Armida Technical Binder

2018 FIRST POWER UP Week 3

Fernbank LINKS Robotics, 2018

Table of Contents

Robot Summary

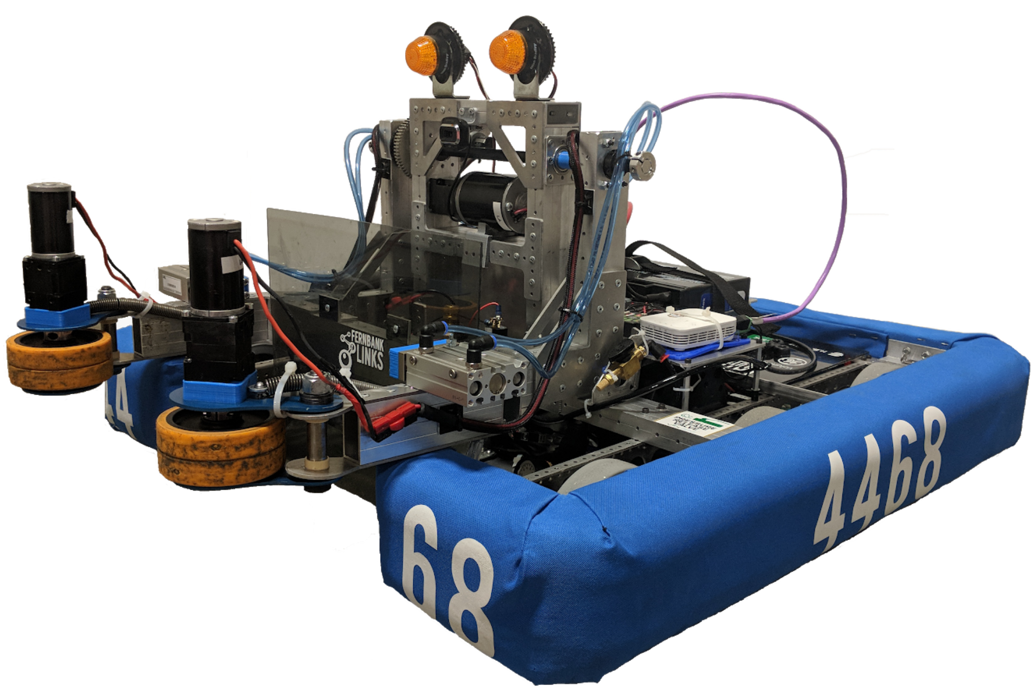
Robot Name: Armida
Frame Perimeter: 28.5in x 26.5in
Weight: 78 lbs - battery - bumpers   All included = 100 lbs
Mechanisms: Intake, Rotating Lift

Drivetrain: 2 Speed 6 MiniCIM tank drive with 6 center dropped 6 in Colson wheels

Intake: Single BAG (VP 9:1) driving 2 BaneBots 40 A wheels per side, with linear actuator piston clamping
Speed: 13.66 ft/s high gear, 5.16 ft/s low gear
Functionality: Outputs to EXCHANGE or SWITCH as well as opponent SWITCH

Rotating Lift: Single MiniCIM (VP 45:1, External 3.4:1, Total 153:1) driven rotator orients the intake at any angle between 0 and 180 degrees, detected by single rotation precision potentiometer

Available Strategy Coverage: Claim switch, load the vault, load “opposing alliance” switch, park or buddy climb



Brainstorming

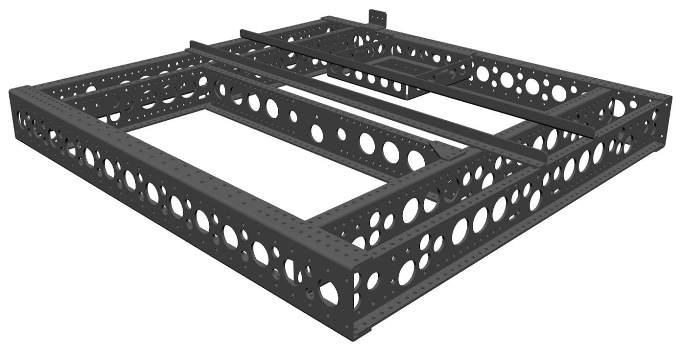
After the kickoff and game reveal, we hold a team brainstorming session in the Clough Undergraduate Learning Commons at Georgia Tech. Every member reads through the important game rules individually before we go through them again as a group in order to discuss confusing sections, identify key rules, and note rules to look up again in the Q&A.

Design Strategy

Starting from day one, we knew that we wanted to keep our robot **simple**, doing only one part of the game extremely well instead of trying to tackle all parts of the game and failing to do any well. Our strategy at kickoff consisted off focusing on the SWITCH and the EXCHANGE which required the use of an "intake" that could intake and output cubes, and a way to clear the cube over the SWITCH wall. We also wanted to be fast. In a game based on cycles, low cycle times are key.

Drivetrain

In line with our goal of simplicity, we elected to use the VEXpro 2014 Drive in a Day chassis. The system was well endorsed by its performance on the field from other teams, and for its versatility and extreme ease of assembly. Keeping the possibility of climbing in mind, the chassis needed to be light.



Before week one we could not determine whether climbing ability was necessary to do well in the rankings, so we did not prioritize it during build season, but kept room for it available. The Drive in a Day offers plenty of mounting points for mechanisms and the VEXpro 3 CIM Ball Shifters that we traditionally use because of their simple and reliable implementation. We chose to use six Mini CIMs because of their small size, weight, and their particular torque and acceleration curves. The Power Up game necessitates speed for quickly cycling POWER CUBES as well as pushing power, which is why we opted for a two speed drivetrain. The ⅛ in center drop makes turning in the tight corridors around the switch and scale trivial, even without omni wheels on the corners. While the Drive in a Day chassis is designed for 4 in diameter colson wheels, we chose to use 6 in wheels in order to easily overcome the 15° angle of the platform.

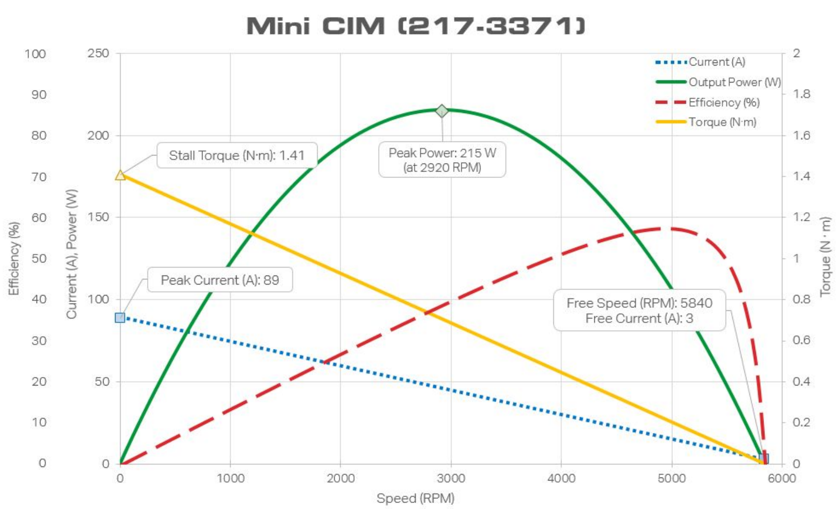


Figure 1: The Mini CIM offers more torque than most other motors available with added efficiency over traditional CIM motors and more protection against burnouts than 775pro motors. Furthermore, to generate enough torque to be competitive with a miniCIM, 2 775pro's and a dual-input gearbox are needed, but due to geometrical limitations, the idea was not feasible.

VEXpro 3-CIM Ball Shifter Drivetrain

Choose Gearbox Motors:	Free Speed (RPM)	Stall Torque (N*m)	Stall Current (Amp)	Free Current (Amp)
3 Mini CIM	5840	4.23	267	9

Wheel Dia. (in)	Wheel Coeff of Friction	Total Robot Weight (lbs)	Weight on Driven Wheels
6	1.1	100	100%

Select VEXpro Gearbox Options:

Choose Motor Pinions:	Standard 12-tooth Pinion [50:12]
Choose Low Gear Option:	Low Gear Option 2 (2.65x Shifter Spread) [54:30]
Choose 3rd Stage Gearing:	3rd Stage Option 2 [60:24]

	Driving Gear	Driven Gear
External Reduction:	1	1

Drivetrain Outputs:

	Drivetrain Free-Speed	Drivetrain "Real Life" Speed	"Pushing" Current Draw per Gearbox	Overal Ratio
High Gear Outputs:	**21.58 ft/s**	**17.48 ft/s**	187.36 Amps	7.08 : 1
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Chosen Gearing Config:

	Driving Gear	Driven Gear
Initial Gearing Stage:	12	50
High Gear Stage:	50	34
Low Gear Stage:	30	54
3rd Gearbox Stage:	24	60
External Stage:	1	1
High-Low Spread:	2.65 x	

Figure 2: JVN Design Calculator with the motor, weight, and gearbox config of Armida

Intake

It was imperative that this mechanism was strongest part of our robot. During the engineering design process, Fernbank LINKS decided to place the intake outside the frame perimeter rather than inside. Because the “Drivetrain in a Day” Kit introduced space limitations on the robot, the extra space required to hold an entire intake inside the frame perimeter removed necessary space for other critical features of the robot. Ultimately, Fernbank LINKS decided to place the intake as safely far away from the frame perimeter as possible to maximize interior space. The CAD and design team tested their designs in SolidWorks CAD to maximize space, creating a digital 15” perimeter rather than the maximum 16” perimeter for safety purposes. The design team then moved the components until they were at their maximum extension and shifted components to maximize exterior space within the given perimeter outside of the robot.

On Day 3 we began prototyping our intake based on drawings of mechanisms done during initial brainstorming by attaching bearing blocks to wood and using power drills to spin the wheels. We were successfully able to intake cubes from Day 3 onwards and refined our mechanism for over two weeks until finally deciding on the design and starting production during Week 3.

Design Iterations

1. 1.0 - Bearing blocks attached to scrap wood driven with power drills
    a. Tested different types of wheels (Colson Performa, Complaint, Pneumatic, BaneBots) and decided on Green Banebots
    b. 1.1 - Swapped the wood for versaframe for increased strength and added BAG motors

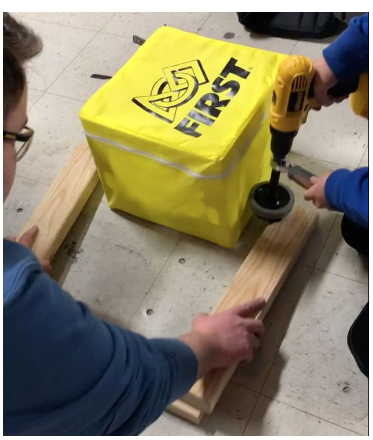

Figure 3: Intake 1.0

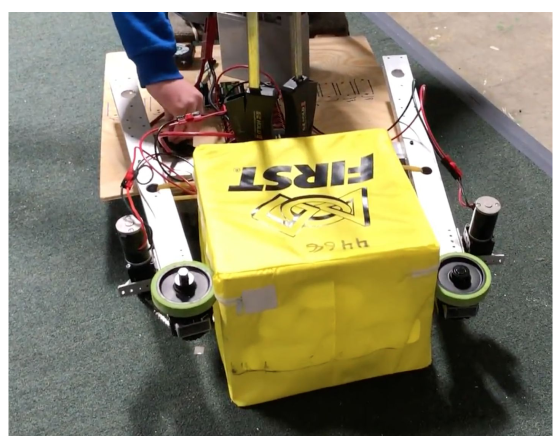

Figure 4: Intake 1.1

2. 2.0 - Added Spring-loaded “Wheel Pods” to design with BAG Motors

a. Springs were added to create tension on the motor pods, thus increasing the amount of friction from the wheels on the cube. We adapted this idea from teams that posted their ideas online for "Robot in 3 Days" challenges.
b. 2.1 - Experimented with thin, regular, and thick springs and decided on regular springs to maximize intaking efficiency

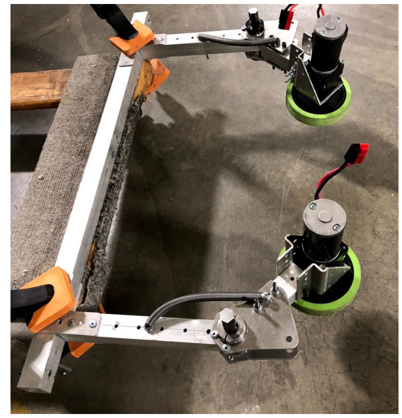

Figure 5: Intake 2.0

   i. The design team hypothesized that adding thicker (stronger) springs would increase the amount of friction on the cubes, and swapped the current springs to make this change. However, the thicker springs actual caused *less* friction on the cubes and made the intake less efficient
   ii. On the other hand, the thinner (weaker) springs caused the pods to bounce of the cubes instead of gripping them, and ultimately the design team opted to stick the original strength springs.

Figure 6: Intake 2.2

c. 2.2 - Added plastic compress to intake, but it did more to force the cube into an angle than to straighten out.
d. 2.3 - Added pneumatic compress to sides and ultimately decided to stick with this design due to its effectiveness at securing the POWER CUBE

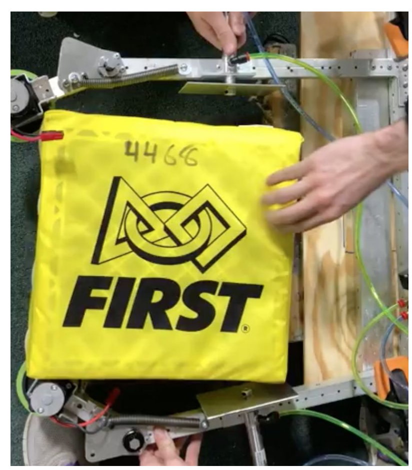

Figure 7: Intake 2.3

The final version uses two pods attached to the versaframe with shoulder bolts through sheet metal gussets. Each pod has a BAG Motor (VP 9:1) and two BaneBots 40 A wheels, for more surface area and therefore grip. On each side of the intake is an Automation Direct rail-guided pneumatic piston[1] with a 3D printed extension for clamping on intaken cubes. The rail guiding makes for an extremely robust piston that will not twist off axis or be damaged, and is much shorter than a standard cylindrical piston. This way the intake will not be smashed to pieces from the side.

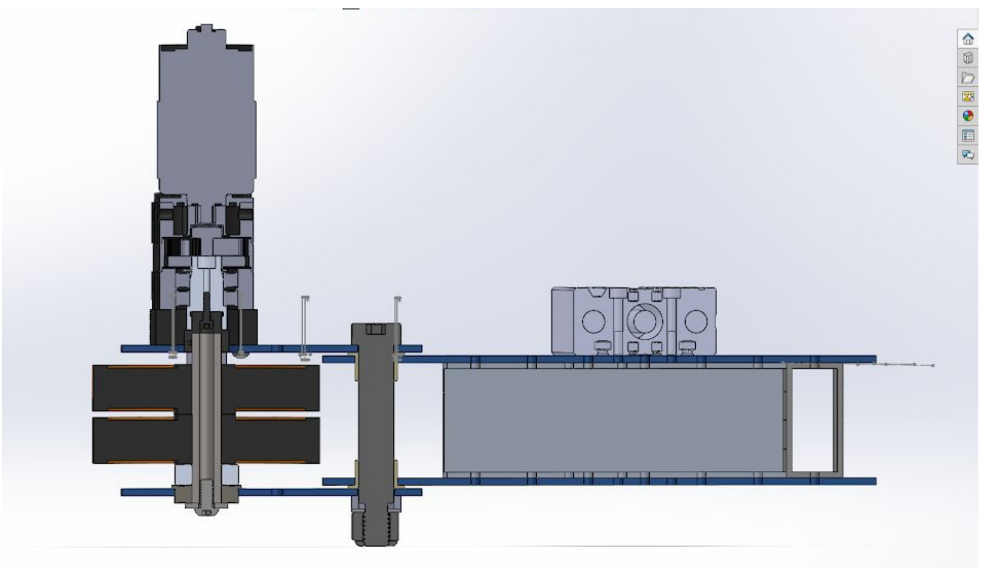

Figure 8: Final Intake CAD

[1] E12M050MD-M 50mm Pistons

Lift

The intake needed a way to be lifted up to the level of the SWITCH and be contained inside frame perimeter for the start of the match. Our strategy of building simple mechanisms excluded any type of elevator because they can be tall, flimsy, and complex. We wanted the lift to have a smooth motion and to orient the intake at intuitive locations for outputting the POWER CUBE in the SWITCH or EXCHANGE.

Figure 9: Initial test of whether general geometry worked

Figure 10: Wood prototype on testing rig

Figure 11: CAD showing range of motion

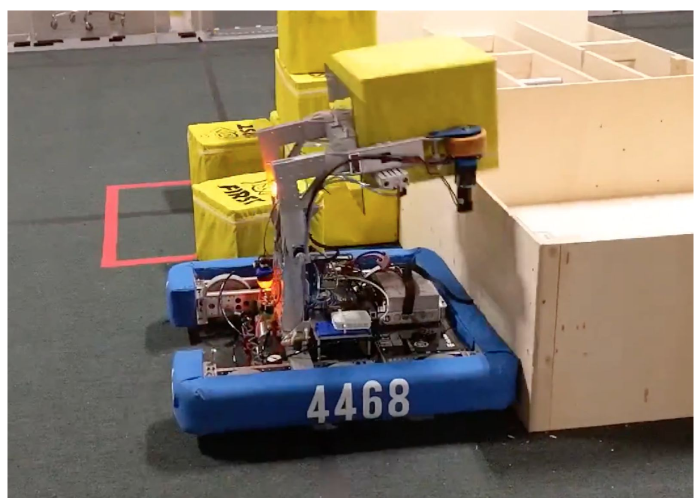

Figure 12: Finished lift in position to launch a POWER CUBE

Design Iterations

1. 1.0 - A four-bar lift made of pieces of wood connected by bolts to rotate around. Wood pieces connecting two four-bar sides help add structural rigidity.
   a. Although adding another idea of lifting the cubes, it didn't seem viable due to the quickness and agility the lift needed, which four-bar didn't have.

Figure 13: Lift 1.0

Figure 14: Lift 2.0

2. 2.0 - A set of linear sliders to lift intake up and down. Used two linear sliders, connected by two wood pieces bolted together.
   a. Even though this was a design we previously used on other robots we have built, it didn't allow the robot to be a "small" robot, or allow the robot to fit into our ideals of what the overall robot should be.

3. 3.0 - A rotating arm that is connected to the intake. It was made through wooden pieces to represent the arms connecting to hex shaft via a bearing.
   a. Able to add strength and rotate around the hex shaft, the team decided to use this design as our lift design.

Figure 15: Lift 3.0

Bumpers

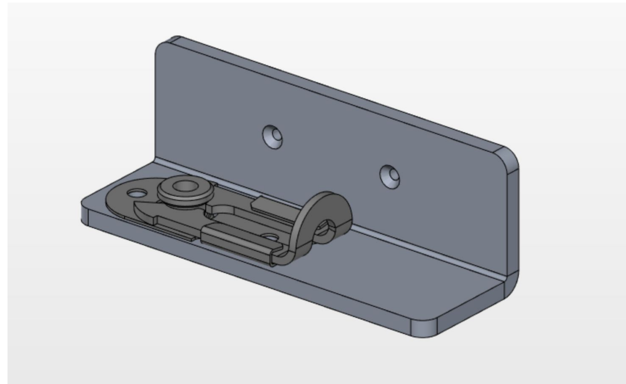

Figure 16: Bumper mounting bracket assembly

Bumpers were a special focus this year. LINKS has had trouble with making good bumpers in the past, so we spent part of our off-season developing a configurable bumper design based on other team's successful bumpers. Each set uses McMaster slide snap latches mounted to 1x1 in aluminum angle extrusion to attach to the Drive in A Day chassis. T-nuts attach the brackets to the wood backing. We found that ¾ in sheet wood was both less susceptible to breaking and easier to rip on a table saw than using traditional wood planks. When determining the dimensions of the wood backing, we left ⅛ in tolerance between the frame and the wood on all sides for the fabric to be snug. The wood frame was built with 2 in aluminum angle on the outsides of the corners, with the wood forming and overlap joint. The fabric used is the RoboPromo bumper fabric and the numbers are iron-on customized with our team font Bebas Neue Bold.

The final result is two very clean sets of bumpers that can be switched in less than 15 seconds.

Blue Bumper Weight: 9 lbs
Red Bumper Weight: 9 lbs
Frame Dimensions: Frame perimeter + ⅛ in tolerance

Programming

Overview

This year programming has been focused on control from our custom PID implementation to motion profiling. We have been using more and different kinds of sensors to better control the robot. This allows for simple and robust mechanisms to be controlled accurately and fluidly.

PID

We implemented a new PID class which better handles input by taking a generic double as the input instead of an object. This has multiple advantages the main one being the ability to mix sensor inputs like averaging the two wheel encoders, but you are also able to create an acceleration PID, and many other uses. Right now we are using the advantages gain to split the drivetrain into two different PIDs for the left and right sides. This allows us to limit drift during autonomous routines. We are also using PIDs in conjunction with our custom motion profiling to smoothly move up to and hold an angle for out arm. The arm PID also allow for an auto correcting angle so even if the arm deviates from the angle it self corrects to the original set point.

```
double proportional = 0;
double integral = 0;
double derivative = 0;
errorSum += error;
double deltaE = previousError-error;
double deltaT = Timer.getFPGATimestamp() - previousTime;

/**** P ****/
proportional = error*kP;

/**** I ****/
integral = errorSum*kI*deltaT;

/**** D ****/
derivative = (deltaE/deltaT)*kD;

output = proportional + integral + derivative;
```

Motion profiles

When you create a control system normally you want the smoothest control, with the lowest settling time and least information. Normal PIDs work by having an error between the state you want and the state you are and it minimizes it. Motion profiles are an extension of normal PIDs where you create a function that sets the target state of every point between your initial and final state. So, instead of having a function which you have less control over you can make a function and have smoother and more controlled motion. This year we are mainly using motion profiles on our rotating lift and our autonomous which now is profiled lines and turns which gives us a smoother and more consistent autonomous routine.

Curving Autonomous

We have developed a system using quintic splines to create a curved autonomous which gives the benefit of rotating while moving which means we get faster and more fluid motion. This means we would not have to acceleration to a complete stop before moving forward or turning like in normal autonomous routines. Our waypoints include the position, velocity through the point, and the acceleration through the point and we feed a series of waypoints into our path generator. The path generator is a system of equations that generates a parametrized 5th order polynomial

```
double[][] A = {
   {0, 0, 0, 0, 0, 1},
   {0, 0, 0, 0, 1, 0},
   {0, 0, 0, 2, 0, 0},
   {1 , 1 , 1, 1, 1, 1},
   {5 , 4 , 3, 2, 1, 0},
   {50, 12, 6, 2, 0, 0}
};

A = Matrix.inverse(A);

for(int i=0; i < W.length - 1; i++) {
   Y.add(new Polynomial(Matrix.multiply(A,
     new double[] { W[i].y, W[i].Vy, W[i].Ay, W[i+1].y, W[i+1].Vy, W[i+1].Ay })));
   X.add(new Polynomial(Matrix.multiply(A,
     new double[] { W[i].x, W[i].Vx, W[i].Ax, W[i+1].y, W[i+1].Vx, W[i+1].Ax })));
}
```

Appendix

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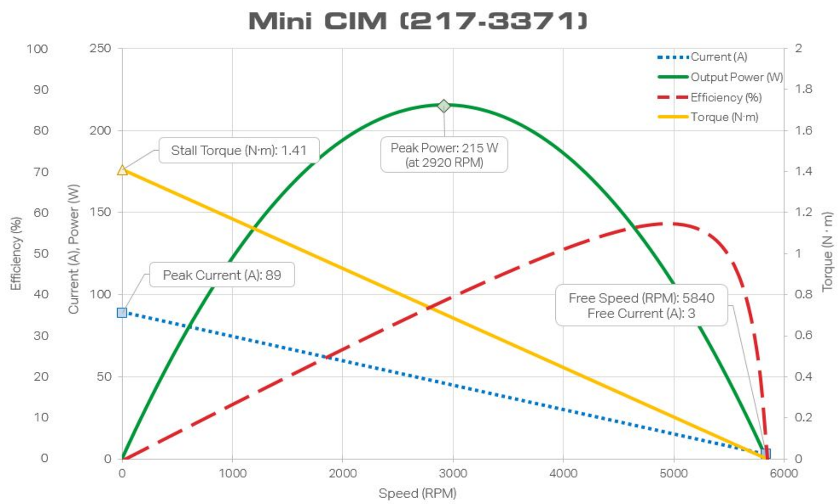

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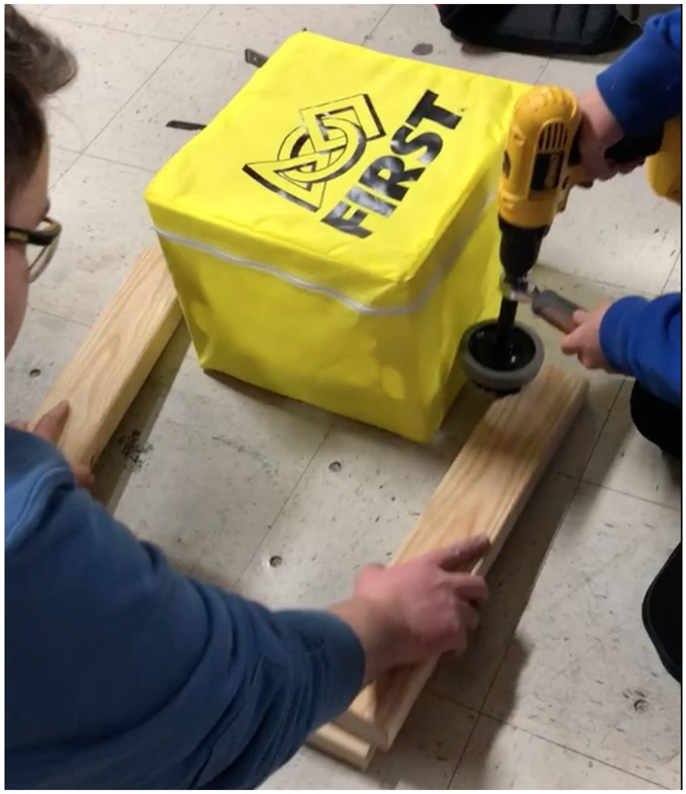

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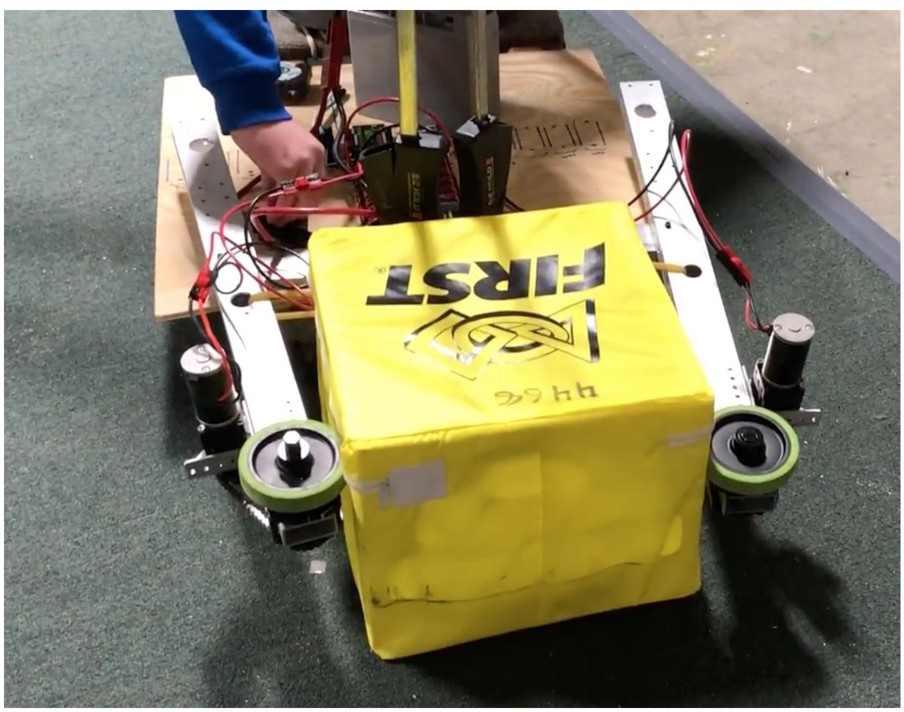

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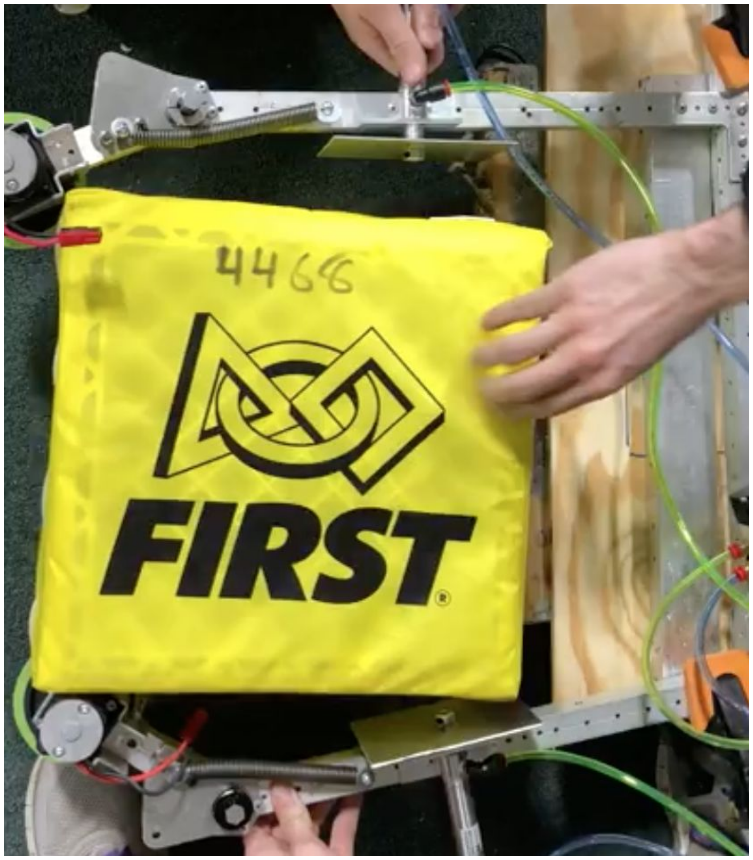
Figure 6: Intake 2.2

Figure 7: Intake 2.3



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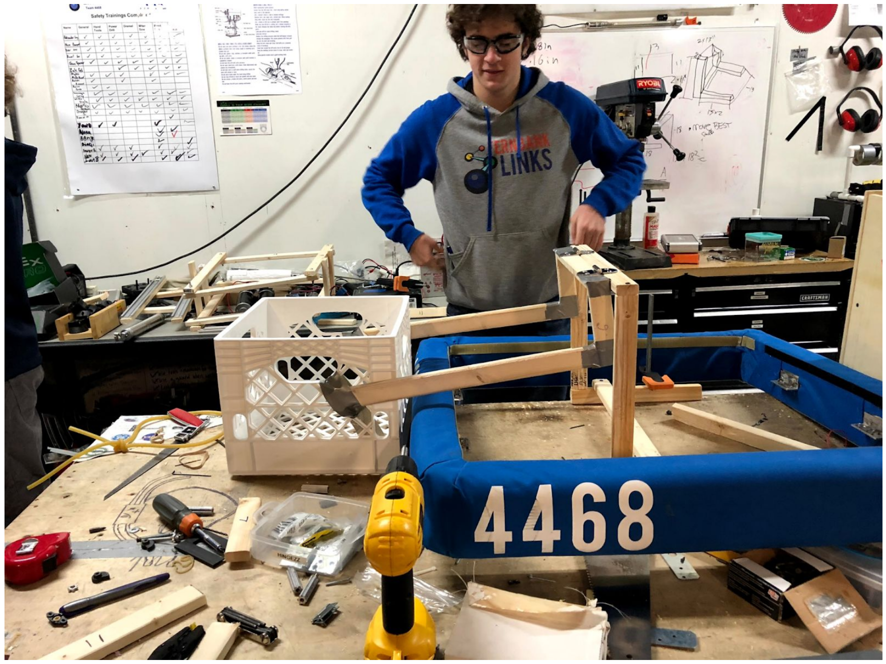

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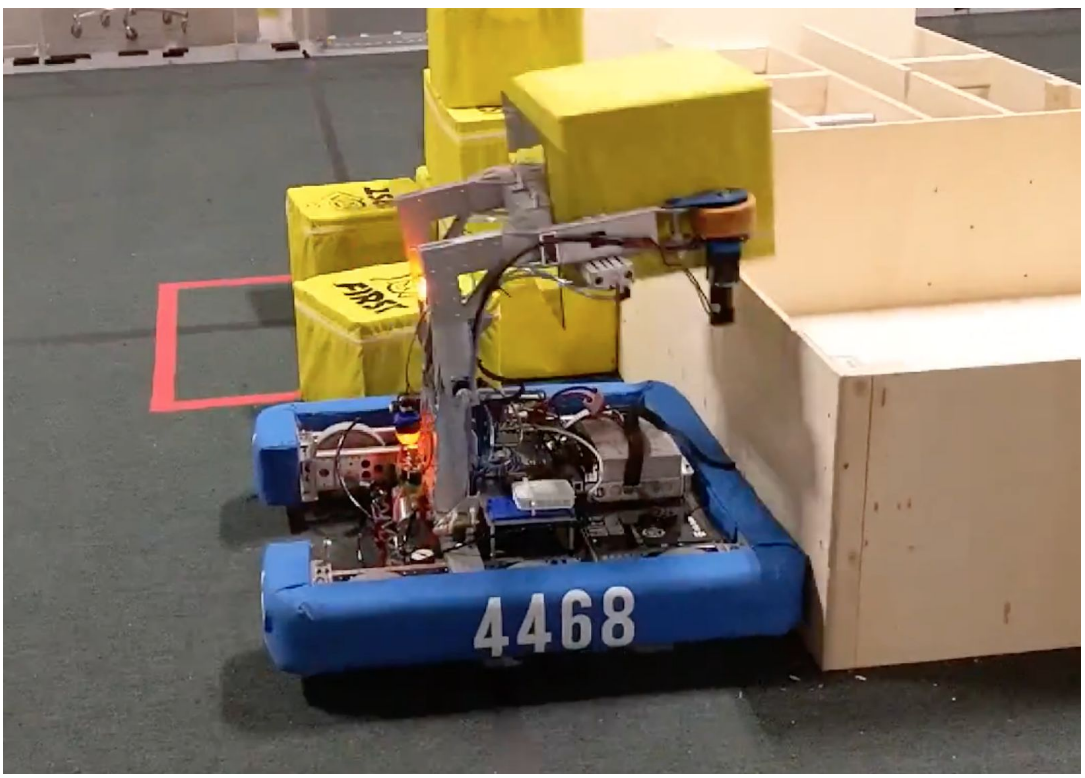

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