HR 2 BREAKDOWN

FROM: **19F18 - Northrop Grumman Standoff**

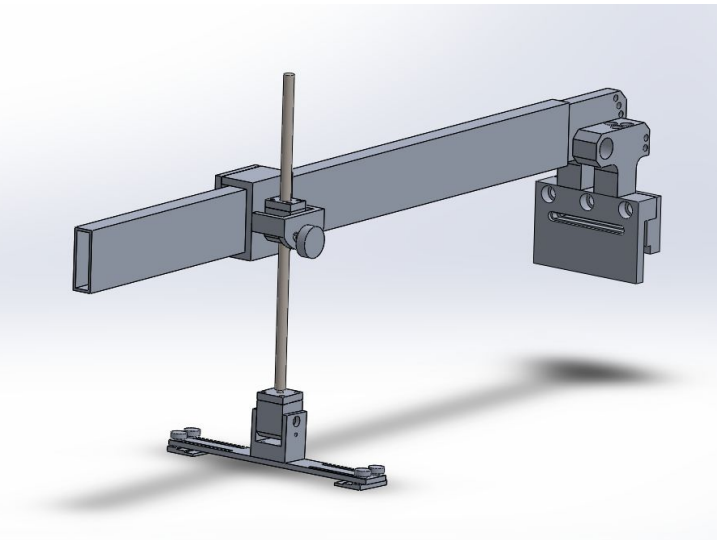
TEAM: **Tyler Hans**
Dakota Saska
Brandon Bass
Sage Lawrence
Elaine Reyes

Due Date:
Friday, March 6, 2020 at 11:59pm

Current Progress

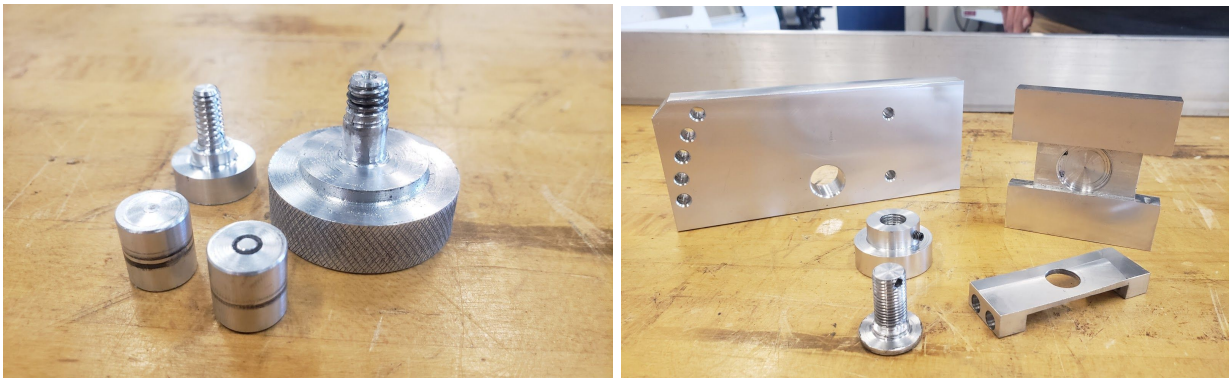
This section will include images of both the current state of the device and the proof of completion for the action items between the hardware review I and II.

(a)



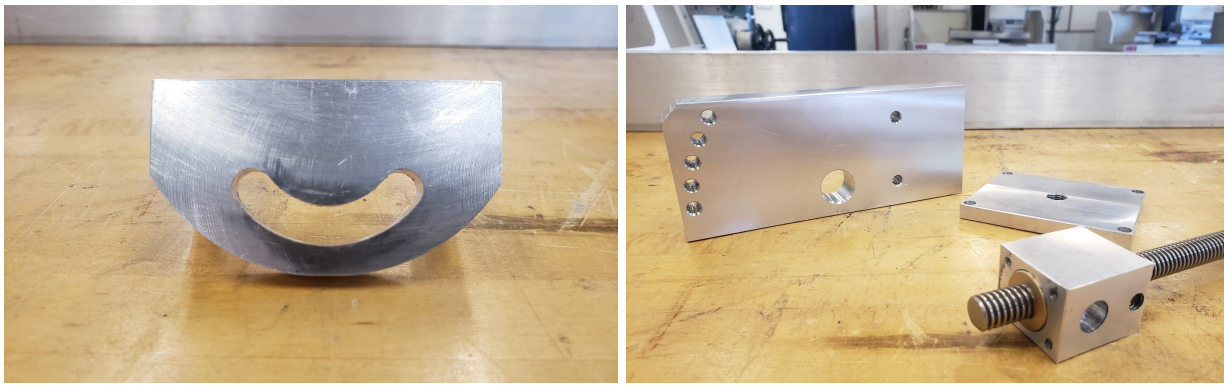
(b)

Figure 1: (a) Current State of Design; (b) Current State of CAD



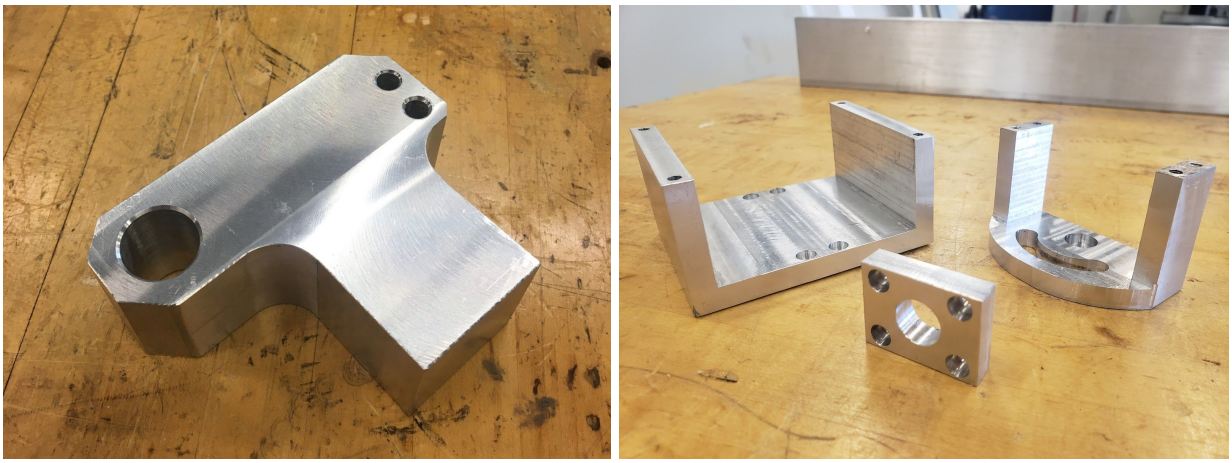
(a) **(b)**

Figure 2: (a) Threaded knobs and rail cart pins; (b) Rail angling mechanism and pressure plate parts



(a) **(b)**

Figure 3: (a) Angle positioner for template holder; (b) Rail angling mechanism, side plate, and power screw assembly

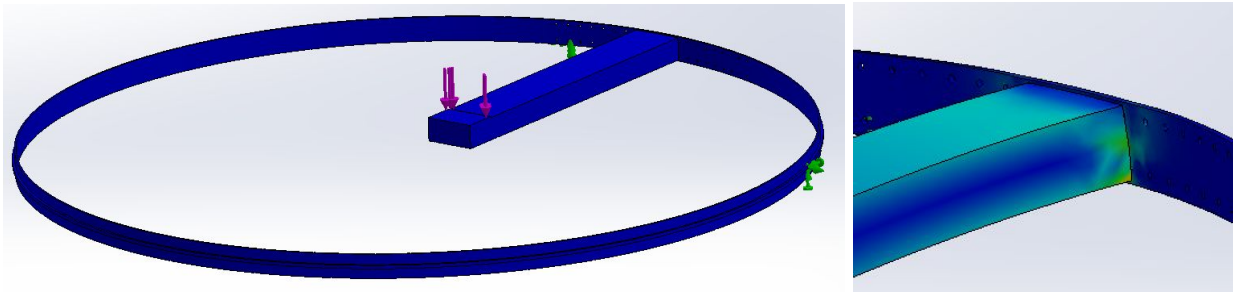


(a) **(b)**

Figure 4: (a) Angling mechanism to adjust rail angle; (b) C-channel, angle positioner, and top plate

(a) **(b)**

Figure 5: (a) Purchased raw materials and cart rail; (b) Purchased hardware: pins, screws and washers



(a) **(b)**

Figure 6: (a) View of FEA rig; (b) Focus view on stress distribution at the ring interface

Angle of Twist

- Length = 36 in
- Torque = 81.625 in-lbs
  - 1.3625" * 50lbs
- Modulus of Rigidity = $3.8*10^6$ psi
- Polar Moment of Inertia = 1.104 in^4
  - Ix = .950 in^4
  - Iy = .153 in^4
- Angle of Twist = .04°

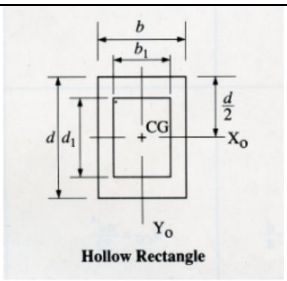


Figure 18. Angle of Twist Dimension Drawing

$$\theta = \frac{TL}{J_{CG}G}$$

$$I_{x_0} = \frac{bd^3 - b_1 d_1^3}{12}$$

$$I_{y_0} = \frac{db^3 - d_1 b_1}{12}$$

$$J_{CG} = I_{x_0} + I_{y_0}$$

Figure 7: Angle of Twist Analysis Results

Rail System

- Hollow Cylindrical Tube:
  - Ixx = .199 in^4
  - Ac = .982 in^2
- Hollow Rectangular Tube:
  - Ixx = .95 in^4
  - Ac = .9375 in^2
- Deflection of Cantilever Beam:
  - δc = .391 in
  - δr = .082 in
    - F = 50 lb
    - E = 10000 ksi
    - L = 36 in
- Weight of Rail System:
  - Wc = 3.46 lb
  - Wr = 3.31 lb
    - ρ = .098 lb/in^3

Hollow Cylindrical Tube:

$$Ixx = \frac{\pi}{64}(D^4 - d^4)$$

$$A_c = \frac{\pi}{4}(D^2 - d^2)$$

Hollow Rectangular Tube:

$$Ixx = \frac{1}{12}(BH^3 - bh^3)$$

$$A_c = BH - bh$$

Deflection of Cantilever Beam:

$$\delta = \frac{F L^3}{3 I E}$$

Weight of Rail System:

$$W = \rho A_c L$$

Figure 8: Rail Deflection Analysis Results

Pin Shear Analysis

- Single pin must resist moment from entire rail cart lever arm.
  - One long, single pin going through both sides subjected to double shear.
- Max Load 50 lbs, results in 360lb internal shear on pin.
- Required diameter for desired factor of safety in pins is 0.207 in.

$$\tau_{failure} = 32\ ksi$$
$$F.O.S. = 3$$
$$\tau_{allowable} = 10.67\ ksi$$

$$\tau_{Avg} = \frac{V_{internal}}{A_c}$$

$$D_{required} = \sqrt{\frac{4\ V_{internal}}{\Pi\ \tau_{allowable}}}$$

Figure 9: Pin Shear Analysis Results

Parameter	Equation
Self-Locking Condition (1)	$\tan(\lambda) < \mu$
Self-Locking Condition (2)	$\pi\mu d_m > l$
Critical Force [Fc]	$F_C = \left(\frac{C\pi^2 E}{L_C^2}\right) * I$
Moment of Inertia [I]	$I = \pi\frac{d^4}{64}$

(a)

Parameter	Equation
Torque required to raise the load [T_R] [1,2,3]	$T_R = \frac{F \cdot d_m}{2}\left(\frac{l + \pi f d_m \sec\alpha}{\pi d_m - f l \sec\alpha}\right) + T_c$
Torque required to lower the load [T_L] [1,2,3]	$T_R = \frac{F \cdot d_m}{2}\left(\frac{-l + \pi f d_m \sec\alpha}{\pi d_m + f l \sec\alpha}\right) + T_c$
Frictional torque of the thrust collar [T_c]	$T_c = \frac{F f_c d_c}{2}$
Efficiency during lifting the load [e] [3]	$e = \frac{Fl}{2\pi T_R}$

(b)

Figure 10: Power Screw Analysis Equation Tables

- Self-Locking Condition
  - Given the current conditions, the ACME screw is expected to be self-locking
- Torque
  - Torque to Raise, 0.313 lbf-ft
  - Torque to Lower, 0.176 lbf-ft
- Buckling
  - Using a design factor of 3.0, the critical force was determined to be 1000-lbf
- Thread Galling
  - Not expected to be an issue given the current operating conditions

Figure 11: Power Screw Analysis Results

The following are the Action Items each person completed between Hardware Review 1 and Hardware Review 2:

Team Member: Sage Lawrence

Action Item	Date Completed	Result/Proof of Completion
Machined Components: C-Channel, Angling Mechanism	February 25th, 2020	Machined components for both the rail cart and angling assemblies of the device. Proof of completion is presented in figure 4 above.
CAD Design	February 27th, 2020	Facilitated the creation and design of the device through interactions with the client and interpretation of the design requirements. Created past and current iterations of the standoff bonding tool, the latter of which can be referred to in figure 1 above. Marked as completed as of the CDR presentation but the design will be likely modified in the future.
FEA Motor Clamp Analysis	February 27th, 2020	Performed FEA analysis of the motor attach ring to determine what the approximate factor of safety would be given the applied forces. Proof of the completion of this analysis can be referred to above in figure 6.

Team Member: Tyler Hans

Action Item	Date Completed	Result/Proof of Completion
Device Coating Research	February 10st, 2020	Identified Micro-Surface Corporation where the parts interfacing with the rail can be coated to reduce friction. Upon completion of the rail cart assembly, the parts will be shipped to Micro-Surface Corporation to have surface coatings applied.
Machined Components: Top Plate	February 13th, 2020	Manufactured the t-piece, front plate of the rail cart assembly, and faced the size and drilled the pilot holes in the rail mount part. Proof of completion is presented in figure 3b above.
Angle of Twist Analysis	February 27th, 2020	Due to modifications of the rail cart design, an analysis was required to determine the angle of twist due to eccentric loading. This was presented in our Critical Design Review presentation at Northrop Grumman. The results of the angle of twist analysis can be referred to in figure 6 above.

Team Member: Dakota Saska

Action Item	Date Completed	Result/Proof of Completion
Machined Components: Rail Mount, pressure plate assembly	February 20th, 2020	Manufactured components of the rail cart assembly using the manual mills and lathes in building 98C. Proof of completion is presented in figure 2b and 3b above.
CAD Design	February 27th, 2020	Worked closely with Sage on the creation of the CAD model. The proof of their efforts can be referred to above in figure 1 which shows the current state of the CAD model as of the Critical Design Review.
Rail Deflection Analysis	February 27th, 2020	Performed a rail deflection analysis in preparation for the CDR presentation to determine the deflection of the rail given the applied loads. The results of the rail deflection analysis can be referred to in figure 8 above.
Pin Shear Analysis	February 27th, 2020	Also performed in preparation for the CDR presentation to determine the critical shear of the pins. The results of the pin shear analysis are presented above in figure 9.

Team Member: Brandon Bass

Action Item	Date Completed	Result/Proof of Completion
Website Check 1	February 21st, 2020	Updated website as well as reformatting the layout and thumbnails to allow for easier access to the team documents. The capstone website can be visited at: https://www.cefns.nau.edu/capstone/projects/ME/2019/19F18_NorthropGrummanStandoff/
Machined Components: Threaded Knob, rail cart pins	February 25th, 2020	Manufactured threaded knobs and pins which fit into the rail cart assembly. Proof of completion is presented in figure 2a above.
Power Screw Analysis	February 27th, 2020	Performed analysis of the power screw in preparation for the Critical Design Review at Northrop Grumman. The proof of the analysis is presented above in figure 10 and 11.

Team Member: Elaine Reyes

Action Item	Date Completed	Result/Proof of Completion
Website Check 1	February 20th, 2020	Added in carousel functionality for the gallery as well as reformatting website code for organizational purposes. The capstone website can be visited at: https://www.cefns.nau.edu/capstone/projects/ME/2019/19F18_NorthropGrummanStandoff/
Learn Fusion 360 and G-code	February 25th, 2020	Learned how to use fusion 360 and interpret G-code in preparation for machining parts using the CNC in building 98C.
Machined Components: CNC curves of angling mechanism.	February 25th, 2020	Manufactured the angle positioner component using the CNC in building 98C. Proof of the completion of this component is presented in figure 3 above.

Future Action Items

The following are the Action Items for each team member between HR 2 and the Final Product presentation with respective due dates. The action items highlighted in orange identify parts that are currently being manufactured:

Team Member	Action Items	Date Due
Brandon Bass	Template Screws	3/11
	Pull Test Threaded	3/11
	Lead Screw Rotation Washer	3/13
	Torque Nut	3/13
	Power Screw Analysis	3/13
	Draft of Poster	3/13
	Website Check II	3/27
	ESD Compliance Test	4/1
	Implementation Memo II	4/3
	Final Poster	4/3
	Peer Eval 3	4/5
	Testing Proof Report	4/10
	Final Presentation	4/15
Tyler Hans	Rail Mount	3/9
	Lead Screw Rotator	3/11
	Lead Screw Top Plate	3/11
	Plate Holder	3/13
	Angle of Twist Analysis	3/13
	Draft of Poster	3/13

	ESD Compliance Test	4/1
	Implementation Memo II	4/3
	Final Poster	4/3
	Peer Eval 3	4/5
	Power Screw Test	4/7
	Final Product Test	4/9
	Testing Proof Report	4/10
	Final Presentation	4/15
Sage Lawrence	Rail Angle Template (1 of 2)	3/9
	Rail Angle Template (2 of 2)	3/9
	Castor 30 Inner Clamp	3/11
	Pull Test Attachment	3/13
	Slot Angler	3/13
	Rocket Ring Moment Analysis	3/13
	ESD Compliance Test	4/1
	Implementation Memo II	4/3
	Final Poster	4/3
	Peer Eval 3	4/5
	Power Screw Test	4/7
	Final Product Test	4/9
	Testing Proof Report	4/10
	Final Presentation	4/15
Elaine Reyes	Rail Angle Template (1 of 2)	3/9
	Rail Angle Template (2 of 2)	3/9
	Pull Test Cap	3/11
	Torque Handle	3/13

	Pin Shear Analysis	3/13
	Draft of Poster	3/13
	Website Check II	3/27
	ESD Compliance Test	4/1
	Implementation Memo II	4/3
	Final Poster	4/3
	Peer Eval 3	4/5
	Testing Proof Report	4/10
	Final Presentation	4/15
Dakota Saska	Rail Mount	3/9
	Castor 30 Outer Clamp	3/11
	Lead Screw Rotator	3/11
	Lead Screw Top Plate	3/11
	Template Holder	3/13
	Rail Deflection Analysis	3/13
	Implementation Memo II	4/3
	Final Poster	4/3
	Peer Eval 3	4/5
	Power Screw Test	4/7
	Final Product Test	4/9
	Testing Proof Report	4/10
	Final Presentation	4/15