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An Innovation Design of the Flying Vehicle Jet Engine for Energy Efficiency and Lightweight Configuration Analysis

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ABSTRACT

The development of lightweight flying vehicles has become increasingly important due to the growing demand for efficient emergency VTOL (Vertical Take Off Landing) transportation and advanced aviation mobility systems. This research focuses on the innovation of flap design integrated with a jet engine system to improve the aerodynamic efficiency and flight endurance of a lightweight flying vehicle. The proposed flying vehicle is capable of carrying a payload of up to 780 kg with a maximum speed of 425 km/h. The study involved literature review, aerodynamic analysis, wing and flap configuration design, Computational Fluid Dynamics (CFD) simulation, and design validation processes. The flying vehicle was designed using lightweight materials such as carbon fiber and aluminum with jet engine formation to improve flight performance and reduce energy consumption. The simulation and analysis results demonstrated that the proposed flap design improved flight endurance by approximately 38% compared to conventional designs. Furthermore, the proposed concept shows strong potential for emergency response applications such as ambulance services, and rescue operations, especially in reducing delays caused by traffic congestion. This research contributes to the advancement of energy-efficient flying vehicle jet engine technology and future aerospace transportation systems in Malaysia.

1. Introduction

The aviation industry has involved significant consideration since the early development of transportation systems [6]. Continuous technological advancement has provided opportunities for researchers and engineers to improve the performance, safety, and efficiency of flying vehicles [2]. Over time, flying vehicles have endured various design developments to accommodate dissimilar operational conditions and applications [3,11].

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Modern flying vehicles are designed to be lighter, more energy efficient, and capable of producing optimum flight performance under various environmental conditions [1,5,10]. These developments have expanded the application of flying vehicles in educational, commercial, and emergency operation sectors in a more cost-effective manner [13].

Urban traffic congestion has become one of the major challenges affecting emergency response services such as firefighters, police, and ambulance teams. Delays caused by road congestion may reduce the effectiveness of emergency operations and increase the risk to human lives [7,8].

Therefore, the development of a lightweight flying vehicle has gained increasing attention as an alternative transportation solution for emergency response applications [4,14]. This research focuses on the innovation of flap design integrated with a jet engine system to improve the energy efficiency and flight performance of the flying vehicle. The proposed vehicle is designed to carry a payload of up to 580 kg with a maximum speed of 400 km/h.

In addition, modern flying vehicle development must comply with aviation standards and operational regulations to ensure flight stability and safety. The use of lightweight materials such as carbon fibre and aluminium alloys has improved take-off and landing performance while reducing the overall structural weight of the aircraft [9,15]. Furthermore, advanced technologies including smart landing gear systems and improved manoeuvring capabilities have enhanced the operational efficiency of current flying vehicles.

Existing flying vehicle designs are capable of attaining manoeuvring forces between +64.4g and −4.8g. However, current developments continue to focus on improving aerodynamic efficiency, flight endurance, and energy consumption [9]. Therefore, this research proposes a new flying vehicle concept integrated with an innovative flap design and jet engine system to improve flight efficiency and operational performance.

This research also supports sustainable development initiatives by introducing an innovative flying vehicle concept for emergency transportation and future aviation applications in Malaysia. The planned design contributes to technological advancement in sustainable transportation systems and aerospace innovation [12].

2. Design Methodology

2.1 Research Methodology

The research methodology for the proposed flying vehicle development was conducted systematically through several engineering design and analysis stages. The methodology began with an extensive literature review related to flying vehicle configurations, jet engine systems, aerodynamic wing structures, and flap design technologies.

The theoretical and simulation phase elaborate two major components, namely data collection and jet engine parameter selection. Relevant aerodynamic and propulsion data were collected from previous studies and technical references to support the design optimization process.

Following, the design modelling stage was carried out, consisting of structural analysis and wing model development. The flying vehicle structure, wing configuration, and innovative flap system were designed to achieve lightweight characteristics and improved aerodynamic efficiency [12].

Computational Fluid Dynamics (CFD) simulation was then conducted to evaluate the aerodynamic performance, lift generation, drag characteristics, and energy efficiency of the proposed design. The simulation results were validated to determine whether the design achieved the essential performance criteria.

Finally, conclusions were drawn based on the validated aerodynamic and engineering analysis results. Figure 1 shows the Research Flow Chart.

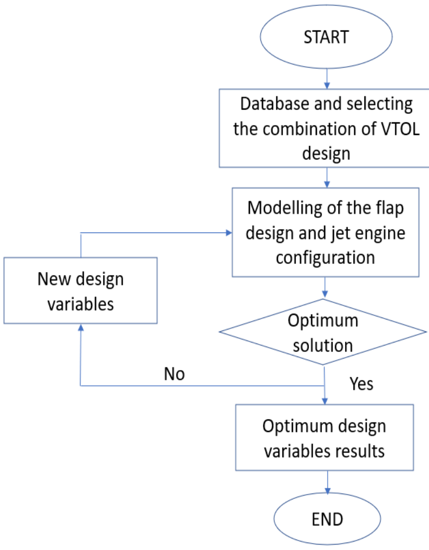

Fig. 1. Research flow chart

2.2 Design Technology and Configuration

The technology applied in this flying vehicle flap design was systematically developed through extensive literature review and analysis of early flying vehicle configurations, including Vertical Take of Landing (VTOL) designs [16]. Several design approaches and aerodynamic methods from previous studies were selected to support the development of the proposed flying vehicle. Figure 2 shows Flying vehicle flap design with jet engine integration.

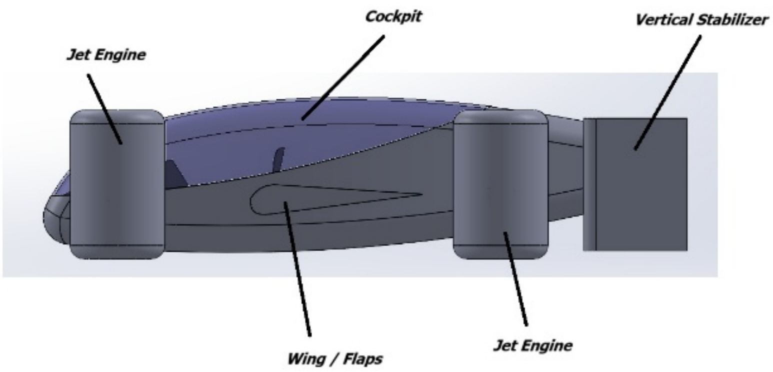

Fig. 2. Flying vehicle flap design with jet engine integration

In this research, the flying vehicle is driven by four jet engines integrated with an optimized wing and flap configuration. The flap system was specifically designed to improve energy efficiency, aerodynamic performance, and flight endurance [16]. The proposed configuration aims to enhance the flying capability of the vehicle while maintaining lightweight structural characteristics. Figure 3 shows Lifting Configuration of the VTOL Flap Design.

The research process started with the group and analysis of significant data obtained from previous literature and aerodynamic studies. Numerous aerodynamic parameters and nomenclatures were identified and applied throughout the analysis process, including:

- : Weight

- : Thrust
- : Co-efficient of lift
- : Density kg/
- : Drag
- : Lift
- : Drag coefficient
- : Lift co-efficient

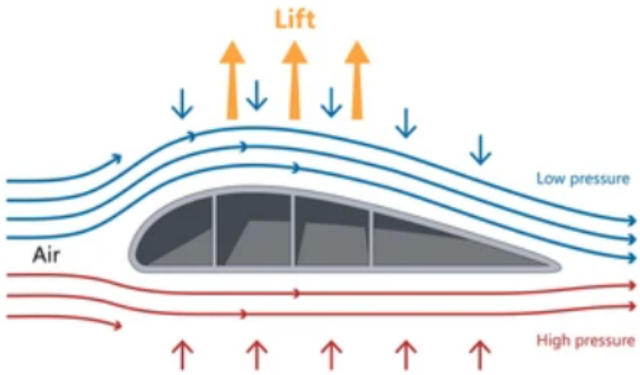

Fig. 3. Lifting configuration of the VTOL flap design

These constraints were used in the aerodynamic calculations and performance simulations of the proposed flying vehicle design.

3. Design Analysis

The design analysis focused on evaluating the aerodynamic performance and energy efficiency of the proposed flying vehicle. The integration of the innovative flap mechanism with the jet engine arrangement was analyzed to control its effect on lift generation, drag reduction, and flight endurance.

It's a result of very specific aerodynamic factors and this formula equation [1] shows exactly how:

$$\text{Lift} = CL \times \tfrac{1}{2} \times \rho \times V^2 \times S \qquad [1]$$

Let's break that down:

- **(Coefficient of Lift):** Depends on angle of attack and wing shape (camber). A higher angle or a more curved wing increases lift, but only to a point.
- **(Air Density):** Thinner air = less lift. High-altitude or hot-day take-offs feel different; density drops, and lift reduces.
- **(Velocity):** Squared, which means speed is the most powerful factor in the whole equation. Double the speed and lift increases four times.
- **(Wing Surface Area):** Bigger wings = more lift, and more drag. Aircraft design is a constant balance.

The aerodynamic study focused on the relationship between thrust, lift, drag, and weight distribution of the flying vehicle. The integration of four jet engines with the flap system was analyzed to determine its influence on flight stability and energy consumption.

The lightweight structural configuration using carbon fibre and aluminum materials contributed to reducing the total aircraft mass while improving take-off and landing performance. The proposed flap design was evaluated to determine its capability in generating additional lift and extending flight duration [12,16].

Constraint diagram simulations were conducted to determine the optimum aircraft performance parameters. In addition, air foil and wing design analyses were performed together with the integration of the jet engine propulsion system.

The proposed flap design was compared with the existing flying vehicle model developed by another company; the comparison focused on flight efficiency, aerodynamic performance, and flight duration improvement [16].

The lightweight structure of the flying vehicle contributed to reduced overall energy consumption while maintaining stability and payload capability. Comparative analysis with the existing teTra Aviation model indicated that the proposed flap configuration provided improved aerodynamic characteristics and enhanced operational efficiency.

4. Results and Discussion

The simulation and comparative analysis demonstrated that the proposed flap design improved the flying vehicle performance significantly. The new flap configuration achieved approximately 36% longer flying time associated to the conventional design.

The optimized wing and air foil design also contributed to better aerodynamic efficiency and reduced energy usage. The results indicate that the proposed concept has strong potential for future lightweight flying vehicle applications, particularly for emergency response operations.

The current stage of the research successfully achieved the conceptual design and preliminary aerodynamic analysis of the proposed flying vehicle. The analysis demonstrated the feasibility of integrating the innovative flap system with the jet engine construction for improved flight efficiency.

The proposed flying vehicle is expected to provide significant benefits for emergency response operations including firefighting, ambulance services, and law enforcement agencies [2,6]. The capability to bypass traffic congestion may improve response time and operational effectiveness during critical situations.

Furthermore, the project has the potential to support the growth of Malaysia’s aerospace technology sector through future flying vehicle development and manufacturing activities. Long-term sustainability plans include the establishment of a dedicated flying vehicle research centre and prototype development facilities.

5. Roadmap and Future Development

The coming progress roadmap of the proposed flying vehicle VTOL project consists of several major phases. The first phase involves the development of the flying vehicle conceptual design and preliminary engineering analysis.

The second phase focuses on prototype development and detailed engineering validation of the flying vehicle system. This phase includes aerodynamic optimization, structural evaluation, and propulsion integration analysis.

The third phase includes feasibility studies and safety testing to ensure the flying vehicle complies with operational and aviation safety requirements. The testing process is essential to evaluate flight steadiness, mechanical integrity, and system reliability.

The simulation verified the reliability of the CFD method/settings against the experimental data of Ref. 44 (Fig. 5); we made a further comparison by referring to the numerical results stated in another journal (Ref. 45 from one of the authors) talking the same airfoil used in this paper (LS (1)-0417) under the very same low-speed condition. Distinct the first one, this latter evaluation is between two numerical models (always at the same). The external flow was set to 20 m/s. The mesh height of the first boundary layer was set to, and other set-ups of mesh and CFD solver were kept equal to those adopted in the replication of 30P30N airfoil. The result between the obtained results and the numerical outcomes of Ref. 45 is. The tendencies of the aerodynamic forces are in good pact with those of Ref. 45 for both take-off and landing; on the other hand, some variances in the magnitude of the forces are evident. These variances are, however, below 5% when in take-off and when in landing. Figure 4 diagrams Numerical outcome from the aerodynamic forces.

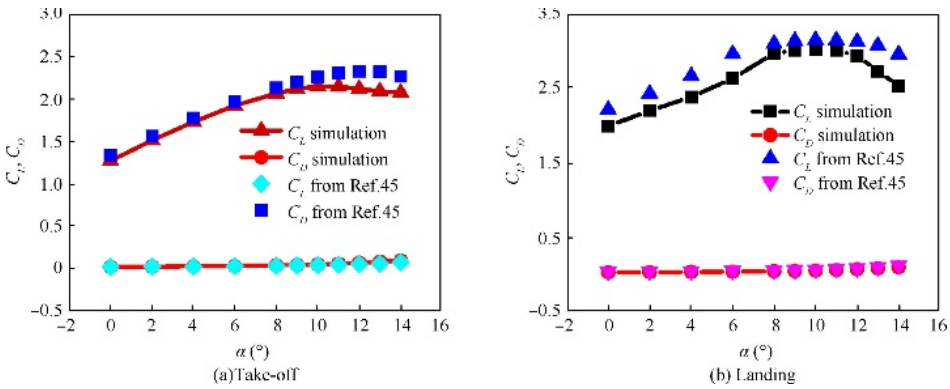

Fig. 4. Numerical outcome from the aerodynamic forces

Subsequently, the flying vehicle will undergo registration procedures with local and international aviation authorities to obtain operational approval and regulatory compliance certification. The final phase involves large-scale manufacturing for both local and export markets. This stage aims to support the commercialization and industrial development of advanced flying vehicle technology in Malaysia. Figure 5 shows VTOL with Flap and jet engine proposed design.

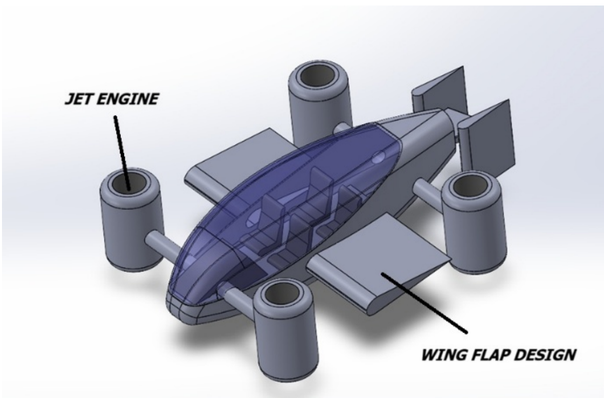

Fig. 5. New design of VTOL with Flap and jet engine

6. Conclusion

In conclusion, this research successfully developed an innovative flap design integrated with a jet engine system for a lightweight flying vehicle. The study demonstrated improvements in energy efficiency, aerodynamic performance, and flight duration.

The proposed design is capable of carrying a payload of up to 478 kg while achieving a maximum speed of 420 km/h. Furthermore, the comparative analysis showed that the new flap design improved flight endurance by 38% compared to existing designs.This innovation has strong potential to support emergency response teams by reducing travel delays caused by traffic congestion. Future studies may focus on advanced aerodynamic optimization and real-flight experimental validation.

The proposed flying vehicle design also demonstrates strong potential for future aerospace and emergency transportation applications in Malaysia. The integration of an innovative flap mechanism with a four-jet-engine configuration contributed to improved aerodynamic efficiency and extended flight endurance.

This research supports sustainable aviation development by promoting lightweight and energy-efficient flying vehicle technology. Future work will focus on prototype development, experimental flight testing, and further aerodynamic optimization.

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