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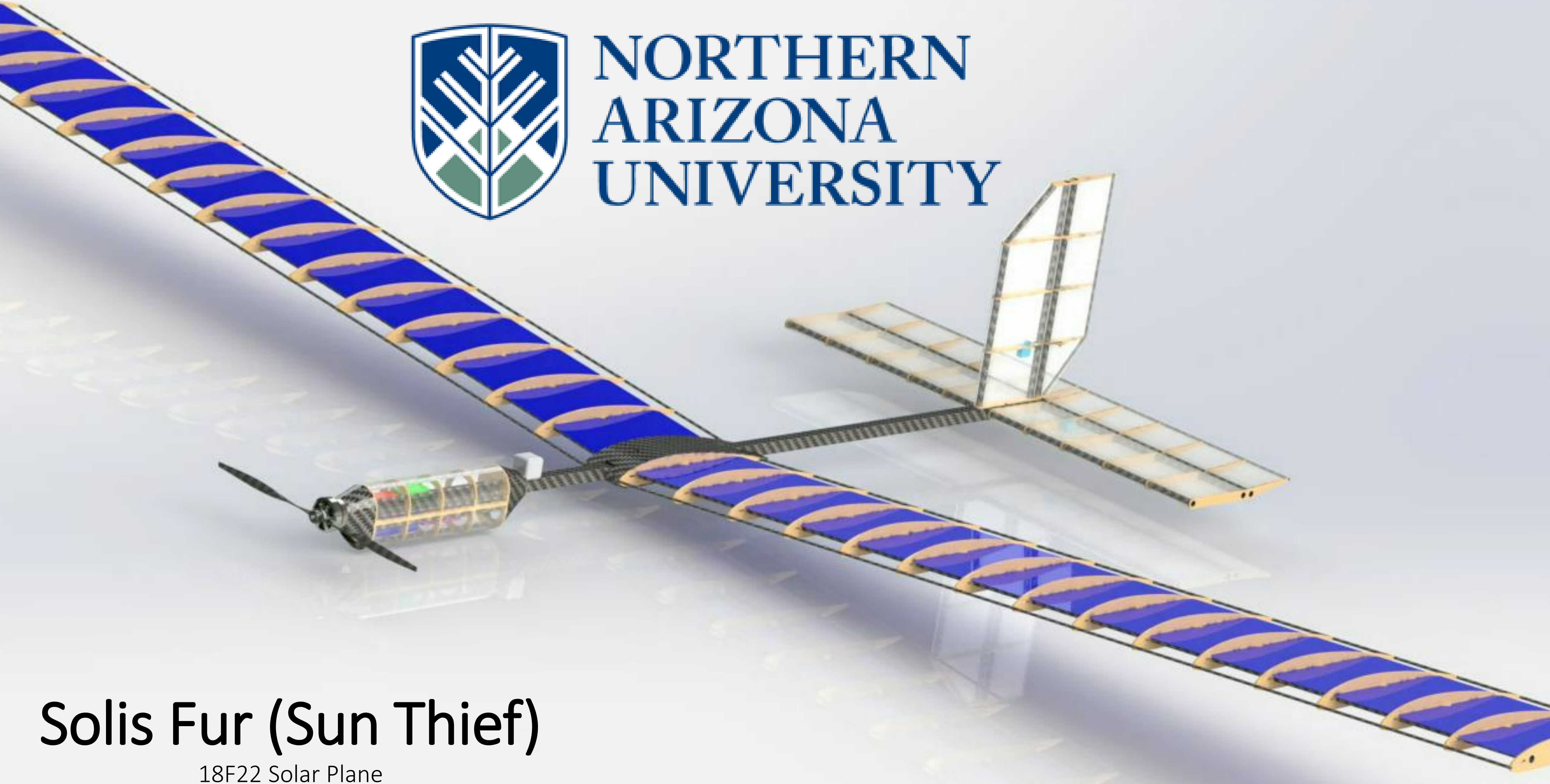

Solis Fur (Sun Thief)

18F22 Solar Plane

Project Title

Application of Photo-Voltaic Cells to Power a Remote Controlled Aircraft Capable of Indefinite Flight

The Team

As viewed Left to right:

Jonathan Hernandez -Website Designer

Michael Broyles – Construction Manager

Nathan Zufelt – Budget Manager

Ethan Smith – Client Contact

Brandon Beaudoin – Project Manager

Project Sponsors / Customer

David Trevas, PhD

- Provided customer requirements.
- Crucial input for design requirements.

Sponsors

- Northern Arizona University
- Novakinetics Aerosystems
- Prometheus Solar
- Flagstaff Flyers
- Coconino High School
- Rock West Composites

Why is this important?

- Teaches students to use engineering principles in a real life application.
- Allows the use of renewable energy to power an RC plane.

Project Description

- Achieve solar powered flight, which few have done before.
- Electric airplanes rely on batteries for energy storage which is limited by the size and shape of current batteries.
- Extending the range and reducing the weight of these electric airplanes could make electric airplanes a viable source of travel and material transportation.
- Indefinite flight through the use of solar power is an important step in moving away from fossil fuels.

Plane Schematic [1]

Possible Applications

- Conducting search and rescue missions
- Game traffic study/mapping
- Military surveillance
- Scouting dangerous areas
- Atmospheric data collection
- Arial imaging
- Infrastructure inspection

Surveillance Drone [2]

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Project Requirements and Goals

Customer Requirements

- Indefinite flight while sun is present
- Log flight data

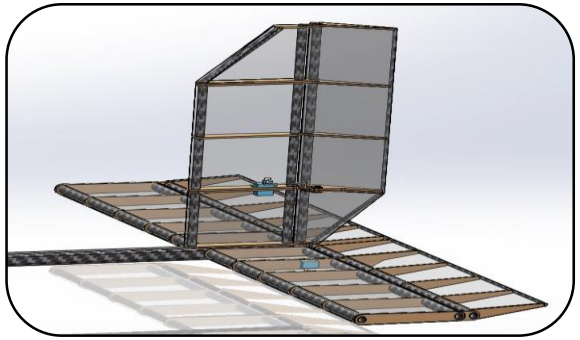
These customer requirements were then translated into engineering requirements

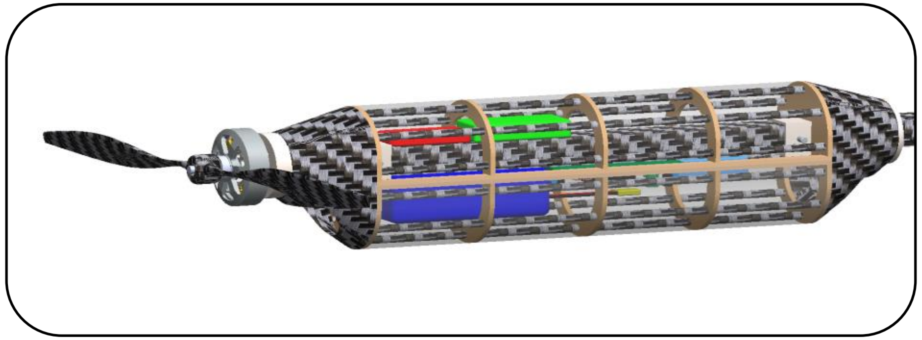
Goals	Methods
Maximize power output	◦ High efficiency solar cells ◦ Innovative wiring methods
Minimize power consumption	◦ Optimize motor/propeller combination ◦ Low power accessories
Minimize weight	◦ Carbon fiber and balsa wood construction ◦ Streamlined body designs
Minimize drag	◦ High efficiency airfoil ◦ Streamlined fuselage and surfaces
Data logging	◦ Sensors: GPS, Airspeed ◦ Sensors: Voltage, Current Draw

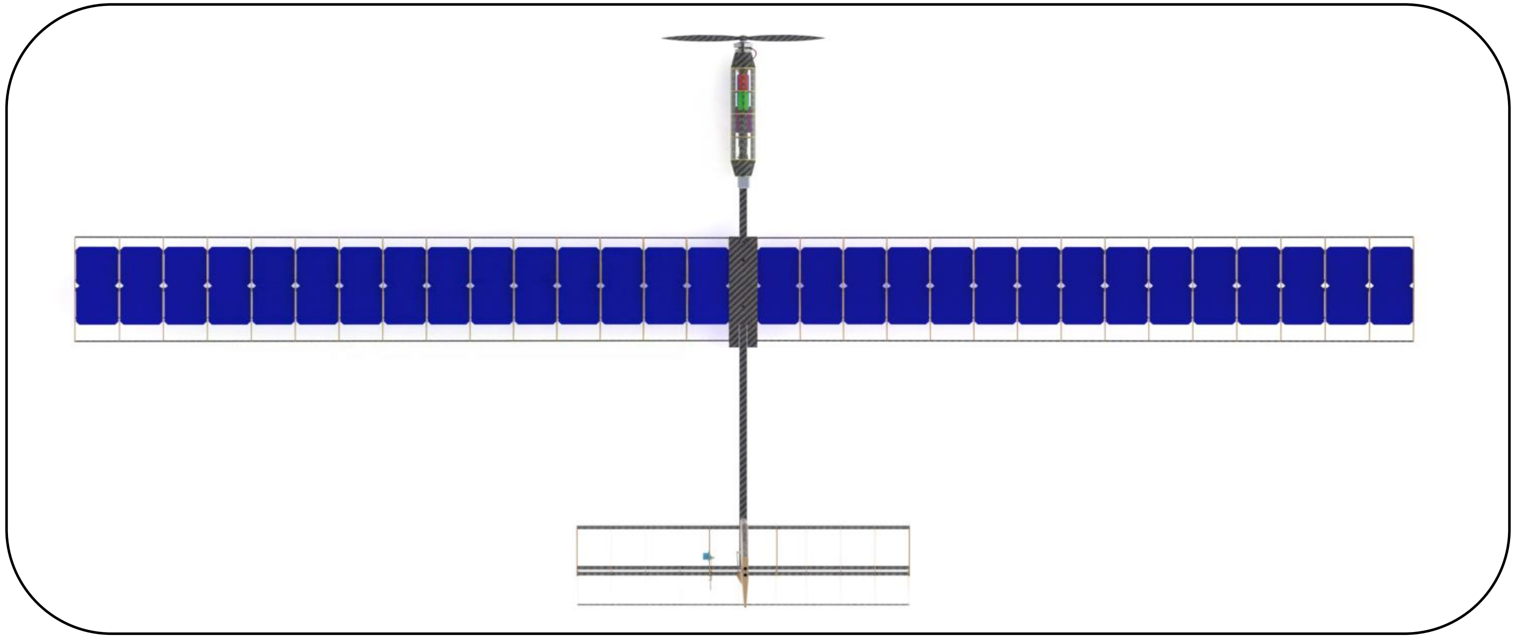
Final Design

Specifications:

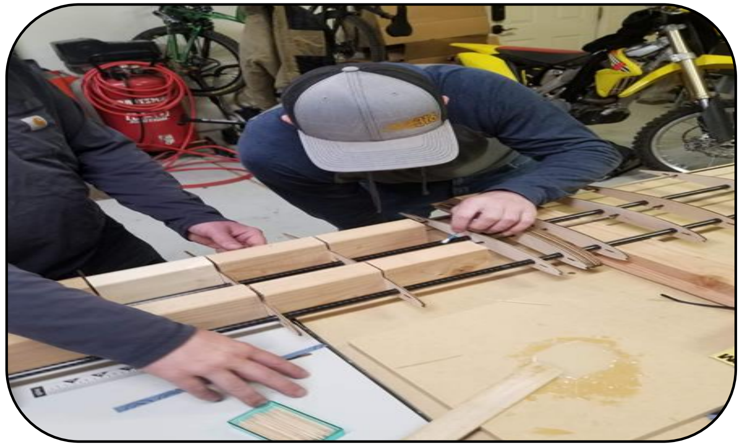
- Wing span: 4 m (13.25 ft)
- Wing dihedral: 6°
- Wing area: 1.4 m^2 (15.2 ft^2)
- Total weight: 3.5 kg (7.6 lbs)
- Number of solar cells: 60
- Maximum power output: 205 W
- Operating voltage: 17.2 V
- Propeller: 457x152mm (18x6 in)
- Flight speed: 10 m/s (22 mph)

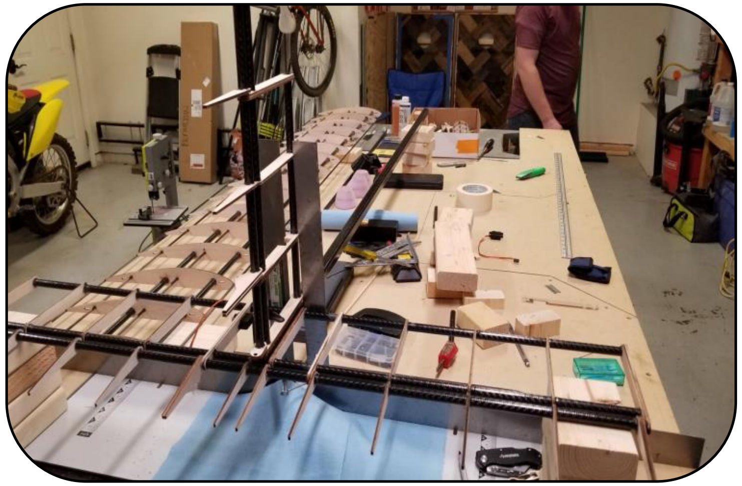






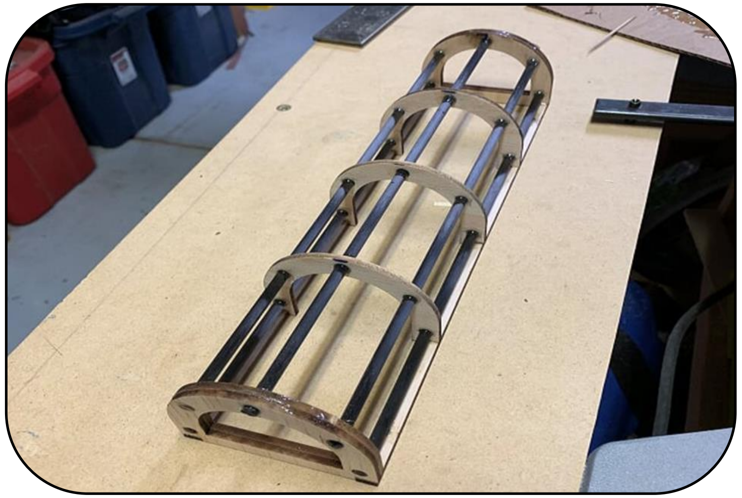
Manufacturing





Total Manufacturing Time

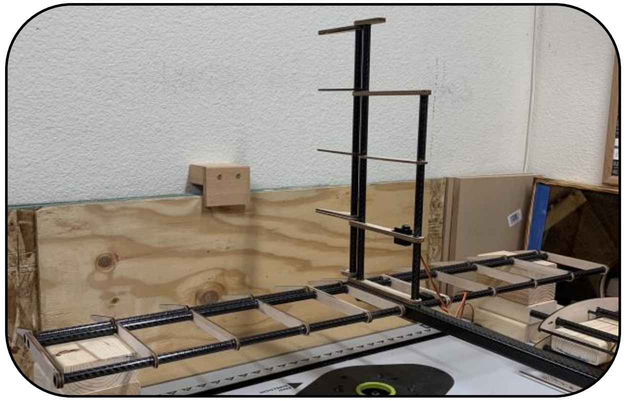
- 218+ man hours
- 32 hours soldering solar panels
- 58 hours building the wings and tail
- 15 hours machining wing mounting brackets



Manufacturing

Construction Tasks

- Carbon fiber/balsa wood assembly
- Aluminum machining
- Carbon fiber layup
- Electrical soldering
- Ultracote application

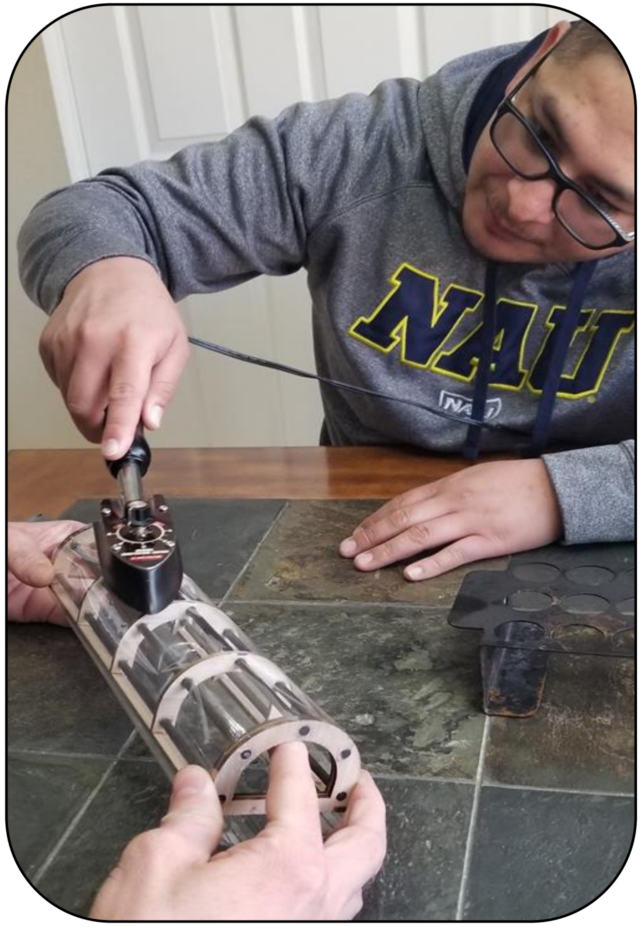


Bottom fuselage shell

Nosecone molds, wing arms

Tail

Manufacturing



Laying up carbon fiber for wing shroud

Applying Ultracote

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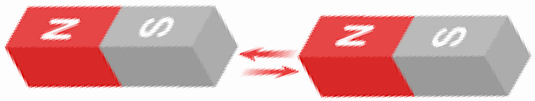
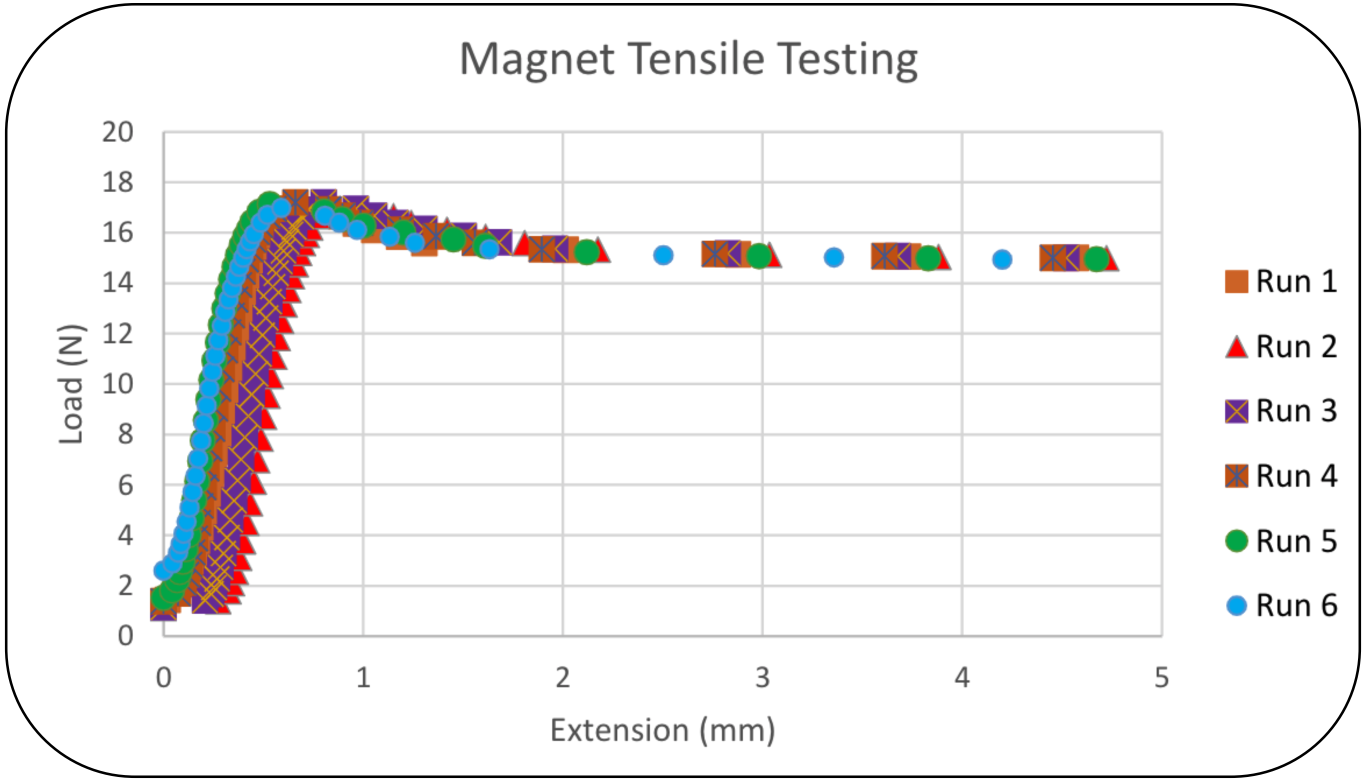
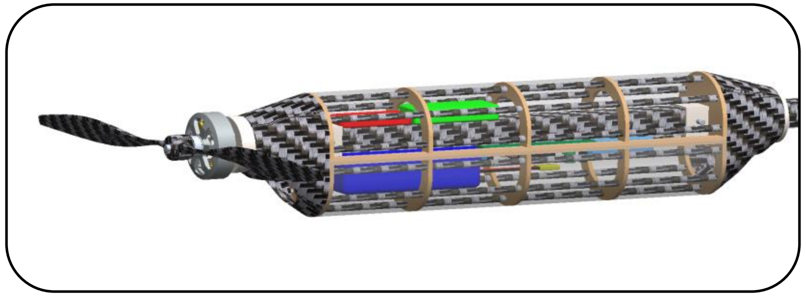
System Analysis

Magnet Tensile Testing



- Maximum separation force was found using a tensile tester.
- Results showed an individual magnet was strong enough to maintain fuselage closure.
- 6 magnets were initially used to locate fuselage.
- Additional magnets were added to increase separation force.

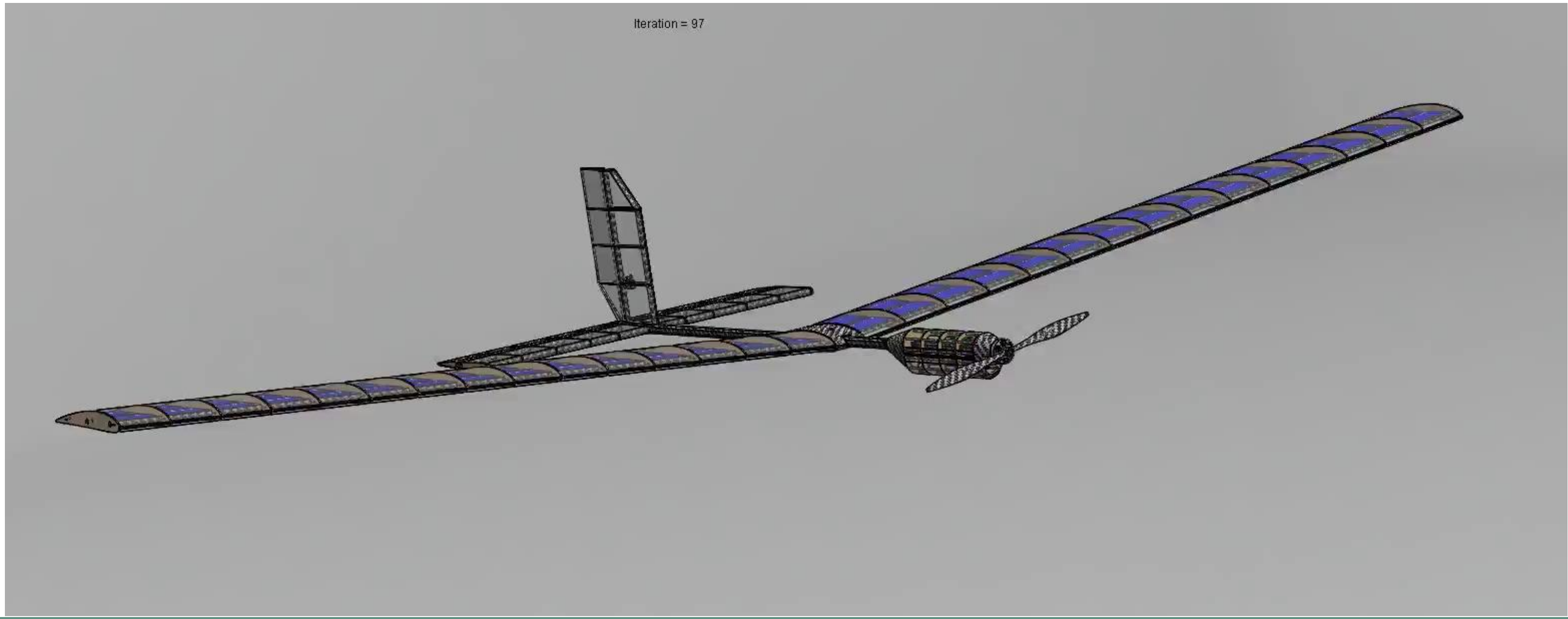




System Analysis

Aerodynamics

- A MATLAB model was built to simulate wing lift
- CFD used to simulate total lift and drag
- Area relations used to ensure stability
- Glide ratio of 24:1

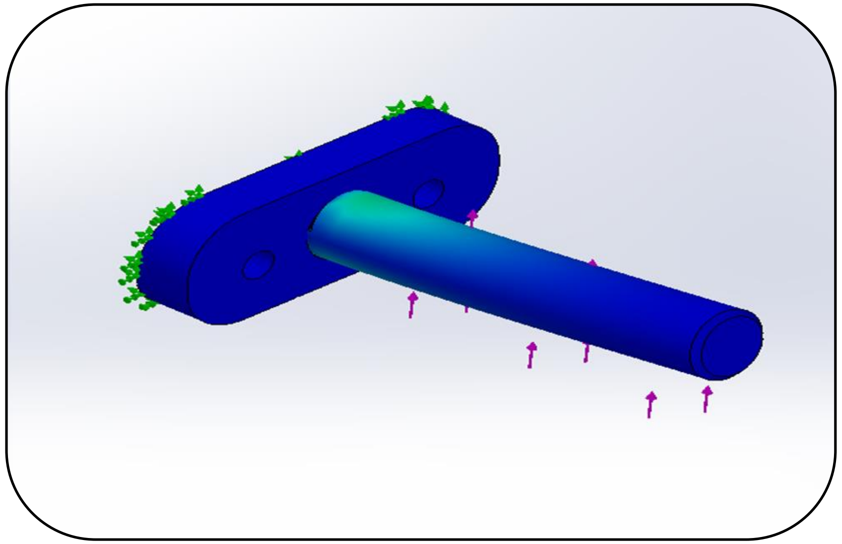


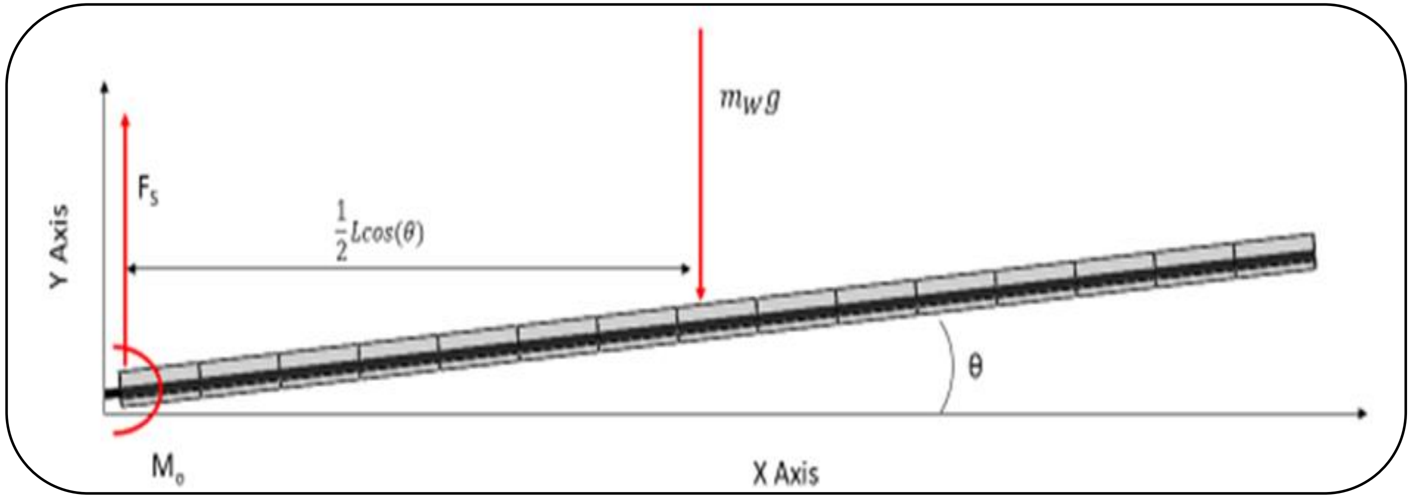
System Analysis

Wing Mount Stress

- In-flight induced moment
- Wings could see ~ 85.65 lb_f
- Designs considered
  - 3D Printed ABS
  - T6 6061 Aluminum

$$M_o = \mathrm{M_{wg}} \frac{\mathrm{Lcos(\theta)}}{2}$$





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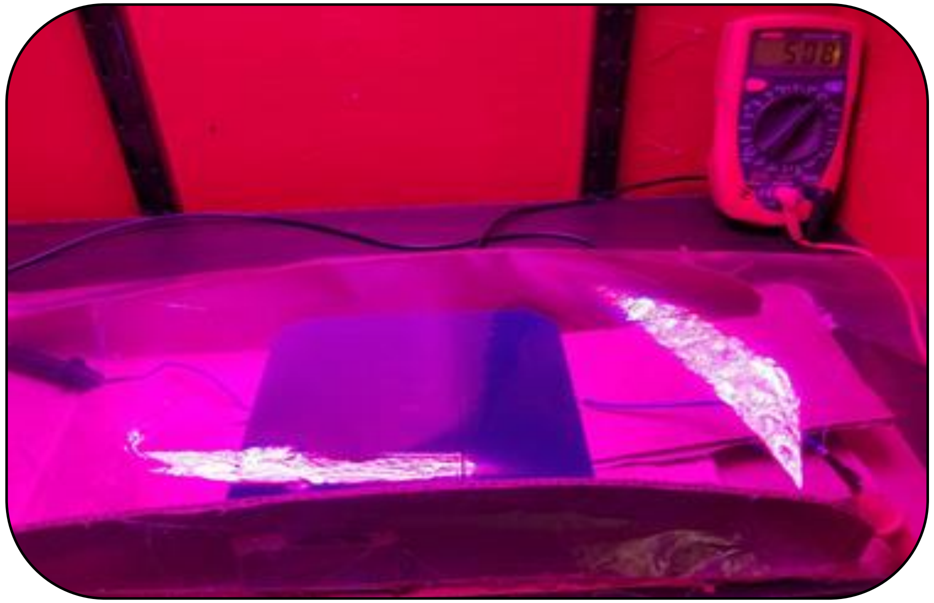
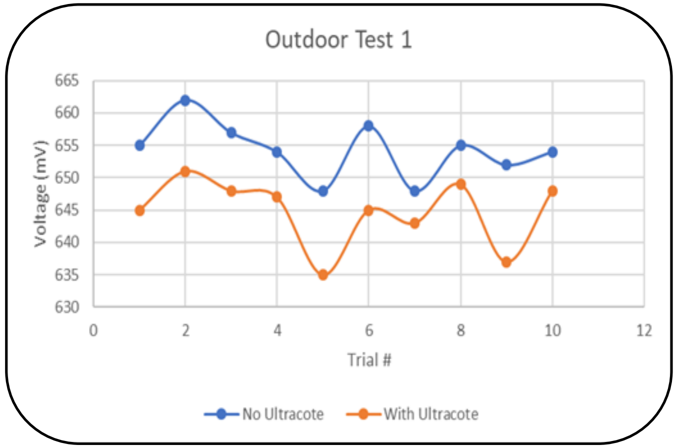
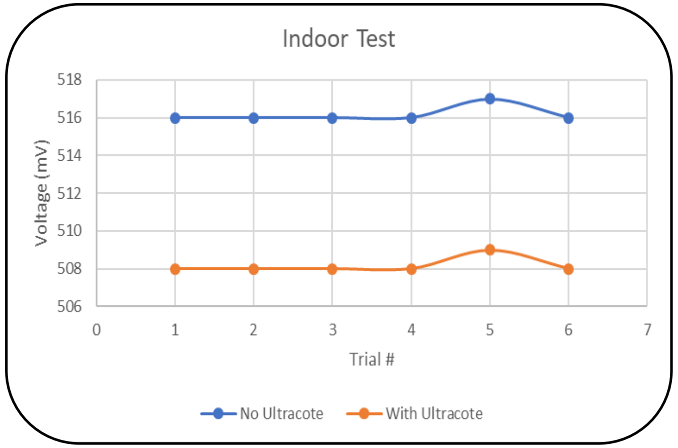






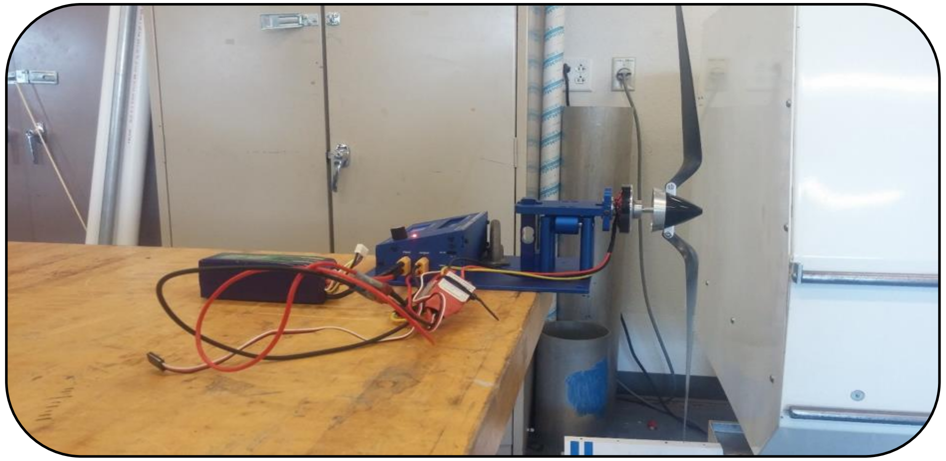
Solar losses due to Ultracote

- Testing solar cells with and without Ultracote overtop showed a 2% loss in voltage.
- Tests were conducted outdoors and with artificial lighting.

System Analysis

Thrust and Power Draw Testing

- Power consumption was found by using a Turnigy thrust stand.
- Voltage, amperage, wattage and thrust were measured.
- At full power our motor propeller combination requires 7.8 amps, and 120.8 watts at 15.4 volts.



- This test verified that we would be able to fly our plane using only solar power.
- Max thrust created by our system was 1030 grams.

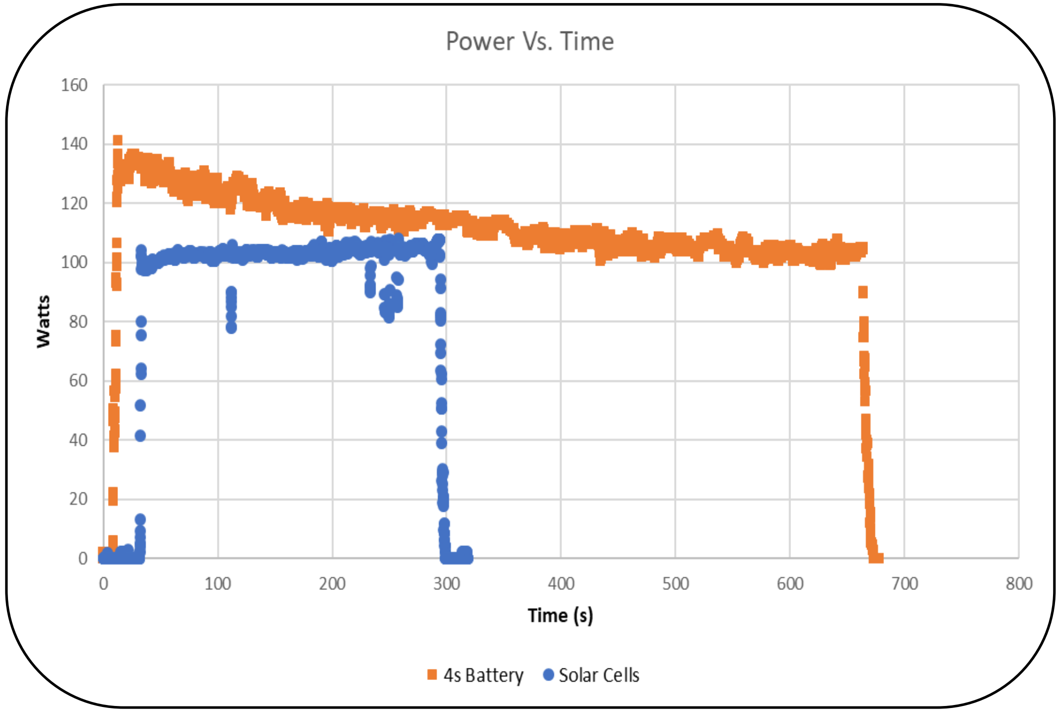
Ground Testing Results

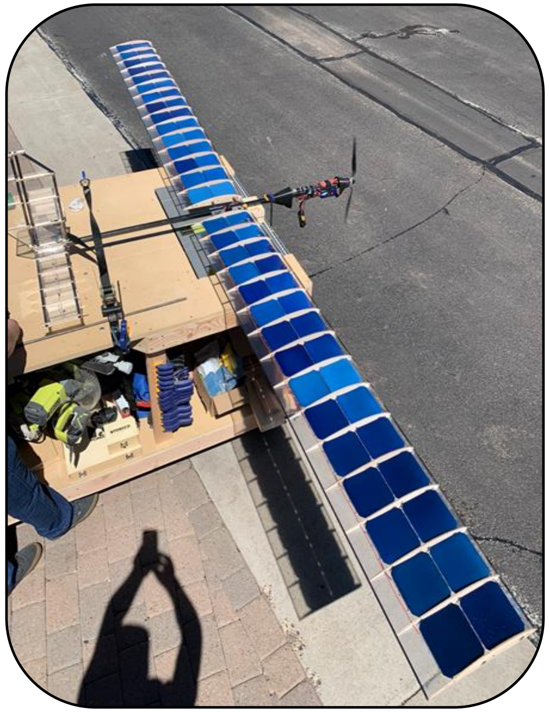
Ground Testing Results

- Solar cells created higher voltage but less amperage than battery.
- Solar power remained consistent over time.
- Plane can be powered by only solar cells.

Estimated Flight Time

- Indefinite while the sun is out!

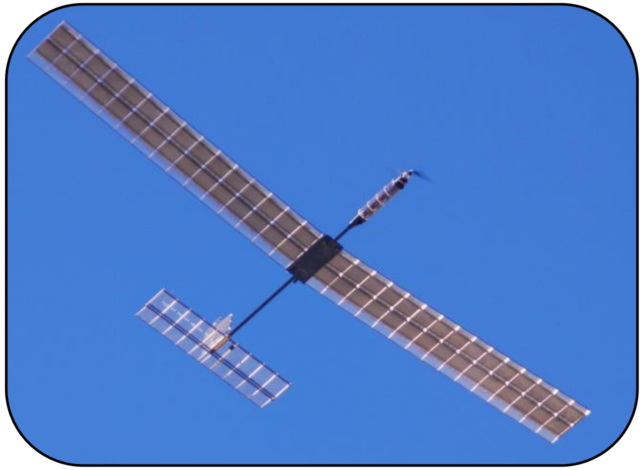


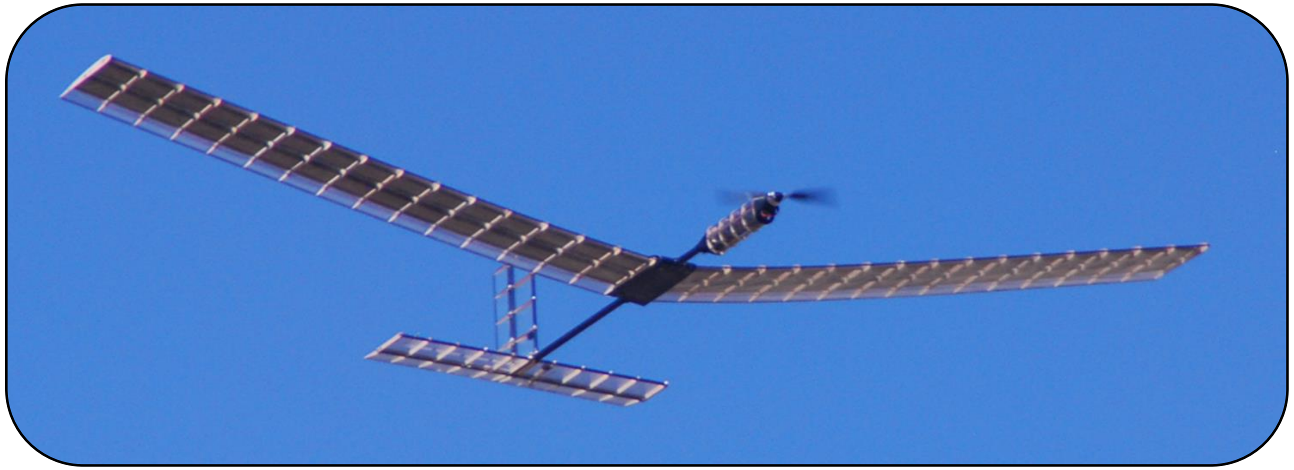


Flight Testing

Initial Test Flight – 4/13/19

- Location: Bellemont, Arizona
- Fly on battery power to prove flight characteristics.
- 2nd flight would be on pure solar.
- Elevator broke upon landing preventing the 2nd flight.
- Data collected:
    - Air speed & ground speed
    - Altitude
    - Power consumption
    - GPS positioning
    - Battery voltage





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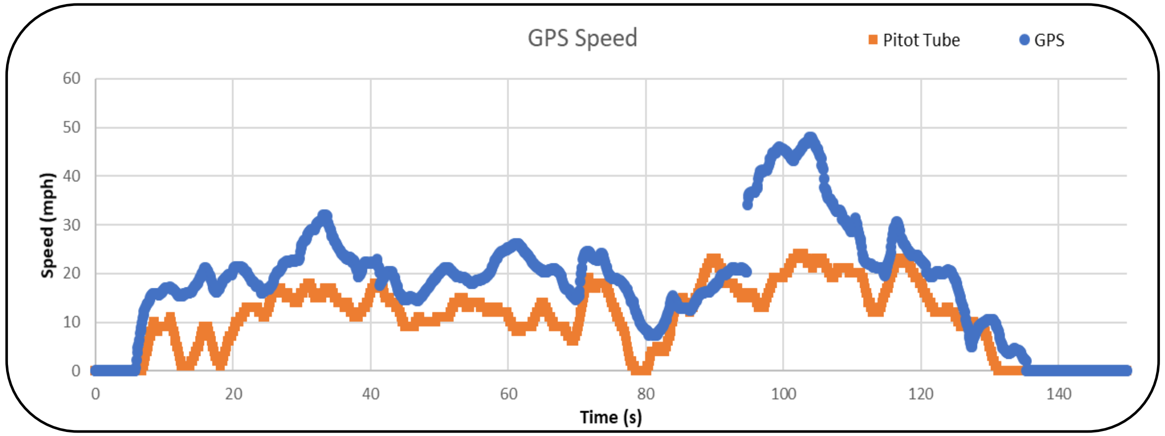
Testing Results

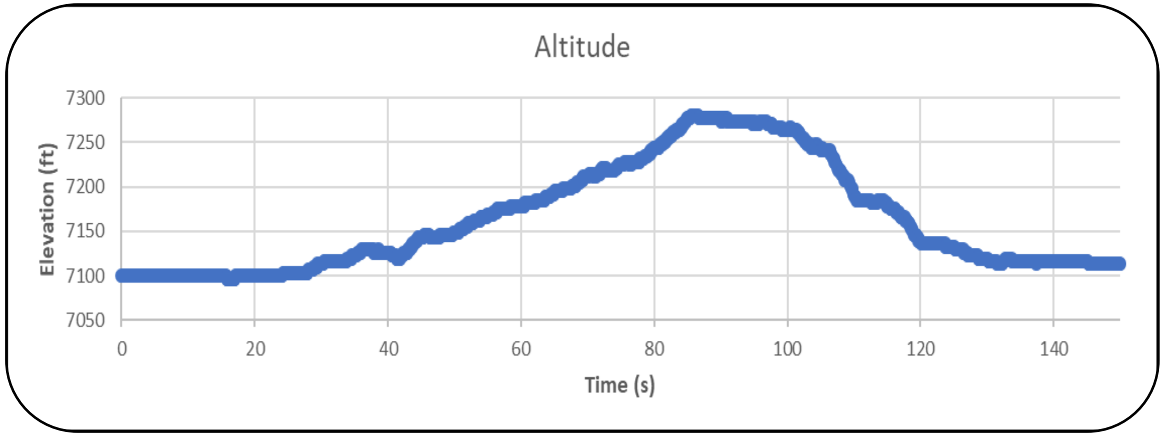
Flight Results

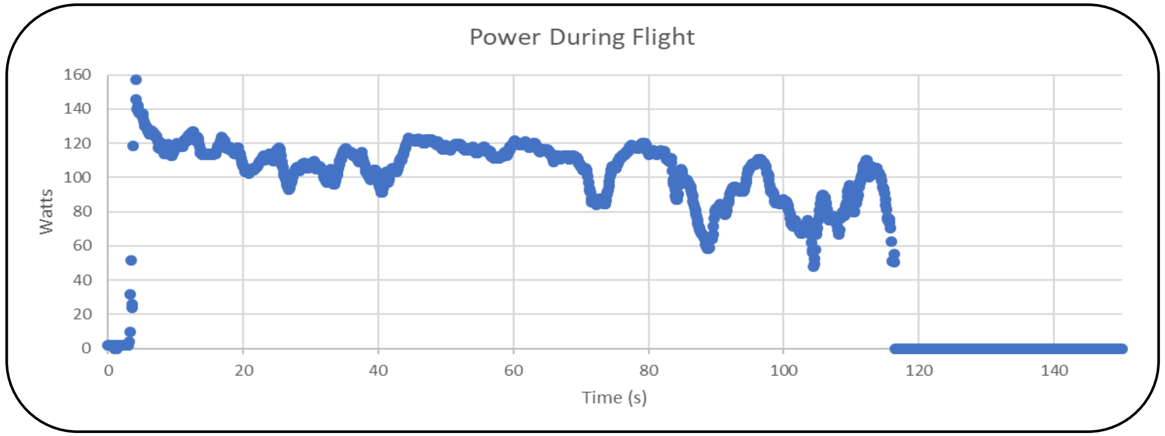
- Test flight reached 170 ft off the ground.
- The plane was able to exceed the calculated speed.

Estimate Flight Time

- Indefinite while the sun is out!







Future Work

Configuration Improvements

- Incorporate a MPPT battery charge controller
- Continue to develop fuselage
- Increase system operating voltage
- Decrease reliance on off the shelf parts

Plane Re-design

- Increase wing stiffness to reduce deflection
- Ailerons could be implemented
- Winglets used to decrease drag
- Add positioning lights
- Higher strength construction materials

Conclusion

Estimated Flight Time

- Indefinite while the sun is out is possible!

Things we learned

- Need to design for wing torsion
- 5 minute epoxy works great
- Maybe we don't need a battery
- Design for manufacturing
- Charge controllers do not come in all sizes and they weigh a lot.
- Time is money!

Skills We Gained

- Soldering solar connections
- Apply Ultracote to aid with appearance and strength.
- How to glue with jigs to get professional results.
- Advanced wiring techniques.
- How to design a solar array for specific power needs.

Acknowledgments

- David Trevas, PhD
- Northern Arizona University
- Novakinetics Aerosystems
- Prometheus Solar
- Flagstaff Flyers
- Coconino High School
- Rock West Composites

References

- [1] "Free Vector," [Online]. Available: https://www.freevector.com/airplanes-blueprint-19757. [Accessed 24 September 2018].
- [2] “Forces Network”, [Online]. Available: https://www.forces.net/news/tri-service/nato-takes-delivery-new-drones. [Accessed 25 April 2019].