FRC TEAM 3647

THE MILLENIUM FALCONS

Technical Binder

2018-2019

Table of Contents

Design **3**

Drivetrain 4

Drive Gearbox 5

Continuous Elevator 6

Elevator Gearbox 7

Four Bar Mecanum Cargo Intake 8

Arm 9

Arm Gearbox 10

Ball Shooter 11

Hatch Grabber 12

Climber 13

Programming **14**

Autonomous Code 15

TeleOp Code 16

Limelight 17

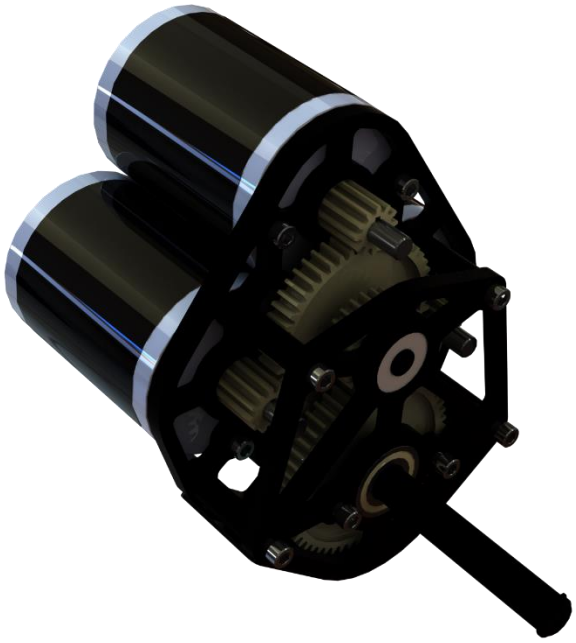
Design

- Drivetrain
- Elevator
- Cargo Intake
- Arm
- Ball Shooter
- Hatch Grabber
- Climber

Drivetrain

- **Chassis**
  - Chain-in-tube West Coast Drive
    - Chain in tube with exact C-C allows for protected and maintenance free chain
    - Constructed with 2" x 1" x 1/8" wall and 2" x 1" x 1/16" wall tube
    - Half-Pocketed drive tubes for weight saving while still protecting the chains.
    - CNC'd ⅛" aluminum belly pan with tapped holes for electronics
  - Bumpers attach through miniature slide latches
- **Wheel base**
  - 6 x 6" by 1.5" wide Colson Wheels space 10.5" apart
  - 0.125" center wheel drop

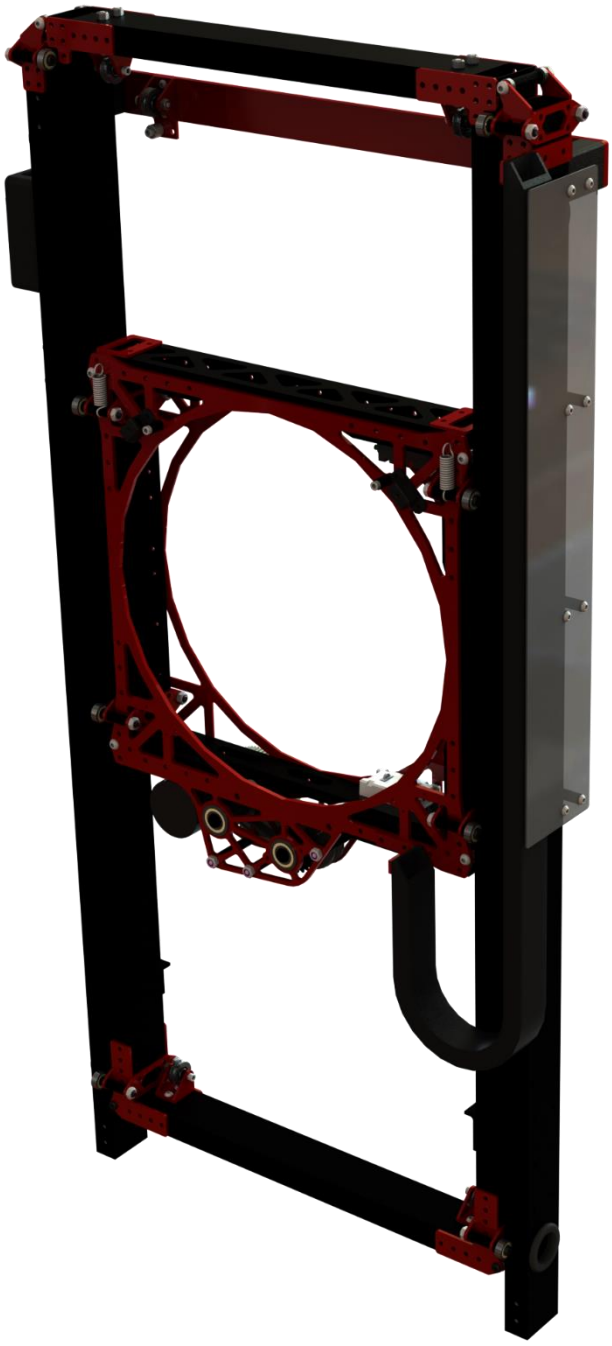
Drivetrain Gearbox



- **Custom Drive gearboxes with 3 Mini-CIMs each**
  - Mini-CIMs provide more acceleration due to pulling less current on start up
- **Theoretical speed is 16.4 ft/s – 14.6 ft/s adjusted**
  - 12:50 24:54 reduction

Continuous Elevator

- **Elevator Construction**
  - 2" x 1" x 1/16" wall tube for maximum weight savings while still maintaining structural integrity
  - 1/8" plate gussets for bearing blocks
  - ¾" R4Z bearings and 0.5" bearings used
- **Continuous Cable Rigging**
  - Uses 1/8" diameter Dyneema cable
    - Stronger, safe, and lighter than steel wire
    - 2 Cables pulling up and 1 down
  - Cable runs on 1" pulleys with integrated bearings
  - Up strings have springs to keep the ropes always tensioned
- **Bearings**
  - Uses ¾" OD ¼" ID bearings on side faces while ½"OD ¼"ID bearings keep the stages from moving constrained on front faces
- **#SidewaysElevatorGang**
  - Sideways elevator allows for our arm mechanism to spin all the way around without the need of a pass through



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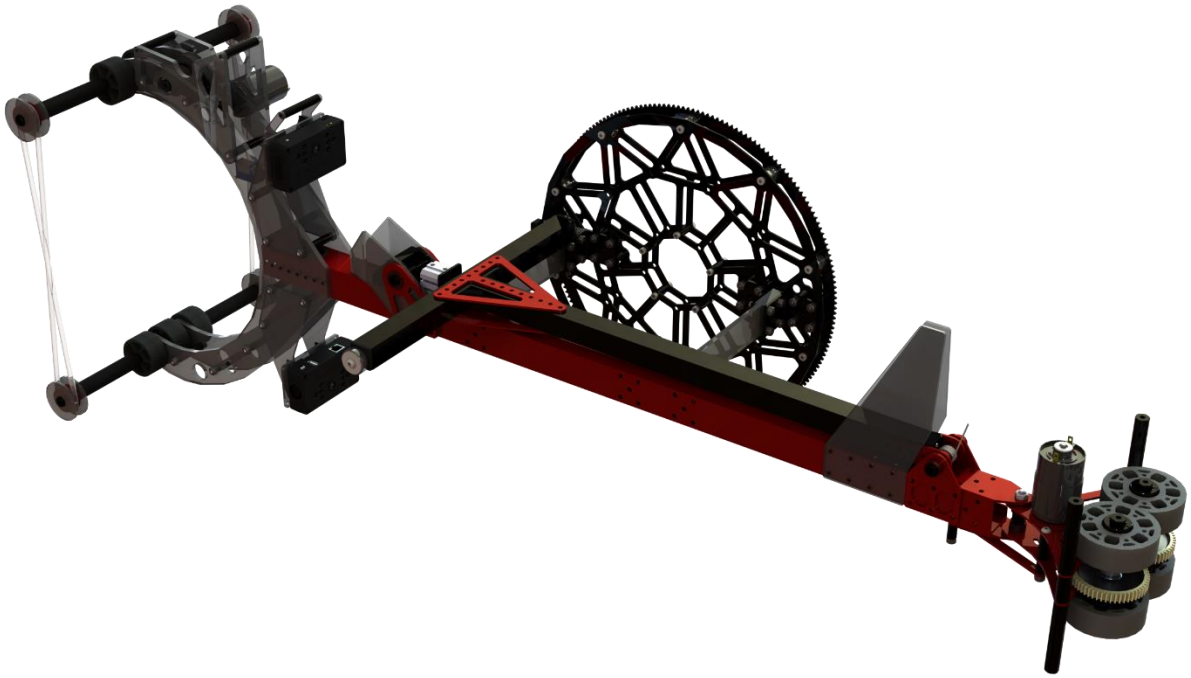
Elevator Gearbox

- **Custom Elevator Gearbox**
  - Powered by 3 775 Pro Motors in 1 gearbox for a peak power of 1041 watts
  - Single speed 2 stage reduction
    - 12:80 and 24:50 reduction
  - Additional 775 on the other end geared the same through a Versa Planetary Gearbox to help with climbing
  - Provides enough power to lift the robot onto the 3rd level of the Habitat
- **Uses an SRX Mag encoder to record drum rotation**
  - Banner Beam Break Sensor to detect bottom of travel
- **Spool**
  - 1.5" OD 1/16" thick aluminum spool

Four Bar Mecanum Cargo Intake

- **2 Stage Roller**
  - Outer roller is a 1.5" OD surgical tubing roller that pulls balls in from over 20"
  - Inner roller consists of 5 mecanum wheels which funnel the cargo into the center of the robot
- **Custom belt reduction**
  - Powered by a single 775 Pro motor with a single stage 12:48 belt reduction for a surface speed of 34 ft/s
- A beam break sensor in the cargo shooter detects when the robot has intook a cargo successfully to prevent intaking multiple cargo

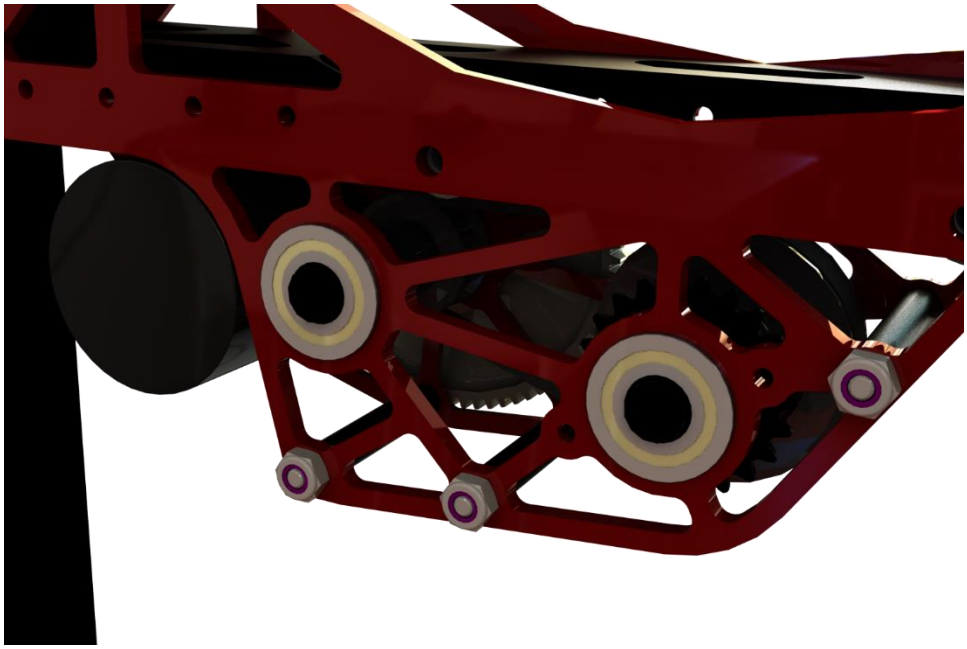
Arm



- **Arm Construction**
  - Arm base constructed out of 1.5" x 1.5" 1/16" thick aluminum tubing
  - Connected to turret by 4 0.25" thick polycarbonate struts
    - Absorbs impacts from the arm instead of transferring them into the turret
- **Turret Construction**
  - Custom 190T #25 chain sprocket drives the arm rotation
  - 0.1" thick plate on turret plates
  - Stacked bearing design

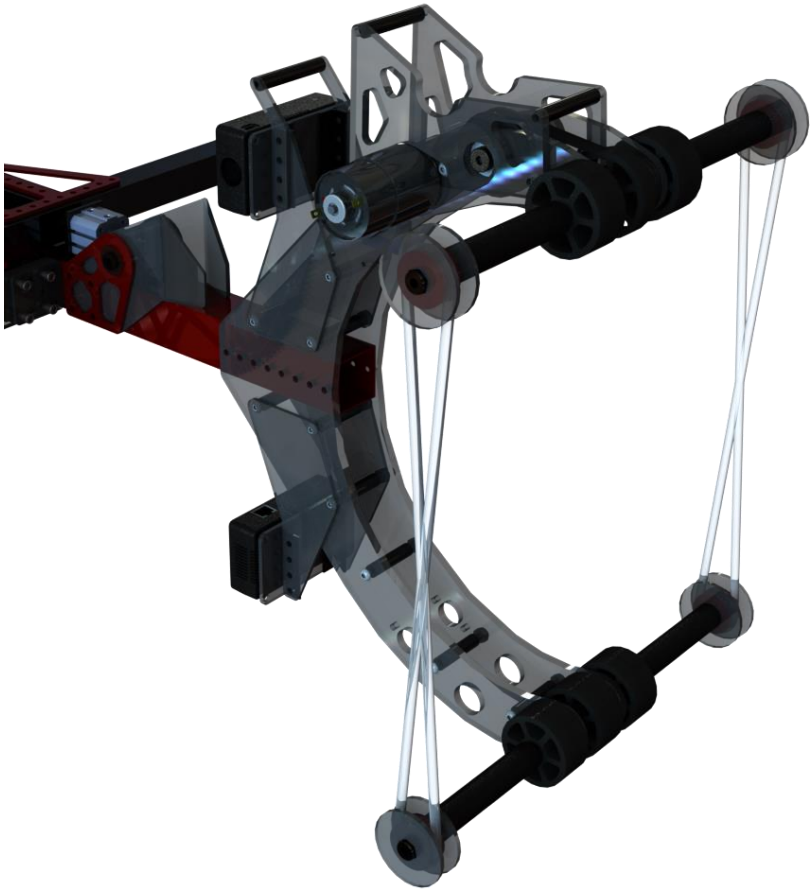
- Dual sided arm allows for easy integration of new hatch and cargo intakes independently
- Front kickstand folds out from arm to support the front of the robot when climbing
- Uses two REV Magnetic Limit Switches to zero on the 2 hard stops that limit the range of motion of the arm

Arm Gearbox



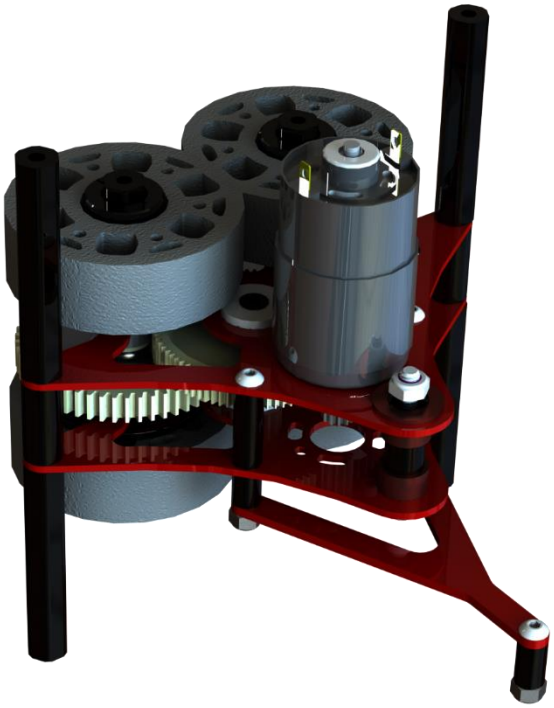
- **Custom 3 Stage Gear-Belt-Chain Reduction**
  - Powered by a single NEO Brushless motor
  - 12:72 18:36 22:190 Gear, Belt, and Chain reduction
- **Custom Spark MAX follower**
  - Due to the buggy Spark MAX software, we were forced to write our own follower software the Spark MAX to follower a Talon SRX running Motion Magic
    - Allowed us to utilize software we were familiar with
    - Enabled us to use a SRX Mag Encoder which had much higher resolution than the built in Hall-Effect sensor in the NEO
- **SRX Mag Encoder to detect arm rotation**
  - Additional REV Magnetic Limit Switches on 2 ends of travel used to zero the arm

Ball Shooter



- **2” Compliant wheels in a line**
  - Pull cargo in from the four bar intake nice a snug
- **Polycarbonate Plate Construction**
  - Perfect size and shape for a Cargo to sit in
  - Folds onto itself to allow the robot to start within frame perimeter
- **Custom belt reduction**
  - Powered by a single 775 Pro motor on a 12:48 and 18:18 belt reduction
- **Polychord figure eight belt**
  - Transfers power to the lower roller
  - Keeps ball constrained in the ball shooter on the sides
- **Beam Break sensor detects if there is a ball present**
  - Used to switch to ball scoring mode, stop the four bar intake from intaking any more cargo, and flashes LEDs to alert drivers

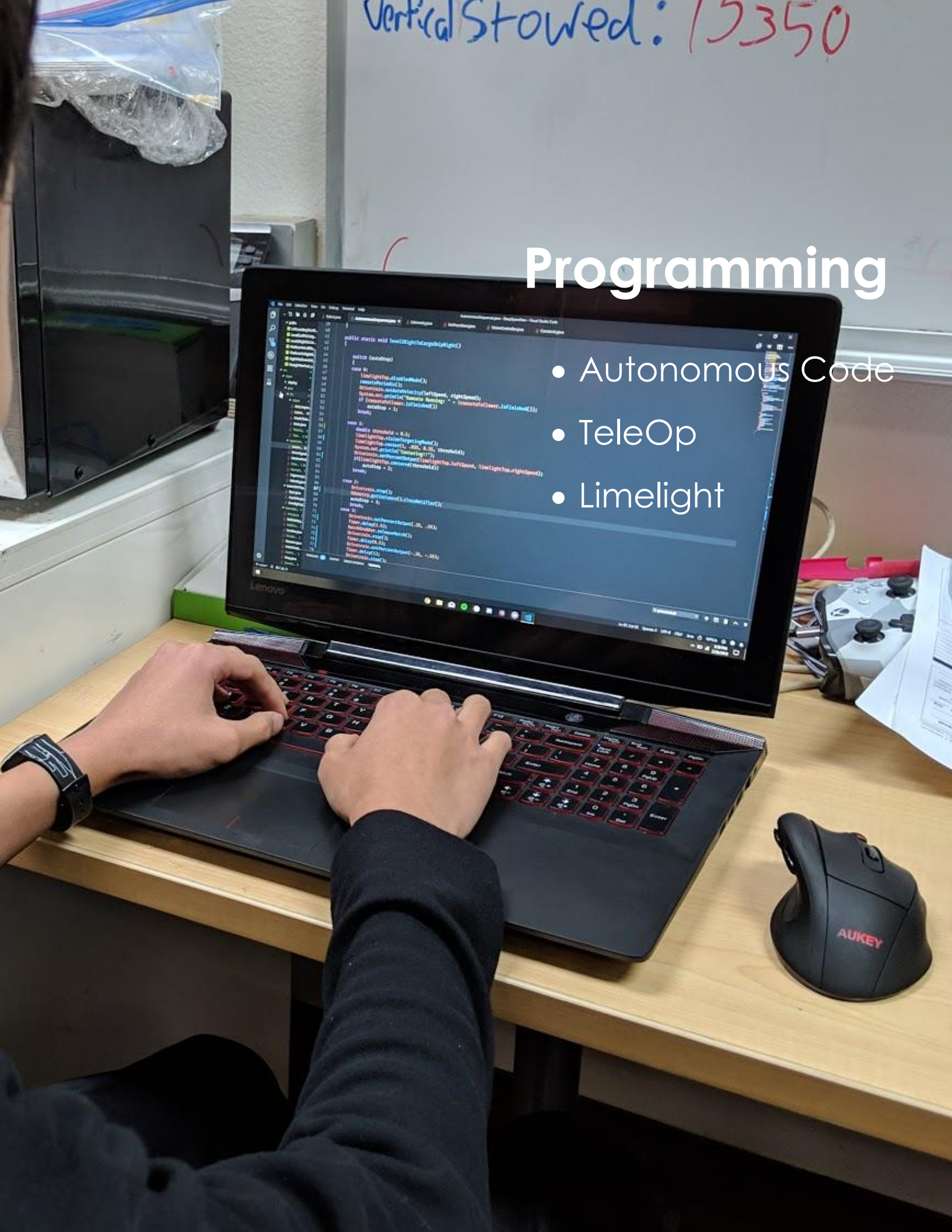
Hatch Grabber



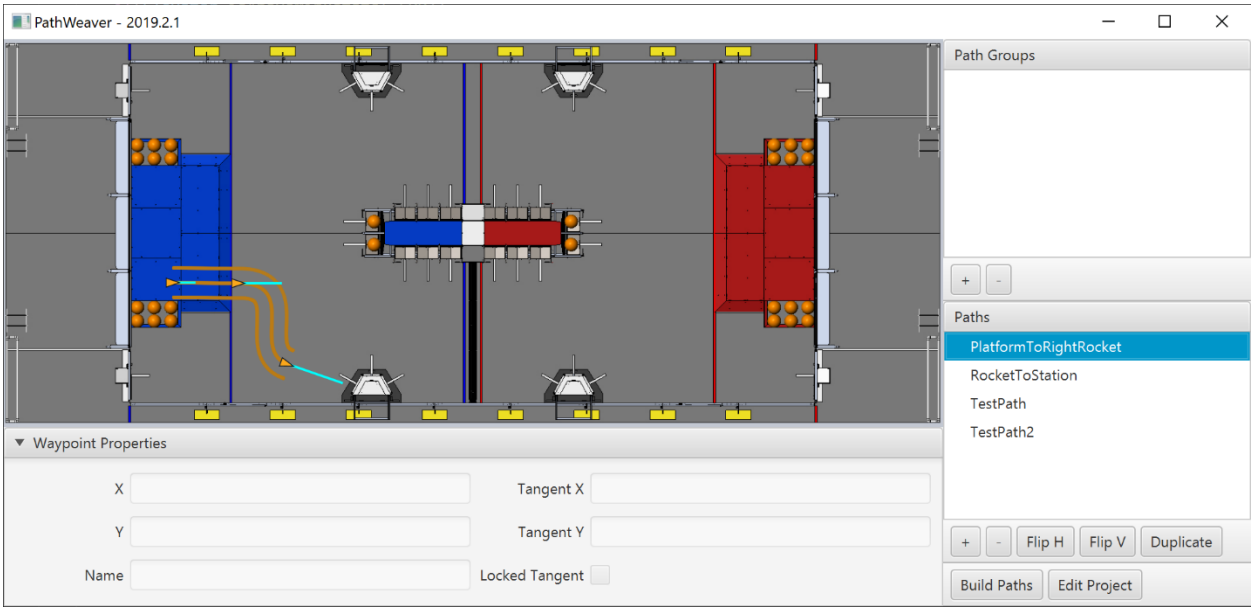
- **Wheeled hatch grabber with 4 3” compliant wheels**
  - Corners of the wheels grab onto the inner circle of the hatch
    - The wheels pull the hatch over center so that it is very secure
  - Wheels spin opposite to each other
- **Custom 2 stage gear reduction**
  - Powered by a single 775 Pro motor on a 12:80, 14:54 gear reduction
- **Center sprung with surgical tubing**
  - Allows for hatch placement at up to 60° off angle
- **Current detection using power draw from PDP detects if there is a hatch or not**

Climber

- **Utilizes Elevator to Lift Robot**
  - Elevator pushes down on the kickstand which comes off the arm to support the front of the robot when climbing
  - Elevator pushes down on the pogo stick to lift the back of the robot
    - Arm locked into place on the pogo stick
  - Arm holds position to keep the robot level
- **Automated Climb**
  - A single button on the driver controller releases the climb mechanisms and climbs onto the third level of the Habitat
- **Powered Pogo Stick**
  - A single 775 Pro motor drives the robot forward once it is lifted in the air using small wheels on the bottom of the pogo stick
  - Constant force spring instantly pulls the pogo stick back up once the robot has completed the climb

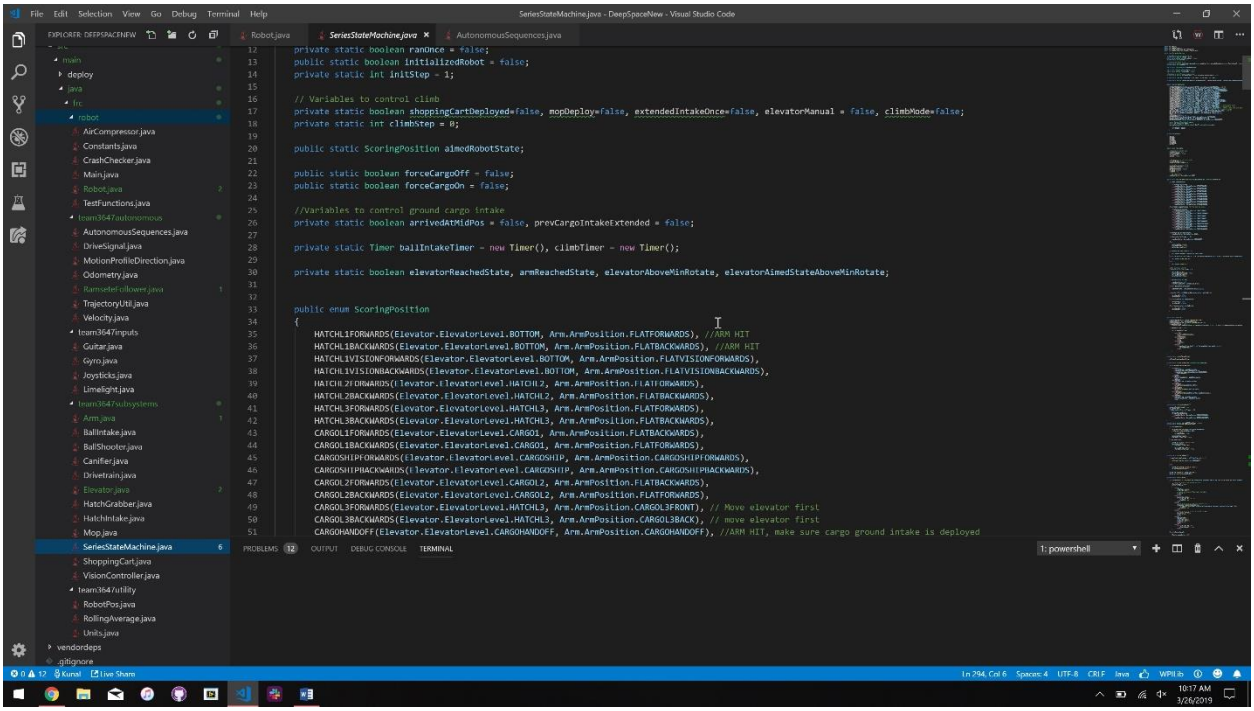

Vertical Stowed: 15350
Programming
• Autonomous Code
• TeleOp
• Limelight
Lenovo
AUKEY

Autonomous Code



- **Path Generation:**
  - We use Quintic Hermite Splines and WPILIB's built in visualizer for spline creation for our paths
  - The path follows a trapezoidal speed ramping function in order to follow paths more accurately and safe.
- **Autonomous Driving Controller**
  - Implemented a new "Trajectory Following" autonomous pathing algorithm known as Ramsete
  - Ramsete is a non-linear, time-varying, trajectory tracking algorithm
  - We use Ramsete to follow a pre-generated motion-profiling path file (using diagrams of the 2019 field)
- **Vision Controller**
  - We combine Ramsete with 2 limelight cameras to center the robot to the retro-reflective tape using a homemade PID algorithm. We are also able to calibrate the robot's current position based on what the camera sees as we line up.
- All of our algorithms and other code is made **open source for all teams** to use and is **actively shared** with other teams.

TeleOp



- **Tele-Op Code**
  - Several safety features to prevent the robot colliding with itself
  - Super Structure State Machine is used to plan and achieve movement between the Arm, Elevator, and Intake Subsystems to prevent any and all collisions.
- **Superstructure State Machine**
  - Observes the current position of the arm and elevator via the precise magnet encoder sensors mounted with custom 3D printed carbon fiber mounts.
  - Limit Switch sensors used to reset position for accurate encoder sensor readings.
  - Calculates fastest way to achieve a “state” or position of the robot
  - Flashing LEDs to alert drivers of cargo in the shooter mechanism
  - Intuitive controls that automatically switch between hatch and cargo scoring modes

Team 3647

Vision Processing

- **Limelight Code**
  - Limelight code was created so that if we ever add more cameras, our code was easily adaptable to any situation.
- **Algorithms**
  - Using an advanced, homemade PID algorithm that utilizes a rolling average to smooth out robot motion while centering
  - Dual Crosshair allows us to put the limelight on the side of the robot, while still maintaining a center lock on the rocket or cargoship
- **Vision Processing**
  - Limelight 2 was a very powerful machine that allows us to vision process off of the roborio decreasing roborio CPU usage and faster vision targeting
  - All vision targeting values are sent over the network via "network tables" to efficiently receive and manipulate that data into drive signals for the drivetrain