PennState College of Engineering | ENGINEERING DESIGN, TECHNOLOGY, AND PROFESSIONAL PROGRAMS

Technical Memorandum
No. EDSGN100.002

Date: April 25, 2016

To: Lockheed Martin Corporation

From: EDSGN100 Section 002
Design Team 5
Carolyn Baker
Shelby Quick
Ricardo Branco
John Guglielmi

Subject: Penn State University
EDSGN 100: Introduction to Engineering Design
Client-Driven Design Project, Spring 2016

Purpose. The purpose of this Memorandum is to discuss and analyze the proposed UAV (unmanned aerial vehicle) part in order to determine if it is ideal for implementation. The goal looked to be achieved is to utilize additive manufacturing to improve the current UAV elevator design and connection. Possible improvements include a decrease in weight, an increase in function, a decrease in cost, or the like.

Background. The Lockheed Martin UAV model we are analyzing lands in a way such that most of the parts are disassembled during the impact. This is a controlled landing, and by separating most parts upon reaching the ground, some stress is avoided in the UAV's parts. However, due to the impact, most of the members and the connections will potentially suffer a moderate amount of stress. In our project, we will focus solely on the elevator part and its connection with the back of the UAV. Our objective will include building a complementary part that will fit between the elevator and the tail of the plane that will primarily serve as a stress reliever.

Sponsor. Lockheed Martin is a global security and aerospace company that is principally engaged in the research, design, development, integration, and sustainment of advanced technology systems. They produce a large variety of products in use all over the world and have facilities across the country, with their headquarters in Maryland. Lockheed Martin is a large defense supplier to the United States government, making the majority of their products and services military-oriented. Because their products are being utilized in harsh environments, the company is working towards expanding their range of manufacturing--incorporating additive manufacturing--to make parts available and ready more easily.

Project Description. Out of the five presented options, the UAV project peaked our team's interests and allowed for the greatest flexibility while still giving a set of guided directions. Lockheed Martin has several UAVs that experience high shock loads upon landing. These UAV parts must be as lightweight as possible yet strong enough to handle the harsh landing

conditions. The project was to develop an internal member to transfer and distribute the shock loads from the tail to the elevator and the work would involve the following: designing a structure that can survive multiple landings and that will see bending moments acting on the lever and fastener holes, additively building structures that are not limited to lab or factory production, lightening the structure's weight to improve the UAVs' maximum flight time and payload, and fitting the structure within the provided volume.

Procedures. The UAV sees bending moments where the tail connects to the rear elevator through its lever arm and fastener holes during landing. The design team decided to minimize the force between the tail and rear elevator during landing by eliminating those moments completely.

This was accomplished by a system that ejects the tail during the landing impacts. Within the connections of the tail and elevator, an additively manufactured spring and housing device now sits. The spring and housing device could be additively manufactured at a remote customer location. One end of the spring is attached to the housing and the other end is attached to a magnet which keeps the spring in compression. The magnet would be attached to the tail of the UAV while the housing would be attached to the elevator. The spring is to be made so that its spring constant, under compression, can eject the elevator from the tail of the UAV. The magnet is chosen so that it is greater than the force of the spring that it is holding in compression plus the maximum drag that could be applied to it during flight, but less than the impulse applied to it during a landing. This would ensure that the tail does not prematurely eject during flight.

During landing, the bending moments acting on the lever arm and fastener holes would shear the magnet from the housing, weakening the magnetic force holding the spring in compression. The spring force by the spring pushing against the elevator would now be stronger than the force of the sheared magnet holding it in compression and thus the tail would be ejected. The rear elevator, now freed from the tail of the UAV, sees no bending moments applied to its lever arm and fastener holes. The tail and elevator are still connected by the uncompressed spring so it is not lost during the landing event.

$F_{landing} > F_{magnet} > F_{drag} + F_{spring}$

Results and Discussion.

I. Conceptual Design

The design team began the first phase of the design process by analyzing the possible forces and stresses that the UAV may undergo during landing. After devising possible ideas for internal components to absorb shock during landing, it was determined that most UAV parts would suffer less damage if they came disassembled upon impact. The final idea for a spring and magnet based shock absorber was then discussed and refined, and a rendering of the prototype was created using SolidWorks 2015 (see attached Figure 2).

II. Analysis

The prototype is meant to fit into the elevator of the UAV (see attached Figure 1) as a small, lightweight component that can survive multiple landings. A spring fits inside the component and ejects the elevator upon impact. In doing so, the shock absorber not only endures much of the shock of landing but also removes all shock from the elevator.

III. Summary

A prototype of the shock absorber component was created using the Penn State MakerBot Innovation Center. The design team chose to create a spring and brace system as an internal shock absorber because it was determined that the structure, being a lightweight internal component, would not affect the flight of the UAV but would eliminate any stress felt by the elevator upon landing.

Conclusions and Recommendations. Ultimately the analyses done of the potential UAV part illustrate the innovative use of materials and additive manufacturing to maximize the UAVs' control in landing. The magnet and spring release system both improve the transfer and distribution of shock to the elevator, as well as provide a part that can be produced in any environment--not limited to labs or factories. Our group was happy to be given the opportunity to contribute our ideas and would gladly do the same, if requested, on any future endeavors. If any additional information is desired or needed please contact group member Shelby Quick at srq5015@psu.edu. Thank you again for this opportunity.

References.

I. EDSGN 100 Spring 2016 Client-Driven Design Project Statement of Work
II. Lockheed Martin Freshman Design Effort Project Listing: 14 Mar 2016

Attachments.

Figure Nos. 1 and 2 are attached.

*****

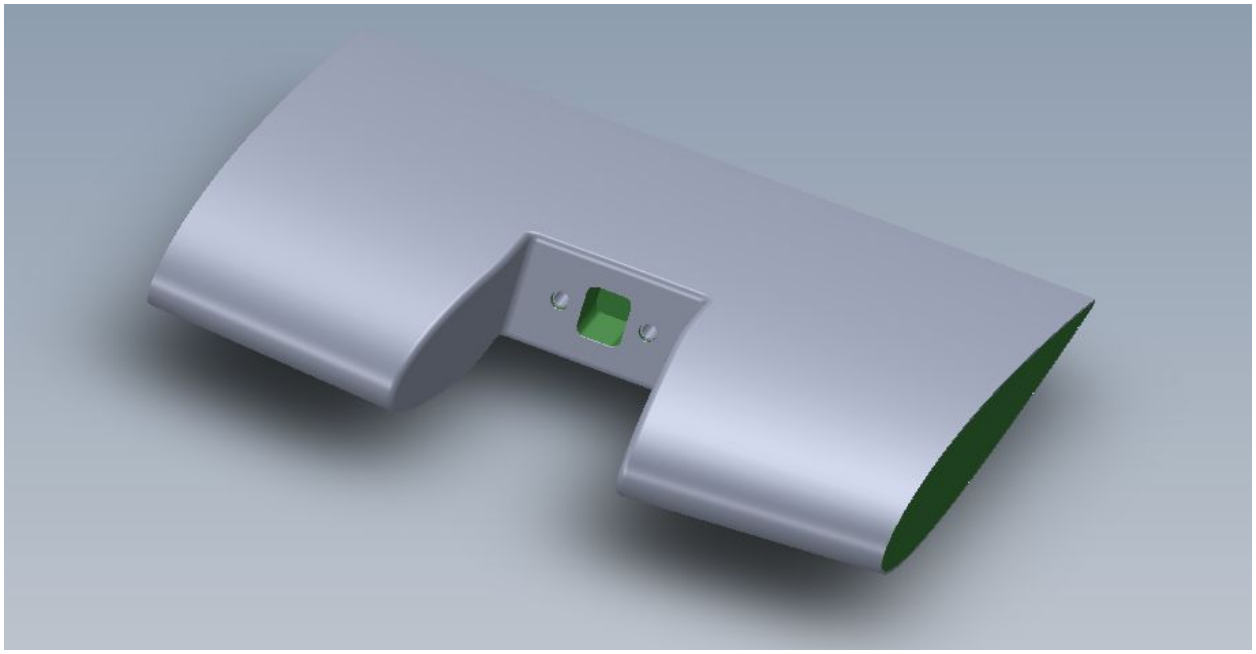

Figure 1. UAV elevator SolidWorks model

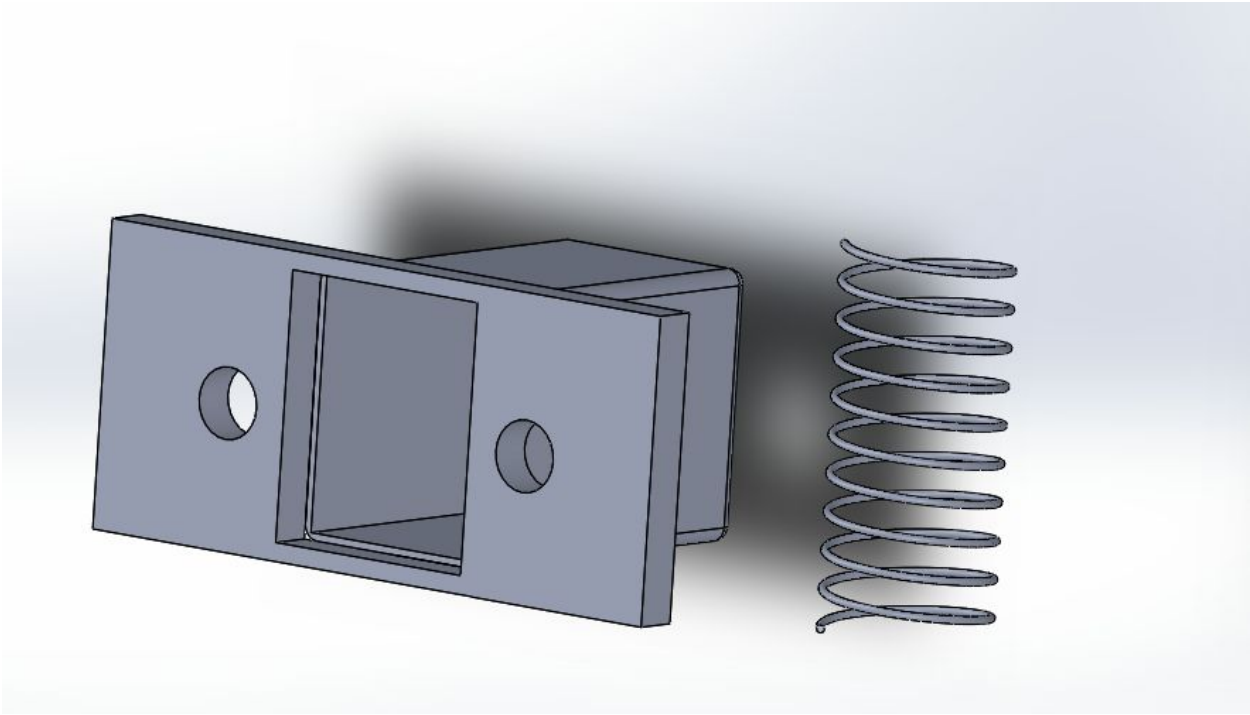

Figure 2. Disassembled shock absorber and spring component