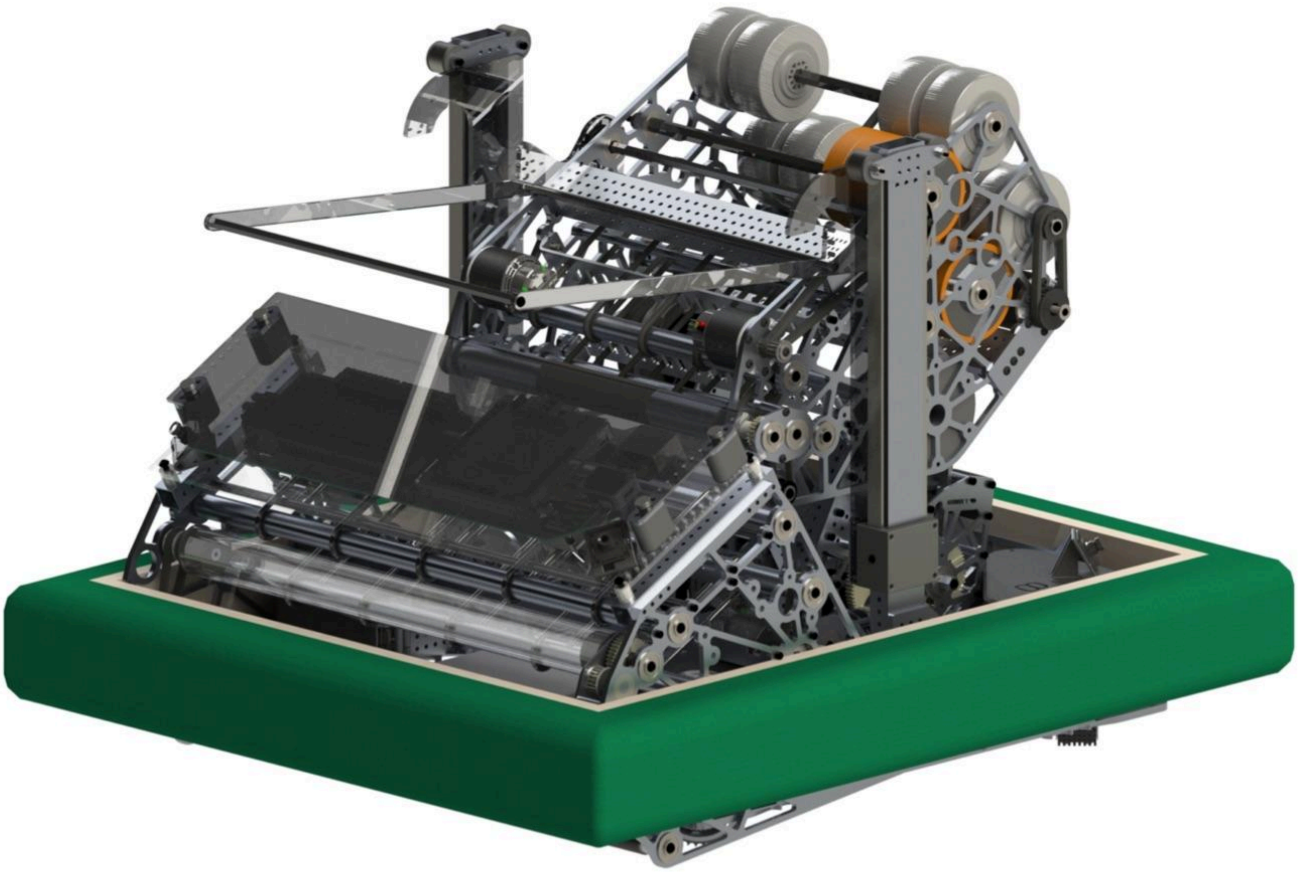
Paly Robotics

FRC Team 8



Baldr

2024 Technical Documentation

FIRST ROBOTICS COMPETITION

CRESCENDO℠ PRESENTED BY HAAS

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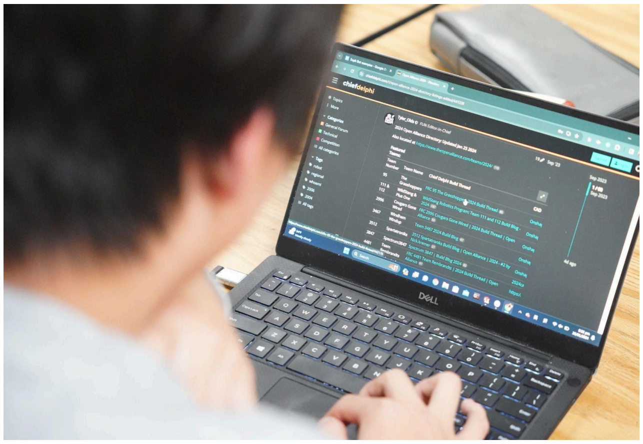
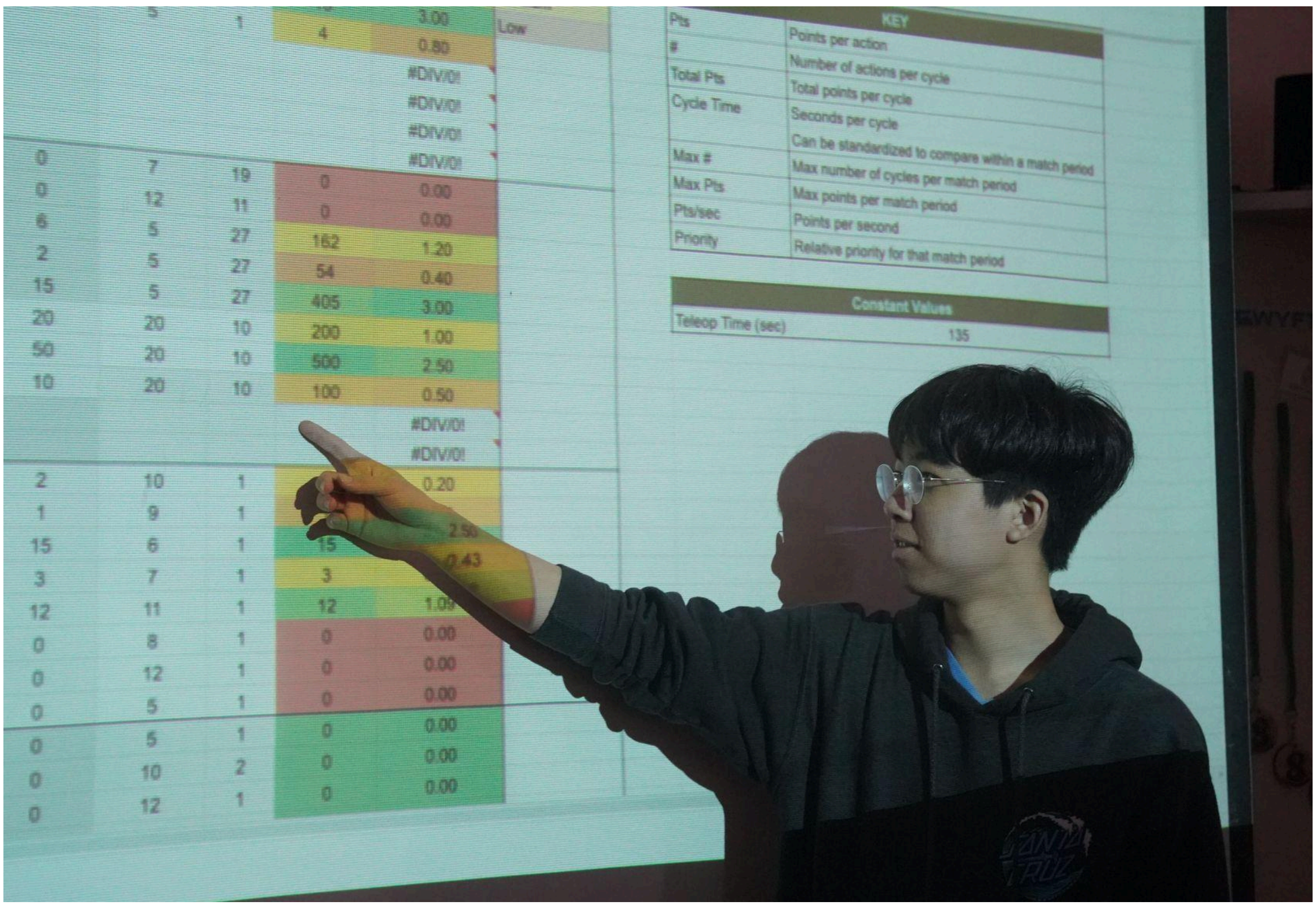
Strategy




KEY
Pts
Points per action
#
Number of actions per cycle
Total Pts
Total points per cycle
Cycle Time
Seconds per cycle
Can be standardized to compare within a match period
Max #
Max number of cycles per match period
Max Pts
Max points per match period
Pts/sec
Points per second
Priority
Relative priority for that match period
Constant Values
Teleop Time (sec)
135
#DIV/0!
Low

Game Analysis

Based on our regional selections and the game challenge, we chose to create a "first-pick" robot rather than a highly-ranked robot. This meant valuing total point contribution over gaining ranking points. As a result, we prioritized scoring in autos and cycling to amp and speaker, where most of the points are available during the match, over endgame.

Needs

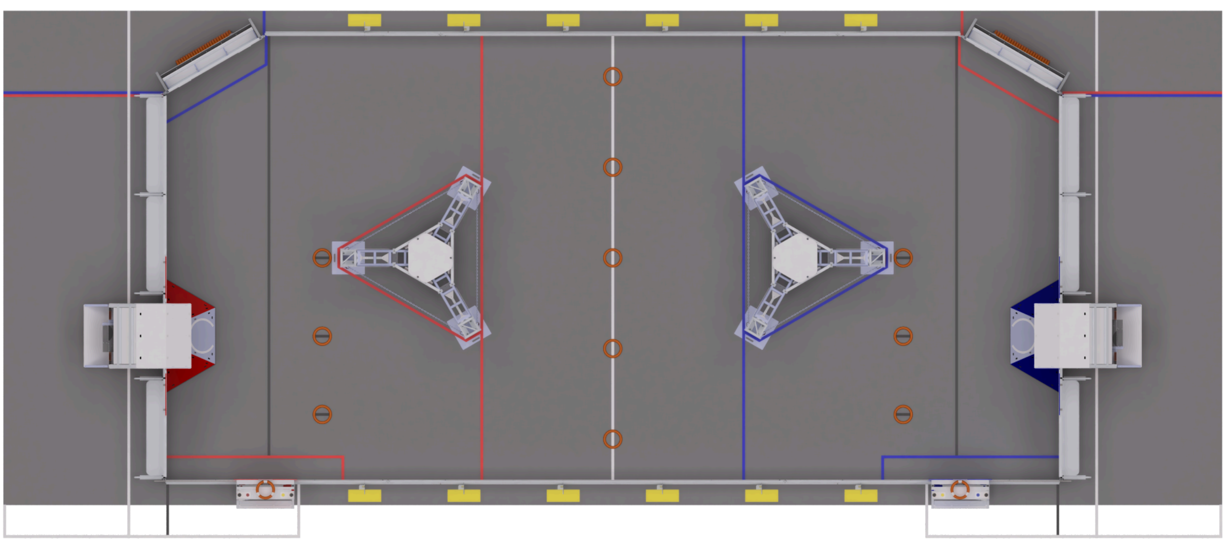
- Swerve drivetrain
- Intake notes from the ground at high speeds
- Score in Speaker
- Score in Amp

Wants

- Climb
- Drive under Stage
- Shooting while moving

Wishes

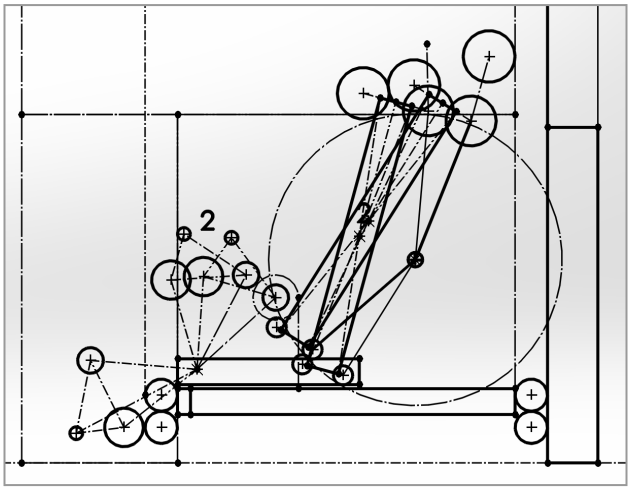
- Score in Trap
- Harmonize
- Intake notes from Source

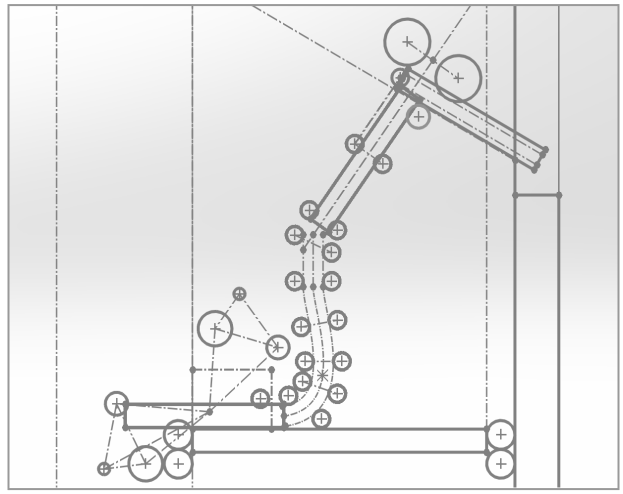


CRESCENDO. Source: FIRST

Macro

We sketched two possible robot macros to address our “needs” list. Both options included a swerve drivetrain and a ground intake opposite from the shooter to minimize drivetrain rotation during autos, increasing scoring capabilities.





Option 1: Low Bot with Pivot

Description:

- Pivoting shooter
- Scores in Amp by either (A) shooting upwards or (B) actuating an additional roller to redirect shots downward into the Amp

Pros:

- Shoot from anywhere on the field
- Drive under the Stage for shorter cycle times
- Lower center of gravity (CG)
- Comfortable with pivots from our 2023 robot

Cons:

- Introduces an additional mechanism to the robot (increased complexity)

Option 2: Tall Bot Without Pivot

Description:

- S-shaped indexer brings notes to the shooter
- Shooter flywheels are reversible to redirect shots downward into the Amp

Pros:

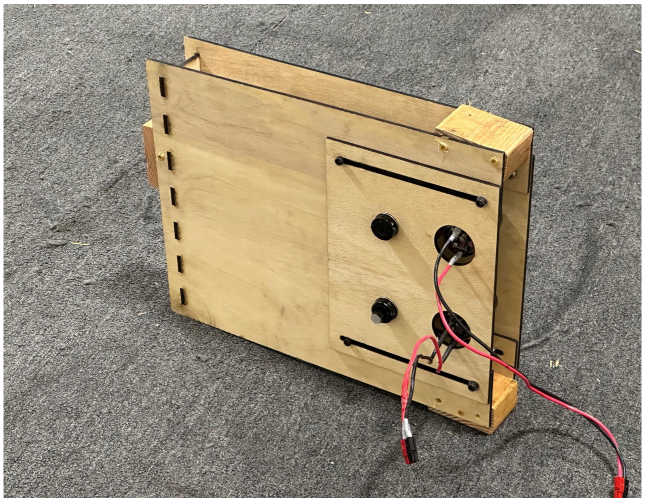
- Fewer mechanisms (decreased complexity)
- Highly consistent flush shots

Cons:

- Slow indexing
- High CG, higher chance of tipping
- Cannot drive under the Stage
- May have to add pivot in future to be competitive

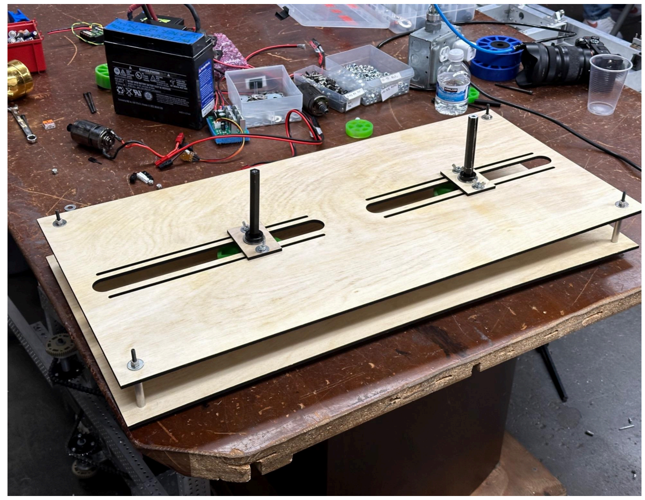
We chose to pursue *Option 1: Low Bot with Pivot*, given its wider scoring range and our experience with pivots in past years.

Prototyping



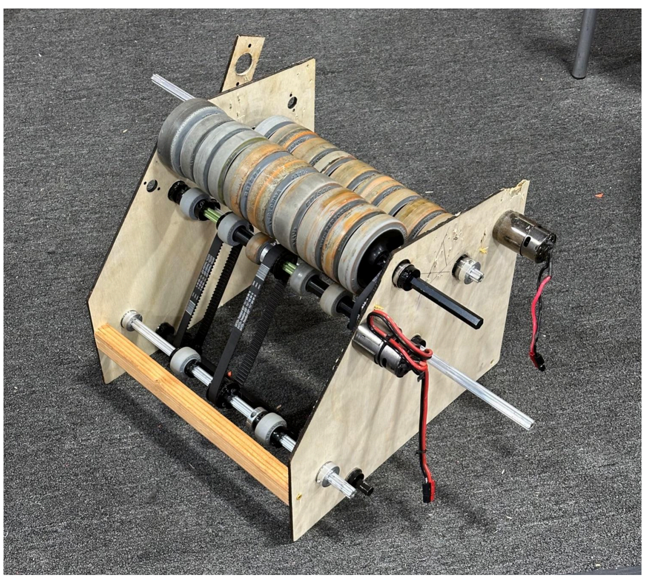
<u>Single Flywheel Shooter with Kicker</u>

Tested compression, wheel types, velocity, and ideal spin.



<u>Double Flywheel Shooter</u>

Tested compression, wheel types, and velocity.



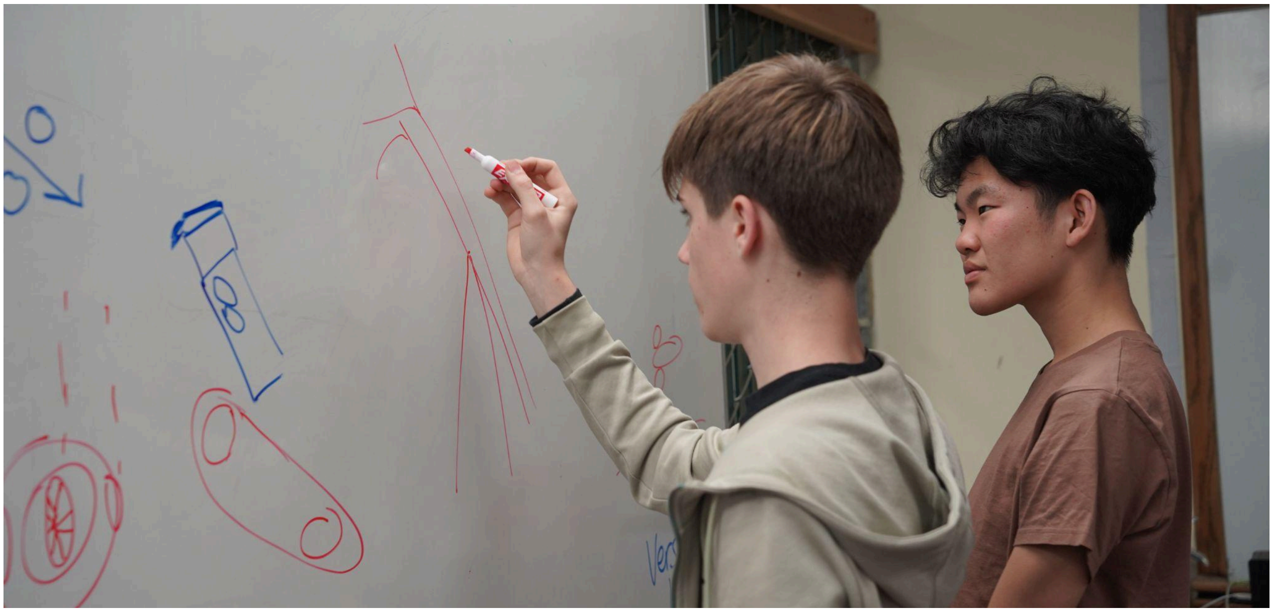
<u>Dual-Roller Shooter and Indexer</u>

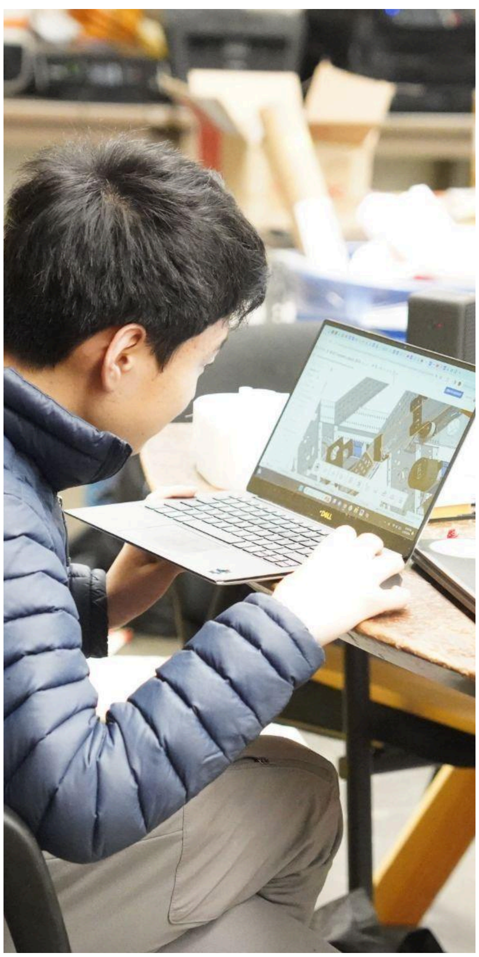
Tested compression, wheel types, wheel placement, and velocity. Experimented with additional rollers for redirecting notes into the Amp.

<u>Intake</u>

Tested materials, roller placement, and several methods of passive vectoring (V-walls, dead-axle rollers).

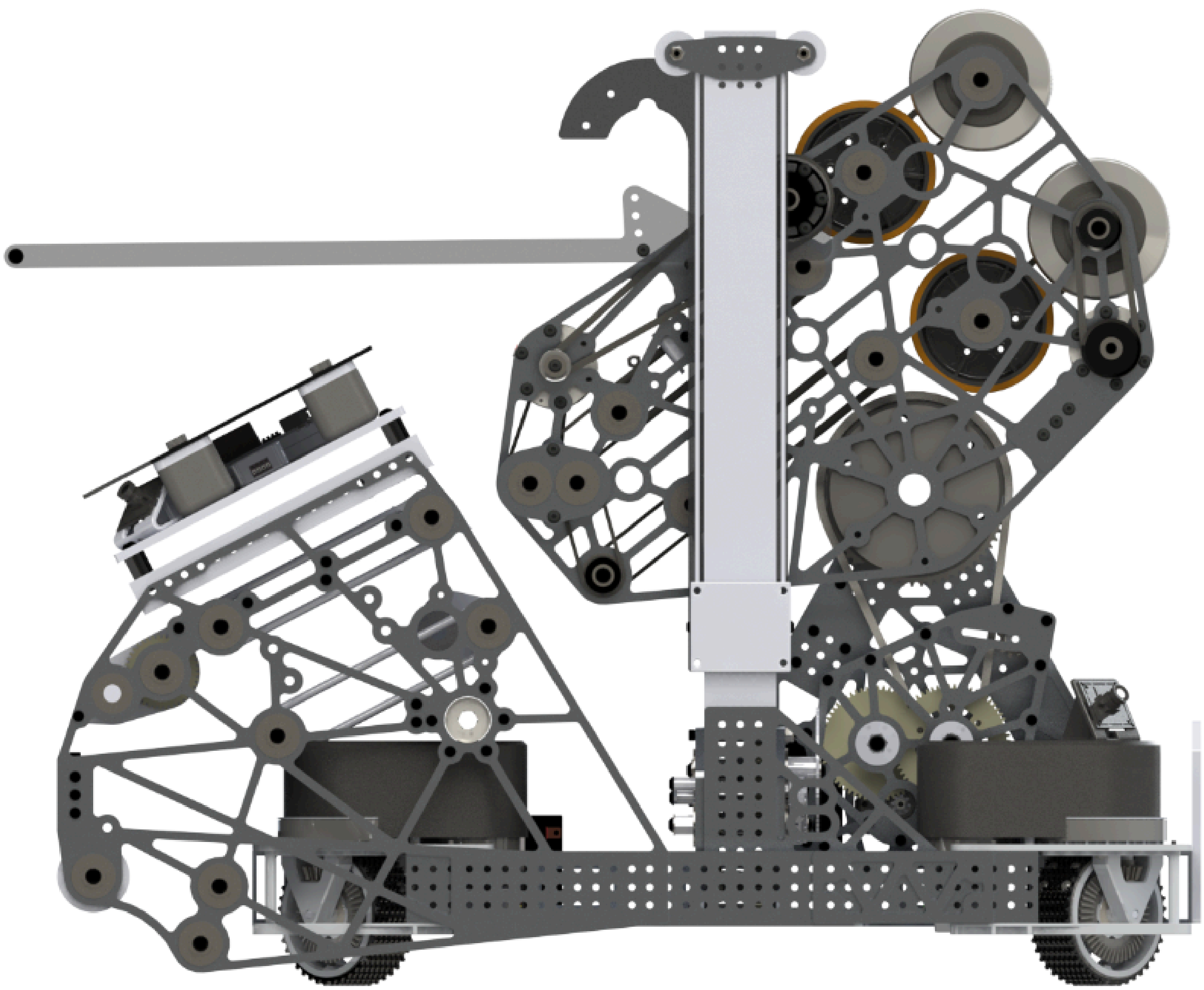
Design





Our 2024 Robot: Baldr

Norse god of Light



Drivetrain

Design Requirements

- Fast, powerful holonomic drivetrain to minimize cycle times
- Strong superstructure for other mechanisms

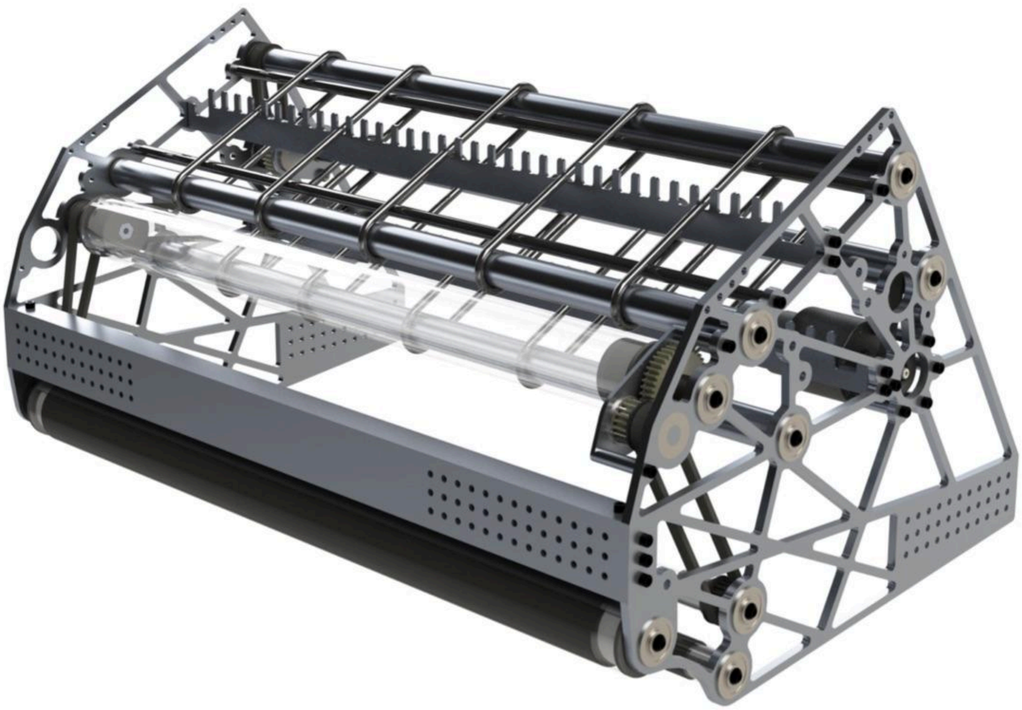
SDS MK4i Modules

- Drive powered by Kraken X60 motors in an L3 reduction with 16t drive pinion adapter plates (18.9 ft/s free speed)
- Steering powered by Falcon 500 motors
- Black nitrile tread on wheels for high grip
- Modules mounted in a 26” x 26” square (32” x 26.5” effective frame perimeter)
- 3D-printed covers protect gears from debris

Chassis

- 2” x 1” x ⅛” box beam structure with hole pattern supports other mechanisms
- 0.09” windowed bellypan and gussets provide lightweight structural support
- Bumpers secured by custom hex nuts for easy removal
- Pill-shaped cutouts in box beams guide wires

Intake



Design Requirements

- Impact resistance for contesting notes during autos
- Consistently intake notes at high driving speeds
- Full-width design

Under-the-Bumper Rollers

- 2:1 reduction 2” OD 1.75” ID and 1:1 reduction 1” OD ⅞” ID polycarbonate tubes driven by a Falcon 500 and 5mm HTD belts
- Bottom rollers wrapped in CatTongue grip tape
- Beam break sensors detect when a note has been intaken

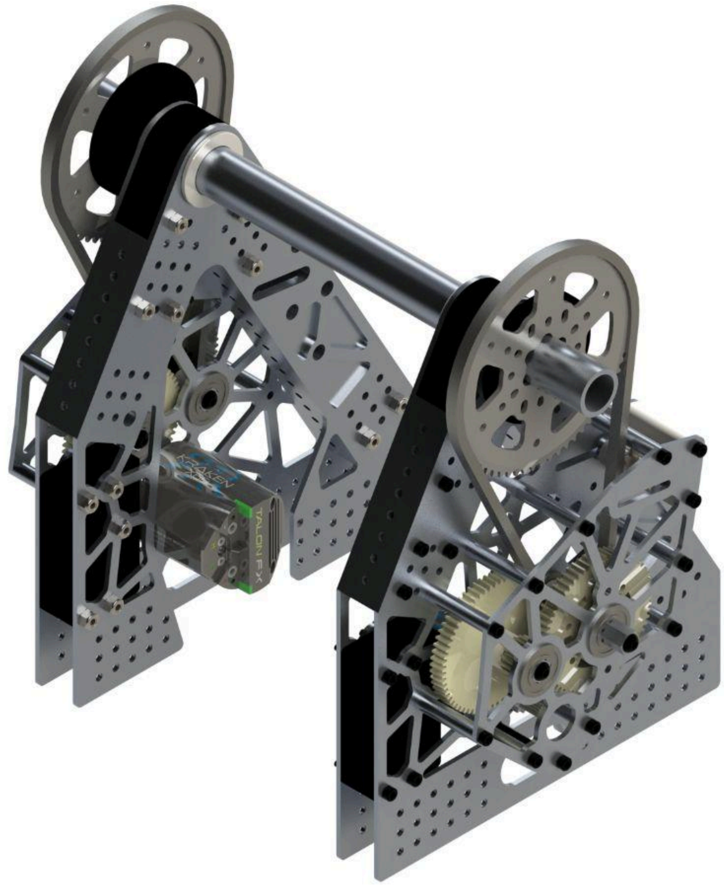
Indexing Section

- 1:1 reduction 1” OD ⅞” ID aluminum tubes driven by a Falcon 500 and 5mm HTD belts
- Polycord belting between rollers with low compression eliminates dead spots and allows for lateral slippage to center notes
- Brings notes to the shooter without jamming

Structure

- C-Channel beam prevents deformation of front box beam in collisions
- Bumpers protect the intake in the event of a collision, particularly during autos

Pivot



Design Requirements

- Robust, reliable
- Allows robot to align and shoot in the Amp and Speaker from anywhere on the field
- Minimal backlash

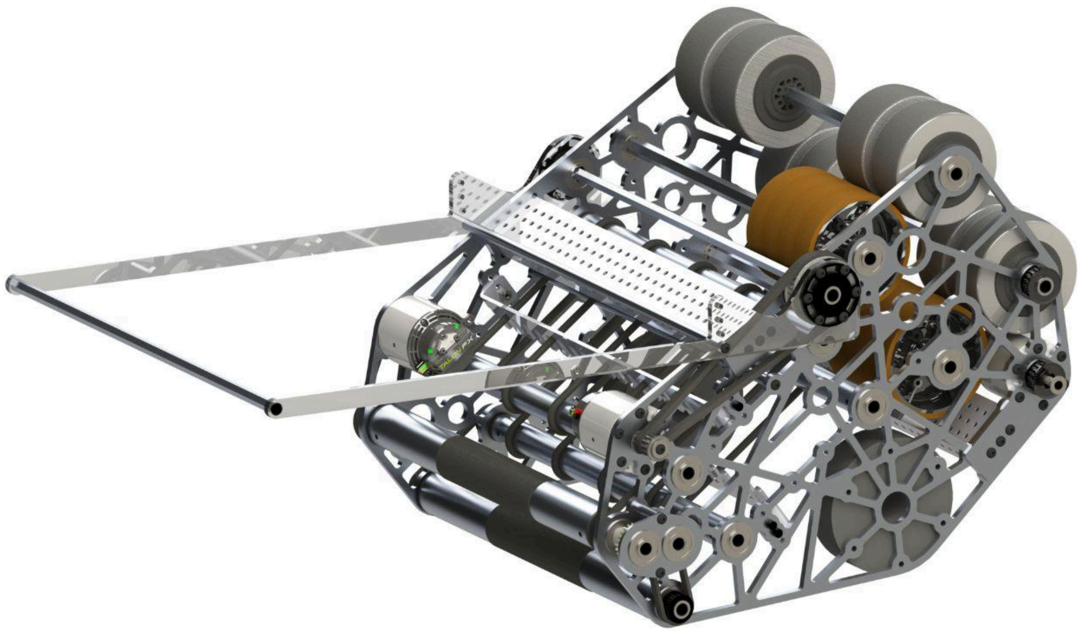
Structure

- Pocketed ⅛” sheet aluminum and box beam for a rigid yet lightweight base
- Aluminum round tube runs on bushings
- Mounts centrally and directly to the shooter to minimize cantilever

Gearboxes

- 1 Kraken X60 motor powers each gearbox, 113.7:1 overall reduction
- 66T #25 sprocket with large bolt pattern to minimize backlash
- Sprocket on slot tensions chain to minimize skipping and backlash
- Through-bore encoder for precise control

Shooter



Design Requirements

- Able to shoot in Speaker and Amp from multiple positions across the field
- Store game pieces while driving
- Reliable handoff from intake
- High accuracy and consistency

Indexing Section

- Falcon 500 motor geared 3:1 runs rollers via 5mm HTD5 belts
- Initial rollers wrapped in CatTongue grip tape grab notes from the intake
- Tensioned polycord feeds game piece to flywheels while allowing for lateral slippage to minimize note deformation
- Beam break sensor detects where the note is within the shooter

Top-Bottom Shooter

- 2 Falcon 500 motors geared 0.75:1 drive top and bottom flywheels separately
- Max wheel speeds: ~8,900 rpm (155.3 ft/s surface speed)
- Eight 4" Colson wheels with one side wrapped in CatTongue grip tape for spin
- Eight 4" 40A durometer Stealth kicker wheels on one side for consistent shots and spin

Amp Bar

- Flips up to trap notes in the Amp after shooting
- Driven by a Kraken X60 motor and 5mm HTD5 timing belt geared 3:1

Climber

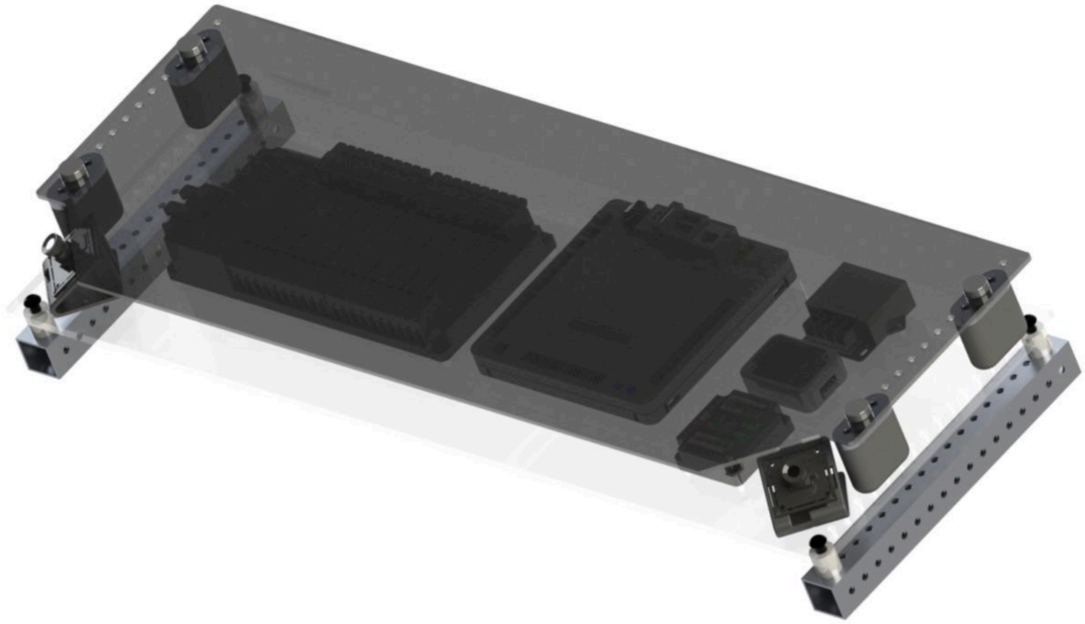
Design Requirements

- Climb quickly and consistently
- Reach multiple chain heights to Harmonize with alliance partners without slipping
- Non-obstructive to shooter

Dual Single-Stage Telescoping Arms

- Dyneema cord spooled down by Falcon 500 motors geared 23.5:1
- Two 7.5lb constant force springs per arm for up-rigging
- Polycarbonate hooks attach to Markforged blocks which slide on the outside of 2” x 1” box beam
- No bearing blocks to minimize the number of parts
- Notches in hooks lock onto the chain to prevent slipping when climbing off-center
- Mounted on either side of the Shooter to align with the robot’s center of mass and not block shots
- Brake mode keeps the robot off the ground after the match ends

Electronics



Design Requirements

- Accessible components for quick maintenance
- Robust and reliable

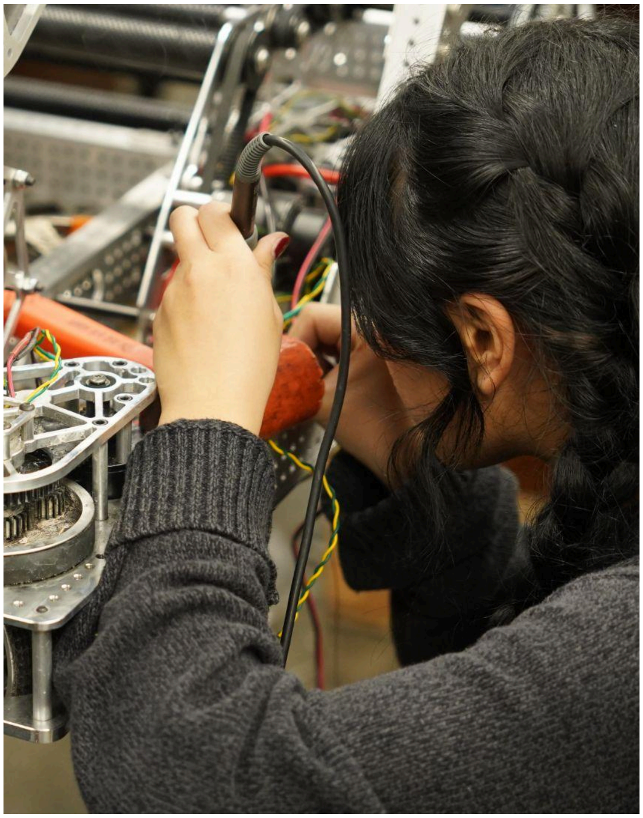
Front E-Board

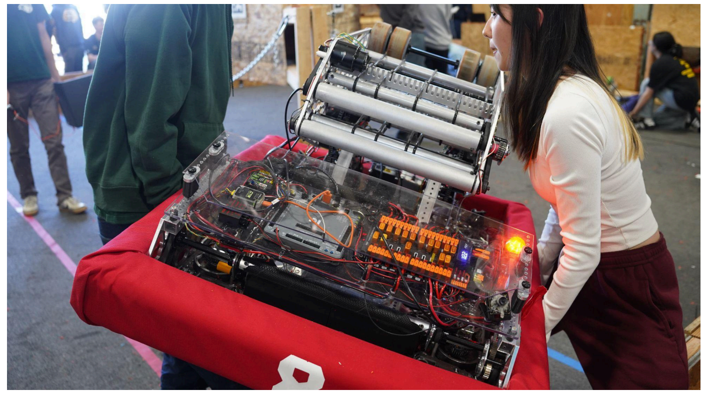
- Vibration-dampening shock mounts prevent interference and broken connections
- Protective cover is easily removable via thumb screws
- Related components mounted together: PDH, RoboRio, VRM, CANivore, and DC-DC converter
- Mounted above intake for accessibility

Rear E-Board

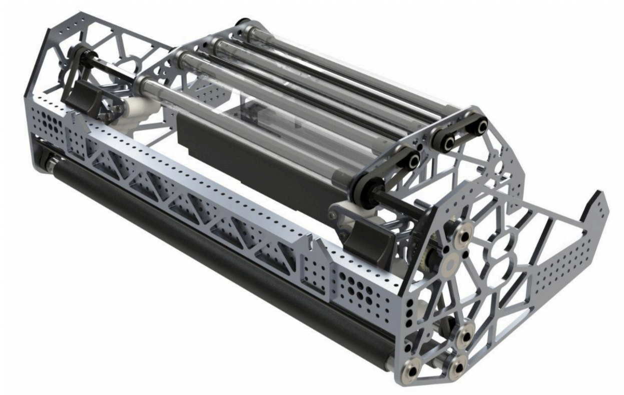
- Radio, Network Switch, and Radio Power Module mounted together
- 3D-printed cases prevent damage

Iteration

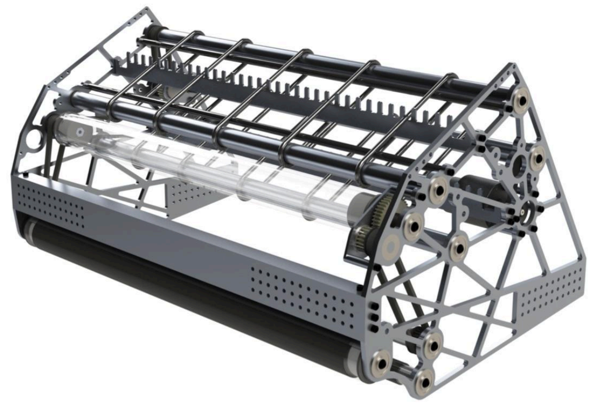




Intake



Practice Robot
Competition Robot (Regionals)



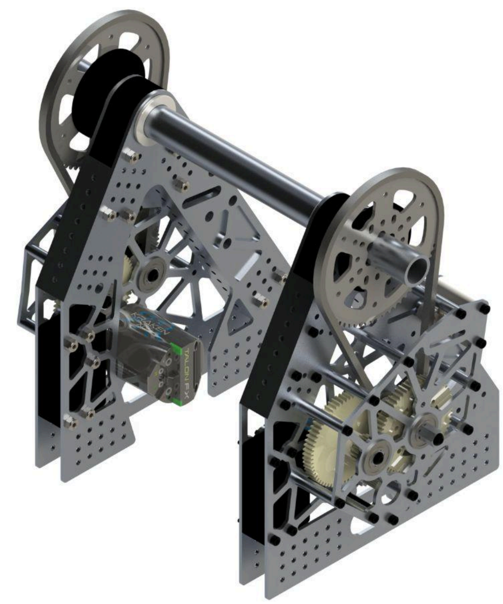
Competition Robot (Championship)

The first version of our intake jammed frequently at the far edges, which slowed it down. Its “vectoring blocks,” used to center notes inside the robot, would snag the notes, despite iteration between regionals. While still functional during the Teleoperated period, the intake’s speed limited our scoring in Autonomous. For Houston, we redesigned the intake to address these concerns.

- Decreased compression with the ground and increased compression between rollers to eliminate the dead spot
- Increased roller diameters for more surface area to contact notes
- Lowered the belt reductions for faster intaking
- Switched from 3mm GT2 timing belts to 5mm HTD5 timing belts to mitigate skipping
- Reduced the number of sharp turns in the game piece path to prevent jamming
- Eliminated the vectoring blocks, notes center as they are handed off to the shooter
- Implemented aluminum C-channel extrusions to support the box beam frame and prevent deformation (following a hard collision at the Arizona East Regional)

Pivot

Practice Robot



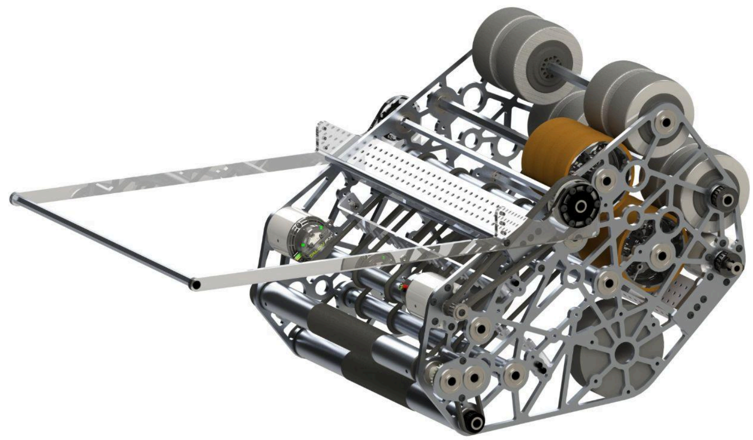
Competition Robot

The first iteration of our pivot was powered by a single gearbox with two Falcon 500 motors. In addition, it had no chain tensioners. We frequently had to replace the chain due to skipping, jamming, and twisting as a result of inconsistent tension on either side.

To address these challenges, we implemented a custom 3D-printed chain tensioner with a passive sprocket in a slot. We also changed the single gearbox to two gearboxes on either side, each powered by a single Kraken X60 motor and synced by through-bore encoders. As a result, the pivot has reached our goal of reliability.

Shooter

Practice Robot
Competition Robot (Regionals)



Competition Robot (Championship)

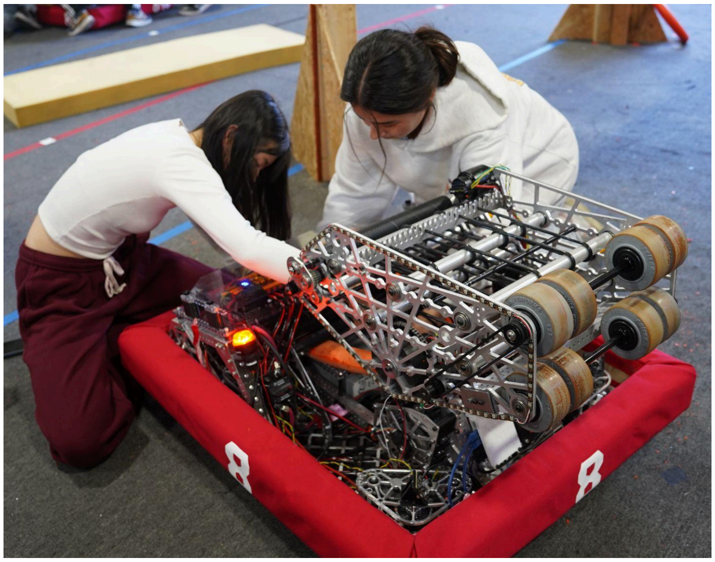
Shooter has been a consistent mechanism for the entire season, but we decided to iterate for Houston in order to fix a few inconveniences and allow for greater modularity.

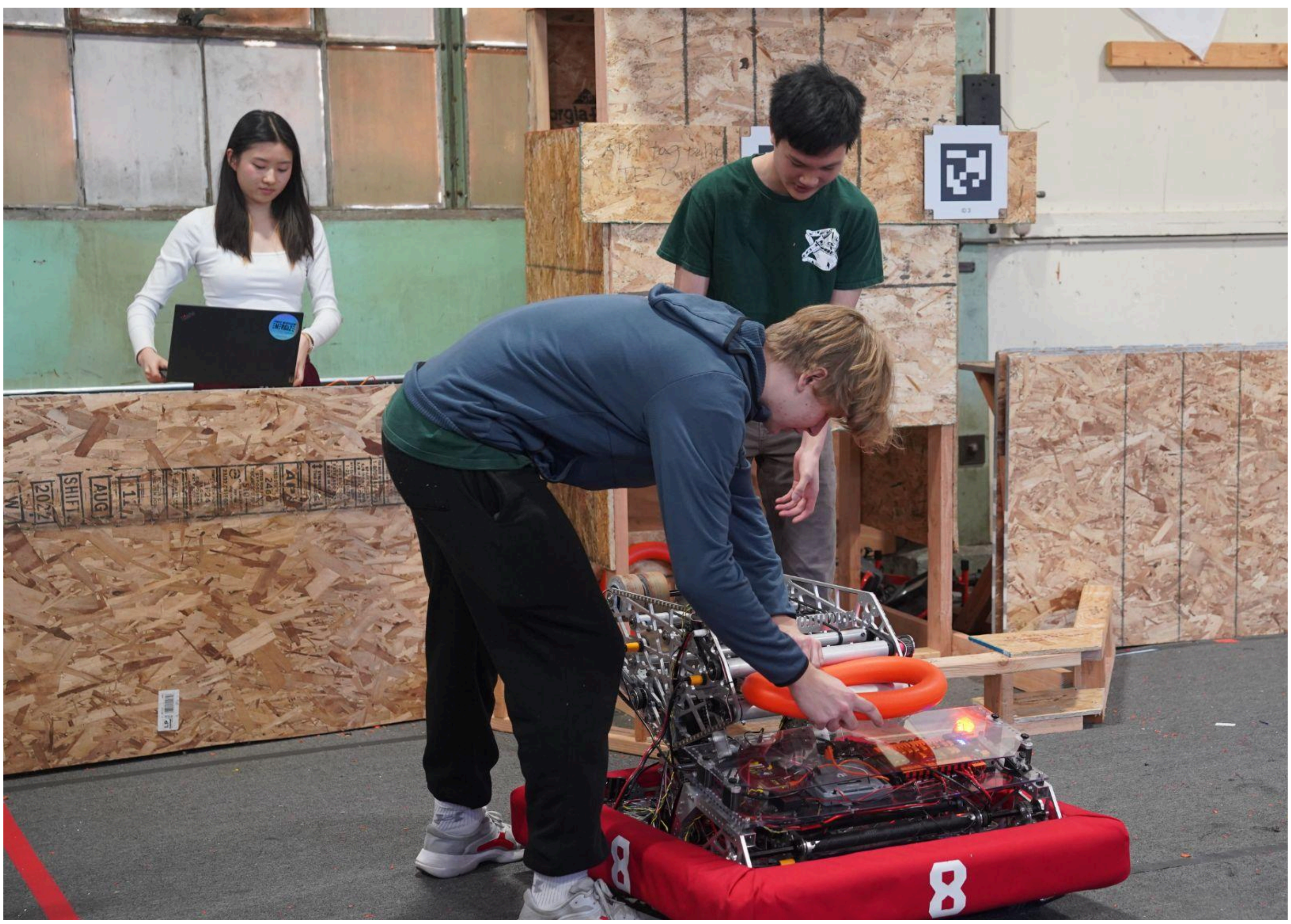
Previously, our robot could not drive under the stage while intaking, increasing cycle time when available notes were underneath the stage. The polycord indexing portion is now shortened so our robot can fit under the stage in all positions.

We also decided to add configurability for a second row of flywheels, a popular design seen throughout the season. Currently, our shooter has a front row with Colson wheels and a back row of Stealth wheels. The Stealth wheels are on the right side of the axle to create spin, improving shooting range and consistency.

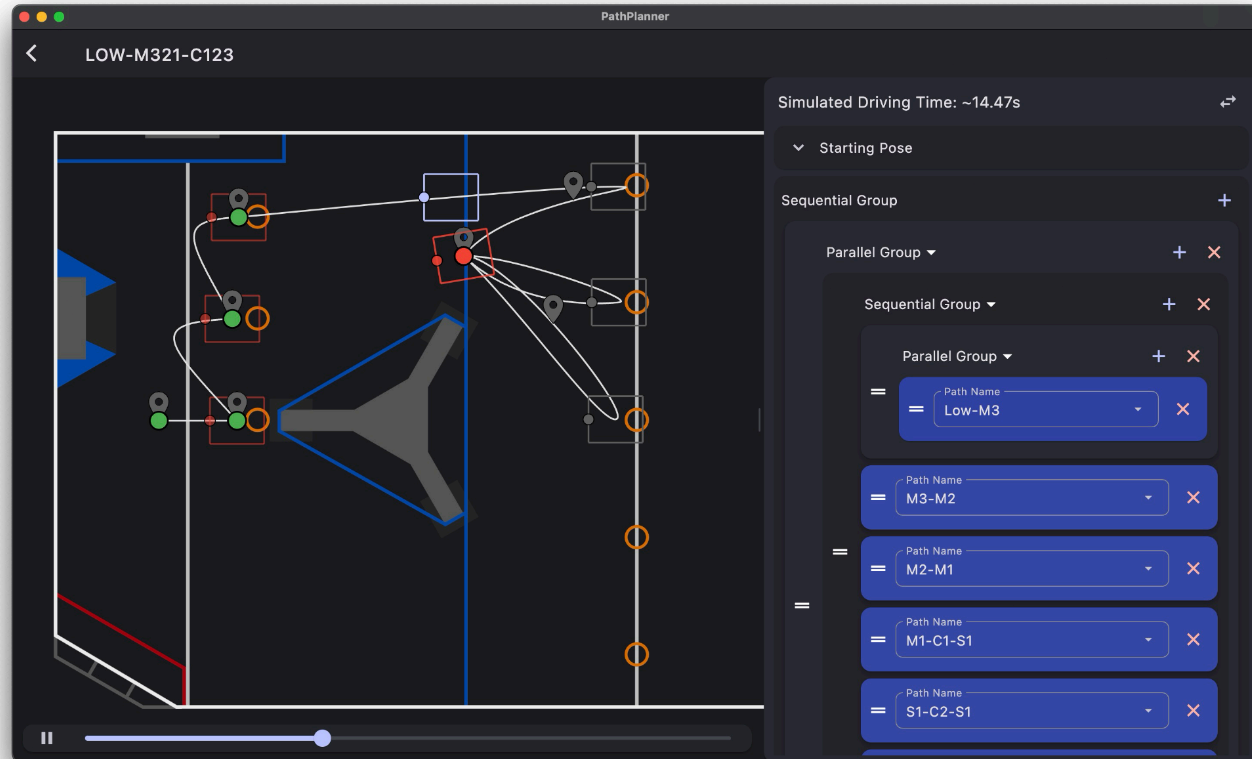
We originally scored in the Amp by shooting upwards. However, when attending our first regional, we noticed inconsistencies with the field's Amp and our lab's Amp, making shots less accurate. For our second regional, we prototyped a passive "Amp Bar" that rebounded notes into the Amp after shooting them. We found success with this method. For Houston, we put the Amp Bar on an active pivot to prevent damage from collisions.

Software





Autonomous



Path Following

- Paths generated with PathPlanner
- Continuously updating robot pose with vision and swerve odometry

Subsystem Commands

- Commands-based architecture allows us to run pre-programmed routines when predicates are reached

Ring Chasing

- YOLOv5 neural network detects notes using an Orange Pi 5
- Adaptively targets center notes with note detection

Teleop

Intake

- Intakes at different speeds based on drive velocity
- Controlled by a velocity voltage PID loop to achieve consistent speeds
- Determines if a note has been intaken based on changes in current draw

Indexer

- Beam break sensors automatically run the indexer until the note is in the right place

Pivot

- Utilizes Motion Magic controls instead of a traditional trapezoidal motion profile to smoothly achieve the correct angle
- An interpolating treemap uses the distance from the speaker based on the robot's current pose to determine the right shooter angle

Shooter

- Flywheels spin up automatically when a note is in the indexer
- Each flywheel is controlled by a velocity voltage PID loop to achieve consistent speeds

Power Distribution Manager

- Each subsystem requests voltage, and this manager distributes voltage to each motor based on its priority to reduce brownout

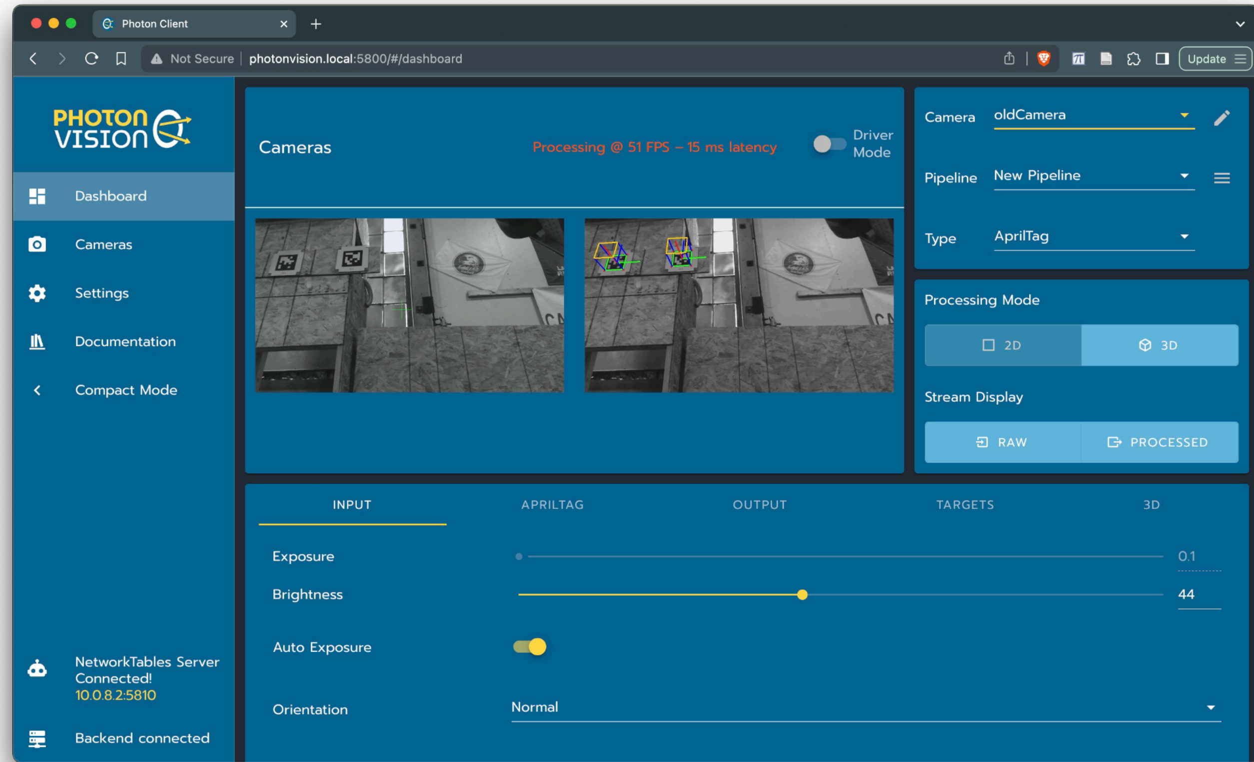
Driver and Operator Feedback

- LED strips on either side of the shooter flash in different sequences based on the state of the robot. For example, if the flywheels are at the right speed or a note is in the robot.
- Beam break sensors throughout the intake and indexer trigger events like controller rumbles and LED states

Shooting on the Move

- Iteratively solves for the robot's future position using vision pose estimates and an interpolating treemap of game piece flight times.

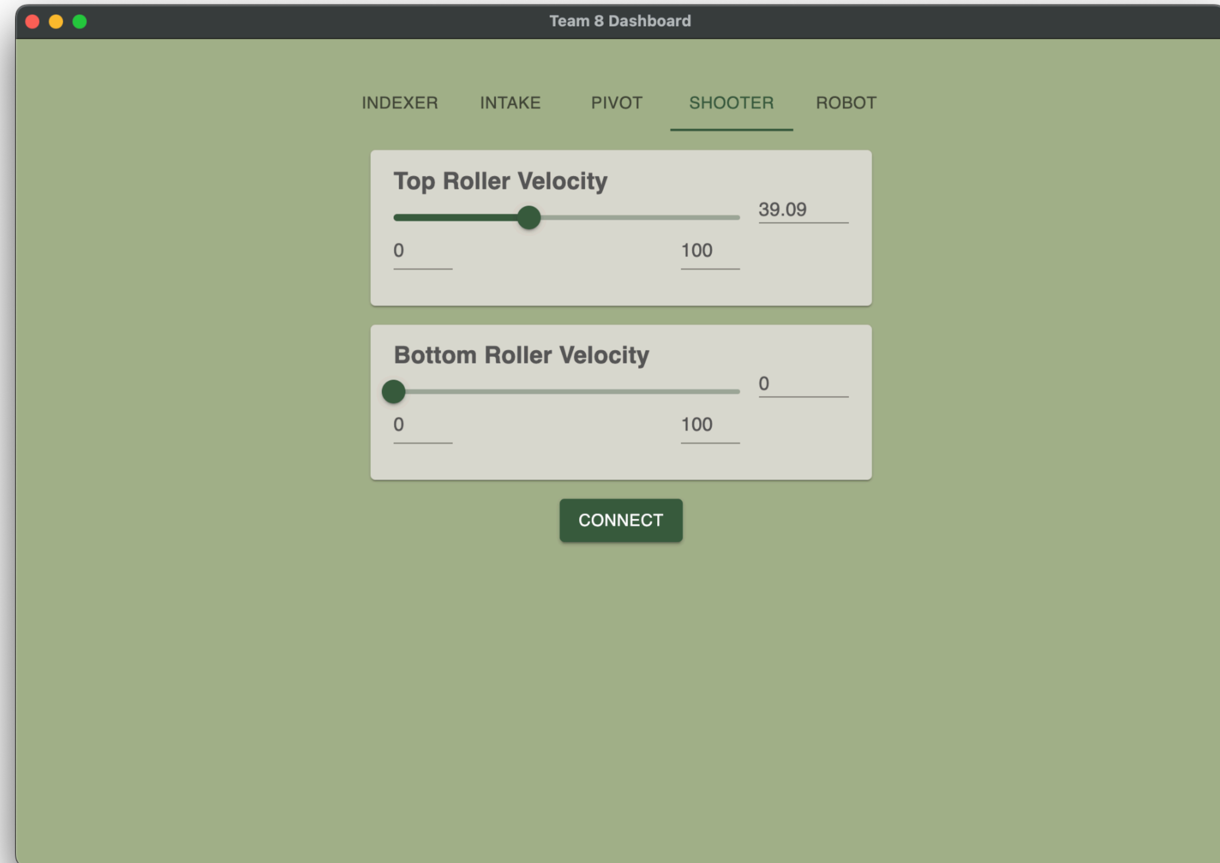
Vision



AprilTag Localization

- PhotonVision with Orange Pi 5
- Three vision coprocessors with two cameras each
    - Used to ensure that there are always AprilTags in view
- Custom Kalman Filter implementation for precise pose estimation that incorporates AprilTag cameras and swerve kinematics
    - Fuses pose estimates using individual tags together with tag estimates using SolvePNP to best account for poor field tolerances

Control Center

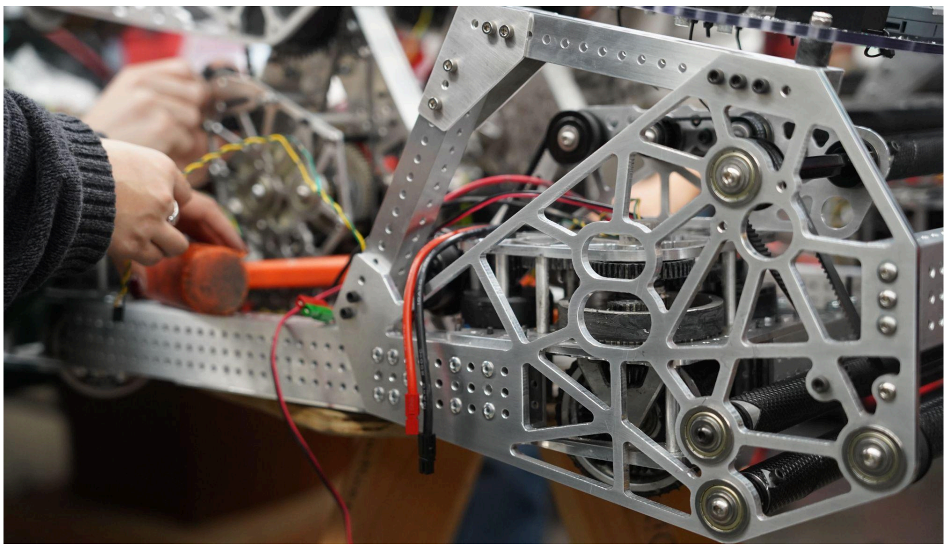


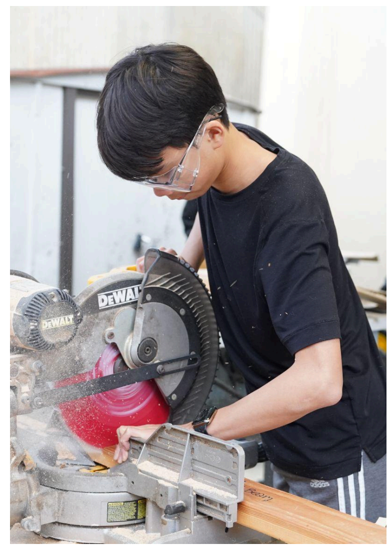
Tuning

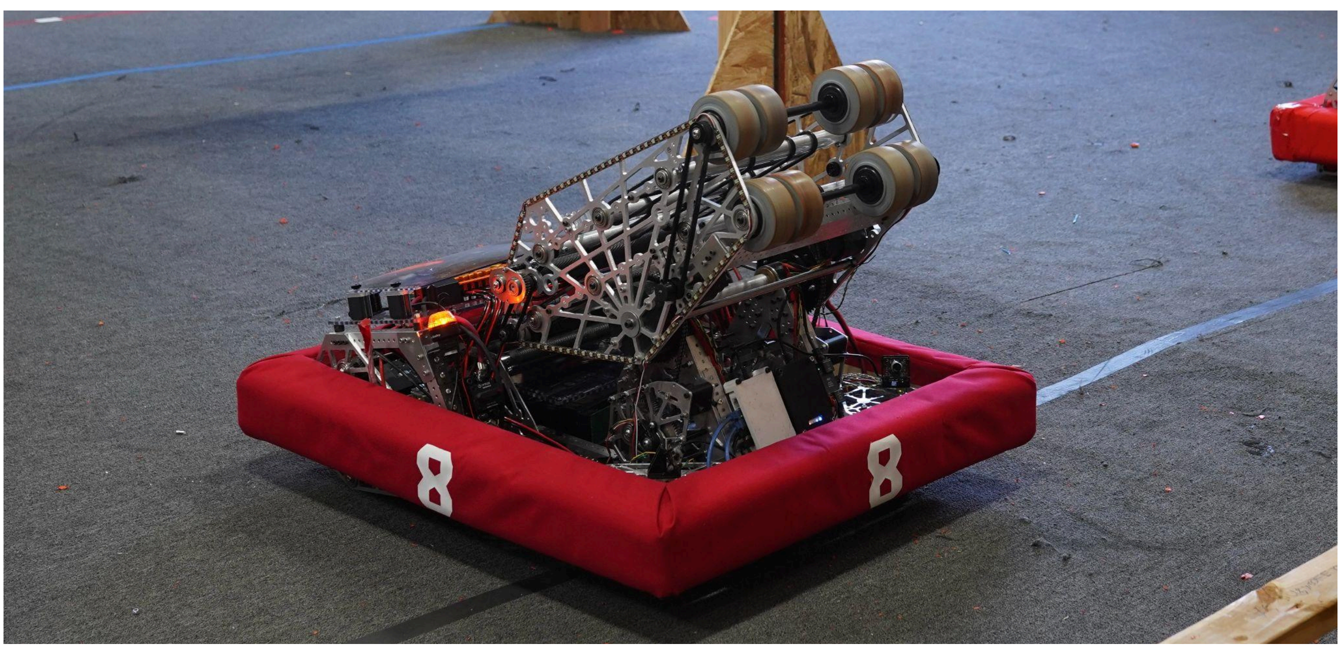
- Updates NetworkTables on the fly to quickly test and tune values
- Tab-based architecture allows for future expansion and versatility, anything from creating autos to changing configs

Setup

- Electron Client communicating through the NT4 Protocol
- Compiled to EXE or DMG to be installed on windows or mac.




DEWALT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