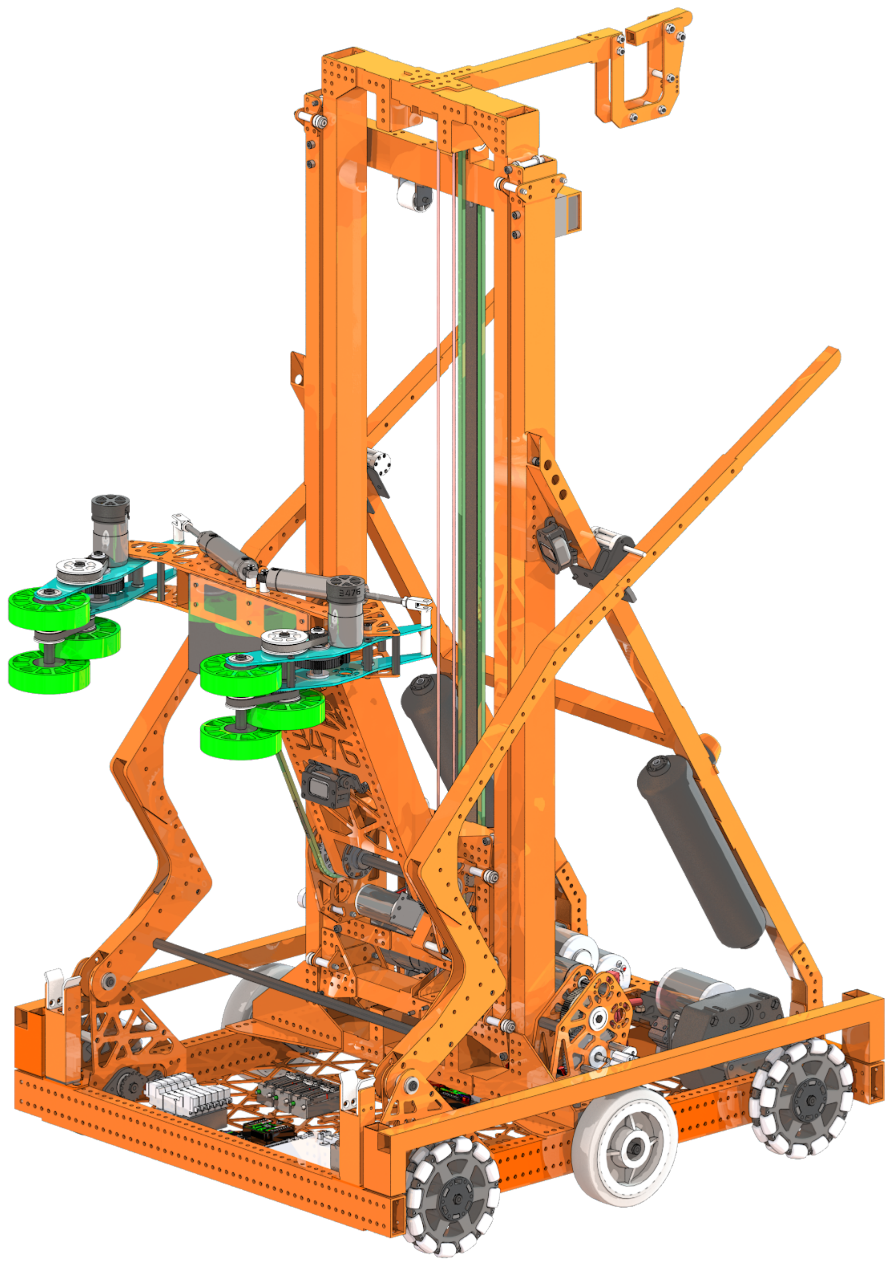
Team 3476: Code Orange

Technical Documentation

Presenting our 2018 robot: Gnaraloo



Design Process

Design Requirements

Win by:

- Manipulate switches and scale in our favor or against the opponents.
- Store power cubes in vault and use power ups strategically in our favor.
- Climb or park to score points.
- Create a robot that we can control effectively and utilize strategically.

Actions:

- Get power cubes
- Place cubes into vault through exchange
- Place cubes on scale/switch
- Defense on robots/other switch
- Use power ups
- Park
- Climb
- Pick up robots

Temporary Wish, Prefer, Demand

Climb individually.	**Demand**
Individually park robot.	**Demand**
Having our robot support other climbing robots.	**Prefer**
Climb carrying 1-2 other robots.	**Prefer**
Transfer cubes to vault from exchange.	**Demand**
Place cubes on scale.	**Demand**
Place cubes on switch.	**Demand**
Pick up cubes from floor.	**Demand**
Get cubes from portals/exchange.	**Wish**
Deal with orientation of the cube.	**Demand**

Drivebase

Design requirements:

- Largest possible wheelbase
- ~8ft/s low gear, ~18ft/s high gear
- 3 Mini CIM motors on each side to distribute power over more circuit breakers
- Enough ground clearance to drive up platform ramp and other teams' ramps
- Keep center of gravity in the back to balance the arm and intake at the front
- Easy to build and repair
- Reliable and proven design
- Make use of COTS components to reduce amount of manufacturing
- Easy to access battery and main breaker
- Minimize length of wiring runs on bellypan

Designs considered:

- 4" wheels
    - Pros:
        - Readily available wheels in many types
    - Cons:
        - Very little clearance between edge of drivebase and platform ramp
        - Possible for bellypan to get stuck on angled edge of platform without wheels touching the ground
- 5" wheels
    - Pros:
        - Enough clearance between edge of drivebase and platform ramp
    - Cons:
        - Not many options for wheels
        - Possible for bellypan to get stuck on angled edge of platform without wheels touching the ground
- 6" wheels
    - Pros:
        - Readily available wheels in many types
        - Lots of clearance between edge of drivebase and platform ramp
        - Robot cannot get stuck on platform ramp
    - Cons:
        - Heavy wheels

Elevator

Design requirements:

- Able to place cubes on a 2-cube-high stack on the scale in its highest position
- Able to position the intake at the level required to pick up cubes off of the ground
- Able to reach maximum height in less than 0.75 seconds
- High rigidity
- Lightweight and low center of gravity
- Easy to build and repair
- Reliable and proven design

Designs considered:

- Single stage elevator
    - Pros:
        - Proven design
        - Easy to design and build
    - Cons:
        - Would need a very long arm to reach the scale
- Cascading elevator
    - Pros:
        - Proven design
        - Able to reach the scale
    - Cons:
        - More difficult to design and build than a single stage elevator
- Folding arm with multiple joints
    - Pros:
        - Able to reach the scale
    - Cons:
        - Not a proven design; difficult to design, build, and program
- Shooter
    - Pros:
        - Able to reach the scale
    - Cons:
        - No proven designs for shooting irregular rectangular prisms
        - Possibility of missing the scale or knocking off other cubes
        - Difficult to design, build, and program

Arm

Design requirements:

- Mounts on the elevator carriage
- Able to place cubes on a 2-cube-high stack on the scale in its highest position
- Able to position the intake at the level required to pick up cubes off of the ground
- Able to position vertically and hold the intake parallel to the floor for stowing the intake inside the frame perimeter
- High rigidity
- Lightweight
- Easy to build and repair
- Reliable and proven design

Designs considered:

- Arm with four bar linkage
  - Pros:
    - Proven design
    - Easy to design and build
    - Always keeps the intake parallel to the floor
  - Cons:
    - Large, heavy, and many parts
    - Cannot control the angle of the intake
- Arm with virtual four bar (chain bar) linkage
  - Pros:
    - Proven design
    - Always keeps the intake parallel to the floor
    - Smaller, lighter and fewer parts than a four bar
  - Cons:
    - Somewhat more difficult to design and build than a four bar
    - Cannot control the angle of the intake
- Arm with base joint and wrist joint
  - Pros:
    - Able to control the angle of the intake
    - Smaller, lighter and fewer parts than a four bar but more parts than a virtual four bar
  - Cons:
    - Most difficult to design, build, and program

Intake

Design requirements:

- Mounts on the arm
- Able to pick up and eject cubes
- Fits inside the frame perimeter when stowed
- Unable to pick up multiple cubes at once
- Clamps cubes tightly so that they do not fall out
- Picks up cubes with little driver effort (no precise alignment required)
- Lightweight
- Easy to build and repair
- Reliable

Designs considered:

- Claw with wheels for intaking on each side and a pneumatic cylinder to clamp the claw around the cube
    - Pros:
        - Easy to design and build
        - Lightweight
        - Used successfully by many teams in the past
    - Cons:
        - Does not intake as quickly in certain positions
- Claw with both movable and fixed wheels for intaking on each side
    - Pros:
        - Smaller, lighter and fewer parts than a four bar but more parts than a virtual four bar
        - Used successfully by Team 1114 in 2015
    - Cons:
        - More difficult to design and build
        - Larger and heavier
        - Clamping the cube is difficult

Climber

Design requirements:

- Lift our own robot
- Lift either one other robot with our own or two other robots without our own
- Lightweight
- Easy to build and repair
- Reliable

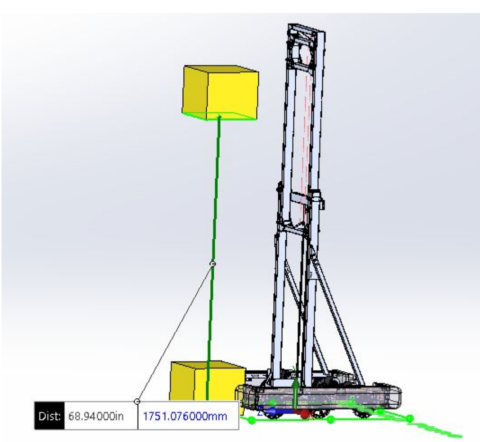
Designs considered:

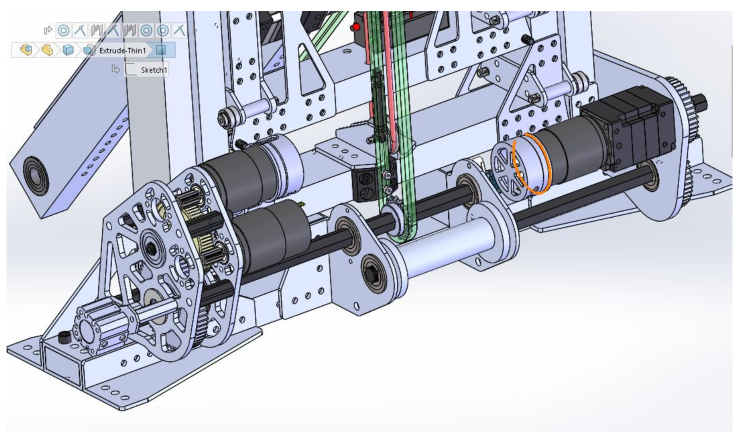
- Two ramps lifted by gas shocks
    - Pros:
        - Easy to design and build
        - Less risk of damaging other robots
        - Used successfully by other teams in the past
    - Cons:
        - Big and heavy
- Fork for lifting another robot with our own
    - Pros:
        - Smaller and lighter than ramps
        - Easy to integrate into the robot design
    - Cons:
        - Easier to drop other robots
        - Used less in the past than other designs
- Forks for lifting two other robots with our own
    - Pros:
        - Possibly smaller and lighter than ramps
    - Cons:
        - Overkill
        - Requires a much more powerful climber/winch
        - Easier to drop other robots
        - Used less in the past than other designs

Prototyping

Elevator

Prototype of cascading elevator and four bar arm

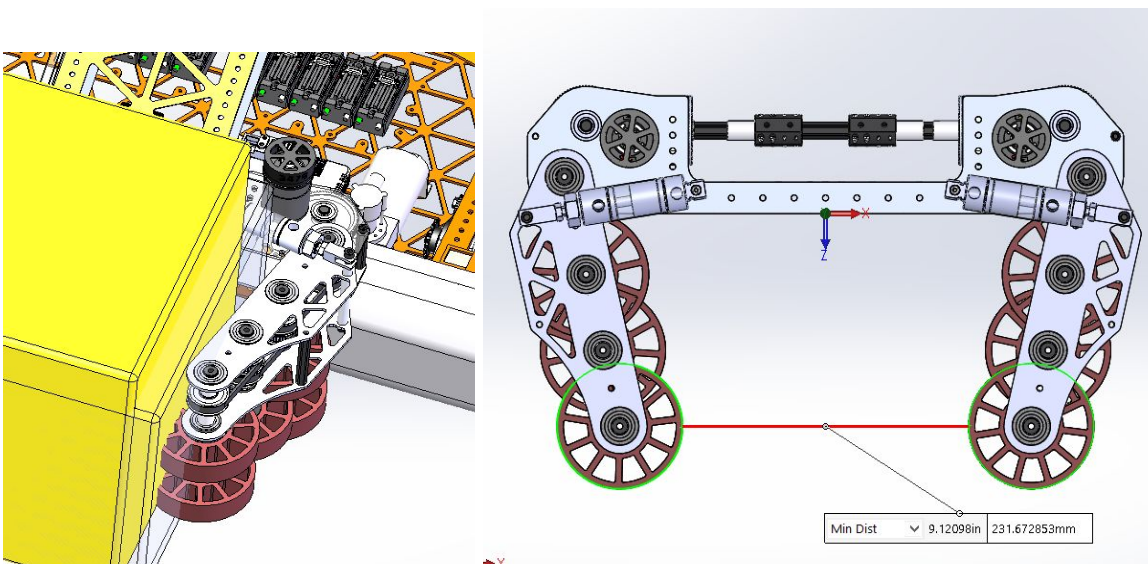




Early CAD of elevator; Elevator cad showing elevator and climber gearboxes

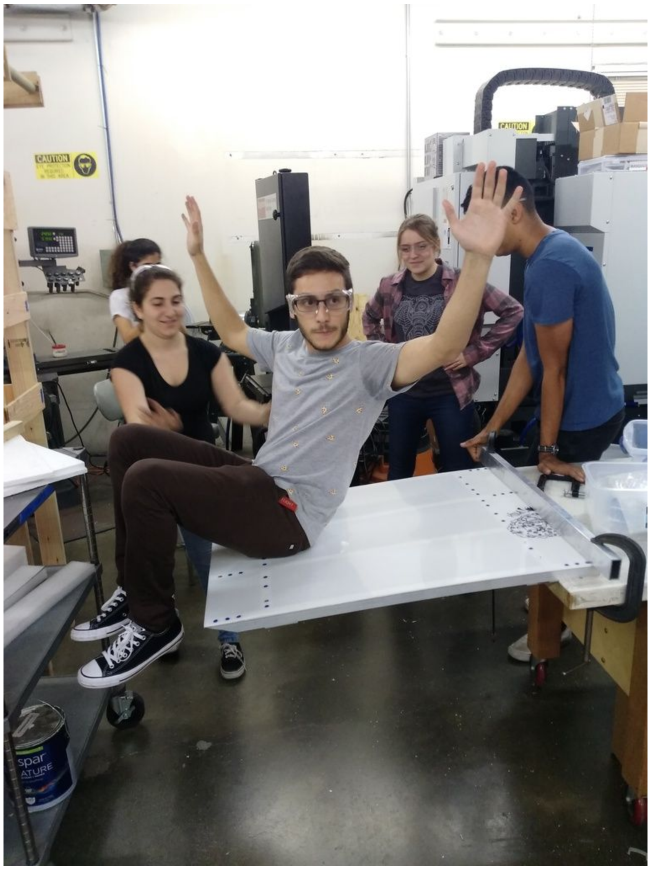
Intake

Prototypes of each intake design

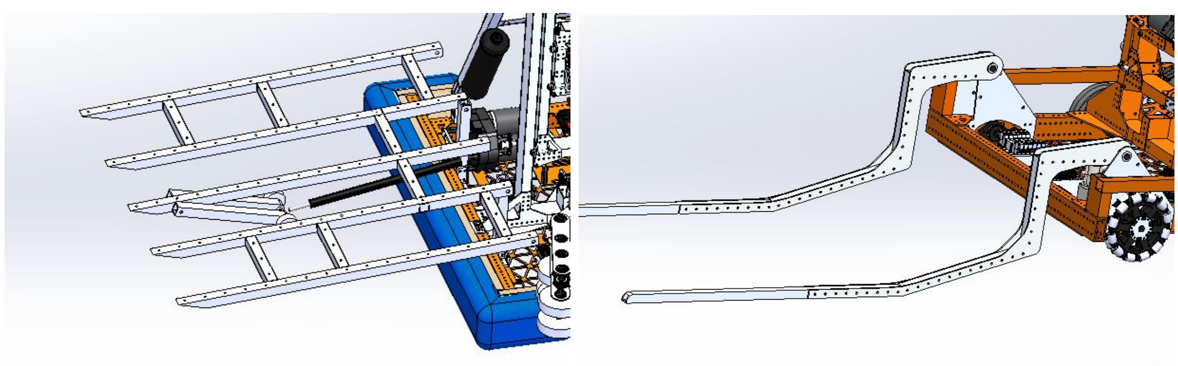


Early CAD of intake

Climber



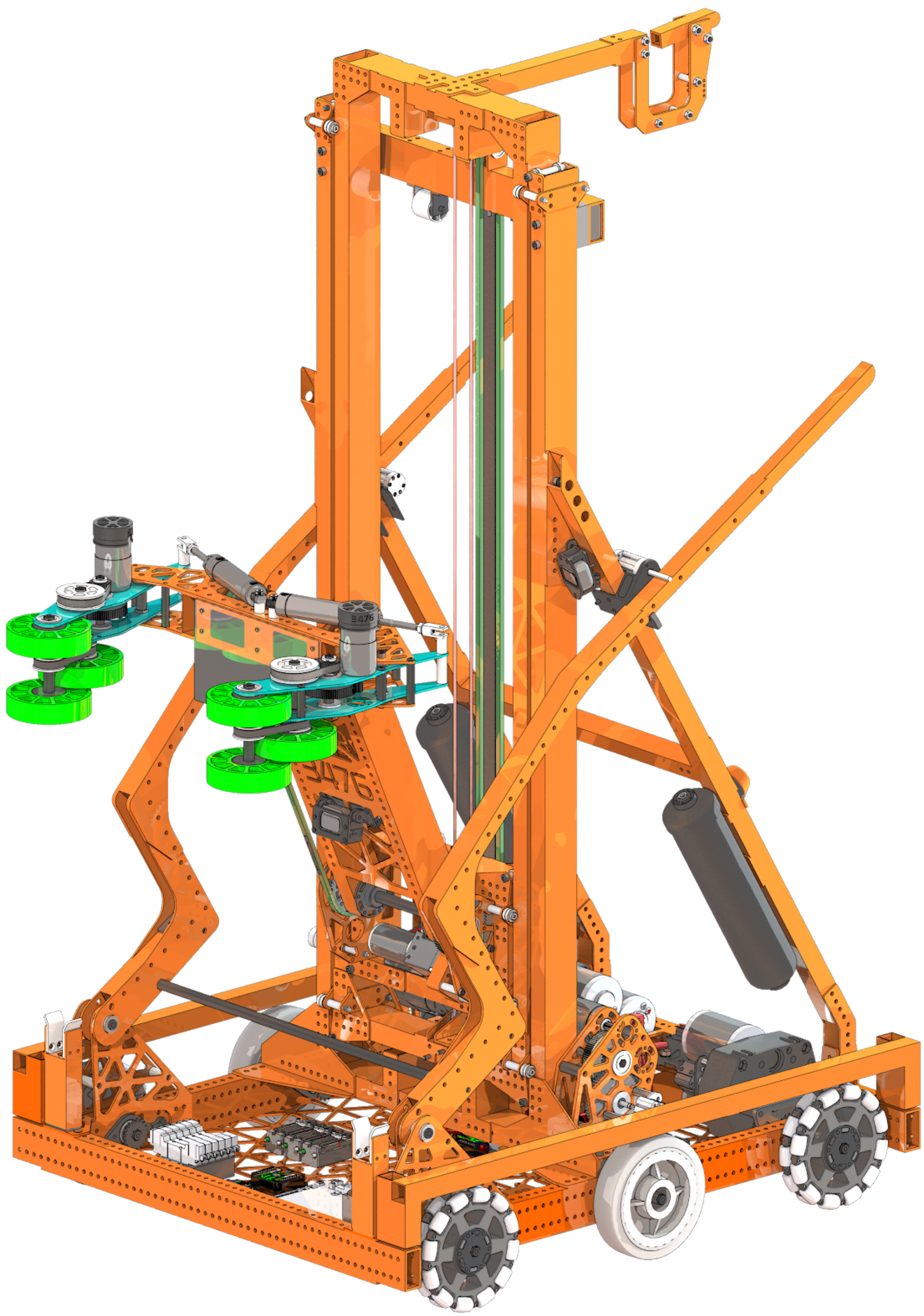
Prototype of ramps



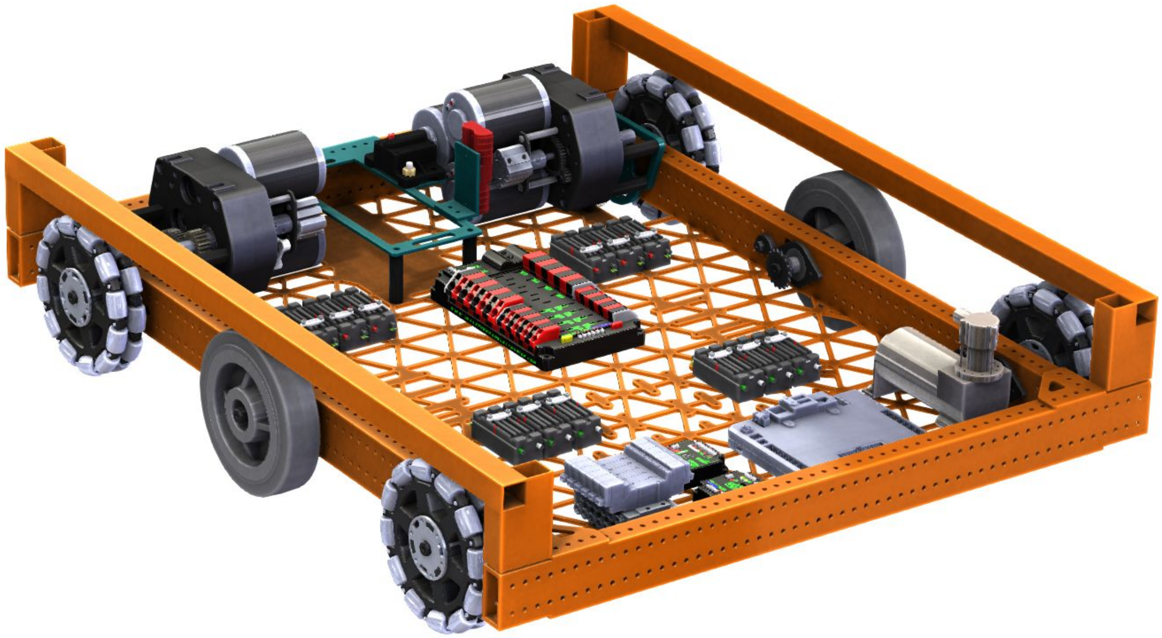
Early CAD of ramps and forks

Final Design

Dimensions: 27.5 x 32.5 x 55 in, 120 lbs



Drivebase



- West Coast Drive
  - 27.5x32.5”
  - 1x2” 0.125” wall thickness box tubing frame
  - 11.5” between wheels
  - 6x1” Colson center wheels and 6” VexPro omni outer wheels - 1.875” ground clearance
- Gearboxes
  - VexPro 3 CIM Ball Shifters, 6 Mini CIMs with custom third stage
    - Low gear: 18.84:1, 8.12 ft/s
    - High gear: 8.74:1, 17.55 ft/s
  - #25 chain with 18t sprockets, tensioned using WCP cam tensioners
  - CTRE mag encoders
  - Rear mounted to maximize space for other subsystems and offset center of gravity
- Bumpers
  - 1x1” 0.0625” wall thickness box tubing bumper rails
  - Bumpers mount with slide latches on bumper rails
- Electronics
  - 0.125” thick waterjetted aluminum bellypan with tapped holes for mounting electronics

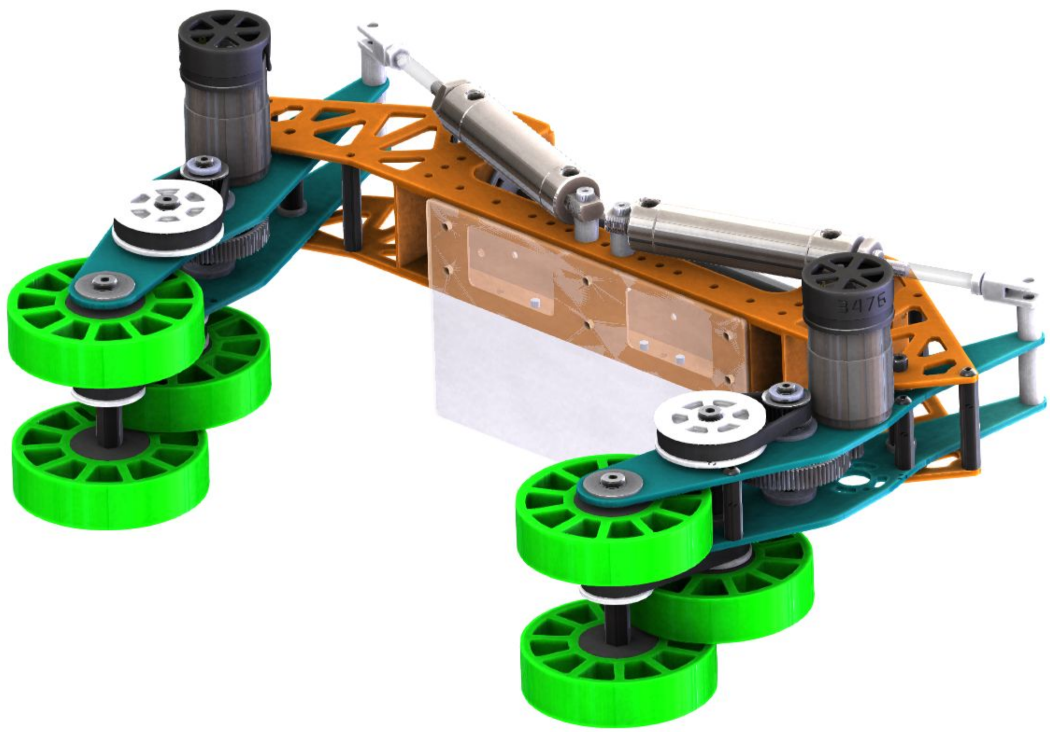
Elevator

- Elevator
  - Two-stage cascading elevator, 70” travel distance
  - Chain driven first stage, rope driven carriage
  - 1x2” 0.0625” wall thickness box tubing frame
  - 1x1” 0.0625” wall thickness box tubing rear supports
  - Two 16 lb constant force springs to counterbalance the carriage, arm, and intake
  - Chain attached to first stage using milled aluminum block with pins that fit into chain
  - Bearings supported with screws through 0.125” thick aluminum bearing plates riveted to the frame
  - Weighs 23.2 lb without arm
- Gearbox
  - Two stage custom gearbox with 22.22:1 reduction
  - 124in/s top speed
  - 2 775pro motors
  - VexPro ball shifter for disengaging elevator motors when climbing
  - CTRE mag encoder on shaft

Arm

- Arm
  - Virtual four bar using chain and fixed sprocket attached to plate to keep the end of the arm parallel to the ground
  - 1x2” 0.0625” wall thickness box tubing frame
  - 0.125” thick pocketed aluminum reinforcement plates on each side
  - Weighs 6.7 lb
- Gearbox
  - VersaPlanetary gearbox with CTRE mag encoder
  - Last stage using 20dp gears
  - 1 VexPro BAG Motor

Intake

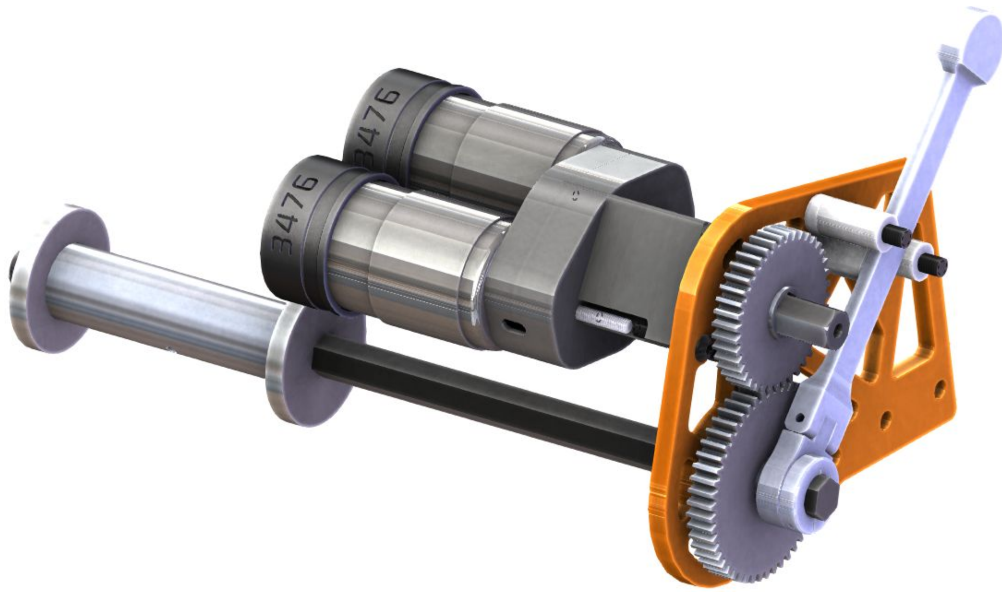


- Intake
    - Claw with two pneumatically actuated arms
    - 2 pneumatic cylinders for clamping cube
    - Pneumatics plumbed for adjustable clamping force (open, 30, or 60 psi)
    - 2 775pro motors
    - 15:1 gear ratio
    - 3 staggered 4” compliant wheels on each side
    - 0.125” thick waterjetted sheet metal frame
    - Weighs 7.8 lb

Climber

- Lifting Forks
    - 2 aluminum forks for carrying a second robot when climbing
    - Forks are spring loaded and released with a pneumatic cylinder
    - 0.75”x0.75” 0.125” wall thickness box tubing fork tines
    - 0.125” thick waterjetted sheet metal frame
    - Weighs 8.0 lb

- Hook
    - 0.125” thick waterjetted aluminum carabiner hook
    - Attached to first stage of elevator
    - Hook is mounted with Dual Lock that detaches when robot starts climbing
    - Attaches to rung from underneath
    - Weighs 0.9 lb



- Winch
  - 2 775pro motors, 49:1 VersaPlanetary gearbox, last stage with 20dp gears
  - Ratcheting wrench to prevent robot from falling when the motor turns off
  - 1” diameter aluminum spool
  - Mounted to base of elevator
  - Weighs 4.0 lb

Software

Requirements

Autonomous

- Place a cube in a switch or scale by the end of the 15 seconds
- Ability to choose autos to minimize collisions with other alliance members
- Go past the auto line
- Should be able to be written with coordinates on the field that are measured

Smart Dashboard

- Choose robot placement and auto options

Cameras

- See cubes in front of the robot and on the scale

Drivetrain

- Operator controls to drive with Ackerman steering
- Compensate for mechanical inefficiencies for consistency in driving and turning
- Limit acceleration to compensate for tipping

Elevator and Arm

- Operator controls to move the elevator to set heights for the scale, switch, exchange, and to intake
- Operator controls to move the arm to set angles for the scale, switch, exchange and to intake
- Ensure the elevator and arm don’t move past hard limits

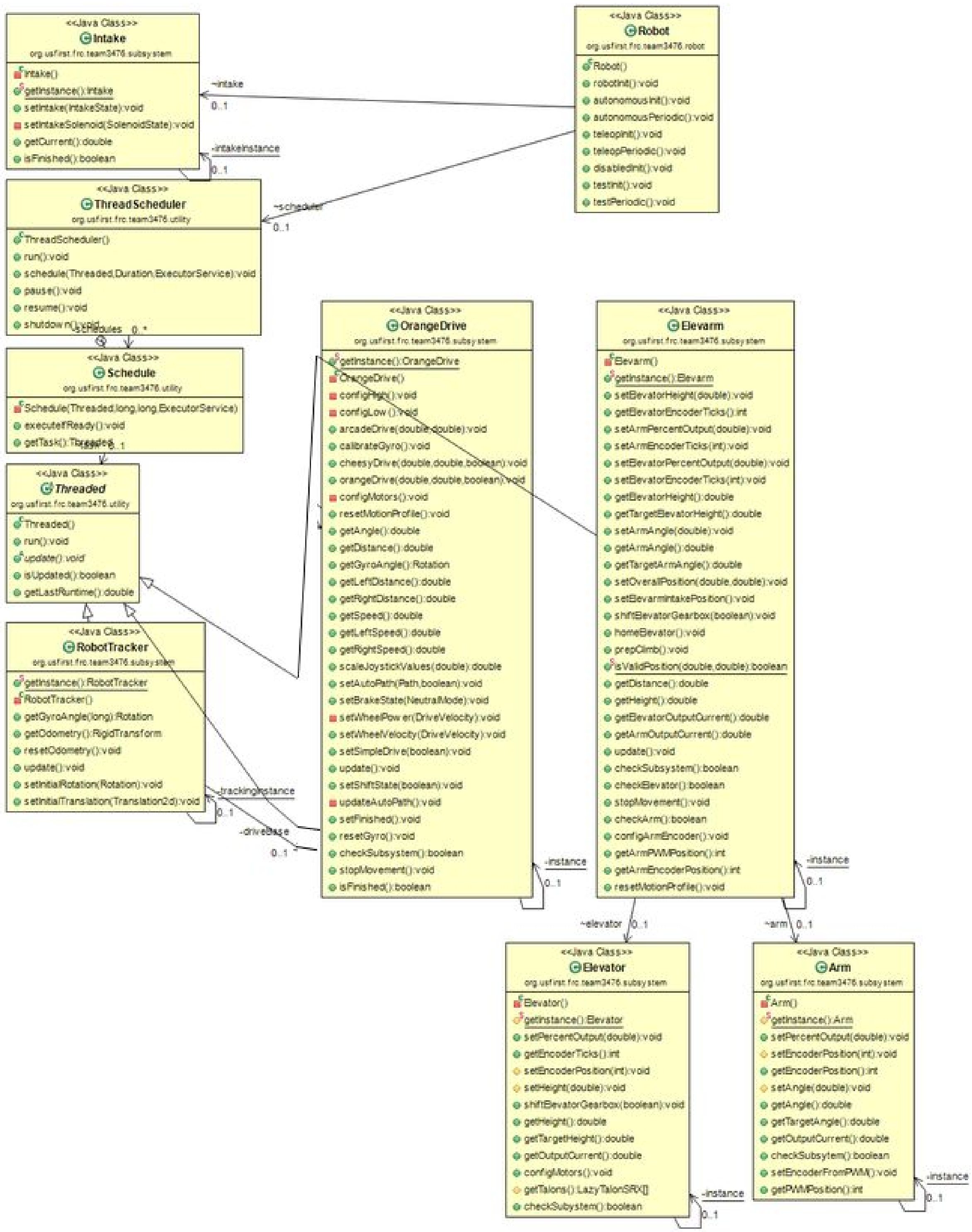
Intake

- Operator controls to run intake motors to intake and eject cubes
- Operator controls to open and close intake
- Move wheels at different speeds to correct cube alignment
- Detect when a cube is fully inside the intake

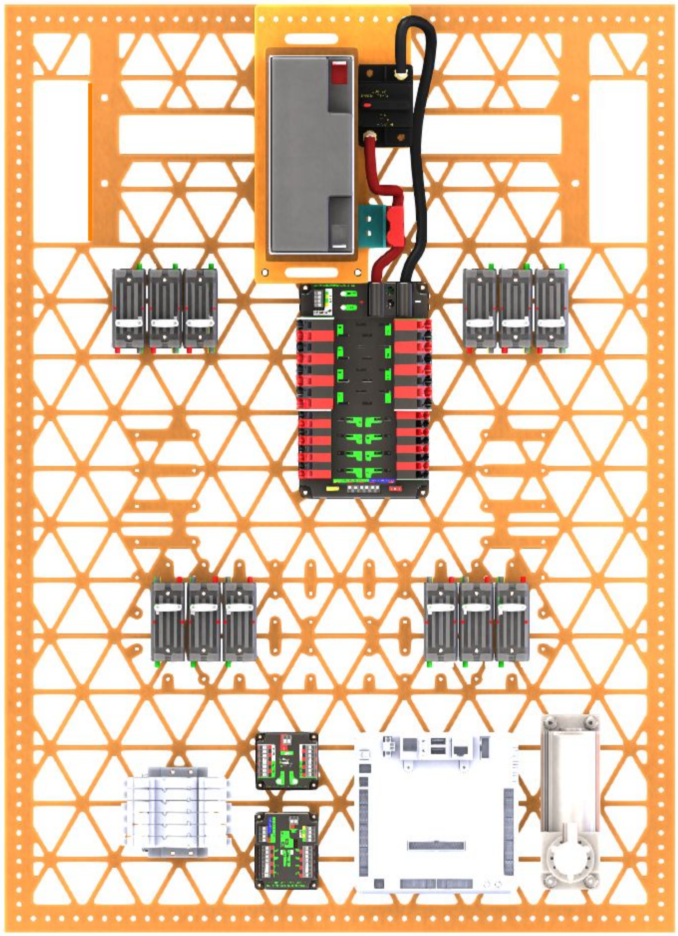
Climber

- Operator controls to latch on to the bar using the elevator
- Operator controls to disengage the elevator
- Operator controls to deploy forks

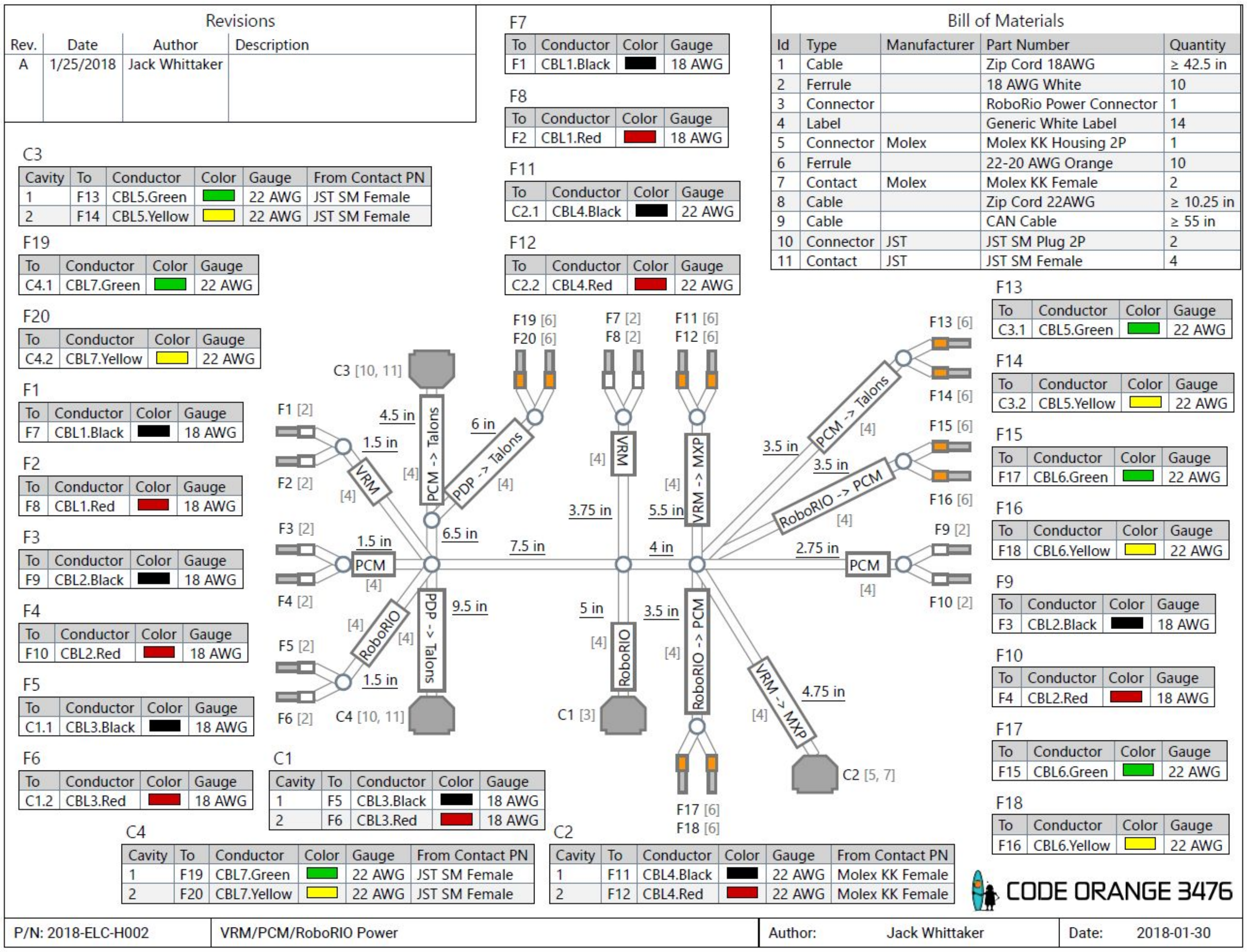
Architecture Diagram



Electronics



Electronic components are laid out in CAD within the drivebase frame and arranged to minimize wire lengths. The bellypan is designed with tapped holes matching the mounting hole locations of the components. Wire run lengths are measured in CAD and used to create the wiring harness diagram for manufacturing.



From	To	Conductor	Conductor PN	Twist With	Gauge	Length	From Contact PN	From Wire Seal PN	Notes
C3.1	F13	CBL5.Green	CAN Cable		22 AWG	≥ 26 in	JST SM Female		
C3.2	F14	CBL5.Yellow	CAN Cable		22 AWG	≥ 26 in	JST SM Female		
C4.1	F19	CBL7.Green	CAN Cable		22 AWG	≥ 22 in	JST SM Female		
C4.2	F20	CBL7.Yellow	CAN Cable		22 AWG	≥ 22 in	JST SM Female		
F1	F7	CBL1.Black	Zip Cord 18AWG		18 AWG	≥ 12.75 in			
F2	F8	CBL1.Red	Zip Cord 18AWG		18 AWG	≥ 12.75 in			
F3	F9	CBL2.Black	Zip Cord 18AWG		18 AWG	≥ 15.75 in			
F4	F10	CBL2.Red	Zip Cord 18AWG		18 AWG	≥ 15.75 in			
F5	C1.1	CBL3.Black	Zip Cord 18AWG		18 AWG	≥ 14 in			
F6	C1.2	CBL3.Red	Zip Cord 18AWG		18 AWG	≥ 14 in			
F11	C2.1	CBL4.Black	Zip Cord 22AWG		22 AWG	≥ 10.25 in			
F12	C2.2	CBL4.Red	Zip Cord 22AWG		22 AWG	≥ 10.25 in			
F15	F17	CBL6.Green	CAN Cable		22 AWG	≥ 7 in			
F16	F18	CBL6.Yellow	CAN Cable		22 AWG	≥ 7 in			

Diagram and wiring table for bellypan wiring harness (connects Power Distribution Panel, Voltage Regulator Module, Pneumatic Control Module, RoboRIO, RoboRIO MXP, and motor controllers) made using RapidHarness software