Variable Angle Target Training System (V.A.T.T.S.)

Design for Manufacturing, Reliability, and Economics

Team 16
Submission Date: April 1 2016
Submitted To: Dr. Nikhil Gupta

Ashar Abdullah
Andrew Bellstrom
Ryan D'Ambrosia
Jordan Lominac
Fernando Rodriguez

Table of Contents

Table of Figures

Abstract

Designing for manufacturing, reliability and economics is a crucial component to any application. In the team's development of a prototype, these factors were taken into account. To design for manufacturing, the team's main designs were modeled around the fact that these components would be casted from aluminum. This was determined through sponsor communication and the design has since been iterated for optimization for casting through the sponsor's aluminum casting vendor. Major component stress analysis was performed to ensure the reliability of our prototype. It was determined given the normal usage and characteristics of our design that the prototype design would last longer than the 25 year standard for stationary infantry targets. While designing, the team kept development costs low by ordering only the parts needed for the project, with slightly extra material for unforeseen occurrence of error. Currently in the final fabrication phase, the team has come in under budget, and expects to stay this way through the end of the project.

1.0 Introduction

Military and law enforcement organizations have always attempted to simulate real life situations while training in order to be more prepared for real life situations. Molded silhouette targets have been used to simulate a hostile and a friendly entity. One of those systems is the Stationary Infantry Target or SIT. The SIT system raises a concealed target up 90 degrees and presents the trainee with a target which can be either friend or foe. Below is the feasibility and design considerations including the manufacturability, design considerations and economic feasibility of the system.

2.0 Design for Manufacturing

The assembly of the design can be broken into three main assemblies. Those being the arm attachments, the bracket installment and the motor with respective gearing. The arm assembly can be started by press fitting a hex bearing into the bottom of the arm. The motor enclosure can be installed from the bottom using ¼-20 x 5/8 bolts and hex nuts bolted from the top. The underside of the arm is now complete. Moving onto the top of the arm, the bearing block can be assembled and installed on top. The bearing block consisted of a 5/8 circular bearing pressed into the top of the block. After the bearing is installed it can then be mounted onto the arm using four 10-32 bevel screws. Once the bearing block is installed the hex hub can then be pressed into the 5/8th circular bearing. This completes the arm assembly. The bracket assembly consist of installing two latches onto the through holes of the bracket. Once they are bolted in the bracket can be installed into the arm using six 10-32x ¾ bolts and respective nuts from the top. The motor assembly can be installed by inserting the bevel bracket into the motor housing and securing it to the housing. The gears are preinstalled and only require keying of the shaft. The vertical shaft is threaded through the bearing block and is connect to the bracket via a ¼-20 x 5/8 bolt. Once the shaft is connected the planetary stages and motor assembly can then be attached. First by assembling the planetary stages and joining them to the motor with the sun gear installed onto the drive shaft. Once the motor assembly is complete it can then be secured to the bevel gears. After the motor and housing are installed the encoder can then be attached to the bottom shaft of the bevel gears. Next is the wiring and closing the motor housing via gasket and bottom lid. The assembly time took less than thirty minutes which was to be expected. There were 53 total components in this design, every component was scrutinized and evaluated for use and functionality. The bolts were to retain the structure, the bearings were to stabilize the shaft, the gasket was to keep the product water tight, the gearing was to provide adequate torque, and the bracket was optimized for all targets. Below is a detailed image of the assembled and exploded structure as well as a detailed view of the motor assembly.

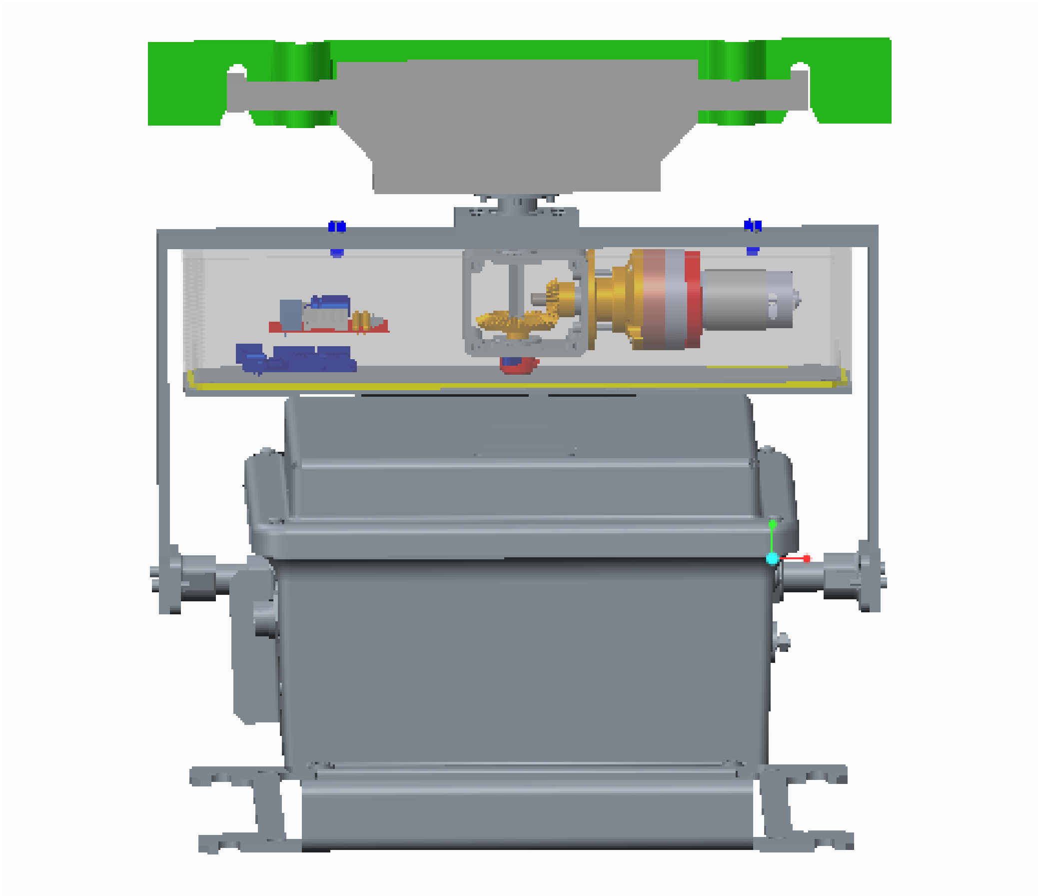

Figure 1. Frontal view of completed assembly

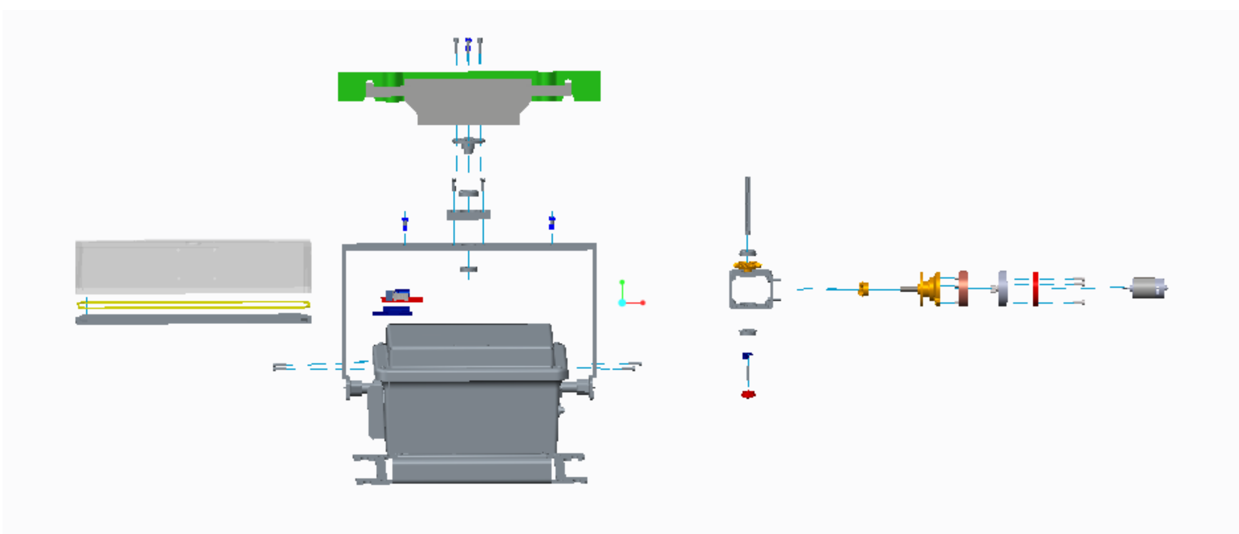

Figure 2. Exploded view of completed assembly

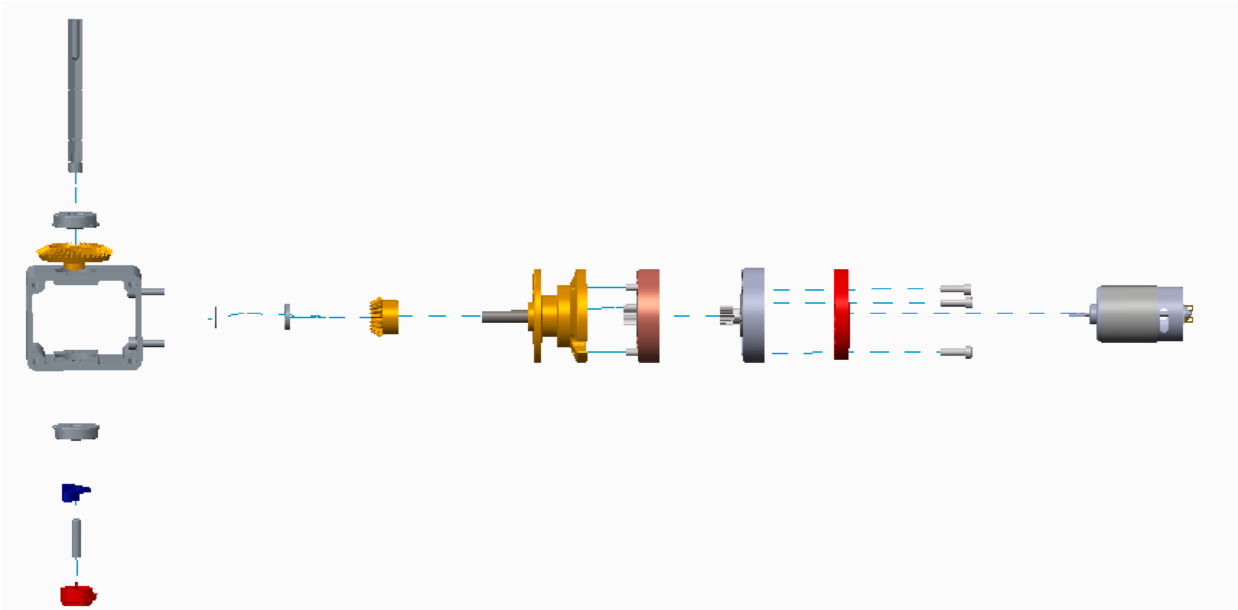
Figure 3. Enlarged exploded view of motor assembly

3.0 Design for Reliability

The reliability of the system can be broken into three main parts. Those being the motor, the arm and the bracket. The motor and gearing was selected to output the required amount of torque of 3000 ozf-in. To improve on reliability a factor a safety of 1.25 was included to ensure the motor would not stall when a wind force is being applied. Below is a static analysis of the forces being applied to the arm. The maximum stress on the object was 20,000 psi during a 35 mph wind, which is considered a tropical storm. Even under these conditions the arm is well below the yield strength of AL6061 which is 45,000 psi. Cyclic loading of the system could not accurately be performed due to the erratic nature of the wind forces during a storm, but it could be safely assumed the design would not experience these types of loading on a regular occurrence enough to cause failure.

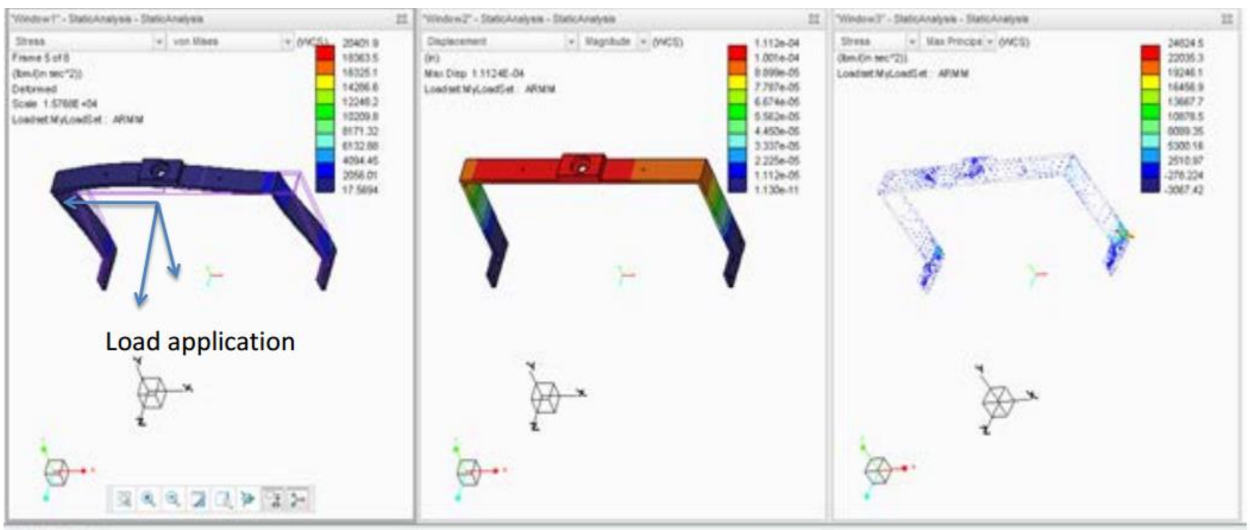

Figure 4. Static loading analysis of arm

The bracket will be undergoing stress during the loading and unloading of the clams. Each clamp is to output a force of 100 psi. Taking this into account a static model of the forces was produced and is shown below.

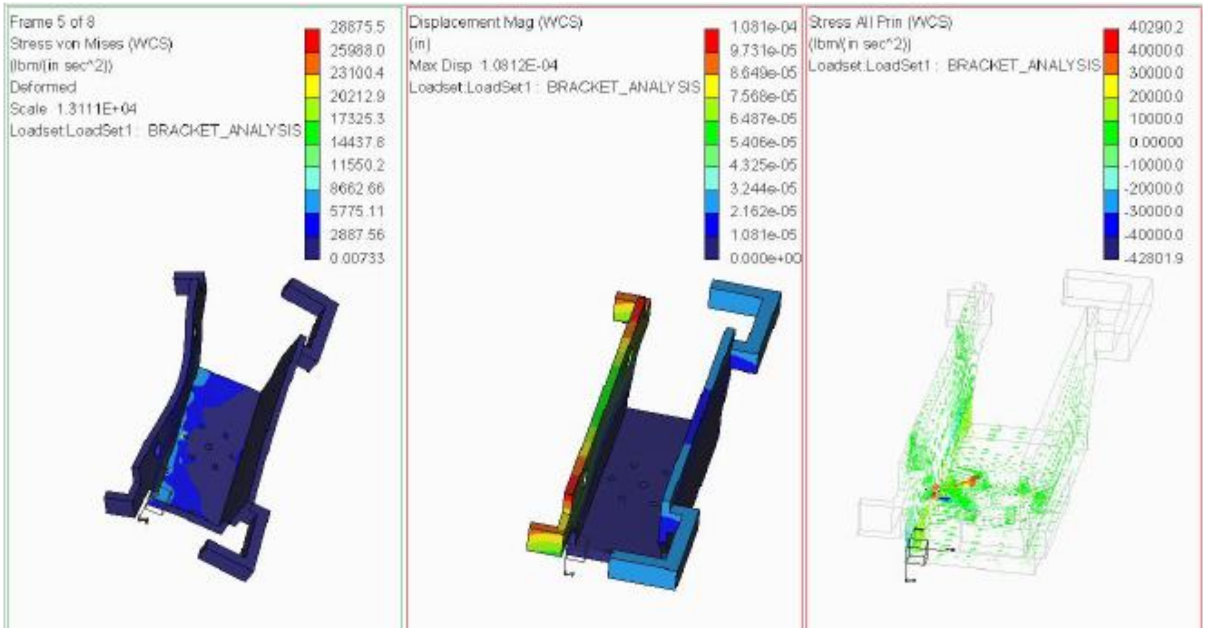

Figure 5. Static loading of bracket

The model will experience a maximum stress of 28,000 psi under normal conditions and experience a deformation of approximately 0.001 when loaded. The point that will experience the most stress is the bolt connection where the bracket meets the hub. To ensure the bracket would not fail over the course of its lifetime which was estimated as 65,000 cycles over a course of 25 years. Fatigue strength calculations were performed and are shown below.

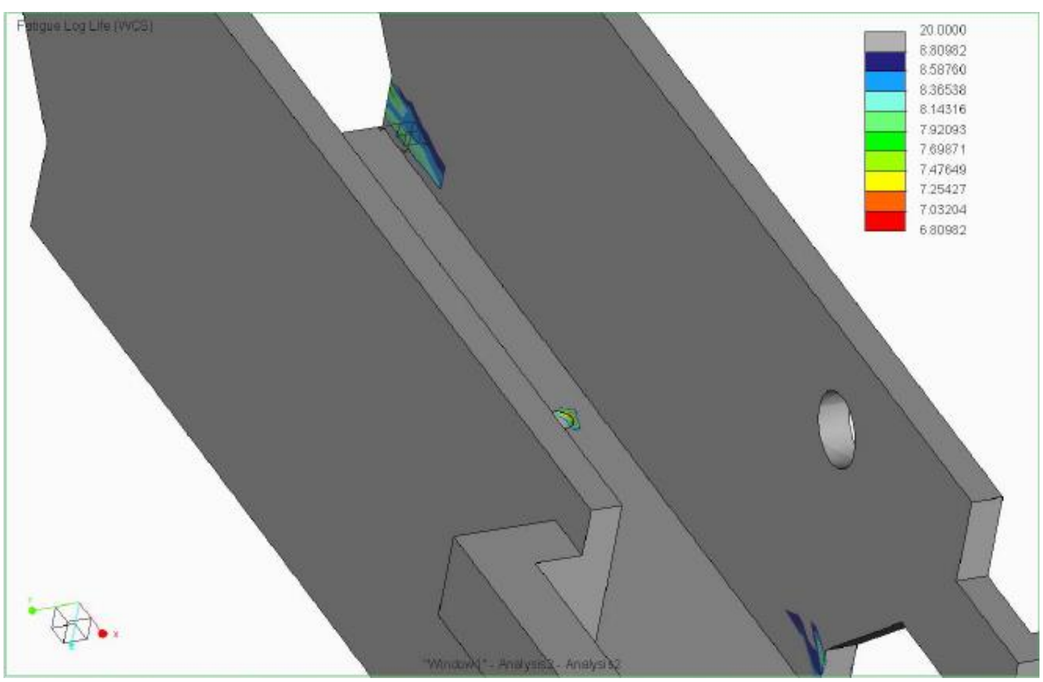

Figure 6. Fatigue failure analysis

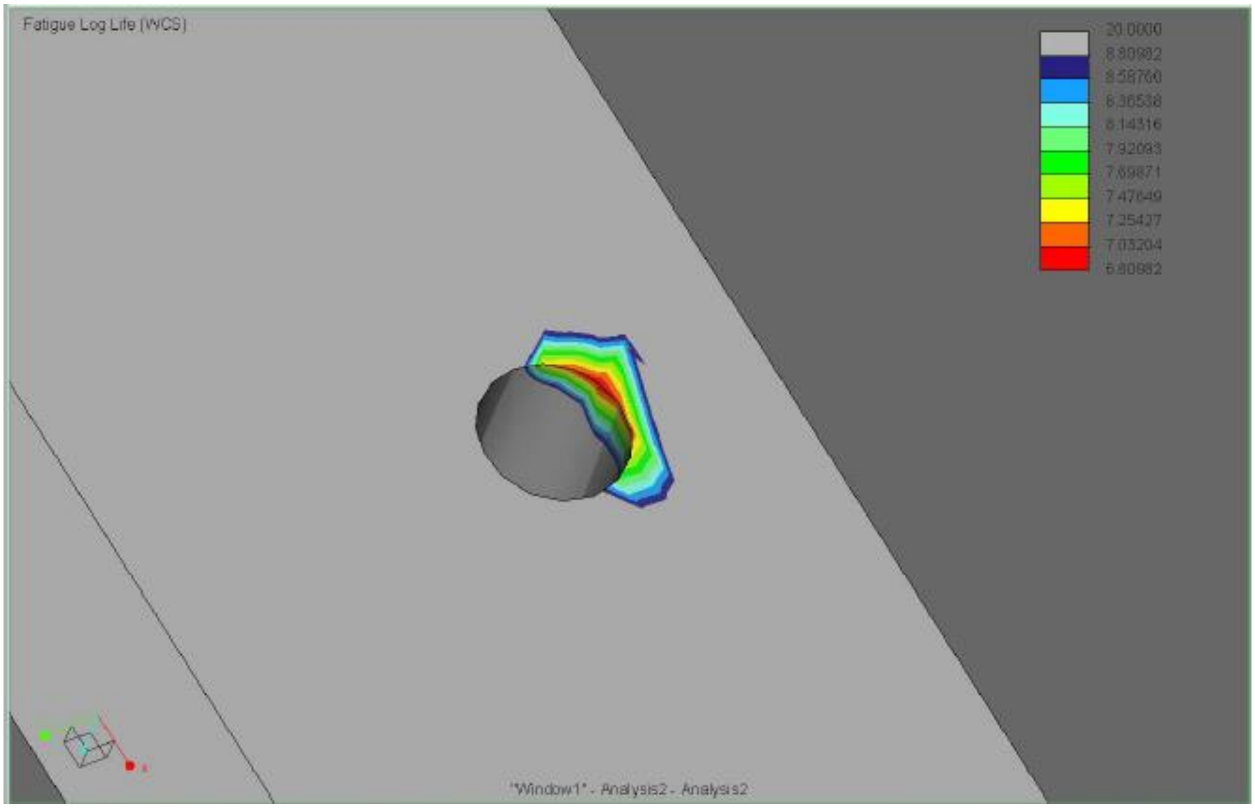

Figure 27. Enlarged portion of fatigue failure analysis

The area that was causal for the largest concern was the bolt hole connected to the hub. According to the analysis it will last to approximately $10^{6.8}$ or 10,000,000 cycles before crystallization of the surface and cause a stress fracture which is well above the required amount.

The main reliability concerns were the adverse effects of the wind beyond the initial requirements. The gearing of the motor would prevent the system from being back driven and it will perform to the necessary requirements, yet it is possible that it could experience a force greater than what it was design for. If this was to occur the motor would stall out until the wind has surpassed and then correct itself to the proper position, this was achieved via programming logic.

4.0 Design for Economics

The completed project cost $1270 to build. With an initial budget of $2000 the design came in under budget. In the table below is a list of all components and their related cost. A graphical representation of is also shown in Figure 8. When considering the marketability of the product, other companies do produce a similar product but due to their militaristic nature, their price isn't freely advertised. The design will be one component of an entire system that will be sold to a US or allied nation.

Product	Price
Aluminum stock	217.00
Motor Controller	169.00
Planetary Gearbox 4:1	180.00
Planetary stage	45.00
Toggle Clamp	40.00
Lubricated Ball Bearing	21.00
Planetary Single Stage	45.00
Sun Gear 15 Tooth	9.00
Bevel Gear Box	129.00
Encoder mount	4.00
optical encoder	42.00
Hex Bearing	5.00
Screws	10.00
Motor	14.00
Hex Hub	20.00
Arduino Uno R3	30.00
Roboclaw	170.00
Plexiglass	120.00
Total	1270.00

Table 1. Cost allocations

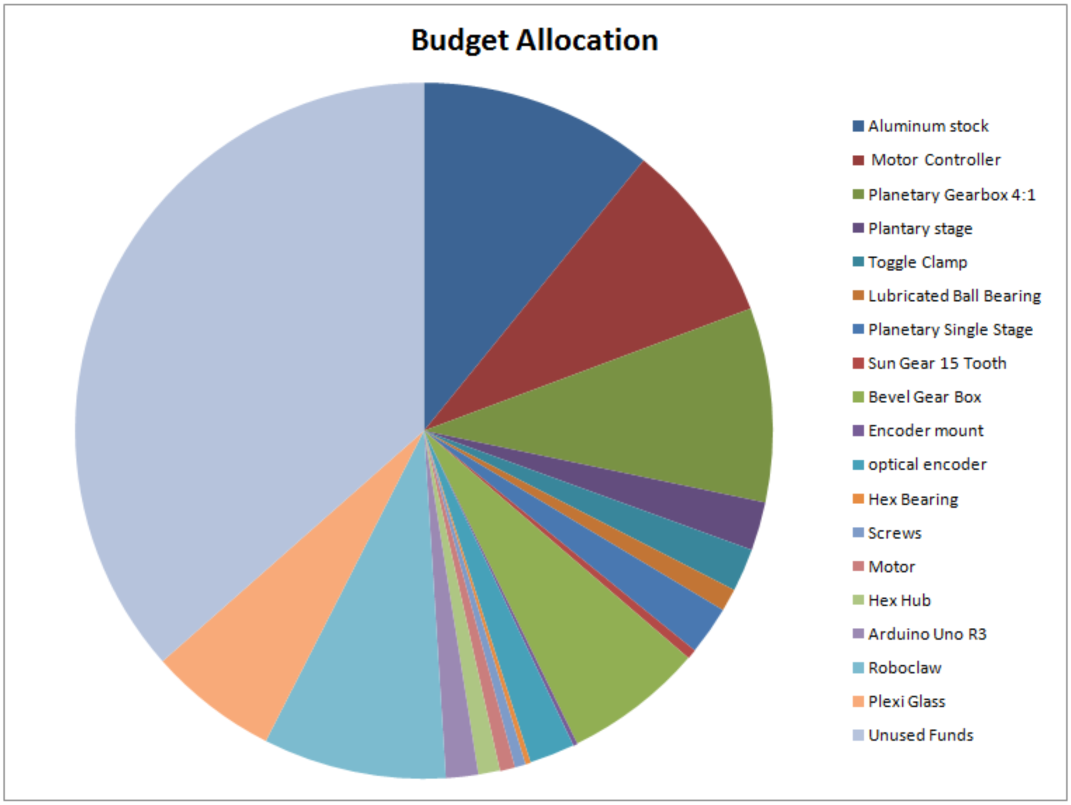

Figure 8. Cost of production

There are similar products on the market like the prototype for Lockheed Martin but very different. One similar target is made by a company called Meggitt training system and its product name is Multi-Function Stationary Target System (MF-SIT). According to their description this device is capable to expose from multiple angles with the ability to pop-up a friend or foe target. It has the capability to rotate the target through 360 degree at multiple angles with pre-programmable scenario archiving a better realistic military operations in urban terrain. Also, the turning has the ability to adjust the angle with an increment of 15 degrees. Since these products are mainly made for military or police training purposes there is little information on price and in depth details. Comparing this SIT to the one from Lockheed we can see that VATTS has the ability to pop-up friend or foe targets as well as have a 45 degree rotation for pup-ups at 45 degrees, letting this make a better realistic environments for trainees.

Another company that makes advance stationary infantry target is Theissen Training System. This particular product is named Stationary Infantry Target- Advance Pop-up Training with the unique specific characteristic of been portable for field training. This system has the ability to alternate between friend, foe or neutral position like the VATTS, but it doesn't have the capability as well as the other company to rotate targets on a 45 degree angle. This portable device have the ability to withstand difficult environmental conditions as well as most of the SIT's build. As well as Meggitt, Thiessen doesn't have any details on price and in depth information.

As an overall comparison, Meggitt and Theissen don’t have all the turning mechanism that VATTS from Lockheed Martin does, as well as having a unique specific bracket for Ivan, fig 11, fig 12, and waffle board style targets. Also it has the ability to withstand rigourous environment changes as high wind speeds.

5.0 Conclusion

The manufacturability, reliability, and economic considerations for the design have been accounted for. The ability for all components to be produced and assembled in a reasonable time and fashion have been shown. The greatest advent would be in the machining of the bracket and arm. A planned production of a castable model would reduce these cost and produce a more replicable model. The reliability of the system has been shown, as well as load considerations proving the design life of the system greatly exceed a planned lifespan of 25 years. The product marketability of the system was kept competitive.