ENGINEERING PORTFOLIO

24-25

HAAS

goBILDA DREAM • MAKE • REPEAT

Rockwell Automation

ACP CUT + PROCESS + SHIP

Qualcomm

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TECHNOMANIACS

16021

STUDENT-LED FRAMEWORK

Every single part of the robot was placed...
Every single sketch in the CAD was placed...
Every single piece of code was written...
Every single email to sponsors was written...
Every single shape in this portfolio was done...

By us **Students**

Student Contributions and Experiential Learning

Throughout our many years, we have learned that students can achieve far more than they initially believe.

Thus, we practice **experiential learning** (learning by doing). More often than not this is quite hands-off and observational as opposed to lectures and formal classes.

Senior members act as role models and guides on their respective specialties:
Rick Gnanasusairaj: CAD and general robot design.
Aryan Mirajkar: assembly and power tool use.
Tanish Ghosh: code and autonomous pathing.

Thereby, we allow members to discover their niches:
Adi Sundarapandiyan: CNCing and fabrication.
Jeffrey Wang: wiring management and soldering.
Eddy Zhao: photography and video editing
Owen Chen: prototyping and connecting.
Rohan Dhati: outreach and event coordination.
Austin Kim: scouting and portfolio content.

While new members are still figuring out the basics:
Ian Chen, **Charles Li**, **Alex Han**, and **Krishan Gohil**.

2 key benefits: **Freedom** and **Completeness**
Our members are **free** to define what robotics means. However, this makes our team diverse and **complete** with multiple interests and perspectives.

Student Driven Solutions and Multiple Eyes

All but two issues this season have been solved with ideas and implementation from students themselves.
And EVEN THEN, we had multiple attempts to solve it first.

This success can be attributed to a unique way we promote experiential learning within our team: **Multiple Eyes**.

First, we use our discord to list out issues or problems that have yet to be addressed.

Second, we encourage new members to scope out issues and explore different ways to contribute to the team.

Third, senior members act as de facto mentors during the new member problem solving process.

Alternatively, members can observe other's work at any time.

Founding Members: Started in 2018

Rick, Aryan, & Tanish

These Three form the core of our team with **6 years** of experience in FTC and as friends. Serving as leaders in their fields.

Team Picture from Skystone

Team Progression

For the past 3 years, our team has gained **3 new members** each year.

2021

2022

2023

2024

Our Plan for the Finale of Our FTC Journey

We truly enjoyed our time with FIRST and the FTC community, but all good things must come to an end.
We are a family team, but the youngest child is graduating.
Multiple students on this team have been here for **6 years**.

Our hope is to leave a legacy and show that **we were here**.

Hence we focus on our **community impact** and making the **coolest robot designs**, so we can realize our dreams.

Community Impact

This year, we volunteered and impacted people the **most in our history**.

250+ PEOPLE
150+ HOURS

CONNECTING WITH EXPERTS

Practically Mentorless, Yet Forever Mentored

Currently, we have one mentor, **Derrick**, but we do not have any intention of acquiring any more.

We are forever **indebted** to the work of our mentor in our rookie years where we especially struggled with coding and soooo many edge cases, but over the years we have learned to do it ourselves.

Though we act **practically mentorless** at a team, we are **forever mentored**, and there is always an invisible guiding hand from those who taught us while we debug and solve our issues.

Still, there will always be issues that are impossible to solve alone, so we list a few industry professionals we contacted for answers to particularly difficult problems below:

Dr. Ho Chit (Hosea) Siu - AI Research Engineer at MIT Lincoln Labs

Last year, we had issues with our active intake, so we asked around, and **Hosea** agreed to meet over zoom. His advice on jams and pixels flying out with tolerances and hoods was invaluable.

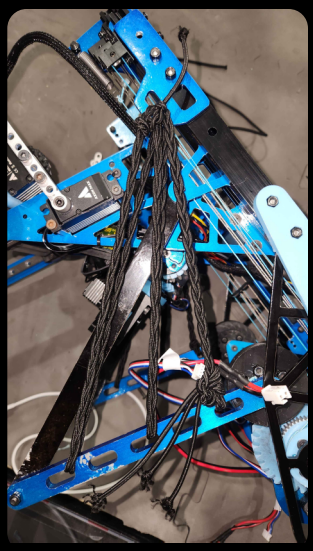
This year, we asked him to be the **keynote speaker** for our hackathon **Bobabyte**.

His expertise in all things robotics was pivotal to **one major issue** with the color sensor in our intake.

The Problem: Our color sensor was initially detecting red when intaking yellow samples.
Our Ideas: Using an And gate between the green and red sensors, or automatically delaying action after detection by a millisecond. But, the And gate was unreliable, and the delay made us slower.
His Solution: Convert all color sensor values from **RGB** to **HSV**.
This was **more reliable and quick** than our ideas, allowing us to properly utilise our auto-reject gate.

Additonally, he explained the concept of **finite state machines** and how to implement them properly. This allowed us to **automate** large portions of our driving with sensors and **state memory**.

Mr. Bradford - AP Physics Teacher at ABRHS



Last year, we asked our **Precalculus H teacher Mr. Montalbano** to check over our torque calculations for the vertical slides because we were scared that it might not sustain our climb.

This year, we asked our **AP Physics teacher Mr. Bradford** to check over our torque calculations for the vertical slides because our deposit module is very heavy.

We calculated that we required 435 RPM motors for the torque, unfortunately, the slides felt **slow**.
His Solution: Counteract the **initial moment of inertia** with counterspringing because it is slowest at the start. He suggested using **bungee cord** as a really **tough and stable** force.

How? We needed to use **Cascade Stringing** to counterspring each stage equally. Continuous Stringing has each stage act independently meaning that an arm would need to extend to the top.

Additionally, this experience allowed us to apply material we were learning in class at the time to a physical and application based problem.

Moriah Lim - Lab Manager at Boston University RASTIC

Our member **Owen Chen**, met **Moriah** at his Church and found a shared interest in robotics.

In February, he offered a tour of the Robotics and Autonomous Systems Teaching and Innovation Center (RASTIC) at Boston University after he became the Lab Manager.

Through this, we saw a snapshot of what more professional or industrial design spaces look like. We applied this information and organizational structure to our workspace by **compartmentalizing** and **sectioning** off space for different types of work.

SUPPORTING FIRST TEAMS

Open-Source Active Intake

We know making an active intake is **really hard**.

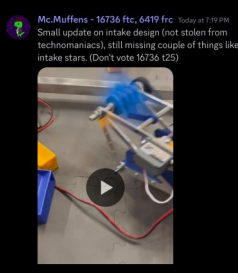
From our first season attempting to do so in Freight Frenzy to our hyper-polished pristine intake this season with millions of details, we have learned so much.
But this would not have been possible without the FIRST community who guided us along the way.

That is why we uploaded the CAD of our active intake for **free with zero need for credit** because we want to give back.

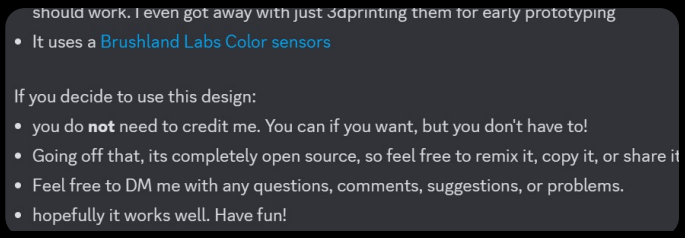
50+ individuals and teams have copied and remixed our intake design in their path toward greatness, and we wish them the best.

Still, many teams have **credited us** when posting their designs.
Here's how it impacted **Team 16736 Atomic Narwhals**:

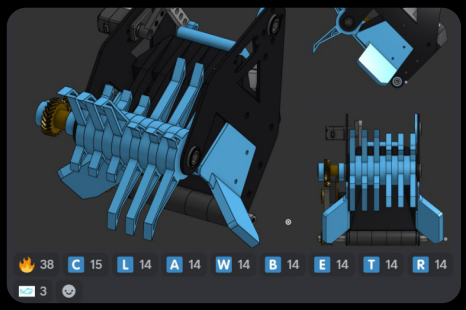
Other succesful teams that have been impacted by our design include:
5189 - Wolves Robotics
18996 - S.T.A.T.I.C.
20744 - 24 Karat
24163 - Illuminate



Note: On March 1st, they qualified for **Worlds !!!**



Instructions and Announcement



V1 CAD Post

Invitation to RoboCAD

RoboCAD Coalition

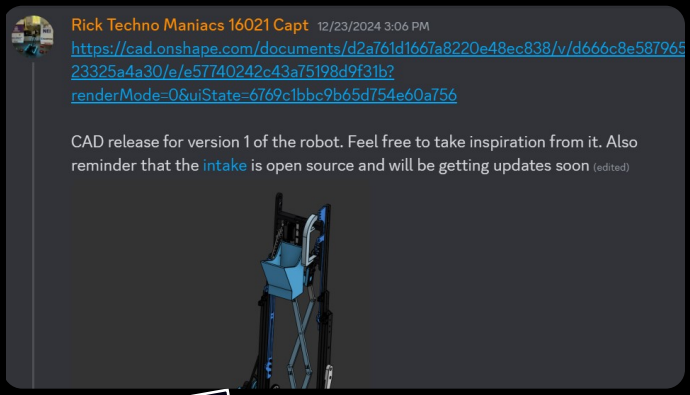
RoboCAD is a coalition of teams that collectively **push the boundaries** of FTC design with open-source and example projects. It is similar to the Loony Squad, and we are happy to join and work with the FIRST community.

Open-Source Robot + Updates

At some point, we realized that we can just open-source and share **our entire robot** because we had nothing to hide.

Additionally, we sent out updates on our intake design, responding to feedback and solving jams or physical issues.

In effect, this created a **mutualistic** relationship with the FTC community where feedback helped us notice critical issues or areas of improvement within our design. Whereas, consistent updates gave better and improved mechanisms back to the community.



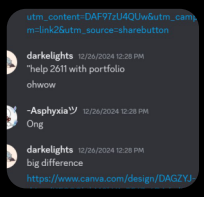
Full Robot Post and Intake Update

Open-Source Portfolio

But why stop at our robot? Why not literally EVERYTHING.
We posted our **two previous portfolios** online with all the design elements and everything for anyone to use. We also guided multiple teams and provided advice on portfolio design.

60+ individuals and teams have accessed the online portfolios.

Also, this portfolio was made using only **open source software**: **Scribus**, **GIMP**, and **Inkscape**, to show anyone can do it for **free**.



Helping **26111 - GNCE EC** w/ portfolio

Powder Coating with Electric Zebras

Team 24173 Electric Zebras asked online how to powdercoat because they wanted to try.
We offered to let them use our powder coating setup and equipment, provided that they bring their aluminum plates and powder.

We gave **advice** on their powder coating, and **provided** a few options they can buy later.

SUPPORTING COMMUNITY

The Robo Hub: Robot Showcase (7/23-7/26)

Our member **Jeffrey Wang**, worked at the Robo Hub over the summer.
We took the offer to showcase our Center Stage robot to **60+ students** from 1st to 8th grade.

Although a few other teams also showcased their robot, we were the only team who came by in person:
1) **Answering** questions about the robot design process and experience
2) **Providing** a safe environment to play with a special parent-child driver mode
3) **Displaying** our portfolio with reasoning behind the layout and design

Boba Byte: Hackathon with Boba (10/26)

Four of our team members partnered with **Hippo Hack** to create Boba Byte this year, a hackathon to learn code and enjoy boba.
This hackathon was entirely **student-led** from renting out the venue to acquiring sponsors to setting up the smart board.

We brought Hosea as our keynote speaker, and he was fantastic.

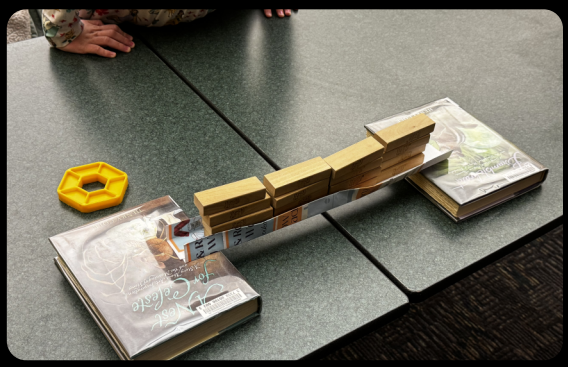
We successfully hosted a hackathon with lots of code and lots of boba with **30+** interested individuals and **$35k+** in prizes.

Boxborough Library: STEAM Presentation (2/19)

Three of our team members hosted a STEAM workshop for elementary school children at the Sargent Memorial Library in Boxborough.

Unfortunately, this was in the middle of February break, so turnout was lacklustre, but each child who attended was super **attentive and engaged**.
For example, each bridge during the paper folding activity could hold at least **10 jenga bricks**, while the one shown to the right could hold **18 jenga bricks!**

Each family asked for further guidance and explanation on FIRST.



Between a Rock and a Hard Place

One of our primary goals this year was to restart or recreate the high school's robotics team **AB Robotics** as it had been dead and forgotten for over 3 years. This is a part of the legacy we want to leave behind.

Unfortunately, we faced **two major issues**:
1) The school has a **"Club Moratorium"** meaning that students could not start new extracurricular activities at the high school.
2) We were **unable to find** a faculty advisor who was willing to dedicate their time toward robotics.

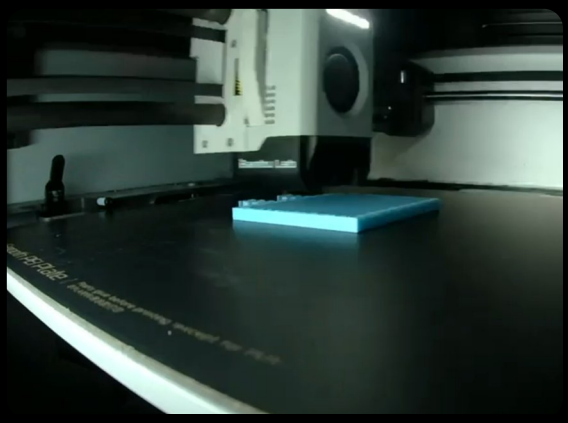
A Way Forward with Science Olympiad?

Our school has an extremely successful and competitive Science Olympiad team. Coincidentally, Science Olympiad happens to have 2 robotics related events: **Robot Tour** and **Electric Vehicles**.

We offered to print their parts when we were not printing something.
Collectively, they used **5+ kg filament** and clocked **100+ hours of print time**.

3D-printed pieces were a huge advantage in iterative design and speed.
It is no surprise they **medaled at Harvard, MIT, and Brown** in these 2 events.

We will support robotics in our community wherever it may be.



ITERATIVE DESIGN PROCESS

Member to Mechanism Focus with Competitve Prototyping

Last Season: Each member was assigned a task e.g. intake or outtake.
- Many mechanisms were **fundamentally flawed** and had to be **redone entirely** later on, ruining our **iterative design** process.

This Season: Each mechanism was protoyped over a specified timeframe with extensive testing, at the end of which, we compare all prototypes.
- More prototyping led to a **better foundation** for **iterative design**.
- **Each member** has the chance to interact with every single part of the robot.
- Provides a **more holistic picture** of game strategy with alliance partners.

Intake:
Prototype (9/14), Testing (9/15), Refine (9/20)

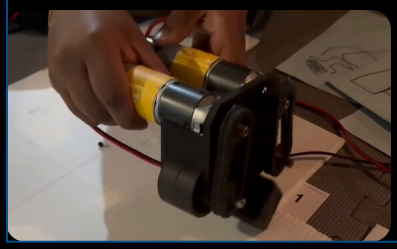
Outtake:
Prototype (9/18), Testing (9/20), Refine (9/21)

Specimen:
Prototype (10/18), Testing (10/19), Refine (10/20)

Intake Prototype Comparison: Compliant Wheels vs Rollers

This was our first time using pro-con charts after creating multiple working prototypes and evaluating their strengths.

One Day after Kickoff: Two Compliant Wheels and a Wedge



- Picks up **only 1** sample
- Only works when **aligned**
- Sometimes **flings out** sample at the edge
- **Hard** to gear/belt the motor out horizontally

One Day after Kickoff: Surgical Tubing Rollers with a Box

- **Automatically aligns** the sample toward the center
- **Easy** to gear/belt everything
- We have **experience** with roller intakes from last year
- **Cannot reach** close samples

Never Free Build: Always CAD First

Over the past 3 years, we have slowly converted our robot building process from **free building** -> **CAD first, then assemble**. In Power Play, we made our first CAD model, in Centerstage, we designed each iteration of our robot in CAD, and in Into the Deep, every single metal plate to servo to battery fit together properly in our CAD before even touching any part of our final robot design.

onshape

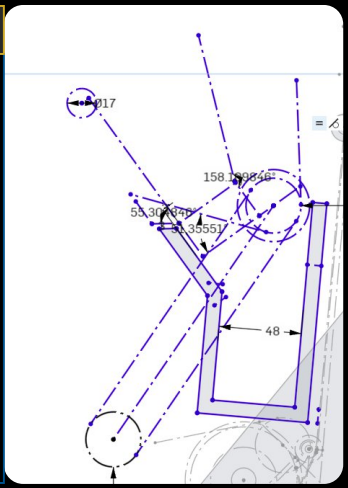
Better Alignment

Before RI3W: The transfer did not work, because the intake and outtake were **not aligned**.

After RI3W: We used **imported sketches** on to make the outtake bucket **snug** with the intake.

We did this for our new deposit too.

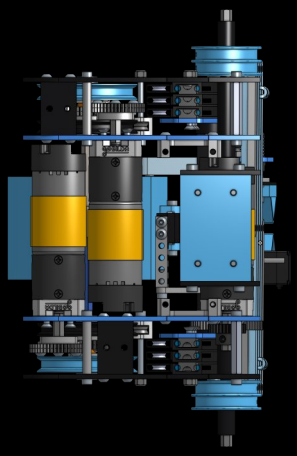
(The image to the right includes an imported sketch of our intake constraining our outtake bucket)



Clearance is a Boolean

Our robot is **small, REALLY small**, BUT to keep it that small, we needed CAD to plan it all out.

The picture highlights exactly how closely packed the motors are: ->
- Vertical slide motors are less than 2 **cm apart**
- Horizontal slide motor is **nestled** under the slides
- Intake motor is **above** this



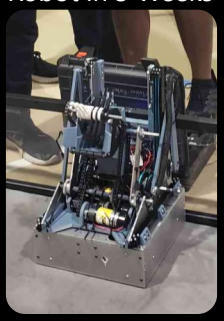
Underside view of the vertical slides module

Consistent Scrimmage Participation

Last Season: We worked on **one iteration** of the robot until the first competition and had large-scale iterations over **2-3 months**.

This Season: We consistently attended scrims meaning that we had to **iterate every 2-3 weeks** to improve our robot. From **deeper stress testing** on the field with alliance partners we noticed major issues that we otherwise would not have.

Robot in 3 Weeks



--> **Better Wiring**

Waring Scrim

--> **Better Code**

Andover Scrim

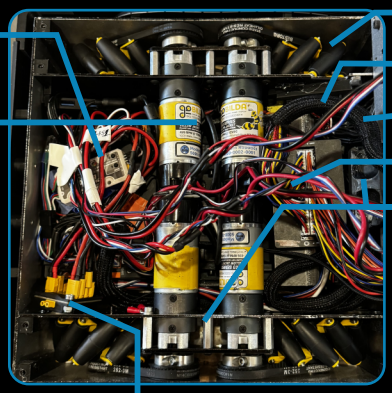
CHASSIS AND DRIVETRAIN

2 Goals

Modular	Small
• This project was **off-season**, so it had to be able to mount any scoring mechanisms afterward. • Allows us to **access the insides** of our robot quickly. • **Minimizes time** to repair a singular mechanism.	• To be **modular**, we need to stuff everything (Hubs, Batteries, Drive Motors/Wheels) under that top cover. • Smaller chassis is **less obstructed** by terrain/other robots. • Smaller robot -> **Faster robot**.

Control/Expansion Hub Stacked on top of eachother

435 RPM Drive Motors



Mecanum Wheels

Pinpoint Odometry

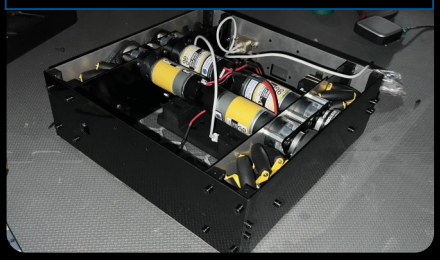
Power Switch

Wire Hub/PCB

Odometry Pods

Power Distribution Board

2mm thick Aluminum



Dead Axle Drivetrain

The wheels are just connected to the belt pulley and mounted on bearings. The axle does not move -> **Dead Axle**.

Why?: **Less moving parts** + Motor does **not take on load** when we crash. **32:31 Belt Ratio**, (This is **FAST**)

Better (and Cooler) Odometry Pods

Change 1 (**Linear Rail**): It is a lot **stronger**, meaning no wobbling -> more **accuracy**.

Change 2 (**Rubber Bands**): They are **more adjustable** and can **withstand deformation**.

Both are also **more accessible**.

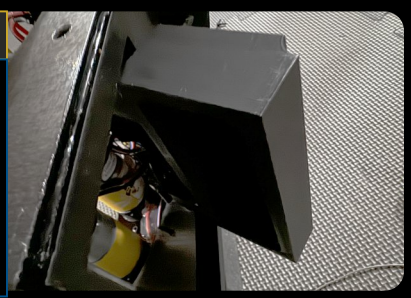
With just a few screws, we can easily access the inside of the robot.
The top is **entirely detachable**.

This is **modularity**.

Pop-Out Battery Holder

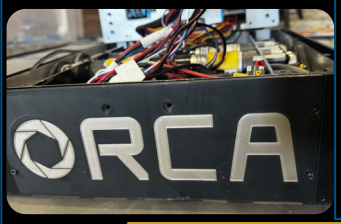
Because our chassis was **COMPLETELY covered** with aluminum on all sides, we needed a **new way** to access our battery.

The holder pops out with a sliding mechanism that first moves horizontally and then vertically. This allows **easy access** but **no accidents**.



FRC Style Bumper

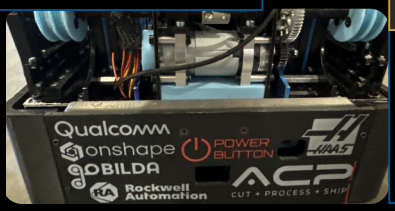
This is a **4 mm thick PLA bumper** around the chassis.
An additional layer of protection from crashes:
Plastic will **brace** the impact
Layer of air between the bumper and the chassis
Prevents **Electrostatic Discharge** (ESD):
Plastic is **not metal** so it will not build up crazy levels of **static** and shut down our entire robot.
Also, it looks cool.



Name Plate

We made a **custom font** for our name plate and number plate for consistency in design.

For years, we wanted to give our robot a name, and we finally have. We all voted, and it's name is **ORCA**.



Sponsor Plate

This is the **most sponsors** we have ever had, so we wanted to highlight them better.

Placing them on a 3D-printed part allows us to add new sponsors since 3D printing is **easier** than CNCing.

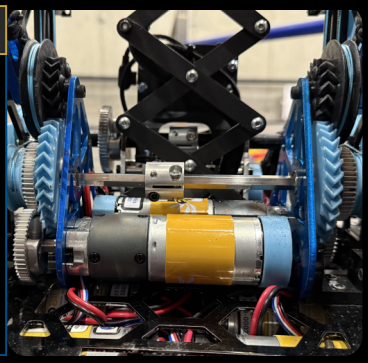
VERTICAL SLIDES

Coupling Our Slides

The Problem: Slides can **desynchronize** which can make them **slower** or **seize up**.

Our Solution: Physically **synchronize** them by adding a **coupler** forcing both axles to rotate at the **same rate**.

This solution works without issues.



"Spike Zeroing"

We track our slide position with the axle rotations from our motors.

In previous seasons: our slide position data would **slowly drift** or **accumulate errors**.

This season: we noticed that our position data **"spikes"** when the slides fully retract.

In class: we were learning about derivatives also known as the **rate of change**.

Our solution: We use derivatives to track **"spikes"** or major changes in the rate, at which point we set a **"relative zero."**
For **extra certainty**, we compare it to the slope to the **previous 24 data points** slopes.

Counter Springing

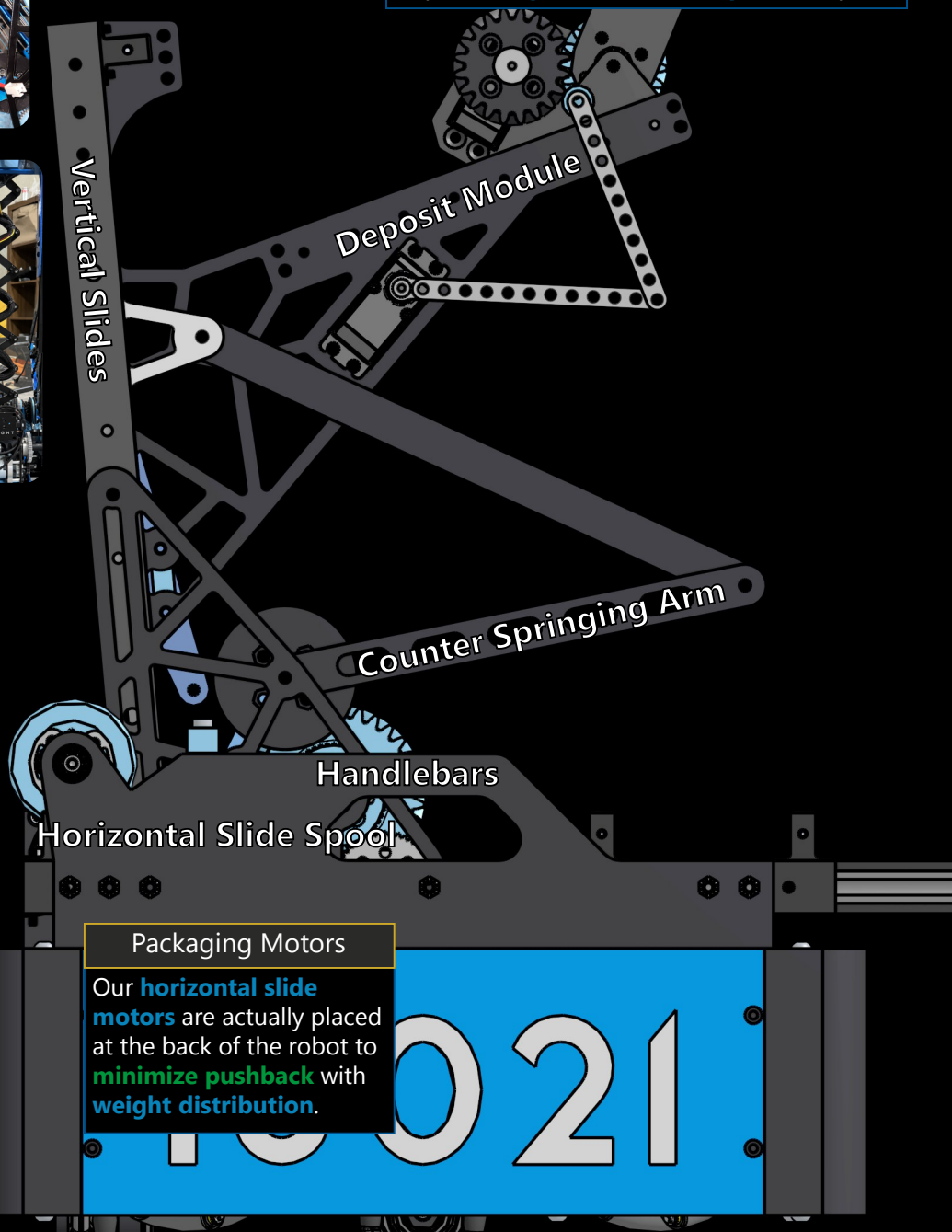
As noted in our meeting with our **Mr. Bradford**, we could counterspring our slides to overcome the **initial moment of inertia**.

We used three **bungee cords** attached to an arm as shown to the right.

Cascade Stringing

Counter springing requires a constant force across the entire extension, unfortunately **continuous stringing** has each stage **act independently**.

We used **cascade stringing**, so we only had to counterspring **one stage** effectively.



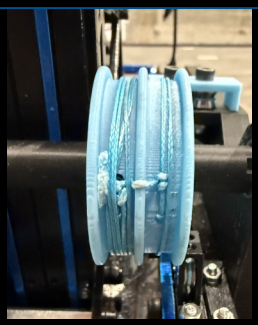
Stringing: Fishing Line -> Steel Cable

For the past few years, we strung slides using fishing line which is really **strong**.

The Problem: The cascade stringing and counterspringing **ripped it apart**.

Our Solution: Use **steel cable** which can **handle lots of tension**.

Mitigation: Steel cable is **not flexible**, so we only use it **on the stages** and still use string on the spool.



Packaging Motors

Our **horizontal slide motors** are actually placed at the back of the robot to **minimize pushback** with **weight distribution**.

HORIZONTAL SLIDES

Horizontal Extension: Linkage -> Stringing

Earlier in the season: we used two **servo linkages** to move the horizontal slides.
Now: we use **continuous stringing** and a motor to extend the horizontal slides.

The Problem: When intaking from under the specimen bars, the arms sometimes **slide against** or **get caught on** the lower bar.
Our Solution: Using strung slides solve this with **no vertical movement**.

Cost benefit analysis:
Pros: Stringing was **slightly quicker** according to our trials.
Cons: It uses up **a motor**. It is slightly **less precise**.

Mitigation: We had an **extra motor** to use on our robot, and we use an **active intake** which **decreases the precision required** for optimal pickup.

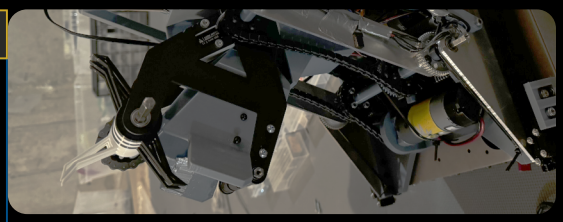
Horizontal Module/Intake Arm: Chains -> Belts

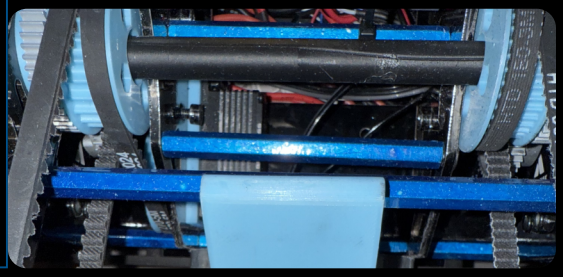
Earlier in the season: We used **chains** to create a **virtual 4-bar** for our intake.
Now: We replaced all of them with **belts**.

The Problem: The **sprockets** would **skip** and were **not tensioned** properly.
The Solution: Use **belts** that **fit perfectly** with the gears for **smooth movement**.

Cost Benefit Analysis:
Pros: **Smoother movement**, **more accurate** positions, and **stronger load**.
Cons: Belts are **fixed** in size, meaning that you cannot adjust them. Belts are generally **more expensive**.

Mitigation: This is the **final iteration** of our robot, meaning that **no adjustments** are required, and this is **our last year**, so we are willing to go the **extra mile**.





Handle Bars

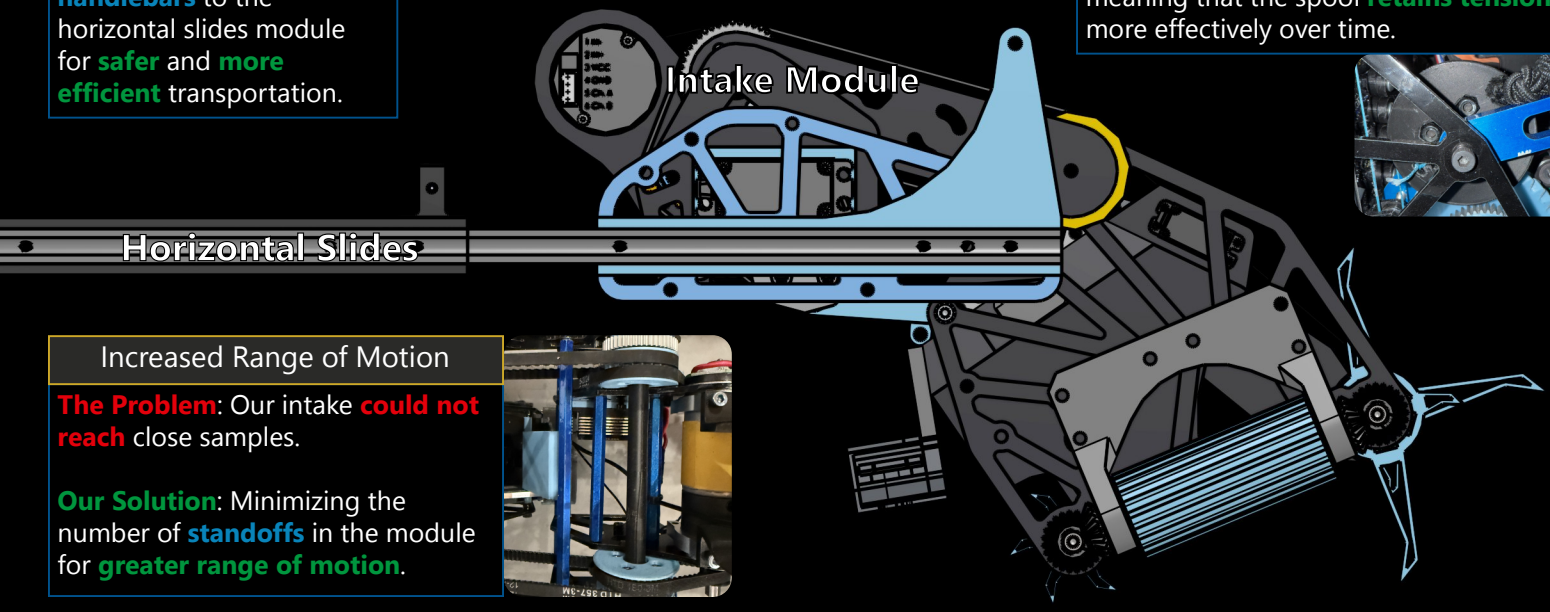
We have **dropped** our robot on the floor before, and it was **devastating** mentally and physically.

We decided to add **handlebars** to the horizontal slides module for **safer** and **more efficient** transportation.

Bigger Spools

The Problem: The strings on the pulley would slowly **lose tension** over time.

Our Solution: Increase the **size of the spool**. A larger circumference requires **less rotations** around the spool, meaning that the spool **retains tension** more effectively over time.

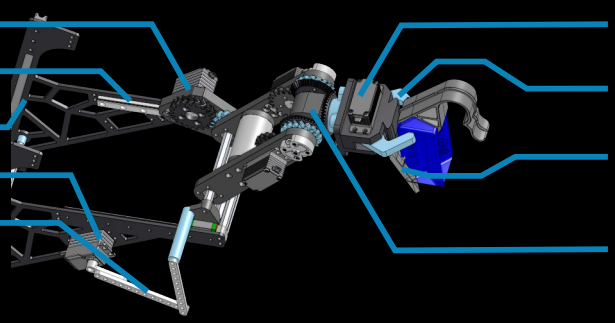


Increased Range of Motion

The Problem: Our intake **could not reach** close samples.

Our Solution: Minimizing the number of **standoffs** in the module for **greater range of motion**.

CLAW DEPOSIT MODULE



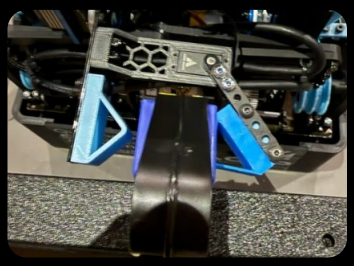
5 Degrees of Freedom

Two Mechanisms -> Single Mechanism

We originally had **2 mechanisms** for outtaking: a **bucket** and a **claw**
However, we decided to change this for **3 reasons**:
1) **Complexity**, the **new mechanism** requires **maintaining one module**
2) **Space/weight**, the **bucket** took **so much space**
3) **Path efficiency**, the **claw** could **not path efficiently**

This is the only **complete redesign** on our robot.

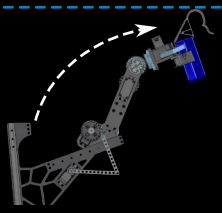
Sample Bucket

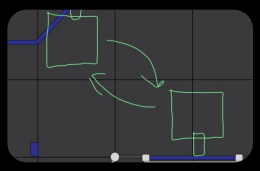

Specimen Claw

Optimal Pathing - No Rotation

With our **previous design**, the **robot had to rotate** because the claw was fixed.

With our **new design**, it can cross over to the other side **without rotation** from the drivetrain, and it rotates the specimen into the **optimal 45° angle**.




Deposit Path

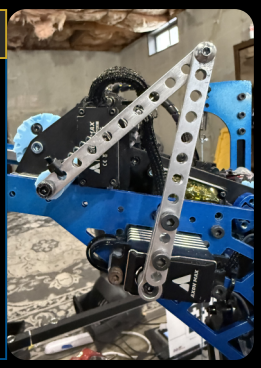
2 Requirements: Linear Rail (Cross Over) + Differential (Optimal Angle)

Linear Rail Linkage

Initally considered an **arm** to **cross over**.

The Problem: **Arms restrict horizontal extension** in the front.
Our Solution: A **linear rail** that **minimizes back extension**.

Mitigation: We **previously used** a linear rail linkage for the bucket mechanism.

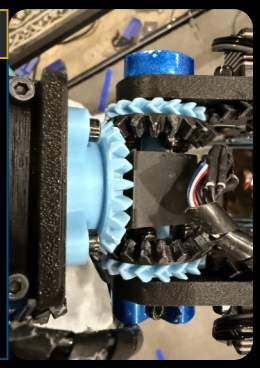


Differential End Effector

The servos are geared to **helical gears** and **bevel gears** to **angle**.

The Problem: The **bevel gear** was being **grinded apart**.
Our Solution: Reprint the **bevel gear** with **wider teeth**.

Mitigation: Exact angle is **not required**.



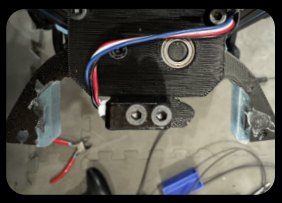
Silicone Tips for Extra Grip

The Problem: The specimen would **slide down** the claw, **unable to be placed**.

The Solution: Add **extra grip** to the claw with **silicone tips** at the ends.

Mitigation: We have **experience** with **silicone claws** from **Center Stage**.

No Silicone

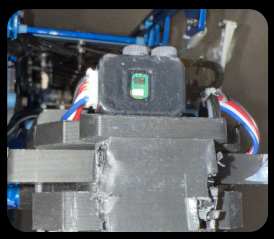

With Silicone

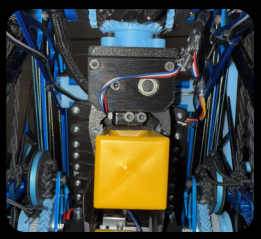
Color Sensor for Transfer

The Problem: The **delay** after opening the **intake gate** is **inconsistent**.

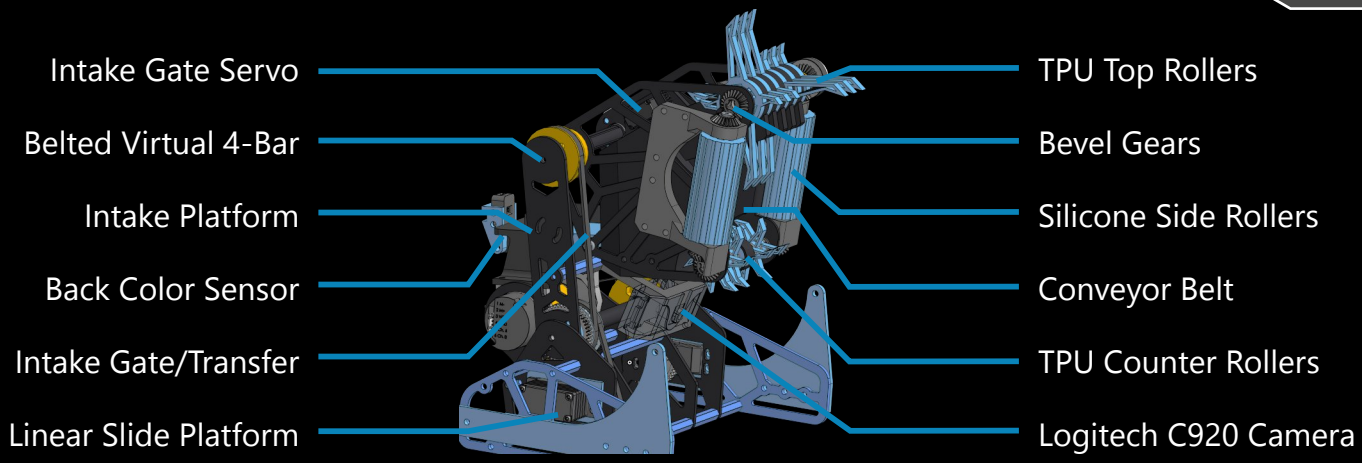
Our Solution: Use **color sensor** to **ensure** that the **sample is in place**.

Mitigation: This follows a **similar line of code** to our **intake auto reject system**.





OPEN-SOURCE INTAKE



2 Changes for Better Alignment: Half-Alternating + Side Rollers

Rollers: Each-Alternating -> Half-Alternating

The Problem: The sample would get **stuck horizontally** at the front and just continously roll.
Our Solution: **Alternate half the rollers** so that the sample would **"kick"** back and forth until it becomes **vertical**.

Mitigation: The intake is **motor driven**, so it is **quick enough** where the orientation of rollers does not matter.

Sides of Intake: Flare -> Rollers

The Problem: The top of the sample can get **stuck diagonally** on the **flare** due to the friction of a flat surface.
Our Solution: Replace them with **soft silicone side rollers** so that the sample would be directed **toward the center**.

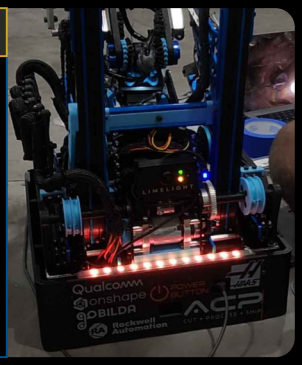
Mitigation: We switched to **bevel gears** instead of **belts** to connect the top and counter rollers, so **no additional work**.

2 Ways to Know the Color Inside: LEDs + Color Sensors and Auto Reject

LEDs: Driver Feedback

The Problem: The robot is **tall**, the drivers **cannot see the sample** inside well.

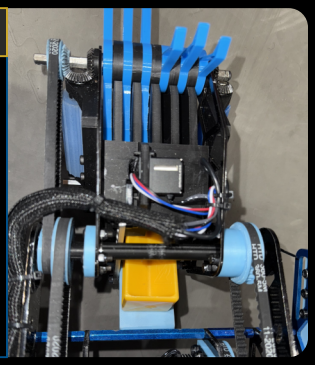
Our Solution: Use **LEDs in the back** to **indicate the color** inside the intake.
The driver is **already looking** at the back of the robot.



Color Sensor + Intake Gate

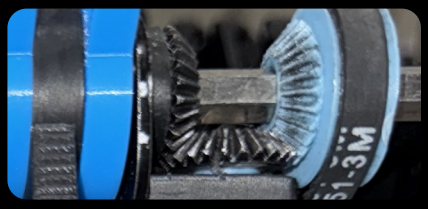
The Problem: An **active intake** is often indiscriminate and may pick up the **wrong color sample**.

Our Solution: Have an **intake gate** that opens out the back at any point to **automatically eject samples** when the **color sensor** detects the **wrong color**.
This is **legal** under **G410D/G411**.



Belts to Bevel Gears: Squeak Squeak -> Grind Grind

We switched from **belts** to **bevel gears** for our intake for **3 main reasons**:
1) It's **more compact** because the **bevel gears** are **small** and can fit right on the perimeter.
2) It requires **less questionable gearing** for the **counter rollers** on the bottom.
3) It allows us to use the **silicone side rollers easily**.



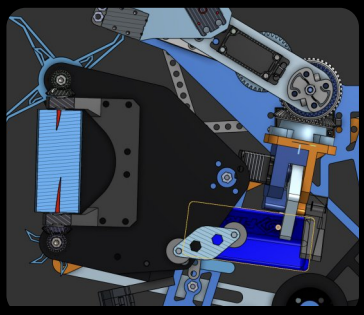
Intake Platform + Transfer

Our **primary concern** with a **claw deposit** was **the transfer**.

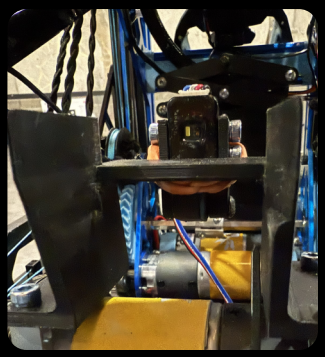
Previously, we could just **dump it** in the **bucket**.

Now, we **mathematically analyzed** using **CAD sketches** to **line up** the outtake with the intake **perfectly**.

Additionally, we used an **intake platform** to **prevent samples from falling** into our robot.



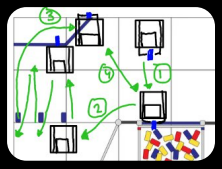
Transfer Alignment



AUTONOMOUS ACTIONS

Autonomous Strategy

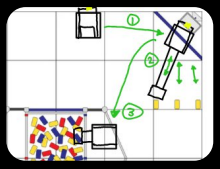
During the autonomous period, we attempt to score either: **5 Specimen** or **5 Samples**.



5 Specimen

The Problem: **Missing** the sample **on the edge**.

Our Solution: **Intake** the last one so it **cannot slip**.



5 Samples

The Problem: Intaking the **incorrect sample color**.

Our Solution: Use a **camera** to find the **correct one**.

Pathing Software: RoadRunner -> Pedro Pathing

The Problem: **Roadrunner** is Slow.
1) **No interpolation** between points, meaning that the robot would need to **completely stop** between paths.
2) **No change in acceleration or constants** within indvidiual paths thereby **limiting** the optimal speed.

Initially, we tried to make a **wrapper for roadrunner**, but found it **easier** to find something else than create something new.

Our Solution: Use **Pedro Pathing**.
1) There is **interpolation** and **customizable acceleration** within and between paths, **maximizing speed**.
2) **Bezier curves**, curves are defined by more points, allowing for **more flexibility and specificity** in a path.

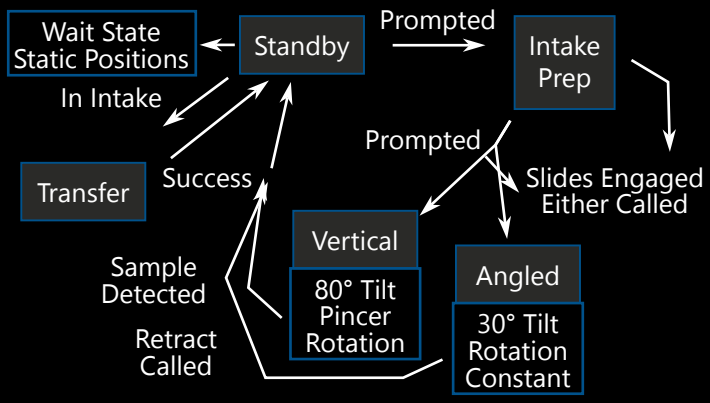
"Robot OS" and Finite State Machines

Previously, on simple **java robot classes** to facilitate both autonomous and teleop.

The Problems: **No parity** between autonomous and teleop, **inefficient** code, and **failing** feedback loops.
Our Solution: Write teleop like autonomous, so a **single method call** can perform **complex movements**.

Connect: **Hosea** explained **finite state machines** to us.
Dairy Library allows us to **integrate** our robot class closely into the **opmode**. With **finite state machines**, the robot can **constantly update** and **perform tasks** with **every loop** of the opmode

Intake State Machine

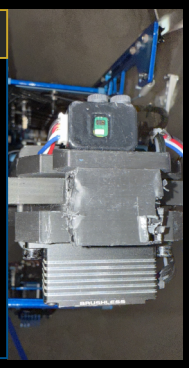


Slow Looptimes: 3 Ways to Fix That

Digital Color Sensors

The Problem: **I2C color sensors** are **clunky**.

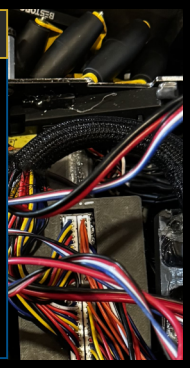
Our Solution: Use **Bulk Cache Reading** with Lynx to read in **1-pass**, and switch to **digital color sensors** to **eliminate delays**.



Pinpoint Odometry

The Problem: **Odometry** is **big**.

Our Solution: Use **pinpoint odometry** to calculate the odometry on a **seperate** computer for **less computation**.



Limelight 3a Camera

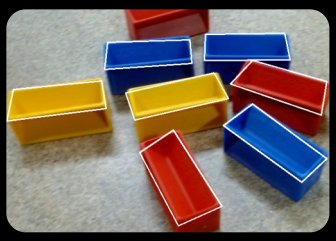
The Problem: **Tracking April Tags** is **intensive**.

Our Solution: Use the **Limelight** camera which does all the image processing **locally** on the camera, meaning **less computation**.

Custom OpenCV Pipeline

The Problem: **Image recognition** is **computationally intensive**.

Our Solution: We created a completely **custom OpenCV pipeline** which **reduced overhead significantly**, and allows us to have **full control** over the resources that are allocated.



MANUFACTURING PARTS

Computer-Aided Design (CAD)

Ultimately, **CAD is the backbone** of any and all fabrication as it gives a **detailed and mathematically precise** instruction to the manufacturer or the machine. CAD precedes each of the following steps:

To CNC or Not To CNC?

We bought a CNC in **2022**, but it was not the greatest.

The Problem: Drill bits would **break**, and pieces would **burr**.
Our Solution: Ask for a Water Jet Sponsor (**ACP Water Jet**) that can **handle heavy metals** like **aluminum**.

Mitigation: We use our CNC for **quicker iterations** using **aluminum composite**, a mix of plastic and aluminum.

ACP
CUT + PROCESS + SHIP

Aluminum Composite

Closed Off CNC Room

The Problem: When CNCing, **metal dust would scatter** across the workspace and serve as a **safety hazard**.
The Solution: Use **clear curtains** to **close off** the CNC from the outside.

Mitigation: We were moving to a **new workspace**, so change **regardless**.

3D Printing

We 3D print a lot of things on our robot: Spools, Gears, and Structural Elements.
PLA for **harder and stable** objects like the double helical gears or the intake box.
TPU for **compliant and flexible** objects like our intake top rollers or counter rollers.

We always print **2-3 spares** of every 3D printed object.

Silicone - Extra Grippiness

Silicone gives **extra grippiness** which we use for **side rollers** and the **tips of our claw**.
We have to CAD and 3D print a mold to cast our silicone inside.

Powder Coating - ESD Prevention

The Problem: The metal would build **static** and **shutdown** the robot.
Our Options: **Anodization** or **Powder Coating**.

Cost Benefit Analysis:
Pros: It is **cheaper**, we can **do it ourselves**, and it looks **cooler**.
Cons: **Less durable** and **more corrosion**.

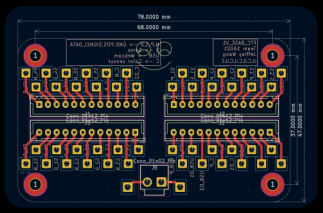
Mitigation: We **replace** our **aluminum plates** between competitions.

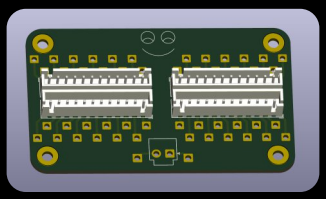
Custom PCBs - Wire Management

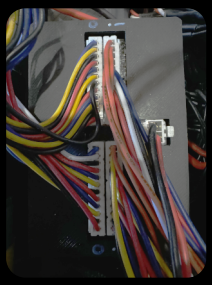
The Problem: Our wires **could not detach** from the chassis, meaning that it was **difficult to perform maintenance**.
Our Options: **Ethernet Ports** or a **Custom PCB**.

Why no Ethernet: It **had too few ports** for the **amount of wires**.
Whereas, a **PCB** can handle up to **24 seperate wires**.
ii
We used **KiCAD** to plan out the PCB, and then sent it to **JLC PCB** to get it etched out.

We even added a **smily face** to show how fun it is !!!







DOCUMENTATION/PLANS

Why do we care SO MUCH about DOCUMENTATION?

We have a free form "**come when you want**" workspace, making it **hard to track who has done what**/**what to do**.

Time Sheet (Who has done what?)

The time sheet is a large **google spreadsheet** where we note down: the **time** we were working + a quick **summary** of our work + what kind of **documentation**/where we put it.

1.0 - Power Play (Time Availability)

- It could not tell us details of work
- People's schedules changed

Name	Sat	Sun
Rick		
Eddy	Usually all day	September only
Brendan	Morning	afternoon - night
Jeffrey	Usually all day	Usually all day
Adi	Afternoon/evening	afternoon - evening
Tanish	Either I can't do 2:3	All day
Siddhant	Usually all day	after 3:00

2.0 - Center Stage (Row-by-Row)

- Adding members is difficult
- Built on spaghetti code and dreams

day	Person(1 per row)	Time Worked(min
9/9/23	Adi	
9/9/23	Eddy	
9/9/23	Rick	1
9/9/23	Aryan	1
9/9/23	Tanish	1
9/9/23	Sneha	

3.0 - Off-Season (Time Debt)

Added: "**Time Debt**"
We have an in-built time requirement for each member over a period of time

2	Krishan	0
3	Rick	0
4	Rohan	0
5	Adi	245
6	Tanish	360

4.0 - Into The Deep (Current Iteration)

Gamification of Working Time

We added **leaderboards** for **how much time** people put in.
We made **sub-teams** for **group spirit**.

#	Team	Time	Tim
1	White	18760	35.
2	Magenta	12952	24.
3	Yellow	10960	20.
4	Cyan	10880	20.

Adjustable Requirements

It is as **easy** as adding a row and a name to add new members.
Dropdown select for teams/time reqs.

Req	Team
5%	Magenta
3%	Yellow

Automatic Time Debt

We encourage members to **stay in touch**, so each week without attendance **linearly scales time debt**.

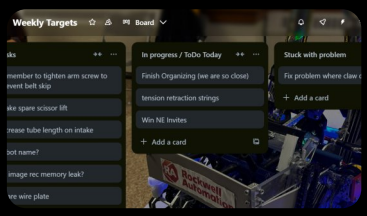
#	Team	Time	Tim
1	White	18760	35.
2	Magenta	12952	24.
3	Yellow	10960	20.
4	Cyan	10880	20.

To-Do List (What to do?)

This is just a **normal to-do list**, noting down what we **must do**, what we **have done**, and who is **working on what**. Also, it helps set **deadlines and goals** for **accountability**.

•1.0 - Trello Board (Last Year)

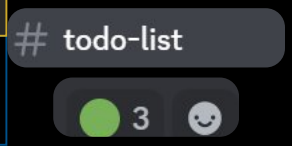
- Nobody checks Trello
- Annoying to fully commit
- No push notifications
- No headers/divisions



2.0 - Discord Channel (Current Iteration)

Everyday Use/Accessibility

Most of us use Discord **regularly**, so it's just **one click** to access it, and **one click** to react to a goal.



Headers/Deadlines

We can put the dates of scrims/quals at the top to invoke **urgency**.

#	Team	Time	Tim
1	White	18760	35.
2	Magenta	12952	24.
3	Yellow	10960	20.

Youtube Channel - @TechnoManiacs16021

We have had this **Youtube channel** for the **past few years**, but we have started **posting more frequently** this season for **two main reasons**:
1) We have **better documentation** and are **more organized**.
2) Our **turnover time** on **iterative design** is **quicker**.

This season, our videos have cumulatively gained **8k+ views**.

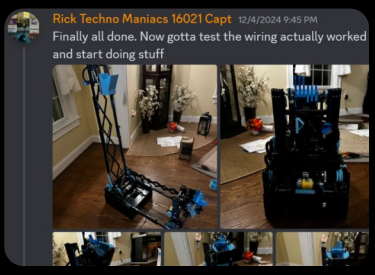
ORCA on the field for the first time
3K views • 2 weeks ago

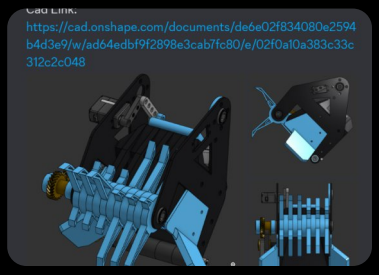
FTC Into The Deep Day 2 intake prototype
2.3K views • 3 months ago

Discord Posts - Open Source/Open Build

We are **active participants** in the FIRST community and we often help others in the **Unofficial FTC discord** with any **technical support** ranging from CAD to code.

This year we have gone a bit further by **displaying** the majority of our design process on the FIRST discord and **answering** any questions that any other teams may have.





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