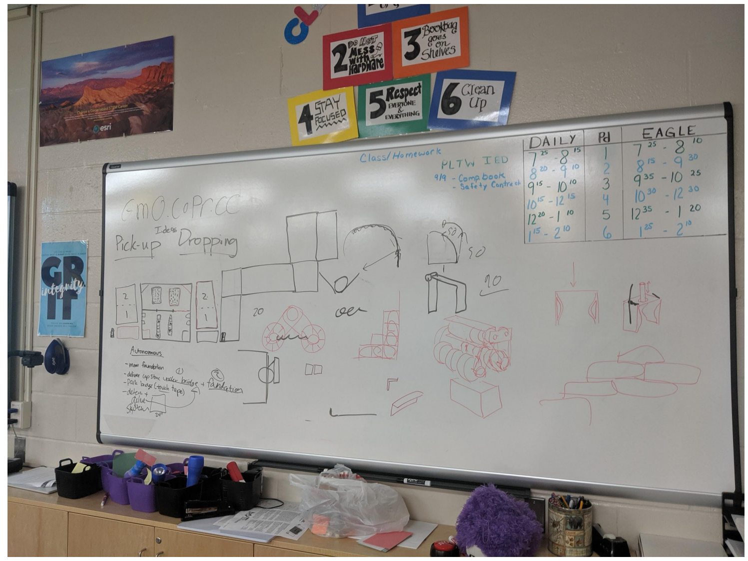
Kickoff

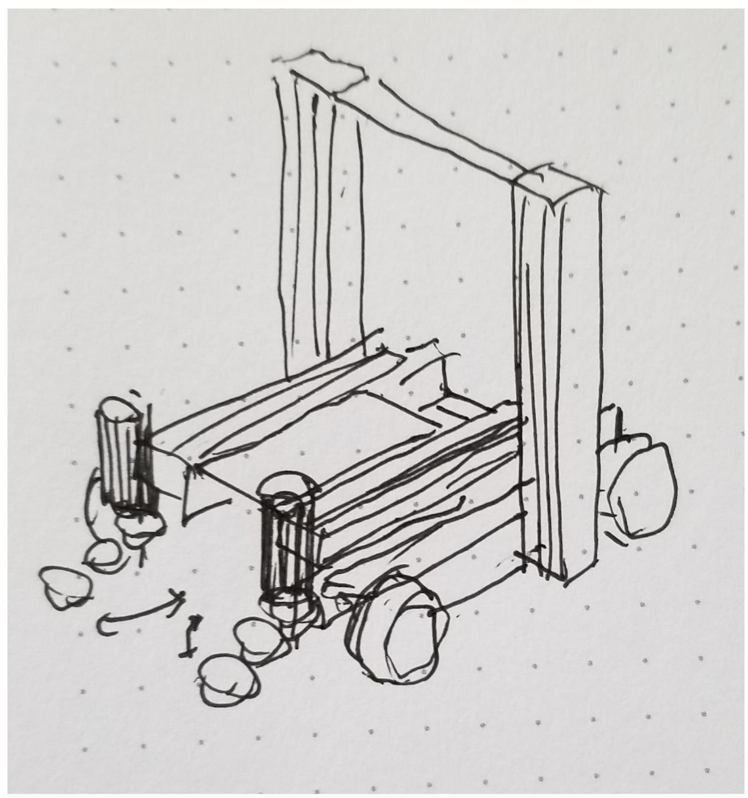
9/07/19
11:30- 2:00

Authors: Matthew

OBJECTIVES:

1. **Host club kickoff**
2. **Watch game video and read game rules**
3. **Brainstorm overall robot design**





PROGRESS:

- Watched game video for the Skystone Challenge, jotting down tasks and point values to help with prioritizing
- Held brainstorming session with the other club teams by handing out whiteboards to sketch and note ideas on, presented all of the ideas and discussed pros/cons of various designs
- Decided on a few ideas that we wanted to explore and began allocating CAD tasks to members

FUTURE PLANS:

1. Set up GrabCAD for members to collaborate on
2. Start CAD for Drivetrain
3. Start CAD for Intake
4. Figure out specifics for mechanisms like slides, stone grabber, foundation grabber after the drivetrain CAD is complete

Drivetrain Design

Authors: Matthew

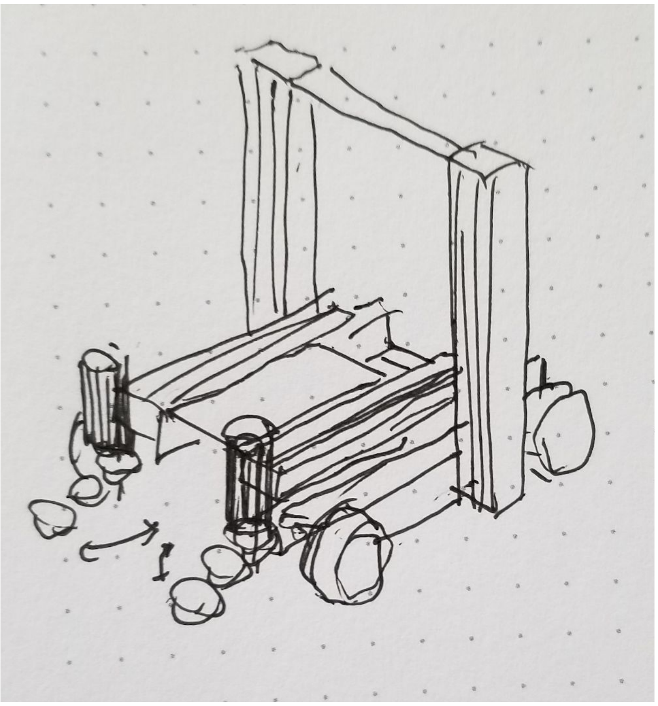
In deciding how to design our drivetrain, the first aspect we considered was whether or not to construct a holonomic (being able to move forwards, left, right, and backwards translationally as well as rotationally, EX: mecanum wheels) drivebase.

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

Ultimately, we decided on a holonomic drivetrain. Although one of the downsides is that a non-holonomic drivetrain like a 6wd design could be a hassle for us if they decided to play defensively, our experience has always been that defense is uncommon, 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

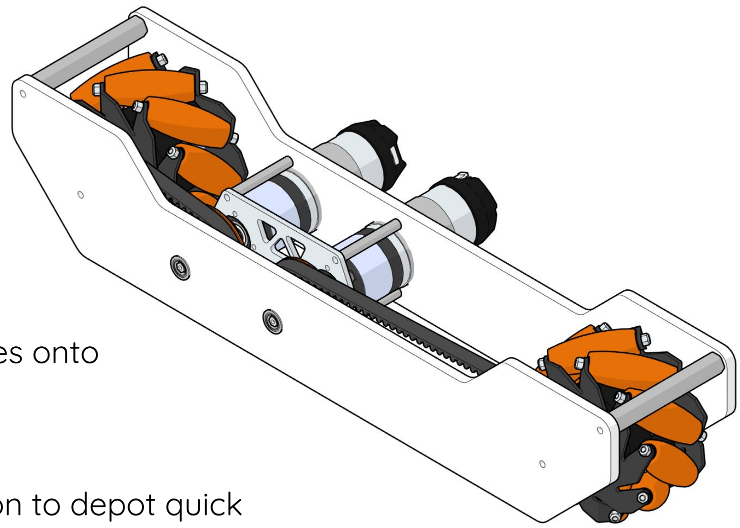
Drivetrain Pod CAD

9/07/19

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.



Drivetrain Requirements:

- **Open space** in the front/middle for intake and stone manipulator mechanisms
- **Mecanum wheels** for easy placement of stones onto the foundation
- **Fast gear ratio** to make going from foundation to depot quick

The design that we had created satisfies all of these requirements

- Motors are sunk into the drivetrain pod and **placed far back** to **increase front/middle 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**
    - Custom design allows for **strength and compactness** that is hard to achieve with kits
    - Parallel plate provides **superior strength** as opposed to cantilevered wheels
    - **Belt was used in favor of chain** because of issues with chain stretch over time, whereas fiberglass reinforced belt stretches much less
    - **12mm hex axle** was used because of the **extra strength** it provides over traditional 6mm D axle and for **easy mounting** using its tapped holes

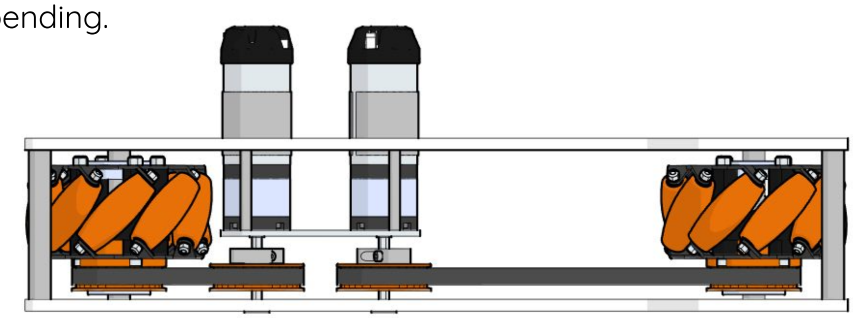
Drivetrain Pod CAD cont.

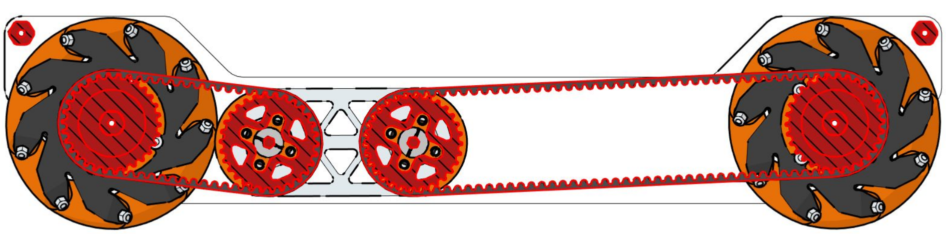
9/07/19

Authors: Matthew

DRIVETRAIN FEATURES:

- **Belt pulley center-center distance** between the wheels and motors was calculated to an exact value for **perfect tension**, eliminating the need for additional tensioners
- The mecanum wheels are driven in a **dead-axle configuration**: the axles do not move, but instead the wheels are driven directly by a pulley and ride on the axle with a bearing
- Using a dead axle provides **more support for the drivetrain**: the dead axle acts as another point of connection between the inner and outer drivetrain plates
- Each wheel has **less backlash** because the wheel is **directly driven** instead of being driven by the axle, eliminating any play that might come from the tolerances in the axle fit
- Motor pulleys use a **clamping hub**, further eliminating backlash
- Motor shafts are supported by a bearing at their end, **increases rigidity of motor mounting** and **strengthens structure**
- Side plate material is **plastic instead of aluminum**, as plastic is **lighter, looks good, and flexes** instead of permanently bending.





Drivetrain CAD

9/08/19

Authors: Matthew

OBJECTIVES:

Continue Drivetrain CAD development

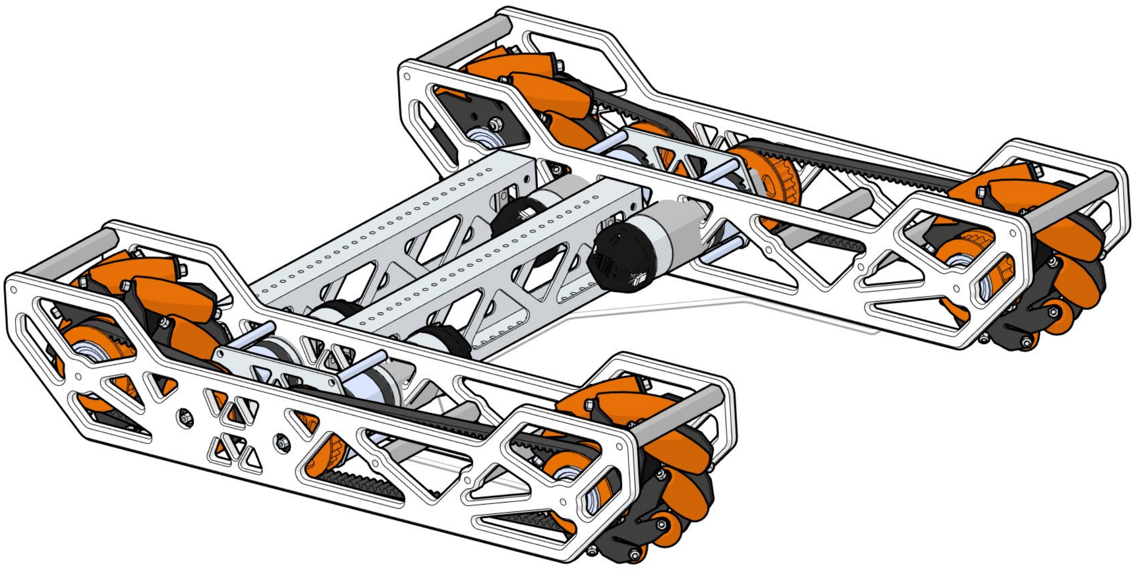
1. **Flesh out drivetrain pod design**
2. **Start connecting other drivetrain pod**

PROGRESS:

- Added pocketing for aesthetics and weight reduction
- Added more support within drivetrain pod
- Added Cross beams between the two drivetrain halves
- Designed a belly pan to add rigidity
- Mirrored drive pod assembly

FUTURE PLANS:

Complete Inner Side plate CAD



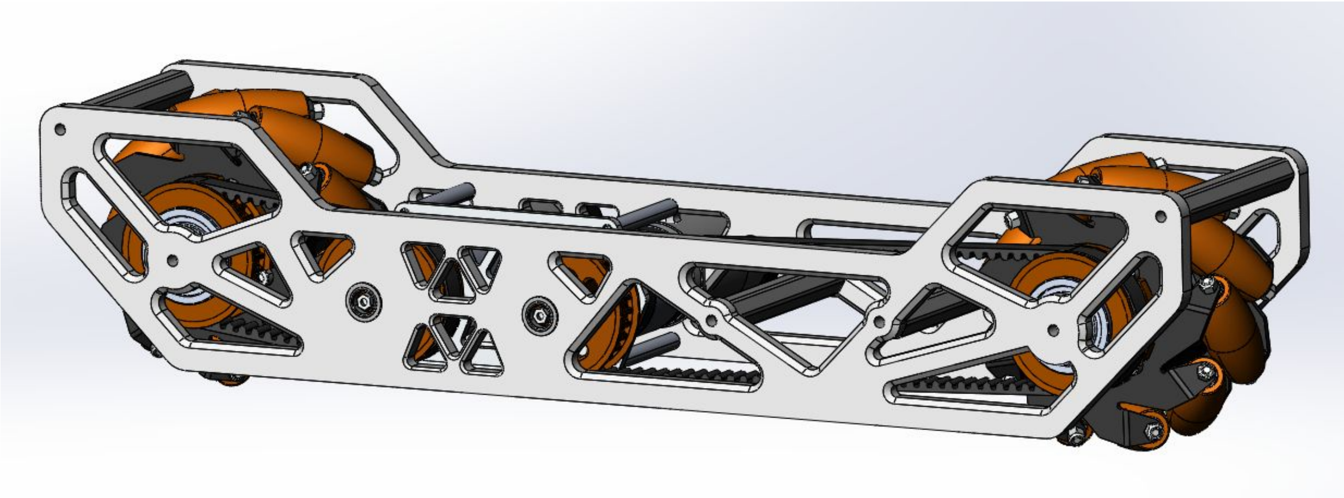
Updated CAD Model at the end of 9/8

Pocketing

Authors: Matthew

DETAILED EXPLANATION:

Taking advantage of our custom design process, we incorporated many pockets into the sides of our plates, that will eventually be machined from our CNC router. A common practice among FRC teams, the primary advantage of pocketing is weight reduction, especially important this year because of the weight limit. Nonetheless, shedding unnecessary weight is usually helpful, as lighter robots are more agile and accelerate faster (and are easier to carry too!) The pocketing pattern was created with both aesthetics as well as strength in mind, as taking chunks of material out of the plates weakens them.



Drivetrain pod with pockets added to the side plates

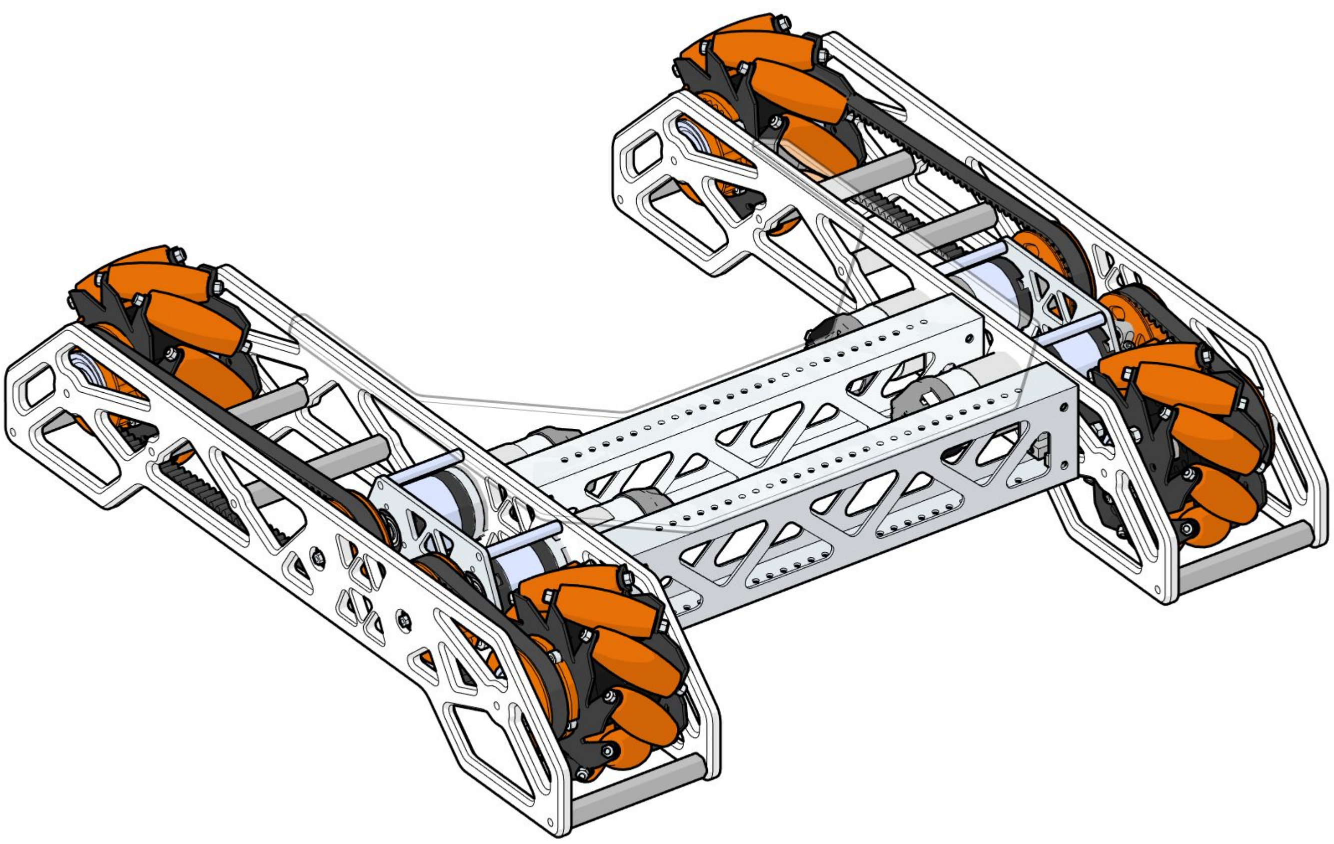
Cross-Support

Authors: Matthew

DETAILED EXPLANATION:

Now that the single drivetrain pod design was reaching completion, it was time to worry about connecting the two halves together. Initially, we intended to use a premade channel from goBilda, the advantage being versatility. However, their channel lengths did not fit our design well, and we decided to go for custom 2x1" box tube cross beams. The box tube will mount in the back, maintaining our goal of leaving space in the front.

One of the issues with having so much space in front was that the front of the robot would probably be able to flex inwards very easily. To solve this, we plan to reinforce the chassis with a polycarbonate belly pan, a large sheet on the bottom of the robot that would help with rigidity and provide shielding as well as possibly mounting options. This polycarbonate sheet extends up near the front of the inner side plates, the belly pan will eventually be attached to in order to provide this extra rigidity.



Underbody view showing the polycarbonate belly pan and box tube

Drivetrain CAD

9/09/19

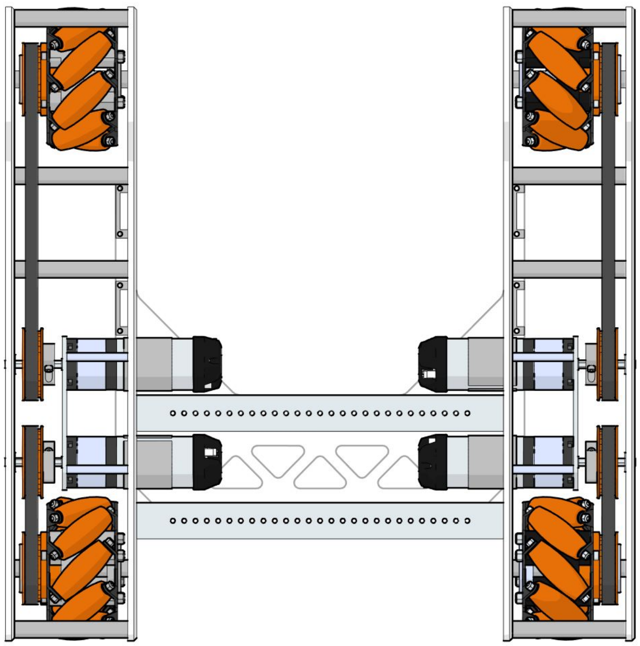
Authors: Matthew

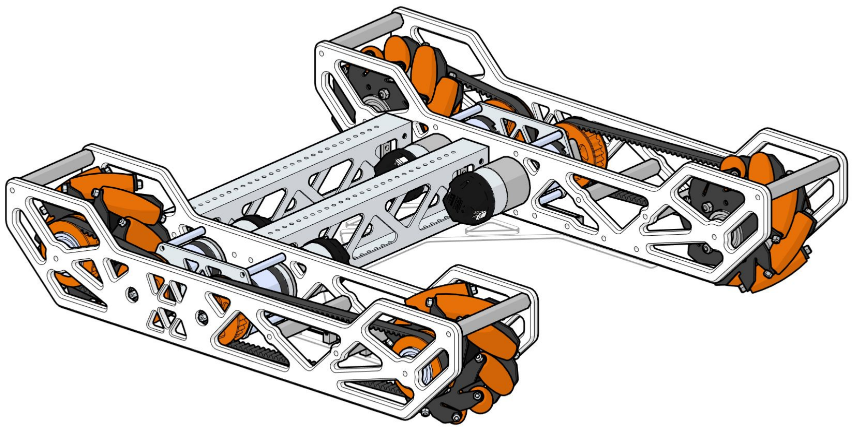
OBJECTIVES:

1. **Continue Drivetrain CAD development**
    a. **Finish Inner Side Plates**
    b. **Start Planning out Intake Draft**

PROGRESS:

- Fleshed out inner side plate design, incorporated holes for mounting components
- Checked pocketing strength using SOLIDWORKS Simulation
- Added pocketing and screw holes for belly pan
- Fixed issues with the mirroring of the drivetrain halves
- "Completed" drivetrain
- Rough design of intake





"Completed" CAD of the full drivetrain

FUTURE PLANS:

1. Continue working on intake
2. Add Odometry Modules
3. Figure out Slides mounting

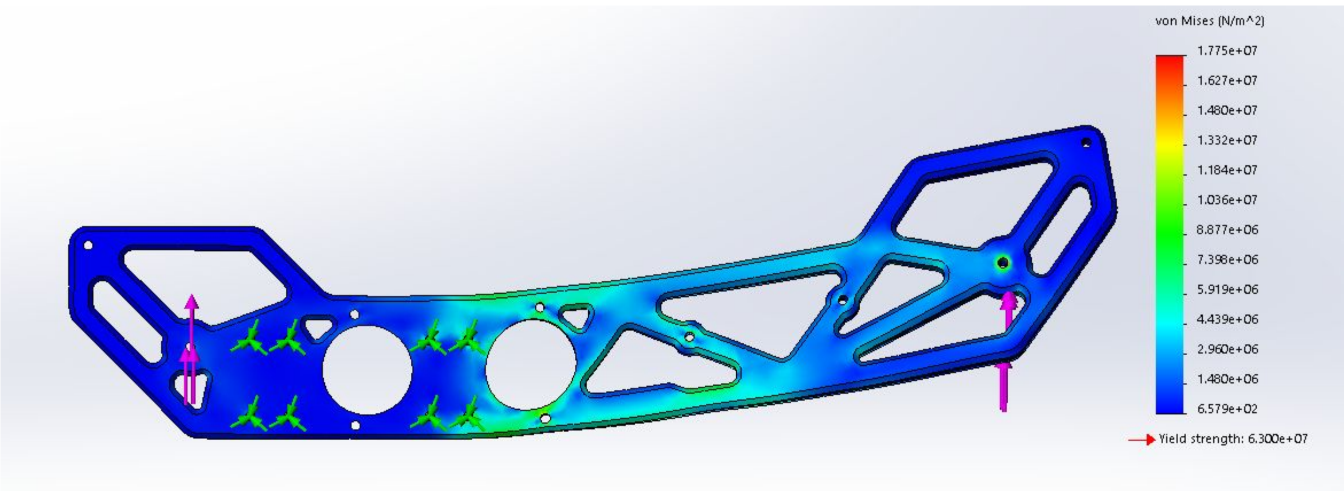
Plate Stress Analysis

9/09/19

Authors: Matthew

DETAILED EXPLANATION:

In order to make sure our side plate pocketing wasn't too ambitious, we tested our side plate in SOLIDWORKS using the Simulation add-in to perform a finite element analysis of the design. In particular, we tested the inner plate. We anchored the holes that would connect the side plate to the box tube, and put a 21 lb force on both of the wheel axle holes, representing the weight of a 42 lb robot.



Using SOLIDWORKS Simulation to check pocketing strength of the Inner Side Plate

The results of the simulation yielded that the maximum stress at any point on the plate would be about 1x107 Pa, 6 times lower than the yield strength of 6.3x107 Pa. Additionally, the final robot will have support from the rest of the robot structure, so we determined that the pocketing pattern is likely fine.

Rough Intake

Authors: Eric

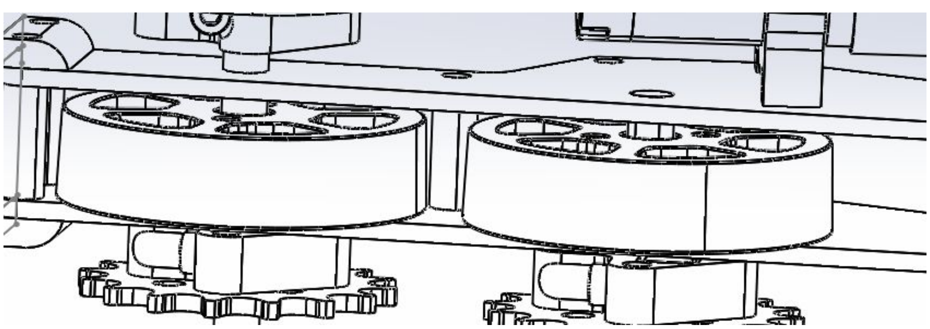
DETAILED EXPLANATION:

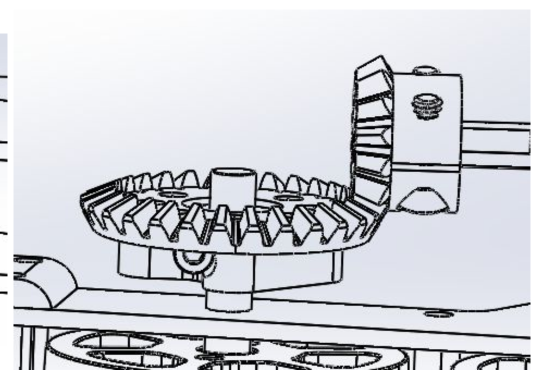
Considerations:

- Must flex inwards as it passes stone inwards
- Enough torque to launch inside robot
- Rollers much make sufficient contact and for a long time to make distance
- Folding inwards and outwards to fit in dimensions
- Easy to repair/make
- OPTIONAL: flipping mechanism for lying down stone

Utilizing the flexible yet grippy properties of rubber, we (are going to) utilize flexible filament to 3D print our own rollers. The current market for flexible rollers are too limited for our purposes, in size and in the level of flexibility we desire. Flexible rollers allow for more pressure and pushing force on the stone, as the intake tries to push on each other, pushing a stone through.

In addition, two 2" rollers are used in order to maximize torque across surface area for the stones to make enough contact and actually are passed through. Because frictional force is based on surface area, it is important we have the largest wheels.





We looked towards a gear ratio that utilized speed of intaking the stone because we must hold one stone at a time in order to abide by the rules. We chose to utilize some torque for speed because was enough in the 20:1 orbital motor. We therefore took the 2:1 ratio of the bevels. There was no other method to create such an angle. The question is if this angle holds due to the nature of bevel gears to skip if there is no adequate mounting solution for both sides of the bevels.

The bevel design was so we can mount the motor on its side and not vertical, due to imbalances in weight and difficulty of transforming motor power to the rollers. Moreover, mounting the intakes to the main body would be easier with a uniform intake body.

Rough Intake Cont.

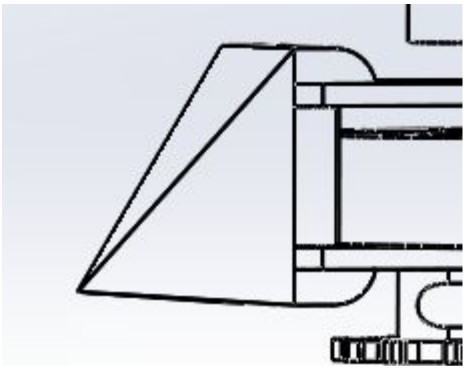
9/09/19

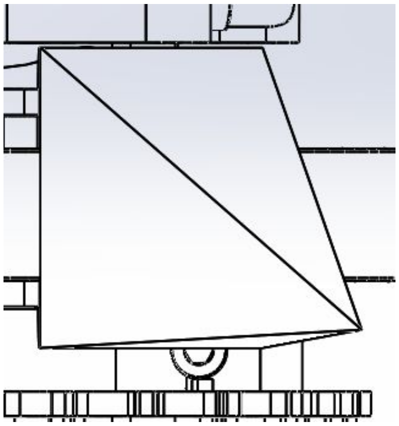
Authors: Eric

DETAILED EXPLANATION:

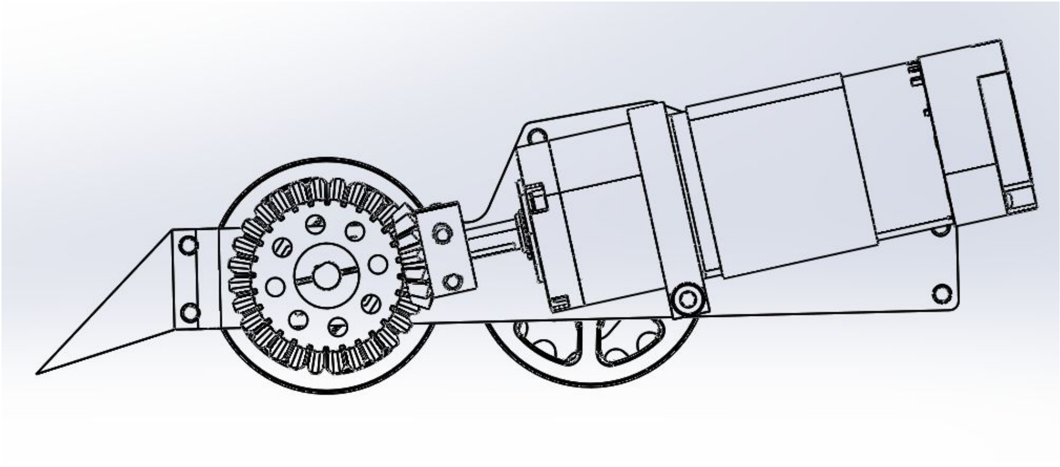
Although highly experimental, we thought stones knocked over should not be wasted, as the time to go back to the loading zone for new stones would take longer than uprighting a stone and utilizing. In addition, in the worst case scenarios where our whole tower falls over, there would at least be hope of rebuilding it if we had a method to upright stones. Realistically, this is very hard to achieve, as the stones do not have easy surfaces to upright stones.

Current design is a sloped tip that guides the pegs of the stone up and at the same time angles the stone towards upright position to be brought in by the intake. The angle for the slope and exact shape are yet to be determined, and there will be better shapes than this current pyramid shape. This is yet to be tested and properly designed.





The design can be fabricated through two identical plates of delrin. Not only is symmetry maintained but complexity is lowered, as only one plate is needed to repair the whole assembly. There is no need to take time and create two sides of the same assembly. Additionally, mirroring the object is simplified, as you can flip the plates to get an instant mirror.



Drivetrain CAD

Authors: Matthew

OBJECTIVES:

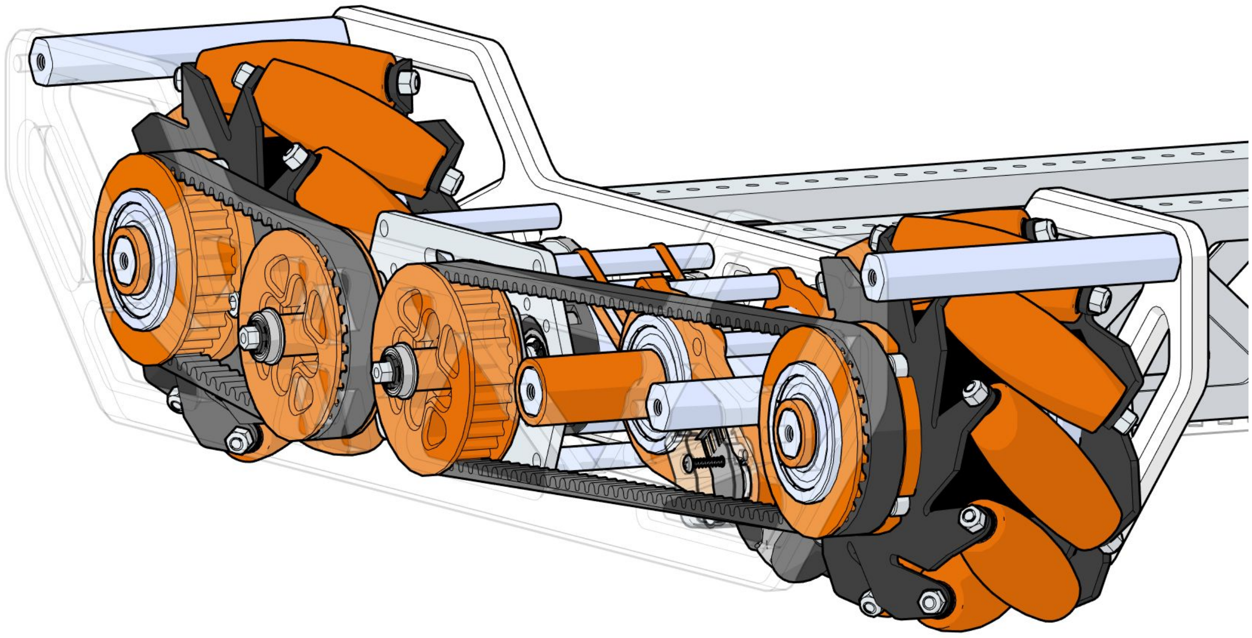
1. **Continue Drivetrain CAD development**
    a. **Complete Odometry Modules**
    b. **Add Spacers to CAD**

PROGRESS:

- Added spacers to constrain wheels, pulleys, and other components on drivetrain shafts
- Incorporated odometry modules to track position in autonomous inside drivetrain pods

FUTURE PLANS:

1. Continue working on intake
2. Add Odometry Modules for strafing
3. Figure out Slides mounting



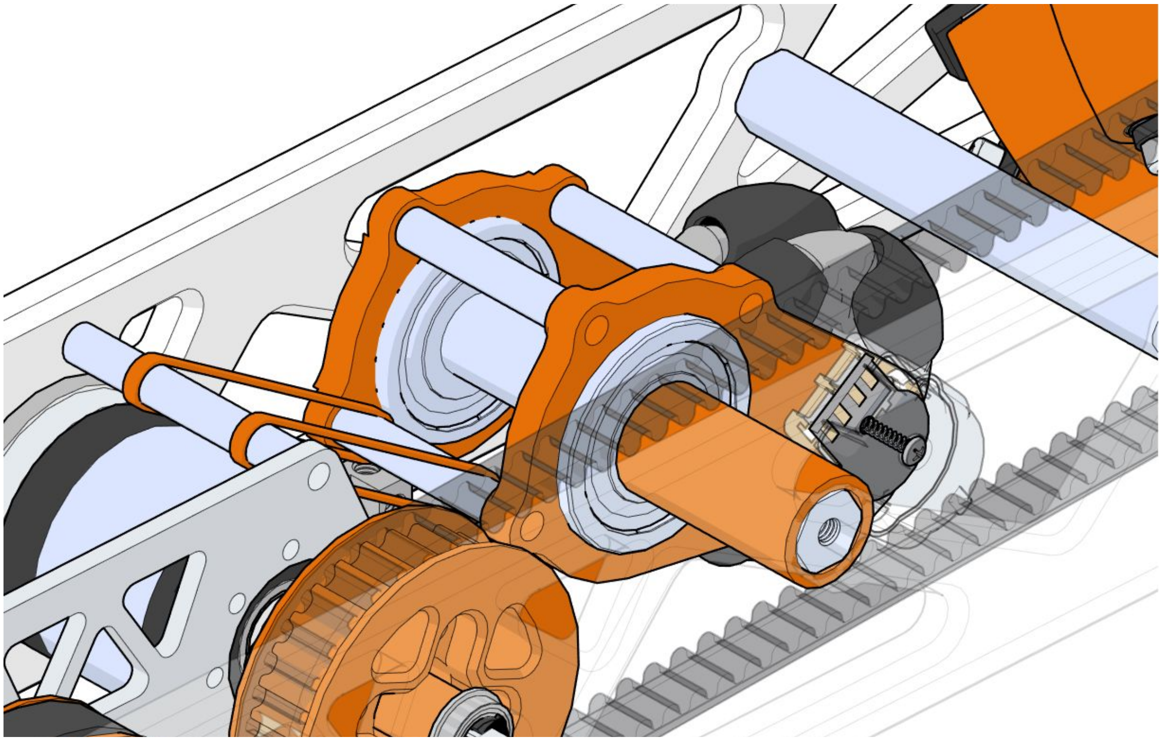
Inner Side Plates with Odometry and Spacers

Odometry

Authors: Matthew

DETAILED EXPLANATION:

One technique used by many advanced teams is to use omni-wheel dead wheels attached to encoders to track the robot's position on the field, often called "Odometry." These dead wheels are advantageous because they eliminate wheel slippage and backlash that can come from using the motor encoders for localization. The odometry modules we designed are compact in order to fit inside a drivetrain pod. They use a magnetic encoder instead of an optical one, eliminating possible issues with dust getting into an optical encoder disk. Furthermore, the wheels rotate on an axle and are spring-loaded to ensure good contact with the floor. This helps make readings much more accurate, as the wheels are always consistently touching the floor.



Odometry dead wheel mounted inside drivetrain pod

Drivetrain CAD

9/14/19

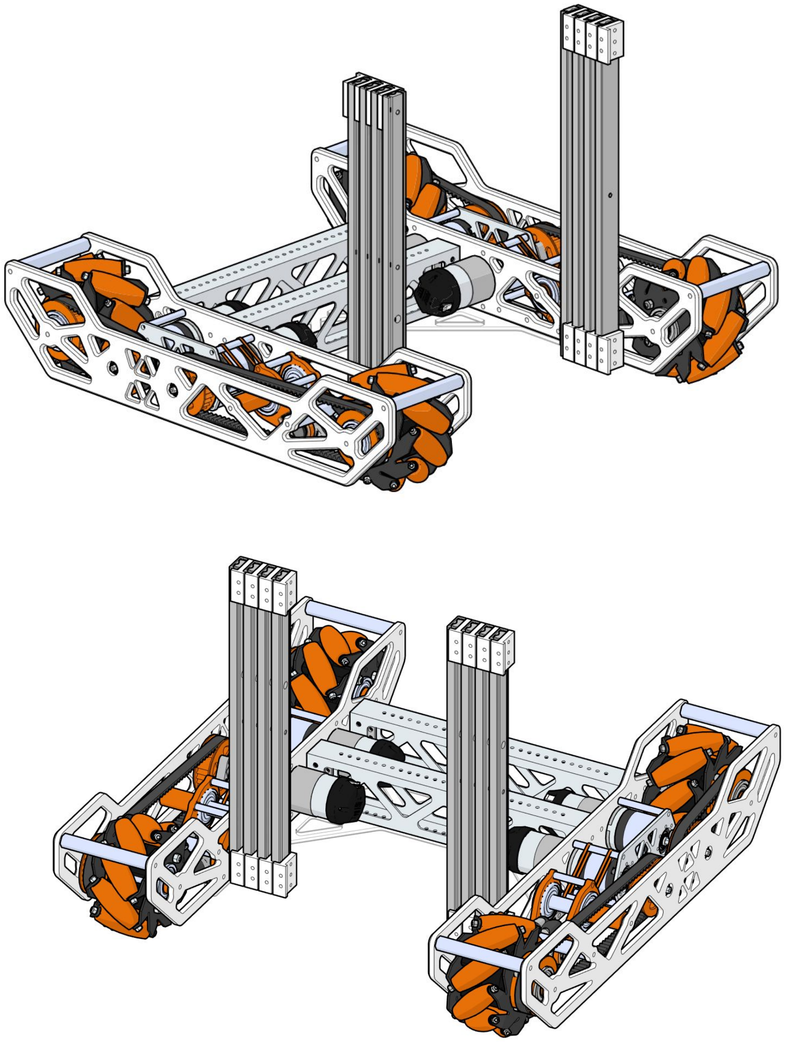
Authors: Matthew

OBJECTIVES:

1. **Continue Drivetrain CAD development**
    a. **Plan for slides mounting**

PROGRESS:

- Developed two possible slide mounting orientations
    - Horizontal towards center
    - Vertical towards front
- Considered the pros and cons of each design



Two Different Slide Mounting Options

FUTURE PLANS:

1. Continue working on intake
2. Add Odometry Modules for strafing
3. Flesh out potential slide mounting designs

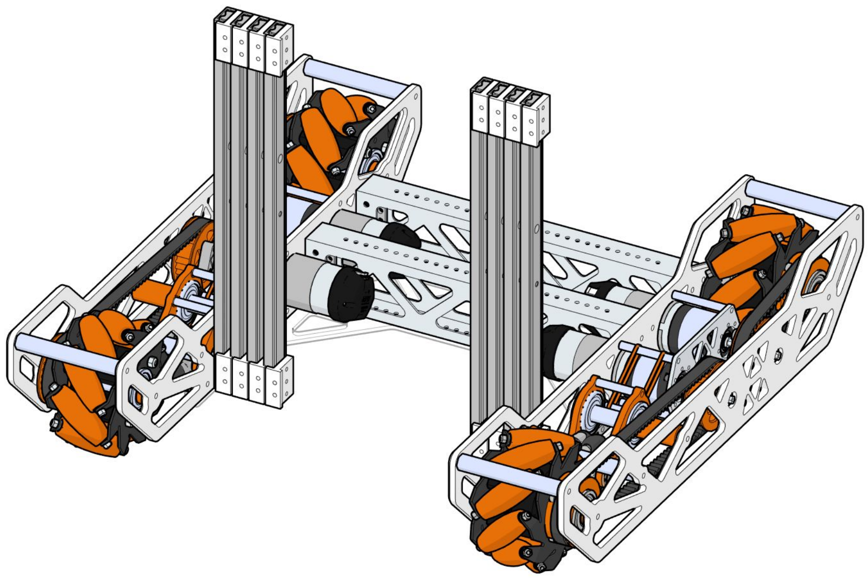
Slides Mounting

Authors: Matthew

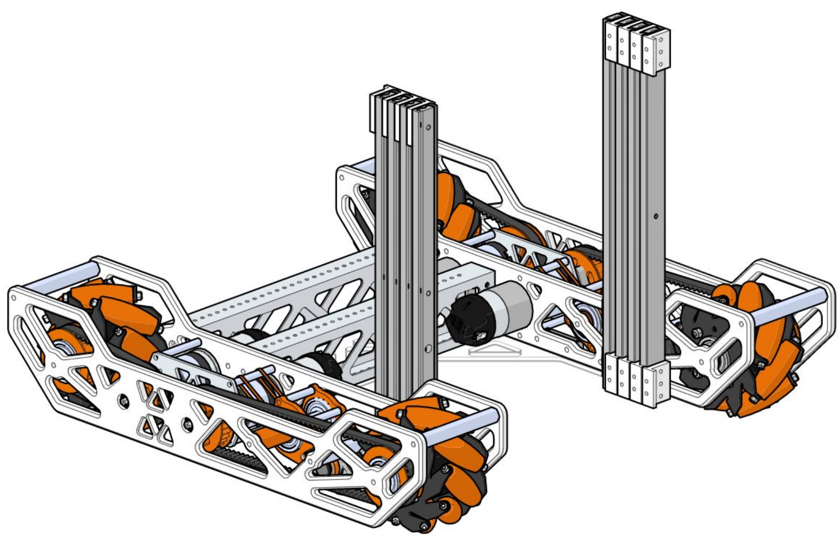
DETAILED EXPLANATION:

One of the major components of our robot is the vertical slides, and we needed to determine where to place them on the robot. The linear slides we used were special aluminum drawer slides that are commonly used in FTC due to their compactness and ball bearing supported motion, as opposed to some linear slides like the REV slides that use delrin friction sliders. The configuration that we attempted was placing them on the inner side plates between the drivetrain pods.

This particular configuration allows the slides to be mounted in their strongest axis, and is relatively convenient to design for. One of the disadvantages is that there is limited space to stack many slides, as there needs to be space in the middle to accommodate a stone. Furthermore, stringing may be difficult because of where the pulleys are located.



In our second configuration, we still have the slides mounted to the inner side plates, but they are stacked from the back to the front of the robot. The advantage of this configuration is that stringing is simplified, and there is room for many more slide stages, as we can keep adding without losing space in the center. However, the main downside is that it is weaker, as the load will be placed in the weaker axis of the slides.



Robot CAD

Authors: Matthew

OBJECTIVES:

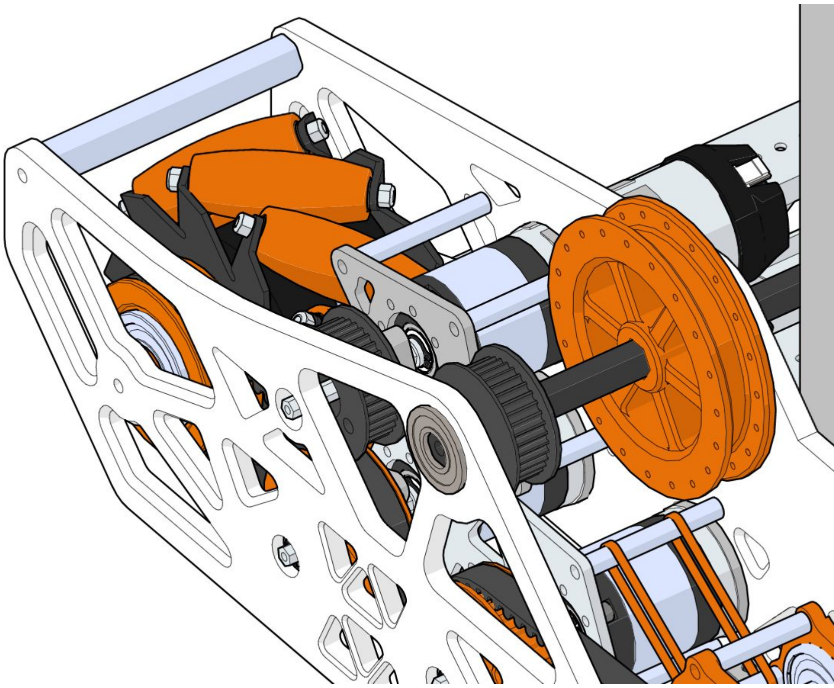
1. **Continue Drivetrain CAD development**
    a. **Flesh out slides mounting in order to plan**
    b. **Decide the merits of the slide mounting design**

PROGRESS:

- Finished major parts of the CAD for mounting slides stacked forwards
    - Winch pulleys
    - Motor mounting

FUTURE PLANS:

1. Continue working on intake
2. Add Odometry Modules for strafing
3. Flesh out potential slide mounting designs



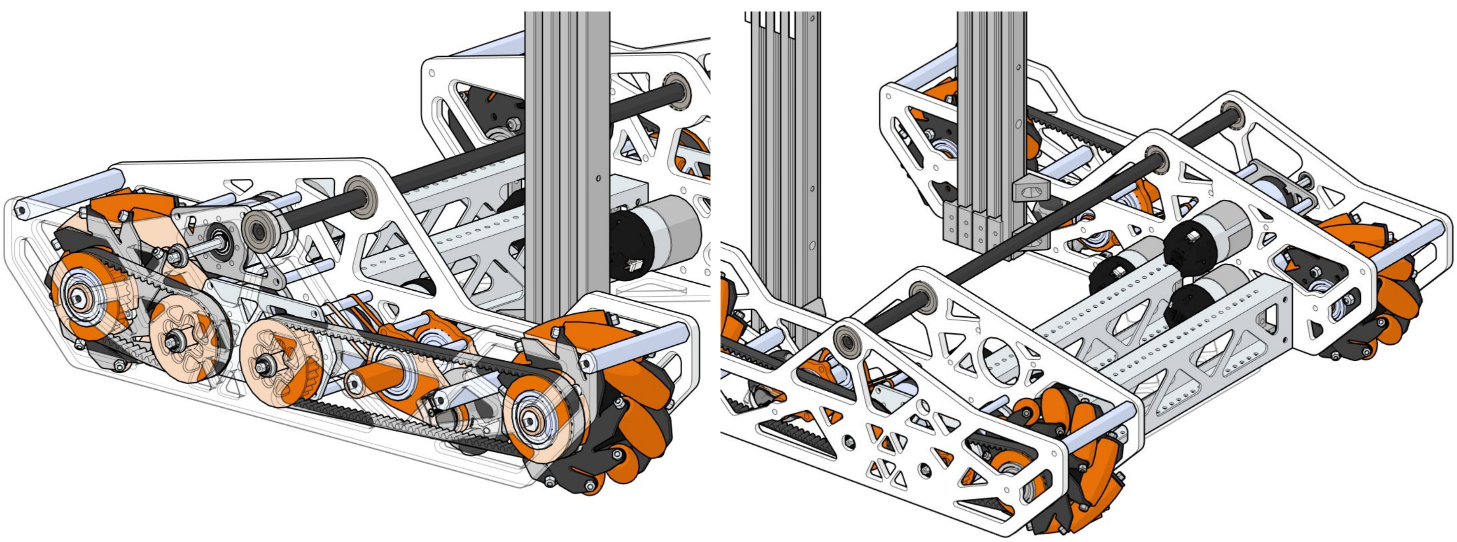
Motor Mounts and Pulley

Forwards Slides Config

Authors: Matthew

DETAILED EXPLANATION:

After some deliberation, we decided to investigate the 2nd configuration, which had the slides stacked towards the front of the robot. The main advantages being that stringing would be much easier, and we had bad experiences last year with complex stringing. In order to move our slides, we needed to design for a pulley system to pull these strings using a motor. To hold the pulleys, we used a long hex shaft that would help make sure both pulleys for each of the sides of the slides were in sync. Next, we added motor mounting near the shaft. The motor is recessed into the drivetrain pod to conserve space in the middle, and will eventually power the shaft via belt. In addition, the assembly is constructed symmetrically so that we can add a second slide motor if we ever desire. The outer side plates support the ends of both the motor and pulley shaft for extra rigidity.



Front and back views showing the slides and pulley shaft/motor mounting

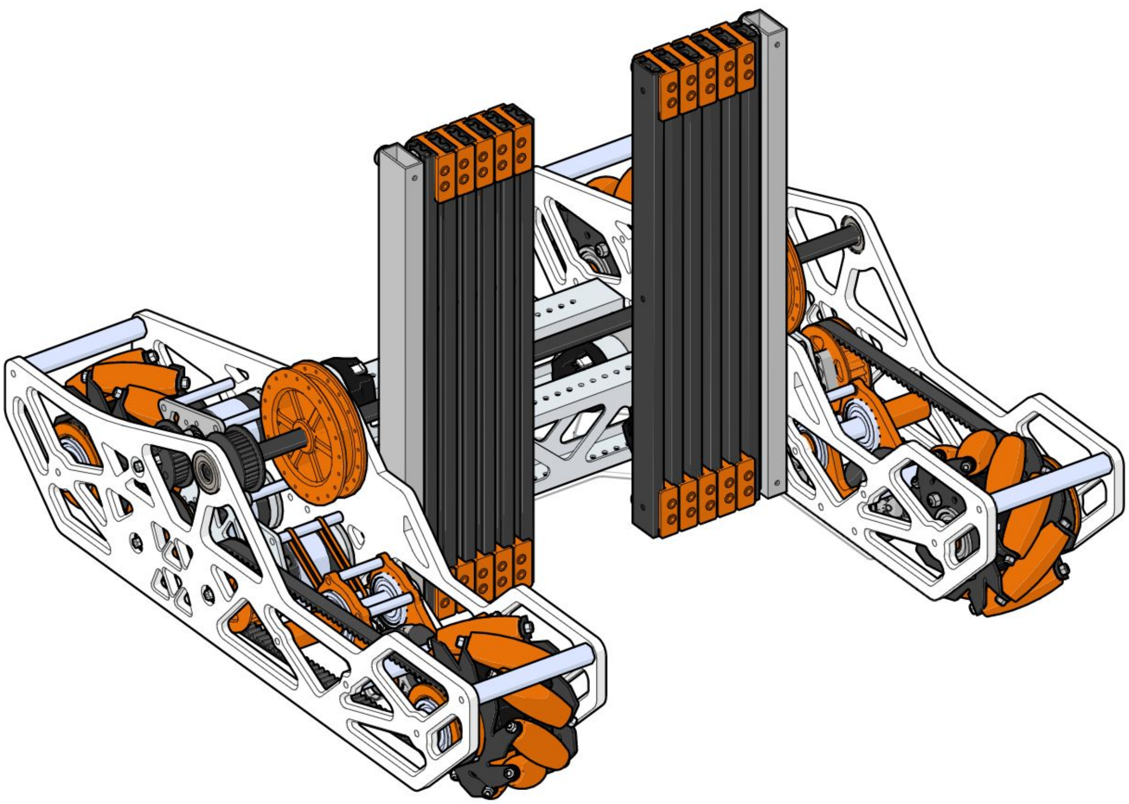
Forwards Slides Config

Authors: Matthew

DETAILED EXPLANATION:

We designed out the other slide orientation, ultimately deciding upon this one. We used much of the design for the previous slide configuration, but instead changed the mounting of the slides

- Used small pieces of box tube to mount the slides
    - Adds rigidity, adds another pulley mounting spot for retraction/lift strings
    - Adds flexibility to design -- box tube easily modifiable
- Stacked more slides inwards
    - Decided that a large number of slides would be unnecessary
    - Using a chain bar eliminates concerns about spacing in the middle
        - Allows more to be stacked
- Updated colors to match robot color scheme



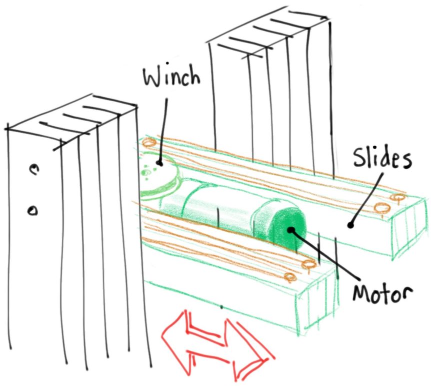
Isometric view of new slides mounting

Chainbar Design

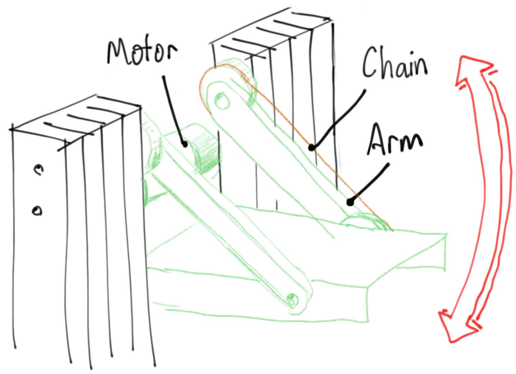
Authors: AndrewZ

DETAILED EXPLANATION:

The drivetrain and slides were well fleshed out, but the stone placing mechanism was undecided. We initially had two proposed designs:



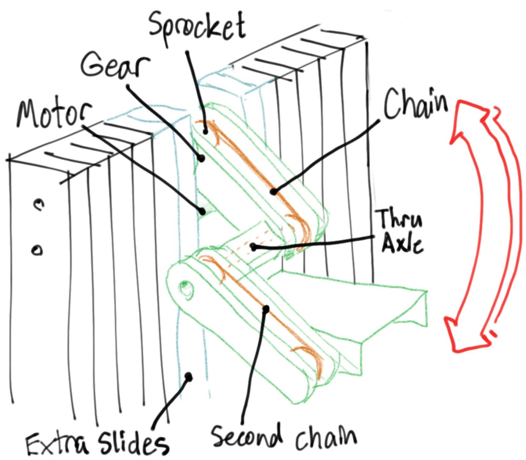
Horizontal Slides



Double Chainbar

Over the weekend, however, we realized that a Z-shaped chain bar variant would have several advantages:

1. Simpler than slides, more space efficient than double
2. Versatile; can stick out horizontally for extra reach, or angle upwards for extra height.
3. Allows more slide stages to be added since it clears over the top of the slides



Z-Chainbar

We decided that in the long run, a chainbar constructed from plates and standoffs would offer the greatest strength for the least weight and cost. However, since our robot is far from a completed state, we designed and 3-D printed adapters to construct a similar chainbar from GoBilda parts, which allows us to easily change the bar's length.

Intake Wheels

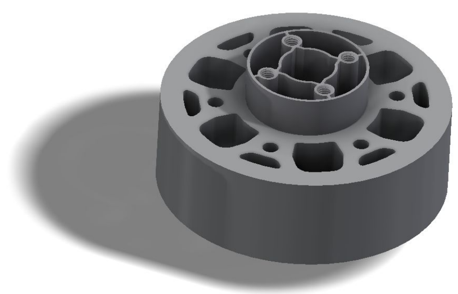
10/12/19

Authors: Andrew

DETAILED EXPLANATION:

We decided that we wanted larger wheels for easier intaking of the skystones, and settled for 3-inch as we judged 4-inch wheels would be too large to easily store and deploy. While we had seen the green Andymark compliants very commonly in years past, we decided to try the VexPro or WCP flex wheels instead, which were rated for a softer durometer. The wheels indeed proved to be exceptionally flexible and high-traction, securing our final decision to use them.

Pros	Cons
Soft, flexy	Weird mounting
High-traction	

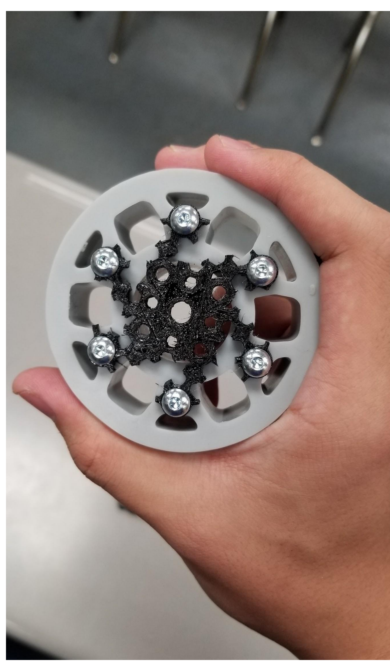


MOUNTING

The wheels offered great performance, but their only drawback was difficult mounting as they were designed for an unconventional VEX hub. The wheels turned out to press-fit onto gotube with a great, tight fit. However, this reduced the wheels' flexibility by a great amount, so we decided to 3D-print hubs.

HUB DESIGNS

To preserve the wheels' high flexibility, we designed hubs to be 3-D printed from flexible TPU filament. We considered three main designs: Hexagons, mimicking airless tires, spokes, or double spokes. Hexagons proved to be a challenge to CAD, and we may attempt them again in the future. We printed a spoke design, but it proved to have too much give and sometimes snapped to an incorrect position, so we will be designing and testing a double spoke design next.



A stiff hexagonal pattern, modified to be spoked

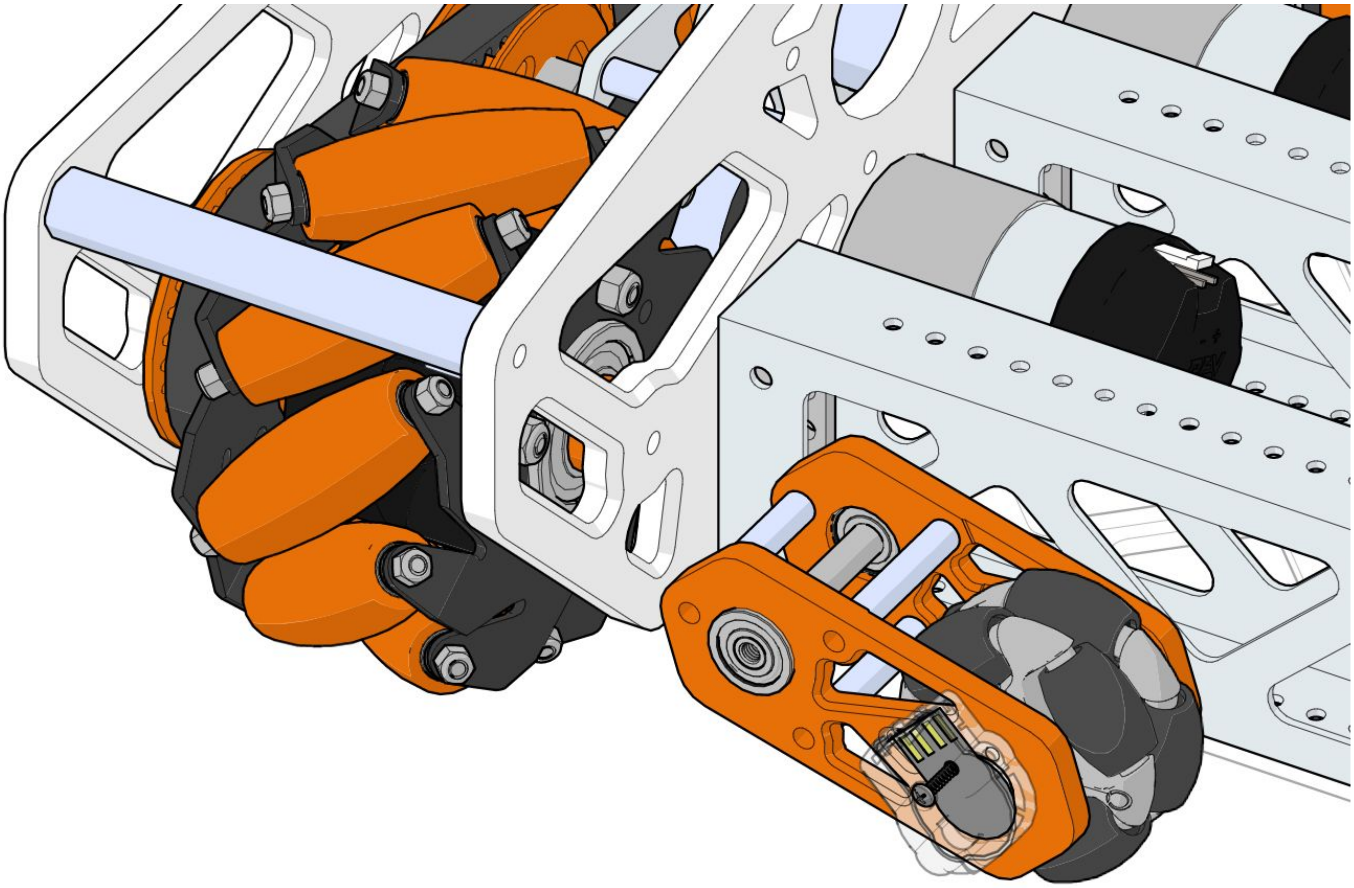
Second design, spokes, mounted to motor to test

X Axis Odometry

Authors: Matthew

DETAILED EXPLANATION:

Although we had already developed odometry inside each drive pod, in order to track both heading and forwards movement, we still needed one more to track our sideways movement in autonomous. We designed a small odometry pod to fit on the rear box tube beams of our robot for this purpose.



Odometry dead wheel mounted inside drivetrain pod

Robot CAD

11/2/19

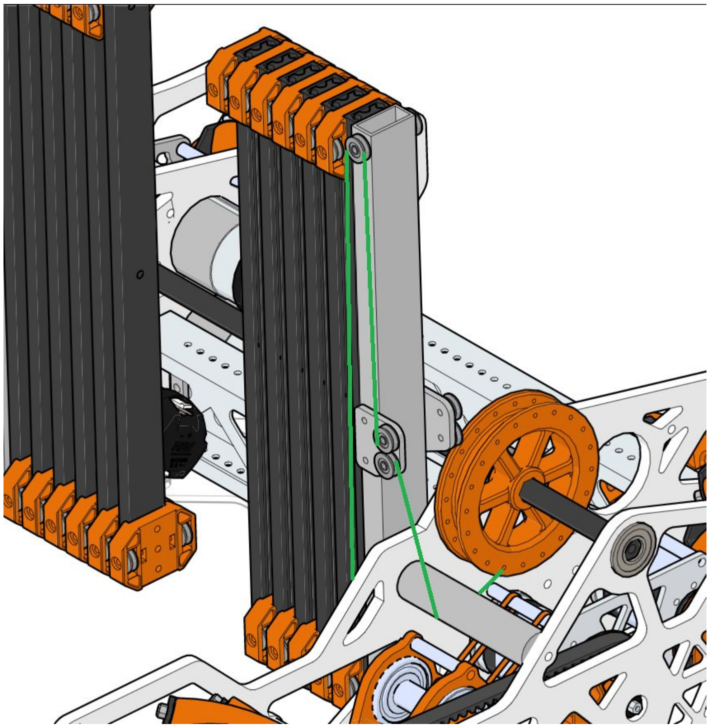
Authors: Matthew

OBJECTIVES:

1. **Continue Developing robot slides CAD**
    a. **Redo Slides Inserts**
    b. **Figure out Stringing**

PROGRESS:

- Revised Slides inserts (details next page)
    - Includes structure to cover strings
    - Nut Inserts
- Determined Stringing for slides configuration
    - Uses pulleys parallel to plates for simplicity
    - String routes around a cylindrical roller to put it into plane for slides bearings
    - A pair of bearings help redirect strings from roller to the top slides pulleys
        - Prevents string from colliding with plate



New Slides Stringing

FUTURE PLANS:

1. Figure out how to mount intake to the front
2. Develop Chain-Bar
3. Figure out string roller specifics
4. Develop Grabber

Slide Inserts V2

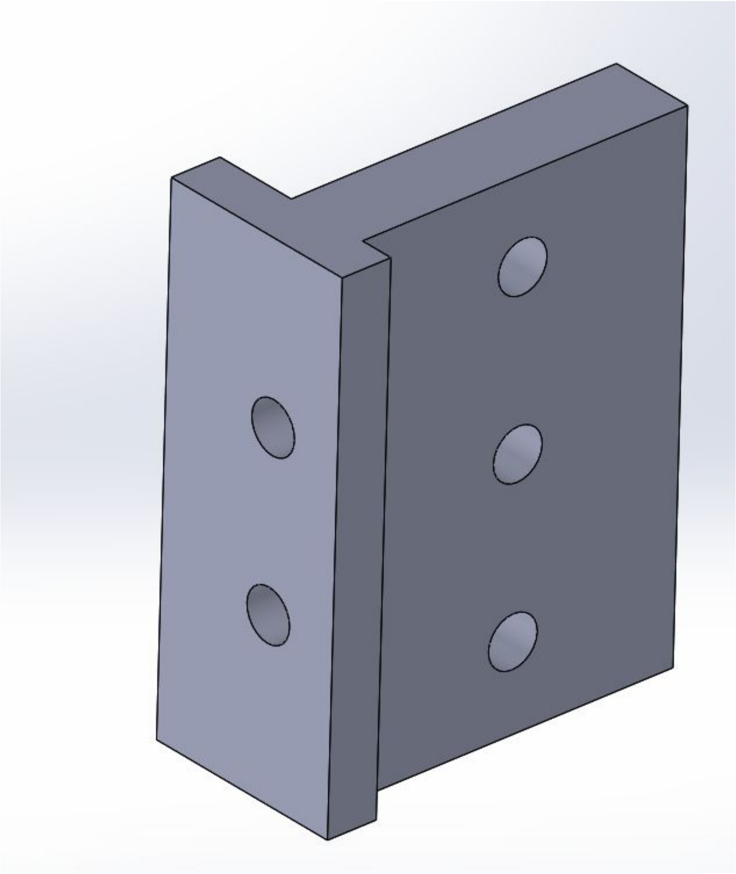
Authors: Matthew

DETAILED EXPLANATION:

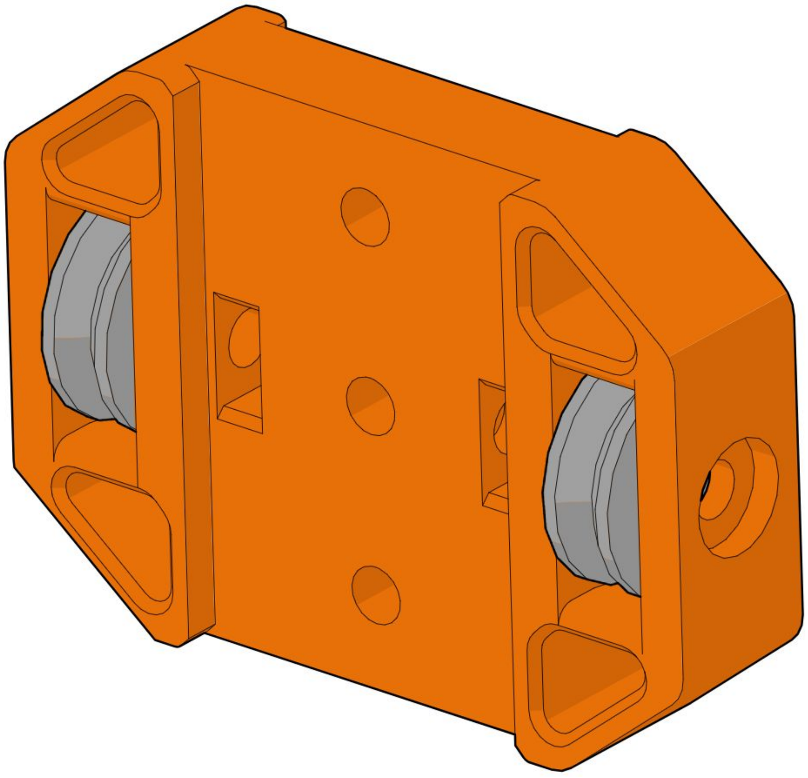
Before we designed a revised version of our slide inserts, we were using some quickly made placeholder inserts which had a few issues.

Features

- Small shims inside insert to prevent bearing from rubbing against walls
- Casing around the pulley, helps to prevent strings from hopping off the pulley
- Insert slots for square m3 nuts to be placed
    - Slide insert designed to be self threading, but slots for m3 nuts are provided just in case
- Small countersink on the part to reduce profile of screw head



Original Slides Inserts/Pulley mounts



Revised Slides Inserts/Pulley mounts

Rear-Slides Redesign

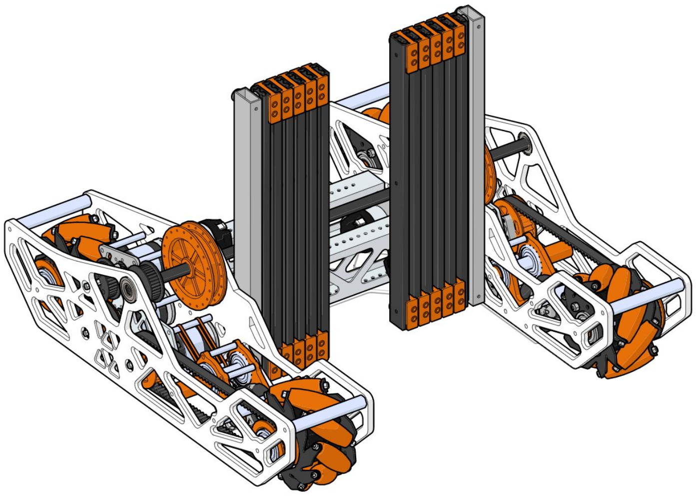
Authors: Matthew

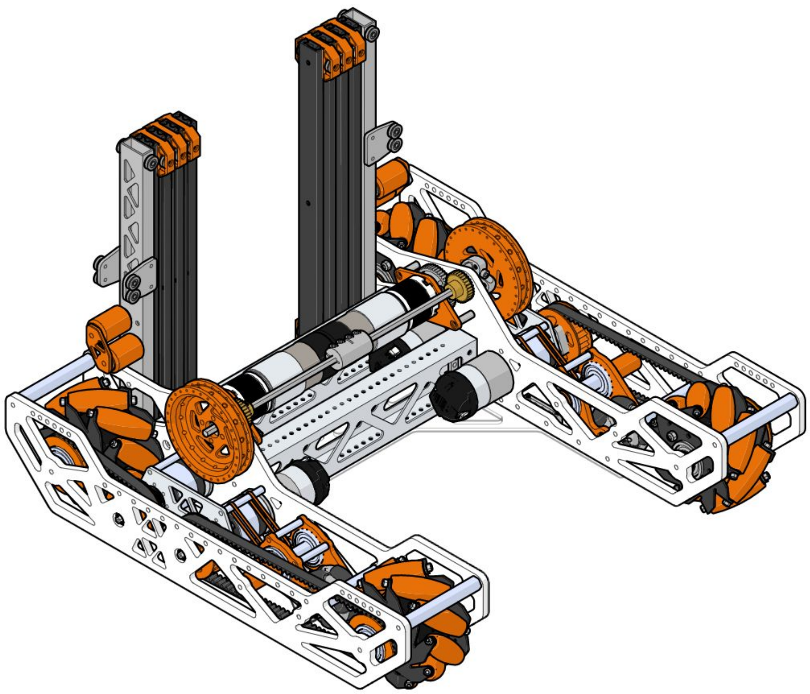
DETAILED EXPLANATION:

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

- Chain bar mounting awkward
    - 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

Rear-Slides Redesign

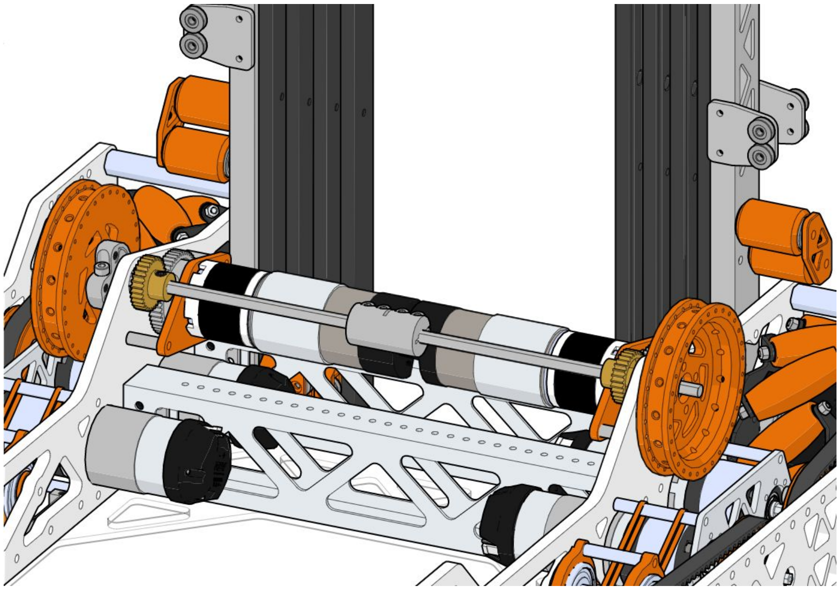
11/11/19

Authors: Matthew

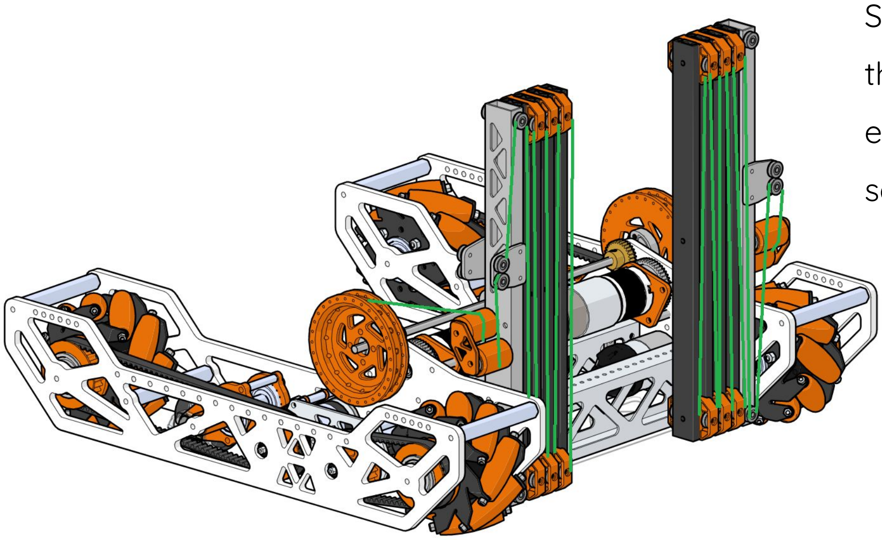
DETAILED EXPLANATION:

Dual Motor lift gearbox/Sync Shaft

- Dual motor powered, each with a 12:1 overall ratio for quick extension
- Long shaft runs across length of robot, linking pulleys
  - Called a "sync shaft", keeps pulley rotation in sync
  - Allows both motors to contribute to extension and retraction, increases efficiency



Slides Stringing



String runs off of pulley, onto pair of idlers that pass the string onto a the plane of the extension pulleys, and then through another set of pulleys

- Configuration guarantees all 90 degree string angles, makes sure that there are no unaccounted for forces in the axial direction
- Sideways pulleys integrate nicely with side plate construction, easily accessible

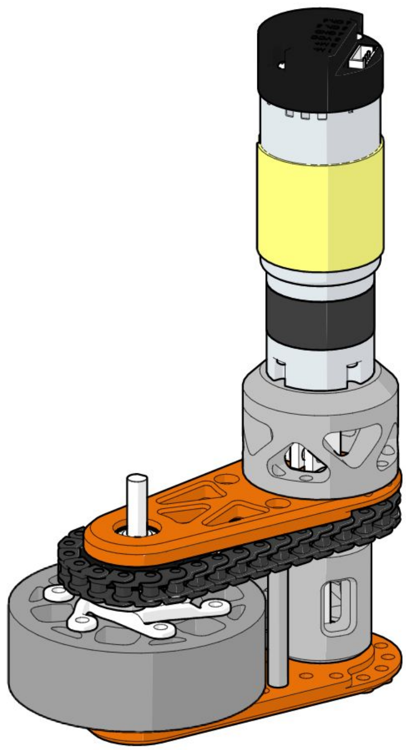
Wheeled Intake

11/18/19

Authors: Matthew

DETAILED EXPLANATION:

Coaxial Wheeled Intake



Powered by 13.7:1 motor

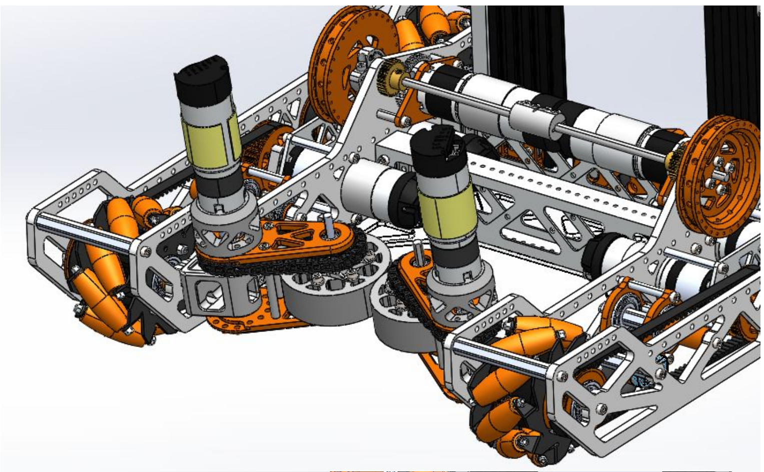
- Aggressive ratio intakes quickly
- Mounted near pivot point, reduces rotational inertia

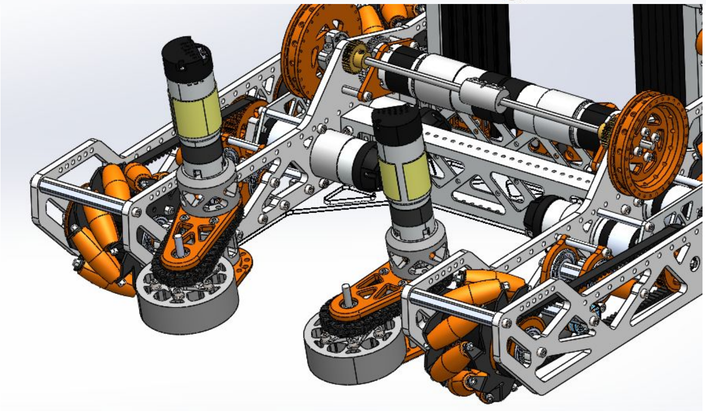
Coaxial Design

- 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
- TPU wheel hubs designed to bend for maximum flex





Deployable Intake

- Two pods fold inwards against each other, run the motors to deploy them
- Stick out of robot when deployed, allowing easier pick up of stones in corners
- Each pod being a pivot allows the intake to move around and adjust to the profile of stones

Grabber

Authors: Andrew

DETAILED EXPLANATION:

Stone Gripper/Placer

High Grip

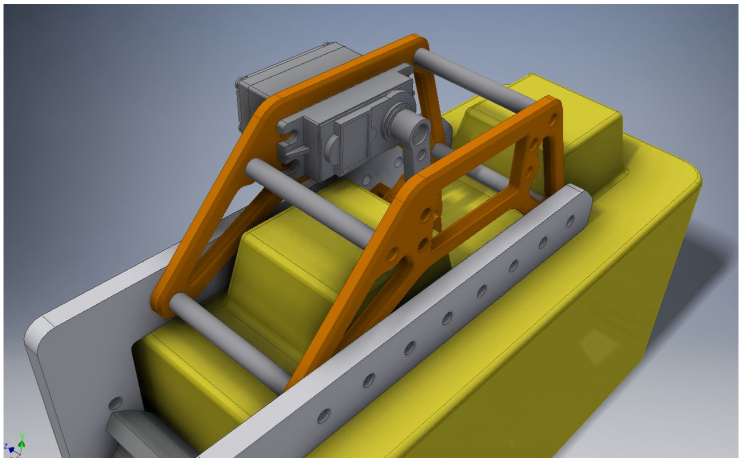
- Uses slices of silicon from spare intake wheels for solid hold
- Small servo arm pushing block against large frame results in few moving parts

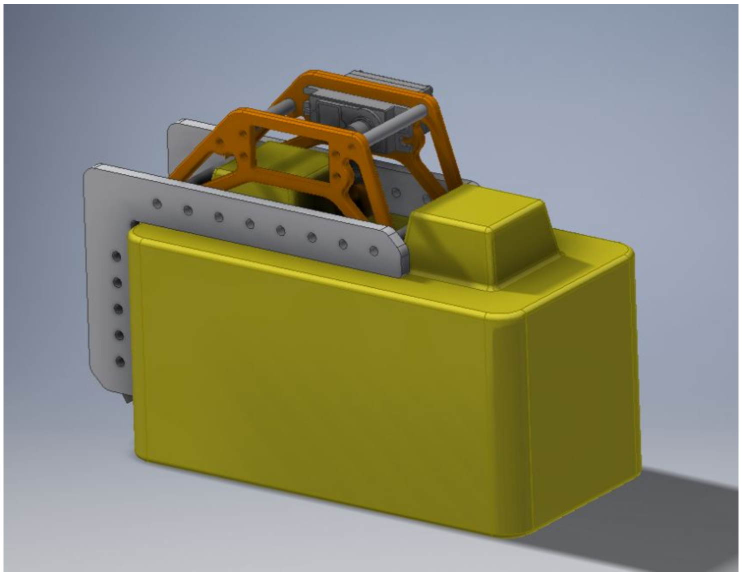
Lightweight

- 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

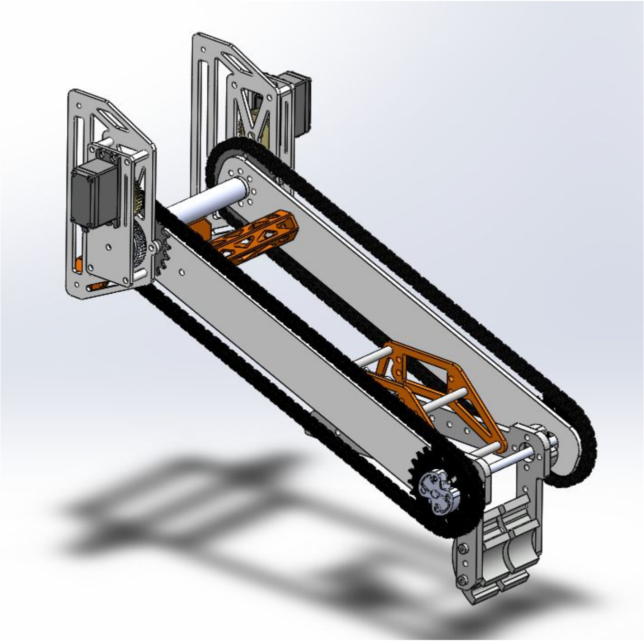




Chain bar/Arm

Authors: Eric

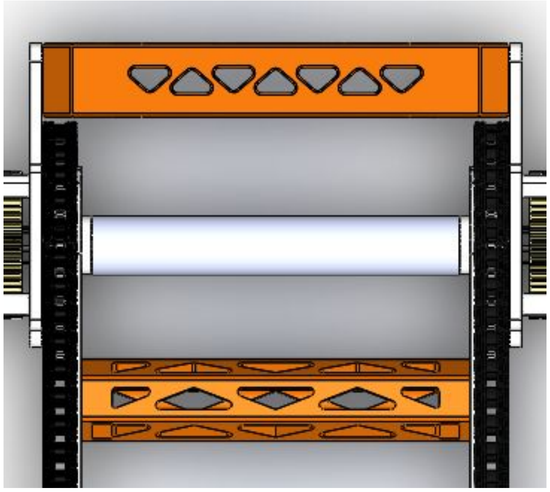
DETAILED EXPLANATION:



Double-Plate Chain Bar

Stability (in terms of the arm)

- Two plates allow for the grabber to be secure on the end
- Placement of blocks is easier with more stability
- Maintain lightness with two thin plates
- Two support beams to couple the arms and the slides and to make the chain bar rigid

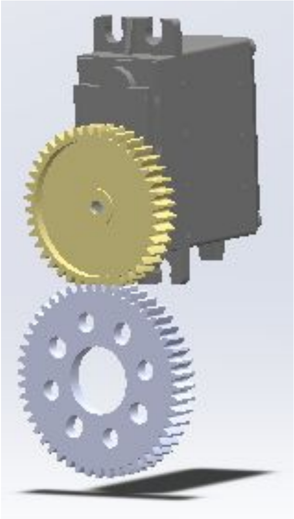


Stability (in terms of the grabber)

- Chain bar relies on the chain attached to two sprockets (one fixed, one free)
- Gimbal effect on grabber, maintains level of the stones for easy, faster placement

Strength

- Two servos power the two arms
- Geared 1.2:1, slightly more torque but trying to maintain speed and 270 degrees
- Sacrifice little range for enough torque to lift the grabber



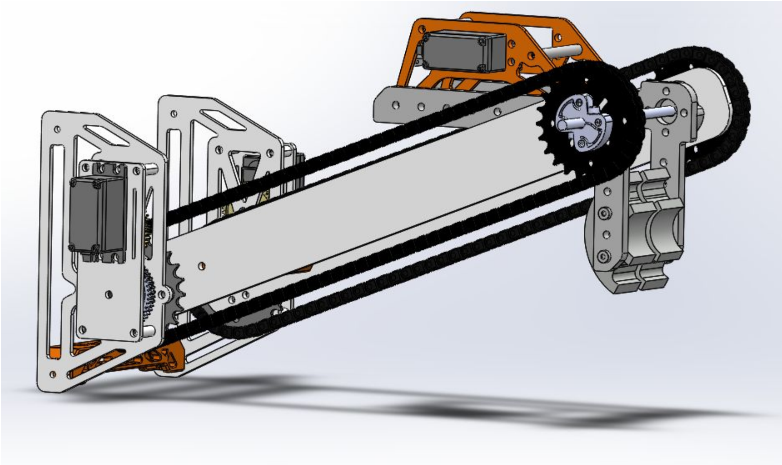
Chain bar/Arm

12/10/19

Authors: Eric

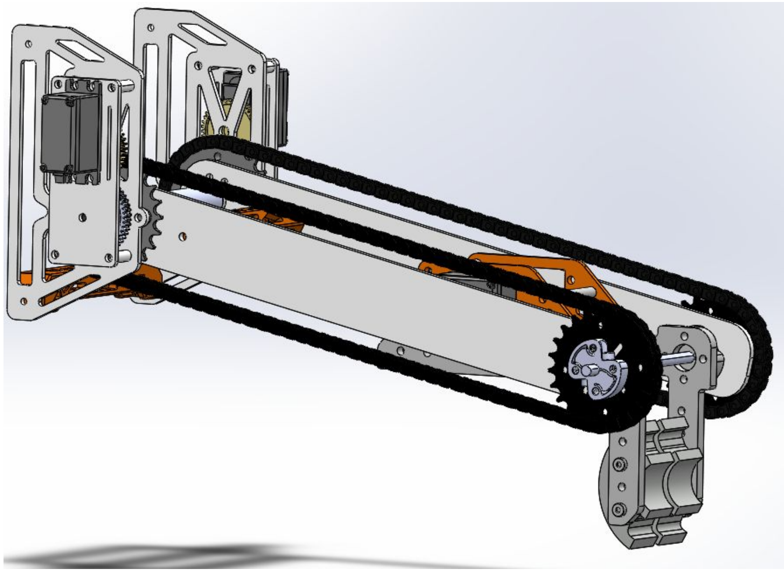
Precision

- Keeps the stone level with the floor at all times
- Passes the stone through tight space between arm
- Space between the stone and the arms at minimum to allow for maximum vertical extension



Lightness

- Minimize instability and shaking when vertically extended high
- Driver ease and high stacking potential
- Increase speed of vertical extension
- Almost all plastic or 3d printed, reduce weight compared to metal parts



Intake Guides/Endstops

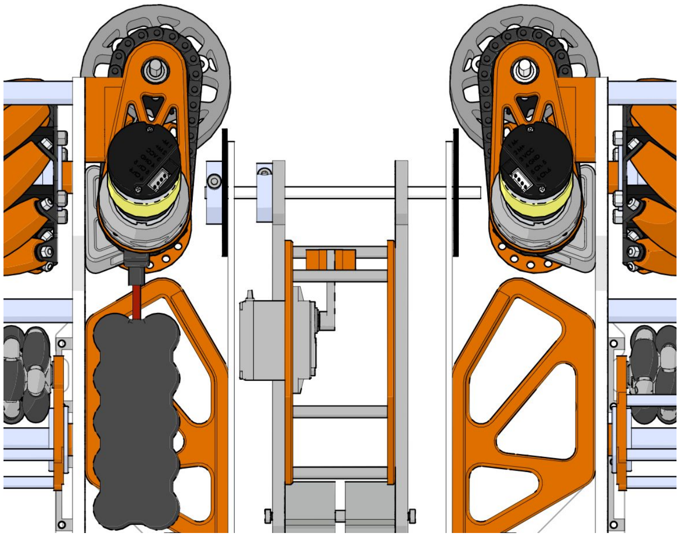
12/15/19

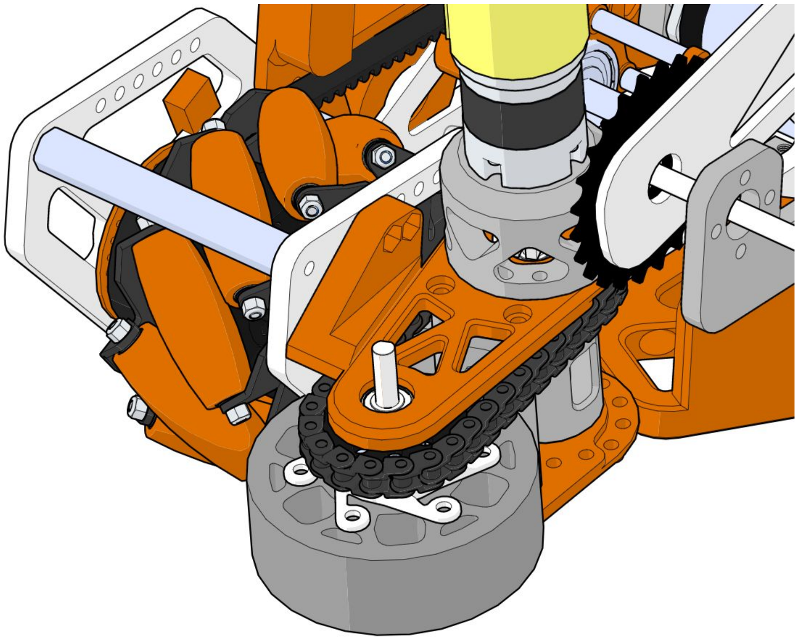
Authors: Matthew

DETAILED EXPLANATION:

Intake Guides

- 3D-Printed
- Ensure that stones that we intake are straight
- Slope inwards to help orient stones that come in
- Tall walls that prevent stone from jumping guides
- Mount to inner side plate
- Serves as battery holder





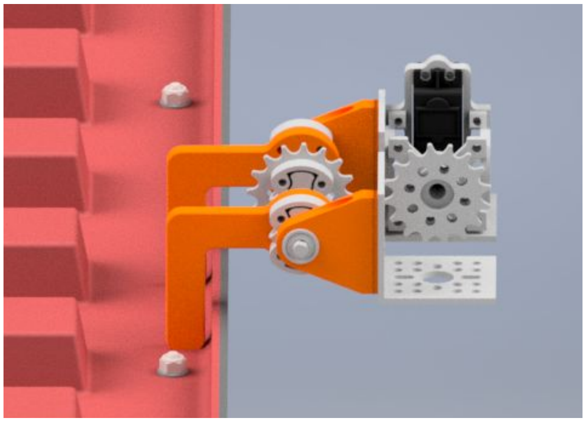
Intake Endstops

- Attach to side plate
- Block the intake from rotating too far
- Prevents intake from getting caught on wall
- Solves jamming issue we had with intake getting sandwiched between block and side plate

Foundation Dragger

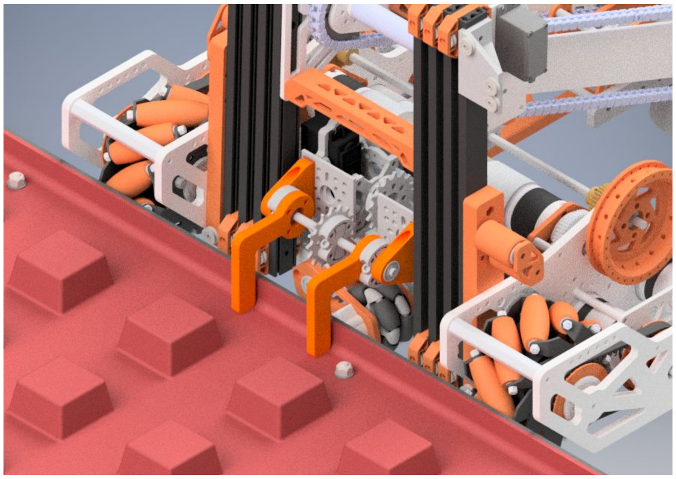
Authors: Keertik

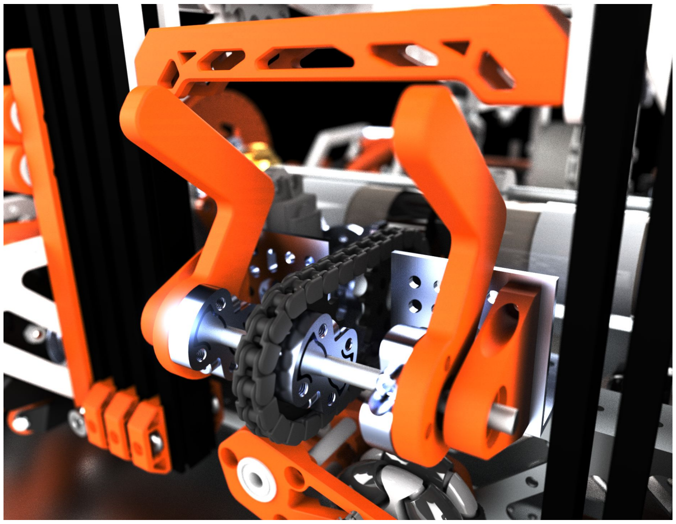
DETAILED EXPLANATION:



Compact design using one servo

- Fits between slides and under chain bar arm
- Both arms share common axle
- Servo moved back and connected to axle
- Attaches onto box tube





Custom designed parts

- Arms designed to make a snug fit for the foundation lip
- Longer pillow block, to move axis of arms closer to robot edge
    - More accessible screws

Flexible foundation movement

- Arms trap lip of foundation against drivetrain edge
- Can pull, push, and turn foundation

Slide Support

1/25/20

Authors: Eric, Matthew, Andrew

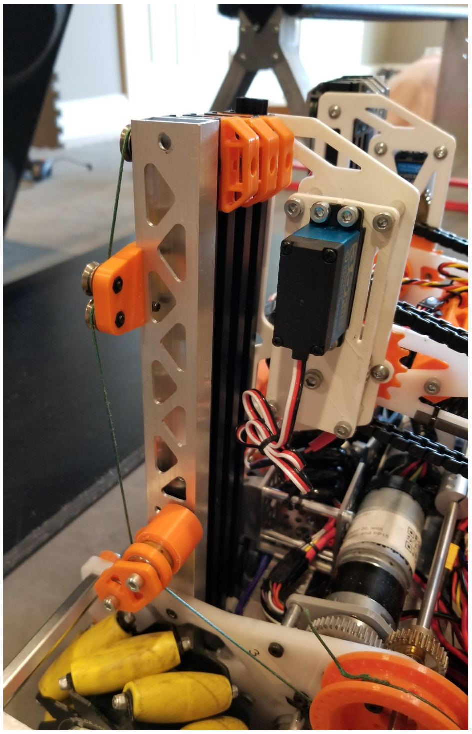
DETAILED EXPLANATION:

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

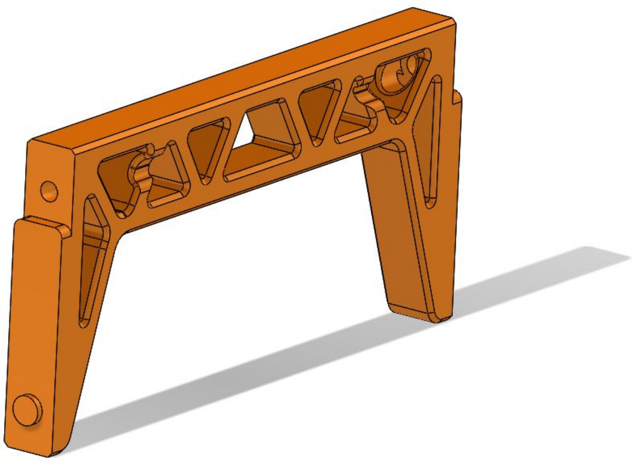
Aluminum replacing 3D printed parts

- 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



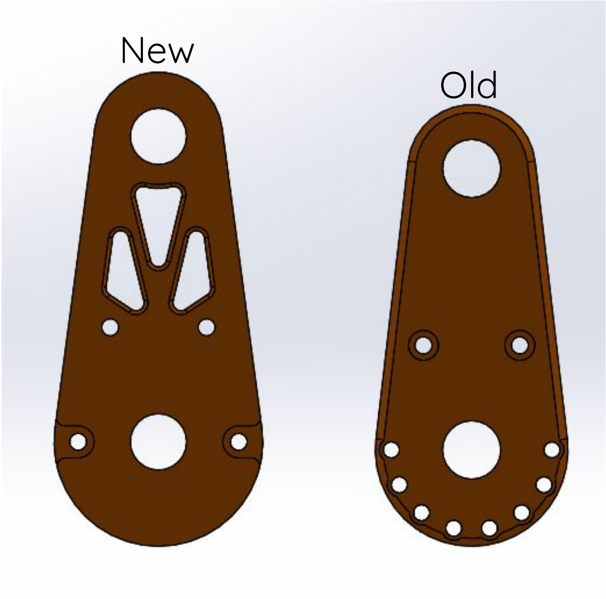
Intake V2

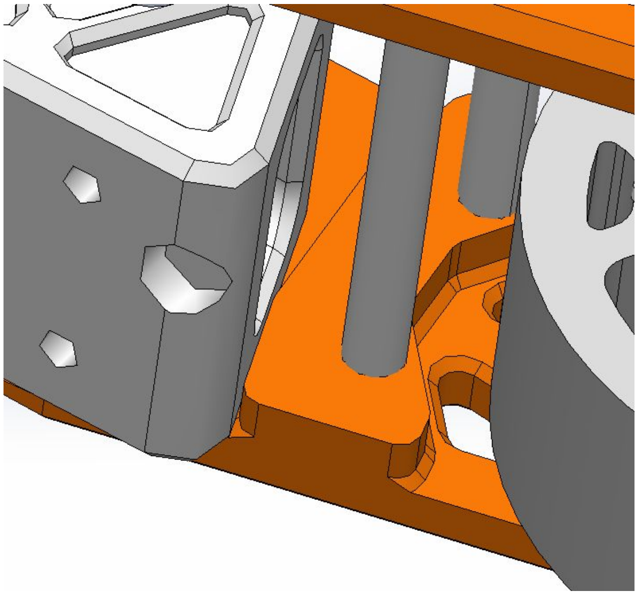
Authors: Matthew, Eric

DETAILED EXPLANATION:

Chain was too loose

- Less efficient energy transfer
- Made vibrations and friction with the structural components, loosening some parts such as our coupler





Extended the body

- More length between sprockets increased the chain tension
- More responsive to driver controls
- Further reach, can pick up blocks from further

Add physical limits

- Previously needed external limits for the intake to hit
- Designed on the intake plate, hits internal parts and saves space

Redesigned compliant hubs

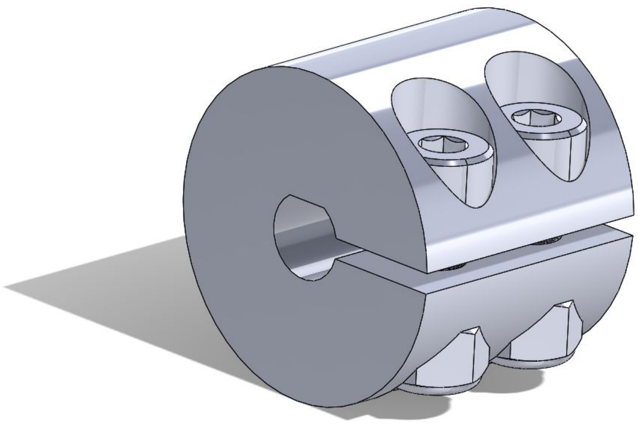
Intake V2 (cont.)

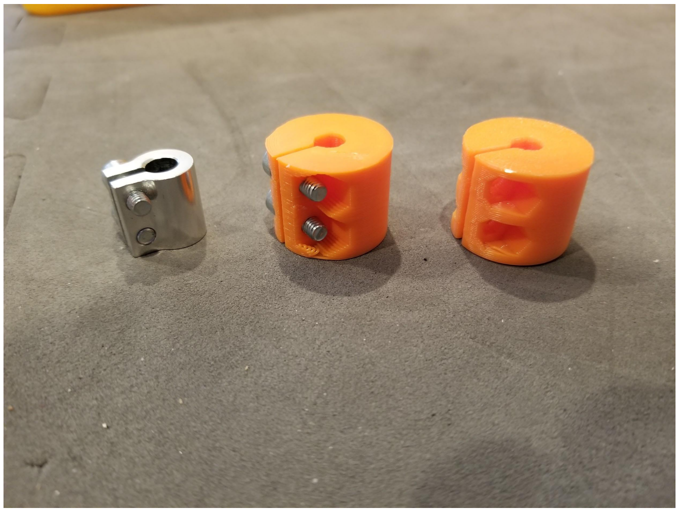
Authors: Matthew, Eric

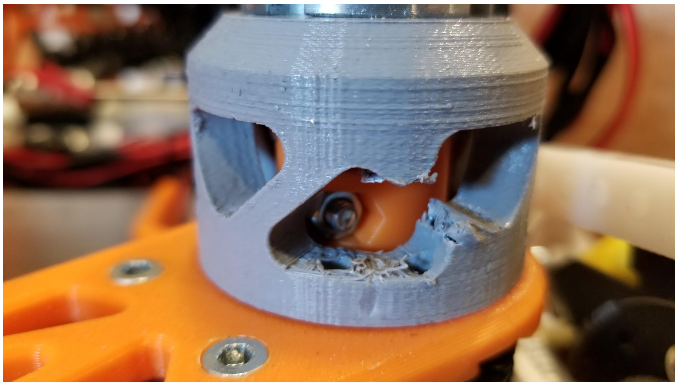
DETAILED EXPLANATION (Continued):

Previous slippage from smoothbore coupler

- Gobilda coupler slipped often
- Even more loss in energy
- Metal threads tore out with excessive tightening







Designed custom coupler

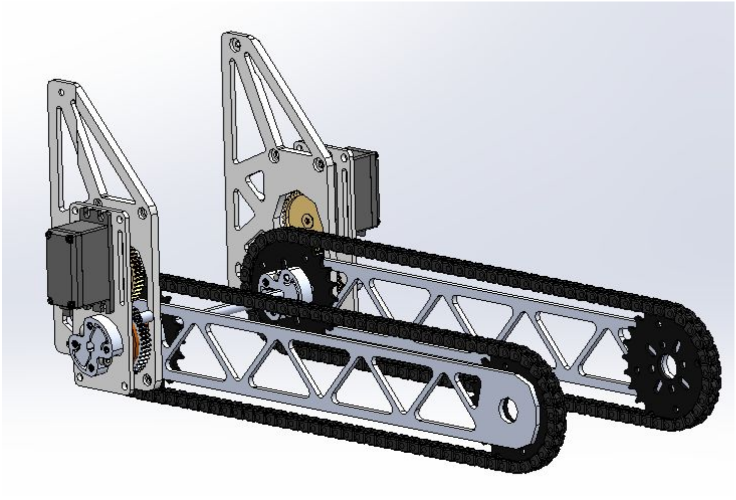
- Extremely thick body to compensate for weaker plastic material
- Countersinks for nuts and screws
- Smaller tolerances for a tight fit
- D-bore to prevent slippage
- Printed with ludicrous number of perimeters for a stronger structure that both resists torsion and accepts tightening

Chain Bar V2

2/1/20

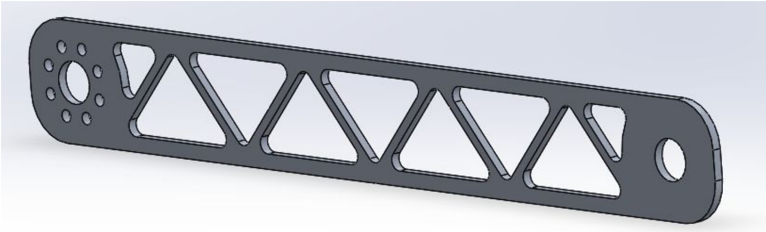
Authors: Eric

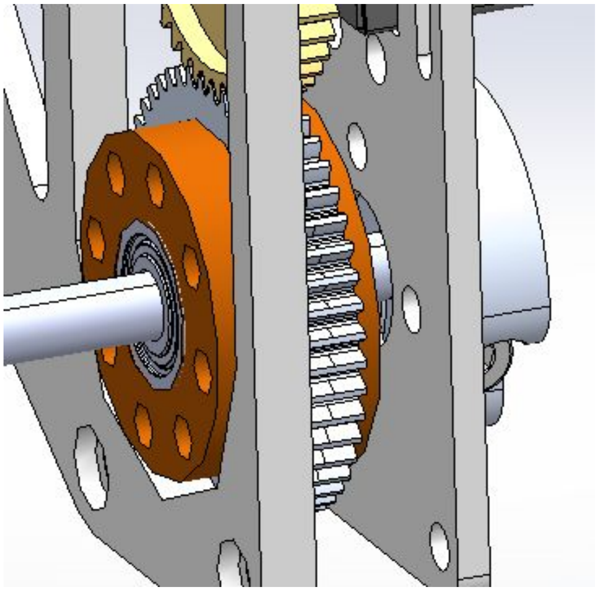
DETAILED EXPLANATION:



Shorter but stronger arm

- Planned to be machined from aluminum, which is slightly heavier but much more rigid than delrin
- Designed with larger cavities and weight reduction features





Consistency when flipping

- Not enough friction reducing features for hexagonal axle (such as bearings, spacers)
- Incorporates multiple bearings and clamps for smooth and consistent operation

Chain Bar V2 (cont.)

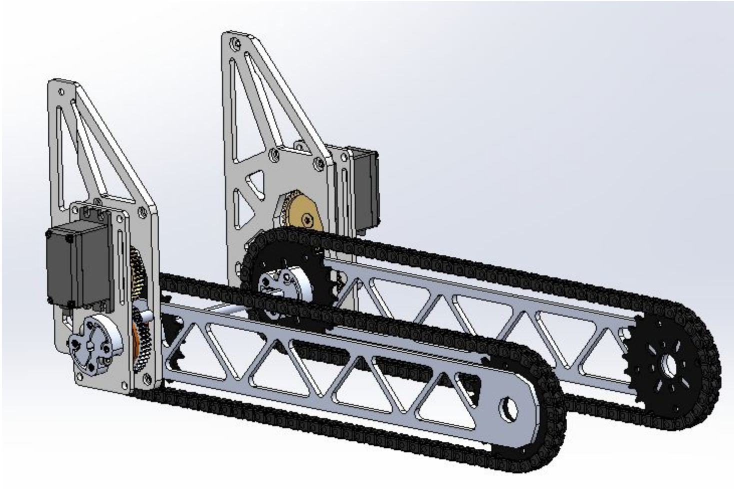
2/1/20

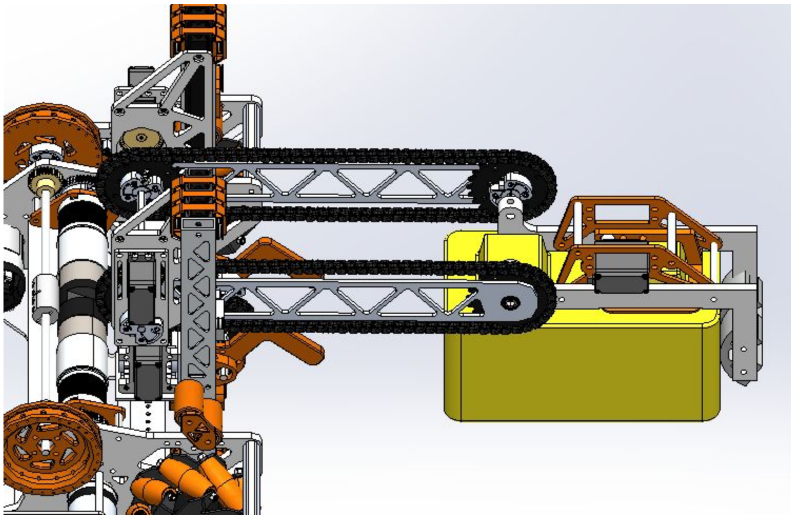
Authors: Eric

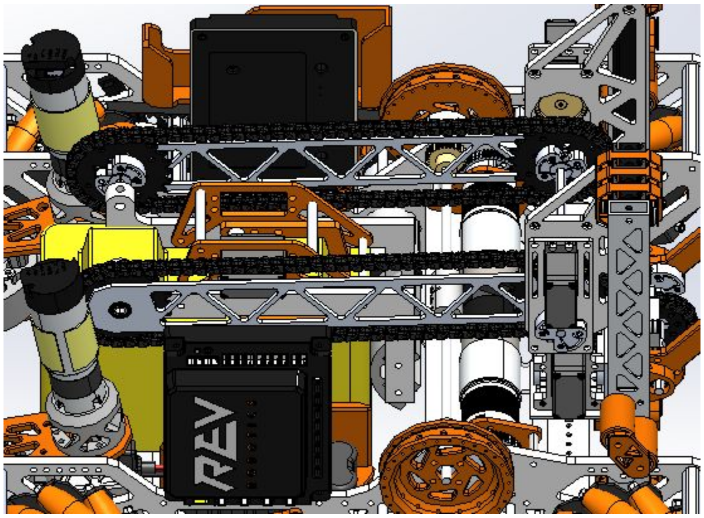
DETAILED EXPLANATION:

Exact length arm

- Utilize a shorter arm but more optimized to maintain chain tension and reach into the foundation
- Perfectly sized to place a stone on the inner nubs, if the robot is aligned along the foundation
- Lowered entire assembly on slides to decrease amount of travel necessary to flip the whole arm, faster stone delivery (decreased from ~270 degrees to ~180 degrees)







Chain Bar V2 Plate FEA

Authors: Matthew

DETAILED EXPLANATION:

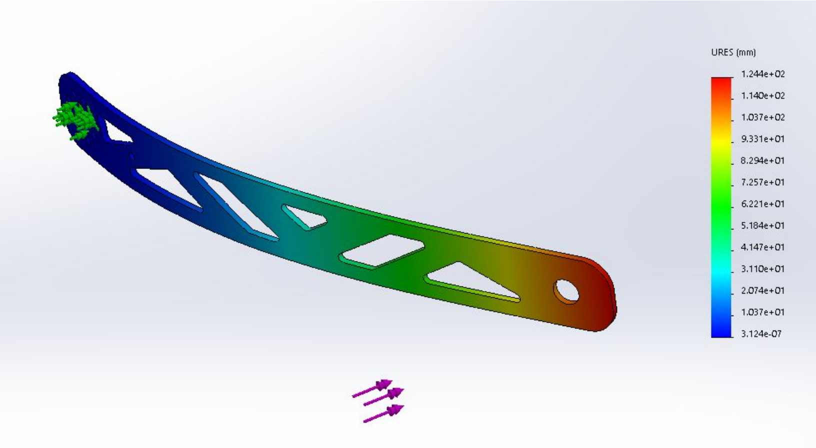
An issue we had at our last qualifier with the chain bar arm was that it would saw due to inertia when we rotated the robot. We sought to make a more rigid assembly, while keeping everything just as light as before. We designed a second plate out of **aluminum**, **heavily pocketed to bring the weight down**, but we didn't know if the strength was comparable.

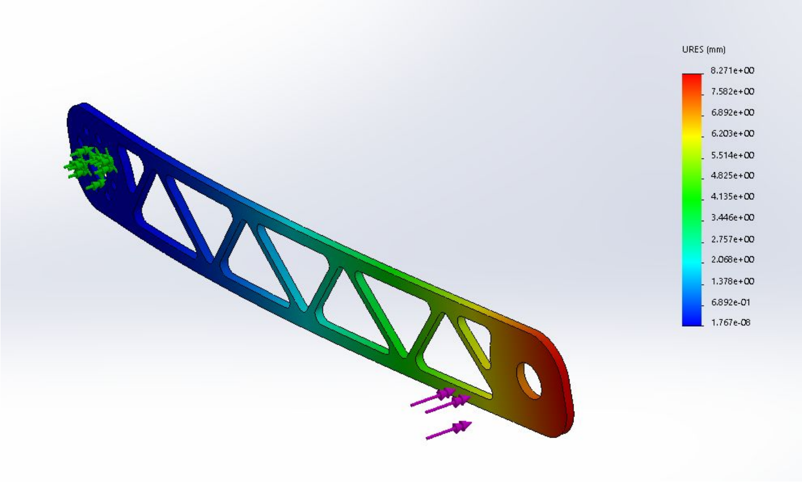
Using the SOLIDWORKS Simulation FEA, we side-loaded each part at the end with 3 Newtons of force to simulate the swaying forces of our arm.

RESULTS:

We found that under these conditions, our aluminum part had a max displacement of about 8mm under 3N, **much better than the max displacement that the delrin side plate** experienced of up to nearly 12 cm.

Furthermore, checking the mass properties in SOLIDWORKS, the new aluminum plate is **only about 5 grams heavier**, coming in at about 52 grams as opposed to the 47 gram delrin plate, meaning that **strength for weight, it is significantly more efficient.**





Old (left) and new (right) designs side by side and the displacement results

Front Crossbar Mount

Authors: Matthew, Andrew

THE PROBLEM

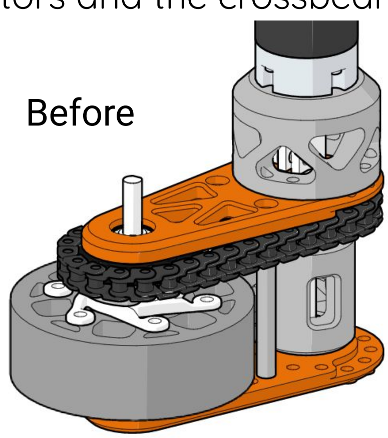
The **drive modules in front of the robot has begun to sag inwards** from the weight of the robot and a lack of support. This problem was hoped to have been solved by a bellypan, but the thin polycarbonate plate simply bent along with the inward sag. Additionally, our intake was swinging around excessively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

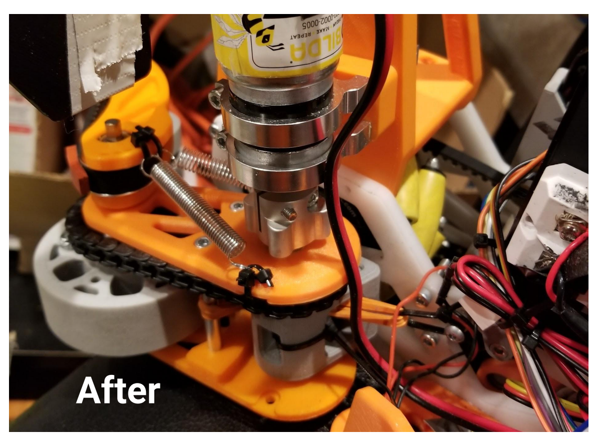
DESIGN EXPLANATION

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





Capstone

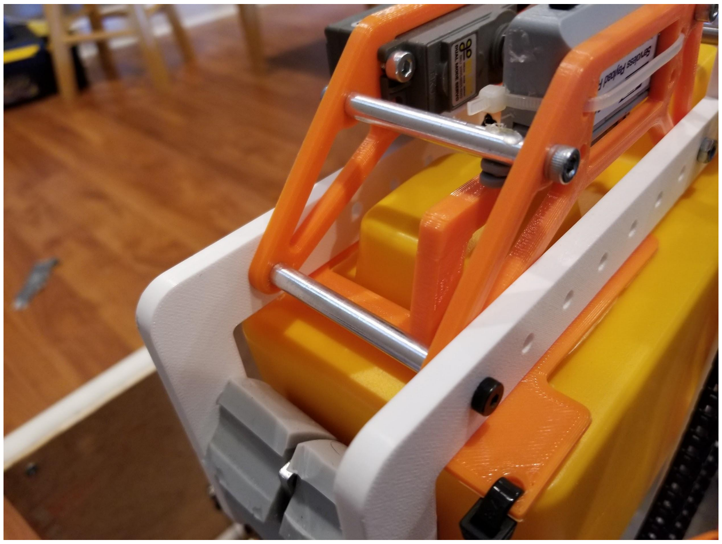
2/15/20

Authors: Eric

DETAILED EXPLANATION:

After analyzing our first qualifier, **we found the most point deficit in the capstone points**. We felt this missed opportunity was too great, however, the compactness of our robot left us with **few mounting options**, especially when holding onto the capstone was very essential so we do not prematurally drop it and lose the potential points gained. This prompted us to **use the servoless payload release mechanism**, which provides a compact solution to our dilemma about how to hold the capstone in place and drop it when appropriate.

The design fits underneath our grabber to **allow the stone to slip into the grabber and to be in the correct position to drop onto a stone**. The minimalist design is enough to meet the minimum dimensions for this scoring element **yet not impede on the grabber's function by blocking the access to the stone**. Small strips of extremely soft 10A durometer silicone keep the capstone from slipping off the tower when we move the foundation or even bump into the foundation. **Any force is cancelled by the high force of friction on the capstone.**



Foundation Dragger V2

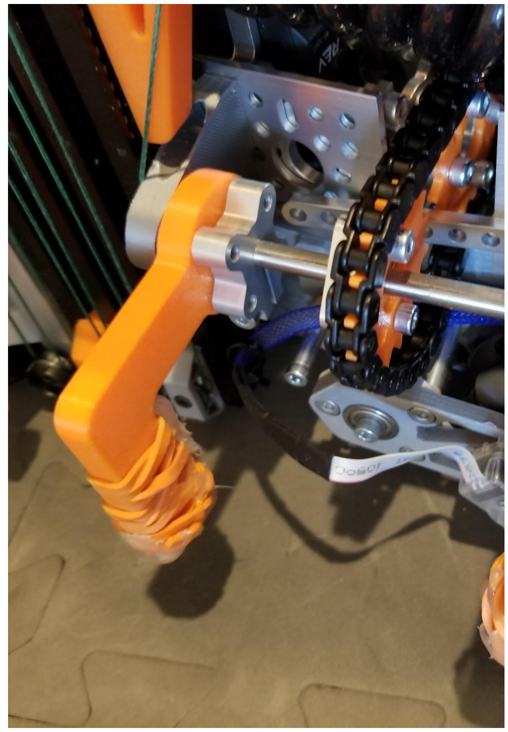
2/17/20

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

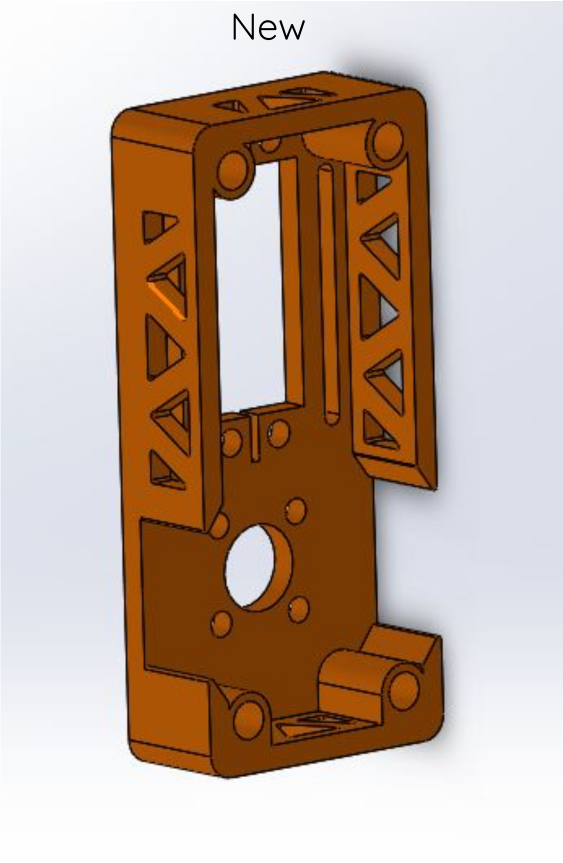
Reinforced Arm Mounts

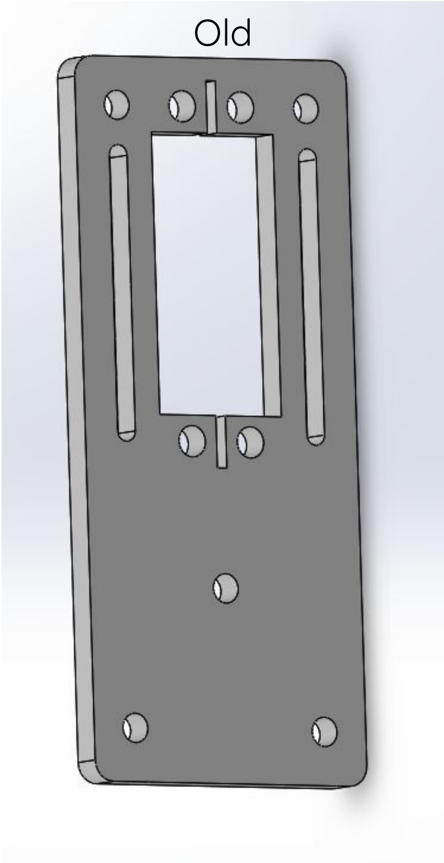
Authors: Eric

DETAILED EXPLANATION:

After analyzing our second qualifier matches and practice runs, we found the mounts the servo connects to warp everytime it tried to flip the arm. The **high torque of the servo was most likely too much for the plates to handle**, with an additional crack forming from a space cut out to fit the servo on the plates in a certain orientation. The bending was preventing the arm from flipping sometimes due to the massive interference from improperly meshed gears on the arm.

This prompted us to redesign the mounts of the servo to have walls and **additional supports around the standoffs and off of the plate**. This way the **force can be distributed to these walls instead of the plate** to prevent bending and the mount can be better aligned with the gear of the arm. Additionally, the part has **increased thickness** to increase the rigidity.





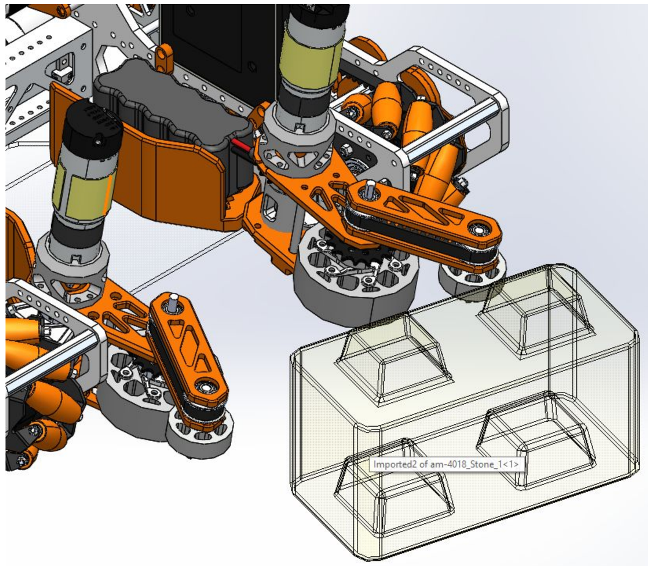
Intake Funnelers Proto

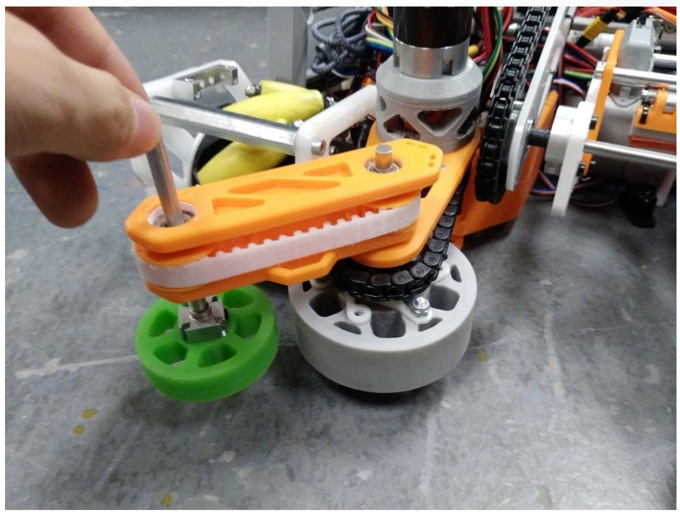
Authors: Matthew

DETAILED EXPLANATION:

Funneling Wheels

- Issue was that the spinning wheels tended to “kick” blocks away instead of bringing them in
- A set of smaller swing out wheels **helps funnel blocks towards the center**, away from the outer parts of the large wheels





Modular Coaxial Hinge

- Powered using old intake shafts, and pivots on them using a bearing
- **Modular**, reuses old components, easy swap

TPU Belts

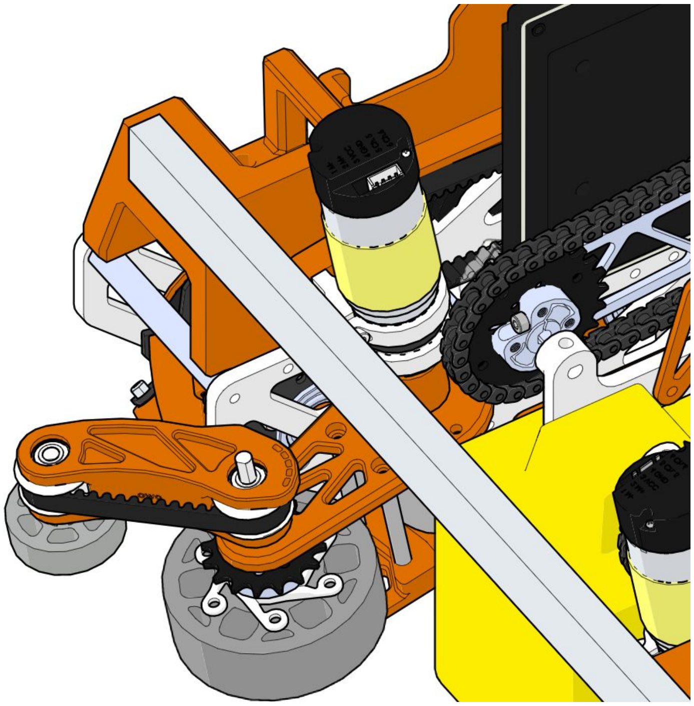
- Tight on time before states competition, designed **3D-Printed TPU timing belts** for prototyping
- Allows us to **iterate before parts come in**

Intake Funnelers V2

2/21/20

Authors: Matthew

DETAILED EXPLANATION:

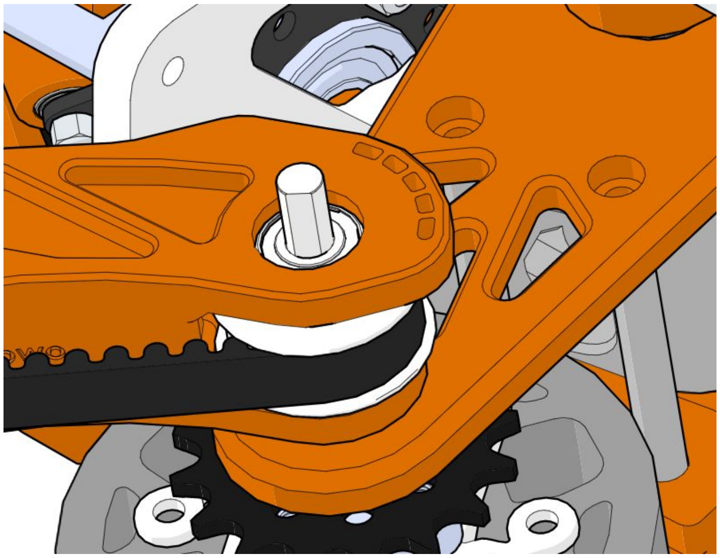


Concave design

- First iteration had dead zones in between wheels
- Concave design leaves room in the middle for **constant wheel contact**

Adjusted Intake Endstops

- Old intake tended to not have enough contact with block
- Moved **intake wheels closer together** by adjust maximum intake endstop angle
    - Blocks are shot through faster due to **better contact**, no half-intaking blocks



Tensioning Slots

- Line of slots on intake serve for **zip-tie points for tensioning** using rubber bands/springs
- Makes it **easy to test** different spring tensions

Grabber V2

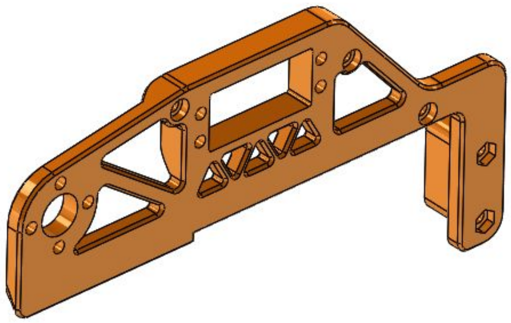
Authors: Andrew

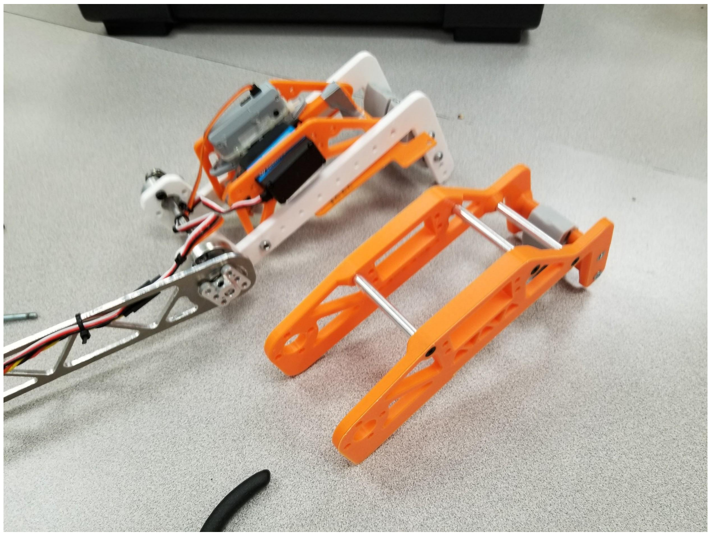
DETAILED EXPLANATION:

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.



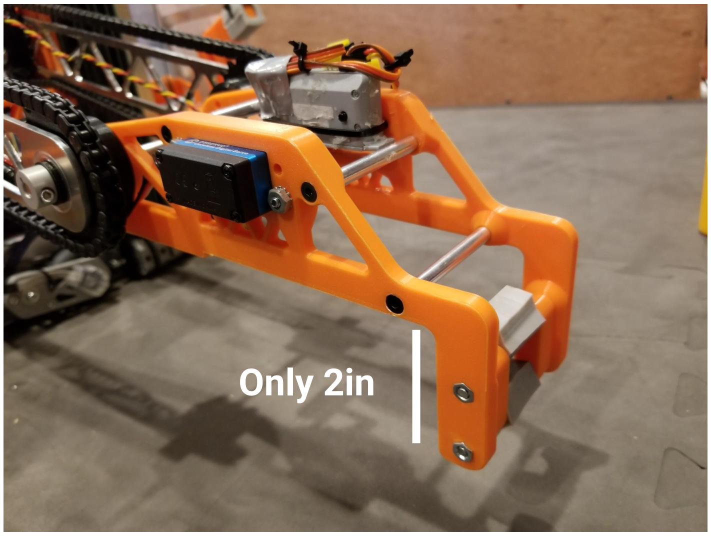


Lighter

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.



Equal Slides Stringing

2/27/20

Authors: Matthew

THE PROBLEM

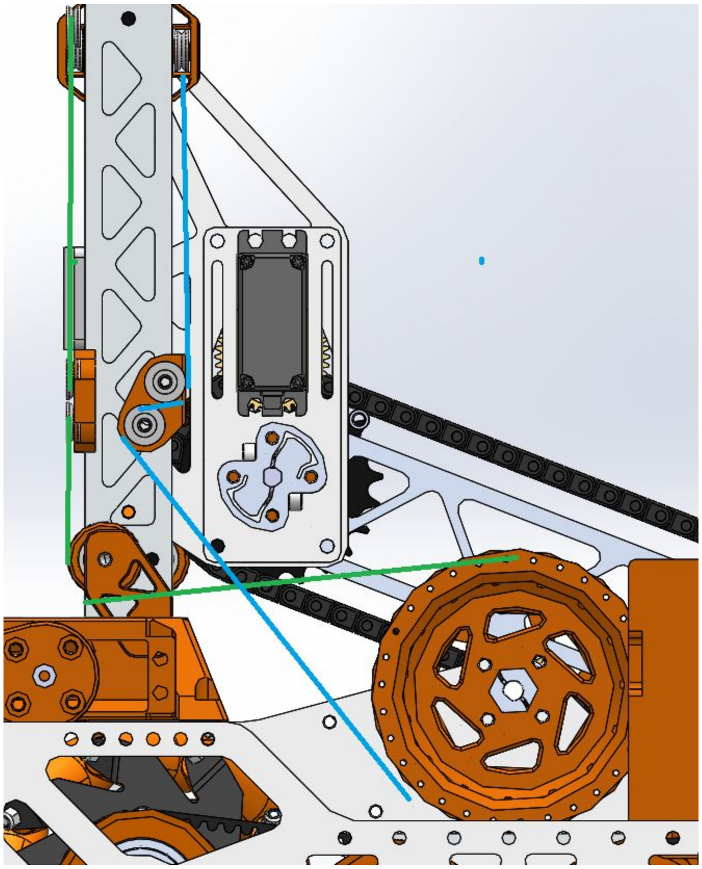
Previous slides tilting left/right

- Slides were **previously strung one side up/ the other down**
- **Slides leaned** one way because only one side was held up

THE SOLUTION

"Double up - one down"

- **Both sets of slides pull upwards**
    - Equal force on each side
    - Keeps the grabber balanced, **eliminates tilt**
- **Only one return string**
    - Alignment doesn't matter as much for return stringing
    - Easy to employ the inner set of pulleys, included earlier for redundancy
    - Easy to double-stack one side's pulleys to power it
    - Having only one return greatly **simplifies stringing**



VIRUS 9866

2019-20 Design Notebook

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