Solar Powered Unmanned Aerial Vehicle (UAV)

NAU SOLAR FLYERS

Northern Arizona University
College of Engineering, Informatics and Applied Sciences

Gabriel Martin & Sultan Alhazawbar

Abstract

In recent years, the demand for renewable and sustainable energy sources has prompted an increased demand for their applications. The sun is an everlasting source of energy, so the idea of maximum power harvest is pivotal. Drones are used for top-level surveillance, and recreational use, and can be weaponized as well. **The goal of the project is to construct a lightweight, unmanned aerial vehicle (UAV), whose flight time can be extended by at least 50% from solar power.** This is achieved by recharging a lithium polymer battery that powers the drone with solar technology to increase its capacity. Within this project, the concepts of maximum power point tracking, solar array development, and power transmission are heavily applied. This project is funded by W.L. Gore & Associates and the CEIAS department at Northern Arizona University. The client for the product is David Willy, the senior lecturer of Mechanical Engineering at Northern Arizona University. Our team will be working closely with the Sol Avem mechanical engineering team to construct the solar-powered UAV. However, our main focus is to adequately implement solar technology to achieve prolonged flight, not the construction of the UAV.

Concepts

Photovoltaic (PV) Energy & Solar Technology:

- A solar panel's performance directly corresponds with the presence of the sun. More specially, it's orientation, the current temperature, and the flux of radiant energy, otherwise known as irradiance.

Maximum Power Point Tracking:

- The idea of maximum power point tracking allows solar systems to produce the maximum power output by using power conditioning methodologies and supporting electrical components to make up for any variance in solar performance.

Properties of Lithium Ion Polymer Batteries:

- Lithium polymer batteries are ideal for a project of this scope, as they are rechargeable. The key is developing a proper charging methodology so the battery is protected and its life is prolonged.

Charge Controller & Charge Characteristics:

- A charge controller is needed to regulate the amount and duration of charge to a battery. A solar system cannot be directly connected to a battery.

Project Requirements

Client Requirements

- Ensure ideal product composition & a marketable appearance.
- Provide a clear display of solar technology .
- Address the critical elements that will ensure the device's complete functionality:
  - Develop a lightweight mechanism.
  - Recharge the lithium polymer battery using solar technology.
  - Prolong the UAV's flight by increasing the battery's capacity while airborne.

Engineering Requirements

- Select and apply lightweight solar technology
- Implement of a charge controller between the solar technology and the battery for the battery's protection against overcharge.
- Install solar technology within the surface area of the UAV

Project Constraints

- The budget, the project duration allotted, & component selection are all considered constraints for this project.

Design

C-60 solar cells were chosen for this project, for their array sizing capability and weight at 7 grams each.

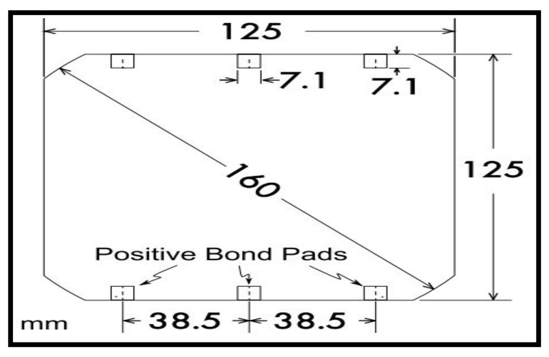

Figure 1: C60 Solar Cell Schematic

The array is sized with respect to the surface area allotted. 24 solar C-60 monocrystalline cells were soldered in series using lead-free, copper tabbing material. Series requires positive to negative terminal connection.

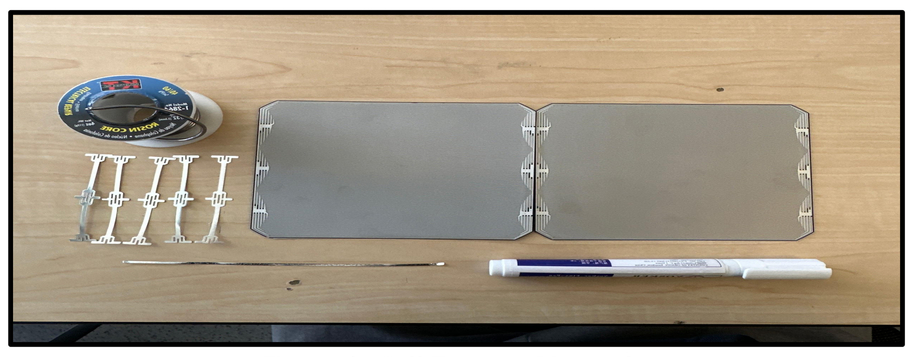

Figure 2: Cell Tabbing Materials

A MPT-7210A solar charge controller was used to accept the input from the solar array, and trickle charge the battery at a preselected rate.

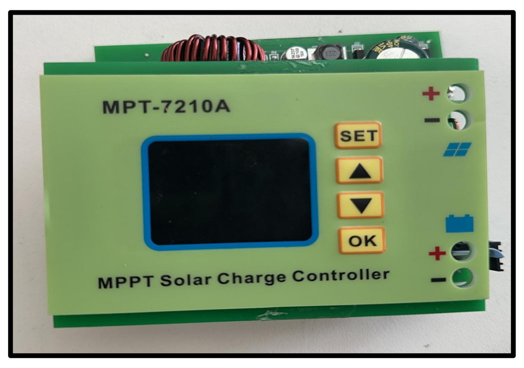

Figure 3: MPT 7210A Solar Charge Controller

A skeleton CAD model of our design was developed. Each element of the product can be seen here.

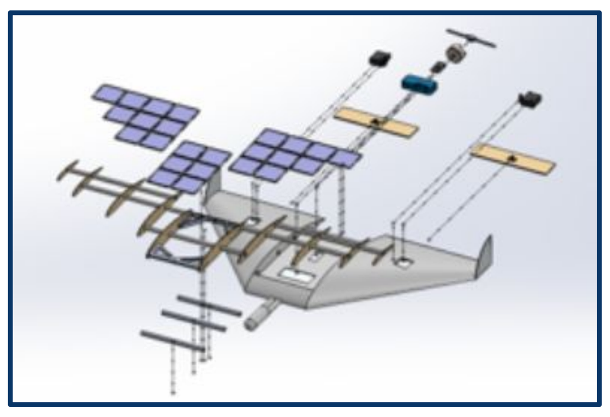

Figure 4: Solar UAV CAD Model

The Solar UAV system architecture is modeled as below. It can be used to help illustrate the focuses of each component between the EE team (Solar Flyers) & the ME Team (Sol Avem).

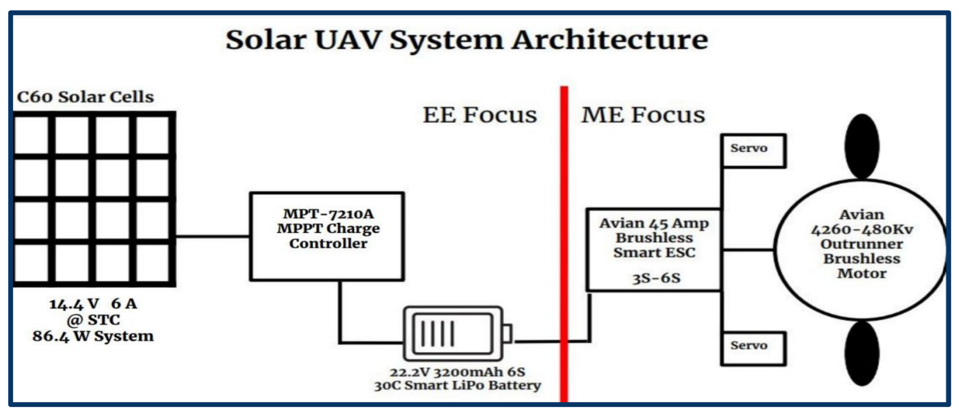

Figure 5: Solar UAV System Architecture

The battery used is a 22.2 V, 3200 mah, 50C, 6S lithium polymer IC5 battery.

Figure 6: 22.2V 3200mAh Smart LiPo Battery

Results & Final Specifications

The solar array consisted of 24 cells soldered in series using flux solder wire, a flux pen, dogbone tabbing connectors, and tabbing wire (Figure 2). The series connection of the cells will allow the voltages of each cell to be added together but draw a constant current. Within the first iteration of the array, the team tested and identified significant voltage loss in the output. The problem was due to an inefficient soldering technique used on the tabbing materials that connected the cells together. After a revised approach, a full, working array was developed. Within the soldering process, the team laminated the cells for protection. The lamination material showed no loss in cell performance. However, solar efficiency is proportional to irradiance and inversely proportional to temperature. Real-time irradiance is difficult to obtain, so it serves as the only undefined variable of the project. The final array was developed based on the surface area allotted by the mechanical engineering team's 3rd iteration of the UAV (Carbon Fiber Frame). See Table 1 for the individual cell (@STC) and PV array testing specifications, a schematic of the solar array, and the actual array in Figure 4.

C60 Monocrystalline Silicon Solar Cell	
- Cell Pmpp	3.4 W
- Cell Vmpp	.582 V
- Cell Impp	5.93 A
- Cell Voc	.687 V
- Cell Isc	6.28 A
- Cell Rated Efficiency	22.5 %
- Cell Dimensions (LxWxH) (mm)	125 x 125 x 1.65
- Cell Weight	7 g
- Array Output Power	71.4 W
- Array Output Voltage	13.7 V
- Array Output Current	5.21 A
- Array Weight	270 g

Table 1: PV Cell & Array Specifications

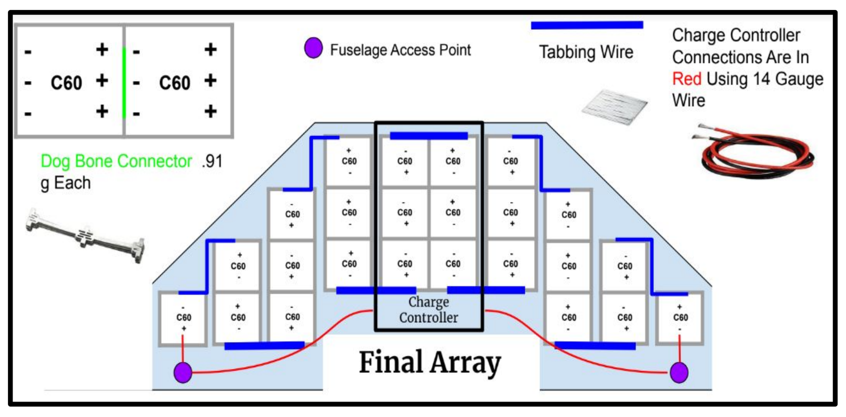

Figure 7: Schematic of Solar Panels on UAV (3rd Iteration)

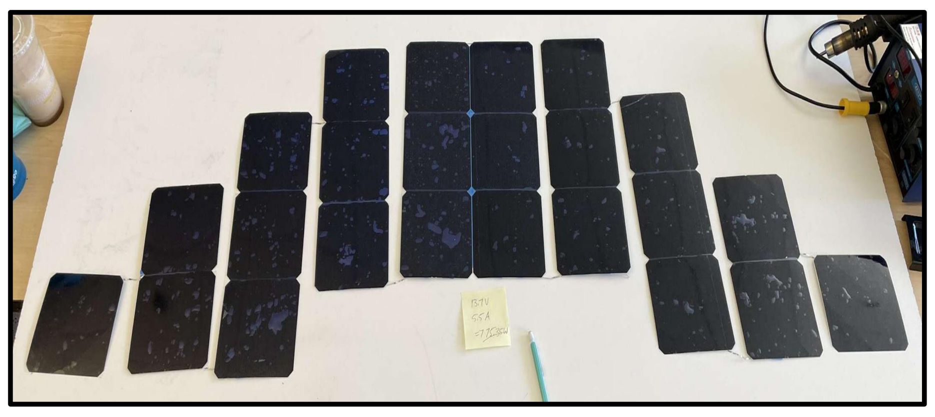

Figure 8: Solar Array for 3rd Iteration

The charge controller has a unique control interface. The controller allowed the team to set a maximum voltage that the PV array input could not exceed, as well as the voltage and current needed to charge the battery. The solar array voltage is significantly smaller than the battery's nominal voltage. However, the charge controller acts as a boost converter. It is able to accept any voltage input (within its parameters) and provide the necessary output current and voltage. We matched a theoretical charging scheme to the actual charging scheme of the battery. To serve as a mark for project completion, the 3rd iteration of the UAV (Carbon Fiber Frame 2300g) flew successfully for 6 minutes without any solar technology on top. With the full integration of the solar array and charge controller, in theory we could extend the flight time to 9 minutes w/ the specs below. Flight will not commence until next week.

Figure 9: Solar Panels on UAV (3rd Iteration)

Aircraft:
Weight: 5.7 lbs. (2600g)
Thrust to Weight Ratio: 0.81
Wingspan: 5 ft
Chord Length (Max): 19.5"
Chord Length (Min): 8"
Surface Area: 6.8 ft^2
Max Speed: 50 mph
Max Duration without solar: **6 minutes**

Photovoltaic System:
24 solar panels (series)
Total Array Voltage (VOC): 13.7 V
Total Array Amperage (ISC): 5.21 A
Max Power Output: 71.4 Watts
MPPT Charge Controller Voltage Output: 24 Volts
MPPT Charge Controller Amperage: 3.3 AMPS
Flight Duration without solar panels: **9 minutes 27 seconds**

Figure 10: Solar UAV in Action !

Websites & More Information Found Here (Scan QR Codes)

Solar Flyers Website Here !

Sol Avem Informational Poster Here !

Solv Avem Website Here !

UAV Fabrication Iterations by Sol Avem Team

Foam Frame (4000g)

Transparent Wrap 4400g

Carbon Fiber Frame 2300g

✔

Acknowledgements

The Home Depot
AMPERE — Advanced Motors, Power Electronics, and Renewable Energy Laboratory
GORE
NAU