Robotic Eagles
15173

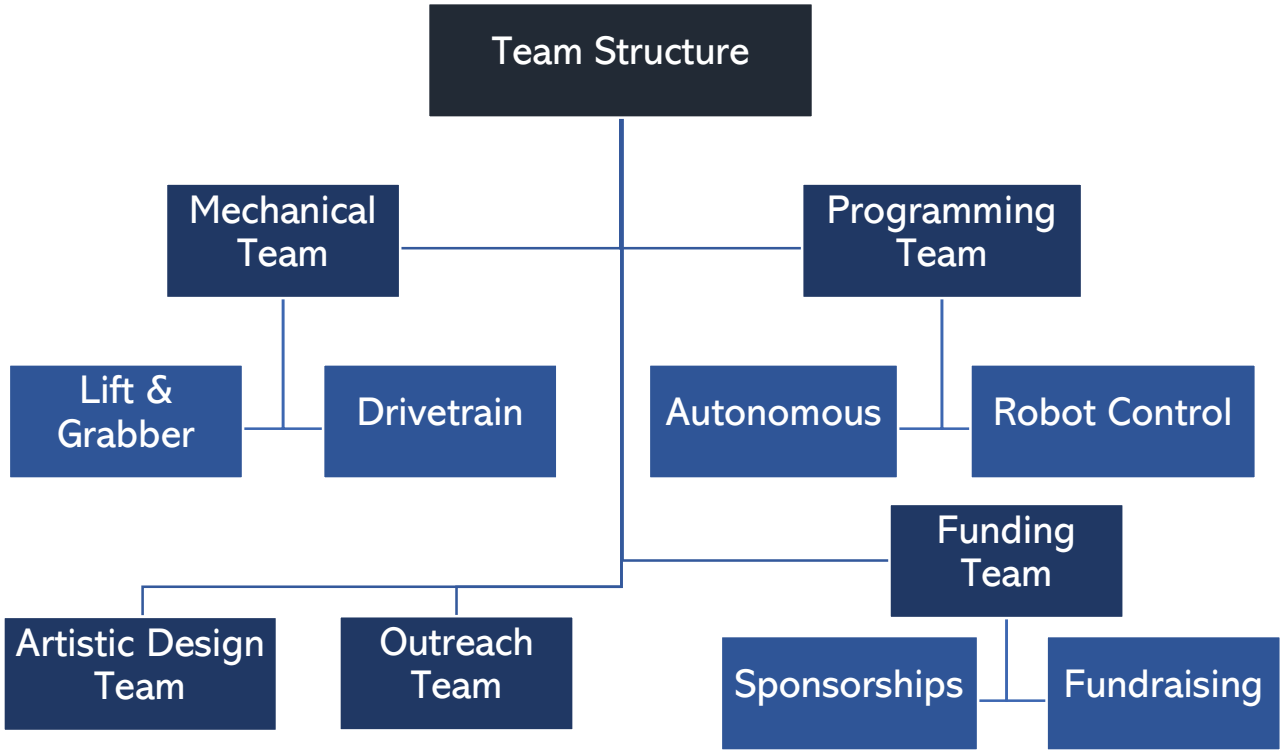
Milton High School – Milton, GA

Power Play Engineering Portfolio
2022-2023

Team Structure

Meet The Robotic Eagles!

- 5th year in FTC based out of Milton, GA
- Has won 3 Inspire Award's (second place) & 3 Innovate Awards
- Let's check out our team:



Neerav (10th grade)	Rudra (12th grade)	Oliver (11th grade)(R)	Shreyan (11th grade)
- Driver - Mechanical - CAD Design	- Driver - Captain - Programmer	- Outreach - Sponsorships - Fundraising	- Drive Coach - Mechanical - Sponsorships
Jahaan (11th grade)	**Krish (11th grade)(R)**	**Nikhil (11th grade)(R)**	**Toby (11th grade)(R)**
- Human Player - Drivetrain - Fundraising	- Outreach - Sponsorships - Fundraising	- Mechanical - Lift/Grabber - Fundraising	- Artistic Design - Sponsorships - Mechanical
Damodar (11th grade) (R)	**Jamie (9th grade)(R)**	**Ananya (11th grade)(R)**	**Vivi (11th grade)(R)**
- Autonomous - Lift - Mechanical	- Mechanical - CAD Prototype - 3D Print	- Outreach - CAD Prototype - Sponsorship	- Mechanical - Drivetrain - Fundraising

(R) = Rookie Member

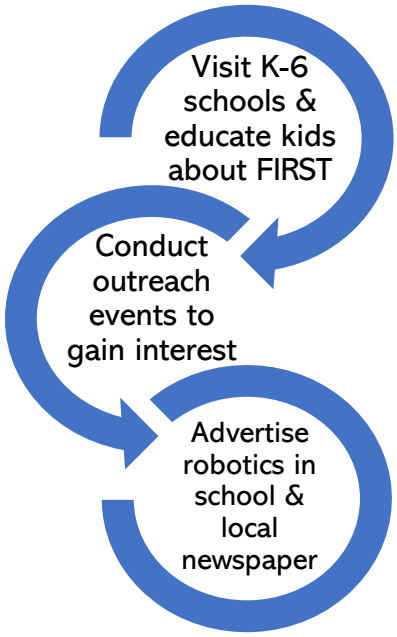
Team Goals

Goal	Overachieved? Achieved?	How did we accomplish it?
Recruit 5 new members to improve sustainability of the team	**Overachieved** We recruited 9 members from our school & local middle schools	- Held robot showcase events - Held robot competitions at local museum
Host at least 1 league meet	**Achieved** Hosted Western GA League Tournament w/ 27 teams & 500+ people in attendance!	- Coordinating with league directors - Organized logistics with school principal - Designated 20+ school volunteers to assist with parking
Raise $6,000 to support team funds & robot needs	**Overachieved** Raised $14,362	- Cold called local businesses - Went in groups to talk to City Hall + Mayor - Emailed & contacted Fortune 500 companies

Give back to our amazing community through 3+ non-technical volunteer events	**Overachieved**
	
	Gave back to our community in 5 different non-technical areas
		- Volunteered at:
		  - Crabapple Senior Living
		  - Chattahoochee Nature Center
		  - Drake House
		  - Meals By Grace
		  - Pure Hearts

Team Plan

Sustainability Plan



Weekly Meeting Schedule

Sunday	Team Meeting on Zoom; Discuss week's progress, plans, and future
Monday	Build (4-7PM); Programming (7-9PM)
Tuesday	Build (5-9PM); Funding (6-7PM)
Wednesday	Build (4-7PM); Programming (7-9PM)
Thursday	Build (5-9PM); Funding (6-7PM)
Friday	Build & Programming (4-10PM)
Saturday	Build (8-11AM); Programming (1-5PM); Outreach & Funding & Design (5-7PM)

Subteam Placement Method

- Using our ***FLY METHOD***, we split the team into different groups
  - (ie. build, program, outreach)
- The individual teams are led by an experienced team member, who helps them learn skills to contribute to the robot and/or team
  - (ie. learning CAD to make a claw, practice funding pitches for sponsorships)
- Members can freely switch between teams, and be part of multiple as we believe each member should be multiskilled

Plans for Outreach to FIRST Community

- Mentor Georgia Teams on unique approaches to our robot subsystems:
  - Teams ask us how we made an efficient autonomous → assist them virtually in implementing **our custom programs made public on GitHub**
  - Teams ask us how we made a fast REV lift → hold more seminars showcasing building lifts w/ explanations why we did what we did
  - Mentor a local FLL team at Fulton Science Academy to inspire them to continue FIRST through High School and beyond.

Timeline 2022-23

August
- Team Service Project at Rucker Farm
- Computer Museum Event
- Recruiting new members via social media campaigns
- India Service Project Planning

September
- Drake House Volunteering
- POWERPLAY Game Release
- Prototyping intake/lift
- Creating custom chassis

October
- Configuring autonomous
- Meet #1

November
- Create lift Version 2
- Meet #2
- Summit Hill/Elkins Elem. Event
- Switch to GoBilda Chassis

December
- Meet #3
- Organized Scrimmage with #1002

January
- Create lift Version 3
- Meet #4

February
- Planning logistics for *hosting* leagues
- Implemented Roadrunner
- Western GA League Tournament
- Create pole guide
- GA State Tournament

Legend:
Green – Outreach
Red – Competition
Purple – Robot/Team Progress

Fundraising

Total Team Balance 2022-2023:

$14,352

- **Goal**: Raised $6,000
- **Result**: More than doubled goal
- **How**: (Shown Below)

<u>Cold Calling at Milton City Hall and Local Businesses:</u>

- We reached out to mayor of Milton, & the city council who have independent businesses. They wanted to promote local STEM growth by supporting us.
  - **Money raised:** $632

<u>Matching Programs at Parents' Companies</u>

- If our parents donated X amount to the team, their company matches that amount, & also donates X amount.
  - **Money raised:** $2,000

<u>Membership Dues</u>

- We collected $150 from each team member.
  - **Money raised:** $1,950

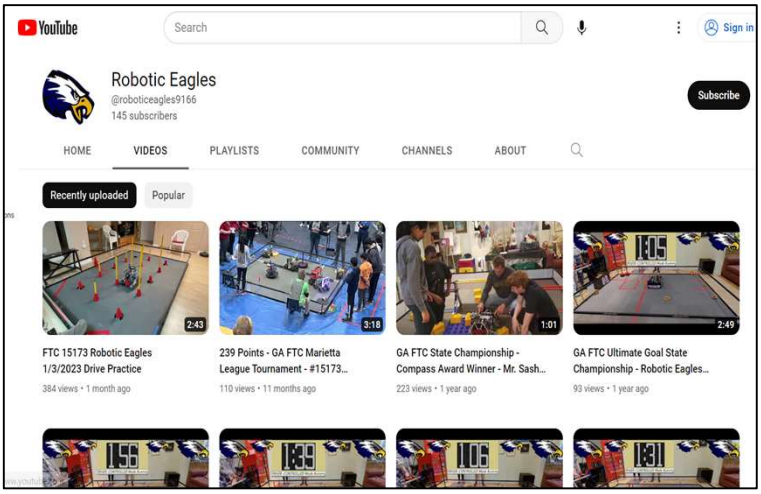
<u>Summer Project: Bike Fixing Shop</u>

- Set up our garage and worked together as a team to fix parts of neighbors' and locals' bikes.
  - **Money raised: $950**

<u>Over 25 Sponsorships:</u>

AT&T - $110	**Honeywell** - $2,000	**PWC** - $500	**Vinny's** - $125
Ace Hardware - $50	**Cisco** - $1,500	**Dunkin** - $20	**Macy's** - $600
UPS - $50	**Edward Jones** - $200	**Actemium** - $50	**Aiden N Co** - $150
EY - $1,000	**Audi** - $350	**Cava** - $25	**Accenture** - $750
Paradies Lagardere - $200	**Veloxiti** - $90	**CFA** - Food	**Starbucks** - $25
Home Depot - Spare Parts	**The Union** - $75	**Lowe's** - $50	**GA Power** - $500
Art Engineering Inc - $100	**BANG! Creative** - $150	**OLM** - $100	**Milton Lighting** - $50

Outreach



YouTube Channel & Mentoring

- Accumulated **over 30,000 views** on object detection & robot match videos
- Created easy-to-follow steps on implementing our custom robot programs
- Contacted and mentored **teams worldwide** from *Israel to Romania* after they commented on our videos

Contributing to **Global FIRST Inclusivity Conference** with #5773

- Sharing experience & advice with teams worldwide
- Connecting with panels of STEM professionals & FIRST alumni

Computer Museum of America

- Demonstrated how the **engineering design process** helps us build robots
- Educating visitors about how FIRST empowers us to learn through robotics
- Showcasing & assisting visitors in driving robots

Host Team for Western GA League Tournament

- Organizing venue, logistics, & emergency preparedness for **27 teams**
- Providing food to **100+ volunteers**
- Showcasing gracious professionalism to **500+ people** in attendance

Three Elementary Schools

- Engaged **100+ students** in robot driving challenges
- Educating them in applying classroom-learned skills to robotics

MILTON Media Group
Bringing People Together

Featuring in a Magazine's March Issue

- Reached **40,000+ locals** on real-life applications of STEM and promoting FIRST
- Having team interviews, & discussing contributions to robot

Drake House

- This is a place that houses single moms & their children
- Showcased previous robots
- Let the kids have some fun operating the robot

GOING GLOBAL TO INDIA

Prosthetics Drive

- Volunteered at a convention in Jamnagar, Gujarat in which we gave physically impaired individuals prosthetics.
- Many could not afford the prosthetics so through our efforts, we could start to change their lives for the better

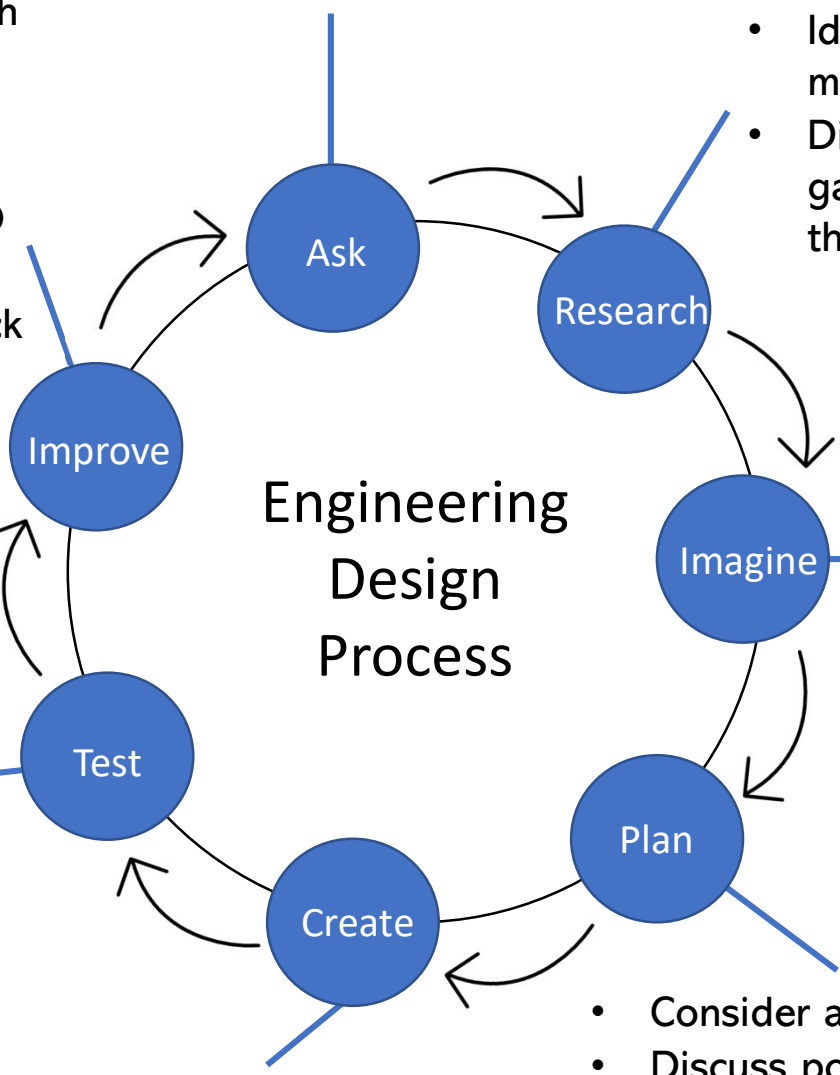
Distributing Goods to Villages

- To locals in Sayla, Gujarat
- **Packaged 40+ boxes** of lentils and shipped them to Raj Saubhag Ashram to be distributed

- Donated $350 (₹ 28,533 rupees) for 100 cataract surgeries in SRS Eye Camp, and **virtually learned about the role of robotics in surgery**

Think

Ask ourselves what we need to build? Code? Do more? Develop/ Edit budget



- Watch the latest YouTube videos
- Identify which materials are ideal
- Discuss how this game is different than previous ones

- Draw possible designs on whiteboard
- CAD prototypes
- Construct various prototypes

- Consider all the prototypes
- Discuss potential issues with each design?
  - What materials needed? Buy those
  - Need input on robot? Contact our alumni

- Divide team into different groups: code, build, fundraise, etc.
- Continually make improvements to robot design
- Weekly meetings with each groups to discuss progress & next steps

- Do driver practice on our practice field
- Compete in scrimmages
- Attend meets

- Watching match recordings & analyzing what went wrong
- Improving CAD prototypes
- Time to go back to the drawing board!

- **Lessons learned:** Our shortcomings encourage us to approach problems with an open view & look at failures as opportunities to improve next time!

Connect

Finding Mentors

As a team, we always look for opportunities to connect with industry professionals for input and help. We are in constant contact with our alumni to partner with their college labs to improve our robot and further our technical skills. We also participate in technology events, such as the ***Georgia Student Technology Competition*** and the ***Computer Museum of America*** to find connections.

Invention Studio

- Working with alumni at Georgia Tech at the Invention Studio, which houses a **cornucopia of advanced tools** such as CNC machines, laser engravers, and large 3d printers
- Alumni helped us design and **fabricate custom parts** for rapid prototyping

Bhamla Lab

- We connected with Georgia Tech's Bhamla Lab to **improve the accuracy** of our cameras
- Bhamla Lab often works with cameras on projects such as tracking microscopes, and therefore have experience in the area
- They helped us improve our **OpenCV readings** for the custom sleeve and our **Tracking Camera Localization**

Michigan Tech

- We connected with one of our alumni who works at the **Applied Quality Control Lab** in Michigan Tech to make sure our 3d prints were as high quality as possible
- We also connected with their engineering department to make sure our robot could handle the stresses put upon it by our lift

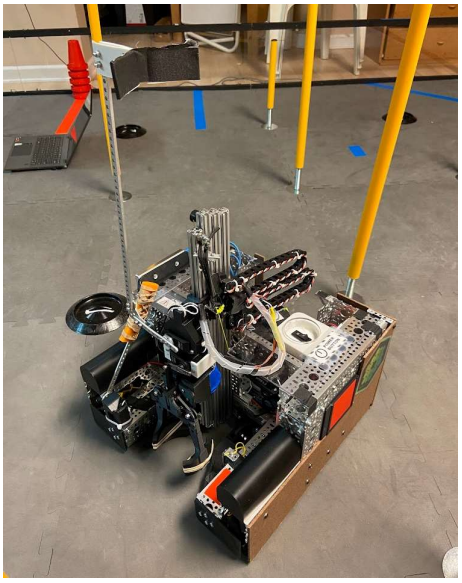
Kennesaw State University

- Connected with KSU computer science department to learn about **programming a mecanum drivetrain** & understand math involved
- **Maintain connection to collect feedback on our robot**

Design

Design Choices

- **14.25”x14.5”** drivetrain, mecanum drive
- Motors mounted inside channels for protection
- Wood side plates for wheel protection
- Low center of mass
- **Horizontal lift spool** allows larger size and motor in center of robot
- **Odometry wheels** coupled with **Tracking camera** for optimal localization
- REV lift instead of GoBilda
- Cone Flipper to make fallen cones upright
- Custom CNC sideplates
- Clean, sleek look



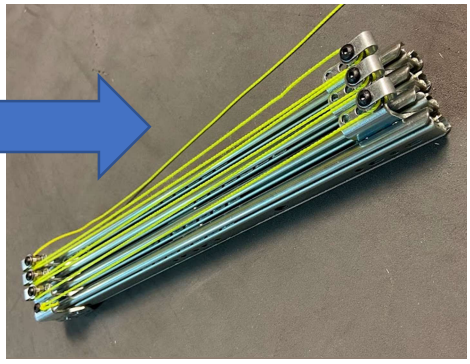
Problems	Solution
Robot does not fit between poles	Robot drivetrain made less than 16in to easily drive **between the poles**.
Lift moved quite slowly due to pole heights	Larger spool with light REV extrusions without slider plates for **less friction**.
Cones got stuck in the robot	Roof covering the robot to prevent cones from getting stuck inside. Side plates to prevent cones from interfering with driving.
Intaking cones was not fast or reliable	3D printed cone guide to push cones into a fixed location. Grabber requires only **small servo movement**.
Beacon cannot be grabbed in the same way as cones	3D printed beacon that sits on top of the cone **without interfering with grabbing**

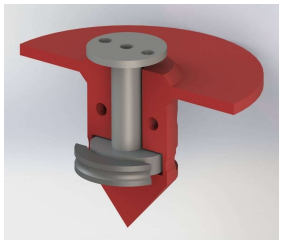
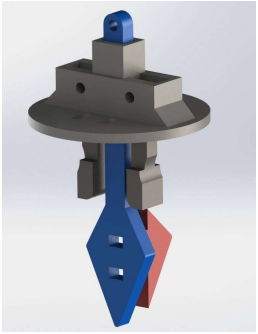
<u>Strategy</u>

- Score cones to **maintain circuit** throughout match (~14 -16 cones)
- Score cones on one pole if teammate is excellent at circuit (~15 -18 cones)
- Reliable autonomous (3 Cones + Park)
- Own a complete row/column of poles on field to **break opposing alliance’s circuit**

REV and GoBilda

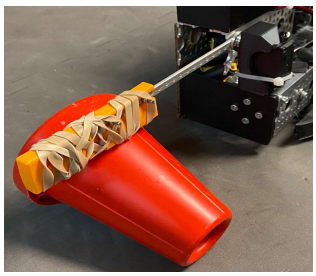
- We use REV and GoBilda parts for most of our robot
- We use the GoBilda pattern system (8mm grid) because it is consistent and has good compatibility with other GoBIlda parts
- Our lift uses **REV extrusions** because they are light. We tested with GoBilda, but they were too heavy, and the lift was slow



Claw Iterations		
V1 (Use conics to expand the grabber)	V2 (Inside cone grabber & expands to hold cone)	V3 (Grabs cone) Current Design
 (Renders made with SolidWorks)		

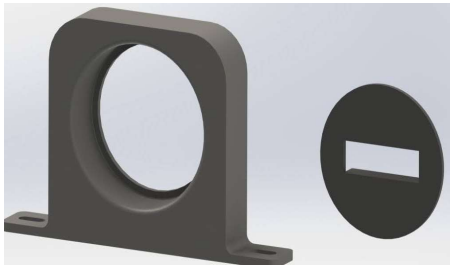
Cone Flipper

- ***Problem***: We could not flip fallen cones upright
- ***Solution***: Created an arm attached to servo



Power Switch

- ***Problem***: Cones could fall on our switch and power off our robot
- ***Solution***: We embed our switch in our roof. Tested and found cones had a 0% chance of turning off the robot



CAD and 3d Design

- We use Onshape to CAD our entire robot
- We use an **iterative design process** to design individual parts on our robot
- We import .STEP files from REV and GoBilda to make sure our 3d prints fit perfectly.

Innovations

Cone Guides

- *Problem:* picking up cones **without alignment** was **slow and tedious**.
- *Solution:* semicircle indentation to guide cones into **exact position**.

Iteration 2

- *Problem:* Autonomous **stack moved**, incurring multiple penalties

Iteration 4

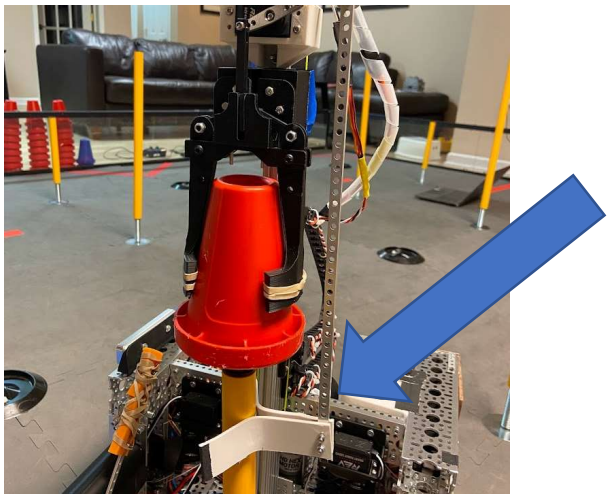
- *Solution:* cone guides **retracted in autonomous** to prevent penalties and **lowered in teleop**

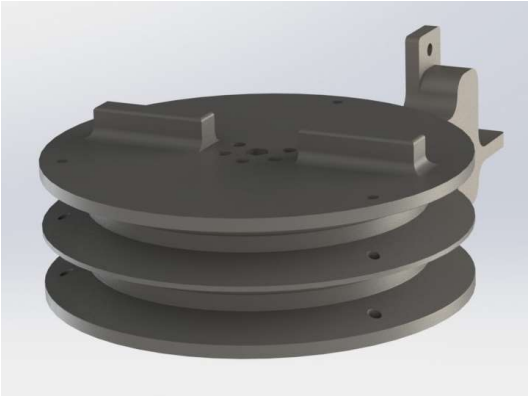
Intel RealSense T265 Tracking Camera

- We use **field centric driving** (see next page for more information), so angle is very important for robot movement
- *Problem:* Inbuilt IMU has a delay, and can lose angle between opmodes
- *Solution:* Use the Intel Camera to get angle & drive robot like Pac Man
  The camera **retains angle** after startup and has a **faster response time** than the inbuilt REV IMU for angle

Pole Guide

- In the West Georgia League Competition, we found that we spent lots of time aligning the robot with poles
- We made a guide that aligns the pole perfectly under the cone
- Because it only has one point of contact with the pole, it is allowed by the rules





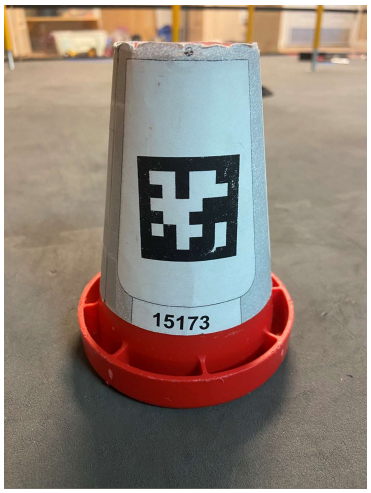
Horizontal Spool

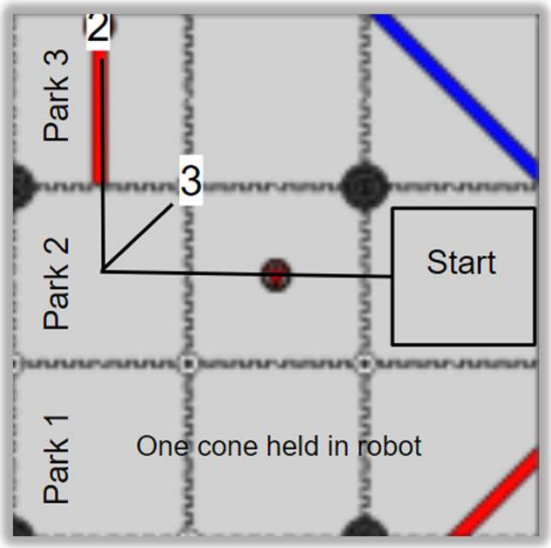
- We use a **horizontal spool design** instead of a vertical spool, providing many advantages:
  - Allows for a vertical lift motor creating **even weight distribution**
  - Created space for spool to be bigger & increased lift extension speed by 65%

Control

Autonomous Objectives:

1. Detect April tags on sleeve cone
2. Drop 3 cones on closest short pole
3. Park in the correct zone





Field Centric Driving

A system we implemented using our Intel Camera, where the robot drives in relation to the driver's perspective, (like playing Pac Man). This allows drivers to score 5 more cones in a game, as we don't have to drive in relation to the robot (like a tank driver).

Sensors we used:

4 Drive Motor Encoders	External USB Webcam
3 Dead Wheels for Odometry	Intel RealSense Tracking Camera for heading & odometry

Teleop Objectives:

- Achieve fast *cycle times* (time from picking up cone to scoring)
- Drop cones accurately
- Move between poles without knocking cones off
- **Claim one complete row or column** to prevent opposing alliance from completing their circuit

PIDF (Proportional, Integral, Derivative, and F)

- We use PIDF to make our movements smoother
- We went through many tuning stages to make our drivetrain & lift constants as close to perfect as possible
- In teleop, it helps us **have better** turns as well as **better acceleration and deceleration**.

Road Runner

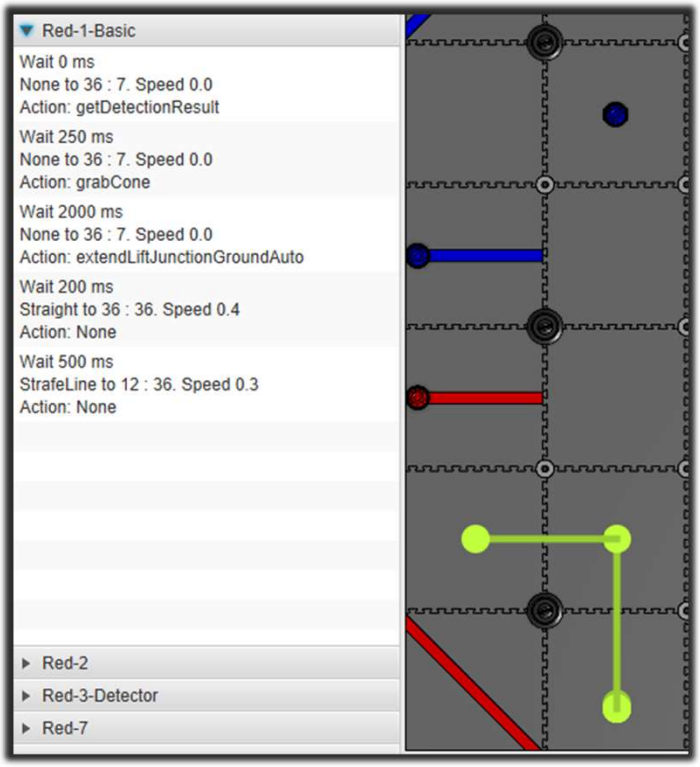
- We use Road Runner to **precisely control** our robot during **autonomous**
- It uses the PIDF constants we tuned to control the robot accurately
- It allows us to use a **variety of movement profiles** to use our mecanum drivetrain to the fullest
- We use **optimized movements** that **change angle and position together**

Robot Positioning

- We use multiple sensors for accurate localization of our robot: dead-wheel odometry, drive motor encoders, and the Intel RealSense T265 Tracking Camera
- *Problem:* Dead-wheel odometry **accumulates error** while the Intel Camera has a **slight delay** that prevents it from working with Road Runner
- *Solution:* **Combine both localization systems** to relocalize the odometry after each movement to **get the benefits of both systems**

BotRoutes (in conjunction with Road Runner)

- Programming autonomous through straight code is **slow and unproductive**
- *Solution*: we created a **completely custom** software which we call BotRoutes
- BotRoutes is a GUI that makes creating routes easy, **even for non-programmers**
- After the route is made, it is sent to the robot as a simple .json file, which robot understands, and executes
- It makes **changing autonomous faster**, allowing us to cater for our partner's autonomous during competitions
- BotRoutes is **open-source on GitHub** for **all teams** to use



FTC Dashboard

- We use FTC Dashboard to quickly change constants in real time
- FTC Dashboard allows us to make changes in our code in real time while opmodes are running, which is extremely useful for tuning, testing, and debugging

Programmed Buttons

To optimize our teleop, we have **preprogrammed buttons** to do certain tasks quickly.

- Like, instead of manually raising the lift to each pole height, we have buttons that **automatically** signal the lift to go to that height, optimizing teleop

Button	"Drive" Controller	"Lift" Controller
Left Trigger	Turn Left	--
Right Trigger	Turn Right	--
Left Bumper	Slow Mode	Grab Position
Right Bumper	Fast Mode	Grab Cone and Lift Up
Dpad Up	Cone Flip Up	Grab Cone
Dpad Down	Cone Flip Down	Release Cone and Disengage Pole
Dpad Left	Cone Guides Down	Stop Lift
Dpad Right	Cone Guides Down	Stop Lift
Left Joystick	Straight and Strafe Control	Manual Control
Right Joystick	--	--
A Button	Pole Guide Engaged	Move lift to High Pole Height
B Button	Pole Guide Ready	Move lift to Medium Pole Height
X Button	Pole Guide Up	Move lift to Ground Pole Height
Y Button	--	Move lift to Low Pole Height

Controllers

- Our drive controller is the Etpark Wired Controller for PS4, and utilizes FTC's rumble method, which vibrates the controller
- Vibration helps the driver to get **haptic feedback** whenever a key event has occurred (like when cone is dropped, *vibrate*, and driver knows to move back)
- Our lift controller is the Logitech F310 because of its reliability and simplicity

Speed

- We closely monitored the speed of our robot through FTC Dashboard to optimize movements to be as accurate as possible
- In autonomous, we implement a **trapezoidal speed movement** profile to speed up and slow down at certain percentages of our movement
- In teleop, we **square the inputs** of the *Left Joystick* so that the values become more extreme and responsive, allowing for more control
- We also have slow & fast modes of speed in teleop which allows us to make fine movements with precise control when needed