EDSGN100 Design
Project #2
Final Design
Report

Production of Advanced USB Casing

Introduction to Engineering
Design
EDGSN 100
Section 007

(Team #7)
(Ryan Baer, rpb5210@psu.edu)
(Kashan Nazim, kmn5381@pu.edu)
(Nicolas Tiches, nmt5183@psu.edu)
(Alex McCoy, aem5750@psu.edu)

Submitted to: Prof. Colledge
Date: 04/26/2016

The goal of this design challenge was to create a new bracket for the D-Link USB hub (pictured above). The original bracket was only made for a hub with 4 USB ports, so we were forced to change the bracket to accommodate a hub with 7 USB ports. 3-D printing technology was utilized for production and the casing also prevents the shaking of cords to keep all cables plugged in. This will be utilized on the dashboard of maintenance carts used in various airplane industries supplied by Lockheed Martin.

Production of Advanced USB Casing

Table of Contents

1.0 Introduction **3**
1.1 Design Principles **4**
1.2 Gantt Chart **4**

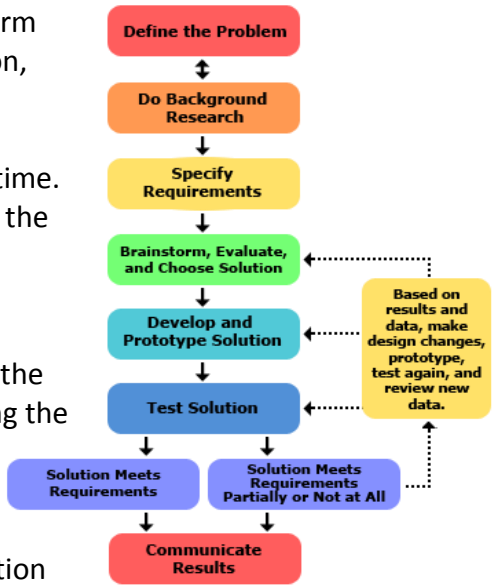
2 . 0 Project Background 5
3.0 Project Objectives 7
4.0 Conceptual Designs 8
4.1 Descriptions 8
4.2 Research & Analysis 8
4.3 Concept Selection 8
5.0 Detailed Design 9
6.0 Conclusions 10
7.0 References 10

1.0 Introduction

Lockheed Martin, an industrial aerospace company involved in the production and supply of various aerospace parts and assemblies, presented E-Design 100 classes at Pennsylvania State University with the opportunity to provide them with plans for the production of various items. Lockheed Martin is a global security, aerospace, and information technology company that primarily does business with the U.S Department of Defense and other U.S federal government agencies[1]. This report aims to provide insight for our own group's project, Team #7, and how we went about accomplishing developing a project for Lockheed Martin.

This report contains a general outline of the design process as we used it to accomplish the production of our product. The design process being; recognize the need/opportunity, define the problem space, specifications, brainstorm ideas, evaluate ideas, analyze the solution, testing/prototype construction, and finally communicating the design solution. Within this Introduction, design principles will be discussed and our Gantt chart will be shown, to display how we deemed what was important and how we managed our time. Lockheed Martin and the project itself will be described in more detail in the Project Background section, along with the small amount of outside information required for our specific project.

FIGURE 1: DESIGN PROCESS



We finally start to go over some of the design process that was described earlier in the Project Objectives section, where we go through the first three parts. These parts (Recognizing the Need/Opportunity, Defining the Problem Space, and Specifications) are extremely important to the overall design process because they set the tone for the project, and if omitted, can skip Four later steps of the design process are hit in the Conceptual Designs section as you can see the brainstorming and evaluation processes through the pictures and descriptions. The inability to perform optimal prototype testing is described beforehand. Much of our actual analysis is split between the Conceptual Designs section and the Detailed Design section, but the latter is mostly used for what might just be the most important part of the process in this context, which is communicating our solution.

In our conclusion we determine how well we satisfied the design objectives and how well we did completing this project overall. The conclusion can definitely be compared to our official sales pitch as this is where we explain why our product design should be used. References are all shown below.

1.1 Design Principles

As a group we decided that it was necessary to adhere to a certain code of ethics while completing this challenge. We knew as a group that we did not want to create anything that had the potential to be extremely damaging towards the environment. This translated into doing research into what materials were feasible for our production while also choosing a project that wouldn't theoretically contribute all that much waste into the environment. It's estimated that in 2007, Americans threw out 570 billion bounds of municipal solid waste, which isn't something we wanted to be a part of with this project[2]. We also did not want to contribute to war and destruction, which limited our options given the scope of Lockheed Martin and the markets they operate on. This ethics system that we established along with our group's interest in making something we would actually be able to prototype led us to pick the USB mounting bracket project over others.

FIGURE 2: ROOSEVELT REGIONAL LANDFILL

1.2 Gantt Chart

Through our Gantt chart you can see the general schedule that we tried to stick to while completing this project. Our specific tasks that had to be completed are listed on the side of the chart while the time we allotted to complete these tasks are listed next to each. You can see on the chart exactly when we started trying to complete a specific task and when we actually completed said task. We tried to be as specific as possible in showing what exactly we were trying to do.

1					WEEKS		
2	**Project Plan**	1	2	3	4	5	6
3	.1 Begin Project						
4	.2 Attend Lockheed Martin Presentation						
5	.3 Select Project						
6	.4 Research AM						
7	1.1 Stakeholder needs						
8	1.2 ideal specs						
9	1.3 state the problem						
10	1.4 Constraint definition						
11	2.1 sustainability discusion						
12	2.2 research existing examples						
13	2.3 Material Investigtion						
14	2.3 present research findings to group for discussion						
15	2.5 Conceptual Designs						
16	2.6 brainstorming ideas			75%			
17	2.7 Select the most practical designs for detailed analysis			75%			
18	3.1 Perform Calculations for each design						
19	3.2 Construct a cost Analysis for each design with different materials						
20	3.3 CAD Drawings				10%		
21	3.4 Choose the best design						
22	4.1 Assemble Prototype(s)						
23	5.1 Prepare final drawings/specs						
24	5.2 Prepare final cost estimate						
25	5.3 Misc. revisions and preparations						
26	5.4 Technical Report						
27	5.5 Formal Presentation						

2 . 0 Project Background

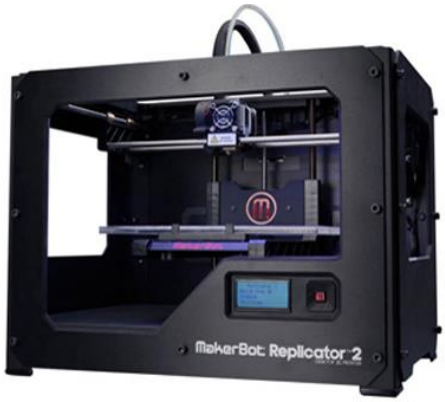
As stated previously Lockheed Martin presented us with a need for various different products. They did this in the form of a contest of sorts, where the winner is given a reward for creating the best design that the company can hopefully put to use. The six options for projects were: an Additively Manufactured Heat Exchanger, Sensitive Payload Shock Absorber, Connector Backshells, USB Hub Mounting Bracket, and a Design for Additive. Since Lockheed Martin is an aerospace company they would most likely be selling these products to the U.S Department of Defense and commercial airline industries.

FIGURE 3: LOCKHEED MARTIN HQ

As stated multiple times earlier Lockheed Martin is an aerospace company but it is also one of the largest companies in the US. They employ 126,000 employees both in the US and abroad, and generated $46.1 billion in sales in 2015[1]. They are headquartered in Bethesda Maryland but operate over 590 facilities nationally. They organize themselves into five broad business areas, which are; Aeronautics, Information Systems and Global Solutions, Missiles and Fire Control, Mission Systems and Training, and Space Systems[1]. This shows the scope of their business and illustrates how good of a pair they are for all military and warfare related equipment, although they do not strictly focus on this field. Knowing this about our source of needs we needed to pick which one of the projects we thought we could best complete.

The first project option was to use additive manufacturing to redesign a heat exchanger. This would most likely be implemented in planes to heat up fuel leaving the aircraft fuel tank before it gets to the engine fuel system[3]. A prototype would have been able to have been built but only using a 3-D printer, so it wouldn't have been made out of the same material that the actual product would have. The main goal of this project was to use additive manufacturing to make the traditional design much more efficient in its use of materials. We decided not to take on this challenge because of the use in actual airplanes and the fact that we would be able to build a usable prototype.

FIGURE 4: MAKERBOT 3-D PRINTER



The second project option was to build a shock absorber for unmanned aerial vehicles when they make impact with whatever they land on. The parts were required to be extremely lightweight yet still be able to handle "harsh landing conditions". We decided against this project because it would have required making an assembly instead of just a part, increasing the difficulty of 3-D printing. The third project option explained to students the need for improved backshells to separate signals and protect rather than potentially damage wires. This project seemed to require a much larger amount of background knowledge over others so we backed off and didn't choose it.

Project five simply required research into any part currently provided by Lockheed Martin and redesigned it using additive manufacturing. It had to provide either reduced weight, reduced part count, faster/easier assembly, and improved performance. These projects seemed much broader than what we were looking for as a group and because of this seemed to put any takers at a disadvantage. It seemed much easier to work on something where we already knew what we had to do, that to work on something that also required figuring that out.

Finally, we chose to do the fourth project option, which was to build a USB mounting bracket. This mounting bracket was supposed to be specifically made for D-Link DUB-H7 USB 2.0 7-Port-Hub®, and the design is needed because of the switch from a four-port USB hub to a seven-port. We chose this design because it stuck with our ethical values that were described earlier while also allowing for a physical prototype that could actually be used to be built.

FIGURE 5: D-LINK 7 PORT USB HUB

Since 3-D printing was going to be the main method of production for this project our team did research on different methods of printing along with the different materials used to try and decide what would ultimately be best for our project. Through this research we found that our prototype would most likely not actually be made the same way as our final product would be. This is because stereolithography, the oldest method of 3-D printing, is what's utilized to make prototypes while Selective Laser Melting (SLM) is the method that would most likely be used by aerospace companies. Stereolithography prints layer by layer converting liquid plastic into solid objects, while SLM uses a high powered laser beam to fuse and melt metallic powder[4]. Even so our prototype was at least serviceable because it was made out of plastic just like the actual product would be. We determined that PLA filament would be the best material to use for our actual product because of its durability and recyclability[5].

3.0 Project Objectives

To start our project, we Team #7 had to define the problem area or space. We recognized that Lockheed Martin has a need for a bracket that can hold 3 USB hubs vertically and retain their cords despite vibrations from the system. We then defined the problem area as being the D-Link DUB-H7 USB 2.0 7-Port-Hub®, since this is specifically what the casing we built would have to mount, and we actually ended up purchasing this device off of Amazon to help us find a solution. Online we found the dimensions of the device to be 3.94 x 2.2 x 0.9 inches (length x width x height)[6]. When measured ourselves, the dimensions actually came out to be 9.80 x 5.6 x 2.4 inches, so we used those for our design.

When deciding what was most important for our design we concluded it was important to first determine who our major stakeholders were, since they would have the biggest say in whether or not our project could ever be purchased. We determined Lockheed Martin, airlines, waste management officials, maintenance workers, and tax-payers were our Stakeholders. Lockheed Martin was an obvious stakeholder since they were the ones that we were actually selling the product with their aircrafts. We knew for them the mounting bracket would have to be durable, made affordable, and easy to produce, so that they would be able to conduct production easily on their own. Next we tried to determine who the primary consumers are to include them as stakeholders. This is because if Lockheed Martin has no one to buy the product there is no reason for them to purchase our design. We determined these stakeholders to simply be airlines, and knew they needed something durable, easy to install, and effective in stopping shaking, or else they wouldn't buy it.

Our other stakeholders were less significant and not given as much attention as Lockheed Martin and airlines. Maintenance workers were determined to be a stakeholder since they would most likely be the ones making use of these mounting brackets. This is because the brackets are meant to be mounted on carts driving around the airport, and maintenance workers would be operating these. We determined that their needs would be the same as the needs of the airlines, and therefore didn't focus too heavily on making sure we satisfied them in regards to the maintenance workers. Next, we determined that any waste management official was a stakeholder because if for any reason one of the products had to be discarded they would be in charge of it. We determined their needs to be that the product should be made out of a recyclable material, if not, an easily disposable material. However, we decided that this should not be a primary concern, since disposability is usually an inverse to durability, and we believed durability was more important. Last, we decided tax-payers may be stakeholders. This is because if Lockheed Martin were to sell this product to the Air Force, tax-payers would be paying for it since the Air Force is funded by the government. We again decided that this shouldn't be a primary focus of ours because their need is too close to one we are already thinking about. They would most likely want the product to be cheap which both Lockheed Martin and the airlines already want, so there was no need to focus on them.

Besides these obvious stakeholder needs Lockheed Martin gave us a specific outline of requirements pertaining to what this product should do. Straight from the Statement of Work, our mounting bracket had to hold a 7-port USB Hub, provide vertical mounting capability, and provide cable retention. There were also bonus objectives of being able to mount three hubs together and being able to mount horizontally as well as vertically. These were obviously the primary objectives for the project, while we operated within these and tried to implement the identifiable stakeholder needs when possible.

4.0 Conceptual Designs

Our brainstorm process included many different designs and concepts being passed around. We thought of using rubber bands like shock absorbers for the vibration. We thought of using a door on our mount bracket so that you could easily plug in cords and then keep them secure by closing the door. We thought that these ideas would be too complicated if someone want to rebuild the model on site if it were to brake; however, we kept them for design analysis. We also thought to make this design one piece with no moving parts and to have encasings around each wire to prevent the vibrations from the aircraft from unplugging them from the hub. These encasings first looked like tubes and ended up looking like small rectangular boxes that had the same dimensions (but a little bigger than) as the USB cords. We thought of them to be made out of rubber, or made out of PLC filament and have small lips at the end that would secure the USB cords in place.

4.1 Descriptions

We had six conceptual designs and each of them allowed us to simplify the design to make our prototype the best it can be. We created a design with a door over the ports, a design with rubber bands to keep hubs from vibrating, a design with three long rectangular encasings over the ports, a design with PLC tubes over the ports, a design with rube tubes around the ports, a design with teethed encasings over the ports, and a design with We started with the door design and then replaced the door with small tubes for the wires, this ended up looking like the final design except for some openings on the walls for ventilation. We thought this was the best design because the tubes could snuggly encase each USB cord so that it would not move during operation. At the same time, this was the design with the least amount of moving parts with least complexity.

4.2 Research & Analysis

Unfortunately, because of the nature of 3-D printing, we were unable to do research and analysis on all of our designs. When determining the best design, we simply had to go off of which one seemed to satisfy the main design objectives most fruitfully without any actual testing. 3-D printing prevented this because of the long production time and long waiting list to get a design printed. This forced us to skip straight to printing what we considered our final design and making slight changes after seeing how it had been printed.

We also were only in possession of one D-Link Hub, so we were left completely unable to test whether or not even our final design could mount all three. We were only in control of making sure the dimensions fit and making sure that it seemed sturdy enough. We did this by specifically picking out nylon for the bracket to make out of, because this is very lightweight and durable.

4.3 Concept Selection

We conducted a concept screening over all the designs. We compared the attributes of lightweight, able to withstand vibration, durable, safe, in one piece, and easy to pull wires out. The results of this screening lead us to pick design 6, the mount with PLC encasings around the ports.

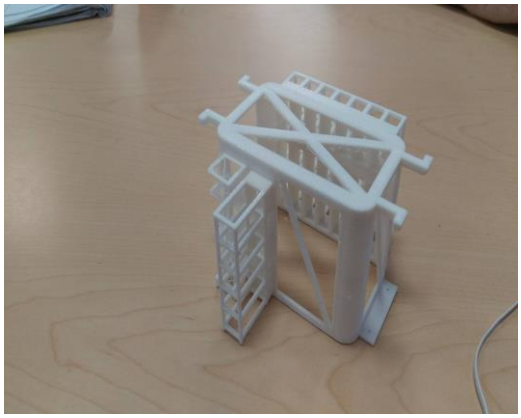
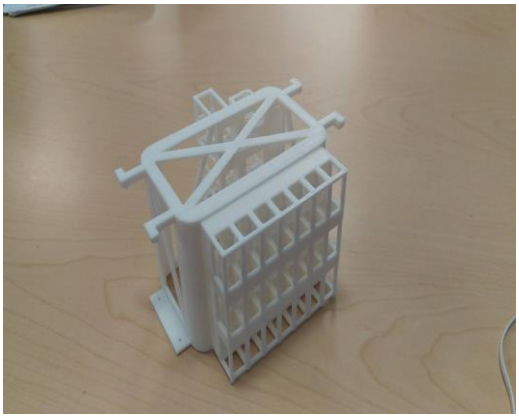
Feature	1	2	3	4	5	6
Lightweight	-	+	+	+	+	+

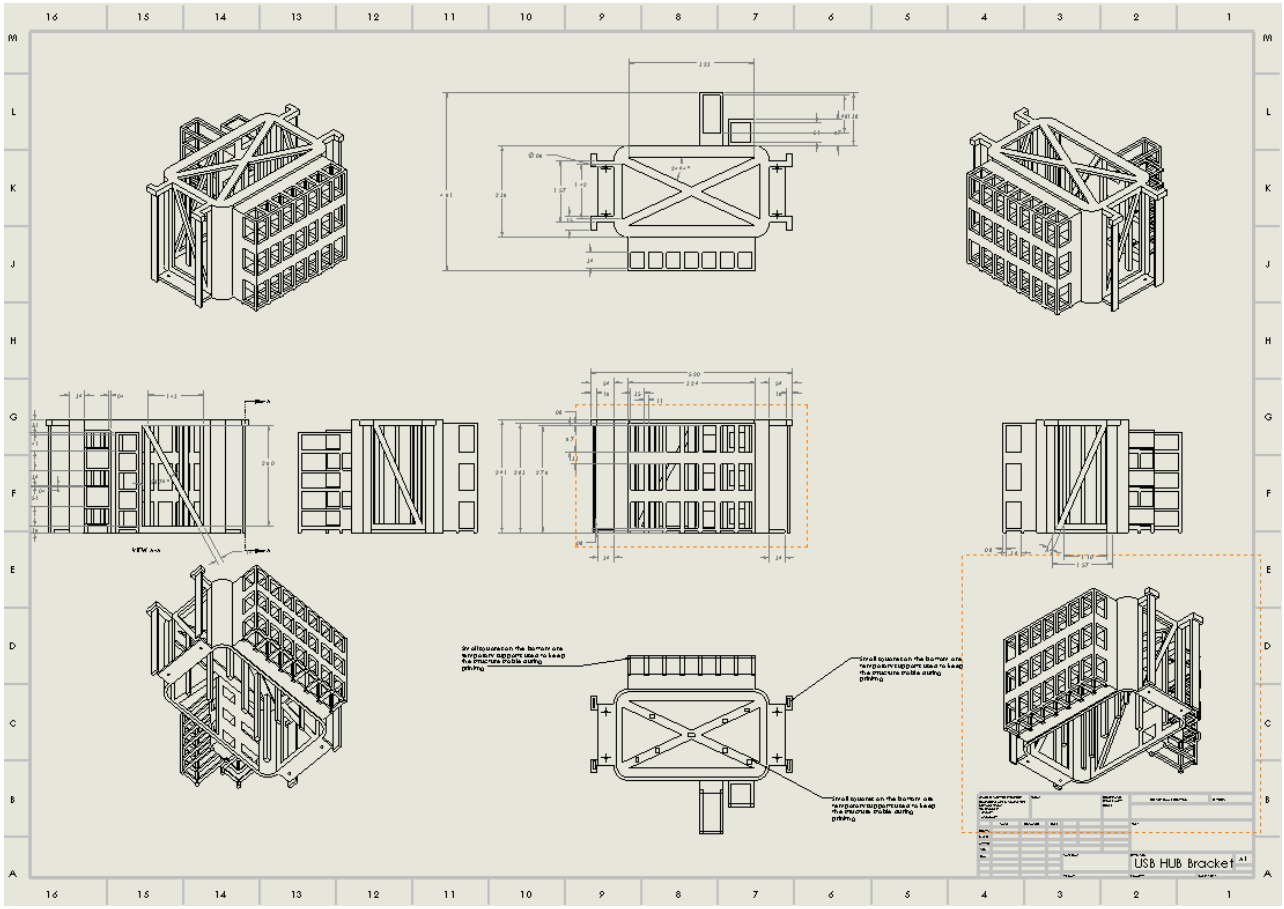
Vibrational Loading	+	-	+	+	+	+
Durable	+	-	-	-	-	+
Safety	+	-	+	+	+	+
One Piece	+	-	-	-	+	+
Easy to Pull Out	-	+	-	-	-	+
TOTAL	3	2	3	3	4	6

Feature	Number
Door Over Ports	1
Rubber Band Holders	2
Three Piece System	3
Rubber Around Ports	4
Plastic Teeth	5
PLC Around Ports	6

5.0 Detailed Design

Our final design was the USB hub mount bracket with PLC filament encasings around all areas of the ports where wires would be plugged in. We decided to make openings on the walls of this mount so that there was proper ventilation. We printed this design and notice that some encasings did not print successfully, so we added some supports on the front of our design so that they could print properly. This is often an issue with 3D printing when PLA filament collapses before it dries during printing[7]. Below are two photos and the isometric of the final design. Visible are the encasings around the ports, the openings where proper ventilation can take place, and lips that we added to the top of the mount to be used to wrap wires that are not plugged into the USB hub. When a USB cord is plugged into a port, the tight fighting of the encasings snugly keeps the cord in place. There are encasings on the front ports and the rear ports, along with supports that allowed the casings to print properly.



6.0 Conclusions

Although each of our prototypes were rendered useless because of the need for supports for 3-D printing, our designs still definitely satisfy all of the requirements given, including the bonus objectives. Our design clearly stops the vibrating of cords through the caging system placed on the front, while the bracket itself fits the 7 port hub and allows it to be mounted vertically. The design also allows for 3 of these hubs to be mounted on top of each other completing one of the bonus objectives showing that we went above and beyond. The only negative quality of our design is the inability for it to be 3-D printed right now but with further exploration into supports that can and will be fixed.

We followed the design process from start to finish as shown throughout this report yet had to skip a step. We were unable to perform an adequate amount of testing on our prototype given the time it takes to 3-D print materials and the lack of overall time to perform these tests after printing. We created a USB mounting bracket that satisfied all the required objectives through the rest of the design process. Although we had slight shortcomings, they can easily be fixed through a small amount of tinkering, and that's why our product design is superb.

7.0 References

[1] "Lockheed Martin - Who We Are." *Who We Are · Lockheed Martin*. Lockheed Martin, 2016. Web. 23 Apr. 2016.
[2] "The Problems with Waste." *The Problems with Waste*. Toxics Action Center, 2015. Web. 23 Apr. 2016.
[3] Smith, Stanley. Fuel/Oil Heat Exchange System for an Engine. Rolls-Royce Limited, assignee. Patent 4498525. 30 Nov. 1982. Print.
[4] "Types of 3D Printers or 3D Printing Technologies Overview." *3D Printing from Scratch*. 3D Printing from Scratch, 2016. Web. 23 Apr. 2016.

[5] Taylor. "Printing With Nylon." *Matter Hackers*. Matter Hackers, 23 Sept. 2014. Web. 23 Apr. 2016.

[6] "D-Link DUB-H7 7-Port USB Hub." *Newegg Business*. Newegg, n.d. Web. 25 Apr. 2016.

[7] Sheppard, Kimberly. “3D Printing - Unabridged Guide.” Dayboro: Emereo, 2012. Print.