

INFINITY TECH #13684

2025-2026 Decode Team Portfolio



East Middle School
Plymouth Canton Community Schools



DECODE

→ EAST MIDDLE SCHOOL TEAM ←

15 Team Members

4 Sixth Graders

8 Seventh Graders

3 Eighth Graders

4 Lead Mentors

Our mission: "To create an infinite stream of technologists"

ESTABLISHED IN 2017

We are Infinity Tech, FTC Team 13684. We were founded by a group of middle schoolers from East Middle School in Plymouth/Canton. 2025 is our 9th Season!



4th out of 643 MI Teams



Decode Season Goals

Achieved

- ✓ Raise **\$7,300** or more
 - Sponsors, fundraising
- ✓ Implement Learning Plan
 - Courses, design challenge
- ✓ Collect More Robot Data
- ✓ Develop Innovative Mech
 - Auto Aim Turret, Spintake
- ✓ Recruit **5 new team members**
- ✓ Identify **5 new mentors**
- ✓ Host or Volunteer at **5 events**
 - Kickoff, RitP, Roundup, etc.
- ✓ Develop Distinct Brand
 - robot styling, colors, design
- ✓ Sensors for More Reliability
 - Limelight, Laser Distance, etc.
- ✓ **550 hours** of Outreach
- ✓ 6 Field Trips

In Progress

- Track Issues with Robot
 - Build & Programming

Student-Led New Team Member Recruitment

We have more interest than we have spots available.

Candidates Complete Application

Prior FLL experience to show interest & commitment

Candidates Interview With Team Members

We seek parents who can mentor for sustainability

Candidates Come to Shadow Day

Good attitude & graciousness for team dynamics

Team Votes on Invitees

Minimum 3 students per grade for sustainability

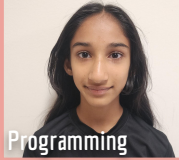
Invitees Do One Month Trial

Additional commitment & team dynamic evaluation



Acceptance & Commitment Agreement

We aid others find another team or help create a new team.



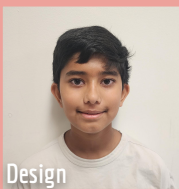
Isha



Frances



Avni



Rishaan



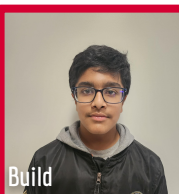
Luke



Davis



Surya



Parth



Ivo



Design/Build Mentor
Manager, Global Lifecycle Cost
Ford Motor Company

Eric Suydam



Programming Mentor
Senior CFD Engineer
Airflow Sciences Corporation

Kanthan Rajendran



Business Mentor
Retail Entrepreneur
Twinkle Twinkle Little Store

Cheryl Courson



Design/Build Mentor
Emergency Medicine Physician
Henry Ford Health

Chris Nedzlek



Vid



Arisha



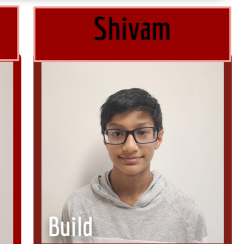
Ramanan



Hudson



Alex



Shivam



BUSINESS

Income & Expenses

Our Expenses

Projected expenses are based on prior years' needs and experiences. We cover these through grants, student fees, and sponsors. Intensive fundraising post-States made our Worlds trip possible; we proudly raised our initial \$23k goal in just two months.

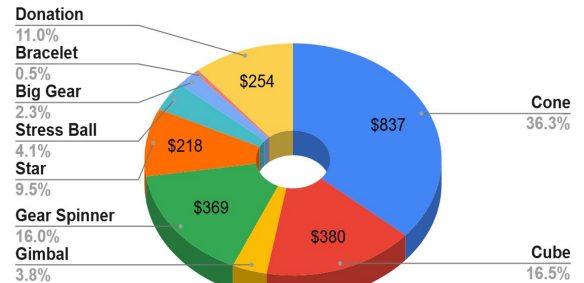
Our Team Expenses	Projected	Actual
Fees and Registration - FIRST Registration and competition Fees	\$2,800	\$3,275
Robot Parts and Materials - Motors, sensors, field pieces, metal extrusions, controllers, Android devices, etc.	\$5,000	\$6,634
Team Operations - T-shirts, food at events, merchandise	\$3,000	\$2,214
Outreach - Workshops, outreach events	\$1,500	\$509
Travel Expenses - Transportation, lodging	\$24,000	\$17,480
TOTAL EXPENSES	\$36,300	\$30,112

**Total Season
Income: \$40,259**

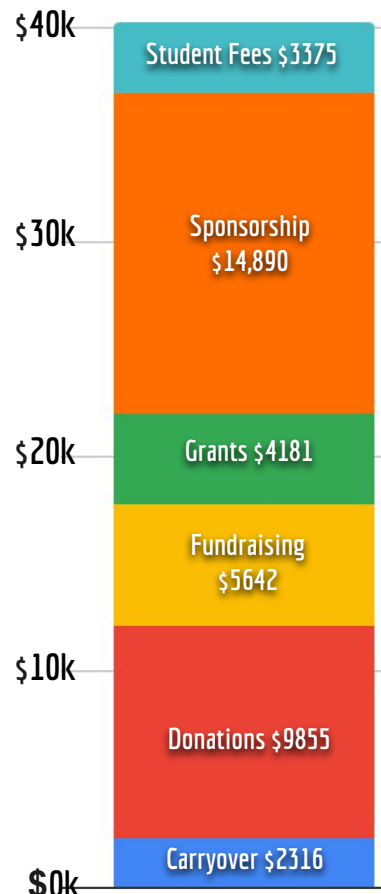
Business Sponsors



Infinity Tech Art Fair Sales Summary



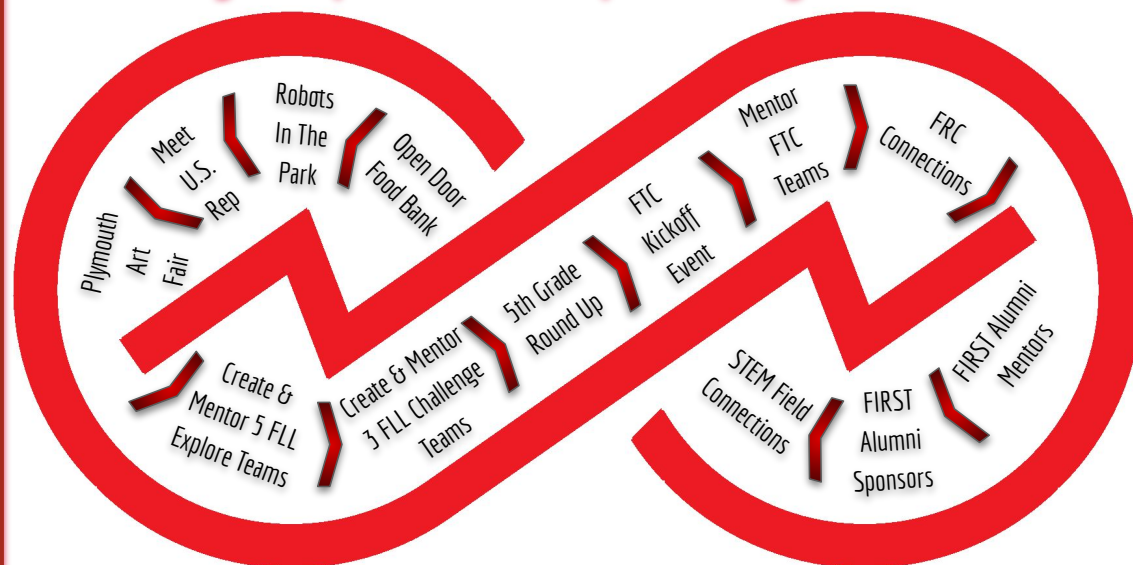
We designed 3D printed fidget toys to sell at the Plymouth Art Fair. **We sold 480 fidget toys for a total of \$2,303**, which helped us in buying robot parts when the season got underway.



Infinity Tech Robotics Team 13684



Creating an Infinite Stream of Technologists Since 2017



789 Total Outreach Hours



5010 Total People Reached



Our Outreach Impact

Community Impact Focus: Committed to expanding STEM opportunities beyond team.

Post-COVID Rebuilding: After the pandemic reduced 12 FTC teams to just 2, we helped rebuild the Plymouth-Canton program to **14 FTC teams** and continuing to expand.

Team Expansion (2022–2025):

- Started **4 new FTC teams**
- Mentored **9 FTC teams**, **3 FLL Challenge teams**, and **5 FLL Explore teams**

Elementary Outreach: Introduced FLL programs into elementary schools without prior robotics access

Community Service:

- Goal: 550 hours → Achieved: **789 hours**
- New goal: **800 hours**

Community Reach: Connected with **5,010 individuals** through outreach efforts

Worldwide Reach: Providing global reach with Youtube channel, Makerworld 3D Prints, Blooket FTC Game, Instagram, Online Tutorials and Website resources.

FIRST Team Partnerships



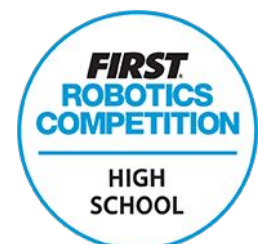
5 FLL Explore Teams
Dodson Elementary



4 FLL Challenge Teams
Dodson Elementary & Gallimore Elementary



9 FTC Teams
East, Pioneer, West & Liberty Middle Schools, and Texas Rookie Team



1 FRC Team
Team Members Graduate into our 862 Lightning Robotics Partner



OUTREACH

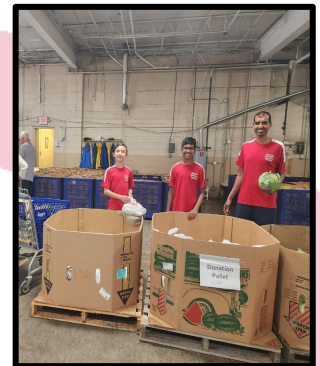
Reach - Non STEM Community

Our Infinite Loop Begins with Reaching the General Non-STEM Community

Type of Service	Hours	# People Reached
Mentoring	138.5	600
Events hosted	160.5	355
Events volunteer	147.5	1560
Reaching out to other FIRST teams	71	95
Creating FIRST awareness	214	1317
Community Service	57.5	1083
Total	789	5010

Open Door Food Pantry

We volunteer several times at our local food bank sorting and filling carts with food. We helped **730 families** (approximately 2920 people) and moved **56,733 pounds of food**.



U.S. Representative Debbie Dingell

We met with **U.S. Representative Debbie Dingell (MI-6)**. She praised our team's volunteer efforts in promoting robotics. We discussed the importance dedicated funding for robotics and STEM education. We conducted letter-writing campaigns to our government representatives during budget reviews to maintain the 99H Michigan Department of Education Grant.

Plymouth Art In the Park

Infinity Tech fundraised at Art in the Park, Michigan's 2nd largest art fair (300,000+ attendees). Team members designed and 3D-printed fidget toys, selling **480 items for \$2,303** (net income: \$1,823.91). Over three days, we directly **engaged 1,230 people not familiar with FIRST**, showcasing our robot and promoting FIRST programs. This initiative successfully raised funds and promoted FIRST.



Media/ Social Media

We improved our online presence on Youtube, Instagram, Facebook and our website with shorts, reels, videos and robot reveal.



Robots in the Park

A free day-long event by Lightning Robotics FRC 862, offers STEM activities for all ages, including physics, electrical, chemical, and aeronautical projects. Demonstrations highlight Plymouth Canton community robotics programs. Infinity Tech hosted the FTC section, where participants drove robots to earn a Robot Drivers License and activity stamp. We directly **interacted with 1,500 kids and adults not yet involved with FIRST**.

Dodson Elementary & East Middle School Robot Demo Day

We demonstrated our practice chassis over 150 students at Dodson Elementary School. Infinity Tech and Rocket Robotics also showcased our competition robot to over 100 students at East Middle School. We demonstrated these to **many students not familiar with the FIRST program**.



FTC Intro at Sri Vidya Mandir (SVM), Bengaluru

We conducted an FTC introductory outreach session for 30-40 6th and 7th-grade students at Sri Vidya Mandir (SVM) Middle School in Bengaluru, India, to generate early interest in competitive robotics.

Girl Scout Brownie Robotics Badges

Infinity Tech ran a robotics build and programming session for **Girl Scouts Brownie Troop 40118** of Hulsing Elementary School for them to earn **Programming Robots** and **Designing Robots** badges. We worked with 19 girls in 2nd and 3rd grades to build, program, and revise the design of LEGO robots.



Team Open House Showcase & Scrimmage

Open to sponsors, mentors, friends and family, this event gave our team the chance to engage both a STEM and non-STEM community. We met with 6 other FTC teams from our community to scrimmage and show off this year's game. The event itself showcased our robot, our judged presentation, and our robot game performance.



OUTREACH

Reach, Connect, Sustain

The Second Part of Our Infinite Loop Is Fostering FIRST Programs from FLL to FTC to FRC



FTC Kickoff - Canton, MI

Infinity Tech and Lightning Robotics hosted an official FTC Kickoff at Canton High School. **Over 180 people from 15 teams attended**, gaining general competition info & participating in popular build, design, programming & business breakout sessions: **six hours of mentoring** were led by Infinity Tech members & mentors, concluding with the live Decode competition reveal.

FLL Explore Mentoring

Infinity Tech organized and mentored **five FLL Explore teams** (30 students, 1st-3rd grade) at Dodson Elementary over 12 weeks from March-May. We taught block programming, building, and prepared them for their Expo. We also showcased our "Mr. Mussel" robot from the 2024-2045 season and a practice chassis, aiming to deepen their understanding and excitement for robotics.



FLL Challenge Mentoring

Infinity Tech founded (2024) and mentored Dodson Elementary FLL #65886 who won Champions Award this year! We donated our old FLL game board to the Dodson team and provided our "Elvis" Spike Prime robot base instructions. We also mentored Gallimore Elementary teams #34357 and #34355, which reached a Florida Invitational. We assist teams with building, programming, Innovation Projects, and share our FLL experience.

5th Grade Robotics Round-Up

Infinity Tech and Lightning Robotics (FRC #862) host an annual 5th Grade Robotics Round-Up in March for prospective FTC team members and help them find or create a team. This year and last, **40 students** attended. We demo'd our robots and explained the FTC program to students and parents, contributing to the formation of more teams in the district.

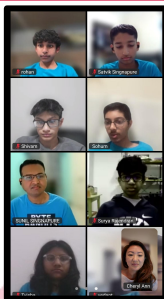


'Gigawatt's' Michigan FIRST LEGO League Explore Festival - Canton, MI

We assisted with preparation for the FLL Festival hosted by Lightning Robotics (FRC #862)

Gamification of 2025 Decode Competition Manual with Blooket

To make learning the 163-page FTC 2025 Decode Game Manual easier, we created a public, interactive Blooket game. The public has played the game over 815 times.



FTC Mentoring - 9 teams

Over four years, we **started 4 FTC teams & mentor 9 teams**. We provide weekly support and donated parts to Liberty Bees #25721 & Bionic Beans #27693. We helped Indecisive Devices #22738 complete their robot for a Spring 2025 competition, scrimmaged with Rocket Robotics #21615 & Robo Challengers #21482, and helped Pioneer Panthers #10262 & Clague GearCats #7305 with programming. We aided #27404 Robotic Angels with practice & field elements. We had a zoom Q & A training session with Byte Bandits #30710 from Richmond, TX.

FTC Connections

Infinity Tech held virtual mentorship meetings with veteran Worlds teams Fusion 4133 (Helena, MT) and Mecha Mantises 19862 (Fremont, CA) to get tips on Worlds and robot improvement. We also mentored rookie team Byte Bandits 30710 (Richmond, TX) via video call, and we hope to meeting all of them at Worlds in Houston.



Young Alumni: Former members mentor our team, ensuring a sustainable culture, helping with Drive Team Selection, presentations, and FRC preparation.

Young FIRST Mentors	FIRST Experience	Sustainability Mentorship
Adam Ong	FLL, FTC, FRC	Design, Build
Karthik Rajendran	FLL, FTC, FRC	Programming, Drive Team
Adithya Srivathsa	FTC, FRC	General, Drive Team
Edison Thai	FLL, FTC, FRC	General, Strategy
Kai Courson	FRC	Presentation, Business
Annabelle Thai	FTC, FRC	Presentation, Outreach
Evan Ong	FLL, FTC, FRC	Presentation, Design
Jade Courson	FRC	Business, Marketing



The Third Part of Our Infinite Loop Is Making Connections with the STEM Community

Amazon Warehouse

We toured Amazon's DT3 Distribution Center in Pontiac, MI, observing autonomous technology like the 3000 lb-lifting Hercules robot, the container-sorting Roxanne robot arm, and sensor-driven conveyance tracks for automatic box sorting.



The U of M Wilson Center

This houses university student competition teams building vehicles like submarines, planes, boats, and race cars for global competitions. The director toured us through the facility, showcasing past builds like the Baja SAE dune buggy. He advised using a Gantt chart with ample "slop" for better season organization.

University of Michigan Robotics Center

We watched students working on advanced projects. A professor led us through several labs, showcasing **walking-robot prototypes**, **a sensor-equipped autonomous vehicle**, **a drone-testing room with high-speed cameras** and **many tracking sensors**.

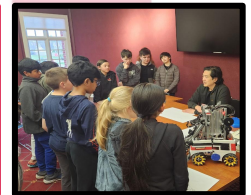


32nd International Ground Vehicle Competition (IGVC) at Oakland University

We met FIRST alumni Oklahoma U students and learned **how they used cameras, LIDAR, and GPS sensors**. We recruited Oakland U Professor, Dr Cheok, & a PhD Grad to mentor our team.

Roblox Innovation Studio Director & Branding

We met with Chiwei Lee, Director of Roblox Innovation Studio, who shared **engineering design, AI, drawing, and branding techniques**, emphasizing how style impacts design perception. Our team incorporated these principles, setting pre-season goals to use more 3D-printed components and develop a consistent color scheme to strengthen robot branding.



Adient Tour

We visited the Adient Facility and got to take a look behind the scenes of how engineering is applied in real life and how they do their **engineering design process**. They have room-sized 3D printers and various molds to quickly create their prototypes. We observed the various rigorous testing that takes place, including crash testing, wear, heat tolerance and sound testing.

Airflow Sciences Corporation

ASC is an engineering consulting company in Livonia, MI whose engineers guided us in performing **wind tunnel testing** of the Decode artifact to determine its aerodynamic drag properties. They also helped us CNC machine an aluminum frame for our shooter. We learned how the rotation of the object can change its stability and why a single flywheel is more consistent than two opposing ones. We applied this to our robot.



Add'l Connect Mentors	Organization/Position	Connect Role
Tom Golub	Detroit Diesel, Legislative Diagnostics	Programming & Build Assistance
Ed Thai	Hyundai, Senior Regulatory Safety Engineer	Design & Build Mentorship
Jay Obsniuk	Plymouth-Canton Community Schools	General Help, Tools, Meeting Space
Jennifer Rajendran	Ford, Inventory Control Manager	Team Operations
Joaquin Gabaldon, Ph.D	Wheel.Me, Robotics Engineer	Motor Behavior review
Meghna Menon	Ford, Robotics Research Engineer	Engineering review
Ka Chai Cheok, Ph.D	Oakland University, Professor of Engineering, Chairman	Mechatronics review
Christabel Sin	Ford, Business Analyst	Engineering, Design review
Marcus Ong	University of Michigan, Web App Developer	Engineering, Presentation review
KaiQiao Tian, Ph.D	Oakland University, Ford, Auton & Sensor Engineer	Engineering, Presentation review
Steve Derry	Ringside Creative, Graphic Designer, Data Specialist	Presentation, Portfolio review
Andy Banka	Airflow Sciences Corporation, Vice-President	Engineering Review, Wind Tunnel
Bruce Devlin	Airflow Sciences Corporation, Laboratory Manager	Engineering Review, Wind Tunnel

GOALS

Preparation & Tracking

An Overview of Our 5 Seasons:

SPRING SEASON JAN to MAY

GOAL SETTING MTG

Prior Season Recap
Recruit & Interview
New Team Members
Outreach
Mentor FLL Explore
teams
Learn New Skills
Outreach
Off Season
Challenge
Meet once per week

SUMMER SEASON JUNE to AUG

BENCHMARK MTG

Outreach
Prepare -
* Engineering
Design Course
* JAVA Course
* CAD Course
Build Chassis
Field Trips
Determine team
member roles
Meet once per
week

BUILD SEASON SEPT to OCT

STRATEGY MTG

FTC Kickoff Event
for Game Release
Design, Build and
Program In Action
Engineering
Portfolio
Meet 3-7 times a
week
Fundraising
Mentor FTC
teams & FLL
Challenge Teams

COMPETITION NOV to DEC

Participate in
Qualifiers
Iterate / Improve
Robot
Improve Portfolio
Compete at States
Aim for States &
then Worlds
Meet 5-7 times a
week
Drive Team
Practice

PREPARE FOR WORLDS!

Participate in
Scrimmages
Iterate / Improve
Robot
Improve Portfolio
Fundraise
Meet 5-7 times a
week
Drive Team
Practice
Scout worlds
teams



BAND App - Group Organization

BAND is our all-in-one app for everything: Events, Messages, calendars, photos, videos, and more

Preseason Preparation, In-House Competition & Goals

- To avoid prior out-of-stock issues, parts were ordered early summer, and chassis construction began in July for both the competition robot and the "Lab Rat/Spinfinity" testing robot. The team focused on managing workload and time.
- We opted for a **smaller 16"x16" chassis**, proving advantageous for this year's end game, and aimed for a lighter robot for smoother, faster movement. Initial difficulty packing the compact drivetrain was resolved using the 2024 Cybugs chassis for inspiration.
- To deepen team knowledge, members became **Subject Matter Experts** on various topics, researching them over the summer. Weekly 5-minute presentations by a different student educated the entire team.
- After the States Competition, we realized we needed more than our original subgroup and reassigned our team roles and added additional Strategy/Scouting, Electrical, Media/Outreach and Fundraising secondary roles.

Infinity Tech Meetings - Decode Season 90% Average Attendance

Description	Count	Hours
Spring Meeting	39	79
Summer Meeting	9	18
Fall Meeting	36	72
Auton Meeting	18	54
Build Meeting	7	22
CAD Workshop	10	10
Business Meeting	18	30
Outreach	36	93
Drive Team Practice	19	35
Competition	4	40
Total	196	452

Team Philosophy and Guiding Principles

Hard work: You get what you work for, not what you wish for. Over 452 hours of meetings, events, outreach and practices.

Continuous Improvement: Never stop improving. Scoring increased by 227% and accuracy by 46% by State competition.

Data driven. Without data, all you have are opinions. Collected lots of data; used analysis to drive robot design and iterations.

Commitment: The more you put into it, the more you get out of it. Contribution by all team members, secondary roles, SMEs.

Sustainability: Create an infinite stream of technologists. Recruiting plan, >\$40k fundraising, multiple revenue streams.

*Inspiration is not finite, it is truly **infinite**.*



Development & Tracking

Think & Sustain

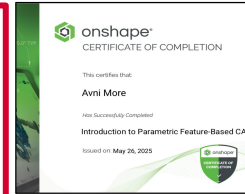


Engineering Design Course on OpenLearn

To foster creativity, our 15-member team completed a free online OpenLearn engineering design course during the spring off-season, finishing one section weekly. All members received participation statements.

Design Challenges - Fusion 360, OnShape & Zoom Lessons

We used Fusion 360 and then adopted OnShape, a cloud-based CAD program, to overcome license limitations and improve team collaboration. To address the learning curve, we held 9 weekly offseason online CAD classes, including students from three other FTC teams. We also completed Onshape tutorials and earned certificates.



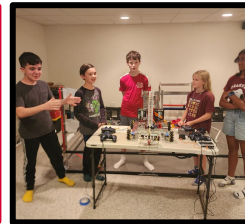
On Bot Java & Codecademy Online Java Course

To transition from 5th-grade SPIKE block coding to Java, all team members completed an online Codecademy Java course over the summer. This enhanced existing programmers' skills, introduced new 6th graders to text-based coding, and informed non-programming members. Programming members began robot coding using the accessible On Bot Java interface before moving to Android Studio.



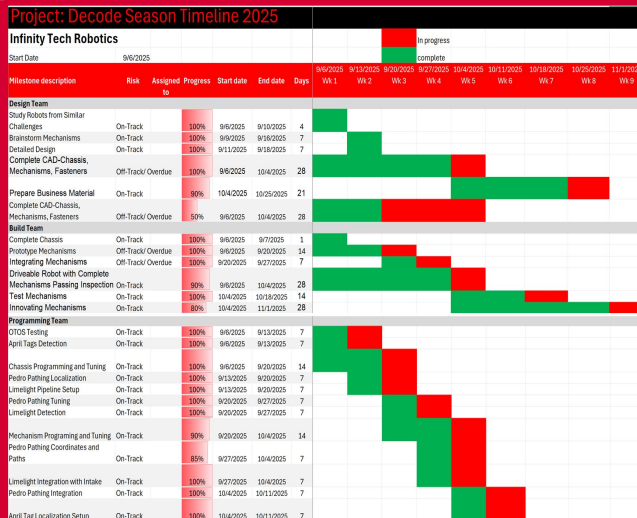
Off-Season Challenge Competitions

For practice we held our own **in house competition**, divided the team into three groups to build different robots, each designed to move various game pieces from prior competitions. This challenge helped us practice, expand our knowledge, and develop different mechanisms to test our robots' capabilities and limitations.



GANTT Chart Timeline

Inspired by UM tour to manage project timelines. We list tasks, set weekly work goals, reviewed these goals weekly, and track completion.



Kanban Board

We track tasks through To Do, In Progress, Testing, and Done, helping team members identify the next item to work on.

Drive Team Selection Process

Unlike our FLL teams, not everyone gets to drive at competition.

To ensure an unbiased drive team selection, we use an alumni managed Spreadsheet with weighted factors and scores. Testing for game knowledge, reaction time, and performance selects the best drive team. We have 4 main and 4 backup drive team members who practice extensively, adding more backups after advancing to Worlds.

Team members pick their 2 preferred roles



Game Manual Written Test Score > 70%



Continue to Reaction Time Tests



Drive Trials - Test Matches



Main & Backup Teams Selected



DESIGN

S.P.I.R.E. & Ball-E

3D Printing Filaments

We used different 3D printing filaments based on functional needs. We made sure to also use filament colors to meet our branding goals.

Type:	PLA	PETG	TPU
Pros	Looks good, Faster prints	Durable, good for gears and other mechanical parts	Flexible, impact resistance, durable
Cons	Not durable	Stringing, more expensive than other filaments	Longer print time, not good for mechanical parts
Usage	Swag, peer awards	Turret, gears, shooter and transfer	Spintake and bumpers

During the season, our build team follows a process called “S.P.I.R.E.” developed in our team’s prior years. Using our version of the Engineering Process, which consists of 5 steps, we turn the idea into a reality. Below is an example of this process, more examples can be found at our pit.

Sketch

Our first step towards a physical piece starts with getting our ideas **represented through a rough sketch**. During this phase, **markers and pencils are our medium**.

Prototype

Next we do our best to turn this **sketch into a physical concept**, which helps us decide if we want to use this design. During this phase, materials like **cardboard and plastic are our medium**.

Innovate

Now knowing this concept works, we design it in CAD, with the intention to **customize the part** to fit our needs more exactly. During this phase, **CAD such as OnShape serves as our medium**.

Revise

Once we have a rough idea/design, we put the concept through different situations and tests, going through multiple iterations, and **optimizing the design**. During this phase, we use a variety of materials.

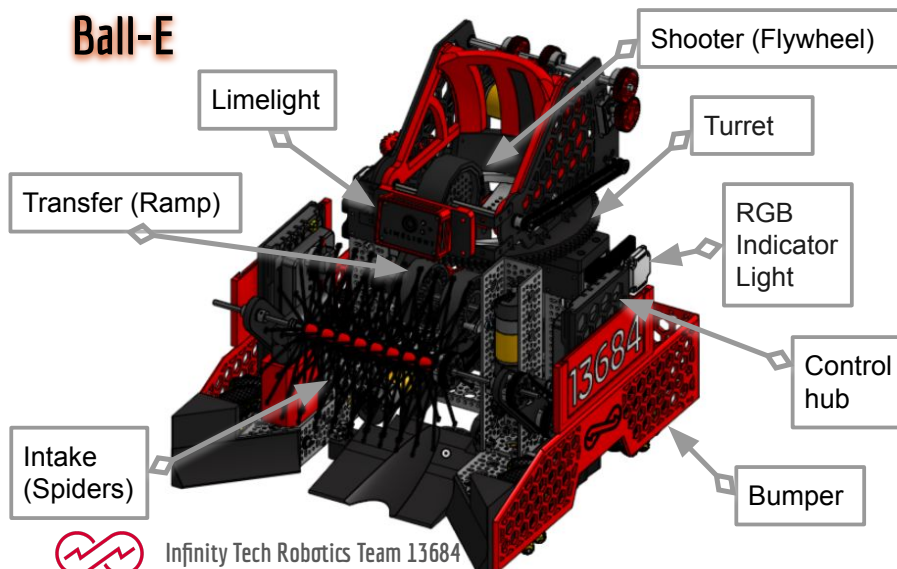
Evolve

After reaching our optimized state, we improve attributes such as **sleekness and aesthetic design**, to make the part competition ready. The design has gone from an idea to a reality, **ready for competition day**.

Build Strategy:

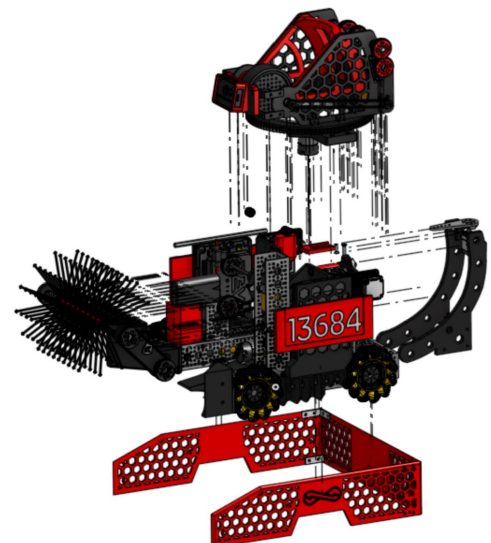
Post-FTC Kickoff, we prioritized the intake and shooter, along with the necessary transfer ramp and stop/push mechanism. When working with a component of the robot, students broke up into groups of 2 or 3 to help make the process more efficient. After basic completion, we moved to our stretch goal: a guided turret. Programming focused on perfecting Limelight with AprilTags for precise aiming and adaptable velocity.

Ball-E



Modularity

Our robot is designed to be modular, allowing easy replacement of broken into 5 mechanisms such as the shooter, transfer, Limelight camera, bumper, and spintake. This proved useful for quickly swapping parts or upgrading designs between matches.



SPINTAKE

Design Goal: Ground intake to reduce human player reliance and improve cycle time

Engineering Process: Iterated from simple prototypes → multiple concepts → final TPU “spider” intake

Prototyping: Tested horizontal vs dual-roller designs; early tubing design lacked efficiency

Final Design (Innovation): 3D-printed TPU “spider” arms with barbed tips for improved capture and transfer

Optimization: Best performance with **long, thick, smooth arms**

Motor Trade-off:

- 6000 RPM → low torque, jams
- **1210 RPM high-torque motor** → eliminated stalling, improved reliability

Lessons Learned: Removed barbs to prevent stalling and lower current draw

Driver Feedback Improvement:

- Issue: Hard to see when robot possessed 3 artifacts when facing away
- Solution: Added **goBILDA laser sensor + RGB lights** to indicate possession

Control Improvement:

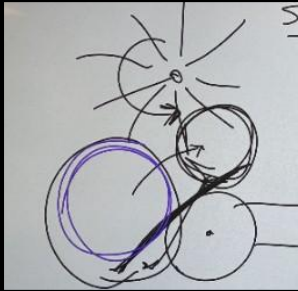
- Automatically **reduces spintake power when 3rd artifact detected**
- Prevents motor stalls and current spikes while retaining artifact

Key Insight: Prioritized **torque, simplicity, and feedback-driven control** for consistency

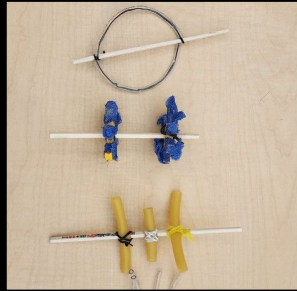
Integration: Optimal axle height **5.5 in (~0.5 in from ball)**; resolved motor interference

Game Impact: Reliable intake w/improved cycle awareness & power management, enabling faster, consistent scoring

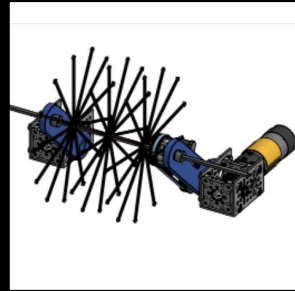
Sketch



Prototype



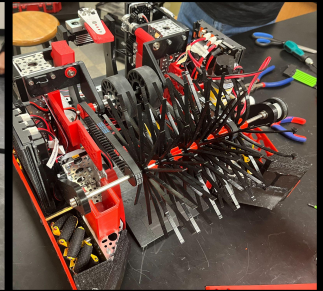
Innovate



Revise



Evolve



TRANSFER

Purpose: Control timing/alignment before shooting (prevents direct feed)

Engineering Process: Sketch → cardboard → CNC → 3D print → simplified ramp

Design Trade-off: Complex belts/pulleys → unreliable → replaced with **simple narrow ramp**

Prototyping: Rapid iteration; resized to meet **18” constraint**

Release Mechanism: Mechanical stop prevents premature firing (chosen over sensors for reliability)

Competition Issue & Fix:

- Issue: Illegal possession of **4 artifacts** during state competition
- Solution: Moved **mechanical stop from shooter to top of transfer ramp**, eliminating overfeeding

Precision Control (Innovation):

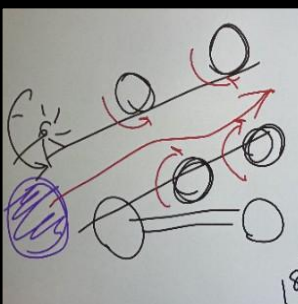
- Horizontal stop blocks early entry
- Vertical flapper feeds flywheel when clear
- Fully **mechanical timing system (no sensors)**

Mechanical Improvement: Belt-driven → **gear-driven flapper system**, eliminating slipping/misalignment

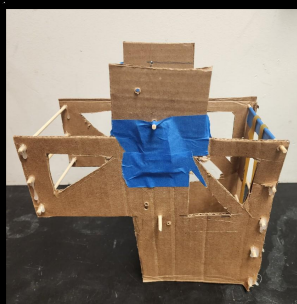
Key Insight: Prioritized **simplicity and mechanical control** for robustness

Game Impact: Improves shot timing, accuracy, rule compliance, and scoring consistency

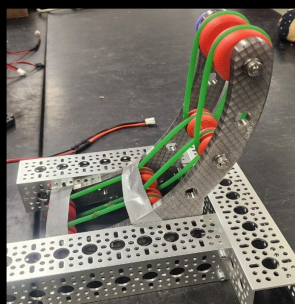
Sketch



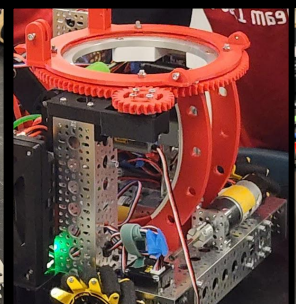
Prototype



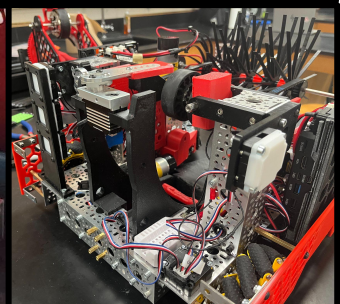
Innovate



Revise

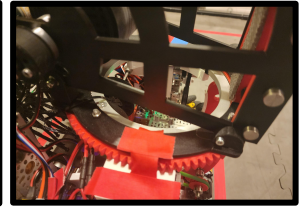


Evolve



TURRET

Our shooter utilized a turret built on a COTS lazy-susan turntable for constant alignment with the Blue or Red Goal. A GoBilda 312 RPM motor actuates a 3D-printed ring gear to rotate the turret, which is programmed to track the AprilTags on the goals. We started with a sketch, then developed an initial prototype. Multiple iterations where we refined the mechanism and code, including gear adjustments for smooth rotation resulted in a 220 degree range turret.



LimeLight 3A Smart Camera for Auto Ranging and Alignment

We use a **Limelight 3A smart camera** mounted on our shooter for machine vision. AprilTags on the goals are used to calculate **range** (distance) to **set the flywheel RPM**, and **bearing** (horizontal angle) to **align the shooter** with our alliance goal for improved shooting accuracy. The process of coding our turret involves finding the tag, reading the camera output, calculating the flywheel RPM and turret positions, and then setting the flywheel and turret motors accordingly.



SHOOTER

Design Goal: Consistent, accurate shooter with sufficient lift/distance

Engineering Process: Concepts → prototypes → CAD → 8+ iterations → final aluminum design

Trade-offs:

- Selected **vertical flywheel** over horizontal/catapult for reliability
- Chose **vertical shooter** for improved loft and scoring consistency

Prototyping: Wood, CNC, and 3D prints used for rapid iteration

Final Design: CNC aluminum and 3D printed shooter with 7.5 mm compression

Optimization: Tuned compression, launch angle, turret integration, and flywheel setup

Motor: Two (2) **6000 RPM** for required speed, lift, and distance

Performance Improvements:

- Added **steel flywheel** for consistent RPM and shot repeatability
- Improved far launch zone accuracy with **second motor, additional flywheels, and adjustable hood**

Reliability: Stronger fasteners + High Flow PETG improved durability

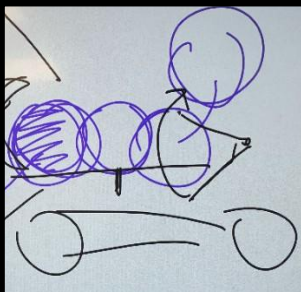
Innovation: Adjustable, modular design enabling fine-tuned performance

Key Insight: Prioritized **consistency and tunability over complexity**

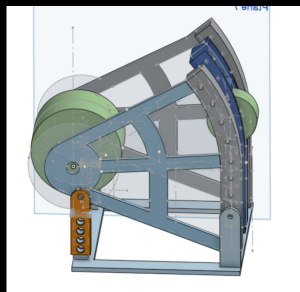
Game Impact: Reliable, accurate scoring from multiple distances; stronger alliance partner

Distance	Flywheel RPM
36 in	2240 rpm
48 in	2380 rpm
72 in	2650 rpm

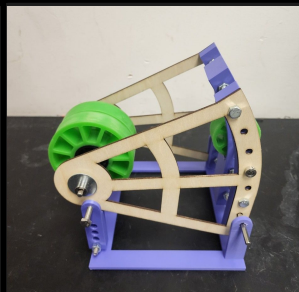
Sketch



Prototype



Innovate



Revise



Evolve



Projectile Motion and Wind Tunnel Test

Projectile motion is the path a free falling object takes, which is what an artifact does after it is launched. Under ideal conditions (no drag), the horizontal and vertical velocity and position is calculated using the launch angle and speed.

Velocity:

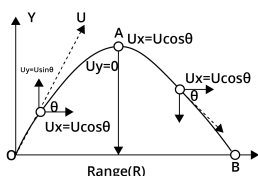
$$U_x = U * \cos \theta$$

$$U_y = U * \sin \theta - g t$$

Position:

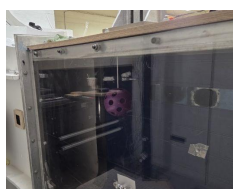
$$x = U_x * t$$

$$y = U_y * t - 0.5 * g * t^2$$



We tested a Decode artifact in the **Airflow Sciences wind tunnel**, and using a force gauge determined the **drag coefficient (C_d)** to be about **0.86** for the typical launch velocity

$$\text{Drag, } D = 0.5 * C_d * \rho * V^2 * A$$

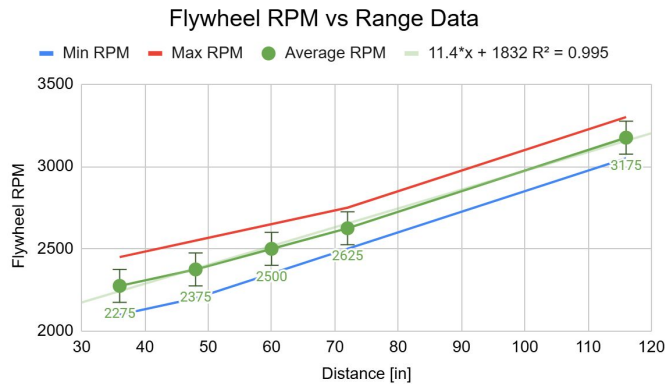


Published data of C_d for smooth sphere is 0.47. We think artifact holes affect drag.

Artifact launch 48" from goal
 $U = 4.8 \text{ m/s}; \theta = 43^\circ$



We used **Desmos** to graph **artifact trajectory** with and without drag. For flight times in the Decode field, drag makes a relatively small difference.



Challenge: Flywheel RPM vs Distance to Goal

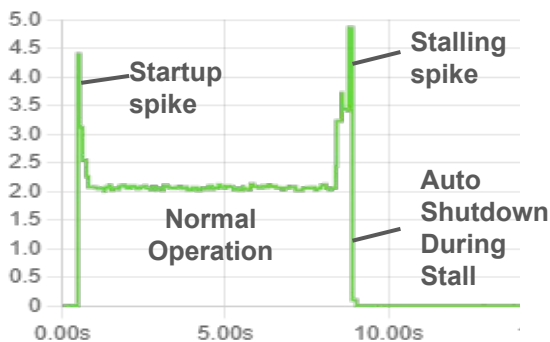
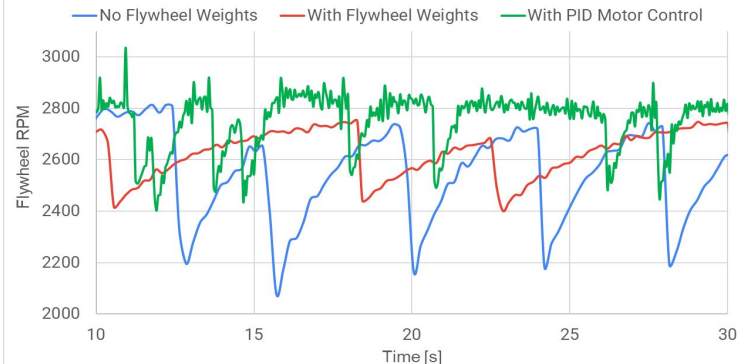
After we came up with our flywheel shooter concept, we realized fairly quickly that the distance the artifact travelled depended on the RPM (rotations per minute) of the flywheel. To understand this, we collected data on what RPM was needed to score artifacts from different distances. Graphing the data using Google Sheets, we came up with the following relationship:

$$\text{Target Flywheel RPM} = (11.4 \cdot \text{Distance}) + 1832$$

$$(R^2 = 0.995)$$

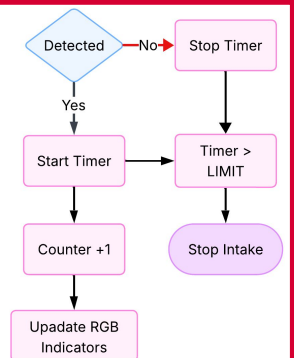
Challenge: Flywheel RPM Drop After Artifact Launch

The next challenge was maintaining the flywheel RPM. We observed that when launching an artifact, the flywheel RPM would drop and we needed to pause for 4-5 seconds before we could launch another artifact (blue line). To reduce the RPM drop, we added a 152 grams weight to increase the inertia, which reduced the drop but increased the recovery time (red line). Then we learned from another team about using PID velocity control to speed up the RPM recovery during launches, and once we tuned the PID coefficients, we can re-shoot within 1 second (green line).



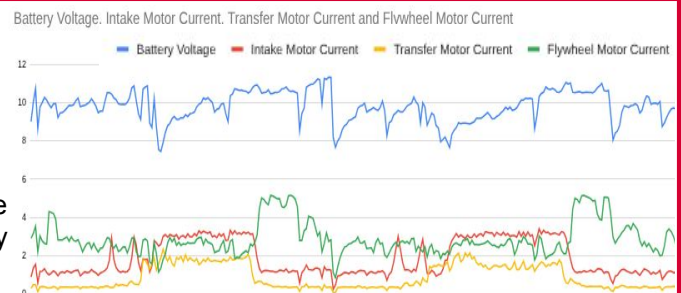
Challenge: Power Management

Excessive power draw from several mechanisms caused our robot to brown out and sometimes reboot. Issues included the intake motor stalling due to spintake encountering resistance with the 3rd artifact. Part of the solution was using a timer to determine how long an artifact stayed in front of the laser distance sensor. If the timer went above a certain limit, which only happened when the 3rd artifact entered the robot, the intake would be shut off.



Power Management Investigation

The current draw on the flywheel and intake/transfer motors are inversely related. When intaking an artifact, resistance causes the intake and transfer motors to push against it; however, opening the mechanical stop allows the flywheel to interact with the artifact, reducing stress on the intake/transfer motors. We concluded the intake motor is the main cause of current drainage, as its usage spikes nearly 200% (3x) when intaking an artifact due to this resistance.



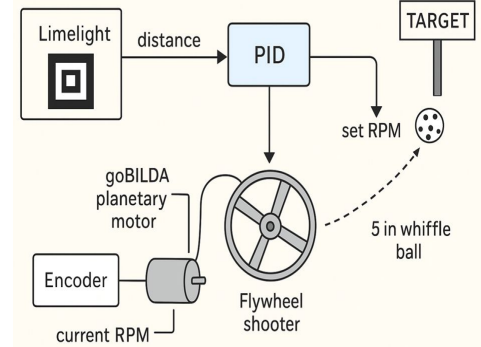
Additional Challenges:

- 4th Artifact Fouls** At States we occasionally collected a 4th artifact which would get us fouls. We solved this by moving our mechanical stop down so there was less physical space inside our robot for artifacts, thereby eliminating to potential for a 4th artifact to be collected. We also connected the intake and transfer to one motor to increase throughput.
- Limited Range of Motion** Our original shooter design to automatically track AprilTags used an Axon servo to rotate the turret which limited the rotation to 120 degrees and was not as fast as we desired. We solved this by designing a smaller shooter that allowed a wider range of turning and replacing the servo with a GoBilda motor to increase rotation speed.
- Inconsistent Far Zone Shooting.** We added additional stainless steel flywheels for more inertial moment, designed an adjustable hood and added a second motor to improve far shot accuracy as well as shooting speed.



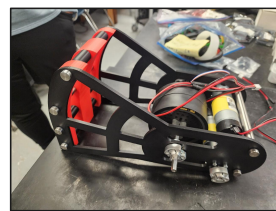
Flywheel Velocity Control Using Limelight + PID

1. **Target Detection:** Limelight camera calculates distance to the AprilTag goal.
2. **Distance determines the necessary flywheel RPM for consistent shots** (e.g., if target is 72 inches away, set flywheel to 2625 rpm).
3. **PID Speed Control:** A PID controller maintains the exact required RPM:
 - o **P (Proportional):** Corrects immediate error
 - o **I (Integral):** Corrects long-term drift
 - o **D (Derivative):** Smooths the response
4. **Continuous Adjustment:** The robot constantly compares target RPM to measured RPM and adjusts motor power to eliminate error.
5. **Consistent Firing:** Shooting only occurs when flywheel maintains correct speed

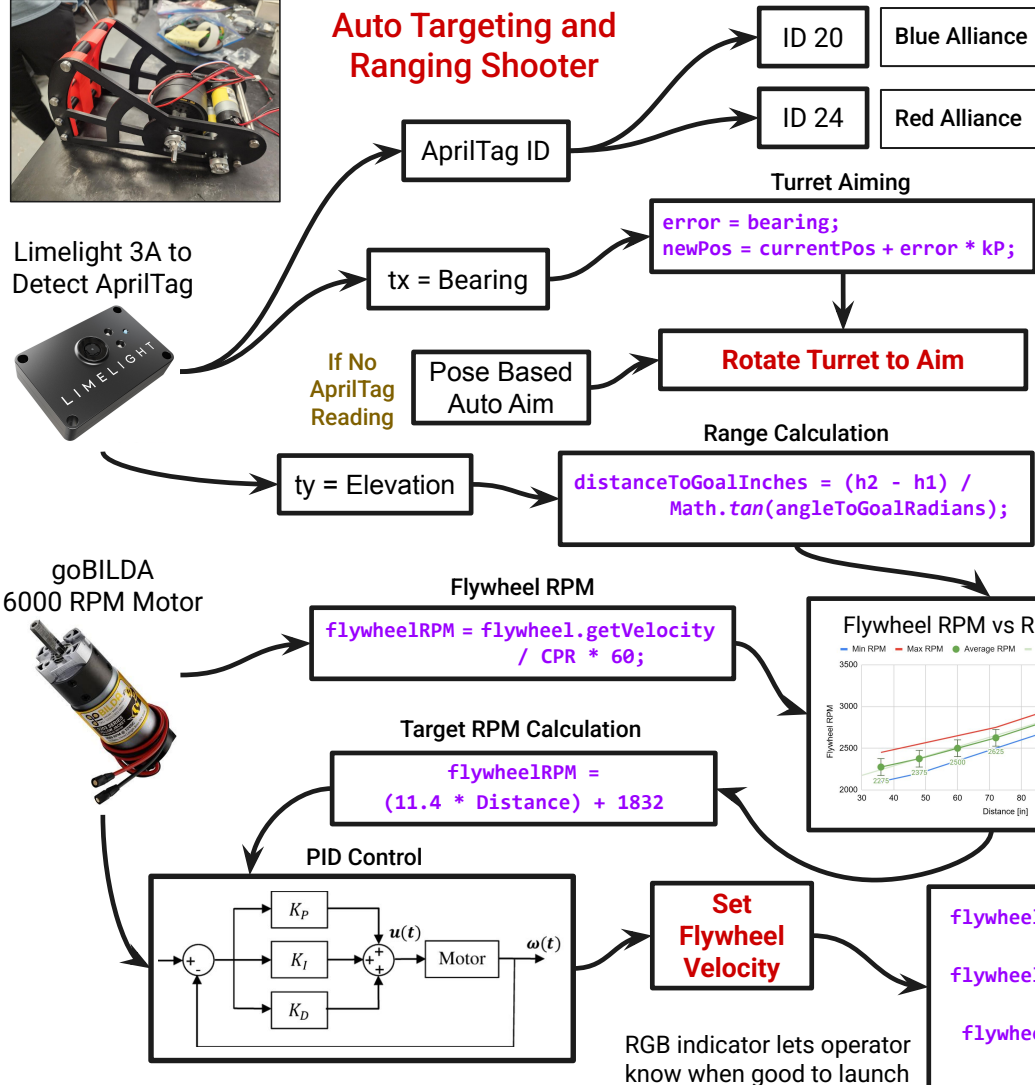


Result: Auto Targeting and Ranging Shooter

To maximize Artifact scoring, we developed an accurate, consistent flywheel shooter. We tested prototypes, collecting data on RPM vs. range and RPM drops when shooting, which allowed us to create empirical relationships for our code. Using bearing and range data from the Limelight 3A camera, a rotating turret automatically aims the shooter. We use the distance to the goal to set the flywheel RPM via the control sequence shown below, utilizing PID to maintain the RPM. This control system eliminates guesswork when shooting from various locations on the field.



Auto Targeting and Ranging Shooter

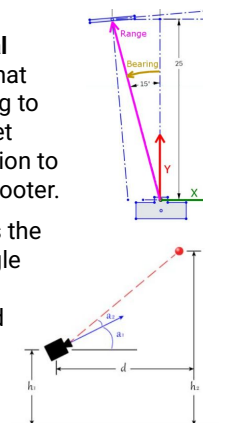


Bearing is the horizontal angle between camera and AprilTag.



We use a **proportional controller** that uses bearing to update turret motor position to align our shooter.

Elevation is the vertical angle between camera and AprilTag.



FIRST PLACE LEGAL

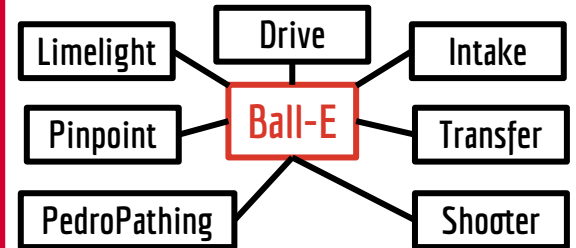


Android Studio and GitHub

In previous seasons, our programmers used Android Studio but lacked direct collaboration, necessitating code exchange via email for revisions. For the Decode season, we adopted GitHub, an online repository, enabling all programmers to simultaneously work on the code, significantly improving teamwork and collaboration. This accelerated progress, resulting in over 300 commits (update milestones) to our repository this season.

Hardware Files Efficiency & Code Structure

We felt that the previous season's code was disorganized, with the main TeleOp nearly 700 lines long. We improved code **readability** and structure by creating separate **hardware classes** for each mechanism (e.g., shooter, intake, etc.) with specific methods for different functions and commands. The main code then simply calls these methods as needed. This also means that our code is **modular**, allowing mechanism updates to be more straightforward to implement without having to revise the main TeleOp.



PedroPathing for Consistent and Reliable Auton

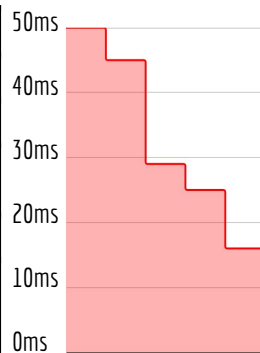
We adopted the new path planning tool, PedroPathing, for autonomous control last year. This system defines field locations as "poses" and combines them into optimal, consistent paths using Bezier curves. A switch-case structure then adds timers and actions to complete the autonomous routine. PedroPathing proved to be a more effective Auton tool for us that RoadRunner, yielding more consistent performance.

PinPoint + 4 Bar Odometry Pods for Better Pose Calculation

The goBILDA Pinpoint is an odometry computer that independently calculates robot position data with its own IMU, avoiding strain on the Control Hub. It connects to two specialized odometry pods. Pinpoint has demonstrated less drift than other systems we have used, including OTOS that we tested in the off-season.



What We Changed	Timer	Savings
State TeleOp Code	50 ms	-
Add Hardware Files	45 ms	5 ms
Remove Current Monitoring	29 ms	16 ms
Bulk Reading	25 ms	4 ms
Send Power Commands only if Changed	16 ms	9 ms



Loop Time Optimization

At the State Championship, we found Ball-E's performance to be sluggish with some errors due to a massive **50 ms** loop cycle time. By stripping unnecessary code and optimizing heavy tasks - including sensor reads and **current monitoring** - we reduced that time to **16 ms** per loop. This **3x improvement** in loop time means we now process sensor and actuator data three times faster, significantly enhancing the responsiveness of our PID controllers and overall robot performance.

State-Machine Shooting Sequence

Initially, our operator pressed a series of buttons on his gamepad to shoot all 3 artifacts, but that took too much time. After States, we experimented with implementing a state-machine shooting sequence into our TeleOp, the same sequence we use in our Autonomous code. Previously, shooting 3 artifacts manually would take around **2.1 seconds**, but implementing the auto shooting sequence resulted in release time of **0.8 seconds** with one press of a button, a **62% improvement**. In a typical match where we are shooting 12-15 artifact cycles, that can save us 16-20 seconds so we can score more cycles.

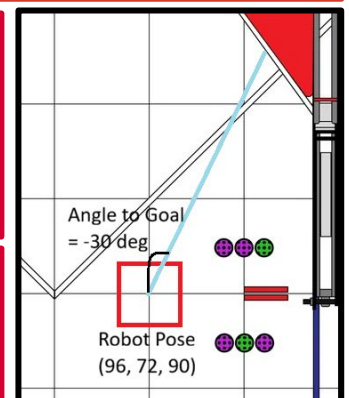
Pose-Based Auto Aim

Our initial system centered the turret without recent AprilTag readings, requiring a full robot rotation to re-aim. We fixed this by developing a **pose-based** aiming system. It calculates the robot-to-goal angle using **trigonometry** and Pinpoint-determined robot position. This angle is used to aim the turret until a fresh AprilTag reading is received from Limelight..

$\text{robotToGoalRelativeAngle} = \text{atan}(\Delta y / \Delta x) - \text{robotHeading};$

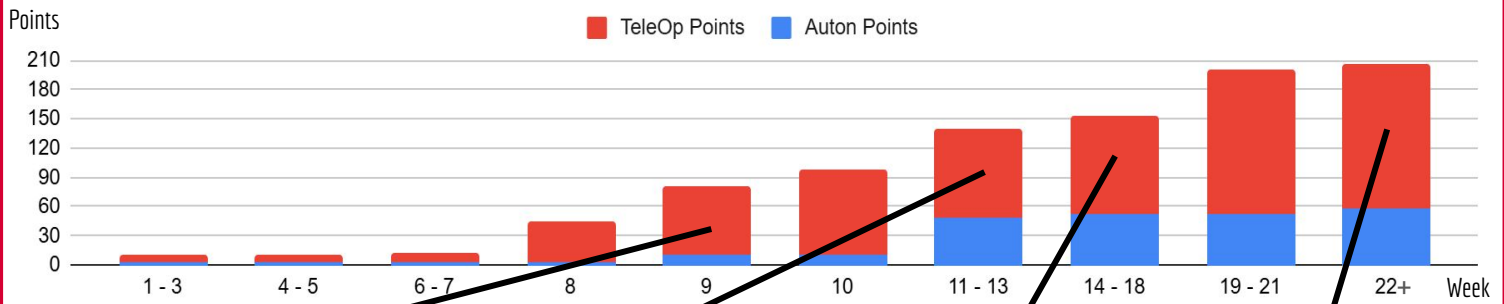
Duplicate Practice Chassis - "Lab Rat" AKA "Spinfinity"

To allow parallel work on the robot by different subgroups, we built a duplicate chassis that shared the competition robot's dimensions, speeding up prototype testing and optimizing meeting time utilization. "Lab Rat" eventually became "Spinfinity", our Worlds robot.



Ball-E's Point Potential

We tracked Ball-E's point potential throughout the season to show our improvement. Heading to Worlds, our **205 point** potential significantly exceeded our original **90 point goal** at the beginning of the season by about **130%**



Royal Oak Qualifier

Ann Arbor Qualifier

States Michigan SE

WORLDS

Improvements Made Between Competitions	Royal Oak To Ann Arbor	Polycarbonate instead of 3D printed bumper	Flywheel PID control for faster shooting	Belt-driven to Gear Driven Flapper	More reliable mechanical stop	LED RPM and Transfer Motor Indicator	6 Artifact to 9 Artifact Auton
	Ann Arbor To States	Full 16" wide intake funnel	435 RPM Drive Motors for Faster Movement	Aluminum shooter frame with better tracking	Barb-less Spintake and Current Monitoring	Artifact Intake Sensor with Indicator RGB	More reliable 12 Classified Artifact Auton
	States To Worlds	2 ball funnel jam and 4th artifact intake issues fixed	Intake and transfer actuated by single motor	Adjustable hood shooter with 2 motor flywheel	Faster shooting with state machine routine	Optimized loop time for better responsiveness	15 Classified Artifact Auton with Gate Intake

15 Artifact Auton

Outline of our primary auton:

- 0 Start at goal
- 1 Drive and shoot pre-loads
- 2 Drive to spike mark 22
- 3 Pick up spike 22 artifacts
- 4 Drive to score pos + shoot
- 5 Drive to gate
- 6 Drive back and pick up
- 7 Drive to score pos + shoot
- 8 Drive to spike mark 23
- 9 Pick up spike 23 artifacts
- 10 Drive to score pos + shoot
- 11 Drive to spike mark 21
- 12 Pick up spike 21 artifacts
- 13 Drive to score pos + shoot
- 14 Drive to end pos

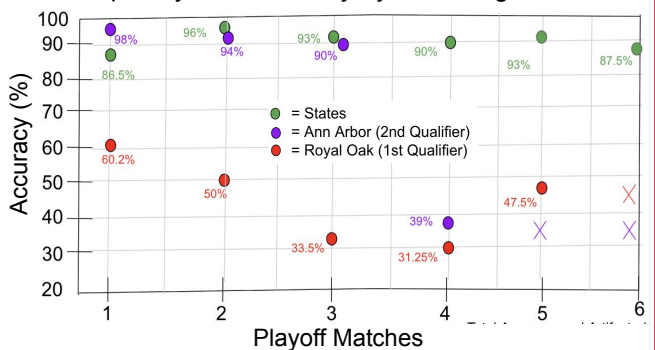
End Result

15 classified artifacts = 45 pts
 Motif pattern = 10 pts
 Leave = 3 pts
Total = 58 pts



Shooting Speed & Accuracy

Our strategy focused on faster shooting cycle times and better accuracy of our shots. We skipped a lift and indexer because their point gains didn't justify the increased cycle time or complexity. We analyzed shot frequency and accuracy by reviewing videos.



Competition	Artifacts	Accuracy
Royal Oak (1st Qualifier)	11	45%
Ann Arbor (2nd Qualifier)	26	80%
MI States	36	91%

227% more artifacts & 46% better accuracy by States

We hope you have *discovered* the team you have been searching for in us, *digging deep* and *decoding* our portfolio. We hope you have a *historical* day for the *ages*!