CLEMENTINE

season ‘19-’20 robot

Clementine is team VIRUS’ 2019-2020 robot, designed, built, and programmed collaboratively among 4 engineers and 4 programmers. With Clementine, Our team won 2nd Place at Maryland States and **qualified for the 2020 World Championships**.

The design is notable for highly customized parts, **abundant and effective use of 3D printing**, space efficiency, and ease of maintenance.

Code and control consideration and integration is another key aspect of our design, featuring idler odometry wheels snuck in the space between the drive wheels for maximum position feedback precision.

CAD modeling was used not only for designing parts to be 3D printed and CNC milled, but for virtually the entire robot to ensure integration and compatibility of components along with maximum use of available space.

Virtually designing the entire robot allowed us to divide design work efficiently among engineers, ensure balanced weight distribution, **plan space for mechanisms in advance**, and select convenient and safe locations for electronic components.

VIRUS 9866

Robot Design Notebook
Selected Pages

Drivetrain Design

9/07/19
11:30- 2:00

Authors: Andrew, Matthew

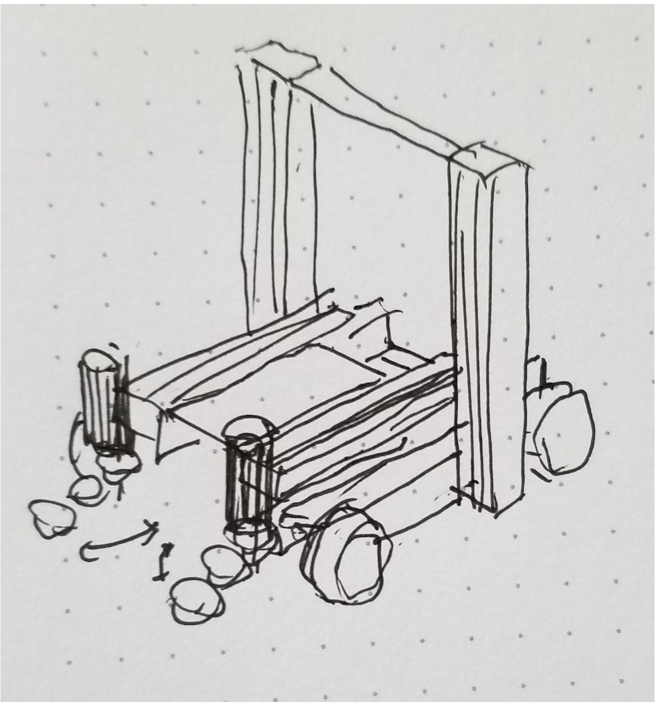
Holonomic Drive: PROS/CONS CHART

	Holonomic (Mecanum, X-drive, etc)	Non-Holonomic (6wd, 4wd, etc)
+	- More agile, helpful for placing stones - More freedom in autonomous paths	- Grippier than many holonomic designs - Useful for defensive play, such as pushing past other robots to get to the bridge - Grippier wheels provide for better encoder-tracking
-	- Usually less grippy, easier to play defense on - Potentially more complicated	- Not as agile as holonomic designs

Based on the game requirements this year, we decided a **holonomic** drivetrain would provide the agility and maneuverability for picking up the highly directional dependent scoring objects.

One potential downside is that a non-holonomic **opponent** would be difficult to deal with if they played defensively due to their **superior traction**. However, our experience has always been that defense is uncommon in the league, and a focus on individual **scoring potential** is more important.

In choosing our holonomic drivetrain design, we decided to use **Mecanum wheels**, as they are relatively simple to implement, allow full speed forwards,left,right, and backwards movement, and have been dominant and tested in FTC for multiple years



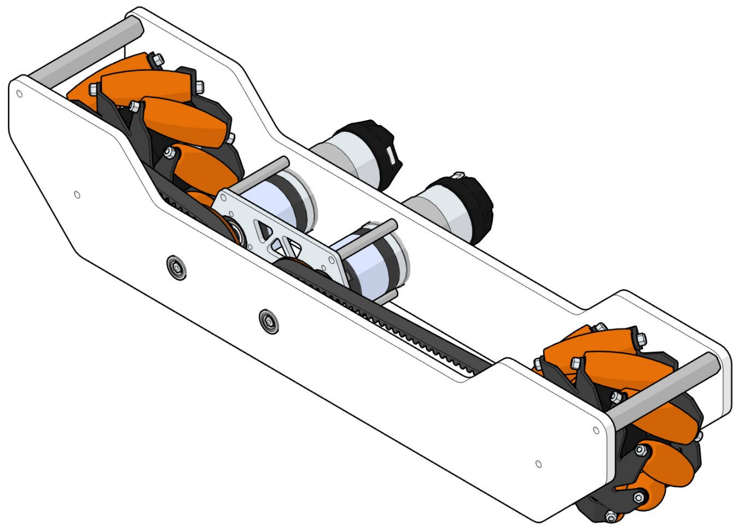
Concept for our Selected Design

Drivetrain Pod CAD

Authors: Matthew

DETAILED EXPLANATION:

We had decided on an overall robot design to start out with and aimed to build our drivetrain around this overall design.



Design Requirements:

- **Open space** in the front/middle for intake and stone manipulator mechanisms
- **Mecanum wheels** for agility in intaking and scoring
- **Low drive gearing ratio** for high speed

The design that we had created satisfies all of these requirements

- Motors are **sunk in**to the drivetrain pod and **placed far back** to **increase central space**
- **Mecanum wheels** are present on the drivetrain
- Drivetrain uses 19.2:1 motors belted 1:1 for a speedy **19.2:1 overall ratio**

Many other considerations were made while the drivetrain was being designed

- Drivetrain uses a **highly-custom design** with a **"parallel plate" chassis**
    - **Ease of maintenance** since removal of one sideplate gives full access
    - Custom design allows for **strength and compactness** that is hard to achieve with kits
    - **Dead axle wheel configuration** was used because of the **extra strength** it provides over traditional 6mm D axle and for **easy mounting** using its tapped holes

Rear-Slides Redesign

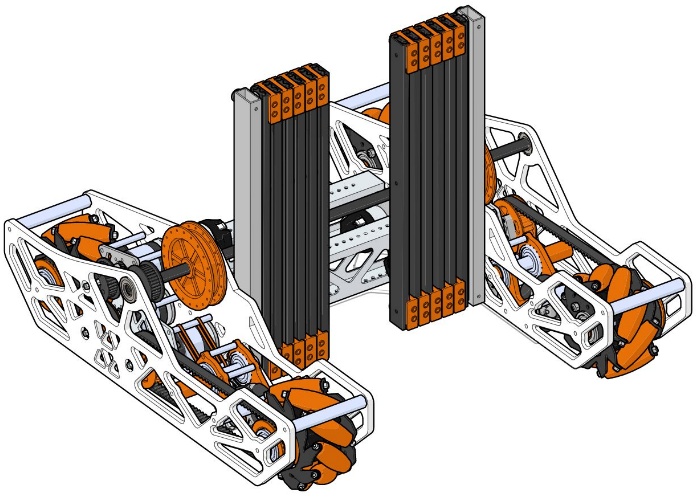
Authors: Matthew, Andrew

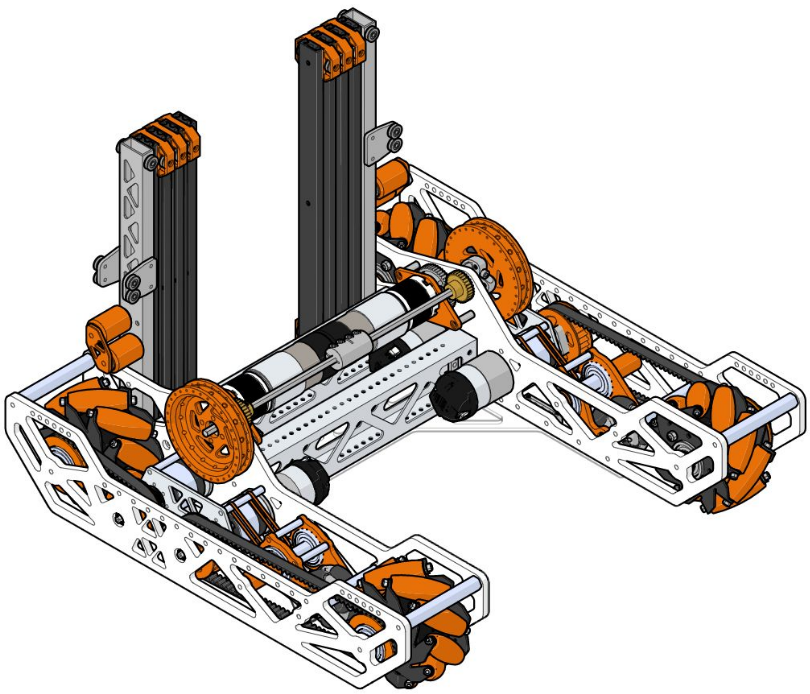
DETAILED EXPLANATION:

Initially, we had planned for a centered set of slides that would have a chain bar attached to it in order to place the blocks. We quickly ran into some issues.

Issues with Centered Lift

- Pivot needs to be mounted in the rear and far from the slides in order reach far enough
- **Arm** needs to be **longer** if near slides
- Issues with block **clearance** over slides
- Consumes space near **intake** for blocks
- Stringing harder to access





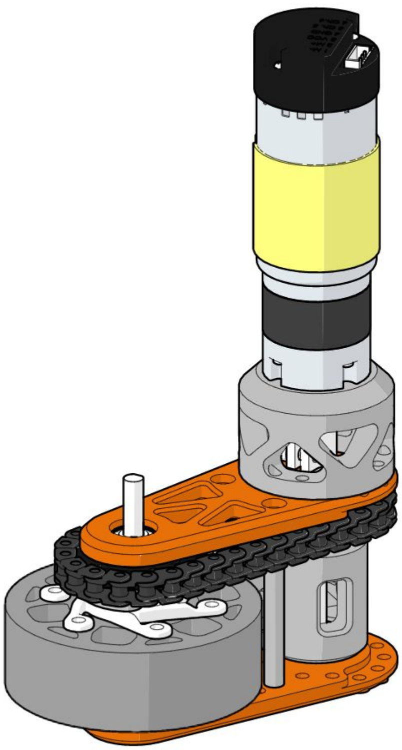
Rear-Lift Redesign

- Slides in the back free up space in the front for intake/block
- Arm pivot naturally is located near the slides
    - Farther reach with a shorter arm
- Blocks can clear over the slides better because of better pivot location
- Less slide stages, eliminates unnecessary extension and allows block to pass through space between slides

Wheeled Intake

Authors: Matthew, Andrew

DETAILED EXPLANATION:



Coaxial Wheeled Intake

Powered by 13.7:1 motor

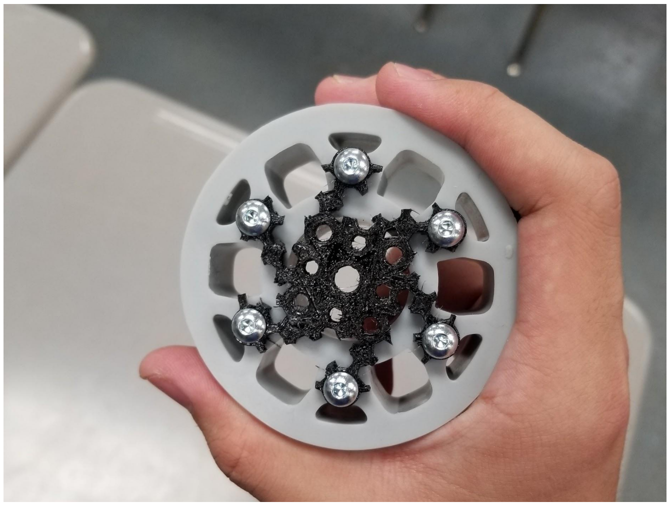
- Aggressive ratio intakes quickly
- Mounted near pivot point, reduces rotational inertia

Coaxial Design

- Intake pivots in order to deploy out of the robot
- Pivot and motor/sprocket are coaxial, saves space

Compliant Wheels

- Flexible 3" wheels are grippy and bend around the stones
- Custom **TPU hubs** designed for maximum wheel squishiness



Early Hub Prototype

Custom Hubs

- Metal hubs in the center of wheels proved **not compliant enough** in prototyping
- Designed and 3D-printed **soft TPU** hubs with **custom geometry** to aid in flex
- Third iteration proved very flexible

Grabber

Authors: Andrew

DETAILED EXPLANATION:

Stone Gripper/Placer

High Grip

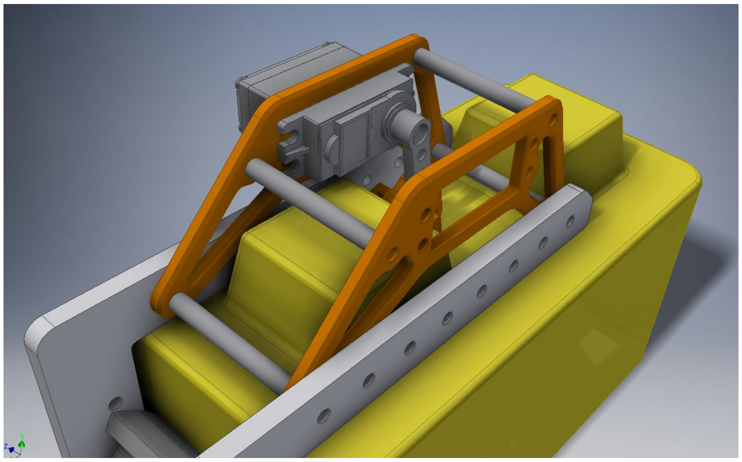
- Uses slices of silicon from spare intake wheels for solid hold
- Small servo arm pushing block against large frame results in few moving parts

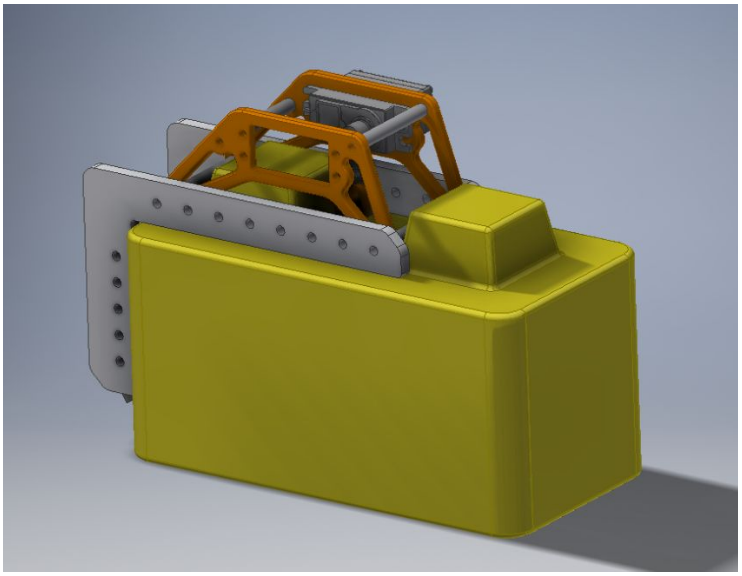
Lightweight

- Plate-and-standoff construction results in easy maintenance and durable structure
- CNC cut delrin plates and 3D printed brackets save weight

Versatile

- Single stud, top-only grip leaves maximum visibility for driver when placing
- Redundant holes allow for future adjustments with no redrilling or major changes to the plates
- Servo arm completely clears stud in open position to allow stones to slide in
- High chainbar mounting point results in low risk of topping when retracting chainbar after placing





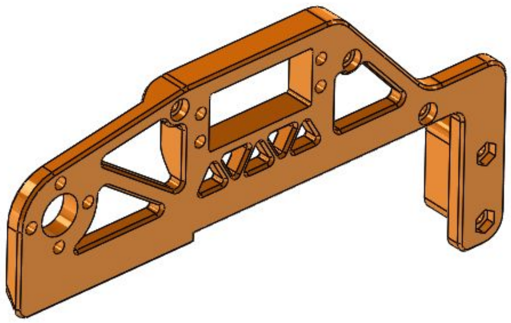
Grabber V2

2/24/20

Authors: Andrew

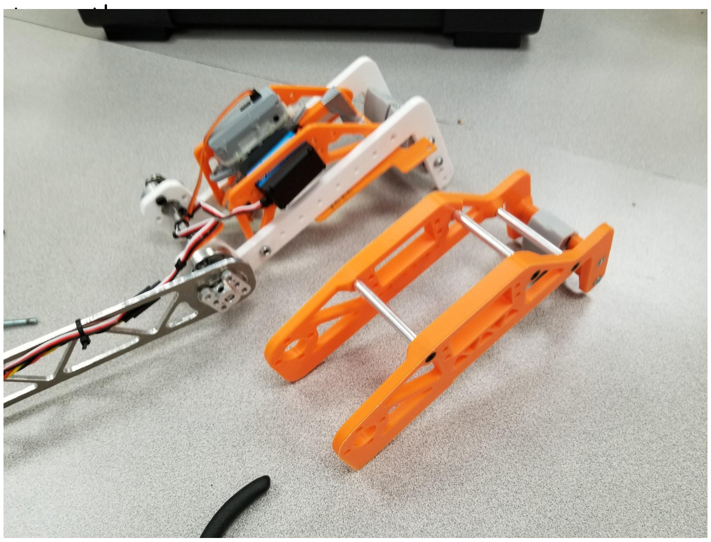
DETAILED EXPLANATION:

The old grabber module functioned well, but had room for refinements and improvements. Taking lessons learned from the first design, we created a second iteration.



Stronger

The new grabber is 3D printed as a single piece, instead of being composed of multiple pieces screwed together.

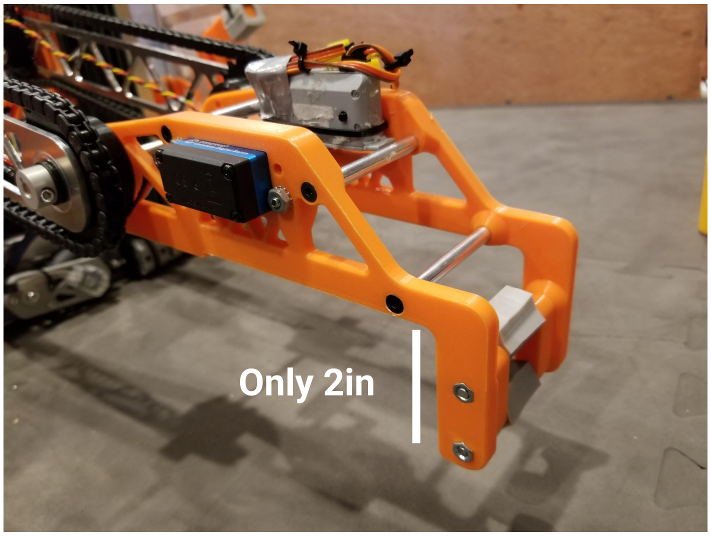


Lighter

Using the upper rails to guide the stone by its studs, we were able to **remove half of the grippy material** that we didn't need while **retaining the compliant shape**. We also 3D printed custom countersunk sprockets to **replace the metal hubs with plastic.**

Better Performance

After prototyping with the previous design, we were able to **cut off 2 inches of the backing height, allowing a 1 block higher stack**. The single piece eliminated screw heads, allowing stones to slide smoothly into the grabber.



Slide Support

1/25/20

Authors: Eric, Matthew, Andrew

DETAILED EXPLANATION:

Severe and detrimental bending for vertical extension

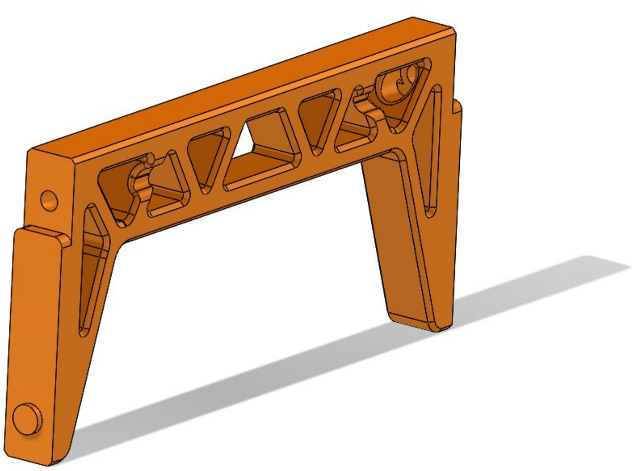
- Prevented scoring high towers because delivering stones at high height was too unstable
- Was physically bending the slides, adding friction and reducing reliability

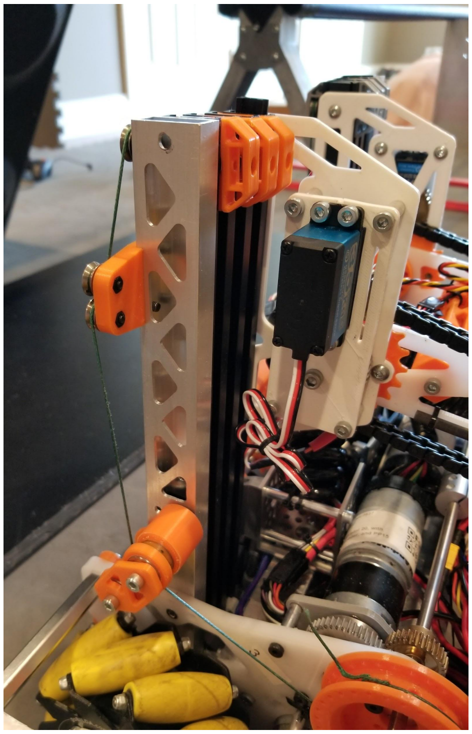
Aluminum replacing 3D printed parts

- Metal being more rigid than PLA plastic
- Rigidity of slides increased overall, enabling us to stack higher than before with more ease

Crossbeam

- Slides are strung in opposite direction, resulting in inevitable tilt
- Thicker, taller crossbeam shape helps reduce tilt



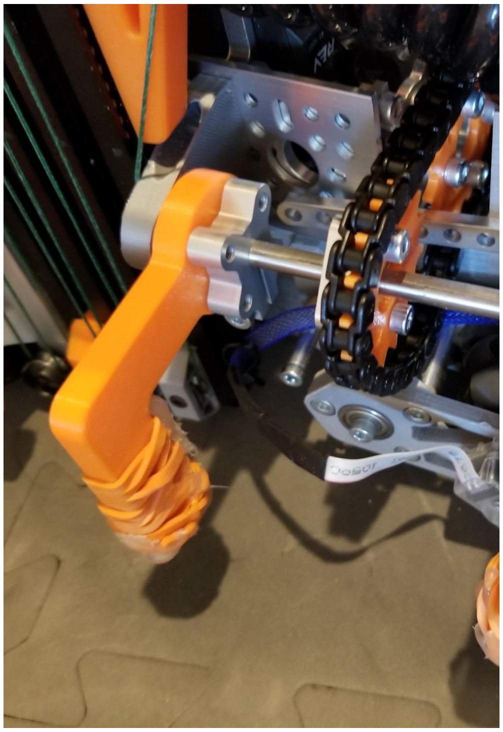


Foundation Dragger V2

2/17/20

Authors: Andrew

THE PROBLEM



We identified a number of problems with the original centered foundation dragger design:

- Grabbers left too much space between robot and foundation
- **Centered position** allowed foundation to rotate and **hit robot's wheels**
- **Tips of grabbers were slippery**, did not grip foundation reliably
- Center space between slides could be used for better slide cross support

NEW DESIGN

We designed a new grabber and mount to address old issues, featuring:

- Slot and mounting to fit **grippy silicone tips recycled from extra intake wheels**
- Side mounting on drivepod for better grabbing stability
- **Extra tolerance** on grabbers to allow successful grabs even at **high-speed in autonomous**
- **Accessible** arm screws, servo horn screws for easy improvements, adjustments, and replacements

Front Crossbar Mount

2/15/20

Authors: Matthew, Andrew

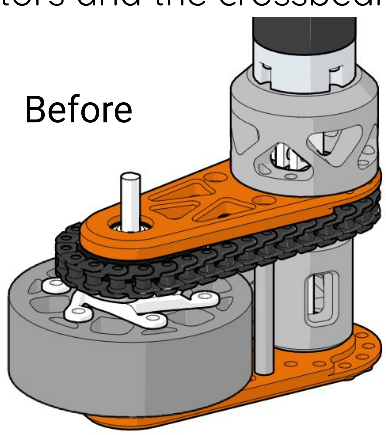
THE PROBLEM

The **drive modules in front of the robot has begun to sag inwards** from the weight of the robot and a lack of support. This problem was hoped to have been solved by a bellypan, but the thin polycarbonate plate simply bent along with the inward sag. Additionally, our intake was swinging around excessively from high rotational inertia.

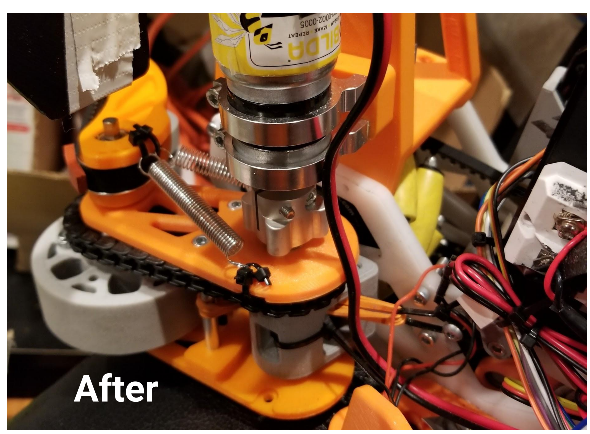
DESIGN EXPLANATION

To solve this problem, we designed a crossbeam to go over the front of the robot. The 3D printed support blocks feature **extremely thick supports** and **redundant mounting points** to both along the sideplates and in the plane of stress of the crossbeam. The part was designed with a **wide stance to prevent long-term sagging**.

We also realized that we could **mount the motors to the crossbar mounting piece** rather than letting them free spin with the intake, making the intake lighter. We designed the crossbeam piece to serve a **dual purpose**, as it securely mounts both the intake motors and the crossbeam to the chassis.



Before



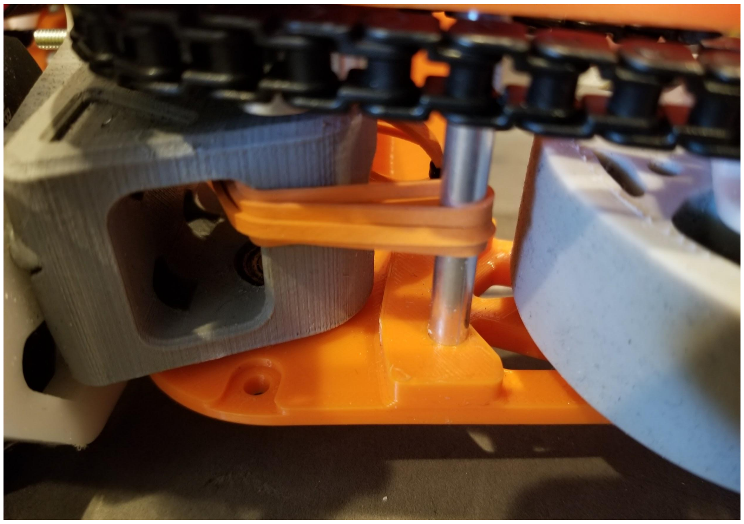
Meeting #40

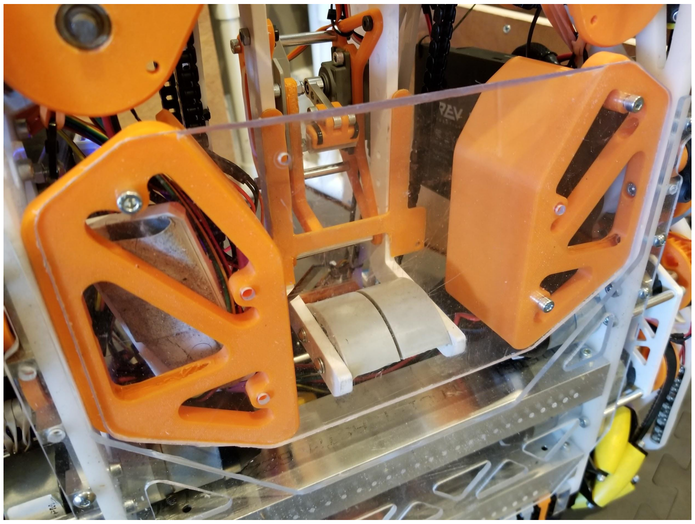
2/14/20
2:10-4:30

Authors: Andrew

PROGRESS:

- Install foundation stoppers
  - Designed parts to form-fit sideplate with a single screw to hold them in place
  - Measured sideplate machining error in outer profile vs. inner perimeters, and appropriately accounted for error in 3D model





FUTURE PLANS:

1. Test intake couplers over time to see how they hold up
2. Print thicker orange layer team numbers for both sides
3. Revise foundation dragger
4. Revise foundation dragger mount