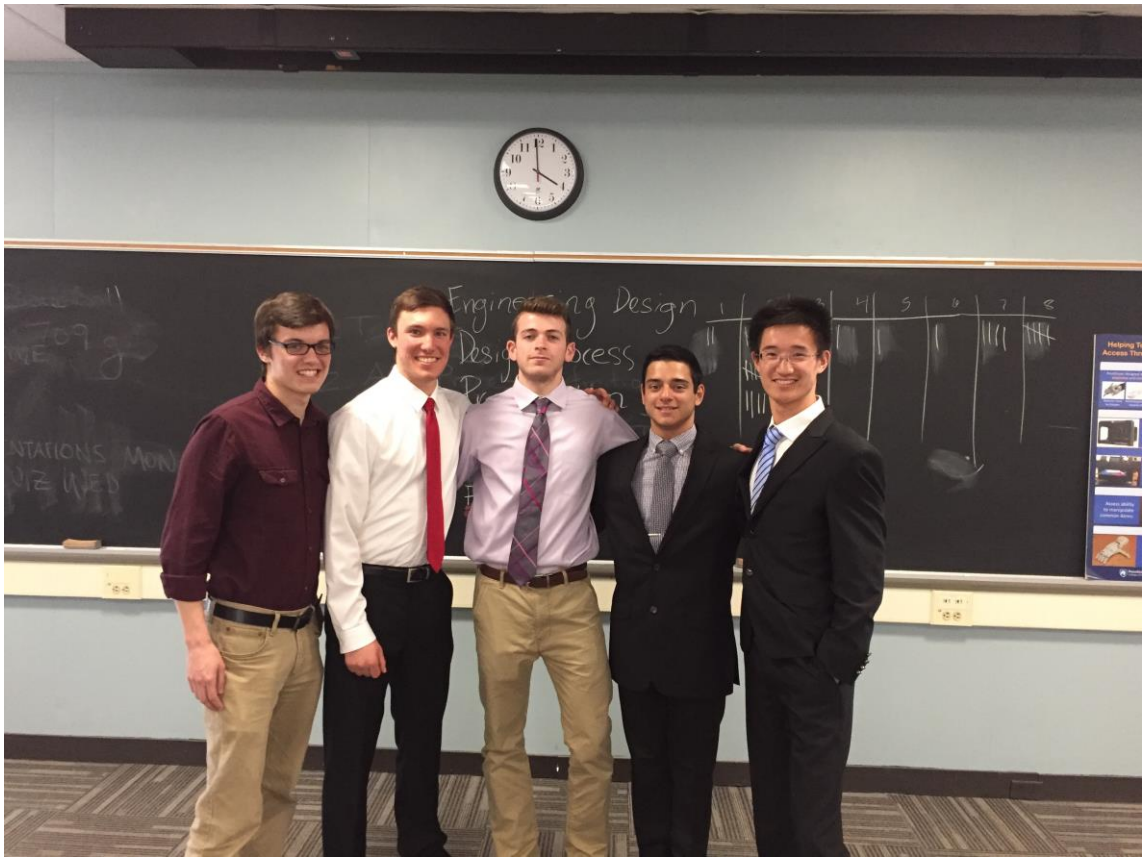
Sensitive Payload Shock Absorber Design Project 2: “The Hawktail”

Introduction to Engineering Design 100, Section 9



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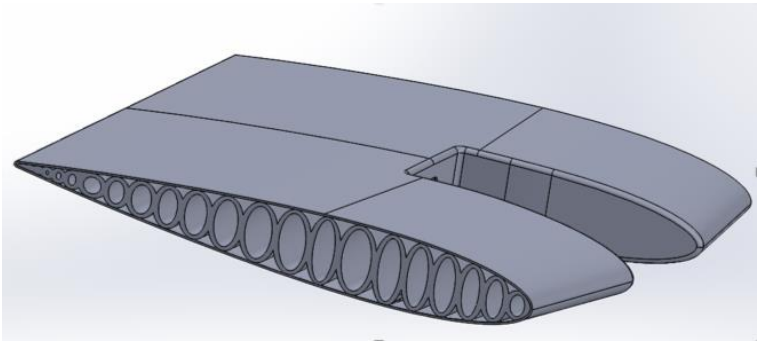

Abstract:

This report details team 4's effort to create a sensitive payload shock absorber that can withstand more than ten landings. Many ideas were brought forth and the team selected the best one. A design had to meet certain criteria in order for team 4 to decide to 3D print it. Once the design was printed a series of tests were done to prove its efficiency.

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Introduction:

We were tasked with coming up with a solution for one of five problems presented to us by the project sponsor Lockheed Martin. The first project is redesigning an existing heat exchanger for an AM. For this project cost and building time must be taken into account. By redesigning an exchanger for an additive could decrease the lead times from multiple months to several weeks. The second project is to design a new backshell, which is a custom wire connector. The current problem is that there are issues separating signals coming out of the electronics assembly and into the harness. The newly designed shell should be able to effectively separate signals coming into and out of the box it is attached to. The next project is to redesign a USB hub mounting bracket. The purpose of this is to reduce the total number of parts required to this assembly. The design is used as a debug and auxiliary mounting device for custom avionics mission system. The next project is simply to design a new additive. Lockheed Martin would like for this project for students to look at their commercial products and pick something they think they can improve and do it. The final of the five projects and the one our group is doing is redesigning a payload shock absorber for an Unmanned Aerial Vehicle (UAV). We are going to redesign the inside to better transfer and distribute the shock loads from the tail to the elevator.

Problem Statement:

Lockheed Martin is in need of a sensitive payload shock absorber that is both lightweight and strong in order to withstand a minimum of 10 hard landings.

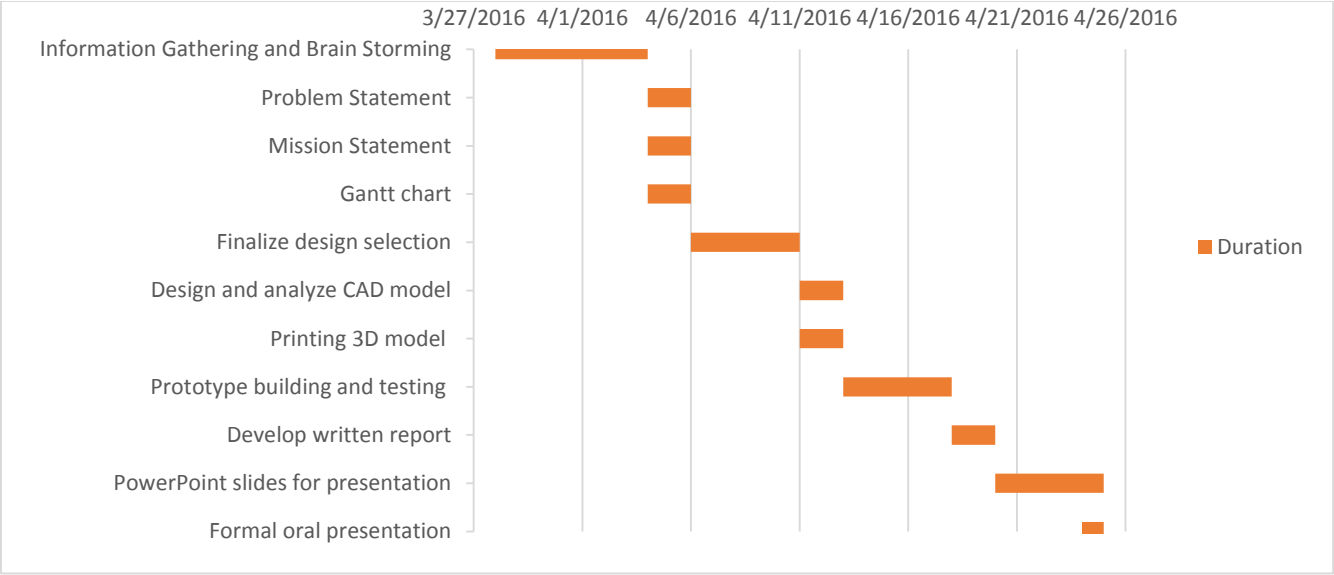
Mission Statement:

To design a new payload shock absorber for the tail of a Lockheed Martin UAV and to build a prototype.

Design Specifications:

The new sensitive shock absorber design must be durable; which means it must withstand 10 hard landings. Must be light/low weight. The design must have a strong internal structure, low cost, and easy to manufacture.

Gantt Chart:



Description of Sketches:

Figure 1 (A)- has a checkered design. It includes supports running horizontally as well as vertically to distribute pressure applied from any side.

Figure 2 (B)- has a cross supported design. As opposed to sketch A that has supports running horizontally and vertically, these supports run on angles in all directions in the shape of X's in order to help distribute pressure applied from any angle.

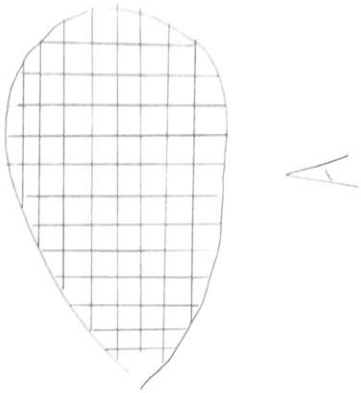
Figure 3 (C)- has triangle shape arranged beams as its design. This design was created to help balance the interior shock load as opposed to the first two designs, which allow the shock from impact to run throughout their entire interior.

Figure 4 (D)- This design incorporates "tire" shaped structures inside the tail section that reinforce the outer structure and distribute the shock.

Figure 5 (E)- This design incorporates rubber beams. They run vertically throughout the structure to absorb shock from landing.

Preliminary sketches:

Figure 1



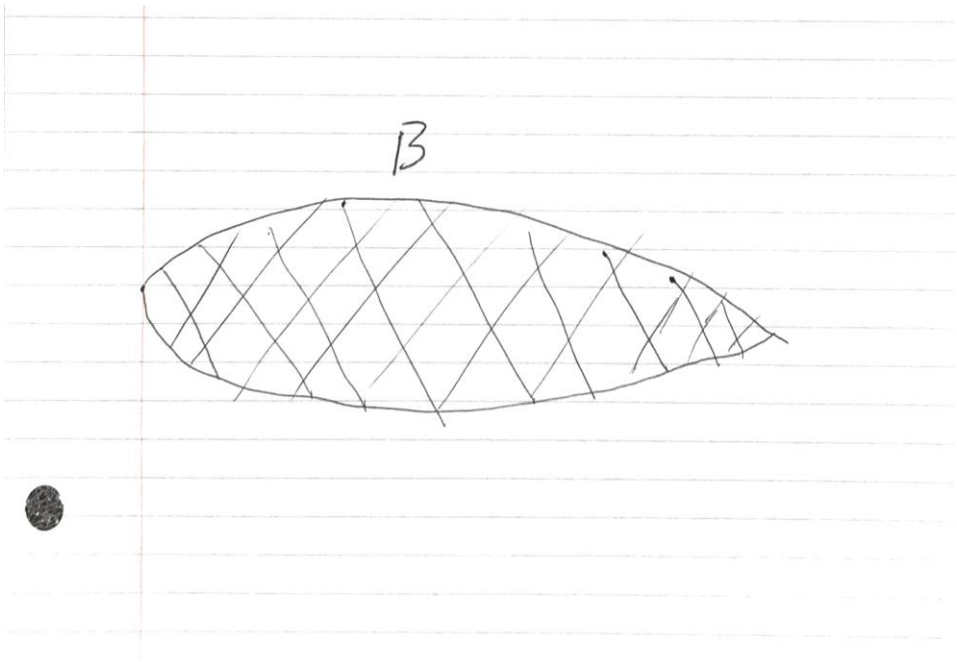


Figure 2

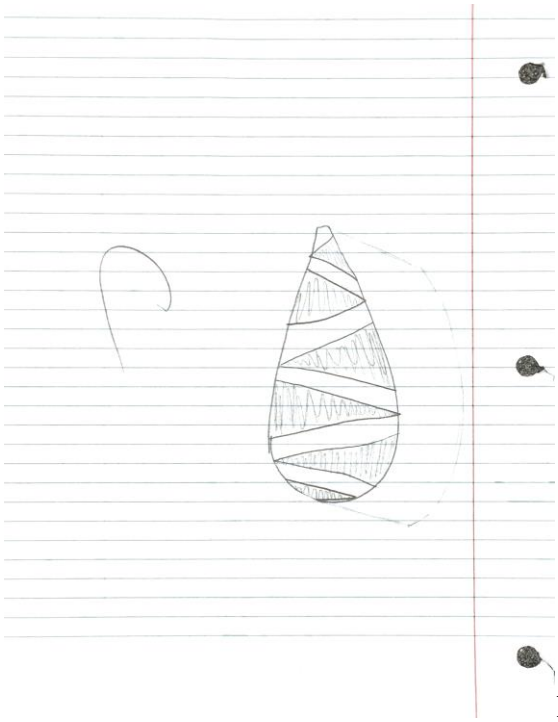


Figure 3

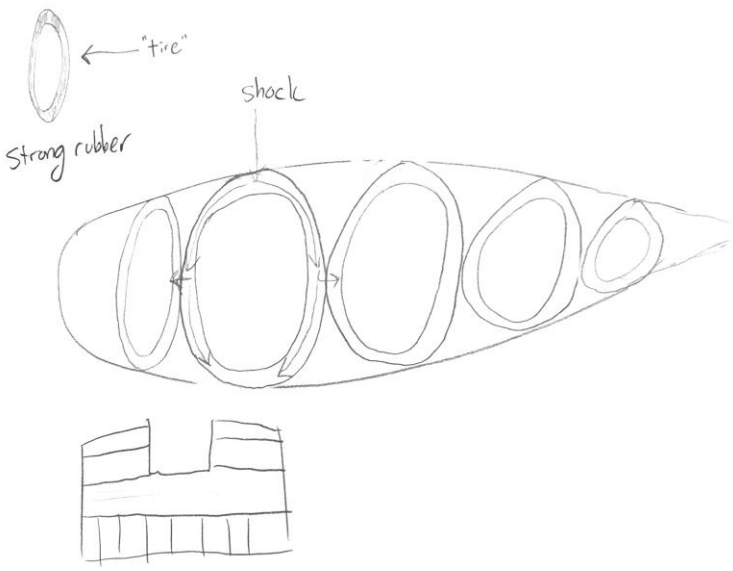


Figure 4

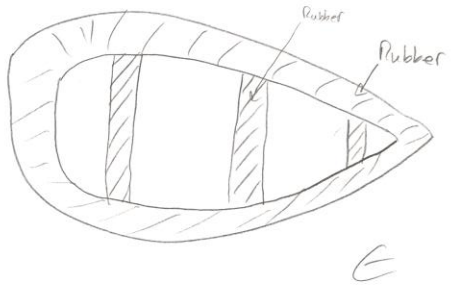


Figure 5

Rationale for the Problem:

We chose this problem because it seemed the most interesting project. Some members of our groups are interested in aeronautics and this project challenged our creativity.

Selection Criteria	Weight	A		B		C		D		E	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
Durability	25%	2	0.5	2.5	0.63	3	0.75	4	1	3	0.75
Weight	20%	3.5	0.7	3.5	0.7	3	.6	3	.6	2	0.4
Internal Structure Strength	35%	2.5	0.88	3	1.05	3.5	1.23	4	1.05	2	0.7
Ease of Manufacturing	10%	1	0.1	1	0.1	2.5	.25	3	.3	2	0.2
Cost Efficiency	10%	2	0.2	2	0.2	1.5	.15	2	.2	2	0.2
Total Score Rank		2.38		2.68		2.98		3.15		2.25	
Continue?		NO		NO		Yes		Yes		No	

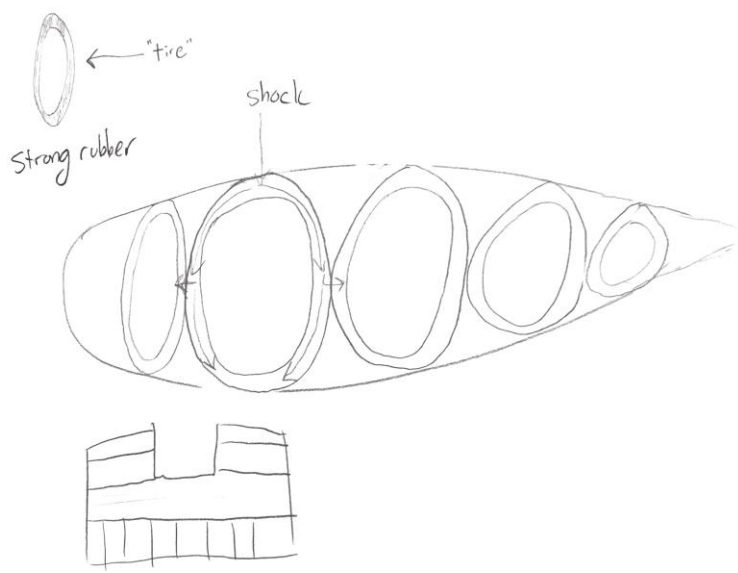
Table 1

Selection Criteria	A	B	C	D	E
	Rating	Rating	Rating	Rating	Rating
Durability	(-)	(-)	0	(+)	(-)
Weight	(+)	(+)	0	0	(+)
Internal Structure Strength	(-)	0	(+)	(+)	0
Ease of Manufacturing	(-)	(-)	(-)	0	(-)
Cost Efficiency	(-)	(-)	(-)	(-)	0
Sum+	1	1	1	2	1
Sum0	0	1	2	2	2
Sum-	4	3	2	1	2
Net Score	-3	-2	-1	1	0
Rank	5	4	3	1	2

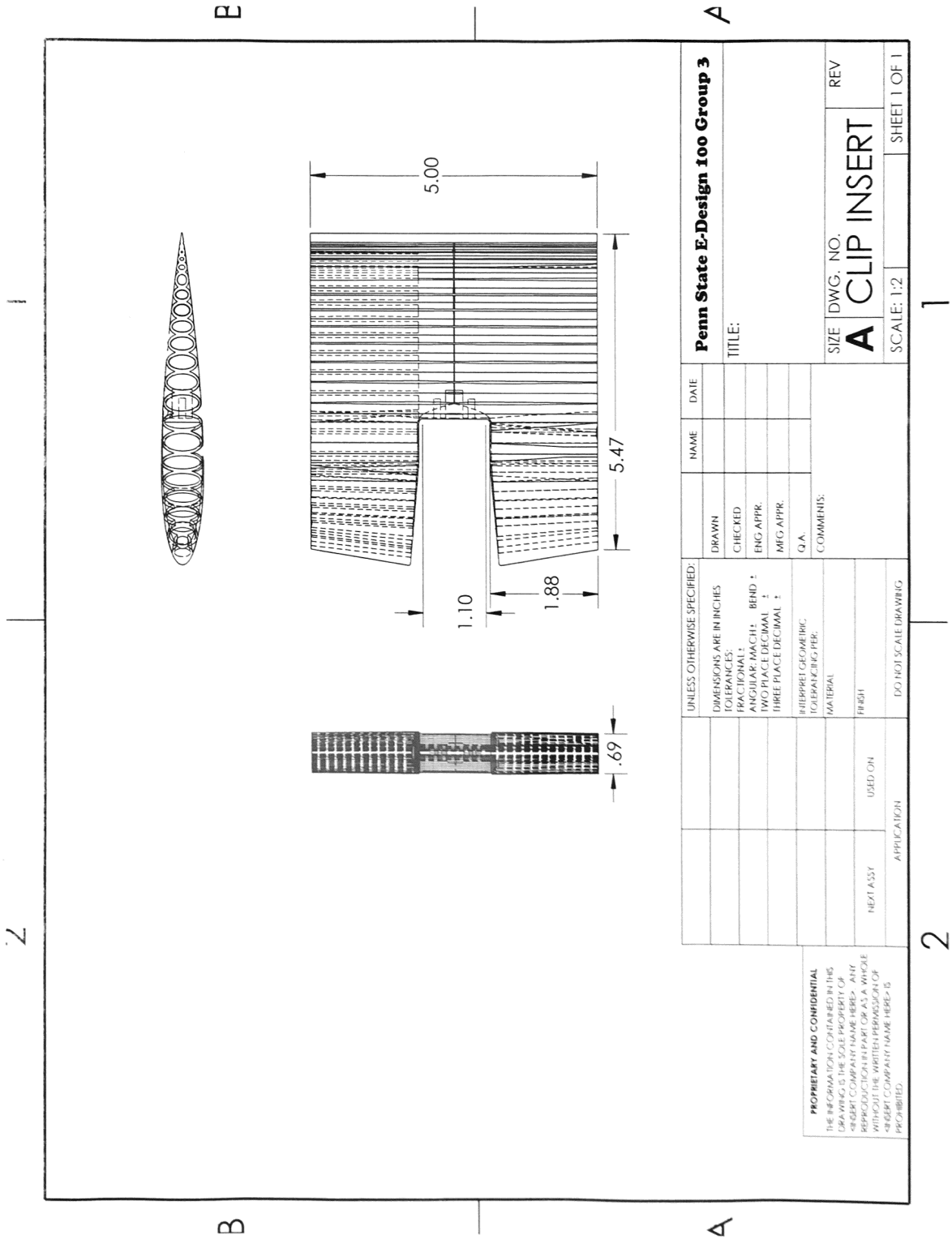
Selection Matrices:

Table 2

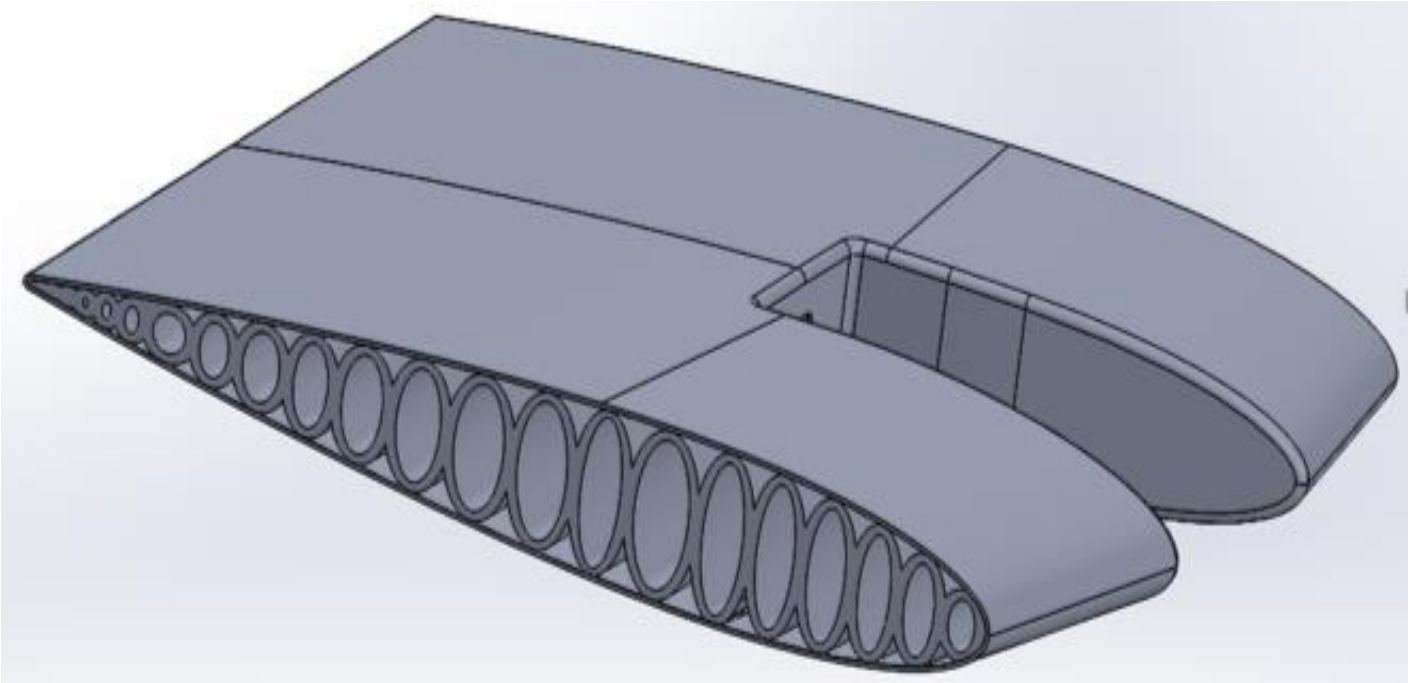
Best Design (D) (Redrawn below): Design D is exceptionally durable and ranks the highest in internal structure strength. These are two key areas that are critical to the success of this project. Design D also does well in all other areas, and it was therefore selected as the best design with which to proceed. The design differs from the other three in that all material is removed from the inside of the structure and replaced with new material crafted specifically to most effectively absorb shock. The design features tire-shaped structures made of strong rubber that are tightly packed inside the aircraft's tail. When impacted, these structures will absorb and distribute the force of the shock amongst themselves, significantly reducing the stress applied to the outer tail structure. This design not only effectively distributes shock, but it *reinforces* the entire outer structure.



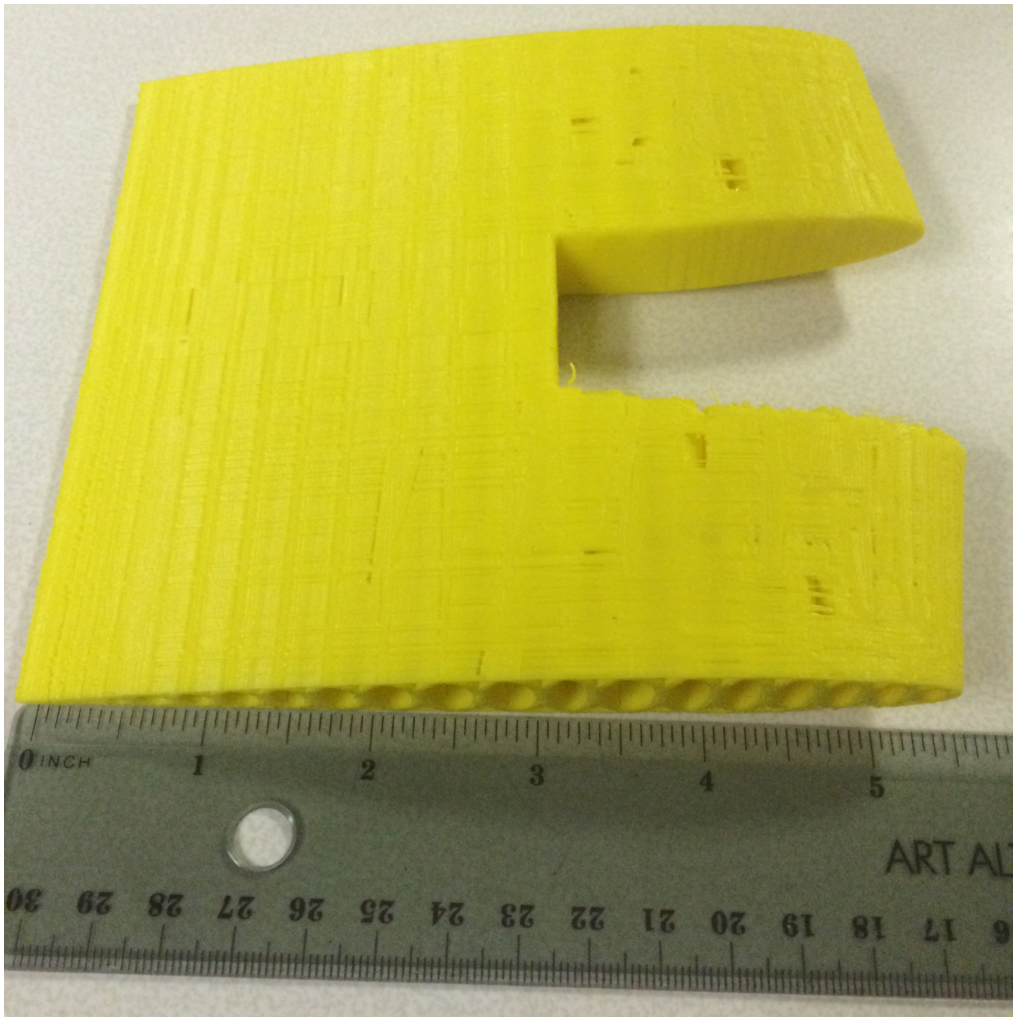
Relevant Design Drawings:

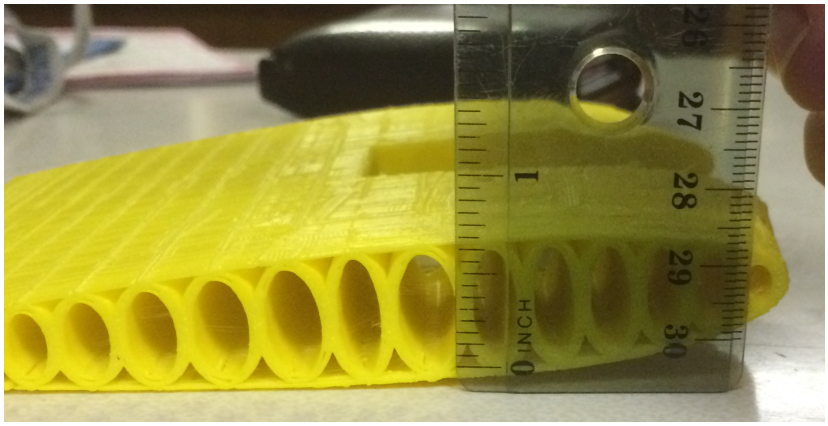


3D Model:



Printed Model





Design Features:

- High internal structure strength
- Exceptionally durable
- Relatively lightweight
- “Tire” shaped structures tightly packed to absorb and distribute impacts
- Shock evenly distributed throughout the length of the tail

Analysis: Of course we cannot attach our design to the back of a real UAV to test it, however we do believe that our design would withstand the minimum of 10 hard landings. The critical difference between our design and the original is the increase in internal strength. Our design has many small rubber tires all packed together on the inside. This strong compact design allows for any shock applied to any part of the surface to be evenly distributed throughout the piece. This prevents stress from being concentrated in just one area and will effectively increase the life span of the UAV part.

Summary/Conclusion:

Building a shock absorbing device for this UAV has been a mostly successful project. The design is extremely favorable with regard to Lockheed Martin’s key requirements: durability, internal structure strength, cost, weight, and ease of manufacturing. The entire process, from brainstorming preliminary sketches to working out the intricacies of the final design on Solidworks, was both challenging and rewarding. It allowed the group to gain valuable insights into the design of unmanned aircraft and the additive manufacturing process.

Power Point: To see our Power Point presentation that was given in class please view the slides posted below.

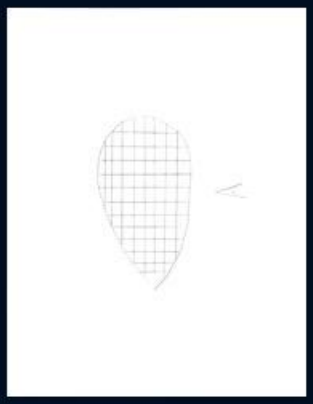
- Lockheed Martin project 3: Sensitive Payload Shock absorber
- Lockheed Martin produces a lot of Unmanned Aerial Vehicles (UAV's) that experience a large shock upon landing.
- Parts must be lightweight and durable.

Tasks

- Shock absorber to distribute shock from tail to elevators
- Must withstand a minimum of 10 hard landings
- As with all parts of a UAV, must be lightweight
- Should be low cost and easy to manufacture

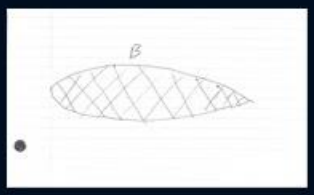
Design A

- Horizontal & vertical supports



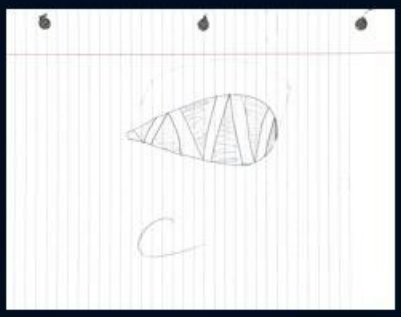
Design B

- Cross-supported design
- Supports run at all angles in X-shapes



Design C

- Supports run across the interior in the shape of triangles



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Durability	25%	2	0.5	2.5	0.63	3	0.75	4	1
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Ease of Manufacturing	10%	1	0.1	1	0.1	2.5	.25	3	.3
Cost Efficiency	10%	2	0.2	2	0.2	1.5	.15	2	.2
Total Score Rank		2.38		2.68		2.98		3.15	
Continue?		NO		NO		Yes		Yes	

Our Reasoning

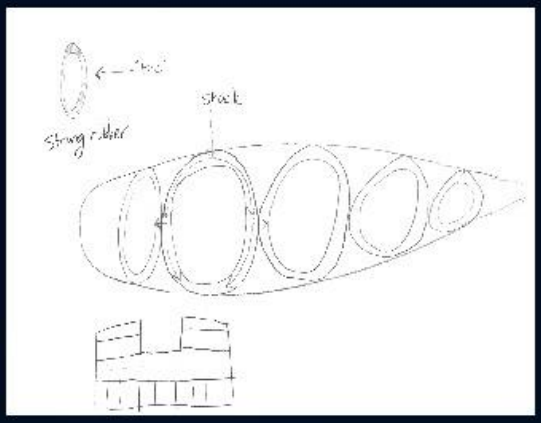
- Arches distribute pressure through structures—they are a common design in bridges.
- Larger degree of curvature=more stress on underside of arch.

SYLVAIN SONNET/PHOTOGRAPHER'S CHOICE/GETTY IMAGES

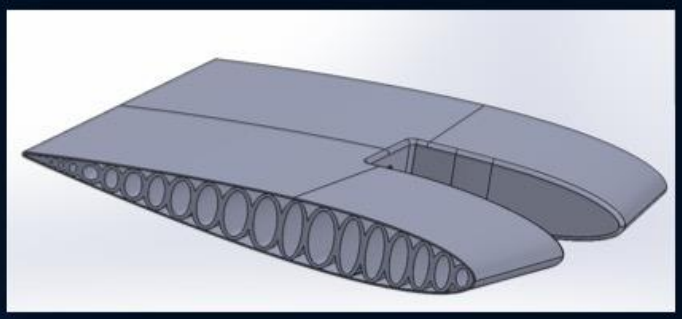
Source: howstuffworks.com

Final Design

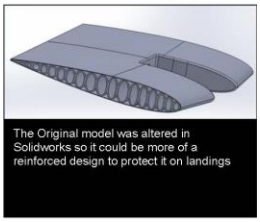
- Extremely durable
- Strong internal structure
- Lightweight
- Inner material removed & replaced
  - "Tire" shaped, tightly packed structures reinforce tail



Finished Product



Brochure: To see our Brochure we have put together for our presentation please view images below.



The Original model was altered in Solidworks so it could be more of a reinforced design to protect it on landings

About the Final Design

- Extremely durable
- Strong internal structure
- Lightweight
- Inner material removed & replaced
- "Tire" shaped, tightly packed structures reinforce tail

Group 3 Members

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Company Name

Group 3, E-Design 100, Section 9

The Aspects and Tasks of the project

- Lockheed Martin project 3: Sensitive Payload Shock absorber
- Lockheed Martin produces a lot of Unmanned Aerial Vehicles (UAV's) that experience a large shock upon landing.
- Parts must be lightweight and durable.
- Shock absorber to distribute shock from tail to elevators
- Must withstand a minimum of 10 hard landings
- Should be low cost and easy to manufacture

LOCKHEED MARTIN DESERT HAWK III

SYLVAIN SONNET/PHOTOGRAPHER'S CHOICE/GETTY IMAGES

Design Reasoning

Arches distribute pressure through structures—they are a common design in bridges.

Larger degree of curvature=more stress on underside of arch.

Tires can keep their shape with the compressed air pushing out on the walls of it.

Selection Criteria	Weight	A		B		C		D	
		Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score	Rating	Weighted Score
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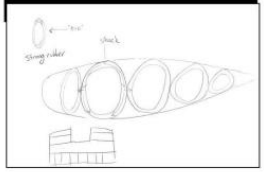
Total Score Rank		2.28		2.68		2.98		3.15	
Continue?		NO		NO		Yes		Yes	

Design Matrices

- Design A = Horizontal and Vertical Supports
- Design B = Cross Support Design
- Design C = Interior Supporting pyramids
- Design D = Final Design

Final Design Concept Drawing



Acknowledgements: First we would like to thank Lockheed Martin for sponsoring our design project and presenting us with the different design problems. We would also like to thank our professor Xinli Wu for teaching us the necessary skills to complete this task and helping us along the way. Lastly we would also like to thank our teaching assistants Jarod Barone and Paul Perreault for helping us along the way.

References:

Lockheed Martin website: http://www.lockheedmartin.com/us/innovations.html

Video of UAV landing: https://www.youtube.com/watch?v=LOu66gSPw08