MANIAC
MECHANICS
18082

2022-23
POWER PLAY
ENGINEERING
PORTFOLIO

Contents and Team Goals

Season Goals:

1. Utilize Stratasys more.
2. Create more custom designed parts.
3. Use “Game Strategies determine Design Requirements” for brainstorming.
4. Contribute to Spontaneous Construction’s “Project Robotica” (including our EP from last year).
5. Outreach: find more ways to share about FIRST and robotics.
6. Have the team volunteer at a local tournament.
7. Be worthy of winning Inspire at a qualifier.
8. Compete for the top robot score in our division at State.

Goals Accomplished (so far):

1. We ordered newer odometry pods from Stratasys, but our old ones ended up sliding more smoothly.
2. We designed a steel shell for our robot, plus our gripper hand, odometry pods, and more.
3. We created a chart at the beginning of the season outlining over 20 game strategies, and how we would achieve them with our robot design. This really helped guide our design!
4. We linked last year’s Portfolio to their website, so other teams can learn from it.
5. We participated at three fairs, organized three classroom demonstrations, visited multiple engineering companies, and even added a foreign exchange student to our team!
6. All 7 of us, plus our two coaches, volunteered at the Prior Lake FTC and FLL Explore tournaments on 11/19.
7. We won 2nd place Inspire at our 1st Qualifier!
8. (TBD)

Team Members

Name	Current Specialty	Area of desired growth
Jason (8th year of FIRST Robotics)	Programming and Robot Design/Construction	Continue to grow in CAD proficiency
Josh (6th year)	Robot Design/Construction and CAD	Participate more in outreach
Seth (5th year)	Portfolio and Engineering notebooks	Get involved in CAD and robot construction
Noah (2nd year)	Robot Construction and Portfolio	Become competent in programming
Emma (2nd year)	Outreach and Portfolio	Help with robot construction
Salim (1st year)	Assisting in programming; learning all FTC disciplines	Learn programming
Roman (1st year)	Programming; learning all FTC disciplines	Apply prior knowledge of programming languages to FTC

"Know everything about something, and something about everything." -Coach Eric

Noah: Noah is 16 and helps with robot brainstorming and construction. He enjoys chess and piano.

Seth: Seth is 16 and is in charge of the Engineering Notebook and Portfolio, and also works on Robot Construction. He loves to read the works of J.R.R. Tolkien.

Jason: Jason is 17 and does programming, robot design and construction. He also enjoys playing tuba, piano, trumpet and guitar.

Emma: Emma is 14 and works on outreach, fundraising, and robot construction. She loves to do aerial silks, which is acrobatics while hanging from a long piece of fabric!

Salim: Salim is 17 and is an exchange student at Jason's school, staying with Jason's family. He is learning everything about robotics, especially focused on programming, and enjoys swimming and playing with little kids.

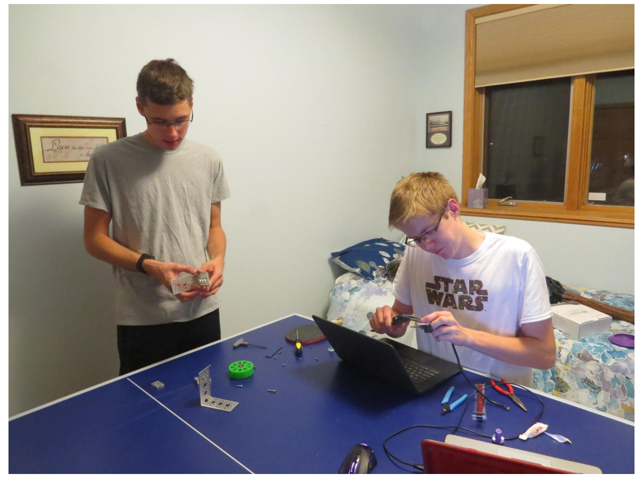
Roman: Roman is new to our team, and goes to Jason's school. He is 16 and works on programming. He enjoys hiking and wearing shorts even in the winter!

Josh: Josh is 17 and is in charge of CAD, and also works on robot design and construction. He enjoys martial arts and playing classical guitar in an ensemble.

Budget

Dues/grants	$2,635.00
Registrations	$1,138.00
Field Kit	$564.42
Parts	$1,117.81
Supplies/misc	$303.10
Total Expenses	$3,123.33
Deficit	$484.51

(We plan to raise money bagging groceries.)



How have we improved from last year?

- We found a more efficient way to record our meetings: taking turns having one member be responsible for all the notes from each week's meeting.
- We followed our design process well.
- We let our game strategies determine our design requirements.
- We have had many more opportunities to get involved in our community and learn about engineering.
- We had more extra meetings to meet our milestones.
- We ordered and printed parts in a timely manner.
- We cleaned up and sorted parts regularly, keeping our workspace tidy.

Lessons Learned from 1st Qualifier

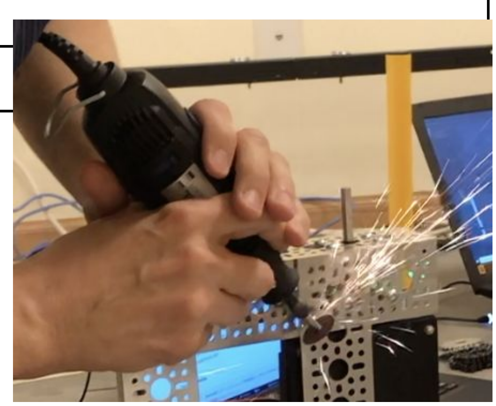
- **What:** Bring a soldering iron.
- **Why:** A wire broke that was critical; thankfully another team had a soldering iron.
- **What:** Finish our robot programming earlier.
- **Why:** Our drive code still wasn't working on the morning of the qualifier, but Roman fixed it little by little between matches.
- **What:** Get a lot of driving practice!
- **Why:** In TeleOp, we struggled to keep a consistent and quick cycle time.
- **What:** Have a robust design, with room for error.
- **Why:** Our pulley strings repeatedly came off, and a servo wire also broke.

Lessons learned this season:

- Extra meetings– don't let the work pile up!
- It is good to test things to make sure they work, so they don't have to be fixed last minute (like at our first Qualifier).
- It is good to chip away at the Portfolio, rather than saving it for the last 7-10 days.
- Try not to waste time early in the season, because it goes quickly.
- Volunteering at a tournament is a great way to prepare for our own tournament!
- Consult the game manuals early and often.
- Always check the battery before a match.
- Use Loctite– always!
- For future demonstrations: have a "go box" including pliers, zip ties, and our Team Shipping Element, and bring a banner saying "Want to drive our robot?" to attract people.
- Extra parts are helpful: We originally ordered 6 slides even though we thought we needed only 4, but it turns out we *did* need six.
- Include the Control and Expansion Hubs in our CAD, and leave room for the USB-C port!

Season Milestones

9/13	Have Game Manual 2 read.✔ Decide how much field to build.✔ Brainstorm "Game Strategies dictate design requirements".✔
9/27	Make a decision about lift vs arm.✔ Odometry working (10/4). Choose drivetrain & Lifter options.✔ Full CAD of gripper (11/6).
10/4	Lift fully CADed.✔ Start taking robot apart.✔ Gripper hand built (10/29).
10/11	Lift and Gripper built and working, including motors/servos (10/29).
10/18	Odometry pods built (10/25); Wrist and Gripper integrated and tested (11/12)
10/25	CAD complete; order all parts ✔
11/1	(no Josh) Chassis/drivetrain built (11/4); Hand/Wrist/Lifter integrated together (11/12)✔
11/7	Demos for Hand In Hand; visit Abbott and Custom Solutions Engineering ✔
11/8	Robot integrated (11/17); Red/Blue TeleOp programming complete (11/12)
11/15	(no Josh) All robot assembly and Autonomous programming complete (11/22)
11/22	Practice driving/Autonomous; work on Engineering Portfolio ✔
11/29	(no Josh) Practice driving with challenges; EP ✔ and speeches complete (12/1)
12/1	Dress rehearsal! Presentations, questions, robot runs. ✔
12/3	First tournament! ✔
12/6	Debrief, decide tasks, and set milestones until 2nd tournament. ✔
12/13	Finish testing hand and order parts, fix lifting cones in autonomous; Begin 3D printing new mounts for the Lift, and order belts and pulleys. Find a time for fundraising and bagging at a store.
1/3	Practice driving! No more robot changes after this week! (1/12)
1/10	Practice driving, finish updating Portfolio (1/12)
1/12	Dress Rehearsal, Scouting Sheets
1/14	Second tournament!
1/17	Debrief and set goals for State.



Goals for 1/14/23 Qualifier, set on 12/6:

- Have a design review with an engineer.
- Improve in Connect.
- Have a fully functional robot.
- Have plenty of time to test our code and practice driving.

Game Strategies… lead to… Design Requirements!

1. Achieve a high robot score, to control our destiny under the new WLT system.
2. Move robot in any direction.
3. Measure movement precisely.
4. Drive between poles, even diagonally.
5. Pick up cones from any level on the Stack.
6. Pick up cones lying sideways on the ground.
7. See freight well to grab it accurately.
8. Score cones at all four levels.
9. Keep the robot's center of gravity low, so it won't tip over when scoring high junctions or in a high-speed collision.
10. Don't let our robot get pushed around, and be able to push defending robots out of our way if necessary.
11. Detect the Team Signal Sleeve during Autonomous.
12. Ensure the robot can't get hung up on a Cone or Signal.
13. Ensure the robot can drive *over* a Ground Junction that has no cone.
14. Grab and place our team Beacon.
15. Gripper can grab cones without precise positioning so there is a margin for error.
16. Swap the battery quickly between matches.
17. All parts of Robot must survive impacts from wall, other robots, even tipping over.
18. Don't get corners caught on Vex field bars to maintain a quick cycle time.
19. Gripper hand must securely hold the cone, for any orientation we picked it up in.
20. Don't let a cone get stuck in our robot.

1. Maximize Autonomous points, and *minimize cycle time*.
2. Use Mecanum wheels.
3. Use odometry: 3 pods with small wheels.
4. Robot is 12" wide, and 15 ¾ " long.
5. Intake Hand needs to grab from top or side.
6. Intake Hand needs a wrist, and one side flat.
7. Intake Hand needs to be small, strong, and light.
8. Intake Hand/wrist mounts on a vertical slide or turret.
9. Mount the motors and battery as low as possible; keep the Gripper and Slide light.
10. Have a low center of gravity, and reasonably heavy weight.
11. Use a protected color sensor, at the optimal height, and inside the chassis frame.
12. Ground clearance should be at most 0.66",
13. Ground clearance should be at least 0.58", and our odometry pods must slide upwards to clear the ground junctions upon contact.
14. Beacon should fit on top of cones.
15. Gripper can grab cones anywhere in the middle (thick or thin), and 1" off center.
16. Battery is accessible but secure, with no Velcro
17. Have a strong metal outer chassis frame.
18. Frame must have round metal corners and no protruding parts.
19. Use a rubber wheel and rubber bands to firmly grip the cone without slippage.
20. Have an easily removable outer shell to prevent things falling into or out of the robot.

How we Motivate!

School Demonstration, 7/27/22 :

- Hand in Hand Christian Montessori in Roseville.
- We demonstrated our robot to a class of elementary school students, whose summer class had a theme of “Robots.”
- We brought mat tiles and part of the field and drove our robot around.
- We talked about robots in the real world, like Roomba and self-driving cars, and showed them a video of the Atlas robots dancing and doing parkour.
- The kids and adults had lots of questions, which we were happy to answer.
- We explained how the battery, motors, wheels, and wires worked.
- We also let them try driving it, even though they almost broke it☺️

Purple Gear Award:

- We volunteered at two HTK tournaments and the 3M demo.
- We also have a team website at **maniacmechanics.weebly.com**

Fundraiser at Chick-fil-A, 3/15/22:

- We fundraised at an Arden Hills Chick-Fil-A and talked about robotics with some customers.
- We ran into a couple friends and shared about robotics with them.

Benton County Fair, 8/2/22:

- We volunteered at the Benton County Fair with the Gear Ratios and Mechatronics (FRC).
- There were a few robots from non-FIRST organizations, so we did our best to represent FIRST and its robotics program.
- We were able to show our robot to various visitors, especially kids.
- Although we had problems with our arm, we let kids drive the robot and they had a lot of fun.
- We answered questions about FIRST and our teams’ robot, and taught the kids to think and drive from the robot’s point of view.

How we Motivate (continued)

Prior Lake Qualifier, 11/19/22

- Noah, Roman, Coach C, and Josh were judges for FLL Explore and helped decide what awards the teams would get.
- Emma sold safety glasses and helped answer questions.
- Seth and Jason helped as Field Technical Advisor Assistants (FTAA) by field inspecting robots, resetting the field after matches, and answering questions.
- Coach E was a judge and got to meet learn how tournaments work from the inside.

State Fair, 8/25/22

- Seth, Salim, Jason, and Coach E went to the MN state fair.
- We went to the area demoing robotics and answered questions about robotics to parents and kids.
- We explained how the robots work and chatted with a couple other teams.
- We talked about robots, FIRST, and our team with some friends who came to see us.

Demonstration at HIHCM, tour of Abbott, Demonstration and Custom Solutions Engineering, 11/7/22:

- Jason, Roman, Salim, Josh, and the coaches took our robot and part of our field to Hand in Hand Christian Montessori.
- We gave demonstrations to two classes, which were very successful!
- We let some kids drive the robot and they loved it.
- We also visited Abbott (see our “Connect” pages).
- Jason, Roman, Salim, and the coaches then went to Custom Solutions Manufacturing in Ham Lake, which is one of our sponsors.
- We gave a robot demonstration for the owner, Mr. Boortz, his three kids, and some of his staff.

How we Connect!

Visit with Cyberhawks (FTC 14188) in Duluth, 7/13/22:

- We demoed our robots for each other, and saw their 3D printer and inventory of parts.
- We discussed all things robot with them and learned some new ideas with respect to coding for odometry.
- We also worked with them to fix an issue where our hand servo would vibrate instead of strongly grip, making it difficult to hold on to blocks we would pick up.
- They gave us their portfolio from last year, which we all browsed and learned from before composing this year's.

1st Qualifier, 12/3/23:

- We met team 19566 **Coding the Cosmics** and shared a table.
- We exchanged portfolios to help each other do better in specific areas, and hope to connect soon.
- We hope to organize our portfolio better, and to help them build a more competitive robot.

Aaron Lam and Norton from Spontaneous Construction (FTC 14779), 9/21/22:

- They helped Jason and Coach E update our SDK and Android Studio to the latest versions.
- They also showed us how to connect Android Studio to download our programs to the robot wirelessly.

BWCA Trip, 7/13-16/22

- Several of us enjoyed the Boundary Waters with our dads.
- We went tent camping, canoeing, cliff-jumping, and invented a new card game!

St. Paul Machine & Design (12/28/22):

- Coach E met with Chris Neutkins, who owns a machine shop, and he agreed to custom bend and drilled a new hand bracket out of aluminum for us. We'll all tour his shop later.

Custom Solutions Manufacturing (11/7)

- The owner, Mr. Boortz, gave us a tour, showed us their huge CAM machines, and explained their process of how they design and make custom machines for other companies.

How we Connect (continued)

3M Super Science Event, 10/1/22:

- We joined a few teams representing FIRST and HTK at a 3M science fair.
- 3M people gave a fun demonstration of some interesting physics.
- Afterwards we let guests drive our robot and and answered questions about robotics and FTC.
- Our battery died, but fortunately Team 10273 could loan us a spare!

Tour of Abbott, 11/7/22:

- We toured Abbott in Little Canada, where our Coach works.
- Chris Bankers, a mechanical engineer, showed us a couple of his robot setups.
- Coach showed us the hardware lab.
- We also explored the Advanced Technology Center and demo lab.
- We scheduled a full demo of our robot and field for **January 30th**, and invited several dozen engineers!

HTK Kickoff Event, 9/10/22:

- We learned from experienced teams about portfolio formatting, robot design, and outreach opportunities during the breakout sessions.
- We made an effort to attend every single session, with at least one team member attending each.
- Thanks to these breakout sessions, we switched our portfolio from Google Docs to Google Sheets.
- We got to see the big reveal of this year's challenge and asked the referees some rules questions.

How we Think and Design our Robot

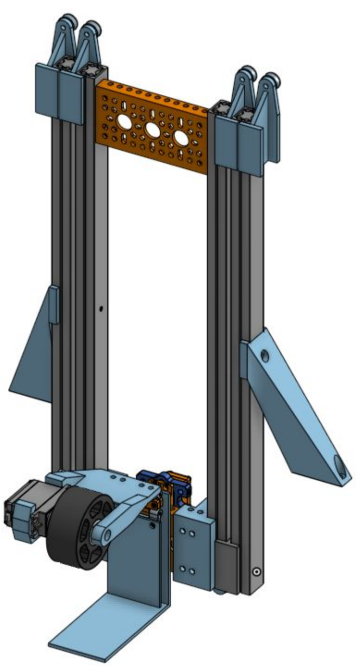
We use our design process to craft our robot:

1. **Brainstorm ideas**- We think about what kind of design we want to achieve the most points per second.
2. **Research and critique ideas**- We research ideas and come up with a list. Then we critique our ideas to fit within our time and money constraints.
3. **Use pros and cons for deliberation**- After we have narrowed down our list of ideas, we list all the pros and cons of each design. Then we vote for a design(s) to move forward with.
4. **Prototype**- We prototype our design(s) with CAD, seeing if we have the necessary parts and whether or not the parts will fit together.
5. **Assemble**- We purchase the necessary parts and use CAD as instructions for the assembly.

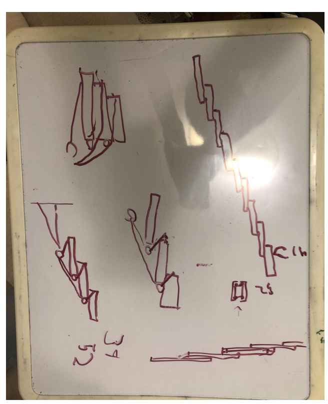
After brainstorming our ideas, we split up into teams of two to go through (and repeat if necessary) stages 2-4 as we were able.

Lift team: Emma and Seth

Iteration 1



- We looked at the Cyberhawks' slides from last year and decided to use the same lightweight aluminum slides, to minimize weight.
- We drew a sketch of ideas, and eventually decided to use one set of slides on each side, for more stability.
- Josh designed a pulley system in CAD, and 3D printed the pulley mounts and spools, and Noah and Josh helped assemble it.
- We also had to figure out a way to connect wires for two servos and one touch sensor to the hubs, so Jason soldered connectors on both ends of a large coil cable with 10 separate wires inside it.



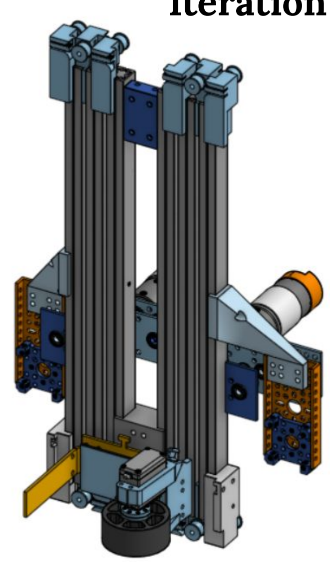
Considerations:

- We considered using only one set of slides, but decided against it for stability.
- The string and spool system we designed was not robust enough to withstand tournament play.

Iteration 2-3

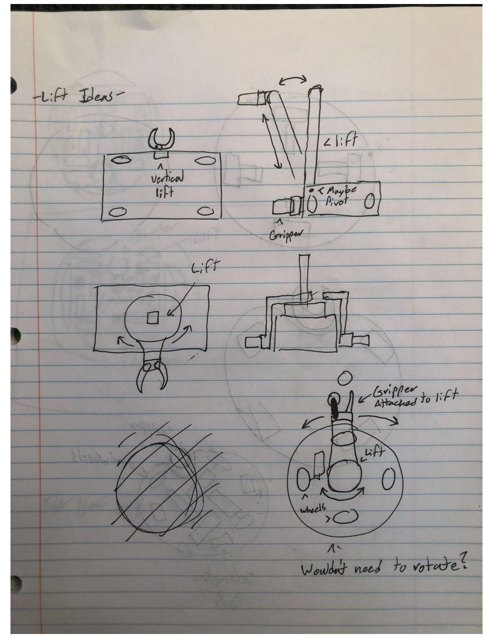
- At our first qualifier, the lift frequently came unstrung, we had trouble reaching the high pole, and it could not be powered down using our motors.
- So Josh designed new slide mounts and redesigned the lift in CAD; it uses toothed belts and pulleys instead of string. But we thought we could eliminate the gearbox.
- For our **3rd Iteration**, we went from 4 slides to 6, to more reliably reach the high poles, and made a new gearbox.
- Now, it has more torque, and can easily reach the high pole–but the belts have sometimes broken from strain.

Iteration 3



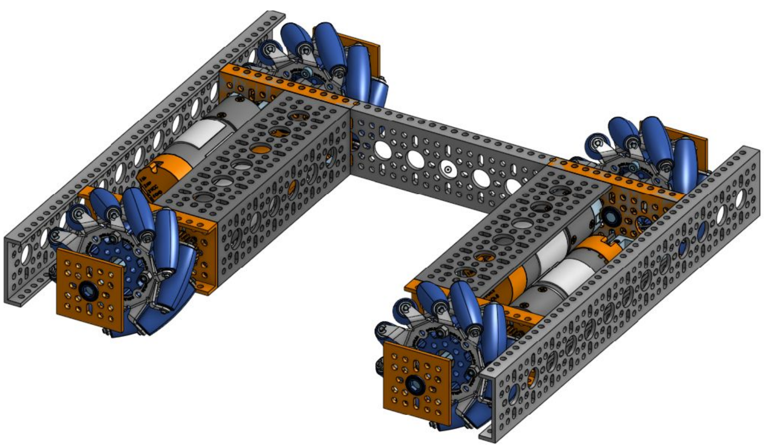
How we Think and Design our Robot (continued)

Drivetrain team: Josh and Salim



- We use several goBilda channel and a large custom steel shell to protect our robot.
- The mecanum wheels allow us to drive in any direction.
- We placed our motors horizontally to keep our center of gravity low.
- The drive train is 15¾" by 12", and is 18" diagonally, so it can drive in between poles with room to spare.
- Emma, Salim, Jason, and Josh each assembled one wheel, and then Josh and others finished assembling it.
- Josh designed and printed the odometry pods, and then he assembled them and Seth helped him install them.
- The steel shell has a box attached that holds our battery.
- Iteration 2 had motors above each other to minimize the total length, but we decided that wasn't as important as a low center of gravity.

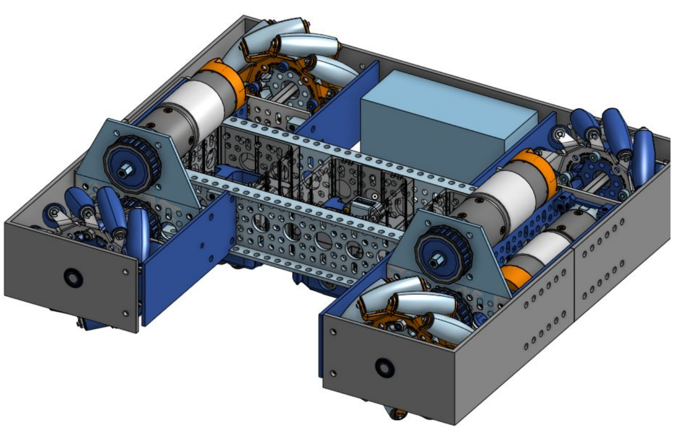
Iteration 1



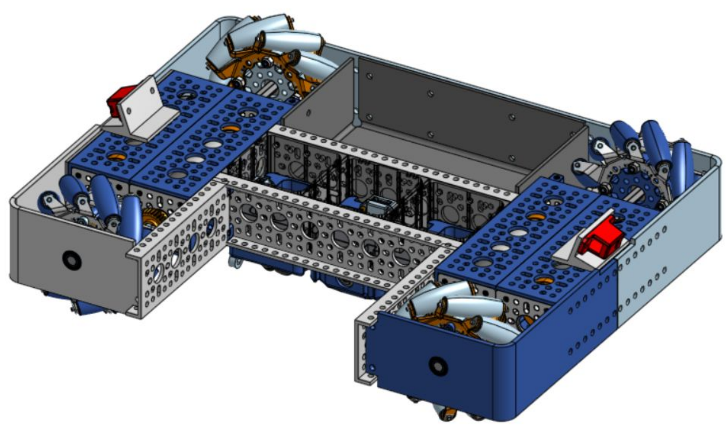
Considerations:

- We considered many different chassis designs, including U-shaped, circular, and H-shaped designs.
- We also considered having two parts to our robot that would detach, or using omni wheels instead of mecanum.
- We considered a mecanum drive train that stacks the motors partially on top of each other and uses gears.
- We considered other motor layouts as well, but we wanted to keep our center of gravity low.

Iteration 2



Iteration 3

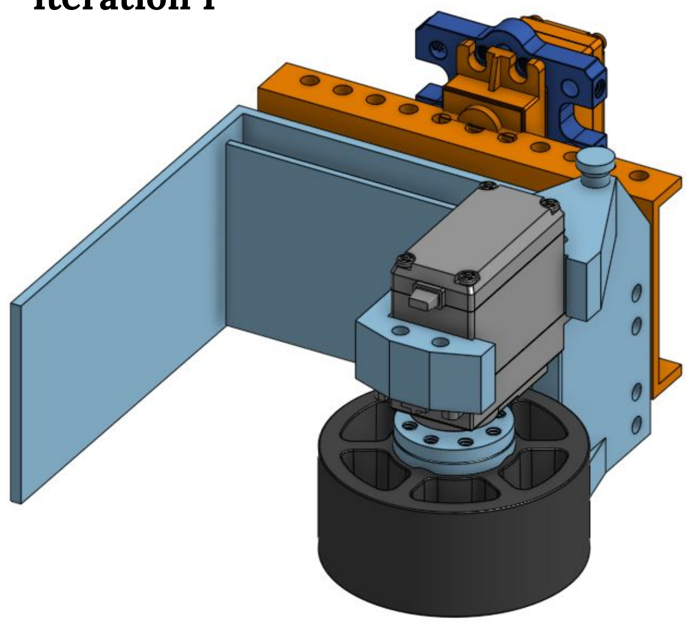


How we Think and Design our Robot (continued)

Gripper team: Jason and Noah

- We designed a gripper that uses a gecko wheel and a flat surface to intake cones.
- The wheel is sticky and squishable to grip cones, and the flat surfaces have special silicone gripper tape.
- The touch sensor stops the wheel from spinning when we capture a cone.
- The entire gripper is on a 'wrist' that allows it to pick up cones from any orientation.
- The wheel uses rubber bands (springs, in the second iteration) to keep tension on the cone against the flat surface.
- We had to redesign the touch sensor flap because it would flop onto the wheel and prevent us from grabbing cones.
- Jason soldered the touch sensor, the wheel servo, and the wrist servo to our wiring cable.

Iteration 1

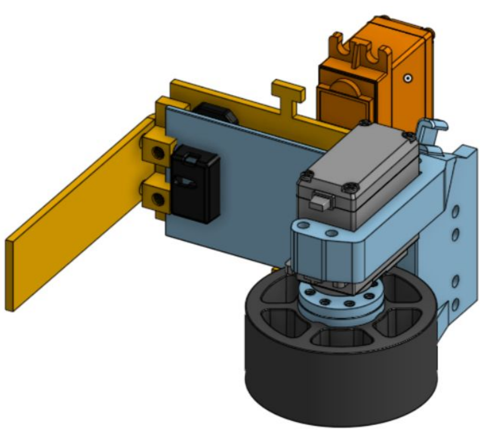


Considerations:

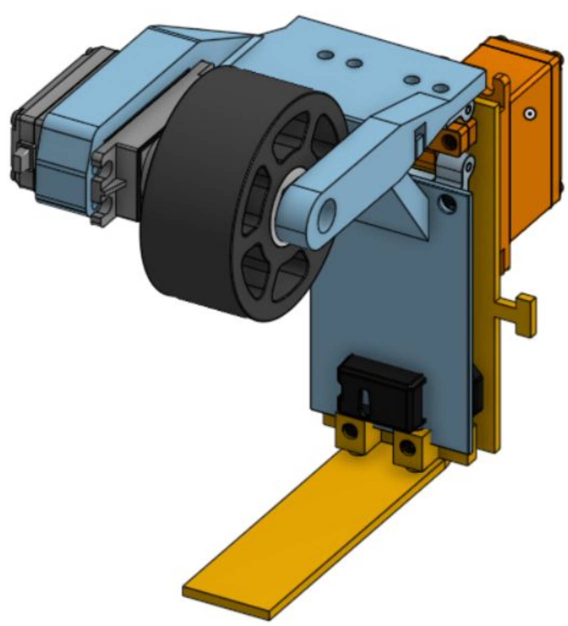
- We considered using pincers to grip it.
- We thought about using a different way to correctly orient the cone.
- We had to find a way to wire it well, and we thought a coil would be best.
- The gripper wheel wire detached at our first Qualifier, but thankfully another team had a soldering iron that we fixed it with.

Iteration 2

- After our 1st Tournament, Noah tested how far of center our hand was able to grab cones.
- Against the wall it could grab cones ranging 9 cm from left to right and less away from the wall, so he determined that we needed a wider intake to grab cones faster and more reliably.
- Josh designed a new gripper bracket that is stronger, has notches for our rubber bands, has a shorter thumb, and is wider (thanks to Noah's testing).



(with Wrist rotated)



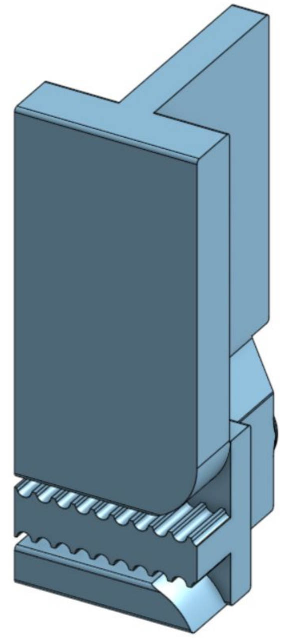
How we Innovate & Use 3D Printing

We designed several 3D-printed robot parts:

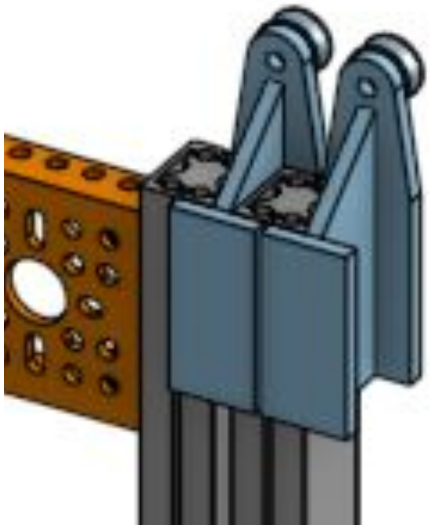
Our lift mounts and belts:

- We expanded to a three-stage lift which can reach well above the highest junction.
- Our first iteration used pulleys and strings, but our second iteration uses belts, which are secured by the lift mounts.
- There are three pairs of belts, one for each stage with the custom 3D printed parts anchoring the belts.
- The 3D printed parts have ridges on the insides that both secure the belt and allow us to adjust the belt in 2mm increments to keep the belts taut–much easier than tightening strings!

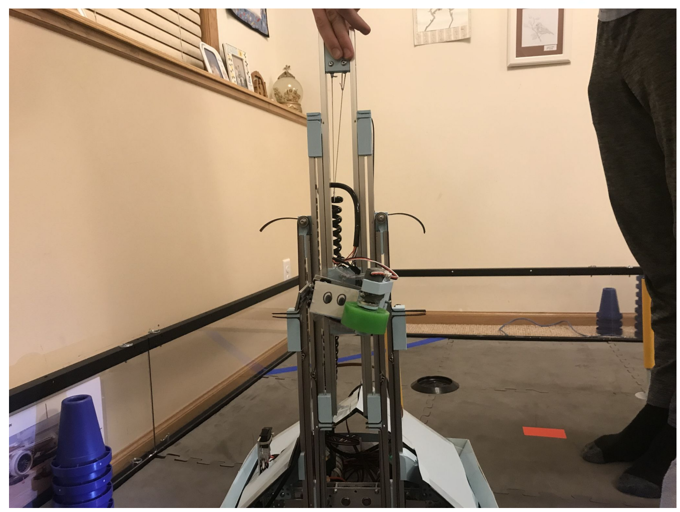
Lift mount Iteration 2



Lift mount-Iteration 1



Current lift



Our Beacon:

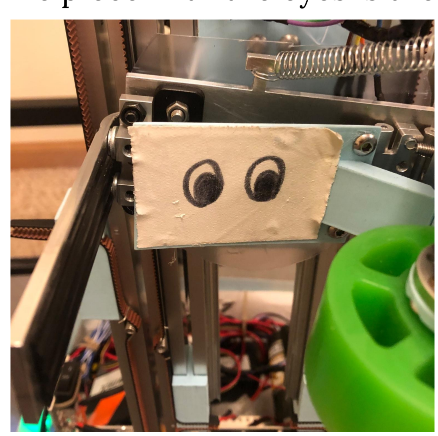
- Our 1st Beacon design was more pliable and easily slid over the top of the cone.
- The current design has a smaller interior to fit more tightly.
- It also rests higher on the cone, so when we intake the cone, the beacon does not come off.

Iteration 1

Iteration 2

Our gripper and Wrist:

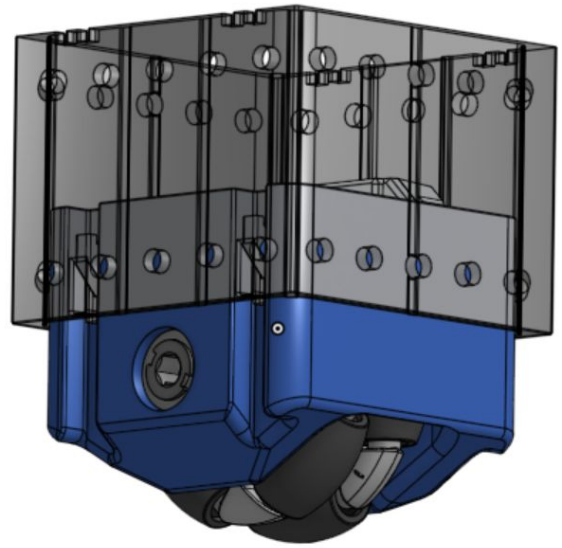
- The servo wheel piece is hinged, with a spring to always press it against the cone.
- A flap presses the touch sensor, so we can start driving as soon as a cone gets grabbed.
- The piece with the eyes is the flap.

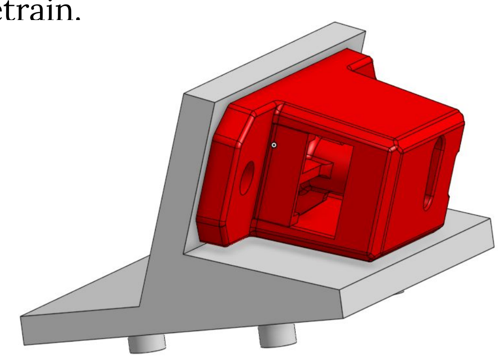


How we Innovate, Control, & Use 3D Printing

Our Odometry Pods:

- Josh designed and 3D printed our odometry pods. They're square and interchangeable, with holes at 12mm spacing so we can mount them to goBilda in 4mm increments.
- They can slide up if they hit a ground junction.
- They use braces' rubber bands to hold the wheels against the mat for traction.
- We use three pods, to accurately calculate our position and rotation.
- We use small omni wheels and encoders that fit inside our pods and inside our drivetrain.



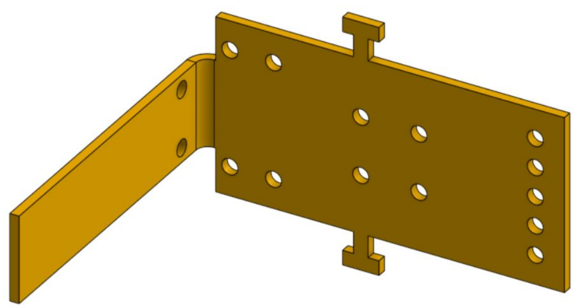


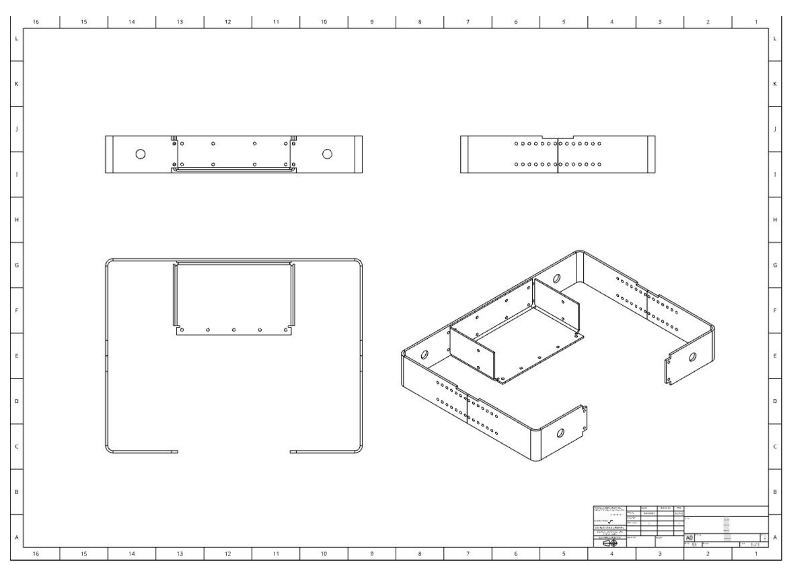
Our color sensors:

- We made 3D printed parts to mount our two color sensors.
- The pieces firmly grip our gobilda channel using zip ties.
- The angle is optimal for sensing the signal sleeve.

Our steel outer frame and aluminum Gripper bracket:

- Josh designed the gripper bracket, and Coach E asked Mr. Neutkins to CNC cut, bend, and drill it for us.
- We designed the steel frame in CAD, specified the bends, and ordered it from SendCutSend.com.
- SendCutSend laser-cut it and bent it before shipping it to us.
- We made it in 3 pieces and designed many screw holes, so we can make our robot bigger if necessary.
- It protects our robot from collision damage.
- It has rounded edges so we don't get stuck on the Vex fields, which was a problem last year.
- We also designed a box for our battery.

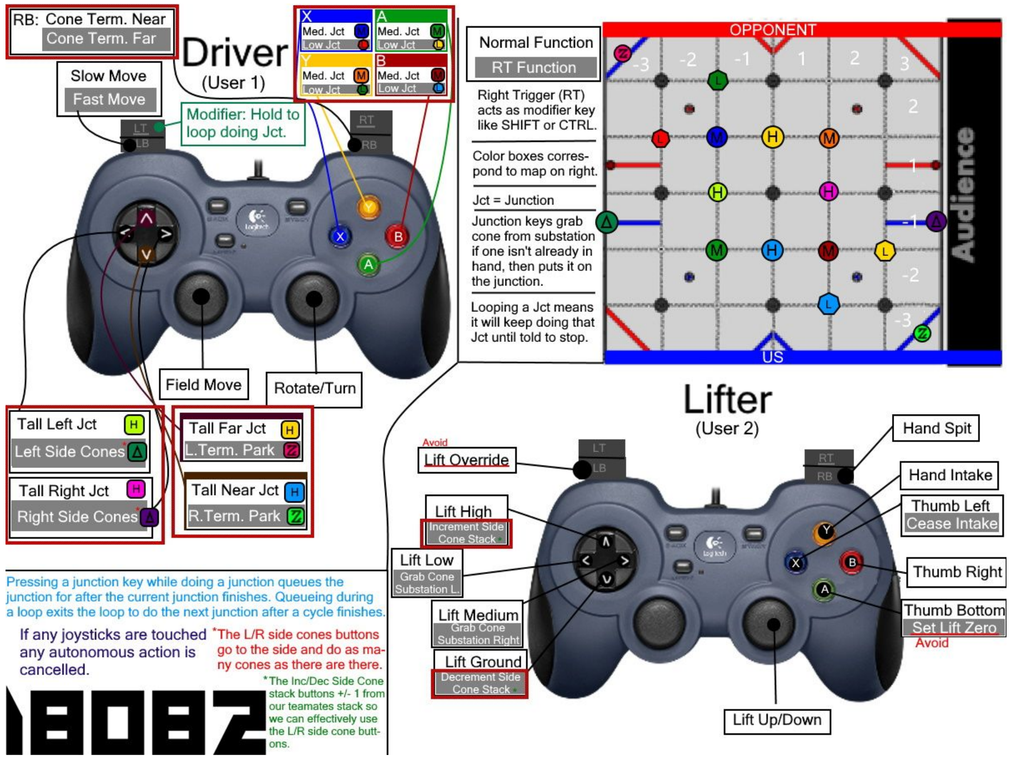




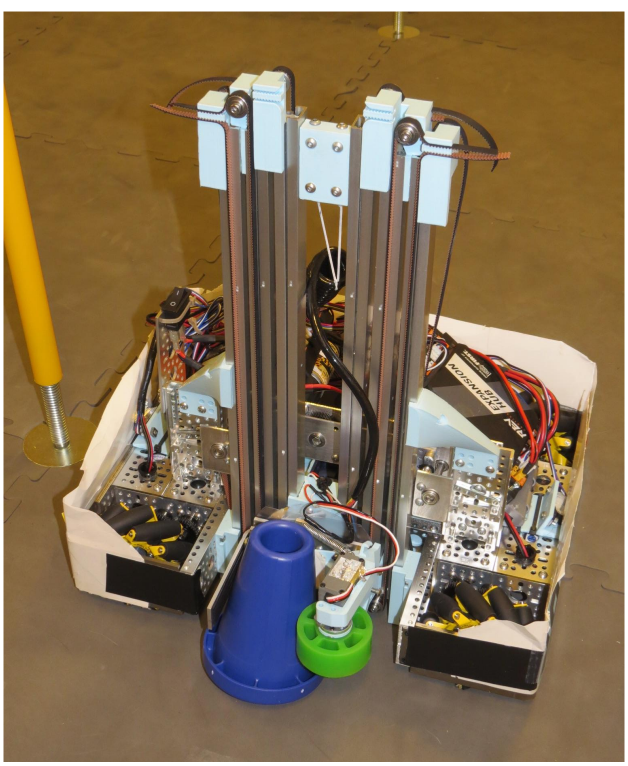
How we Control (and use Odometry)

Our programming:

- We have a standard drive program that uses a field-oriented coordinate system.
- This means that "forward" on the joystick is the same direction no matter which direction the robot faces.
- We can have our gripper pick up a cone from any orientation using the right pad of our controller.
- The left side of our controller has pre-set heights for delivering cones in TeleOp.



- Roman put together the above diagram of our robot controllers and functions.
- He wrote most of the code over Christmas Break, however, some of the autonomous features during TeleOp are still in the debugging phase and will not be ready for this tournament.



- We can put cones on any specific junction, by grabbing a cone from the substation, then delivering it with the click of a single button.
- The red outlined parts are most relevant and important.
- Jason, Roman, and Salim worked on odometry with Coach E. It took a ton of work, but we persevered!
- Our pods last year were not in the middle of our robot, which caused coding problems.
- Now our spring-loaded pods are centered in the robot chassis, and got reliable odometry!
- Our driveTo() function follows a path and steers the robot back toward it if we get off.
- Now we can drive within a centimeter or two of the exact positions we specify!