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(Research Article)

# Self-consuming solar-powered campus monitoring drone

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## Abstract

Drones are utilised for a variety of purposes and are a regular sight these days. Selfies, insecticide application, and military monitoring. The issue with surveillance and monitoring is that a lot of applications call for continuous surveillance. Although they have a major disadvantage, drones do offer a good view for surveillance and monitoring. This is the battery life of the drone. The main worry a drone operator has when operating a surveillance drone is that the battery might die and the drone might crash into a building, tree, or other unreachable place from which it cannot be recovered and hence cannot be charged. This is also true for drones used in military surveillance; the risk of a drone's battery dying and becoming unusable places restrictions on drone operators while they are conducting surveillance or monitoring. Here, we've developed a drone that solves these issues by using solar power to continuously charge the device, extending its flying time. It can also land anywhere and remotely recharge its battery so it can take off later. The development and deployment of a solar-powered, self-charging campus surveillance drone are suggested in this research. By offering continual monitoring capabilities without requiring manual charge, the drone seeks to answer the demand for increased security measures on campus. The drone can recharge itself during the day because to the solar panels in its construction, which capture energy from sunshine. The drone can recharge itself during the day because to the solar panels in its construction, which capture energy from sunshine. This maximizes security coverage while minimizing downtime and guarantees continuous operation. Drone capabilities are further enhanced by the incorporation of cutting-edge surveillance technology, which enable detection of threats and constant surveillance. With possible applications in educational institutions, corporate campuses, and large-scale facilities, the suggested method provides an effective and long-lasting answer to campus security concerns.

**Keywords:** Solar panel; drone; Surveillance; Security coverage; Monitoring

## 1. Introduction

A number of safety concerns have led to an increasing need for more stringent security measures on campuses. The flexibility and coverage of traditional monitoring techniques, such security patrols and stationary cameras, are constrained. This research proposes a self-charging solar-powered campus surveillance drone as a solution to these problems. The goal of this creative approach is to overcome the drawbacks of traditional surveillance systems and offer continuous monitoring capabilities.

The drone provides an effective and environmentally friendly solution for campus security by utilising solar energy and incorporating cutting edge features like automated threat recognition and real-time video transmission. The design, execution, and possible uses of this innovative system will be covered in detail in the upcoming sections, along with its advantages and contributions to enhancing campus safety.

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The aim of this mission is to provide a proof of concept, which will be turned into a fully working prototype after being approved for particular military and commercial applications. The effectiveness of the subsystems will have a significant impact on the aircraft's performance. In the beginning, this UAV will be needed for:

- Stay aloft for 6 hours' minimum
- Maintain 500m max. altitude (day time)
- Achieve autonomous fight (after liftoff)
- Return safely without any major damage to body or components

Setting a new world record for the lightest solar-powered unmanned aerial vehicle (UAV) and advancing clean energy sources for aviation in particular are our goals by allowing students to apply the knowledge they have learnt in the classroom to the development, manufacturing, and testing of air vehicles. According to the specifications of the mission, the HALE solar drone must be able to use the installed solar panels to fully recharge the batteries inside.

The HALE to R/R is never throughout the flight. When the HALE returns, it must be able to retain adequate energy reserves to allow for a maximum 24-hour reuse period (if needed). A recharging is advised if the device is grounded for more than 24 hours.

## 2. Literature review

Because of technological advancements in the fields of aeronautics and astronautics, there has been a renaissance of interest in unmanned aerial vehicles (UAVs) over the last ten years. The uses for UAVs are growing as sensors, motors, and other control devices get more accurate, compact, and lightweight. It is hardly surprising that UAV research has been welcomed by both industry and academics, with applications ranging from military reconnaissance drones to simulating flight patterns and formations inspired by biology. When opposed to manned aerial vehicles, unmanned aerial vehicles (UAVs) offer a low-risk, inexpensive, and repetitive flying environment. As such, UAVs can also act as a test platform for new technologies before they are used in commercial applications.

UAV functioning is frequently restricted by on-board energy, which is usually derived from electrical or fuel sources. This is especially true for long-duration missions like surveillance or reconnaissance. Therefore, research into sustainable and renewable energy sources for aviation is becoming more and more important. Owing to the high heights at which unmanned aerial vehicles fly, solar energy is a plentiful and renewable resource. Because of their affordability, compactness, and maneuverability, which enable them to be utilised in circumstances where larger UAVs are impractical, mini-UAVs are becoming more and more popular.

However, in contrast to the extensively studied solar High Altitude Long Endurance (HALE) UAVs, solar-powered or solar assisted micro-UAVs have distinct limitations and obstacles. While integrating solar energy to HALE UAVs has been proved to be advantageous, whether the same benefits are there when extending is questionable.

Applications of photovoltaic (PV) modules on unmanned aerial vehicles (UAVs) have garnered more attention from the academic and industrial communities. R.J. Boucher of Astro Flight, Inc., with funding from the Advanced Research Projects Agency, designed Sunrise I, the first known solar-powered aircraft, which was flown in November 1974 [1]. Sunrise I was able to fly for 20 minutes at an altitude of 100 meters with a wingspan of 9.75 meters and a weight of approximately 8.6 kg [2].

Subsequently, solar UAVs have become capable of nighttime flight due to advancements in PV modules, materials, and aircraft architecture. As a result, flight is made possible indefinitely. The 4.75 m wingspan, 12.8 kg weight, and usage of Sun power A300 solar cells in conjunction with lithium-ion batteries made AC Propulsion's So Long UAV the first UAV ever to fly through the night [3]. The So Long UAV managed to fly nonstop for 48 hours. Today, QinetiQ's Zephyr, which weighs little over 50 kg and has a wingspan of 22.5 m, has demonstrated the ability to fly for 14 days at heights above 20 km [4]. Noth's PhD thesis [4] is a well-organised compilation of the specifications of all solar-powered aircraft that have been flown to date.

Several articles about the design process for solar-powered aircraft have been published. A multidisciplinary tool called the Design Structure Matrix optimization method is employed in Morrisey's master's thesis [5] to support the utilization of current high altitude, long endurance, high aspect ratio UAVs like NASA's Helios [6]. Once aerodynamic, structural, propulsive, and energy aspects have been identified, more techniques for optimizing aircraft layout are offered by Roberts et al. [7], Boldock et al. [8], and Phillips [9]. On the other hand, hardly much research and development has been done on solar-powered small aircraft.

The MikroSol, NanoSol, and PicoSol created by Dr. Sieghard Dienlin [10] are prominent examples of this category's implementation. The PicoSol, the smallest of the three, had a wingspan of 0.99 meters and weighed 0.127 kilogrammes, although not much is known about this aircraft. An 8.64W solar power output was claimed for the previous version, the Nano Sol. Wilson and colleagues [11] conducted research on the design of miniature solar-powered aircraft.

Only in the last 60 years have unmanned aerial vehicles, or UAVs as they are frequently called, been put into use. These days, UAVs represent a significant addition to the air defenses of several nations [11,12]. The unmanned drones utilised by the USAF in the 1940s have been replaced by much more advanced models of UAVs. These drones had significant operating system problems, which made them ineffective for the surveillance and reconnaissance tasks for which they were designed. The "Firebee" drone was the first of its kind; it was a jet powered by a Ryan Aeronautical Company engine. When significant problems were found and fixed in the 1960s, they were first widely utilised over Communist China [11–13]. UAVs, and drones in particular, were not widely employed in combat or reconnaissance until the Vietnam War. Many Firebee drones were deployed for basic daytime reconnaissance tasks. Initially, they were equipped with basic cameras.

The Pioneer was used in the Gulf War to good effect. Following the Gulf War, officials recognized the importance of unmanned & systems. UAVs that are in use and under development are both long-range and high endurance vehicles. The Predator, for instance, can stay in the air for around 40 hours. The Global Hawk can stay in the air for 24 hours [11,12]. First of all, the Predator proved its value in the skies over the Balkans as an Advanced Technology Demonstration Project [14]. For attacking reasons, Hellfire missiles are installed in some of the most recent Predator models. Global Hawk UAVs are another well-liked type. In Afghanistan, this jet-powered unmanned aerial vehicle proved to be an excellent tool. Operational altitude: approximately 60,000 feet; sensor array: broad [15].

## 3. Proposed methodology

### 3.1. Design methodology

Conceptual and preliminary are the two stages of the overall aircraft design process. Calculations are made about size, weight, performance, and basic configuration arrangement in conceptual design. The next step in preliminary design is to develop the CAD modelling of each component to satisfy the necessary goals and optimize it. As the entire aircraft configuration is developed, it is guided and assessed by its architectural requirements.

### 3.2. Flight theory

An aircraft's performance is directly correlated with the height at which it operates. Standard atmospheric values at sea level, 40,000 feet, and 65,000 feet .

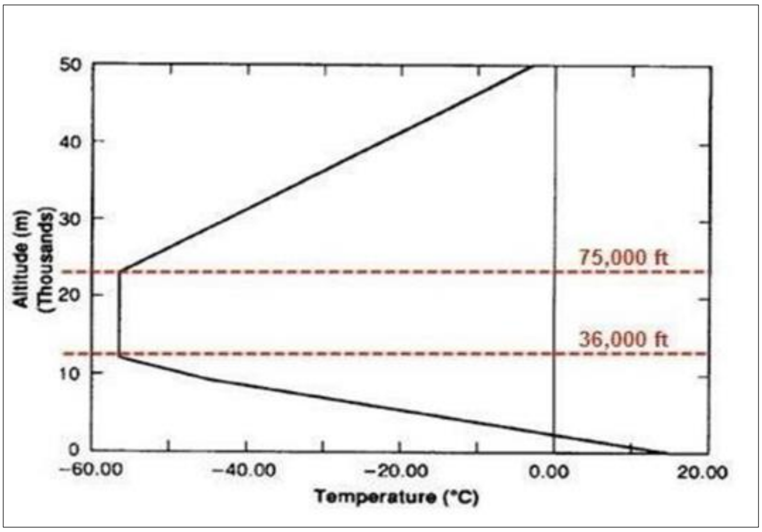

**Figure 1** Air Temperature Vs. Altitude

As shown in figure 3.1, between 36,000 feet – 75,000 feet (11 km – 23 km) the air temperature is fairly constant at approximately -70°F (-57°C).

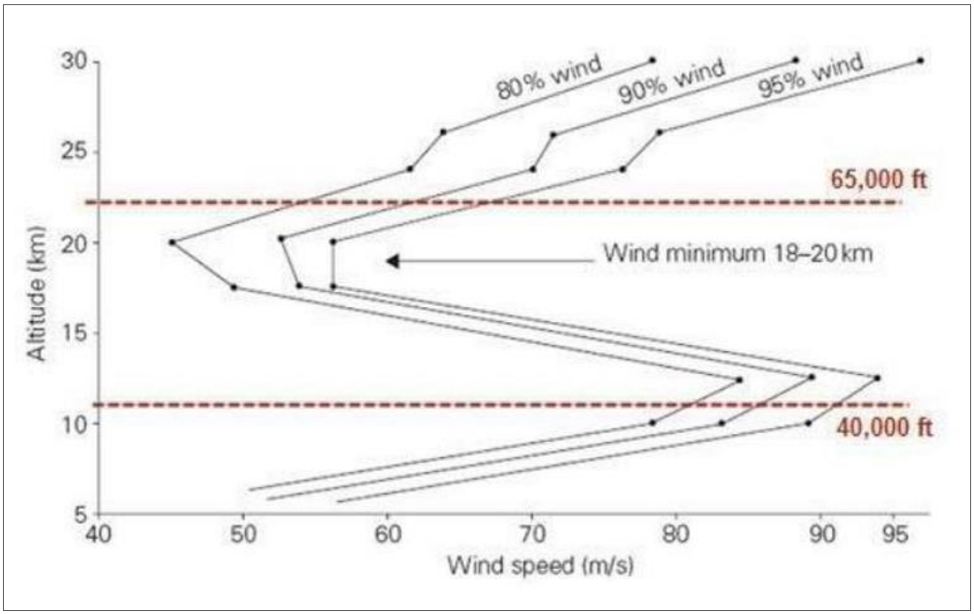

**Figure 2** Wind Speed Vs. Altitude

### 3.3. Mission specifications

Examining whether solar power is necessary to power an airplane is one of the primary goals of this section, which helps to extend the aircraft's endurance from a few minutes to hours. This maintains the plane's gross weight of 2.4 kg (Table 1). Since the objective was just to stay in the air and not to get anywhere, there was no range requirement.

**Table 1** Plane's Design Parameters

| **PARAMETER** | **SI UNITS** |
|---|---|
| Gross Weight | 2.4 kg |
| Payload | 0.5 kg |
| Altitude | 30-50 m |
| Average Air Density | 1.22 kg/m^3 |
| Clearness Factor | 0.7 (1=clear sky) |
| Payload | 0.5 kg |
| Take off distance | none |

### 3.4. Calculate the required quantity of solar cells and setting them up on the wing

The 3S battery was selected for this design for two reasons: first, adding additional lithium polymer (Li-Po) cells in series (> 3S) necessitates a higher voltage to start the charging process, which increases the number of solar cells and wingspan and adds to the model's weight. However, if fewer Li-Po cells are used in series (2S), it will be more challenging to provide the necessary power to get a reasonable climb rate. The 3S battery has to be charged at a steady, safe voltage of roughly 12.4 V. The solar cells used in this design, Sun Power C-60 photovoltaic cells, are required to provide this voltage. The Sun power cells outperformed most silicon-based ones in terms of efficiency. The C-60's 18.4% efficiency (Table 2) represented a substantial improvement over the 15% to 18% efficiency of ordinary silicon solar cells.

**Table 2** Solar cell Specifications

| PARAMETER | SI UNITS |
|---|---|
| Mass of solar cell | 4gm |
| Length and width | 6x6 sq. inch |
| Efficiency of solar cell | 18.6% |
| Rated voltage | 0.5volt |
| Rated current | 8amp |

## 4. Result and discussion

### 4.1. Performance analysis

The distribution of electricity from the battery and solar cells [1] during the flight is shown in Figure 5.1. As demonstrated, the solar cells won't start producing enough energy to run the drone until around 7:00 am and won't stop producing until about 5:30 evening.

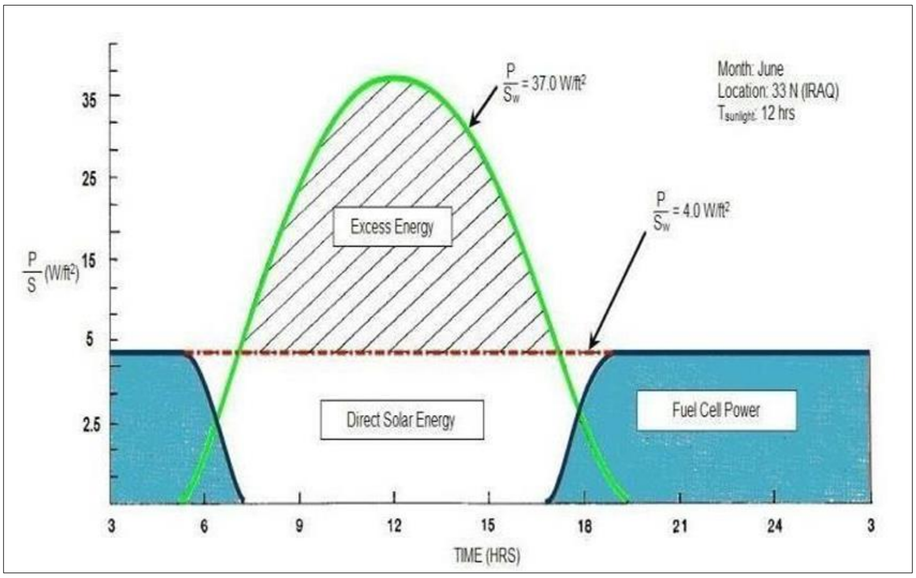

**Figure 3** Power Breakdowns During Flight

When the lift-to-drag ratio is divided by the total drag and the aircraft weight, the power needed for the HALE UAV [2] to maintain altitude at steady and level flight is found. The drone could successfully lift off at a height of about 981 feet. The drone will need to lift off a far greater distance if it does not match the takeoff criteria, which are dependent on the thrust requirements. To guarantee that it can always generate the necessary take-off thrust, the drone must have an assisted takeoff mechanism, such as a pulley system or a conventional ground vehicle. How quickly the drone stalls. It can be found and it is shown in below table 3

**Table 3** Drone Performance Parameters

| Altitude (ft) | Stall Speed (ft./s) | Cruise Speed (ft./s) |
|---|---|---|
| Sea level | 25 | 27 |
| 40,000 | 49 | 57 |
| 65,000 | 88 | 101 |

The drone will take little more than three hours to reach its 500-foot maximum altitude. The power needed rises with altitude, as seen in Figure 5.2; this is all presuming an overall efficiency of 85%. This indicates that in order to maintain the drone in flight at 50 feet, a maximum of about 120w is needed.

Figure 4 provides information on the rate of rise. It appears plausible that the power needed would only rise in proportion to the increased velocity needed to maintain the drone at the necessary altitude, meaning that the UAV's power consumption rises with altitude.

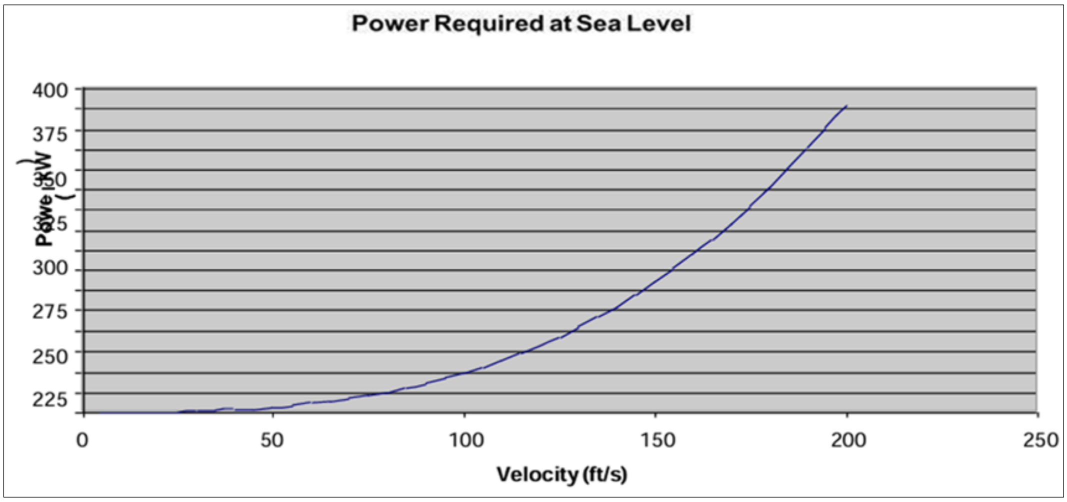

**Figure 4** Power Required At Sea Level

Under normal circumstances, the drone can reach 100 feet in about one hour, with a speed of about 26 feet per second (18 miles per hour). This is assuming a 5° ascent angle. It is plausible that the power needed would only rise in proportion to the rising velocity needed to maintain the drone at the necessary height, as depicted in Figure 5.2. Measuring the effects of altitude during night flight is crucial because there can be a considerable loss of power. The developed model of drone shown in figure 5.

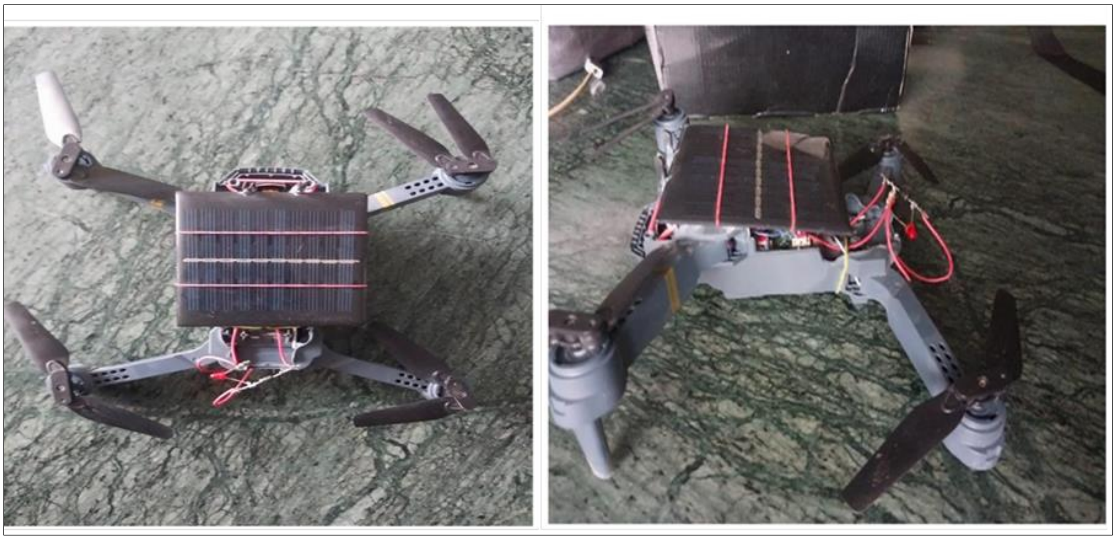

**Figure 5** Solar powered drone model

## 5. Conclusion

The history of solar flight has been compiled in this study, and it includes examples of comparable aircraft that might easily fulfill the work's minimal mission requirements. After comparing several airfoils, it was discovered that these kinds of aircraft can utilize a variety of high lift/low drag airfoils. The twin-boom configuration was determined to be the optimum fit after a comparison of other aircraft types was carried out. The weight distribution limits led to a comparison between the designs and the flying wing and conventional configurations. This analysis has shown that a HALE that depends only on reusable energy may be designed and built using existing and emerging technology. The study's design was dictated by the quantity of solar energy needed to power a system for several days. Since the wing area is large, it was determined to be a serious defect. It might be useful when installing the stiff solar cells, though, as solar cells cannot cover the entire surface area. Certain portions of the surface will not be covered by the solar cells; if necessary, this can accommodate greater spacing. Performance was enhanced by the early design's consideration of reducing the total weight. This indicates that an airplane can be planned and constructed with the right materials and components chosen.

## Compliance with ethical standards

### *Disclosure of conflict of interest*

No conflict of interest to be disclosed.

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