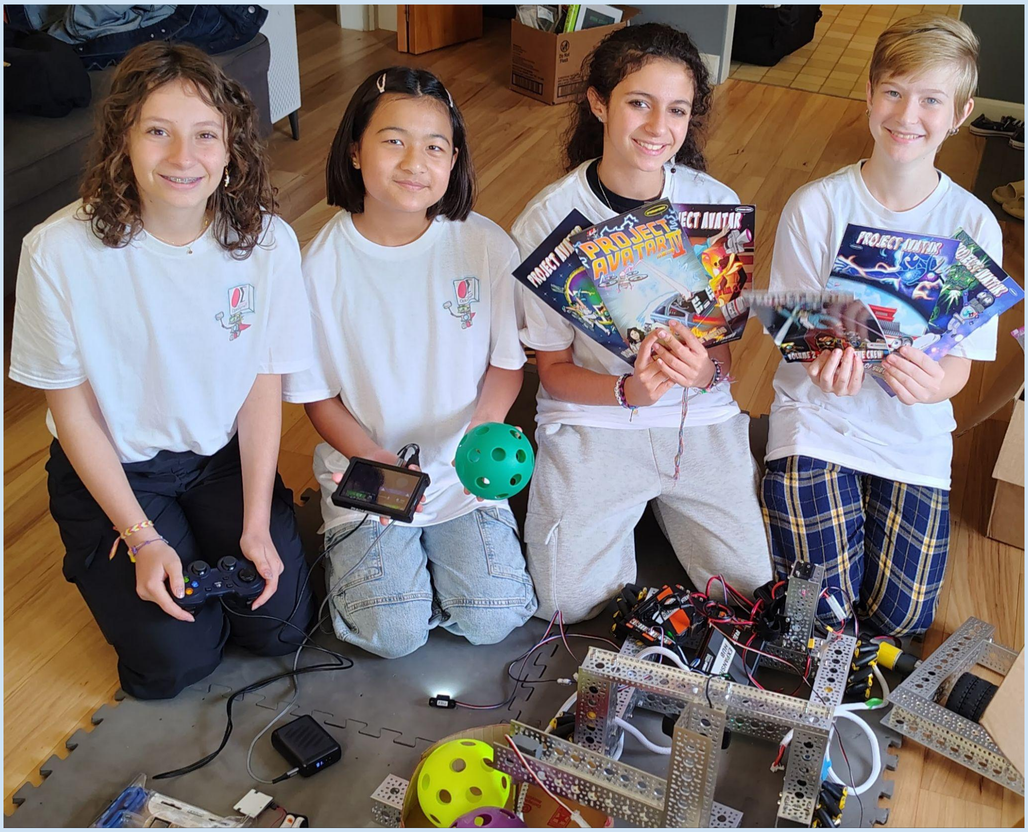
Engineering Portfolio

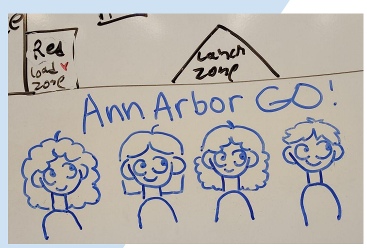
FIRST Tech Challenge Decode Competition

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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Highlights

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, Business, Drive team). We <u>plan and track our progress in our engineering notebook</u>- it's a Google Doc that we keep updated.

We love being part of FTC because it's really fun to make robots. It's very satisfying to get everything to work together. AND we LOVE to play competition matches! But the best is getting to work 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. I'm bringing my experience from business from last year. I am the Driver Coach on the field. I have a good sense of perspective, strategy, and knowledge of the rules.

Daphne E. – I'm returning for my third and final year in FIRST Tech Challenge as an 8th grade student. DECODE is a great challenge for my last year in middle school! I am excited to bring experience from participating in Centerstage and Into The Deep. I have experience with designing, building, and programming Arduino-based robots. I love all parts of the FTC program. As one of our drivers, I strive to balance competition with gracious professionalism.

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. I am one of our drivers on the field, and I handle the mechanisms that control the artifacts, including artifact sorting and launching to create patterns.

Mezel S. – This is my second year in FTC. I am in 7th grade and I enjoy the business and building parts of robotics. My past FTC experience is mostly related to 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 coding, building, and building robots at home. I am our human player. I focus on how to work with our alliance partners before a match, and efficiently load artifacts into our robot to enable patterns.

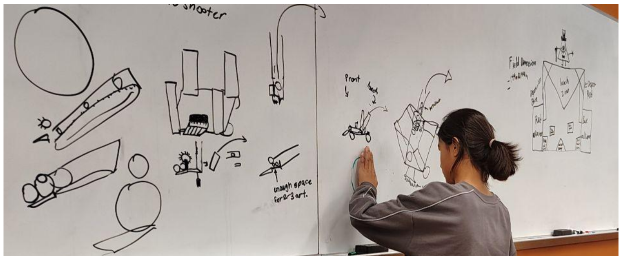
Goals & Reflections

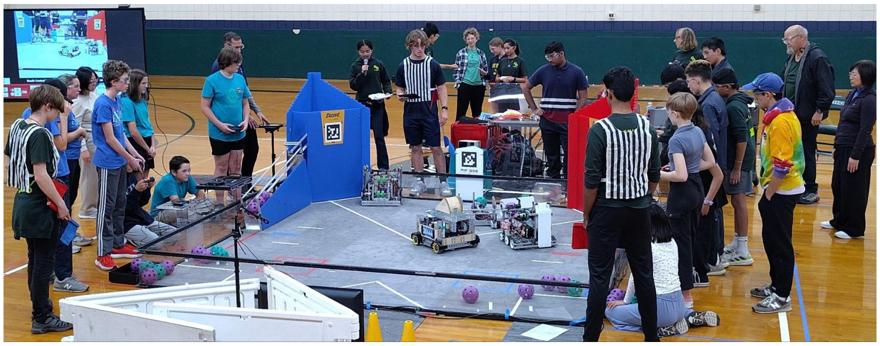
Goals
As a team, we hope to go on to compete at States. We hope that we have demonstrated Gracious Professionalism and lived up to the expectations that it resolves around while being a part of Decode.

At the start of the season, we attended the launch event hosted at the University of Michigan by FAMNM. Right from the start, we set a series of goals. We wanted a robot capable of both ground and human artifact intake, sort artifacts to be able to form patterns, the ability to release artifacts from the ramp, and a turret with hooded flywheel launcher to aim and shoot artifacts. We also want to achieve a full park for both robots, and to develop a strong autonomous program. We decided that our robot design didn't have enough room for a full rotating turret, and we haven't yet had time to implement an advanced parking or autonomous program.

We wanted our robot to be reliable, strong, and unique. We wanted to go above and beyond to make a design that was specific to our team: one that would stand out in a crowd. We're really happy with how the season is progressing, although it has taken a huge effort to get where we are. We're looking forward to things calming down a bit after our first qualifier, getting in more driving practice, and just relaxing a bit and having fun.

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





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 works well.	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?

Budget & Fundraising

We initially expected to have 6 team members, but two of our student team members didn't end up joining our team.

Our families will contribute to team costs, but we haven't finalized that yet. We would like to cover more of the costs via sponsorships.

	Actual	Projected
Team size	4	6
Registration fee	400	400

Revenues	Column 1	Actual	Projected
	Family contributions	$0.00	$2,400.00
	corporate sponsors	$0.00	$500.00
	in kind donations	$0.00	$500.00
	fundraisers	$0.00	$500.00
	Grants?	$0.00	
	Total Revenues	$0.00	$3,900.00
Expenses		Actual	Projected
	FiM Registration	$325.00	$300.00
	Competition 1 registration (GLBR Qualifier)	$100.00	$100.00
	Competition 2 registration (MSCRL league)	$175.00	$200.00
	Kickoff (FAMNM @ UMich)	$26.92	
	States competition (if moving on)	$0.00	$200.00
	Parts kit (main parts purchase)	$1,198.93	$650.00
	Linear slides (not purchasing)	$0.00	$300.00
	Camera (not purchasing)	$0.00	$200.00
	Pinpoint odometry module (included in Parts)	$0.00	$80.00
	Other COTS parts	$1,303.84	$0.00
	Custom parts	$153.87	$0.00
	Battery for driver station	$39.99	$0.00
	Cart & Pitts	$170.51	$600.00
	Field elements	$80.52	$0.00
	Tools	$49.75	$50.00
	Marketing	$26.32	$1,000.00
	Shirts	$0.00	$200.00
	Total Expenses	$3,650.65	$3,880.00

We have spoken to several companies about sponsorship, but they all asked that we return when we have built a robot and can show some competition results. Also, many will only sponsor official non-profit organizations.

We look forward to starting fundraising after our first qualifier, now that we have built our robot and we will have some results to present to prospective sponsors.

So far EWT has provided coverage of all our direct costs, though some of that will be reimbursed from other sponsorships and family contributions. Base Camp and Himalayan Bazaar have sponsored team dinners during practices. PrintCitee sponsored our shirts. OptoSigma provided merch and t-shirts. We plan to return to OptoSigma and Utilidata soon.

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

Outreach

Online Outreach:
Web site - https://a2go.ing/
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.
Neighbourhood kids - reaches 2 kids. Showed robot and driving.
Friends from other activities (fencing, school, & everywhere we go) reached 22 kids.

Mentors & Community:
FRC Team # 5708, Zebrotics members Dom, Lena, and Marc 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").

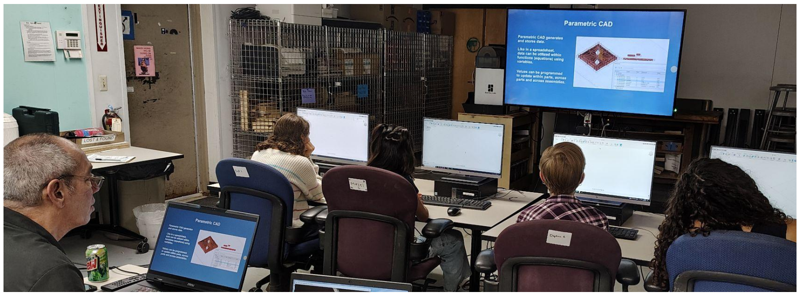
Assisted by:
28804 Cybersmiths - the cybersmiths and TechWorkshop have taught us how to program PedroPathing, let us use their practice field, given mechanical feedback and troubleshooting, and been incredibly supportive!
26606 - H.I.V.E. Saline, MI. Their lead coach Jeroen Spitael has provided a lot 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.
23247 - ARES. Their ball lifter tool was helpful to safely test the flywheel Launcher.
21351 - Cybotz. Their web site was helpful for learning and testing our understanding of this year's competition rules. https://challenge.cybotzrobotics.org/
FTCSim
First Alumni and Mentors Network at Michigan, https://famnm.club/. We attended kickoff at FAMNM. We will also join the presentation and portfolio workshop to be held Nov. 18..

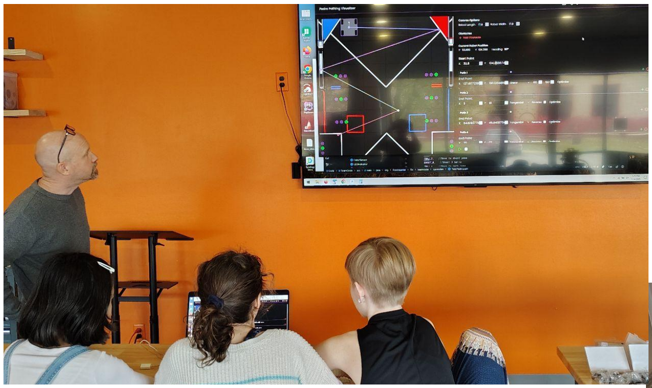
A2Go Direct Sponsors:
Esmonde-White Technologies, Himalayan Bazaar, Base Camp, PrintCitee
Maker-Works and the Ann Arbor Rotary Club (complementary training classes & shop space use)
RevRobotics - for providing our FTC team a discount
GoBilda - for providing our FTC team a discount
AutoDesk - for providing 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!

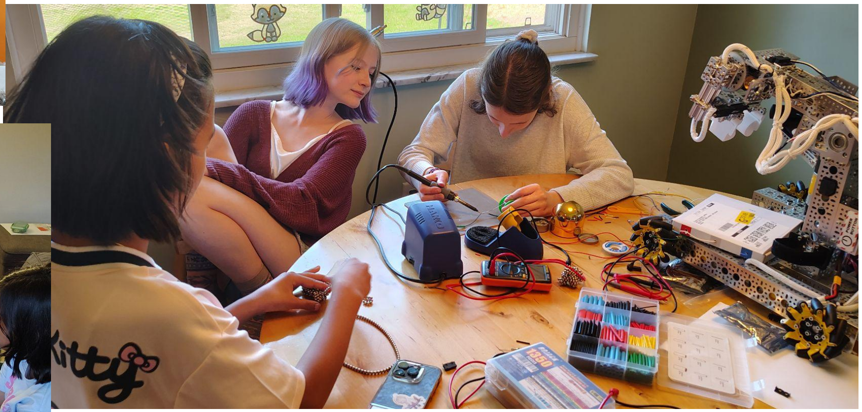
Member Training

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. Here's what we learned this year:

Basic electronics & sensors
Configuration of hardware in the control hub
Blocks coding for hardware control
FTCSim for understanding robot control
Basic JAVA (starting from Blocks)
Basics of path following PedroPathing
PID tuning
Basics of vision processing & using AprilTag poses
Basics of odometry using encoders and pinpoint
Learning about FRC
Using multimeters to measure basic electronics
Soldering
3D Printing
Laser cutting
Cutting, bending, and drilling thin sheet metal
CAD
Assembling mechanisms







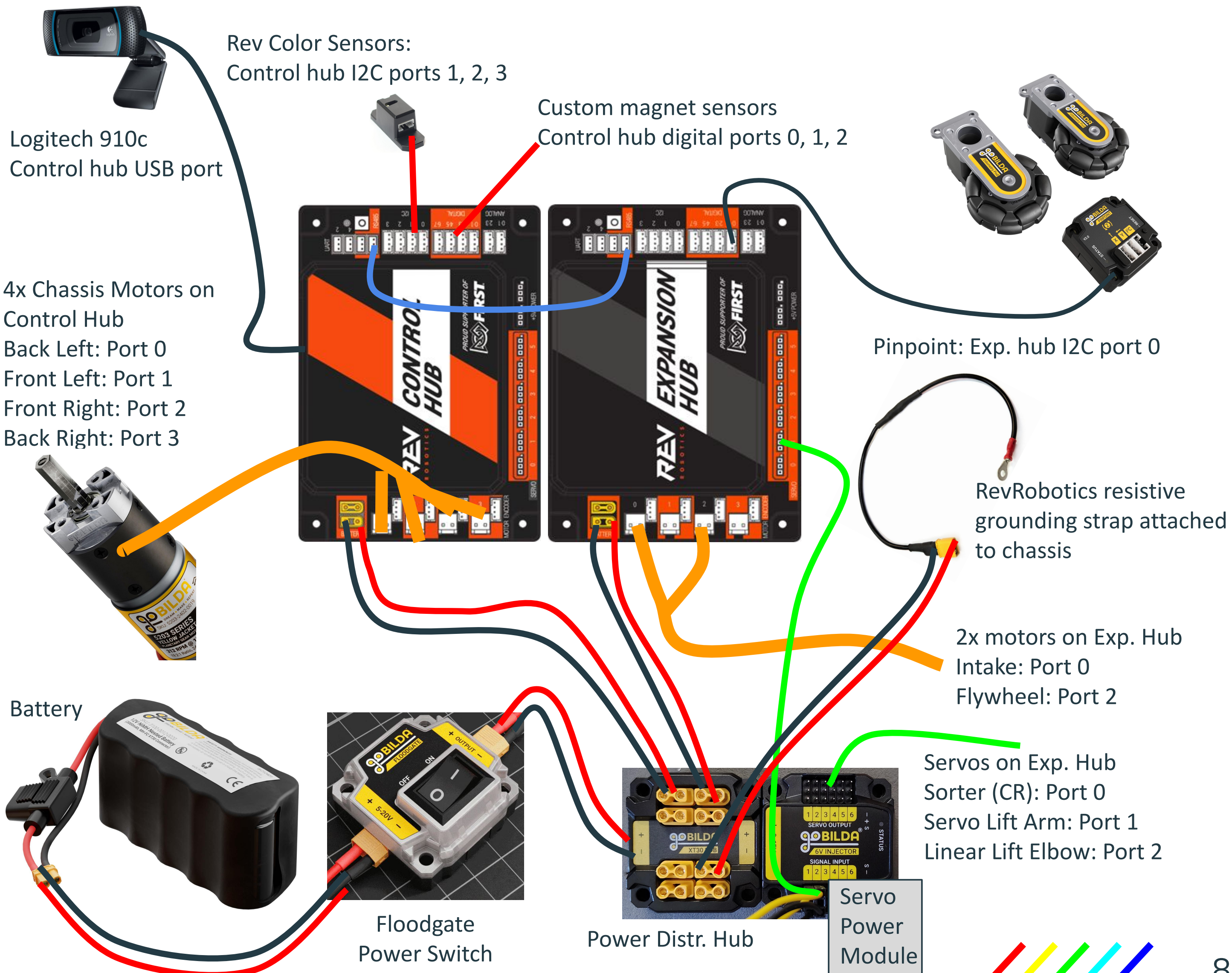
Robot Overview

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. A rotating servo arm with second linear servo lifts artifacts up into the launcher flywheel hood. The flywheel hood has four belt-driven Rhino wheels that operate at up to 6,000 rpm.

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

We are using new electronics from GoBilda, including a new Floodgate power switch, 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.

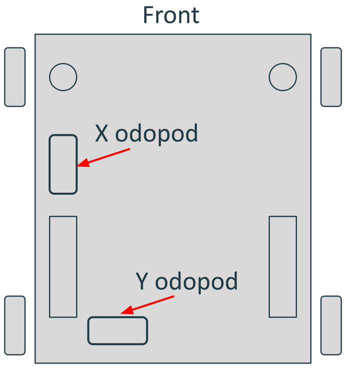
Electrical Diagram



Drivetrain

Midway through 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 decided to re-make 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 took us about an hour to replace all the rollers, and it has improve our robot's traction. We can now drive at full speed without slipping.

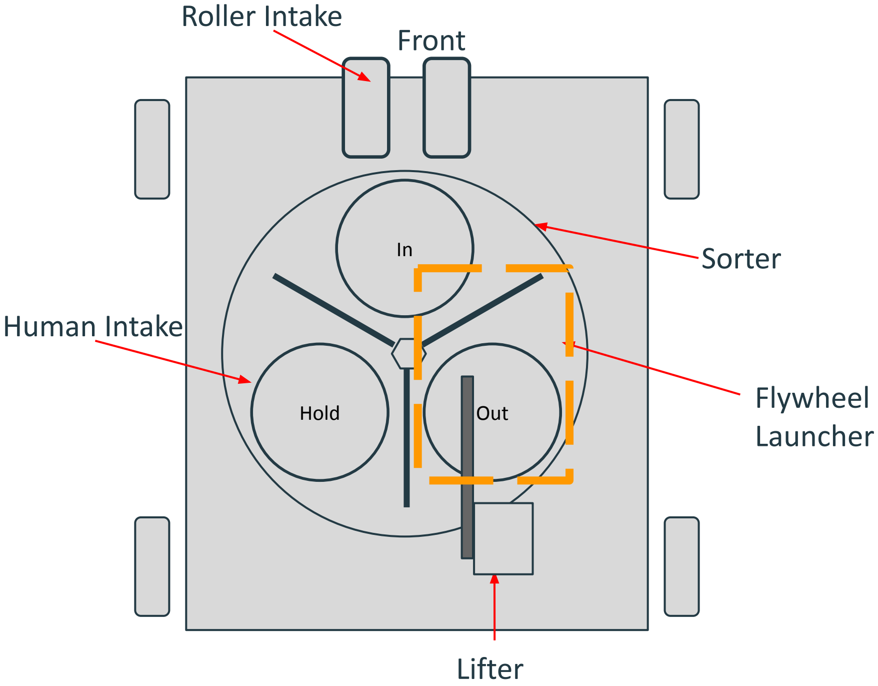
We have older swingarm odometry pods, and this season we added a GoBilda Pinpoint module for position tracking. This makes it much easier to track the robot position. We have also added a Logitech C920 camera, and have begun trying to incorporate automatic identification of the artifact pattern and goal targeting using AprilTags.

Currently our robot teleop is programmed via Blocks, using initialization and update functions for each robot subsystem. We are actively working on developing autonomous and teleop programs using PedroPathing.

We have tuned the PID for PedroPathing.

It was fun to see how the robot feels incredibly heavy when the PedroPathing control loops are running. It feels like an immovable boulder!

The major robot subsystems are shown on the right.

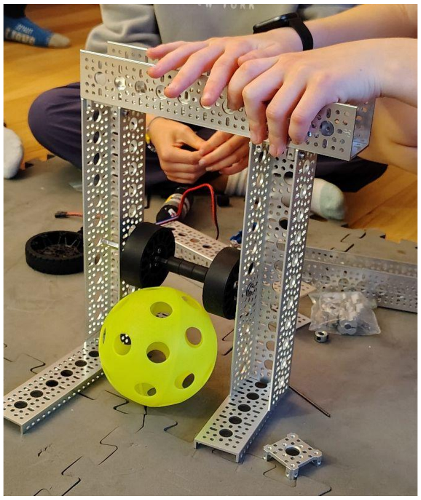


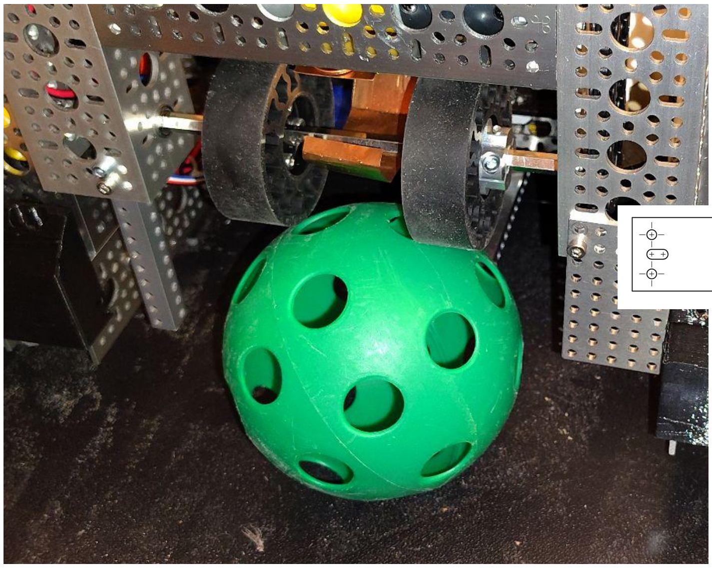
Intake

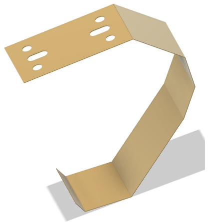
Ground Roller Intake

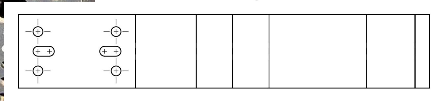
We use a ground roller intake with 72 mm GoBilda Gecko compliant wheels. We are also using a custom designed and fabricated phosphor bronze spring on top to help hold the balls in the sorter. Originally we used a larger phosphor bronze spring underneath, but it was catching on tiles and deforming. The spring compresses the artifact ball onto a step made from low channel extrusion into artifact sorter. We originally didn’t think it would work, but after testing various configurations, that configuration worked really well.

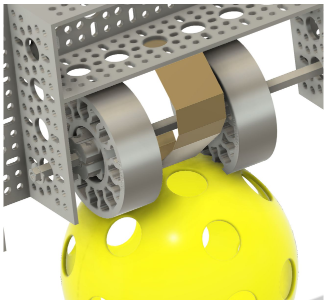
Our intake is operated by rolling the artifact inwards. <u>Our sorter is designed to hold only 3 artifacts</u>, and <u>our intake rollers can be reversed</u> to actively push out any unwanted extra artifacts.







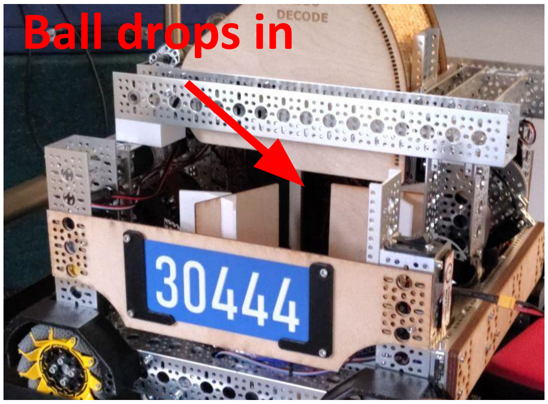




Human Player Intake

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 opened up the plastic ring more so that the ball can now be dropped in.

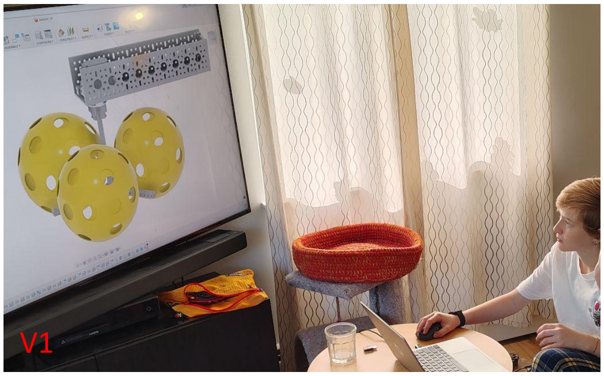


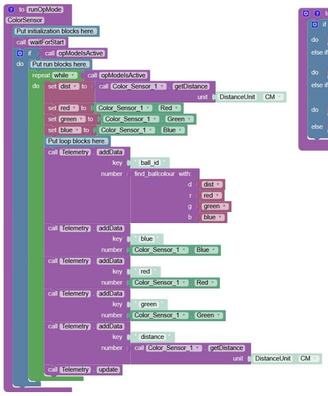
Artifact Sorter

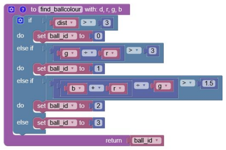
A tray holds up to 3 balls, and a servo operates paddles to push the artifact balls in a circular motion. The paddles each have a magnet at the tip, so that custom magnetic sensors we fabricated can be used to detect the paddle positions. There are also magnets in 2 of the 3 paddles closer to the central axis, and we plan to upgrade our software to use the central magnets to keep track of the individual artifact balls later in the season.

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. Magnets are inserted into the 3D printed paddle arms.

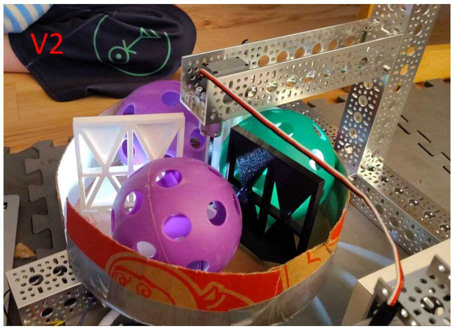
We developed an algorithm for identifying artifacts with Rev color sensors by collecting data and then looking at different combinations of the data. Our algorithm uses a decision tree, first checking whether an artifact is present (based on whether an object is within a reported distance of 3). Then 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.

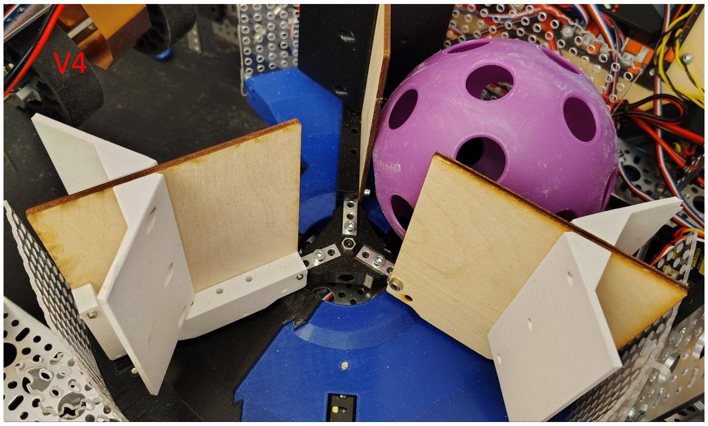


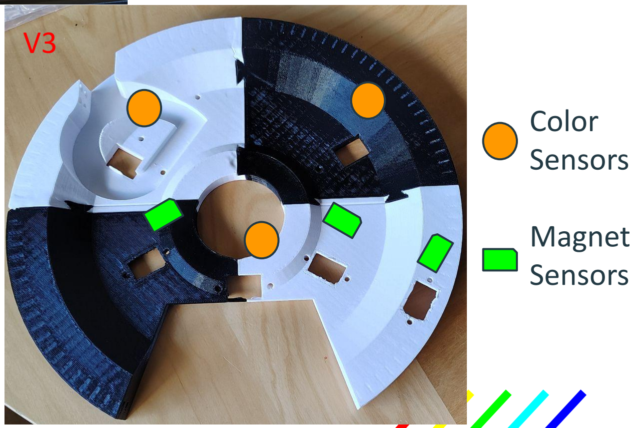




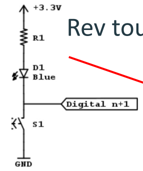
red number	green number	blue number	dist	type
300	1200	1000	1	green
600	2400	1800	0.7	green
200	1000	750	1.3	green
950	1000	2000	1	purple
1750	1900	3500	0.7	purple
700	750	1300	1.3	purple
2200	5600	2000	1	yellow
3500	8500	3300	0.7	yellow
1500	3400	1200	1.3	yellow



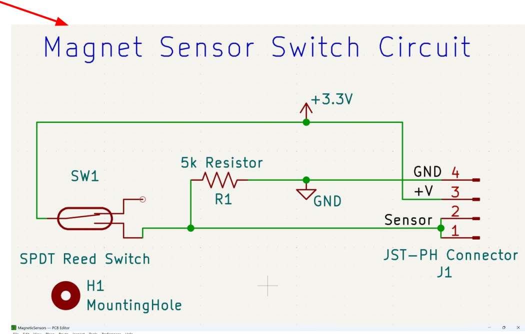


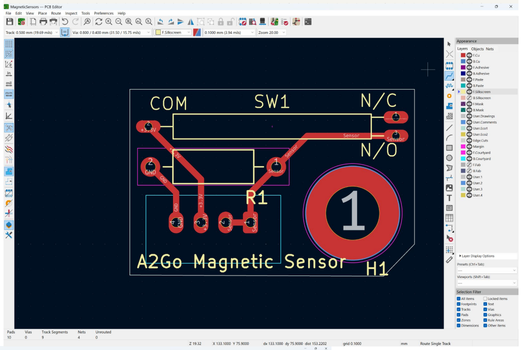


Custom Sensors



Rev touch sensor circuit

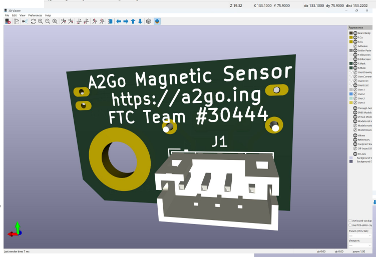




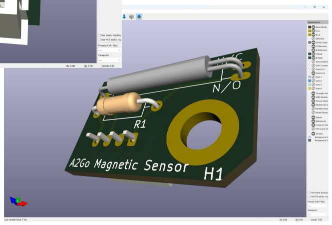
In early 2025, we started looking at how to add sensors to extension mechanisms. We assumed that the competition would require an arm, and we needed to add limit switches to our GoBilda Linear Actuators. The linear actuators are very powerful, and can run hard into the ends.

We looked at mechanical limit switches and magnetic reed switches, and decided magnetic switches would work best. We designed and made 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.

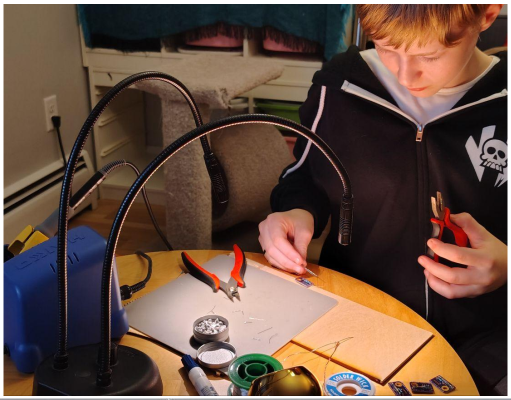


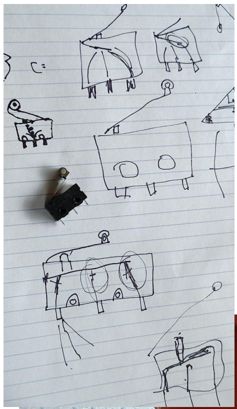
When it turned out that we didn't need an arm, we realized that the same sensors could be used to track the position of an artifact selector. That became the core of our artifact sorter.

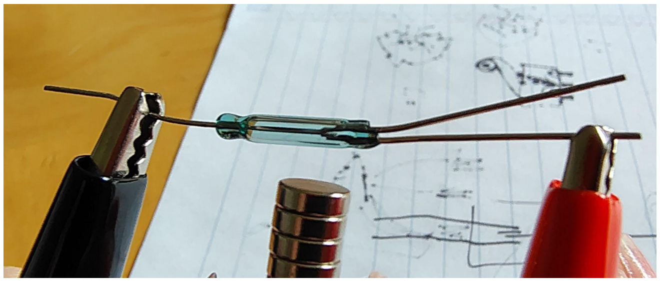


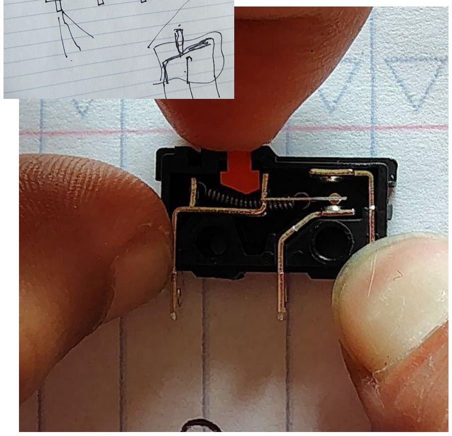
The shape of the wire based magnetic switches didn't work well for our selector. We decided to make custom circuit-board mounted reed sensors so that they would mount right into the artifact sorter.

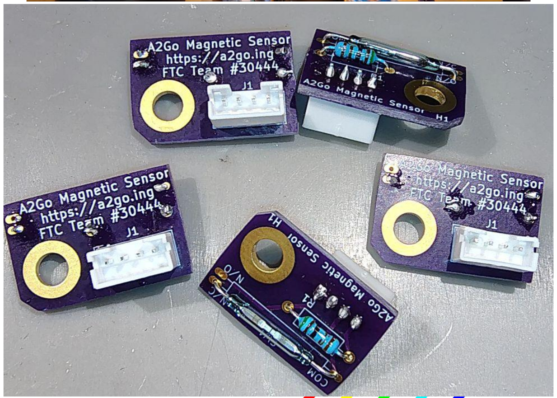
We designed PCBs using KiCAD, ordered (from OSH Park in the USA), assembled, and have now integrated the sensors into our artifact sorter.









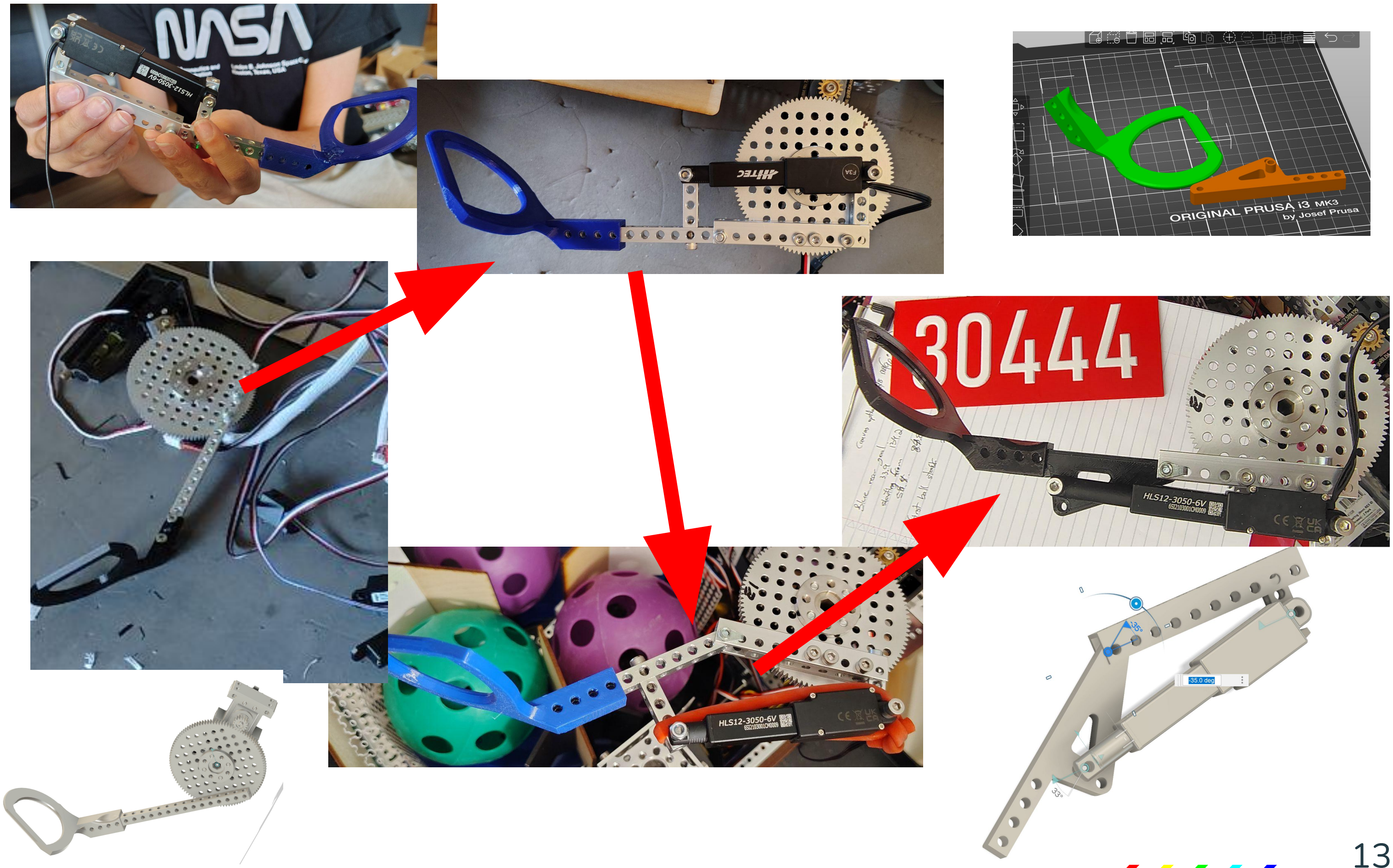


Artifact Lifter

We started with the idea for a linear lift. However, it was hard to find a way to push the balls high enough into the hooded Launcher mechanism to catch the ball on the flywheels. We then moved onto a design with a servo turning a solid arm. That mechanism was able to push balls into the Launcher mechanism, but sometimes the ball ended up getting stuck and compressed by the arm. That in turn caused the arm to experience extremely high forces and break the aluminum beam. If it breaks, we risk not being able to launch artifacts. To mitigate that risk, we added a linear servo to control an elbow joint. The linear servo operates the elbow on the lifter so that it can push the ball straight upwards at the top of the travel distance, instead of compressing into the back wall of the Launcher hood.

We have had difficulty with the 30mm Hitec linear servo. It hit the selector and then broke. Our coach took it apart, and managed to make it work again, but it's not consistent anymore. We have to keep adjusting the setpoints in the state machine. Overall, our lift mechanism takes a long time to lift the ball and return to the bottom position. It is controlled with a state machine, which sets a variety of servo positions and uses times to wait for the servos to move. It takes about 4 seconds to launch each artifact, and we would like to speed this mechanism up.

We realized that the linear servo is really designed to push, not pull. We moved it to the bottom of the assembly, and that made it much more consistent. We also 3D printed it from PETG, so that it's more flexible than the original aluminum assembly. We have also been adjusting the program to make the lifter more consistent and faster. It's tricky because it sometimes hits the sorter paddles.



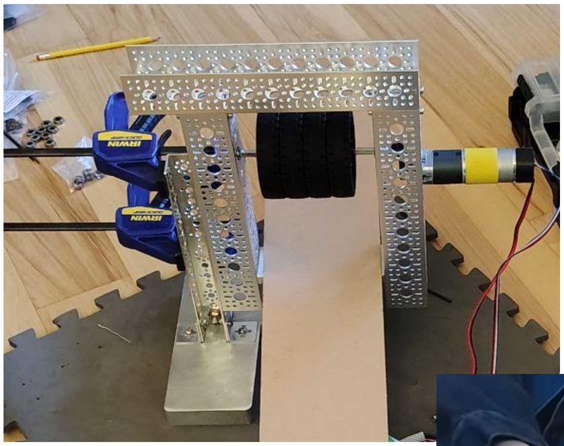
Flywheel Launcher

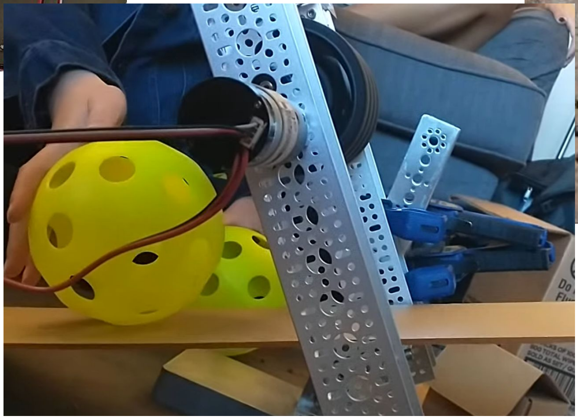
Our flywheel launcher uses a 312 rpm GoBilda Yellowjacket motor that we modified with a gearbox conversion kit to provide a 6000 rpm output. The motor drives the flywheel axle using a GT2 belt and 20 tooth pulleys. For the flywheel, we are using 4 GoBilda Rhino wheels all mounted to an 8mm Rex shaft.

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 <u>risky</u>. 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, <u>we mitigated the risks of compression issues</u> 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 <u>we eliminated the risk of the hood breaking</u>.

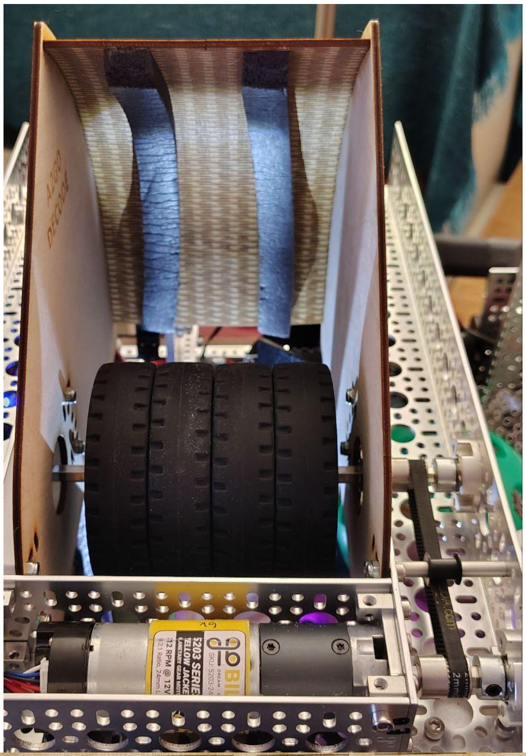


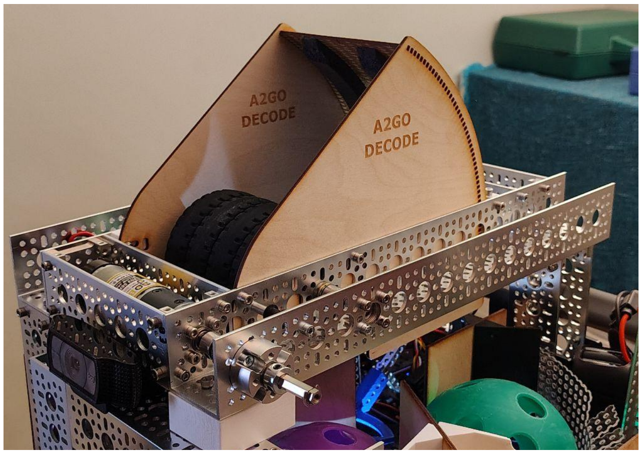


Flywheel Launcher (continued)

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.

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 rpm flywheel speed, and from the small far triangle with a 60 rpm 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).





Kerf cutting pattern (short, offset lines)

Stretch Goals

At the moment, our robot is designed so that it is less than the 18” maximum allowed size, but only just barely less than that size (17.8”). We are able to park in the endgame, but not achieve the bonus RP dual-robot parking.

We are thinking about adding more features, such as a parking lift mechanism (probably based on 1 or 2 GoBilda lead-screw based linear actuators). Videos by coach Brogan Pratt were very inspirational. However, our really heavy robot would be extremely difficult to lift, even if we had space inside the robot. Our linear actuators only extend 12”, probably not high enough for most robots to park under. Rather than a high lift, we have also considered a tilt-lift, where a leg could push from the center of the robot, partially tipping it so that we could park with just 2 wheels touching the ground inside the parking zone, but the other 2 wheels outside the parking. That would leave about half of the parking zone for the second robot. We could attach that mechanism to the side of the robot where we drop the artifacts into the top of the sorter, but we haven’t had time to test that approach yet.

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.