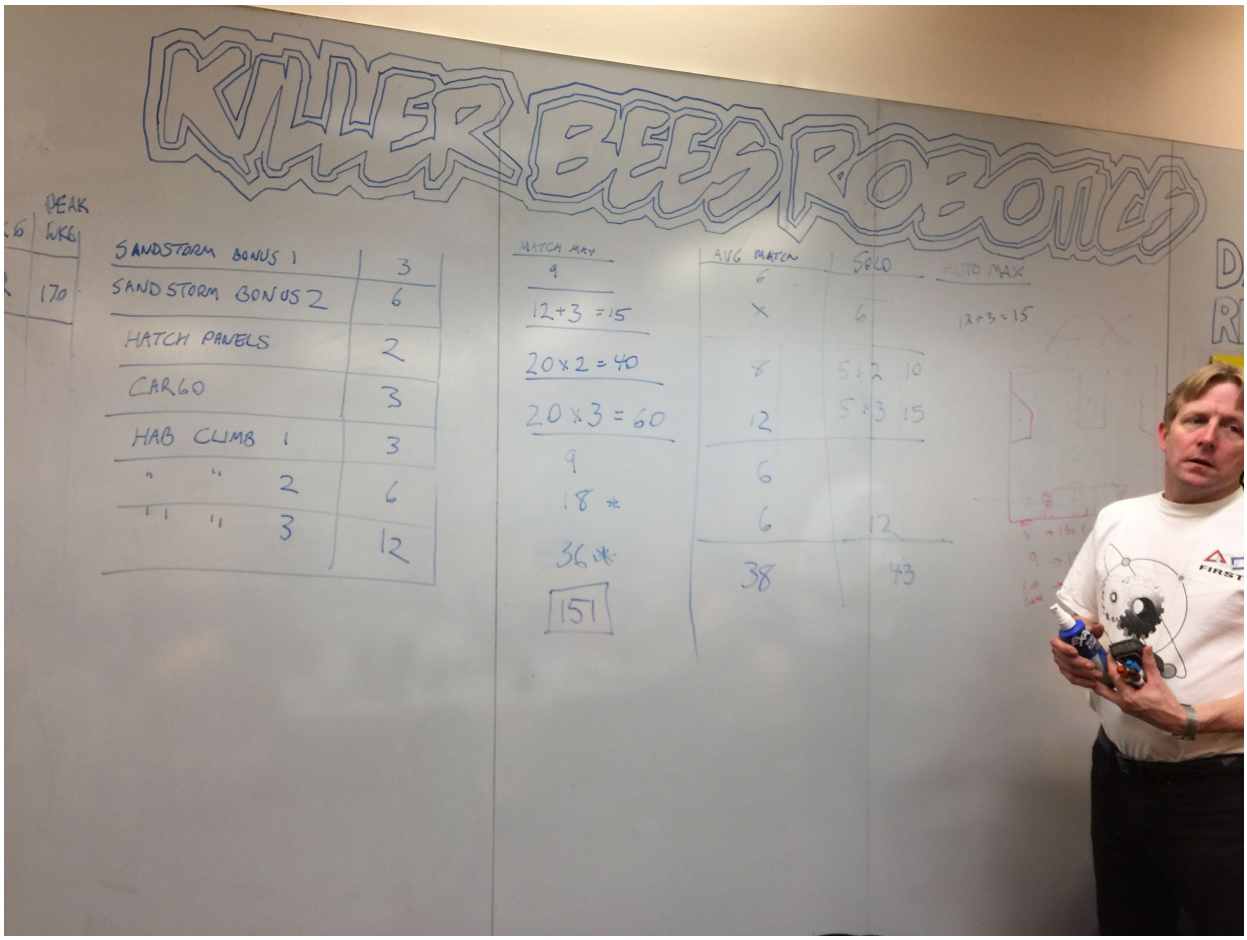
BLIZZ XXIV

33 The Killer Bees
2019 Technical Binder

Table of Contents

Strategy

Our goal is to score the most Match Points and Ranking Points possible so that we can the highest rank. The two main ways to score points are hatch panels and cargo. In order to score cargo, a hatch panel must be placed. You can score an RP if you have a completed rocket (6 hatch panels and 6 cargo). Therefore, we decided that it's essential to score both game elements, and score on all levels of the rocket.



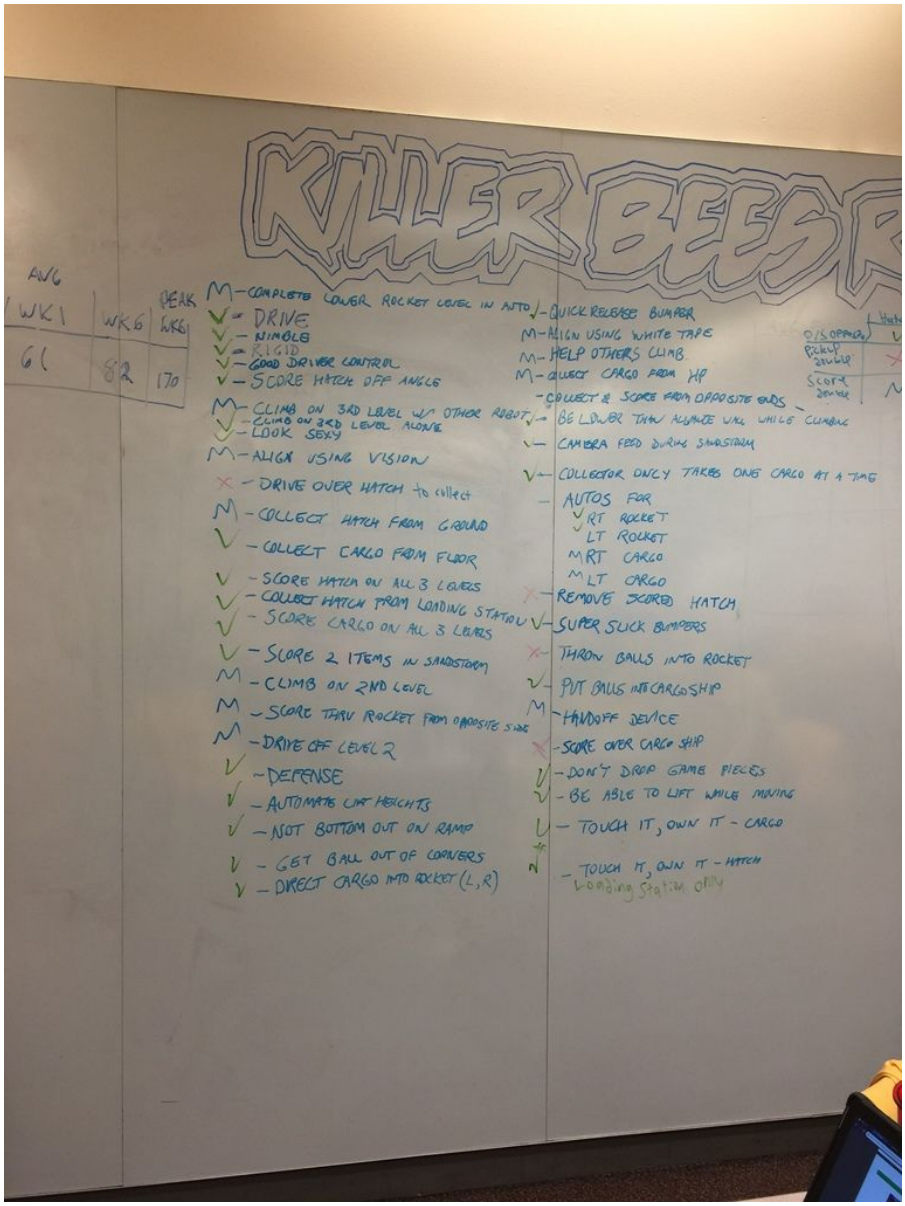
Strategy

In order to score 12 game pieces on the rocket by ourselves, it is necessary to achieve low cycle times. We obtained these times by having a wrist on our elevator that allows for quick cycle times. Furthermore, one of our season goals is to score 3 game pieces on the rocket in sandstorm to obtain the RP easily.

The other way to score an additional RP is to get 15 points during the endgame. In order to achieve this we decided that it is necessary to climb onto the level 3 platform. Therefore, if 1 other robot drives onto level 1 we can achieve the RP.

High Level Design Goals

When brainstorming design objectives for the robot, we very early prioritized the mechanisms of the robot. We wanted to make our system as automated as possible, leaving as little room for human error.



High Level Design Goals

The subsystem we prioritized the most in development for this was the hatch panel collector, because we believed it to be the most challenging procedure for success. To achieve this minimal error, we wanted a self-correcting passive alignment for the hatch collector, and automated visual alignment systems to make scoring hatches much more reliable.

Our goal was to have our robot be capable at everything - collecting both hatches and cargo, climbing onto the third level, score on the higher goals o the rocket, etc. In order to incorporate both a hatch and cargo collector system, we wanted to design a mechanism that would allow us to fluidly switch between the two. The goal for an efficient scoring cycle is that the robot can easily and swiftly transition from the scoring of one game piece to the other, while completely in movement.

Criteria

- Drivetrain
  - Low center of gravity to avoid tipping
  - Drive over cable protectors and up level 1 HAB platform
  - Drive off level 2 platform
  - Be fast and maneuverable

- Drivetrain Gearbox
  - Have chain inside frame
  - Good speed and acceleration for cycling from human player station to rocket
  - Able to cool and lubricate gearbox in between matches; serviceable

- Elevator
  - Wide enough to sweep the hatch cover or cargo ball through the elevator while raising or lowering the elevator at any height
  - Raised or lowered quickly
  - Complete at least 12 cycles per match in order to score a complete rocket
  - Reach all 3 levels of Rocket

Criteria

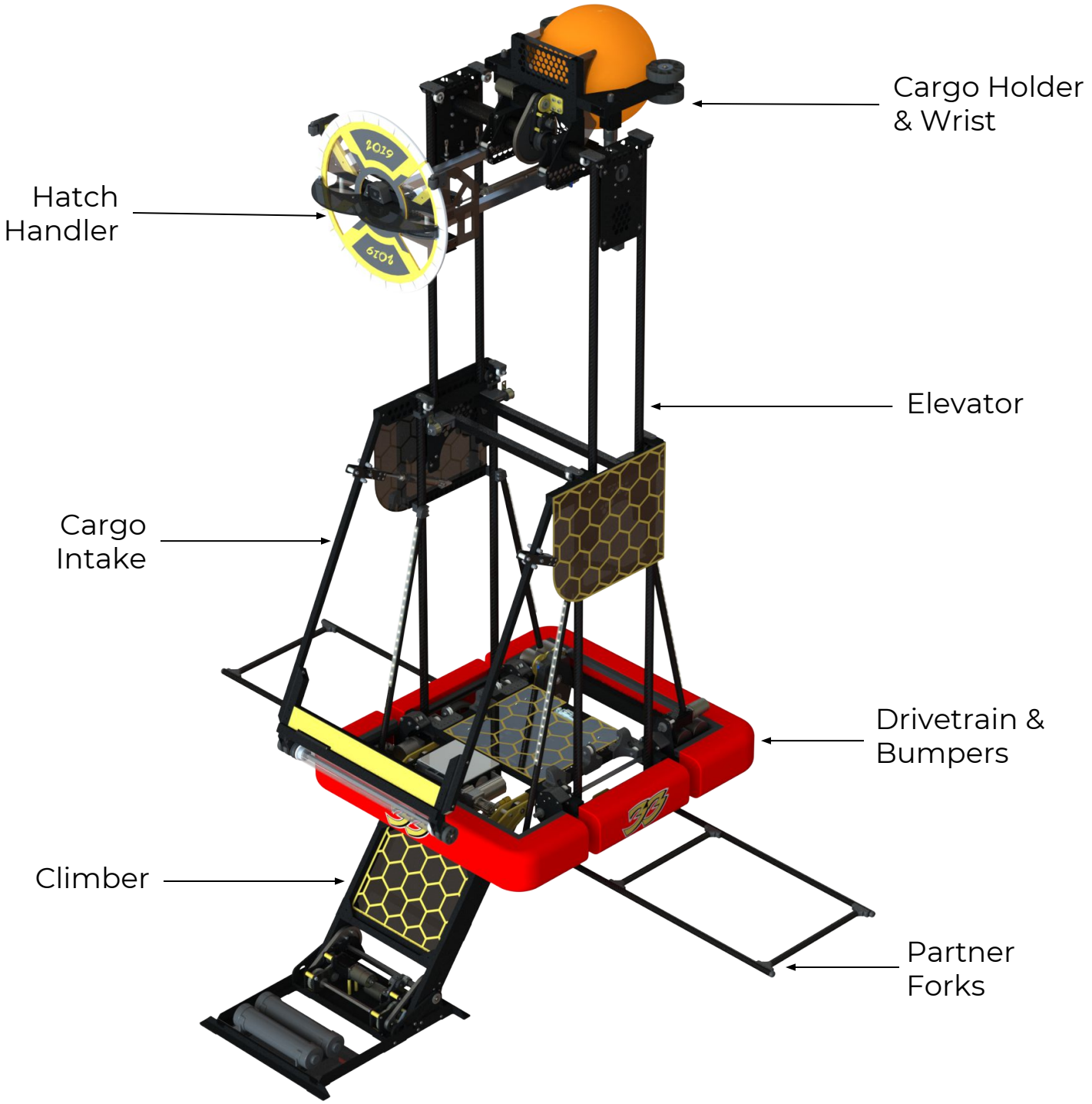
- Cargo
  - Touch it own it
  - Collect and score in under 12 seconds

- Hatch
  - Passively align to easily score and collect
  - score when on an angle
  - Hatch can only touch the velcro if it is centered
  - Collect and score in under 12 seconds

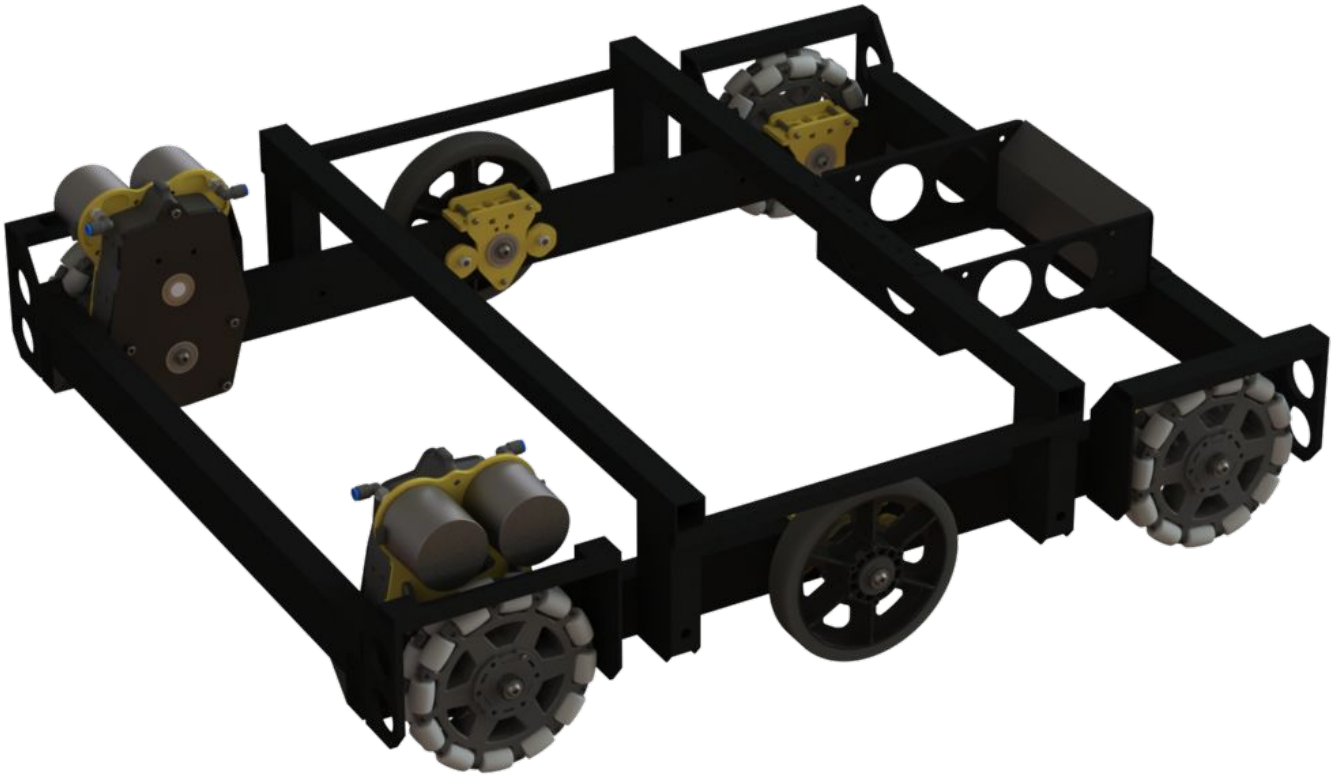
- Climber
  - Enough power to lift 2 full weight partners
  - Not tip/damage robot
  - Climb solo under 5 seconds
  - Climb with partners in under 10 seconds

- Partner Forks
  - Be sturdy enough to carry robot
  - Prevent robots from falling off
  - Can carry any robot regardless of wheel layout
  - Winch forks back in to bias partners center of gravity

Buzz XXIV Layout



Drivetrain



- Goals
  - Low center of gravity
  - Drive over cable protectors and up level 1 HAB platform
  - Have drive chain inside frame tube
  - Drive off level 2 platform
  - Agility in order to quickly traverse from HP station to Rocket and Cargo Ship
  - Easy and quick bumper change
  - Have enough space for climber to package between the drive tubes and gearboxes

Drivetrain

- Construction
  - 32” long and 27” wide
  - 2” x 1” x 1/16” aluminum tube welded construction
  - 2x 6” Andymark SmoothGrip Wheels
  - 4x 6” Vexpro Omni-Directional Wheels
  - Each wheel is 12.25” apart

- Bumpers
  - Four piece bumpers that slide onto bolts on the frame of robot
  - Bolted on with thumb nuts and thumb screws that allow the bumpers to be taken off by hand
  - Slots on bumpers to allow partner forks to fall

Drivetrain Gearbox

- Goals
  - Good speed and acceleration for cycling from human player station to rocket
  - able to cool and lubricate gearbox
  - Narrow profile to keep the chassis open as much as possible for climber packaging
  - Easy access to parts and quick maintenance capability

Drivetrain Gearbox

- Motors
  - 2 Rev NEO brushless motors per gearbox
  - Motors are above the gearbox to make packaging space for the climber
  - Utilizes built-in encoders on motors for positioning during sandstorm and vision alignment

- Gearing
  - First stage is a 12:80 tooth 20DP gear ratio
  - Second stage is a 36:62 tooth 20DP gear ratio
  - Total gear reduction of 11.48:1
  - This results in an output shaft speed of 494rpm Free speed of the drive is 12.94 ft/s

- Construction
  - Aluminum motor mount plate acts as a heat sink
  - 3D printed casing keeps gears protected
  - Casing is split in two to allow for easy removal and quick access to the inside for maintenance
  - Access holes in casing allow for lubrication between matches
  - Pneumatic fittings installed on motors allow for quick air-cooling between matches

Elevator

- Goals
  - Tall enough to reach top portal of rocket
  - Collapses enough for robot to be under 48”
  - Fast enough to run at least 12 cycles per match in order to score a complete rocket
  - Wide enough to fit the hatch and cargo mechanisms through

Elevator

- Construction
  - Max height of elevator is 84”
  - 2 stage continuous design driven by pulleys and strings
  - Vertical tubes made of 1” OD carbon fiber for lightweight construction
  - 3D printed rollers on each stage allows it to roll up and down on carbon fiber poles with little friction

- Pulley/winch system
  - 1.5” drum at bottom of elevator connected to 1x Rev NEO brushless motor, and a 9:1 Versaplanetary gearbox
  - High tension Strings: elevator is motivated in both directions by strings
  - Eyebolts on carriage allow for fine tuning of tension, and elastics keep strings from jumping off pulleys
  - Counterbalanced with 6x 6lb constant force springs
  - 2x 360 absolute encoders on 28 tooth and 30 tooth gears keep exact position of carriage

Cargo Intake

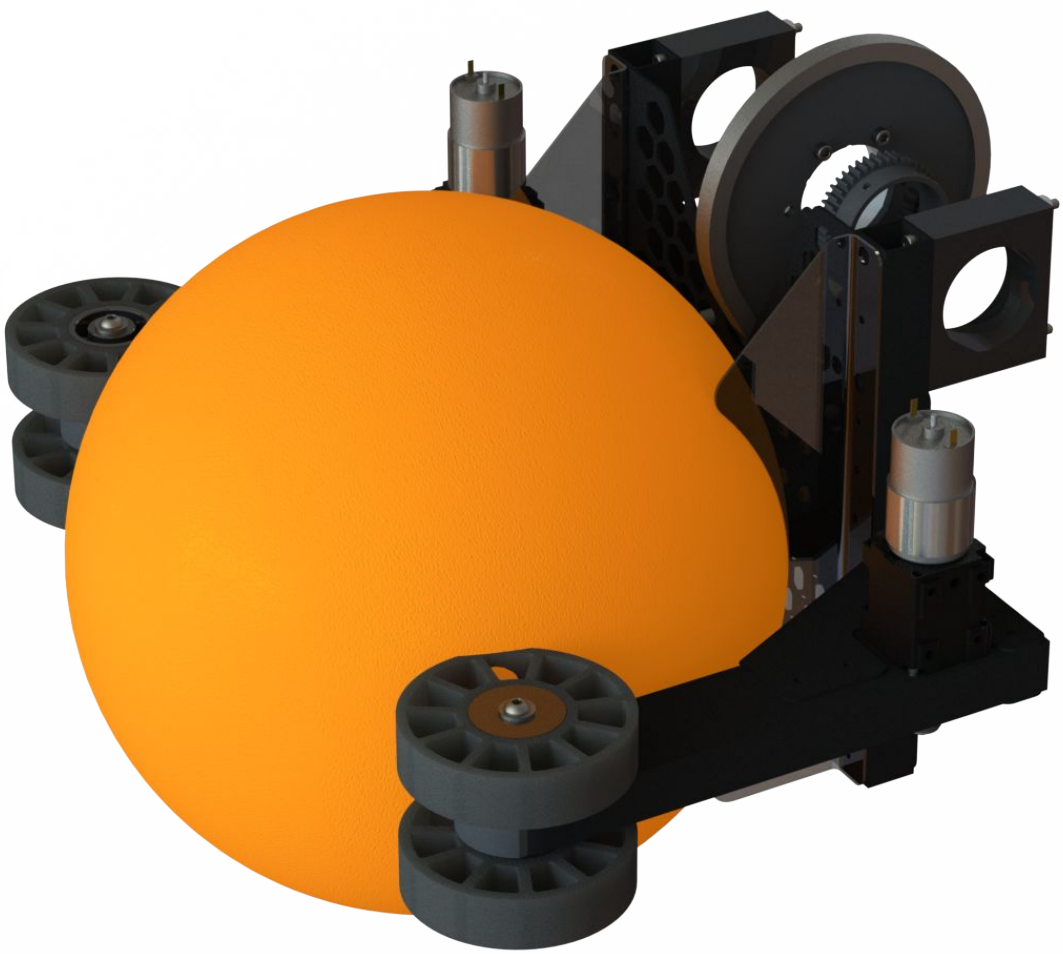
- Goals
  - Touch it, own it
  - Easily and securely passes to cargo holder
  - Allow to float over cargo while intaking
  - Securely hold intake in the robot when stowed
  - Easily able to take off arm or roller assembly if damaged

Cargo Intake

- Roller
  - 2” diameter delrin tube
  - 2 x 2” plastic wheels at each end; space between wheels docks against hard stop
  - 1x VEX 775pro motor with a 3:1 ratio versaplanetary and 12 tooth to 24 tooth GT2 belt and pulley stage, for a final ratio of 6:1

- Arm Actuators
  - Run by 3” cylinders that mount onto elevator
  - When extended, arm is trapped in a lost-motion block that allows the arm to float a few degrees, resulting in the roller being able to ride up and over the ball while intaking
  - When retracted, the arms are trapped against the hard stops on the frame so the arm cannot bounce around

Cargo Holder & Wrist



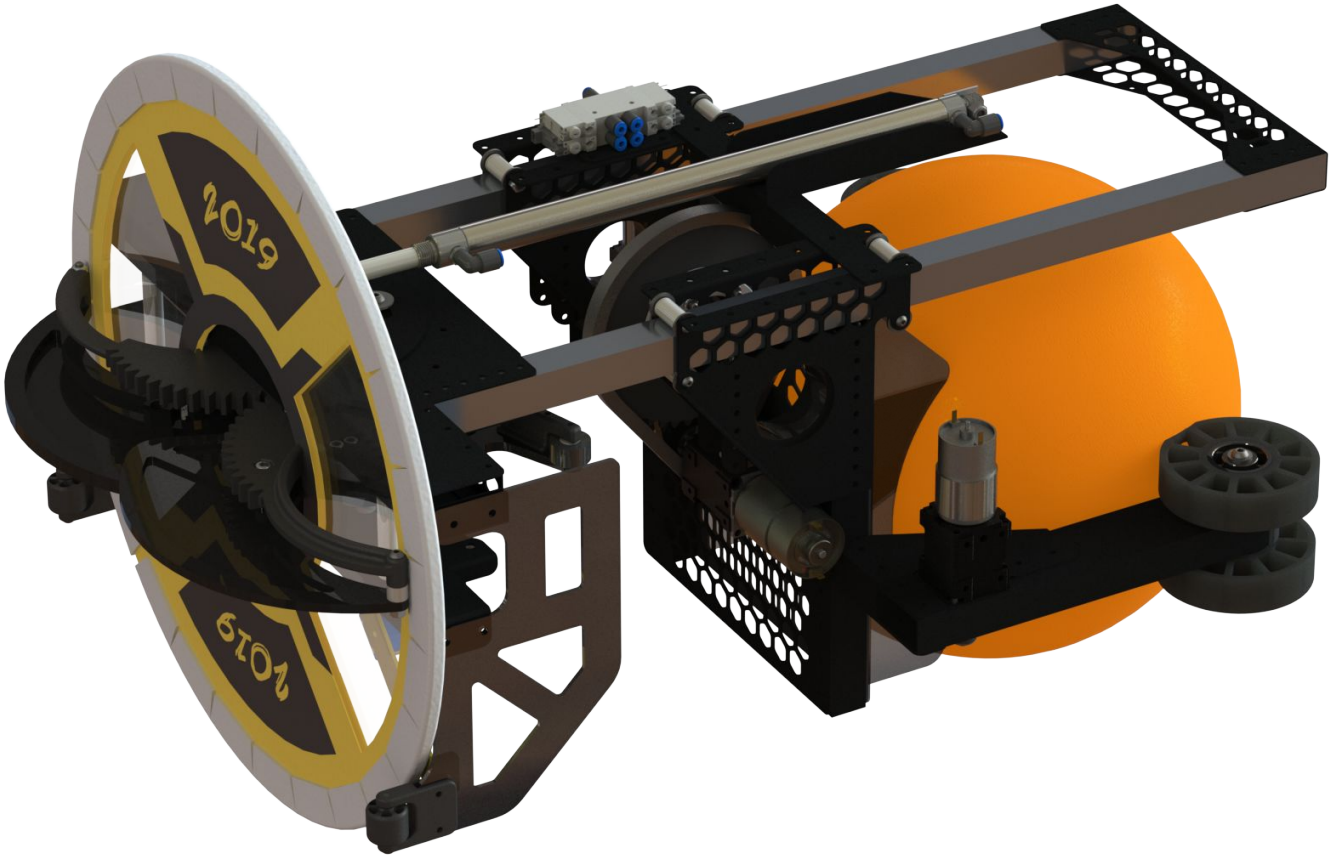
- Goals
  - Cargo is easily centered by holder when the ball is fed from the intake
  - Can swing through elevator using the wrist
  - Wrist allows both cargo and hatches to be scored on both ends of the robot
  - Wrist needs to be fast enough to be in position before arriving at target

Cargo Holder & Wrist

- Cargo Holder
  - 2x compliant wheels on each arm keeps the ball centered vertically and horizontally
  - 18 tooth GT2 pulleys and belts connect the motor to the wheel inside the tube
  - The belts are run by 2x 550 motors with 10:1 ratio versaplanetary gearboxes
  - QM photo sensor used to detect when cargo is present in the holder

- Wrist
  - Made of 2” diameter carbon fiber tube
  - Powered by 1x VEX 775pro motor connected to a 63:1 ratio versaplanetary gearbox followed by a 12 tooth to 48 tooth #35 chain reduction, for a final ratio of 252:1
  - 360 pot encoder used for positioning

Hatch Handler



- Goals
  - Collect hatches from human player station
  - Passively align to easily score and collect
  - score when robot is misaligned
  - Hatch can only touch the velcro if it is centered
  - Score in under 12 seconds (acquisition to placement)

Hatch Handler

- Claw Mechanism
  - 2x articulated claws comprised of CNC nylon plates and 3D printed gears
  - As the claws extend they create a semi-circle shape through the center hole of the Hatch and grows as wide as the portal opening, acting as an alignment device to the portal only able to score when the Hatch is centered on the portal
  - Two QM photo sensors on either side of the Hatch to detect when it is present

- Slide Arm
  - Claw mechanism is mounted on an arm that is able to slide in and out with a 12” cylinder
  - Provides enough reach out past the bumper to be able to score on the rocket ship and have a cushion when the claw runs into the wall

- Passive Aligning System
  - Claw is mounted on a horizontal pivot with +/- 15 degrees travel to allow for imperfect alignment to the portal and HP station
  - Idler wheels stick out past the hatch so that if one side of the claw mechanism hits the wall early it will gimbal to the correct position

Climber

- Goals
  - Climb from HAB1 to HAB3 to maximize our likelihood of getting the ranking point
  - Have enough power to lift 2 partners with us
  - Climb in under 5 seconds solo, under 10 seconds with 2 partners
  - Not fall or tip off of platform
  - Easy alignment to HAB to execute fast

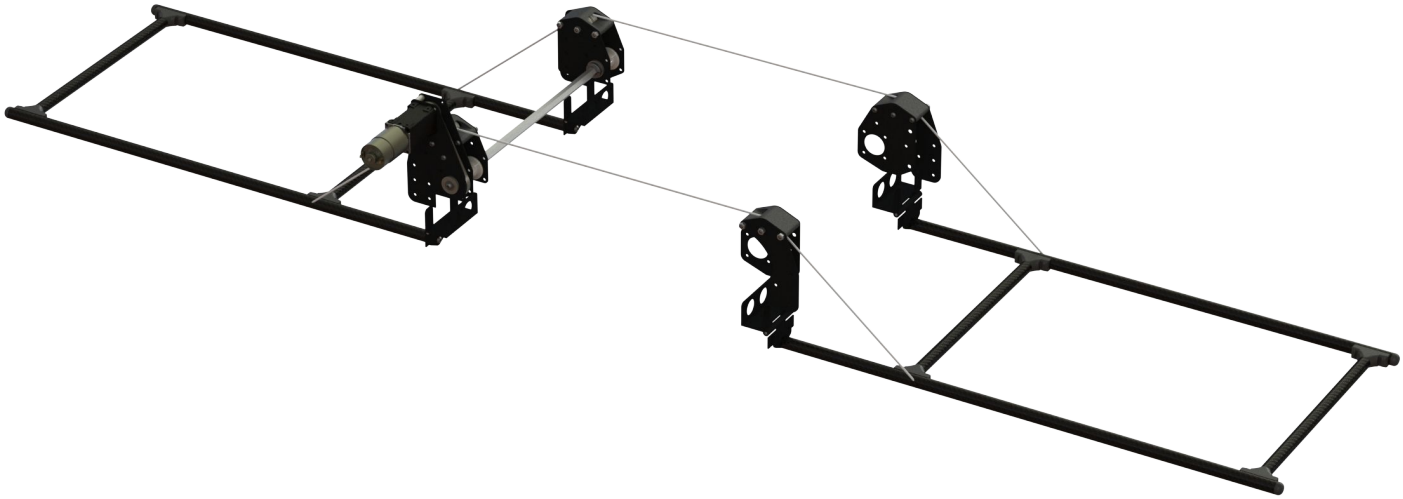
Climber

- Foot
  - 20” wide x 22” long for good stability
  - Nests inside of chassis

- Gearbox
  - Powered by 2x VEX 775pro motors with 150:1 versaplanetary gearboxes
  - 2x 20 tooth to 48 tooth 20DP spur gear reductions
  - 12 tooth to 36 tooth #35 chain final stage
  - Total ratio of the gearbox is 2592:1
  - 180 pot sensor for positioning of the links

- Four Bar Linkage
  - Extends from underside of robot; foot bottoms out into the HAB1 platform and then lifts the robot up, keeping it parallel to the ground
  - Linkages are 22.5” long from the center of the pivot points, and the two links bottom out against each other when fully extended
  - Once robot has landed on the top of the HAB3 platform, the linkage rotates slightly further lifting the foot off the HAB1 platform

Partner Forks



- Goals
  - Securly lift 2 other robots onto HAB3 with a sideways forklift mechanism
  - Supports the weight of a max weight robot
  - Supports any type of drivetrain
  - Shift their center of gravity closer to our robot

Partner Forks

- Forks
  - Each fork made of 2x ¾” diameter tube that are 31 ½” long and 15” apart
  - Hinged from the bottom of the drive frame allowing them to fold from the stowed vertical position to the flat horizontal position

- Motors
  - VEX 775pro with a 200:1 versaplanetary gearbox
  - 12 tooth to 22 tooth #35 chain stage drives the 1” diameter drum, for a final ratio of 366:1

- String Routing
  - Forks are 2 x ¾” diameter carbon fiber tube 31.5” long and 15” wide
  - Hinged at bottom of the frame to easily stow and deploy
  - Piston releases forks during end game
  - Secure parter robots with

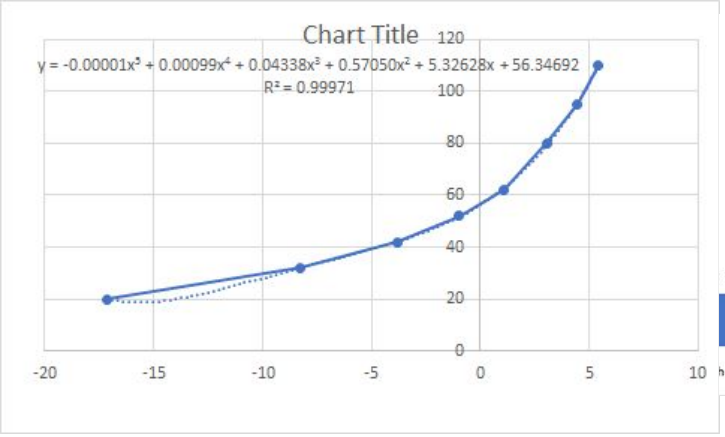
Programming

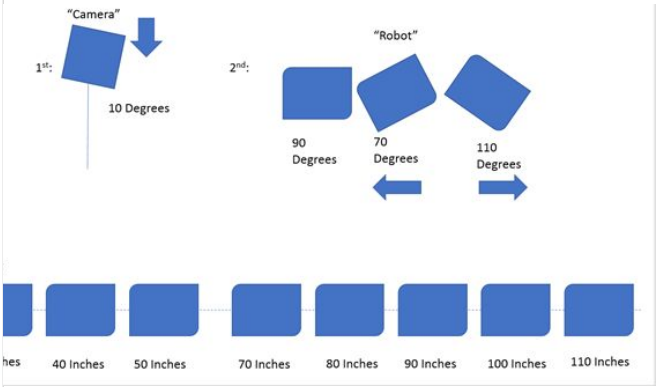
- Programmed in LabVIEW
- Torque-based driving controls with current limiting and yaw rate compensation
- State-based mechanism control focused on achieving drivers intent rather than inputting individual actions
- Coordinated elevator and wrist control with collision avoidance
- LED indicators to signal robot and game piece state
    - Active end of the robot is identified by which side lights up
    - Colors dictate which game piece is active and whether it is acquired
- Multiple point-of-view cameras gives best possible view for each game piece; camera selected and rotated automatically based on robot state
- Sandstorm goals:
    - Score 3 game pieces in 15 seconds
    - Have different routines for scoring on rocket and cargo ship
    - Allow driver override if necessary

Camera Tracking

- Goals
  - Determine position of goal relative to robot
  - Accurately measure distance to target
  - Drivetrain auto-align to target
  - Reduce drivetrain speed on approach relative to distance from target

- Methodology
  - Generate lookup data from collected targets
  - Compute coordinate of target in field space
  - Control robot heading to target coordinate
  - Scale drive throttle based on distance to target





Left: Chart for Calculating Distance

RIght: Target Calibration Process

Electronics

- 5x Rev Spark MAX motor controllers utilizing CAN
- 7x CTR Talon SRX's utilizing CAN
- CTR Gadgeteer Pigeon IMU gyro and accelerometer
- Electronics packaging to minimize wiring length
- 1x VRM, 1x PCM, 2x CANifiers
- Energy chain utilized to manage cable run throughout the elevator travel