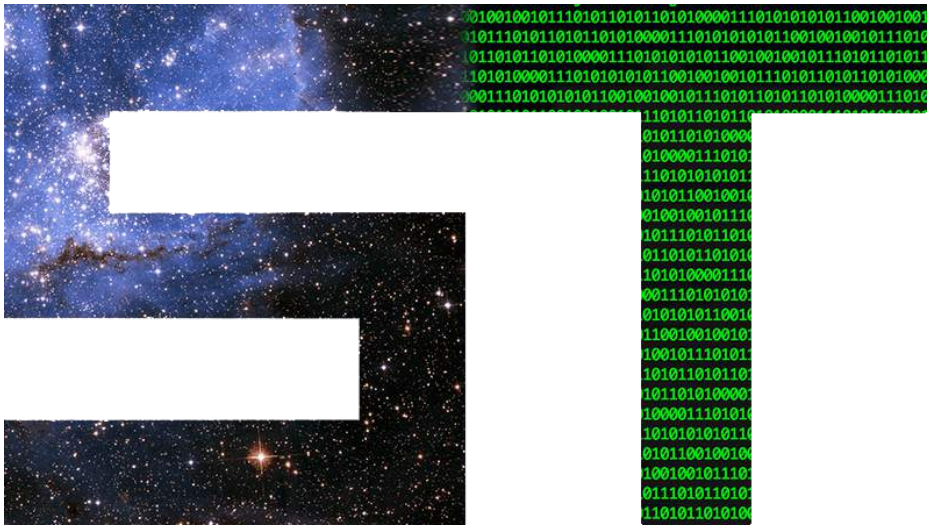
Singularity Technology

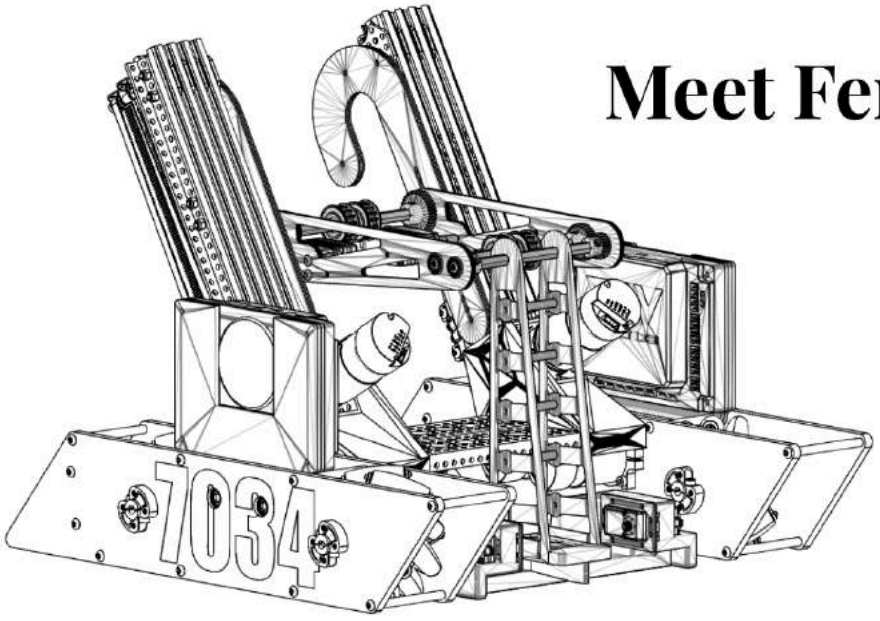
Team 7034

Wilton Library Robotics Team



Centerstage Engineering Portfolio

2023-2024



About the Team

Singularity Technology is a tenth-year FTC Team based out of the Wilton Library in Wilton, CT. Our team is unique since we are sponsored by a private library, as opposed to a local school. This opens up the team to many more community members. Currently, we have a mix of members from public and private schools in the area. In the past, our members have also included homeschooled students. We are truly open to the public.

What's Inside

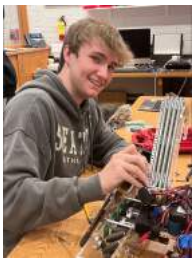
Team 7034 was founded in 2013 by a group of students from seventh through twelfth grade, along with dedicated mentors with a passion for STEM. For four years, our team was the only team in Wilton, Connecticut. Throughout the years, the number of mentors has decreased, but the liveliness and spirit of the team have only increased.

Currently, the team is split into two groups: eight members on the Main team, and seven members on the Testing and Prototype (TAP) team. We have one team coordinator and two mentors: both of our mentors are ASML Engineers and stop by once a week to help the team. However, mentorship has consistently been a struggle in recent years after COVID because of lack of consistency.

Mission Statement

Singularity Technology's mission is to inform, enrich, connect, and inspire our community by promoting STEM. We use robotics as our gateway to discovery and to foster an environment in which everyone can prepare to become a leader in science and technology, building a vibrant young community of future engineers. Through our community outreach and fundraisers, our team promotes FIRST programs and recruits new members for our TAP team. Our TAP team is effective in teaching kids who are interested in STEM more about building and programming a robot, and also prepares younger members for full participation in future FIRST programs

Meet the Members

Anant - 12th	Aarushi - 12th	Jack - 12th	William - 10th	Leo - 9th
 Co-Captain Head of Programming	 Co-Captain Head of Build	 Build CAD	 Build CAD	 Programming
Achintya - 9th	**Henry - 9th**	**Anirudh - 10th**	**Angela - 9th**	**James - 9th**
 OOF	 OOF	 OOF	 TAP	 TAP
Vivaan - 9th	**Saara - 8th**	**Anaya - 7th**	**Ben - 7th**	**Arav - 7th**
 TAP	 TAP	 TAP	 TAP	 TAP

What is TAP?

TAP, the Test and Prototype team, is a group of younger members who are mentored by the main team. TAP initially works on CAD skills before they begin building their own test bot; they then work on coding the chassis and familiarizing themselves with the basics. TAP eventually moves up to the main team and carries on the team's legacy. It has been successfully running since its establishment in 2016, with the exception of COVID years.

More on OOF (Outreach Organization Force) in the Outreach section.

Mentors

Mrs. Valmai Hanson	Dr. Danika Luntz-Martin	Mr. Kyle Zheng
Mrs.V is the Head of Teen Services and the manager of the makerspace at the Wilton Library Association. She coordinates the team administration.	Danika is an optical engineer at ASML. She has a Ph.D. in experimental physics with a focus on optics.	Kyle is an Engineer at ASML.

Team Plan

Our technical goals this year include building a robot without static issues and incorporating dead wheels into our design and code.

Last year, we were the only team at our qualifiers dealing with static issues. Electrical charge would build up on our robot causing the connection between our robot and the Control Hub to suddenly drop; it became entirely unreliable as it would come back at any time between 30 seconds to even eight minutes. It was a problem that may have cost us World's last year. We vowed to overcome that obstacle this season with an acrylic robot—this unconventional change is fully explained in the Build Overview section.

Additionally, we wanted to expand our roadrunner odometry capabilities by using dead wheels, as they vastly improve movement. They allow it to self-correct during its movements and allow us to program it on a virtual mapped cartesian plane.

Another goal this year was to work on communication and team cohesion.

With so many new members, we wanted to centralize all of our communication within the team. Last year we started using a team discord server to foster a greater connection with teammates and ensure that everyone was on the same page. We use it almost every day, in and out of meetings, to keep track of things. It works really well.

Finally, the team plans on spreading the word about FIRST in order to involve more of the community members in our events. Ultimately, the team aspires to mentor an FLL team, in addition to the TAP team, to allow primary school students to learn about robotics with experienced members of our team, and to give current team members more experience with teaching younger roboticists. We have been working towards this goal with our rigorous outreach program.

Outreach

About OOF → The Outreach Organization Force works on coordinating hands-on STEM outreach events and presentations for the team during the year.

We have maintained a vigorous outreach program this season, complete with events all throughout our town of Wilton. Below is a quick summary.

Date	Season	Event	Event Type	Team Hours	Impact (people)	Money
06/03	Pre-Season	Wilton Library Ice Cream Social	→ Sell 3D Printed Toys and Earrings → Showing off the Robot	21	100	$170
05/05	Pre-Season	Meet w/ Seven Acres Middle School Kids	→ Robot Demonstration + Presentation → Answering STEM Questions	8	10	
6/21	Pre-Season	Library Program: Rube Goldberg	→ Taught the Engineering Design Process (EDP) → Talked about FIRST	12	25	
08/24	Pre-Season	Library Program: Rubber Band Powered Cars	→ Taught the EDP + potential v. kinetic energy through these cars → Talked about FIRST	24	25	
12/09	Season	Destroy Your Hard Drive	→ Charged $20 to destroy people's hard drives → Had robot on display + talked about FIRST	130	100	$1,400
10/22	Season	Toy + Bake Sale @ Stop and Shop	→ Sold 3D printed gizmos and gadgets + baked goods in front of our local Stop and Shop. → Had robot on display + talked about FIRST	120	70	$338
12/20	Season	Girl Scouts	→ Presented to our local Girls Scout troop → Taught the EDP creating balloon-powered hoverboards in the process.	28	20	
01/10	Season	Alumni Visit	We maintain an excellent relationship with our team alumni. → Edwin and Navod visited while back from college	20	15	
01/23	Season	MB Science Fair	We presented and judged at Wilton's Middle School Science Fair, which is a yearly tradition for us. We focus on the engineering design process and show off our robot.	25	250	
02/04	Season	Winter Carnival	We have planned an outreach event to sell hot chocolate at the Library's Winter event. We look forward to showing our community the robot and spreading the spirit of FIRST.	Predict :16	Predict: 75	$500
02/14 + 02/15	Season	Cider Mill	Each year, we present to 100 fifth grade students at our local elementary school about topics in computer science and how they apply to our robot code.	predict :25	predict :150	
		Totals:		428	765	$1,908

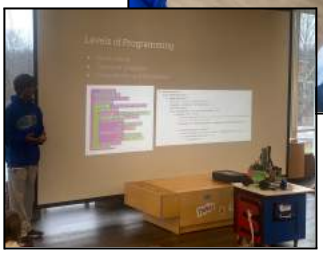
Pre-Season Library Programs (June 21, August 24)

Each year, while school is out, we conduct 2-3 STEM summer programs at the library focused on the engineering design process. This summer, we hosted a Rube Goldberg inspired program as well as a Rubber Band Powered Cars program. The focus was to make sure kids had fun while simultaneously gathering knowledge about real world applications for engineering.

Destroy Your Hard Drive Fundraiser (December 9)

This event is our biggest annual fundraiser: Destroy Your Hard Drive. We charge $20 to destroy people's hard drives while we put our robot on display and talk to community members about *FIRST*, FTC, and our ongoing season. We have a projector with a rotating slideshow of pictures in the back. This is an annual season highlight for us, and we are happy to have raised $1400 through the event this year.

Cider Mill Elementary School Presentation (Scheduled for February 14 & 15, 2024)



Each year, we present to about 100 fifth grade students at our local elementary school and talk to them about our challenge and the design process. Our presentation is very programming oriented as we tailor our discussion to their current computer science unit. We aim to inspire them and help them discover the various STEM opportunities in the real world. We will return to Cider Mill in mid February this year.

Middlebrook Middle School Presentation (January 23)

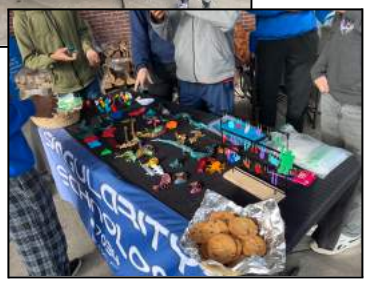
Upholding a yearly tradition in Wilton, we presented and judged at our middle school's science fair. In between student project judging and the awards ceremony, we presented to over 200 students, parents, and teachers about FTC and the various challenges we faced during the season. Kids also drove our bot!

Alumni Visit (January 13th)

The team was able to reach out to two alums, Edwin and Navod. They were back in town from college and we invited them in for our meetings where we presented our robot and got tips on how to succeed in this year's challenge. It was exciting to learn about various post-high school opportunities in engineering from them.

Ice Cream Social (Pre-Season June 3rd) / Winter Carnival (Season Feb 5th)

The Wilton Library, where we are based out of, hosted an ice cream social for the town and we decided to set up a table where community members could buy a 3D printed toy or pair of earrings and interact with last year's robot. We enjoyed talking about robotics and FIRST with younger kids who seemed interested. This event not only served as a fundraiser, but also helped us develop a connection with our local community. We have planned a similar event selling hot chocolate instead of ice cream (we are very seasonally aware) that will take place in early February.



Toy + Bake Sale at our Local Stop and Shop (Oct 22)

We decided to do another fundraiser but with more innovation than ever before. Rather than holding a regular bake sale with chocolate chip cookies and more, we incorporated 3D printed gadgets into our sale. There were many interested people who stopped by to check it out, those with and without kids. It is safe to say that it was well liked by the general community.

The Outreach Organization Force (OOF)

Our OOF sub-team consists of younger members in their freshman year of high school. They have played an instrumental role in making a lot of the events possible. We also have a TAP liaison to OOF, known as TOOF, to involve the TAP team in our community outreach.

The Innovation Station

Our team's working space is essentially a large glass box. In our small town of Wilton, the library is the heart of our community. We are lucky to be located in the center of our library where we are accessible to all members of the community. Oftentimes children, parents, and even Library Staff members peek in to see our robot and ask us about what we are working on. It is a great way to stay connected with everybody and spread FIRST.

Within our workspace, we have a massive 3' x 4' whiteboard that we continuously use. Every week we make cohesive to-do lists; the whiteboard plays a key element in keeping us on track with deadlines. Additionally, we use it for designing parts of our robot, making pro/con lists for important decisions, and team building with the occasional (but competitive) game of hangman.

We also have a full field in the basement of the library, where we conduct driver practice and develop our strategies. We also test our autonomous code here.

Anant and Leo at MB for Coding Club, Will at Trackside for CAD

Fun Fact

We have a little side business selling 3D printing earrings. The idea initially came to us when we wanted to initiate a fundraiser but wanted to stray away from the repetitive idea of just a bake sale. And hence the idea of earrings was born; later on we revised our idea to include little 3D printed toys as well.

Our products are well enjoyed by young kids and adults alike.

Build Overview

We use Fusion 360/OnShape to create computer-aided design (CAD) models of our ideas, which allows us to see potential problems before we build them. This saves time and improves the accuracy and speed of the build. This year CAD saved us a countless number of times because... we do not have a metal robot.

Last year, at around this time, as we completed the construction of our robot, we faced static issues during competitions. Around this time, in January, as we finished building our robot, the robot, covered in dryer sheets to counteract metal-on-metal static, disconnected from controllers during the first competition. This experience prompted a strategic shift, leading to the decision to construct the current robot entirely from acrylic, foregoing the use of metal. We wanted to come up with an innovative idea to battle this idea.

Interestingly enough, not everyone on the team was immediately on board with a non-metal bot. After building the drivetrain, we spent a week in deep discussion weighing the pros and cons of the two materials. It all came down to a vote... The acrylic bot had won by one.

Despite finding many temporary solutions for this issue, we never were able to address the root of the problem. Despite rewiring, replacing the motor, and covering all exposed metal, static persisted. The upcoming competitions will serve as a platform to really test the effectiveness of this new unconventional design.

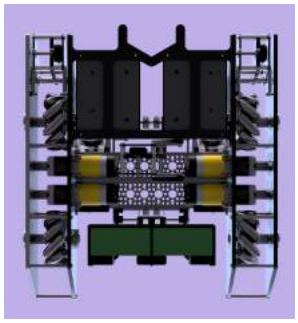
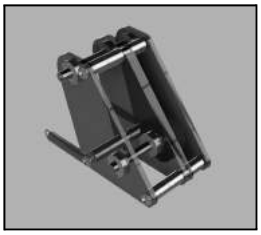
Kickoff Day

Keeping with tradition, our team held our first meeting of the season by gathering in person at the library on the day the FTC season video was released. We watched the video together and had an interactive discussion as we brainstormed ideas for tackling the challenges of the current year, all while enjoying snacks.

To begin the process, we started by sketching out ideas for a new robot design. We also made sure to consider the specific tasks that the robot would be required to perform such as agility, stability, and more. After several rounds of iteration and refinement, we arrived at an initial design that we believed would be both functional and compact.

We have split our priorities into three main categories: Chassis, Intake + Depositing system, Deadwheels.

Mechanism Breakdown

Drivetrain (Acrylic) 	This was the most time consuming section of our robot. Deciding what to prioritize regarding the height and base of the robot was difficult. Not only did we want to maneuver under the truss system but also drive through them with ease. We ended up prioritizing height by keeping it under 14". In a perfect world we would have it short enough (12") so that we could go under the gate without touching it, but perhaps that is a future improvement. Designing the chassis and predicting where we would mount our deadwheels, the crossbars, and our slides proved to be more complex than it might have been had we used metal. We needed to plan *everything* because each screw hole needed to be lasered in advance. Needless to say, there were many iterations, however, the initial design has remained the same.
Odometry (Acrylic) 	Deadwheels were a priority this year, but they were incredibly difficult to build and took over a month to finalize. We learned all about tolerances, how to build the odometry modules, making custom resin shafts to combat the Metric and SI system differences, and even how to work with acrylic. In addition to learning about dead wheels, we needed to ensure that our design was compatible with the chassis. The integration of this part alongside the chassis was not an easy task.
Slides Mount (3D Print) 	We thought that these mounts would be a one and done (once we had decided on the 30* angle of course), but it turned out to be quite the opposite. Our slide mounts were printed and reprinted numerous times. Sometimes it was just because it was super hard to screw in and other times the screw holes misaligned. We also learned that when trying to hang the entire robot the candy canes put all the weight of the robot onto those connecting joints as it lifts into the air. We then increased infill - the inner filling of the 3D printed piece in order to make it more solid - from 20% to 100% to ensure that would never happen again. We have been successful thus far. The Graveyard is filled to the brim with many variations of these mounts, some broken, others just discarded.

The Intake (3D Print)

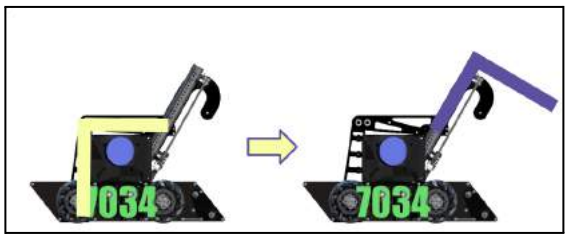
The grabber design that we had put together last minute before our last qualifier (Jan 13th) wasn't as successful as we wanted it to be. Due to the time crunch we faced, we didn't make a grabber that was as functional as we thought it would be and ended up becoming a pushbot for ⅘ of our qualifying matches. It was a 3D printed hollow rectangle that would act as a "scoop".

These past two weeks we have returned to the drawing board and come up with a completely different design. Whereas before we had a scooper design to pick up the pixels and drop them onto the backboard, now we have a more complex and efficient mechanism that will intake the pixels with independently controlled flippers. This will allow us to place the pixels onto the backboard with more accuracy. This mechanism is still 3D printed; it seems to be the best material to work with for this personalized mechanism.

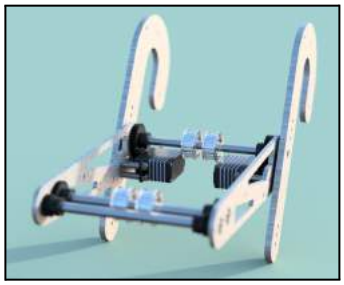
The Deposit (Metal)

We were initially skeptical about using this deposit design due to the complexity but decided to stick with and pursue this idea. It is attached to our linear slides and moves with a complex gear system in the middle. Every part, down to the gears, is a custom part. We hope that we can maximize time and efficiency for this second qualifier.

This system works in a 3:2 gear ratio. When the servos closest to the candy canes (hooks) are powered, the entire system moves of its own accord in rhythm. This plan was carefully constructed and it's better demonstrated in this diagram on the left so that we could maximize efficiency.



The Climb (Metal)



These are by far the simplest design on our robot. The design that is currently on the robot is pretty much exactly the original idea; the only changes that were made were just to add in a couple screw holes. We tested our initial design/idea with a 3D printed prototype to ensure it would be strong enough before committing our design to acrylic.

We also call them the candy canes.

The Launch (Spare Parts)

First qual launcher

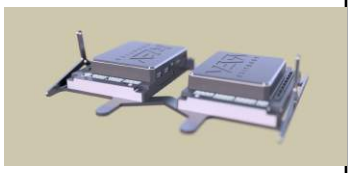
Second qual launcher

Initially, we simply used a rubber band with a catch to launch the plane: crossbow style. While this simple launcher did technically work, we found it far too unreliable to be trusted, with a circular error probable (CEP) of about 2.5 meters. This unreliability, combined with the fact that the rubber band would tear up the back of the plane made this method essentially unusable.

At first we were stumped on what to do. This time we took inspiration from the US Navy's aircraft catapult systems. We decided to reuse a linear rail from a previous robot as a sled. Using the simplest design to keep the paper plane in place, we used two prongs to hold the plane in with friction. This prototype worked exceptionally well with a CEP of about 2 feet max, and with only some minor surface level changes that became our launcher for the first qualifier.

While we did have success with it, making the first successful drone attempt in Connecticut, we never made a zone one landing and had many rubber bands snap after only one use. While our first plan called for simply replacing the rubber bands on our existing design with tension springs, as the second qualifier drew ever closer, it became clear that these springs simply wouldn't arrive in time to be used. We still wanted to use springs as we believed they were the logical next step, so we found a set of some and quickly went to work building our next design. Our first design only used one spring, but we realized we needed two at the least. Lacking the parts to properly extend the launcher forward we instead just doubled our design and placed the two new launchers side by side.

HUB Mounts (3D Print)



These were very simple, yet designed last minute. As we implemented our grabber on Thursday, Jan 25th we realized that our current location (standing vertically on either side of the robot) would interfere. We decided to relocate these to the front side of the robot to be parallel with the ground and made mounts for these just a day before the competition. Duck tape didn't seem like the best solution in this scenario.

Camera Mount (3D Print)

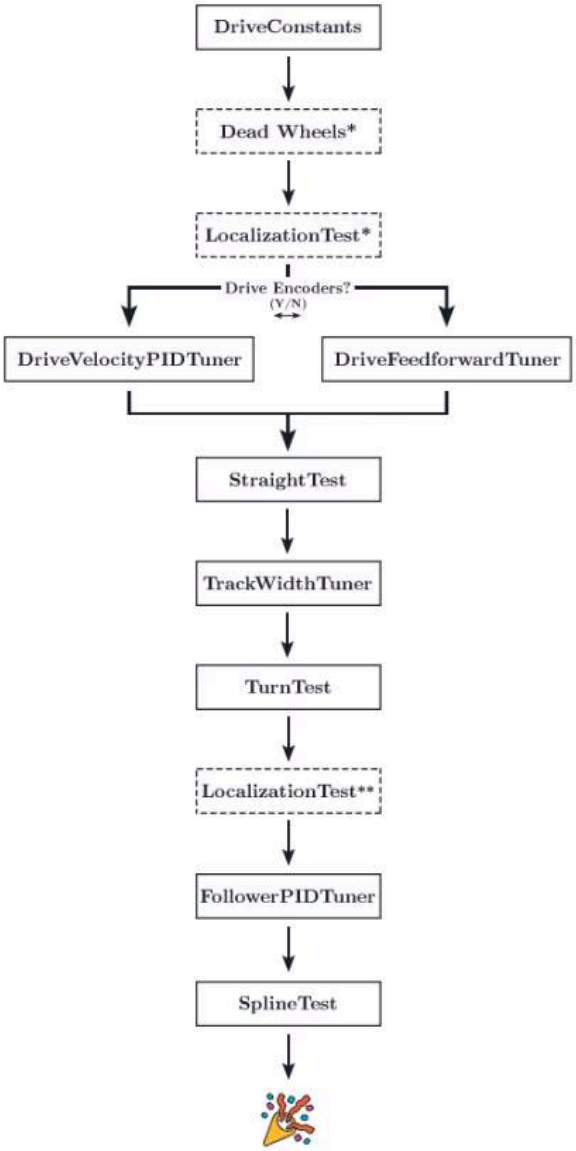
Programming Overview

Goals

a) Implementing roadrunner on the robot
b) Programming a high-scoring autonomous that gives our team a boost right from the beginning of the match
c) Make tele-op as simple and easy to use as possible

Roadrunner

After our 2021-22 Freight Frenzy season, our software team inherited legacy code that had been developed in 2018 that nobody understood anymore. In light of this, we decided last season to rebuild all our code from the ground up using the powerful tools Roadrunner offers. We have done this again this year.



Going through the process of tuning roadrunner was especially tedious and required a lot of learning. Many of the topics in math and physics were incredibly advanced, and Dr. Luntz-Martin worked with the software team to understand a big-picture view of the physics at play in roadrunner. Eventually, after many hours and failed attempts, the software team managed to successfully tune roadrunner to a very accurate level.

Presently, our teleop is built with Roadrunner's Pose2D function, and our autonomous drive is driven by the path following capabilities of this dynamic library.

Autonomous

During the autonomous period, we identify the location of our team element and move the spike accordingly We have programmed a color-detection pipeline, which divides our camera's viewing frame into three sections(called regions of interest), checking for the number of red or blue pixels in each—the color is dependent on our team element. This allows us to identify where our robot should go.

At the start of the autonomous period, one of three things happen:

1) The team element is in the middle, and the robot moves forward to the middle spike.
2) The team element is on the left side, and the robot moves to the left spike.
3) The team element is on the right side, and the robot moves to the right spike.

These movements are done using roadrunner trajectory paths. We also use roadrunner trajectory paths to transport the other loaded pixel into the backstage section of the field during the autonomous period.

Tele-Op Strategy

Our strategy in Tele-Op is to cycle between the zone in which the human player deposits pixels and our backboard to maximize the amount of points scored. We will work to encourage good communication and coordination with our alliance partner team to make sure that these cycles are done in an orderly fashion without traffic and collision.

Finances and Budget

Income		**Fundraising**	
Rollover Funds as of August 2023	3339.98	Destroy Your Hard Drive	1,400.00
		Bake + Toy Sale 10/22	$338
Estimated Expenses		Earrings + Toys (March - June)	$270
Season Registration	295		
Field	460		
Competition Registrations	320		
Website	82		
Parts	500		
Sweatshirts	375		
Parts bought between 01/13 and 01/27	350		
Total	2,382		
Funds Left to Spend	**1,566**		

Shown above is our spending for the 2023-2024 competition year. Fundraising was a priority for us this season. We held our biggest annual fundraiser again this year, Destroy Your Hard Drive, which raised about $1400. However, we aim to garner sponsors for the team. After the loss of all of our previous mentors along with COVID-19 years, we lost all of our previous sponsors. This season, we have reached out to over forty local businesses, unfortunately receiving not one response.

Without sponsor support, we have been conducting bake sales and selling 3D printed gizmos and gadgets, raising over $500. We started selling 3D-printed earrings, which has bolstered women in STEM in our community and increased female interest in the team. These efforts have funded the entirety of our spending on parts so far this season. This is a goal we aim to maintain as the season progresses and gets more expensive.

CAD