FTC Team 20037 – Standard Deviation
Eden Prairie, MN

2025-2026 Decode
Engineering Portfolio
Otsego Qualifier Tournament –
January 17th, 2026

Team
Outreach
Strategy
Robot Design
Programming

Team Overview

Standard Deviation, hailing from Eden Prairie, Minnesota, is a dedicated team of six students from the International School of Minnesota. As a veteran FTC team, we are composed of a third-year senior, a fourth-year junior, a fifth-year member who is now a sophomore, and three more first year sophomores. Our roster includes three original team members and three new additions.

Mission Statement

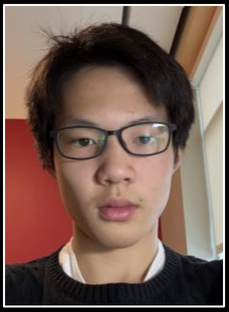
Our team strives to make ourselves and our community better. We plan to do our best to get out into the community to demonstrate and explain to others what we do in robotics. We strive to learn all aspects of STEM. We hope to get other students into STEM, FIRST Robotics, or think about signing up for a class in engineering in the future.

Team Members

Jason
Building & Driver
A Senior at International School of Minnesota. This is his third year in FTC. Jason likes anime (bandori). His favorite subject is physics. He joined because he likes mechanics.

Asif Haider
Building
I am a Sophomore at the International School of Minnesota. This is my first year in FTC. I enjoy playing badminton. My favorite subject is Math. I joined FTC because I enjoy working with robots and love to build machines.

Ryan
Building & Programming & Driver
A Junior in the International School of Minnesota. This is his fourth year in FTC, Ryan likes to play instrument and music. His favorite subject is Biology.



Alex
Building
I am a sophomore at international school of Minnesota. I like to play sports especially team sports. My favorite subject is physics and math. I joined FTC because my friend strongly encouraged me to.

Roshan
CAD & Building & Programming
A Sophomore at International School of Minnesota. This is his fifth year in FTC. Former Catlateral Damage Member. Roshan enjoys swimming. His favorite subject is math. He joined because FTC sounded fun.

Ean Liu
Building
I am a sophomore at the International School of Minnesota. I like to play volleyball and tennis. My favorite subject is math. I joined FTC because I am very interested in building things and enjoy to see them working.

Mentors

Erik
Lead Mentor
This is Coach Erik's second year with FTC. He joined the team because his kids (8 & 6) like building LEGO robots. During the day, Erik is an engineer with Amazon.com. He prefers coaching robotics.

Future Goals

- **Increasing Skills Within the Team:** Our primary goal is to strengthen our technical capacity by teaching new members essential skills, particularly in CAD and programming, where our team is currently under-resourced. This focus ensures that every member grows in capability while supporting the long-term sustainability of our team.
- **Expanding Outreach:** We aim to increase our outreach hours to address the current lack.
- **Performing Better at Events:** Another goal is to improve our average scores at events.
- **Connecting with Lower School:** We plan to build stronger connections with our lower school robotics team.

About The Team

Founded in 2021 at the International School of Minnesota by three passionate juniors and a dedicated parent mentor, our team launched during the COVID-19 pandemic and consistently participated in the FIRST Tech Challenge from 2021 to 2024. Despite the challenges, our founders built a strong, collaborative environment that led to significant achievements.

In 2024, as the original members graduated, Roshan and Coach Erik joined, revitalizing the team. Now consisting of Jason, Ryan, and Roshan, and guided by Coach Erik, we continue to uphold our legacy and mentor the next generation of team members. In 2025, we expanded once again, welcoming three new members who bring fresh energy and perspectives to the team. Together, our resilient and passionate group is prepared to embrace future challenges and maintain our success in the FTC.

Sustainability

We are practicing economic sustainability by 3D-printing and laser-cutting our part. 3D printed and cut parts cost less than COTS parts, so it reduces our spending.

We plan to sustain our team by recruiting new middle- and high-schoolers at the beginning of every year. We mentor them in building, programming, CADing, and driving.

Budget

Outreach - Motivate

Valentine's Bot Community Event

Our team designed and built a fully functional gifting robot specifically for Valentine's Day. The robot navigated around campus delivering chocolates and small 3D-printed gifts donated by the Friends of ISM. This event not only showcased our engineering creativity but also strengthened our presence across the school community, bringing joy and excitement to hundreds of students.

International Day Robotics Exhibition

During our school's International Day celebration, our team hosted a full exhibition room dedicated to robotics. We demonstrated our current season robot, showcased past innovations, displayed engineering notebooks, and presented interactive STEM activities. Parents, students, and guests were able to see the impact of robotics education, helping us grow interest, recruit new members, and build a stronger, more diverse robotics community.

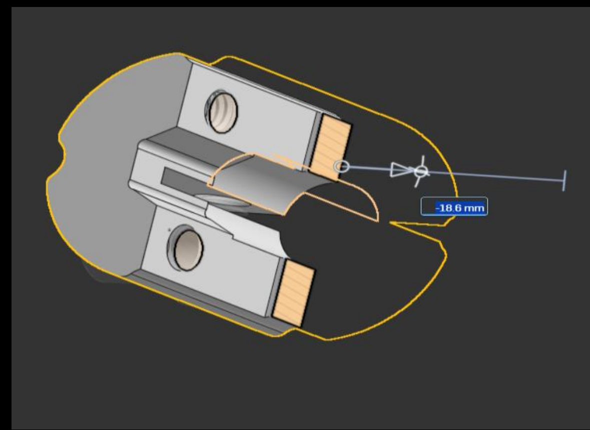
Robotics Demonstration at the City Park

We brought our competition robot to a public park where families, students, and community members could interact with it. Visitors were invited to try driving the robot, learning firsthand how FTC mechanical systems and control software work. This outreach helped raise awareness about STEM opportunities and inspired younger students to become future engineers.

Outreach - Connect

Problem/Solution

Originally designed in CAD, the endgame lift mechanism was intended to raise the robot during endgame within a compact layout. Torque was routed through a three-gear train onto the Z-axis, then through a small coupler to the lead screw. We initially thought the coupler would transfer torque reliably, but it was insufficient, preventing the lead screw from properly moving the nut along the open goRail. The nut was supposed to actuate a scissor lift to raise and lower the robot. We attempted to reassemble and adjust the mechanism, testing different alignments and connections, but it continued to fail to move smoothly, revealing a critical flaw in the original coupler design.



Esmeril Industries LLC Trip

After struggling to get the lift mechanism to work, we reached out to connections within our school community and discovered parents experienced in industrial manufacturing. They gave us a tour of their factory and showed us how their machines and processes worked. During discussions about our lift mechanism, we focused on the coupler and other parts of the robot that could be improved. Their expertise allowed them to give practical suggestions, and they even helped us design a customized coupler that resolved the torque transfer issues and made the lift mechanism function more reliably.

Game Strategy

Minimum Goal	Maximum Goal
At minimum, we want to be able to gain LEAVE points during auto and score some artifacts and have a partial park in our base during endgame.	In our ideal match, we want to score 3 artifacts and gain LEAVE points during auto. For teleop, we want to score some artifacts. For endgame, we want to complete a full and a partial return to base with our partner.

Design Process

We adopted this design process from former team Catlateral Damage. This process helps us think through and organize our ideas to optimize the outcome of our goals.

IDENTIFY
Write down all points, tasks, rules goals, strategies, etc. Based on these findings, what does it need to do? What do you want it to do?

IDEATE
Brainstorm & Research – What do you think will work for what it needs to do, and for what you want it to do? Figure out the best way to accomplish this task.

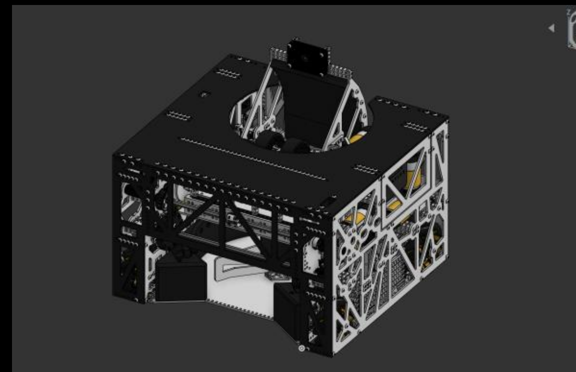
DESIGN
Design it – Draw it out, write it down, come up with a rough prototype (even with cardboard, zip ties, and duct tape), CAD, 3D print, math equations, etc.

CREATE
Prototype & Build – Take your drawings, writings, math, CAD, or rough prototype, and create it with parts (COTS, 3D printed, or fabricated)

TEST
Try it out – What works? What doesn't work how you wanted? How can you improve it? Start the process all over again if needed or start at any one of the steps above.

CAD

For CAD, we use Onshape, a free online CAD collaboration software. We made use of 3D-printed parts to run through various iterations faster. We used the modular design process; each module is discussed in the following pages. Using Onshape, we were able to work on the modules individually and combine them into one assembly. To put our team Numbers and logo on the robot, we used a DXF file to convert a picture into a sketch for use in CAD.



3D Printing

We continued to use 3D printing this year because it was cheap and easier to customize parts than COTS parts. With four printers at our disposal, we were able to iterate every meeting. This helped us stay organized and make the most of our meeting time.

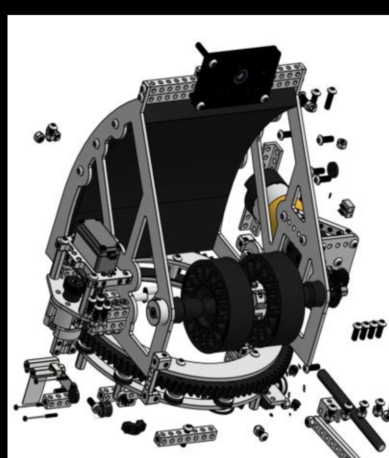
Most of our parts are printed on a Bambu Lab P1S but we also have a Prusa MK3S+, an Anycubic Vyper and a Bambu Lab X1C in our workspace.

We use mainly PETG-CF material on our robot for it being shock-resistant but also being rigid.

Robot Design Summary

General Thoughts

When we saw the game, we knew we wanted to have a mecanum drive with a custom drivetrain after success using it from last season for a robot that could score maximum points.



Chassis

We designed and sent out custom drive train and plates to SendCutSend for them to cut. This gave us a lot of freedom with our design and allowed our indirect mecanum drive to be supported on both sides for structural integrity and drive consistency.

Scoring Mechanism

Our launcher underwent multiple iterations to improve consistency, compactness, and control. Early designs used dual flywheels with an external 2-axis wrist, but they were bulky and top-heavy. Later versions internalized the wrist and added a flexed polycarbonate backplate, reducing size but still facing space constraints. We then transitioned to a flat flywheel system with an adjustable hood, later replaced by a fixed hood for improved stability. Although the fixed hood enabled reliable long-range shots, it performed poorly at close range, prompting us to revisit and refine the adjustable-hood design for our sixth iteration.

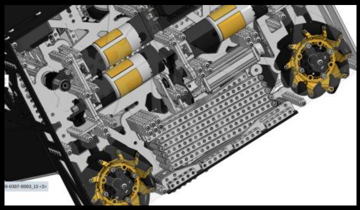
Robot Design – Chassis

Ideating:

Recognizing the effectiveness of parallel plate drivetrain with custom CNCd plates, we chose to utilize this approach for our DECODE robot.

Design:

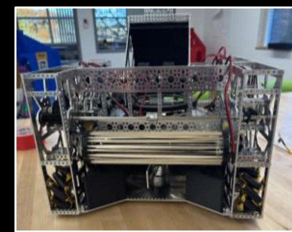
For our design, we leverage the full flexibility provided by our custom 1/8-inch 5052 aluminum plates from SendCutSend. These plates support 7 of our motors – four for driving, two for lift and one for intake – secured between the inner and outer panels. We've also pocketed the plates to reduce weight and enhance speed. The pockets conveniently double as spots to secure loose wires with zip ties.

1: Drivetrain Each Mecanum wheel is powered by an independent 5.2:1 GoBilda motor. We utilize a custom 2:1 gearing system to connect the Mecanum wheels to the motors indirectly while maximizing space.	**Pros:** The system offers great traction and torque. The setup is durable, and it provides motor protection from shocks. **Cons:** The system adds weight and may have potential energy limitations without optimization.	
2: Two-Panel Design The inner panels house the electronics and internal plates, while the outer panels provide structural support for the motors, wheels, and lift system situated between the panels.	**Pros:** This configuration maximizes space for the intake and launcher, offering greater design flexibility. It also simplifies wiring and minimizes the risk of electronic damage from vibrations or impacts. **Cons:** It increases design and assembly complexity, requiring precise alignment of both panels.	
3: Custom Built Chassis We employed two custom side panels to support the robot. The pocketed design reduces overall weight and can also function as a handle.	**Pros:** The design is lightweight, facilitating easier access and tightening of screws, and incorporates built-in handles for added convenience. **Cons:** A limitation is the reduced flexibility for adding extra screw holes.	
4: Drag Chain We implemented a drag chain to protect the turret-mounted electronics from disconnecting during rotation and to reduce the risk of cable snagging.	**Pros:** This setup minimizes the risk of cable disconnections during turret movement and enhances overall system reliability. **Cons:** It introduces additional design considerations and slightly increases wiring complexity.	
5: Battery Door Our team designed an integrated battery door on the rear of the robot.	**Pros:** The design enables rapid battery swaps and frees up space by positioning the battery in a previously inaccessible location. **Cons:** Opening the door requires the use of a tool.	

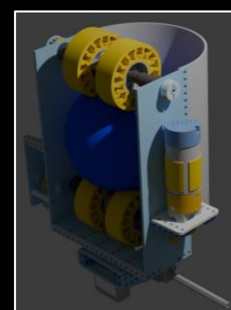
Robot Design – Intake/Deposit

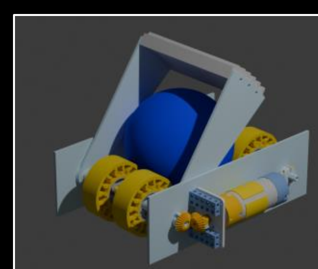
Ideating:
We decided on a design capable of quickly picking up and scoring artifacts.

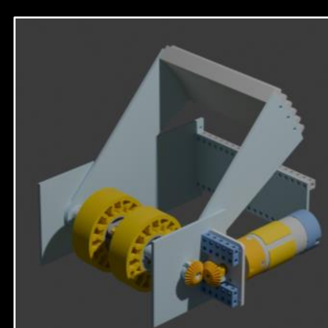
Design:
We selected a front-mounted rubber band intake with zip ties and a flywheel-based launcher to enable rapid and efficient artifact acquisition and scoring.

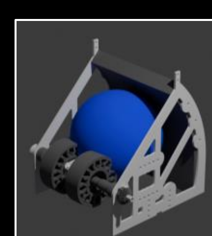


Iteration 1: Our initial iteration incorporated a dual flywheel system with an additional set of fins to secure the ball on a 2-axis wrist.	**Testing & Issues:** Models highlighted the design's excessive size and the instability resulting from its top-heavy configuration.
Iteration 2: For the second iteration, we refined the initial design by removing the feeding wheels, internalizing the 2-axis wrist within the launcher, and incorporating a flexed polycarbonate backplate to achieve a more compact form.	**Testing & Issues:** Despite these improvements, the design remained bulky and top-heavy.
Iteration 3: In the third iteration, we reoriented the flywheels into a flat configuration and integrated an adjustable hood to regulate shot distance.	**Testing & Issues:** Iteration three continued to face spatial constraints.
Iteration 4: In the fourth iteration, we eliminated the rear flywheel to optimize space utilization.	**Testing & Issues:** Limited time prevented further development and testing.
Iteration 5: For the fifth iteration, we transitioned to a fixed hood design.	**Testing & Issues:** Iteration five enabled long-range shots from the far launch zone but was ineffective at distances under four feet from the goal.
Iteration 6: In the sixth iteration, we plan to reintegrate an adjustable hood.	Testing & Issues:

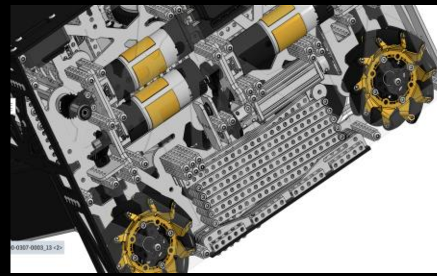


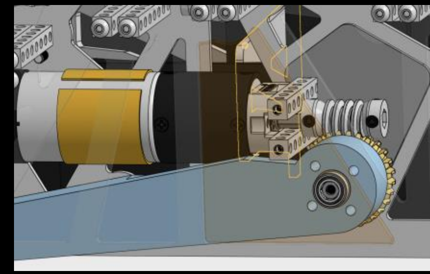






Robot Design – Lift



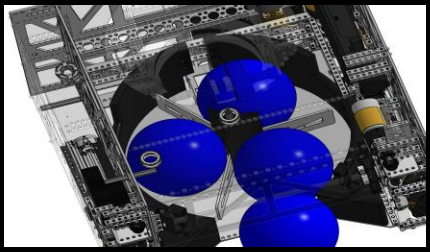


Ideation:
This year, we focused on designing a lift system that delivers both high speed and torque for efficient operation.

Design:
To achieve an 18-inch lift while maintaining a compact Z-axis profile to accommodate the turret, we selected a scissor lift design. We calculated that two 188:1 GoBilda motors, one per side, would provide the required power.

Iteration 1: For the scissor lift, we utilized GoBilda flat beams as the linkage components.	**Testing & Issues:** After constructing our first scissor lift, we noticed that these beams were weaker on one side.
Iteration 2: To enhance structural strength, we paired two flat beams and reinforced them with an additional outer beam.	**Testing & Issues:** The added flat beams eliminated flexing, but the lift could not achieve the full 18-inch clearance due to the inherent springiness of the scissor mechanism.
Iteration 3: To compensate for the reduced clearance, we incorporated additional flat beams.	**Testing & Issues:** This iteration successfully addressed the lift height but raised concerns about the two scissor lifts – one on each side of the robot – separating under load.
Iteration 4: To mitigate this issue, we installed a bottom plate to prevent the scissor lifts from separating.	**Testing & Issues:** Initial testing confirmed that the scissor lift operated as intended. However, once additional parts were added to the robot, the coupler connecting the leadscrew to the hex shaft inside the lift experienced excessive strain. This strain caused the coupler to slip, ultimately preventing the lift from functioning at all under load.
Iteration 5: Coupler slippage was resolved by using a custom coupler, improving grip and ensuring reliable torque transfer.	**Testing & Issues:** The couplers performed effectively; however, the leadscrew repeatedly loosened, and no reliable solution has been identified.
Iteration 6: The design was transitioned to a flipper mechanism, where motor torque is transmitted through a worm gear set, enabling the robot to tip itself.	**Testing & Issues:** The worm gear assembly exhibits insufficient tooth engagement and inadequate axial support of the shaft preventing rotation.

Robot Design – Indexer

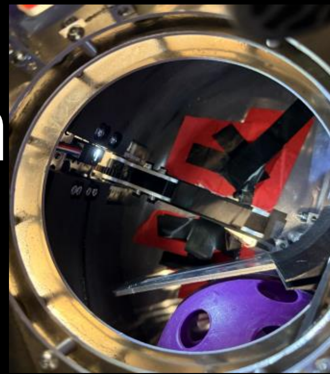


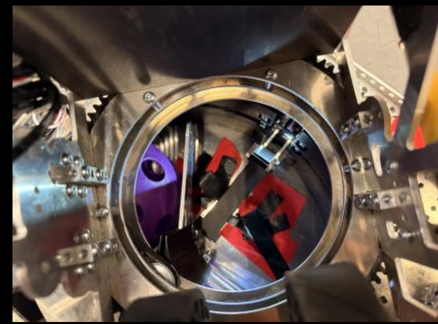
Ideation:
This year, our goal was to design an indexer capable of reliably completing a MOTIF cycle with speed and efficiency.

Design:
To achieve our objectives, we implemented a carousel-style sorter with a kicker mechanism to feed artifacts into the flywheel efficiently.

Iteration 1: Initially, our indexer design routed artifacts through two passages controlled by a servo, allowing selective feeding to the flywheel.	**Testing & Issues:** Upon evaluating potential scenarios, we determined that this design could not reliably ensure completion of a MOTIF.
Iteration 2: In the second iteration, we developed a carousel indexer driven by a centrally mounted motor, with a row of mini 3D-printed Mecanum wheels guiding all intake balls to one side of the robot.	**Testing & Issues:** This design exceeded our available space and required more motors than we had, leaving insufficient allocation for both the indexer and the intake.
Iteration 3: To resolve the space constraint, we eliminated the row of mini 3D-printed Mecanum wheels, allowing the intake to feed directly into the carousel via a funnel. Additionally, we mechanically linked the intake and indexer using a 10:1 gear ratio coupled with a Geneva mechanism.	**Testing & Issues:** Although this design functioned reliably, it was not the most efficient because the indexer could not be controlled independently of the intake, limiting overall flexibility and responsiveness.
Iteration 4: To gain greater control and precision in the indexer, we transitioned the mechanism to be powered by two Axon servos, allowing more consistent positioning and improved feeding reliability.	**Testing & Issues:** This iteration best met our indexer objectives, though we later identified a more efficient design approach.
Iteration 5: To improve efficiency, we plan to replace the carousel with three servos equipped with kickers positioned beneath a tray holding the artifacts, funneling each kicked artifact directly into the flywheel.	**Testing & Issues:** A potential issue is that artifacts could become dislodged from their tray indentations, causing jams in the indexer.

Robot Design - Kicker





Ideation:

This year, we focus on creating an efficient kicker with consistent values that feeds the ball to the launcher at a constant speed, helping maintain the accuracy of the projectile.

Design:

To ensure reliable ball transfer to the flywheels, a kicker mechanism was integrated directly beneath the indexer at the same vertical plane. The kicker selectively advances balls from the indexer into the flywheel intake, enabling consistent engagement and successful launch.

Iteration 1: To prevent mechanical jamming and incomplete flicking caused by excessive kicker length, the kicker was shortened by removing material to achieve an optimized geometry.	**Testing & Issues:** Shortening the kicker reduced the required actuation torque by decreasing the moment arm, which in turn lowered the power demand on the servo. Following the modification, the kicker was structurally reinforced with tape to limit elastic deformation, maintain positional stability, and prevent binding at the initial rest position.
Iteration 2: To prevent restricted motion of the kicker caused by its transformation and to avoid overextension that could obstruct the indexer fins, control logic was implemented to disable kicker actuation when a ball is not detected.	**Testing & Issues:** The implemented control logic effectively prevents the kicker from becoming stuck or jammed in the indexer fins. Additionally, an iterative testing approach was used to determine the optimal initial kicker position and appropriate servo power settings.
Iteration 3: To reduce servo instability, we designed a rigid mount that stabilizes and securely restrains the servo.	**Testing & Issues:** Persistent gear wear remains a critical issue because the gears are fabricated using 3D-printed materials, which have limited durability under continuous mechanical stress. The repeated need for gear maintenance and replacement leads to excessive downtime, increased labor demands, and decreased operational efficiency.
Iteration 4: To avoid constant gear wearing, we switched to metal gears to reduce wear and eliminate the need for constant gear replacement.	**Testing & Issues:** The elimination of gear stripping reduced maintenance requirements and downtime by removing the need for frequent replacement of 3D-printed gears. This improvement resulted in increased system reliability, time savings, and enhanced mechanical stability.

Programming – Driver Controlled

Our goal is to ensure that our robot remains intuitive and natural to drive, even with the enhancements. We want to maintain full manual control while minimizing the stress of driving through automated actions and driver feedback.

Controller Layers

In previous years, we consistently faced issues with insufficient buttons on the two controllers for our needs. To address this, we developed controller layers. Each button on a different layer can be assigned a unique function. These layers are accessible by holding the triggers: the first layer is accessible without holding any trigger, the second layer by holding the left trigger, and the third layer by holding the right trigger.

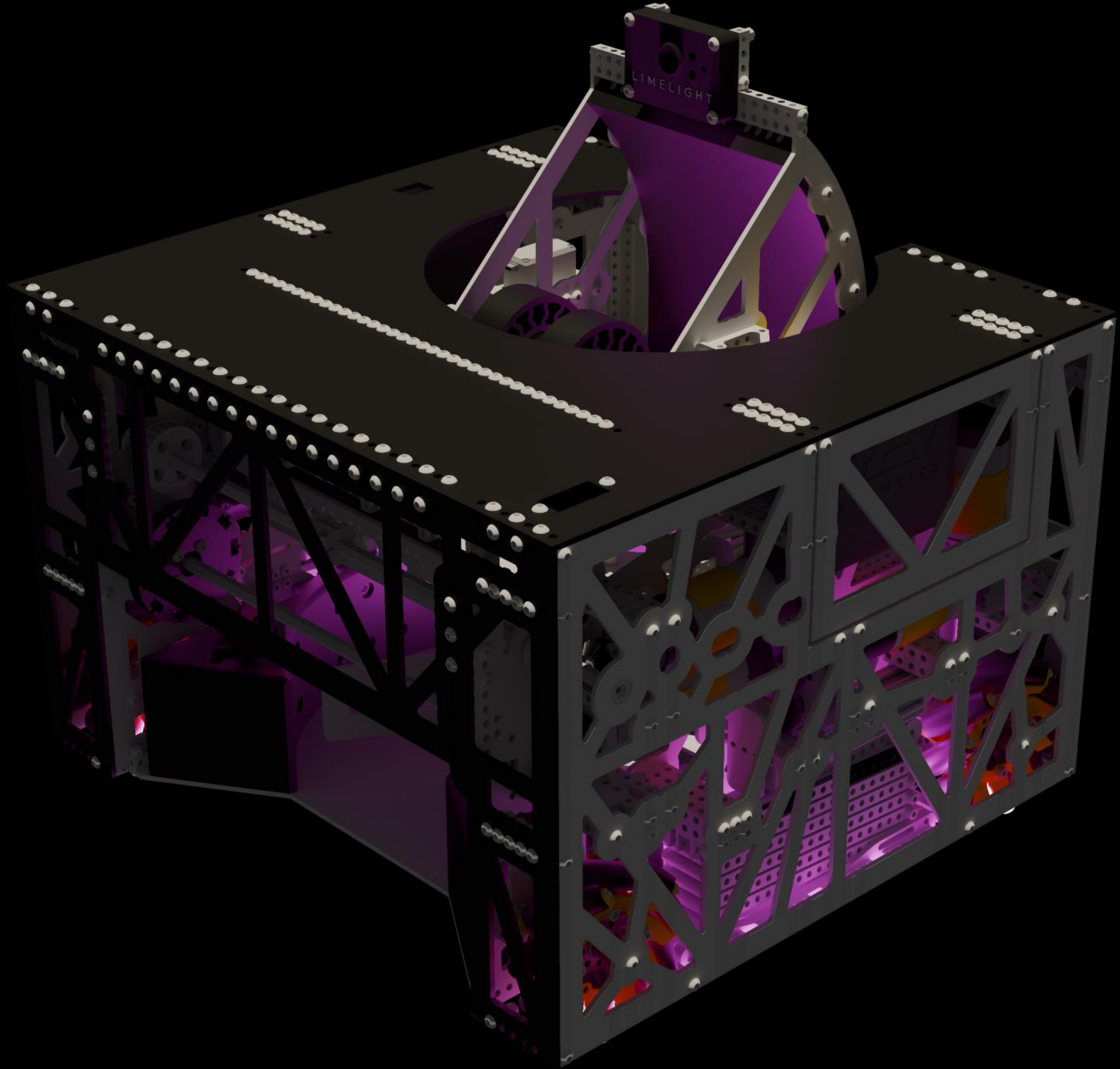
Driver Enhancements

- A toggle button enables reduced robot speed, allowing for more precise drivetrain control.
- Button macros have been implemented for the flywheel, intake, and turret, streamlining driver operations and enabling efficient artifact cycling.
- Drivers also retain manual control options for the flywheel, intake, and turret when needed.
- The macros integrate with a color sensor, adapting in real time to game conditions.
- We achieve automatic aiming, and the robot adjusts its shooting power dynamically using the math functions we developed in our code.

Programming - Autonomous

Auto Paths

- We can achieve LEAVE points and score some artifacts from any location and can easily adjust for partners if needed.



Thanks to former team Catlateral Damage for the slide template.