2024 *FIRST*® Robotics Competition

KitBot Instruction Guide

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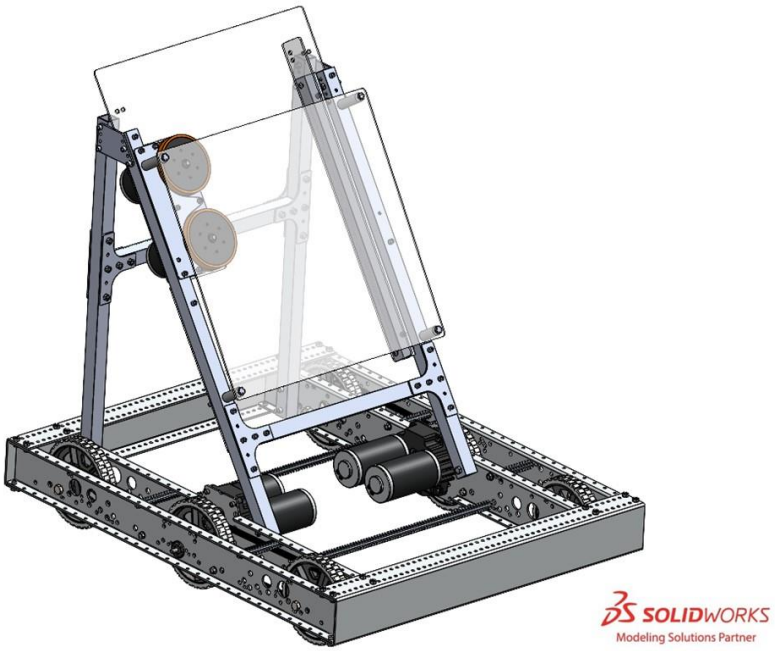
Figure 1: 2024 KitBot



The KitBot for CRESCENDO℠ presented by Haas is capable of completing the following actions. Some actions will need the team to explicitly add code to make this possible (e.g. Auto code):

- Drive around the field (other than under the Stage) using a differential drivetrain (also commonly referred to as "tank") geared for a top achievable speed of ~15 feet per second (~4.5 m/s).
- Pre-load a Note for use in auto
- Score Leave points
- Score Notes into the Speaker
- Collect Notes from the Source
- Play defense

This is a fairly basic set of capabilities with respect to all of the possible tasks in the game. Additionally, the KitBot has been designed to keep things very simple, which means there may be opportunities to iterate and improve on the existing capabilities it has. With this in mind, teams may choose to add additional components to allow the robot to pick game pieces up off the ground, climb on the stage, or more! Teams can reference the KitBot Enhancement/Iteration Guide for a process to explore these improvements.

Thanks to the community member who helped us create the KitBot Design and to Team 118 and their Everybot project for providing inspiration and allowing us to utilize pieces of their previous documentation in these instructions. No details of the game, or this design, were shared with Team 118.

2 Before you get started

2.1 AM14U Integration

While the KitBot superstructure could feasibly be integrated with a variety of drivetrain shapes and types, it is designed to most easily integrate with the AM14U chassis constructed in the long orientation. If your team has sufficient resources, assembly of the AM14U, electronics, and KitBot superstructure may all be done in parallel up to a certain point.

2.1.1 AM14U Assembly

Follow the AM14U instructions for the Long Chassis. It is recommended to pause AM14U assembly at Step 10 (gearboxes and motors installed, wheels and outer frame rails not yet installed) in order to most easily attach the KitBot Superstructure for the first time.

After the KitBot Superstructure holes are drilled, you may optionally choose to remove the superstructure while completing the chassis build and electronics installation. Resume the AM14U assembly through to the end with the only modification being to relocate one of the Churro Standoffs from Step 17 from the recommended location (your KitBot Superstructure will be attached there) to a nearby available hole.

2.1.2 Electronics Board

In order to avoid interfering with the KitBot Superstructure, it is recommended to utilize the Option 2 electronics board from the Robot Quick Build documentation.

You can cut and wire this electronics board outside the robot (with the exception of the motor controller -> motor connections) in parallel with the chassis and KitBot Superstructure construction. Make sure to add two additional Spark MAX motor controllers (available in the Black Tote) to control the Note launching wheels. After the KitBot Superstructure has been attached, you can maneuver the board into place and make the motor controller -> motor connections.

2.2 Fasteners and Hole Sizes

There are a few locations on the KitBot superstructure where specific fasteners are required. See the Fasteners section for details on what is required.

All other fasteners are specified as #10-32 but may be modified based on team preference and fastener availability. The plates provided in the Black Tote have 0.201 in. holes suitable for 3/16 in. rivets or #10-32 bolts. These holes may also be a loose fit for a M4.5 bolt or a tight fit for M5 (may need to be opened with a slightly larger drill). For all through hole hardware, teams should drill the appropriate size based on the hardware they choose as noted in Table 1.

Table 1: Drill Bit Size for Common Fasteners

Hardware	Recommended	Tight Fit	Free Fit
#10-32 Bolts	#7 (.201 in.)	#9 (.196 in.)	#7 (.201 in.)
3/16 in. Rivets	#7 (.201 in.)	#11 (.191 in.)	#9 (.196 in.)
M5 Bolts	5.5 mm	5.3mm	5.5mm
5mm Rivet	5 mm	5mm	5.1mm
¼-20 Bolts	17/64 in.	F (.257 in.)	17/64 in.
M6 Bolts	6.6 mm	6.4mm	6.6mm

2.3 Precision Machining Tips

Here are some tools and tips to getting more accurate parts in a modest shop:

- **Squares**: A combination square can be used to easily mark lines to cut perpendicular to the edge of a piece of material. The metal "handle" slides along a ruler and can be tightened in place and provide a perpendicular edge to mark along. A "scribe" for scratching cut lines is also commonly screwed into the handle. A "speed" square or carpenter's square can help to make sure two components are at perfect 90-degree angles to one another.
- **Marking Tools:** When marking measurements, a number of tools can be used for marking:
  - **Scribe –** A scribe or scratch awl is used to make a thin scratch line in the surface being marked. This scratch is generally smaller than most drawn lines and therefore can be more accurate. This can be used in conjunction with a sharpie (make the sharpie mark first) for increased visibility (this mimics the professional technique of using layout fluid).
  - **Pen or Mechanical Pencil –** These tools can often make fairly narrow lines but may not have the best visibility when used on metal or plastic components.
  - **Sharpie –** Shows up very well on all surfaces, but generally draws thick lines. Make sure to align one edge of the wide line with the desired measurement, not the center.
- **Punch**: To make accurate holes, consider marking where you need to drill with a center punch, which will leave a small indentation that you can line a drill bit up with. Automatic punches are available which do not need to be struck to make an indentation. Always drill your holes as straight as possible. If available, teams can use a drill press to help ensure straight holes.

- **Calipers**: Calipers are sort of a very accurate ruler or tape measure – but only for shorter parts. They read the distance between the two "teeth" – if you are trying to mark a hole 4.25 in. inwards from the edge of a part, slowly slide the display section along the ruler until it reads 4.25. Then place one of the teeth against the edge of your part, and the other will measure to the point 4.25 in. from there. Use the teeth of the calipers to make a straight scratch in the metal, then change the distance to the 2nd dimension for the desired location and make a 2nd scratch. The center of the cross will be much more accurate than marking the location with a Sharpie, especially if you use a punch right where the marks cross before drilling.
- **Drill vs Drill Press**: Although the KitBot can be built with just a drill, many parts will appreciate a high degree of precision, and holes will turn out straighter and more accurately located if drilled out on a drill press. When using a drill press it is still important to use a punch as the drill bit can still wander when beginning a hole. Make sure your piece is clamped firmly and that the drill bit is lined up to come down directly at the mark from your punch.

2.4 KitBot Machining Techniques

There are two machining techniques used in multiple places in the KitBot build that require some explanation, "match drilling" and "pattern transfer."

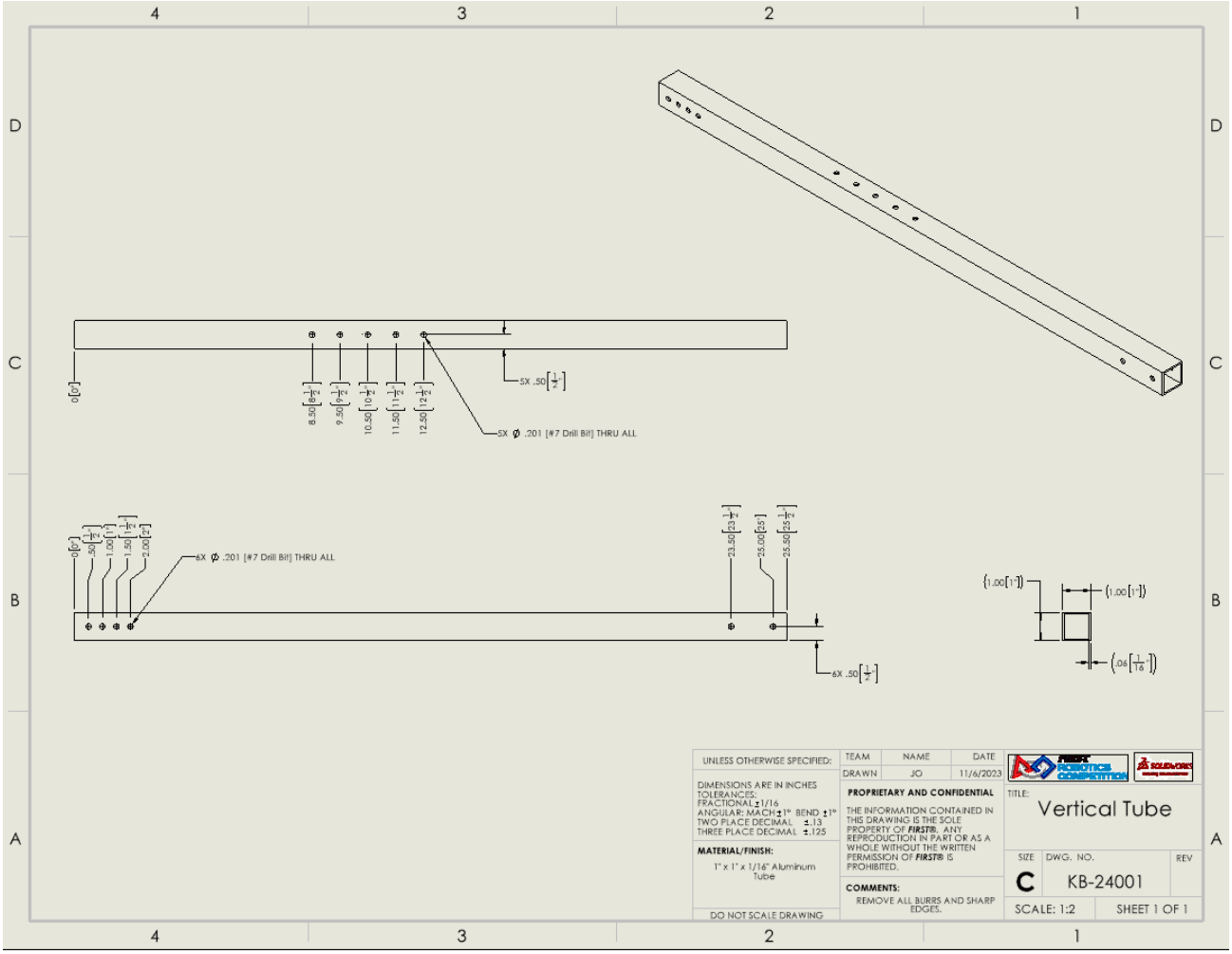
- **Match Drilling**: Match drilling is a phrase used to describe drilling a hole through multiple different components at the same time in order to ensure the hole lines up. Match drilling is helpful when precision machining (such as a mill or laser cutter) is not available and the exact location of the holes is not important, only the location of the components relative to each other (e.g., connecting a gusset plate to a box tube). In order to match drill through multiple components, first ensure the components are aligned properly according to any provided instructions, then clamp the components together to make sure they don't move while drilling. Drill a single hole at a time, filling with hardware as you go to ensure that slight movement of the parts doesn't cause misalignment of the holes.
- **Pattern transfer:** Pattern transfer is a phrase used to describe a technique of printing a 1:1 pattern of your desired part and using that pattern to directly mark or machine the part.
    - Print the template out. To verify that your printer has not scaled the drawing, measure one of the dimensions shown on the drawing, ensuring that the size matches up with the listed dimension. Then carefully cut out the image of the part to be fabricated, making sure to cut right along the outside edge of the part.
    - Secure the image to the material using double stick tape, small loops of tape, or similar.
    - You can now trace the outside geometry of the part. Or you can cut the part directly, using the template as a guide.
    - Make sure to mark the center locations of all holes, using a punch if available, before removing the template

> This technique is only needed for fabricating T-Brackets (which may be purchased as noted in Team Sourced Parts for teams who opted out of the Black Tote and need to produce Motor Mount Plates, Tube Mount Plates and/or Top Corner Brackets by hand.

2.5 Reading Part Drawings

This document uses engineering "drawings" like the one below to aid you in machining parts of the KitBot correctly.

Figure 2: Example Part Drawing



The name of the piece you are looking at is in the bottom right corner. For the purposes of this document, all dimensions directly provided will be shown in both imperial and metric units. All links to drawings within this document will be linked to the imperial version but there are also versions of the drawings using metric available.

Each drawing will generally show multiple views of the same part in order to show you all relevant dimensions and features. The overall 3D view (isometric view) can be used to help orient yourself when looking at the other (front, top, side) views.

The drawings use a few types of dimensioning.

- Ordinate Dimensioning – This is where dimensions are all indicated relative to a single origin. In a given view, the origin (generally on the left) will be marked with a dimension of "0".

Subsequent features will be marked with leader lines pointing to them and a dimension measured from that origin point along a straight horizontal or vertical line.

- Relative Dimensioning - These dimensions are indicated by a pair of lines pointing to the features that define the dimension and a set of arrows, either inside or outside the line pair. The dimension indicated is the measurement between the two features marked by the line pair.
- Diameter Dimensioning - These dimensions are indicated by a ⌀ symbol and reflect the diameter of holes. Often only a single hole will be marked with a number followed by the letter 'X' indicating how many of that size hole are on that face (e.g., 6X .201).

Technical drawings can be complicated and hard to understand initially. We suggest trying to go through each drawing slowly and mark the parts you understand down onto your physical pieces as you go. **Don't forget to double check your work before you cut and drill!**

2.6 What if I have questions or need help?

The *FIRST*® Forums contain a specific section for posting questions or discussion about the KitBot. Staff will be monitoring this forum throughout the build and competition season and will attempt to provide timely answers to all questions.

3 Materials

This section covers all the materials needed for the KitBot Structure.

3.1 Raw Materials

Table 2: Raw Materials List

Material	Qty	Info
1 in. x 1 in. Aluminum Square Tube 1/16 in. wall thickness. 8 ft. long. (25mm x 25 mm, 1.5mm wall thickness, ~244 cm long)	2	Okay to use other wall thickness if preferred. Okay to use other lengths down to 28 in., use cut list below to figure out quantity of shorter lengths.
2 ft. x 4 ft. Polycarbonate Sheet 0.118 in. thickness (~1200mm x 600mm, 3mm thickness)	1	Make sure to use polycarbonate and not acrylic. Acrylic of this thickness is likely to shatter either when machined or when subjected to the shock of robot operation. It is okay to use 0.125" instead if preferred.
(Optional) 1 ft. x 2ft. Aluminum Sheet 1/8 in. thick (~300mm x 600mm, 3mm thickness)	1	Used to make T-Brackets. Can be omitted if T-Brackets have been purchased (see Team Sourced Parts).
(Optional) – ½ in. PVC Pipe (12, 16, or 20 mm pipe)	1 ft (~300 mm)	This material is to make spacers which can also be purchased or can be 3D Printed. (see Team Sourced Parts).

3.2 Black Tote

These items come in the Black Tote which is provided to teams along with their Kickoff Kit as long as they did not opt out of this tote.

Table 3: Black Tote Parts List

Part	Qty	Info
Top Corner Bracket	2	Aluminum gusset, 2 lines of 4 holes at angle to each other (KB-24005)
Motor Mount Plate	1	Aluminum rounded rectangular plate (KB-24006)
Tube Mounting Plate	2	Aluminum T-shaped plate (KB-24007)
Wheel	2	4 in. AM Wheel (am-2647_orange)
8mm to ½ in. Hex adapter	2	am-0588_long, REV-21-1879 (also includes retaining ring and key), TTB-0044, WCP-0794
CIM Motor Hardware	4	#10-32 3/8" bolts Teams can alternatively use #10-32 x 0.625 in Socket Head Cap Screw: am-1120, REV-29-2916-PK50, or commonly available from hardware suppliers.
CIM Motor	2	am-0255, WCP 217-2000. See the game manual for a complete list of legal CIM part numbers.
Spark MAX motor controllers	2	REV-11-2158, am-4261

3.3 Team Sourced Parts

These are the parts needed for the KitBot that can be either sourced or made.

Table 4: Team Sourced Parts List

Part	Qty	Info
Motor Spacer #10 or M5 – long (0.625 in., 15.875mm)	4	Can be 3D printed from provided files. Available at many hardware stores, WCP-0203, REV (will need to use ½ + 1/8), McMaster, MSC, etc.
Motor Spacer #10 or M5 - short (0.25 in., 6.35mm)	4	Can be 3D printed from provided files. Available at many hardware stores, WCP-0308, REV, McMaster, MSC, etc.
T-Bracket	6	Fabricated (KB-24004) from 1/8 in. aluminum or purchased from am-4158, REV-21-2328-PK2, TTB-0083, WCP-1069.
2 x 2 x 10mm machine key	2	am-1121, WCP-0793, included with REV-21-1879, or commonly available from hardware suppliers as 2mm key stock to cut down.
8mm Push on retaining ring	2	am-0033, included with REV-21-1879, TTB-093, or commonly available from hardware suppliers.
1 1/8 in. (28.575mm) Spacers for 1/4 in. thread (or M6).	4	Can be 3D printed from provided files or made from PVC pipe. Available at many hardware stores, McMaster, MSC, etc.
Cable Ties	3	50lb, 14 in. Cable Ties (~5mm width, 355mm or greater length)

3.3.1 Fasteners

The are a few locations on the KitBot superstructure where specific fasteners are required:

Table 5: Required Fasteners

Part	Qty	Info
1/4-20 1.5 in. long hex head bolt (or M6 ~40mm)	4	**Required – Attachment to AM14U**. Other bolt head styles are acceptable.
1/4-20 3 in. long Hex Head Bolt (or M6 ~75-80mm)	4	**Required – Launcher Top Panel**. Other bolt head styles are acceptable.
1/4-20 Locknut (or M6)	8	**Required – Nuts for bolts above**
#10-32 1.5 in. long Socket Head Cap Screw (or M5 ~40mm)	4	**Required – Motor Plate assembly**. Other bolt head styles are acceptable.
#10-32 Locknut (or M5)	4	**Required – Nuts for bolts above**

Remaining fasteners may be nuts and bolts **or** rivets. For nut and bolt assembly the quantities and lengths of fasteners needed are listed in Table 6. These fasteners are recommended to be #10-32 or M5 but 1/4-20 or M6 will also work.

Table 6: Fasteners for Nut + Bolt Assembly

Part	Qty	Info
1.5 in. long Socket Head Cap Screw (~40mm)	41	Other bolt head styles are acceptable.
1.5 in. long Button Head Cap Screw (~40mm)	2	For attaching Launcher Rail Plastic to Launcher Rail
Locknut	43	

For rivet assembly the quantities and lengths of fasteners needed are listed in Table 7.

Table 7: Fasteners for Rivet Assembly

Part	Qty	Info
3/16 in. diameter, 0.126 in. - 0.25 in. grip range pop rivets (5mm diameter, 4-6mm grip range)	85	Aluminum or steel rivets may be used.

4 Tools

The following tools are needed to prepare & assemble the KitBot Structure:

- Safety Glasses
- Tape Measure
- Punch
- Marking tool
- Jigsaw or Bandsaw
- Drill + Drill Bits
  - #7 (or 5.5mm for metric hardware) Drill Bit
  - 17/64 in. (or 6.6mm for metric hardware) Drill Bit
  - See Table 1: Drill Bit Size for Common Fasteners for alternate sizes
- Clamps
- Flush Cutters/Diagonal Cutters
- Fastener Tools
  - 5/32 in. (or 4mm for metric hardware) Allen key
  - 1/8 in. (or 3mm for metric hardware) Allen Key
  - 3/8 in. (or 8mm for metric hardware) Open Ended Wrench or Socket
  - 2x 7/16 in. (or 10mm for metric hardware) Open Ended Wrench or Socket
  - Other tools may vary based on chosen hardware
- Digital Protractor or Phone with Level / Protractor App
- (optional) Circular or Table Saw

- (optional) Deburring Tools
- (optional) Calipers
- (optional) Square
- (optional) Pop Rivet Tool

5 Prep

The first step in building the KitBot is to gather all the Raw Materials needed for the KitBot and to prepare pieces for assembly. The KitBot assembly process heavily relies on match drilling. In this preparation step, only drill the holes indicated by the instructions, other holes indicated in images and drawings will be added later. Teams with access to precision machining equipment such as mills or CNC routers may wish to fabricate the parts, including all holes, directly from the drawing and skip all steps indicating match drilling during assembly.

> Cutting and drilling holes can leave sharp edges and burrs on both aluminum and polycarbonate. Teams should take care around machined holes and edges and may wish to use a file or deburring tool to remove this hazard.

5.1 Cut List

The following cut lists for 1 in. x 1 in. x 1/16 in. square aluminum tubing are designed around 8 ft. long pieces which are commonly available from local hardware stores. If using other lengths, you may need to re-do the cut list layout to optimize material usage.

Table 8: Cut List for Stick #1

Part	Length	Quantity
Diagonal Tube (KB-24003)	28 in. (~71.1cm)	2
Horizontal Tube (KB-24002)	16.25 in. (~41.3cm)	2

Table 9: Cut List for Stick #2

Part	Length	Quantity
Vertical Tube (KB-24001)	25.50 in. (~64.8cm)	2
Launching Rail (KB-24009)	19.50 in. (~49.5cm)	1

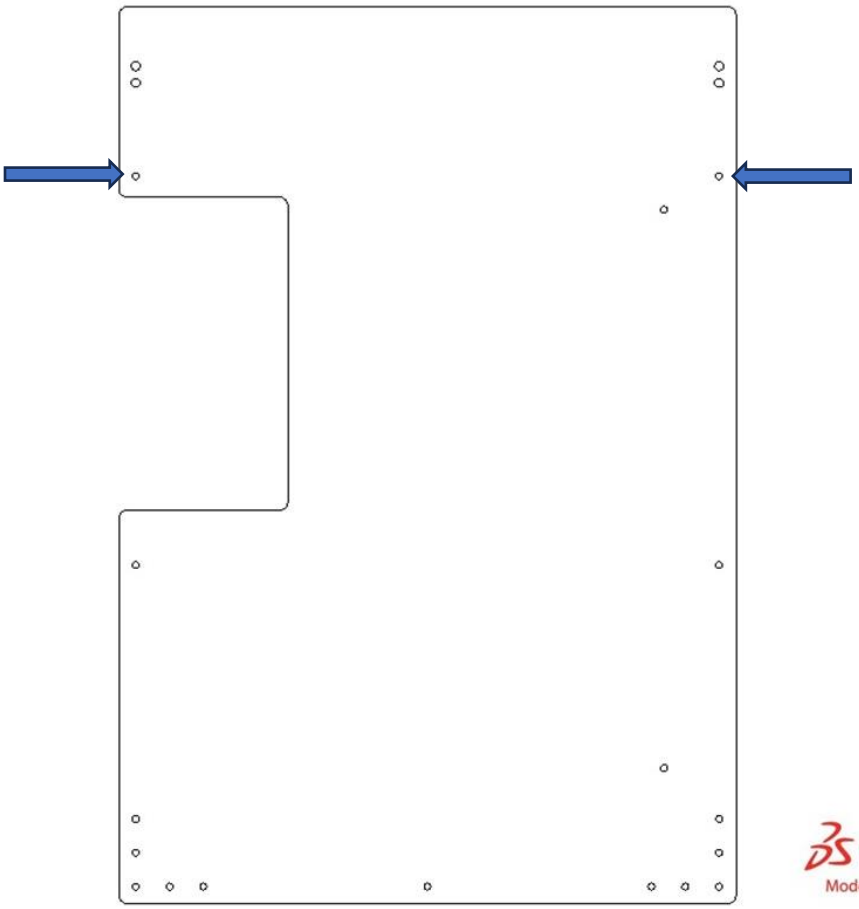
5.2 Part Preparation:

Step 1: Cut 1 in. square tubing per the cut list in Table 8 and Table 9.

Step 2: Using the drawing for the Launcher Base Plate (KB-24008, appended to this document), cut the back plate out from 0.118 in. (3mm) Polycarbonate.

a. Using a tape measure and/or square, measure and mark the outside dimensions of the rectangle.
b. Next measure and mark the notch for the motor cutout.
c. Cut out the rectangle from the sheet using a circular saw, table saw, bandsaw or jigsaw.
d. Next, cut out the notch using a jigsaw or bandsaw.
e. Only drill out holes indicated below in Figure 3 with a #7 drill bit. They are 5 in. (12.7cm) from the top of the part and 0.5 in. (~1.3cm) from their respective sides. **Do not** drill remaining holes as the remaining holes will be drilled using the "match drilling" technique.

Figure 3: Launcher Base Plastic



While other materials (1/8 in. aluminum, 1/4 in. plywood) may be used for the majority of the back plate, they will not accommodate the bend in the overhung portion. Teams will likely need to split the plate into two pieces with one remaining polycarbonate or otherwise modify the design. Bolt and spacer lengths may also be affected if modifying material thickness.

Step 3: Using the drawing for the Launcher Top Panel (KB-24011, appended to this document), cut the Launcher Top Panel out from a sheet of 0.118 in. (3mm) polycarbonate, and drill all 4 holes with a 17/64 in. (or 6.6mm) drill bit.

> Polycarbonate is recommended for the Launcher Top Panel in order to maintain visibility of Notes inside the robot. Other materials (0.125 in. aluminum, 0.25 in. plywood, etc.) may be used but bolt and spacer lengths may be affected if modifying material thickness.

Step 4: Using the drawing for the Launching Rail Plastic (KB-24010, appended to this document), cut the plate out from a sheet of 0.118 in. (3mm) polycarbonate.

> Polycarbonate is recommended for the Launching Rail Plastic in order to accommodate the bend on the cantilevered portion to smoothly transition the Note into and out of the robot. If using another material, you may wish to shorten the Launching Rail Plastic to remove the cantilevered portion entirely.

Step 5: (Optional) Cut the following spacers from ½ in. PVC pipe. **Do not use a miter saw or other high-speed rotary saw to cut these small PVC parts as it's dangerous**. Instead use a PVC pipe cutter, hand saw (such as hacksaw) or oscillating/reciprocating saw (such as a jigsaw).

Table 10: Optional Spacer Cut List

Part	Length	Quantity
Launcher Top Panel Spacers	1 1/8 in (~2.8cm)	4

> The PVC pipe spacers may be replaced with:
> – 3D printed spacers,
> – exact length, hardware appropriate, spacers, or
> – assembled from smaller common length spacers.
> See Team Sourced Parts for more information.

Step 6: (Optional) Using the Pattern Transfer method described in KitBot Machining Techniques to cut out T-Brackets (KB-24004) from a 1/8 in. aluminum. This part can be made by the team, or a similar item from one of the following part numbers can be used: am-4158, REV-21-2328-PK2, TTB-0012, WCP-1069. If fabricating your own brackets and using bolts for fastening, you may wish to leave 2 T-Brackets undrilled to match drill later.

The following items are provided in the Black Tote but may be fabricated using this technique if not available:

- Top Corner Bracket x2
- Motor Mount Plate x 1
- Tube Mounting Plate x2

6 Assembly

Before beginning assembly, be sure you have the parts from Table 3 & Table 4 and the materials noted in Table 11: Fabricated Parts List.

Table 11: Fabricated Parts List

Part	Qty	Part Number	Info
Diagonal Tube	2	KB-24003	1 in. x 1 in. x 28 in. aluminum tube
Vertical Tube	2	KB-24001	1 in. x 1 in. x 25.50 in. aluminum tube
Horizontal Tube	2	KB-24002	1 in. x 1 in. x 16.25 in. aluminum tube
Launching Rail	1	KB-24009	1in. x 1 in. x 19.5 in. aluminum tube
Launcher Top Panel	1	KB-24011	17 in x 18.5 in x .118 in Polycarbonate plate
Launcher Base Plate	1	KB-24008	26.5 in x 18.5 in x .118 Polycarbonate plate
Launching Rail Plastic	1	KB-24010	2 in. x 22 in. x 0.118 in. Polycarbonate plate
Launcher Top Panel Spacer	4		1 1/8 in. PVC or 3D printed or sourced ¼ in. ID spacer

6.1 Assembly Notes

Images included in assembly steps will show all holes in the part, including those from future assembly steps. There is no need to try to create these holes unless instructed by the step.

When tightening bolts which pass through box tubing, it is easy to overtighten the fastener and begin crushing the tube. Make sure to pay close attention when tightening bolts to avoid this.

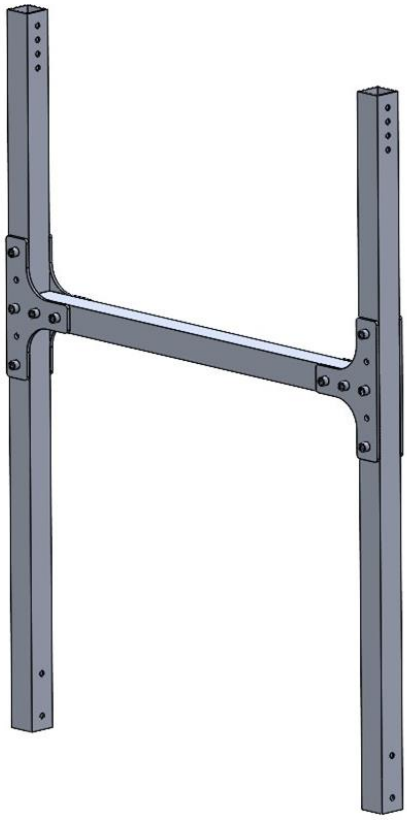
The Front Frame (Section 6.2.1) and Brack Frame (Section 6.2.2) may be assembled in parallel before they are combined into a single assembly.

Holes for specified fasteners will call out the drill size. Holes for team selected fasteners will not call out a specific size and teams should use the appropriate size for their fastener per Table 1.

6.2 Assembly Instructions

6.2.1 Build the Front Frame

Figure 4: Front Frame



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Parts needed:

- Vertical Tube (KB-24001) – qty 2
- Horizontal Tube (KB-24002) – qty 1
- T-Brackets (KB-24004) – qty 4
- Desired Hardware

Step 1: Measure and mark 8 in. (~20.3cm) from the same end on 2 opposite faces of each Vertical Tube.

> Commercial brackets other than the AndyMark bracket have a major leg measurement of ~3.5 in. (~8.9cm) instead of 5 in. (12.7cm). If using one of those, measure and mark 8.75 in. (~22.2cm) instead and then proceed.

Figure 5: Marking 8 in. on Vertical Tube

Step 2: Using the marks on a Vertical Tube place 2 T-Brackets, one on each side of the tube, such that the top of each bracket is in line with the far side of the mark (such that the 8 inches measured is fully exposed) and the long edge of each T-Bracket is flush with the outside edge as shown in Figure 6.

Figure 6: Correct placement of T-Bracket

Step 3: Clamp the T-Brackets in place and using one bracket as a template, drill a hole all the way through the bar. Add hardware of choice to the hole to connect the T-Bracket to the bar.

Figure 7: Clamping T-Brackets to Bar

> If using Rivets, this step can be done for each face separately if preferred.
>
> If you are having trouble getting both brackets aligned at once, securing one with tape temporarily may help.

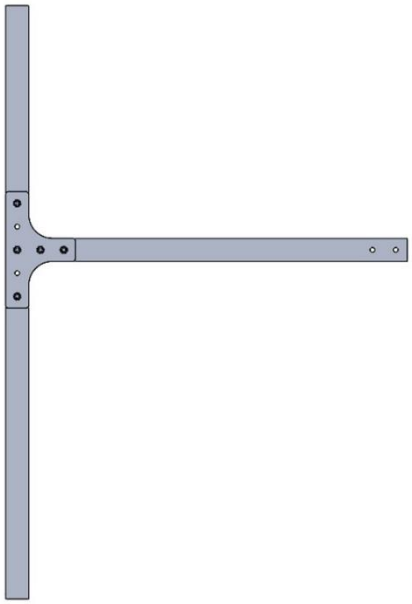
Step 4: Repeat the process of drilling a hole and immediately securing with hardware until the desired number of holes have been secured. After securing two holes with hardware, you can remove the clamp. You may wish to leave bolts slightly loose to facilitate step 6.

> For bolted connections, a minimum of 3 holes (the two ends and the middle) is recommended, for rivets all 5 holes are recommended.

Step 5: Repeat steps 2 – 4 on the second Vertical Tube.

Step 6: Lay out one Vertical Tube and a Horizontal Tube to intersect as shown in Figure 8. If available, use a square to ensure the Horizontal Tube is square to the Vertical Tube. Apply a clamp to the T-Brackets to temporarily secure the Horizontal Tube.

Figure 8: Vertical Tube and Horizontal Tube Layout



Step 7: Using one of the T-Brackets as a template, drill a hole completely through the end of the Horizontal Tube. Add hardware of choice to secure the first hole.

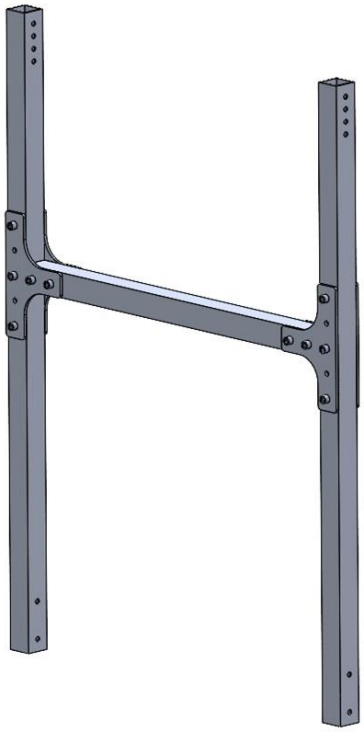
If using Rivets, this step can be done for each face separately if preferred.

Figure 9: Securing the Horizontal Tube

Step 8: While drilling the 2nd hole all the way through the Horizontal Tube, you may have to remove and re-locate your clamp, or utilize just the initial hardware and a square to help keep everything aligned. Add hardware of choice to complete the connection. Tighten all hardware.

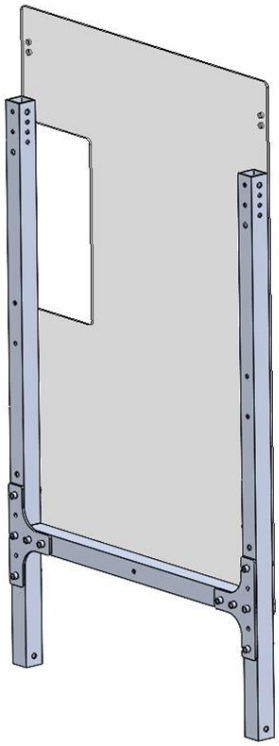
Step 9: Repeat Steps 6-8 to secure the second Vertical Tube to the assembly, forming an H shaped structure as shown in Figure 10. Set this structure aside.

Figure 10: Vertical Tube to form H shaped Structure



6.2.2 Build the Back Frame

Figure 11: Back Fame



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Parts needed:

- Diagonal Tubes (KB-24003) – qty 2
- Horizontal Tube (KB-24002) – qty 1
- Launcher Base Plate (KB-24008) – qty 1
- T-Brackets (KB-24004) – qty 2
- Desired Hardware

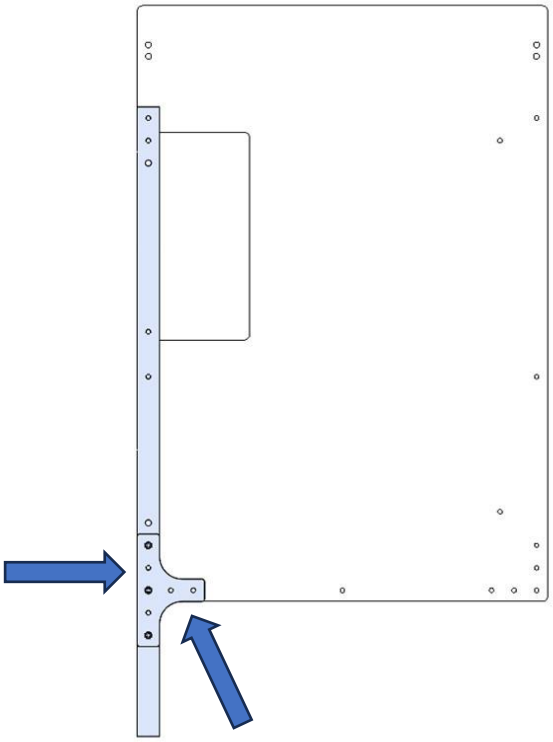
Step 1: Measure and mark 4 in. (~10.2cm) from one end on each Diagonal Tube on 1 side.

> Commercial brackets other than the AndyMark bracket have a major leg measurement of ~3.5 in. (~8.9cm) instead of 5 in. (12.7cm) If using one of those, measure and mark 4.75 in. (~12.1cm) instead and then proceed.

Figure 12: Marking 4 in. on Bar

Step 2: With the measured side of the diagonal tube towards you, place 1 T-Bracket such that one short edge of the bracket is in line with the far side of the mark (such that the 4 inches measured is fully exposed) and the long edge of the bracket is flush with the left edge of the Tube (so the 'T' points to the right) as shown in Figure 13. On the underside of the tube, place the Launcher Bottom Plate, with the cutout up and to the left, such that one long edge is aligned with edge of the Diagonal Tube and one short edge is aligned with the closer edge of the T-Bracket protrusion.

Figure 13: Correct Placement of T-Bracket and Launcher Bottom Plate



> If you are having trouble getting the parts aligned at the same time, temporarily securing the T-Bracket with tape may help.
>
> Make sure the base plate does not stick out past the diagonal tube or it will interfere with the bracket attached in 6.2.3. Once the plate is attached, it will be harder to file it down without also hitting the tube.

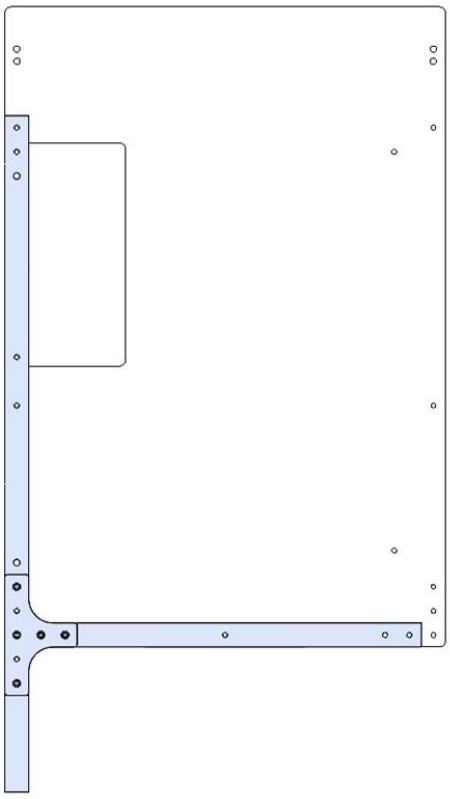
Step 3: Clamp the T-Bracket and Launcher Base Plate and using one bracket as a template, drill a hole all the way through. Add hardware of choice to connect the T-Bracket to the bar.

Step 4: Repeat the process of drilling a hole and then immediately securing hardware until the desired number of holes have been secured.

> For bolted connections, a minimum of 3 holes (the two ends and the middle) is recommended, for rivets 5 holes are recommended.

Step 5: Lay out the Diagonal Tube assembly and a Horizontal Tube to intersect as shown in Figure 14. If available, use a square to ensure the Horizontal Tube is square to the Diagonal Tube. Apply a clamp to the T-Bracket to temporarily secure the Horizontal Tube.

Figure 14: Diagonal Tube with Horizontal Tube



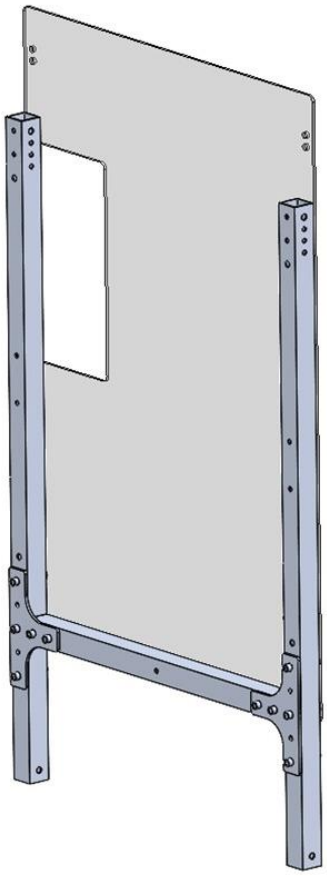
Step 6: Using the T-Bracket as a template, drill a hole completely through the end of the Horizontal Tube and Launcher Base Plate. Add hardware of choice to secure the first hole.

Figure 15: Attaching the Horizontal Tube to the Back Frame

Step 7: To drill the 2nd hole all the way through the Horizontal Tube, you may have to remove and re-locate your clamp, or utilize just the initial hardware and a square, to help keep things aligned. Add hardware of choice to complete the connection.

Step 8: Using the marking on the second diagonal tube, lay out the diagonal tube and T-Bracket to complete the H-shape frame and clamp in place as shown in Figure 16.

Figure 16: Diagonal Tubes with T-Brackets



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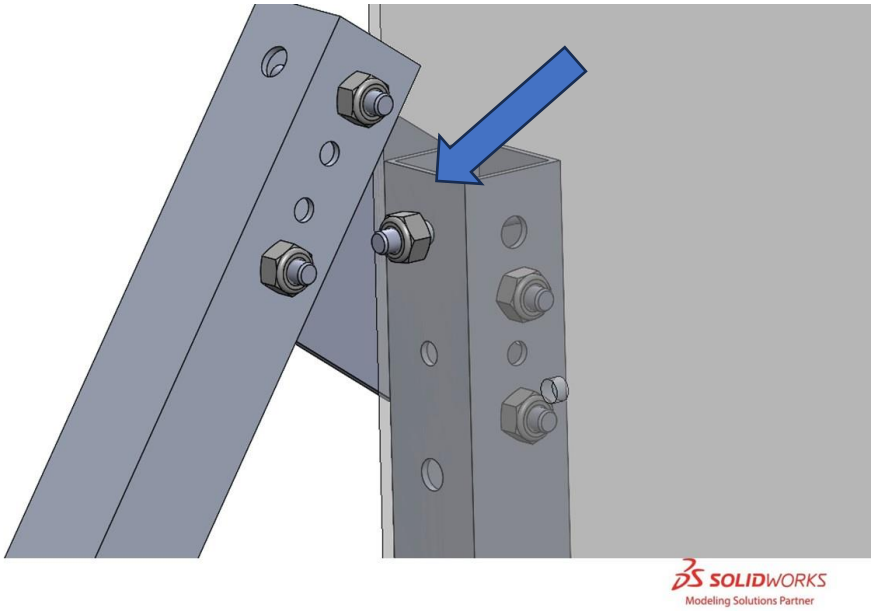
Step 9: Using the T-Bracket as a template, drill holes through the T-Bracket, tubes and Launcher base plate one at a time, securing with hardware as you go.

> For bolted connections, a minimum of 3 holes on the Diagonal Tube (the two ends and the middle) are recommended, for rivets all 5 holes are recommended. Both holes on the Horizontal Tube should be used regardless of hardware.

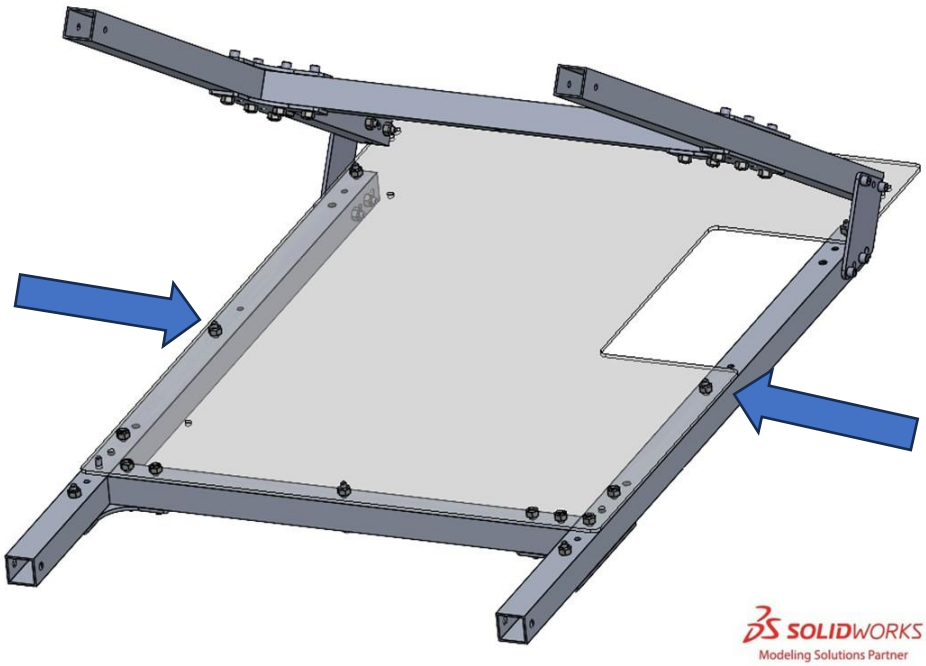
Step 10: Use the hole through the Launcher Base Plate that was already drilled in step 2e of 5.2 as a template to drill through the Diagonal Tube, and secure with hardware as shown in Figure 17.

Figure 17: Bolts at top of Launcher Base Plate



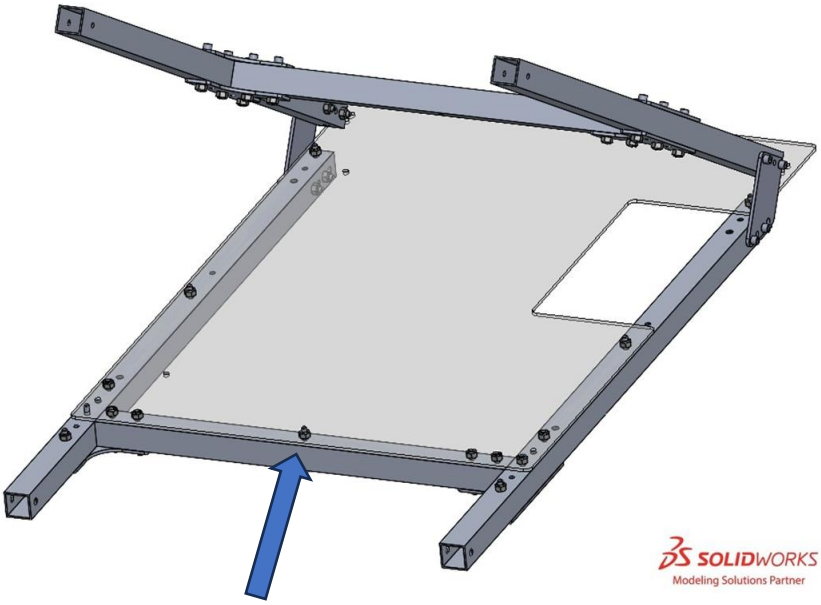
Step 11: Approximately 12 in. (~30.5 cm) from the top of each Diagonal Tube, drill through and secure with hardware to attach the Launcher Base Plate.

Figure 18: Bolts in the middle of Launcher Base Plate



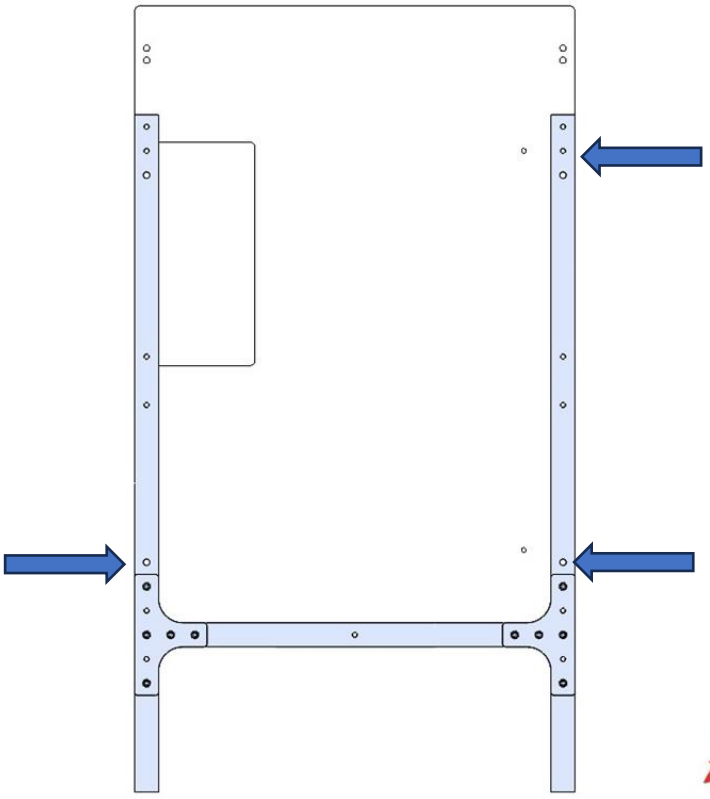
Step 12: In the center of the rear Horizontal Tube approximately the middle (8.125 in.) from each Diagonal Tube, drill through and secure with hardware to attach the Launcher Base Plate.

Figure 19: Bolt at the bottom of the Launcher Base Plate



Step 13: Measure, mark, and drill three 17/64 in. (or 6.6mm) holes as indicated in Figure 20. These will be used later for securing the Launcher Top Panel. The holes are 2.5 in. (~6.4cm) and 18.5 in. (~47 cm) from the top of the diagonal tube, centered on the tube horizontally.

Figure 20: Location of holes to drill out



6.2.3 Use the Top Corner Brackets to Attach the Frames Together

Figure 21: Attaching the Frames Together

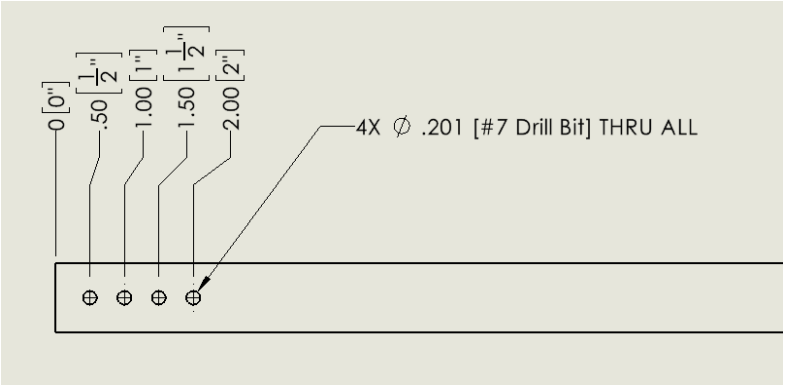
Parts Needed:

- Front Frame (from 6.2.1) – qty 1
- Back Frame (from 6.2.2) – qty 1
- Top Corner Bracket (KB-24005) – qty 2
- Desired Hardware

Step 1: Measure, mark, and drill 4 holes on the top of each of the Vertical Tubes (KB-24001) and Diagonal Tubes (KB-24003) as shown in Figure 22. Be sure to drill the holes on the narrow sides of the frame as shown in Figure 23.

> The top of the Diagonal Tube is the side further from the Horizontal Tube and the top of the Vertical Tubes is the side closer to the Horizontal Tube.

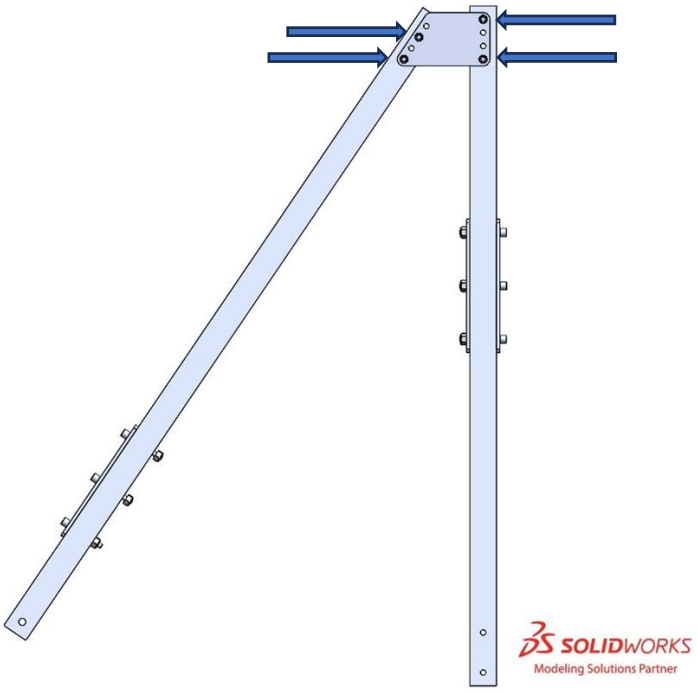
Figure 22: Holes on top end of vertical and diagonal tubes



Step 2: Lay out the two frames and a Top Corner Bracket as seen in Figure 23 ensuring that the polycarbonate side is towards the front frame. Secure only the highlighted holes as bolts through other holes will interfere with hardware installed later.

> If using rivets, secure all holes except the top hole on the Diagonal Tube with hardware.

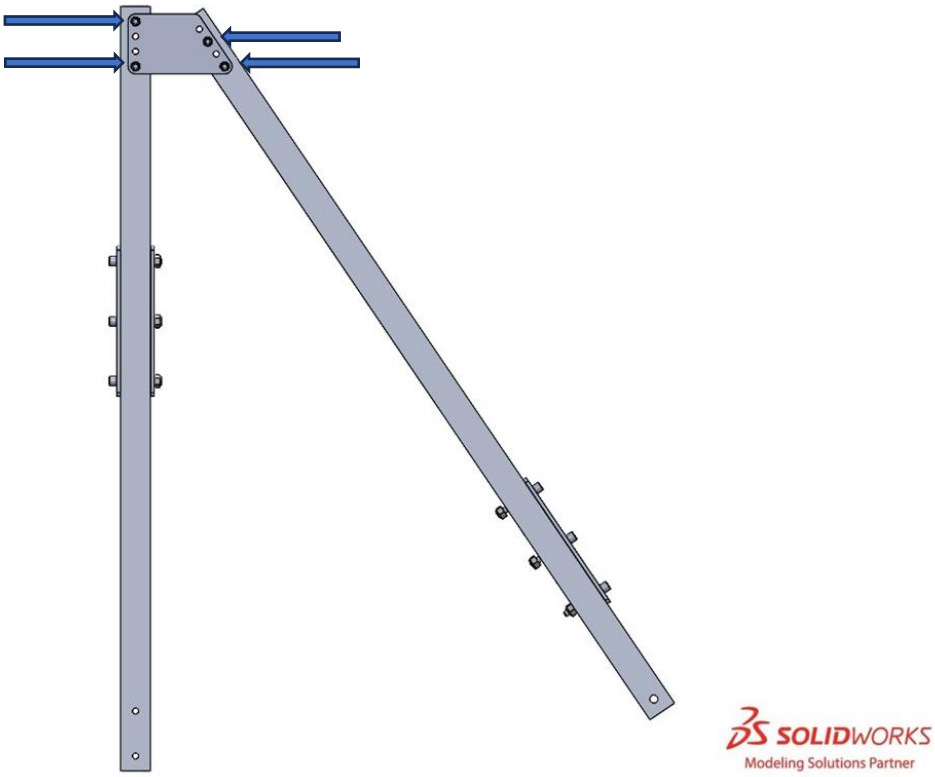
Figure 23: Bolts that need to be attached



Step 3: Carefully flip the structure over and install the Top Corner bracket on the other side as shown in Figure 24. If using bolts, secure only the highlighted holes.

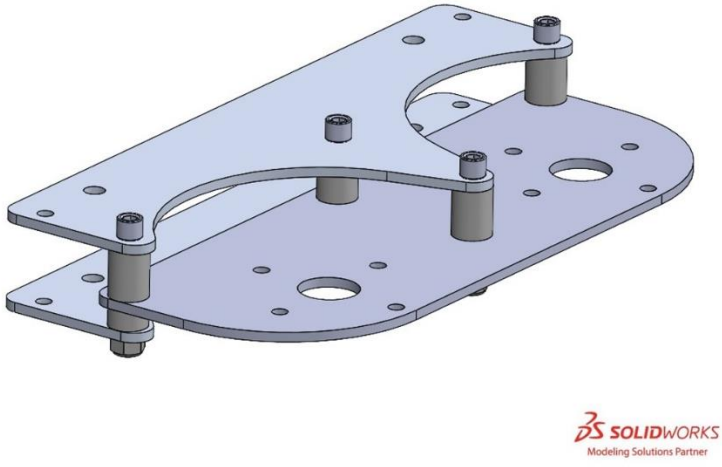
If using rivets, secure all holes with hardware.

Figure 24: Bolts on the other side



6.2.4 Build the Motor Mounting System

Figure 25: Motor Mounting System



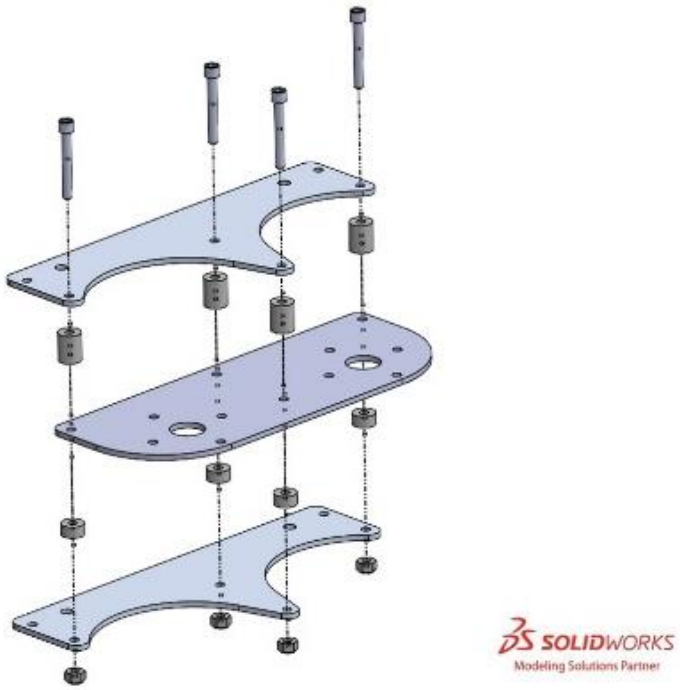
Parts needed:

- Motor Mount Plate (KB-24006) – qty 1
- Tube Mounting Plate (KB-24007) – qty 2
- #10 Spacer, 0.25 in. long – qty 4
- #10 Spacer, 0.625 in. Long – qty 4
- #10-32 x 1.5 in. bolt (or M5 ~ 40mm) - qty 4
- #10-32 nylock nut (or M5) - qty 4

Step 1: Using a 1.5 in. (or 40mm) bolt for each hole, assemble motor support assembly as follows (do not tighten all the way) and as shown in Figure 26:

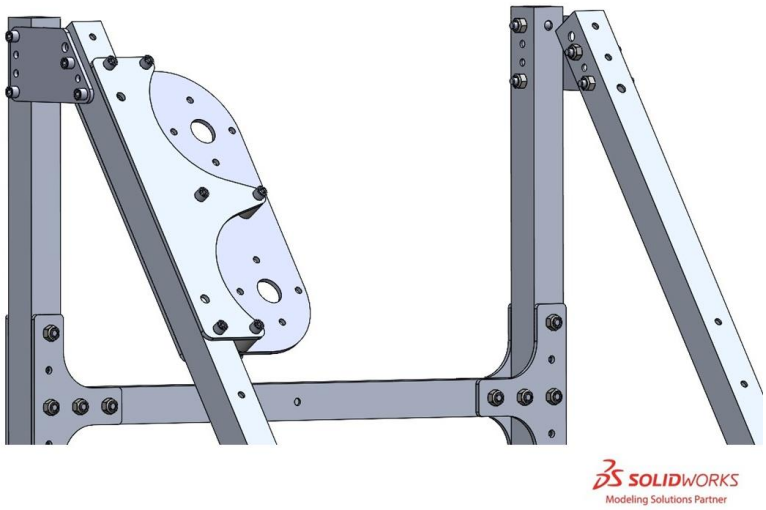
a. Tube Mounting Plate
b. Large spacer
c. Motor Mount plate
d. Small spacer
e. Tube Mounting Plate

Figure 26: Exploded view of motor mounting system



6.2.5 Attach the Motor Mounting System

Figure 27: Motor Mounting System on the KitBot

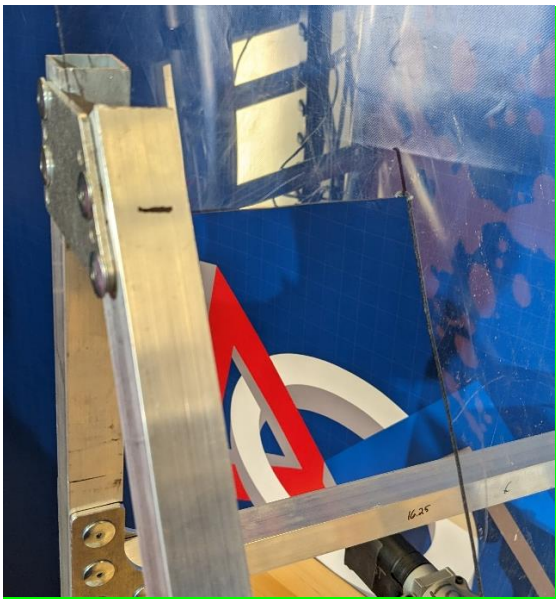


Parts needed:

- Frame structure (from 6.2.3) – qty 1
- Motor mount assembly (from 6.2.4) – qty 1
- Desired Hardware

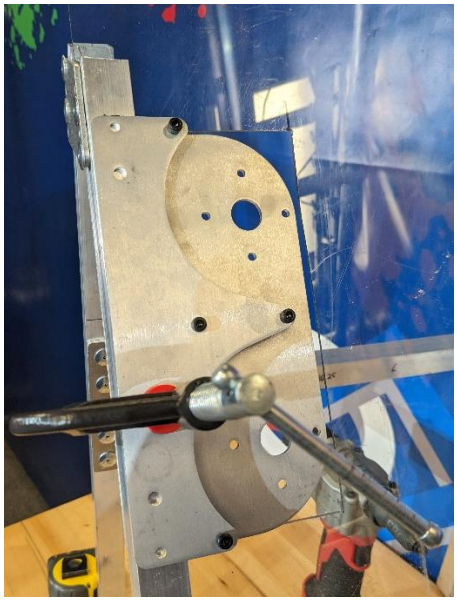
Step 1: Holding the frame structure with the Diagonal Tubes towards you (the Vertical Tubes away from you), measure and mark 1.25 in. from the top of the left Diagonal Tube, on the face nearest you.

Figure 28: Marking the Diagonal Tube



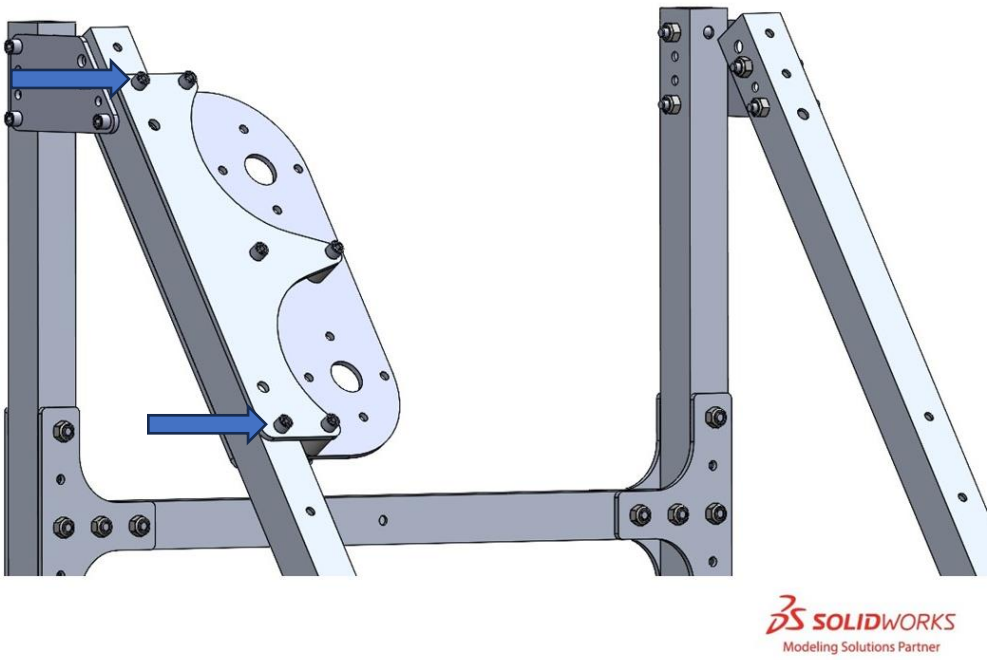
Step 2: Line up motor mount support assembly so the Tube Mounting Plates are on opposite sides of the marked Diagonal Tube lined up with the marked line. The ¼ in. spacer should be on the bottom and the 5/8 in. spacer should be on top when assembled.

Figure 29: Motor Mount Assembly Positioned on Bar



Step 3: Clamp in place and then using the Motor mount assembly as a template, drill highlighted holes, as shown in Figure 30, through the front structure bar one at a time, securing with desired hardware as you go.

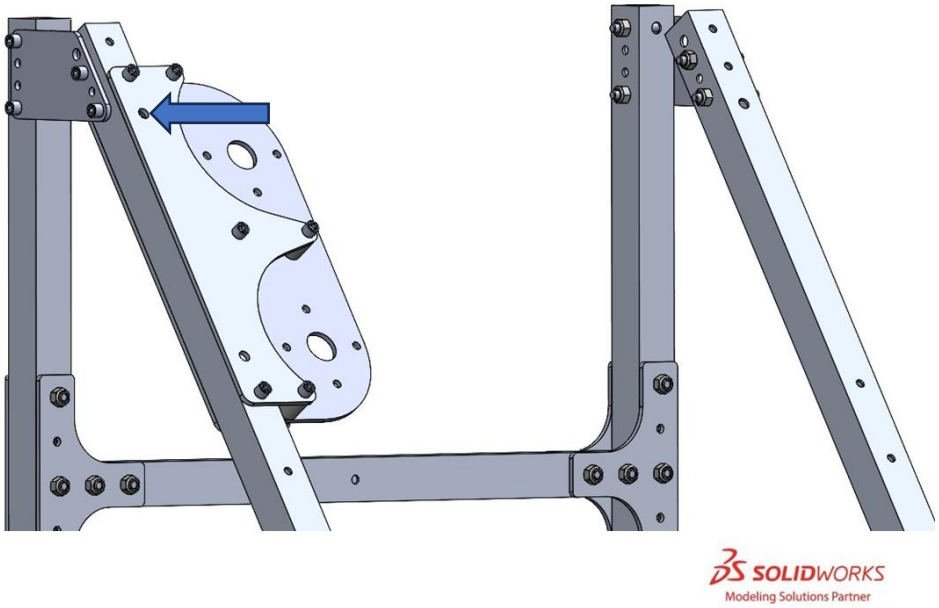
Figure 30: Attach the Motor Mount



Step 4: Tighten all hardware on the Motor Mount assembly.

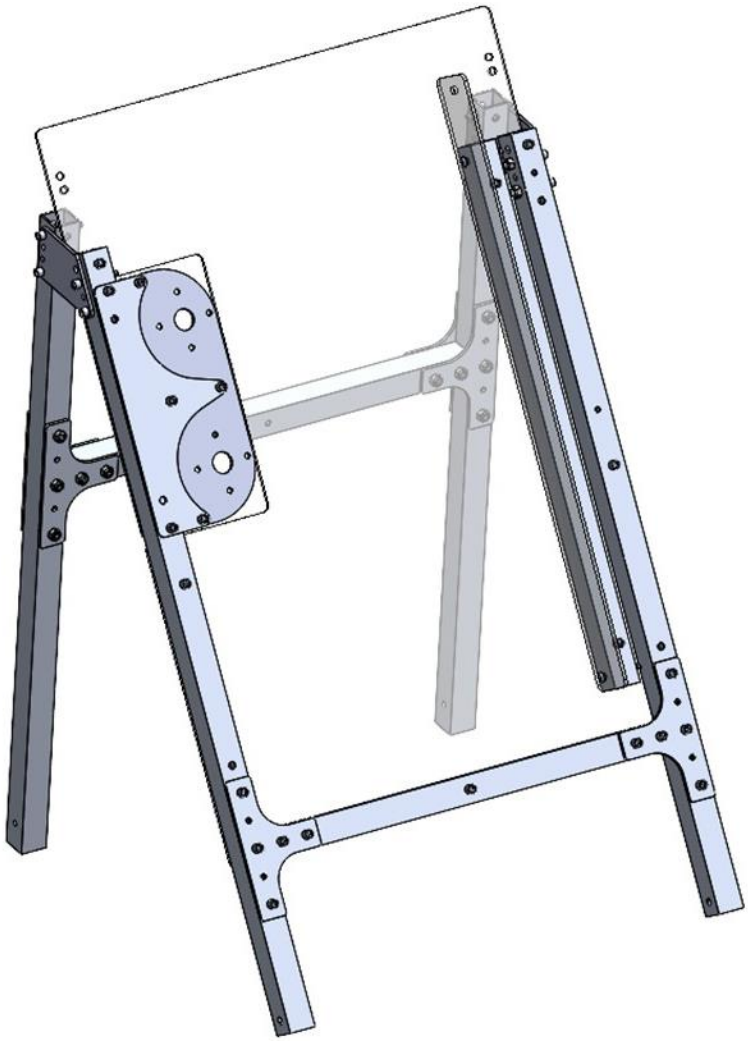
Step 5: Drill a 17/64 in. (or 6.6mm) hole through as shown in Figure 31 (hardware will be attached later)

Figure 31: Drill a 17/64 in. Hole



6.2.6 Attach the Launching Rail

Figure 32: Attaching the Launching Rail



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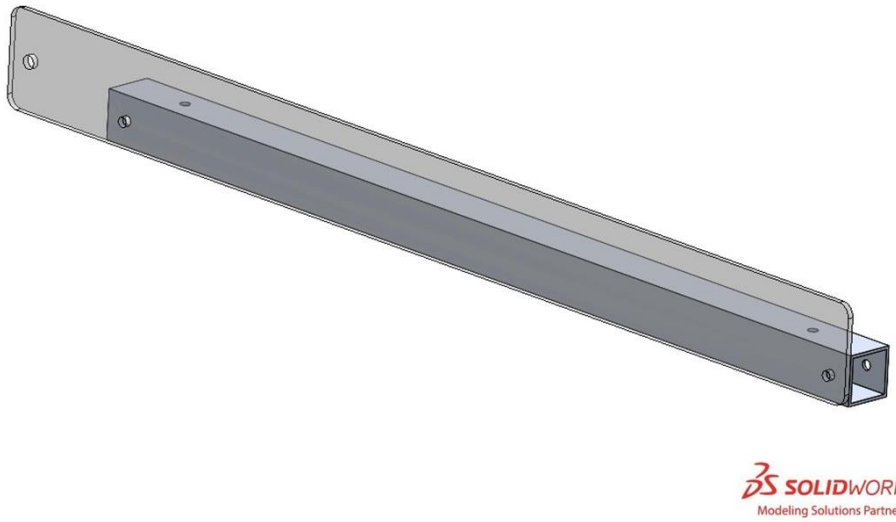
Parts needed:

- Superstructure Assembly (from 6.2.5) – qty 1
- Launching Rail Plastic (KB-24010) – qty 1
- Launching Rail (KB-24009) – qty 1
- Desired Hardware

Step 1: Align the Launching Rail Plastic and Launching Rail as shown in Figure 33 so the long edge of the Launching Rail Plastic is along the long edge of the Launching Rail. Align one short edge of the Launching Rail Plastic with one end of the Launching Rail. Clamp both pieces together.

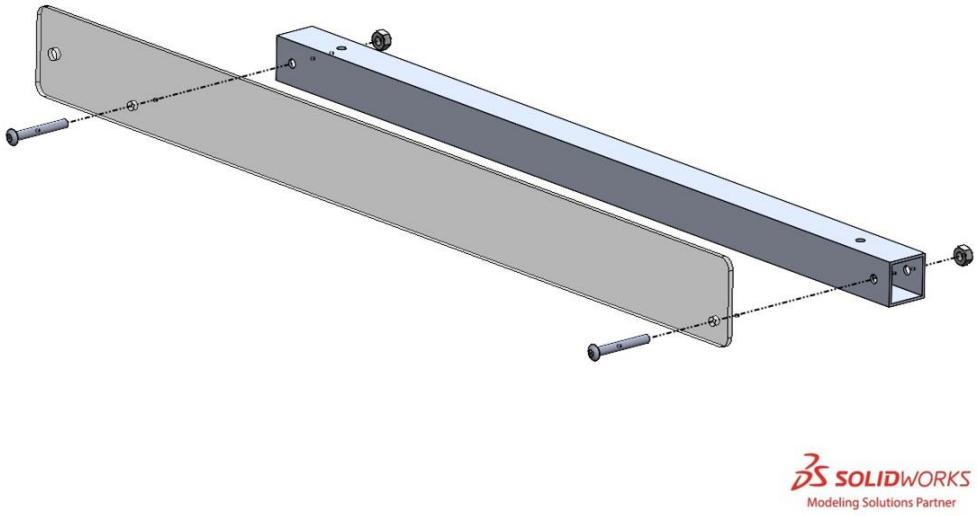
Ensure the orientation matches what is shown in Figure 33.

Figure 33: Launching Rail Clamped Together



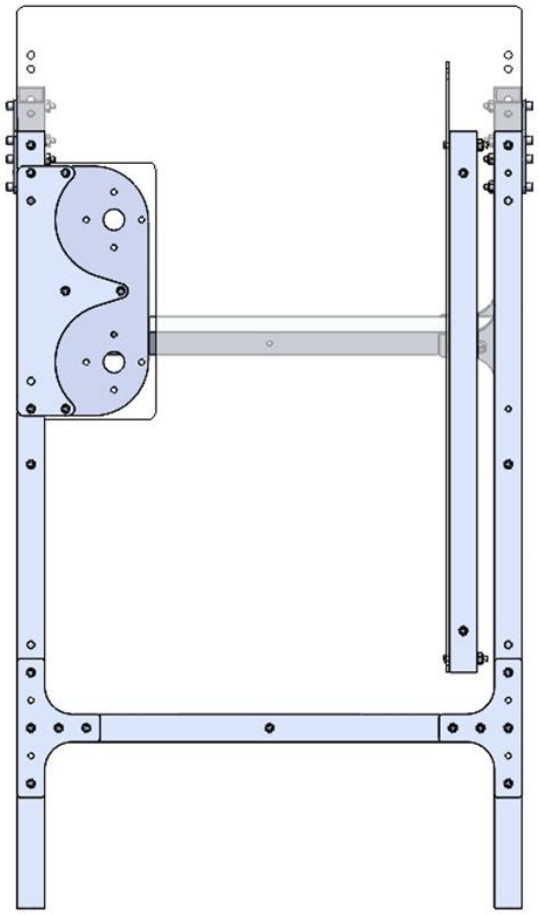
Step 2: Approximately 1/2 in. (~1.3cm) from each end of the Launching Rail, drill a hole through the Launching Rail Plastic and Launching Rail and secure using hardware. This step should either use rivets, or low-profile hardware such as a button-head.

Figure 34: Launching Rail Assembly



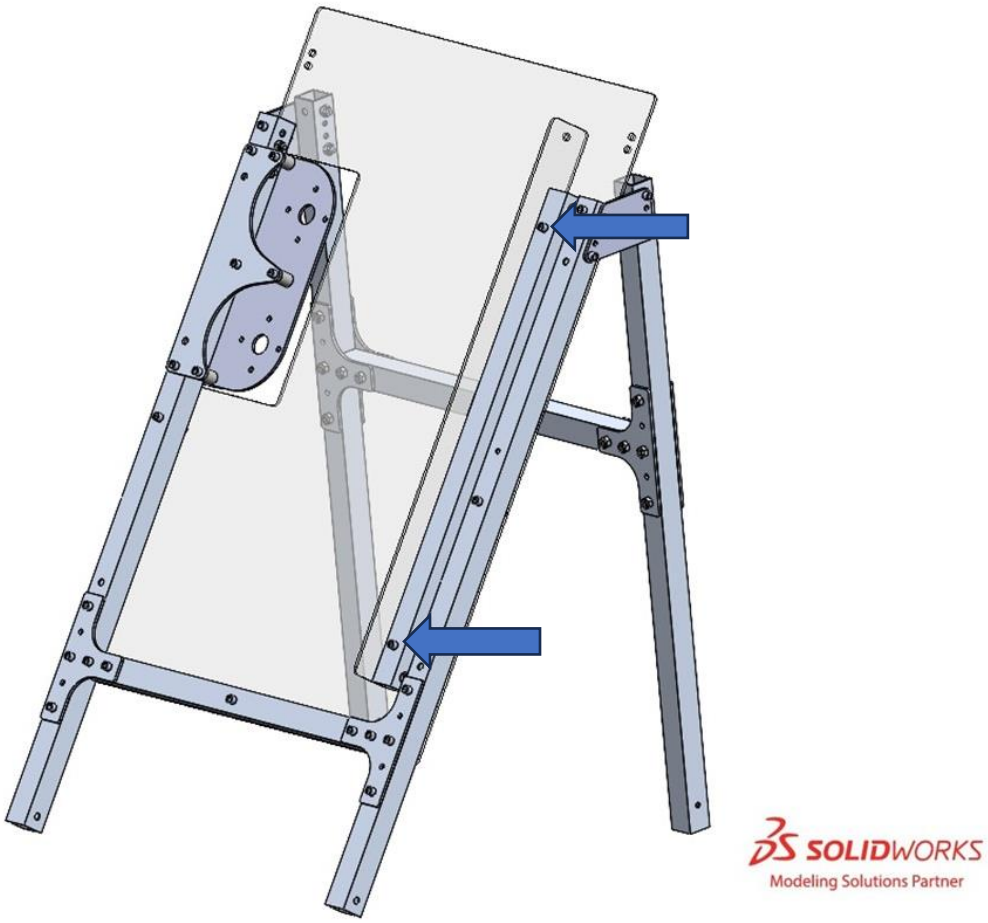
Step 3: Place the Launching Rail Assembly onto the Launcher Base Plate with the end of the Launching Rail flush with the end of a Diagonal Tube and the parallel faces of the Launching Rail and Diagonal Tube 5/8 in. (~1.6cm) apart. The Launching Rail Plastic should be facing the motor mounting system as shown in Figure 35. Clamp the assembly in place.

Figure 35: Launching Rail Location



Step 4: Drill a hole through the Launching Rail and Launcher Base Plate approximately 1.5 in. (~3.8cm) from either end of the Launching Rail and secure with hardware. Drill a second hole at the opposite end and secure with hardware.

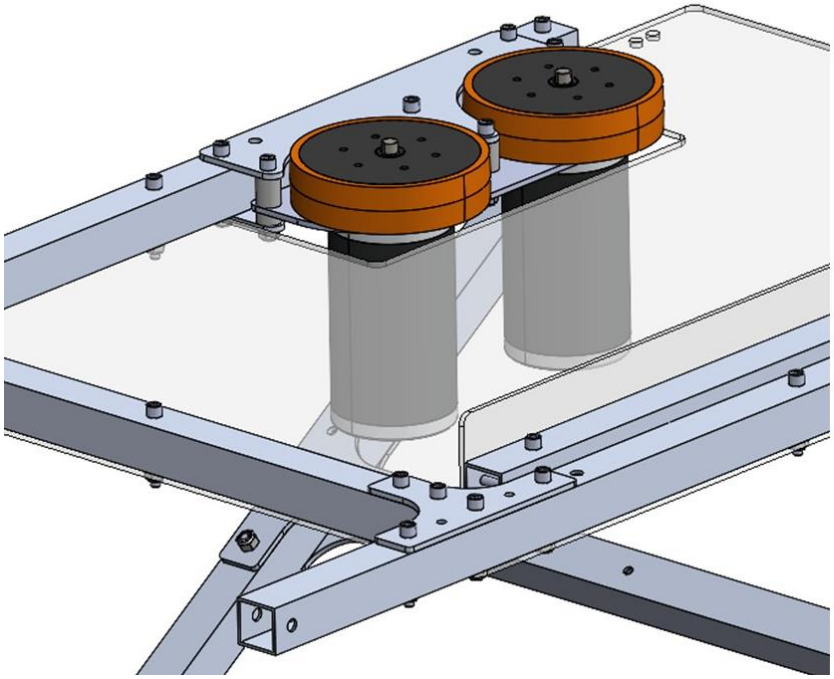
Figure 36: Frame with Launching Rail



This bar can be adjusted to change to desired compression. Repeat steps 3 - 4 further away from wheels for less compression and closer for more compression.

6.2.7 Attach the Motors and Wheels

Figure 37: Attaching the Motors and Wheels



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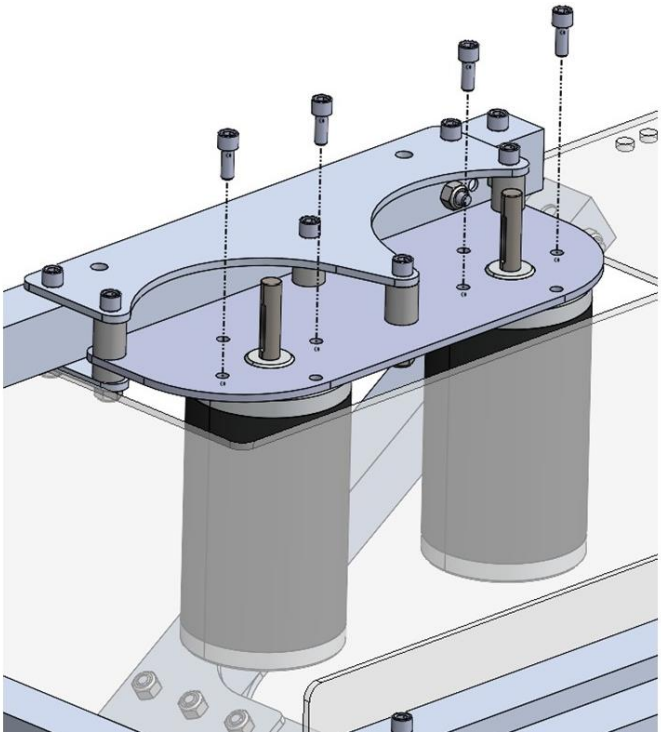
Parts needed:

- Superstructure Assembly - (from 6.2.6) – qty 1
- CIM Motors – qty 2
- 8mm key to ½ in. Hex adapter – qty 2
- 8mm Motor shaft key – qty 2
- 4 in. AM Wheel – qty 2
- 8mm Shaft Retainer clip – qty 2
- #10-32 x 5/8 in. bolts – qty 4

Step 1: Attach both motors to the bottom of the motor mount plate with #10-32 hardware.

> Any opposite pair of holes can be used, the exact orientation doesn't affect the assembly.
>
> Threadlocker can be used to help ensure these bolts do not vibrate loose during operation.

Figure 38: Bolting the Motors to the Motor Mount Plate



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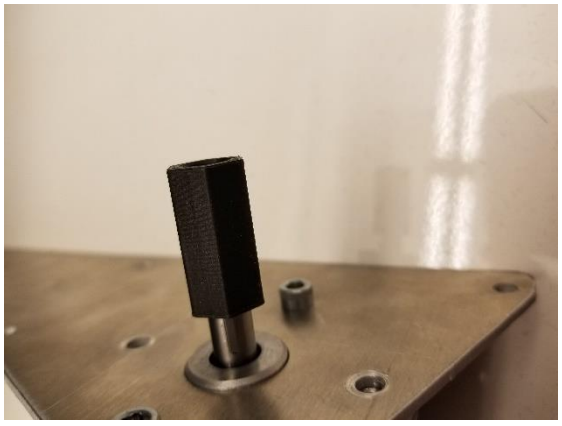
Step 2: Place the motor shaft key into the keyway on one motor and, ensuring the key stays in the shaft and that the notch in the Hex Adapter is aligned with the keyway, slide the Hex adapter over the shaft. Repeat for the 2nd motor.

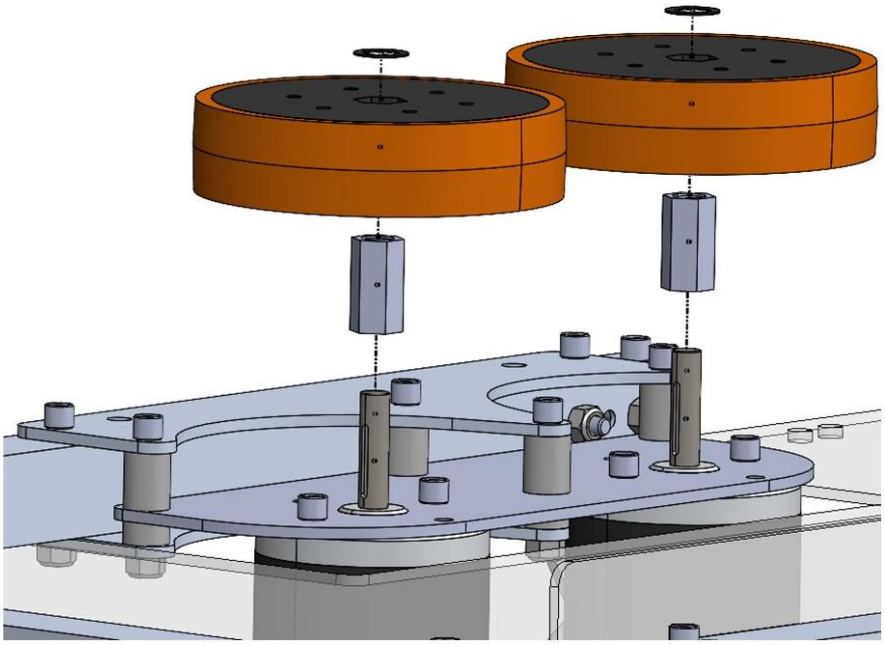
Figure 39: Hex Adapter Installation



Step 3: Slide a wheel over each hex adapter with the flat face of the wheel facing up. Slide a Retaining Clip, with the teeth angling up towards you, over each shaft and press down until it reaches the wheel as shown in Figure 40.

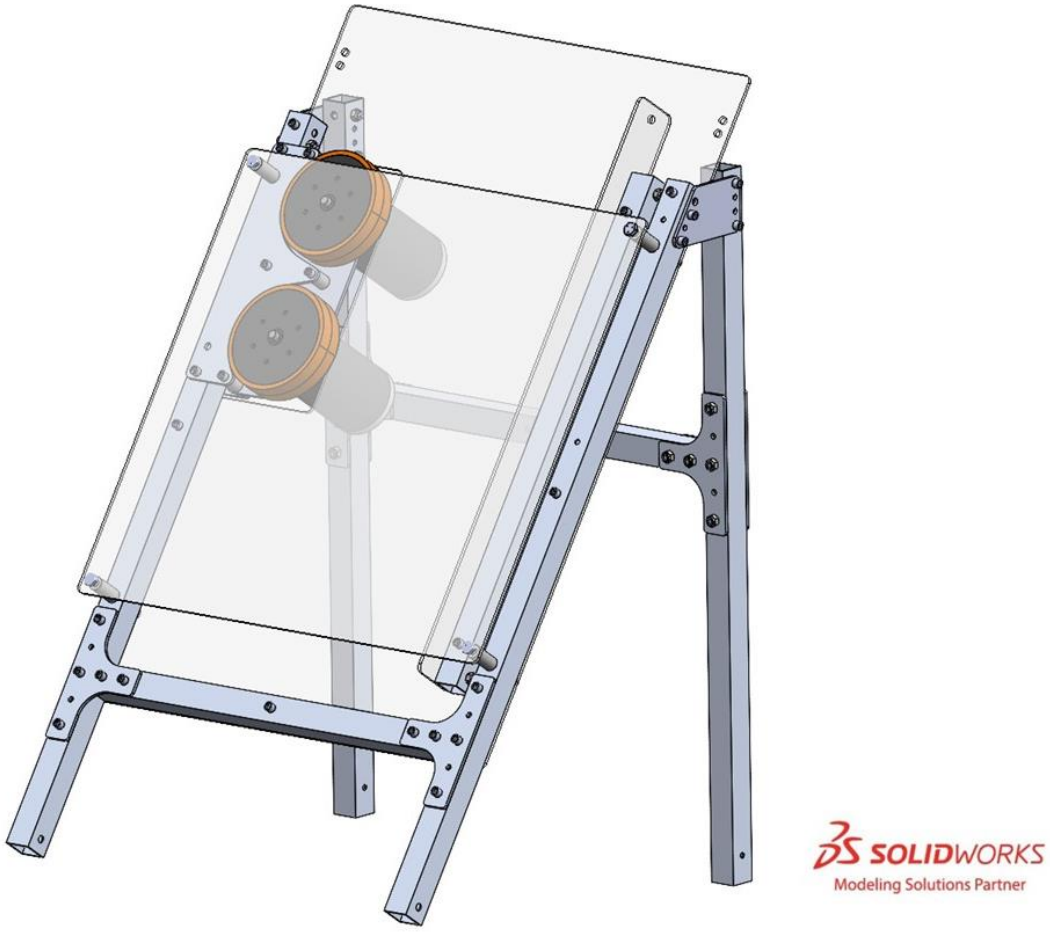
> While this can be completed by hand, a 1/2 in. socket or nut driver can be used to ease the installation.

Figure 40: Attaching the wheels to the motors



6.2.8 Attach the Launcher Top Panel

Figure 41: Attaching the Launcher Top Panel

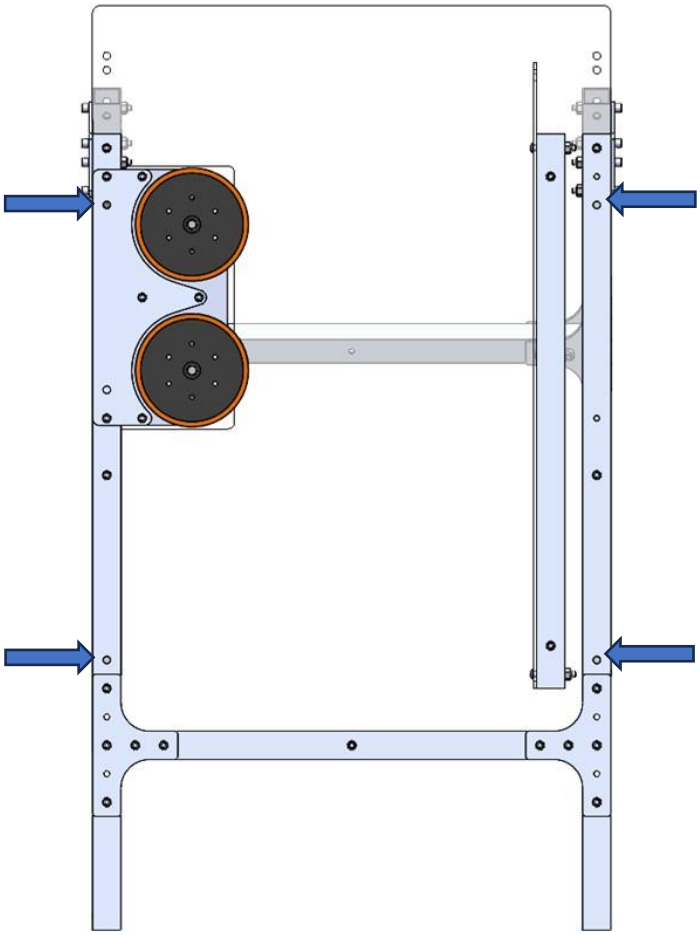


Parts needed:

- Superstructure Assembly - (from 6.2.7) – qty 1
- Launcher Top Panel – qty 1
- Launcher Top Panel Spacers – qty 4
- 1/4-20 3 in. long Hex Head Bolt (or M6 ~75-80mm) – qty 4
- 1/4-20 locknuts (or M6) – qty 4

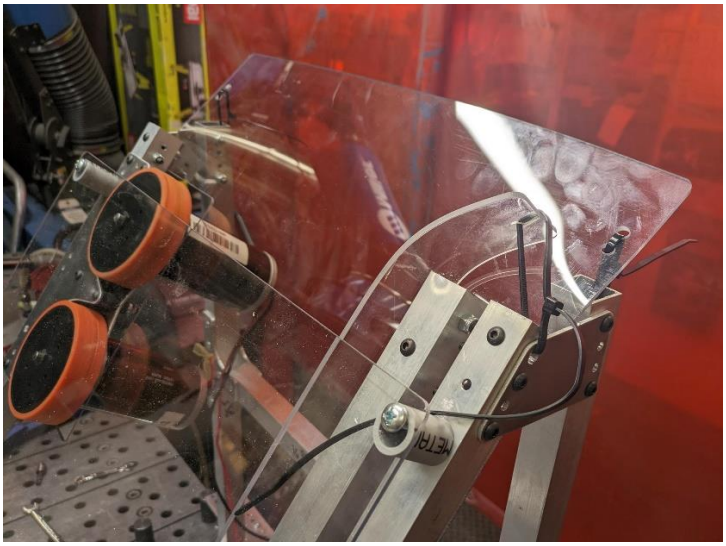
Step 1: Secure the Launcher Top Panel to the superstructure, using the 1-1/8 in. spacers on all 4 bolted connections as shown in Figure 42.

Figure 42: Locations of holes for mounting Launcher Top Panel



6.2.9 Attach Cable Ties to Shape Polycarbonate

Figure 43: Attaching Cable Ties to Shape Polycarbonate



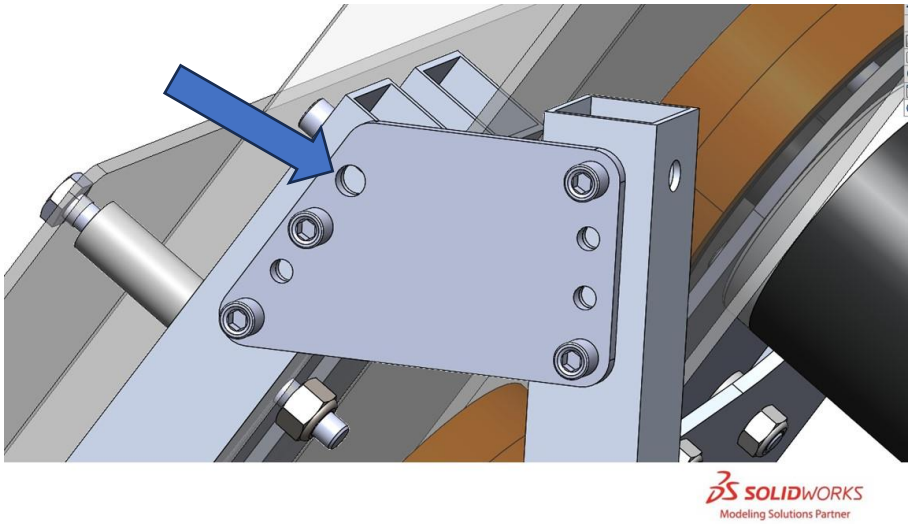
Parts needed:

- Superstructure Assembly - (from 6.2.8) – qty 1
- 50lb, 14 in. long Cable Ties – qty 3

Step 1: Punch and drill a 17/64 in. (or 6.6mm) hole approximately 1/2 in. (~1.3cm) from the end of the Launching Rail Plastic where it overhangs beyond the Launching Rail. Approximately center the hole along the height of the plate.

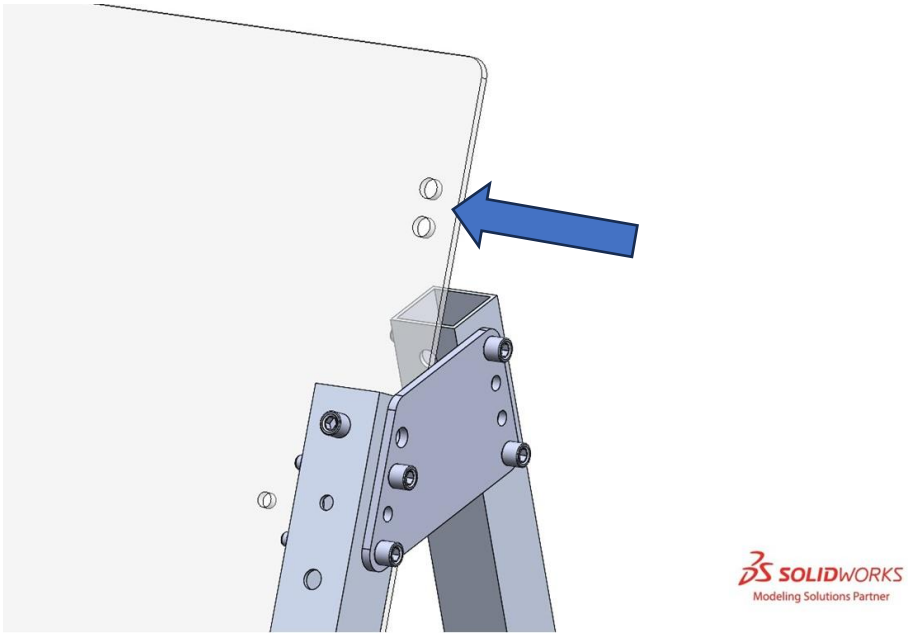
Step 2: Drill out the top hole of the Top Corner Bracket and Diagonal Tube as shown in Figure 44 using a 17/64 in. (or 6.6mm) drill bit.

Figure 44: Drill top hole of Diagonal Tube to 17/64 in.



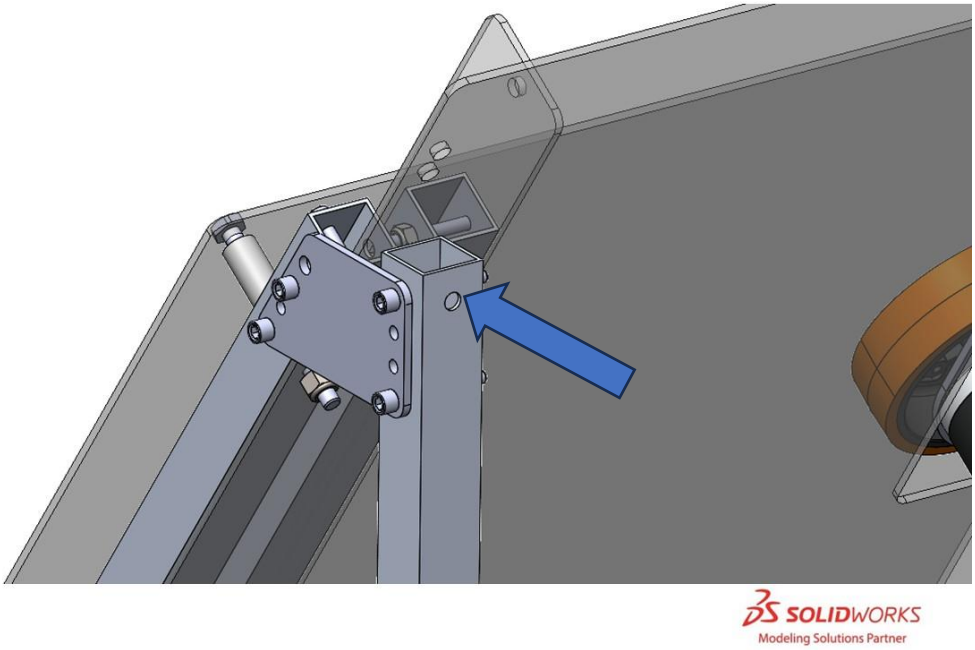
Step 3: Using the drawings if desired, drill two holes on each side of the Launcher Base Plate, directly above each Vertical Tube as shown in Figure 45.

Figure 45: Drill two holes on each side of the Launcher Base Plate



Step 4: On each side of the Front frame, drill a 17/64 in. hole approximately 1/2 in. down through one face as shown in Figure 46.

Figure 46: Drill 17/64 in. hole at top of Vertical Tube

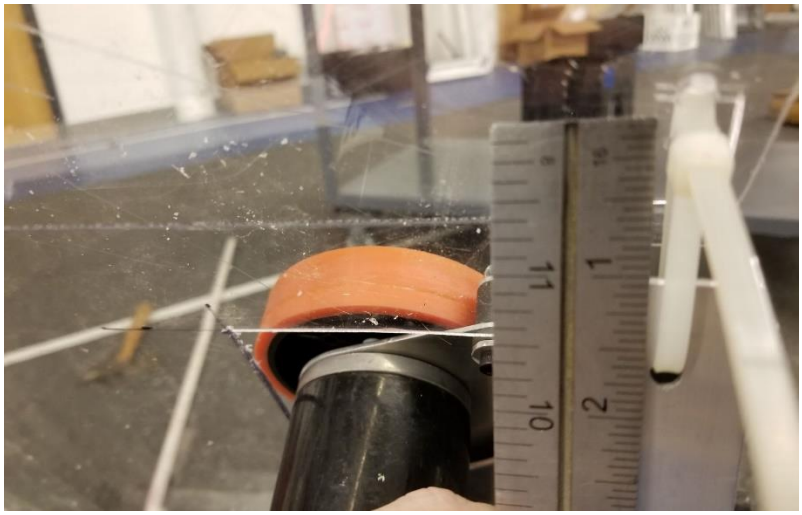


Step 5: Using a cable tie, secure the hole in the Launching Rail Plastic to the hole drilled in Step 2. Slowly tighten the cable tie until the distance between the Launcher Rail Plastic and Top Corner Bracket is approximately 3 in. (~7.6cm) as shown in Figure 47.

Figure 47: Launcher Rail Plastic Cable Tie

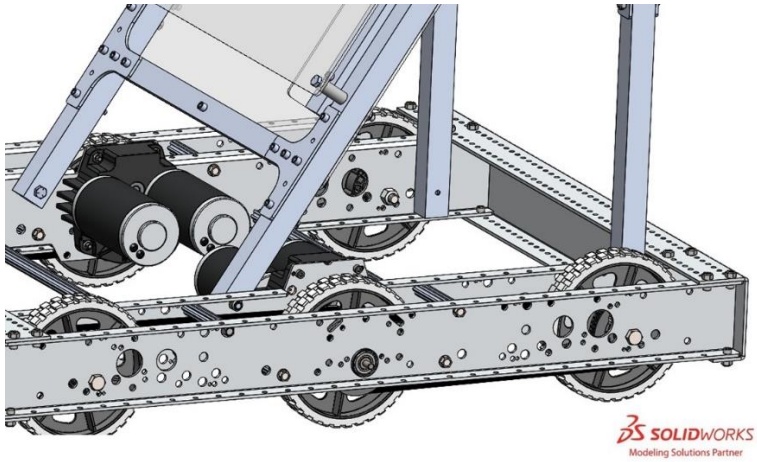
Step 6: Using a cable tie, secure each pair of holes from Step 3 in the Launcher Base Plate to the top hole from step 4 the Vertical Tube. Slowly tighten these cable ties to begin bending the Launcher Base Plate downwards until the Launcher Base Plate is ~1 in. above the top of the Vertical Tube, measured with the Vertical Tube facing you.

Figure 48: Launcher Base Plate Cable Tie



6.2.10 Attach the Superstructure to Chassis

Figure 49: Attach the Superstructure to Chassis

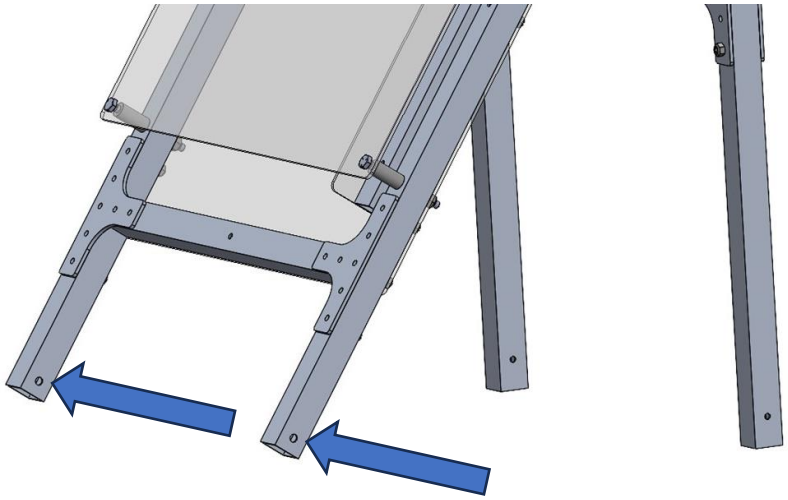


Parts needed:

- Superstructure Assembly - (from 6.2.9) – qty 1
- AM14U Chassis completed to at least Step 5 – qty 1
- 1 1/2 in. 1/4-20 bolts (or M6 ~40mm) – qty 4
- 1/4-20 Locknut (or M6) – qty 4

Step 1: Measure 1/2 in. (~1.3cm) up from the bottom on the outside of each Diagonal Tube and drill a 17/64 in. (or 6.6mm) hole through the upright.

Figure 50: Drill 17/64 in. holes at bottom of Diagonal Tubes



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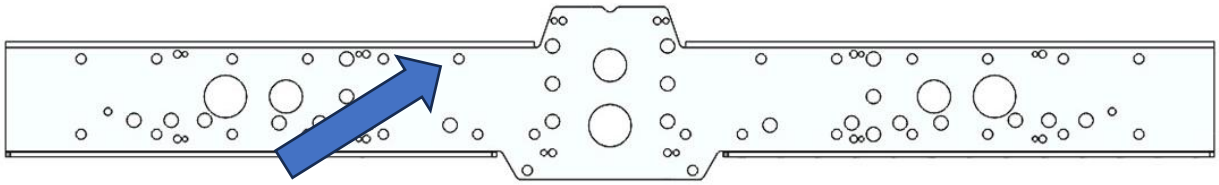
Step 2: Secure the Diagonal Tube to the indicated holes as shown in Figure 51 on each side of the AM14U chassis using 1 1/2 in. 1/4-20 bolts (or metric equivalent).

Figure 51: Rear mounting hole location on AM14U



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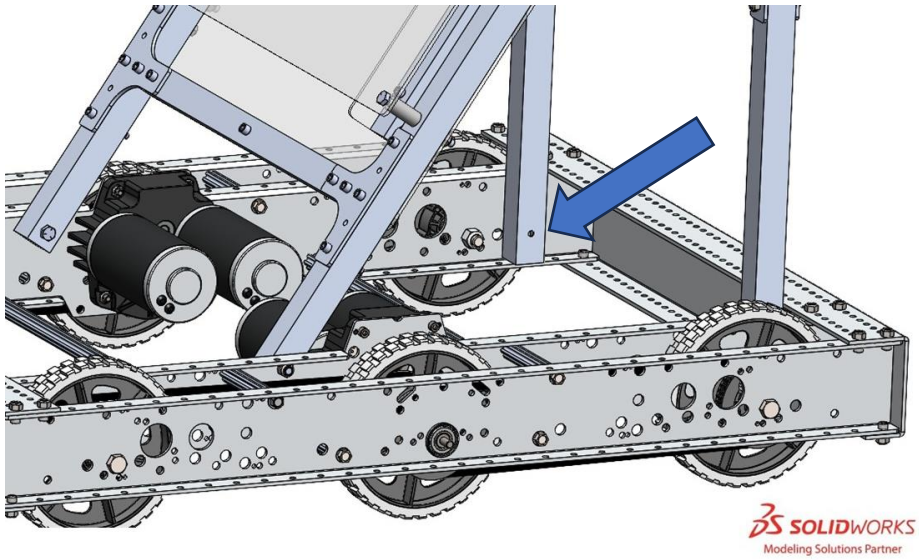
Step 3: Using a digital protractor or phone app, align the front tubes such that the angle of the Back Frame is between 56 and 56.5 degrees. Clamp the KitBot Superstructure in place.

> You may want to shim the ends of the chassis to keep it level while completing this step.
>
> This angle may need to be adjusted after testing the KitBot to ensure successful collecting and scoring of Notes. See the Troubleshooting section for more details.

Step 4: Drill a hole approximately 1 in. up from the bottom of each Vertical Tube, through both the vertical tube and AM14U Inner Rail. Secure this with 1 1/2 in. 1/4-20 bolts (or metric equivalent), and then repeat this process on the opposite side of the robot.

Figure 52: Drill and attach front rails to chassis



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7 Next Steps

Congratulations, you have successfully completed the build of the KitBot Superstructure. You may now complete the remaining steps of the AM14U chassis build, electronics board creation, wiring, battery mounting, and bumper mounting. You may wish to temporarily remove the KitBot Superstructure in order to make the assembly smaller and easier to manipulate while completing the chassis build and electronics installation (be aware that completing the chassis build will make it more difficult to install the hardware, particularly on the front).

After your robot is constructed, check out the code and software guides to get it up and running. The KitBot Enhancement/Iteration Guide has some tips on how to purposefully test your robot and decide on improvements. One of the first enhancements you may want to consider is adding some shielding to prevent Notes from ending up, and staying, inside your robot chassis. Plywood, polycarbonate, or thin sheet metal are all good materials to use for this purpose.

The Guide to Selecting Drivers can provide some ideas about how to narrow down who will drive/operate your robot in competition and the Improving Driver Performance document can help provide ideas for how they can practice effectively.

8 Troubleshooting

The KitBot is most accurate when using fully charged batteries. With this, we highly recommend teams check the batteries they are using and have multiple batteries to ensure time to recharge between matches.

8.1 Problem: Robot launches Notes too low

Potential Solutions:

- Look or listen for points of excess friction.

- Change the angle of the superstructure by adjusting the front mounting point on the drivetrain.

- If the problem persists, other motor and wheel combinations may provide more power.

- Make sure your controllers do not have a current limit set below the default 80A value. This may happen if you have written your own code, modified the provided code to set a lower current limit, or re-used a Spark MAX with a limit already set that you are now controlling over PWM. The code provided by *FIRST* explicitly sets the limit to this value if using CAN. If using PWM, you can use the REV Hardware client to check/set the current limit. The launcher undergoes very short duration (i.e. does not show up in the Driver Station current logs) spikes when launching a Note.

8.2 Problem: Robot cannot intake Notes from the Source

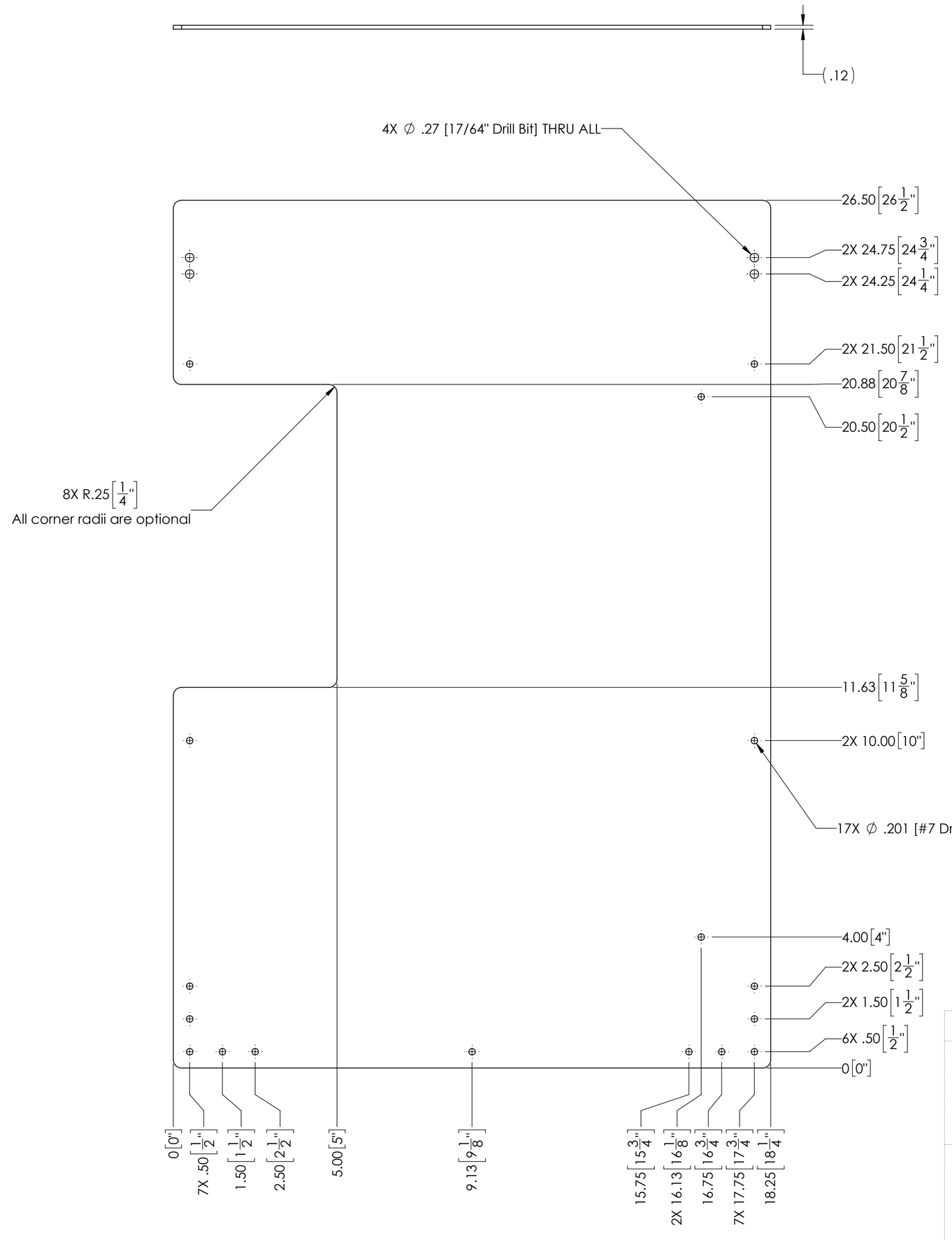
Potential Solutions:

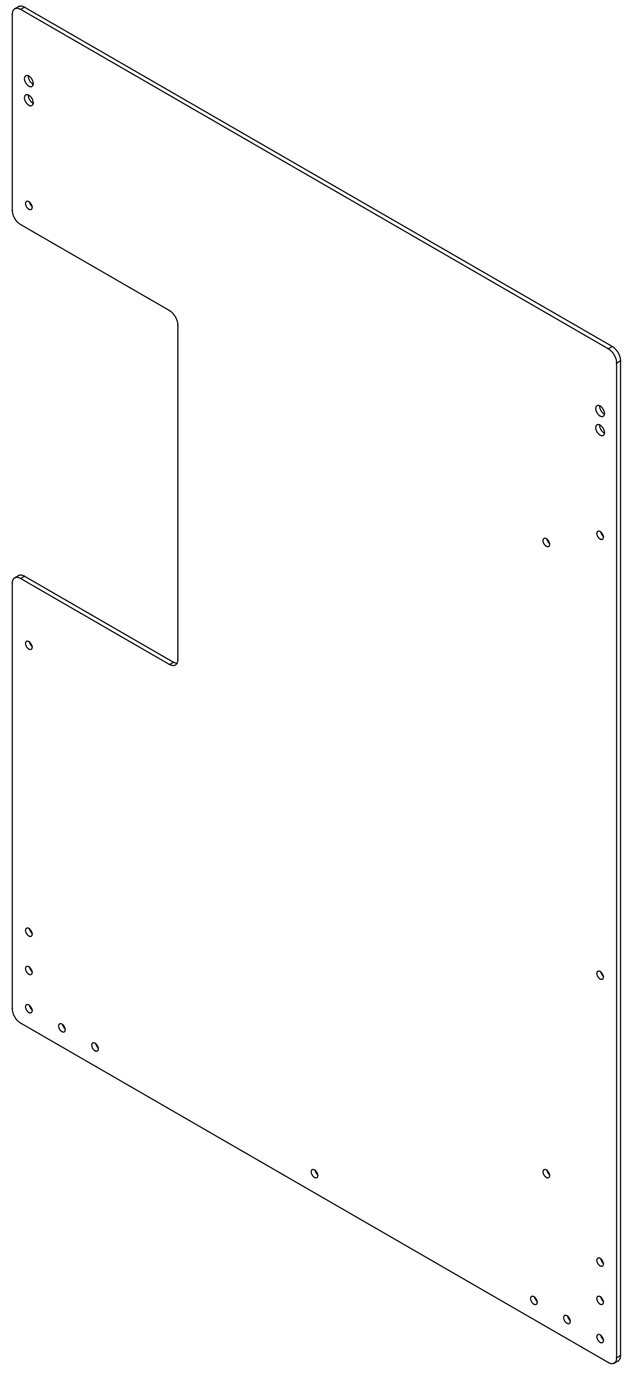
- If Notes are landing too low and getting stuck on the Launcher Base Plastic lip, adjust cable ties on end of Launcher Base Plastic to angle it down more at the end.

- Change the angle of the superstructure by adjusting the front mounting point on the drivetrain.

- If Notes are landing above the super structure, try adding a piece of material on top to help guide the ring into the launcher.

Also pay attention to how the weight distribution affects the angle of the robot due to the dropped center wheel of the AM14U chassis. Your robot may naturally rest towards one side or the other or may alternate between them. Pressing the bumper firmly against the Source will rock the robot backwards for almost any weight distribution. Make sure to test a variety of scenarios to ensure robust operation on the field.





UNLESS OTHERWISE SPECIFIED:	TEAM	NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: MACH ±1° BEND ±1° TWO PLACE DECIMAL ±.13 THREE PLACE DECIMAL ±.125	DRAWN	JO	11/7/2023

MATERIAL/FINISH:

1/8" Polycarbonate Sheet

DO NOT SCALE DRAWING

COMMENTS:

REMOVE ALL BURRS AND SHARP EDGES.

FIRST ROBOTICS COMPETITION

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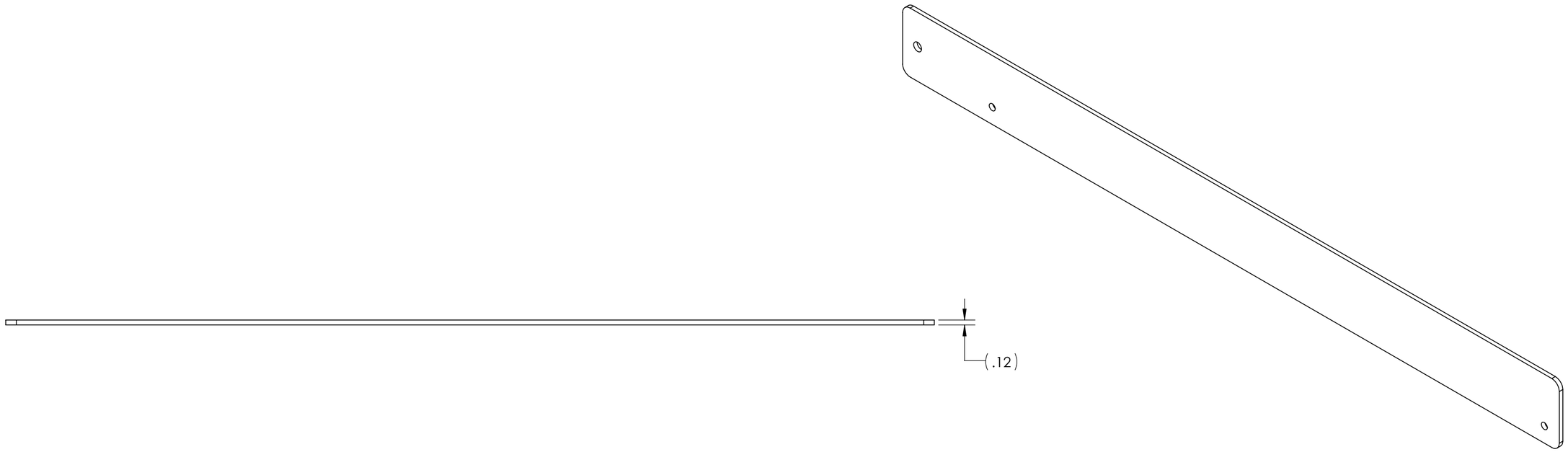
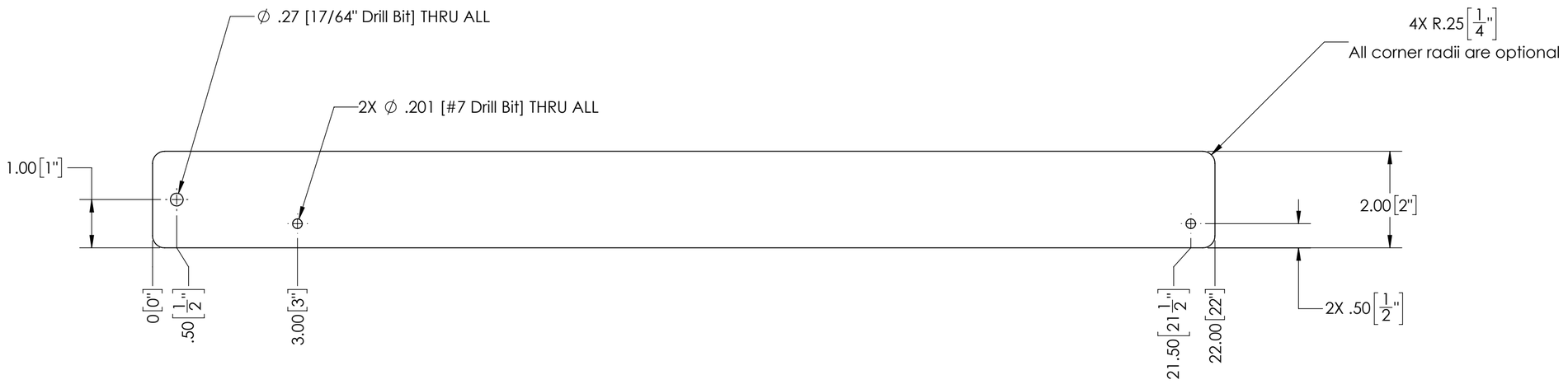
TITLE:

Launcher Base Plate

SIZE	DWG. NO.	REV
C	KB-24008	
SCALE: 2:5	SHEET 1 OF 1	





UNLESS OTHERWISE SPECIFIED:	TEAM	NAME	DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: MACH ±1° BEND ±1° TWO PLACE DECIMAL ±.13 THREE PLACE DECIMAL ±.125	DRAWN	JO	11/7/2023

MATERIAL/FINISH:

1/8" Polycarbonate Sheet

DO NOT SCALE DRAWING

COMMENTS:

REMOVE ALL BURRS AND SHARP EDGES.

FIRST ROBOTICS COMPETITION

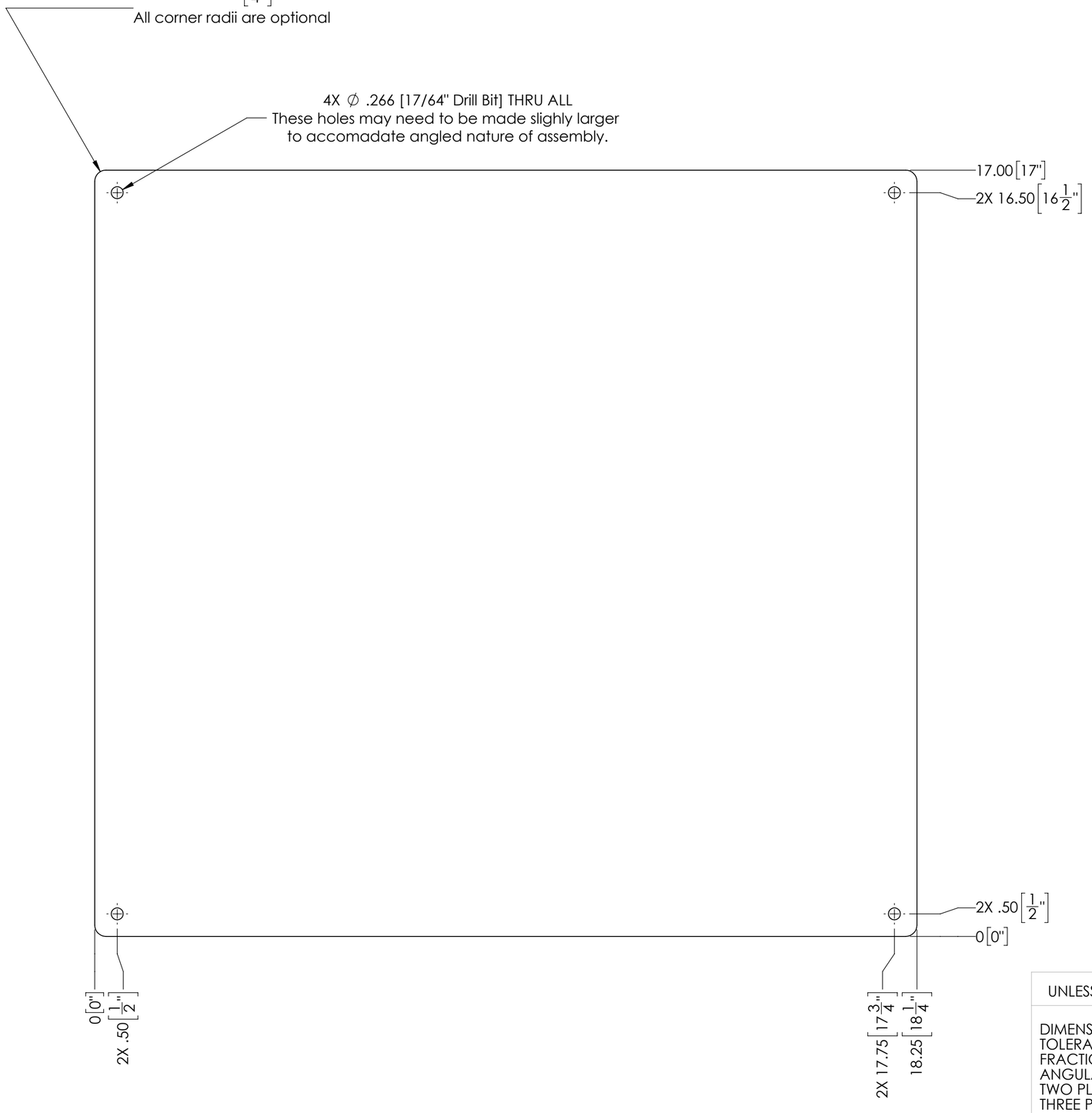
SOLIDWORKS Modeling Solutions Partner

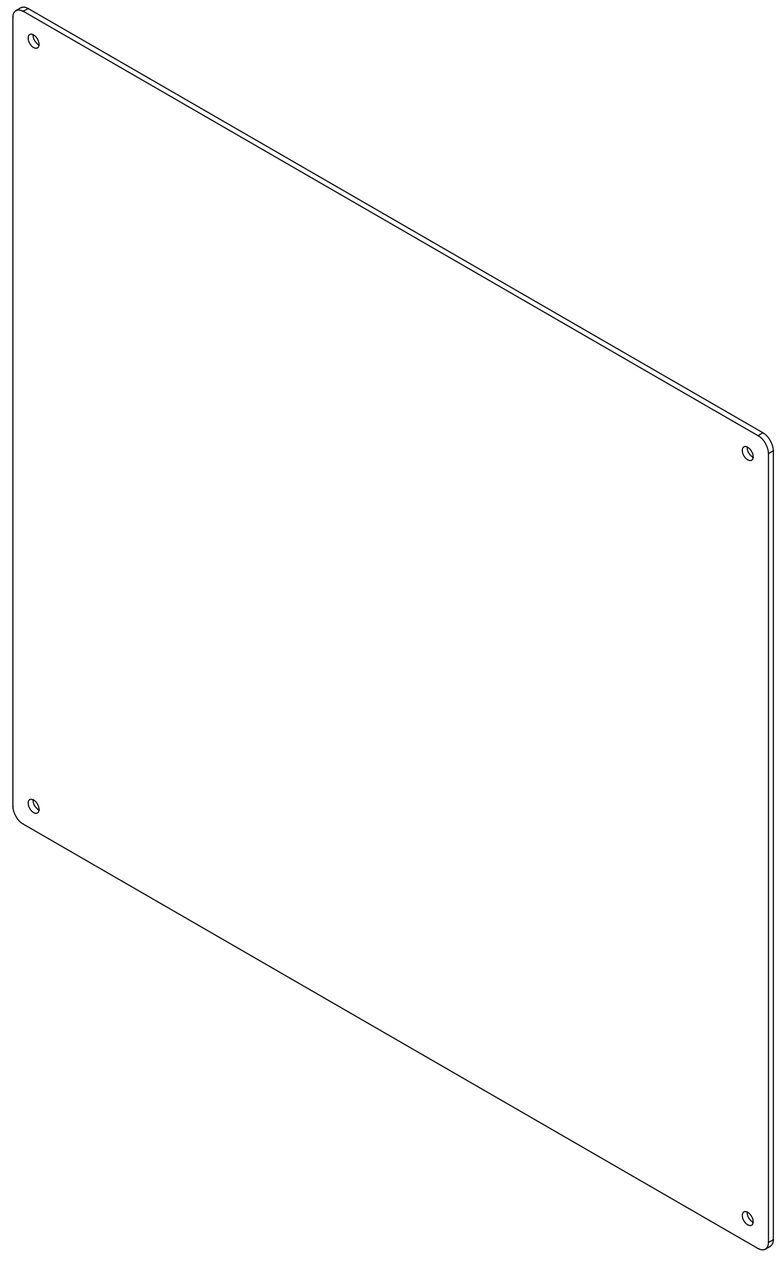
TITLE:

Launching Rail Plastic

SIZE	DWG. NO.	REV
C	KB-24010	

SCALE: 1:2 | SHEET 1 OF 1





UNLESS OTHERWISE SPECIFIED:	TEAM	NAME / DATE
DIMENSIONS ARE IN INCHES TOLERANCES: FRACTIONAL ±1/16 ANGULAR: MACH ±1° BEND ±1° TWO PLACE DECIMAL ±.13 THREE PLACE DECIMAL ±.125	DRAWN	JO / 11/7/2023
MATERIAL/FINISH: 1/8" Polycarbonate Sheet	**PROPRIETARY AND CONFIDENTIAL** THE INFORMATION CONTAINED IN THIS DRAWING IS THE SOLE PROPERTY OF ***FIRST®***. ANY REPRODUCTION IN PART OR AS A WHOLE WITHOUT THE WRITTEN PERMISSION OF ***FIRST®*** IS PROHIBITED.	TITLE: Launcher Top Panel
DO NOT SCALE DRAWING	**COMMENTS:** REMOVE ALL BURRS AND SHARP EDGES.	SIZE: C / DWG. NO.: KB-24011 / REV:
		SCALE: 1:2 / SHEET 1 OF 1