

Lockheed Martin

Team IDK

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Abstract

Lockheed Martin has developed several different kinds of unmanned aerial vehicles that undergo harsh forces when they are landing. The tail of the UAV is particularly vulnerable to the impact upon landing so an internal member has to be created to protect the tail from sustaining damage. This internal member must be able to protect the tail on landing as well as be light enough to not hinder flight. The volume must fit within the tail of the plane and created at remote location by the process of additive manufacturing.

While designing the shock absorber, there were many criteria that had to consider. All of the customer needs had to be met when the final product was completed. Factor pertaining to material, shape, cost, and weight were just some of things that had to be decided to best meet our needs. Lockheed Martin needs this design by April 27.

Introduction

The Lockheed Martin based project we are focusing on revolves around Unmanned Aerial Vehicles. For this project, we have been given the task to develop an internal mechanism that will protect the tail of our UAV, which we have chosen to be the Dessert Hawk III. Like any aircraft, once it has left the surface of the Earth, it has to land at some point. With any landing, high levels of impact take a toll onto the aircraft once it actually touches the ground. The primary focus of this project is to transfer and distribute the shock loads from the tail to the elevator of the aircraft. In order to achieve this, we will be implementing additive manufacturing to produce a lightweight and more efficient product. Our UAV must be designed to withstand multiple landings. The internal compartments of our design have to fit within a certain volume and be created from a 3D printer.

While designing the shock absorber in-between the envelopes, many factors had to be considered. Defining our customer needs, and making sure that the shock absorber fulfilled the requirements made by Lockheed Martin was crucial. Since our UAV is roughly 8 pounds, the structure has to be as light as possible. In order to achieve minimum weight, we chose to use high density foam because of its lightweight and strong properties.

Many problems can arise from our prototype design. The internal member has to be light yet strong at the same time. If the internal component isn't strong enough the tail of the aircraft can begin to vibrate and hinder the performance of the aircraft. The risk of our internal member failing must be minimal so that the aircraft will not sustain any major damage. Because the product can be developed through additive manufacturing, it can be produced anywhere.

Mission Statement

Our mission is to build an internal shock absorber that can fit inside the tail of the Dessert Hawk III in order to transfer the shock loads from the tail to the elevator.

Customer Needs Analysis

Customer Needs	Customer Statements	Metric	Unit
Survive multiple landings	Internal member protects tail wing from damage	number of landings without any damage	
Lightweight	light materials and trusses will reduce overall weight	overall weight of internal member	kilogram
Must fit a certain volume	Additive manufacturing has precise measurements	length and width of internal member	meter
Absorb high amounts of shock loads	Rib-like structures will support the tail and envelopes	maximum amount of force without damage	newton
Reasonable cost	Additive manufacturing is cheap and assessible	cost to build one unit	dollar
Distribute the shock loads from the tail to the elev	Truss layout will effectively distribute the stress evenly throughout the tail	amount of force evenly distributed	newton
Durable	Aluminium is a strong light metal that should be able to handle large amount of forces	amount of tension, compression it can withsta	newton

Establishing our customer needs was absolutely crucial in order to accomplish this project.

However, luckily we did not have to dig too deep in order to find them. Since this project is sponsored by Lockheed Martin, right off the back we were able to determine our customer. And to no surprise, it was Lockheed Martin itself. To develop this internal shock absorber, we were given Lockheed Martin's statement of work which in essence told us what to do. Inside this

statement of work, we were able to pick and choose the needs specified by Lockheed. Some of the needs that stood out the most were cost, weight, volume, and durability. Once we gathered our customer needs, we then translated them into need statements as you can see above. From there, we then established target specifications which consisted of a metric and a value. After completely defining and analyzing our customer needs, we began our project; first b conducting research

External Research

Internal Structure of a wing:

- Composed chiefly of spars, ribs, and possibly stringers

Spars:

- Main members of the wing
- Extend lengthwise of the wing.
- All the load carried by the wing is taken by the spars. In flight, the force of the air acts against the skin. From the skin, this force is transmitted to the ribs and then to the spars.

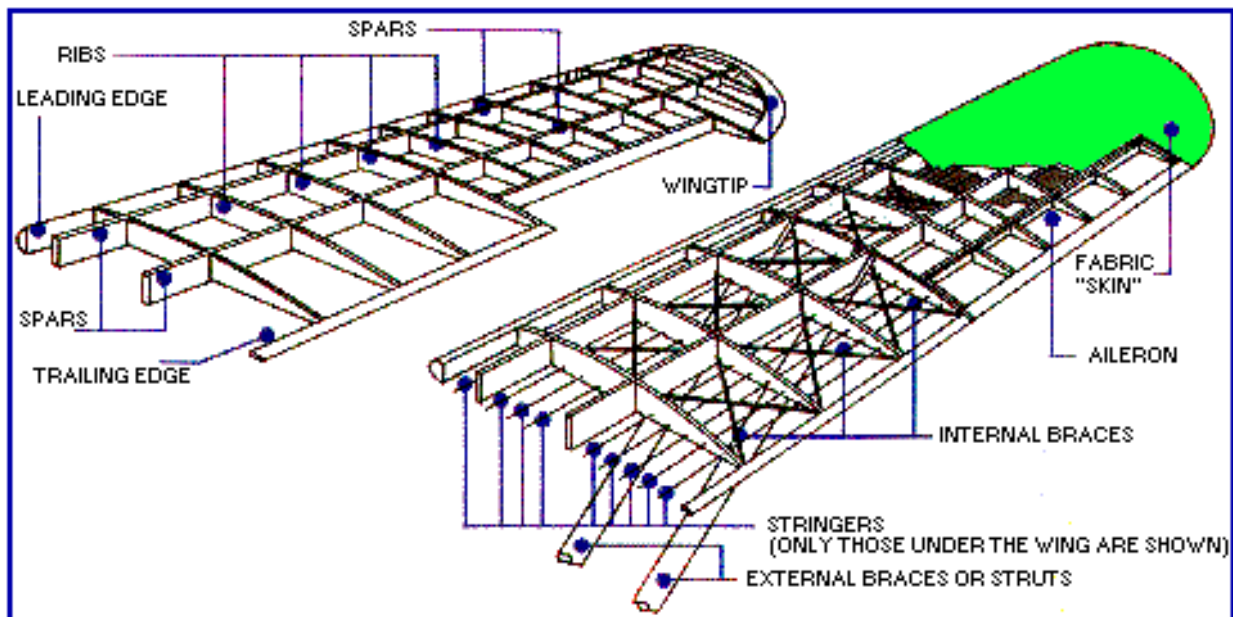


Figure 1-5 Wood-and-fabric wing structure

- Wing structures have two spars, the **front** spar and the rear **spar**.
 - The front spar is found near the leading edge
 - The rear spar is located two-thirds the distance to the trailing edge.

Ribs:

- Parts of the wing that provide overall structure, also called forming ribs.
- Some ribs are designed to bear flight stress; these are called compression ribs.

The Tail of an Aircraft:

- The tail of the aircraft provides stability and control for the aircraft.
- The empennage is comprised of two main parts: the vertical stabilizers (fin) in which the rudder is attached and the horizontal stabilizer where the elevator is located.
- The rudders control the yaw of the aircraft
- The elevator controls the pitch
- The front section of the tail is called the tailplane.
- The rear section is called the elevator
- The fin of the aircraft is used to restrict side-to-side motion of the aircraft.
- The rudder, a movable aero-foil that is used to turn the aircraft's nose to one side or the other

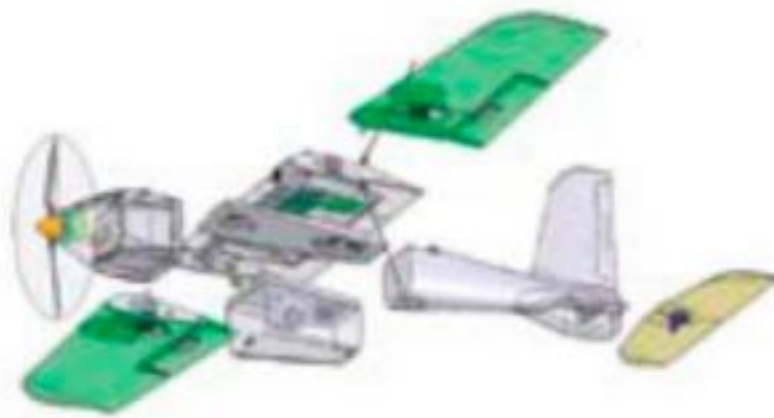
Desert Hawk III:

- Small unmanned aircraft system (SUAS) designed to conduct real-time surveillance with operational ease.
- Employed in support of combat missions since 2005

System Specifications:

- Propeller Blades – 2
- Dimensions
 - Length – 2.81 foot (33.7 Inch)
 - Wingspan – 4.30 foot (52 inch)
- Weight – 8.2 pounds
- Endurance – 1.5 hours
- Cruise/Dash speeds – 25/50 knots
- Payload – 2 pounds
- Cost - \$224,000

Desert Hawk III UAS Description:



Desert Hawk III Air Vehicle

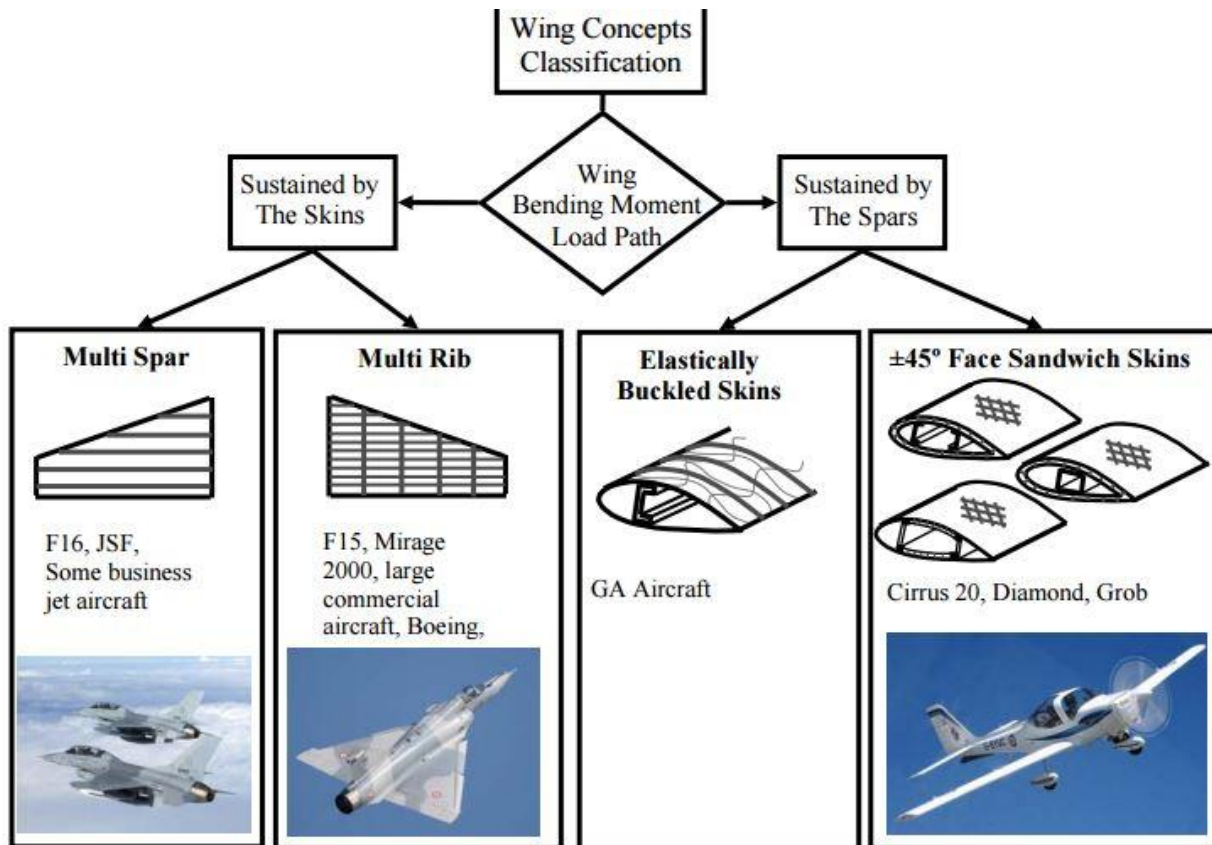
- The DH3 is made of special polypropylene materials
- Polypropylene provides for more flexibility and durable finish
- Kevlar skids located on the nose of the aircraft and its tail are used for enhanced durability.

Multi-Spar Construction:

- Multi-spar construction of a wing consists of using three or more spars

Advantages:

- Ease of manufacturing the panels
- Simple design and ease of ribs` sealing;
- Increased stiffness of the outer wing panel, which is important when using composite materials for the designed structure
- Rational technological spacing of manholes at the bottom panel due to the small number of ribs



Concept Generation

Metrics	number of landings before breaking	weight of internal member	length and width of internal member	maximum newtons of force	cost of internal member	Force per area	amount of time before internal member breaks
Needs							
The internal member will survive multiple landings	x						
The internal member is lightweight		x					
The internal member fits a maximum volume			x				
The internal member can absorb a high amount of shock				x			
The internal member is affordable to develop					x		
The internal member can distribute shock from the tail to the elevator						x	
The internal member will be durable for long periods of time							x

To come up with designs for our shock absorber, we got together and brainstormed ideas that would best meet our customer needs. Most of the design ideas came from our external research. There were a wide variety of ideas for the design that could be used in our final product. All the

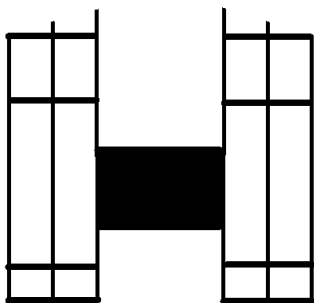
design ideas were similar in that they were all made to make the shock absorber lighter while maintaining strength. There were a total of four different designs created from brainstorming and research.

Concept Selection

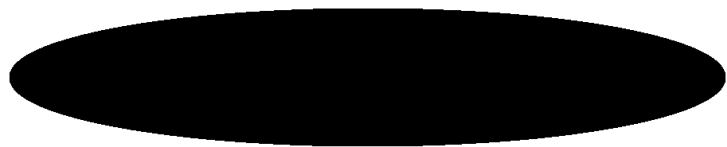
Selection criteria	1	2	3	4
cost	+	+	-	-
stability	+	0	+	-
efficiency	+	0	0	0
weight	0	+	-	+
maintenance	0	-	+	-
sum +'s	3	2	2	1
sum 0's	2	2	1	1
sum -'s	0	1	2	3
net score	3	1	0	-2
rank	1	2	3	4
continue	yes	no	no	no
selection criteria	aluminium	foam	polypropylene	steel
cost	-	+	+	+
weight	-	+	0	0
flexibility	+	0	-	-
strength	+	0	0	+
sum +'s	2	2	1	2
sum 0's	0	2	2	1
sum -'s	2	0	1	1
net score	0	2	0	1
rank	3	1	3	2
continue	no	yes	no	no

1

Front view

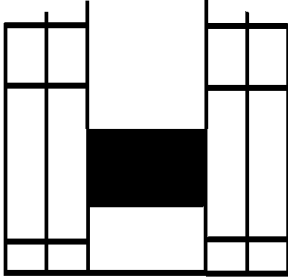


Side view

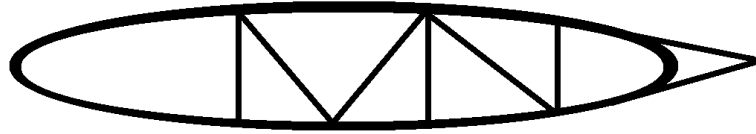


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Front view

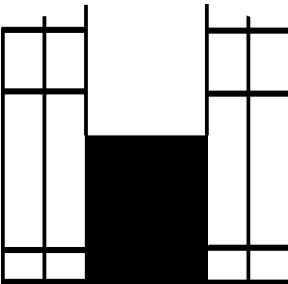


Side view



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Front view

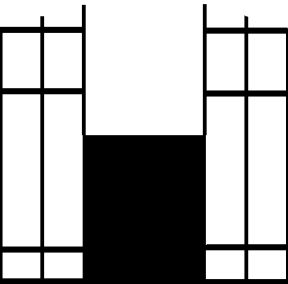


Side view

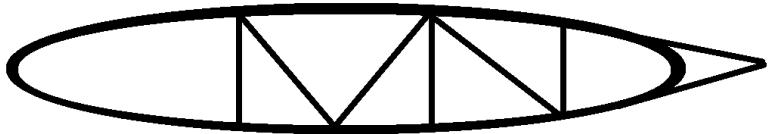


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Front view

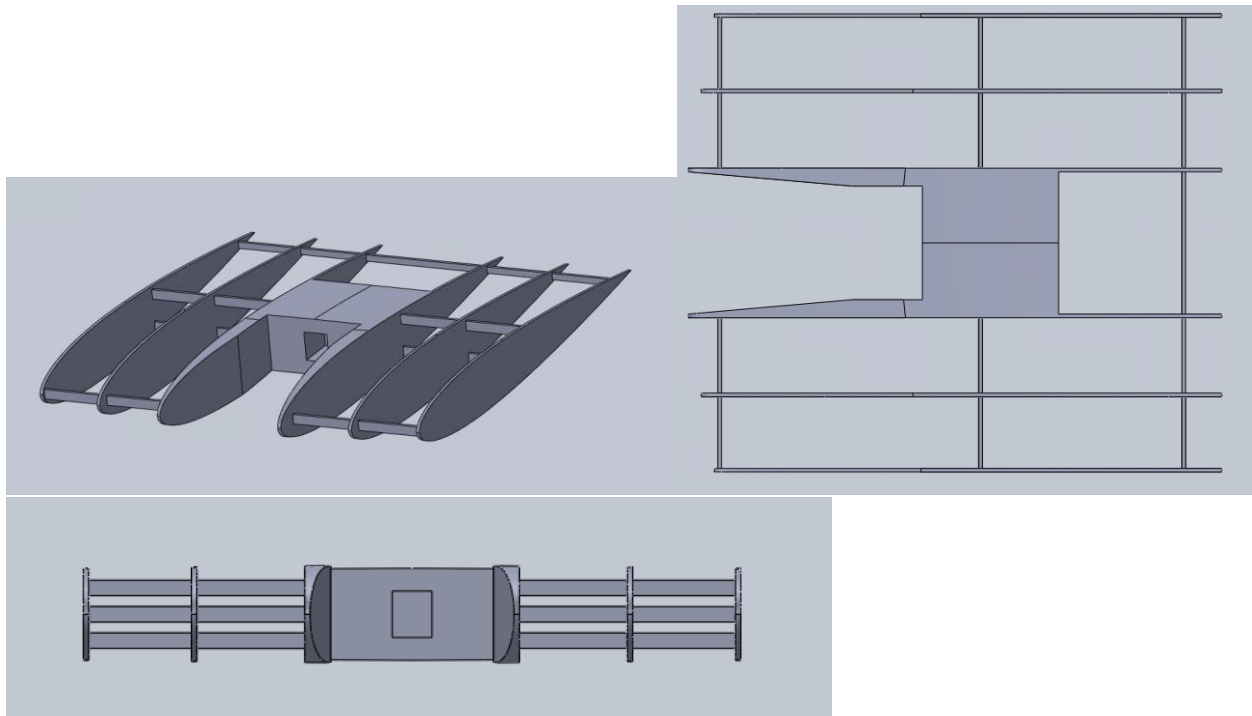


Side view

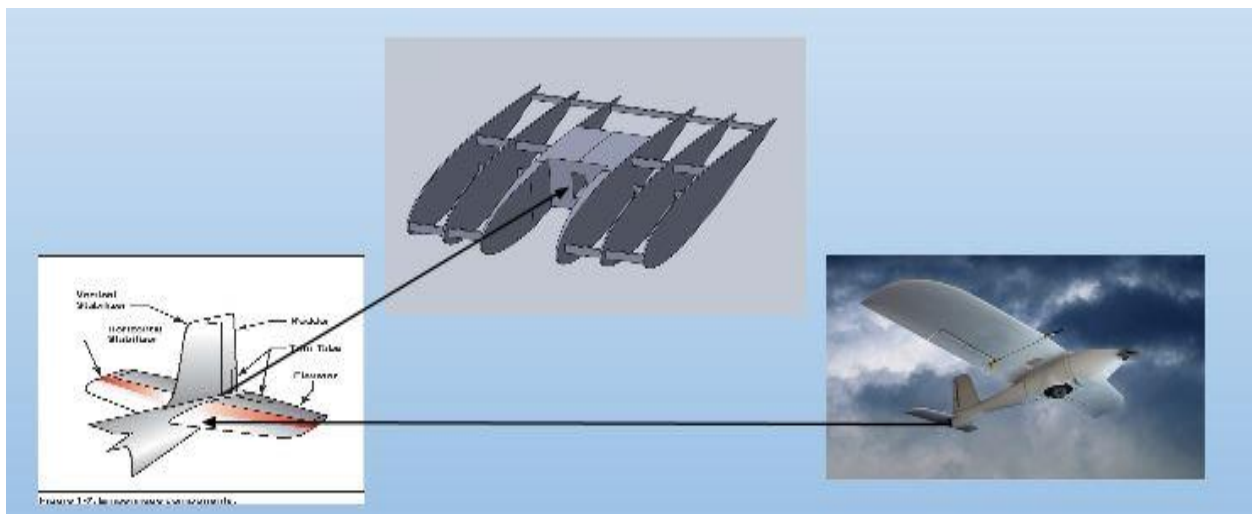


There were four different prototype designs that were created. A concept selection matrix was used to determine which design would be best suited to meet the customer needs. Things we considered were weight, cost, and stability. These factors were used to compare the strength and weaknesses of each design.

Design



The final design for our prototype is a balance of strength and lightweight characteristics in which we ultimately chose to utilize multi-spar construction methods. The ribs are solid to keep it from bending from the forces of the air. The spars keep the ribs together and distribute the force evenly throughout the internal member. The centerpiece of the shock absorber is hollow to decrease weight.



Conclusion

Throughout the course of designing the shock absorber, many different steps were needed to be taken in order to successfully organize our group for success. The unmanned aerial vehicle needs to have an internal member that could keep the tail of the plane from taking any damage upon landing. The mission for our group was to design an internal member that can protect the tail on landing without hindering the UAV during flight.

The process for designing our internal member required an extensive amount of research. Everything from aerodynamics to materials was researched to get an understanding on how to design our shock absorber. After that, our group brainstormed ideas based on the research we gathered. Then a concept selection was used to rank the different prototype design. The best design was created into a CAD model and sent to a additive manufacturing program to then be turned into a 3D model.

In conclusion, the final design of the shock absorber meets all the requirement to protect Lockheed Martin's UAV. The printed 3D model didn't come out perfectly, but the model shows that it can be created in the appropriate size and shape. The Lockheed Martin project came out to be successful.

References:

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