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

Operations Manual

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

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

LOCKHEED MARTIN

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Abstract

It is important that the operator understands how to operate the developed system. This document serves as a guide to the developed prototype, complete with full assembly pictures, component functions, and troubleshooting methods. A functional analysis serves to explain the useful operation of all components. Operator instructions have been written to aid the user in proper operation of the system. System maintenance instructions have been provided to improve the reliability and life cycle of the product. Finally, a list of spare parts is included to aid in the use of the target system. The operator should be thoroughly familiar with the components of the assembly before attempting to operate the system.

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.

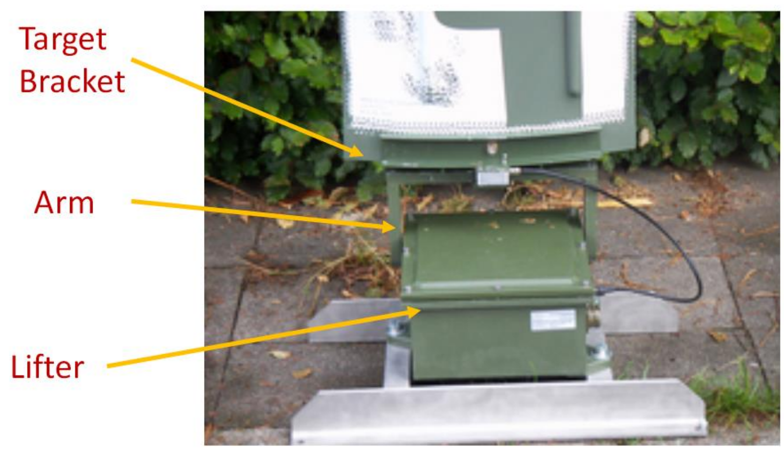


Figure 1. Example of Standard Infantry Target (SIT)

2.0 Functional Analysis

2.1 Project Function

The final prototype is designed to be used, as stated before, in live-fire training sessions for military infantry. This prototype can be set up in an open field side by side or they can be installed in bunkers, this is up to the personnel conducting the exercise. On the initial prototype there will be no connection between the bracket/arm and the lifter. However, the sponsor company may decide to integrate the two. This will lead to seamless integration of the prototype into already existing systems. The motor driven mechanism can be controlled wirelessly or by wired connection. The entire assembly is designed to endure tough conditions in different locations throughout the world. The system will operate outdoors and will be exposed to fluids, debris, sand, dust, rain and strong gusts of wind. This prototype will be made in order to be mass produced in hopes of distributing the prototype to various training ranges throughout the world.

A full picture of the prototype can be seen below in Figure 2. More details of the full assembly can be seen in Section 3.0. As seen in the picture, there are three main components of the prototype: the bracket, the arm, and the motor housing. The motor housing protects and encloses the motor/gearbox and electronics including the Arduino Uno R3 microcontroller and the 2x45 Amp RoboClaw motor driver needed to operate the angular position feature of the system.

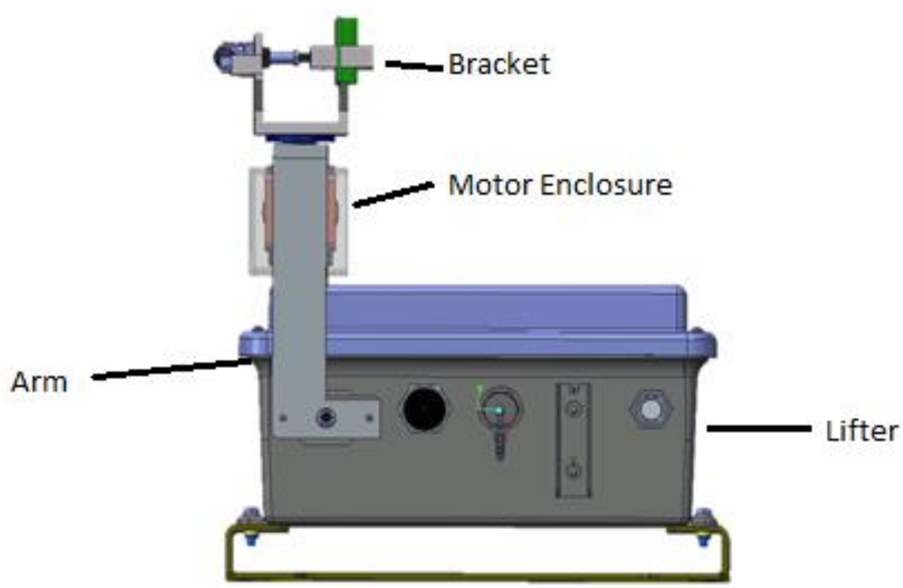


Figure 2. Full Assembly Side View

2.2 Component Functions

The component that is most important to the successful implementation of the prototype is the bracket. Without a functional bracket there is no way to secure any of the targets. Nearly every dimension of the bracket must be exact to insure target fitment. It has been designed to secure all four targets that Lockheed and the military are currently using. A detailed drawing of the bracket can be seen in Appendix. Two toggle push-pull clamps are used to secure targets to the front plate of the bracket. These clamps are secured in the bracket with the use of a hex nut and stabilize each of the targets with the use of an extendable plunger or rubber stopper. Both the plungers and the clamps can be changed without having to modify or create a new bracket. A drawing of the clamps utilized in this bracket design can be seen in Appendix.

The arm serves as the connection between the lifter and the bracket and also has the motor housing mounted to it. This motor housing acts as a shield which protects and seals the motor/gearbox and electronics from the elements. The motor/gearbox package has been chosen to provide enough torque and speed to meet design specifications even in the worst conditions. The motor is an AM–0912 from Andy Mark and the gearbox is a planetary type. The motor requires a 32 Amp current and 12 Volts in order to operate. The datasheets for the motor and gearbox can be seen in the Appendix. The motor is driven by a Roboclaw 2x45A motor driver/contoller and controlled by an Arduino Uno microcontroller. The only input required from the operator is the command for which desired angular position the target will rotate to when the lifter is activated. This command can be delivered wirelessly or by wired communication.

3.0 Project Assembly

The final assembly of the prototype design consists of many moving parts and is shown in Figure 3 below. There are three main components of this design: the bracket, the arm, and the motor housing. These components are critical to the design of this prototype and are important to consider to ensure proper placement of the targets and mating of these components. In order to ensure that the components properly mount and align to each other and the lifter the 3D CAD of the final system was assembled before any of the components were fabricated.

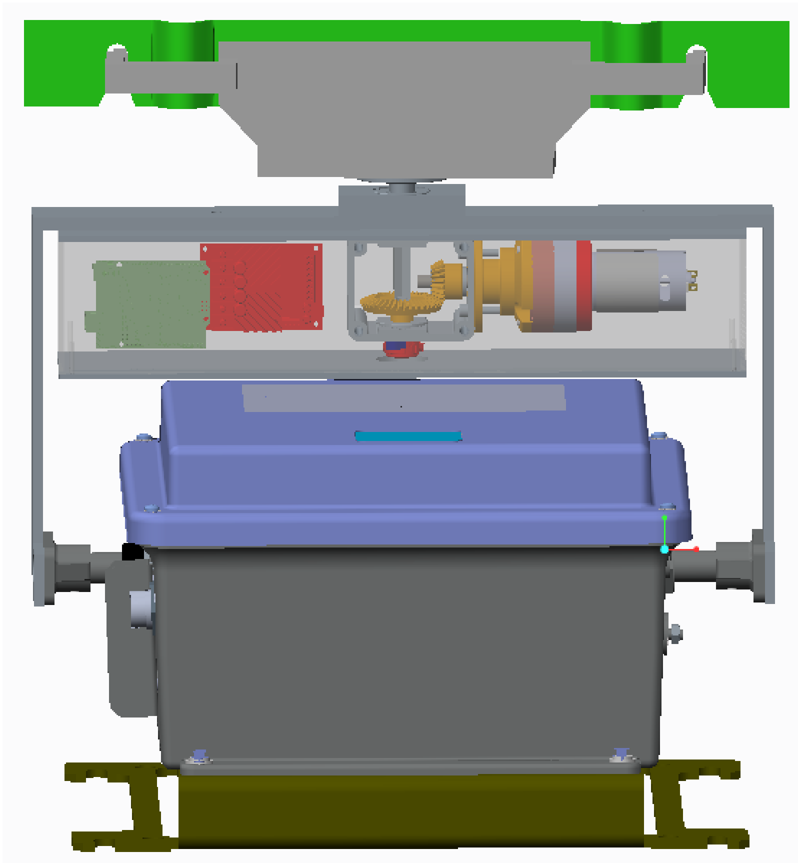


Figure 3. Front View of the System's Final Assembly.

The bracket, shown below in Figure 4, consists of various critical dimensions which include the overall length, the placement of the "hooked" tabs, the bracket width, the bracket height, and the bolt hole placement for the drive shaft and motor enclosure. Any alteration of these dimensions will throw off the alignment of the system and prevent the lifter from functioning properly. The through hole must be centered on the arm in order to allow the motor, motor driver, motor controller, encoder and drive shaft to position the target and bracket correctly with the angular position feature. To prevent error the tabs were welded on and the through hole was machined within a tolerance of 0.001".

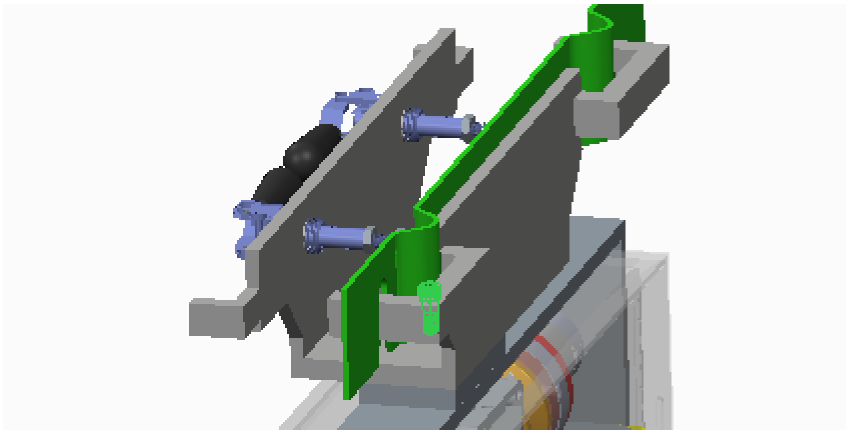


Figure 4. CAD Enlargement of Bracket

The enclosure which protects the motor, gearbox and electronics from exposure to the elements is a critical component to the functionality of the system. This motor enclosure is sealed with a gasket using an o-ring on the bottom of the housing. The gasket is able to be removed to be removed in order to access the internals for maintenance and upkeep. This enclosure can be seen in Figure 5. Improper placement of this enclosure would cause an imbalance on the motor drive shaft that will create a torque on the drive shaft of the right angle bevel gearbox needed to position the target and bracket correctly. To ensure proper alignment and eliminate errors in the manufacturing process the tolerances of the motor enclosure where kept to 0.001".

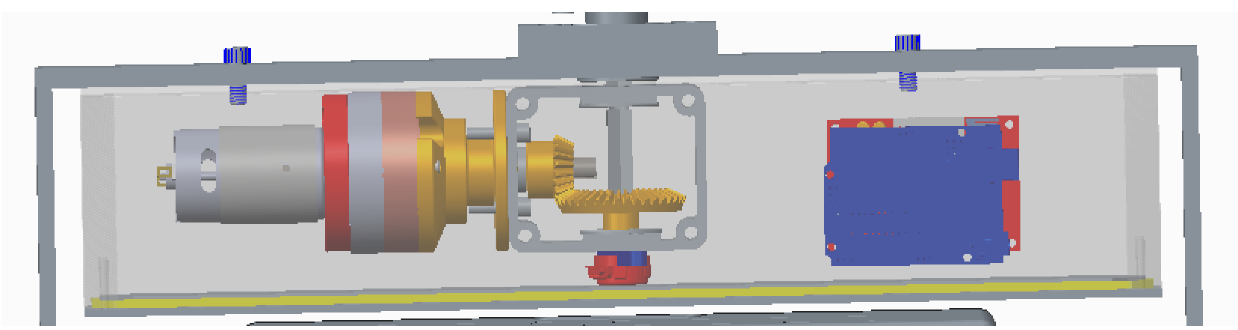


Figure 5. CAD Enlargement of Motor Enclosure

An additional critical component of the design is the alignment of the arm to the lifter. Without proper alignment the shaft from the motor will not properly mate with the bearings in the arm and bracket which will impede the rotation of the targets and bracket. In order to ensure that the arm properly mounts to the lifter the 3D CAD of the final system was assembled before any of the components were fabricated. To prevent any obstructions in the alignment of the arm the arm was manufactured within a tolerance of 0.001".

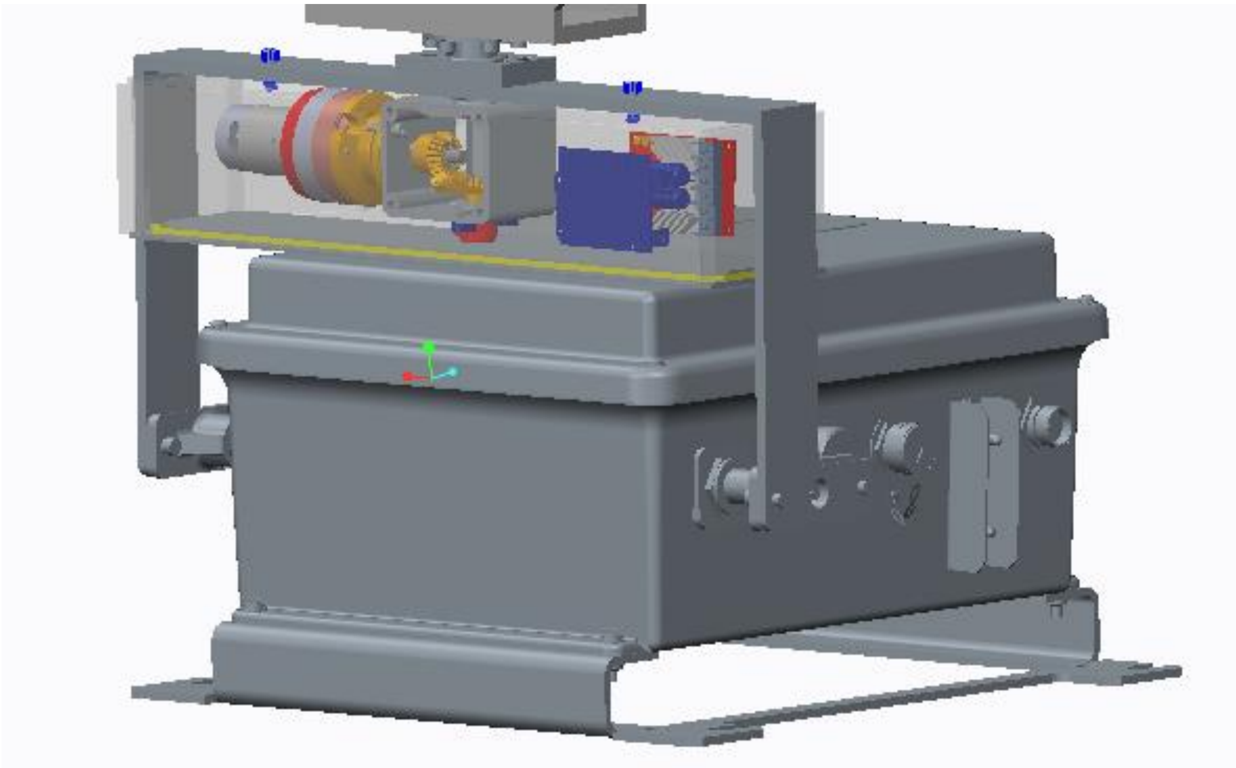


Figure 6. 3D CAD of Lifter System

4.0 Operation Instruction

The final product will have the lifter and the target assembly connected electronically. This allows the target to lift and rotate to its desired position at the same time. When the target is shot the target drops down while rotating back to its original position. The lifter features a hit detector sensor which enables the lifter to know when the target has been shot or hit. The operator can set a predetermined angle that the target should be presented at before the training begins. When the lifter is activated the target will turn to its desired position and stay there until it is shot. Also, the system can be configured to rotate the target at will when the target is flipped up. The various positions the target can take can be seen below in Figure 7. This allows for a more stressful target training session as the target can be presented small, large, friend, or foe.

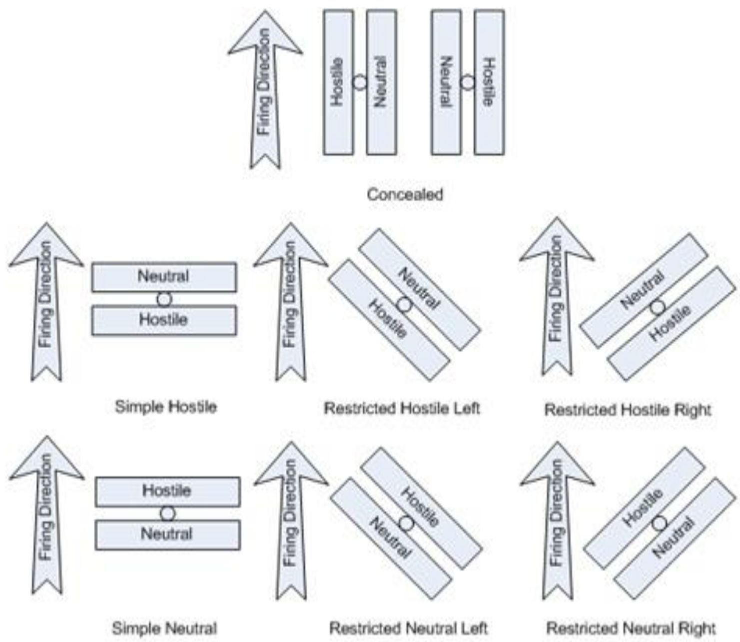


Figure 7. Target Rotation Positions

5.0 Troubleshooting

The design of VATTS requires many different components to operate in sync. Due to this, some operational problems may arise. It is important for the user to understand the possible points of failure. This section will serve to highlight features of the system design that may cause the operator trouble, and present solutions to those common issues.

5.1 Bracket Assembly

5.1.1 Clamps

The clamps can present a number of issues. The clamps should be tightened onto the bracket in place through the provided holes in the bracket so that no rotation of the toggle clamps occurs. It would behoove the operator to secure the clamps to the bracket using a wrench. If the target is not fitting properly, the length of the clamps may be adjusted by unscrewing the nut on the plunger, then unscrewing the plunger itself to the desired position, and refastening the nut to lock the plunger in position. If the toggle clamps are having trouble being pushed in and out of toggle, grease may be added to the length of the push pull shaft which is causing friction.

5.1.2 Drive Shaft Attachment

In order for the bracket to be securely attached to the arm and turning mechanism, the ¼-20 screw must be properly secured to the drive shaft, and hex motor hub secured to the bracket respectively. The motor hub should be properly secured using the 10-32 machine screws and nuts provided with the system. A hex wrench with the respective bolt size should be used to torque the bolts into position.

5.2 Arm Assembly

5.2.1 Bearings

There are two bearings in the arm. One cylindrical bearing on the top, one hexagonal shaft bearing on the bottom. The top bearing is seated in a bearing block, which is secured to the arm via screws. The orientation of the top bearing block is important. Due to a machining complication, the bearing block is slightly misaligned due to the position of the screw holes. Because of this, the bearings will only be alighted if the bearing block is secured in the orientation the lifter was delivered to the sponsor in. The bearing block and the arm also have a mark (permanent marker) which must be lined up to display the bearing block is in the proper orientation.

The bearing in the bottom of the arm (hexagonal) is known to be slightly unreliable. This is due to the force fitting of the bearing into the arm, pinching the sides of the bearing, slightly binding the motion. This may be alleviated in future iterations of the design, or by a machinist very slightly widening the force fit of the bearing

5.2.2 Arm to Lifter Attachment

The arm is secured to the lifter with 10-32 machine bolts affixed with nuts on their ends to the lifter. These bolts should be properly torqued to ensure proper arm securement to the lifter.

5.3 Turning Assembly

5.3.1 Gearing

The gearing calculations are theoretical for the amount of torque required. If for some reason it is determined that more torque is needed at the sacrifice of less speed out of the output shaft, an additional stage of gearing may be added to the AM gearbox. The gearbox should be greased periodically. The right angle gearbox must be keyed to the AM (horizontal) gearbox. If for any reason the key should slip out, the shaft may be keyed again.

5.3.2 Turning Control

The motor will operate at 12V and about 30A. If the motor stops working, and the operator wants to dismiss the motor as the issue, 12V at a lower amperage than the operating amperage may be applied directly to the motor connectors to determine if the motor is burned out or not. If the power is applied and nothing happens, the motor is the problem, but if it does turn with directly applied power, it can be determined that the motor controller and microcontroller are the problem. Make sure that all pins and wires are secured to the RoboClaw and Arduino respectively. Sometimes wires may come loose, simply screw them back in if trouble is encountered. The code for the turning control is to be provided along with its own troubleshooting instructions.

5.3.4 Enclosure

The enclosure was designed to protect from water and dust intrusion into the turning components. The plexiglass enclosure must be removed to do any troubleshooting on the above components, and for the enclosure to come off, the arm must be removed. The enclosure is sealed with an o-ring on the bottom, all holes are to be sealed with silicone to prevent damaging from the elements. The enclosure is sealed from the bottom with four machine screws. These should be properly torqued to ensure protection of the components

6.0 Maintenance and Upkeep

This prototype is designed to endure tough conditions in different locations throughout the world. The system will operate outdoors and will be exposed to fluids, debris, sand, dust, rain and strong gusts of wind. This system was created to account for the maintenance and upkeep that operates and technicians will have to perform during the lifespan of this product. The motor enclosure consists of a removable gasket which protects the motor, gearbox, and electronics of the system. The gasket can be removed by detaching the arm from the lifter and unscrewing 4 screws on the base of the housing gasket. Once the gasket is removed a technician will be able to access the internals easily. This is where most of the maintenance and upkeep will take place to ensure that the motor and electronics are operating properly. It is also suggested that grease be applied to the lifter's rotating mounts, drive shaft, and toggle clamps periodically.

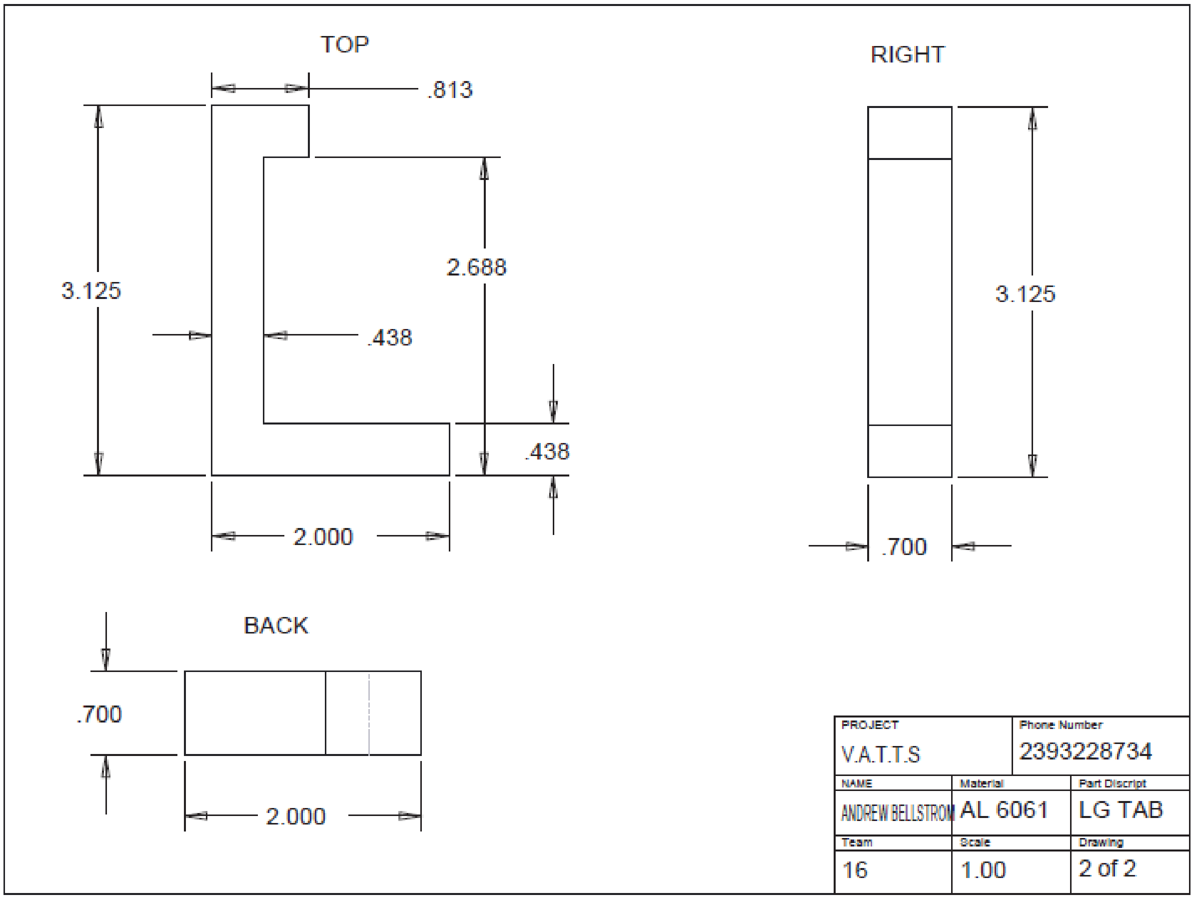
6.0.1 Spare Parts

Since the clamps and plungers are changeable it is recommended that extra clamps and plungers be kept to be used in case a clamp seizes up. It is also recommended that extra bolts and nuts that fit the in the project be kept on hand.

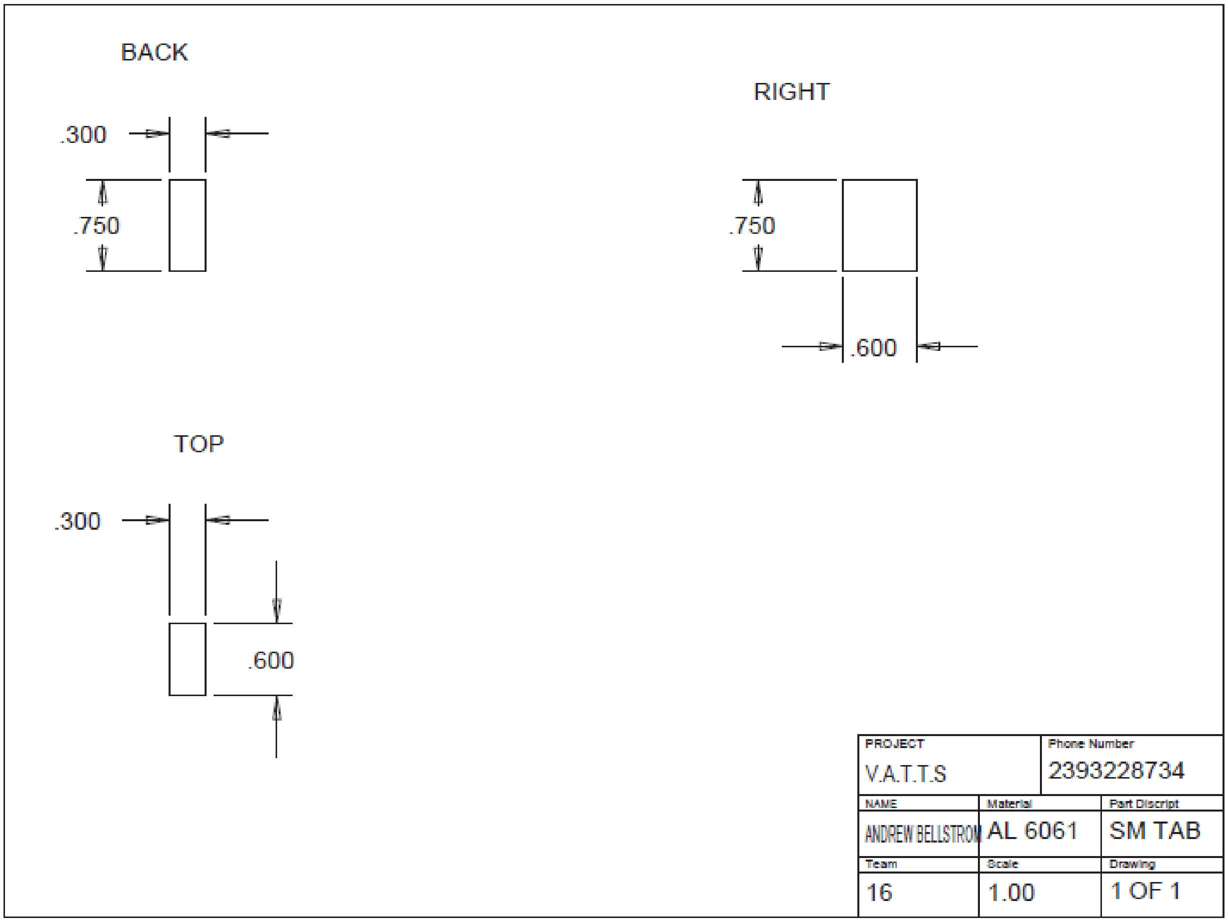
7.0 Conclusion

Using the technical data provided it was possible to operate the Variable Angle Target Turner System in a safe conventional manner with a proper assembly and functionality. Using design analysis all components were specified to proper tolerances to meet the sponsor’s guidelines and provide safe operations to the overall user. With proper maintenance replacement parts the system will remain operational and only require routine maintenance.

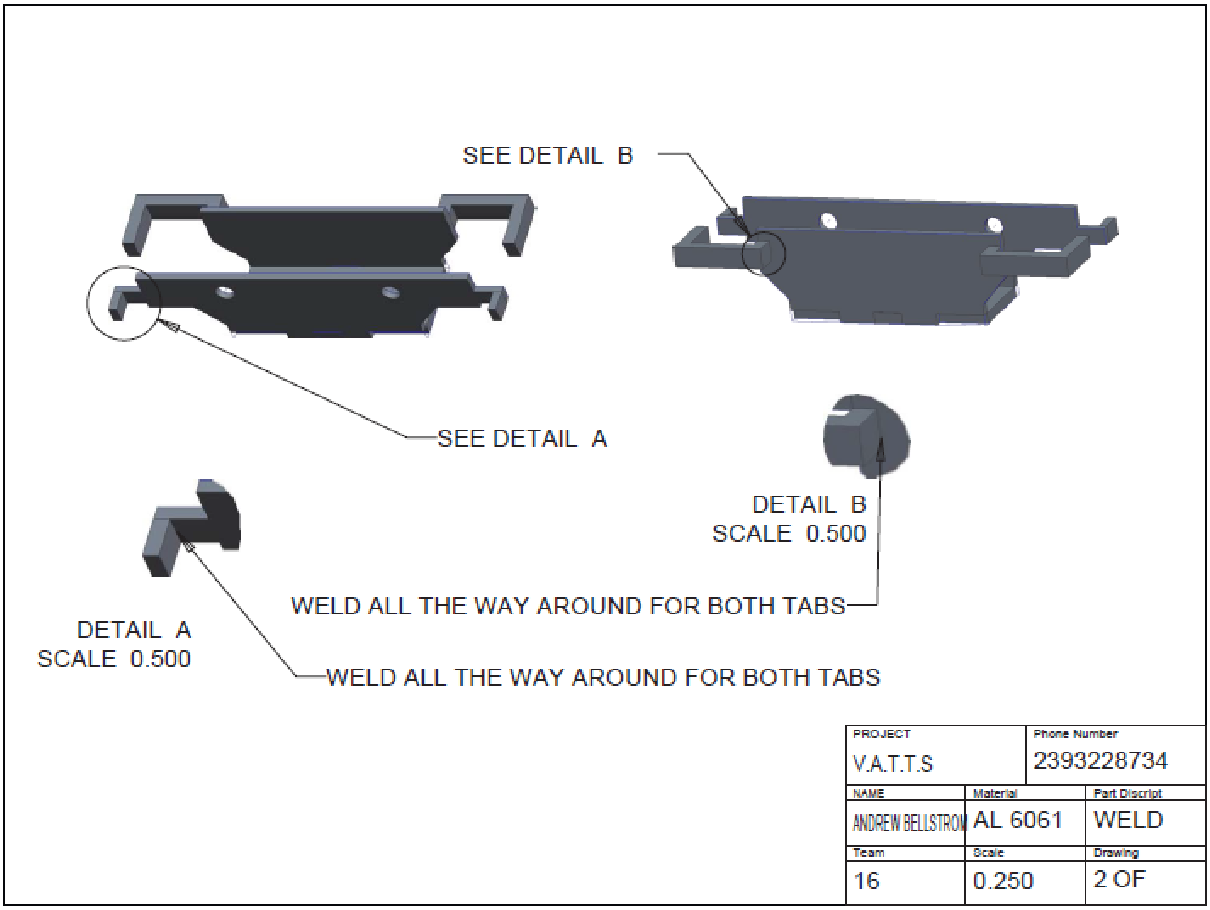
Appendix A



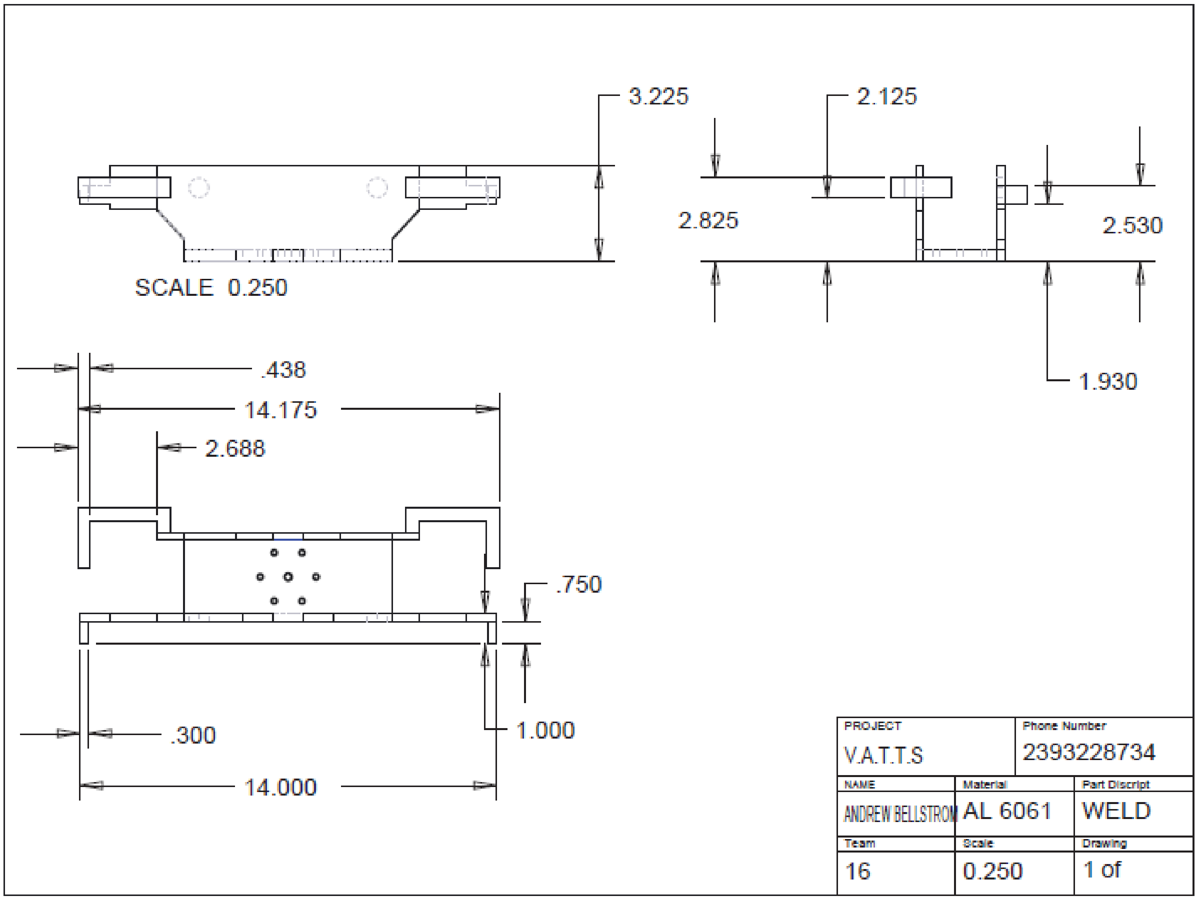
Large tab for bracket attachment



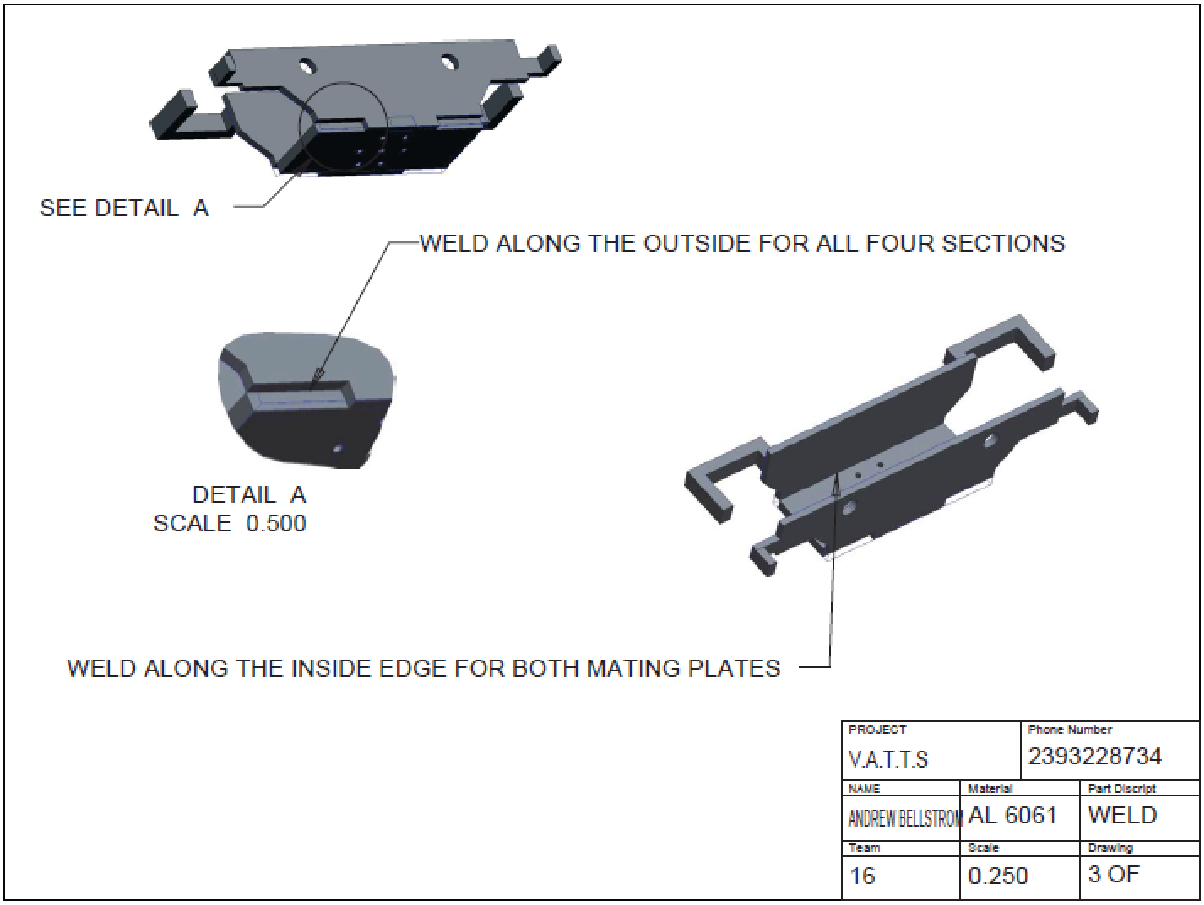
Small tab for bracket attachment



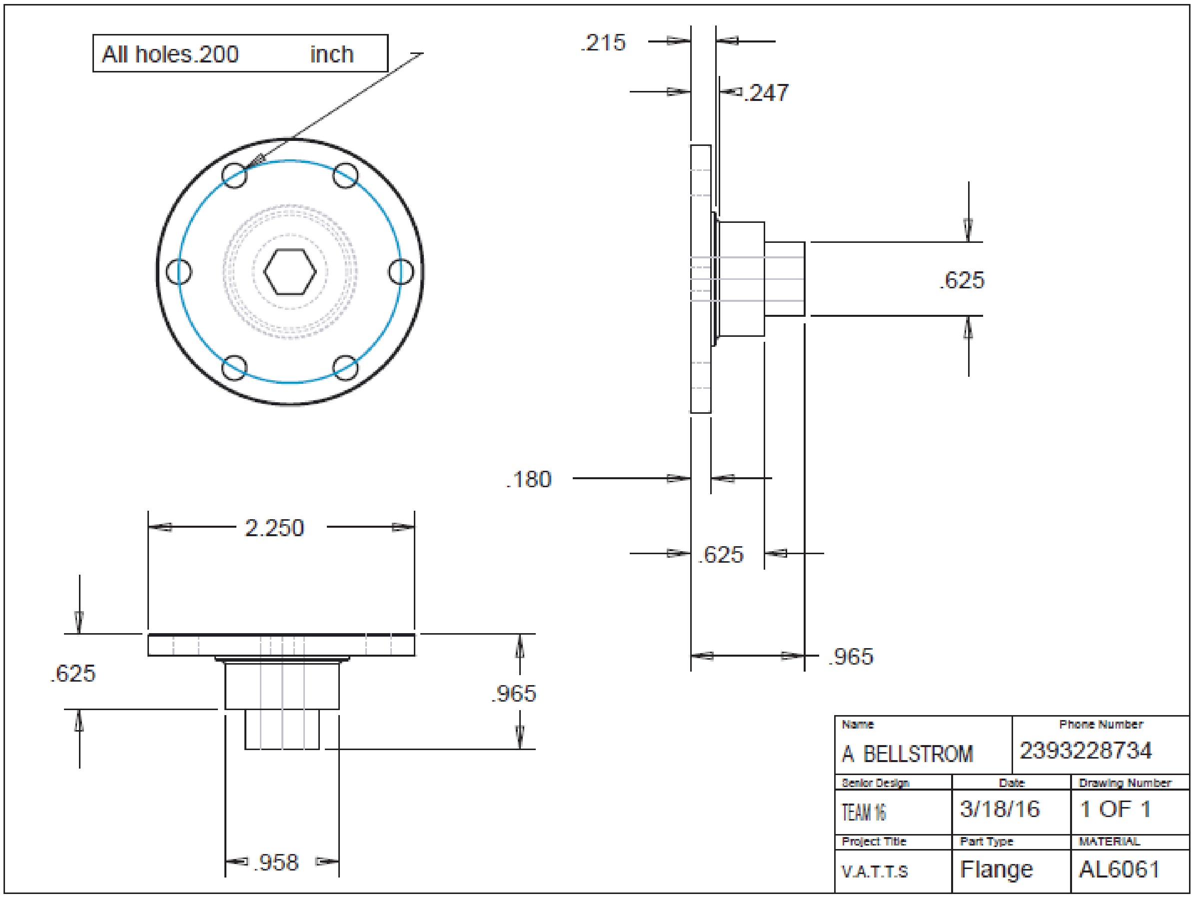
Welding instruction for tabs



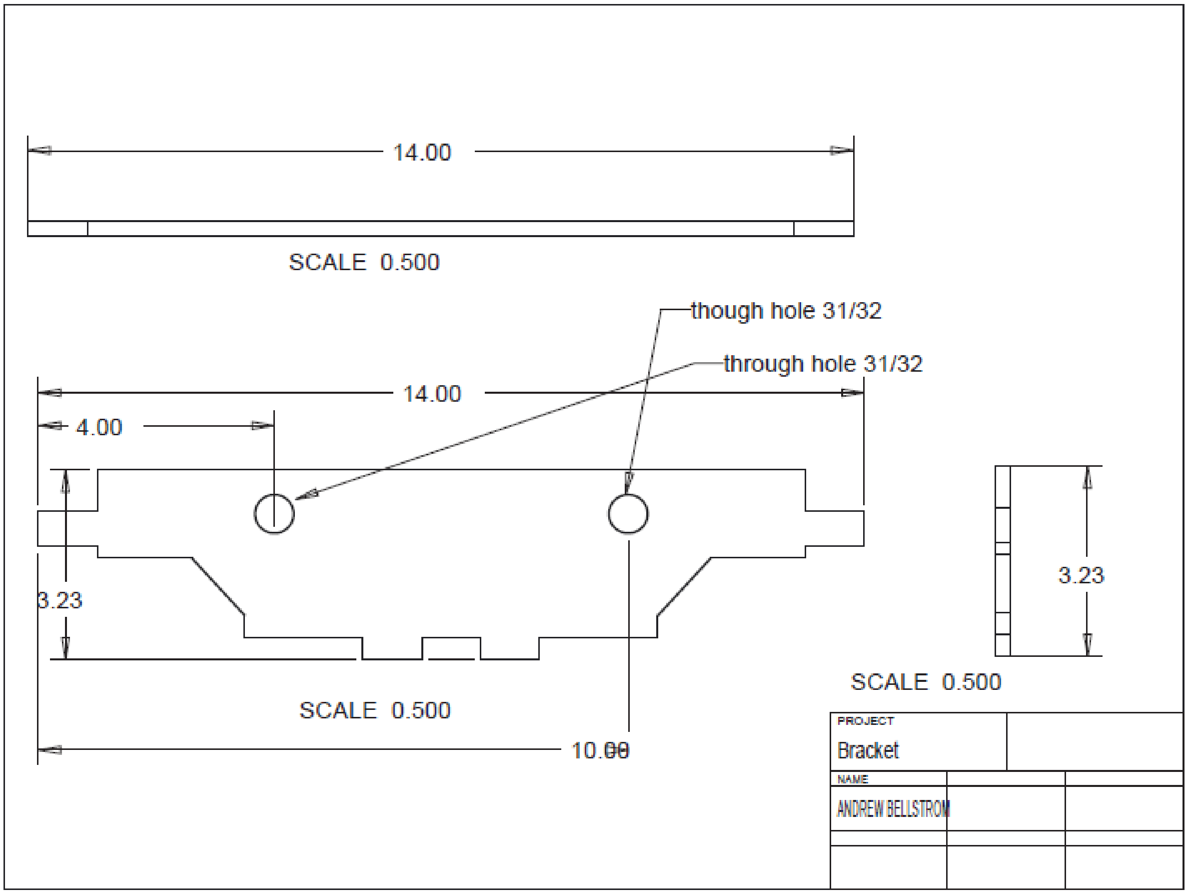
Welding dimensions for bracket



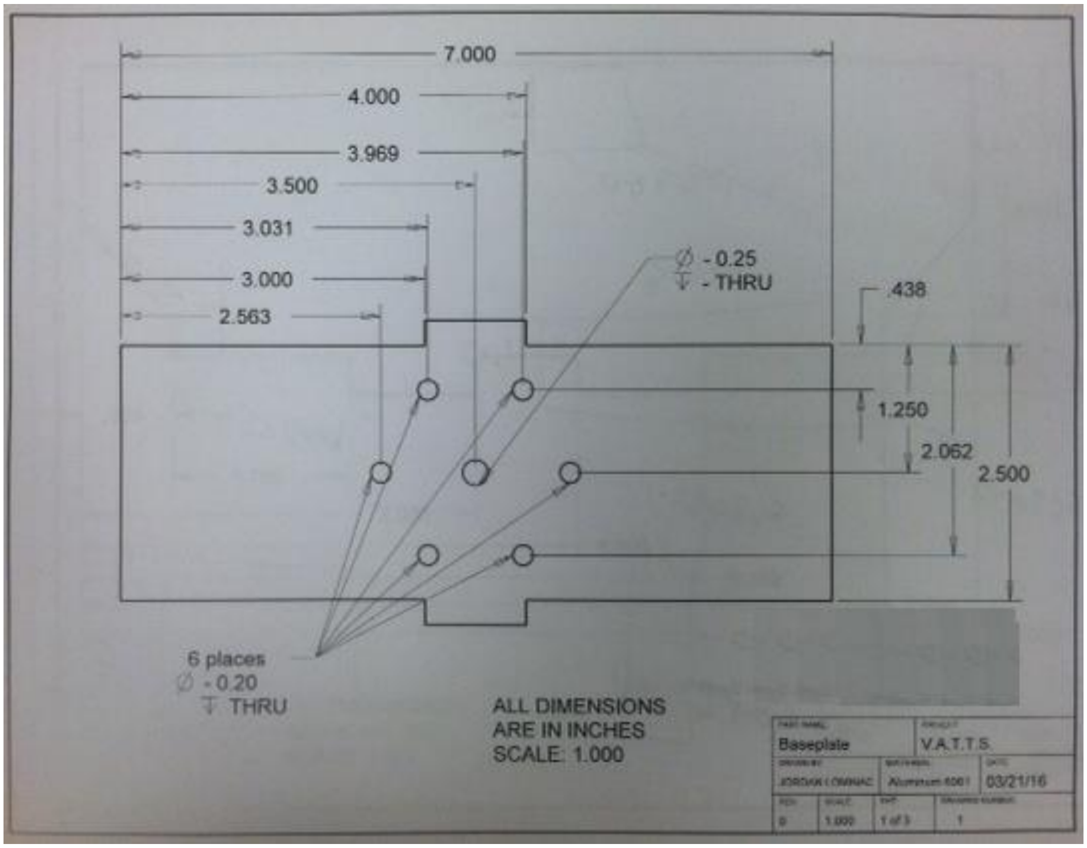
Welding instructions for bracket



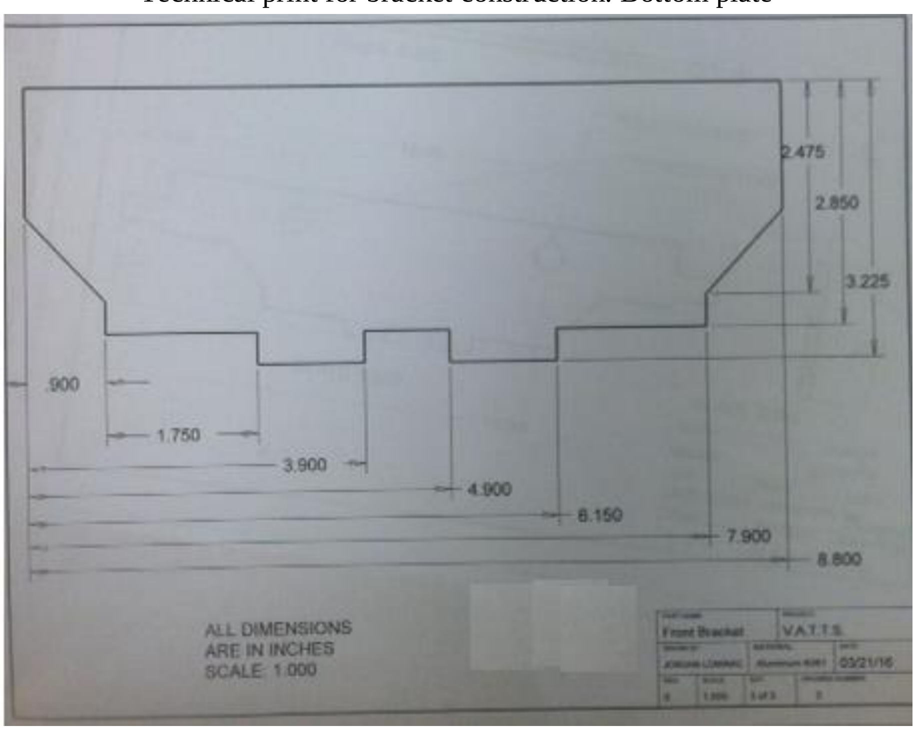
Flange drawing



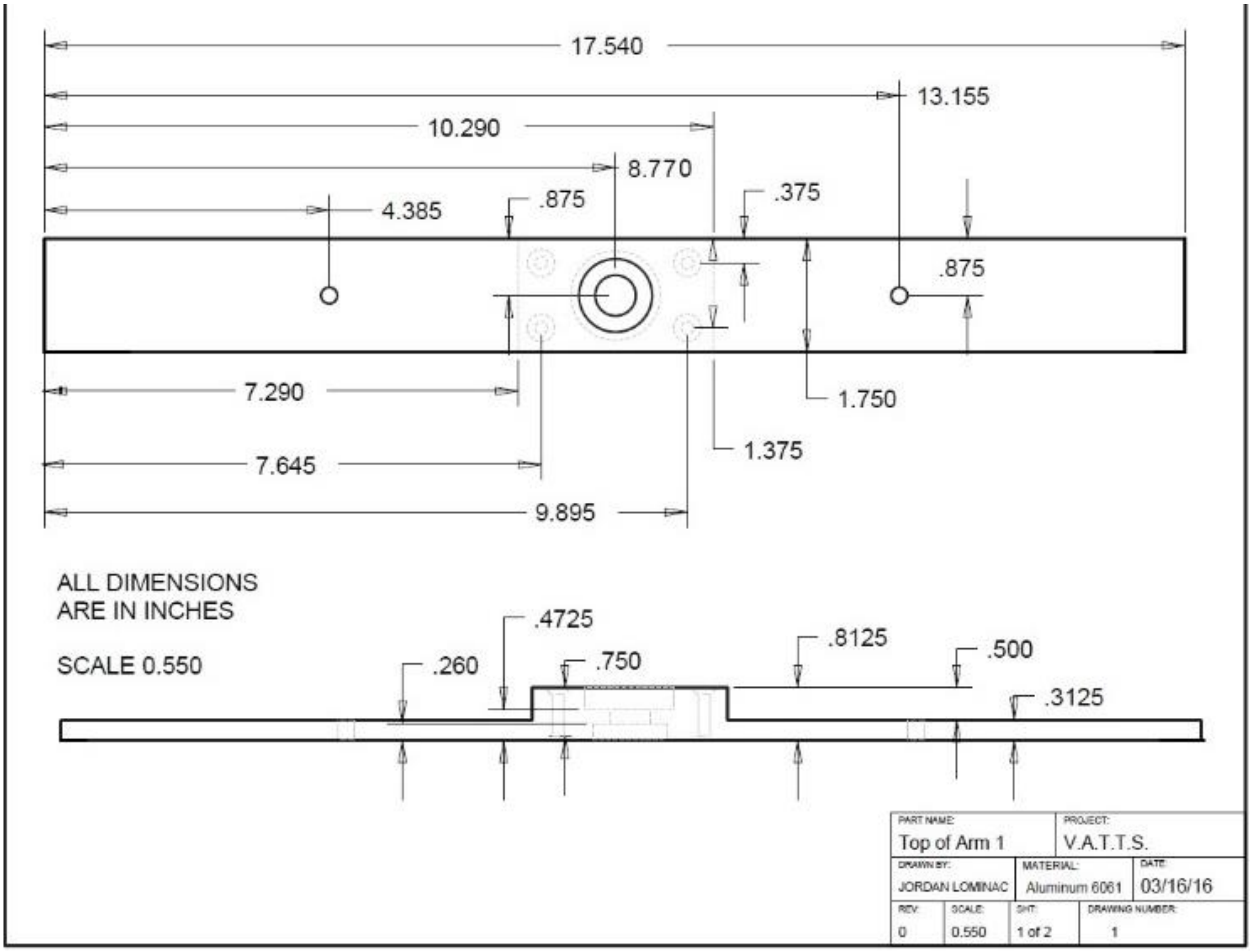
Technical print for bracket construction. Bracket rear faceplate



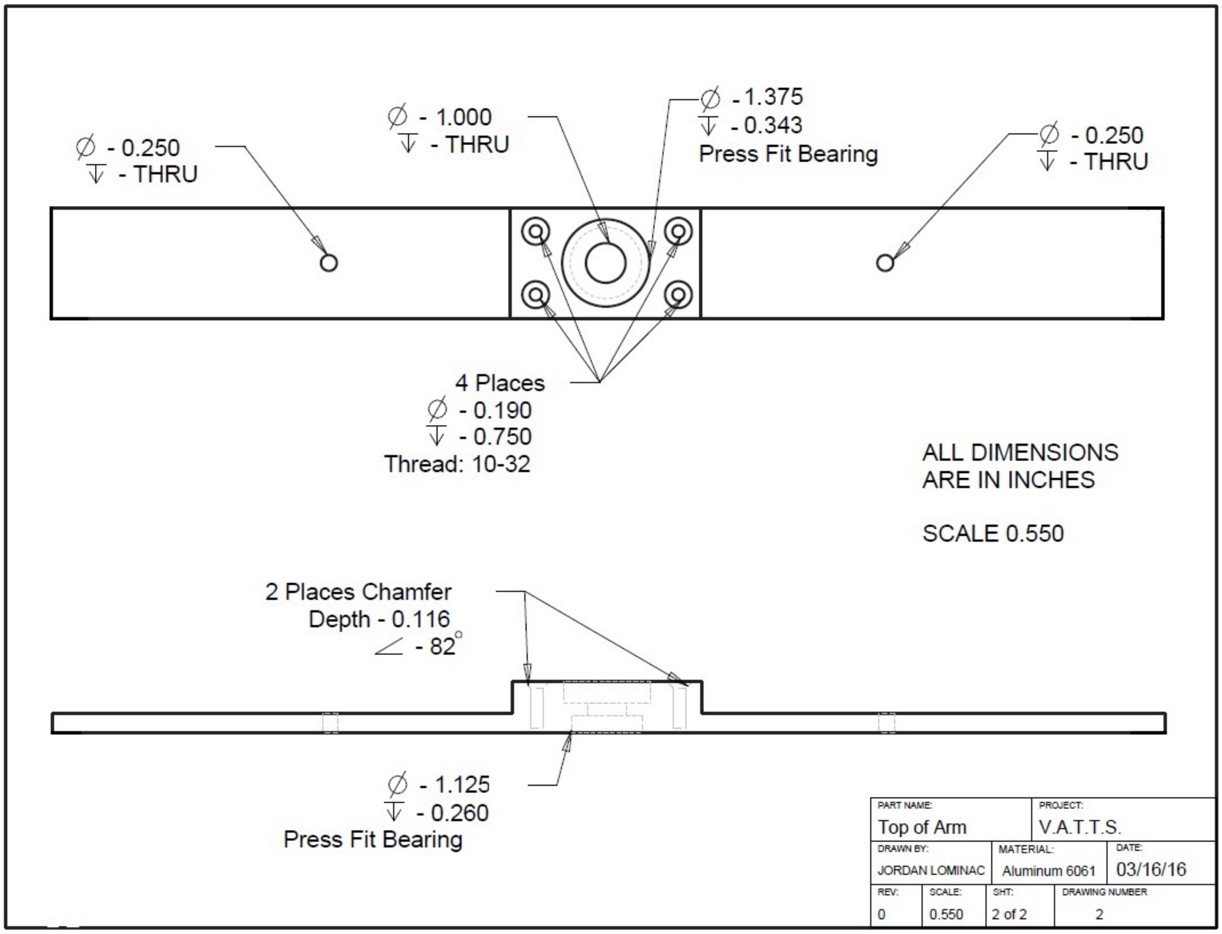
Technical print for bracket construction. Bottom plate



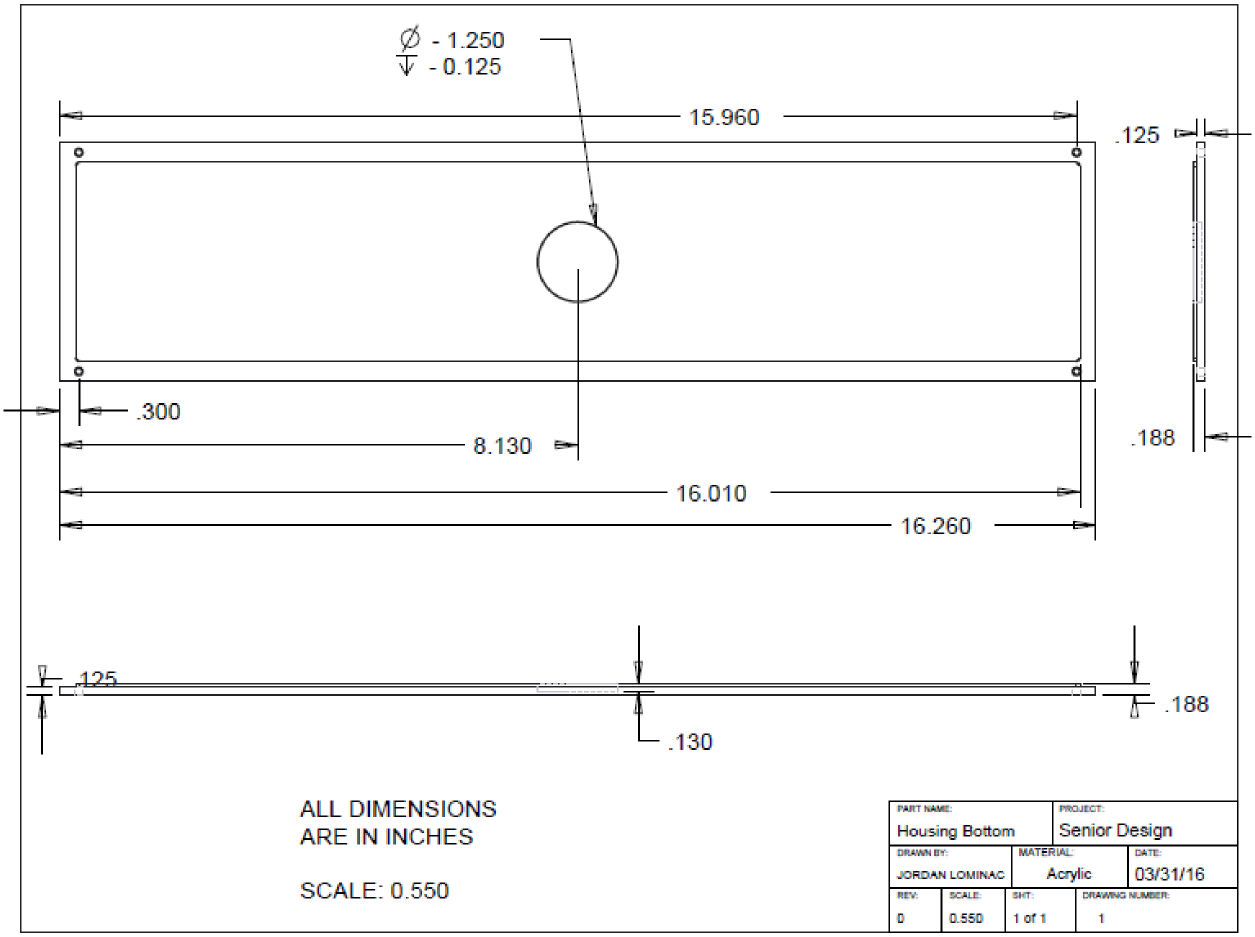
Technical print for bracket construction. Front face plate



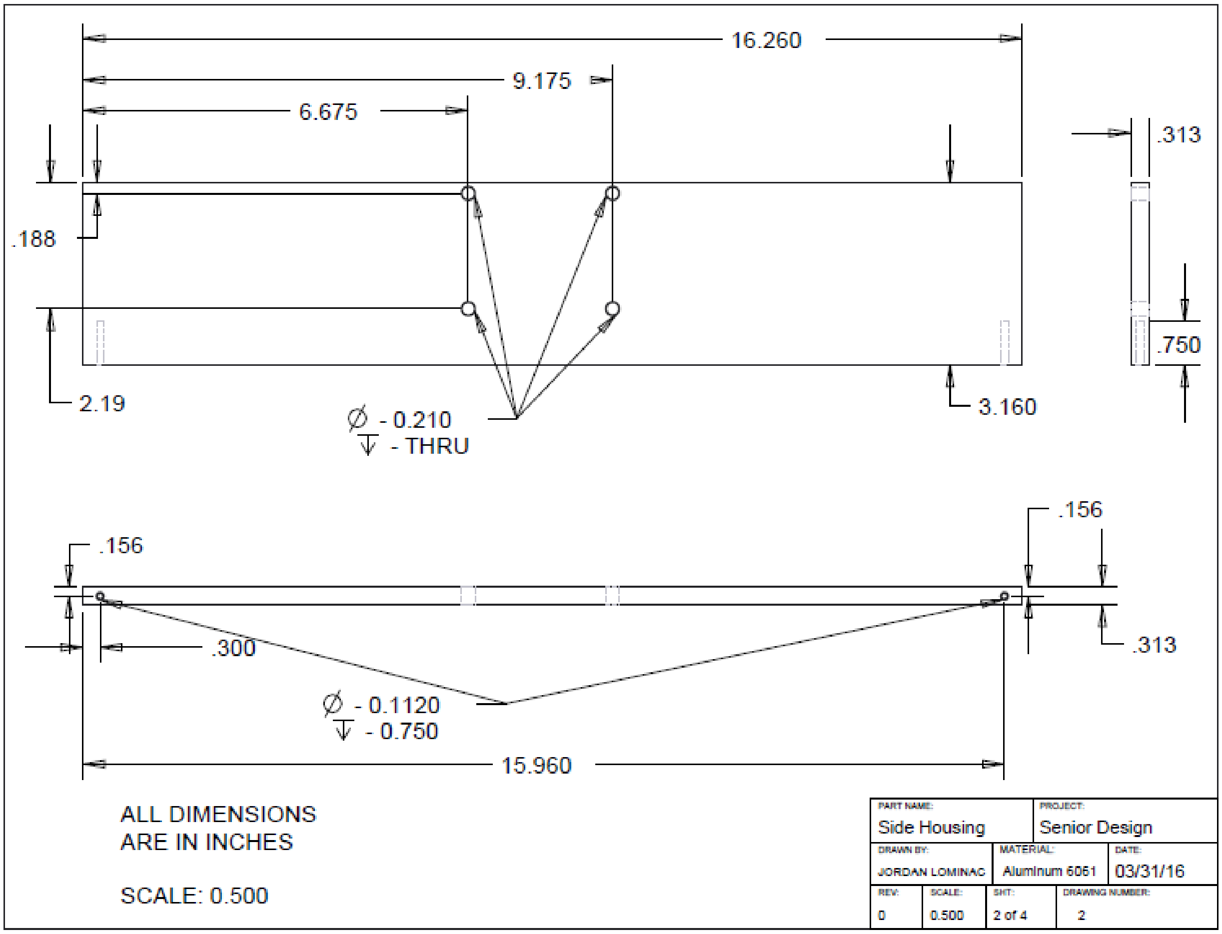
Technical print of arm



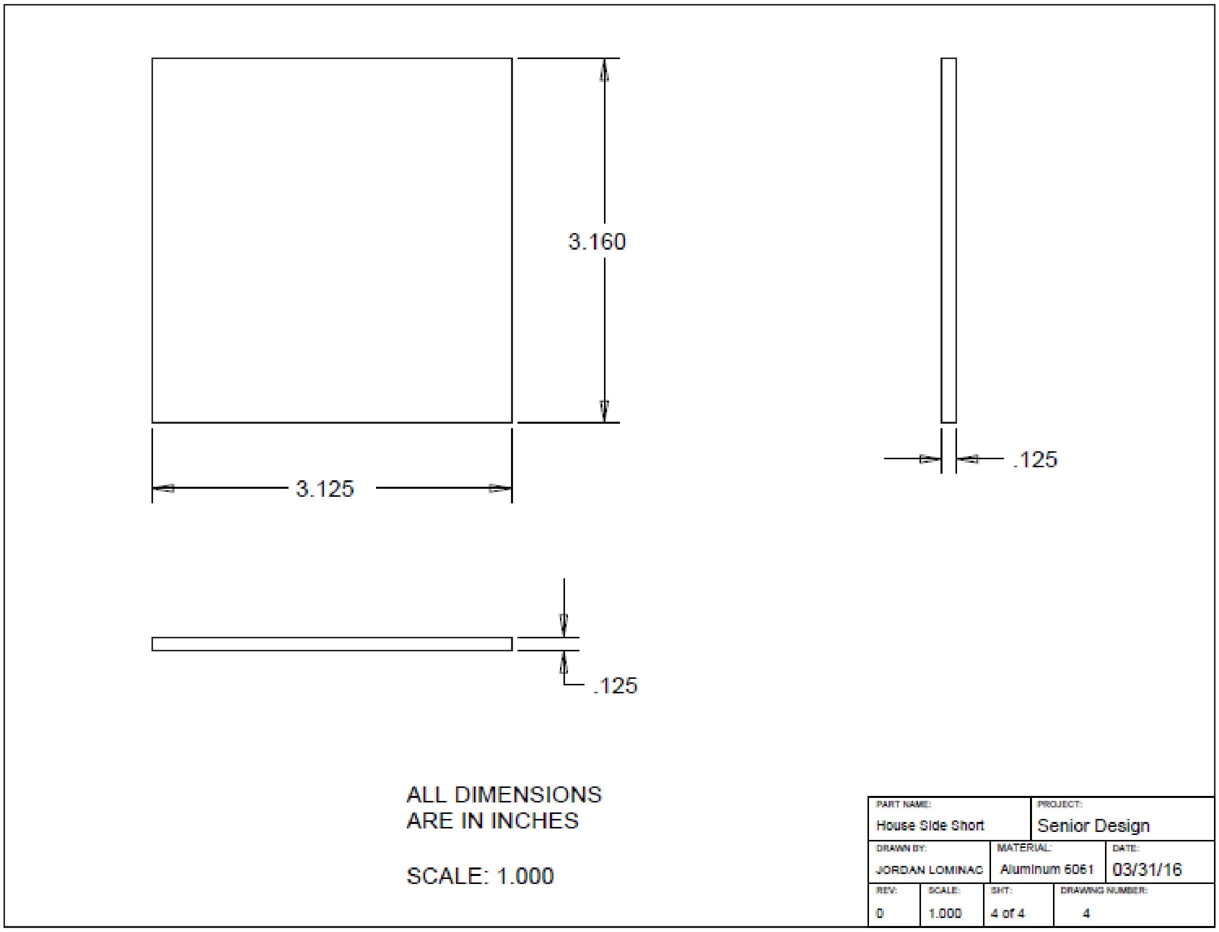
Technical print of arm hole positioning



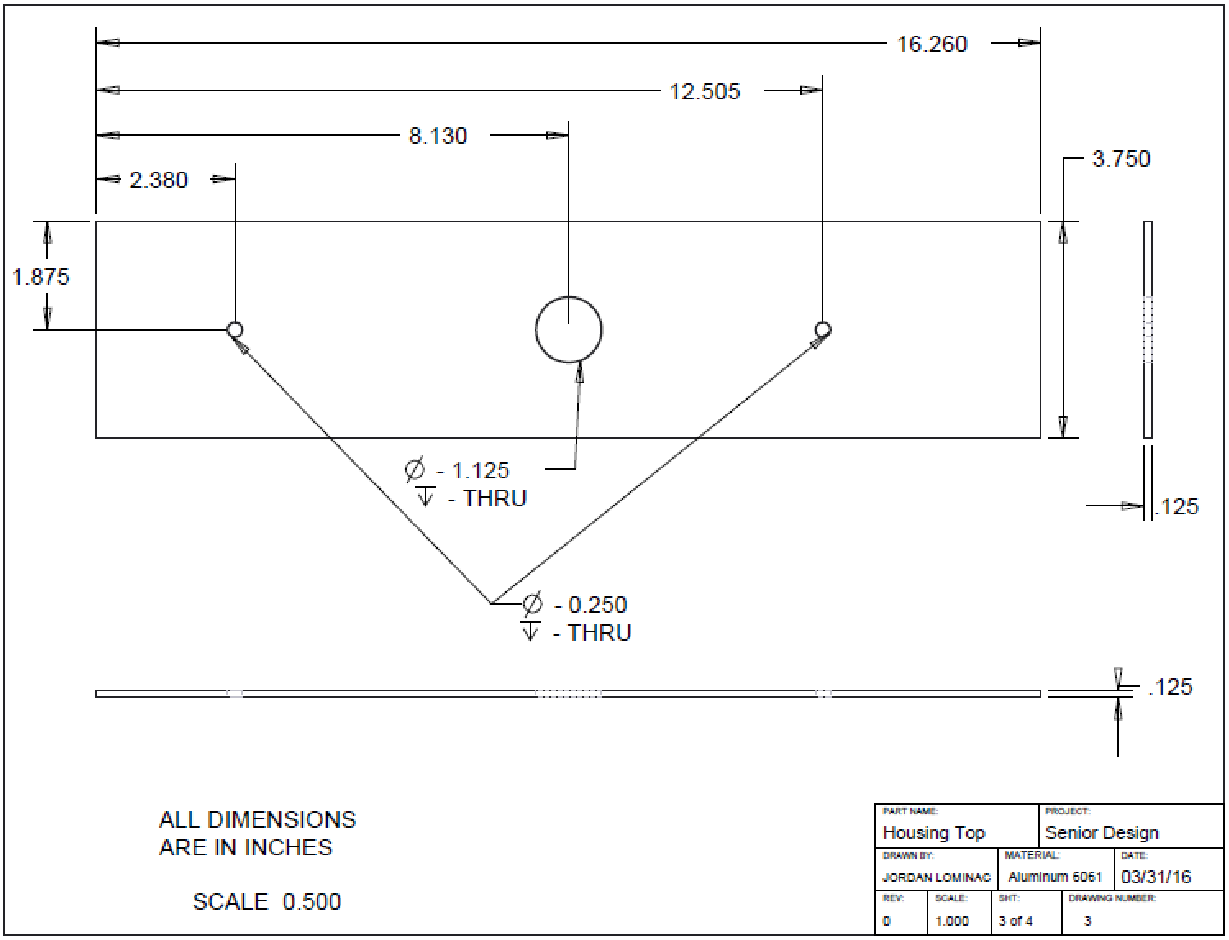
Technical print of motor housing top plate



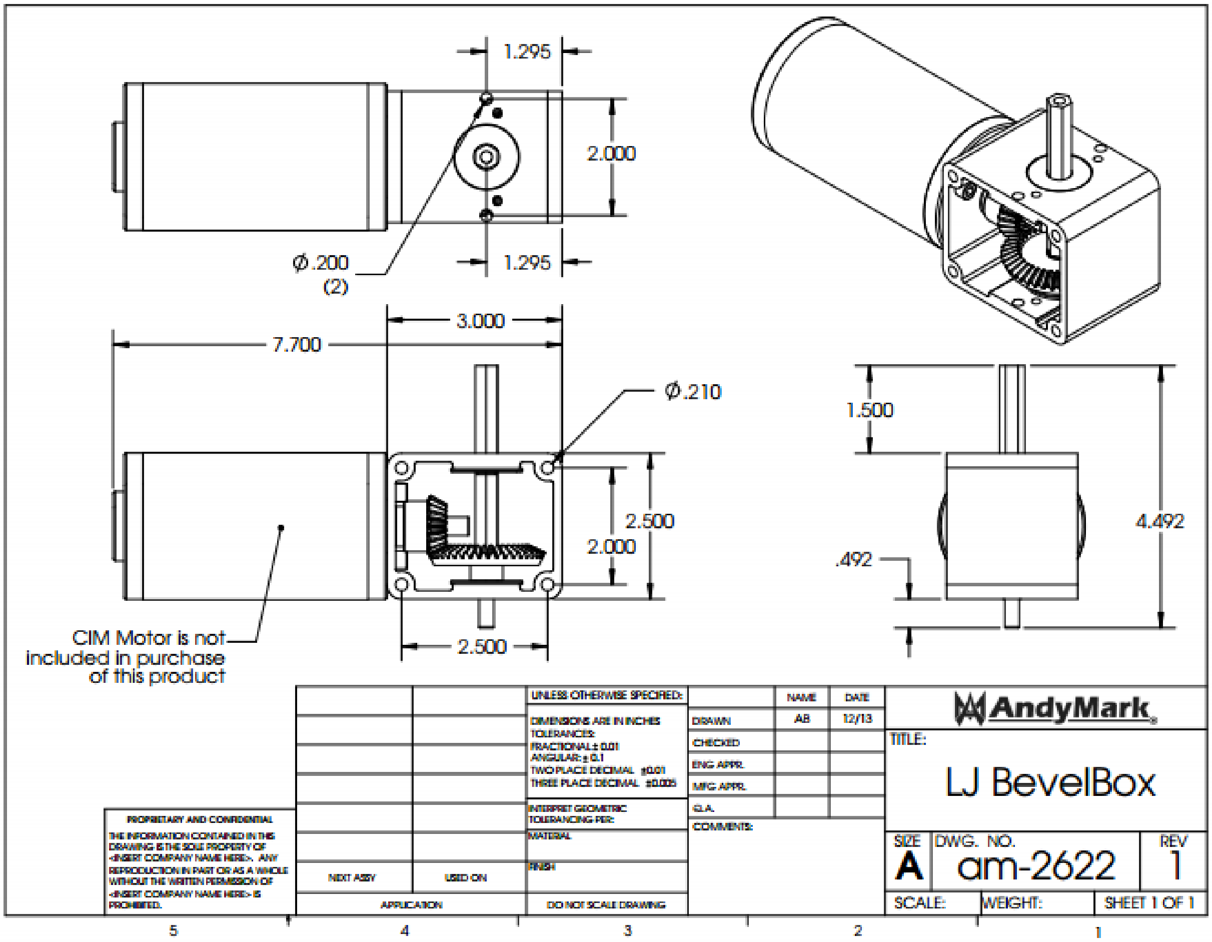
Technical print of front motor housing



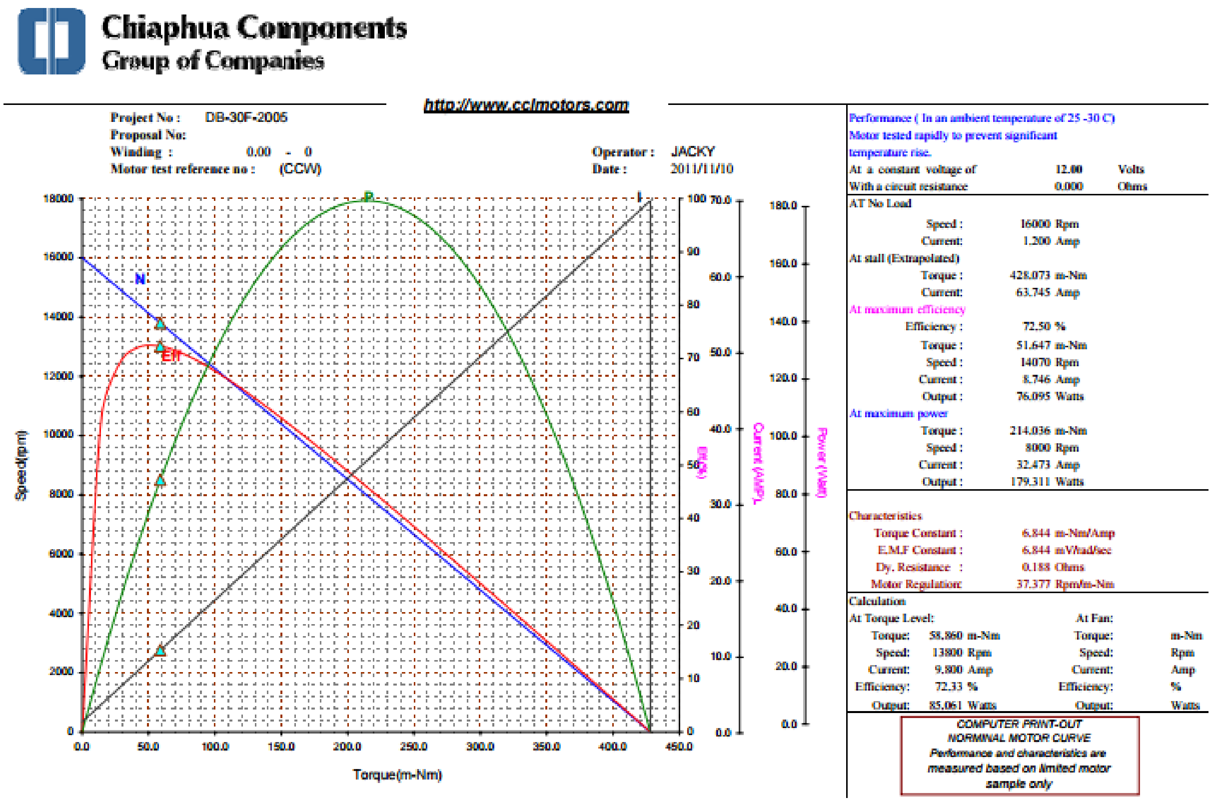
Technical print of side motor housing



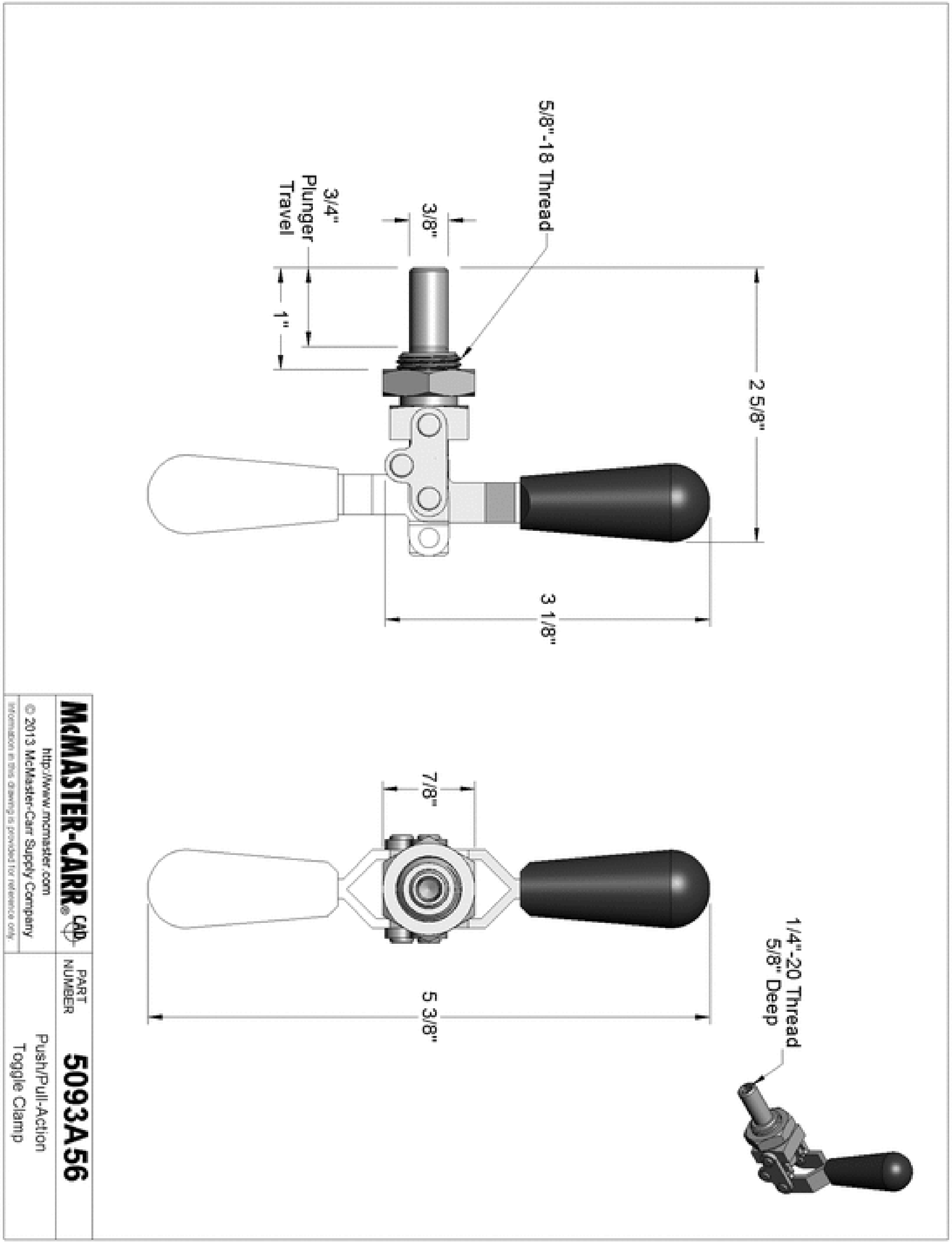
Technical print of bottom motor housing



Technical drawing of motor housing



Motor technical sheet


5/8"-18 Thread
3/8"
3/4"
Plunger
Travel
1"
2 5/8"
3 1/8"
7/8"
5 3/8"
1/4"-20 Thread
5/8" Deep
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PART
NUMBER
5093A56
Push/Pull-Action
Toggle Clamp