THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

Standoff Project

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Project Description (1)

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- Problem:
  - Adhesive is applied and bracket is taped to help cure adhesive
  - Taping is unreliable and costs money and man hours when it fails
- Objective:
  - Analyze and build a prototype that will hold standoff brackets while adhesive cures

<u>Customer Needs</u>

1. ESD compliance
2. Apply axial forces
3. Six degrees of freedom in movement
4. Usable 4" - 36" inboard of ring
5. Transportability
6. Ease of operation
7. Durability
8. Reliability
9. Adjustable Interfaces
10. Support 10lbs in locked position
11. Minimum 3.0 Factor of Safety

Project Description (2) - Black Box Model

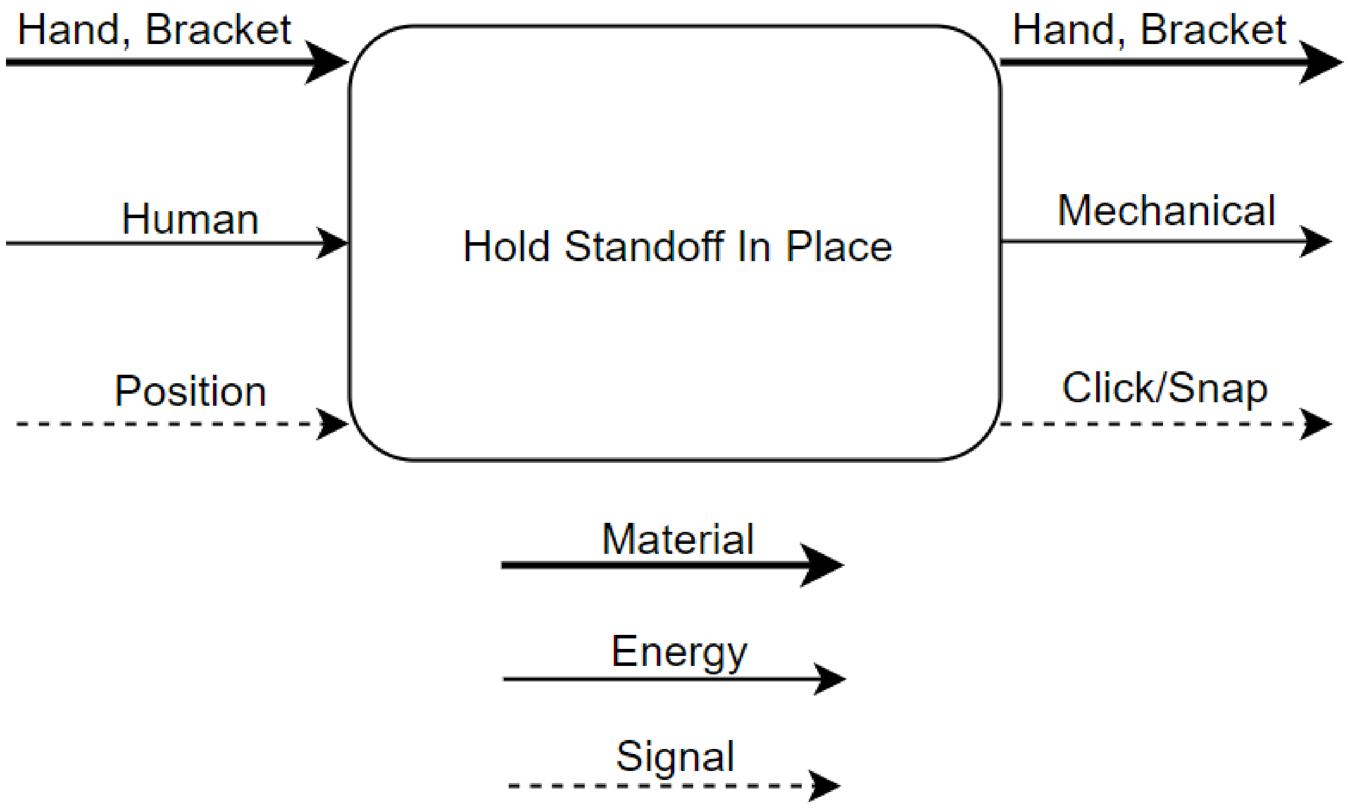

Figure 1. Black Box Model

Project Description (3) - Functional Model

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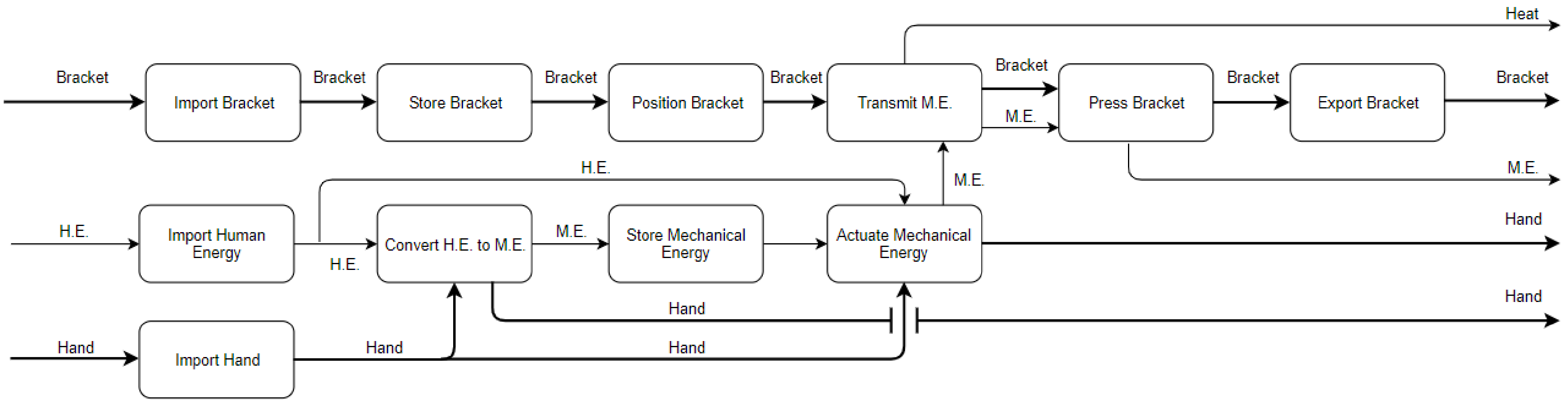

Figure 2. Functional Model

Concept Generation Sub-Functions:

1. Mount to Ring (“Import Bracket”)
2. Hold Bracket (“Press Bracket)
3. Apply Axial force (“Transmit M.E”)
4. Angle bracket (“Position Bracket”)
5. Translate bracket (“Position Bracket”)
6. Locking (“Position Bracket”)

Concept Generation

- From the six sub-functions of our design, a morphological matrix was constructed.
- Using the morph matrix as a reference, the team used a variation of the gallery method to develop concepts.
- Developing concepts by taking one method from each sub function and essentially building the design from the ring to the bracket.

Morph Matrix

- Six sub-functions for the concepts
- Using the Morph Matrix, six designs were created that are displayed in a design table

Table 1. Morph Matrix

Sub-Functions	Concepts		
Mount to Ring	C-Clamp	Hose-Clamp	Spring Clamp
Hold Bracket	Spring Clamp	Threaded Clamp	Claw
Apply Axial Forces	Telescope	Locking Screw	Floor Jack
Angle & Socket	Ball & Socket	U-Joint	Parallel Plates
Translate Bracket	Rail	Telescope	Sleeve
Locking	Threaded Joint	Spring Lock	Self Locking Screw
Grip	1	2	3

Design Table

Table 2. Design Table

Sub-Functions								
	Design Name	Mount to Ring	Hold Bracket	Apply Axial Forces	Angle Bracket	Translate Bracket	Locking	Grip
Datum	Computer Articulating Arm	C-Clamp	Threaded Clamp	Locking Screw	U-Joint	Telescope	Threaded Joint	1
Design 1	Rail System	C-Clamp	Threaded Clamp	Locking Screw	U-Joint	Rail	Threaded Joint	2
Design 2	Rail Crane	Spring Clamp	Claw	Locking Screw	Ball & Socket	Rail	Self Locking Screw	1
Design 3	Construction Crane	C-Clamp	Claw	Telescope	Ball & Socket	Telescope	Self Locking Screw	1
Design 4	Biological Design	Hose-Clamp	Spring Clamp	Telescope	Parallel Plates	Telescope	Spring Lock	1
Design 5	Mechanical Design	Hose-Clamp	Threaded Clamp	Foor Jack	U-Joint	Sleeve	Self Locking Screw	3
Design 6	Spider Web	Spring Clamp	Threaded Clamp	Locking Screw	U-Joint	Rail	Self Locking Screw	3

Pugh Chart

Table 3. Pugh Chart

		Concepts						
Engineering Characteristics	Weights	Standard	Rail System	Rail Crane	Construction Crane	Biological Crane	Mechanical Design	Spider Web
ESD Compliance	4	Computer Articulating Arm	(s)	(s)	(s)	(s)	(s)	(s)
Mass	3		(-)	(-)	(-)	(-)	(+)	(-)
Principle Dimensions	2		(+)	(+)	(+)	(-)	(+)	(+)
Working Length	4		(+)	(+)	(+)	(-)	(-)	(+)
Working Angle	4		(s)	(-)	(-)	(+)	(s)	(s)
Durability	5		(+)	(+)	(+)	(-)	(-)	(-)
Reliability	3		(+)	(+)	(-)	(-)	(-)	(-)
Use of Space	3		(-)	(-)	(-)	(s)	(-)	(-)
Adjustable Interfaces	4		(s)	(-)	(-)	(-)	(s)	(s)
Total +		0	4	4	3	1	2	2
Total -		0	2	4	5	6	-4	4
Overall Score		0	2	0	-2	-5	-2	-2
Weighted Total +		0	14	14	11	4	5	6
Weighted Total -		0	6	14	17	21	15	14
Weighted Overall Score		0	8	0	-6	-17	-10	-8

Concept Generation (1)

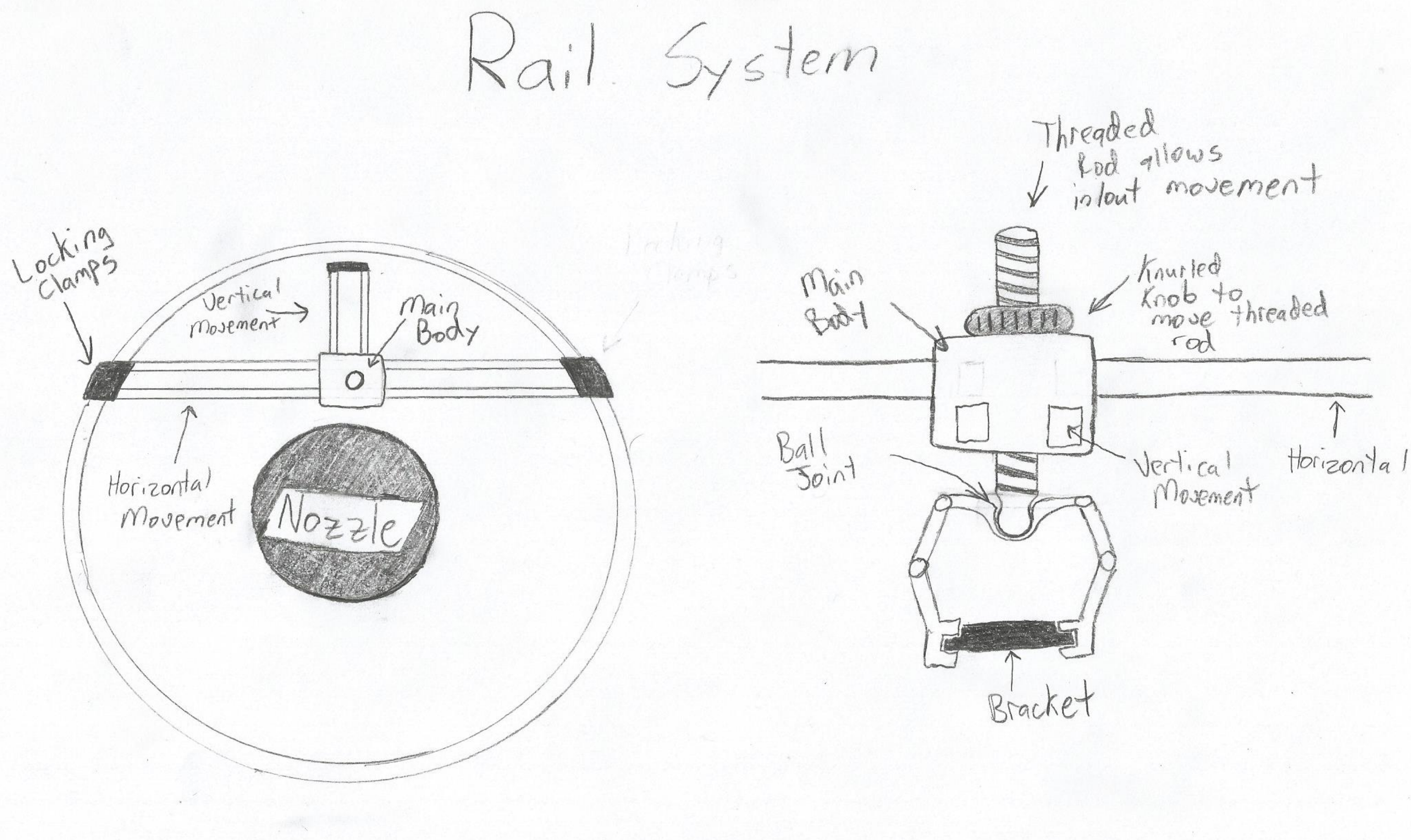

Figure 3: Rail System Concept

Concept Generation (2)

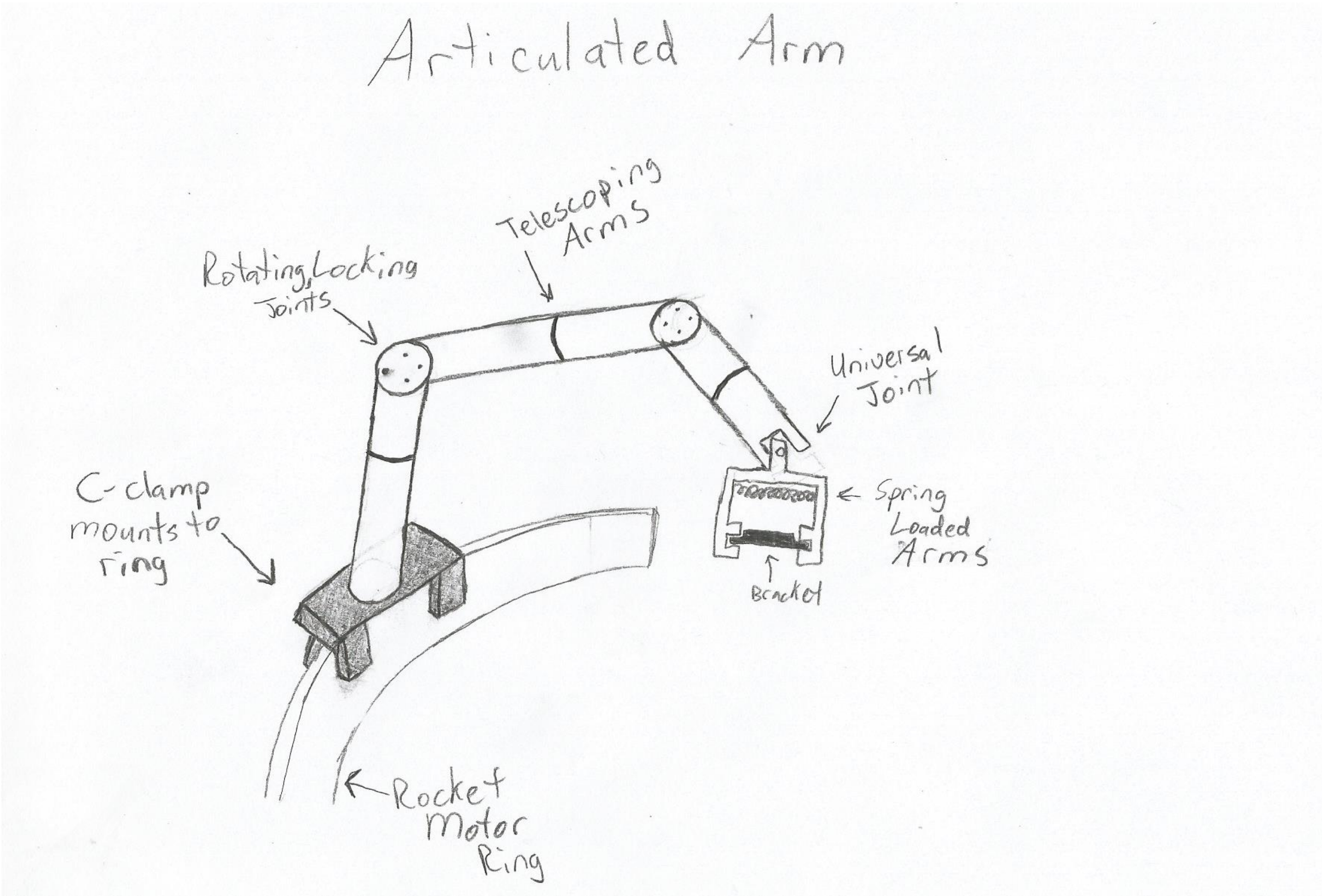

Figure 4: Articulated Arm Concept

Concept Generation (3)

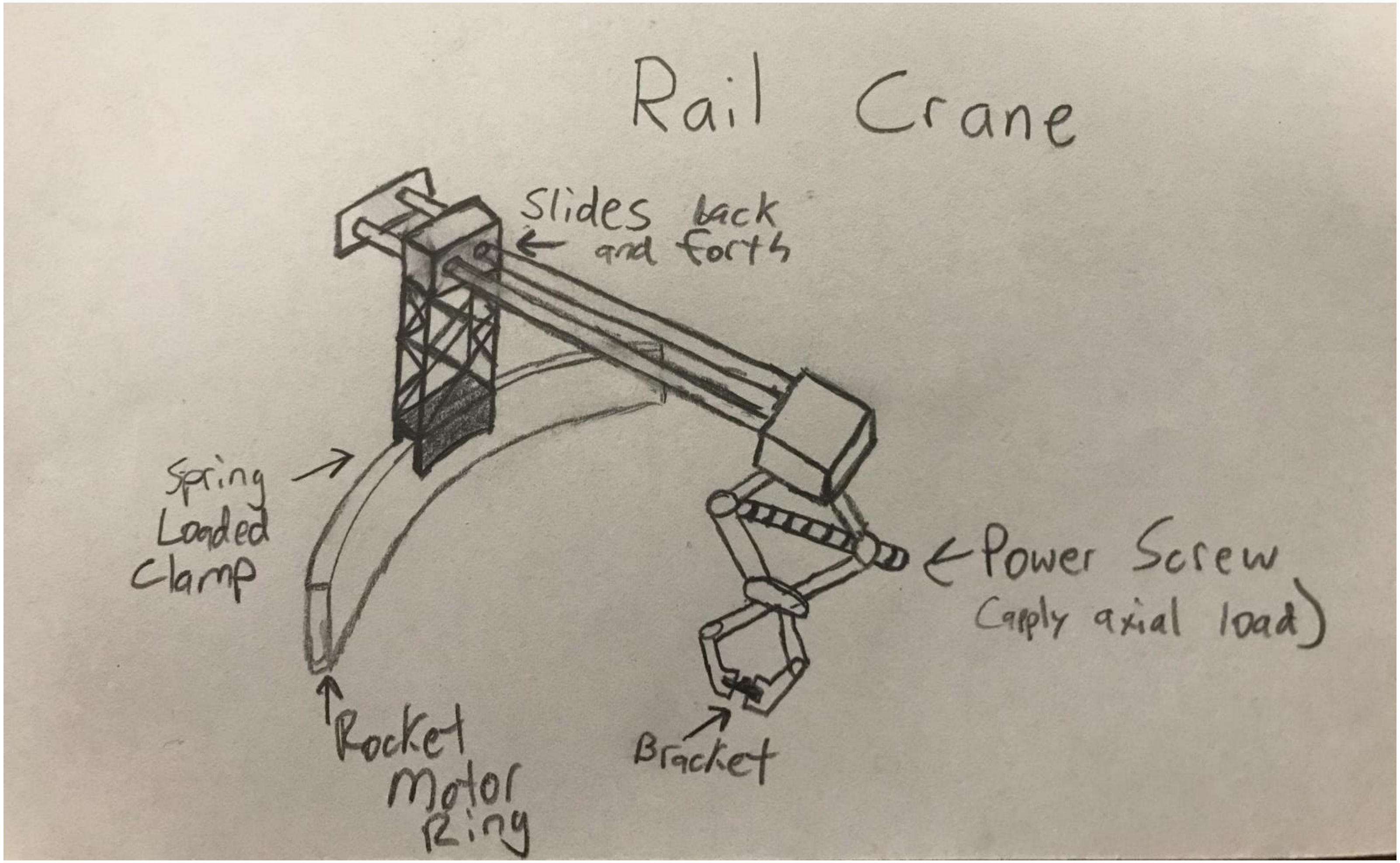

Figure 5: Rail Crane Concept

Decision Matrix

Table 4. Decision Matrix

		Computer Articulating Arm		Rail System		Rail Crane	
Criteria	Weight (%)	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
ESD Compliance	10	100	10	100	10	100	10
Mass	10	60	6	30	3	60	6
Principle Dimensions	5	70	3.5	40	2	60	3
Working Length	15	85	12.75	90	13.5	90	13.5
Working Angle	15	85	12.75	80	12	80	12
Durability	20	50	10	70	14	70	14
Reliability	15	50	7.5	60	9	70	10.5
Use of Space	5	80	4	30	1.5	80	4
Adjustable Interfaces	5	80	4	80	4	80	4
Total	100		70.5		69		77

Current State of Design

- Single mounting point arm
- Future Improvements
  - Adjustable rail length
    - Account for ring size
  - Lockable component positions
  - Finish ring clamp design
  - Ensure Modularity

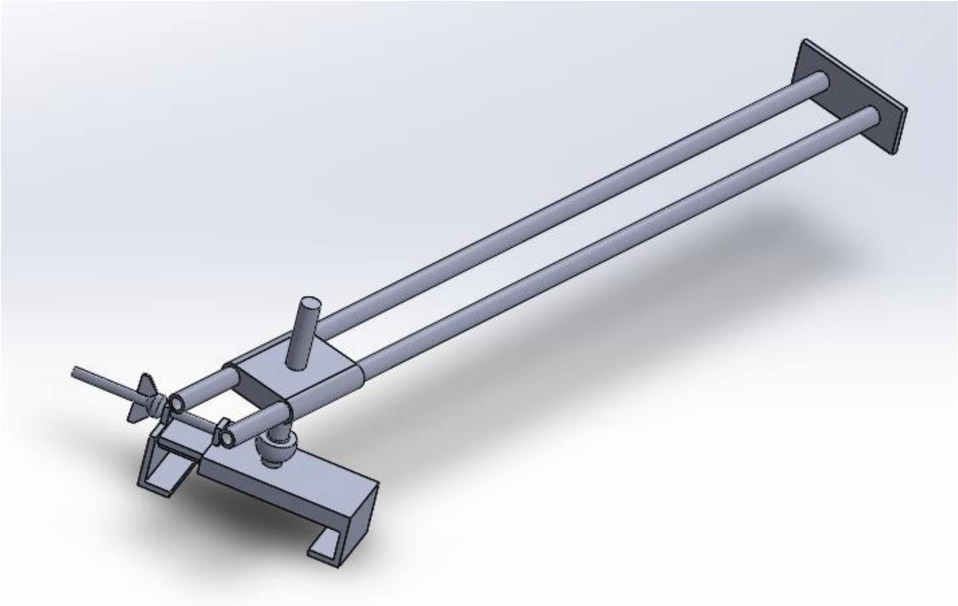

Figure 6: Rail Crane CAD

Clamp Force Calculation

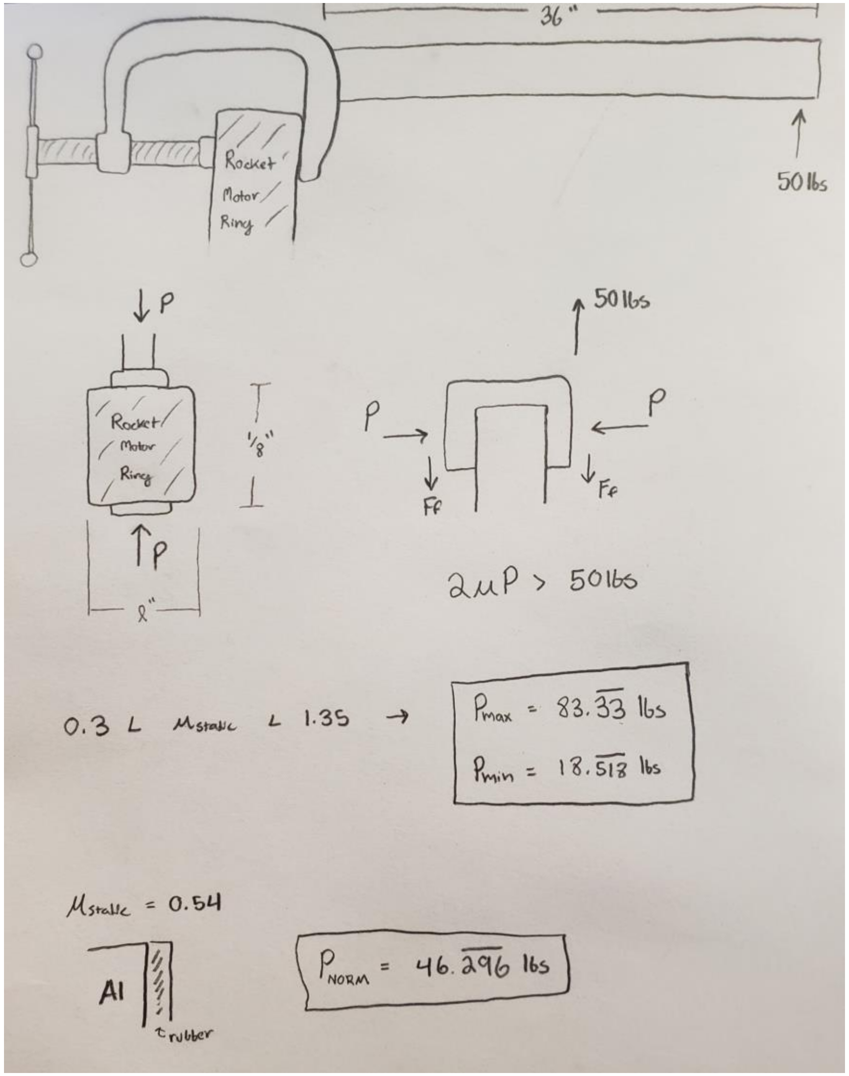

Figure 7: Clamp Force Calculation [1,2,3]

Ring Moment Analyses (1)

- Diameter of 92” (max)
- Thickness of ⅛”
  - Below specified 3/16” minimum
- 50 lbf applied (max)
- 36” lever arm (max)
- 7075 T6 Aluminum (specified)
- 1.75” clamp depth
  - Less than 2” minimum available

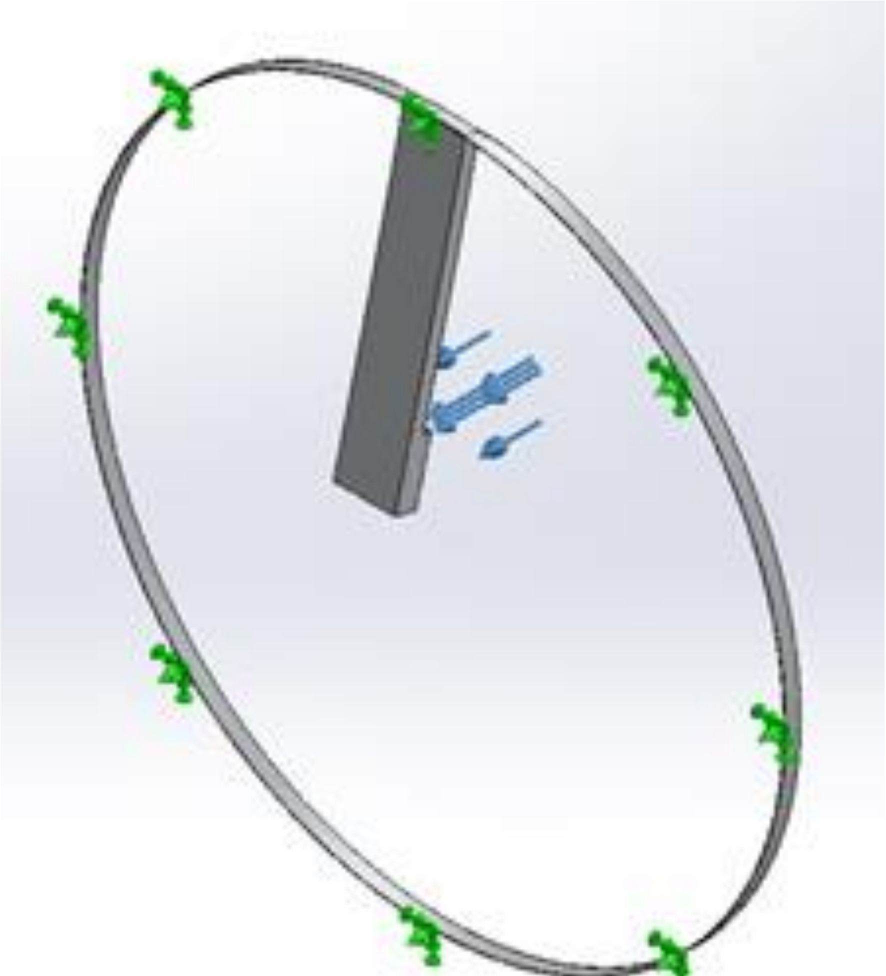

Figure 8: Ring Moment

Ring Moment Analyses (2)

Stress distribution in the ring

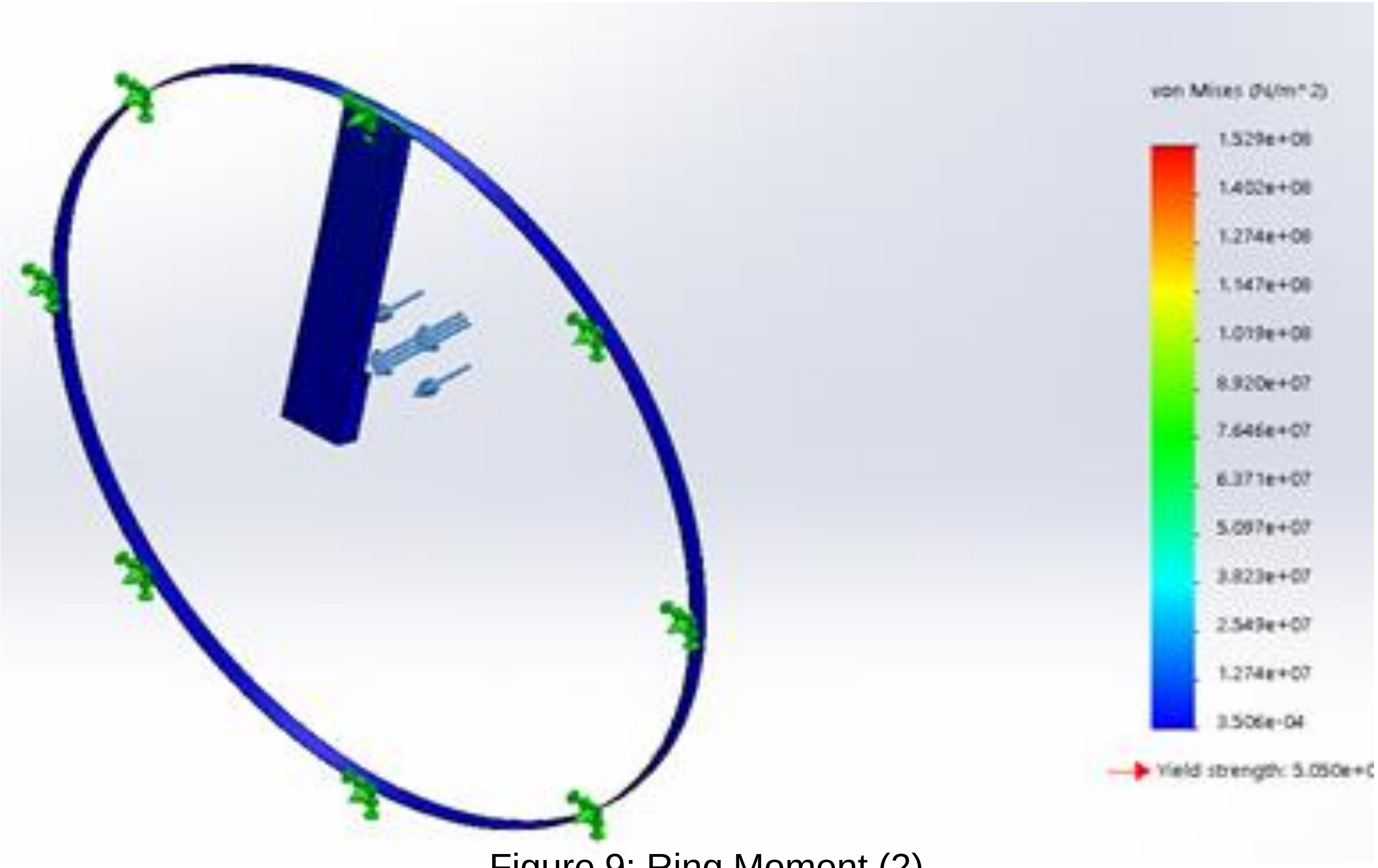

Figure 9: Ring Moment (2)

Ring Moment Analyses (3)

3.30 Minimum FOS for ring under load

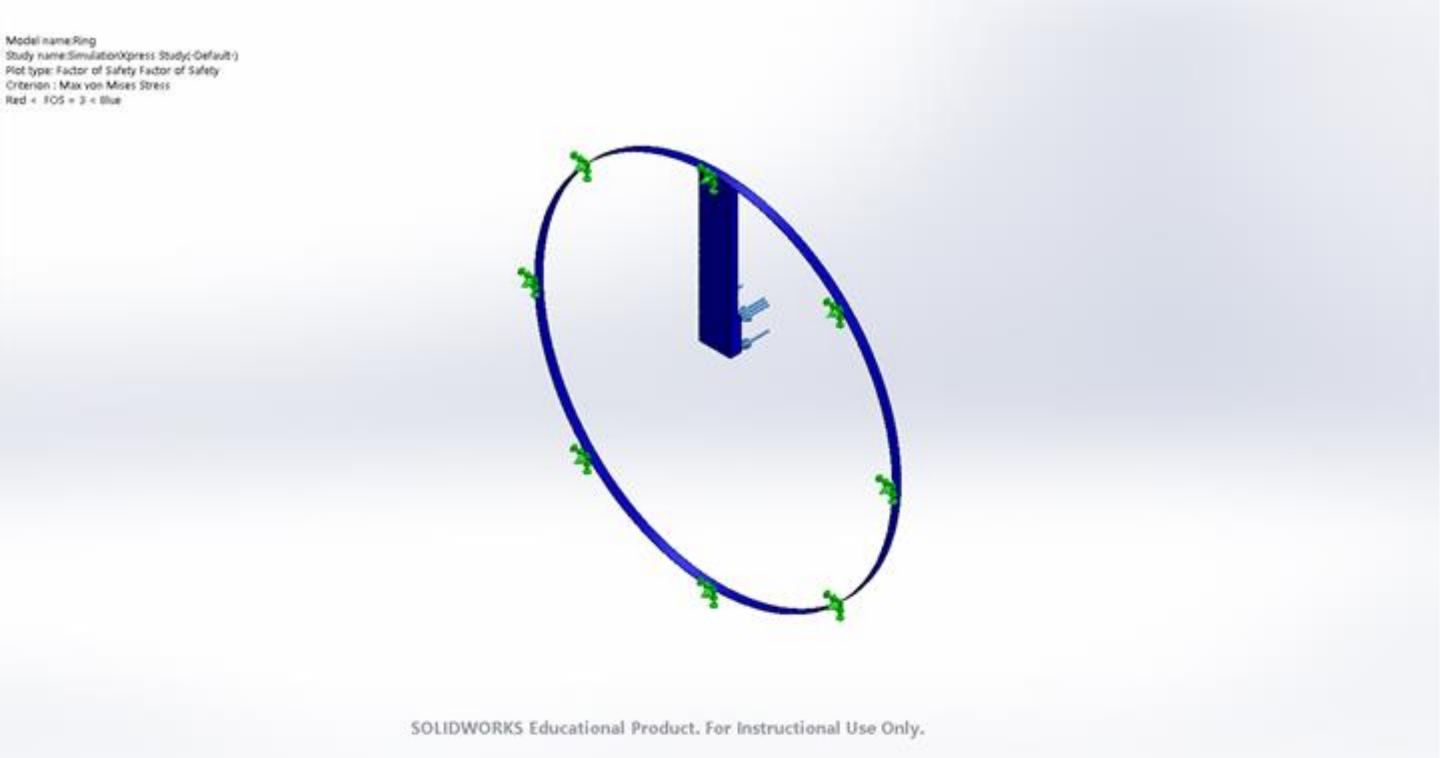

Figure 10: FOS for Ring Moment

Budget Planning (1)

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Bill of Materials Final Design								
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Part #	Part Name	Qty	Description	Functions	Material	Dimensions	Cost	Link to Cost estimate
1	Rail	2	41L40 Alloy Steel Round Rod 1/2" Diameter x 3' Length	Mode of translation for the Bracket Holder Mechanism (rail cart).	Steel	1/2" x 1/2" x 3'	39.25	https://www.amazon.com/41L40-Alloy-Rod-500-Diameter-Length/dp/B07WGWQCJJ/ref=sr_1_1?fst=as%
2	Clamp	2	Adjustable Clamp 9133 Corner/Splicing Clamp	Secure the device to the motor ring.	Steel	1.5" x 7.8" x 6"	14.5	https://www.amazon.com/Adjustable-Clamp-9133-Corner-Splicing/dp/B0009JGYH0#customerReviews
3	Bracket Holder	2	Custom made bracket holder, to be manufactured in machine shop.	Secure the bracket to the device.	Aluminum	16" x 3" x 2"	174.00	https://www.custompartnet.com/estimate/machining/
4	Universal Joint	1	https://www.amazon.com/TEKTON-4964-Impact-Universal-3-	Universal joint to help position the bracket onto the rocket.	Vanadium Steel	6.5" x 5" x 1.1"	11.98	https://www.amazon.com/TEKTON-4964-Impact-Universal-3-Piece/dp/B000NPZ40I/ref=sr_1_21?keywords=
5	Drive Knob	1	Genuine Echo KNOB, FASTENER for driveshaft coupler assembly	Transmit force into the push/pull system.	Steel	4" x 1" x 2.5"	10.59	https://www.amazon.com/Echo-V299000160-Fastener-driveshaft-Assembly/dp/B07FDJSSFZ
6	Power Screw	1	Carbon Steel Acme Lead Screw Right Hand, 1/2"-10 Thread Size, 2 Feet Long	Translate force from the knob onto the bracket.	Steel	1/2" x 2'	5.93	https://www.mcmaster.com/98935a911
7	Lubricant	1	Super Lube 51004 Synthetic Oil with PTFE, High Viscosity, 4 oz Bottle	Reduce friction of the rail system.	Synthetic PTFE Oil	2" x 2" x 6.5"	4.60	https://www.amazon.com/Super-Lube-51004-Synthetic-Viscosity/dp/B000UKUHXK/ref=sr_1_1?keywor
8	Hanging Scale	1	Klau Portable 150 kg / 300 lb Heavy Duty Crane Scale	Method of measuring force imparted onto bracket.	Stainless Steel	9.1" x 3.1" x 1.3"	23.99	https://www.amazon.com/Klau-Portable-Digital-Hanging-Backlight/dp/B07BHLR9DN/ref=sr_1_5?keywor
9	Rail Cart	2	Custom made for fabrication at machine shop	Transports bracket holder across rail system.	Aluminum	4" x 3" x 1"	178.00	https://www.custompartnet.com/estimate/machining/
10	Fastener	1	Black Oxide Alloy Steel Socket Head Screw 1/4-20, 4" Long	Works with wing nut to secure bracket to the clamp.	Black Oxide Alloy Steel	3/8" x 4"	9.25	https://www.mcmaster.com/90044a131
11	Wing Nut	1	18-8 Stainless Steel Wing Nut 1/4"-20	Part of clamping mechanism to secure bracket to clamp.	Stainless Steel	31/64" x 1 1/8" x 5/8"	7.32	https://www.mcmaster.com/92001a321
Total Cost Estimate:							885.16	

Budget Planning (2)

- Budget based on best estimation of the requirements of the design, travel costs, contingency plans, and initial prototype
- Cost of Proposed Final Design: ≈ $885.16
- Cost of Initial Prototype: ≈ $200.00
- Travel Costs: ≈ $70.00
- Remaining Budget: ≈ $8,800.00
- Budget Uncertainties
  - Design Revisions
  - Machine Shop Costs
  - Component Failures

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References

[1] G. Elert, “Coefficients of Friction for Rubber,” Coefficients of Friction for Rubber - The Physics Factbook. [Online]. Available: https://hypertextbook.com/facts/2005/rubber.shtml. [Accessed: 09-Oct-2019].

[2] “Friction and Friction Coefficients for various Materials,” Friction and Friction Coefficients for various Materials. [Online]. Available: https://www.engineeringtoolbox.com/friction-coefficients-d_778.html. [Accessed: 09-Oct-2019].

[3] R. C. Hibbeler, Mechanics of Materials. Harlow, England: Pearson, 2019.