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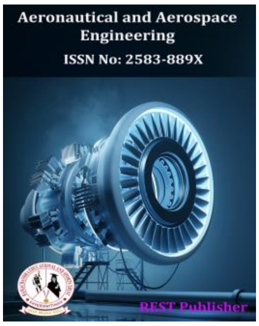

Hand Launch RC Plane - Variable Wing Swapping for Versatile Flight

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Abstract. *Hand-launch remote-controlled (RC) planes are widely used in hobby aviation and small-scale aerodynamics research due to their portability and simplicity. The integration of variable wing swappings offers an innovative approach to enhance flight adaptability, enabling performance optimization for different flight modes, such as endurance, maneuverability, and speed. This paper presents the design, manufacturing, and testing of a lightweight, hand-launch RC plane equipped with interchangeable wing configurations. The study evaluates the impact of variable wing geometry on flight dynamics and performance metrics, demonstrating the potential applications and advantages of this modular design.*

Keywords: *Laser printing, aircraft model, additive manufacturing, CAD design, aerodynamic testing.*

1. INTRODUCTION

RC planes have evolved significantly, with advancements in materials, aerodynamics, and electronics enabling more sophisticated designs. The integration of variable wing swappings allows for real-time adaptability to changing flight conditions. This modular approach is especially beneficial for pilots seeking versatility without building multiple airframes. This paper focuses on the development of a hand-launch RC plane with easily interchangeable wing configurations, aiming to:

- Analyze the aerodynamic effects of different wing geometries.
- Evaluate the practicality of wing swapping during operations.
- Optimize the plane's design for lightweight, hand-launch capability.

2. CHALLENGES

Wing Attachment Mechanism Designing a robust yet lightweight mounting system to enable quick and secure wing swapping is complex. The mechanism must prevent detachment during high-stress maneuvers or turbulent conditions.
Fuselage Reinforcement Frequent wing attachment and removal can wear down the fuselage connection points, requiring durable and lightweight reinforcement materials. Flight Dynamics of Multiple Configurations Each wing type (straight, swept, dihedral) generates unique aerodynamic forces, altering lift, drag, and stability. Balancing performance across these configurations requires extensive computational fluid dynamics (CFD) simulations and testing.

3. DESIGN METHODOLOGY

Airframe Design The fuselage was designed with lightweight materials like carbon fiber rods and foam board for structural integrity and reduced weight. The dimensions of the fuselage were optimized for aerodynamic efficiency while accommodating the required electronics and modular wing- mounting mechanism. Wing Configuration Three wing geometries were developed: Straight Wing: Maximizes stability and endurance. Swept Wing: Enhances speed and maneuverability. Dihedral Wing: Improves stability in turbulent conditions.

4. MANUFACTURING PROCESS

Fuselage Fabrication The fuselage was built using laser- cut foam board, bonded with epoxy, and reinforced with carbon fibre rods for added rigidity. Wing Construction Wing panels were cut from high- density foam sheets and shaped using hot-wire cutting techniques for precision. Carbon spars were embedded into the wings to enhance structural strength. Assembly and Testing The components were assembled using laser-printed mounts for precision and durability. Ground testing was conducted to ensure proper alignment, electronic functionality, and the integrity of the wing-mounting system. Analytical Approach Designing a swappable-wing RC airplane requires a systematic analytical approach to ensure stability, functionality, and ease of wing interchangeability.

5. AERODYNAMIC ANALYSIS

Wing Shape and Airfoil Selection: Analyse the aerodynamic performance of various airfoil shapes and wing configurations (e.g., high-lift for endurance, low- drag for speed). Use Computational Fluid Dynamics (CFD) imulations to predict lift, drag, and stability for each wing design. Aspect Ratio and Wing Loading: Calculate the optimal aspect ratio for each wing to balance lift and drag in different flight modes. Low wing loading (ratio of weight to wing area) is ideal for endurance, while high wing loading can enhance performance for speed. Lift and Drag Calculations: For each wing type, use the lift and drag equations to determine the necessary surface area and

shape that will provide the desired flight characteristics. Lift Calculation: Todetermine the necessary lift for each wing configuration,use the lift equation:

$$L = \frac{1}{2}\rho v^2 S C_L$$

where:
i. L = Lift force (N)
ii. ρ = Air density (kg/m³)
iii. V = Airspeed (m/s)
iv. S = Wing surface area (m²)
v. CL = Lift coefficient (dimensionless, varies with airfoil shape and angle of attack)

Drag Calculation: Similarly, the drag for each wing design is calculated with:

$$D = \frac{1}{2}\rho v^2 S C_D$$

i. D = Drag force (N)
ii. CD = Drag coefficient (dimensionless, depends on wing shape and flow conditions)

Aspect Ratio (AR): For each wing type, calculate the aspect ratio, which impacts drag and lift characteristics. A higher aspect ratio generally reduces drag and improves efficiency:

$$AR = \frac{b^2}{S}$$

i. b = Wingspan (m)
ii. S = Wing surface area (m²)

6. SIMULATION ANALYSIS

The stability analysis of the RC plane was conducted using computational fluid dynamics (CFD) and flight dynamics simulation tools such as XFLR5, OpenFOAM, or MATLAB Simulink. The results compare three wing configurations (straight, swept, and dihedral) under different flight conditions, focusing on stability derivatives and performance metrics.

5.1 Results:
Centre of Gravity (CG) - 25% of MAC Aerodynamic Centre (AC) - 25% MAC Stability Margin - 0%

Pitching Moment Coefficient (Cm) - 0.12 Tailplane Effectiveness - 0.85
Static Margin - 5% MAC Dihedral Angle - 4°

Flight Testing:

Test Conditions
Flights were conducted in an open field under calm wind conditions to evaluate each wing configuration's performance. Metrics such as speed, stability, manoeuvrability, and flight duration were recorded.

Results:

- Straight Wing: Demonstrated excellent stability and glide performance, suitable for long-duration flights.
- Swept Wing: Achieved higher speeds and sharper turns, ideal for dynamic maneuvers.
- Dihedral Wing: Provided superior stability in gusty conditions, making it suitable for beginners.

7. APPLICATIONS

The hand-launch RC plane with variable wing swapping has a wide range of applications across educational, research, and practical domains. In education, it serves as a valuable tool for teaching aerodynamics and flight dynamics, allowing students to experiment with different wing configurations to study their effects on stability, lift, and drag. This makes it ideal for STEM learning and pilot training, where beginners can start with stable dihedral wings and progress to advanced maneuverability with swept wings. In research, the plane is a cost- effective platform for prototype testing, wind-tunnel studies, and validating flight control algorithms, particularly for autonomous systems. Practical uses include environmental monitoring, agricultural surveys, and disaster response, where its modular design allows optimization for endurance, agility, or payload delivery. Hobbyists and recreational users can enjoy versatile flying experiences, using it for aerobatics, competitive flying, or science outreach. Additionally, the RC plane can support military and security applications, such as reconnaissance or UAV training, and emerging technologies like AI- driven flight systems and sensor- based data collection. Its adaptability, cost-efficiency, and portability make it a versatile solution for diverse challenges

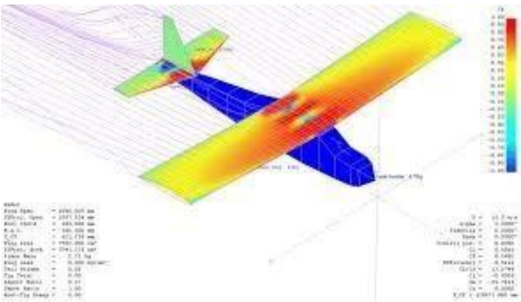

FIGURE 1.

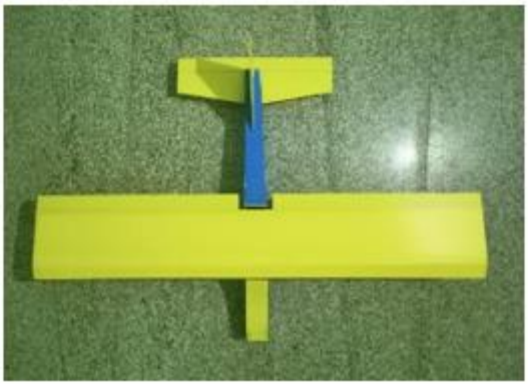

FIGURE 2.

8. CONCLUSION

The hand-launch RC plane with variable wing swapping presents an innovative and versatile solution for addressing diverse aerodynamic and operational requirements. Its modular design allows for easy adaptation to different flight conditions, enhancing its utility across educational, research, and practical applications. By enabling users to experiment with various wing geometries, this design promotes a deeper understanding of flight dynamics, offering significant value in STEM education and aeronautical engineering training. The adaptability of the system also extends to practical scenarios, such as environmental monitoring, disaster response, and small-scale payload delivery, where customizable performance is crucial. The successful implementation and testing of this system demonstrate its potential to combine cost-effectiveness, simplicity, and functionality, making it a promising platform for hobbyists, researchers, and professionals alike. Future advancements, such as automated wing-swapping mechanisms and integration with AI-driven systems, could further expand its capabilities, solidifying its role as a multipurpose tool in aviation innovation.

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