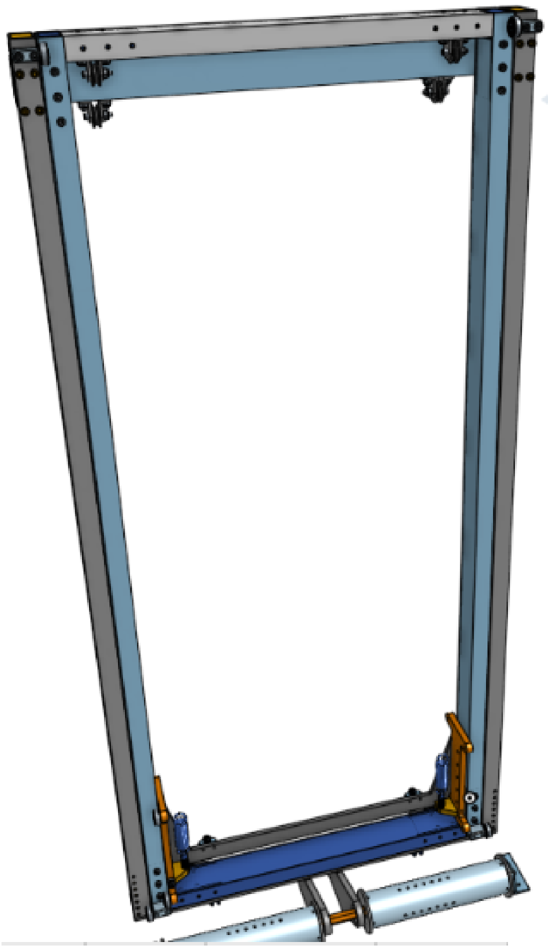
FRC Team 7407 - Wired Boars

Two-Stage Parametric Elevator Project

CAD Process & Fabrication Results

Fabrication & Assembly Support from our friends at FRC

Team 2168 - Aluminum Falcons!



[Onshape Link]

Project Background

This project was used for CAD training for FRC7407 members in preparation for the 2022 FRC game, Rapid React. We included this project in the Advanced Robotics Concentration (ARC) course CS560 Competition Robotics as final training before build season. This project taught more advanced CAD methods and the importance of 2D sketches in mechanism design. This project also served as machining and CAM/CNC training for many students on FRC 2168 as their team members fabricated the final elevator design.

We used Onshape to create our model. Onshape is an online CAD tool made for computers of any performance level, and allows anyone access due to its web-based interface.

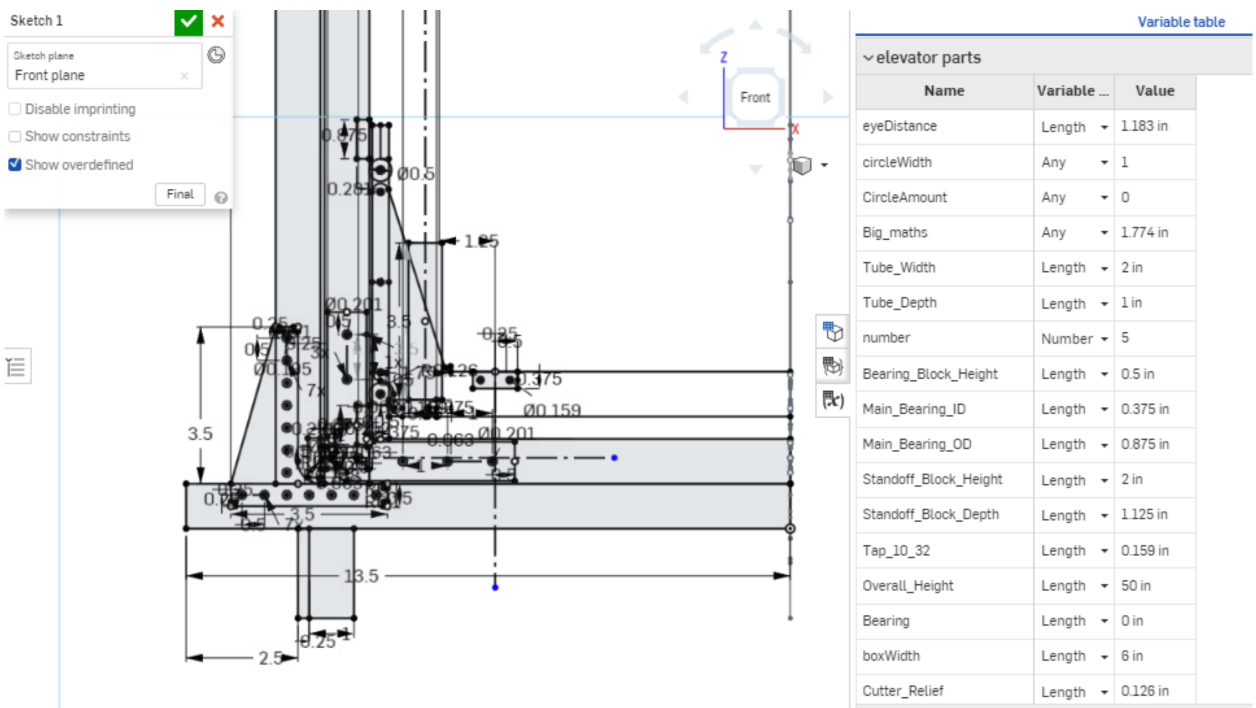
The 2D sketches were made perpendicular to each other, and each represented the two sides of the full model. Each shape was extruded from one and constrained around the other sketch. Once the sketching is out of the way, it becomes a breeze to create parts. To get through the 2D sketching process, all you need is a mouse, keyboard, and lots of patience.

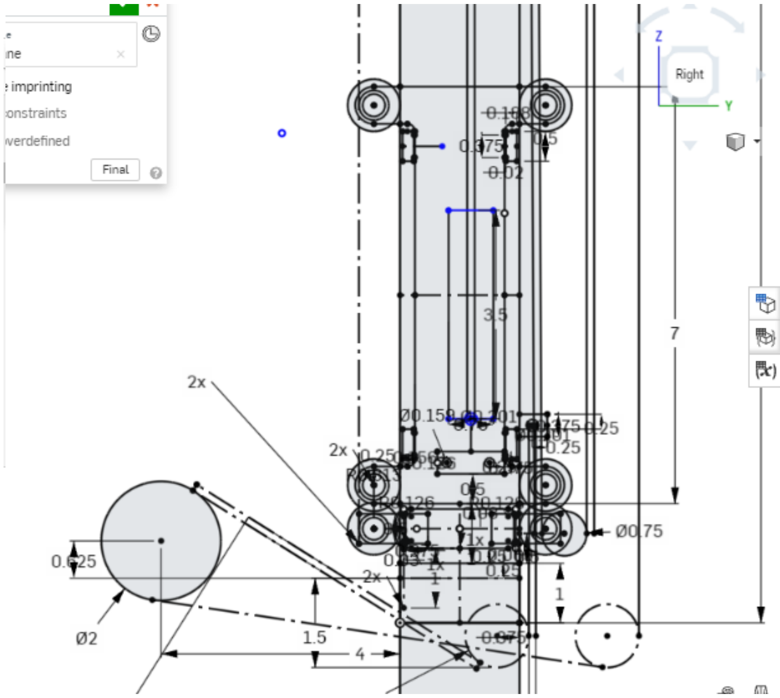
The variables we included allows the parametric elevator to be converted and modified to your specifications (I.E Drivetrain, forklift, skyscraper, anywhere else you might need a parametric elevator). Be mindful that some variables influence others throughout the entire model, so if your team decided to use this model, make sure to change the variables carefully.

2D Sketches & Variables

Variables to Use:

- Overall Height: Overall_Height
- Tube Dimensions
  - Width: Tube_Width
  - Depth: Tube_Depth
  - Thickness: Cross_Tube_Wall_Thicknes
- Bearing Holes
  - Inner Diameter: Main_Bearing_ID
  - Outer Diameter: Main_Bearing_OD
- Cutter Relief: Cutter_Relief
- Stage Gap (the gap between each section of the elevator): Stage_Gap
- Bolt: Tap_10_32 (change the value of the variable, not the name, Onshape gets mad otherwise)





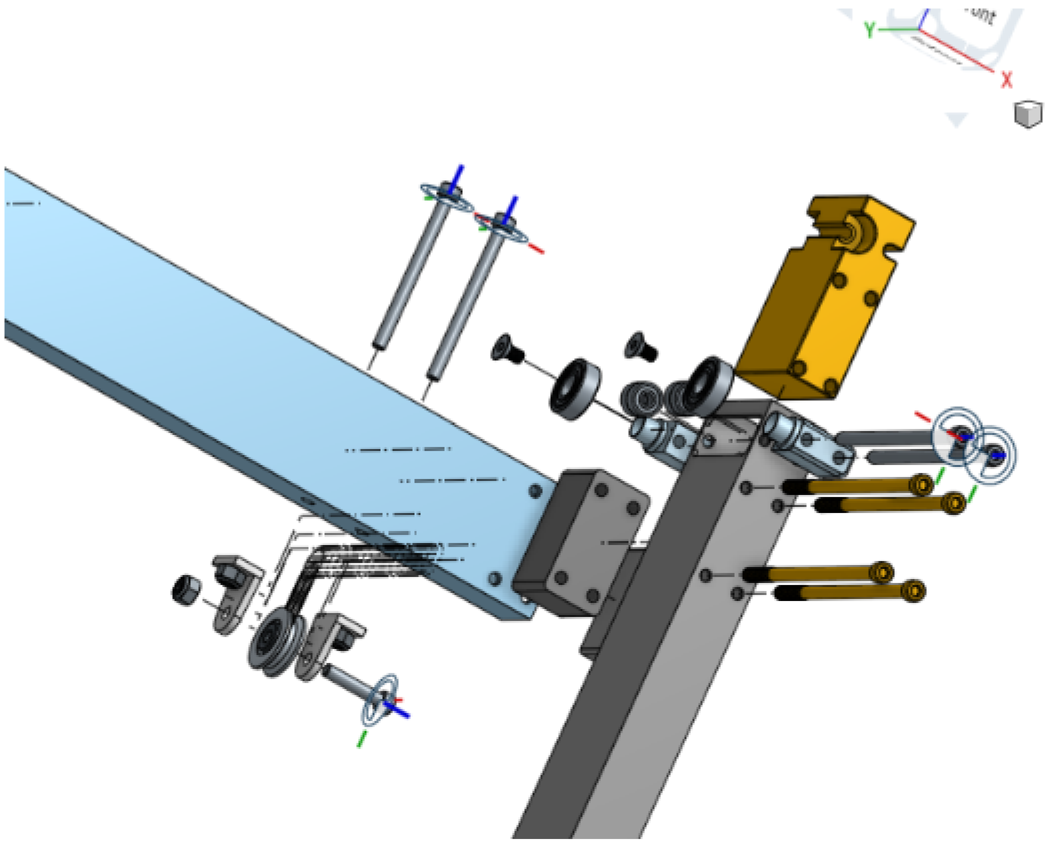
elevator parts

Name	Variable ...	Value
eyeDistance	Length	1.183 in
circleWidth	Any	1
CircleAmount	Any	0
Big_maths	Any	1.774 in
Tube_Width	Length	2 in
Tube_Depth	Length	1 in
number	Number	5
Bearing_Bloc...	Length	0.5 in
Main_Bearing...	Length	0.375 in
Main_Bearing...	Length	0.875 in
Standoff_Blo...	Length	2 in
Standoff_Blo...	Length	1.125 in
Tap_10_32	Length	0.159 in
Overall_Height	Length	50 in
Bearing	Length	0 in
boxWidth	Length	6 in
Cutter_Relief	Length	0.126 in

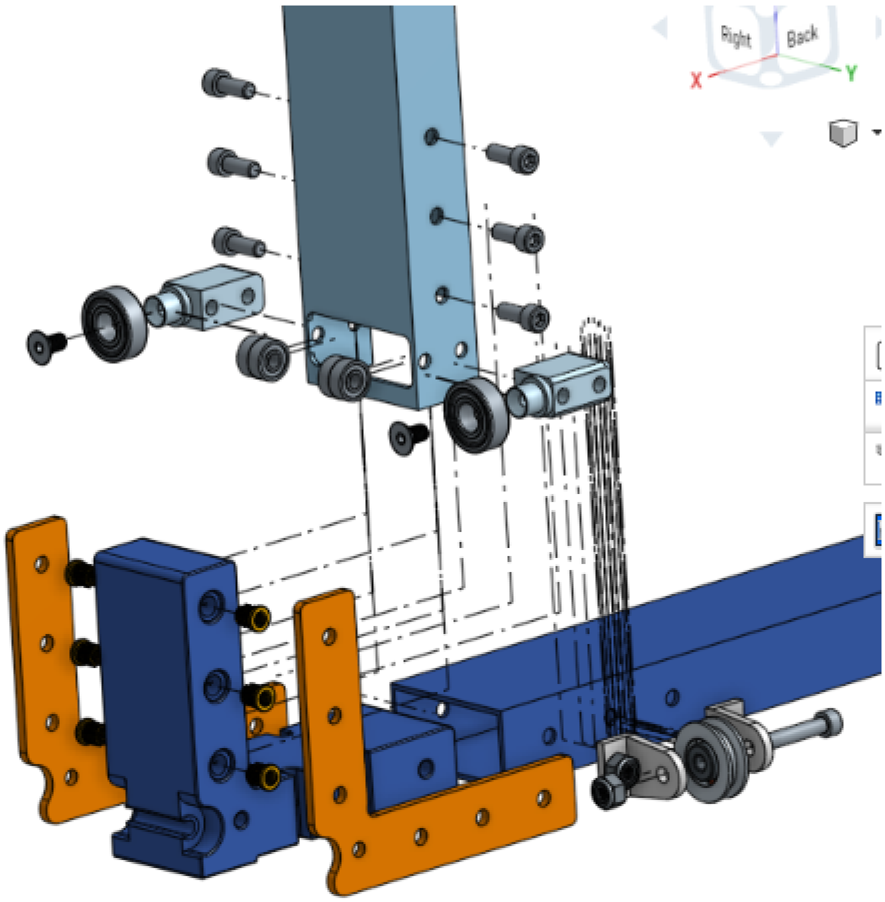
General Construction

This elevator leveraged 3D printed tube plugs at the ends of each tube. This served several purposes, varying by location, but one general benefit was the ability to tighten fasteners past the point that would normally crush tubing. This results in a more rigid bolted joint at a small weight cost.

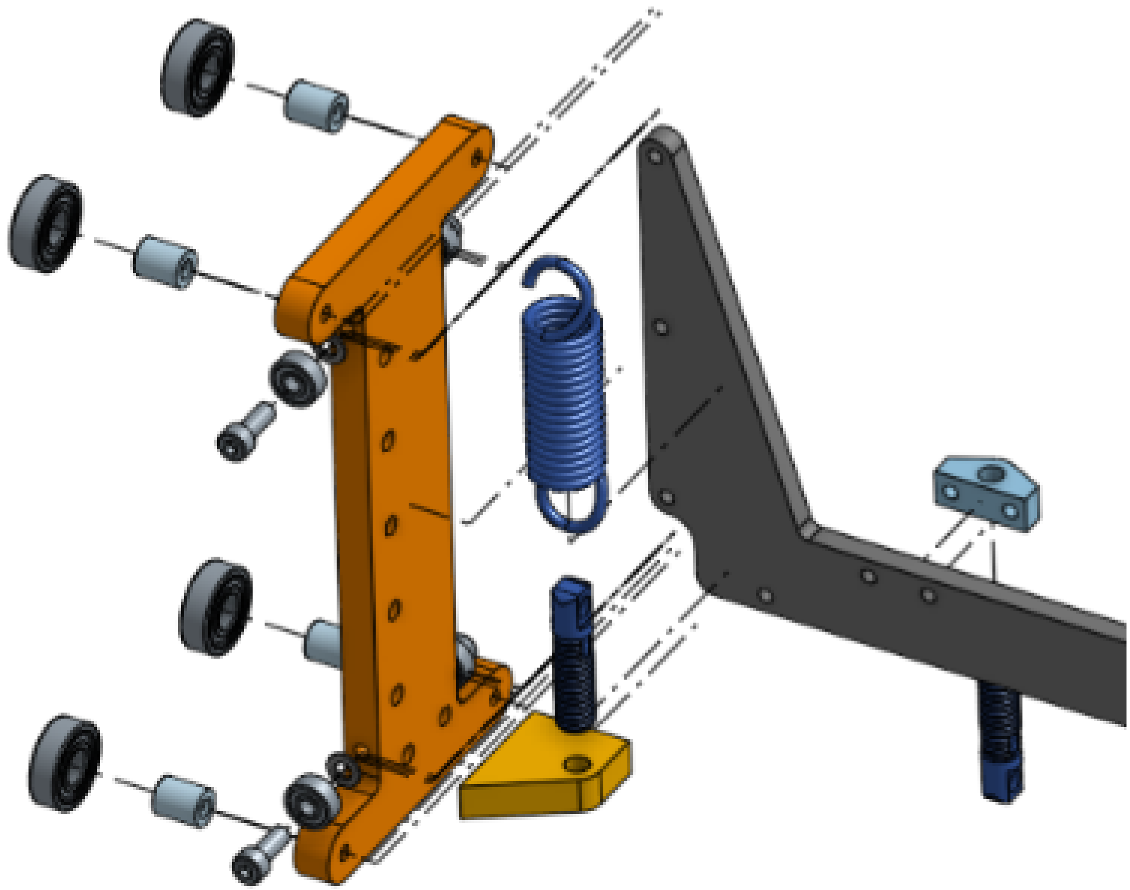
Stage 0



Stage 1



Stage 2 (Carriage)

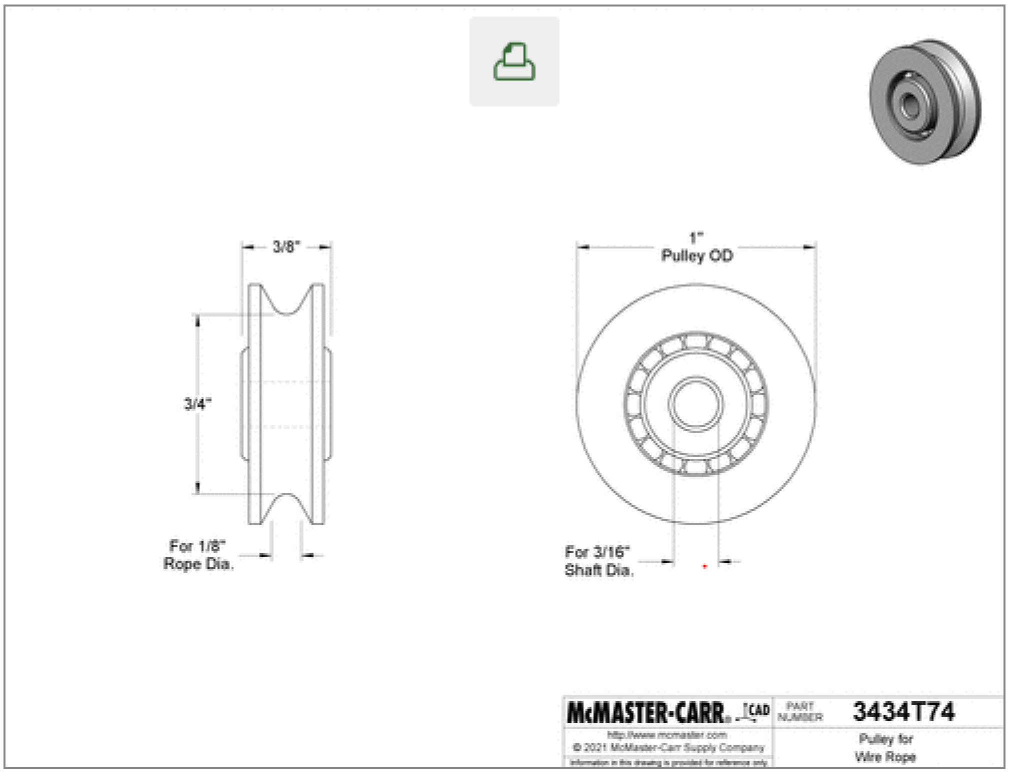


Rigging

COTS Hardware

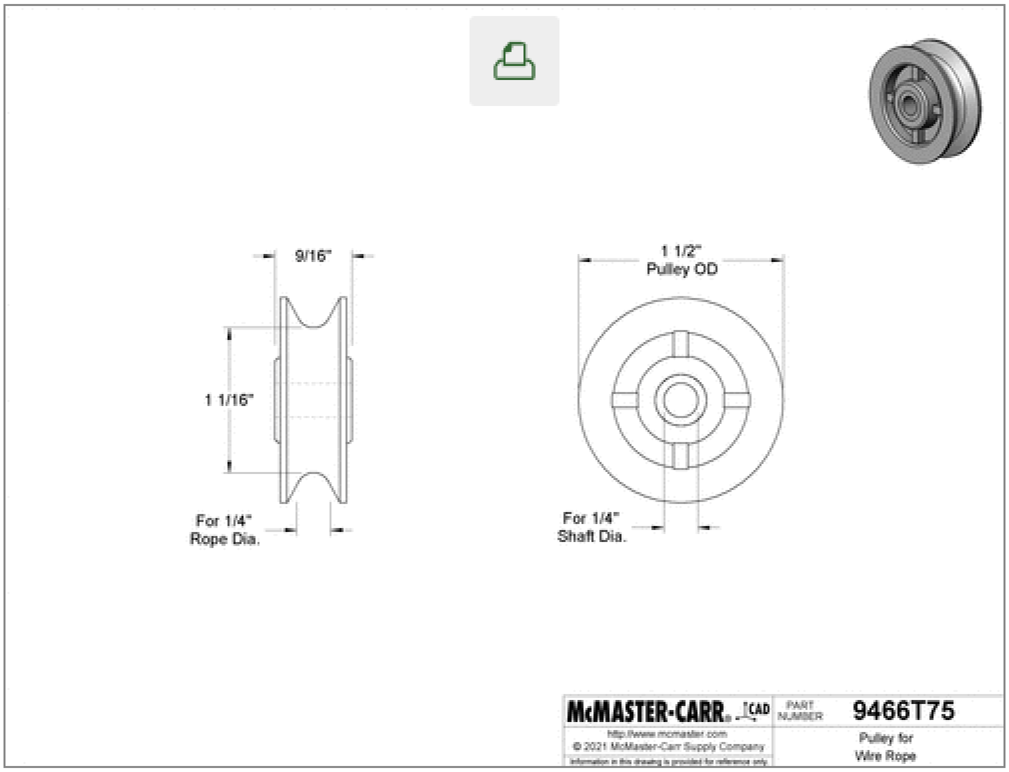
The majority of the elevator pulleys were the below component:

https://www.mcmaster.com/3434T74/

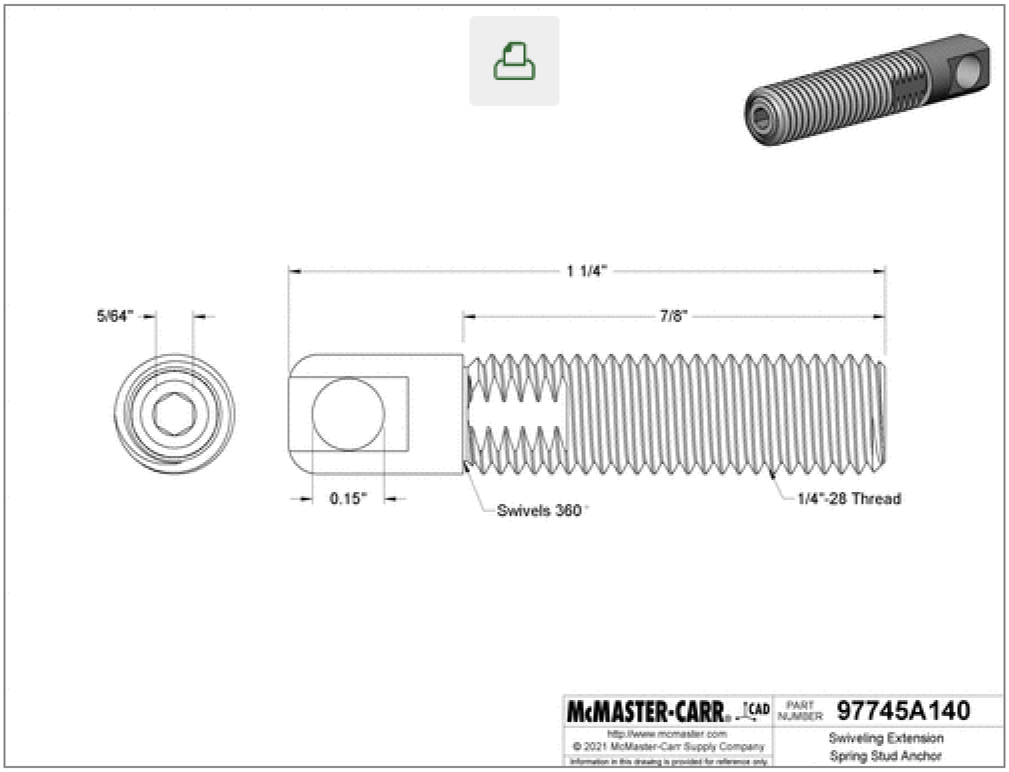


https://www.mcmaster.com/9466T75/

The 4 pulleys used to redirect the cable onto the elevator cable drum were selected for a larger rope size than what was used. This was done so that the likelihood of jumping the pulley groove when spooling at higher fleet angles was reduced which is only applicable to the pulleys that feed the spool drum.

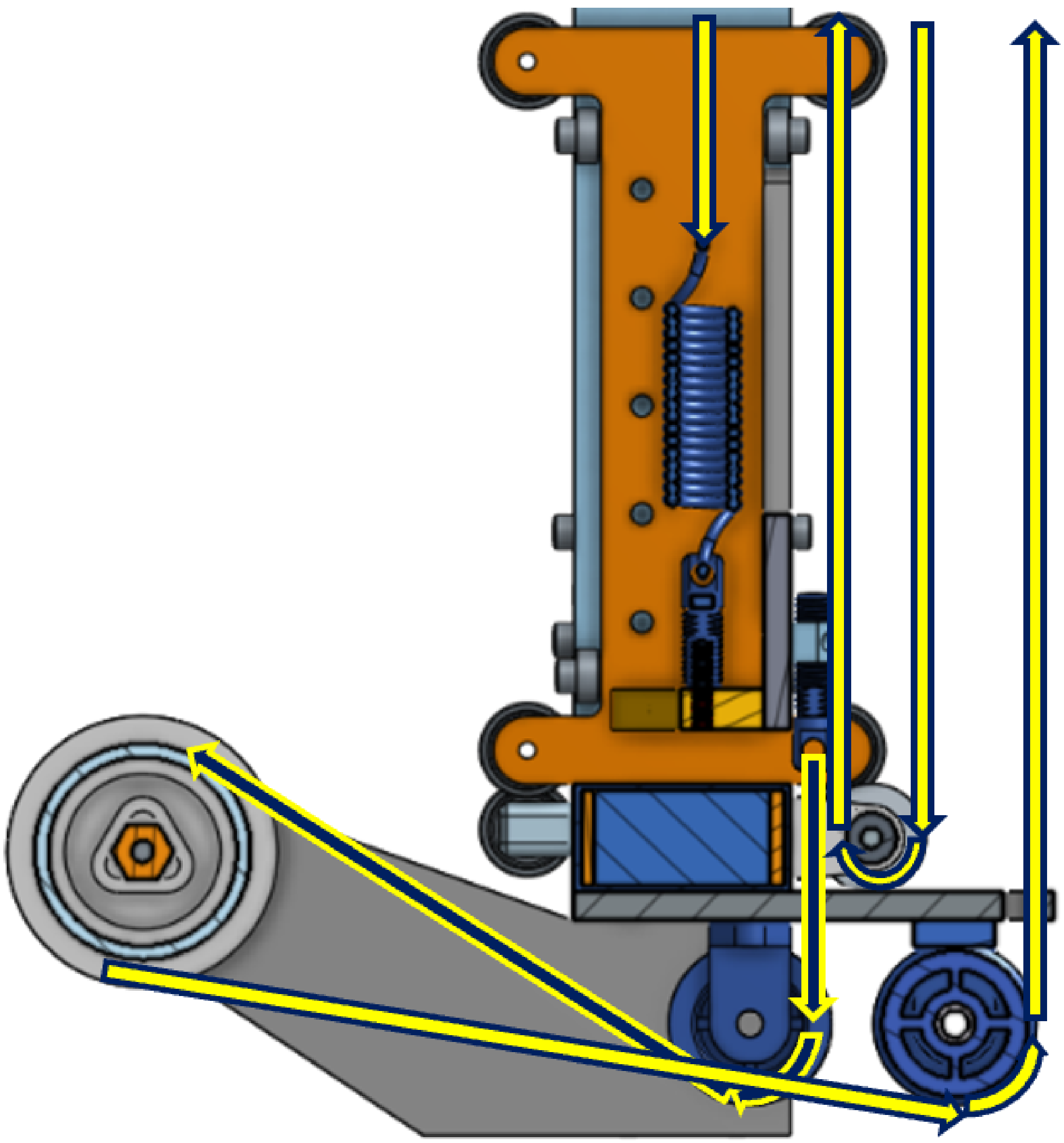


To anchor the cable into the carriage an interesting component called a Swiveling Extension Spring Stud Anchor (https://www.mcmaster.com/97745A140/) was used. These are a bit pricey and Eye bolts would definitely work here. The hope with these was that they would allow us to tune the cable tension as well as the level-ness of the carriage to account for slight differences in cable knot position/loop size.



1 1/4"
7/8"
5/64"
0.15"
Swivels 360°
1/4"-28 Thread
McMASTER-CARR
CAD
PART NUMBER
97745A140
http://www.mcmaster.com
© 2021 McMaster-Carr Supply Company
Information in this drawing is provided for reference only.
Swiveling Extension Spring Stud Anchor

Layout

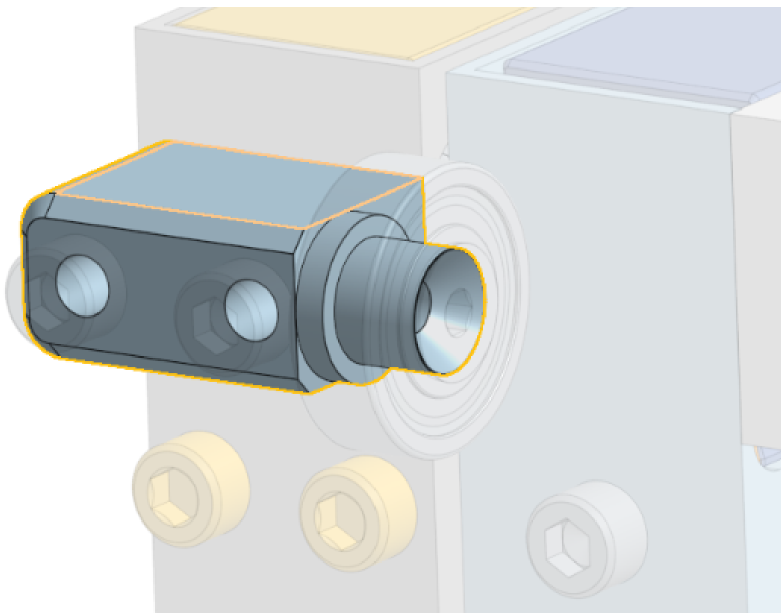


Fabrication Resources

Custom Aluminum Components

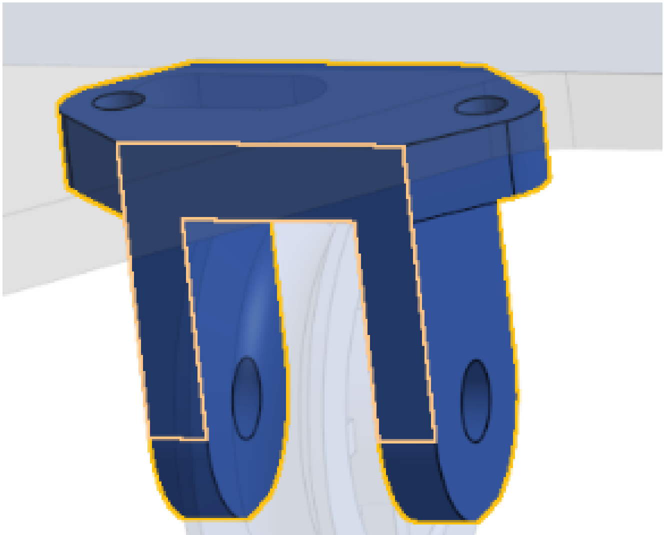
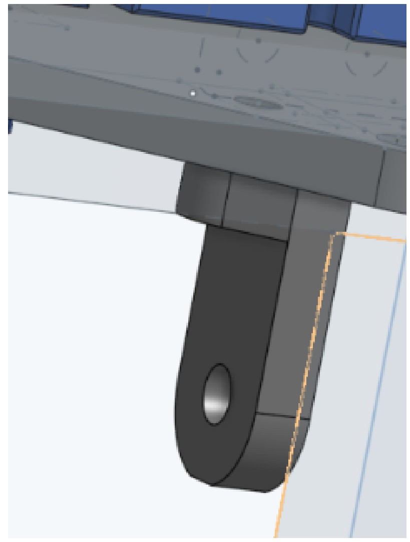
All custom aluminum components were designed to be machined on a CNC router like an OMIO x8 or a CNC mill. However, the tubes could also have been machined on a normal bridgeport by a skilled user as none of them carry any shapes that aren't circular or rectangular features.

One difficult part to machine is the bearing blocks. Bear in mind the chamfer was completely decorative.



This was accomplished with .5” x .75” bar stock. We had accomplished it in two operations. We had to tune the outer diameter fit of the bearing post to fit the ID of the bearing.

Another difficult part to machine was the lower pulley blocks. These blocks, as it would turn out, are needlessly complicated, machined from billets. In the future these will be machined in two pieces from ¼” wall structural tubing or angle aluminum.

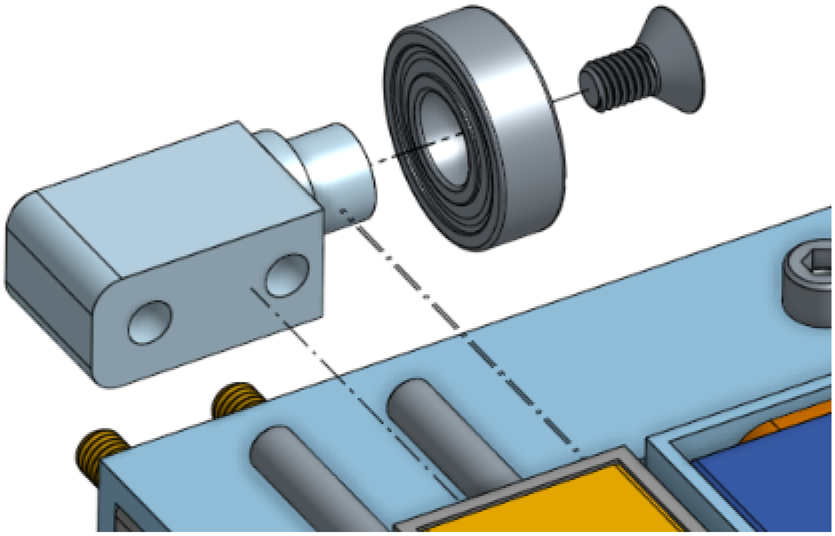
Every other part was a standard tube program or a standard sheet program.

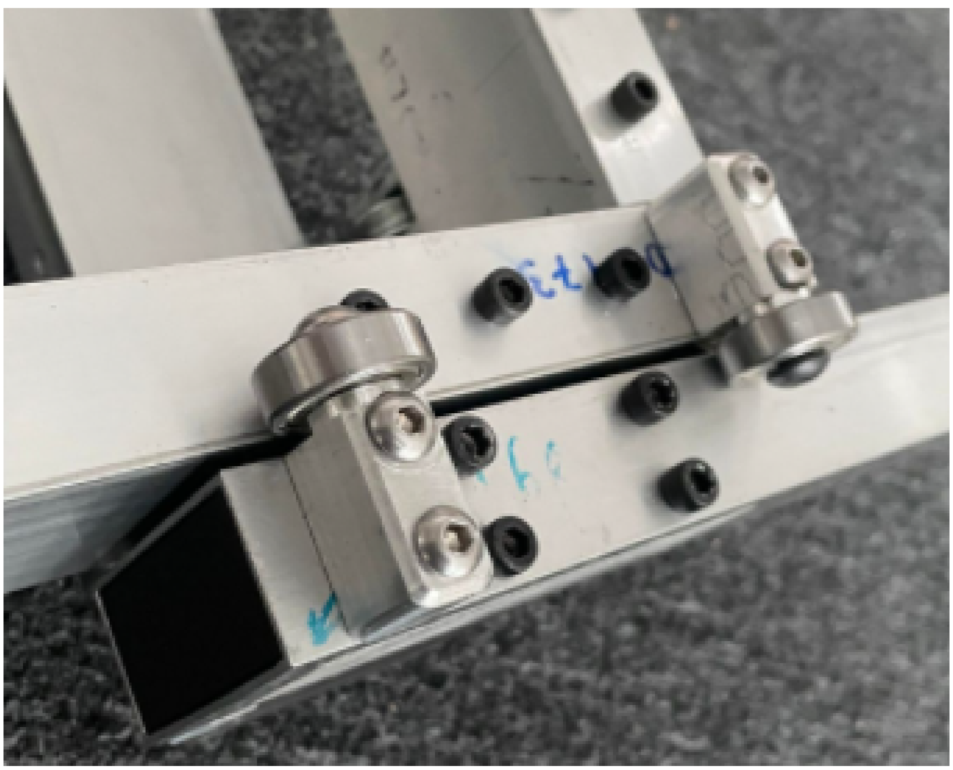
3D Printed Components

There was a 3D printed block at every end of every tube. This helps with crushing the tubes when fastened as mentioned before. For this elevator, all the components were 3D printed on a MarkForged Onyx One. It should be noted that these didn't need to be as strong as they are in just about every situation due to the strategic placement of aluminum gussets in stage 1 to reinforce the prints, and all other 3D printed blocks acting in compression primarily.

Lessons Learned in Construction

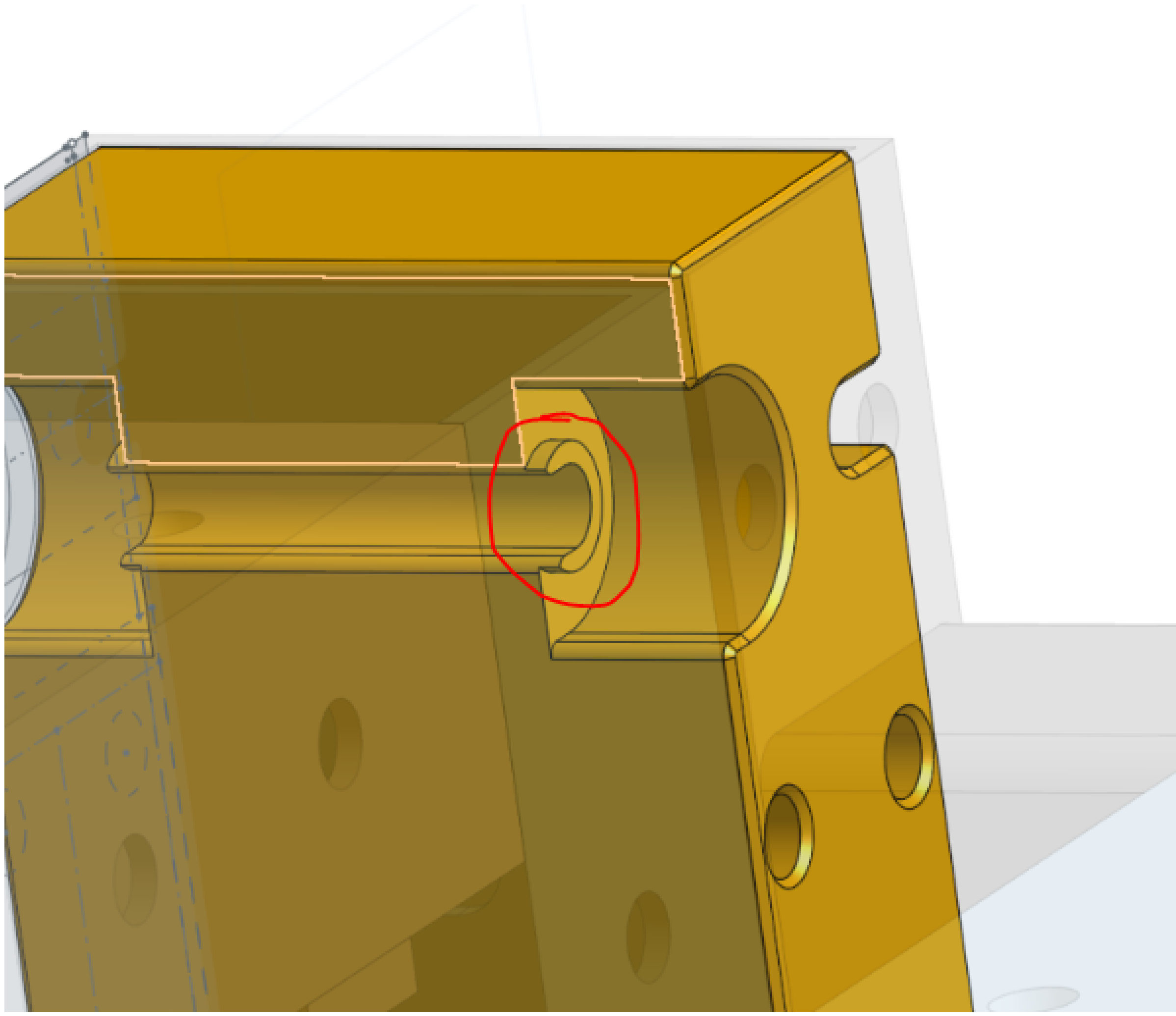
1. 10-32 countersink bolt heads are smaller than ⅜" OD. This is misrepresented by the bolt models on McMaster-Carr and resulted in a last second design change to ¼-20 bolts to secure the elevator bearings to the bearing block.





2. Some of the hole patterns on the elevator are inconsistently sized and needed to be drilled larger. This wasn't a huge issue but could be easily altered to save time in the future.

3. The 3D printed stuffing blocks fit well but the inner race support was printed a bit too tall on one side of the block by printer accuracy (MarkForged Onyx one) shortening that inner race support should make the axial clearance better.



4. The inserted blocks required some significant persuasion with hammers and sandpaper to get them to fit into the ends of the tubes. This was preferable in some ways though as it resulted in a very stiff construction once assembled fully.