Redesigned, 3-D Printed, Micro-D Backshell

Lockheed Martin

Introduction to Engineering Design (EDSGN 100) Section 25

Team #1 Triple A

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**Executive Summary**

The Astounding Aerospace Amigos chose to redesign the connector backshell for Lockheed Martin. The problem that the company faced was that over time the internal wires in the backshells would fray because of sharp edges and their ability to separate signals coming out was limited. They had to purchase these backshells from commercial sellers. Triple A redesigned these backshells so that they would be able to be produced quickly and cheaply using additive manufacturing. The design eliminated sharp edges and had two ports, making it possible to separate signals.

**Problem Statement**

The purpose of this project is to design a completely, 3-D printed connector backshell that is lightweight, protected from EMI, and has minimal sharp edges on the interior as well as the ability to separate signals in all of Lockheed Martin products.

Currently, Lockheed Martin purchases their backshells from commercial manufacturers. The present backshells limit the company’s ability to separate signals coming out of the electronics assembly and into the harness. Another problem with the existing backshells are the internal sharp edges that deteriorate the wires over time.

For this project, the team will investigate ways to modify the connector backshell that Lockheed Martin orders off the shelf in order to meet their specifications by reducing internal sharp edges and separating multiple signals. The new, modified design has two angled ports and all edges on the inside have been filleted to acceptable angles.

**Background**

Wire harness and connectors are a universal challenge throughout Lockheed Martin’s product lines. Lockheed Martin procure backshells from connector manufacturers, and these current backshells limit their ability to separate signals coming out of the electronic assemblies and into the harness. Another issue with the current backshells are the internal sharp edges. Internal sharp edges can abrade and damage the wiring and cause signal loss from assembly to assembly (Lockheed Martin).
**Customer Needs**

Based on the design features and requirements developed for the final project the team decided to weigh each of the customer needs to determine the relative importance of each one of them. The design consisted of eight customer needs that the team chose to evaluate the designs.

The design of the connector backshell had to meet different criteria given by Lockheed Martin. The customer needs are as follows:

- Light weight
- EMI Protection
- Reparability
- Temperature Stability
- No Sharp edges
- Environment Friendly
- 45° Angle port
- Cost

The customer needs were based on the design requirements given by Lockheed Martin. The team decided to choose these customer needs as they were in regards with the project requirement. These backshells would be used in an airplane, so they had to be lightweight and EMI protected. Since these backshells were required to be printed more than once, the team had to make sure that the production was achieved at minimal cost. Moreover, due to the regular use of the connector backshell, it had to be easily repairable and had to have a temperature stability that would ensure safety of the design. One of the main issues of the backshell was that it damaged the wires and caused loss of signal. The team ensured that the final design had no internal sharp-edges, which was also one of the most important customer need requirement.

The picture below shows the AHP matrix that the team used to determine the relative importance of the customer needs. According to the data collected, having no sharp edges was the highest weighted feature. With these customer needs kept in mind the team decided to design the connector backshell that met all the requirements of the project.

![AHP Matrix](image)

*Figure 1: AHP Matrix*
Concept Generation

After going over the process of writing the problem statement and understanding the requirements of the project, the team decided to sketch plausible designs for the connector backshell. The team came up with six individual designs that all had no internal sharp edges and one single port for the wires. After the sketching process, the team used the concept selection matrix to decide which design best met the needs and desired features of the project.

Figure 2: the six different designs the team came up with.

Figure 3: Concept selection matrix
Concept Selection

The concept selection matrix was used to select the design that best fit all the customer needs. As figure 2 suggests most of the designs had a 45° angle port, this would make it easy to modify the design in further stages if an extra port was needed. All the designs had curved inner edges, which was an advantage as this was the most weighted customer need. Design 4 had a specifically different shape compared with the rest of the designs. It had curved edges throughout the shape, however as the concept selection matrix suggests it had the least rating for being lightweight, and due to its bulky design it would cost the most amongst other designs, which was one of the main problems. Evaluating all the designs and keeping the concept selection matrix in mind, the team decided to finalize design 3 as it had the highest rating in all the features compared to other designs. Most of the designs were pretty similar which made it slightly difficult to pick the best one out, however the team was dependent on the matrix and agreed that design 3 was the perfect choice. Design 3 had a 45° angle port with no internal sharp edges, it was small in size, which would reduce cost, and the simple design ensured that it would be easily repairable. Our first prototype was based on design 3; however after further evaluation the team decided to slightly change the design. Our final design met all the requirements of the customer need but was slightly different than prototype 1. The biggest change that was made was adding an additional port for the wires and adding in screw holes at the base of the backshell for extra support and stability. The image below shows the final design of the backshell after it was designed on solidworks.

Figure 4: Isometric view of the final design       Figure 5: The inside view of the backshell
**Description of Prototype**

The team designed the prototype with the main goal of preventing wires from being frayed in mind. They designed the backshell with an angled port, which would keep the wire out of the way and would allow for an additional port to be added if necessary. The filleted edges, which will prevent the wires from fraying, are shown in Figure 9. This prototype looks a bit different from the designed selected because the team had to take into account that there needed to be room and holes so that screws would be allowed to fit in. The team went with this design concept because it was the most feasible and saved the most amount of material. The team also decided that this design would be easiest to add ports to, so that Lockheed Martin would be able to separate its signals. Figure 8, Figure 6, and Figure 7 show the space and material saving design. Figure 2 shows that the team made sure to insert holes for the screws that were the appropriate size and distance from each other.

Figure 6: An isometric view of the 3D printed prototype.

Figure 7: A view from the bottom of the 3D printed prototype. There are two screw holes and an area large enough to fit the plug with the wires.
Figure 8: A side view of the 3D printed prototype. The port for the wire is angled so that another port could be added if necessary.

Figure 9: A side view of the inside of the 3D model. All edges are filleted so that there is a lesser risk of wires getting frayed.
Design Review

During the design review, the other group told us that our design was sleek and that we did a great job designing it; however, they also said we should try to add another port for a wire to go into. Although this was an optional requirement from Lockheed Martin, they said that we could definitely just add another port coming out of the flat side of the connector backshell. They also told us that we should design how we are going to open and close our connector backshell if they were to actually be printed. To fix these problems we decided to make our backshell hinged and have it click in so that it won't open easily, and we added another port coming out of the slanted side of the original backshell, so it could be a multi port backshell, and in our final prototype we added another port coming out of the slanted side of the first prototype. Finally, they asked us what our backshell is going to made of. After talking it over with them with whether it should be made of a plastic or a metal, we finalized on an aluminum alloy, which is what we were initially thinking of making it out of.
Description of the Final Design

The final design follows the backshell’s ability to separate signals coming into and out of the box on which it would be attached, and eliminate rough surfaces or sharp edges to protect the wiring; as shown in Figure 14, the team added fillets to the inside of the backshell to ensure the easy access and movement of the wires and prevent any damages to the wires or the signals. The final design meets the connecting and mating requirements found in Mil-DTL-24308 Figure 11; the screw holes follow the correct measurements listed by Lockheed Martin, Figure 12, for both the radius and the distance separating the holes. The design also allows the use of band clamps once the harness has been installed.

Figure 11 Mil-DTL-24308

<table>
<thead>
<tr>
<th>Shell Size</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>1</td>
<td>1.228</td>
</tr>
<tr>
<td>1.198</td>
<td>1.638</td>
</tr>
<tr>
<td>30.43</td>
<td>16.21</td>
</tr>
</tbody>
</table>

Figure 12. Measurements provided by Lockheed Martin for screw holes.

The team decided to use an aluminum alloy as the material for the final backshell. Aluminum alloy is a strong material that can be used in a 3D printer, and it will stop electro magnetic induction from affecting the signals. The team decided to use powder bed fusion to 3D print the connector back shell because it’s the best process for additively manufacturing metals. The final design for backshell is hinged for easy access to the where the signals are, in case they need to be changed. As show in Figure 14, the final design has a dual port, with the purpose of allowing the consumer to have the option of having more than one signal going into the connector backshell.
The final design and the material in which it is projected to be made out of will allow Lockheed Martin to safely place the backshell in an environment under high temperatures, high pressure or weight without causing any damage to the backshell itself or the box it will be attached to.

Figure 13. Final Design

Figure 14 Added Fillets
Conclusion

Overall, our connector backshell could work in any of Lockheed Martin’s products because it’s compact, and has room for multiple ports to go into. There isn’t any sharp edges on the inside of the backshell too, so none of the signals are going to be severed. Another pro is that our backshell won’t take very long to print, which is going to be useful because we are using powder bed fusion as our printing process, which does take longer to print. Even though powder bed fusion isn’t the most time efficient, it is able to 3D print metal, which is important for our design since we are making it out of an aluminum alloy. Having our backshell made of metal is good too because it will protect the signals from electromagnetic induction, or EMI. Also, our design has slanted ports that are going to take some of the stress off of the wires that are going into the backshell. Although, having two ports on the backshell isn’t always a good design idea. Sometimes, Lockheed Martin may only need one port for the backshell, so they would have to either print new ones, or just have an open port, which wouldn’t be good since dust could get into the backshell and may even ignite and cause a fire inside of the vehicle or missile that Lockheed Martin put the backshell in. A solution to this would be to add caps to the ports that can be taken on or off depending on whether that specific port is being used.

One thing we learned from this project is that a lot more goes into a product than just building it, there is designing prototyping and testing and then redesigning, and then testing again, and in some cases the whole idea has to be scraped. Also, what the product is going to be made of has to be taken into account and how it’s going to be made whether it be an assembly line or additive manufactured. We also learned that it’s important to know all of the specifications before getting into anything so that you can make ideas that are going to fit the guidelines. Another thing we learned about is all the different kinds of additive manufacturing that exist and their best applications. All in all, we learned that a lot goes into the making of any design no matter how big or small it is and how working with a team makes sure the design comes out the best it can be. We learned that teamwork actually does make the dream work, and we all had a fun time designing the backshell and learned lots along the way.

Sources


-This source was used to obtain the required measurements and size specifications listed by Lockheed Martin.


-This source was used to learn about the project and the general customer needs.