Airfoil Selection for Low-Altitude, Low-Speed UAV

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I. Abstract

Assumptions were made to calculate a Reynolds number for three wings and simulate aerodynamic capabilities under a set of conditions. With these assumptions, a low Reynolds number was obtained. While the velocity and chord length can be adjusted, the density and dynamic viscosity at sea level are indirectly given in the flight specifications. Based on these assumptions, the calculated Reynolds number implies the UAV will remain flying in laminar flow. It is important to note that the critical Reynolds number for external flow is 500000 which was farm from the one used herein. Lastly, it was concluded that the Selig 1223 wing performed the best in the simulations, taking into account the most relevant parameters for flight (lift, drag and pitching moment)

III. Introduction

Objectives: The purpose of this simulation is to compare the performance of three wings composed of different airfoils in order to select the best candidate for a slow-flying UAV at low altitudes. This helps to understand the effects different wing designs can have in lift and drag generation which are crucial for flight.

Outline: Values for velocity, chord length and wingspan were arbitrarily chosen to align with those typically found in UAV at low speeds and altitudes. These values were used to calculate the Reynolds number for these aircrafts in air, this low value was then input in XFLR5 to obtain different plots and polars which offer a good aerodynamic comparison for these three counterparts. The first reference listed (El Adawy et al.) was used to get a general understanding of UAV, their design and normal conditions they may be subject to.

V. Results and Discussion

Reynolds Number:

Velocity (m/s)	**Chord Length (m)**	**Density (kg/m^3)**	**Dynamic Viscosity (Ns/m^2)**	**Re**
10	0.1	1.225	0.00001789	68474

Table 1: Reynolds Number Calculation

<u>Plots:</u>

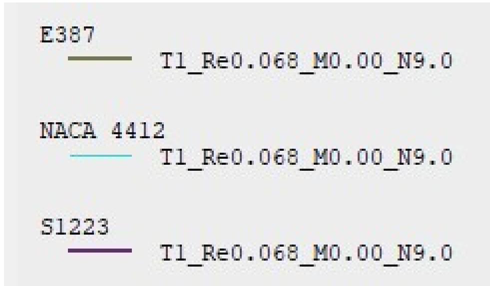

Fig.1: Legend

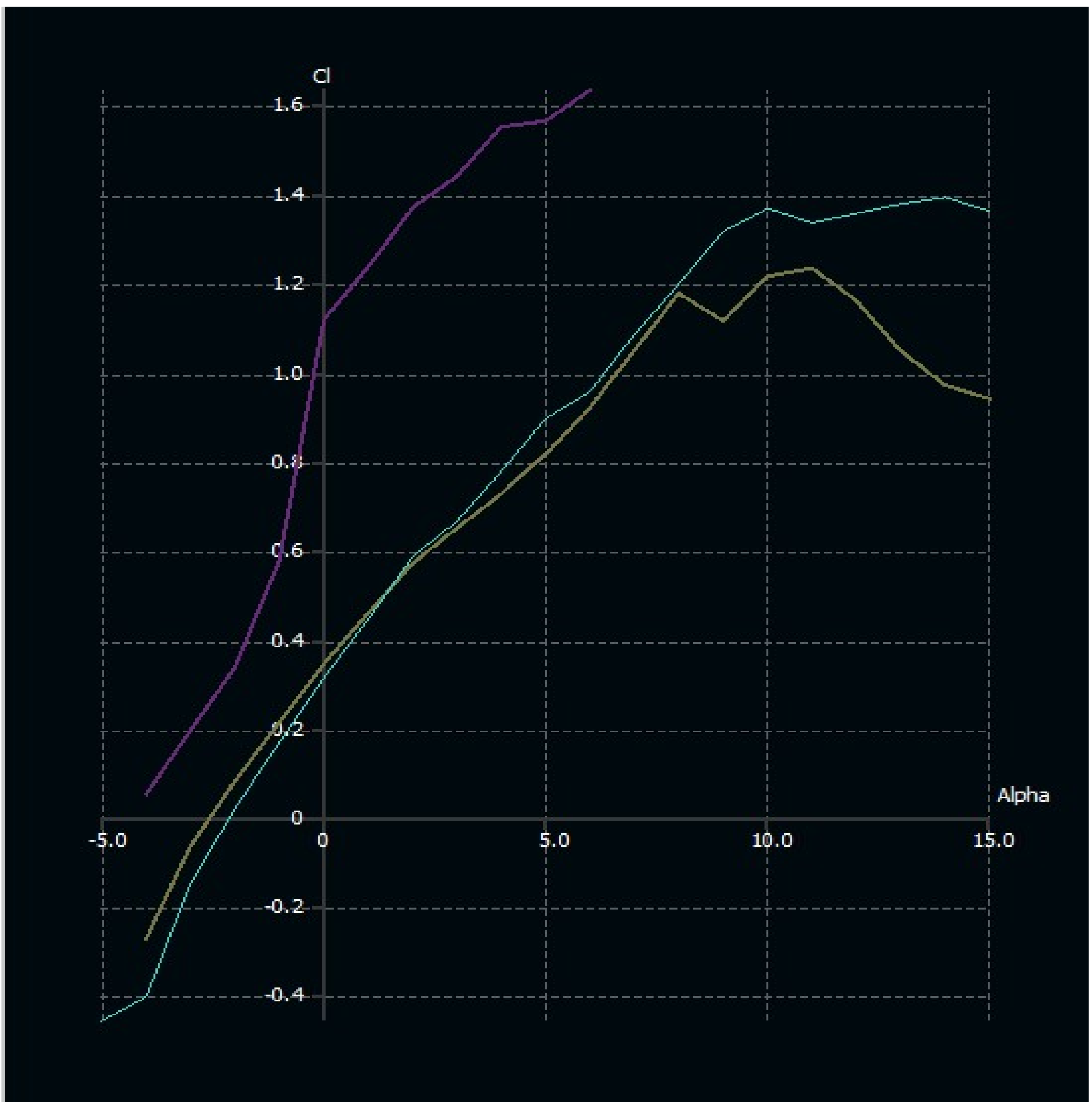

Fig. 2: Cl vs alpha

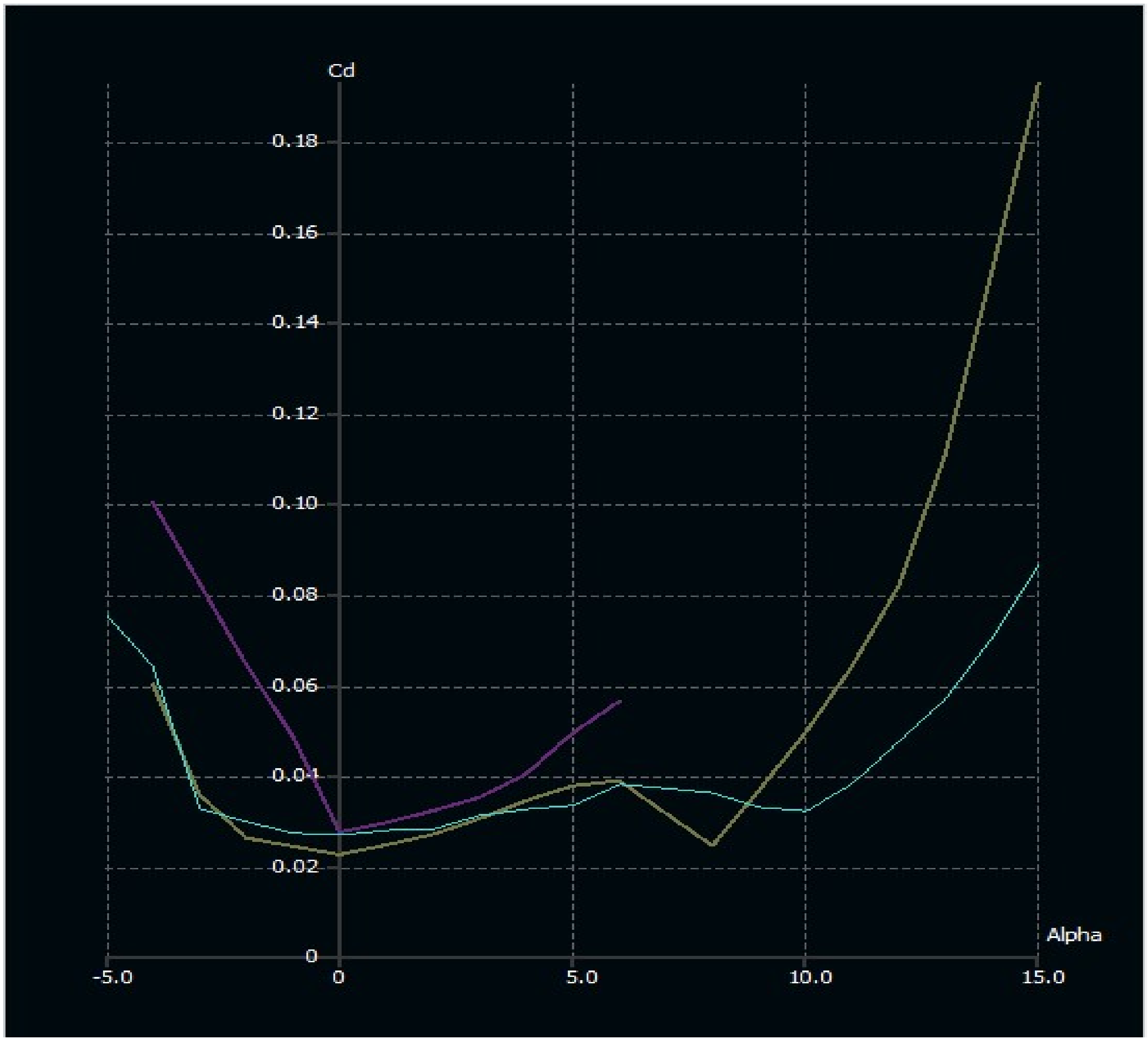

Fig. 3: Cd vs alpha

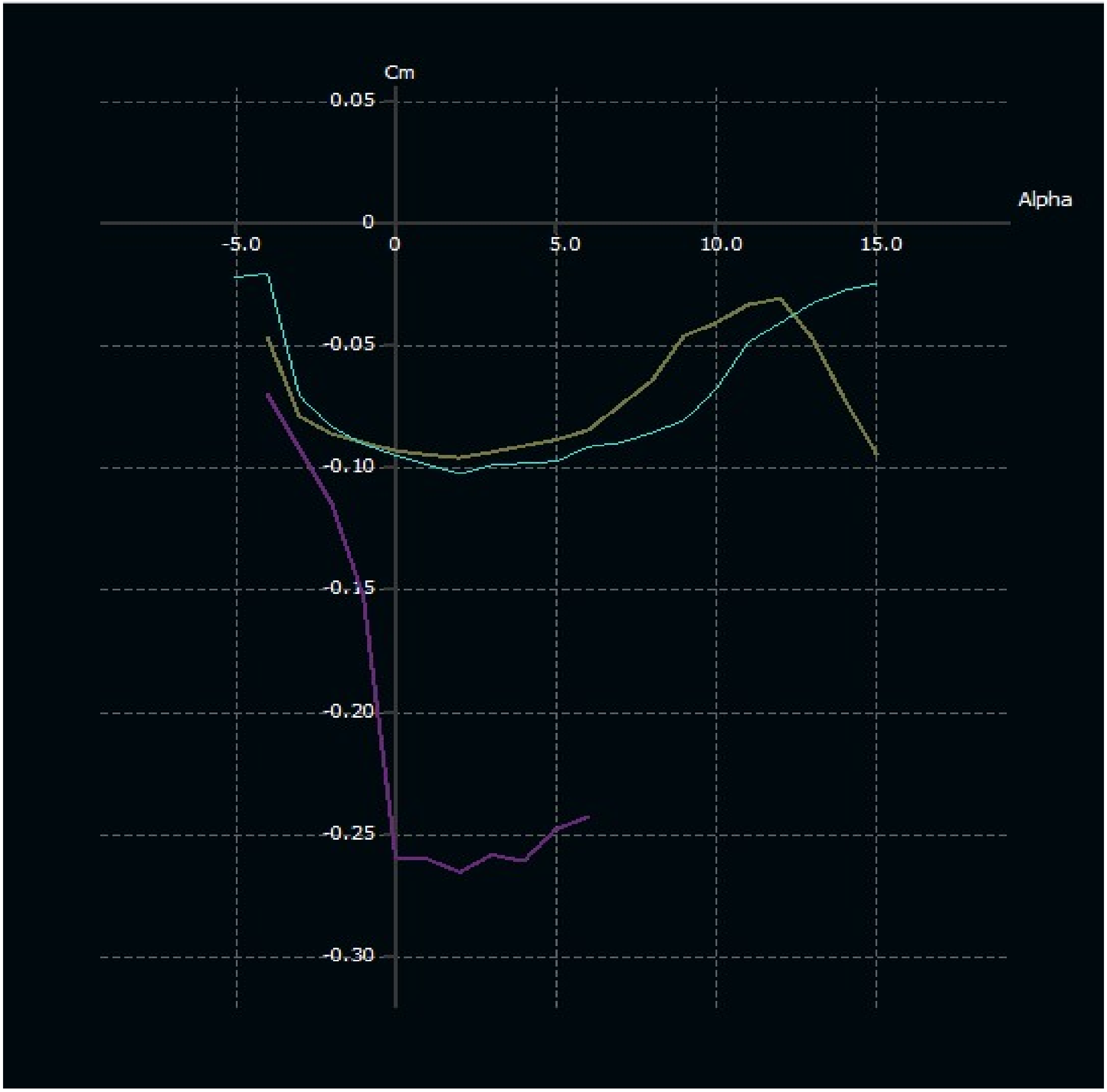

Fig. 4: Cm vs alpha

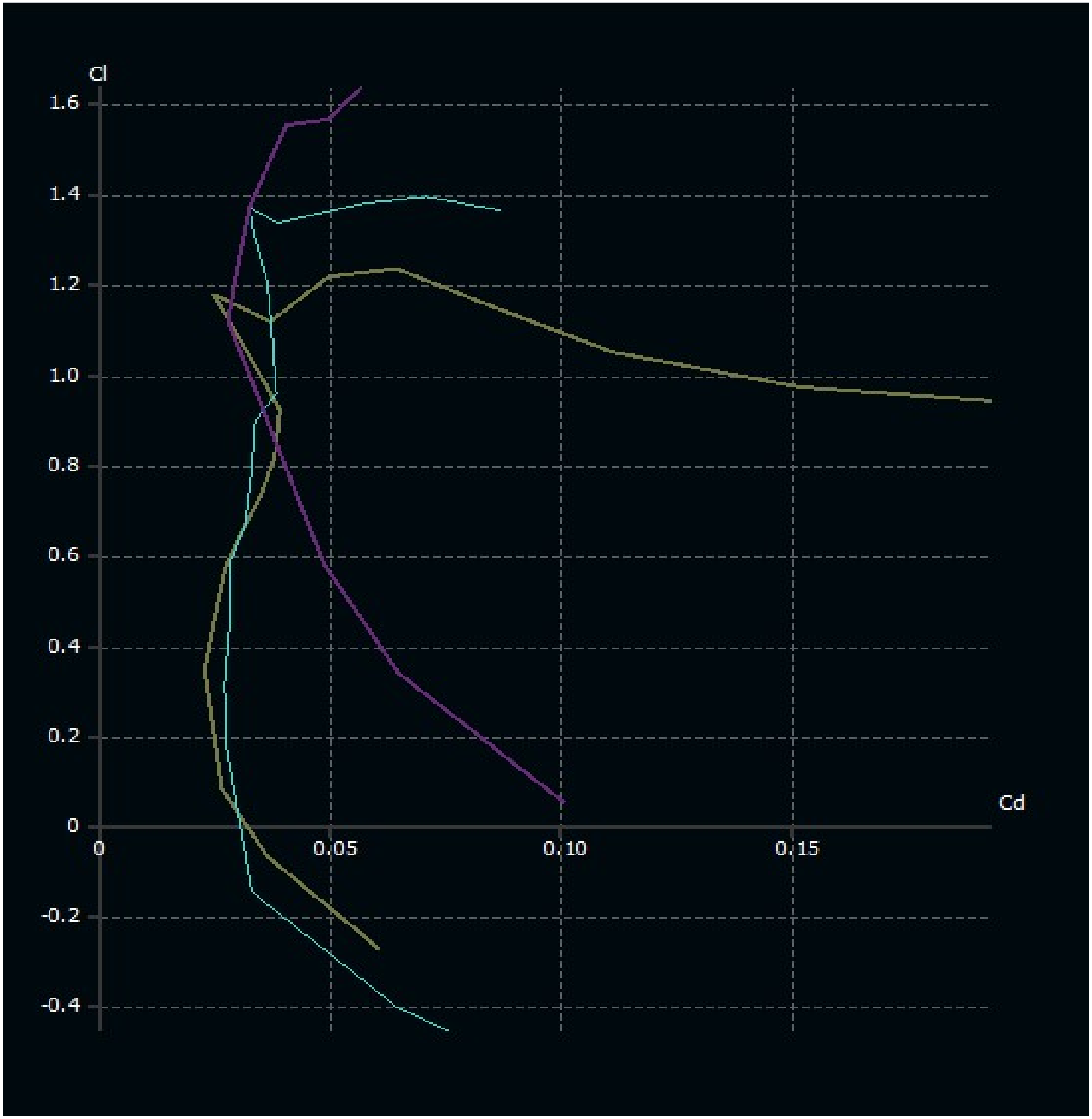

Fig. 5: Cl vs Cd

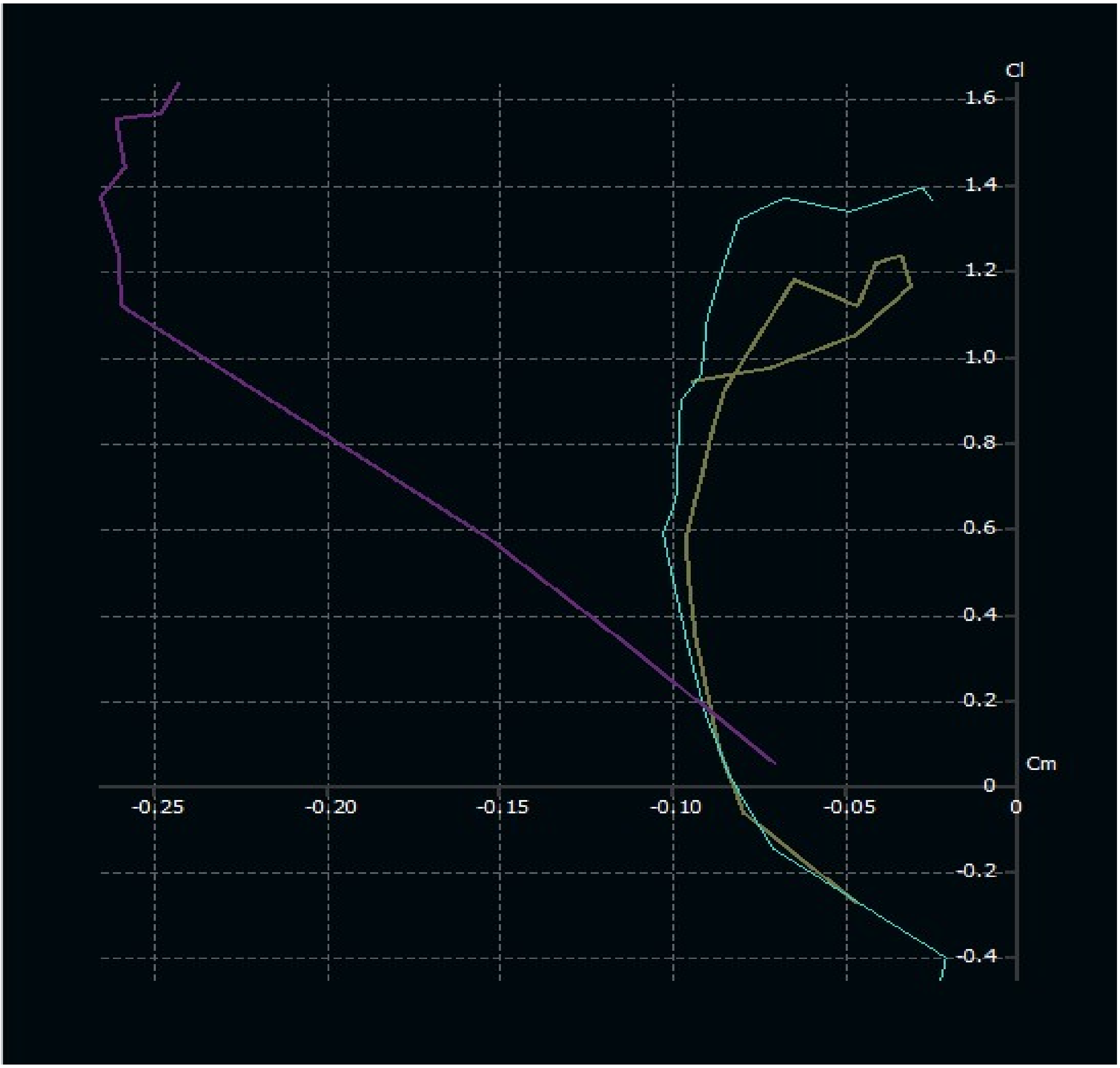

Fig. 6: Cl vs Cm

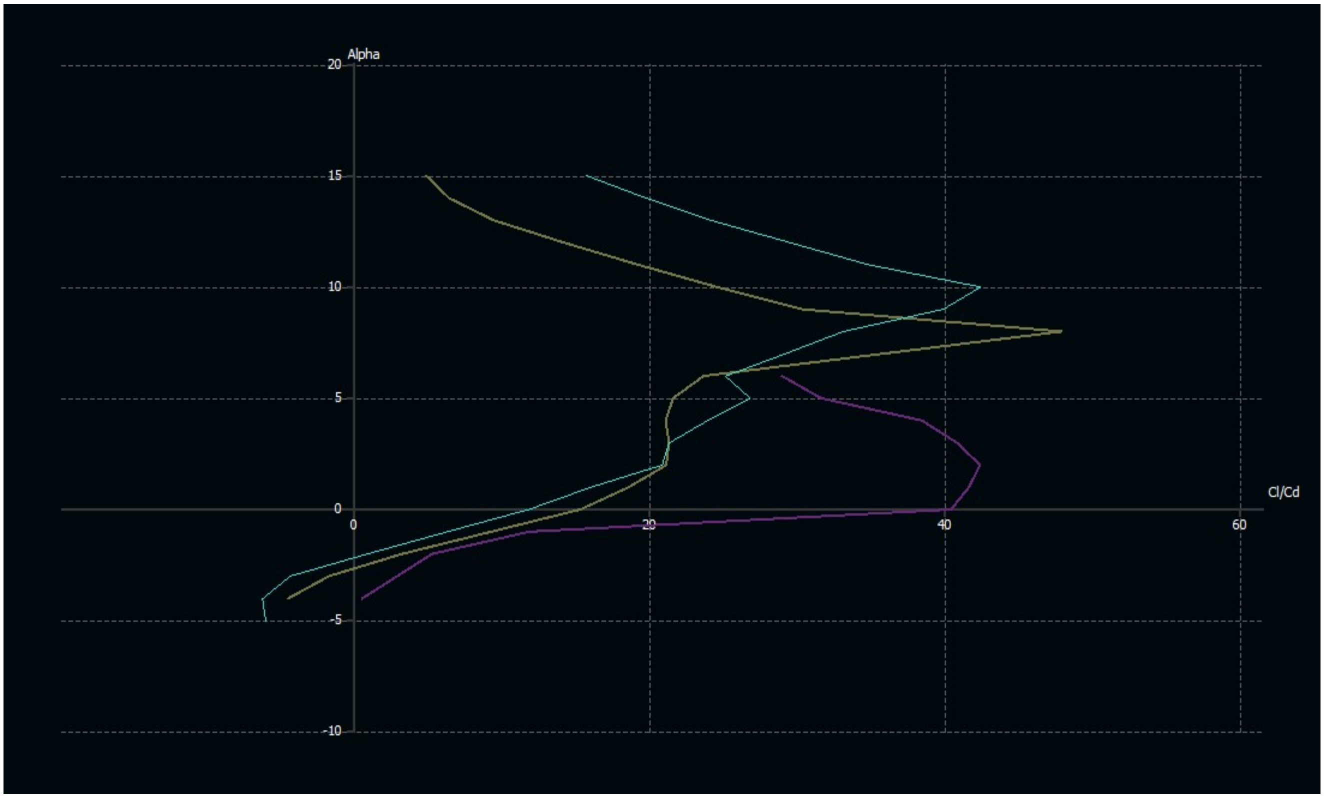

Fig. 7: alpha vs Cl/Cd

Airfoil	Maximum C_l (-)	$\alpha_{Cl,MAX}$ (degrees)
Eppler 387	1.235	11
NACA 4412	1.39	14
Selig 1223	1.635	6

Table 1: Comparison of $C_{l,\,max}$

VI. <u>Conclusion</u>

<u>Main Findings:</u> From the plots it can be observed that the Selig 1223 wing produces by far the most lift under these conditions. Taking a closer look, this airfoil selection also seems to produce more drag, which could present some efficiency issues; however, an argument can be made to justify its implementation given that it has a significantly better performance for pitching moment which is crucial for stability during flight. Furthermore, it can be seen in Figure 7 that the lift-to-drag ratio peaks for the Eppler 387, NACA 4412, and Selig 1223 airfoils occur at angles of attack of 8°, 10°, and 2°, respectively.

Equations Used

$$R_e = \frac{\rho V D}{\mu}$$

References

1. El Adawy, M., Abdelhalim, E. H., Mahmoud, M., Abo zeid, M. A., Mohamed, I. H., Othman, M. M., ElGamal, G. S., & ElShabasy, Y. H. (2023). Design and fabrication of a fixed-wing unmanned aerial vehicle (UAV). *Ain Shams Engineering Journal, 14*(9), 102094. Retrieved from https://www.sciencedirect.com/science/article/pii/S2090447922004051

2. Selig, M. (n.d.). Airfoil database. Retrieved December 1, 2024, from https://m-selig.ae.illinois.edu/ads/coord_database.html#E

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