BEACH CITIES ROBOTICS 294

TECHNICAL BINDER

2024-2025 Edition

Mechanical, Programming, Electrical, and Strategy

Beach Cities Robotics

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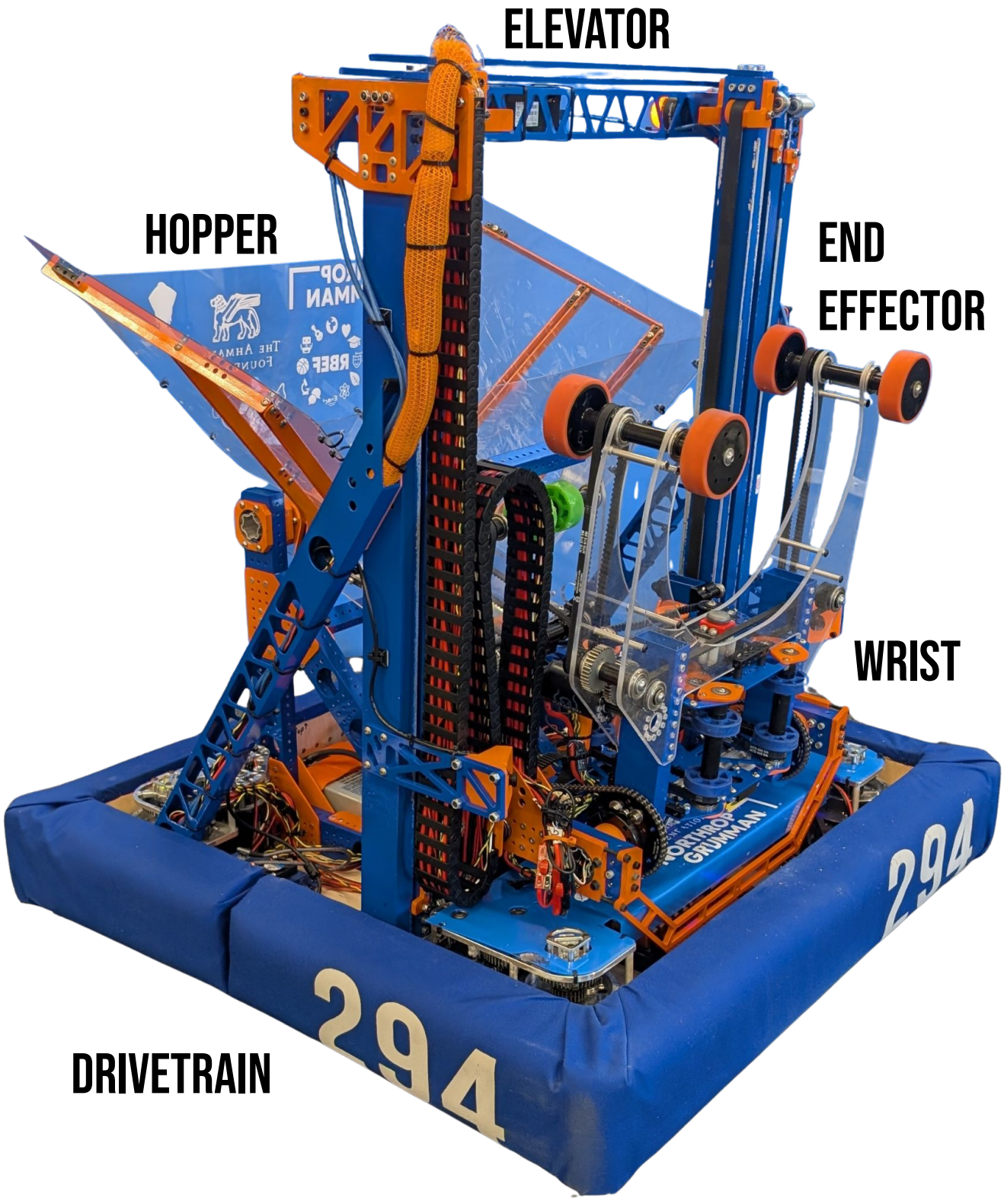
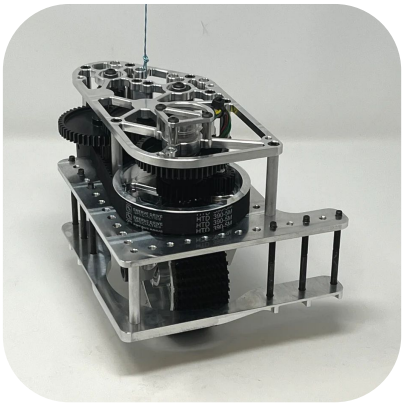
ROBOT ARCHITECTURE



DRIVETRAIN

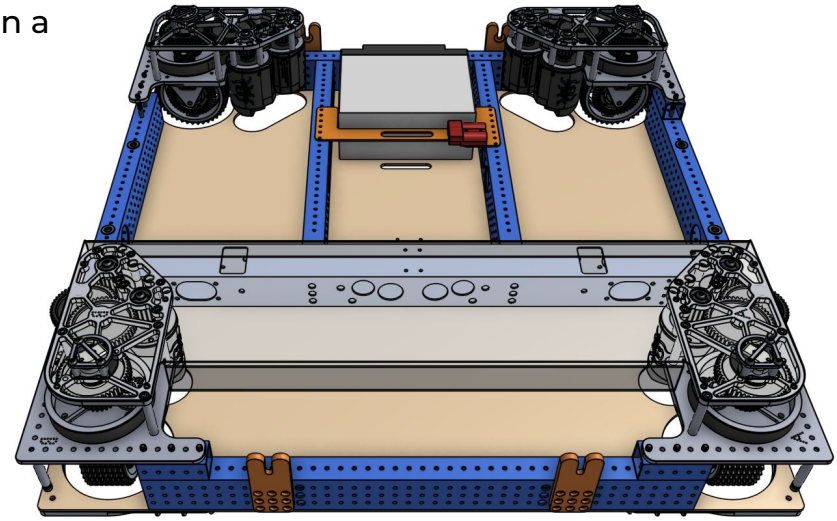
REQUIREMENTS



- Low center of mass
- Counter balances elevator mass
- Integrate with a tilted elevator

DETAILS

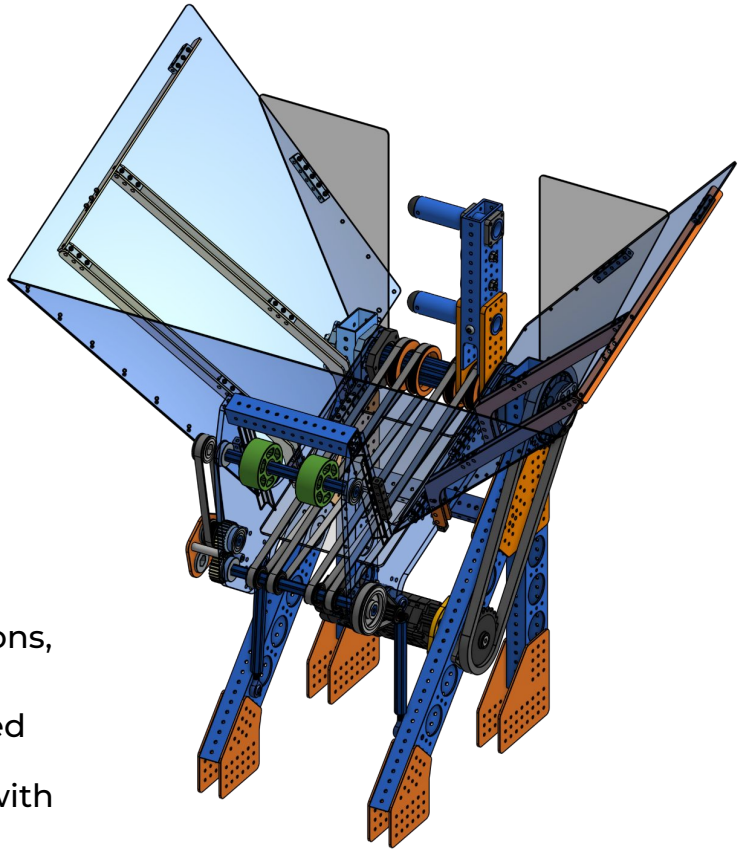
- Constructed of 2” x 1” x 1/16” and 1” x 1” x 1/16” aluminum tubing
- The entire chassis is reinforced with a 2” x 2” x 1/16” aluminum cross member that doubles as the bottom of the elevator
- Custom 2” x 2” tube plugs allow the elevator to be mounted at 3°
- 1/8” polycarbonate cover to prevent coral from damaging electronics and getting stuck inside the drivetrain
- *SDS MK4n L2+* Swerve
- Modules driven by *Krakens*
- *X60* motors resulting in a top speed of 17 ft/sec
- Front modules in portrait orientation while back modules are landscape to maximize space for electronics



HOPPER

REQUIREMENTS

- Sort coral from any orientation
- Ability to load while not flush with station
- Multiple loading sides



DETAILS

- Compounded angle 1/16” polycarbonate funnel with ±21° downward, and 45° inward slope
- Center belts to orient coral, powered by a *Kraken X44* with a 3:1 reduction
- Custom 3D-printed 36T pulleys with future customization options, including the ability to add climbing functionality as needed
- Configurable angle for tuning with end effector load angle ±5°
- A bottom plate to eliminate bouncing and jamming, featuring four belts for automatic coral centering in the hopper

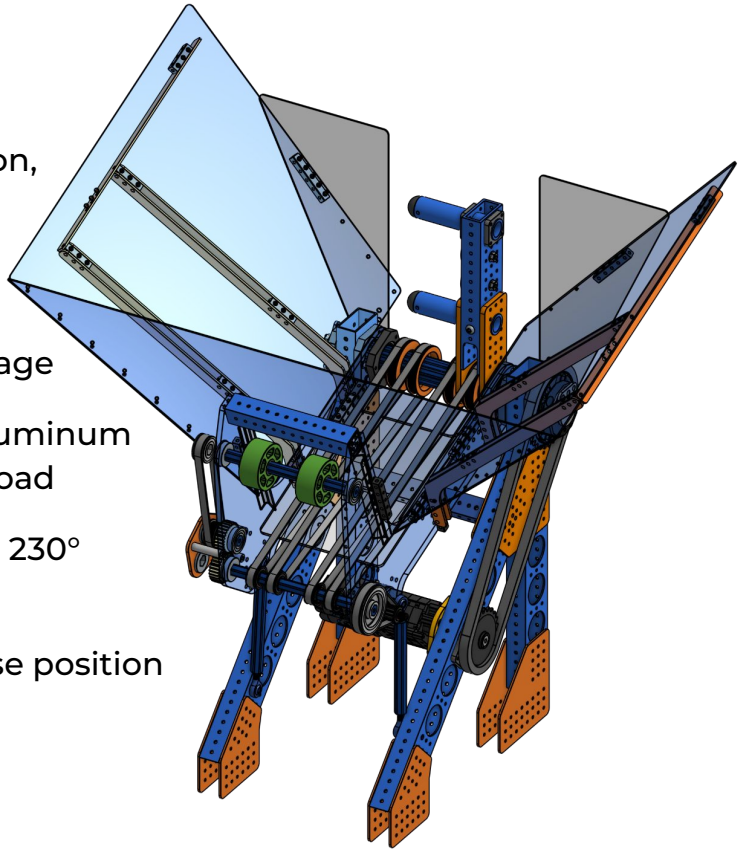
CLIMB

REQUIREMENTS

- Able to climb within 10 seconds or less
- Able to hold position for more than 5 seconds
- Fits entirely within the Hopper

DETAILS

- Kraken X60 with a 192:1 reduction, featuring a PETG ratchet actuated by a 9G servo
- Taffy puller–style dual-prong design for engagement with cage
- Reinforced Max Spline using aluminum “cookies” to support full robot load
- Adjustable climbing angle with 230° of controlled motion
- CANcoder integration for precise position feedback during climb



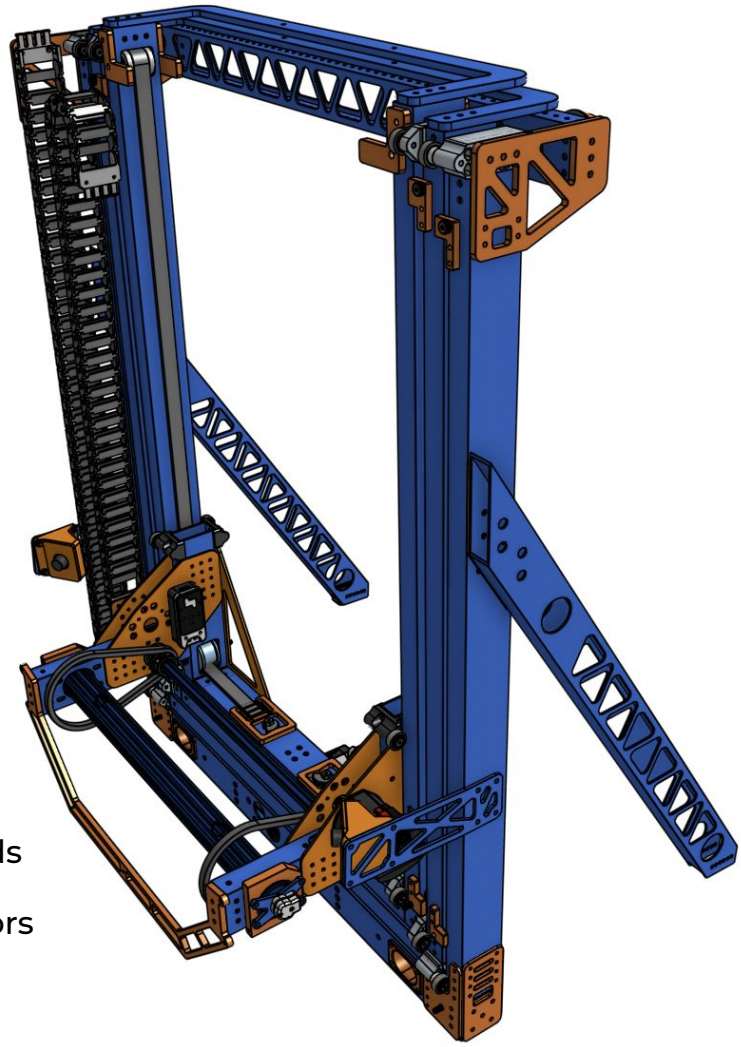
ELEVATOR

REQUIREMENTS

- Ability to score on all levels of the reef, processor, and net with high precision

DETAILS

- Continuous belted in tube elevator powered by two *Kraken X60s* with a 5:1 reduction
- Angled 3° forward to optimize packaging within the robot and prevent the cage chain from clipping the base stage crossbar
- Three-stage design with 90” of vertical travel, reaching a final height of 105” when fully extended
- Capable achieving full extension in under 2 seconds
- Redundant hall effect sensors



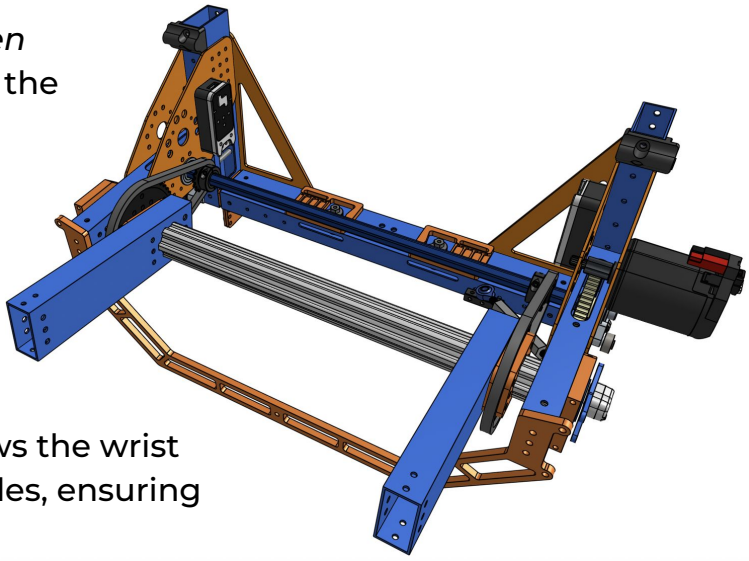
WRIST

REQUIREMENTS

- Drive the end effector to its desired position at high speed
- Minimal backlash to eliminate positional inaccuracy when the robot accelerates
- External encoder

DETAILS

- Gearbox driven by a *Kraken X60* and is integrated into the pivot tubes
- 60t gear packaged inside the pivot tube to eliminate the need for a separate motor mount plate



- 18” long ½” hex shaft allows the wrist to be powered on both sides, ensuring they move together
- 22.5:1 reduction, all gears and sprockets were shimmed with 0.02” aluminum tape to reduce backlash
- ¼” aluminum plates support shoulder bolts that attach the final sprockets to the end effector

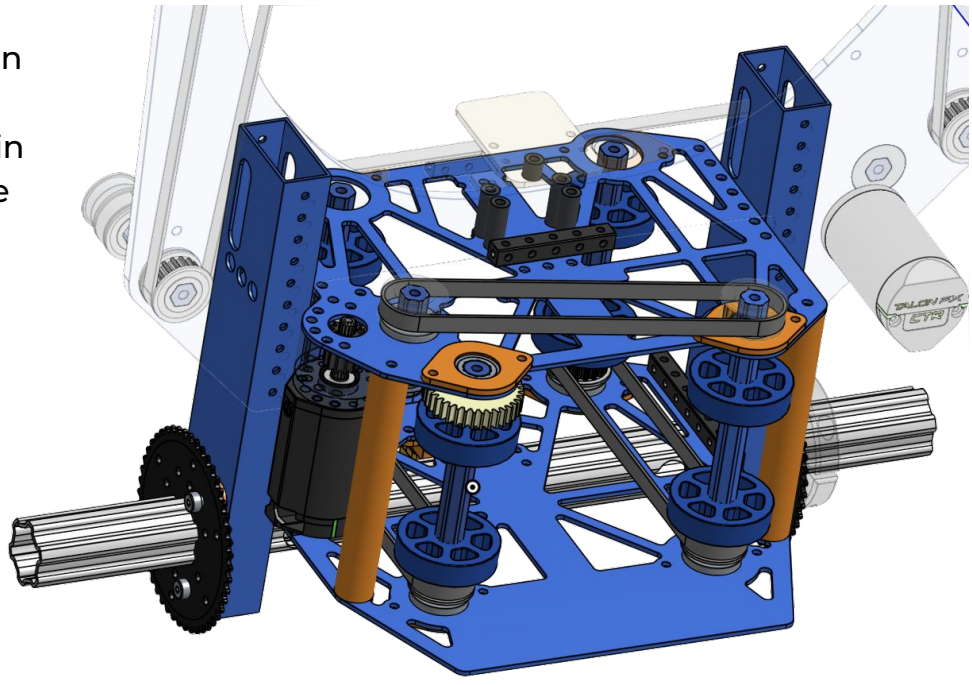
END EFFECTOR, CORAL

REQUIREMENTS

- Lightweight
- Reliable goal scoring
- Seamless coral acceptance from hopper conveyor
- Varying release angle to allow for scoring at all levels of the reef

DETAILS

- Constructed out of .009” aluminum plates for a balance of weight and rigidity
- 4 2” 50A compliant wheels are driven by a *Kraken X44* with a 3:1 reduction
- 2 sets of wheels keep coral scoring straight and predictable
- Photoelectric sensor and retroreflective tape at the exit used to detect and position coral
- Wires routed in MAXSpline to minimize strain through range of motion



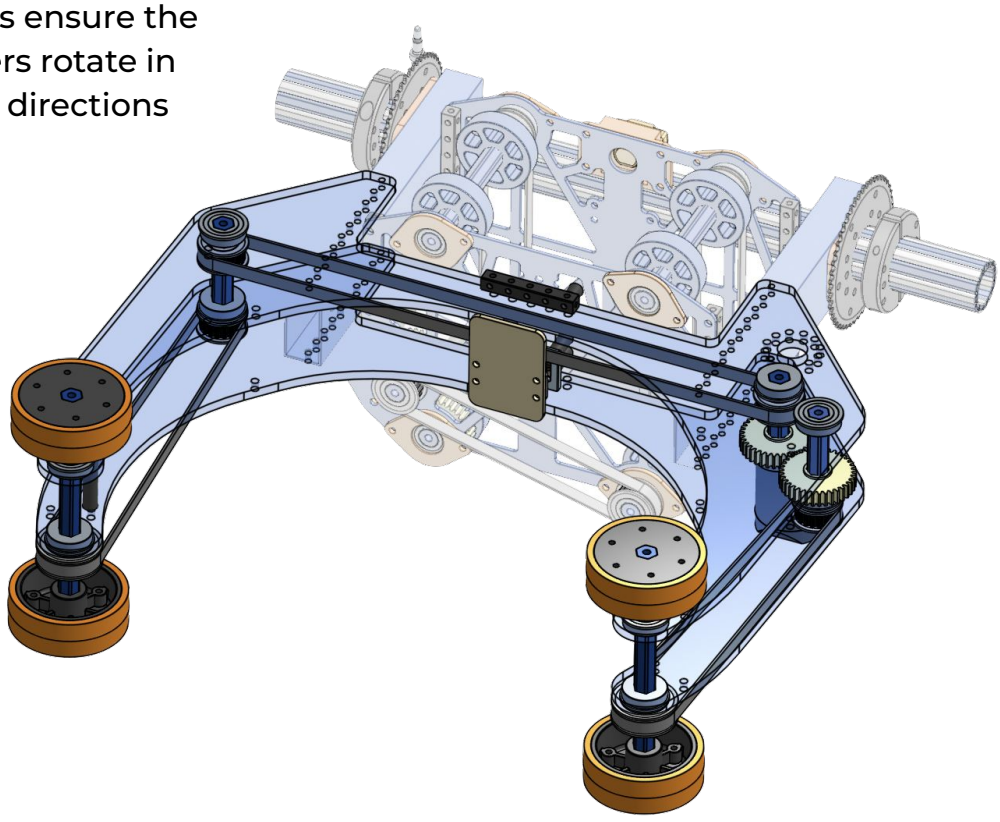
END EFFECTOR, ALGAE

REQUIREMENTS

- “Touch it, own it” for picking up from the ground and reef
- Hold on to algae while traversing the field without any motor power
- Effectively score algae in the net and processor

DETAILS

- Constructed out of ¼” polycarbonate for a balance of weight, compliancy, robustness, and rigidity
- A bump switch is used to detect algae
- The polycarbonate plates mimic the shape of the compressed algae
- 4 3” 40A Stealth Wheels are driven by a Kraken X44 with a 3:1 reduction
- The gears ensure the side rollers rotate in opposite directions

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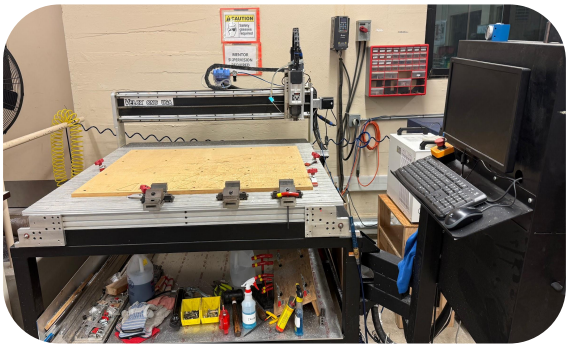
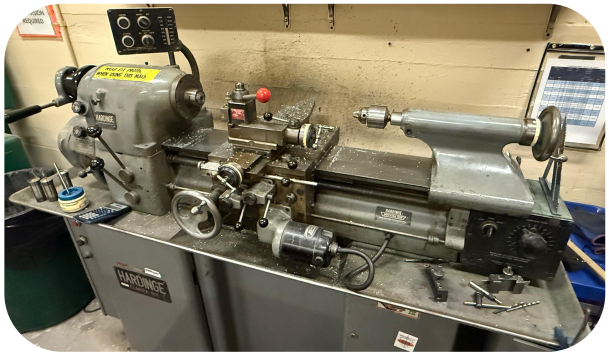
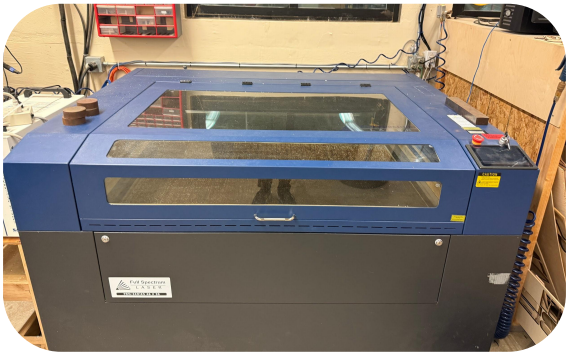
FABRICATION

DETAILS

- All manufacturing done in-house
- CNC Router
  - For manufacturing parts with precision and speed
  - Used for tubes and plates
- Laser Cutter
  - For cutting plywood for prototypes
- Manual Lathe
  - For machining and end facing round stock
  - Commonly used to machine, drill and tap hex and round shaft
- Manual Mill
  - For simple plate and tube manufacturing
- Chop Saw
  - For cutting tubes with speed
- Bandsaw
  - For cutting stock with speed when precision is not needed



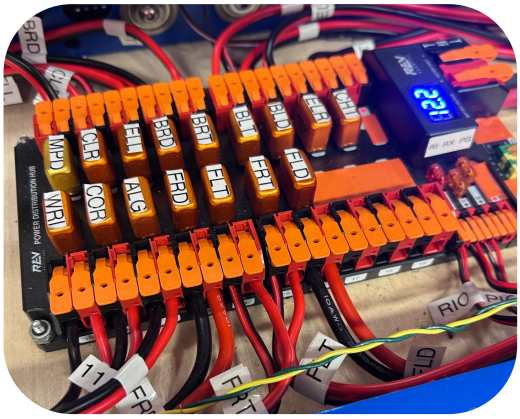




ELECTRICAL

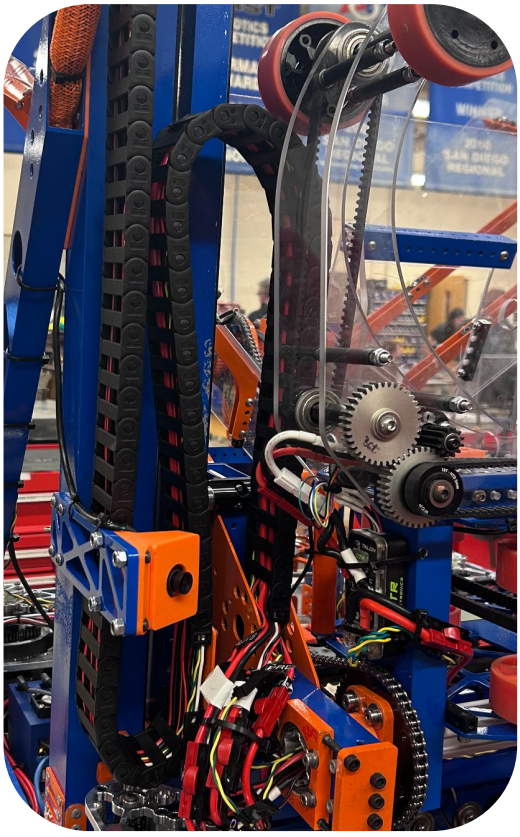
REQUIREMENTS

- Critical system redundancy
- Repairability



DETAILS

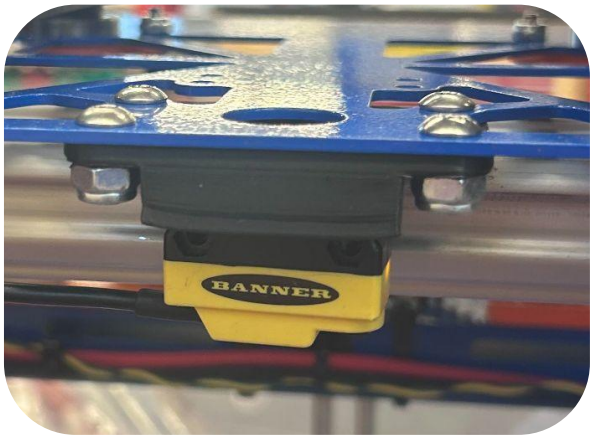
- Redundant, disconnected CAN wire in IGUS chain if primary is damaged, avoiding rerouting the entire daisy chain
- All work is double-checked by a second person as standard practice
- Motor fastener torque specs strictly observed using a torque wrench
- Integration of redundant sensors wherever feasible
- Elevator features motor encoders in both motors, with two hall effect sensors for lower limit

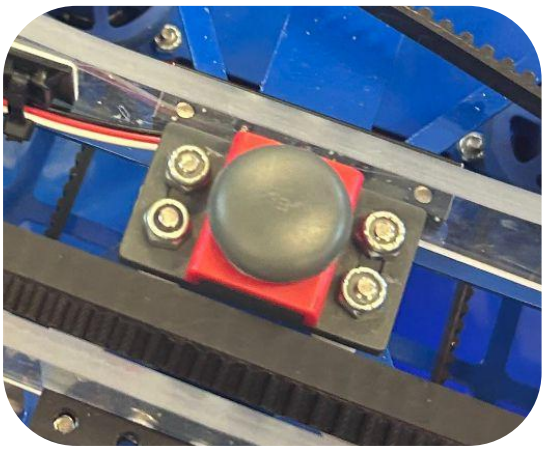


SENSORS

QS18 BEAM BREAK

- A sensor that emits a beam of light and triggers an output when it is broken
- Used on End Effector to detect position of coral





VEX BUMP SWITCH

- A mechanical sensor that triggers when the button is pushed
- Used on Algae End Effector to detect if Algae is being held

CANCODER

- An encoder that uses CAN to provide angular position and velocity
- Used on the drivetrain and the wrist to ensure extra control and precision

SENSORS

PIGEON

- Tracks physical position on field using x-y coordinates
- Located at the center of the robot, on the belly pan

REV MAGNETIC LIMIT SWITCH

- Two redundant switches installed
- Triggers an output when magnet is within range
- Used on the elevator as a hard stop

CANDLE

- Controls LED strips on the superstructure through CAN bus
- Located on the belly pan

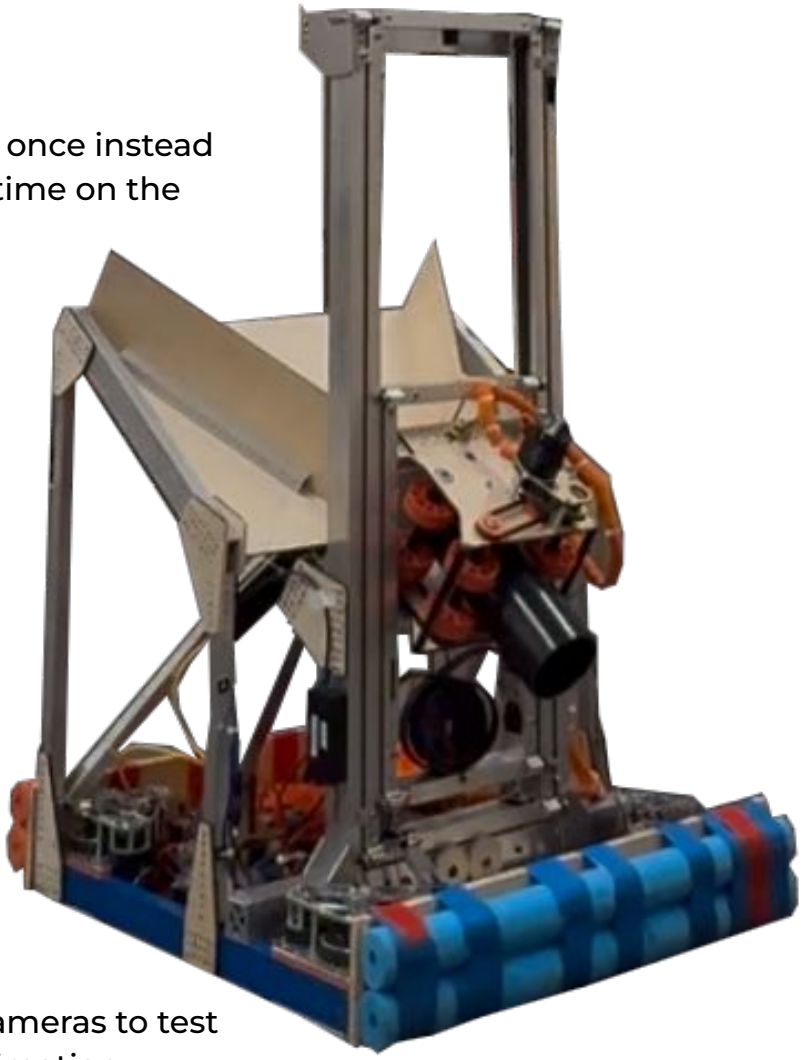
ENGINEERING TEST UNIT

DESIGN, FABRICATION, ASSEMBLY

- Experimental robot designs
- Practice full design process from CAD to final assembly
    - Especially useful for the belted in tube continuous elevator
- Largely built out of wood to improve manufacturing speed
- Get a hands on approach to manipulating game pieces and seeing how they interact with the robot

ELECTRICAL

- Practice wiring a robot once instead of doing it for the first time on the competition bot



PROGRAMMING

- Create the framework for reused subsystems, like the elevator and drive train
- Test sensors
- Plan and test auto trajectories
- Practice calibrating subsystems, such as the elevator
- Test having multiple cameras to test multi-camera pose estimation

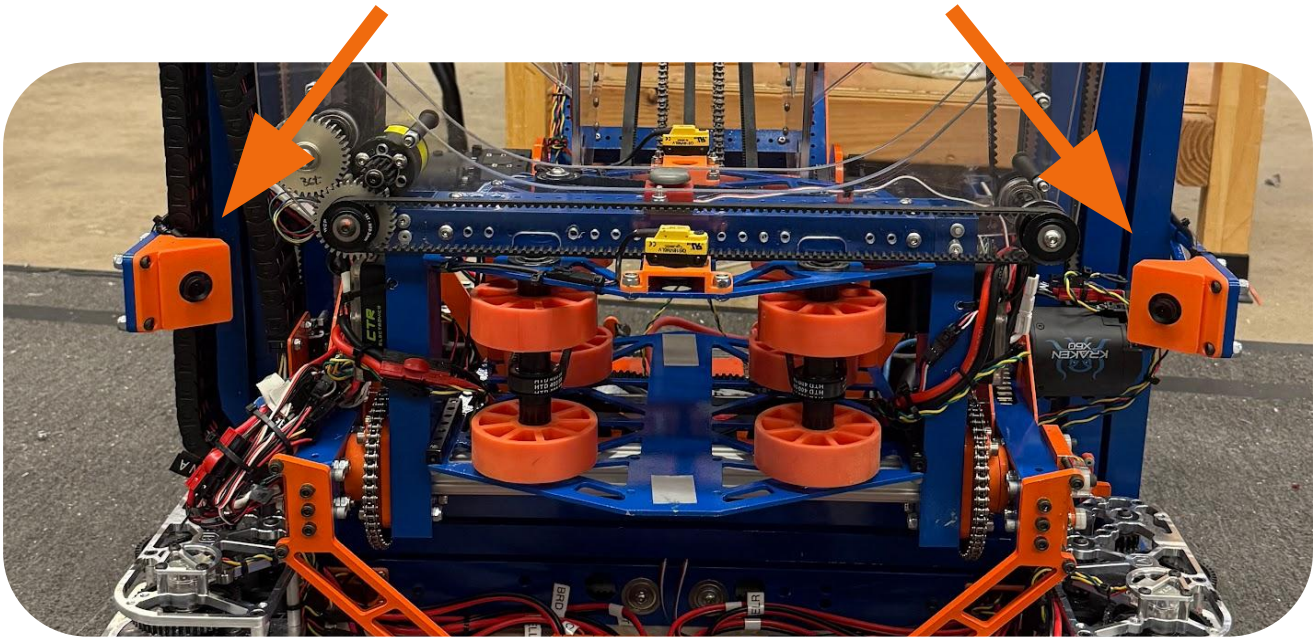
PROGRAMMING

BASICS

- Programming exclusively in Java
- Github for version control

MECHANISM CONTROLS

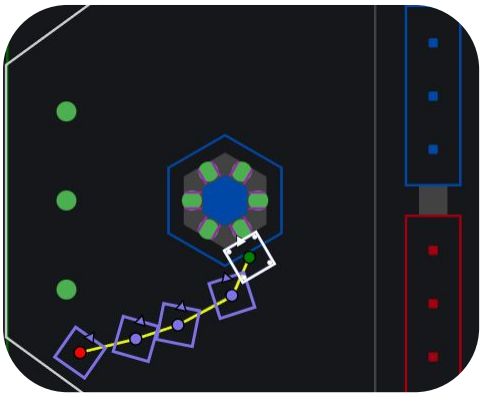
- Trapezoidal motion profiling for elevator control
- Motion Magic for wrist control
- Software limits on both wrist and elevator
- CANcoder on wrist, switch to internal rotor encoder if CANcoder fails
- Use Choreo to create autonomous routines with ease
- Automated drive and scoring routines using odometry, so the driver and co-driver each hold down a single button to run a full scoring routine
- Use PhotonVision to update odometry with cameras on the robot, doing multi-camera pose estimation with two inward-facing cameras



PROGRAMMING

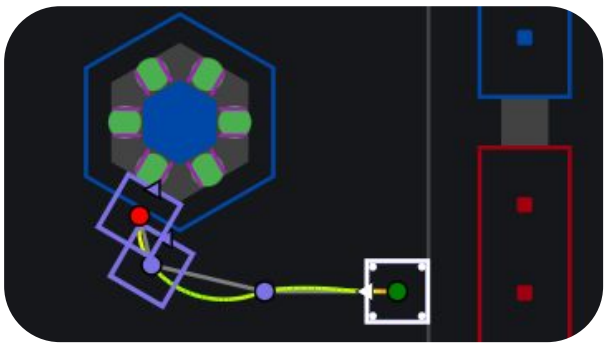
AUTONOMOUS

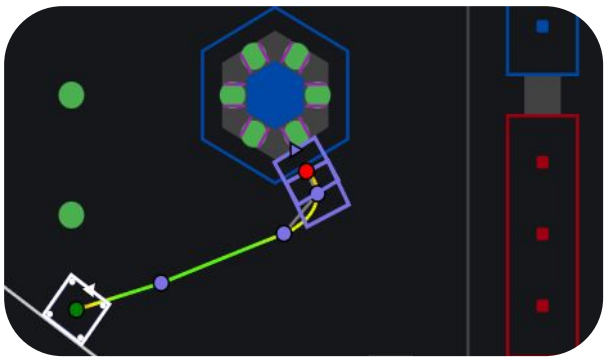
- Created a custom modular structure
- With just a list of reef positions, we can make a full auto routine that travels between the reef and the loading station
- Trajectories are mirrored across the reef so we can share one trajectory across multiple positions



CHOREO

- Graphical Interface that makes creating trajectories easier
- Simulates autonomous routines in real time, using physical robot attributes to generate accurate trajectories
- Less time spent modifying inaccurate trajectories
- Trajectories are cached on boot and are integrated with other autonomous routine components

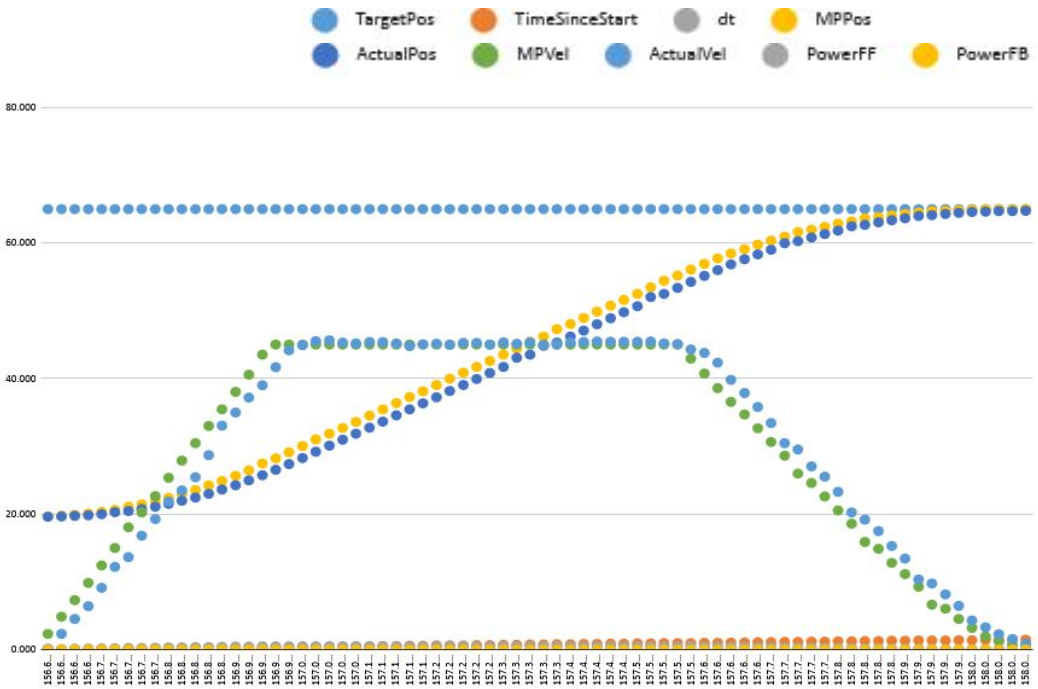




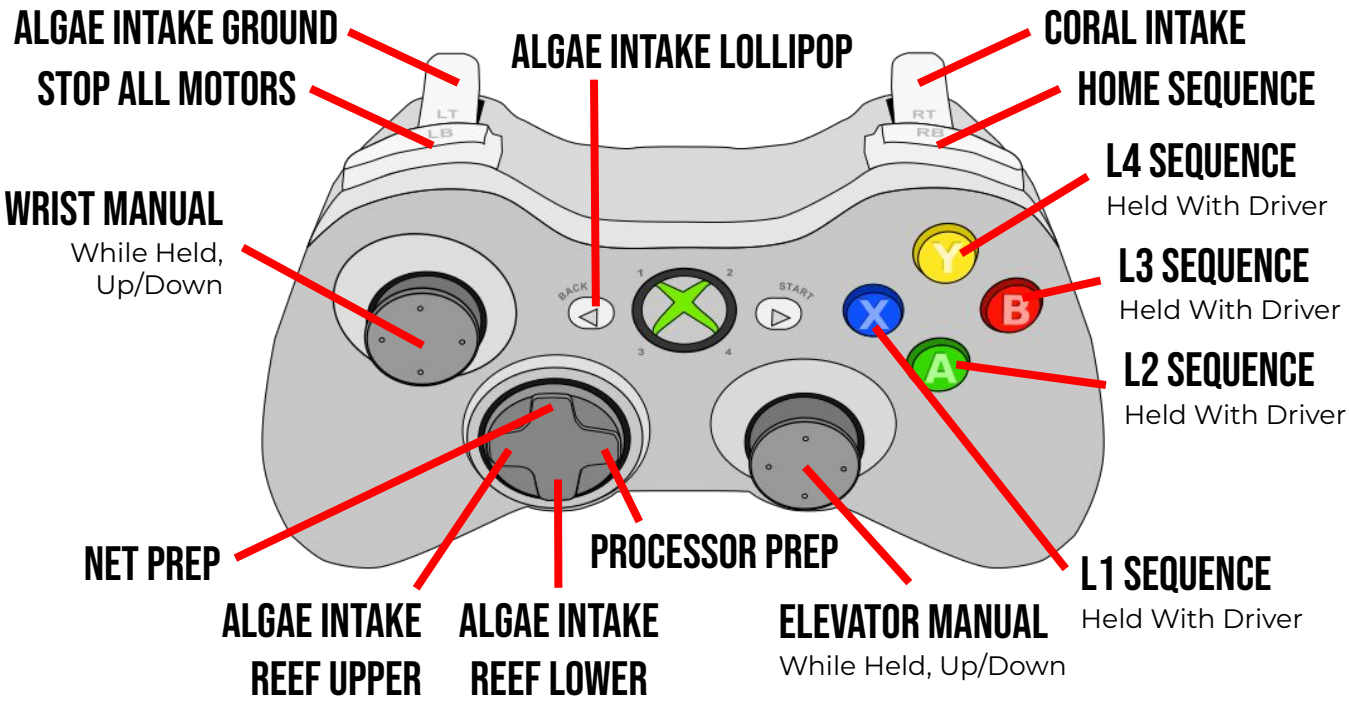
PROGRAMMING

TRAPEZOIDAL MOTION PROFILING

- Ramp Up (Acceleration)
    - Elevator gradually accelerates at a constant rate, steadily increasing velocity
- Constant Velocity
    - Elevator stops acceleration, maintains desired maximum velocity
- Ramp Down (Deceleration)
    - Elevator decelerates at the same constant rate as acceleration

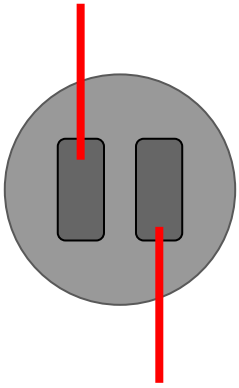


CONTROLS



DRIVE JOYSTICK

RELEASE/SCORE ALGAE

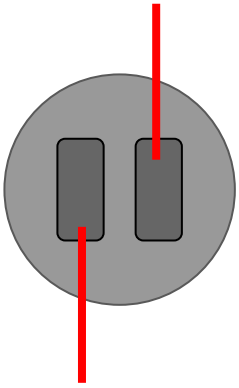


RELEASE/SCORE CORAL

TURN JOYSTICK

DRIVE TO BARGE TO SCORE ALGAE

While Held, Move Side-To-Side to Strafe Along Barge



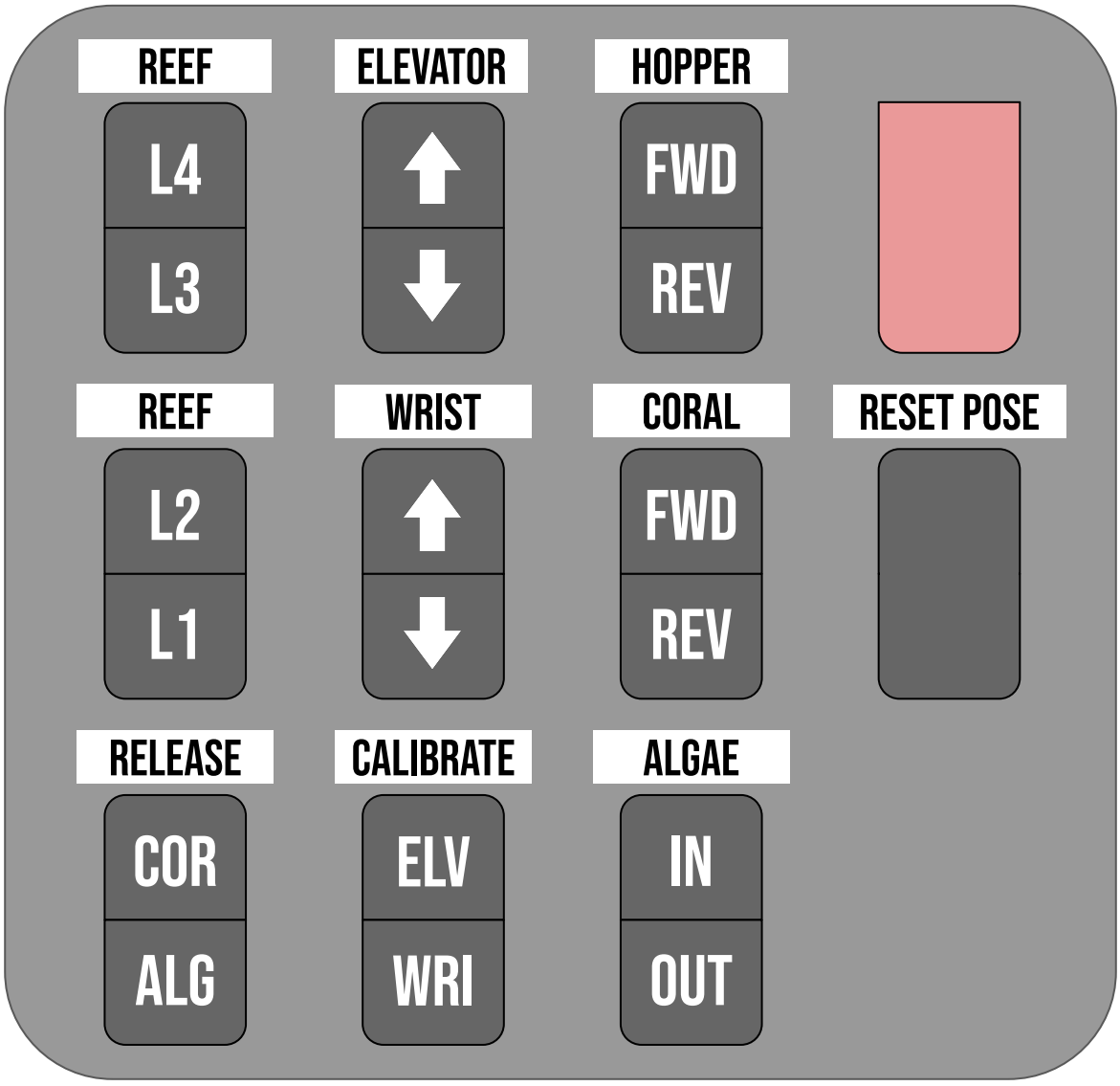
DRIVE TO REEF AND SCORE CORAL

While Held with Co-Driver, Move Side-To-Side to Jog Between Reef Branches

CONTROLS

CO-DRIVER PANEL

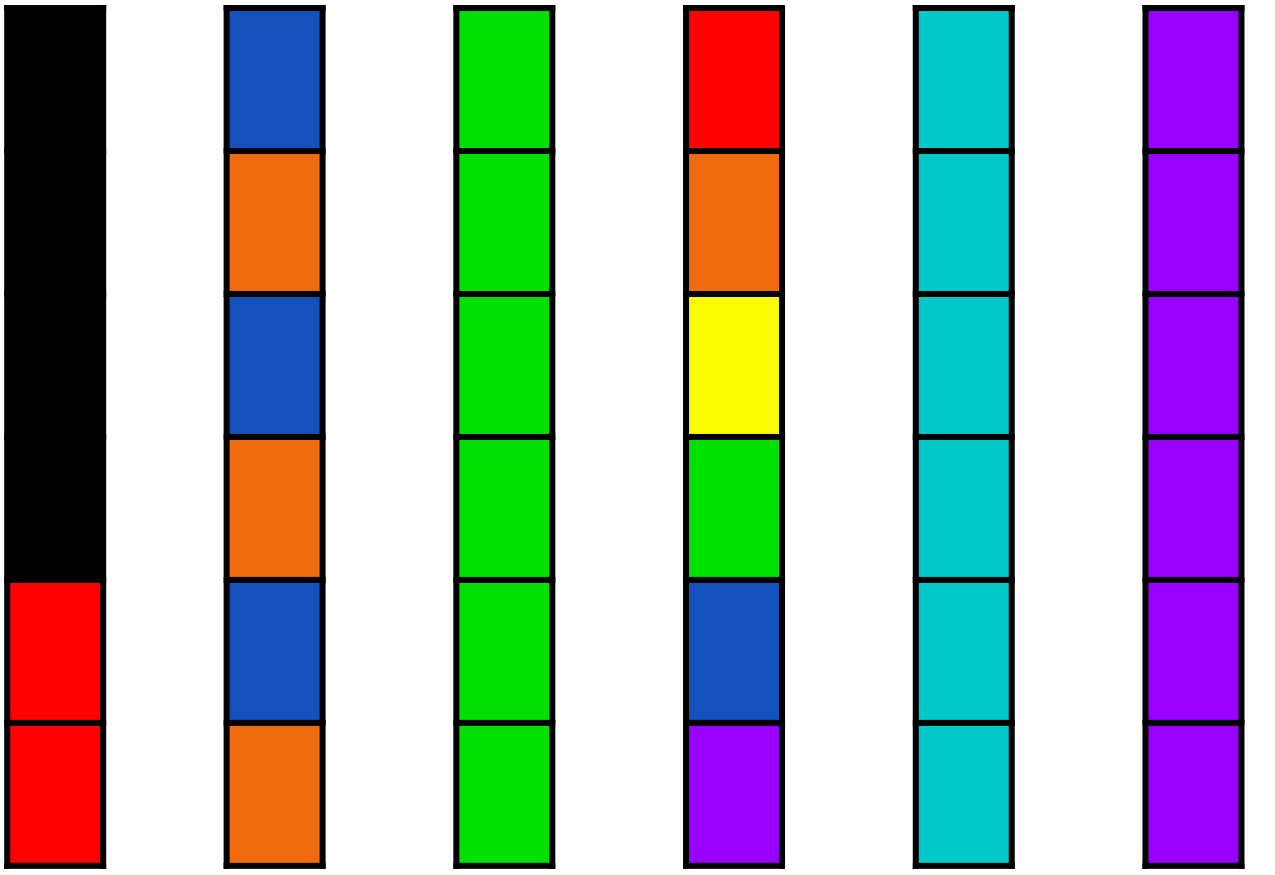
- Used mainly during the pit checkout routine before matches and for manual controls as a fallback during matches
- Includes the following controls:
  - Manual controls for every subsystem (ignoring interlocks)
  - Manual re-calibration for the elevator and wrist
  - Manual wrist/elevator setpoints for scoring on the reef



CONTROLS

LED STRIPS

- Used to communicate with the drive team various statuses and events that the robot goes through
- Controlled through the CANdle with both built-in and custom animations and patterns
- 3 strips on the robot (2 vertical, 1 horizontal)
- Use the CANdle for displaying sticky faults so that the drive team can check mechanism calibrations when getting on the field



MATCH TIMER
15-Second Countdown

DISABLED
Animated

AUTOMATED DRIVE/SCORE
Complete

AUTOMATED DRIVE/SCORE
In Progress, Animated

ALGAE MODE
Flashing While intaking

CORAL MODE
Flashing While Intaking

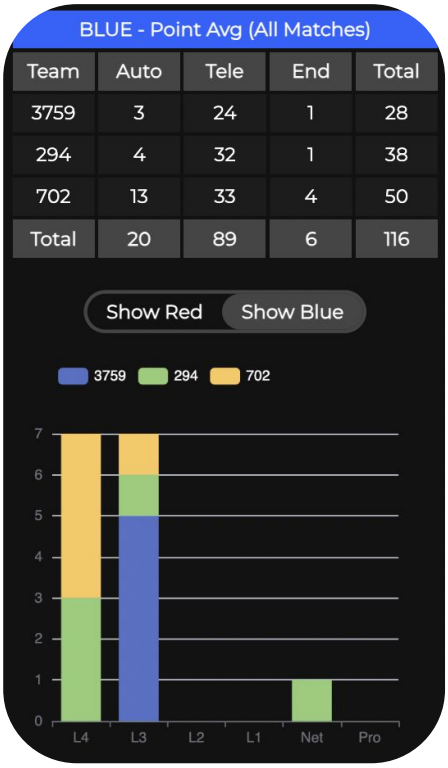
STRATEGY

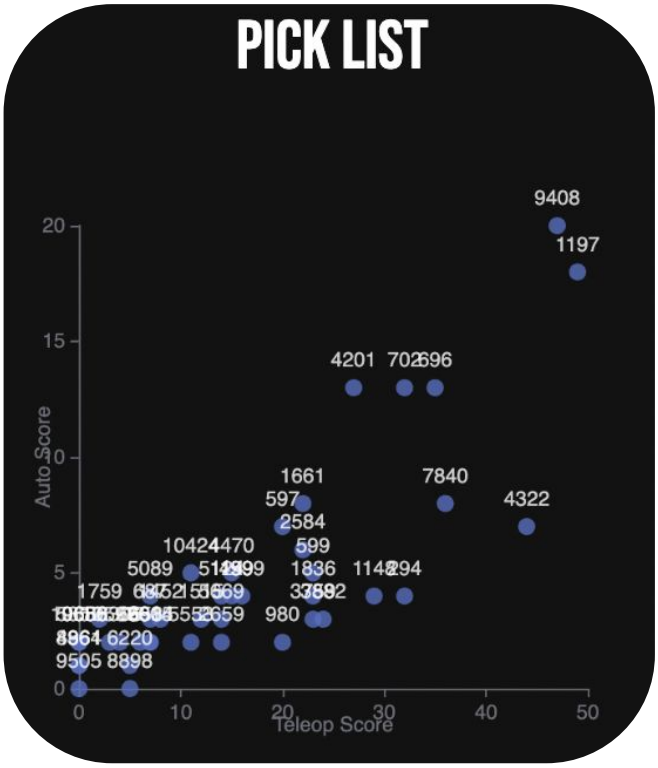
DATA COLLECTION

- Custom scouting app: *Squid Scout*
- Data shared with *687, The Nerd Herd*
- Collect less data, better
  - Canned comments provide uniform qualitative data

DATA DISPLAY

- Predict matches to guide match strategy
- Pick List page for alliance selection
  - Display data via graphs to assist with alliance selection
  - Sort by specific categories to find teams that best fit our alliance
  - “Pick” teams as alliance selection progresses to hide from charts

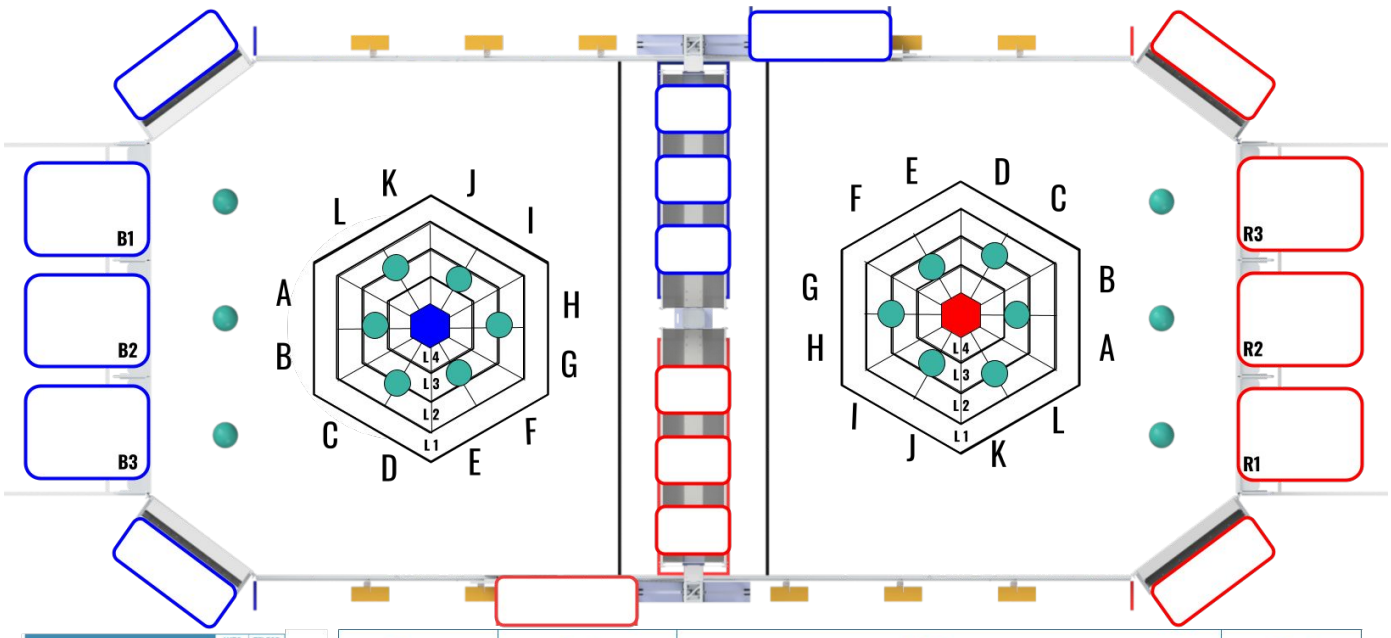




STRATEGY

MATCH STRATEGY

- Watch as many matches as possible
    - For qualification matches, maximize ranking points
    - For elimination matches, maximize points
- Discuss pre-match strategy with all teams present
    - Plan out every second of the match
    - Include contingency plans
- Ensure everyone on the alliance is comfortable with the match strategy
    - Enthusiastic partners will play a better match
- Strategy board to organize discussion
    - Drive team should only think about executing the strategy



		AUTO	TELEOP
LEAVE		3	
CORAL	CORAL scored in trough (L1)	3	2
	CORAL scored on L2 BRANCH	4	3
	CORAL scored on L3 BRANCH	6	4
	CORAL scored on L4 BRANCH	7	5
ALGAE	scored in PROCESSOR	6	6
	scored in NET	4	4
BARGE	PARK in the BARGE ZONE		2
	off-the-ground via shallow CAGE		6
	off-the-ground via deep CAGE	12	RP
***Coopertition* Bonus** – at least 2 ALGAE scored in each PROCESSOR			
AUTO RP - all non-BYPASSED ROBOTS LEAVE and at least 1 CORAL scored in AUTO			1
***CORAL RP** - If at least 5 CORAL scored on each level. If *Coopertition* achieved, at least 5 CORAL must be scored on each of 3 levels.			1
***BARGE RP** - at least 14 BARGE points are scored			1
Win	completing a MATCH with more MATCH points than your opponent		3
Tie	completing a MATCH with the same number of MATCH points as your opponent		1

Team	Auto	Teleop	End

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