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NORTHROP GRUMMAN

Midpoint Presentation:
NAU Standoff Project

Team:
Sage Lawrence
Dakota Saska
Tyler Hans
Brandon Bass
Elaine Reyes

3/4/20

1.1 Project Description

- Sponsor: Daniel Johnson
- Client: Northrop Grumman
- Standoffs are bonded to motor domes using adhesive
- Adhesive is applied and bracket is taped to help cure adhesive
- Taping is unreliable and costs money and man hours when it fails
- Analyze and build a prototype that will hold standoff brackets while adhesive cures

Figure 1. Castor 50XL

Figure 2. Castor 30XL

1.2 Project Description (cont.)

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The mounting arm shall:

- ❑ Support brackets bonded 4-36 inches inboard from the motor ring
- ❑ Have 6 degrees of freedom
- ❑ Be mountable to several rocket motors
  - Orion 38
  - Orion 50XL
  - Castor 30XL
- ❑ Be ESD (electrostatic discharge) compliant
- ❑ Perform a pull test of 50 lbs at 45 degrees of freedom
- ❑ Maximum deflection of .1” for rail design
- ❑ Be adaptable to several mounting bracket templates
- ❑ Hold a bracket to up to 10 lbs
- ❑ Lock in place and apply a force of 20 lbs
- ❑ Have a Factor of Safety of 3.0 based on maximum expected loads
- ❑ Be easily manipulated by hand
- ❑ Allow the use of multiple mounting arms at a time

1.3 Project Description (cont.)

- Change of Design Requirements
  - Make design changes to perform a push test of 20lb. per standoff (max of 6) on the bracket template (120lb max)
  - Recently reverted back to perform a 20lb. push test per bracket template
  - Maximum deflection of .1” for rail design

2.1 Design Description

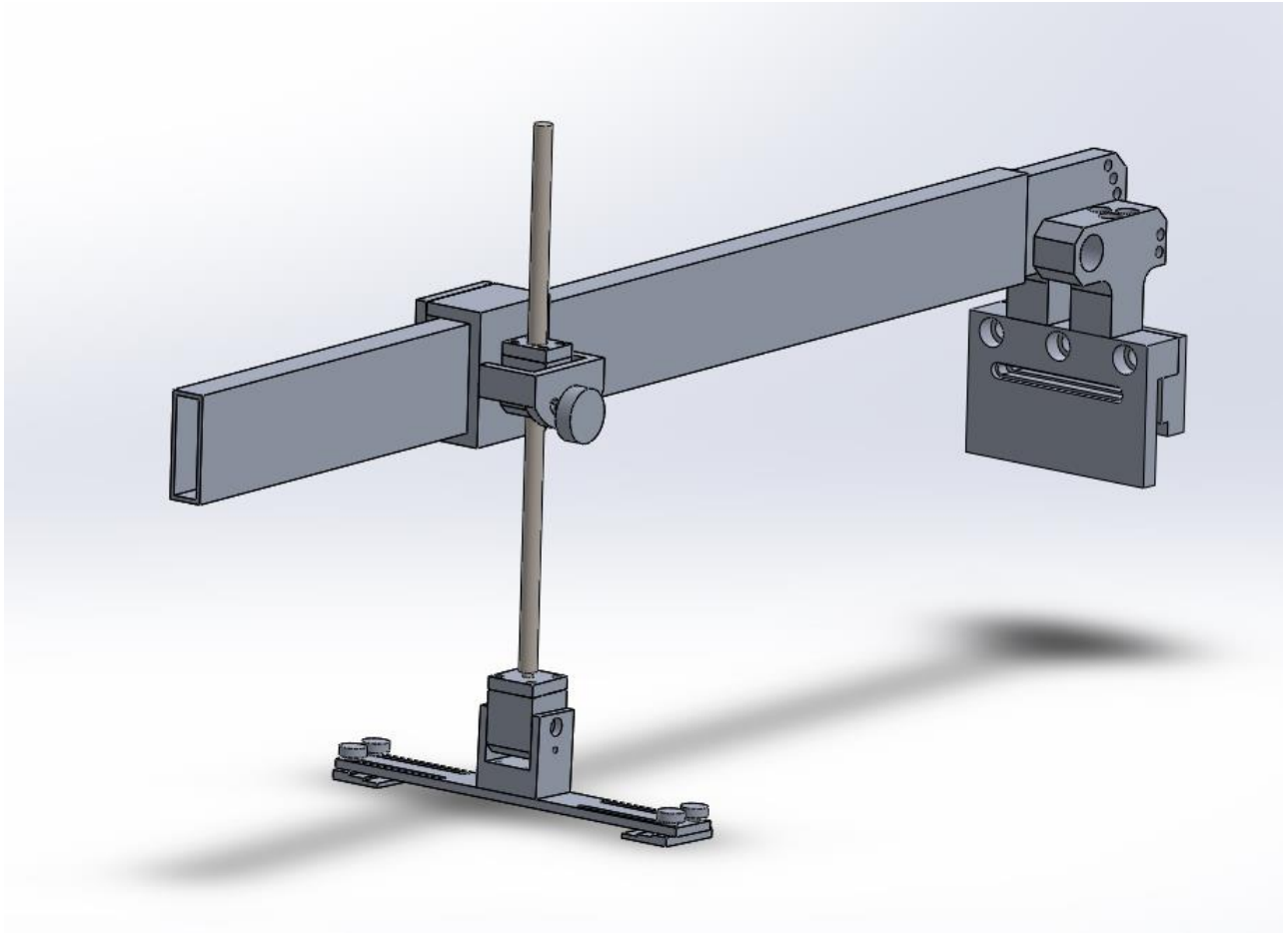

Figure 3. Current CAD Model

2.2 Design Description (cont.)

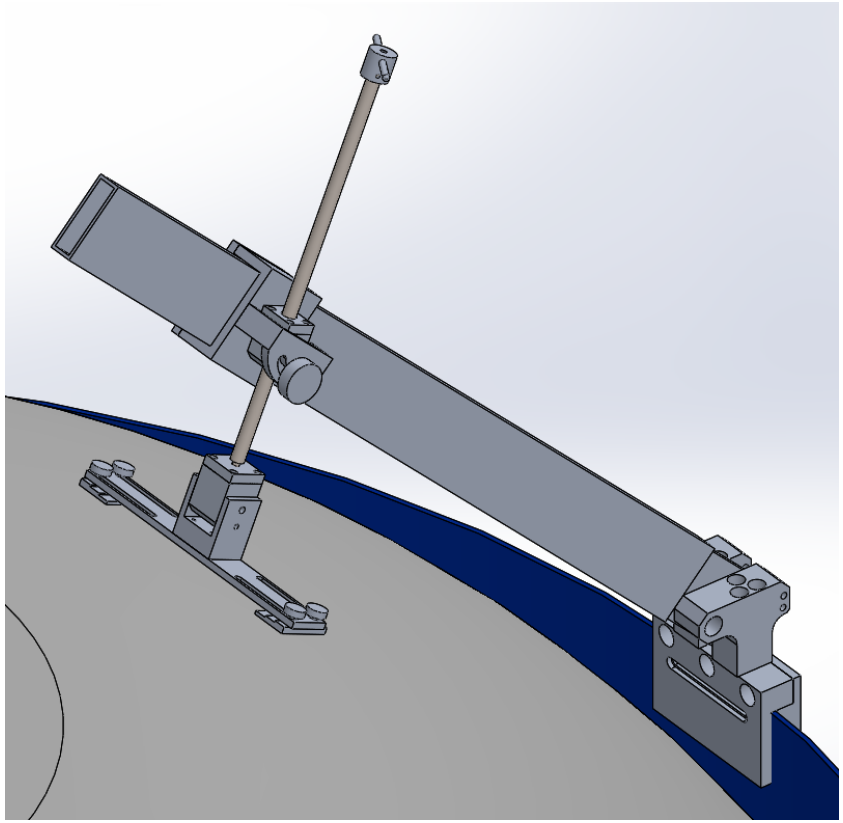

Figure 4. Final Design Clamped on Ring (1)

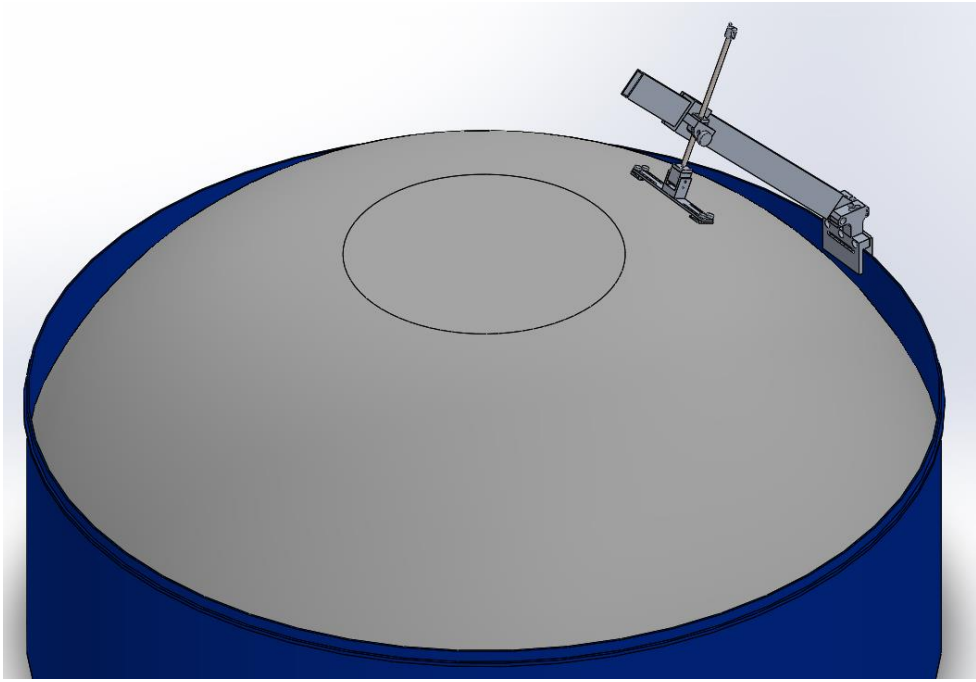

Figure 5. Final Design Clamped on Ring (2)

Rocket Motor Clamp

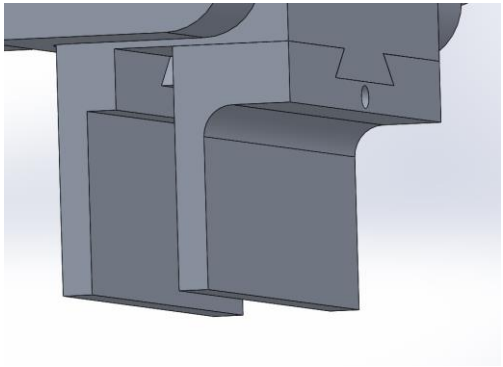

Figure 6. Previous Motor Ring Clamp

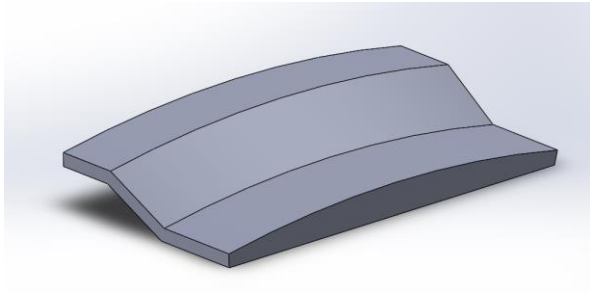

Figure 7. Custom Clamp Jaw for Orion 50 Motor Rings

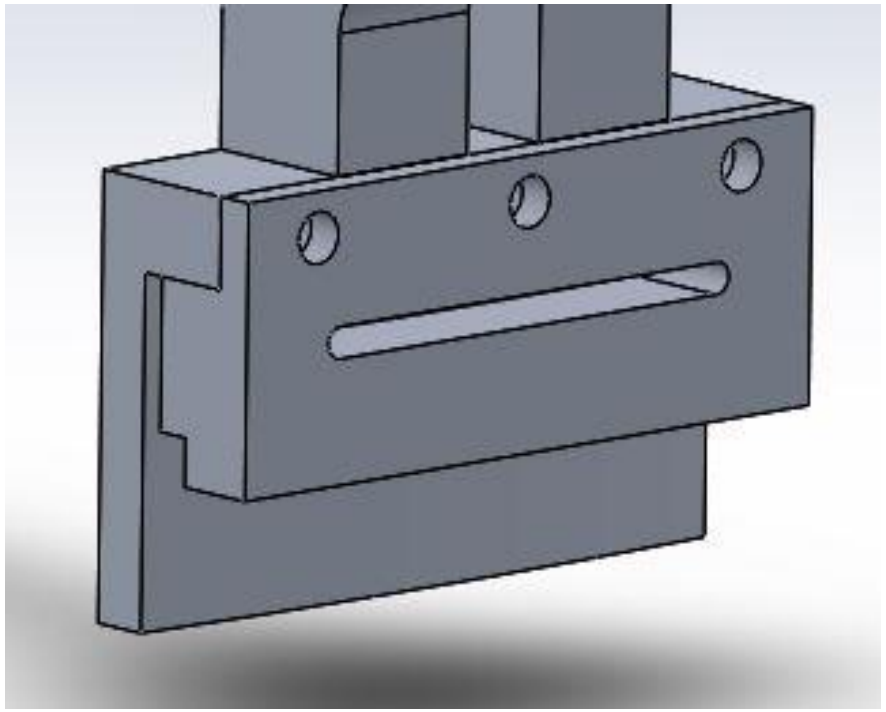

Figure 8. Current Motor Ring Clamp

Angling Mechanism

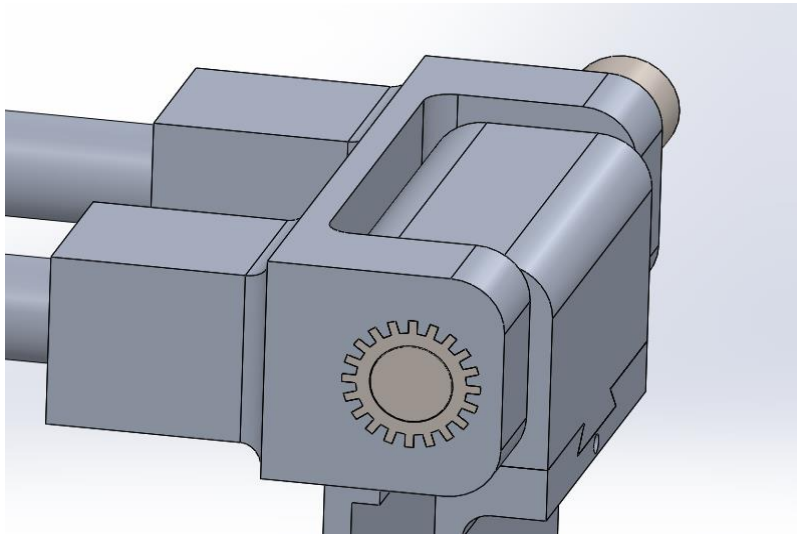

Figure 9. Spline Shaft used to Adjust Rail Angle

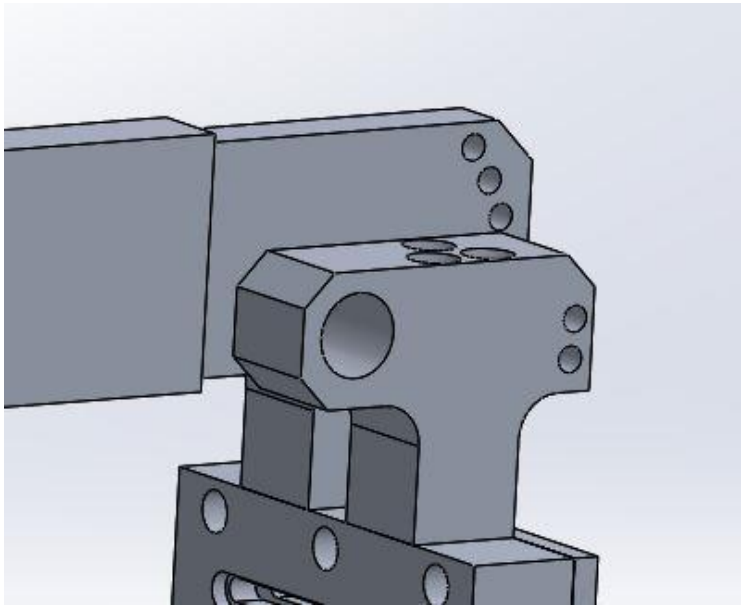

Figure 10. Updated Angling mechanism to Adjust Rail Angle

Rail System

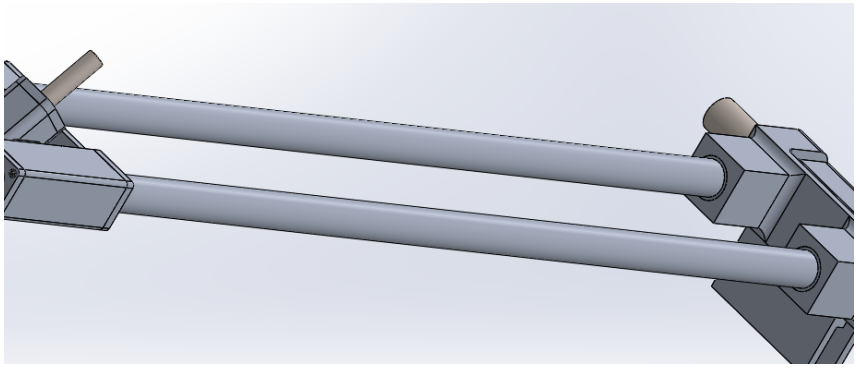

Figure 11. Previous Rail System

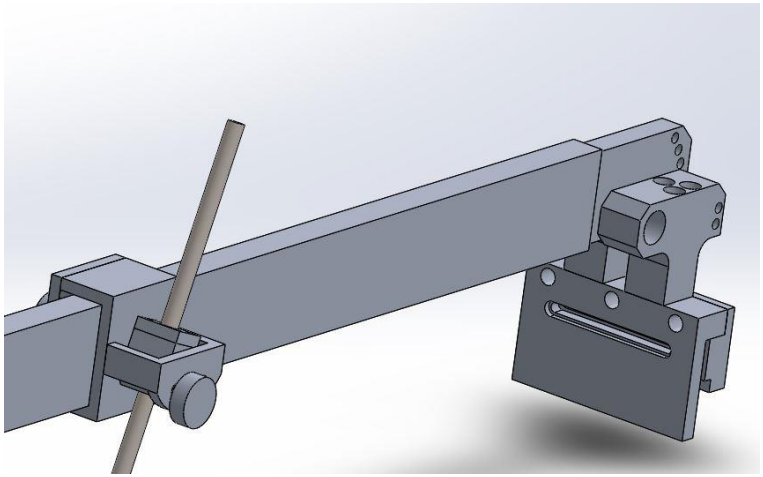

Figure 12. Current Rail System

Rail Cart

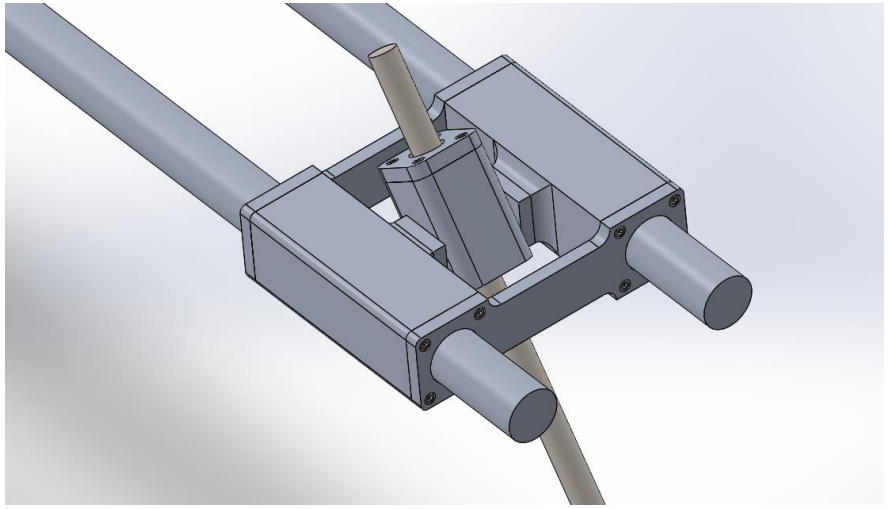

Figure 13. Previous Rail Cart and Angleable Lead Screw

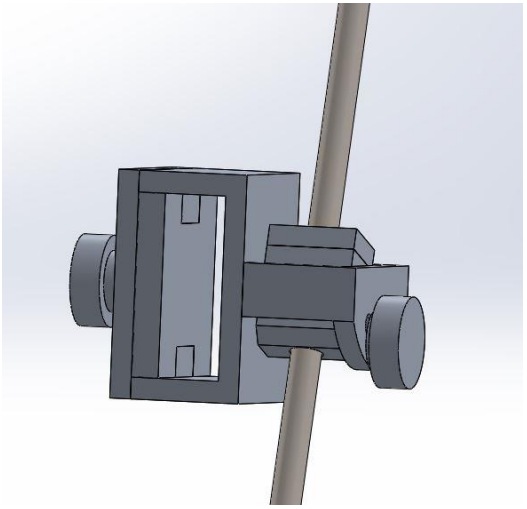

Figure 14. Current Rail Cart and Angleable Lead Screw

Angle Locking Mechanism

- Locking of the power screw angle is essential
- Easier for operator to set up and use
  - Counteracts moment created from weight of bracket template

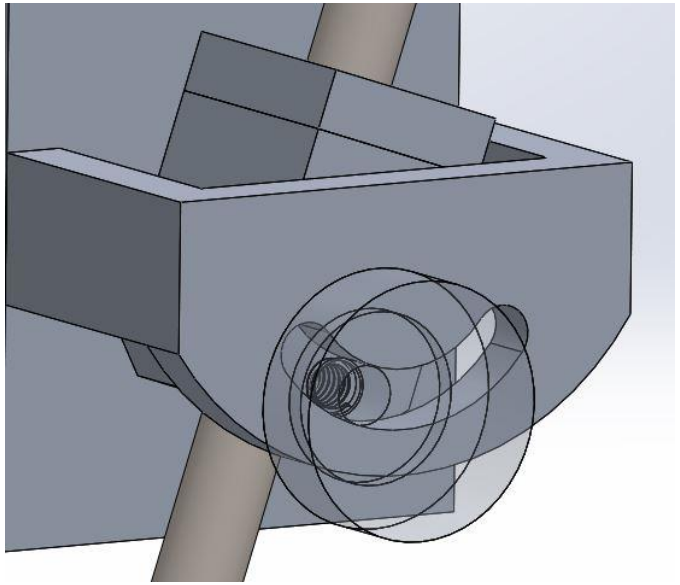

Figure 15. Current Angleable Lead Screw

Torque Wrench (Added Feature)
Spring Scale (Removed Feature)

- Reason for Change
  - Complicated to Manufacture
  - Requires Spring Analysis
- Justification:
  - Gives reading for torque applied to lead screw
  - Allows the operator to know when to stop applying torque
  - Allows for more precise application of force to the bracket templates

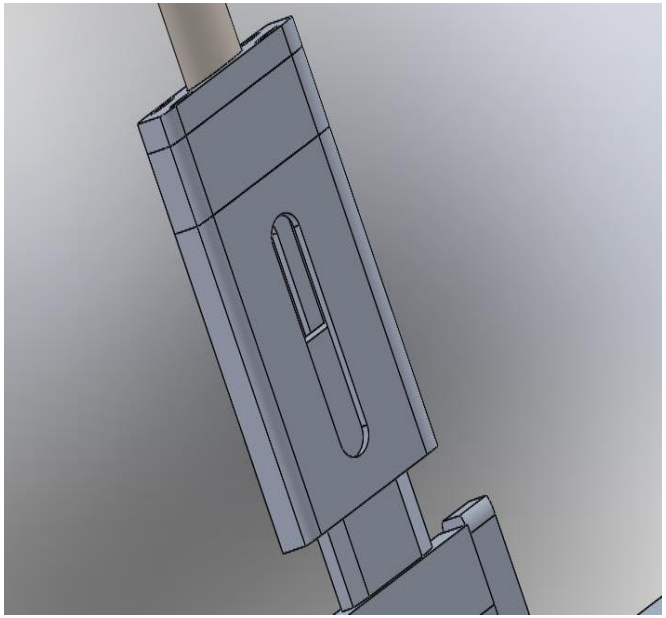

Figure 16. Force Gauge Spring Housing

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Push Test Template

- Lightweight universal solution to hold all bracket templates
- Easy to secure brackets with knurled knobs
- Can be angled normal to the surface
- Accommodates plates of both given thicknesses

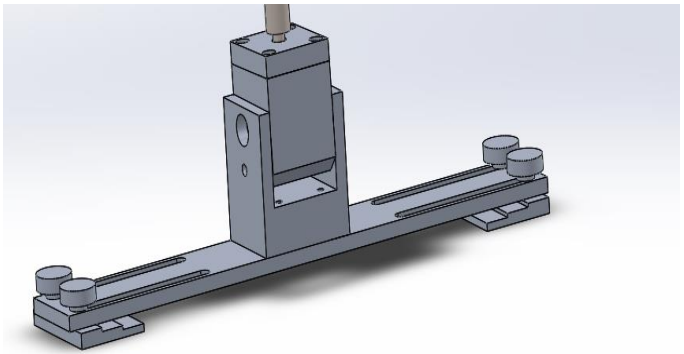

Figure 17. Template Holder for push test

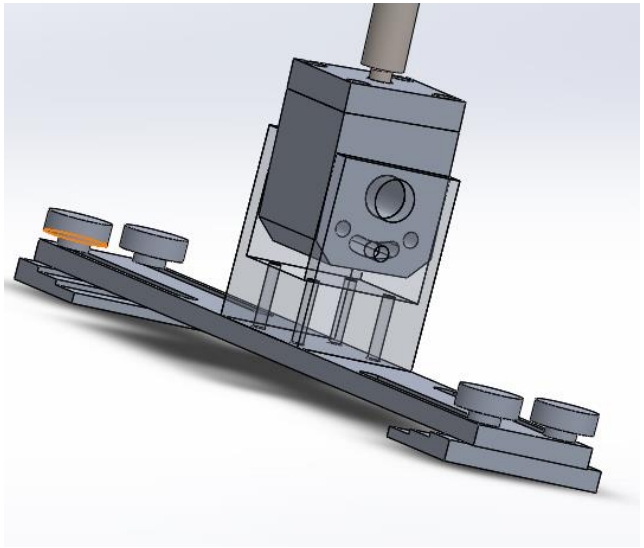

Figure 18. Template Holder Angling Mechanism

Pull Test Piece

- Allows for the 45° pull test needed for the device
- Threads into the standoffs directly
- Easily interchangeable with the push bracket with two pins

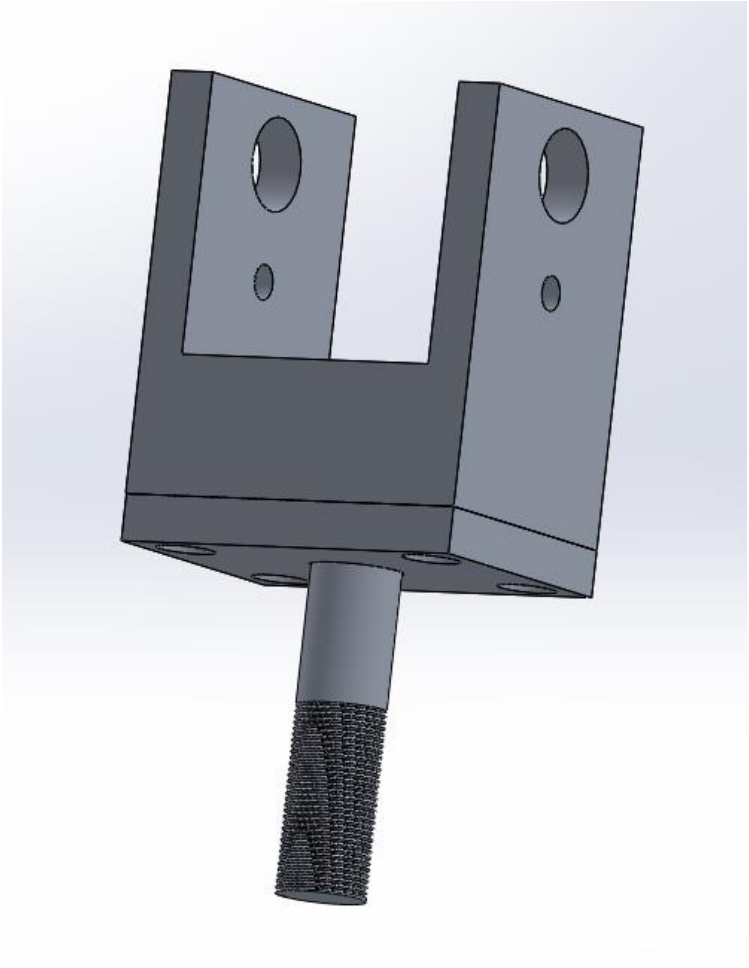

Figure 19. Standoff threaded piece for pull test

3.1 Current State of System

- **Electrically Conductive (Y or N)**
  - Metallic structure allows for electrical conductivity
- **Weight (lbs)**
  - Aluminum material allows for a lightweight and strong frame
- **Principal Dimensions (in)**
  - Clamps onto an appropriate amount of the rocket motor ring
  - bracket template clamps onto the correctly sized templates
  - clears the rocket motor dome
- **Working Length (in)**
  - Rails allow operability 36” inward of motor ring
- **Working Angle (Degrees)**
  - Pins located at joints allow for mobility around the motor dome
- **Modulus of Elasticity (lbf/in2)**
  - The material of the device has lower yield strength than the motor ring

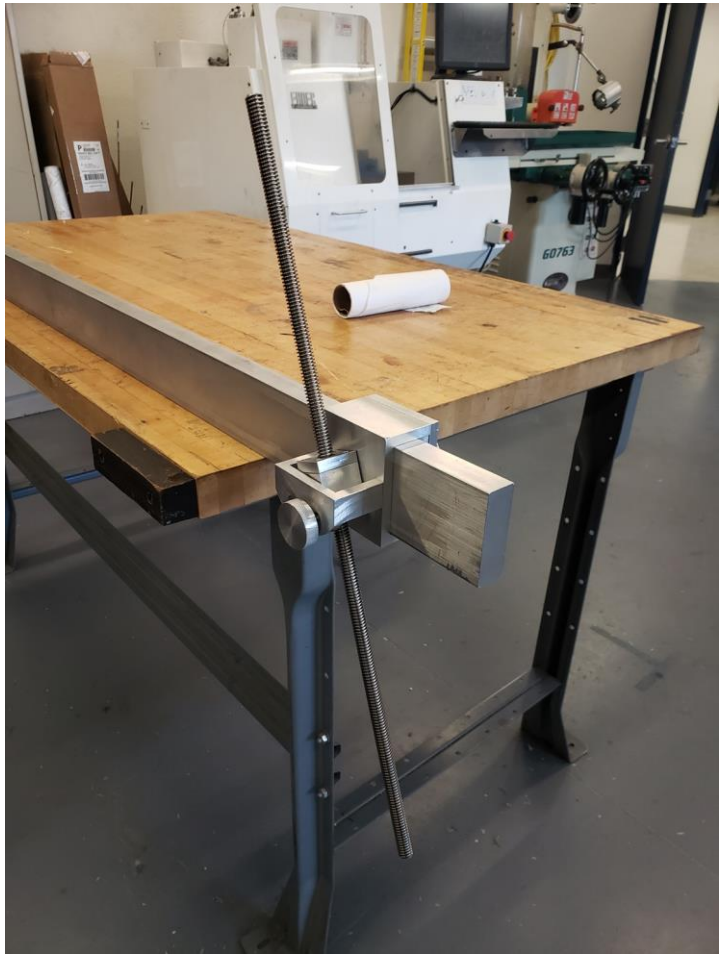

Figure 20. Current state of manufactured system

3.1 Current State of System - Brandon Bass

- Action Items:
  - Website Check
  - Power Screw Analysis
  - ERs and TPs revamp memo

Figure 21. Threaded knobs and rail cart pins

3.1 Current State of System - Dakota Saska

- Action Items:
  - CAD Design
  - Rail Deflection Analysis
  - Pin Shear Analysis

Figure 22. Rail angling mechanism and pressure plate parts

3.1 Current State of System - Elaine Reyes

- Action Items:
  - ERs and TPs revamp memo
  - Website Check

Figure 23. Angle positioner for template holder

3.1 Current State of System - Sage Lawrence

- Action Items:
  - CAD Design
  - FEA Motor Clamp Analysis

Figure 24. Angling mechanism to adjust rail angle

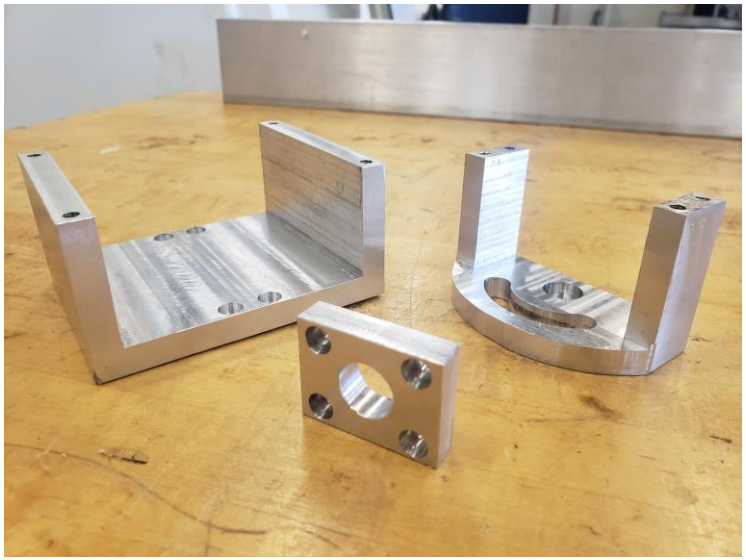

Figure 25. C-channel, angle positioner, and top plate

3.1 Current State of Design- Tyler Hans

- Action Items:
  - Device Coating
  - Angle of Twist Analysis

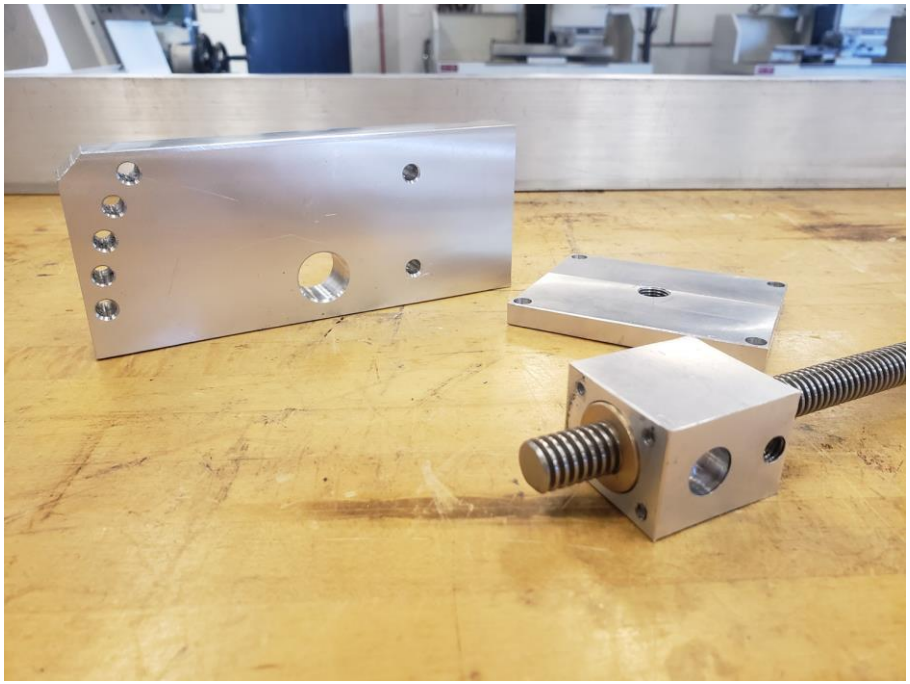

Figure 26. Rail angling mechanism, side plate, and power screw assembly

3.2 Budget

Table 1. Previous Spendings Chart

Material	Unit Cost	Quantity	Total Cost	Source
6061 Aluminum Block, 4"x4"x12"	100.25	2	248.84	McMaster-Carr
PLA 3D Printing Filament	12.99	1	14.18	Amazon.com
Linear Sleeve Bearing, for 1-1/2" Diameter	141.17	1	175.05	McMaster-Carr
6061 Polished Aluminum Tube, 1/4" wall thickness, 1-1/2" OD	28.95	1	35.90	McMaster-Carr
Acme Lead Screw, 1/2"x10, 2ft long	31.68	1	39.28	Roton.com
Acme Sleeve Nut, 1/2"x10, Bronze	19.09	1	23.67	Roton.com
6061 Aluminum Rect. Tube, 1-1/2"x3"x3/16" thickness, 6 ft long	93.16	2	231.04	McMaster-Carr
Aluminum Socket Head Screws, 8-32, 1/2" long, Blue-Anodize	11.88	5 Packs of 5	73.66	McMaster-Carr
Strain Gauges	52	1 Pack of 8	80.78	Omega.com
		Total Cost to Date	922.40	
		Remaining Budget	9077.60	

3.2 Budget (cont.)

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Table 2. Current Spendings Chart

Material	Unit Cost	Quantity	Total Cost	Source
Aluminum 6061 3"x1"x1/8" rectangular tubing 6 ft long	76.68	1	23.53	McMaster-Carr
6061 Aluminum Rod, 2"x1ft	32.31	1	32.31	McMaster-Carr
18-8 Stainless Steel Ring-Grip Quick-Release Pin, 3/4"x4"	19.42	1	19.42	McMaster-Carr
18-8 Stainless Steel Ring-Grip Quick-Release Pin, 1/4"x4"	6	1	6	McMaster-Carr
18-8 Stainless Steel Ring-Grip Quick-Release Pin, 1/4"x1-1/8"	4.48	2	8.96	McMaster-Carr
18-8 Stainless Steel Ring-Grip Quick-Release Pin, 1/4"x2-1/16"	4.69	2	9.38	McMaster-Carr
Aluminum 6061 3/8"x2"x2ft	23.53	1	23.53	McMaster-Carr
PTFE Plastic Washer pack of 10	5.88	1	5.88	McMaster-Carr
Aluminum Socket Head Screw, pack of 5	11.88	3	35.64	McMaster-Carr
Aluminum Shoulder Screw, Socket Head Cap, Hex Socket Drive, Standard Tolerance, 1/16"-18 Thread Size, 3/8" Sholder Diameter, 2" Shoulder Length	5.58	8	44.64	Amazon
		Total Cost of Future Materials	251.15	
		Cost of Future Materials + Total Cost to Date	1173.55	
		Expected Remaining Budget	8826.45	

4.1 Implementation Plan

- Week of March 1st
  - Manufacture the Rocket Motor Ring Clamp/Angling Mechanisms
- Week of March 8th
  - Manufacture the Bracket Template Clamp
- Week of March 22nd
  - Assemble/ Manufacture Miscellaneous Elements
- Week of March 29th
  - Perform Testing Procedures
- Week of April 6th
  - Make Design Changes Based on Results of TPs
- Week of April 13th
  - Perform Final Testing Procedures & Prepare for UGRADS
- Week of April 19th
  - UGRADS
- Week of April 26th
  - Northrop Grumman Symposium

4.2 BOM and Responsible Engineers

Table 3. Bill of Materials

BOM			
Part	Quantity	RE	Progress
Brass Nut	1	N/A	x
Cart Angle Locker	1	Brandon Bass	x
Cart Angler	1	Elaine Reyes & Sage Lawrence	x
Lead Screw	1	N/A	x
Pressure Plate C	1	Dakota Saska	x
Pressure Plate H	1	Dakota Saska	x
Pressure Plate Knob	1	Dakota Saska	x
Pressure Plate Rotational Piece	1	Dakota Saska	x
Rail Cart Plate	1	Tyler Hans	x
Rail Cart	1	Sage Lawrence	x
Rail	1	N/A	x
T Piece Top	1	Sage Lawrence	x
T Piece	1	Tyler Hans	x
Torque Handle	1	Dakota Saska	
Torque Nut	1	Dakota Saska	
PTFE Plastic Washer	2	N/A	x
Socket Head Screws #8-32	16	N/A	x

Progress Legend	
finished	x
being manufactured	o
not worked on	

4.2 BOM and Responsible Engineers (cont.)

Table 4. Bill of Materials (cont.)

Castor 30 Inner Clamp	1	Work Order & Sage Lawrence	
Castor 30 Outer Clamp	1	Work Order & Dakota Saska	
Rail Angle Template	2	Elaine Reyes & Sage Lawrence	o
Rail Mount	1	Dakota Saska & Tyler Hans	o
Rocket Clamp Shoulder Screw	6	N/A	x
Quick Release Pin 3/4x4"	1	N/A	x
Quick Release Pin 1/4x4"	1	N/A	x
Quick Release Pin 1/4x1-1/8"	2	N/A	x

4.2 BOM and Responsible Engineers (cont.)

Table 5. Bill of Materials (cont.)

Lead Screw Rotator	1	Tyler Hans	
Lead Screw Rotation Washer	1	Brandon Bass	
Lead Screw Top Plate	1	Elaine Reyes	
Plate Holder	2	Tyler Hans	
Pull Test Attachment	1	Sage Lawrence	
Pull Test Cap	1	Elaine Reyes	
Pull Test Threaded	1	Brandon Bass	
Slot Angler	1	Sage Lawrence	
Template Holder	1	Dakota Saska	
Template Screws	4	Brandon Bass	o
Quick Release Pin 1/4x2-1/16"	2	N/A	x
Socket Head Screws #8-32	4	N/A	x
Total # of Parts	68		

4.3 Assignments and Responsible Engineers

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Table 6. Future Action Items

Midpoint Presentation and Hardware Review				
Midpoint Presentation	Everyone	0%	3/1/20	3/2/20
Hardware Review	Everyone	0%	3/1/20	3/4/20
Individual Analyses	Everyone	0%	3/1/20	3/13/20
Final Product Completion	Everyone	0%	3/1/20	3/27/20
Website Checks				
Website Check 2	Elaine, Brandon	0%	3/1/20	3/27/20
Website Check 3	Elaine, Brandon	0%	3/1/20	5/4/20
UGRADS Preparation				
Proof of UGRADs registration	Everyone	0%	3/1/20	3/7/20
Draft of Poster	Everyone	0%	3/1/20	3/13/20
Final Poster	Everyone	0%	3/1/20	4/3/20
UGRADS (Friday) Presentation	Everyone	0%	3/1/20	4/24/20
Peer Evaluations				
Peer Evaluation 2	Everyone	0%	3/1/20	3/8/20
Peer Evaluation 3	Everyone	0%	3/1/20	4/5/20
Final Peer Evaluation	Everyone	0%	3/1/20	5/5/20
Implementation Memo II	Everyone	0%	3/1/20	4/3/20
Testing Proof				
Testing Procedures		0%	3/27/20	4/10/20
Testing Proof Report		0%	3/27/20	4/10/20
Final Report	Everyone	0%	3/1/20	5/1/20
Operations/Assembly Manu	Everyone	0%	3/1/20	5/1/20
Final CAD package with BOI	Everyone	0%	3/1/20	5/3/20
Client Handoff	Everyone	0%	3/1/20	5/6/20
NG University Symposium D	Everyone	0%	3/1/20	5/1/20

5. Test Procedures

Procedure 1: ESD Compliance

Objective: To verify that the device is electrically conductive

Testing Procedure:

1. Place the anti-static table mat onto a table, anti-static mat on the floor, and ground the table mat
2. Mount the entire device on the anti-static table mat
3. Use a multimeter between a team member who's standing on the anti-static mat and the device to read 0V

Table 7. Test Procedure 1 BOM

Index	Tool	Dimensions	Reference	Price ($)
1	Anti-Static Table Mat	2'x4'	https://www.uline.co	85.00
2	Common Ground Cord	15'	https://www.uline.co	17.00
3	Multimeter	n/a	https://www.homedep	40.00
4	Anti-Static Mat	2'x3'	https://www.uline.co	50.00
				192.00

5. Test Procedures (cont.)

Procedure 2: Torque Wrench

Objective: To evaluate the actual torque input to obtain a 20lb push and a 50lb pull.

Expected Values:

- Torque to Raise, 0.313 lbf-ft
- Torque to Lower, 0.176 lbf-ft

Testing Procedure:

1. Place a spring scale at the end of the device
2. Apply torque to the wrench at incremental forces and record results
3. Plot the results of torque vs force

Figure 27. Torque Wrench

5. Test Procedures (cont.)

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Procedure 3: Working Angle and Length

Objective: To prove the functionality, reliability of the angling mechanisms of both the ring clamp and bracket holder, and that the device meets the required mass and working length applying a maximum force of 50 lbf

Testing Procedure:

1. Weigh individual parts
2. Mount device
3. Apply a 50 lbf force
4. Repeat procedure at all angles

Table 8. Test Procedure 3 BOM

Index	Tool	Dimensions	Source	Price ($)
1	Torque Wrench	n/a	https://www.onlineme	159.99
2	Digital Scale	n/a	NAU	0
3	Ruler	n/a	NAU	0
4	Measuring Tape	n/a	NAU	0
5	Calipers	n/a	NAU	0
				159.99

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