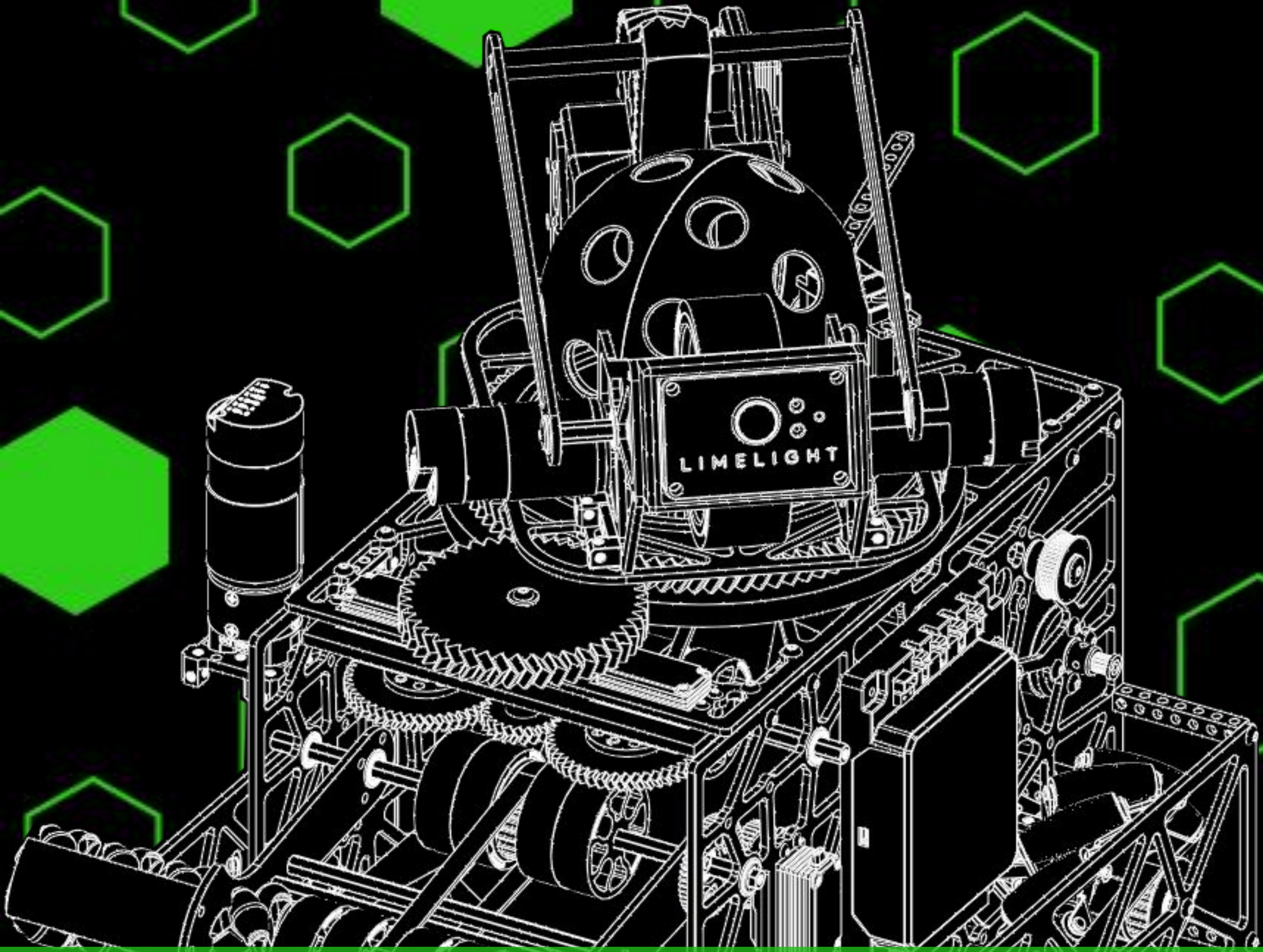
ENIGMA #16265
2025-2026 Portfolio
"BALL-E"



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AMBITIONS CONSULTING GROUP

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AV

verus RESEARCH

Team Members

Coach Russ

7^{th} year of robotics

Technical Coach

Coach Dan

4^{th} year of robotics

Managerial Coach

Luke (Age 17)

5^{th} year of robotics

Co-Captain, Design, Build, Drive Teams

Callie (Age 15)

4^{th} year of robotics

Co-Captain, Build, Business, Drive Teams

Elliott (Age 14)

4^{th} year of robotics

Programming, Drive Teams

Gabriel (Age 14)

3^{rd} year of robotics

Build, Drive Teams

Anirudh (Age 17)

3^{rd} year of robotics

Design, Build, Drive Teams

Cody (Age 17)

3^{rd} year of robotics

Business, Art Teams

Sammy (Age 16)

3^{rd} year of robotics

Programming Team

Davy (Age 16)

3^{rd} year of robotics

Programming Team

Asa (Age 16)

2^{nd} year of robotics

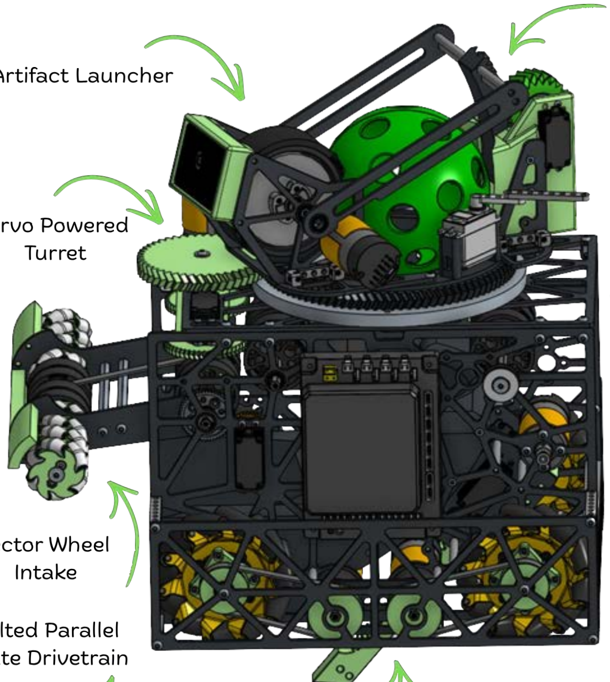
Design, Build Teams

James (Age 13)

1^{st} year of robotics

Design, Build Teams

Meet BALL-E



Design Priorities

This season, we decided to set aside three main priorities for our robot design.

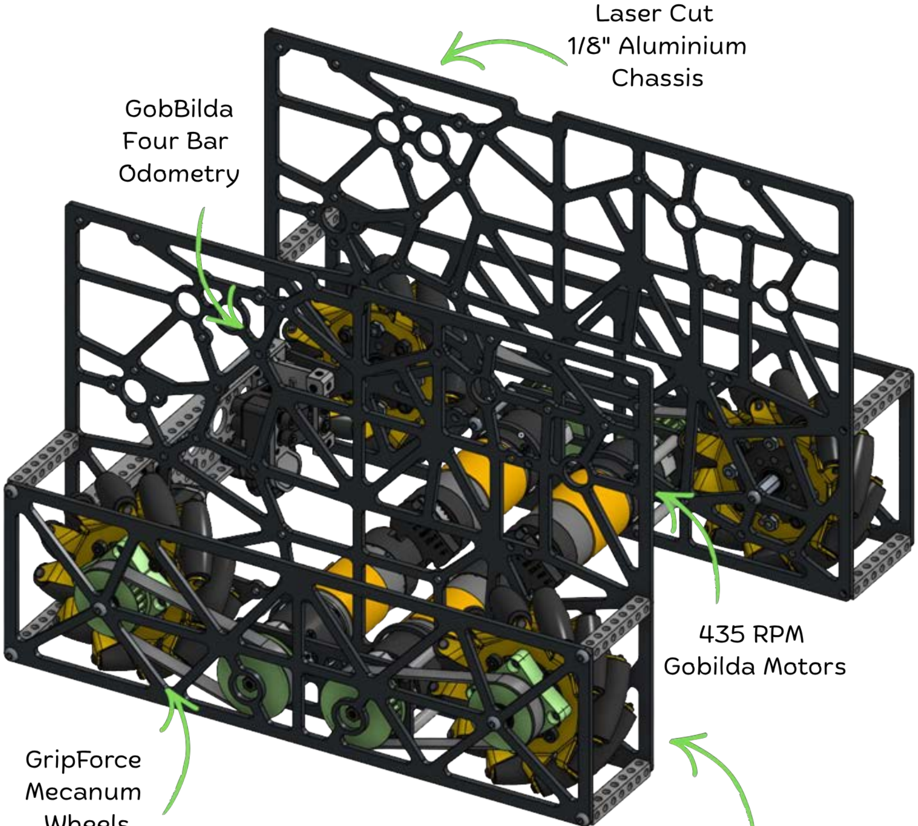
1. **Artifact Cycle Speed**
   1.1. Optimize intake and launcher speed
   1.2. Fast drive speed
2. **Match Flexibility**
   2.1. Be able to shoot from most areas of the field
   2.2. Compatible partner autos.
3. **Ranking Points**
   3.1. Be able to achieve at least 5 ranking points in competition
   3.2. Attempt all ranking points

Following the start of the season, we narrowed down our general robot archetype into two main choices, **Spindexer**, or a **Direct Feeder**. A spindexer consists of a spinning mechanism with a divider, allowing you to pick and choose which ball to score, allowing you to consistently score Motiffs. In contrast, a direct feeder feeds balls into the launcher in the order they were intake, leaving sorting up to the driver.

To make sure our decision aligned with our three main priorities, we created a decision matrix.

Criteria	Weight	Direct Feeder			Spindexer		
		Comments	Rating	Weighted Score	Comments	Rating	Weighted Score
Artifact Cycle Speed	5	Fastest Possible Feeding Method	5	25	Delay Between Shots Slows Down Cycles	3	15
Match Flexibility	4	Not Compatible with sorted autos	3	12	Not Compatible with unsorted autos	3	12
Ranking Points	3	Able to achieve 5 RP	3	9	Able to achieve 6 RP	5	15
Total Score				46			42

Drivetrain & Electronics



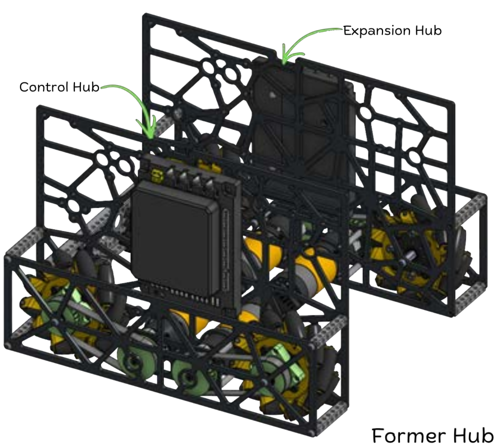
Drivetrain Features

One of our main design goals for drivetrain, was to keep it **under 13x13**, in order to help achieve the park ranking point during endgame.

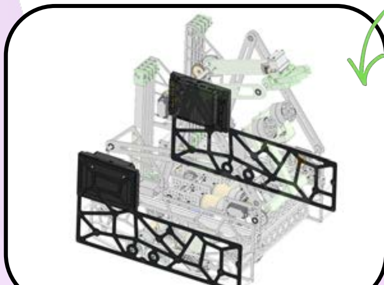
As a result, our drivetrain comes in at **12.5 inches wide, and 13 inches long**, allowing us to easily achieve the **partial park** in endgame, and achieve a **double park** with the addition of a tilt mechanism.

Another important consideration of drivetrain design is speed. We decided to gear our drivetrain up to approximately **500 RPM** in order to help speed up cycle times. We do this by stepping a GoBilda 13.7:1 435 RPM motor up 21:24 for an final ratio of approximately **12:1**.

The parallel plate structure of the chassis helps provide **customizable mounting** for other mechanisms.



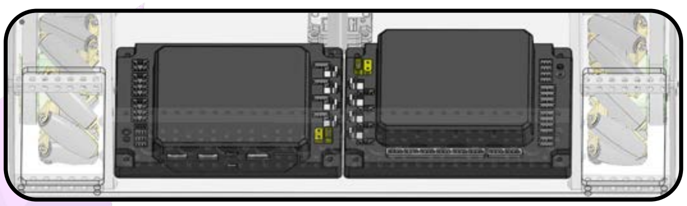
Former Hub Mounting Attempts



Control & Expansion Hub Mounting

After experimenting with mounting the control & expansion hubs in different ways, we came to the conclusion that mounting them **facing outwards** was the best option.

Mounting the hubs facing outwards allows for more accessibility than other designs. In order to not compromise the safety of the hubs, we utilize a **polycarbonate cover** that protects the hubs from potential contact from other robots, yet allow **easy access to our wiring.**



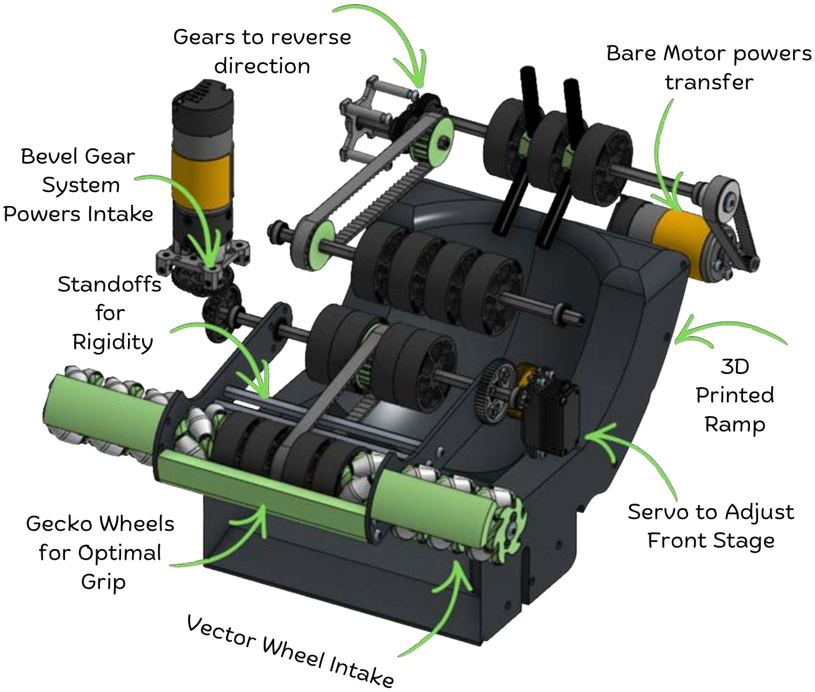
Laser Cut Aluminium

Our chassis uses pocketed 1/8" aluminium in order to create rigidity, while still remaining relatively light. Pockets **reduce drivetrain weight by 27.5%,** and **reduce plate weight by 63.5%**

Through our sponsor, **VBS Manufacturing**, we are able to get our custom designed plates machined quickly, locally, and affordably.

Intake & Transfer

Our Intake and Transfer system received the most iteration of any mechanism on our robot. After spending a large portion of the season, experimenting with different intakes, we decided on a dual motor floating intake as our solution to this years challenge.



How Our Intake Works

We utilize a four stage, two motor **floating intake** in order to collect artifacts.

The front stage of our intake is adjustable through a **servo powered arm**. It utilizes 48mm gecko wheels for grip, and 48mm **vector wheels** on the outside to center the artifacts. The remaining stages use 48mm gecko wheels, with stage 4 additionally having 2in surgical tubing rollers

Our **3D Printed ramp** helps ensure we maintain consistent compression throughout the system.

Our split motor design helps us **maximize intake RPM** without worrying about stalling our motors.

Intake Ratio Calculations

- 1620 RPM belted 0.75:1 for **2160 RPM** on first stage
- 1620 RPM geared 1:1 for 2nd stage
- 6000 RPM Belted 3.33:1 for **1800 RPM** on transfer (3rd and 4th stages)

Intake should exceed drive surface speed to achieve the “Touch it Own it” effect

2x For Safety

$.104m*\pi*497.14rpm/60 = 2.71\ m/s$

$2.71\ m/s = (.048m*\pi*X)/60$

$X = 1078$

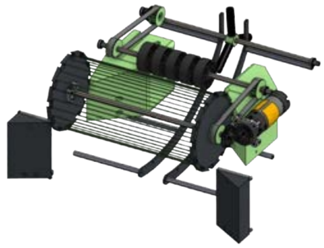
2160 RPM Required

Intake Development

V1.0

- Uses One Motor
- Only able to hold two artifacts
- Struggled to lift artifacts over ramp
- Slow transfer into shooter
- Can only grab artifacts against wall

V2.0



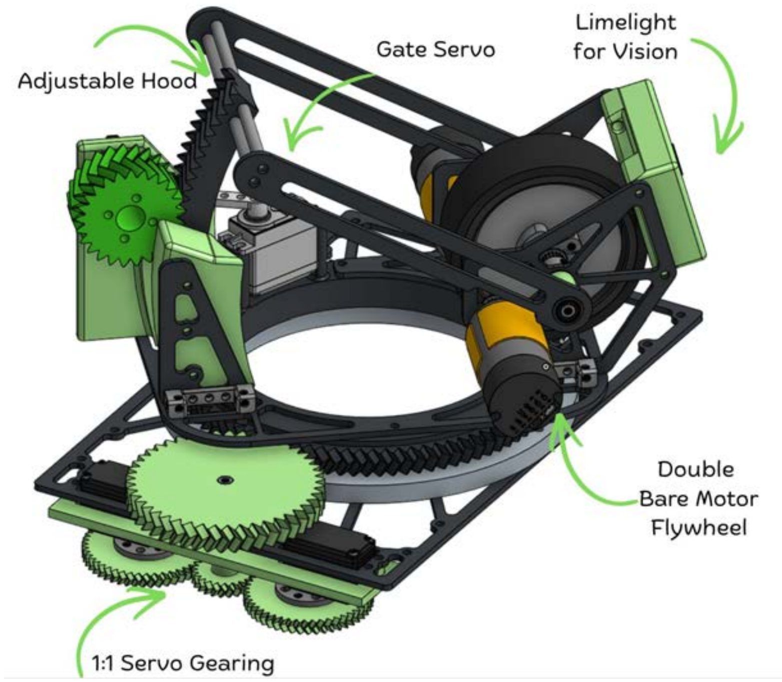
- Uses One Motor
- Holds Three Artifacts
- Able to grab artifacts while driving
- Slow transfer into shooter
- Struggles to intake from corners
- Rubberband hubs prone to breaking

V3.0

- Three ball wide intake
- Able to intake at full speed
- Fast transfer into shooter
- Adjustable compression
- Split intake & transfer prevents possible stalling issues
- Mechanically complicated

Artifact Launcher & Turret

For our artifact launcher this season, we use a hooded flywheel design, allowing us to easily adjust our shot distance. Additionally, we designed a turret mechanism to track the goal during match play, helping improve our cycle times, and decreasing load on our drivers.



Key Features

We utilize two GoBilda bare motors, belted to the flywheel shaft using GT2 belts.

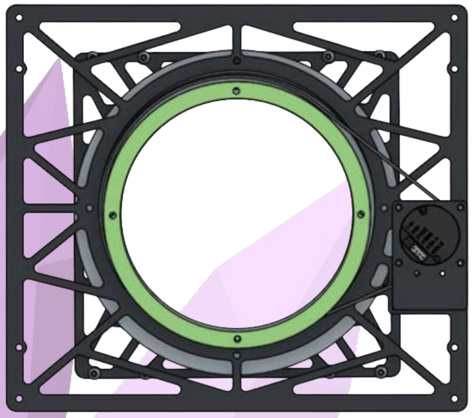
We use a single gobilda **rhino wheel**, in addition to one 96mm swyft **steel flywheel** weight, and three 72mm steel weights. This helps increase our **moment of inertia,** ensuring our shots remain consistent during match play.

Our turret spins on an Andymark lazy susan bearing through a fully custom **3D printed gear chain**. We use two Axon Mini servos **geared 1:1** to power our turret, allowing us to use “**servo mode**”, and quickly rotate the turret.

Additionally, we use one Axon Mini servo to power our **adjustable hood**, allowing us to shoot from anywhere on the field.

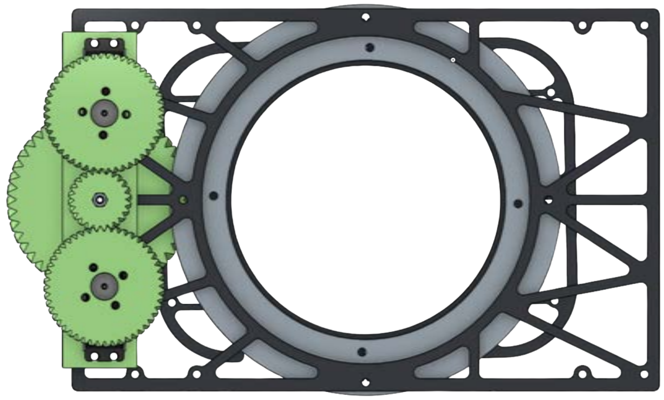
Turret V1.0

- 0.22 second no load rotation
- Studica Encoder for more accurate measurements
- One Motor
- Lazy Susan Bearing
- Skipping issues
- Required belt tensioners (increased friction)
- 33.9 kg-cm stall torque
- Large footprint (Motor takes up vertical space)

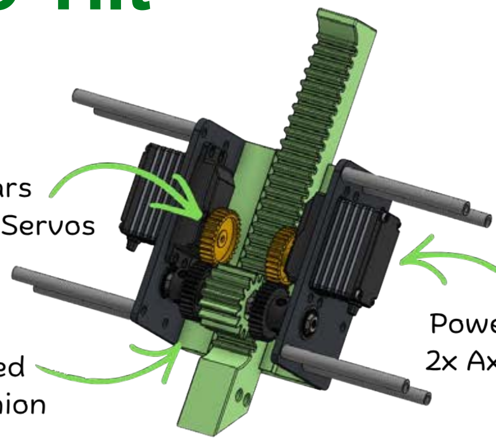


Turret V2.0

- 50 kg-cm stall torque
- No skipping issues
- Flat & compact design
- Frees up extra motor for use elsewhere
- Lightweight
- Two Servo
- Lazy Susan Bearing
- 0.54 second no load rotation
- More expensive



Servo Tilt



Servo Tilt Design

Our Servo Tilt mechanism uses two Axon Max servos to power a **rack and pinion** system.

This system is used to lift the front of the robot off the ground, allowing us to take up a smaller area of the parking zone during endgame.

We use an external gearing system to help **protect the internal servo shaft** from potential shock loads caused by this heavy use case.

Torque Calculations

We utilize two Axon Max+ Servos geared 1:1, each with 34 kg-cm stall torque for a total of **68 kg-cm**. This meets our calculated minimum torque while still allowing for a **sub 3 second lift**.

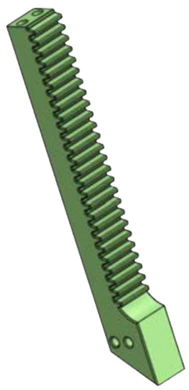
T = F * r
Robot Weight = 26.5 lbs = 12.02kg
Pinion Pitch Radius = 0.5 in = 1.27 cm
T = 12.02kg * 1.27 cm = 15.26 kg · cm
2.5x Safety Factor
Minimum Torque Required = 38.15 kg · cm

Failure Analysis

Problem: During first testing of the tilt mechanism under the full weight of the robot, the 3D Printed rack **snapped under the pressure** of the robot.

Solution: Switch rack filament from PETG to **Nylon-CF**.

Result: Reliable rack and pinion system, not prone to breakage.



Servo Tilt v. PTO

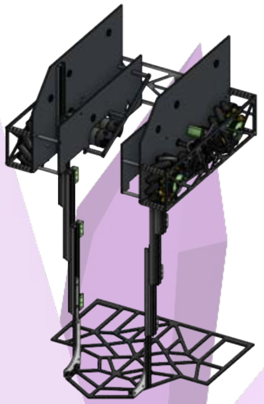
This season we had two main ideas for achieving this years endgame task: **A servo tilt mechanism**, and a **linear slide Power-Take-Off (PTO).**

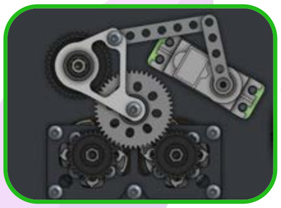
While the tilt mechanism is relatively simple, a PTO lift is more complex, using a servo linkage to engage gears connected to all four drive motors in order to a **power a lift.**

In order to help us decide between the two options, we created a **weighted decision matrix.**

Weighted Decision Matrix

Criteria	Weight	PTO Lift		Servo Tilt	
		Rating	Weighted Score	Rating	Weighted Score
Alliance Compatability	5	4	20	3	15
Size (Smaller is better)	4	2	8	5	20
Time to lift	3	4	12	3	9
Mechanical Complexity	2	1	2	5	8
Weight (Lighter is better)	1	2	2	4	4
Total Score			44		56



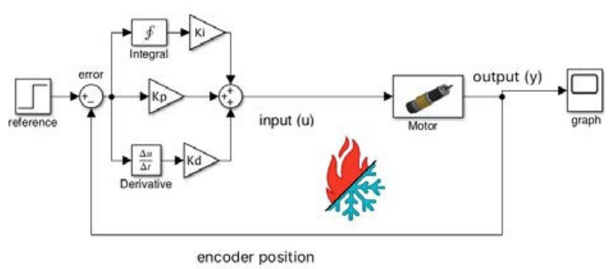


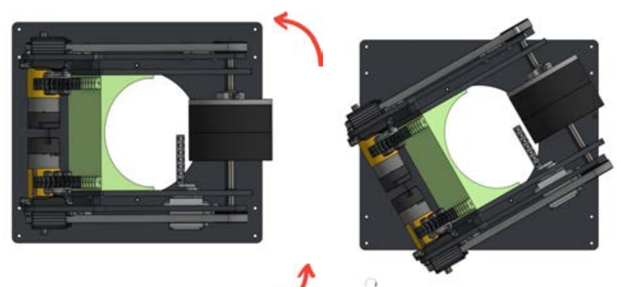
Early PTO Designs

Programming Features

Control

- Ball-E is programmed in Java, and contains many features which elevate gameplay in both the autonomous and tele-op periods
- Proportional-Integral-Derivative (PID) controllers power the shooter flywheel, keeping the wheels rotating at a constant velocity to decrease variability in each shot, keeping our scoring extremely consistent throughout competition.
    - Without PID controllers, the flywheel, which is commanded to run at certain velocities, becomes dependent on the battery voltage, which does not stay constant throughout a match.
    - Non-constant voltage creates unaccountable variability; since one of our season goals was to maximize consistency, PID controllers were a necessary implementation on the robot.





- Ball-E is also driven field-oriented as opposed to the traditional robot-oriented drive,
    - This simplifies the controls for our driver, achieving the season goal of robot simplicity.
- Ball-E is able to shoot from nearly anywhere within the shooting zones, regardless of current robot heading and other field variables.
    - By changing the shooter's angle, Ball-E alter the artifacts' trajectory in order to score from any distance. It accomplishes this by constantly tracking the current position of the robot relative to the goal, and determines the optimum angle in order to improve shot consistency.
    - By tracking the current position of the robot, including its current yaw, the turret mounted on the robot can always face the target goal. This eliminates the need for our drivers to line up a shot, saving crucial time.
        - This sysem has some potential flaws. If the robot gets bumped to aggressively, the dead wheels used to track position may become less accurate, leading to potential inaccuracies. To combat this problem, a Limelight camera is mounted on the turret, so that vision feedback can be used to focus on the april tag on the goal.

Autonomous and Feedback

Control

- Ball-e uses a program called Pedro Pathing to create and follow planned routines during the autonomous period.
    - Pedro Pathing works with the robot's GoBilda Pinpoint Odemetry Computer to accurately determine the robots position and current velocity. It then uses this information to command the drive motors to move in just the right way to make the robot follow a predetermined route with up to an inch of accuracy every time.
    - This allows every routine to be rehearsed and predictable, necessary for consisteny.
- Pedro Pathing Ivy is a library designed to work with Pedro Pathing used for running actions and commands dynamically and efficiently.
    - Using Ivy, programming can be done very quickly, as instead of writing all the code to tell the robot how to do something, it can instead be told how to do it.
    - The used commands take feedback from the current robot status in order to determine what to do, and when to do it, allowing for even more consistency.

- While having a consistent and reliable autonomous is great, it's essentially useless in a match if it isn't compatible with your alliance partner. That's why ENIGMA has many different autonomous programs in order to have synergy with all of our alliance partners.
    - Ball-e is capable of running an autonomous on the blue or red alliance, along with being able to start from both the close and the far side. This ensures no conflicts while setting up.
    - Even if Ball-e has an autonomous from either alliance on either side, it still doesn't ensure compatibility. That's why Ball-e is equipped with variants for all autonomous programs, in order to prevent collisions or conflicts with our parter during autonomous.
- These different feedback systems allow for a smooth, reliable, and effective autonomous program. Without this feedback, our robot would be lacking in the ability to adapt to the ever changing conditions on the field.

Skill Development and Mentors

Think & Connect

Development Plan

- Younger students shadow older students
- We use Onshape CAD Classes
- Use old robots to develop skills such as CAD and Coding

Mentors in Team ENIGMA

How We Find Our Mentors:

- Outreach events
- Parents
- Friends of students or parents
- FIRST Alumni

What our Mentors Taught Us:

Coding

- How to debug errors
- Good coding habits
- How to distinguish between good and bad programs within code
- How to write more dynamic code

Build

- Gave new ideas for Wire Management - Peter & Mark
- Good CAD practices and organization - Gray
- Game Strategy - Peter
- Taught younger members how to create and test prototypes - Felix

Current Enigma Mentors:

Gray

- ENIGMA FTC and FRC Alumni
- CAD and Build Mentor
- Electrical Engineering @ UNM

Peter

- FRC Alumni
- CAD and Build Mentor

Felix

- ENIGMA FTC and FRC Alumni
- Build Mentor
- Mechanical Engineering @ NMTech

Dave

- ENIGMA Parent
- Code Mentor
- Software Engineer

Mark

- FRC Alumni
- Build Mentor
- Robotics & CS @ WPI
- New Mentor

Team Development Plan

Recruiting

- Recruit new members through outreach, school connections, and personal connections
- Share content on social media and run live streams for events to expand program reach
- Operate two teams within the ENIGMA program: ENIGMA 16265 and sister team 33778 Mechanical Error
    - Provide less experienced members with increased roles and hands-on experience
- Mentor newer members through guidance from more experienced team members

Build & Design Development

- Younger members began the season by free-building a robot to learn FTC build and electronics systems, then competed with it in the first two qualifiers
- New members developed CAD and design skills through Onshape training, enabling them to design and build a fully custom robot for the state championship

Code Development

- Provide new members with last year's robot to practice coding while the current robot is being built
- Onboard new students by setting them up with the team's coding software and tools
- Assign guided coding projects to help new members build skills and confidence
- Offer mentorship and feedback as students work through their projects

Business/Outreach Development

- Educate team members on our business plan and fundraising strategies
- Create opportunities for students to participate in and lead STEM outreach events
- Involve every team member in contributing to the team portfolio
- Encourage students to network within their communities to set up outreach opportunities
- Build communication and organizational skills through real-world outreach planning

Current Outreach

Reach

We have improved outreach events from last year by bringing robots kids can drive so we are not just talking at them. For the Albuquerque FLL Qualifier we improved by hosting at a better location and had 2 judges panels so competition went faster.

ENIGMA started Rookie FTC 33778 Mechanical ERROR

- Sister team
- Mentor 2-3 times a week
- Share a workshop and tools with them
- Consists of all first or second year FTC members

ENIGMA mentors 9 other 2025/2026 season robotics teams at Desert Ridge Middle School

- Mentored by Co-Captain Callahan
- Estimated 50 kids weekly
- 2nd year mentoring

FTC team 27413 (SPQR Robotics), Rookie FTC 31652 (Gearheads^2) & FTC team 21797 Hack City

- Gearheads^2 - Helped with field set up, code, and mechanical issues through an in person visit, as well as through zoom.
- SPQR - We helped SPQR gain access to a field in order to test their robot, as well as gave them access to tools and parts. Additionally, we provide help with the robot online.
- Hack City - Helped teach FTC programming to a team of rookie members.

ENIGMA Hosts First Lego League Albuquerque Qualifier

- Organized event, provided food and drinks for the volunteers
- Students, parents, and mentors volunteered to help run the event along with FTC 23794
- Help from FTC 21797 for providing the venue
- Recruited other volunteers to help fill additional roles.
- 3rd year hosting
- Estimated 250 people

ENIGMA @ NASA Space Apps Challenge

- Established a presence at a local annual hackathon
- Created pathways for team sustainability, pipelines for prospective mentors and students alike
- Connected with community programs, and helped expand the STEM presence within Albuquerque and NM as a whole

Goals & STEM Connections

Connect

Season Goals

- Make it to Worlds
- Spread STEAM in New Mexico
- Help to create new FIRST teams and develop current teams

Steps to Reach Goals

- Managed time wisely, continue to make improvements
- Promote STEAM at all outreach events to try and get kids involved in any form of STEAM
- Host FIRST Lego League Qualifier so Albuquerque teams can compete
- Mentor other teams such as FLL team at Desert Ridge and new FTC team-27413 SPQR

Science, Technology, Engineering, and Math Connections

We worked with:

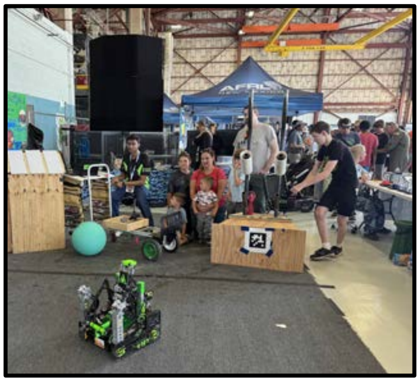
- Matt Williams- Mechanical Engineer

This helped us by:

- Giving us feedback on our robot to help fix errors

Larger Events Completed

- Ran a two-day-long booth at the Kirtland Air Force Base, showcasing FTC robotics and FIRST as an organization, connecting families across NM to FIRST organizations in their communities and neighborhoods.



SMART Goals					
Goal	Specific	Measurable	Achievable	Relevant	Time-Bound
Build Competitive Robot	We as a team need to build a competitive robot through planning, build, and code	Top 100 Offensive Power Ranking in the world according to FTC Scout by performing well with alliances	Our goal is achievable based on past seasons	Increased acknowledgement across the country means more opportunities to learn from world class teams	Reach top 100 OPR by the end of the regional competition
Reach World Competition	We want to receive an invitation to the worldwide FIRST competition from our Regional Competition	We will receive an invitation at the end of Regional Competition	Our goal is achievable based on past seasons performance.	Allows us to learn from world class teams for better improvement next year	Have an invitation by end of State Championship

ENIGMA Business - SWOT ANALYSIS

Sustain

A SWOT Analysis is a strategic way of planning that is designed to help organizations and individuals, to identify internal and external factors that can impact their goals and objectives. Benefits of a SWOT Analysis:

a. Simplify large amount of data in an easy to visualize way
b. Promotes communication
c. Helps us see different perspectives

Strengths

- Community-based (frequent/flexible meetings)
- Intense student commitment
- Team works well together
- Very organized
- Access to tools and machinery
- Not opposed to change
- Experienced members

Weaknesses

- New members need to find niche within team
- Lack of member sustainability
- Most members split time between FTC and other extracurriculars

Opportunities

- Skill & individual growth
- Grow FIRST in NM
- Collaborate more with other teams
- Secure more sponsors
- Volunteer more in the community
- Connect with the engineering community
- Win state competition & place at worlds

Threats

- **Loss of students**
  - **Prevented by:** Allowing everyone to participate in what they want to do
- **Loss of mentors**
  - **Prevented by:** Always recruiting new mentors and helping mentors feel a part of our family
- **Loss of funding**
  - **Prevented by:** Keeping good relations with past sponsors, and reaching out to new possible sponsors
- **Experienced students aging out**
  - **Prevented by:** Constant recruiting, outreach, and community involvement
- **Injury**
  - **Prevented by:** Making sure to take all safety precautions such as safety glasses

Planning and Contributions

Sustain

Individual Contributions and Lessons Learned

Code Team (Elliott):
- Worked on theoretical code to be able to code robot faster.
- Developed better coding practices and made high quality code.

Build Team (Luke, Anirudh, Callahan, Gabriel):
- Improved our design process, involving much more prototyping and testing, and shortening time spent designing.
- Worked to improve CAD skills in order to help design a competitive robot.

Managerial Team (Cody, Callahan):
- Created the portfolio, team buttons, as well as other items to give away at competitions.
- Helped with fundraising, and team organization.

As a Team:
- We improved our teamwork and organizational skills throughout the season.
- Set clear goals and expectations for members.

Organizational Plan

Fundraising
- Make budget
- Fundraise $19,620
- Lower spending by being resourceful with parts

Risk Management
- Using Computer Aided Design (CAD) discover mechanical issues before beginning build.
- Have multiple members able to drive the robot, in case main driver isn't able to make an event.
- Make design decisions that allow parts from previous robots to be reused, reduce financial strain.

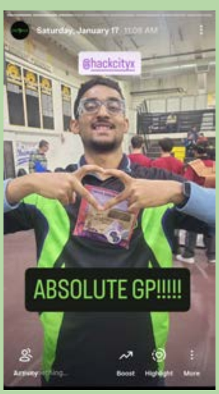
Outreach and Service
- Reach out to our community as much as possible and give demonstrations where ever possible.
- Spread the FIRST ethos of gracious professionalism at outreach events.

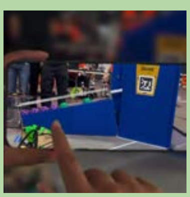
Member	Contributions
Luke	Worked on CAD for drivetrain, intake, and shooter. Helped to build robot and was the main mentor with 27413 (SPQR).
Cody	Designed this season's pins, jerseys, and other team identity materials. Modified the robot's decorative elements.
Elliott	Lead the code team, and also mentored developing members of the programming team. Additionally, served the main mentor with 31652(Gearheads²).
Gabriel	Helped design prototype mechanisms for testing. Worked on the final assembly of the robot.
Anirudh	Helped to create a timeline for robot design, provided robot improvement suggestions, troubleshooted issues, and kept designers on track.
Callahan	Helped others thoroughly think through ideas and helped build the robot. Helped to strategize with alliances at competition and help the drivers design strategies for matches.

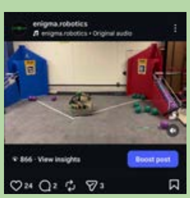
Connections & Marketing

Reach

ENIGMA created many **marketing items**, including buttons and jerseys for competitions. These materials revolved around the FIRST AGE theme, promoting both team ENIGMA and the FIRST Organization as a whole.







Additionally, ENIGMA has made an effort to increase its **social media** presence, showing its robot progress and collaborating with other teams, further enhancing its marketing efforts and **promoting FIRST beyond competition**.

Through helping with New Mexico's FIRST Lego League **Explore Fair**, and in the process of assisting other teams to develop code, ENIGMA developed its connections with the STEM community in New Mexico while **supporting FIRST teams** in the state.