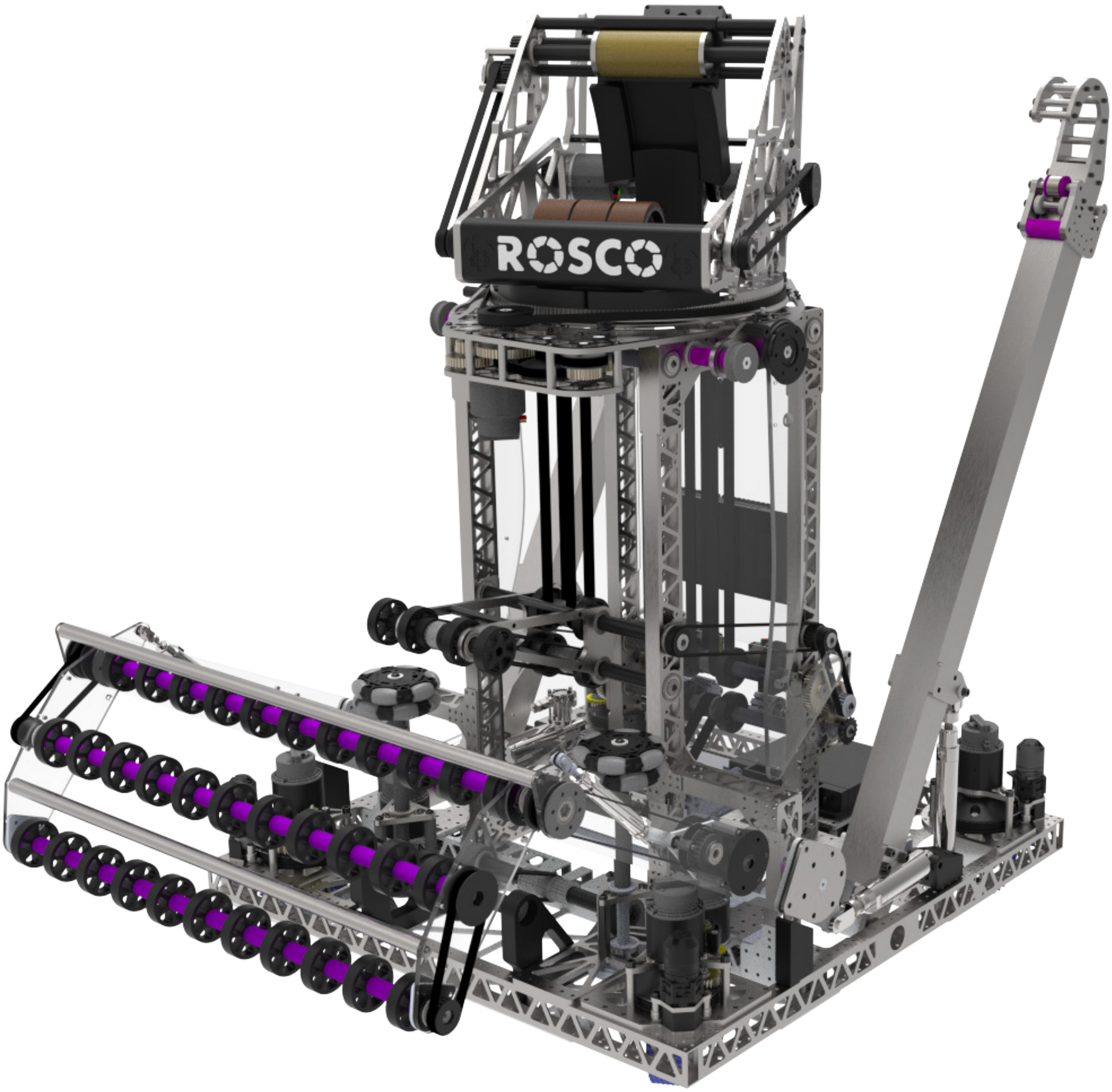
Ha-Dream Team #3075 Presents:

ROSCO



2022- Rapid React Technical Binder

3075

Foreword

After weeks of thinking, learning and working hard, we are proud to share with you our final product.

This Technical Binder contains our creative journey. One half contains theoretical game analysis, Understanding the optimal way to play Rapid React. The second half entails the technical specifications of each part of our robot.

In short, this technical binder encompasses the process of determining what our ideal robot looks like, and how we brought it to life.

This is best represented by one word: ROSCO.

Here we will present our game analysis, decisions and technical designs that guided us from the kickoff to our final robot for the 2022 FRC Season – Rapid React.

Game Analysis

After the hardships that Covid had imposed on our team, we were incredibly excited for the reveal of the new game for the 2022 season.

Immediately after the game reveal we started to analyze the objectives and the rules of the game, interpreting the manual to decide which strategies will be the most effective.

The game has introduced a lot of new challenges that were never before seen, a 4-step transition climb while Airborne, color deduction between cargo, and other complex concepts.

The game offered a number of dilemmas and questions, each with far reaching consequences determining how our final robot will function, these are just a few:

- shooting the cargo to the UPPER or the LOWER HUB?
- Will we utilize the Lunch pad? The Terminal?
- How crucial is the ability to distinguish blue cargo from red cargo?
- How high do we want to climb? How fast does our climb mechanism have to be in order to be effective?

As with every year, we put an emphasis on maximizing our ranking points. That meant that climbing to the traversal level and scoring 5 cargos at the autonomous period will dramatically increase the chance of completing the RP challenges with different alliances. We want to minimize our dependencies on what our allied robots are capable of. So that meant that we had to climb to traversal and be able to score 20 cargo in a match (Auto Included).

Game Analysis

Below we outline the prioritized requirements that we set before designing our robot

Shooter/Turret

- Reliability (>95%) shooting into the UPPER HUB (from the TARMAC).
- Reliability (>80%) shooting into the UPPER HUB (from every orientation and location on the field).
- Rapid fire (2 cargo in < 1 sec).
- Shooting from every orientation and location on the field.
- Fixating on the High hub throughout the match (in order to shoot in every orientation).

Intake

- Touch it, own it (grab cargo regardless of driving speed).
- Intake 2 cargo at once without jamming.

Conveyor & Feeder

- Hold 2 cargo at once without jamming.
- Feed concisely to the shooter.
- Fast feeding to the shooter (<2 sec into shooter).
- Using sensors to index cargo (number of cargo, the color of them).

Game Analysis

Climbing

- Climbing to the Traversal rung.
- Fast climbing to the traversal (<15 sec).
- Able to climb with another robot already on the bar. (take minimalistic space on the bar).
- Fast deploying (<5 seconds already in air).

Autonomous Period

- Pickup and score 5 cargo into the High Hub (100% accuracy), in order to achieve a quintet every match.
- Make alternative routes that pickup and shoot at least 2 cargo.
- Make a route that steal quickly opponent's cargo.

Game Analysis

Final designs that come from strategics decides:

Intake:

We decided to build an external system to collect cargo from the field and over the bumper, without centering the cargo. The external system is retractable to avoid damage when colliding with other robots. The system is wide enough to collect more than one cargo while a different system is centering the cargo into the conveyer.

Conveyer + Feeder:

We built the conveyer with an IR sensor in its entrance. The IR sensor allows the robot to know how many cargos are in the conveyer and in which colors. It also allowed the conveyer to control the space between cargos, and to eject opponent cargos.

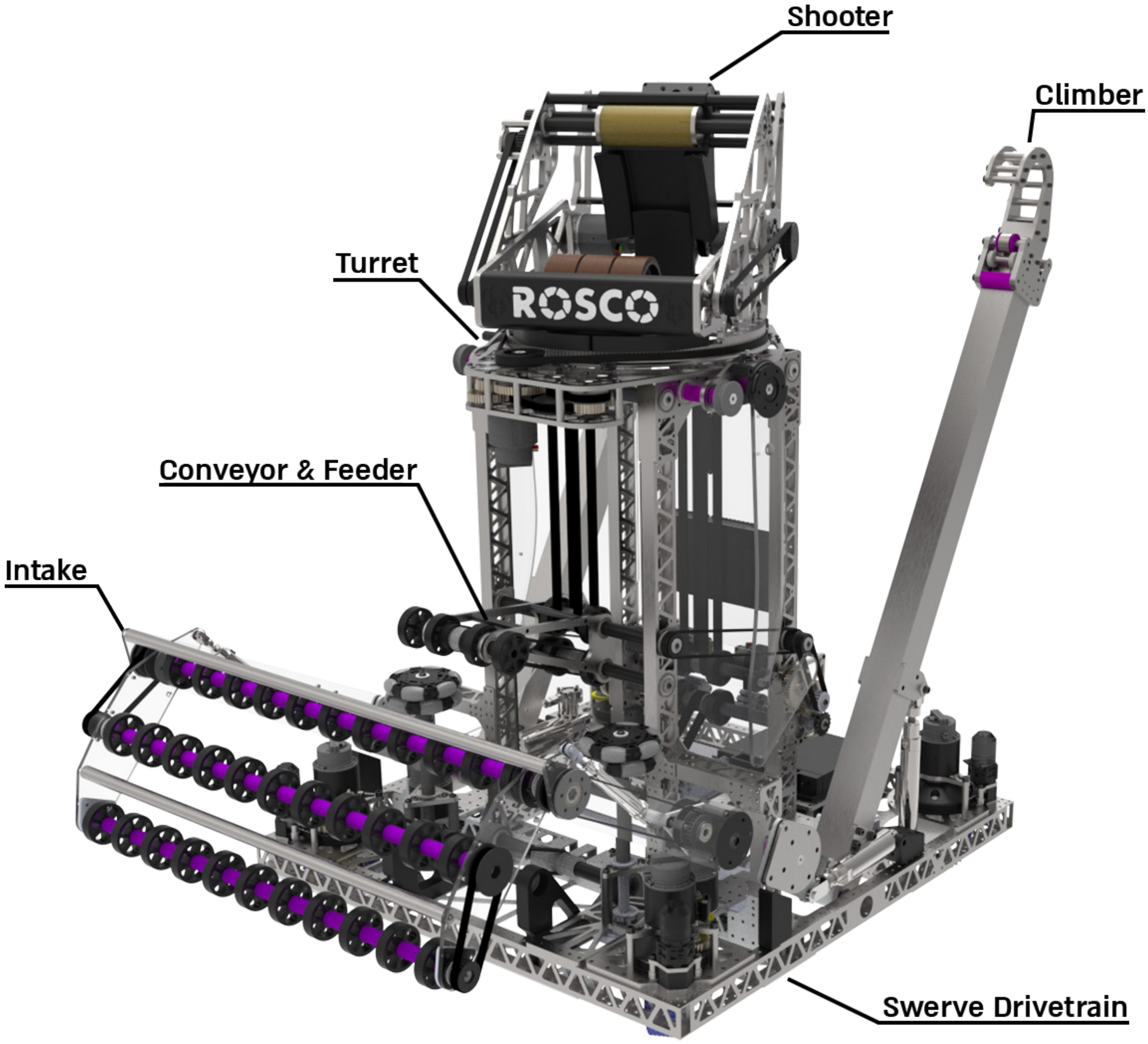
Shooter:

We decided to build a turret shooter with an adjustable hood, which allowed us to shoot from every position on the field. Controlling the speed and the shooting angle gave us the option to score from different distances, while the turret kept the shooter fixated on the high hub.

Climbing:

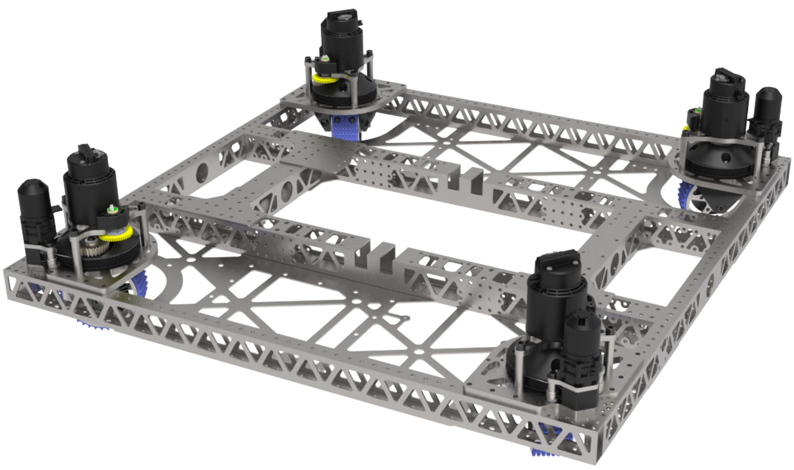
We decided to build a traversal climber, in order to increase the chance of gaining the additional RP in any alliance, and to maximize game points. We chose to climb from rang to rang so that if one of the transitions fail, the robot is still hanged, another benefit is the flexability to climb to different heights, in case our alliance robots decide to climb to the traversal, we still have the option of climbing to the high rung.

ROSCO



Shooter
Climber
Turret
ROSCO
Conveyor & Feeder
Intake
Swerve Drivetrain

Swerve Drivetrain

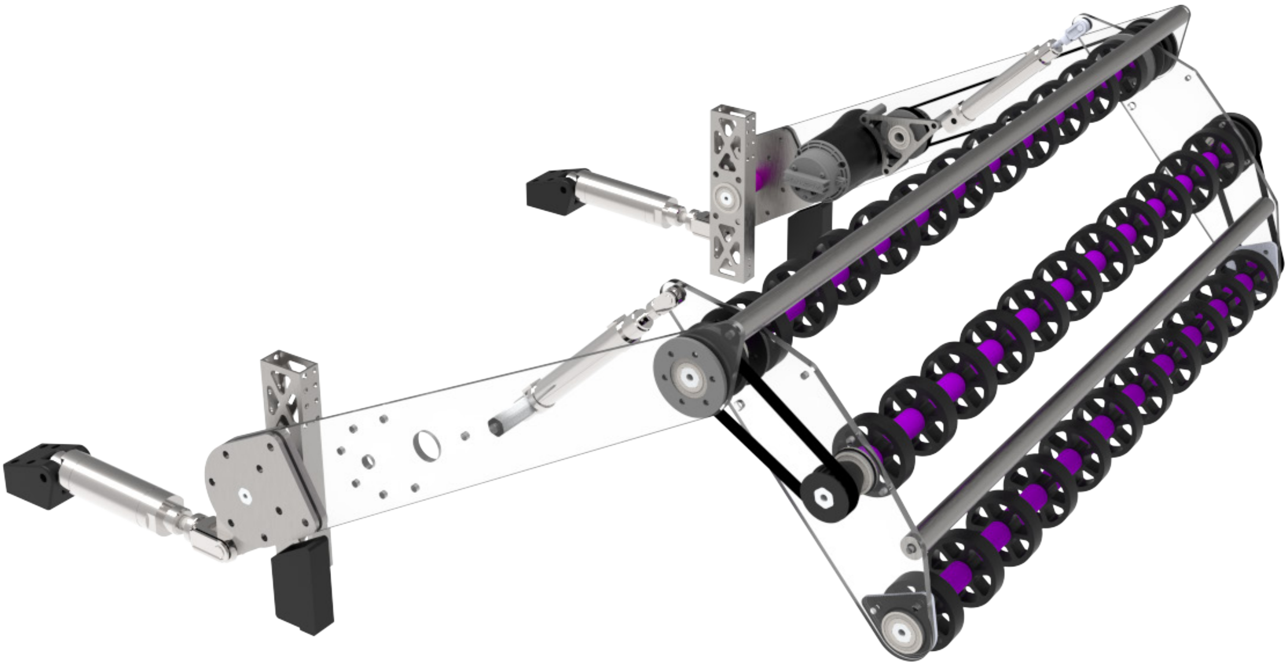


The drivetrain allows the robot to maneuver around the field quickly and precisely. This year's design is a custom swerve drivetrain that we developed over the past few years.

Swerve Module MK5

- The drive is powered by a Falcon 500 motor via a 1:7.5 gear reduction
- The Steer movement is powered by a NEO 550 motor via a 1:5 Rev Ultraplanetary transmission ratio and a 1:3.75 Timing belt reduction.
- The total weight of the module is 2kg (4.4 lbs).
- Steering encoder - MA3 Absolute Encoder.
- Most of the module parts are 3D printed from ABS reinforced with Carbon Fibers.
- The steer movement is powered a timing belt in order to reduce backlash.
- The driving motor is located in the center of the module, optimal for decreasing the footprint of the module.

Intake



Double actuated intake designed to withstand high impacts and abuse during play.
The intake utilizes the term "Touch it, own it", the design enables collection of cargo quickly all along the width of the robot.

Rollers

- 3 belt-driven rollers powered by a Falcon 500 motor.
- 2" black flex wheels provide compliance when collecting the cargo.
- High-speed low roller grabs cargo quickly off the ground
- High-speed middle roller supports the cargo over the bumper.
- upper roller leads the cargo into the conveyor.

Deploying

- 6 mm thick polycarbonate plates allow the intake to withstand high impact.
- The intake is actuated in and out of the frame perimeter using two pneumatic cylinders:
  1. 32 mm bore / 50 mm stroke   Pneumatic Cylinder on each side open and close the intake
  2. 16 mm bore / 50 mm stroke Pneumatic Cylinder on each side change the roller's position

Conveyor & Feeder

Two subsystems control the cargo in the robot, the conveyor and the feeder. Using an IR color sensor we are able to maintain an even pace of shooting and collecting.

Conveyor

- The conveyor is powered by a Falcon 500 motor via a 1:3 reduction
- 2" black flex wheels center the ball
- The top belts prevent incoming cargo from bouncing out of the robot
- A 4" omni wheel is located on each side of the conveyor, powered by a Falcon 500 motor via a 1:2.77 Timing belt reduction.
- The omni wheels center and pull the incoming cargo into the conveyor.

Feeder

- Vertical Timing-belt conveyor leads into the shooter
- Powered by a Falcon 500 motor via a 1:3 reduction
- 2" black flex wheels keep the ball centered

Color deduction

- in order to identify the cargo and it's color, a Rev Color Sensor V3 is located between the conveyor and the feeder.

Turret

The turret allows the robot to quickly score cargo from any orientation and location on the field. It is powered by a Falcon-500 motor, and controlled by an absolute encoder.

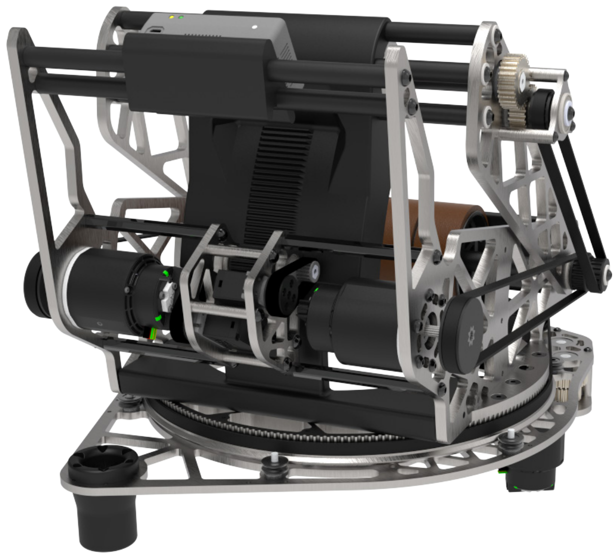
Turret

- Powered by a Falcon 500 motor via a 1:55.6 gear reduction.
- Custom 234T HTD 5 pulley machined from Aluminum.
- Capable of ± 300° of rotation to each direction.
- Six V-Groove Bearings placed around the shooter interface with a machined Aluminum plate fashioned to fit the bearings.
- The V-Groove Bearings sit on a custom eccentric stand, that allows us to compensate for imperfections in the parts, and wearing out over time.
- a MA3 Absolute Encoder is conncted via a 1:5.3 gear reduction to the last stage of the turret transmission. This way we synchronize the turret and the encoder.

Wire management

- Wires are managed with a protective sleeve which is anchored to the the turret on one end, and a static point on the robot on the other end. The sleeve is kept under tension by a piece of surgical tubing and a 3d printed roller.

Shooter



The shooter contains dual-flywheels with an adjustable hood angle to enable shooting from every location on the field. A Limelight camera vision tracks retro-reflective tape on the high goal to aim the turret, control the hood angle , and adjust the flywheel speed to ensure a successful shot.

Dual-Flywheel Shooter

- Powered by 2 Falcon 500 motor with a 1.5:1 Timing belt ratio.
- Lower flywheels are 4" diameter traction wheels
- Upper flywheel is 2" diameter polyurethan
- Limelight camera

Adjustable Hood

- Enables shooting angles from 25° – 45°.
- Powered by 2 Rev Smart Robot Servos via a 1.75:1 ratio
- The Rev Smart Robot servo operates like a standard 270° servo, this way we can adjust the shooting angle precisely without requiring another component.
- 3D printed hood designed to center the ball.

Climber

Two sets of 2 stage telescopic arms, and a pair of static hooks allow us to traverse the rungs.
The telescopic arms are able to change their angle using pneumatic cylinders.

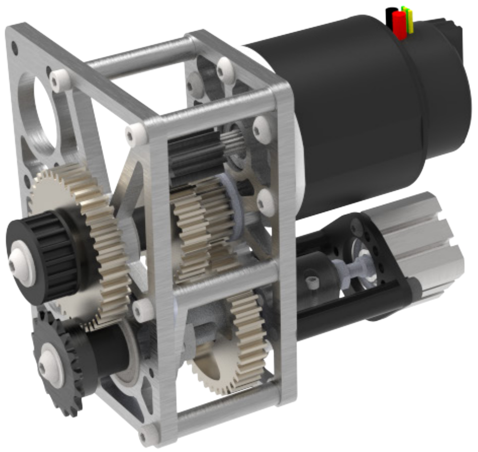
Telescopic Arm

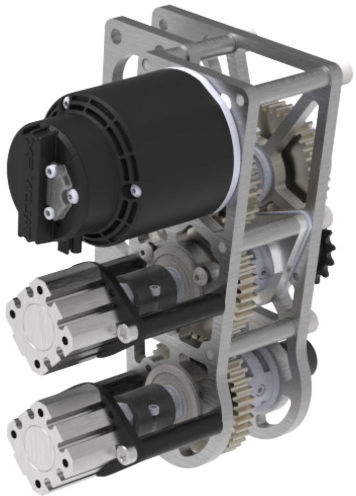
- The external tube is an aluminum extrusion 50X50mm 2mm thick
- The internal tube is an aluminum extrusion 40X40mm 2mm thick
- Extends up to 163 cm (~ 5 ft. 4.2in) above the ground Deploys the second stage with two Constant Force Springs.
  Rev 1.2mm Ultra-high-molecular-weight Polyethylene Cord retracts climber
- Powered by 2 Falcon 500 motors using a custom PTO from the Conveyor gearbox, a total reduction of 1:7.5.
- A Dog shifter in the Conveyor gearbox is able to brake the arm on command.

Passive hooks

- 6 mm thick polycarbonate
- The hooks are spring loaded by a surgical tube and are stowed in place by two pancake pneumatic cylinders. Transitioning into endgame the hooks can be deployed to their full height while remaining compliant.
- Designed to support the entire weight of the robot.

Conveyor PTO





The Conveyor gearbox provides the power to the Conveyor, the Feeder and the Climb in the endgame. There are two similar gearboxes that attach to each side of the conveyor structure, one controls the conveyor, and the other one controls the feeder. In the last seconds of the match, both of the gearboxes combine using a dog shifter, in order to power the climber's telescopic arms.

Climber Integrations

- Pneumatic actuated dog shifter engages Power Take-Off (PTO) gear train – 7.5:1 reduction to 31.75mm (1.250in) spool.
- Both gearboxes are connected by a single 1/2'' thunderhex shaft running across the width of the robot.
- One of the gearboxes contains an additional shifter with the option of engaging a ratchet which prevents the robot from over-extending after the end of the match.

Software

Autonumous

- The driving in the autonomous part is programmed using a custom made web based python app.
- The path is drawn using cubic Bezier curves on a map of the field.
- The app optimizes the trajectory by time (not by distance) and limits by the kinematics constraints of the swerve.
- The app exports the path to a CSV file that's saved in the robot code.
- We follow the trajectory with Motion Profile on all 3 axes (x, y. rotation).

Automations

From the moment the cargo ball enters the robot and until it exits, the robot follows this fully automated procedure:

- The robot recognizes when a ball enters the robot and determines its color by using an infrared sensor and a color sensor in the conveyor.
- The robot uses the driver station to determine the color of its alliance.
- The robot has two different sequences depending on whether the next ball's color matches the color of our alliance.
- \- If the ball's color does not match that of the robot's alliance, the ball is ejected from the shooter at a low power and at an angle away from the hub.
- \- If the color of the ball matches the color of our alliance, we begin a warmup sequence in the shooter so that the shooter is ready to shoot in minimal time.
- \- The warmup sequence has two parts:
- In the first part, the shooter is given a small amount of power that is gradually increased in order to avoid stress and strain on the timing belts.
- In the second part, the shooter receives a velocity that varies with distance from the hub. (the velocity is 80% of the velocity needed to successfully score the ball in the upper hub).

Software

Vision

- A Limelight 2+ camera uses vision targets to automatically align the turret and hood and determine the shooter's velocity, allowing us to shoot and score balls quickly and accurately with the press of a button.
- The robot calculates the yaw angle from the robot to the target and aligns the turret to face the upper hub using known heights of the target and data received from the Limelight.
- The robot knows its position relative to the field and inherently its position relative to the target using odometry and vision, so the robot knows where to point the turret even when the limelight loses the target.
- The robot determines the ideal angle for the hood based on an equation and the distance from the hub in order to get the best ball trajectory.
- The robot calculates the velocity of the shooter based on the distance from the hub using mapping.

Climbing

- The climb is divided into three stages, with the third stage repeated twice. After the driver presses a button, each stage begins.
- The first stage opens the linear climbing mechanism in order to reach the second bar.
- The second stage pulls the robot towards the bar.
- The third stage opens the linear climbing mechanism and pulls the robot towards the next stage.