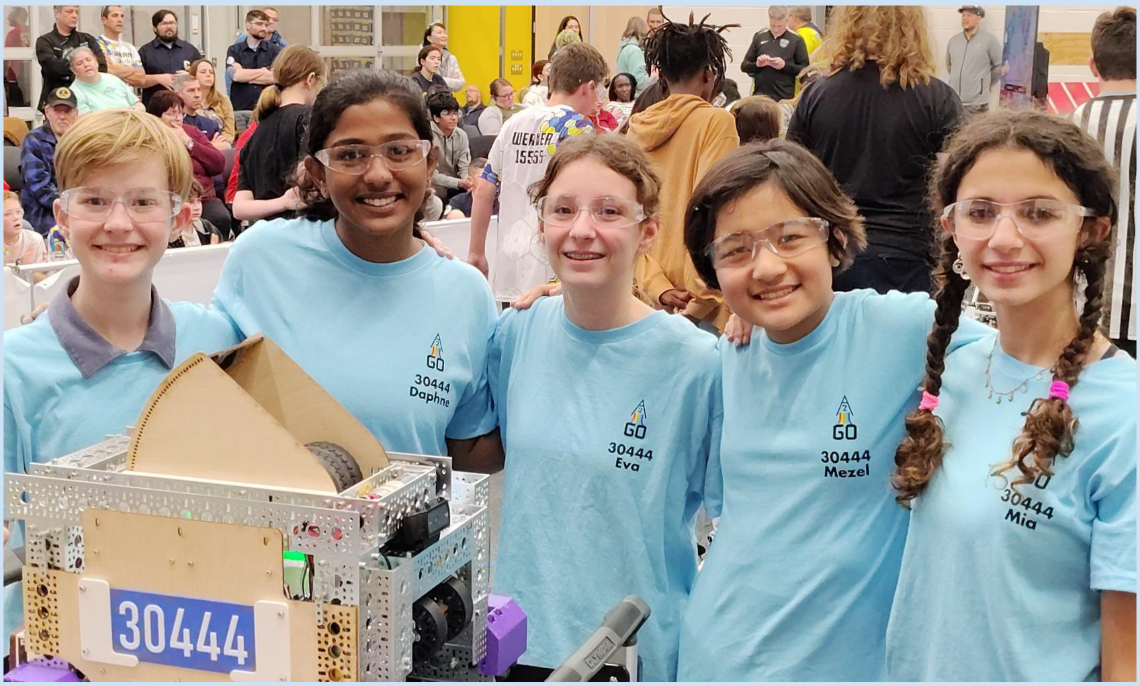
Engineering Portfolio

FIRST Tech Challenge Decode Competition

A2GO: FTC Team 30444



Community team from Ann Arbor (A2), MI • https://a2go.ing

DIGGING DEEPER INTO MYSTERIES AND DECODING OUR FUTURE.

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Also please note that all our work is shared openly on our web site, and through FTC Open Alliance.

We really appreciate all the people who make this competition possible, THANK YOU!

Meet A2GO

Our rookie team decided to start our team meetings early in January 2025 so that we would be ready to dig in right at the start of the 2025-2026 competition. As a community team, we didn't qualify for any startup grants or funds. Our coach bought us a used robot. Since then we have completely disassembled, redesigned, programmed, and built our robot back up from scratch. We ALL participate in ALL aspects of the team (CAD, Coding, Build, Marketing, Drive team).

We love being part of FTC because it's really fun to explore the wonders of engineering and the satisfactory to get everything working together. We also love playing competition matches, but the best part is being able to have this experience side-by-side with our friends!

Mia B. – I'm in 8th grade and am excited for this year's competition! Last year I enjoyed FTC, and am delighted to come back and compete in my final year doing FTC. I love all things business & build and am excited to expand my knowledge this year in Decode!

Daphne E. – I'm returning for my third and final year in FIRST Tech Challenge as an 8th grade student. I am excited to play DECODE as my final game in FTC! I am excited to bring experience from participating in Centerstage and Into The Deep. I bring my knowledge of Coding, CADing, Building, and marketing to the team

Eva L. – I'm new to robotics, and excited to be part of an FTC team in 8th Grade. I enjoy technical aspects of robotics including CAD, coding and building. I'm excited to participate in DECODE. I'm bringing past experience with block coding and 3D modeling to the team. I'm excited to be working on a team with my friends.

Mezel S. – This is my second year in FTC. I am in 7th grade and enjoy business and building. I shine as the team ambassador, bringing my friendliness, enthusiasm, and gracious professionalism to network and scout with other teams. I have experience with block and Java coding, building, and making robots at home. I hope to show gracious professionalism in all aspects.

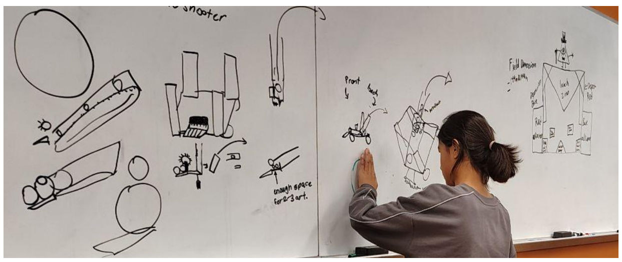
Hima J. – I found out about FTC robotics at an outreach A2Go held at my fencing club. I was excited about robotics, but it was not offered at my school. I'm thrilled to be part of this team now. I'm interested in coding and math. Programming Java for FTC is a great opportunity to develop these skills.

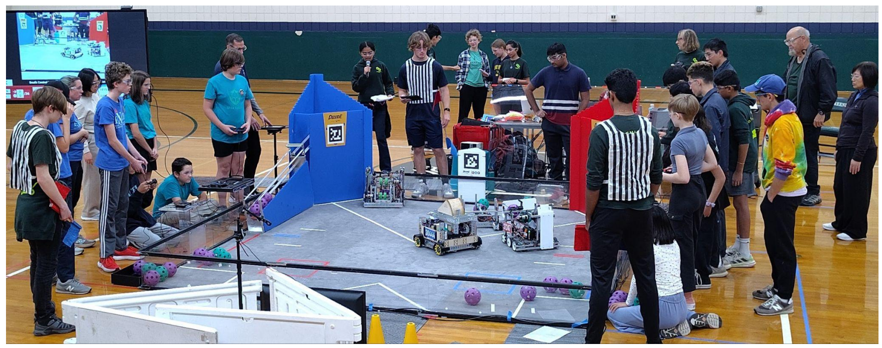
Goals & Reflections

Goals

We hope to embody Gracious Professionalism while competing intensely in the Decode season. We are excited to learn, have fun, and show what our rookie team is capable of!

We attended the launch event hosted at the University of Michigan by FAMNM. We immediately wanted a robot capable of both ground and human artifact intake, sorting to match patterns, and a turret with hooded flywheel launcher to aim and shoot artifacts. We also want to achieve full park for both robots, and to develop a strong autonomous program. We wanted our robot to be reliable, strong, and unique.





Reflections

	What Went Well	What Didn't Go Well	Next Steps
MSCRL League Meet 1	Robot is heavy (30lbs!) but also fast and can push other robots. Can shoot & score from the far triangle. Robot is quick. Roller intake works well Human player loading great!	No autonomous program. Lifter mechanism jammed. Ball sorter servo broke when the lifter jammed. Drivers had trouble aiming Launcher. Drivers had trouble with sorter & lifter.	Build autonomous Replace sorter servo. Fine-tune lifter code. Fine-tune sorter code. More driver practice. Automate aiming? Automate flywheel speed?
GLBR Qualifier	Won the INSPIRE award! Made many team friends. :D Almost no penalties (5 pts) Strong defense when the sorter broke (no launching). Worked well to replace sorter.	Very limited autonomous progr. Trouble with starting programs. Sorter servo burned out. Getting bumped out in parking. Wifi disconnection / hub resets. Team uncoordinated.	Make a REAL auto More drive practices! Software locking in place (for shoot & parking) Prevent sorter and lifter collisions with software
Saline League Meet 10	Great autonomous! Great teleop with s/w! Great teamwork! New MEMBER :D	Started auton backwards once Slow lifter (7s) & intake Flywheel slow to get to speed Never dual full park Lifter broke	Make a drive checklist New fast lifter & intake PID tuning flywheel Add parking lift

Budget & Fundraising

	Actual	Projected
Team size	5	6
Registration fee	400	400

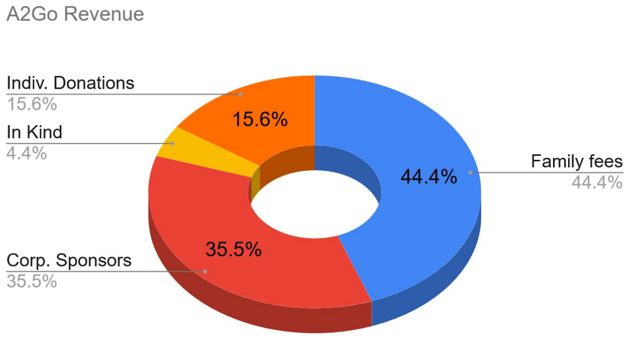
As a community based team we rely on the support of family and community to help us be competitive at the state level and hopefully the world level.

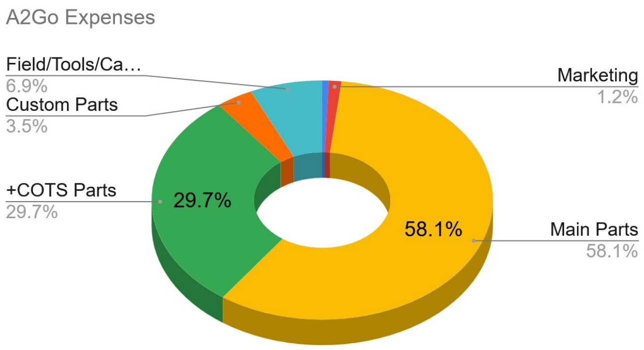
We needed to prioritize our limited funds! We decided to use the money to build a great robot and participate in as many events as we could.

We were very energized after our Inspire Award to fundraise!

We expected to have 6 team members, but 2 student team members didn't end up joining. We recently recruited a 5th teammate! Our families will contribute to team costs, but we haven't finalized that yet. We would like to cover more of our costs via sponsorships.

Starting at Thanksgiving we began a major outreach and fundraising effort. Our business team raised over $2,500 from 8 sources in less than a week! Our new corporate sponsors include Base Camp Restaurant ($500), Rock N Roll Sushi ($500), Key Realty ($500), and Farm Bureau ($100). Numerous family members have also donated to support our team.





We thank our sponsors for their belief in our team and all they've done to help support our goals!

Revenues		Actual	Projected
	Family contributions	$0.00	$2,400.00
	Sponsors	$1,600.00	$1,800.00
	In kind donations	$200.00	$500.00
	Fundraising	$0.00	$50.00
	Friends & Family Donations	$701.00	
	Total Revenues	$2,501.00	$4,750.00
Expenses		Actual	Projected
	Team Registrations	$876.92	$800.00
	Marketing	$52.64	$1,000.00
	Parts kit (main parts purchase)	$2,544.92	$2,480.00
	Other COTS parts	$1,303.84	$0.00
	Custom parts	$153.87	$0.00
	Field elements, Tools, Cart, Pitts	$300.78	$650.00
	Total Expenses	$5,232.97	$4,930.00

EWT has provided initial coverage of all our direct costs, some of those costs are being reimbursed from other sponsorships and family contributions.

Base Camp Restaurant are both a major financial sponsor, have also provided team dinners during practices. Kosmos Bop Shop and Himalayan Bazaar hosted us for fundraising activities during Midnight Madness on December 5th. PrintCitee sponsored our shirts. OptoSigma provided merch and t-shirts. We plan to follow up with several other potential sponsors soon.

We look forward to developing more marketing materials, including things for giving away at competitions. We're pretty excited to make some fun items for the pits!

Outreach

As a result of Outreach, we had a new member join mid-November. We're thrilled Hima joined us!

Online Outreach:
Web site - https://a2go.ing/
https://ftcopenalliance.org/teams/30444
Reddit (few), Discord (drfew_75112)

In Person Outreach:
Go-Tech Group - in person monthly meeting of 40-50 people, mostly adults, presented about our team and robot.
Washtenaw Elementary Science Olympiad (wesoscience.org)
Utilidata - reached 4 kids, 8 adults. Assisted with soldering & robot driving.
Neighborhood kids - reached 2 kids. Showed robot and driving.
Friends from other activities (fencing, school, & everywhere we go) reached 37 kids.
Family - across the team we spoke with about 65 family members across our families

Mentors & Community:
FRC Team # 5708, Zebrotics members Dom, Lena, and Mark have mentored our team. https://zebrotics.org/
Tech Workshop in Ann Arbor (https://techworkshop.org/)
Maker Works (maker-works.com), Nova & Marty have taught classes (laser cutting and Fusion) to our team.

Assisted:
28804 Cybersmiths - we assisted the Cybersmiths by sharing our color sensor artifact classification algorithm.
32285 SPAA Cybirds 2 - we assisted the Cybirds by providing an e-clip and helping to repair one of their mecanum wheels when it broke at the 2025 South Central Meet 1 at Greenhills. We also connected the Cybirds with the Cybersmiths for additional mentorship and training.
29555 - Via reddit: helped student find resources to learn to program JAVA from the offline Blocks editor ("tysm omg 😭 you have no idea how helpful this is").

Assisted by:
28804 Cybersmiths - The Cybersmiths and TechWorkshop have taught us how to program PedroPathing, let us use their practice field, given mechanical feedback and troubleshooting, and been incredibly supportive!
26606 - H.I.V.E. Saline, MI. Their lead coach Jeroen Spitael has provided a lot of feedback and guidance to our lead coach. They helped us to find a cart, and even picked it up and brought it from west Michigan right to our team! Their guidance has been extremely supportive and instrumental to helping us start our team. They also introduced us to the Michigan South-Central Robotics League (MSCRL), which we ended up joining. Coach Spitael also helped us with concepts for our improved lift mechanism!
11618 - Gremlins, Chelsea, MI. We attended a Gremlins practice. Their spirited & fun routines build community!
23247 - ARES. Their ball lifter tool was helpful to safely test the flywheel Launcher.
21351 - Cybotz. Web site helpful for learning this year's competition rules. https://challenge.cybotzrobotics.org/
19250 - VikingBots. They ran robot-rescue at the GLBR qualifier and 3D printed a critical replacement part for us!
First Alumni and Mentors Network at Michigan, https://famnm.club/. We attended their kickoff event Sept. 6, and their presentation and portfolio workshop Nov. 18. Great experiences w/ FIRST alumni!

A2Go Direct Sponsors:
Esmonde-White Technologies, Base Camp Restaurant, Key Realty, Rock N Roll Sushi, Farm Bureau, Himalayan Bazaar, PrintCitee, Staples, Kosmos Bop Shop
Maker-Works and the Ann Arbor Rotary Club (complementary training classes & shop space use)

RevRobotics, GoBilda, OSHPark - for providing our FTC team a discount
AutoDesk - for providing Fusion for FTC teams! Our robot is designed in Fusion

A2Go Indirect Sponsors:
RTX - thank you for sponsoring the 2025-2026 FIRST Tech Challenge season!

Team Training Plan

One of our key goals is to help all team members develop new skills. As a small team, we train every member in *everything* and typically work on tasks in small breakout groups. We track skills that have been learned by each member in a spreadsheet.

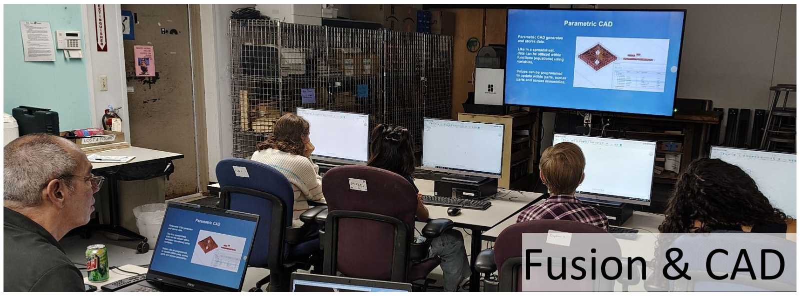
Here are some of the things we have learned this year:

- Basic electronics & sensors, and using multimeters
- Design, Ordering, and Assembly of Printed Circuit Boards
- Configuration of hardware in the control hub
- Blocks coding for hardware control
- FTCSim for learning programming & robot control basics
- Introduction to JAVA (starting from Blocks)
- Basics of odometry using encoders and pinpoint
- Basics of path following using PedroPathing
- PID tuning, State Machines, Using Sensor Data
- Basics of vision processing & using AprilTag poses
- CAD & Parametric Design
- 3D Printing, Soldering, Laser cutting
- Cutting, bending, and drilling thin sheet metal
- Prototyping and Assembling mechanisms
- Learning about FRC & Professional Engineering
- Presentations, Outreach, and Basic Finance

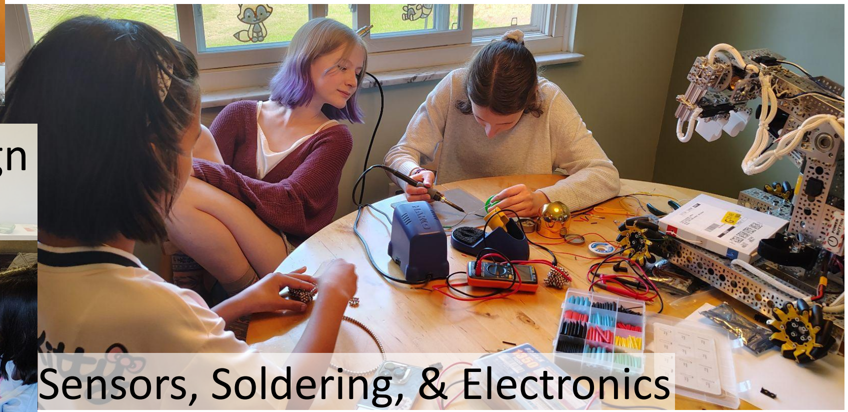

Portfolio & Presentation

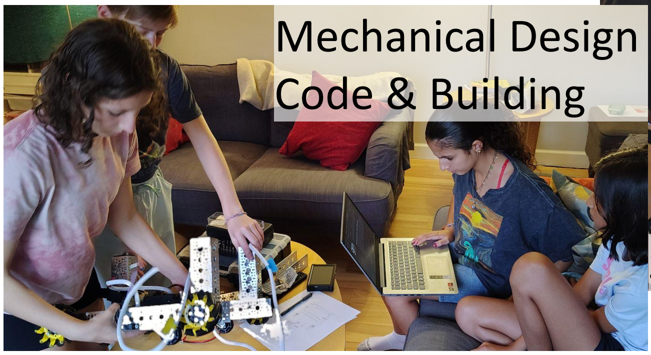

Fabrication (Sheet Metal, Power tools, 3D Printing)


Fabrication (Laser Cutting)


Fusion & CAD


PedroPathing Training


Sensors, Soldering, & Electronics


Mechanical Design Code & Building

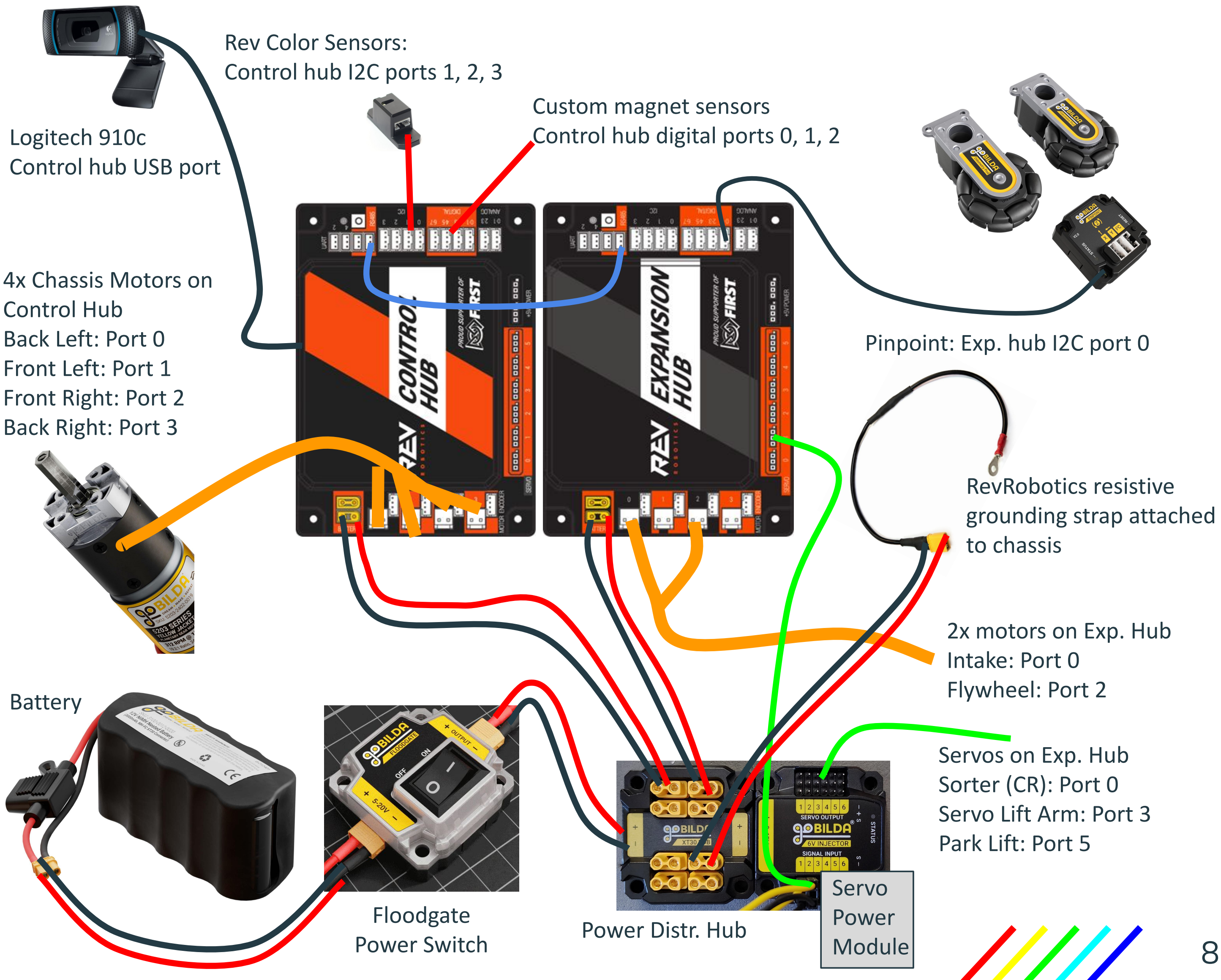
Robot Overview

Our robot has two ways for intaking artifacts, a ground roller intake and open area for dropping artifacts into. We have an artifact sorter, which incorporates magnet sensors and color sensors. Custom magnet sensors index the artifact positions and are used to start and stop a continuous rotation servo. The color sensors identify the artifact colors when the servo is stopped. Our artifact launcher is powered by one speed servo and pushed the balls from our sorter into the flywheel hood. The flywheel hood has four belt-driven Rhino wheels that spin at up to 6k rpm. We use many electronics from GoBilda, including a power distribution hub (to avoid voltage drops to the different modules), servo power module (to provide constant voltage to the servos), and a Pinpoint module for odometry management.

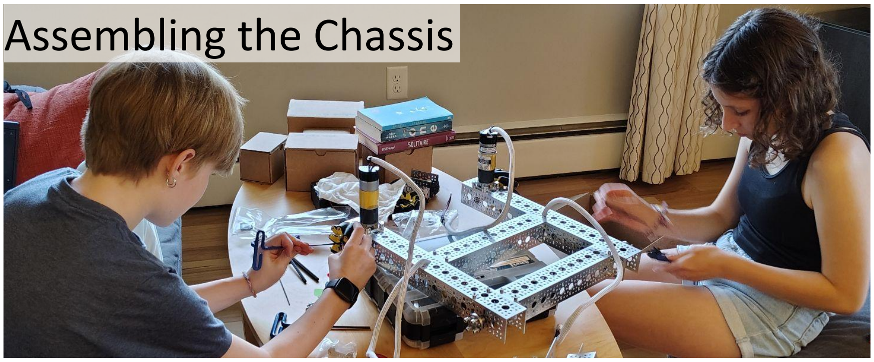
Our launch mechanism can be removed with just a few screws for maintenance of the sorter and lifter assemblies. We also designed the robot with a hinged door to access the electronics for maintenance.

We use Blocks to prototype software for new mechanisms, then program modules in Java for our final autonomous and tele-operation code.

Electrical Diagram

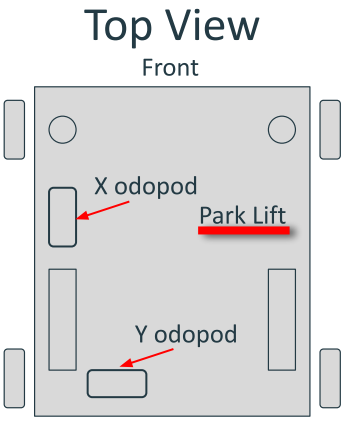


Drivetrain


Assembling the Chassis

In June we disassembled our previous robot chassis and arm. We rebuilt it into our current chassis, still based on a GoBilda Strafer design with 104mm wheels

We rebuilt the chassis with the front two motors mounted vertically. This allows space for the odometry pods and roller intake. We use direct drive with four 312 RPM GoBilda Yellowjacket motors and 90 degree bevel gears, just like the original Strafer design.

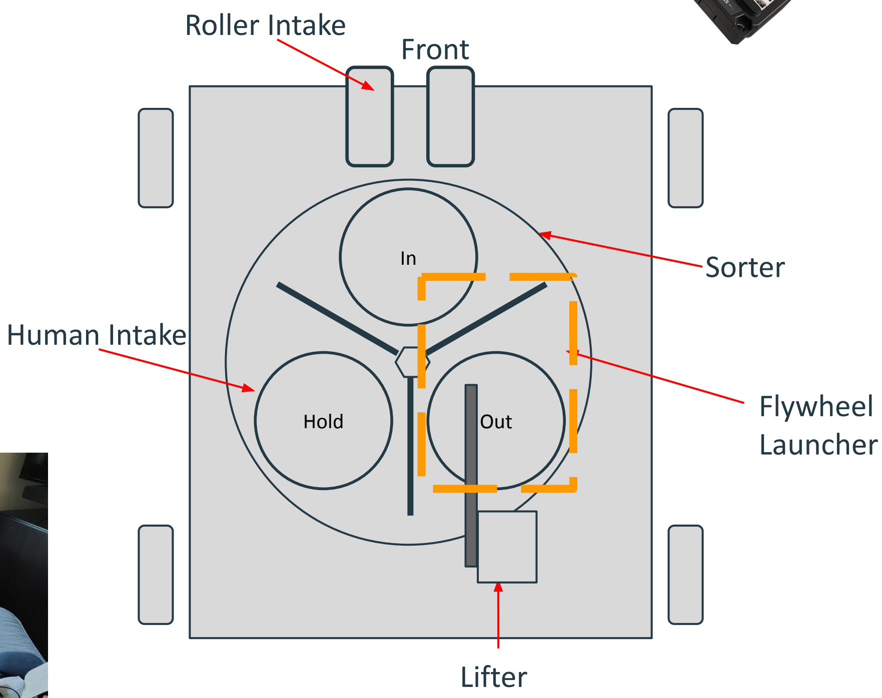


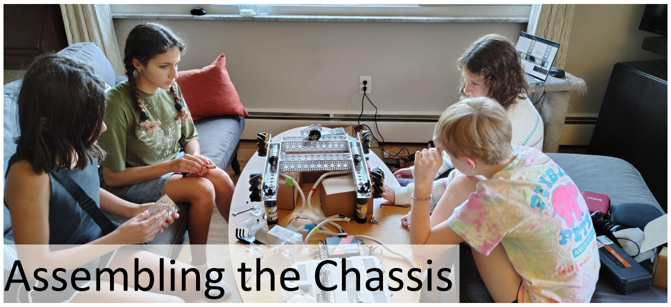
Because we have a really heavy robot, we decided to upgrade to GripForce Mecanum Wheel rollers (30A) for better traction. It has improve our robot's traction. We can now drive at full speed without slipping.

We have older swingarm odometry pods, and this season we added a GoBilda Pinpoint module for position tracking. This makes it much easier to track the robot position. We have also added a Logitech C920 camera, which we use in auton to read the obelisk AprilTag to determine the correct ramp pattern.

At first we used blocks for out Teleop and auto, but now we have moved over to Java using Pedropathing. Moving to pedropathing allows us to drive in robot or field-centric coordinates, but also to build simple autonomous programs using simple line segments with headings for automatically reading AprilTags, launching artifacts, and picking up a ball stack.

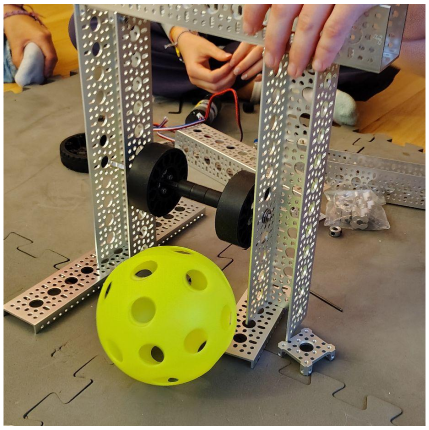
We also added pre-programmed drive target locations to speed up teleop, and a lockdown mode!




Assembling the Chassis

Intake

First Intake Prototype!

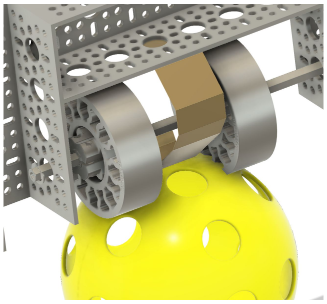


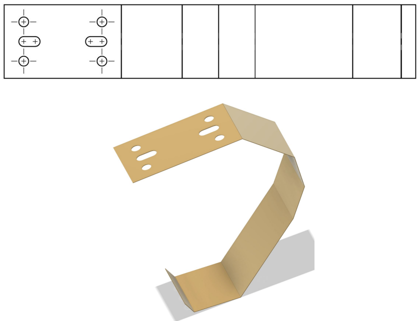
Ground Roller Intake

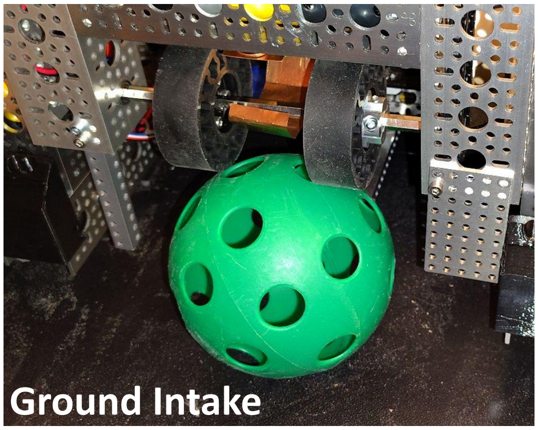
Our first prototype included two 72 mm GoBilda Gecko compliant wheels and 3 smaller rollers on a shaft with bearings, and was powered by a drill to spin the axle and wheels.

We decided that our ground roller intake could work with just the Gecko wheels. We are also using a custom designed and fabricated phosphor bronze spring on top to help hold the balls in the sorter so they don't contact the Gecko wheels once loaded. We use a phosphor bronze spring underneath to spring the artifacts up during intake and keep them from falling down during sorting. We originally didn't think it would work, but after testing various configurations, that configuration worked really well.

Our intake is operated by rolling the artifact inwards. Our sorter is designed to hold only 3 artifacts, and our intake rollers can be reversed to actively push out any unwanted extra artifacts. We also recently updated the intake motor to now go three times faster (117RPM to 312RPM).





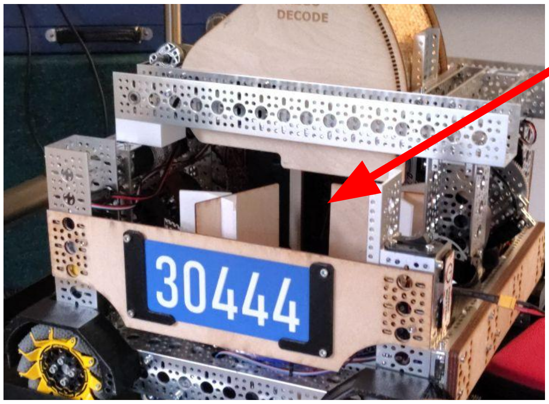


Human Player Intake

We also left space on one side of the top of our robot, so that our human player can drop artifacts into the ball sorter. Only one artifact ball can be dropped in at a time, and the artifact selector needs to be rotated in between each artifact. The design of our sorter means our robot can only ever be in control of 3 artifacts.

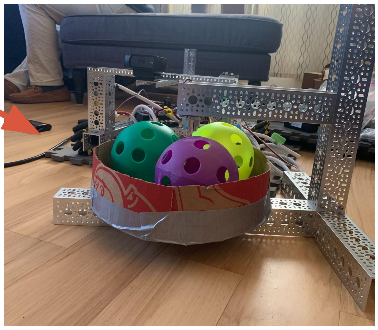
We had problems with this during our first league meet. We received penalties because we were pushing the ball into the robot. We cut open a slots in the plastic ring so that the human player can easily drop the balls in and staying safe.

Ball drops in



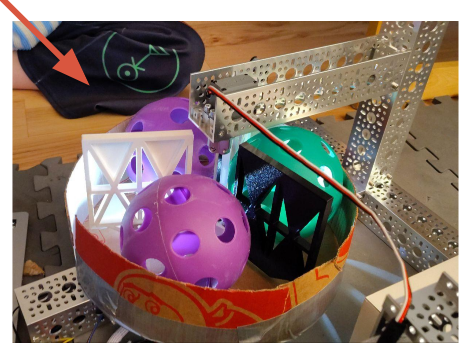
Artifact Sorter

Prototype 1



Our original ball sorter prototype was made of cardboard, using a continuous rotation torque servo to spin the artifacts. In our first design we had three GoBilda 1106 series square beams moving the balls. From the beginning, we optimized the tray size to only hold 3 artifacts.

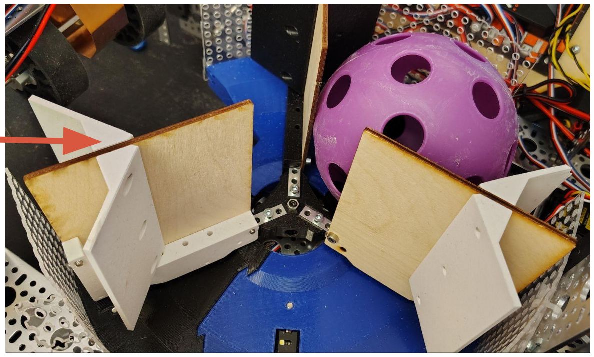
Prototype 2

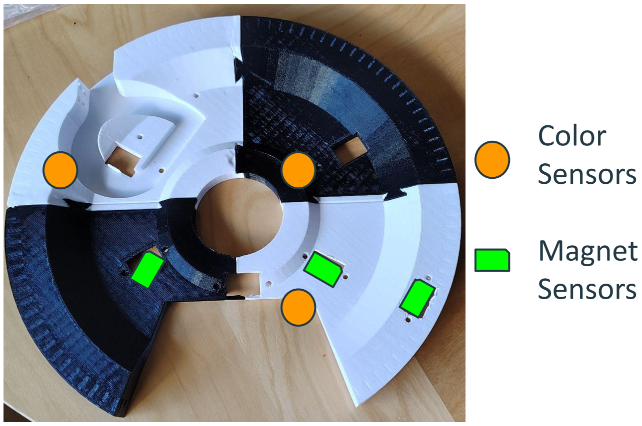


Once we had a design for our launcher hood, we redesigned the sorter arms to include paddles. These paddles provided sideways support so that the ball doesn't move sideways while being lifted. Each paddle has embedded magnets, and our custom magnetic sensor PCBs are installed under the sorter tray so that the paddle positions can be detected in the robot control software.

We use a state machine to control a continuous rotation servo, where the software keeps track of the sorter rotation. At the end of each sorter operation, we use the color sensors to identify which artifacts are located in each position.

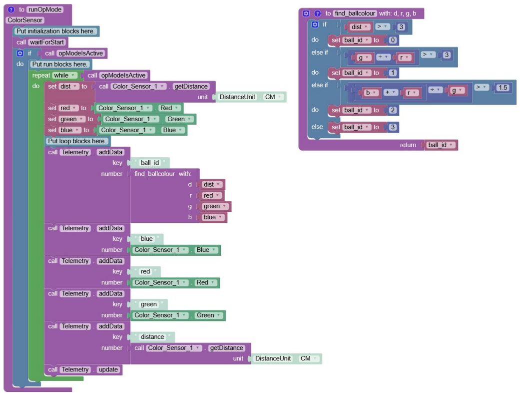
Optimized

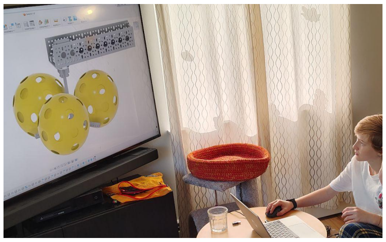




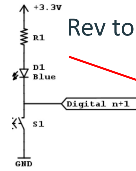
We developed an algorithm for identifying artifacts with Rev color sensors by collecting data and then looking at different combinations of the data. Our algorithm uses a decision tree, first checking whether an artifact is present (based on whether an object is within a reported distance of 3). Then we look for green artifacts: green/red >3 means it's green. Then we look for purple artifacts: (blue+red)/green > 1.5 means it's purple. We have shared our data and algorithm on our web page, and with several other teams, including the Cybersmiths who are also using our approach.

red number	green number	blue number	dist	type
300	1200	1000	1	green
600	2400	1800	0.7	green
200	1000	750	1.3	green
950	1000	2000	1	purple
1750	1900	3500	0.7	purple
700	750	1300	1.3	purple
2200	5600	2000	1	yellow
3500	8500	3300	0.7	yellow
1500	3400	1200	1.3	yellow





Custom Sensors



Rev touch sensor circuit

In June of 2025, we started looking at how to add sensors to extension mechanisms. We assumed that the competition would require an arm, and we needed to add limit switches to our GoBilda Linear Actuators. The linear actuators are very powerful, and can run hard into the ends.

We looked at mechanical limit switches and magnetic reed switches, and decided magnetic switches would work best. We designed and made magnetic limit switches embedded in wires and zip ties by soldering them together (we LOVE heat shrink tubing!). The magnet sensors work well, and they don't need to come into contact to sense the motion. That is a big advantage with the linear actuators because they can crush mechanical switches.

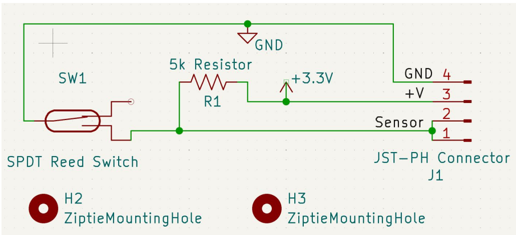
Testing showed that when we used tiny rectangular magnets the reed switches were consistently triggered at up to 10 mm away.

When it turned out that we didn't need an arm, we realized that the same sensors could be used to track the position of an artifact selector. That became the core of our artifact sorter.

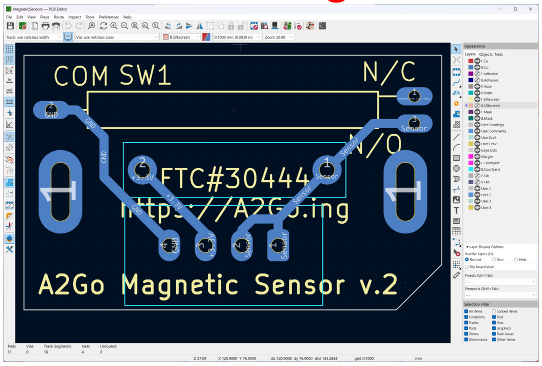
The shape of the wire based magnetic switches didn't work well for our selector. We decided to make custom circuit-board mounted reed sensors so that they would mount right into the artifact sorter.

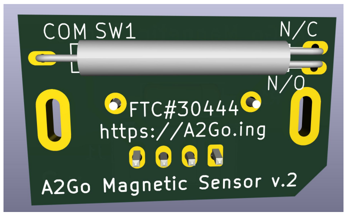
We designed PCBs using KiCAD, ordered (from OSH Park in the USA), assembled, and have now integrated the sensors into our artifact sorter.

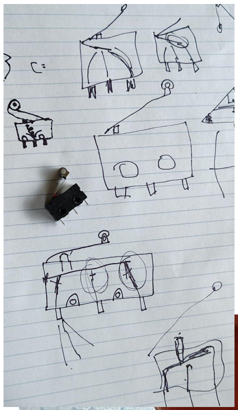
Circuit Schematic

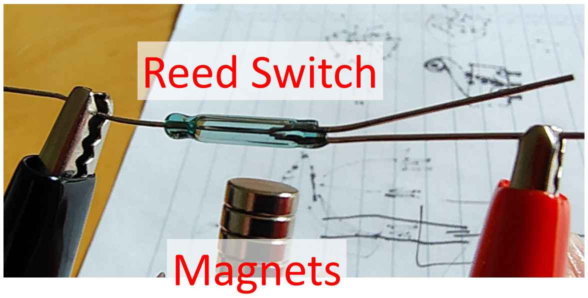


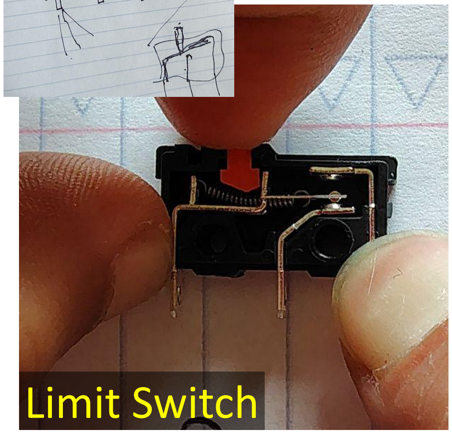
PCB Design







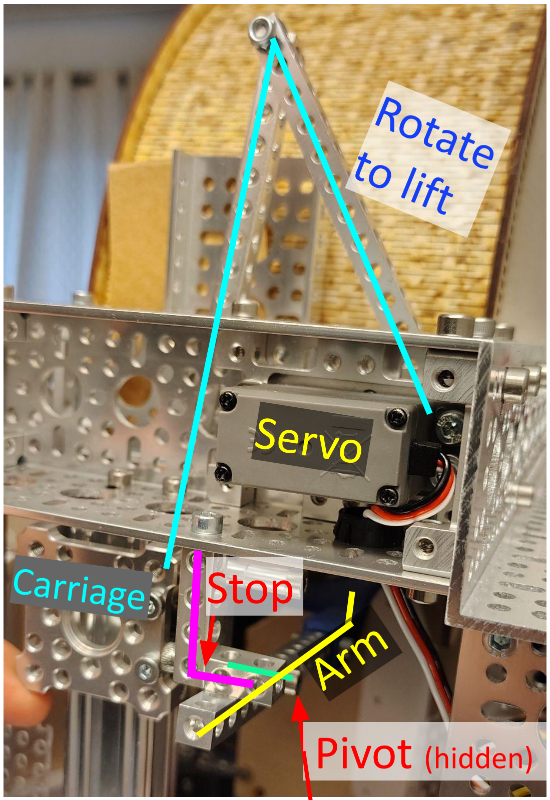




Custom Sensors for Sorter

Artifact Lifter

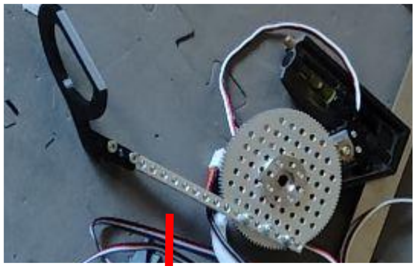
One of our biggest challenges was making a artifact lifter to get the artifacts from the ball sorter up into the flywheel. We started with a rotating mechanism. We later added a linear servo to control an elbow joint so that the balls wouldn't get caught at the back of the launcher hood. The linear servo broke, and we redesigned to have it pushing instead of pulling the joint. That lift mechanism was prone to failure, and very slow. It took about 7 seconds to launch each artifact.



We redesigned the lift mechanism using a fast servo to pull a linear carriage using two long beams. The carriage has a linear arm that is lifted upwards. The arm is mounted on a screw so that at the top of the motion it contacts a stop and pivots automatically to push the artifact into the launcher hood. This mechanism with a passive degree of freedom is very reliable and much (10x) faster than our original design.

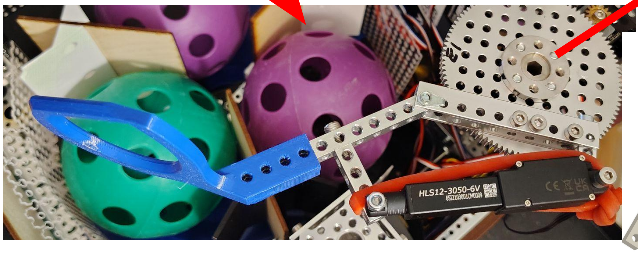
Original Lift (7s) → **New Lift (0.7s!!!)**

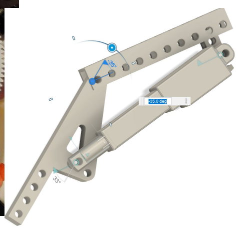
Version 1



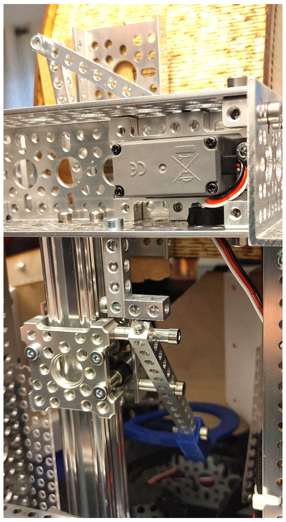
Version 2

Version 3

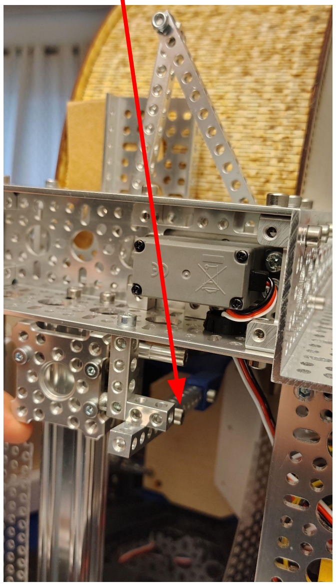




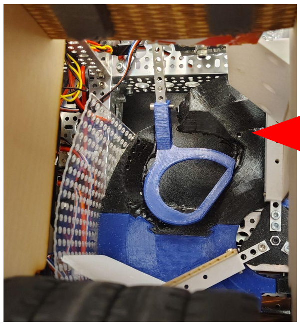
Version 4



Midway



Top Position



Inside view (bottom position)

Flywheel Launcher

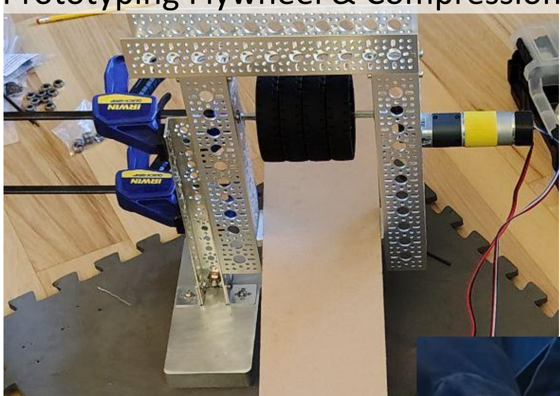
Our flywheel launcher uses a 312 rpm GoBilda Yellowjacket motor that we modified with a gearbox conversion kit to provide a 6000 rpm output. The motor drives the flywheel axle using a GT2 belt and 40 tooth pulleys. For the flywheel, we are using 4 GoBilda Rhino wheels all mounted to an 8mm Rex shaft.

We initially tested various configurations, including different launch angles, drive speeds, and numbers of Rhino wheels. We could have used 1 or 2 wheels, but the extra wheels provide enough momentum to the shaft that we can shoot artifacts at 55-60 rps (3300-3600 rpm) and consistently land the artifacts in the goal. When we tried 6000 rpm, the plastic from the Rhino wheels and artifact balls was melting. Having fewer Rhino wheels also meant that the wheels would slow down a lot more when the artifact was launched, and this was very inconsistent.

Artifact compression was risky. With too little compression (<5mm) the artifacts didn't get shot consistently. With high compression (>5mm) the artifacts launched at high speed, but the flywheels would slow down a lot. We read on Reddit that foam could be used to increase the compression inside the Launcher hood. Through testing different materials, we mitigated the risks of compression issues and found that Frost King rubber foam self-stick Weatherseal (¾ inch wide, 7/16 inch thick) provided good compression and traction for the artifacts. Having the two strips spaced 1.5 inches allowed the ball to move very smoothly through the hood. We also noticed that we needed to trim the foam with scissors to a tapered thin end because it was interfering with how the ball launched. After tapering the foam, it worked really well.

The walls of the hood have about 2 mm clearance on either side of the artifact, so the artifact usually doesn't contact the baltic birch plywood walls. We also added a metal channel on the back so that the wood wouldn't bend as much, and we eliminated the risk of the hood breaking.

Prototyping Flywheel & Compression



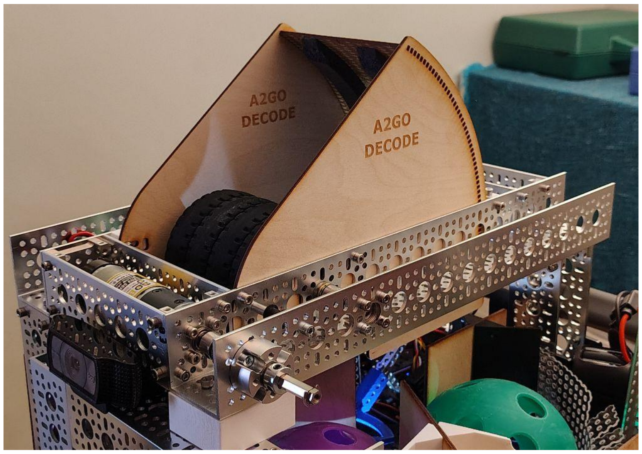
Optimizing Hood Compression

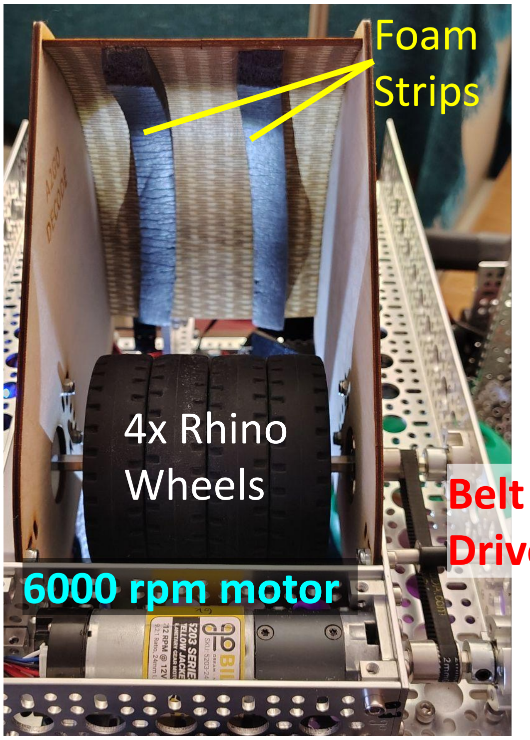
Testing Flywheel Launcher

Flywheel Launcher (continued)

The back of the hood is cut in a pattern to allow the wood to flex into an arc. Using this kind of cut-pattern to make wood flexible is called kerf-cutting. The flexed wood sheet is pressed into holes cut on the side walls, then glued in place with CA (cyanoacrylate) adhesive. We were able to use Fusion to create a design, and a laser cutter at Maker-Works to cut these parts out. The design matched the GoBilda motion pattern for mounting the launcher hood onto the GoBilda channels. The bottom of the hood walls stick down below the channels, making it easier to guide the artifacts up into the Launcher. This also made the artifact lift mechanism much more complicated, but we overcame that challenge by redesigning the lifter using a fast servo and a passive degree of freedom.

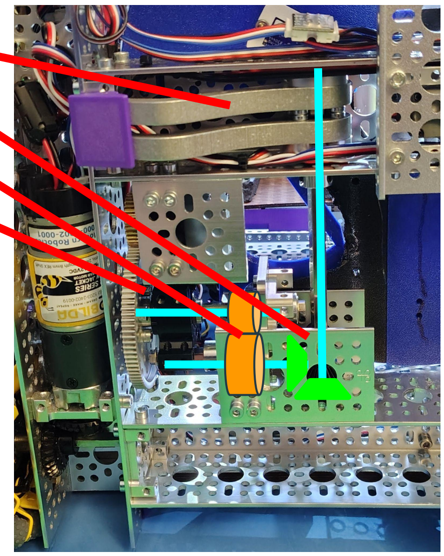
We have been experimenting with using the Logitech vision camera to control the flywheel speed based on the goal distance. We know that our robot can consistently score from the apex of the large triangle with 55 rps flywheel speed, and from the small far triangle with a 60 rps flywheel speed. The small triangle is more than 6 feet from the goal, so using April tags to set the speed is quite simple. However, our mechanisms haven't been very consistent, so <u>to mitigate the risk of vision not working right</u> we currently prefer to adjust the speed in real time based on actual results (our drive coach reads the speed values and then our drivers adjust the flywheel setpoint). We also added an LED indicator to turn green when the flywheel is within 1 rps of the correct speed!

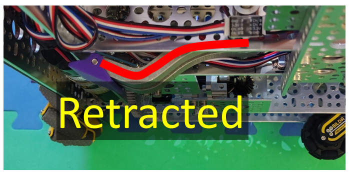


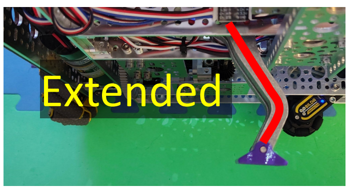


Returning to BASE (Parking)

Our robot is just under the 18” maximum allowed size (17.8”). We are able to fully park in the endgame, but have never achieved the bonus RP dual-robot return to base. We finally added a mechanism under our robot to lift the right side so that our robot is supported using only 2 wheels and a centrally-located kickstand. We call it our en-pointe mechanism, like a ballerina standing on her toes. With the lift, the robot can be supported by an 18”x11” rectangular space, or diagonally in half of the BASE zone area.







Stretch Goals

We also wanted to attach a rotating turret, but when we tried to design turret mechanisms based on a set of bearing stacks. The bearing stacks worked really well, but the turret would exceed the robot dimensions when it turned to the 60 degrees we desired. We have put that design aside, because it ended up making the sorter and lifter mechanisms really complicated.

We have achieved most of the primary goals we had at kickoff, though we still want to improve our auto-aiming and launching throughput. We are considering a full redesign of our robot if we are able to qualify for the FIRST Championship. We are also very excited to continue competing in the spring DECODE off-season events!