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

Technical Memorandum

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To: Lockheed Martin Corporation

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

Purpose. The Purpose of this memorandum is to provide a solution for the problem given by Lockheed Martin. The problem for this project is to develop an internal member to transfer and distribute the shock loads from the tail to the elevator.

Background. Additive Manufacturing, or industrial 3D printing, is the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing (drilling, milling, grinding, or turning). In the aerospace industry, the most critical aspect of almost any design is the elimination of weight. Subtractive manufacturing methods start with more material then remove it to get to a finished shape. However, it is not always possible to remove all of the material due to limitations. With additive manufacturing, materials are added only in the required places, resulting in much lighter and more efficient results. Additive manufacturing is also used to create fixtures such as drill fixtures, alignment templates, custom hand tools, etc. very quickly and at significantly lower costs. Finally, it is being used to dramatically reduce weight on the products delivered to the customers and create new parts and structures that were never before possible.

Sponsor. The primary sponsor for the project is Lockheed Martin. Lockheed Martin is an American global aerospace, defense, security and advanced technologies company with worldwide interests. Its headquarters is located in Bethesda, Maryland. It is the world's largest defense contractor based on revenue for fiscal year 2014. Lockheed Martin also operates in Information Systems & Global Solutions, Missiles and Fire Control, Mission Systems and Training, and Space Systems.

Project Description. Lockheed Martin provides solutions across multiple lines of business. These lines of business (LOB) employ engineers of all disciplines, focusing on that LOB's unique area of expertise, be it air, land, sea, or space. Out of the five options provided, developing a shock absorber for an unmanned aircraft project seems to be something that can be really

useful in real life for many jobs. Thus, the reason for this project to be chosen out of the options provided. Lockheed Martin has several unmanned aerial vehicles (UAVs) that experience high shock loads upon landing. The UAV parts for the unmanned aircrafts must be as lightweight as possible yet strong enough to handle the harsh landing conditions. The purpose of the project is to develop an internal member to transfer and distribute the shock loads from the tail to the elevator. The tasks involved in the project is to find a material for the shock absorber, which is both lightweight and feasible. Then the last step will be to develop a shock absorber within the provided parameters with the material chosen.

Procedures. The first step in the project was to develop an internal member for the unmanned aircraft within in the parameters provided. The internal member was supposed to be installed in the elevator of the unmanned aircraft according to the parameters provided. The internal member does not have any restrictions in shape, but it must fit inside the elevator part. After several weeks of research, it was decided to create a design that would serve two purposes. First, the design must prevent the internal member from bending to avoid breakage. Second, the member must be long enough to disperse vibrations, which allows it to absorb the shock upon landing. Due to these requirements, a solid material would serve best, as opposed to some form of foam, which is also a common material for shock absorbers. A lightweight material would be needed to avoid interfering with flight, so a plastic would work better than a metal. After organizing the research materials, solid works would be used to design and create a prototype.

Results and Discussion. The design which satisfies the two requirements listed above is a rod. The rod connects the two pieces attached to the elevator, which prevents the member from bending, while dispersing the vibrations outwards to the ends of the rod. The design is shown in figures 2, 3 and 4. Figure 1 shows another type of plastic shock absorber. That design, however, is not suitable for the given problem, because it wouldn't be able to attach to both pieces of the elevator. It is also too large to fit inside the given area, and would be ineffective if it were adjusted to fit. The material used to make the shock absorber was decided to be Polyurethane, a polymer composed of organic units joined by carbamate links. Polyurethane is less dense and lightweight compared to metal. It is also cheap and flexible as compared to other materials used as shock absorbents. Polyurethane has a high load capacity in both tension and compression and may also undergo a change in shape under a heavy load, while will returning to its original shape once the load is removed. Polyurethane has high abrasion and impact resistance and it can withstand low temperatures. It also exhibits good electrical insulating properties. Since polyurethane has good shock absorbing properties with low density and economically affordable price it is decided as the material to be used for the internal member.

Conclusions and Recommendations. As stated earlier, the recommended design would be a rod made of polyurethane connecting the two pieces on the elevator. This additional piece would enable the elimination of bending/breakage as well as the dispersion of any vibrations. Trials would need to be implemented in order to test the success of the shock absorber. The design team would be more than willing to be involved in the trials, as well as follow up designs according to needed modifications. In order to reach us, Lisa Livote can be contacted at

lvl5360@psu.edu to discuss further involvement. We thank you greatly for this opportunity and hope to be hearing from you.

References. The project description and requirements can be found in the Design Project 2 Statement of Work, as well as the Lockheed Martin Presentation discussed in the Project Kick Off Meeting held on March 14, 2016. Details on the properties of polyurethane can be found at http://www.precisionurethane.com/urethane-advantage.html

Attachments. Figures 1, 2, 3, and 4 are included on the following pages.

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Figure 1. Typical Plastic shock absorber

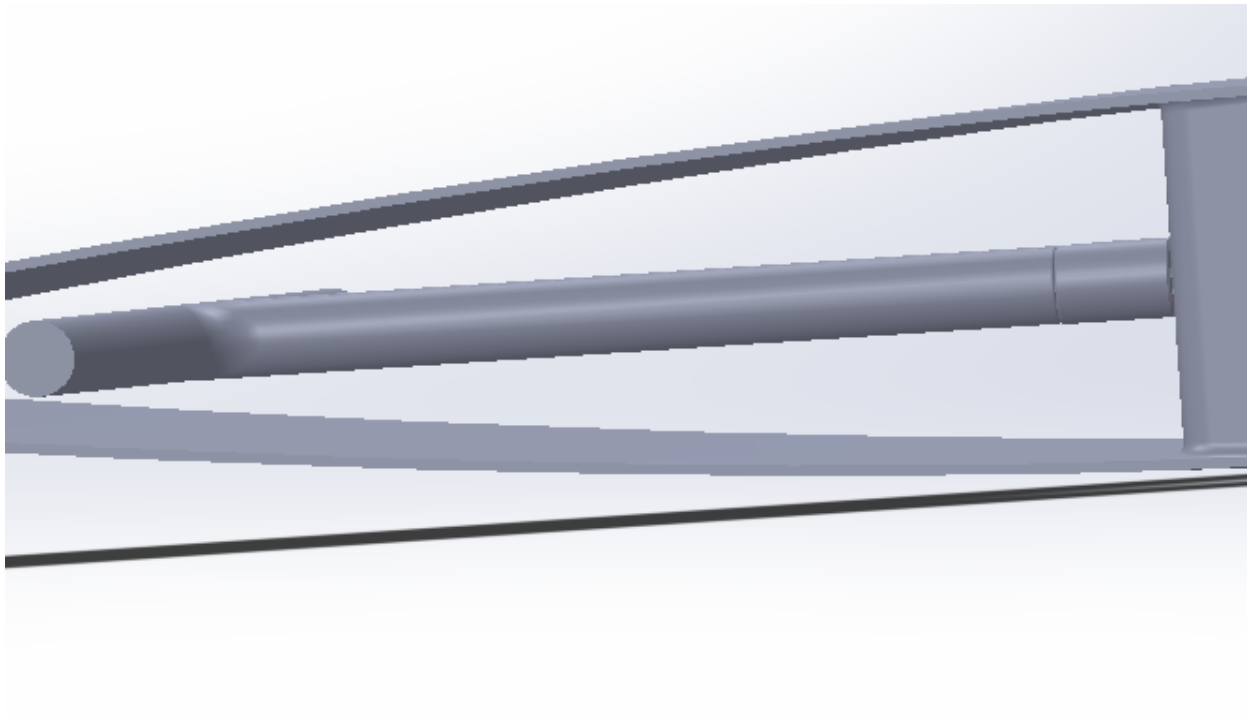

Figure 2. Picture of the Internal Member

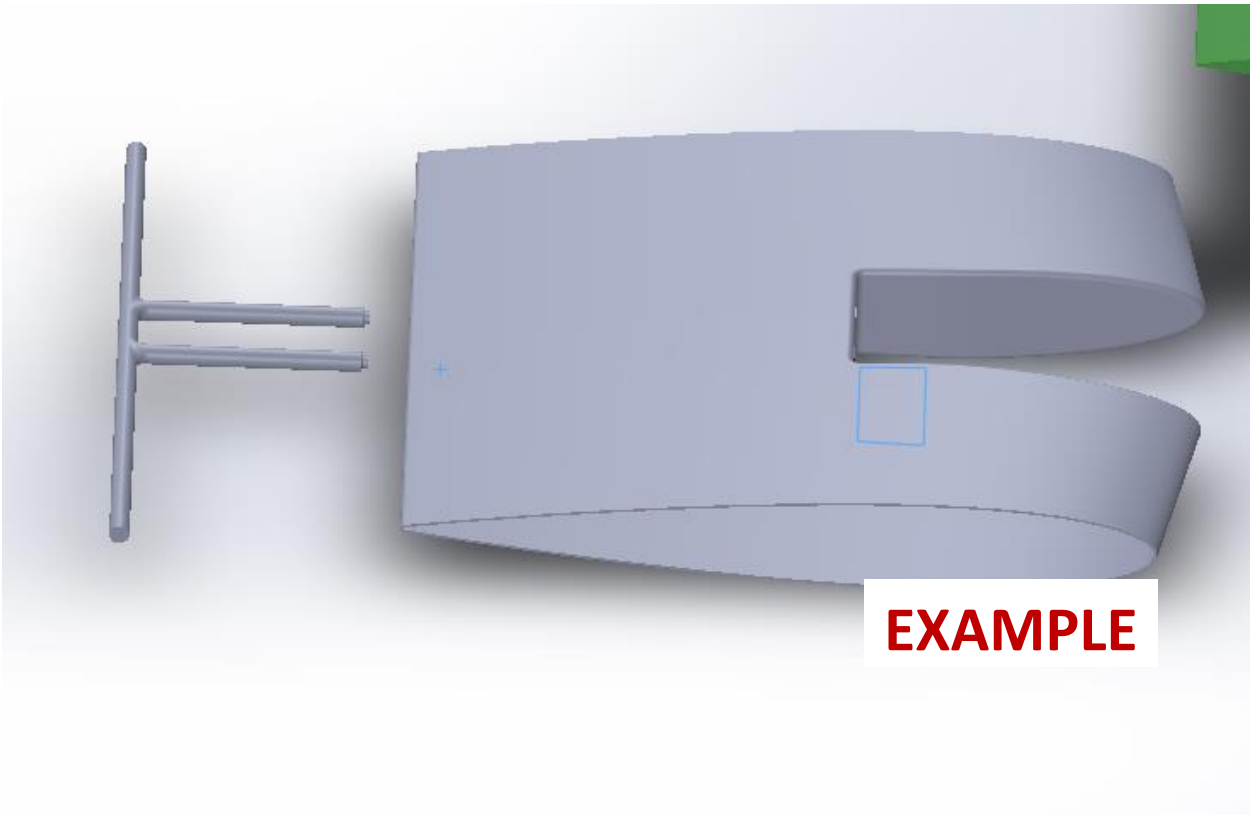

Figure 3. Original Elevator

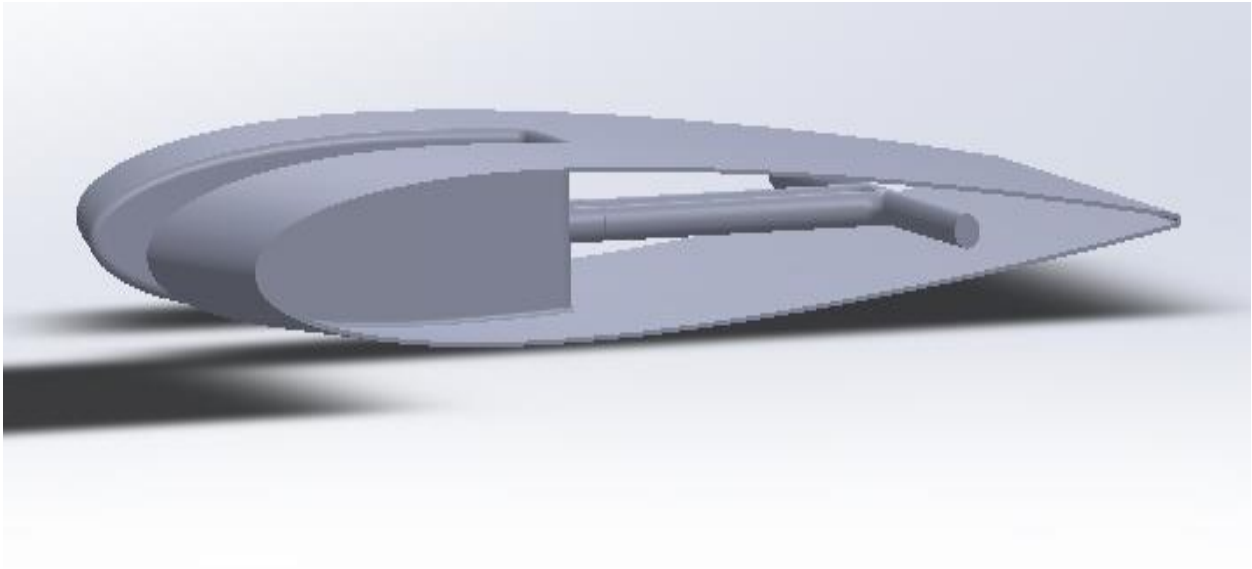

Figure 4. Modified elevator with shock absorbing capacity