Release Lanyard Design

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Document

Mid-Point Report

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Introduction

Many weapons constructed by Raytheon use a lanyard to activate the weapon after it has been released. Unfortunately on a few occasions the lanyard has failed to activate the weapon due to icing, poor installation, and contaminates such as sand and dust. Raytheon has proposed this project to our team to find a new design that is more reliable and less susceptible to these modes of failure.

Needs Identification

This project will consist of developing a new design for an arming system lanyard and a functional prototype. The current lanyard design does not address issues relating to extreme temperatures and environmental effects, which leads to system malfunction.

Project Goal

Our goal is to design a reliable, low cost system that can withstand extreme temperatures and environmental effects. This system will also be constrained due to size and specific material requirements.

After a meeting on January 10, 2013 with Raytheon's release lanyard design supervisors, the emphasis of our design analysis has changed to focus primarily on the internal activation mechanism, instead of the external components. This changed the original design problem from redesigning an entire lanyard system to redesigning the slider switch assembly, which disregards the cable, cable guide components, and activation arm.

Constraints

i. The device has to fit within the dimensions of the environmental testing chamber, which can simulate conditions that the current design is failing under.
ii. The placement of the lanyard mounts and associated devices such as the battery have already been predetermined.
iii. Internal components must fit in the allowable housing space.
iv. Internal activation switches cannot be modified.
v. The allowable cost must not exceed that of the current design which is $300 in material cost.
vi. Must be easily assembled within 30 minutes.

Objectives

With the information provided to us by our client, we have constructed the following table based on the most important criteria.

Table 1: Objectives

Objectives	Basis for Measurement	Units
Inexpensive	Manufacturing Cost Based on Current Design	$300
Maintain Current Location of Devices	Location Based on Current Design	Meters
Installation and Assembly	Timed Trial	Seconds
Successful Activation of Devices	Minimum Force Required	Newton's
Low Susceptibility to Contamination	Amount of Contamination Required to Induce Failure	Kilograms
High Performance Reliability	Number of Successful Attempts vs. Failed	%

Current Internal Components

As mentioned in the introduction, the current lanyard design has failed to activate the weapon due to icing, poor installation, and contaminates such as sand and dust. The exact location of the icing or debris build up is unknown, but results in the cable breaking at the fuseable link prior to activation. The current slider design can be found in the Figure 1 below. One of the primary issues upon seeing the internal components of the activation system was the complexity and surface area for ice and debris to accumulate.

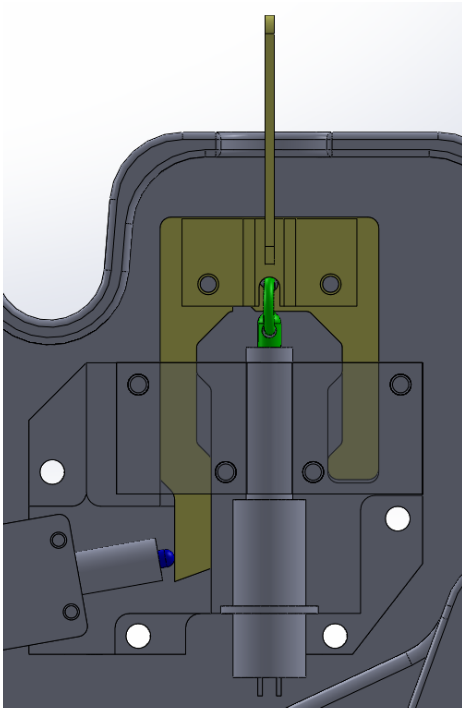
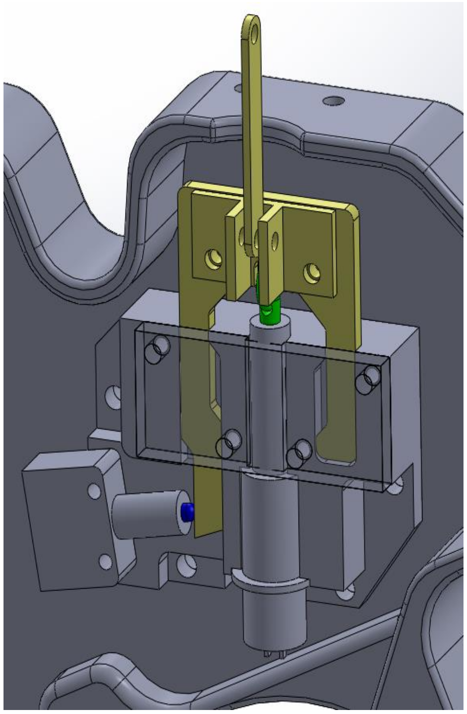

Figure 1: Current Slider Design

Preliminary Designs

After visiting our client's facilities our team has been refocused to address the complexity of the internal battery slider assembly. The team is currently working on designs for the slider switch and the arrangement of associated components. Two of the designs being considered can be found in Figures 2 and 3.

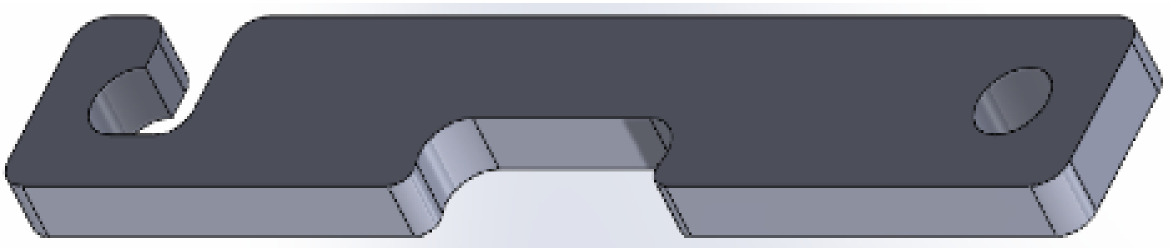

Figure 2: Slider Design 1

The primary difference between these designs and the current slider is switch location and the surface area. With a smaller, more compact slider the internal complexity should decrease as a result.

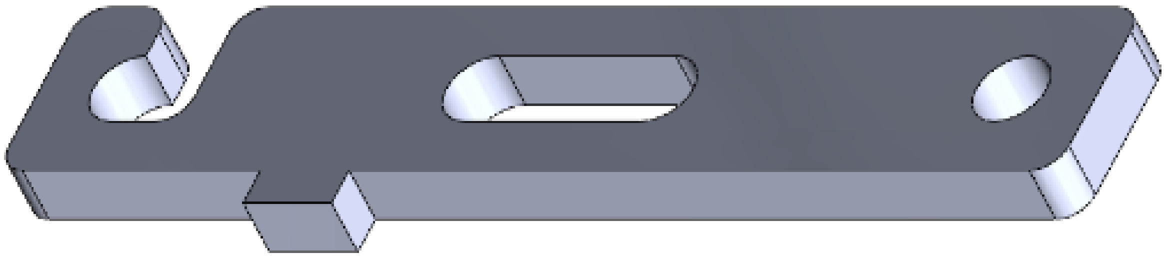

Figure 3: Slider Design 2

Design Analysis and Modifications

The newly designed assembly had certain criteria which needed to remain constant. The battery and switch location on the assembly of the weapon were modeled as fixed features while the rest of the assembly could be moved for modifications. When taking into account these factors for the new assembly, the team came up with a new design to accommodate the constraints. A few factors came into consideration, such as having fewer parts, shorter machining and assembly time, easy to install, lower material cost, and overall less surface area for ice buildup. The angle of the switch which is currently placed at 10 degrees is mimicked to facilitate easier analysis. This affected where the switch could be placed. Therefore imposing some constraints to where assembly components could be positioned in the new design.

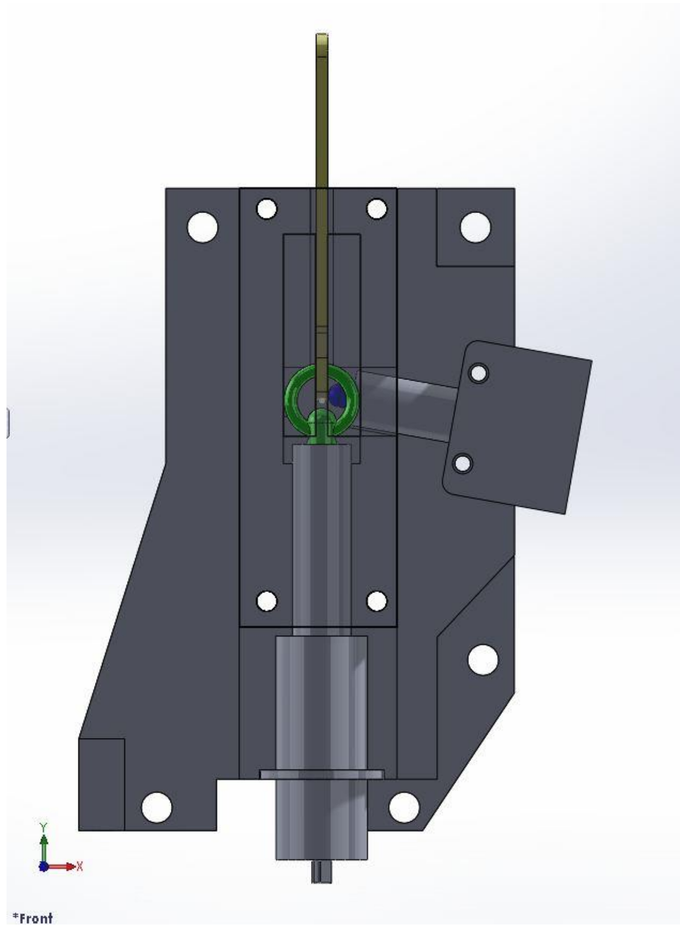

Figure 4: New Design Concept

The switch location for the new design is best placed in a current void to the right of the current design. The location of the switch cavity along with having a single link/slider determined that the switch needed to be placed in a location close to the battery pull pin. As seen in Figure 1, the ideal location was found to be at the same line of action as the battery pull pin to the weapon rocker arm via the slider. This lead to modifying the slider for a location above the mount, centered on the slider, or below the slider closer to the mounting location. Mounting the switch above or centered normal to the slider were eliminated due to interference with adjacent features. Thus placing the switch in between the slider and the mount was deemed the best fit for a new design.

By taking these considerations into account, along with the actual size of the switch, the location of the switch was determined to be approximately 0.75 inches above the battery as seen in Figure 4. By placing the switch in this location no modifications are needed to the current weapon rib, which the mount attaches to. As requested by Raytheon the mount for the new design was extended a half inch higher from the mounting location rib to facilitate a smoother transition of the force from the outside of the weapon to the inside assembly.

With less material, less surface area, fewer nuts, bolts, washers, and fewer parts allows for a better design. The improvements from the current design can be seen in the Table 2.

Table 2: Current vs. New Design Properties (Scaled)

Current					
Part	Volume	Mass	S.A.	S.A. of Concern	Critical Dimensions
	in^3	lbs	in^2	in^2	l*w*h "in"
Mount	4.22	0.16	35.68	2.78	5.4*4*1.24
Cover	0.64	0.02	10.40	2.66	4.1*1.8*.38
Link	0.04	0.01	2.12	1.92	3.5*0.5*0.125
Slider	0.16	0.00	5.18	0.00	2.4*1.2*0.8
Battery Slider	0.44	0.02	9.84	4.12	3*5*0.25
Screws needed	16.00				
Washers needed	32.00				
Nuts needed	16.00				
Different sizes	6.00				
Total	5.50	0.21	63.22	11.48	5.4*7*1.24

New					
Part	Volume	Mass	S.A.	S.A. of Concern	Critical Dimensions
	in^3	lbs	in^2	in^2	l*w*h "in"
Mount	4.74	0.17	44.12	2.12	4.75*7*1.74
Cover	0.48	0.02	10.94	0.84	1.72*4.78*0.46
Link	0.14	0.02	3.78	3.78	4.26*1*0.25
		% Reduction			
Screws needed	13.00	-18.75			
Washers needed	26.00	-18.75			
Nuts needed	13.00	-18.75			
Different sizes	4.00	-33.33			
Total	5.36	0.21	58.84	6.74	4.75*7*1.74
					Customer requested depth change to match rocker arm
% Reduction	-2.55	-0.28	-6.93	-41.29	

Two parts were removed from Raytheon's current design, allowing for the removal of 12 hardware components. This along with a 41% reduction in surface area is a great improvement upon the current design. The goal is to further improve upon the new design through testing, analysis, and inspections. Note values in document are scaled due to proprietary information.

New Base Plate Design

In redesigning the base plate, the team looked into minimizing the surface area and complexity of the activation system resulting in a more compact base as seen in Figure 5.

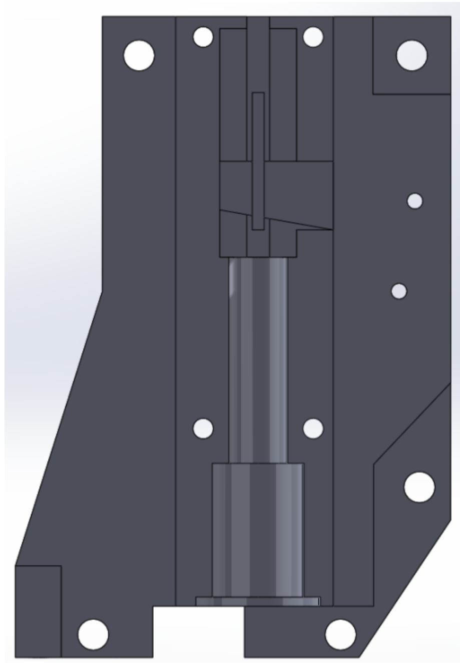

Figure 5: New Base Plate Design

This not only reduced the surface area and complexity of the system, but also eliminated two pieces in the manufacturing process. The new base plate also eliminates two screw types which will reduce confusion during assembly and installation time.

Material selection

The current material being considered is AL6061 due to its properties at cold and hot temperatures. Due to the purpose of this device, it must be able to withstand a temperature range of -50°C to 150°C (-58°F to 302°F). Figure 6 below, indicates AL6061 yield strength values at various temperatures above room temperature.

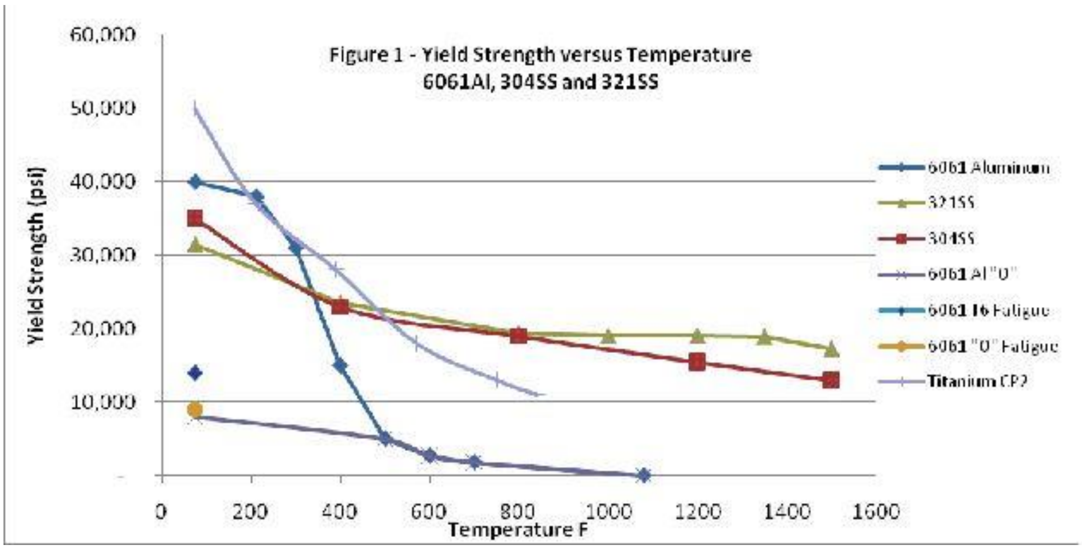

Figure 6: AL6061 Yield Strengths vs. Temperature [4]

As Figure 6 indicates the yield strength of AL6061 drops with increasing temperatures. This lower yield strength will need to be considered in future design decisions. Another material which was considered was steel. However, due to the temperature range exhibited by the device, steel was eliminated since it becomes very brittle at cold temperatures. While Aluminum increases in yield strength at colder temperatures as indicated by Figure 7.

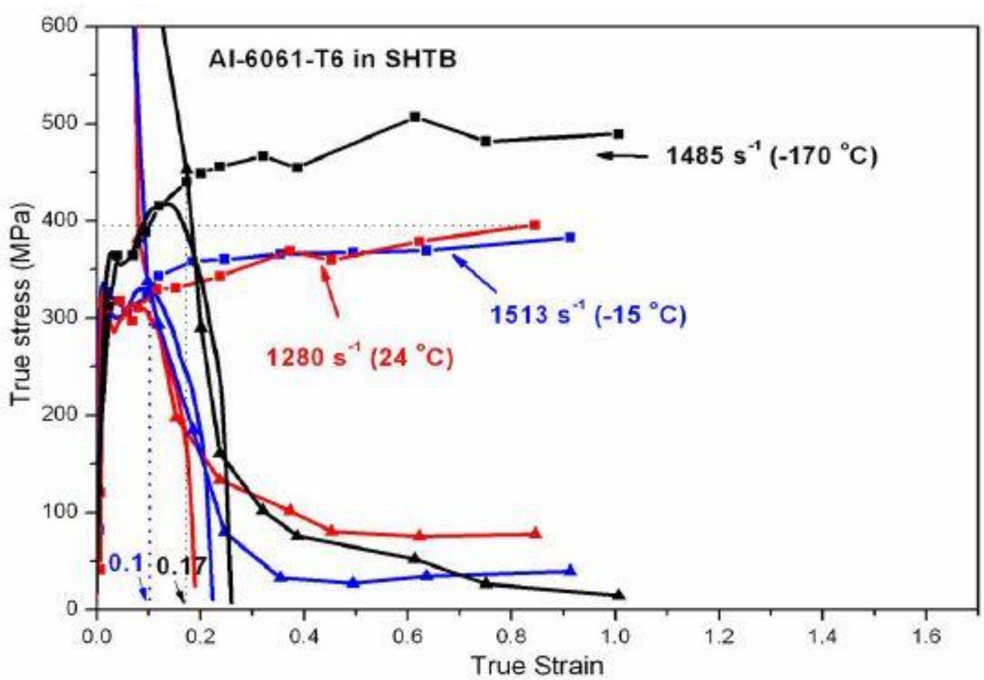

Figure 7: AL6061 True Stress vs. True Strain at Room Temperature to -170°C [3]

Top Designs

After receiving various dimensions needed to design the new slider and base plate, the previously mentioned designs were reconsidered and redesigned, resulting in the slider seen in Figure 8.

Figure 8: Slider Design 3

This design raised many concerns about its ability to perform the necessary tasks. To determine the performance of this design finite element analysis (FEA) was utilized. The FEA results of the applied force of 50 N can be seen in Figure 9.

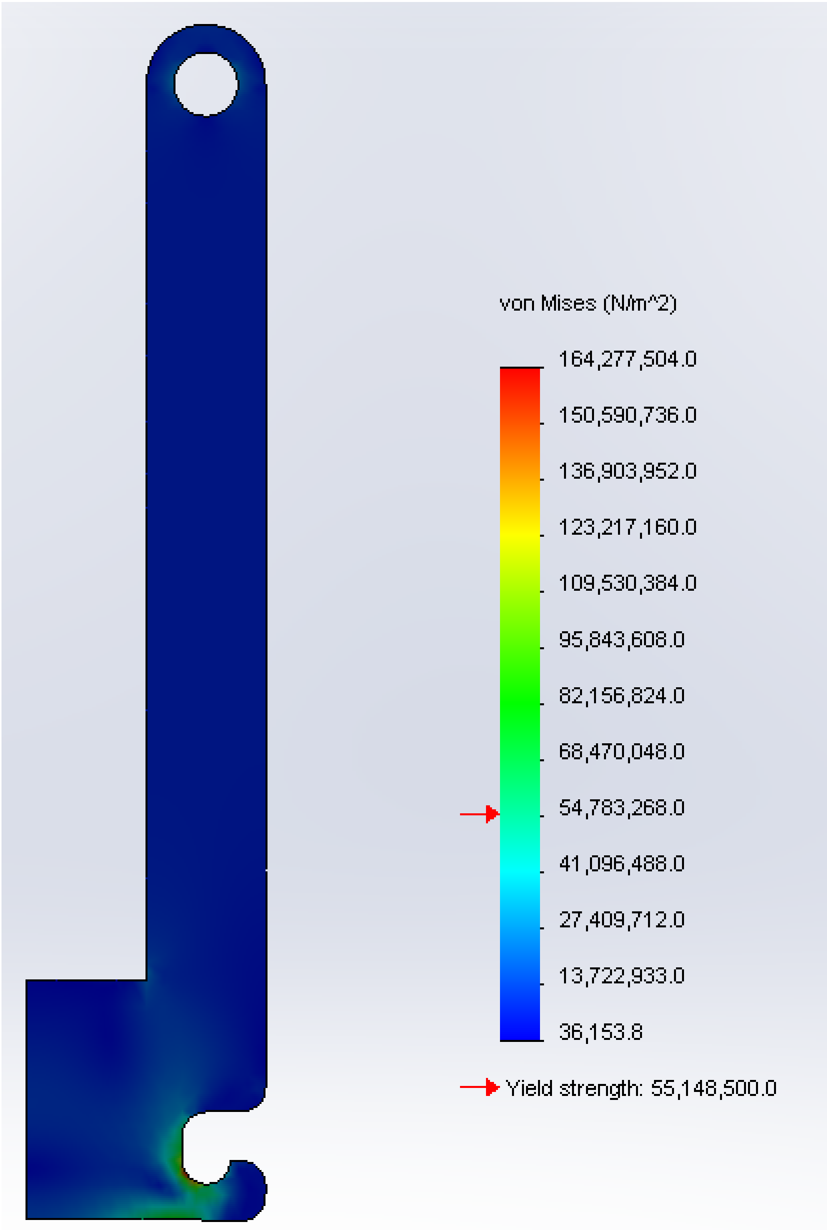

Figure 9: FEA of Slider Design 3

Figure 9, was computed considering AL6061 with yield strength of 55 Mega-Pascals (MPa). Noticing that the stresses exhibited by the slider would be well above yielding, it was decided to double the thickness and adjust the geometry of the slider. The resulting design can be seen in Figure 10.

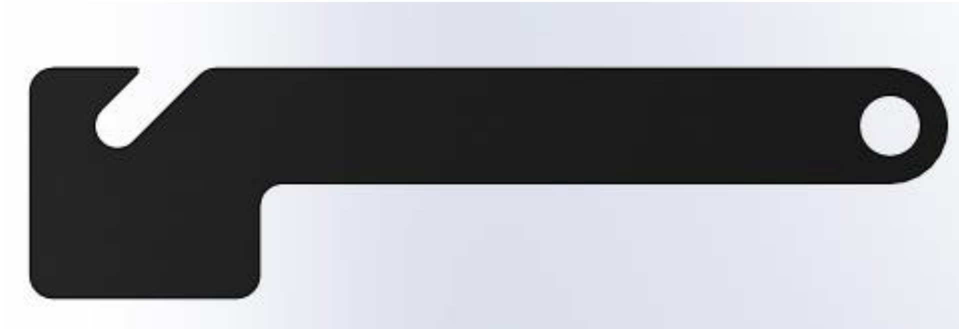

Figure 10: Top Design 1

After performing FEA on the new design, the results can be seen below, the maximum stress experienced by the slider dropped from 164.28MPa to 32.47MPa.

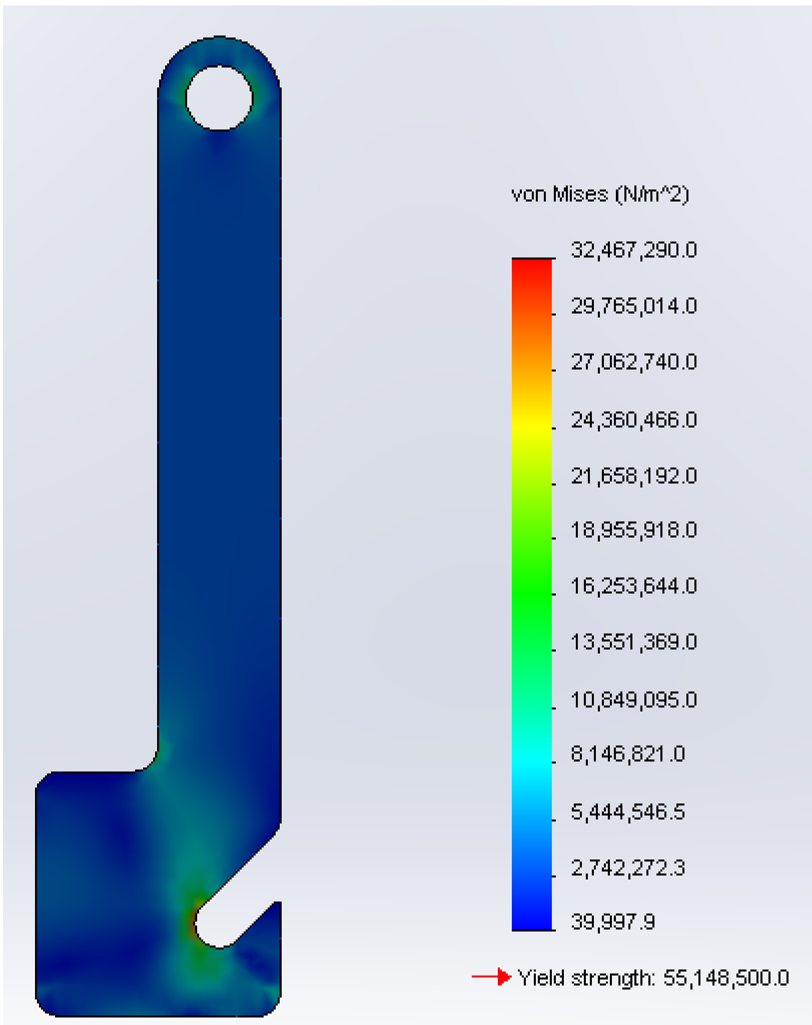

Figure 11: Top Design 1 FEA analysis

The resulting factor of safety for this design was approximately 1.70. This slider was then placed in an assembly to get an idea of how the assembly would fit together. The assembly can be seen in Figure 12 below.

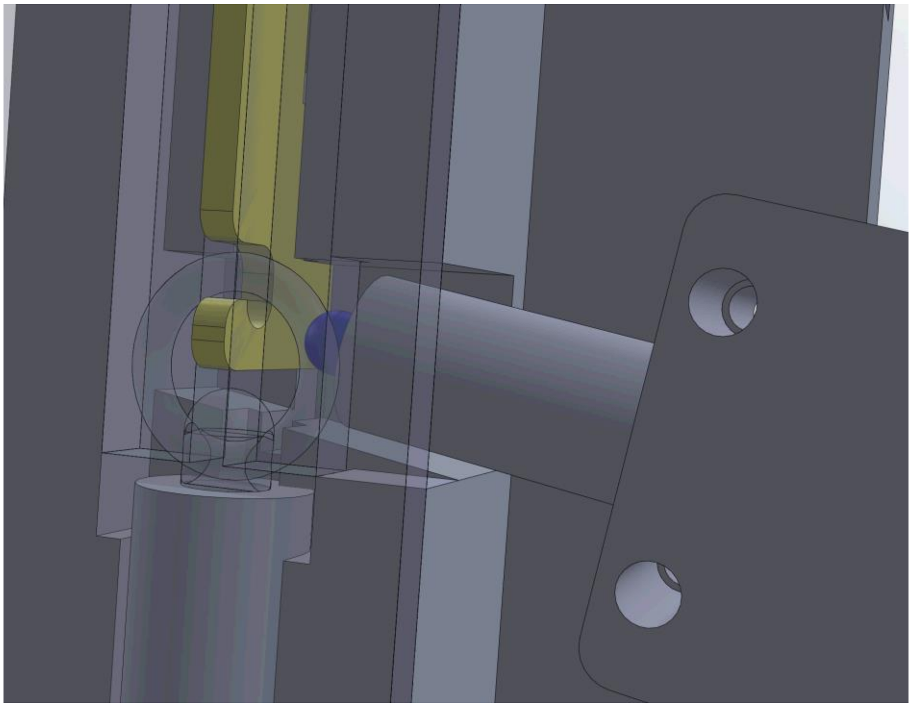

Figure 12: Slider Assembly Design

Based on the orientation of the slider and switch components, it was decided to consider an extended tab for the activation pin to rest on. This altered design can be seen in Figure 13. This extended tab creates more area for the activation pin to grip onto incase vibrations or other anomalies causes the slider to move out of place prematurely.

Figure 13: Top Design 2

Figure 14 below, displays the results of the finite element analysis performed on this new slider design. These results indicate no significant change in stress concentrators and the same factor of safety of 1.70.

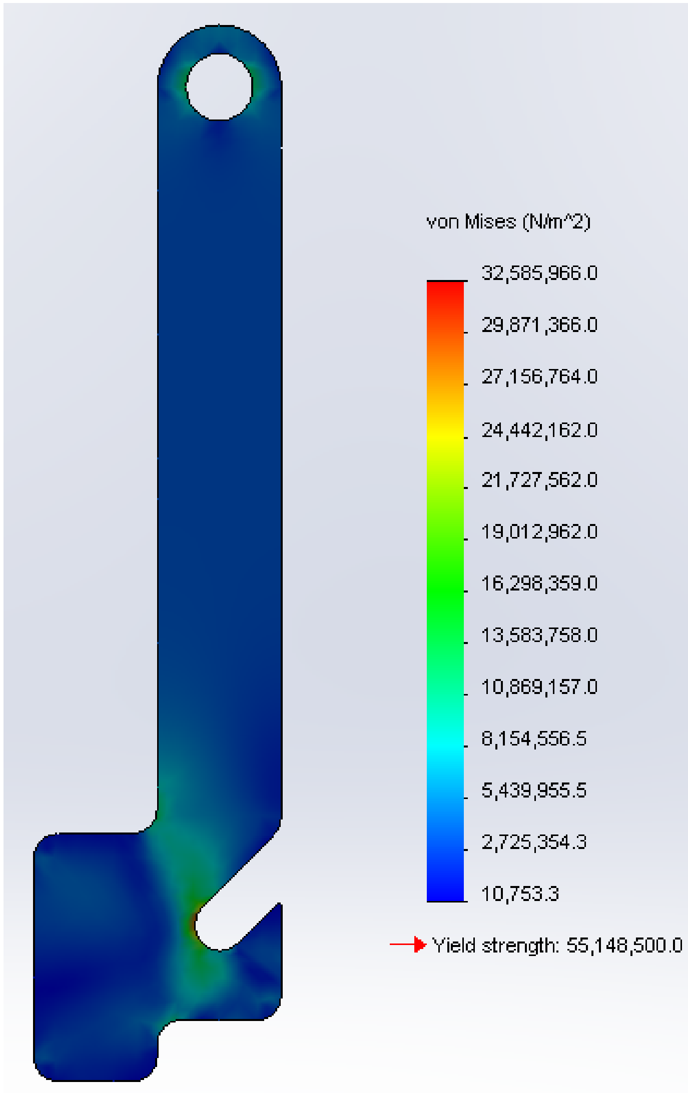

Figure 14: Top Design 2 FEA analysis

It was then decided to run the same analysis on the current slider switch to get a baseline of where our max stress and factor of safety should land. The resulting FEA model can be seen in Figure 15.

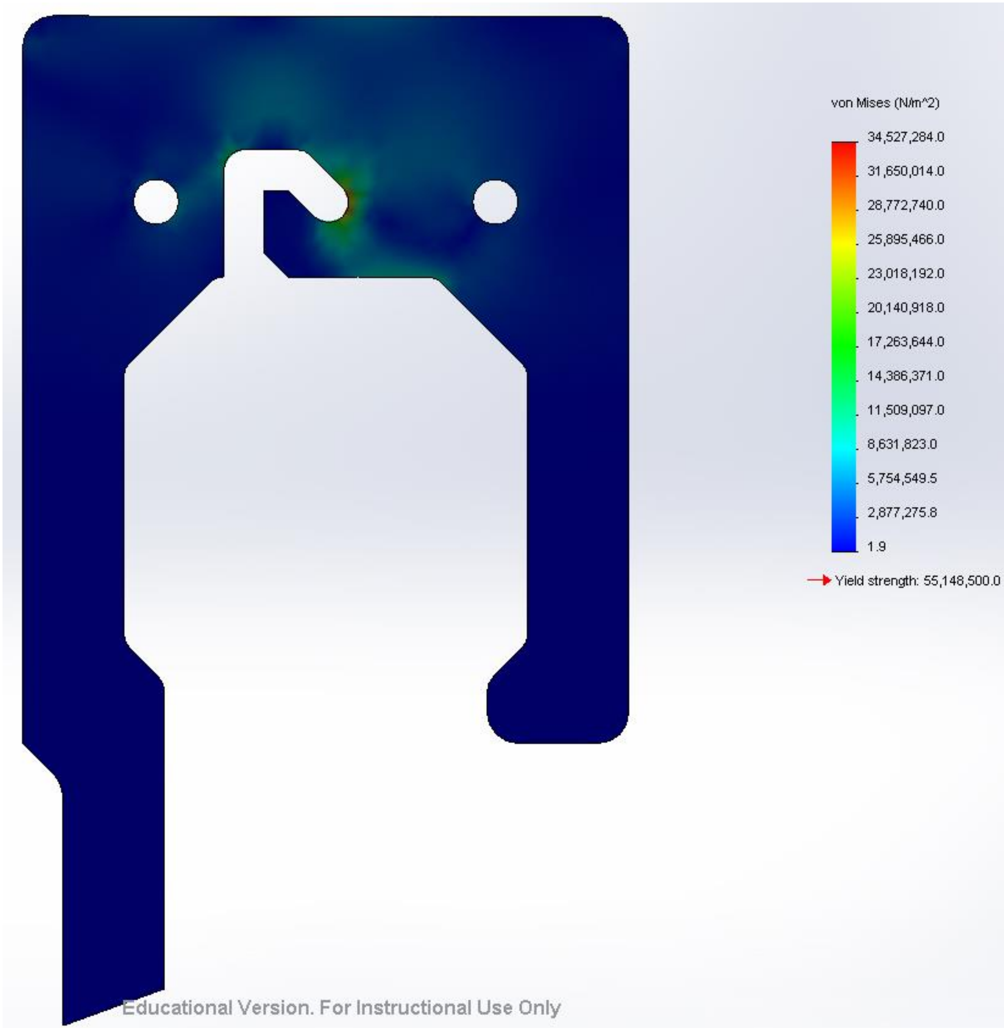

Figure 15: FEA of Current Slider Design

The maximum stress experienced in Raytheon's design is 34.53MPa which results in a factor of safety of approximately 1.60. Our ultimate goal is to address all the issues experienced by the current design while at least maintaining this factor of safety.

Based on the results above, the two top slider designs are being considered for manufacturing. Figure 16 displays the assembly of the first top design slider and the accompanying baseplate.

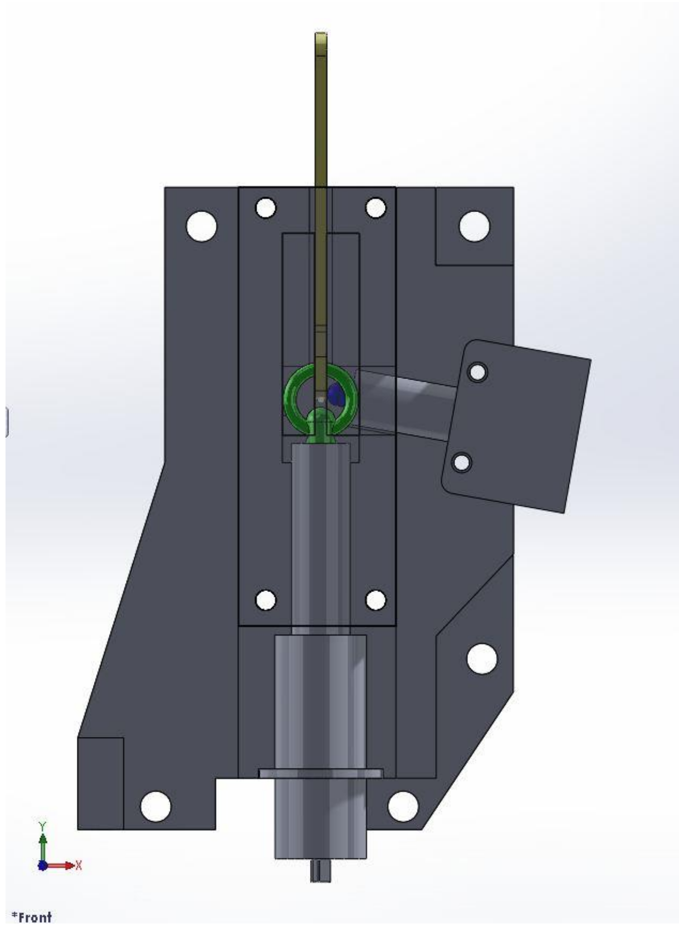

Figure 16: Top Slider 1 Assembly

Future Tasks

Future tasks of our design include: testing prototypes and analyzing the test results. Further analysis of our design will include vibrations, finite element, mechanics of materials and manufacturing to aid in our design process. Using these forms of analysis, our design can then be finalized and proposed to our client.

Some initial steps to manufacturing our prototype out of aluminum will include collecting materials, and writing the appropriate Computer Numerical Code (CNC) to perform the machining. To also save time and lower the cost of the parts the base, slider and cover will all be machined at the same time using the CNC Mill.

After manufacturing our prototype we will complete testing of our design. Our design will first be tested at room temperature to ensure that the design operates properly and performs all necessary tasks. Then the team will repeatedly spray and freeze the design to build up a layer of ice of predetermined thickness and again test the slider to verify that it performs the necessary tasks. Throughout each test applied static loads will be applied to simulate the forces of the switches on the slider. After testing, further analysis of the results will be performed and necessary modifications will be made.

While the design is being tested some members of the team will perform cyclic temperature testing on Aluminum. This is to determine if Raytheon's design failed due to fatigue. For this testing three test specimens will experience cyclic thermal loading.

Project Plan

The Gantt Chart in Figure 17 shows how the team plans to use the remainder of the semester's time, which is represented by the solid green bars. The black diamonds are milestones that represent the dates of presentations and report due-dates. The orange bars indicate the actual amount of time tasks took. Prototyping and testing of the design will need to be completed by mid-April at which point we must present our final design to our client.

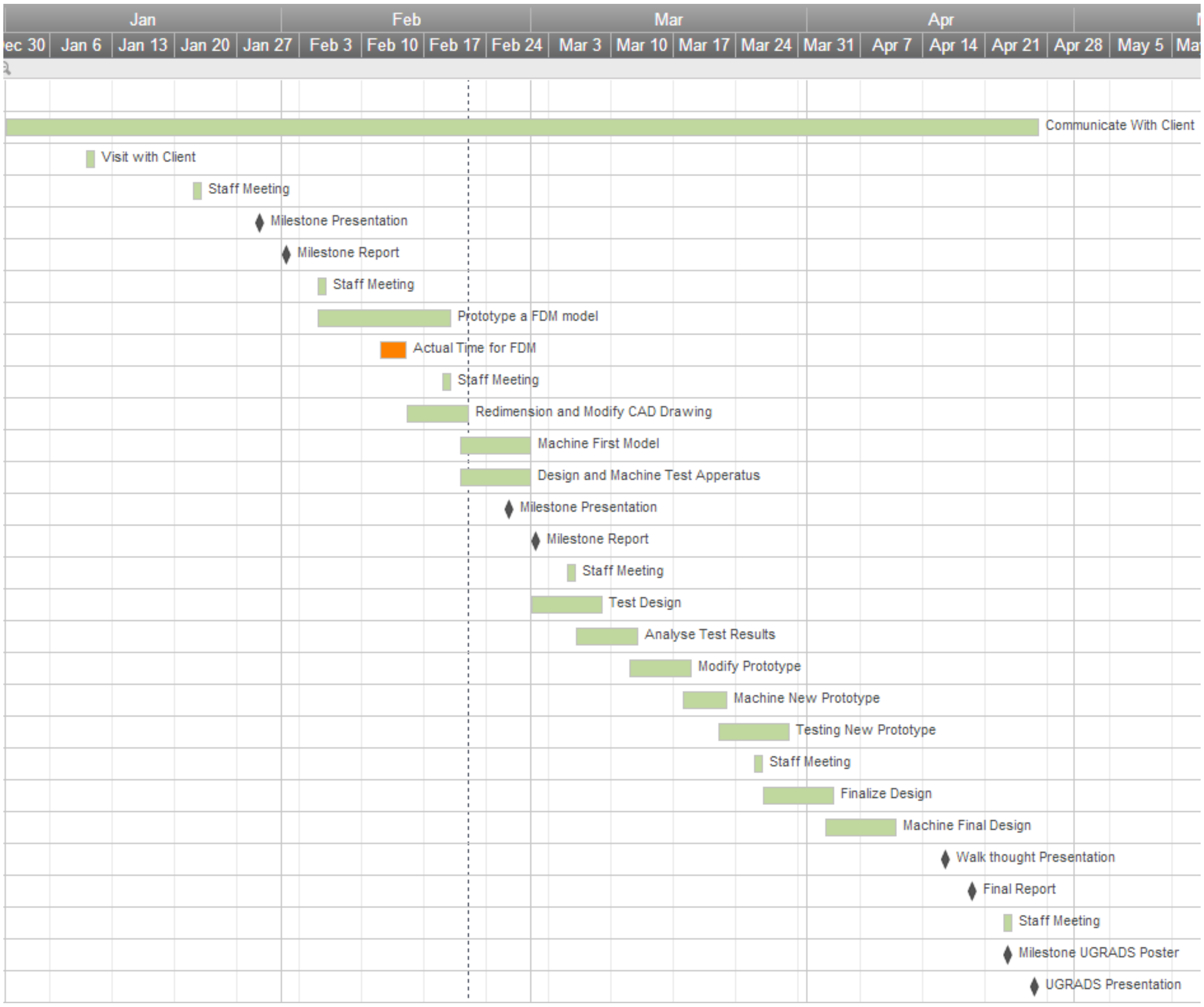

Figure 17: Gantt Chart for Spring 2013

Conclusion

The activation system used within Raytheon's weapons is experiencing failure due to icing, poor installation, and contaminates such as sand and dust. Raytheon has requested our team to find a new design that is more reliable and less susceptible to these modes of failure. The activation slider that the team has designed shows an increase in the factor of safety, reduced surface area, and fewer parts. The team anticipates that the failure percentage, time to assemble, and cost of manufacturing will decrease as a result. To verify that this design works as anticipated the design will undergo thorough testing and further changes will be made to ensure the design meets Raytheon's requirements.

References

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