OPERATION P.E.A.C.C.E. ROBOTICS

4-H FIRST ROBOTICS TEAM 3461

TECHNICAL BINDER

2024 REPORT

OPENING STATEMENT

PREFACE

The purpose of this doucment is to guide new generations with an up-to-date, focused, and organized document for Operation P.E.A.C.C.E. Robotics' robot for the 2024 season. This plan's goal is not only to guide the team, but to help the public with organizing their documentation if needed. This document is split into 3 separate overall sections;

- Team information
- Prototyping & Strategy
- Overview of 2024's Robot.

This documentation is highly encouraged to be referenced upon for future team members, sponsors, and fellow robotics teams. However, parties cannot forge or copy our documentation without the consent of the team.

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WHO WE ARE

Operation P.E.A.C.C.E. (Practicing Engineering and Competitive Cooperative Excellence) Robotics was established in 2010 to excite students to pursue STEAM through competitive robotics in Bristol, CT. Our team is a community team, meaning that we are not tied with any school system, being financially independent with the help of 4-H. Furthermore, we accept anyone regardless of background and skill level to join our team so they can learn the nessecary skills to become the next generation of innovators.

Every year, we strive to compete at the highest level as our students gain more experience in STEAM to outperform previous year achievements. Today, the team is a strong player in the FIRST community, competing not only at the New England District Championships, but also the World Championships in Houston, TX.

OUR MISSION

"Our mission at Operation P.E.A.C.C.E. Robotics #3461 is to teach students to explore and appreciate STEAM, encourage students to realize their capabilities, and to inspire others to learn and improve skills."

HOW WE ACHIEVE OUR MISSION

- How to apply engineering principles via the designing and construction of the robot
- Gained fluency in industry standard engineering software (Labview, SolidWorks, Java, etc.)

OUR VISION

"Our vision is to provide a learning opportunity for <u>everyone</u> to become STEAM leaders, regardless of circumstance."

HOW WE ACHIEVE OUR VISION

- Reach out to students from diverse backgrounds
- Create opportunity for people of all ages
- Promote accessible & sustainable STEAM in our state & the world

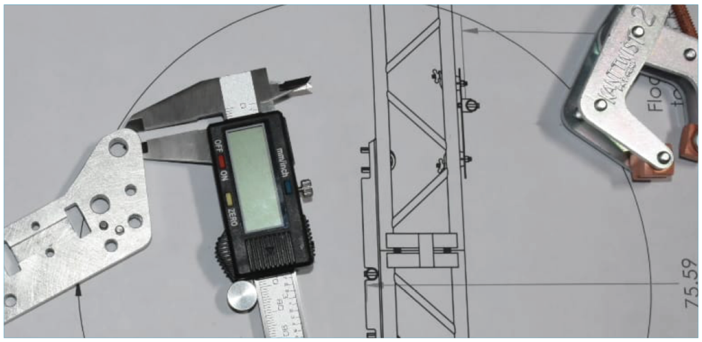
ACHIEVEMENTS

2011

- Our First Year!
- Highest Rookie Seed at Northeast Utilities FIRST Connecticut District Event

2014

- Team Spirit Award at Southington District Event
- Quality Award at Pine Tree District Event



2016

- District Event Winner at Hartford District Event & UMass Event
- Dean's List Finalist Award at New England District Championship

2017

- District Engineering Inspiration at NE SE Mass Event
- District Event Finalist

2018

- District Engineering Inspiration at NE Rhode Island Event
- First Time at the World Championships!

2019

- District Event Finalist at Western New England Event

2022

- Entrepenurship Award at Waterbury District Event
- 3rd Seed Captain at New England District Championship
- 5th Seed Captain at World Championships -- Newton Division
- Quality Award at World Championships

2023

- Excellence in Engineering Award at NE Waterbury Event
- Innovation in Control at NE Greater Boston Event

14 AWARDS

CRESCENDO℠

PRESENTED BY HAAS Gene Haas Foundation

STRATEGY

PLANNING

NEED

- Swerve Drive
- Score NOTES in the SPEAKER
- Intake NOTES from the ground
- Capable of getting ONSTAGE

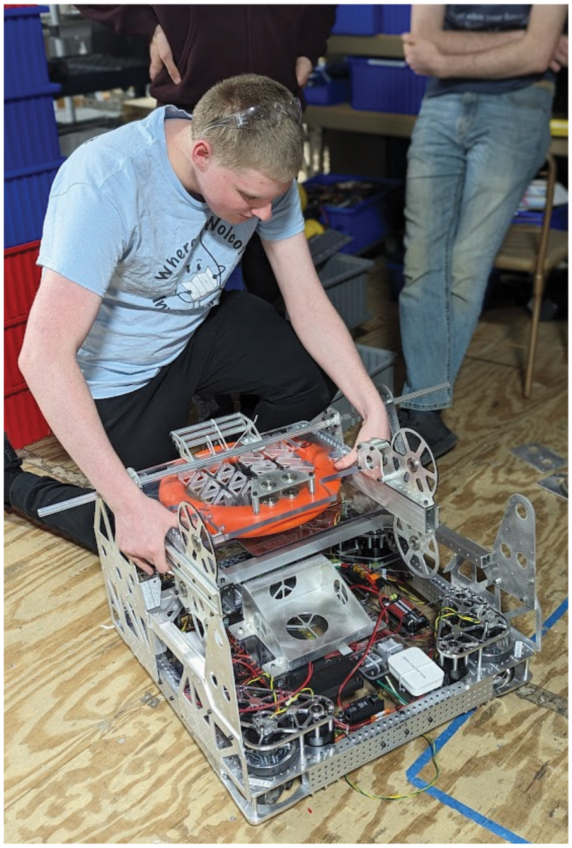
WANT

- Score NOTES in AMP
- Can drive under the STAGE's chains
- Intake NOTES from the source
- Can achieve HARMONY
- Capable of scoring TRAP

WISHLIST

- Combined mechanism to score NOTES in all locations
- No pneumatics on the robot

We approach our build season with the same mindset: **engineering is an ongoing and iterative process**. Even when we have developed solutions, there are ways to optimize them further. Because of this mindset, we decided to spend longer on prototyping potential designs and researching new ones. The team focused heavily on creating physical prototypes, utilizing a variety of material including wood, maytec, bent sheet metal, and polycarbonate. Furthermore, we tested out materials we already had, in order to understand their capabilities for this year's game. For example, we tested both 6" and 4" wheels in order to recognize how much grip force it has with the game pieces.
We also collected data on potential power, angles, and distances it would take in order to reach the high goal. We learned that the more power it released, the further it went and higher arch it would get. This data was used to help narrow down design choices on the robot, and open the option for new designs to be created.



PROTOTYPING PROTOCOLS

When prototyping, we look for creating designs that fit a certain criteria.:

- Small
- Effective
- Lightweight
- Compact

SCHEDULE

			WEEK SCHEDULE							
TASK DESCRIPTION	START	END	1	2	3	4	5	6	7	8+
SEASON PLANNING										
Game Analysis	01/06	01/08								
Strategy	01/07	01/12								
Code Specification	01/07	01/13								
Prototyping	01/10	01/19								
Crayola CAD	01/10	01/13								
Design Parameters	01/12	01/15								
CAD Design	01/16	03/01								
DESIGN / ASSEMBLY										
Swerve Drivebase	01/07	01/14								
Superstructure	01/13	01/21								
Intake #1	01/13	02/04								
Shooter	02/04	02/17								
Climber	02/10	02/29								
Diverter	02/20	03/04								
CREATION										
Design Review	01/07	<								
Assembly	01/07	<								
Wiring	02/08	<								
Programming	02/06	<								
Debugging	02/11	<								
Drive Practice	02/11	<								

On January 8th, Operation P. E.A.C.C.E. Robotics gathered to watch the reveal of the 2024 Game: *CRESCENDO*. First, we read everything in the manual including the rules, allowing our students to brainstorm possible designs. Second, we looked to meet a day after the reveal to decide on what we should focus on at a team. We use this time for every student to provide drawings of their ideas, and explain what they feel we should focus on. After this, we vote on our priority list, and we begin work. At this point, each subteam meets to discuss their own to-do list for the season, and how to collaborate with other subteams.

By the end of Week 4, the team started fully CAD-ing designs and started assembly.

DESIGN CONCEPTS

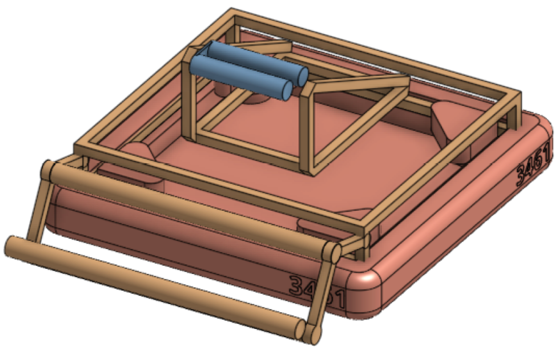
Our team had multiple design concepts to tackle the complex challenges of CRESCENDO. To flesh out designs, our team created a design matrix at kickoff to help narrow down what ideas are important to the team. This allowed us to identify key points of the game, such as a small design, and ideas we'd prefer to have. The design matrix is below:

CONCEPT	SIZE & WEIGHT	DURABILITY	DESIGN	COST	REPAIRABILITY	TOTALS
A	3	2	1	2	2	**10**
B	3	2	2	2	2	**11**
C	5	3	1	2	1	**12**
D	2	2	2.5	2	3	**11.5**

To further design concepts, our team utilized KrayonCAD: a robot planning library for Onshape This library allows us to tap into common mechanism designs to plan out robot designs, and flesh upon designs that are unique for the robot. The following are some robot designs and their takeaways:

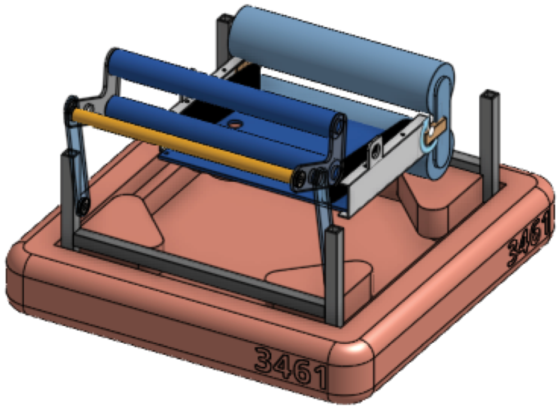
Design A

Design A was one of 3 concepts pitched in Week 1 of Build Season. Design A/B ended up being very similar to each other and because of that, Design B was given more development time than Design A, leaving very little details. The main take away from Design A was the Superstructure concept, having a set of rails that all the mechanisms can mount to, allowing for all the mechanisms to be full width and scaled to the whatever frame perimeter size with a lot more ease than would be normal.



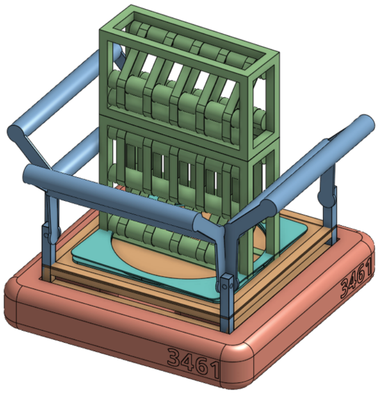
Design B

Design B contributed the horizontal shooter concept to the final design, allowing the most contact with the game pieces and imparting the most force into the game piece to allow our shooter to be extremely powerful and accurate.

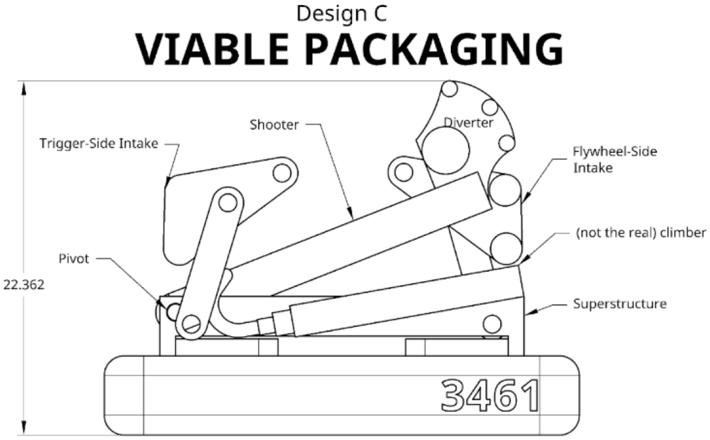


Design D/G

Design D departed from all the other designs as an attempt to ensure the team takes all possibilities and designs into account. This triple-intake configuration was conceived to maximize efficiency in collecting game pieces. The shooter is mounted on a turret that can rotate 180+ degrees (rotation is how the game pieces enter the tower) with a horizontal shooter at the top of the tower.

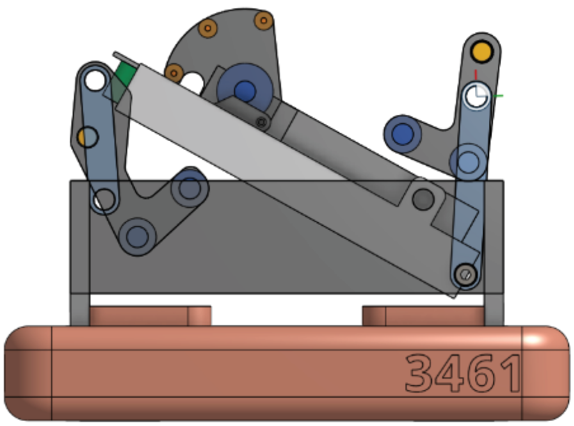


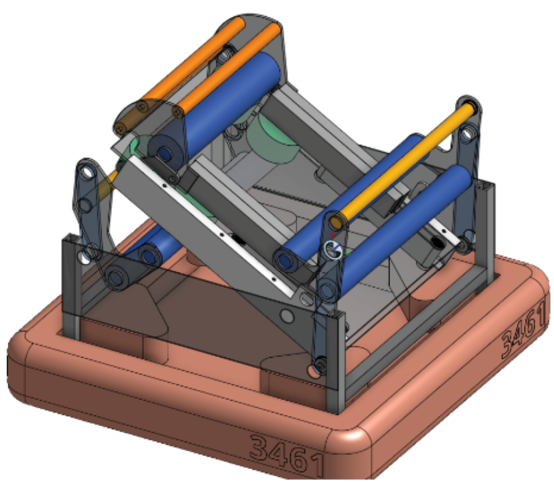
To take into account all of the designs into account, the team combined all of the notable charateristics of each to create Design C.

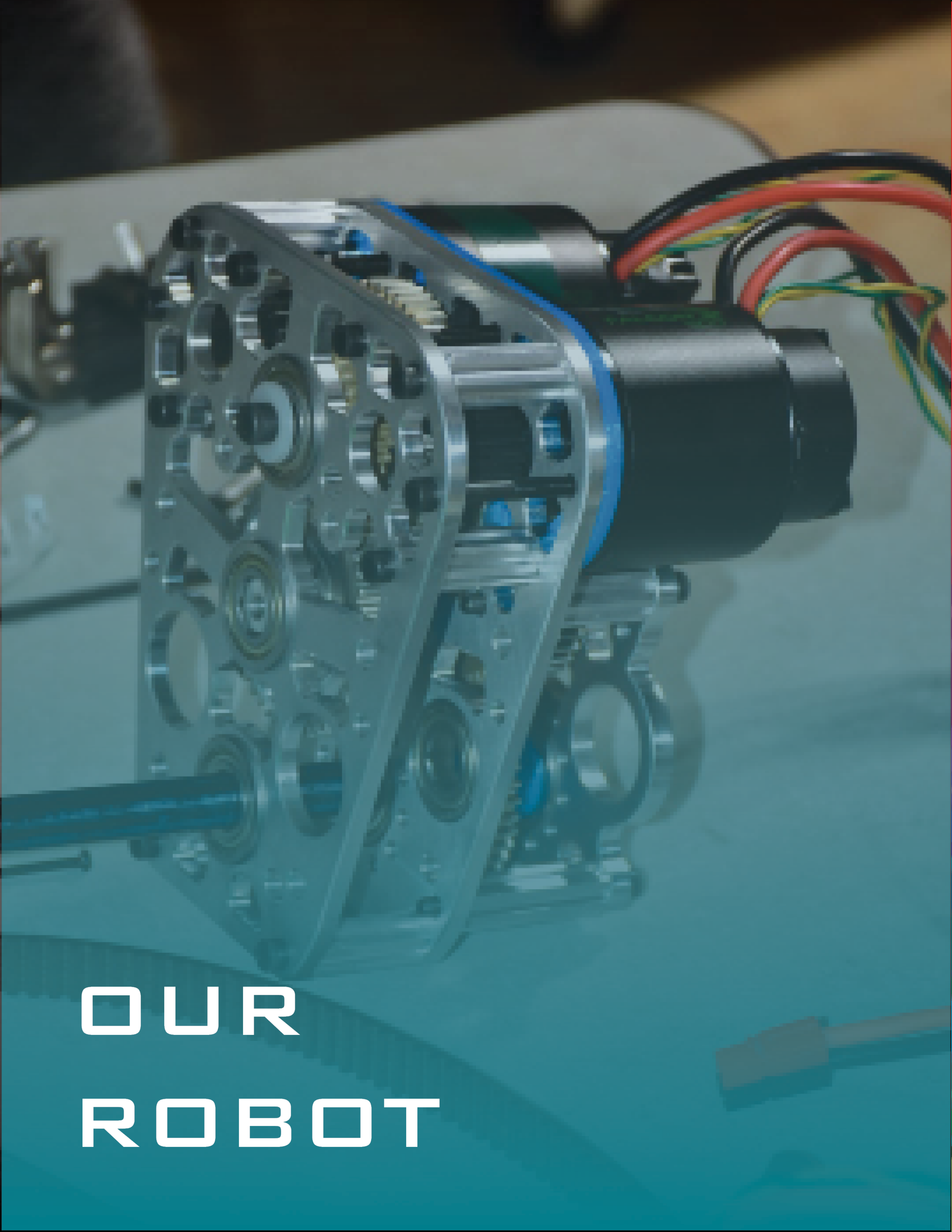


Design C

1. Notes enter through either intake
   - They enter the shooter assembly either through the trigger or by backfeeding through the flywheel
   - The flywheel-side intake interferes with the shooter sitting flat, so the shooter rests above the intake and then the pivot flattens after the intake is deployed
   - Which intake will be used can be auto-selected based on which direction the robot is moving
     - Default to non-flywheel-side intake for stationary robot
2. Shooter can auto-align from any viable angle
   - Use odometry with AprilTags for targeting to provide stable & accurate range data
   - Use manually collected data points for flywheel speed + pivot angle based on distance to the target
   - Align rotation with the drivetrain
   - If beneficial, offset the aiming target at based on the angle into the speaker to minimize shots bouncing out (e.g. shooting into the opposite side of the speaker)
3. Score into the amp by pivoting the shooter approximately vertical and using the diverter
4. Score into the trap by climbing (using one of the above mechanisms), and extending the diverter to reach







OUR ROBOT

OVERALL DESIGN

Operation P.E.A.C.C.E. Robotics presents C#.

This season, Operation P.E.A.C.C.E. Robotics presents C#. When creating C#, we kept our main objectives in mind: shooting notes consistently and accurately. To accomplish this purpose, C# comes with an adjustable pivot on the shooter, dual limelights and Photonvision running on an Orange PI for vision, and a climber on the drive frame base for fast and easy ONSTAGE points.

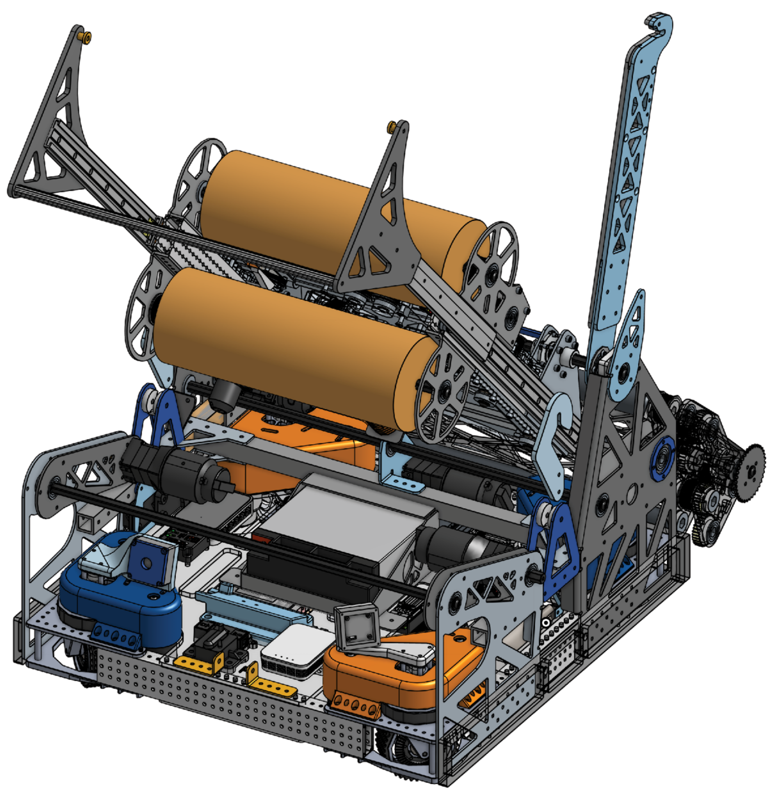
By week 6 of build season, various designs for the climber were created. The current iteration of C#'s climber consists of two parts: a stage climb, and a TRAP mechanism. By using these two, the robot can get ONSTAGE while giving alliance partners enough room to gain the MELODY Rank Point. The drivetrain of the robot is a 24.5in x 25in swerve drive. With a small perimeter the drivetrain allows us to have more creative freedom in the weight and center of gravity for the robot. Furthermore, it's easy to repair in between matches.

FRC 3461 primarily uses materials such as lexan, sheet metal, box tubing, and aluminum sheets. These materials proved to create a sturdy robot to mount systems on, while also being aesthetically pleasing. The robot is primarily powered by multiple Falcon 500 and Neo 550 motors, because of the power and consistency they possess when powering mechanisms.

FEATURES

- MK4i Swerve Drive L2
- Fast & Small Robot
- Fits under STAGE
- Pivoting Shooter
- 2 Limelights for recognizing NOTES and AprilTags
- 2 PhotonVision cameras for recognizing AprilTags

- Dimensions
  - Base Dimensions: 24.5″ x 25″
  - Height: 26″ to 48″
  - Weight: 120lbs



HARDWARE

Motors are not simple electrical devices that you can just plug in, a motor will spin as fast as the electrical input it is supplied, and reversing the polarity (red to red black to black or red to black and black to red) will change the direction of the motor. This device is called a motor controller. The motor controller will vary the voltage and polarity delivered to the motor allowing for fine control. Some motors have motor controllers built into their housing, therefore the motor must only be connected to power in the correct polarity and the controller connected to the appropriate bus (CAN or PWM).

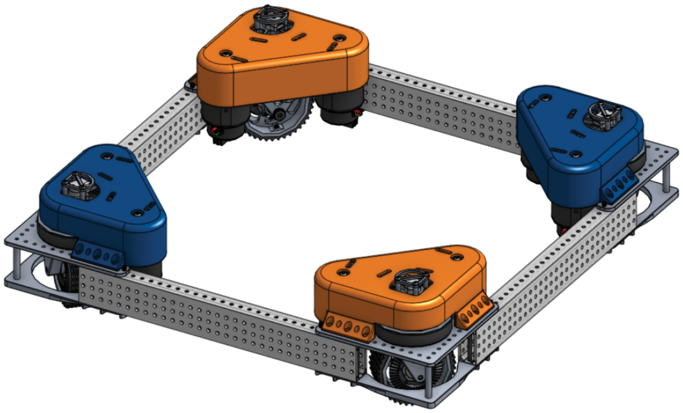
Falcon 500

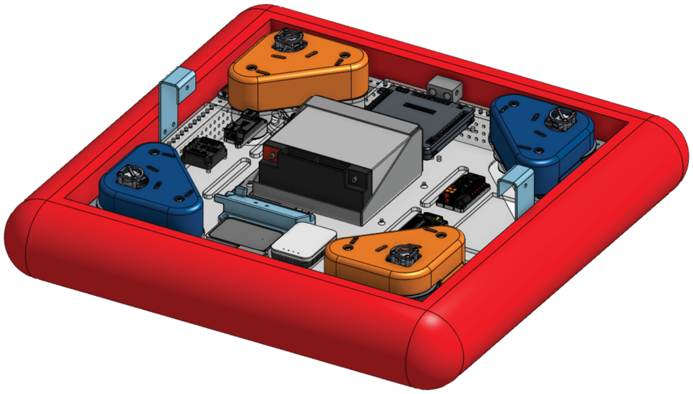
A Falcon 500 is a brushless motor with an integrated motor controller (TalonFX). It has a red V+ (voltage in) and a black V- (common or "negative" or "ground") lead. Although the motor controller has integrated reverse polarity protection, do not plug the motor in backwards because the protection is meant for accidental polarity reversal, not actual use. The integrated motor controller connects to the CAN bus for signal.

Neo 550

A Neo 550 is a brushless motor without an integrated motor controller. It has a red, white, and black three-phase power connection leads. Because the motor is driven by PWM and does not have an integrated controller, you must use a discrete controller, namely a REV Spark MAX. The Spark MAX takes power in (red and black leads) and outputs 3-Phase power to the Neo 550 using the red white and black leads. You can not reverse the polarity of the motor or it will short out and break. The Spark MAX connects to the CAN bus for signal.

DRIVE TRAIN





OVERVIEW

When creating the robot, the first step involves the drive train. As the base of the robot, we wanted a drive train that is easy to repair, customiziable for different sizes, and be competitive on the field. After much deliberation, Operation P.E.A.C.C.E. Robotics decided to orient towards a swerve drive base. As a swerve drive train, we can manuver with ease with because of our SDS MK4is, without sacrificing area and size.

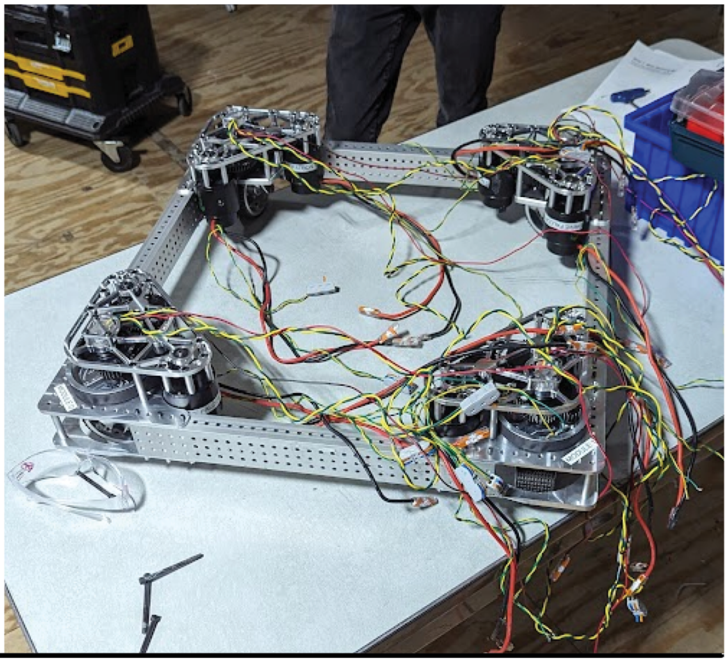
TRANSITION TO SWERVE

We decided to transition to swerve to fit better to the needs of the game. This year, the frame shrunk to a 24" x 24.5" frame to be compact and quick, which was thanks to the little space our swerve takes, which allows more room for mechanisms.

DESIGN

- 4x SDS MK4i swerve modules
  - 8x Falcon 500 motors @ L2 gearing
- 24.5" x 25" frame perimeter
- Pigeon 2 IMU used for navigation
- Aluminum

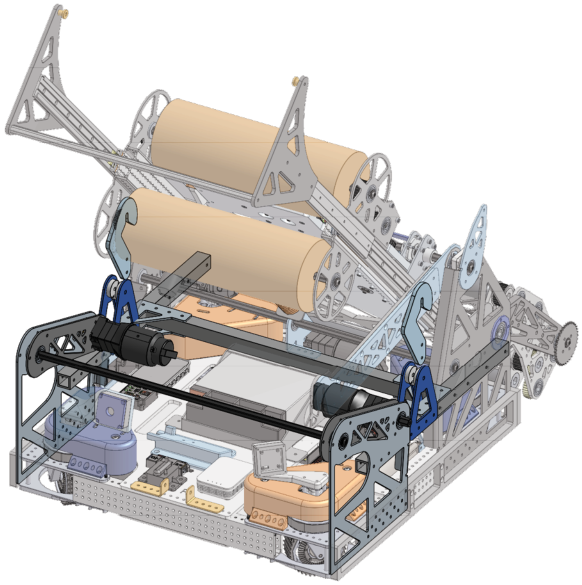
- **<u>WHY SWERVE?</u>**
  - Manuverability
  - Servicability
  - Flexibility with designs
  - Competitiveness



SUPERSTRUCTURE

OVERVIEW

With a small robot, our team created a aluminum frame superstructure between the drivebase and bumpers. This allows for easy mounting, servicability for both mechanical and electrical, and assist with electrical wiring both inside & outside on the sides.



DESIGN

- Strong to hold all mechanisms
- Spaced out to not interfere with mechanisms
- Allow easy access into electrical panels

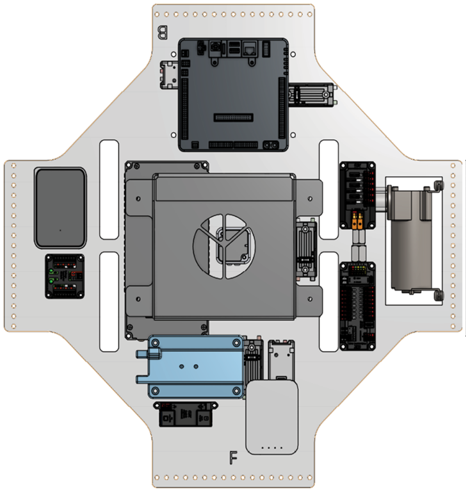
HOW IT'S DESIGNED

- Custom aluminum frame
- 24" length for whole robot

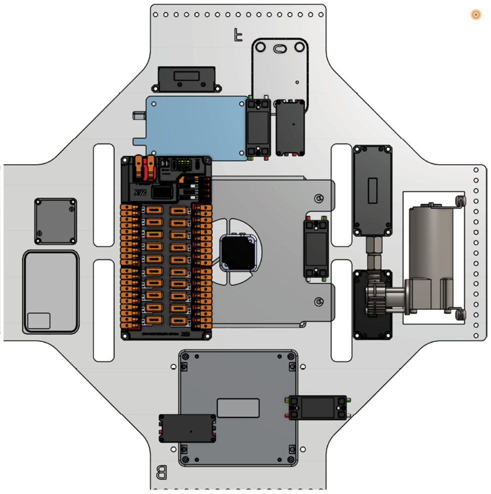
ELECTRICAL PANELS

This year, our robot utilizes a polycarbonate bellypan to hold electronics on both sides. This allows us to compress our electrical into one place, and more servicable when repairing after matches. To learn more information about the panels, please consult the 2024 Electrical Manual.

Top Face of Panel



Bottom Face of Panel



DESIGN

- Servicability
- Easy to take out for repairs
- Access for electrical
- Middle carved out for weight

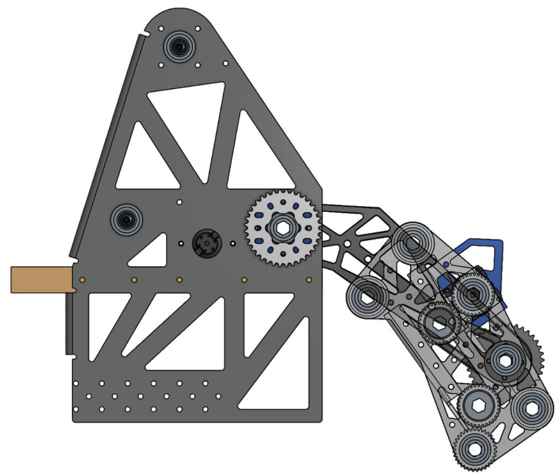
HOW IT'S DESIGNED

- Second version of polycarbonate bellypan
- Electronics mounted on both sides for space
- Protected by floor by a second polycarbonate panel

INTAKE(S)

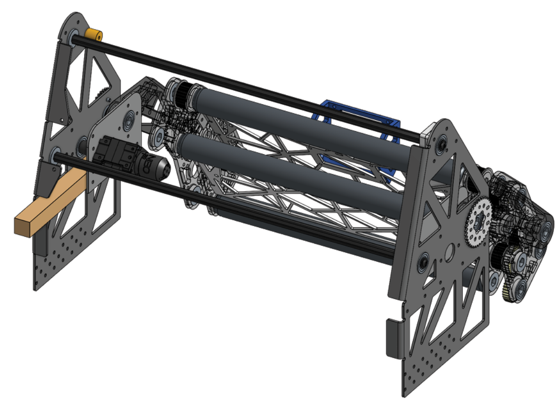
DESIGN

- Serves as intake for delivering NOTES into the shooter
- Hands NOTES to the Shooter via the Trigger
- Functions in tandem with the Shooter via code automations



OVERVIEW

To maximize the possibility of NOTES coming into our possession, Operation P.E.A.C.C.E. uses four full length rollers. The virtual four-bar intake maximizes the NOTES that can be directed into our Shooter; they're positioned facing inward into our bumpers, pushing toward the center. Both the rollers and the machined profile on the Shooter's trigger side are used to maximize the possibility that NOTES will come into our possession, instead of being pushed away by an opposing robot.



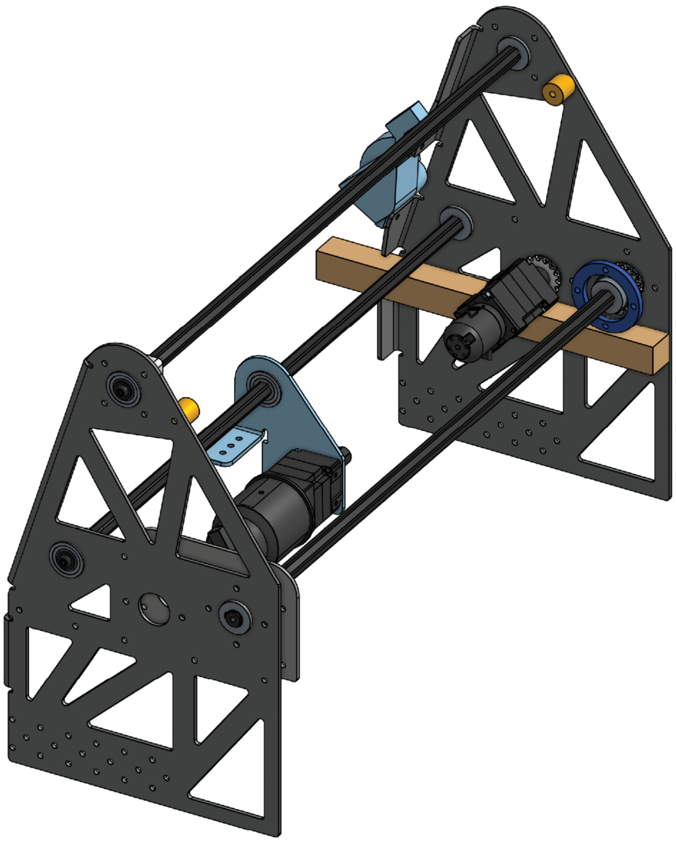
Our intake is held up by two custom made polycarbonate arms. These arms have two bars that spin to direct notes into our traversal. Furthermore, this intake is powered by a Neo 550. By using a Neo, we can quickly move our arms up and down, precisely to the correct position to fit the NOTES within the Shooter as fast as possible.

A PREVIOUS SECONDARY INTAKE

A key aspect of Design C was to utilize two intakes for maximizing our chance of intaking notes. However, after our Waterbury competition, **we realized a second intake was not nessecary due to a new intake design listed above.** We have kept the description of the second intake below to showcase our design iteration.

To further maximize NOTES coming into our possession, our design included a secondary intake in our design. Identical in concept to the Primary Intake, but with slightly different geometry, the Secondary Intake feeds into the Shooter through the flywheels, the same method of loading from the SOURCE with our Human Player.

PIVOT



OVERVIEW

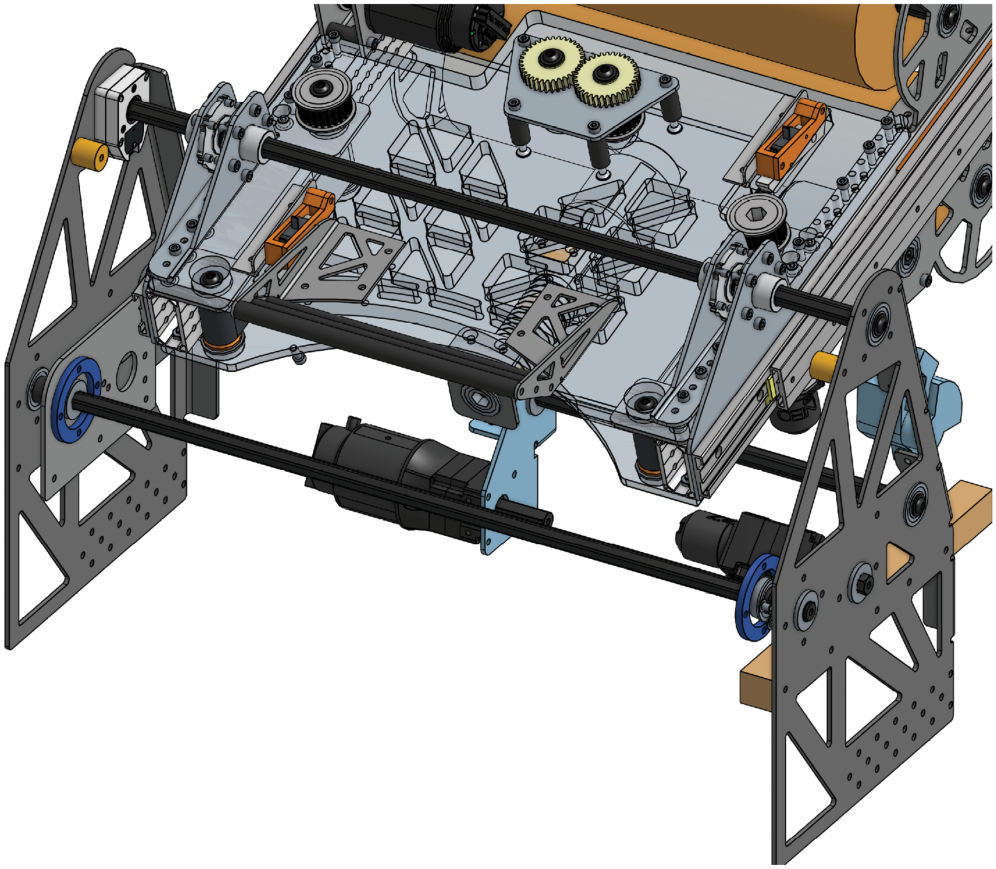
The Pivot controls the angle of our Shooter and the trajectory of the NOTES fired. Because this is essential to our gameplay this year, the Pivot is powered by two Falcon 500 motors on a common shaft to keep the Pivot as steady as possible

DESIGN

- Part of superstructure & shooter
- Assists shooter to manuver to both intakes

HOW IT'S DESIGNED

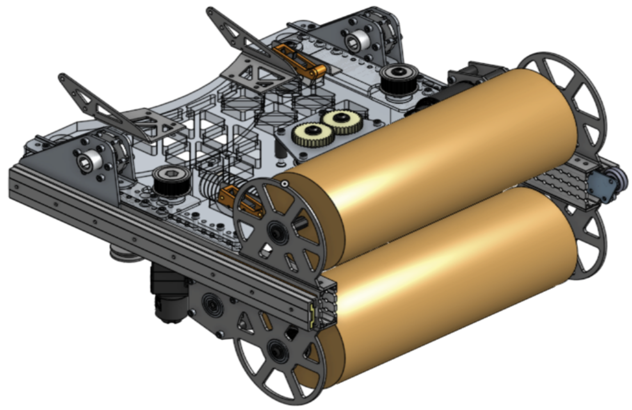
- 2 Falcon 500s
- Hex Shafts
- Aluminum



SHOOTER

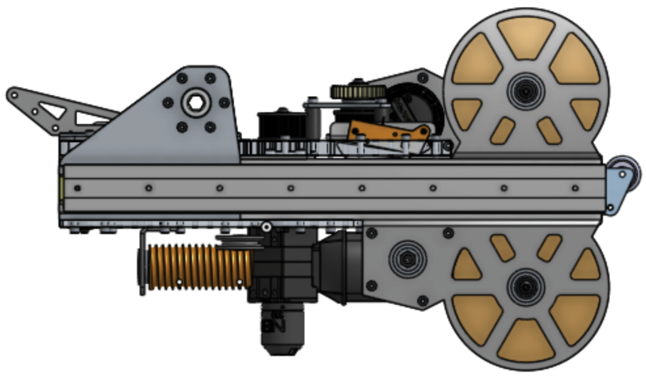
DESIGN

- Pivoting integral part of the design
- Double manipulators for both intakes



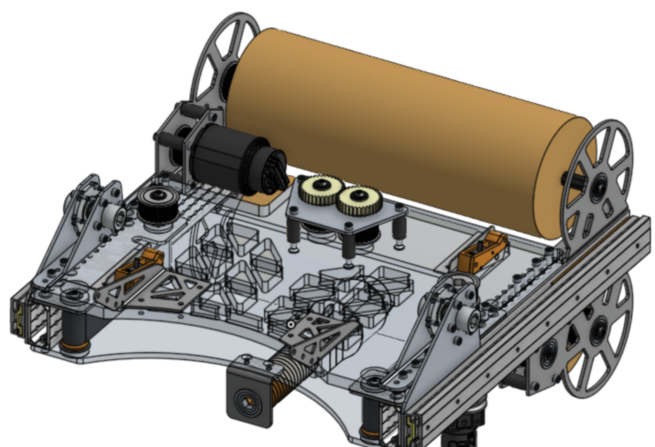
HOW IT'S DESIGNED

- Aluminum
- ¼" & ½" Polycarb as required for design
- Powered by
  - 2 Falcon 500s – flywheels
  - 1 NEO 550 – trigger mechanism



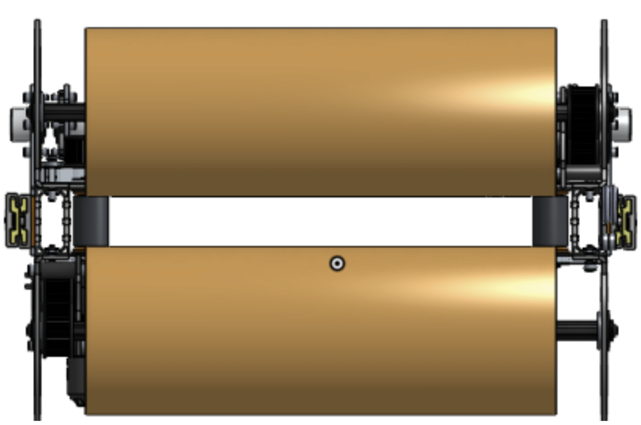
OVERVIEW

To ensure our FRC 2024 shooter meets the demanding requirements of the game, our team has designed a compact yet powerful subsystem. Our shooter prioritizes accuracy, consistency, and power to launch NOTES into the speaker accurately. In addition, the shooter's design allows it to seamlessly integrate with our flipper mechanism, maximizing efficiency and versatility on the field.



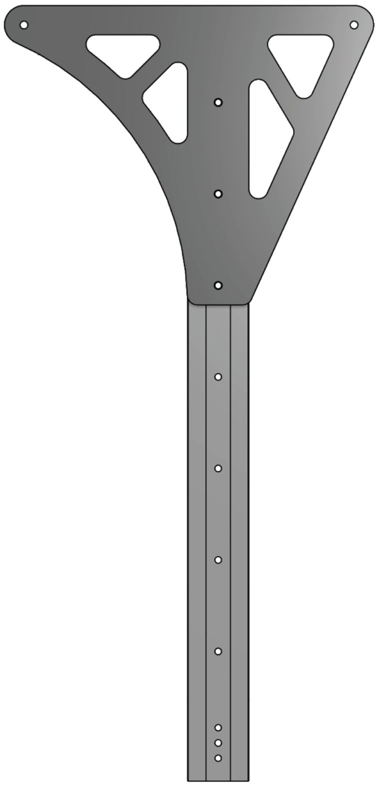
The design features dual horizontal rollers operating at a 1:1 ratio, driven by two Falcon 500s to maintain consistent velocity and accuracy. Additionally, a NEO 550 motor powers the trigger mechanism, ensuring precise control over the release of game pieces.

ACCOUNTING WEIGHT



When designing the shooter, our main concern was its weight on the robot. To reduce weight concerns, our team introduced precise lightning geometry to cut out holes while keeping foundation of the mechanism strong. Our triangle designs in the shooter later became a common theme for the robot to help reduce weight.

CLIMBER



OVERVIEW

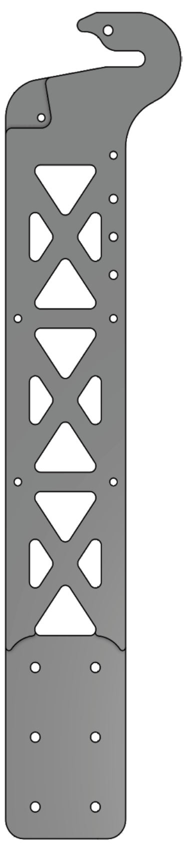
Our climber posesses two hooks that extend off the shooter and push open the trap door. Two other hooks rotate up from the Superstructure and then rotate back down to pull the robot off the ground, Our Bumpers support us against the Trap Wall to hold the robot steady while climbing.

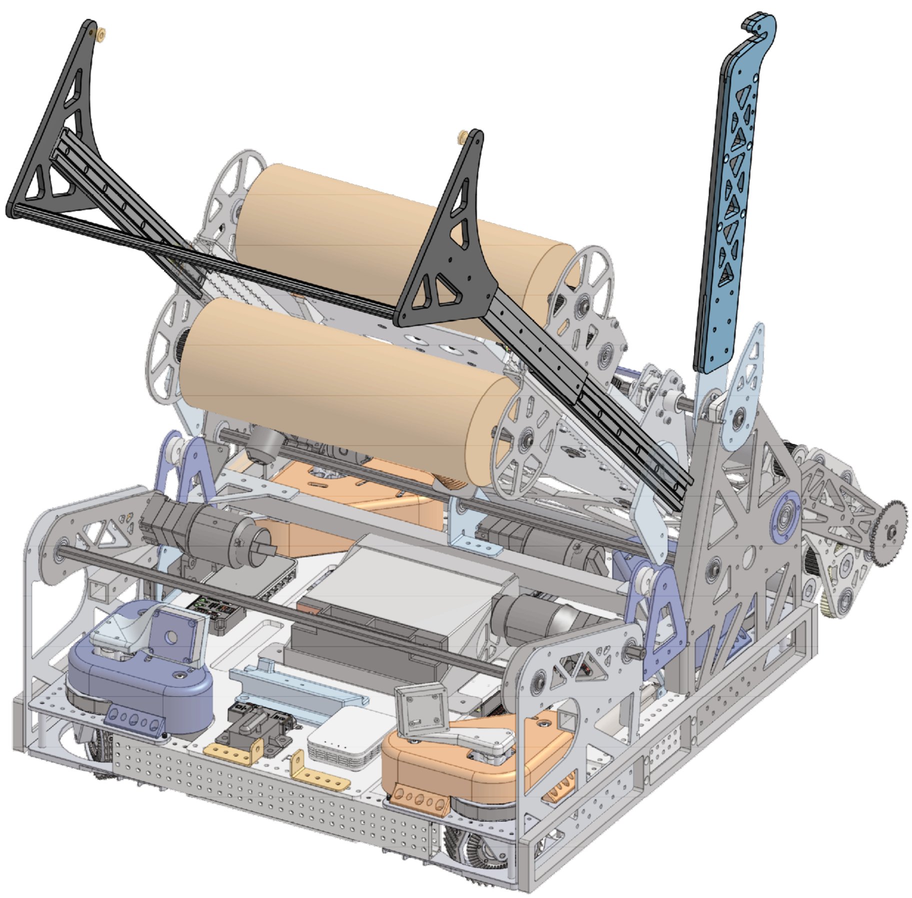
DESIGN

- Two climbers to balance robot for TRAP
- Custom designed hook for hanging ON STAGE
- Roller mounts to glide against STAGE

HOW IT'S DESIGNED

- IGUS Sliders
- Springs-powered extension, motor powered





SOFTWARE THEORY

STATE MACHINES

The Robot this year functions on the basis of robot states instead of using the standard command based framework. Each mechanism has all of it's operating conditions specified in a set of states, and the states have preconfigured transition routes between them to avoid robot damage. This approach makes robot control more predictable and easier to implement.

VISION

The Robot has a PhotonVision equipped Raspberry PI X that takes in data from X cameras on the robot, this near 360 degree vision system allows the robot to correct for odometry drift and to quickly and accurately determine its position on the field.

AUTOMATION

The Robot's mechanisms are equipped with encoders that are constantly monitored by the control loop so that mechanisms will automatically move out of each other's way. The robot also has several automations that allow the robot to be operated with as few human interactions as possible for less input error and greater cycle times.

MAWNE EVENT UPDATE

GENERAL CHANGES

1. Updated all CAD photos to their most current iteration
2. Fixed spelling mistakes in opening paragraphs
3. Updated instances of previous designs within the Strategy section

INTAKE

Updated Intake page to include recent changes:

- Team has decided to not pursue a double intake akin to the original Design C listed in our strategy section
- Team has built upon design to include Intake V2, now listed in the main pages

~~Intake #2~~	~~03/01~~	~~???~~								

DIVERTER

- The team has decided to not pursue the Diverter, thus it has been removed from the current technical binder

CLIMBER

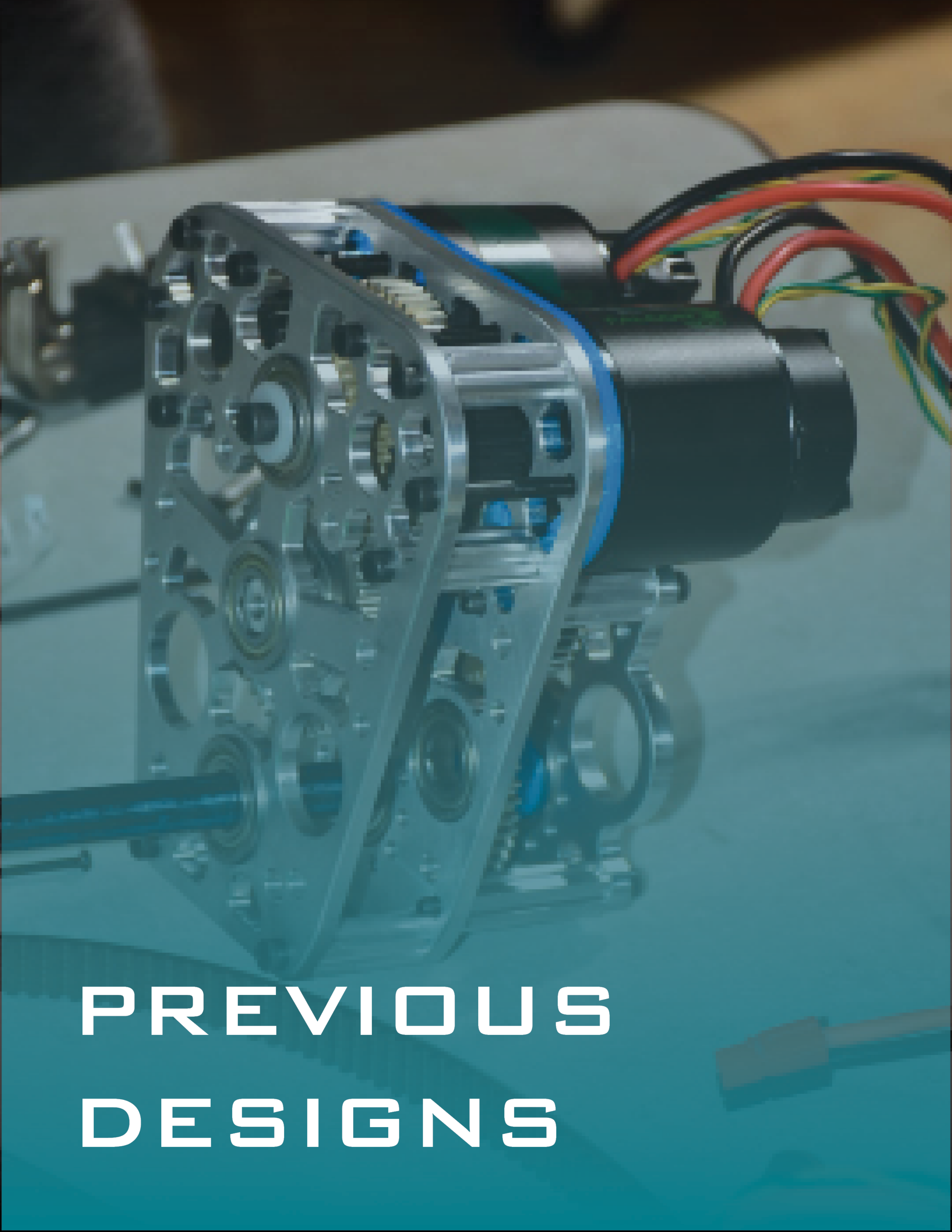
Updated Climber page to include recent changes:

- Team has decided to not pursue the Waterbury design due to incompatibility
- Team has decided to pursue a double climb design that includes a lift and arm to do TRAP

INTAKE

Updated Intake page to include recent changes:

- Team has decided to not pursue a double intake akin to the original Design C listed in our strategy section
- Team has built upon design to include Intake V2, now listed in the main pages



PREVIOUS DESIGNS

OVERVIEW

PEACCE recognizes that robot design and construction is a constant and ongoing process. Therefore, it's nessecary to change the robot in order to play the game to its maximum. This section details each iteration of each mechanism that updated.

WHY DETAIL EACH ITERATION?

Each iteration of the subsystems provides an insight to what went right, and what didnt. By including each iteration, we can educate future members about past designs and accomplishments.

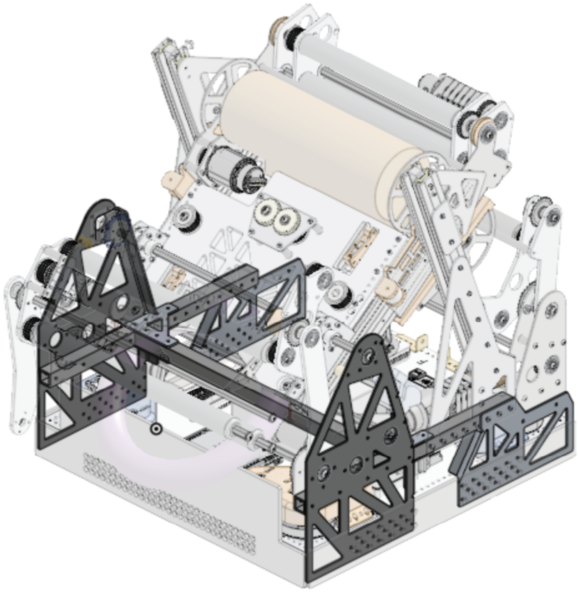
SUPERSTRUCTURE V1

OVERVIEW

With a small robot, our team created a aluminum frame superstructure between the drivebase and bumpers. This allows for easy mounting, servicability for both mechanical and electrical, and assist with electrical wiring both inside & outside on the sides.

This superstructure was utilized at the 2024 NE District Waterbury Event.

We added on new sideplates to carry the climber and rollers for the STAGE.

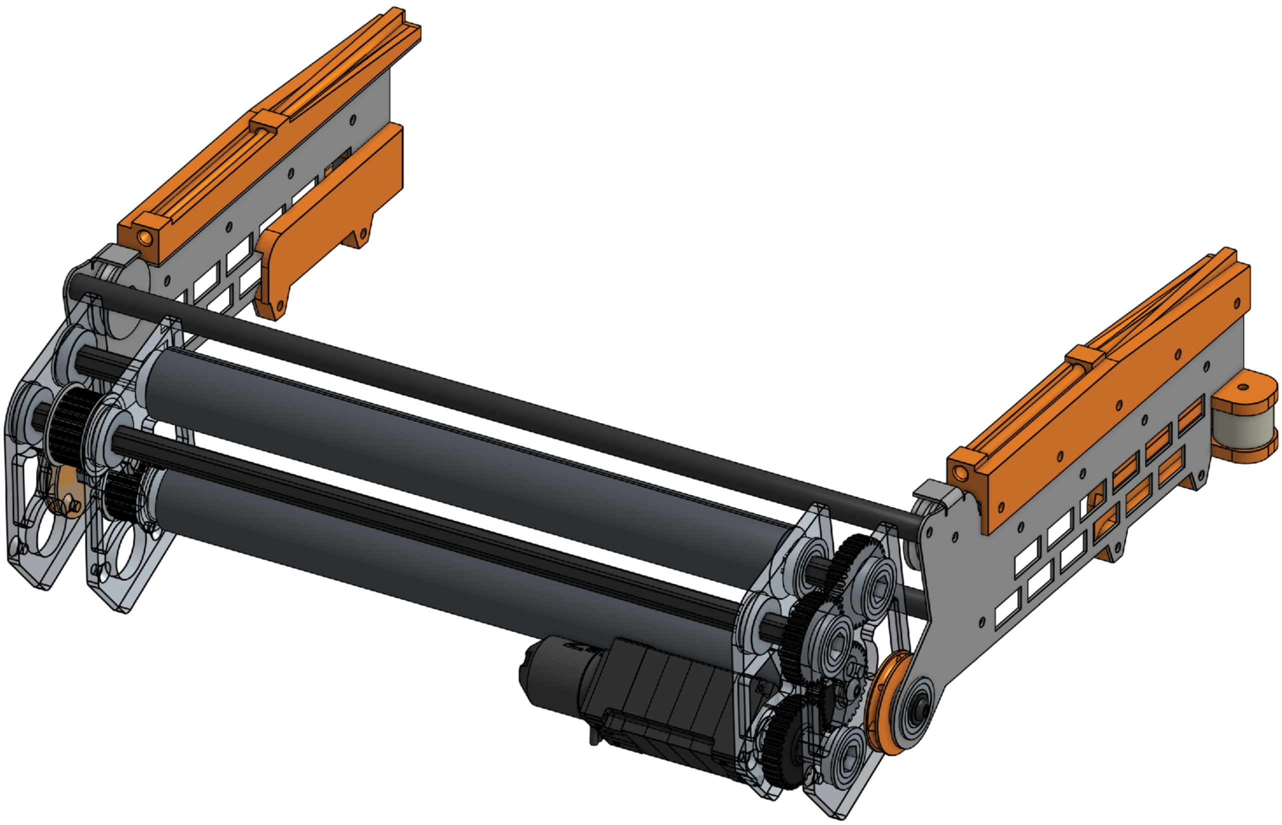


DESIGN

- Strong to hold all mechanisms
- Spaced out to not interfere with mechanisms
- Allow easy access into electrical panels

HOW IT'S DESIGNED
- Custom aluminum frame
- 24" length for whole robot

DIVERTER



OVERVIEW

The Diverter is our mechanism for the AMP and TRAP. This mechanism is designed to be an attachment, sitting above the Shooter and allows NOTES to fly below it and it drops down when ready to score in the AMP or TRAP.

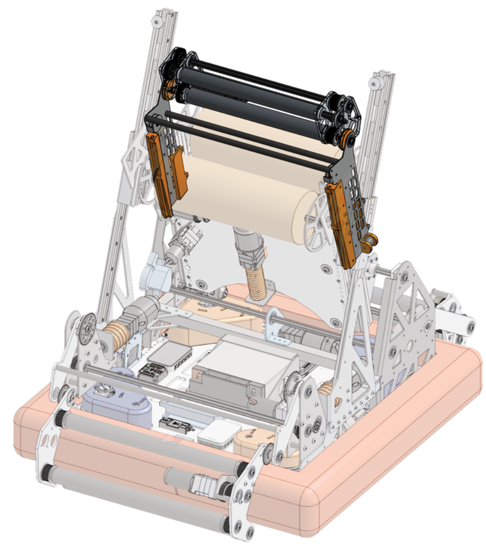
This idea was never played in official competition. We switched to a lightweight mechanism.

DESIGN

- Mounted to shooter on IGUS sliders
- Extends out to score game pieces

HOW IT'S DESIGNED

- Springs-powered extension, motor powered retraction
- 2 Motors:
  - Falcon 500: Controls extension and rotation
  - 775: Controls handoff

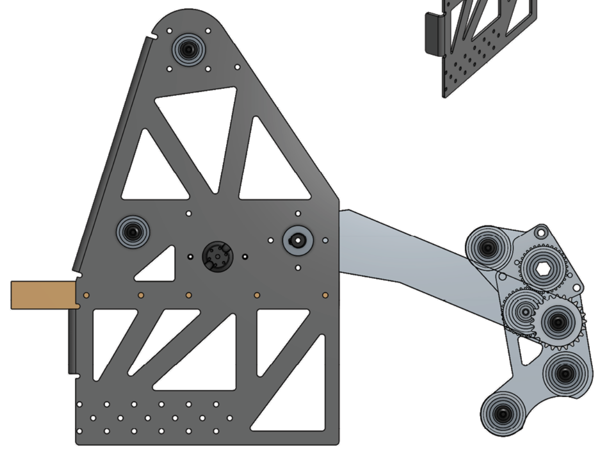


INTAKE(S) V1

DESIGN

- Serves as primary intake for picking NOTES
- Hands NOTES to the Shooter via the Trigger
- Functions in tandem with the Shooter via code automations

OVERVIEW

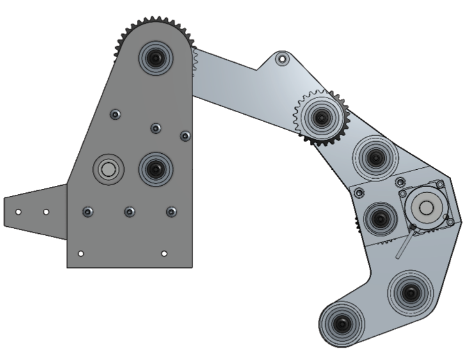


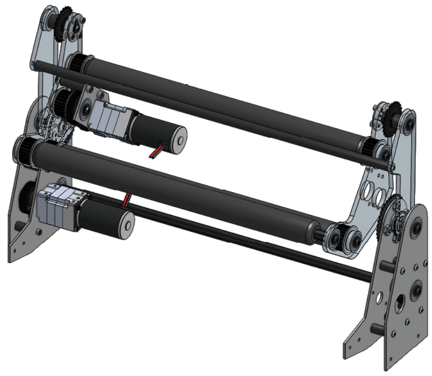
To maximize the possibility of NOTES coming into our possession, our team uses three full length rollers. The virtual four-bar intakes NOTES that can be directed into our Shooter; they're positioned facing inward into our bumpers, pushing toward the center. Both the rollers and the machined profile on the Shooter's trigger side are used to maximize the NOTES will come into our possession. Our intake is held up by two custom made polycarbonate arms with two bars that spin to direct notes into our traversal. Furthermore, this intake is powered by a Neo 550. By using a Neo, we can quickly move our arms up and down, precisely to the correct position to fit the NOTES within the Shooter as fast as possible.

After the NE District Waterbury event, we decided to change the intake to be more reliable and have less issues with the shooter pivot.

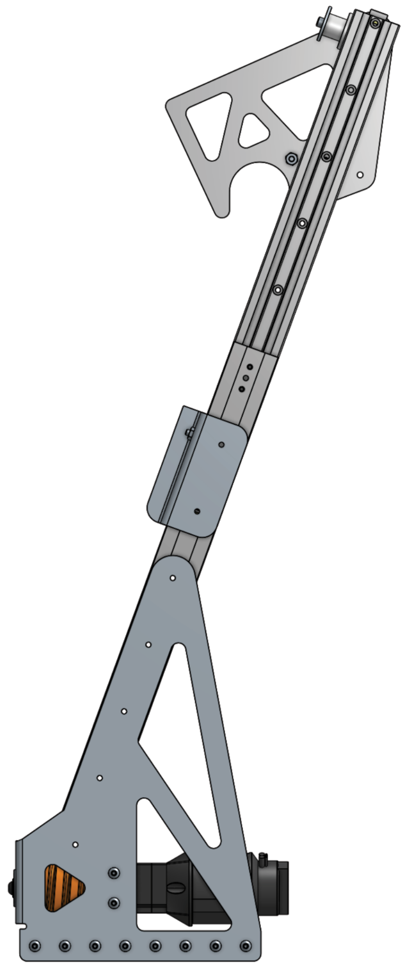
SECONDARY INTAKE

To further maximize NOTES coming into our possession, our design included a secondary intake in our design. Identical in concept to the Primary Intake, but with slightly different geometry, the Secondary Intake feeds into the Shooter through the flywheels, the same method of loading from the SOURCE with our Human Player.





CLIMBER V1



OVERVIEW

When designing our climber, we looked to past designs in order to tackle the challenge. We looked to climbers that we've built in the past, yet could be modified for holding the chain. For our 2024 climber, we took inspiration from our 2022 climber, and added on support for the super structure. One noticable change was the larger hook to account for the chain. Our two hooks allow us to level the robot off of the floor. The hooks are also centered, allowing us to do TRAP at the same time.

We were not able to utilize this design for our Waterbury competition due to design incompatibility.

DESIGN

- Two climbers to balance robot for TRAP
- Custom designed hook for hanging ON STAGE

HOW IT'S DESIGNED

- IGUS Sliders
- Springs-powered extension, motor powered retraction