# Paly Robotics

FRC 8 | 2020


# Nari

## Technical Documentation

Infinite Recharge

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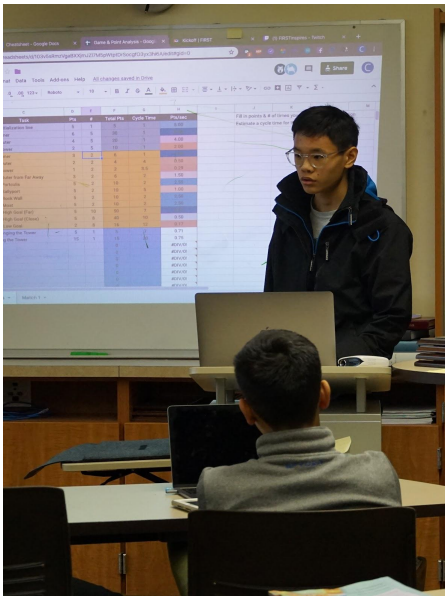
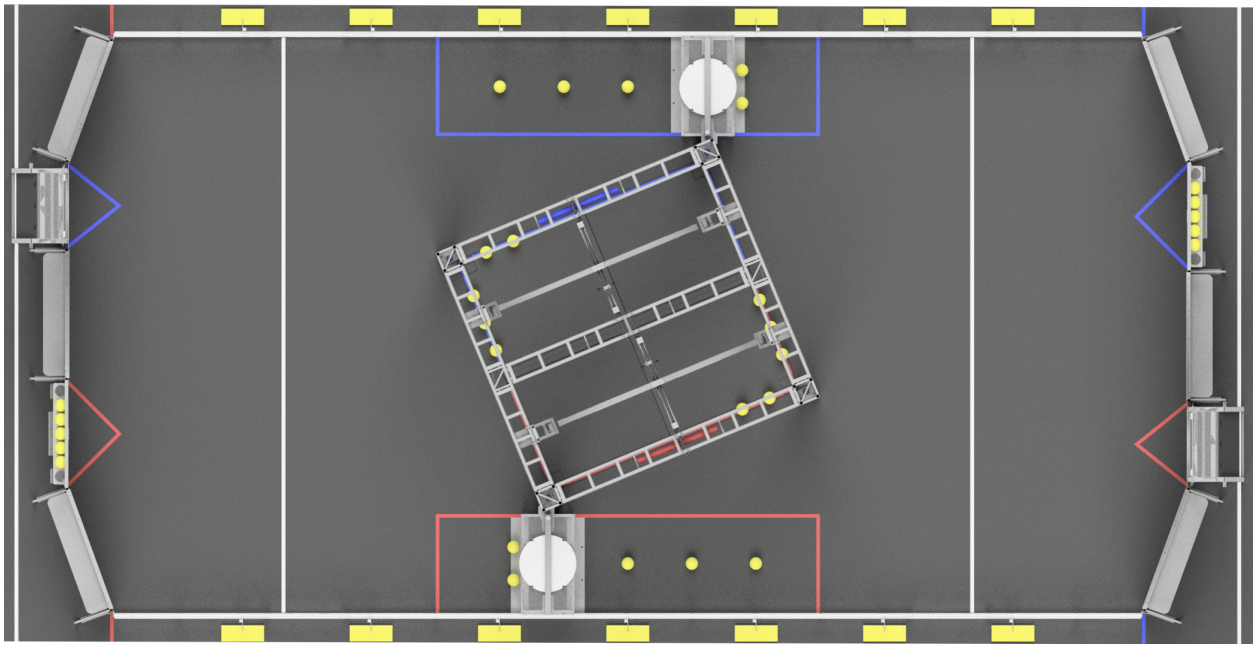
# STRATEGY



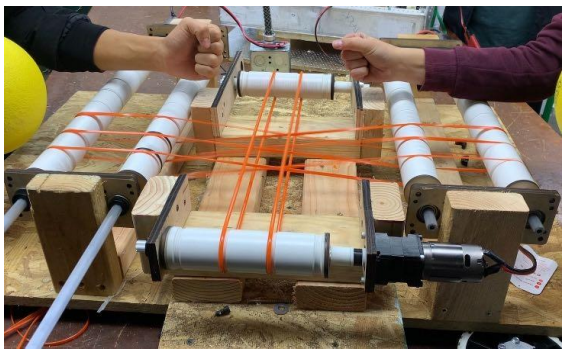
# Infinite Recharge



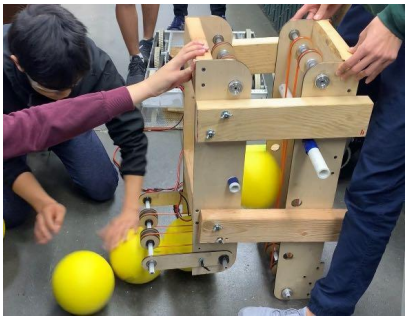
# Goals

| Needs | Wants | Wishes |
|---|---|---|
| • Robust Drivetrain<br>• Score in outer goal<br>• Intake ball from ground<br>• Fast Indexer<br>• Climb | • Score in inner goal from initiation line<br>• Rotation Control<br>• Position Control<br>• Intake balls from loading station | • Score in outer goal from behind the color panel<br>• Trench Capable<br>• Active rebalance on climber |

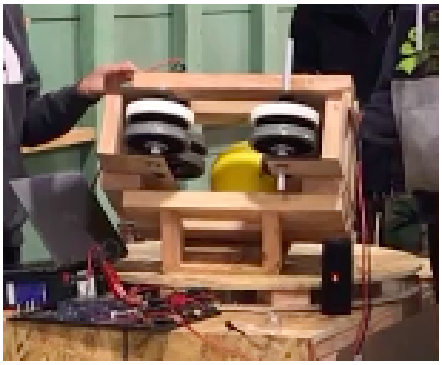
# Prototyping



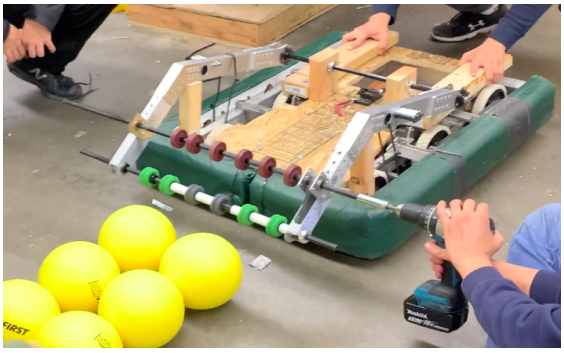
Beavertail: 6 pvc pipe rollers driven by 2 775s and connecting polycords. Used to test whether a beavertail can handle intaking multiple balls at a time.  Also used to try different polycord patterns and configurations.



Horizontal Indexer: A wooden column with poly cord on pulleys used to test compression and slippage of balls.



Double and Single Flywheel Shooter: Test for ideal compression and wheel type, consistency of shot, peak velocity and range of the shooter.

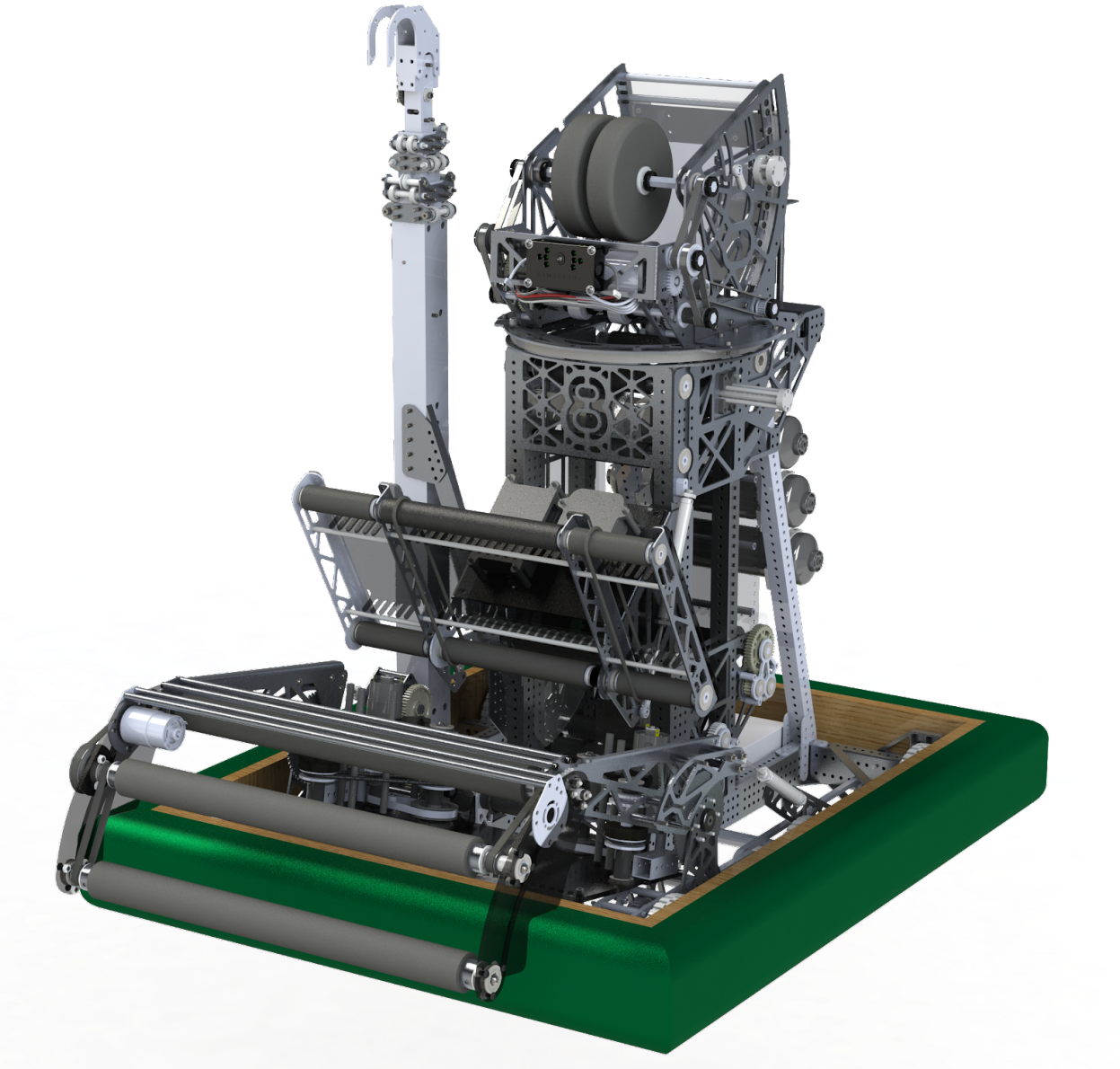


Intake: Tested for the best wheel type/configuration and best compression for intaking balls.

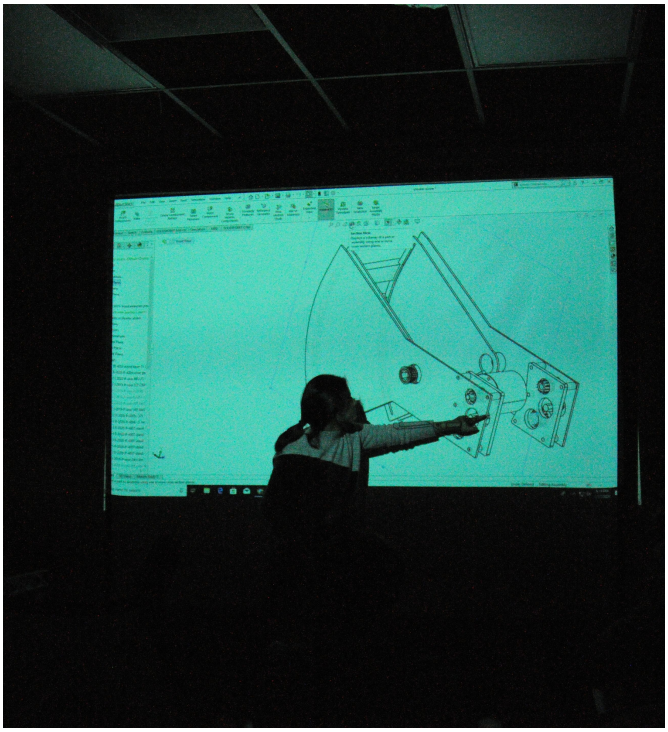
Hooks: Tested a variety of different hook shapes as well as different active rebalancing hooks using a combination of laser cut wood, wheels, and spools.

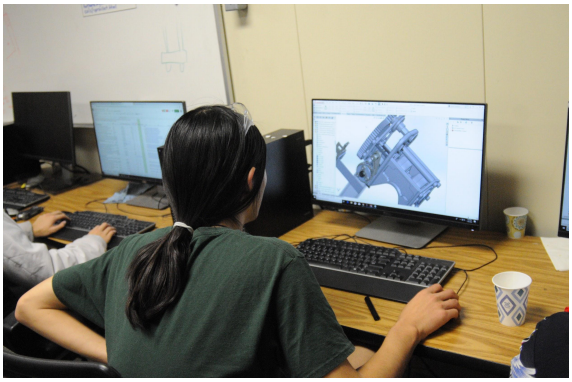
Integrated Prototype: The combination of four separate prototypes: the beavertail, horizontal indexer, intake, and shooter. It was used to test packaging and integration from the time the ball enters the robot, to the time it exits.

# Nari

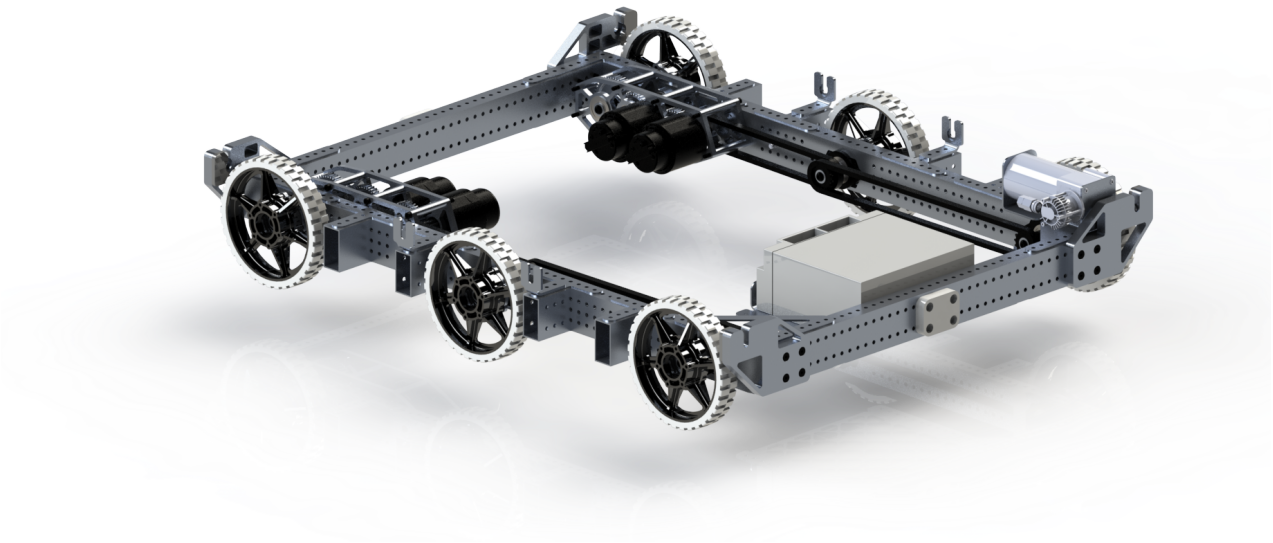


# DESIGN



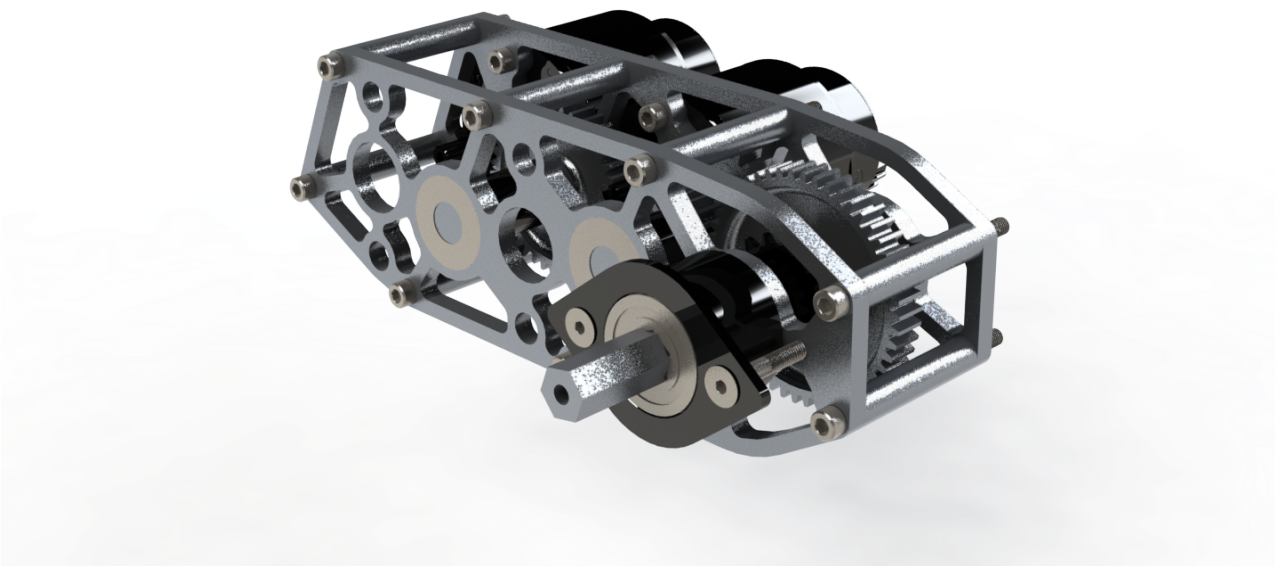


# Drivetrain



- **Design Constraints**
  - Minimize weight by using 1/16” wall box beam and 25H chain
  - Optimize both for short sprints and full field cycles
  - Offset weight of other mechanisms to achieve low center of gravity and centered center of rotation
- **West Coast Drivetrain**
  - 33” x 26.5” frame perimeter to maximize space for mechanisms and to achieve a wide wheel base for stability and smooth turning
  - 6 x Andymark 6” Hi-grip wheels for lightness and grip
  - 1/8” center drop for minimal scrub when turning and easy traversal through the rendezvous zone
  - WestCoast Products bearing blocks with cam tensioners
  - Bumpers secured by custom hex nuts for easy removal
  - 2 x 2 Falcon 500 gearboxes

# Drive Gearbox

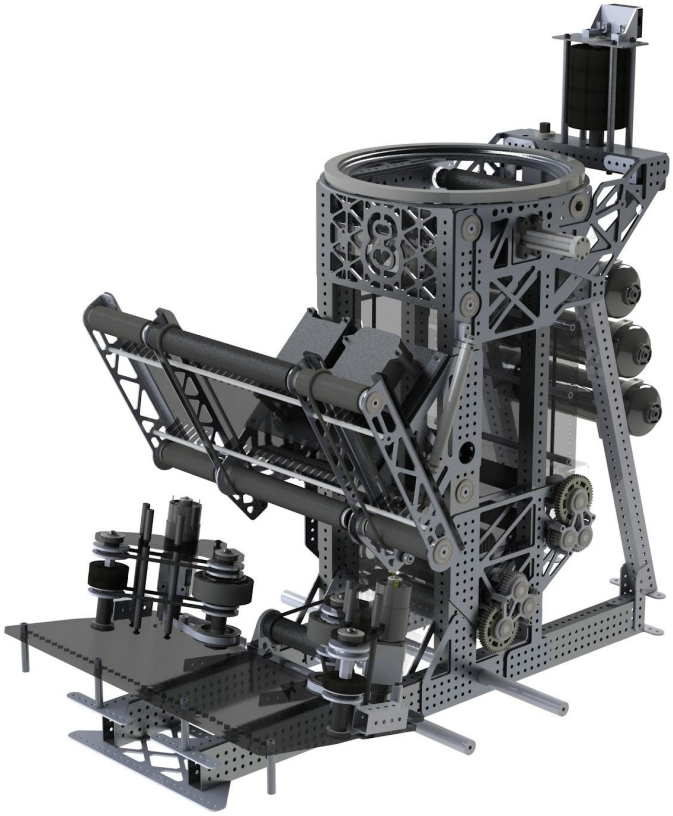


- **Design Constraints**
  - Low profile to sit below intake and indexer and keep center of mass low
  - Flexibility to change between multiple gear ratios
  - Powerful enough to win pushing matches or cause wheels to slip and prevent stalling
- **Flat 2 Falcon gearbox**
  - 12.3:1 overall reduction
  - Drivetrain 13.5 ft/s theoretical max
    - Able to swap gears for speeds of 12.0, 13.9, and 15.7 ft/s

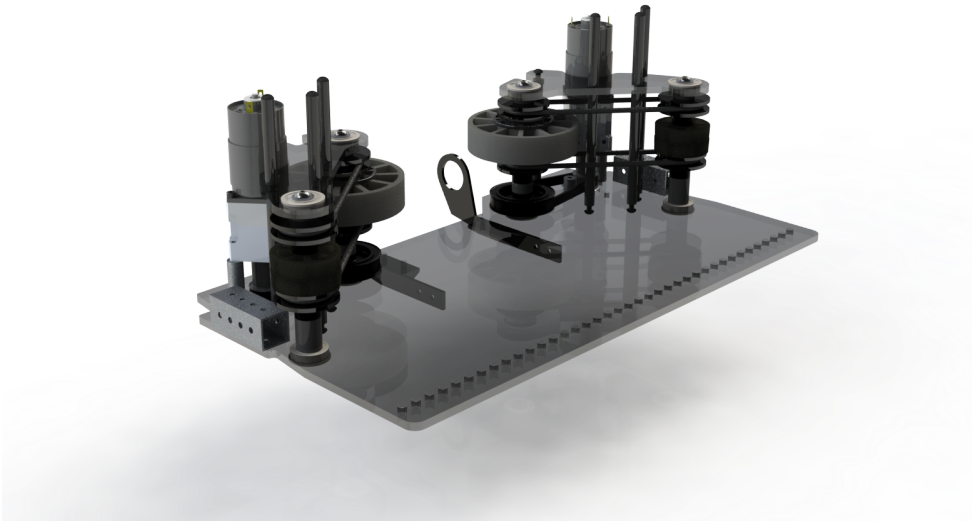
# Intake

- **Design Constraints**
  - Stow into a horizontally unintrusive configuration
  - Be able to withstand impacts against the loading station wall and against other robots
- **Virtual 4-bar**
  - Short stroke pistons to minimize air use
  - 58t base and 16t joint sprocket with chain allow intake to retract while keeping compact geometry
  - Passively retracts when hit or pushed

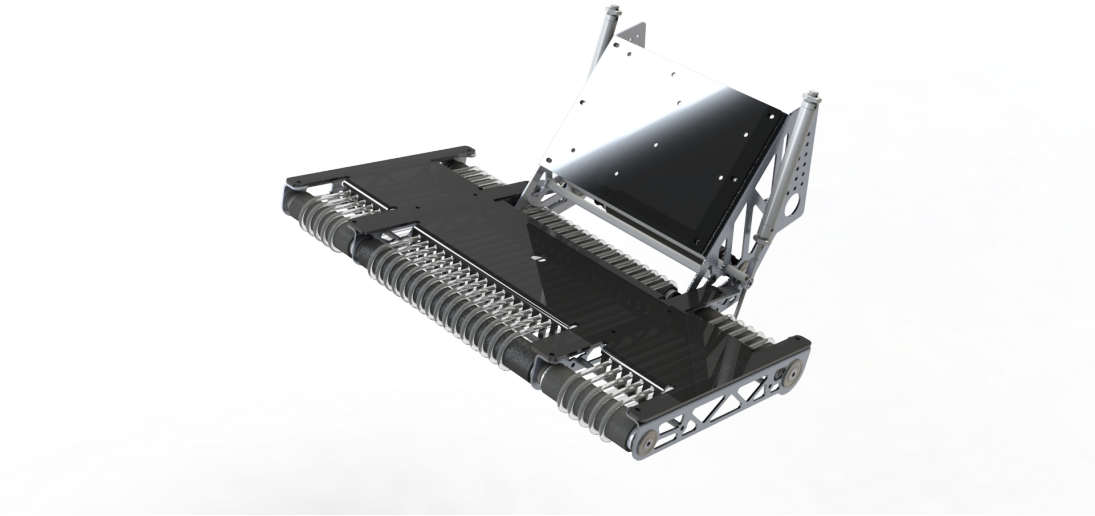
# Indexer



- **Design Constraints**
  - Ability to hold 5 balls at once
  - Quick unloading
  - Complete control of fuel cells while in robot
- **Polycord conveyor system**
  - Wide rollers with inserted combs to separate cords allow for extreme versatility and adjustability of cord placement
  - Combination of timing belts and tensioned polycords create strict mechanical linkages between some rollers while others can slip
  - Fine tuned for optimal compression and control
- **Pneumatic hard stop**
  - Simple actuation prevents balls at the top of the indexer from moving forward while others are being indexed

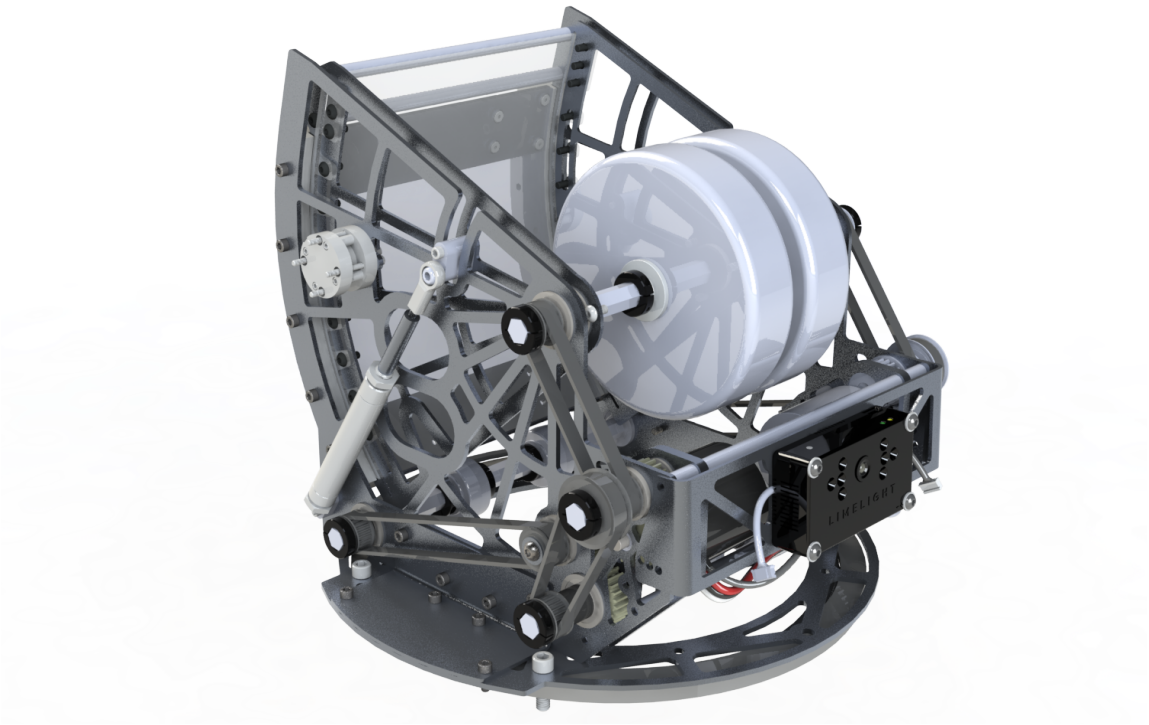


- **V-belt Indexer System**
    - Can index multiple balls at the same time
    - Internal sorting allows for driving while sorting balls



- **Top Roller**
    - Top belts constrain balls while driving through rendezvous zone
    - Flips up to allow intaking directly from loading station

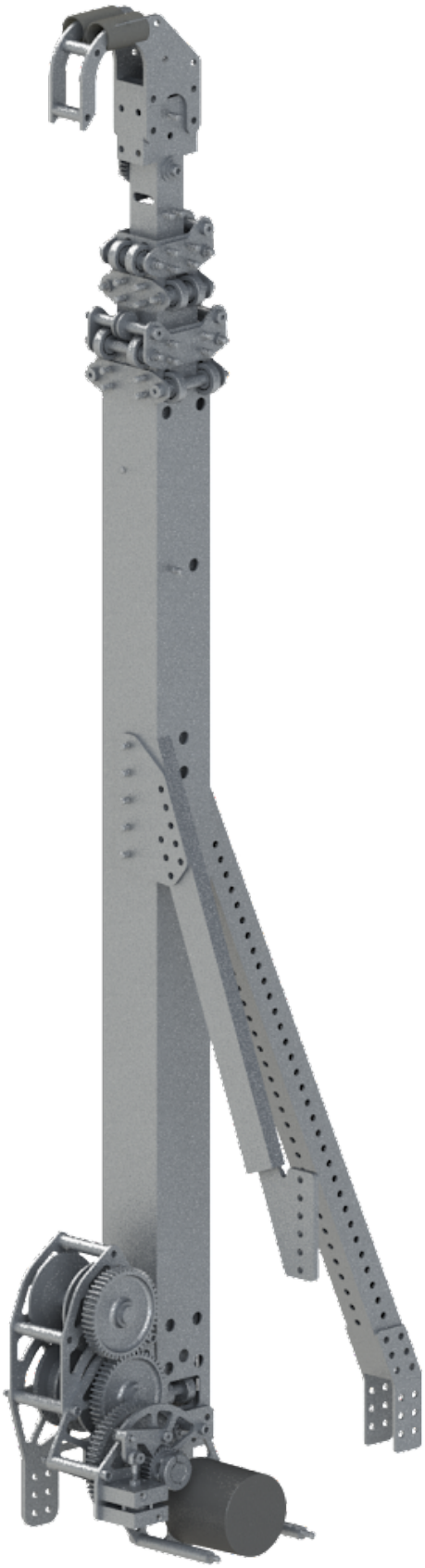
# Shooter



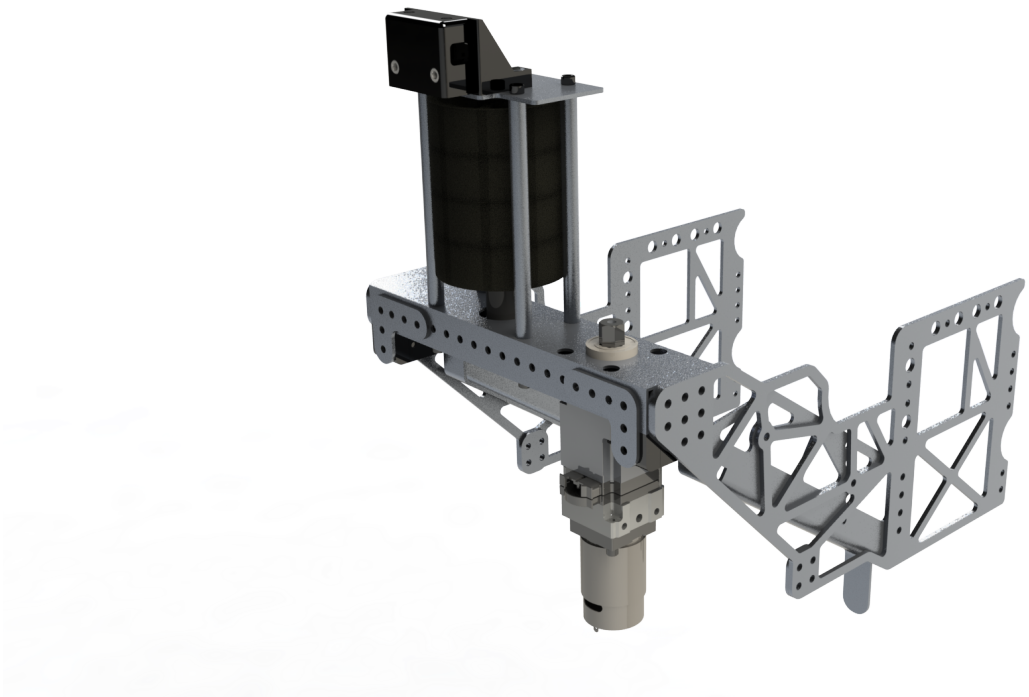
- **Design Constraints**
  - Powerful enough to shoot from long range
  - High accuracy
  - Low drop-off between rapid shots at close range
- **Single Flywheel Shooter**
  - Two 6” Colsons with seven 84t gears for increased inertia
  - Two NEO motors geared up 1:1.3
  - Wheel Speeds: 4500 rpm (117.8 ft/s surface speed)
- **3-position hood**
  - Allows for shooting from the target zone, the initiation line, the trench, and from behind the Control Panel
- **Secondary Kicker Wheels**
  - Two pairs of 1.625” Colsons geared up 1:1.5 from the main flywheel
  - Accelerate fuel cells from the indexer to the flywheels to minimize flywheel velocity drop and prevent jamming

# Climber

- **Design Constraints**
  - Robust, reliable, and minimal weight
  - Capable of reaching max generator switch height when fully tilted.
  - Unintrusive to ball path and other mechanisms
- **2 Stage Continuous Telescoping arm**
  - Max reach of 84”
  - Generous (10”) overlap between stages
  - Ratchet system to tension cable rigging
- **1 NEO Gearbox**
  - 16.7:1 overall reduction
  - Climbs max generator switch height (79”) in 2.3 s (theoretical max speed)
  - Pawl pneumatically locks into a ratchet to hold robot position after match ends
  - Dual spool system for both up and down rigging to avoid dyneema tangling
- **Passive Hook**
  - Rubber urethane tubing minimizes sliding on the bar when tilted
  - Makes it easier to balance the switch through repositioning by raising the hook off the bar

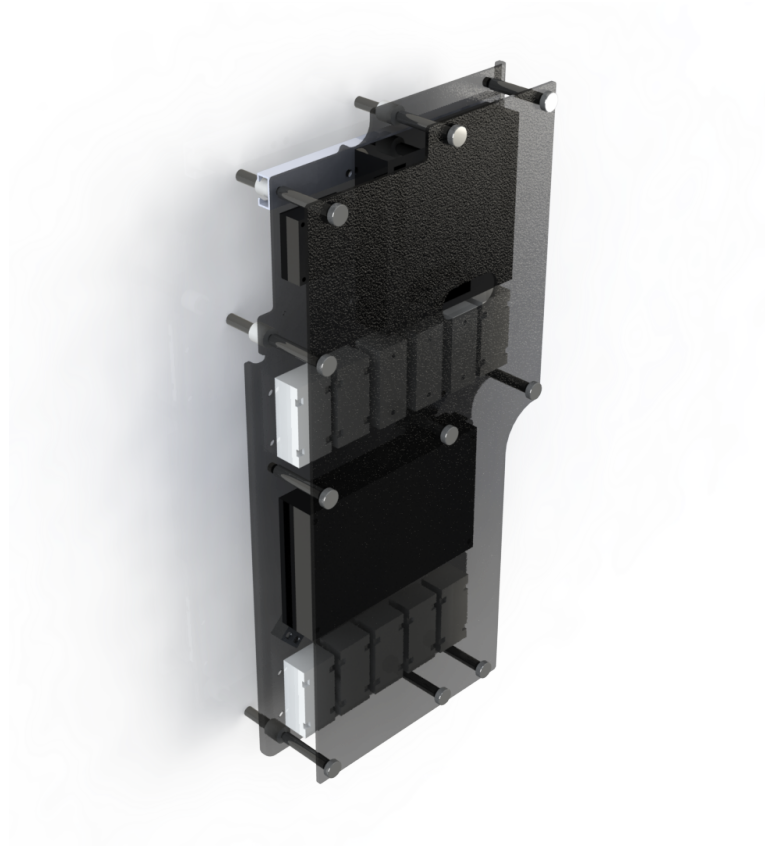


# Control Panel Spinner



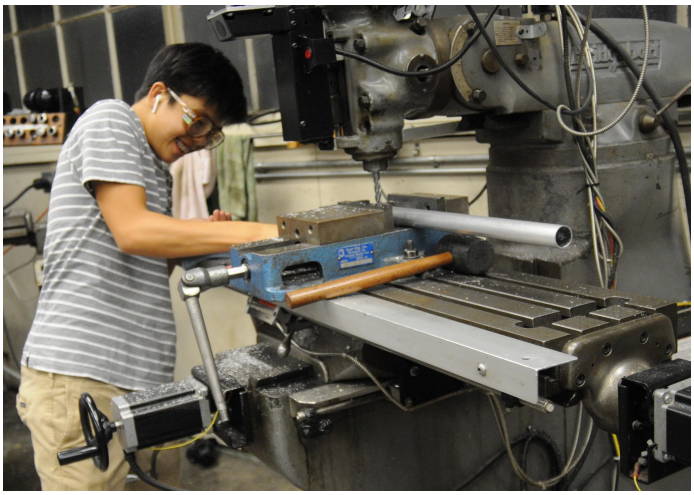
- **Design Constraints**
  - Completely within frame perimeter (no actuations)
  - Allow for fast alignment when driving into Control Panel
  - Achieve position and rotation control as fast as possible
- **Flex wheel spinner**
  - Layered plates and bent sheet metal create a robust structure capable of withstanding forces in any direction
  - Large, high durometer wheels allow for some compression while maintaining a consistent grip on the Control Panel
  - Geared 16:1 for control panel speed of 1 rotation/second
    - Versaplanetary gearbox allows for easy adjustment
- **3D Printed Color Sensor Case**
  - Blocks interfering light so sensor readings are accurate
  - Light, strong, and low profile

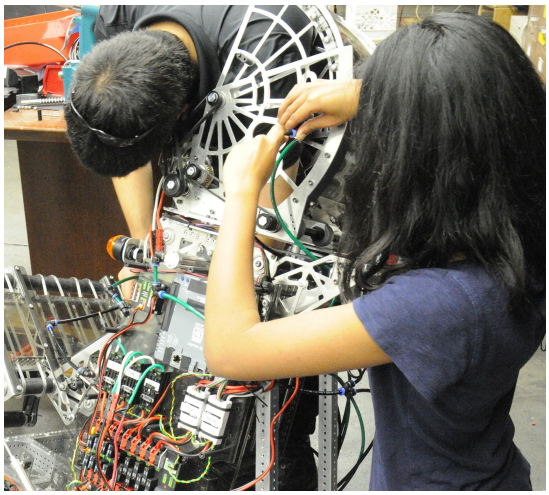
# Electronics

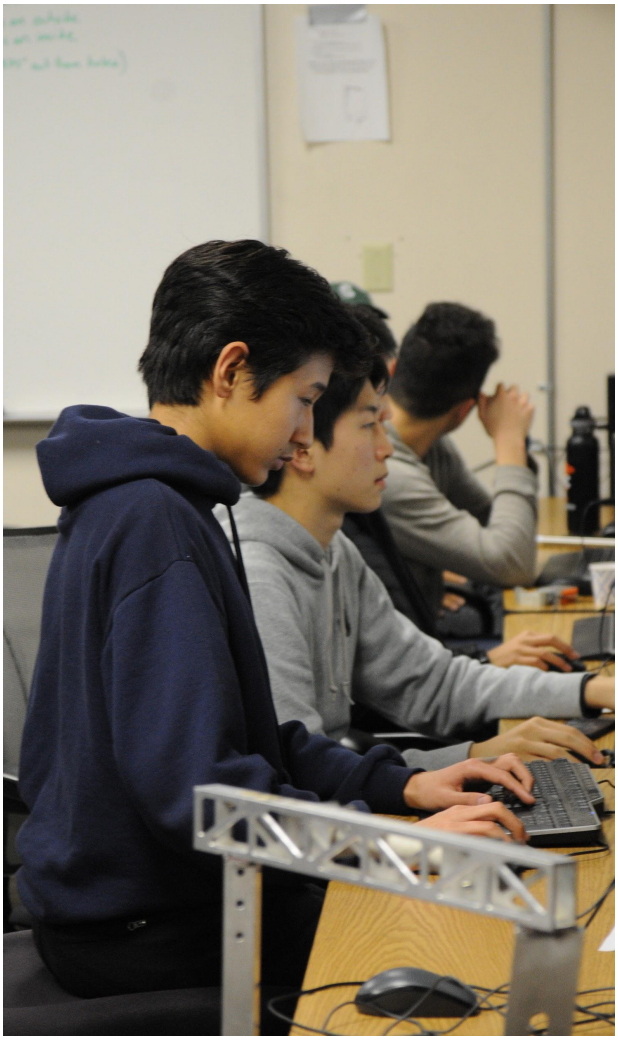


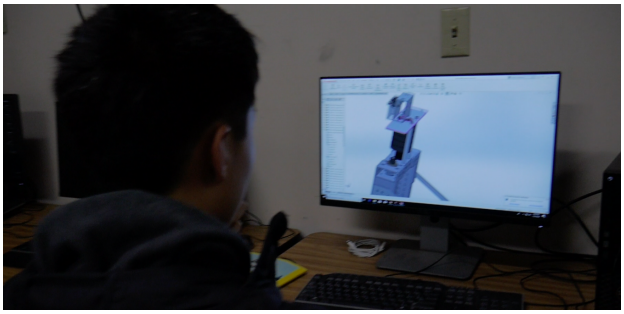
- **Design Constraints**
  - All electronics easily accessible from the side of the bot for easy maintenance
  - Electronics protected from fuel cells, other robots, etc.
- **Vertical electronics board**
  - Easily accessible, not blocked by any mechanisms
  - Centralized board makes it easy to diagnose issues
- **Removable cover**
  - Attachment with thumbscrews makes it easy to remove, service, and replace between matches

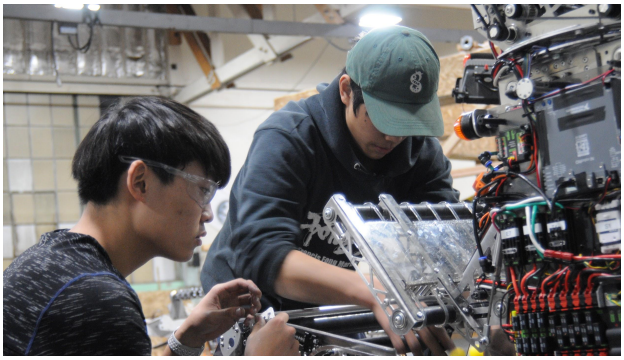
# ITERATION





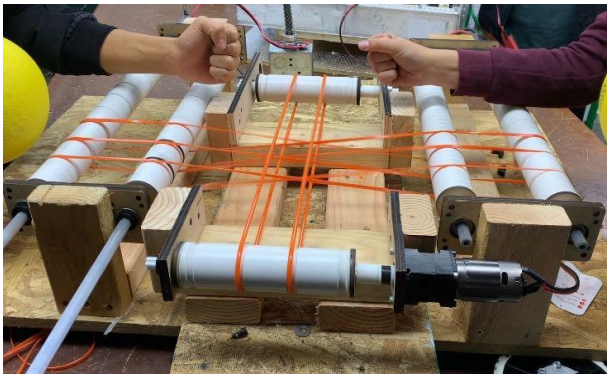


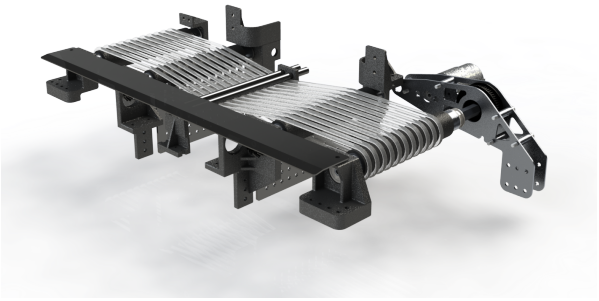




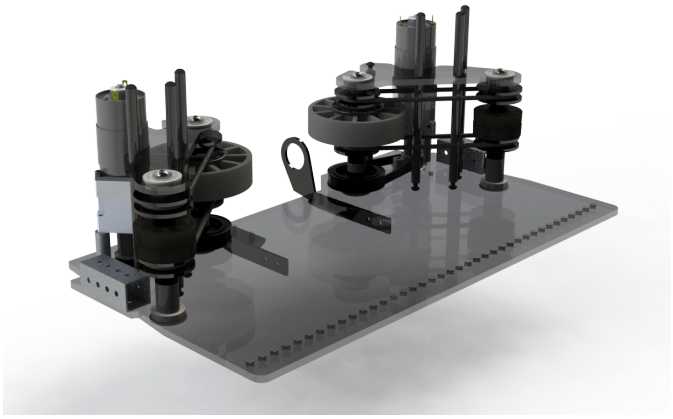
# Beavertail/V-belts

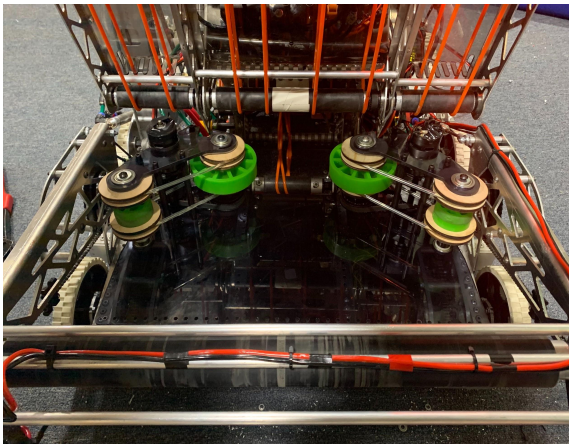
Beavertail: We started out by prototyping a beavertail, and then integrated it into our robot design. However, when we tested it on the field, it was unable to intake multiple balls a time and frequently jammed.



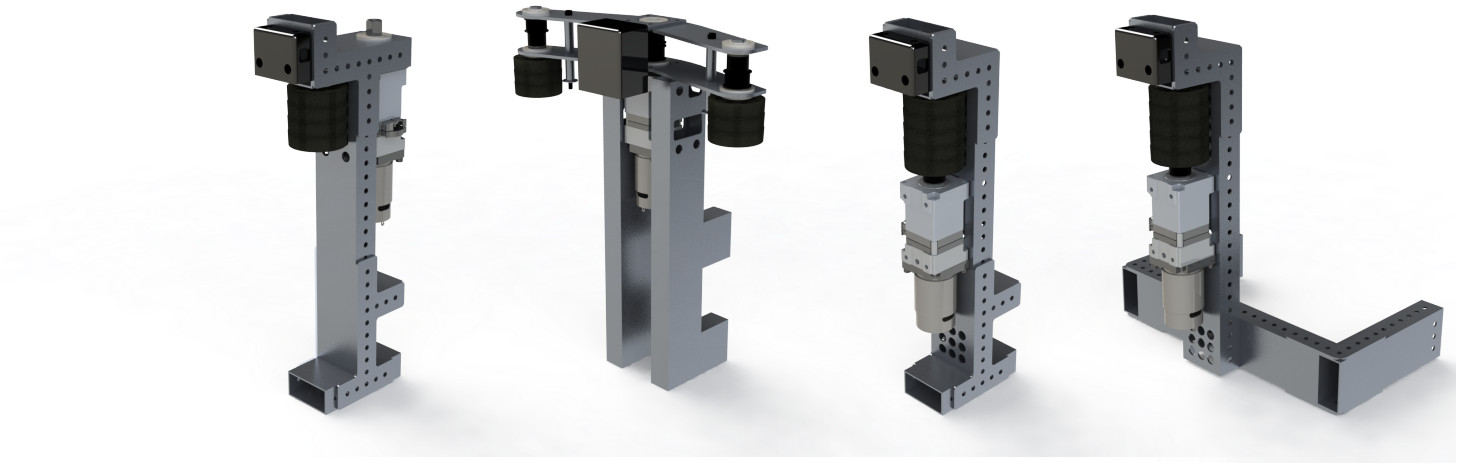


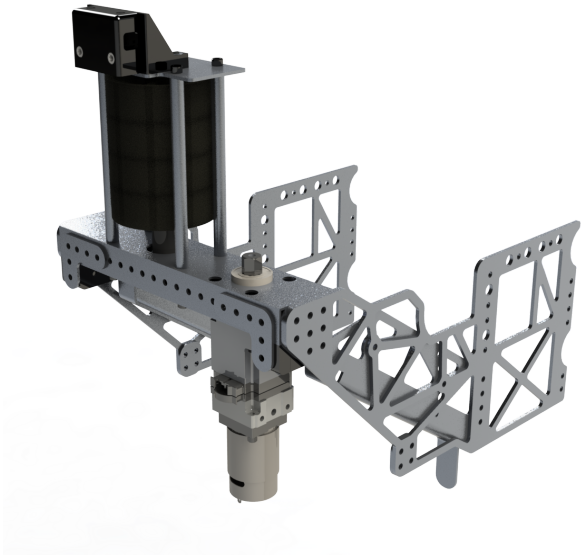
V-belts: We replaced the beavertail with v-belts, which allows us to intake and index multiple balls at the same time without jams.





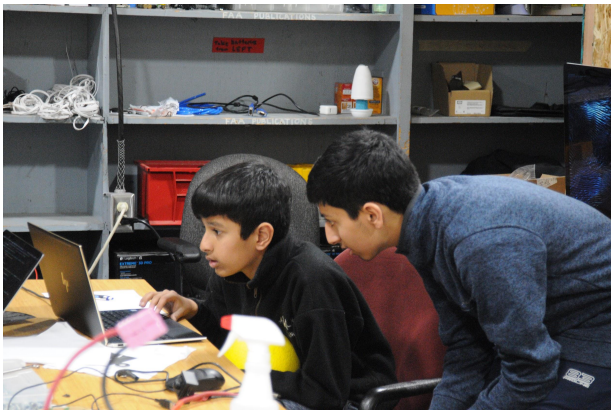
# Spinner

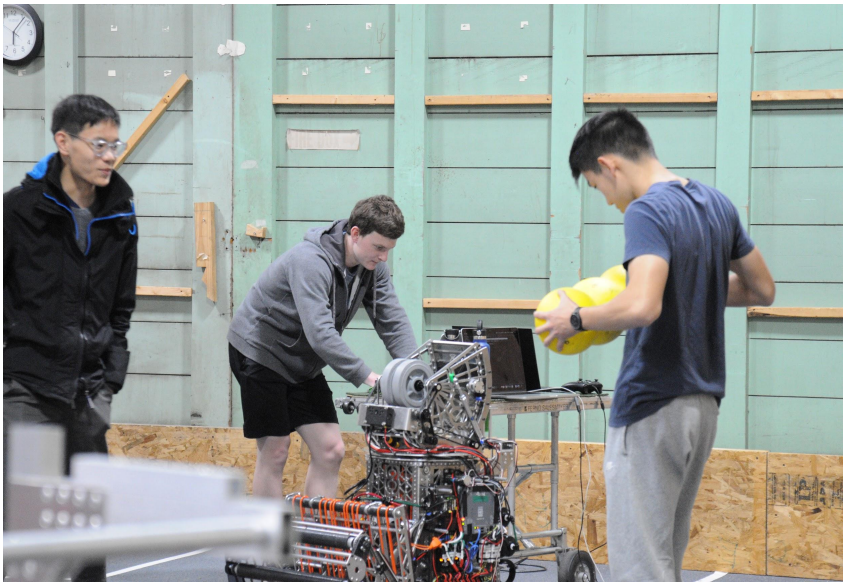




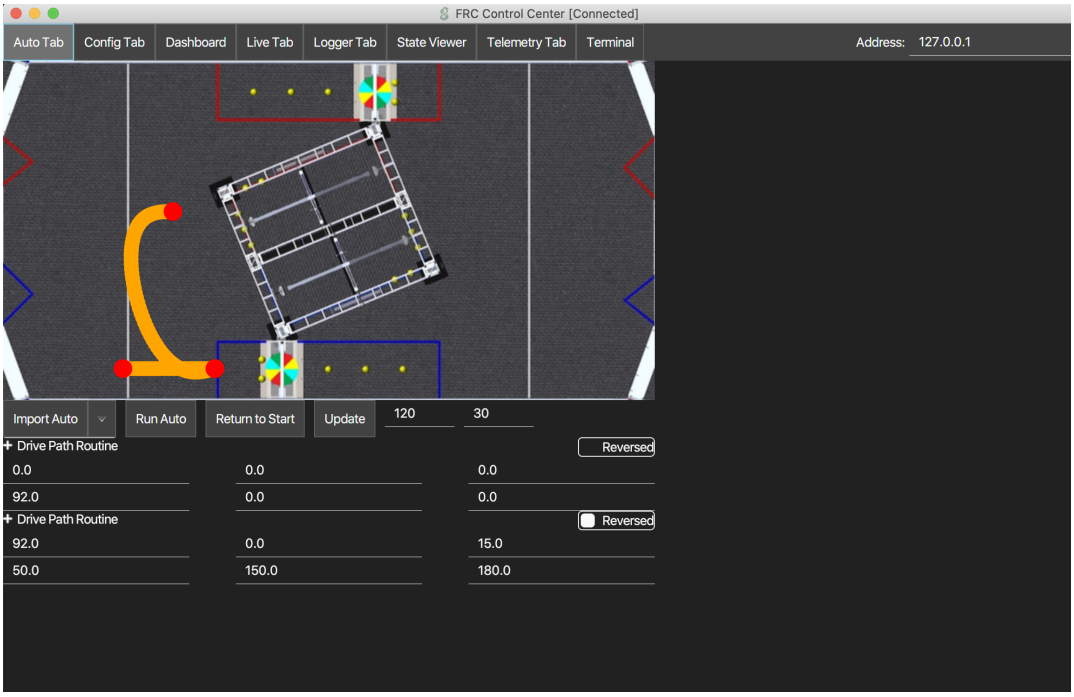
Our spinner mechanism went through 5 different iterations within CAD before being machined and physically tested. The final design contains multiple bent sheet metal parts to be able to withstand forces from all directions, as well as 3” flex wheels for reduced impact forces, and it is optimized to save weight and space.

# SOFTWARE





# Autonomous Code

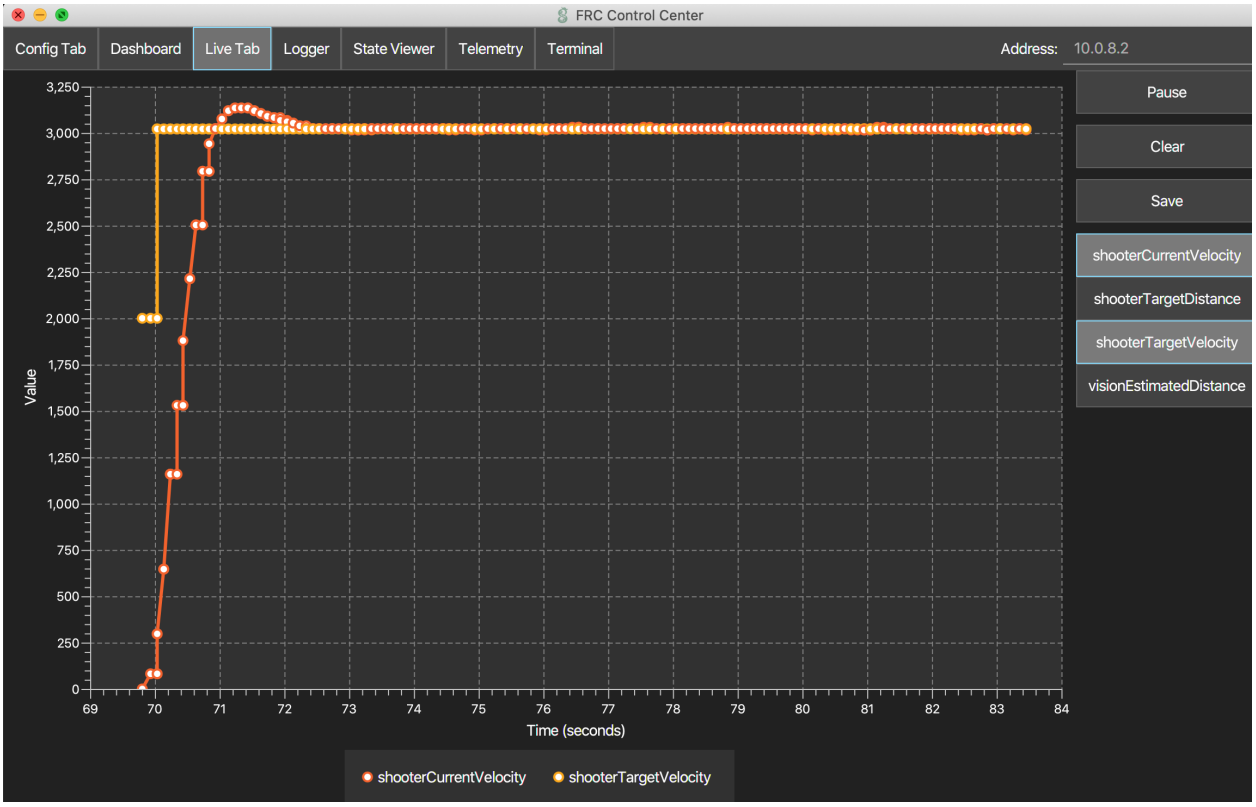



- Path following + Feedback
  - Paths are generated from multiple poses
  - The velocity of the robot is controlled through a trapezoidal motion profile
  - The current velocity and field position of the robot are recorded through a gyroscope and encoders
  - The drive controller uses the Ramsete algorithm to adjust the drivetrain's motor output based on error with target pose
- Computer Vision
  - Incorporates limelight to detect vision targets through pixel and contour filtering
  - Allows us to automatically align to the vision target
  - Provides us the distance to the target, enabling our shooter to determine an appropriate target flywheel velocity
- Path Graphing
  - Control Center can edit, graph, and run multiple autonomous modes all in one custom application to streamline auto testing

# Tele-Op Code

- Interpolating Map
    - Automatically determines target flywheel velocity for shooting
- Indexer held at constant velocities using trapezoidal motion profiles
- Integrated control for coordinating Indexer, Intake, and Shooter
- Shooter hood control
    - Blocking piston and extending piston move without colliding with each other
- Control panel spinner
    - Color sensor allows us to determine how many rotations of the control panel have occurred
    - Controlled by two buttons; one for position control and one for rotation control
- Driver and operator feedback
    - Xbox controller rumbles when the flywheels are at the appropriate velocity
    - LEDs on the back and front of the robot provide a plethora of information
        - Aligning, intaking, indexing, shooting, climbing, etc.

# Control Center




- Custom new 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