Journal of Aircraft and Spacecraft Technology

Original Research Paper

Preliminary Design and Performance-Stability Analysis of a Fixed-Wing UAV Using XFLR5

Campos Rodriguez Victor Antonio and Su Yan

Department of Civil Aviation Engineering, University of Aeronautics and Astronautics, College of Civil Aviation, China

Article history
Received: 25-11-2023
Revised: 10-12-2023
Accepted: 11-12-2023

Corresponding Authors:
Su Yan; Campos Rodriguez Victor
Department of Civil Aviation Engineering, University of Aeronautics and Astronautics, College of Civil Aviation, China
Email: suyannj@nuaa.edu.cn; camposvictor66@nuaa.edu.cn

Abstract: This research aims to find the best airfoil and tail configuration for the designing of a UAV of 30 kg capable of carrying a payload of at least 5 kg; for this purpose, work focuses on the analysis of different airfoils for low Reynolds numbers in specific do airfoils with an under cambered design and capable of reaching high lift at low altitudes at subsonic speeds, at the same time four different tail configuration of similar sizes are contrasted to each other to find out what configuration gives the best design in terms of performance and stability. XFLR5, specialized software for analyzing airfoils, wings, and planes operating at low Reynolds numbers, is used for all simulations. This study successfully determined the Eppler 216 as the best airfoil along with the conventional tail configuration while providing a valuable methodology for designing future and similar UAVs.

Keywords: UAV, Airfoil, Tail Configuration, XFLR5, Performance and Stability

Introduction

In recent years, the use of Unmanned Aerial Vehicles (UAVs) in military and civilian applications has increased. UAVs with the potential to deliver goods are gaining interest. Indeed, to achieve the same capability as current delivery methods, the UAV must be capable of reaching all types of terrain in a short time. Recent research, such as (Yolcu and Akdağ, 2021; Ashish *et al.*, 2020; Kovanis *et al.*, 2012) test and present conceptual designs of small and light cargo Vertical Take-Off Landing (VTOL) UAVs able to carry payload for civilian purposes. Moreover, (Ashish *et al.*, 2020) designed and described the potential of hybrid power VTOL for emergency delivery, (Finger, 2016) and collected data from 250 VTOL and Conventional Take-Off Landing (CTOL) UAVs for performance comparison (Nugroho *et al.*, 2022) to analyze different Tails configurations for UAVs and (Khadka *et al.*, 2020) presents the benefits of an inverted V-tail for a UAV. The present work concentrated on developing a conceptual design procedure for fixed-wing UAVs with a range of 30 kg MTOW, applying various methodologies and approaches. With the outcome of the current work, it was possible to determine the best conceptual design of a fixed-wing VTOL UAV and tail configurations for stability and performance while providing valuable data for designing similar UAVs in future work.

Design and Analysis

Conceptual Design

With the objective of designing a delivery UAV, it is necessary to emphasize its stability and performance. This is due to its need to fly within urban areas. Table 1 shows the design requirement objectives to be met and Fig. 1 shows the mission profile.

Table 1: Design requirements and objectives

No.	Requirements	Value
1	Stall speed	16 m/s
2	Cruise speed	25 m/s
3	Max speed	30 m/s
4	Payload	5 kg
5	MTOW	30 kg
6	Wingspan	3.4 m
7	Length	2 m

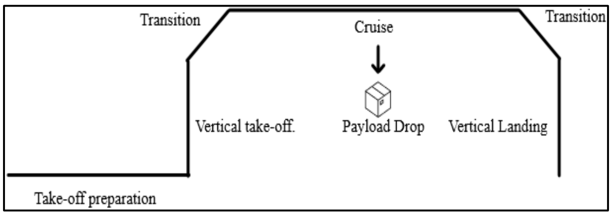


Fig. 1: Flight mission profile

Table 2: Market analysis VTOL UAV

Model	MTOW (kg)	Empty weight (kg)	Empty weight/ MTOW
SKYLANE-250 VTOL	15.0	13.80	0.9200
SKYLANE-350 VTOL	35.0	28.00	0.8000
SKYEYE SIERRA VTOL	12.5	9.50	0.7600
TANGO VTOL	19.0	14.00	0.7370
FOXTECH GREAT SHARK 330 VTOL	20.0	15.00	0.7500
FOXTECH WHALE-360 VTOL	30.0	25.00	0.8330
WINGCOPTER	25.0	20.00	0.8000
YANGDA WHALE	34.0	24.00	0.7060
PENGUIN C MK 2.5 UAS	32.0	27.50	0.8590
YANGDA WHALE Mini	16.5	14.00	0.8480
P330 Pro	14.0	12.00	0.8570
SKIRON-X VTOL	22.2	20.75	0.9350
Average			0.8171

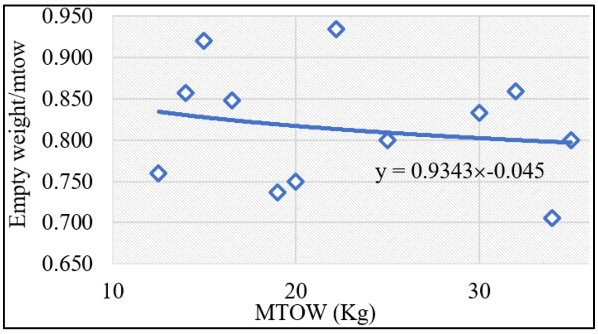


Fig. 2: Maximum take-off weight

Table 3: Reynold's number vs. speed

Speed (m/s)	Reynold's number
$V_{stall} = 16.7$	343,151
$V_{cruise} = 25$	513,699
$V_{max} = 33.3$	684,247

Reynolds numbers play an important role during simulations

Calculation of Maximum Take-Off Weight (MTOW)

MTOW is calculated from statistical data of similar characteristics UAVs in the market and followed by a repetitive weight estimation based on the ratio of empty Weight (We) and maximum take-off Weight (Wo), a procedure stipulated by Finger (2016) study based on Reymer's formula (Raymer *et al*., 1992) to determine the weight ratio of a small UAV, while Finger's study focuses on those UAVs with a maximum take-off weight of 350 kg. However, to obtain more accurate data for UAVs of similar weight and proportions to the desired in this research, it was necessary to develop a new formula based on data collected from different fixed-wing UAVs of similar weight. The result obtained from the statistical study is shown in Fig. 2.

Equations 1-2 are obtained from Fig. 2, Finger's study, and data obtained in Table 2:

$$\frac{w_e}{w_o} = 0.9343x^{-0.045} \quad (1)$$

$$w_o = w_e + w_{payload} \quad (2)$$

Airfoil and Wing Geometry Selection

Reynolds number is an important dimensionless parameter needed to get an idea of how the flow through the wing will behave; the higher the number, the more turbulent it will be. In this research, Reynold's number was calculated using Eq. 3, where ρ denotes the density of air, V the velocity of the air, C the characteristics length, μ dynamic viscosity and v kinematic viscosity:

$$Re = \frac{\rho VC}{\mu} = \frac{Vl}{v} \quad (3)$$

Calculations are done based on standard sea level conditions at 15°C, while other parameters, such as estimated wing chord length are shown below:

$$\rho_0 = 0.00238\left(\frac{Slug}{ft2}\right) or\ 1.225\frac{kg}{m^3} \quad (4)$$

$$\mu = 1.789\times10{-}5\left(\frac{kg}{m} - s\right) \quad v = 1.460\times10{-}5\ m^2/s$$

$$V_{stall} = km/h----16.7m/s V_{cruise} = 90km/h------25m/s$$

$$V_{max} = 120km/h----33.3m/s\ C = 0.3$$

Reynolds numbers are calculated to be around 343×10-3 to 684×10-3, as shown in Table 3, making it in the category of low Reynolds numbers.

Once Reynolds numbers were found, preliminary research of potential airfoils from the UIUC airfoil coordinate database was carried out; around 170 airfoils labeled as for low Reynolds number or high lift airfoils were analyzed as possible options and consequently, only 10 of them were selected for a more detailed comparison based on the amount of lift they can generate, the chosen set of airfoils and its characteristics are shown in Table 4.

Table 4 shows the airfoils that were analyzed and compared in XFLR5, a software specialized in analyzing airfoils, wings, and planes operating at low Reynolds numbers. A 2-D airfoil analysis was carried out within a range of 100×10-3 to 800×10-3, then results for the estimated cruising speed Reynolds number of 500× -3 of each airfoil were compared as shown in Figs. 3-4.

Table 4: List of selected airfoils

	Airfoils	Max thickness (%)	Max camber (%)
1.	Eppler 423	12.5 at 23.7	9.5 at 41.4
2.	Eppler 216	10.4 at 26.2	4.7 at 59.0
3	AH 79-100 B	10 at 30.9	6.4 at 50.0
4.	GOE 447	12.7 at 29.7	8 at 39.7
5.	Selig 1223	12.1 at 19.8	8.1 at 49.0
6.	Selig 1210	12 at 21.4	6.7 at 51.1
7.	Wortmann FX 63-137	13.7 at 30.9	5.8 at 56.5
8.	FX74C15140MOD	14 at 30.9	9.9 at 37.1
9.	DAE-31	11.1 at 29.3	6.7 at 47.0
10.	CH10	12.8 at 30.6	10.2 at 49.3

Airfoil Tools (2023) points and their characteristics are obtained from the aifoiltools.com database

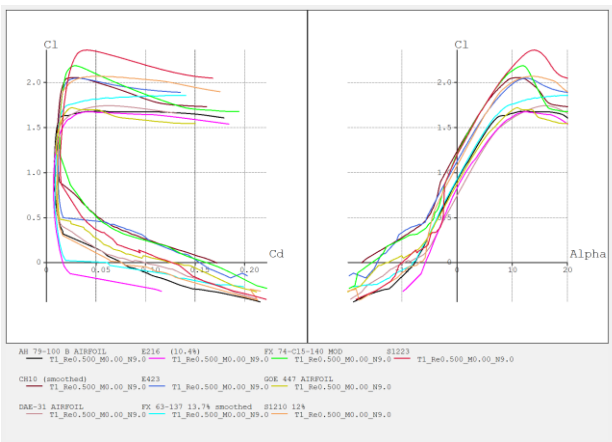


Fig. 3: Lift Coefficient (CL) vs. Drag Coefficient (CD), and CL vs. Angle of attack (alpha)

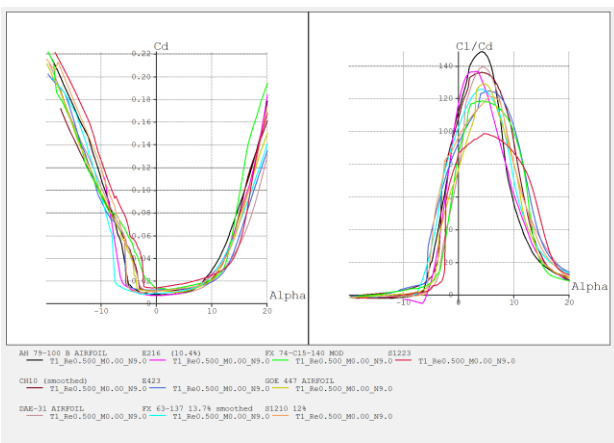


Fig. 4: CD vs. Alpha and lift-to-drag ratio (CL/CD) vs. Alpha

Figures 3-4, we can notice the airfoils with the highest lift coefficient are at the same time those with the lower lift-to-drag ratio (CL/CD), due to their high Drag Coefficient (CD); on the other hand, those airfoils with the higher lift-to-drag ratio are also the ones with the lowest lift coefficient. Based on this, to find out if those airfoils with the higher CL/CD can lift our UAV, Eqs. 5-7 are solved:

$$Lift = \frac{1}{2} CL \rho_0 V^2 A \quad (5)$$

$$CL = \frac{(30\times9.8)2}{1.225\times25^2\times1.02} = 0.75 \quad (6)$$

where, *V* is cruising speed, *A* is wing area and lift is weight times gravity force.

From this, it was determined that for the UAV flight, a minimum *CL* of 0.75 and a lift force of approximately 294 N is necessary; It is concluded the best airfoil for the UAV is the E216 since its high *CL*/*CD* ratio guarantees good performance and is capable to generate the necessary lift force for the UAV while having a low drag coefficient compared to the rest.

Wing Design

The next step was designing the Wing 3D modeling in the software's wing and airfoils design module as follows Fig. 5.

Where wingspan (*B*) is 3.4 m, Chord (*C*) = 0.3 m at tip and root, with offset and dihedral of zero, other parameters such as Aspect ratio, Taper ratio, Wing loading, and MAC were calculated by the software. However, their corresponding formulas are shown below:

$$AR = \frac{b^2}{c} \quad (7)$$

$$\lambda = \frac{c_{tip}}{c_{root}} \quad (8)$$

$$\frac{W}{S} = Wing\ Loading \quad (9)$$

$$M.A.C = C_{root}\frac{2}{3}\left[\frac{1+\lambda+\lambda^2}{1+\lambda}\right] = 0.3\ m \quad (10)$$

Wing Performance and Stability Analysis

Before independently analyzing the E216 airfoil, each airfoil's performance and stability analysis with the same Wing geometry and parameters was performed, as shown in Figs. 6-7.

Both Performance and Stability analyses are done using the Vortex Lattice Method (VLM), which can be divided into two types, the horseshoe Vortex (VLM1) and the ring Vortex (VLM2); both methods give similar results. However, in this research, the VLM 2 will be preferred. Furthermore, both analyses will be carried out under a viscous environment. Performance analysis will be carried out on a type 2 analysis (fixed lift) and stability under a type 1 analysis (fixed speed of 25 m/s).

Figure 6 we can again observe the E216 is the best option for fulfilling our design requirements since it has the highest lift-to-drag ratio and can reach high fly speed.

In the same way, Fig. 7 shows a performed stability analysis confirming that the wing by itself is unstable and hence cannot fly.

DOI: 10.3844/jastsp.2023.8.16

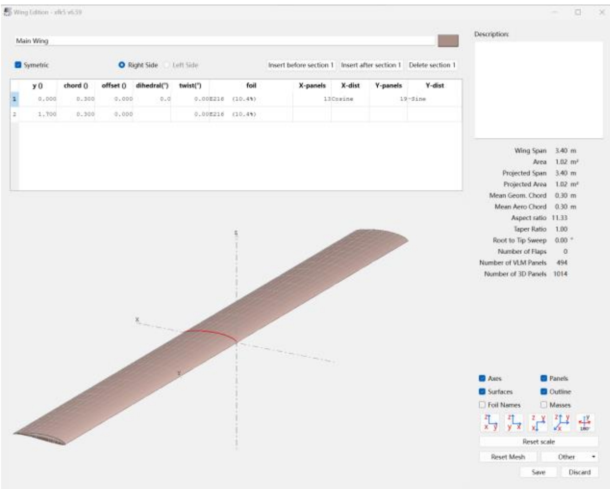


Fig. 5: 3-D Wing model

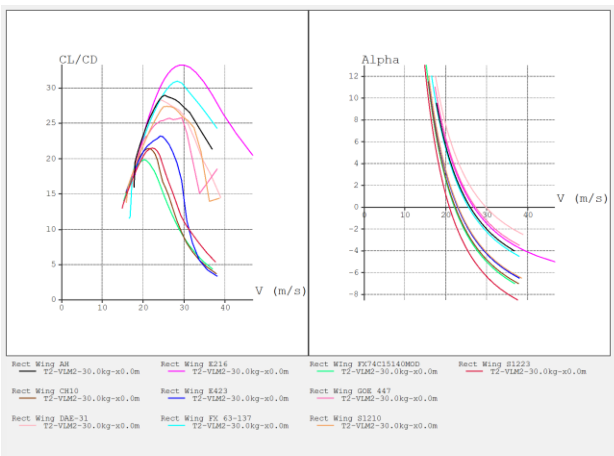


Fig. 6: Performance analysis, CL/CD vs. V and alpha vs. V

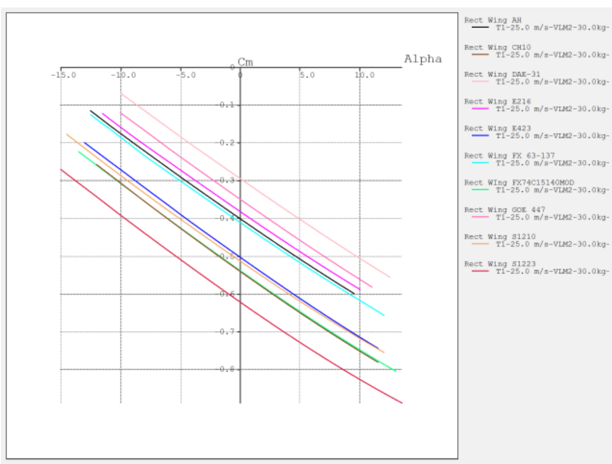


Fig. 7: Stability analysis, pitching moment (Cm) vs. Alpha

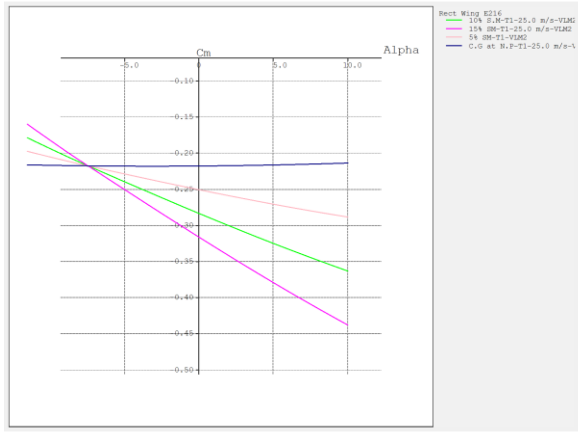


Fig. 8: Static margin analysis, Cm vs. Alpha

Static Margin Calculation

Static Margin (SM) is a fundamental factor for the designing of a stable plane and it helps to determine the position of the Center of Gravity (CG) on the wing. Static margin is the length measured between the center of gravity and the Neutral Point (NP). Typically, most planes have an *SM* of 5-15% Mean Aerodynamic Chord (MAC), which means the CG is 5% MAC to 15% MAC in front of the *NP*, where 5% is limited stability and 15% is great stability. *SM* for the wing was found, as shown in the following formula:

$$S.M = \frac{(X_{np} - X_{cg})}{M.A.C} \quad (11)$$

where:

NP = 0.075 (Blue line)
S.M 5% *C.G* = 0.06 (salmon line)
S.M 10% *C.G* = 0.045 (green line)
S.M 15% *CG* = 0.03 (pink line)

Figure 8, we can observe that at 15% *SM*, the UAV has the greatest stability since, compared to the rest, it is less horizontal or faces more downward; based on this, it is decided to design the whole UAV at 15% *SM*.

Wing Parameters

Tail Parameters

In this part, four different tail configurations of similar geometry dimensions were designed and compared to find the best tail shape for the UAV that can provide the best performance and stability. An iterative analysis to find the most adequate wing-to-tail distances was performed as shown in Tables 6-7 and Fig. 9, where it can be seen how CG and stability are affected by the distance.

From Tables 6-7 and Fig. 9, a wing-to-tail distance of 1.5 m is selected, since we do not want an airplane that needs to pitch a lot to achieve stability. Furthermore, at Alpha below 1, not enough lift force is generated for our aircraft and for Alpha greater than 2, more than enough lift force is obtained, which could also lead to the stability problem.

DOI: 10.3844/jastsp.2023.8.16

Table 5: Wing design parameters

Component	No.	Parameter	
Wing	1.	Airfoil	E216
	2.	Wingspan	3.4 m
	3.	Chord	0.3 m
	4.	M.A.C	0.3 m
	5.	Wing area	1.02 m^2
	6.	Wing load	29.412 kg/m^4
	7.	Aspect ratio	11.333
	8.	N.P	0.075m from L.E
	9.	S.M	15%
	10.	C.G location	0.03m from L.E
	11.	Dihedral	0%
	12.	Incidence	0%

Table 6: Center of gravity to wing-to-tail distance

	Conventional tail			
Wing to tail distance (m)	CG 15% S.M (m)	Inverted-V-tail (m)	Inverted-U-tail (m)	V-tail (m)
1	0.103	0.103	0.106	0.105
1.1	0.112	0.112	0.115	0.114
1.2	0.121	0.121	0.125	0.123
1.3	0.131	0.130	0.134	0.131
1.4	0.140	0.139	0.143	0.140
1.5	0.149	0.147	0.152	0.149
1.6	0.159	0.156	0.161	0.158
1.7	0.167	0.164	0.170	0.167
1.8	0.176	0.173	0.179	0.175
1.9	0.185	0.182	0.188	0.184
2	0.194	0.190	0.196	0.193

Table 7: Stability to wing-to-tail distance

	Conventional Tail			
Wing to tail distance (m)	Alpha at zero Cm (°C)	Inverted-V-tail (°C)	Inverted-U-tail (°C)	V-tail (°C)
1	-6.5	-6.5	-6.5	-6.5
1.1	-4.9	-5.0	-4.7	-5.0
1.2	-3.3	-3.5	-2.9	-3.3
1.3	-1.7	-1.8	-1.3	-1.8
1.4	0.1	-0.2	0.3	0.2
1.5	1.5	1.2	1.8	1.3
1.6	3.2	2.7	3.2	2.8
1.7	4.5	4.0	4.6	4.3
1.8	6.0	5.5	5.9	5.5
1.9	7.4	7.0	7.2	7.0
2	8.8	8.0	8.2	8.4

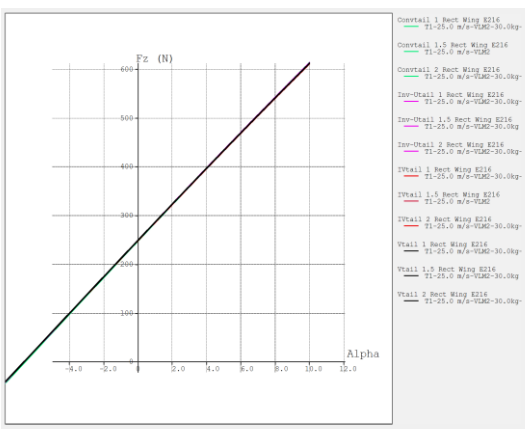
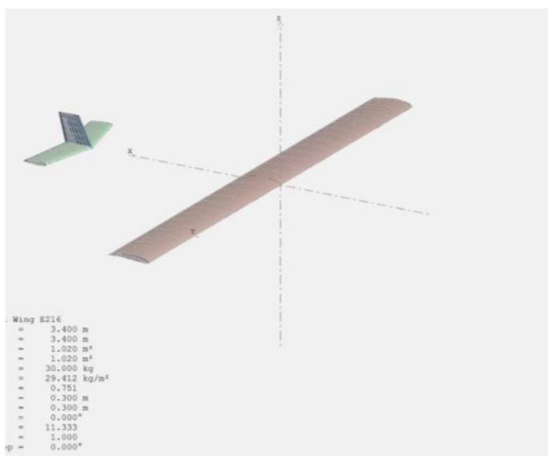
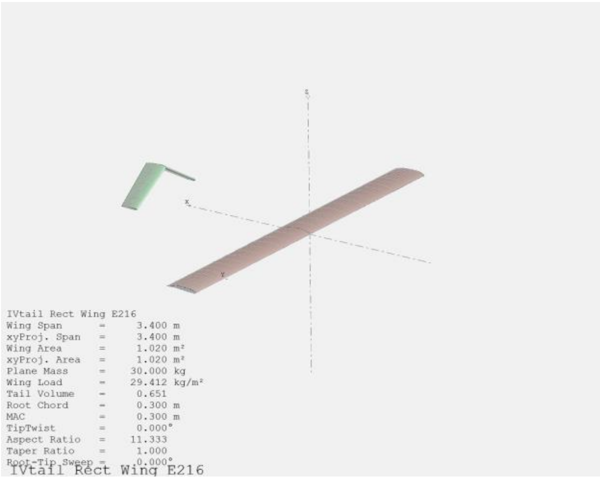


Fig. 9: Lift Force (FZ) to alpha

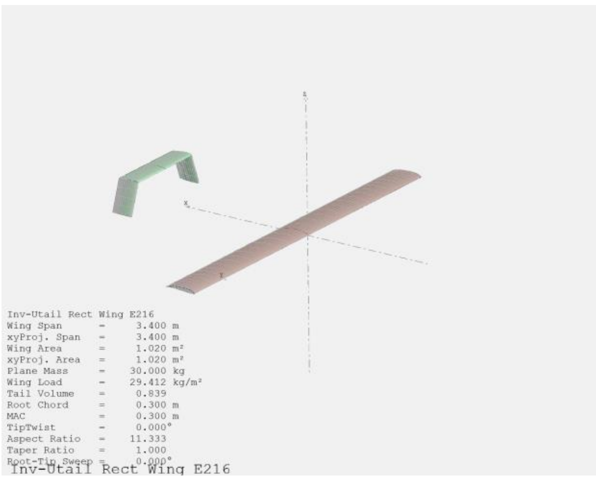


(1)

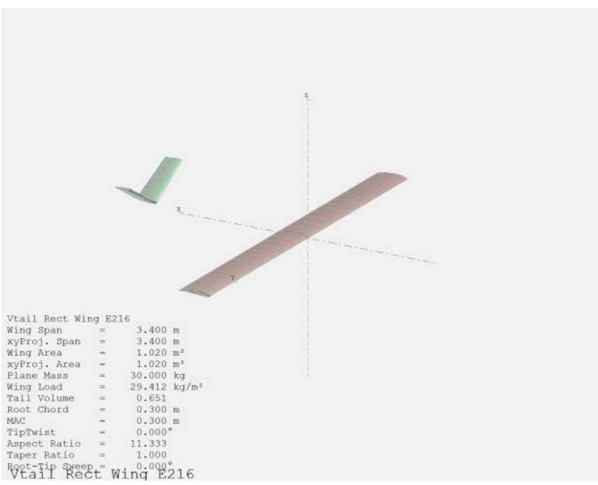
DOI: 10.3844/jastsp.2023.8.16



(2)



(3)



(4)

Fig. 10: (1) Conventional tail; (2) Inverted V-tail; (3) Inverted U-tail; (4) V-tail

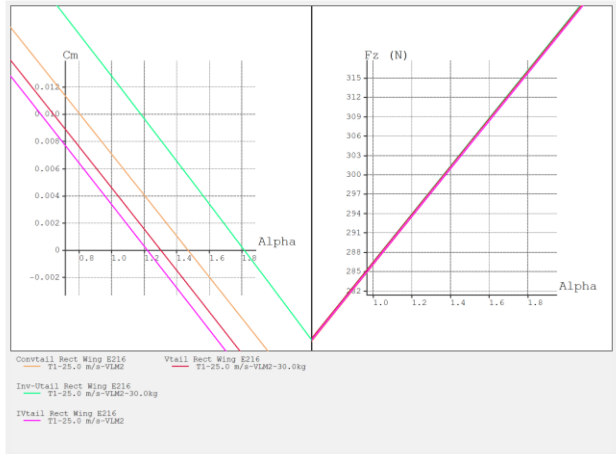


Fig. 11: Stability analysis, Cm vs. Alpha, and FZ vs. Alpha

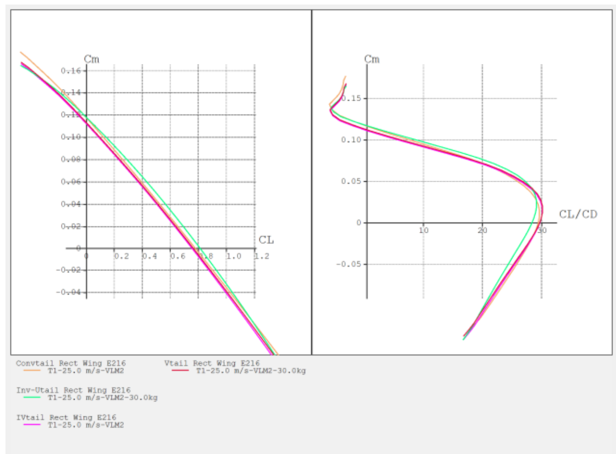


Fig. 12: Stability analysis, Cm vs. CL, and Cm vs. CL/CD

Other parameters of each tail are provided in the following Table 8 and are represented in Fig. 10.

Stability Analysis

This analysis is done using the previous rectangular wing under different tail configurations, Fig.10.

Figure 11 can be observed that when using an inverted V-tail, the highest stability is reached, followed by a V-tail, Conventional tail, and Inverted U-tail as the less stable; this is due to it reaching stability at a higher angle of attack compared to the rest, at the same time reminding that 294 N needs for the UAV to fly, it can be noticed that with the Inverted V-tail and V-tail configurations, we can barely reach the necessary force, this since according to cm vs. alpha, both configuration reach stability at around 1.2 angle of attack, at this angle, the plane will be generating exactly 295 N, on the other hand, the other shapes conventional and inverted U-tail are stable at 1.4 and 1.6 angle of attack, reaching 303 N and 316 N correspondingly.

DOI: 10.3844/jastsp.2023.8.16

Figure 12, Cm vs. CL graphs show the lift coefficient reaching stable mode, again the inverted U-tail configuration, which provides us with the higher values and near followed by the rest.

At Cm vs. CL/CD analysis, it is found that V-tail and inverted V-tail configurations provide the higher lift-to-drag ratio followed by conventional configuration and inverted U-tail configuration.

Performance Analysis

In the performance analysis, we have four different graphs. Figures 13-14, The first one is the Vz vs. V (sinking speed vs. flying speed) graph, in which it can be observed that the conventional tail configuration has a sinking speed ≈ of 1 m/s at ≈17.4 m/s. In contrast, the other 3 have a sinking speed ≈ of 1.2 m/s at ≈17.6 m/s, meaning if we fly slower than 17.6 or 17.4 m/s, the plane will fall from the sky.

Next, the Cm vs. V (pitching moment vs. flying speed) graph determines the speed of the plane at balance fly; in this case, while using the Inverted V-tail configuration, a balanced fly of 25 m/s (trim speed) is possible while with the V-tail configuration only 24.8 m/s, followed it with 24.5 by the conventional configuration and 24.1 with the U-tail configuration.

Table 8: Tail design parameters

Component		No.	Parameter	
Inverted V-Tail	Elevator	1.	C.G at 15%S.M	0.147 m
		2.	Airfoil	NACA 0012
		3.	Wingspan	1 m
		4.	Chord at root	0.2 m
		5	Chord at tip	0.160 m
		6.	Offset	0 m
		7.	Dihedral	-30%
		8.	Incidence	0%
		9.	Distance to wing	x =1.5 m z = 0.25 m
V-tail	Elevator	1.	C.G at 15%S.M	0.149 m
		2.	Airfoil	NACA 0012
		3.	Wingspan	1 m
		4.	Chord at root	0.2 m
		5	Chord at tip	0.160 m
		6.	Offset	0 m
		7.	Dihedral	30%
		8.	Incidence	0%
		9.	Distance to wing	x = 1.5 m Z = 0 m
Inverted U-tail	Elevator	1.	C.G at 15%S.M	0.152 m
		2.	Airfoil	NACA 0012
		3.	Wingspan	0.866 m
		4.	Chord at root	0.15 m
		5	Chord at tip	0.15 m
		6.	Offset	0 m
		7.	Dihedral	0%
		8.	Incidence	0%
		9.	Distance to wing	x = 1.5 m Z = 0.35 m
	Fin	10.	Wingspan	0.634 m
		11.	Chord at root	0.2 m
		12.	Chord at tip	0.15 m
		13.	Offset	0.1 m
Conventional Tail	Elevator	1.	C.G at 15%S.M	0.149 m
		2.	Airfoil	NACA 0012
		3.	Wingspan	0.87 m
		4.	Chord at root	0.2 m
		5	Chord at tip	0.160 m
		6.	Offset	-0.1 m
		7.	Dihedral	0%
		8.	Incidence	0%
		9.	Distance to wing	x = 1.5 m Z = 0 m
	Fin	10.	Wingspan	0.4 m
		11.	Chord at root	0.2 m
		12.	Chord at tip	0.150 m
		13.	Offset	0.1 m

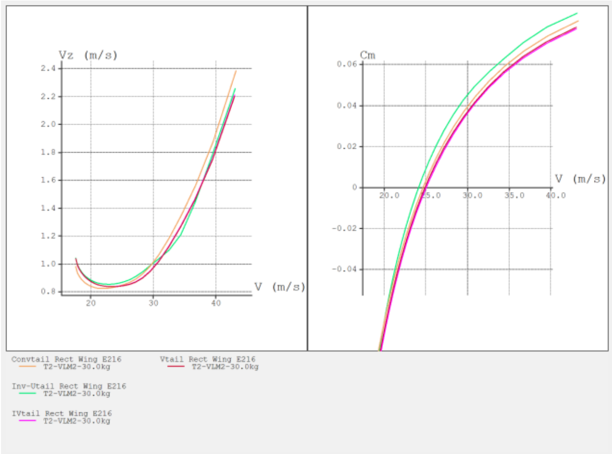


Fig. 13: Performance analysis, Vertical speed (VZ) VS flying speed (V), and Cm vs. V

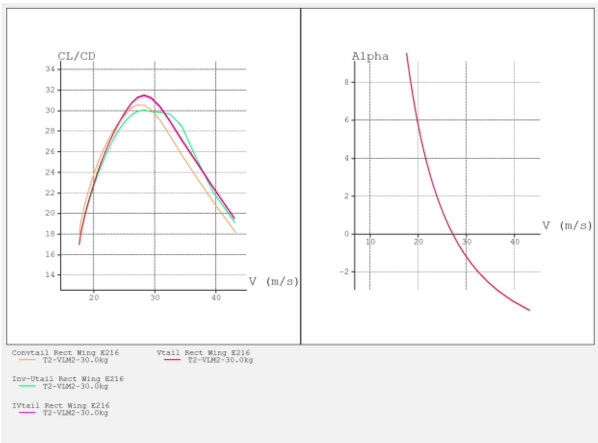


Fig. 14: Performance analysis, CL/CD vs. V, and Alpha vs. V

CL/CD vs V let us know the speed at which the plane should fly to go as far as possible; the higher the CL/CD, the better.

This time, while using the V-tail configuration followed by an Inverted V-tail configuration, it is possible to reach a high gliding ratio of 31.5 and 31.4 at a max speed of 28.2 m/s followed by the conventional tail configuration and inverted U-tail configuration with a gliding ratio of 30.5 and 30 at a speed of 27.2 and 28.2 m/s.

Finally, Alpha vs. V (shows AoA for a given speed) at 0o AoA speed for each tail configuration at approximately 27.8 m/s-stall speed at 17.6 m/s. All the above performance calculations can also be found manually using the formulas below:

$$V_{stall} = \sqrt{2\frac{l}{(\rho_\infty S CL_{max})}} \quad (12)$$

$$V_{cruise} = \sqrt{\frac{2}{\rho_\infty}\frac{W}{S}\sqrt{\frac{K}{CV}}} \quad (13)$$

$$CD = Cv + Ci \quad (14)$$

$$CD = Cv + kCL^2 \quad (15)$$

Results and Discussion

Through extensive analysis in XFLR5, Airfoil E216 emerged as the optimal choice, displaying superior performance with an excellent lift to drag ratio. Moving on to the comparison of tail configuration, our study explored the inverted V-tail, inverted U-tail, V-tail, and conventional tail. While all parameters demonstrated unique characteristics, the conventional tail consistently outperformed others, achieving an optimal balance between performance and stability. This is attributed to its ability to provide effective control and stability, as evidenced by the favorable stability and maneuverability derivations observed. The findings align with the literature on queuing configurations, confirming the effectiveness of conventional queuing in providing the desired performance-stability ratio. Practical implications suggest that for our UAV application, combining Airfoil E216 with a conventional tail configuration offers an optimal solution to achieve the desired balance between performance and stability. However, further research is warranted to explore additional factors and refine our understanding of these adjustments under various flight conditions.

Conclusion

In conclusion, the E216 airfoil has been found to be the best option among the rest due to its capacity to reach high performance, high lift, low drag, and higher lift-to-drag ratio without the need to incorporate any lifting device.

With respect to tail configuration, both V-tail and inverted V-tail configurations present the best stability and performance. However, both can barely produce enough lift force for the UAV to fly; with this in mind and after reevaluating the other two configurations, it was determined that the conventional configuration produced more than enough lift force with 303 N while having the best sink speed and just below V-tail and inverted V-tail configuration by a short difference in other performance and stability parameters. It is important to remark that the objective of this research was to find the best airfoil and tail configuration for our UAV in terms of performance and stability while trying to accomplish the design objective of a cruising speed of 25 m/s, a stall speed of 16 m/s and max speed of 30 m/s. With the conventional configuration, a cruising speed of 24.5, a stall speed of 17.6, and a max speed of 27.2 were obtained; hence the design objective was accomplished.

Acknowledgment

The authors wish to acknowledge the relentless help and support of the research group for aircraft system tests and prognosis.

Funding Information

The authors have not received any financial support or funding to report.

Author's Contributions

Campos Rodriguez Victor Antonio: Writing of the manuscript, Collected all the required data and references. Perform all simulations and designed work.

Su Yan: Supervisor in charge, periodically check progress, data, and results.

Ethics

The authors declare that there are no ethical issues that may arise after the publication of this manuscript. This article is original and contains unpublished material.

References

Airfoil Tools. (2023). http://www.airfoiltools.com/

Ashish, M., Muraleedharan, A., Shruthi, C. M., Bhavani, R. R., & Akshay, N. (2020, July). Autonomous Payload Delivery using Hybrid VTOL UAVs for Community Emergency Response. In *2020 IEEE International Conference on Electronics, Computing and Communication Technologies (CONECCT)* (pp. 1-6). IEEE. https://doi.org/10.1109/CONECCT50063.2020.9198490

Finger, D. F. (2016, September). Comparative performance and benefit assessment of VTOL and CTOL UAVs. In *Deutscher Luft-und Raumfahrtkongres*, (p. 3). https://www.researchgate.net/publication/309311189_Comparative_Performance_and_Benefit_Assessment_of_VTOL_and_CTOL_UAVs

Khadka, S., Abeygoonewardene, J. I., & Liyanage, N. P. (2020). Conceptual Design of Boom Mounted Inverted V-Tail in the Searcher MK II UAV. http://ir.kdu.ac.lk/handle/345/3680

Kovanis, A. P., Skaperdas, V., & Ekaterinaris, J. A. (2012). Design and analysis of a light cargo UAV prototype. *Journal of Aerospace Engineering*, *25*(2), 228-237. https://doi.org/10.1061/(ASCE)AS.1943-5525.0000120

Nugroho, G., Zuliardiansyah, G., & Rasyiddin, A. A. (2022). Performance Analysis of Empennage Configurations on a Surveillance and Monitoring Mission of a VTOL-Plane UAV Using a Computational Fluid Dynamics Simulation. *Aerospace*, *9*(4), 208. https://doi.org/10.3390/aerospace9040208

Raymer, D. P. (1992). Aircraft Design: A Conceptual Approach (Aiaa Education Series): *American Institute of Aeronautics and Astronautics*. ISBN-10: 0-930403-51-7.

Yolcu, S., & Akdağ, M. (2021, June). Conceptual Design of a Cargo UAV That Can Take-off and Land Vertically. In *2021 3rd International Congress on Human-Computer Interaction, Optimization and Robotic Applications (HORA)* (pp. 1-6). IEEE. https://doi.org/10.1109/HORA52670.2021.9461393