Design and Analysis of Solar-Powered Unmanned Aerial Vehicle for Tropical Countries

PRASETYO EDI
Politeknik Kirana Tangerang
INDONESIA

Abstract: As a tropical country, Indonesia has unlimited source of solar energy. This advantage can be used to increase the performance of mini unmanned aerial vehicles (i.e., its endurance or flight time without adding significant mass or increasing the size of the fuel system). Hence, a vehicle is designed to simulate the advantage of using the unlimited available renewable green solar energy together with a comprehensive analysis of the latest advancements in design requirements & objectives (payload, speed, range/endurance), aero-configuration, solar-based power integration, and hybrid energy management strategies for UAVs. Key components, including motors, electronic speed controllers (ESCs), propellers, and energy storage systems, are examined alongside emerging technologies such as photovoltaic (PV) materials. Power management techniques, including maximum power point tracking (MPPT) and intelligent energy control algorithms, are also discussed in the context of long-endurance missions. Challenges related to energy density, weight constraints, environmental adaptability, and component integration are highlighted, with insights into potential solutions and future directions. The objectives of this design simulation are to guide the development of efficient, sustainable, and high-endurance UAV platforms leveraging electric-solar hybrid propulsion systems.

Key–Words: Solar energy, Unmanned aerial vehicle (UAV), Renewable green energy, Endurance, Design simulation, Solar cell, Tropical country

Received: March 5, 2026. Revised: April 8, 2026. Accepted: May 9, 2026. Published: July 16, 2026.

1 Introduction

Indonesia is a large group of islands located between the Indian Ocean and the Pacific Ocean, making it extremely important geographically. It acts as a connector between the continents of Asia and Australia. Indonesia, an archipelago with over 17,000 islands, has more than 6,000 inhabited islands. Indonesia mostly sits on the equator, spreading across the southern part of Southeast Asia and stretching into Oceania. Indonesia is roughly situated between 6°N and 11°S latitude and 95°E and 141°E longitude, spanning three time zones: Western Indonesia Time (WIB), Central Indonesia Time (WITA), and Eastern Indonesia Time (WIT). Indonesia shares land borders with three countries: Malaysia on the island of Borneo (shared with Kalimantan), Papua New Guinea on the island of New Guinea, and Timor-Leste on the island of Timor. To the south, Indonesia borders Australia across the Timor Sea. To the north, it has maritime boundaries with the Philippines, while Singapore lies to the west of Indonesia, across the Strait of Malacca [1]. With abundant natural resources and a very important geographical position, to serve and guard its territory, Indonesia needs an efficient armament, transportation and communication tool.

An Unmanned Aerial Vehicle (UAV), commonly known as a drone, is an aircraft operated without a human pilot on board, controlled either remotely by a human operator or autonomously via onboard sensors and software. Powered by electric batteries or engines, they are used for surveillance, reconnaissance, agriculture, communication, and logistics. UAVs have undergone remarkable development over the past decade across military, civil, and academic domains, due to their versatility, efficiency, and cost-effectiveness, fundamentally transforming the landscape of modern aerospace engineering. However, their operational endurance remains constrained by limited onboard energy storage. Recent research has focused on electric propulsion systems integrated with

DOI: 10.37394/232030.2026.5.2

hybrid energy sources, particularly the combination of solar cells and advanced battery technologies to overcome this limitation. In recent years, increasing attention has been devoted to achieving adequate mission performance through low-cost and lightweight platforms without relying on expensive composite structures or aviation-grade sensors [2 - 37].

With the main objective to have UAV with long endurance time, in this paper the author concentrates on the design and analysis of mini-UAV powered by solar energy use in Indonesia, namely M-SP-UAV-X1.

2 UAV Configuration

One of the main problems in mini unmanned aerial vehicles is endurance or flight time since the general domain aircraft uses conventional fuel, which is a pollutant, has a limited life and is costly. Then, there is a huge demand for using an unlimited non-exhaustible source of energy. Solar energy is one of the unlimited available renewable energies, especially in tropical country like Indonesia, which can be used to increase the endurance of unmanned aerial vehicle without adding significant mass or increasing the size of the fuel system [2 – 12 and 28]. Table 1 presents the DR&O, Design Requirements (R) & Objectives (O) of M-SP-UAV-X1. The approach to develop the configuration is shown in Figure 1, where the input is the DR&O.

Table 1. Design Requirements (R) & Objectives (O)

Payload	0.5 kg (R)
Speed	26 km/h (O)
Endurance	long/extended endurance (O)
Mission	reconnaissance and surveillance (R)
Certification	Indonesian certification (R)

The DR&O are used to guide and evaluate the development of the overall aircraft configuration. There are two simple balances:

a. Weight balance: the lift force has to be equal to the weight of all the elements constituting the airplane.
b. Energy balance: the energy that is collected during a day from the solar panel has to be equal to or higher than the electrical energy needed by the airplane during its level flight.

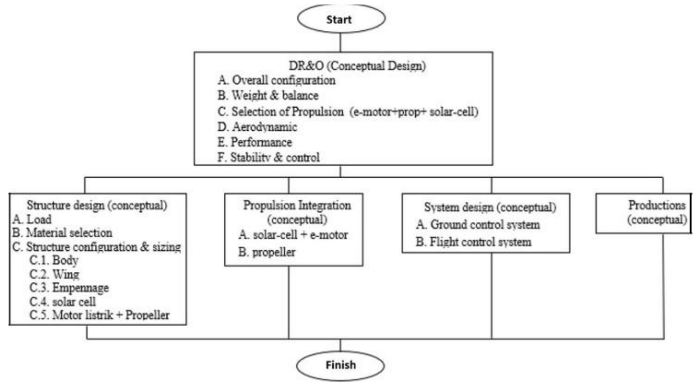

Figure 1. Flow chart to develop the configuration

On the basis of the design requirements & objectives defined and the results of the market analysis, a twin-boom high-wing pushing propeller and inverted V-tail, as shown in Figure 2, has been selected. Such configuration is very versatile, is most famously embodied by the RQ-7 Shadow Unmanned Aerial Vehicle (UAV), this specific design is common in many modern surveillance and logistics drones [5, 6, 7, 8 & 9]. This configuration is primarily used in Unmanned Aerial Systems (UAS) for its aerodynamic and practical advantages, particularly for long-endurance missions:

a. Pusher Propeller: The engine and propeller are mounted at the rear of the aircraft, which provides a cleaner airflow over the wings, improving aerodynamic efficiency. It also allows for an unobstructed view for surveillance equipment in the nose of the central pod.
b. Twin-Boom Tail: The tail assembly is supported by two separate booms extending rearward from the wings or the central pod. This structure allows the central fuselage area to be free for large cargo hatches or equipment placement.
c. High-Wing: The wing is mounted high on the fuselage, which enhances stability.
d. Inverted V-Tail: Instead of a conventional horizontal stabilizer and vertical fin, the aircraft uses two slanted surfaces angled downward (forming an "A" shape, or inverted "V"). This design reduces drag and overall wetted area compared to a traditional H-tail configuration. It combines the functions of the elevator and rudder into single control surfaces called "ruddervators". Placing the inverted V-tail above the immediate propeller wake reduces turbulent flow and potential buffeting, leading to better low-speed responsiveness and stability characteristics.

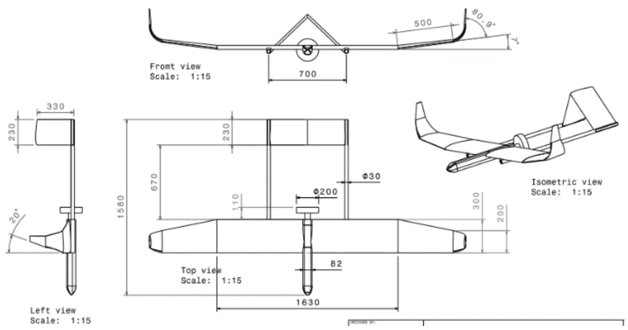

Figure 2. M-SP-UAV-X1 overall configuration

Based on the requirements of lift and power and competitor survey, the rectangular center-wing and taper at the wing-tip planform, as shown in Figure 3, has been selected. To increase the stability, 7 deg. dihedral has been adopted at the wing-tip on both sides, which also includes ailerons for easy control.

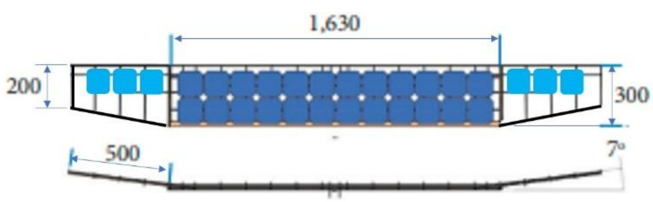

Figure 3. Wing configuration

The airfoil used for the wing was specifically designed by W. Engel (WE3.55-9.3) for its best wing efficiency ($C_D/C_L^{3/2}$), performance and less camber for cell placement of solar cells, which is the same airfoil designed for Sky-Sailor [3, 7, 8, 9, 10 and 11]. Table 2 gives the wing data.

Table 2. Wing data

WING		
root chord	0.3	m
tip chord	0.2	m
semi-span-inner	0.815	m
semi-span-outer	0.5	m
Total span	2.63	m
Taper ratio	0.667	
Area	0.739	m^2
Aspect Ratio, AR	9.36	

3 Power required & available

Circuit diagram

From the circuit diagram shown in Fig. 4, the energy received from the Sun is collected by the solar panel, which converts it into electricity and then there is the maximum power point tracker (MPPT), which helps in tracking the maximum power of any solar cell and provides it at all times. In MPPT, there are 3 terminals: one is connected to the solar panel; the other, to load (motor); and the last one, to the battery. Then, in level flight, the MPPT sends power directly to the motor from the solar cells and, when gliding, as the motor does not require power, the battery starts charging [3, 4, 8, 12, 14, 15, 18, 19, 22 and 26-37].

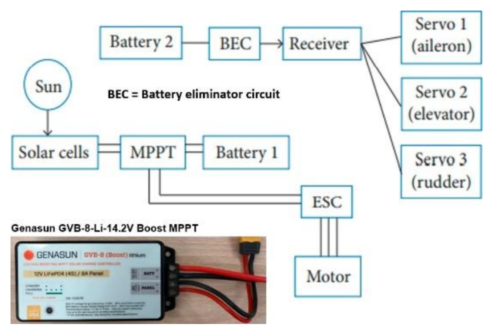

Figure 4. Circuit diagram for M-SP-UAV-X1

If an excess of power is required, during climbing or when the solar intensity is low, the battery supplies the required power, which is stored into the motor. Thus, from the battery, the energy goes to the motor, which rotates the propeller and, between them, there is an electronic speed control (ESC) regulating the speed.

Besides the present battery, there is an additional small pencil battery to control the avionics; the reason to separate it is, even if there is any problem in the main circuit or else, any damage in the cells still controlling the plane can be done as the control system's battery is not connected to the main circuit, which helps in safe landing.

Power required for level flight

At steady level flight, the lift force generated by the wing exactly compensates for the weight, and the propeller thrust, for the drag force [3, 8, 27, 29 and 38], hence aircraft weight (W) = lift (L) and thrust (T) = drag (D). Table 3 presents the required parameters for calculating level flight.

Table 3. Required parameters for calculating level flight

Parameters	SI units
Maximum weight, m	2 kg
Gravity, g	9.81 m/s^2
Airfoil lift coefficient, C_L	0.91
Airfoil Chord	0.3 m
Wing area, S	0.7389 m^2
Airfoil drag coefficient, c_d	0.0115
Oswald's efficiency, e	0.773

$$W = m*g = L = 0.5*\rho*V^{2*}C_L*S \quad (1)$$

$$T = D = 0.5*\rho*V^2*C_D*S$$

$$T = D = (c_d + C_{Di})(0.5*\rho*V^2*S) \quad (2)$$

$$\text{Induced drag } C_{Di} = C_L^2/(\pi*e*AR) \quad (3)$$

Oswald's efficiency:

$$e = 1.78*(1 - 0.045*AR*0.68) – 0.64 = 0.774 \quad (4)$$

The power required for level flight is:

$$P_{req} = T*V=D*V, \text{ where } V = \text{speed (km/h)} \quad (5)$$

Aircraft lift coefficient $C_{L\text{-}a/c} = 0.9*0.91 = 0.82$

Aircraft weight $W = m*g = 2*9.81 = 19.62\ N$

$V_{cruise} = SQRT\ (2*19.62/(1.22*0.739*0.82))$

Cruise speed, $V_{cruise} = 7.3\ m/s = 26.244\ km/h$

The total drag (fly at $(L/D)_{max}$):

- the wing cd, which is around = 0.2755 N;
- the induced drag, which accounts for 0.7069 N due to very high lift
- the body (fuselage) + tail drag, which is taken 1.7 times the airfoil drag.

Power required = P_{req} = *D*V = 10.575 watts*

In order to get this much power, more power should be extracted from batteries as there are electronics in the circuit for which there will be losses during conversion and efficiencies involved must be included [3, 8, 27, 29, 30, 31 and 38]:

Propeller efficiency of 80%, motor efficiency of 80%, ESC efficiency of 70% and the battery discharge efficiency of 90%, so that it is obtained a total of 40.32%. Here, extra 2 W are added to other losses.

Hence, the total power required from the batteries is = Total power required =

$P_{tot.req}$ = 10.575 watts /40.32% = 28.229 watts

The other circuit was from the battery to solar cells in which solar encapsulation was 90%; solar cells, 22%; camber efficiency, 90%; MPPT efficiency, 90%; and battery charging efficiency, 90% [3, 8, 27, 29, 30, 31-35 and 38], totaling 14.43%.

In order to get this power, the required solar irradiance is:

$$\frac{\text{Total power required from batteries}}{\text{(Sunlight to battery efficiency × Area of Solar cells)}} = \frac{28.229}{(0.1443*24*0.0156)} = 522\ W/m^2.$$

Hence, for 24 solar cell, 522 W/m2 of solar irradiance is required in order to have a level flight. Figure 5 shows the arrangement and connection of solar cells (up to 30 cells) on the wing.

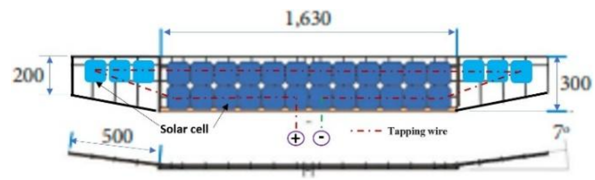

Figure 5. Arrangement and connection of solar cells on the wing

Power available

According to [3, 4, 11 and 39], the power available from solar energy is calculated during February 16th, 2025, since February represents the coldest seasons in which minimum solar radiation occurs.

Figure 6 gives solar power available at Jakarta, latitude (Φ) = - 6.2 deg. (above sea level = 0.2 km).

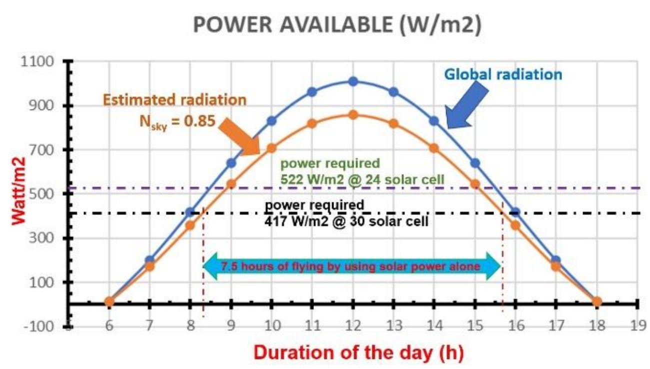

Figure 6. Solar power available at Jakarta.

Based on Figure 6, M-SP-UAV-X1 can have 7.5 hours of flying/endurance-time by using solar power alone (for wing with 30 solar cells).

4 Parametric analysis and optimization

Designing long-endurance, solar-powered unmanned aerial vehicles (UAVs) require careful coordination across aerodynamic, structural, and energy subsystems, particularly when targeting flexible, high-aspect-ratio configurations. Parametric analysis and optimization of solar-powered UAVs focus on maximizing endurance by balancing aerodynamic efficiency, structural weight, and solar energy harvesting. Key design parameters include wing aspect ratio, airfoil shape, solar cell efficiency, battery energy density, and flight speed. Optimization aims for minimum power consumption and maximum flight endurance, often using tools like Python-based CAD software FreeCAD for geometric modelling [40-52].

Key benefits of optimization: extended endurance: increased flight durations, with some systems achieving 24+ hour, multi-day, or continuous, uninterrupted flight; enhanced energy efficiency: significant reduction in battery consumption (e.g., up to 22.5% improvement) and improved adaptability: enhanced performance under variable weather conditions, such as cloudy or low-sunlight periods [45 and 48-52].

These optimizations allow solar-powered UAVs to operate efficiently in critical applications like environmental monitoring, surveillance, and as aerial communication relays.

5 Conclusions and recommendations

Solar-electric hybrid propulsion systems present a promising solution to overcome the endurance limitations of conventional battery-powered UAVs. This design simulation has explored the enabling technologies, including high-efficiency electric motors, solar–battery–fuel cell architectures, MPPT-based energy management, and hybrid system modelling techniques.

As solar-electric UAVs progress toward real-world implementation, sustained interdisciplinary research will be vital to address ongoing challenges in integration, efficiency, reliability, and scalability.

References:

[1] Maria Gomez, “Where is Indonesia? A Geographic and Cultural Overview”, 14 Nov. 2025, https://www.iroamly.com/indonesia-travel/where-is-indonesia.html, retrieved on 29-12-2025.

[2] Sezer Coban and Tugrul Oktay, “A REVIEW OF TACTICAL UNMANNED AERIAL VEHICLE DESIGN STUDIES”, The Eurasia Proceedings of Science, Technology, Engineering & Mathematics (EPSTEM) “ICONTES2017: International Conference on Technology, Engineering and Science”, Volume 1, Pages 30-35, November 2017. https://www.researchgate.net/publication/321184310_A_REVIEW_OF_TACTICAL_UNMANNED_AERIAL_VEHICLE_DESIGN_STUDIES

[3] Karthik Reddy Buchireddy Sri, Poondla Aneesh, Kiran Bhanu, M Natarajan, “Design Analysis of Solar-Powered Unmanned Aerial Vehicle”, Journal of Aerospace Technology and Management, São José dos Campos, Vol.8, No 4, pp.397-407, Oct.-Dec., 2016. doi: 10.5028/jatm.v8i4.666.

[4] Norliza Ismail, Nadhiya Liyana Mohd Kamal, Nurhakimah Norhashim, Sabarina Abdul Hamid, Zulhilmy Sahwee and Shahrul Ahmad Shah, “Review: Electric Propulsion and Hybrid Energy Systems for Solar-Powered UAVs: Recent Advances and Challenges”, Drones 2025, 9, 846. https://doi.org/10.3390/drones9120846.

[5] Textron Systems, “RQ-7 Shadow Unmanned Aerial Vehicle (UAV), Tactical UAS”. https://www.textronsystems.com/products/shadow-tactical-unmanned-aircraft-systems, retrieved on 29-12-2025.

[6] Rufino, G.; Conte, C.; Basso, P.; Tirri, A.E.; Donato, V. “Mission Design and Validation of a Fixed-Wing Unmanned Aerial Vehicle for Environmental Monitoring”, Drones, 2024, 8, 641. https://doi.org/10.3390/drones8110641

[7] Prasetyo Edi, Nukman Y. and Aznijar A. Y. “The Design Improvement of Airfoil for Flying Wing UAV (Unmanned Aerial Vehicle)”. WSEAS TRANSACTIONS on APPLIED and THEORETICAL MECHANICS, Issue 9, Volume 3, September 2008, ISSN: 1991-8747. http://www.wseas.us/e-library/transactions/mechanics/2008/28-776.pdf https://www.researchgate.net/publication/236657704_The_design_improvement_of_airfoil_for_flying_wing_UAV.

[8] Catur S. K., Prasetyo Edi, Mohd. Ramly Mohd Ajir, ShahNor Basri and Abdul Aziz Jaafar. “Technology Concepts for Long Endurance UAV”. National Symposium: Aerospace Technology of the XXI Century (Aerotech-2005), Aerospace Engineering, University Putra Malaysia, Serdang, Selangor, Malaysia. February 21, 2005.

[9] Prasetyo Edi, Nukman Y. and Aznijar A. Y. “Airfoil Design for Flying Wing UAV (Unmanned Aerial Vehicle)”, p. 106. The 4th WSEAS International Conference on APPLIED and THEORETICAL MECHANICS (MECHANICS '08), Cairo-Egypt. Dec 29 – 31, 2008. https://www.wseas.org/multimedia/books/2008/cairo/MECHANICS.pdf.

[10] Bruscoli, “Airfoil optimization for a solar powered aircraft (PhD thesis)”. Pisa: Università degli Studi di Pisa, 2011.

[11] Noth A. Design of solar powered airplanes for continuous flight (PhD thesis). Zürich: ETH Zürich, 2008.

[12] Chu, Y.; Ho, C.; Lee, Y.; Li, B. “Development of a Solar-Powered Unmanned Aerial Vehicle for Extended Flight Endurance”. Drones 2021, 5, 44. https://doi.org/10.3390/drones5020044.

[13] Park, Y.-D.; Kim, T.-W.; Kim, H.-K. Design and Autonomous Flight Demonstration of a Low-Cost Cardboard-Based UAV. Drones 2025, 9, 848. https://doi.org/10.3390/drones9120848.

[14] Long Suo, Zhichu Zhang, Lei Yang and Yunfei Liu. “Performance Analysis of Uplink Opportunistic Scheduling for Multi-UAV-Assisted Internet of Things”. Drones 2025, 10(1), 18. https://doi.org/10.3390/drones10010018.

[15] Jorge L. Hernandez-Toral, Iván González-Hernández and Rogelio Lozano. “Sun Tracking Technique Applied to a Solar Unmanned Aerial Vehicle”. Drones 2019, 3(2), 51; https://doi.org/10.3390/drones3020051.

[16] Yang, J.; Zhao, L.; Peng, B. “Joint Path Planning and Energy Replenishment Optimization for Maritime USV–UAV Collaboration Under Bei Dou High-Precision Navigation”. Drones 2025, 9, 746. https://doi.org/10.3390/drones9110746.

[17] A. Bulent Koc, Patrick T. Anderson, John P. Chastain and Christopher Post. “Estimating Rooftop Areas of Poultry Houses Using UAV and Satellite Images”. Drones 2020, 4(4), 76; https://doi.org/10.3390/drones4040076.

[18] Valencia-Ortiz, M.; Sangjan, W.; Selvaraj, M.G.; McGee, R.J.; Sankaran, S. “Effect of the Solar Zenith Angles at Different Latitudes on Estimated Crop Vegetation Indices. Drones 2021, 5, 80. https://doi.org/10.3390/drones5030080.

[19] Le, W.; Xue, Z.; Chen, J. and Zhang, Z. “Coverage Path Planning Based on the Optimization Strategy of Multiple Solar Powered Unmanned Aerial Vehicles”. Drones 2022, 6, 203. https://doi.org/10.3390/drones6080203.

[20] Tian, Z.; Haas, Z.J. and Shinde, S. “Routing in Solar-Powered UAV Delivery System”. Drones 2022, 6, 282. https://doi.org/10.3390/drones6100282.

[21] García-Gascón, C.; Castelló-Pedrero, P. and García Manrique, J.A. “Minimal Surfaces as an Innovative Solution for the Design of an Additive Manufactured Solar-Powered Unmanned Aerial Vehicle (UAV)”. Drones 2022, 6, 285. https://doi.org/10.3390/drones6100285.

[22] Jenie, Y.I.; Pardomoan, G.Y. and Moelyadi, M.A. “Development of an Automatic Solar Tracker Control System for a Tandem-Winged UAV and Its Implementation Strategies”. Drones 2023, 7, 442. https://doi.org/10.3390/drones7070442.

[23] Tiškus, E.; Buˇcas, M.; Vaiˇci¯ ut˙ e, D.; Gintauskas, J. and Babrauskien˙ e, I. “An Evaluation of Sun-Glint Correction Methods for UAV-Derived Secchi Depth Estimations in Inland Water Bodies”. Drones 2023, 7, 546. https://doi.org/10.3390/drones7090546.

[24] Elfarkh, J.; Johansen, K.; Angulo, V.; Camargo, O.L. and McCabe, M.F. “Quantifying Within-Flight Variation in Land Surface Temperature from a UAV-Based Thermal Infrared Camera”. Drones 2023, 7, 617. https://doi.org/10.3390/drones7100617.

[25] Li, S.; Fang, Z.; Verma, S.C.; Wei, J. and Savkin, A.V. “Navigation and Deployment of Solar-Powered Unmanned Aerial Vehicles for Civilian Applications: A Comprehensive

Review". Drones 2024, 8, 42. https://doi.org/10.3390/drones8020042.

[26] Cao, X. and Liu, L. "State-of Charge Trajectory Planning for Low-Altitude Solar-Powered Convertible UAV by Driven Modes". Drones 2024, 8, 80. https://doi.org/10.3390/drones8030080.

[27] Diogo, C.M.A.; Fernandes, E.C. A Mass, Fuel, and Energy Perspective on Fixed-Wing Unmanned Aerial Vehicle Scaling. Drones 2024, 8, 396. https://doi.org/10.3390/drones8080396.

[28] Yan, Y.; Cao, H.; Zhang, B.; Ni, W.; Wang, B. and Ma, X. "Large-Scale Solar-Powered UAV Attitude Control Using Deep Reinforcement Learning in Hardware-in-Loop Verification". Drones 2024, 8, 428. https://doi.org/10.3390/drones8090428.

[29] Yang, X.; Ma, D.; Zhang, L.; Li, F.; Guan, H. and Yu, Y. "Mission-Based Design and Retrofit for Energy/Propulsion Systems of Solar-Powered UAVs: Integrating Propeller Slipstream Effects". Drones 2024, 8, 584. https://doi.org/10.3390/drones8100584.

[30] Valencia, E.; Cruzatty, C.; Amaguaña, E. and Cando, E. "Paving the Way for Sustainable UAVs Using Distributed Propulsion and Solar-Powered Systems". Drones 2024, 8, 604. https://doi.org/10.3390/drones8100604.

[31] Wu, S.; Nie, K.; Lu, X.; Fan, W.; Zhang, S. and Wang, F. "A Solar Trajectory Model for Multi-Spectral Image Correction of DOM from Long-Endurance UAV in Clear Sky". Drones 2025, 9, 196. https://doi.org/10.3390/drones9030196.

[32] de Bruyn, C.; Ralebitso Senior, K.; Scott, K.; Panter, H. and Bezombes, F. "Search, Detect, Recover: A Systematic Review of UAV-Based Remote Sensing Approaches for the Location of Human Remains and Clandestine Graves". Drones 2025, 9, 674. https://doi.org/10.3390/drones9100674.

[33] Soya, H.; Inagaki, K. and So, H. "A Flight Route Design Method Considering Multi-Hop Communication Using Delivery UAVs". Drones 2025, 9, 751. https://doi.org/10.3390/drones9110751.

[34] Martínez-Rozas, S.; Alejo, D.; Carpio, J.J.; Caballero, F.; Merino, L. "Long-Duration Inspection of GNSS-Denied Environments with a Tethered UAV-UGV Marsupial System". Drones 2025, 9, 765. https://doi.org/10.3390/drones9110765.

[35] Deng, C. and Fang, X. "Target Allocation and Air–Ground Coordination for UAV Cluster Airspace Security Defense". Drones 2025, 9, 777. https://doi.org/10.3390/drones9110777.

[36] Li, J.; Fan, C.; Ou, C. and Zhang, H. "Infrared and Visible Image Fusion Techniques for UAVs: A Comprehensive Review". Drones2025, 9, 811. https://doi.org/10.3390/drones9120811.

[37] Yang, F.; Zhao, J.; Liu, J.; Luo, Z.; Gu, X. and Wang, S. "What Are the Preferences of Chinese Farmers for Drones (UAVs): Machine Learning in Technology Adoption Behavior". Drones 2025, 9, 817. https://doi.org/10.3390/drones9120817. yy

[38] Simons M. Model aircraft aerodynamics. 3rd edition. Hemel Hempstead: Argus, 1994.

[39] A. Noth, R. Siegwart, W. Engel. Design of Solar Powered Airplanes for Continuous Flight. Autonomous Systems Laboratory, ETH Swiss, December 2007.

[40]Mohammad Khaneghaei, Davood Asadi, Benyamin Ebrahimi, Majid Hazeri, Touraj Farsadi, Yaser Nabavi Chashmi and Tahir Durhasan. A unified and experimentally validated design framework for long-endurance solar UAVS using model-based multi-objective multidisciplinary optimization. Structural and Multidisciplinary Optimization (2026) 69:3. https://doi.org/10.1007/s00158-025-04194-6

[41]Di, W.; Dong, X.; Wei, Z.; Liu, H.; Tu, Z.; Li, D.; Xiang, J. Towards Efficiency and Endurance: Energy Aerodynamic Co-Optimization for Solar Powered Micro Air Vehicles. Drones 2025, 9, 493. https://doi.org/10.3390/drones9070493

[42]JIANG Rui, LIN Jianqin, LIN Zonghui, LIU Aimin, DENG Konghong, ZHOU Zhiyan. Design and Operational Parameter Optimization of Endurance-extended Drone for Supplementary Pollination in Hybrid Rice Breeding. Transactions of the Chinese Society of Agricultural Machinery. Vol 56, No 2 (2025).

[43]Huang Zihan, Long Bo, Li Jiyu. Optimization model for endurance performance of electric rotorcraft transport drones and its application prospects. IAES International Journal of

Robotics and Automation (IJRA), ISSN 2089-4856, e-ISSN 2722-2586, Vol 14, No 1, 2025. DOI: http://doi.org/10.11591/ijra.v14i1.pp129-142.

[44]Qin, T.; Zhang, G.; Yang, L.; He, Y. Research on the Endurance Optimisation of Multirotor UAVs for High-Altitude Environments. Drones 2023, 7, 469. https://doi.org/10.3390/drones7070469.

[45]Aun Haider. A Parametric Study on Design Variables for Solar Powered Long Endurance Unmanned Aerial Vehicle. Reports in Mechanical Engineering. Vol. 5, No. 1, 2024, pp. 1-12. ISSN: 2683-5894, DOI: https://doi.org/10.31181/rme313.

[46]Nuno Ant´onio Silva. Parametric Design, Aerodynamic Analysis and Parametric Optimization of a Solar UAV. June 2014.

[47]Karali, H.; Inalhan, G.; Tsourdos, A. Advanced UAV Design Optimization Through Deep Learning-Based Surrogate Models. MDPI, Aerospace 2024, 11, 669. https://doi.org/10.3390/aerospace11080669

[48]K You, X Zhao, S-Z Zhao and M Faisal. Design and Optimization of a High-altitude Long Endurance UAV Propeller. September 2020IOP Conference Series Materials Science and Engineering 926(1):012018. DOI:10.1088/1757-899X/926/1/012018.

[49]Seok-Ho Son, Byung-Lyul Choi, Won-Jin Jin, Yung-Gyo Lee, Cheol-Wan Kim and Dong-Hoon Choi. Wing Design Optimization for a Long-Endurance UAV using FSI Analysis and the Kriging Method. International Journal of Aeronautical & Space Science 17(3), 423–431 (2016). DOI: http://dx.doi.org/10.5139/IJASS.2016.17.3.423

[50]Chaoyu Zhang, Chengming Zhang, Liyi Li, Qingbo Guo. Parameter analysis of power system for solar-powered unmanned aerial vehicle. Applied Energy, Volume 295, 1 August 2021, 117031. https://doi.org/10.1016/j.apenergy.2021.117031.

[51]Bakar, A.; Ke, L.; Liu, H.; Xu, Z.; Wen, D. Design of Low Altitude Long Endurance Solar-Powered UAV Using Genetic Algorithm. Aerospace2021, 8(8), 228; https://doi.org/10.3390/aerospace8080228.

[52]Olivier Montagnier and Laurent Bovet. OPTIMISATION OF A SOLAR-POWERED HIGH ALTITUDE LONG ENDURANCE UAV WITH COMPOSITE WINGS. 3RD EUROPEAN CONFERENCE FOR AEROSPACE SCIENCES (EUCASS 2009).

Contribution of Individual Authors to the Creation of a Scientific Article (Ghostwriting Policy)

The author contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

Sources of Funding for Research Presented in a Scientific Article or Scientific Article Itself

No funding was received for conducting this study.

Conflict of Interest

The author has no conflict of interest to declare that is relevant to the content of this article.