IRON UMMAH

27859

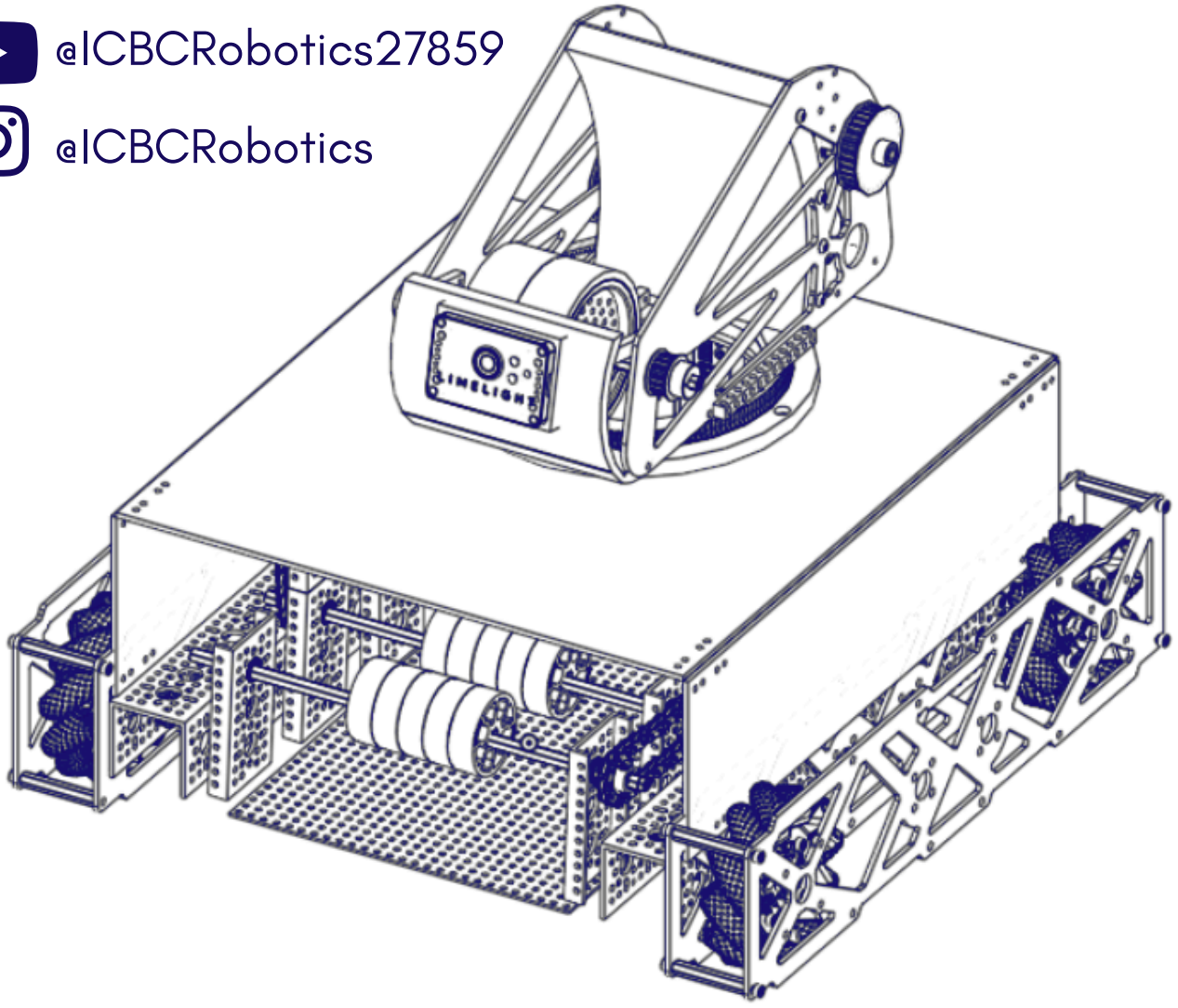
Engineering Portfolio

2025-2026

27859.icbcrobotics.org

@ICBCRobotics27859

@ICBCRobotics



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Contents & Overview

Award Highlights:

Think (pgs. 6, 7, and 14)
Our engineering process, mathematical analysis, and financial plan

Connect (pg. 4)
Teaching future members and our resources to improve

Reach (pg. 3)
Introducing STEM, recruiting members, and reaching companies

Sustain (pgs. 5, 6, and 7)
Team goals, member recruitment, design process, and finances

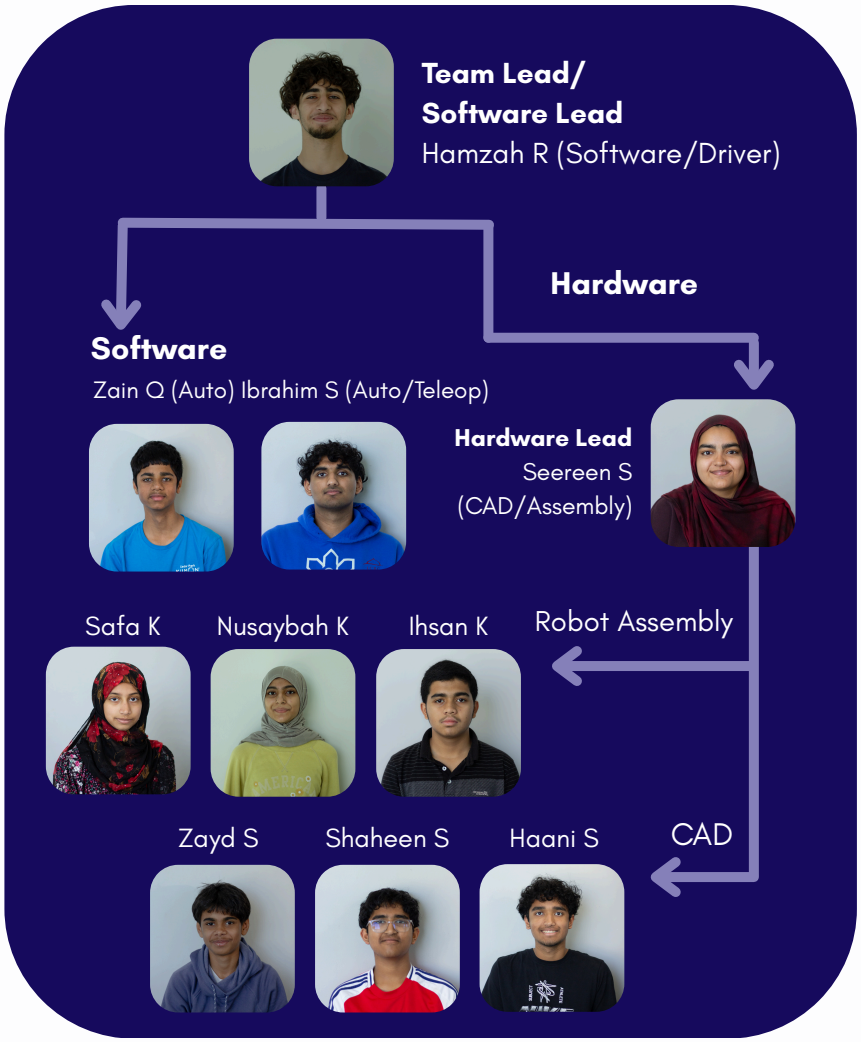
Innovate (pgs. 10, 11, and 12)
Turret, backplate, and shooter iterations and uniqueness

Control (pgs. 13 and 14, and 15)
Limelight, sensors, and tracking

Design (pgs. 8, 9, 11, and 15)
Overall robot and a convenient backplate

2 Contents & Overview
3 Outreach
6 Finance
7 Robot Design Process
8 Robot Overview
10 Robot Specification
13 Autonomous
14 Tele-op
15 Competitions

27859 is a community team based at the ICBC in Cedar Park, Texas. We started our team in 2024 and since expanded our own team, started multiple FLL and FTC teams, and conducted several STEM-related classes to expand FIRST.



We thank our mentors and coaches: **Mohib I. Hawzhin R., Akram M, Hadeed K, and Idris K.**

Our team is divided into **subteams**:

1. **Software** works on autonomous and tele-op code
2. **Hardware (CAD)** works on designing different versions of the robot in CAD
3. **Hardware (robot assembly)** works on printing, buying, and building the parts from the cadded design

Outreach In addition to technical work and being divided into technical subteams, all team members collaborate and help with outreach and finances to keep our team sustainable.

Team goals:

Some of our team members personal goals include:

- Seereen: "Have a deeper understanding of mechanical failures to identify issues earlier and prevent them from reoccurring"
- Safa: "To learn how hardware in robots can be designed as opposed to lego parts in FLL"
- Nusaybah: "To learn how to create real-life industrial machinery to have future impacts"
- Shaheen & Haani: "Advance CAD skills by designing more complex and precise robot components"
- Zayd: "Working toward mastering CAD and improving my design proficiency"

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Outreach

Reach: Mentorship & Expansion

Team Background + Offseason Brief

After our first season, **growing community interest** in FTC from several offseason showcases led us to **recruit more members**. We held interviews, selecting students based on interest, experience, and **participation in our summer classes.**

Teams launched & helped launch

FTC 31675
FTC 32738
FLL 69715

FTC Teams

We worked with several teams as a part of outreach, and helped with the **establishment of 4 teams** in order to expand FIRST.

- During the off-season, we founded our sister team, **#31675, Qur'antum Mechanics**, and work closely with them throughout the year.
- We helped **start FTC Team #32738** at the ICRR, by hosting an informational meeting and showcases. We continue to mentor them throughout the season.
- Our members presented our designs and achievements to a **board in Tennessee**, proposing the creation of a robotics team (FLL or FTC), and we remain in contact to support their launch next season.
- With a growing community interest in robotics, we've worked with **QCIC to help start an FTC** team there.



#32738 Showcase


#26903 Scrimmage


LightSaders Rookie Invitational

Invitationals + Scrimmages

Last season, we attended the the **LightSaders rookie invitational** where we achieved an OPR of 73 while **collaborating with #26903.** Earlier this season, we participated in KIPP's scrimmage. Moreover, during the Into the Deep season in 2025, we've participated in **scrimmages with FTC team #26903.**

Growth Over the Years

2024

- 3 Mentors
- 15 team members a part of #27859 ITKAN ICBC Ravenbots
- 2 classes offered
- Sponsor(s): 1
- 2 bake sales

2025

- 6 Mentors
- 20 team members split into two teams, launching sister team #31675
- 4 classes offered
- Sponsor(s): 8
- 4 bake sales, 1 showcase & fundraisers
- Launched /helped launch 3 FIRST teams
- STEM workshops & summer camps for youth

2026

Future Plans:

- Start another team from recruitment, planning to have 30 team members
- More future classes offered
- Sponsor(s): 8+
- Additional summer camps for younger students
- 6 bake sales planned
- Scrimmages with other teams

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Outreach

Connect: Education + Workshops

FLL Teams and Robotics Camps

- During the summer of 2025, we ran several camps to grow **STEM and FIRST** Robotics in our community. These camps included teaching elementary and middle school students
  - **Java**
  - **Arduino**
  - **Python**
  - **OnShape**
- In addition, we **directly recruited** some of our members from these classes into our team and plan to do so next year.
- We also have **three FLL teams,** which we helped start and support. Through these teams, we not only do outreach in our community but **scout for new members**.

~100
students in STEM classes

$1200
raised from classes and camps

100+
community members reached through presentations

~100
students in summer camps

Showcases/Presentations

- We've attended and held several presentations for our community. During the end of our 2025 season, we held a **presentation and demonstration for ICBC's board,** and later a public event for the entire ICBC community.
- In terms of other teams, we held an i**nterest meeting at ICRR community center** and attended a presentation of **#26903** team to learn more about how other teams work.





Team #27859 giving an interest presentation at ICRR.

Fundraising in the Community

- We've held several events to fundraise in our community. This includes showcases we've held at ICBC, bake sales, etc. We've made a **total of around $1000 from, but split this amount between our sister team.**

Certifications

- During our offseason, all team members received **certifications** for **HTML/CSS/ Javascript Workshop** from an online website called SoloLearn, in order to help with web development and create our website.



Bake sales held during offseaosn



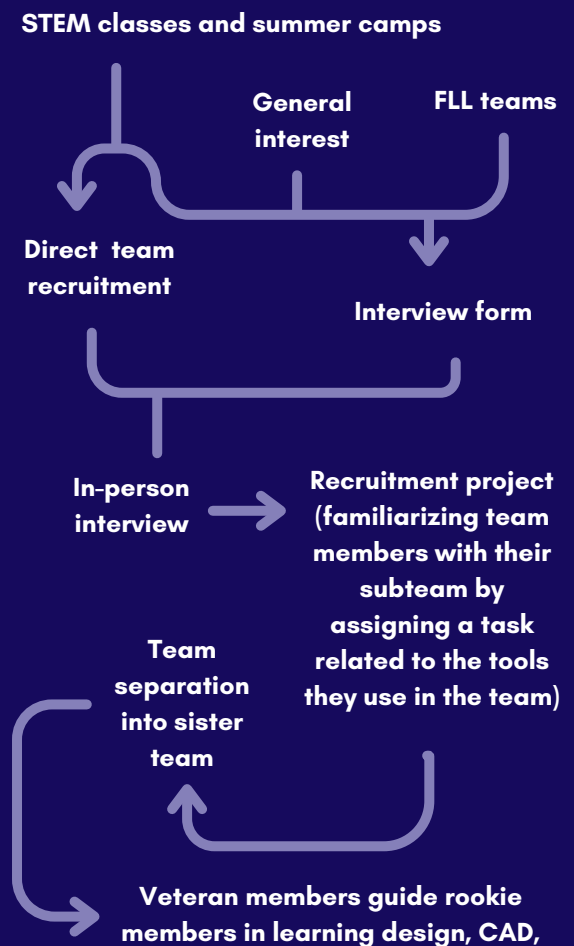
Summer camps taught for younger students

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Outreach

Sustain: Recruitment and Mentors

Recruitment Process



20
new members (split into 27859 and 31675)

In the future,

we plan to continue presentations and technical classes at ICBC during our offseason. We are planning to organize another bake sale this month. Finally, we plan to create a **third sister team** next season with similar outreach.

Mentors

- Mentors help expand our **technical skills** in coding, building, CAD, **and soft skills** such as networking and teamwork.
  - **Coach Hawzhin** guides us in hardware.
  - **Coach Hadeed** helps us with CAD, outreach, and season documentation.
  - **Coach Mohib** helps us in project planning, finances, and guides us in software.
- We reach out and acquire several of these mentors from our community and showcases.
- Alongside this, we have **several parent volunteers** who also help us build upon such skills.

Coach Mohib is a community member who works at Google. He found our team through a showcase is now one of our most active and beneficial coaches.


All our coaches in the bottom row

Reaching Out to Companies

- Every month, **each team member is required to send 2** sponsorship/grant/mentorship **requests** to companies.
- This is usually done through personally **setting up a meeting** with someone from the company, **calling** them, or **emailing** them.
- We've **raised a total of $2180** and reached out to 144 people/businesses. A community member saw our hard work and vision and **donated $1000+ in equipment** to our team.

Our Sponsors

Kababji grill · International Foods · Qualcomm · Academic Tutoring · Phoenicia Bakery & Deli · Kumon · The Rahman Family

$2180
raised from sponsors

144
businesses contacted

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Outreach

Financial Sustainability and Social Media

Income		Expenses	
Team Member Fees	$4500	$544	Acetal/Laser Cut Parts
Qualcomm Grant	$250	$2433	GoBuilda Orders
Apple Grant	$250	$500	Team Registration
Fundraising (Bake Sale)	$512	$201	Batteries
Summer Classes	$918	$194	Limelight
Int'l Foods Sponsorship	$250	$145	Cart + Tray for robot
Rahman Family Sponsorship	$500	$309	Swyft + Thrifty Orders
Kabeer Family Sponsorship	$250	$603	Regular/Electrical parts
		$581	3D Bambu printers
Team Joint Purchases	**- $1225**	$230	Cabinets
		$230	Storage and glasses
		$184	Room Furnishings
Total	$6205	$6154	**Total**

Financial Plan for the future:

- Maintain funding through team dues, sponsorships, and grants
- Continue community fundraising events such as bake sales and showcases
- Expand summer STEM classes and camps to support the team budget
- Build long-term partnerships with sponsors and local organizations

Social Media

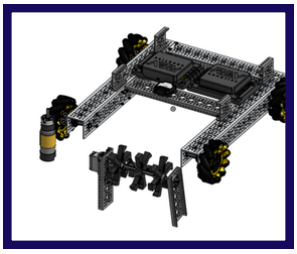
- We regularly post **team updates on Instagram**, **network with other FIRST teams** online, and research how other robots look and function.
- It allows us to share our **impact with sponsors and the community** while learning from other teams' designs and strategies.
- We also use **Discord to network with other teams and communicate within our own,** but mainly we use the unofficial FTC server, PedroPathing server, and SWYFT robotics server to get inspiration, solve technical issues, learn more about the game, etc.
- We have our own **YouTube channel** which we post on.



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Robot Design Process

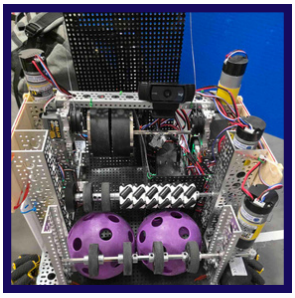
V1 CAD



V1 - Initial Approach

- Built the robot and **simultaneously created the CAD model** for documentation.
- Several subsystems, including the **transfer system and shooter angling mechanism, did not perform as expected.**
- Encountered **hardware conflicts** and **performance limitations** that required us to rework significantly.

Final V1

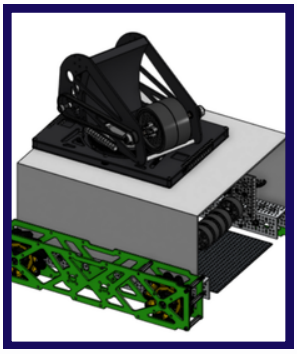


V2 - Improvements

- Dedicated 2-3 weeks to **fully designing and validating the robot in CAD before beginning assembly**. This allowed us to:

1. Purchase all required parts beforehand
2. **Order custom acetal parts** for the first time
3. Finalize **subsystems before fabricating** them
4. Use the **CAD model as a blueprint during assembly**

V2 CAD

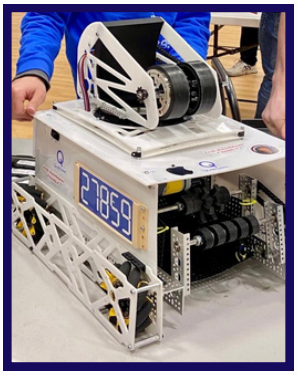


CAD allows us to test ideas before implementation.

V2 - Failure Analysis

- **Failed to account** for necessary **mounting holes** in acetal plates for components such as the battery, motors, and sizing constraints.
- As a result, **manually drilled holes** while building the robot
- Build time i**ncreased, and precision** reduced.
- **This showed us the importance of design reviews, verifying hole placements before ordering parts.**
- The bearings that held the turret lacked grip and stability, limiting rotation to **slow 360° or smooth but limited 180°** rotation.

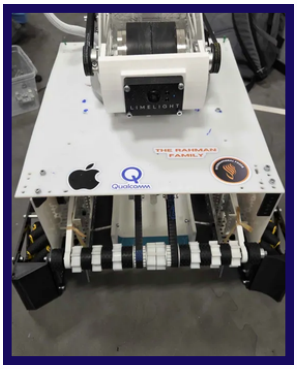
Final V2



V2.5 - Improvements

- Added compliant intake: created a **large compliant intake** that sticks out of our box and can **easily grab balls during gameplay.**
- We also **experimented with 3D printed parts:**
  - our compliant intake
  - create **funnels** attached to our chassis to **intake smoothly.**
  - create **several versions of our turret gears** so we would finally have a working turret.

Final V2.5



Identifying failures in CAD allowed us to iterate quickly and improve our robot design.

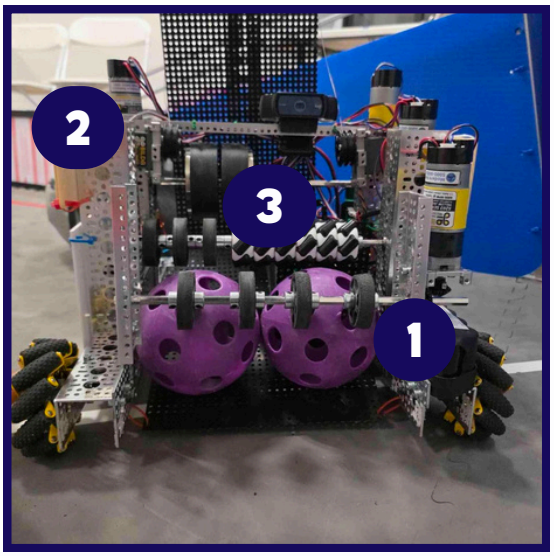
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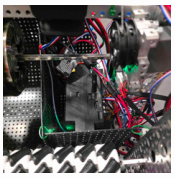
Robot Overview

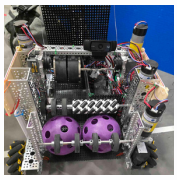
Our robot collects game elements using a compliant intake system and scores them using a hooded shooter mounted on a rotating turret.

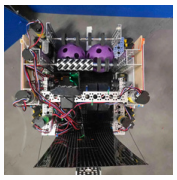
V1

Initial Robot









Key Mechanisms:

1. **Intake + Buffer System**
- **Compliant GoBilda wheels intake balls**
- **Vector wheels guide balls toward shooter**

2. **Adjustable Ramp**
- Made from ABS plastic
- Servo-controlled angle adjustment

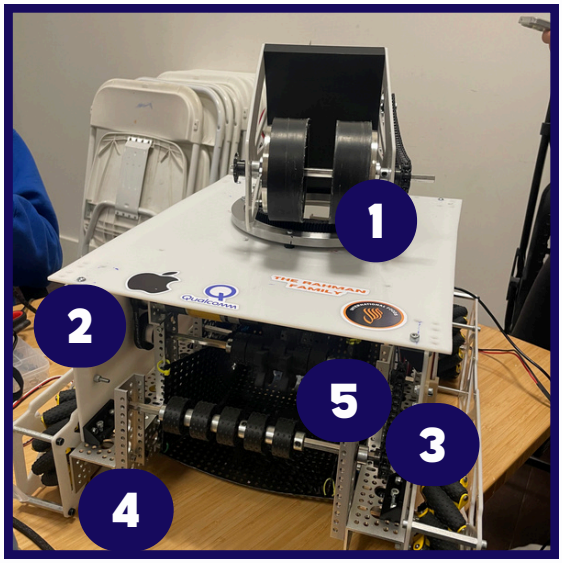
3. **Dual Rhino Wheel Shooter**
- Weighted wheels provide consistent launch speed
- Can hold balls before shooting

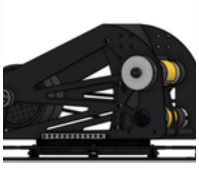
Limitations:

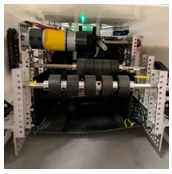
- Slow shooting (fixed with a hooded shooter *above* the intake and a turret),
- Vulnerable parts (hence the wheel covers in V2),
- Stores only 2 balls

V2

Improved/Iterated Robot









Key Mechanisms:

1. **Turret + Shooter Assembly (pgs. 10 and 12)**
- 3D printed and acetal components
- Rotates using belt-driven pulley system

2. **Protective Robot Frame (pg. 11)**
- Laser-cut acetal box protects internal systems
- Swinging backpack design allows easy maintenance

3. **Wheel Covers (pg. 11)**
- Protect shooter and intake components

4. **Intake + Transfer (pg. 12)**
- Chain-driven transfer moves balls to kicker

5. **Kicker Mechanism (pg.12)**
- Launches balls into shooter
- Uses GoBilda wheels for improved grip

V2 Improvements Over V1

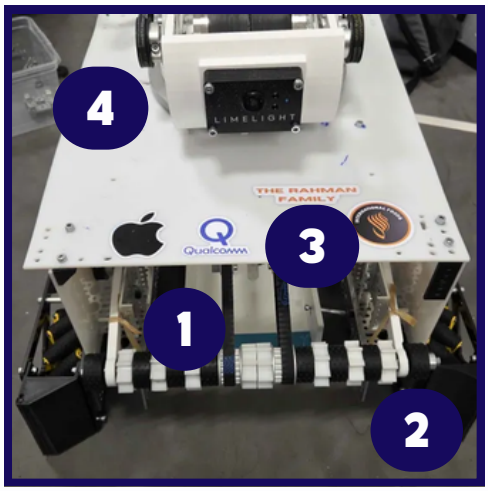
- Improved shooter reliability
- Protected internal components
- Faster intake and transfer
- Easier battery and code access
- Shorter cycle time

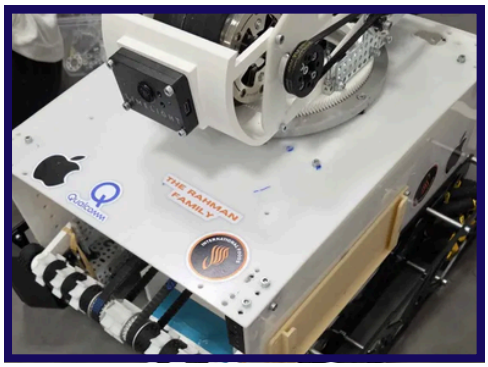
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Robot Overview + Performance Metrics

V2.5

Final Robot





Due to time constraints, we were not able to fully build a V3, so we decided to update our V2 instead with enough iterations to create our V2.5.

1. **Intake Redesign (pg. 12)**
   - Uses 3D printed mounts with compliant and SWYFT intake wheels to create larger compliant intake
   - Extends beyond the box
   - Picks balls up more quickly and efficiently

2. **Funnel System**
   - Added 3D printed funnels to guide balls into the intake.
   - Direct balls toward the 3D printed ramp for better alignment.

3. **Ramp Improvement (pg. 12)**
   - Replaced ABS plastic ramp from V1/V2 with a 3D printed ramp at an optimized angle for smoother, consistent transfer.

4. **Turret Gear Optimization (pg. 10)**
   - Increased gear tooth size by modifying the gear module.
   - Improved tooth engagement and prevented slipping during impacts.

Metric	Value
Cycle Time (seconds)	1.5
Shooter RPM	Varies based on distance
TeleOp Accuracy	95%
Autonomous Success	90%
Turret Rotation Time	21 rpm
Weight (KG)	14

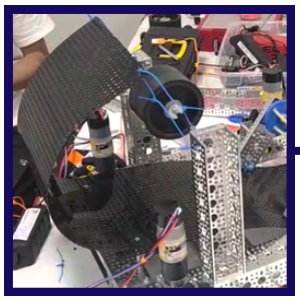
Key Improvements from V2

- Faster ball intake
- More consistent and reliable ball transfer
- Improved turret reliability
- Better ball alignment
- More structured box
- Faster cycle time

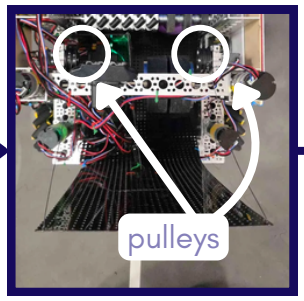
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Robot Specification

Hood development



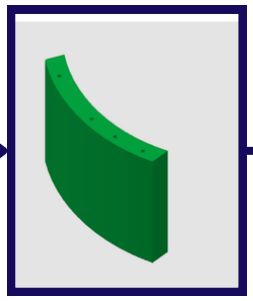
V1: Used an ABS ramp to angle balls while shooting, but results were **inconsistent**.



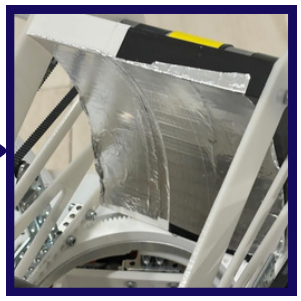
Added GoBilda pulleys and servos to **adjust the ramp** angle during gameplay, which still proved unreliable.



V2: Designed a hooded shooter using 3D printed and acetal parts for a fixed and consistent launch angle.

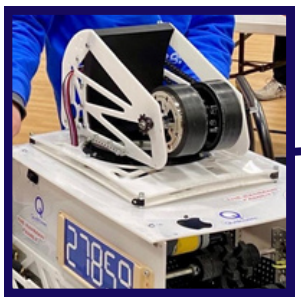


The curved hood ensured that **every ball is shot at a perfect angle.**

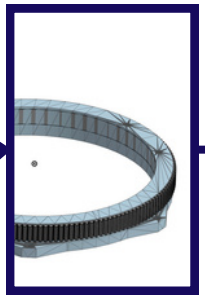


3D printed components provided the **most reliable solution** across iterations.

Turret development



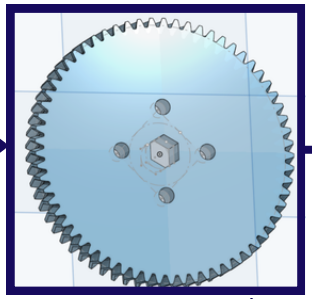
Original turret



Belt-driven



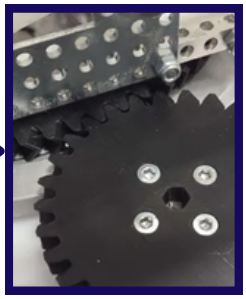
First gear design



Larger gear teeth + servo mount



v2.3



Final stable turret system



Some gear iterations

V1 Approach

- Shooter angle controlled by robot position and **ramp + pulley adjustment.**
- This method was slow and inconsistent during matches.

Iteration 1 - Belt Driven Turret

- Belt connected to a pulley powered by a motor.
- Turret was 3D printed and supported by bearings between acetal sheets.
- Design proved unstable, causing the turret to slip.

Iteration 2 - Gear Driven System

- Switched from **belt drive to gear system for reliability.**
- Easier to modify and adjust gear placements.

Final Design

- Implemented V-shaped herringbone gears for **improved grip.**
- Mounted turret on a table turner for stability.
- Increased gear tooth size to **prevent slipping** during impacts.

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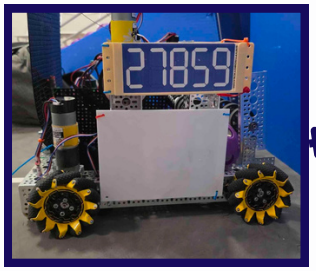
Key Engineering Decisions

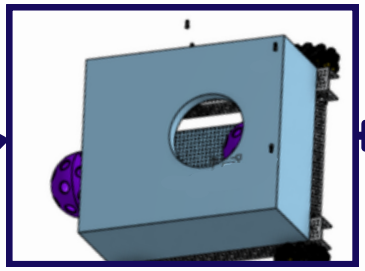
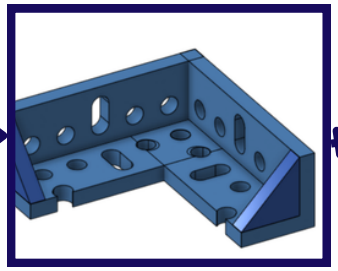
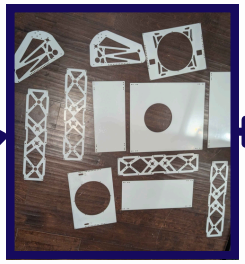
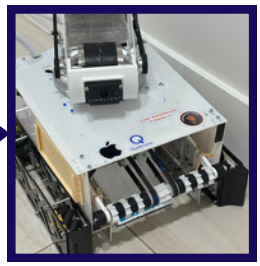
- Switched from adjustable ramp → fixed hood for consistentcy
- Replaced belt with gear system for reliability and ease
- Used herringbone gears large module to prevent slipping
- Added table turner support for turret stability

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Robot Specification

Box development



Side plates on **V1** to **protect components like motors.**

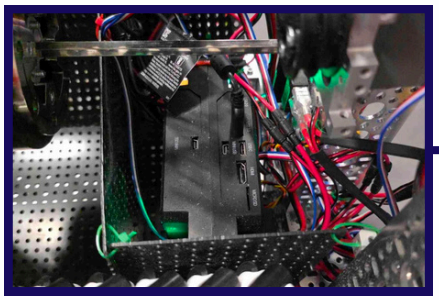
Acetal enclosure with 3D-printed connectors for improved rigidity during impacts

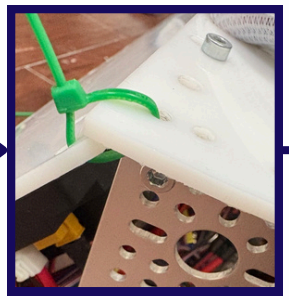
Measurement inaccuracies in our first acetal order required drilling and adjustments during assembly.

Though we had problems with inaccuracies, this led to the creation of a removable backplate, improving access and maintenance.

Reinforced the box with **low-side channels** inside the acetal sheets after connectors alone proved unstable.

Backplate Design





Hinged backplate reduced maintenance time between matches



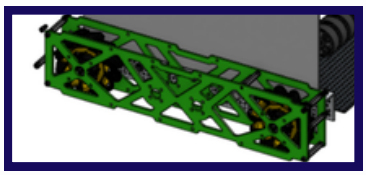
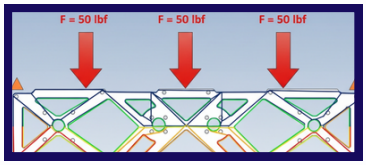
Limited space made protected hub placement difficult, since **we had to access components to push code.**

V2 CAD placed hubs in the back without considering accessibility.

We added **zip ties to the backplate** instead of screws so it could **open as needed**.

Later upgraded to a more **secure** velcro mount to prevent opening during matches.

Wheel Covers




- We designed our wheel covers in our CAD to cover our wheels as shown.
- Made a simulation to identify stress points and where we would have to fasten the covers to the chassis.
- First version was **scaled incorrectly**, requiring **manual drilling** to mount and **delaying V2** progression.
- **V2.5** redesign fixed hole alignment and **added clearance for the compliant intake.**

Risk:
A mecanum wheel was destructed during our first league meet.
We did not want this to occur again.
Response:
Created wheel covers in CAD.
Analysis:
Used 2D truss simulation to identify stress points and prevent cracking.
Assessment:
Since implementing wheel covers and our box, robot damages from matches have not happened.

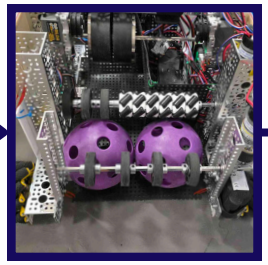
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Robot Specification

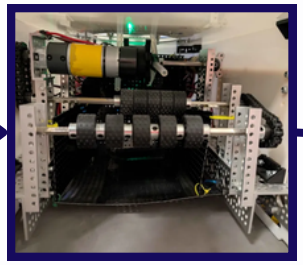
Intake + Transfer development



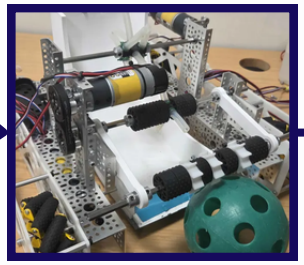
V1 intake: GoBILDA boot wheel → surgical tubing (better grip but exceeded 18×18×18) → switched to circular rubber wheels.

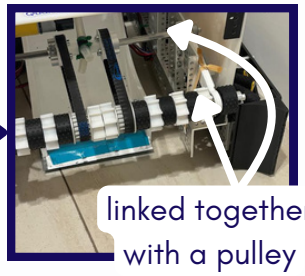


Added buffer/transfer system with compliant wheels and tubing to **prevent jams** and move balls to the shooter.



V2.5: Intake made raisable with 3D-printed mounts, adding traction rubber and SWYFT intake wheels.

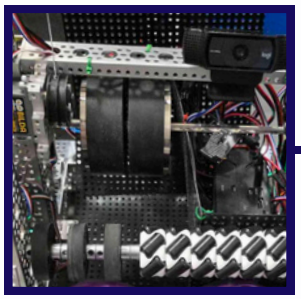




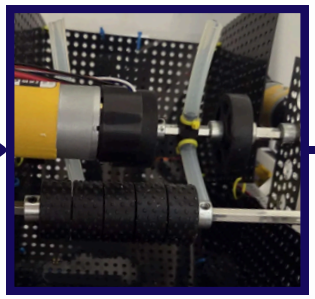
Pulleys link the intake and transfer system, feeding balls toward the shooter.

A compliant intake reduces ball compression and improves **cycle time**.

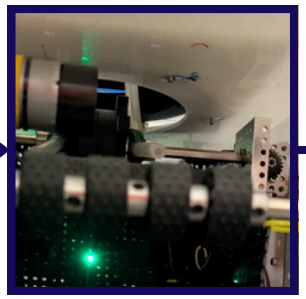
Kicker + Ramp



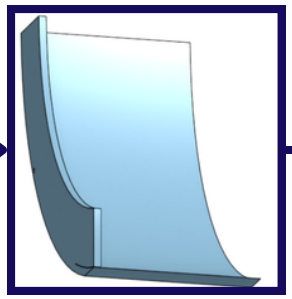
V1 used a buffer with vector and rubber wheels leading up to weighted rhino wheels.



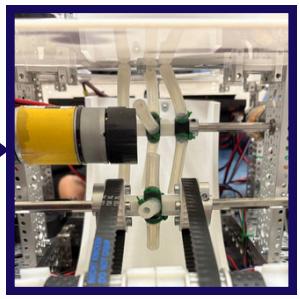
V2 added surgical tubing and rubber wheels to kick balls up to the shooter



Surgical tubing shortened + higher motor RPM for improved, faster throughput

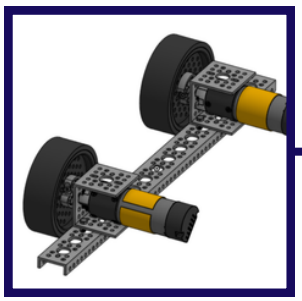


3D printed ramp to replace ABS bendable plastic and improve shooting consistency and cycle time

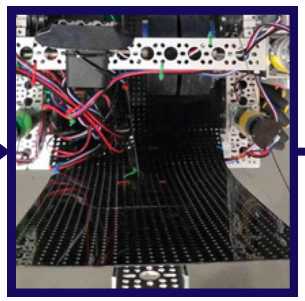


Surgical tubing only Additionally, ABS plastic was added under the kicker to **reduce compression**

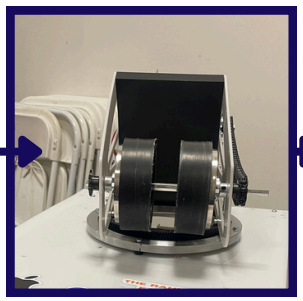
Shooter



The **initial shooter** that was designed right after kickoff was two rhino wheels on a single channel.

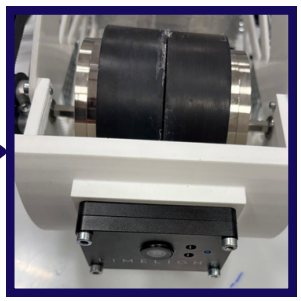


Upgraded to weighted Rhino wheels on a shaft for holding/ shooting balls.



Hooded shooter and Limelight mounted to shooter for constant AprilTag alignment





We also use our limelight to read april tags of the goals and the motif.

Making our turret servo-based allowed us to have **two 6000 RPM motors for our shooter** and provide high-speed flywheel power.

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Autonomous

V1 Autonomous

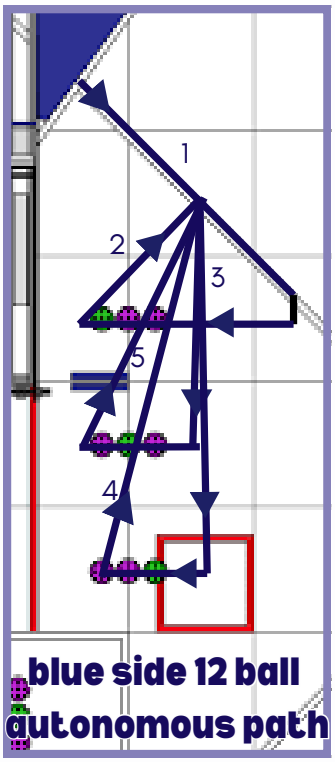
- Scored about **3 balls** with no consideration of motif
- Accuracy much closer to 90%
- Could only **pick up 2 balls** at a time
- Relied on motor encoders and .sleep() cooldowns to shoot

V2.5 Autonomous

- Shot and scored about **12 balls**
- Accuracy much closer to **90%**
- Can **pick up 3 balls** at a time
- Robot's end position was ideal for beginning of Teleop period.

V2.9 Autonomous

- Shot and scored about **15 balls**
- Accuracy much closer to **95%**
- **Cycle time** reduced by **4 seconds** than rest of the iterations
- Paths are more efficient reducing.



blue side 12 ball autonomous path

Pedro Pathing

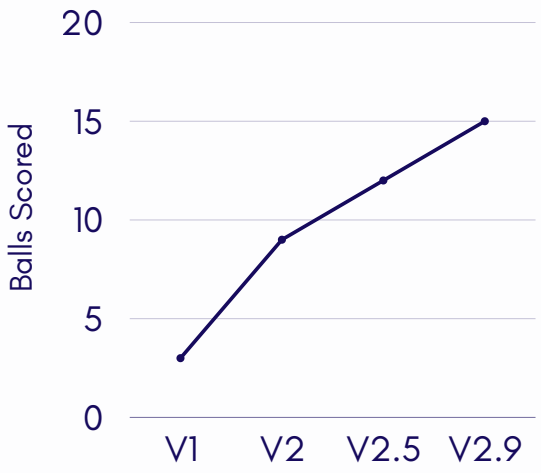
- We did not encounter many major problems when implementing Pedro Pathing onto the robot.
- Because of this, we developed **theoretical auto scripts that could score 15 balls.**
- We will use Megatag2 in the autonomous soon, which is superior to Megatag 1.
- Megatag 1 (less accurate):

$$(x, y, \theta) = \frac{1}{n}\sum_{i=1}^{n}(x_i, y_i, \theta_i)$$

- Megatag 2 (more accurate):

$$min_{x,y}\sum_{i=1}^{n} w_i \left|\left|z_i - h_i\left(x, y, \theta_{gyro}\right)\right|\right|^2$$

Balls Scored in Autonomous



Color Sensor

- used to detect whether the robot has 3 balls
- avoid turning the robot around to check
- buzzes controller when 3rd ball was intaked

Odometry Deadwheels

- used to locate robot's position in auto
- used in turret tracking to find goal position relative to robot (see pg. 14)

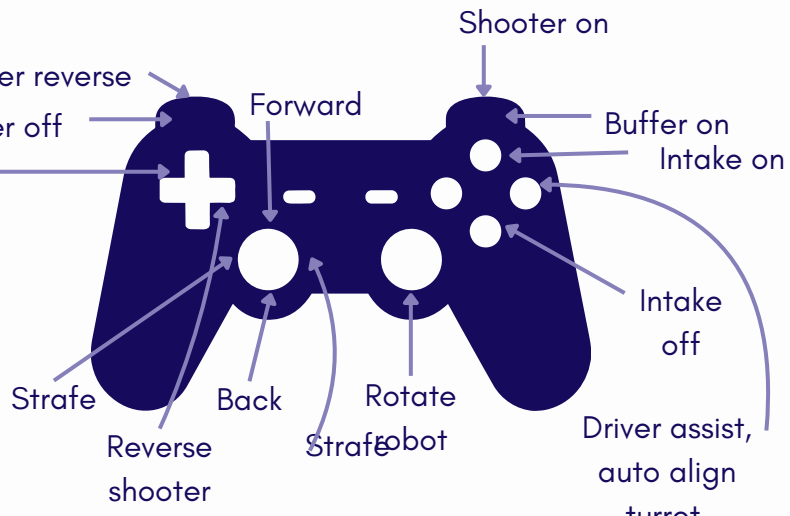
RGB Light

- Lets the driver know if the shooter RPM is ready
- Shooting artifacts effectively, only under the controlled conditions of the maximum RPM

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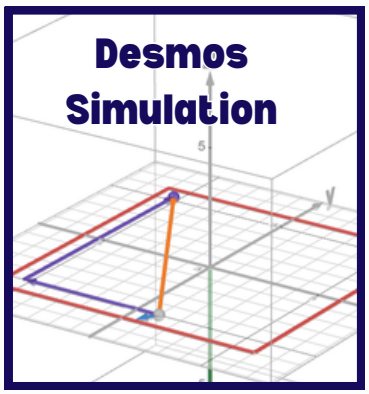
Tele-op

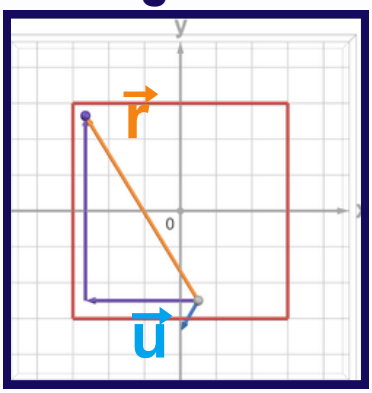
Our Tele-Op system combines driver control with automated turret tracking and distance-based shooting to maximize scoring speed and accuracy.



We use a PS4 controller to receive better feedback from our sensors, especially through haptic feedback.

Turret Tracking





We completely use odometry to track the goal using our turret. The angle theta is calculated as shown.

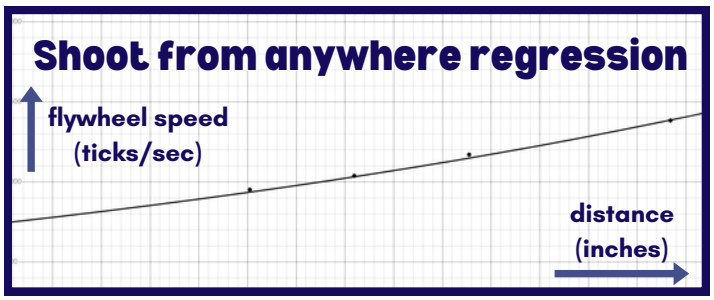
$$\theta = \cos^{-1}\left(\frac{r \cdot u}{|r||u|}\right)$$

$$d = \frac{u \times r}{|u||r|}$$

$$\theta_{final} = \theta \cdot d$$

See: https://www.desmos.com/3d/rvol9oe0pq

Shoot from anywhere regression



$$y = 742.99031 \cdot 1.00456^{x}$$

We use a 5-point exponential regression to shoot from anywhere on the field. We measure distance from the goal using odometry and feed the distance into a function that returns the shooter velocity required to arc into the goal.

inches	flywheel speed
x_1	y_1
50.467	950.562
71.896	1036.754
95.485	1168.871
136.834	1382.274
144.895	1454.548

Gameplay strategies:

- We focus on throughput rather than matching the motif.
- Software-wise, we use a turret to track the goal. We calculate the required angle for our turret using the formulas above, allowing for constant alignment of the shooter with the target. On demand, we relocalize using MegaTag2 with our Limelight 3A. This improved accuracy and reduced cycle times for the driver.
- Worked on adding new sensors such as color sensors so we know when we have 3 balls stored.
- Switched to using a PS4 controller to assist with smoother driving and haptic control. When our color sensor detects 3 balls stored, our PS4 controller rumbles to notify the driver.

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Competitions

Top OPR (np)

102.3

Best Match

220 points

Most Samples in a Match

48 artifacts

Improvement factors:

- We made our intake much more effective in v2.5.
  - Its funnels and grip wheels made intaking fast.
  - More throughput and more teleop points.
- We had more time to refine our auto from our league tournament
  - There were no constant tournaments that required a consistent auto, so we could upgrade to a higher point auto.

