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Conceptual Design of HALE UAV
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Abstract

This work emphasizes the conceptual design and system integration of HALE UAVs to meet the growing demand for sophisticated designs. HALE UAVs' ability to fly at high altitudes for extended periods makes them ideal for remote sensing, communication, and surveillance applications, revolutionizing ISR capabilities.

The design process for HALE UAVs starts with market research on existing models, informing the assumed design configuration based on its advantages and disadvantages. Weight estimation establishes a design point, followed by selection of airfoils and initial sizing of wings, and tail. Iterative refinements lead to the selection of a suitable propulsion unit. The weight estimation process is repeated with resizing to achieve a refined final design configuration of the HALE UAV.

After finalizing the configuration, the dimensions of the elevator, aileron, and rudder control surfaces are determined to meet specifications. System integration ensures the seamless incorporation of components, completing the construction of the HALE UAV. Aircraft modeling, based on provided aerodynamic parameters, generates a 3DOF model that is analyzed for different flight scenarios and varying solar irradiation. This analysis yields response curves and meaningful insights.

Introduction

Unmanned aerial vehicles (UAVs) have seen an increasing demand, particularly High-Altitude Long-Endurance (HALE) UAVs, due to their potential for various applications such as remote sensing, communication, and surveillance. Solar energy is recognized as a promising power source for HALE UAVs, offering the advantage of extended flight durations by harnessing abundant solar energy at high altitudes. Solar HALE UAVs can revolutionize Intelligence, Surveillance, and Reconnaissance (ISR) capabilities.

The design process for HALE UAVs involves market research on existing models, followed by assumption of a design configuration considering its pros and cons. Weight estimation, initial sizing, and stability analysis are conducted to refine the design. System integration and control surface sizing lead to the complete development of the HALE UAV. Solar cells are strategically placed on the large wingspans of these drones to collect sufficient solar energy and maintain flight.

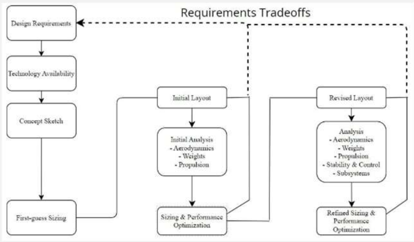
Solar HALE UAV is seen as a more affordable alternative to satellite technology with regard to certain key applications because of improvements in UAV and solar cell efficiency. In the future, HALE UAVs may replace satellites in the monitoring of the outer atmosphere's pollution levels.

Aim and Objectives

- Design a solar-powered HALE UAV.
- Achieve a service ceiling of 20 km and an endurance of 45 days.
- Incorporate payloads for remote sensing and ISR purposes.
- Select a suitable solar-powered propulsion system to operate the UAV during the day, night, and low-light conditions.
- To fully integrate all systems of the UAV, such as flight control, energy management, propulsion and solar system etc.

Methodology

The design process for HALE UAVs involves market research on available options, leading to the assumption of a design configuration considering its pros and cons. Weight estimation and initial sizing, including airfoil selection and wing/tail sizing, are conducted. Stability analysis and power system selection refine the design, followed by control surface sizing and system integration, resulting in the complete development of the HALE UAV. The flowchart of methodology is as shown below.

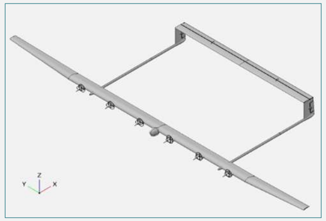


Results

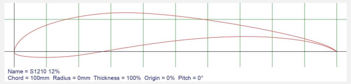
Dimensions of UAV are as follows:

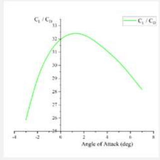
W_0 = 400.68 kg	b_W = 48.768 m
S_W = 73.737 m	AR_W = 32.25
L_{RCW} = 1.640 m	MAC_W = 1.537 m
Y_{MAC} = 11.978 m	b_t = 21.3 m
S_{wt} = 33.82 m^2	AR_t = 13.46
L_{Ct} = 1.58 m	L_B = 13.71 m
H_t = 2.43 m	CG = 1.1 m
b_e = 21.3 m	L_{Ce} = 0.632 m
b_a = 4.876 m	L_{Ca} = 0.492 m
b_r = 0.632 m	L_{Cr} = 1.458 m
λ = 0.86	$\Gamma = 5^0$

Final Aircraft Configuration Layout

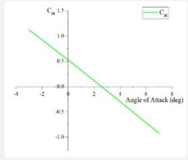


S1210 Airfoil Profile





C_L/C_D vs AOA



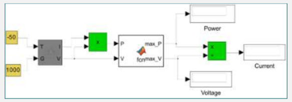
C_m vs AOA

Motors: T- Motor MN1015 KV70, Battery: Tattu 16Ah ,6s 15c

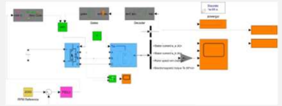
Solar cells: Sunpower MAXEON SP Gen 3

Solar Irradiance Model

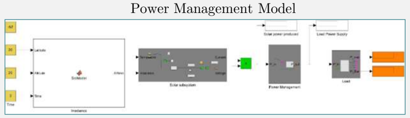
Solar Cell Model



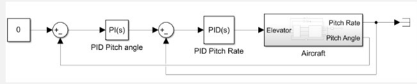
Brushless DC Motor Model



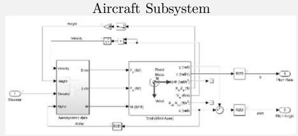
Power Management Model



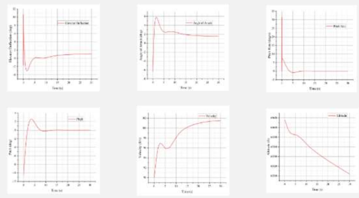
3DOF Aircraft Model



Aircraft Subsystem



Performance Plots



Conclusion

The following conclusions were arrived at upon the project's completion:

- All the aims and objectives of the project have been achieved.
- The designed UAV is capable of achieving a service ceiling of 20 km and an endurance of 45 days. It is incorporated with a suitable solar-powered propulsion system capable of powering the UAV throughout the mission duration.
- Solar system, propulsion system and various other UAV components have been integrated into the UAV.
- The UAV meets the minimum control and stability requirements. The UAV is both statically and dynamically stable.

Overall, this project satisfies the design and mission requirements. The project, in its current form, can be taken up in the future for potential improvisations and eventual use for ISR purposes.

Acknowledgements

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