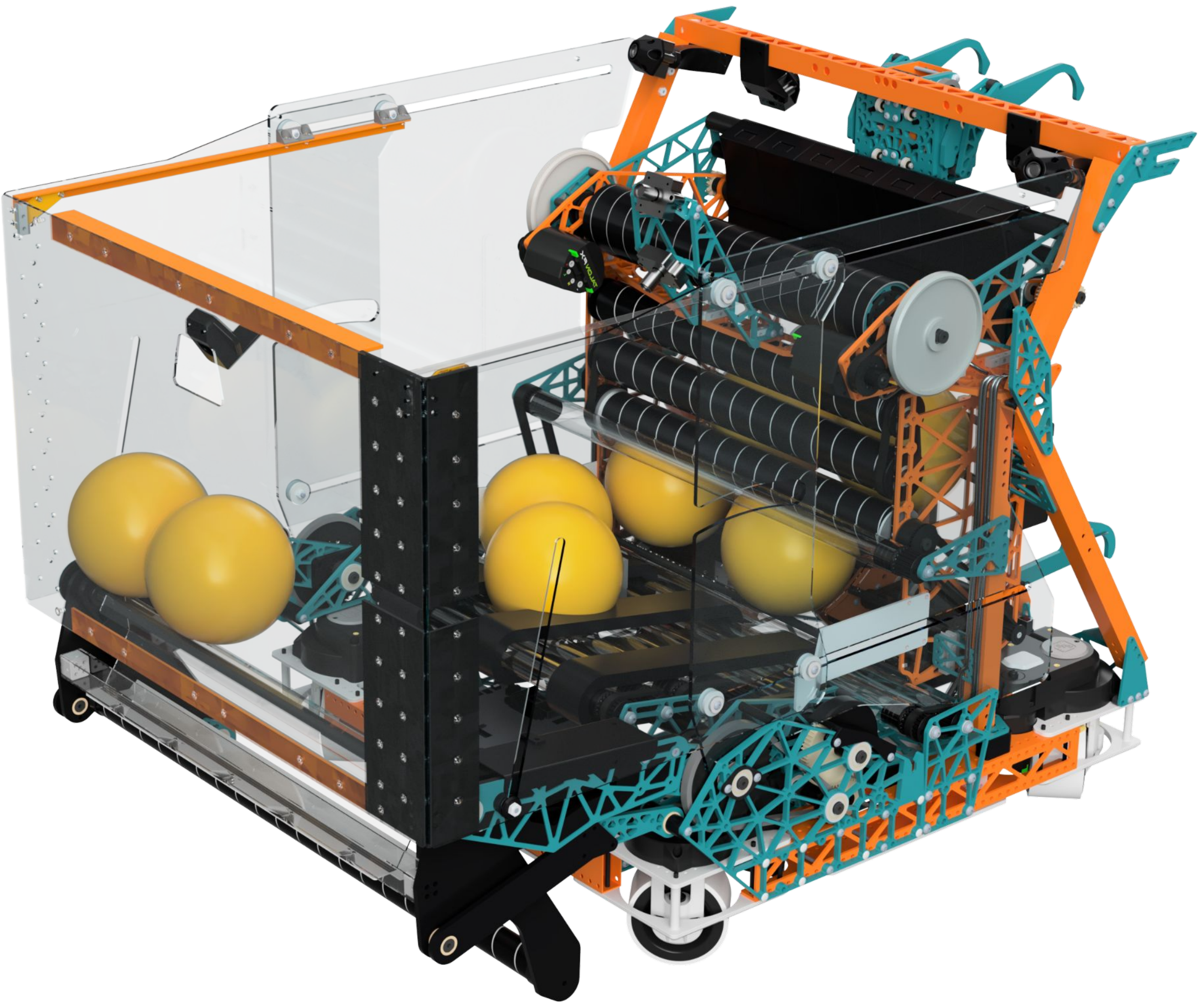
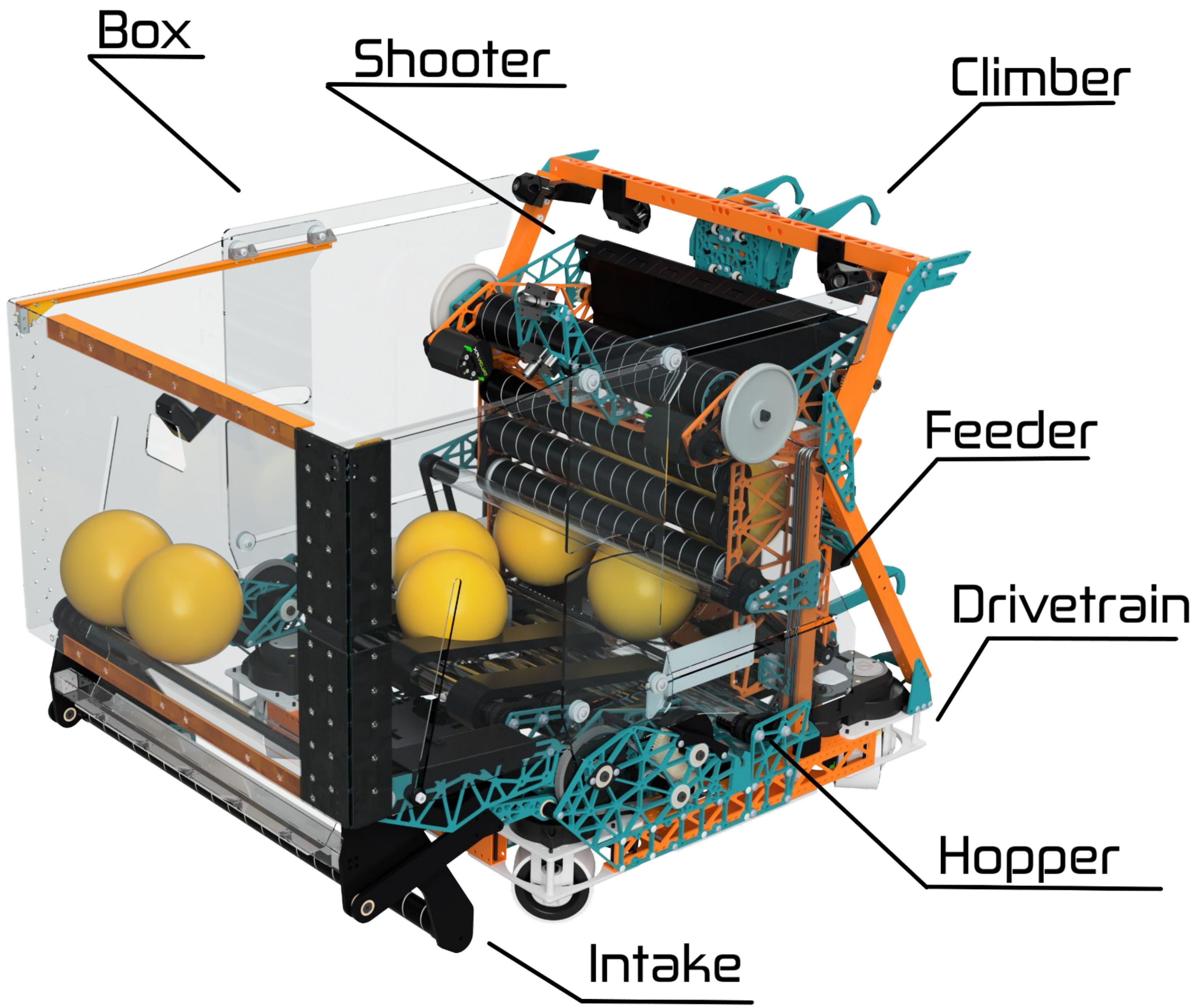
# SANDSPIT



# 2026 Rebuilt Tech Binder

# Table of Contents

# Final Design



# Game Analysis

In the early stages of our analysis, we discovered that capacity is critical to maximize active scoring time. The goal is to control most of the fuels on the field, and having a large capacity allows teams to take full advantage of the high concentration of center balls.

- Autonomous this year will require robots to rush to the center, taking multiple trips to get fuels
- Climbs are worth a minimal number of points compared to the potential fuels scored in the time it takes to climb.
- This means that time may be better spent continuously cycling and scoring rather than going for a high endgame

To win games of REBUILT, you have to:

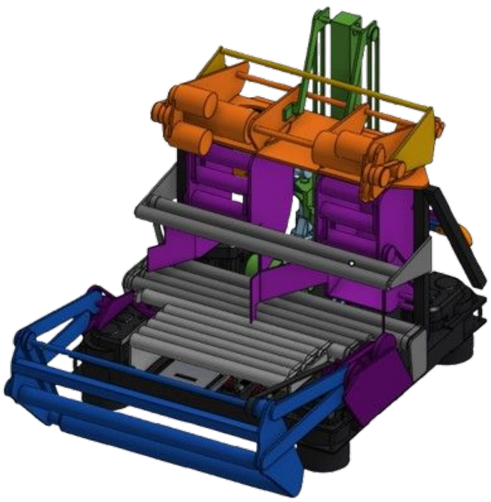
- Maintain center field control and keep fuels on your side at all times
- Disrupt opponents strategy by creating chaos and poaching fuels via defense
- Maximize fuel collection per trip to make cycles more efficient and continuous
- Minimize the amount of time wasted

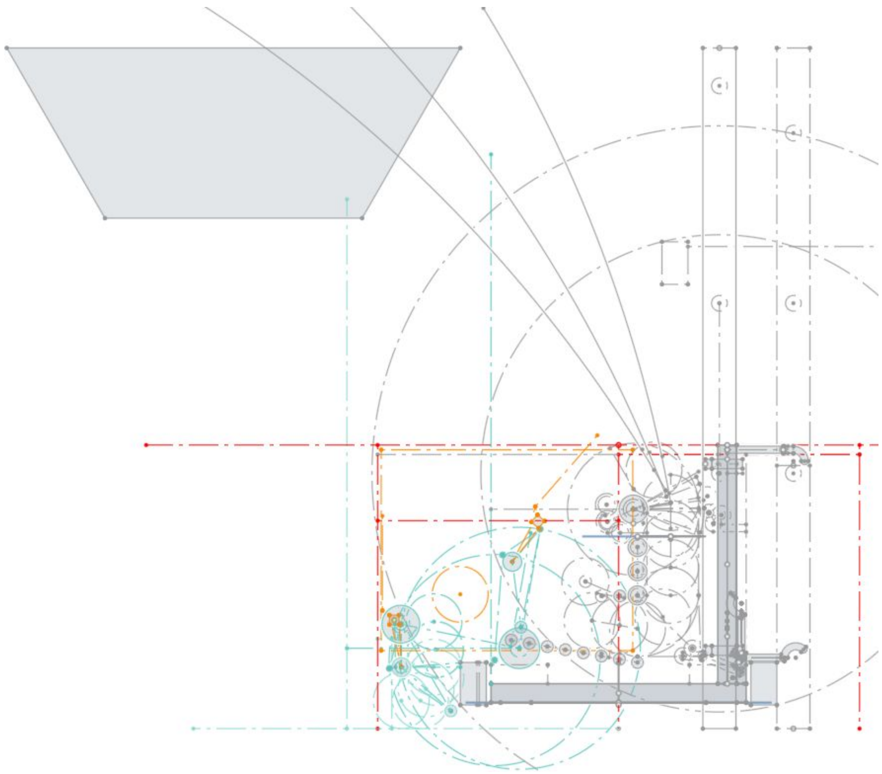
# Wish Prefer Demand

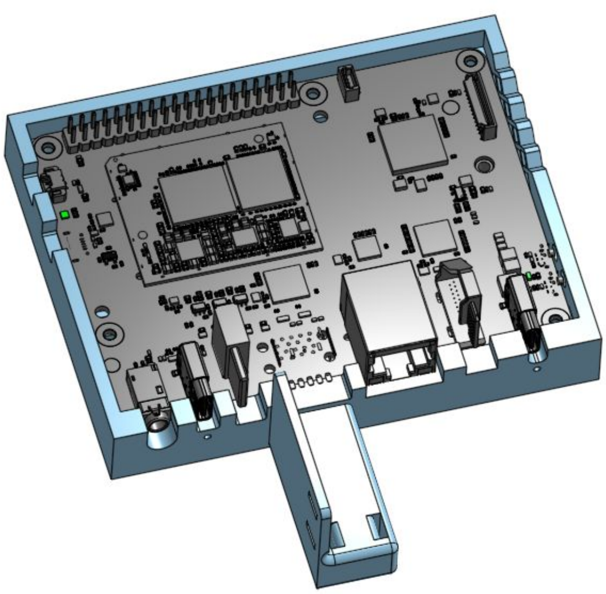
At the beginning of the season, as soon as we finish reading the game manual, we have a tradition of generating a Wish Prefer Demand (WPD) list. This list is generated based on criteria we believe are required to have a successful season (winning). This list outlines the priorities of certain actions that can be performed in a match. For example one of our highest priority items (Demand) is being able hold a lot of game pieces, while one of our lowest (Wish) is being able to drive under the trench.

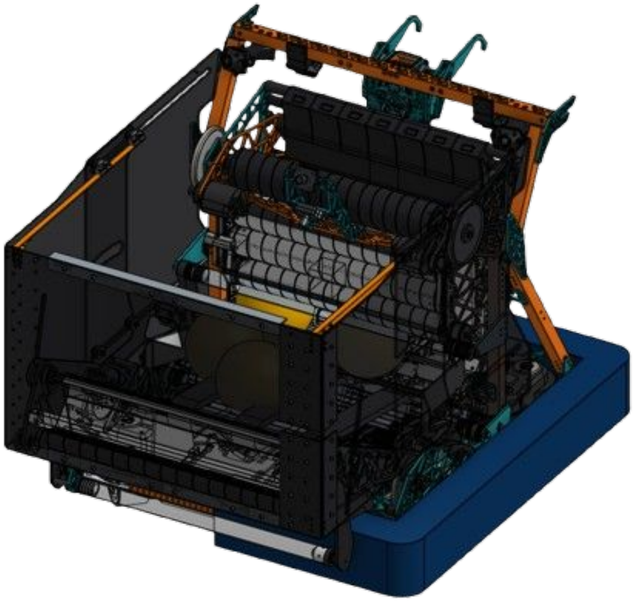
| | |
|---|---|
| Drive | DEMAND |
| Shoot and intake in independent directions dynamically | PREFER |
| Hold at least 8 fuels for preload | DEMAND |
| Shoot while moving | PREFER |
| Holding a lot of fuels (entire robot is a hopper) | DEMAND |
| Hold fuels (half full) | DEMAND |
| Index fuels into scoring mechanism | DEMAND |
| Holonomic drive (any direction) | DEMAND |
| Drive over BUMP | DEMAND |
| Fit under TRENCH | WISH |

# Design









# Subsystem Strategy

**Drivetrain:**
- **Withstand impacts**
- **Able to drive over bump**
- **Robust structure to support subsystems**

**Intake:**
- **"Touch it own it" intake allowing continuous flow of fuels**
- **Able to index fuels further into the robot**

**Hopper:**
- **Quickly transfer fuels from front to back without any fuels spinning idly**

**Feeder:**
- **Quick vertical transfer of fuels from Hopper to Shooter**
- **Acceleration reducing shooter load**

**Shooter:**
- **Able to shoot rapidly**
- **Shoot from any distance in our zone**

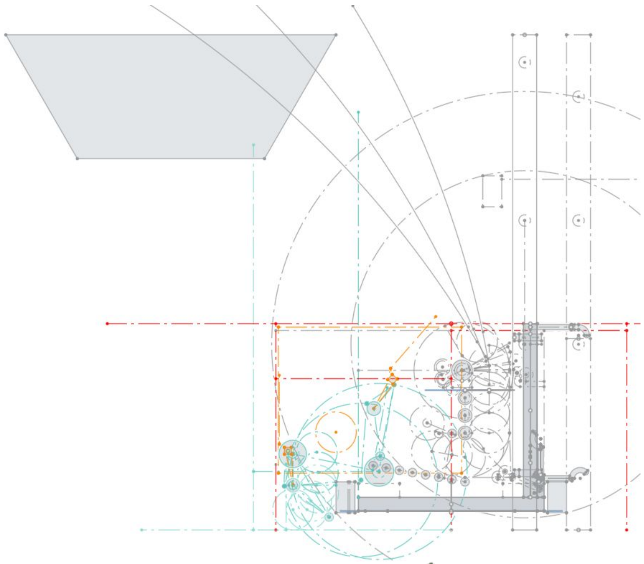
**Climber:**
- **Climb to L1 in a repeatable manner**

**Box:**
- **Smoothly move in and out and hold as many fuels as possible**
- **Able to assist in pushing fuels towards feeder**

# Prototyping

After outlining the goals for our robot, we begin brainstorming ideas of mechanisms that we believe will most efficiently accomplish our goals. Then, with these ideas, we test them. This season we utilized configurable 8020 extrusions, CNC routered wood plates, and 3D printing to greatly increase our prototyping efficiency.

# Design Process



**Master Sketch:**
**Includes key geometry such as rollers and ball path**

**Block cad:**
**Details overall 3d design, allows us to create interface points that packages without interference**

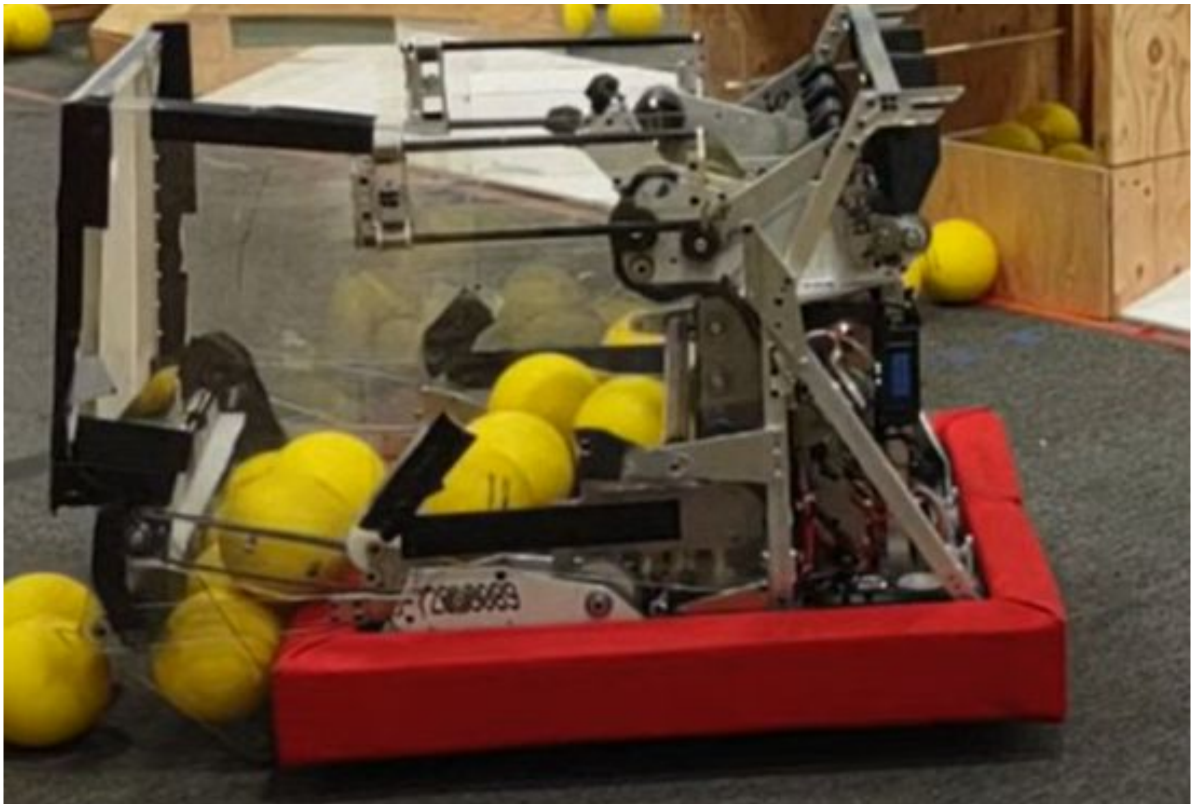
**Detailed Cad:**
**Derived block cad for designing final subsystems, then reassembling to check interferences and dependencies. All designs are peer reviewed followed by mentor review.**

# Revision 1


## What we learned:

- Box needs to have multiple points of rolling contact to prevent any binding
- Intake needed to have more compression
- Double shooters did not provide enough fuel output
- Climber hooks need to have more rigidity
- Feeder needs to accelerate fuels fast and smoothly

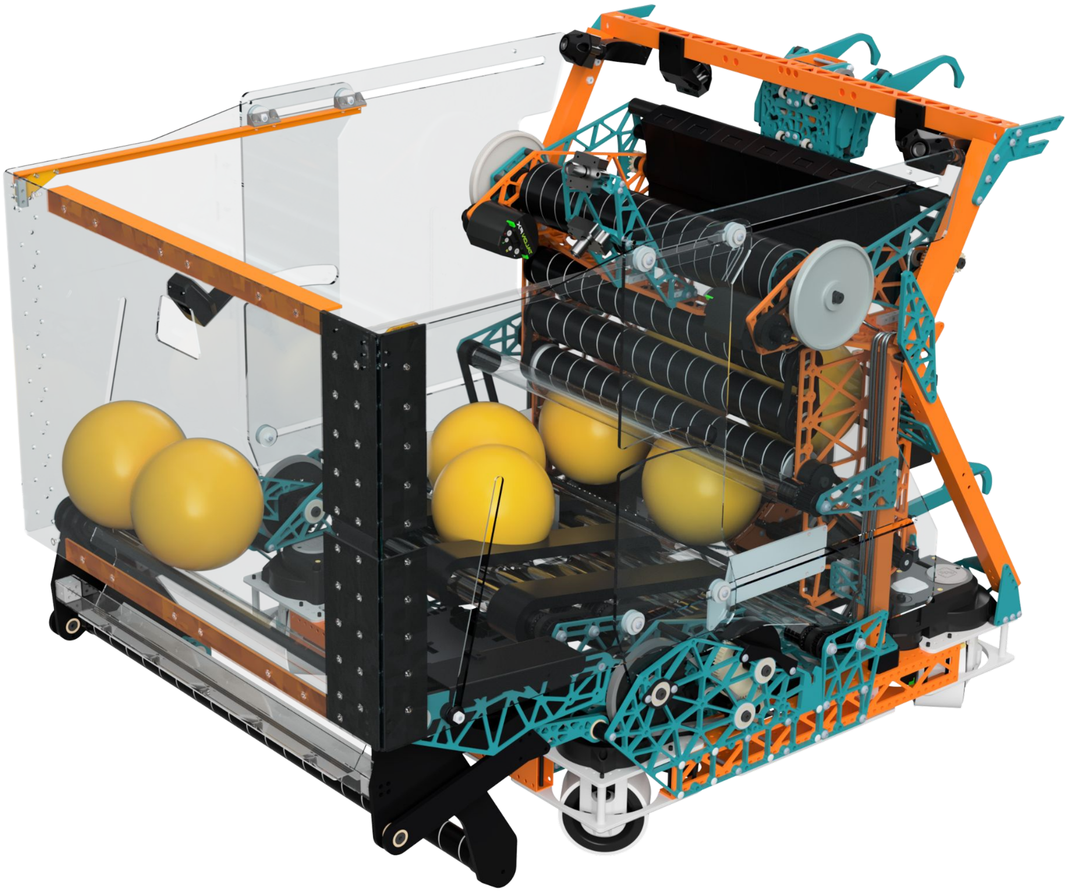
# Revision 2



**What we learned:**

- **Divider walls on a triple shooter cause jams**
- **Fuels resting on the intake roller also causes jams**
- **Intake needs more torque**
- **Foam intake rollers compressed and shrunk causing inconsistencies**
- **Angled hopper for quicker fuel transfer**
- **Further attachment points to prevent cantilever for the box**

# Revision 3



## Final Design:

After our first two revisions we landed on a final design for this competition. This design minimized any jams with the drum shooter design (no divider walls), maximized intake efficiency (double motor and hard polycarbonate rollers), eliminated box binding (scotch yoke setup), and increased fuel throughput (angled hopper rollers). There is always room for improvement, we are continually revising this robot.

# Design Features

**Drivetrain:**

- 27" x 27" perimeter for maximum ball capacity
- 2" x 2" side driverails for integrated gearboxes

**Intake:**

- 4 bar style linkage to pivot up and down
- Able to push balls into feeder to increase FPS (fuel per second)

**Hopper:**

- 10° slant to improve FPS
- Optional "Cleated" belts on top of rollers to agitate fuels towards feeder

**Feeder:**

- 19" wide "Drum style" feeder to bring fuels to shooter

**Shooter:**

- 3" diameter drum roller to shoot fuels with custom 5" OD flywheels on each end

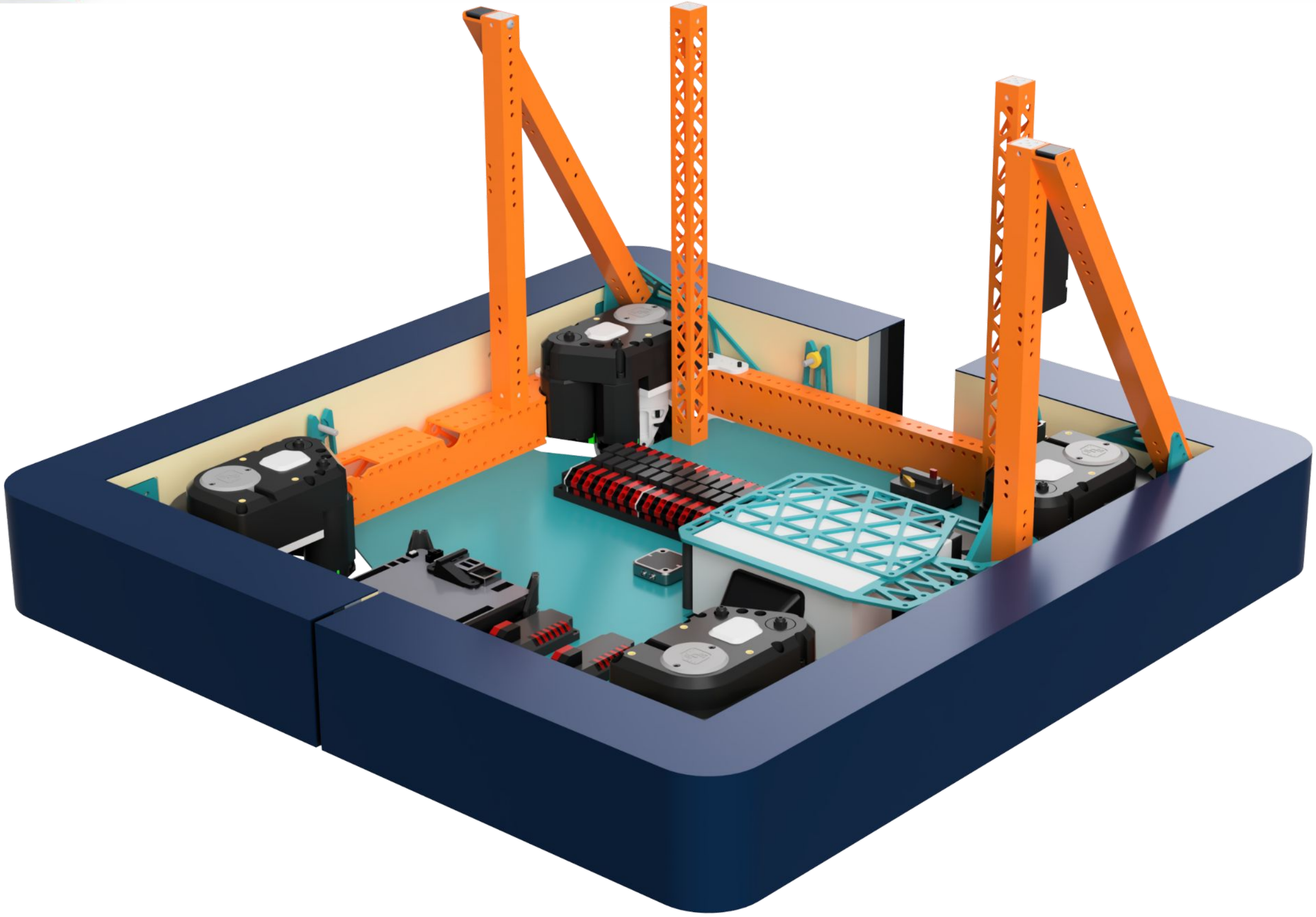
**Climber:**

- Hooks that fold down to stay within frame

**Box:**

- ~70 fuel capacity

# Drivetrain



**Features:**

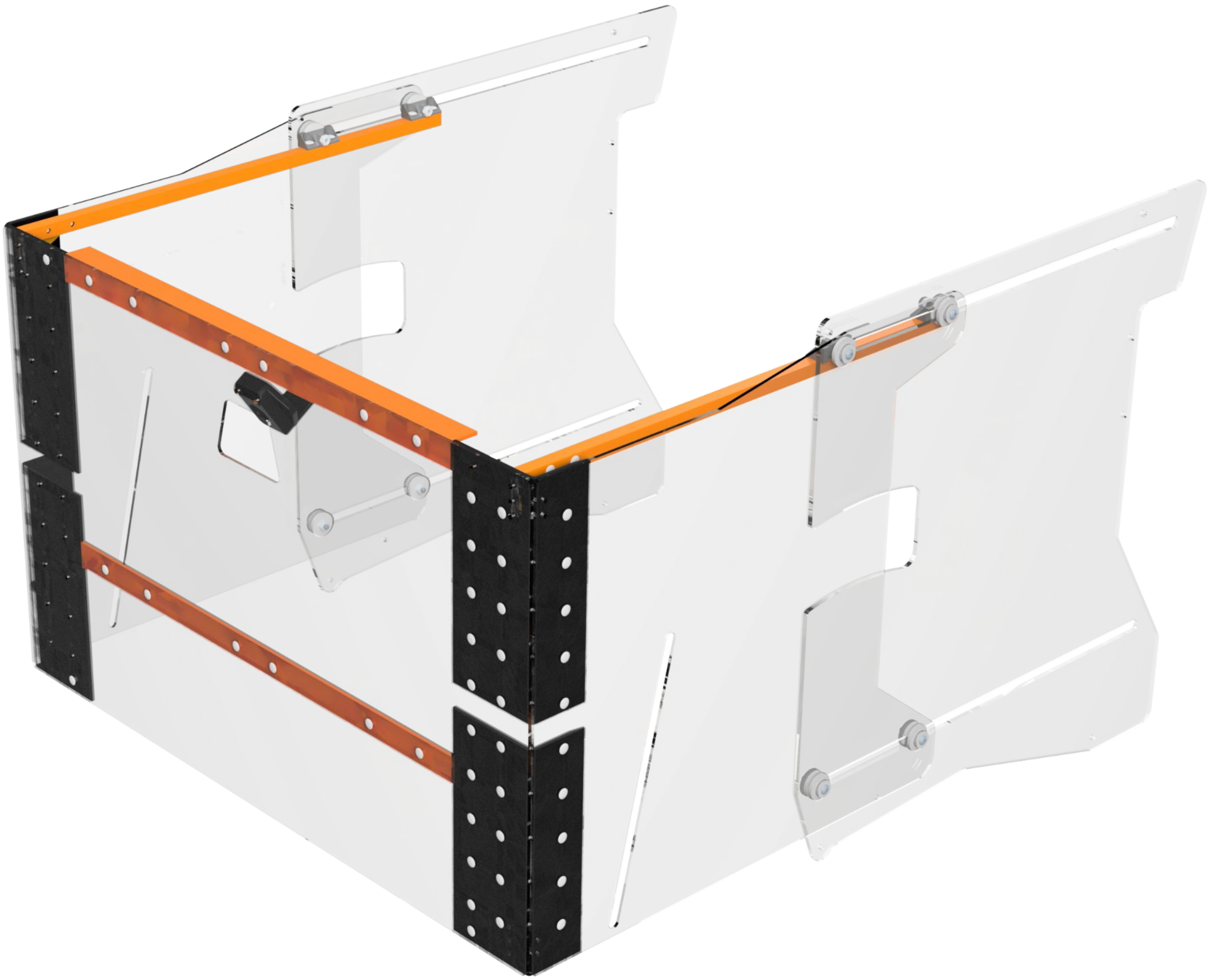
- 38 lb drivetrain (including electronics)
- 27" x 27" frame with 2" x 2" side drive rails for integrated gearboxes to maximize packaging
- 1/16" Thickness 2" x 1" box tubings for super structure rigidity
- 1/8" Thickness non-pocketed bellypan for ease of wiring and stability while driving
- L1 SDS MK5N swerves with lift kit
- 1678 style nut-in-pocket bumper brackets with split bumpers for easier mounting
- 4.75" bumper gap for climb

# Intake

**Features:**

- 13 lb Intake
- 2 Kraken x60 1.67:1 gear ratio rollers “Touch it own it”
- Pivot is geared to 39.51:1
- 2” OD Stub Rollers wrapped in CatTongue
- “Jack Shaft” to transfer torque to ensure both sides move together
- 24.5” usable roller width
- 4 bar linkage to maximize packaging and to push fuels into feeder
- Through Bore Encoder mounted directly to pivot point (1:1) to report the angle of the intake pivot

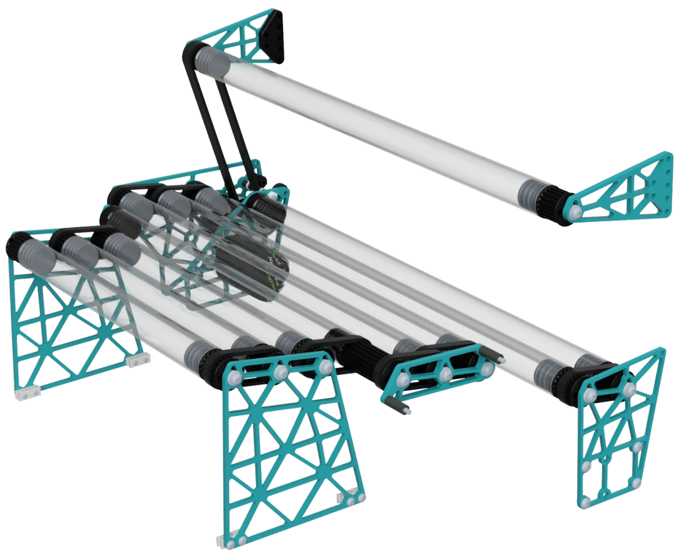
# Box



**Features:**

- **14 Lbs**
- **Horizontally extending box**
- **"Scotch Yoke" style slides to push intake in and out**
- **Slots with bearing pins to slide**
- **Actively deployed and retracted with the intake**
- **Frontal camera for driver view and fuel detection**
- **TPU corner brackets to absorb impacts**
- **Added stiffening rails on the side**

# Hopper

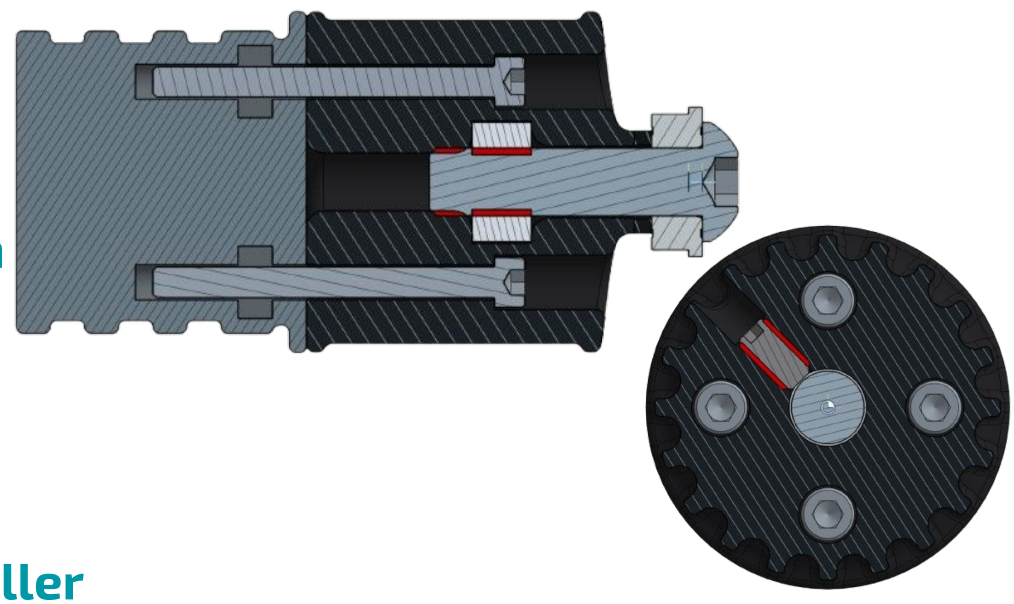


**Features:**

- 8 lb Roller floor
- 2:1 gear ratio with Kraken x60 with 1 ¼" OD polycarbonate rollers
- "Cleated" belts that agitate balls towards the feeder
- Custom lightweight 3d printed "coupler" stub rollers
- 10° slant

**Roller Features:**

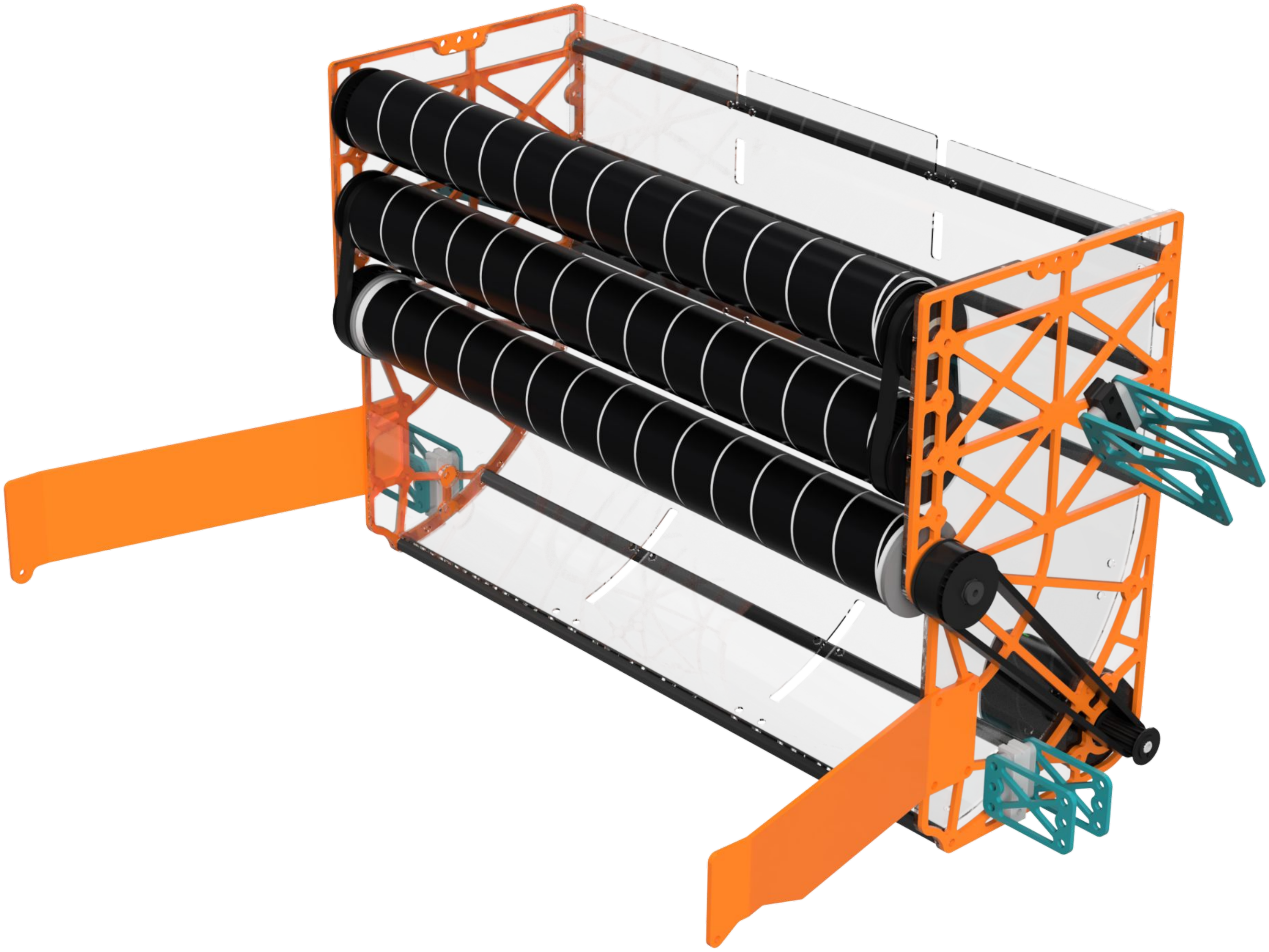
- ~.14 lbs per stub
- 50% lighter than WCP COTS stub roller



**Repairability:**

- Two part stub roller
- Epoxy plug with embedded 4-40 nuts for quick roller changes
- Pulley coupler with embedded ¼-20 nut for quick pulley changes
- Side set screws to prevent backing out of bolts

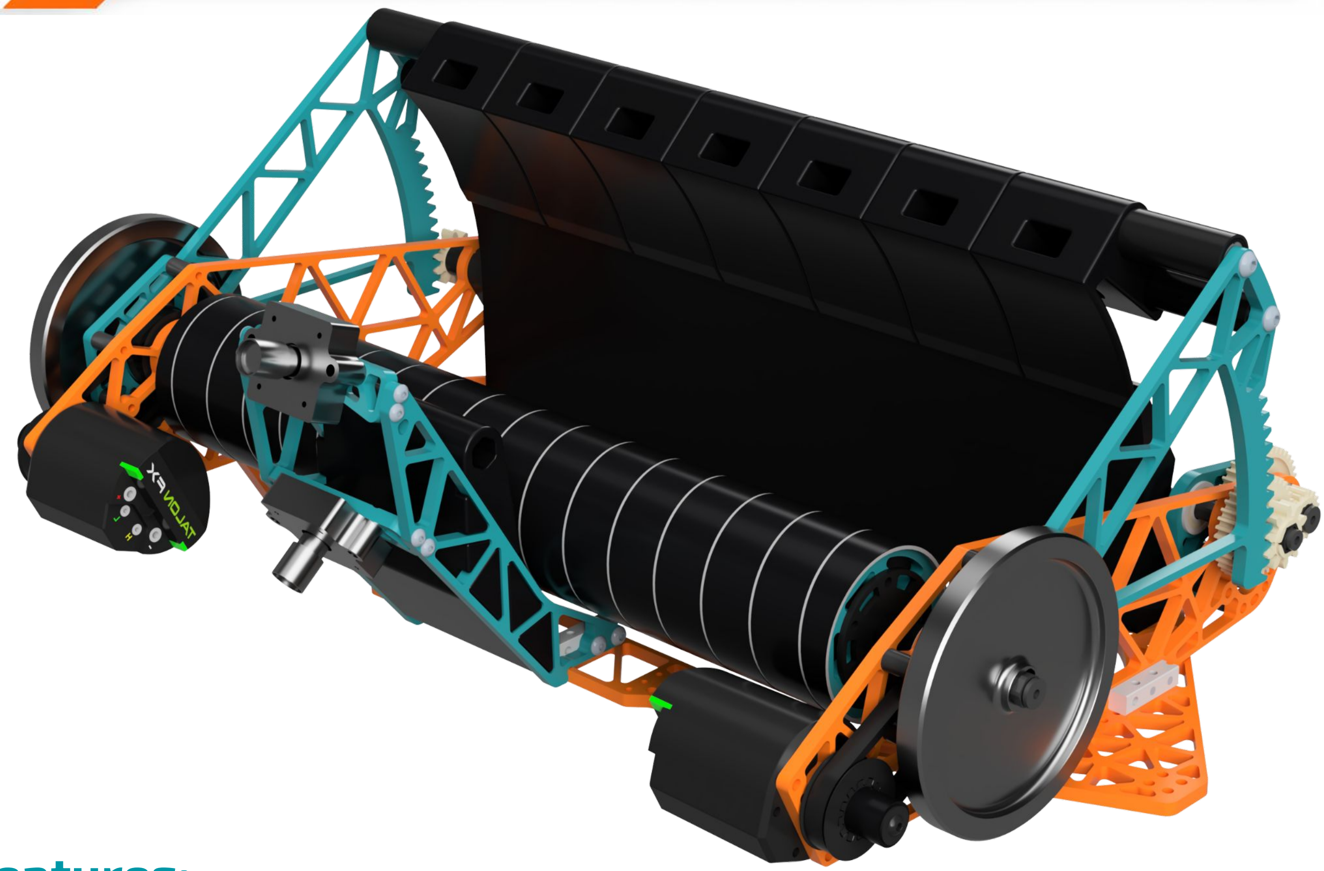
# Feeder



**Features:**

- **2" OD stub roller polycarbonate tubing with CatTongue**
- **Rollers powered with Kraken x60**
- **Gradually increasing gear ratio accelerating the ball**
    - **1:2 -> 17:12 -> 17:12**
    - **Ratio at final roller ~ 1:1**
- **8.4 lbs**
- **Passive side walls to funnel balls**
- **Smooth polycarb contacting ball preventing damage**

# Shooter



**Features:**

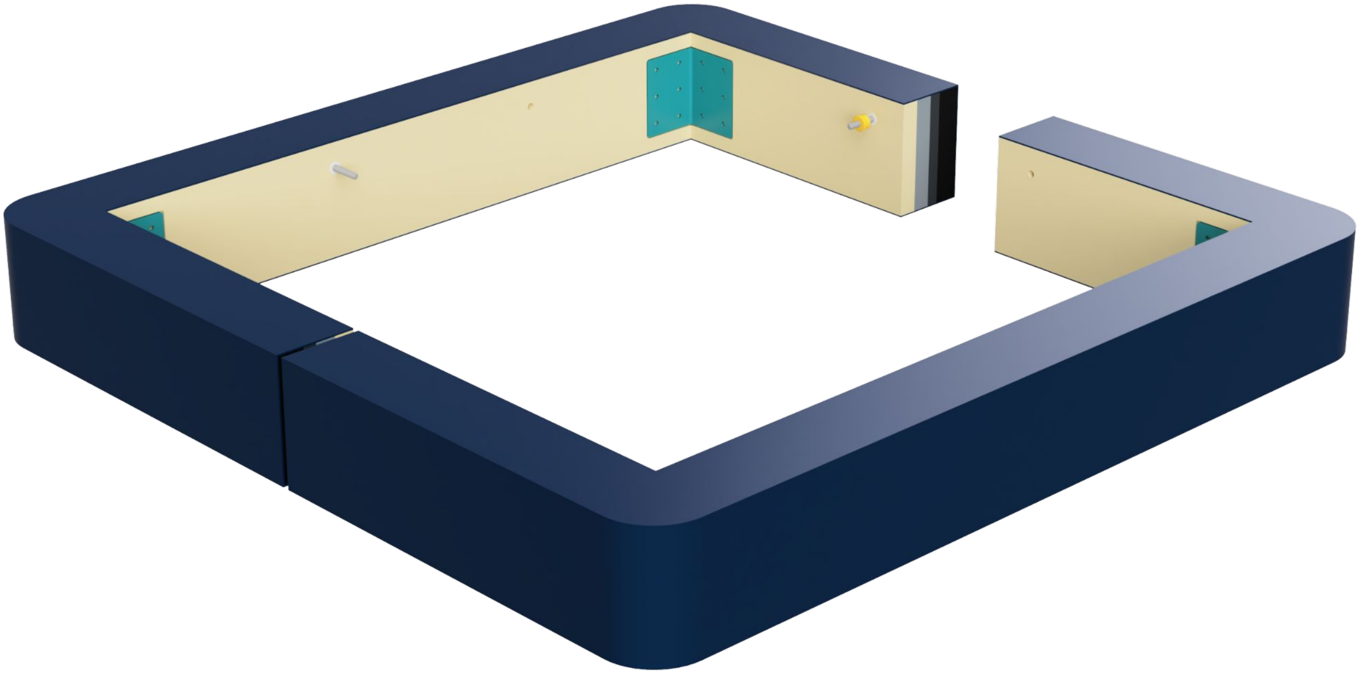
- 3” diameter aluminum drum wrapped in Cats Tongue for high throughput
- ⅝” compression
- Custom 10dp gear rack to drive hood
- Custom flywheel (manufactured in house)
  - Inertia comparison:
    - Ours: 5.1 in^2 - lb (1.16 lbs)
    - WCP: 2.7in^2 - lb (.98 lbs)
    - SDS: 4in^2 - lb (1.54 lbs)
- Adjustable hood with 1:150 gear ratio
  - 60°- 77° hood range
- Roller Gear ratio: 1:1
- Flywheel Drum powered by 2 Kraken X60’s
- Hood powered by Kraken X44

# Climber


**Features:**

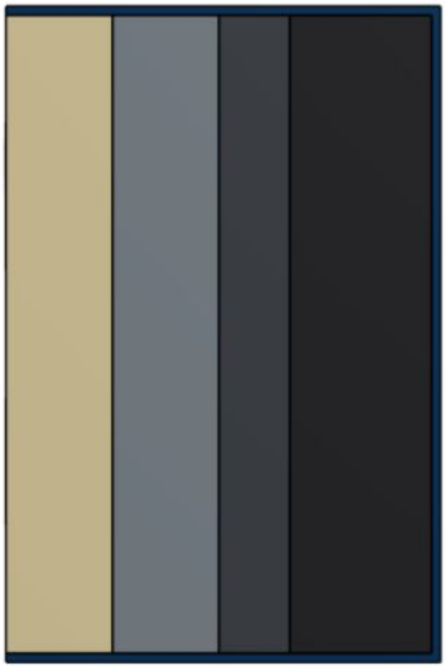
- 10.7 Lbs
- 25:1 max planetary with brake stage powered by Kraken x60
- Servo actuated bearing guide
- 3D print cam pushes hooks down for stow

# Bumpers

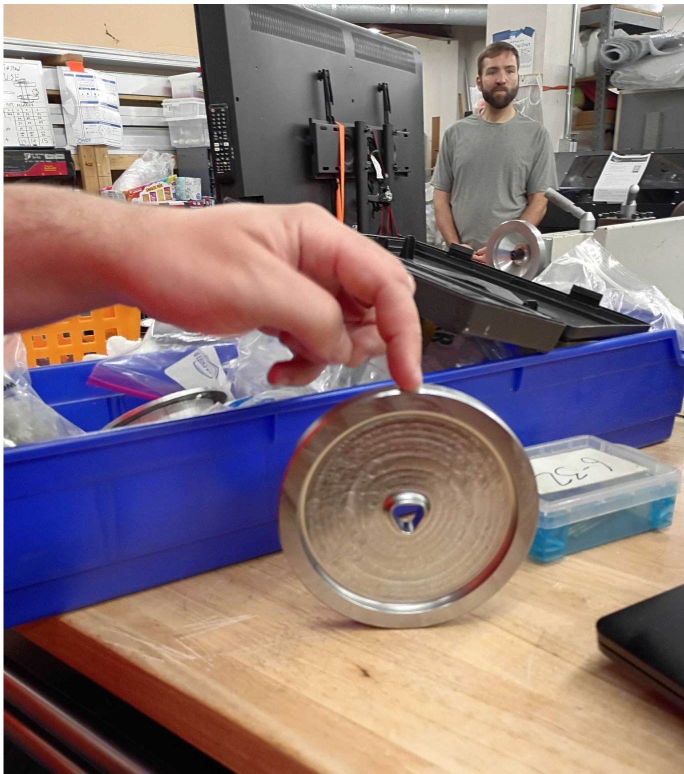


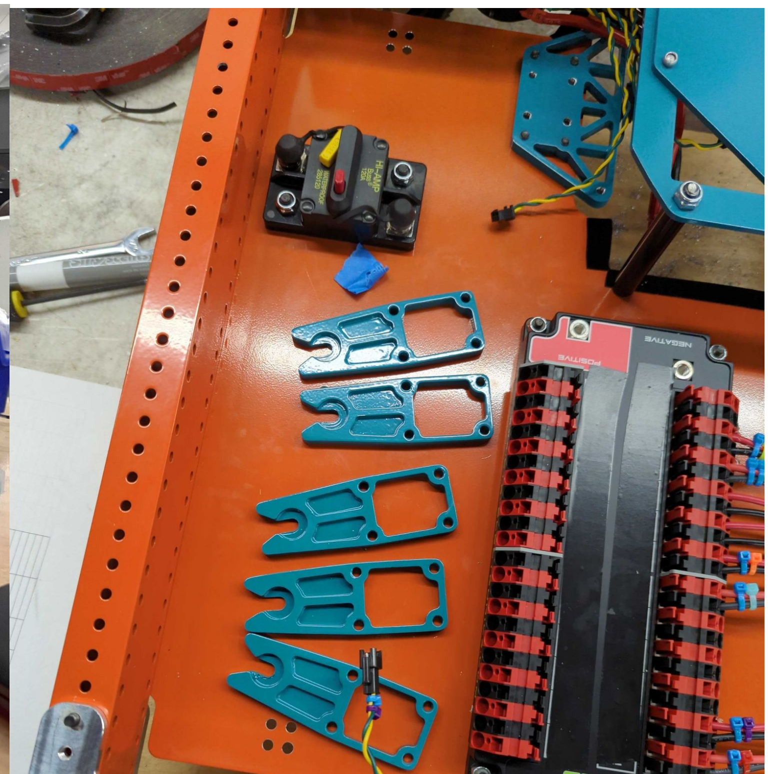
**Features:**

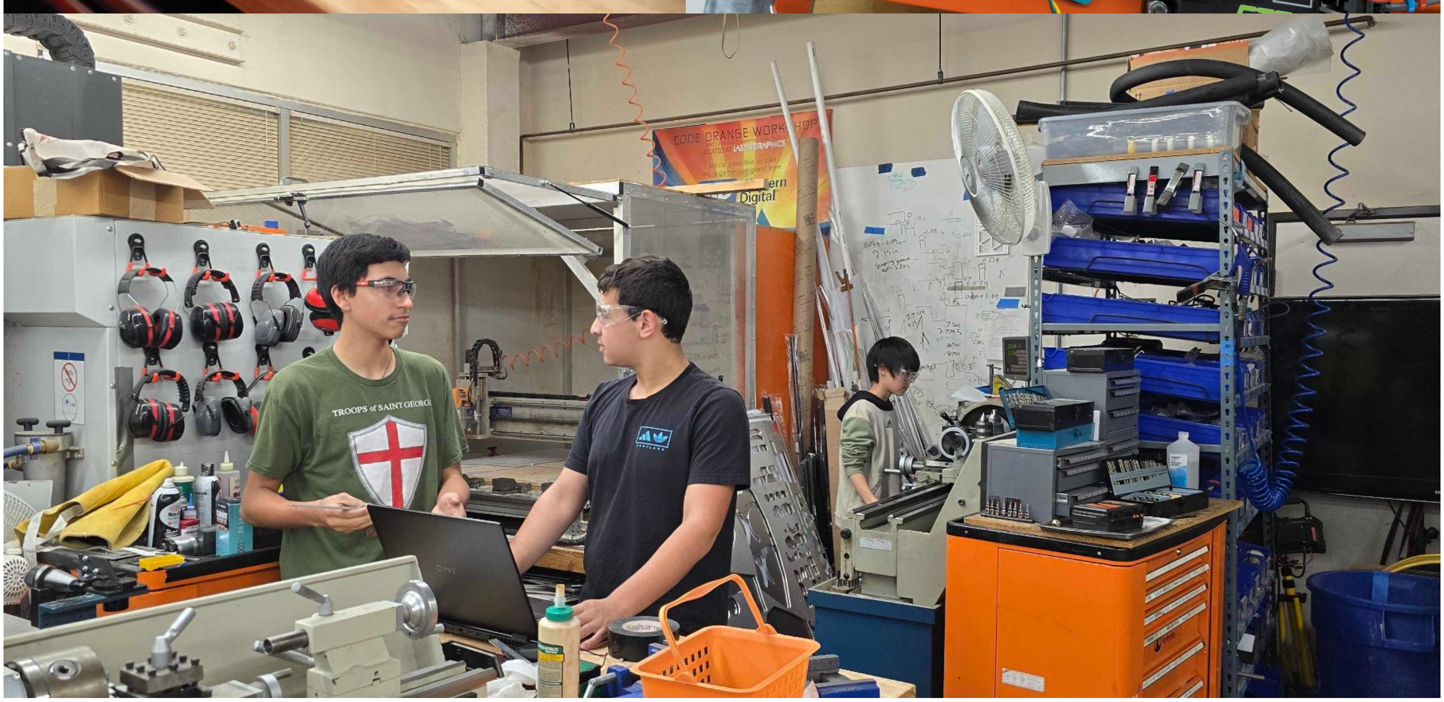
- **13 Lbs**
- **2 kinds of foam in 3 layers (¾" EVA foam, ½" floor tiles and 1" floor tiles)**
- **Bent Aluminum Sheet Metal Corner Brackets for strength and rigidity**
- **1678 Style Bumper mounting for efficient swaps**



# Manufacturing

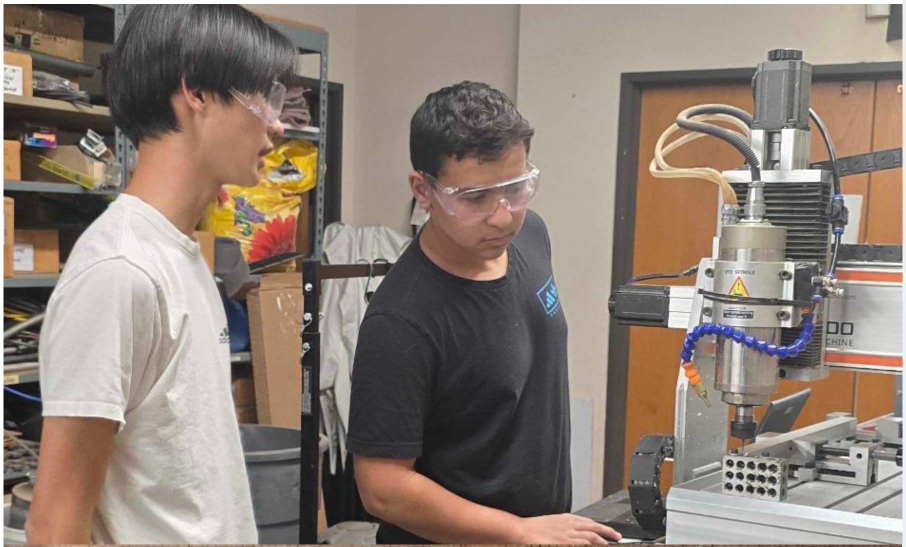


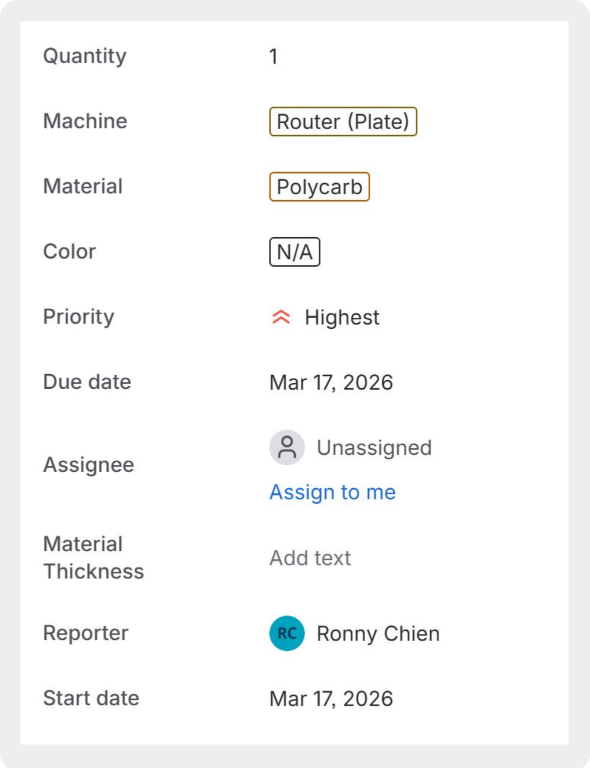


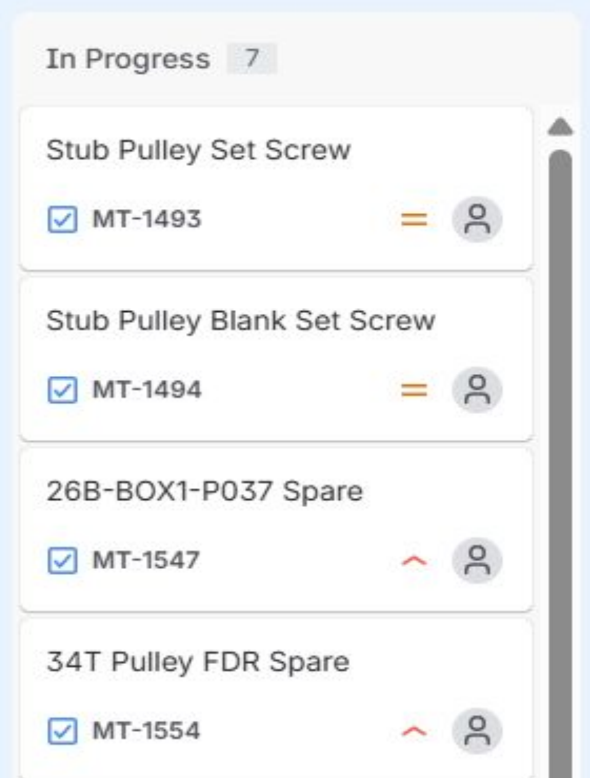


# Workflow

- We use the program Jira to track every part's status and to keep part files and drawings
- Parts are checked for accuracy by manufacturing leads





# Basic Manufacturing

## Creating aluminum and polycarbonate tubes and brackets

- **Miter Saw**
- **Band Saw**
- **Drill Press**

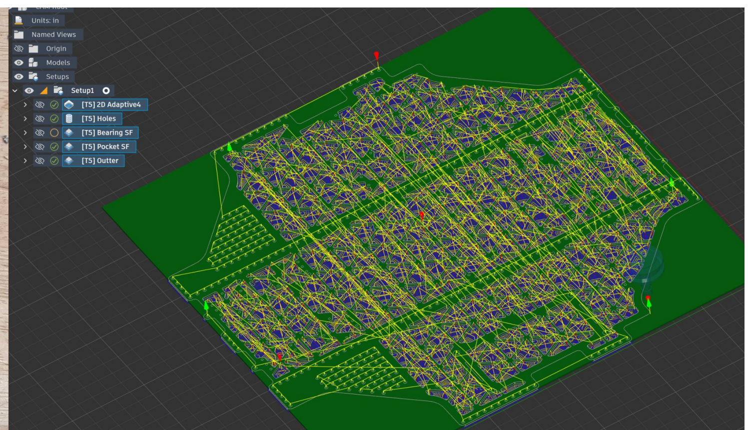

# Advanced Manufacturing

**Creating precise plates, tubes, and brackets in aluminum, polycarbonate, SRPP, carbon fiber, PLA, TPU, and steel**

- **Manual Lathe**
- **Manual Mill**
- **3D Printing**
- **Powder Coating**
- **CNC Router**
- **CNC Mill**

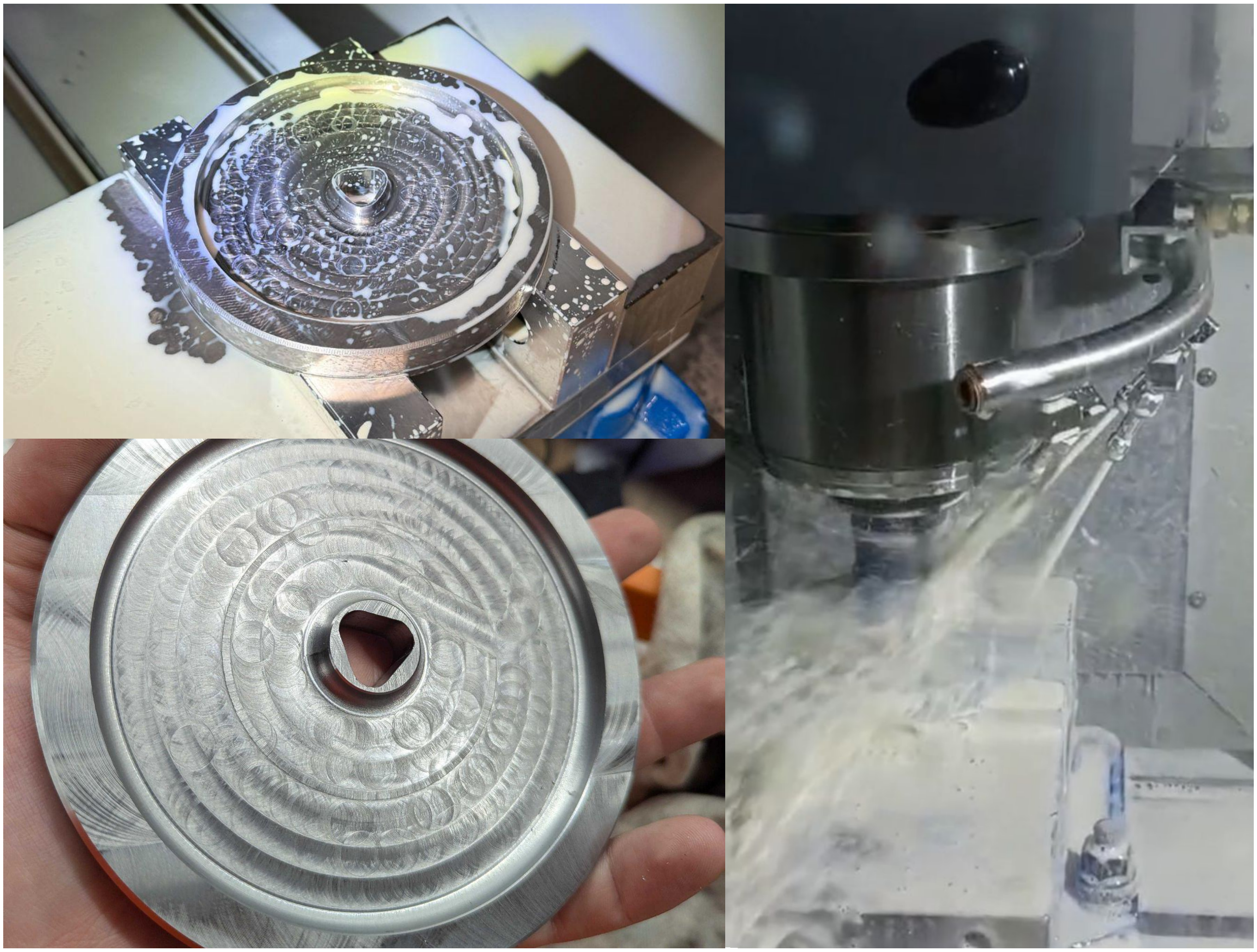

# CNC Router

- **Used for making different hole patterns/pockets/cutouts on box tubing.**
- **Cutting high precision robot plates with pockets and bore holes**
- **This season, we optimized feed rates and spindle speeds to cut production time by over 50%**
- **This season, we also pushed the boundaries of our machines to create parts with precise depth cuts**





# Haas CNC Mill



- **Steel flywheels are fabricated from mild, low carbon steel bar. They are designed, programmed, and manufactured by students on the Haas CNC. Days of planning and optimization are used to maximize the performance.**
- **Flywheel inertia comparison:**
    - **Ours: 5.1 in^2 - lb (1.16 lbs)**
    - **WCP: 2.7in^2 - lb (.98 lbs)**
    - **SDS: 4in^2 - lb (1.54 lbs)**

# Electrical

## Goals

*Create an electrical system that is capable of consistently running the robot.*

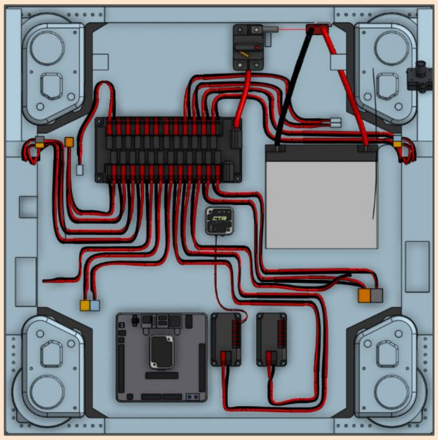
*The system should be:*

- **Simple to implement**
- **Easily serviceable**
- **Modular**

**These goals are reflected in our electrical system design choices.**

# Planning Process

## Computer Aided Design



## Spreadsheets

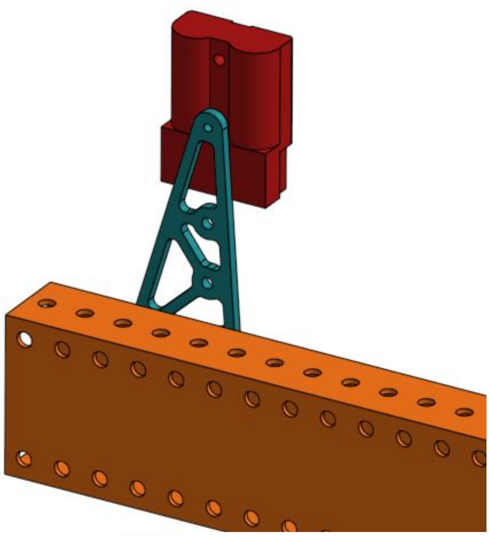
| | Port Number | Device | Colors | | Wire Gauge (AWG) | Fuse Amperage (A) |
|---|---|---|---|---|---|---|
| PDP | 0 | Shooter Hood | gold | rose | 12 | 40 |
| | 1 | RIGHT FLY | gold | orange | 12 | 40 |
| | 2 | BL DRV | blue | red | 10 | 40 |
| | 3 | BL STR | blue | purple | 12 | 40 |
| | 4 | Left Feeder | aqua | aqua | 12 | 40 |
| | 5 | Radio | lime | orange | 18 | 10 |
| | 6 | CMB 1 | rose | rose | 10 | 40 |
| | 7 | CMB 2 | rose | slate | 10 | 40 |
| | 8 | MitoCANdria | lime | white | 12 | 40 |
| | 9 | RIO | lime | lime | 22 | 10 |
| | 10 | Right Feeder | aqua | orange | 12 | 40 |
| | 11 | Hopper Roller | white | white | 12 | 40 |
| | 12 | BR DRV | blue | white | 10 | 40 |
| | 13 | BR STR | blue | slate | 12 | 40 |
| | 14 | L TOP FLY | gold | gold | 12 | 40 |
| | 15 | L BOT FLY | gold | aqua | 12 | 40 |
| | 16 | INT PIV | orange | rose | 12 | 40 |
| | 17 | FL DRV | blue | blue | 10 | 40 |
| | 18 | FL STR | blue | lime | 12 | 40 |
| | 19 | MPM R | lime | purple | 12 | 40 |
| | 20 | MPM L | lime | green | 12 | 40 |
| | 21 | INT ROL | orange | orange | 12 | 40 |
| | 22 | FR STR | blue | orange | 12 | 40 |
| | 23 | FR DRV | blue | aqua | 10 | 40 |

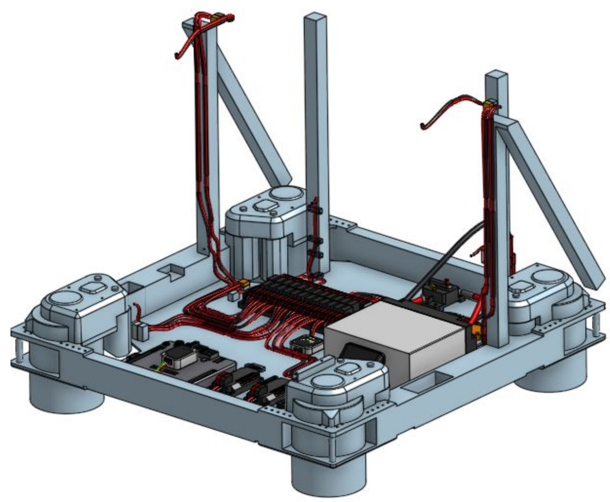
# Electrical

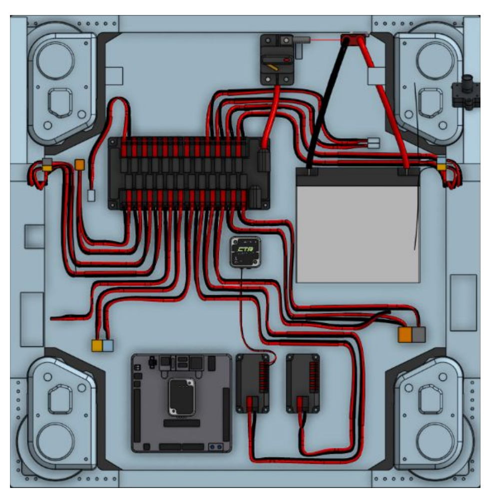
## PLANNING PROCESS

## Electrical-Design Integration

**Something new our team tried this year was adding our electrical system into the robot CAD. By pre-planning our wiring paths, our team was able to set up the electrical system more quickly and efficiently. This allowed for our robot to be finished faster and created more room to test and improve on our design. The electrical team worked hand in hand with the design team to also create various 3D-printed mounts that made the electrical setup more robust.**





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| | 22 | FR STR | blue | orange | 12 | 40 |
| | 23 | FR DRV | blue | aqua | 10 | 40 |

| MISC. Bus | | DRIVE Bus | |
|---|---|---|---|
| # in loop | Device | # in loop | Device |
| 0 | CANivore | 0 | CANivore |
| 1 | Intake Throughbore | 1 | **Front Right Drive** |
| 2 | **Intake Roller Motor** | 2 | Front RIght CANcoder |
| 3 | **Intake Pivot Motor** | 3 | **Front Right Steer** |
| 4 | **Hopper Roller Motor** | 4 | **Back Right Drive** |
| 5 | **Leftside Shooter Bottom** | 5 | Back Right CANcoder |
| 6 | **Leftside Shooter Top** | 6 | **Back Right Steer** |
| 7 | Left Feeder CAN-Range | 7 | **Climb 1** |
| 8 | **Left Feeder Motor** | 8 | **Climb 2** |
| 9 | **Right Feeder Motor** | 9 | CANdi 1 |
| 10 | Right Feeder CAN-Range | 10 | CANdi 2 |
| 11 | **Right Shooter Motor** | 11 | **Back Left Drive** |
| 12 | Hood Throughbore | 12 | Back Left CANcoder |
| 13 | **Hood Pivot** | 13 | **Back Left Steer** |
| | | 14 | **Front Left Drive** |
| | | 15 | Front Left CANcoder |
| | | 16 | **Front Left Steer** |
| | | 17 | Pigeon |

**Our team utilized spreadsheets to plan out our power distribution system and CAN bus.**

***The power distribution plan included:***

- **Port number on the Power Distribution Panel**
- **Device**
- **Wire size**
- **Breaker/fuse amperage**
- **Color code**

***While the CAN bus plan included:***

- **CAN device**
- **Order of devices in CAN bus**

**This organization allowed us to streamline our wiring process by working more efficiently by following a plan. The planning document also serves as a reference guide should we need to make repairs, helping to ensure that our entire robot is easily serviceable.**

# Electrical

## Important Components

***Motors:***

- **10 x Kraken X60**
- **6 x Kraken X44**


***Sensing:***

- **CTRE Pigeon (accelerometer, gyroscope, magnetometer)**
- **4 x CTRE CANcoder**
- **2 x CTRE Throughbore Encoder**
- **5 x ThriftyCam (camera)**

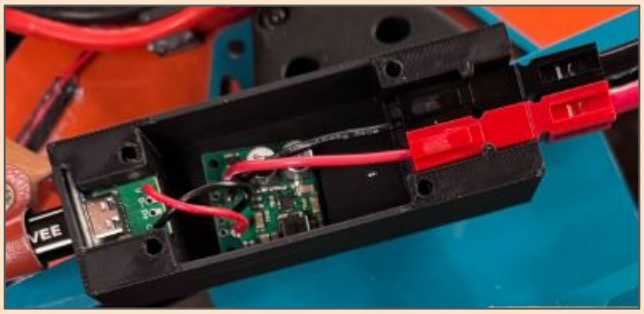

***Control/Processing:***

- **roboRIO**
- **2 x RubikPi**

# Electrical

## Notable Features

### *Powering the RubikPi's*



**The computers we selected required that they be powered via USB-C with 12 volts. The solution we devised was to use a voltage regulator chip (from Pololu) soldered to a USB-C connector board, all wrapped up in a 3D-printed case. The entire setup was designed and created in-house.**

### *3D-Printed Wire Guides*

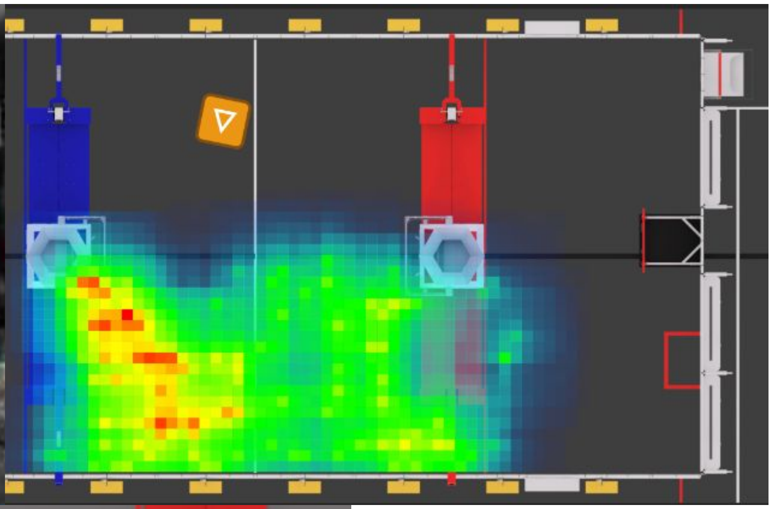
**Rather than using zip ties to secure our wires, our team has opted to use 3D-printed wire guides. These allow wires to be removed without having to cut anything, making repairs quick and efficient.**

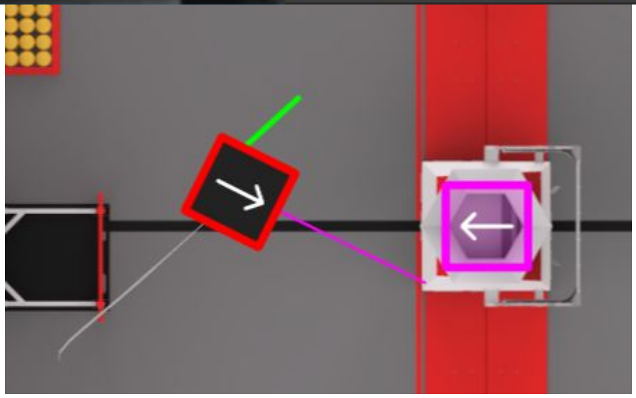
### *Zip Tie Color Coding*

**Drawing inspiration from fiber optic cable color coding, our team uses zip ties to color code our robot. Each device as a unique color combination, both for powered connections and in the CANbus. This helps greatly with troubleshooting problems as wires are easily traceable.**

# Programming

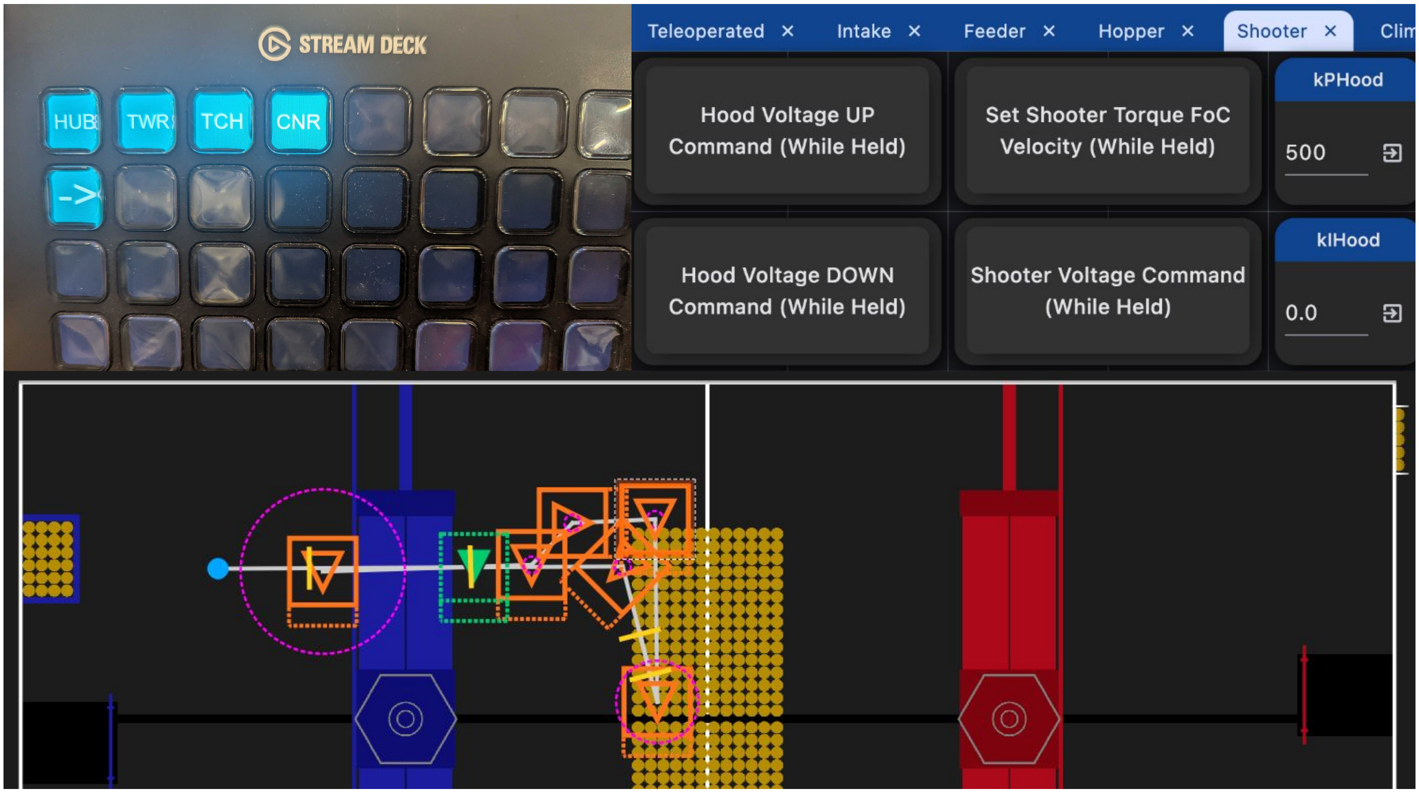
- **LUT-based shoot on the move**
  - **Acceleration and polar velocity limits keep shots accurate while driver controls robot**
  - **Dynamic center of rotation offset**
- **PhotonVision for full-field localization and fuel detection**
  - **5 ThriftyCams connected to two RubikPis**
  - **Custom fork of PhotonVision allows machine learning detection of AprilTags - ~2x speedup**
  - **Bump compensation for odometry and vision**
- **Fuel pose tracking**
  - **Fuel detected by cameras is tracked on the field**
  - **Heatmap of fuel density is available for driver**





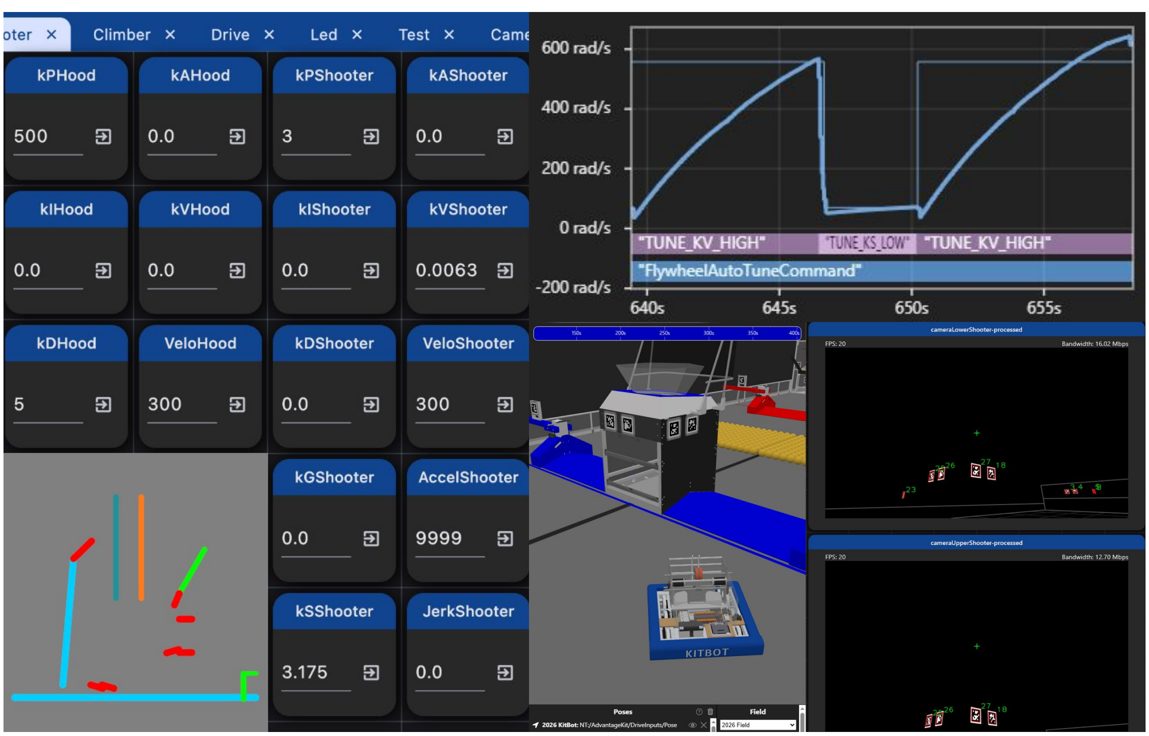
# Controls

- Bline for 12 unique autonomous paths
  - Robot is controlled to go to positions rather than velocities - consistency over optimization
  - Handles uncertainty from the bump without issues
  - Able to recover from “surfing” on balls
- Elastic buttons used to test individual commands
  - Generated by robot code
  - Dashboard layout automatically generated
- Stream Deck used as operator button board
  - Communicates with the robot over Network Tables
  - Buttons fully configurable in robot code
  - 32 buttons for manual control and overrides



# Simulations

- Simulation extensively used to validate code
  - Before the code is tested on the real robot
  - Before the robot or subsystem exists
  - Enabled by AdvantageKit I/O logging
  - 2D visualization confirms robot motion controls
  - Vision, including object detection, fully simulated
- Flexible code base accommodates rapid robot architecture changes and practice bots
  - Generic subsystems handle motor-level logic
  - Live-tunable subsystem motion control (PIDFF)
  - Subsystems can be disabled during testing
  - Different automatically selected constants for different robots
- Automatic flywheel tuning for kS and kV
  - Tune flywheels following the CTRE recommended process in a few minutes of hands off time



# Final Remarks


**New students make up a majority of our team as we enter the 2026 Rebuilt season. We have molded each and every one of them to create one of Code Orange's most ambitious robots. The biggest lesson we learned is that time runs out quickly so you have to spend it well. The time we've spent together has opened the eyes of many of us and we are incredibly proud of what we have built and can't wait to compete!**

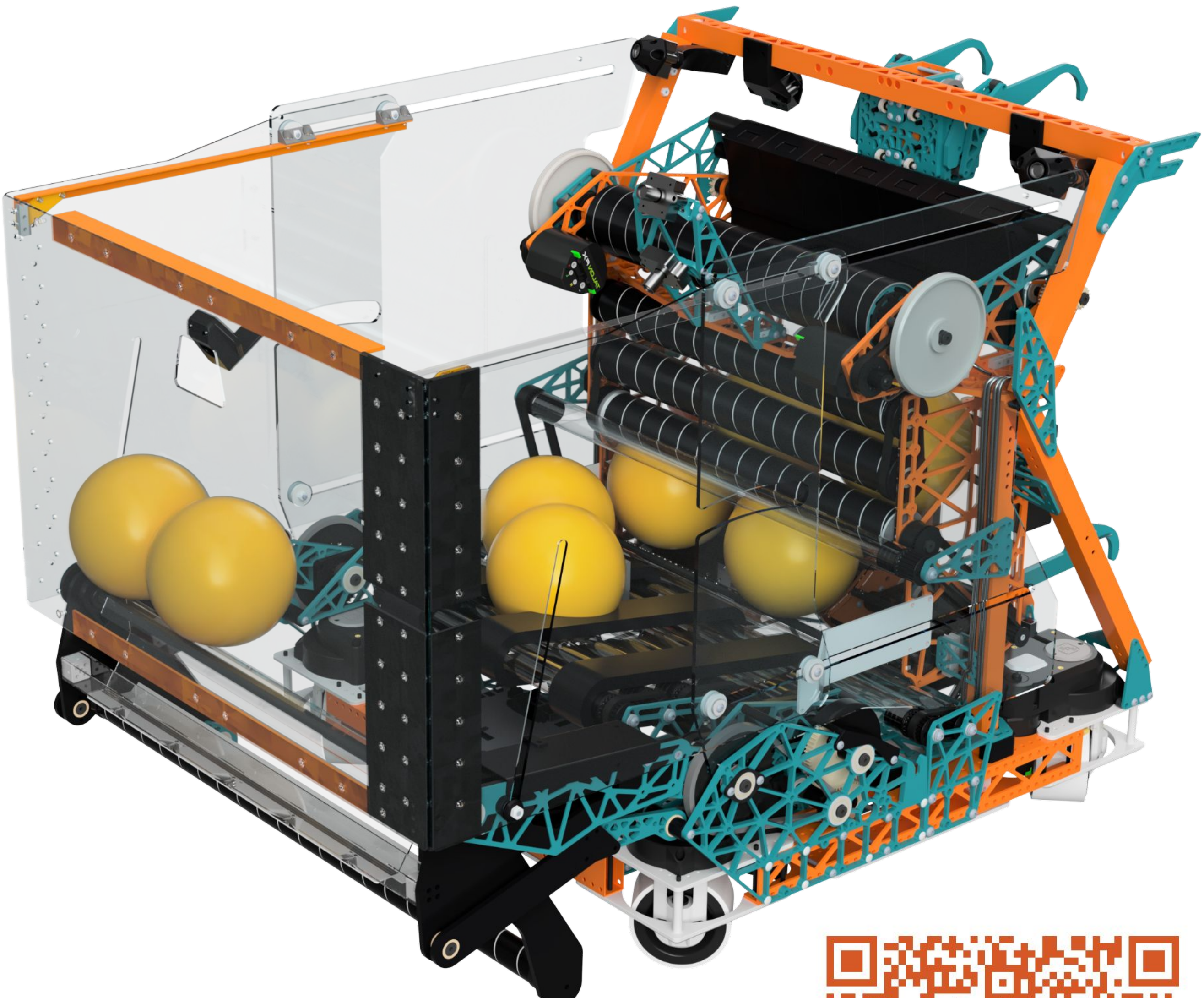
**Thanks to our parents, mentors, and sponsors for supporting us, believing in us, and making our ambitious project come to life.**

**Lastly, we'd like to thank you for reading our 2026 Rebuilt technical binder for Sandspit. Feel free to visit our website: "teamcodeorange.com" for more information, our CAD files, previous robots, Github repository, and guides.**

**Thanks,**
**Code Orange**
**FRC Team 3476**

Team 3476: Code Orange

# SANDSPIT



2026 Rebuilt Tech Binder