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

Mid-Term 1 Report

Team 16
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Table of Contents

Table of Figures iii

Table of Tables iv

Abstract v

1.0 Introduction 1

2.0 Project Scope 2

2.1 Background research 2

2.2 Need Statement 3

2.3 Goal Statement & Objectives 3

2.4 Risk Assessment 4

3.0 Constraints and Requirements 5

3.1 House of Quality 8

4.0 Methodology and Approach 9

4.1 Gantt Chart 9

5.0 Product Specifications and Performance 10

6.0 Preliminary Designs 11

6.1 Design A 11

6.2 Design B 14

6.3 Design C 15

6.4 Design D 16

6.4 Design E 17

7.0 Design Matrix 18

8.0 Results 19

9.0 Conclusion 20

10.0 References 21

11.0 Team Biography 22

Table of Figures

Figure 1. Example of SIT 3
Figure 2. Target Examples 5,6
Figure 3. FASIT Target Actions 7
Figure 4. Constructed House of Quality 8
Figure 5. Fall 2015 Semester Gantt Chart 9
Figure 6. Provided Lockheed-Martin SIT 10
Figure 7. CAD of Overlapped Targets showing universal gap 11
Figure 8. Toggle clamp CAD 12
Figure 9. Bicycle seat clamp CAD 12
Figure 10. Limiting height of lifting arm on SIT 12
Figure 11. CAD of Design A 13
Figure 12. CAD of Design B 14
Figure 13. CAD of Design C 15
Figure 14. CAD of Design D 16
Figure 15. CAD of Design E 17

Table of Tables

Table 1. FASIT 2.0 Commands....6
Table 2. Design Matrix for Designs A – E 18

Abstract

Stationary Infantry Targets (SIT) have been used in the past to give a more realistic training experience to military and law enforcement. Many of these targets employ the same overall target actions, but actions such as "pop-up" or rotation have recently been implemented in order to create a more robust training model. Specifically Lockheed-Martin's version of the SIT does not have the capability to rotate the attached target once in an upright position. The team's objective is to create a lifting bracket to mount on Lockheed-Martin's current SIT design. The new lifting bracket will accommodate various types of standard targets, as well as rotate the target using standard Future Army Systems of Integrated Targets (FASIT) regulations. Following the typical design process, he team has developed various preliminary bracket designs and corresponding design selection matrix, which are being reviewed by the team sponsor and mentor. Though no there have been no concrete results related to the prototype, the team has gained a better understanding of the sponsor needs and preferences with respect to the turner design. Moving forward, the team plans on designing the turning mechanism for the selected target bracket. Once these two main component designs have been selected, the team plans on ordering parts based on the given budget in order to successfully produce a functional prototype.

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. Targets that vary from simple paper and cardboard posters, to more complicated molded silhouette targets have been used to simulate real life situations where there is a need to distinguish between a hostile and a friendly entity. Coupling these target presentations with realistic spatial movements provides a robust model for what one might encounter in real life. There are various mechanisms available on the market that fully simulate an encounter where there is a need to discern friend from foe. 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. There are limitations of the SIT such as, the time to switch the physical target between a friendly target and a foe target, the manner in which the target is attached to the system is not universal for different, widely used targets, the target presented cannot rotate and is fixed in a fully presented position, limiting the realistic simulation of a quartering body.

The objective of this project is to implement a new target arm to the SIT, which alleviates many of the shortcomings of the original design. The new target arm shall make replacing used targets quicker and easier, accommodate various standard training targets, be able to rotate the target between a range of quartering angles once fully deployed in its upright position, as well as rotate a full 180 degrees to reveal a second, different presentation.

2.0 Project Scope

Team 16 plans is to develop a target turner for Lockheed Martin's Live Training organization for domestic and international militaries practices. An arm mechanism with turning function is for "pop-up/rotation" mechanism for various target presentationspictured below in Figure 3.

2.1 Background research

The Stationary Infantry Target, or SIT, has been used for many years and is a staple of live training equipment. They are primarily used in infantry platoon/squad battle courses but can also be used at gun ranges as well **[1]**. A picture of the mechanism can be seen below in Figure 1 **[2]**. The SIT mechanism has gone through many iterations over the years, making it more reliable, flexible, and simple to use. Therefore, the SIT systems that exist today are very robust. There are many different companies who design and market SIT systems, these companies include Strategic Systems, Meggitt, Lockheed Martin, and more. All the different SIT systems these companies produce essentially perform in the same way. Therefore, to incentivize organizations into buying their SIT systems, engineers are required to innovate and constantly improve their designs. These improvements are not just limited to the operation of the system but also to things such as portability, reliability, and cost **[3]**.

The competition between companies as well as increasing requirements from clients has given rise to complex SIT systems that provide more variable training. These variables add additional stress and also simulate real combat more closely giving rise to better trained personnel. Some examples include thermal targets which are used for night training, hit detection, and muzzle flash. However, the feature that the design team is primarily interested in is the rotation of a mounted target.Theissen already implements a friend/foe SIT on their MOUT (Military Operations in Urban Terrain) courses **[4]**. Also, Meggitt has a product called the MF-SIT which has the ability to raise and rotate the target a complete 360 degrees in less than a second **[2]**. This is of interest to the team since this feature is one of the goals of this project. Also, it can be seen that a rotating target has already been done and is currently in use.

It has been seen that SITs can vary in their combat simulation variability, but beyond these aspects, many systems follow a standard. For example, all SITs present the same basic targets. These include E-type, F-type, and Ivan-type targets. Also, all target systems run of FASIT 2.0 compliant firmware. FASIT is a set of regulations that helps simplify programming a training routine by keeping a universal set of commands among differing targets, and target manufacturer hardware on a range. More can be learned in the FASIT 2.0 Interface Control Document. The team will have to take these given factors into consideration in order to meet the project requirements.

Figure 1. Example of SIT

2.2 Need Statement

Lockheed Martin's Live Training organization specializes in training domestic and international ally militaries. Currently Lockheed supplies live fire "pop-up" targetry training systems for military target identification purposes. The new target training system requires the ability to rotate the target through various angles in either direction once the target has been lifted in order to present a friendly or foe target.

"Lockheed-Martin's current Stationary Infantry Target does not allow for suitable target presentations"

2.3 Goal Statement & Objectives

"To create a target system that can deploy a variety of targets from a resting position, and rotate to a friendly or foe position on command."

Objectives:

- Lift and rotate targets on command
- Firmware interface with FASIT
- Create a universal mount for variety of targets
- Easily attach and detach various types of targets
- Withstand 35 mph cross winds
- The motor may not be back driven
- Motor will be unaffected by heat, sand, dust, and rain
- Use Figure 11, Ivan, "E" type and "F" type targets

2.4 Risk Assessment

As with most any project, there is a risk element. The team has performed a risk assessment and submitted the document to the Senior Design Capstone advising faculty. In said risk assessment, the team outlined the potential risks presented by this specific project. The main risks were found to be in the Prototype Construction and Prototype Testing phase of this project. Where construction of the prototype would present risks such as machine tools, and prototype testing risk would involve potential bodily injury from moving parts on the prototype. In order to reduce the risk the team will take appropriate steps to avoid injury. Steps include being certified for use of required machining tools, deferring to experts in the machine shop for majority of the machining process and following Lockheed-Martin's safety guidelines for use of their provided Stationary Infantry Target system. All members of the group have understood proper emergency procedures and all potential risks will be reported to group mentors as well as senior design faculty. In the event of accident, or close call, the group understands that it has a responsibility to inform its project advisors.

3.0 Constraints and Requirements

- The total cost may not exceed $3,000.
- Motor must meet FASIT requirements. **[5]**
- Distance from bottom of lifter to top of the arm shall be no more than 18 inches.
- Weight of lifter arm with turner motor shall be no more than 10 lbs.
- Time to install new target shall be less than 10 seconds
- Motor shall rotate the target up to 90 degrees in either direction within 1 second of receiving turn command.
- Motor housing shall be rated to at least IP67.
- Arm shall survive a loose cargo test (details TBD).
- Target arm shall operate -20°C to 50°C and shall have a minimum storage temperature range of -40°C to 60°C.
- Target arm shall accommodate an Ivan-style target (Figure 2a.), an E (Figure 2c.) and F-style (Figure 2d.) target, and a Figure 11 target (Figure 2a.) without reconfiguration.
- Target arm shall fit on the new Lockheed Martin Stationary Infantry Target (SIT) – part number 15721510G1 (dimensions provided).
- Arm shall not impede functionality of muzzle flash feature on the SIT.
- The new bracket and arm must be able to hold the target in wind conditions up to 35 miles per hour
- Firmware shall be compatible with all applicable FASIT 2.0 commands (Refer to Table 1)

Figure 2a." Figure 11" Target Face

Figure 2b. "Ivan" Style 3D Target

Figure 2c. “E” Style Target

Figure 2d. “F” Style Target

Figure 2. Target Examples

Table 1. FASIT 2.0 PD IDC calls out ASPECT field: values 0 through 6

FASIT 2.0 PD IDC Command	Target Action
0	Concealed
1	Simple Hostile
2	Restricted Hostile Left
3	Restricted Hostile Right
4	Simple Neutral
5	Restricted Neutral Left
6	Restricted Neutral Right

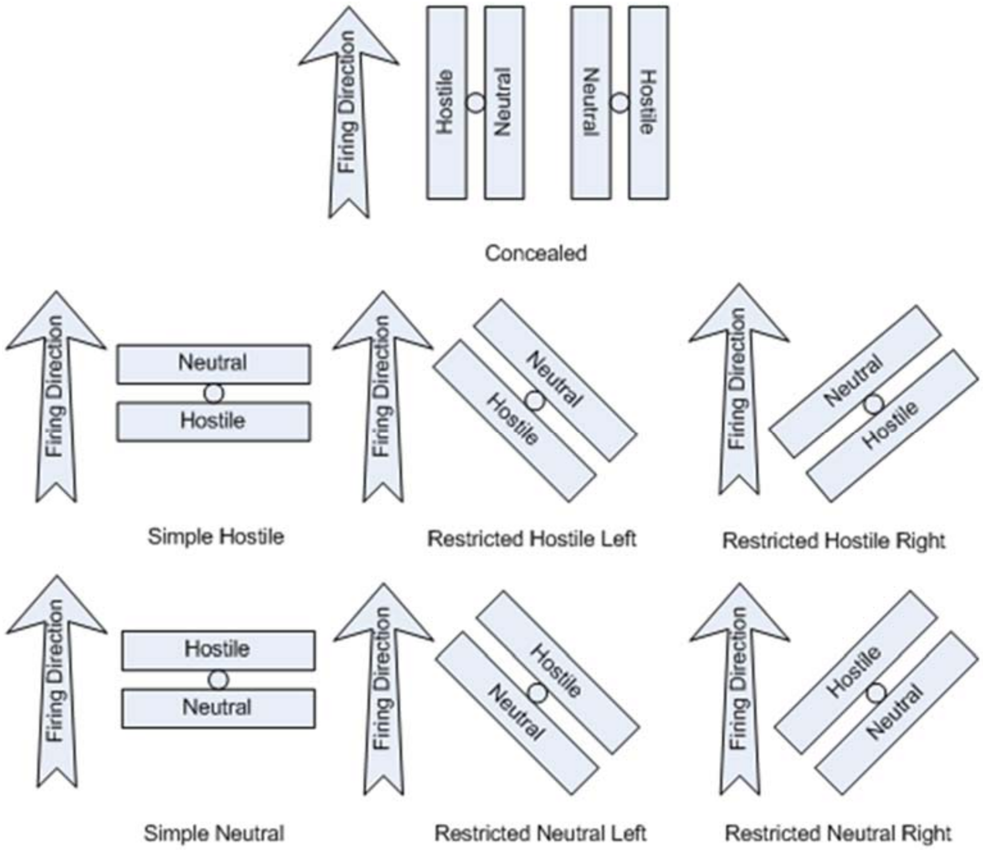
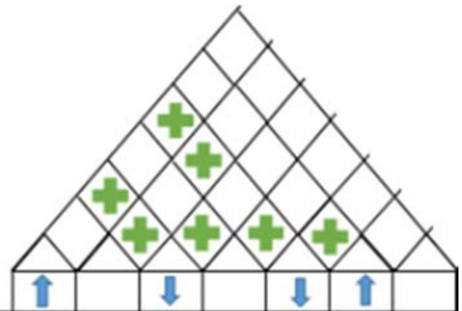


Figure 3. FASIT Target Actions

3.1 House of Quality

Based on the customer requirements and given project constraints a house of quality was constructed to better observe the importance of different needs for the project.



	Customer Requirements	Weight Factor	Motor Speed/ Torque	Dimensions/ Shape	Weight	Materials	Manufacturing Cost	Clamp Force	Electronics/ Programming
Performance	Low Installation Time	5						2	
	Rotation Angle	4	3						1
	Compact Lifter Arm	3		3		2	2	1	2
	Low Weight	1	2	2	3	3	3	1	1
	Target Security	5		2		1	2	3	
	Rotation Time	3	3		2				
Features	Target Accommodation	5		3				2	
Durability	Wind-Resistant	2	1					1	
	Loose Cargo Test	1			1	2			2
	Temperature Resistance	3	1			2	1		3
	Weather Resistance	3				3	1		3
Serviceability	FASIT 2.0 compatible	5							3
Conformance	Meets Firmware Standards	5							3
	SIT integration	5		3	2		1		
	Flash Feature of SIT	4		2					
	Motor Meets Standards	2	3				2		
	Mass Producibility	2	1		1	3	3		
	Technical Priority		36	59	22	37	40	40	51

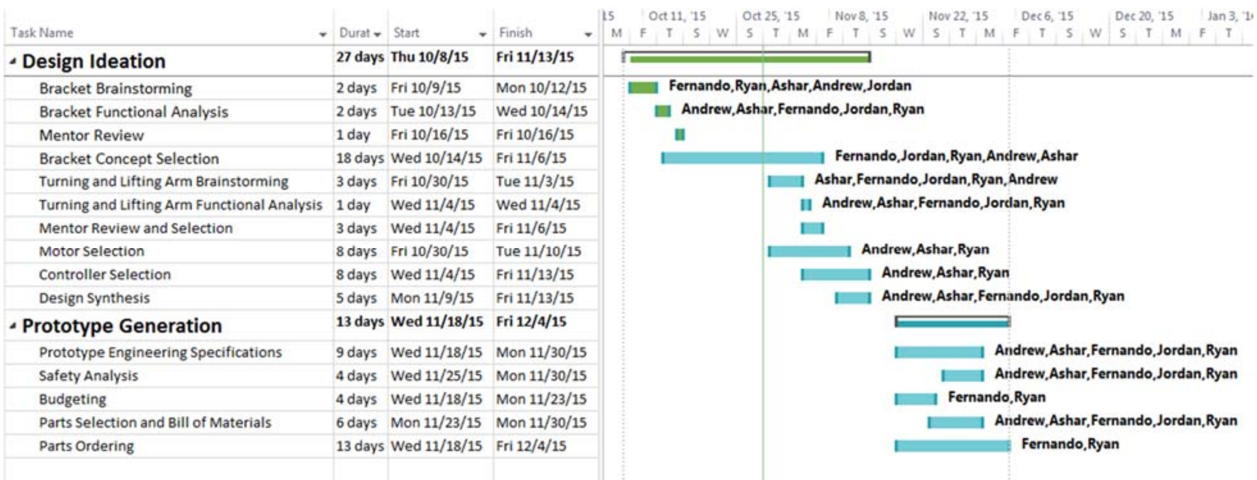
Figure 4. Constructed House of Quality

4.0 Methodology and Approach

Currently the team meets with each other on a weekly basis. The team also meets with the sponsor, Chris Isler, on a weekly basis via conference call. Anything that is discussed about in the meeting is written down by the historian, Andrew Bellstrom. Also, any documents that are given to us by the sponsor goes to the team leader directly who can then decide to delegate it among the members. This way, information sharing is more streamlined.

The team produced a Gantt chart to help plan out the nine months left to work on this project. The time allotted to work on deliverables are concrete due to deliverable deadlines. The time allocated to the design process is more flexible, but will be followed as stringently as possible. The Gantt chart should provide a general idea of the project's statuson a given day.Assignment of responsibility for respective tasks can be found on the gantt chart diagram.

4.1 Gantt Chart



Task Name	Durat	Start	Finish
Design Ideation	**27 days**	**Thu 10/8/15**	**Fri 11/13/15**
Bracket Brainstorming	2 days	Fri 10/9/15	Mon 10/12/15
Bracket Functional Analysis	2 days	Tue 10/13/15	Wed 10/14/15
Mentor Review	1 day	Fri 10/16/15	Fri 10/16/15
Bracket Concept Selection	18 days	Wed 10/14/15	Fri 11/6/15
Turning and Lifting Arm Brainstorming	3 days	Fri 10/30/15	Tue 11/3/15
Turning and Lifting Arm Functional Analysis	1 day	Wed 11/4/15	Wed 11/4/15
Mentor Review and Selection	3 days	Wed 11/4/15	Fri 11/6/15
Motor Selection	8 days	Fri 10/30/15	Tue 11/10/15
Controller Selection	8 days	Wed 11/4/15	Fri 11/13/15
Design Synthesis	5 days	Mon 11/9/15	Fri 11/13/15
Prototype Generation	**13 days**	**Wed 11/18/15**	**Fri 12/4/15**
Prototype Engineering Specifications	9 days	Wed 11/18/15	Mon 11/30/15
Safety Analysis	4 days	Wed 11/25/15	Mon 11/30/15
Budgeting	4 days	Wed 11/18/15	Mon 11/23/15
Parts Selection and Bill of Materials	6 days	Mon 11/23/15	Mon 11/30/15
Parts Ordering	13 days	Wed 11/18/15	Fri 12/4/15

Figure 5. Fall 2015 Semester Gantt Chart

5.0 Product Specifications and Performance

To ensure the product meets all constraints and specifications listed above. The following features will be measured, calculated and designed to meet all goals. The torque and angular velocity of our motor will be calculated to insure the target moves at the proper speed, with a desired amount of torque. The overall size and weight of the unit will not interfere with the SIT, and will accommodate all needs. The provided lifter, shown inFigure 6, along with the proprietary CAD drawings will be used to allow proper pairing with the SIT and the design of the mechanisms. The stresses experienced by the design are relatively low but a structural analysis will be performed to insure proper material selection. Using these design specifications the expected performance characteristics will meet all needs.

Figure 6. Provided Lockheed-Martin SIT

6.0 Preliminary Designs

The following designs are based on the target lifter bracket only, not the turning system. The team chose to focus on the bracket first, as the sponsor emphasized it as being the most important outcome of the project.

6.1 Design A

This design is based on minimum weight and cost. The first thought was to measure all the targets and put them together to visualize a pattern between them. As one can see from Figure 7, there is a pattern between the flat targets. The "Ivan" target can be seen with the small hole in the back at an estimate of 80 degrees from the other targets. The next step was to conceptualize the locking mechanism, which is a main challenge in this project. There are many locking mechanism to choose from, but only one will be chosen based on sponsor feedback and design constraints. Examples of these mechanisms are Line Actuators, clamps, Pneumatics or even motors with gears. Some of this will increase the price and/or the weight. The best choice in this case are clamps, specifically toggle clamps, pictured in Figure 8, or bicycle seat clamps, seen in Figure 9. The toggle clamp is better suited for the ability to lock after the rotation, making this the choice for this design. For Design A, three of these clamps will be placed on the target rack, one in the middle and the other two located seven inches from the center. The side clamps will have the ability to rotate 80 degrees inward in order to accommodate the Ivan style target. Design A can be seen in Figure 11. Figure 10 shows the maximum clearance for the turner bracket which must be met by this design. As one can see, the height up from the pinch point of this mechanism must be less than 3.8".

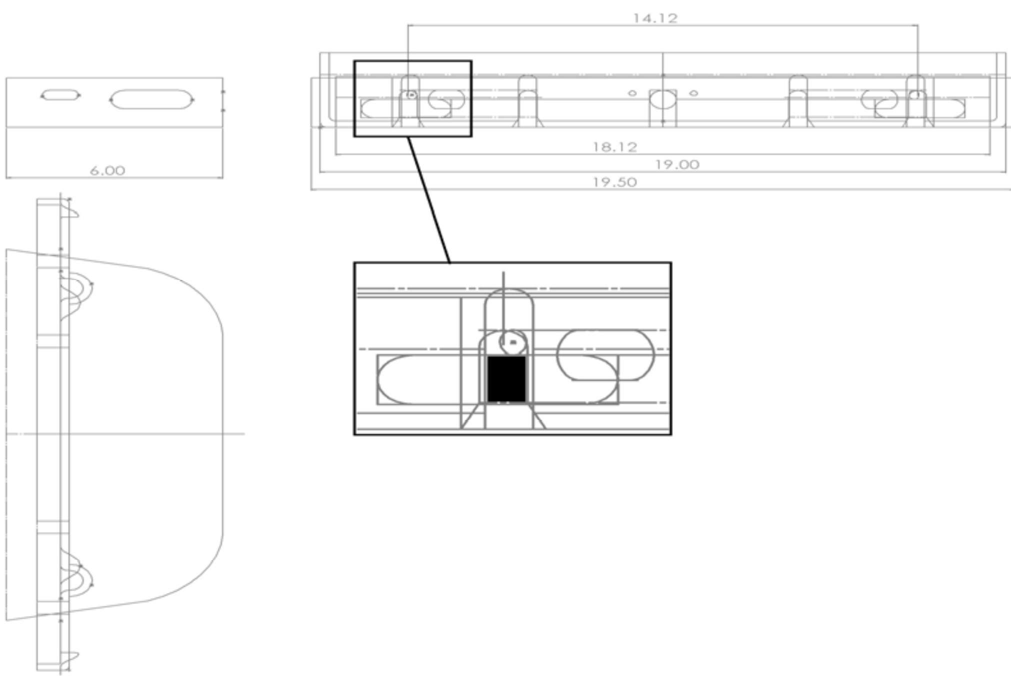


Figure 7: CAD of Overlapped Targets showing universal gap

Figure 8: Toggle clamp CAD

Figure 9: Bicycle seat clamp CAD

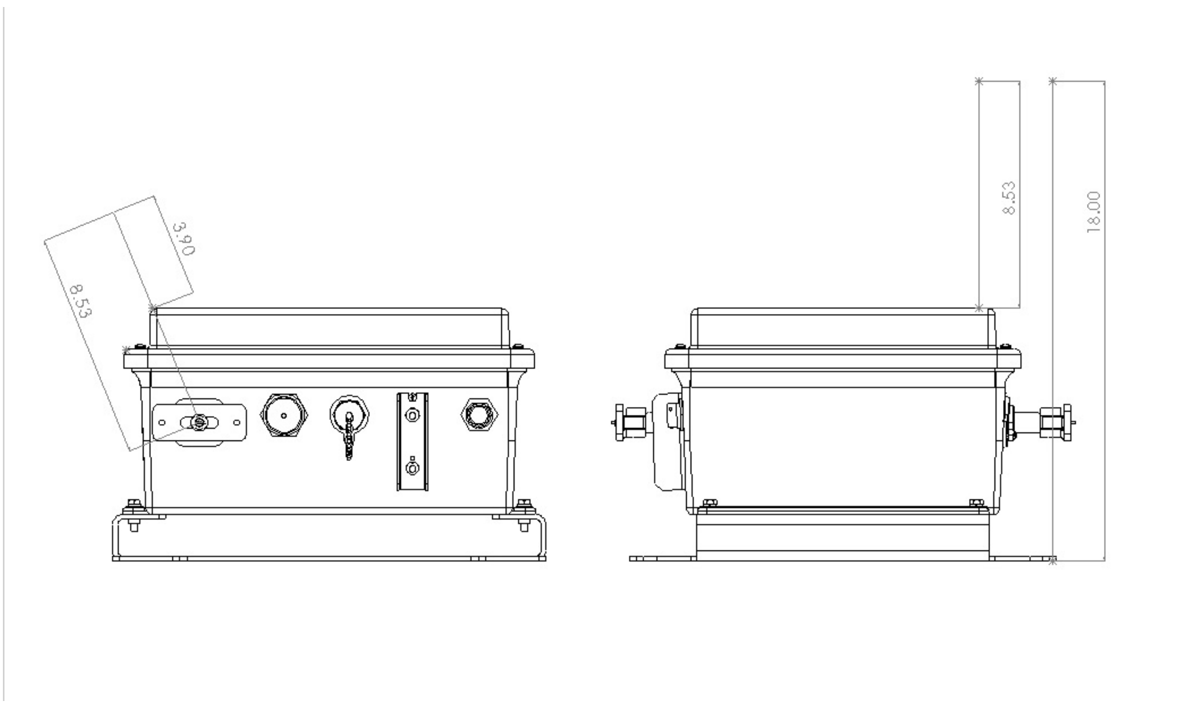


Figure 10: Limiting height of lifting arm on SIT

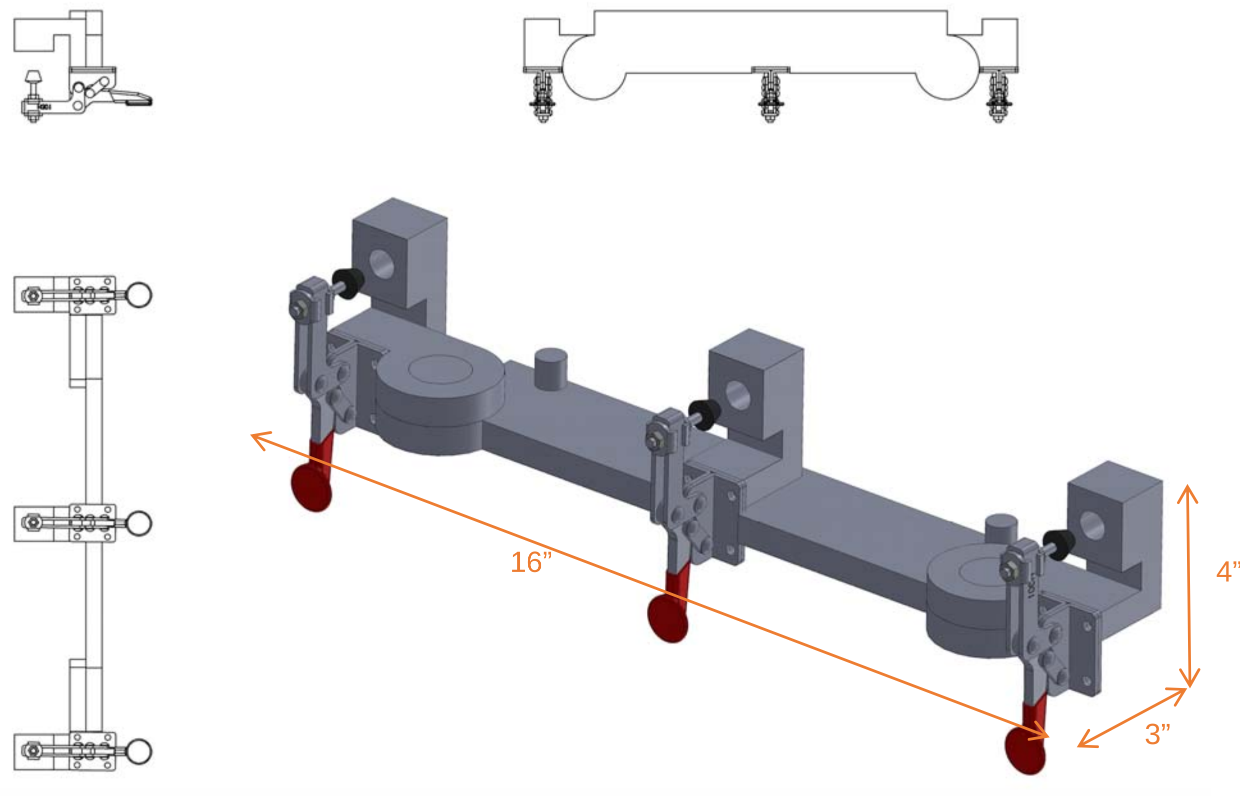


Figure 11. Design A

6.2 Design B

This a preliminary design concept of the target bracing mechanism. The goal of this design is to securely hold all 4 target types while the lifter operates. This design features a swinging gate attached by a hinge, which will rotate upward and be clamped to the back of the bracing mechanism. Design B will operate similar to the tailgate of a truck. To lock/unlock the system, a clamp can be utilized. To incorporate the Ivan target the back of the target brace will be slotted to allow the Ivan to fit securely in place. In order to connect the brace to the motor/gearbox a pin and collar can be used on the bottom plate.

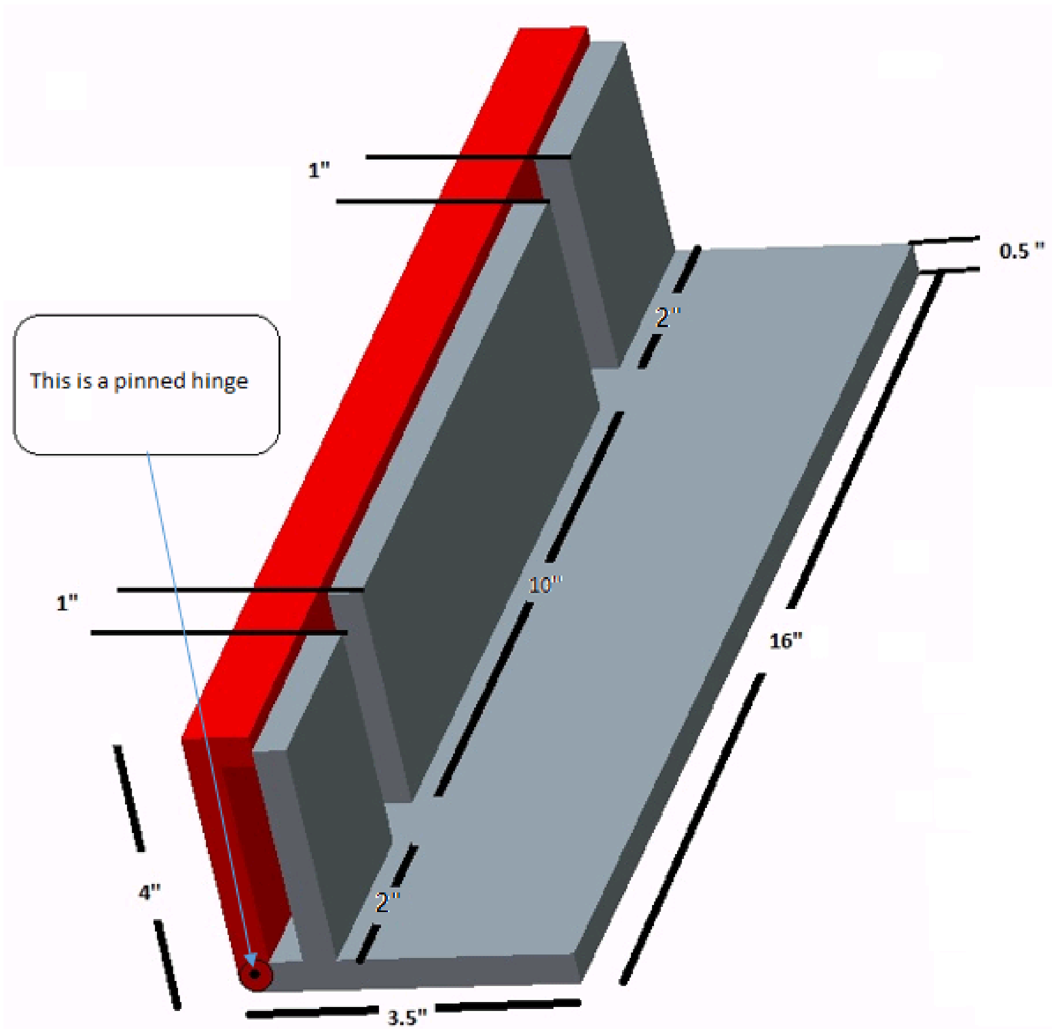


Figure 12. Design B

6.3 Design C

Design C implements a toggle mechanism coupled with a simple one point bracing against a plate. The toggle mechanism used would be similar to that of vice grip pliers. The benefits of this include increased speed of interchanging targets and firm locking. However, the one point brace may present a problem for ensuring a suitable target hold. This design would work of all targets utilized in the project by bracing only the front part of the target, not the sides, such as those on the "Ivan" style target.

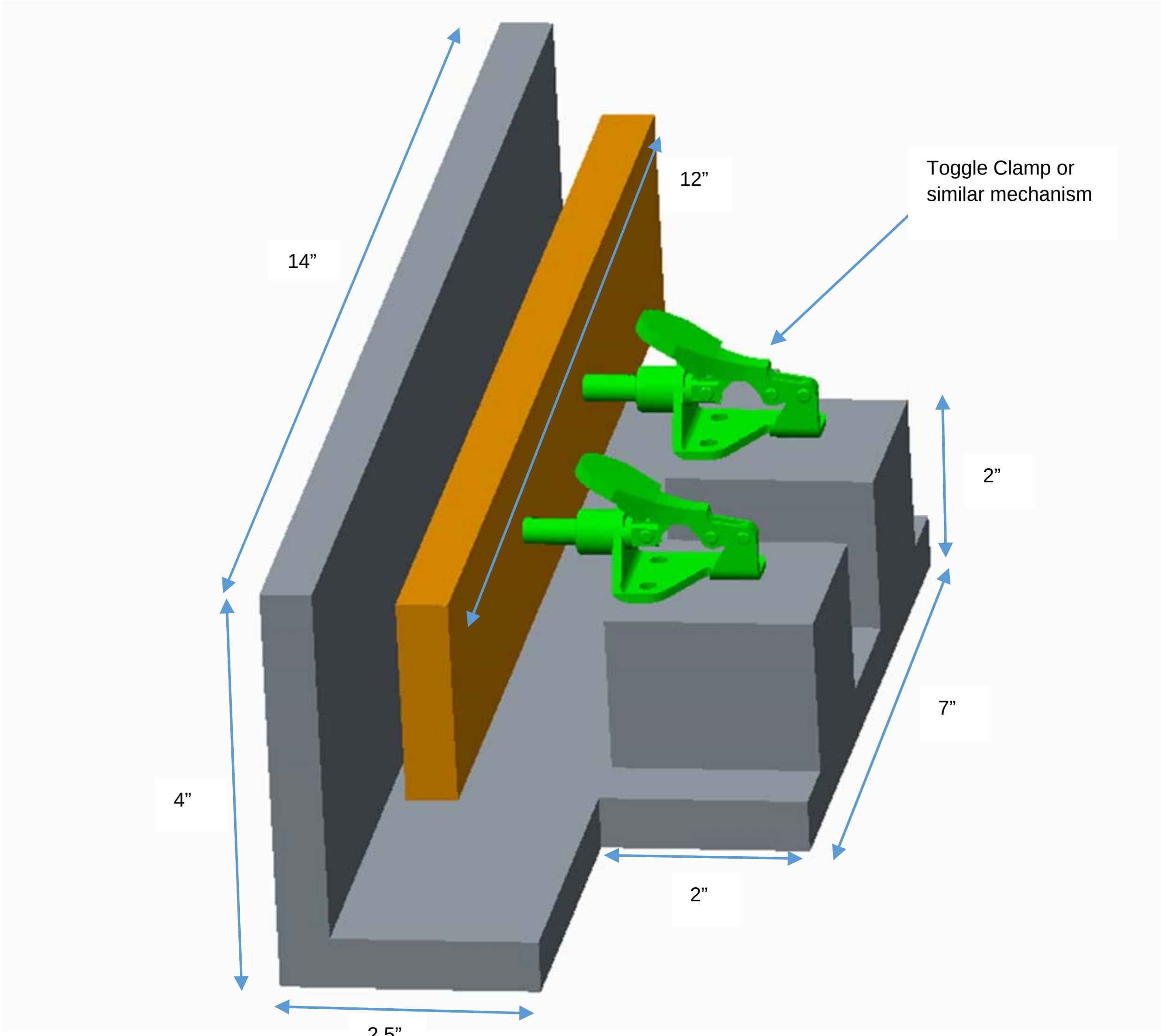


Figure 13. Design C

6.4 Design D

Design D is very similar to Design C, but instead of a toggle mechanism, screw-in bolts are utilized to brace the target against the front plate. This design is simple, but the screw-in bolts increase the time to interchange targets. Also, the sponsor has communicated issues in the past systems where weathering of bolts contributes to difficulty of target removal.

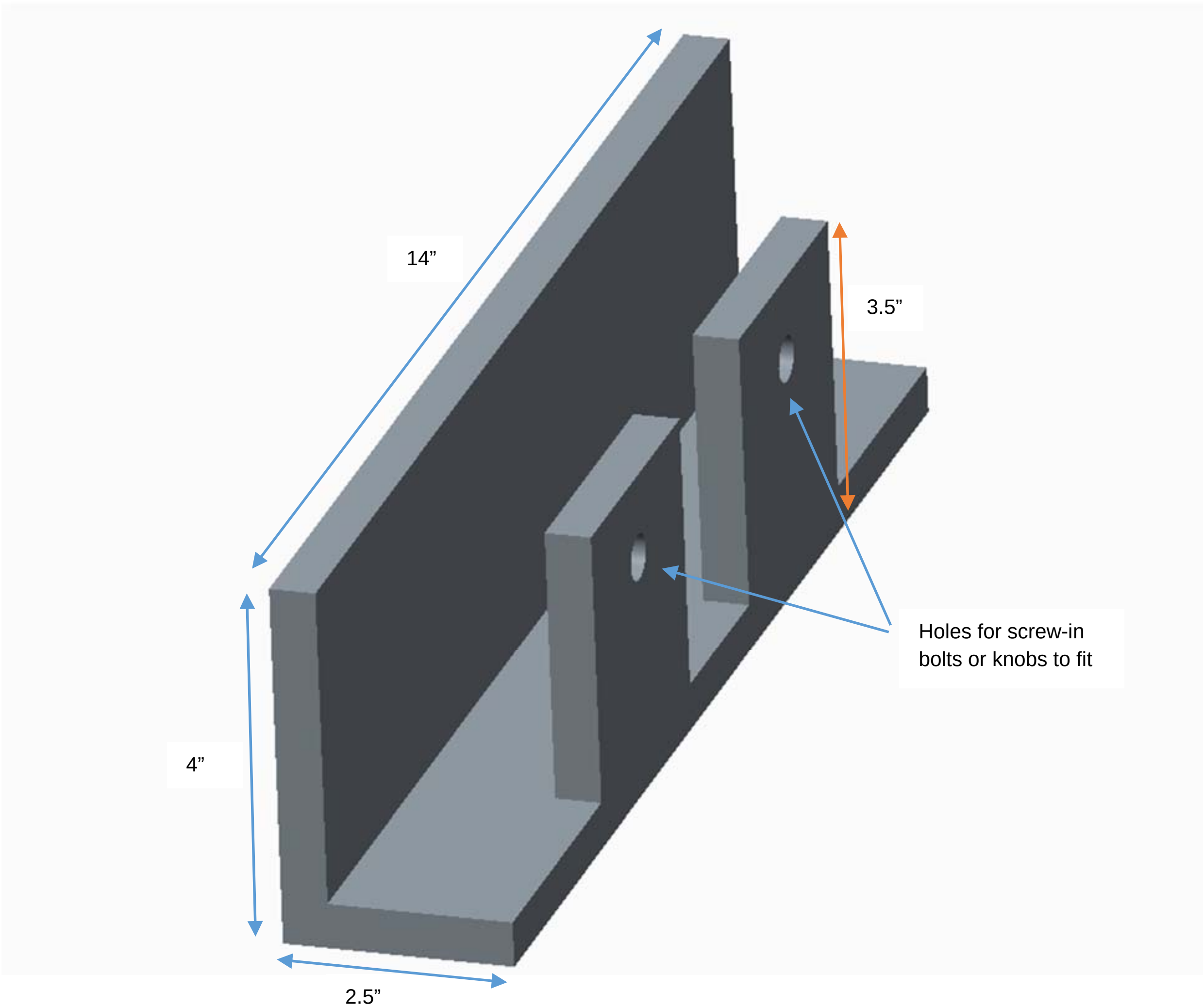


Figure 14. Design D

6.4 Design E

The below image in Figure 15is a conceptual idea more than a design. It pays no heed to any of the constraints but it does provide a possible solution to the problem at hand. Further iteration would require the design to be more viable.

This design accommodates all four targets without any reconfiguration. The Ivan and Waffle Board targets are held against the back plate with a help of a cord. The end pieces swivel back to accommodate the Ivan target. The “Figure 11” and “Figure 12”standard targets are clamped to the front plate and held in by the rectangular slots shown. The sprung pin/threaded knob would come in from the front and would hold the target against the back of the rectangular slot.

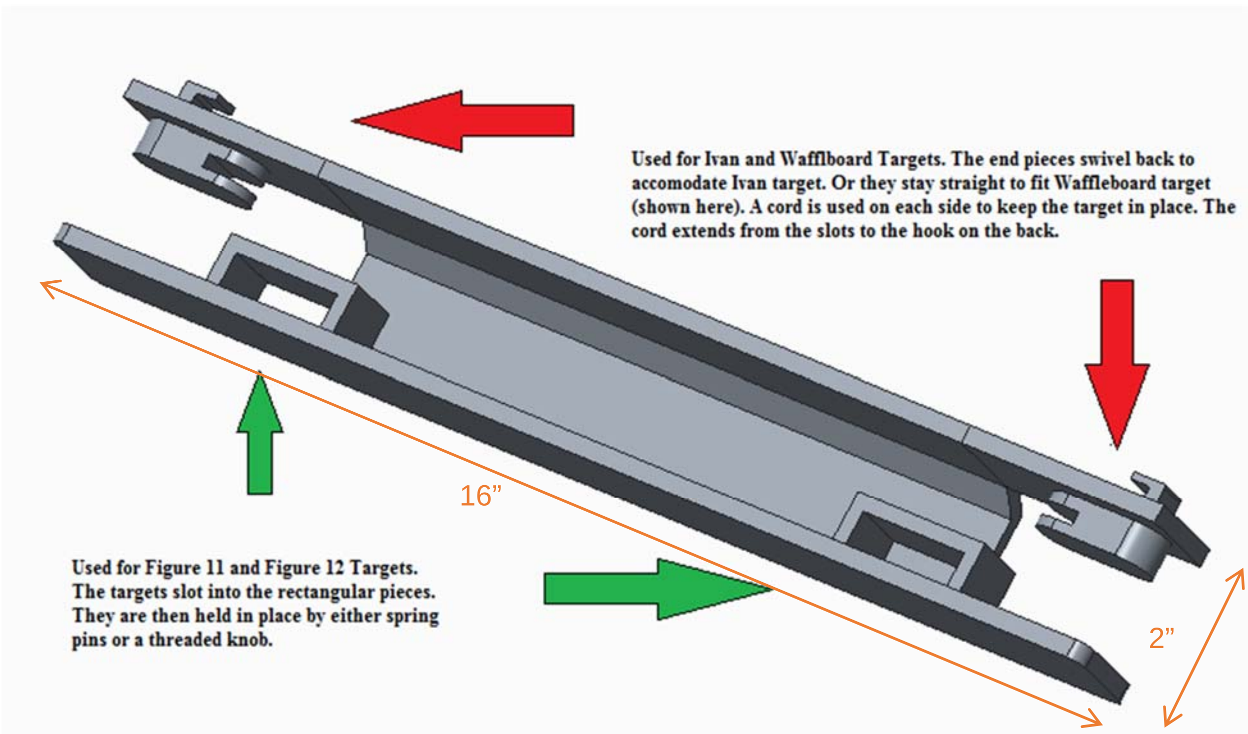


Figure 15. Design E

7.0 Design Matrix

Table 2. Design Matrix for Designs A - E

Target Bracket Design Matrix							
	Weighted	Design A	Design B	Design C	Design D	Design E	Design based on a 1-5 scale
Simplicity	5	3	4	4	4	4	
Cost	3	4	2	3	3	3	
Size	1	4	2	4	4	3	
Weight	2	4	2	4	4	3	
# of parts	4	1	4	2	2	4	
Loading time	4	3	4	4	2	4	
Reliability	5	2	3	1	2	3	
Total Point Value		65	79	70	67	85	

The Design Matrix, seen in table 2 above, compares the six preliminary designs conceptualized by team 16. For this matrix each of the engineering factors have been weighted numerically from 1 to 5. A 1 implies that the factor is of little concern and a 5 indicates that the engineering factor is very important.

The goal of these five mechanical arm designs is to hold each of the 4 standard targets securely while the lifter operates. The engineering factors have been weighted based on the customer's specifications and the lifters constraints. Lockheed Martin's current mechanical arm is inefficient and inconvenient for the user when loading each of the four different types of targets into the lifter.

Simplicity, reliability, loading time, and number of parts were determined to be the highest weighted and most important factors of our preliminary designs. The loading time was presented to be one of the more important constraints, as our design must allow for each target to be changed and loaded within 10 seconds. The designs ranked highest on the matrix (B,C,E) feature a locking mechanism that can be placed in toggle, versus the lower ranking designs are using a latching system. Under high stress a latching mechanism can be a safety concern.

Simplicity was found to be another key factor, as it determines how simple it will be to change or load our targets, and how easy it will be to manufacture the selected design. The designs that were ranked the simplest (B,C,D,E) were chosen due to their limited movement to accommodate the Ivan Target.

The higher the number of parts, the less simple the design, and the higher the risk that the design will not withstand the elements or required testing. Designs B and E were considered favorable do to their limited parts and were ranked accordingly.

Reliability is weighted as very important due to the fact that the mechanical arm design must be able to withstand variable environmental elements including water, dust, wind, and sand. The design must also be reliable to ensure that the bracket will continually hold the targets as they are shot at repeatedly the designs that scored well in this area were B and E, they were ranked so because of their limited movement, and thus deemed more reliable.

Weight, cost, and size are other factors that our team took into account while designing the mechanical target arm. These factors happen to be weighted lower than the previously discussed factors but are still necessary design elements to consider. Using all weighted factors it was determined the best designs were B and E.

8.0 Results

At this point in Team 16's progress, there are few physical, concrete results due to being in the conceptual design process. However, there have been other outcomes to this point. The team has made a number of realizations that have assisted in a better understanding of the project and desired outcomes. Through proper sponsor and mentor communication, the team has:

- Constructed a proper House of Quality to illustrate the sponsor needs
- Discovered a universal locking gap between all required targets to be mounted
- Developed multiple target bracket designs to be reviewed by the sponsor and team mentor
- Constructed a design selection matrix for the various target bracket designs
- Obtained the Lockheed-Martin Stationary Infantry Target system to prototype and test on
- Operated the Stationary Infantry Target system with no target attached
- Determined the pros and cons for different target bracket designs via sponsor feedback
- Explored various types of locking and latching mechanism to ensure proper target mount
- Gained a better communication skills through presentation in order to present the team's ideas more easily

9.0 Conclusion

The SIT system is part of Lockheed martin live training exercises. Used for training domestic and ally international militaries. This system is being improved upon by the addition of a rotational feature that will allow a single unit to be a potential friend or foe target. Through communication with the team's sponsor, a house of quality was constructed based on presented requirements and constraints. The team set attainable goals and organized a schedule with respective task responsibilities assigned to each member. The team began design on the target bracket, which accommodates various standard target types, as this was stated to be the most important outcome of the project by the sponsor. Moving forward, the team plans to incorporate the turning element into the lifting arm. Designs were conceptualized and based on a design matrix constructed by the team, an optimal design was chosen for the target bracket. These designs, and respective selection matrix, were submitted to the sponsor and project advisor for review. The team is currently waiting on detailed feedback to proceed with a final design selection. Though there have not been any concrete results from the project so far, the team has gained a better understanding of the sponsor requirements and preferences. Future work will include the designing of the turning element of the target bracket, design synthesis of all designed elements, budgeting and parts ordering for prototype construction.

10.0 References

[1]Infantry Squad Battle Course, Army Engineers
[2]Meggitt MF-SIT Specification Document
[3] MS Instruments Stationary Infantry Target Specifications
[4]Theissen GSA Federal Supply Schedule Price List
[5] Future Army System of Integrated Targets: Presentation Devices Interface Control Document 2.0

11.0 Team Biography

Ashar Abdullah (Lead Programmer)

Senior at Florida State University majoring in Mechanical Engineering. He is currently involved with SAE and has been charged with designing Drivetrain/Ergonomic components. He is also involved with research in Ceramic materials, specifically for the purpose of creating a wireless Temperature sensor for use in nuclear reactors. Ashar hopes to go into industry after he graduates in May of 2016.

Andrew Belstrom (Web Design / Historian)

Andrew Bellstrom is a senior in mechanical engineering at Florida State University. He is going for a specialization in thermal fluid science track and is due to graduate Spring 2016 with a minor in physics and mathematics. Previous work experience includes an internship for Source Refrigeration where he contributed to optimization of components. His future plans include entering the work force in the field of fluid science.

Ryan D'Ambrosia (Team Leader)

A senior in the mechanical engineering department, Ryan has achieved his minor in both physics and mathematics and is due to graduate in April 2016. Ryan has participated in a variety of research at Florida State University's Aeropropulsion Mechatronics and Energy Center (AME) , and participated in the National Science Foundation (NSF) funded Research Experience for Undergraduates Program (REU-MASS) over the Summer 2015 term. As a Research Assistant, Ryan has been involved in various topics including the National Parks Service Penetrometer Capstone Project, Autonomous Quadcopter projects and Embedded Smart Material Sensing for Aerospace Structures, Wind Energy, and Legged Robotics Applications. Ryan has also been a Teaching Assistant for the graduation prerequisite Mechatronics 1 course, where students are introduced to the basics of C programming and hardware integration through integrated development environments (IDEs). Ryan intends to pursue a graduate degree in Mechanical Engineering after graduating from Florida State University.

Jordan Lominac (Lead Mechanical Engineer)

Jordan Lominac is a senior at Florida State University and will be graduating with his Bachelor's of Science Degree in Mechanical Engineering Spring of 2016. This past summer Jordan worked as a Supply Chain Engineer for Johnson&Johnson where he gained experience in project management and continuous improvement methodologies. Jordan focused on developing a round wire fixture to improve the efficiency of Cordis' Receiving Inspection and supported the Shelf Life Extension Project for Listerine and Reach Dental products. Jordan is currently in progress of receiving his Thermal Fluids Specialization from Florida State. After receiving his degree, Jordan plans to be working full time and plans on receiving his Professional Engineering License.

Fernando Rodriguez (Financial Advisor)

Fernando Rodriguez currently senior undergraduate student on Mechanical Engineering (ME) from Florida State University (FSU). Born and raised in Cuba, came to the United State of America at the age of fourteen. Pursuing his goal in science let him be a part of Miami Dade College from 2010 to 2012. Transfer to Florida State University to continue his studies as undergraduate ME from 2012 up to 2016. Had opportunity to be a part of Florida Center for Advanced Aero-Propulsion (FCAAP) as research assistance during the Summer 2015. Helped and learned from graduate students with new experiment with Particle Image Velocimetry (PIV) in the supersonic, and subsonic wind tunnel facility. As of Fall 2015 Fernando is working under Dr. Kumar's research for Asymmetric Vortex Control of Slender Body at High Angle of Incidence. Also, working on Variable Angle Target Training System (VATTS) for Senior Design, sponsored by Lockheed Martin.