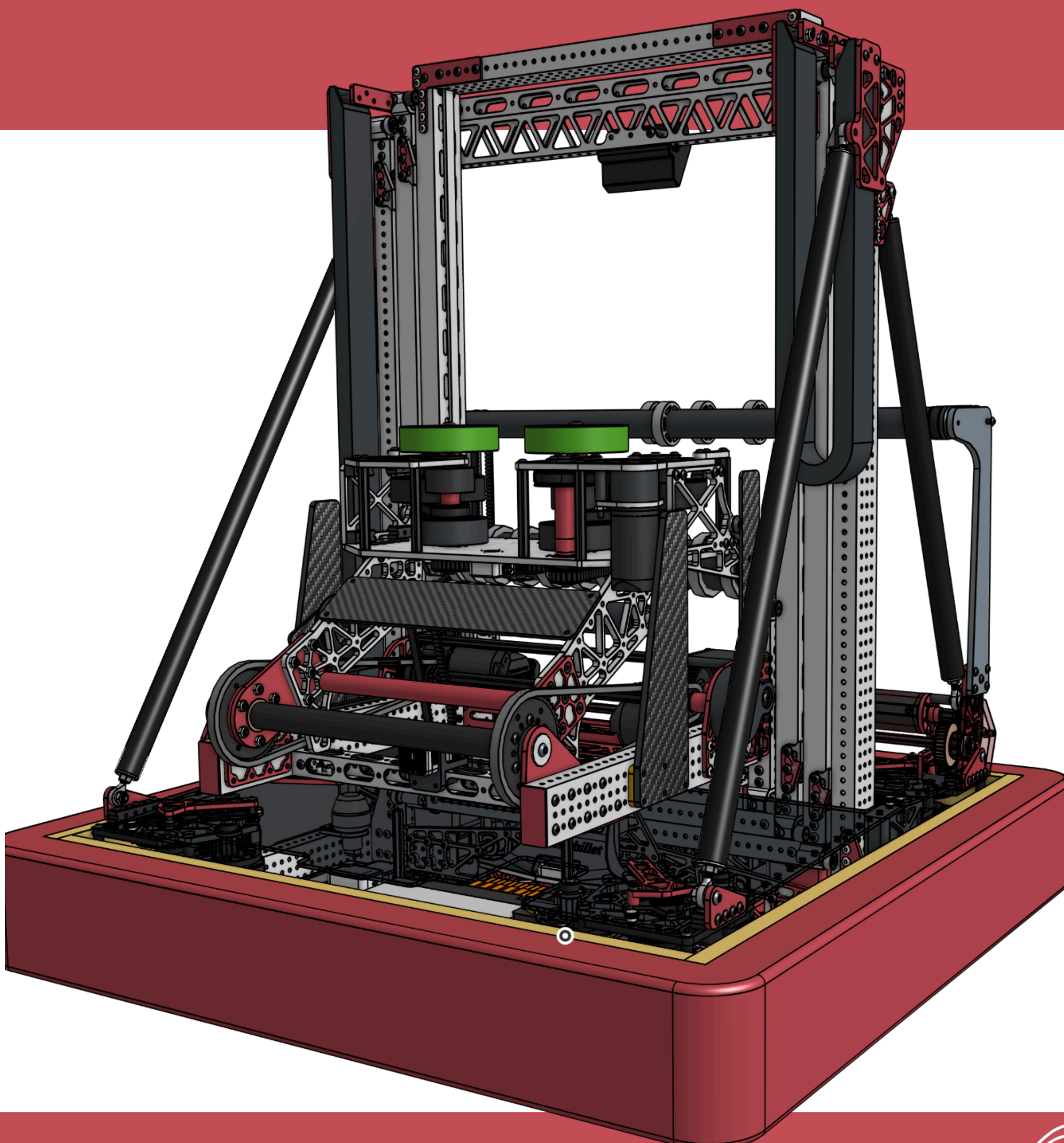
Miso Mechanics 9442

The Machine

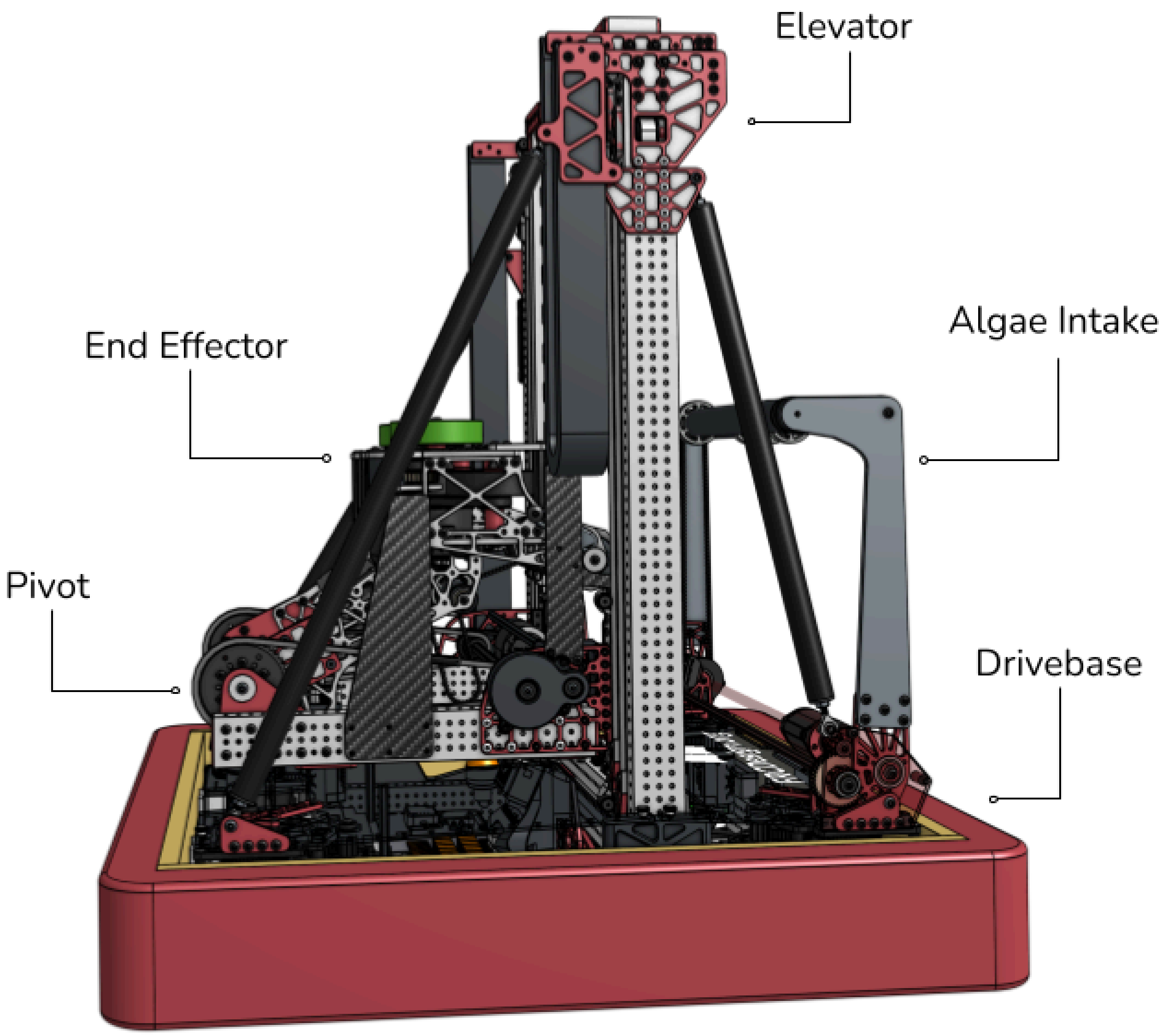


潮 (Shio)

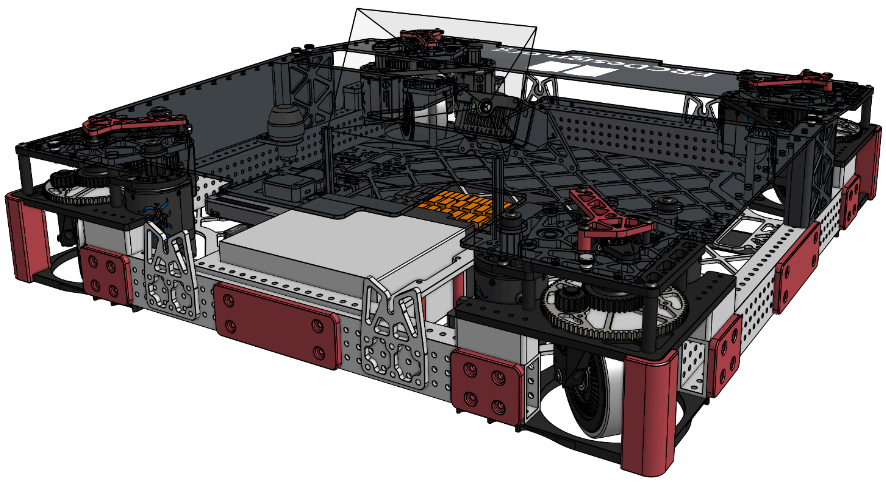
9442

Table of Contents

Mechanical Systems



Drivebase



Chassis

- 28” by 28” frame perimeter
- Frame assembled with ⅛” wall 2”x1” aluminum tubing
- ⅛” pocketed aluminum bellypan reduces weight and allows for efficient electronic mounting and wiring
- 3D printed bumper shims support bumpers and absorb shock along the length of the frame
- 1678-style bumper mounts allow for quick and easy bumper attachment

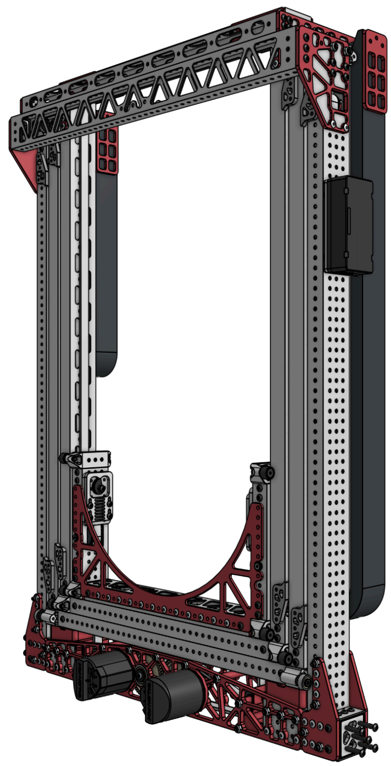
Swerve Modules

- Swerve X2i modules supplied by our sponsor West Coast Products
- X1 Gearing enables rapid acceleration
- Custom-made billet dropdown blocks keep both bumpers and Center of Gravity low
- Protective metal plates prevent falling Coral from breaking CANcoder wires
- Molded tread on wheels keeps traction high and wheel wear low

Polycarbonate Covers

- Catch falling Coral, keeping electronics safe
- Angled slightly, allowing Coral to easily roll off without getting stuck
- Attach to swerve modules for easy mounting
- Display our generous sponsors

Elevator



Rigging

- Driven by polyurethane and Kevlar belts for a compact profile
- Rigging routed through structure tubes for protection and durability
- Carriage-mounted belt tensioning system keeps belts tight and prevents skipping

Structure

- Built with 2”x1” aluminum tubing, WCP and SDS inline bearing blocks, and custom metal plates
- Supported with carbon fiber tie rods
- Access holes along the belt run allow for easy maintenance

Electronics and Wiring

- Powered by two Kraken x60s
- Twin energy chains run wires to the carriage
- Mounts a Limelight 4 and indicator LED strips inside crossbar

Pivot

Mounting

- Mounts onto elevator carriage via nutstrips and WCP tube plugs
- Structure upheld with ⅜” hex shaft and 1”x1” aluminum tube crossbars and custom bent sheet metal plates
- 3D printed crush blocks in the end of tubes add extra support and help the tubes hold shape
- WCP SRPP ‘wings’ help control algae for barge scoring

Deadaxle Pivot

- Pivot driven 42:1 by a Kraken x60, leading coral roller driven 2:1—pivoting arm sits on a, 2” OD round aluminum tube, which turns to transmit power to the leading coral roller
- Deadaxle pivot transmits no torque, and therefore doesn’t twist or otherwise deform
- Jackshaft powers both sides of the pivot to prevent twisting

Tensioning

- Shim tape on all gears and sprockets to minimize backlash
- WCP turnbuckles on pivot chains to tension as the chain stretches from use
- Custom gearboxes let us reduce backlash in the important places; this wasn’t an option on earlier versions that used a MAXplanetary

End Effector (V1)

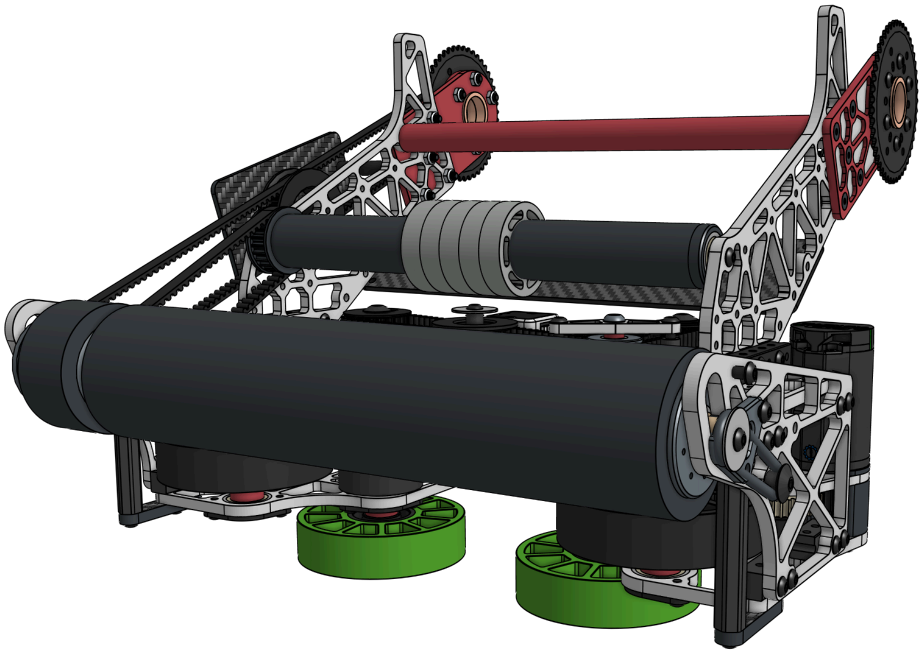
Algae

- Powered by a Kraken x60 geared 1.7:1
- Transmission features carbon fiber nylon 3D printed herringbone gears to save weight and minimize backlash
- Polycarbonate deadaxle rollers on top and bottom pull algae from the reef with ease
- CANrange sensor detects held algae for scoring

Coral

- Driven by a Falcon 500 geared 4:1
- Star wheels and compliant round wheels reorient and center coral lying on the floor
- Omni-wheels provide a consistent hard stop on the ground
- Top roller maintains a hold on coral to guarantee pickups
- CANrange sensor for piece detection

End Effector (V2)



Design Improvements

- Pocketed and half-pocketed 7075 aluminum plates provide more durability than previous intake iterations while staying lighter than previous designs
- Nutstrips and SRPP supports connect metal plates, providing stronger structure
- Simplified wheel layout shortens game piece travel path, making intaking faster
- Reworked power transmission powers leading and algae control rollers from the pivot, keeping one more motor safe inside the frame perimeter
- Floating leading roller keeps better control over coral as it enters the intake
- Extended arm length, along with thinner bumpers, allow for scoring from further away
- Double-sided belt run simplifies transmission by replacing a gear swap, lowering the part count of the intake and helping to save weight
- A second CANrange sensor makes piece detection faster and more accurate

Power Transmission

- Coaxial transmission drives leading and algae control rollers with a Kraken x60 with a 2:1 gear reduction
- Double-sided belt drives coral indexing rollers at different speeds with a gearing totalling 8.89:1 on a Kraken x44

Algae Ground Intake

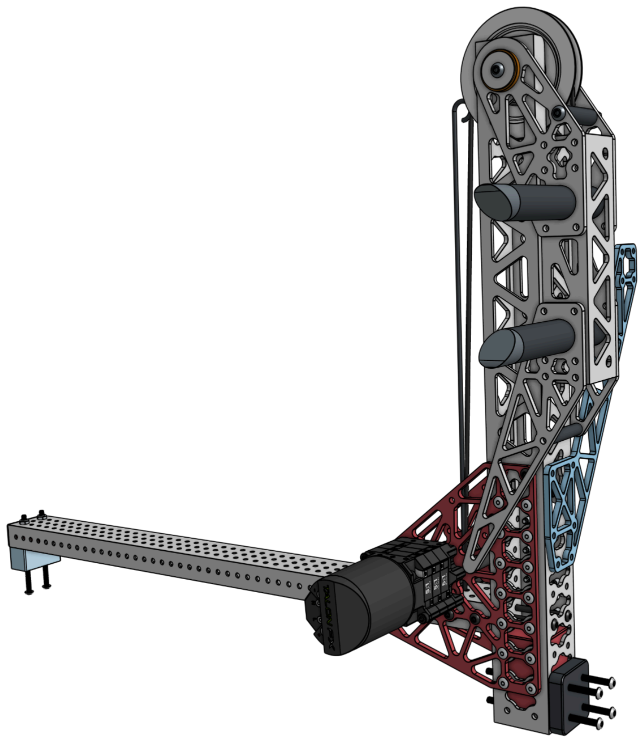
Mounting and Pivot

- Twin pivot and roller power gearboxes mount to swerve modules via WCP nustrips for simple mounting and packaging
- Elevator-supporting carbon fiber tie rods connect to gearbox plates, supporting the elevator and preventing algae from falling out the sides of the robot
- Deadaxle pivot prevents pivot axle deformation, improving robustness
- Sheet metal rack and pinion pivot keeps pivot profile small
- ⅜" aluminum jackshaft drives both sides of the pivot at the same speed, preventing twisting
- Pivot powered by a Kraken x44 geared 13:1

Rollers

- Sturdy and lightweight WCP SRPP arms hold rollers
- Polycarbonate rollers are held to pivoting arms with a 3D printed stub axle setup, keeping weight lower and durability higher
- Coaxial transmission drives rollers 3:1 with a Kraken x44

Climber



Mounting and Structure

- Milled 2”x2” aluminum tube supports arm
- 2”x1” tube spans across drivetrain to spread forces over the whole robot
- 4” OD wheel redirects Dyneema cable to ease pivot motion

Climber Arm

- Pivot driven by a Kraken x60 and a 225:1 MAXplanetary gearbox
- Dyneema cable utilizes the capstan effect to reel in cage
- Arm assembled with 5mm aluminum plates and 2”x1.5” aluminum boxtube
- Bronze bushings keep pivot actuation smooth and low-friction
- 1” OD, ⅛” ID aluminum tubes hold cages to climb
- 3D printed tips and grip tape on tubes assist in cage acquisition
- Compact design allows arm to be deployed and retracted in a single motion

Design Process

Simplicity makes our robot unique

As a small team in our second year, we lack many of the resources of larger teams. To be competitive, we knew even before the season began that we needed a clean robot design with a limited number of moving parts. Fewer elements and moving parts mean there are fewer things to break, repair and maintain. And it's what puts a working robot reliably on the field for team Miso Mechanics every match.

Minimizing the amount of complexity in our design allows us to focus on the most important parts of the robot and making them as good as possible. This year our robot has only two degrees of freedom, or two moving parts – the elevator and the pivot. This decision freed up time to iterate the intake, which we did no fewer than 30 times during design.
The elevator and the pivot-intake are basically our whole game. That makes our robot effective and able to do what matters most – be consistent.

Putting up the most points of anybody at an event doesn't matter if we could only do it once. What really matters is being able to do that every single match we play. By cutting out things we don't need right now, we've been able to maximize efficiency in the design process, building the robot, and how we've been able to score.

Virtually every decision we have made and everything we have done since before Day One of the season up to today, we have been focused on being as effective as possible, on and off the field.

An engineering process based on game strategy

On the first day of the season we decided we would start small, picking out one or two game elements that would make the biggest splash in our first competition. Getting really, really good at the most essential elements of gameplay would be our baseline, and we'd add more features as the season progressed and gameplay demanded more.

This did mean making sacrifices, though. For example, this meant deprioritizing a Deep Climb in favor of spending more time getting coral on the reef. And this meant that we wouldn't get as many bonus rank points. Yes, bonus RPs can be obtained in any match, win or lose, those require more robot functions, and designing a robot with Week 6 capabilities would take a lot of time. Alternatively, we could focus on the elements that would win a match and spend more time with those, garnering a more consistent, if maybe lower, stream of rank points. Given that we limited our time by going to Week 1 and 2 events, we chose the latter.

For Week 1, we determined that these key gameplay elements would be:

- Score lots of coral, especially on L4 (most points per cycle)
- Remove algae from the reef—this opens more scoring opportunities for us and for our alliance partners
- Avoid defense

And then we considered what would go into these gameplay elements. Nothing specific yet, just what each of these really means.

- Score lots of coral, especially on L4 (most points per cycle)
  - Shorten cycle times—an easy way would be to have to drive a shorter distance
  - Make every cycle count—basically, make sure every coral we try to score goes somewhere. Even if it takes a little longer to guarantee a score, it takes longer to miss and have to get a new piece
  - Prioritize higher-scoring placements—we're not going to be filling the reef alone, so get the most score out of each piece
- Remove algae from the reef—this opens more scoring opportunities for us and for our alliance partners
  - Even if the algae doesn't score, getting it off the reef gives you more places to score.
  - If L4 gets full, we need somewhere else to score.
- Avoid defense
  - Defense is easiest near the sources, where a robot can simply park against the wall and cut the flow of game pieces to the field. Yes, you can go to the other source on the field, but this adds more congestion to your driving.

When we broke each of these sub-priorities down to their smallest nuances, we decided that we needed the following:

- Ground coral pickup
  - Keeps cycles shorter, distance wise
  - Less punishing to miss a score—if we or an alliance partner drop a piece or misalign, we can simply recover and try again without driving halfway across our side of the field
  - Harder to defend—one way to think of this is that by parking against the source, you're essentially playing defense against the coral (in the sense that you prevent it from getting to the robots on the field). If you drop a bunch of coral on the ground, this isn't an option and you have to play defense against the robot This is much harder, and we have experience driving around defenders from last year, in which defense was a pivotal role in every high-level match
- The ability to score coral on any level of the reef

    - Every cycle counts—with this, you'll always be able to score somewhere, even if it's in the trough. If L4 gets filled, you can score on L3, and you get value out of every piece you hold.
- Automatic alignment for scoring
    - The most time consuming thing you can do in a match is miss your scoring. Now, you've taken the full time of a cycle, but you haven't actually made a cycle. The driver can take their time to ensure successful scoring, but the robot can do it faster.

When discussing further improvements and upgrades, we do the same type of breakdown, looking at what other teams have found success with. For example, we took note of how teams 604 and 1678 combine algae and coral cycles to put up big points. We also take note of where other teams struggle—teams 1323 and 2930 have lost matches after getting stuck on top of algae. Learning from our mistakes, as well as the mistakes of others, is just as important as the successes when trying to improve.

Efficiency above all else

To sum up everything in the last section, the driving force behind our design this year is focusing on efficiency. Efficiency in scoring and, more importantly, efficiency in building it. Efficiency means, at least for us, that we produce the best possible product for the amount of time spent working on it. That doesn't mean making the best robot in the world, but rather making the most of the time you spend on each individual aspect. More importantly, though, it means knowing when to quit.

Think of the law of diminishing returns, where you can always spend more time on something and get it closer and closer to perfect. There will always, every single time, no matter how long you spend working, be room for improvement, and spending time with it will improve its performance. But as you spend time working, you leave less and less room for improvement. It's still there, but you make less and less—however, this means you'll need to put more time in to get less improvement out.

Another way you can think of this is in Points Per Hour (PPH). Basically, the more hours you spend on something, the more points that thing will earn in a match. You want to get as many points as possible, spend the fewest possible hours getting those points. By doing this, you maximize the amount of points you make per hour of work—for example, you can spend ten hours redesigning your intake mechanism to wring ten more points out per match. Here, one hour of your real life time is worth one point in a match. Is it worth it to spend the time, or is it better to work on something else?

Say you do spend the time, and now you earn ten more points per match. You could keep redesigning to make another five points, but it still takes ten hours of work to get those points. Is it worth it now?

PPH is all about knowing when to quit. Knowing your limitations and when it's no longer worth it to pour time into milking tiny improvements. Time during the build season is incredibly limited, and making sure we know how we can best spend our time each day means that we can get the most out of our work and out of the season.

Redesigns and Changes

Since competing in our Week 1 and 2 District Events, we are very happy with the robot's performance, but as strategies evolved and developed, we've had to adjust the robot to excel with new requirements.

After Week 2, we redesigned our coral intake, making it significantly lighter. Saving weight let us replace the polycarbonate (which had broken at our earlier competitions and needed to be replaced) with thicker, denser, and sturdier 7075 aluminum.

With the intake redesign, we added barge scoring to our list of capabilities. Being able to take a coral from the ground, placing it on L4, and scoring the preplaced reef algae has shown itself to be arguably the single most efficient way of scoring points in this game, and the ability to execute these efficient cycles was a priority for us going from our Week 1 and 2 events and into our DCMP.

We experimented with adding a climber to improve our endgame, the area where we currently fall the shortest. In fact, we had a climber built since Week 1, but our original design didn't work as well as we'd hoped, prompting a lighter, smaller redesign that better fit into our robot's structure, but we didn't have the time to completely build and test it before DCMP.

Aside from major changes, we dropped the gear reduction on our elevator to make the extension faster, switched from a MAXplanetary to a custom gearbox on our intake pivot to minimize backlash, and replaced damaged elevator tubes. Though they may be smaller, repairs like these can make the difference between breaking down and surviving one more match.

Going into Worlds, we reevaluated optimal match strategy. During Week 6 District Championships and Regionals, teams started running out of both coral to score and places to score it. When this happens, the most obvious thing to do is score algae, often necessitating the ability to score the prestaged 'lollipop' algae and any knocked off the reef by alliance partners—and opponents as well.

To accommodate this new layer of the game, we finally added the intake for grounded algae that we'd been planning on adding. Inspired by the likes of 254 in 2014, 1323 in 2019, and 4414 in 2025, this allows us to pick up algae as well as score it in the processor.

We also revisited the ever-problematic climber. The new intake takes up much more vertical space than the original design, and the new climber design didn't look capable of pulling the robot far enough off the ground to count for points. Because we had extremely limited time before shipping our robot, we made changes to the original climber design instead of testing a brand new concept.

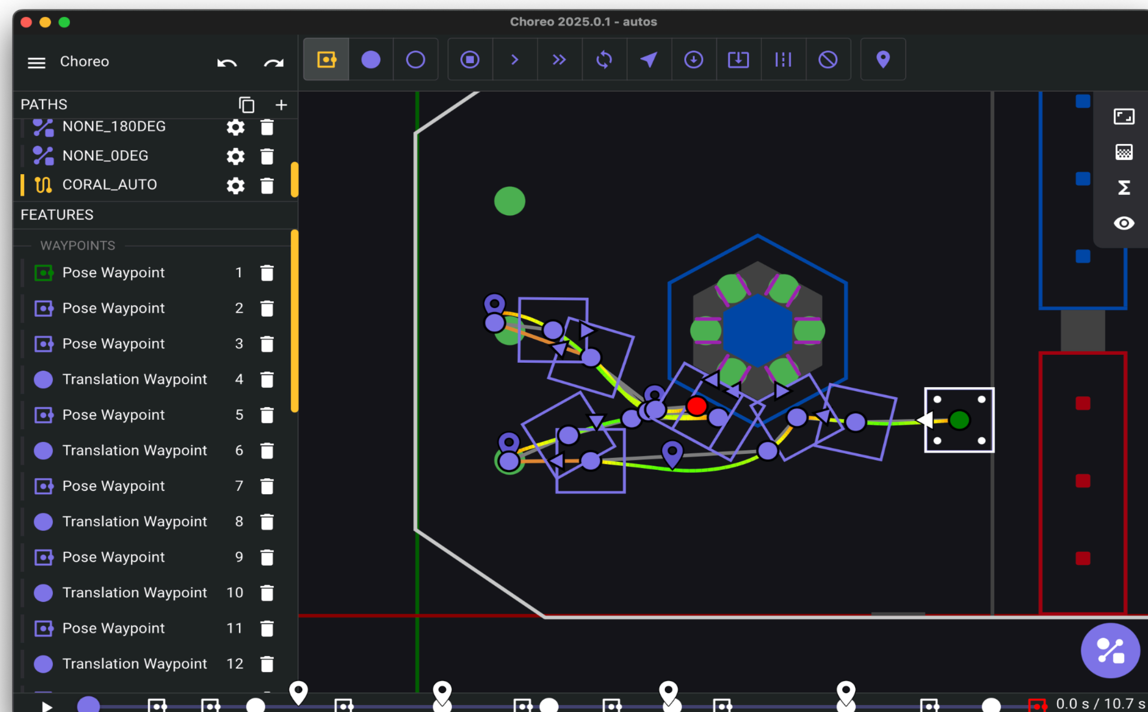
Programming

Autonomous

We have 7 unique autos:

- 6 coral only autos.
- 1 coral and algae auto.

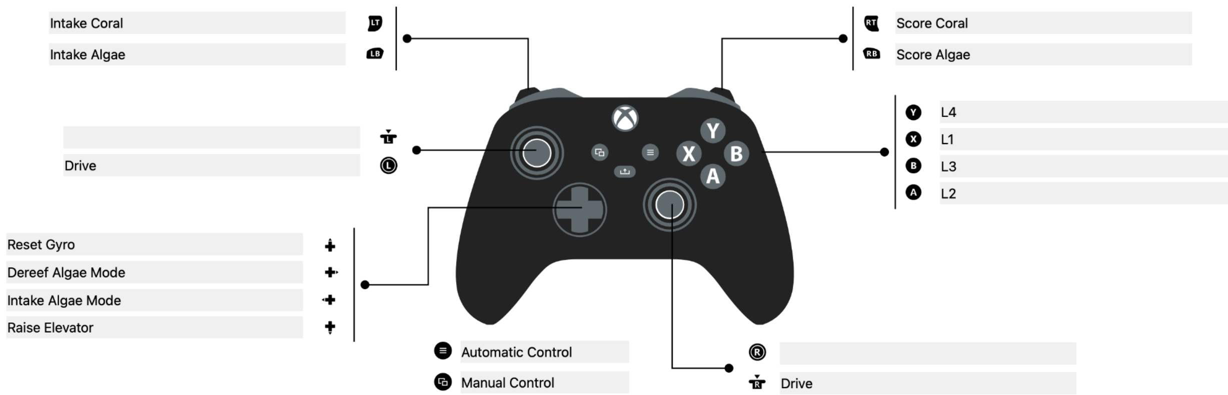
To simplify the process of creating these autos, we use one monolithic path to more easily sequence each auto. Each path is split into pieces and sequenced with other subsystems. In places where splitting the path is not appropriate, we use an event marker to trigger commands.



For this path, we split it up into cycles and added event markers for when we deploy and stow the intake.

Teleop

Controller Mapping



*The back paddles are bound to the ABXY buttons.

Before coming up with this layout, we set some constraints:

1. Only one driver is required to drive the robot.
    a. The option to have two human players gives our driveteam a lot of flexibility.
2. Face buttons should not be necessary to press in normal gameplay.
    a. Letting go of the joysticks is not ideal.
3. Everything should have a manual fallback.

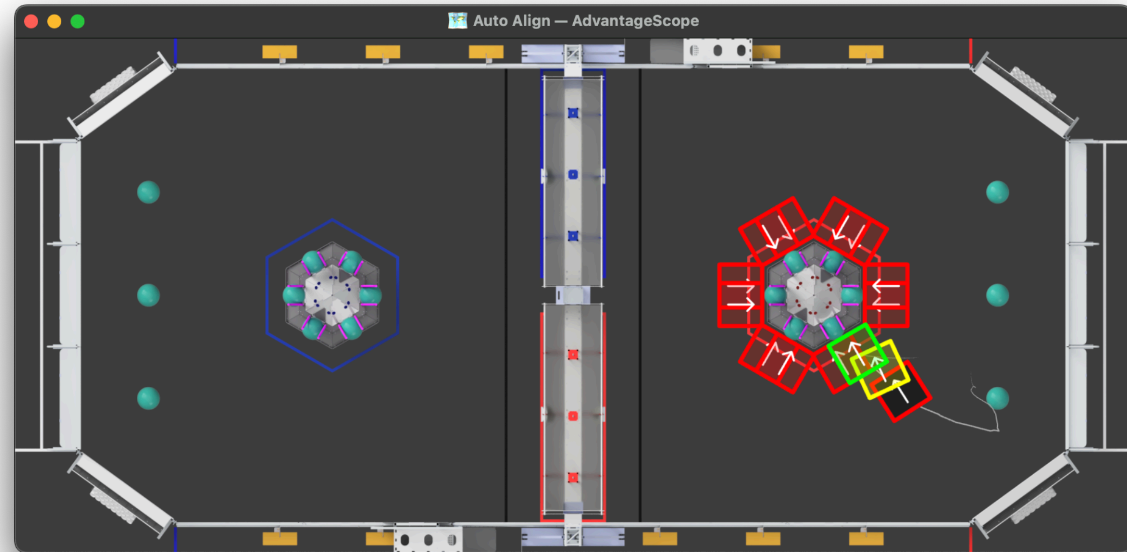
Heading Lock

In many places, we want the driver to focus only on translating the robot, so we created a system in which we can decide on a location or rotation to lock the robot heading to.

- Robot is holding a coral.
    - Aim towards the reef.
- Robot is holding a coral and is near the reef.
    - Lock the heading with the nearest face of the reef.
- Robot is scoring algae in the barge.
    - Lock the heading towards the barge.

Auto Align

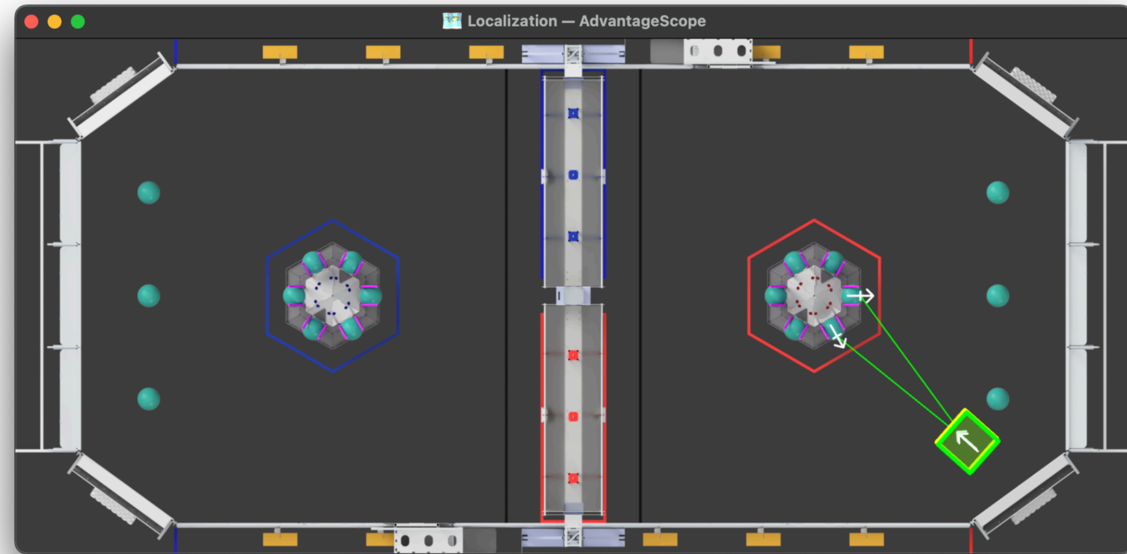
Instead of having a complicated system of buttons to choose where to align to, we decided on using the robot's position and velocity to decide a scoring location on the fly. This system makes scoring feel very natural while only requiring one button press.



Green is the selected pose, yellow is the expected pose, red is the robot pose.

Vision

All the above features require great localization, so to achieve that we use two Limelight 4s positioned at the front and back of the robot. We use both MegaTag1 and MegaTag2 and we filter the resulting measurements as necessary. We use MegaTag2 for robot translations and MegaTag1 for robot rotation; this is so we don't rely on the gyro being accurate for the entire match.



Green is the filtered pose, yellow is the unfiltered pose; the rest of the vision measurements are hidden under the two poses above.

Logging & Performance

We believe that logging is very useful, especially when synced up with video. If we identify any problems we couldn't solve at a practice field or anything weird in an official match, we go straight to the logs. We have tried many logging solutions, but so far only one has met our requirements of performance and ease of use. We log everything from controller inputs to motor signals.

Optimizing loop times is an important part of FRC programming, to ensure consistent closed loop feedback for applications such as pathing. Java is notably an object oriented programming language, without explicit allocation of memory resources, which causes issues with loop times on embedded systems with low performance, such as the NI roboRIO 2. One especially expensive operation is memory-read writes. While profiling loop overruns with VisualVM, we found that our original logging solution, Monologue, was using up a lot of available memory, to the point where garbage collection became a significant factor in our loop times. Using DogLog helped solve this issue for us, by moving the performance intensive writes to a separate thread.