Smith Solar Airplane Group- Solar Plane Project

Jeffrey Hong

Newman Smith High School

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Abstract

The Smith Solar Airplane Group is a four student team that constructed a Solar Airplane with superior flight characteristics and outstanding structural integrity that nearly had the ability to recharge during flight. Their quest to create this plane taught valuable lessons that other students could only ask for.

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Introduction

Hunkered down in the Skunk Works Lab, the only room in the school that could remain ours for two months, we began our project. Only one team member had prior experience with radio controlled aircraft, but even then, he only knew about gas powered aircraft, not electrical ones. That was our team alright, but we were not fazed. Each team member conducted research and reached out for help to finally build an impressive machine that took the jaws off the judges. Our Skunk Works lab lived up to its name. Our high hopes for our project followed the real Skunk Works tradition by creating a new aircraft never before seen by the public. Our project was just the beginning. A solar plane could go on to revolutionize solar technology in aviation. The NASA Pathfinder Solar plane had already proven solar planes were possible. Solar Impulse, a manned solar plane from Switzerland was also coming to our town to demonstrate its viability. Why not show that a solar plane can be built in our very own backyards?

Beginnings

Our team was introduced the solar airplane project by a Texas A&M Professor and his graduate students Grayson Helmreich and John Guthery. Grayson, president of the Texas A&M Chapter of the Society of Flight Test Engineers (SFTE), and John, a member, facilitated the short introduction about Solar Aircraft and project details at our high school. The purpose of the competition was to test our aircraft design as well as the electrical aspect. Questions to be answered included: were the components able to recharge during flight, was the airframe airworthy, could the plane of this magnitude be built in two months? There were so many questions and so little time and so we began our project. My role as team leader brought me to contact people from all over the world for help. Also, as the soldering expert, I was the electrician. This research paper is written from my point of view.

Airplane Wing

The first problem encountered was reading the manual. From the starting materials, we received a pre-cut Balsa-Wood glider and most of the electrical components needed. The wing was the first part to be built. Right from the start, the manual for the airplane looked confusing. The parts listed were all over the place, and finding them and sorting them into a comprehendible format took two days. We could not follow the manual completely however. Much of the plane needed to be modified to accommodate twenty four solar panels to generate enough voltage for the MPPT to operate. Technically, the first challenge was calculating the amount of voltage to be used, but that was simple enough. If each panel generated half a volt, then, twenty four panels would generate twelve volts, the voltage that was recommended.

In order to build the wing to fit at least twenty four panels, the middle of the two meter wingspan aircraft needed to be expanded by ten inches. The metric and standard conversions became confusing and so our team went the customary route and began using inches and feet. To extend the dihedral wing, we decided to start from the center. The center of the wing could not hold any panels because that would be the attachment point to the plane. First, we replicated the plane's manual, five inches from both sides and cut balsa wood to fit the specifications. With the center wing expansion portion cut, we began assembly of the wing, one portion at a time. All the spars were put in place and each rib was then carefully slipped on and CA glued in place. A spray of the accelerator rendered the glue dry immediately and any mistakes would take a long time by comparison to correct. Nearly a full week later of afterschool building, the wing was complete.

Solar Cells

What is as thin as paper but snaps more easily than pencil lead? Our team would not have known the answer until we met solar panels. 3x6 Tabbed Multi-Crystalline Silicone Cells generating 1.8 Watts, 3.6 Amperes, and 0.5 Volts each were brittle and cracked even with a slight bit of mishandling. That was how five of our precious forty panels broke the first time we handled them. Forty panels seemed like a large amount considering we only needed twenty four cells, however, since realizing that these cells were so brittle, we were no longer so sure. Brittleness aside, we still had to mount them onto the wing. Mounting each panel directly onto the wing did not seem like a viable option. The panels would snap if they were glued to the curvature of the wing. We considered cutting each cell to fit in between each rib, but that would be too risky cutting all the panels. Good thing we decided on spacing out the ribs to accommodate the panels before gluing the wing. There was a slight twist however, now that we were going to mount the panels in-between the ribs, we could only fit 20 panels now instead of the original 24 as our calculations showed we needed. Despite this setback, we thought we could probably work our way around it. Twelve volts we heard was the optimum voltage so we thought 1.5 volts below the optimum wouldn't be that far off. (the other .5 volts is from the panel on the fuselage). The only problem was that we did not consult anyone about this problem which later came back to bite us behind the back.

Soldering was the next big task. After gluing all the panels onto the plane, we began the tedious task of maneuvering a soldering iron on the brittle cells. Any sudden movement or too much pressure could break the cells. This problem did occur and to our dismay, another five cells were lost. The tabbing on the panels was badly done and we had to re-tab many of the panels ourselves. All the panels were connected in series to generate enough voltage.

**Through experimentation, cutting solar panels was deemed risky because of the high shatter rate, even while using a high speed rotary tool with a diamond carbide cutting disk. A layer of monokote had to be applied in order to create cuts of any usable fashion.

After soldering all the panels together, we used monokote, a thin plastic shrink wrap to cover and form the surfaces of our plane. We pre-cut it to fit and then ironed the edges in place so we could blow dry it on with the heat gun.

Fuselage

The next part of the plane to be built was the fuselage. The fuselage turned out to be the easiest part of the build. As shown in the glider's user manual, it was straight forward. The rudder, elevators, and horizontal and vertical stabilizers were all easily assembled and attached to the servos. After securing all the mechanical components to the plane, we began wiring the standard plane electronics including the servos, receiver, motor and the electronic speed controller. This part was easy to do because A&M University provided us with a PowerPoint presentation on the wring. We attached our Maximum Power Point Tracker (MPPT) afterwards and everything was ready for testing.

Preparing for competition

After soldering on all the connections and parts, we joined the two parts together and brought the plane outside for its first sun test. Armed with a digital multimeter, we measured just over 11.3 volts on the bright, sunny day. Good enough we thought, our plane would be able to charge. The MPPT however did not show a charged, or even a charging status, but another one was available for us for the day of the competition so we were not worried. The problem we now faced was a low quality transmitter matched with an even more confusing electronic speed control. The high and low pitched being patterns could not be distinguished by any of us. But again, no worries, the experienced fliers at the competition would use their transmitters. The plane seemed ready to go. We packed onto the Chevy Suburban and headed down to A&M on May 25th, 2013 at five in the morning.

Competition Day

Competition day was an overcast day. Cloudy and overcast, even the SFTE did not know if the competition would be canceled. It was not and competition went on. The first team to arrive was ours. Looking at our plane, the Aerospace Graduate students quickly pointed out problems with our plane. The center of gravity was too far back, the wiring was a bit astray. But some quick fixes with the soldering iron, duct tape, quarters, and a stick cut fresh from a tree, and the plane was ready for its maiden flight. Five minutes into its flight off a fully charged battery, the ESC triggered the low battery monitor on the transmitter and our plane came in for a smooth landing. A perfect maiden flight by our standards, but what happened? The battery had cut too early. A closer inspection revealed that the MPPT needed a full twelve volts to charge and our 11.3 volts wouldn't have been enough even on sunny day. Because of the cloudy day, the 11 volts was one volt shy from success.

The team sporting 25 panels was next. They would have the perfect amount of panels for this overcast day. But theirs lacked something important. Their aircraft was not airworthy. As the plane began to pull out from a dive, a fracture in the spar snapped wing in two and the plane tumbled out of the sky, landing in a heap of broken balsa wood and monokote. The third team was up. Their 24 panels did not charge their plane that day either. However, their plane had more panels and took home 1st prize for endurance. Our plane out of all the other teams that day took home 1st prize in creativity. Our impressive placement of cells on the spars within the ribs did not affect the aerodynamics of our aircraft. In addition, our last minute adjustments done with duct tape, sticks and quarters sealed our creativity. The judges were awed by how fast we were able to make the changes in our few minutes grace period. A quick run to the tree line with a knife, and before anyone had realized what had happened, we finished our adjustments, giving the judges something to talk about for the rest of the day.

Conclusion

Our solar plane on many terms was a success. Although it was not able to charge midflight and required the use of another panel that was put in series with it on the ground to charge, our plane accomplished the rest of the goals. This plane is now retired, but its predecessor has just begun. The next version will have a longer wingspan to accommodate 30 panels, telemetry, and an autopilot system to fully utilize the plane’s capabilities. From this project, we learned about solar technology, Maximum Power Point Trackers, and solar panel types and designs in other real world applications. Not enough flights were made with this plane to begin the data collection process. Many problems with the solar panels afterwards forced an early retirement with this plane.

We entered our plane into the Instructables Green Design Contest and it won 1st place out of over six hundred other entries. It also won 2nd place in the Drones Contest. The project gained recognition on treehugger.com and other websites as well.

Acknowledgements

First and foremost, our team would like to thank Texas A&M University and the Society of Flight Test Engineers for making the project possible. Our school has started on our second plane already, for our own research purposes and will continue to work on plans for the future. Our mentor, Mr. Pat Hardage is another person who must be thanked. He not only gave us advice, but also went out to buy new tools when they broke. Heat guns blowing up and dried up

CA glue bottles were not part of the original plan. Dr. Sheu-Fen Lee, a biology teacher at our school lent us supplies and tools to make our project possible. Other teachers at school who aided in the construction of our project include the sewing teacher when we needed string. She is among many that gave their support. Allen Pan, aerospace engineer at Bell Helicopter gave input on the wing construction and solar panel placement.

The online community is the other group that receives the largest thank you. DIY Drones brought many experts together to troubleshoot our project. In addition our team was invited to join the North Texas Drone Users Group. Solar Impulse also showed their support of our project when they interviewed our team at the Dallas Fort-Worth International Airport.

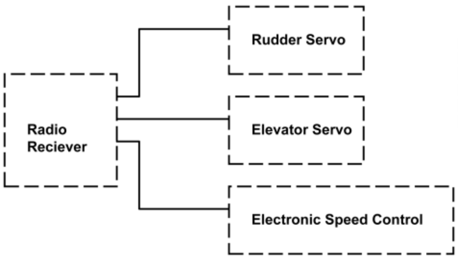
Much of our project was done in uncharted territory so few references were able to provide the full picture. However, we were able to create one via our how-to on instructables and hopefully that will aid others with creating their own solar airplane.

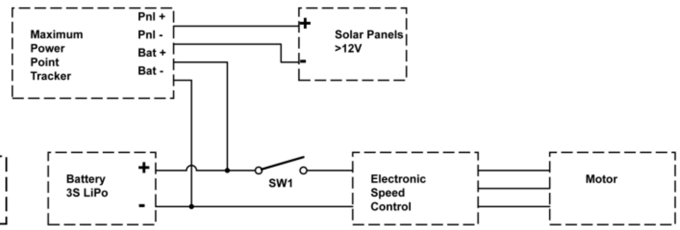
Appendices

PowerPoints by Texas A&M:

https://drive.google.com/folderview?id=0B_bYmGJ0v1Ncb283TF8tWXF6ZWc&usp=sharing

Included: Aircraft Stability and Control, LiPo Battery Procedures, Introduction to solar panels, aircraft components, and wiring diagrams.





Photographs:

https://plus.google.com/photos/115818106101964096893/albums/5882408272451794625?banner=pwa&authkey=COvzy-PyiLOp9AE

Instructables Link: http://www.instructables.com/id/Introduction-47/

Tree Hugger:http://www.treehugger.com/gadgets/how-build-your-own-solar-powered-plane.html

References

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All about maximum power point tracking (mppt) solar charge controllers. (2012). Retrieved from http://www.solar-electric.com/mppt-solar-charge-controllers.html