

16.810: Team M4

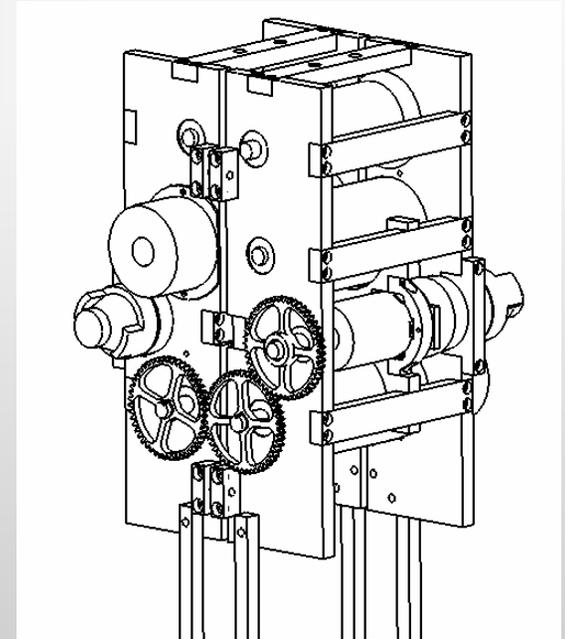
Optimizing Roller Assembly

Ryan McLinko
Carolyn O'Brien

IAP 2007

Motivation

- Roller assembly moves climber up ribbon
- Rollers, plates, and sidebars all have extra mass
- Purpose
 - Less power needed to climb
 - Increased score



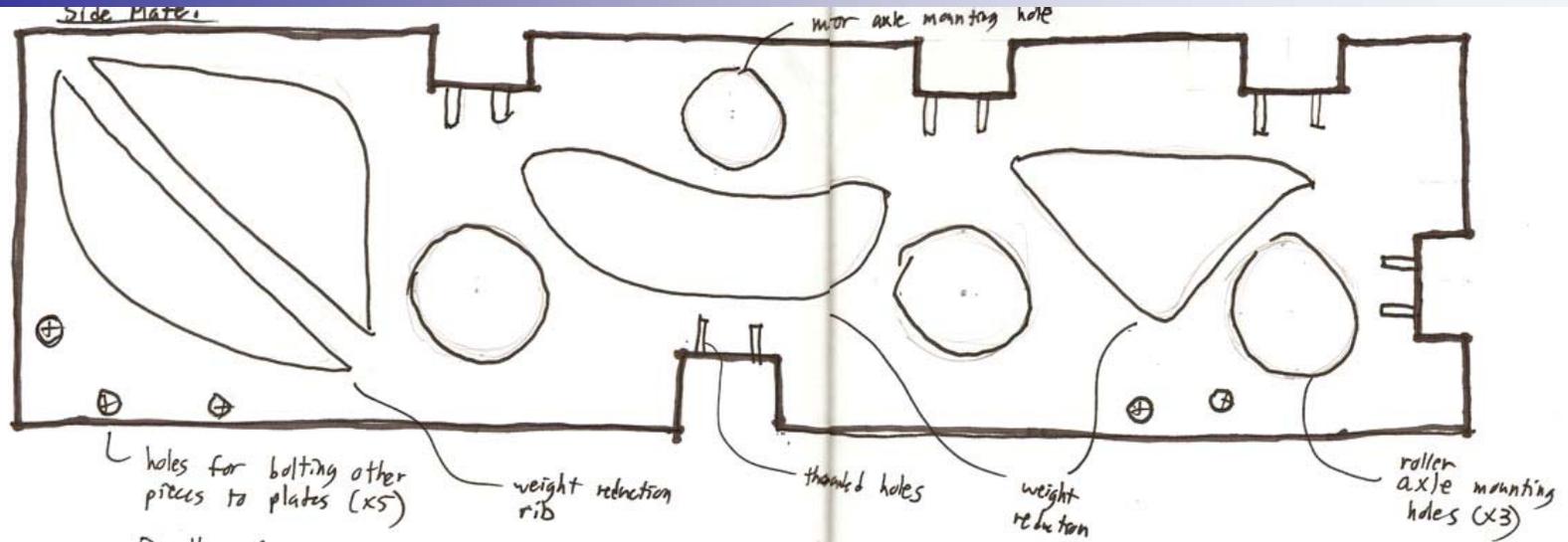
Requirements

- Minimize climber weight
- Minimize climber cost
- Minimize time to attach climber to ribbon
 - Must be < 4 min
- Maintain von Mises Factor of Safety > 2

Constraints

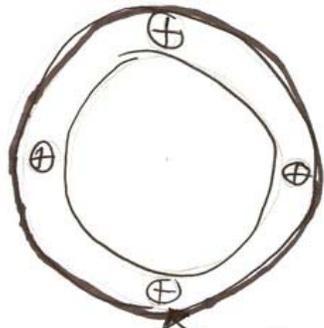
- Climber must survive a 2 m drop test
- Climber must lift own weight
- Average speed > 2 m/s
- Material unaffected by 5.8 GHz microwaves
- Climber unaffected by water
- Climber must resist 11.5 mph winds

Initial Sketch



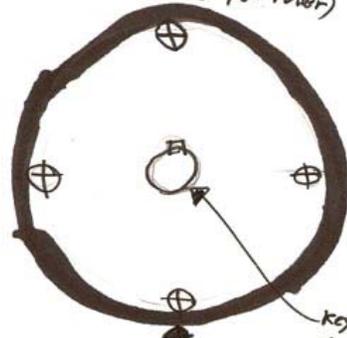
Rollers:

Roller tube



4x screw holes to screw caps into roller tubes

Roller cap (2 per roller)



keyed shaft hole

Side Bar:



counter sunk holes to bolt into side plate (x5)

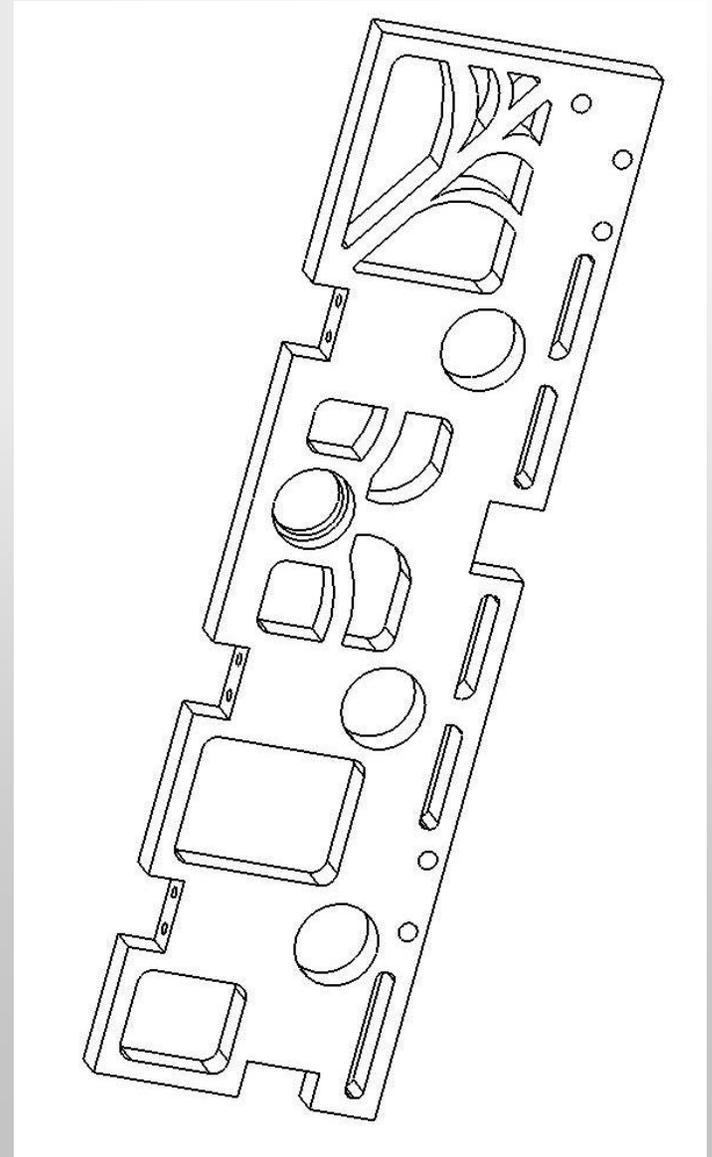
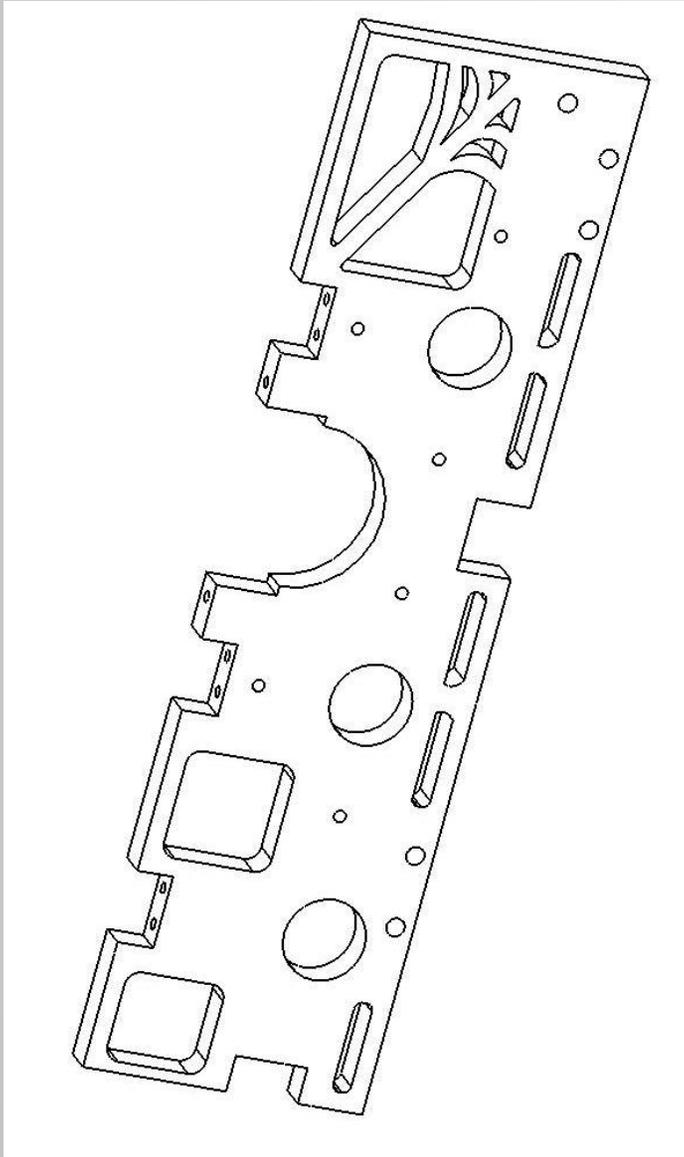
weight-reduction rib structure

Team M5: Initial Concept
 Orthographic
 Carolyn O'Brien
 Ryan McLinko

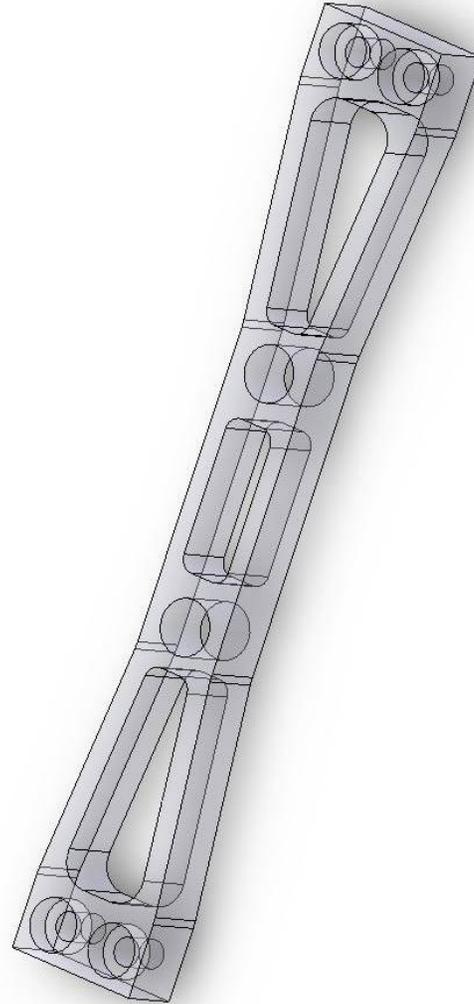
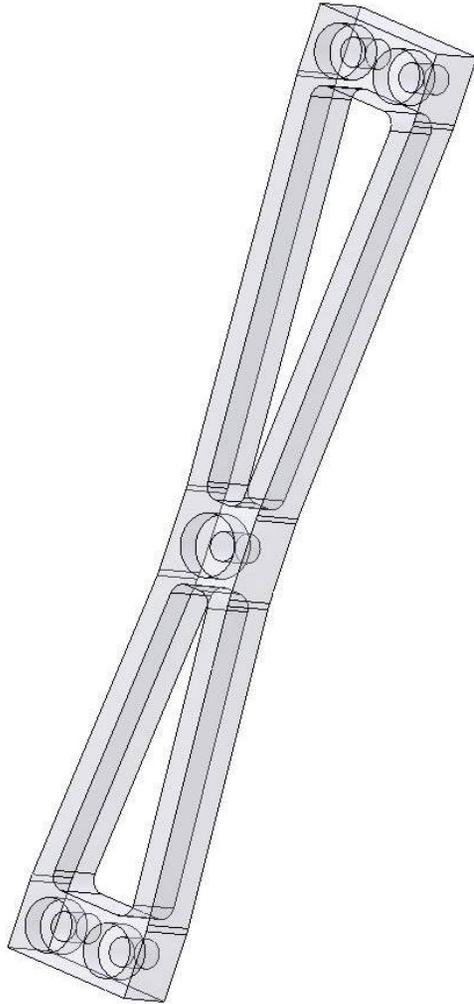
Design Choice

- Initial design was given
- Holes placed in strategic locations
- Refined with FEA software

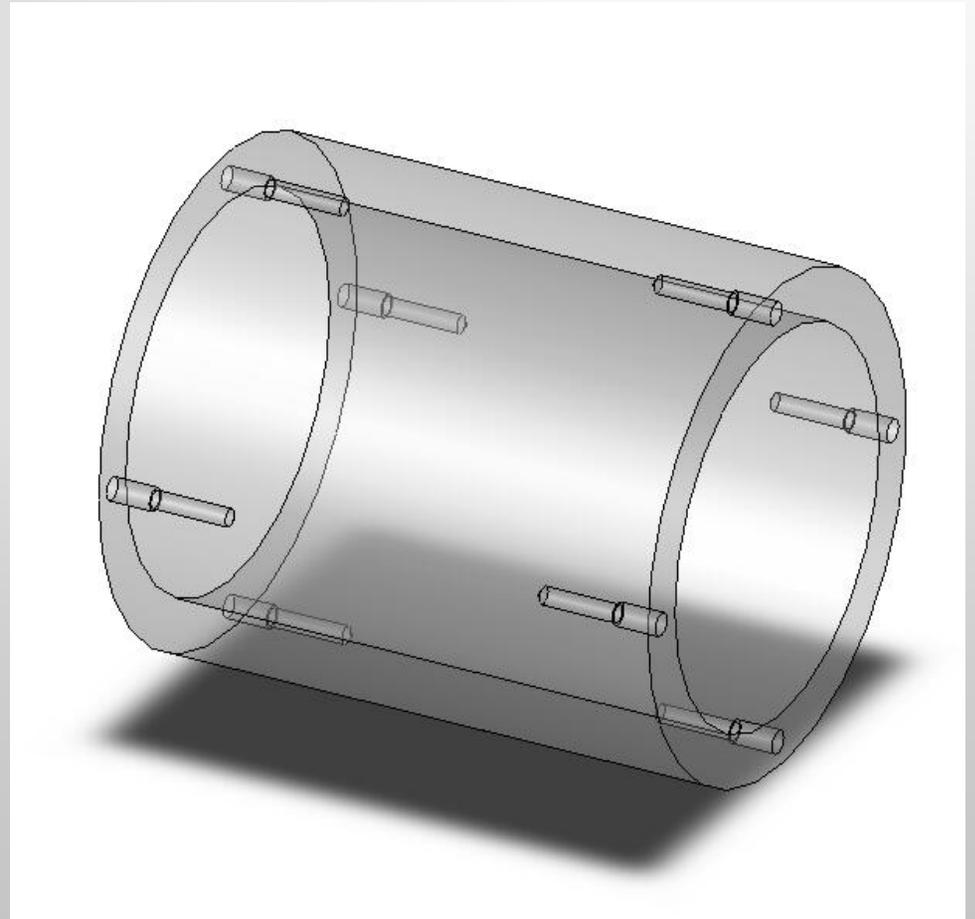
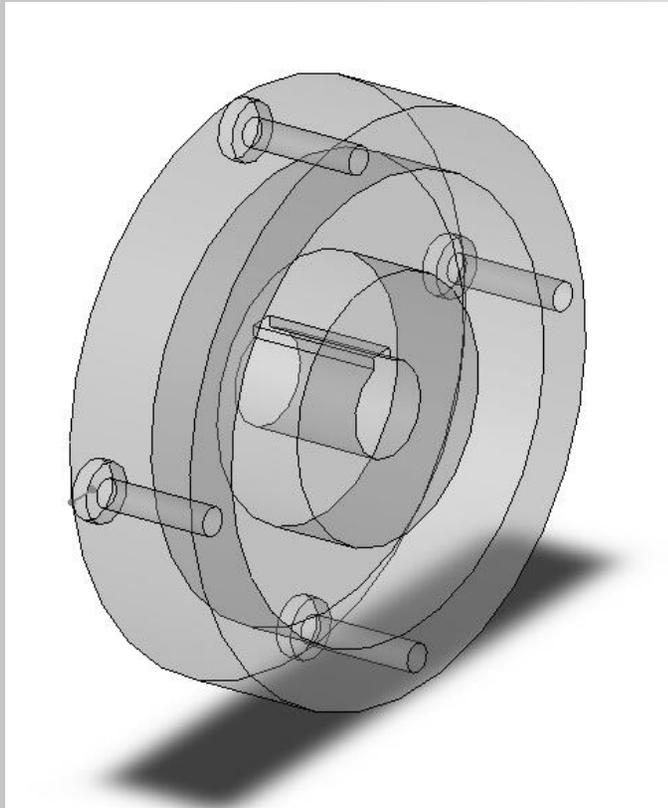
CAD Model: Side Plate



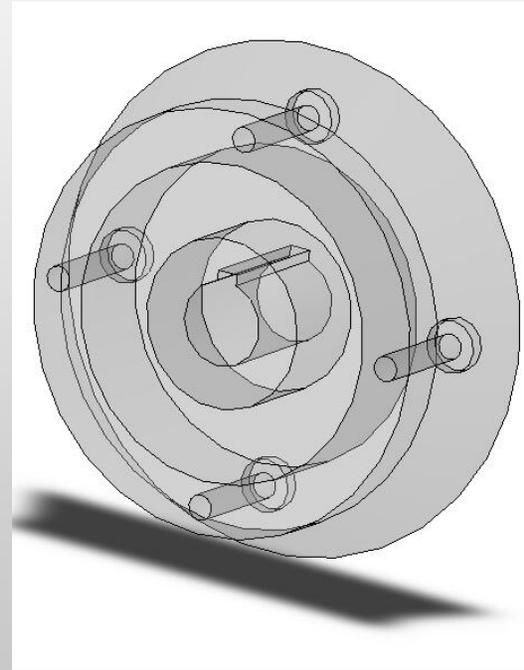
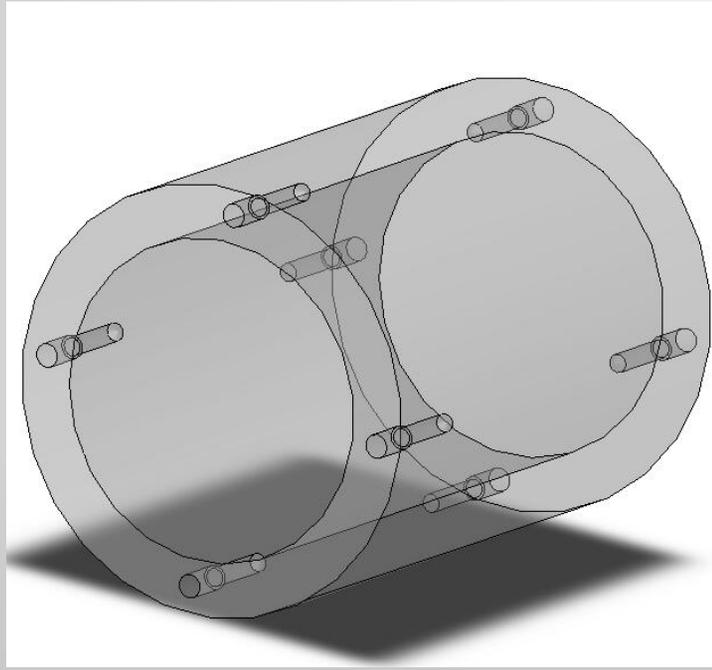
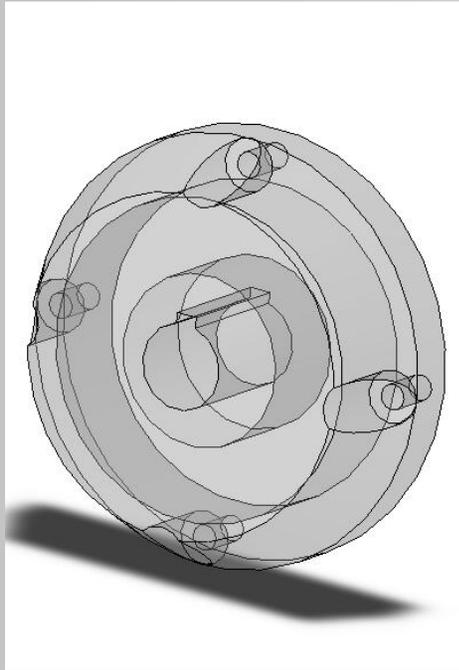
CAD Model: Side Bar



CAD Model: Drive Roller

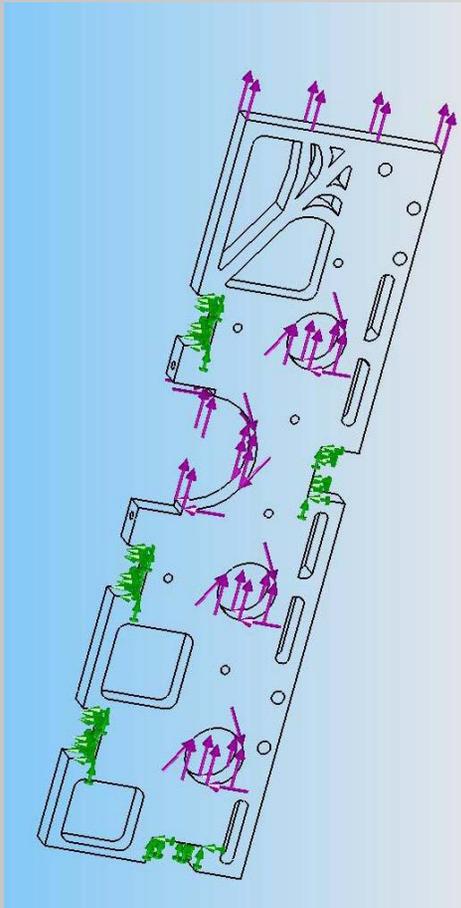


CAD Model: Guide Roller

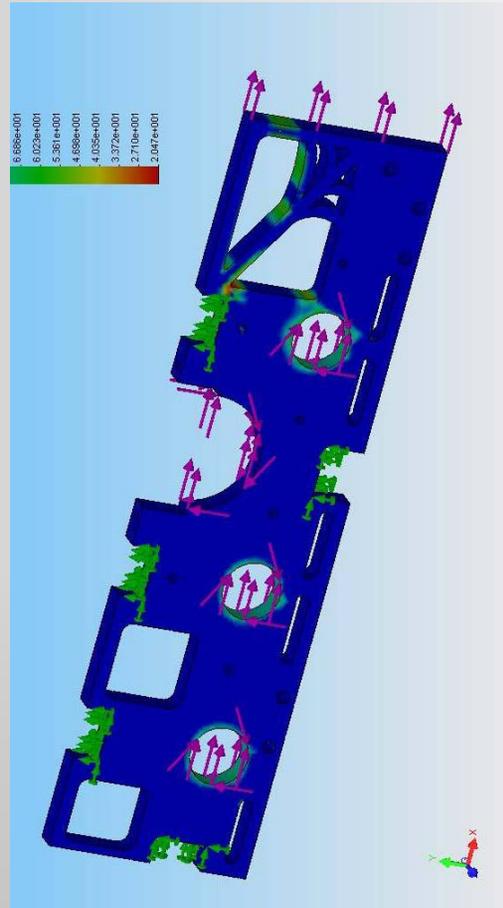


FEA Analysis: Side Plate Left

Forces

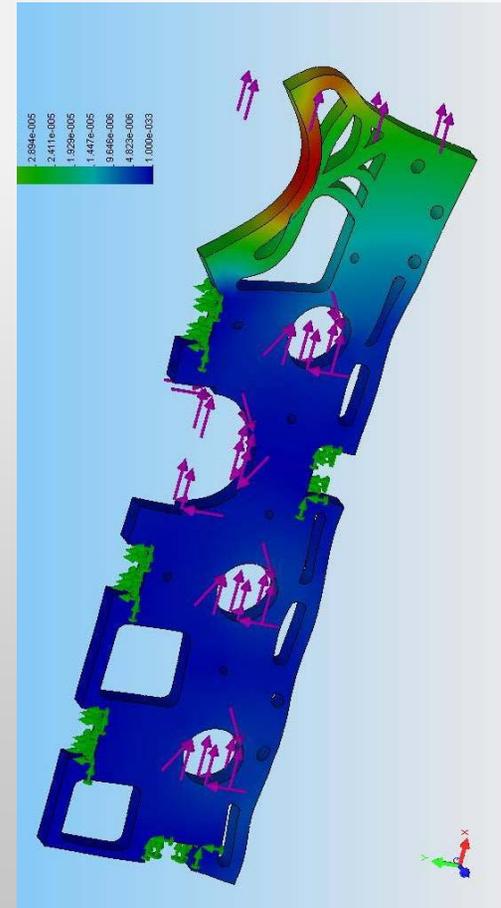


FOS



min: 20

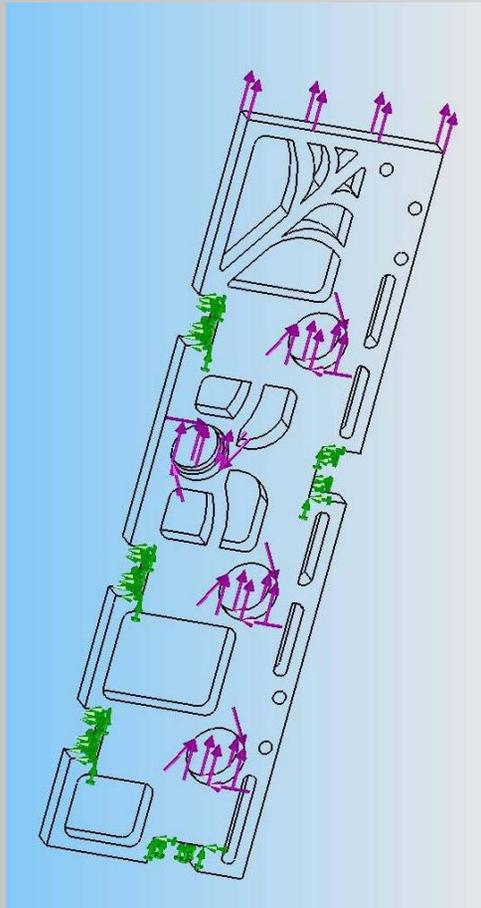
Displacement



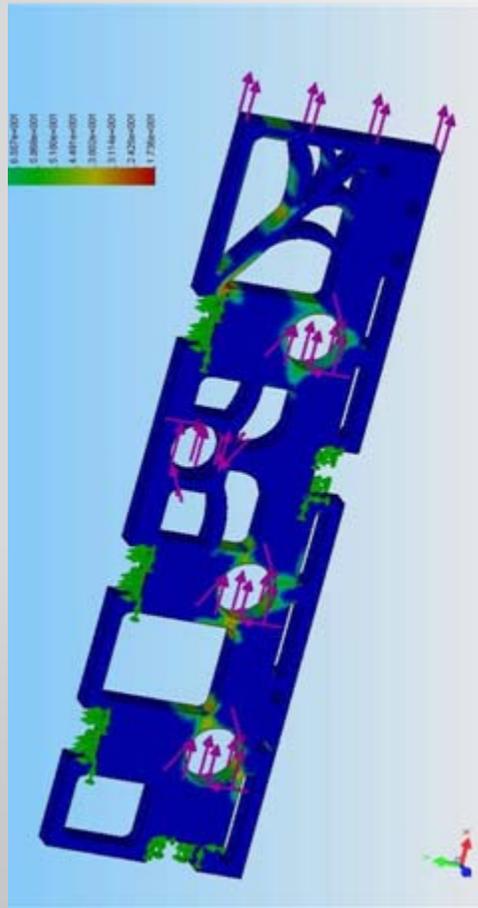
max: 5.8e-
5m

FEA Analysis: Side Plate Right

Forces



FOS



Displacement

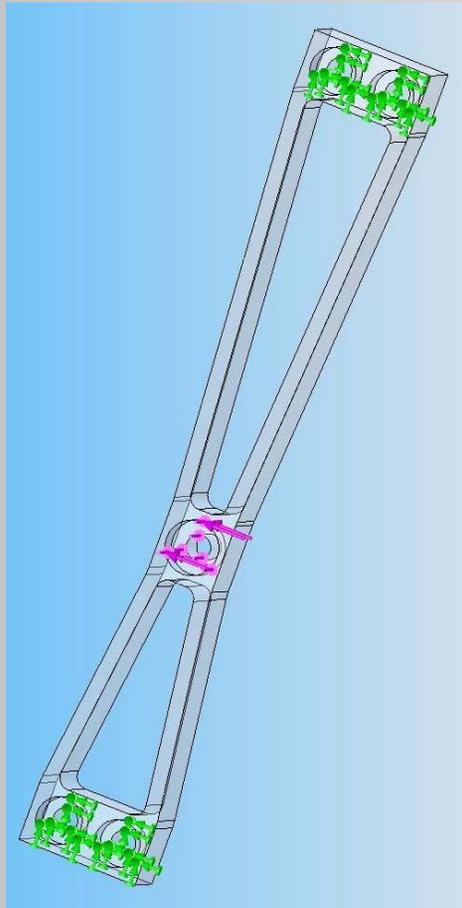


min: 17

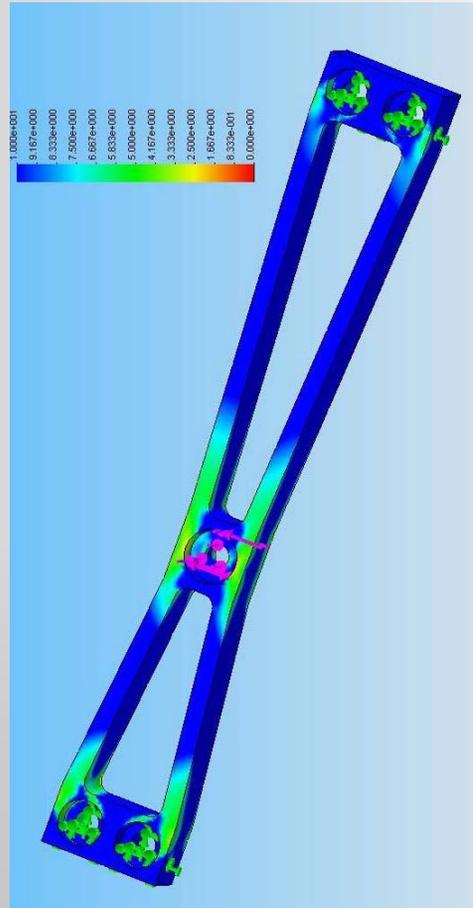
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5m

FEA Analysis: Side Bar

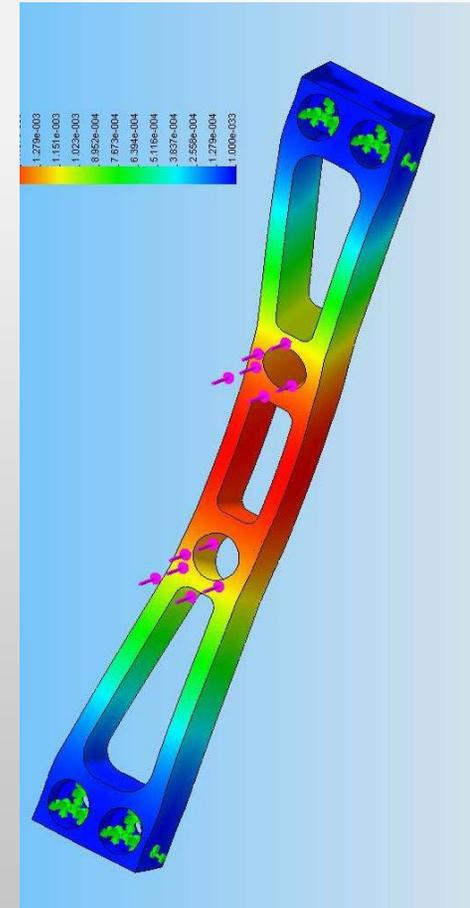
Forces



FOS



Displacement

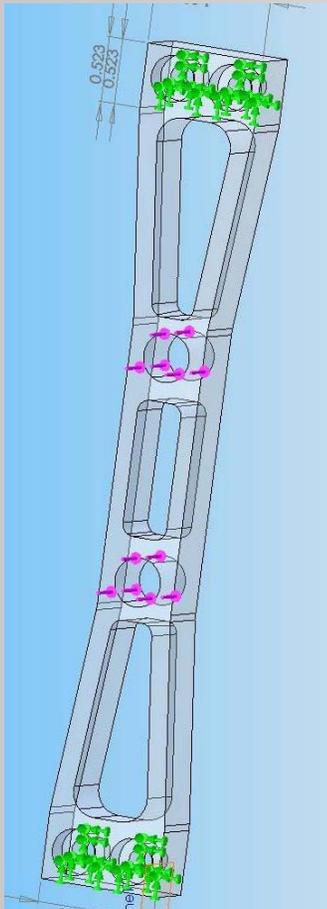


min: 2.2

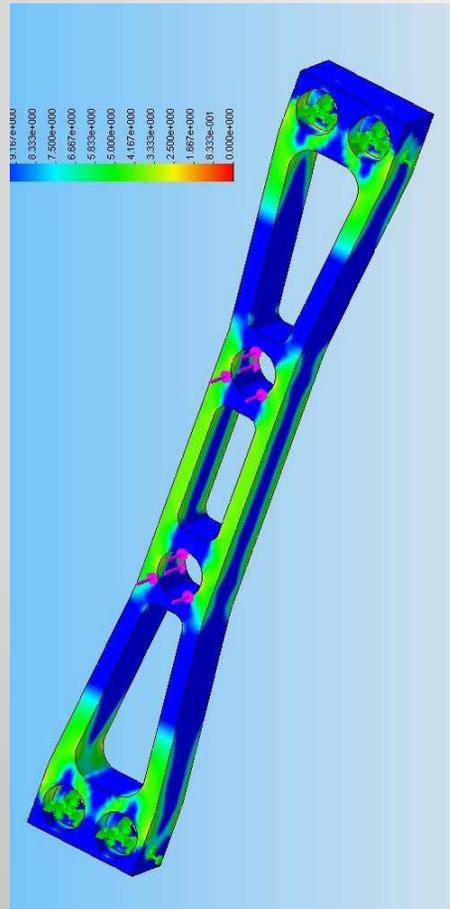
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4m

FEA Analysis: Side Bar Belay

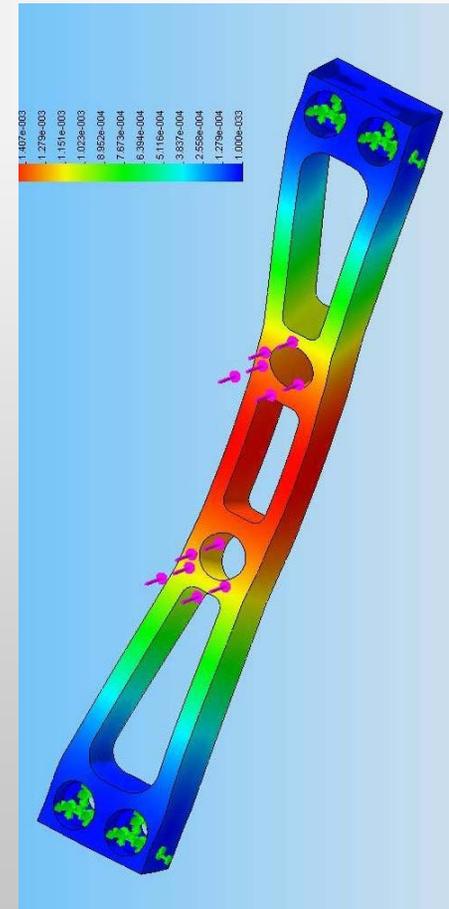
Forces



FOS



Displacement

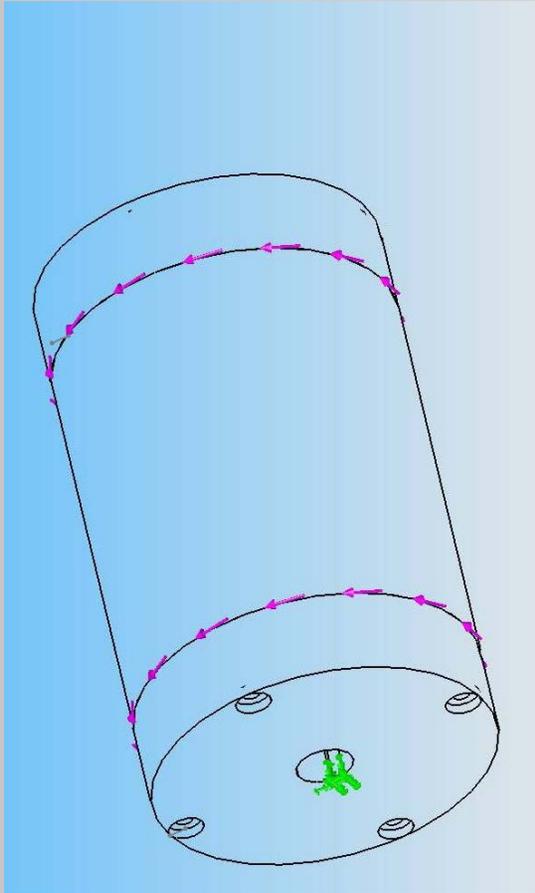


min: 2.3

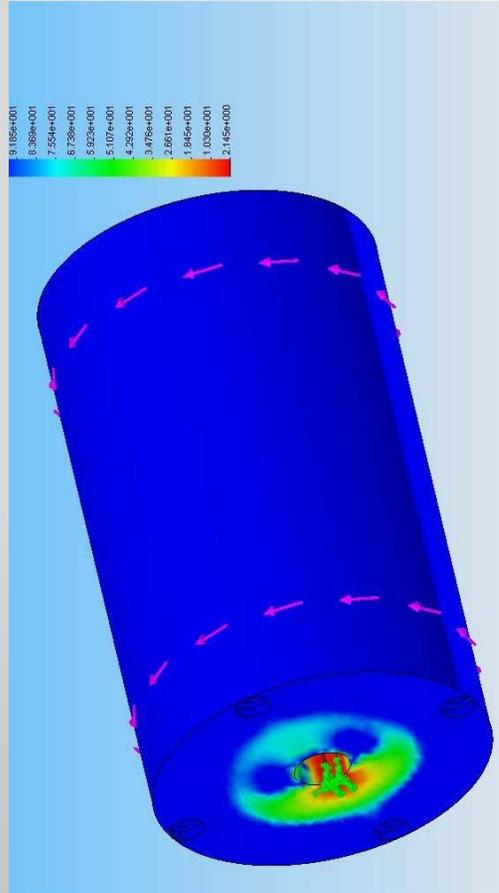
max: 1.5e-
3m

FEA Analysis: Drive Roller

Forces

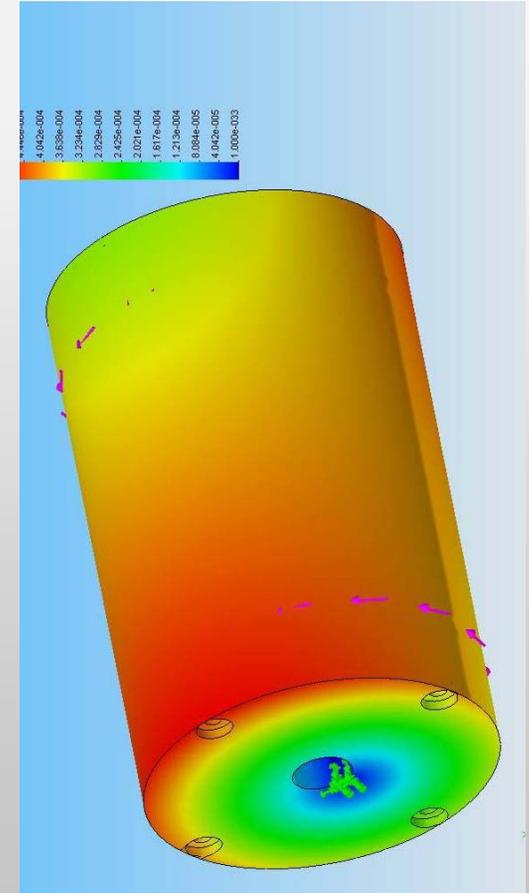


FOS



min: 2.1

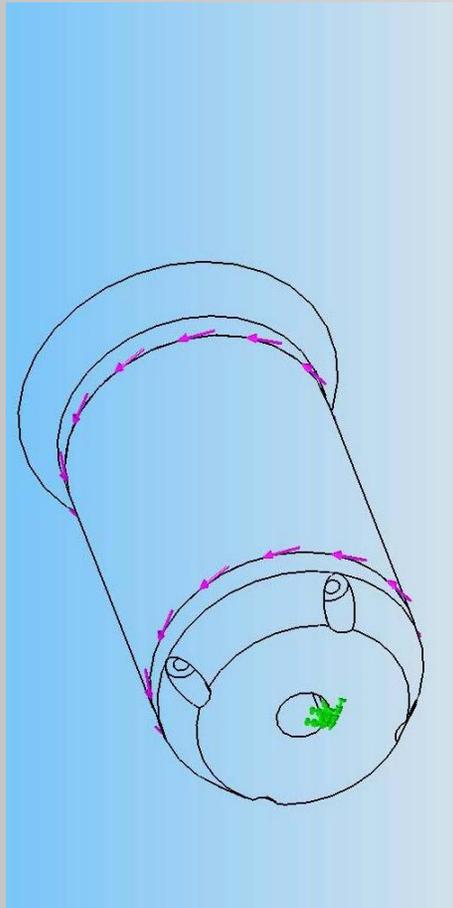
Displacement



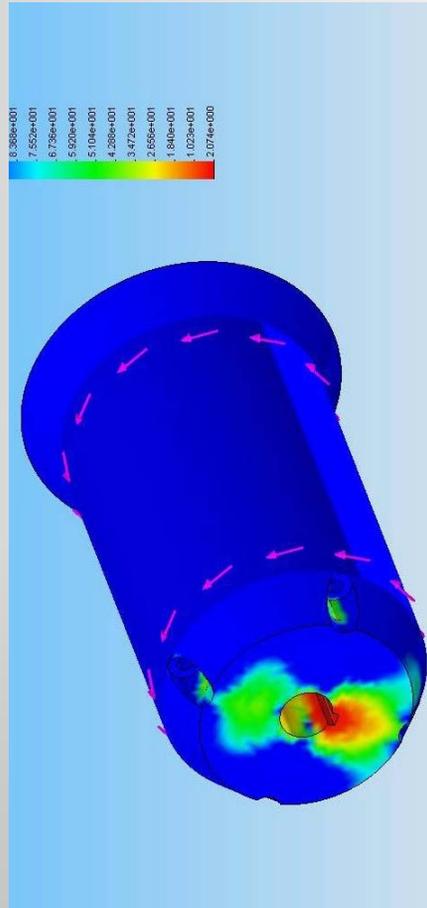
max: 4.9e-
4m

FEA Analysis: Guide Roller

Forces

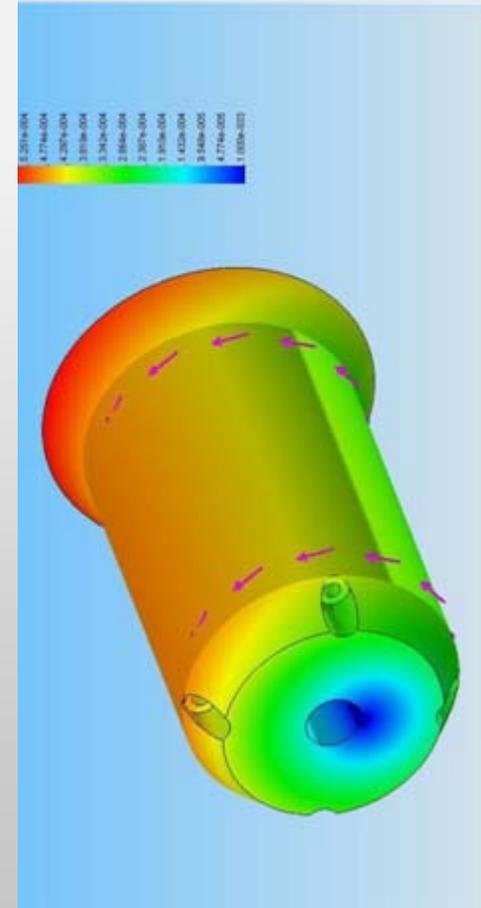


FOS



min: 2.1

Displacement

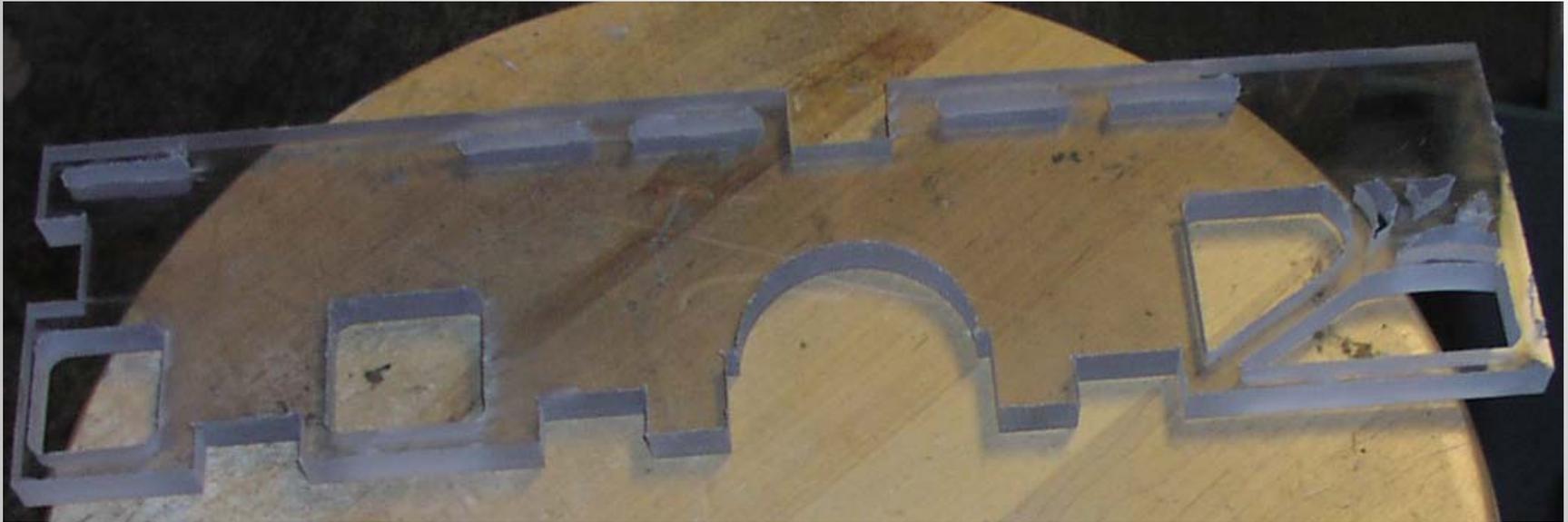


max: 5.7e-
4m

Machined Part: Belay Side Bar



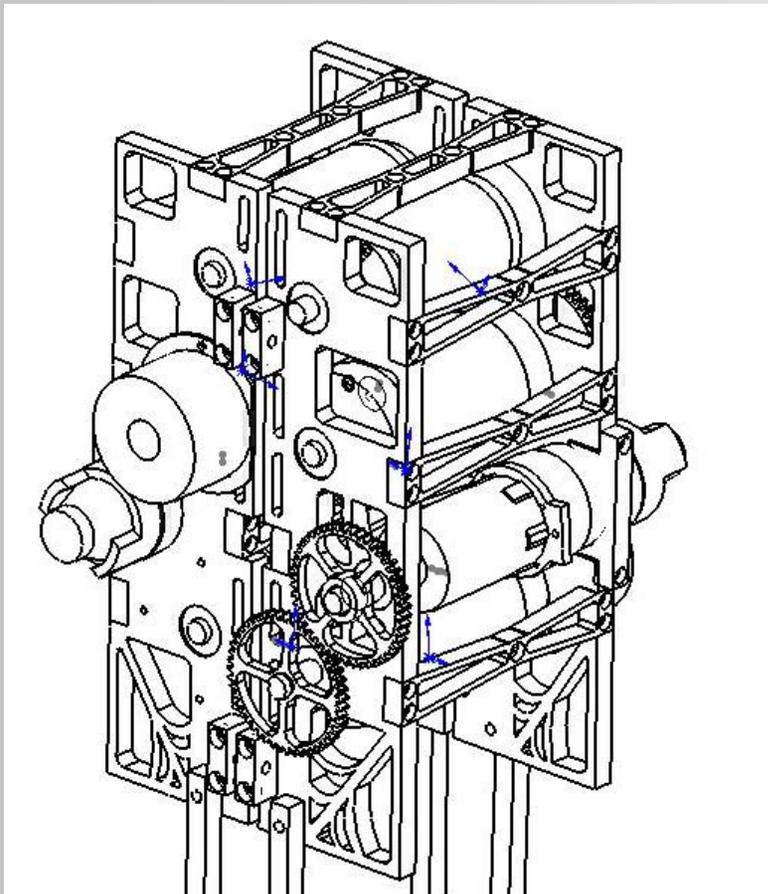
Machined Part: Side Plate



Final Specifications

Requirements

Minimize Weight



Results

Difference:

Side Bar Cross (x10)	.073 lbs
0.124 lbs	
0.051 lbs	
Side Bar Belay (x2)	.066 lbs
0.121 lbs	
0.055 lbs	
Side Plate Left (x2)	.19 lbs
0.89 lbs	
0.70 lbs	
Side Plate Right (x2)	.31 lbs
0.96 lbs	
0.65 lbs	
Drive Roller (x4)	.69 lbs
1.32 lbs	
0.63 lbs	
Guide Roller (x2)	.44 lbs
0.91 lbs	
0.47 lbs	
Total	5.5 lbs
33.7 lbs	

Final Specifications

Requirement

Keep Cost Low

Clamp Time

FOS>2

Result

Cost to team: \$100

Kept clamp simple

FOS: Belay Side Bar-2.3

Side Bar-2.2

Roller-2.1

Side plate (left)-20

Side plate (right)-17

Design Rationale

Focus

Minimize weight in order to aid in speeding up the climber

Cost was less important, but didn't use strange materials

Wanted something simple and effective

Manufacturing

- Side Bars and Belay Side Bars
 - Water jetted out of ½” polycarb
 - Milled holes for screws
- Side plates
 - Water jetted
 - Milled holes for axles and screws
- Rollers
 - Cut on bandsaw
 - Lathed
 - Drill pressed holes for screws

Assembly

- Side Bars and Belay Side Bars
 - Screwed into the slots on the side plates
 - Belay hook will be added to the central two holes
 - Side bars will be mounted to the motor
- Side plates
 - Attached to the motor, side bars, rollers, and clamps by screws or simply pressed together
- Roller
 - Attached by screws and an axle to the side plates

Cost Estimate

Section	Rate	Qty	Total Cost
I. Design and Engineering			
Labor Rate for Each Designer	\$75/hour	5	375
Labor Rate for Each Cad/Cam Machine	\$40/hour	4	160
II. Materials Cost			
Polycarbonate Sheet	\$19.47/sqft	3	58.41
Polycarbonate Rod	\$62.50/ft	2	125
III. Waterjet Manufacturing			
Labor Rate	\$55/hour	1	55
Machine Use Rate	\$100/hour	1	100
IV. Other Machining			
Labor Rate	\$35/hour	4	140
V. Assembly Rate			
Assembly Work Labor Rate	\$55/hour	2	110
Miscellaneous Test Rate	\$55/hour	4	220
		Hours	Cost
	Total	21	1343.41

Future Work

- Not everything could be completed during IAP
 - Work will continue after the class ends
 - The side plates will be finished
 - Rollers will be hollowed out
 - Side bars will be created
- After all this occurs, the new pieces will be put together and tested as a new recursion of the climber

Final Conclusions

- The weight drop is significant
- Will alter the performance of the climber for the better
- Cut large pieces out of the materials while maintaining a good FOS
- Further iterations of this process will be necessary to achieve the ideal parts
 - Continued shaving off of material may occur
 - Many of the pieces achieved a radical new design
 - Sign of the evolution of a project

Lessons Learned

- Do not trust random other students regarding the operation of machinery
- If it can go wrong, it will—over and over again.
- The iterative process is effective and can be repeated infinitely
 - There's always something better out there
- -Double checking position of hole before optimizing

Lessons Learned

- Peel the plastic off before water jetting
- When doing large water jet parts, pause water jet periodically to make sure the piece hasn't shifted
- Standard truss ribs are very inefficient for side bars, ribs connecting forces make much more sense