Engineering Portfolio

2021-2022

Contents:

CRYPTIC

#20123

Team Members

Rayan Elias
Captain

Rayan is the captain of the FTC team Cryptic #20123. As an inquiring student and avid advocate of STEM, Rayan hopes to take Cryptic beyond FTC and promote the joys of STEM throughout the community.

Enoch Li
Building Lead

Enoch is the build lead of team Cryptic. He designed the custom plates for the robot as well helped assemble the robot together. In his free time, Enoch enjoys learning physics and hanging out friends.

Bill Wang
Programming Lead

Bill directs the software sector for the team. He also designs and 3D print parts for the robot. During his free time, Bill likes to read science fiction and watch movies.

James Li
Builder

James is in charge of graphics design and rendering. Outside of robotics, his interests include graphic design, 3D modeling, and math.

Daud Idrees
Builder

Daud is an aspiring engineer. He helped design and print the outtake system using CAD. Outside of FTC, Daud enjoys spending time learning about machines, tinkering, and reading.

Sidharth Garg
Builder

Sid is a senior in Centennial High School. During middle school, he joined a class involving Ev3 and hopes to solve worldwide problems with these skills.

Kelsey Lo
Programmer

Kelsey developed a strong desire to pursue further into computer science as she explored its limitless possibilities. Now, she aspires to expand her programming knowledge into the field of FTC robotics and construct a robot with her team.

Emil Jiang
Programmer

Emil Jiang is new to FTC and a programmer on Cryptic. He likes taking CS classes at school and hopes to do it in the future. He aspires to get better at Java and help build a robot with his team.

Raiyan Zaman
Programmer

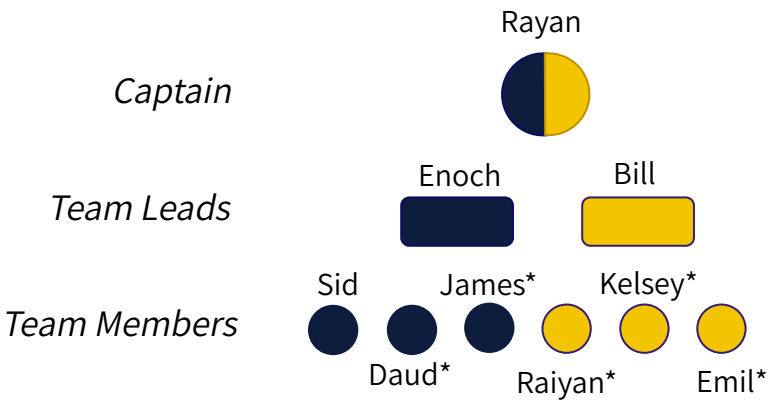
Raiyan assists in programming and engineering the robot. Aside from FTC, he enjoys watching football and basketball.

Team Overview

ABOUT US

Team **Cryptic #20123** is a **first** year FTC team that is based in Ellicott City, MD. Our members are all from Centennial High School and range from **freshmen** to **seniors**. Many of our members have previous experience in FTC, FLL, and even FRC. Despite our unique backgrounds, our love for robotics have resulted in us forming this team. Currently, we have 9 members, 5 of which are **new** and 4 returning **veterans**.

TEAM STRUCTURE



**New members in FTC are denoted with an asterisk*

Our team is mainly split into two subgroups: building and programming. Due to the difficulty outreaching this year with the **COVID-19** pandemic, everyone helped to market and find **outreach** opportunities. All our members have multiple roles at some capacity, which leads to a higher level of **cooperation** and **communication**. We have two leads and one captain on the team, which offers members to both **collaboratively** learn through their **experiences** while finding the opportunities to take **initiative** in their respective subgroups.

OUR MISSION AND GOALS

Our mission is to encourage learning in all aspects of FTC through hands-on building, programming, and marketing, as we support students of various interests in collaboration. We also strive to provide outreach opportunities for our members to learn, while we engage and educate our local community in STEM.

Our primary goal for 2021-22 season:

- Teaching our members who are new to FTC: As a rookie team, Cryptic relied heavily upon the experience and knowledge of its returning FTC competitors. We wanted our inexperienced members to learn valuable skills in the future in FTC.

Organization

2021-22 MEETINGS & STRATEGY

We had 2 weekly team meetings (1 virtual and 1 in-person) where everyone discussed the plan of it and then split into groups:

- Builders focused on **CAD** and **design**, planning the design before physically building to minimize wasted parts and in-person meetings.
- Programmers simultaneously created **code subsystems** while components were being designed.
- Marketers focused on optimizing virtual/physical **outreaches**, planning and coordinating virtual engagement in the community.

To collaborate virtually, we took advantage of various platforms:

Communication/Meetings

Discord, Google Meet, Zoom

Files/Organization

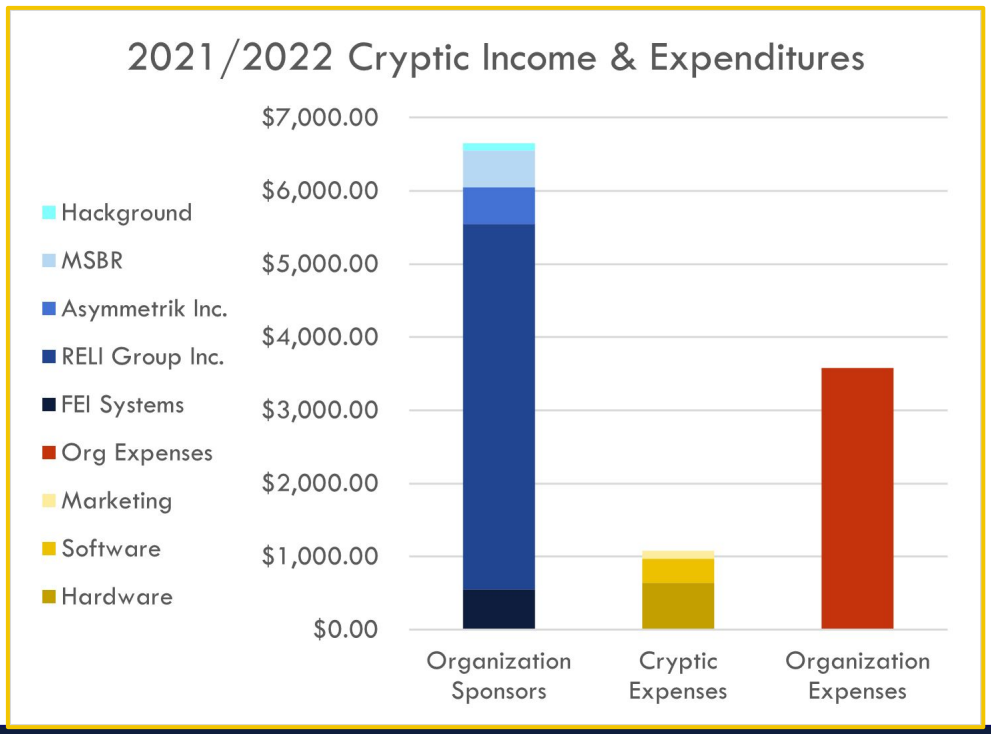
Excel, Jamboard, Google Drive

Cloud-Based Version Control

GrabCAD, GitHub

With these adaptations, we significantly reduced the number of physical meetings, which were only used for necessities: testing, building, and recording.

FINANCIAL INFORMATION



Our team's sponsors are able to redeem tax exemption from their donation to our team due to our affiliation with **Centennial Robotics Inc.**, a non-profit organization that hosts our team and two others.

As the **COVID-19** pandemic progressed, it became increasingly difficult to collaborate with sponsors. Nevertheless, a few generous local businesses helped support our team.

To alleviate costs, we built our robot to be exactly as we envisioned it. This meant that every part had to be designed carefully for **CNC milling** or **3D printing**

Outreach

Miller Branch Library Outreach

In partnership with the **Howard County Library System**, Cryptic debuted the **"Taking Your FIRST Steps in STEM"** event at the Miller Branch Library. We hosted this event and other variations later at **other HCLS Libraries**.

Some of the activities we coordinated:

- **Build a Boat:** Participants are given a sheet of aluminum foil and are tasked with creating a **boat-like structure** that can float in a tub of water with added pennies
- **Learn to Code:** Participants will get an accurate feeling of how programmers try to solve **difficult** problems in different ways using block code
- **Design a Plane:** Students learn to create an efficient paper airplane using the **design process** taught by the design team

Maryland STEM Festival

At the Maryland STEM festival, we were invited to **present** our team robot as well as host a workshop for **various FLL teams**. We decided to display a **robotic arm** that can mirror a person's **movement** as well as give an aluminum boat challenge.

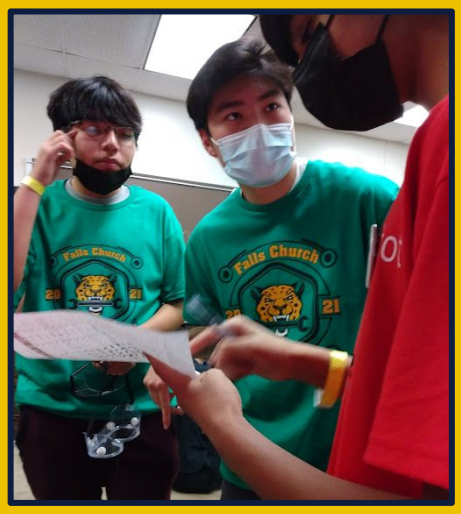
Partnering with Hope to Hands

We supported Hope to Hands, a nonprofit organization created to support families in need from COVID-19. They helped create our custom team shirts! The organization:

- Raises funds to **donate** money
- Gathers **necessities** for the needy
- Provide diverse career speeches to help high school students **discover** potential career paths

Volunteering at Qualifier

At the beginning of the season, many qualifiers needed **volunteers** to help manage the competitions. To support the **hard-working** individuals who make FTC possible, our team **volunteered** at the Laurel qualifier.



During the qualifier, we assisted in a **queuing** up teams up for various matches as well as helping clean up the fields afterward. We learned **numerous** lessons from other teams and **experienced** how the competition worked **in person** and up close. This opportunity also allowed us to **network** with other teams and learn about other team's robots and set up potential future **outreaches**.

Central Branch Library

We **hosted another event** at the Central Branch to reach a new set of **audience** in a different part of the county, after the successful turnout rate of our previous outreach. Our event **instantly** filled up and many people were waiting on the waitlist. Our targeted audience is students in middle school to **introduce** them to FLL and potentially FTC in the future.

We expanded our workshop to add a **new lego activity**. The students will **design** and **build bridges** using these legos. Then to test the structural integrity of the bridges, we added books and pennies on top of the bridge to **test strain**.

RISE Conference

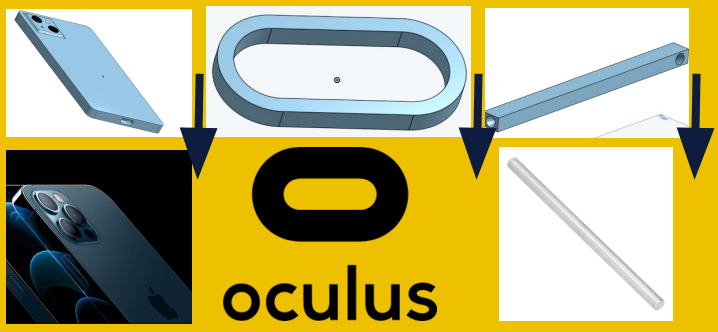
- We participated in our school's **science conference** and set up a station for FTC and robotics
- Showed **live** demos of robot to students of **various** ages as well as professors and **engineers** in **different** fields

CADathon with A.L.I.E.N

We partnered with FTC Team **A.L.I.E.N #19367** from Greendale, Wisconsin to host a "**CADathon**" competition for students across the **country** using OnShape. In this event, we plan to teach the **engineering design process** and different **tools** in CAD. To coordinate our teams respective assignments and discuss ideas, we would have **weekly** meets to stay updated.

Timeline

Date	Task Description
2/21-2/26	Brainstorm event ideas and timeline: • What CAD software: **OnShape** • What's our deadline: **End of April**
2/27-3/9	Create CAD models for students to replicate*
3/10-3/23	Develop **instructional material** for students to learn CAD (presentations, videos, etc.)
3/28-4/14 (currently in progress)	Promote the event: • Acquire **sponsors** • Reach out to **community** institutions • Utilize **social media**
4/15-4/18	CAD Classes! Students will join a **daily** class to learn **new CAD techniques** each day
4/19-4/22	Q&A Session: Open to students for **1 on 1** help
4/23-4/24	CADathon day! Exemplary competitors will receive **prizes** from sponsors



**Some of instructional CAD ideas include: iPhone, Oculus logo, and a simple beam with screw holes.*

Hackathon with Pingry

We are collaborating with **Pingry Robotics #6069** from New Jersey to create a **one-week long** online hackathon. The event will be constituted of **competitive programming** exercises, **project-based** submissions, and educational programming **workshops**. In partnership with local sponsors, we will host our competition through their support.

Networking with Other Teams

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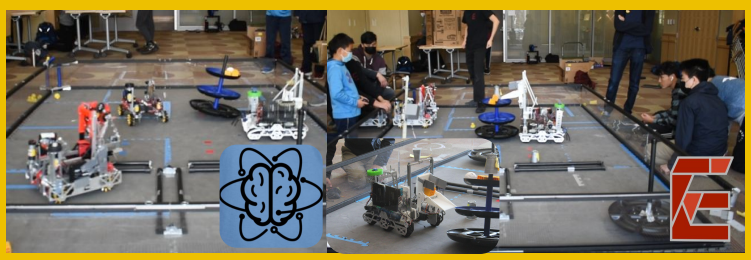
As a **rookie** team, Cryptic was primarily composed of **new** members to FTC. As a result, we had to collaborate with **many** teams, particularly **veteran** ones, to **learn** as much as we could.

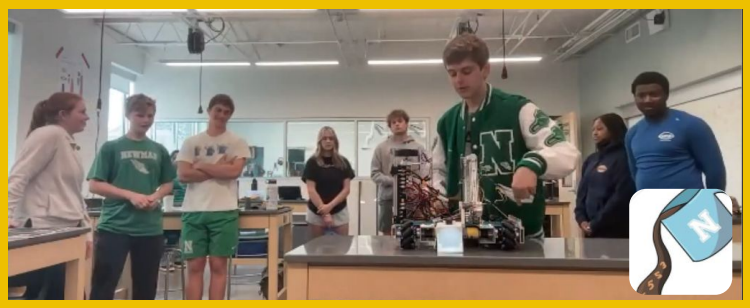
Scrimmages

Full Matches in PA with teams **Robotic Doges** #8645, **Before Orange** #18053, and **G-Force** # 2818

From our interactions with experienced teams, we acquired **connections** to mentors who helped us develop our **robot vision** and **autonomous** paths



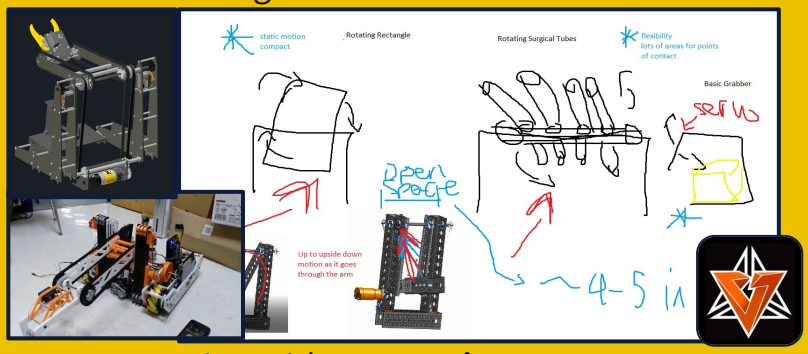
Practice with teams **BigBrainBots** #18477 and **Epsilon** #20124



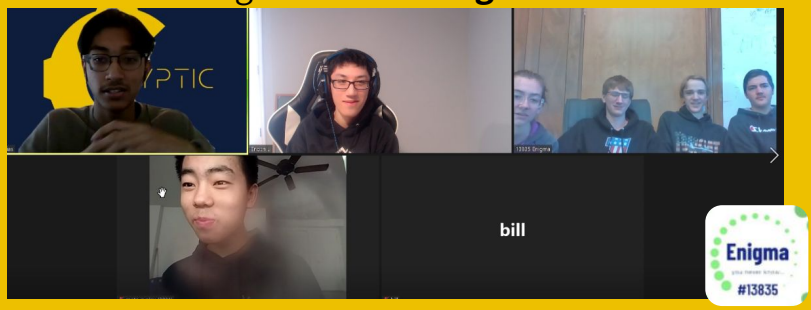
Mock Judging Session with team **Newman Robotics** #16553

Engineering Discussions

Meeting with team **VIRUS** #9866



Meeting with team **Enigma** #13835



Meeting with Greek robotics team **Robot Birds**

Meeting with team **Pirates** #13735

https://crypticrobotics.weebly.com/

@crypticrobotics

20123

Design Brief

Basic Info

- Project Name: *FTC Freight Frenzy*
- Team: **Cryptic #20123**
- Organizer: *FIRST Tech Challenge*
- Deadline: **Jan 29th**

Defining Problem

Create a robot capable of delivering freight with accuracy, efficiency, and reliability into the designated locations

Background

Transportation has been evolving rapidly ever since the beginning of civilization. From horses to carts all the way to modern planes and rockets, the need to efficiently transport goods from one location to another rapidly increases. This year's FTC game Freight Frenzy ***inspires*** future engineers into tackling the problem of transportation.

Targets & Constraints

Targets:

- 7+ freights into Alliance shared hub(SH)
- Tilt Shared SH towards our side
- Traverse freely around the barriers
- High structural integrity
- Modular design for flexibility & low maintenance
- Scoring in high range **consistently**
- Ensure all our members understand the tasks and bring their perspectives to the table

Constraints:

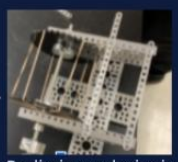
- Time limit - 30 seconds
- Obstacles on the field
- Physical robot constraints
- Rules and penalties in Game Manual 1&2
- Project period: 3 months
- Budget: $3,500
- Rookie members need to be trained with the appropriate skills they need

Timeline

9/2021

Team Cryptic is formed as a rookie FTC team and programming training sessions were held.

10/2021



Preliminary designing process begins and prototypes like the intake were tested.

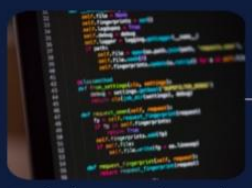
11/2021

Design for custom side plates is finished and ordered. The plates have special features tailored for our robot

12/2021

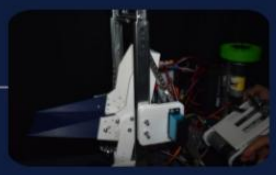
The 6-wheel drivetrain is assembled and features a unique bevel gear chain system.

1/2021



Intake is mounted unto the robot and tele-op code is finished

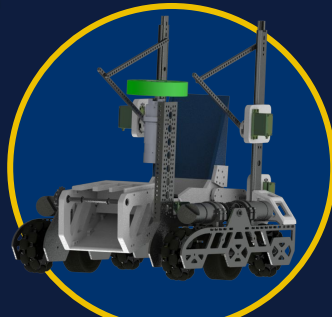
1/2021



After several iterations, the final outtake system is mounted.

Future Plans

We will continue to improve our design and implement new ideas that we've learned throughout the season



Chassis

Brainstorming

While discussing through a series of in-person and virtual meetings, our target **criteria** for the chassis include:

- Traction: Have enough grip and **stability** to go over the pipe boundaries
- Power: Produce high amounts of **torque** to contain and transport freight efficiently
- Compact: Has open spaces to fit other components; will **not interfere** with other mechanisms

Preliminary Design

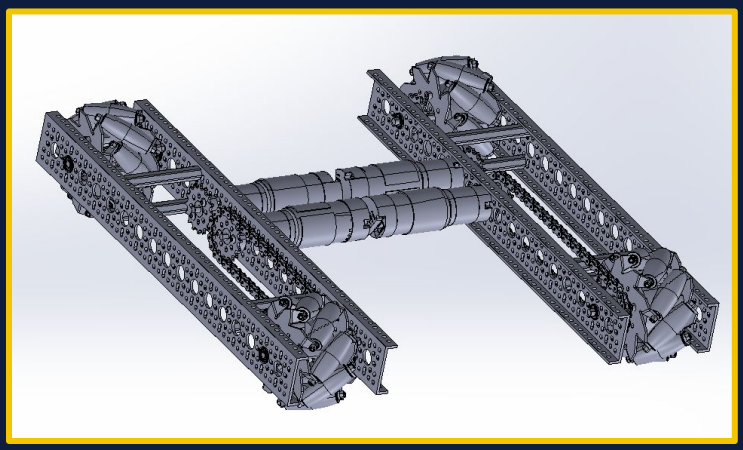
4-wheel Drivetrain

A simple popular design that consists of four mecanum wheels with a motor chained to each wheel. Some advantages of using this design are:

+ Uses less parts
+ Ability to strafe
+ Simple and straightforward

However:

- Can't pass through trench
- No space in middle



Final Design

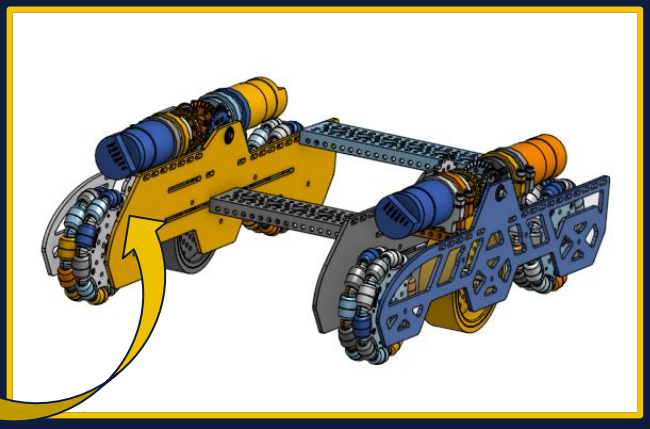
6-wheel Drivetrain

A unique drivetrain with 2 rhino and 4 omni wheels all connected using a chain. Some advantages of this design are:

+ Large free space in center for other mechanisms
+ Can pass through barriers

However:

- Unable to strafe



Special Features of the design:

- Innovation miter gear/chain design for equal power throughout the three motors.
- Custom side plates to easily fit and assemble it
- Accessible REV Hub location out of the way of other mechanisms

Because our strategy involves driving over the barriers and having mechanisms between our chassis, ***this solution is the best choice*** *even if it is unable to strafe.*

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Intake

Brainstorming

With mainly in-person meetings used to discuss the intake mechanism, we decided on some **criteria** that it should adhere to:

- Efficient: Should be able to intake one freight in under **two** seconds
- Compact: Take up **minimal** space for other components
- Reliable: Act as a **failsafe** to score points if the outtake malfunctions

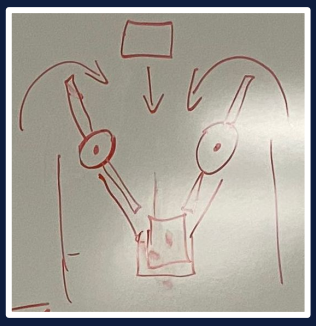
Preliminary Designs

Idea 1: Surgical Tube Funnel
Using two motors on either side with surgical tubes to **"funnel"** any game piece into the desired location. Some advantages of using this design are:

+ Intake any game piece

However:

- Not reliable

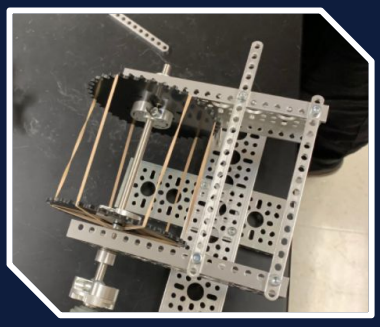


Idea 2: Rubber Band Roller
A unique drivetrain with 2 rhino and 4 omni wheels all connected using a chain. Some advantages of this design are:

+ Good traction

However:

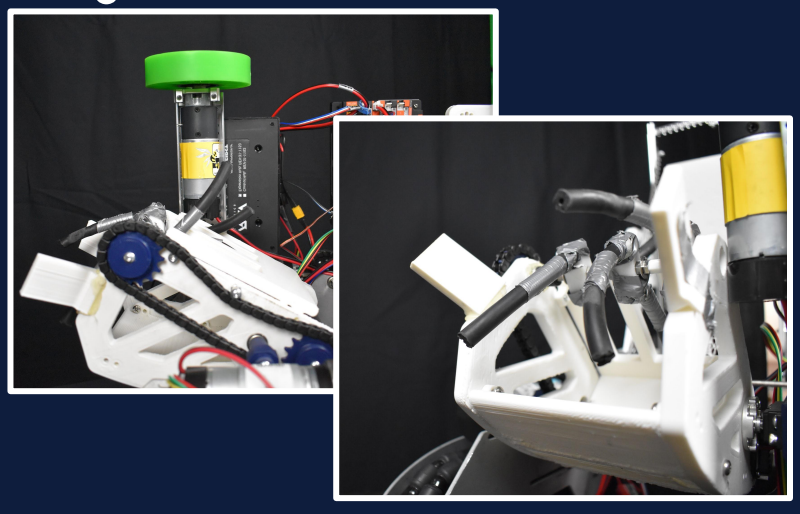
- Bands could snap
- No range



Problems Encountered

At first, our intake count not pick up anything at all. We tested **many** trials like increasing the power and changing flapper materials to **TPU** or **silicone**, but they did not help significantly. However, we realized angling the intake higher helps the intake **control** the freight better. This shows that the power of the intake does not affect it much, but instead, the **angle** is what really matters, because exerting power in the wrong direction will never pick the cube up.

Final Design



Surgical Tube Sweeper
We used some of the principles of **idea 2**, but are using **surgical tubes** instead of rubber bands and it has a compartment that can tilt up or flip around to transfer the game piece into the deposit system. Some **advantages** of this design are:

+ High range from intake to outtake positions
+ Able to intake freight in **0.23** seconds
+ Simple to build and integrate with other mechanisms
+ Could become outtake
+ Reliable and consistent
+ One main piece, not too many separated parts

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Outtake

Brainstorming

While discussing, we were inspired by past FIRST competition shooters and created some target **criteria**:

- Quick: Can deposit game piece into shipping hub in less than **three** seconds
- Accurate: Smallest chance of **error** when scoring points
- Compact: Doesn't **interfere** with other mechanisms

Preliminary Designs

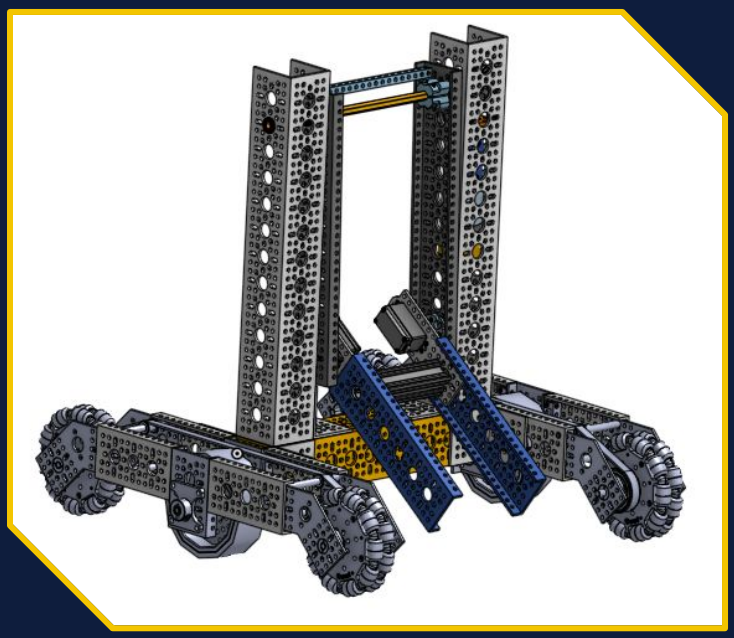
Idea 1: Rotating Arm

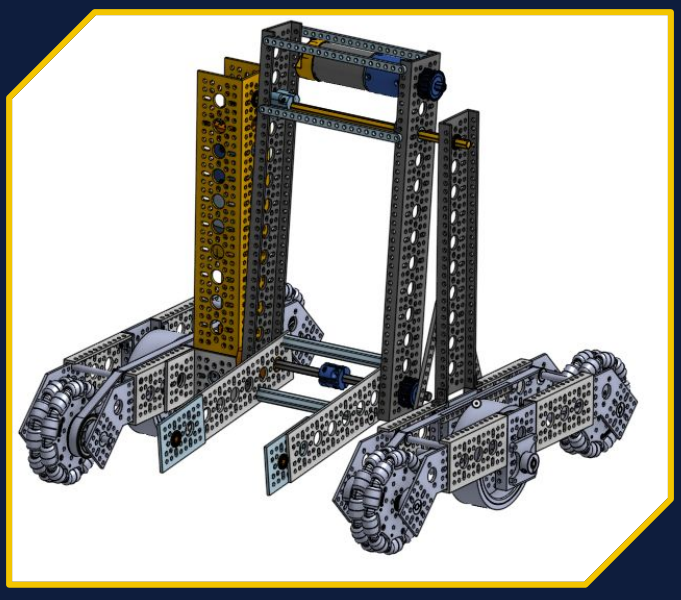
To test this design before ordering parts, we built a simple prototype using multiple U-channels and axles to demonstrate how the deposit would function and fix any complications that arose.. Some advantages of using this design are:

+ Intake on 1 side of robot, outtake on the other

However:

- A lot of moving parts which leads to high chance of error
- Too much strain on servos from weight of mechanism
- Easily rock robot with high center of mass





Idea 2: Rotating Arm (Updated)

We wanted to develop the previous idea further and made many improvements. Some advantages of this design are:

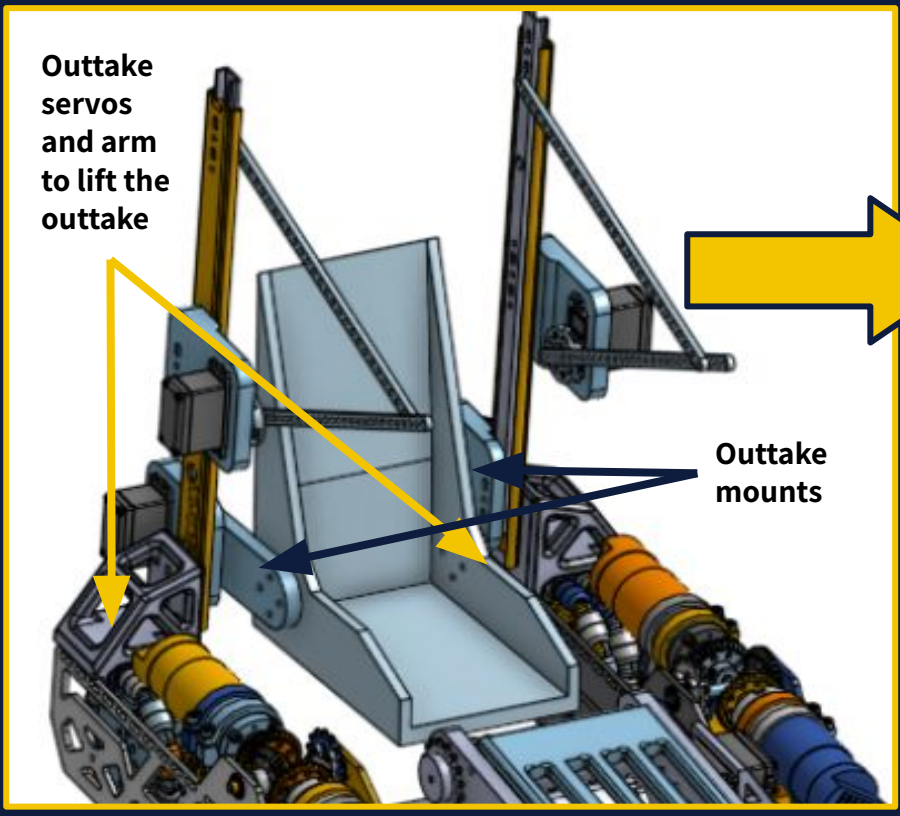
+ Move game piece vertically and horizontally
+ Easily move game piece to different heights

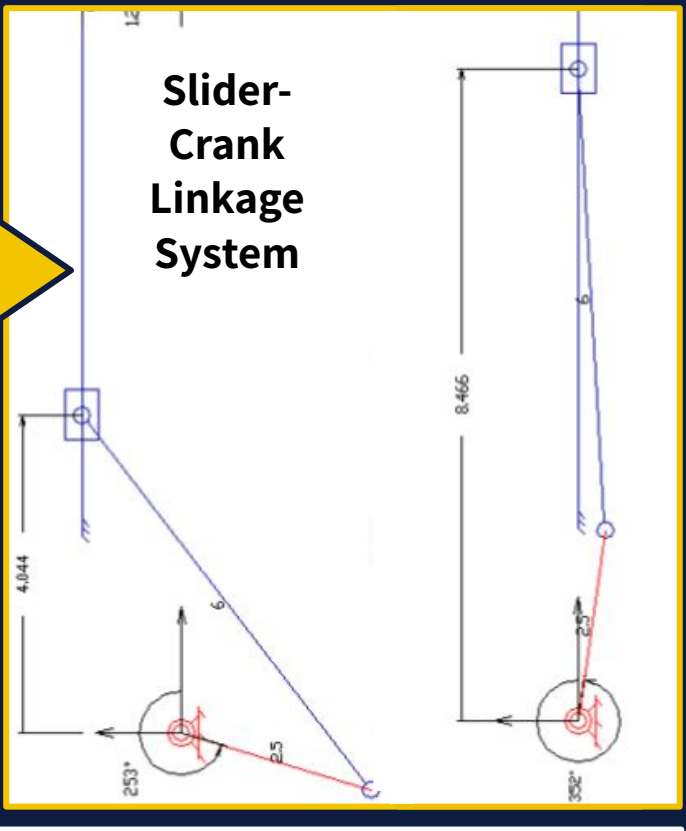
However:

- A lot of moving parts which leads to high chance of error
- High center of mass
- Too much strain on servos from weight of mechanism
- Difficult to wire the motor on the top of mechanism

Outtake

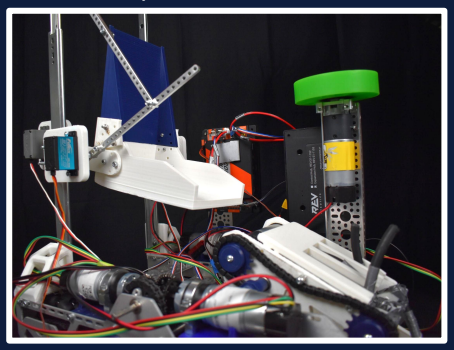
Final Design

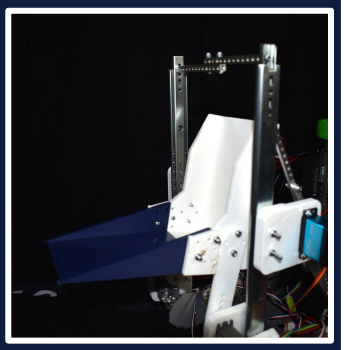


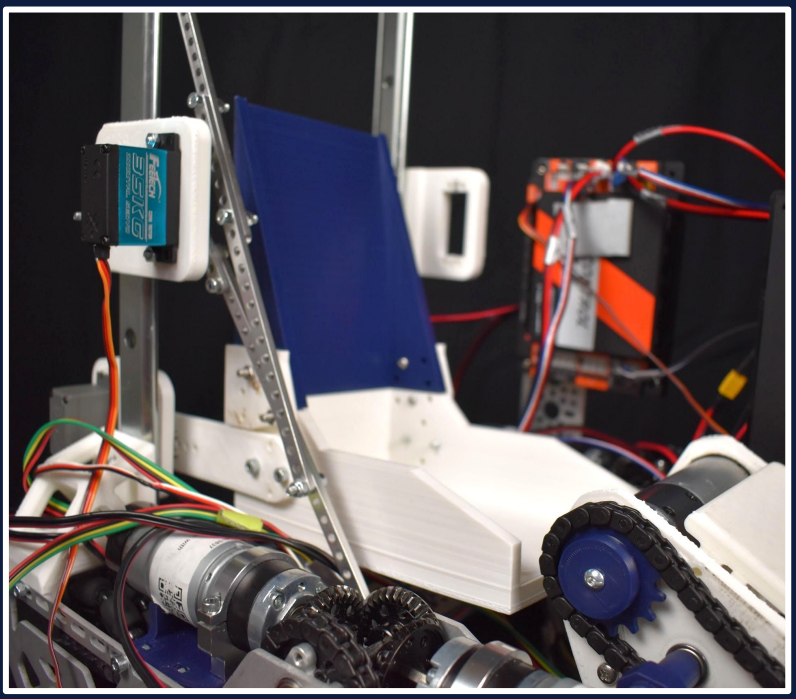


We modified the design of the deposit system because:

- *We wanted to be able to reach the 14 in. mark to dump elements into the shipping hub*
- *It would be more efficient and faster to have two separate mechanisms work at the same time*







Because of the problems with the previous design, we are now using a design with slides and a storage container that will rotate 90 degrees to deposit the game piece. Some **benefits** of using this design are:

+ Much more **compact**
+ Fluid motion with little to **no strain** on servos
+ Move game piece to **different** horizontal heigh
+ Can be used for Alliance SH too

Autonomous

Autonomous Paths

Path One Code

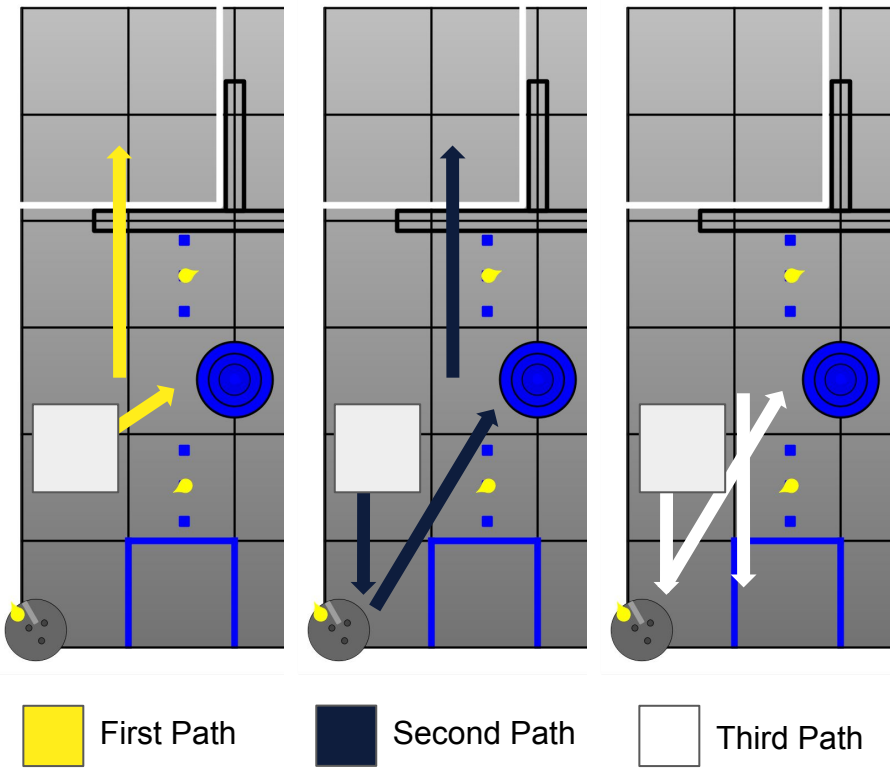
```
// We want to start the bot at x: -12, y: 66, heading: 90 degrees
Pose2d startPose = new Pose2d( x: -12,  y: 66, Math.toRadians(270));

drive.setPoseEstimate(startPose);

TrajectorySequence traj1 = drive.trajectorySequenceBuilder(startPose)
        // Robot drives straight forward to the shipping hub
        .lineTo(new Vector2d( x: -12,  y: 36))
        .waitSeconds(3)
        // Robot drops the freight on the top row
        .addDisplacementMarker(() -> {
            robot.extensionServoLeft.setPosition(0.9);
            robot.extensionServoRight.setPosition(0.9);
            robot.outakeServo3.setPosition(0.722);
            robot.outakeServo4.setPosition(0.722);
        })
        .waitSeconds(3)
        // Robot resets outake to original position
        .addDisplacementMarker(() -> {
            robot.extensionServoLeft.setPosition(0);
            robot.extensionServoRight.setPosition(0);
            robot.outakeServo3.setPosition(0);
            robot.outakeServo4.setPosition(0);
        })
        .waitSeconds(3)
        // Robot drives back to the warehouse
        .lineTo(new Vector2d( x: -12,  y: 52))
        .splineTo(new Vector2d( x: 10,  y: 66), Math.toRadians(0))
        .lineTo(new Vector2d( x: 55,  y: 66))
        .build();
waitForStart();
```

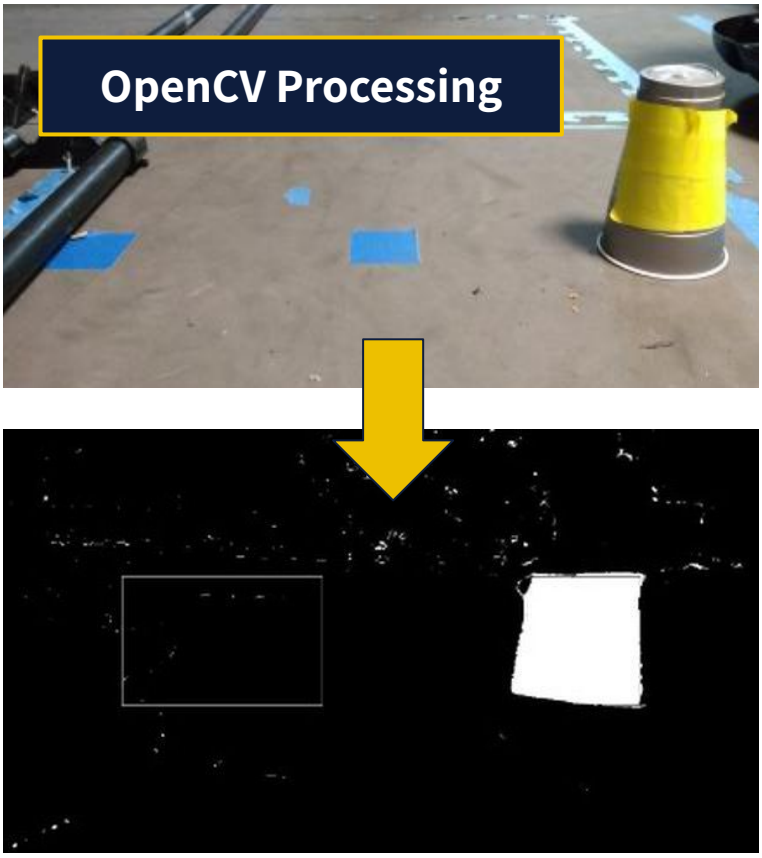
We programmed **three** autonomous paths. These paths utilize **displacement**, line to, **trajectories**, and **waitsecond methods**. It is critical for us to implement **multiple paths** to accommodate to our alliance team. If one of our paths interfered with our alliance's autonomous path, we could use a **separate path**. This allows us to **maximize** points earned during the competition.

Each autonomous path are expanded upon each other. The first path **detects the barcode** and travels to the alliance shipping hub to **release the preloaded freight** onto the corresponding level. Then **parks inside the warehouse** to initiate the game round in an advantageous position. The second path **scores the carousel** points then continue the first path. Finally, the last path is identical to the second path but park in the alliance storage unit instead of the warehouse.



Autonomous

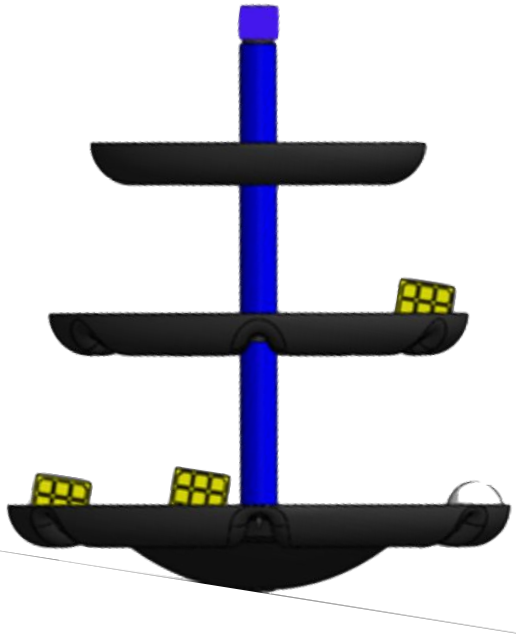
Vision Implementation



We integrated a **vision** functionality to our robot to detect the barcode during the autonomous period. We decided to utilize Open Source Computer Vision Library (**OpenCV**) to perform the visual analysis. OpenCV applies a mask filter to the video input to identify **pixels within a specific range**. It identifies the yellow portion of our capstone, which is visualized as the white box after processing.

To **maximize efficiency**, our vision mechanism only **detects** two of the three barcodes. When the capstone is not detected within the camera, it performs the remaining path.

For the top level of the alliance hub, the outtake servo is **fully extended** to release the freight. For the middle level, the outtake servo is **slightly elevated** to release the freight. For the lowest level, the robot **shifts backwards prior** to rotating the outtake servo.



Controls

To keep code organized, we used **GitHub**, a version-control repository, for programmers to share and edit code. It was especially useful in helping us work **virtually** during the pandemic and keeping others **safe**

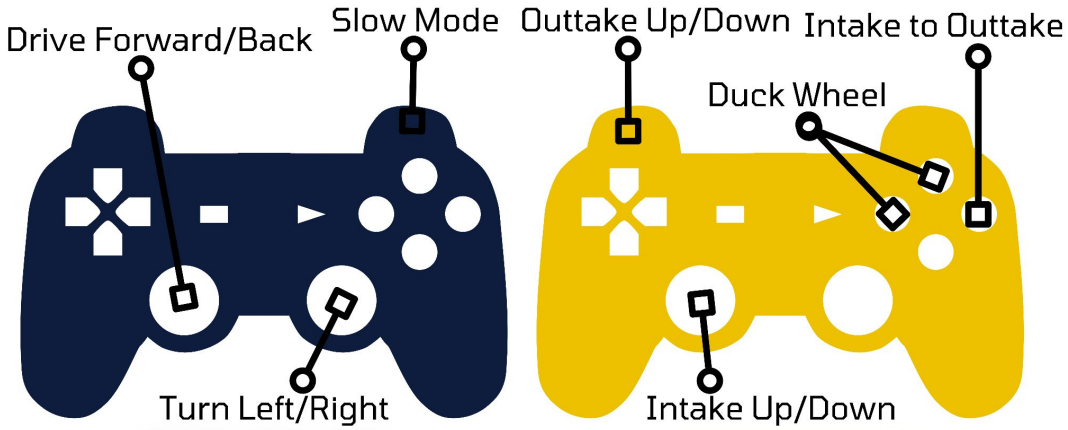
Automation in TeleOP

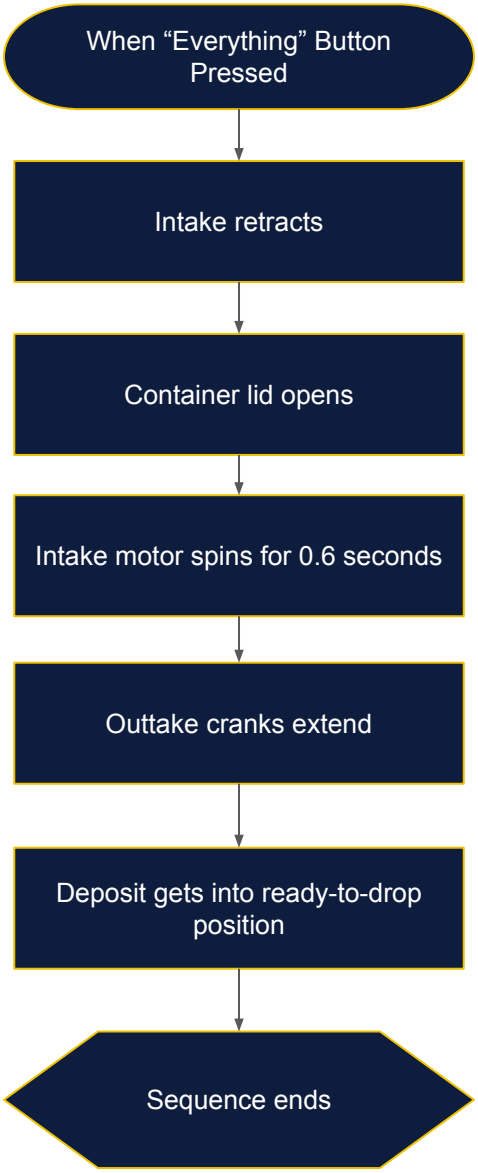
Freight Transport Sequence - *<u>One Button to Rule Them All</u>*

We implemented an **"*everything button*"** that when pressed, it performs a series of tasks that **automatically** transports the freight into the ready-to-outtake position so that our driver doesn't have to laboriously initiate the movements **manually**. This also eliminates about **80%** of the human error.

Passive Freight Retaining System

When going over the barriers, the freight would always **fall** out due to the shake, so we implemented a **passive** method that activates whenever the robot goes over the barriers. When **IMU,** a **gyroid**, detects large **fluctuations**, it knows that it is going over the barrier, and **automatically** closes the container lid and slowly rotates intake motor to push the freight back inside.





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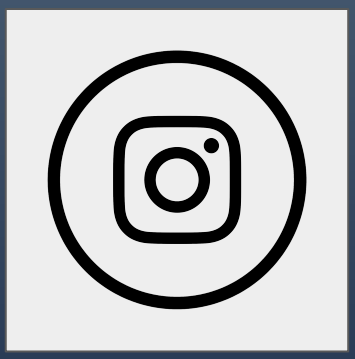

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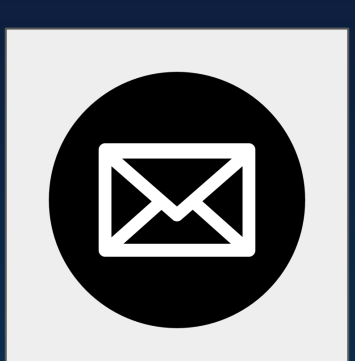

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