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October 20th, 2017

UAV DASL D1

Analysis of Strength of Materials in Antenna Frame

ME 476C Section 7 with Dr. Oman, Tuesdays

With the weight requirements of this project, the material used to create the frame and other components of the system become very important. One of the largest concerns in this project is ensuring that the weight of the entire system does not exceed 0.5 lbs.

The current design being analyzed will use Stratasys ABS-M30 material for the bulk of the design. From data provided on the Stratasys website, ABS-M30 has a tensile yield strength of 4,050 psi[1]. The team has decided to use 3D printing technology since it allows for rapid prototyping and is relatively inexpensive. Initially the team was going to analyze the strength of the materials in relation to being dropped from 200 ft. However, after recently meeting with the client and getting further guidance, the new height assessment will be from 3 ft. The reasoning for this is that the UAV is comprised of many other parts that would be very likely to fail at 200 ft. Instead, 3 ft. is a more realistic crash height that the other components of the UAV would be expected to endure with the exception of the propellers.

Currently the team has not been provided with a final weight of the entire UAV system put together, but rough estimates are 2.5 lbs. for the drone, 0.8 lbs. for the antenna with an additional 0.5lbs allotted for the system. While this total comes to 3.8 lbs., for this analysis we will round to 4.0 lbs. which should provide a marginal factor of safety in the final calculation.

Lastly, while a crash of the UAV would most likely result in compressive forces, we will instead be looking at a worst-case scenario where the part experiences solely tension forces as a result of the crash. This will again ensure that the analyses done here does not underestimate the potential forces and chance of breakage of the material.

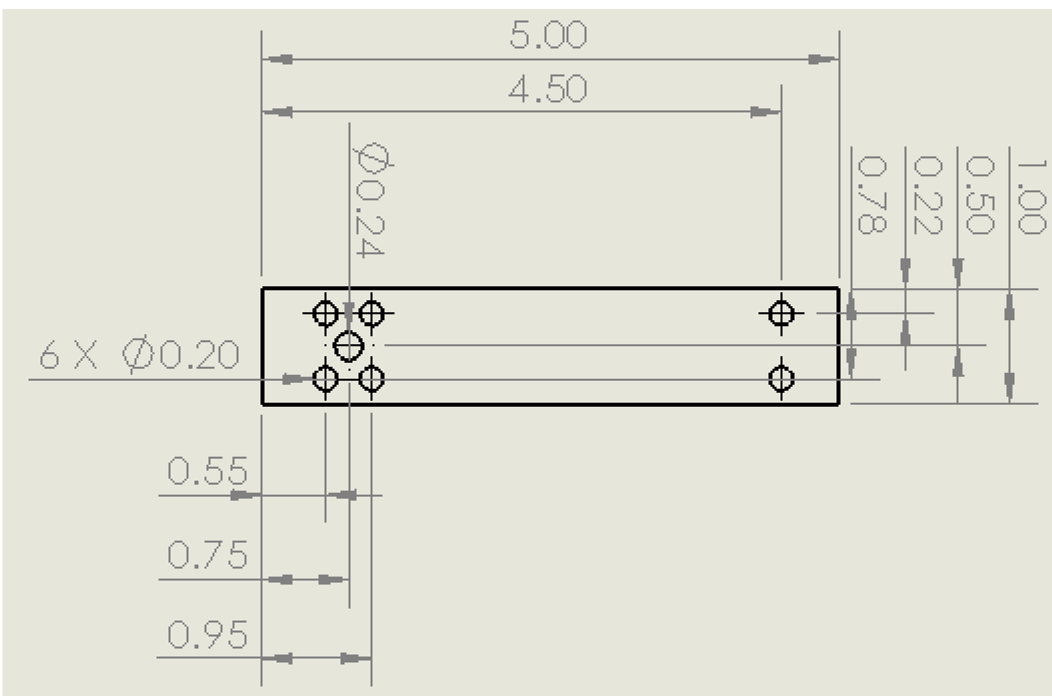

Figure 1: main support

In Figure 1, the front view of the primary support is shown. Not shown is the depth of the part which is 0.25 in. The dimensions of this part are such that they allow for clearance of the antenna that the UAV will be carrying.

Equations:

Velocity at impact:

$$v = \sqrt{v_0^2 + 2gh}$$

$$= \sqrt{0 + 32.2\left(\frac{ft}{s^2}\right) * 3ft}$$

$$= 9.83ft/s$$

Force of Impact:

$$F = WG$$

$$= 4lbs * 32.2ft/s^2$$

$$= 128.8lbf$$

Pressure of impact, assuming it lands directly on the 1x0.25in edge:

$$P = \frac{F}{A}$$

$$A = 1in * .25in = .25in^2$$

$$P = \frac{128.8lbf}{0.25in^2}$$

$$= 515.2psi$$

However, this doesn't take into account the mounting holes, at the mounting hole location where there is the smallest cross-sectional area:

$$D = .20x2$$

$$\therefore there\ is\ 0.4\ inches\ missing\ from\ the\ cross\ sectional\ area$$

$$A = 0.25in * (1in - 0.4in) = 0.15in^2$$

$$P = \frac{F}{A} = \frac{128.8lbf}{0.15in^2} = 858.67psi$$

Factor of Safety:

$$FoS = \frac{S_m}{S_W} = \frac{4{,}050psi}{858.67psi} = 4.72$$

Going further we can maximize this equation to find the theoretical smallest cross-sectional area that we can use:

$$P = 4{,}050psi > \frac{128.8lbf}{A}$$

$\therefore our\ smallest\ potential\ area\ could\ be\ 0.032in^2.\ Using\ this\ area, if\ we\ wanted\ to\ maintin\ our\ 1in\ width,$

$to\ allow\ for\ clearance\ of\ mounting\ hardwear\ and\ the\ motor\ shaft\ the\ area\ equation\ becomes$:

$$A = 0.032in^2 = 0.4in * d \rightarrow d = 0.08in$$

From the above findings, we should theoretically be able to decrease our cross section to measure 1x.08in before reaching a potential failure in tension. Such a shallow depth however would allow for only 1 or 2 layers of material to be laid down, depending on how the part is oriented, and at that point there would likely be issues arising from the printing capabilities of the machine. Based on this analysis the team may want to eventually pursue a metal alternative such as aluminum, steel or even titanium.

[1]"ABS-M30 Production-grade Thermoplastic For FDM 3D printers", *Stratasys*, 2017. [Online]. Available: http://usglobalimages.stratasys.com/Main/Files/Material_Spec_Sheets/MSS_FDM_ABSM30.pdf. [Accessed: 20- Oct- 2017].