Lockheed Martin
USB Hub Mounting Bracket

Engineering Design 100 Section 025
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Executive Summary

The purpose of this project is to re-design the USB hub mounting bracket. The current model of the USB hub mount that is being used has a lot of parts and we were given the task to reduce the number of parts, increase the holding capacity of the mount, enabling the product to be orientated in different directions while keeping some of the original design properties. First, we researched the company and the product we are suppose to be redesigned. We gained a better understanding of what needed to be achieved through our research. Next we began our brainstorming process of how we will change the current design to the customer’s need. After we created our design, we processed to analyze and test our prototypes until we were satisfied with our results and after we meet all out the customer’s wants.

Introduction and Problem Statement

M.A.A.T aims to develop a mount that meets the customer’s needs; a mount that can hold 2, 7-port USB hubs, with minimal parts and maintaining a 4-point screw mount. Currently, the mount is intended for a 4 port hub that was previously used, not the 7-port hub that is going to be used. Additionally, it is meant for horizontal orientation rather than the customers desired vertical installation, consists of many parts, and is susceptible to vibration that causes cords to fall out of the hub. This project will investigate ways to create a solution to these problems through additive manufacturing, developing a solution that will exceed the wants of the customer, proving useful for as long as needed. This will be accomplished through extensive research, design, and testing, taking weight, durability, and user friendliness into account. With all these factors, the best product for the customer will be developed.

Background

In its most general sense, a USB hub bracket holds and stabilizes individual USB hubs that are used to connect equipment to a computer source. In the case of this project, these particular brackets are going to be used in aircraft by the company Lockheed Martin. They need to be durable able to stand the turbulence that aircraft can cause so that the equipment does not become detached or damaged. These brackets are typically made out of aluminum and other lightweight metals, and are produced using subtractive manufacturing, where the products and parts are taken out of a large piece of raw material and then molded and assembled. This kind of manufacturing usually produces a lot of waste due to the material, not being specifically in the shape of the part to begin with. This method also takes a longer amount of time and labor/machinery compared to additive manufacturing, which can produce a part with one printer in a matter of hours.
Customer Needs

Customer needs are a very important component of the design process. Almost the entire process is centered around meeting these needs since the product is being designed for the specific customer. The various customer needs of this project included: lightweight, minimal parts, high durability, resistance to vibration, high capacity, and vertical orientation. Each of these are important to the buyers in their own unique way. In order to meet a looming deadline, the product would need to be produced with the least amount of parts as possible to streamline assembly. Using less parts also contributes to reducing the weight of the product. Since these brackets are being used in aircraft, it is especially important that they are durable and vibration resistant. The vibration resistance will help the external equipment that is plugged into the hub to remain stable throughout the entire mission. In regards to the capacity, Lockheed Martin requested for the bracket to hold a 7-port hub rather than the usual 4-port. They also specifically requested that the orientation should be vertical, while a vertical and horizontal installation method would be a stretch goal. In order to determine the importance of these needs, an analytical hierarchy process (AHP) matrix was made. This weighs two individual needs against each other at a time and then each result is added up for a grand total which assigns a particular weight to each. This matrix can be seen in figure 1.

![AHP matrix]

**Figure 1.** A picture of the original AHP matrix.

From the matrix, the most important customer needs in decreasing order are as follows: installation orientation, fewer parts, lightweight, capacity, vibration resistant, and durable. The installation orientation was initially a large part of the original project. It was stated that Lockheed Martin specifically wanted a bracket that could be mounted vertically while a horizontal/vertical mount was a stretch goal. About halfway through the project, though, they
released a memo stating that they would prefer the bracket to be mounted horizontally in comparison to their previously desired vertical installation. Also within that memo, it was said that there was a deadline set in the summer and in order to meet that deadline, the main focus would need to be on fewer parts to expedite the printing and assembly time. Lockheed is switching from 4-port USB hubs to 7-port USB hubs, so our bracket needs to accommodate to that. It also needs to be able to hold two hubs stacked on top of each other with three being a stretch goal. The team decided that our part would need to be lightweight as to not add any more weight than there needs to be on an aircraft. It also need to be vibration resistant and durable. There is important equipment attached to these and it cannot be easy for these cords to be unplugged. The durability keeps the hub safe while the vibration resistance keeps the cords and wires from being damaged. These very important customer needs were the basis of M.A.A.T’s design process.

**Concept Generation**

In order to design the best possible idea for the project, Team M.A.A.T decided that each member would first come up with their own unique ideas before sharing them with each other. This allows original ideas to come about without the fear of them being too “out there” or judged by other team members. After doing this, the team came together and formed six main concepts for the design of the USB hub bracket from the individual ideas. A photo of the six original concepts can be seen in figure 2.

Figure 2. A photo of Team M.A.A.T’s original concepts.
The first design is of a basic rectangular bracket with a four screw attachment. This was the basis for the next two brackets as well. The second design has the base of the first design but it has a retractable secure mechanism so that you can fit up to three USB hubs stacked on top of each other. The third design is very similar except it expand lengthwise rather than vertically. The fourth design has the standard mount as shown in the first design centered inside of a gyroscope. This design is mainly focused on being vibration resistant rather than anything else. The fifth design is an ellipse with a mounted bracket inside. This design was mainly for shock absorbance considering the flexible round outer shell. The sixth and final design the team originally came up with included a single hub bracket that is attached and supported by suspension wires. In the end, none of these designs were used due to the aforementioned changes Lockheed Martin issued in their memo.

**Concept Development and Selection**

To begin this project of re-designing the usb hub mount, we conducted research on current models of USB hub brackets. Information about the uses of the mount, the different material it could or is composed of, and any research that has been previously conducted on this product was necessary to inform us of it’s limitations. We thought it would be a good idea to create a model of different aspects of our product. For example, we extruded line segments with different widths to represent the different thickness we may want to use while creating our product. This model gave us an idea of the dimensions and shapes we may want to use in the remodeling of our project. In addition to that, we were able to grasp a better understanding of the additive manufacturing process and limitations. Based on all the research we did and from what Lockheed Martin wanted, we decided that weight, strength, vibration- resistances, reduction in parts, installation orientation and capacity were the most important needs. When we worked on the concept scoring matrix, the weight of the product weighed the most, while the capacity of the product weighed the least. This matrix, along with the data, can be seen in figure 3. After this was completed, Lockheed sent out a memo saying that they changed their needs. They now needed a bracket for two 7-port USB Hubs with cable retention for USB and Power cables; maintain 4-point, screw mounting for base bracket; and minimize any additional screw / mounting holes required in platform structure and as a bonus that wanted vertical hub mounting and if possible they wanted to us to make the mount hold three USB hub. We had to rethink our approach and rethink about all the important part of the design. Capacity and orientation become the most important aspects while strength became the least. Once that was completed we used the CAD program SolidWorks to create our design of the mount. Next step was taking all the knowledge we gained and use it to achieve our goals of re-designing the existing USB hub mount. Lastly we have to analyse the product and fix any shortcoming until we were satisfied with our design.
After brainstorming the designs mentioned in the concept generation, Lockheed Martin sent a memo with updated requirements, as well as images of prototypes. After review of their initial prototype, the decision was made to use the premise of their prototype, and improve upon it, making it more lightweight, less parts, and more user friendly. For this reason, not one of the six ideas on the concept generation sheet was used. This design was superior to all other designs, for it met all the customers needs, as well as met some of the stretch goals. The power and cable retention that this model had took vibration into account, unlike the other ideas developed in concept generation. In addition, the USB hubs would be supported on all sides, and were easy to remove and switch out if needed. The previous brainstormed designs did not take these factors into account, so by choosing these models, the best product was created. The solidworks design can be seen in figure 4, and the 3D printed model of this design can be seen in figure 5.
Design Review

M.A.A.T’s design review was primarily directed towards ensuring that all important requirements were met. The team drafted a mount that could hold not seven, but twenty-one usb ports from 3 hubs. In addition to that, the team completed all bonus requirements when they incorporated a horizontally oriented mount. Sufficient research and testing guaranteed M.A.A.T’s prototype would not spare the minimum specifications. The researchers took into account factors such as vibration, and with that concluded the customer preferred vertical orientation was inadequate for withstanding the shakes and tremors of an airplane. After review, it was confirmed that all minimum requirements were exceeded, in addition to some of the stretch goals. In the end, the only suggestion the reviewers had was to remove material to decrease the weight of the model even more. Taking this into account, the final design would remain the same, except for some removed material.

Description of Final Design (3D Model)

After the preliminary design review, the prototype was altered following the suggestions that were given. Material was removed from the top and sides of the model to make it more lightweight. To ensure that the model could withstand the removal of material, force tests and drop tests were performed in SolidWorks. As can be seen in figure 6, there was significant stress on the sides of the model, and this was concerning. Since this model was going to be put into an aircraft which will undergo significant force, there could not be any concern about the mount breaking due to the conditions it is operating in. For this reason, the team put the material back into the sides of the model, and only removed material from the top. The same tests were
performed again, and as can be seen in figure 7, the stress was more evenly distributed into the joints on top, rather than the sides.

The current prototype for Lockheed Martin is made out of metal, which is relatively heavy. Additionally, it was made out of 7 unique parts, with a total part count of 38, and it can hold two 4-port USB hubs. M.A.A.T’s prototype, however, was made out of 7 unique parts, with a total part count of 21, and it can hold 3, 7-port USB hubs. Since M.A.A.T’s model would be created using material extrusion with Nylon 101, a lightweight and strong plastic, the model will be lighter and have a greater capacity, while still being as strong as a metal bracket.

Since the 3D model was 3D printed out of PLA, as well as scaled down 50%, it did not have the same structural integrity as our final model will. That being said, the printed model was relatively sturdy. When dropped from a height of about two meters, no effect was noticed to the model, and when pressure was applied by hand, there was little to no movement in the model. Since Nylon 101 is significantly stronger than PLA, M.A.A.T’s prototype should outperform the PLA printed model ten-fold. Nylon 101 also has great heat transfer properties: a melting point of 500°F, a thermal conductivity of 1.7 BTU-in/hr-ft-°F, and a V-2 flammability rating, so the effects of heat transfer from computers onto the plastic mount will be of no concern[1]. The mount will be able to perform in any condition without concern.

Conclusions

Team M.A.A.T thanks Lockheed Martin for giving them this opportunity to sharpen and hone the skills that they will use for the future. The team believes they have successfully redesigned this mounting hub to Lockheed Martin’s desires. They were able to reduce the number of parts of the product; maintain the 4-point, screw mounting for base bracket; and
enable it to hold two 7-port USB Hubs. The next step would be to revolutionize the hub mount so that it’s adjustable for all types of USB hubs. A significant goal in the future would be finding a way to merge the design with the USB hub so that the need for a hub mount would be completely eliminated.

References