2024-25 Engineering Portfolio

27248

Franklin High School

Franklin, VA

BLACKWATER ROBOTICS

Team Overview

Background

Blackwater Robotics was founded in 2005 and competed in the FIRST Robotics Competition for 20 years, winning multiple regionals and FIRST Chesapeake district events and qualifying to compete at the FIRST Championship seven times. Due to changes in the school system and subsequent loss of our FRC practice space, we have decided to swap our participation to FTC. The 2024-25 Into The Deep season is our first season competing in the FIRST Tech Challenge. Our team works out of a classroom at the newly launched JP King Career and Technical Academy which previously housed the middle school.

Team Membership

Franklin High School houses grades 8-12 and total enrollment is less than 400 students. Our team has five members ranging from grades 9 – 11. We have one returning student member with FRC experience, and no students had FTC experience before this season.

Team Funding

Our largest sponsor is a local non-profit organization, Franklin-Southampton Charities, that generously funds the majority of our season expenses including the playing field components and robot parts. Other notable sponsors include longtime sponsor BAE Systems and the International Paper Foundation who recently awarded our team a grant for an 80W laser cutter that was used to produce many custom parts on our robot.

intentional innovation foundation inc.

Blackwater Robotics is a member organization of Intentional Innovation Foundation (IIF), a 501(c)(3) organization founded in 2015 and based in Newport News, VA. IIF is focused on supporting STEM activities in the Hampton Roads area. Along with FRC teams 122 NASA Knights and 2363 Triple Helix, we are able to pool resources and assist each other. Having access to non-profit status through IIF allows us to keep our finances separate from the school, write our own grants, and own all of our tools and equipment.

Our team develops a budget for each season that must be approved by the IIF Board of Directors and outlines our expected incoming grants and fundraising income, and expenses such as robot parts and travel.

GAME ANALYSIS

Build and Game Strategy

Our top priority is to rank as an alliance captain by winning matches to gain Ranking Points.

After evaluating the game, our initial design strategy was to focus on scoring in the HIGH BASKET to maximize scoring potential:

- A SAMPLE scored in the HIGH BASKET is only 2 points less than a SPECIMEN scored on the HIGH CHAMBER
- Converting SAMPLEs to SPECIMEN requires a trip to the OBSERVATION ZONE (human player), time to add the clip, and time to pick the SPECIMEN up.
- Attempt to combine horizontal and vertical extensions to reduce the quantity of motors used for scoring in order to reserve motors for climbing.

We continued with this strategy for some time and developed an extending arm with a large sector gear. Upon construction, the intake weighed too much and caused the arm to sag. We also realized that our strategy would stick us in a specific role in the match and we needed to be more offensively versatile.

Using what we learned, we modified our design strategy:

- Separate the horizontal and vertical movements
- Develop a “handoff” between the horizontal intake and the vertical scoring mechanism
- Make the intake “flexible” to help with pickup from odd angles

Design Priority List

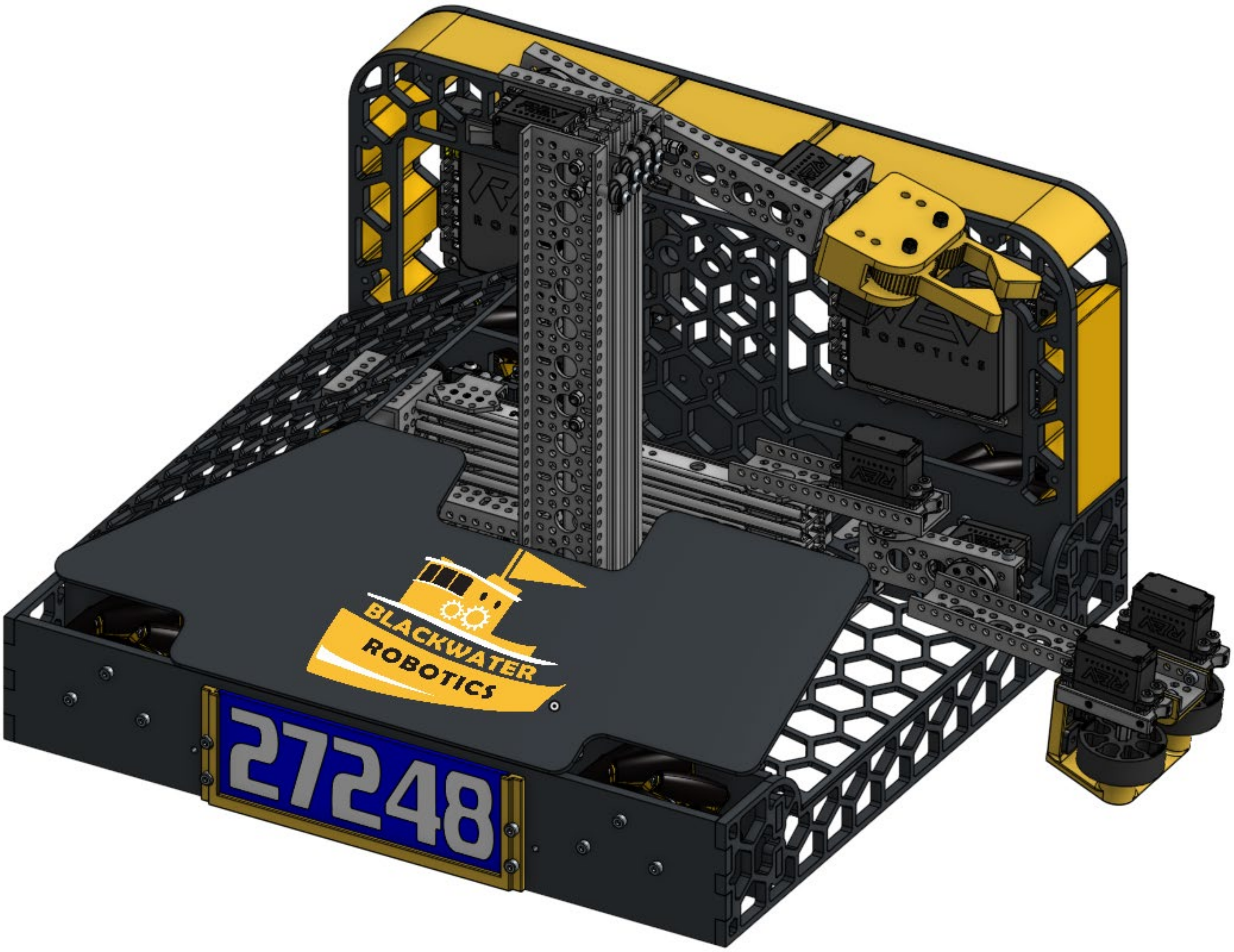
At our first few meetings, we researched previous FTC games, watched Robot-in-3-Days videos, and planned out the main points of how we wanted to build our robot:

1. **Drivetrain**
    a. Fast and powerful mecanum drive
    b. Lightweight but strong
    c. Low center of gravity
2. **Intake / Floor Pickup**
    a. Can only manipulate one SAMPLE at a time
    b. Prefer "active" intake over pinch style intake
    c. Active probably faster to pick up but pincher seems better if a handoff is required
3. **Horizontal Extension**
    a. Need to move laterally to pick up SAMPLEs from under the SUBMERSIBLE
    b. Must clear 2" barrier at bottom of the SUBMERSIBLE
    c. Must not exceed 42" total
4. **Vertical Extension**
    a. Need ability to extend up to score on CHAMBER or in BASKET
    b. HIGH CHAMBER height: 26"
    c. HIGH BASKET height: 43"
5. **Endgame Climb**
    a. Climb to the HIGH RUNG
    b. Must climb to the LOW RUNG first
    c. Lowest priority because we could just keep scoring SAMPLEs and gain more points than climbing
    d. ASCENT points are the third sort order for rankings. Scoring in autonomous is more important.

Design Process

Team members work together with experienced mentors to make our ideas come to life. Researching previous designs of FTC and FRC robots, we work together to sketch out ideas on the whiteboard in our classroom, prototype with available parts, and then move those ideas into CAD to make sure everything fits before making custom parts or building complex mechanisms from COTS components. Student team members work directly with mentors to learn concepts related to conceptual design, CAD processes, and manufacturing custom components utilizing our 3D printers, CNC router, or laser cutter.

DESIGN



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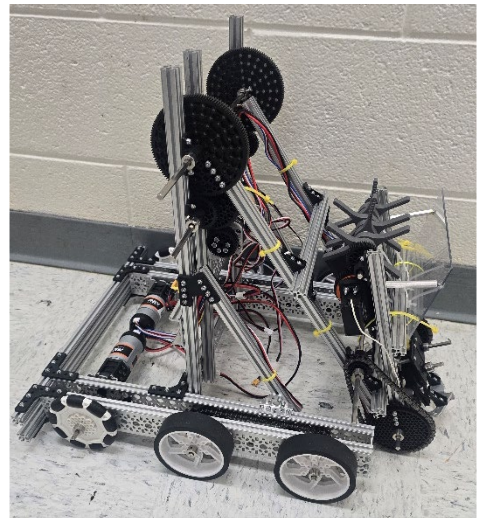
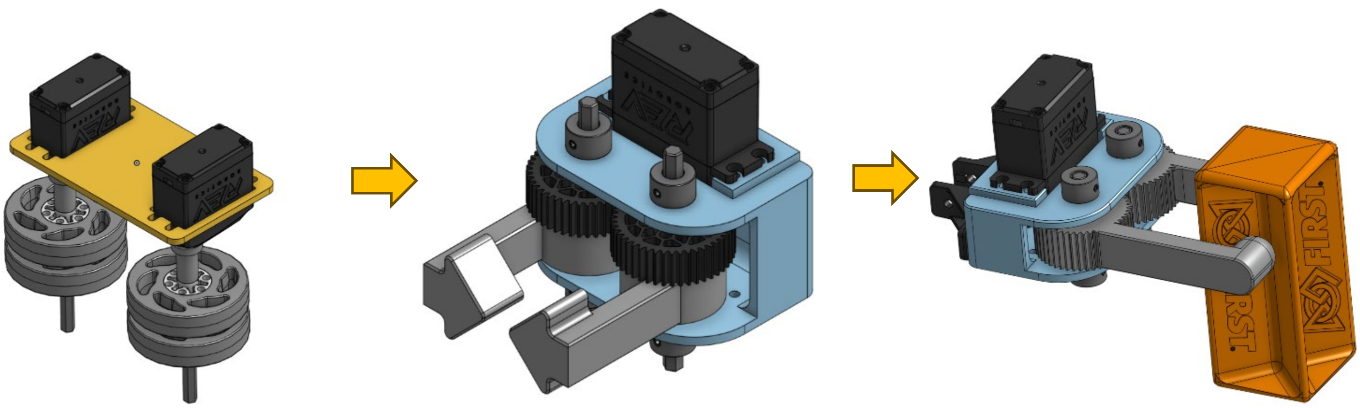
Design Iteration & Prototyping



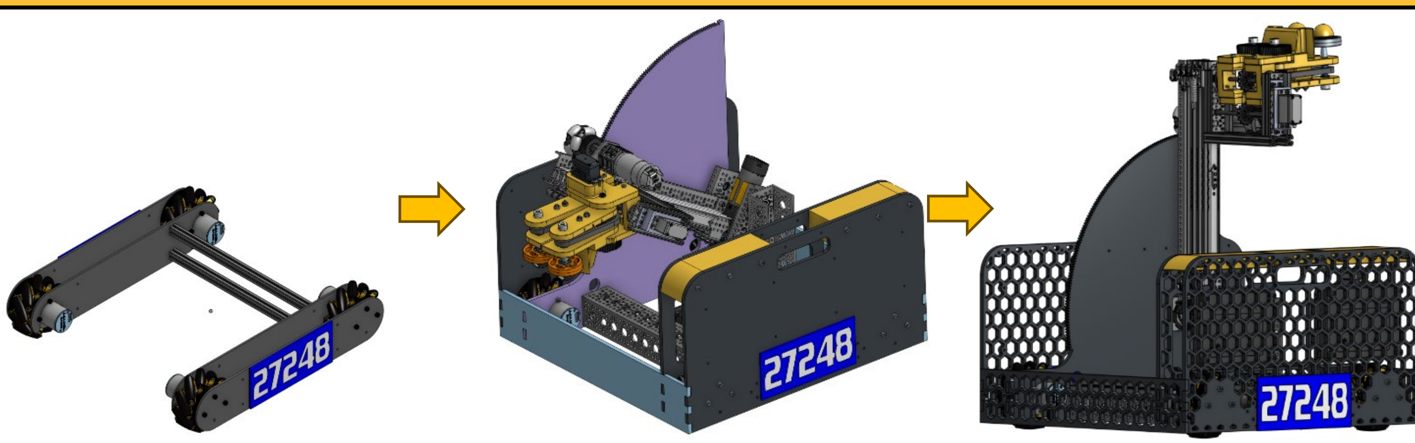
The design you see today is of course not the original design. We iterated through a handful of different designs. First, we built the Rev Starter Bot, seen to the right. We had the majority of the required parts for this robot in stock and only had to purchase intake wheels. Building this bot helped us better understand common FTC construction methods and become familiar with the parts.

We pretty quickly decided to use the new Swyft Drive mecanum modules and designed and cut out wooden plates to make sure everything fit and worked the way we expected. Wooden side rails became Delrin side rails and changed sizes multiple times as the design moved forward.

Intake Design Evolution



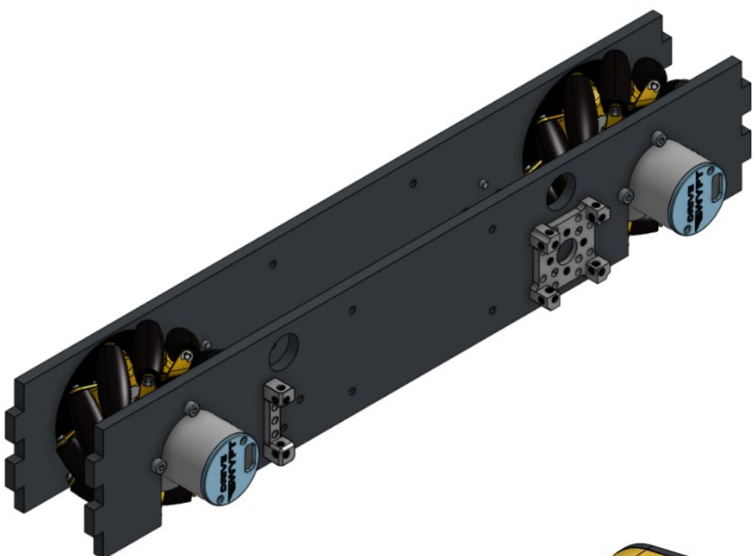
Chassis Design Evolution



Drivetrain

While our team doesn't have previous experience with mecanum wheels, they are the go-to wheel choice for high-performing FTC teams. Historically, using mecanum wheels used up a ton of interior space to fit the required motors and gearboxes, often including the use of 90-degree gearboxes to make everything fit.

Due to this complexity, we chose to use the brand new Swyft Drive modules. These modules combine an AndyMark NeverRest motor <u>through</u> a GoBilda Mecanum wheel, creating a very compact drive module.



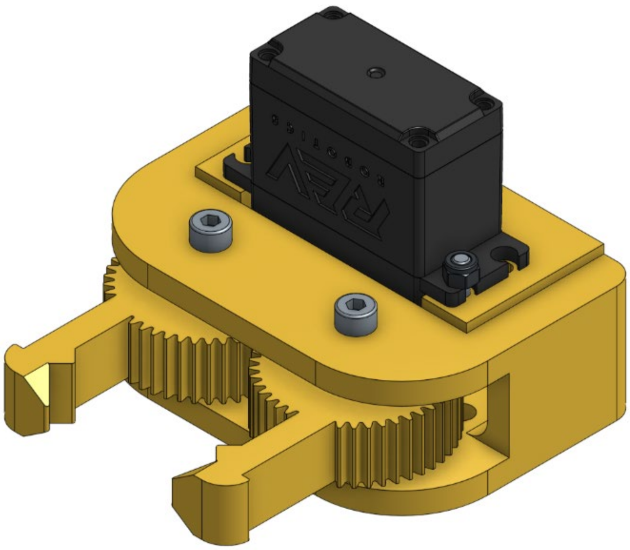
Drivetrain Specifications:

- Swyft Drive FTC modules
- AndyMark NeverRest motors
- GoBilda 96mm mecanum wheels
- 12.7:1 total gear reduction
- 7.1 feet/second (estimated)

Drivetrain Rails:

- Custom designed 0.25" Delrin plates
- Laser-cut in our shop

Intake Pincher Subassembly – Deep Run Event

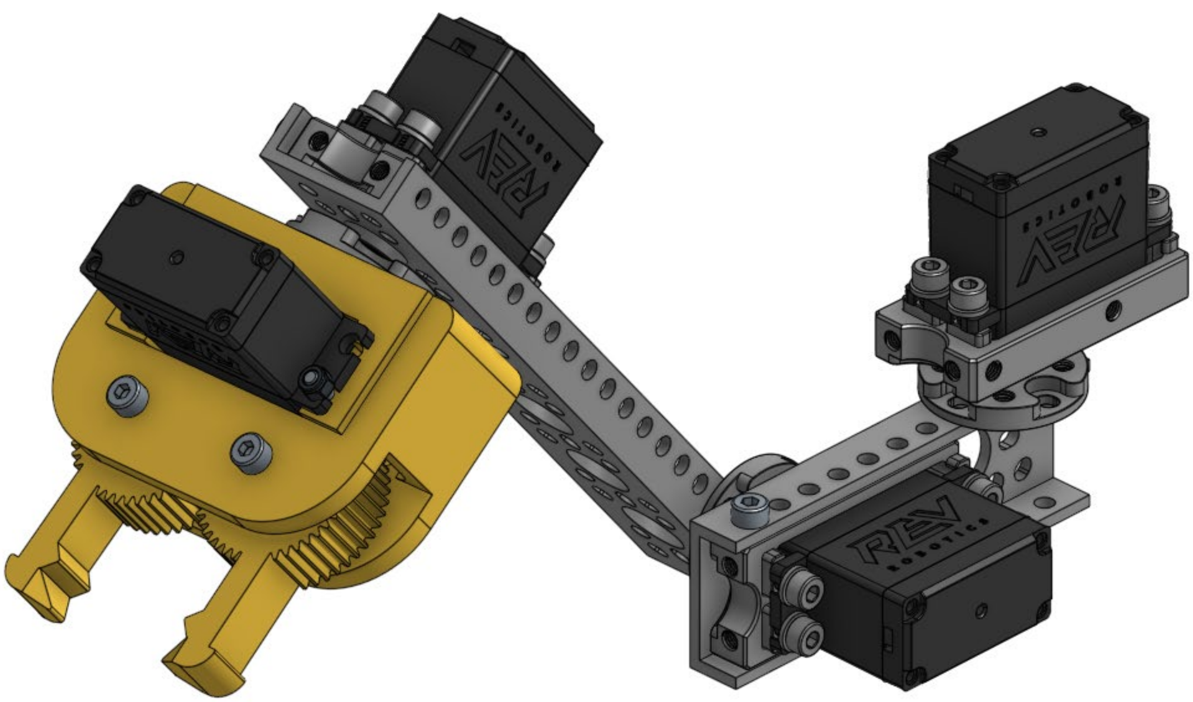


The intake pincher is a completely custom designed mechanism consisting of a 3D printed housing and two 3D printed pinchers. The pinchers have an integrated gear profile that reduces the height and total number of parts in the mechanism. A servo with a gear output adapter powers the mechanism.

The geometry of the claw allows the pincher to grip the outside or inside of the SAMPLE. The Pincher housing includes hex key access holes on the bottom to assist in securing the servo.

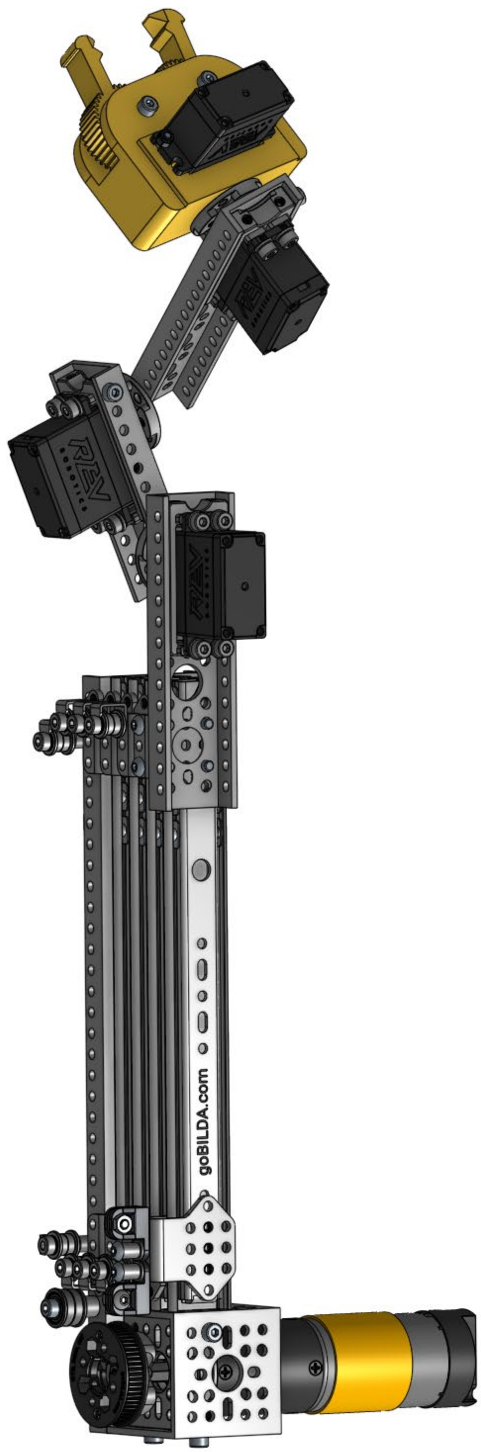
Intake Arm Subassembly – Deep Run Event

The Intake Pincher is attached to the Intake Arm. The Intake Arm subassembly is constructed completely from COTS (Commercial Off The Shelf) components and when combined with the custom pincher results in a four degree of freedom mechanism. The intake arm assembly collapses completely inside the frame perimeter.



Intake and Elevator Assemblies

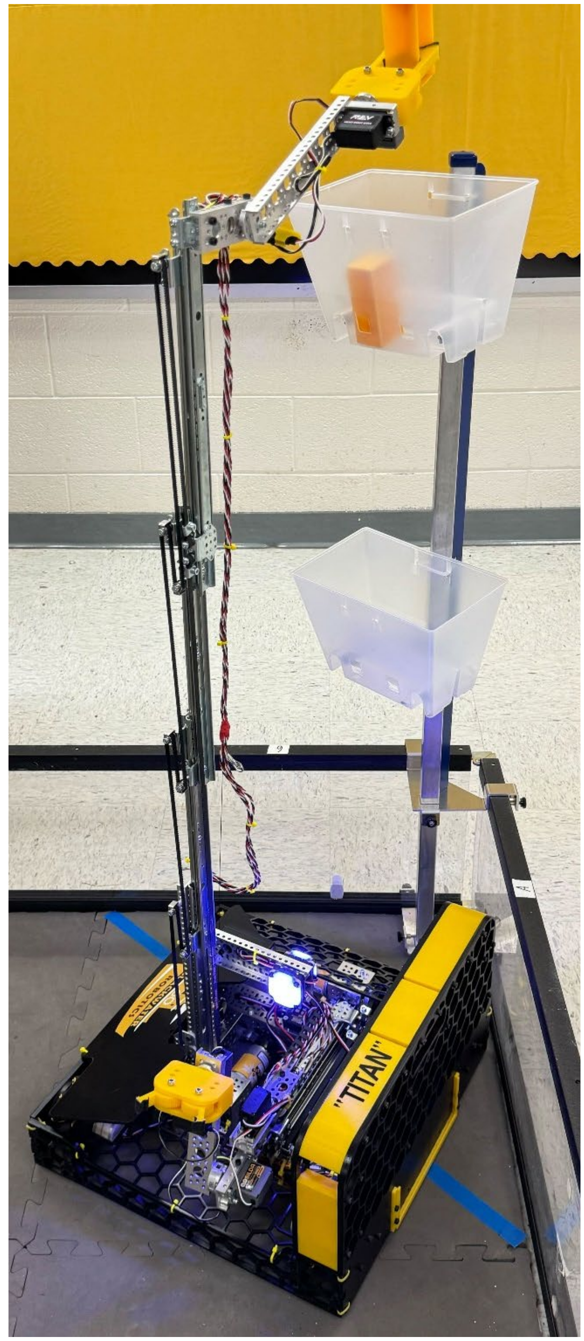
The Intake Pincher and Intake Arm combine with a set of 240mm GoBilda Viper Slides to complete the intake assembly. We only needed to use three of the slides to reach the full 42” allowed extension.



The elevator assembly is very similar to the intake assembly, just mounted vertically. The elevator uses the 336mm GoBilda Viper Slides to reach the height required to score in the High Basket.

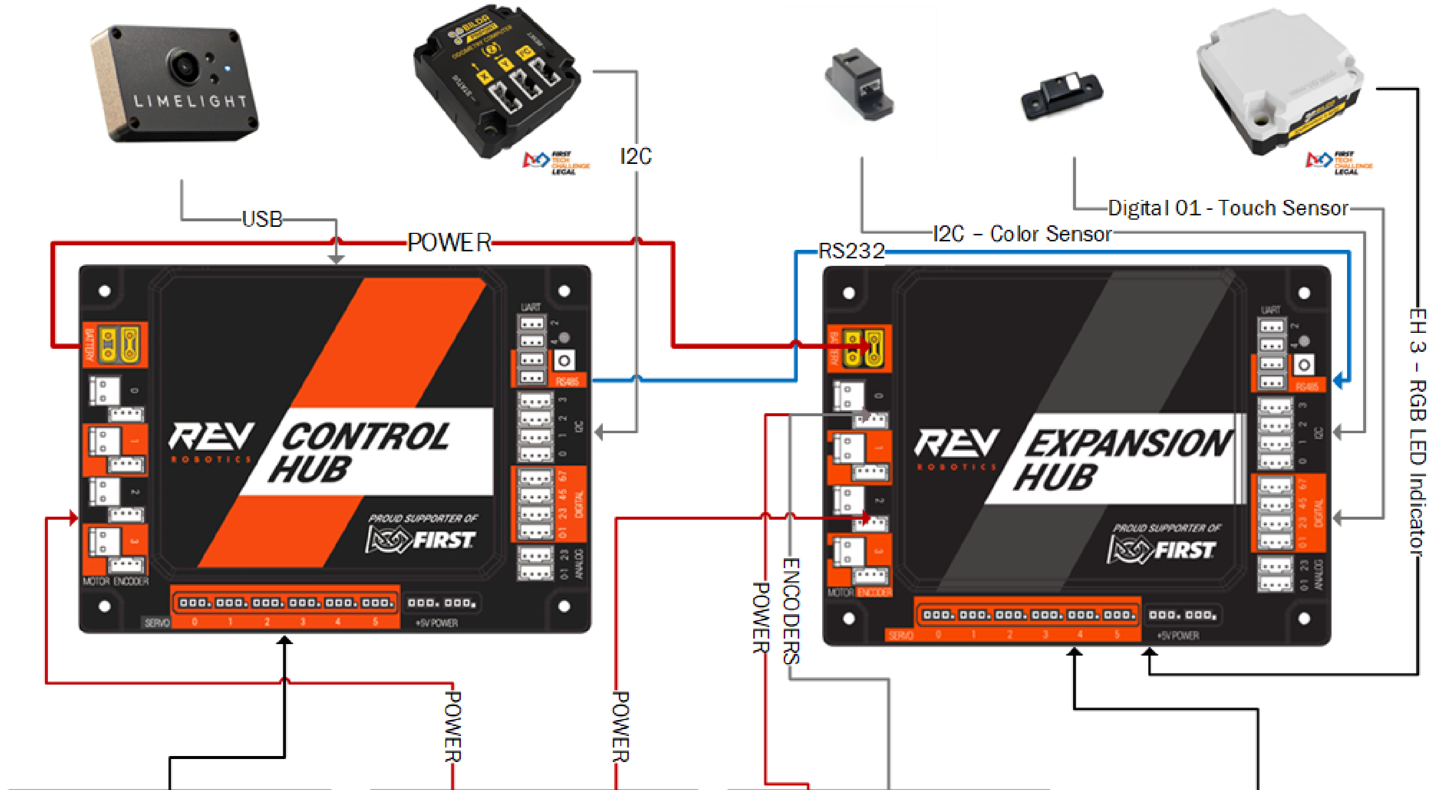
Three servos control the scoring mechanism on the top of the elevator: one to pivot, one to rotate the pincher, and one servo to operate the pincher.

The pincher claw on the elevator reuses the same housing as the intake but has a different style pincher.



PROGRAMMING AND CONTROLS

Wiring Diagram



Intake Servos

Port	Name
CH 0	intakeLeft
CH 1	intakeRotate
CH 2	intakeLift
CH 3	intakeRight

Drive Motors

Port	Name
CH 2	leftBack
CH 3	rightBack
EH 2	leftFront
EH 3	rightFront

Linear Slide Motors

Port	Name
CH 0	elevatorLift
CH 1	intakeSlide

Elevator Servos

Port	Name
EH 0	elevatorPivot
EH 1	elevatorPincher
EH 2	elevatorPincherRotate

Programming Overview

Since we had some experience using Java in FRC with version control, we decided to skip Blocks and OnBot Java and go directly to the Android Studio based Java programming option. Code is maintained on Github and we utilize branches and pull requests to ensure that only code that has been tested is merged into code for competition.

Github Repository: https://github.com/FRC1610/2024-27248

Outside of OpModes, our code is split into three main classes:

- Constants – This public class contains all motor power settings, linear slide positions, and servo setpoints, so that
- Hardware – Another public class where motors and servos are configured to allow access from both teleoperated and autonomous OpModes.
- StateMachine – A large state machine for executing complicated and repetive intake and elevator actions. More detail in the next section.

Intake & Elevator State Machine

We determined that a state machine with multiple cases was the best way to make sure that all of our motor and servo positions for the elevator and intake could be controlled easily and repetitively.

Available States:

- Home – All mechanisms retracted – this is the starting position
- Intake Search – Deploy the intake and position servos for pickup
- Pickup – Run intake wheels, execute color check, raise and retract to Handoff position
- Handoff – Perform the handoff between the intake and elevator
- Wall Pickup – Position the elevator and pincher for pickup from the human player
- Dropoff – Drop a sample into the Observation Zone
- High Chamber – Rotate the elevator servo and raise elevator into scoring position
- High Basket – Rotate the elevator servo and raise elevator into scoring position
- Wait – Various wait states exist for transitions between other states

Multiple states can be chained together to trigger longer sequences. An RGB inidcator light is used for driver feedback and displays different colors depending on the state the robot is in.

Position Tracking

A Limelight 3A camera is mounted facing the rear of the robot to be utilized in autonomous mode to return robot pose estimation based on the visibility of April Tags around the field perimeter.

Two GoBilda four-bar dead-wheel odometry pods are mounted under the chassis, one to track movement in the X plane and one on the Y plane. These feed into a GoBilda Pinpoint Odometry Computer. This computer has an Inertial Measurement Unit (IMU) that feeds precise location data back to the Control Hub.

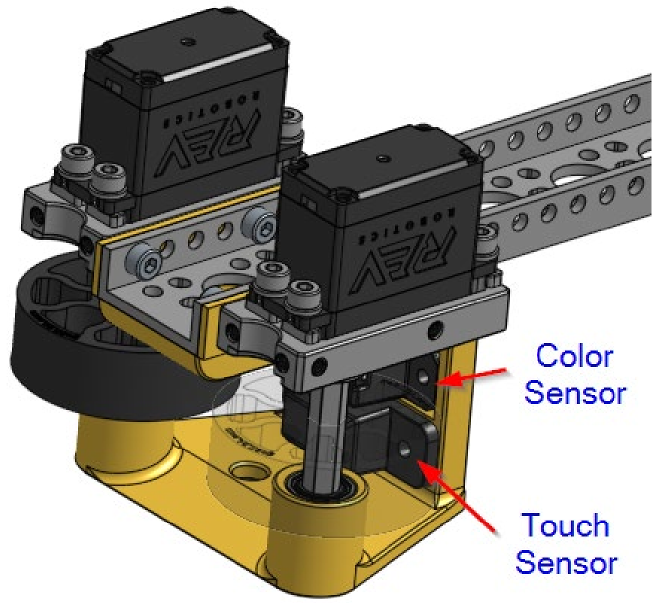
Data from these two tracking devices assist in keeping track of the robot position in Autonomous.

Active Intake – Automatic Color Checking

The recent swap from a pincher intake to an active intake created an issue where we may accidentally pick up a SAMPLE of the wrong color when intaking from inside the SUBMERSIBLE. To alleviate this we added sensors to the active intake.

Mounted to the rear of the active intake housing are two sensors:

- Rev Robotics Color Sensor V3
- Rev Robotic Touch Sensor



These two sensors allowed us to build an automated intake sequence:

1. Any time the intake is running, the touch sensor begins looking for input.
2. Once the intake sensor is touched, we evaluate the color sensor.
3. If the detected color is either yellow or our alliance color, retract the intake and execute the handoff sequence. If the detected color is the wrong alliance color, eject the SAMPLE and try again.

The "correct" alliance color is determined pre-match from a toggle button on the robot. When initializing the robot, the LED lights will indicate to the drive team what color is configured.

```
if (robot.intakeColor.red() > Constants.intakeColorRed &&
robot.intakeColor.green() > Constants.intakeColorGreen){
    //YELLOW
    detectedColor = DetectedColor.YELLOW;
    robot.rgbIndicator.setColor(rgbIndicator.LEDColors.YELLOW);
    ColorCheckSubstep++;
    break;
} else if (robot.intakeColor.red() > Constants.intakeColorRed) {
    //RED
    detectedColor = DetectedColor.RED;
    robot.rgbIndicator.setColor(rgbIndicator.LEDColors.RED);
    ColorCheckSubstep++;
    break;
} else if (robot.intakeColor.blue() > Constants.intakeColorBlue) {
    //BLUE
    detectedColor = DetectedColor.BLUE;
    robot.rgbIndicator.setColor(rgbIndicator.LEDColors.BLUE);
    ColorCheckSubstep++;
    break;
```

Deep Run Qualifier – December 14, 2024

Lessons Learned

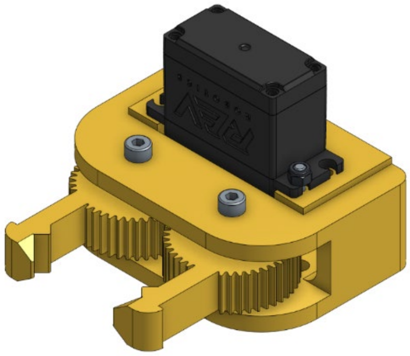
The Deep Run event was our first ever FTC competition and we learned a ton:

- Four specimen autonomous into the High Basket was only perfect in 2 of 8 matches. We need to find a way to make this more reliable.
- Intake pincher design does not leave much room for alignment error.
- Intake pincher takes too long for the driver to line up.
- Intake always fully deploys but usually only needs to be out halfway.
- Need more driver training time.
- Driver struggled with robot-oriented drive. Look at swapping to field-centric drive.
- A servo wire was destroyed during testing in the pit. Need to secure our cables better.
- Found multiple bolts loose throughout the event. Need to use threadlocker during assembly.

Upgrade Goals

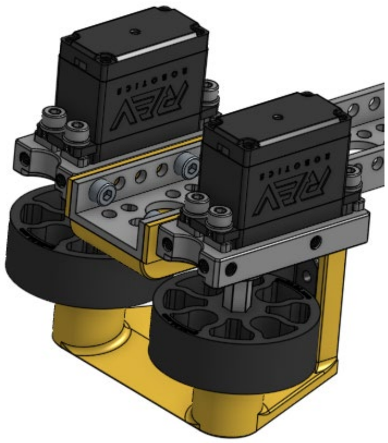
The following items were determined as potential upgrades for the Virginia Beach event:

Item	Goal	Upgrade items	Status
Programming	Intake Distance	Create a toggle for intake distance to go half/full	Complete
Programming	Intake Speed	The intake is jumpy when extending and retracting	Complete
Drivetrain	Field Centric Drive	Use data from the IMU to track robot rotation	Complete
Intake Slide	Increase speed	Swap up from 435RPM to 1150RPM motor	Complete
Elevator Slide	Increase speed	Swap up from 312RPM to 1150RPM motor	Complete
Intake	Add sensors	Add touch and/or color sensors	Complete
Intake	Increase reliability	Different pinchers or develop active intake	Complete
Climber	Level 2 Climb	Find a way to climb	In Progress



Left: Old intake pincher

Right: New active intake



Bill of Materials

While not required, we wanted to know how much the components used in our robot were worth. List prices of COTS products used in major mechanisms are listed below:

Sub-System	Description	Vendor	Item-Number	Quantity	Cost Each	Extended Cost
Control System	Rev Control Hub	Rev Robotics	REV-31-1595	1	$ 350.00	$ 350.00
Control System	Rev Expansion Hub	Rev Robotics	REV-31-1153	1	$ 250.00	$ 250.00
Control System	12V Slim Battery	Rev Robotics	REV-31-1302	1	$ 55.00	$ 55.00
Control System	Battery Holder Plate	Rev Robotics	REV-41-1166	1	$ 2.75	$ 2.75
Control System	Switch Cable and Bracket	Rev Robotics	REV-31-1387	1	$ 12.00	$ 12.00
Control System	Limelight 3a	Limelight Vision	LL3A	1	$ 189.00	$ 189.00
Control System	RGB Indicator Light	GoBilda	3118-0808-0002	2	$ 24.99	$ 49.98
Control System	4-Bar Odometry Pack	GoBilda	3203-3110-0002	1	$ 279.99	$ 279.99
					Control System Sub-Total	**$ 1,188.72**
Drivetrain	Swyft Drive	Swyft Robotics	SR-61	1	$ 389.99	$ 389.99
Drivetrain	96mm Mecanum Wheel Set	GoBilda	3213-3606-0002	1	$ 169.99	$ 169.99
Drivetrain	1120 Series U-Channel, 12 Hole	GoBilda	1120-0012-0312	1	$ 14.99	$ 14.99
Drivetrain	1121 Series Low-Side U Channel, 12 Hole	GoBilda	1121-0012-0312	1	$ 13.99	$ 13.99
Drivetrain	1201 Series Quad Block Pattern Mount	GoBilda	1201-0043-0002	2	$ 6.99	$ 13.98
Drivetrain	1205 Series Dual Block Mount	GoBilda	1205-0001-0005	1	$ 5.99	$ 5.99
					Drivetrain Subtotal	**$ 608.93**
Elevator	4 Stage 336mm Viper Slide Kit	GoBilda	3210-0003-0004	1	$ 219.99	$ 219.99
Elevator	8mm REX 24mm Shaft 5203 Series Motor	GoBilda	5203-2402-0005	1	$ 44.99	$ 44.99
Elevator	2000 Series Dual Mode Servo - Torque	GoBilda	2000-0025-0002	1	$ 33.99	$ 33.99
Elevator	Smart Robot Servo	Rev Robotics	REV-41-1097	2	$ 30.00	$ 60.00
Elevator	Compact ServoBlock 27mm	GoBilda	3217-2701-2501	2	$ 29.99	$ 59.98
					Elevator Subtotal	**$ 418.95**
Intake	4 Stage 240mm Viper Slide Kit	GoBilda	3210-0004-0004	1	$ 209.99	$ 209.99
Intake	8mm REX 24mm Shaft 5203 Series Motor	GoBilda	5203-2402-0005	1	$ 44.99	$ 44.99
Intake	2000 Series Dual Mode Servo - Torque	GoBilda	2000-0025-0002	1	$ 33.99	$ 33.99
Intake	2000 Series Dual Mode Servo - Super Speed	GoBilda	2000-0025-0004	2	$ 33.99	$ 67.98
Intake	Smart Robot Servo	Rev Robotics	REV-41-1097	1	$ 30.00	$ 30.00
Intake	8mm REX Servo Shaft 36mm	GoBilda	1922-0025-0036	2	$ 9.40	$ 18.80
Intake	48mm OD Gecko Wheel	GoBilda	3613-4008-0048	2	$ 7.99	$ 15.98
Intake	8mm REX Flanged Bearing 2 Pack	GoBilda	1611-0514-4008	1	$ 5.99	$ 5.99
Intake	Compact ServoBlock 27mm	GoBilda	3217-2701-2501	3	$ 29.99	$ 89.97
Intake	1143 Series Mini Low-Side U-Channel, 3 Hole	GoBilda	1143-0003-0096	1	$ 4.49	$ 4.49
Intake	1143 Series Mini Low-Side U-Channel, 4 Hole	GoBilda	1143-0004-0120	1	$ 5.39	$ 5.39
Intake	1143 Series Mini Low-Side U-Channel, 6 Hole	GoBilda	1143-0006-0168	1	$ 6.99	$ 6.99
					Intake Subtotal	**$ 534.56**
					Total	**$ 2,751.16**