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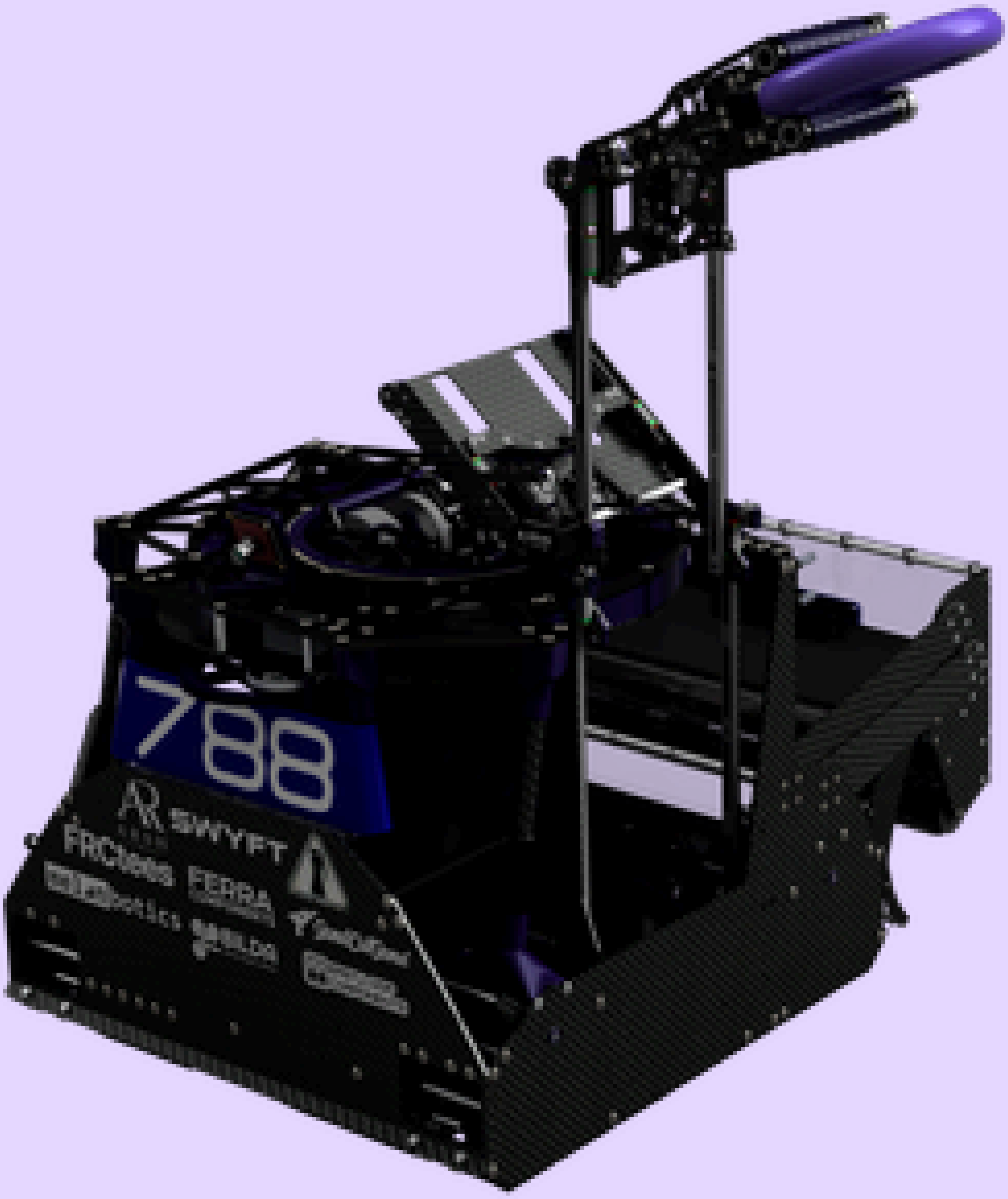
Horizon x Loomy Squad

Attached below is our 1st place winning competition portfolio and explanation of our robot for the CHAIN REACTION CAD Competition, **created by Horizon members Levin and Saket**, as well as Bilal (alumni of FTC 26000 who we later recruited to be Horizon's mentor). We participated under the number 788 and the name "Loomy Squad" because we had not decided on our team name and not received our official team number from FIRST at that time.



788 | Loomy Squad

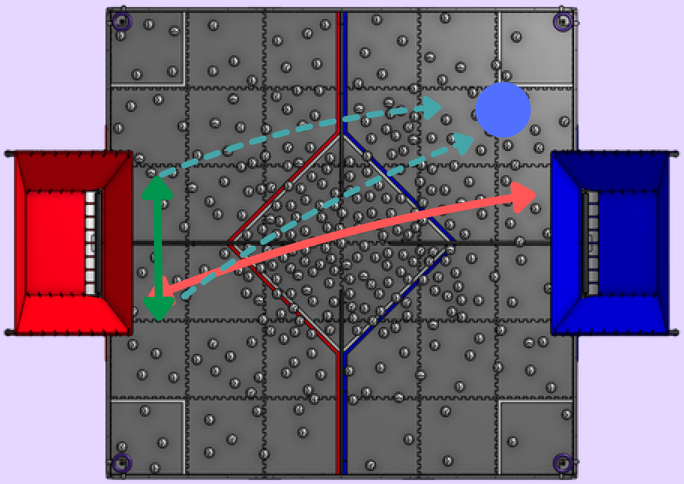
Chain Reaction CAD Competition
Engineering Portfolio

Game Analysis

Our team followed a **strategic design process** in order to ensure our solo robot is able to score the maximum amount of points in **both qualification and elimination** matches. This gives us the highest possible chance of winning high level competitions like MTI or Worlds, where balancing specialization and generalization is key.

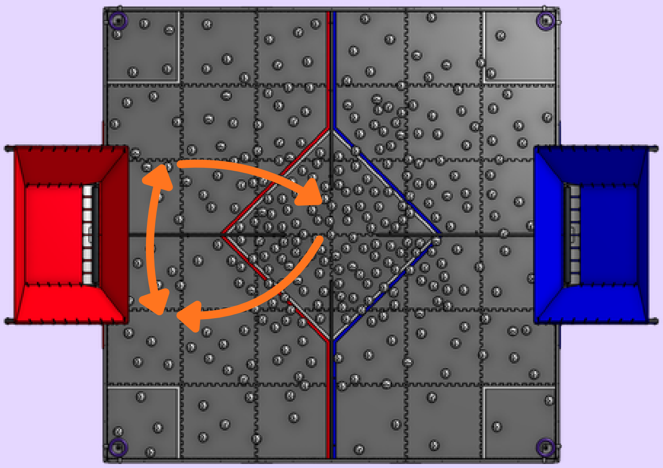
After **crunching numbers** for potential chokehold strategies, running **2v2 matches in DSim**, and discussing r**ealistic robot limitations**, our team came up with the following strategy that defined our robot design:

We realized that **catalyst control** was the single biggest contributor to scores in matches. Consistently having less active catalysts than your opponent effectively guaranteed a loss, and was very rarely able to be overturned with throughput or intaking skill. This led to our innovative design of catalyst differential slides, intake, and slingshot, as well as the need for the optimal 4 bar suspension to cross the barrier. The **new path** we came up is **600% faster** than **the standard cycling path**, and ensures we can at minimum level the catalyst playing field, and most likely secure a significant advantage with catalysts by **scoring a stockpile of catalysts** we have launched over.



Our robot can **stockpile catalysts** by **launching them across the field** and use a ground intake to gain full catalyst control in under 15 seconds

The next most important factor to scoring points in Chain Reaction is **sustained throughput**, or how many balls the robot can score per second (**BPS**), as even if a robot can intake a large quantity of particles and score them at once like a **drum**, because particles are recycled, a robot that continuously fires particles can be equally dominant. This made our initial chokehold strategy of intaking all the particles on the field impossible, and instead we pivoted to a **dye rotor and turret** design so that we could score particles at an extremely competitive level while **still making catalysts our main priority**.



Our **final, main cycling path** to descore opponent catalysts and score particles **at the same time.**

Finally, for our strategy to work, we realized that a **large extending hopper** that could **store 100+ particles** to allow for **sweeps through the middle** to parallelize catalysts and scoring particles. We **considered other design additions** such as swerve, an ascent mechanism, and dual sided intakes, but came to the conclusion that they required too many actuators or added unnecessary complexity as our paths were relatively straight and scored thousands of points.

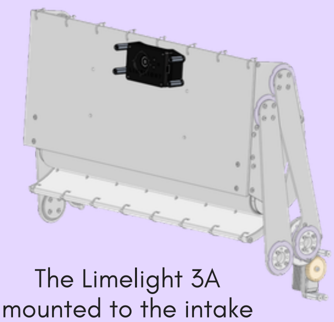
Robot Overview

Meet **Ender**, our robot for the Chain Reaction CAD Competition.

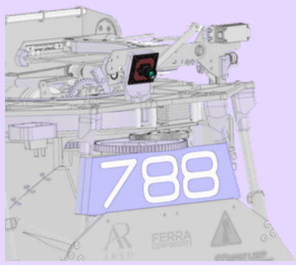
NOTE: Our plate appearances unfortunately were not able to be set in Onshape, but all 3.2mm plates are aluminum, 3mm plates are all carbon fiber (except on the intake, which are SRPP), all 2mm plates are carbon fiber, and all 1.5875mm plates are polycarbonate. Also, we were unable to add our planned nets that would hold balls inside (as Onshape would simply freeze due to the sheer size of this document), but a standard cubic (apart from the front intake side which would attach to the zipties), highly tensioned net would be used when the robot was built to hold balls inside the hopper.

Design Differentiation

This page covers some of the **key highlights** to our robot and what sets our mechanisms apart from existing designs and other submissions:



The Limelight 3A mounted to the intake

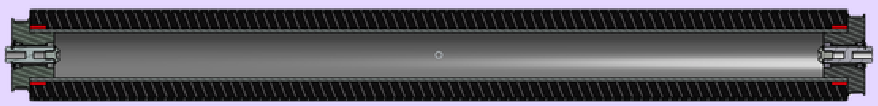


Our back Arducam OV9281 for AprilTags

We **only use 2 cameras on our robot**, and through a clever placement of the Limelight 3A, our front camera can **switch pipelines** in auto from powering an extended Kalman filter (combined with drivetrain encoders and modified REV mecanum wheels of 30A urethane rollers) to running a neural network for ball detection. This keeps loop times and power draw low.

Inspired by FTC 18438's Freight Frenzy robot, each of our mecanum wheels is placed on an individual **4 bar suspension** that allows the wheel to pivot backwards and compress in both directions. We also added pivoting **stabilizing omni wheels** for when we are not traversing terrain to keep intaking and shooting precise by eliminating drivetrain wobble.

The pin slot linkage for stabilizing wheels

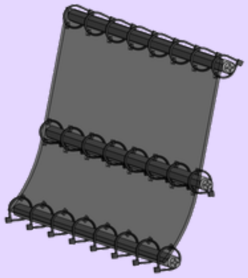


A cross section of our hollow stub rollers, showing the goBILDA steel standoffs on the ends, polycarbonate roller, foam, and silicone.

The intake uses a **custom stub roller stackup**, which reduces weight by only having steel standoffs on the ends of the roller, a polycarbonate **impact-resistant** main roller. In addition, the stub rollers allow us to wrap the roller in foam and then in silicone surgical tubing, inspired by FRC 254's 2025 robot, as our **bent, passively pivoting polycarbonate ramp** that sits above the terrain never needs to pivot comes with the need for a high (6mm) variable compression.

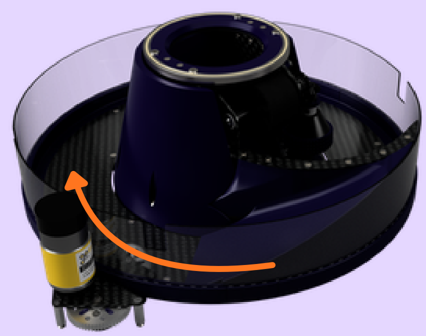
Our fully compacted 4 bar intake

Passive rubber band extension to pivot out the kickup ramp plates



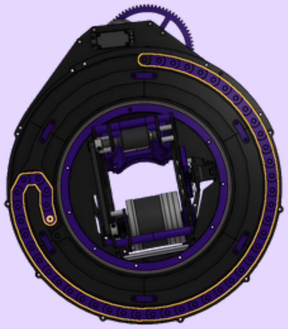
The cold bent polycarbonate ramp, attached with zipties

Our dye rotor implementation is made to **maximize the dish diameter**, as its 360mm OD allows for 11 balls to easily fit, enabling a theoretical output of **20+ BPS** even under a loaded 115+ RPM (125 RPM free speed). We understood that **ball flow is the limiting factor** in dye rotor designs, and hence even added a **dolphin fin 3D print**, inspired by FRC 4414 that pushes ball backwards into the robot while intaking in order to **maximize hopper capacity and lower power draw** while making sweeps through the middle.



The dolphin fin to push balls up and backwards when the rotor is **spun backwards (CCW)**

Design Differentiation (cont.)

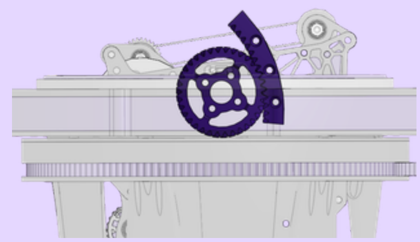


Our bidirectional energy chain on the turret

Four carbon fiber rod mounts for the turret

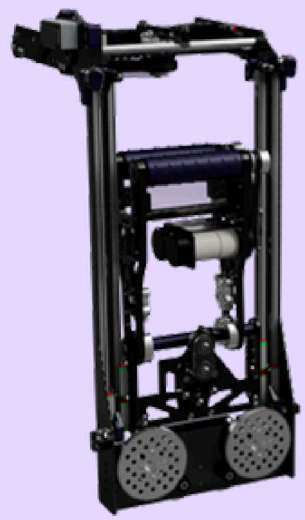
The turret utilizes only **one Axon servo for power**, as we realized due to the sheer size of the goal, precision wouldn't be critical. Furthermore, because of the compact radius of the shooter mechanism, the **moment of inertia would be exponentially lower** than what it was for robots in Decode, allowing for faster acceleration. When combined with our bidirectional energy chain that gives **over 570 degrees of range** and localization stack, our turret will always remain locked onto the goal. Our entire turret is supported by **lightweight carbon fiber rods** and an X-contact bearing as well.

The last mechanism to handle particles is our shooter, which utilizes one counterroller to **eliminate 80% of backspin**. Complete with a 3D printed cover to prevent jamming or inconsistent tracking in the turret, all space inside the shooter is used, including that for a servo which uses a ring gear to power the actuated hood compactly.



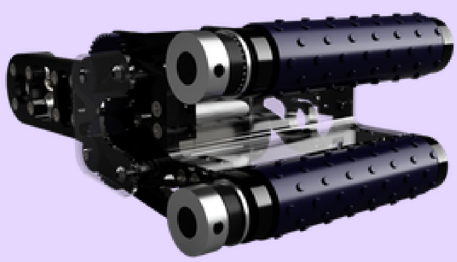
The unique ring gear hood for our shooter

Our differential lift/arm subsystem, powered by two Axon servos allows for our catalyst **intake to work not only intake/score on the hooks, but also on intake from the ground and pivot around to hand off to our catalyst shooter**, enabling our strategy of stockpiling and scoring catalysts across the field. Packaged into one of the **smallest form factors ever seen in FTC**, this entire set of mechanisms fits in just 3" on the side of our robot and uses the 6" of horizontal extension available for the arm.

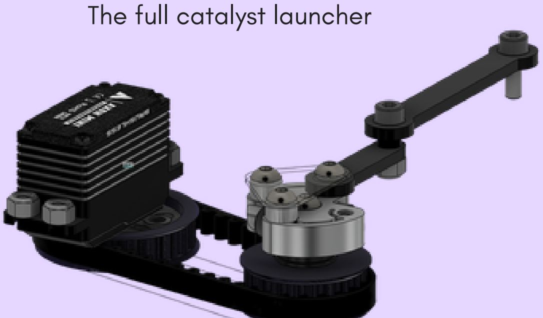


The full set of subsystems to handle catalysts, including the MGN differential lift, lightweight arm, and catalyst launcher

The full catalyst launcher



Our catalyst intake which monts onto the arm



Our choo choo mechanism

Finally, we used a **Choo Choo mechanism** to **launch catalysts** across the field. This mechanism works by pulling back on bungee sprung rails, and then releasing it once the linkage crosses the center point. **New to the design and never done before**, is a **one-way bearing** (in the pulley at the base of the system), which ensures that once the linkage goes over the center, it is instantly released, with **no external resistance force from the servo**.

Thank You!

Our team greatly appreciates the effort from the entire CAD Competition team and support from sponsors to make this challenge possible.