Singularity Technology

Team 7034

Wilton Library Robotics Team

PowerPlay Engineering Portfolio

2022-2023

About the Team

Singularity Technology is a ninth-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 included homeschooled students and students from Norwalk, Connecticut. Thanks to the library's generosity, we are truly open to the public.

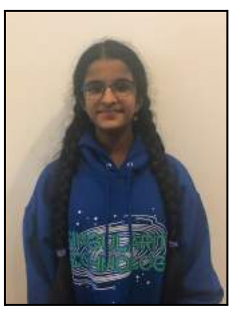
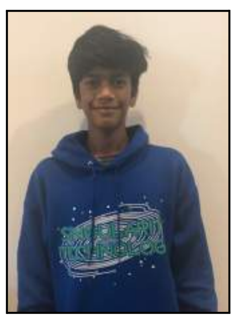
Team 7034 was founded in 2013 by a group consisting of seventh through twelfth graders, along with dedicated mentors with a passion for STEM. For four years, the team was the only team in Wilton, Connecticut. Throughout the years, the number of mentors and members has decreased, but the liveliness and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

Currently, the team is split into two groups: five members on the main team, and four members on the Testing and Prototype (TAP) team. We have one team coordinator and two mentors: two are library employees and our third mentor is an ASML engineer. However, mentorship has been a struggle this year due to lack of consistency. The team has been on our own in designing and executing the robot for the past couple months.

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	Aarushi	Jack	William	Anirudh
 - Junior - Captain - Programming - Outreach	 - Junior - Captain - Build - Outreach	 - Junior - Build - CAD	 - Freshman - Build - CAD	 - Freshman - Programming - Website
Angela	**James**	**Achintya**	**Henry**	**The Viper**
 - Eighth Grade - TAP	 -Eighth Grade - TAP	 - Eighth Grade - TAP	 - Eighth Grade - TAP	 - extremely high maintenance - scented like fresh laundry

What is TAP?

TAP, the Testing and Prototype team, is a small group mentored by the main team who will eventually move up to the main team. This is our first year having TAP again after our COVID break (three years) during which we were not able to recruit new team members. TAP was first established in 2016 and had been successfully running until March 2019. This year we hope to grow the team and ensure that the legacy of Singularity Technology remains intact.

Mentors

Ms.Findorak	Dr. Danika Luntz-Martin	Thomas
Ms. Findorak 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. She has a Ph.D. in experimental physics with a focus on optics.	Thomas is the Head of Technology at the Wilton Library Association.

Team Plan

Our main goals this year were to find new mentors, recruit new team members, and re-establish our TAP team after the difficulties we faced during COVID.

During COVID we lost all four of our consistent mentors. To recover from this we aspired to find a new mentor to help us out. An ASML engineer, Dr. Danika Luntz-Martin, visited us in December and we showed her what we had been working on. In January she began mentoring the team by coming in for about an hour a week. Although she has no previous FTC experience we look forward to working more with her.

Our TAP-related goals were also realized this season. We have four new members. In future years we aim to increase this number to make learning robotics accessible to all members of our community. This TAP team will be the feeder team to the main team for future seasons.

Another main goal for the team this year was communication. With so many new members and mentors, we wanted to centralize all of our communication within the team. We created a team discord server to foster a greater connection with teammates and ensure that everyone knows what is going on at any given time.

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.

Build Overview

By using science and technology, we can build more efficiently. We use Fusion 360/OnShape to create computer-aided design (CAD) models of our ideas, which allows us to see what they will look like before we build them. This saves time and improves the accuracy and speed of the build.

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 a final design that we believed would be both functional and compact.

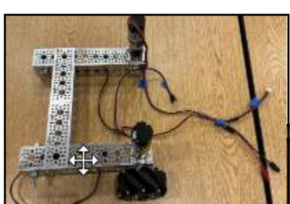
We have split our priorities into three main categories: drivetrain, intake system, and depositing system.

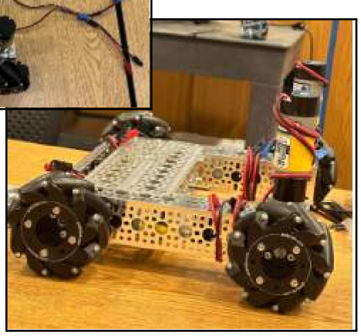
DriveTrain Engineering and Design

Design Decisions: Small Footprint (12 x 16), compact chassis using mecanum wheels.

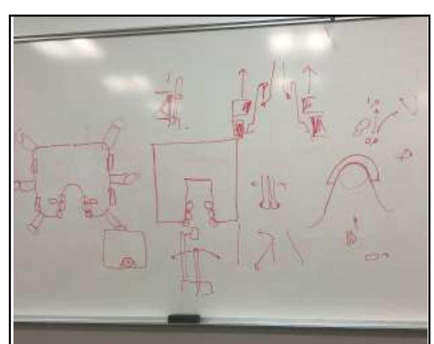
Pros: Mecanum wheels allow for speed and maneuverability; they also give us the ability to strafe.

Cons: With the small footprint and tall linear rail system, the robot is more prone to tipping due to jerky movement and collisions. To combat this, we decided to decrease the overall speed of our robot, emphasizing maneuverability over speed.





In the past, our team built the robot using the base structure that we had used for several previous years. We always maxed out our robot to the 18 inches cubed size restriction. However, for Powerplay having such a large bulky

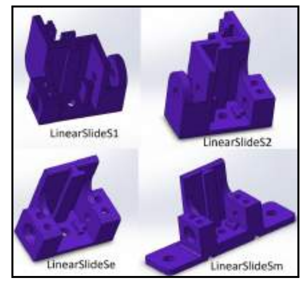


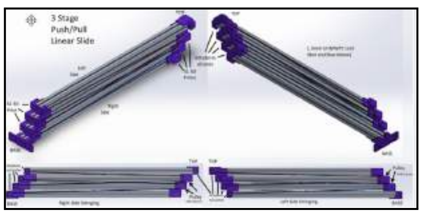
build would hinder the robot on such a crowded field. To be able to maneuver around all the poles on the playing field we would have to make some changes. This meant that we needed to start from scratch to design a drivetrain that wasn't too cumbersome and bulky.

Linear Rail System

Goals: Robust, 40+ inches of expandability, sturdy, fast

Generation 1: In efforts to re-use parts, for the first prototype/iteration we tried using linear rails that we had from previous competitions. Unable to effectively screw them together, we tried sanding down nuts to allow them to fit together. In the end, it still limited the movement and was only capable of 24 inches of height





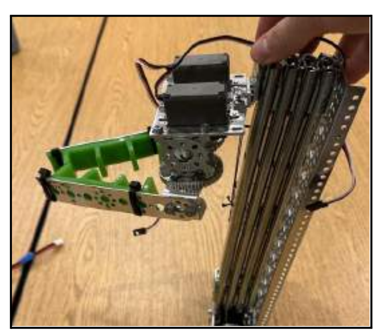
Generation 2: In our second iteration of the linear rails, we designed and built our own custom-printed linear rail system using 3D-printed parts and x-rails. While these prototypes performed well in initial testing and practice runs, they proved to be unreliable under load and had a significant amount of wiggle.

Generation 3: For our third iteration of the linear rails, we used Gobuildas linear rails. This allowed flexibility in mounting, which proved to be helpful later in the design process. They are very reliable and less wobbly, allowing us to only use one set of linear rails rather than 2 fitted together.

Generation 4: Our final iteration of the grabber we decided, last minute rush time, that we wanted to order and replace our slides. We had determined that the slides were a major static developer and wondered if the manufacturing on the ones we had might have been off. These are belt driven slides as opposed to threaded because of the major issues we experienced with thread snapping due to a number of errors.

Grabber Engineering and Design history:

Goals: Robust, large area to grab, small, light, fast.



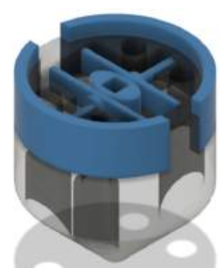
Generation 1: For our first iteration, we needed a grabber that would be capable of grabbing a single cone right side up, while also being as light as possible. Our design mainly focused on using 2 moving arms that could move in and out, squeezing the cone

Generation 2: In our first iteration, our primary constraints were in material and versatility. We considered a mechanism that would drop into the center hole of the cone and expand, gripping the cone internally and preventing it from being laser-precise, an almost unattainable goal in competition.

V1: The first version of the grabbers met all of our requirements; both falling out. However, there were many errors with this design. Mainly, our robot and grabbers were a light wire frame style model. The static inside grabber could hold the servo and could easily attach to the servo horn. However, the inserts for the nuts were too small which meant that we couldn't get a servo to stay there properly.

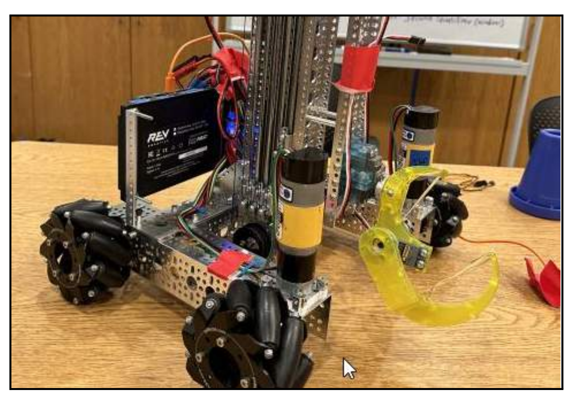
V2: For the second version of the static grabber, we found the error from the previous model and remedied it. In our test trials, we found that too much force from the moving grabber pushing against the cone would break the moving grabber.

V3: In fear that both of the grabbers were susceptible to breaking, we supported them by adding walls to cover the wireframe on some sides and using filets at the edges. The walls would help prevent the grabbers from flexing horizontally and breaking. The filets made sure that there wasn't too much stress on the corners of the grabbers.



Generation 3: This final mechanism was a work of trial and error, followed by even more trial and error. This mechanism is mostly credited to the errors and strengths that we encountered in our previous two designs.

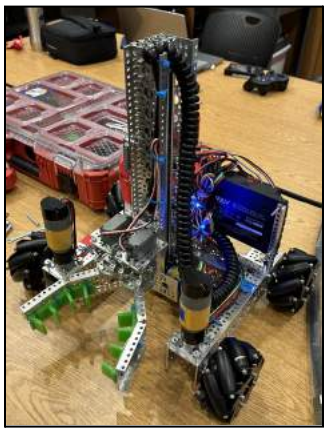
V1: The first design for the mounting of the turning mechanism was created quickly with digital calipers and printed twice to connect. The design is meant to fit snugly around the servo's wire and bolt mounts.



V2: The second version of the mount was designed to fix the errors from the first version. The final issue, however, was that the inside of the servos was too short, caused by the servo being squeezed, which caused its long edges to bloat outwards.

V3: In the third prototype of our mechanism we tried fixing the problem of the previous prototype. We did this by adding .5mm to the sides of the mount that touched each other. Unfortunately, when we printed this change the servo did fit, but the holes that mounted to the metal bracket did not line up anymore. Although we sacrificed an aspect of our design for another, ultimately this didn't work, warranting yet another design version.

V4: We tried to fix the continued problem of the previous version by taking V2 and subtracting space from the inside of the mount. When it came to mounting this design, it all ended up working out.

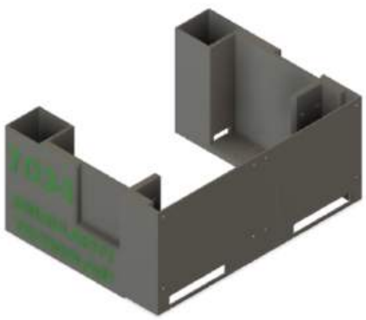


Generation 4: After the second and third iterations of the grabber proved to be unreliable and ineffective in one of our criteria, we decided to improve what we knew worked well in the version 1 prototype. We shaved down weight using fewer parts and bent the plates that grab the cone by 20 degrees allowing more room for it to open while also holding the cone tighter. We also added a custom coiled cable that allowed the system to move up and down on the linear rails without catching on anything. The memory retention rubber cable coils and uncoils itself every time we move the linear rails, while connecting both servos to their necessary places on the control hub.

Generation 5: We wanted to upgrade our metal grabber and create something less bulky. Generation four was basic and extremely heavy. With this new 3D printed design, petg printing, the plastic of the print is extremely strong and won't break as we experienced with previous prints. The entire grabber is printed with a one servo controlling two printed gears. This design allowed to minimize the usage of one entire servo as the previous design required two servos simply for attachment purposes.

3D Designs

 **Wheel Bubble**	We were experiencing major static issues till February 13th, despite the addition of the REV Grounding Strap which was meant to solve the problem. Through trial and error with various solutions we found that covering all exposed metal with tape helped. This led to the creation of the wheel bubbles, 3D printed side barriers preventing the wheels from coming into contact from any metal/plastic field parts. Somehow we have been experiencing static issues to a far greater extent in comparison to all the teams and this solution so far has proved reliable.

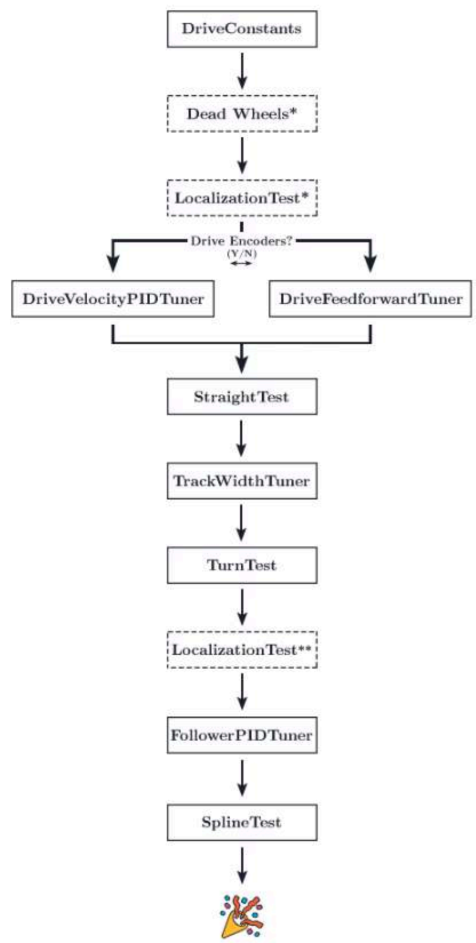
 **License Plate**	This is the license plate for our robot, now renamed to the Viper. It has gone through multiple make-overs. Our first qual robot was named the Tarantula, our second the Scorpion, finally with all the new additions we have decided on the VIPER and added an aesthetic looking license plate to the back.
 **Robot Barrier + Hub Attachment**	The robot barrier is to also assist with our static problem and ensure that exposed metal and wires aren't interfering with our connection. Our build up of static was causing the robot to crackle and disconnect. The barriers also protect the front motor wheels and display important information. Our team name and number is displayed on the sides :)
 **Team Scoring Element**	We needed to design and manufacture an element that incorporated our team number and be at least 3" by 3" by 3" but no larger than 4" by 4" by 4". By 3D printing it we were able to design and manufacture a team element that was light, easy to pick up and hard to break. We used FDM printing which is better for large, simple objects.

Programming Overview

Goals

Given that Anant has had limited experience with FTC programming and Anirudh is new to the team, we kept our goals for programming the robot directed and realistic. Our goals were the following:

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) Using encoders to effectively program the lift mechanism
d) One of our future goals is to greatly simplify teleop operation of the robot. With a competition as hectic as PowerPlay, we aim to automate as much teleop 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 to rebuild all our code from the ground up using the powerful tools Roadrunner offers.

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 in roadrunner. Eventually, after many hours and failed attempts, the software team managed to successfully tune roadrunner to a very accurate level. Our autonomous program works 85-95% of the time in scoring the preloaded cone.

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.

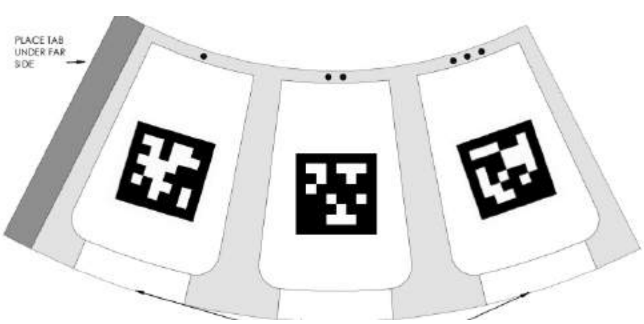
Autonomous

When deciding on our plans for the autonomous period, our software team looked to the FTC discord for guidance on how to sense the different sides of our custom signal sleeve. We decided to focus on this because it grants a sizable 20-point boost in the autonomous period and involves computer vision.

Originally, we had planned to use Tensorflow Lite to create a model for color detection of three panels, each with one of the three primary colors. However, various teams in the FTC discord had already tried this and encountered issues with recognizing the colors in various settings due to variability in lighting. Just because a model might work in our innovation station, it may not work while testing on our field in the basement or at the competition.

Opting for a safer option, we explored the idea of Apriltags. Developed by researchers at the University of Michigan, AprilTags is a popular visual fiducial system, or marker system, used for a wide range of applications such as augmented reality, robotics, and camera calibration. They are small, black and white square tags that can be attached to objects in the real world. Each tag has a unique binary code, or "tag ID," encoded in the black and white pattern. When a camera or other imaging device captures an image of a tag, computer vision algorithms can analyze the image to determine the tag's ID and trigger certain actions.

Our signal sleeve employs three AprilTags from the 36h11 family, and we used OpenFTC's EasyOpenCV Apriltags plugin to form the base of our autonomous code. Using a logitech webcam attached to the front of our robot, we use EasyOpenCV to identify the AprilTag facing the robot. This all happens during the initialization phase - before the 30 second timer begins. At the start of the autonomous period, one of four things happen:



1) The tag on side 2 is detected, and the robot moves forward into the middle parking area
2) The tag on side 1 is detected, and the robot moves forward into the middle parking area and then moves left
3) The tag on side 3 is detected, and the robot moves forward into the middle parking area and then moves right

```java
SampleMecanumDrive drive = new SampleMecanumDrive(hardwareMap);

drive.setMode(DcMotor.RunMode.RUN_WITHOUT_ENCODER);

Trajectory middle = drive.trajectoryBuilder(new Pose2d())
        .lineToConstantHeading(new Vector2d( x: 28,  y: 0))
        .build();

Trajectory left = drive.trajectoryBuilder(middle.end())
        .lineToConstantHeading(new Vector2d( x: 28,  y: 32))
        .build();

Trajectory right = drive.trajectoryBuilder(middle.end())
        .lineToConstantHeading(new Vector2d( x: 28,  y: -32))
        .build();
```

4) In the unlikely case no tag is detected (probably because the orientation of the cone is not head-on with the robot's front webcam), the robot will simply move into the middle space

These movements are done using roadrunner trajectory paths.

Also, our autonomous scores the preloaded cone on the nearest low junction. We have used roadrunner (in harmony with the run to position functions of our slide encoders) to get to the low junction, drop off the cone, return to the original place, and then park according to the signal sleeve.

This helps us because it gives us a 6 point boost in autonomous (3 points for the autonomous period and another 3 for staying on after tele-op). Also, it helps advance our circuit, since it is essential to get a cone on a low junction to connect the circuit.

We have improved this system since our Windsor qualifier, and it now scores the preloaded cone with 80-90% accuracy.

Tele-Op Strategy

Our strategy in Tele-Op is to cycle between the high pole and the substation as fast as possible. Also, we will coordinate with other teams to build our circuit. However, we can also move all around the field because of our small drivetrain, and will work to maximize ownership points.

Drive Operation

Servo/Slide Operation

Finances

Income			
Rollover Funds - May 2022	$6,711.03		
Destroy Your Hard Drive Fundraiser - November 2022	$2,400		
Total Income as of 2/15/23	**$9,111.03**		
		December	
Expenses		Misc. supplies (zip ties, chargers, etc)	$35.07
August		Competition Registrations	$321.52
FTC Season Registration	$295.00		
		January	
September		Dead wheel encoders	$119.84
Kickoff Team Lunch	$198.40	GoBilda parts	$8.44
Team Sweatshirts	$447.79	Safety side shields for glasses	$14.88
Team T-shirts	$298.25	Replacement gamepads	$37.18
AndyMark Field	$501.54	Poster Board & portfolio supplies	$28.14
		Food for 1/21 Competition	$157.00
October		Grounding Straps	$22.11
GoBilda Parts	$294.44	Misc. supplies (anti-static, cable clips)	$50.96
GoBilda Parts	$17.51		
USB C Male to Dual USB Female Cable Adapter	$9.56	February	
GoBilda Parts	$62.80	Registration for States	$161.90
Extra Sweatshirts and T-Shirts	$451.99	Viper Slide Kit	$173.98
		New Wheels	$136.48
November		Portfolio Supplies	$6.49
Safety Gloves	$21.24	New cart for robot	$55.16
New Tool Cases for TAP	$43.58	Misc. supplies (cables, servos, etc)	$102.83
Snacks and Donuts for Destroy Your Hard Drive Day	$53.71	Total Expenses as of 2/15/23	**$4,127.79**

Team Budgeting

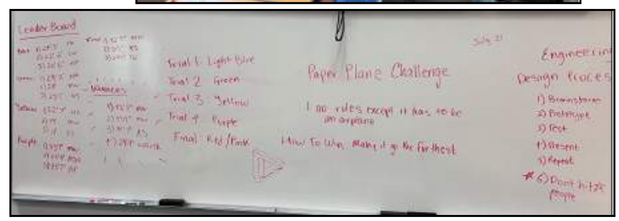
Shown above is our spending for the 2022-2023 competition year. Because of our sizable rollover funds, fundraising wasn't a main priority this year. We held our biggest annual fundraiser again this year, Destroy Your Hard Drive. However, we aim to garner more sponsors for the team. After the loss of all of our previous mentors along with COVID-19 years, we lost all of our previous sponsors and will be working on improving those connections in the postseason.

Outreach

We have maintained a vigorous outreach program this season, complete with events all throughout our town of Wilton. Here are some of our highlights.

Pre-Season Library Programs (Jul 14, 21 and Aug 12)

We conducted three summer programs for kids grades 5-8 and introduced various activities through the Engineering Design Process: Build a Bridge, Paper Plane Challenge, as well as Oobleck. The focus was to make sure kids had fun while simultaneously gathering knowledge about real world applications for engineering.



Destroy Your Hard Drive Fundraiser (Nov 12)

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 season. This is an annual season highlight for us, and we are happy to have raised $2400 through this event.

ASML Engineer Visit (Dec 16)

We had an ASML Engineer, Dr. Danika Luntz-Martin, come to visit us. She had shown interest in mentoring and we were extremely excited for this opportunity. She joined as a mentor in January and has been assisting with programming and the physics required in engineering the robot, helping us simplify complex topics like roadrunner. Since we have experienced static problems this entire season, Danika helped us diagnose problems with static and solve them.

Alumni Visit (Jan 13)

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

Cider Mill Elementary School Presentation (Jan 23)

We presented to 100 fifth grade students at our local elementary school and talked to them about our challenge and the design process. Our presentation was very programming oriented, and we tailored our discussion to the current computer science unit they are working on. We plan to return to Cider Mill in the postseason.

Middlebrook Middle School Presentation (Jan 24)

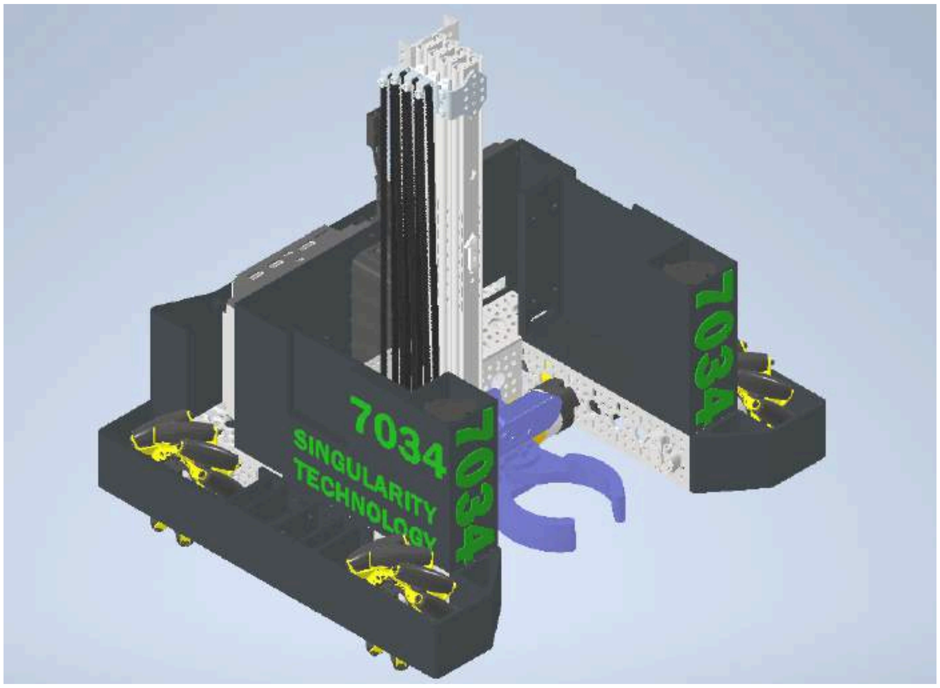
Upholding a yearly tradition in Wilton, we presented at our middle school's science fair. In between project judging and the awards ceremony, we presented to over 200 students, parents, and teachers about our robot and the various challenges we faced this season. Many students were able to relate to our design process, and they were surprised to hear about how many different iterations we have gone through during this season! The team stayed to watch the awards ceremony and talk to teachers and parents afterwards.

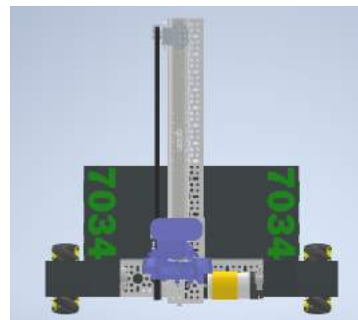
The Innovation Station

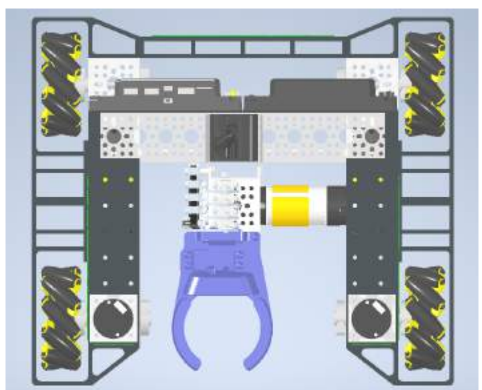
In our small town of Wilton, the library is the heart of our community. We are lucky to be located in the center of our library where we are accessible to all members of the community. Our team's working space is essentially a large glass box. Oftentimes children, parents, and other members of the community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

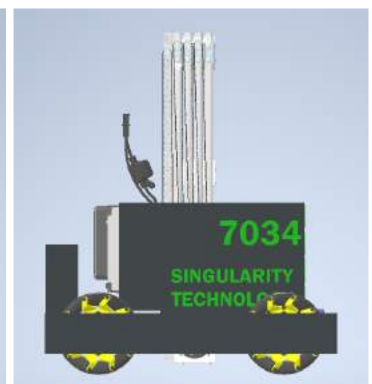
Within our workspace, we have a massive 3' x 4' whiteboard that we have used all year. It plays a key role in keeping us all on track with the timelines and due dates we set for ourselves. Every week we update it and make cohesive lists of what needs to be done. Additionally, we use it for designing parts of our robot, making pro/con lists to make important decisions, and team building with the occasional (but competitive) game of hangman.

CAD

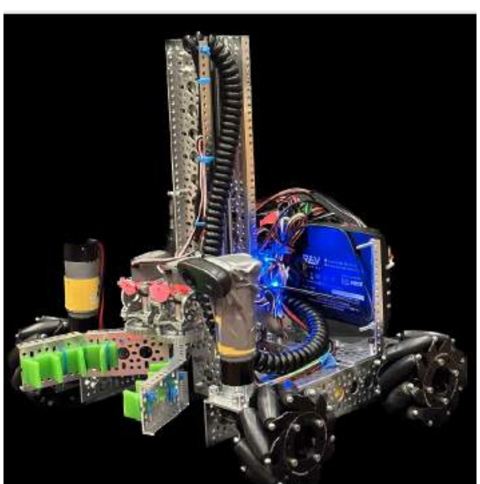


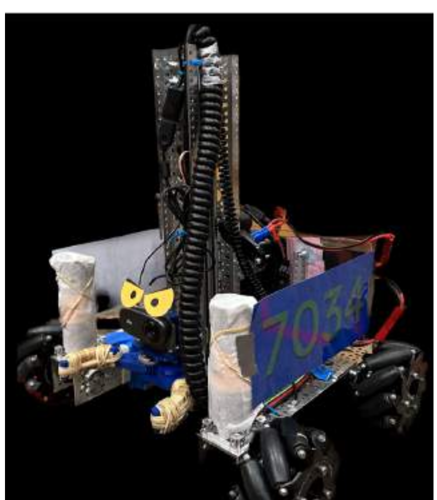






Watch the Robot Grow :D


The Tarantula


The Scorpion

The VIPER