Battery Spar

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Abstract

Problem Identification: To maximize the power/weight ratio of a fixed-wing UAV, one of the fundamentals of the Battery As iNtegrated Structure High Endurance Experimental Unmanned Aerial Vehicle (BANSHEE UAV) team is using batteries as a structural component of the UAV. **One instance of such would be placing batteries inside wing spars as shown in Figure 1, which provide rigidity to the wing. Since it is common for wing spars to be hollow, the space saved by moving the batteries there, could result in a smaller and lighter fuselage of the UAV.**

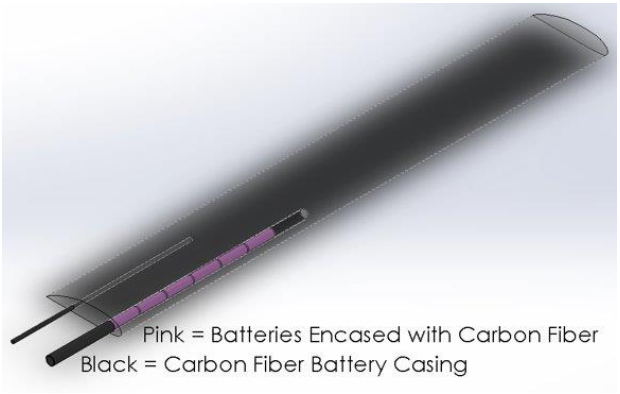

Figure 1 Battery Spar design concept

Approach of This Project: Rationale for battery spar: Rather than having a battery in the fuselage of the plane doing nothing for the structural integrity of the aircraft, the battery spar uses the additional structural strength of the batteries to reinforce the wing spars of the aircraft. Originally, the aircraft used a lithium polymer (LiPo) battery. These have high discharge and charge rates, as well as a decent power to weight ratio.

Commented [JY1]: Add wording to refer Fig 1, 2, and 3 in the abstract

The current design swaps this out in favor of lithium ion (Li-ion) batteries. These have a larger energy density and, due to their size, are more flexible in their placement inside the UAV, albeit with smaller charge and discharge rates. Because of the cylindrical shape of Li-ion batteries, they can be placed inside of a carbon fiber tube, which we are using as the spar for the wings. Because of the support of the spars in tandem with the batteries, either the cans of the batteries can be removed, using the carbon fiber to support the battery structure and reduce weight further, or the carbon fiber can be made thinner since the batteries can support more load than a hollow spar.

In either case, the use of the battery in the spar allows for a way to further reduce weight. Additionally, the Li-ion battery has a higher energy density than the LiPo battery, even with the weight of the spars included, making these an improvement regardless.

To create these battery packs, the Li-Ion cells are welded together using Nickel strips as shown in Figure 2. The connections between cells also have a wire connected so as to connect to the Battery Management System (BMS) which will control the charge and discharge of the batteries to ensure even charge and drain.

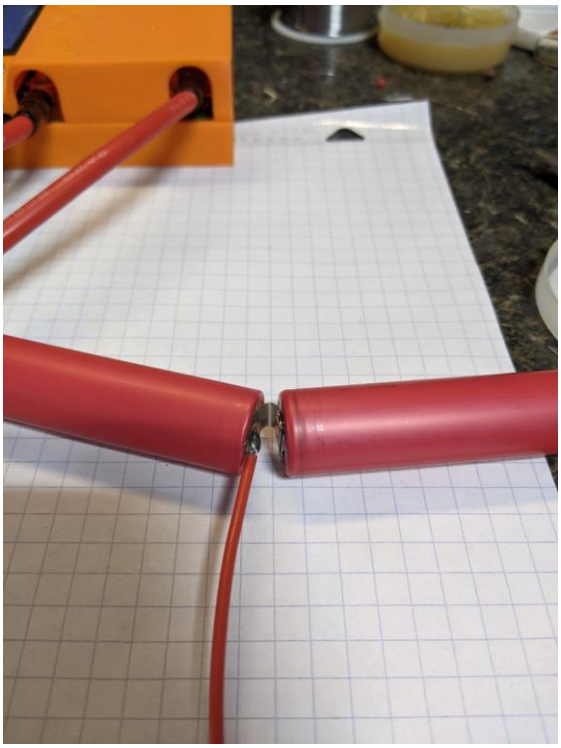

Figure 2 Manufactured Battery Connections

As seen in Figure 3, each of the battery packs consists of 3 cells to give 12.6V at full charge. The final aircraft will have two of these packs connected in parallel to double the storage capacity and recharge rate.

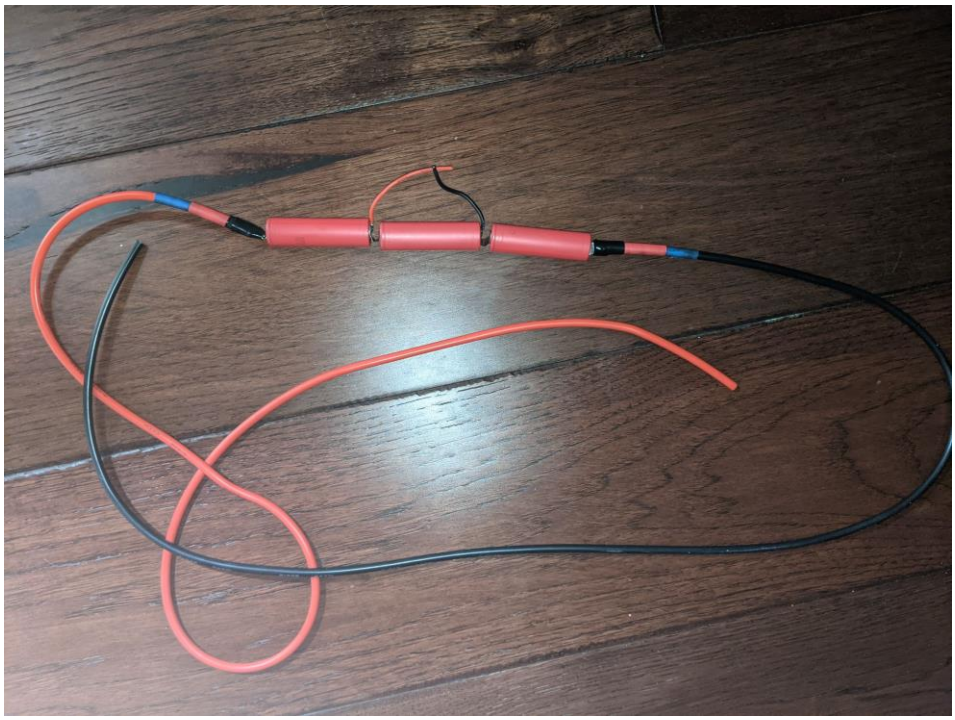

Figure 3 Completed Single Pack of NCR18650GA cells

How Do We Consider this Project Successful: The team has designed the battery system and built the battery pack for the battery spar design. Further work must be done on finalizing design decisions related to building the structure and implementing it in the aircraft. This system will be successful if the endurance of the aircraft is improved.

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How Your Results Will Impact The World:

The goal of this project overall is to increase the endurance of battery powered UAVs, which have historically had a lower power to weight ratio compared to gas powered equivalents. Unlike gas powered UAVs, battery powered UAVs have the opportunity to regain endurance while in air via recharging the battery. There are also a few other benefits of battery powered UAVs compared to gas. Batteries do not have a reliance on fossil fuels and do not create emissions to affect the environment. Since UAVs are only becoming more popular, the higher percentage of

these UAVs are battery powered, the better off the environment will be. Another benefit is that batteries are solid. Since gasoline is a liquid fuel, it cannot be used as a structural component. It also will result in a dynamic weight for the aircraft as the fuel is burned. As the aircraft maneuvers, the fuel also will shift in weight due to gravity and the G-forces the aircraft experiences. In a battery powered aircraft, none of these circumstances apply. Batteries do not change in mass as they discharge and do not change the center of gravity of the aircraft. Using the batteries as a part of the structure would give them an extra advantage over gas powered aircraft, as now the weight of some structural elements, primarily the spars, can be reduced since the batteries can now take some of the load instead.