Paly Robotics

FRC 8 | 2023

Eir

Technical Documentation

Charged Up

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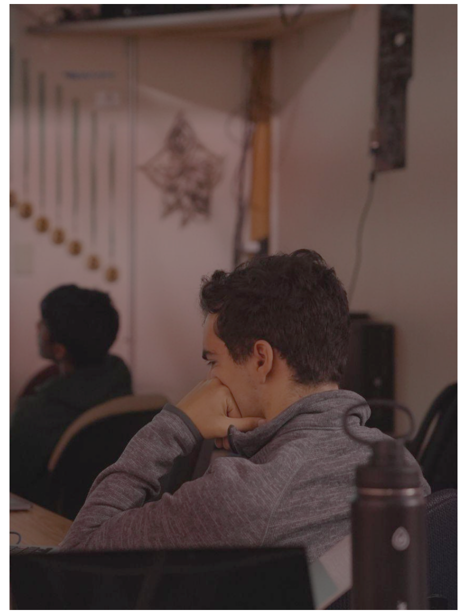
STRATEGY

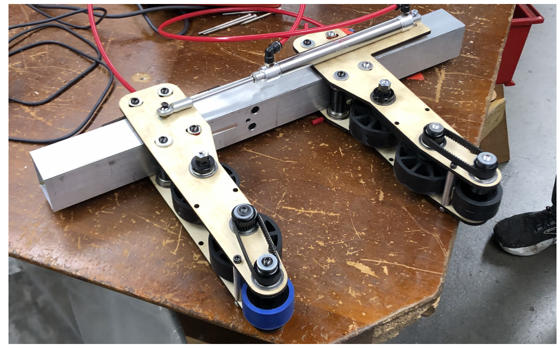

Dock Not Engaged Low
Cube L1 (Preload) Low
Cube L2 (Preload) High
Cube L3 (Preload) Low
Auto Cube L1 Low
Auto Cube L2 High
Auto Cube L3 Low
Cone L1 High
Cone L2 High
Cone L3 Low
Cube L1 Medium
Cube L2 Medium
Cube L3 Medium
Cube Intake Ground Low
Cube Intake Shelf High
Analysis
Priority List



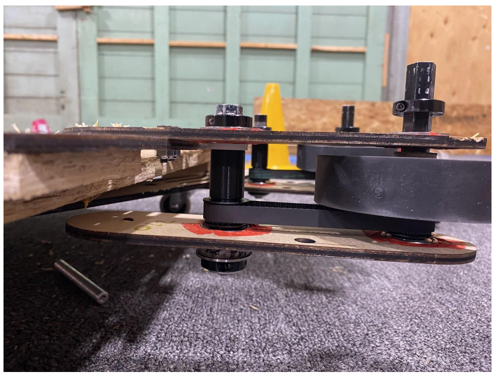
Goals

Needs	Wants	Wishes
• Holonomic drivetrain • Intake cones & cubes from substation • Intake upright cones & cubes from ground • Place game pieces on middle & top rows • Engage charge station	• Intake tipped cones from ground • Place game pieces on low row	• Score cubes while moving • Auto-balance charge station

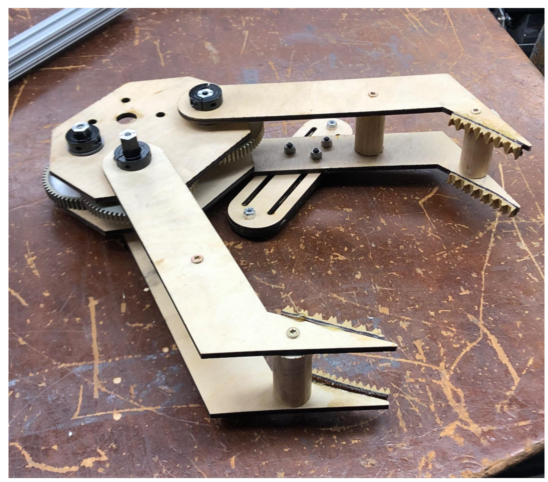
Prototyping



Intake 1: bearing slider and flip-out prototype, tested for cube and cone height and compression numbers



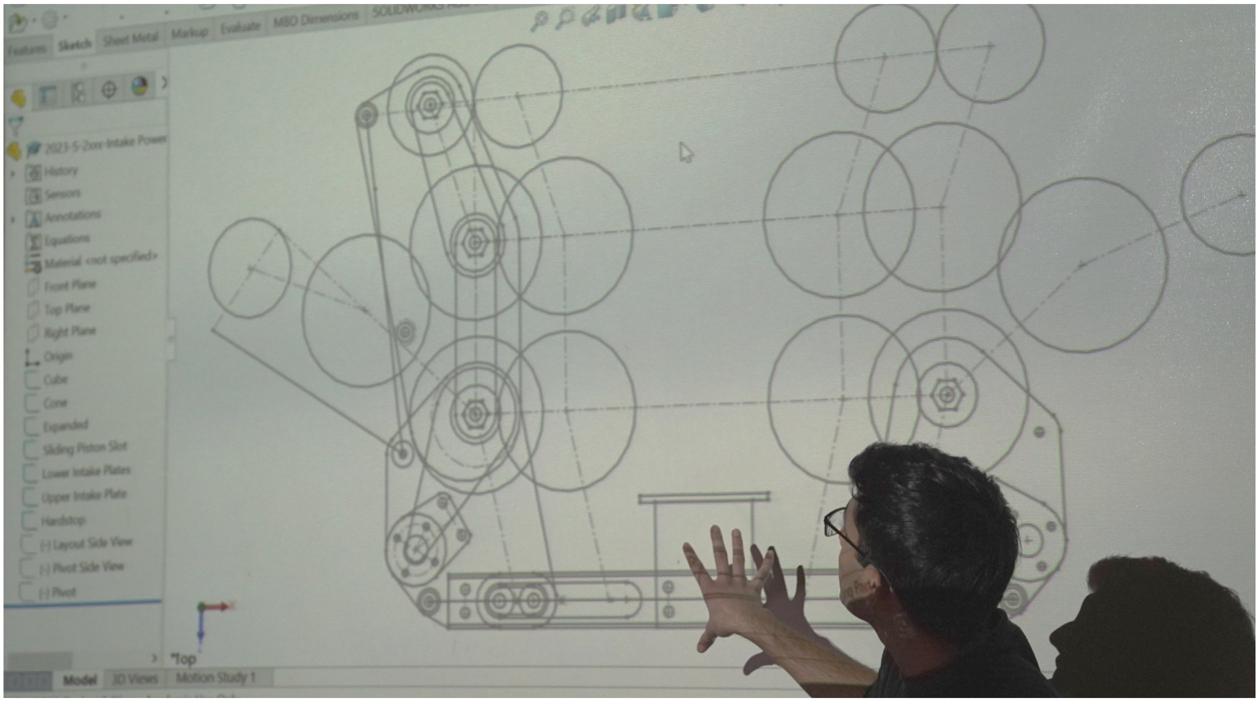
Intake 2: two-position pivot setup, tested for wheel size and type



Claw: tested different clamping shapes and compression numbers for cones and cubes

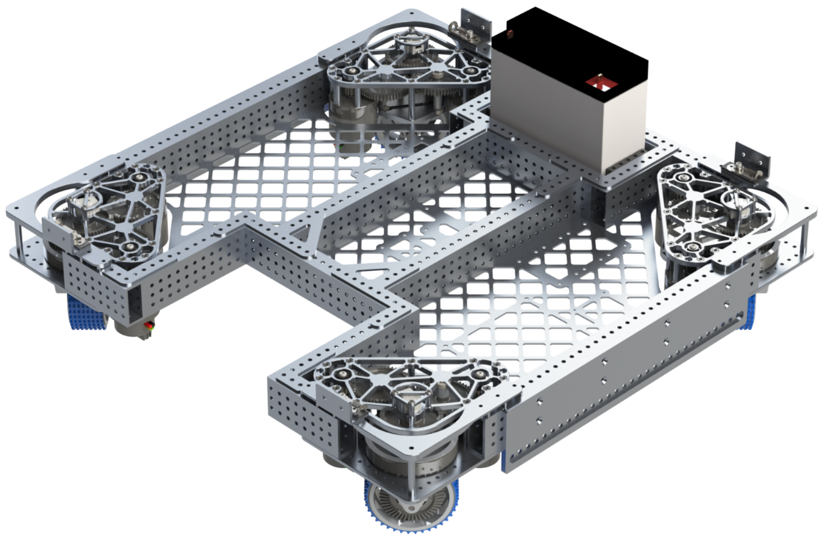
Cone-Righter: tested height for knocking cones back upright and different materials for the righter, including star wheels and a powered roller

DESIGN


Features
Sketch
Sheet Metal
Markup
Evaluate
MBD Dimensions
History
Sensors
Annotations
Equations
Material <not specified>
Front Plane
Top Plane
Right Plane
Origin
Cube
Cone
Expanded
Sliding Piston Slot
Lower Intake Plates
Upper Intake Plate
Hardstop
(-) Layout Side View
(-) Pivot Side View
(-) Pivot
*Top
Model
3D Views
Motion Study 1


USERNAME: STUDENT ID
PASSWORD: PAUSD PASSWORD

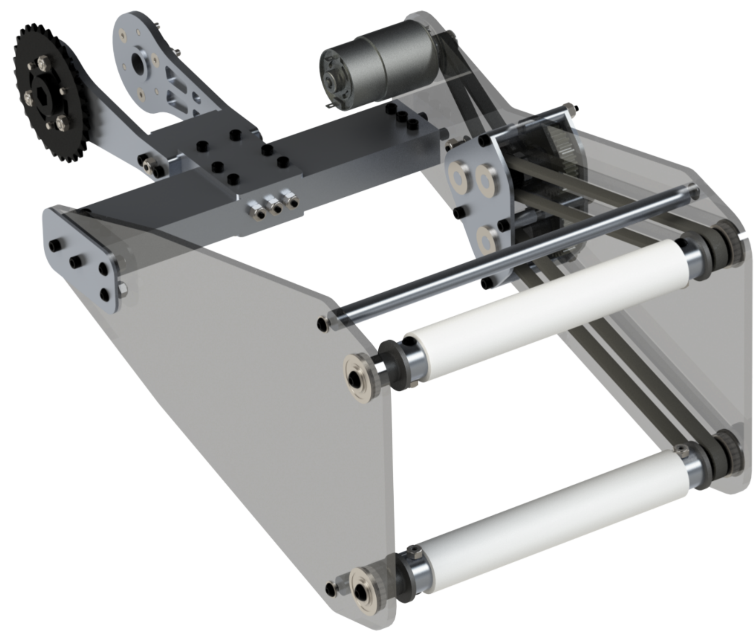
Drivetrain



- **Design Requirements**
  - Strong structure to support other mechanisms
  - Convenient maintenance considerations

- **Swerve Drivetrain**
  - 26.5” x 26.5” frame perimeter to minimize space taken up on charge station
  - Belly pan to increase structural integrity
  - Four Swerve Drive Specialties MK4i swerve modules with Falcon 500s
  - 16.3 ft/s theoretical maximum speed
  - Bumpers secured by custom hex nuts for easy removal
  - Steel ballasts run under to add weight and keep center of mass low, attached to side plates

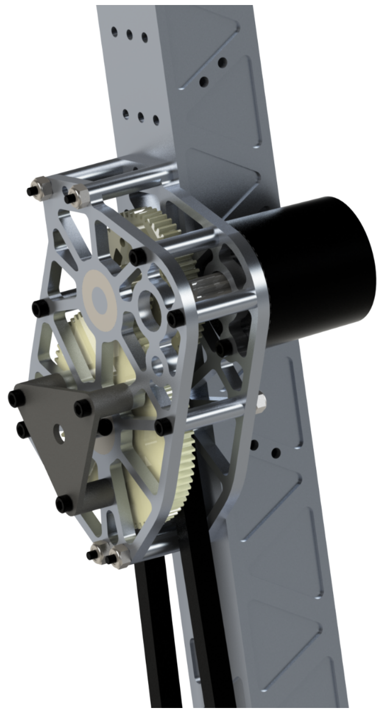
Intake



- **Design Requirements**
  - Capable of quick deployment from stowed position
  - Able to withstand impacts against grid, substations, or other robots
  - Can reliably intake and score both cones and cubes with speed

- **Two-Roller Grabber**
  - Compliant polycarbonate construction
  - Same compression for cones and cubes to maximize simplicity
  - 1” custom silicone rollers for grip
  - Powered by single 775 Pro
  - Rollers at 6:1 ratio
  - ~5lbs

Intake Pivot Gearbox

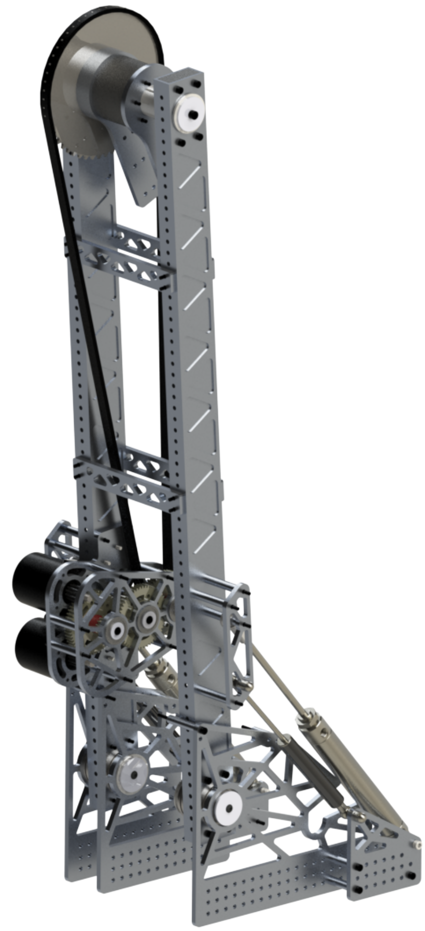


- **Design Requirements**
  - Flexibility to change between multiple gear ratios by swapping pinions
  - Powerful enough to lift intake quickly and consistently
  - Minimal backlash to maintain precise intake position

- **Neo Gearbox + Chain & Sprocket**
  - 58.5:1 overall reduction
  - Chain and sprocket run from gearbox to pivot
  - Located close to arm pivot in order to reduce torque created
  - Inline chain tensioner to minimize backlash
  - Pivot sprocket mounted using combination of dowel pins and bolts onto ⅜” CNC'd aluminum plates to secure it

Arm

- **Design Requirements**
  - Robust, reliable, and minimal weight
  - Capable of reaching top row and loading station
  - Compact form factor



- **Bottom Pivot**
  - Pneumatic cylinder actuated
  - Round tube and bearing setup stronger than using hex stock
  - Gas shocks to counterbalance the torque created by gravitational force

- **Top Pivot**
  - Two Neo motor gearbox used for actuation
  - Bushing and round tube setup
  - Gearbox mounted low to help maintain low center of mass with chain run up to pivot
  - Inline chain tensioner to reduce backlash
  - 182.25:1 overall reduction

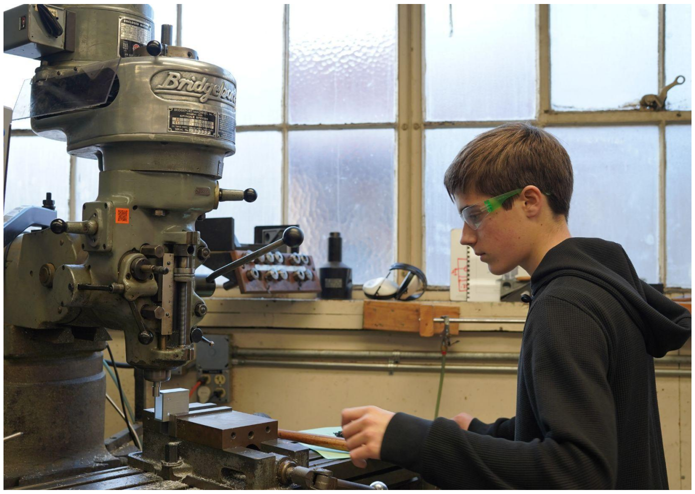
Electronics + Pneumatics

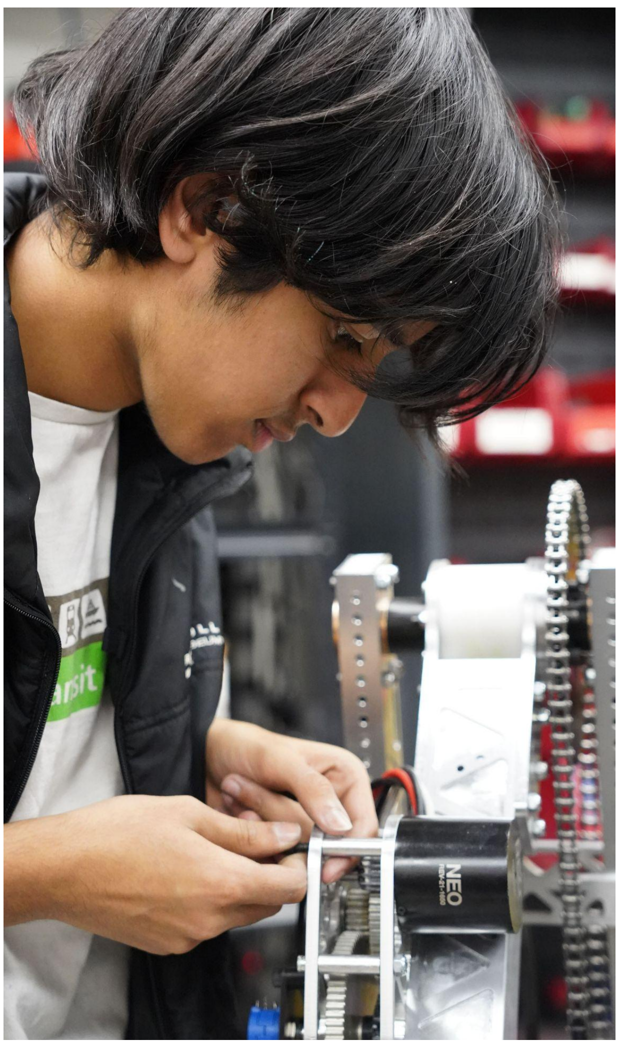
- **Design Requirements**
  - All electronics accessible for quick maintenance
  - Limited space
  - Keep weight down low

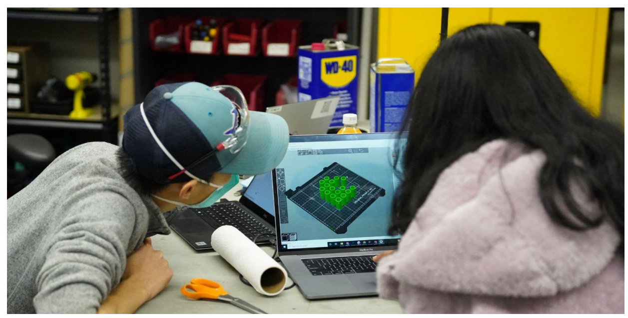
- **Electronics**
  - Easily accessible along the sides of robot
  - Covers to keep protected
  - Organized so quick to service

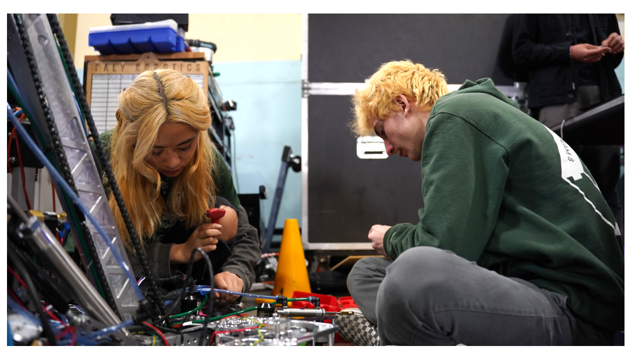
- **Pneumatics**
  - Mounted along sides of drivetrain
  - Separate plate to limit vibrations caused by the compressor
  - Air tanked mounted in free space over swerve modules

ITERATION





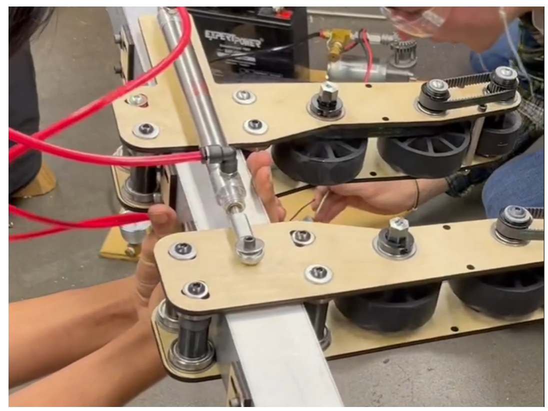


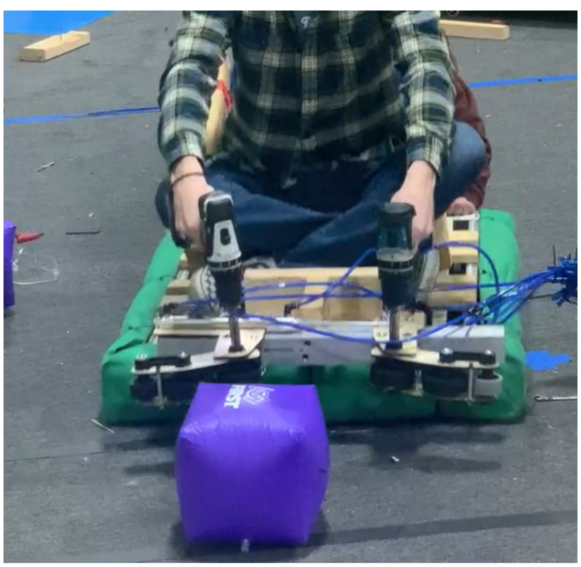


Intake

We believed that our intake would make or break our robot, so we put the majority of our prototyping resources into making a robust intake. Our final intake design went through many iterations, even before it was put into CAD.

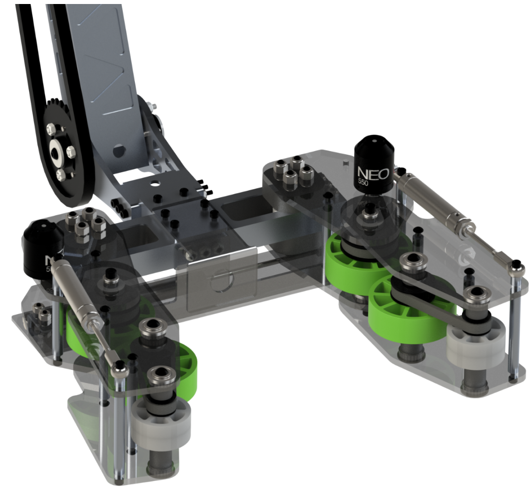
We started by trying to design an intake to grab both cones and cubes, and we decided to do this by using a piston to slide each side of the intake, adjusting between positions for each game piece. We improvised a bearing block in order to save time and get compression numbers as quickly as possible.

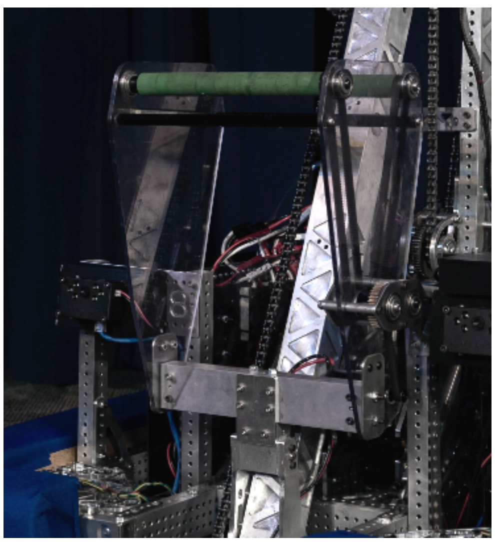




This design worked for us, but we decided that we needed more width to our intake, so we added on two more pistons, and split the intake into two stages, so that we could flip out the final pair of wheels. When the flippers were outwards, the wheels were able to vector in game pieces and then clamp down on them to allow us to drive into game pieces and ensure full control of them.

After perfecting the design into its final version, we mounted this intake ahead of our Utah regional event. Although the mechanism worked decently well during matches, the main issue was that, given the complexity of this intake, it often broke down. So, it did not meet our goal of reliability.





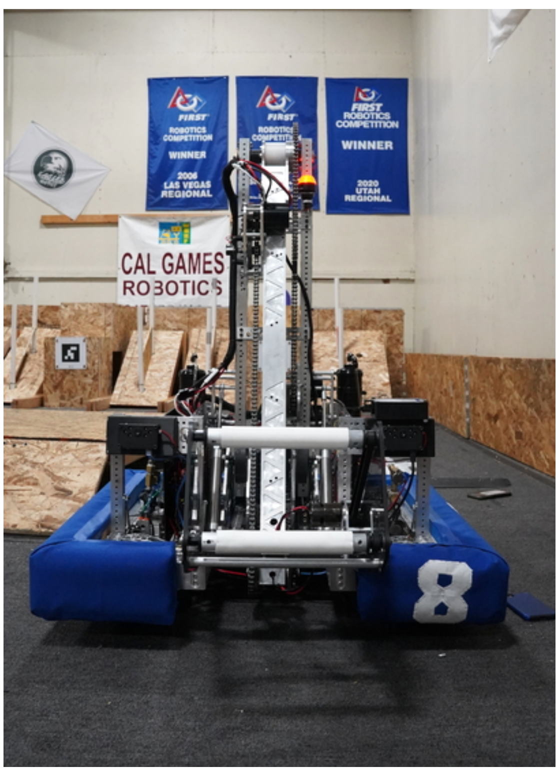
We decided to completely reimage our intake into the simplest design possible that would still give us all the functionality we needed. We ended up with this two-roller design powered by a single motor. Its simple construction allows it to be robust and very easy to service. It also lets us quickly align to and intake from the single substation. We initially were using AndyMark Sushi Rollers, but they were not providing us with the grip we needed. So, we switched them out for custom silicone on aluminum tube rollers. We also increased the gear ratio to increase the torque of the motor, allowing a tighter hold on cones and cubes.

Cone-Righter

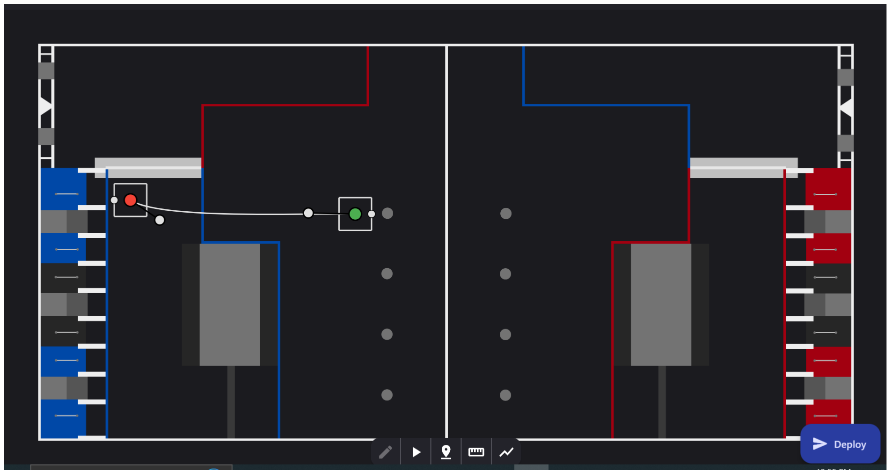
We initially thought that we would need a mechanism in order to right tipped cones, so we prototyped a few options. They ended up being pretty effective at easily and quickly reorienting cones upright.

Given the prototype's success and the extra space we had on the bot, we decided to develop a polished version of the prototype mechanism to add on. The final design was a four-bar powered by a single Neo 550 connected to a Versa Planetary gearbox. However, after testing our robot once fully built, we found that the side of the intake could actually be used to tip cones just as easily. Given this discovery, we decided to remove the cone-righter mechanism from our bot all together to make space for steel ballasts to increase our weight and lower our center of mass.

SOFTWARE


FIRST
ROBOTICS COMPETITION
WINNER
2006
LAS VEGAS
REGIONAL
FIRST
ROBOTICS COMPETITION
WINNER
2020
UTAH
REGIONAL
CAL GAMES
ROBOTICS
8

Autonomous Code



- **Path Following**
  - Drive paths created using the PathPlanner tool
  - Robot’s velocity controlled through a trapezoidal motion profile
  - Current velocity and field position of the robot are recorded using a gyroscope and encoders
  - Drive controller uses the Ramsete algorithm to adjust the drivetrain’s motor output based on error with target pose

- **Subsystem Routines**
  - Commands-based architecture allows us to run pre-programmed routines when predicates are reached; allows for a more streamlined creation of autonomous paths and teleoperated controls

- **Vision**
  - Uses two Limelight 3s, which allows us to use multiple perspectives to align to the vision tape since it combines the yaw measurements of each Limelight to shift our robot towards a desired target; multiple perspectives make our vision measurements more accurate

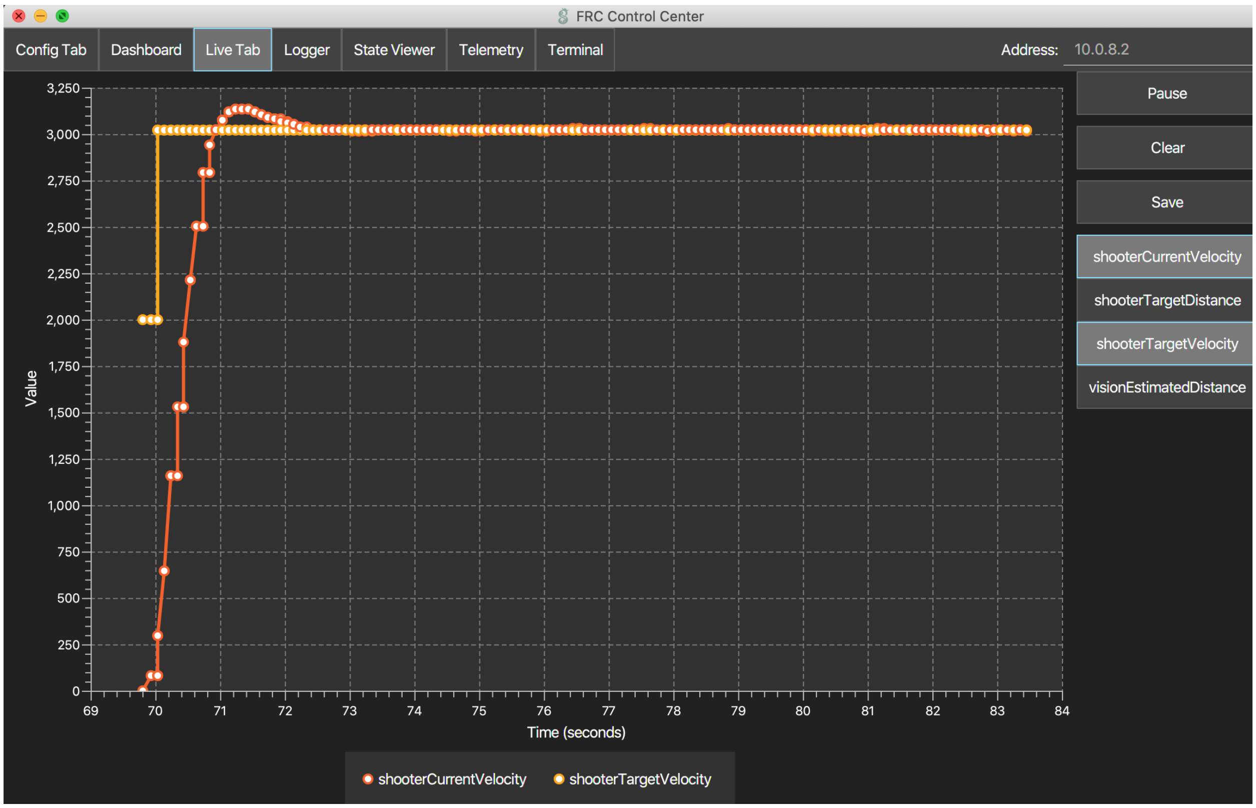
Tele-Op Code

- **Arm**
  - Uses the arm's mass to programmatically account for the force of gravity by recalculating the center of mass based on the rotation of the intake
  - Moves using procedurally generated trajectories, profiling the arm to move in a set amount of time so that it can move as slow as possible and reduce the rate of change of the robot's center of mass
  - Optimally times the extension and retraction of the large base pistons to reduce tipping

- **Intake**
  - Runs in tandem with the arm and the pivot to automatically move to the optimal positions and avoid obstacles, such that the operator does not have to worry about the individual movement of each joint

- **Drivetrain**
  - The swerve drivetrain uses the gyro to always move in a field oriented direction
  - Using vision, the drivetrain is able to use April Tags to align towards scoring positions by automatically generating trajectories to target positions

Control Center



- Custom application allows for quicker debugging and a faster workflow overall
- Streamlined UI that can display the robot's state
- Tab based architecture allows for future expansion and versatility, anything from creating autos to changing configs
- Live graphing of values for debugging, both quantitative and qualitative