SPARTAN ROBOTICS

FRC 971

Technical Documentation 2015

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971 on Design

On Spartan Robotics, we believe that engineering is the process of optimizing a solution to perform its task as efficiently as the laws of physics allow. Our goal is to develop the highest quality robot possible and relentlessly chase perfection.

Design Process

1. Identify necessary functions.
2. Determine assemblies and allocate the necessary functions.
    - Prototype subassemblies.
    - Use CAD to determine geometry and prototype to confirm feasible geometry.
3. Use CAD to design the robot and produce drawings for manufacturing.
4. Integrate subsystems with code. Use state feedback control to make the robot run reliably and consistently.

Game Analysis
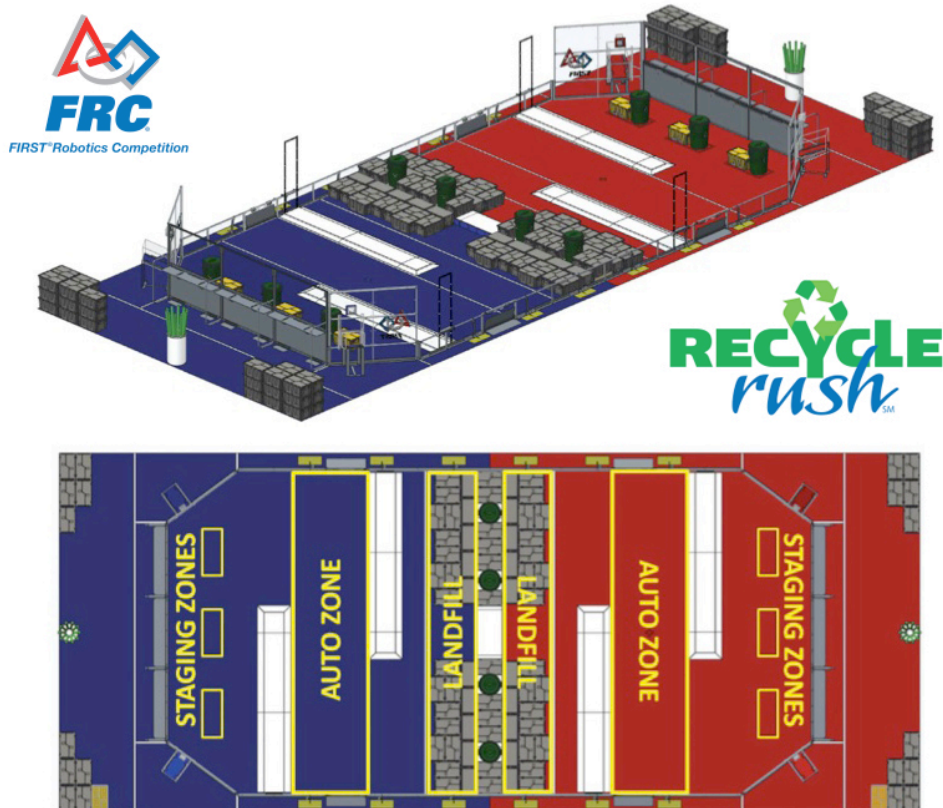
- Six tote stacks with a container is the ideal: our estimates show that is the most efficient with regards to time and space.
- Being able to place stacks close to each other is important for visibility, but the risk of knocking over previous stacks must be minimized.
- Feeding from human player station should be sufficient for many matches
- Ground pick up needed for more competative play, coopertition
- Center containers will be a deciding factor in competitive matches
- It is not efficient to go after litter.

Prototyping

Human Player Station Intake

Actively powered rollers to speed up totes exiting human player station for faster stacking.

Vertical Rollers

Test of prototype vertical rollers.

Pros:

• Lots of contact with tote

Cons:

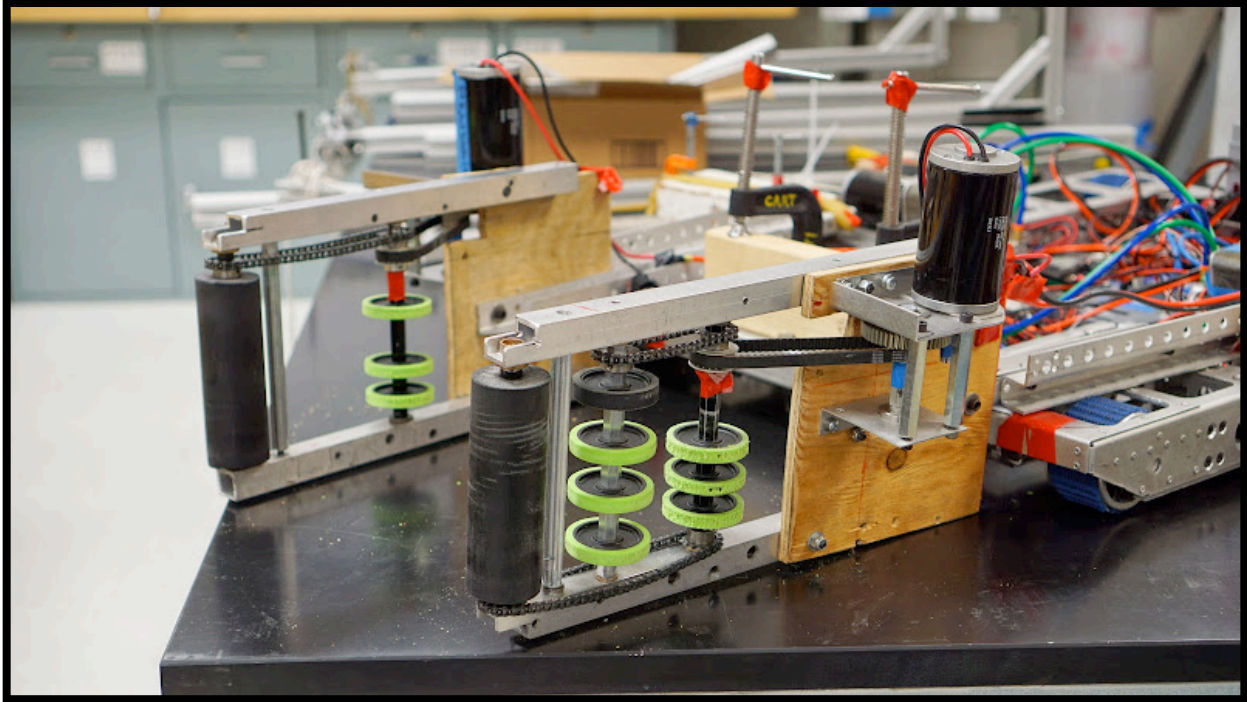• Harder to line up with human player station

Horizontal Rollers

Pros:

• Easier to line up with human player station

Cons:

• Less contact with totes

A way of quickly grabbing totes from the ground.

Early prototype of intake attracted to old drivetrain.

## Pros:
• Can easily grab totes from landfill and center

Cons:
• Cannot grab upside down totes

Tote Handling

We decided to stack on top of the robot and then push the stack out of the robot to score. This allows intaking through one side and placing stacks from the other, so the robot can build and score without turning around. This also eliminated the issue of stack instability when the robot drives up an angle onto the scoring platform, because the robot can place the stack without being on the platform.

Double elevator
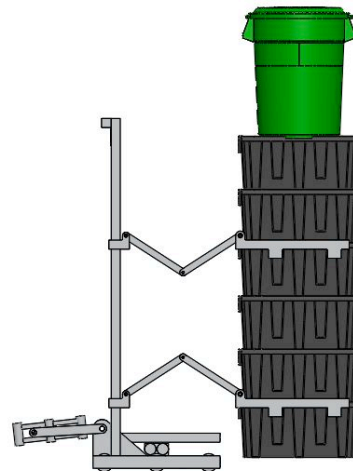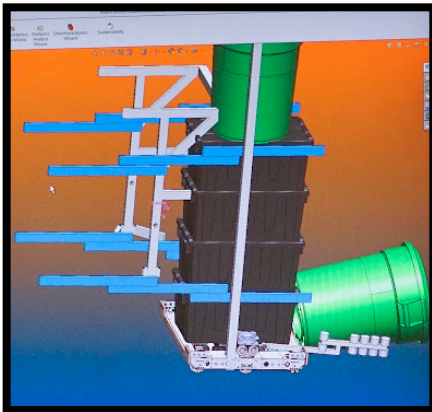
One elevator move up to stack totes and one moves out to place the stack.
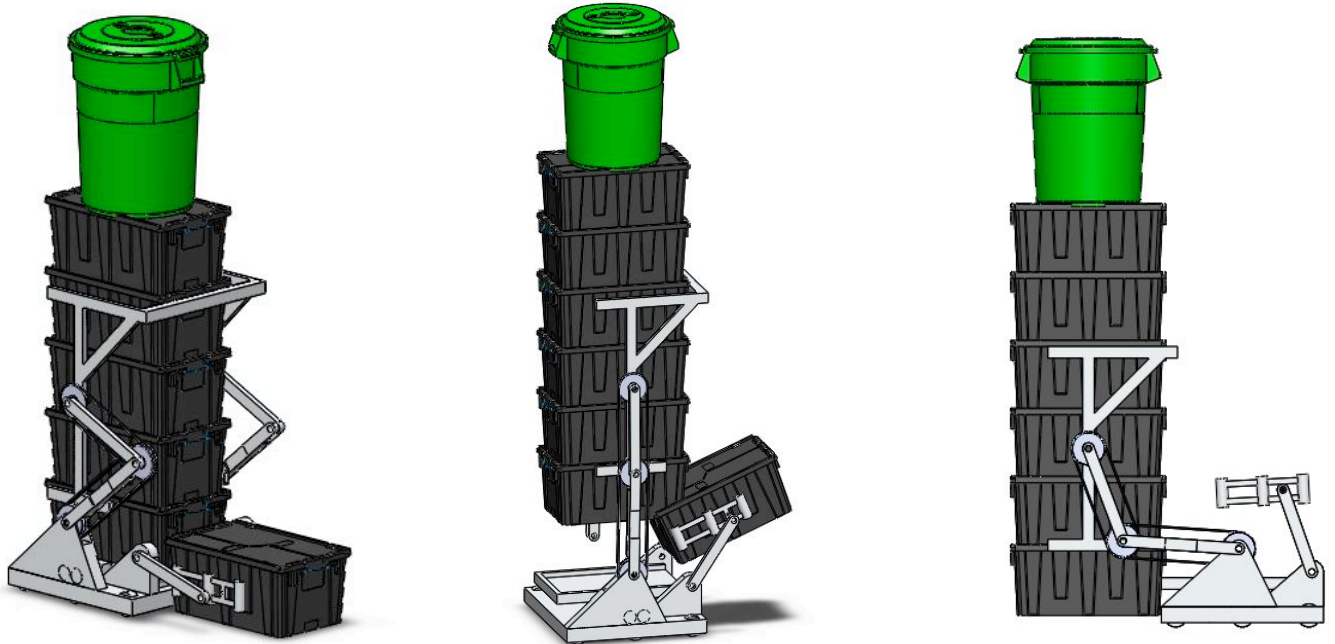
CAD mockups of two versions of the elevator.

Cons:
- Difficult for horizontal elevator to move back and forth.
- Hard to grab and manage containers.

Double jointed arm

A double jointed arm both builds and places the stack.

Double jointed arm preparing to intake, intaking, and scoring.

Pros:

- One subsystem for both movements
- Provides an interesting coding opportunity
- Incredibly flexible, capable of countless configurations
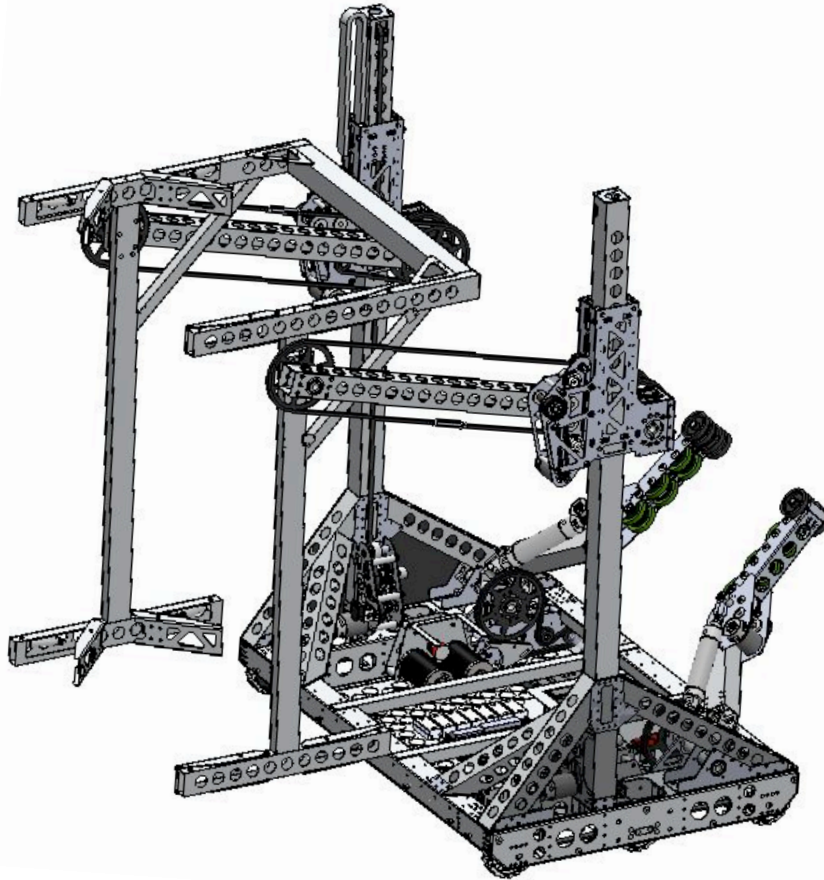- Can possibly work as a can grabber.

Cons:

- Very heavy
- Not strong enough (determined by FEA)

Single Arm/Elevator

An elevator lifts totes to build a stack while an arm places the stack.

CAD of single/arm elevator model.
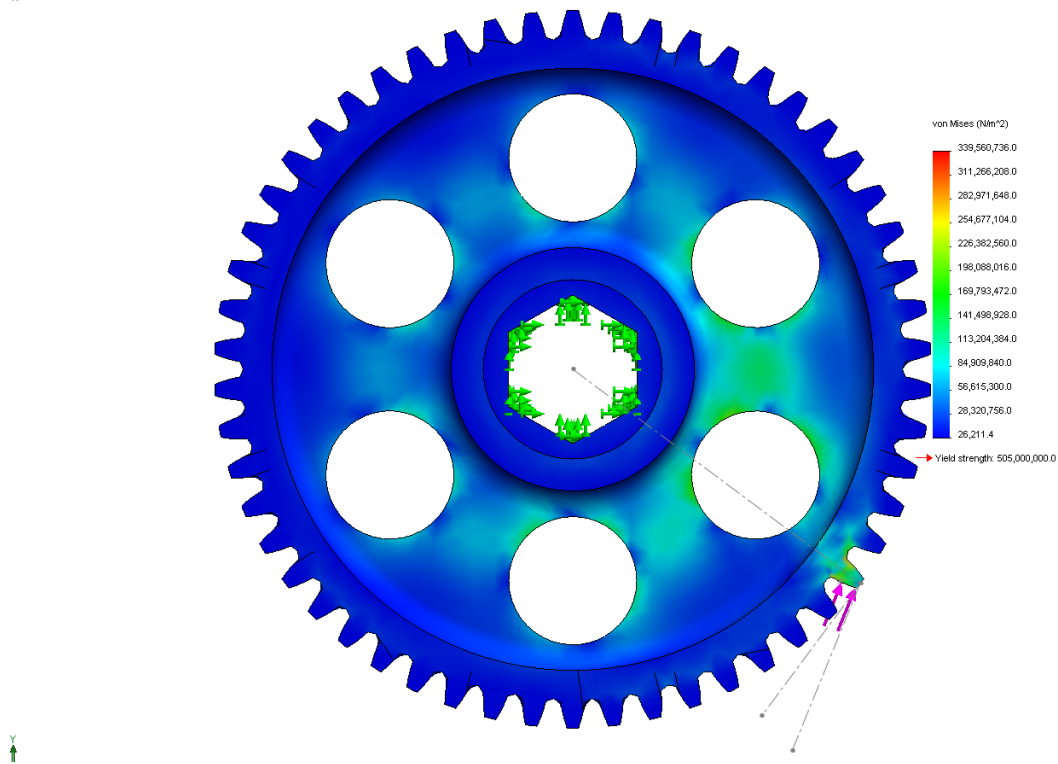
Pros:

• Flexible

• Buildable

Cons:

• Not as versatile as double jointed arm

Finite Element Analysis

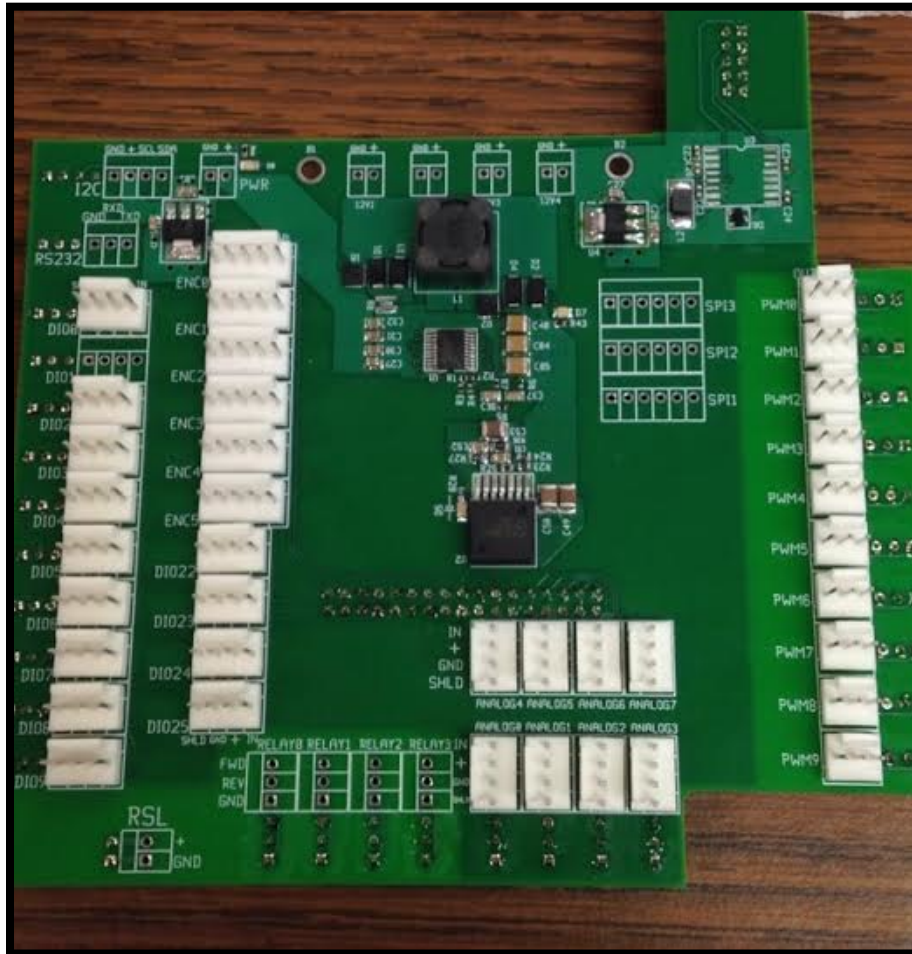We used finite element analysis (FEA) to reduce weight.

FEA told us what sort of loads we could expect to put on specific areas of a part or assembly. We were able to determine redundant areas in terms of strength and remove material.

Model name: 971-14-P-0280_Shooter Lightened 54 Tooth Gear
Study name: Study 1
Plot type: Static nodal stress Stress1

von Mises (N/m^2)

339,560,736.0
311,266,208.0
282,971,648.0
254,677,104.0
226,382,560.0
198,088,016.0
169,793,472.0
141,498,928.0
113,204,384.0
84,909,840.0
56,615,300.0
28,320,756.0
26,211.4

➤ Yield strength: 505,000,000.0

FEA analysis of a gear

Prototype RoboRIO Add-On Board

Board Prototype

- Noise reducing measures
  - Grounding strip
  - Twisted wires (also helps with organization)
- 6 strand encoder wire shares ground and power for potentiometers and encoders

Can Grabbing

A fast arm to grab cans from center during autonomous

Goals:
• As fast as possible

• Super light, for speed and weight limit
• Hooks grab securely but fall off easily when needed

Prototype

Using high speed video, we analyzed and iterated on a PVC prototype, acknowledging that it was slower because of weight.
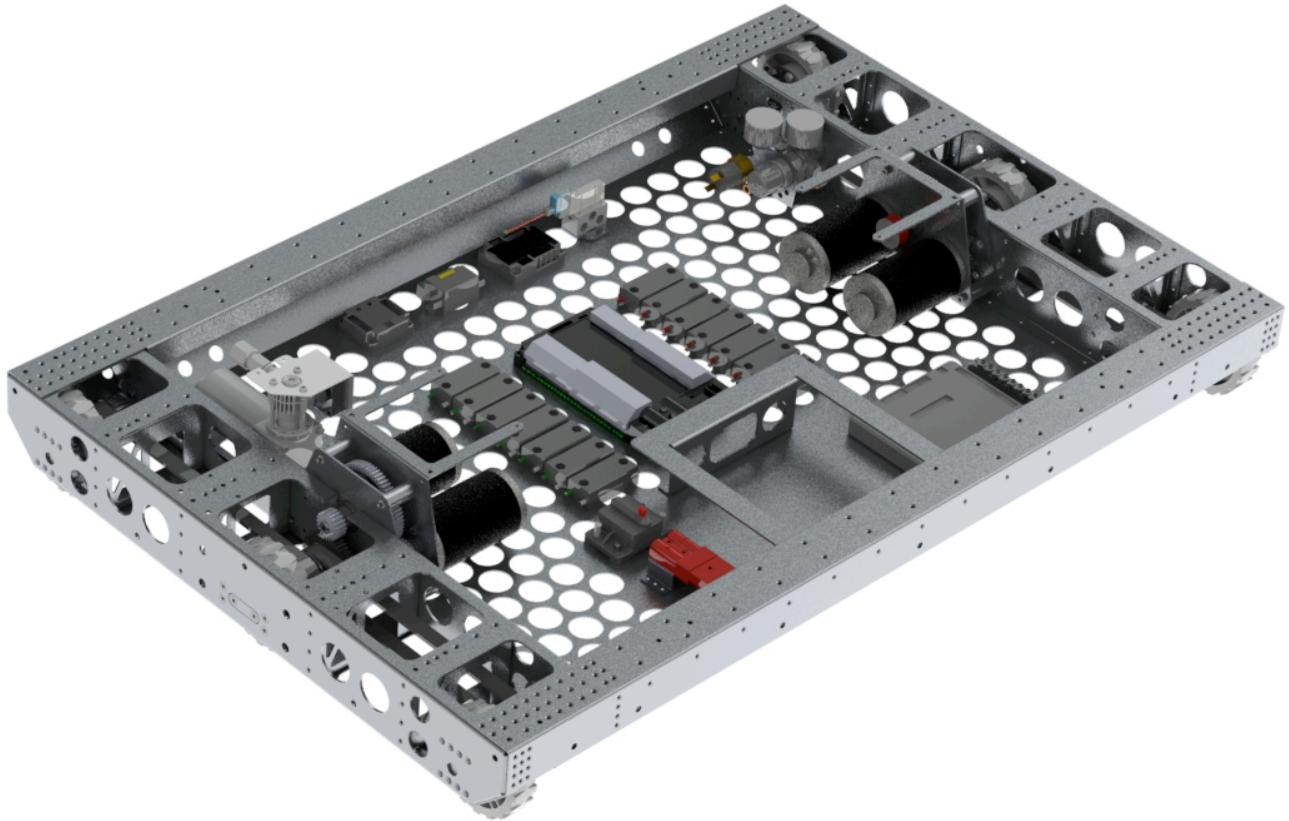
Conclusions:
• Use springs
• Motors too heavy, would take too long to program
• Two pivots, two different angles needed for transport configuration and for grabbing
• Hook geometry allows us to grab securely but release the containers easily

The Final Design
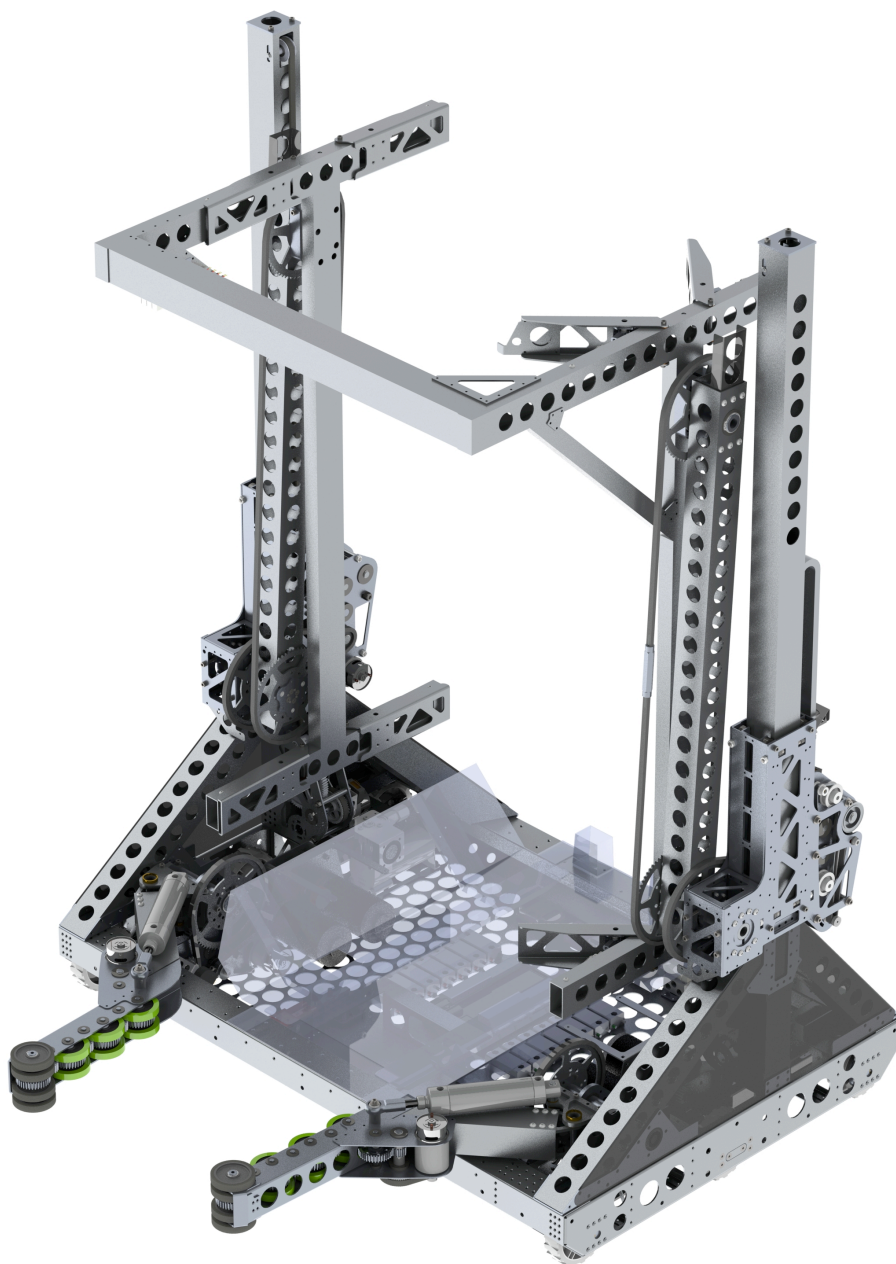
Drivetrain

- 41 ⅝ x 26 ⅞
- 971 sheet metal drive train
- 12 f/s, single speed

- Horizontal roller
- Open and close to clamp down on totes and containers
- 30lb pushing in on each side from a piston that acts like a spring
- Intakes:
    - Totes on the ground
    - Totes from the human player station
    - Rightside up containers
    - Knocked over containers
- Low profile to let totes slide through
- Connected by shaft running through the drive base frame
- Ran motion profiling to ensure totes don't slide out of claw

Elevator and Arm

- Places stacks, including for coopertition
- 4 bar linkage insures stack always stays level
- Two sides are linked through software, not mechanically connected
- Merged carriage and arm gearbox
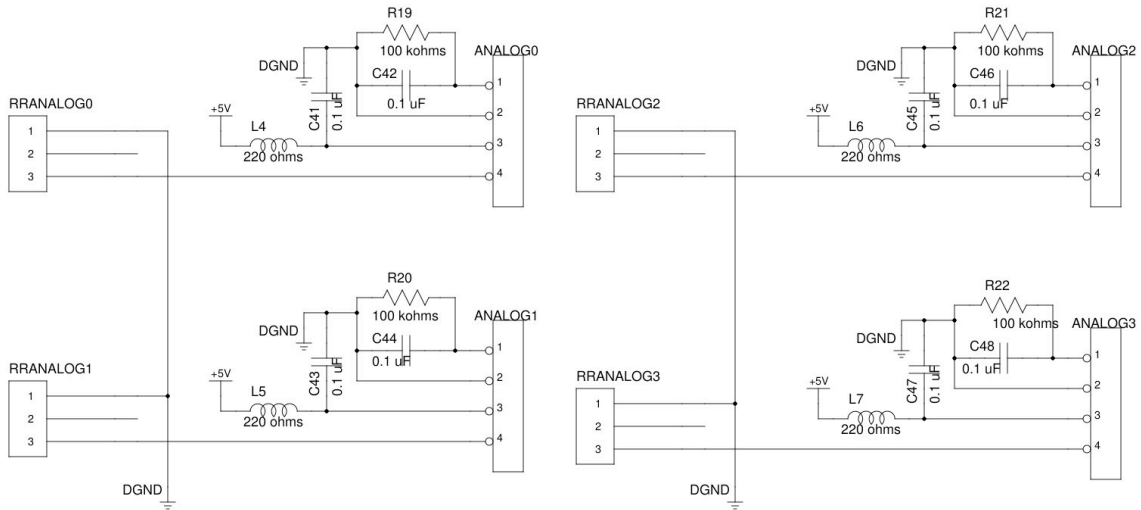- Potentiometer and encoder on each gearbox

- Holds stack at multiple points for stability while driving
- Maximum capacity: 5 cans + a container (6th can held in intake)
- Manifold on fridge shortens tubes to save air
- Several positions, including one to pick up containers

Custom RoboRIO add-on board

- Noise reducing measures
- Grounding strip
- Twisted wires (also helps with organization)
- 6 strand encoder wire shares ground and power for potentiometers and encoders
- Shared with several other teams

Can Grabber

- Carbon fiber for low inertia and super fast swing
- Spring powered
- Two pivots, one for transport configuration and one for grabbing
- Hook geometry allows us to grab securely but release the containers easily

Carbon Fiber

We used carbon fiber to make lightweight and durable can grabbers and a tote tray.

- 6k twill carbon fiber cloth pieces
- Fused with epoxy during layups
- Laser cut molds
- Molds assembled with wood glue and epoxy
- Balsa wood and foam used for creating ribs
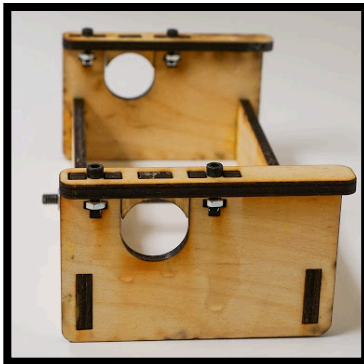
A mold, students fabricating, and a carbon fiber part.