THE 2018 ROBONAUTS EVERYBOT

The Robonauts Everybot, with a final budget of $1000, is an affordable, robust, and simplistic robot that can be built with nothing but basic tools and items found in either the kit of parts, purchased from your local hardware store, or FRC retailer such as AndyMark and VEXPro.

Table of Contents

A 2018 Robot Can:

On the Sunday after the game reveal we created a list of everything we could think of that a robot could do in FIRST Power UP. We tried to avoid putting things in the robot can that have to do with robot design. Bolded are things that the Robonauts Everybot does/attributes it has. Those that are underlined went into the robot will.

- Accurately navigate the field
- Track at Minute Maid
- Determine the switch/scale target
- Pick up a cube from the floor
- **<u>Receive cube from portal/exchange</u>**
- **Be agile/fast**
- **Have a Low CoG**
- **<u>Score in Switch</u>**
- Stand its ground
- **Avoid Defense**
- **<u>Put Cubes in Exchange</u>**
- Score on Scale at all Heights
- Provide visual aid to drivers
- **Have a touch it own it intake**
- Strafe
- **Be light**
- **Drive onto the platform**
- **Drive over cable protectors**
- Climb by itself
- Climb and get out of the way
- Assist another robot in climbing
- Assist another robot in climbing and also climb
- Assist 2 robots in climbing
- Assist 2 robots in climbing and also climb
- **Place cube while moving**

- Track cube (vision)
- **Throw cubes**
- Lift a cube
- Pick up cube from anywhere
- **Cimb on other robots**
- Drag dead robots
- Flip tipped over robots
- Flip ourselves
- **Herd a cube**
- Index off of a wall
- See vision targets
- Index off the exchange
- **Grab cube in all orientations (13” and 11” side)**
- Accept cube from another robot
- Give cubes to other robot
- Reorient cubes once inside the robot

The 2018 Robonauts Everybot Robot Will

Bolded capabilities in the robot can list were then put into the robot will. For certain capabilities in the robot can we said we will not put resources into having those capabilities but would be nice if they came for free.

- Deposit cubes in the exchange
- Place cubes on a switch
- Accept cubes from the portal
- Be able to be lifted by an alliance partner for climb points
- Cross the auto line in autonomous

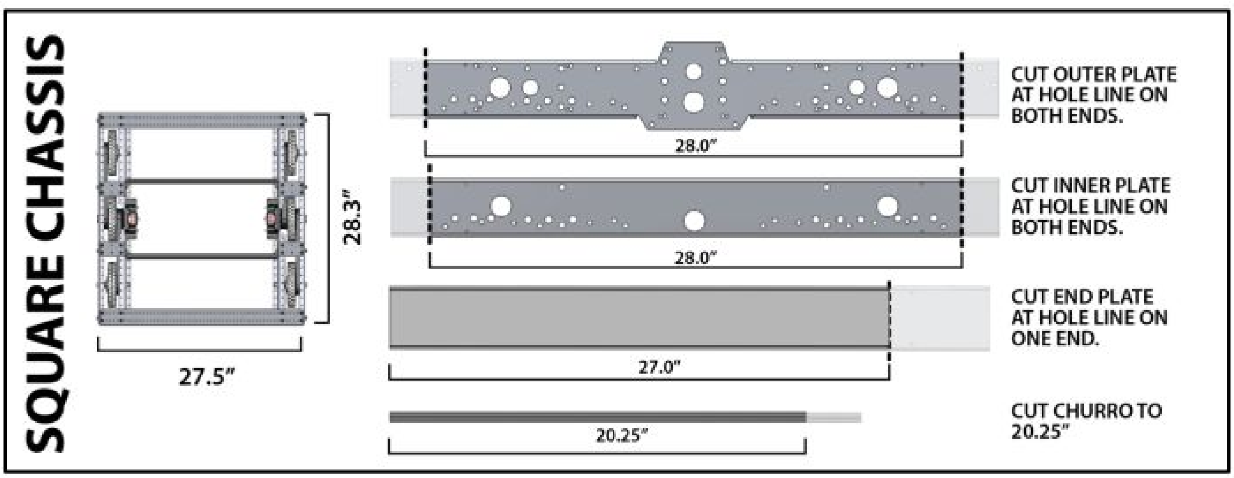
To be more specific, the following is a basic breakdown of time allotment for tasks in matches:

- Auton should dump a cube into the switch
- If Auton did not place the cube, place cube in your own switch, then drive to the other end of the field. **15 seconds**
- Cycle cubes from the portal to your opponent's switch. Strive for 5 second cycle times. Empty out one portal (5-6 cubes). **25-30 seconds**
- Drive back to your end of the field. **10 seconds**
- Cycle cubes from your power cube pile to the exchange. Strive for 7 second cycle times. Score 9 cubes for all power ups. **63 seconds**
- Total time: **~115 seconds** (conservatively) Strive to complete these tasks in any given match. We think this equals success.

This is a tight timeline of tasks… This accounts for one reason we decided the floor intake did not need to feed into the switch scoring mechanism. We think the cube you place in auton will either keep ownership of your switch for a large portion of the match, or that you will not be able to outpace a robot playing this same strategy against you. The other reason we decided to segregate the scoring mechanisms was to be able to optimize each mechanism for its one task rather than compromise each to achieve another task. Everybot should be simple and fast at placing in the opponent's switch and gaining power ups for its own alliance.

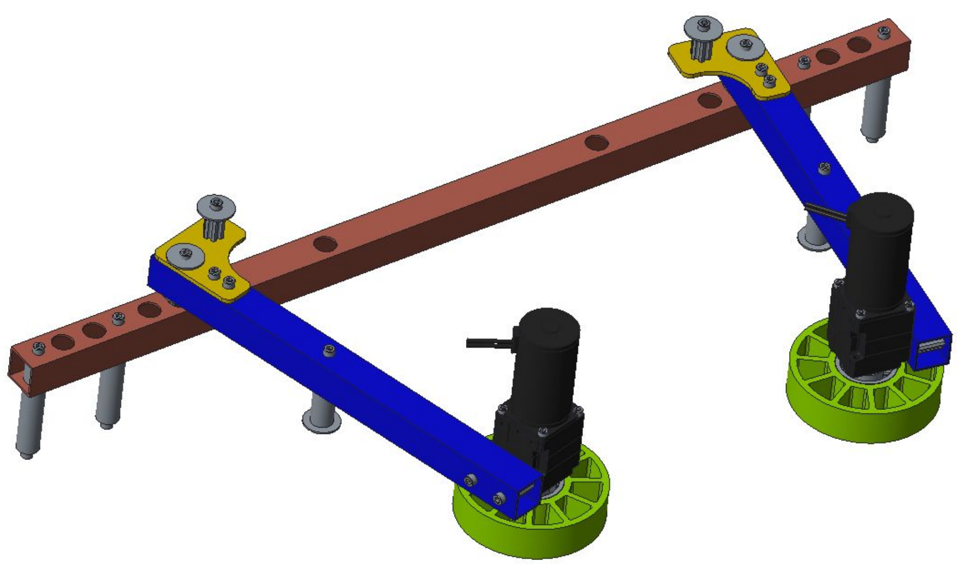
The Everybot Chassis

Chassis Type: We decided to use the AM14U3 chassis since it comes in the kit, is a decent chassis, and with the 6 inch rubber treaded wheels that come with it allow it to drive onto the platform with almost no issue (bumper scrapes a little).
Chassis Size: For the frame size we knew we did not want to build a wide robot as wide robots are harder to maneuver around cluttered fields. We cut the frame to be 27.5” X 28.3” which is the square configuration of the AM14U3. We also cut the front end plate to where there was a 6” long section at each corner on the front of the robot to satisfy rule R23 that states that at least 6 inches of bumper must be placed on each side of each outside corner.



Intake

We decided early on that a side-roller intake similar to the popular landfill tote intakes from 2015's Recycle Rush would be a good solution for picking up power cubes. Everybot's intake structure is made up of 1x1 1/16" wall aluminum square tube that comes in the kit of parts. At the end of each of two pivoting arms, we put BAG motors into 10:1 versaplanetary gearboxes driving AndyMark compliant wheels.

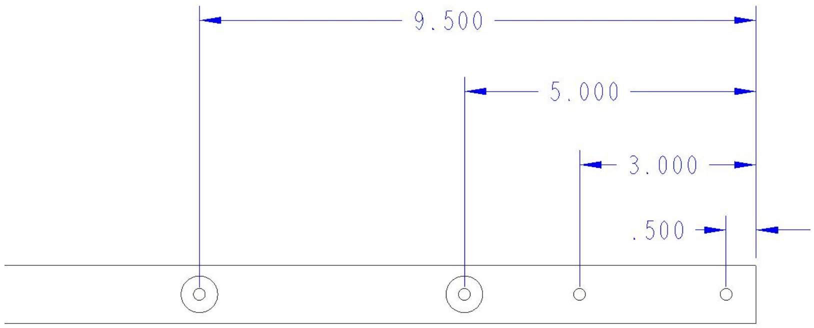


There are four types of aluminum extrusion used on the intake:

- 1" x 1" x 1/16" wall boxtube (16' in the KoP also available at Home Depot)
    - Qty(1) x 27.5"
    - Qty(2) x 12.75"
- ⅝" round aluminum (hard anodized igus rod in the KoP)
    - Qty(4) x 3.1875"
    - Qty(4) x 2.125"
- Churro shaft (left over from the AM14U KoP drivetrain)
    - Qty(6) x 0.875"
- ⅛" plate (left over from the cutout in the front of the AM14U frame)
    - Qty(2) x ~2.7" x ~2.45"

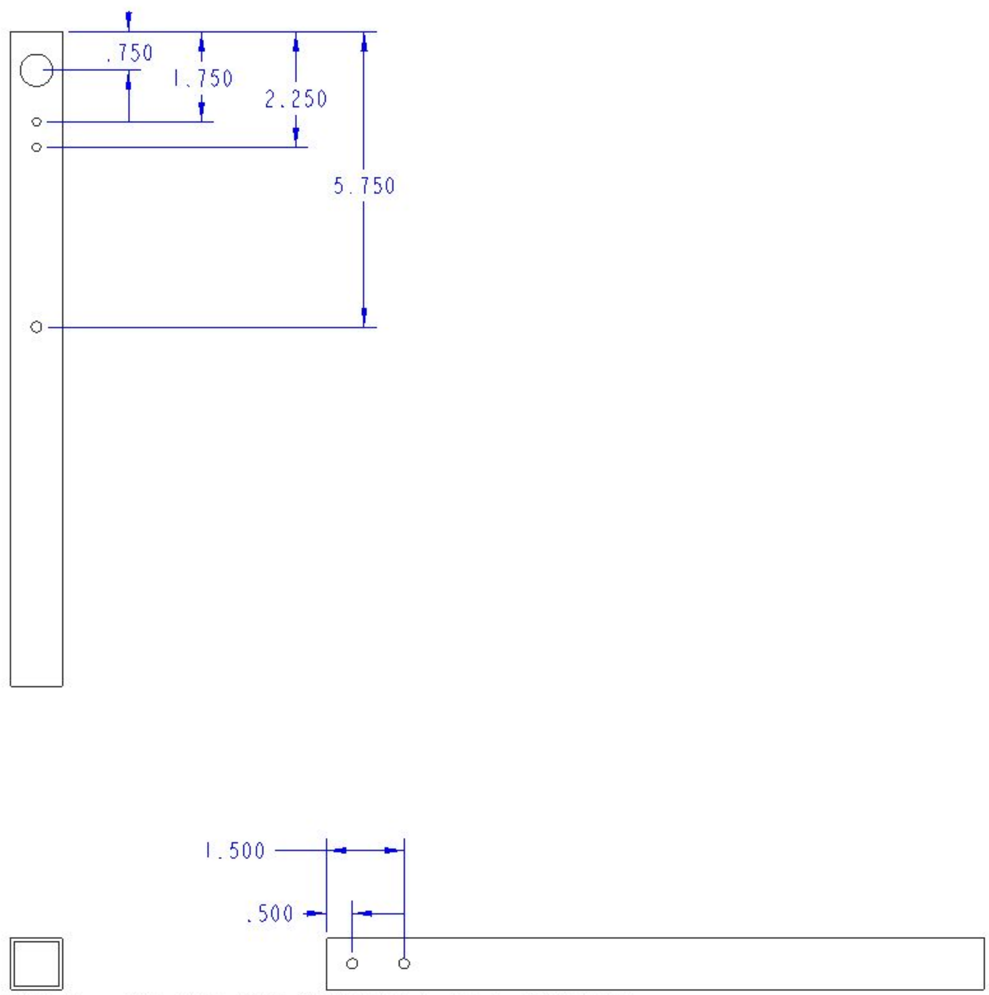
To manufacture the boxtube parts one they are cut to size, measure out the positions of the holes you'll be drilling based on the drawings below:

Ladder bar (27.5" part):



(mirror on the other side of the boxtube)

Intake arms (12.75" parts):



(there are two of this part; be sure to check the CAD or other pictures to be sure you drill each hole out to the right size)

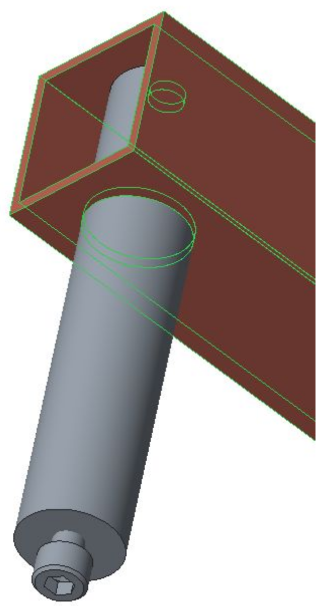
All “small” holes are clearance holes for 10-32 bolts (#7 drill bit).

All “large” holes on the ladder bar are ⅝”, created using a step drill.

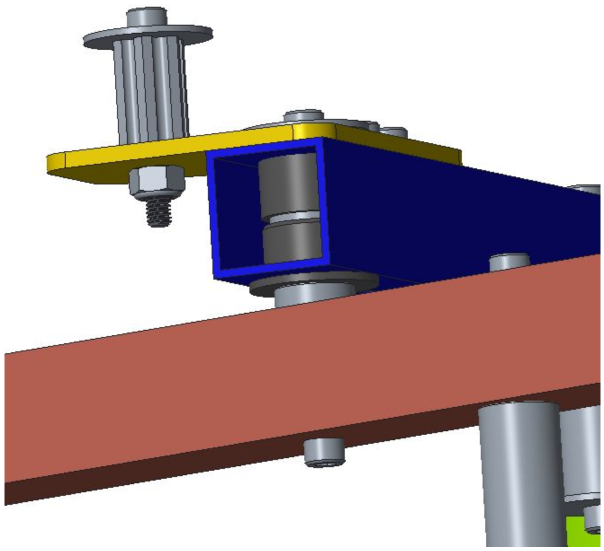
All “large” holes on the intake arms are ¾”, created using a step drill.

To ensure that the holes on each side of the tube line up with each other, first drill all the way through the tube using the 10-32 clearance drill, then drill out the applicable holes to ⅝” using the step drill.

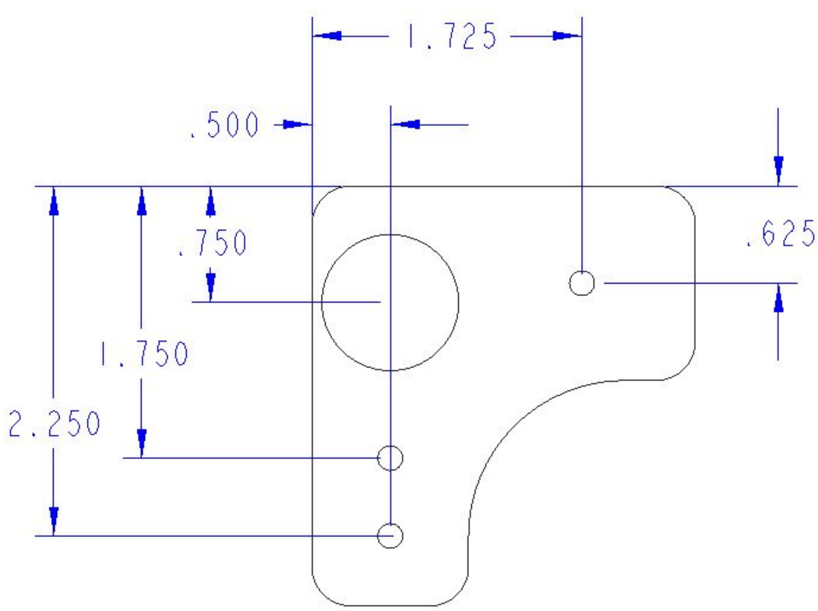
When assembling the structure with the ⅝” aluminum rod standoffs, you can estimate the center to drill and tap to 10-32 by hand. This operation could be done on a lathe, but it will be close enough for this application. To ensure that the holes line up, we drilled and tapped many of these standoffs in place while assembling. They may be a tight fit into the holes you made with a step drill. You may need to press in your custom standoffs using a vice.



To create the pivot points for the intake arms, press the Igus plain bearings (in the Igus bag in the kit) into the ¾" holes you put in the intake arms. These should make for a low-friction and sturdy joint.

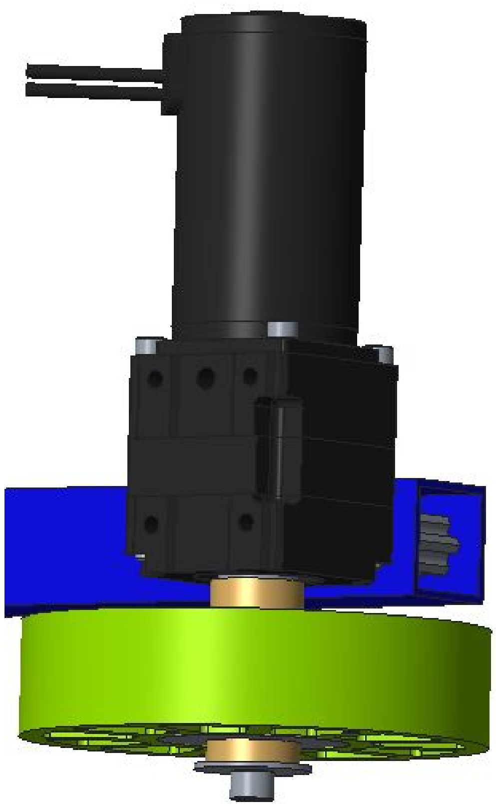


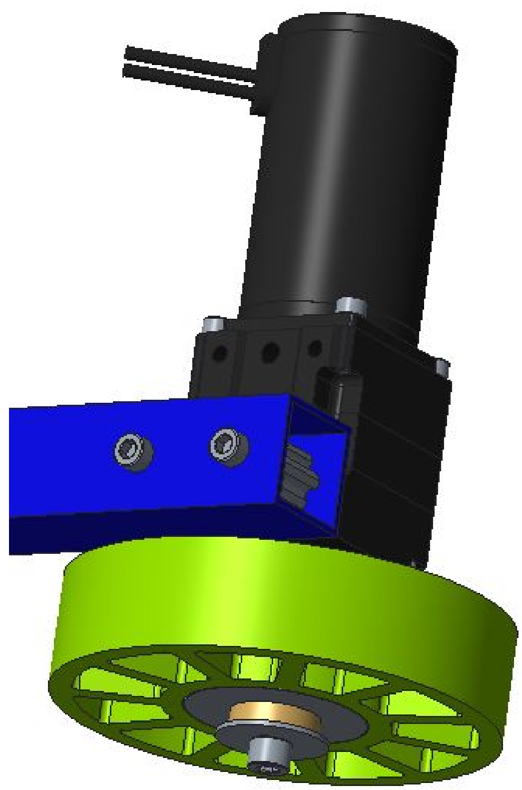
The final part you need to fabricate is from the leftover ⅛" plate from the front section of the AM14U chassis. Just cut a flat section from the C-channel and measure measure out these dimensions. This is the yellow part in the pictures above. The positions of the holes are the only critical dimensions, not the shape of the part.



Roller assembly:

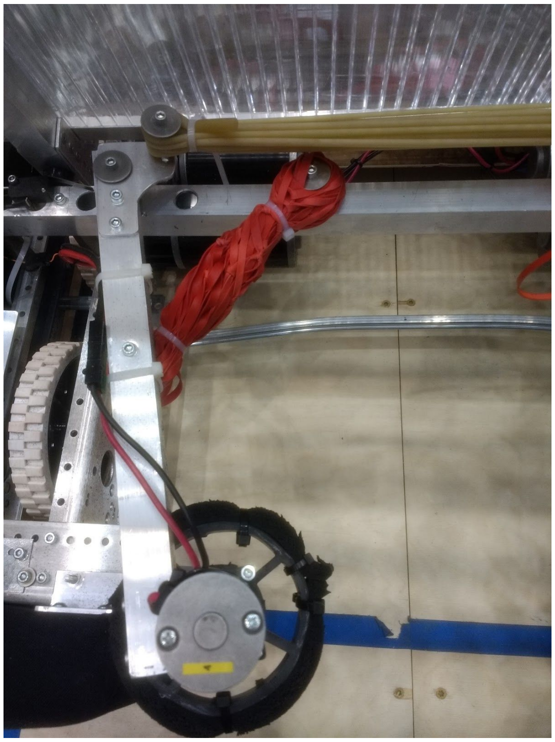
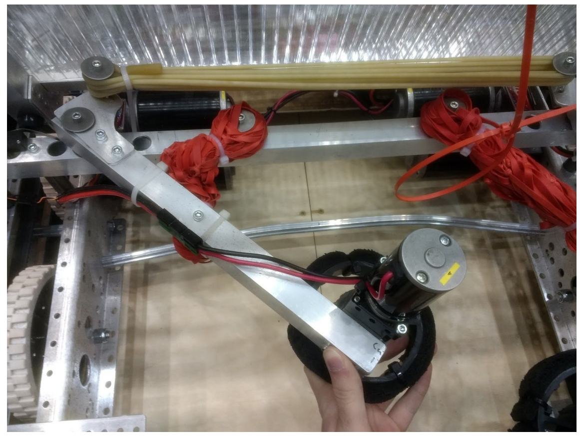
Build up two versaplanetary gearboxes with 10:1 reductions and BAG motors. See the VEXPro product page for assembly instructions. Space out the AndyMark compliant wheel such that they do not touch the box tubes using schedule 40 ½” PVC spacers. We cut ours to about ¼” long. Cap the end of the versaplanetary output shaft using a ¼”-20 bolt and large washer. Bolt each versaplanetary gearbox to each of the intake arm boxtube parts. Be sure to use the 0.875” long churro pieces to keep from crushing the boxtube as you tighten the 10-32 bolts.



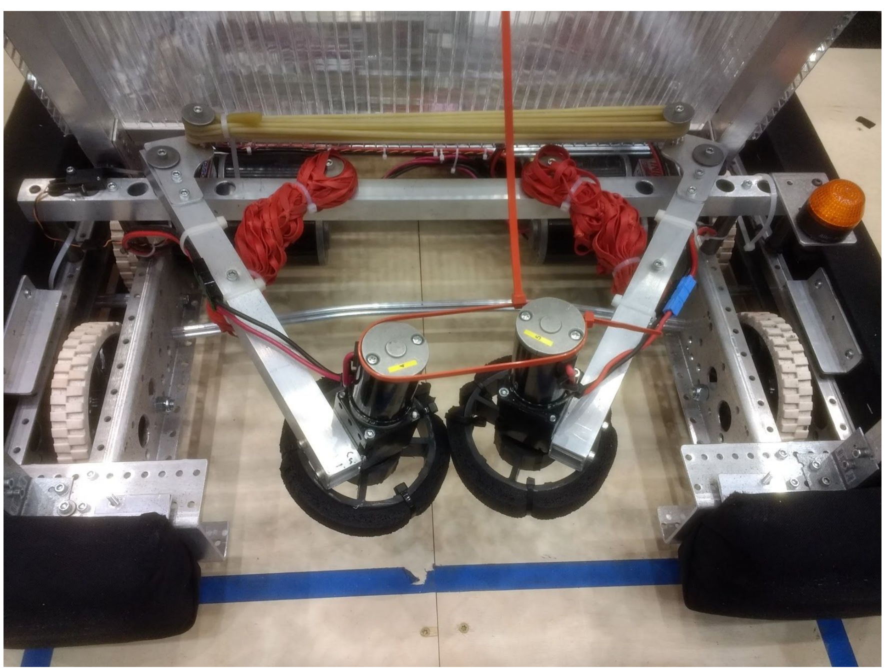


Tensioning configuration:

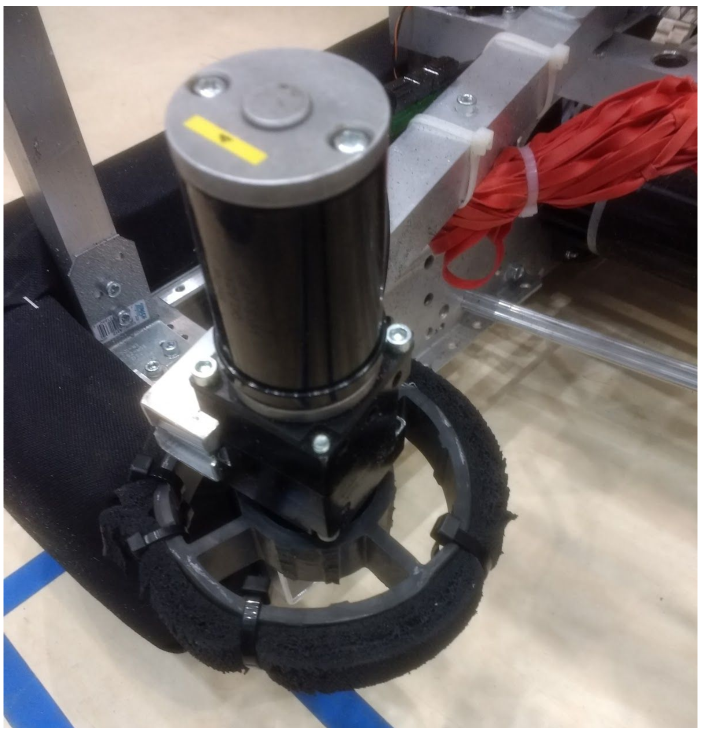
There are three sets of elastic. One, done with 5’ of latex tubing (in the kit) pulls the arms out from a stowed position. The other two sets, made up of size 64 rubber bands (lots of them) are slack until the arms have folded out to the correct width for intaking cubes. They stretch as cubes are sucked into the robot and provide force between the rollers and the cube.

To start the match, the rollers are folded in towards each other and a zip tie is put loosely around the BAG motors. This loop is attached to the arm so that when it lifts, the intake flips outward, extending past the frame perimeter above the bumpers.



We struggled with getting the intake wheels to grip cubes reliably. The black AndyMark 4” compliant wheels were too stiff so we cut out some of the spokes so they would compress more easily. To make them more grippy, we stretched latex rubber bands around them. This worked well but they often fell off. We settled on strips of gum rubber zip tied to the outside of the wheels. There’s a million ways to increase the coefficient of friction between your wheels and the cube. You should experiment with materials you have.



Switch Scoring Arm

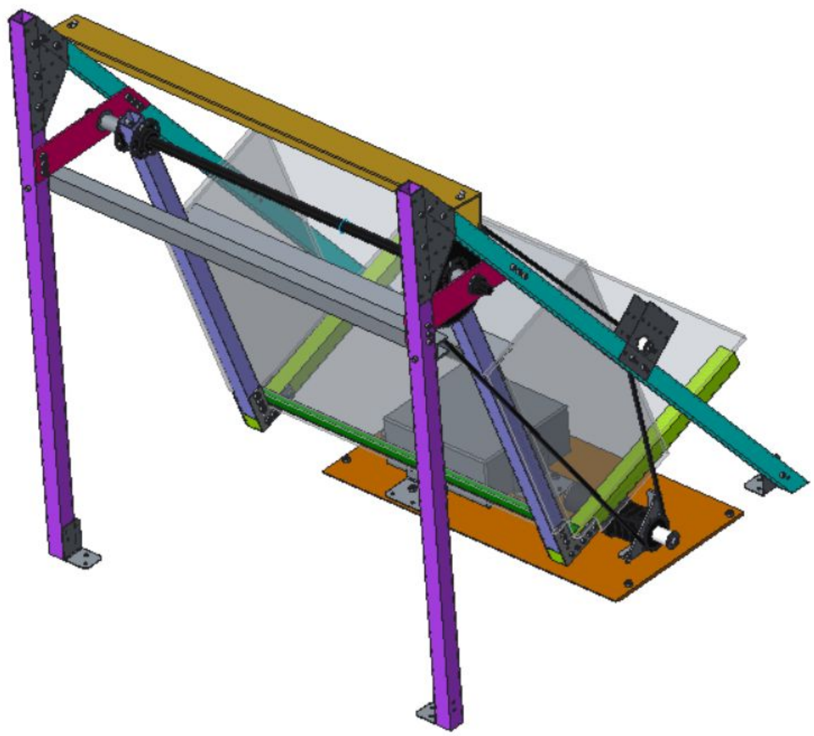
When conceptualizing the scoring arm we knew we wanted to get cubes on one side of the robot and score them on the other. This lead to an "over the head" scoring arm. We looked into using the 775 Redline and the 4:1 57 Sport gearbox along with a very large external reduction however we settled on a VexPro BAG motor on a 100:1 VersaPlanetary gearbox with a 22:72 Chain reduction. The following is a screenshot if the [JVN Mechanical Design Calculator] used to determine what ratio would be appropriate.

Rotary Mechanism

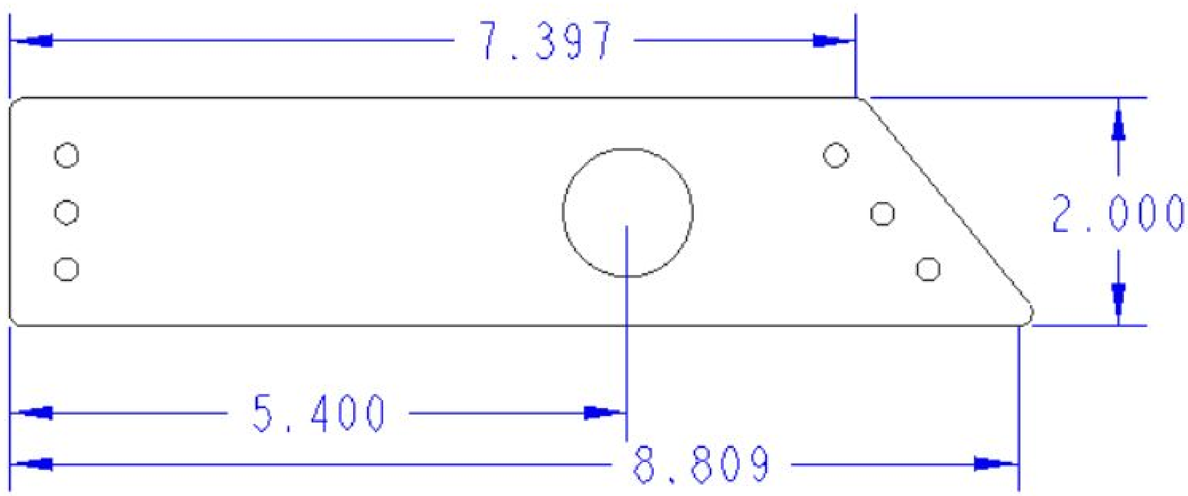
	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
BAG Motor	13180	0.43	53	1.8
# Motors per Gearbox	Gearbox Efficiency		Arm Load (lbs)	Arm Length (in)
1	65%		10	18
Driving Gear	Driven Gear		Arm Rotational Speed	Arm Time to move 90-degrees
1	100	No Load:	241.6 deg/s	0.37 sec
22	72	Loaded:	187.9 deg/s	0.48 sec
1	1			
1	1			
327.27 : 1	<-- Overall Ratio		Current Draw per Motor (loaded)	Stall Load
			9.20 amps	44.98 lbs

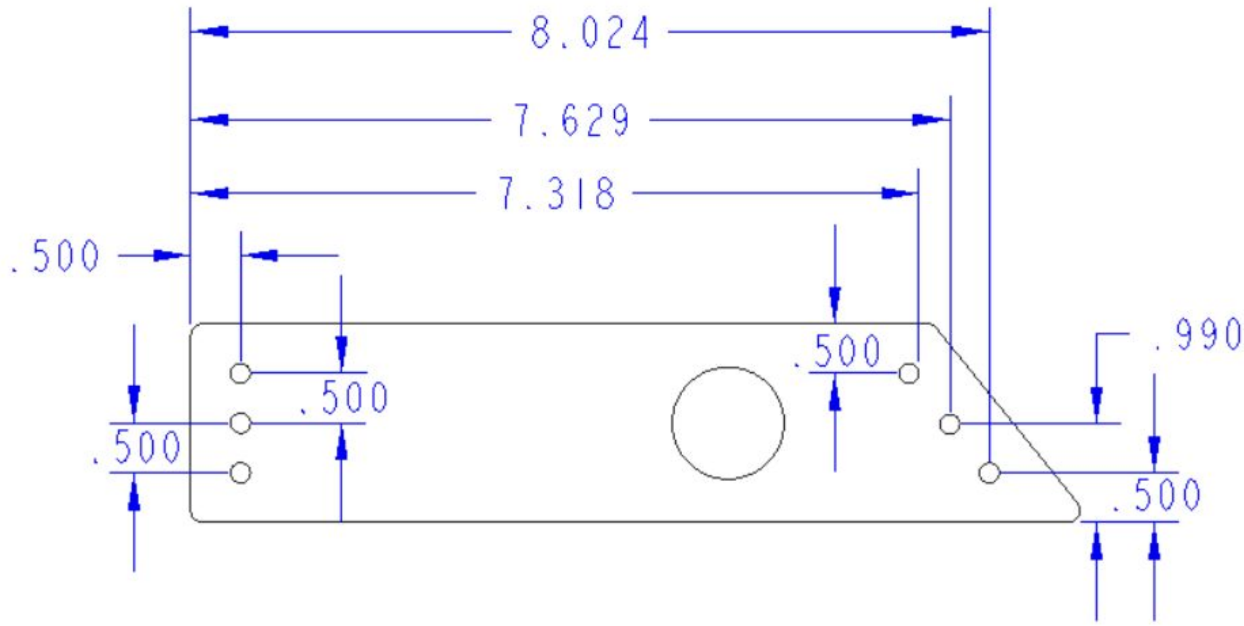
This is the cut list for the scoring arm:

- 1" x 1" x 1/16" wall boxtube (16' in the KoP also available at Home Depot)
  - Qty(2) x 33.875"
  - Qty(2) x 41.5"
  - Qty(2) x 24"
  - Qty(2) x 15"
- ¾" x ¾" Aluminum Angle (From Home Depot)
  - Qty(1) x 22"
- ¾" x 9/16" Aluminum C-Channel (From Home Depot)
  - Qty(1) x 27.75"
- 1-½" x 1-½" Aluminum Angle (From Home Depot)
  - Qty(1) x 27.75"
  - Qty(1) x 22"
- ⅛" Thick Aluminum Plate (From Home Depot)
  - Qty(2) @ 2" x 9"
- .300" Corrugated Polycarbonate (From Home Depot)
  - Qty(2) @ 8.5" x 13"
  - Qty(1) @ 7.5" x 32"
  - Qty(1) @ 15" x 22"
  - Qty(1) @ 12" x 22"
- 3/16" Thick Plywood (From Home Depot)
  - Qty(1) @ 20.25" x 10.125"
- ½" VexPro Hex Shaft
  - Qty(1) x 27.75"
- ½" Schedule 40 PVC
  - Qty(1) x 1.1"
  - Qty(1) x .10"
  - Qty(1) x 1.875
  - Qty(1) x 1.175"
  - Qty(1) x 1.19"

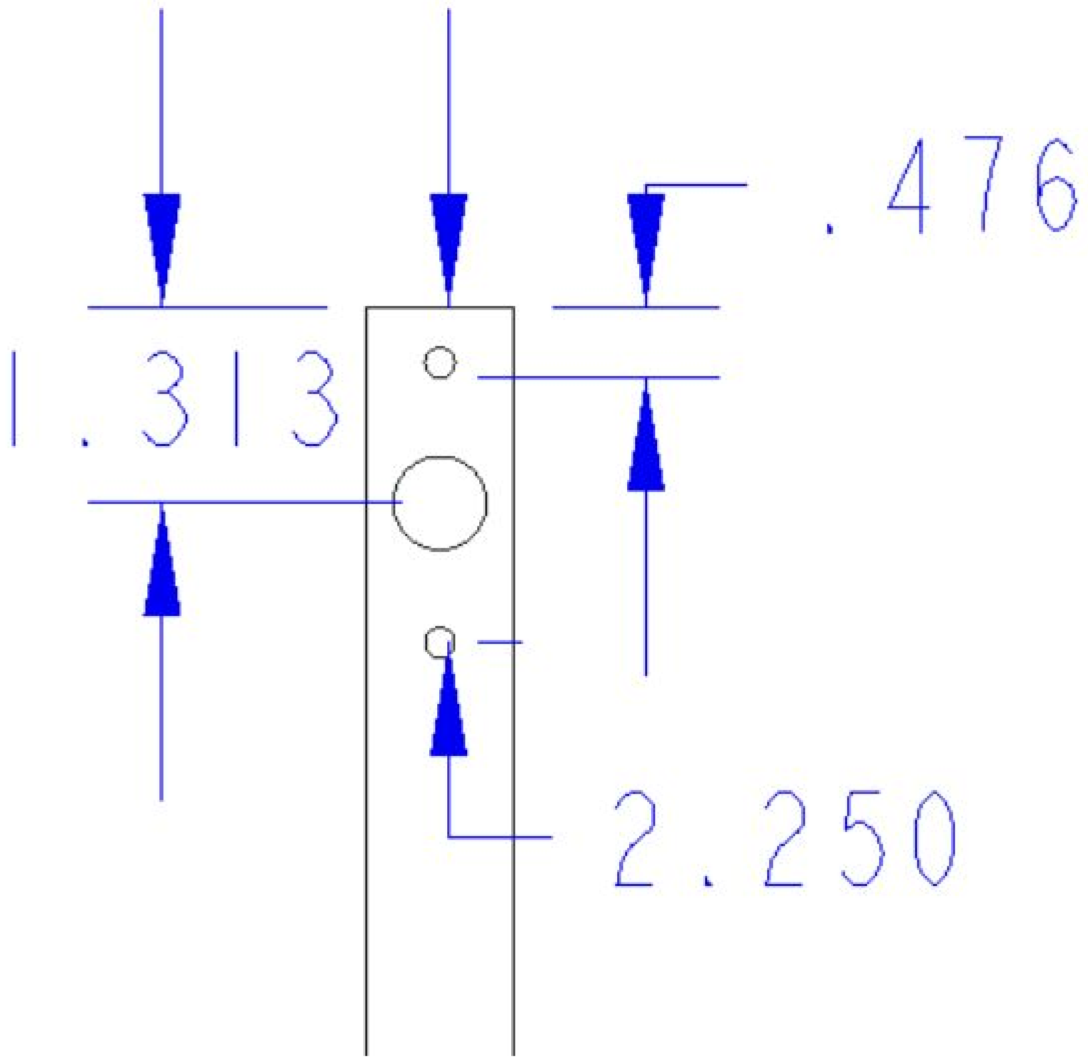


Once all the parts are cut to the sizes specified above the ⅛" thick plates should be cut according to the drawings below. The large hole is a 1.125" bearing hole and the smaller holes are .201" a number 10 clear hole.




8.024
7.629
7.318
.500
.500
.500
.500
.500
.990
.500

The two 24” long 1”x1” box tubes need to be machined on one end according to the following drawings. The small holes are #10 clears (.201”) and the large hole is .75” to allow for a ½” hex shaft to fit through. I recommend drilling this hole with a step drill.

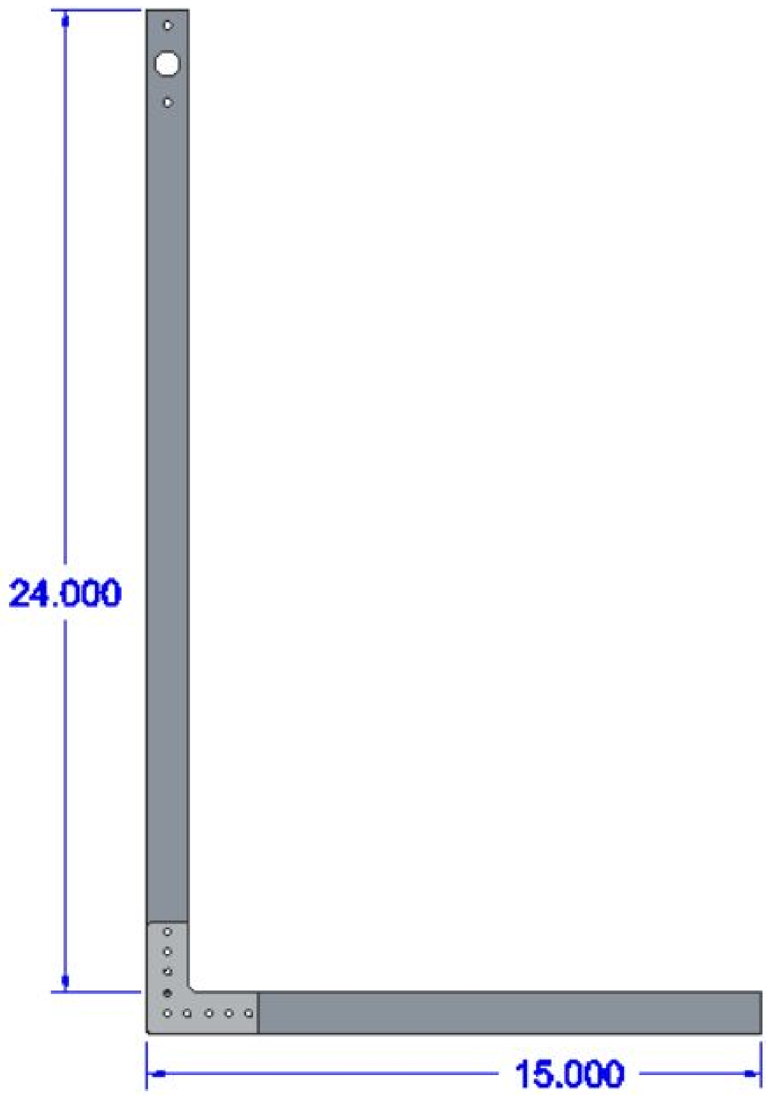


These are the only parts that need to be machined before being assembled. The rest will be clamped together and match drilled.

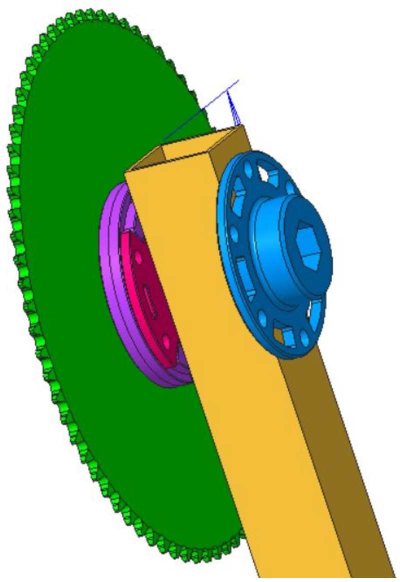
Arm Assembly

Most of the assembly on the arm was done by clamping parts into place and then match drilling. For the most part this eliminated any part misalignment.

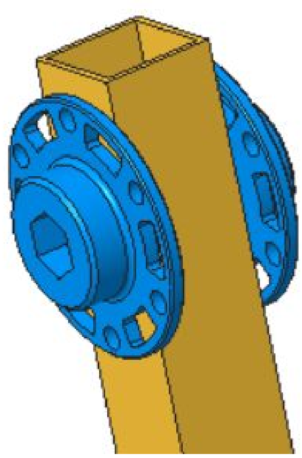
To begin the arm assembly we will put together the actual arm. To start we need the two 24” long 1”x1” box tubes machined above along with the two 15” long 1”x1” box tubes and two VexPro Versaframe 90 degree gussets. Everything should be clamped together and match drilled. 5/32” rivets or 8-32 bolts can be used to attach these components. The following drawing shows how the parts should be clamped together. You will need to put two of these together.



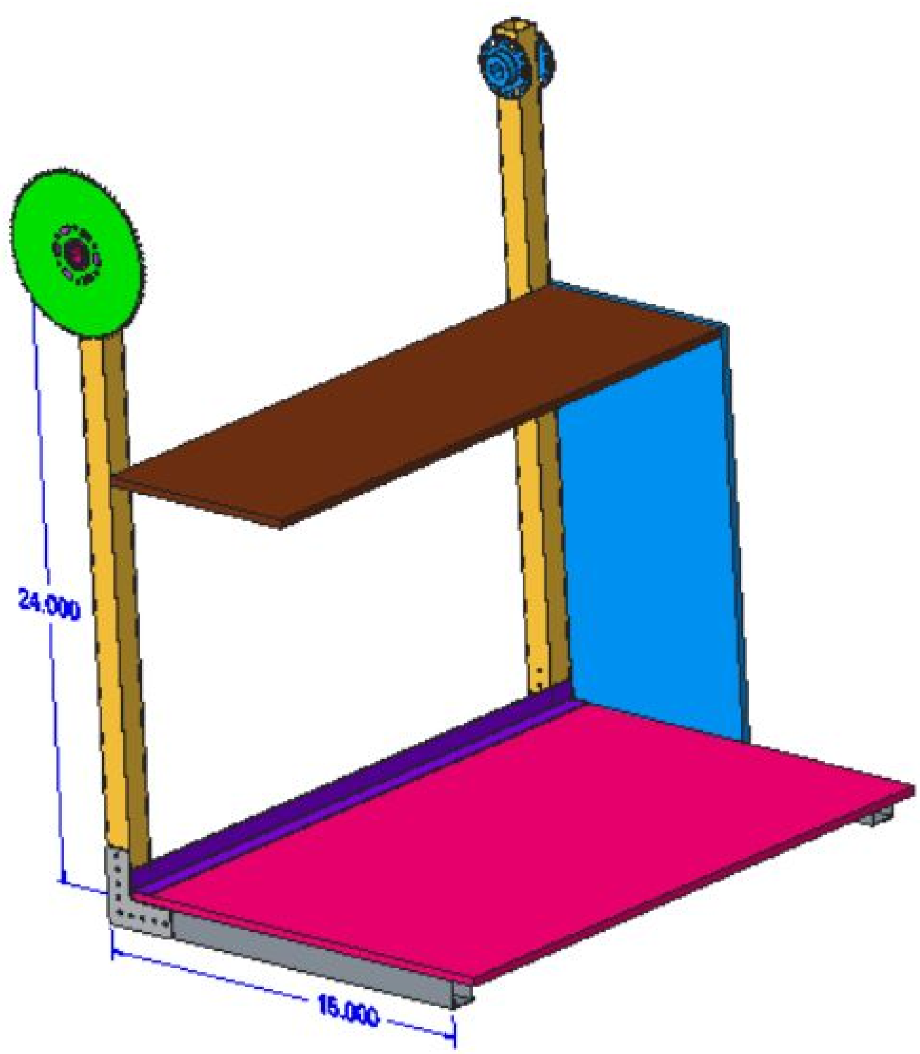
Once both arm sides are assembled VexPro Versahubs and the 72 tooth plate sprocket need to be attached to the arm. The left arm will be assembled according to the following drawing. The holes on the 24” long arm should line up with the holes on the VexPro components. Green is the 72 tooth plate sprocket, purple is the 1.125” ID bearing bore VersaHub, pink is the plastic ½” hex VersaHub, yellow is the 24” long arm and blue is the ½” hex metal VersaHub. The holes in these Vex components will need to be drilled out to a #10 clear (.210”) to allow the bolts we are using to fit through them.



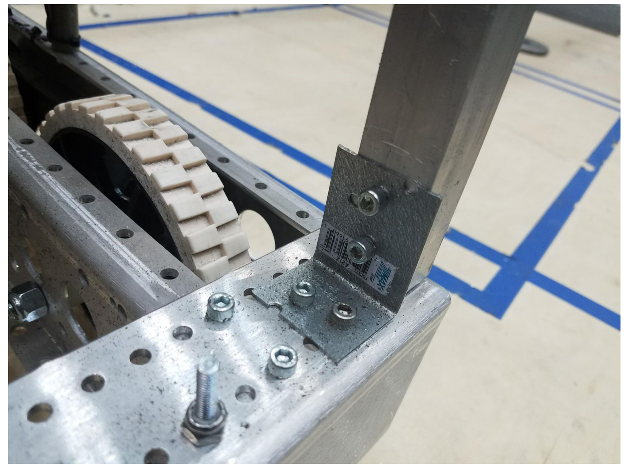
The right arm should be assembled to the following drawing which matches the color scheme above.



After both sides of the arm are assembled the ¾” x ¾” angle (purple)can be attached to both arm sides using rivets or bolts. All of the polycarbonate plates were attached with VHB tape that is included in the kit. In the following drawing the blue plate is the 8.5” x 13” polycarbonate sheet, there is one on each side of the arm. The pink plate is the 22” x 15” polycarbonate plate. The brown plate is the 22” x 7.5” polycarbonate plate. The 22” long 1-½” x 1-½” angle gets mounted below the brown polycarbonate plate using rivets or bolts.



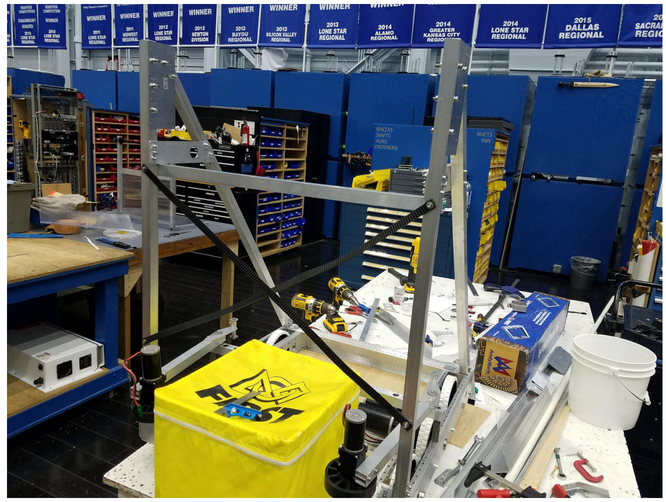
Master Pivot A-Frame Assembly

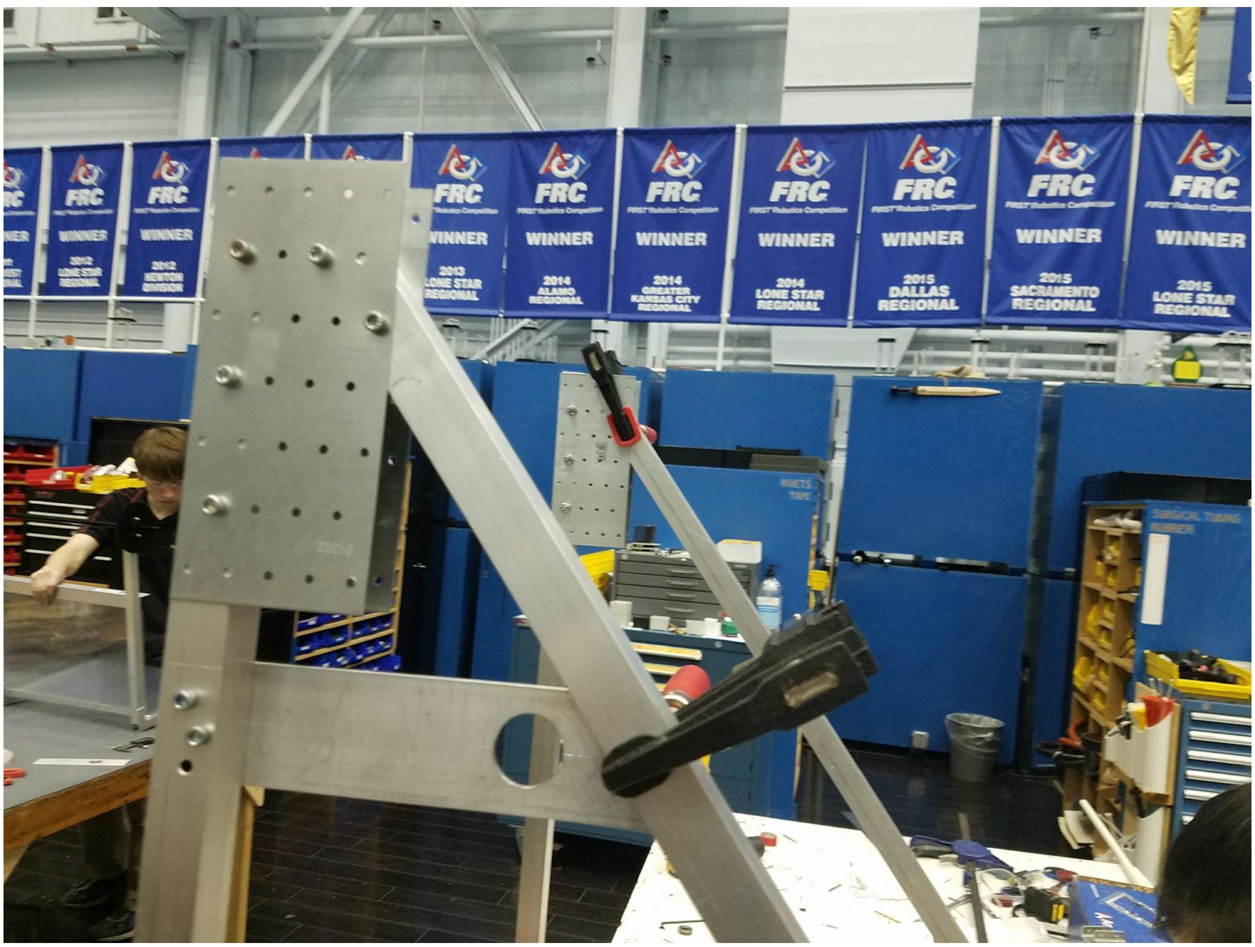


Most of the master pivot A-frame is match drilled. We placed the two 33.875" 1" x 1" box tubes in the two front corners of the robot and attached them at the bottom with 10-32 bolts to steel angle gussets from Home Depot. The gussets are also attached to the chassis using 10-32 bolts. During this process it is best to have someone holding the box tubes vertical until the rest of the a frame is assembled to keep the angle gussets from bending.

After the vertical box tubes are installed the tie plates can be clamped to either side of the 1x1s at the top. They need to be match drilled for a 10-32 bolt (.201") 1.5" long bolts need to be used to attach these components. If desired you can mark them and trim them to make them match the box tubes. Once the tie plates are installed the the two 41.5" 1" x 1" box tubes can be installed to support the vertical box tubes. Two 10-32 bolts should connect the box tube at the top and at the bottom it should be attached to the frame using another steel angle gusset. We also connected the two vertical box tubes with two timing belts (come in the kit as a part of the kit chassis) that were cut to act as tension members. These greatly strengthened the arm assembly.

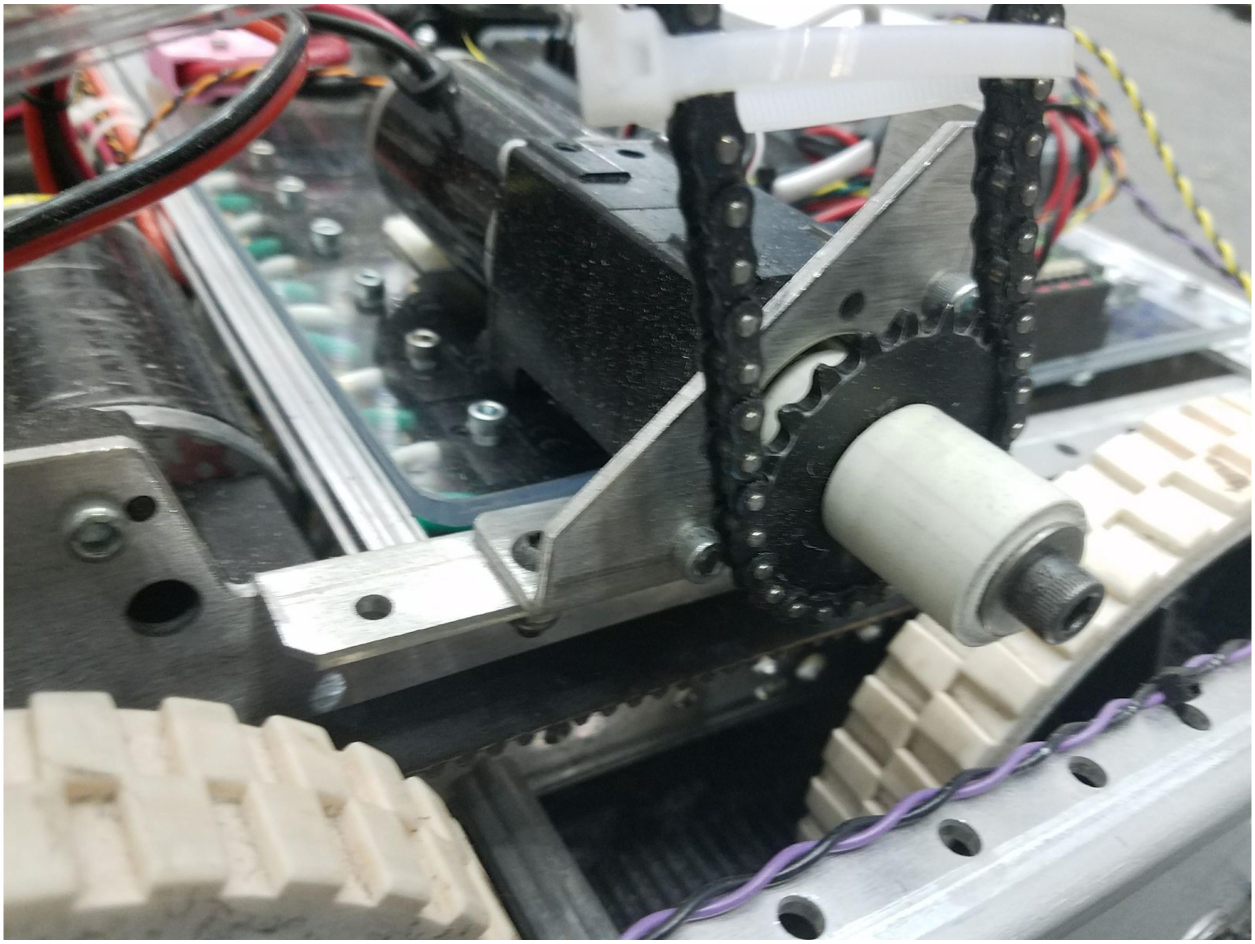
Next the ⅛” master pivot plates need to be installed, these should be clamped to the box tubes and then match drilled and bolted in with 1.5” long 10-32 bolts. Below these plates we mounted the 27.75” long C-Channel with 10-32 bolts.



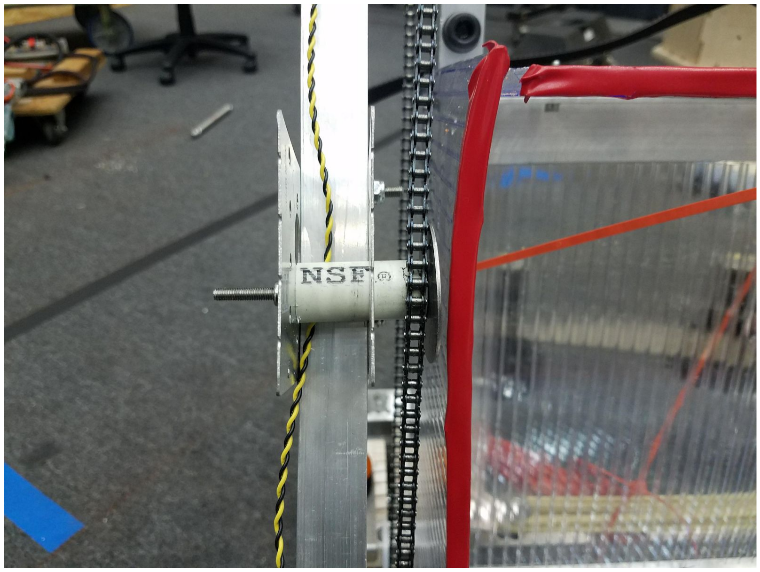


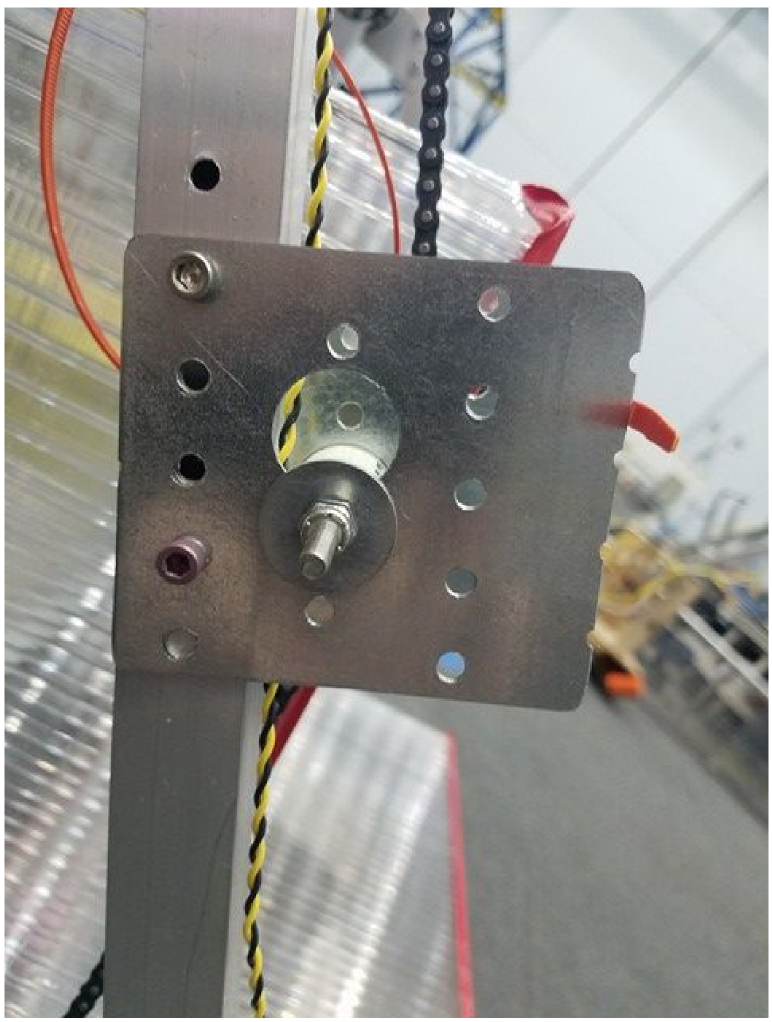
Next the ½” hex bearings can be placed into these bearing holes. The arm can also be placed in with the PVC Spacers. The 1.175“ long spacer goes on the left and the 1.19“ long spacer goes on the right when looking from the back of the robot. The ½” hex shaft is then pressed in, you may need to loosen the bolts on the Versahubs on the arm to get the shaft through all of them. Shaft collars then go on each end of the shaft.

The last major thing to do for the arm is install the motor and the chain tensioner. Assemble a VersaPlanetary with a 100:1 and a BAG motor. Bolt the VersaFrame Corner Gusset in the location shown in the photo below with 10-32 button head bolts and then install the .10” long spacer closest to the motor followed by the 22 tooth sprocket followed by the 1.1” spacer then use a large ¼-20 washer and bolt to retain the spacers on the shaft.



The chain tensioner consists of a tie plate cut in half with one of the holes drilled out to .86" A metric step drill is ideal for this, but it's ok if the hole is a little oversized. The other plate needs to have the hole directly across from the .86" hole drilled out for a 10-32 (.201") The following photos show how the tensioner is mounted with 10-32 bolts.


NSF®

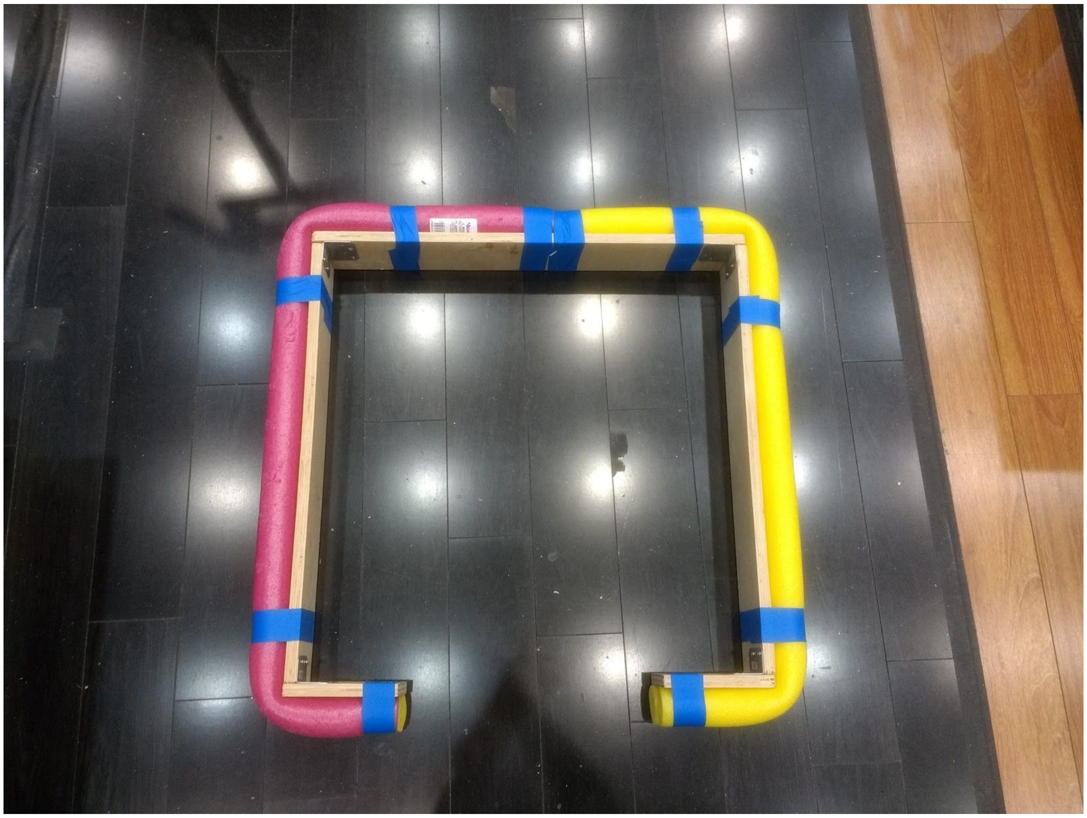


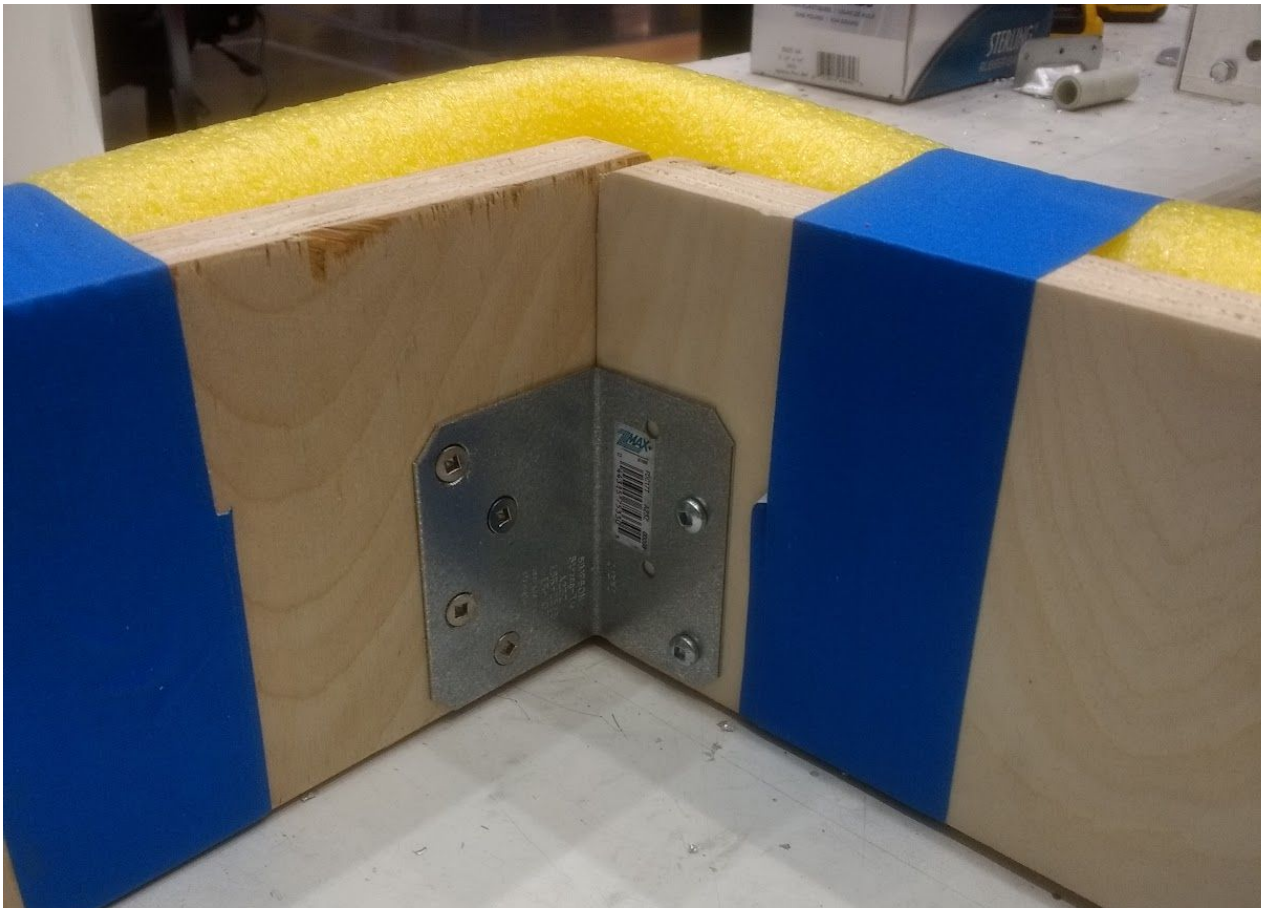
For the length of the chain run we just put together pieces of chain until it looked about right and then added a tensioner. There are better ways to do this such as calculating the center-to-center distance for the shafts however the VexPro Corner Gusset flexes making a chain tensioner necessary. Slide the assembled tensioner under the chain along the box tube until the chain is tight and match drill the holes for a 10-32 bolt, 1.5” long.

Bumpers

For the bumpers we made a single piece unibumper with wood that was 4.5” tall due to the rule stating your bumper wood must be 5+/- ½”. The bumper wood is ¾” thick as required. The bumper cut list is as follows

- 1” x 1” Aluminum Angle .125” Thick (From Home Depot)
  - Qty(2) x 4”
  - Qty(2) x 2”
- ¾” Thick Plywood
  - Qty(2) @ 4.5” x 7.25”
  - Qty(2) @ 4.5” x 28.75”
  - Qty(1) @ 4.5” x 30”

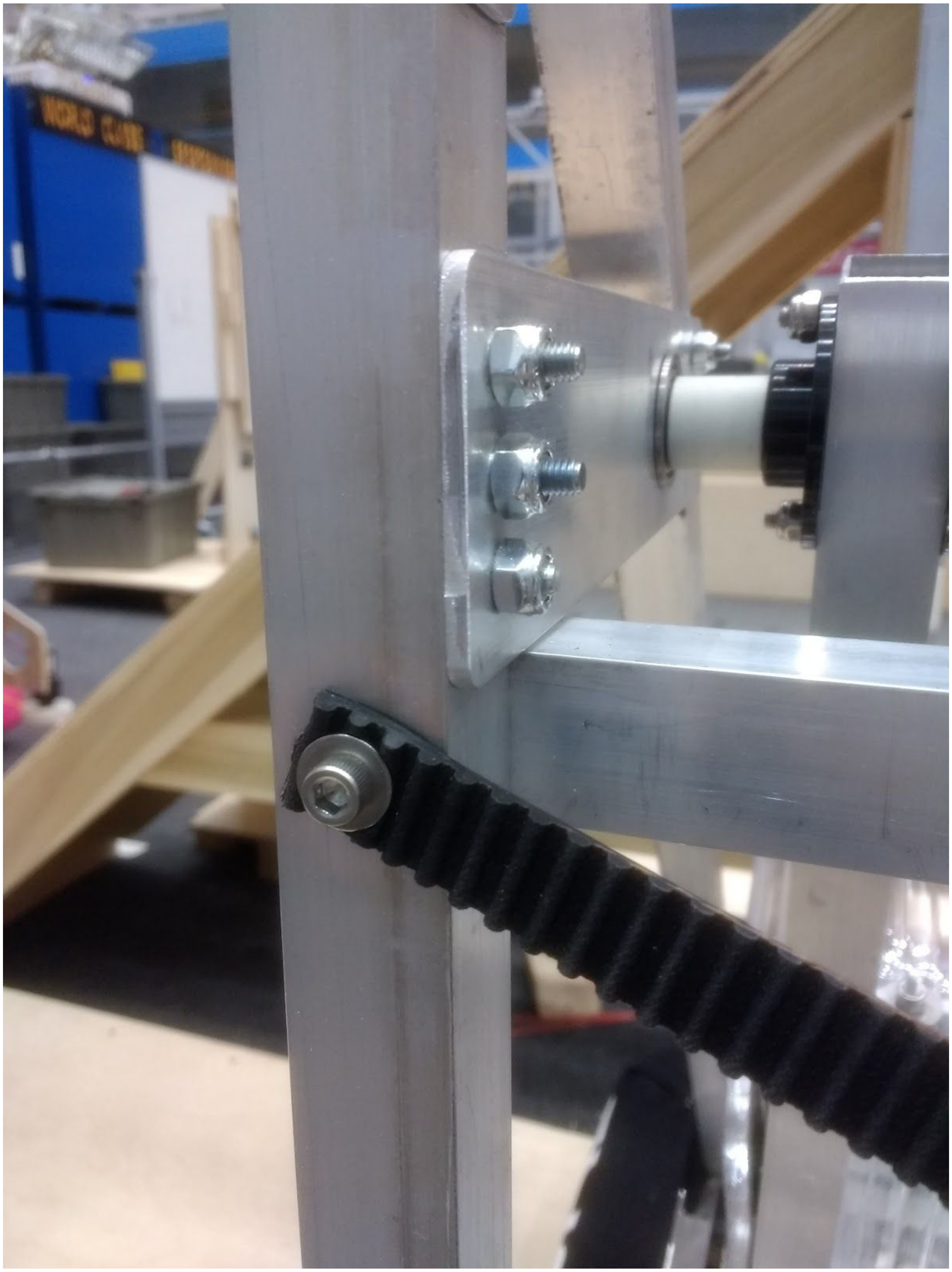




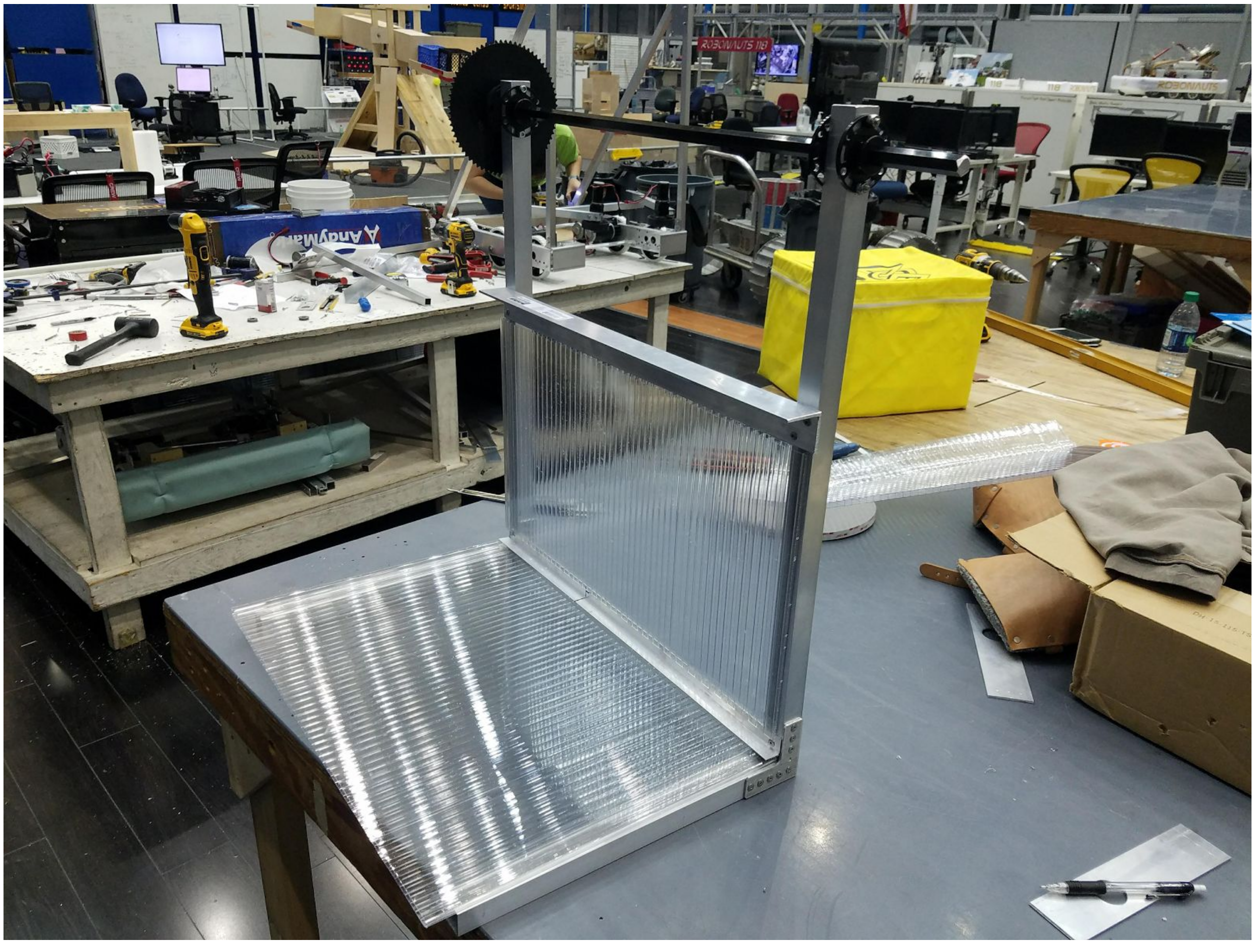
We used these steel gussets in the corners and attached them with wood screws. The two 4” long segments of angle mount the back of the bumper to the robot and the 2” long segments of angle attach the front of the bumper to the robot. Wood screws are used to attach the angle to the bumpers and then 10-32 bolts are used to attach the angle to the robot. The following pictures show an example of this.

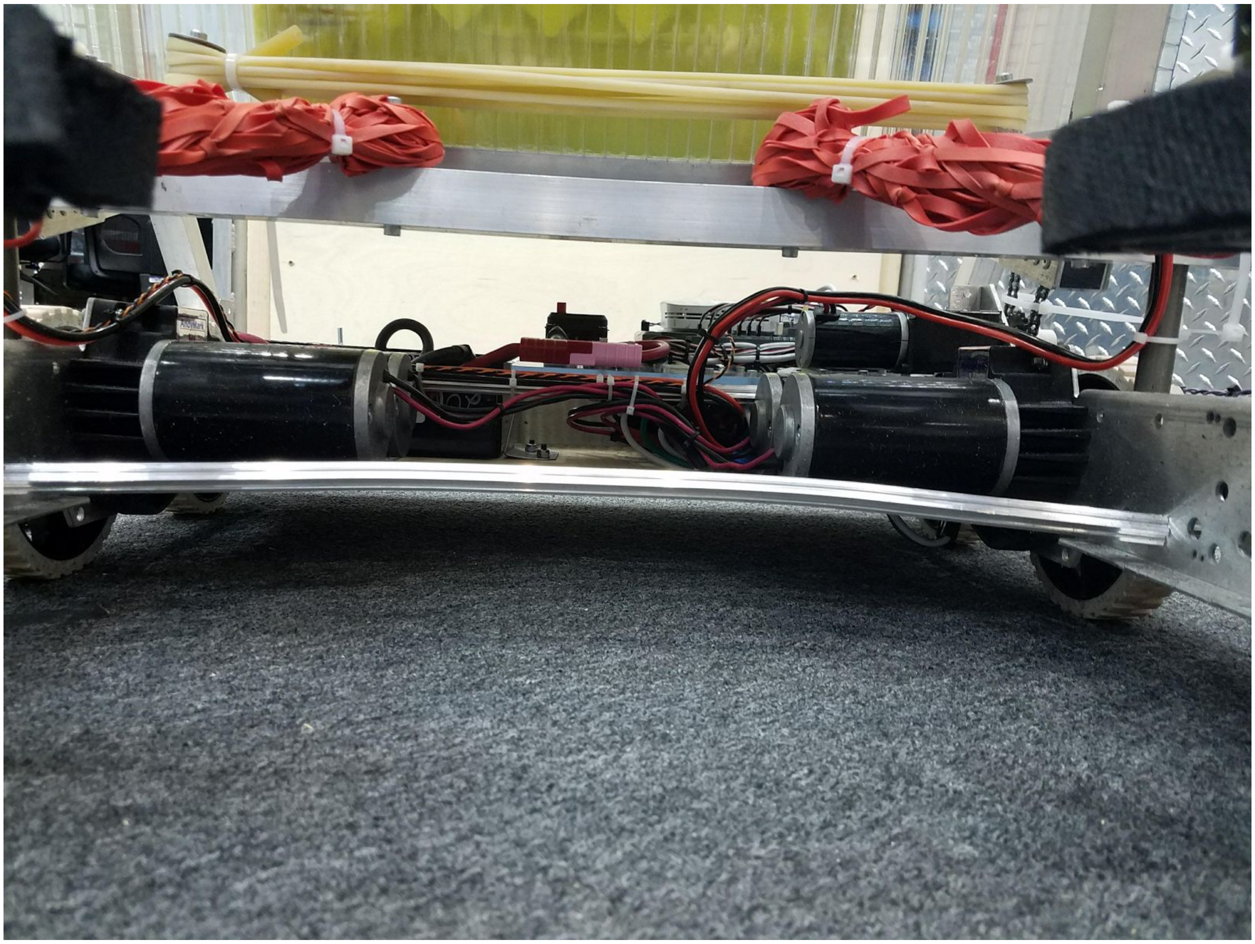

EVERYBOT

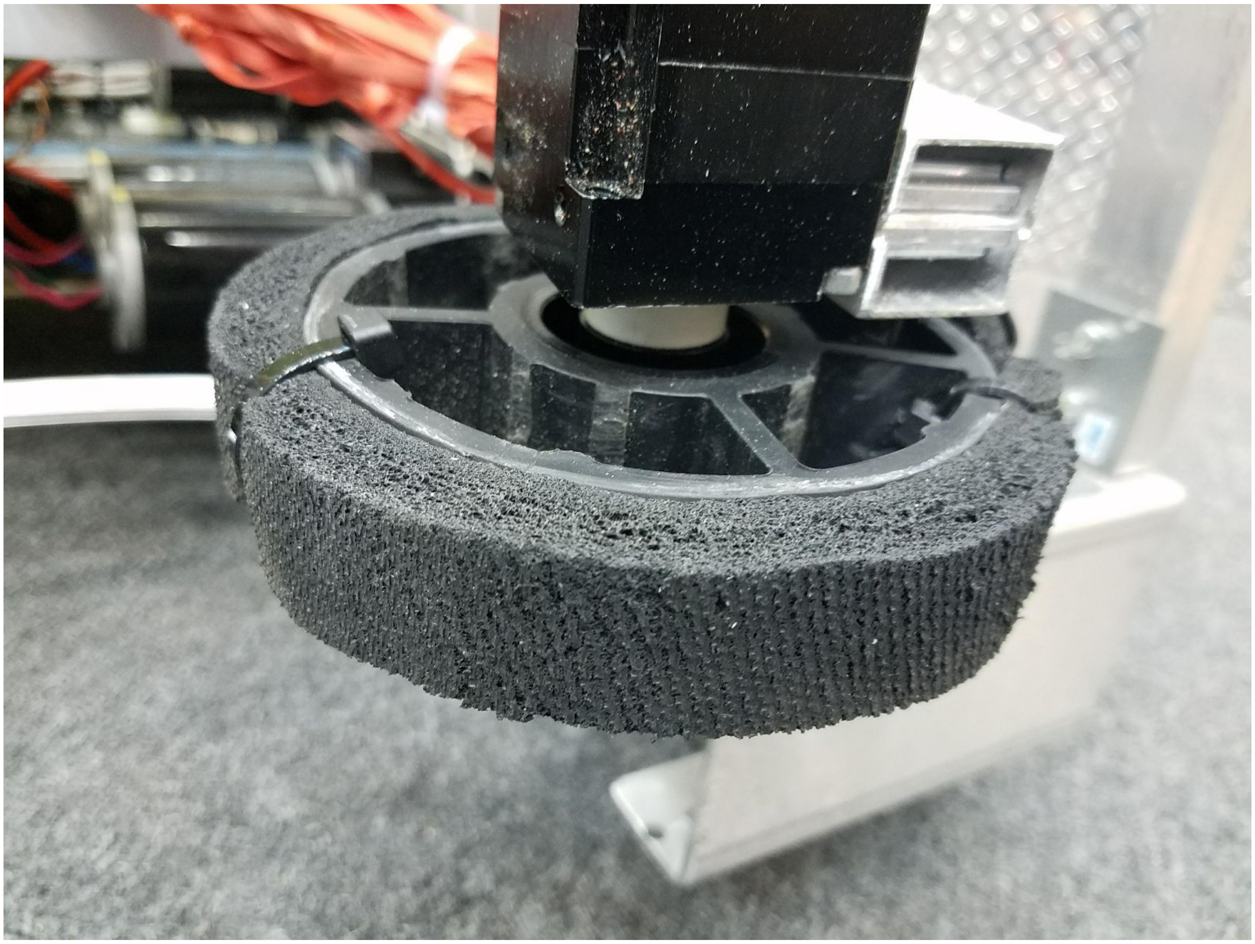
Everybot Photos

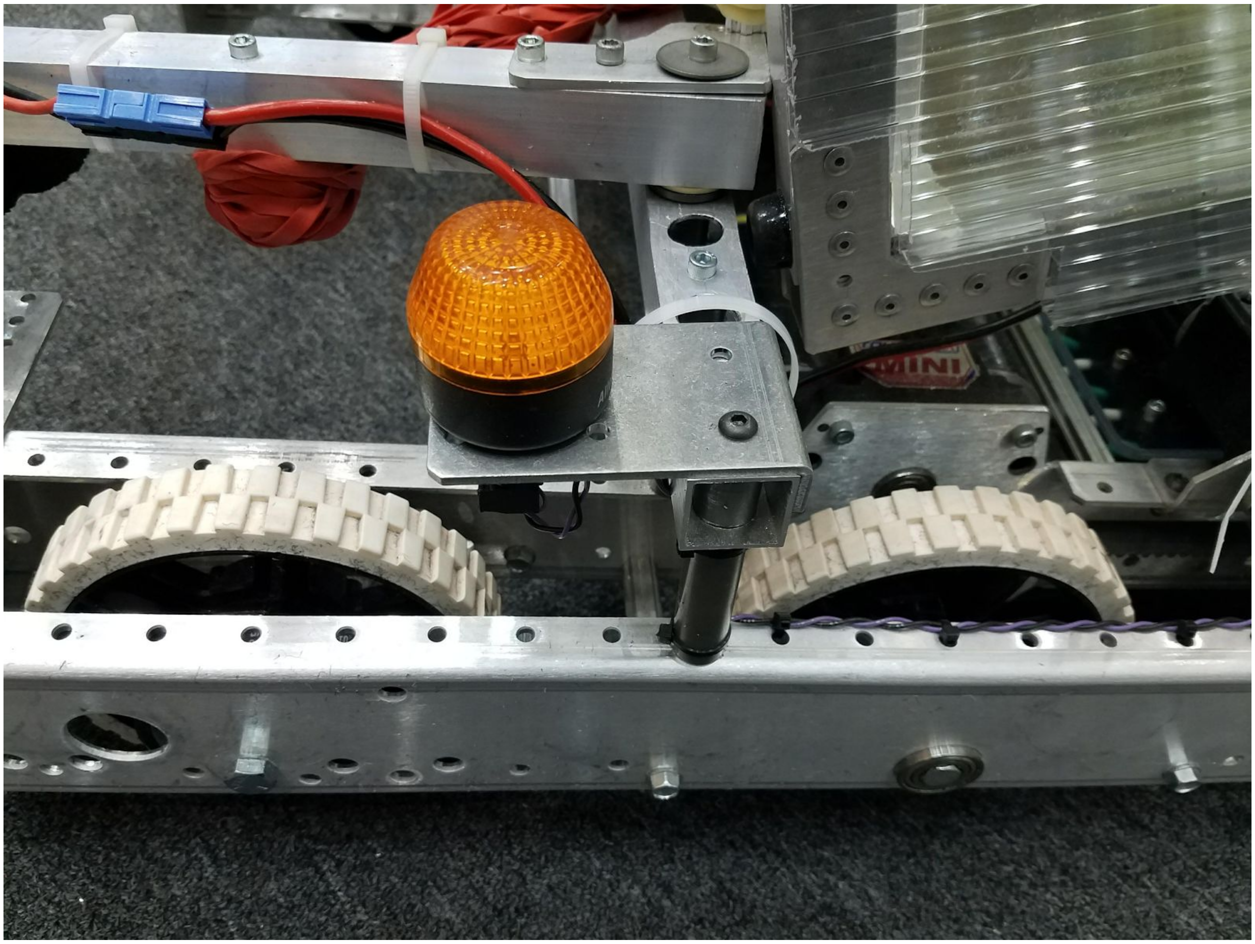


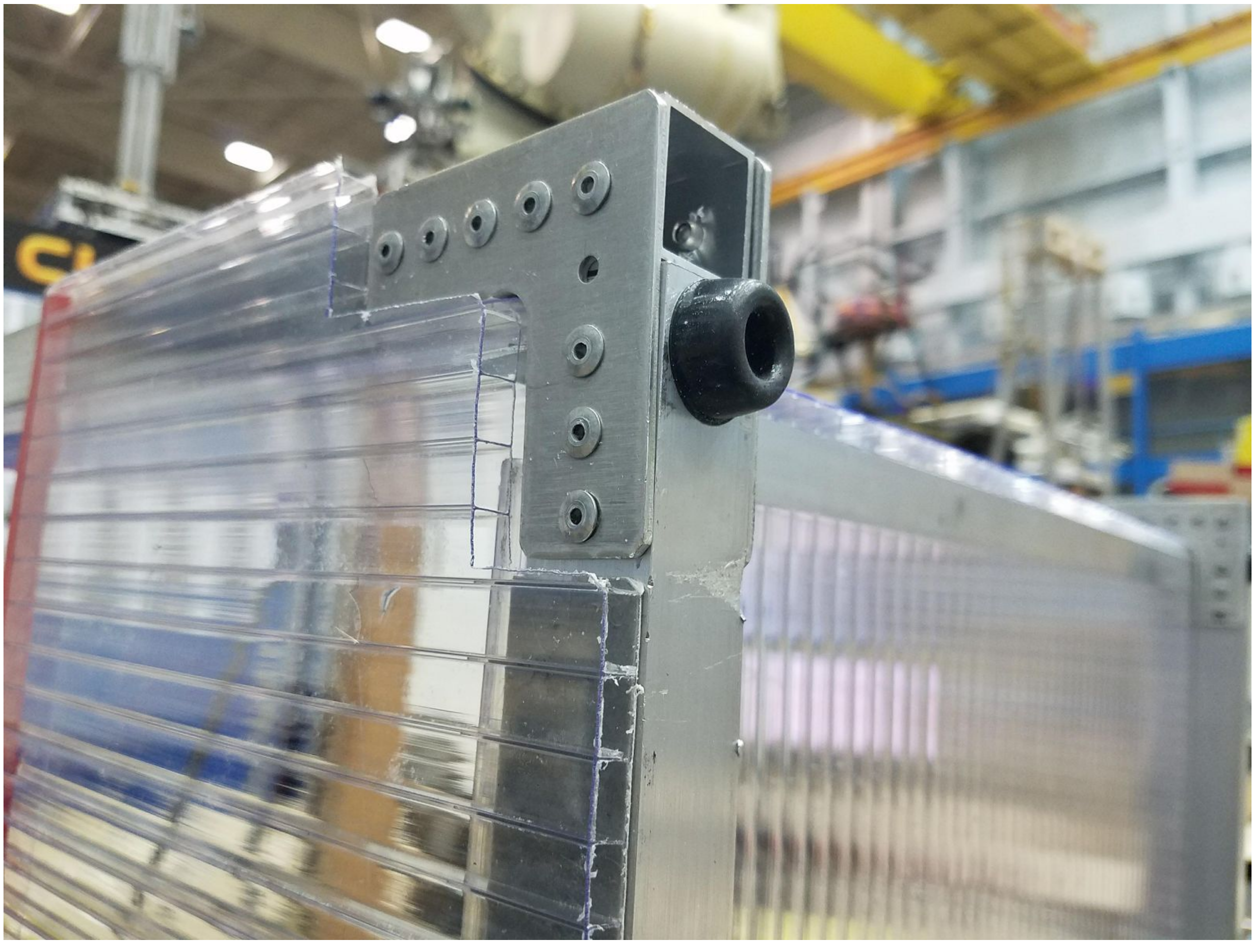

RE EDM CART

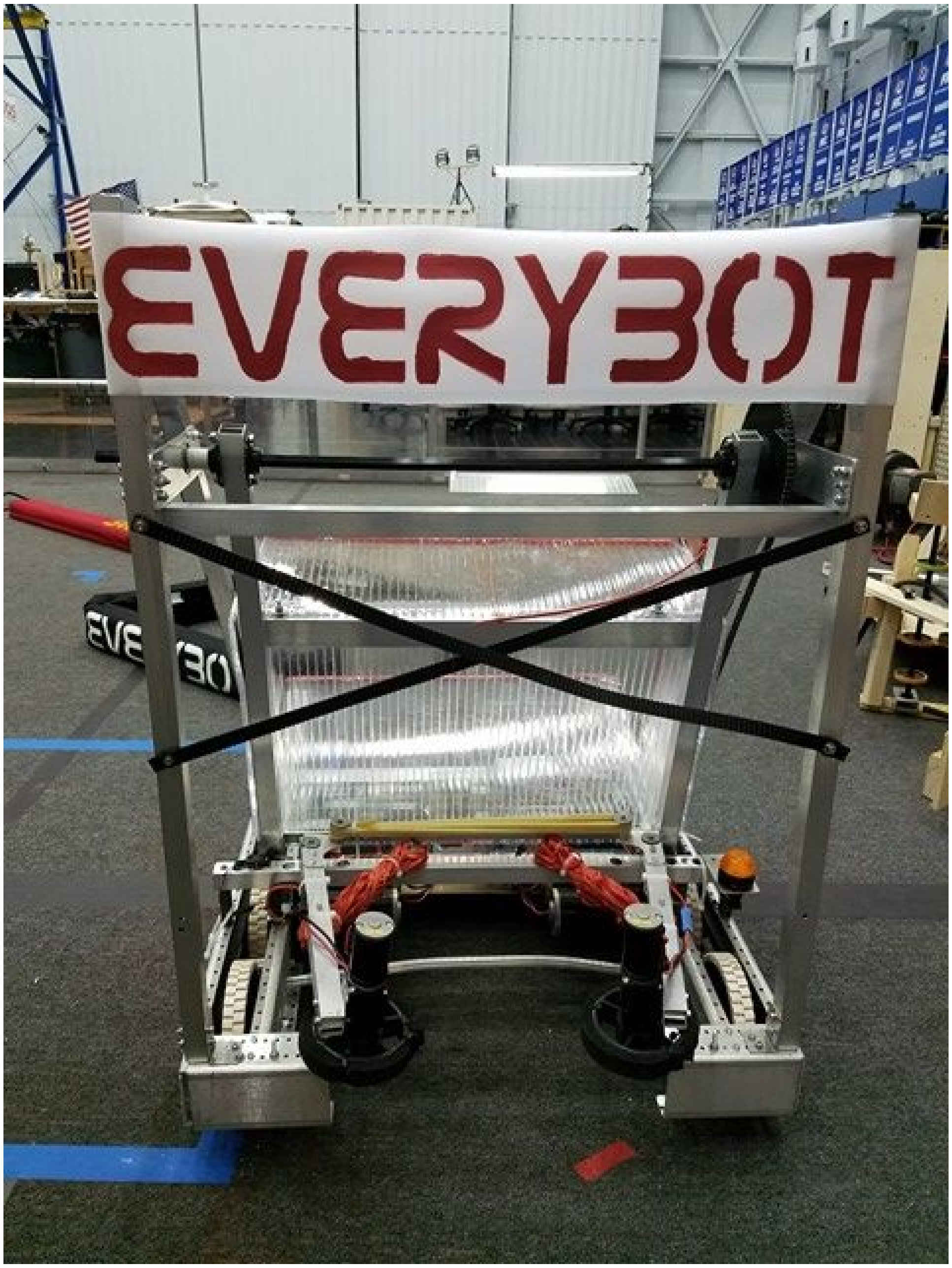


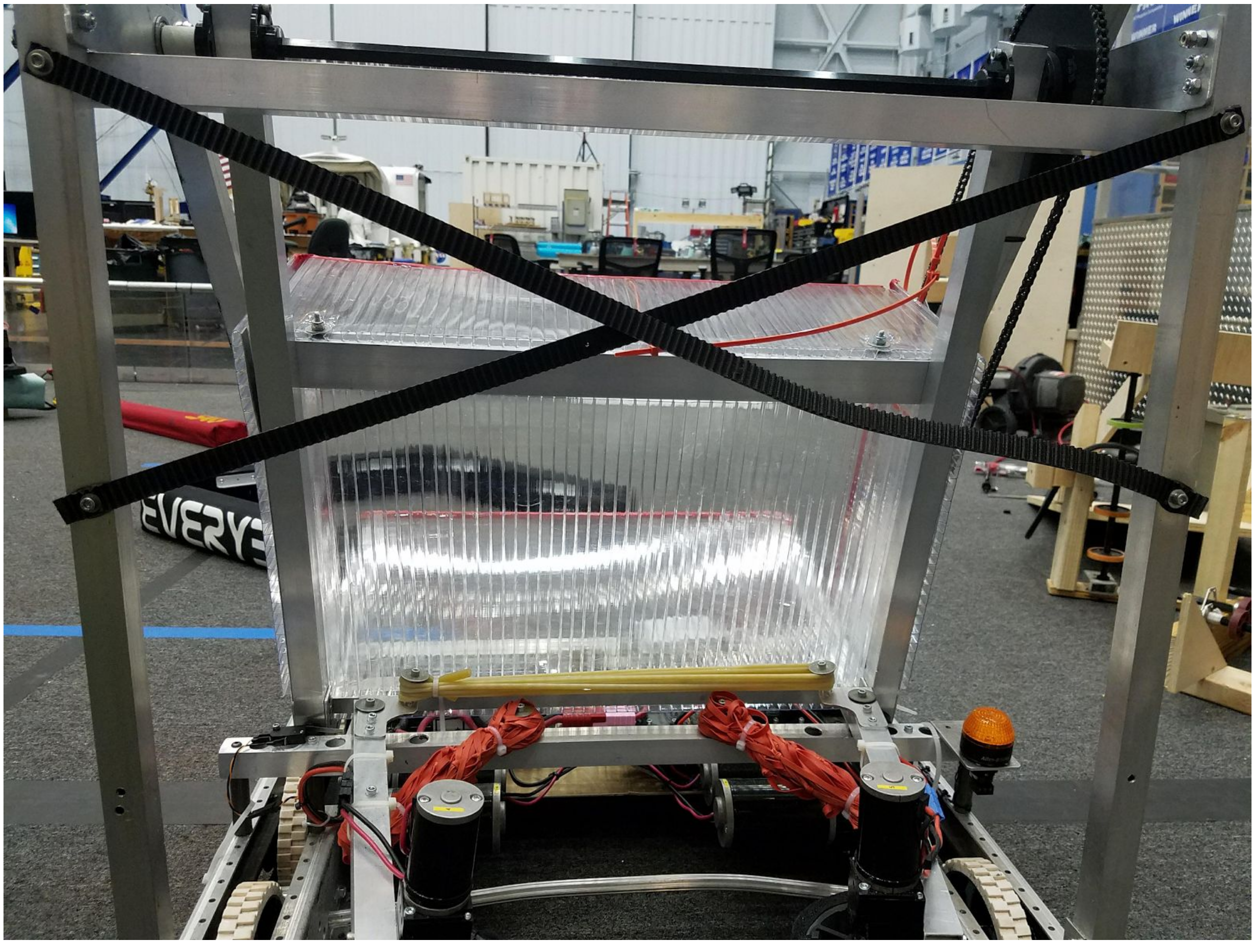


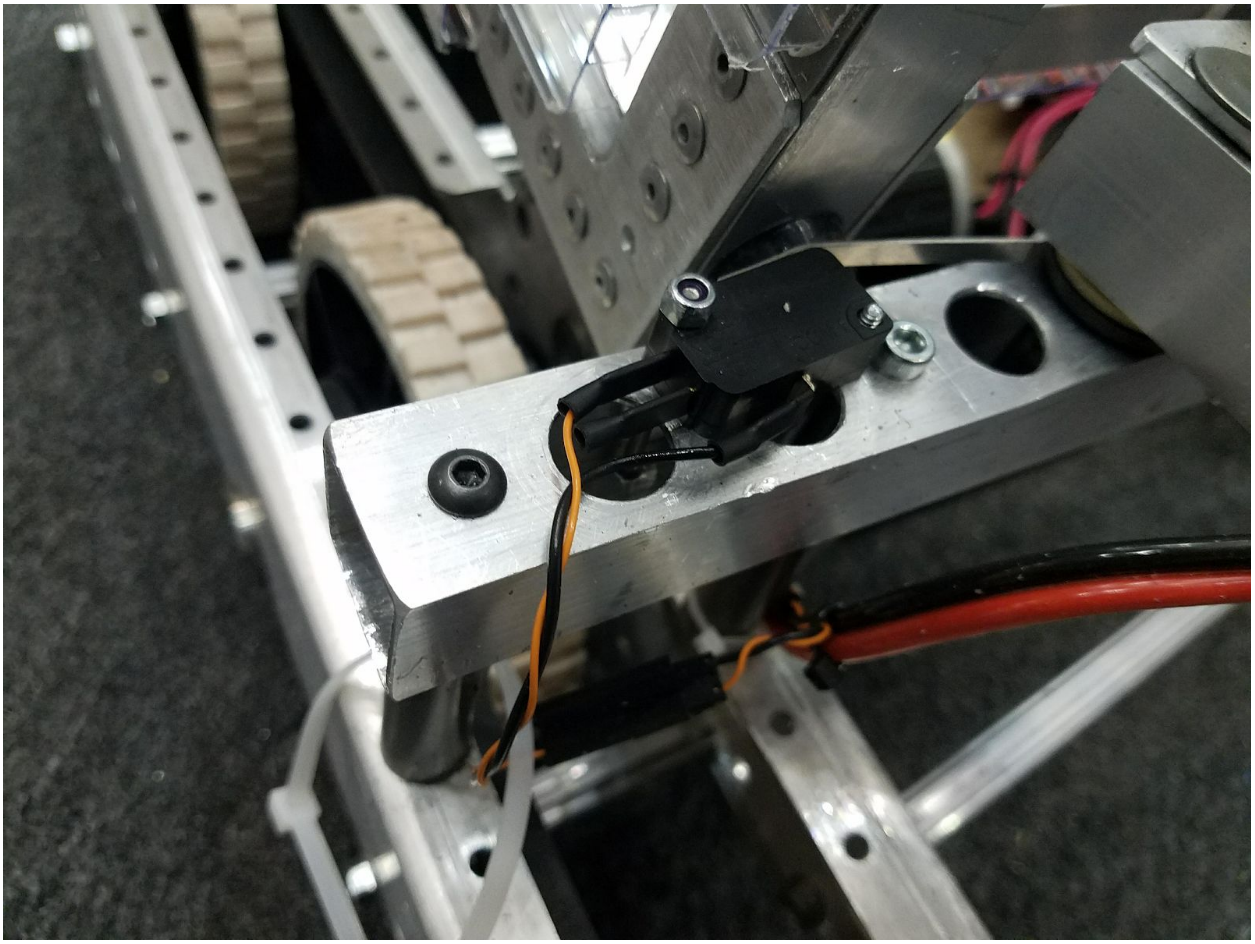


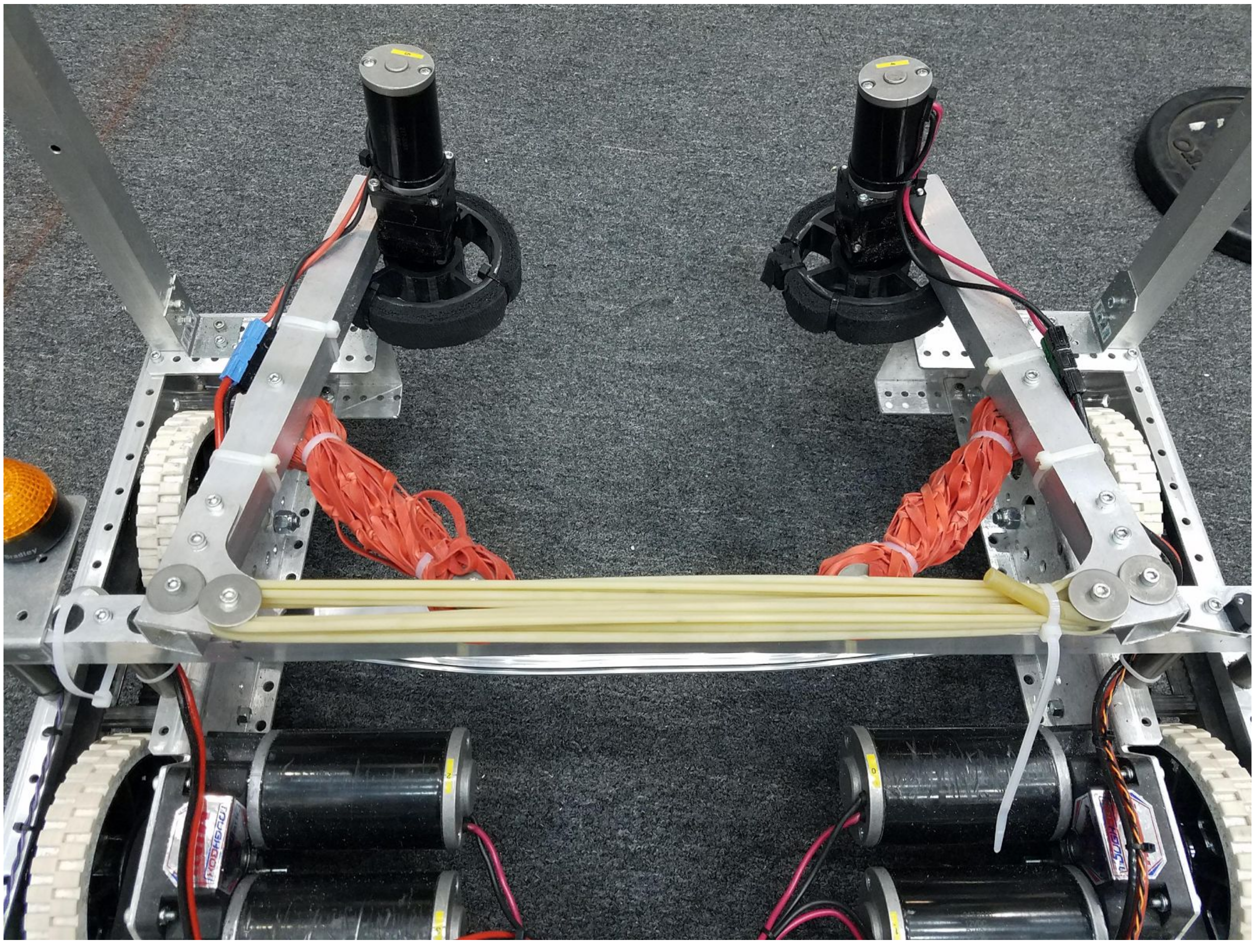


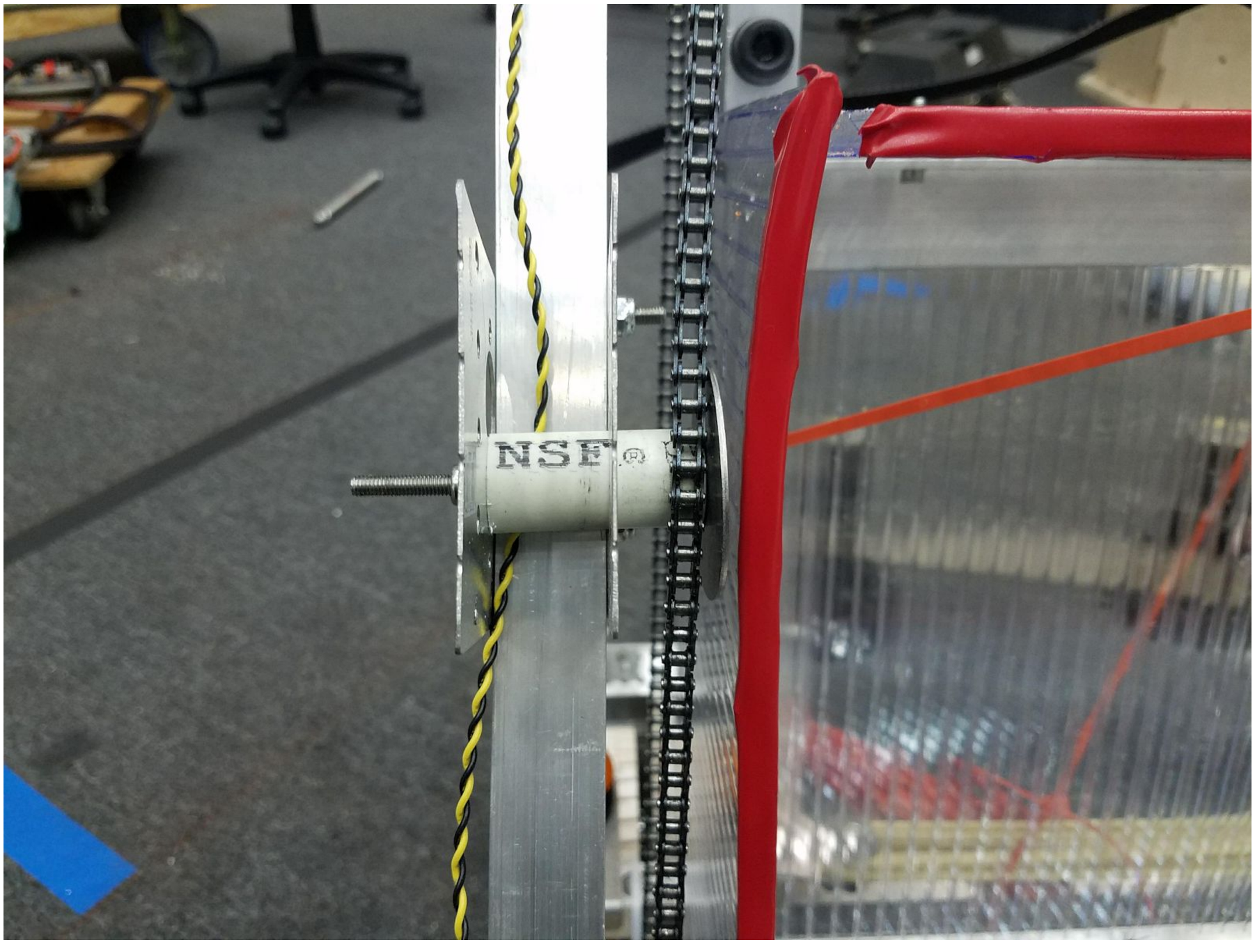


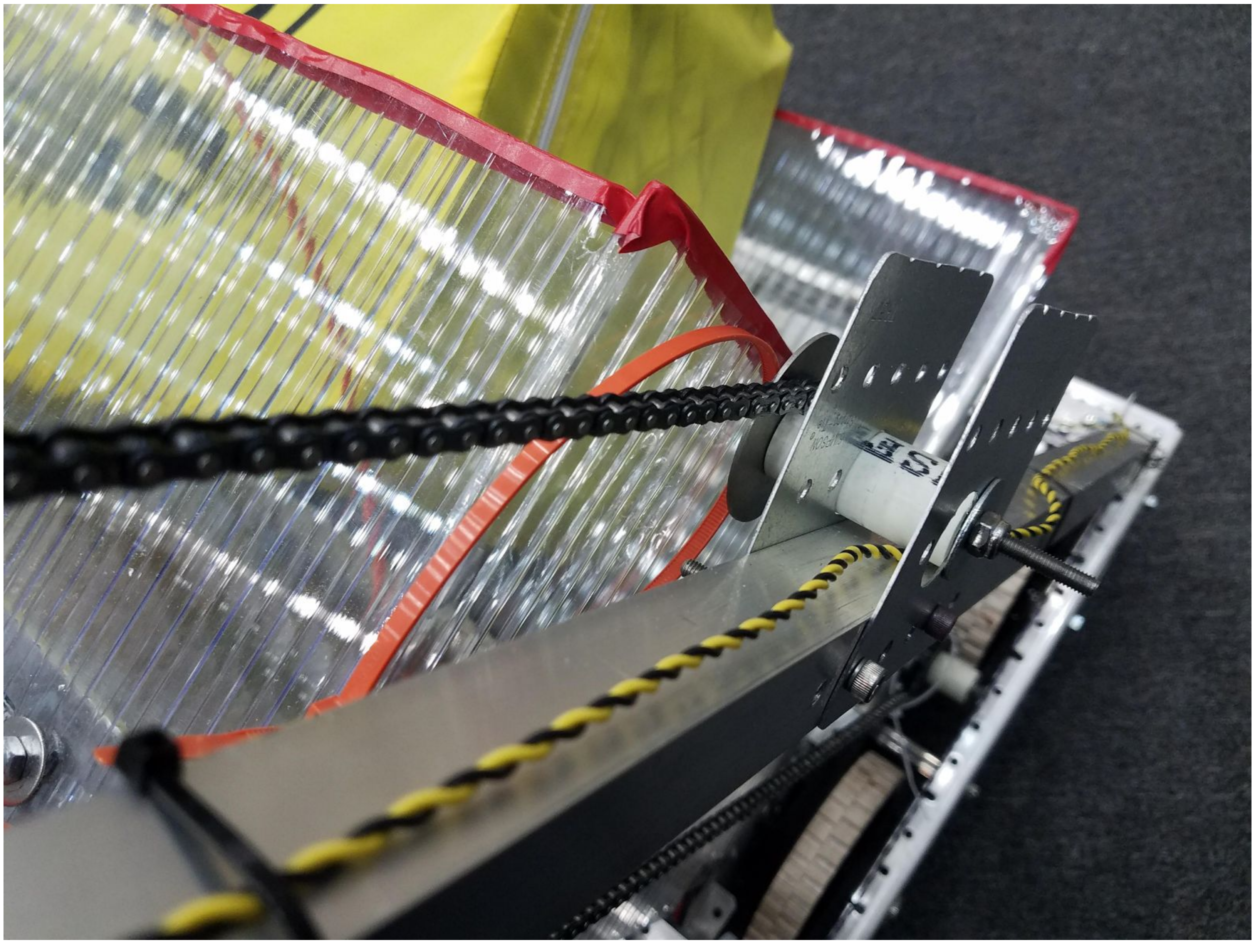

EVERYBOT

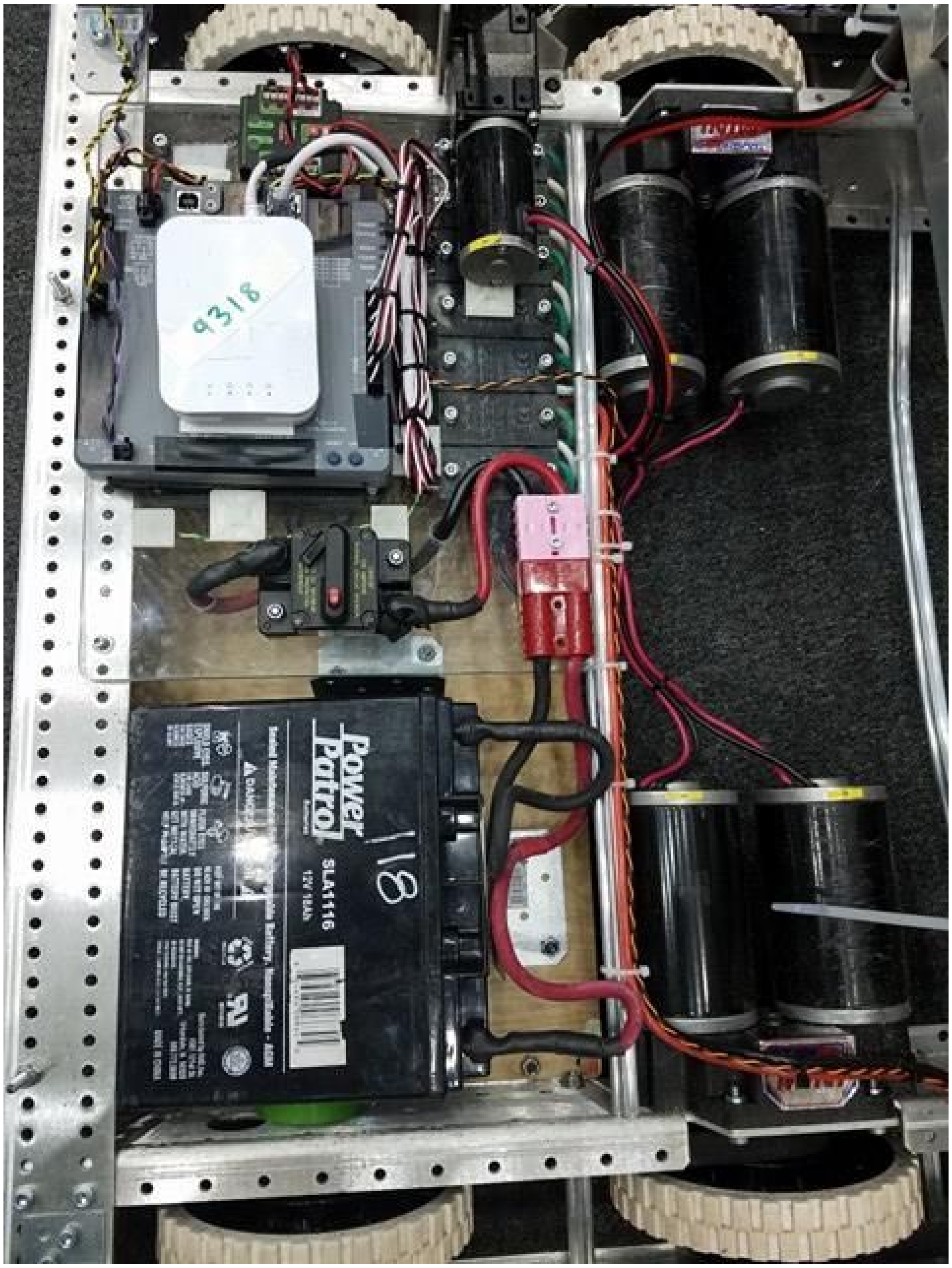







NSF®




9318
Power Patrol
SLA1116
118