# Design for Manufacturability, Reliability, and Economics

## Team # 7

## Revision of Lockheed Martin Human Type Target for Manufacturability


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**Instructor:**

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Date Submitted:

4/7/17

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For figure (or table) click insert and select caption**. In caption window, select label as figure (or table) and click ok. To add the Table of Figures (or Table of Tables) click insert and then index and tables. From the pop out window select the Table of Figures (or Table of Tables) and click ok.

* If there is no table or figure (which is highly unusual), then you do not make a table of tables or table of figures.

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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 the target, which will be able to detect vibrations caused by a bullet being fired into the target. The target itself will be a commercially available mannequin, sold for use specifically as a small arms 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 in order to bring it to a production ready state. This will include designing, at a minimum, a stand for the target, interface plates between the target and stand, 2x4 adapters, and a test stand to activate the fall mechanism. The final outcome of this project will be an operational human type target which will fall when hit with an appropriate sequence of small arms fire, including ready for manufacturing designs of the aforementioned components. Team #7's prototyping components have been designed, are currently being analyzed, and will soon be ready for production and testing.

# ACKNOWLEDGMENTS

Team #7 would like to thank our contact and representative from Lockheed Martin, Mr. Chris Isler. Chris has been a pleasure to work with and from the start of the project and has done everything he can to ensure the success of this project. He has provided a tremendous amount of wisdom and input that has proved extremely beneficial to the team and has allowed the project to progress quickly over the semester.

Team #7 would also like to thank our faculty advisor Dr. Patrick Hollis. He has not only made himself available and present for our presentations, but he has also provided us with meaningful critique and advice throughout the semester.

# 1. Design for Manufacturability

When assembling Team #7's prototype, there are 3 main areas to consider: the stand, the mounted interface plate, and the dummy interface plate. The general assembly of these three areas can be seen below in Figure 1.

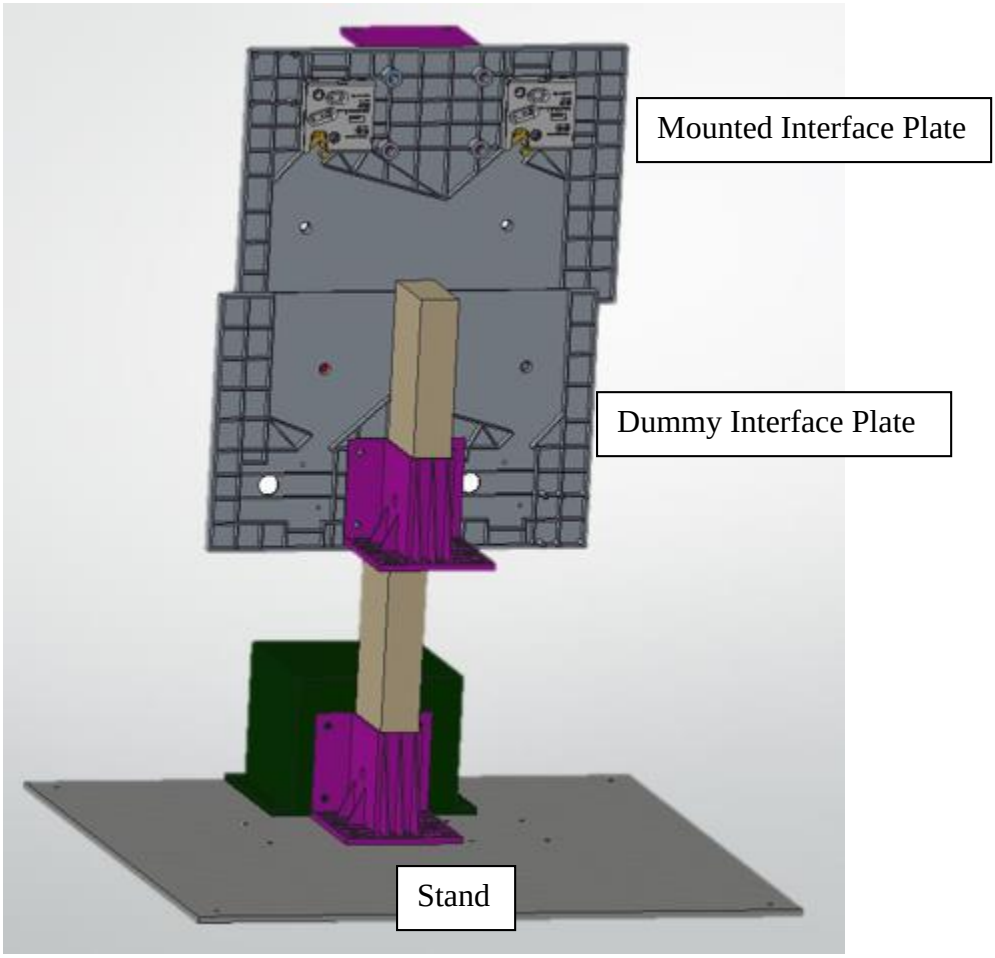



**Figure 1: Assembly without dummy attached**

Starting with the dummy interface plate, the 2x4 adapter is oriented to have the 2x4 face project upward as to support the dummy target when inserted. The adapters are then attached to the dummy interface plate using bolts, washers, and press-in-inserts. This orientation and alignment can be seen on the next page in Figure 2.

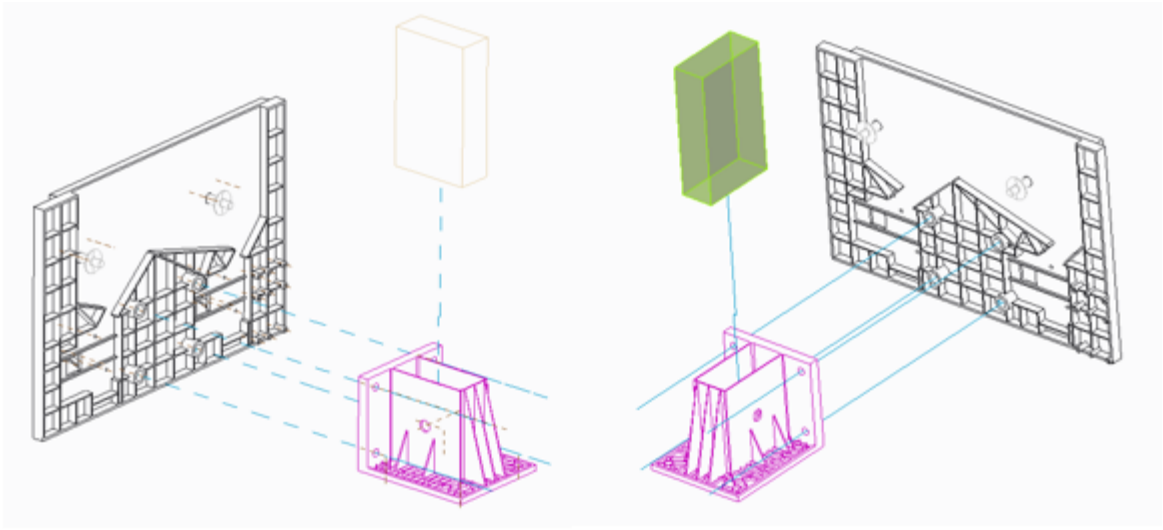


**Figure 2: Dummy interface plate**

With the mounted interface plate, it's important to note that it will be attached to the top of the 2x4 which protrudes from the base plate. This means it should be oriented in a way that attaches to the 2x4 while also ready to secure the dummy by connecting with the other interface plate. Seen below in Figure 3, one can see where and how the 2x4 adaptor will attach to this interface plate. The screws, press-in-inserts and latches align their mounting holes as shown in the figure. The press-in-inserts were installed using a sauntering iron. When heated they were simply pressed into the plastic interface plate to mold into the structure.

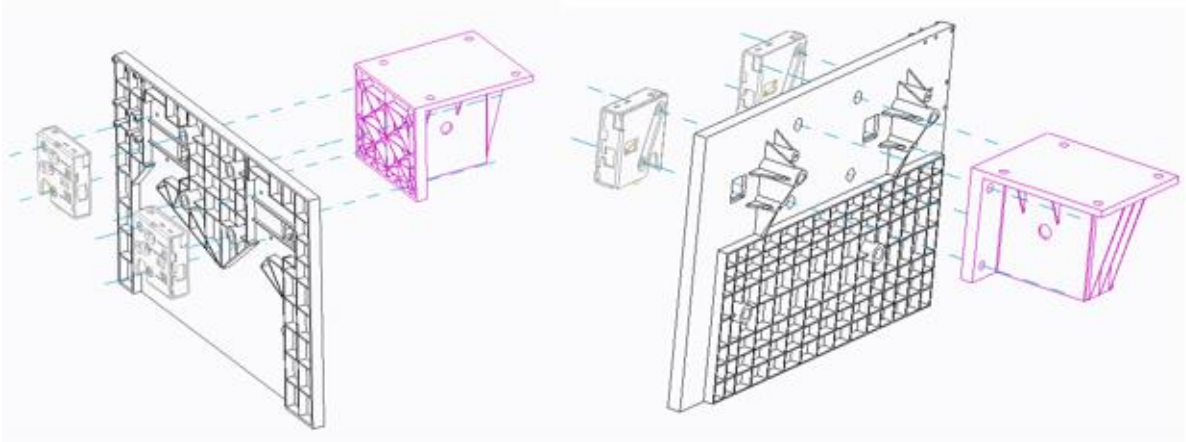


**Figure 3: Mounted interface plate**

Lastly, looking at the stand in Figure 4 the green control box, additional 2x4 adapter, wheels, and leveling feet are also secured using bolts and press-in-inserts. Their alignment and orientation are also shown below.

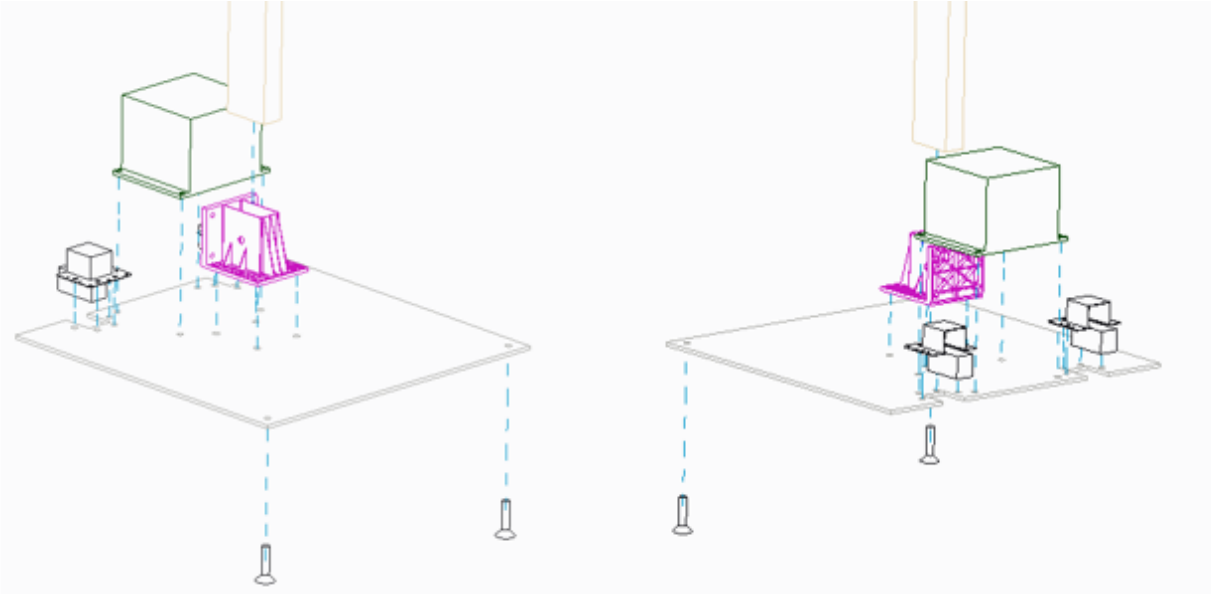
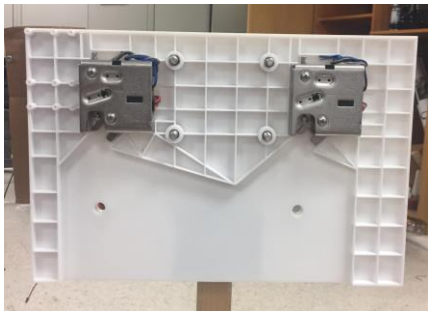
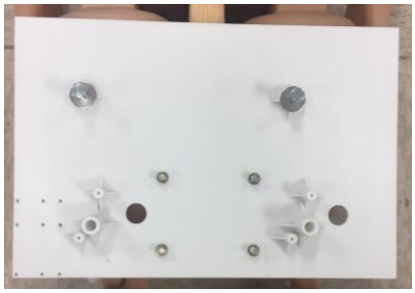


**Figure 4: Stand**

Further assembly details are outlined in the Operations Manual for this prototype. The assembly process should take approximately 25-30 minutes. Our particular assembly took a bit longer than expected because it was discovered that the tolerances on the bolt holes of the 2x4 adapter where too small. In order to correct this for future production the hole size will be increased to prevent the extra reaming process that was required. In terms of component and design and number of parts, Team #7's current designs are used interchangeably in multiple locations and meet and provide a suitable level of simplicity. Any fewer parts and we sacrifice possible structural integrity; any more parts includes increased complexity and most likely a cost increase as well. The team is content with the current design concepts and the amount of components needed to meet the project function.



*Stand Side Interface Plate*



*Dummy Side interface Plate*

**Figure 5:** Ready-to-Fall position and stand to dummy interface.

Starting from the left side, the mannequin can be seen standing upright in the Ready-to-Fall position. The two interface plates on the right are used to allow the target to fall when triggered.

The center plate has two latches attached whereas the right most interface plate has two bolts attached. These two bolts slide into the latches and hold the mannequin in place. When the latches receive a signal from the Arduino Uno, the target will fall to the ground. The direction of the fall will be controlled by the buttons shown below in Figure 2.

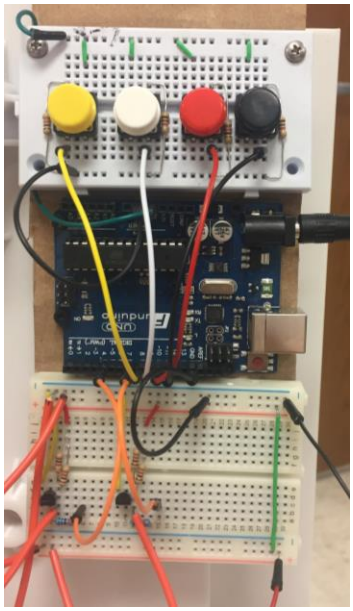


**Figure 6:** Here the four buttons used to trigger the target can be seen.

As shown in Figure 2, the yellow button triggers a fall to the left, the white button triggers a fall straight down, the red button triggers a fall to the right, and the black button allows the latching mechanism holding the mannequin up to be reset.

# 2. Design for Reliability

The Human Type Target consists of two main parts; the stand and the mannequin. The stand is responsible for supporting the target, providing an easy means for mobility, and housing the electronics needed to trigger the fall. The mannequin is responsible for receiving impact from a variety of ammunition rounds and falling when a lethal blow occurs.

## 2.1 The Stand

Figure 4 below provides a visual of the stand and all of the components attached:

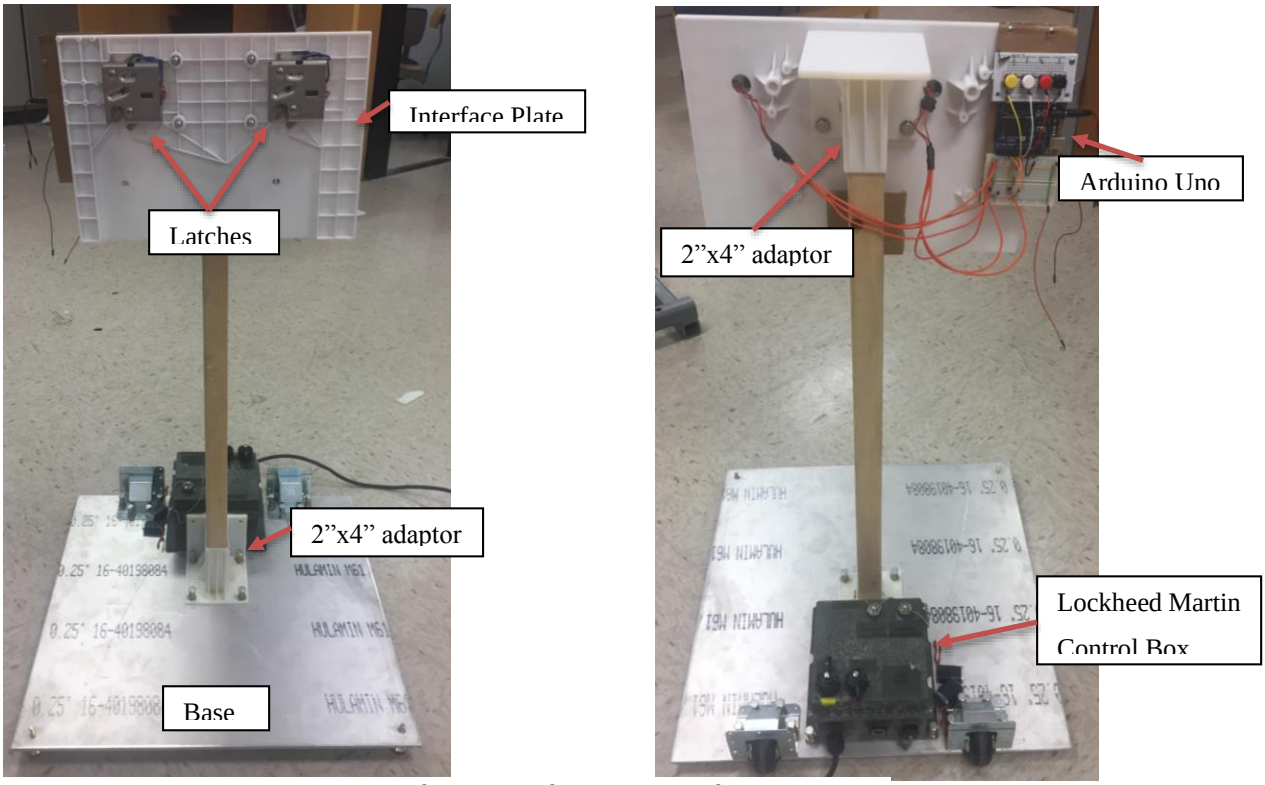



**Figure 7:** Front of stand (left) and rear of stand (right)

Looking at the image to the left of figure 4, the front of the interface plate can be seen with the two latches purchased from Southco installed. In order to trigger the latches (when a lethal series of blows is experienced), a signal of 12-24 volts must be sent to the latches. Moving down the image, the 2”x4” can be seen inserted into the 2”x4” adapter and attached to the base. The approximate dimensions of the 2”x4” adapter is 3.5”x4”x4.5”. The aluminum base itself occupies a 2’x2’ area

with two feet attached to the front and two wheels attached to the rear. Referring to the image on the right, the control box provided by Lockheed Martin can be seen attached in a location where it should be safe from the falling target. The Arduino Uno located in the top right corner will be used to simulate the “lethal blow”. Depending on which button is pressed, the target will fall in a different direction.

## 2.2 The Mannequin

Figure 5 below shows the mannequin and its attachment point to the stand.

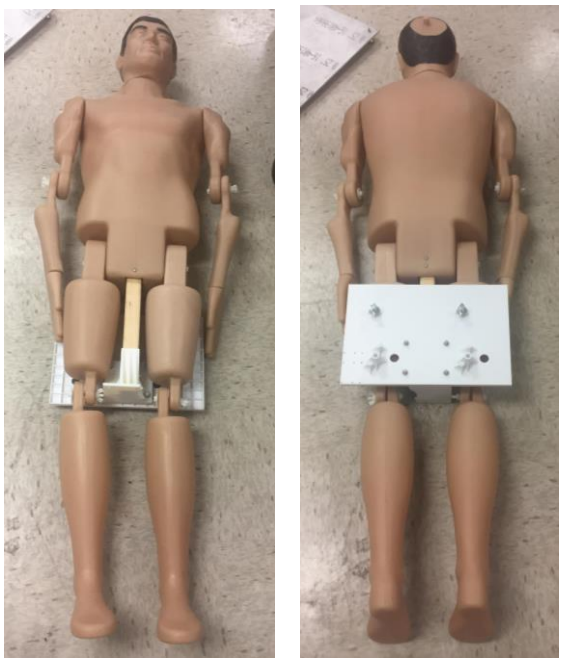


**Figure 8:** Front and rear view of mannequin

The mannequin is commercially available and comes with a 2”x4” slot set into is torso. The 2”x4” then sets into  attaches to the stand with the two bolts shown attached to the rear of the interface plate. The mannequin stands approximately 6’ tall and has adjustable arm and leg positions. Once set into the latches, the mannequin stands about 6’2”. This is easily adjusted if desired by trimming the length of 2”x4”.

When assembled, the target stands about 6’ tall and has an aluminum base which is 2’x2’. The base is outfitted with two wheels attached to the rear for ease of mobility and two adjustable feet on the front to ensure stability. The 2”x4” adaptors as well as the interface plates have been designed for injection molding and should be strong enough to withstand hits from a variety of

ammunition round. The overall device is designed to be quickly and easily repaired if something is damaged beyond working condition.

The latches used to hold the target up and drop when triggered are rotary latches purchased from Southco. The device used to trigger these latches is an Arduino Uno hooked up to several different buttons.

# 3. Design for Economics

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 XXX,** will a total of $1209 remaining.

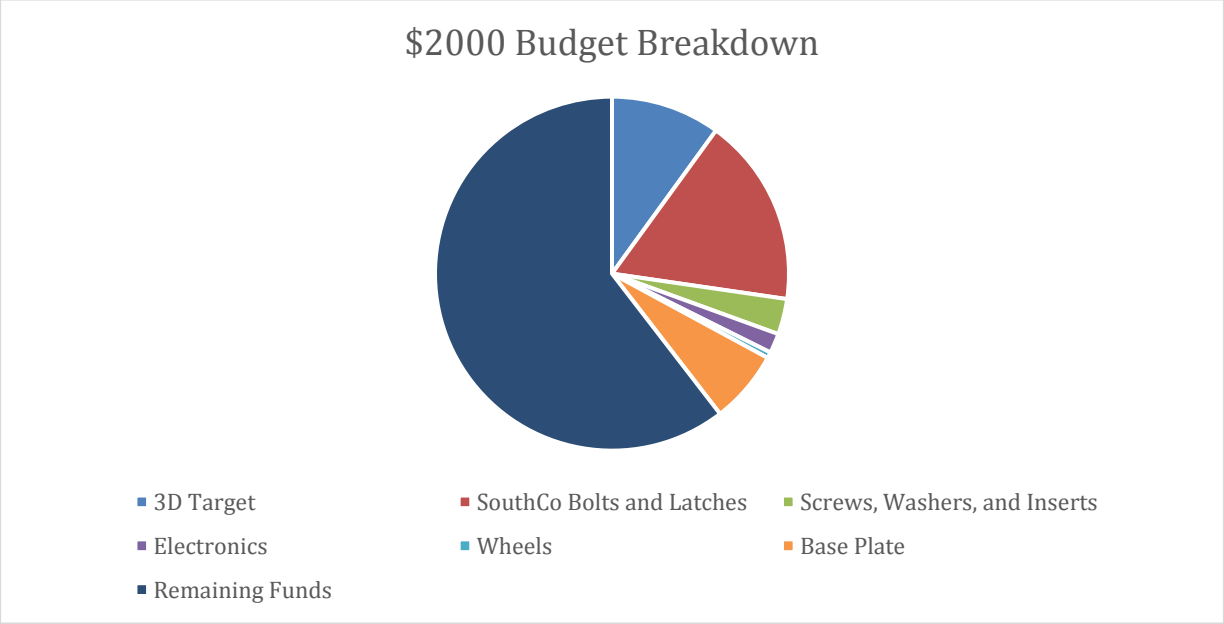



**Figure 9: Budget Breakdown**

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.

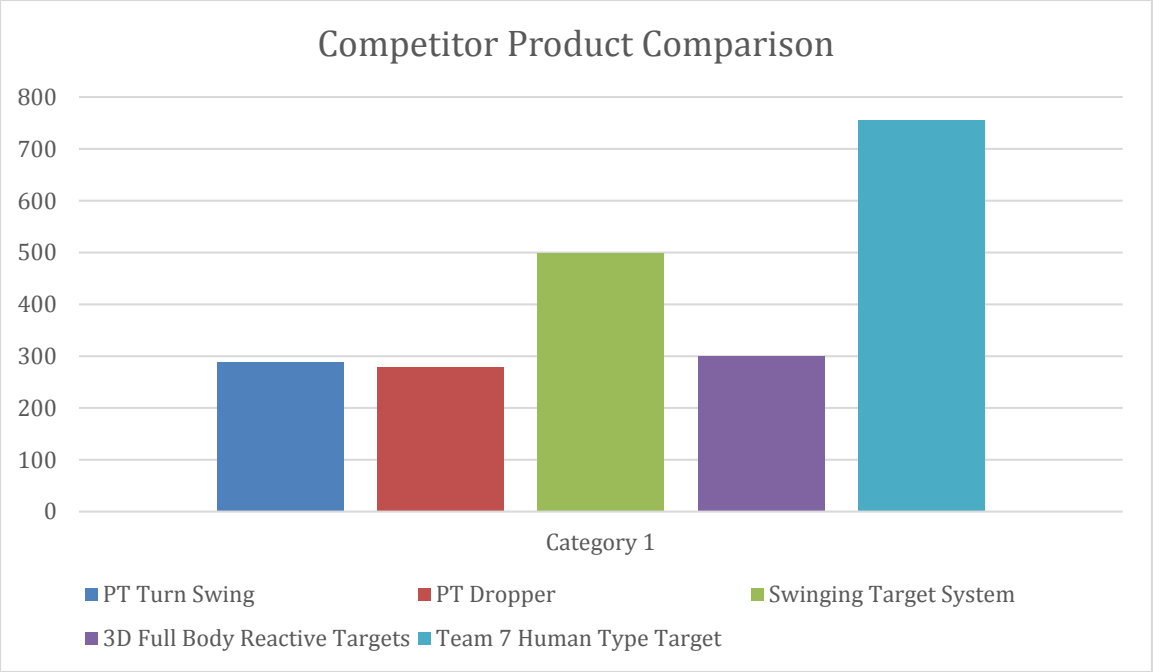
Costs ($) = (4*(Cost of material($ / lb)*Weight of Part(lb))) + ($2*Number of inserts) + ($1* Number of manual operations)

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 XXXX**.\

**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.




Marathon targets

Moto shot

Led targets

PT Turn Swing 289

PT Dropper 279

Swinging target system 499.

3D Full Body Reactive Targets 300

Team 7 Human Type Target 755

https://shop.actiontarget.com/prodcat/targetsystems-manualgravity.asp

In addition to the detailed methods you need to describe in this section, you need to provide specific objectives and an overview of your approach if they have not already been presented in the introductory section. The best place to put those items can vary among reports. Sometimes the background and literature review is really necessary to justify and substantiate the specific objectives and approach and, therefore, it is best to save those details for the beginning of this section.

These paragraphs are in "Normal." Other styles including captions, headers etc. can be used as presented in the previous section. Table 2 summarizes all of the styles that can be used with this template.

Table 2: Styles used in this template

| Style name | When used |
|---|---|
| Heading 1 | Section titles |
| Heading 2 | Primary headers |
| Heading 3 | Sub headers |
| Heading4 | Sub-sub headers |
| Normal | All paragraphs |
| Report-bullets | Bullets |
| Report-figure caption | All figure captions. |
| Report-table caption | All table captions |
| Report_table_body | All table content |
| Report-eqn | equations |
| Report-reference | Reference list at end of thesis |

# 4. Results

Results, findings, discussion of results OR project. It is best to also reiterate information in your literature review to help substantiate the findings of your research/project.

This template is best used for directly typing in your content.

# 5. Conclusion

This chapter could also be called “Conclusions and Recommendations” or “Conclusions and Implications.” In general, there should be no new information presented here. It should be a synthesis of information that you’ve already discussed.

This generic report-writing template provides the general guidelines and tips to write an effective, clean, and well-organized report. One should note that the purpose of the template is to provide a better mean (with auto style format) when it comes to report writing. A report should have required and important technical details and should be well organized to communicate effectively. If any of this is missing, it reflects a bad impression of the author (team members in this case) on the reader. Sometime the project demands to have different section heading or address different/additional concern. In that case the format can still be same with either introduction of completely new section or changing the title of existing sections. At this stage of the degree, students should know what to take and what to leave from this template when it comes to different report writing for ME Senior Design Course.

# References

https://www.3dhubs.com/knowledge-base/pla-vs-abs-whats-difference

Includes all references: articles, media facts, books, reports, regulations, internet articles, papers that you referenced from the text. In the text, citations should be [1] or [1-4] (if more than two citations are required at same place) and should be placed in "Reference" section in the order of their introduction. The computer software "End Notes" or the MS WORD tools – "insert, reference, footnote, endnote" (or "cross reference" if you refer to the same reference more than once) should be used to help you organize and manage your references.

References can be written in single space with extra space between references as in the format below. There are many different ways to arrange the information and punctuation in a reference listing. The most important thing is to make sure all references are complete and that the format of your references is consistent throughout. See additional suggestions and possible formatting options online.

Example:

[1] N. Gupta. Dynamic modeling and motion planning for robotic skid-steered vehicles, Ph.D. dissertation, Florida State University, Tallahassee, FL, June 2014.

[2] C. Ordonez, N. Gupta, W. Yu, O. Chuy, and E. Collins. Modeling of skid-steered wheeled robotic vehicles on sloped terrains. In Proceedings of the ASME Dynamic Systems and Control Conference, pages 91–99, 2012.

If you use the "Report-reference" style you will get the proper line spacing and indent style without further changes. Above are examples to show complete citation.

# Appendix A

Type or paste your appendices here. Appendices are a place to organize and include all of the "extra" material that is important to your research work but that is too detailed for the main text. Examples can include: specific analytical methods, computer code, spreadsheets of data, details of statistical analyses, etc. But, these materials do not speak for themselves. There should be a reference to these materials from the main section (complete details included in Appendix A) and there should be some text at the beginning of each appendix to briefly explain what the information is and means that is included in that appendix.

# *Biography

Each report should have the group member's small introduction (short bio – maximum of 50 words) at the end of the report.

*Only applicable to mid-term and final report.