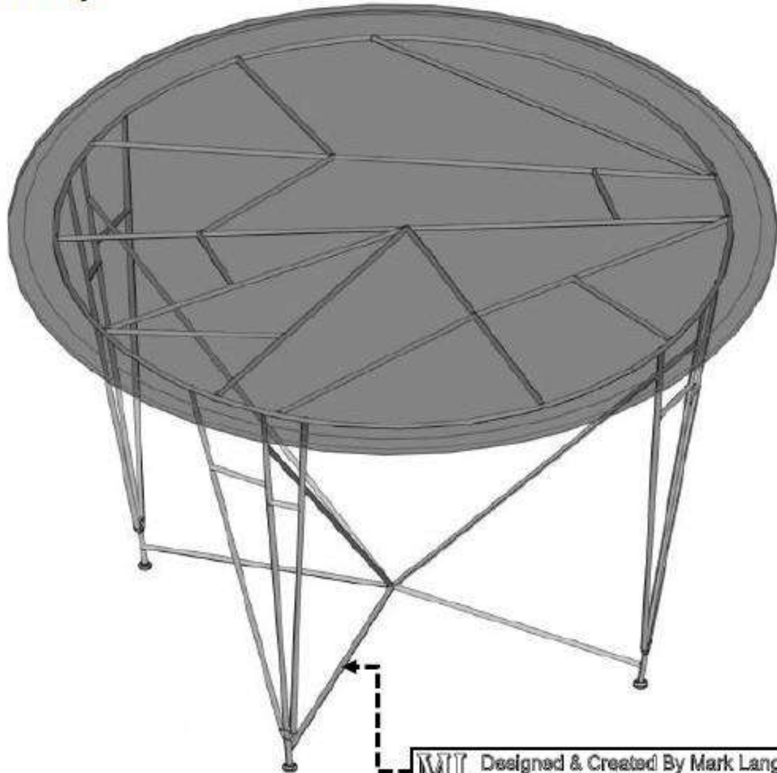
Ideation to Creation By Mark Langlois--May--2021

Certification of Authentication and Registration Of Ownership

Free Form Geometric Patio Table in 3/8 Steel Bar
Original Design By Mark Langlois, Created By Mark Langlois

Purchased By ___________N/A_______________
Date Purchased ___N/A__________
Color _______N/A_______
Design Iteration Number 121775-1A
Registration Number ML-ISC-0 0 0 0 1



ML Designed & Created By Mark Langlois
Reg. No. ML-ISC-00001

Registration Tag Location

Certificate of Registration

This Certificate issued under the seal of the Copyright Office in accordance with title 17, *United States Code*, attests that registration has been made for the work identified below. The information on this certificate has been made a part of the Copyright Office records.

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Registration Number
VAu 1-383-371
Effective Date of Registration:
August 12, 2019
Registration Decision Date:
February 12, 2020

About the man behind the design and creation of your table and author of this book, detailing its development and construction.

Name: Mark Bradford Langlois
Status: Married with Children, Grandchildren
Education: B.S. Liberal Arts, Central Michigan University
Career: Design, Engineering, Product Life Cycle Management, IT Consultant, Software Development
Music: J.J. Cale, Jackson Brown, Mark Knopfler, Snowy White, Jazz, Classical
Favorite Book: Catcher in the Rye, by J.D. Salinger
Drink: Oban Single Malt Scotch, Jack Daniels or whatever you have
Cigar: Rocky Patel Vintage 1990, 1992, Undercrown Maduro Robosto
Hobbies: Travel, Photography, Music, Art, Creative Design and Engineering

Acknowledgments:
A very special note of thanks to my wife Marianne, who has supported me in every way throughout this entire project.

To John and Edward Darnbrook, Oneida Tool Company. Thank you both for your avid interest, advice and continued support in the development of my project.

Book Completed: May 17^{th}, 2021

Ideation to Creation, History and Background

I was a young college student attending Central Michigan University from 1975 to 1980. I was pursuing a Bachelor of Science Degree in Sociology with a Minor in Industrial Technology. While my degree was in Sociology, I also took many classes in Computer Science, Art and Business.

My industrial technology classes were focused on manufacturing and hands on practical applications in casting, welding, machining, computer assisted design and manufacturing (CAD/CAM), manufacturing communications and in the new industrial applications associated with the emergence of simple pick and place robots.

During the semester associated with the hands on application of my industrial technology course work, my instructor had a set of defined projects we were to complete. In addition, we were required to complete one project of our own design and present it to the rest of the class.

My selected project was to create two tables made from 3/8 inch steel rod. I had no particular design in mind other than they were going to be 30 inches high, have a round top and made of welded construction.

The industrial technology lab, had only limited equipment; the steel I needed, a MIG Welder, and space that I had to share with other students. I had to bend the 40 inch diameter table top around a plywood form that I made by hand; clamp it and weld it. The result was a top that was not completely round and I had to work the metal hoop in as close to a circular shape as I could get. I spent the rest of the semester in the industrial technology lab every free minute I could get; creating and welding the free form design for the top and designing and welding the legs and cross members. I had two tables completed by the end of the semester and was very pleased with the results.

My instructors were also quite amazed with what I had been able to accomplish in a single semester along with all of my other assigned projects.

I gave the tables to my parents as a graduation present in 1980. They used them in their home for many years. My parents eventually moved into an apartment and I regained ownership of the tables that I had made.

I have had these tables and used them for more than 30 years; both inside my home as a dining table, office desk, living room table and outside as patio tables. I enjoy them very much both from an aesthetic standpoint and in the way they are constructed; functional, solid and strong.

In late 2019, I was sitting at one of the tables I had made on the patio and it came to me that I had created these tables using my own creative energy using an ad hoc design approach; the tables had no established origin or documentation. The tables existed, but there was nothing to establish how or when they were made or that I was the individual that created them (other than historical fact). They really didn't exist in any other form other than some hard work and creative energy that came to pass in a small college lab in 1980, which now date these original creations to roughly 40 years ago.

I have spent the better part of 37 years working in the field of computer aided manufacturing, computer aided design, computer simulation, PLM configuration and software development. In consideration of the existence of these tables without any actual design content, I decided to chart a path to formally define the design and creation of these tables and to capture the major steps in the process to produce them.

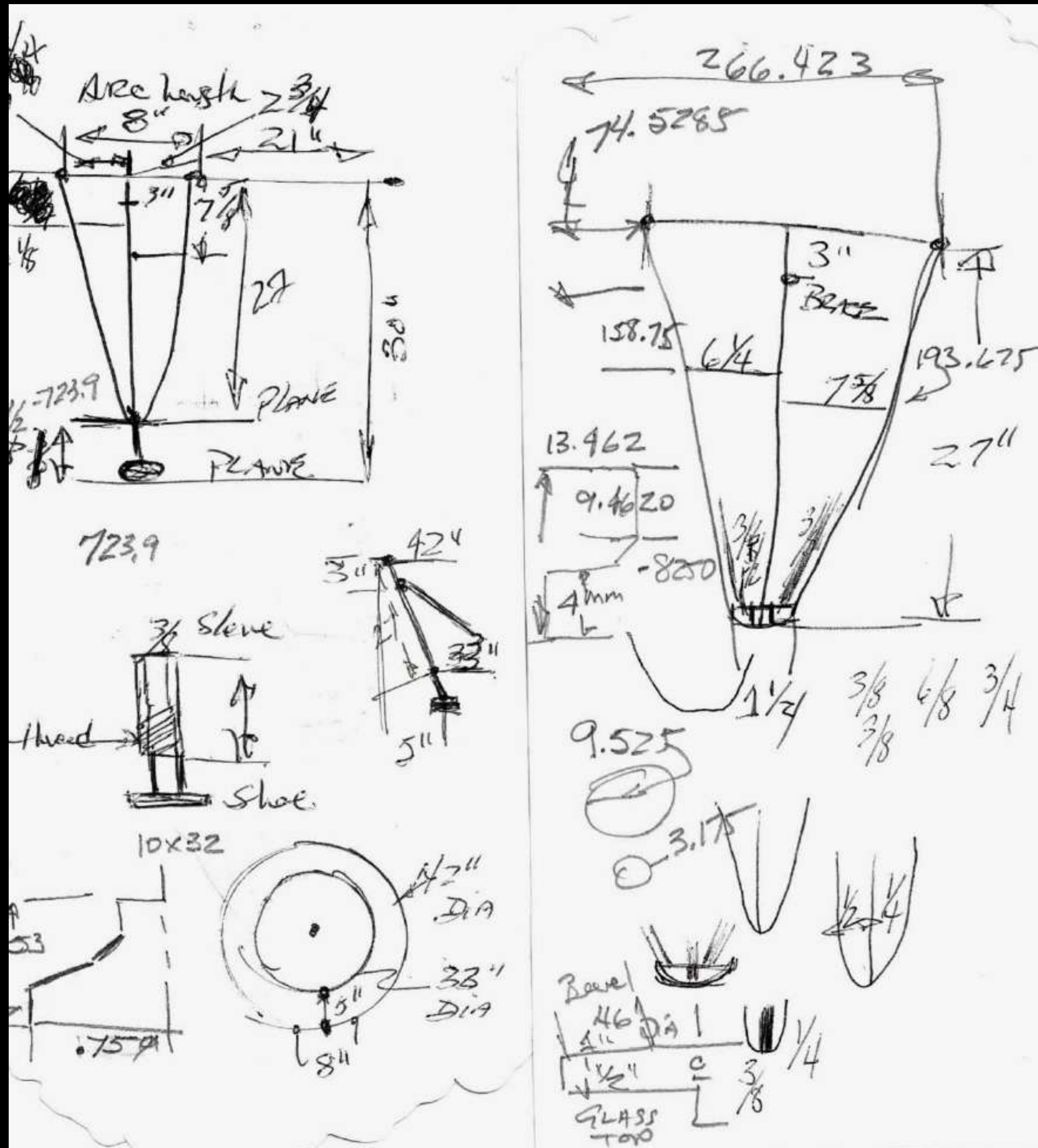
My vision was to provide some historical documentation in the transformation of what it takes to go from an idea or metaphysical muse, to the physical existence of that dream—"Ideation to Creation".

Historical Reference: This is a photograph of my son and daughter taken approximately 27 years ago (1993). My son is almost 8 months old and my daughter is 2 years old. You can see both the tables that I made in college in the background of this photo.

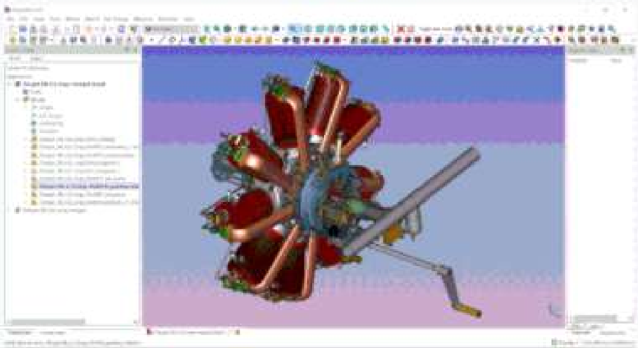
This is a shot of one of the original tables designed and made by me some 40 years prior. The table is a contemporary geometric design that creates an intentional 3D perspective looking down through the top. This table was the conceptual basis for the development of the new documented design and contains most of the elemental constructs of the original design.

I started the process to capture the new design by creating a napkin drawing with some of the basic sizes and dimensions from the existing original tables.

This served as the starting point for capturing the height, diameters, basic shapes, angles and the desired changes in design from the originals. One of the desired changes was incorporating leveling feet into the new design so the tables can adjust for minor unevenness and will not rock.



Basic Design Criteria:
Diameter of top: 42 Inches
Height: 30 Inches
Material: 1018 Cold Rolled Steel
Size: 3/8 Inch Steel Rod
Construction: Welded
Weight: 30 pounds
Top: 46-48 Inches In Diameter Glass, 1/2 Inch Thick, 1” Bevel, Color, Clear or Gray



FreeCAD Screen of Version 0.19

Original author(s)	Jürgen Riegel, Werner Mayer, Yorik van Havre[1]
Initial release	29 October 2002; 18 years ago
Stable release	0.18.5 / 25 November 2019; 12 months ago
Preview release	0.19_pre / 3 November 2019; 13 months ago
Repository	github.com/FreeCAD/FreeCAD
Written in	C++, Python
Operating system	GNU/Linux macOS Unix Windows
Type	3D Modeling, CAD, BIM, FEM
License	LGPLv2+
Website	freecadweb.org

In order to create the three dimensional solid model of the new tables I intended to design, I had to research and select a computer aided design (CAD) software application to do the work.

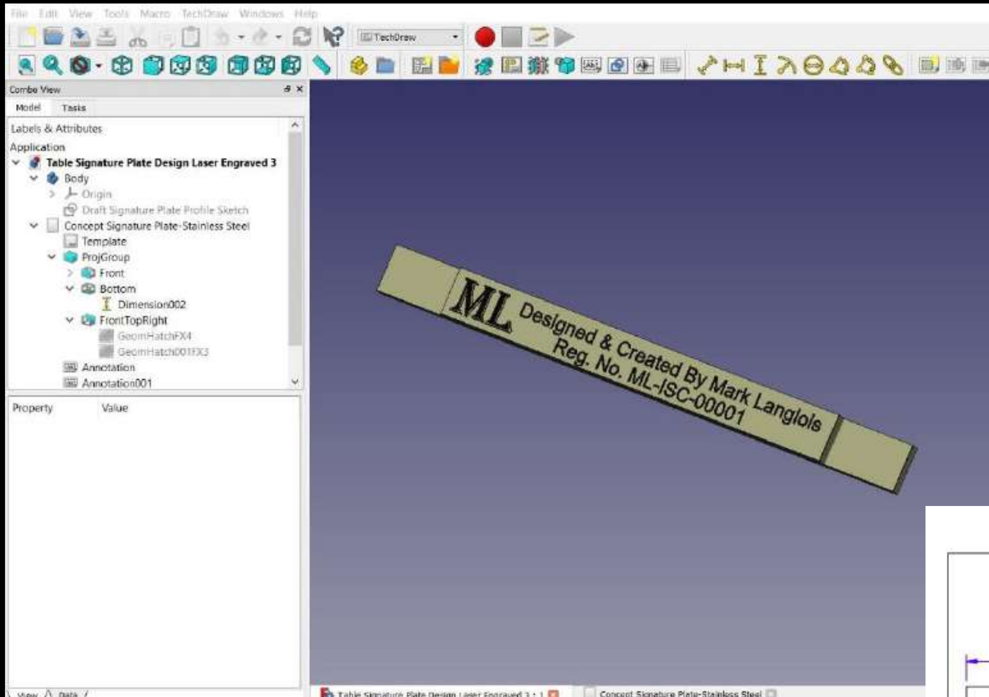
In my 37 plus years doing design and engineering using CAD/CAM systems, I had access to many "top of the line" design applications used by large companies. These software applications were well known to me and very capable, providing different options that assisted greatly in creating solid models.

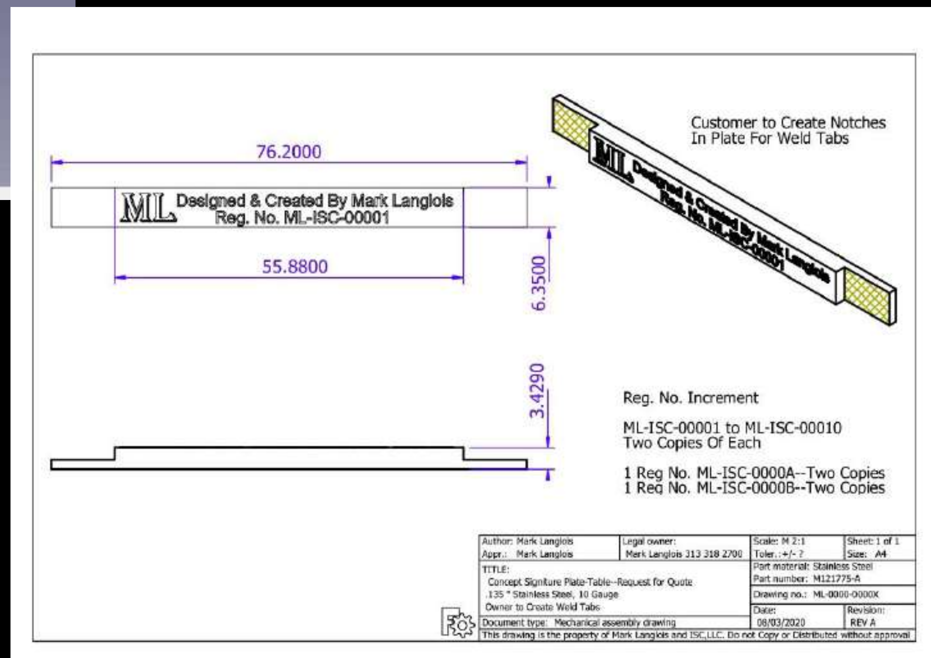
However, these software applications are quite expensive to acquire and use. They have licensing levels (cost based on capability) depending on the tool sets you require.

I needed a solution that was capable and cost effective. During my Internet search I came across several potential CAD applications that I downloaded and tested for the functionality and user interface that I felt would satisfy the complexity of the design and included a build and edit structure that allowed me to easily manipulate the design components.

I selected an open source CAD software application called FreeCAD. This CAD software is a free download and worked very well for the design of my project. In addition, "open source" means that apart from the initial CAD software development, other developers can create additional tools and compile them so that they are compatible with the source system.

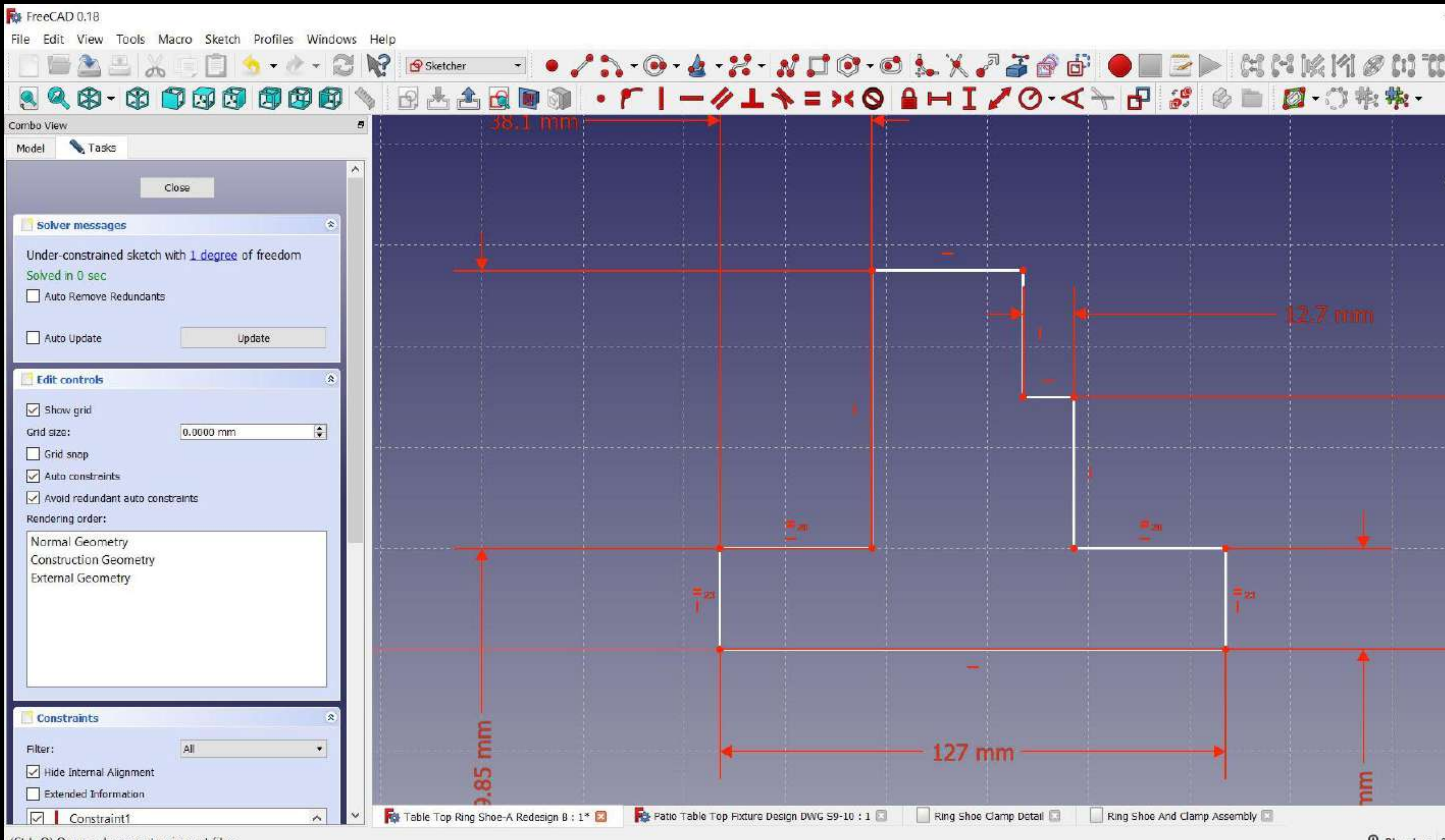
Picture, Source Reference: https://en.wikipedia.org/wiki/FreeCAD



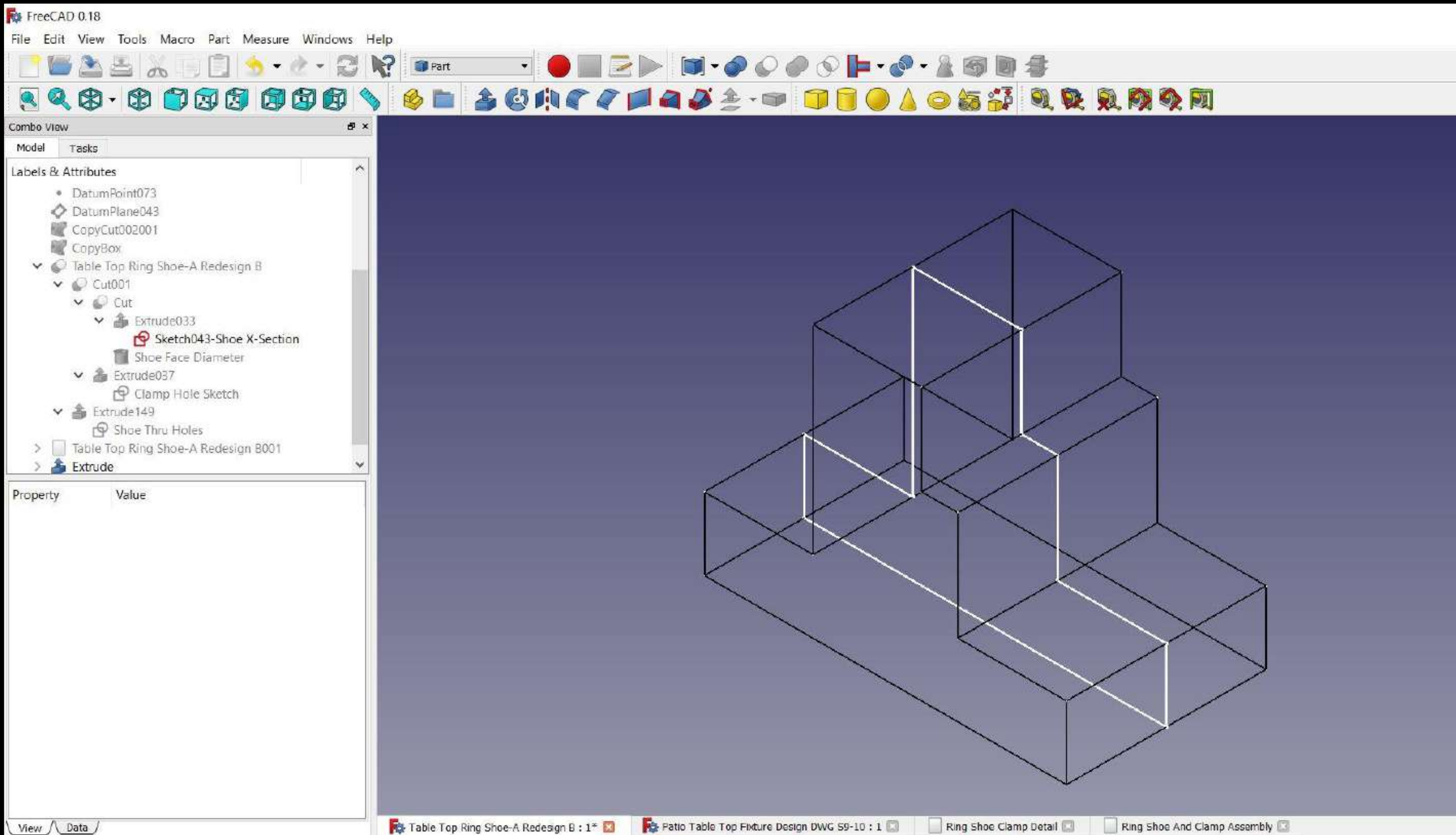


The FreeCAD design application software is displayed above, showing a solid model and drawing of my signature plate to identify the table's designer and builder.

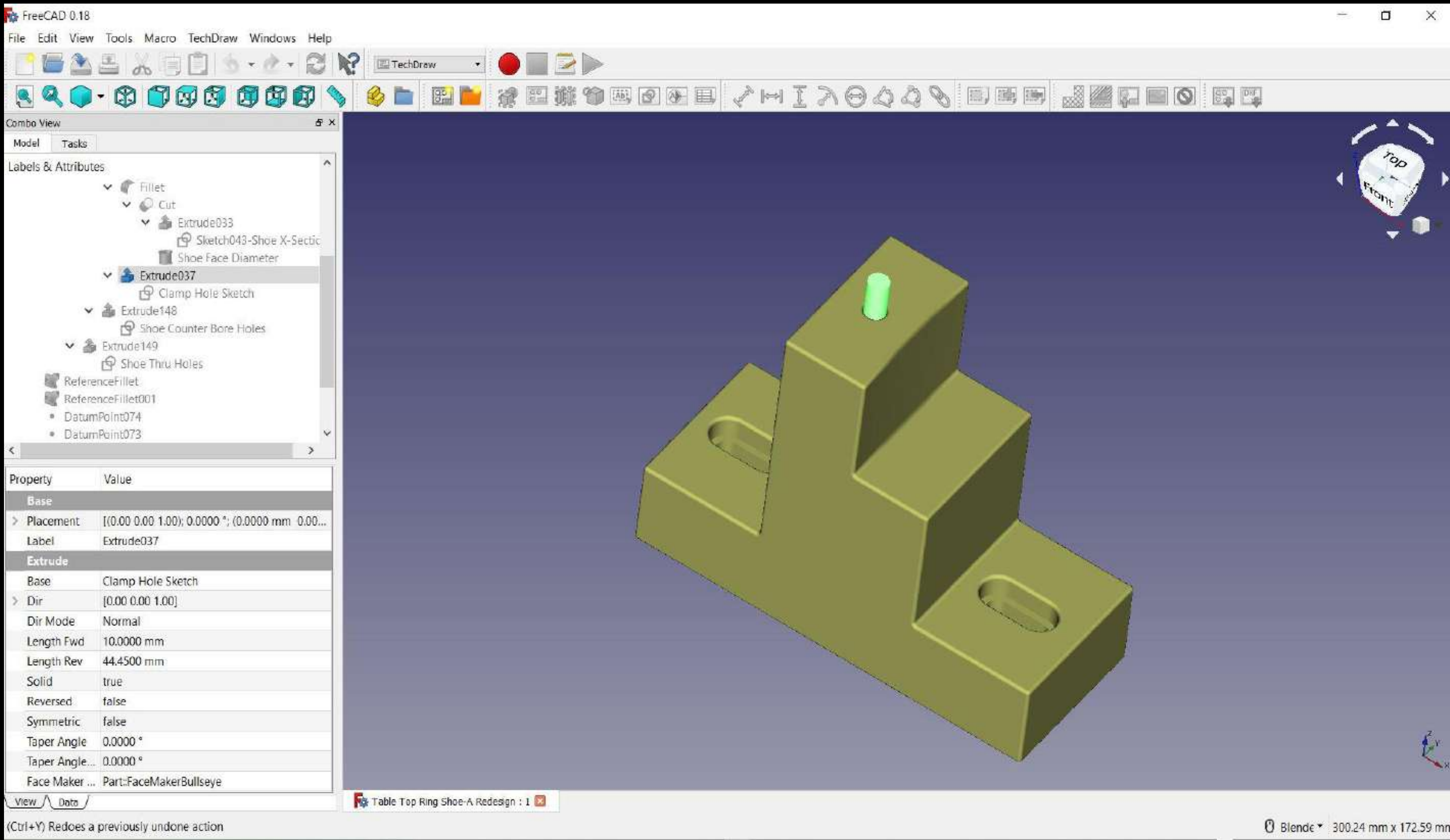
FreeCAD Software Web Site: https://www.freecadweb.org



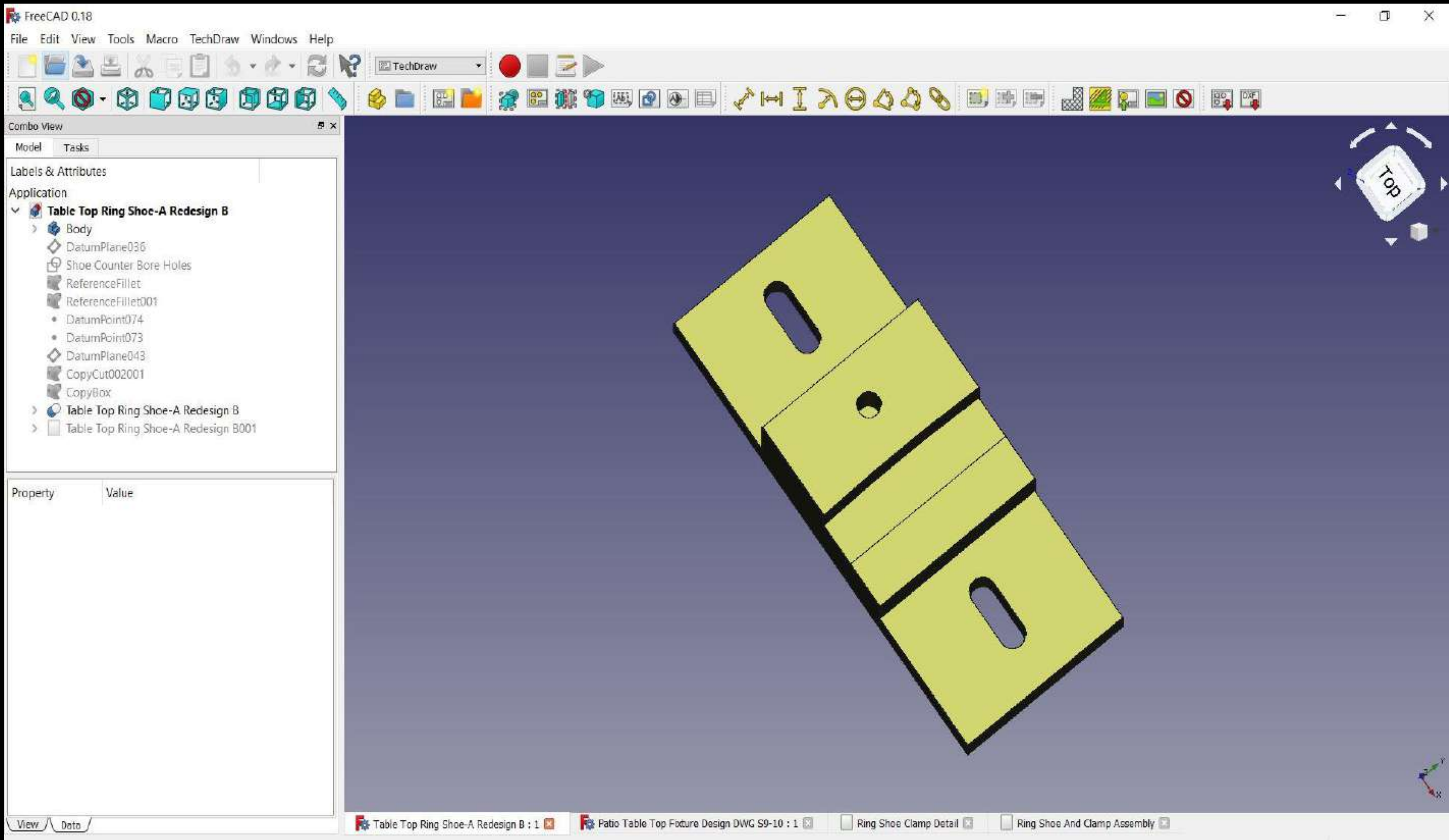
A brief introduction to CAD design as it relates to the creation of my new table. Many CAD systems have as a key component, the ability to create a dimensioned and constrained sketch that provides the application with information on how to construct a solid shape. The benefit of a sketch, is that it allows the user to change the dimensions and or constraints and the solid construct will update to match the changes. The example profile shape shown above is created and then saved in a tree structure so that it can be modified later or utilized by other CAD tools within the application.



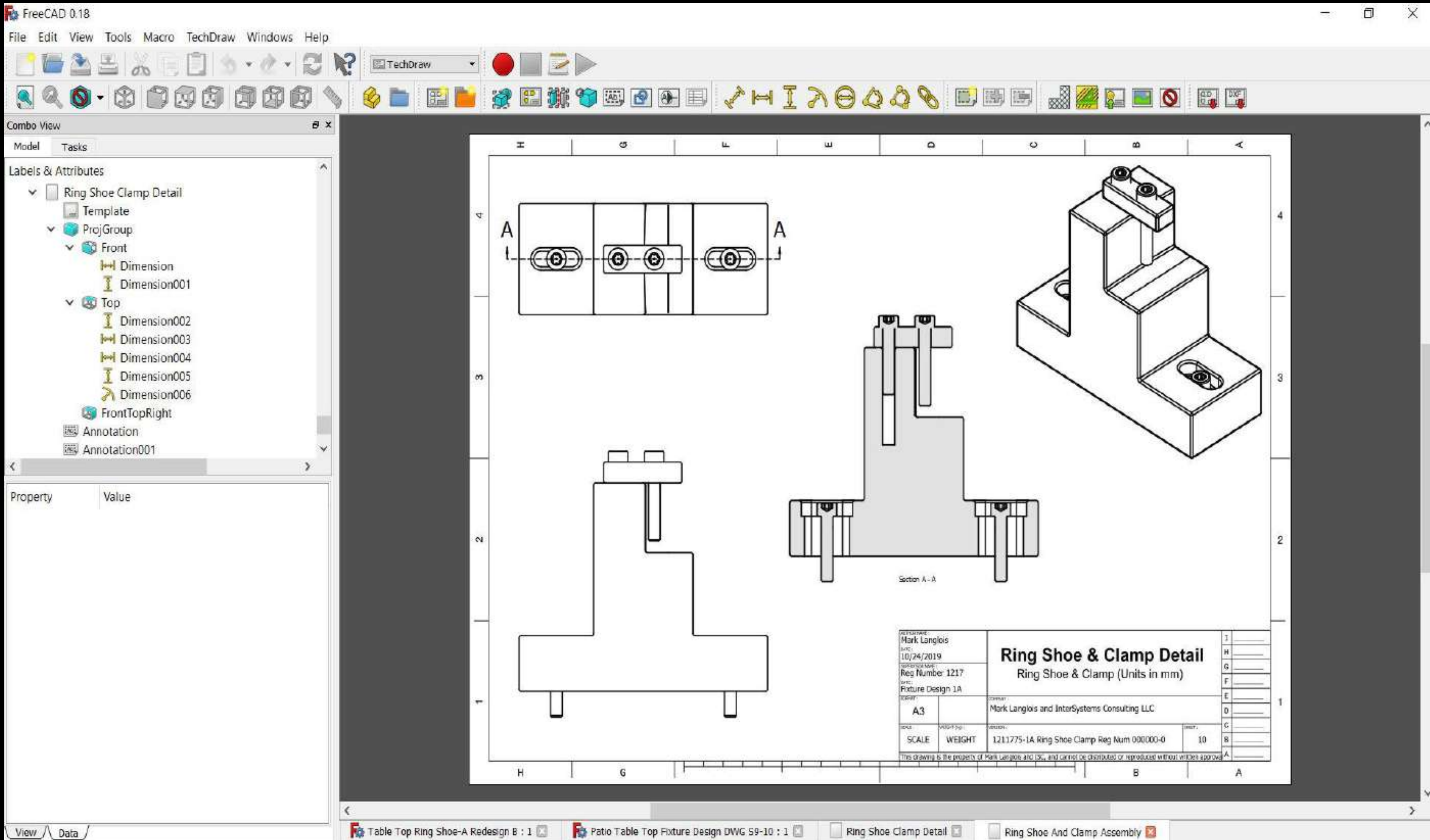
Using the sketch profile I created from the previous page, the profile was "extruded" (another common CAD application tool) to create the solid shape above. The sketch profile shown in white, overlays the extruded solid profile shown in black (the shaded solid model is shown on the next page). I created numerous sketch profiles and extrusions in this same way, to create my new table and the tooling to make it.



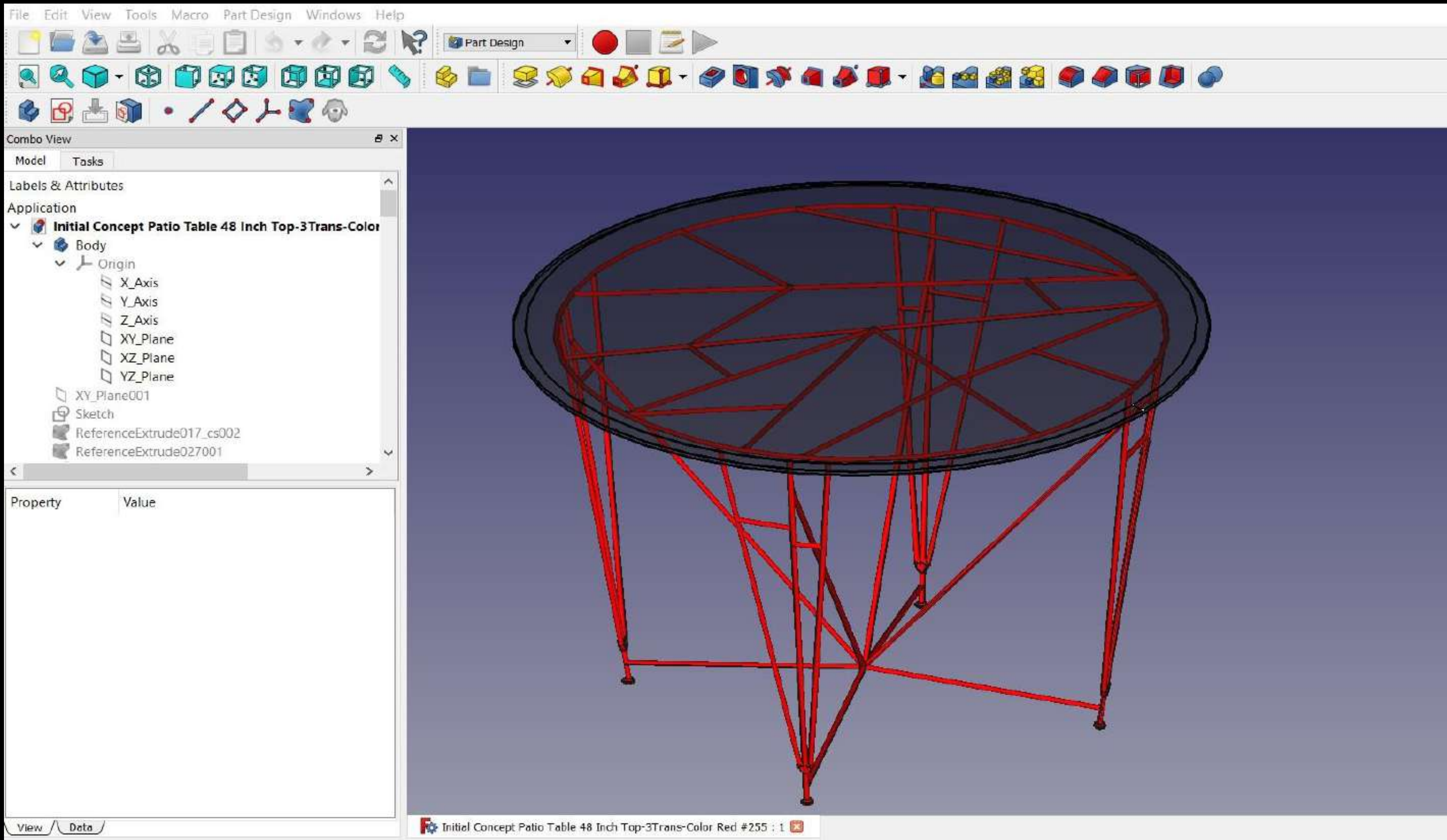
Another common solid modeling practice found in most design applications today, is the ability to construct a number of other solid shapes using sketches or by using other design tools, and then adding, subtracting, or intersecting these features to progressively define the intended shape or design. These operations are generally referred to as Boolean operations. In the picture shown above, I created a new solid cylinder highlighted in green, using a sketch, and extruded it. This new solid can now be used to perform operations on the existing solid body.



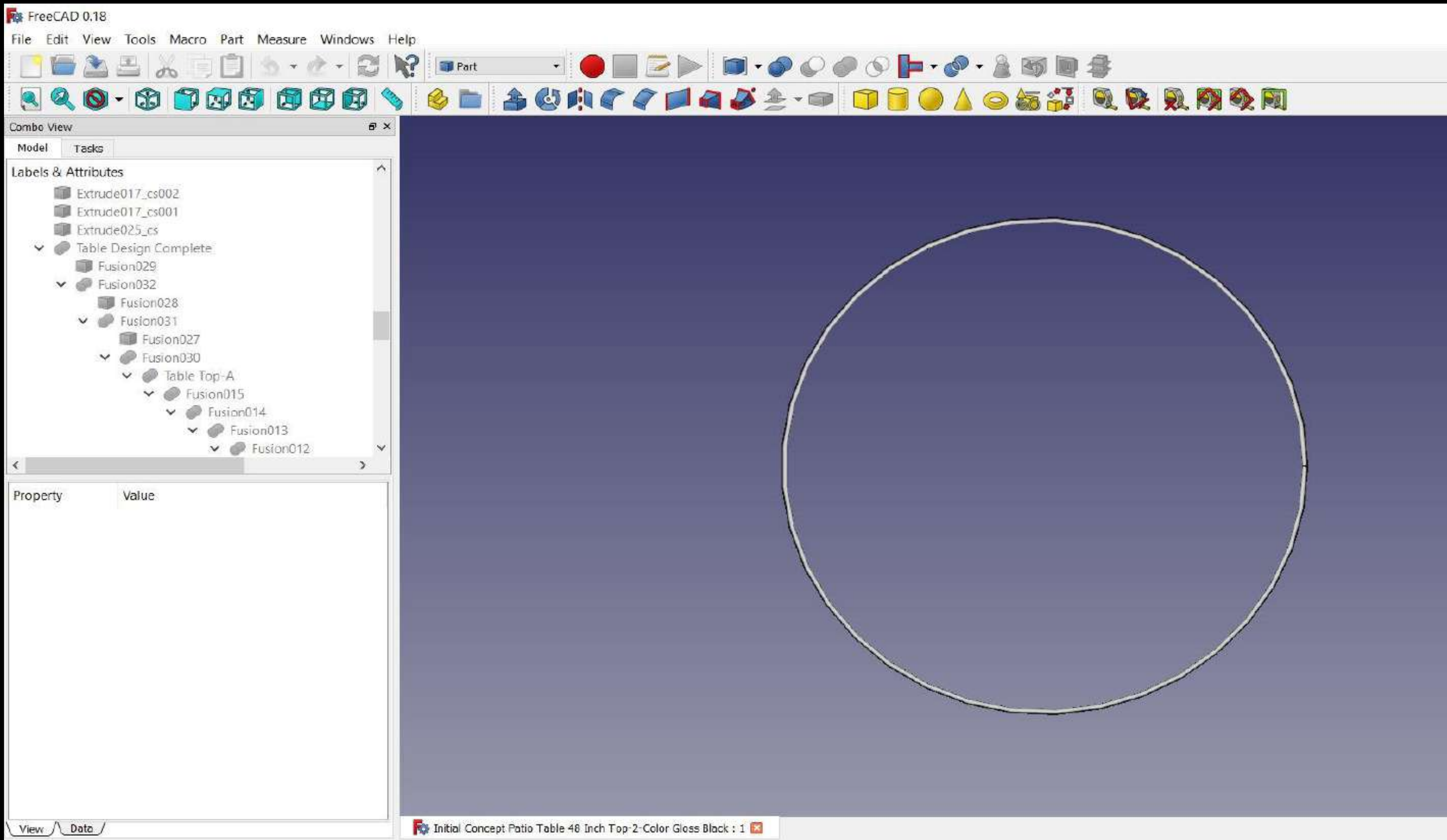
On the previous page, the new solid cylinder highlighted in green was "subtracted" from the solid body (the physical space defined by cylinder was removed from the existing solid), leaving the representation of a drilled hole in the top of the part being created. I used many of these types of operations to create the components necessary to make my new table.



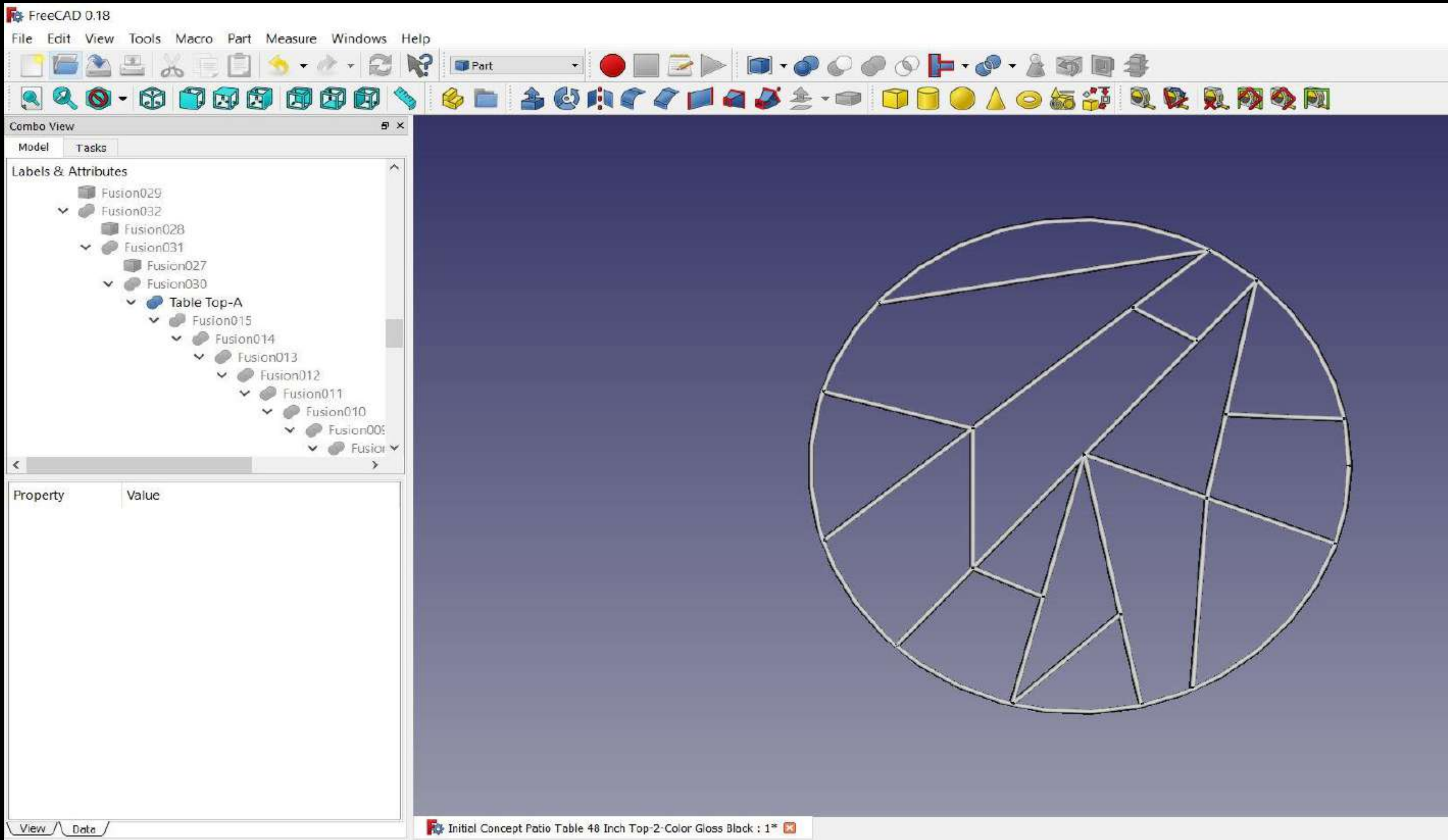
In addition to sketches and solid modeling tools, drawings may also be necessary to provide more detailed information. The solid model itself, in some cases, is all that is necessary for a machine to create the part. However, other information regarding type of material, datum locations, tolerance, tap hole size, surface finish and validation of the specific version in the design iteration are not necessarily associated with the 3D solid model. They are still conveyed to suppliers and vendors using a drawing. I make the drawings I need by creating views and dimensions of the part designed as a solid model.



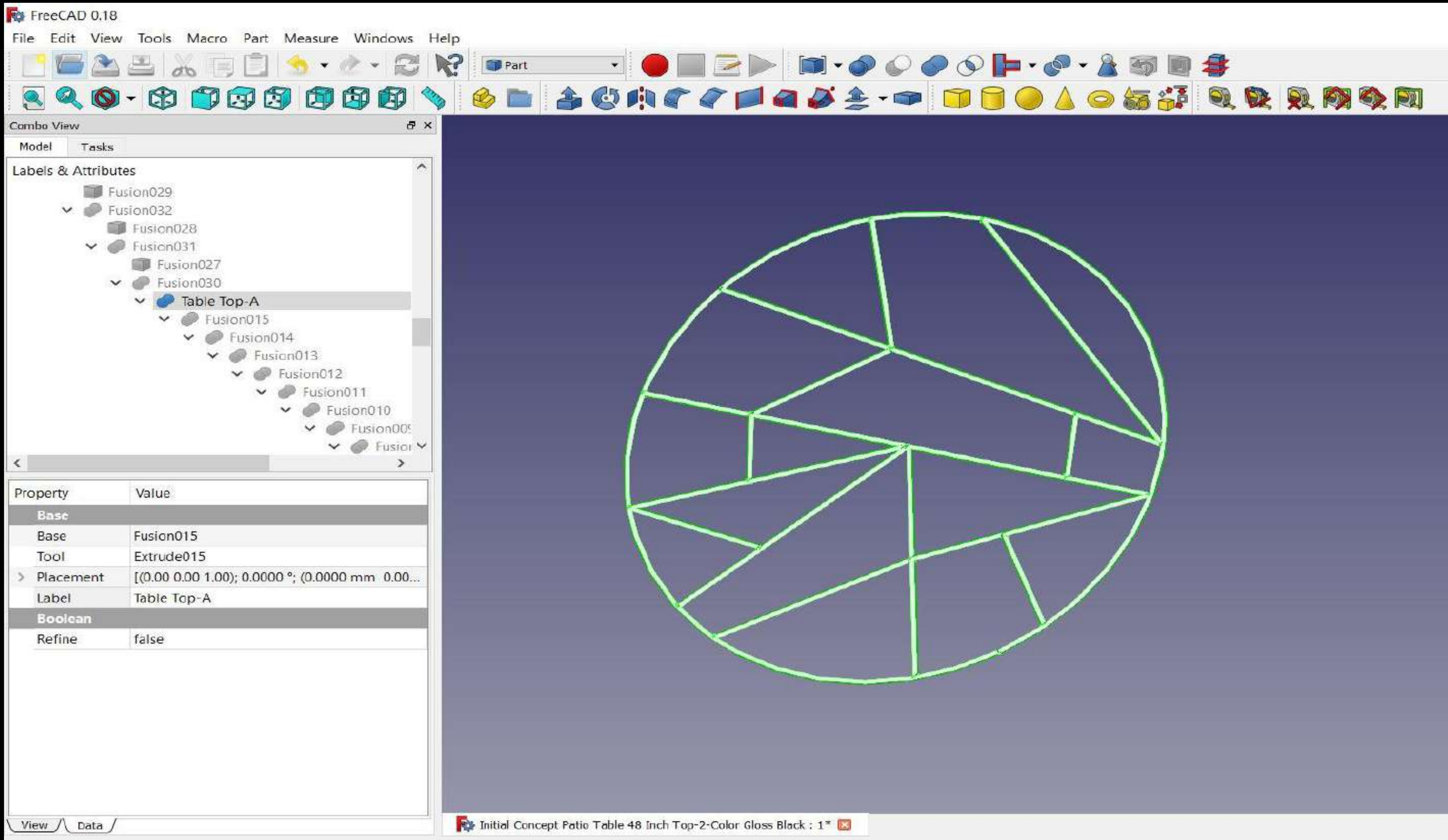
Pictured above, is a CAD rendering of my finished table design. The table design is shown here in red, complete with leveling feet and 1/2 inch, gray glass top with a 1 inch bevel. In the next section of this book, I will detail the individual development stages I went through to create my new table design as a 3D solid model.



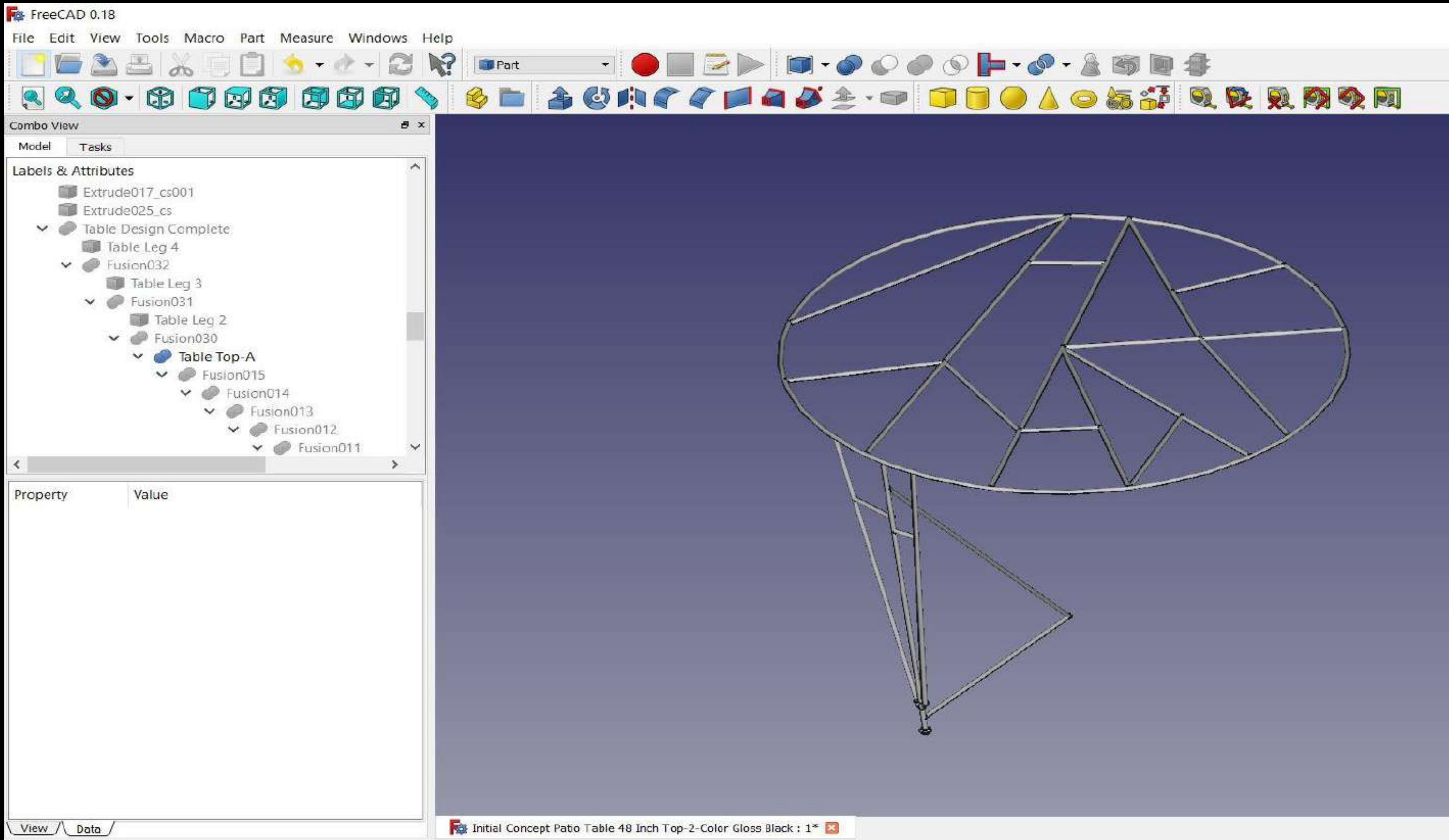
The first component that I created in the design process to construct the table, is the solid model representation of the table top ring. This ring will define the outer boundary of the table top as well as define the limits for the tops interior components. I created this ring by developing a sketch of the ring cross section; a circle 3/8” in diameter and then sweeping this sketch 360 degrees around the circle center to create a solid circular ring.



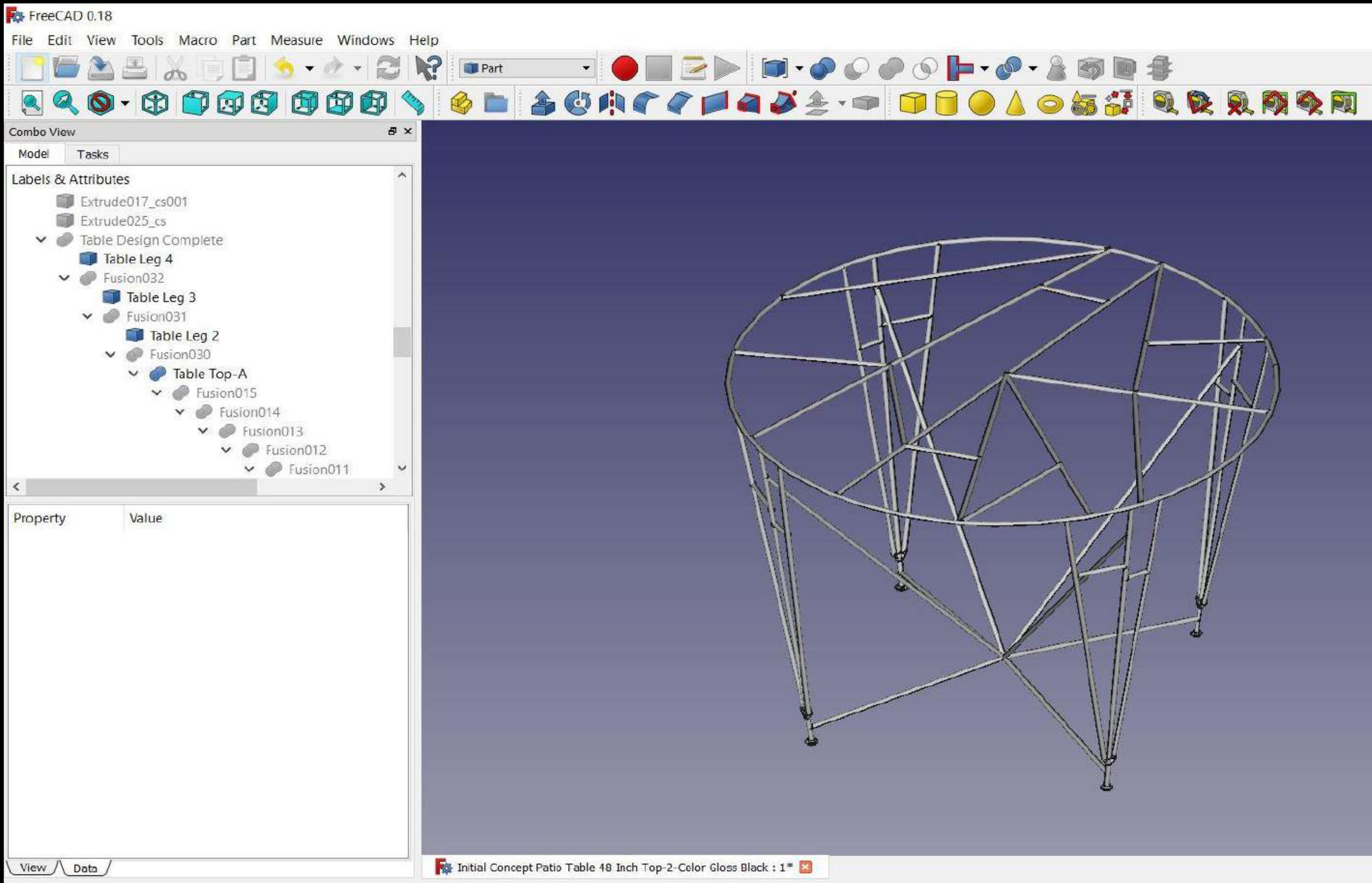
Now that I have the table ring defined, I can develop the interior geometric design. This is a multi-step process. First, I must define a plane in the correct orientation for each component part being constructed. Second, I need to create a sketch of a 3/8 diameter circle at the correct elevation and location on the defined plane. Third, I must extrude this sketch to create a solid 3/8" diameter shaft that intersects the existing outer diameter or other interior components. Last, I have to unite or integrate each of these newly constructed components so that they represent a single solid model.



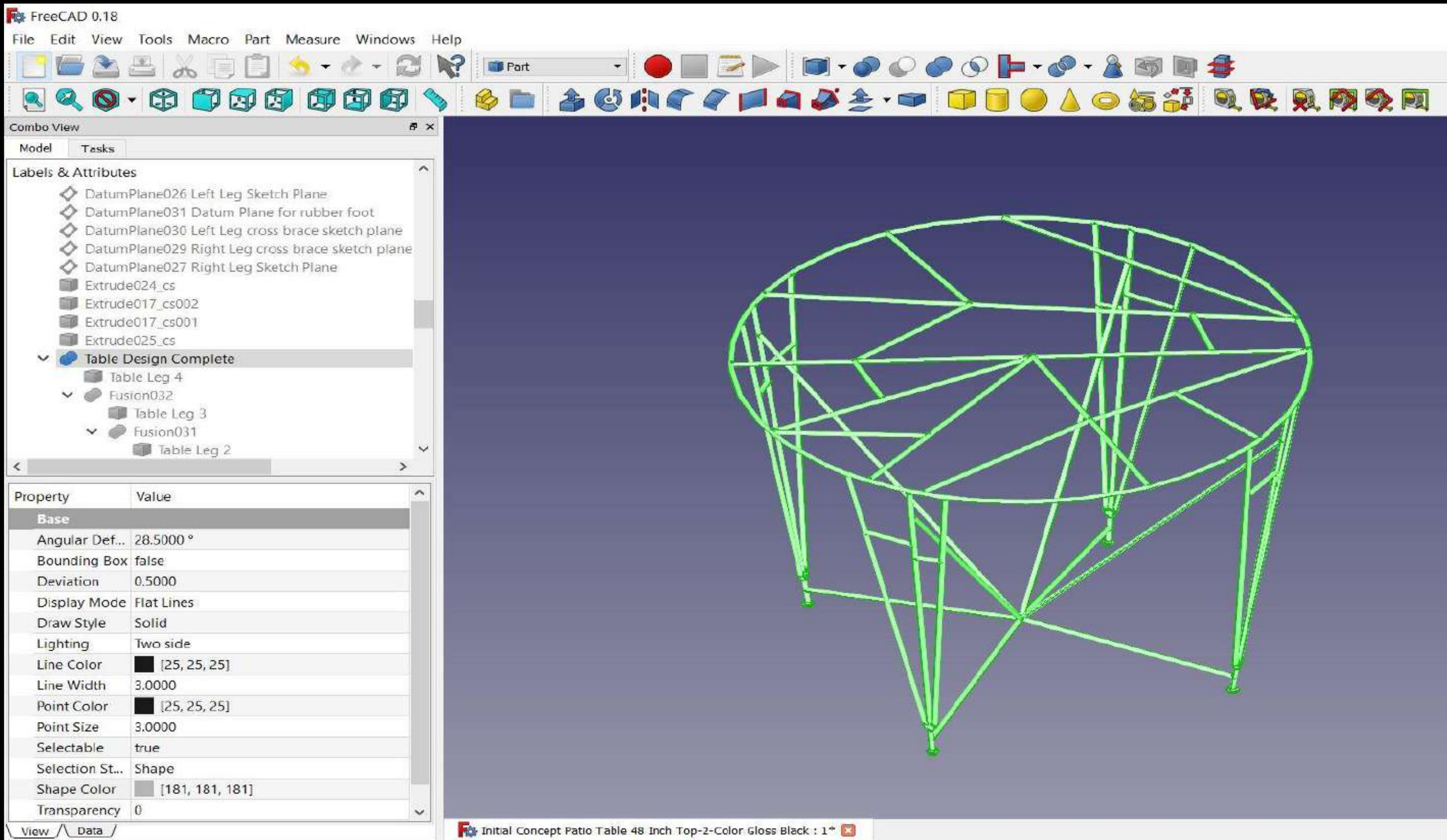
I have completed the geometric interior design for my table top. The highlighted top includes the previously defined table top ring and all of the interior geometric components. This means that the table top is represented as a single solid model; the individual collection of components I have constructed are now one.



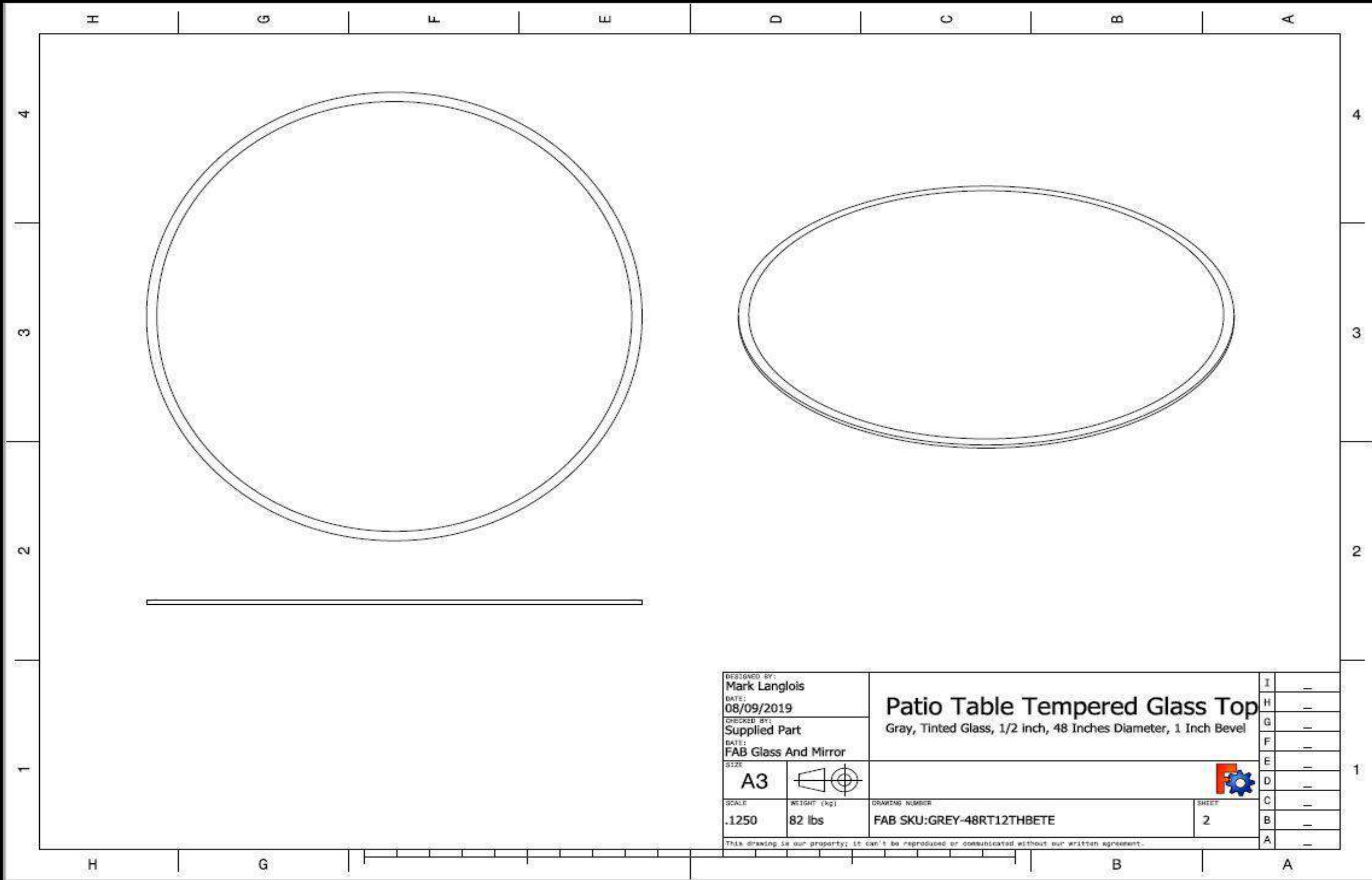
Having completed the table top design, the next components I need to construct are the legs for the table. The construction process, in this case, is the same approach I used to create the top. I will create one leg that incorporates all my design criteria and integrate that into single solid model. Once I have completed the design of one leg, I can produce the other three legs for the table by copying the one leg and rotating it about the table center to create the other three legs.



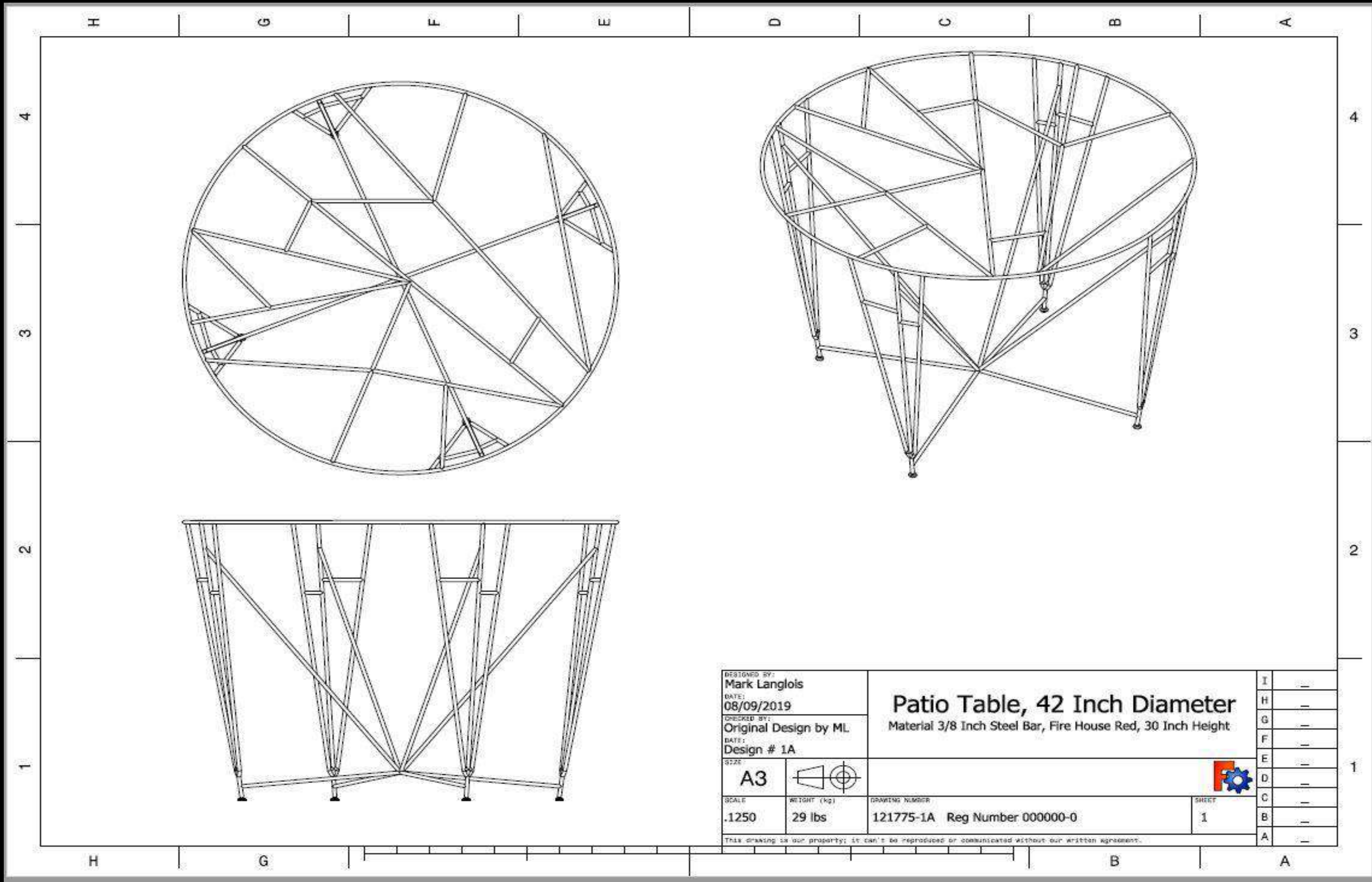
I have replicated the other three legs by rotating them around the table top ring center point. Currently, each leg represents a single solid body, along with the table top. I still need to integrate or unite each leg to the table top so all the components are incorporated into a single solid body. Once I perform this operation, the design of my new table will be complete.



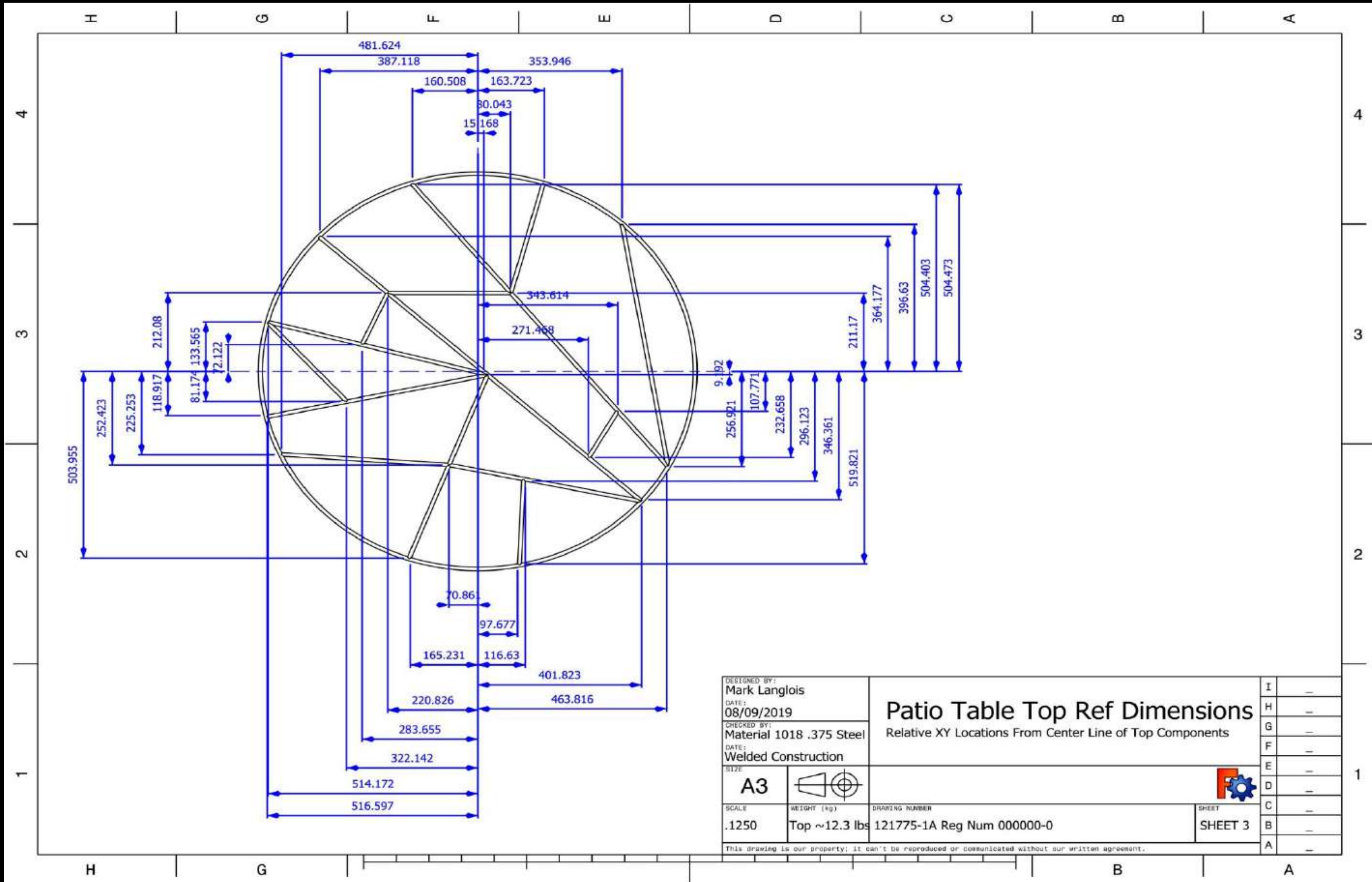
Having executed the Boolean operation to unite all of the table's remaining individual components. The highlighted table indicates that the legs are now integrated with the table top as a single solid. All of the design constructs and CAD operations required to create the table are captured in a tree structure. This tree structure allows me to select any of the individual components (table top ring, interior geometry, and leg components) and view or modify them if necessary.



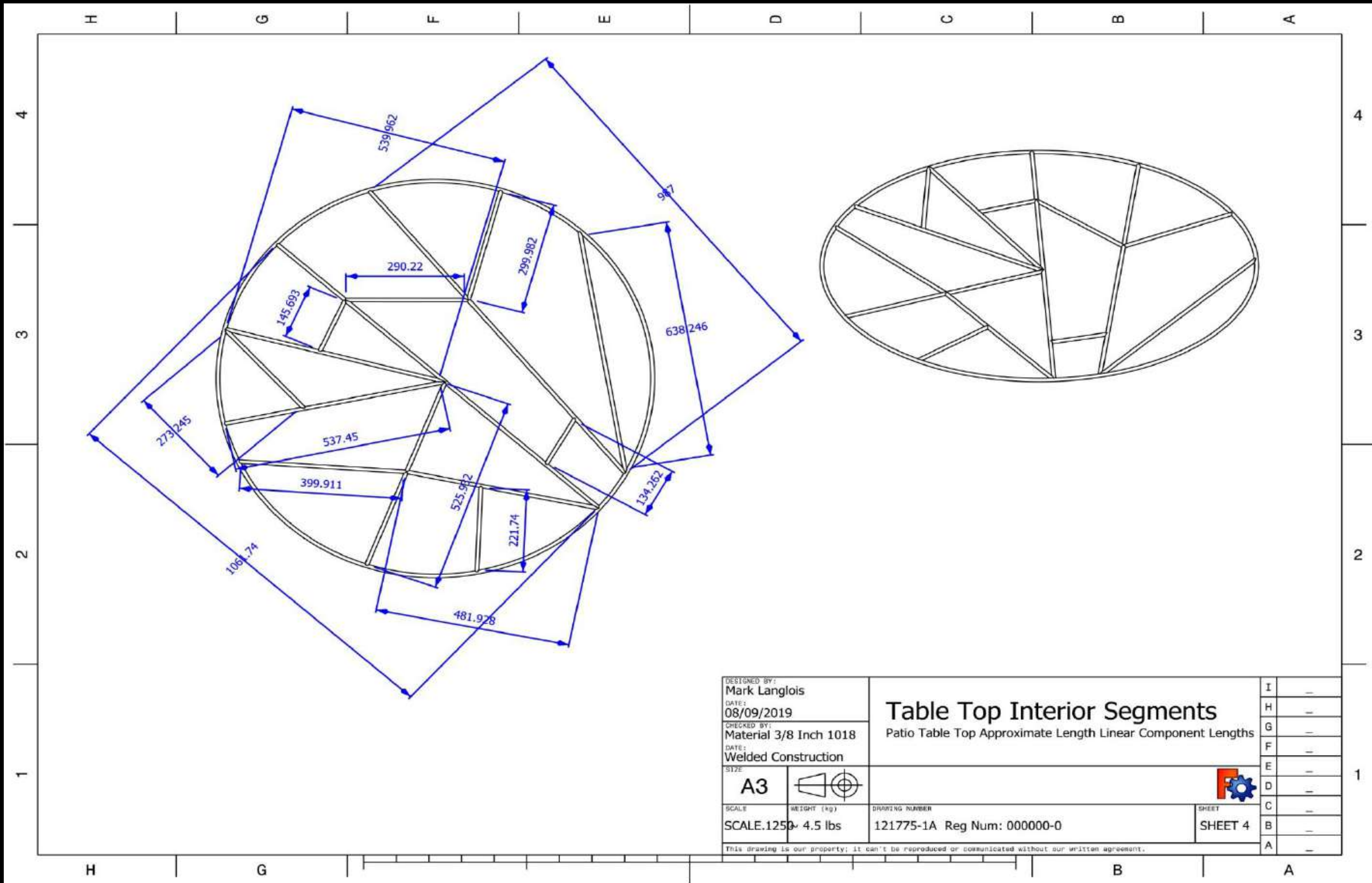
Having completed my table design, I have the option to capture and export pictorial representations of the design in both the solid form as a picture and in the context of a drawing. While the CAD files themselves can be shared, they must be exported in a format that can be imported into another CAD application.



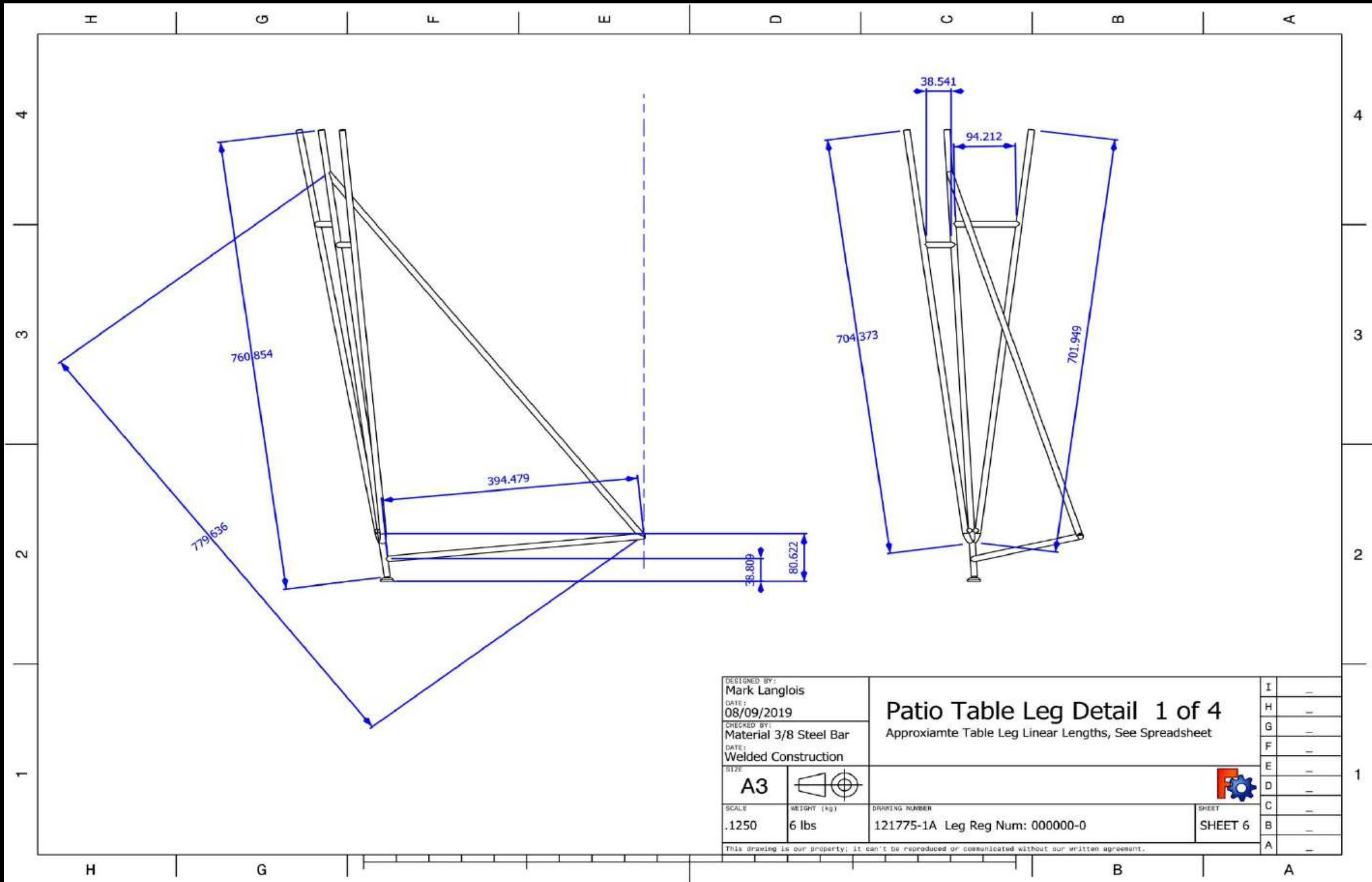
Pictorial representations in the form of PDF files, JPEG files or other formats, allow users of CAD applications to transmit and share lightweight images of design ideas and design information by email, messaging, stored on a mobile phone or other device or printed as a hard copy. I carried a large number of drawings and part designs on my iPhone to share with vendors, send as an email and for reference.



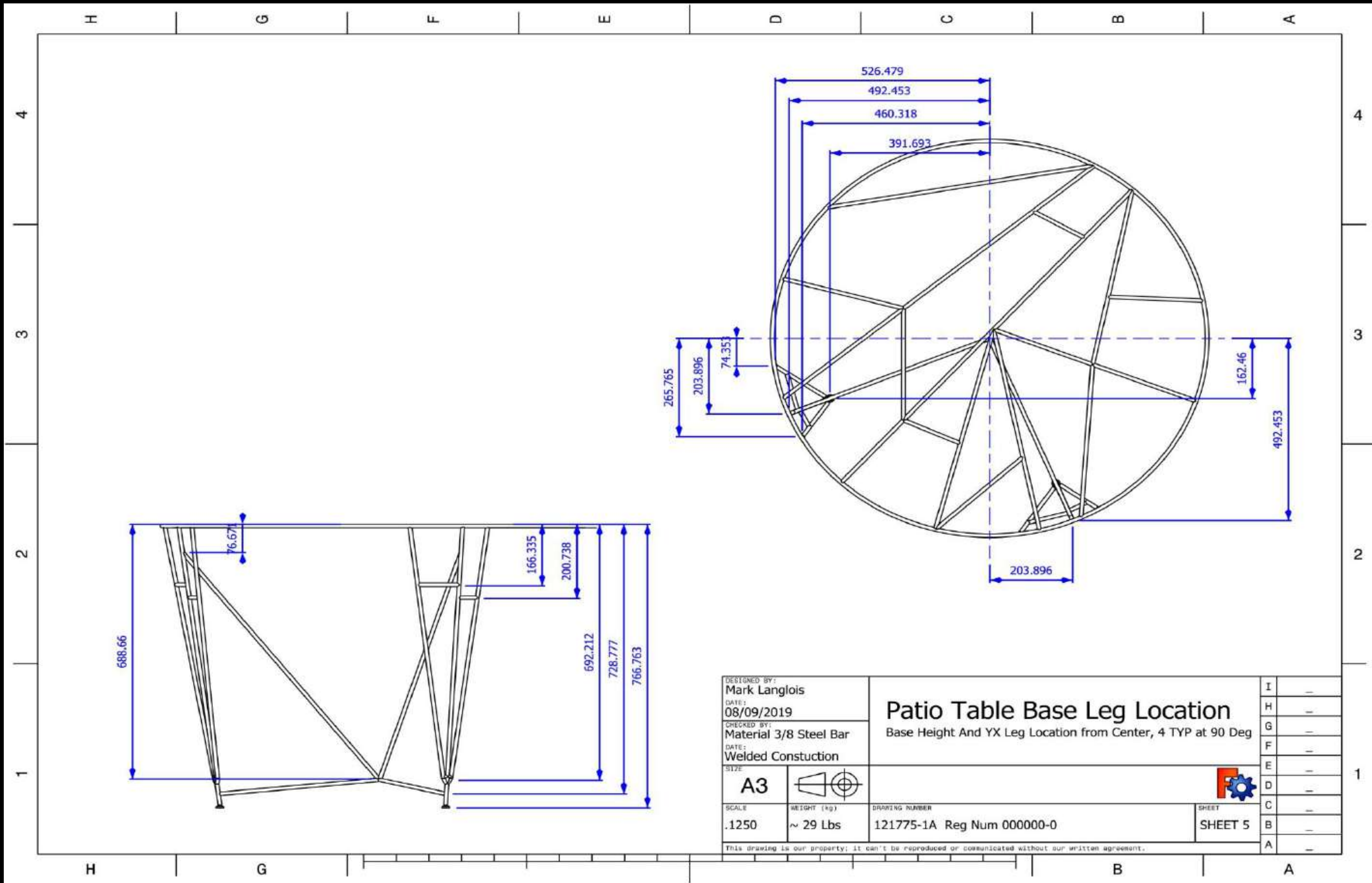
Exporting drawings and images of the component parts of my design also allows me to reference specific information without having to use the CAD application and view the model. In addition, it alleviates the necessity for me to have to repeat measurements that have already been captured. These drawings and images can also remain in a digital format, making them portable, accessible and easily viewed.



Completing the solid model that represents my table is a big first step. If I intend to bring this design into the physical world, there is a lot more work to complete. Now, I need to capture critical information that will allow me to understand the key attributes associated with this design. Capturing the true lengths of the table top interior segments is an example of the kind of information I need to evaluate.



Capturing the true lengths of each of the leg segments is another necessary key piece of information that I need. The true length measurement for each of these component segments, is the distance measured along the segment's axis or centerline.



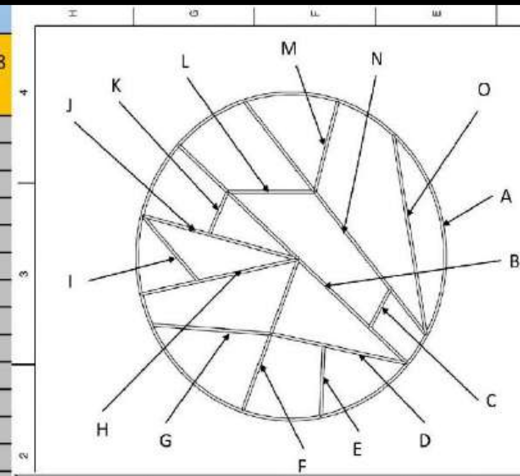
Additional key criteria that I need to evaluate, are locations and positions where rod segments are joined or oriented.

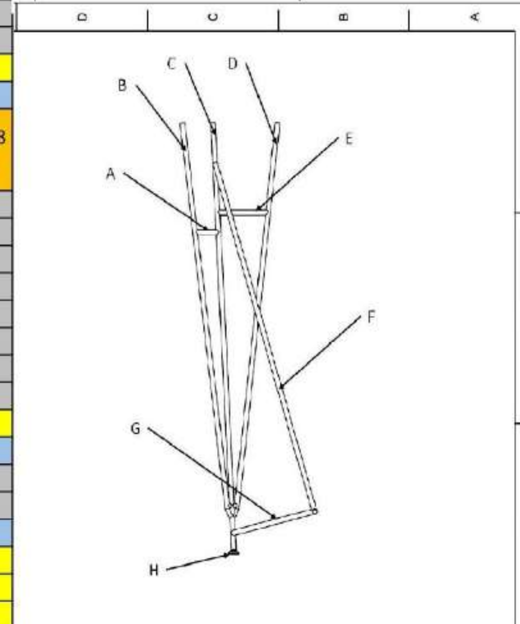
To evaluate the solid model design content associated with the table, I constructed a component breakdown chart identifying and labeling each rod segment in the completed design.

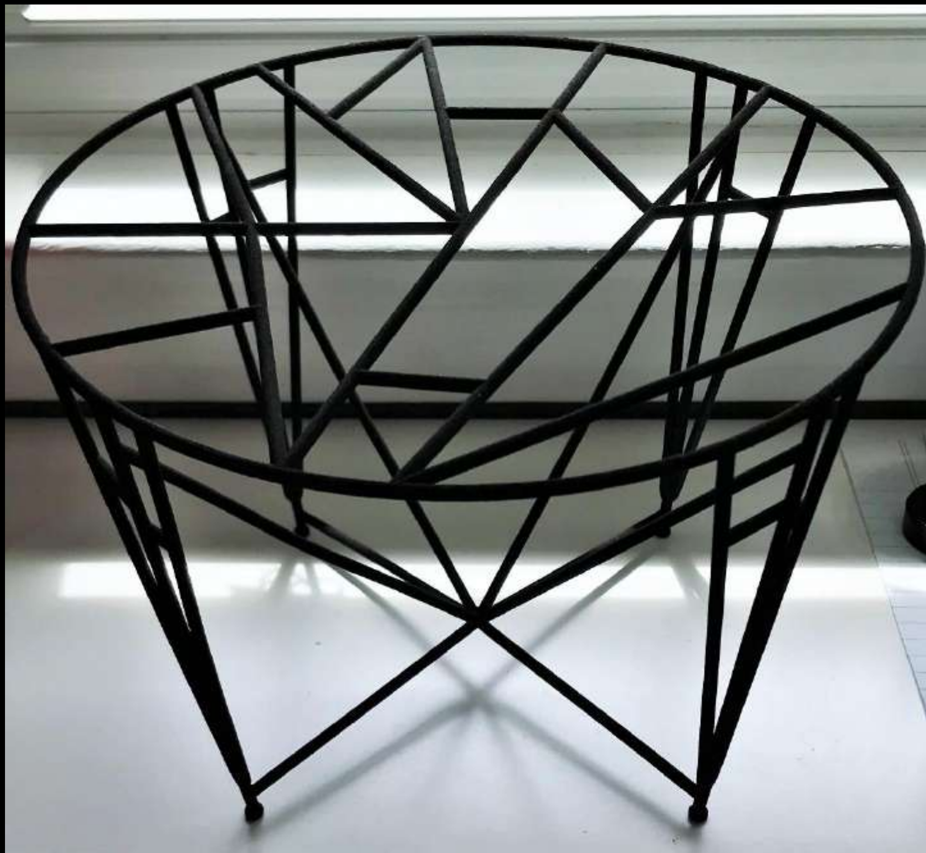
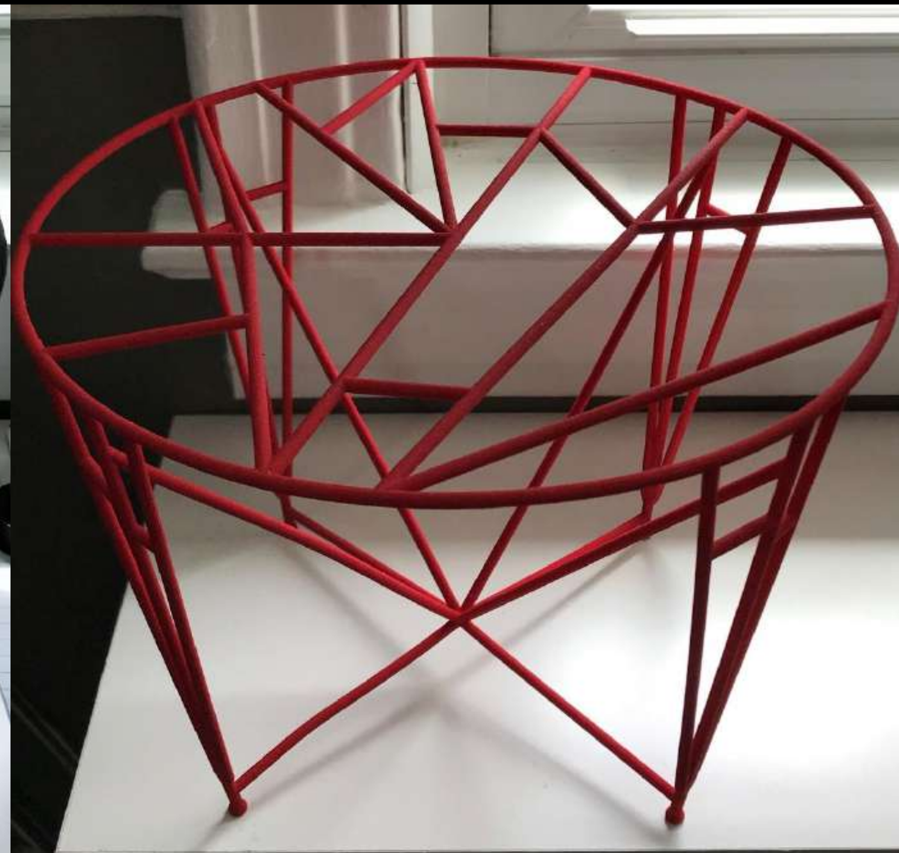
I included the true lengths captured from the previous drawings for each rod segment in the table top and for the legs. This allowed me to approximate the total linear feet of steel I would need to make a table, the approximate weight and total number of welds.

Creating this type of chart also provided the ability to forecast some initial cost estimates for material, shipping, equipment and tooling.

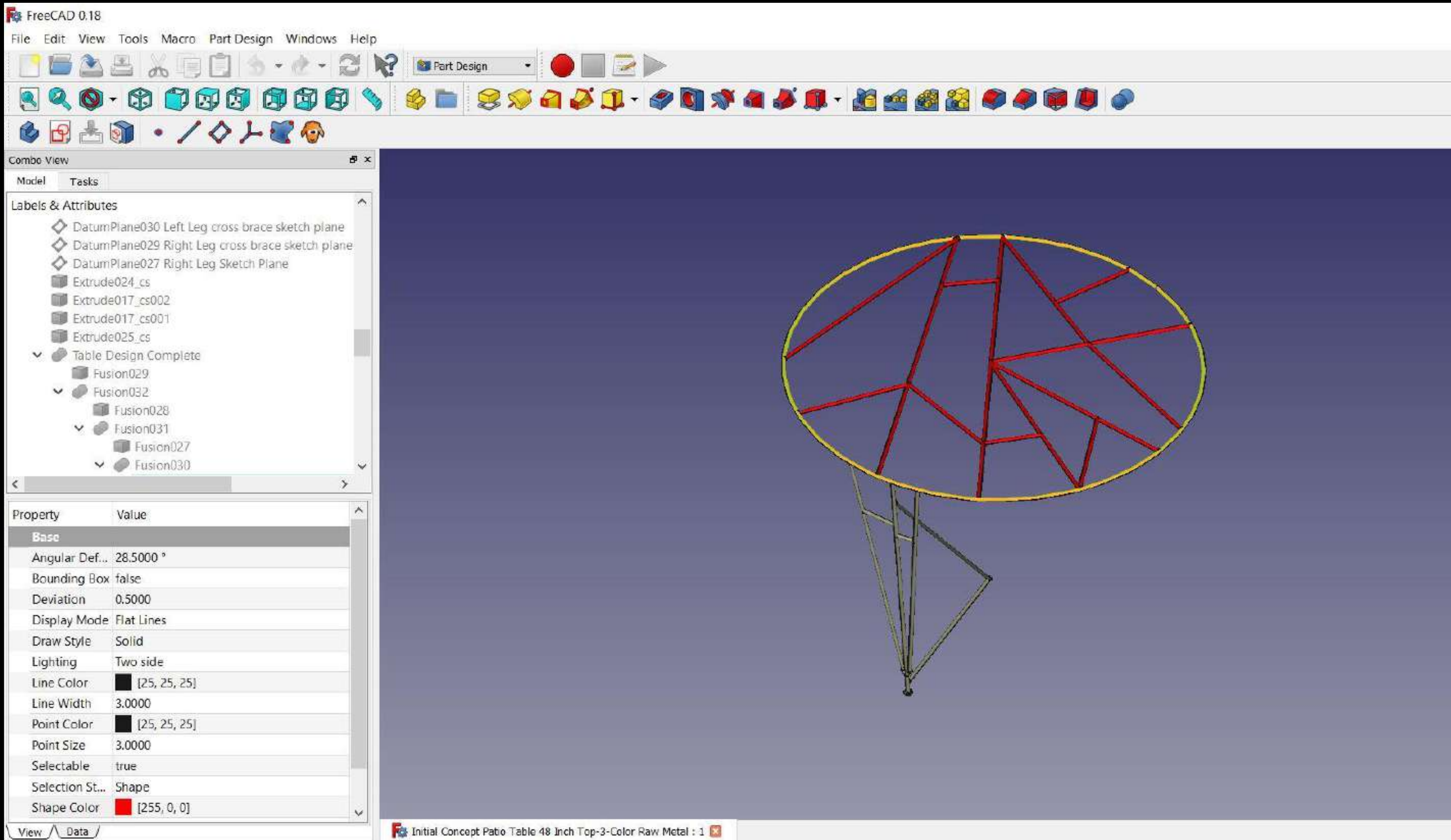
Patio Table Top Component Chart					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	156.0000	156.0 Inches	13.000	4.888	1
B	41.5000	41-1/2 Inches	3.458	1.300	4
C	5.3125	5-5/16 Inches	0.443	0.166	4
D	18.2500	18-1/4 Inches	1.521	0.572	4
E	8.7500	8-3/4 Inches	0.729	0.274	4
F	20.6250	20-5/8 Inches	1.719	0.646	4
G	16.0000	16.0 Inches	1.333	0.501	4
H	21.2500	21-1/4 Inches	1.771	0.666	4
I	11.0625	11-1/16 Inches	0.922	0.347	4
J	21.5000	21-1/2 Inches	1.792	0.674	4
K	5.6875	5-11/16 Inches	0.474	0.178	4
L	11.7500	11-3/4 Inches	0.979	0.368	4
M	11.5000	11-1/2 Inches	0.958	0.360	4
N	38.2500	38-1/4 Inches	3.188	1.199	4
O	24.9375	24-15/16 Inches	2.078	0.781	4
Totals	412.375		34.365	12.921	57
Patio Table Legs (4) Component Chart 1 Leg					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	1.6875	1-11/16 inches	0.141	0.053	4
B	27.1875	27-3/16 Inches	2.266	0.852	4
C	30.0000	30.0 Inches	2.500	0.940	4
D	27.4375	27-7/16 Inches	2.286	0.860	4
E	3.7500	3-3/4 Inches	0.313	0.118	4
F	30.3750	30-3/8 Inches	2.531	0.952	4
G	16.6250	16-5/8 Inches	1.385	0.521	4
H	0.0394	N/A	0.003	0.001	0
Totals	137.102		11.425	4.296	112
Total Approx. Patio Table Base & Top--Linear Length and Weight					
A	Linear Length ft.		80.065		
B	Table Weight lbs		30.105		
Total Welds, Top, Legs, Leg to Table Top, Center Bars To Center Bars					
A	Weld Legs to Top				12
B	Weld Center Bars To Center Bars				8
Totals	Total Number of Welds				189



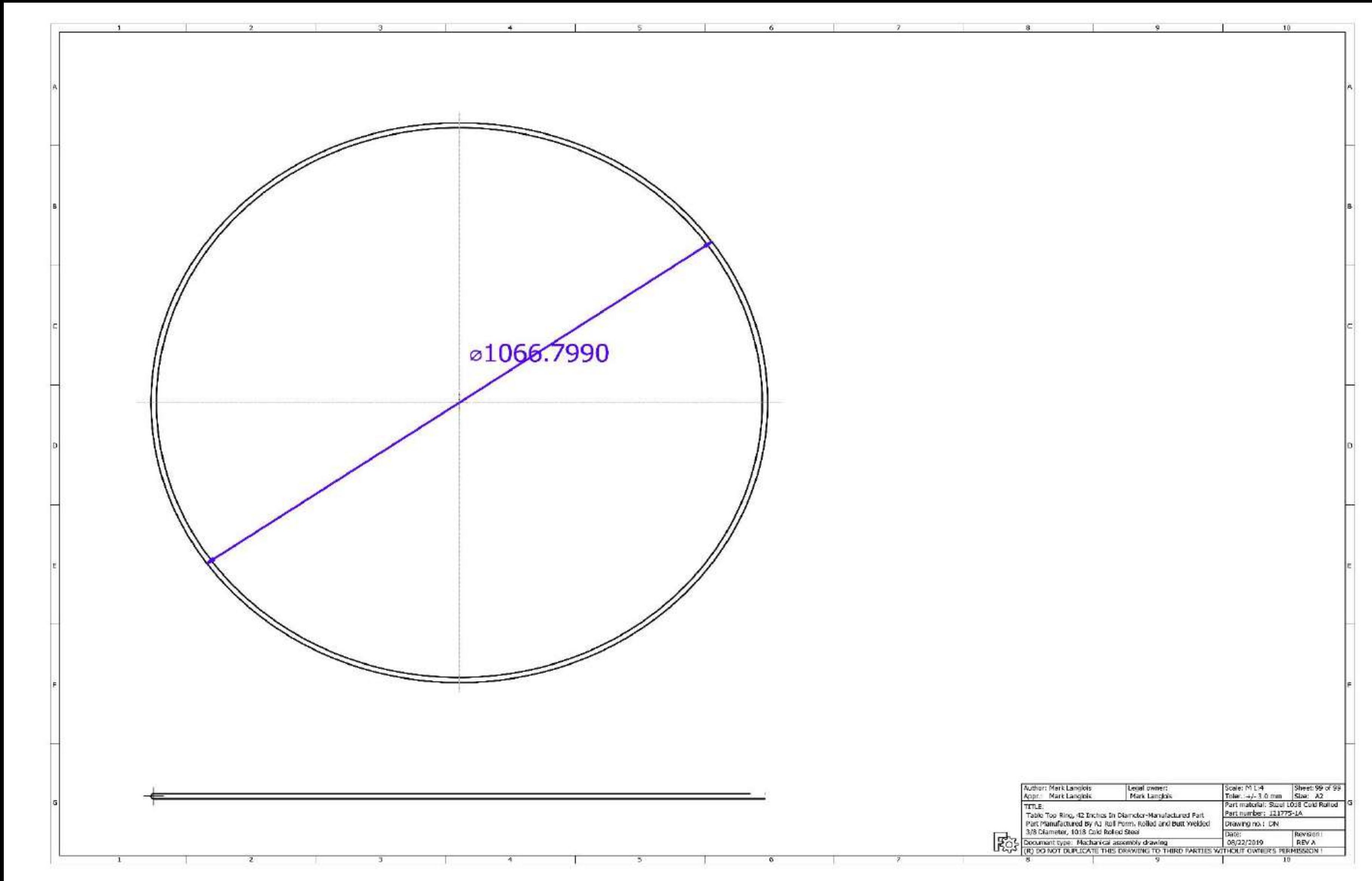


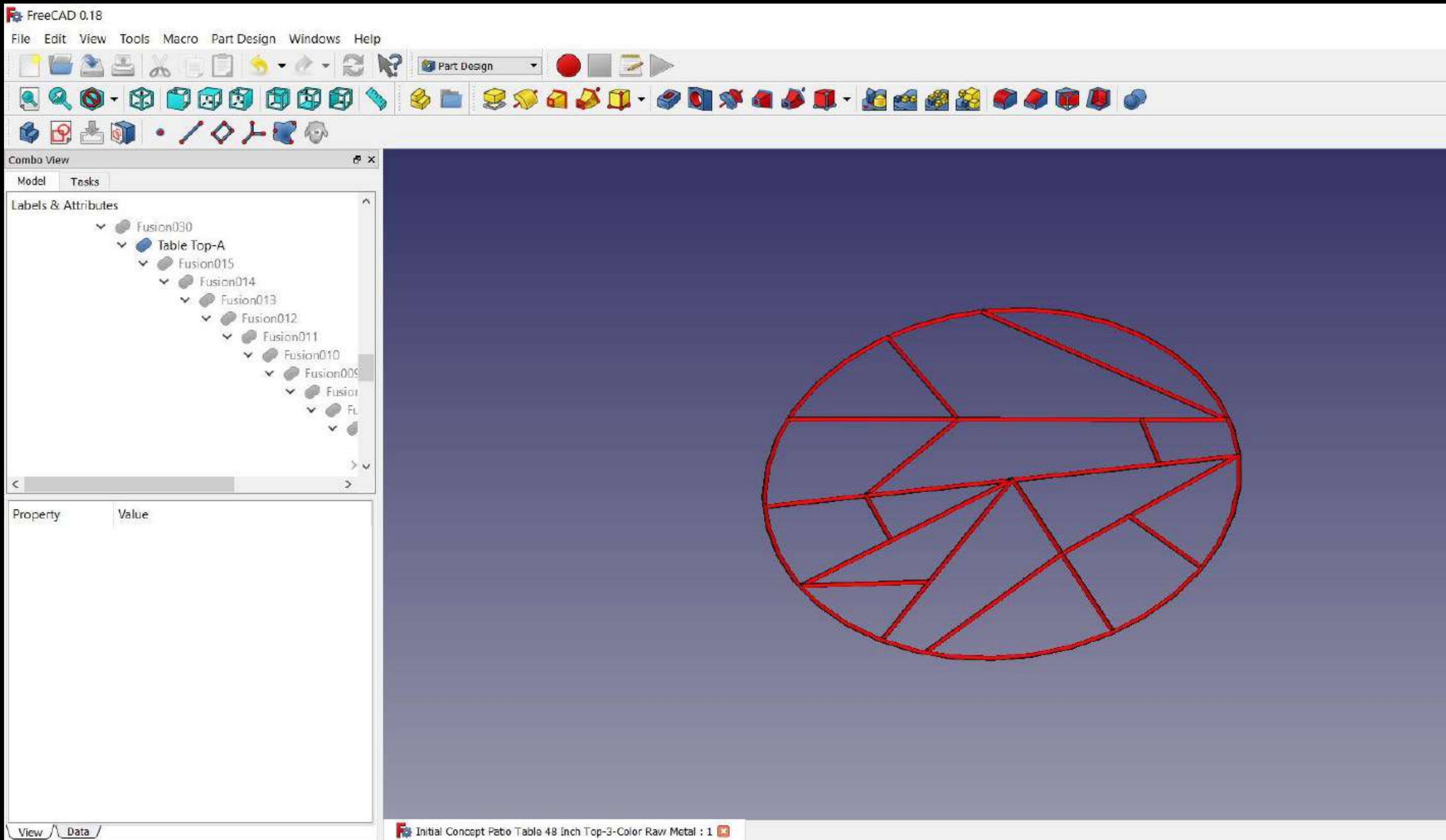
While I have completed the initial table design, extracted some important information from the model and charted some estimates on component build criteria, the decision to go forward and make the table has not yet been determined. Up to this point, all of the work that has been accomplished has been an investment in my individual time. The decision to bring the table as designed represented by the CAD solid model, now requires an investment in cash. The first sum of money that I spent in the creation of these tables, was to have a 3D printed model made so that I could see a physical representation of my design. Validating the CAD model with a physical model, was important for me in deciding to move ahead with further development.   After evaluating the 3D printed models and some serious thought, I decided to move forward with the next step in the process and create the fixtures necessary to make this table as designed.



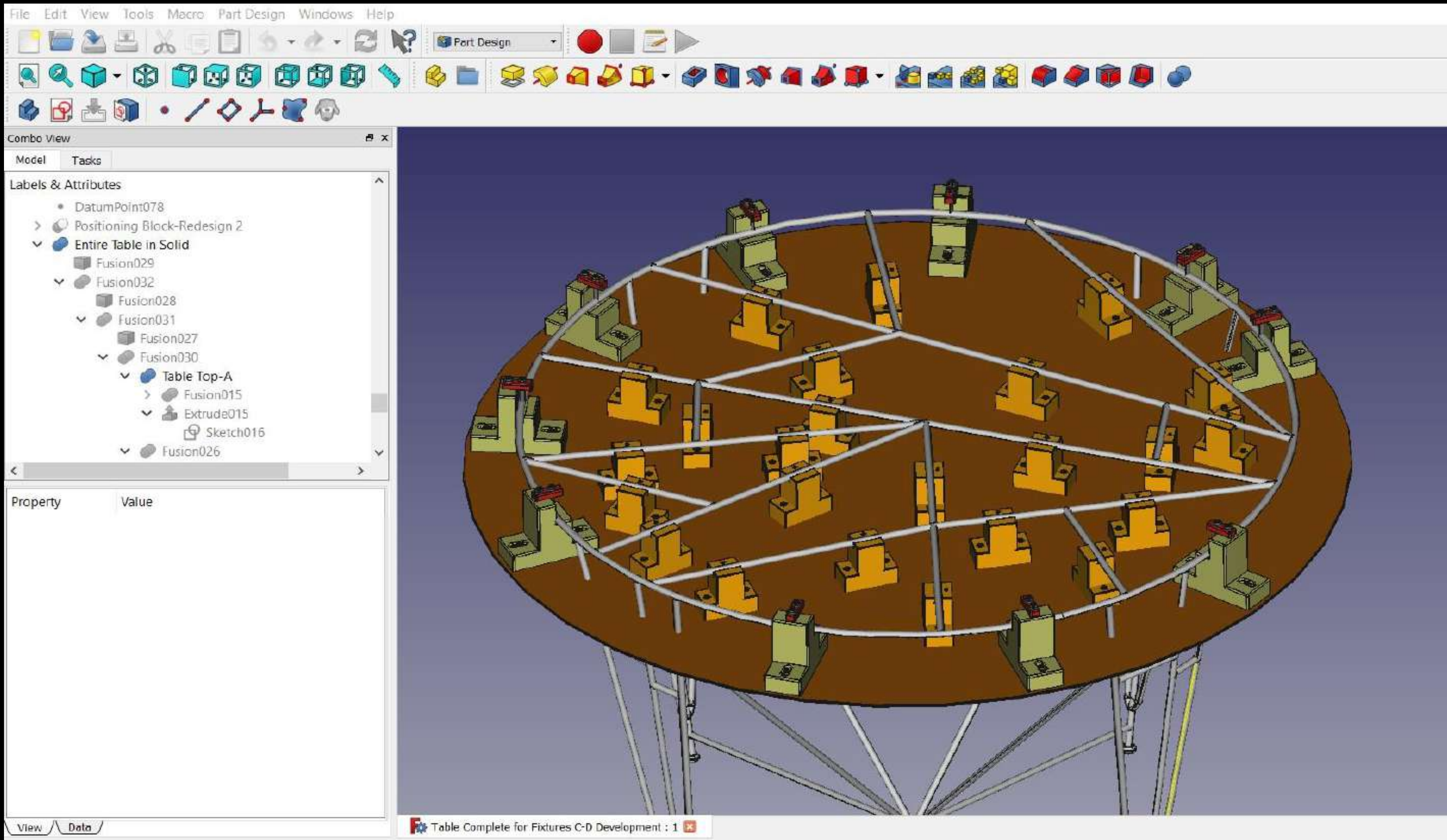
The table as designed is made of steel and the components are welded together. There are three major components in the construction of my design. The first, being the table top ring (shown in orange), the second, are the interior components that define the geometric design in the table top (shown in red), and the third component, is the leg that support the table top (shown in olive). The leg is constructed once and copied three more times, spaced 90 degrees apart.



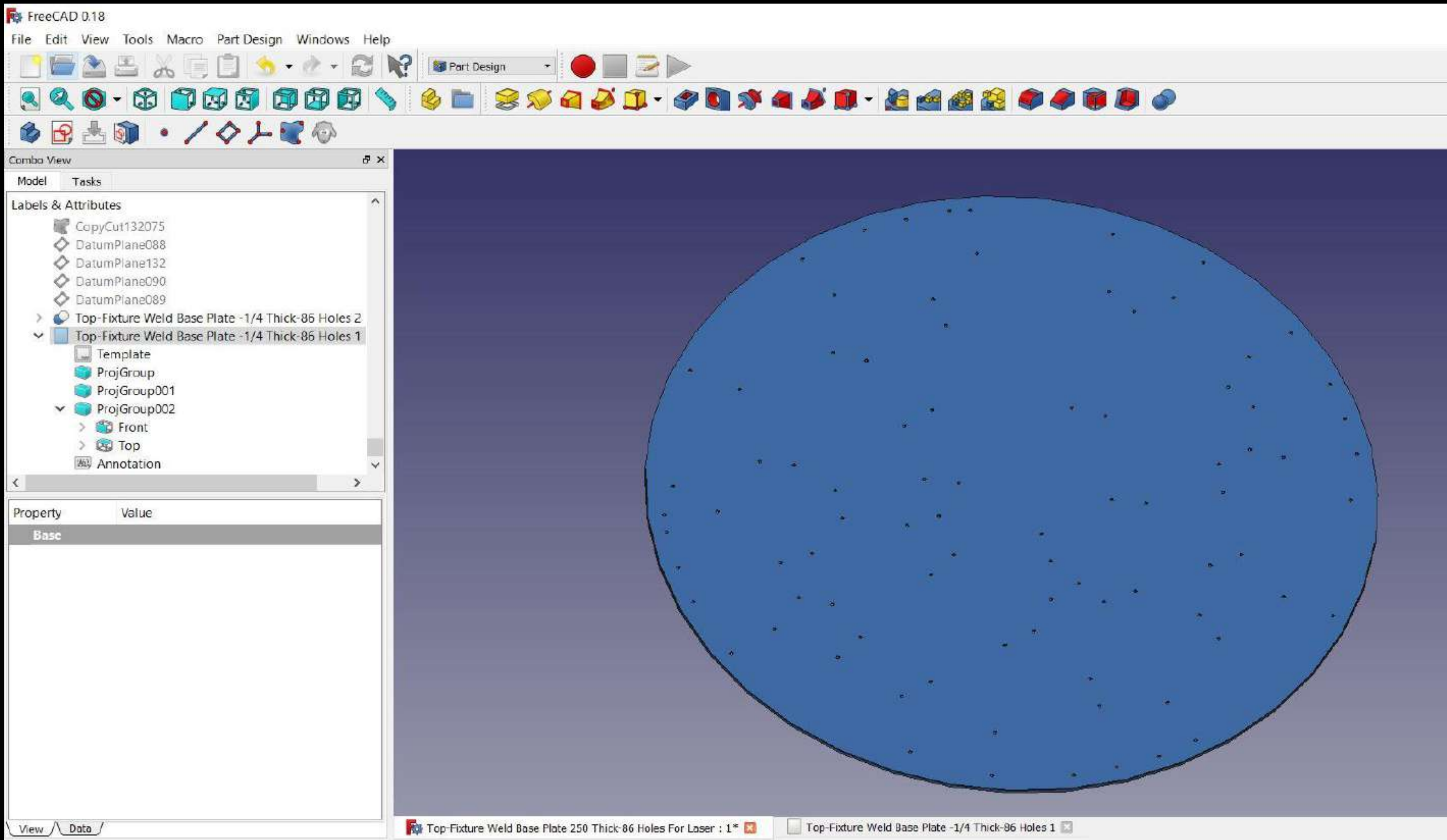
The First Component, The Table Top Ring: The table top ring is a purchased, manufactured component. The reason for this is simple. I didn't have the space or equipment to make the ring. The last time I made this ring 40 years ago, I hand bent 13 feet of steel rod around a plywood form and welded it. My ring was never really round. This ring is roll formed and butt welded; it is round. I hand finished each welded ring so there is no visible seam.



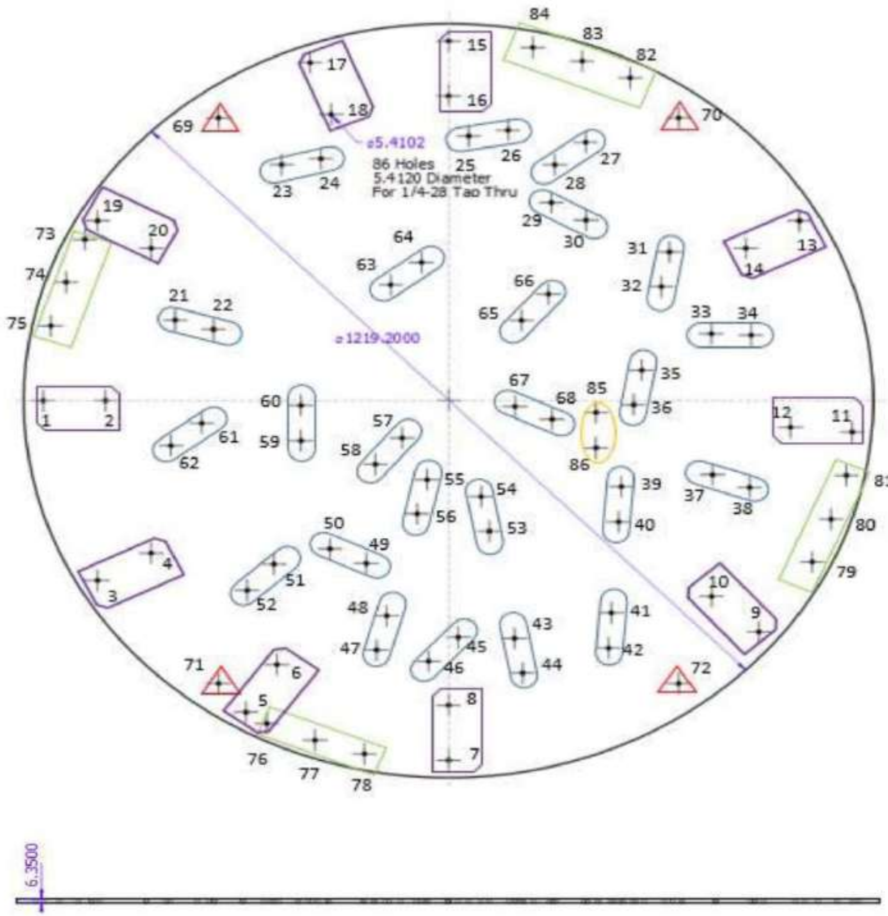
The Second Component, The Geometric Interior Segments For The Table Top: This second component includes the first component, the outer table top ring. At this point, we enter into a new phase of design and development; design for manufacture. In this phase, I need to design work holding and positioning devices that will keep the top in the correct location, orientation and in the correct plane. To do this, I will need to use existing elements of the table solid model to create the necessary tools and fixtures. This design approach is often called "Design in Context".



The picture above shows the basic concept of "Design in Context". The geometric elements that define the table solid model are leveraged to locate, position, orient and shape the tooling required to make the table top. To construct the table top what do I need? I need a base plate; to attach, locate and position the work holding devices. I need to design some fixtures to hold the table top ring and I also need some fixtures to locate, position, and orient the interior components for the top.



Weld Fixture Base Plate: The weld fixture base plate that I designed is 48 inches in diameter, 1/4 inch thick, A36 steel plate. The plate is used as a weld fixture base for the construction of the table top only. The solid model of the plate is shown above, with holes in the plate that are extrusions sized for a 1/4-28 tap drill and subtracted from the solid body. All holes are tapped with a 1/4-28 tap through the plate.



See (X,Y) Hole Locations From 48 inch Diameter Center Corresponding to Number Shown. All Holes, 1/4-28 Tapped Holes

Note: Footprint grouping of holes done for visual clarity only

Fixture Base & Weld Skirt Hole Locations: Units in mm					
Ring Shoe Hole Locations From 1219.2 Dia. Center Point: 1/4-28 Tapped Holes All Holes					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
1	-581.5172	0.0000	2	-492.6172	0.0000
3	-503.6086	-290.7586	4	-426.6190	-246.3086
5	-290.7586	-503.6086	6	-246.3086	-426.6190
7	0.0000	-581.5172	8	0.0000	-492.6172
9	445.4680	-373.7920	10	377.3666	-316.6482
11	579.3043	-50.6826	12	490.7426	-42.9344
13	503.6086	290.7586	14	426.6190	246.3086
15	0.0000	581.5172	16	0.0000	492.6172
17	-198.8906	546.4474	18	-168.4850	462.9087
19	-503.6086	290.7586	20	-426.6190	246.3086
Position Block Hole Locations From 1219.2 Dia. Center Point					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
21	-392.4053	130.2626	22	-337.2448	115.3147
23	-239.4051	381.4279	24	-183.0913	391.1685
25	28.9569	427.8539	26	85.2707	437.5945
27	196.7242	417.6224	28	152.6165	381.2818
29	147.5402	320.2420	30	197.1332	291.8403
31	316.9471	240.2478	32	305.3398	184.2889
33	377.0267	108.3445	34	434.1227	105.8610
35	277.2371	49.2878	36	265.6298	-6.6711
37	378.7341	-119.7080	38	431.9851	-140.4555
39	247.7406	-139.0432	40	243.8244	-196.0588
41	233.7481	-342.9742	42	229.7324	-399.9829
43	94.6292	-384.3201	44	106.2993	-440.2659
45	13.7501	-382.6157	46	-28.5111	-421.0879
47	-103.4225	-403.0823	48	-88.8060	-347.8330
49	-118.2094	-263.0398	50	-170.3028	-239.5366
51	-250.6781	-264.2169	52	-288.9638	-306.6472
53	58.5313	-210.9122	54	46.8612	-154.9664
55	-30.6890	-127.7210	56	-45.3055	-182.9703
57	-66.6781	-60.2981	58	-104.9638	-102.7284
59	-211.6661	-64.5683	60	-211.6483	-7.4183
61	-354.2758	-36.3776	62	-398.3835	-72.7182
63	-82.8835	187.2818	64	-38.7758	223.6224
65	104.8362	129.8558	66	143.1219	172.2861
67	95.3741	-9.3270	68	148.6251	-30.0745
Weld Base Lift Block Hole Locations From 1219.2 Dia. Center Point					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
69	-330.2000	457.2000	70	330.2000	457.2000
71	-330.2000	-457.2000	72	330.2000	-457.2000
Top-Leg Assembly Locating Block, 4 Places					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
73	-522.0638	260.8012	74	-549.0170	191.7253
75	-570.9240	120.8872	76	-260.8012	-522.0638
77	-191.7253	-549.0170	78	-120.8872	-570.9240
79	522.0638	-260.8012	80	549.0170	-191.7253
81	570.9240	-120.8872	82	260.8012	522.0638
83	191.7253	549.0170	84	120.8872	570.9240
Assembly Top Orientation/Position Block					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
85	211.7137	-76.2978	86	211.6959	-19.1478

Author: Mark Langlois Appr.: Mark Langlois	Legal owner: Mark Langlois	Scale: M 1:4 Toler.: +/- .2 mm	Sheet: 1 of 1 Size: A2
TITLE: Fixture Weld Base Plate, Top, 48 In. Dia, Redesign for Laser Laser Cut .213 in (5.4102 mm) Diameter, 86 Holes Tap All Holes 86 Holes, 1/4-28 Thread Thru		Part material: Steel Plate, A36, 1/4 In. Part number: ML-0000-A100-2	
		Drawing no.: ML-121775-A100-2	
Document type: Mechanical assembly drawing		Date: 05/14/2020	Revision: REV C

Base Plate Drawing: The base plate has 86 holes that were laser cut using an exported .step file. The table on the drawing provides the X-Y hole locations for reference and correspond to the hole number on the plate. I made the drawing showing the holes grouped with different outlines to identify the component fixtures located on the plate. The holes outlined with a diamond are for lift hooks; the plate without fixtures weighs close to 400 lbs.

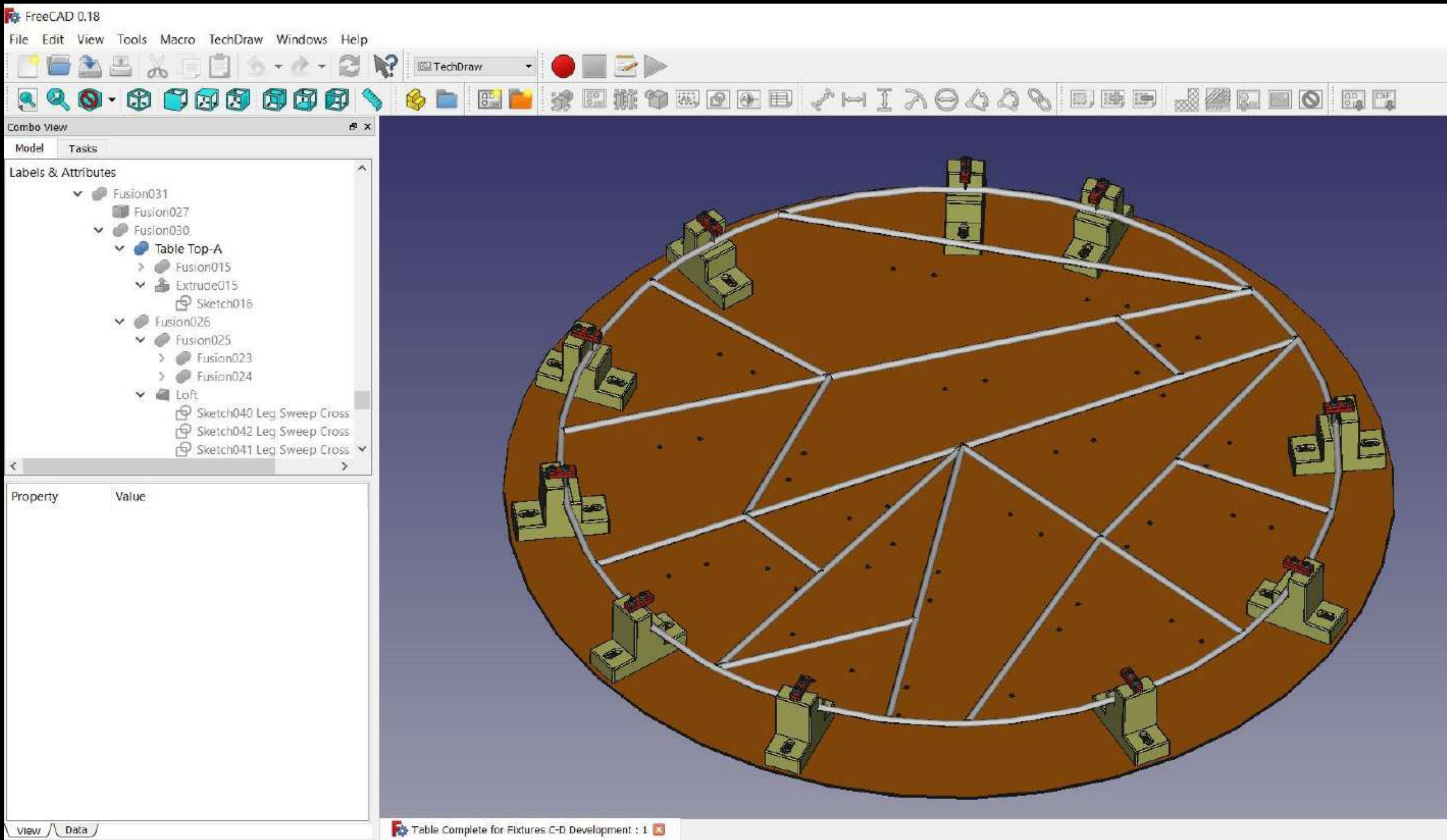


Table Top Ring Weld Shoes: I designed the table top ring weld shoes to perform a number of functions. They are a work holding device to secure the table top ring in place. They also elevate the ring off of the base plate 2.5 inches. The shoes are located and spaced so that they don't interfere with the interior table components that get welded to the inside ring diameter. Each weld shoe can move in a direction perpendicular to the table top ring diameter. The ten ring weld shoes provide a consistent level of support around the ring diameter and also keeps the ring in plane.

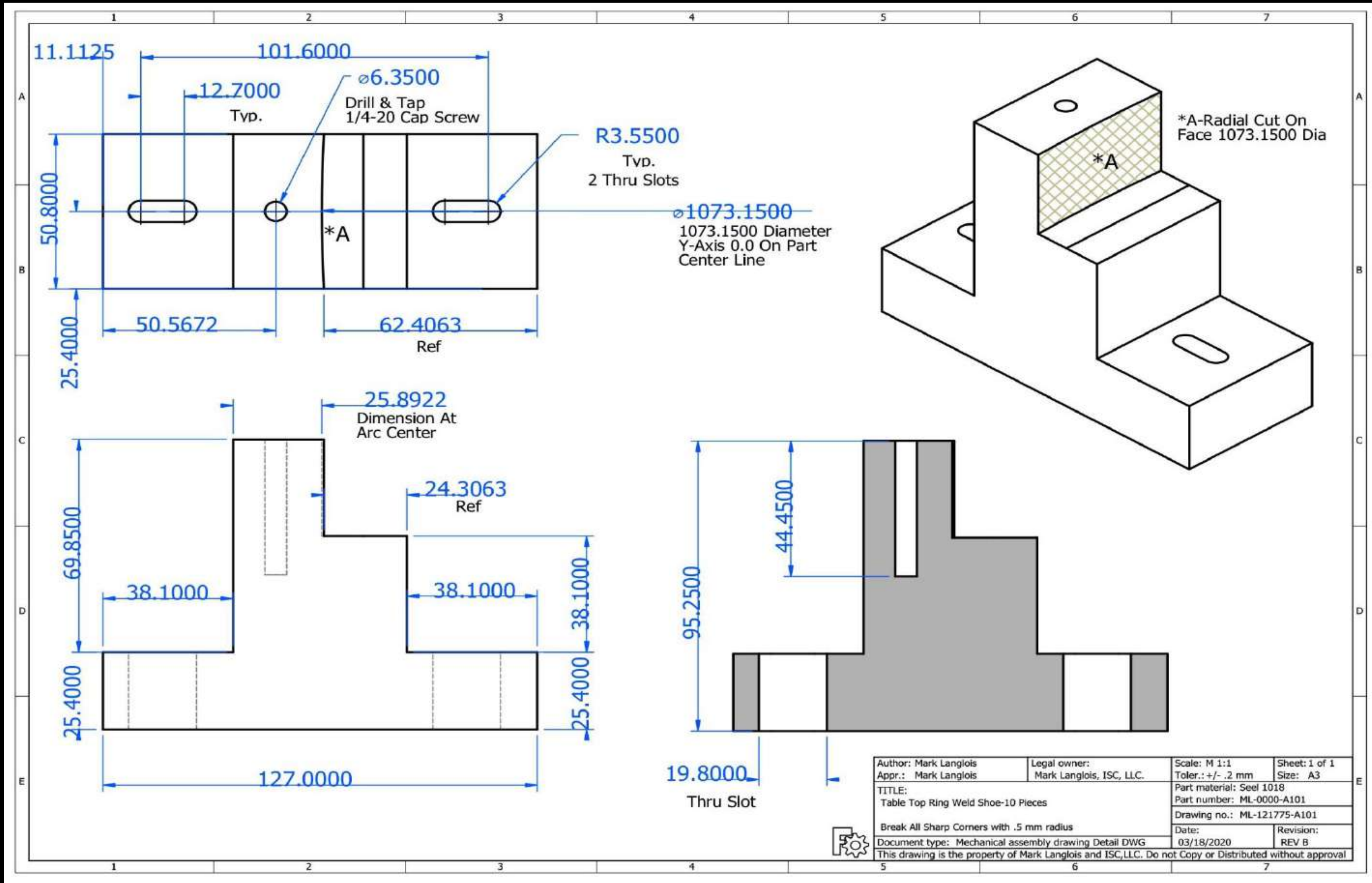
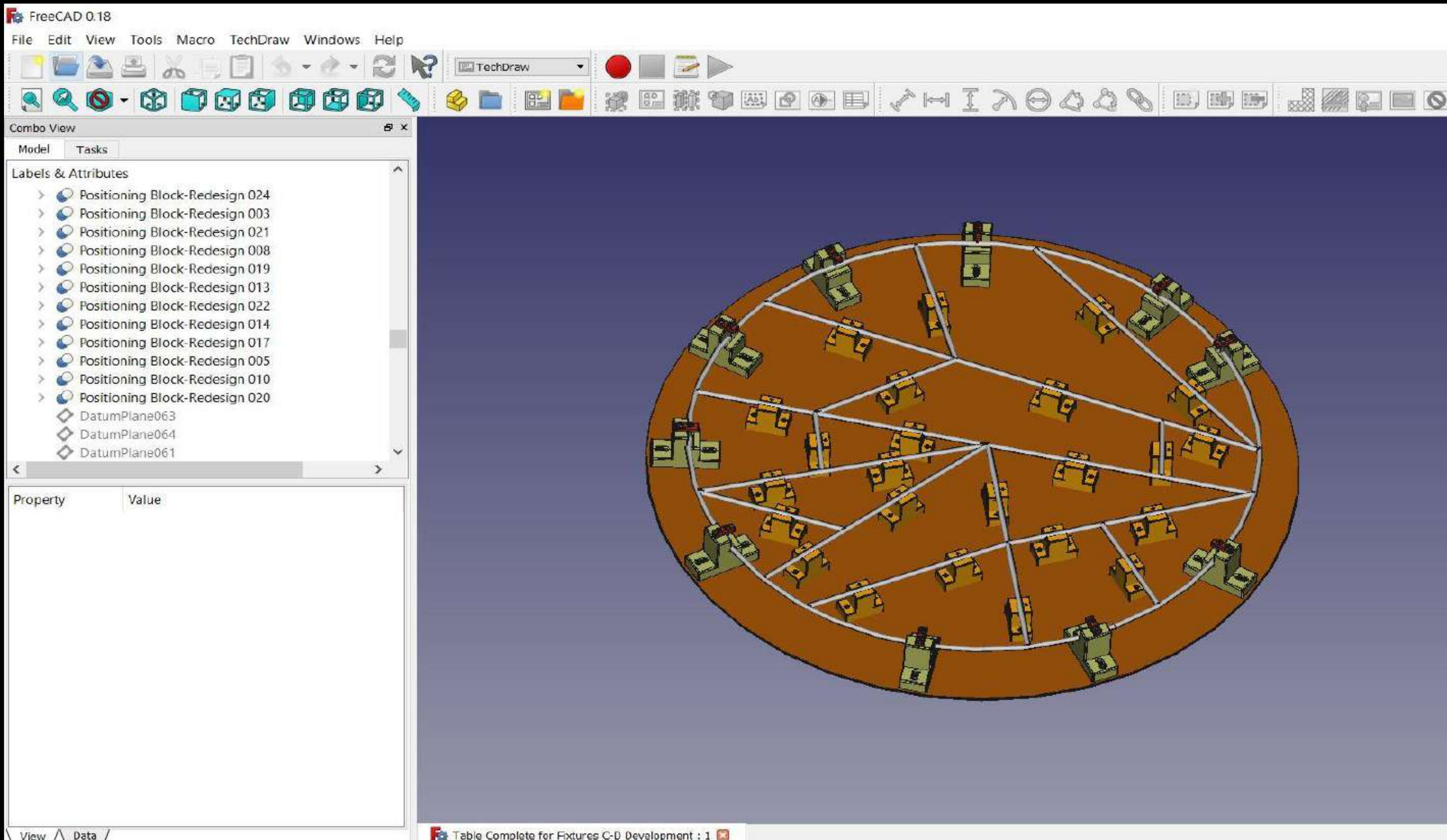
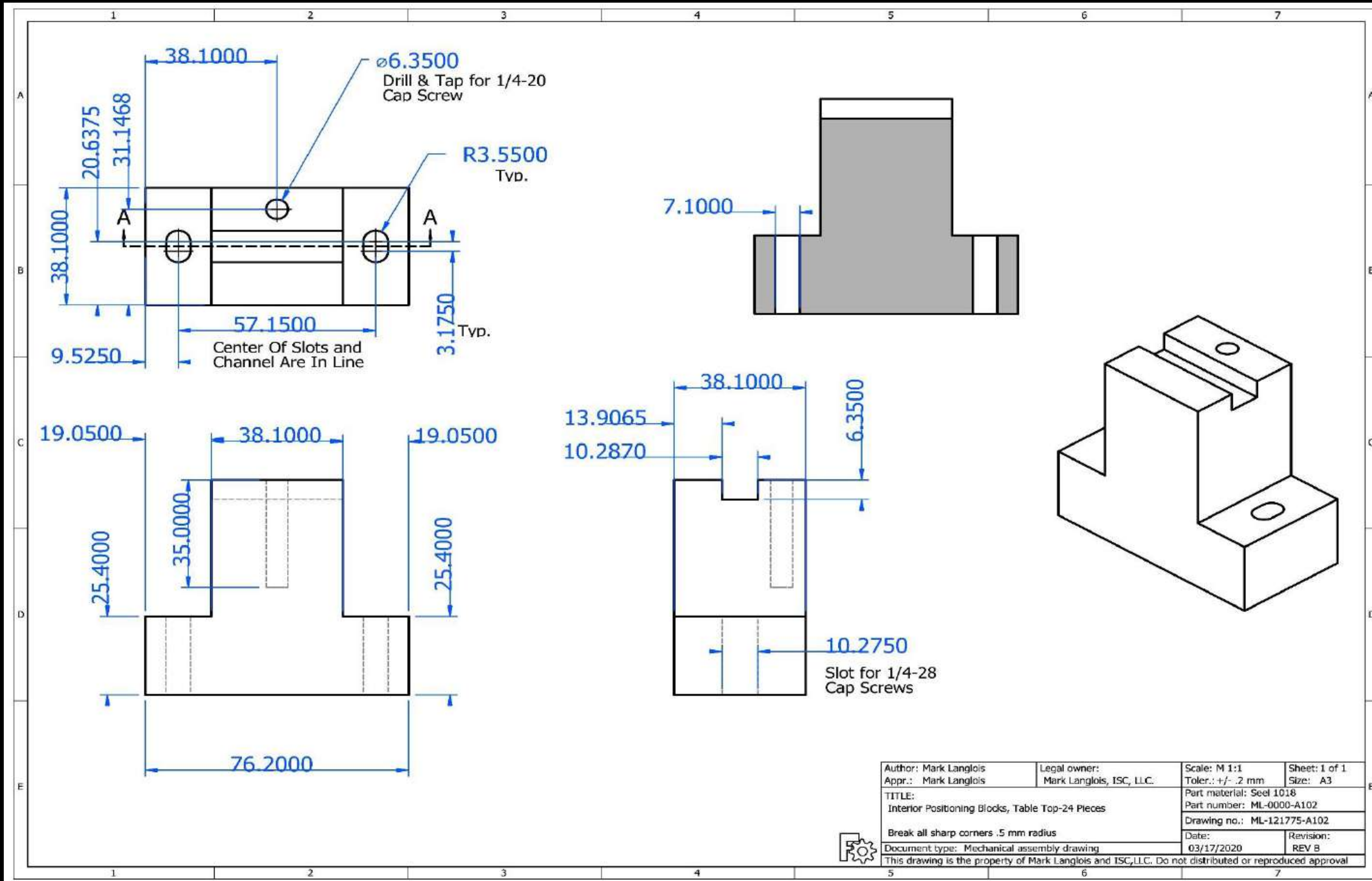


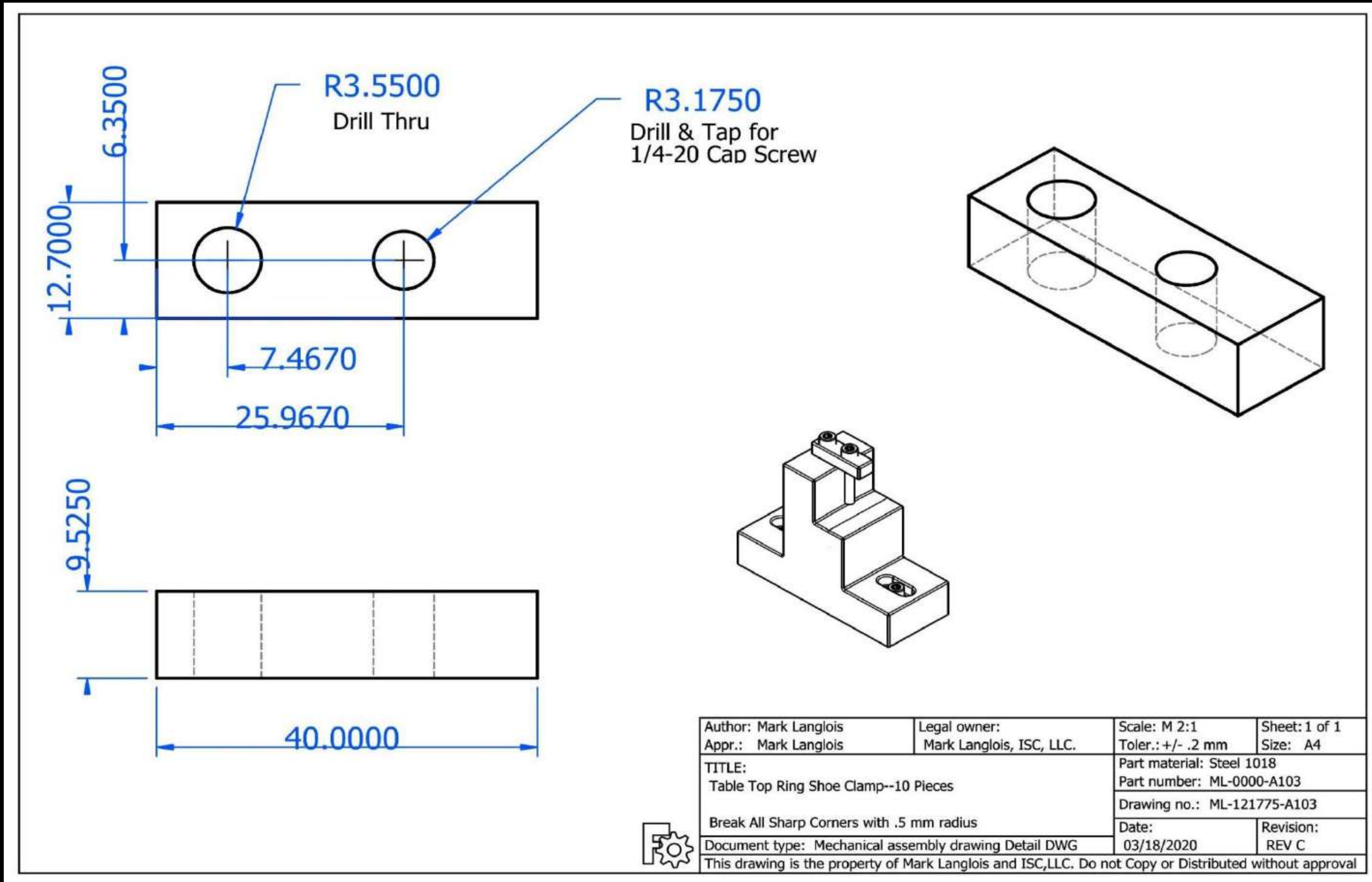
Table Top Ring Weld Shoe Drawing: The ten top ring weld shoes were made by my supplier using CNC machining. The outer diameter of the table top ring is machined into the upper face on all of the ring shoes to allow for consistent contact and easy alignment (Face *A on the print). A clamp secures the table top ring to the weld shoe on the bottom of Face *A.



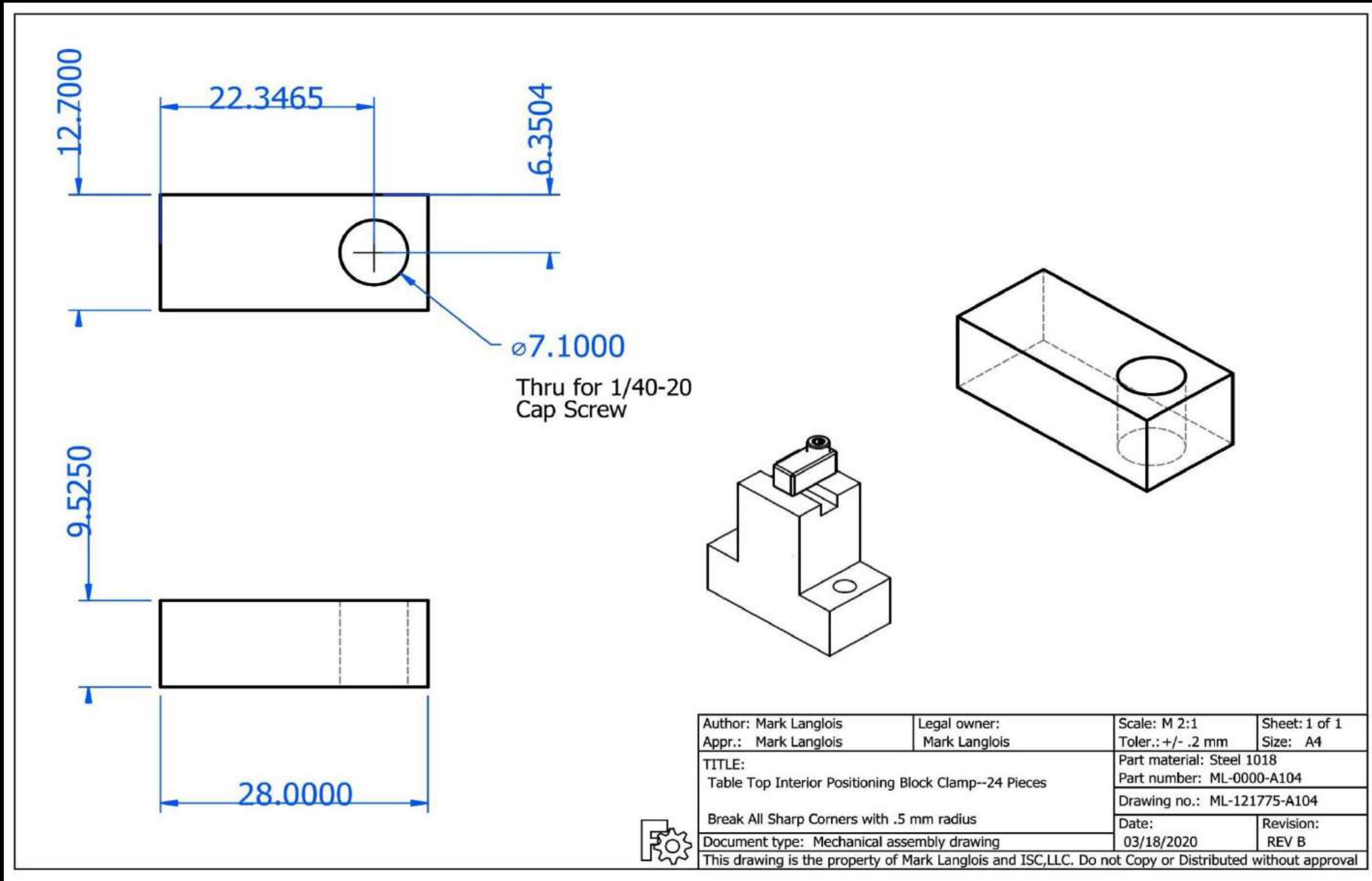
Interior Positioning Blocks: The interior positioning blocks shown above in orange, were designed to align and clamp the steel bar that defines the interior of the table top. The positioning blocks locate the steel bar segments in the same plane as the table top ring and supports the bar across the length of the segment. The longer segments however, require more blocks. My objective in designing these blocks was to provide the functional support in a simple fixture with a small footprint and easy to make.



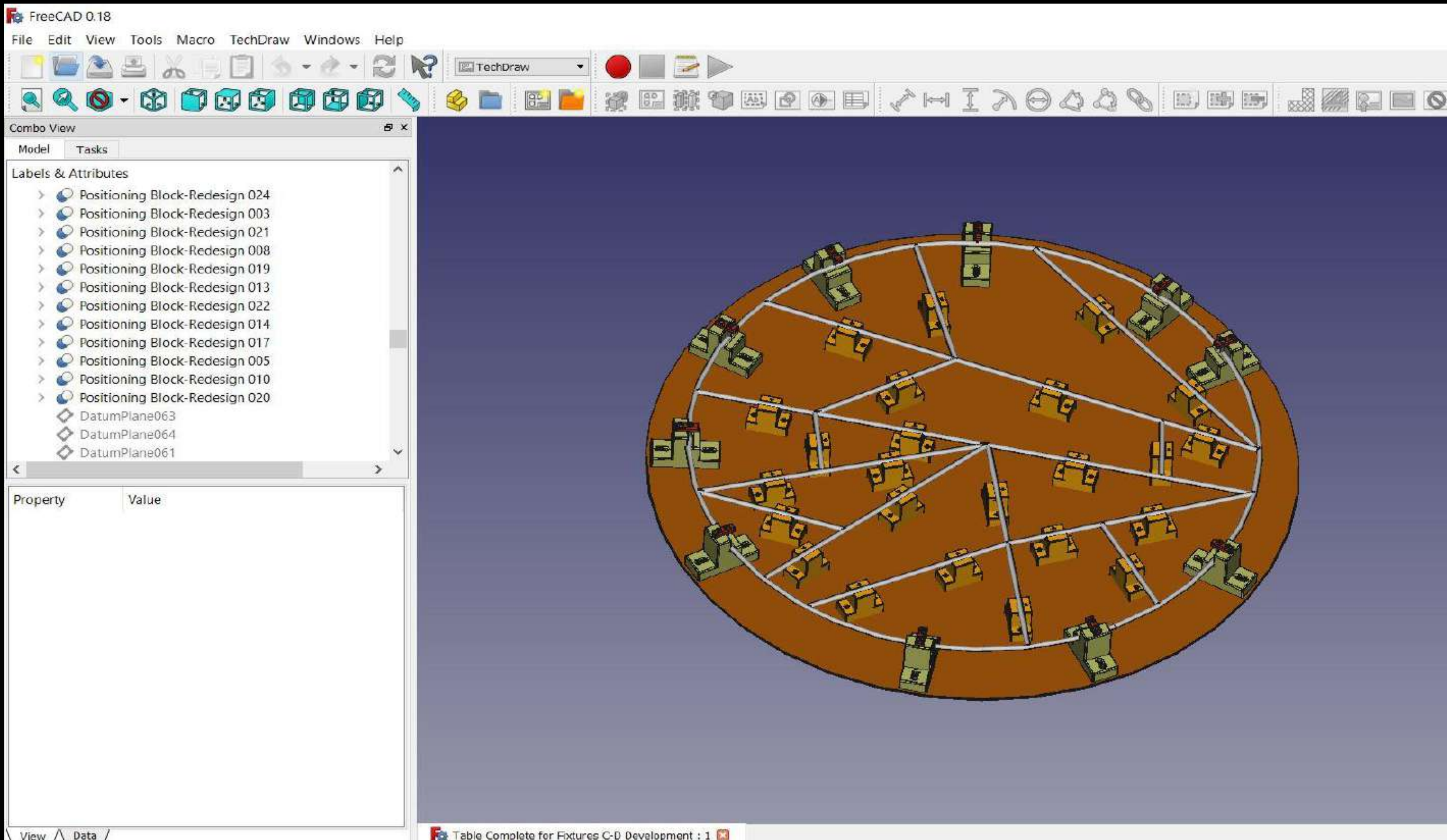
Interior Positioning Block Drawing: There are 24 positioning blocks that are paired with the interior steel rod segments. The blocks were CNC machined by my supplier. Each of the block's hole positions were aligned with the axis of each steel rod segment and transferred to the weld base plate. The positioning blocks locate on these holes. The slotted holes in the blocks allow the blocks to float slightly, perpendicular to the steel rod segment axis for alignment.



Ring Weld Shoe Clamps: My clamp for the table top ring weld shoes was designed to hold the table top ring in position with a set screw, clamping the ring on the center line of the ring diameter. There are 10 of these clamps, one for each of the ring weld shoes.



Interior Positioning Block Clamps: There are 24 of these clamps. I designed these clamps as a simple strap clamp, where the clamp body lays on top of the steel bar. When the screw on the back is tightened down, the clamp forces the round steel bar into the positioning block's channel, locking it in place. Both the weld shoe clamps and the positioning block clamps were CNC machined by my supplier.



My Table Top Fixture Design Complete: 1) Weld Base Plate, 2) Table Top Ring Weld Shoes, 3) Interior Positioning Blocks, 4) Ring Weld Shoe Clamps, 5) Interior Positioning Block Clamps.

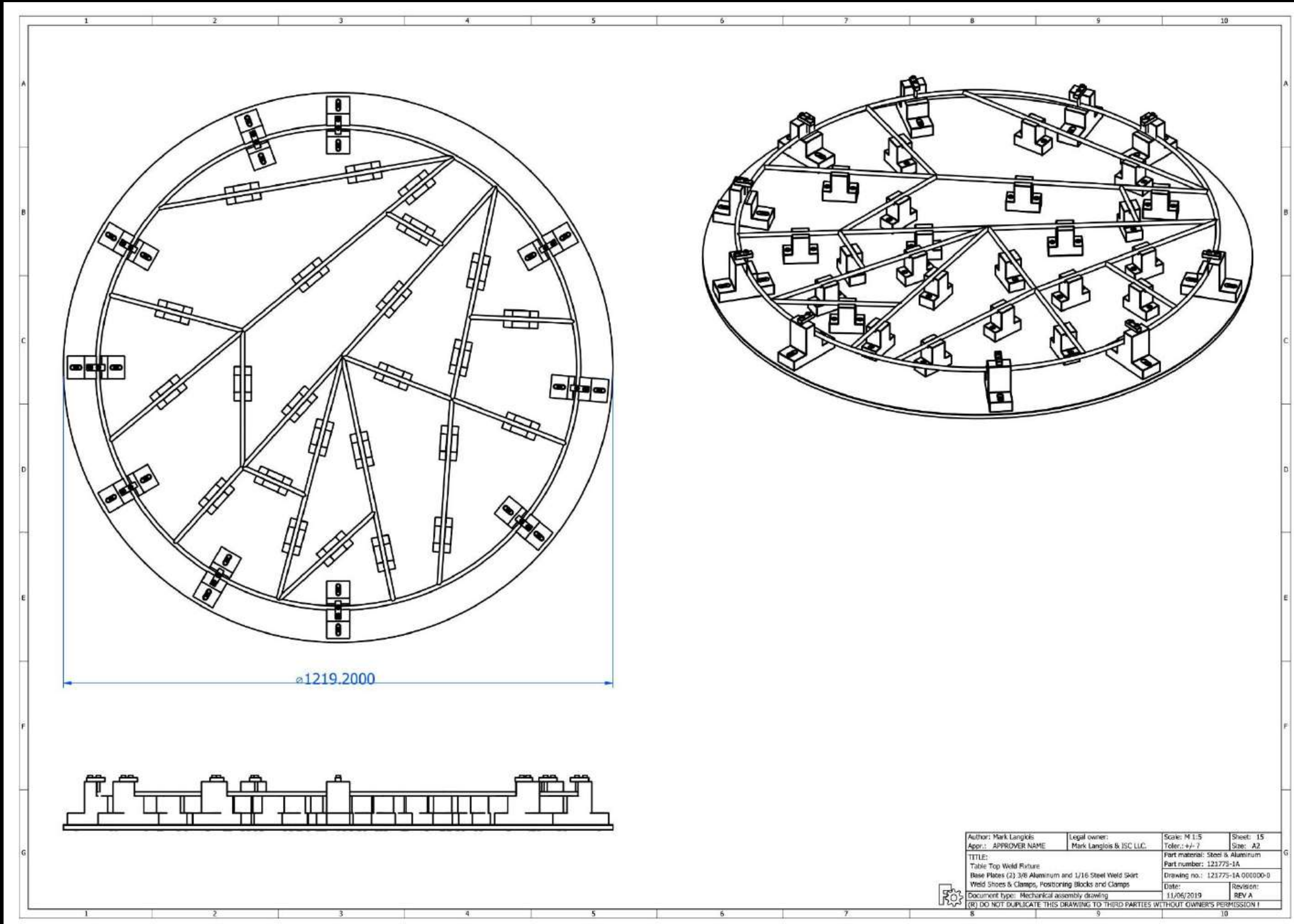
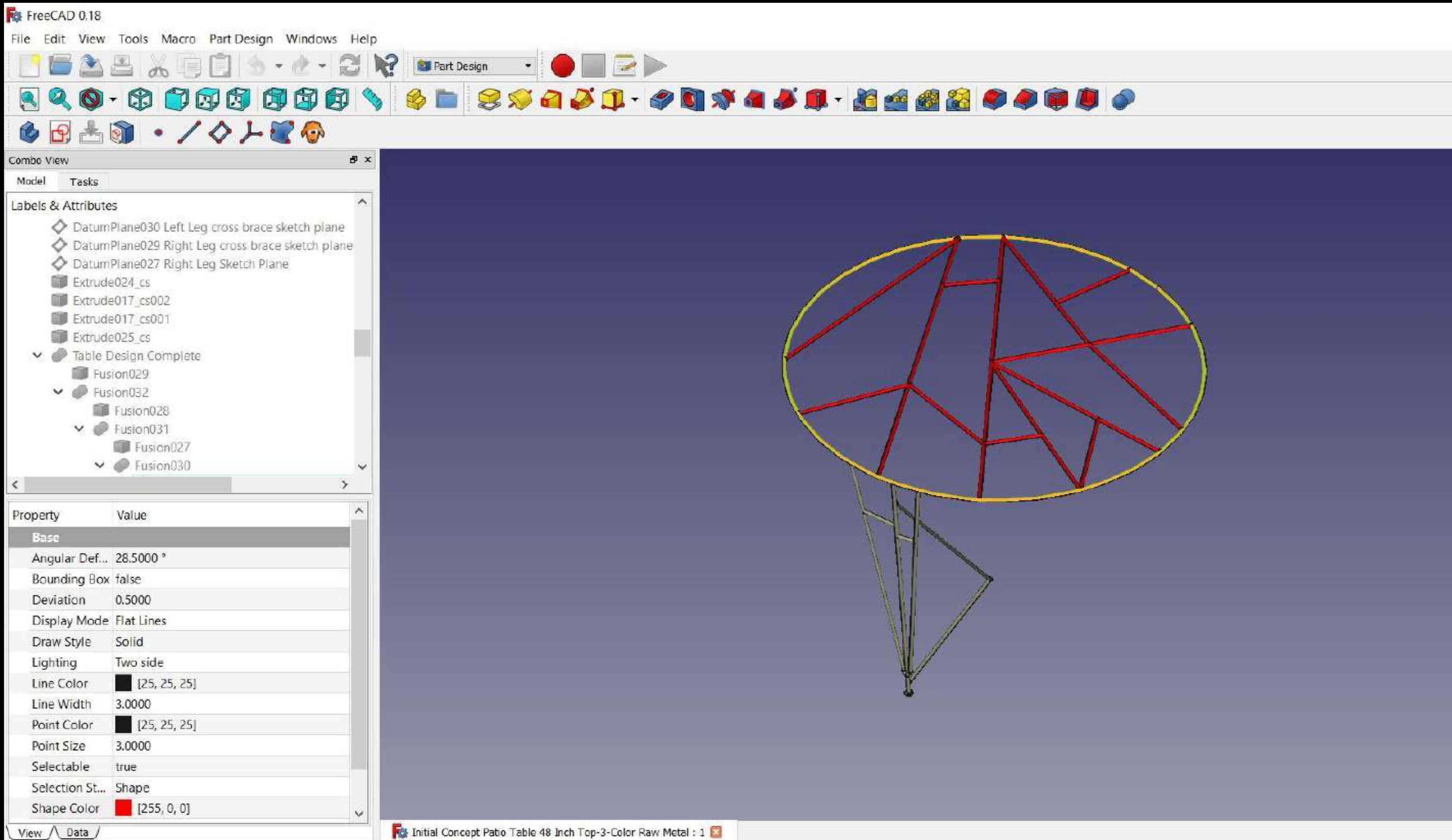
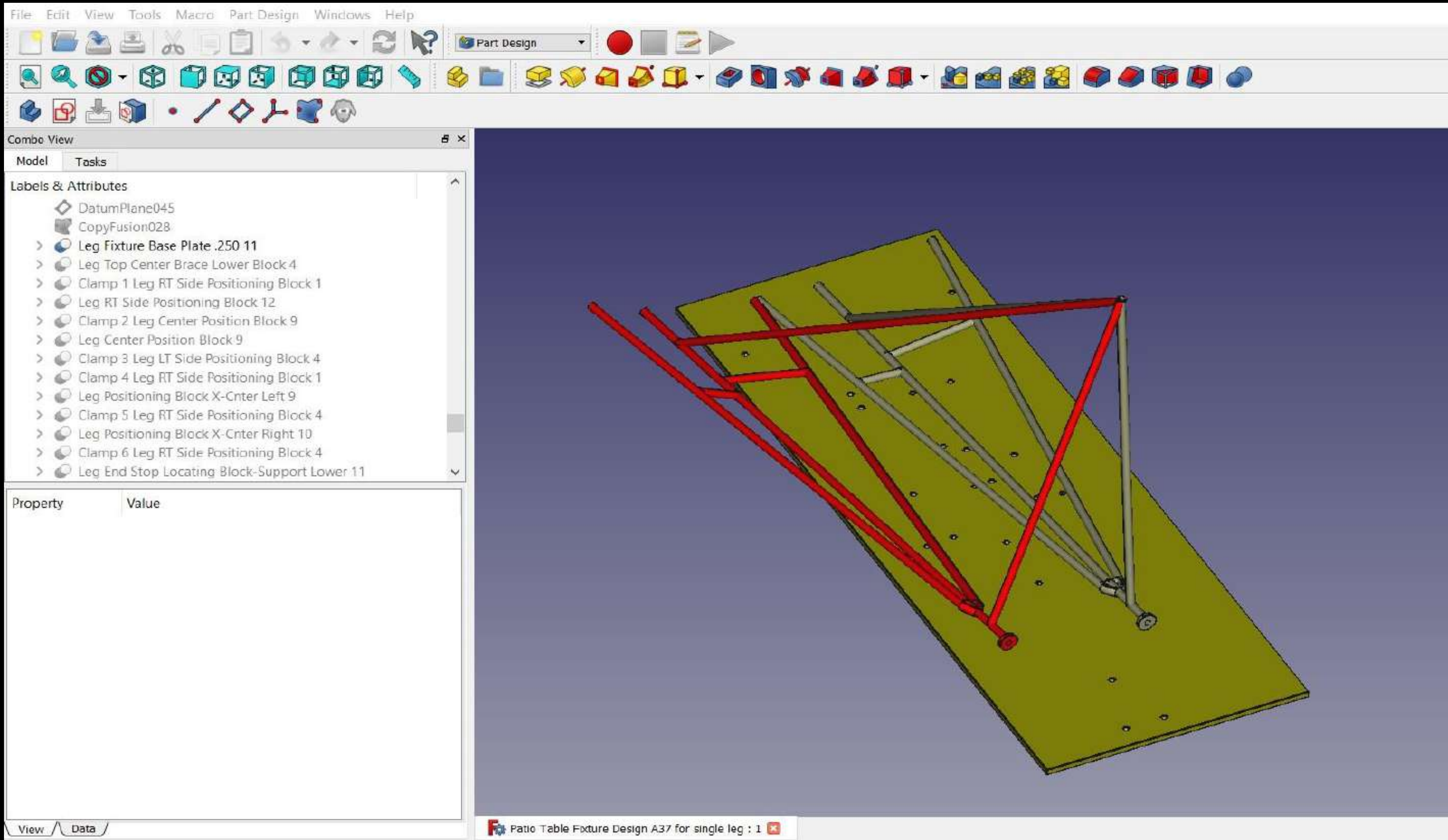


Table Top Fixture Assembly Drawing.



The Third Component Is The Leg: The leg component not only requires using "Design in Context" (using the existing solid model to assist in the development of tools and fixtures), it requires that I orient this solid model into a suitable build position. While the leg tooling could be designed to be welded in a vertical position as shown, I believe it would be more difficult. I designed the fixture and tooling to build the leg, in a plane parallel with the table top. This required making a copy of the leg and taking it out of its initially designed position.



The leg in the new build position will be constructed in a plane parallel with the table top. In the solid model design, the position of the leg (shown in red), is at an angular orientation off of the table top centerline location at 0 degrees. I need to rotate the leg component so that the center rod segment is in the new position (shown in gold), on the table centerline at 0 degrees. In this position, the design complexity necessary to create fixtures for the leg is greatly reduced. Creating the leg in this "build" position will have no impact on the original design. Each leg will be assembled in its original design position.

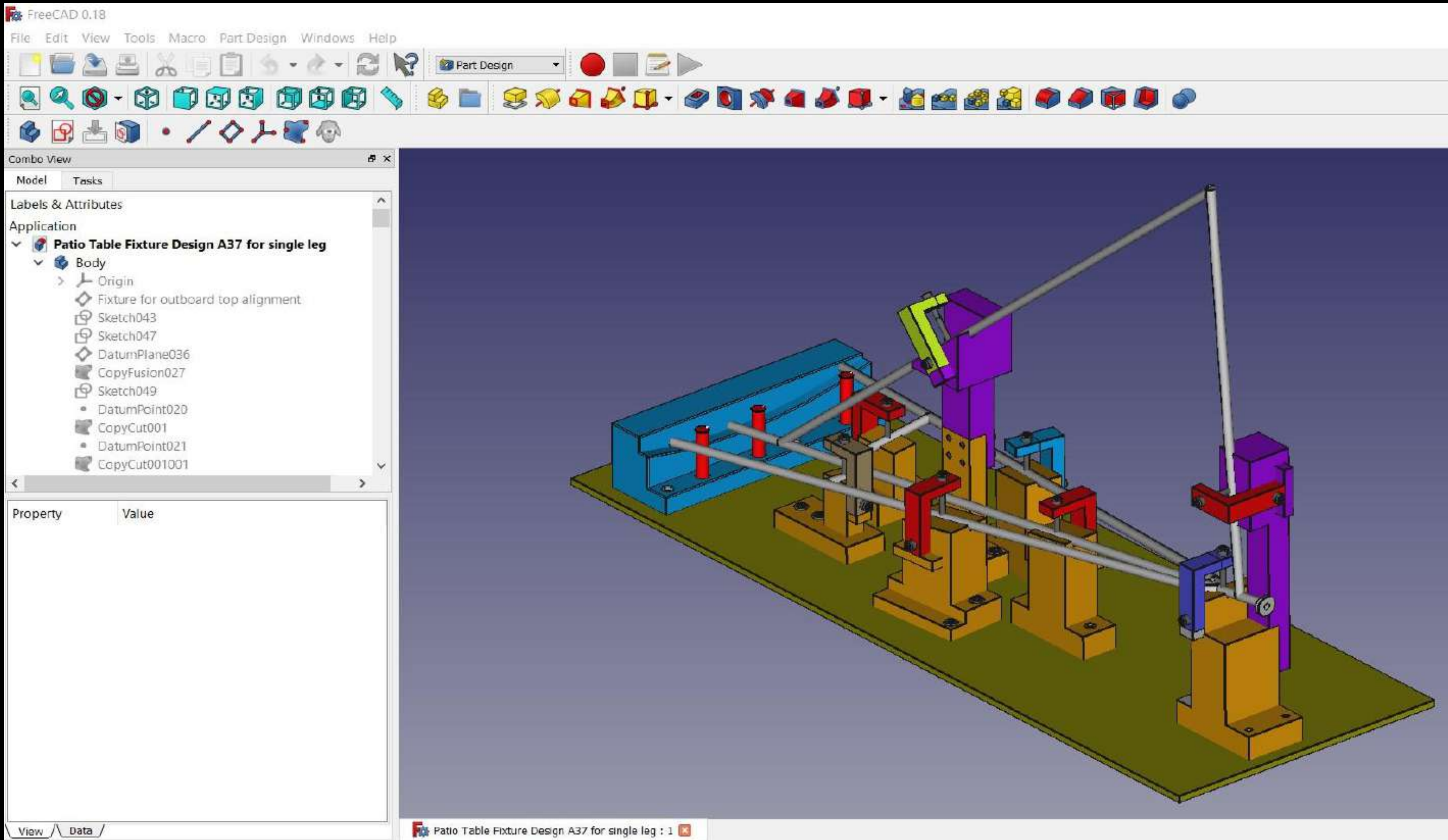
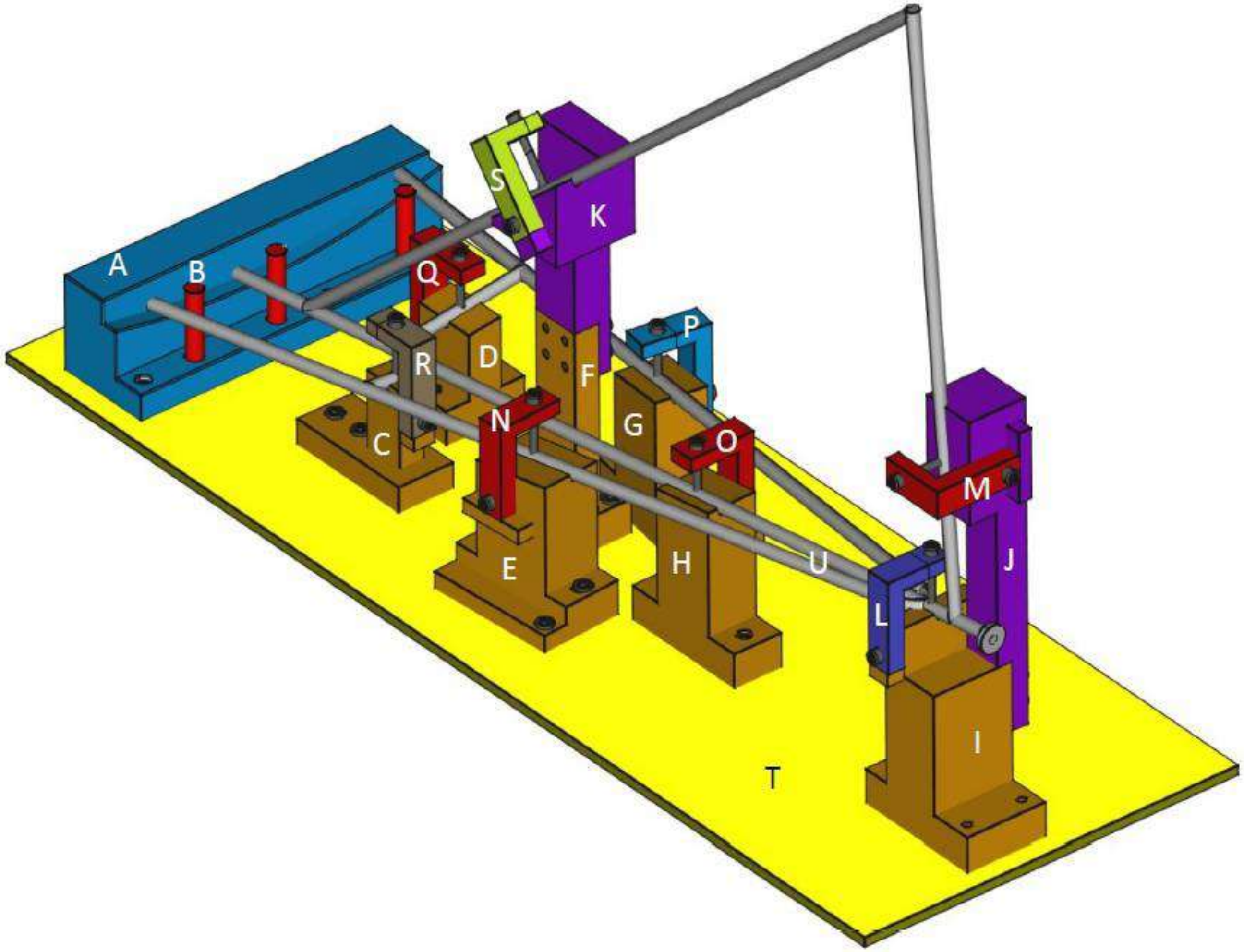
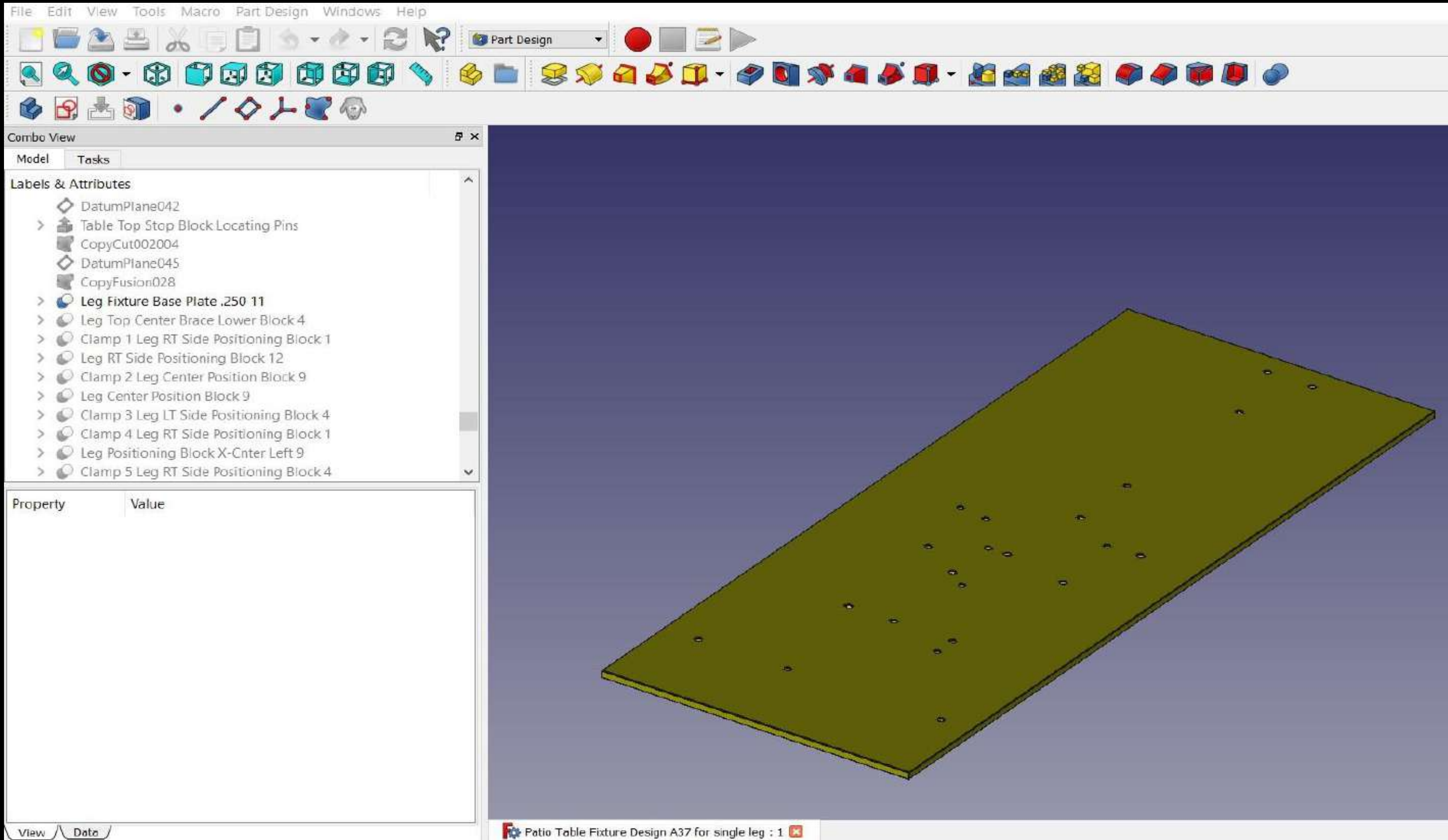


Table Leg Fixture: The leg is made up of 7 pieces of steel rod. From its appearance, it looks like a rather simple component to create. However, that is not the case, I experienced a number of challenges in creating this fixture. The top of the legs sweep the centerline of the table top ring and the legs are on a 7 degree angle inboard of the table top ring diameter. The leg center segment is in the same plane as the two center cross members, and each rod segment is at a different height and angle that needs to be held in the correct position.

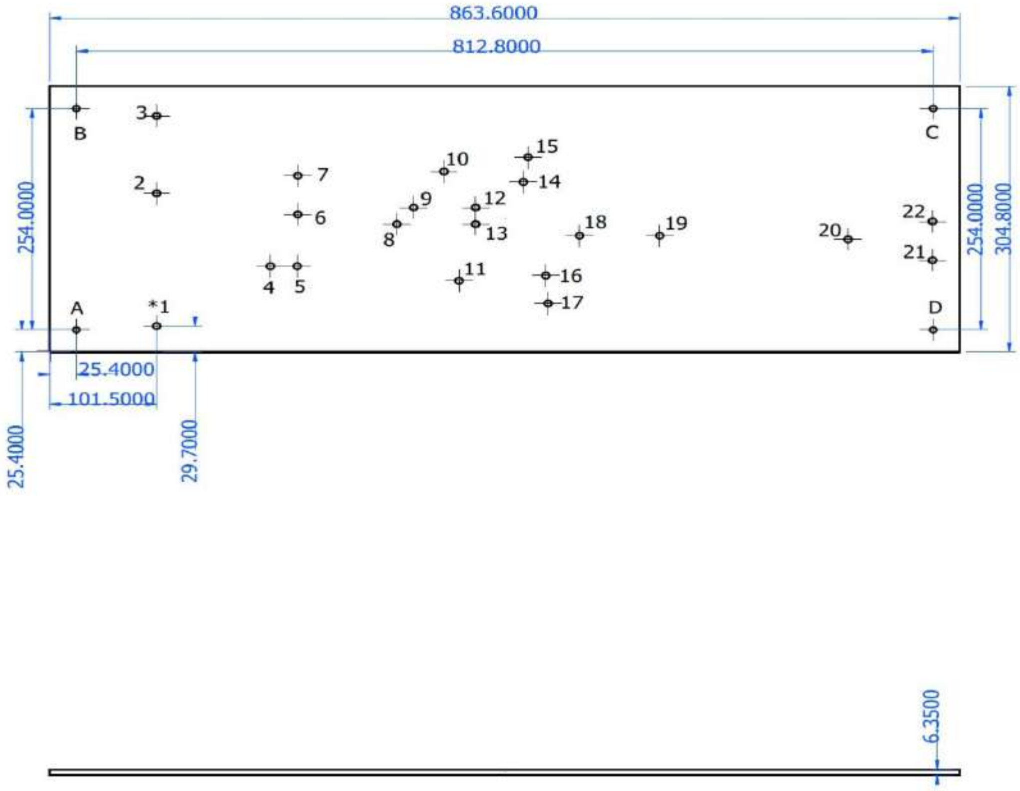
A. Table Top Diameter End Stop Block
B. Table Top Diameter Stop Block Pins
C. X-Brace Positioning Block-Right
D. X-Brace Positioning Block-Left
E. Right Leg Positioning Block
F. Center Bracket Assembly, Lower, Upper Leg Support
G. Left Leg Positioning Block
H. Center Positioning Block
I. Leg End Stop Block-Lower Assembly Block, Leg Lower Support
J. Lower Leg Center Support Positioning Block, Assembly-Upper
K. Upper Leg Center Support Positioning Block, Assembly-Upper
L. #6-Clamp-Leg End Stop Block
M. #1-Clamp-Upper Bracket-Lower Center Leg Support
N. #2-Clamp-Right Leg Positioning Block
O. #3-Clamp-Leg Center Positioning Block
P. #8-Clamp-Left Leg Positioning Block
Q. #4-Clamp-X Brace Positioning Block-Left
R. #5-Clamp-X Brace Positioning Block-Right
S. #7-Clamp-Upper Bracket-Upper Leg Center Support
T. Base Plate
U. Table Leg 3/8 Steel Rod



A parts list for the leg fixture is shown above. The leg design itself looks fairly simple, however, the feature content in the design and the fixtures required to maintain the design intent, is not so simple. I had to design 17 unique fixture components to maintain the leg in design position. In comparison, the table top required only 5. The fixture design allows all of the individual leg components to be welded together in a single pass. Each individual fixture block maintains the leg rod segment at the correct angle, height and on the correct radial sweep and spacing between segments.



Leg Fixture Base Plate: I used the same design method to create the leg base plate that I did for the table top. The leg fixture base plate is not large, 12 inches wide by 34 inches long. The base plate is made out of 1/4 inch thick, A36 steel plate. All of the fixture components to construct the leg are bolted to this plate. The plate has 4 holes dedicated to leveling feet to allow the plate to be in plane. The relatively small size of the plate is in relation to the actual physical part dimensions as designed. As with the table top fixture, one leg is welded on this fixture at a time and the raw components needed to make the next, are reloaded.



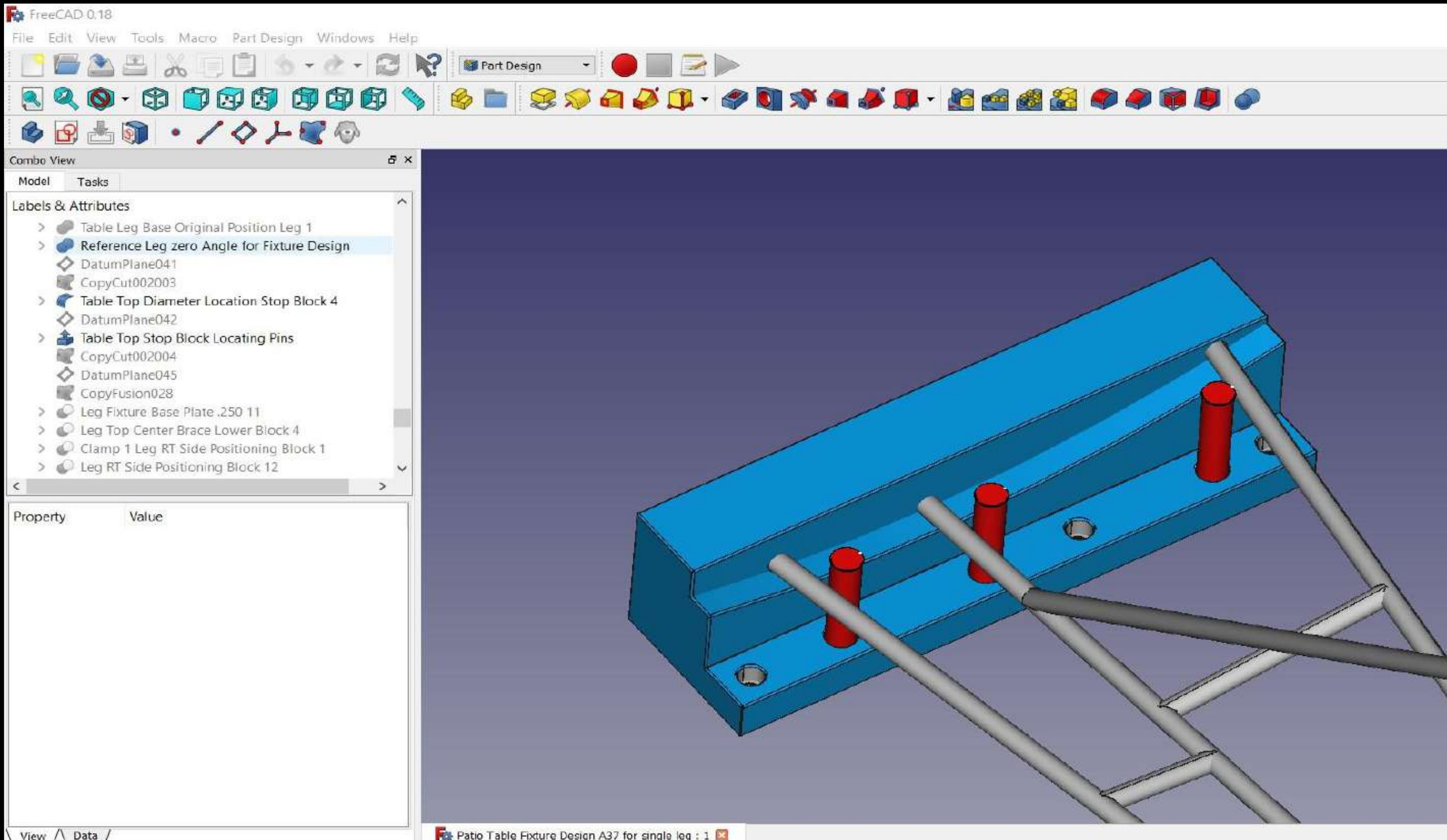
Fixture Base & Leg Assembly Hole Locations: Units in mm					
Lift Shoe Hole Locations Tapped 1/4-28					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
A	25.4000	25.4000	B	25.4000	254.0000
C	254.0000	812.8000	D	812.8000	25.4000
Positioning Block Fixture Hole Locations From Reference Hole Position 1, Tapped 1/4-28					
Hole Number	Location X	Location Y	Hole Number	Location X	Location Y
1*	101.5000	29.7000	2	101.5000	152.4000
3	101.5000	88.9000	4	107.9052	68.8693
5	133.3052	68.8693	6	133.9005	128.1215
7	133.9005	172.5715	8	228.0250	117.1250
9	243.9000	136.1750	10	272.6826	177.4549
11	286.8985	52.2797	12	302.6375	136.1750
13	302.1750	117.1250	14	347.9377	165.4473
15	369.2474	193.7805	16	369.2474	58.0381
17	371.5000	26.0901	18	401.2095	103.7191
19	477.4095	103.7191	20	656.1161	99.6344
21	736.1161	75.7524	22	736.1161	120.2024

Drill and Tap for 1/4-28 Cap Screw, All Holes, Thru

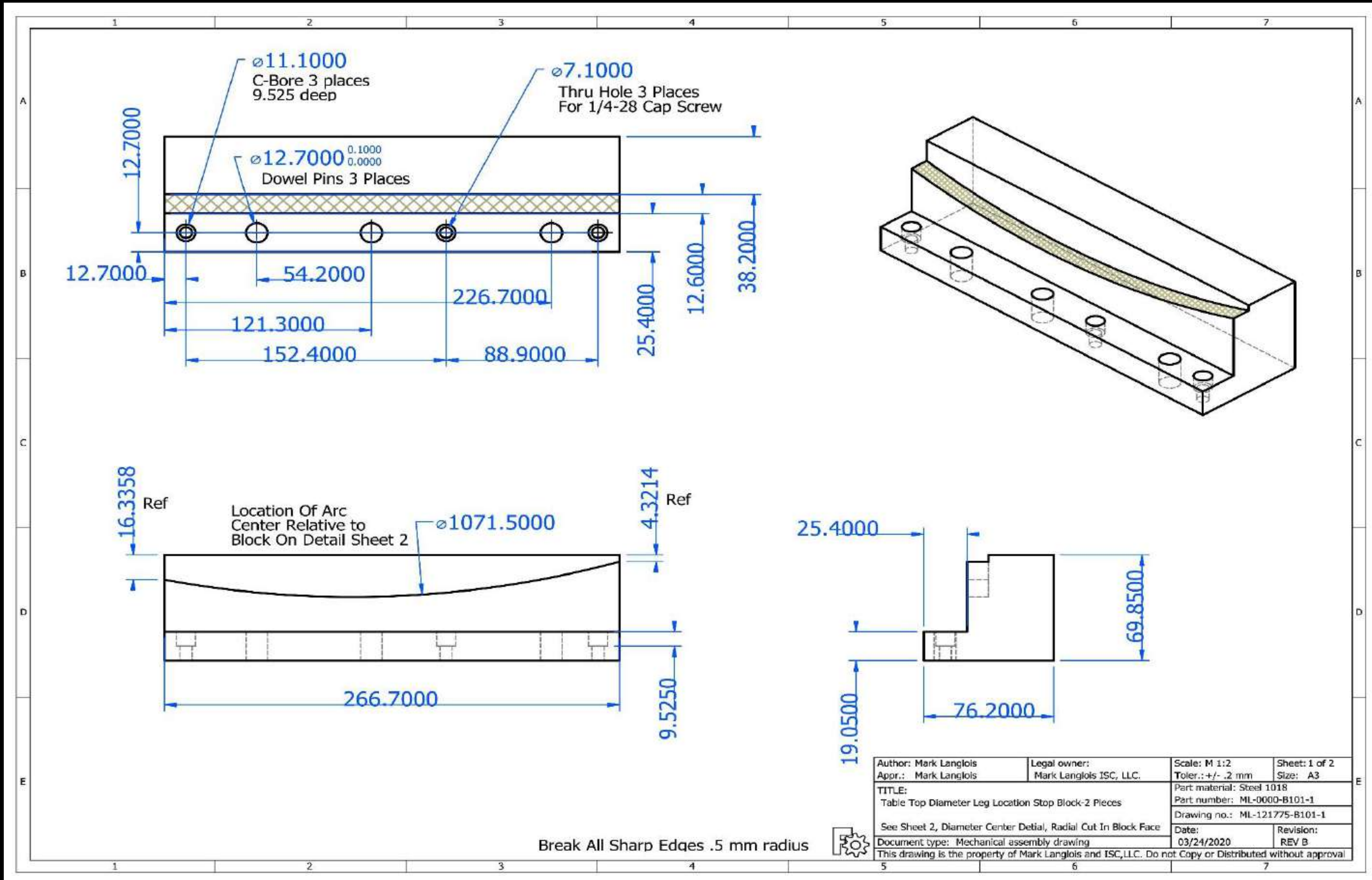
Break All Sharp Edges .5 mm

Author: Mark Langlois Appr.: Mark Langlois	Legal owner: Mark Langlois ISC, LLC.	Scale: M 1:3 Toler.: +/- .1 mm	Sheet: 2 of 2 Size: A2
TITLE: Steel Plate Fixture Base, Leg Assembly 26 Holes, Drilled And Tapped, 1/4-28 Thru See Hole Location Chart and Reference Notes On Drawing		Part material: 1/4 A36 Steel Plate Part number: ML-0000-B100 Drawing no.: ML-121775-B100-2	
Document type: Mechanical assembly drawing		Date: 03/24/2020	Revision: REV B

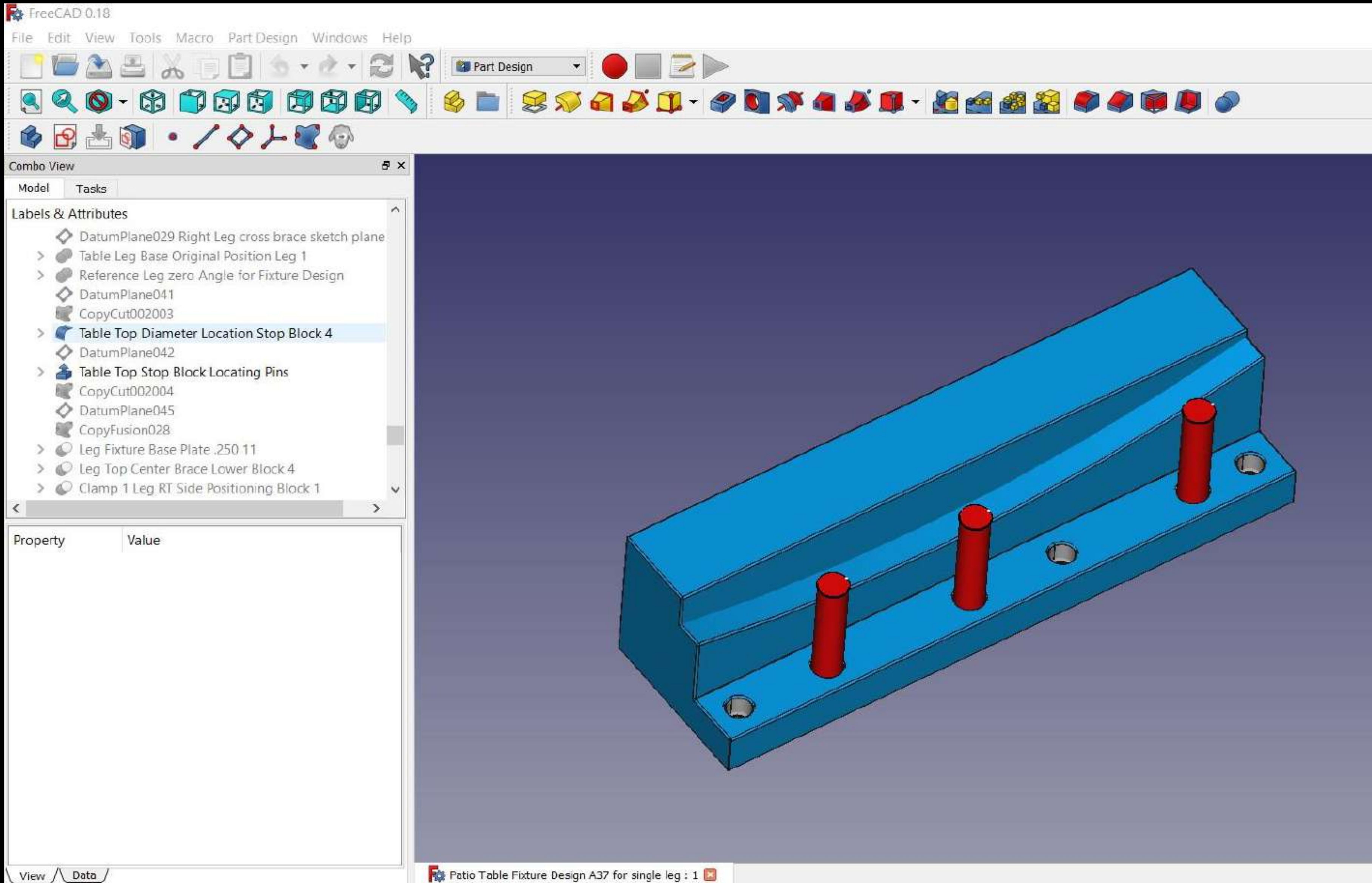
Base Plate Drawing: The base plate has 22 holes that were laser cut for a 1/4-28 tap drill to accommodate the fixture blocks. I put four holes in the corners of the base plate for leveling feet so I can level out the fixture plate. All of the holes in the plate were tapped for a 1/4-28 thread. The reason I choose to use a 1/4-28 fine thread was to provide some additional thread engagement to hold and tighten the fixture blocks. I believe the 1/4 in plate will work well in this case, but is still not all that thick.



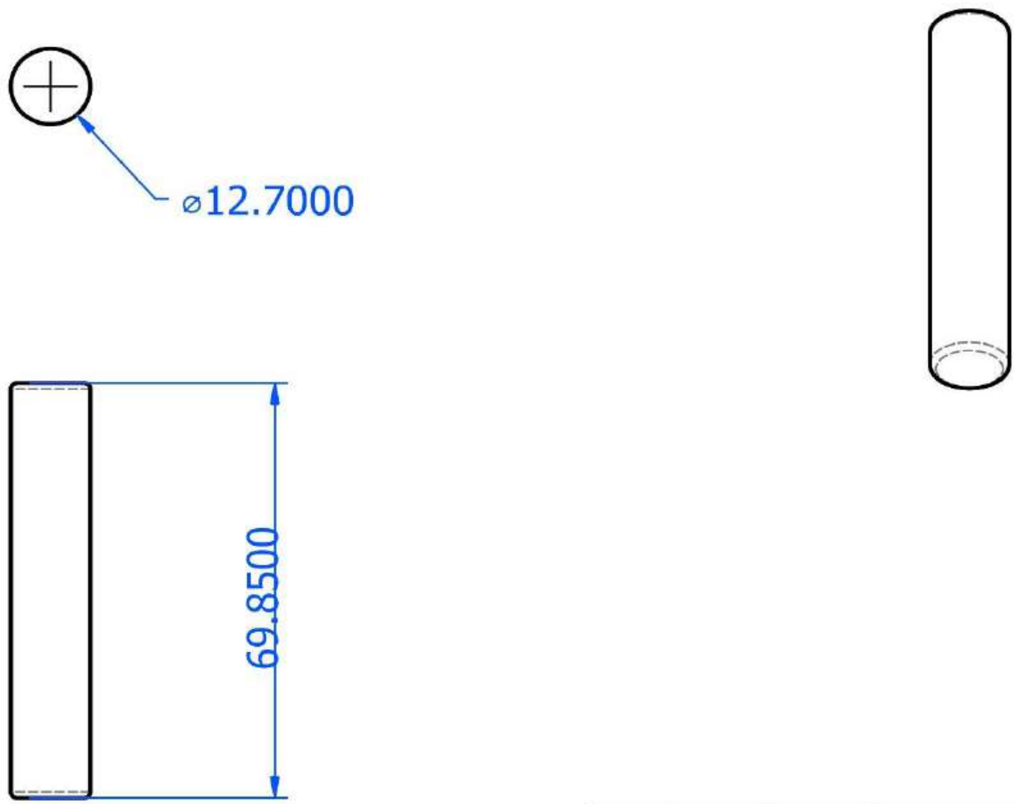
Top Diameter End Stop Block: I designed this fixture component to keep all three steel rod leg segments radially located on the centerline of the table top ring. The leg rod segments must follow the radial sweep of the table top because these three rod segments get welded to the top during assembly. The radial sweep of the table top has been machined into this stop block to position each leg on the table top centerline. The dowel pins shown in red, locate the leg rod segments at the correct angle and distance apart on this radial sweep.



Top Diameter End Stop Block Drawing: This fixture component is critical because it not only radially positions the orientation of each leg segment to the table top centerline, it also makes each center leg rod segment the same length. The leg, as an assembly component (1 of 4), requires that I consistently replicated the correct orientation, angle, spacing and length for the three rod segments positioned in this block, in order to assemble (weld) them to the table top as designed.

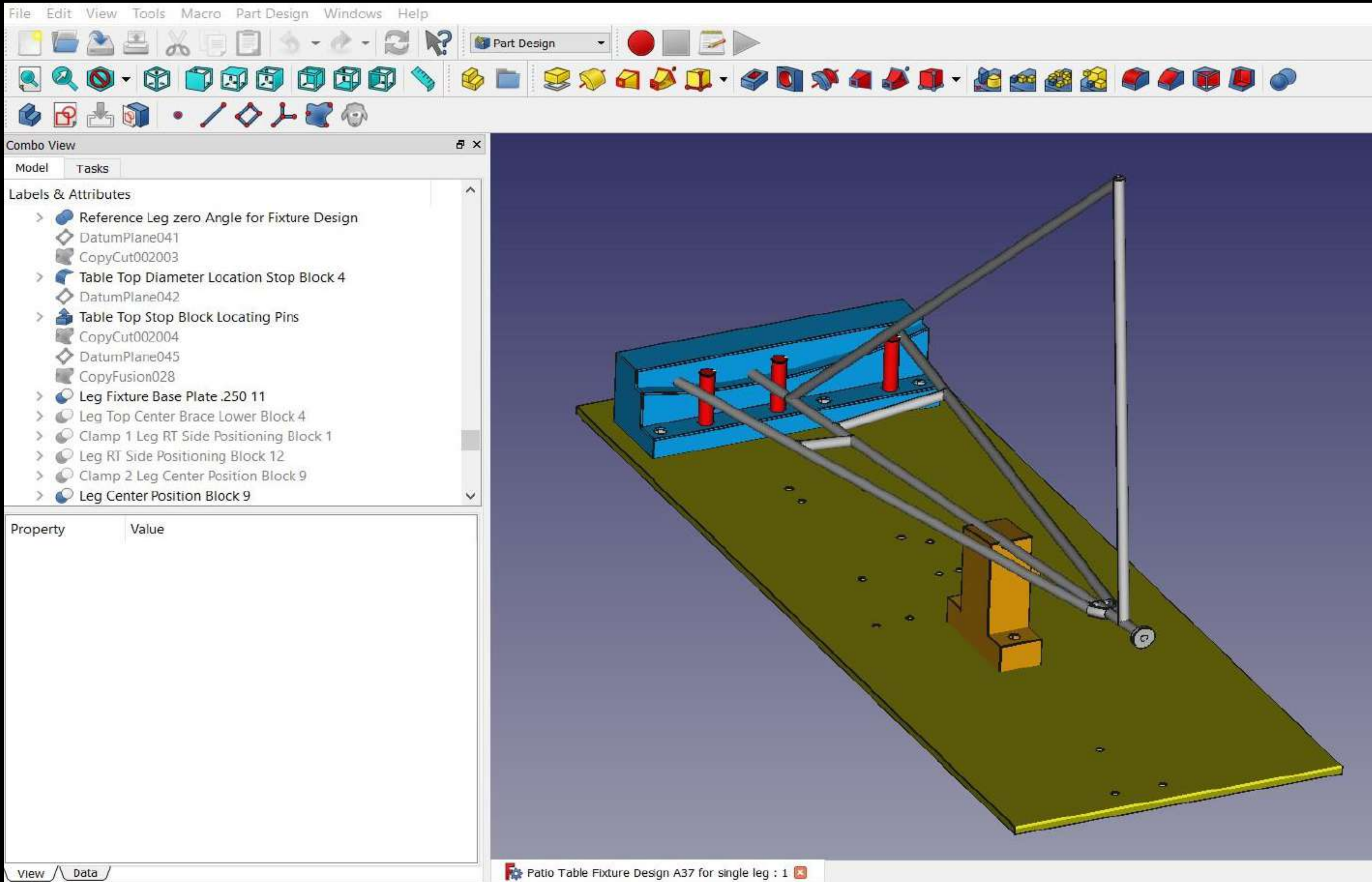


Dowel Pin Component: I used 1/2 inch diameter dowel pins that are positioned precisely in the stop block to accurately locate the three main rod segments that define each leg. Each of the rod segments, the center, right and left, sit on the outside sweep diameter of the table top that has been machined into this block and is tangent (contacts the pin outside diameter) to each of the locating pins.

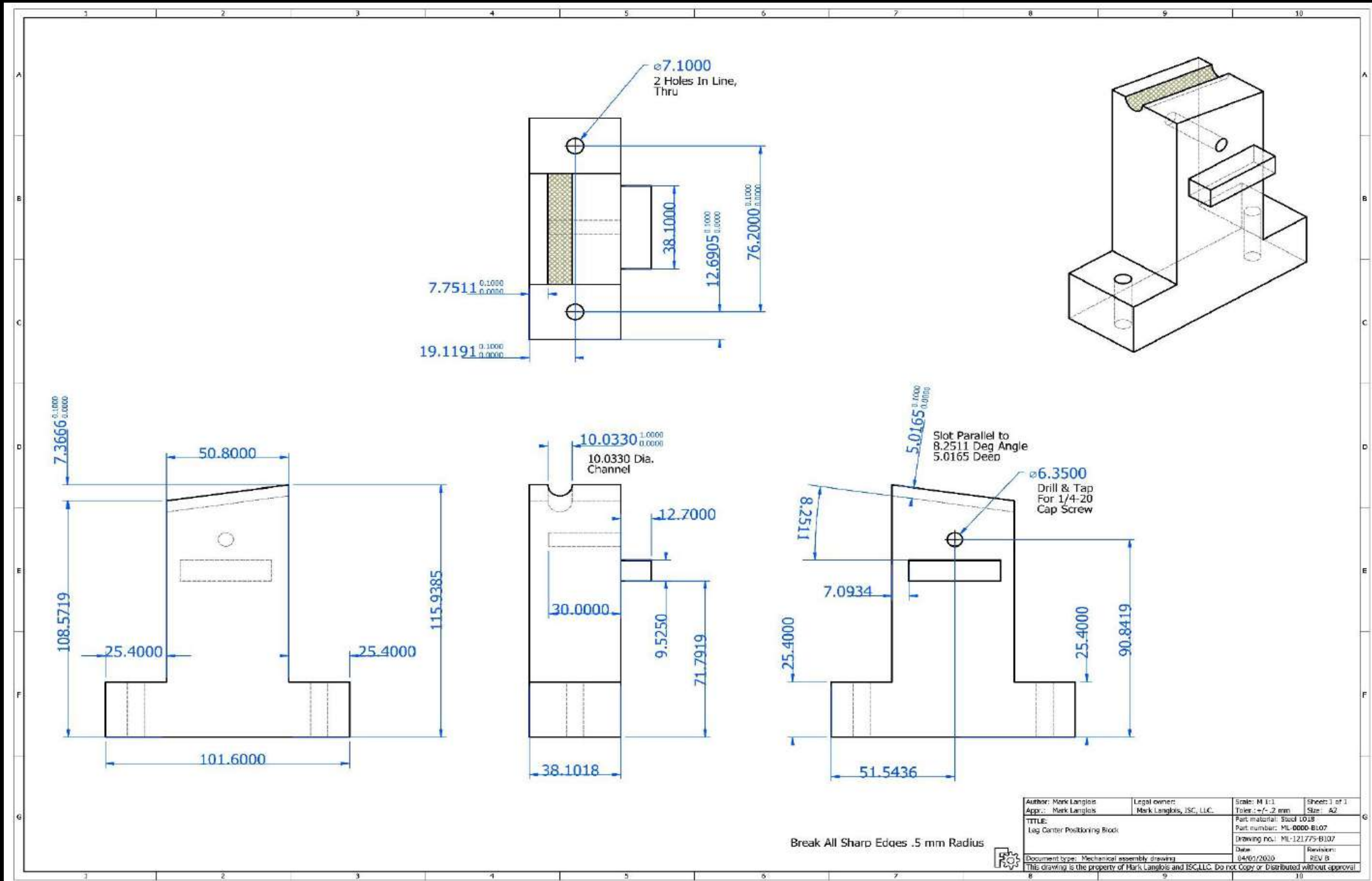


Author: Mark Langlois Appr.: Mark Langlois	Legal owner: Mark Langlois, ISC, LLC.	Scale: M 1.1 Toler.: +/- .1 mm	Sheet: 1 of 1 Size: A4
TITLE: Top Diameter Leg Locator Stop Block Dowel Pins, 3 Pieces Purchased Part		Part material: Steel Part number: ML-0000-B102	
		Drawing no.: ML-121775-B102	
		Date: 03/24/2020	Revision: REV B
Document type: Mechanical assembly drawing			
This drawing is the property of Mark Langlois and ISC,LLC. Do not Copy or Distributed without approval			

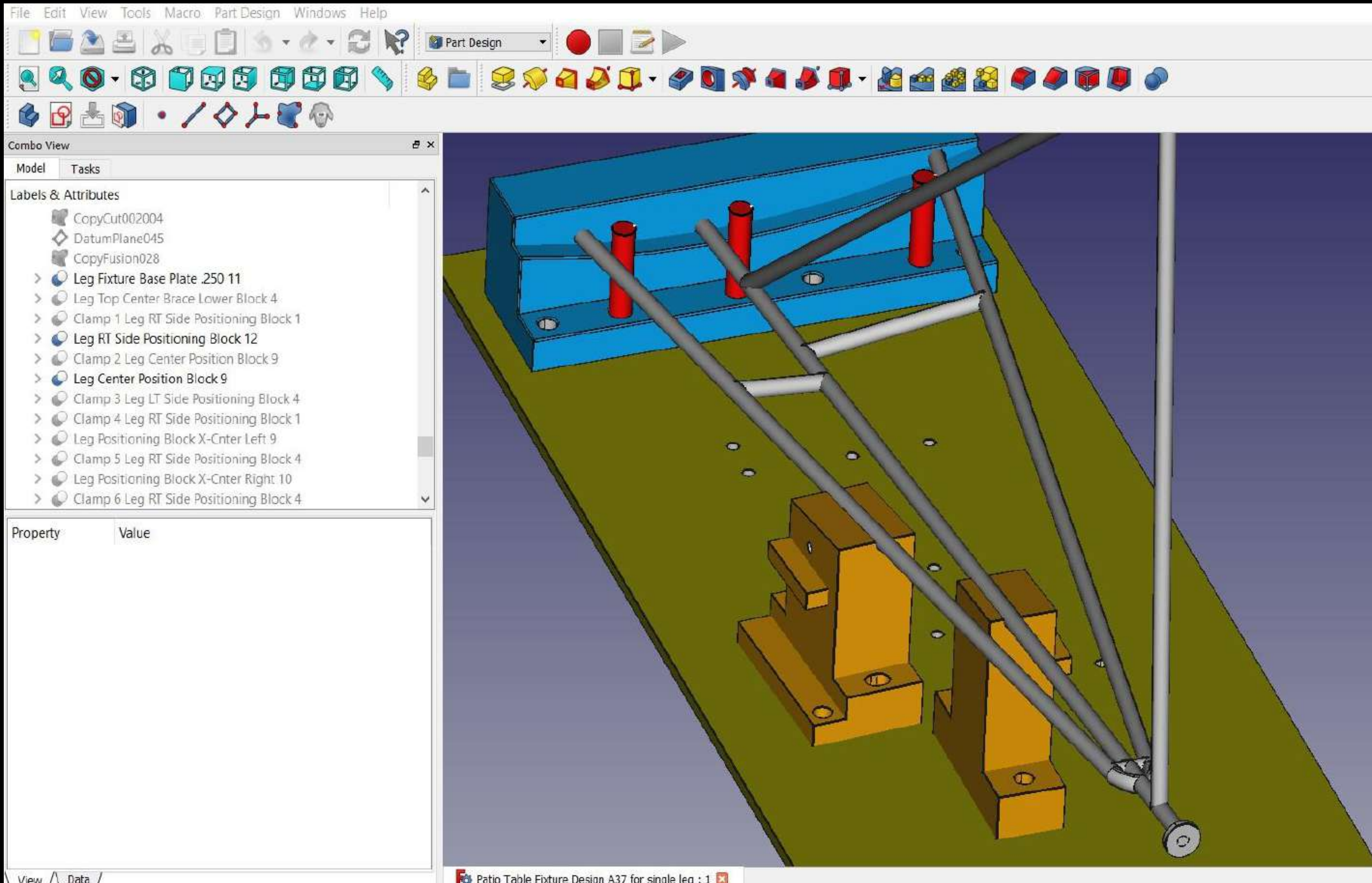
Dowel Pin Component Drawing: My stop block design tolerance calls for a precise location and hole size for the dowel pin components. The dowel pins are inserted into holes in the stop block with just enough room to fit without applying any force. The dowel pins are a purchased item that I ordered from a tool supply company. Dowel pins are a common fixture component and are easily purchased in many sizes.



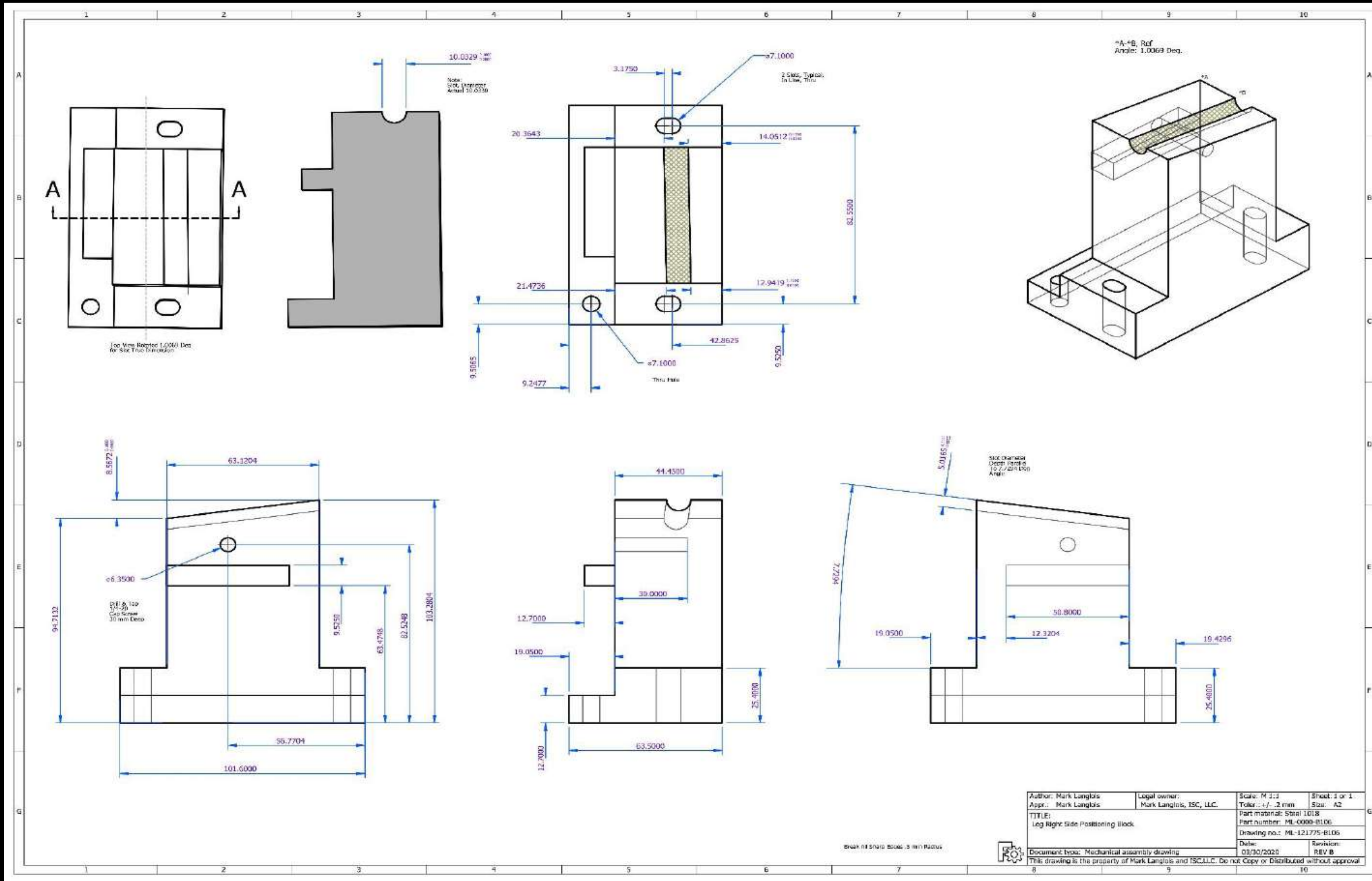
Leg Center Positioning Block: The leg center positioning block locates the steel rod center leg segment at the correct height to maintain the 7 degree inboard angle required by my design, It also sets up the initial position for all of the other rod segments in my leg fixture. The center rod segment is tangent to the center dowel pin in the stop block and is clamped into the groove in the center positioning block.



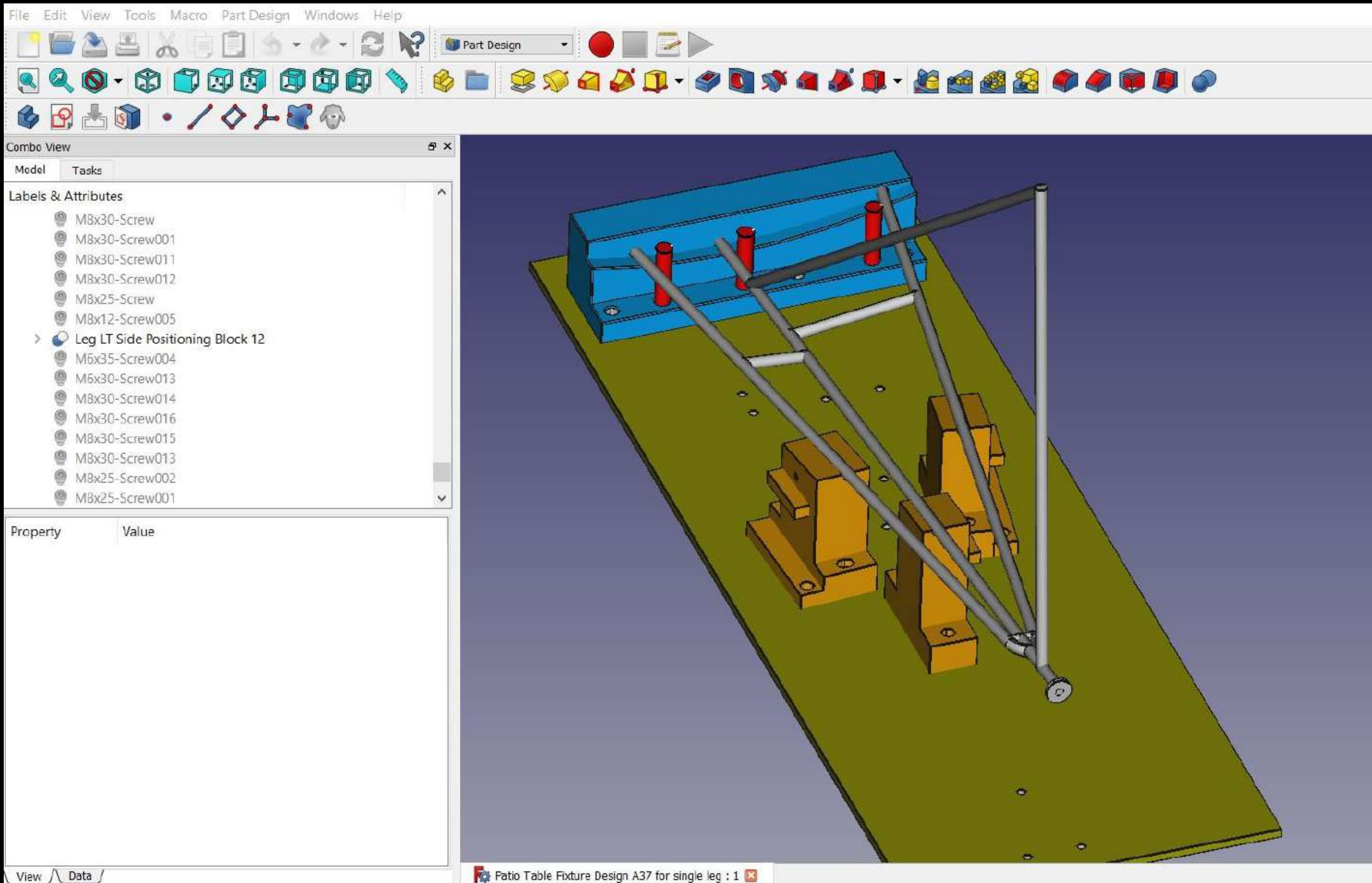
Leg Center Positioning Block Drawing: The leg center positioning block and all of the other fixture block locations are managed by the mating holes in the leg base plate. The location and orientation of each of the blocks is important because it defines the height and angle of the groove in the block. The height and angle must be precise so that each rod segment is closely aligned to its mating rod segment center line.



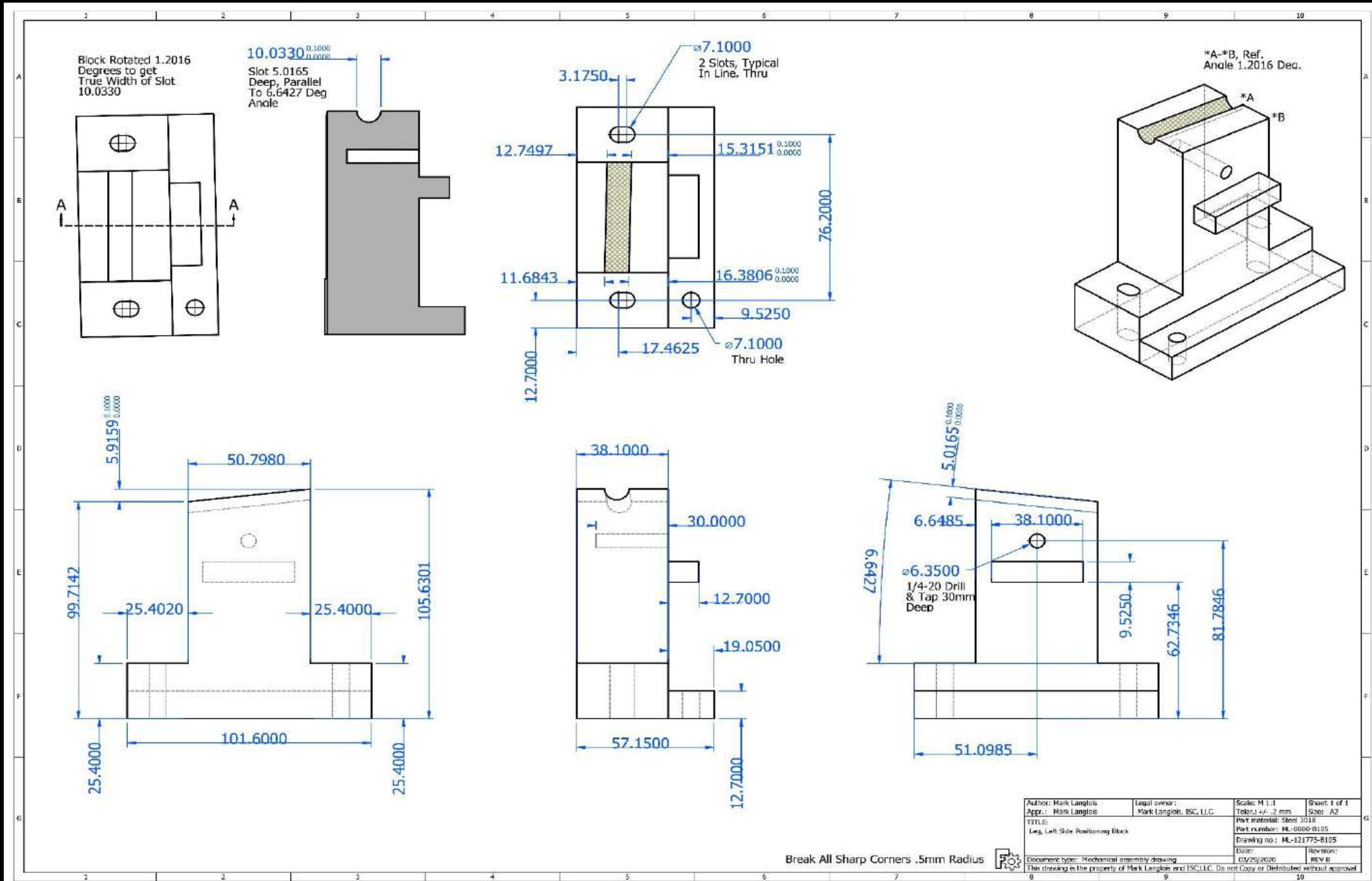
Leg Right Side Positioning Block: The right side positioning block locates the rod segment tangent to the dowel pin on the table top diameter on the right and locates the height and angle of the rod segment so that the rod follows the 7 degree inboard angle to meet with the center rod segment. I designed the block to allow minor adjustments perpendicular to the right side leg angle defined by the base plate hole locations. (Note: Right and Left is viewed from behind the blue stop block looking toward the leveling foot.)



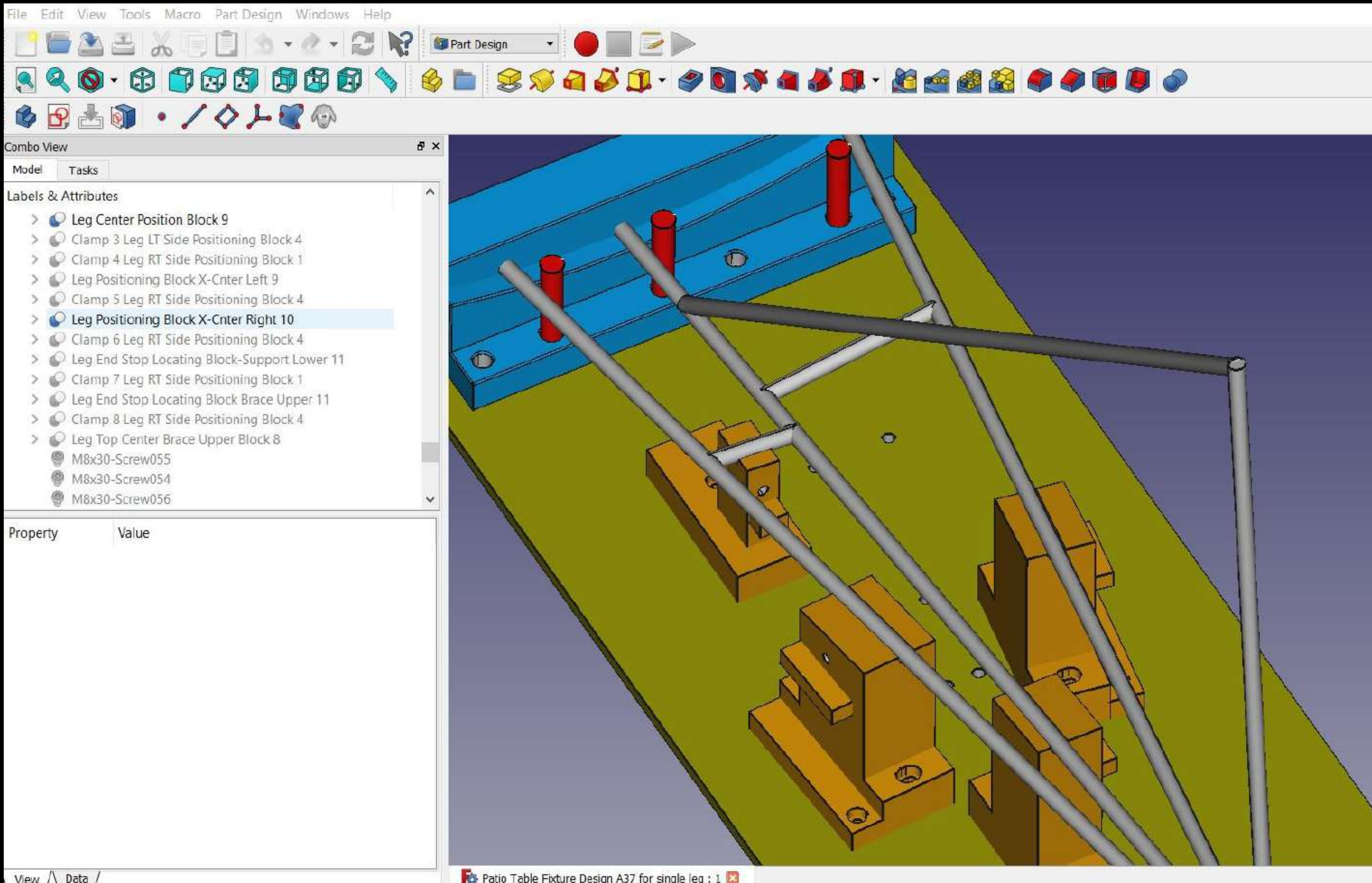
Leg Right Side Positioning Block Drawing: The right side positioning block locates the leg rod segment, tangent to the dowel pin, on the right side of the leg and at the correct angle and height to meet with the center leg, on its center line. In each of these block drawings I made, the heights, location of the groove and the groove angle are different due to its location on the base plate and the rod segment angle.



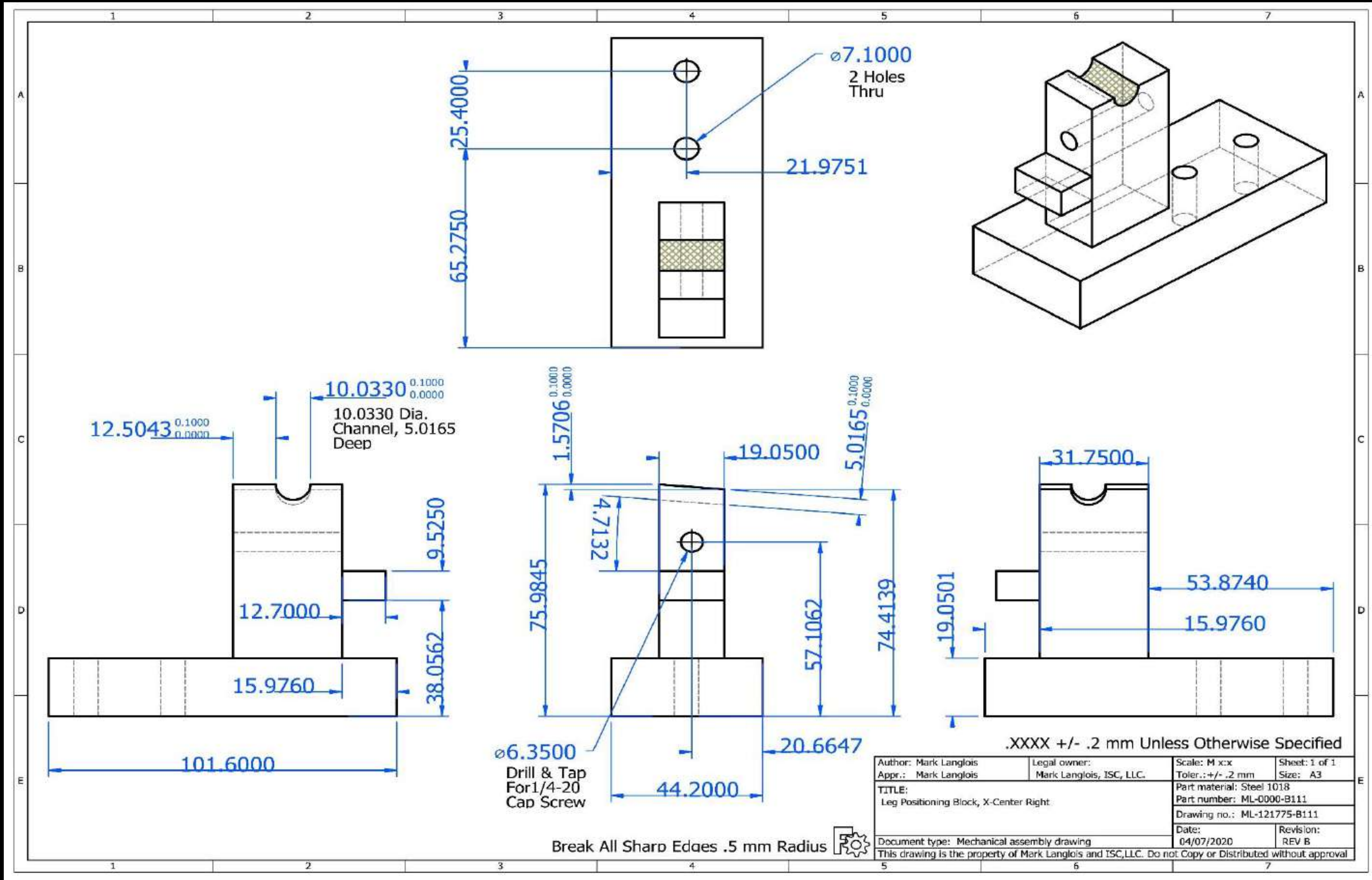
Leg Left Side Positioning Block: The left side positioning block locates the rod segment tangent to the dowel pin on the table top diameter on the left and locates the height and angle of the rod segment so that the rod follows the 7 degree inboard angle to meet with the center rod segment on its centerline.



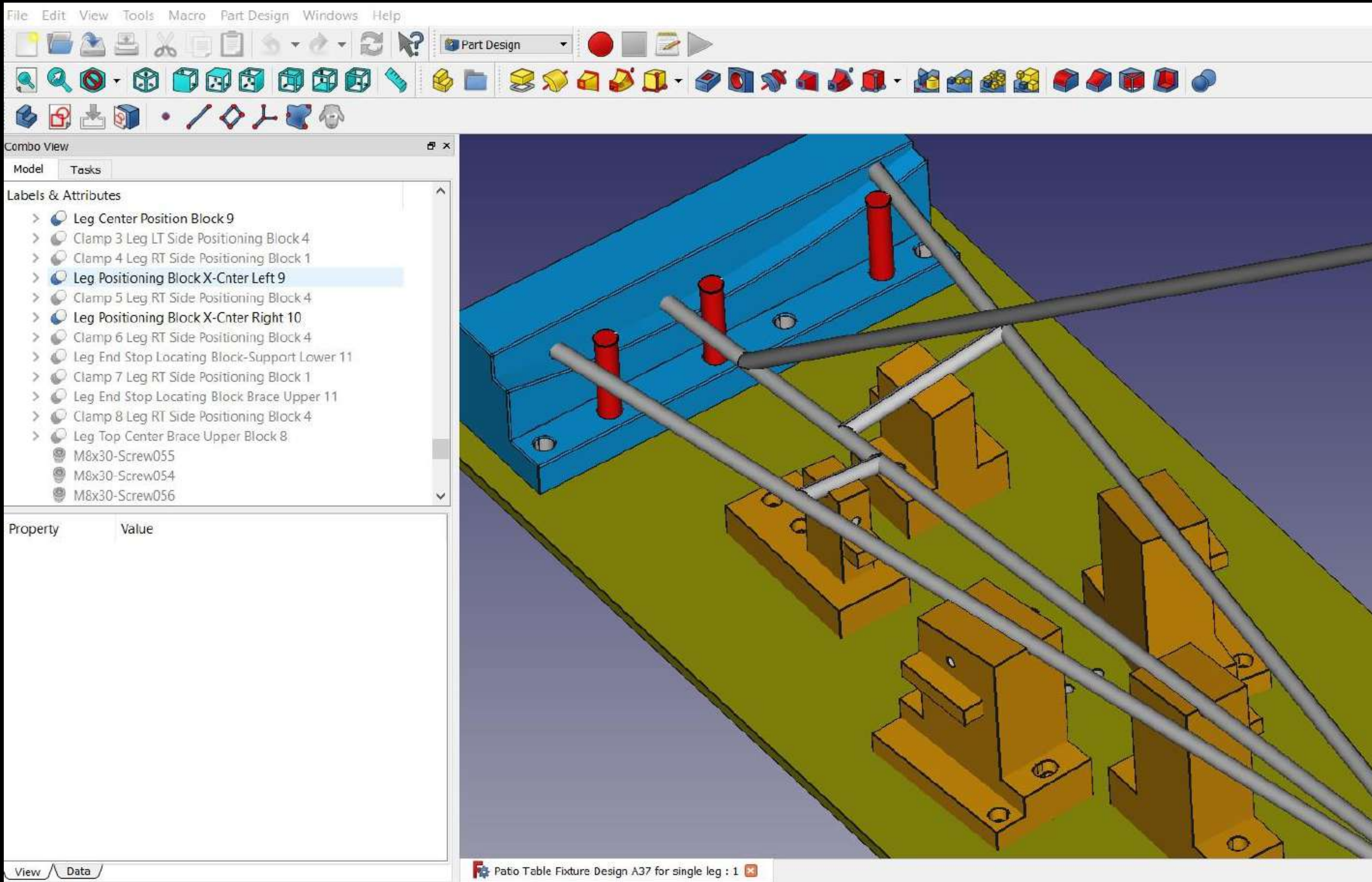
Leg Left Side Positioning Block Drawing: The left side positioning block locates the leg rod segment, tangent to the dowel pin, on the left side of the leg and at the correct angle and height to meet with the center leg, on the center line. Like the right side positioning block, I designed it to allow minor adjustments perpendicular to the angle defined by the hole locations in the base plate.



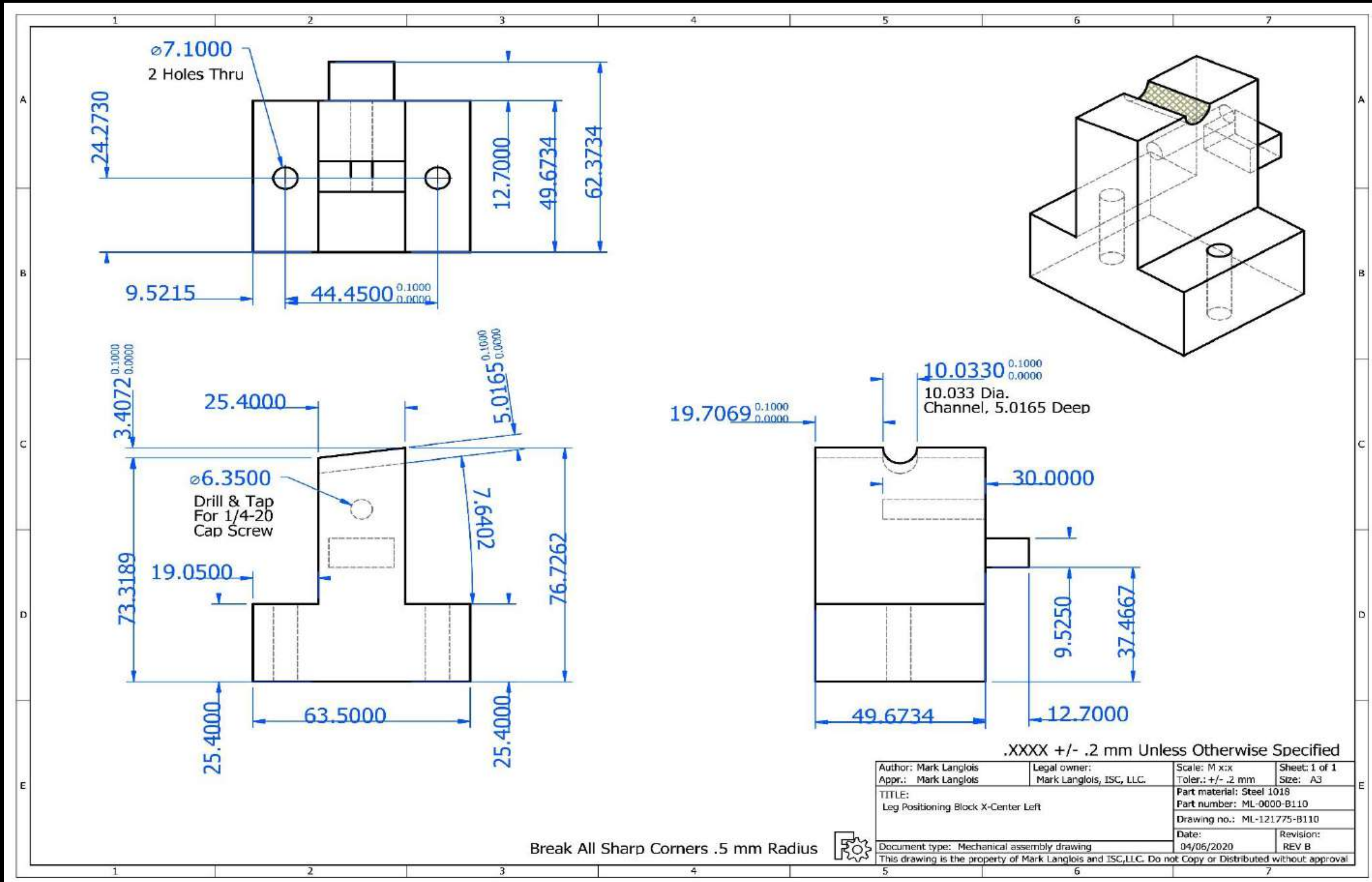
Leg Positioning Block, X-Center Right: This positioning block locates the right cross member steel rod segment of the leg. This rod segment is on a compound angle. The angle is both inboard to the table top diameter and also at an angle between the right and center rod segments. The height manages the angle inboard and the angle of the groove aligns the cross member to the centerline of the right and center rod segments.



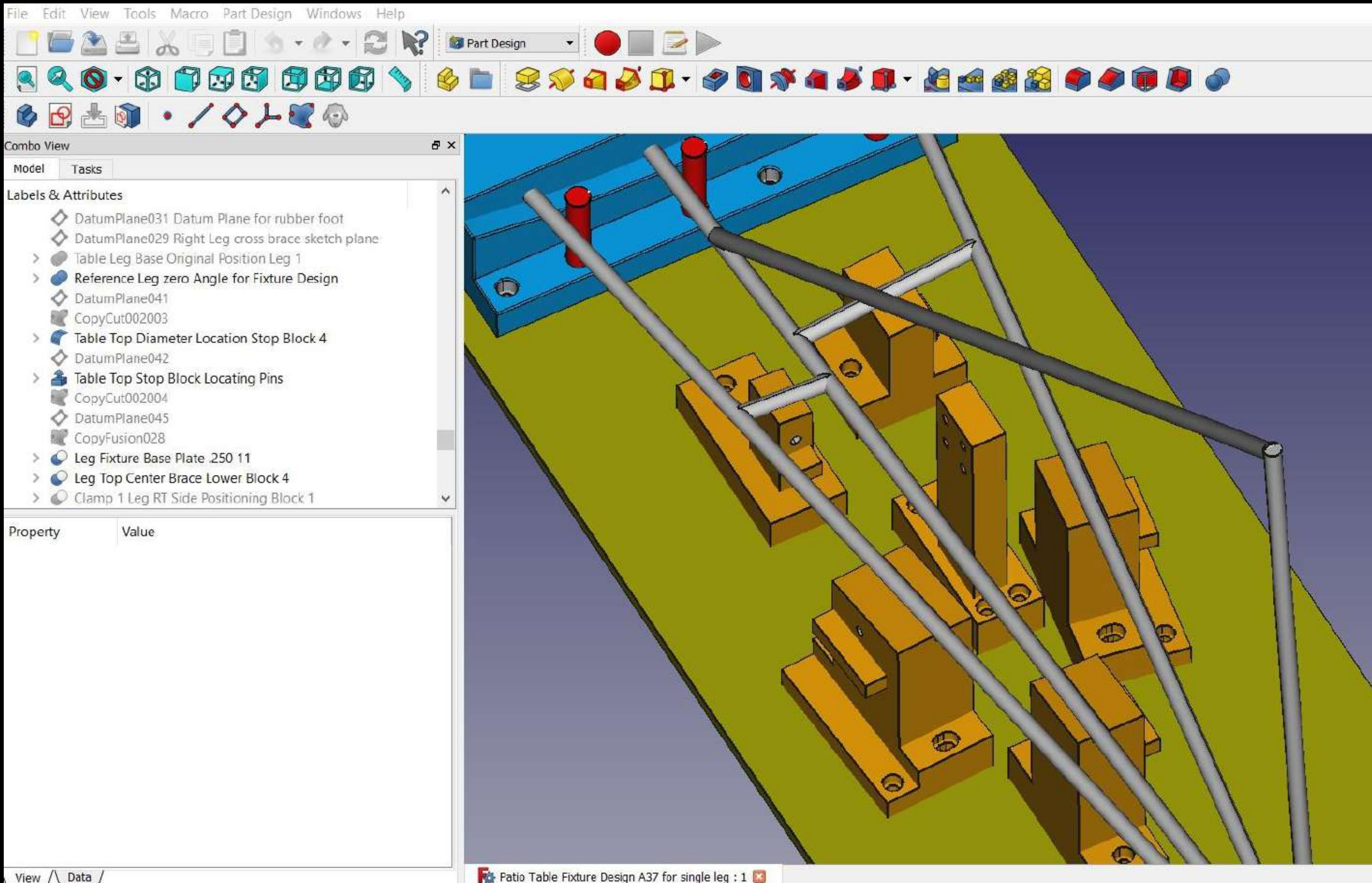
Leg Positioning Block, X-Center Right Drawing: I have to design each positioning component for more than just the functional alignments required for the design. Each block's size, shape and location on the base plate must allow me to access the locating screws, give me room to load the rod segments, clamp the rod segments in place, provide sufficient space to weld and finally, remove the finished leg.



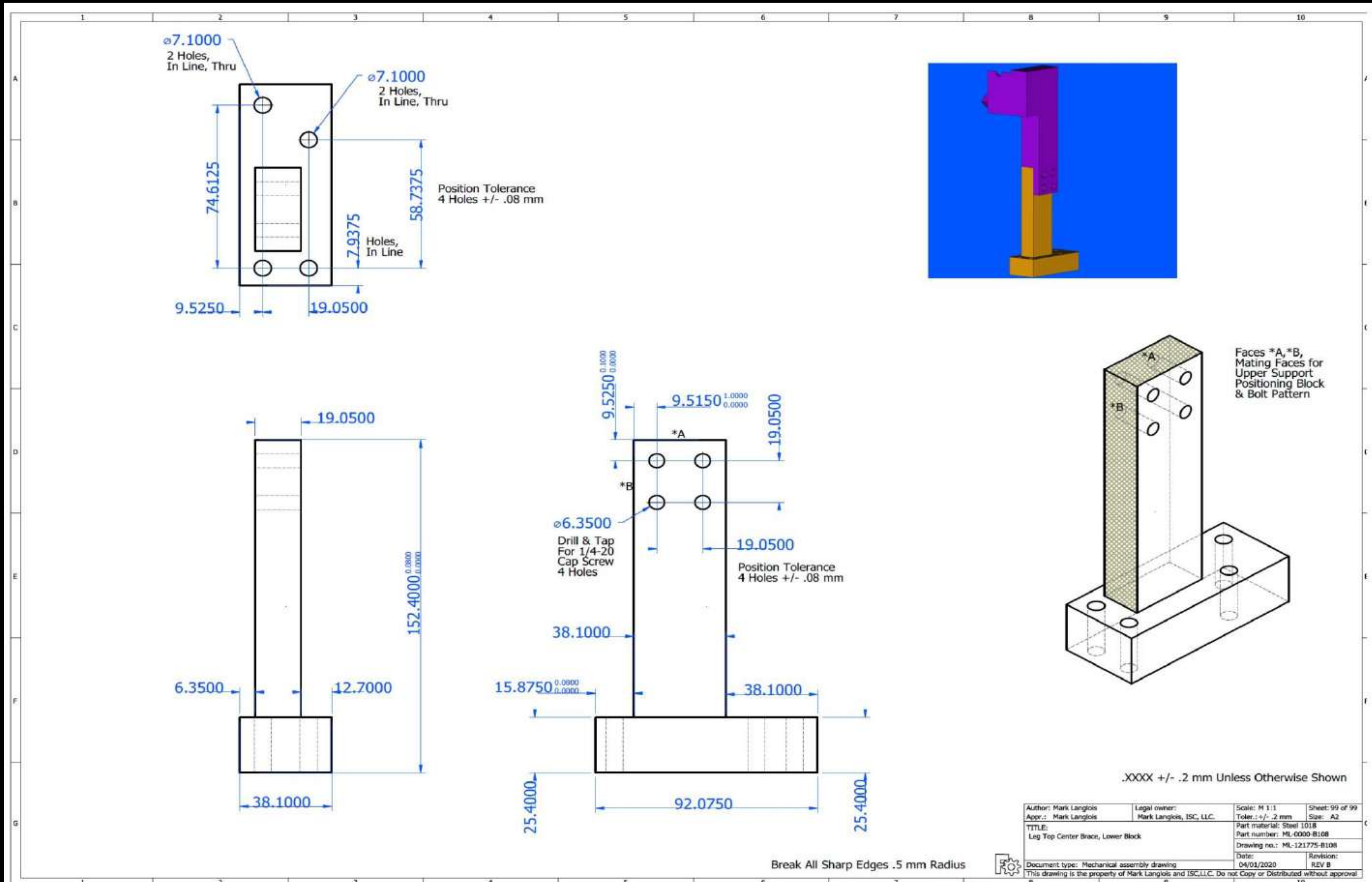
Leg Positioning Block, X-Center Left: This positioning block locates the left cross member steel rod segment of the leg. This rod segment is on a compound angle as well. The angle is both inboard to the table top diameter and also at an angle between the left and center rod segments. The height manages the angle inboard and the angle of the groove aligns the cross member to the center of the left and center rod segments.



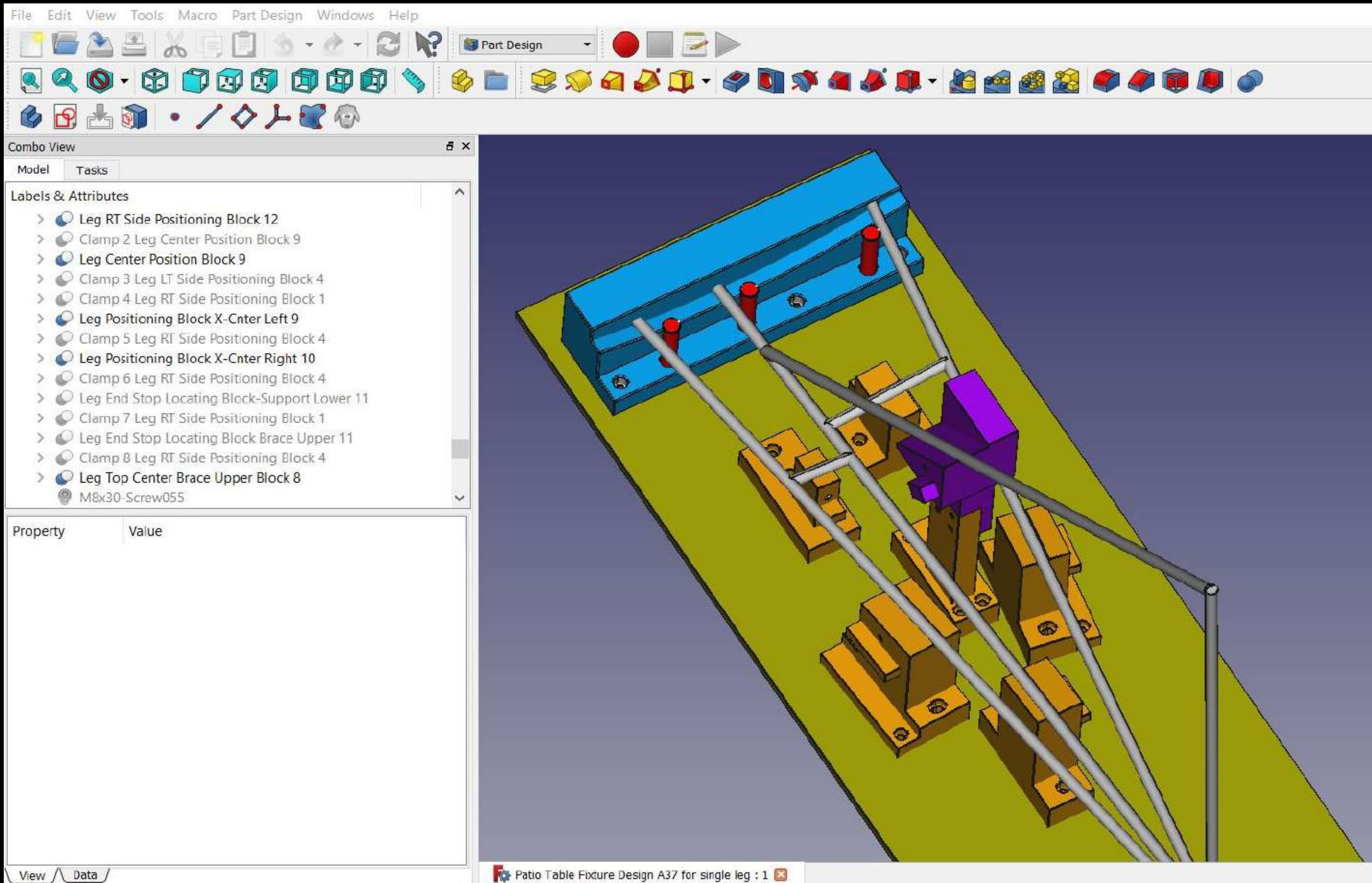
Leg Positioning Block, X-Center Left Drawing: I designed the left cross member positioning block wider then the right block. I did this to allow the block to more accurately locate the left cross member rod segment. Because it is a longer rod segment, the additional groove width helps keep the rod segment in alignment and easier to load.



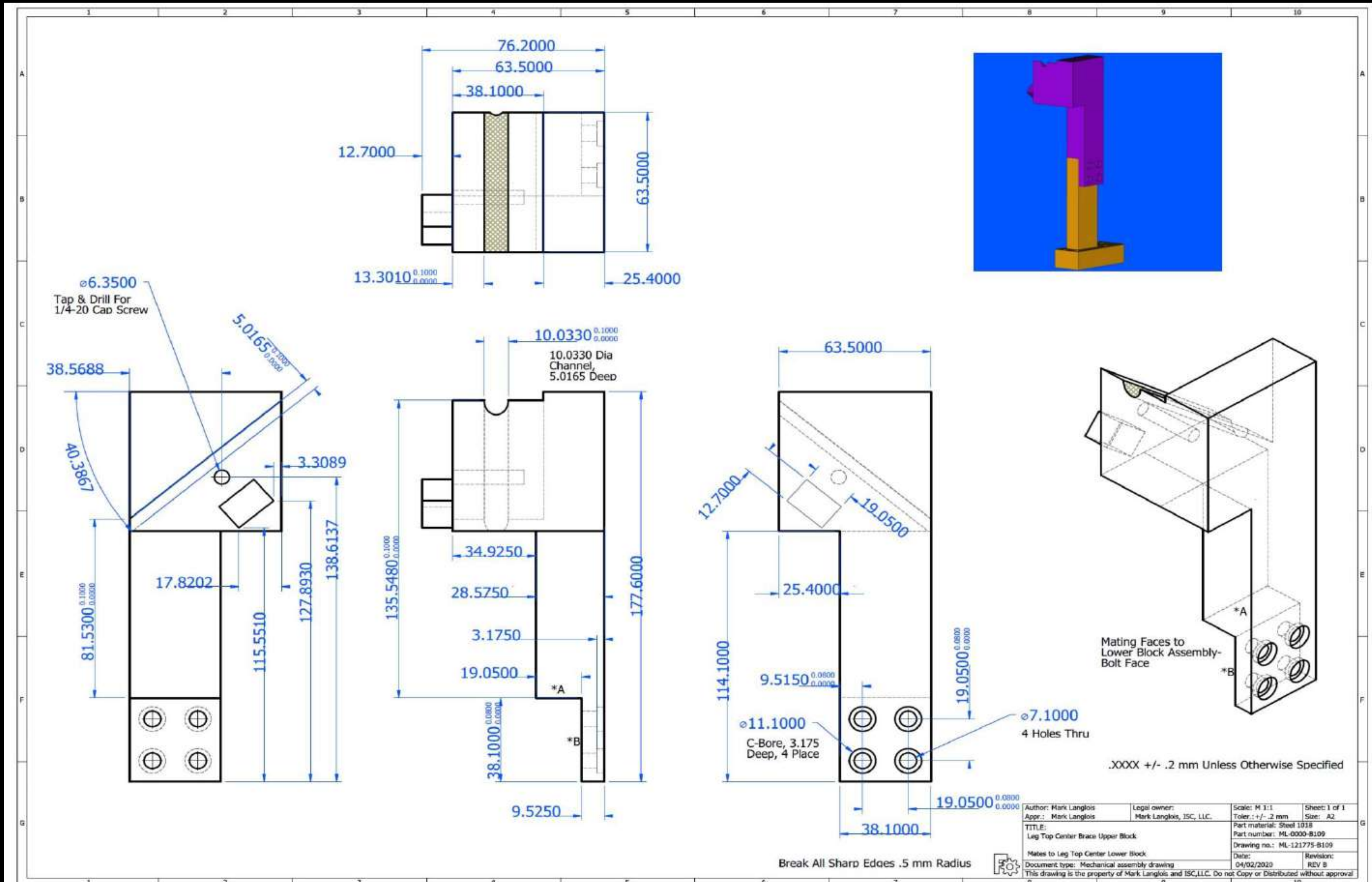
Leg Top Center Brace, Lower Block: I designed this positioning block as part of an assembly. This fixture block is elevated above the leg center rod segment. The top of this block and right side are locating faces for the upper block assembly. This block was necessary because the upper center brace rod segment is in the same plane as the center rod segment. The upper positioning block that mates to this block, must be above and extend over the center rod segment.



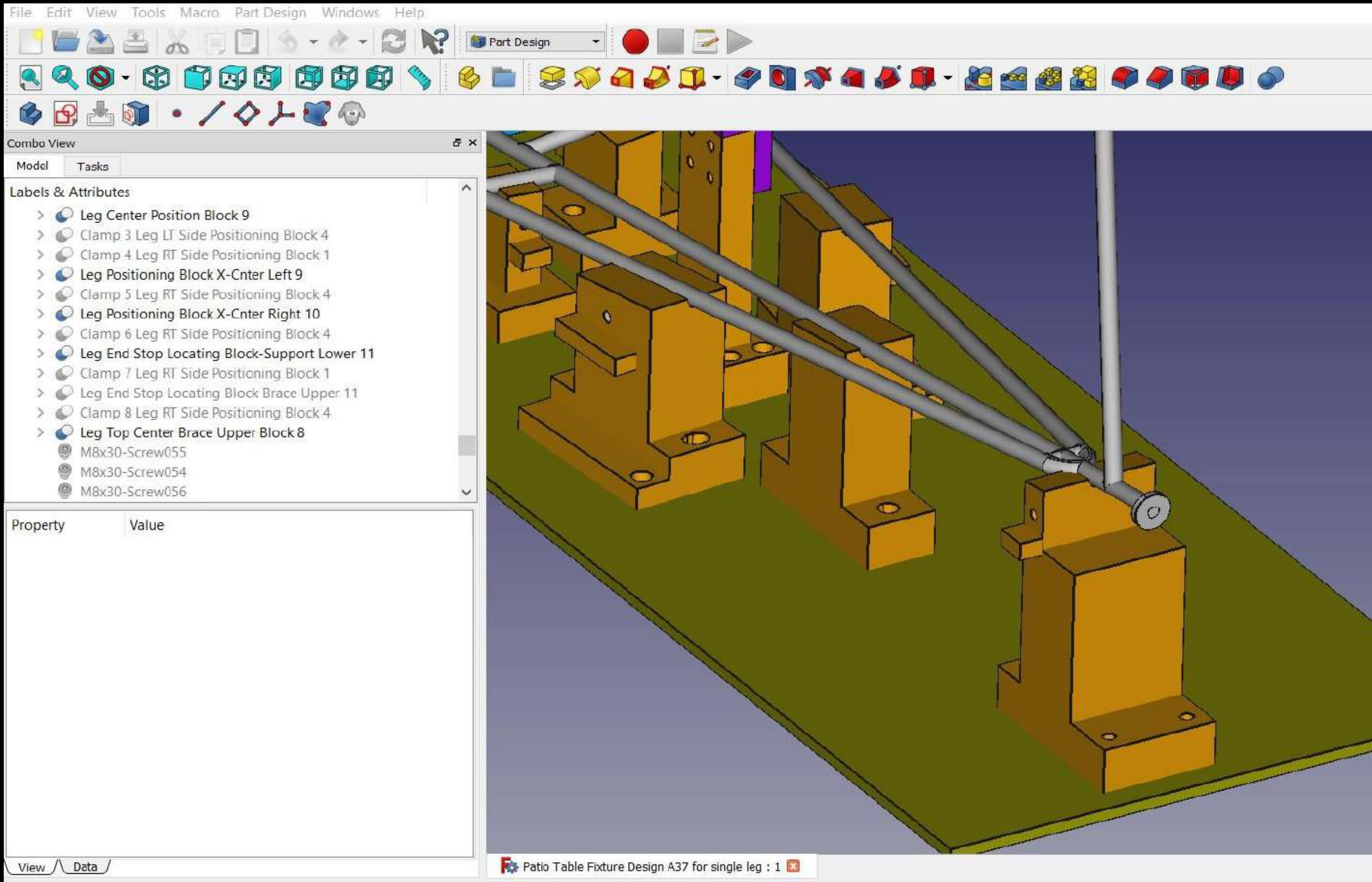
Leg Top Center Brace, Lower Block Drawing: I designed this block as an assembly for two reasons. First, breaking this positioning block down into two smaller parts made the components less complex and easier to make (cost effective). Second, I wanted the option to disassemble the upper positioning block to remove the leg from the fixture after welding, if that were necessary. As you can see, the fixture space is getting tight.



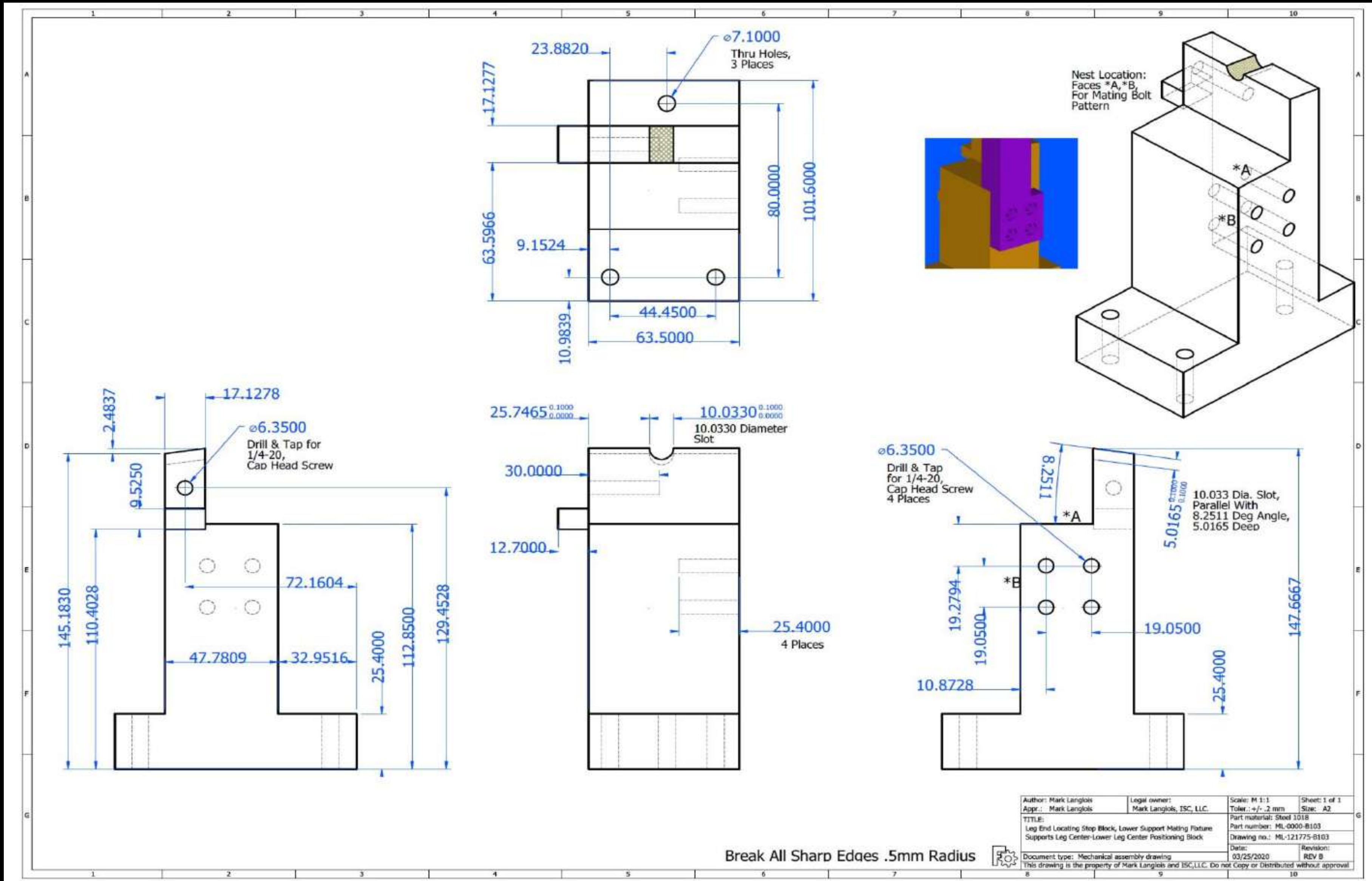
Leg Top Center Brace, Upper Block: This assembly block mates with the lower positioning block, locating the leg top center brace. The positioning block locates the brace position at the top of the leg, holds the brace in plane with the leg center rod segment and aligns the center brace rod segment to meet with the lower brace rod segment. I created these positioning blocks with some strength and mass so they can secure the top center brace accurately.



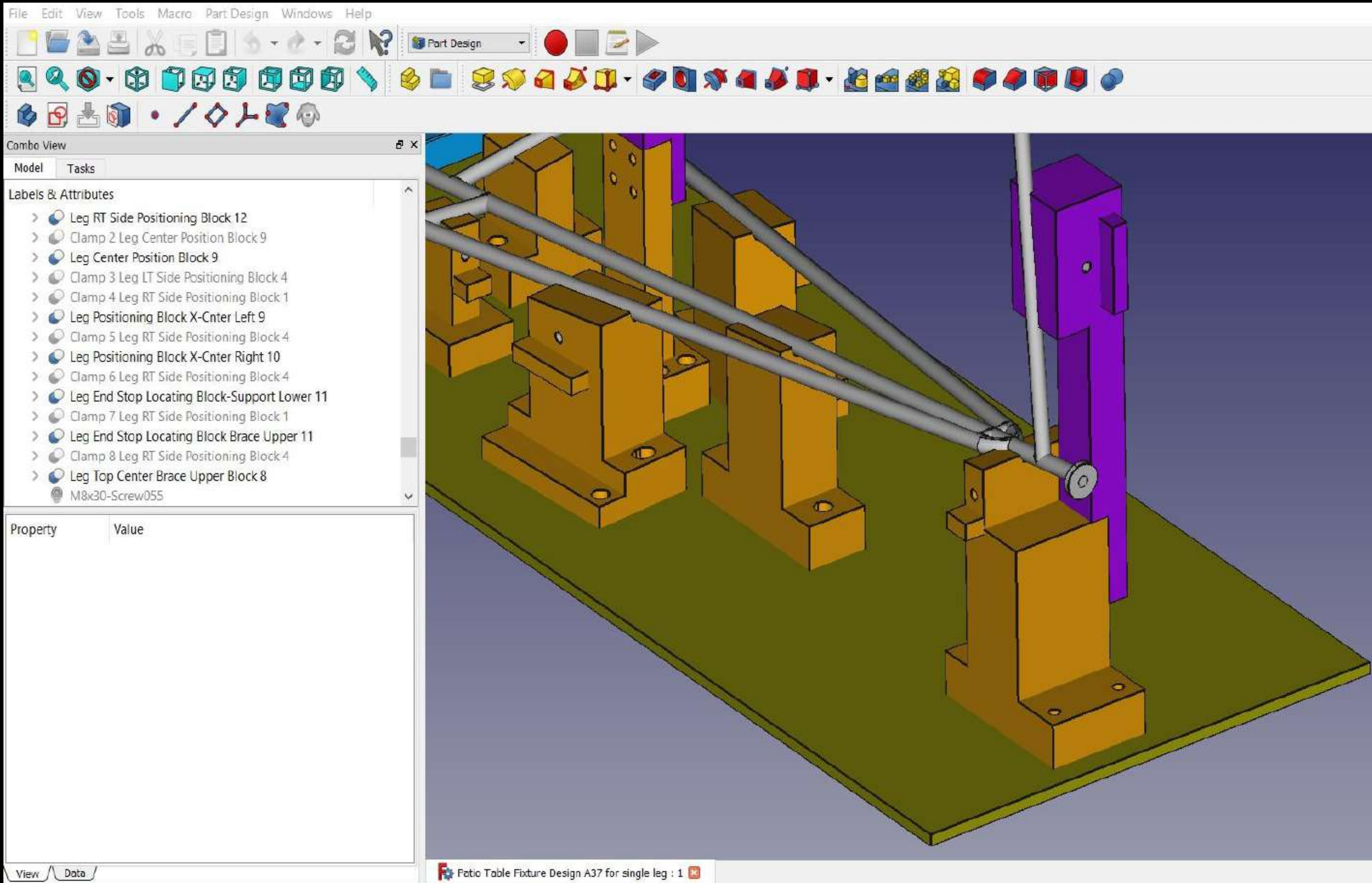
Leg Top Center Brace, Upper Block Drawing: This positioning block is doing a lot of work, positioning and clamping leg center brace. The leg center brace is also the longest rod segment component in construction of the leg. It took me some considerable time to conceptually visualize how I was going to hold and clamp this leg top center brace before coming up with this assembly configuration.



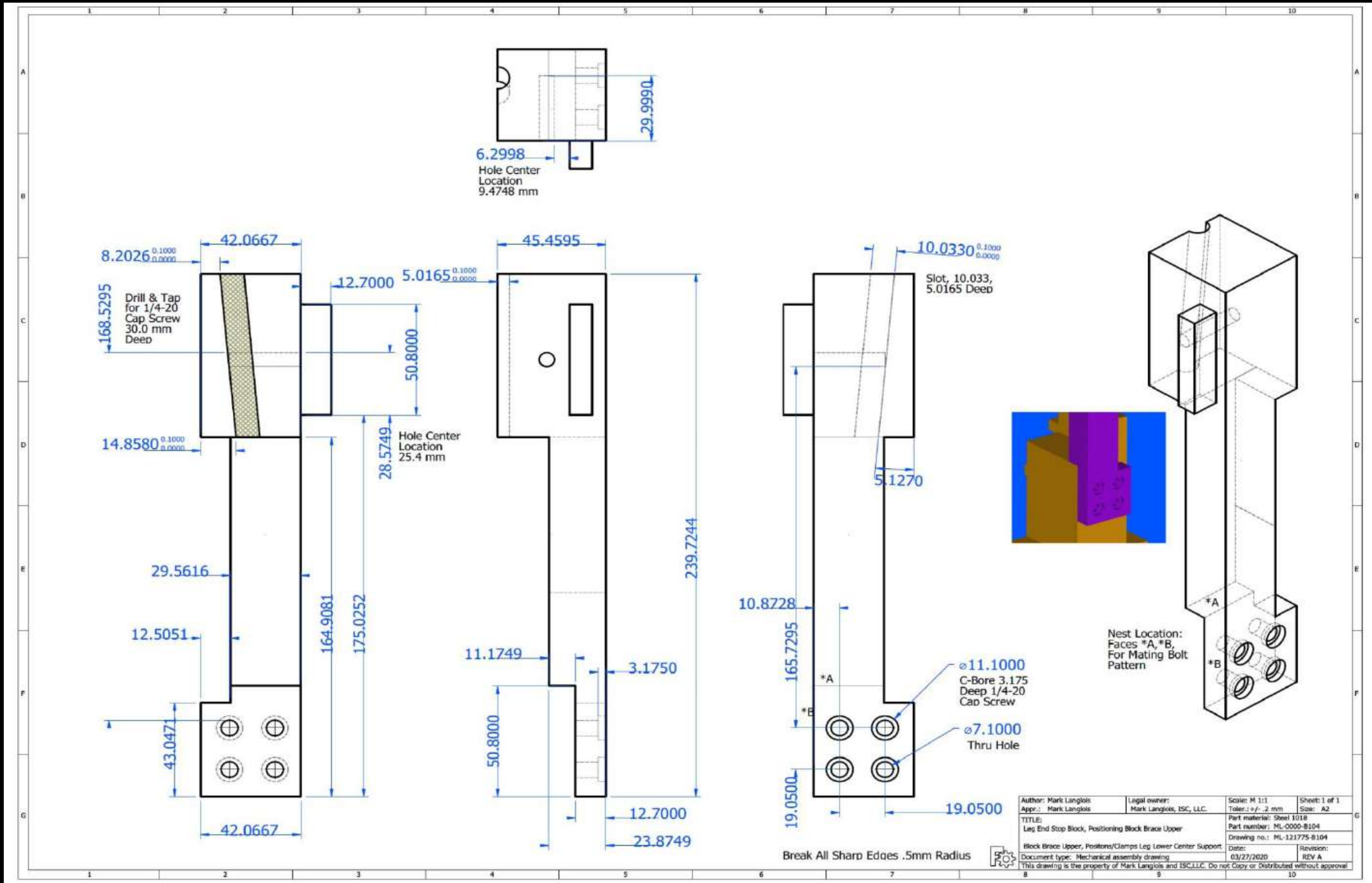
Leg End Locating Stop Block: The leg end locating stop block is also an assembly component. This block mates with the Positioning Block-Brace Upper. I designed this as an assembly for the same reasons as the other mating block components. The leg end stop block supports the center leg rod segment at a junction, whereby, the right and left rod segments are welded to the center rod segment on the one side. On the other side, the lower center brace rod segment is welded to the center leg rod segment.



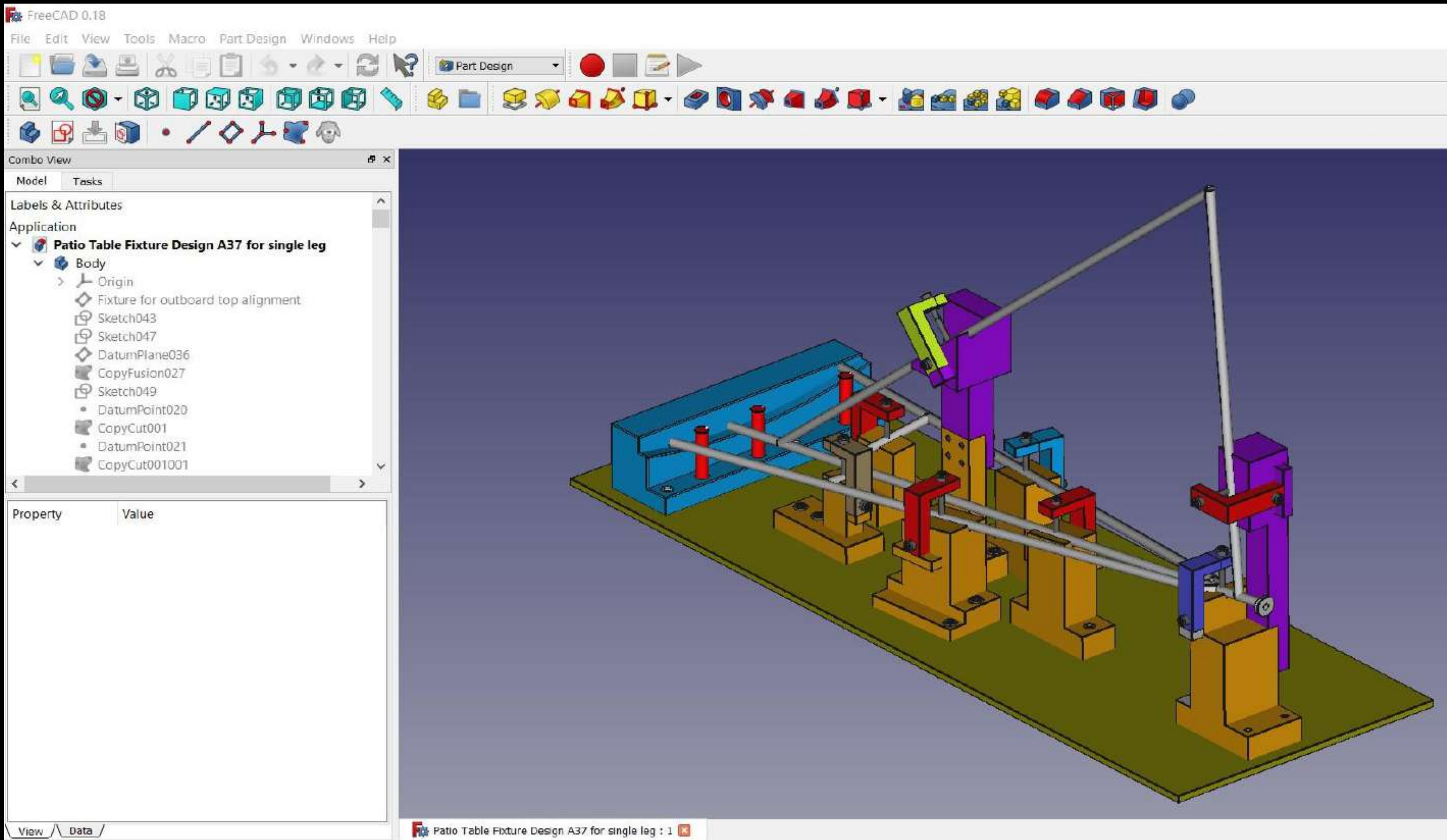
Leg End Locating Stop Block Drawing: The leg end stop block maintains the leg center rod segment at the correct angle and height in conjunction with the center positioning block. The end locating stop block marries the right and left leg rod segments at the 7 degree inboard angle to the center rod segment. It also positions the center leg segment, in plane, to accept the lower center brace rod segment positioned by its mating assembly block.



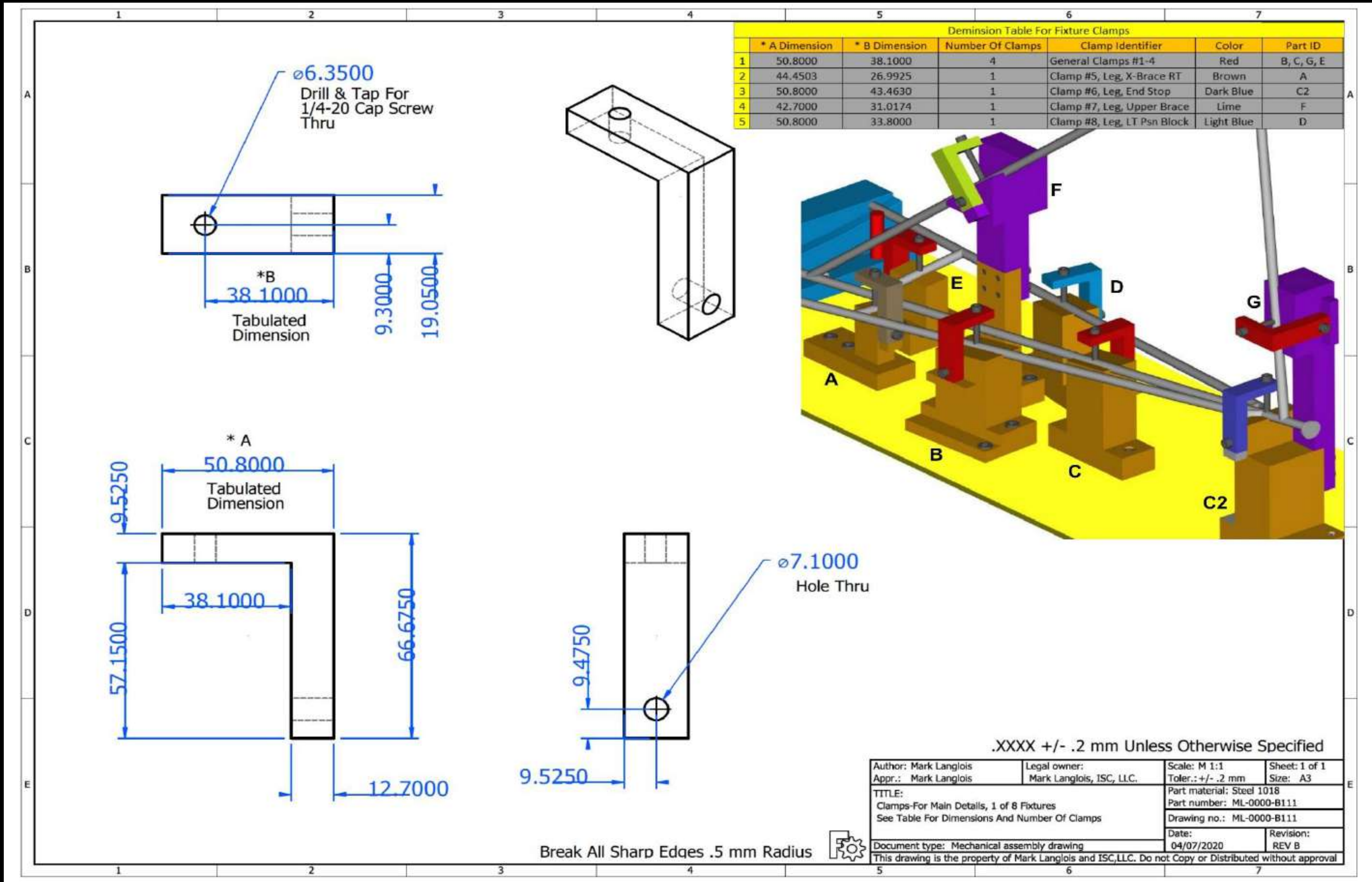
Leg End Stop Block-Positioning Brace Upper: This upper assembly component to the leg end stop block, positions the lower center brace in the same plane as the leg center rod segment and the upper center brace. All Three are aligned in plane with the center leg rod segment when clamped. It also locates the lower center brace rod segment in the correct weld location on the center rod segment.



Leg End Stop Block-Positioning Brace Upper Drawing: One of the critical concerns with respect to my design of the leg fixture positioning components, was having enough clearance and space to weld the components and not weld the fixtures holding the rod segments. This positioning block and the mating lower assembly, was very tight on sufficient room in that respect.

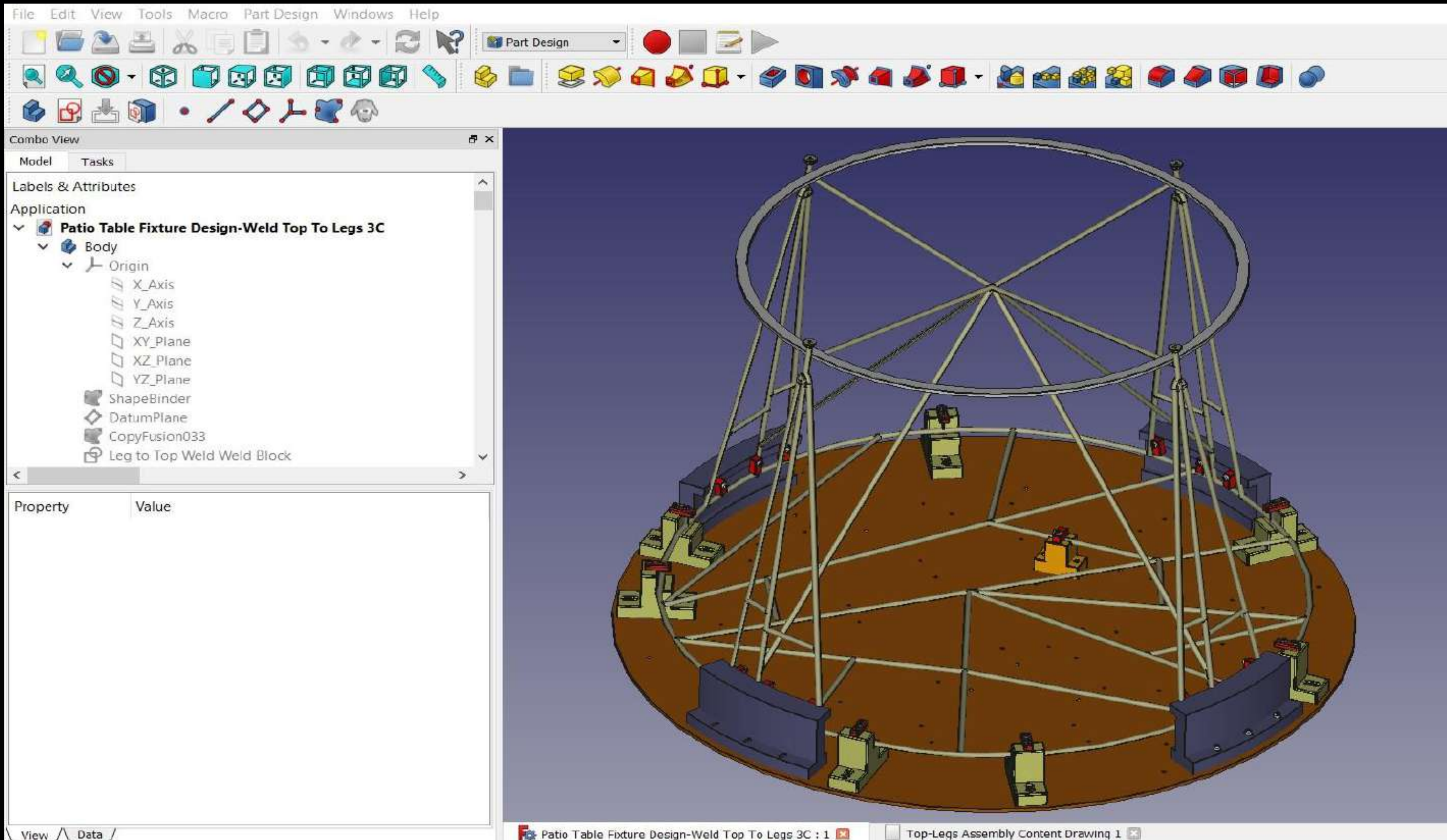


Leg Fixture Clamps: The clamps that are associated with each positioning block, in some cases, are the same length and have the same hole locations (shown in red, pictured above) and in the tabulated drawing on the next page. The specific angle and location of each positioning block groove requires that the location of the clamp be centered on the axis of the rod segment being clamped. This is an ideal outcome. In reality, if the clamp is within an allowable margin, I can use the same size camp to lock the rod segment securely in position.

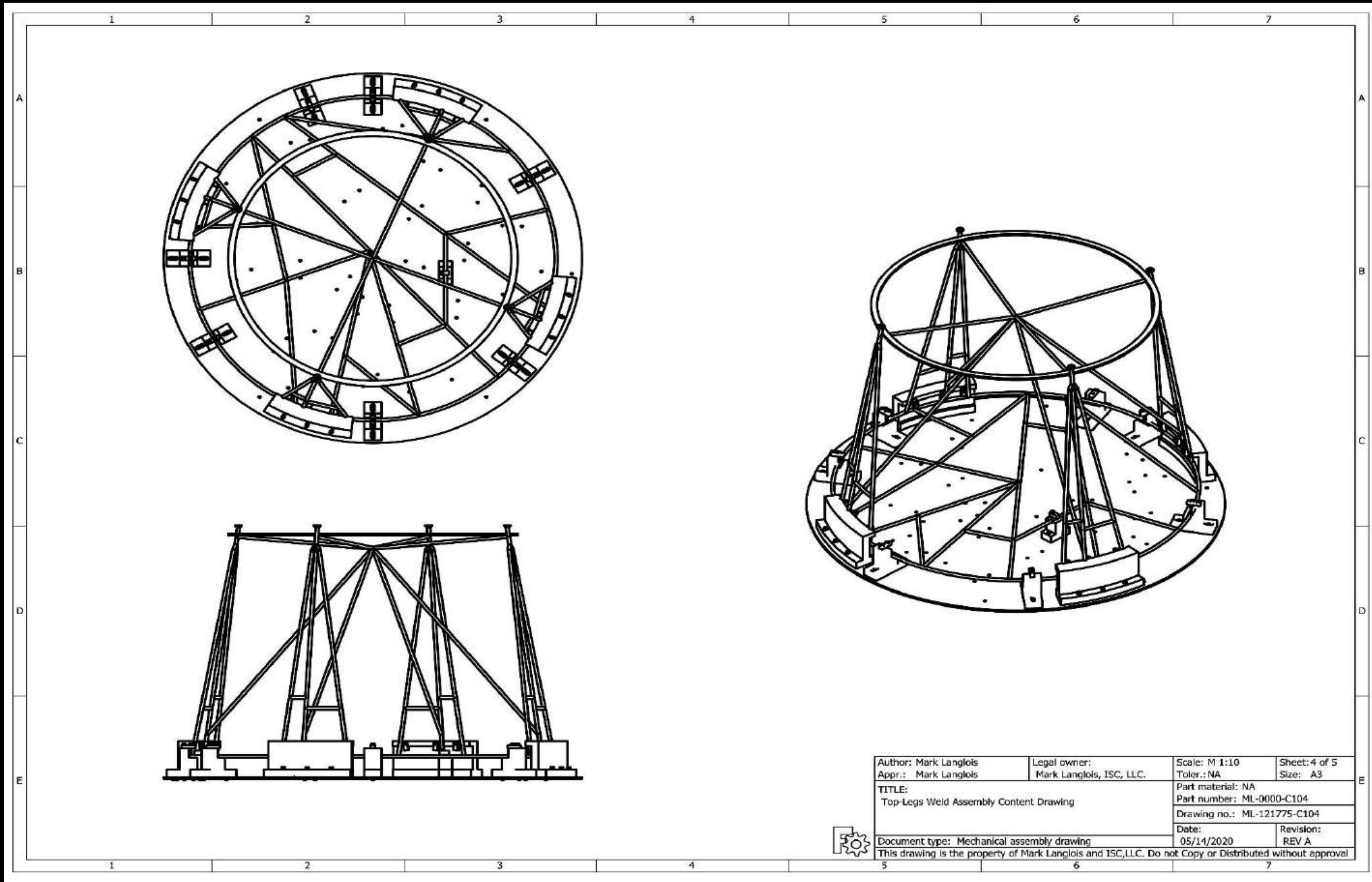


	* A Dimension	* B Dimension	Number Of Clamps	Clamp Identifier	Color	Part ID
1	50.8000	38.1000	4	General Clamps #1-4	Red	B, C, G, E
2	44.4503	26.9925	1	Clamp #5, Leg, X-Brace RT	Brown	A
3	50.8000	43.4630	1	Clamp #6, Leg, End Stop	Dark Blue	C2
4	42.7000	31.0174	1	Clamp #7, Leg, Upper Brace	Lime	F
5	50.8000	33.8000	1	Clamp #8, Leg, LT Psn Block	Light Blue	D

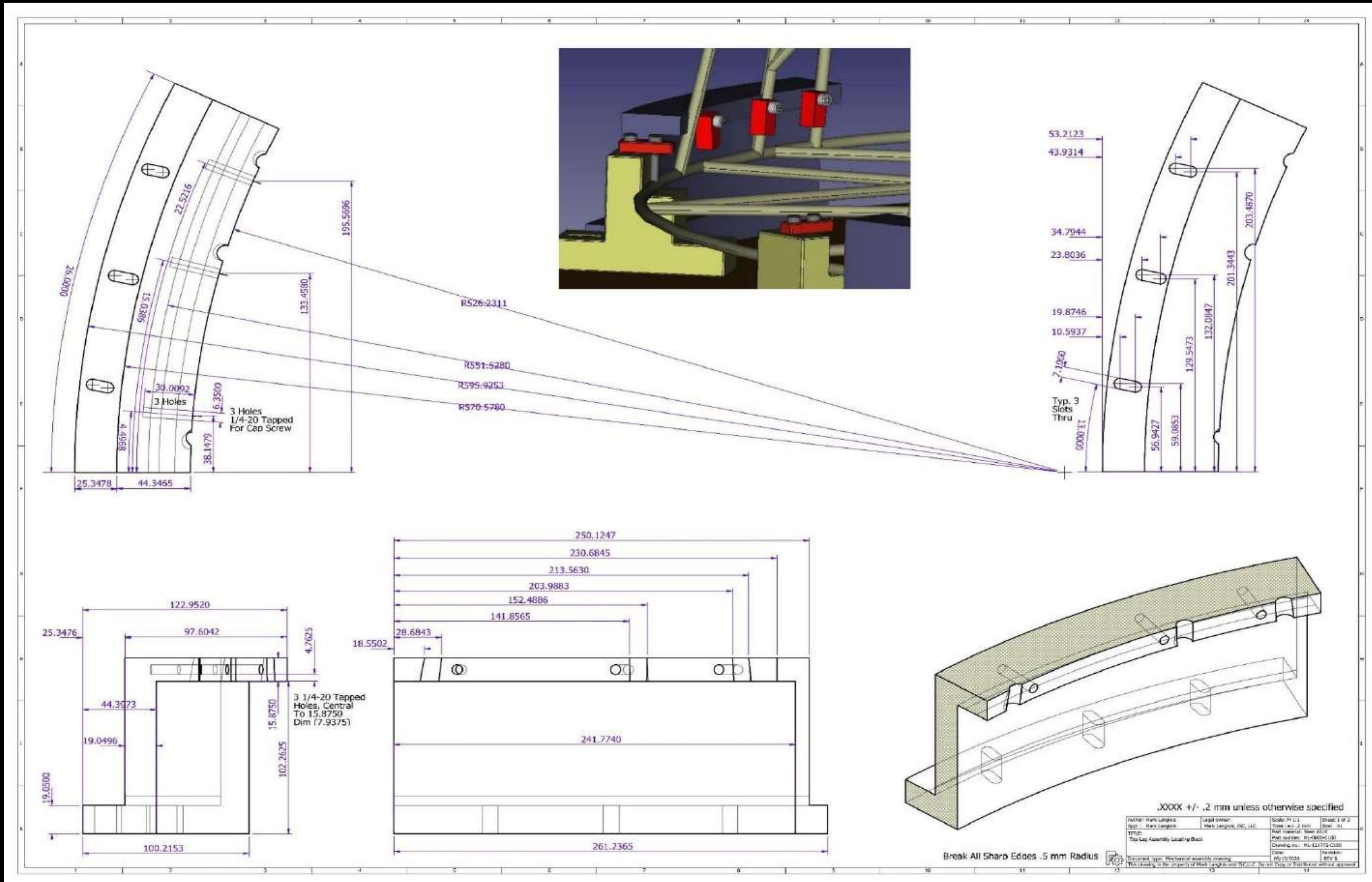
Leg Fixture Clamps-Tabulated Drawing: I created this tabulated drawing showing the common dimensions for the 4 red clamps. The remaining 4 clamps use the dimensions from the table. The *A dimension "length" in the (front view) from the back face to the end of the clamp. The *B dimension shown (top view) provides the dimension to the hole center location as called out in the table.



Assembly Fixture Components-Mating The Legs To The Top: The last fixtures that I designed were 4 assembly positioning blocks that locate the legs spaced 90 degrees apart. It also positions the top of the right, center and left leg rod segments on the center line of the table top ring and incorporates slots cut into the block face to orient and clamp the right, center and left leg rod segments to maintain the correct spacing on the outer diameter. In addition, I designed a ring gauge to locate each of the 4 legs at the proper inboard diameter.

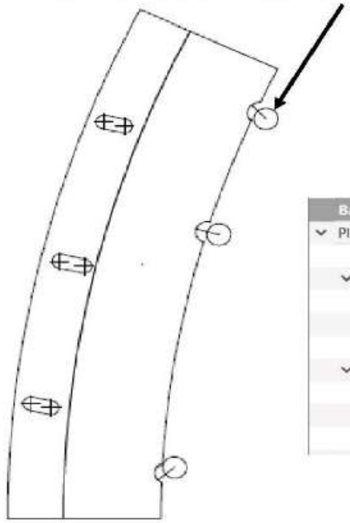


Assembly Fixture Component Drawing: In addition to the assembly positioning blocks and ring gauge, I leveraged the existing weld base plate and 7 of the table top ring weld shoes from the previous component weld operations to hold and position the table top.



Top-Leg Assembly Locating Block Drawing 1: I designed the top-leg assembly block to position the right, center and left leg rod segments on the center line of the table top ring. Slots are cut into the radial diameter to position and clamp the right, center and left rod segments. This radial diameter, is the sweep of the welded leg assembly, approximately 34 mm below the table top ring.

Diameter True Size: 11.1125 mm



Line/Vector 1

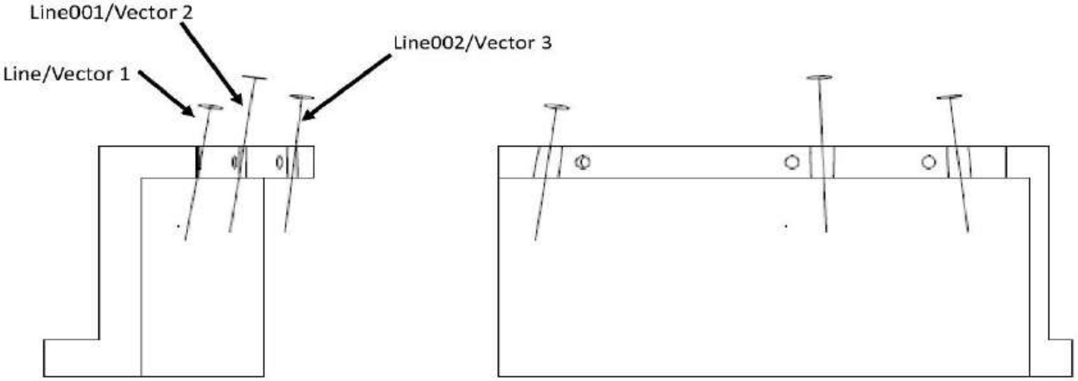
Base	
Placement	[(-0.86 0.40 -0.32); 110.5706 °; (-519.9752 m...
Angle	110.5706 °
Axis	[-0.86 0.40 -0.32]
x	-0.8602
y	0.3979
z	-0.3191
Position	[-519.9752 mm 26.2509 mm 70.2510 mm]
x	-519.9752 mm
y	26.2509 mm
z	70.2510 mm

Line001/Vector 2

Base	
Placement	[(-0.49 0.66 -0.57); 133.9132 °; (-499.7201 m...
Angle	133.9132 °
Axis	[-0.49 0.66 -0.57]
x	-0.4943
y	0.6578
z	-0.5683
Position	[-499.7201 mm 145.7746 mm 85.4475 mm]
x	-499.7201 mm
y	145.7746 mm
z	85.4475 mm

Line002/Vector3

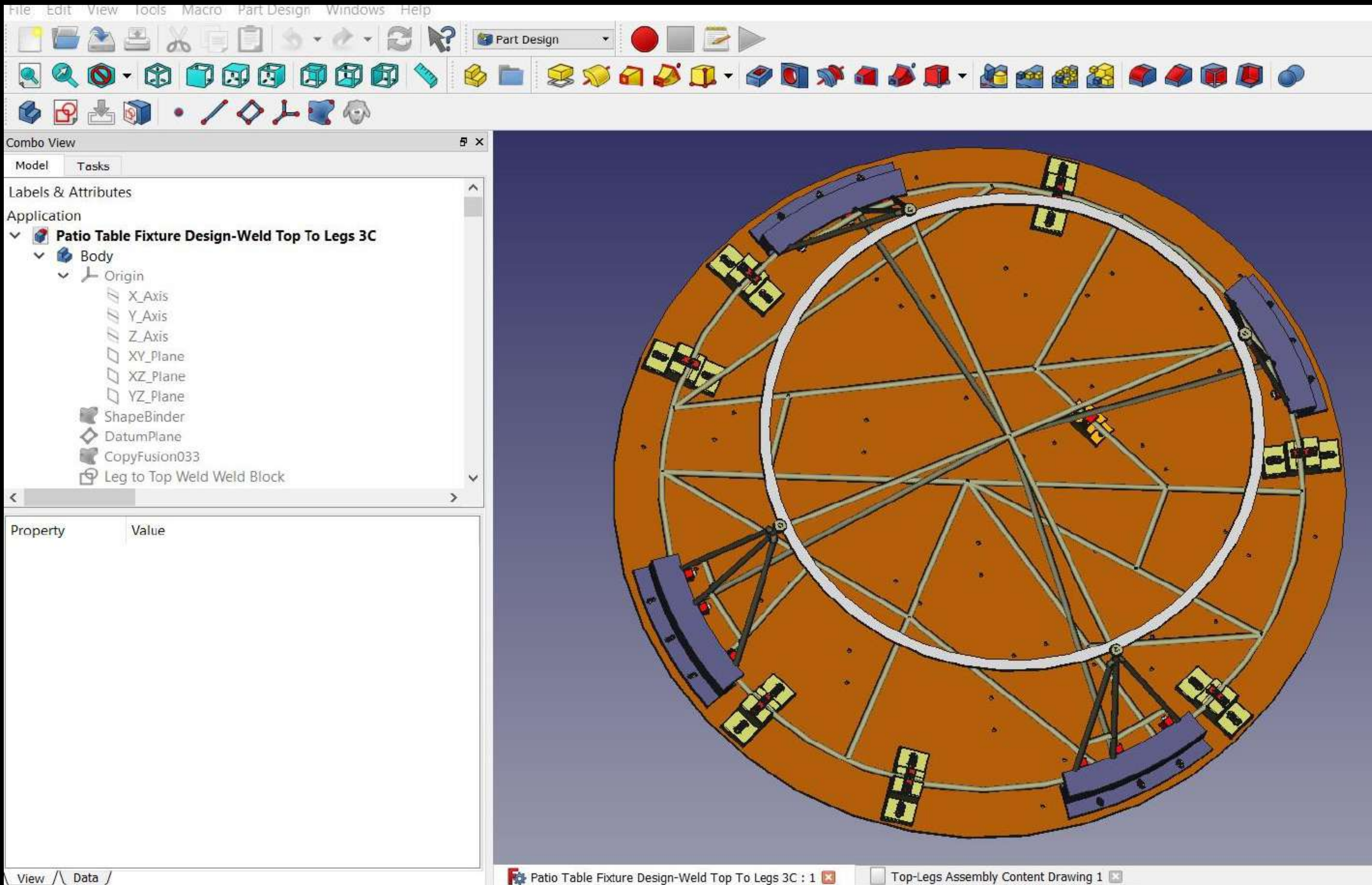
Base	
Placement	[(-0.27 0.73 -0.62); 153.9246 °; (-478.3921 m...
Angle	153.9246 °
Axis	[-0.27 0.73 -0.62]
x	-0.2750
y	0.7323
z	-0.6230
Position	[-478.3921 mm 205.1454 mm 75.3419 mm]
x	-478.3921 mm
y	205.1454 mm
z	75.3419 mm



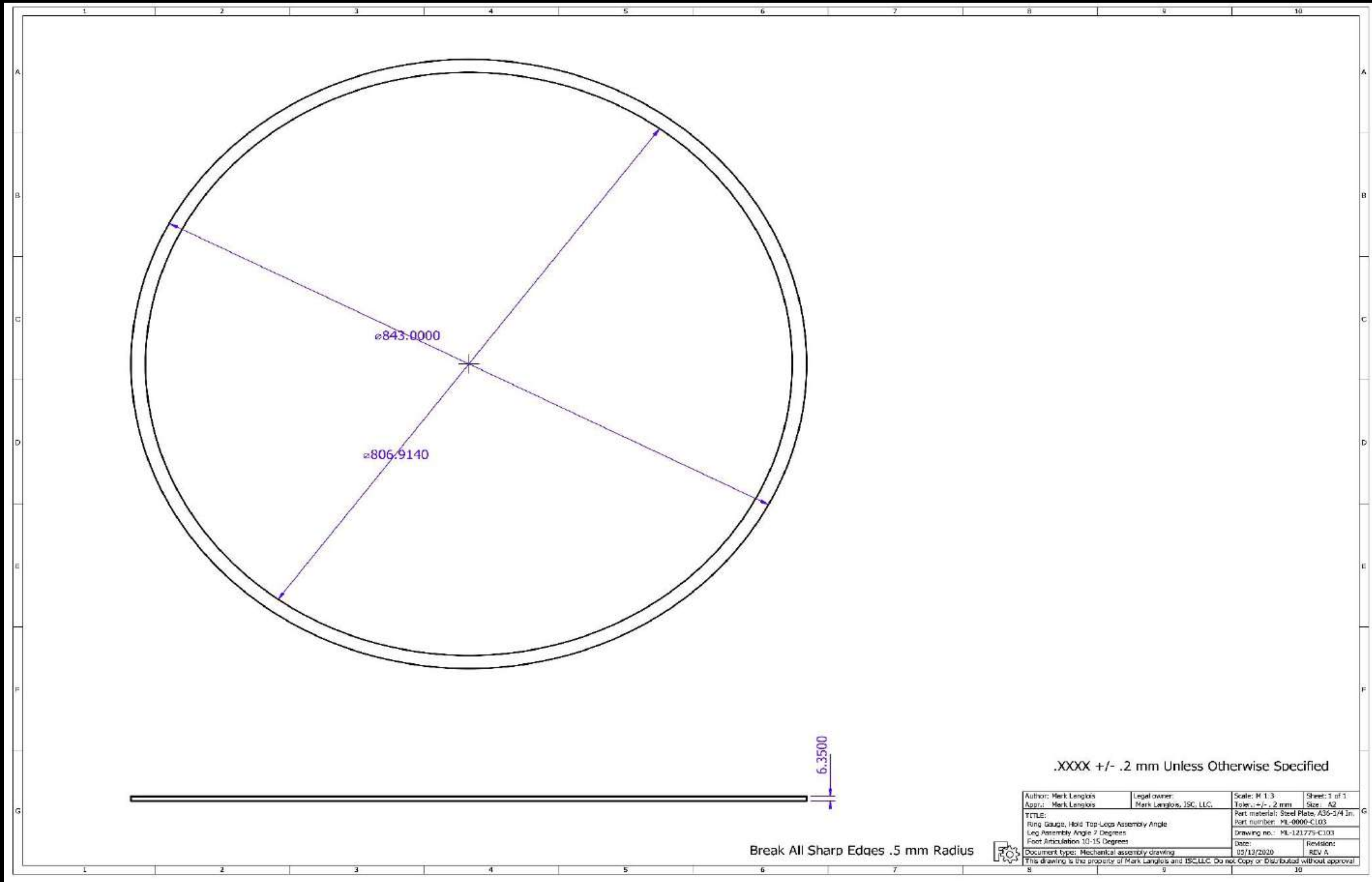
Note: Vector Information provided as reference only, master is vector/plane included in CAD file.

Author: Mark Langlois Appr.: Mark Langlois	Legal owner: Mark Langlois, ISC, LLC.	Scale: M 1.7:1 Toler.: +/- .2 mm	Sheet: 2 of 2 Size: A1
TITLE: Top-Leg Assembly Locating Block--Vector Information		Part material: Steel 1018 Part number: ML-0000-C100-2	
		Drawing no.: ML-121775-C100-2	
Document type: Mechanical assembly drawing		Date: 05/13/2020	Revision: REV B
This drawing is the property of Mark Langlois and ISC,LLC. Do not Copy or Distributed without approval			

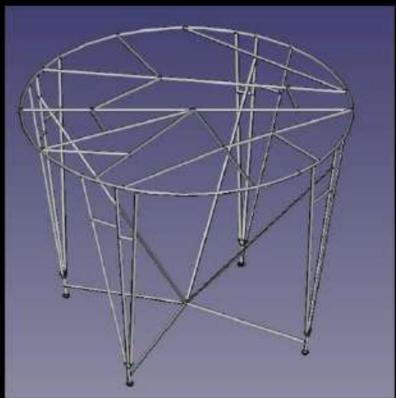
Top-Leg Assembly Locating Block Drawing 2: I created this drawing to provide my vendor with the necessary vector information to make this assembly block. My vendor will need the vector information for each of the rod segments as it passes through the radial sweep in the block. The right, center and left leg rod segments are all oriented along a different vector through the block. These vectors were also included as part of the CAD file to assist the vendor in making the cuts.

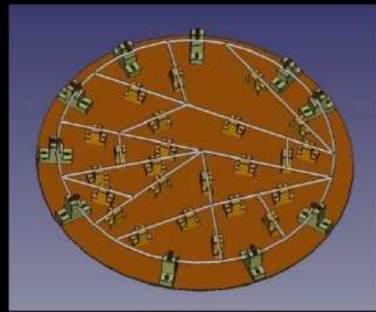


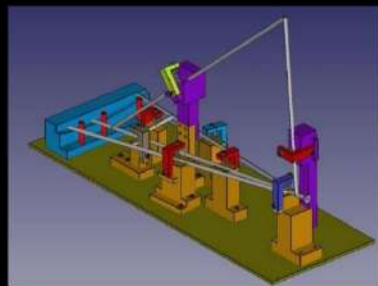
Ring Gauge Component: The ring gauge is a steel ring that has been cut to the inboard diameter where each of the legs should be located. The ring gauge is both a locating and measuring tool to keep each leg at the same angle. However, this gauge is not fixed in position and allowed to float. I anticipate that the welded construction will result in some assembly deviation. The ring gauge can show me how much variation and will assist in making balanced adjustments.

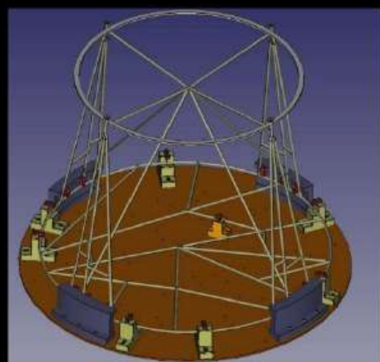


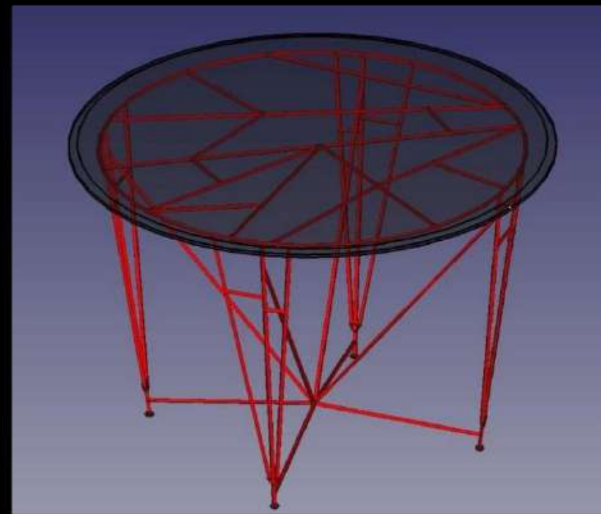
Ring Gauge Component Drawing: The ring gauge is 3/4 of inch wide and 1/4 inch thick and cut from A36 steel plate. I designed this ring to be placed between each of the legs to balance and measure the inboard leg angle. The ring gauge outside diameter is the diameter defined at 7 degrees inboard from the outside diameter of the table top ring. This ring was laser cut by the same vendor that made both of my base plates.



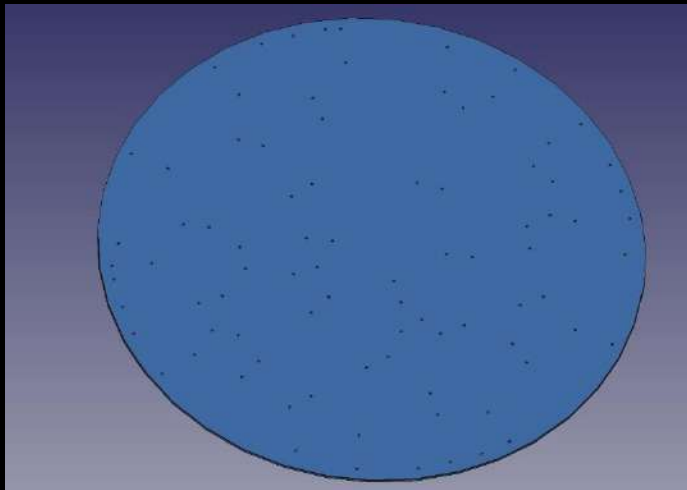


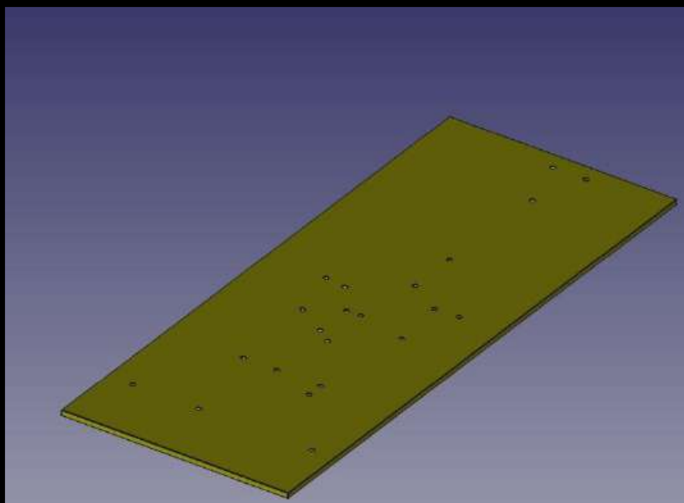


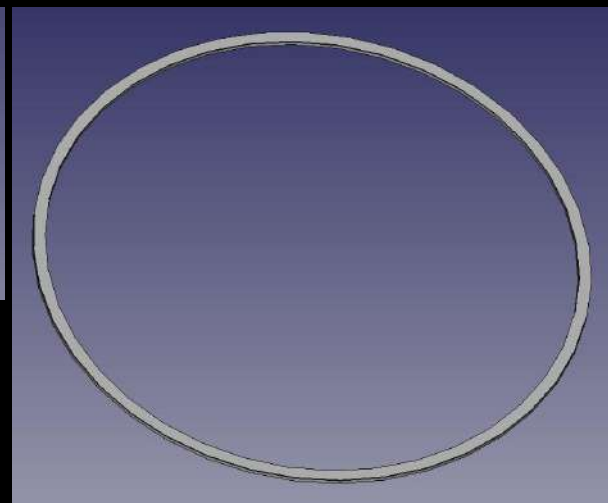




I have created a 3D solid model of the table. I have leveraged the table solid model to design all of the fixtures necessary to maintain the design intent. So now it’s time to make an important decision. Do I build the table? The table, its design, and the creation of all of the fixtures has been an expenditure of my own time; with the exception of having the 3D printed models made. Actually making the table will cost money and the probability of additional unknown problems to solve. My decision; go forward and build the table using the designed fixtures and tooling.





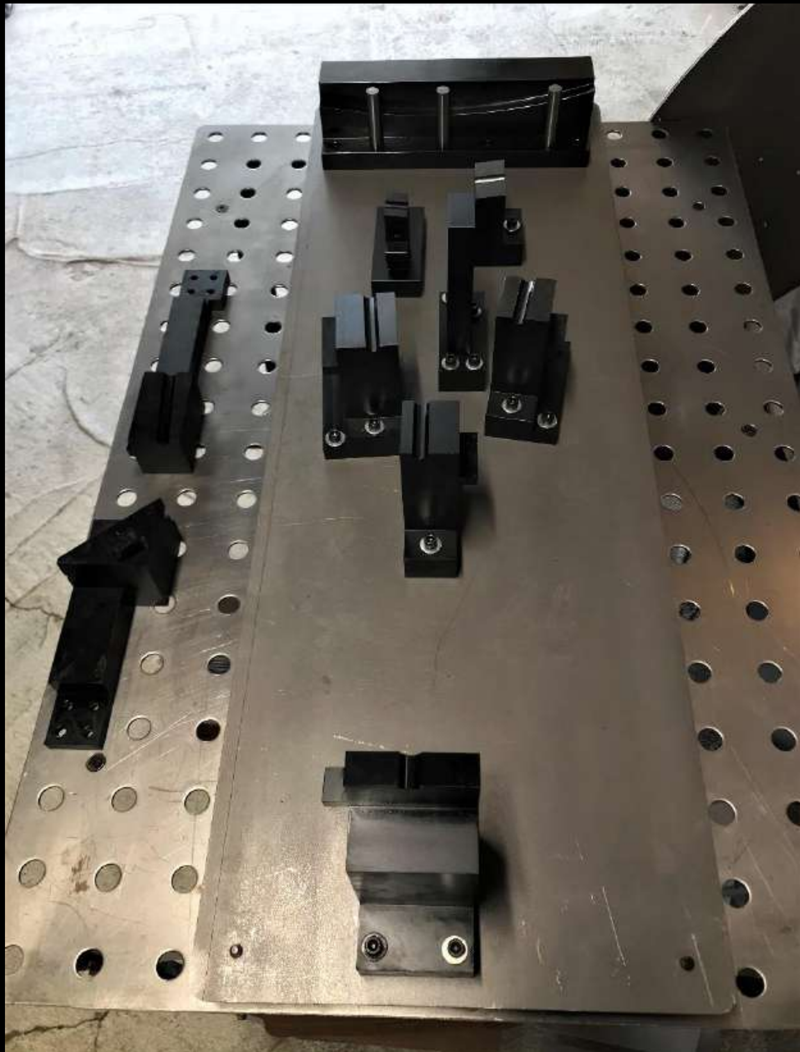


Locate Machining Vendors And Make The Tooling: I put in a good amount of effort into contacting fabricators and tooling vendors, getting material costs and machining quotes. The material costs associated with the tooling is not that expensive. However, machining the fixture details, is not inexpensive. I needed to find the right vendor, get and accept a quote, send the vendor the CAD files that define the part detail along with all of the drawings and other necessary information, and then, get my credit card out!

Receiving And Inspecting Vendor Made Details: After the fixture details were CNC machined and delivered, I needed to inspect each one to make sure they were made according to the 3D design and drawings. The tooling details shown above were made for the table top and leg fixtures.



Vendor Made Base Plates And Ring Gauge: My base plate for the legs is on the left, the ring gauge in the center and the base plate for the table top on the right were all cut to size and holes made by a CNC laser cutting machine. The holes in the plate were then tapped for a 1/4-28 cap screw. The plates and the ring gauge are all 1/4 inch steel plate. The leg and top base plates will locate and position all of the fixtures details.

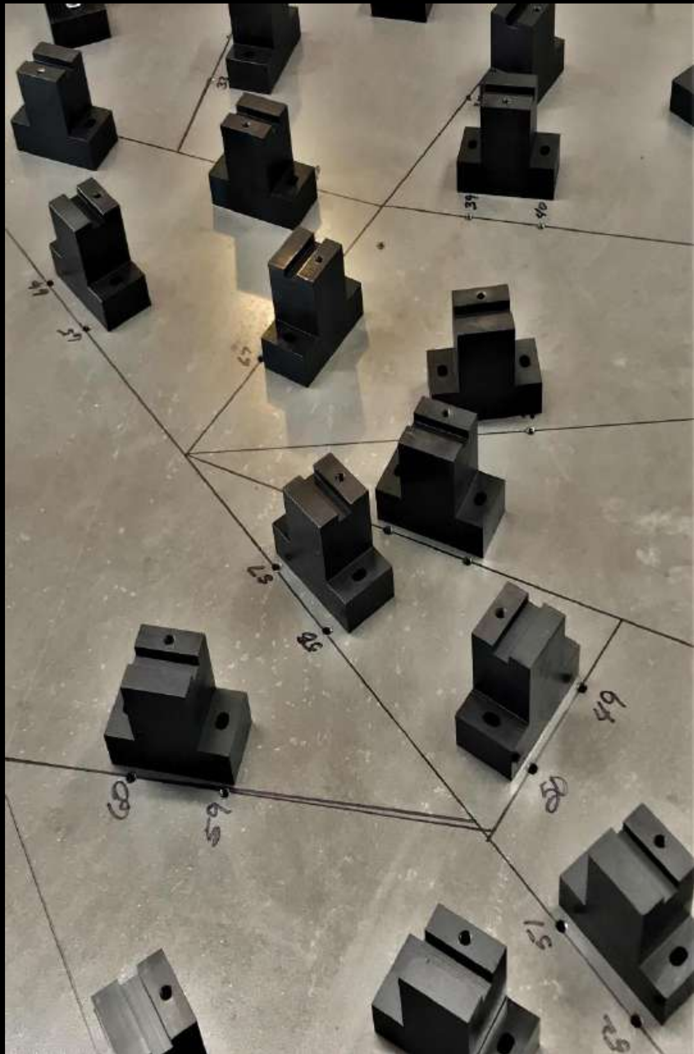
 

Assembling Leg Weld Fixture Blocks: After I inspected each of the weld fixture details, I cleaned each one and then took them to a vendor to have them coated in black oxide to help prevent rust. I installed leveling feet in the designated leg base plate mounting holes first and got the base plate level. Then, I assembled the fixture details for welding the legs on base plate. The location and position of the leg fixture details must still be qualified to position each of the steel rod segment as designed. I anticipate that minor adjustments will be required to locate each block precisely, relative to the fixed center leg positioning block.

Installing The Table Top Base Plate: Like the leg base plate, I installed the leveling feet in the mounting holes for the table top base plate first. Next, I used another base plate, 3/8 inches thick; the same diameter as the table top base plate but without holes, and located that on the top of two welding tables and got the plate level. Last, I need to position the table top base plate. The table top base plate weighs around 400 pounds. I needed to use a chain hoist to lift the plate up and onto the steel support plate, align the diameters and then get it level.

Assembling The Table Top Weld Fixtures-Weld Shoes: I assembled the 10 table top ring weld shoes on the table top base plate first. The radial locations are precise and are incorporated into the hole locations on the base plate. There is an adjustment allowance on the diameter for each weld shoe, perpendicular to the table top diameter; only in and out.



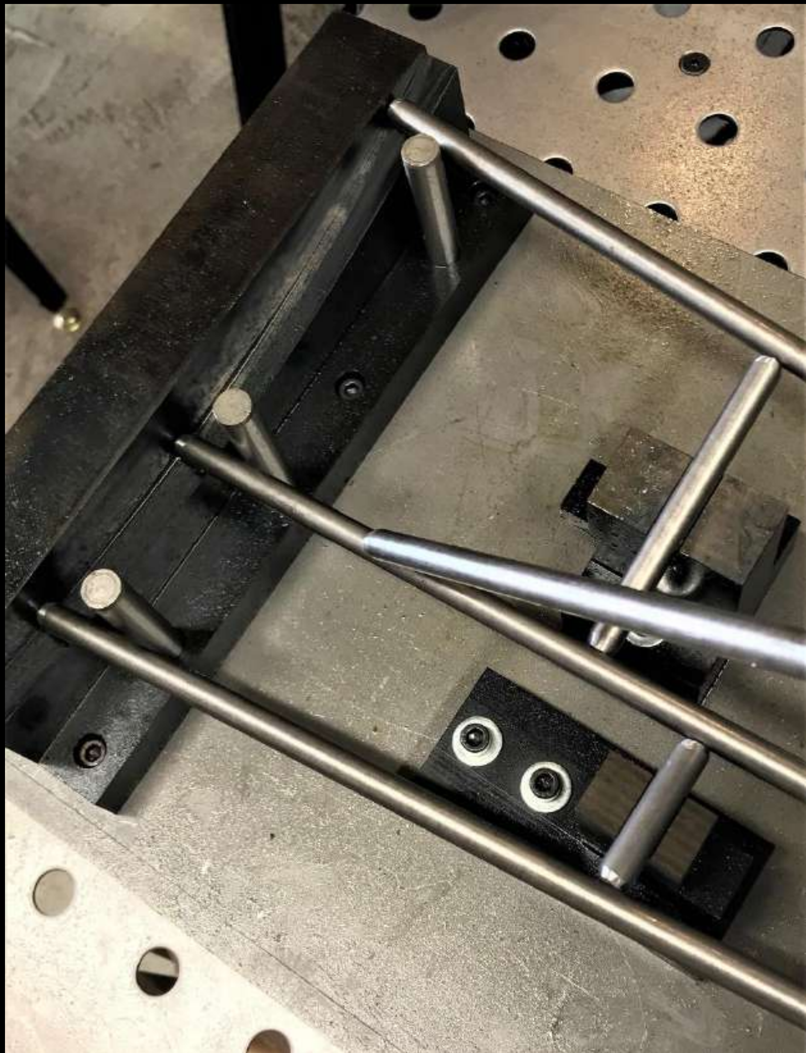
Assembling The Table Top Weld Fixtures-Interior Positioning Blocks: To start, I laid out the base plate using a sharpie to align the positioning block hole centers. The lines provide an approximate alignment for each steel rod segment that will be located and managed by the 24 interior positioning blocks. My design allows the positioning blocks to move perpendicular to their respective linear line, defining that segment only. Pictured on the left, is the approximate alignment drawn on the plate and the assigned hole number from the base plate chart. The shot on the right, shows the positioning blocks assembled on the base plate, along these initial layout lines.

Qualifying The Leg Weld Fixture: Qualifying the leg weld fixture first involves aligning the leg center segment, top center brace and lower center brace to be in the same plane.

These pieces are the core components that all of the other rod segments will be positioned to.

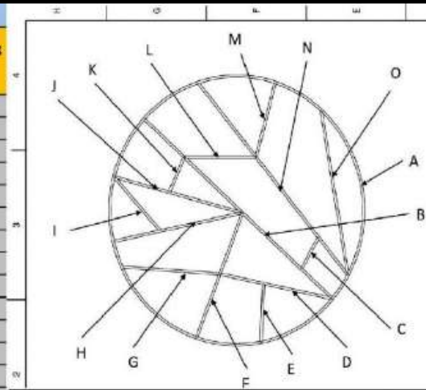
The leg center components must also lie in the same plane when welded to the table top, 180 degrees apart.

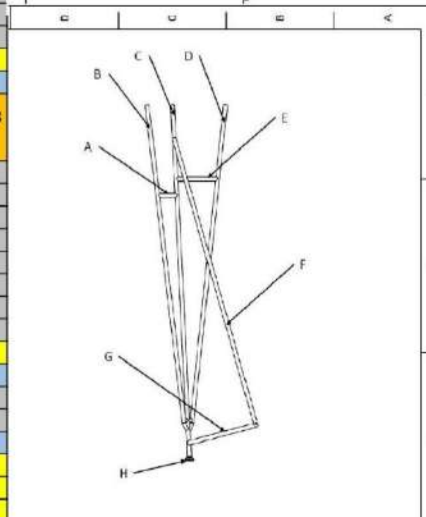
It is important that I am able to consistently replicate these positions in the leg fixture.

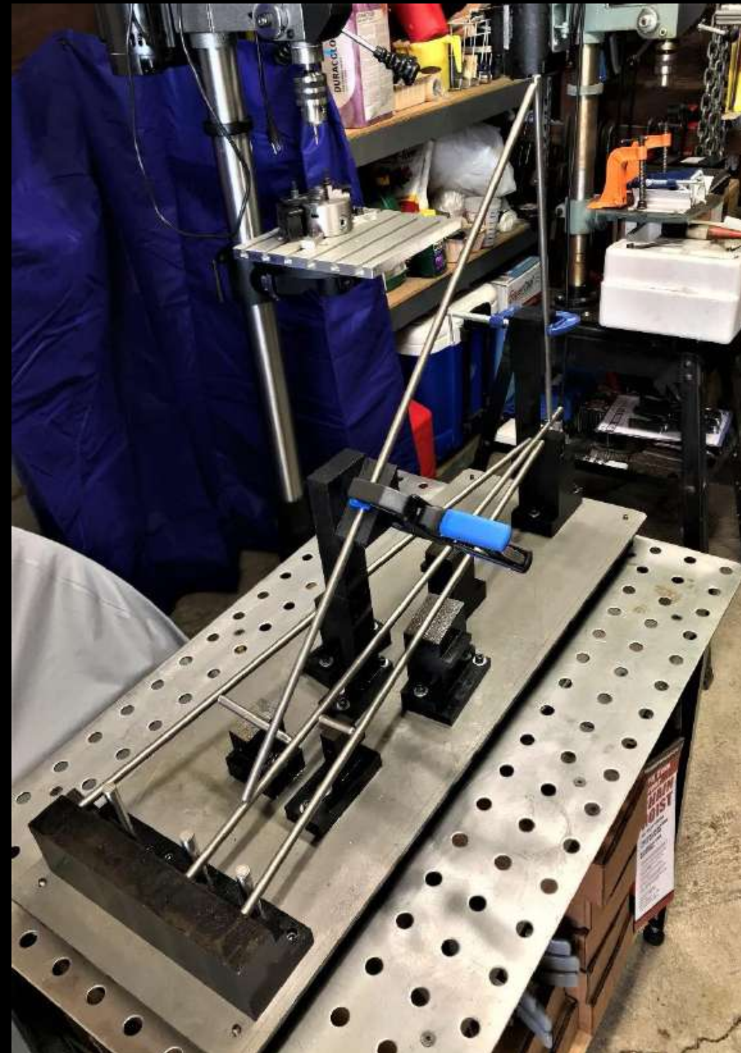


Next, the top diameter end stop block positions the center, right and left rod segments on the center diameter of the table top ring. The pins locate the rod segments in the correct angular position on the top diameter. The center, right and left positioning blocks provide the correct angle and height so the leg rod segments are joined at the correct location on the center leg rod segment. The center blocks are fixed locations and the right and left positioning blocks are allowed to move about an 1/8 of an inch perpendicular to the location angle for correct alignment.

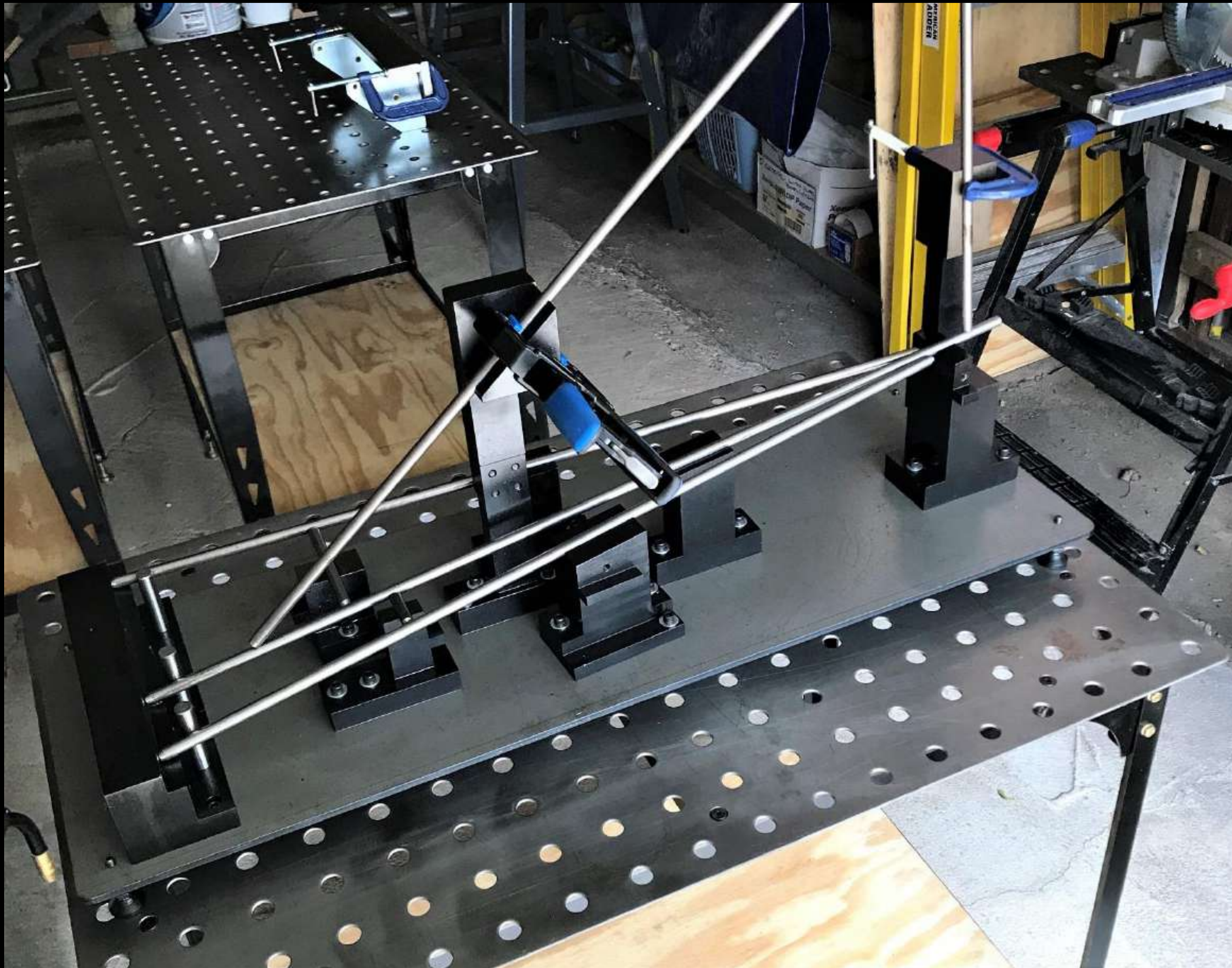
Patio Table Top Component Chart					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	156.0000	156.0 Inches	13.000	4.888	1
B	41.5000	41-1/2 Inches	3.458	1.300	4
C	5.3125	5-5/16 Inches	0.443	0.166	4
D	18.2500	18-1/4 Inches	1.521	0.572	4
E	8.7500	8-3/4 Inches	0.729	0.274	4
F	20.6250	20-5/8 Inches	1.719	0.646	4
G	16.0000	16.0 Inches	1.333	0.501	4
H	21.2500	21-1/4 Inches	1.771	0.666	4
I	11.0625	11-1/16 Inches	0.922	0.347	4
J	21.5000	21-1/2 Inches	1.792	0.674	4
K	5.6875	5-11/16 Inches	0.474	0.178	4
L	11.7500	11-3/4 Inches	0.979	0.368	4
M	11.5000	11-1/2 Inches	0.958	0.360	4
N	38.2500	38-1/4 Inches	3.188	1.199	4
O	24.9375	24-15/16 Inches	2.078	0.781	4
Totals	412.375		34.365	12.921	57
Patio Table Legs (4) Component Chart 1 Leg					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	1.6875	1-11/16 inches	0.141	0.053	4
B	27.1875	27-3/16 Inches	2.266	0.852	4
C	30.0000	30.0 Inches	2.500	0.940	4
D	27.4375	27-7/16 Inches	2.286	0.860	4
E	3.7500	3-3/4 Inches	0.313	0.118	4
F	30.3750	30-3/8 Inches	2.531	0.952	4
G	16.6250	16-5/8 Inches	1.385	0.521	4
H	0.0394	N/A	0.003	0.001	0
Totals	137.102		11.425	4.296	112
Total Approx. Patio Table Base & Top--Linear Length and Weight					
A	Linear Length ft.		80.065		
B	Table Weight lbs		30.105		
Total Welds, Top, Legs, Leg to Table Top, Center Bars To Center Bars					
A	Weld Legs to Top				12
B	Weld Center Bars To Center Bars				8
Totals	Total Number of Welds				189



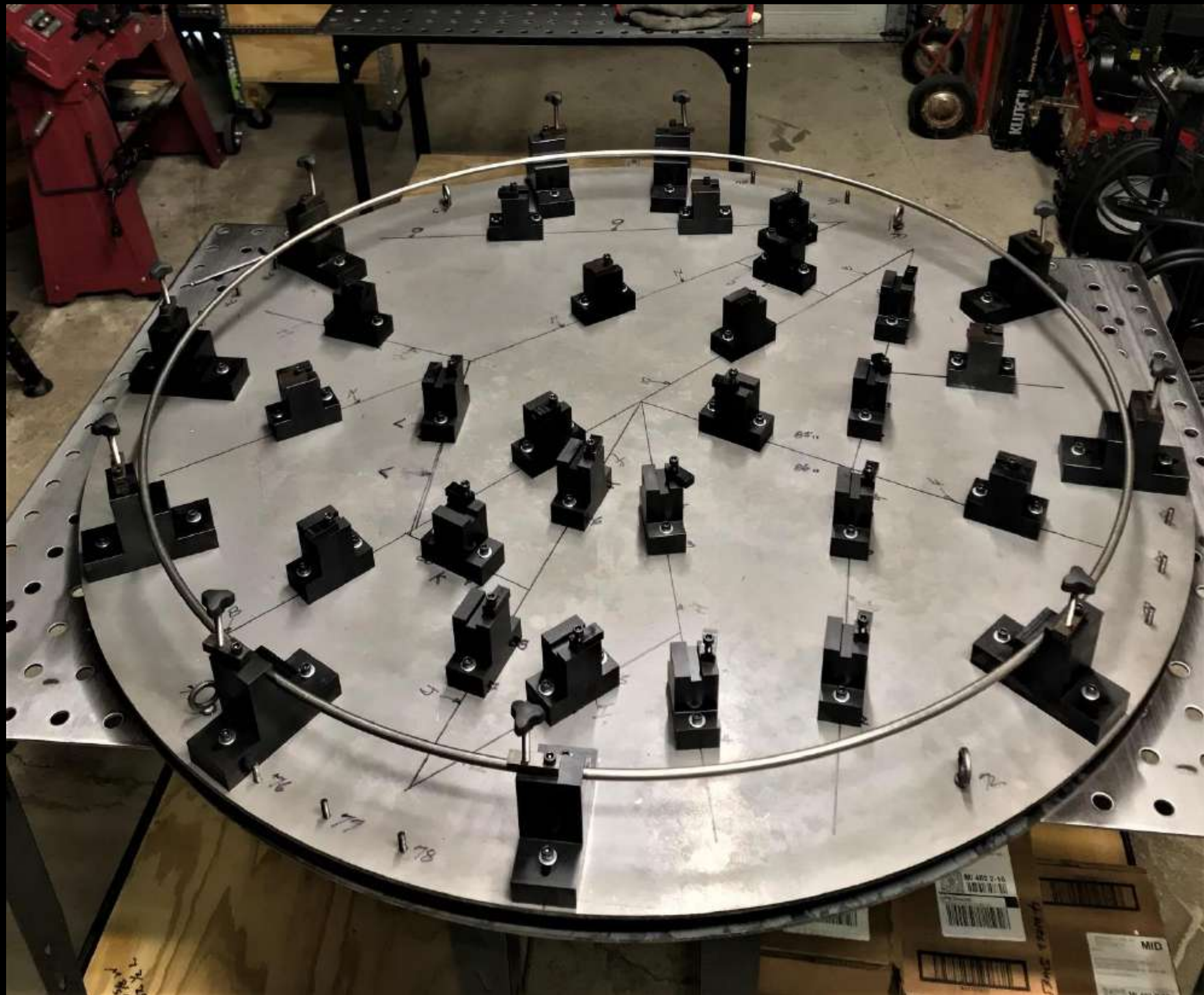




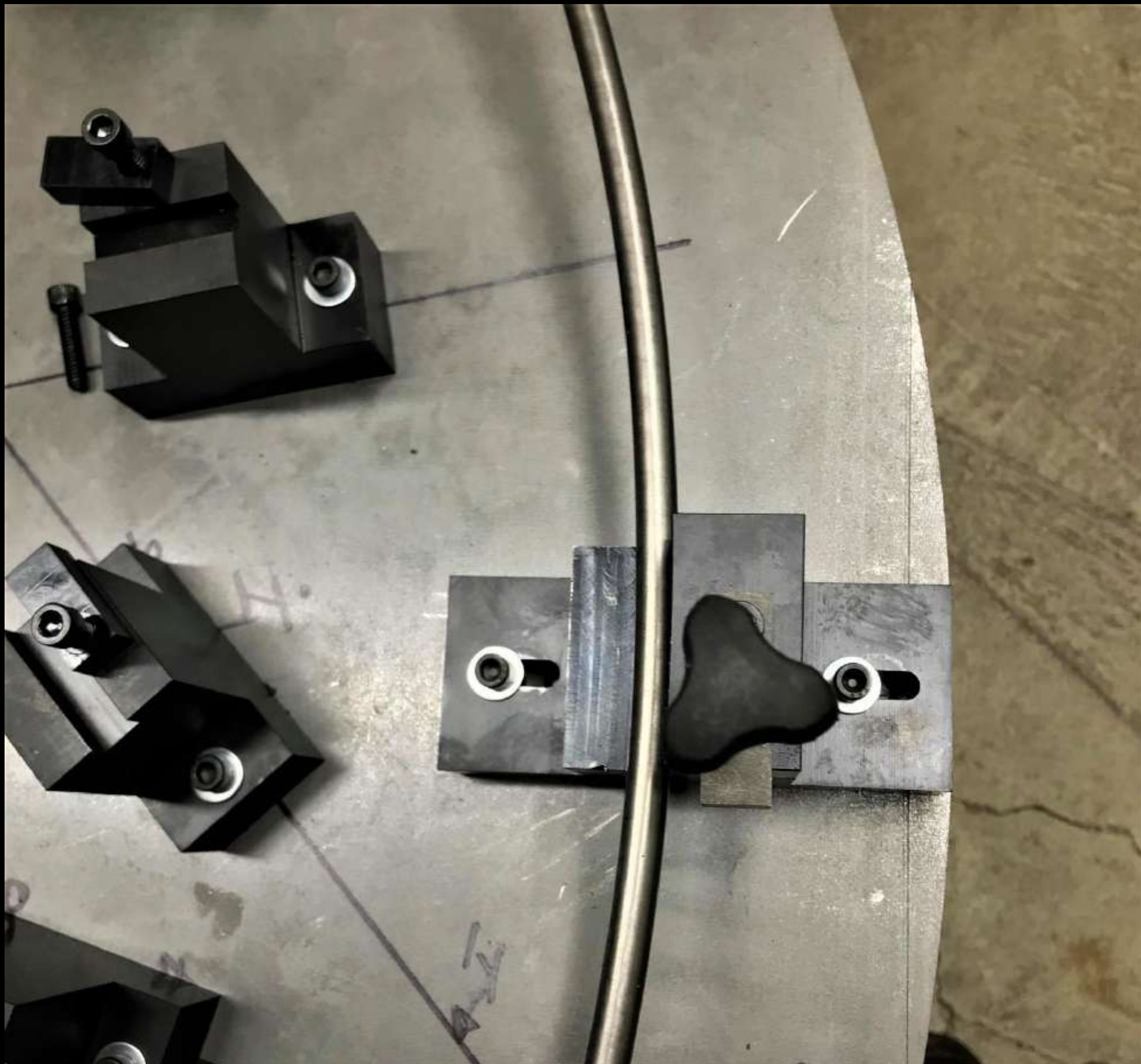
Lastly, qualifying the fixture requires capturing the actual linear length of each rod segment to be placed in each positioning block. The linear lengths that I initially captured with the 3D solid model are only good for reference. In the 3D solid model, the linear rod segments intersect so that they can be united into a single solid model. In reality, the steel rod segments can only be in contact with its neighboring piece. Each rod segment placed in the fixture must be cut and pencil ground for a custom fit. The rod segment is then measured, and that length, is the qualified length. I updated the component chart spreadsheet for each rod segment with its qualified length.



The weld fixture and rod segment lengths have been qualified to weld the table legs. However, I did not have a vendor make the fixture clamps for the leg positioning blocks. I decided to make these clamps myself and I will cover that process shortly.



Qualifying The Table Top Ring: Earlier in the book, I mentioned that the table top ring is a purchased component from a vendor. It was roll formed and butt welded. I have hand finished the weld areas on each of the table top rings and they are ready for locating in the fixture. The table top ring is supported and positioned by the 10 weld shoes on the weld base plate. The ring is clamped into positon with a screw clamp. The table top ring diameter tolerance per the vender is 1/8 inch, so I had to be able to adjust the weld shoes normal to the diameter (in and out only).

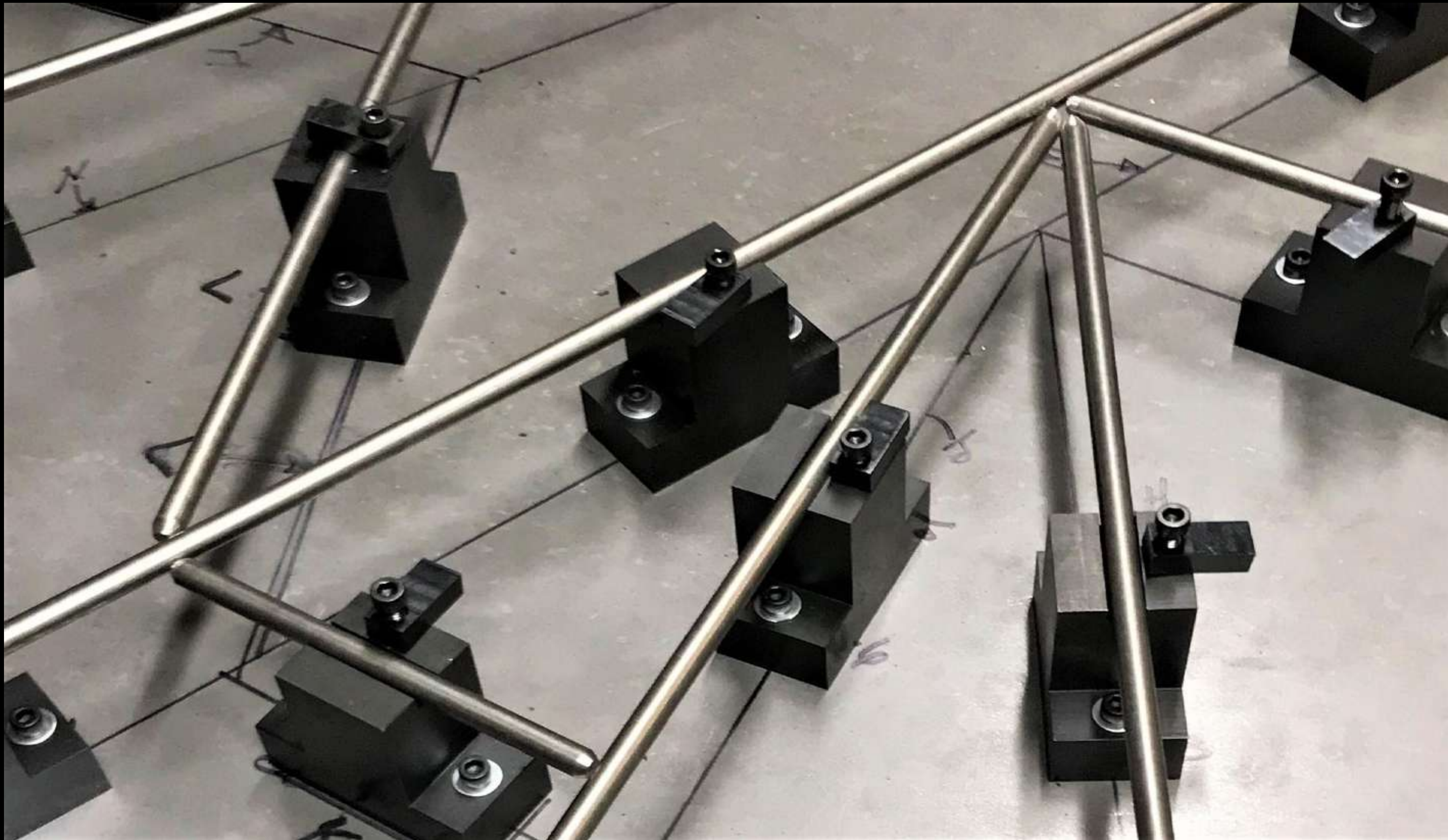


The table top ring diameter is machined into the face of each of the weld shoes to provided accurate positioning (the ring and fixtures diameters were very uniform) and positive contact for work holding the table top.

The table top ring rests on a machined face of the weld shoe elevated off the base plate.

The positioning blocks that locate the interior rod segments need to match this same plane.

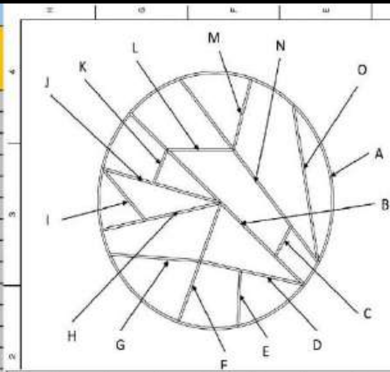
Qualifying Table Top Interior Positioning Blocks: Qualifying the table top rod segments requires me to align two or more blocks holding a rod segment along the same vector. The blocks are allowed to move perpendicular to the line defined in the base plate by the hole locations. These adjustments are made in conjunction with evaluating and qualifying the linear lengths of each interior rod segment in the table top. These qualified lengths are measured for each interior rod segment and updated on the spreadsheet, just like the leg rod segments.

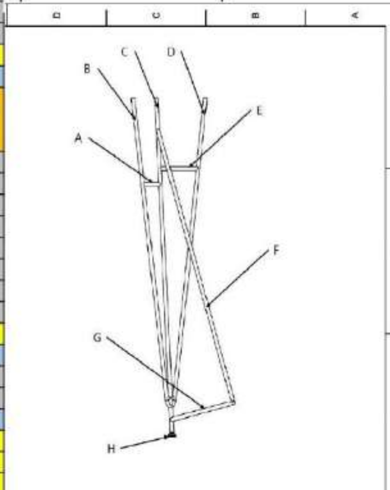


The actual linear lengths of each rod segment are very important. In replicating the table top and legs, I will be cutting steel based on the size indicated on the spreadsheet for the designated component. For example, if I am cutting steel for the center leg and I am making 10 tables, I need to cut 40 pieces of 3/8 steel bar the same length. Replicating the qualified dimensions allows me to pencil grind the weld relief into the rod segment with minimal time spent on sizing the component. Nonetheless, every piece loaded into either of these two weld fixtures must be custom ground and fit into position.

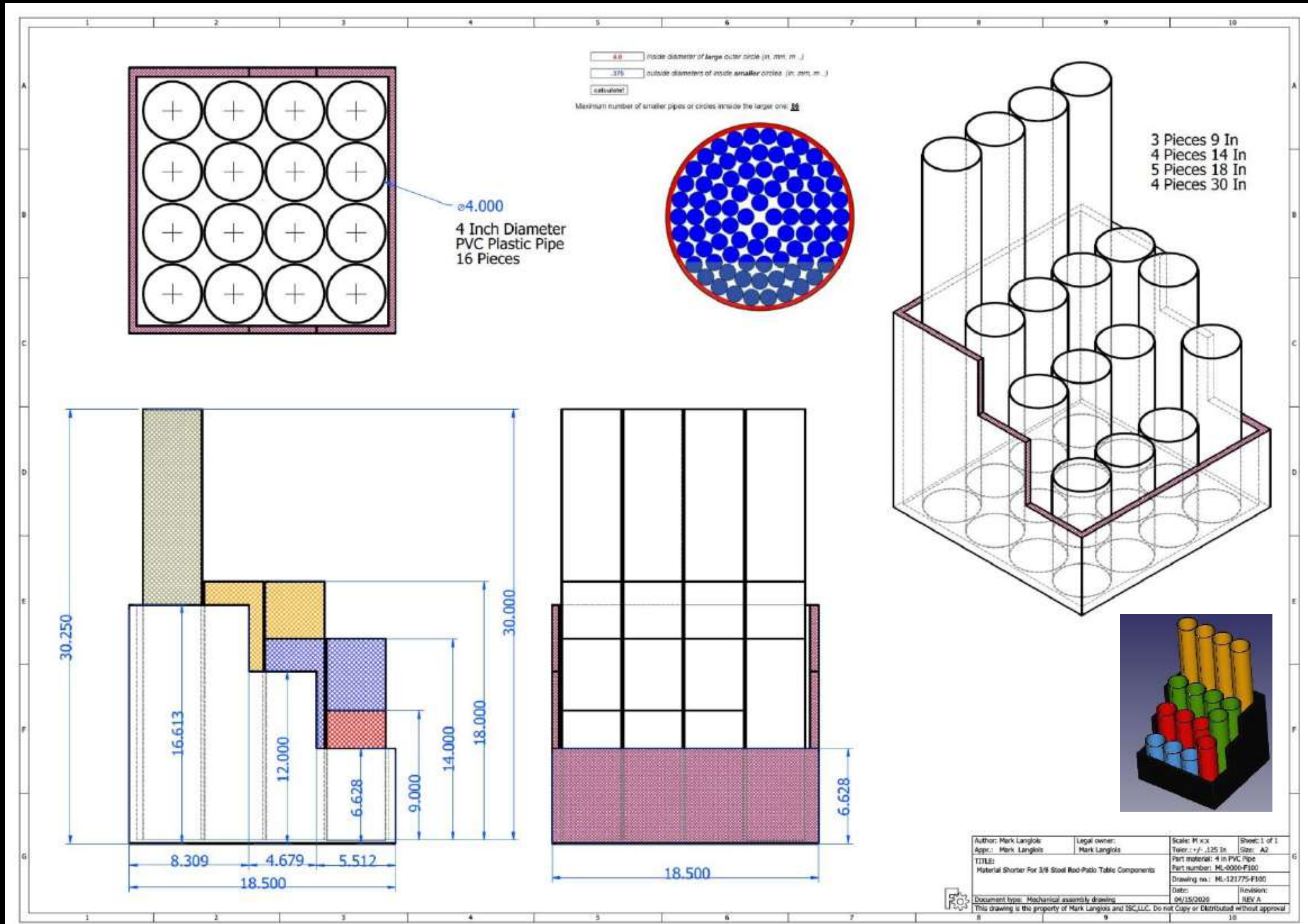
The Table Top And Leg Weld Fixtures Are Now Qualified: In the background of this shot, you can see my updated spreadsheet hanging from the cabinet. Now that I have captured all of the qualified lengths for each of the table's component rod segments, its time to cut a lot of 3/8 steel rod to make these tables.

Patio Table Top Component Chart					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	156.0000	156.0 Inches	13.000	4.888	1
B	41.5000	41-1/2 Inches	3.458	1.300	4
C	5.3125	5-5/16 Inches	0.443	0.166	4
D	18.2500	18-1/4 Inches	1.521	0.572	4
E	8.7500	8-3/4 Inches	0.729	0.274	4
F	20.6250	20-5/8 Inches	1.719	0.646	4
G	16.0000	16.0 Inches	1.333	0.501	4
H	21.2500	21-1/4 Inches	1.771	0.666	4
I	11.0625	11-1/16 Inches	0.922	0.347	4
J	21.5000	21-1/2 Inches	1.792	0.674	4
K	5.6875	5-11/16 Inches	0.474	0.178	4
L	11.7500	11-3/4 Inches	0.979	0.368	4
M	11.5000	11-1/2 Inches	0.958	0.360	4
N	38.2500	38-1/4 Inches	3.188	1.199	4
O	24.9375	24-15/16 Inches	2.078	0.781	4
Totals	412.375		34.365	12.921	57
Patio Table Legs (4) Component Chart 1 Leg					
Label	Optimized Linear Length In inches	Optimized Fractional Size In Inches	Appr. Linear Length in Feet	Material Weight in lbs	Material 1018 Num Welds
A	1.6875	1-11/16 inches	0.141	0.053	4
B	27.1875	27-3/16 Inches	2.266	0.852	4
C	30.0000	30.0 Inches	2.500	0.940	4
D	27.4375	27-7/16 Inches	2.286	0.860	4
E	3.7500	3-3/4 Inches	0.313	0.118	4
F	30.3750	30-3/8 Inches	2.531	0.952	4
G	16.6250	16-5/8 Inches	1.385	0.521	4
H	0.0394	N/A	0.003	0.001	0
Totals	137.102		11.425	4.296	112
Total Approx. Patio Table Base & Top--Linear Length and Weight					
A	Linear Length ft.		80.065		
B	Table Weight lbs		30.105		
Total Welds, Top, Legs, Leg to Table Top, Center Bars To Center Bars					
A	Weld Legs to Top				12
B	Weld Center Bars To Center Bars				8
Totals	Total Number of Welds				189



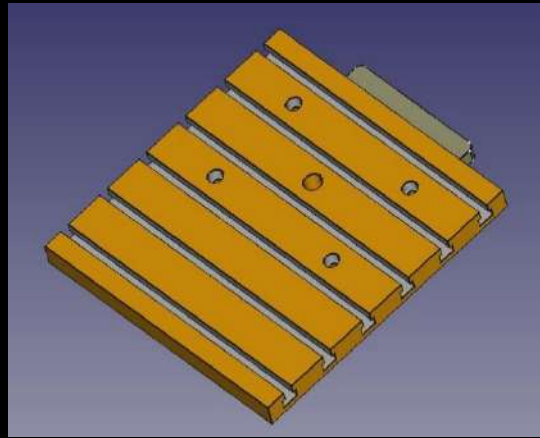
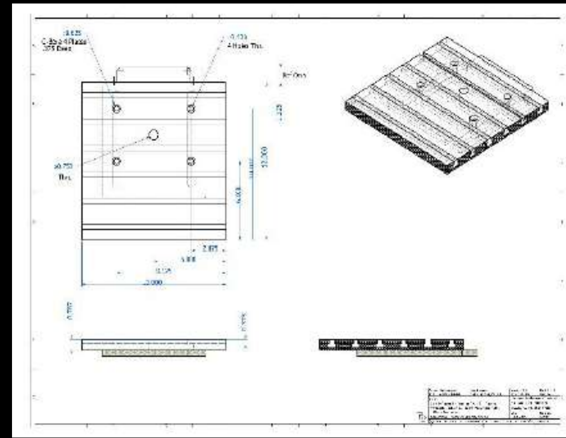


Cutting Qualified Steel Rod Segments To Length: In my table, there are 14 steel rod segments that make up the table top interior design and 28 steel rod segments that make up the 4 legs (7 steel rod segments for each leg). The spreadsheet sums the linear lengths of each of these components. From the total, I can calculate how much steel I will need to make a single table. Having purchased and finished the table top rings, each table requires 67 linear feet of steel to make. I chose to make 10 tables initially. This equates to a purchase order of 56 bars of 3/8" steel rod, 12 feet long. Total number of individual pieces to cut to the qualified length is 420.

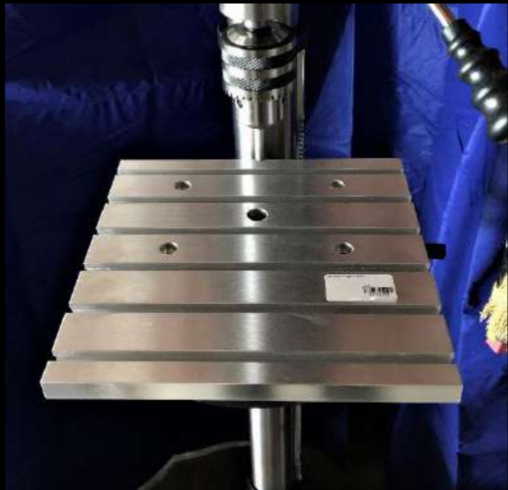


Material Handling And Organization: Because I am cutting 420 pieces of steel and the quantity and qualified length is specific to each component, I will need some organizational tools to assist me in keeping the same components grouped together as well as a way to identify each component. Prior to ordering the 3/8” steel rod to make the tables, I designed an organizer to hold each steel rod segment required to make the top interior design and each leg. In addition, a picture showing the location of where the component is in the design, along with its spreadsheet label and qualified length is on each tube. There will be over 300 pounds of steel in this organizer when all of the steel is cut.

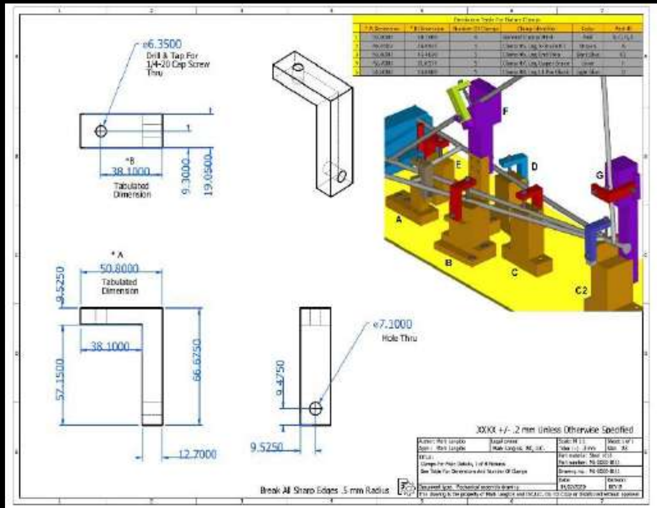
Cutting Steel: Each of the 420 steel rod components were cut on my band saw (left) to its qualified length. I measured each component again after completing the cut and placed it in the proper location in the part organizer. In spite of my gauging each piece, there will be some minor variations in size; these bars are not cut to a machined tolerance. In addition, there will be a small burr on each end of the bar to sand off before it gets custom fit into its place in the weld positioning blocks. Each tube has a picture of the specific part, its location and size. The organizer is also fitted with wheels so I can roll it around and get it out of the way.

Drilling And Tapping The Center Leg: A considerable amount of thought, prototyping and communication with vendors went into the development of how to mount the leveling feet for the table center leg. One of my major concerns was finding a leveling foot that had at least 15 degrees of articulation; the center leg is already consuming 7 of the 15 degrees of articulation just to lay flat, due to the inboard angle. I wanted the center legs to be able to adjust at least 1 inch in height. My options were to use a sleeve or drill and tap the center leg. I chose to drill and tap the center leg for aesthetic appearance and also weld considerations. To make this work, I needed to acquire a new drill press, a three jaw chuck, design a tee slot plate for the drill press and get some work holding components.



I mounted the tee slot table on the drill press with the thru holes aligned. The three jaw chuck was mounted and aligned with the center of the drill press spindle and clamped down. I needed the new floor standing drill press to allow the 30 inch long center leg to load from underneath the drill press table and pass up through the chuck center hole. I used a magnetic torpedo level as a stop gauge to locate the center rod height in the chuck. Each center leg rod was center drilled, then tap drilled. Following that, I lowered the drill press table and hand tapped each leg . I tested each tapped hole to make sure the it was deep enough for the 1-1/4 inch leveling foot thread.

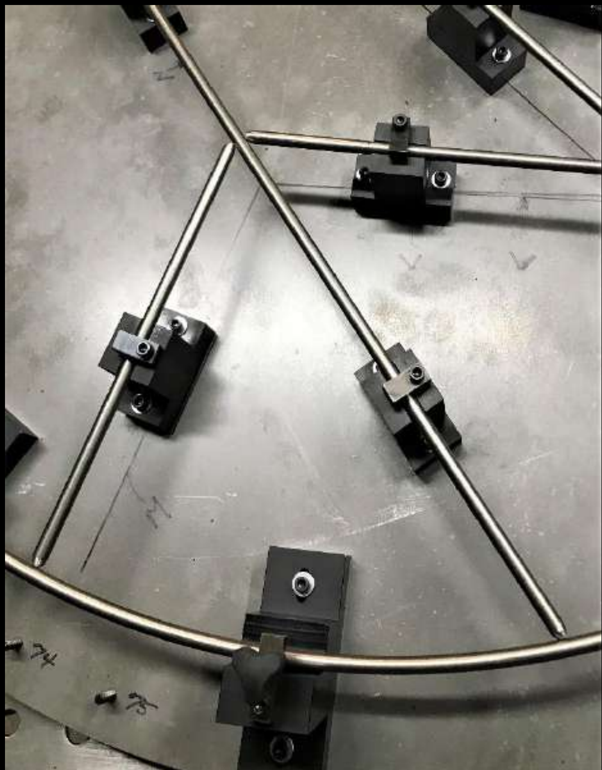


Making The Leg Fixture Clamps: I didn't have the leg fixture clamps CNC machined with the positioning blocks, to save money. I made them myself using two pieces of 3/8 steel plate. First, I angle ground weld relief on both sides of the plate and welded them together. Then, I cut the weldment on the bandsaw according to the clamp drawing dimensions. Next, I positioned each clamp in a compound vice on the drill press to drill the thru hole on the bottom for a 1/4-20 cap screw and the other hole on the top; drilled and tapped for a 1/4-20 screw. There are 8 clamps in the leg fixture to secure the rod segments.

Completed Leg Fixture Clamps: Like the fixture positioning blocks, I had all of the leg fixture clamps coated in black oxide to prevent rust as well.

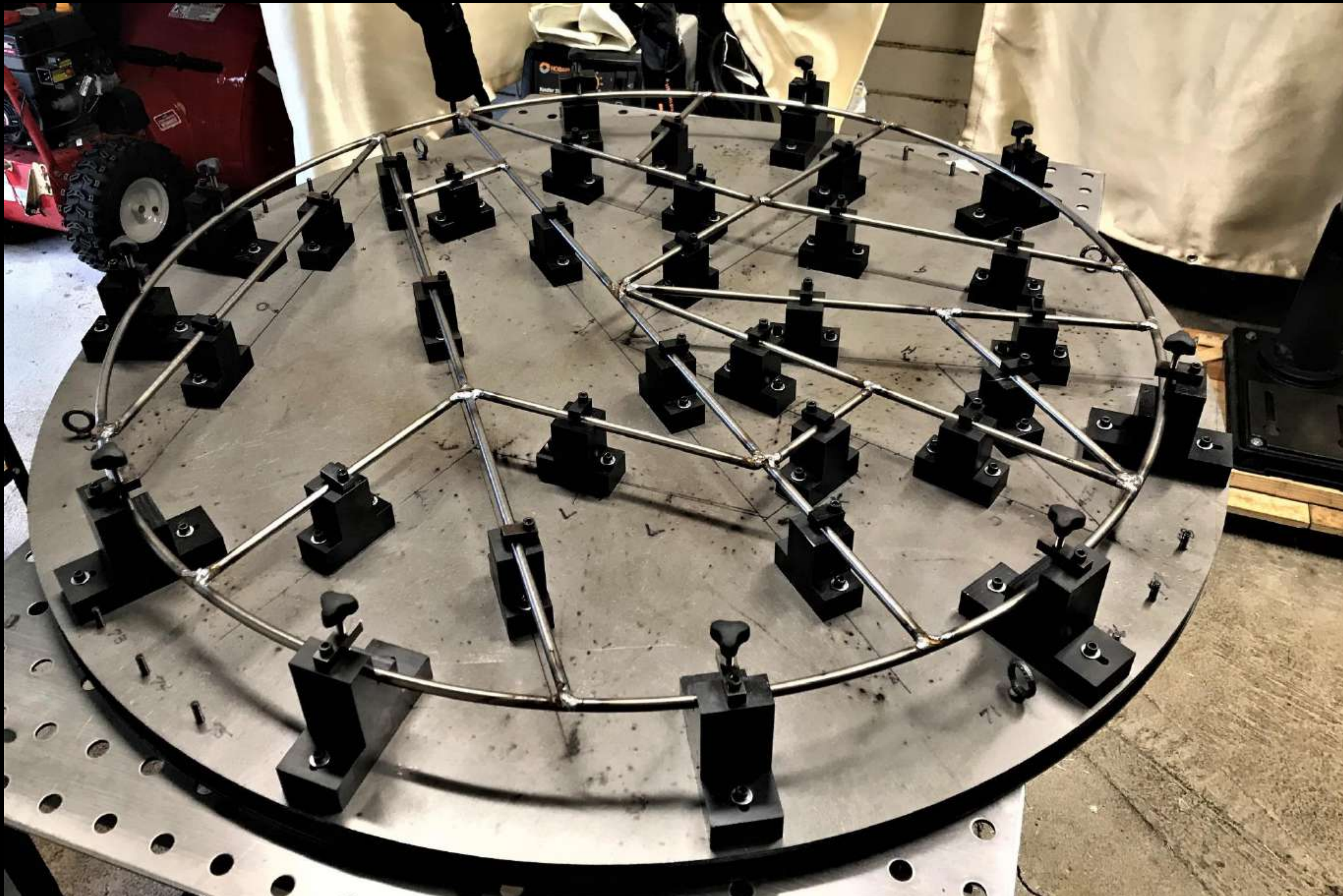
A & B Side Welding: Each steel rod component welded in the construction of the table requires welding both the front and back sides. The 3/8" round steel rod when welded on the "A" side fills in the weld area around only half of the diameter of the bar. In the picture on left, the "A" side weld is complete. Flipping the welded sample over shows what remains on the "B" side on the right. The "B" side must be welded for two reasons; for strength and integrity of the welded component and because the tables "B" side will be a visible show surface on many parts of the table. Both the A & B sides must be welded and finished.

Pencil Grinding The Rod Segments For Welding: Each end of the steel rod segments that make up the interior design on the table top and in the construction of each leg requires, "pencil grinding“; a relief between the bars before welding. The “pencil grind” at each end of the rod segment allows the weld to flow into the spaces between the intersecting bars. This space filled with weld creates additional surface contact on the steel bar and adds weld mass, creating a strong weld bond. Because each rod segment is "pencil ground", the weld must fill in all of the gaps around the relief areas. After I have finished welding a rod segment, the pencil ground relief areas should not be visible.



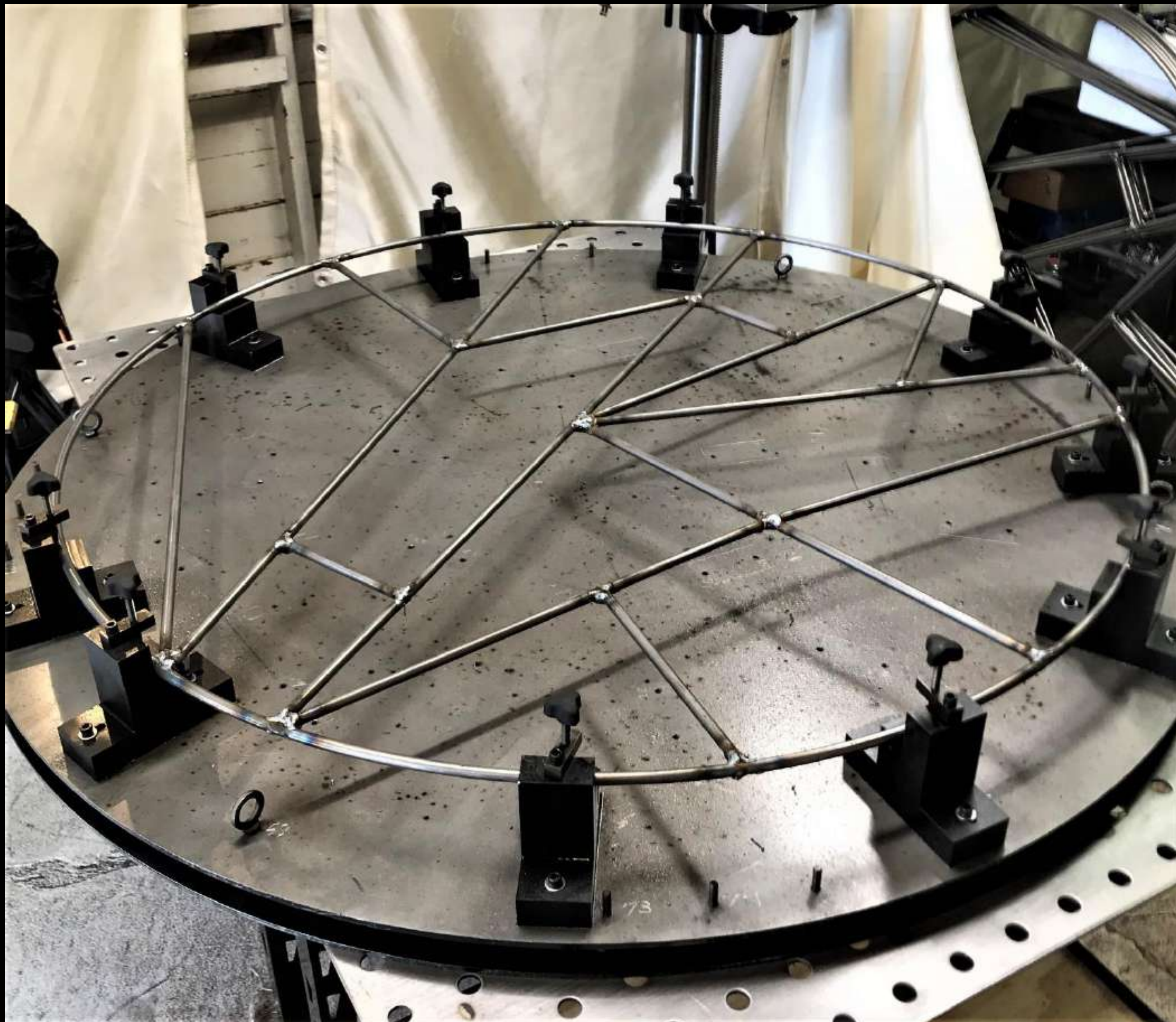
Creating Weld Transitions: In the solid model of my table design, the steel rod segments intersected each other so they could become a single solid model. If the top and legs were made of cast steel, it might be possible to incorporate the blend transitions between each rod segment intersection. However, because the table is welded, these blend transitions do not exist. When I am welding the individual rod segments, it is not enough to simply weld the components together and cover the “pencil grind”, I must also weld the components to deposit enough weld material to create and finish a smooth, natural looking transition between the components. I found it to be a challenge to create and control these component weld transitions for finish.

Welding The "A" & "B" Side Table Top Interior Design: After I custom fit each rod segment into its designated position for the interior design, it's time to weld the table top "A" side.



Welding The "A" & "B" Side Table Top Interior Design: I have completed the first “A” side welds for table top 1. I must repeat this process for each of the remaining 9 table top “A” side rings. Each rod segment is positioned in the correct location, custom fit to size, pencil ground, clamped in the fixture and welded.

Welding The "A" & "B" Side Table Top Interior Design: I have now completed welding the “A” side interior rod segments for all 10 table top rings.



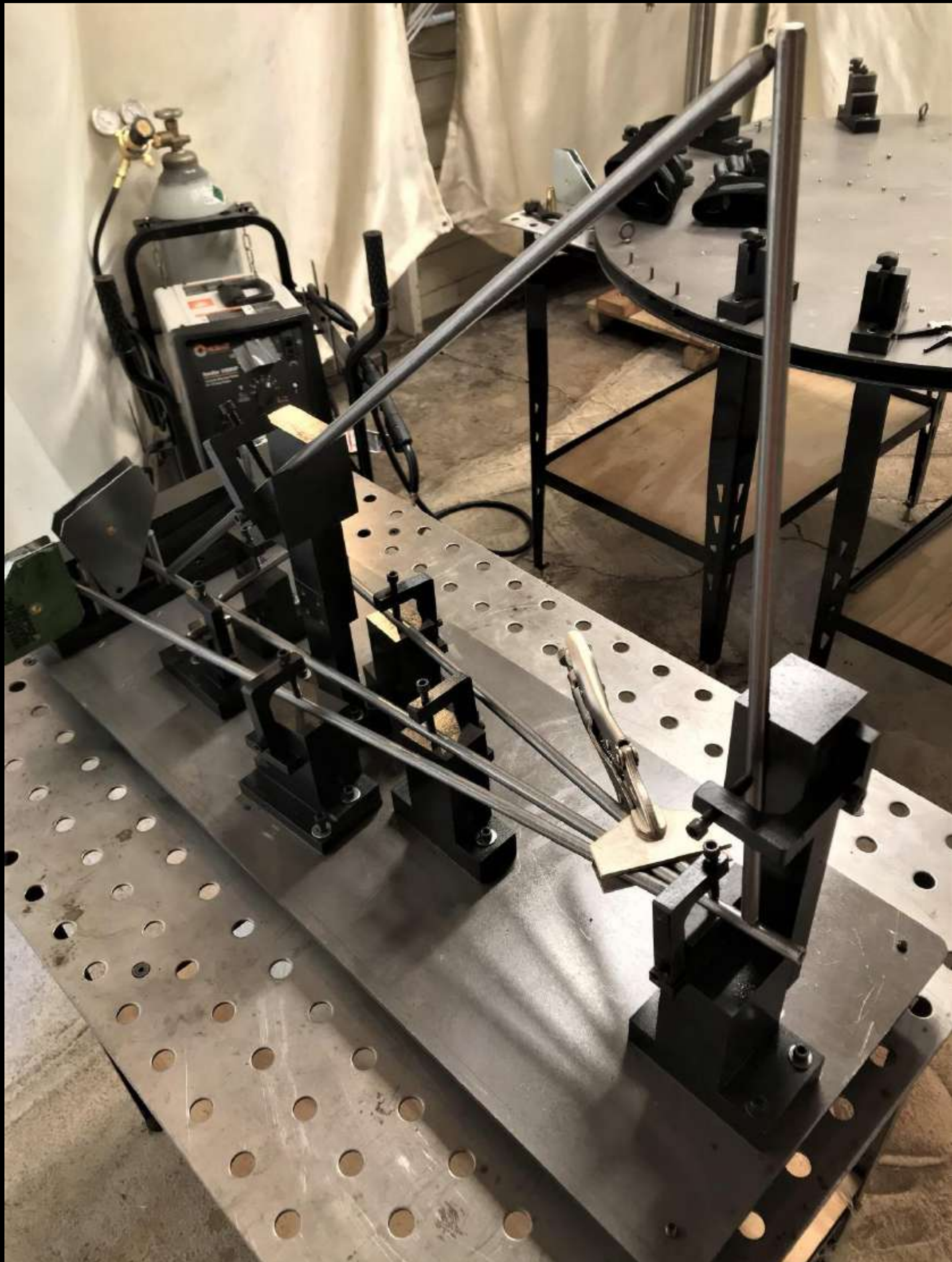
Welding The "A" & "B" Side Table Top Interior Design: To weld the "B" side of the table top, I must remove all of the interior positioning blocks. They cannot be on the base plate because all of the welded rod segments are in a different position when the top is turned over to the “B” side. All I need to do, is clamp the table top ring to hold it in place and weld each table top segment on the "B" side.

Creating Semi-Finished Transitions On The Welded Tops: I have finished welding the table top interior design on both the "A" and "B" sides. My next task is to rough grind each individual weld and then hand file them to create a smooth, natural looking transition, between each intersection on both the "A" and "B" sides of the table top.

Creating Semi-Finished Transitions On The Welded Tops: The most labor intensive process in the construction of these tables is developing the weld transitions. Power tools can only get me so far in the process and the rest of the transition must be hand filed. Each pass I make with the grinder or file removes weld material from the joint. The trick is to leave as much weld in the joint as possible and still create a transition that looks natural and flows as part of the design.

Creating Semi-Finished Transitions On The Welded Tops: The weld shoes on the base plate serve as a work holding device while I am developing the weld transitions. I can rotate the table top ring and grind or file the intersections without it moving. In the shot above, I have all of the semi finished transitions completed, with the exception of the one in the center. It takes me approximately 40 man hours to complete the "A" & "B" side transitions for one top.

Creating Semi-Finished Transitions On The Welded Tops: I have completed semi-finishing the welds for the “A” and “B” sides on table top 1. Only 9 more to go.



Welding "A" Side Legs: I found that welding the legs is a much more involved process than welding the table top. There are only 7 steel rod segments, however they are positioned in close proximity to each other.

The center rod segment has a tapped hole in the same location where the lower center brace must be welded. The tapped hole creates a thin wall of steel where the rest of the rod segments are solid. I don't want to melt through this thin wall when I weld the lower center brace.

The legs also need to be welded in a specific order so that the angles and heights remain in place. I need to make sure that the center rod segment is in plane with the upper and lower center braces when I weld them.

Just like the table tops, I must “pencil grind” and custom fit each of the leg rod segments in the fixture. Forty leg components need to be made (280 pieces) to mate with the 10 table tops.

Welding "A" Side Legs: The first components I am welding are the two cross braces that tie the right and left leg rod segments to the center rod segment.

The magnetic welding squares attached to the radial stop block are clamping the right, left and center rods to the dowel pins.

The two cross braces must fit exactly so they don't push the leg components off the pins when I clamp them into the fixture.

Welding the cross braces first will keep right left and center rod segments positioned at the correct spacing on the radial diameter.

Welding "A" side Legs: The next component I am welding is the upper center brace to the leg center rod segment.

I used a magnetic square to align the upper center brace to the center line of the center rod segment. The outside diameters of each rod will be tangent to the face of the square.

The square is aligned to the center rod and the upper center brace follows. These welding magnets are quite strong and very handy to work with.

I must tack weld the upper brace to the center rod first, remove the magnet, and then finish this "A" side weld.

My other goal here, is not to weld the magnet to either of the rod segments. It’s a tight fit in this spot.

Welding "A" Side Legs: Welding the lower center brace to the center rod segment is my next weld to make.

This weld is made where the 1/4-20 tapped hole is located, at the end of the center rod.

Welding these components creates a lot of heat and it may impact (shrink) the internal threads in the center bar.

I must be careful not to melt the thin wall of this part of the bar creating a hole or getting weld on the internal threads when welding this lower center brace.

I will have to run a tap back into each of these threaded holes after welding both the "A" & "B" sides, to clean out and smooth any thread distortion.

Welding "A" Side Legs: Next, I am welding the ends of right and left rod segments to the center rod segment.

I used a magnetic square to align the upper center brace in a previous weld. In this case, I am using a sheet metal vice grip which has a wide, straight, flat face to clamp all three bars.

This clamp attaches to the top and bottom outside diameters of all three rods, keeping the right and left rod segments on the center line with the center rod segment.

I tack welded all three rods in position first, removed the vice grip clamp, and finished welding the rods.

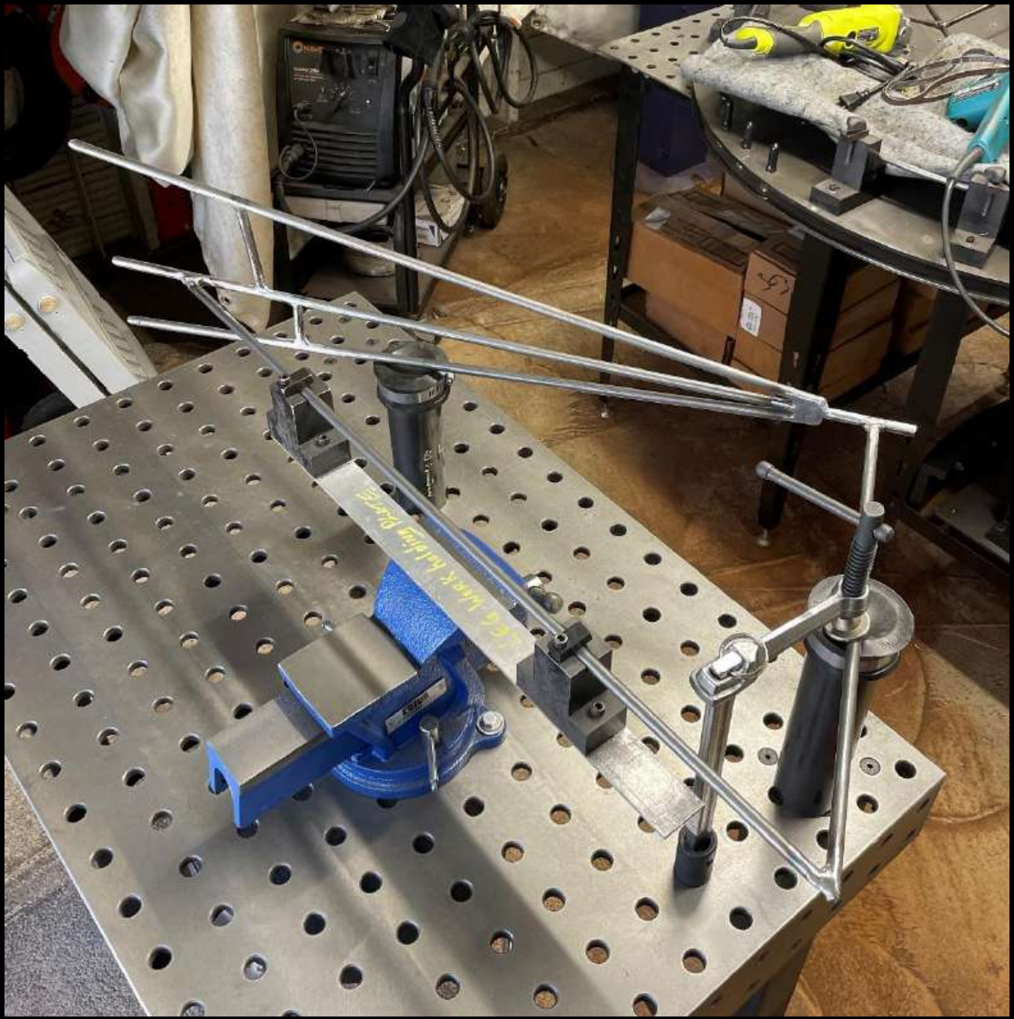
There is a considerable amount of weld that goes into joining these three components at this junction.

Welding "A" Side Legs: My last weld in creating the leg component is joining the upper and lower cross braces that meet at the table's center. The sheet metal vice grip clamp I used on previous page was also used here to align both the upper and lower rods on center. The rods were tack welded, the clamp removed and finish welded. There are 8 welds on the "A" side to complete the leg component from the 7 rod segments.

Welding "A" Side Legs: I have completed the "A" side welds on the first leg component and it has been removed from the fixture. On one of the table's 4 leg components, I need to weld my signature plate on the underside of the lower cross brace. This signature plate is a laser etched stainless steel bar with my name on it as the designer and creator, along with its registration number. The signature plate provides identification and authentication for each table made.

Welding "B" Side Legs: Welding the "B" side of the leg component was a much easier task then welding the "A" side, now that the leg is a solid component. I was able to leverage the weld fixture used for the '"A" welds as a work holding device by clamping the upper cross brace to the upper cross brace positioning block and locating the legs on the base of the radial stop block. Completing the "B" side welds on the outside of the leg went rather quickly. I used the white fire blanket to cover the fixture to keep weld and weld splatter off the components underneath.

Welding "B" Side Legs: I have finished welding 16 leg components thus far. There are 8 legs on the base plate and another 8 hanging up in the background on the left. Pictured on the right, I have 10 welded table tops hanging on the wall; four of the 10 tops are semi-finished. My plan is to semi-finish 8 legs and weld them to 2 of the semi-finished tops. I want to take 2 of the tables through to completion first, so that I can resolve any technical issues that may come up in the assembly and finish process before starting any more.



Semi-Finish "A" & "B" Side Legs: Semi-Finishing the leg components is a bit of a challenge. I had to come up with a way to hold the leg down firmly without bending any of the rod segments. I repurposed a couple of my interior positioning blocks and attached them to piece of 2” aluminum angle bar. I clamped that into a vice. Then cut steel tubes different sizes and put rubber caps on the top to support the work. This allowed me to swing the leg into different positions and access the interior welds. Still, developing the weld transition areas on the legs is more difficult and time consuming. It took me roughly 16 hours to semi-finish one of the leg components; grinding, sanding and hand filing.

Semi-Finish "A" & "B" Side Legs: In the shot on the left, I have a set of 4 legs semi-finished, ready to weld to table ring #1. I am working on the other 4 legs for table ring #2. The ends of the upper and lower cross braces that will meet in the table's center are not semi-finished; they are ground smooth, and free of dirt and weld splatter. The leg center braces are all welded together after they are qualified in the assembly positioning blocks and finished after the table top welds are complete.

Qualifying Table Assembly Locating Blocks: To weld the legs to the table top ring, I have to install and qualify the assembly locating blocks. I designed the assembly locating blocks to use the threaded studs from the leveling feet; the assembly block hole locations and spacing are the same. The assembly locating blocks mount on these studs and can move in and out on the table ring diameter. The assembly blocks position the top of the leg components on the centerline of the table top ring diameter.

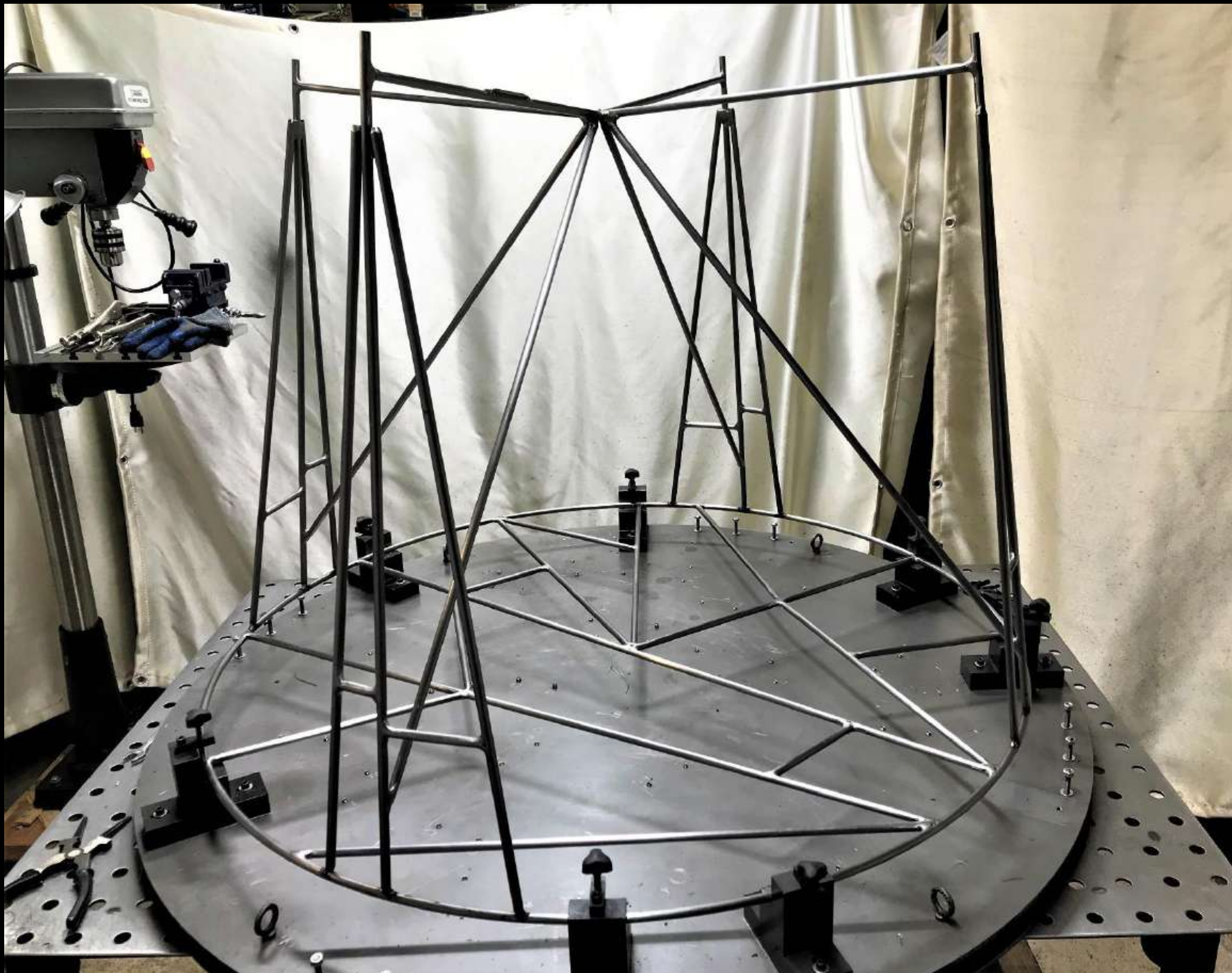
Qualifying Table Assembly Locating Blocks: After installing the assembly locating blocks, the table top ring diameter is clamped by the base plate weld shoes. The legs are then positioned in the assembly locating blocks and qualified so that the right, center and left, rod segments of each leg sit on the centerline of the table top ring. The assembly locating block clamps can be tightened or loosened so that each rod segment is aligned with the table top ring centerline.

Qualifying Table Assembly Locating Blocks: I used the assembly gauge ring to help me position the legs at the required inboard angle of 7 degrees. The position of the center cross braces will be clamped and evaluated with the ring gauge several times. In addition, I will measure each of the vertical leg heights from the base plate and take cross measurements between the legs to assist me in getting the legs into position.

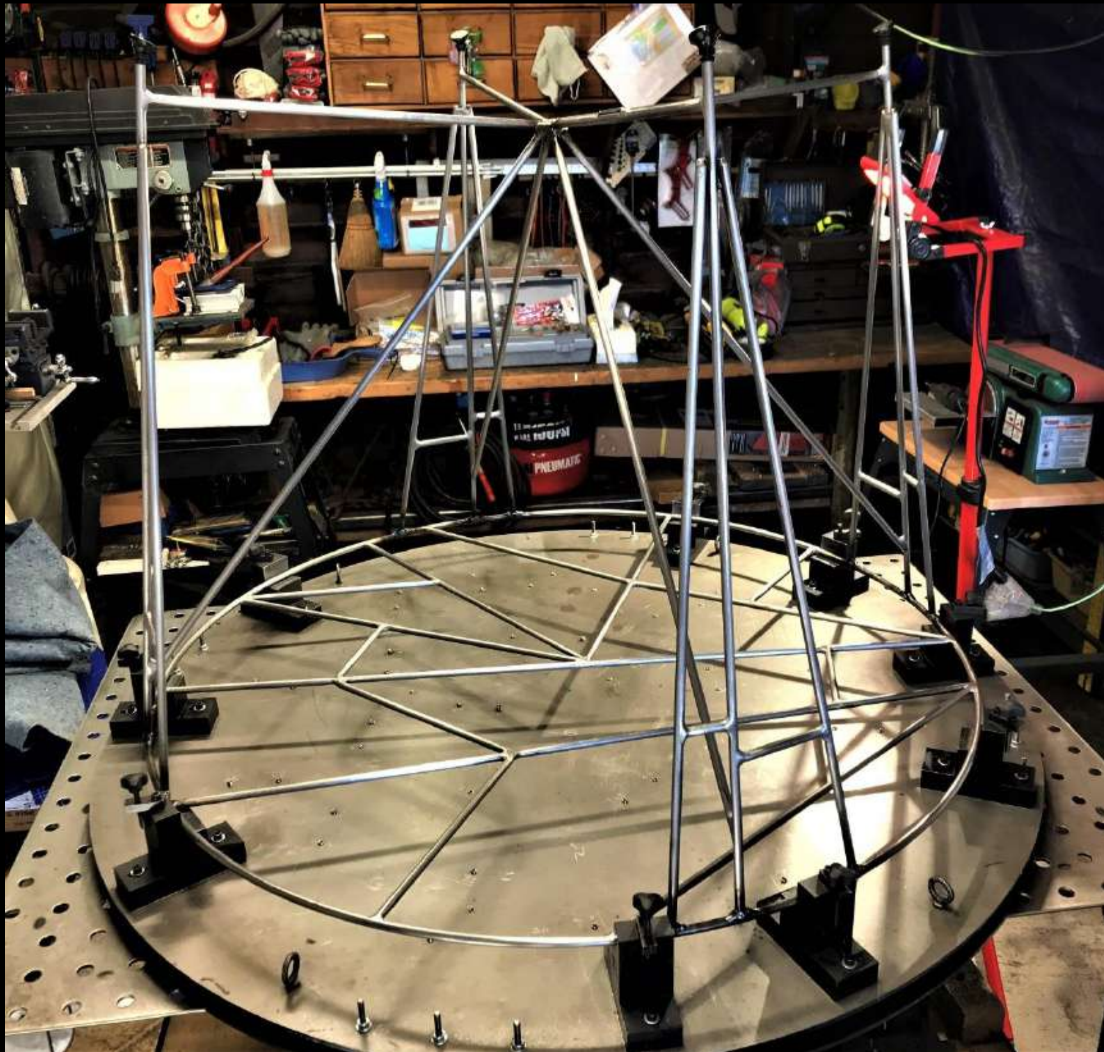
Qualifying Table Assembly Locating Blocks: Positioning and clamping the center cross braces is an important step in aligning all of the leg components to the table top. The center cross braces will be the first components that I tack weld. Once the center braces are tack welded, I can make the minor adjustments required to align the top of the legs to the table top ring. The assembly locating blocks did an excellent job in keeping the leg end segments on the center line of the table top ring.

Tack Welding Legs To The Table Top Ring: The cross braces are tack welded in the center and on the bottom of where the center braces meet while clamped with the sheet metal vice grips. I removed the clamps and then added some additional radial welds between each of the adjoining cross braces. After tack welding the center cross braces, I used the ring gauge to check on the relative position of each leg.


Tack Welding Legs To The Table Top Ring: After tack welding the 4 center braces, I can now tack weld the rod segments to the table top ring. The legs are tack welded so they are held in place on the table top ring center line. The assembly locating blocks do not allow me enough room to complete welding the legs to the top. The assembly locating blocks must be removed from the base plate and the welds finished on the "A" & "B" sides clamped in the weld shoes. The picture, above right, shows the top of the leg rod segment tack welded to the table top ring. All of the leg rod segments will have similar welds. However small these welds appear, the legs will not move.



Finish Welding "A" & "B" Side Legs To The Table Top Ring: I have all of the legs tack welded to the table top ring and I have removed the assembly locating blocks. The base plate weld shoes will serve as the work holding device so I can finish welding the cross center braces and the "A" and "B" side welds for the legs to the table top ring. The leg "A" side welds are on the outside diameter, the "B" side welds are on the inside diameter.



Finish Welding "A" & "B" Side Legs To The Table Top Ring: The "A" & "B" side welds for each of the leg rod segments are now complete. Pictured bottom right, shows the finished leg segment welds. The legs segments are "over welded" to allow for the creation of a smooth, radial transition, back into the table top ring. The center cross braces are also finish welded (top right). I put a considerable amount of weld into this area to provide the necessary torsional strength and rigidity.

Finish Welding "A" & "B" Side Legs To The Table Top Ring: With the completion of the "A" & "B" side welds, I must now managed and handle the table as a single piece. I have installed the leveling feet in the center rod tapped holes as well. The table is level and strong and I am very happy with the performance of the fixtures and tooling in locating and positioning the table components. I will repeat the assembly process for table 2.

Finish Welding "A" & "B" Side Legs To The Table Top Ring: After installing the assembly locating blocks again, I repeated the process to weld the second set of legs to table #2. Tack welding first and then finish weld. Now, I have two tables with rough welding complete. The welds now have to be ground and hand filed to create smooth transitions into the table top ring.

I have completed welding the assembly of legs to the table top for tables ISC-00001 and ISC-00002.   The assembly welds now need to be ground and hand filed to create smooth radial transitions where they meet.

Semi-Finish "A" & "B" Side Assembly Welds: The table is now one single welded piece. This requires some creative adaptation in how I hold and finish the rough welds on the table top ring. The center cross brace "group welds" also have to be ground and finished. It takes me approximately 55 man hours to develop the welds into smooth transitions after one table top assembly. However, I am not working 8 hours a day on them, so it might take me a couple of weeks to semi-finish the weld transitions.

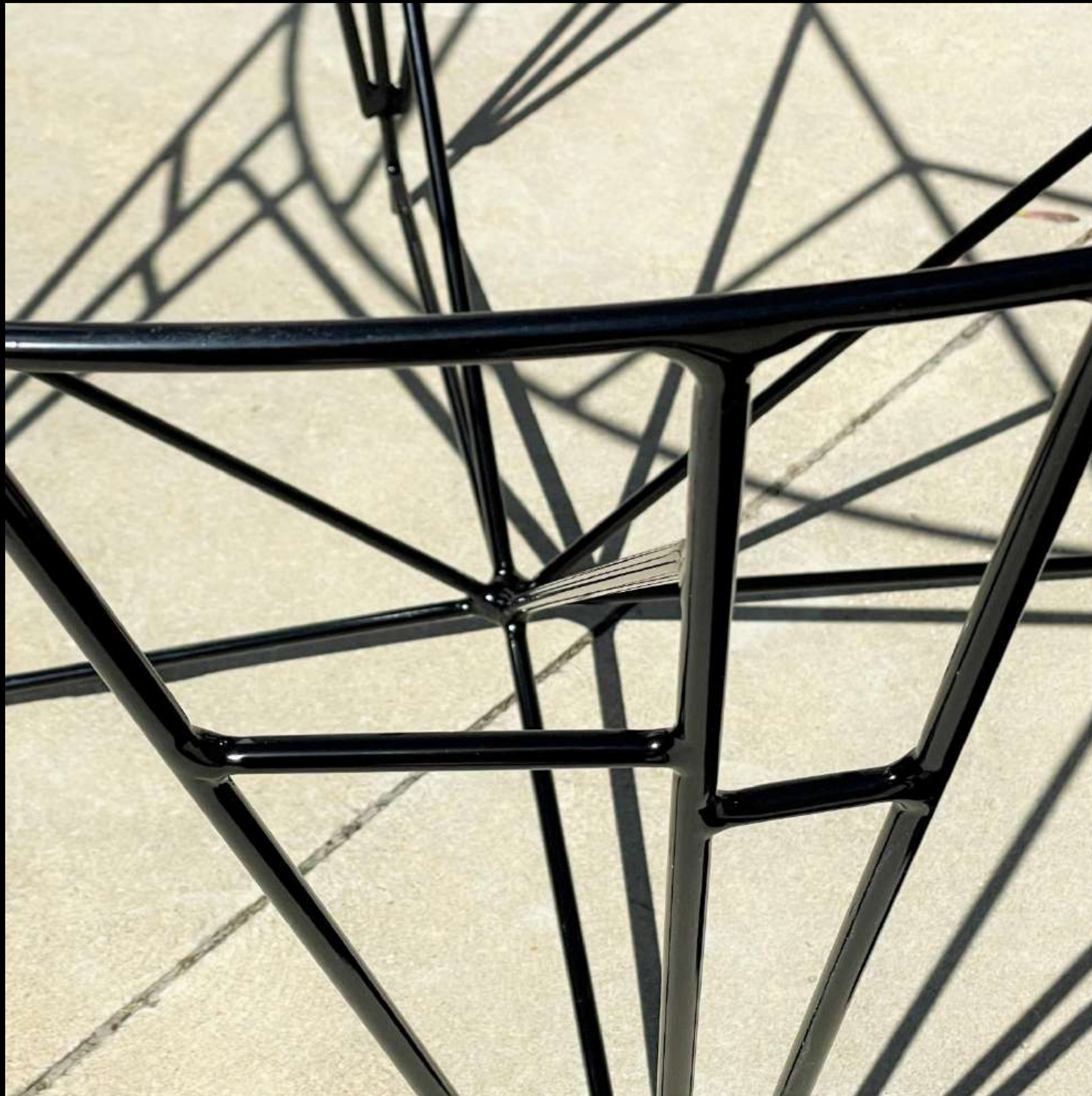
Semi-Finish "A" & "B" Side Assembly Welds: This is my table ISC-00001. It is the first table that I have welded and semi-finished. I must also get table ISC-00002 in the same condition. The next step in the finishing process is to powder coat both tables. Powder coating is a process that uses an electrical charge on the metal surface to be coated. Powdered paint when sprayed on the metal will adhere to all of the surfaces evenly. The coating is then baked in an oven at approximately 400 degrees to create a very smooth, strong and durable coating over the entire surface.

Sandblast Tables For Powder Coating: The first step in the powder coating finishing process for my tables, is to sandblast them to remove any dirt, oil, weld discoloration and loose metal fragments. The sand or media blasting process also creates a texture on the metal surface that allows the powdered paint to better adhere to it. My once shiny metal tables are now a dull gray color after sandblasting. The sandblasting was performed by my powder coating vendor as part of the powder coating process.

Powder Coating Tables ISC-00001 & ISC-00002: Next, I need to choose a powder coating color to apply to my tables; that can be a challenge. There are thousands of colors to choose from and custom colors can be mixed to create your own unique color. In this case, the color choice for coating both of the tables was Gloss Black. The sample shown above is for reference only.

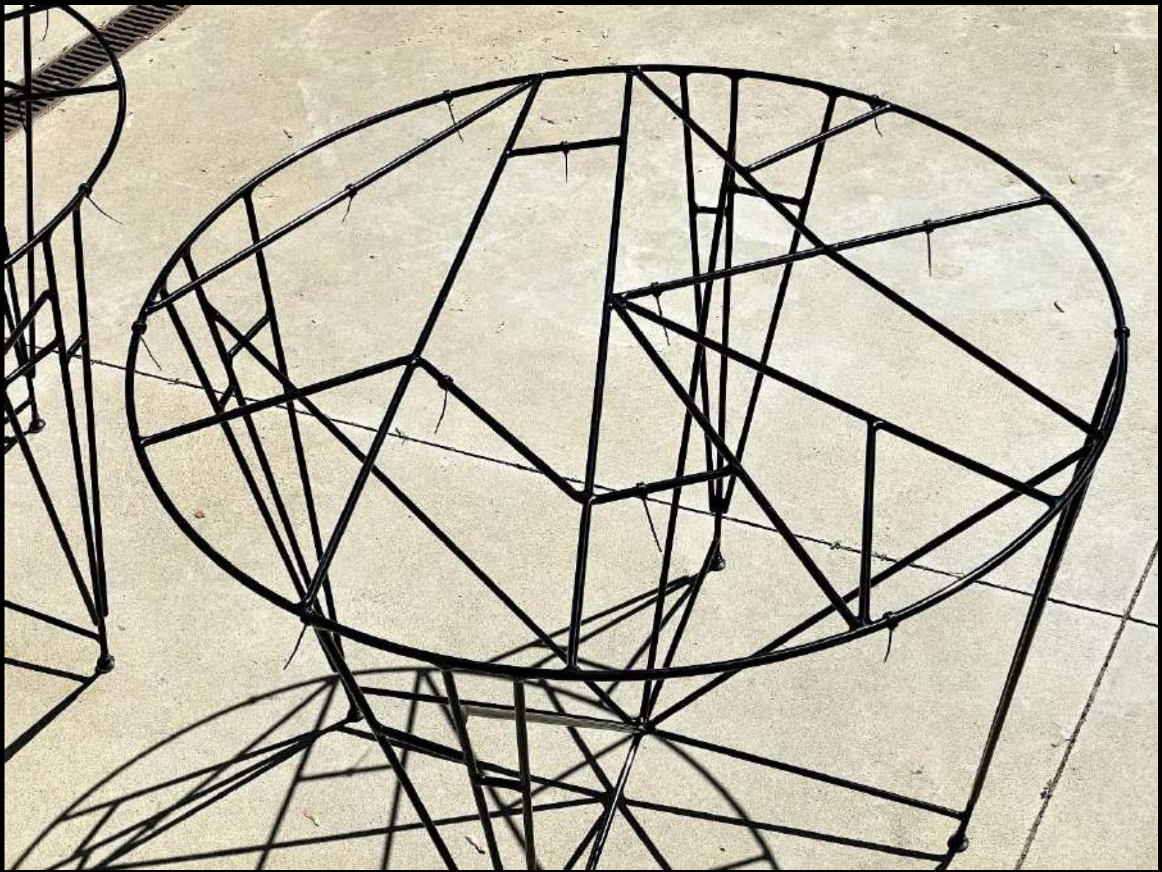
Powder Coating Tables ISC-00001 & ISC-00002: Time to powder coat. I have delivered my two tables to the powder coating vendor to get coated and baked in the oven.

Powder Coated Tables ISC-00001 & ISC-00002: Powder coating is complete. My tables have been powder coated in the gloss black color that was selected.



Powder Coated Tables ISC-00001 & ISC-00002: The coated table finish and texture is smooth, very high gloss in color and coated in a uniform thickness of approximately 5mm.

Tables ISC-00001 & ISC-00002 Install Leveling Feet (Pads Optional): Now that the tables are powder coated, I can re-install the table's leveling feet into the leg center rod. The Leveling feet swivel on a ball, allowing 10-15 degrees of articulation and up to 1 inch of height adjustment. The leveling feet are made of steel. If the table is going be placed on hardwood flooring or tile, I will apply a felt pad to the bottom of the feet to prevent any damage to the floor and it can be moved easily.

Tables ISC-00001 & ISC-00002, Install Table Grommets: The plate glass I ordered that will sit on the table top is a 1/2 inch thick, 48 inches in diameter and weights 80 lbs. The glass top cannot sit directly on the powder coated steel; it needs a flexible cushion and something to keep it from sliding around. I decided to use rubber grommets with an outside diameter large enough to provide adequate cushion for the plate glass top and an inside diameter that fits the steel rod. The grommets are cut so they open and are strategically placed on the outside diameter of the table top ring and on the rods in the interior. The grommets by design, have a groove in the center. The groove allowed me to use a thin but strong zip tie to hold them in place. I found this approach to work very well to cushion the glass and keep it in place, while keeping the glass top off the steel surface.

Table ISC-00001 Complete

Table Construction Details:	
Material: 1018	3/8, 1018 Cold Rolled Steel, 57-12 ft. Bars
Steel Bar, Total Linear length, 1 Table	80 Linear Feet
Circular Ring, Top 42 Inches Diameter	13 Linear Feet
Top & Components	64 Linear Feet
Single Leg	11.5 Linear Feet
4 legs	45.7 Linear Feet
Table Top Construction	15 Steel Components
Leg Construction (1 Leg)	7 Steel Components
Center Leg Construction	1 Leveling foot, Tapped Hole, ¼ -20 Thread
Top, Number of Welds	57 (1 Butt Weld For Circular Ring)
1 Leg, Number of Welds	28
4 Legs Number of Welds	112
Mating welds, Legs To Top	20
Total Number Of Table Welds (A & B Sides)	189
Top Diameter	42 Inches
Top Diameter With Glass	48 Inches
Table Height	30 Inches
Table Leg Angle	7 Degrees Inboard From Vertical
Table Weight	30 lbs.
Glass (1/2 Inch Beveled Plate Glass)	82 lbs.
Weld Base Plate, ¼ A36 Steel Plate (Top)	48 Inches Diameter
Weld Base Plate (Top)	86 ¼ -28 Tapped Holes
Weld Shoes & Clamps, 1018 Steel (Top)	10
Weld Positioning Blocks & Clamps, 1018 Steel (Top)	24
Weld Base Plate, ¼ A36 Steel Plate (Legs)	12 X 24 Inches
Weld Base Plate (Legs)	26 ¼ -28 Tapped Holes
Weld Base Plate, Positioning Blocks & Clamps (legs)	10
Assembly Weld Blocks & Clamps, 1018 Steel	4
Assembly Ring Gauge, ¼ A36 Steel Plate	1
Weld Method, MIG Welding, Gas Shielded, Wire Feed	.035 Wire, Gas: Argon 75% / CO2 25%
Approx. Man Hours To Weld, Grind, Finish 1 Table	320