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AN ANALYSIS OF SOLAR POWERED UNMANNED AERIAL VEHICLE

Sushil Kumar Jaiswal
M. Tech in wireless communication, Amity University, Noida, U.P.
sushil188696@gmail.com

ABSTRACT
Unmanned Aerial Vehicles (UAVs) or otherwise known as Drones define that on-board pilot is replaced by a remote controlled computer system and the radio link. The increasing presence of drone technology and its influence in today's world is quite apparent. UAVs have immeasurable potential in different services where they are becoming eyes and ears and providing a broad range of solutions. Flying opens new opportunities to soar above the horizon and snap a photo or videoand we experience the benefits that they are providing. However, despite the promising potential, one of the main problem is endurance or flight time as it uses limited energy storage batteries or conventional fuel which has a limited life and is costly. Using solar energy through solar cells into modern aircraft technology instead of increasing the size of the fuel system or battery sizing will increasing the potential of unmanned aerial vehicle. The aim of this paper is to gives an overview of solar-powered drones and their design for a 36-hrs endurance flight.

Keywords
UAV, Solar energy, solar cells, airfoil, MPPT, performance.

1. INTRODUCTION
Unmanaged Aerial Vehicles (UAVs) were in service since the 19th century mainly developed for military applications and used for years by the armed forces for reconnaissance as small aircraft are difficult to be detected by radarsbut the capability of performing a variety of functions in different areas make it a key element in research. New shapes in the sky or Smart Planes are equipped with automatic control system with unmanned hardware and software, navigation and path planning units, necessary sensing and information processing units, communications systems and multi-agent systems which make them capable of performing missions autonomously without human intervention on aerial, ground, underwater and unconventional platforms[1][2][3].

Implementation of solar cells on UAV have become a familiar technology and academics, researchers and hobbyists are continuously experimenting with it. Solar cells connected via a power electronic circuit that supplies the motor and also charges the battery which would use as a buffer when UAVs are flying at night or under clouds. Improved technological developments of remote sensing techniques and both private and military investments in the UAV industry making it more capable and less expensive. Complete study of both low-altitude long-endurance (LALE) applications and high-altitude long-endurance (HALE) applications is done before designing our solar powered UAV [4].

2. DESIGN METHODOLOGY
The conceptual design is based on maximum take-off weight and the desired energy for flight as the altitude increases, the air density and pressure decrease. This requires more area to generate enough lift to sustain the weight of the aircraft. In order to meet the required functionality CAD modelling of the individual part is done and then refining, improving the design and optimizing it is done. The general configuration in order to have a good counter roll and lift, constant chord wing is preferred (also it increase the area for solar panels) and the ends of the main wing are extended having a positive dihedral angle. This kind of design helps in attaining stability. At the end, twin-tail is connected to wing via booms. A longitudinal boom is fixed to main wings on its central line to provide a supporting structure for external ancillary items.

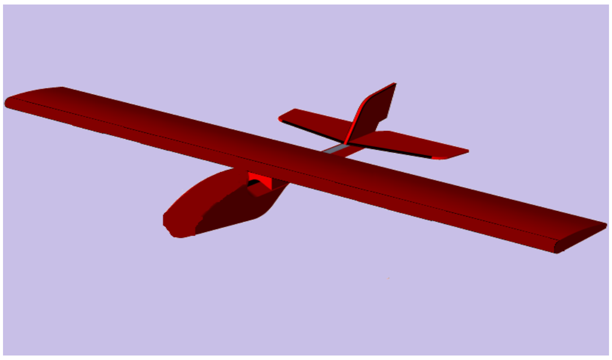

Figure 1: CAD model

After preliminary analysis of the wing, the airfoil selection is very important considering the high lift coefficient and low drag coefficient. Based on the "Stall" behaviour the airfoil is selected which have high C_L/C_D ratio (Lift (C_L) and drag (C_D) coefficients) that is the part of the calculation of the level flight power. The sailplane airfoil named WE3.55/9.3 is chosen as it is good at low speed because of the low Reynolds number. Airfoil easily accommodates the given solar cell. Wing configuration and airframe design are done regarding the position of the wing on the fuselage in order to improve the lift-to-drag ratio [5].

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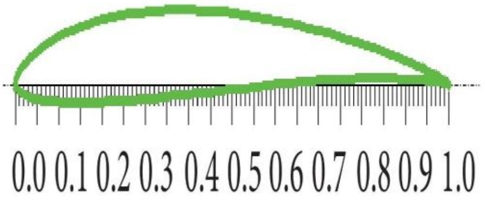


Figure 2: Airfoil

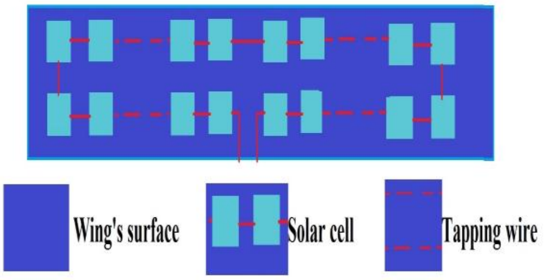


Figure 3: Solar Panel layout

Depending upon open circuit voltage and short circuit current of the solar cells, the design of the MPPT (Maximum power point tracking) circuit consisting of resistors, rectifiers and microprocessor capable of turning excess power into additional charge current and solar charge controller to prevent battery from overcharge. Solar tracker help in moving the array of panels so that directly face the sun with timer and motor.

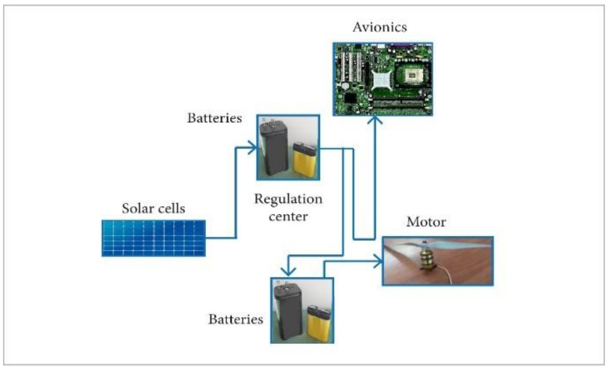


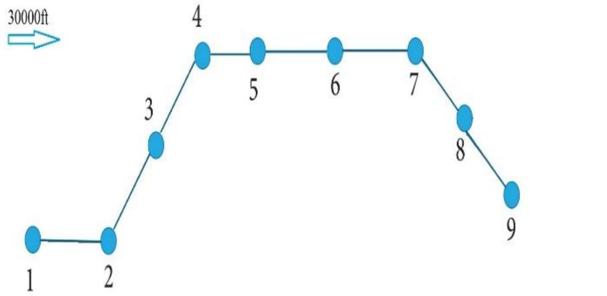
Figure 4: Power distribution

The built aircraft is running with the applications of simple theory as identifying the flying altitude with estimation of total hours of the day, instantaneous hour angle [deg], declination [deg], hour angle of sunset [deg], daily average total extra-terrestrial irradiance [W/m^2] and extra-terrestrial irradiance (≈1353 W/m^2). Converting unlimited solar energy into electricity through solar cells with the goal of simply fly in a clear sky, average air density of 1.32 kg/m^3 having area of single solar panel of 0.92 m^2 the gross weight of plane of 3.05 kg having twin motor MN2214-Antigravity, turnigy plush 12A speed controller, 8045 propeller and autopilot APM 2.6 flying at the altitude of 300-325 meter. Silicon solar cell with length and width of 0.125 x 0.125 m giving 0.57 V placed with sufficient gap and 3S Lithium Polymer battery added between the solar cells and the load so that excess power from cells can be used simultaneously to charge the battery[6].

Figure 5: Final UAV.

3. FINAL TESTING

The aircraft was assembled in its original configuration. After few test flight and increasing the duration of each flight attempt as it is difficult to control. Final process undergoes from takeoff to landing. Flight time estimation has been done assuming zero charge in the battery at take-off and considering only level flight. UAV motor will turn on and take off at 5 AM. After six hours at 11 AM the climbing of UAV will cruise at 10,000ft and after five hours of direct sunlight to recharge batteries enough to use the rest of the day. After 5PM, UAV will rely on onboard batteries to stay in the air till the duration drone is in action and this autonomous UAV can stay for 36 hours running on solar power and battery power and after 36 hours the plane landed due to drifting and results in overall exhibited expected performance as climbing. This is explain simply in figure 5 in 9 steps with the initial plan to fly for as long as the battery would allow.



Transition points-1: Engine ON; 2: Take-off; 3: Gaining height; 4: Achievable height ; 5-6: Remain at same height; 7-8: Start descent; 9: Landing and stop.

Figure 6: Take off to landing Procedure of UAV.

4. CONCLUSION AND FUTURE SCOPE

In the aeronautical engineering field, revolutionary technology of solar panels, its efficiency and desire for a greener society make widespread use of UAV with potential benefits to individuals and business. Use of UAVs includes military missions like search, rescue and navigation, agriculture, data collection, communication and media and newly the delivery of packaged goods and other mail using payloads. Additional challenges and concern like the potential invasion of privacy and safety issue of individuals make UAVs to operate with few regulations.

During hardware testing, fabrication and flying time one can identify the strengths and weaknesses of a good design like increasing solar panel area, wing and tail airfoils, batteries and balanced weight which will improve the flight duration. Continue research in automated launch and landing, coordinated flight between groups of UAVs and lightweight, flexible solar power solutions for UAVs like gallium arsenide based technology which is the combination of advantages of both rigid wafer-based solar cells and thin films and use of it will eliminate the need to recharge from power grid.

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