VORTEX

254

2024 Technical Binder

Foreword

This Technical Binder details the game analysis, decisions, outcomes, and technical designs that guided us to our final robot for the 2024 FRC Season: Crescendo.

Our season started with game analysis, which helped the team determine the optimal strategies and robot requirements. With these requirements, subsystems were prototyped, designed, and built. With software unlocking the capabilities of this machine, we are ready for competition.

Team 254 is proud to present our 2024 robot: **VORTEX**

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GAME ANALYSIS

CRESCENDO presents two challenges: shooting ring-shaped Notes into the Speaker, Amp, or Trap and climbing on a chain in the Endgame. Our team's goal is to win regionals and the World Championship. To achieve this, we need to do the following in each phase of the tournament:

Qualifications

- Maximize acquisition of ranking points

Seeding first allows us the flexibility to form the type of alliance we want for the Playoffs

Playoffs

- Maximize our alliance's score to win all matches

Obtaining Ranking Points

- Ranking points are awarded as follows:
    - Two for winning a qualification match, one if tied
    - Ensemble: One for acquiring at least 10 stage points with at least 2 robots onstage
    - Melody: One for shooting at least 18* Notes into the Amp or Speaker
- To maximize ranking points in qualification matches, we must do the following:
    - Win: Amplify the Speaker as much as we can to increase the value of points each Note is worth
    - *Achieve Coopertition Bonus to reduce the number of Notes required for a Melody from 18 to 15
    - Ensure at least 2 robots in our alliance climb to gain the Ensemble RP
        - We must score in the Trap so all we need is one partner that can climb
        - Our Cheesy Care team works to help our alliance partners climb

SUBSYSTEM STRATEGY

Drivebase
- Fast swerve maximizes maneuverability
- Low CG, wide base robot to prevent tipping

Intake
- Maximum acquisition area, funnel Notes from sides
- Pickup multiple Notes without jamming
- Under-bumper Intake to be robust to collisions, especially during autonomous race to midline Notes

Feeder
- Take Notes from Intake to Shooter with Turret at any position
- Store Notes and accelerate into Shooter when ready
- Exhaust Notes out to either the Shooter or the Amplifier

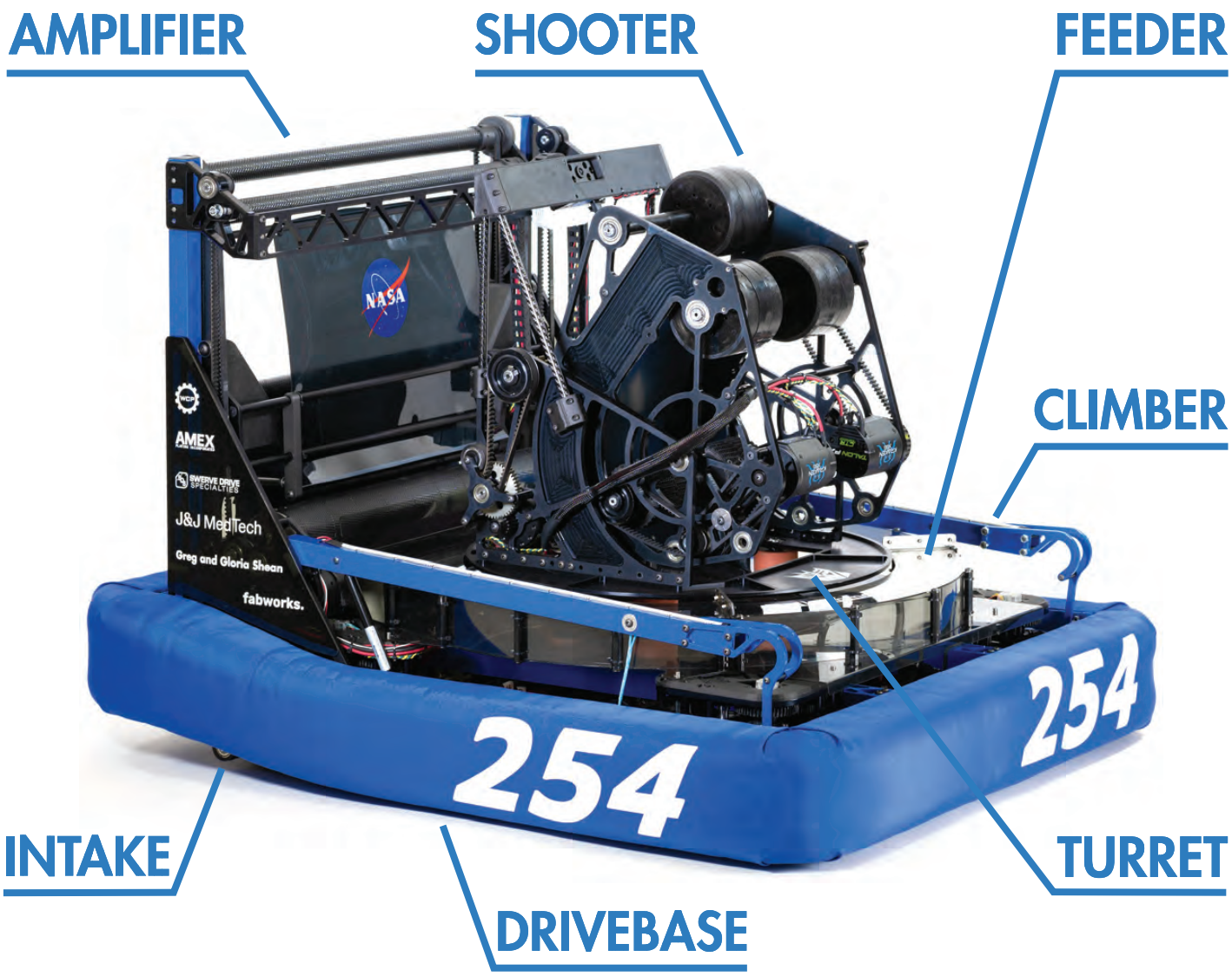
Turret
- Allow Shooter to rotate separately from the robot to enable shoot-on-the-move and faster alignment
- Large range of motion (>360deg) to maintain tracking on goal and minimize wrap arounds

Shooter
- Shoot into Speaker from different distances
- Highly accurate; missed shots are costly
- Camera to quickly aim and align automatically

Amplifier
- Acquire Notes from Source / Human Player for Shuttling strategy
- Redirect and shoot Notes down into Amp or Trap
- Passive Rollers to react against Stage while climbing for Trap scoring
- Elevator to raise Trap scorer to required height

Climber
- Climb the chain in <2 seconds
- Climb high enough (~16″ off ground) to enable scoring in Trap
- Utilize Camera / April Tags to automatically align / quickly climb (nice to have)

VORTEX


AMPLIFIER
SHOOTER
FEEDER
CLIMBER
INTAKE
DRIVEBASE
TURRET
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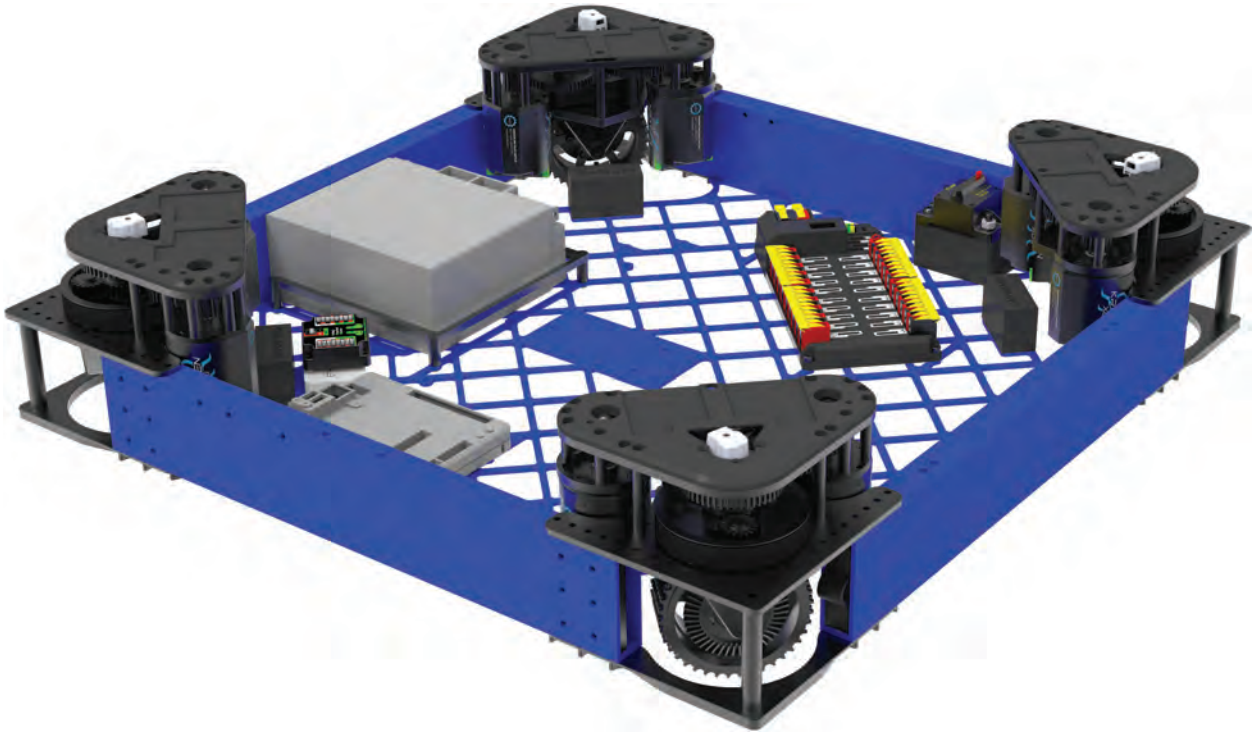
NASA
AMEX
J&J MedTech
Greg and Gloria Shean
fabworks.

DRIVEBASE



The Drivebase allows the robot to maneuver around the field quickly and precisely. The swerve was chosen for its increased maneuverability and ability to avoid defense.

SDS MK4i Modules

- L3 drive reduction (18 ft/s) with 4″ black neoprene treaded wheels
- Krakens with Field Oriented Control for drive and steering
- 3D printed Swerve covers for mounting Feeder

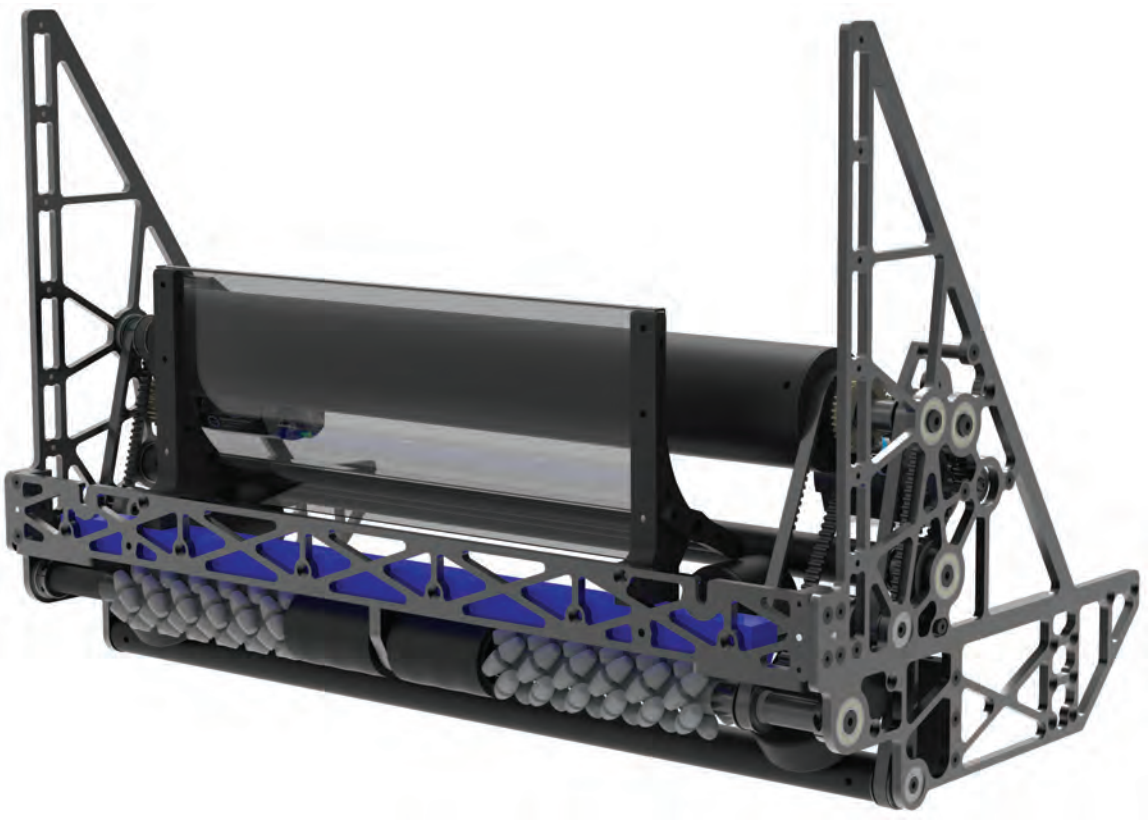
Chassis

- 27″ by 27″ frame with 1/4″ plates on left/right sides
- 3″ x 1″ x 1/8″ aluminum tubes lower bellypan to 1/2″ above the floor to reduce CG
- 1/8″ aluminum pocketed bellypan

Electronics

- Battery opposite to Intake/Amplifier to balance CG
- REV Power Hub, with all 40A breakers for 19 motors

INTAKE



The Under-Bumper Intake gets Notes off the ground and into the Feeder. Mecanum and sideways funneling wheels allow Notes to come in from the sides and not jam.

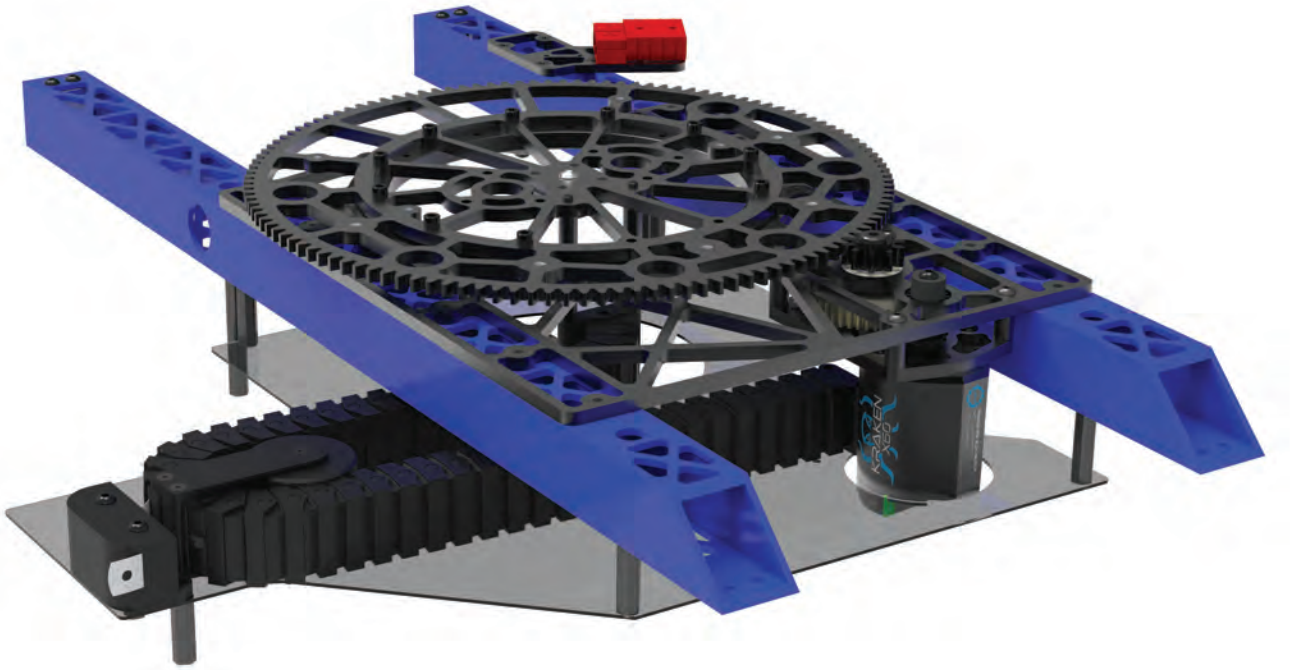
Structure

- Aluminum 1/4″ sideplates hold the Intake and Amplifier
- 1/4″ aluminum plate extends forward from Drivebase to stiffen against side impacts
- Front 1/4″ plate and 1x1 7075 solid bar stiffen Bumper against front impacts

Rollers

- Front roller pulls Notes in and allows for sideways funneling
    - 2″ mecanum wheels on 1/2″ hex shaft
- Kicker roller and Upper roller lifts Notes off ground
    - 1.125″ OD 1/32″ wall aluminum tube covered with silicone
- Redirect roller pulls Notes from Feeder to bring into Amplifier
    - 3″ OD 1/16″ wall polycarbonate tube covered with silicone
- Angled Funneling Wheels center Notes
    - 3″ OD 3D printed wheel, dead-axle
- Powered by 1 Kraken geared for ~15 ft/sec surface speed

TURRET



The Turret enables the Shooter to continuously track the Speaker. A bidirectional energy chain (BIGUS) provides clean wire management through a 720° range of motion.

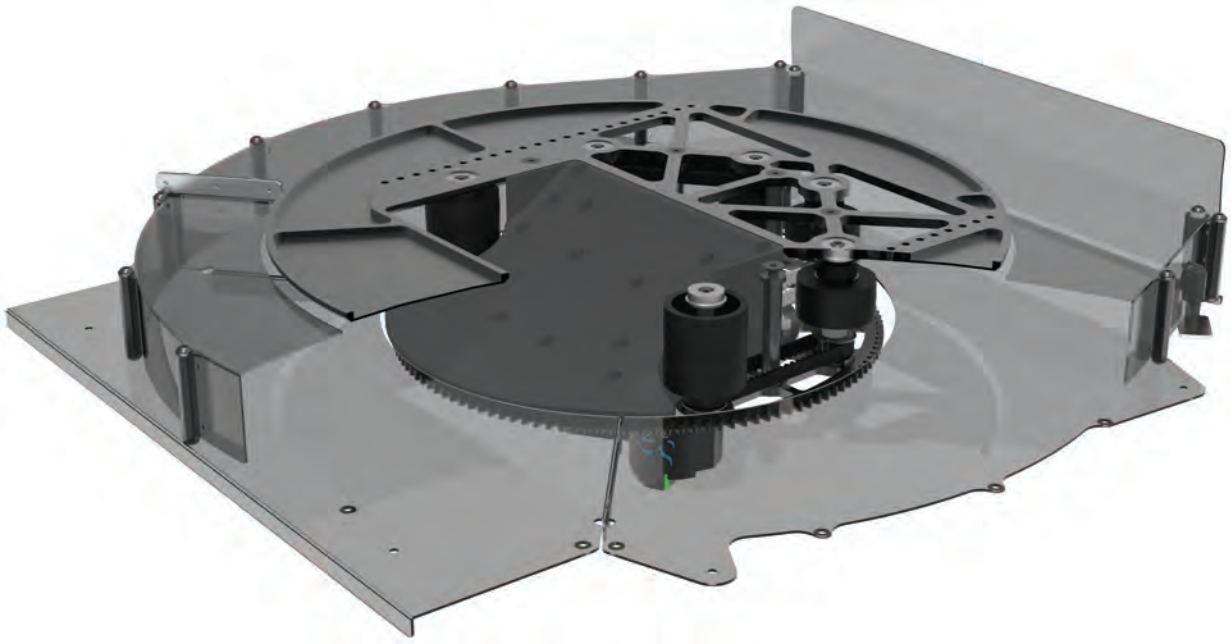
Structure

- 1.5″x1.5″x1/8″ tubes mount Turret plate to Drivebase
- 8″ ID thin-section bearing clamped into plates provides stiff connection
- Output gear 1/4″ plate serves as base for Feeder rollers
- 1 Kraken with 14:52T 20DP then 10:125T 10DP reductions

Electronics

- 3D printed BIGUS provides custom profile for required amount of wires
- BIGUS sits on polycarb shelf above bellypan and is tensioned by constant force spring
- 3D printed box and gears with SRX Mag Encoders measure rotation 1:1 and 1:2.3 so position, even through multiple wraps, is known

FEEDER



The Feeder takes Notes from the Intake and rolls them around the Turret to be fed into the Shooter. Notably, unlike other robots with turrets, this architecture allows the Shooter to be pointed in any direction; it does not have to align with the Intake as the Note comes in. This enables uninterrupted tracking of the goal for faster aiming and reliable shoot-on-the-move.

Structure

- 1/16″ polycarbonate covered in Teflon tape provides slippery walls to guide Note
- Mounts to tops of Swerve modules with velcro so is removable for servicing

Rollers

- 2″ REV Stealth Wheels have high grip and roll Notes around the Turret and into Shooter
- Powered by 2 Krakens via 15:18T belt then 15:15T belts
    - Two motors allow direction switching to prevent jams and ensure shortest path of Note to Shooter

SHOOTER

The Shooter, our second revision, uses feed rollers and then quad-flywheels to launch Notes into the Speaker. A sector-gear Hood provides angle adjustment to shoot from different distances.

Shooter

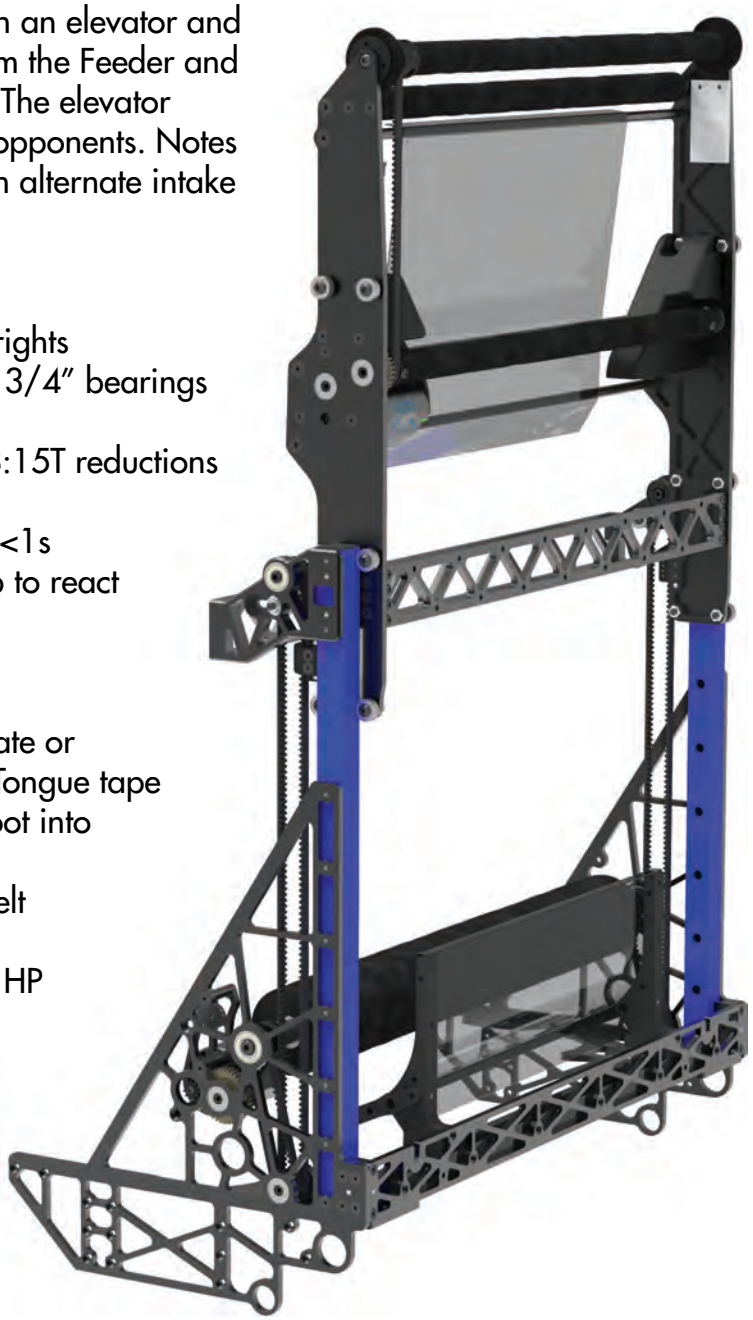
- Stage 1: 3D printed rollers with black nitrile tread, 2.8″ OD
  - 1 Kraken powers 12:30T then 15:30T with belts
- Stage 2:
  - 3″ OD REV Stealth Wheels, 2.5″ urethane wheels, and 2.5″ printed wheels with cattongue tape
  - Asymmetry puts spin on Note to travel flatter and farther
  - 1 Kraken powers top, 1 powers bottom rollers via belts on 32:18T pulleys
  - Limelight camera is mounted on Feeder/Turret top plate for low viewing angle

Hood

- 1 Kraken powers 14:48T, 15:36T, then 10:160T sector gear
  - Shims between gears and hex shafts eliminate backlash
- Range of motion enables shooting at +10° to +50° above horizontal

AMPLIFIER

The Amplifier is a carriage with rollers on an elevator and has many functions. It receives Notes from the Feeder and redirects them down into the Amp/Trap. The elevator provides height for the Trap or blocking opponents. Notes can be fed in by the Human Player for an alternate intake path to enable the passing strategy.



Elevator

- 1x1x1/16″ aluminum tube Uprights
- 1/4″ Carriage side plates with 3/4″ bearings and teflon
- 1 Kraken powers 11:36T -> 18:15T reductions then 15:15T lifting belt
- Travels 17″ range of motion in <1s
- Passive wheels roll against Trap to react while climbing

Rollers

- 1″ OD 1/16″ wall polycarbonate or aluminum tube rollers with CatTongue tape
- Upper rollers pinch Note to shoot into Amp/Trap
- 1 Kraken powers via 12:30T belt reduction
- 3DP wedges center Note when HP feeding

CLIMBER

The Climber pulls down on the Chain to lift the Robot 16″ off the ground and enable the Amplifier to reach the Trap. Dyneema rope around a hex jackshaft winches down the Climber in ~1 second.

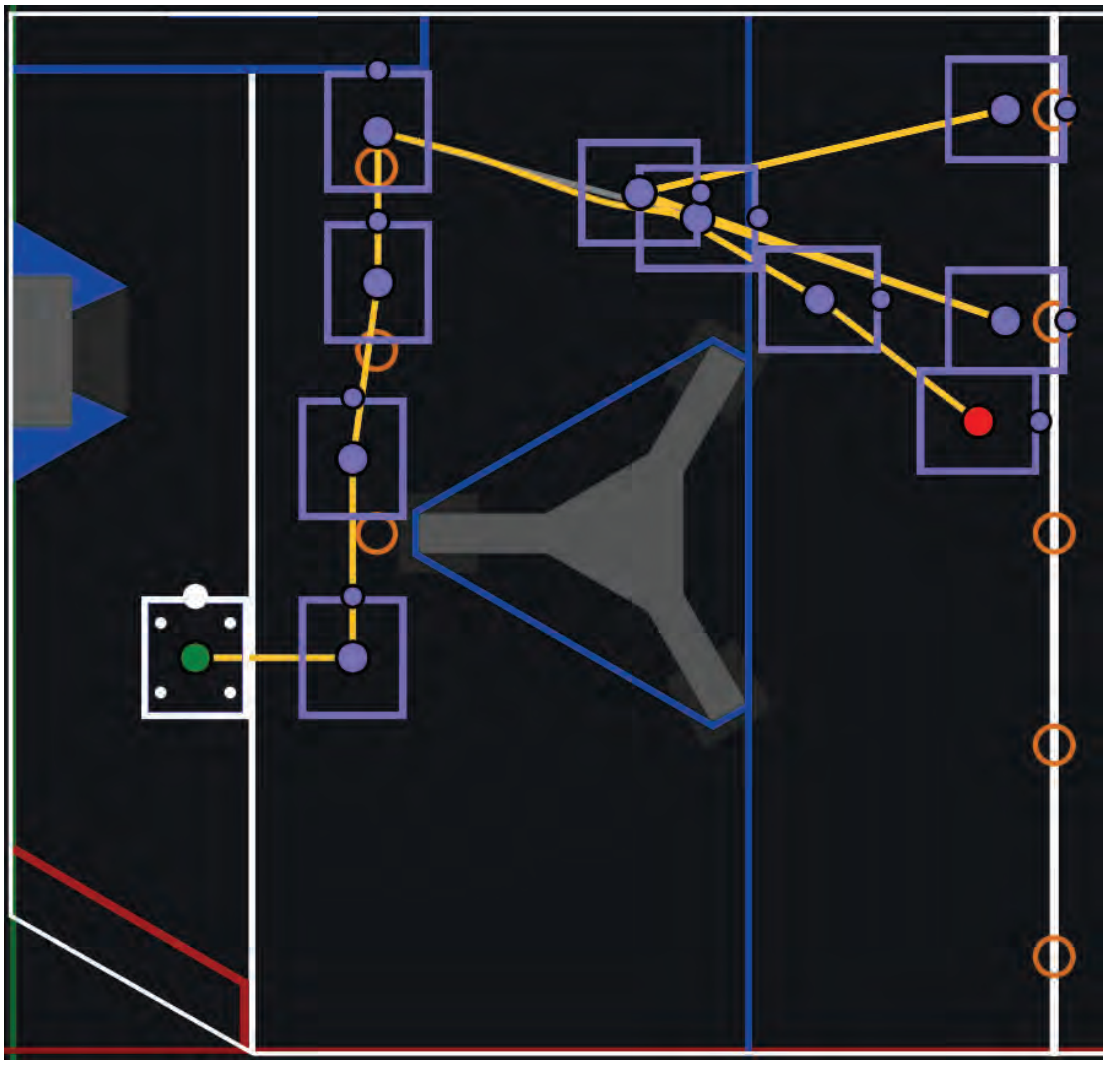
Hook Arms

- 1x1x1/16″ aluminum tubes
- Lifted by 15 lb gas springs
- 3/16″ thick aluminum Hook Plates with long alignment leading edge

Gearbox

- 1 Kraken powers 1/2″ hex spool/jackshaft via 11:40T then 14:42T 20DP gearbox
- Kraken brake mode keeps Arms down during match and after match ends

AUTONOMOUS

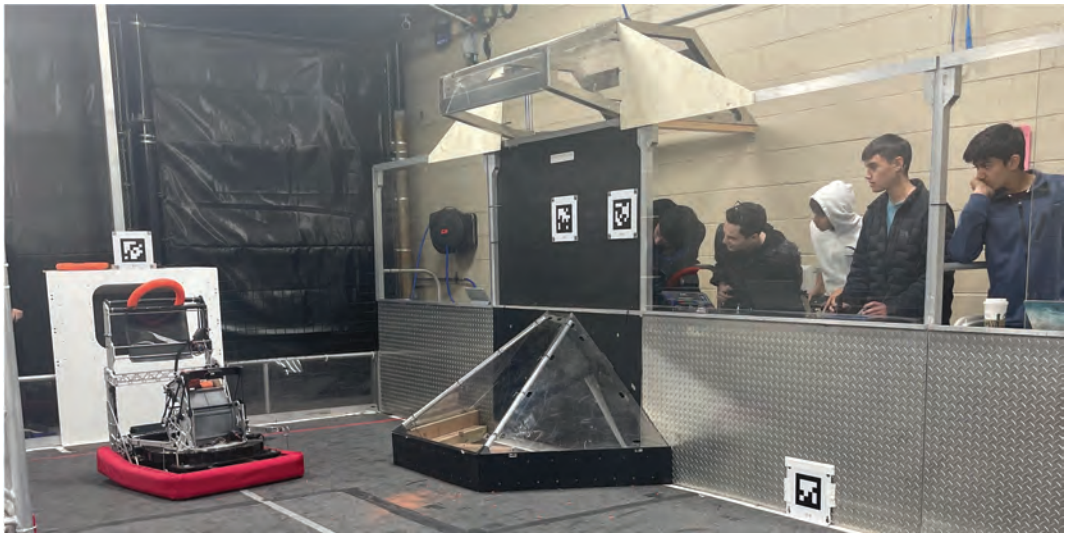


During the 15 second autonomous period, the robot follows one of our several routines to score as many Notes as possible. Different permutations allow for working with Alliance Partners or avoiding opponents when racing for midline Notes.

Path Generation

- Generated using Sleipnir Group's Choreo
- PathPlanner's library enables use of event markers with Choreo's trajectory
- Optimized to minimize curvature changes to limit wheel slip and inaccuracies

TELE-OP



The software helps the drivers to maximize their points during the teleoperated portion of the match by providing smooth and accurate controls. Automations for shooting and climbing reduce driver alignment burdens.

Driver Simplicity

- Driver is able to fully control intaking and shooting to ensure perfect pickup and release timing
- Operator controls the mode of the robot: Speaker vs Amp vs Climb
- This ensures effective control of the robot by eliminating communication barriers between Operator and Driver

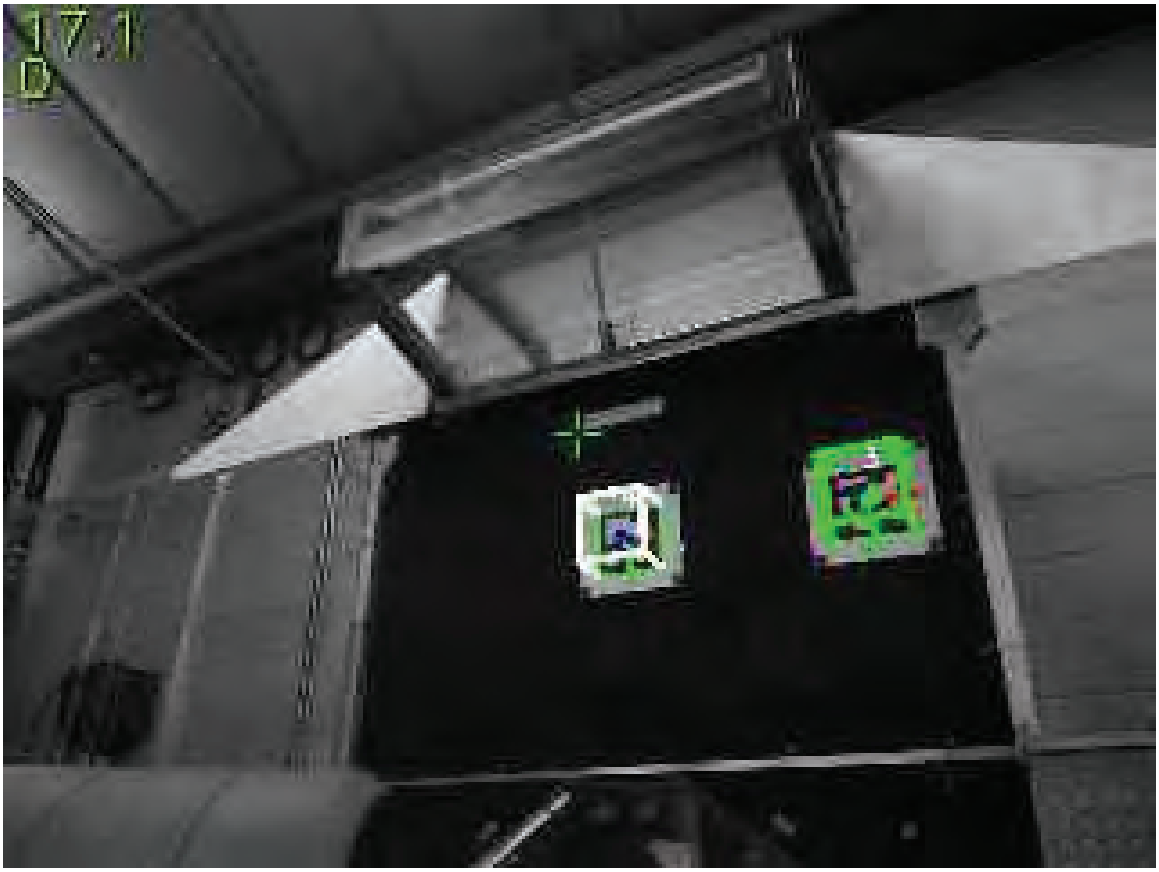
Shooting

- Shooter uses projectile motion with robot motion and gravity compensation to accurately deliver Notes to the intended location
- This intended location can vary depending on driver intention and strategy

Controller

- Standard field-centric swerve controls using odometry and vision to localize
- Velocity and acceleration constraints on Drivebase prevent wheel slip for more controlled movements
- Heading controller maintains robot direction and snaps to desired directions
    - Computes desired position and works backward to determine individual module states, reducing skew while simultaneously rotating and translating

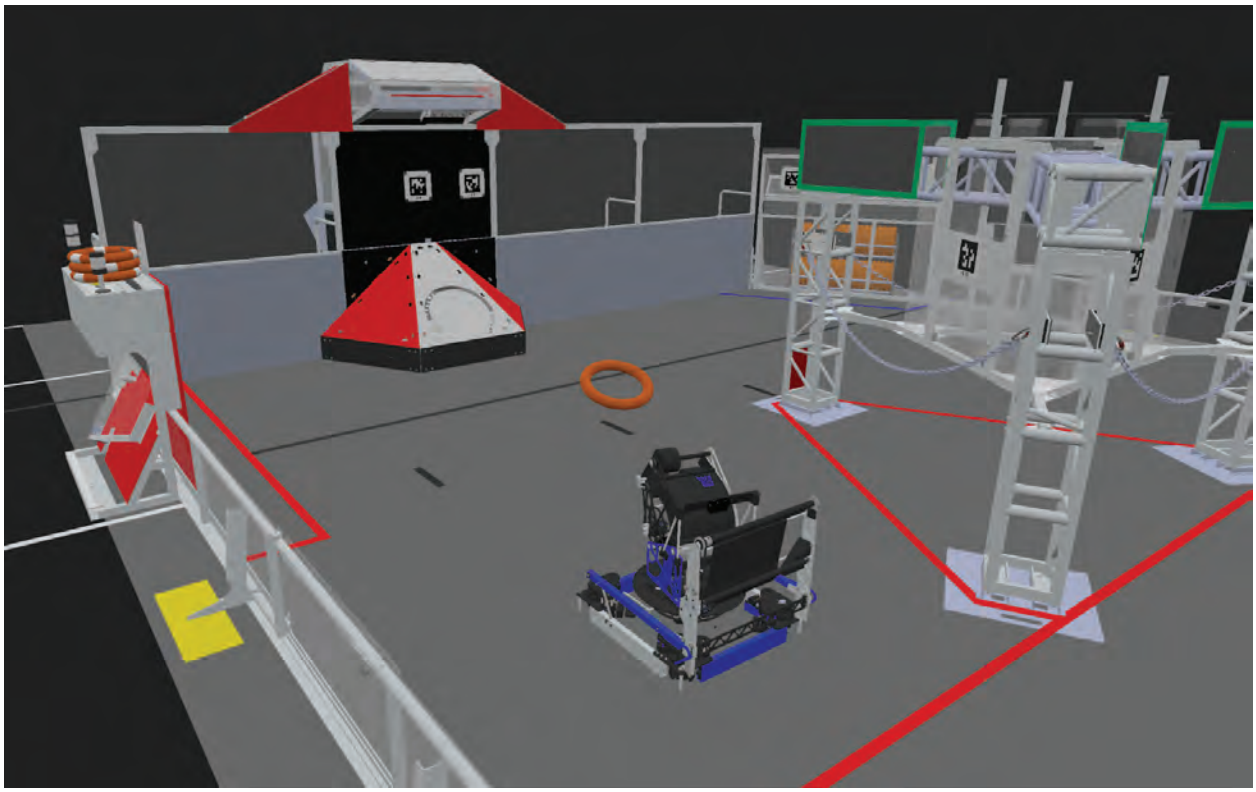
LOCALIZATION



To enable various functions such as accurate shooting or a rapid passing strategy, it is important for the robot to know where it is on the field. Using a Limelight camera and the field's April Tags, we localize the robot using 2 methods:

- When near Speaker:
    - Solve PNP for full robot pose estimations when we can see the 2 tags
    - This fixes gyro misalignments from initial robot placement or gyro drift
- When farther from Speaker:
    - Pinhole model estimates distance from target, and infers location from Turret and gyro angle
    - This method is less error prone than Solve PNP and allows for more accurate placement relative to the Speaker
- A Kalman filter (part of WPILib) updates the pose, with certainties based on estimation type and distance from target

SIMULATION



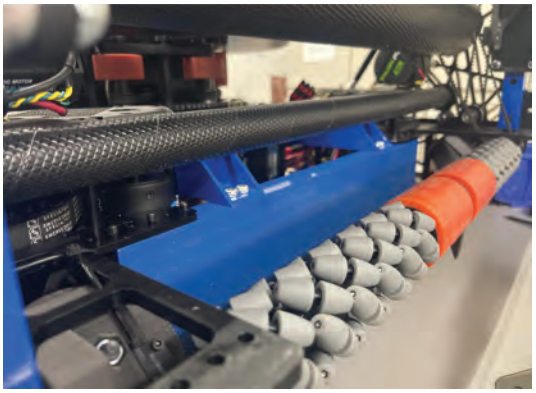
New this year, the team utilized Advantage Scope to simulate subsystem movements and test new software, especially autonomous paths, without the need for the robot.

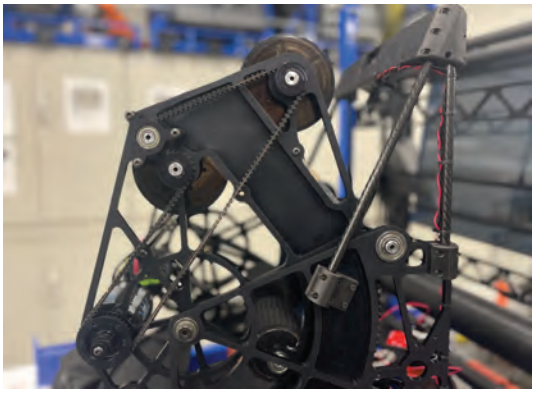
Advantage Scope Features

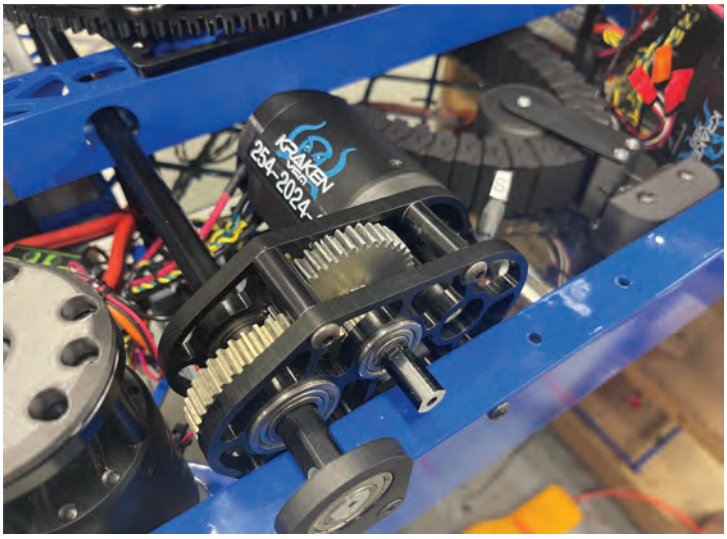
- Storing robot logs and visualizing data
- Live robot telemetry to improve vision accuracy, including physics projectile simulation of Note shots
- Iterating on autonomous routines

Accuracy

- Imported robot 3D model with fully articulating Turret, Hood, Amplifier, and Climber for visualization
- Subsystems complete with masses, moments of inertia, and gear ratios






KRAKEN
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