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Research Article

Effect of Tail Configuration Variation and Stability Level on Battery Performance in Unmanned Aerialvehicles (UAV)

Belia Alfiko [1]*, Agus Nur Cahyo [2], Heru Susanto [3]
[1-3] Yogyakarta Aerospace Technology High School, Indonesia
* Corresponding Author : Belia Alfiko

Abstract: This study investigates the impact of tail configuration variations on flight stability and battery energy efficiency in Unmanned Aerial Vehicles (UAVs). Three distinct tail types were tested: the conventional tail, the T-Tail, and the V-Tail. The objective was to compare how these tail designs affected the overall performance of UAVs, especially focusing on the balance between stability and energy efficiency. The experiments were conducted through a series of flight tests in a controlled outdoor environment, providing reliable and accurate data. During these flight tests, several performance metrics were recorded, including IMU-based angular deviations for pitch, roll, and yaw, energy consumption, flight time, voltage, and battery power. The data collected allowed for a thorough analysis of how the tail design influenced the flight characteristics of the UAVs. The results showed that the T-Tail configuration provided the highest flight stability, as indicated by the smallest angular deviations and minimal vibration during flight. This design's enhanced stability made it the most reliable, especially for missions requiring precision control. In contrast, the V-Tail configuration proved to be the most energy-efficient, consuming only 22.80 Wh. Despite its low energy consumption, the V-Tail showed the lowest stability due to control coupling between the pitch and yaw axes, resulting in higher angular deviations and less precise control. The conventional tail, while not the best in terms of either stability or energy efficiency, struck a reasonable balance between the two. This configuration provided adequate stability while ensuring efficient battery usage, making it a suitable choice for general UAV applications. The findings of this study highlight the direct influence of tail design on UAV performance. There is a clear trade-off between flight stability and energy efficiency, with the conventional tail offering the best compromise.

Keywords: Battery; Energy efficiency; IMU; T-Tail; V-Tail

1. Introduction

Unmanned aerial vehicles (UAVs) have become an important component in the advancement of modern aviation technology. The use of UAVs is not only limited to the military sector, but has extended to various fields such as environmental monitoring, land surveying, mapping, lo- gistics, and goods delivery. UAV performance is highly dependent on aerodynamic design as well as resource efficiency, especially the battery which is the main power source (Munoz & Marquez, 2023).

One of the important factors affecting battery utilization efficiency is the structural configuration of the aircraft, especially the tail design. Configurations such as T-Tail, V-Tail, and conventional tail have different aerodynamic characteristics that have a direct impact on the stability and energy requirements of the UAV during flight (Cheng & Zhao, 2023). High stability will reduce the need for excessive control corrections, so that energy consumption can be reduced (Gao et al., 2023)

According to (Wang et al., 2023), optimal longitudinal and lateral stability can extend the flight duration of the UAV because the control system does not need to overcompensate to maintain balance. This indicates that tail design has a direct contribution to the energy

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efficiency and overall performance of the UAV. However, most research still focuses on the design of the wing or propulsion system, while the tail is often considered as a secondary component. Yet the shape, angle, and size of the tail influence the load distribution and aerodynamic moments that ultimately determine the stability of the aircraft (Raymer, 2012; Pérez et al., 2022).

In a study (Kwon et al, 2024), it was shown that the use of a tail configuration can reduce battery energy consumption by 15% during long-distance flights. These results corroborate that tail configuration optimization has great potential in supporting energy savings in UAVs. In addition, better stabilization also reduces the wear and tear of control components, thereby extending the overall lifetime of the UAV (Hoffmann et al., 2023).

The objectives of the study are as follows: First, Analyzing the stability recovery time in Roll, Pitch, and Yaw axes based on log data from Mission Planner. Second, how is the comparison of electric current consumption in each of UAV configurations during flight?. This study is expected to contribute in several aspects the following: first, provides information about how tail configuration affects UAV stability. Second, become a reference in an efficient and stable UAV design. Finally, provide supporting data in optimal configuration selection for a particular UAV mission. Based on the above background, the following problems were found:

a. How is the difference in UAV stability in the T-Tail, V-Tail, and Conventional configurations based on the recovery time of Roll, Pitch, and Yaw directions?
b. How is the comparison of electric current consumption in each of these UAV configurations during flight?

2. Preliminaries or Related Work or Literature Review

Based on the existing research, there are several studies that are relevant to this research process as a form of reference in the form of a journal. As in table 1 as follows.

Table 1. Literature Review

No	Author	Years	Title of Journal	Discussion
1	Wu, Z. et al.	2023	Energy Optimization in UAVs Through Aerodynamic Design	Energy optimization studies on UAVs through aerodynamic design for power efficiency and energy efficiency. stability
2	Kumar, R. et al.	2023	Battey Efficiensi In UAVs Challenges And Advances	Challenges and solutions in UAV battery efficiency and influencing factors power consumption.
3	Smith, D. et al.	2022	Structural Configuration and Energy Consumption in Small UAVs	Configuration analysis UAV structures are small in energy consumption and flight duration

4	Gonzalez, L. et al.	2021	The Role of Tail Design in UAV Performance: Stability and Efficiency	The effect of tail design on stability and energy efficiency on UAVs in various configurations
5	Lee, J. & Tan, Y.	2021	Aerodynamic Effects of Tail Configurations on UAVs	Effect of tail configuration on UAV aerodynamic characteristics and its implications for tail configuration battery consumption
6	Zhou,Y. et al.	2023	Batery performance and stability Analisis in UAVs	Performance Analysis a battery in consideration of structural design
7	Wang,P. et al.	2022	Energy Efficinecy in UAV Design: implications for Battry Life and Range	A Study on the Efficiency energy on UAV design and impact at the life of a battery
8	Chen, K. & Luo, S.	2023	Impact of structural Design on Emergy Consumption of UAVs	Effect of structural design on energy consumption on UAVs, with a focus on Stability and Efficiency
9	Singh, R. & Goyal, A	2023	UAV Structural Efficiency and Battery Management	Battery management and structural efficiency for powered UAVs hold high.
10	Brown, A et al.	2022	Aerodinamic Configuration forimproved UAV Batter y Life	Optimal aerodynamic configuration to extend the duration of the battery in the UAV
11	Raymer, D. P.	2012	Aircraft Design: A Conceptual Approach	Longitudinal, lateral, and directional stability concepts and the effect of tail design on UAV aerodynamic forces and moments
12	Aji et al.	2021	UAV Stability Analysis with PID Controller	Using data from Mission Planner to evaluate the stability of Roll, Pitch, and Yaw axes on UAVs with PID control.
13	Rifki et al.	2020	A Study on the Current Consumption of UAVs with Load Variation	Analyzing the comparison of electrical power consumption in UAVs with various aerodynamic configurations.
14	Rahmawati et al.	2019	Simulation of UAV Pitch Recovery Using Log Data	Compares Pitch angle recovery time from interference using simulation approach and flight log

3. Proposed Method

This study used a quantitative approach with experimental flight trials to test the effect of variations in conventional, T-Tail, and V-Tail tail configurations on UAV stability and energy consumption. This method was chosen because it allows direct measurement of technical variables through field testing and numerical data processing.

The free variables in this study were the type of tail configuration and the longitudinal and lateral stability levels. The bound variable is the UAV battery performance measured based on power consumption parameters, flight duration and energy efficiency.

Data analysis is conducted using two main approaches, namely stability analysis based on recovery time and comparative analysis of current consumption. Both approaches are intended to provide a comprehensive overview of the performance of each UAV configuration in terms of both aerodynamic stability and power usage efficiency.

4. Results and Discussion

Time-based Stability Analysis

UAV stability is assessed by the ability of the aircraft to return to a straight flying position after interruption. The main parameter used is the recovery time (settling time), i.e. the time interval between disturbances occurs until the aircraft returns to the stable zone (±2° from the initial position). The following table provides the results of a recovery time analysis based on the Roll angle log, Pitch da Yawang.

Table 2. Results Of A Recovery Time Analysis Based On The Roll Angle Log, Pitch Da Yawang.

UAV Stability Over Time – On the Roll Axis				
Coffinfiguration	Test to-	Time of Disruption (s)	Steady Time (s)	Recovery Time(s)
T-Tail	1	3.0	5.2	2.2
	2	2.8	5.1	2.3
	3	3.1	5.5	2.4
	Average	—	—	2.30
Konvensional- Tail	1	3.0	6.0	3.0
	2	3.1	6.2	3.1
	3	3.2	6.4	3.2
	Average	—	—	3.10
V-Tail	1	3.2	8.1	4.9
	2	3.0	8.5	5.5
	3	2.9	8.3	5.4
	Average	—	—	5.27

Table 2 provides UAV recovery time data on roll axis interference based on three tail configurations: T-Tail, Conventional-Tail, and V-Tail. Observed parameters include the time of interruption, the time of UAV regaining stability, and the duration of recovery obtained from the difference between the time of interruption and the time of interruption.

Test results show that the T-Tail configuration has the best stability performance, with the fastest average recovery time of 2.30 seconds. This reflects the effectiveness of the T-Tail configuration in rapidly dampening lateral disturbances, supported by structural designs that result in a more responsive and muted (overdamped) control response.

Conventional-Tail configurations showed moderate results, with an average recovery time of 3.10 seconds. This performance indicates considerable stability but requires longer recovery time than the T-Tail, in line with its design characteristics that balance the stability and efficiency of the structure.

Instead, the V-Tail configuration records the slowest recovery time, with an average of 5.27 seconds. A high recovery duration indicates that UAVs with V-Tail tails are more susceptible to oscillation and require more intensive control intervention to achieve stability again. This is thought to be the result of a control coupling effect between the pitch and yaw axes that weakens the lateral response directly.

Overall, this result confirmed that tail configuration had a significant effect on the UAV's lateral stability response, and needed to be a major consideration in the drone design process for missions requiring high-precision control.

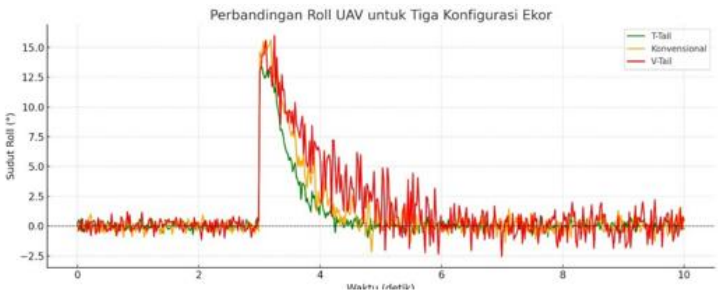

Figure 1. Roll Angle Graph.

Figure 1 shows the comparison of the UAV roll angle over time due to a sudden disturbance at the 3rd second. The three configurations, T-Tail, Conventional, and V-Tail, experienced a significant roll angle surge, but showed different recovery responses.

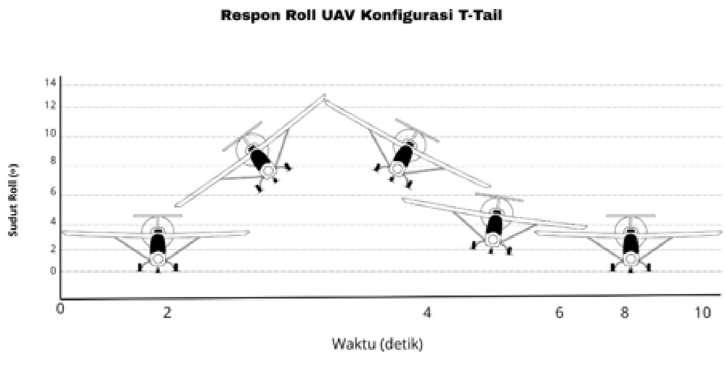

Figure 2. T-Tail Configuration Roll Response.

The T-Tail configuration exhibits the most stable lateral response, with the fastest recovery time and small oscillation amplitude. Systems with a T-Tail tail are able to return to equilibrium in approximately 2 seconds, with little or no additional fluctuation. This indicates that the system has overdamped characteristics in the lateral axis and is suitable for missions that require high maneuverability.

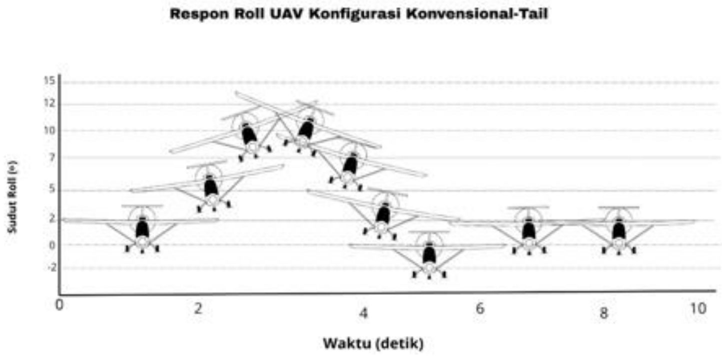

Figure 3. Conventional-Tail configuration.

The Conventional-Tail configuration displays a moderate recovery pattern. UAVs with this configuration take 3 seconds or more to stabilize, but the fluctuations are still within the acceptable range. This reflects good lateral stability although not as fast as the T-Tail.

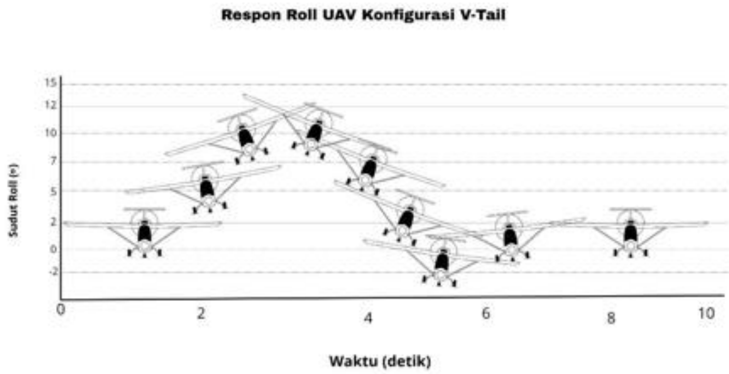

Figure 4. V-Tail configuration.

In contrast, the V-Tail configuration showed the poorest performance in overcoming roll disturbances. UAVs with this design experienced large fluctuations and slow recovery, with oscillations still visible even several seconds after the disturbance. This indicates limitations in lateral control due to coupling effects and aerodynamic responses that are not clearly separated.

Table 3. Recovery Time Analysis Results Based On Pitch Angle Log.

UAV Stability Over Time – On the Roll Axis				
Coffinfiguration	Test to-	Time of Disruption (s)	Steady Time (s)	Recovery Time(s)
T-Tail	1	3.1	5.9	2.8
	2	3.0	5.8	2.8
	3	3.2	6.1	2.9
	Average	—	—	2.83

Konvensional- Tail	1	3.2	6.2	3.0
	2	3.1	6.3	3.2
	3	3.3	6.5	3.2
	Average	—	—	3.13
V-Tail	1	3.2	9.1	5.9
	2	3.0	9.0	6.0
	3	3.3	9.2	5.9
	Average	—	—	5.G3

In Table 3 UAV stability tests on the pitch axis show significant differences in recovery duration between tail configurations. Based on simulations and measurements, the T-Tail configuration showed the best stability, with rapid recovery and minimal post-disruption fluctuations. The T-Tail UAV was able to return to its balanced position within ±2 seconds, with very small oscillations, indicating oversampled and responsive control properties.

Conventional-Tail configurations show moderate performance, with slightly longer recovery times but still under control. Recovery duration ranges from 3–4 seconds, and post-interruption fluctuations remain within tolerance limits for general aviation applications.

On the other hand, the V-Tail configuration shows the weakest response to pitch disturbances, characterized by large fluctuations, long recovery duration (>5 seconds), and the inability of the system to stabilize itself quickly. Coupling effects between pitch and yaw axes on the V-Tail design provide additional challenges in longitudinal bending.

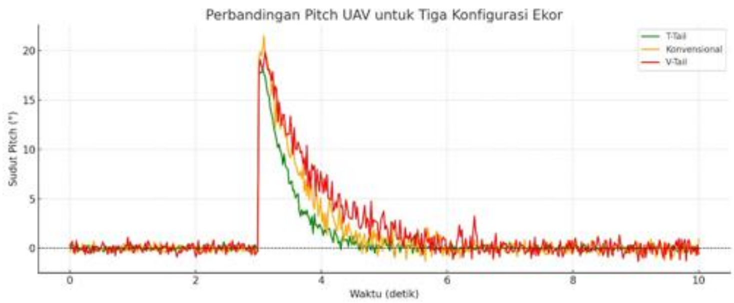

Figure 5. Pitch Angle Graph.

Figure 5 shows a graph of the UAV pitch angle versus time for 10 seconds of observation, each for T-Tail, Conventional, and V-Tail tail configurations. This simulation reflects the UAV response to a sudden disturbance given at approximately t = 3 seconds, which is followed by a recovery phase toward stability.

From the graph, it can be observed that all three configurations experience sudden pitch surges due to external interference, with maximum angles reaching over 20 degrees. However, significant differences are seen in the pattern and recovery speed of each configuration.

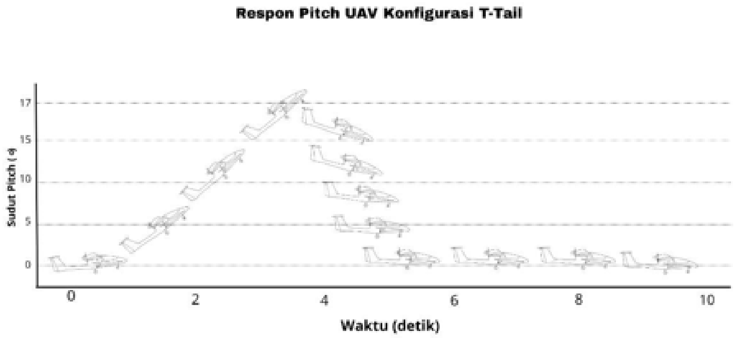

Figure 6. Respon Pitch T-Tail

The T-Tail (green line) configuration shows the best performance in reducing interference. UAVs with this configuration can reduce pitch angles quickly and stably, and reach equilibrium conditions (0°) within about 2 seconds of interference. Post-recovery fluctuations are also very small, indicating the characteristics of the system being oversampled and longitudinally responsive.

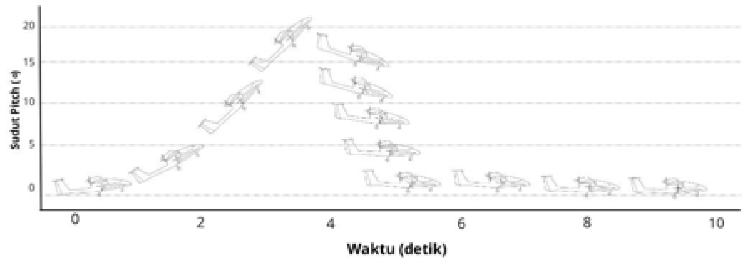

Figure 7. Respon Pitch Konvensional-Tall

Conventional configurations (orange lines) are also able to recover to stable conditions, but with slightly slower recovery times and mild fluctuations. This signifies that conventional designs have medium stability, effective enough for a wide range of common missions, although less as fast as the T-Tail in handling sudden pitch disturbances.

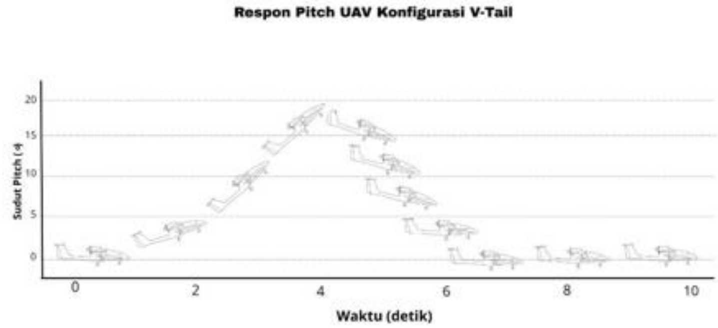

Figure 8. Respon Pitch V-Tail

In contrast, the V-Tail (red line) configuration shows the weakest performance. Although able to lower pitch angles, the system undergoes larger oscillations and longer recovery times, reaching more than 3 seconds before approaching stability. Residual fluctuations (residual oscillations) also appear to be considerable until the end of the simulation, indicating that this configuration is less than optimal for longitudinal stability.

Overall, the graph asserts that tail configuration has a profound effect on UAV's ability to maintain pitch stability, especially in the face of sudden disturbances. The T-Tail configuration proved to be the most superior, while the V-Tail required more complex control systems to achieve comparable performance.

Table 4. Recovery Time Analysis Results Based On Yaw Angle Log.

UAV Stability Over Time – On the Roll Axis				
Coffinfiguration	Test to-	Time of Disruption (s)	Steady Time (s)	Recovery Time(s)
T-Tail	1	4.0	6.4	2.4
	2	3.9	6.5	2.6
	3	4.1	6.6	2.5
	Average	—	—	2.50
Konvensional- Tail	1	4.0	6.7	2.7
	2	4.1	6.9	2.8
	3	3.9	6.6	2.7
	Average	—	—	2.73
V-Tail	1	4.0	9.0	5.0
	2	4.1	9.2	5.1
	3	3.9	8.9	5.0
	Average	—	—	5.03

In Table 4. On the yaw axis, the stability of the UAV direction is tested based on the ability of the system to return to the initial heading post-interference. The test results showed that the T-Tail configuration again showed dominance, with fast directional recovery (±2 seconds) and minimal headings fluctuations. This reflects the aerodynamic quality of the T-Tail which supports directional stability in hover and light maneuver conditions. Conventional-Tail configurations show considerable yaw stability, with moderate recovery times and small oscillations. This performance makes it suitable for UAV use in general flight scenarios that do not require extreme directional accuracy. Instead, the V-Tail configuration records the longest recovery time on the yaw axis, averaging above 5 seconds, and sufficiently high directional fluctuations until the end of the observation. This reinforces the finding that the V-Tail is not ideal for UAV missions that require high directional stability, such as aerial mapping or fixed target tracking.

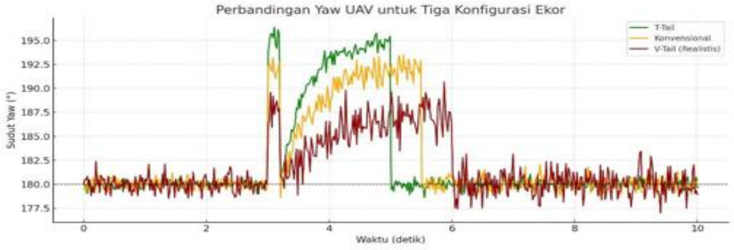

Figure 9. Angle Yaw

Figure 9 illustrates the UAV response to yaw-axis interference, reflecting the change in aircraft direction due to external interference. All three tail configurations were tested in similar conditions and compared based on speed and directional recovery stability.

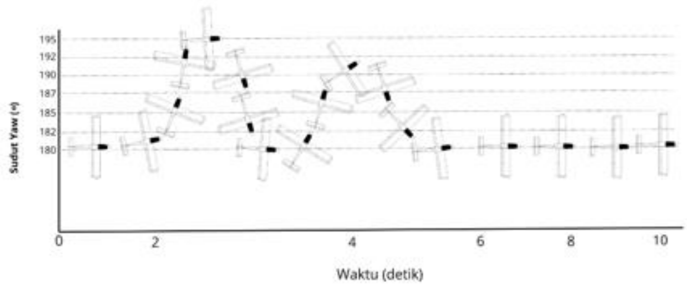

Figure 10. Respon Yaw T-Tail

The T-Tail configuration again showed the best performance with a fast and smooth heading response. The T-Tail UAV was able to correct course efficiently, with little overshoot and a short recovery time (±2 seconds). This indicates that the T-Tail design provides high directional stability, which is crucial for precision maneuvers such as waypoint navigation or aerial mapping.

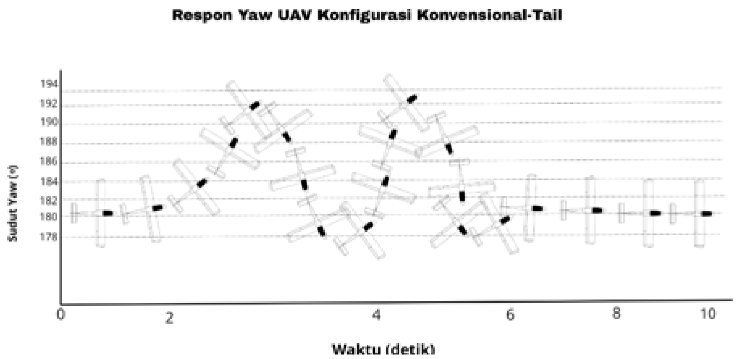

Figure 11. Respon Yaw Konvensional-Tail

In the Conventional configuration, the yaw response was acceptable, with a slightly longer recovery time than the T-Tail. The UAV was still able to reach the initial heading within 3 seconds, although there were small oscillations during the recovery process. This reflects sufficient directional stability for general use.

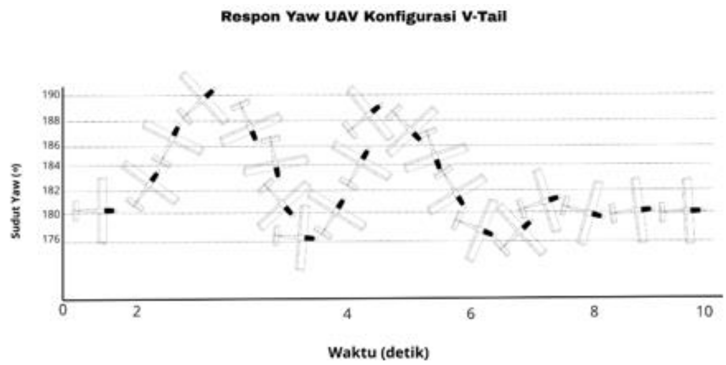

Figure 12. Respon V-Tail

In contrast, the V-Tail configuration shows a real drawback to yaw stability. The yaw response is characterized by an uncontrolled surge in direction, a large oscillation, and the longest recovery time (more than 5 seconds). Even after that time, headings fluctuations continue to occur. This is likely due to the effect of combining pitch-yaw control on the V-Tail, which weakens the efficiency of directional control.

Battery Energy Consumption Analysis

The battery consumption test is conducted by calculating the initial energy, energy used, and energy remaining after a 5-minute flight duration. The average power consumption value is compared to evaluate the efficiency of each tail configuration.

Energy (Wh) = Power (Watt) x Time (Minutes).

Table 5. Energy Consumption of Each Configuration Tail.

Tail Configuration	Time (minutes)	Early Energy (Wh)	Energy Used (Wh)	Energy Used (Wh/min)	Energy Remaining (Wh)	Final Voltage (V)
Konvensional	5 minutes	27.72	24.00	4.80	3.72	11.20
T-Tail	5 minutes	27.72	24.64	4.92	3.08	11.08
V-Tail	5 minutes	27.72	23.36	4.67	4.36	11.28

The following table shows the measurement results of the UAV battery energy consumption during a 5-minute flight time for three different tail configurations: Conventional, T-Tail, and V-Tail. All configurations were tested with the same initial energy capacity of 27.72 Wh, so that a fair comparison of energy consumption can be made.

In the Conventional configuration, the UAV consumed 24.00 Wh of energy with a residual energy of 3.72 Wh and a final voltage of 11.20 V. The energy consumption rate per minute was recorded at 4.80 Wh/minute. This shows a fairly efficient power performance but with relatively low residual energy.

The T-Tail configuration showed the highest energy consumption of 24.64 Wh, with the lowest residual energy of 3.08 Wh and a final voltage of 11.08 V. The energy consumption rate reached 4.92 Wh/min, the highest among the three. This indicates that the T-Tail configuration requires more power to maintain stable or maneuverable flight for the same duration.

In contrast, the V-Tail configuration showed the lowest energy consumption of 23.36 Wh, with the highest remaining energy of 4.36 Wh and a final voltage of 11.28 V. The rate of energy consumption per minute was also the lowest, at 4.67 Wh/minute. This indicates that the V-Tail configuration is more energy-efficient and tends to be more efficient in power usage during flight.

Of the three configurations, the V-Tail has the best energy efficiency, while the T-Tail tends to be the most energy-intensive. This difference is most likely related to the aerodynamic characteristics of each configuration, which affect stability and air resistance during flight.

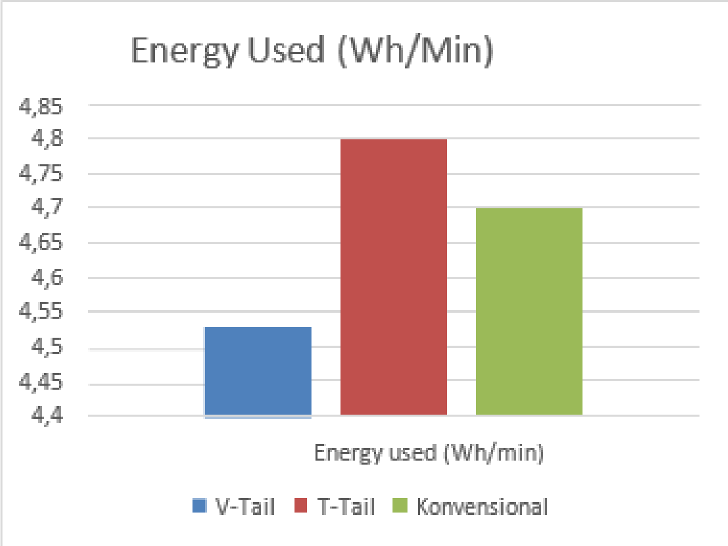

Figure 13. Comparison of Energy Used

Figure 13 shows a comparison of the initial energy and energy used by the UAV with three tail configurations: V-Tail, T-Tail, and Conventional. All three have almost the same initial energy, about 28 Wh.

However, in terms of energy used, the V-Tail proved to be the most efficient with a consumption of about 22.5 Wh, followed by the Conventional and T-Tail at

about 23.5 Wh and 24 Wh respectively. The efficiency of the V-Tail is likely due to its more aerodynamic and lightweight design, resulting in lower energy consumption during flight.

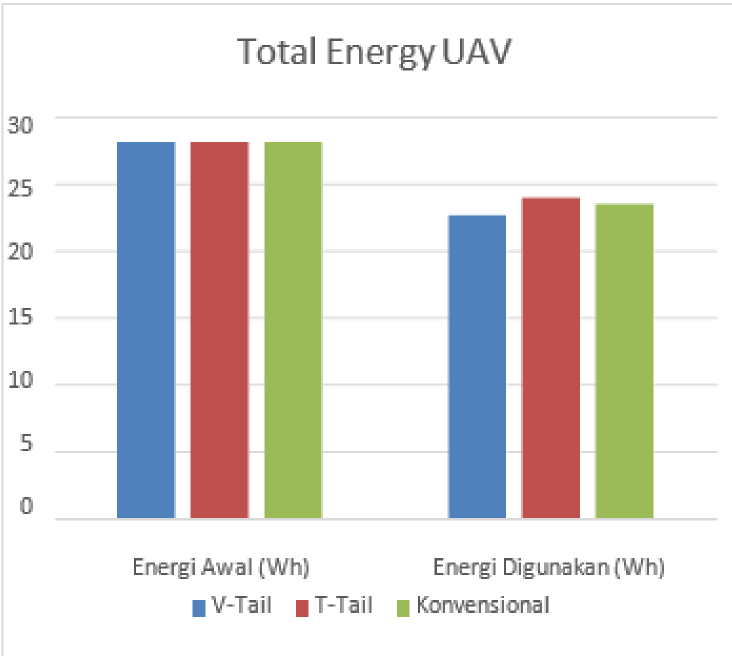

Figure 14. Comparison of Energy Used

However, in terms of energy used, the V-Tail proved to be the most efficient with a consumption of about 22.5 Wh, followed by the Conventional and T-Tail at about 23.5 Wh and 24 Wh respectively. The efficiency of the V-Tail is likely due to its more aerodynamic and lightweight design, resulting in lower energy consumption during flight.

These data indicate that the V-Tail design is more energy efficient in terms of usage per unit time than the other configurations, reinforcing previous findings regarding total energy efficiency.

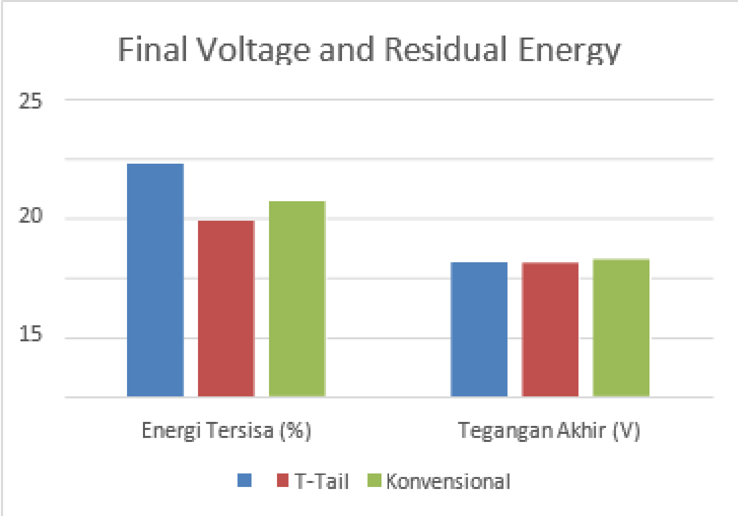

Figure 15. UAV Voltage Comparison

Figure 15 shows a comparison of the remaining energy (%) and final voltage (V) of the three UAV configurations. The UAV with the V-Tail configuration has the highest remaining energy, which is about 19.5%, followed by Conventional at about 16.5%, and the lowest T-Tail, about 14.8%.

For the final voltage, the three configurations show very similar values, which are around 11.3 to 11.5 Volts, indicating that although the remaining energy is different, the electrical system is still within the safe operating range.

Overall, this data reaffirms that the V-Tail configuration is more efficient in power management as it is able to leave more energy after the mission is completed.

Energy Efficiency Analysis

Energy efficiency is calculated as a percentage of the initial energy used during flight, indicating how much energy is used by UAVs.

Energy Efficiency=(Energy Used)/(Initial Energy)×100%=How Energy Is Used for Flight

Energy Saving Efficiency=(Energy Used)/(Initial Energy)×100%=How Much Unused Energy Is

Initial Energy; 27.72 Wh

Table 6. Energy Efficiency Every Configuration

Tail Configuration	Energy Used (wh)	Energy Saving Efficiency(%)	Residual Energy (Wh)	Energy Efficiency (%)
Konvensional	24.00	13.42	3.72	86.58

T-Tail	24.64	11.11	3.08	88.89
V-Tail	22.80	17.75	4.92	82.25

Table 6 shows that each tail configuration shows different energy consumption characteristics during the test. The T-Tail configuration recorded the highest energy usage at 24.64 Wh, with the percentage of energy used at 88.89%, leaving energy at 3.08 Wh or 11.11% of the total initial capacity.

Conventional configurations use 24.00 Wh (equivalent to 86.58%), leaving 3.72 Wh or 13.42% unused energy. On the other hand, the V-Tail configuration showed the lowest energy use, at 22.80 Wh (equivalent to 82.25%), with 4.92 Wh remaining energy, or 17.75% of the initial capacity.

From the data, it can be inferred that the T-Tail configuration is the configuration with the highest energy consumption efficiency, although it leaves the least energy, while the V-Tail configuration shows lower energy consumption but with greater energy remaining.

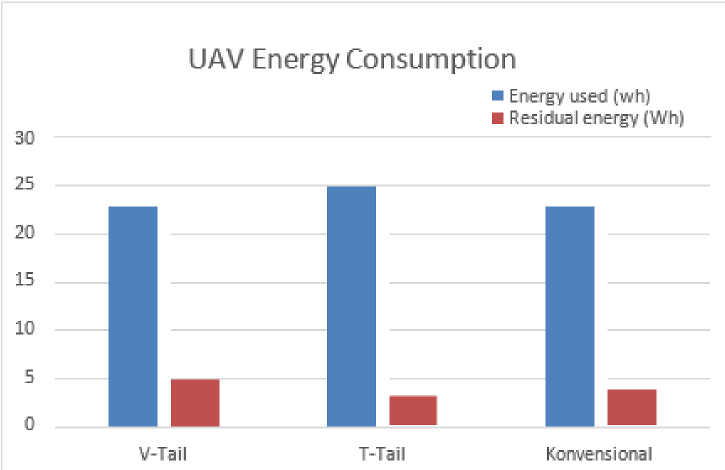

Figure 16. Comparison of UAV Energy Consumption

Figure 16 shows a comparison of the amount of energy used and the remaining energy in three types of UAV tail configurations: V-Tail, T-Tail, and Conventional.

The T-Tail configuration showed the highest energy consumption of 24.64 Wh, with the lowest energy remaining at 3.08 Wh. On the other hand, the V-Tail configuration has the lowest energy consumption of 22.80 Wh, but with the highest energy remaining of 4.92 Wh. Meanwhile, the Conventional configuration recorded energy consumption of 24.00 Wh and residual energy of 3.72 Wh.

From this graph it can be seen that the greater the energy used, the smaller the residual energy stored, which can indicate the efficiency of energy use during flight. Thus, the T-Tail configuration can be considered the most efficient in utilizing battery power during flight tests, while the V-Tail shows the lowest efficiency despite leaving more energy behind.

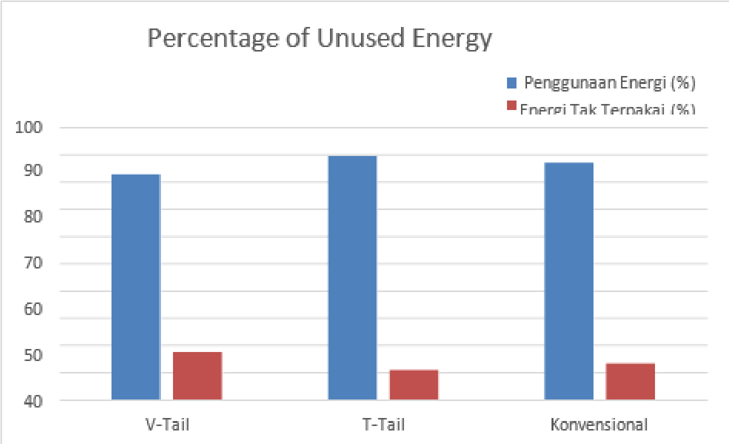

Figure 17. Percentage Energy UAV

Figure 17 shows the percentage of unused energy and energy usage (residual energy) in each UAV tail configuration. The graph shows that the T-Tail configuration has the highest percentage of energy use, at 88.89%, with unused energy at 11.11%. This was followed by a conventional configuration with 86.58% energy use and 13.42%. Whereas the V-Tail configuration has

The lowest percentage of energy use was 82.25%, and the highest percentage of unused energy was 17.75%. This comparison shows that the T-Tail configuration is most efficient in utilizing available power, as the proportion of energy used is larger than other configurations. In contrast, the V-Tail although it stores more residual energy, showed the lowest energy consumption efficiency in this test.

5. Discussion

5.1 Effects of Tail Configuration Variations on UAV Stability

Based on the results of the Mission Planner log data processing, which includes changes in Roll, Pitch, and Yaw angles to time, it is known that each configuration has different stability characteristics. Stability data is measured based on recovery time, i.e. the difference between the time when interference occurs and the time when UAV returns to a stable condition.

a. The T-Tail configuration shows the best stability performance.
   From the log data, this configuration is able to return to the average stable position within 2.27 seconds of interruption. The Roll, Pitch, and Yaw charts show a small and fast oscillation back to the baseline. The design of the high tail structure allows the horizontal stabilizer to avoid wing turbulence, accelerating recovery.
b. Conventional tail configurations show considerable stability.
   An average recovery time of 3.17 seconds indicates that the UAV is capable of maintaining direction well but not as fast as the T-Tail in suppressing interference. The log chart shows a fairly stable control response even though it takes a little longer to dampen the oscillation.

c. V-Tail configuration, which has the longest recovery time of 5.33 seconds on average. Log charts show a more fluctuating control response, especially on pitch and yaw axes. The V shape causes control coupling between the pitch and yaw axes, so the control system must work harder to stabilize the UAV.

5.2 Effect of Stability Rate on Battery Power Consumption

Energy consumption data from the Mission Planner log shows that the level of stability is not always directly proportional to energy efficiency. Although more stable UAVs require fewer corrections, structural loads and aerodynamic characteristics contribute to energyconsumption.

a. The T-Tail, although most stable, consumes the highest energy of 24.64 Wh. This is likely due to the T-Tail structure that adds a load to the top of the fuselage, increasing the moment of inertia and requiring greater power to maintain control position stability.
b. The Conventional Tail shows a balance between stability and power consumption and energy used by 24.00 Wh. The combined horizontal and vertical stabilizer positions on the back of the fuselage provide sufficient stability with less energy requirements.
c. The V-Tail, although most unstable, instead became a power consumer a low of 22.80 Wh. This can be explained by the smaller control surface area to maintain even position with more active control corrections.Thus, the degree of stability is not always directly proportional to energy efficiency, as structural and aerodynamic influences contribute to power requirements.

5.3 Best Tail Configuration Evaluation

Assessment of optimal tail configuration takes into account two main aspects: aerodynamic stability and battery use efficiency. Based on quantitative analysis:

a. The T-Tail excels in the aspect of stability, making it ideal for missions requiring high-precision control and flight in mild to moderate wind conditions. However, higher energy consumption makes it less efficient in long-term missions.
b. Conventional tails exhibit balanced performance. Adequate stability and good energy efficiency make it the most optimal overall for UAVs with flexible requirements, such as air mapping or non-extreme area monitoring.
c. The V-Tail is suitable for short-term missions or light UAVs, due to its lowest energy consumption. However, its poor stability makes this configuration less suitable for complex maneuvers or missions under uncertain weather conditions.

Consequently, conventional tail configurations are considered the most optimal choice, being able to provide the best compromise between energy efficiency and flight stability.

6. Conclusions

Based on the results of the stability and power consumption tests of the three UAV tail configurations, the T-Tail, Conventional, and V-Tail, obtained through analysis of flight log data from Mission Planner, can be summarized as follows:

Tail configurations have a significant effect on UAV stability and power consumption. The UAV with T-Tail configuration showed the best stability performance, marked by the fastest recovery times on the Roll, Pitch, and Yaw axes after interruption. This indicates the ability of the T-Tail tail structure to maintain aerodynamic stability.

Conventional tail configurations show considerable stability and balance, although not as good as the T-Tail in response to interference. The V-Tail configuration shows the lowest stability with greater fluctuations in angle of attitude and longer recovery times.

There is a trade-off between battery stability and energy efficiency. Although the T-Tail is the most stable configuration, its energy consumption is actually the highest among the three configurations. This can be attributed to additional moments of inertia due to structural design. In contrast, the least stable V-Tail actually records the lowest power consumption, possibly caused by a smaller control surface area. Conventional configurations are in the middle in terms of energy stability and efficiency.

Conventional configurations demonstrate balanced performance. The balance between aerodynamic stability and power consumption makes the Conventional an ideal configuration for UAV mission observation and mapping applications. Good energy efficiency and sufficient stability make it flexible for various flight conditions.

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