Prospects of Improving surveillance using solar unmanned aerial vehicles

Bilji c mathew

bilji.20206@lpu.co.in

School of mechanical engineering

Lovely professional university

kapurthala

Punjab

Abstract

This project deals with the design of the Solar UAV with wingspan 1.5 meter. The objective of the project is to provide sufficient solar energy to sustain the flight during cruising phase. To achieve desirable efficiency the selection of the fabrication material to the devices and equipments on board are to be chosen accordingly. The focus to achieve maximum area for solar panels and placed accordingly to get more solar rays over the aircraft. Thus Analysis Can Be Done for Estimating the Precise Location In Order To Achieve maximum Endurance.

Introduction

Nowadays, there are numerous unmanned aerial vehicles (UAVs) in service and further future planning, in Military, across the world for several different purposes. These vehicles can fly remotely as well as autonomously. Despite their usage in various applications, they lack in performance because of power restrictions, which means they either must land to refuel or to depend on another UAV to complete the task.

In recent times, the ability to fly without using conventional fossil fuels is primarily focused on, both in application point of view and scientific field. The use of electric aircraft has been widespread but here the crucial issue is their high-power consumption when compared with their limited energy storage capability, which leads to an endurance that can rarely exceed half an hour.

The main principle is to make use of available unlimited solar energy by converting it into electricity through solar cells. When sunlight strikes the solar cell, the cell creates electrons and holes as charge carriers and, when a circuit is made, the free electrons pass through a certain load in order to recombine with holes and, in this way, the current is generated.

Here, by arranging solar cells in series on the top of the wing and then wrapping the entire wing with transparent material for the safety of solar cells during flight, cells are arranged in series to get the required voltage in order to safely charge the 3S battery; from there, the battery power is supplied to the motor for throttling during constant level flight. In this study, the aircraft was assumed to be a glider, which means it also stores the energy in the battery during the gliding period. In this way, both flying the plane by using solar energy alone and storing the energy in the battery in order to extend the flight time can be achieved.

The main principle is to form use of obtainable unlimited solar power by converting it into electricity through solar cells. When sunlight strikes the photovoltaic cell , the cell creates electrons and holes as charge carriers and, when a circuit is formed , the free electrons undergo a particular load so as to recombine with holes and, during this way, the present is generated. Here, by arranging solar cells serial on the highest of the wing then wrapping the whole wing with transparent material for the security of solar cells during flight, cells are arranged serial to urge the specified voltage so as to securely charge the 3S battery; from there, the battery power is supplied to the motor for throttling during constant level flight. During this study, the aircraft was assumed to be a glider, which suggests it also stores the energy within the battery during the gliding period. during this way, both flying the plane by using solar power alone and storing the energy within the battery so as to increase the flight time are often achieved.

Literature Review

Recent records of research paper purposed on Solar UAV's shows the constant effort of humankind to achieve maximum efficiency from the Solar powered UAV'S, thus provides another sustainable source of energy to power a flight operation. Innovative ideas are being built and implemented. Various public and private Patents have been filed for the enhancement of the technology. These are providing us the crucial and valuable data to build a High Endurance UAV.

Gao Xian-Zhong, Hou Zhong-Xi, Guo Zheng, Zhu Xiong-Feng, Liu Jian-Xia and Chen Xiao-Qian , they have done the search on the topic **Parameters determination for concept design of solar-powered, high-altitude long-endurance UAV** which says **:**

The power density determines the up boundary of wingload. According to power density distribution on earth, where HALE UAVs are capable to operate and how long they could work can be determined. The high energy density of LS-battery is the key technology to enhance HALE UAVs' long-endurance ability. . The only way to enhance carrying ability of HALE UAVs is to redistribute their wing load, so the lighter structure materials and better method to fix P-cell with lighter alternative are the key technologies to enhance HALE UAVs' carrying ability.

JAW-KUEN SHIAU presented a proposed research study on **Design of a Solar Power Management System for an Experimental UAV** which says that :

The power bus structure provided in this paper contains three power conversion stages in cascade. The power efficiency of the overall system is the combination of the efficiency of all of the three stages. This structure is useful for low power applications such as UAV systems where we need to deal with possible rapid changes of atmospheric condition. Three different loads (5 −, 10 −, and 15 −) are used to conduct the test. The results show that the solar power changes with the incident angle correctly. To verify the extraction of the maximum power, we take the power at zero degree incident angles as the reference and times cosμ with μ varying according to the experiment setup to generate a simulated maximum power. The test results show that when the sunlight incident angle varies from 0 to 45 deg, the power drawn from the solar cells depends on the load conditions and can have a reduction of up to some 30%. This implies that the changes of aircraft attitude will directly affect the power obtained from the solar system. This in turn will limit the pitch and roll angles of the aircraft maneuver and must be taken into consideration for optimal flight path design. The test results also provide a good reference for the sizing, power, weight, and performance consideration for the development of a fully solar powered UAV.

Scott Morton has done the search on the topic **Solar Powered UAV: Design and Experiments** which depicts that**:**

In this work, design considerations associated with solar powered UAVs are presented, a prototype small scale solar UAV is described, and validation of the prototype is demonstrated through several experimental tests. The experiments show that captured solar power accounts for over 300% of a conservative estimate of the power required for level flight. Although this work adds to the few experimental efforts for developing solar powered aircraft, significant theoretical and experimental work remains before a mature understanding and accurate modeling of small scale solar powered UAVs is developed. Specifically, an investigation into smaller scales is warranted since many factors associated with scaling such as aerodynamic efficiency, realizable aircraft weight, and maximum theoretical flight time are not well understood in the context of optimizing solar UAV design. Future work with the solar UAV prototype will be focused on experimental measurements of maximum flight endurance in various flight conditions. In addition, studies into optimal path planning and control of solar UAVs appear to be promising research topics to further enhance solar UAV performance.

Giulio Romeo a proposed research study on **HELIPLAT: Design, Aerodynamic, Structural Analysis of Long-Endurance Solar-Powered Stratospheric Platform** which depicts that**:**

The design activity of a new concept platform has been presented including the many different topics involved. The aerodynamic optimization of the HeliPlat platform (flying at a very high altitude of 17–20 km, a low speed and low Reynolds numbers) has been performed with the computational-fluid-dynamics (CFD) codes VSAERO to increase platform efficiency, in particular to achieve the minimum induced drag vs local Reynolds airfoil (at constant aspect ratio and wing surface). The numerical airfoil aerodynamic results show that airfoil is capable flying at low Reynolds numbers. The experimental results differ only slightly from the theoretical results, and greater efforts should be made in this field to reduce the gap. The wing configuration platform has been optimized to reduce platform drag and thus decrease the required flight power. A platform drag reduction up to 30% has been obtained with respect to the initial platform configuration, giving a reduction in the required flight power and increasing the power available for the payload. A CFD analysis has also been completed, which includes the effect of the eight propellers and has resulted in a 7% increase in the whole drag coefficient. The aerodynamic derivatives have also been obtained in order to evaluate the flight mechanics. By restricting flight to the spring–autumn months, a smaller platform size could be used and could be manufactured with present-day technologies. The manufacturing of a scaled-size prototype showed the capability of the platform to meet the planned mass and costs. The finite element method numerical analysis of the scaled-size technological demonstrator shows that the aircraft can meet flexural stiffness requirements. Limited values of wing deflections have in fact been used as design allows. A good correlation between analytical, numerical, and experimental results has been obtained from the static test on the complete aircraft. The numerical design of the HeliPlat solar powered platform shows the feasibility of a very long-endurance high-altitude platform, at least for low-latitude sites in Europe and for six months of operation. A significant reduction in platform size (consequently expanding mission range, altitude, or latitude sites) would occur by increasing solar-cell efficiency to 25%, specific energy of the fuel cells to 600 Wh/kg, and their efficiency to 70%; it is also very important to obtain these performances at a reasonable production cost. The improvement in the definition of an airfoil database, especially designed for low Reynolds numbers, could increase the platform performances. It is very important to avoid high structural wing flexibility in order to minimize the aeroelastic effects that could produce undesirable structural failure. A flight simulation activity is in progress in order to check the specific characteristics obtained during this design process.

Methodology

Thus from the literature review we have seen that there a lot research paper and working models of solar UAV’s but most of them are for UAV’s with wing span more than 15 meter. Due to big wing span certain task and operations are hard to be executed. These UAV’s are also not cost efficient as they have such a big body to be fabricated and requires more power to work thus making it heavier in weight also. In the table below we can see that all the aircraft based on solar power are quite big in dimensions than an ideal compact UAV.…

DESIGN

Table 1 Complete Design Parameters for Similar Aircraft

	Sunrise I	Sunrise II	Solar Solitude	Solar Excel	SoLong	Zephyr	SunSailor 1/2
Weight (in kg)	12.25	10.21	2	0.72	12.6	50	3.6
Endurance	4 hours	Unknown	Unknown	11 hours, 34 minutes, 18 seconds	48 hours, 16 minutes	336 hours, 21 minutes (14 days)	Unknown
Range	Unknown	Unknown	38.84 km in a straight line	48.31 km in a straight line	Control and telemetry range: 8 km	Unknown	139 km
Wingspan (in m)	9.75	9.75	2.7	2.1	4.75	22.5	4.2
Aspect Ratio	11.4	11.4	13.3	12.8	15	11.6	13.15
Wing Area (in m^2)	8.36	8.36	0.55	0.35	1.5	27.9	1.35
Cruise Altitude	Unknown	Unknown	Max altitude = 1283 m	2065 m	Unknown	Max is 70,000 ft. Climbs to 40,000 ft on first day, then maintains 60,000 ft.	Max is 500 ft above ground level due to restrictions
Cruise Velocity	Unknown	Unknown	Unknown	Max velocity = 80.63 km/hr	27-50 mph	Unknown	25 knots
Max Climb Rate	Unknown	Unknown	Unknown	Unknown	2.5 m/s	Unknown	300 ft/min

In the above table we have comprised some well known Solar UAV with their specification and dimensions. From the above data we conclude that we need to consider our design similar to those Aircraft as they are well performing aircrafts. At such a note we consider the design to pass on those parameter that are listed in the table. The main focus our project will be to make the UAV light weight and of high endurance. Thus we need to select the material to be wisely to make it light weight and make good selection of the efficient devices such that overall efficiency of the system could be higher.

The whole aircraft prototyping task was composed of two phases: elementary and fundamental. In elementary blue print of the prototype, size, weight, performance are enforced. In fundamental phase with the help of computer aided design, individual components are displayed and each part is analyses to enhance the actions performed in elementary phase to fulfill the mandatory objectives. Plan prerequisites are employed to command and assess the advancement of the entire aircraft prototype. The two common accommodations were:

Weight balance: The weight of all the components that build up the lift force plane must be equivalent to the lift.

Energy balance: the energy plane accumulated in a day through the solar panels must be equivalent or exceeding the sum of electrical energy needed for that particular altitude.

For getting the exact idea of the specification and design measurement, we need to find the various aspects of the aircraft that is having the **Wingspan of 1.46m.**

As observed from the above data of the UAV’s certain Parameter should be fixed so that the performance of the aircraft could increase.

Aspect ratio of the aircraft should be **7**

Taper Ratio should be fixed **0.6**

Weight of the aircraft with payload should not exceed **8N**

These are the confined areas on which the design should constraint its limits. According to the need, the UAV comprises of such dimensions and parameter should be design. So we need to plan some mission specification to satisfy such parameters and constraints.

MISSION SPECIFICATION

The main objectives of this paper is to determine the energy required from the Solar panel to drive the aircraft and also which helps to increase the aircraft's endurance for specific period of time during its time of flight by keeping the gross weight (0.75kg) of the aircraft as constant .There is no limit to the goal because the goal is just jumping and not reaching any destination.

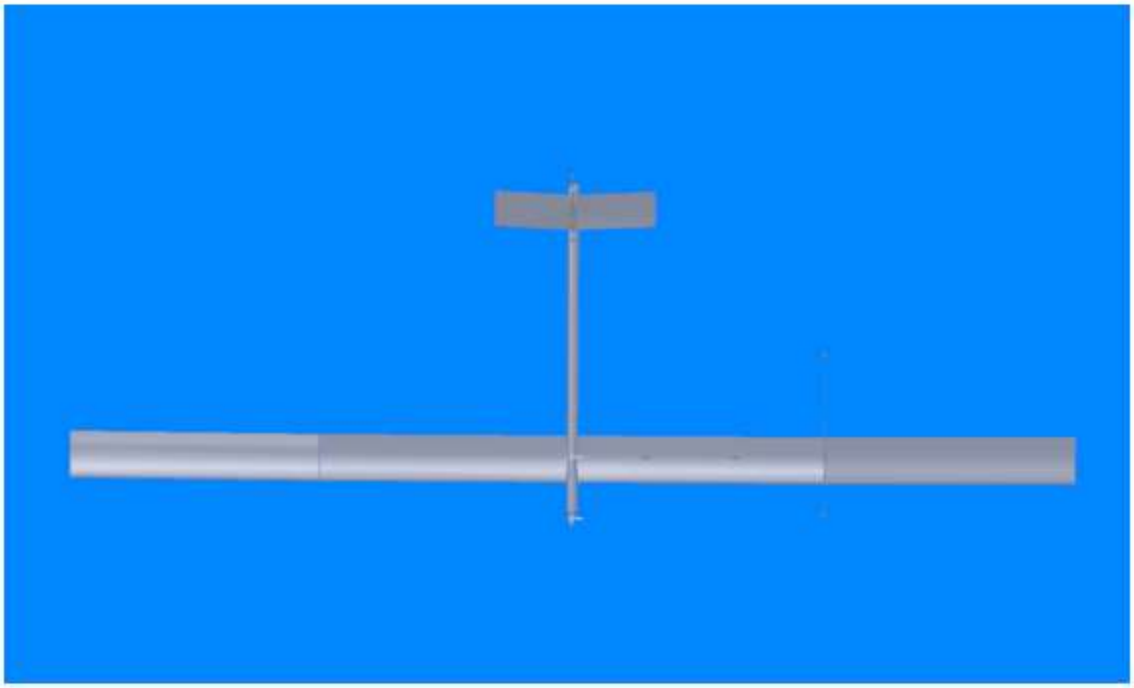
Table 2 Mission Specification

Parameter	**SI Units**
Gross weight	0.550kg
Payload	0.150kg
Altitude	30 – 50 m
Average Air density	1.22 kg·m-3
Clearness factor	0.7 (1 = clear sky)
Take-off distance	None (hand toss launch)

ESTIMATION OF THE NUMBER OF SOLAR CELLS REQUIRED AND IT’S ARRANGEMENT ON THE WING

It is mandatory to finalize the number of solar cells and their types change which will not affect the aerodynamic profile and basic structure of the wing .we selected 3-S batteries are for numerous reasons such as they offers high specific energy compare to other lithium batteries. They are light weight and compact size. It offers high capacity and hence can be used to hold more power. They are safe from explosion unlike Li-Ion battery. On the other hand, if fewer LI-PO cells were used in the series (2-S), it would be difficult to supply the energy needed to achieve a good climb rate.

Figure 1 CAD of early design of Solar UAV



- The wing is two long, which requires a tough structure, increasing the weight and cost.
- Controlling will be difficult as it does not have ailerons.

These problems are solved as the solar cells are placed on the mid wing and tip wing; the end wings are for stability with a polyhedral angle of about 7° on both sides, which is followed by dihedral angle of 4 degree.

As each solar cell has 0.110m in length, for 12 solar cells in a row, a wingspan (middle portion) of 1.32 m is required. However, apart from this length, extra space is required for the soldering purpose. Besides, at the ends, at least 2 – 3 cm should be left because there will be abnormal forces at the junction. Then, a central wingspan of 1.46 m was chosen by considering all parameters. The ends of the wing are tapered from a **root chord of 19.5** cm **to a tip chord of 17.5cm** over a length of 70 cm. The **aspect ratio** of the entire wing is **7.48**.

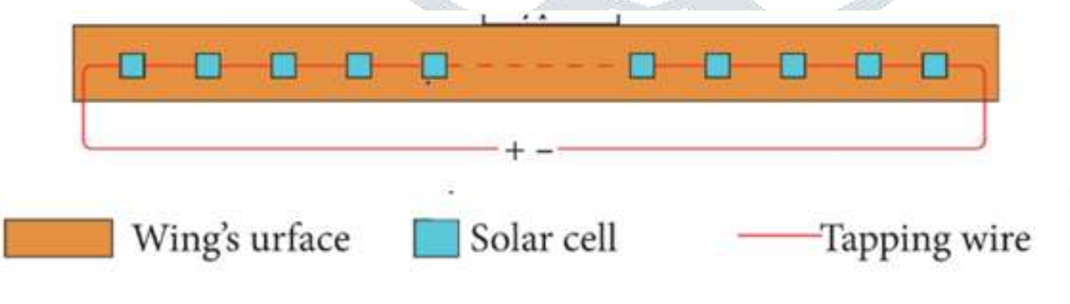


Figure 2 Placement of Solar Panel over the Wing

AIRFOIL SELECTION

After finalizing the design of the wings, the airfoil is selected based on the following requirements: high lift coefficient; Low drag coefficient; Less camber for cell placement.

Table 3 Specification of the Airfoil

Parameter	SI Units
Aspect ratio	7.48
Root Chord	0.195m
Tip Chord	0.175m
Taper Ratio	0.87
Length and width of airfoil	1.46 x 0.195
Wing Area	0.28 m^2
Cruise velocity	6.15m/s
Thrust to weight ratio	1.1
Thrust required for the aircraft	7.7
Coefficient of lift	1.1
Coefficient of drag	0.0115

Figure 3 Actual work model of airfoil

Conclusions

In this paper, we successfully designed an UAV which is actually very much light weight. The UAV with all the devices and components weighs 700gm. An additional 100gm of payload can be equipped on the UAV when required. Thus this UAV qualifies less than 1kg weight limit. Solar panels are installed in such a way to provide higher endurance and cause lesser drag. To install Solar panels on the wings the wing structure is also chosen in the way to provide maximum area. Thus while doing that we eliminated the control surfaces from the wings. But it engenders the instability due to wing structure, so that problem was tackled by introducing dihedral and polyhedral angle on the wing. All the components were designed, considering various factors for better performance, and analyzed for deflection and stress to keep the design under the safer limit. This gives a basic foundation in order to fabricate a solar-powered UAV.…

References

1. Anderson, John, D (2007). Fundamentals of Aerodynamics. McGraw-Hill.
2. History of Solar flight André Noth, andre.noth@a3.epfl.ch Autonomous Systems Lab, Swiss Federal Institute of Technology Zürich
3. Development and Integration of a Solar Powered Unmanned Aerial Vehicle and a Wireless Sensor Network to Monitor Greenhouse Gases Alexander Malaver 1 , Nunzio Motta 1 , Peter Corke 2 and Felipe Gonzalez 3,*
4. Solar Powered UAV: Design and Experiments Scott Morton, Ruben D'Sa, and Nikolaos Papanikolopoulos morto091@umn.edu, ruben@cs.umn.edu, npapas@mail.cs.umn.edu Department of Computer Science, University of Minnesota
5. Design of a Solar Power Management System for an Experimental UAV JAW-KUEN SHIAU, Member, IEEE DER-MING MA PIN-YING YANG GENG-FENG WANG JHIJ HUA GONG Tamkang University
6. Manishaben Jaiswal "Big Data concept and imposts in business" International Journal of Advanced and Innovative Research (IJAIR) ISSN: 2278-7844, volume-7, Issue- 4, April 2018 available at: http://ijairjournal.in/Ijair_T18.pdf
7. Parameters determination for concept design of solar-powered, high-altitude long-endurance UAV Gao Xian-Zhong, Hou Zhong-Xi, Guo Zheng, Zhu Xiong-Feng, Liu Jian-Xia and Chen Xiao-Qian College of Aerospace Science and Engineering, National University of Defense Technology, Changsha, People's Republic of China
8. HELIPLAT: Design, Aerodynamic, Structural Analysis of Long-Endurance Solar-Powered Stratospheric Platform Giulio Romeo,∗ Giacomo Frulla,† Enrico Cestino,‡ and Guido Corsino‡ Politecnico di Torino, 10129 Turin, Italy
9. Manishaben Jaiswal, "COMPUTER VIRUSES: PRINCIPLES OF EXERTION, OCCURRENCE AND AWARENESS ", International Journal of Creative Research Thoughts (IJCRT), ISSN:2320-2882, Volume.5, Issue 4, pp.648-651, December 2017, http://doi.one/10.1729/Journal.23273 Available at http://www.ijcrt.org/viewfull.php?&p_id=IJCRT1133396
10. AirfoilTools.com (2016) Airfoil tools; [accessed 2016 Aug 11]. http://airfoiltools.com/index [Links]
11. Bandel A (2015) Aviation studies design build and fly minor. Amsterdam: University of Applied Sciences. [Links]

12. Bansal RK (2010) A textbook of the strength of materials. Bangalore: Laxmi Publications. [Links]
13. Bruscoli S (2011) Airfoil optimization for a solar powered aircraft (PhD thesis). Pisa: Università degli Studi di Pisa. [Links]
14. GoodWinds Composites (2016) Carbon rods; [accessed 2016 Aug 11]. Available: http://gwcomposites.com/carbon-rods/ [Links]
15. Jashnani S, Nada TR, Ishfaq M, Khamker A, Shaholia P (2013) Sizing and preliminary hardware testing of solar-powered UAV. The Egyptian Journal of Remote Sensing and Space Sciences 16(2):189-198. doi: 10.1016/j.ejrs.2013.05.002 [Links]
16. Kederoglu OG, Yanbastioglu S, Saraç B, Kocaoğlan MH (2012) Solar powered aircraft: PV Power System Definition & Solution Development Project; [accessed 2016 Aug 11]. http://www.academia.edu/7515954/Solar_Powered_Aircraft_Project [Links]
17. Kumar G, Sepat S, Bansal S (2015) Review paper of solar-powered UAV. International Journal of Scientific & Engineering Research 6(2):41-44. [Links]
18. MakeitFrom.com (2016) Balsa; [accessed 2016 Aug 11]. http://www.makeitfrom.com/material-properties/Balsa/ [Links]