VELOCITY RAPTORS

GP ADVISED

ENGINEERING NOTEBOOK

Crescendo 2024

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1.0 ROBOT STATS

Weight: 117 lbs.

Dimensions with bumpers: 30.5 in X 36.5 in

Cycle time: 15-20 seconds

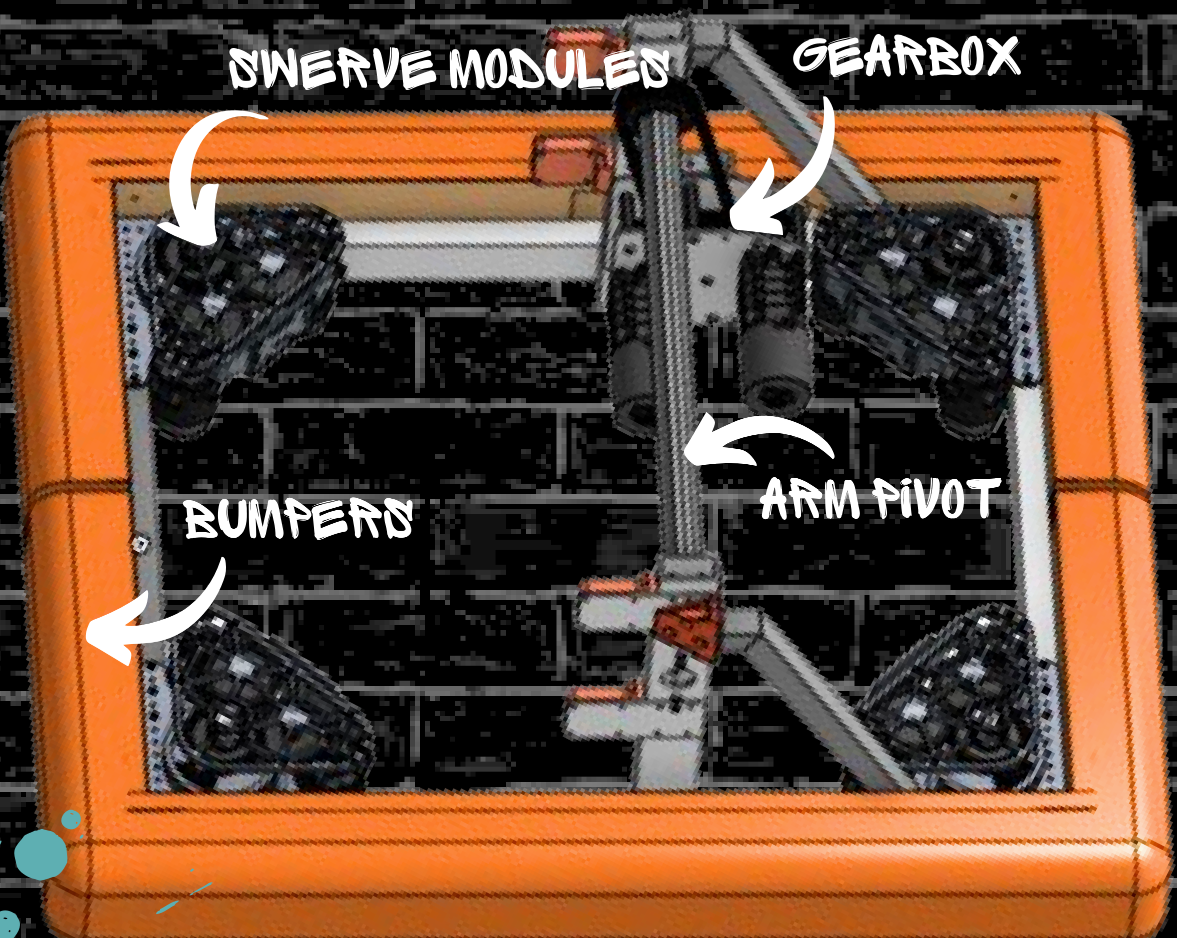
Scoring: Amp

Intaking: Ground and Source

Endgame: Climb + Trap

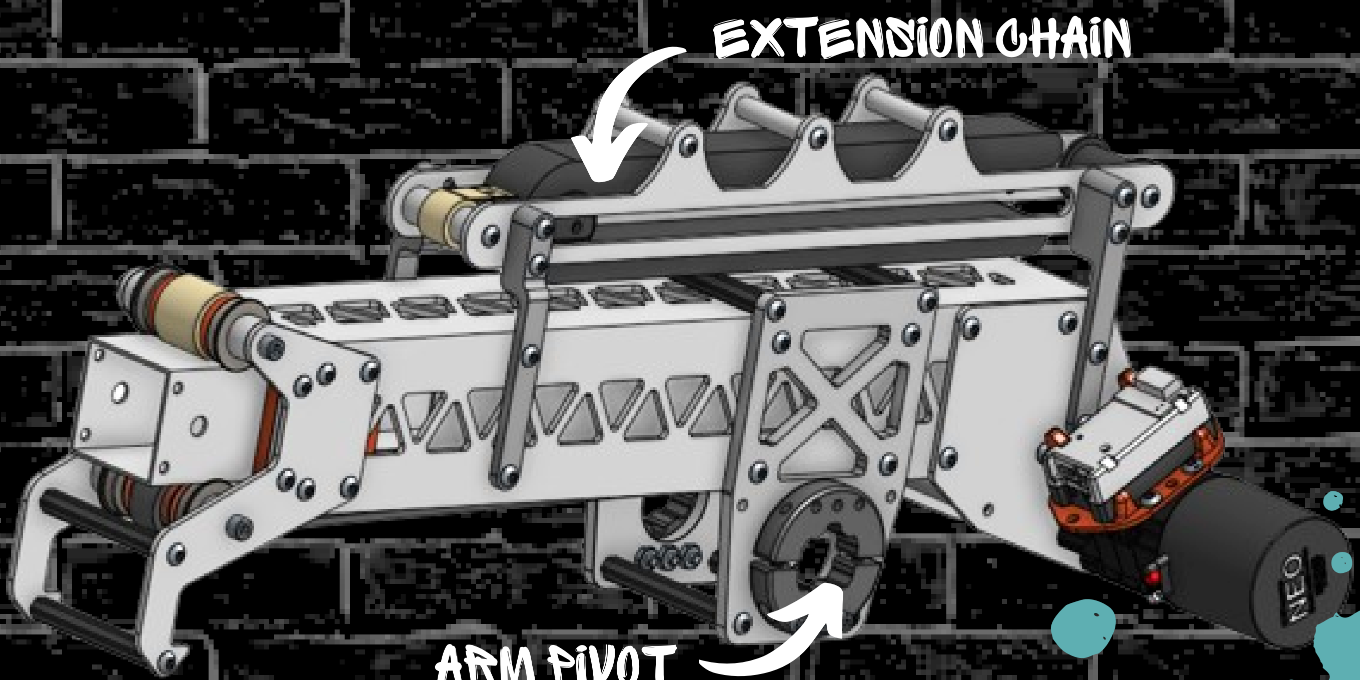
2.1 DRIVETRAIN

- Consists of MK4i L2 Swerve Modules
- Empirical top speed of 20.1 ft/s
- Maneuverable and agile
- Avoid obstacles and cycle in **15-20 seconds**

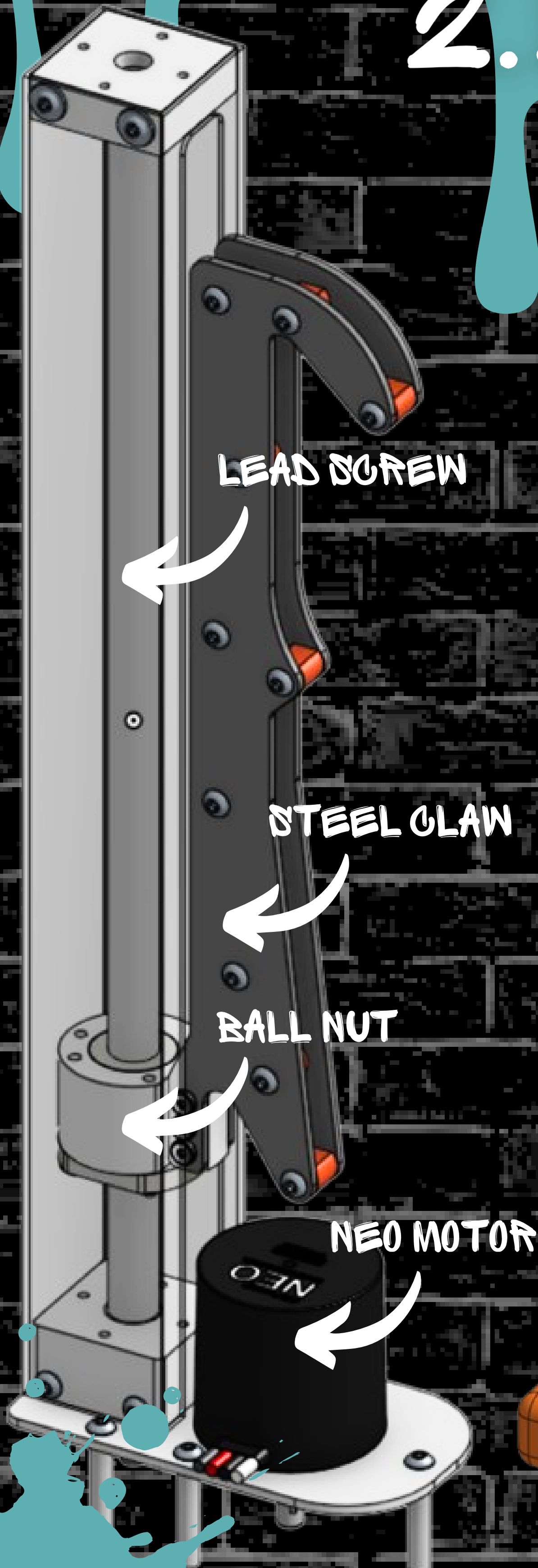


2.2 EXTENSION ARM

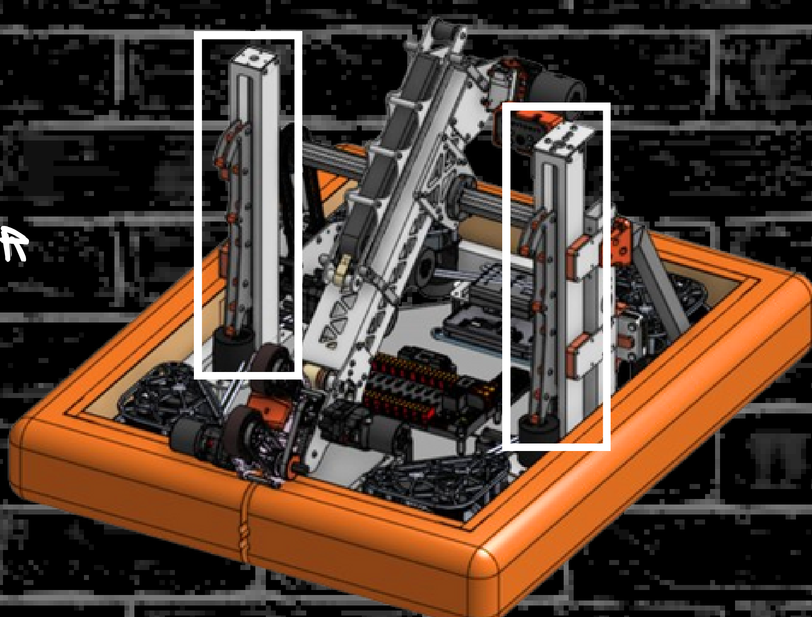
- Through design on a pivot
- Collect from **Source**, score in **Amp**, and score in **Trap** during endgame
- Can rotate down to fit under the stage



2.3 CLIMBERS

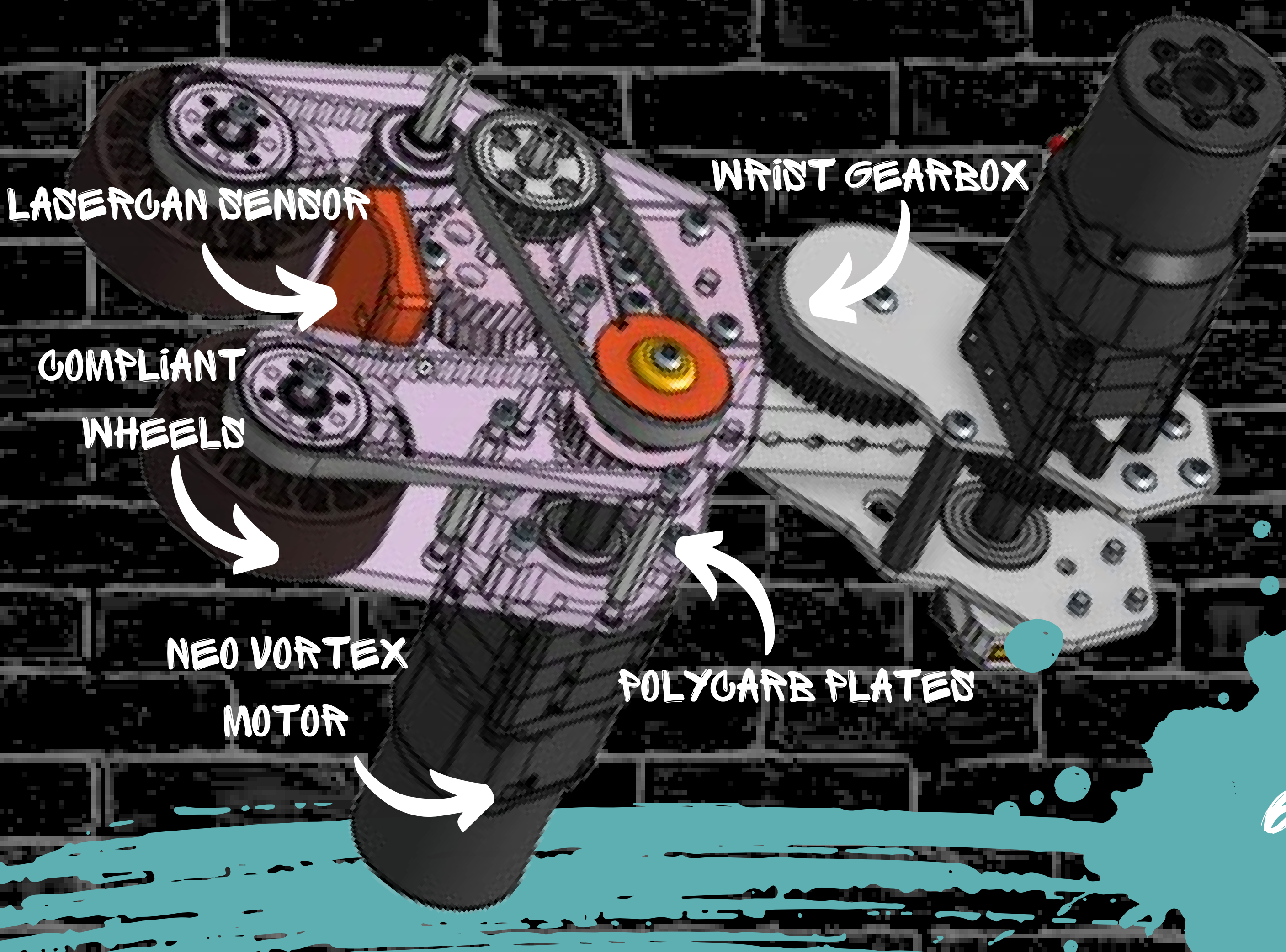


- 2 Identical climbers
- **Ball screw** moves the claw up or down
- 1-stage climb to hang
- 2-stage climb to reach the **trap**



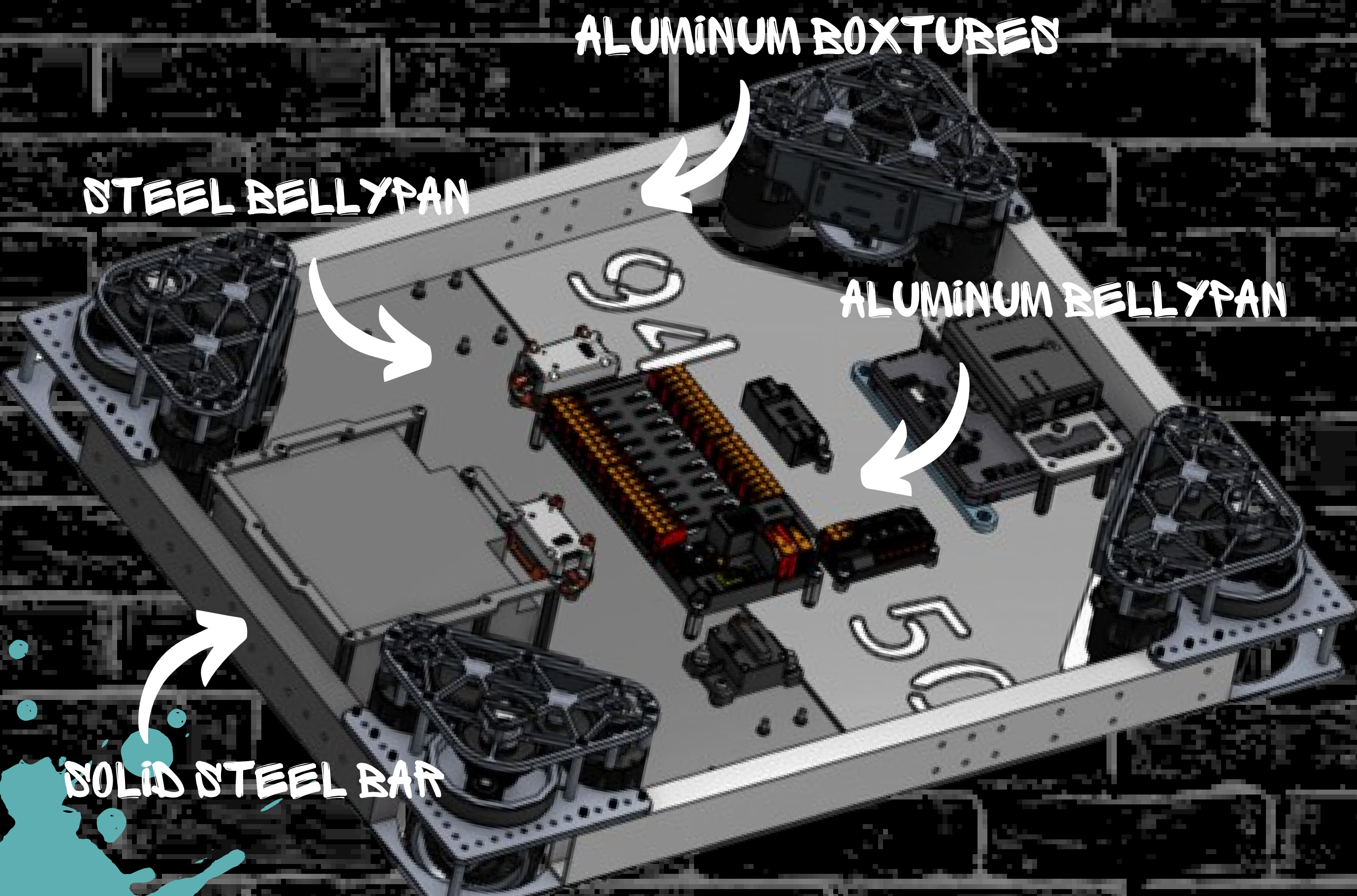
2.4 WRIST/INTAKE

- Two 30a wheels
- Intake notes from the **Source** or **Ground**
- Score notes in the **Amp**
- Intake mounted on a wrist to collect and score accurately



2.5 BELLY PAN

- **Balances** robot during endgame
    - Helps with **climb** and **trap** accuracy
- Rigid surface to mount electronics
- Low CG enable speed



3.1 GOALS

Maneuverability

- Low CG
- Drivetrain speed
- Arm speed

Ranking Points

- Amplifications
- Trap scoring

Our main goal for this season was to design a robot that could score the most RP as possible with a simple design. We implemented a mechanism that we were most familiar with to minize build time, and in turn, maximize the drive time we would have with our robot. Since we are a rookie team, we wanted to get as much drive practice as possible with other teams so that we could be ready for our first competition.

3.2 ROBOT ARCHITECTURE

Swerve: Fast drivetrain, very versatile and mobile. Lots of ability for local support - many teams in our area use sds swere pods

Arm: System that we're familiar with - built in offseason for Charged Up game (competed at offseason events), efficient through design

Bumpers: Design influenced by Robototes (FRC 2412) to slide easily onto robot perimeter. Wood milled to cleanly integrate metal brackets without any sharp edges.

3.3 TIMELINE

Week 1: Began Bumpers + Robot Design + Prototyping

Week 2: Continued building robot and bumpers, ended prototyping

Week 3: Continued building bumpers and robot

Week 4: First version of robot complete - continued building bumpers

Week 5: More bumpers and robot iteration

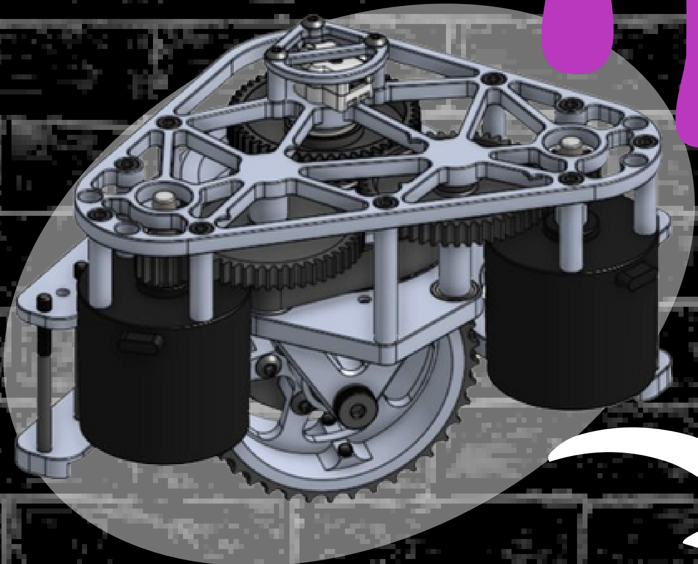
Week 6: Bumpers cont. + more robot iterations

Week 7: Bumpers complete, finishing touches on the robot

Week 8: Finalized robot

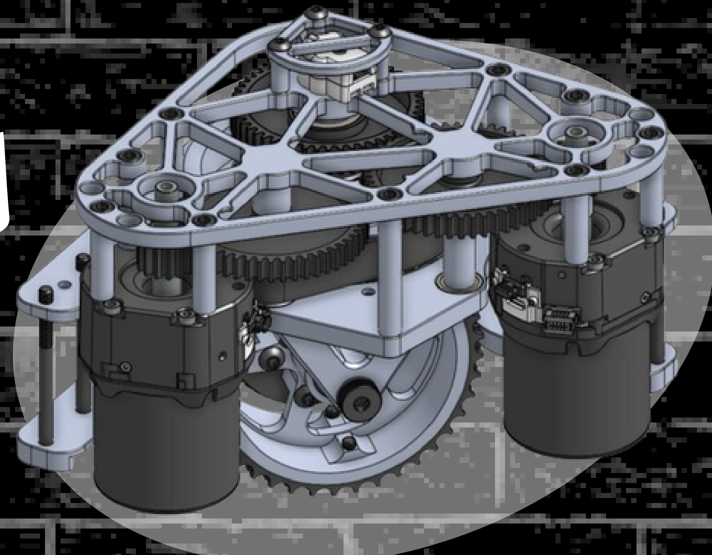
4.1 DRIVETRAIN

Swerve Iterations



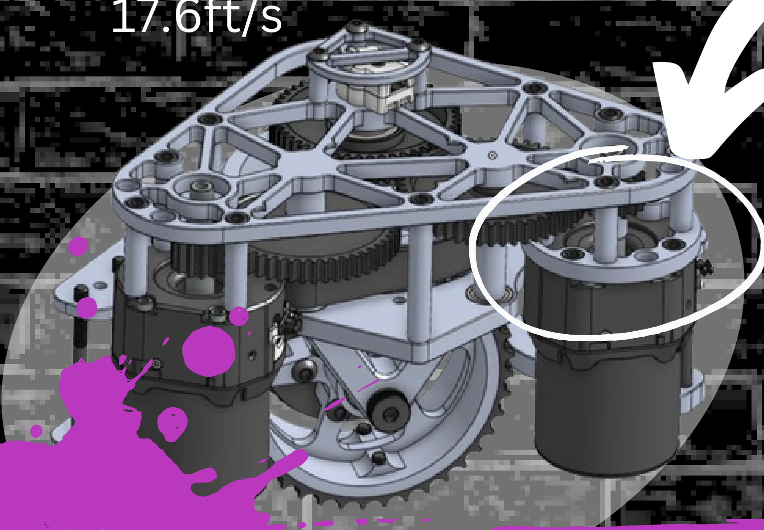
Neo Swerve

- NEO - MK4i L2 configuration
- Motor Free Speed = 5820 RPM
- Drivetrain Free Speed = 15.1 ft/s



Neo Vortex Swerve

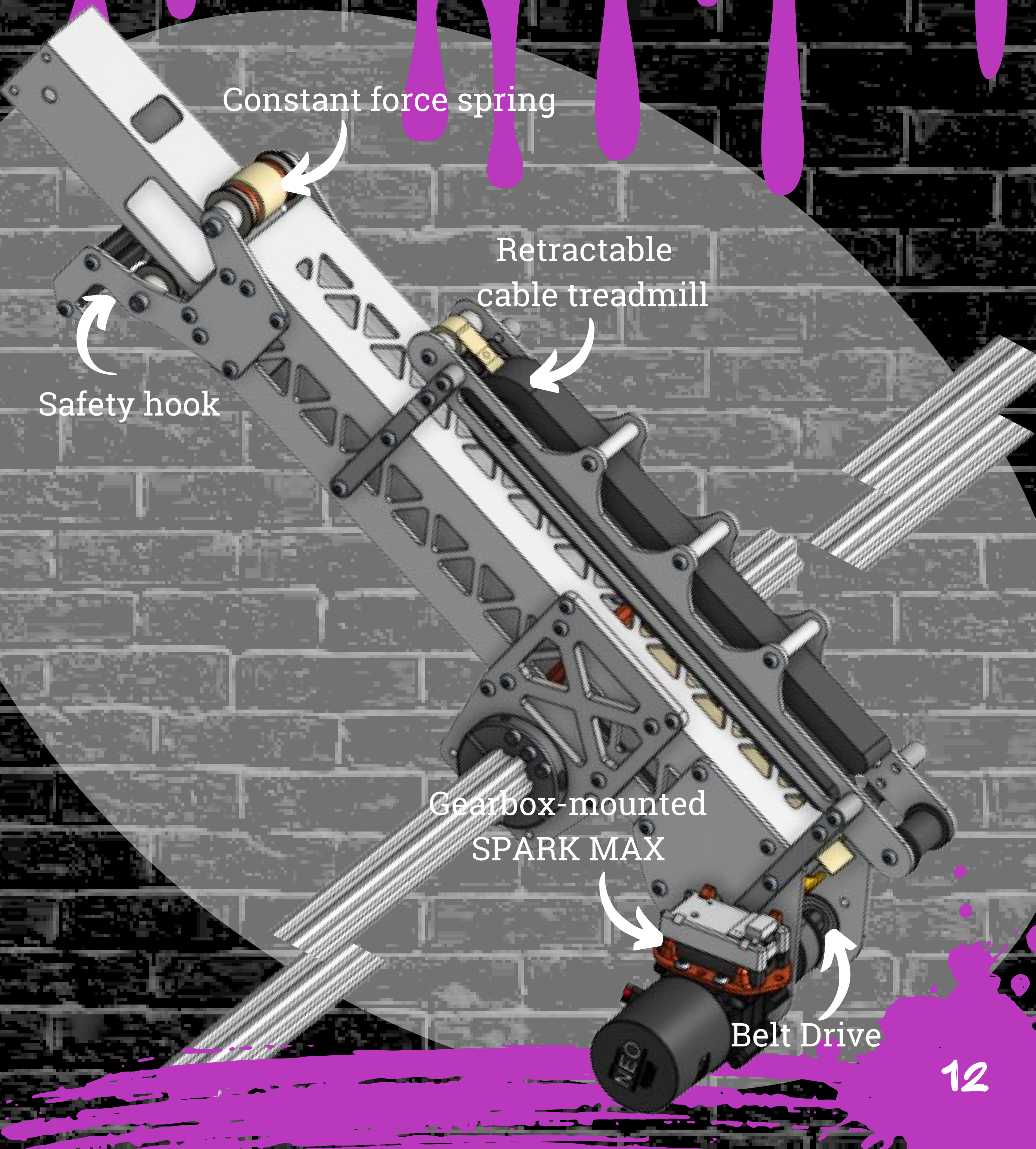
- NEO Vortex - MK4i L2 configuration
- Motor Free Speed = 6784 RPM
- Drivetrain Free Speed = 17.6ft/s



+ 16T Pinion Swerve

- NEO Vortex - MK4i L2 configuration
- Motor Free Speed = 6784 RPM
- Drivetrain Free Speed = 20.1 ft/s

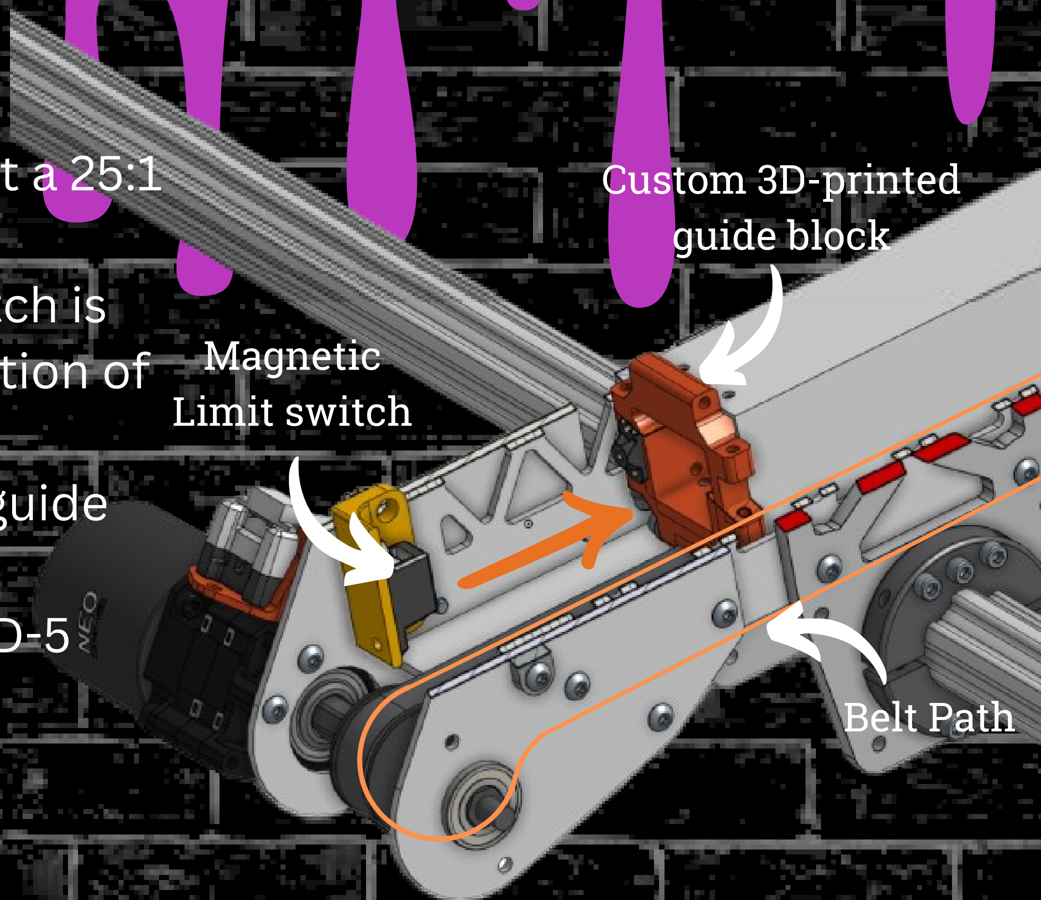
4.2 EXTENSION ARM



4.2 EXTENSION ARM

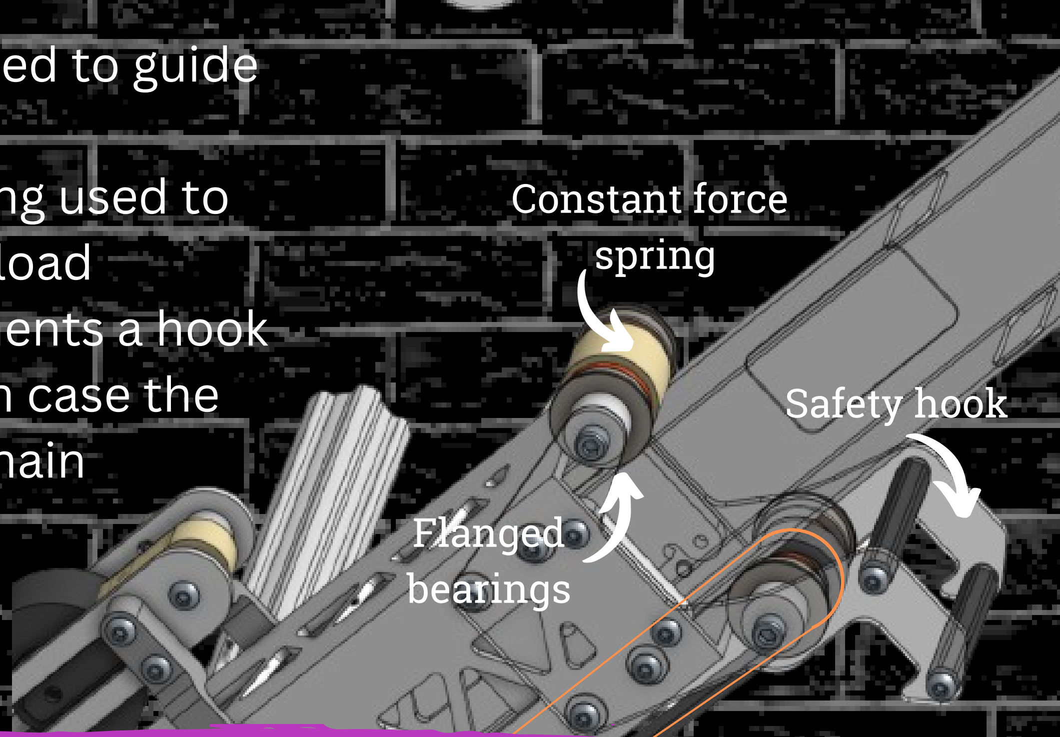
Motor Side

- Driven by one NEO at a 25:1 reduction
- A magnetic limit switch is used to find the position of the extension
- Custom 3D-printed guide block with bearing
- Belt driven using HTD-5 belt



Intake side

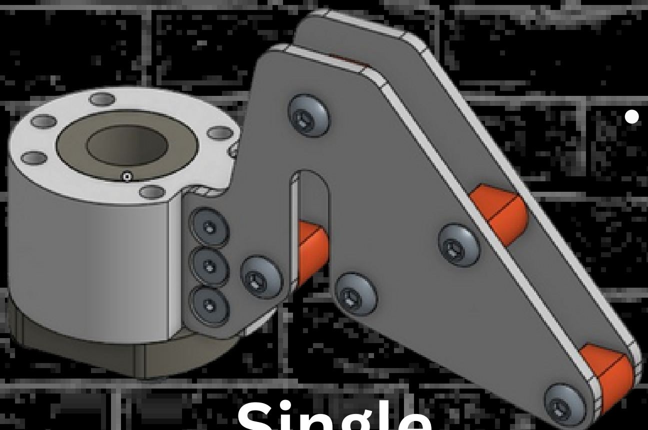
- Flanged bearings used to guide the tube
- Constant force spring used to assist in speed and load
- Top bracket implements a hook to catch the chain in case the robot falls off the chain



4.3 CLIMBERS

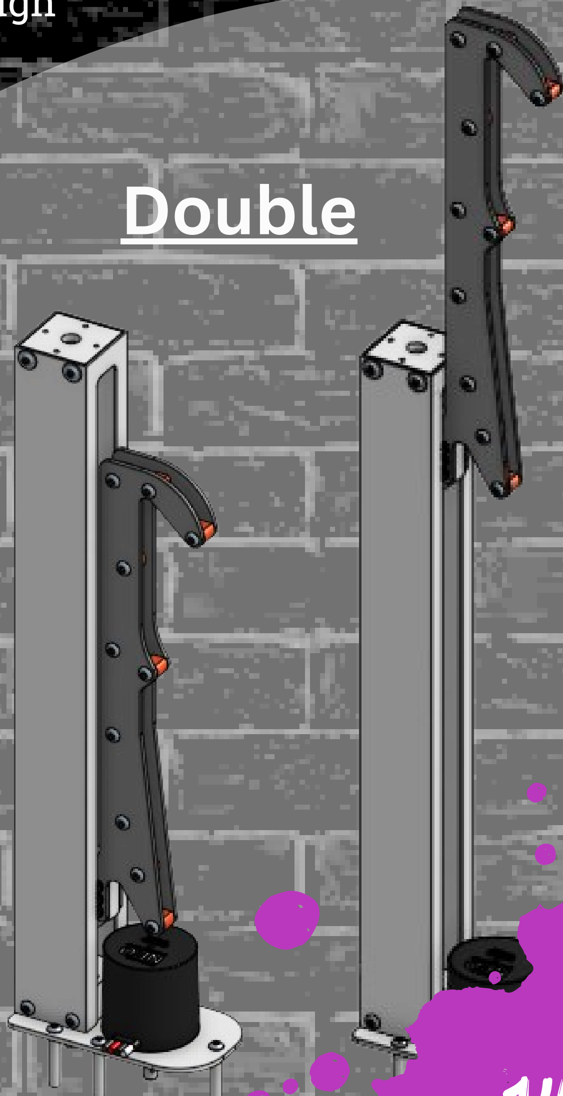
Version One / Prototype

- Originally theorized that the arm would execute the entire first stage of the climb sequence through rotational climb but this idea was found to be infeasible
- First claw acted as a prototype to test the lead screw's ability to hold and lift the robot
- Due to the failed rotational climb, we required the development of a two-stage design



Single

Double

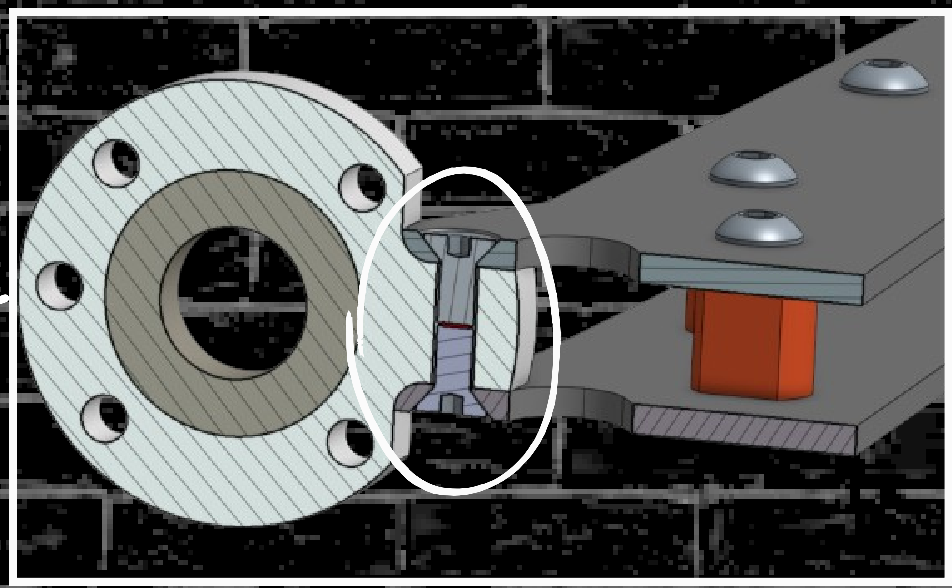


4.3 CLIMBERS

Version Two - Double Stage Claw

Pros

- Double claw design allows for a two-stage climb
- Middle hook was added to protect from misses and slips
- Steel construction for strength



Cons

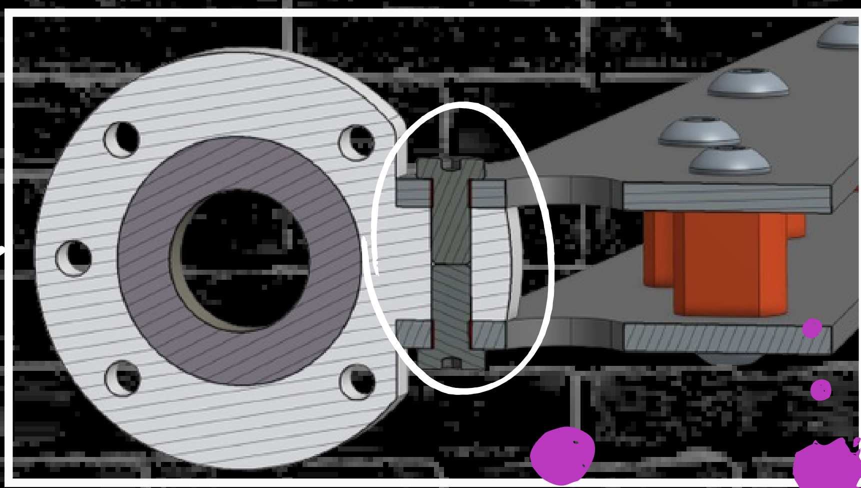
- Top claw is unnecessarily thick
- Top claw geometry is too far forward causing the robot to swing
- The filet and countersink bolts lead to a major weak point causing catastrophic failures
- #8 bolts easily stripped the threads

4.3 CLIMBERS

Version Three - Improved Claw

Pros

- Top stage was pushed back half an inch to be closer to the center of mass and slim the design
- Changed bolts to improve strength and reliability
  - #8-32 countersink → #10-32 low profile bolts
- No filet or countersink drastically improves strength.

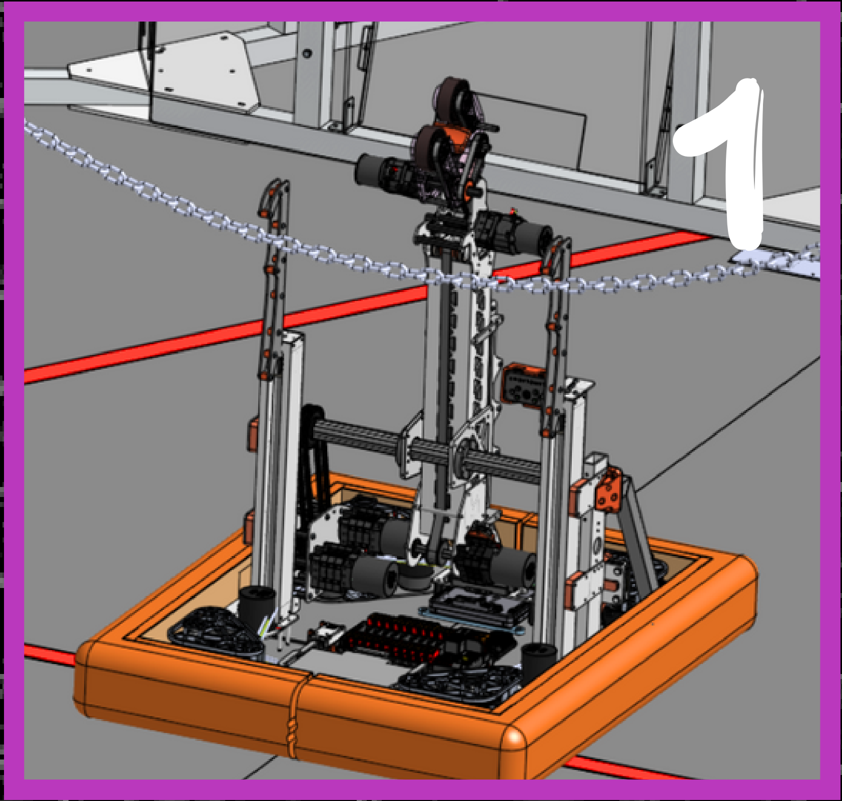


4.3 CLIMBERS

Final Design

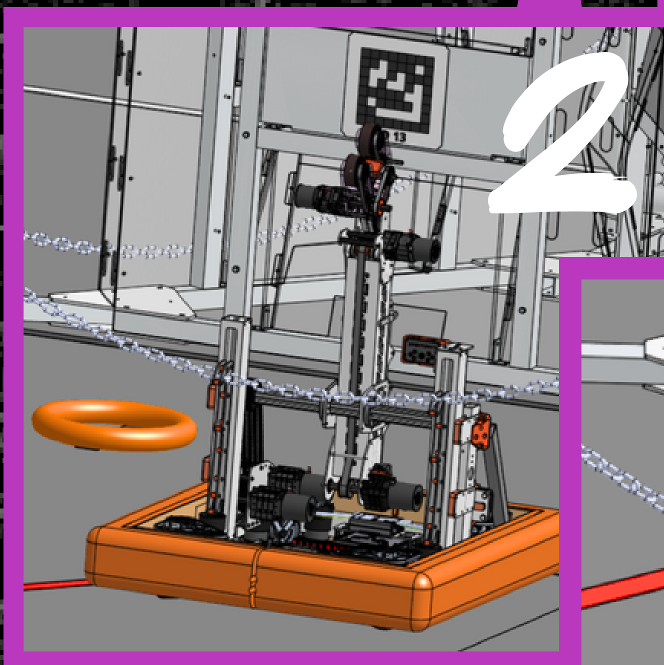
- Powered by a single NEO driving a pulley at 1.5:1 reduction
- Lead screw: fast, reliable, hold position without power
- <22 inches tall when retracted
- 32 in. when extended to grab chain
- Two climbers enable climb, hang, and trap scoring along with arm

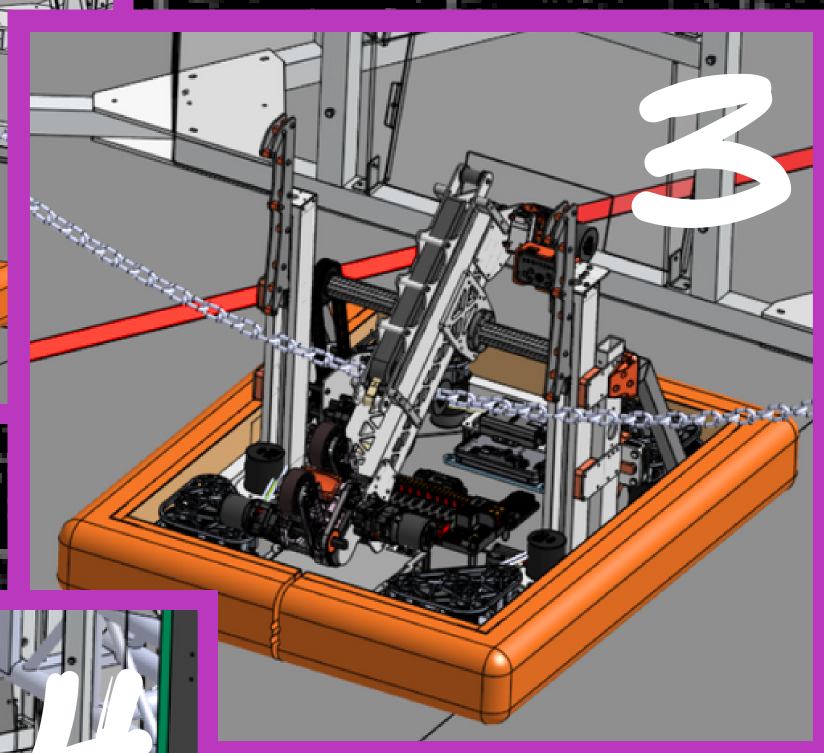
Climb Sequence

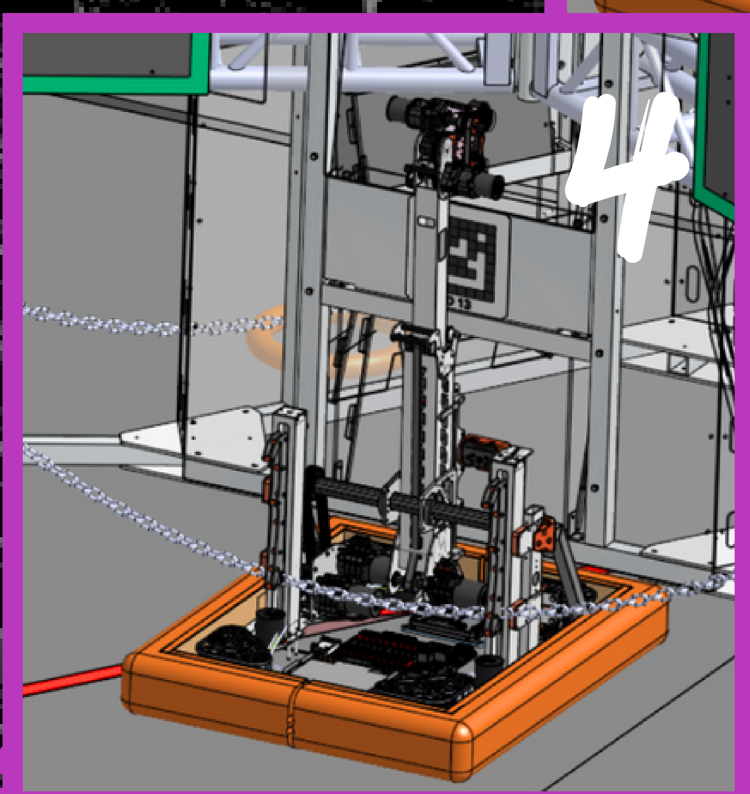


4.3 CLIMBERS

Climb Sequence

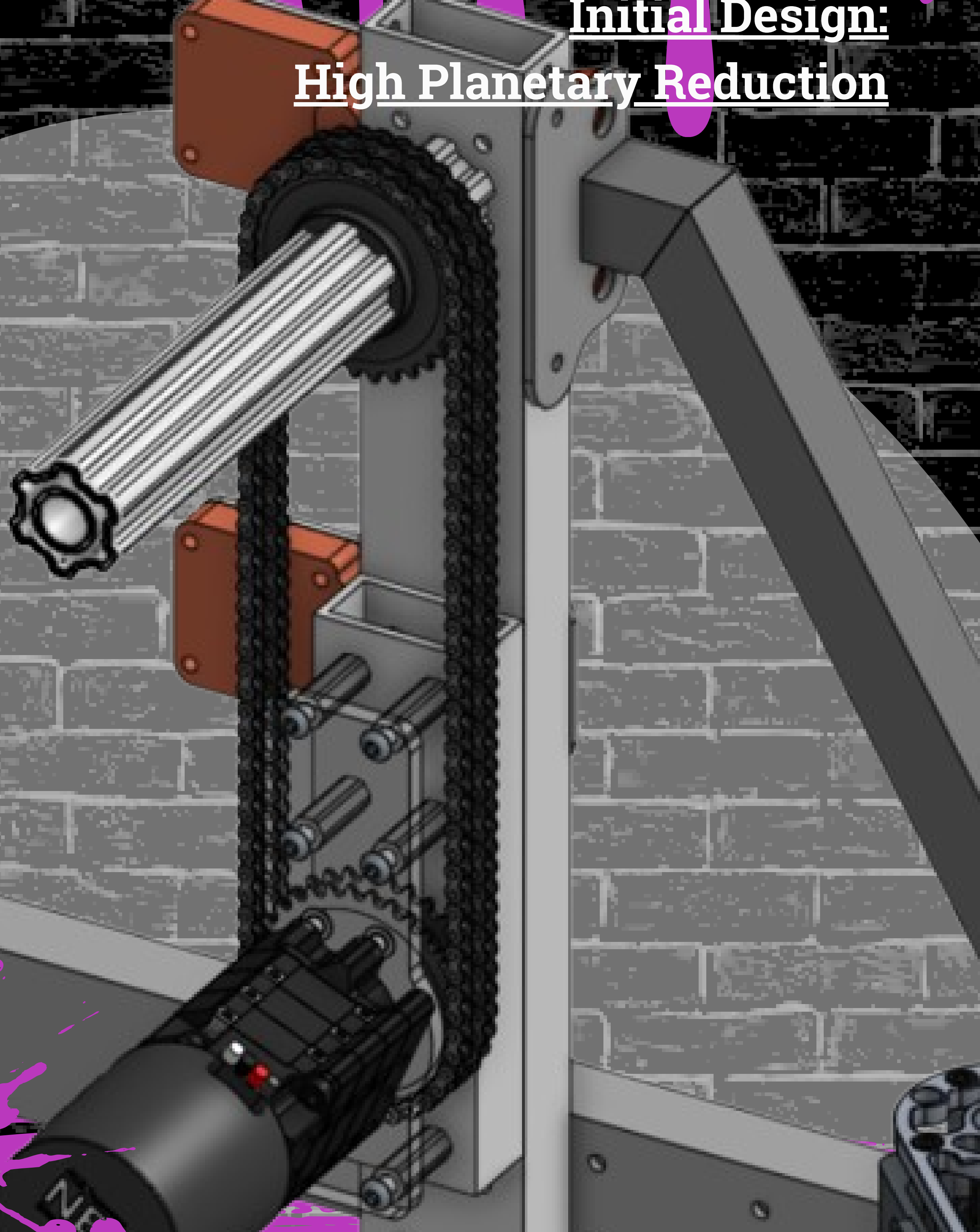






4.4 ROTATION GEARBOX

Initial Design: High Planetary Reduction



4.4 ROTATION GEARBOX

Iteration 1

- One NEO:
  - 125:1 reduction from 3 5:1 MAXPlanetary cartridges
- Double chain:
  - Redundancy in case one were to break
- Spartan Tensioners:
  - Opposite sides of the two chains
  - Tensioned the chain to reduce slop and backlash
- Hardware:
  - 1/8" aluminum plate
  - Long standoffs

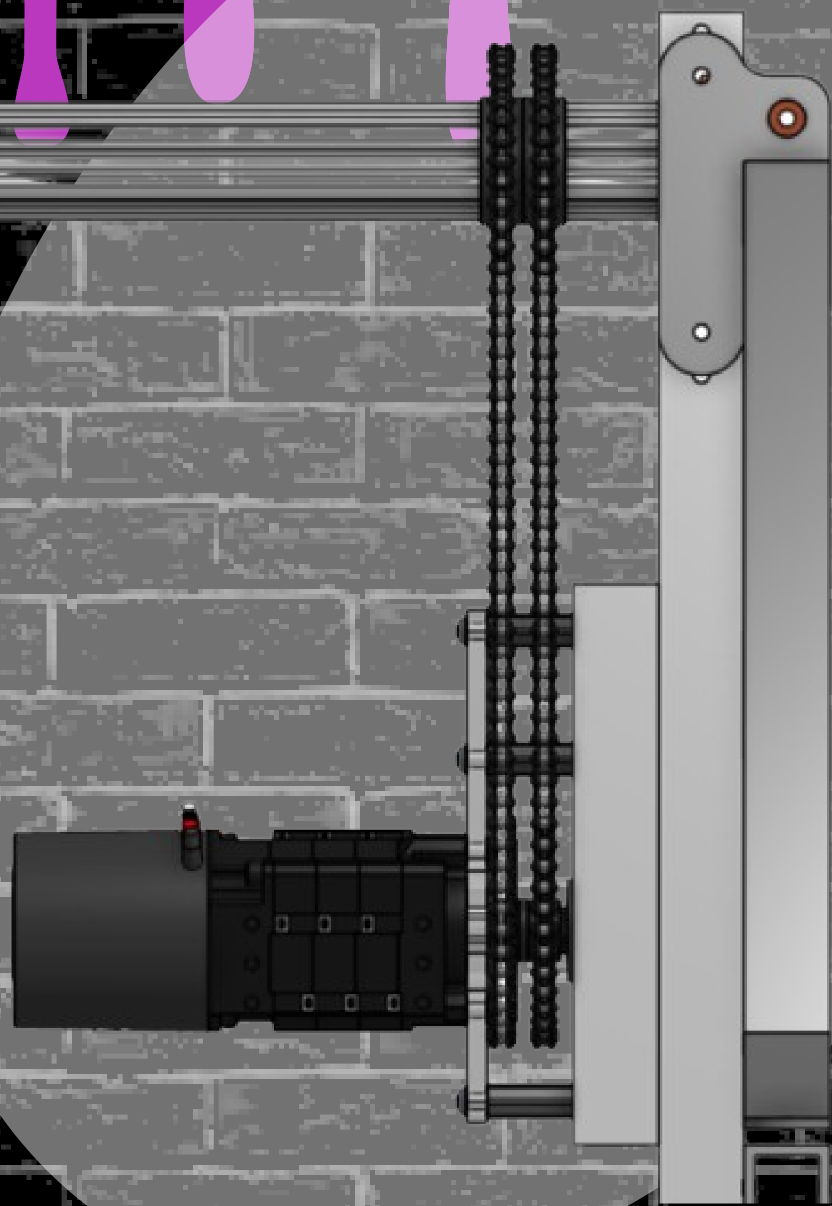
Drawbacks

- Couldn't handle high torque
- Materials would bend
- The stress of climbing was too great on the arm

4.4 ROTATION GEARBOX

Iteration 2

- 9-4-4 combination for a 144:1 reduction
    - We thought the increase in torque would help the climb
- Materials:
    - 0.25" aluminum plate
    - Extra 2" box tube
    - Shorter standoffs

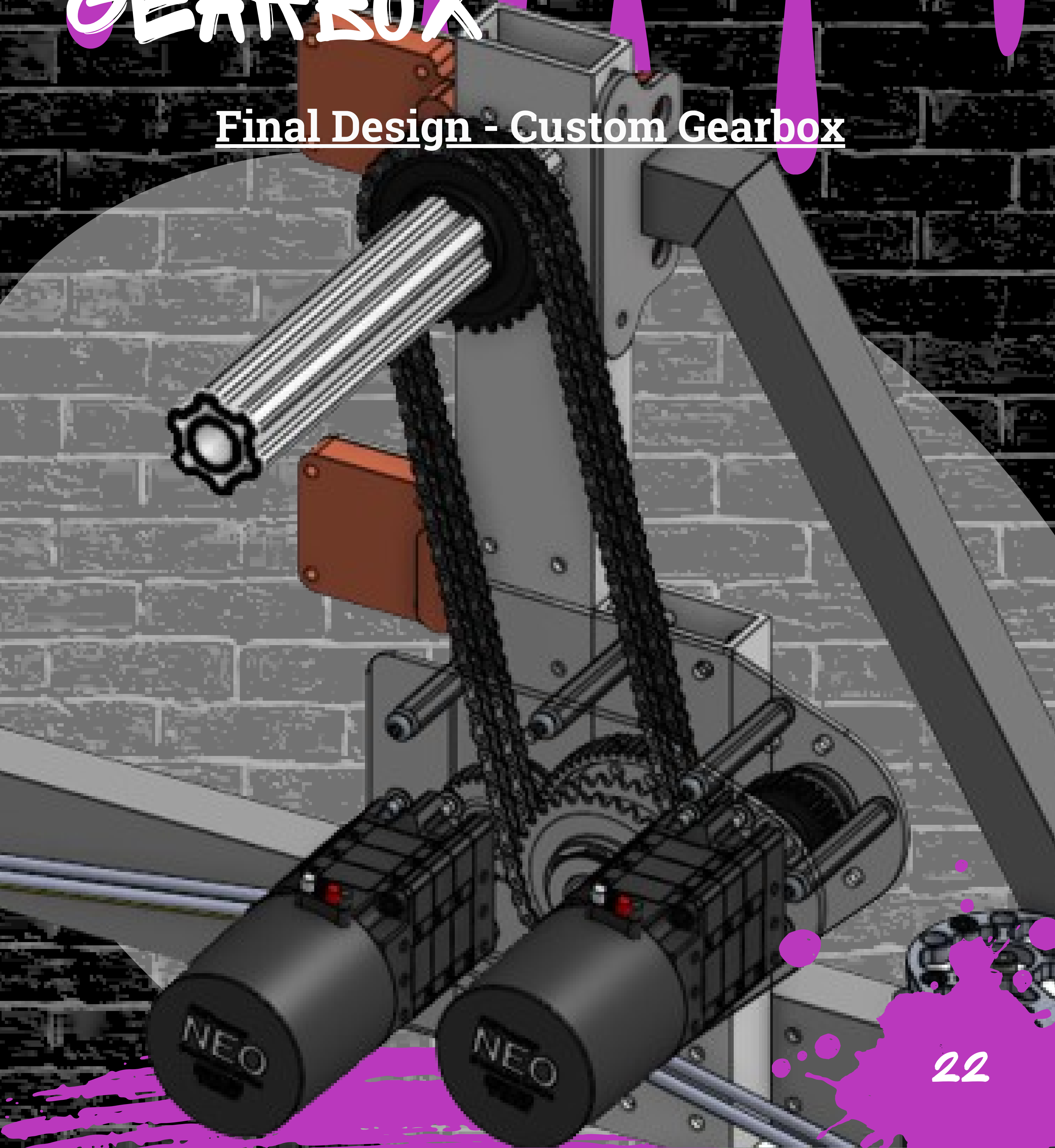


Drawbacks

- Still underperforming on the climb sequence
- Forces would twist the motor
    - Mounting hardware coming loose
- 9:1 cartridge failed under high load

4.4 ROTATION GEARBOX

Final Design - Custom Gearbox



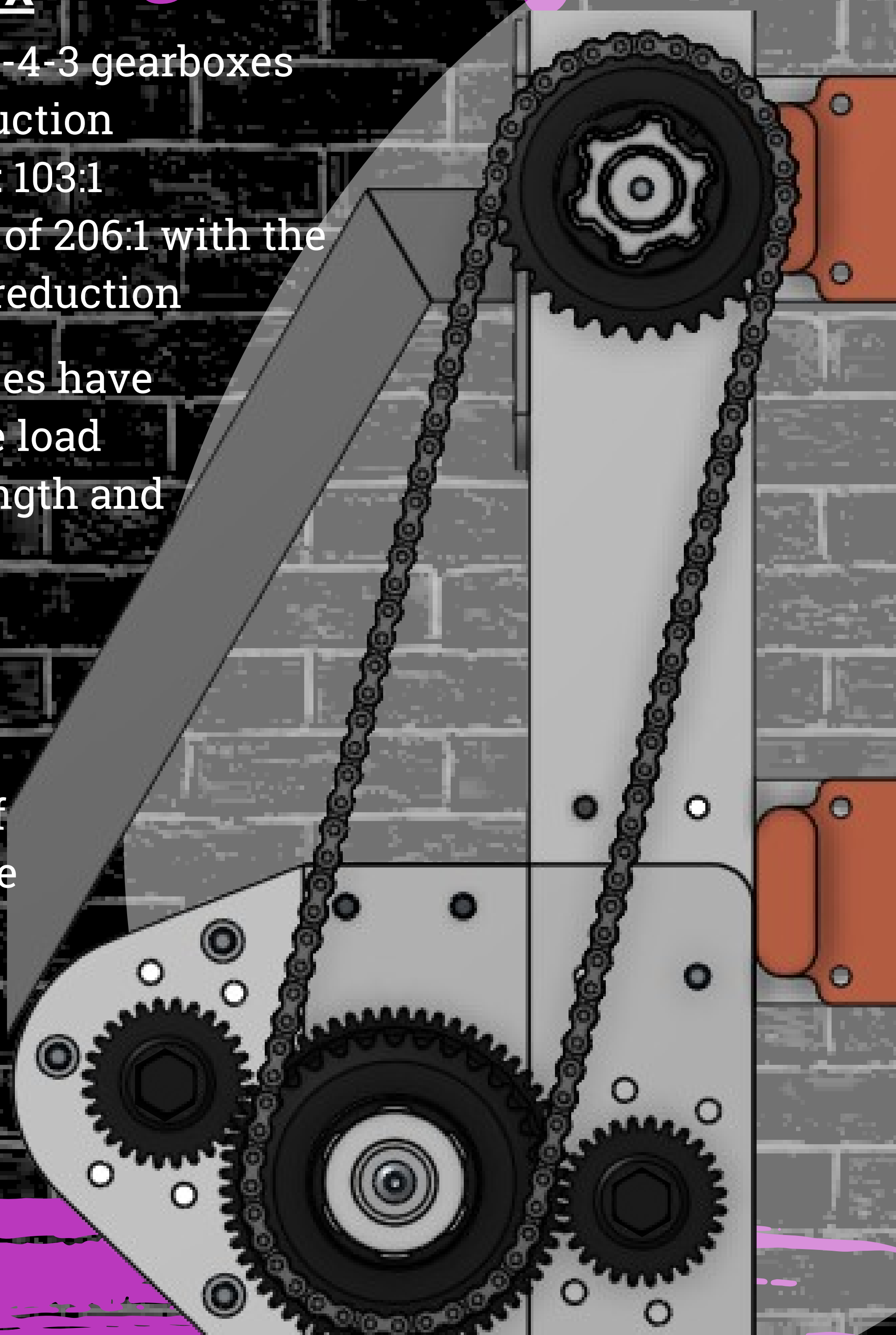
4.4 ROTATION GEARBOX

Custom Gearbox

- 2 NEOs, each with 4-4-3 gearboxes
- 28T to 60T gear reduction
  - Total Reduction: 103:1
  - Effective torque of 206:1 with the speed of a 103:1 reduction
- 4:1 and 3:1 cartridges have higher max torque load
- Dead axle for strength and serviceability

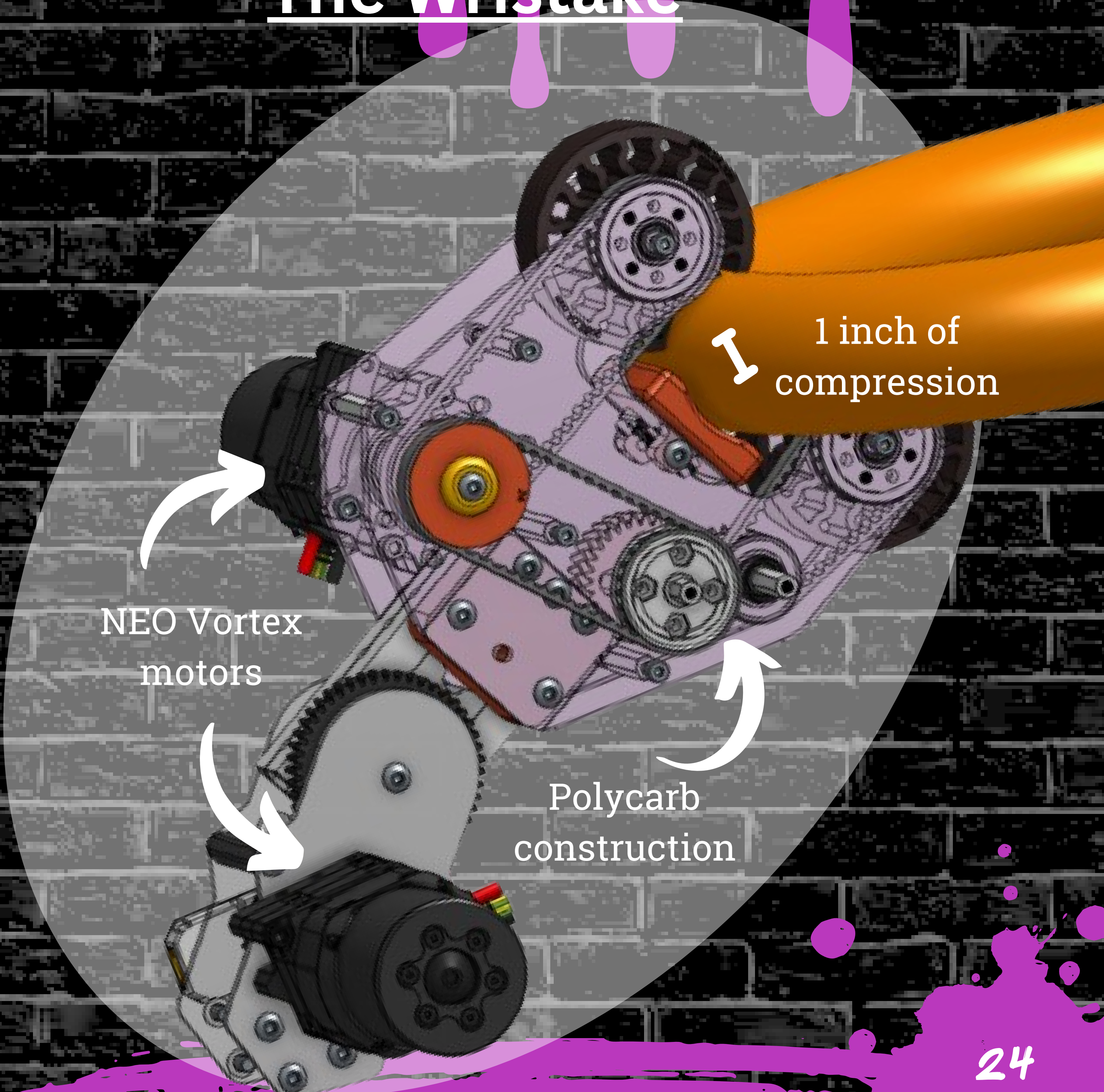
Results

- Most backlash eliminated
- Rotation portion of the climb sequence is much smoother
- No need for janky control system overrides



4.5 WRIST/INTAKE

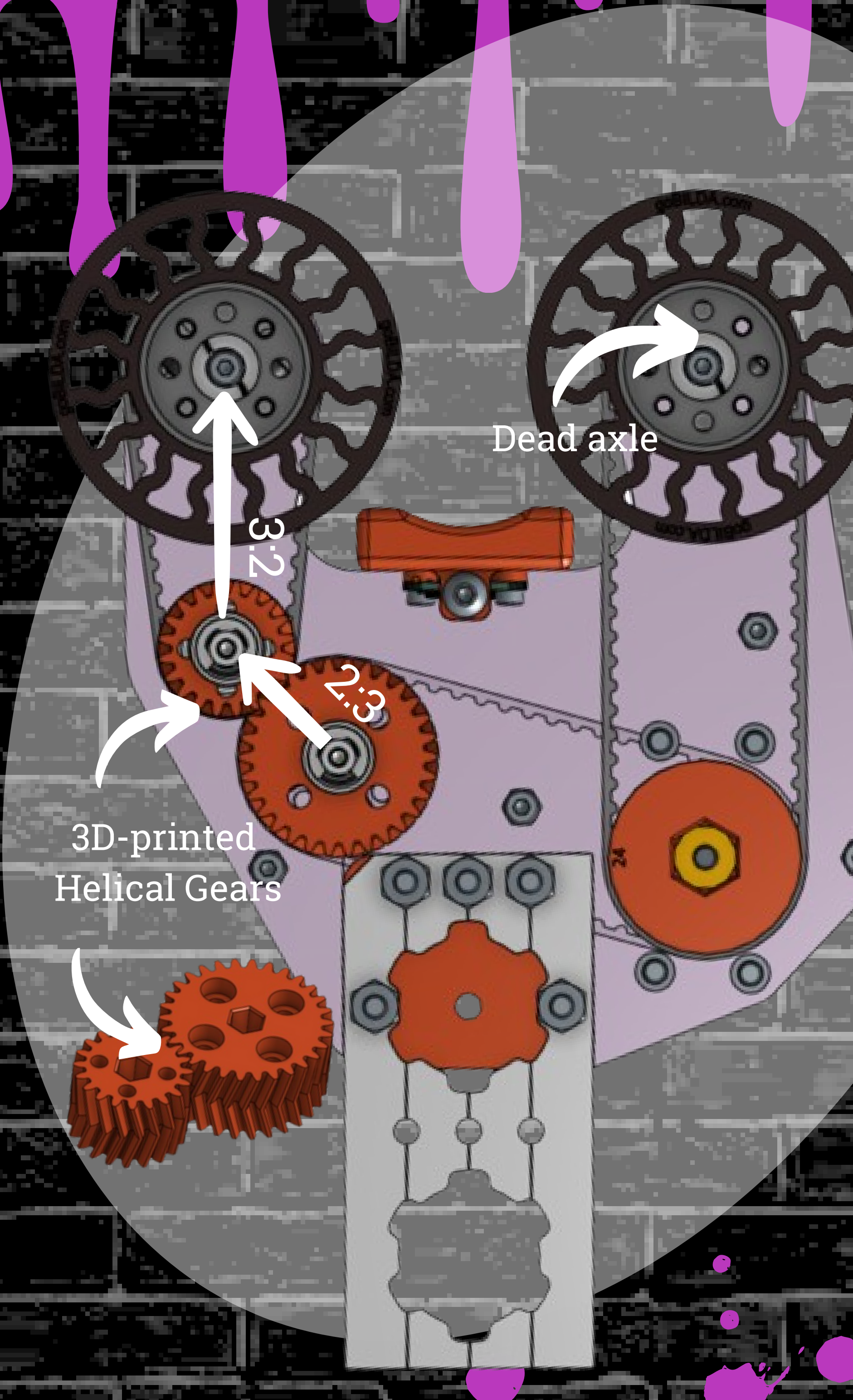
The Wristake



4.5 WRIST/INTAKE

Intake

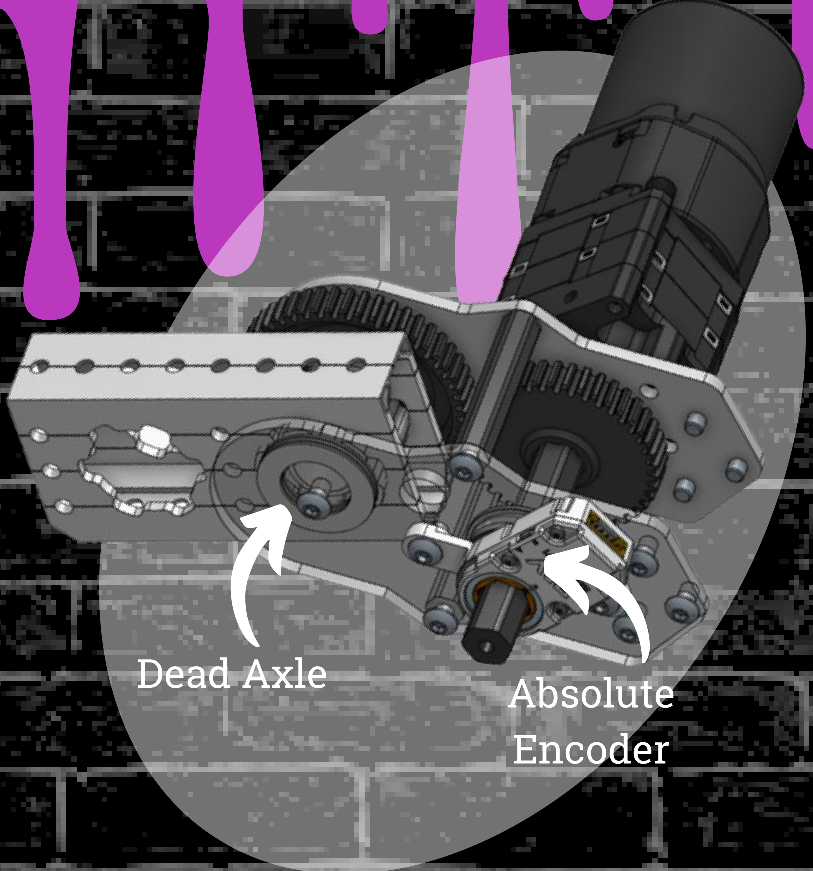
- Narrow two-wheel intake
- Can pick up notes directly from the Source and the ground
- Can intake even if the Note is not centered
- Intake is a width of a note and <3" wide
- Dead axles for our wheels as it is more resistant to failure
- 30T to 20T gear overdrive + 16T to 24T pulley reduction
  - Maintains a 1:1 relationship between the intake wheels
  - Compact intake by using shorter belts and smaller gears



4.5 WRIST/INTAKE

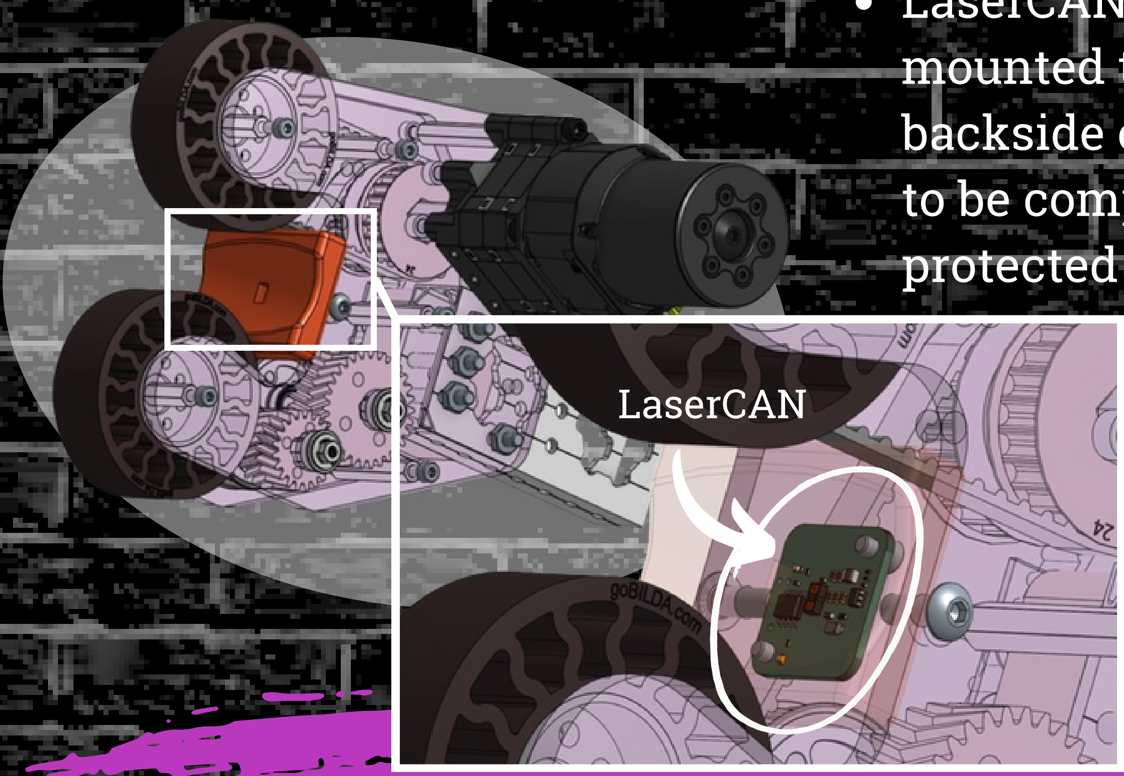
The Wrist

- Wrist powered by NEO Vortex on an 81:1 Planetary and a 1.2:1 gear reduction
- A through bore encoder tells us the absolute position of the wrist at all times
- Dead axle used allowing us to use the MAX spline shaft and tub for mounting



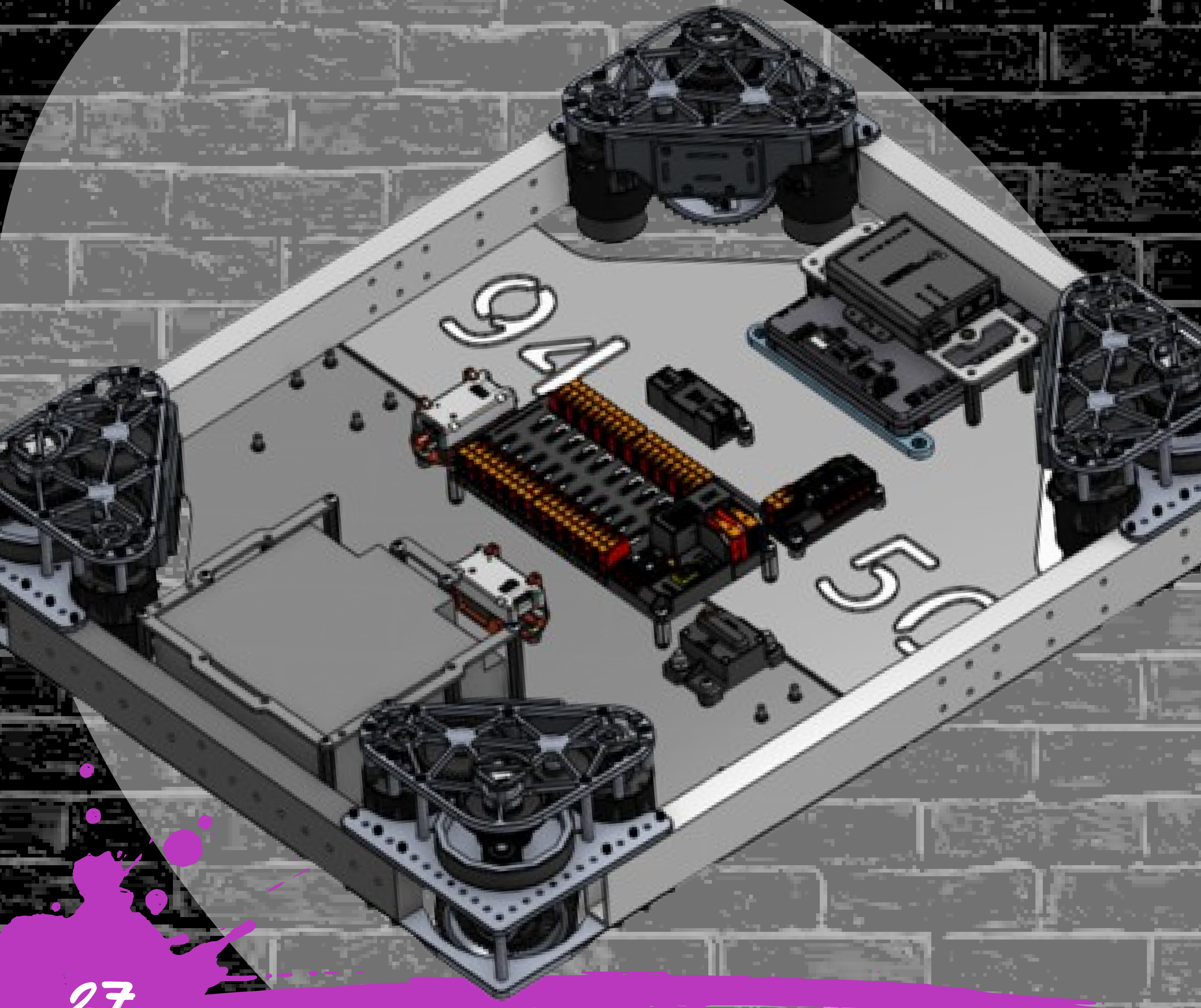
LaserCAN add-on

- LaserCAN sensor is mounted to the backside of a 3D print to be completely protected and reliably detects when a note has been intaken.



4.6 BELLY PAN AND DRIVE BASE

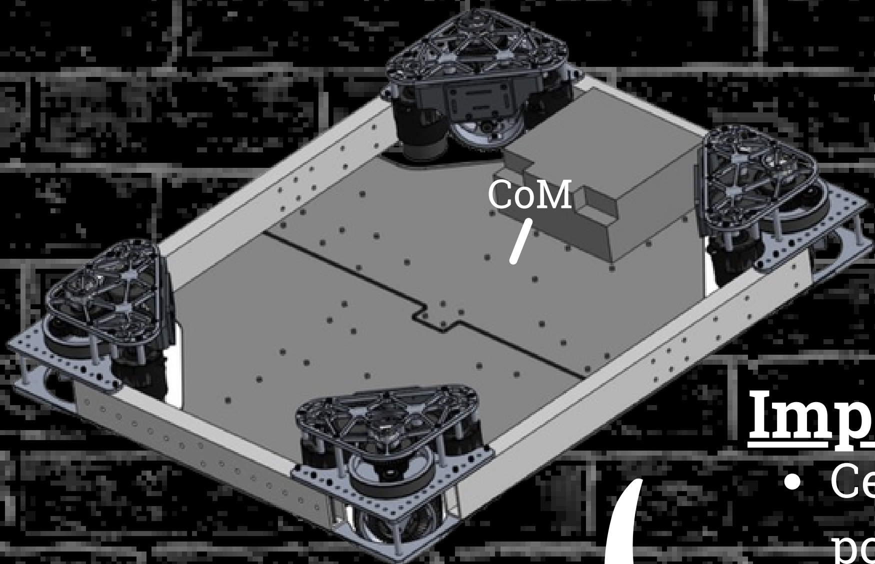
The Fight for Balance



4.6 BELLY PAN

Considerations to Weigh

One important aspect of this system is weight distribution. By manipulating the material and the position of the battery, we were able to move the center of mass of our robot forward which aided in our climb.



First Iteration

- Full steel belly pan
- Aluminum box tube
- Battery mounted to the back

Impacts:

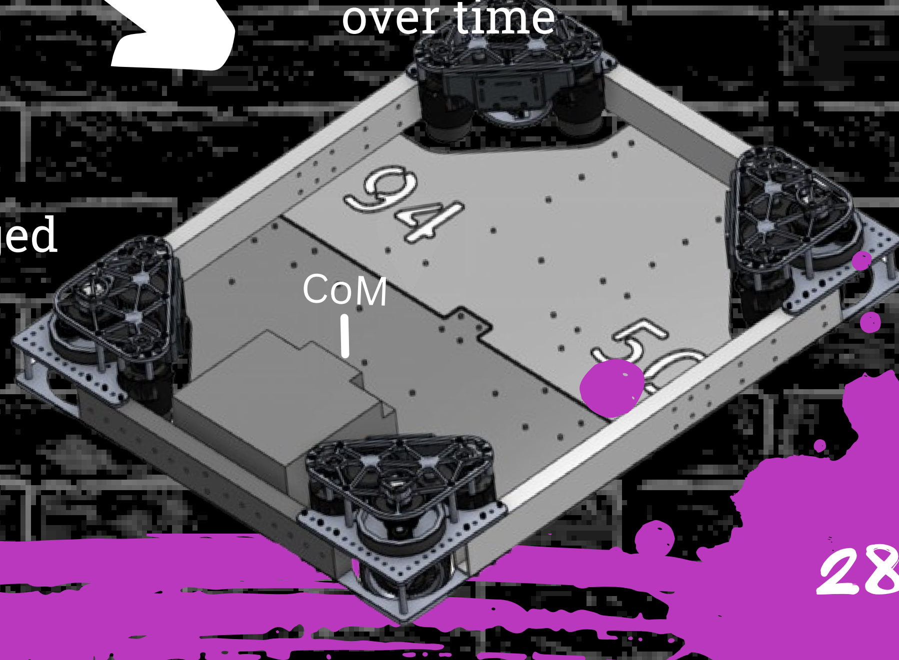
- Center of mass behind hang point
  - Robot falling off chain
  - Climber claws bending over time

Final Iteration

- Aluminum back half of belly pan
- Battery moved to the front
- Front box tube changed to solid steel

Impacts:

- Balanced climb
- Allowed robot to stay on the chain



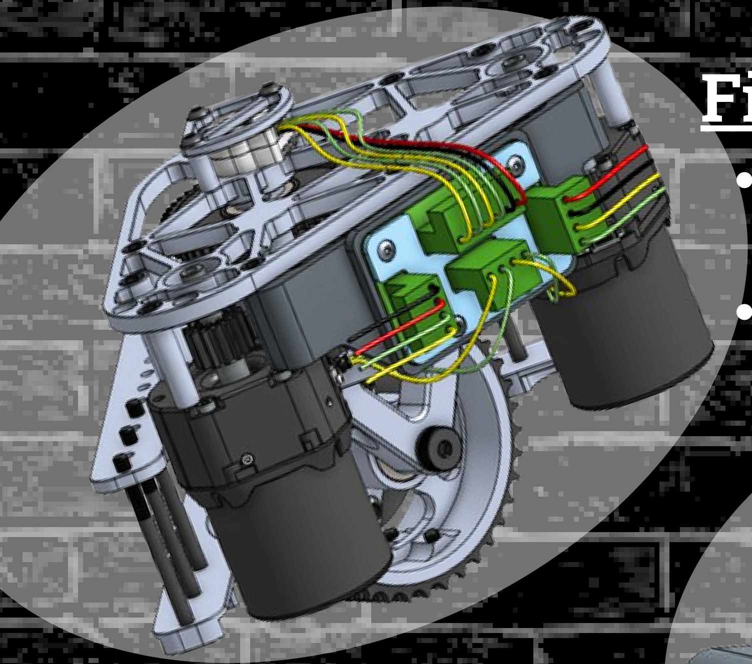
4.7 ELECTRONICS

Custom Swerve PCBs

MK4i swerve module wiring

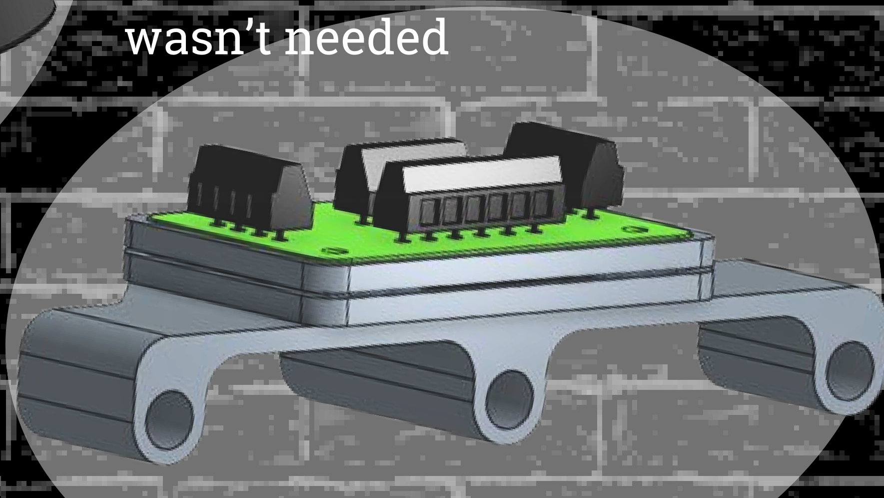
- Simplifies Can and power wiring
- Easily attaches to MK4i swerve pods

To produce these, we reached out to an electrical engineer alumnus of our program for help.



First Iteration

- Prioritized high serviceability
  - Easy to unplug and swap
- In practice, serviceability wasn't needed



Second Iteration

- Traded high serviceability for slimmer model
  - Depth decrease from 23mm to 12mm

Future Plans

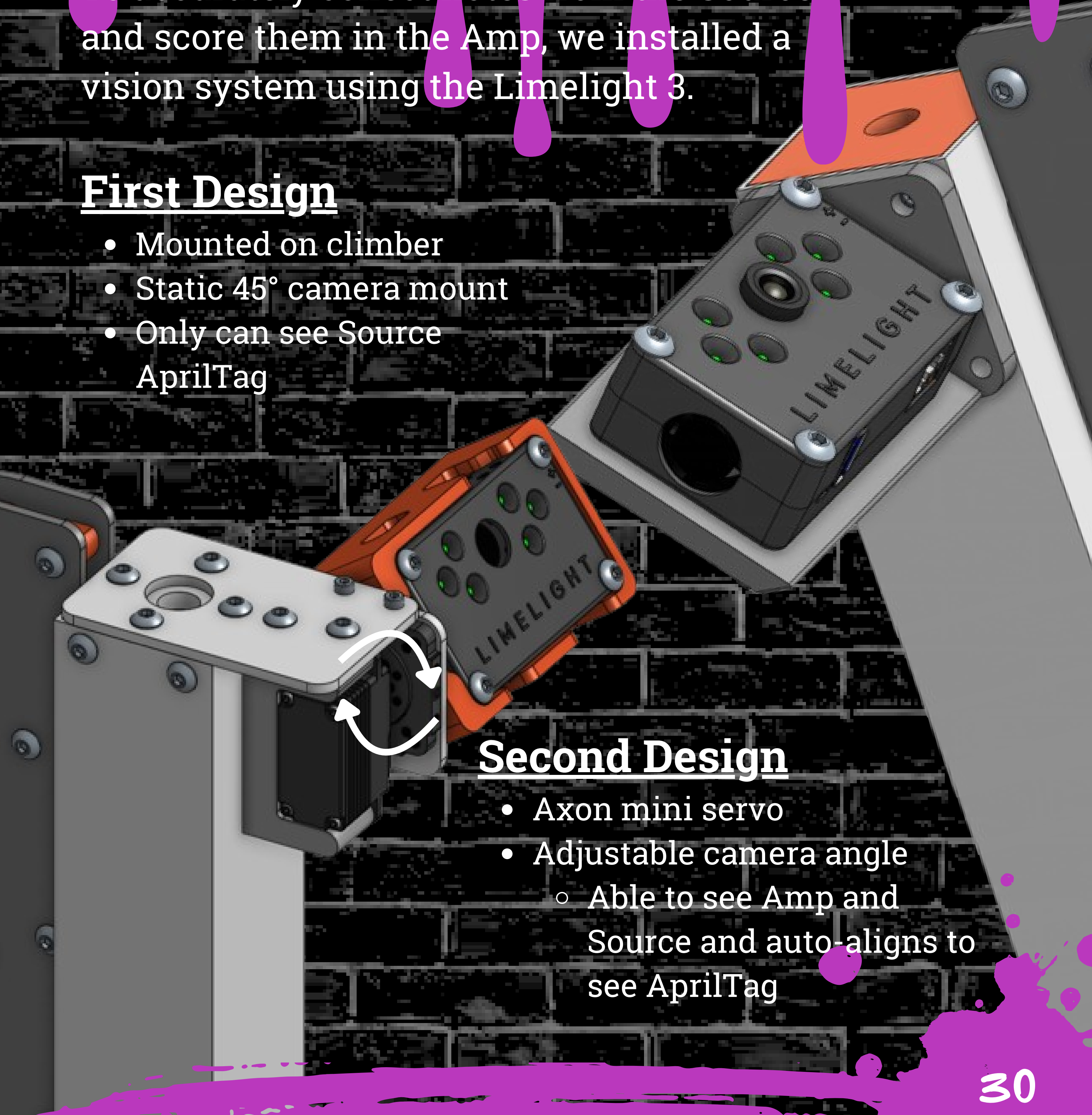
- Selling PCBs as an upgrade to MK4i swerve pods
  - Allows teams to improve swerve pod wiring

4.8 LIMELIGHT

To accurately collect notes from the Source and score them in the Amp, we installed a vision system using the Limelight 3.

First Design

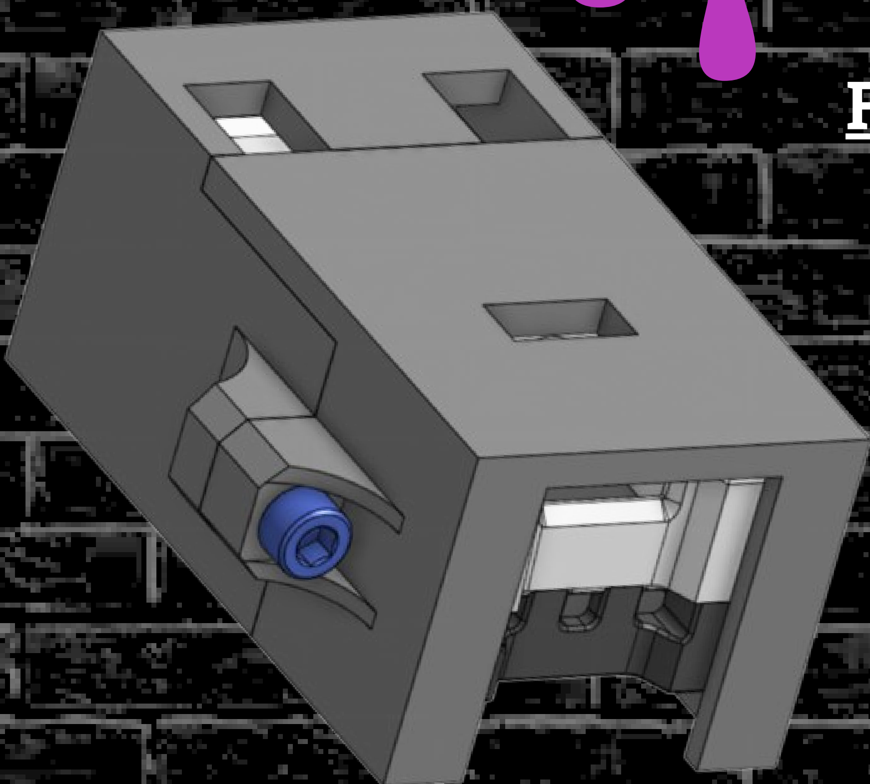
- Mounted on climber
- Static 45° camera mount
- Only can see Source AprilTag



Second Design

- Axon mini servo
- Adjustable camera angle
  - Able to see Amp and Source and auto-aligns to see AprilTag

4.9 SPARK MAX MOUNT

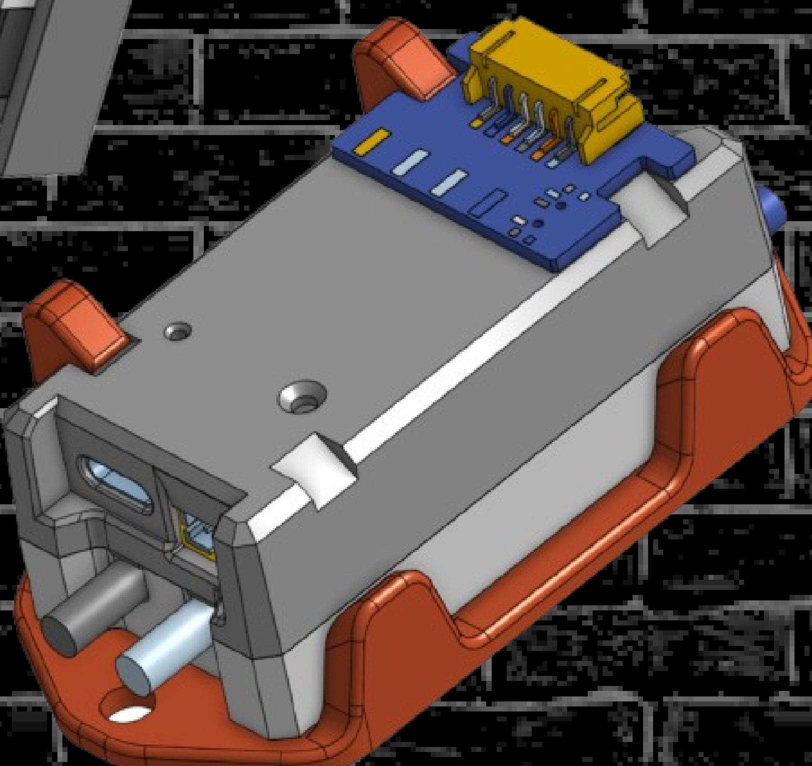


First Design

- Full covering
  - Difficult to swap a bad SPARK MAX
- No space for the data port

Second Design

- Printed from PETG
  - Flexibility of plastic allows for serviceability
- Open design
- Uses less material than first design

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