FIRST TECH CHALLENGE

Electric Quahogs

2023 - 2024 Season Engineering Portfolio

CENTERSTAGE℠

PRESENTED BY RTX

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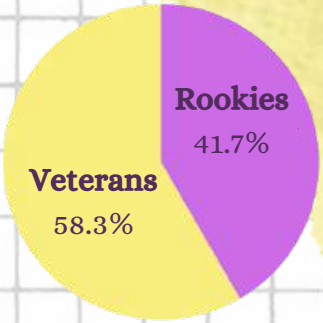
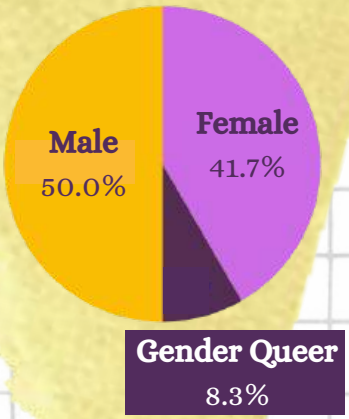
Content for Judged Awards

Think: 5, 6, 7, 8, 9, 10, 11, 12
Motivate: 3, 14
Design: 6, 7, 8, 9, 10, 11,12
Connect: 3, 4, 5, 15
Innovate: 6, 7, 8, 9, 10, 11, 12
Control: 13





Team Details

- Based out of the Wheeler School in Providence, Rhode Island
- Established in 2007
- Team of 12 members
  - Biggest our team has been in 3 years

We pride ourselves on the multifaceted skills of our members, encouraging people with a wide range of interests to consider joining. We emphasize how important every aspect of FTC is to participation, such as operations work, visual design, marketing, etc.

Our practices are a mixture of in and out of school time. On Tuesdays during the school day, we have a 45-minute “Enrichment” period. During this time, we focus on our outreach, operations, and research work; grounding us in the non-engineering aspects of FIRST. Monday, Wednesday, and Friday are days that members can come in after school. This mix of in and out-of-school time allows team members to efficiently devote what time they have to the team.

Our Team

Mayte Segura
Co-Captain ‘24
She/Her

Beatrice Schroeder
Lead Builder ‘24
She/Her

Lily Thornton
Editor ‘24
Xey/He/She

Daniel Duarte-Baird
Co-Captain ‘25
He/Him

Charles Shea
Co-Lead Designer ‘25
He/Him

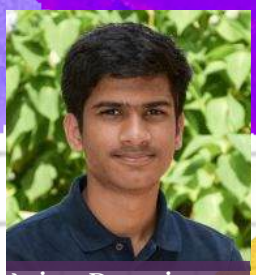
Aaron Felzenszwalb
Programmer ‘25
He/Him

Luyao Lei
Co-Lead Designer ‘26
She/Her

Sabrina Andreu González
Lead Operations Coordinator ‘26
She/Her

Kailash Saxena
Builder ‘27
He/Him

Amelia Collins
Builder ‘27
She/Her



Arjun Dasari
Builder ‘27
He/Him

Kilian Maddock
Builder ‘27
He/Him

Coach & Mentors

Dylan Ryder
Coach
Director of Design Innovate Build Lab, Wheeler School

Sophie Ginsberg-Hayes
FTC 2856 & FRC 8032
Building and Outreach Mentor

Napali Raymundo
FTC 4174
Programming and Building Mentor

Zoe Rudolph-Larrea
Operations and Outreach Mentor

Sustainability Plan

Pre-Season

As a soft entry to the season, we hold Pre-Season Workshops during the last week of summer break. During this week, new and returning members establish a learning-friendly environment where veterans are able to well-equip interested students for the upcoming season with introductions to skills like programming, building, CAD, fundraising, and operations. This time also acts as a head start for returning members to begin working on outreach and expand their technical knowledge.

Recruitment

When recruiting, we consider the diverse roles we need to fill. To meet this need, we especially encourage those intrigued by less technical jobs such as outreach, graphic design, and operations.
Providing a better opening for less experienced students is also essential. To do so, we ensured that our Pre-Season schedule was flexible enough to offer an opportunity for new students to get experience in whatever field they wanted regardless of their schedule.

Monday 8/28	**Tuesday** 8/29	**Wednesday** 8/30		**Thursday** 8/31	**Friday** 9/1	
9-10:15 Welcome to Wheeler Robotics	9-10:15 CAD [1]	9-10:15 Programming [1]	9-10:15 Mechanical & Building [2]	9-10:15 Documentation & Judged Awards	9-10:15 Fundraising	9-10:15 Programming [2]
10:15-11:30 Welcome pt.2	10:15-11:30 Mechanical & Building [1]	10:15-11:30 Community Outreach		10:15-11:30 Mechanical & Building [3]	10:15-11:30 CAD [2]	
Lunch	Lunch	Lunch		Lunch	Lunch	
12:30-1:45 Robot Game Demo ("Driving")	12:30-1:45 Team Building Field Trip	12:30-1:00 Social Media, Marketing & Online Content		12:30-1:45 Team Building Field Trip	12:30-1:45 Game Strategy & Scoring Analysis	
		1:15-3:00 Open Time				
1:45-3:00 Open Time	1:45-3:00 Open Time			1:45-3:00 Open Time	1:45-3:00 Open Time	

Finances

To keep track of our finances we maintain a spreadsheet where we record our income and expenses. With the dedicated time we have assigned to our operations work on Tuesdays and the soft introduction our pre-season provides the team, we have gained a variety of sponsors and gracious donors.

Income

Grant / Donor Name	Amount	Date
Wheeler School	$1,000.00	9/1/2022
REV Robotics	$150.00	9/15/2023
Dassault Systems	$2,500.00	10/3/2023
Providence Engineering Society	$500.00	1/12/2024
Total Grants & Donations		**$4,150.00**

In-Kind Services

In-Kind Services	Amount	Date	Notes / Follow Up
GT3 Creative Inc.	$200.00	2021	Free vinyl banner
Metal Supermarkets of Warwick	$122.89	1/10/24	Free sheet of 1/8th" 5052 grade aluminum
Precision Laser Inc		1/2/2023	Cut aluminum parts for free

Expenses

Item	Vendor	Cost	Date Paid	Notes
FIRST Registration	FIRST Inc.	$295.00	7/11/2023	
Centerstage Game Set	AndyMark	$460.00	9/11/2023	**$460** Full / **$350** Half +54.72
Robotics Parts	GoBilda			$98 Linear Slide Kit
Powder Coating	Ocean State Powder Coating	$100.00	1/25/2024	Retail Price: $574.02
Qualifer Registration Fee	RI-FIRST	$150.00	12/10/2023	**$135** due: Dec
State Championship Registration Fee	RI-FIRST	$250		
Total Expenses				**$1,255.00**

Finances

The Electric Quahogs was one of the 32 chosen out of 2,000 FTC teams to receive a sponsorship from REV Robotics this year. Along with a gift card to REV Robotics products, the sponsorship allows our team to receive even more prizes, as long as we complete milestones that are guided to promote REV and FIRST, and help the general public. Being a part of the #TEAMREV family is a huge honor for us, as it helps us to flourish as a team and to continue the impact we have on the community.

PRECISION LASER, INC.

TEAM REV

DASSAULT SYSTEMES

PROVIDENCE ENGINEERING SOCIETY · 1894 ·

OSPC

Discounted Service

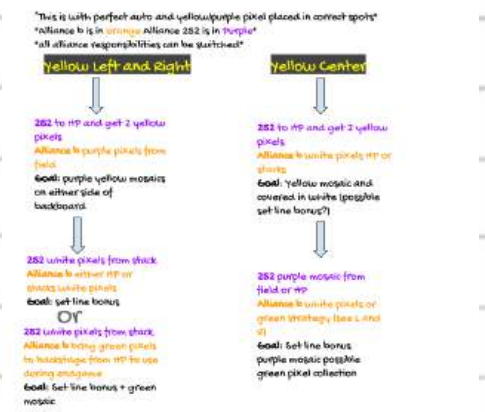
GT3 CREATIVE

METAL supermarkets

The Convenience Stores For Metal™

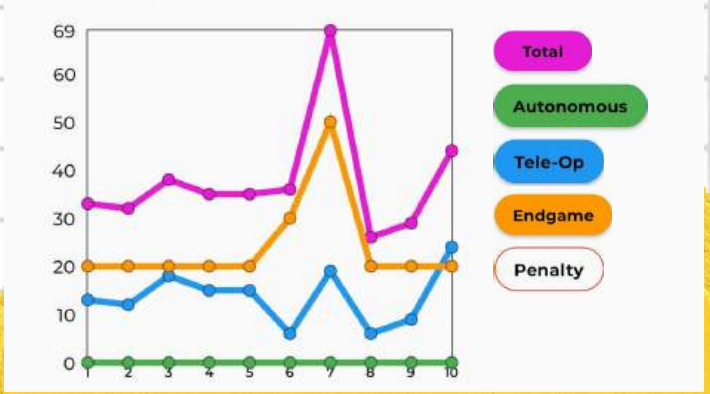
Game Strategy

At the start of the season we chose to focus on refining our end-game strategy due to the unpredictable nature of the game this year, as they were elements that we could control. In doing so, we have been able to secure consistent robot performance in this time period.



We also worked on communication within the whole drive team. Streamlining communication between human player and coach with hand signals and verbal confirmation to signal how many pixels the robot is in possession of, and pre-set action plans to keep in mind in a variety of scenarios.

Between qualifiers and states, we studied and researched matches from the first two qualifiers to fine-tune our strategies and provide insight on how to support our alliance partners best. We compiled this data into charts and graphs for easy use.

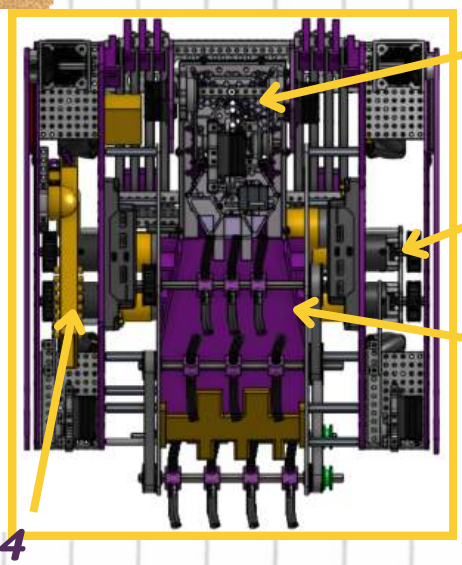


Robot Overview

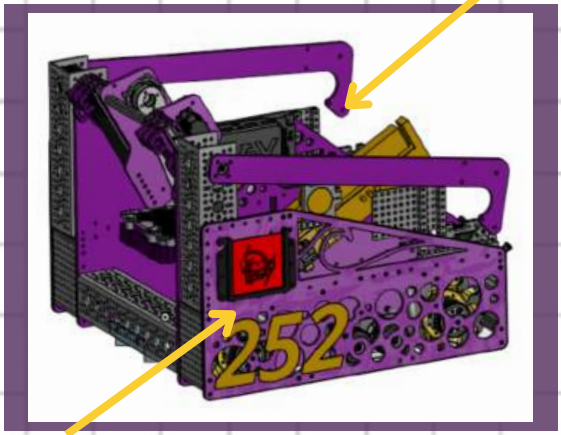
Key

1. Active Intake
2. Deposit
3. H-Chassis
4. Drone Launcher
5. Hang Arms
6. Custom Side Plate

Top View



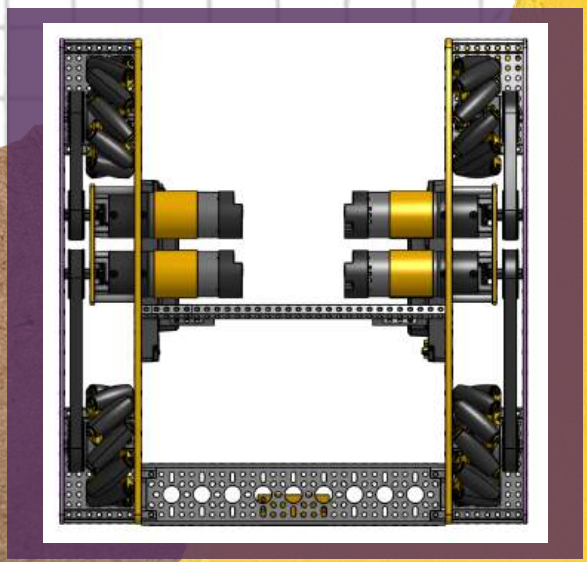
Side View



- Maximized maneuverability
  - 14.5" x 17" x 12" robot to fit under and between trusses
  - “Through robot” design - minimize unnecessary rotation

Chassis

“Our chassis was optimized for drivability and efficiency. We designed it to be as small as possible to easily fit under and between trusses, but large enough to fit all the necessary components.”- **Charlie, Co-Lead Designer**



- H-shaped chassis
- Custom drivetrain plates
- Belt-driven Mecanum wheels
- Custom drivetrain pulleys

6 - Think and Design Awards

Design Process

1 -Brainstorming
We identify a goal we want to achieve, then brainstorm while researching and evaluating mechanisms for their effectiveness and efficiency in completing the task.

2- Prototyping
Concepts are then quickly prototyped with materials like cardboard to provide immediate feedback on a design.

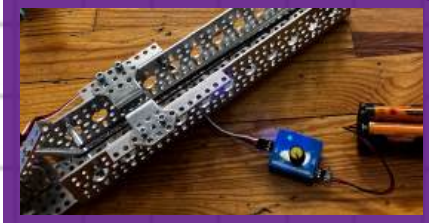
3 - CAD/Design
Then they are digitally fabricated with CAD using information gathered from research and the original prototype.

4 - Building
Mechanisms are then assembled using the CAD model as a reference.

5 - Testing
Effectiveness of the mechanism is tested and recorded to see how efficient it is.

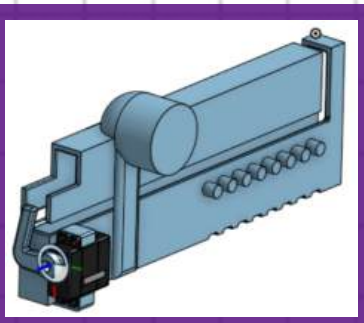
Repeat

Drone Launcher Case Study



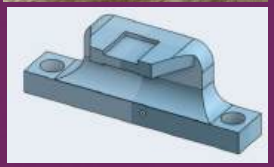
Using the 1st iteration of our drone launcher we established criteria
1. Needs to be able to fit on the robot
2. Needs to be reusable and consistent - no ripped rubber bands or planes
3. Needs to have a controllable release mechanism

The next iteration used surgical tubing and structural channel. However after qualifiers we realized
- The drone would fall out
- Difficulty reloading
- Surgical tubing would tear



Our current iteration is a custom 3D printed case, which allows for
- A safe and secure drone
- Adjustability with
  - Angle mounting
  - Rubber band Tensioning

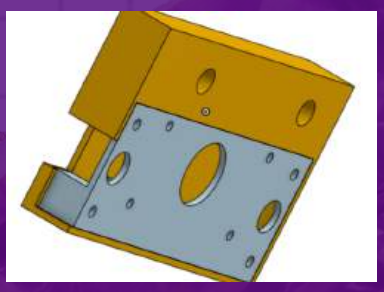
Camera Mount Case Study



The first design was only held into the casing by friction. It was bulky and clunky.

78% decrease in volume

The camera needs to fit into a small space to view the team element and AprilTags. To minimize volume we removed the plastic case. This allows for an incredibly small printed mount that is 55mm by 20mm by 7.7mm.

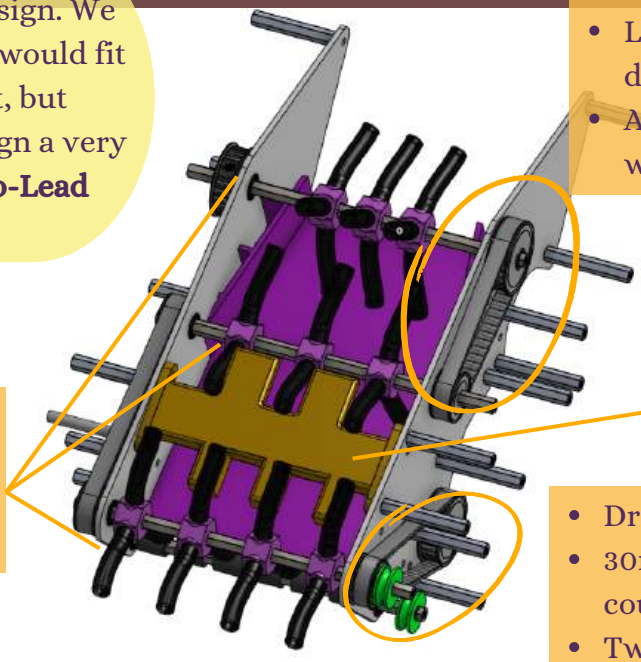


This is the final design. Holes for the wires and screws were added for the mounting location. One additional benefit of this design is that all connections use screws.

8 - Innovate, Think and Design Awards

Intake

"The intake was probably the most difficult part of the robot to design. We had trouble figuring out how it would fit in with the rest of our robot, but eventually we were able to design a very elegant solution!" - **Luyao, Co-Lead Designer**



- Three spinner axles and one counter roller to bring pixels up
- Upward slope of 30°

- Last line of spinners is slowed down with a 2:1 pulley ratio
- Attached to the inner plates with standoffs

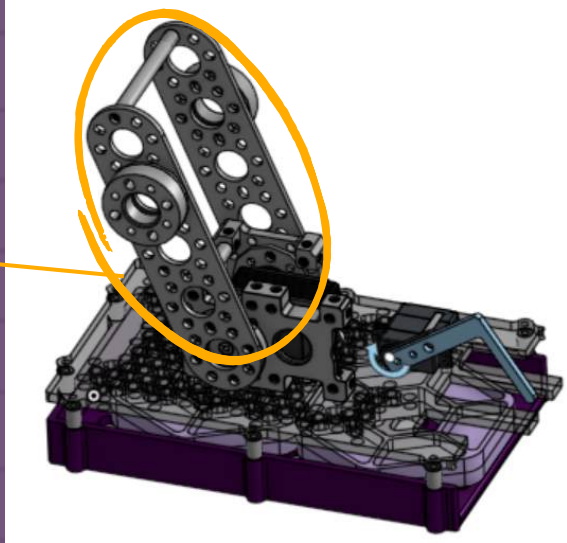
- Intake hood to prevent pixels from ejecting
- During qualifiers, we noticed pixels were escaping the intake, so we designed this cover to prevent that

- Driven by one torque motor
- 30mm-22mm pulley wheels for counter roller
- Twisted pulley belt to invert the counter roller's rotation

Deposit

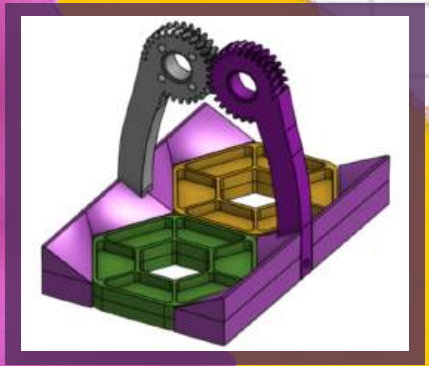
Arm

- Two points of rotation
- Two servos at the top: rotate the arm through the slides
- One servo on box: tilt the box further in order to reach desired drop off angle



Pixel Container

- Fits two pixels
- Top and bottom have small hexagonal cutouts for driver visibility and weight reduction
- Top has long cutouts to avoid last row of spinners and to block pixels from flying out
- Micro servo with pivoting latch to prevent pixels from falling out

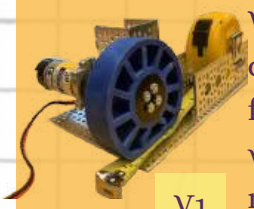


Previously, instead of a pixel container, we designed a claw, but we realized that because it didn't have a top, the pixels wouldn't be able to reliably make their way inside. To solve that problem, we changed our design to a box, that way the pixels could all be funneled into a closed space for depositing.

Hang

9 - Innovate, Think and Design Awards

Initial Designs:



V1

We started by researching different hang mechanisms from past games. We started with testing a tape measure mechanism but it did not have enough torque to life the bot

V2

For the scrimmage, we used a lead screw assembly from Go-Builda. But it was not tall enough to reach the truss.

Current Mechanism

- Two independently driven arms on either side of the chassis
- Custom CAD-designed aluminum arms
- Driven by 5203 Yellow Jacket 188:1 gear ratio motors

V3 - Final Iteration

Challenges and Solutions

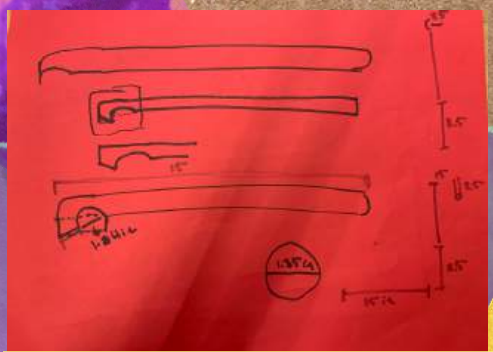
After the scrimmage we moved on to design custom arms. When creating them we ran into some challenges and tried to improve upon issues we noticed the lead screw design had.

Challenges with V1 & V2

- **Material:** While the medium-density fiberboard was good for many iterations it was not strong or durable enough to sustain through a whole competition season
- **Power:** We needed to decide what motors and gearing system would provide enough torque to lift our robot consistently
- **Height:** The lead screw hook was too short to reach the truss

Solutions

- **Material:** We switched to laser-cut aluminum which is much stronger and durable
- **Power:** Multiplied the robot's weight (about 10kg) by 2.5 to get the stall weight and compared it to stall torque on GoBuilda motors, which led us to use two 5023 Yellow Jacket 188:1 gear ratio motors.
- To add even more torque we mounted the arms with crown gears.
- **Height:** Used field measurements and geometry to create a custom arm that would reach



Sketches with Measurements

3
Hang Iterations

Materials

10 - Think, Design and Innovate Awards

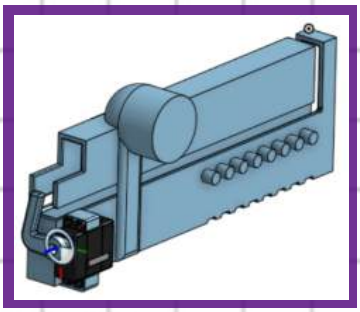
Drone Launcher

This plane design is similar to the traditional dart, however has been modified to be small and be durable to allow for reusability by folding the paper horizontally

"Creating the drone launcher as a rookie really helped me learn the iterative design process, as well as learn different technical skills such as CAD "
- **Arjun, Rookie**

9
Drone Designs

6
Launcher Designs



This design was inspired by Blue Bot Builder - 14380. We changed the mounting mechanism and the rubber band tension to have more variables to reach consistency.

Since our qualifier:

- **3D printed** a full cover to keep the plane from falling out
- Completed **extensive testing** to determine tension, angle, and distance

80+
Drone Tests

90%
Scoring Success Rate

Key

Tension - Notch closest to point of rotation is 1 and so on

Angle

Black - 70
Red - 65
Purple - 60
Blue - 50

Airplane	Rubberband Size	Tension	Placement	Angle	Zone	Misses
Dart	length - 8 cm Thickness - 0.5 cm Tan	3rd	Pixel line	Purple	zone 3 zone 2	
Dart	length - 8 cm Thickness - 0.5 cm Tan	3rd	Pixel line	Blue	zone 3	
Dart	length - 8 cm Thickness - 0.5 cm Tan	4th	pixel line	blue	zone 2 zone 1 zone 2 zone 1 zone 1	5
Dart	Length - 8 cm	4th	Pixel line	Blue	zone 1 zone 1 zone 1 zone 1 zone 1 zone 1	3

Digital Fabrication

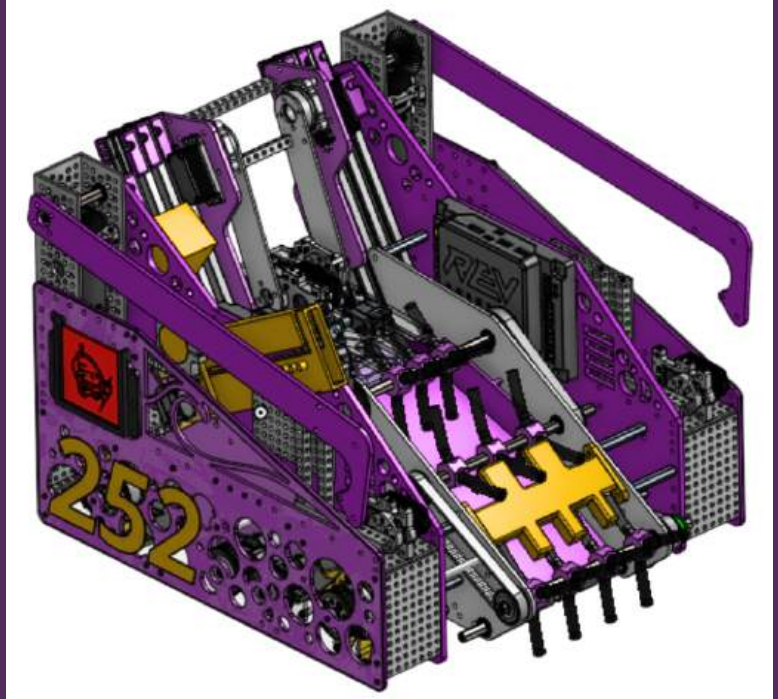
One of our major goals this year was to grow our digital fabrication skills, and much of that growth is reflected in our robot. We use a CAD software called Onshape to document our design process and to create custom parts in a simulated environment, allowing us to make changes to our designs efficiently and quickly. The finished CAD also acts as an instruction manual to help the builders put together the robot, as well as keep track of what parts we need.

70+
3-D printed parts

13
laser cut parts

200+
CAD hours

Digital Fabrication



Custom Parts:

- Chassis side plates (6)
- Hang arms (2)
- Active intake plates and ramp (4)
- Active intake hood (1)
- Spinner-axle attachments (20)
- Custom spacers (12)
- Mecanum wheel pulley attachments (4)
- Pixel container (2)
- Deposit servo mounts (2)
- Belted slide attachments (16)
- Pixel pusher (1)
- Battery holder (1)
- Custom camera (2)
- Alliance markers (2)
- Intake pulleys (5)
- Drone launcher (1)
- Echain mount (1)
- Acrylic plate covers (2)

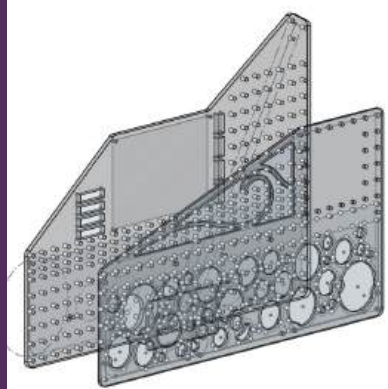
3 Chassis Iterations

6 Plate Designs

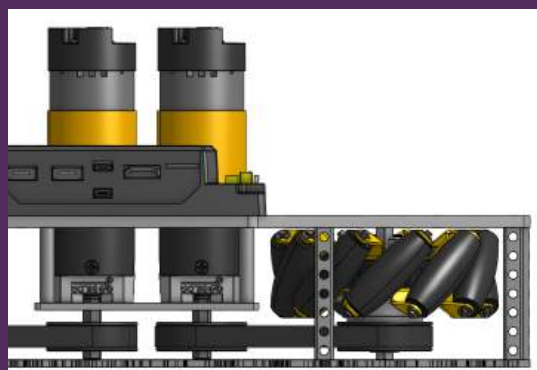
Chassis

One of our main goals this season was to create a chassis that could easily fit under and between the trusses. We used OnShape, which enabled us to design a chassis that would be small enough for these requirements, but big enough to fit all the necessary components, such as the active intake, deposit, drone launcher, and hang arms. Using OnShape to fully lay out our robot design in CAD before building made sure we could design a very drivable bot that can score in a variety of situations while being as space-efficient as possible.

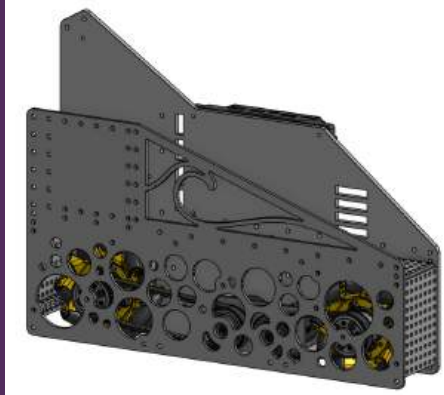
Chassis plate design



Motors sunken 32mm



Chassis pod with drivetrain components



12 - Think, Design and Innovate Awards

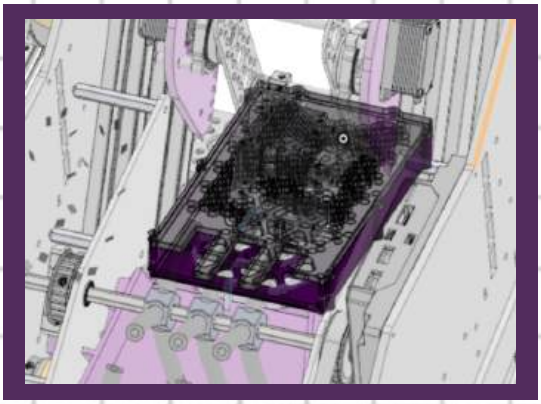
Digital Fabrication

Deposit

During and after qualifiers, we realized that pixels were falling off the backdrop during deposit. So, we altered the pixel container arms to be longer, that way the container would be flush against the board, and no pixel would drop.

As part of our arm, we needed to add spacers in order to space it correctly from the slides. Having the CAD allowed us to figure out exactly which size spacers we needed right away instead of guessing and checking.

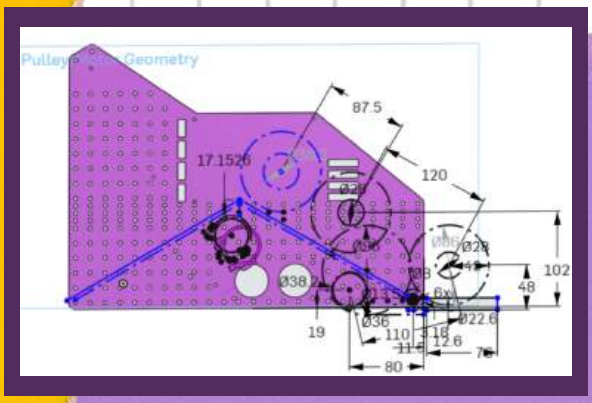
In CAD, we were able to make the pixel container the perfect size because we could import pixels into the CAD and design around them.



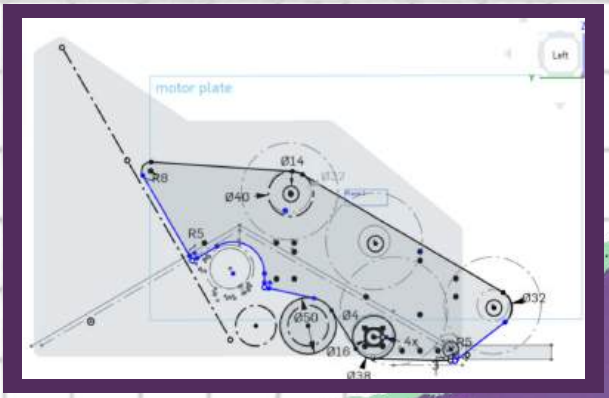
3 Deposit Iterations

4 Intake Iterations

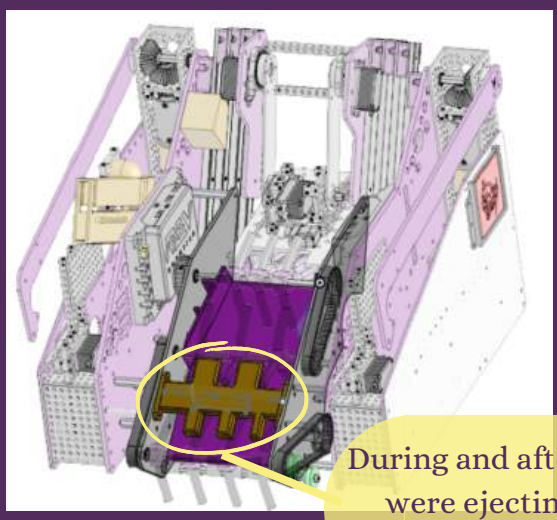
Active Intake



In the CAD, we were able to make the pixel container the perfect size because we could import pixels into the CAD and design around them.



We started off the active intake with a basic sketch of all it's components, such as the motors and pulleys. We created this sketch in context to the rest of the robot, so that we knew what space we had to work with. Onshape helped so much during this process, as we were able to measure the distances between the components and were able to build directly off of the model.



Then, we drew an outline of the plate around all the components of the active intake. The previous sketch was really important because it mapped out the borders of the side plate. It also helped us realize that one of our pulleys were not far out enough, saving time in the long run.

During and after qualifiers, we noticed that pixels were ejecting out of the active intake. So, we designed this hood to prevent that.

Programming

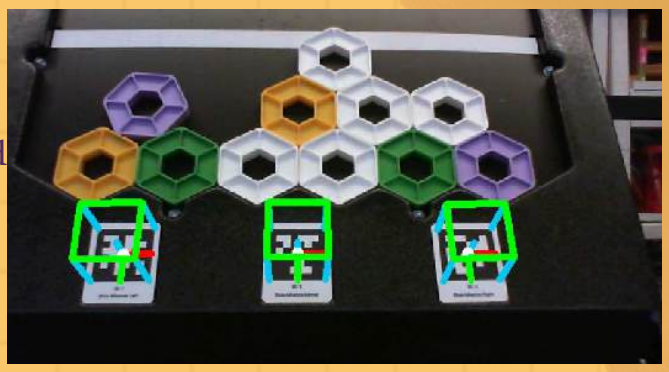
35 Custom Spline Paths

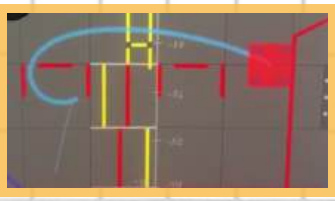
10 Sensors

7 Key Algorithms

5,000+ Lines of Code

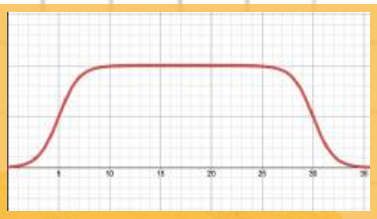
We have a plethora of different autonomous paths, to account for the variety of actions our alliance partners may take. We detect our prop with a color-isolating vision algorithm, and then place purple and yellow pixels in their corresponding places. After that, if our partner's path allows, we can pick up 2 white pixels from the stacks, and deposit them on the backdrop before parking in the backstage. All the while the robot updates its subsystems asynchronously, and localizes with odometry pods/looking at the AprilTags on the backdrop to ensure we know where we are on the field.

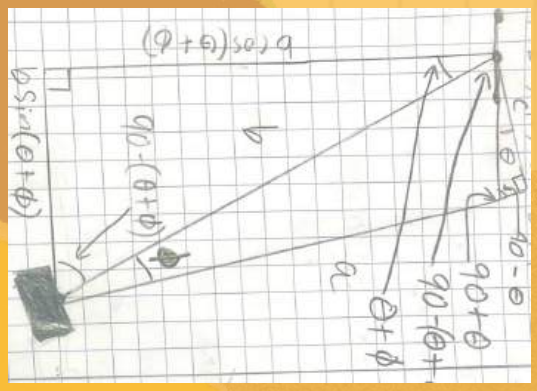




We use custom formulated splines for autonomous pathing. We have figured out the optimal path for our robot to take for each opmode while maintaining a robust autonomous period.

One of the many driver controlled enhancements on our bot is a sigmoid function modifying the power curve of our linear slides. This ensures our drivers can use the linear slides at high speeds without overextending them at either the top or the bottom.





One major challenge we ran into this season was some trigonometry associated with AprilTag localization. The problem is rooted in the fact that the information given in the FIRST SDK for AprilTag readings was robot-centric, while we wanted our field-centric position. To overcome this we created mathematical drawings, carefully mapping all the robot-centric and field-centric information in one place. It required many iterations to get it right, but once we did the trigonometry we were able to greatly increase the robustness of our autonomous period.

14 - Motivate and Connect Awards

Outreach: Motivate

Our team aims to consistently make meaningful impact in our community, connecting with as many people as possible. This year, we wanted to improve on our long lasting relationships.

Total Time: 26 hours **Total Volunteer Hours: 132.4 hours** **Total Reach: 314**

Learning Community Workshop Series: 10/13, 10/20, 10/27, 11/3, 11/17, 11/9

During October and November our team conducted six workshops for third graders at a local charter school named, the Learning Community Charter School. During the span of those educational events, we were able to connect with younger students and teach them about Lego Worm Gears, motors, and gear ratios. Our team has formed a strong partnership with the school and is appreciative to have bonded with younger kids over STEM. **Reached 10 students**

Providence Public Library STEAM Crew - 3/6/23

We hosted a robot meet and greet for the students of the Providence Public Library's STEAM Crew. Our team connected with young members of the community, answering their questions about robotics, and showing them what it takes to build a robot. We were able to share the future possibilities of how they could be more involved with STEM as they grew older. **Reached 7 students**

Vartan Gregorian Workshops - 4/26, 9/15

Not only have we hosted multiple workshops, including one this season for nine 3rd grade students, at the Vartan Gregorian Elementary School, but we have also been helping them expand their STEM program. With our sister team, Team 636, we have been working with the school to potentially start FLL teams for 4th and 5th grade students. We presented the school this plan over the summer and are working with faculty to work through the logistics of launching a robotics program. .We will be hosting a second workshop in late February. **Reached 9 students**

Robots on Fire - 9/30/23

We were invited to showcase our robot to the entire Providence community during a WaterFire event hosted by FRC Team 6328. During the seven hours, we were able to meet other FTC and FRC teams that had their own booths, and converse with thousands of people who were curious about FIRST and our robot. **Reached 200 people**

Mentoring FLL Team #50625 The Robotic Terriers

Since August, Arjun Dasari, one of our members, and an alumn of the FLL team 50625 The Robotic Terriers, a local RI team. He has been mentoring this team focusing on udging practice and different mechanical aspects of their robots. They recently won the RI State competition and are going to Worlds in Houston.

Outreach: Connect

Season Analysis & Presentation Analysis - 04/03/23 & 02/6/2024

After our competition season ended last year we wanted to turn our focus to preparing for Centerstage. In an effort to hit the ground running we got in contact with Amy Schroeder, a healthcare technology executive at Salesforce. She advises large hospital systems and health insurance companies on how to best use technology to meet business goals. During this meeting, we were able to define clear goals and action plans for the oncoming season. We met again during our in school practice on February 6 to run through our presentation. She offered valuable feedback and advice that helped prepare us for State Championships.

Zoom with Team 207389 Paranoid Androids on Steroids - 10/05/23

In October, we spoke to Team 20789 from Riverdale, NY, and exchanged ideas for outreach and strategy. We were fortunate enough to speak to them last year and are very grateful to have formed a withstanding connection with them. Next week, we will be calling two other FTC teams!

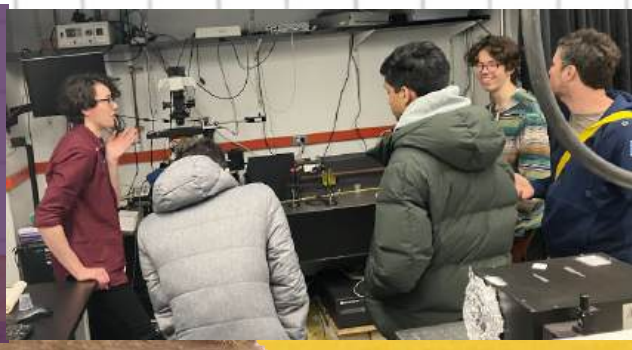
Connected with 5 students

SICK Sensor Intelligence Call - 12/11/23

While attending Robots on Fire, a previous event, we met Kevin Welsh an employee at SICK AG, a Germany based sensor company. Later on, we held a Zoom meeting where we spoke about future collaborative opportunities we plan on enacting. Such as business visits, demos, and visits from more professionals to share the different paths available in robotics.

Visit to Brown University Labs - 01/08/24

We got to hear about some robotics during the 90s, Prof F's work with autonomous robots using ultrasonic sensors and his work with Andy Ruina's passive walkers. Then we heard about their research in high-resolution imagery using low-resolution sensors. Afterwards, Gabby, A PhD student showed us the optics lab where they are currently collecting data for their research.



Dassault Systemes Visit - 2/28/24

As part of the money they gifted us, Dassault Systemes invited us to visit their Rhode Island location. During this visit, we will tour their facilities, meet some of their team, and present our robot. We are incredibly thankful for the significant sponsorship they granted us and are excited to visit them later this month!