Final Report

Team # 7

Revision of Lockheed Martin's Human Type Target for Manufacturing

Members:

Joe Nowicki	jdn14
Raymond Lessig	rtl12c
Daniel Kozell	djk12c
Kraig Williams	kmw12g

Faculty Advisor

Dr. Patrick Hollis

Sponsor

Chris Isler

Instructor

Dr. Chiang Shih

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ABSTRACT

Lockheed Martin desires to produce a human type target system, resembling a human in size, shape, and appearance, which will react appropriately to being hit with small arms fire. This will be done via hit sensors on a mannequin, which will be able to detect vibrations caused by a bullet being fired into the target. Seeing as the mannequin is indeed commercially available, and the fall mechanism itself has already been invented by Lockheed Martin and is currently patent pending, Team #7 is tasked with revising the prototype and making improvements on it to bring it to a production ready state. This includes designing, at a minimum, a stand for the target, an interface plate between the target and stand, and 2x4 adaptors. Currently Team#7 has finalized and received the designs for the adaptors and interface plates, both of which were 3D printed by Lockheed Martin. Team #7 has also received all other necessary components to complete assembly of the prototype and conduct testing. The final steps include testing, reporting our finding to Lockheed Martin, and noting and improvements we would plan to make if we had more time to complete work on this project.

1. Introduction

Lockheed Martin has begun to take action with the final goal of producing a human type target system, resembling a human in size, shape, and appearance, which will react appropriately to being hit with small arms fire. Lockheed Martin already has a patent pending on a fall mechanism which they desire to use, and the mannequins which will be used for the target are commercially available as targets for law enforcement and military applications. The mannequin comes already equipped with a hole by which it is able to be mounted to a simple 2x4. Consequently, Team #7 has been tasked with redesigning the stand, interface plate, and 2x4 adapters for manufacturability. These will be designed in such a manner as to facilitate performance up to the standards and constraints given by Lockheed Martin concerning the final product.

Since this product is to be manufactured for mass production by Lockheed Martin, the design team must consider the basic rules of design for manufacturing and design for assembly. Additionally, the team has target prices for each of the pieces. Producing in batches of 100, the cost of the interface plate is not to exceed $50/each, the 2x4 interface adapter is not to exceed $25/each, and the stand is not to exceed $70/each.

Lockheed Martin has provided an early wood-based prototype for the design team to use as a starting point for their progression.

2. Project Definition

Lockheed Martin has produced a human type target system, resembling a human in size, shape, and appearance, which will react appropriately to being hit with small arms fire. This is done via hit sensors on the target, which will be able to detect vibrations caused by a bullet being fired into the target. Lockheed Martin is now ready to move the product to a production ready state and has asked Team #7 to redesign the prototype for manufacturability.

2.1 Background Information

Military and law enforcement departments all over the world use a variety of human-like targets in order to provide effective, realistic combat training to their personnel. Aside from the shape and size provided by human-like targets, a great deal of development has been done to make them react to ballistic impacts and indicate accurate marksmanship from the shooter. Enhancing combat target training even further requires that targets not only indicate impacts, but also accurately respond to the different magnitudes of damage, further demonstrating the lethality of the firearms utilized. Currently there are a number of different products seeking to meet this level of simulation.

2.1.1 Rubber Dummies

Rubber dummies are generally 3D models of a human torso characterized by their ability to withstand a significant amount of repeated damage with their self-healing properties. Contacting bullets are allowed to pass through the material while also leaving an indication of the impact location on the outer skin. This skin can be replaced between simulations or shooting sessions to give the marksmen a clean target to only indicating his/her immediate hits [1]

Figure 1: Rubber dummy with impact indication [2]

2.1.2 Reactive Stand Targets

Other targets commonly used for law enforcement training, specifically SWAT team members, react to a certain amount of hits by falling backward slightly to simulate a neutralized target. These models are made of a self-sealing poly urethane compound that is designed to withstand anywhere from 5,000 to 10,000 live rounds. These models are also helpful for "Shoot/No Shoot" drills and can be customized to different appearances and sizes. They do not, however, indicate the specific impact locations without inspecting the target up close [3].

Figure 2: Reactive dummy representation showing fall-down mechanism [3]

2.1.3 Autonomous Robot Targets

Combining the effects of the reactive fall-down targets with simulated target movement, robotic targets have been manufactured for more authentic marksmanship training. These targets also utilize self-sealing materials to prolong the target life, while also neglecting to indicate a specific impact location. To make up for this potential shortfall, the dummies are designed with integrated sensors in specific locations termed “kill zones”. These sensors, when triggered, communicate with the fall-down mechanism to cause the target to tilt backward. After a set amount of time, the target will reset to its upright position while continuing its autonomous movement for continuous target practice [4].

Figure 3: Robotic dummy with integrated fall-down mechanism upon “fatal” ballistic impacts

2.1.4 Injection Molding

Lockheed martin would like Team #7 to design two components of this human type target so that they can be manufactured using injection molding. These components are referred to as the interface plates and 2x4 adapters.

Injection molding is simply the shaping of rubber or plastic articles by injecting heated material into a mold. With this process, there are several conventions in which Team #7 plans to follow when designing the specified components. A visual is provided below in Figure 4 to aid in the description of some of these conventions.

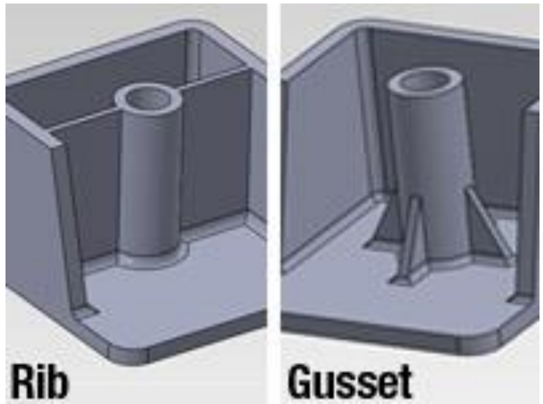

Figure 4: Ribs and Gussets

The figure above provides a visual aid of the components that are important to be considered when designing something for injection molding. One of the major ideas to keep in mind when designing for injection molding is that the thickness of the part designed must remain relatively constant. At the same time, the wall thicknesses should remain pretty thin; around 1/8" is fairly common. This can result in issues when attempting to provide good strength to thin plastic parts. This is where the use of ribs and gussets comes into play.

A depiction of a rib design is shown to the left of Figure 4; these ribs serve as structural supports that extend out from the walls of the design to provide strength. The convention Lockheed Martin uses when designing injection molding is that the base thickness of a rib is 60% the nominal wall thickness. The ribs are also design with what is referred to as a draft angle; a draft angle allows the part to easily be removed from its mold once it is set. A picture showing draft angle as well as several other common standards can be seen below in Figure 5.

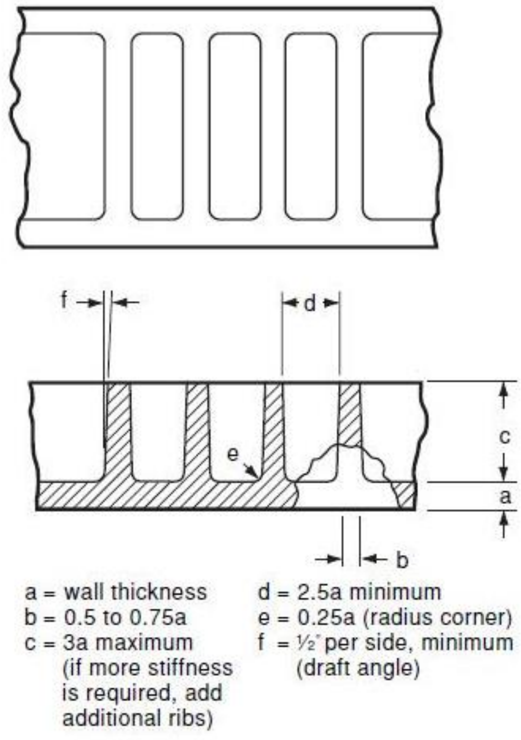

Figure 5: Picture showing good rib design standards

These standards will be considered and implemented into Team #7's designs moving forward. Furthermore, gussets (shown right in Figure 4) are used to support locations in which bolts or screws would be attached to a part. They also serve as a method of support to strengthen the area without causing a large increase in wall thickness. Gussets are also designed with a base thickness of 60% the nominal wall thickness. The Design Selection section of this report will touch on how exactly these standards are applied.

2.2 Need Statement

Lockheed Martin desires to move forward with a design for a Human Type Target (HTT) System, utilizing a commercially available mannequin and ensuring that it falls appropriately when hit. In order to bring this product to market, Team # 7 has been tasked with designing and preparing the interfacing components and stand for manufacturing as well as enhance the mobility of the target. The team needs to prepare these components for manufacturing, ensuring their durability as well as keeping their mass production costs below the given values. Finally, Team # 7 needs to test the device under the various conditions, including gunfire, to determine the suitability of the device to meet these needs and requirements.

"Lockheed Martin's current human type target system is incomplete and requires further design for manufacturability and durability."

2.3 Goal Statement and Objectives

"The goal of this project is to revise a prototype human type target system, that falls automatically when hit with a series of lethal shots, and take it to a production-ready-state."

Objectives:

- Stand-to-Target Interface Plates
- Interface Adapters
- Target Stand
- Test Stand to Activate the fall mechanism (electrical/firmware interface needed)
- Stand to be movable by 1 person
- Stand to take up no more floor space than 2ft x 2ft and mannequin
- The interface plate, adapter, and stand shall be capable of surviving no less than 1000 target drops.
- The interface plate, adapter, and stand shall be capable of being exposed to the elements
- Items above 6" from the floor shall be made of non-ricocheting material (e.g. plastic) or shall be protected in a way such that bullets will not ricochet back to the shooter (e.g. bullet guards).

Figure 5 below provides a visual for the main components mentioned above:

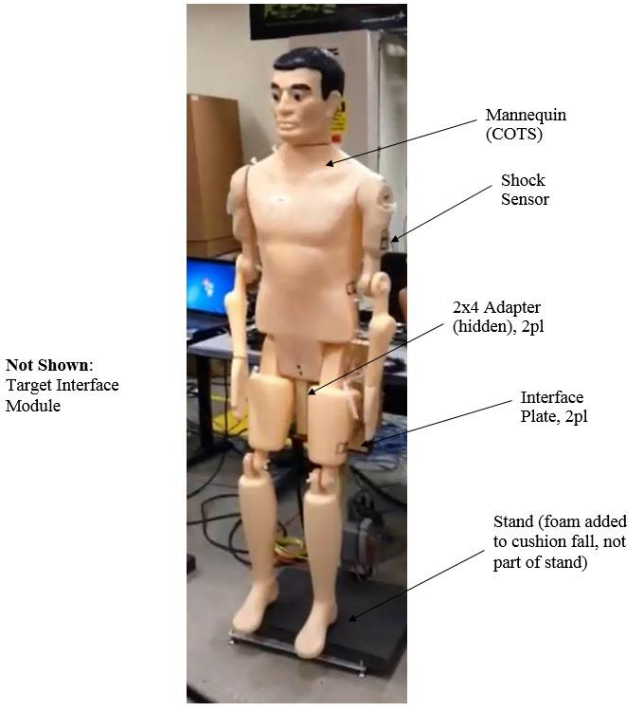

Figure 6: General layout of current prototype with main components noted

2.4 Constraints

As with any project, there are a whole host of constraints which apply to the design and construction of the human type target system. The majority of these constraints have been provided to Team # 7 by Lockheed Martin. The stand must be able to be moved by one person, according to MIL-STD-1472. This same stand must not take up more than a 2ft x 2ft square of floor space for the footprint, as well as necessarily interfacing with the Lockheed Martin Target Interface Module, dimensions and sizing of which will be provided at a later date. The stand must be able to withstand direct hits from 5.56mm, 7.62mm, and airsoft ammunition without toppling, either during the hit or the sequence which involves the fall mechanism. While the 5.56mm NATO round is very small and carries relatively little energy, the 7.62 NATO round (also known as 7.62x51mm or .308) carries significantly more force. These same three rounds must trigger the fall mechanism. Seeing as an airsoft round carries so little energy, it is crucial to note that the mechanism must be very sensitive, while also rugged enough to withstand the forces of the 7.62 NATO and the rapid fire nature of the 5.56 NATO round. In the same vein as ruggedness is the lifetime criteria—the interface plate, adapter, and stand must be able to survive at least 1000 target drops before failure. Due to the varying conditions in which the system shall be deployed, it is also crucial that all components are able to withstand various harsh environments, ranging from the heat and dryness of Saudi Arabia, to the freezing cold of Alaska, to the salt air and humidity of coastal regions across the globe. While many of the materials shall be chosen by the design team with a relatively high level of freedom, safety is still a concern. Since bullets tend to ricochet upon contact with metal, any and all components which will be more than six inches above the ground shall be made of a non-ricocheting material, such as plastic, or covered with an appropriate guard in order to ensure the safety of the operators and prohibit a bullet from ricocheting back into the shooter.

3. Design Selection

3.1 Interface Plate Designs

There are two interface plates present on the current prototype; these are shown below in Figure 6. The arrow on the left of Figure 6 points to the interface plate that connects to the mannequin and the arrow to the right points to the interface plate that connects to the stand. The objective is to create two identical interface plates that can connect to the mannequin and stand. Some of the current issues are binding in the latches as well as difficulty setting the mannequin back up once it has fallen. The binding in the latches comes from torque on the bolts that support the mannequin’s weight. Potential solutions to this include better distribution of weight as well as better support for the interface plate. The main reason setting the mannequin back up is difficult is because it is hard to accurately align the bolts with the latching mechanism. Guides will be added into the design to allow the bolts to be more easily set.

The interface plates have gone through several stages of design. For the purposes of this report, Team #7 will briefly discuss two preliminary designs as well as the final selected design which will be 3D printed for testing purposes in the coming weeks.

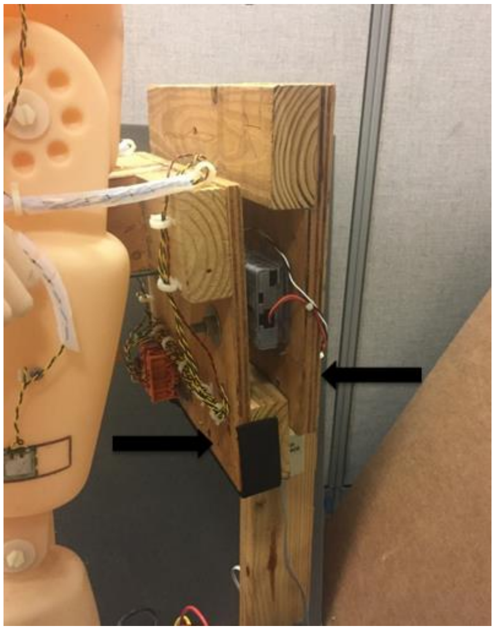

Figure 7: Human Type Target prototype (interface plates)

3.1.1 Interface Plate Design A

The following figures represent a rough drawing of the first design Team #7 came up with, Design A. This design was very simple with minimal features built into the mold itself. The approximate dimensions of Design A were 14in wide by 10in tall.

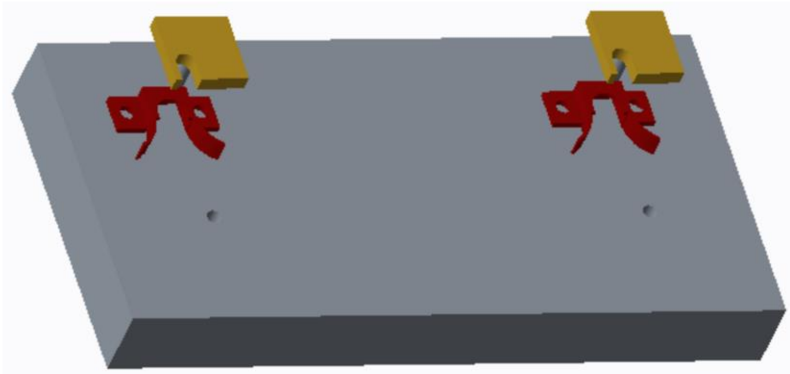

Figure 8: Interface plate Design A with latches and guides attached

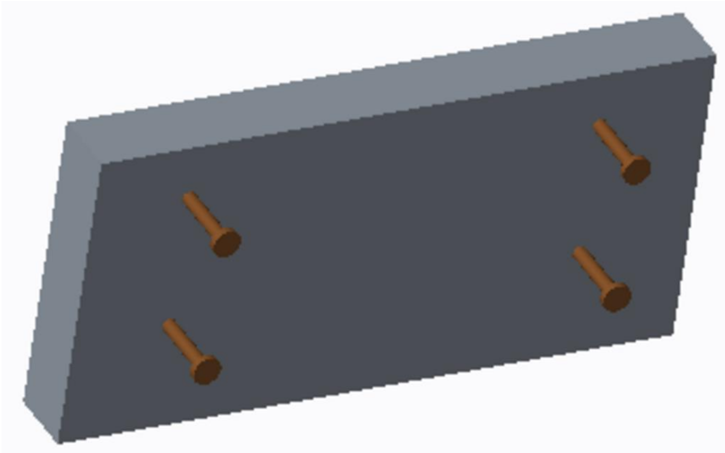

Figure 9: Interface plate Design A with bolts attached

The idea of this design was to have two clips (red in Figure 9), which serve as guides for the bolts (shown brown in Figure 10) to help the latches get set. The upper two bolts would get sent into the latches while the bottom two bolts would serve to hold the two plates parallel to one another.

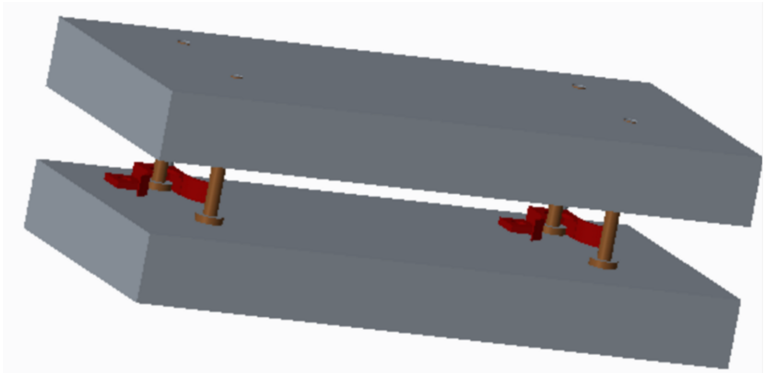

Figure 10: Interface plate Design A assembly

The full assembly of Design A is shown here in Figure 11. Design A was a very simple approach to solving Lockheed Martin's problem. While a simple solution is good, this solution had several pressing issues that needed to be addressed.

One issue with this design is that it is not designed with injection molding in mind. The base thickness is too large and would likely result in warping of the material. Another issue with this design is that Lockheed Martin wants minimal assembly required. This design requires several of the major features to be assembled after the part is removed from the mold.

3.1.2 Interface Plate Design B

Concept Design B (shown below in Figures 11 and 12) is another design for the interface plate that did not quite meet the full needs Lockheed Martin set forward. While this second design incorporates many features that are pre molded in, as opposed to needing assembly, it is also not designed with injection molding in mind. This design would not be possible to injection mold in its current state and also does not practically allow the two plates to mesh together fully.

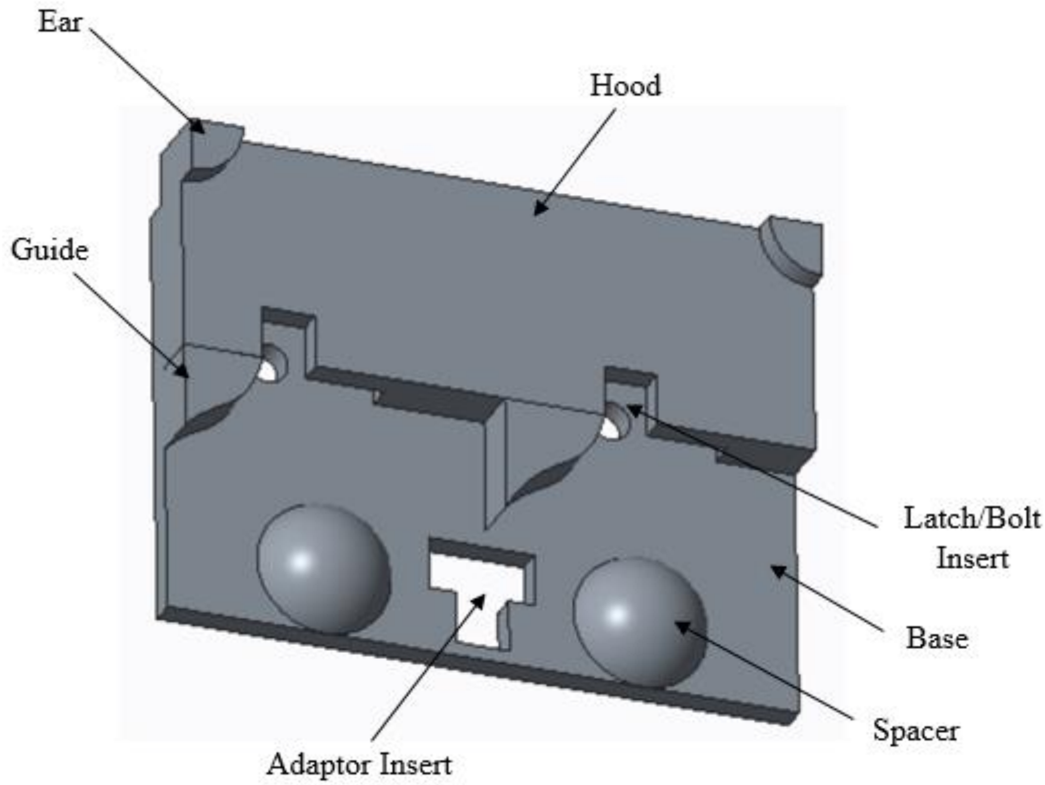

Figure 11: Interface plate conceptual Design B (front view)

The idea with this design was that that guides previously found in Design A are now built into the mold of Design B. Similarly, the bolts used to hold the plates parallel in Design A have been replaced by the Spacer in Design B.

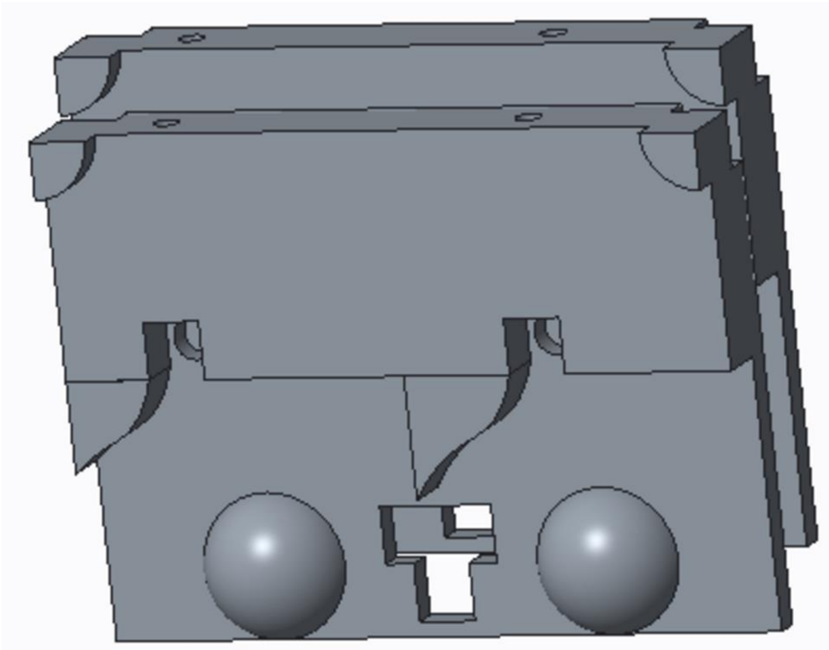

Figure 12: Interface plate conceptual Design B (assembled view)

Figure 13 shows the full assembly of Design B and how the plates would mesh together.

3.1.3 Selected Interface Plate Design

Taking into consideration the advantages and disadvantages of both Design A and B of the Interface Plate, the Interface Plate shown below in Figure 13 was designed.

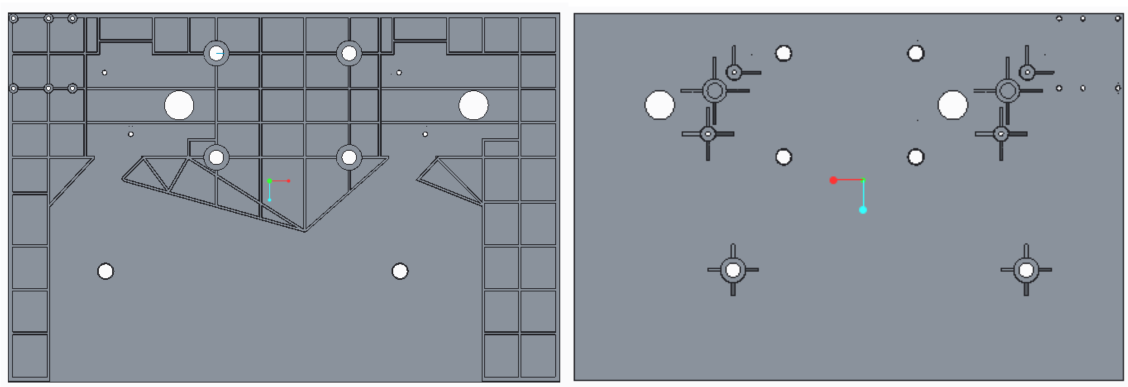

Figure 13: Interface plate designed for injection molding

The two images shown above in Figure 13 are the front (left) and rear (right) of the interface plate design. This design has successfully taken into account all the features Lockheed Martin requires; it has minimal assembly required, it is designed for injection molding, and the interface plate can be used for both the stand side of the assembly and the dummy side of the assembly. Images showing the full assembly will be found below in the Stand Design Section.

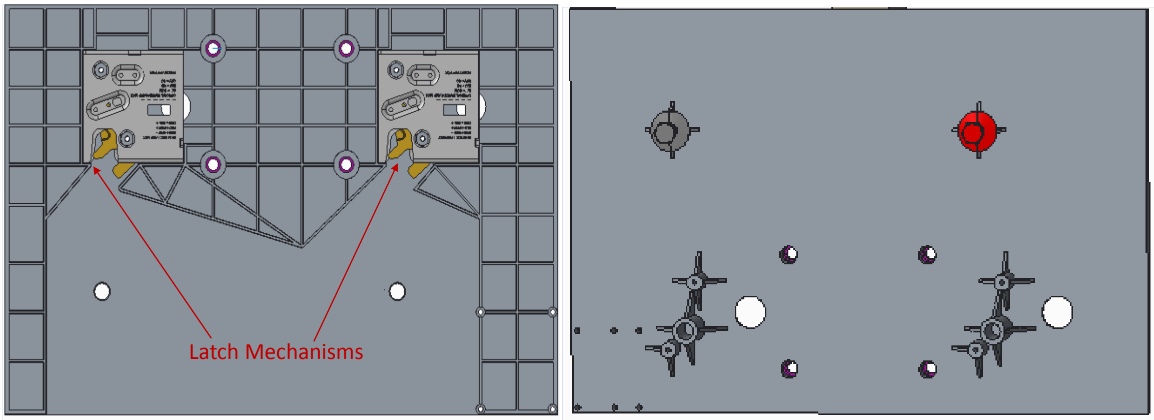

Figure 14: Interface Plates with components attached

Figure 14 above shows the final Interface Plate design with the latches and bolts attached. In the left image of Figure 14, the latch mechanisms can be seen. The ribs we have designed also serve as the rails that guide the bolts into the latches. The right image shows the rear of the plate where the bolts will be inserted.

After speaking with the sponsor, Team #7 had received positive feedback on this design and hopes to soon 3D print this design to begin testing and analyzing its performance. Upon further analysis we found that further improvement s could be made on the interface plate. First the wiring port holes which were originally circular were changed to a square shape to better fit the electronic adapter piece that comes attached to the latching mechanism. Additional ribbing was added on the back side as well to minimize bending maximize structural strength during impacts with the ground. Lastly the protruding spacers that were adjusted to have a slanting rib connect them to prevent any binding during the reset of the interface plates after a simulation cycle was completed. This allows the plates to slide against each other freely as to prevent any corners from being problematic. These changes are reflected in the latest design shown in Figure 15.

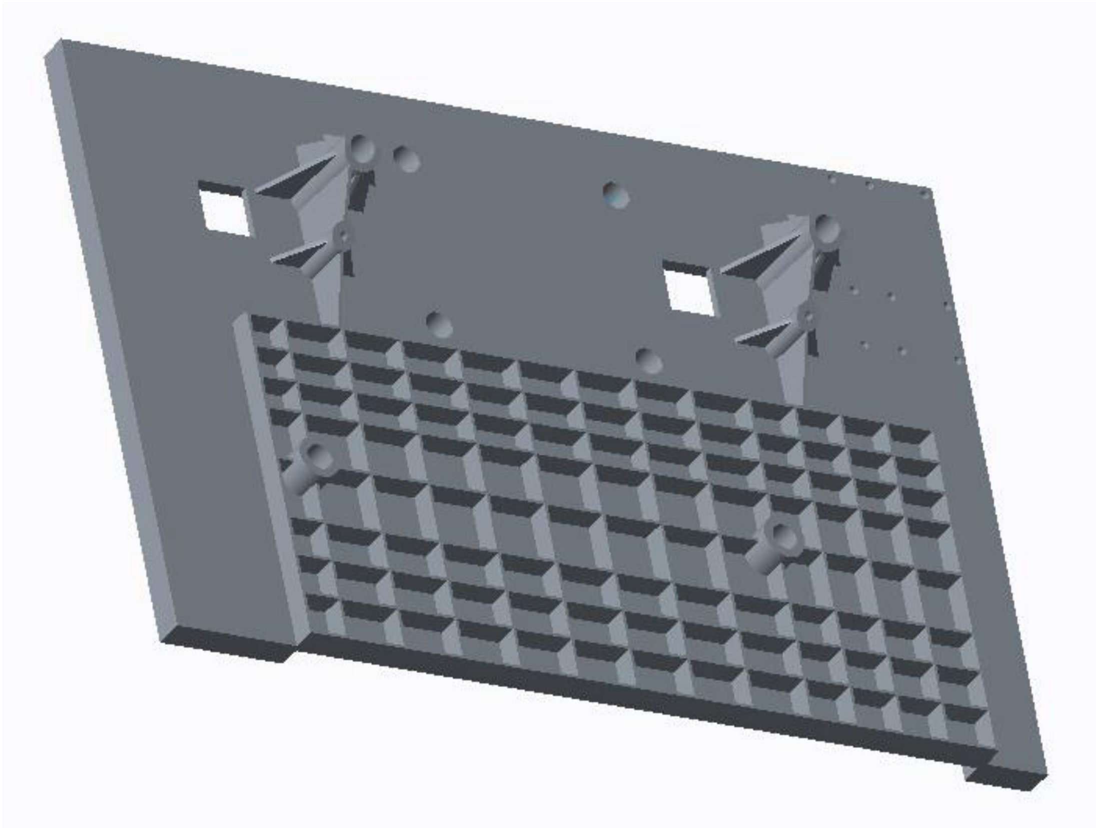

Figure 15: Updated Interface Plate

3.2 Stand Design

After more discussion with the contact at Lockheed Martin, Team #7 learned that the base was not to be injection molded like the plates. Lockheed Martin has also made it clear that they wish for the base to be reasonably mobile, stable, and light, while keeping with the other restrictions for the project, including ricochet resistance. With these desirable characteristics in mind, Team #7 came up with concepts similar in style to a dolly, or hand truck. Discussion with Lockheed Martin proved their acceptance of this concept.

As has been previously stated, this is not the final solution; however it was a viable first step towards the next generation prototype for the base and stand. It is also worth noting that the base may required further revision in order to meet the stability requirements. Discussion with Lockheed Martin clarified that the constraint of a 2’ x 2’ baseplate is not necessarily a hard and fast constraint, rather a guideline for the relative desired size of the baseplate. Team #7 also proposed the concept of utilizing pop out stabilizers for the stand, which would fold to be inside of the desired footprint for transportation and storage, but could possibly flip out for field use, adding a higher level of stability and adaptability to the platform. Lockheed Martin showed interest in the concept, especially as a possible “expansion pack”, which could be offered separately, and would be able to easily attach to the existing stand and base. This would have little implication on the actual design of the base and stand, except for perhaps designated attachment points, and would instead be a simple addition which may be worked on separately. Since these additions would be necessarily planned to be very low to the ground, their material is much more flexible.

An original concept design for the stand can be seen in Figure 16. This design is incomplete, but shows the basic layout of the stand. When finalizing the design for mobility a couple of designs were considered. This layout remained in the final design which can be seen in the full assembly section of this paper.

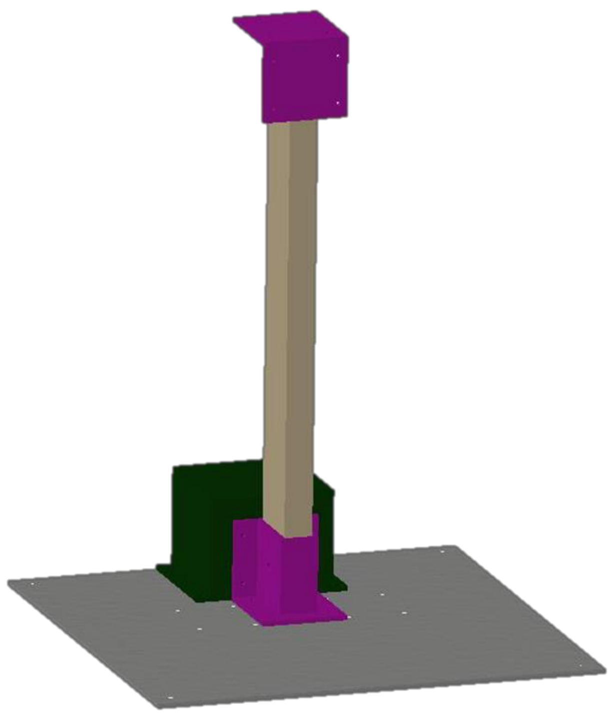

Figure 16: Original stand design

3.3 2x4 Adaptor

Similar to the interface plate requirements, the 2x4 adaptor needs to be standardized for all necessary locations on the stand. Meaning there needs to be one adaptor to serve many purposes. The selected 2x4 adaptor design is shown in Figure 17. The adaptor will need to accomplish the following requirements: connect the stand to the base, connect the stand to the back interface plate, and connect the mannequin to the front interface plate. The placement of the adaptors is depicted in Figure 20.

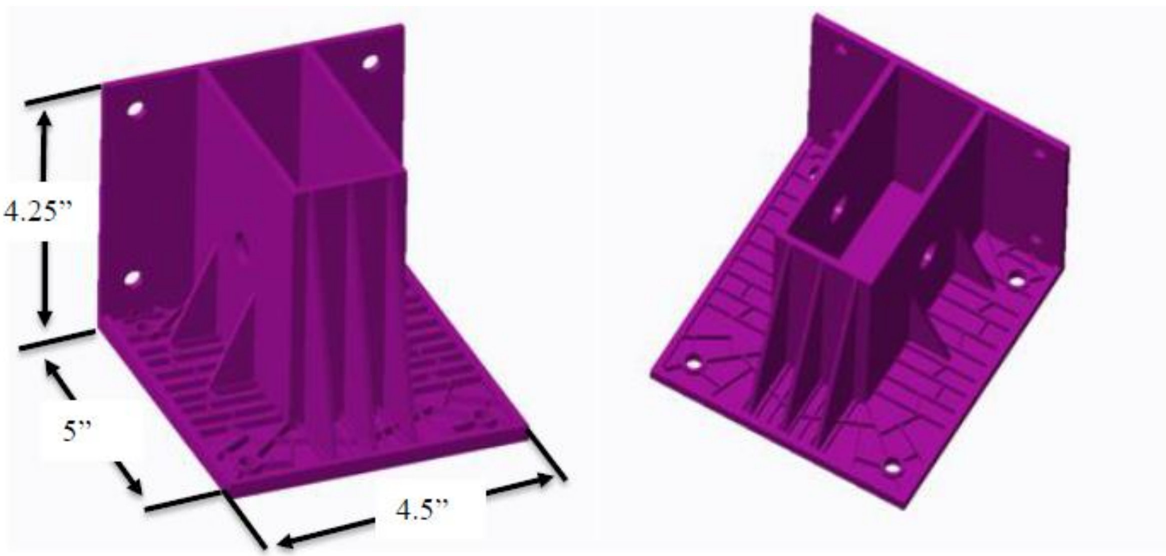

Figure 17: Selected 2x4 adaptor design with ribbing support structures included

The design of the adaptor is acceptable for all necessary requirements because it allows mounting in two separate directions. Having mounting holes on two surfaces 90 degrees apart allows 2x4 wood to be inserted from any direction that will be required. Since this part will be made with injection molding there are specific design aspects that had to be met. To increase the strength of the part ribs were added to diffuse stress on that face. Ribs were added at angles to improve strength from stresses in all directions since this is a multi-purpose part. Gussets were added to the sides to resist stresses especially on the front where long gussets were placed. Long gussets were placed on the front because when the dummy sits in the adaptor most of the stress from the resulting torque will be on that side's edge. The hole in the middle is to pin the 2x4, if necessary a bolt can be drilled through holding the wood in place.

Figure 18: Different views of the 3D printed 2x4 adaptor

Upon further discussion with the sponsor, we realized that we could in fact reinforce the weakest wall of the adaptor, the back wall. This reinforcement design was simply added thickness and ribbing as seen in the other walks of the adaptor. This change can be seen below in Figure 19.

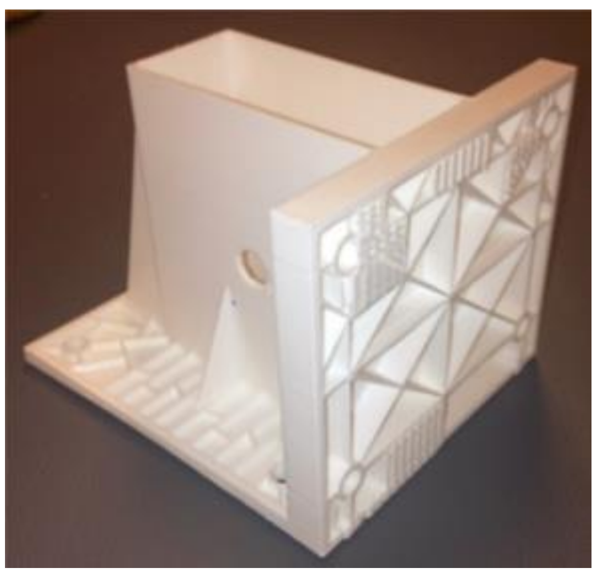

Figure 19: Final 2x4 Adaptor Design

3.4 Full Assembly

Figure 20 shows the full assembly of all the components necessary for this project. This includes the newly designed interface plate and 2x4 adaptors. However, also includes the placement of the control box on the base plate.

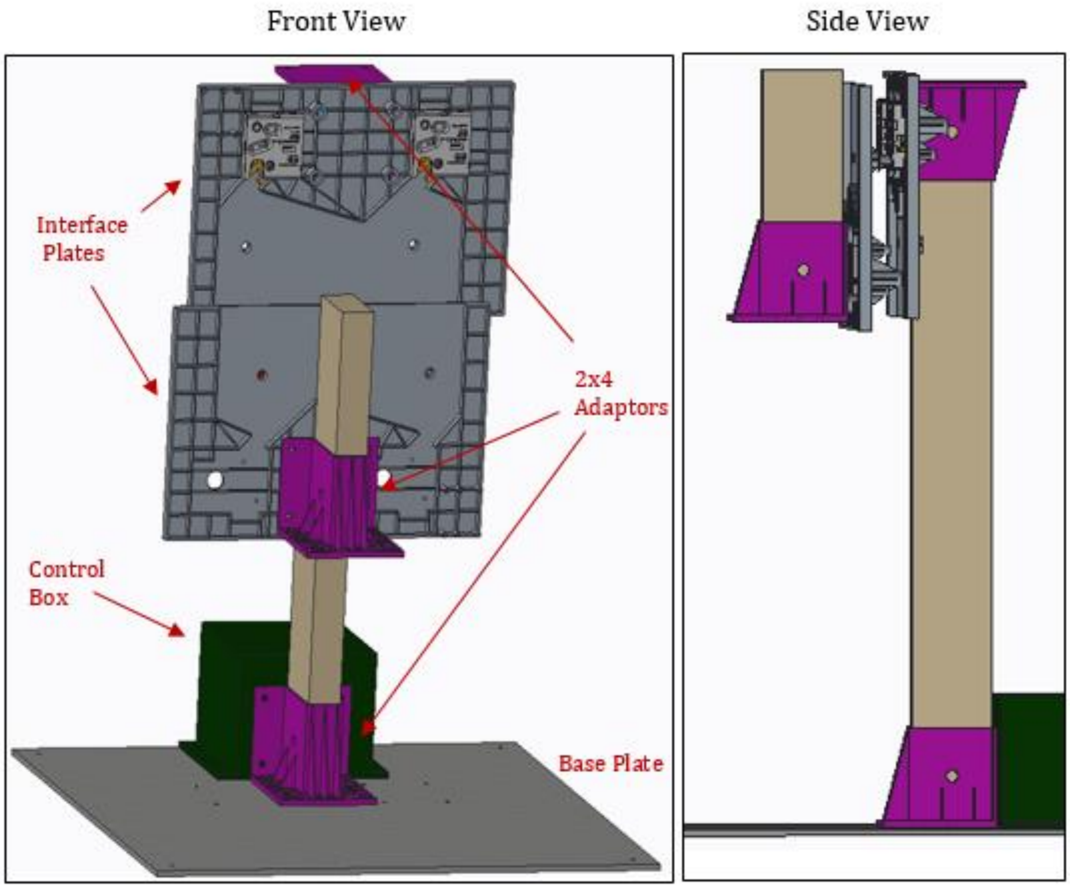

Figure 20: Assembly of current stand, 2x4 adaptors, and interface plates

The mannequin has been removed from this assembly to enable better views of the designs assembly, but the dummy will sit on the 2x4 attached to the front interface plate. The front interface plate is the same as the back interface plate, but when assembling the components it is flipped upside down and the bolts on the back slide into the clamps using the guides designed on the plates. The 2x4 adaptor on the front and back plate are drilled into the same holes respectively and are oriented in different directions. Another 2x4 adaptor connects the 2x4 of the stand to the base plate. The control box is place behind the 2x4 giving it a little more protection.

4. Stress Analysis

Upon viewing the assembly with the updated components, one can see that the 2x4 adaptors are utilized in three different location, each with their own load bearing conditions. Depending on their location, they will have multi-directional stresses on multiple or isolated areas of the adaptor. To verify that the material and structure can support the various stresses applied from the weights of the mannequin, 2x4s, and interface plates the adaptors were tested through Pro Engineer's Finite Element Analysis (FEA) feature.

Starting with the 2x4 adaptor's bolt hole feature used to mount the part to the interface plates and stand, the FEA was conducted assuming all the stress was placed on said holes. This includes the weight of the mannequin and other components as the entire structure is lifted off the ground, simulating a condition in which the maximum vertical stressed is placed on the part. The maximum stress came to just under 10.8 MPa, well below the material yield stress of approximately 79 MPa. This FEA with the representative color-coded stress value can be seen below in Figure 21.

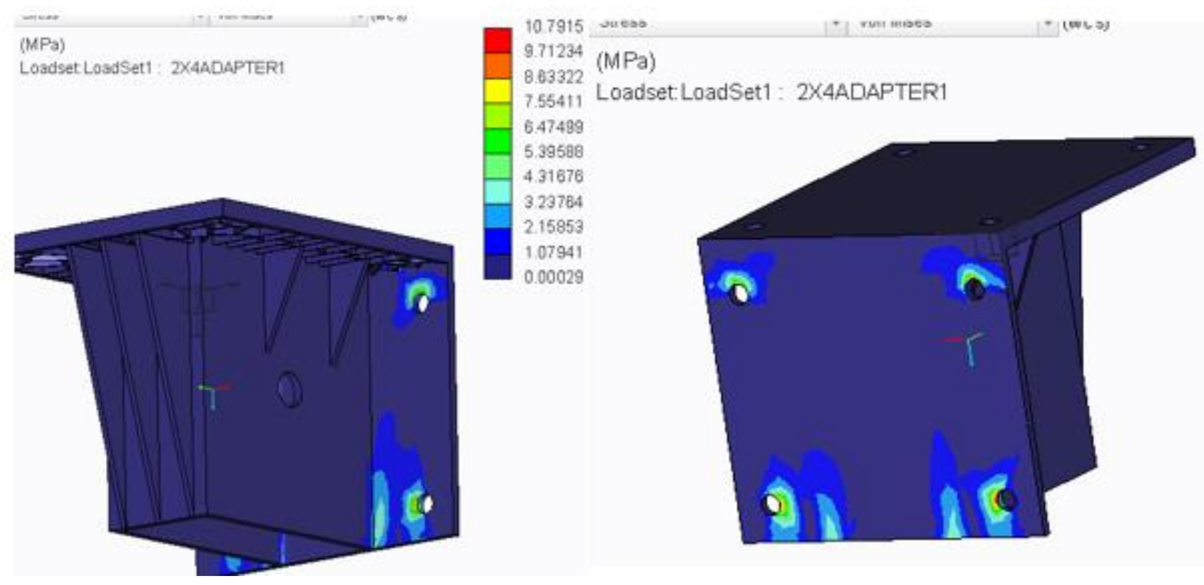

Figure 21: FEA of 2x4 Adaptor bolt holes

This same method was applied with a focus on the beam slot of the 2x4 adaptor. This is the larger opening of the part that the 2x4 board would slide into. The most significant stress applied to this section would come from the torque generated by the 2x4 that attached to the mannequin. This 2x4 adaptor would be attached to an interface plate the supports the full weight of the mannequin, suspended approximately 6 inches away from the vertical beam of the stand. This torque was taken into consideration with a mannequin and interface plate weight of approximately 22 lbs. As seen in Figure 22 below, the torque would apply a load in the opening of the slot near the corners. The maximum stress in this region was shown to be just under 22 MPa, the highest stress value on the whole structure. Thanks to the tall fin structures on the outside of the beam slot, this stress is dissipated and deemed non-threatening to the structural integrity during operation.

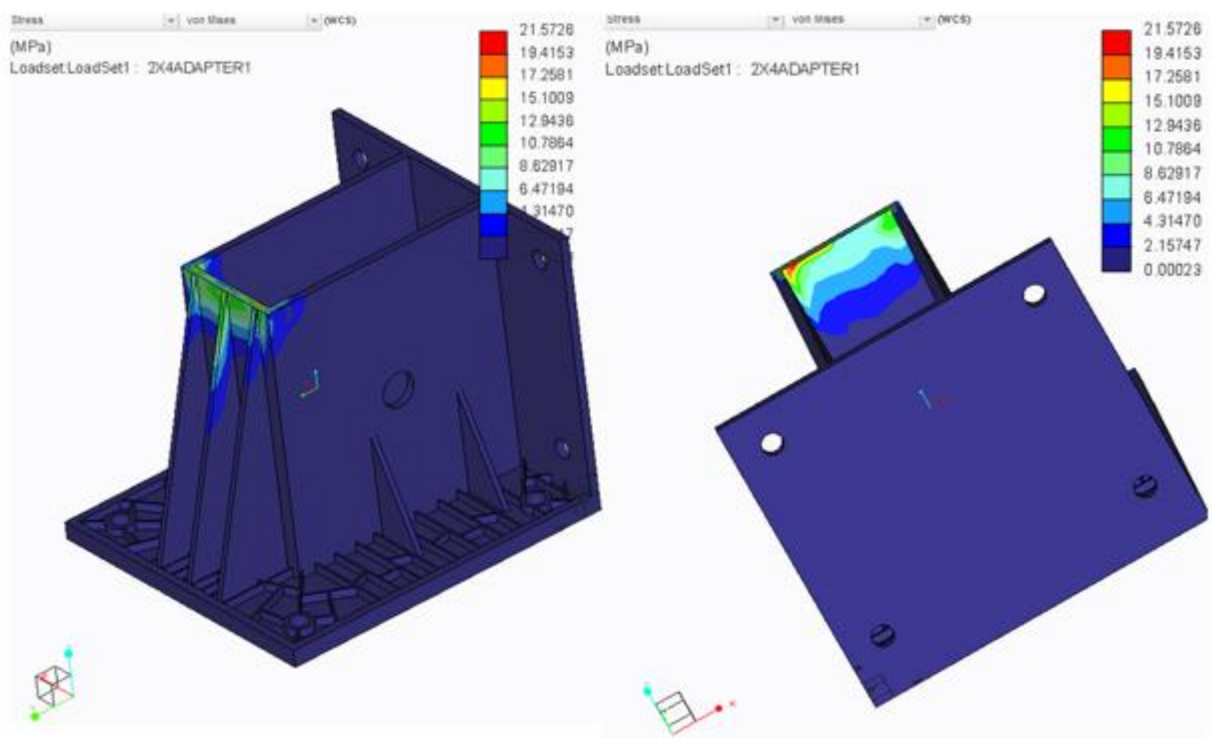

Figure 22: FEA of the 2x4 Adaptor beam slot

Lastly the 2x4 adaptor underwent FEA with the focus on the flat surface containing the ribbing structures. This would simulate the applied weight of the device placed on the 2x4 adaptor located on the top of the vertical beam. To ensure the part could withstand the bending forces always present in the device, the mannequin and interface plate weight of 22 lbs. was used again as the applied load. As seen in Figure 23 below, the ribbing structures do a phenomenal job of preserving the integrity of the structure, reducing the maximum stress of the area to around 11 MPa.

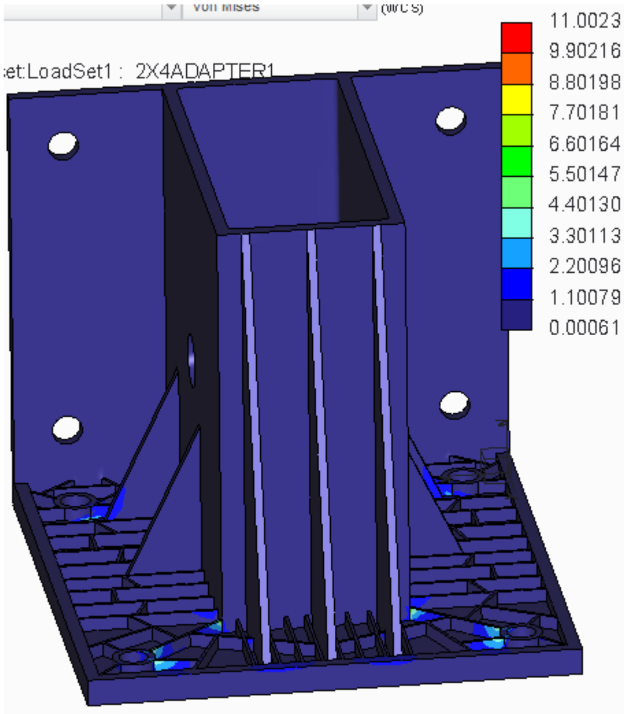

Figure 23: FEA of 2x4 Adaptor flat structure

5. Problems Encountered

Throughout this design process Team #7 has had minimum issues. However one notable discrepancy was the 3D print job of the latest interface plate design. Normally these parts have been 3D printed by our sponsor at Lockheed Martin, however, due to a busy printing schedule we were forced to seek a different source. The company used notified us that in order to print our large 15 inch wide part, the cost would be simply out of our budget, causing us to use a cheaper option of printing in sections for reattachment and reinforcement. We discussed with the manufacturer the use of this part and he seemed convinced at the time that he could make it work.

Two interface plates were printed in a matter of weeks for $710. When received in the mail it was found that the epoxy that was meant to hold the sections together failed. Two interface plates were received in eight poorly printed parts that even had some warping present wither during the printing phase or transportation. One of the plates can be seen below in Figure 24. So with two completely incompatible components we asked for a refund and preceded to use the old design for simulation purposes.

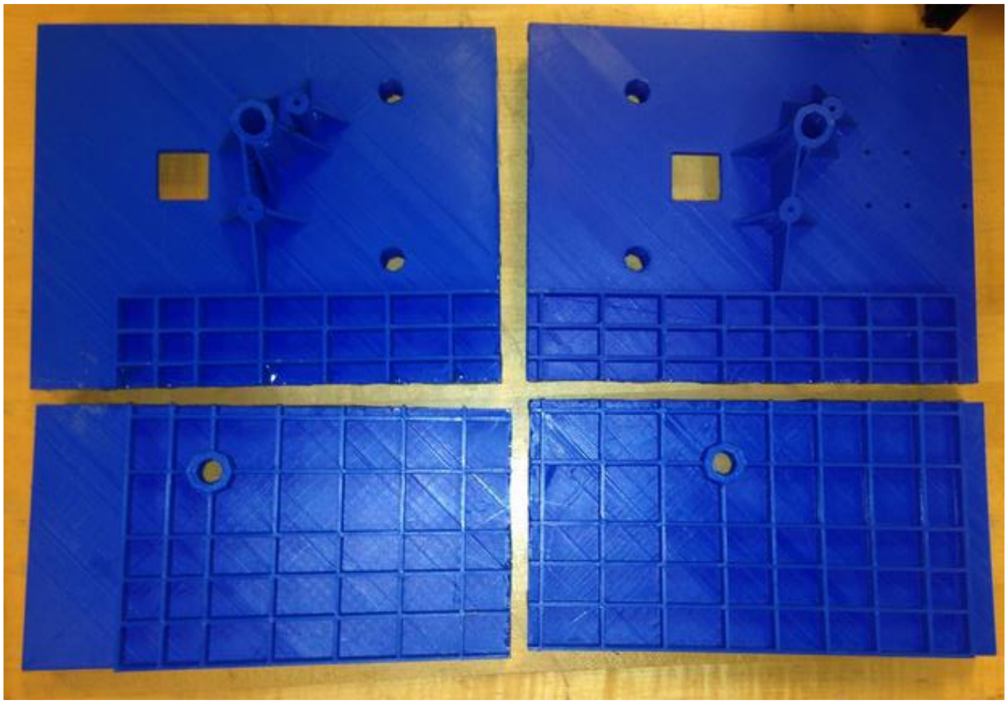

Figure 24: Incompatible Interface Plate

6. Cost Analysis

The importance of the design for economics of this project was explicitly stated in the outlining objectives. By reducing the component variability and making this product easier to produce, the overall cost is reduced. Given the initial $2000 budget allotted to this project. The majority of the cost covers the SouthCo bolts and latches, totaling to $346, used to secure and release the dummy to and from the stand. Next the target dummy costs another $200, also accounting for a larger portion of the expended budget. Slightly less expensive than that is the ¼ inch thick aluminum base plate used to support the whole system, costing $133. The more commonly consumed components such as screws, washers, and the press-in-inserts were on the cheaper side of the spectrum but still costing approximately $65. Then we have our electrical components including the arduino board, wiring, plastic buttons, and more which only cost $36. Lastly, the addition of thick rubber wheels to satisfy the mobility component of our project only cost $11. The breakdown of the team's budget can be see represented as a pie chart below in Figure 25, with a total of $1209 remaining [5].

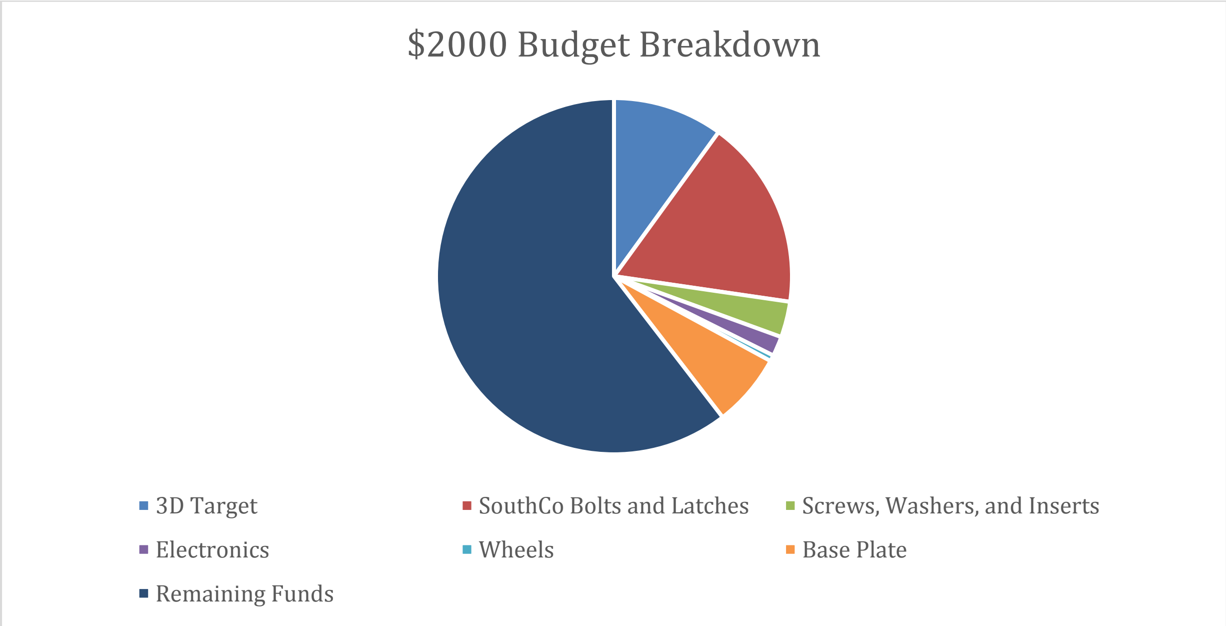

Figure 25: Budget Breakdown

Unaccounted for in our current budget is the production of the 3D printed components: the interface plates and the 2x4 adapters. For our prototype 3D printing was utilized for its convenience, however Lockheed Martin would plan to use our design for injection molding and mass production. Our sponsor, therefore, proposed some guidelines to calculate what it would cost to injection mold the 2x4 adapters and interface plates. The proposed method of cost calculation can be seen below incorporating material cost, the number of press-in-inserts used, and the number of manual operations required to meet final production specifications.

Costs ($) = (4*(Cost of material($ / lb)*Weight of Part(lb))) + ($2*Number of inserts) + ($1* Number of manual operations)

Using this method the cost of both parts ended up being less than the targeted cost, a small yet important improvement to the original prototype provided by Lockheed Martin. The cost comparison of these components can be seen below in Table 1.

Table 1: Injection Molded Component Costs

Component Name	Target Cost	Current Cost
Interface Plate	$50	$25
2x4 Adapter	$25	$15

After summing each of the component prices we see that the total cost of Team #7's prototype is approximately $755, however one must remember that this was the cost of only one system. Once produced in bulk this price is expected to drop significantly, especially with the machining capabilities possessed by Lockheed Martin. Looking at similar target applications from competitors like Marathon, Moto Shot, and LED targets we can confirm that this high price will not be viewed as a competitive product initially. Again, once the cost is reduced from higher production quantities it should be viewed more favorably.

7. Findings and Suggestions

As previously shown the 2x4 adaptors and interface plates were 3D printed and those components were assembled onto the stand to make a prototype. Wheels were place on the back of the stand to provide more mobility allowing for one person to move the whole target. It was found that the material the parts were printed with were too brittle and weak to perform accurate tests. Once new parts are made with the appropriate material and injection molded then testing can begin. However, according to the finite element analysis the injection molded parts should easily withstand the impacts.

One suggestion for the final product is to consider removing the 2x4 adaptor that connects the base of the stand to the stand 2x4. The original prototype had a metal slot welded to the base of the stand with a pin through the 2x4 keeping it in place. When moving the stand that location get put under a great deal of stress and the welded metal will withstand that stress better than the 2x4 adaptor designed. The adaptor works in every other necessary location.

The future design changes for the interface plate should prove to be useful. Once these changes are applied the target should be easier to reset and it should also allow the mannequin to stand vertically which decreases the chance of binding. These changes need to be applied before the final product is made and tested. Other than the changes to the interface plate and the 2x4 adaptor mentioned, the target should be ready to be tested.

8. Conclusion

Lockheed Martin provided Team #7 with their current Human Type Target prototype. The main objectives of the team will be to design a new stand, interface plate and adaptors for manufacturing. When the design is complete for each component it will need to be at market quality level and easily manufactured, meaning that each component needs to be cost and time effective when being made. The aspects of this project that have been most challenging include designing interchangeable interface plates for ease of manufacturing and designing a durable stand that is not only mobile and durable, but stable when shot with a series of bullets. A design for the interface plate and 2x4 adaptor has been produced and received. This plate and adaptor meet all the design requirements, are interchangeable, and are designed with injection molding in mind. All components were assembled into a prototype however, it was not tested. The 3D printed 2x4 adaptors and interface plates are weaker than the planned injection molded parts. Therefore, the prototype was not tested due to the brittleness of the material of which the components are made. Overall, the project scope and budget are reasonable parameters to work with and the finalized Human Type Target will be able to provide realistic training for law enforcement and the military.

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