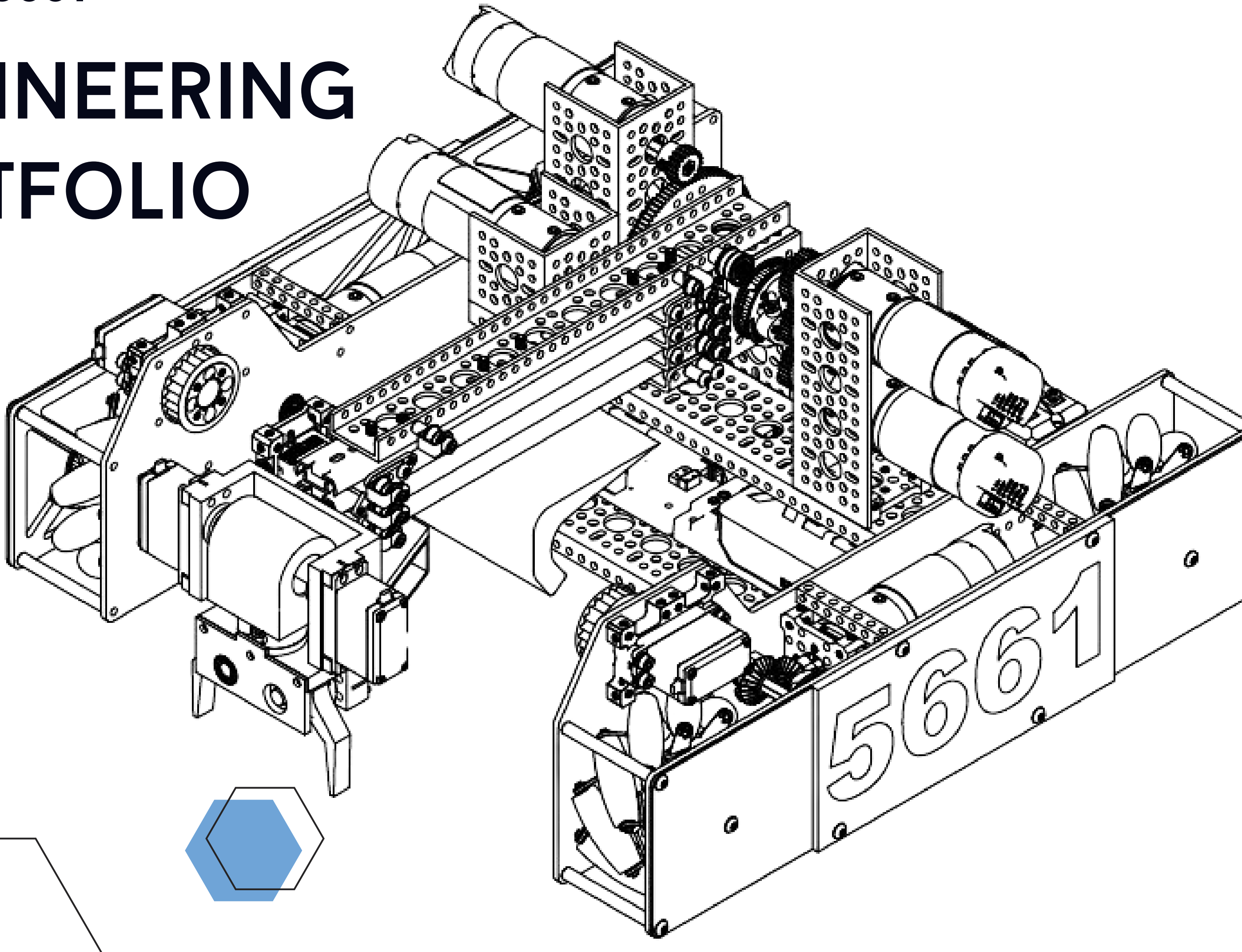
2024-2025

ESTRELLA FOOTHILLS HIGHSCHOOL

WOLVES ROBOTICS

TEAM: 5661

ENGINEERING PORTFOLIO



FIRST TECH CHALLENGE

INTO THE DEEP

PRESENTED BY RTX

Introduction

Who are we?

We are **FTC Team 5661 Wolves Robotics 1** located in **Goodyear, Arizona**. We compete **alongside** our sister team **7156 Wolves Robotics 2**.

Our team has been around for nearly **15 years**, only not competing for one year due to the COVID-19 pandemic. The pandemic created a gap between the Senior and Freshman years.

Our team has now filled this gap, leading to most of the 5661 members being **seniors**. After many years of learning, we made it a goal to make this season the best we possibly could, allowing future members to pick up right where we left off.

What makes us unique

Our team number represents the age of our team and the history we have in Arizona FTC. With **generations of our team** existing we are all proud to carry the number **5661**

Drive Team Costumes was an idea our team came up with during the **CENTERSTAGE** season. At each competition our drive team will show up in a **new and interesting costume** to set us apart from the rest of the teams competing. Some costumes we have done are:

- Men In Black
- Scooby-Doo
- Hawaiian
- Lethal Company

Milestone Goals

In the post season of our centerstage year we created milestone goals that will take the duration of the 2024-2025 **Into The Deep** season to reach.

- Qualify for the **FTC World Championship**
- Push towards **inclusivity and positivity** within FTC
- Win a **Winning Alliance Captain** award
- **Teach and mentor** the large class of incoming Freshman
- **Develop skills** in hardware, software, and creative design

Our Pack

Our Mission

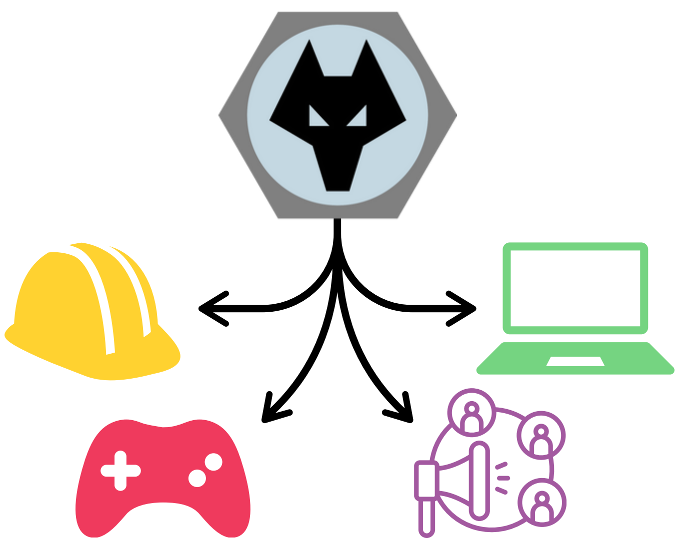
Using the environment provided by our club and FTC, we aim to foster:

- **Teamwork** skills to improve our ability to work effectively in teams.
- **Self-confidence** allowing everyone to contribute their own unique and interesting ideas.
- **Leadership** within our community and mentorship for new members who will follow in our footsteps.

Team Structure

Our club has always had a focus on being fully **student-led**. Our new club management system has everyone split into **4 different departments** each with their **department lead**. One **team lead** will keep in contact with the department leads to make sure deadlines are met.

The team lead will also **update our CEOs (Coaches)** on progress. Each of these departments has sub-categories that **build up our team.**



Team Lead - Baden A - 12th

Engineering - Samantha C - Grade 12

- **CAD design** - Baden A - Grade 12
- **Chassis Specialist** - Elijah L - Grade 12
- **Tool Specialist** - Deagan M - Grade 12
- **Sub-Assemblies** - Declan S - Grade 12

Software - James B - Grade 12

- **Autonomous Design** - James B - Grade 12
- **Tele-Op Design** - James B - Grade 12
- **Driver Aid Design** - Wesly A - Grade 12

Communication - Luis V - Grade 12

- **Fundraising** - Matilde C - Grade 10
- **Community Outreach** - Hope M - Grade 11
- **Professional Outreach** - Shawn S - Grade 11
- **Documentarian** - Luis V - Grade 12

Driving - Derek L - Grade 12

- **Coach** - Deagan M - Grade 12
- **Driver(s)** - Derek L - Luis V - Grade 12
- **Human Player** - Samantha C - Grade 12
- **Strategist** - Shawn S - Grade 11

Communication Methods

With all these new methods of sorting out our team **strong communication** is crucial to our success.

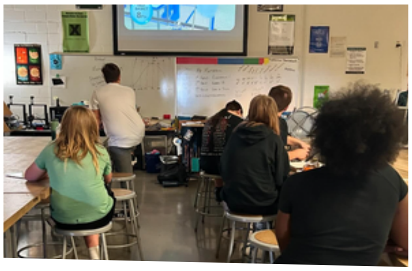
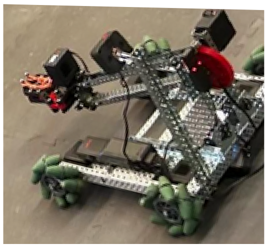
- **Discord & Department Group Chats** are all used to keep **deadlines in order** while also being able to communicate with each other at all times
- **Google Drive** is also crucial in being able to keep all our **photos organized** but also shared along with each other

Club Sustainability

Recruitment

As a large portion of our 5661 team is **seniors** our main mission is to **recruit and teach** as many freshmen as possible this year. We do many events at our school to make our club known and **push the idea of STEAM** further in our school partaking in:

- Freshman Gear Up
- School Carnival
- Club Rush
- Concession Stands
- Career Technical Education Advisory Meeting


Teaching new members

Passing down knowledge is the best thing we can do to ensure our club is always **prepared** for the season. Some of the activities we put into motion to teach the rookies were:

- Starting **chassis design** using our vex kits
- **Teaching members** simple mechanisms, CAD, and Programming in the **Pre-Season**
- Sending members down to #7156 to help them learn some more basics and **lead** them throughout the season.

Sponsorships

With the **succsess** we had last year with **reaching out** to businesses for **sponsorships**, we decided to use the same approach for obtaining sponsors. After emailing, calling, and spreading the word of our club and our need for sponsorships, we were able to **gain 4 sponsorships**.

Thank You to all our sponsors!

MILLSON NETWORKS

THE TACK ROOM RESTAURANT

HFB CONSULTING

SYMPHONIC

Booster Club and Finances

Last year a parent created our team's **Booster Club** as a means to keep parents in the loop as well as **provide ways to support** our team. The booster club can be used for **Tax Credit** so parents donating will have the money go to their taxes. The money from the booster club allows us to **skip the PO process** and obtain **new parts** in a **fraction of the time**.

Carry Over	1400 $
Fundraising	400 $
Sponsorships	1500 $
Parts and Fees	-1275 $
Total Remaining	**2,025 $**

Program Outreach

Website

Our website includes many **resources** for teams like:

- Scouting sheets
- GitHub
- CAD files
- Portfolio
- Contact information and MUCH more!

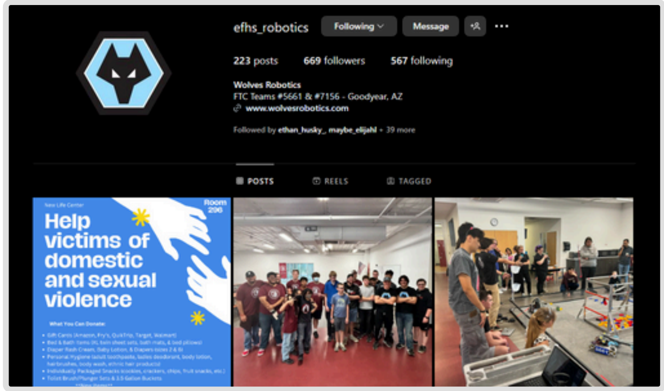
Girl Scouts - 5 scouts

In our off-season, we had the opportunity to collaborate with Girl Scouts and assist them with obtaining their Robotics badge. They built a LEGO Brainstorm robot which we then challenged them to obstacle courses, races, and freight delivery.

Social Media - 780+ Followers

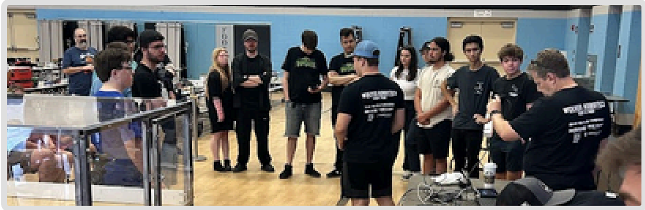
Our Instagram/Facebook keeps the FIRST community updated on where we will be competing during the season. We also document achievements and create fun posts for the FTC community.

We also use our social media to follow and support other teams by following and interacting with posts.



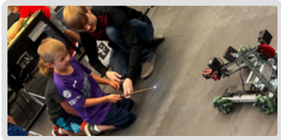
Wolves Combat Classic - 25 competing

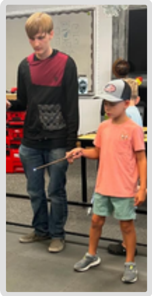
Our team hosted a Combat Robotics event which many students in FTC attended. Using our laser engraver we created trophies for the winners of the event.



Westar Elementry S.T.E.A.M. Camp - 80+ students

We participated in the Westar Elementary STEAM Camp where we had our very own robotics section. We worked with grades K-6 and had them work on robotics-related activities like: Building VEX kits, Controlling the robot, and Learning about the engineering design process. We also 3D printed many Harry Potter-themed prizes for the students as that was the theme for that year's STEAM Camp





Program Outreach

Club Involvement

We made it a goal this year to partner with many CTSO and community clubs within our school to push the idea that **robotics is EVERYWHERE** in total we worked with **8 different clubs** and CTSO chapters

- Some of the clubs we worked with were:
    - Skills USA
    - FBLA
    - FCCLA Ed Professions
    - HOSA
    - Interact
    - Coexist

Donation Drives

Partnering with CTE clubs we were able to orchestrate **2 donation drives**.

Code RED - EFHS CTE Organizations
Code RED was the **largest school drive** we ran partnering with 6 different CTE chapters to donate water for those struggling in the heat.

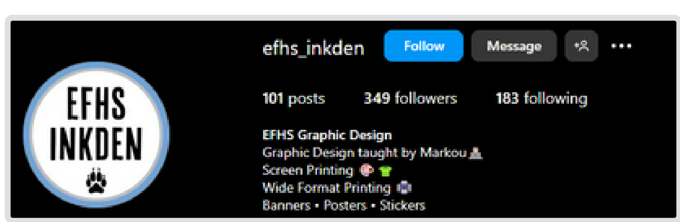
New Life Center - Skills USA: Engineering
After getting into contact with the New Life Center we created a donation drive to **help victims** of domestic/sexual violence.

St. Mary's Food Bank - 1892 people fed

Our members alongside interact helped prepare **emergency food** boxes for those in need. Each box created meals for 2 people to **eat for a whole month**!

Portfolio Help - FBLA Graphic Design

Our school FBLA Graphic Design team helped create our engineering portfolio. They gave **revision tips** and **design ideas** to make the portfolio more visually appealing



Program Outreach

Trivium Scrimmage

We **participated in a scrimmage** hosted by trivium teams. This was a great experience and gave us a **feel for the competition** this year.

Arizona Robotics Discord - 60 teams

Our team manages a Discord server with over **60 teams statewide**, providing robot troubleshooting **support** and organizing engaging **student** events throughout the year.

M.E. FIRST Ambassadors

Team **18421 Unscheduled Dissasemly** reached out to our team with an opportunity to be M.E. FIRST Ambassadors. As ambassadors, we spread **menstrual equity awareness** online and provide period products for teams during competitions. We are set to provide products for **4 competitions**.

Cactus Wren Qualifier - 24 teams

We contacted the PDP and were given the opportunity to **host a robotics competition** on our campus this year. The event will take place on **January 11th, 2024**.

Team Support - BASIS Java Beans

As a way to assist other teams, we **provide lab space** for teams who don't have the resources to pay for a field. **Team 18538 BASIS Java Beans** came by our lab to finish their robot and test without field. We competed in a few **scrimmages** as well.

Industry Mentors

Former AXON Engineer - Brent H.
Provided our team with **design insights**, planning, and making smart financial decisions

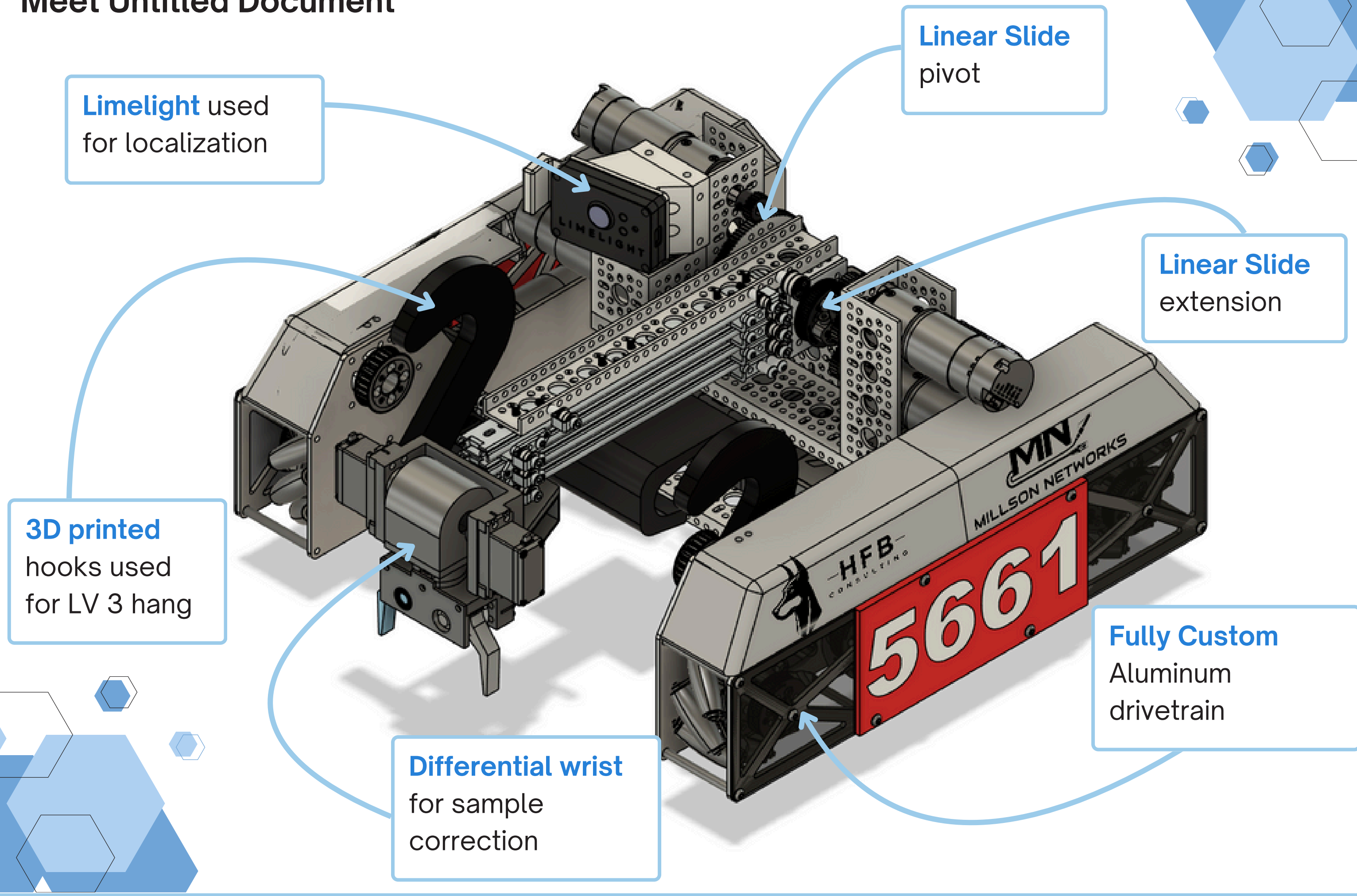
AXON

Northrop Grumman Employee - Christian M.
Gave us important insight on how we should go about **planning** a project like a robot subsystem

NORTHROP GRUMMAN

Robot Overview

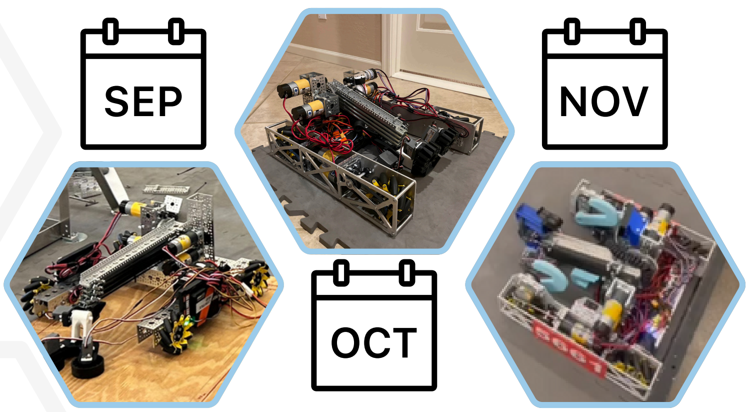
Meet Untitled Document



Some backstory

The robot name “Untitled Document“ came from my team not being able to come up with a name so we ended up with an unnamed robot leaving Untitled Document as the perfect name.

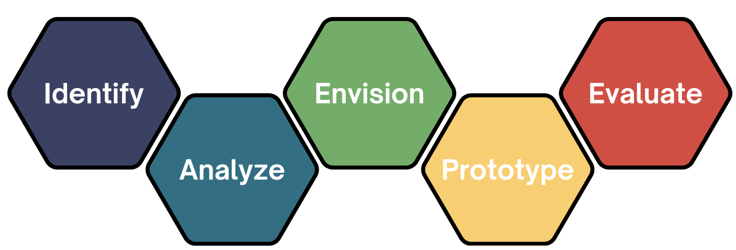
- This year we **challenged ourselves** by attempting to create as **simple of a robot** as possible to complete the tasks of the game



Our Engineering Plan

This year our team developed a **new engineering plan** system to make sure our robot was well thought out through all stages of development

- Our Engineering Plan was **KEY to our success** in developing new efficient and rigid designs



Engineering Plan

Identify

At the season's kickoff **Into The Deep**, we identified the following:

- This year's game was simple with the biggest points being able to score in the top basket
    - To be able to do that we would need a robot that could reach up high to place them in that basket
- The 3rd level hang was also worth a lot and will be game-changing to pull off.

Analyze

Basket Height: was measured from the rim to the floor is to be set at 43 inches.

- So in our design, we would need to create a mechanism that could exceed the 43 inches to go over the fill line of the basket to score maximum points.

Samples / Specimen: We knew to carry the pieces to the basket we would need to design a separate system to grab them accurately

- There were several locations to grab from, such as the Submersible, Observation Zone, and Spike Marker. The design should be diverse to allow for flexibility in strategy.
- With the added High Rung scoring option, our team wanted the design to be able to score there to work more efficiently with other teams.

Match Limits: This new season added a new Horizontal extension limit which would limit our robot's reach.

- Our team wanted to use one extension for both the height and horizontal reach to work around this.

Envision

After discussing our limits our team started brainstorming mechanisms and creating sketches to slowly begin envisioning our design. Our team settled on:.

- **Linear Slides** would allow the robot to fit within the 18X18 inch size constraint and allow for long-distance reach.
- **Mechanical claws** that mount to the chassis and arm to achieve the 3rd level hang
- **Custom chassis** to make the robot lighter and more compact
- **Active and Claw intakes** were tested to prove which performed better in a match

Prototype

To better aid our speed of designing new parts we spent much more time making use of CAD (Computer Aided Design)

- Afterward, we created physical models of these designs and made use of our manufacturing machines to create them.

This process saved us time and allowed multiple people to design different subassemblies.

Evaluate

Once we got our parts shipped, we split up into Sub-Teams to build each mechanism much quicker.

- Not only was this more efficient but it allowed us to incorporate and teach our sister team these more complex mechanisms so they can apply that to their robot.

After each mechanism was built we added code to the sub-assemblies and determined how effective they would be in a match and showed any issues that were an oversight in development.

From here we now cycle back to the Envisioning stage of our robot to continue to develop and improve upon our designs.

Match Strategy

Autonomous

Here is our plan for the autonomous period:

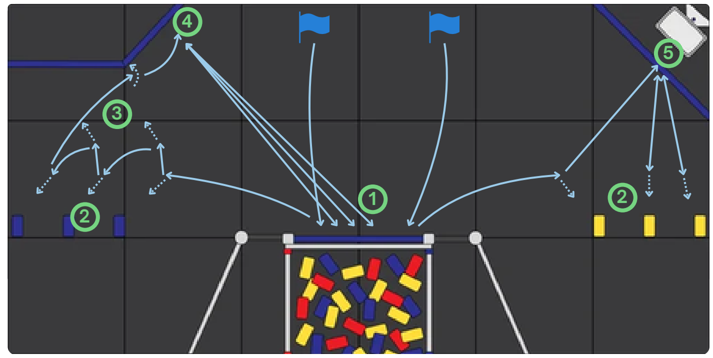
1.) Move to the high chamber and place a preloaded specimen - **10 Points**

2.) Move to the alliance samples and place 3 in the observation zone

3.) Grab 3 specimen from the human player and score on the high chamber and park - **33 points**

Total points scored in autonomous: 43 points

Autonomous Routes



Tele-Op

Our main goal for tele-op was to cycle as quickly as possible. We can consistently score:

- 10 Samples - **80 points**

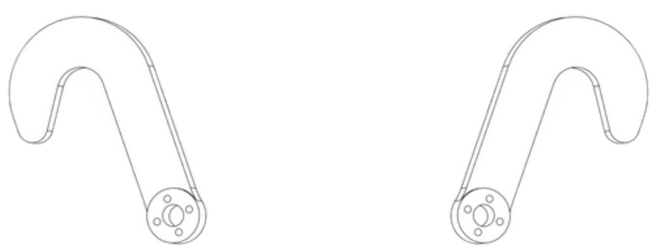
All game elements scored in autonomous are re-counted in the tele-op for an additional **40 points.**

Total points scored in Tele-Op: 120 points

End Game

During the last 30 seconds of the match, we plan on:

- Continuing to score Samples
- In the last 5 seconds, move to the ascent zone to achieve a level 2 hang - **15 points**



Match Difficulties

We noticed that after **too many game elements** were scored it would become **difficult to score**

- 13 Samples in the Baskets
- 15 Specimen on the High Chamber

For this, we would need to **quickly change up our strategy** and start to fill up one of the 2 scoring locations **if they became overcrowded**.

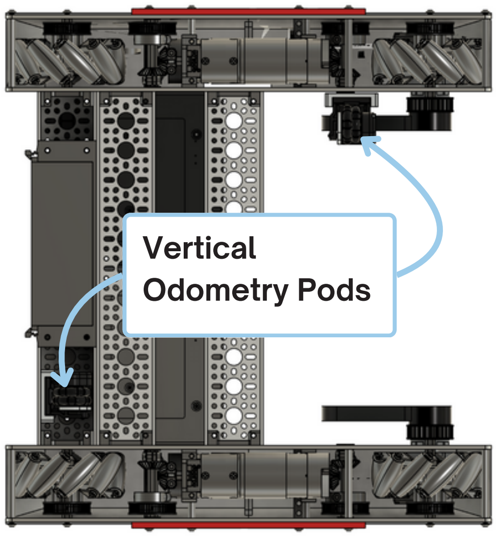
Overall match point total of

178 POINTS SOLO

Chassis

Our chassis has gone through **3 design phases**. These changes were made to accommodate better the amount of space needed for our designs and create a lighter robot.

Chassis Overview



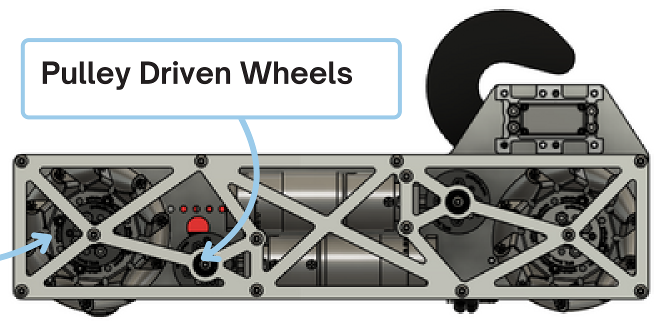
Custom Manufacturing

By using **SendCutSend**, we were able to **custom-manufacture** side plates that enclose the wheels, resulting in a rigid, lightweight chassis tailored to our specifications.

SendCutSend

Mecanum Wheels for Omni-Drive

Pulley Driven Wheels

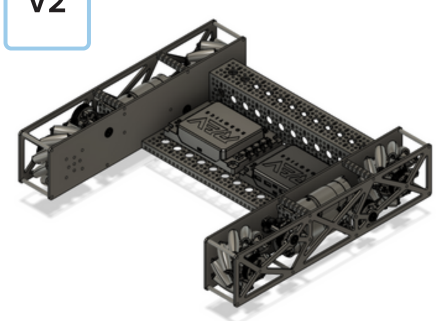


Chassis Iterations

V1

A GoBilda Strafer kit was used to prototype our mechanisms in the early season

V2



This was our first custom iteration that was developed over the summer

V3

small tweaks were made so we were able to fit all the mechanisms on the new chassis

Pivot Slide

Linear Slide

The **linear slide is essential** to our robot's **gameplay** this year. It stays compact, keeping us within the **sizing box**, but once the match begins, it can **extend up to four times its initial length**.

- Our linear slide operates on a **pivot**, allowing us to **rotate it smoothly**. This joint enables the slide to **move back and forth**, making it easy to reach **into the submersible** and then **place items** directly into the basket.

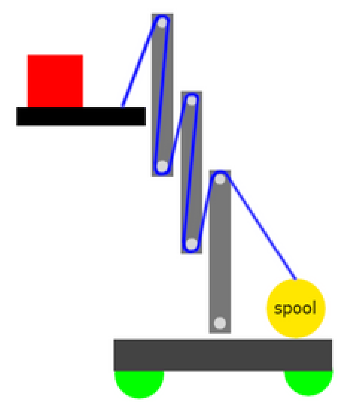
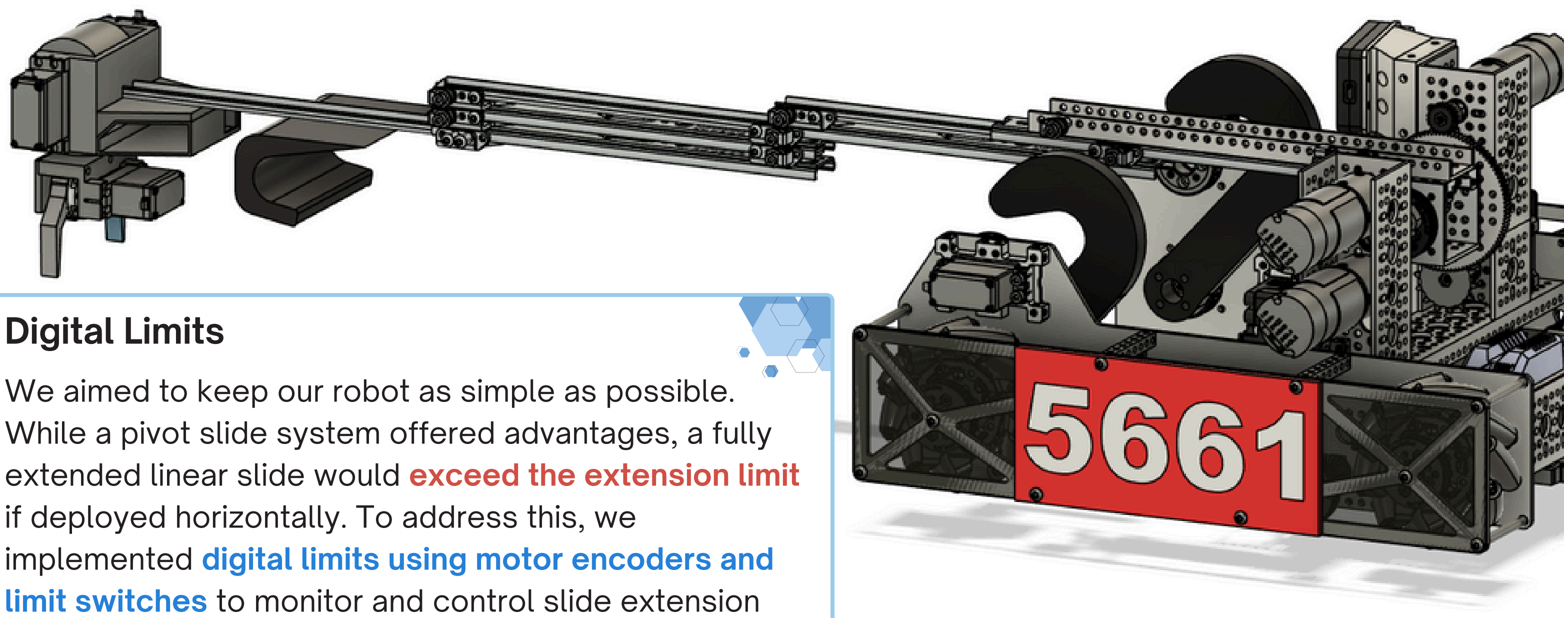


Image credits: GM0.org

Additional Electronics

This season we invested in some new electronics for our robot:

- **REV Blinkin** - used for robot cosmetic LEDs
- **Melonbotics Absolute Encoders** - Used to give further insight into the position of the linear slide
- **REV Servo Power Module** - Applys additional voltage to servos making them stronger and faster



Digital Limits

We aimed to keep our robot as simple as possible. While a pivot slide system offered advantages, a fully extended linear slide would **exceed the extension limit** if deployed horizontally. To address this, we implemented **digital limits using motor encoders and limit switches** to monitor and control slide extension accurately.

Intake Mechanisim

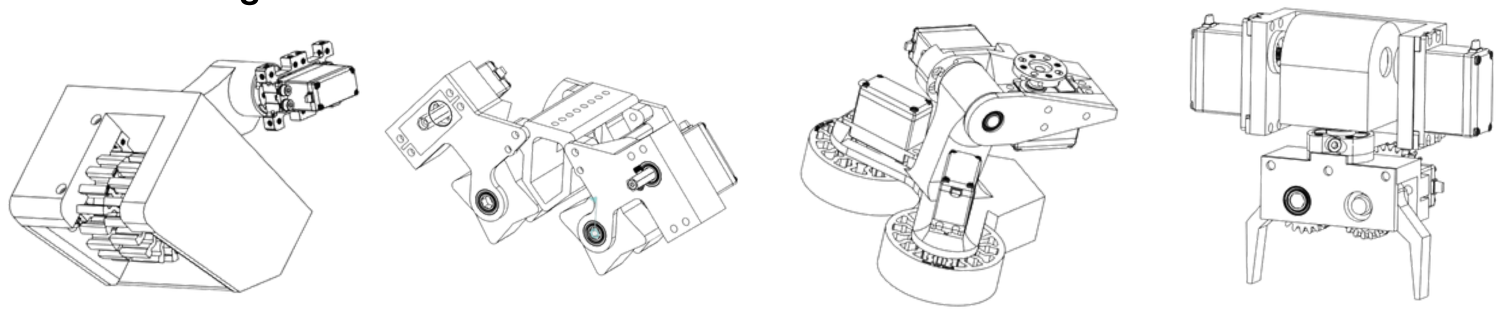
Active VS Passive

While Envisioning designs for our intake we knew right away there were two routes of intake we could do:

Passive: Commonly known as a claw, would just be a straightforward claw to grab game elements

Active: This would use some form of wheel or intake that would sweep items into the robot

Previous Designs



Passive

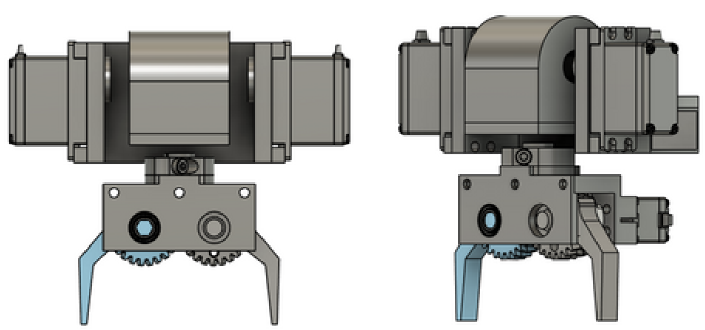
Pros:
- Grabbed only 1 element
- Compact

Cons:
- Good drivers needed
- Claws are more fragile

Active

Pros:
- Less accuracy needed
- Durable

Cons:
- Clunky
- Grabbed 1< element
- More points of failure

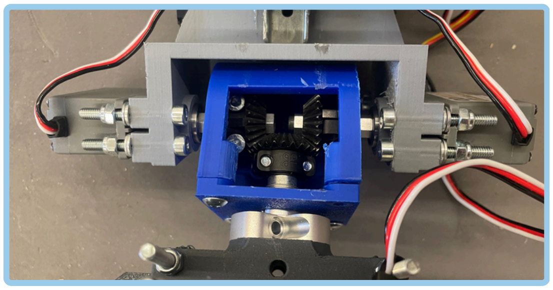


Current Design

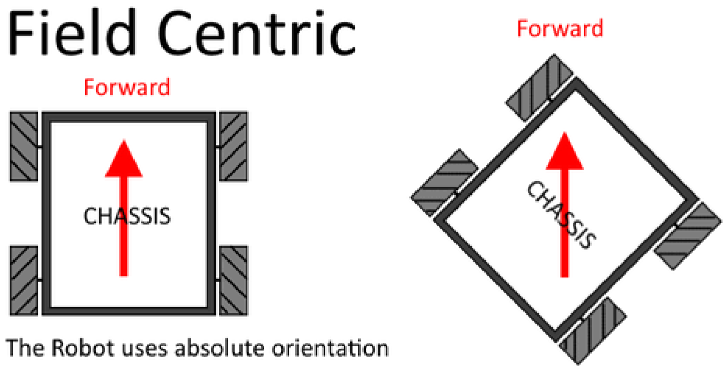
After implementing minor adjustments to the size and width of the claw to improve its functionality and compatibility, we have finalized this version as our current design for the season.

Differential Wrist

We designed a differential wrist joint for our intake well, using two servos to enable precise movement. When spinning in the same direction, they provide up-and-down rotation; when spinning oppositely, they rotate the claw, facilitating sample collection from awkward angles.



Chassis Software



Field Centric Drive

Our goal with this year's chassis software was to implement **driver assistance** features to decrease cycle times and time spent on driver practice. One feature we've implemented is a **field-centric drive**. Compared to standard, **local drive** where the robot moves relative to its heading, **field-centric** moves **relative to the field coordinate system**, allowing for **easy sample intake with high accuracy**.

Localization

A core system required for our robot's autonomous operation is **odometry**. This year we've opted to use both of **GoBilda's new odometry products**: the compact **4-bar odometry pod** and the **pinpoint odometry localizer**. The **combined loop times** of the pinpoint localizer and **April Tag correction** allow our robot to have **precise and accurate localization** throughout the duration of autonomous.

Closed Loop Systems

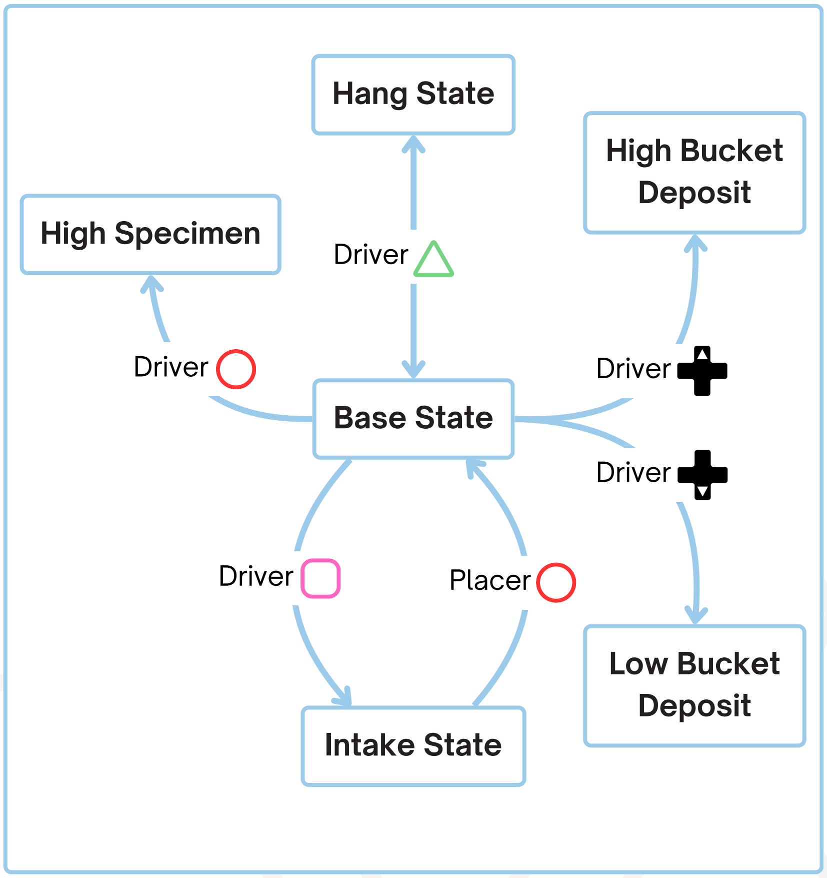
Another priority for our robot this year was to implement **closed loop systems**. Systems like these rely on **secondary sensors** to validate that a specific function is working properly. We use a **Modern Robotics Touch Sensor** as a **limit switch** for our **linear slide** to reset the extension if the belt ever skips. This is crucial for a second aspect of our arm, the **pivoting**, which uses a **melonbotics absolute encoder** to detect the current slide angle as an **analog voltage** which is then passed in to a **PID algorithm**, along with the slide extension, to accurately control the arm.

Control Systems

Custom Finite State Machine & Command Paradigm

To accompany the main mechanical systems of our bot, we've integrated **robust control systems** to aid our drivers in TeleOp to make scoring consistent. There are two main parts to our control system, a **custom finite state machine** and a **command based paradigm** from FTCLib. The FSM allows our code to be organized and expandable, where states can be implemented based on the **developing needs of the game** and our bot, which encompass the FTCLib commands themselves.

TeleOp State Machine



Driver Control

Our TeleOp FSM contains **6 states**, each representing a key part of our Into The Deep strategy. Each state has a transition to every other state allowing for **custom transitions** can be defined between each state, allowing for **full flexibility** over the control of our robot.

PIDF Arm Control

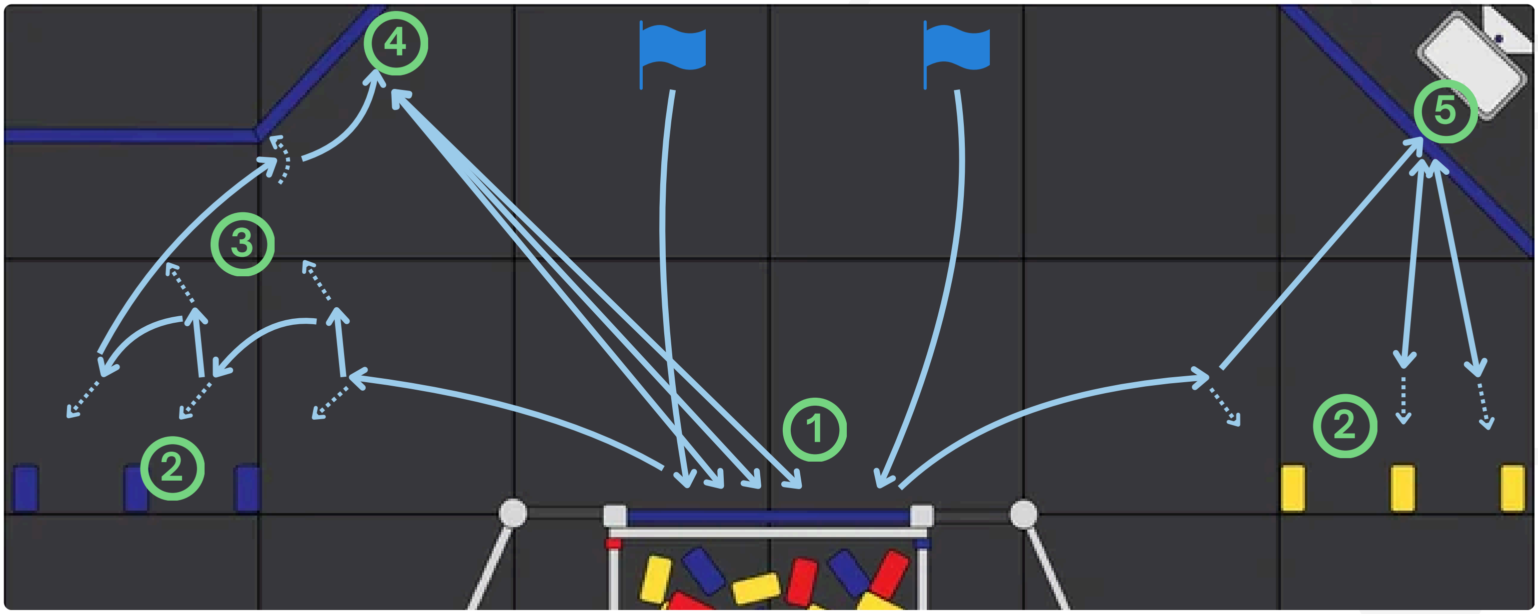
The key control system of our robot that operates our key mechanical system is an advanced **PIDF algorithm**. Our current iteration of the algorithm takes in **7 parameters** to give us **complete control** over our pivot slide. The algorithm also takes in the slide extension, slide extension target, and arm angle from the absolute encoder. These parameters allow our arm to compensate for linear slide weight and bending once extended.

PIDF Feedforward Parameter Calculations

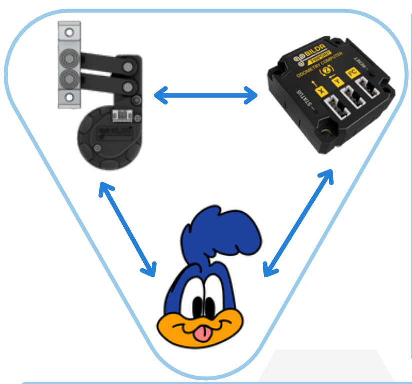
$$\cos(\theta) * (kf + (kf\_ex * currExtension) + (kf\_ex\_err * extErr))$$

θ = Arm Angle   kf = Feedforward   kf_ex = Extension Feedforward
kf_ex_err = Extension Error Feedforward

Autonomous Systems



(1) Place specimen on high bar
(2) Intake sample
(3) Transfer sample to player
(4) Intake specimen from wall
(5) Place sample in high bucket



Autonomous Routes

Our autonomous can complete a **4 specimen** route, placing one pre-loaded specimen and handing the 3 remaining samples to the human player to then place a hook on them to place on the high bar. It can also complete a **1 specimen and 3 sample** autonomous for the bucket side of the field. This allows us the freedom to comply with whichever autonomous **our teammate excels at.**

System Integration

The **combination of all systems** mentioned previously and the integration of **RoadRunner**, an FTC community path following library, allow our robot to **consistently score high point autonomous periods** alongside our teammates.

Autonomous Aids

With all of the previously mentioned control systems, we've been able to implement some **helping features** for our autonomous system. One such feature we make use of in our sample autonomous route is **holding a slide endpoint position**. Knowing the robot position, and slide extension, we were able to implement a feature where, **regardless of robot position** the slide would **maintain its point in space**, specified as a 2D vector, compensating for slight errors in RoadRunner pathing. It's accomplished by taking the magnitude of the difference vector between the target point and slide endpoint on the robot, and converting it to the slide motor PPR to extend to, making intaking samples **more consistent**.