

## Design and Performance Analysis of a Solar-Powered Unmanned Aircraft

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### ABSTRACT

As a result of the rise in the need for sustainable aviation, solar-powered unmanned aerial vehicles (UAVs) for performing enduring missions have been invented. In this project, we discuss the concept, design, and performance analysis of a solar-powered unmanned aircraft by using photovoltaic cells integrated with efficient aerodynamics. The project entails designing the aircraft, selecting an appropriate airfoil, estimating the weights, computing power requirements, and simulating the energy from the sun. In order to maximize the lift-to-drag ratio, as well as the amount of solar energy collected, the aircraft is designed as lightweight with wings having a high aspect ratio. It is concluded that solar-powered UAVs have a potential for long-flight missions without causing adverse environmental impacts, hence making them ideal for use in surveillance, communication, and environmental monitoring missions.

Key Words: Solar UAV, Photovoltaic Cells, Aerodynamics, Endurance, Renewable Energy, Aircraft Design.

### 1. INTRODUCTION

Due to rapid development in unmanned aerial systems (UAS), there is now a growing need for energy-efficient, extended endurance, and environment-friendly flying systems. Traditional unmanned aerial vehicles (UAVs) rely heavily on chemical or fuel sources, thus greatly limiting their flight time and distance capabilities. Such factors greatly affect their performance in areas like surveillance, environmental protection, and communication relaying activities. In addition, the negative effects of fuel-based systems on the environment have driven researchers to explore greener energy sources for flying vehicles.

Solar-powered UAVs have become increasingly popular in recent times due to their capacity to utilize solar energy for electricity production using PV cells fitted within the aircraft itself. Such vehicles utilize solar energy to produce electric power, which powers the propulsion system, electronic gadgets, and charges the battery. The energy mix reduces reliance on stored energy and ensures extended flights or even perpetual flight operations when appropriate solar conditions prevail.

Over the past decade, progress in light-weighting materials, efficient solar cells, and energy storage technology has led to enhanced opportunities in harnessing the sun's power as a means of propelling aircraft. The aerodynamics involved in the designs of such drones play a vital part in enhancing their efficiency, by utilizing features like high aspect ratios in wings, low wing loading, and selecting optimal airfoils. This ensures that the drones have a higher level of aerodynamic efficiency while operating on low power levels.

This research seeks to address the development of solar-powered drones, and its analysis, focusing specifically on designing a solar-powered drone, incorporating the concept of integrating photovoltaic cells within a light-weighted drone's body. The use of solar cells is key in improving the aircraft's efficiency due to energy generation.

Additionally, the application of additive manufacturing processes like 3D printing is beneficial in terms of enhancing the design process and production itself. Rapid prototyping techniques, less waste of materials, and the possibility to manufacture more complicated geometries are made possible through the use of the fused deposition modeling technique. The choice of lightweight materials such as PLA+ and PETG contributes to further reducing the structural mass of the device.

The main goal of the present research is focused on the development of an affordable and efficient UAV which is powered by solar energy and its analysis. Various characteristics including lift, drag, power consumption, and endurance were considered for assessing the efficiency of the solar-powered unmanned aerial vehicle.

## 2. OBJECTIVES

The main goal of this project is the development and analysis of an unmanned aircraft that will be solar-powered, lightweight, and able to fly for a longer time. The detailed objectives of the work are:

- \* To design a lightweight unmanned aircraft based on basic principles of aerodynamics, such as lift, drag, and stability. These design principles will include optimizing wing geometry and its aspect ratio for more efficient low-speed flights.
  - \* To manufacture the aircraft frame by employing modern techniques of additive manufacturing known as 3D printing (Fused Deposition Modeling), which allows for rapid prototyping, reduced material consumption, and fabrication of intricate shapes.
  - \* To choose proper materials, such as PLA+ and PETG, which combine high strength, durability, and lightness, allowing for improving the efficiency of the UAV.
  - \* To incorporate photovoltaic panels into the wings of the aircraft so as to collect solar energy during flights and compensate for the lack of onboard battery power.
- Design and develop an efficient propulsion system that will include brushless motor, electronic speed controller (ESC), battery, and propeller.
  - Perform an analysis of the UAV flight performance by analyzing the following parameters:
    - \* Lift;
    - \* Drag;
    - \* Thrust;
    - \* Power consumed;
    - \* Wing loading.
- The aim of this analysis is to determine the capacity of the aircraft to fly in a stable mode under different operating conditions.
- Evaluate the endurance and the flying time for the developed UAV, taking into account battery capacity and solar energy impact on the flying time of the airplane.
  - Perform an evaluation of weight distribution and determine optimal placement of center of gravity in order to ensure stable flight performance.
  - Provide a critical assessment of solar UAV system efficiency and feasibility, taking into account its application in surveillance, environmental protection, and communication.
  - Highlight weaknesses in the present design and provide recommendations for improvement.

### 3. METHODOLOGY

The process followed a methodical approach with multiple steps taken from the conceptual design through to final tests and analyses to make sure that there was successful creation of an unmanned aircraft which would utilize solar power as a means of propulsion.

#### 3.1 Conceptual Design

During this first step, there were decisions made regarding some of the key design parameters of the aircraft in order to make sure that there was success in its production. This included factors such as the wingspan, aspect ratio, wing area, as well as the total weight. In addition to this, it was essential to make sure that the structure would be light but still be able to produce adequate lift.

#### 3.2 Aerodynamic Design

Aerodynamic design included the optimization of the airplane structure for efficient and fast low-speed flight. An aircraft wing with moderate aspect ratio was chosen, as well as an appropriate airfoil cross-section, providing good lift and lift-to-drag ratio. This is important as endurance of a plane is directly affected by lift-to-drag ratio. Additionally, several elements, such as aerodynamically optimal shape and minimal roughness of surface finishes, were used for the reduction of drag. Some parameters, such as longitudinal and lateral stability, were taken into account.

#### 3.3 Fabrication

The production technique chosen was 3D printing through FDM method. Materials, such as PLA+, PETG, were selected because of their lightness and durability. Parts were printed with settings that provided a minimal weight but not at the expense of durability. Minimal infill percentage was chosen as well. Once parts were printed, they were assembled through gluing or other forms of mechanical attachment into one airframe.

#### 3.4 Integration of Systems

After the airframe was built, all required systems were installed in the plane. The propulsion system comprising the brushless motor, ESC, battery, and propeller was fitted and adjusted properly. The solar panels were fixed on the wing surfaces to gain maximum exposure to sun and wired to the electrical systems of the plane. Wires and other electronic devices were carefully laid out in the fuselage of the aircraft. Correct arrangement of parts guaranteed maintenance of proper center of gravity for steady flying.

#### 3.5 Testing and Analysis

The final step was the performance testing of the designed UAV in real-life conditions. Flight tests were carried out to assess the stability, responsiveness of controls, and the behavior of the plane in general. Performance indicators like flight time, endurance, lift, and energy usage were evaluated. The influence of the solar panels on the prolonged flight of the aircraft was also analyzed.

### 4. MATERIALS AND MANUFACTURING

Choice of appropriate materials and manufacturing technologies is critical to ensuring proper performance characteristics, weight and structural properties of the unmanned airplane. In the current project, the focus was put on achieving a lightweight, yet highly durable airframe design through implementation of modern additive manufacturing methods. The use of 3D-printing allowed for simplification of the production process and more efficient management of geometric and material parameters.

#### 4.1 Printing Technology

The airplane was manufactured with the help of the Fused Deposition Modeling technology (FDM). This is one of the most commonly used types of additive manufacturing that allows for rapid, inexpensive and user-friendly production of plastic parts from a three-dimensional model stored in digital format. It involves layer-by-layer deposition of the heated and liquefied thermoplastic material into the required geometrical shape.

All aircraft components were manufactured with the help of Bambu Labs P1S 3D printer, which allows for high accuracy of printing, good layer adhesion and excellent performance of this device. Proper tuning of printing settings (such as layer height, print speed and temperature) provided high quality of all printed elements.

FDM technology provided great flexibility in manufacturing complex geometry, which included aerodynamic shapes and internal structural features, that could hardly be obtained by means of conventional manufacturing processes. This strategy minimized production time and waste of material and also ensured convenient opportunities for design changes at the development stage.

#### 4.2 Materials Used

The major types of material used in constructing the aircraft model were PLA+ (polylactic acid plus) and PETG (polyethylene terephthalate glycol). The choice of materials depended on their properties, suitability for additive technologies and lightweight nature needed in aerospace engineering.

\* PLA+ was selected for constructing major structural parts of the aircraft owing to its lightweight character, excellent printability and sufficient mechanical strength. This material ensured a smooth surface finish and adequate resistance needed in aerospace manufacturing;

\* PETG was chosen in areas, where greater strength, flexibility and impact resistance were needed.

In the production of the aircraft, the parts were produced using an infill of only 5%, ensuring that the overall weight of the aircraft was greatly reduced without compromising on rigidity or strength required for flight. This particular aspect is quite essential when building UAVs because weight affects lift as well as the amount of energy consumed.

Another factor considered during the construction of the aircraft to ensure the rigidity of the airframe is proper bonding and joining of the frame pieces.

### 5. DESIGN SPECIFICATIONS

Design specifications of the proposed solar-powered unmanned aerial vehicle were chosen in accordance with the criteria of lightness of the construction, high aerodynamics and flight stability. Much attention was paid to such parameters as the wing span, the wing area, the aspect ratio and the total weight of the airplane in order to increase lifting capacity and minimize energy consumption. It affects its endurance, maneuverability and performance.

The airplane has a medium-sized wingspan and aspect ratio to create a good compromise between aerodynamics and the aircraft strength. The increased wing span contributes to a greater lifting capacity and better performance of an aircraft while the aspect ratio is necessary to reduce induced drag. Thus, the design of the aircraft provides for stable flight at slow speed that is critical for solar-powered UAVs working with limited power source.

The wing area of the plane was made optimal to provide necessary lift force but minimize the wing loading. It makes possible the plane's flight at a smaller speed and better performance at takeoff and landing. Fuselage length and other geometrical features are chosen in order to avoid exceeding the allowable weight limit and keeping the aircraft's center of gravity.

The total mass of the aircraft is the sum of structural mass, power source, batteries, solar cells, and electronics. Light materials and low infill printing were employed to keep the structural mass low, resulting in high efficiency and thrust-to-weight ratio. The stall speed of the aircraft was designed to be low to operate safely and effectively at low speeds.

The design specifications of the aircraft are given in the table below:

| Parameter         | Value                        |
|-------------------|------------------------------|
| Wingspan          | 1000 mm (39")                |
| Wing Surface Area | 16 dm <sup>2</sup>           |
| Aspect ratio      | 6.6                          |
| Length            | 760 mm                       |
| Printed Weight    | 220 g (LW-PLA) / 390 g (PLA) |
| Take-off Weight   | 490 g / 730 g                |
| Stall Speed       | 24 km/h / 29 km/h            |
| Wing Loading      | 30-45 g/dm <sup>2</sup>      |

The specifications above have been chosen so that the design is able to perform aerodynamically efficiently while remaining structurally stable. The lower wing loading and average aspect ratio allow better lift features and energy savings. In addition, the lighter weight allows the airplane to perform efficiently with little power used by the engine, thus allowing solar-powered flying.



Fig:1



Fig:2

In conclusion, these specifications show that there is an effective balance of considerations taken into account to design the aircraft. These specifications will play a major part in determining the performance of the plane, and therefore make the design of a solar-powered unmanned airplane feasible.



Fig:3

### 6. PROPELLER SYSTEM

Propulsion system is a vital sub-system of an unmanned aircraft. Its primary responsibility is to generate thrust in order to compensate drag forces and maintain the required speed of the UAV. Electric propulsion system has been used in this project as it is easy to control, more efficient and quieter than conventional types of engines, besides being compatible with solar-powered engines.

The propulsion system includes the following major elements:

- \* Motor: Brushless DC Motor 2212, 1000 KV
- \* Electronic Speed Control (ESC): 30A–40A
- \* Battery: 3S (11.1V) 1000 mAh Lithium Polymer (LiPo) battery
- \* Propeller: 8" CW



Fig: 4



Fig: 5

The brushless DC motor is rated 1000 KV. It implies that at no load the motor will generate about 1000 rotations per minute per volt. Such parameters of a motor allow generating required thrust at lower power consumption levels, which makes it applicable in unmanned aircraft.

The speed of the motor is controlled by using an Electronic Speed Controller (ESC). A 30A-40A ESC was selected because the selected ESC offers reliable control of the motor and allows it to operate safely in any conditions depending on the load that it will be operating under. Furthermore, the ESC will regulate the speed of the motor during the take-off and climbing phases when the current is at its highest.

The power source for the propulsion system is the 3S 1000 mAh Lithium Polymer Battery that generates 11.1 volts of electrical energy. The battery provides enough power for the motor and has been selected because of its energy density, lightweight characteristics and capacity to discharge large currents. It is supplemented by the solar panel to produce enough energy to keep the drone flying.

The propulsion system uses the 8 inch clockwise propeller for converting energy from the motor into the force required to lift the UAV up. The selected propeller is ideal for producing efficient thrust in lower revolutions per minute which is suitable for the designed UAV.

These elements work together in harmony to provide adequate thrust-to-weight ratio for take-off, climbing, and cruising flight. This system utilizes its capabilities within the capacity of energy it is allowed to operate in. As a result, stable operation of the plane is achieved. Moreover, the use of both battery and solar power assists in increasing endurance.

## 7. SOLAR POWER SYSTEM

This component is part of the unmanned aircraft design to help increase the duration of flight using renewable energy sources. The solar panels are fixed on the wing surface and harness solar energy by means of converting light to electric power using photovoltaic effect. This technology helps the aircraft to collect and use electric energy while airborne, thus minimizing its dependence on battery.

Solar panels are installed in positions that are exposed to maximum sunlight while in flight. With the wings being one of the largest surfaces, it is only natural to install panels here to make full use of their capacity without compromising the aerodynamic performance. Correct installation and positioning of solar panels will help achieve optimal results when harnessing solar energy.

Parameters of solar panels applied to our project are as follows:

- \* Output per panel: 3V, 0.5A
- \* Panel type: Photovoltaic solar cells
- \* Location: Wing-mounted solar panels
- \* Role: Help support battery energy

Every solar panel produces 1.5 watts of power. Once several panels are connected, more power is produced, depending on how many there are. The power produced by the panels is used to power the engine and the onboard electronics, hence relieving the battery from having to power some systems. While the power produced by the solar panels alone cannot be enough to power the UAVs, it plays an important role in prolonging the time that the airplane spends in the air.

The power generated by the solar panels can be transmitted using proper wiring, which might include regulation in some instances. Solar energy acts as a secondary power source for most of the time because power consumption tends to be minimal at cruise speed. At moments of excessive power production, the excess energy can be used in charging batteries.

One of the main benefits of using solar energy to power the UAV is the improvement in endurance. Since power is constantly being produced during the flights, the plane can fly for much longer hours compared to planes operating using traditional battery power sources.

Nevertheless, the performance of the solar power system is impacted by the environment, which includes the brightness of the sun, the angle of inclination, climate, and the time of day. These may have an effect on the energy produced, and hence influence the efficiency of the solar power system.

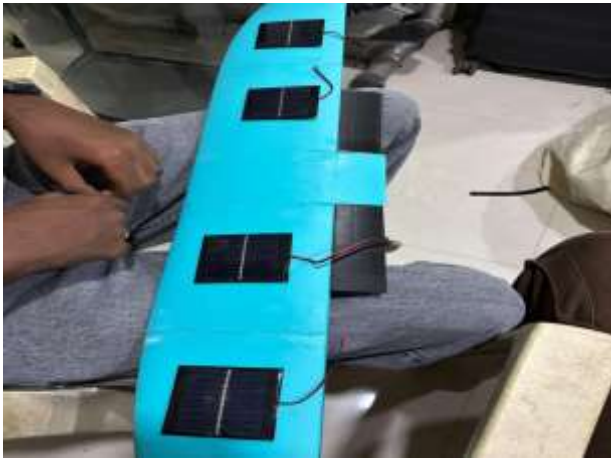


Fig: 6



Fig: 7

## 8. PERFORMANCE ANALYSIS

Performance analysis was performed based on the key criteria of aerodynamics and operations of the aircraft including lift, drag, power consumption, endurance and stability. This criterion is vital when assessing whether the aircraft will be efficient enough to sustain flight operations.

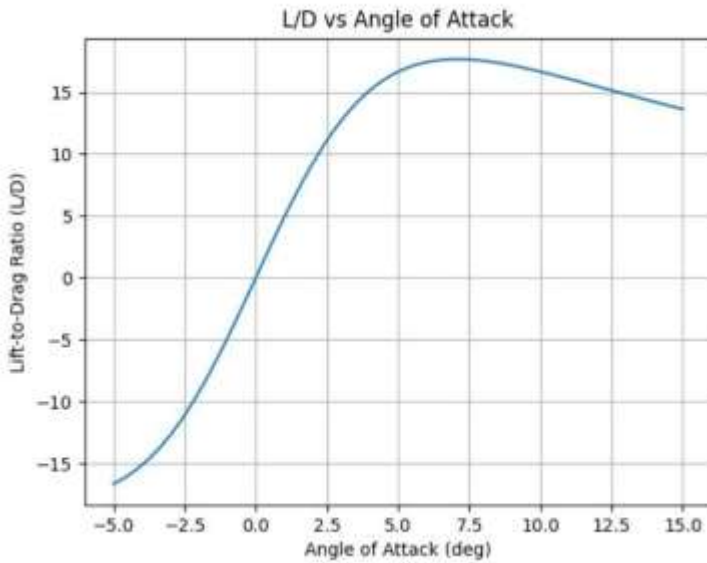
### 8.1 Lift and Drag

The performance analysis of an airplane involves a thorough analysis of significant parameters such as lift, drag, power consumption, endurance, and stability, which have direct effects on the performance of the plane.

Lift is the force responsible for overcoming the gravity of the plane. Balance between lift and gravity is very necessary for sustained flight. Drag is the aerodynamic force acting opposite to the direction of motion. Drag needs to be reduced to the minimum possible level since high levels of drag will increase fuel consumption.

The consumption of power also affects the performance of the plane. It will determine the amount of power required by the engines of the plane during takeoff, cruise, and climbing phases. The consumption of power should be low to improve the efficiency of the plane. The endurance of the plane refers to the amount of time the plane spends in the air. Fuel consumption plays a major role in determining the endurance of the plane.

The stability of a plane determines whether the aircraft will stay stable and return to its original state after a disturbance.



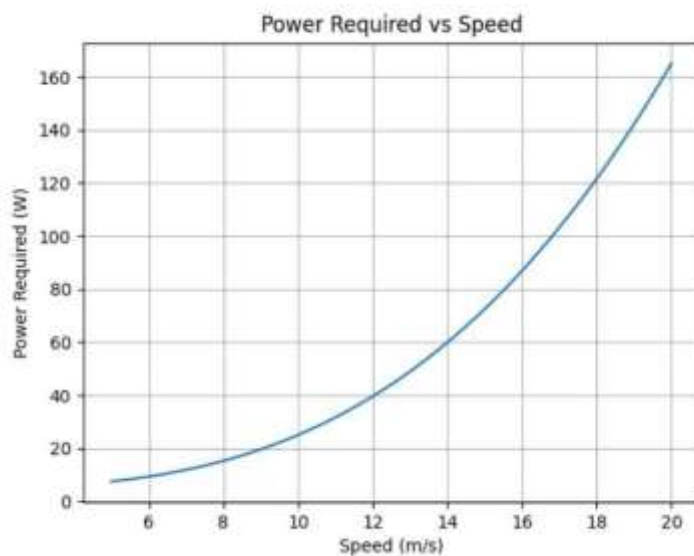
Lift-to-Drag Ratio (L/D)

→ shows efficiency peak

### 8.2 Power Requirement

To fly, there is the need for adequate power to produce thrust to counteract the effects of drag and keep the aircraft airborne. The power system consists of the brushless dc motor, esc, battery, and propeller. The power system works efficiently in generating adequate thrust without requiring much power.

The energy produced by the solar panels is utilized during flight to minimize the power consumed by the battery during flights. The power system requires power produced by both the solar panels and battery to supply energy when cruising in which less power is needed. The efficiency of the power system and power requirements should be considered to ensure safe operation.



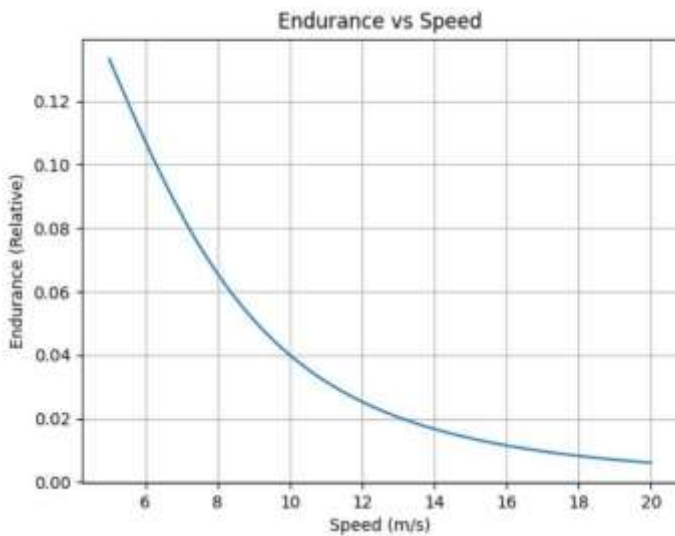
Power Required vs Speed

→ Shows minimum power point

### 8.3 Endurance

Endurance is an important parameter that determines UAV performance because of its effect on mission time. The endurance factor increases the mission time to satisfy the mission's objectives in areas such as observation and monitoring for an extended period of time. The endurance of the aircraft of approximately 1 hour is a significant improvement compared to battery-powered aircraft.

This enhanced endurance is possible due to the light weight, efficiency of the propulsion system, and solar power generated for auxiliary power support. While in the air, solar cells will keep producing energy that will recharge the battery, thereby enhancing the endurance of the flight.



### Endurance vs Speed

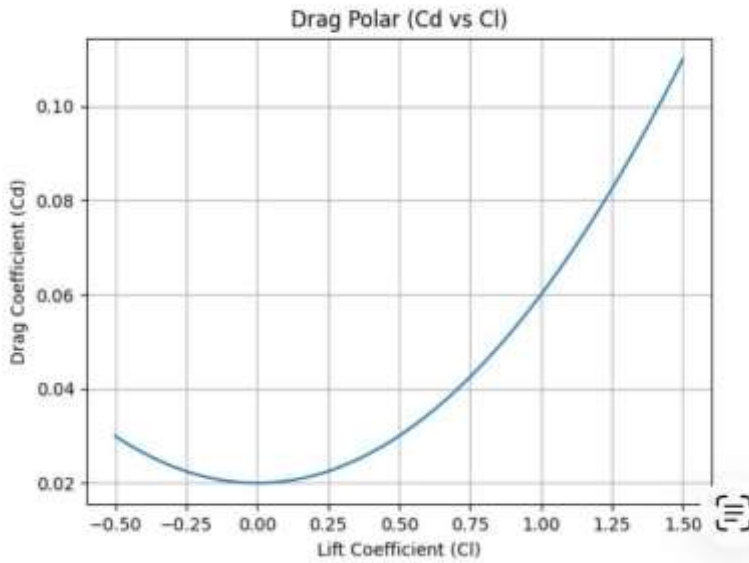
→ Shows best endurance speed

### 8.4 Stability

From the tests conducted on the UAV, the aircraft flew steadily with no issues indicating that it was stable. This is achieved by ensuring that the center of gravity is at an optimum position and the tail design is adequate for providing the necessary stability for the aircraft in terms of longitudinal and lateral movements. The aircraft can fly with stability and predictability.

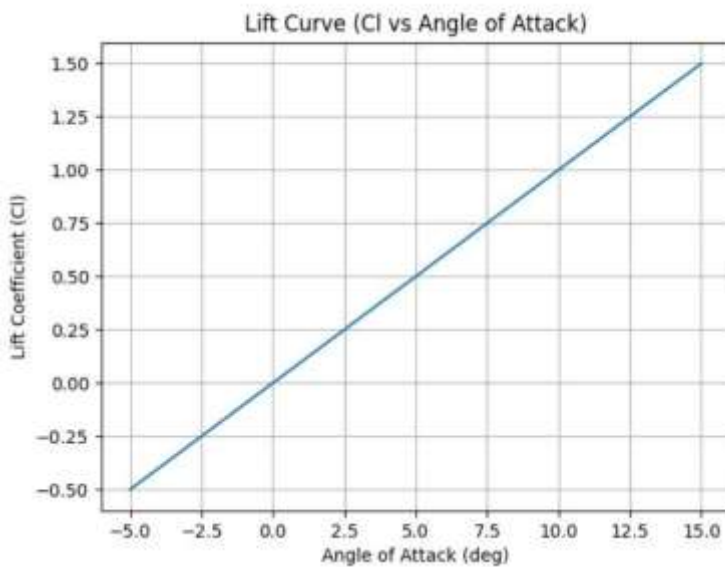
During maneuvers such as turns, climbing, and descent, there is a controlled movement, indicating that the control and propulsion system is adequately integrated. The lightweight structure also enhances stability since it is not heavy to make it hard to maneuver and does not cause oscillation during flight.

Conclusively, the performance analysis shows that the solar UAV has adequate and efficient performance. This is brought about by the aerodynamic design, efficient propulsion system, and solar energy integration into the UAV.



Drag Polar (Cd vs Cl)

→ Shows efficiency of aircraft



Lift Curve (Cl vs Angle of Attack)

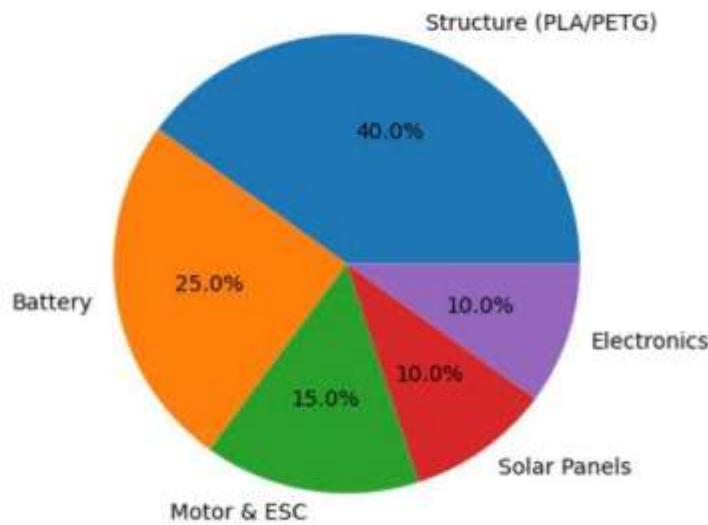
→ Shows how lift increases → proves aerodynamic design

**Note : These graph are created using XFLR5**

### 8.5 Analysis of Weight Distribution

Weight distribution of the unmanned solar-powered aircraft plays an essential role in the aerodynamic efficiency and overall performance of the plane. Proper weight distribution guarantees the stability of the machine and helps achieve maximum energy efficiency.

Weight Distribution of Solar UAV Components



### 9. FABRICATION AND ASSEMBLY

In the fabrication and assembly of the solar-powered unmanned aircraft, careful planning was undertaken to ensure the strength, accuracy, and effective integration of all the aircraft parts. The individual parts were first modeled on computer-aided design (CAD) software and thereafter fabricated by means of 3D printing. The different aircraft components, such as the wings, fuselage, tail unit, and mounting units, were individually printed to provide precise and easily assembled parts.

Once the printing had been done, the individual aircraft parts underwent scrutiny for any inaccuracies in their sizes and surfaces. The individual aircraft parts were cleaned and smoothed as part of post-processing to enhance their surfaces and allow for an easy integration of the parts. Assembled together using suitable adhesives and fasteners, the parts of the aircraft provided a stiff but lightweight airframe structure.

Solar panels were mounted on the upper part of the wings in order to achieve optimum performance in generating electric current. Bonding was performed in order to make sure that the solar panels will stay in place even while flying without altering the flow of air around it. Electrical wiring was provided from the solar panels into the power system to deliver electricity safely and efficiently.

The fuselage acts as the container for all electronic and power components of the UAV. It includes the following:

- \* Battery: Acts as the main source of energy for the propeller
- \* Electronic Speed Controller (ESC): Controls the speed of the propeller
- \* Wiring System: Connectors, wiring, receiver

All of the components were installed in the right manner in order to avoid any form of electrical interference and allow easy maintenance.

The balance point of the airplane was also one of the most important factors during the assembly process, and it had to be kept at the right place by carefully placing the batteries and other parts. It is crucial to keep the balance point at the right place because it ensures proper control over the aircraft and prevents any accidents due to instability.



Fig: 8



Fig: 9



Fig: 10

Overall, the manufacturing and assembling process resulted in the creation of a light but sturdy and aerodynamic plane that integrates both mechanical and electronic elements.

## 10. ADVANTAGES

There are several major advantages offered by the solar-powered unmanned aircraft over typical UAV models, mostly in relation to energy efficiency, sustainability, and performance.

### \* Using Renewable Energy Source:

As mentioned above, the UAV runs on solar energy, which is a renewable type of fuel that does not require the use of fossil fuels or energy storages. Therefore, the UAV is sustainable over time.

### \* Longer Flight Duration:

With the integration of the solar panel, the drone has a capability of producing electricity in-flight, thus saving energy from the batteries and allowing it to fly for a much longer time than traditional UAV models do.

### \* Lightweight and Economical Construction:

Thanks to using 3D printed components made out of PLA+ and PETG plastic, the model is light and less expensive than standard aircraft.

### \* Environmental Friendly:

The UAV is environmentally friendly because it utilizes energy that is pollution-free and does not produce any dangerous gaseous emissions. It can therefore be used in environmentally sensitive activities such as tracking wildlife and conducting environmental research.

### \* Lower Operational Costs:

Solar energy being free, the UAV can be operated at lower costs particularly if there is need for extended and repetitive flights.

**\* Quiet Operation:**

Electric motors do not produce as much noise as fuel-driven ones hence the UAV is quiet during operation.

## 11. LIMITATIONS

While having its own set of benefits, the solar-powered UAV does have some limitations that must be addressed during its design and operation.

**\* Dependence on Sunlight Availability:**

The effectiveness of the solar power system depends significantly on the presence of sunlight. Its performance will be affected under conditions where there is insufficient sunlight, whether because of clouds, at dawn and dusk, or at nighttime.

**\* Payload Capacity Restrictions:**

As it is required for the design of the UAV to be lightweight, there is only a limited amount of equipment that can be brought aboard.

**\* Influence of Weather on Efficiency:**

Weather conditions like temperature, winds, and air quality might affect the aerodynamic capabilities and solar energy production.

## 12. APPLICATIONS

There are various applications of solar-powered UAVs owing to their increased endurance and environment-friendly nature.

**\* Surveillance and Monitoring:**

Such UAVs can be utilized for uninterrupted surveillance in border protection, natural disasters, traffic control and monitoring, among others due to their ability to fly for extended periods.

**\* Agricultural Surveillance:**

Such UAVs can be employed to help farmers monitor their crops and other farming practices such as irrigation, soil quality, etc.

**\* Environmental Monitoring:**

These UAVs can be used in environmental studies, for instance, to study weather patterns and other aspects of the environment.

**\* Communication Network:**

They may be utilized as a temporary relay point for communication in places where normal means of communication cannot be accessed easily.

**\* Search and Rescue Missions:**

With their capability of prolonged flight, they are effective for finding missing persons or monitoring disaster-affected regions.

\* Military and Defense:

Solar-powered UAVs can be utilized for reconnaissance operations that require extended flights undetected.

### 13. FUTURE SCOPE

The scope for the development of UAVs that run on solar power is quite promising with advancements in technology and design.

\* Utilization of High-Efficient Solar Cells:

Solar UAVs can make use of future-generation solar cells that offer greater efficiency in power generation per unit area.

\* Enhanced Battery Energy Storage:

Next-generation batteries capable of storing more energy in shorter time frames can contribute towards increased performance levels.

\* Fully Autonomous Flights:

Artificial intelligence and advanced flight controls can be used to make these UAVs completely autonomous without any human input.

\* HALE UAVs Designing:

Solar UAVs can be designed to fly at great heights acting like pseudo-satellites used for surveillance and communication purposes.

\* Advanced Light-weight Materials:

The use of light-weight materials such as polymers and composites can increase the strength of the body while reducing weight.

\* Combination with Other Renewable Energy Sources:

These UAVs can combine solar energy with other sources of energy to ensure consistent performance.

### 14. CONCLUSIONS

This research demonstrated the possibility of designing and testing an unmanned aircraft with solar panels and showed how renewable energy could be integrated with UAVs. The application of light-weighted materials and 3D printing technology led to the creation of structurally efficient airframe and ensured lighter weight and higher aerodynamic characteristics of the UAV. The inclusion of PV solar panels in the wing resulted in continuous production of energy during the flight and improved the aircraft endurance due to increased energy sources.

The analysis showed that the unmanned aircraft had steady and controllable flight parameters with a flight time of about one hour. The combination of solar-assisted power together with the propulsion system worked effectively taking into account limited amounts of energy. The paper emphasized the role of optimizing certain parameters (wing, weight, and power) to achieve more effective solar UAVs operation.

Solar-assisted unmanned aerial vehicles can be considered a sustainable alternative to traditional UAVs for long-term missions.

Future improvements in the field of solar cells' effectiveness, material weight, and energy storage will definitely increase the capabilities of such devices. Solar-powered UAVs can prove to be extremely important in the future of sustainable flying, providing great benefits for civilian and commercial purposes.

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Link: <https://www.easa.europa.eu>

## BIOGRAPHIES



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