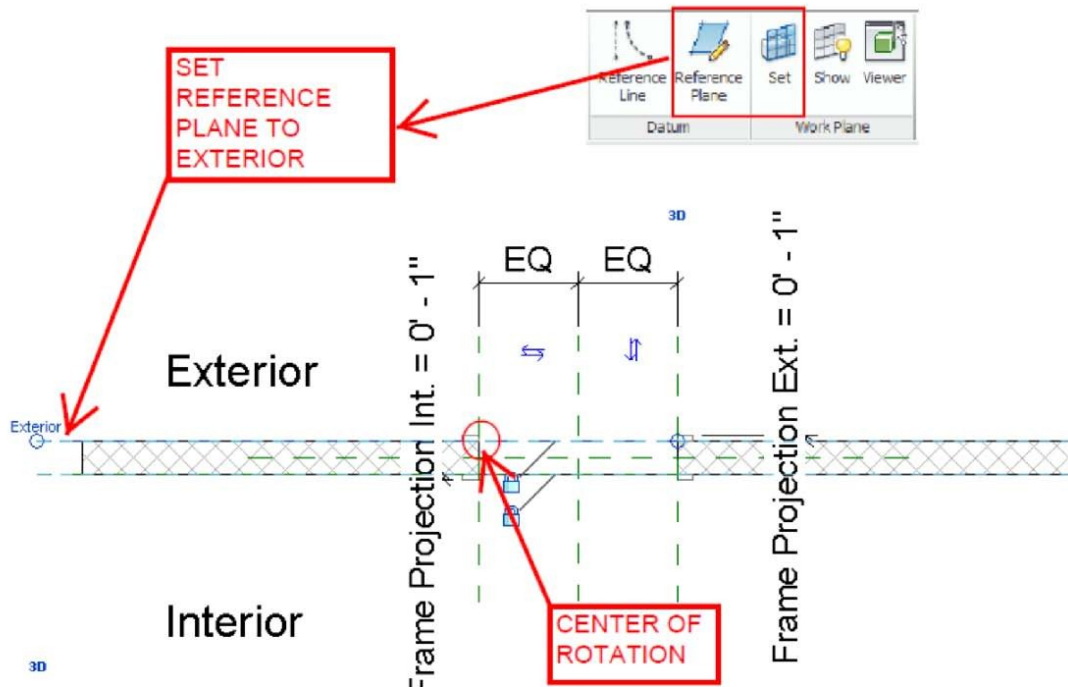


From this, I created the "Revolve" rotation method as shown above in the rotation rig above and notice that it uses the preset revolve form parameters of the start and end angles to control the angle NOT the angle parameter. This way, the revolve element could be a constant arc length/angle and the end angle is "chasing" its start angle.

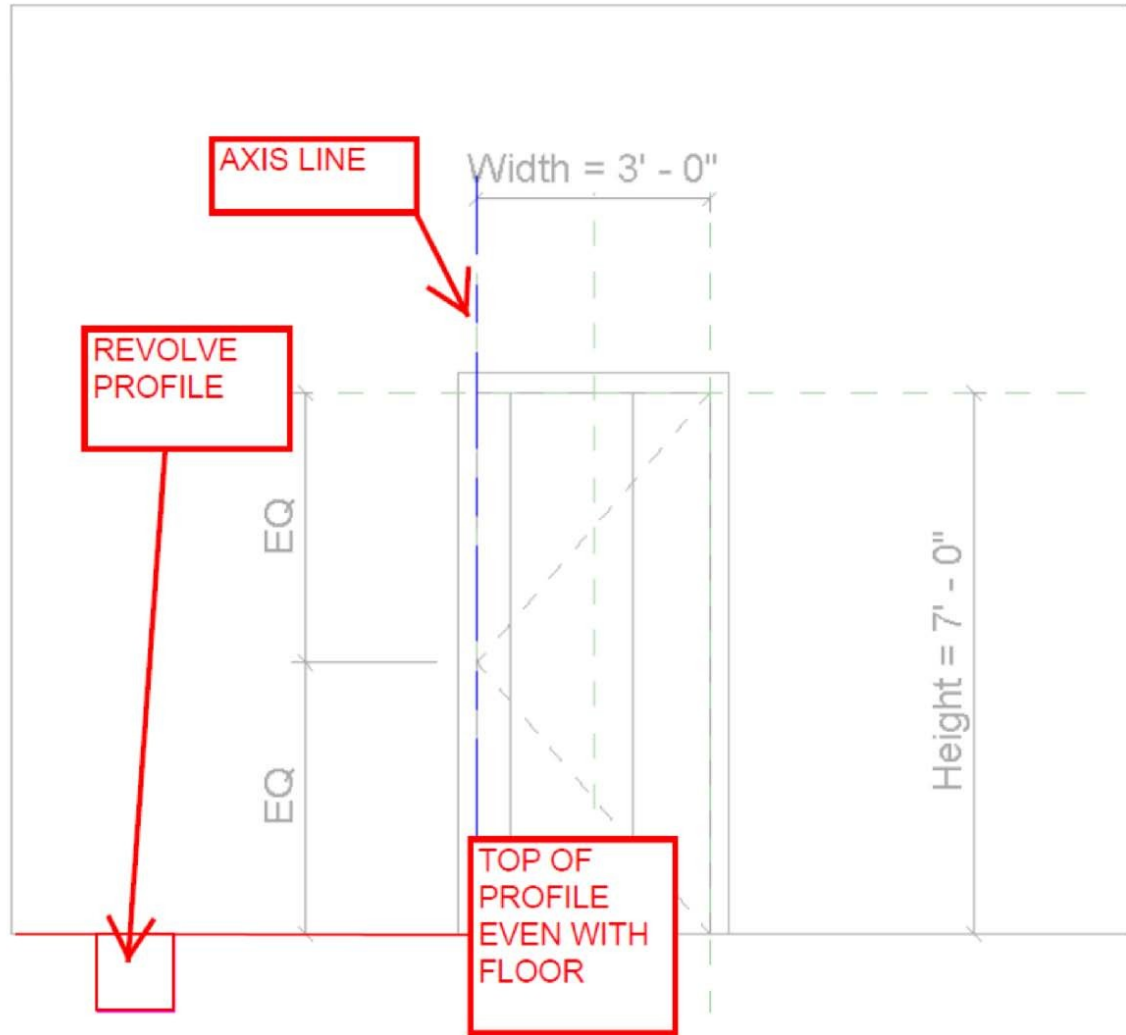
PART 1

Creating Door Panel 1

1. First start a new door family from the default family template in Revit. or open EX-02_BI_DOOR_START.RFA. Go to the reference plan view.
2. Set the reference plane to interior. This will host the revolve profile as shown

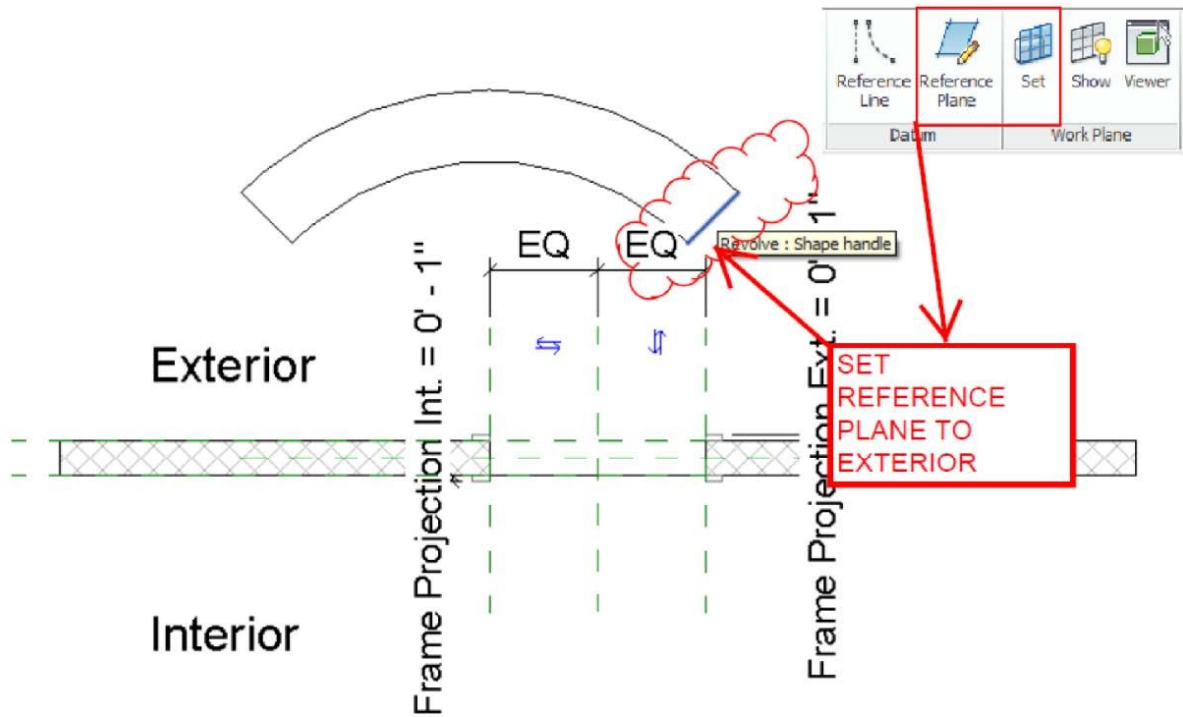


3. Create a rectangular profile where the top of the profile is at the floor line.
4. Select the revolve axis line as the vertical reference plane that intersects the center of rotation as shown. Click OK when done and the revolve element will be created.

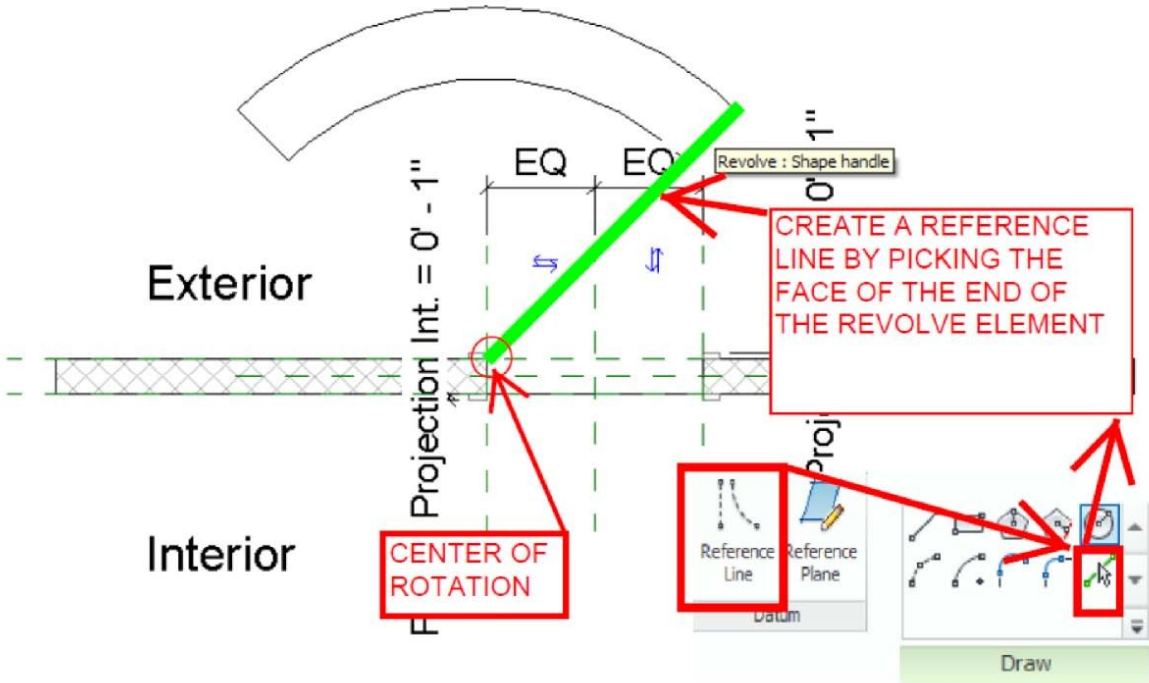


5. Click on the revolve element and make it "not" visible. This will make the revolve element not visible in the project environment. **Note: this element could be left as "visible" and be changed to look like a door handle instead of how the revolve element looks in this example.**
6. Create two angle parameters, create an angle parameter called "INPUT." This will be used as the input angle, what is traditionally used to define how "open" a door is. I like to use the end angle to control the back side of the angle instead of the front because it is easier to work with.
7. Create another angle parameter called "a1" and "a2" and give it the formula as shown in the figure below.
8. Assign the "a1" and "a2" parameter to the start and end preset parameters of the revolve element respectfully.

9. Go to the top down 3D view and set the work plane to the end of the revolve element, this is done so that the reference line that will host the door geometry is placed at the correct plane.



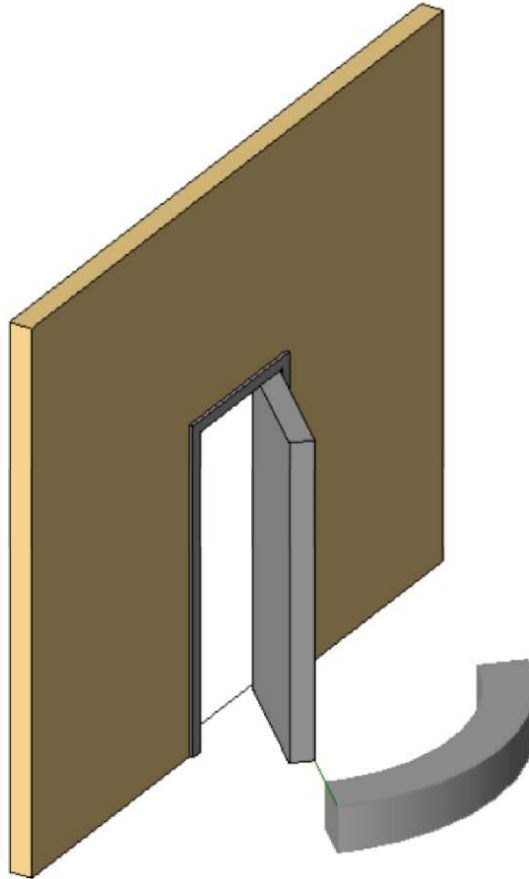
10. Create a reference line by picking the face of the end of the revolve element.
Congratulations! The Revolve rotation rig is now complete. If you are not finished simply open EX-02_BI_DOOR_MID.RFA to catch u p !



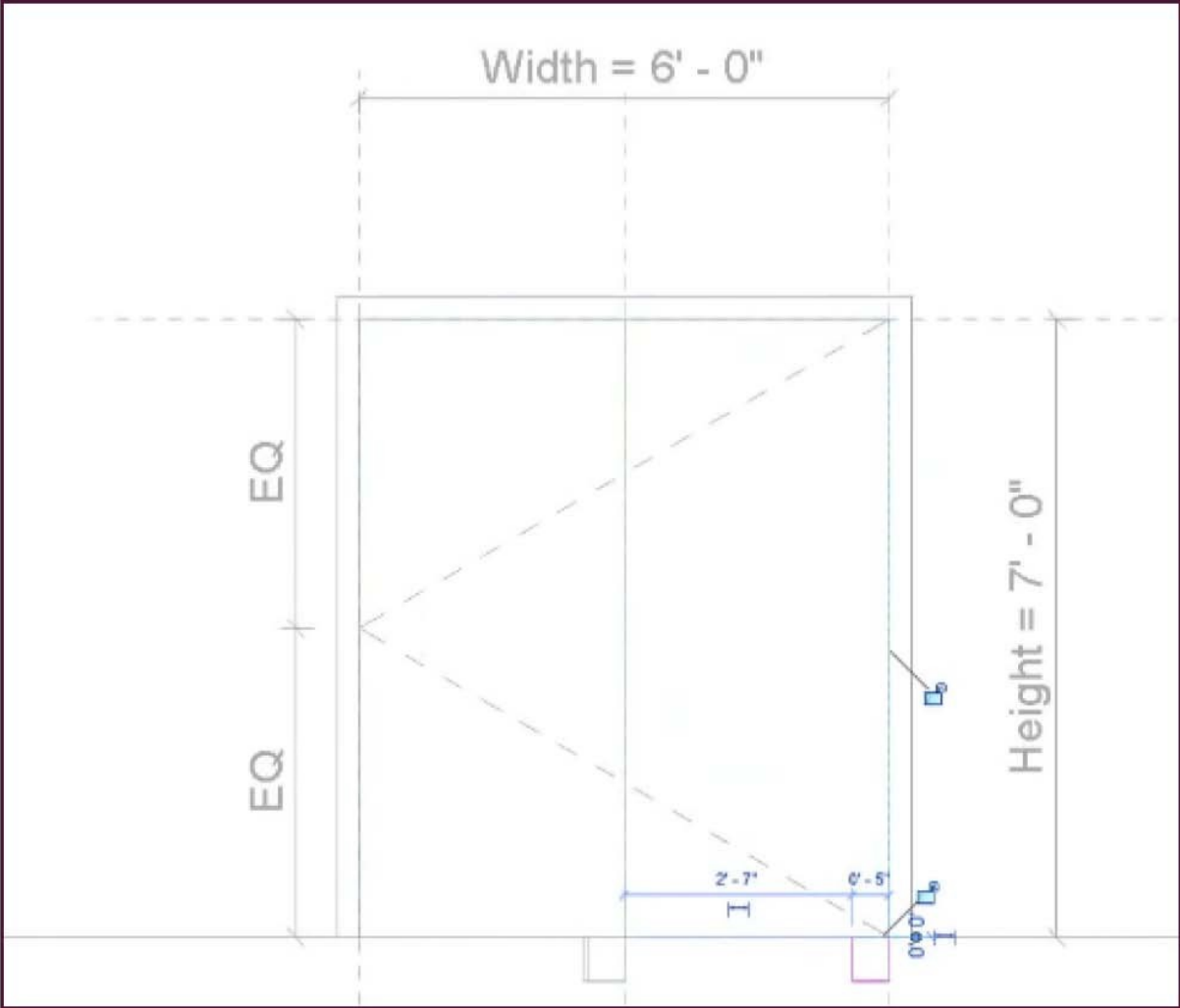
PART 2

Creating Door Panel 2

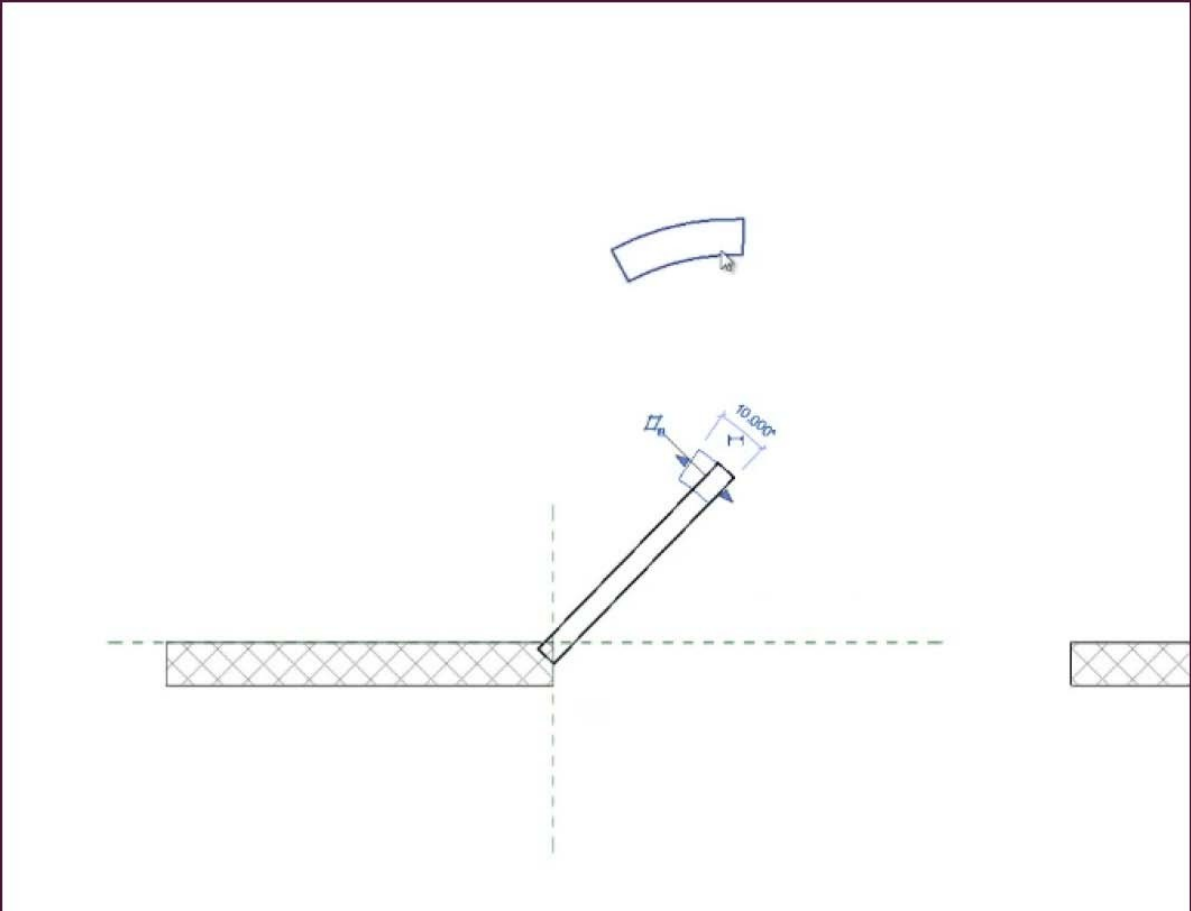
11. Open EX-02_BI_DOOR_MID.RFA or continue from part 1 and Set the reference plane of the host reference line to receive the door geometry, create the door geometry on the hosting reference line.



- 12. The door geometry will not be covered in this posting however; it is very simple to perform just add an extrusion or nest a door family on the reference line.
- 13. Repeat Steps 2 thru 10 in part 1 except this time set the reference plane in step 2 to the face of the revolve.

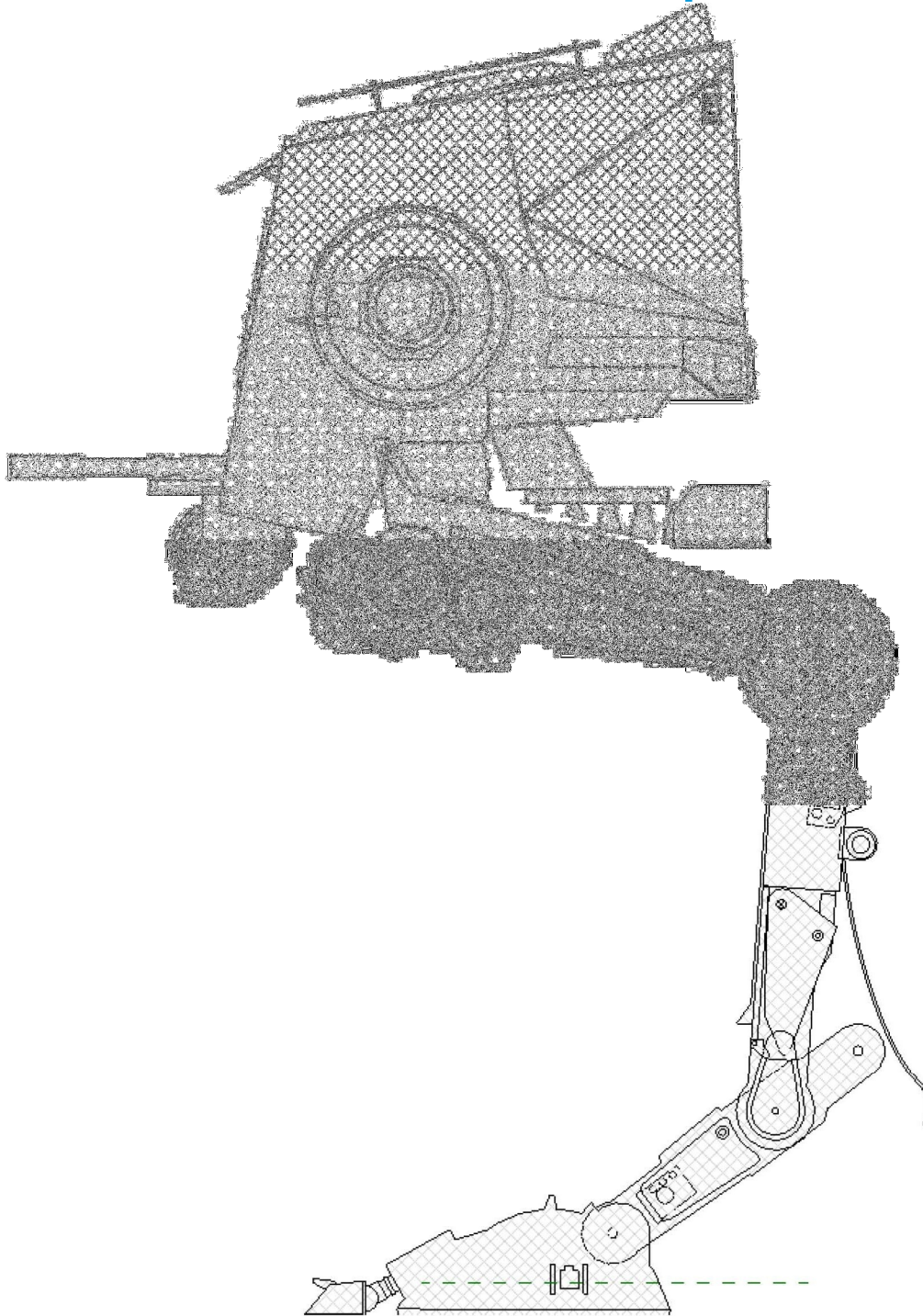


14. Notice that the second bi-fold door moves with the first door. That is relative IK motion in the classical family editor. If you are not finished open EX-02_BI_DOOR_FINAL.RFA to catch up. Load the family into the WALL_IN_PROJECT_START.RFA file and flex it!



15. More detailed steps are shown in the video in this link <https://www.youtube.com/watch?v=8UuAHxq5CGg>.

Introduction: 2D Components

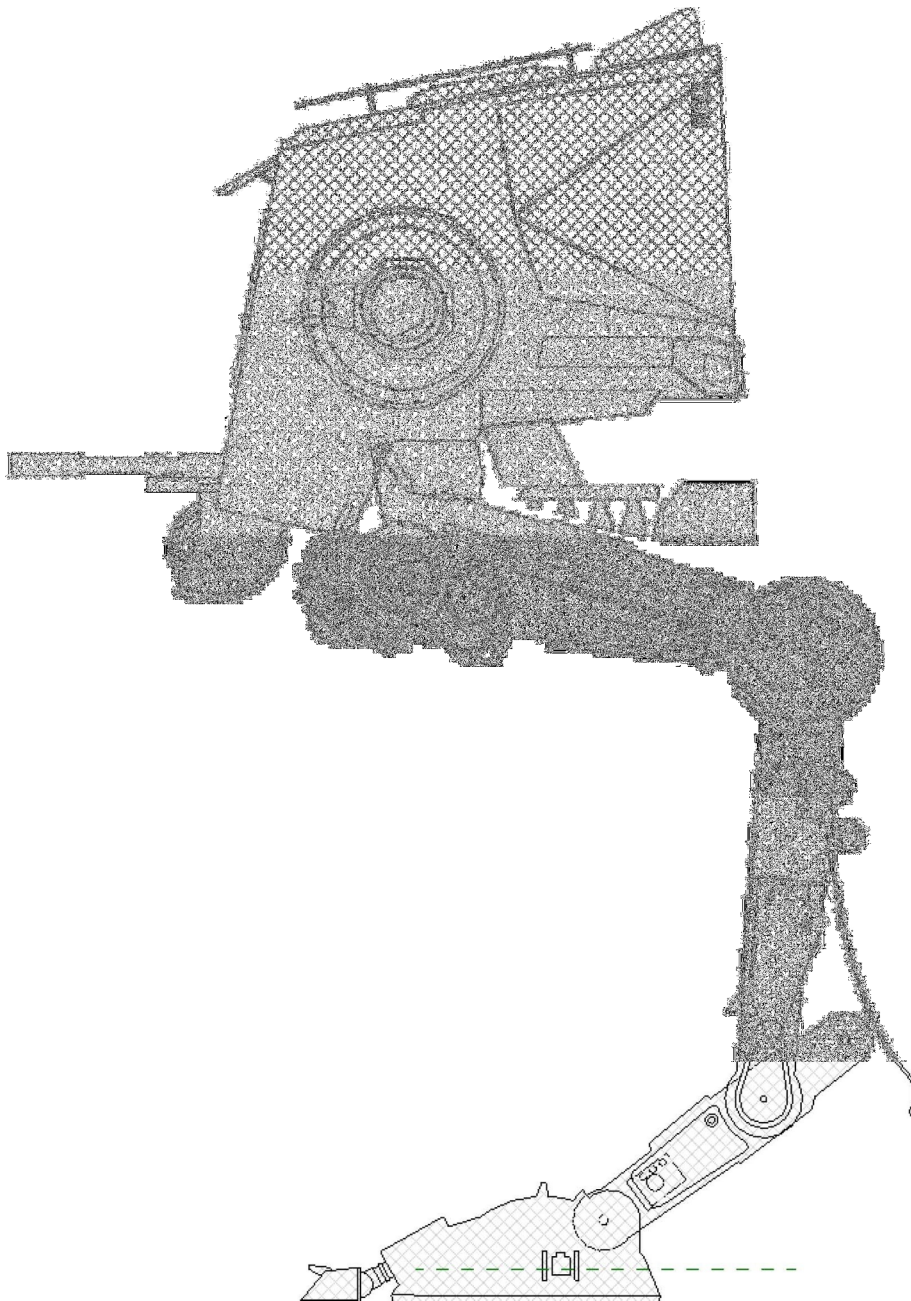


In this example we will show how to create complex rotations (inverse kinematics) or joint motion for a piece of complex mechanical equipment with multiple moving parts...oh and apply it to a 2D detail component as shown a b o v e .

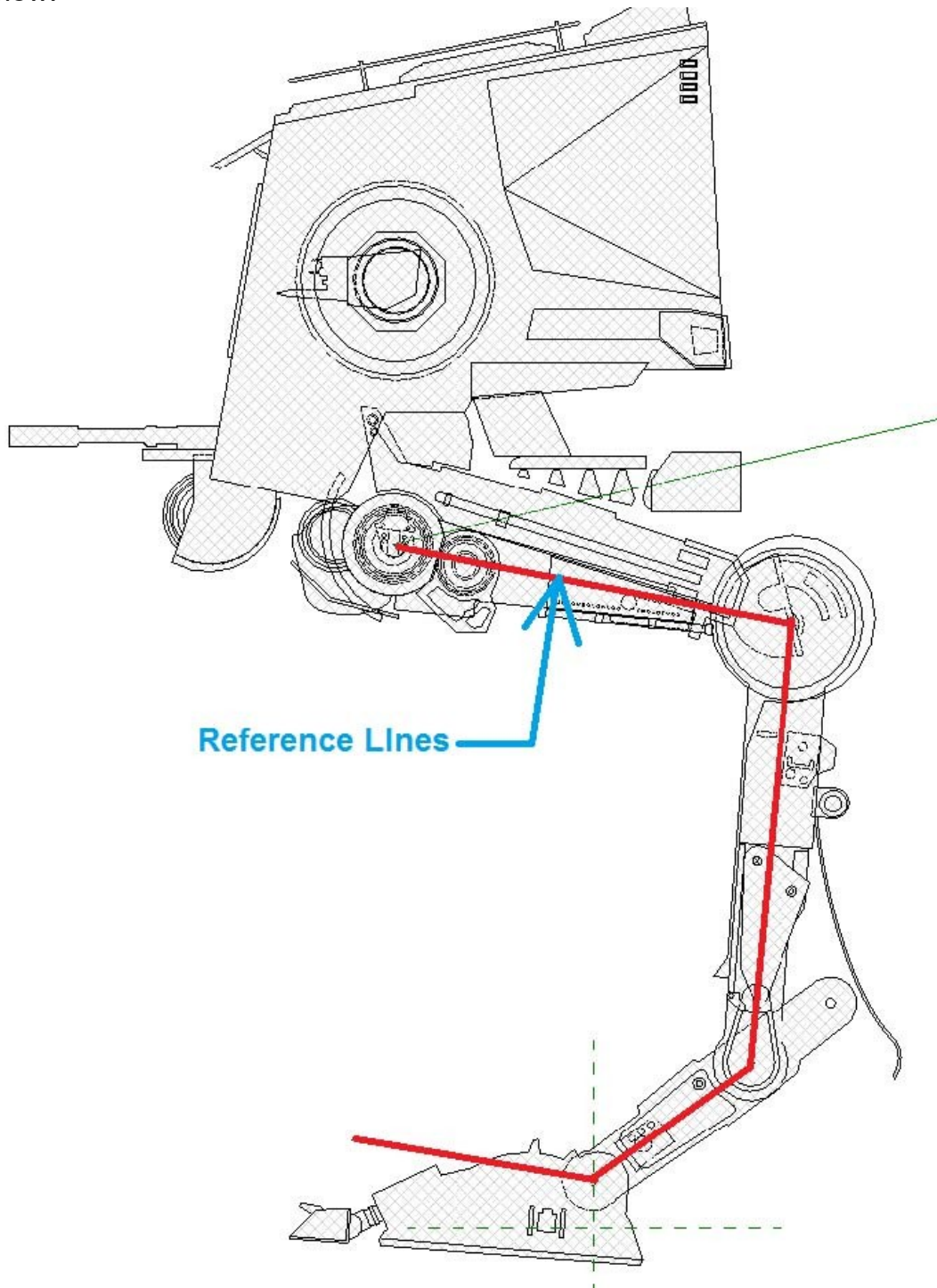
PART 1

Building the Bones

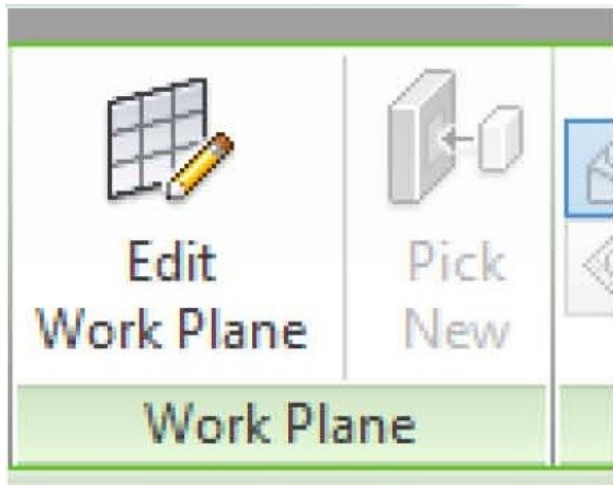
1. Create an ATST detail component as shown in the figure below or open the file:
ATST2D_START.RFA



2. Add reference lines where all the rigid links would occur as shown in the figure below.



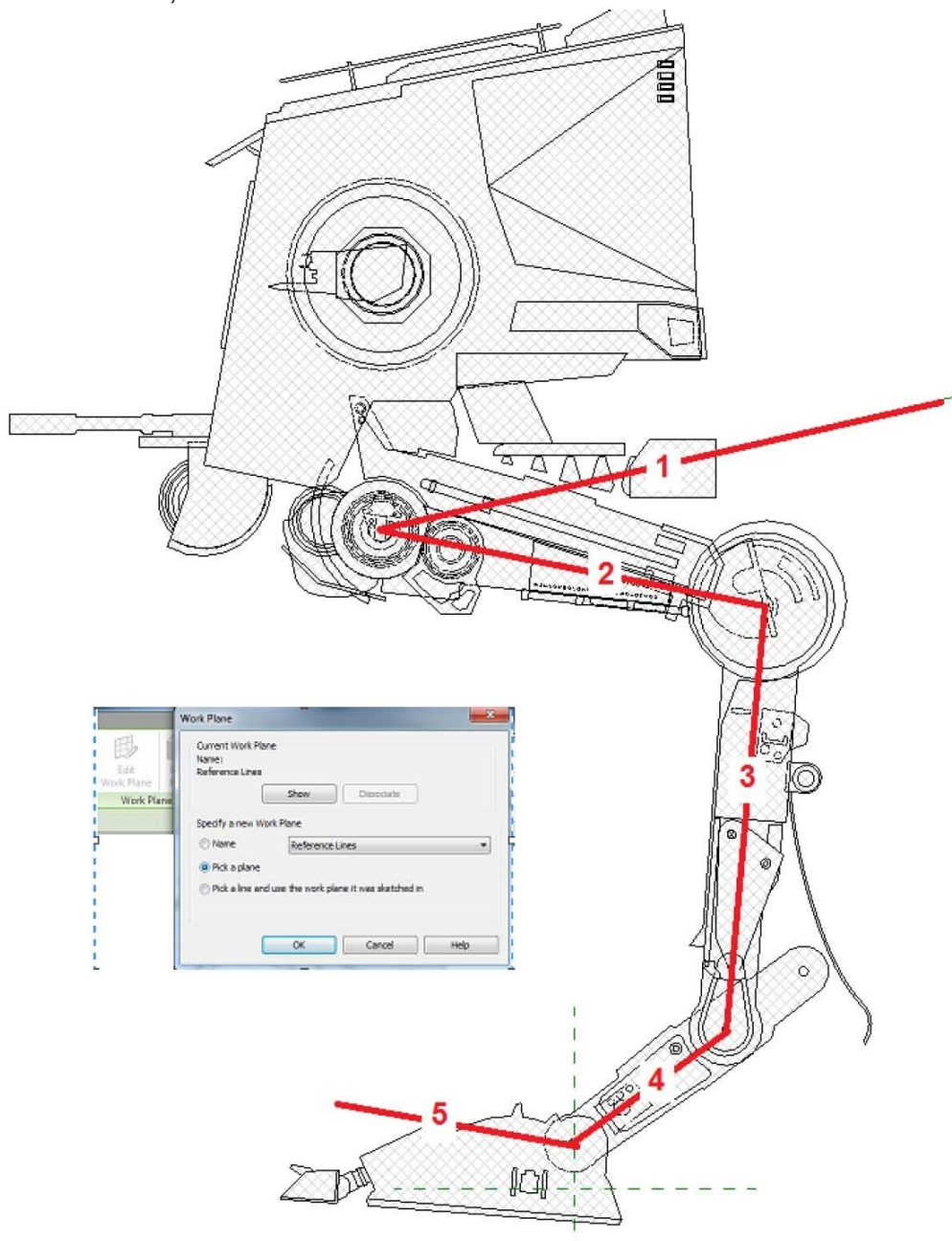
3. Select each detail component filled region and element and click edit work plane as shown in the figure.
4. Then select the reference line that the element is associated with. This will now allow for the element (filled region) to move relative to the reference line.



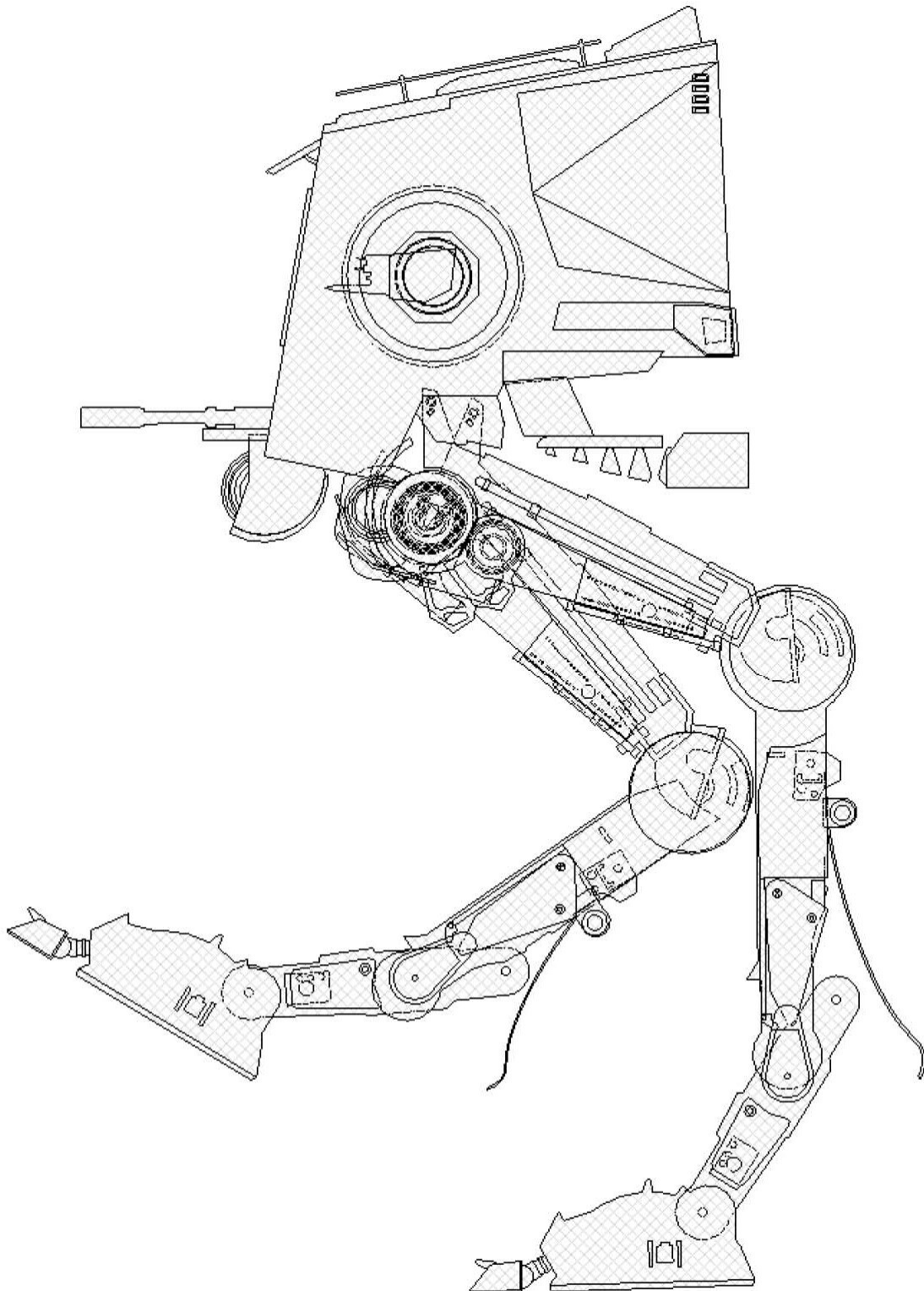
PART 2

Building Rotation Rigs

1. Open up ATST2D_MID.RFA or continue your model from part 1. Select each reference line in the order shown and host them onto each other in the order of the number shown in the figure below. This will allow for reference plane 2 to move relative to reference line 1 and reference line 3 to move relative to reference line 2; which will move relative to 1 and so on.

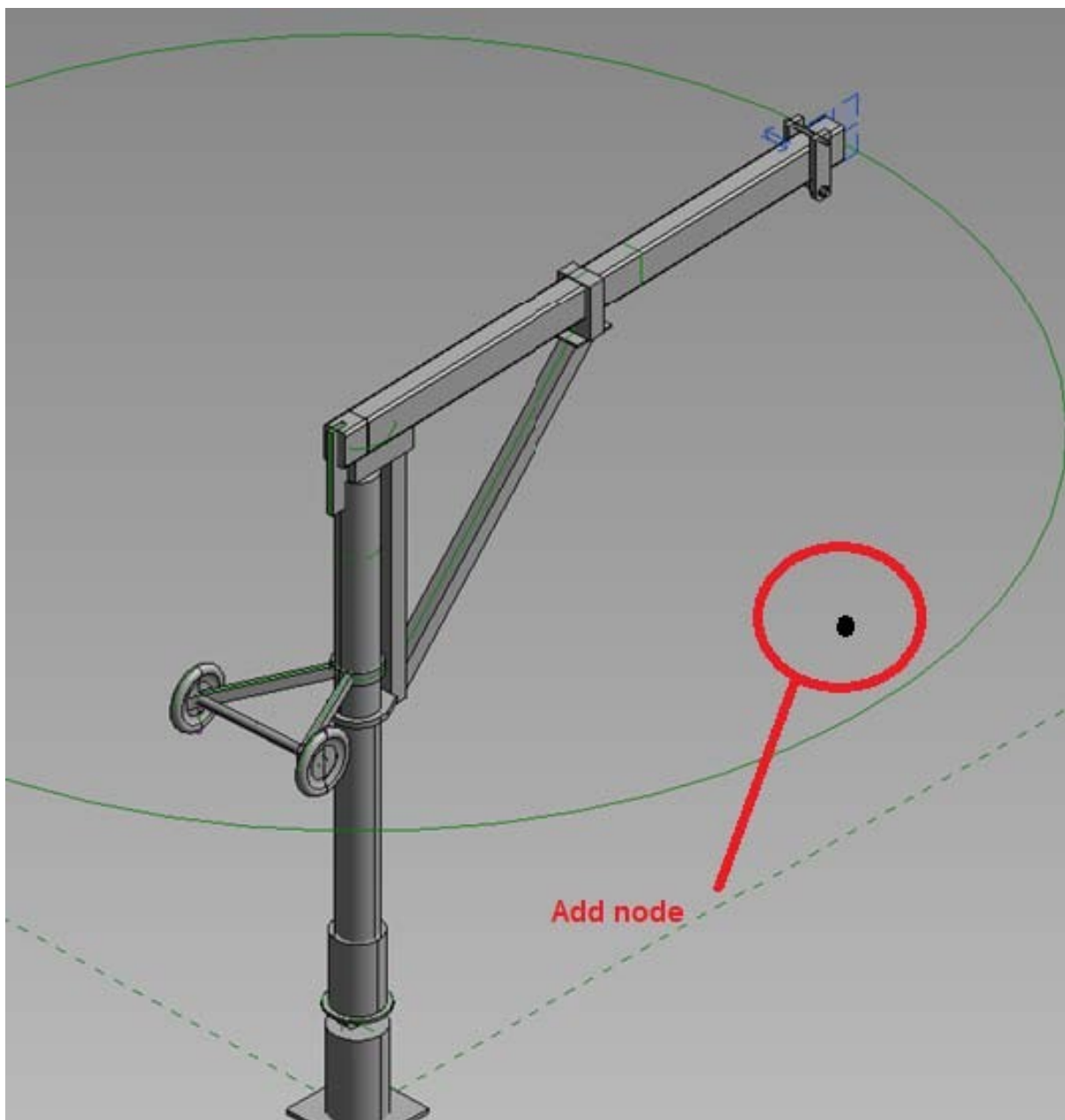


2. Set angles between each reference line. Select reference line 1 and watch the whole detail component joints move together as shown in the figure below! If you are not finished simply open up ATST2D_FINAL.RFA and you will be caught up!

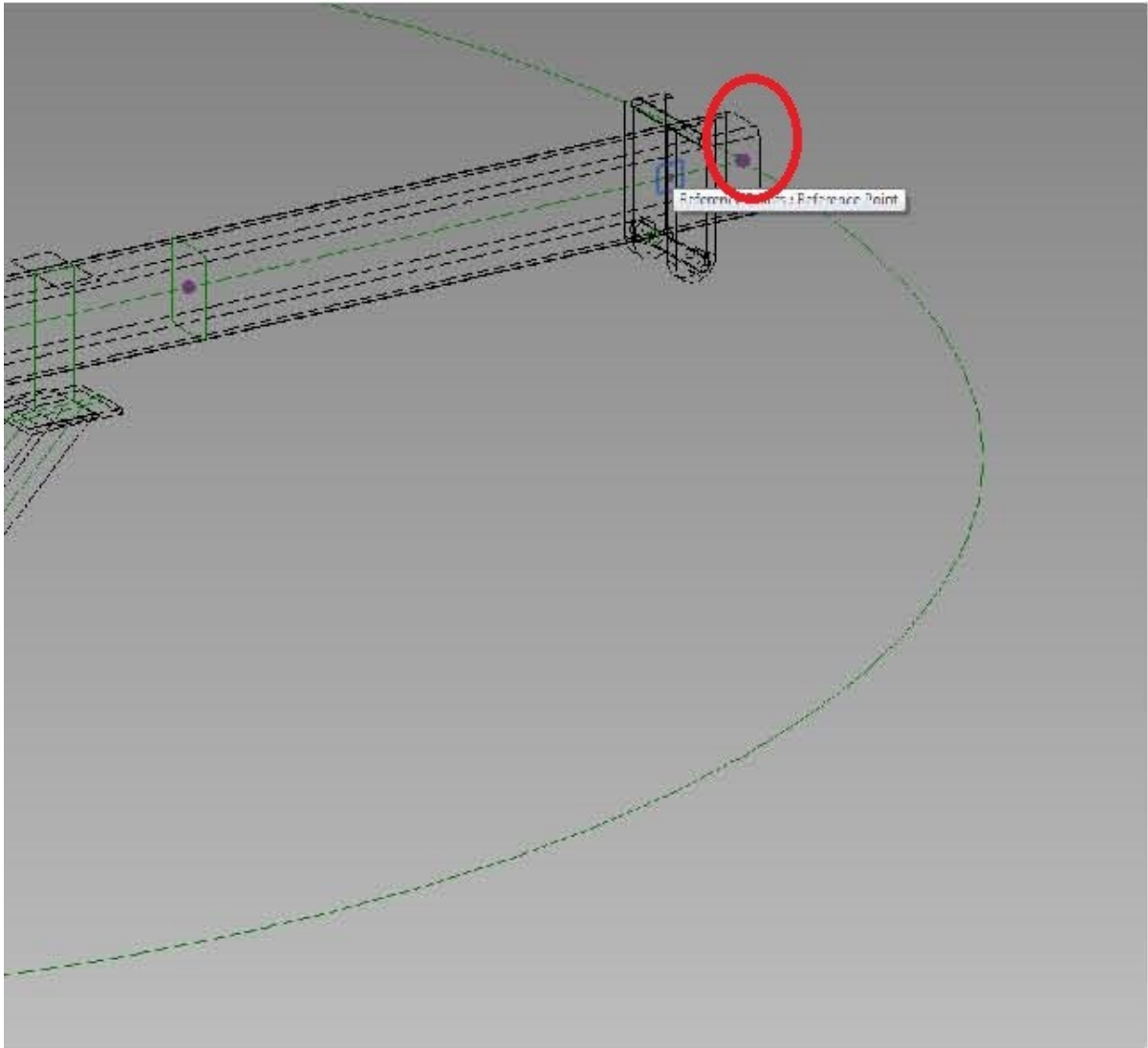


Davit Cable Creation and Movement

1. First Open EX_04_DAVIT_MID.RFA
2. To add a cable, first place a reference point anywhere in the family as shown below.

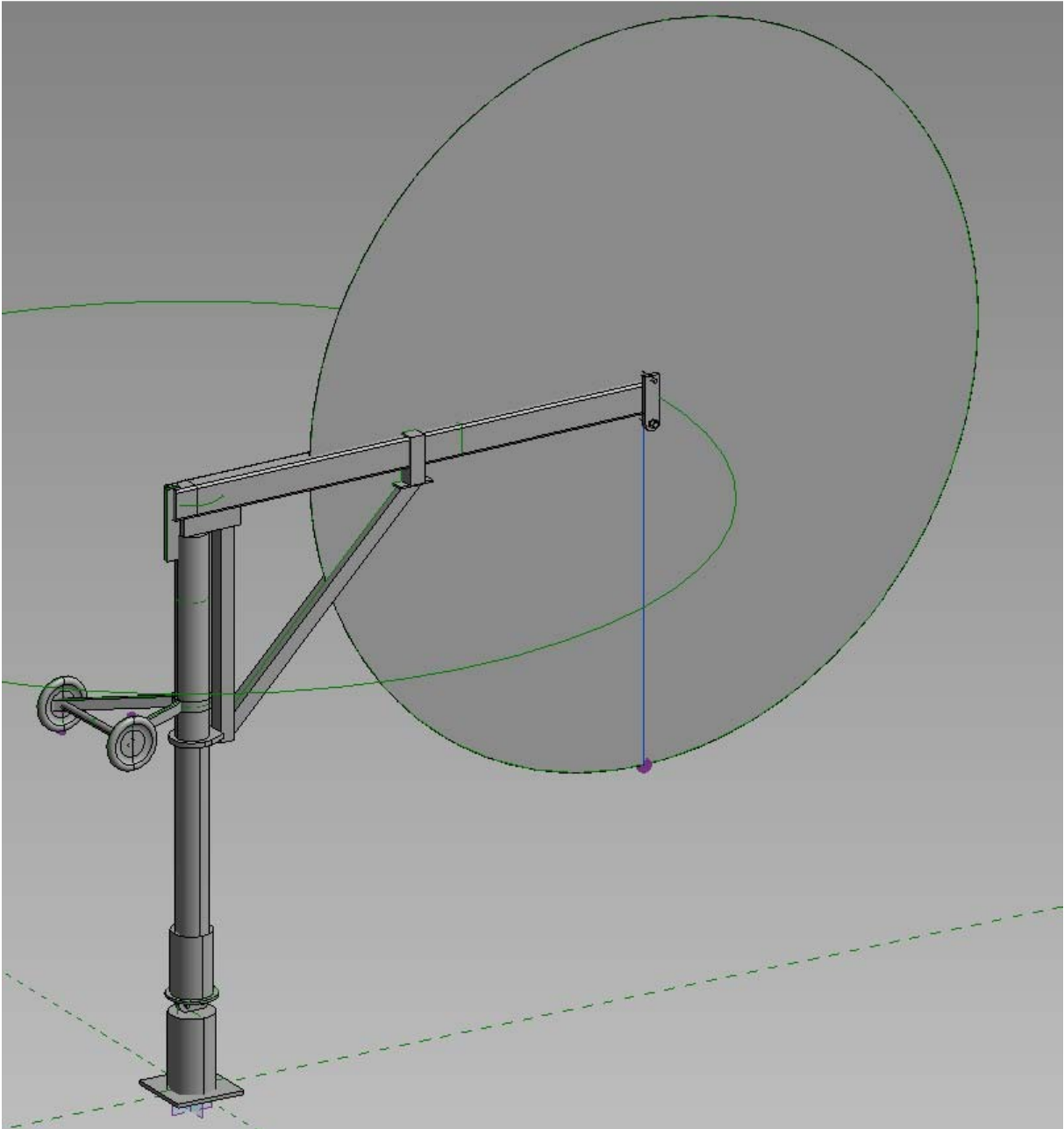


3. Select the new placed node and the node in the slider cradle as shown in the figure below and click "spline thru points." This will create the cable. Next we need to place the cable in the correct location.



4. Draw a circle as a surface that is hosted on the end point of the davit and the radius is the max travel radius of the cable.

5. Host the end point of the cable onto the circle as shown in the image below. You now have realistic cable movement. You are able to "extend" or "retract" the cable as needed. This method could also be used on cranes or any equipment that uses cables.



Note: If you want to "flex" and move the cable in the project environment, simply create a surface as shown in step 3 using an in-place mass then make the end point of the cable "adaptive." Load the family into the project and host the adaptive point to the circular surface. Now you could move the cable in the project environment!

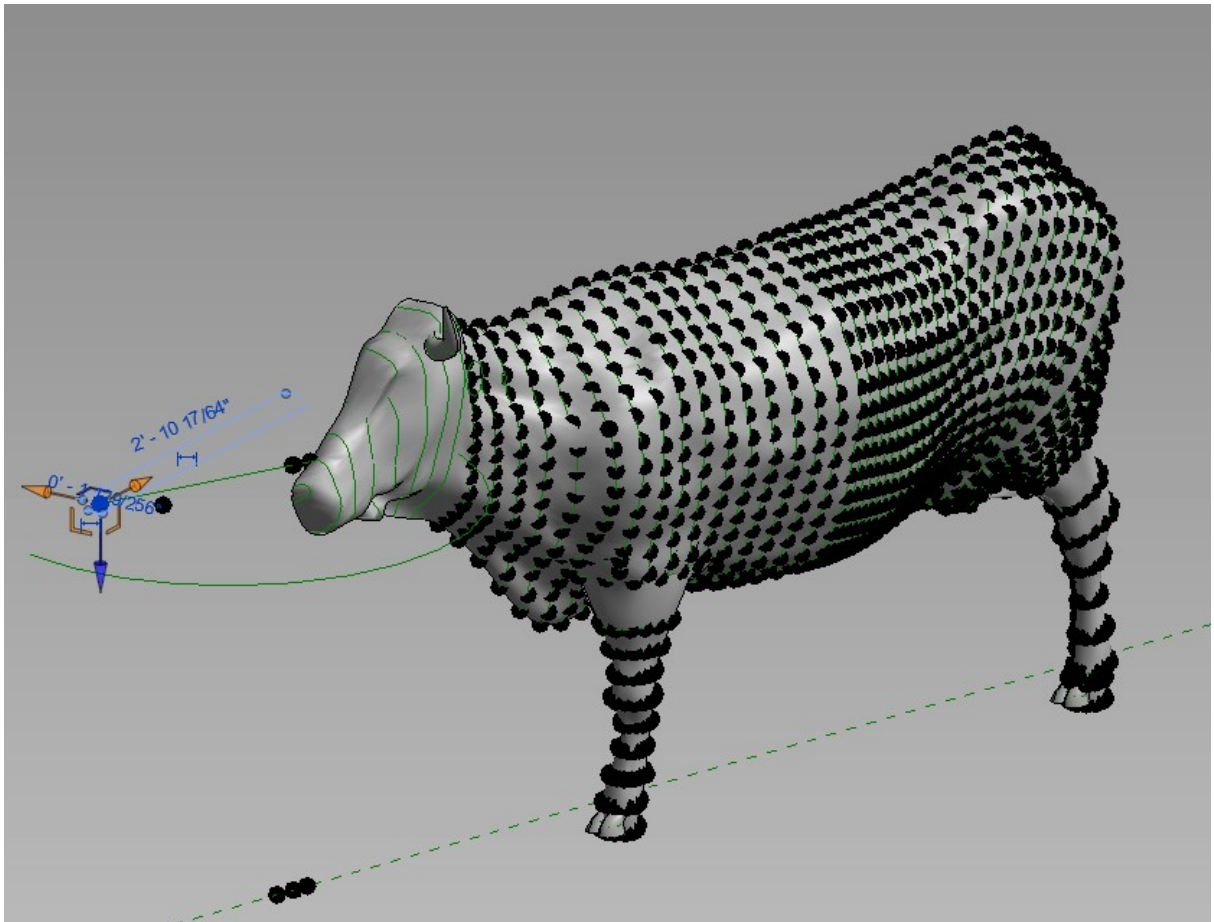
Introduction: Ball Joint Movements

In this example we will show how to create realistic ball joint movement by using the Revit cows head movement as an example. The existing Revit cow model was created as a mass family shown in the figure below.



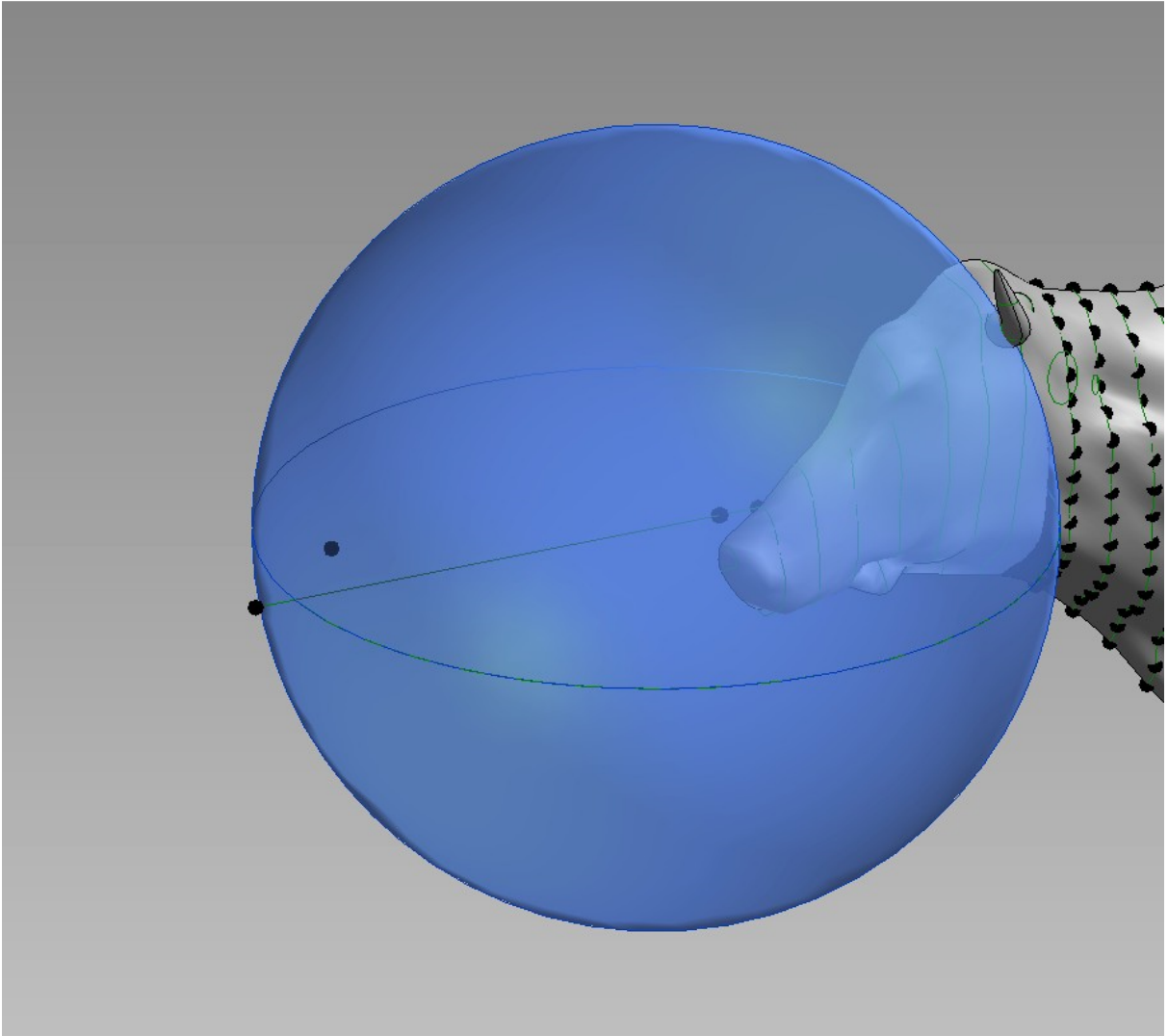
Ball Joint Rotation using the Revit Cow

1. Open file EX_05_COW_ROTATION.RFA. It should look like the figure below

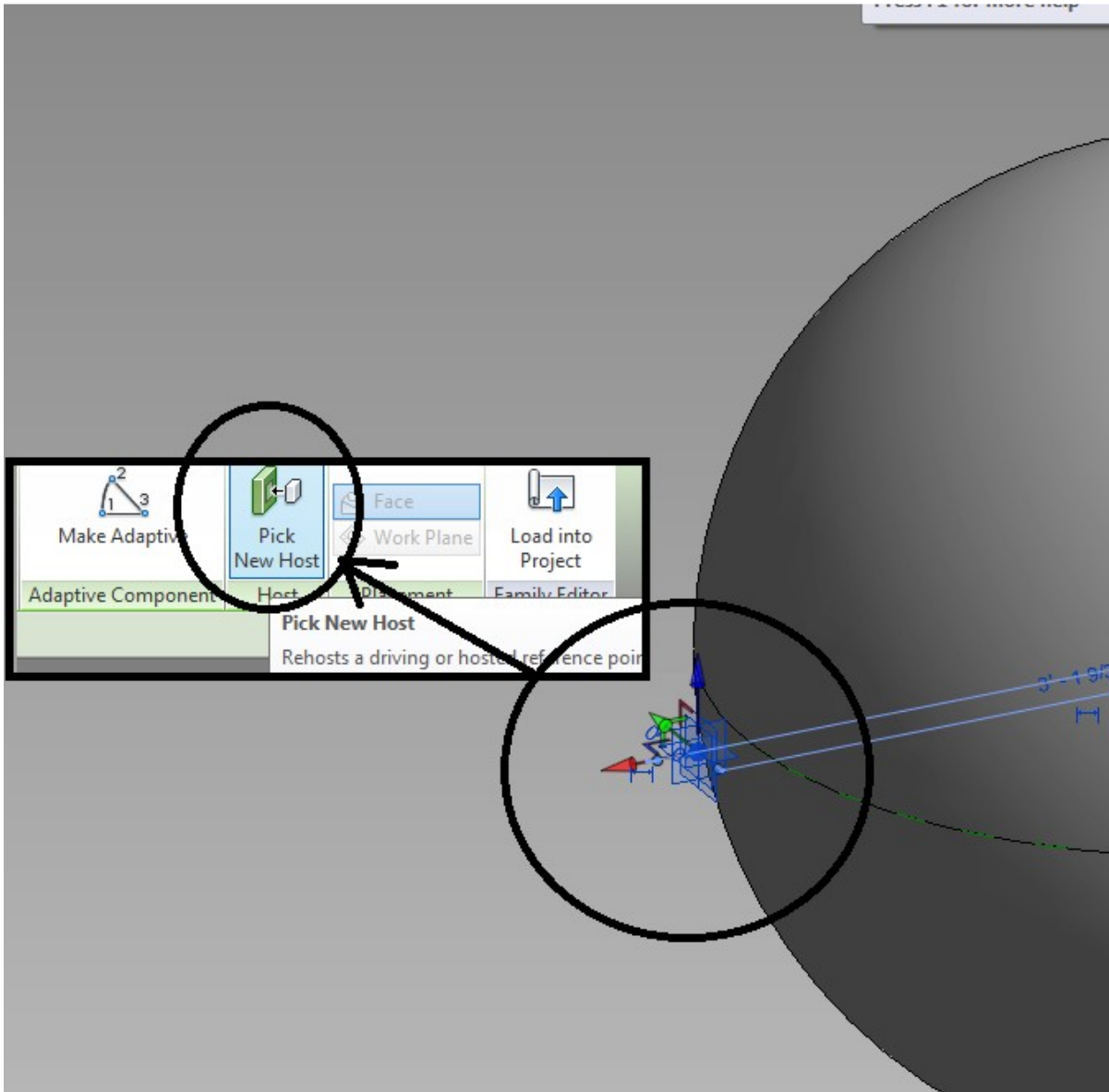


2. Change to 3D view and wire frame mode

3. Select the curve and the reference line to and click create for to make a sphere as shown in the figure below



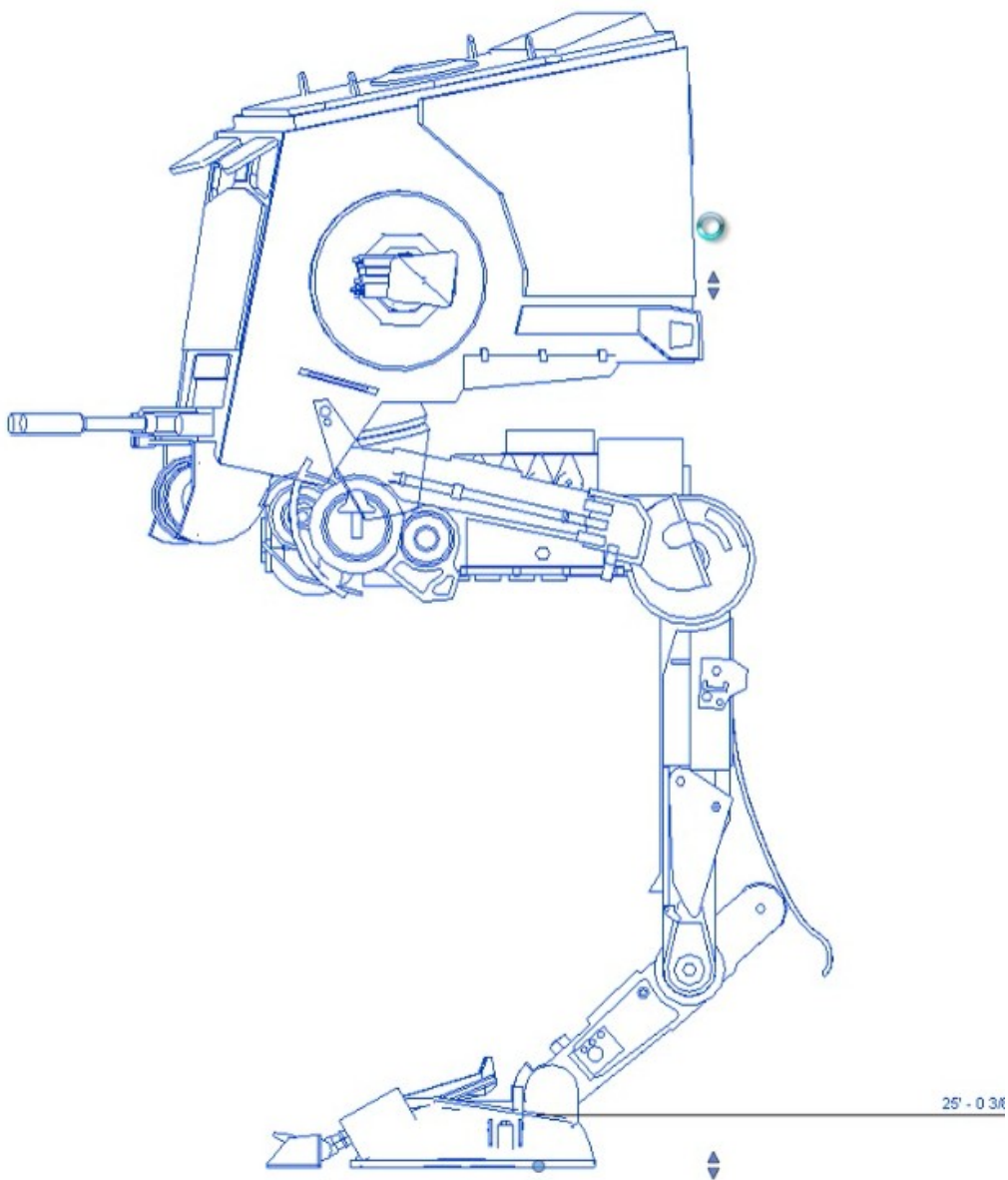
4. Select the point at the end of the line and select "pick new host" and host it to the sphere as shown in the image below.



5. Select the hosted point and roll it around the surface! That's joint rotation in Revit. Link those to other ball joints or other planar (ride the rail) joints and you have an amazing IK system! Good luck

Introduction: 2D - Out of Plane Movement

In this example we will show how to create realistic out of plane movement from a 2D component by using the 2D component from the previous example. The existing 2D ATST component model was created as a 2D detail component family and is shown in the figure below.

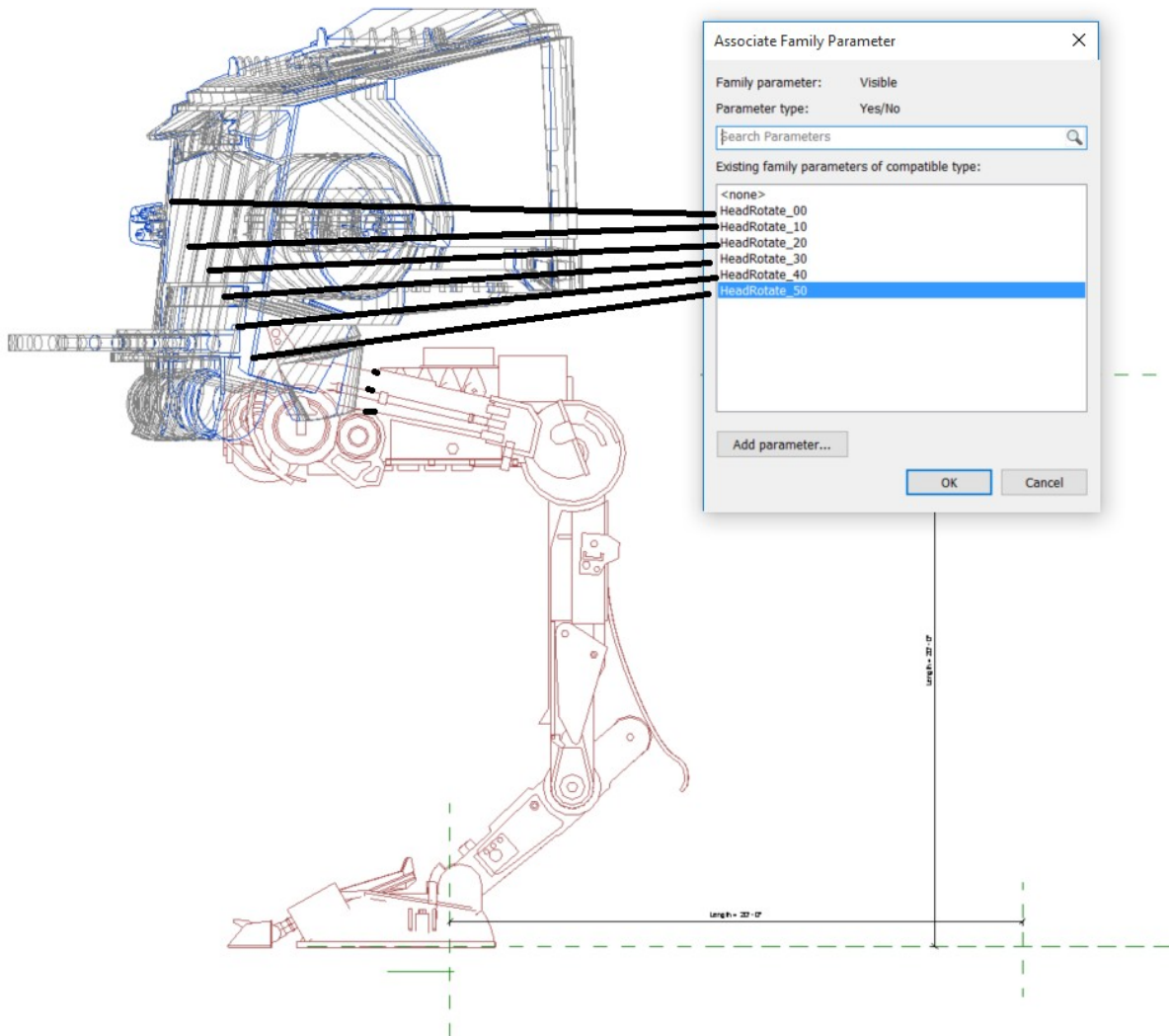


Out of Plane Movement from a 2D detail component (ATST)

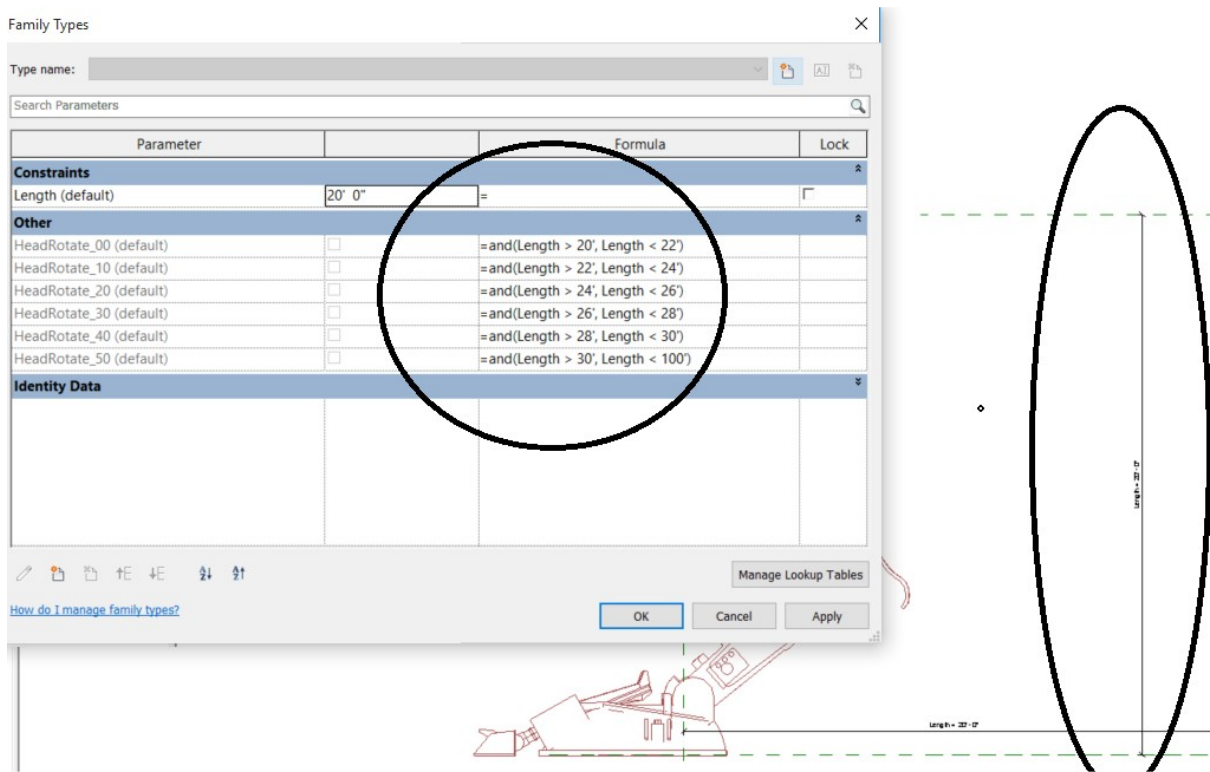
1. Open file "EX_06_ATST2D_OUT_OF_PLANE_START3D.RFA" it is the 3D version of the ATST as shown in the image below



2. Change the view to a elevation view and rotate the head at 10 degree increments, each time save the view as a 2D dwg and repeat this for 0,10,20,30,40, and 50 degree head rotations.
3. Open up a new 2D detail component family and load in all of the dwg files you exported in the previous step. Change each of the loaded dwg files visibility to parameters as shown. The family should look like the image below.



4. Create equations and a dimensional parameter in each parameter as shown in the figure below.



5. Load the family into a project.
6. Select the family and move the "pull handle" and you are done! Now you have 3D out of plane movement in a 2D detail component. If you are not finished simply open up file "EX_06_ATST2D_OUT_OF_PLANE_FINAL.RFA" and flex the rotations and you will be caught up!
7. I hope you had fun in this lab with rotation. Good luck!