Abstract
With the inevitable and rapid rise of technology, creating and designing specific apparatus in order to maximize the efficiency and use of current technology is of great importance. Companies are being faced with the challenge of not only developing new products to be placed into production, but also modifying current products in use. Additive manufacturing plays a large role in this change. Additive manufacturing is a new way to manufacture products. It is highly efficient and eliminates a lot of waste. Engineers are faced with designing products that can be manufactured using techniques such as 3D printing so that companies can quickly make precise parts, with little waste. Lockheed Martin is a leader in the defense industry and is taking a large step forward using these new techniques. This includes modifying many of their current products to maximize efficiency by the use of additive manufacturing, rather than traditional processes. Lockheed Martin reached out to The Pennsylvania State University Engineering Design classes to help develop some of these modified products, one of which was a USB Hub Mounting Bracket.

Keywords: USB Hub Bracket, Lockheed Martin, Additive Manufacturing, 3D Printing, Shock Absorbance

1. Introduction
Lockheed Martin is a worldwide aerospace company that consists of 115,000 employees, 60,000 of which are scientists and engineers. They are operating in 70 countries, and have more than 500 facilities in the United States. Some of their areas of focus include, but are not limited to, space systems, mission systems and training, missiles and fire control, and aeronautics. The company has been operating for more than 100 years to advance technology, materials, and manufacturing methods. Lockheed Martin has recently been exploring the potential of additive manufacturing, which they have found is capable of significantly reducing time, cost, material, and weight.

Additive manufacturing is a process that shows promise as being one of the most efficient ways to manufacture new or redesigned products. 3D printing fabricates parts layer by layer, which allows for the parts to have unique geometries that are impossible with subtractive manufacturing techniques. Additive manufacturing minimizes waste and reduces the weight and cost of the models without sacrificing strength and durability. Being in the aerospace industry, Lockheed Martin stresses the need for products that are as lightweight as possible. Additive
manufacturing is significant to the company because it allows them to minimize material and weight in their parts in areas that subtractive manufacturing could not have accessed.

Additive manufacturing is often the most convenient option for companies like Lockheed Martin because it allows them to produce prototypes and custom products quickly and for a cheaper cost than traditional methods. Since it is less expensive, 3D printing provides the opportunity to model different design ideas as prototypes without wasting material. Design teams can compare designs from physical models that can be quickly and easily produced using the additive manufacturing process.[1]

The purpose of this project is to apply the additive manufacturing techniques to one of five projects, all of which redesign current Lockheed Martin products. This report is specific to Option 4, the USB Hub Mounting Bracket. The bracket is for a 7-port USB hub; the current design stacks two of these hubs inside the bracket. Lockheed Martin created the primary goal that the redesigned bracket have less parts than their current model. They also required that the bracket be able to mount the hubs vertically rather than having the horizontal orientation that they have now. Other characteristics of the new hub include newly designed cable retention, larger capacity with the ability to stack three hubs, versatility in the orientation, and shock resistance.

2. Literature Review
   a. Patent Search/Existing Products
   We observed a design by Justin Taylor [2]. In this design, there were two brackets that were placed on either end of the hubs. The brackets then each had two hole to screw into the ground. The design was made to be 3D printed. From this design we like how secure the USB hubs were inside. However, we were concerned about its ability to withstand high vibrations. We also disliked the difficulty of removing the USB hubs once the bracket is mounted to a surface. By exploring the design by Taylor we were able to better determine what features our own model should have.

   b. Lockheed Martin’s Current Bracket
Lockheed Martin’s current bracket is designed to hold 4-port USB hubs. This bracket is not designed for additive manufacturing, but provided a concrete reference for what Lockheed Martin was looking for in our design. Their current design, while functional, requires excessive amounts of material, does not protect the hubs from shock well, requires numerous parts, and is difficult to mount in various orientations.[1]

3. Design Process
   a. Defining requirements/needs
      i. Reduction of parts (initially 38 total, 7 unique)
      ii. Holds Lockheed Martin’s 7-port USB hubs
      iii. Allows for stacking of three hubs
      iv. Can be horizontally or vertically mounted
      v. 4 point screw mount
      vi. Retains power cables
      vii. Minimizes waste and total materials used
      viii. Designed for additive manufacturing

   b. Developing Ideas
Initially we had several ideas for the bracket. First and foremost, we wanted to design aspects that allowed for the bracket to contain the USB hubs in a single enclosure. One idea to allow the bracket to be a fixed enclosure, while also making it possible to both be vertically and horizontally mounted was a circular track on an outer casing. This would allow the bracket containing the hub to be oriented in any desired direction. Another idea for the bracket was a lid attached to the main enclosure by a pair of hinges. This lid would be secured with a latch once the hubs are loaded into the bracket. We also considered several different methods for how the USB hubs would be loaded into the bracket, and what their orientation would be with respect to the base of the bracket.
c. Modifications
After deciding that a bracket that follows a circular track may be very difficult to additively manufacture, we decided upon a fixed bracket that's orientation could be changed simply by the manner in which you choose to mount it (on a wall or the floor). We also decided on a lid that could be removed and secured by a bolt and nut. This requires less parts and assembly than the hinged lid would have.

4. Design Result

Our final design includes eight total parts (4 unique parts), and can be mounted to any flat surface. The hubs may be placed into the bracket so that if placed on the floor, the USB ports would face upward through the lid. The lid slides onto two threaded pegs that stem up from the bracket, and is secured to the bracket by two nuts. It allows the hubs to be removed without unmounting the bracket. All interior surfaces that make contact with the USB hubs will have thin rubber inserts that both help to absorb shock from vibration and create a more snug fit. All other aspects shall be manufactured out of either a light metal such as aluminum, or any other rigid material that could withstand the forces that the bracket will encounter.

The main modifications that we made to Lockheed Martin’s current design and the other models that we researched were minimizing the total part count and raising the overall structure of the bracket. We made the body one part so that there is less parts and assembly, while the original has sides that disconnect with more parts. The structure of the body can be easily 3D printed without wasting materials. Our design fully encloses the USB hubs and also elevates them off of the surface they are mounted to in order to minimize the shock that would be caused from the hubs being in contact with the floor or wall of an aircraft. The legs of the bracket provide more distance for shock absorbance to minimize damage to the hubs. They also allow the cables to be retained or separated from each other in any direction.

5. Conclusion & Summary
Our final design for the bracket can fit 3 USB Hubs, and can be mounted to the wall or floor, either vertically or horizontally. Once a general body design was decided on, we proceeded to
add on other features, such as slots in order to provide easy access and removal of the USB ports, as well as rubber padding in order to ensure shock absorption as well as the protection of the USB hubs. The goals that we defined in the beginning of the project were met, and our final product can be effectively 3D printed.

Overall, while dealing with the necessary specifics of our design given to us by Lockheed Martin was difficult, it was all in good practice. As future engineers, our tasks will almost always involve being given specifications, and conforming as well as improving our ideas to those fit the needs of those specifications, while at the same time trying to come up with a design that is both efficient as well as satisfactory. We were able to meet all of the requirements with our model even though the guidelines changed halfway through the project. Adjusting our design was not ideal, but we were able to do it and we found that it is a necessary skill to have.

The additive manufacturing process is one that is essential to have knowledge about in the engineering field. For some products such as this hub bracket, it is the most efficient way to manufacture. If our design were to be cut from metal or plastic, materials, time, and money would be wasted.
References (APA)