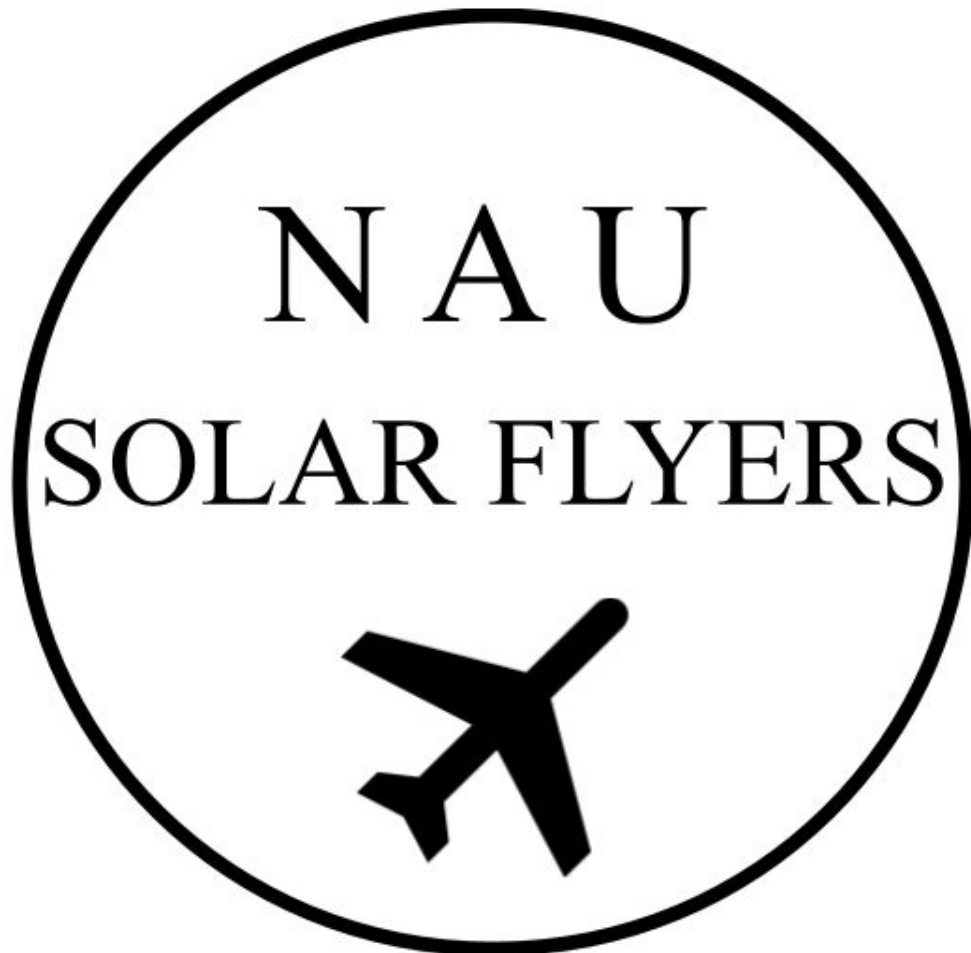


Solar-Powered Unmanned Aerial Vehicle



Final Presentation & Reflection

12.9.22

Sultan Hazawbar & Gabriel Martin

Project Client: David Willy

Project Sponsor: Gore

Project Advisors: Venkata Yaramasu, Ph. D &
Alexander Dahlmann, GTA

Project Partners: ME 486C Team

EE (NAU) Solar Flyers

Gabriel Martin & Sultan Alhazawbar

Project start date: 11/01/2022

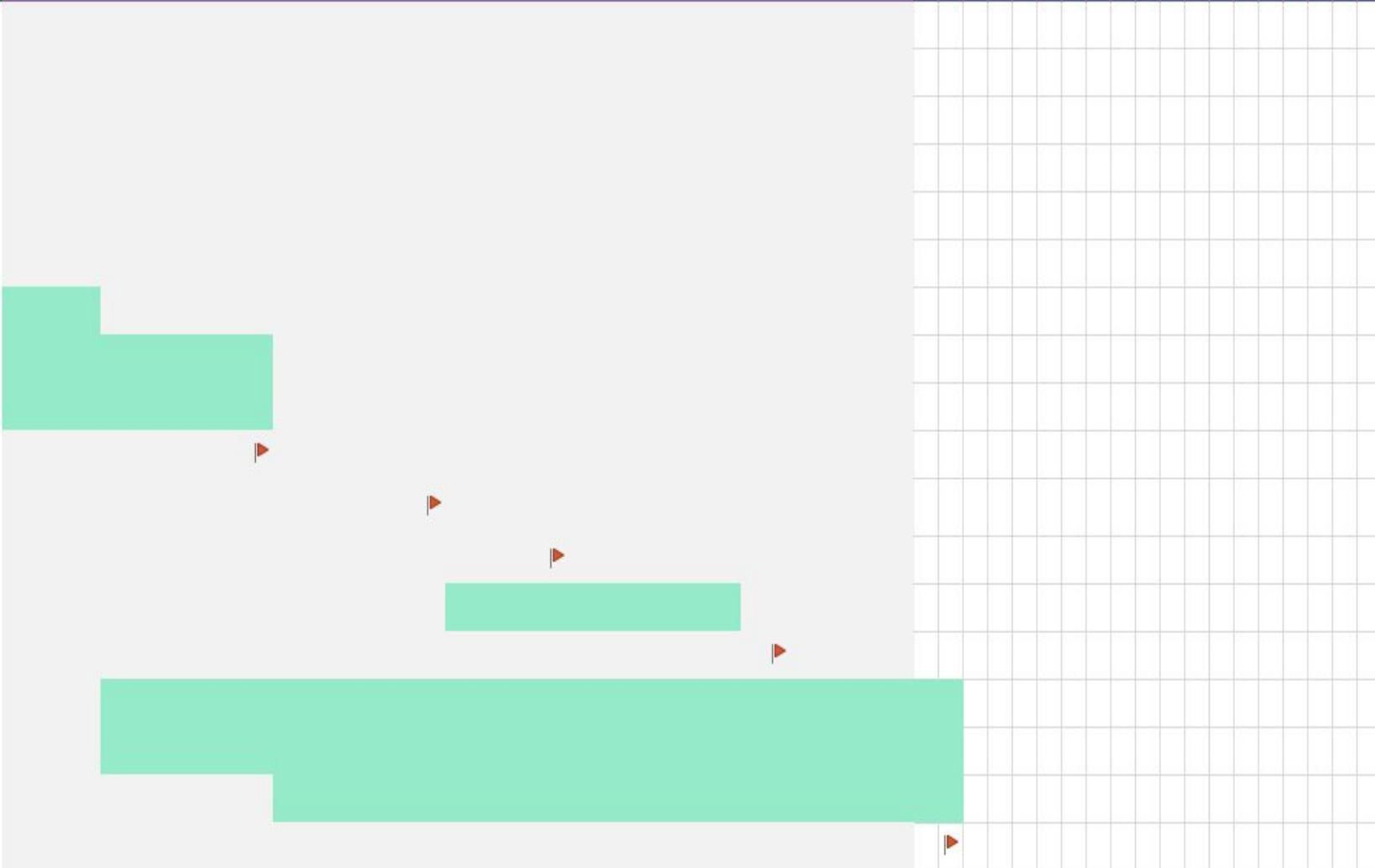
Milestone marker: 1 

Scrolling increment: ##

Milestones

Milestone description	Assigned to	Progress	Start	Duration (# Days)	Finish
EE476C					
EE486C					
Recap Assessment	G.M	100%	8/29/2022	10	9/9/2022
1/3 Build Assessment	G.M & S.A	100%	9/9/2022	37	10/14/2022
Individual Contribution Assessment	G.M & S.A	100%	10/14/2022	16	10/28/2022
Website Check I	S.A	100%	10/14/2022	16	10/28/2022
2/3 Build Assessment	G.M & S.A	100%	10/14/2022	23	11/4/2022
Team Design Document II	G.M & S.A	100%	10/14/2022	30	11/11/2022
Website Check II	S.A	100%	10/28/2022	16	11/11/2022
Prototyping Phase A: Array Assembly	G.M	100%	11/11/2022	1	11/11/2022
Prototyping Phase B: Charge Controller Configuration / Connection	G.M & S.A	100%	11/18/2022	1	11/18/2022
Prototyping Phase C: Full Integration	G.M & S.A	100%	11/23/2022	1	11/23/2022
UGRAD Poster	G.M	100%	11/18/2022	14	12/2/2022
UGRAD Symposium	G.M & S.A	100%	12/2/2022	1	12/2/2022
3/3 Build Assessment	G.M & S.A	100%	11/4/2022	37	12/9/2022
Team Design Document III	G.M & S.A	100%	11/4/2022	37	12/9/2022
Website Check III	S.A	100%	11/11/2022	30	12/9/2022
Project Completion	G.M & S.A	100%	12/9/2022	1	12/9/2022

November														December																																					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M			



Overview

Goal: To construct a solar assisted unmanned aerial vehicle (UAV) that will fly 1 1/2 times the duration that a sole onboard battery would fly it for.

Progress Update Since 11.18.22 & Semester Recap

- 1) Full Integration
- 2) Concluding Analysis
- 3) UGRAD's
- 4) Reflection
- 5) The Future for Solar UAV's

Solar UAV System Architecture

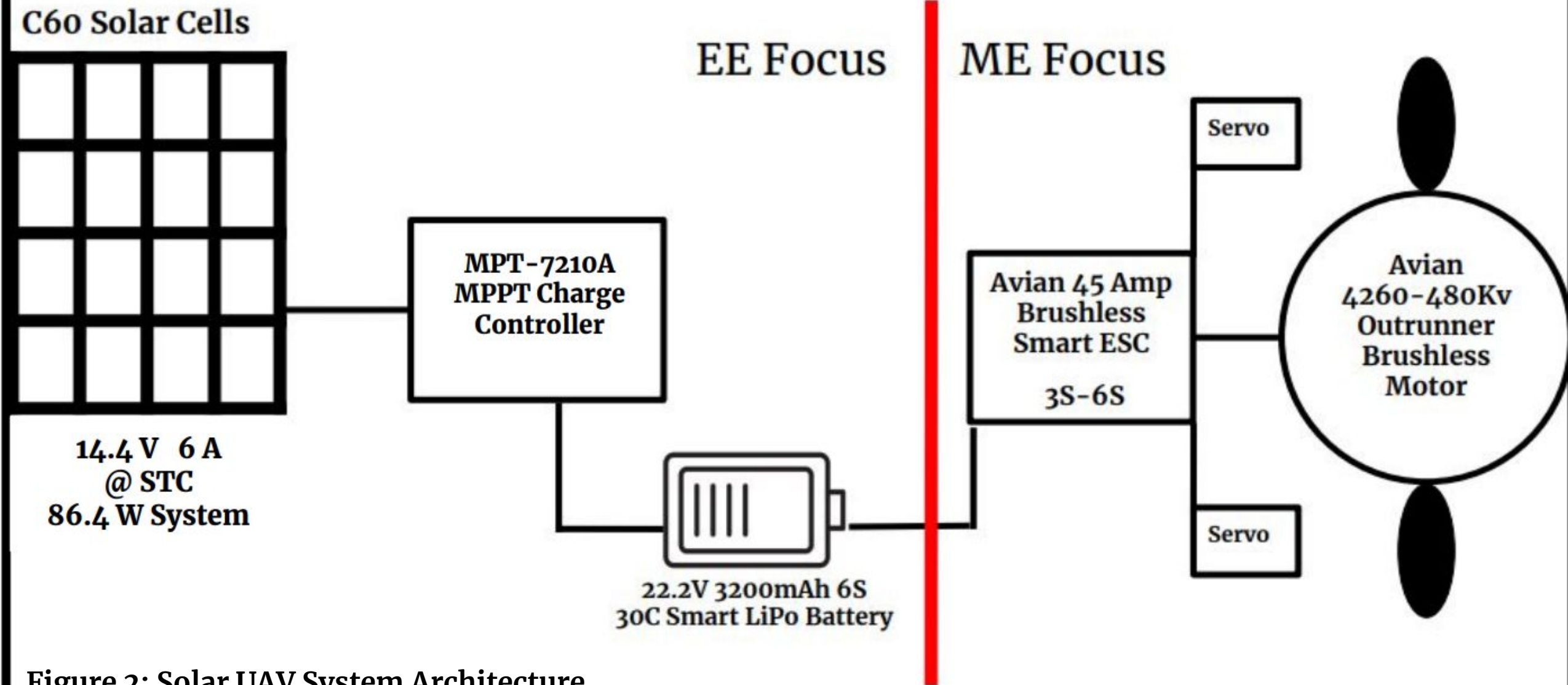


Figure 2: Solar UAV System Architecture

Full Integration

We integrated our solar system onto the mechanical engineering team's UAV.

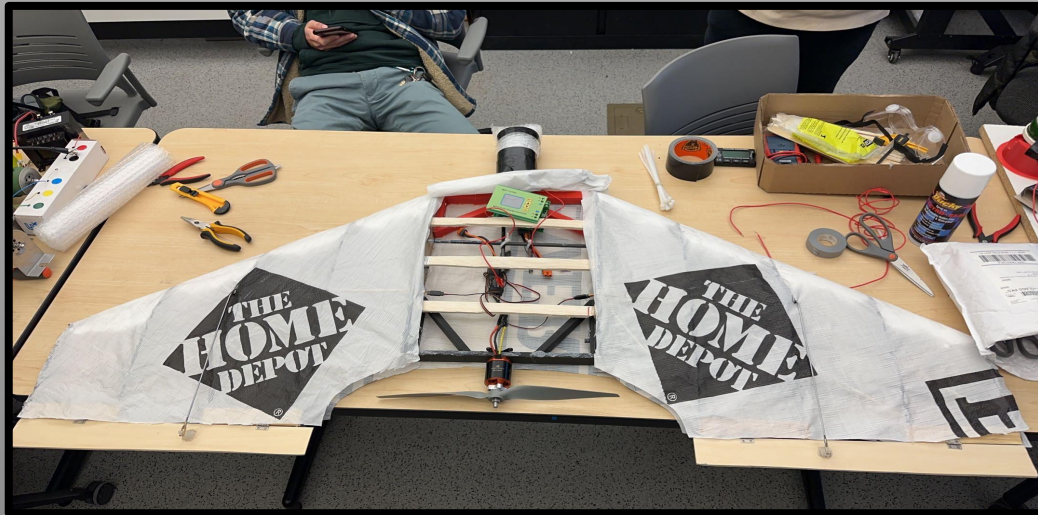


Figure 3: Exposed Fuselage Prior to Integration

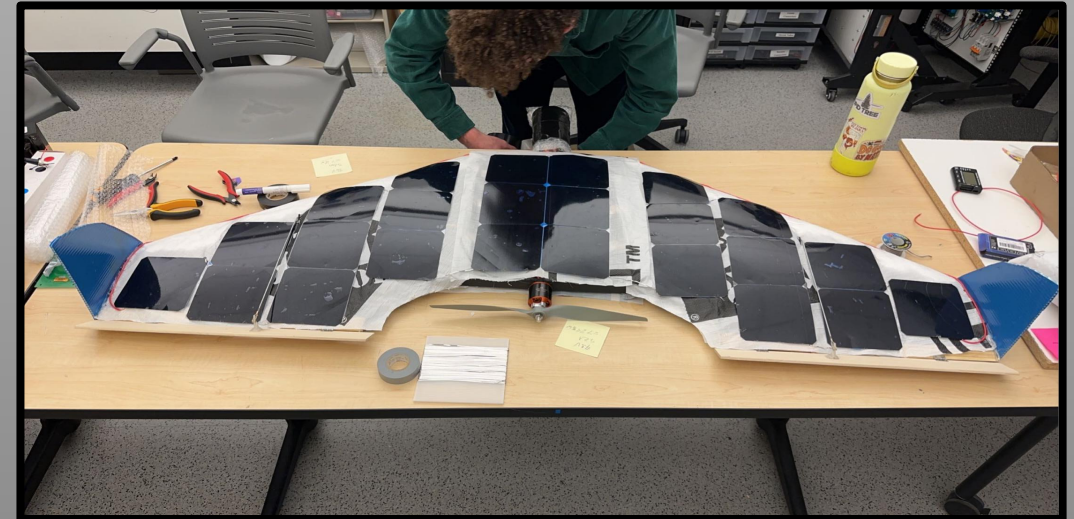


Figure 4: Full Integration of Solar System

- The UAV's plastic coating allows the easy installment of the solar array.
- The charge controller is hooked up to the solar array and the 22.2 V 6S battery inside the fuselage.
- The final product was 5.86 lbs / 2.66 kgs

Full Integration

We developed a charging scheme for our battery.

Our charge controller wasn't a self-acting MPPT mechanism, that read real-time individual cell capacity, and delivered ideal charge. It was really just a configurable boost converter.

The charge controller only charged the battery with these particular charging specifications. In other words, we found the MPPT.

Our PV input never exceeded 5 Amps, which meant we were never going to be able to charge the battery efficiency enough to meet our goal.

Flight without solar was 6 minutes, flight with solar is just over 7 minutes. Our flight time was only extended 17 %.

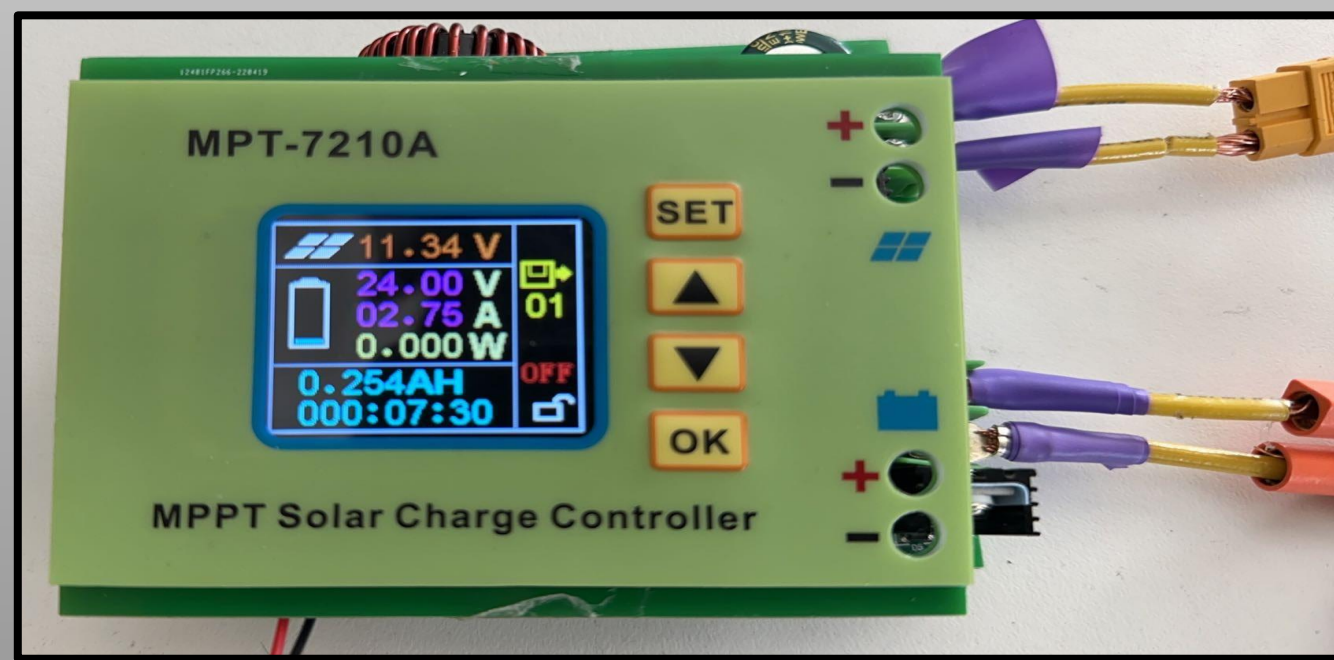


Figure 4: Charge Controller Charging Specifications

<u>Charge Controller Application</u>	
- Solar Input Voltage	10.90 - 13.60 V
- Charging Voltage	24 V
- Charging Current	3 - 3.4 A
- Charging Power	70 - 80 W
- Wire Size Connection	Solar - 14 AWG Battery - 12AWG
- Charging Performance	The charge controller over the course of 30 minutes charged the battery 8% in capacity. Against 45% throttle on ground , 1%.

Table 1: Charge Controller Charging Specifications

Concluding Analysis

Not enough solar. An increase of overall PV output allows:

- A higher charging current. A higher charging current allows:
 - The allowance of a better charge controller. A better charge controller allows:
 - A faster charge to our battery. This is where we fall short of our goal.

There are MPPT charge controllers that are used for residential PV systems, but most of them are rated over 100 watts of power, 15 Amps of current, etc.

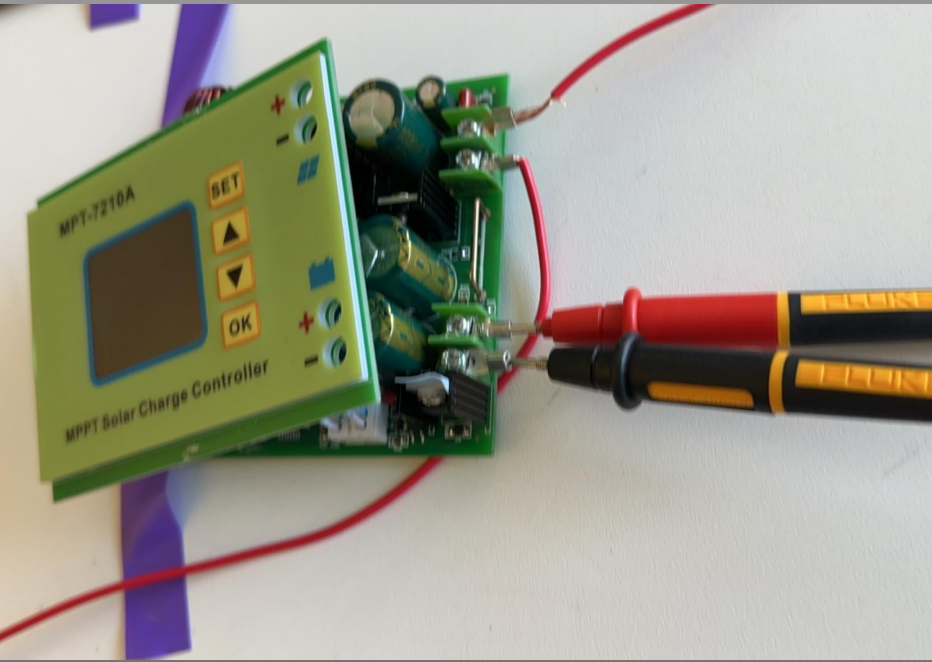
These charge controllers will adequately read PV voltage and overall battery capacity, and output the most efficient charging current. However, they are too heavy or they exceed our PV's compatibility.

There is a heavy restriction for our PV system size because the amount of surface area we were allotted, and the weight we had to stay in bounds of.

Concluding Analysis

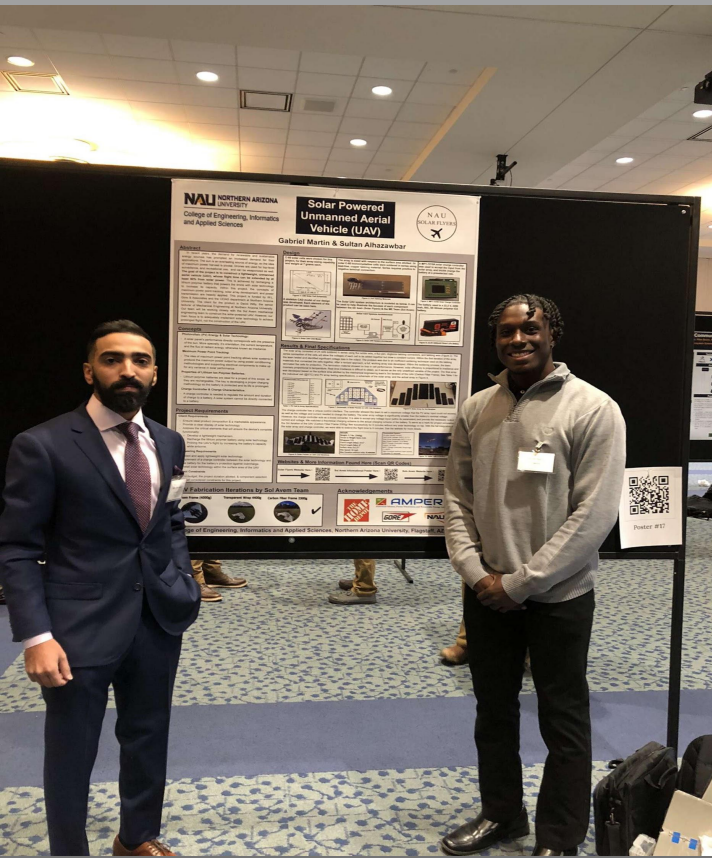
We were still able to recharge the battery, which is the essence of our project. If we can extend the flight time of the UAV even a little, we can develop a new plan to ultimately meet our goal.

We assembled a functional product at most, with all the elements of our system architecture working, separately. We built a working PV array, chose the right charge controller, and installed the entire system on the UAV with everything working as intended.



UGRAD's Festival

We attended the UGRADs Symposium, and spoke with students, professors and surrounding engineering community members about our project.



We received 2nd place in the Electrical / Computer Engineering Category and took home a \$600.00 prize

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. Gore & Associates and the CEIAS department at Northern Arizona University. The client for the project 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.

Design

C-40 solar cells were chosen for this project, for their top output capability and weight of 7 grams each. The array is, covered with a panel for this system area collected 20 cells. C-40 monocrystalline cells were selected to cut the weight of the array, despite having a higher price. Further, regular panels have negative horizontal orientations.

A 3D model of our design was developed. Each element of the printed case is seen here.

The solar array system architecture is shown in the figure below. It was used to help illustrate the formation of each component.

The solar array system architecture is shown in the figure below. It was used to help illustrate the formation of each component.

Results & Final Specifications

The solar array consists of 20 cells, soldered in series using a flux pen, diagonal heating connections, and tinning wire (Figure 2). The series connection of the cells will allow the voltage of each cell to be added together and draw a constant current. Within the first iteration of the array, the team learned and identified significant voltage loss in the output. The problem was due to an inefficient soldering technique used on the soldering materials that connected the cells together. After a second iteration, a full working array was developed. Within the soldering process, the team discovered the cells had problems. The laminator material showed no loss in cell performance. However, solar efficiency is proportional to irradiance and inversely proportional to temperature. Heat loss (irradiance) is utilized to obtain, so it serves as the only unaltered variable of the project. The final array was designed based on the surface area offered by the mechanical engineering team's 3rd iteration of the UAV (Carbon Fiber Frame). See Table 1 for the individual cell (BPTC) and PV array testing specifications, a schematic of the solar array, and the actual array in Figure 4.

The charge controller has a unique control interface. The controller allowed the team to set a maximum voltage that the PV array 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 (most positive) and provide the necessary output current and voltage. We matched a fractional charging scheme to the actual charging scheme of the battery. It serves as a mark for proper completion of the 3rd iteration of the UAV (Carbon Fiber Frame). See successfully for 8 minutes additional solar technology on the UAV for the full integration of the solar array and charge controller. In theory we could extend the flight time by 9 minutes at the same battery. Flight will not occur until next week.

Project Requirements

Client Requirements

- Develop ideal product composition & a renewable 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.

UAV Fabrication Iterations by Sol Avem Team

Foam Frame (4000g) Transparent Wiro 4000g Carbon Fiber Frame 2300g

Website & More Information Found Here (Scan QR Codes)

Solar Flyers Website Here Red Brown Informational Poster Here Red Brown Website Here

Acknowledgements

THE HOME DEPOT AMPERE GORE NAU

Reflection

Challenges of a multidisciplinary project

Weather & flight testing

Budget allotted

Motor choice

Project flow

5 iterations of the UAV

The Future for Solar UAV's

Why Solar UAV's ?

- 1) Inspiration for similar renewable energy applications
- 2) Optimal use of a UAV as a tool
- 3) Prolonged or indefinite Flight

Questions ?

