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DESIGN AND ANALYSIS OF FLYING WING UAV USING XFLR5

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ABSTRACT

This paper presents the design and analysis of flying wing UAV. The design and analysis was performed using XFLR5 code (an interactive program for the design and analysis of subsonic UAVs), where the Mathematical Modeling with efficient numerical method i.e. Vortex Lattice Method (VLM1) through XFLR5 results of Flying Wing UAV of the airfoil MH 60 10.08% (Martin Hepperle MH 60 for flying wings Max thickness 10.1% at 26.9% chord & Max camber 1.7% at 36.6% chord) is discussed.

KEYWORDS: *Bit Flying Wing UAV, Tailless Aircraft, Body-Less Model Aircraft, Aerodynamic Design Static Stability, longitudinal Stability, Lateral Stability*

Article History

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INTRODUCTION

The importance of UAV in operations and the unprecedented variety deployed today is growing. The UAVs can be used both for military , civilian and Commercial purposes such as science & Research (Forest and Natural Resources Management , Studying Biodiversity , Measuring nuclear contamination , climate observation , Meteorological Research) , Security (Anti-Terror Operations , Criminal Investigation , Traffic Surveillance , Searching for missing persons , Emergency communication networks , Anti – privacy operations , Monitoring International summit meetings) , Inspections (Oil, Gas & Methane pipelines, Solar panel , power line / cable , cooling tower ,Bridge , Dams) , cargo delivery application, construction applications and surveying applications. These Indications are that there is a growing market for this type of aircraft.

So next-generation UAVs will require low-cost and efficient configurations. Many of existing UAV use conventional (i.e.: low/mid/high-wing, fuselage tail and tractor engine) and unconventional (i.e.: flying wing, three surfaces, low/mid/high-wing, high aspect ratio wing, fuselage tail/canards/inverted V-tail and pusher engine) configurations. The design of low-cost and efficient configurations of UAV becomes increasingly more important for improving the performances, flight characteristics, handling qualities and UAV operations. Most of small UAV fly at low Reynolds number, this allow to uses fuselage-wing-tail with laminar flow technology, to improve its cruise performance. Therefore, the understanding of and ability to design and analyze those configuration and technology for UAV is a problem that must be solved in order to allow the UAV designer to develop a UAV which satisfy the prescribe design requirements and objectives.

However, the presence of unconventional configuration and laminar flow technology seriously complicates design and analysis procedures because of important and often complex interaction between the individual elements of UAV often present very different and distinct challenges. Here in this paper, we have flying wing configuration where ***the wing is everything***. It does not have a conventional tube type fuselage for payload. All structure, engine and payload are fixed inside the wing. The design and analysis of it done through VLM1 Mathematical Modeling by XFLR5.

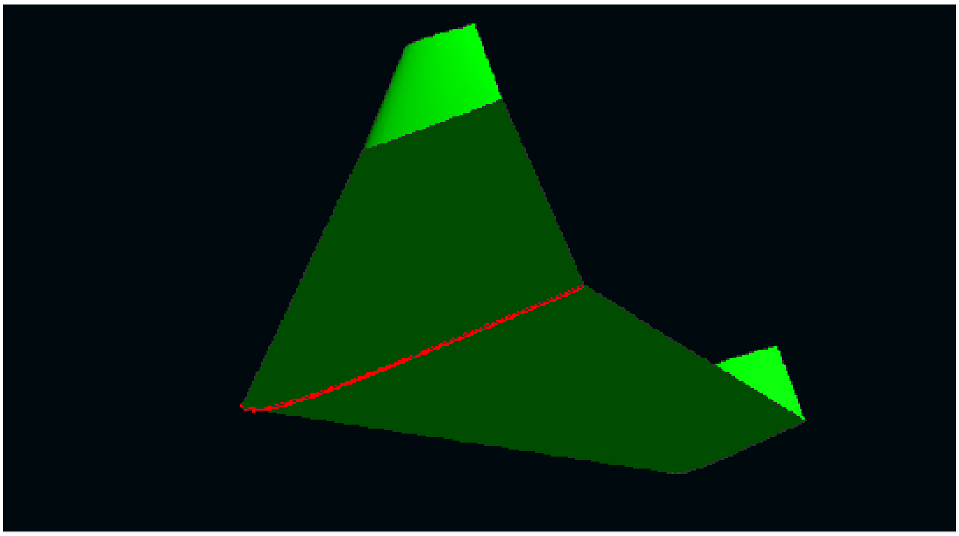

Figure 1: Flying Wing Designed in XFLR5

Airfoil Selection and Analysis

Conventional cambered airfoils produce a negative pitching moment (Cm), nose-down effect, on the airfoil. This is counteracted through the empennage by the horizontal stabilizers. In a flying wing type aircraft, careful selection of the airfoils is essential, since Cm strongly contributes to the aerodynamic longitudinal stability of the aircraft

The Cm is measured around the aerodynamic centre (A.C.). With no tail for longitudinal stability, the airfoils selected should have low or zero Cm. Instead of using a symmetric airfoil, which has zero Cm at zero α, a suitable solution is to choose a reflex airfoil. It can be seen that swept wing have Reflex airfoil with small twist which can produce zero pitching moment. We can estimate amount of Reflex required having negative pitching moment [1]

It can be observed that influence of location camber on Reflex airfoil's moment coefficient, where at X/c=20% -40% we have low moment coefficient at same Angle Of Attack (According to Reference I). On this basis, we can select the best results predicating Reflex airfoil (i.e.; Max thickness 10.1% at 26.9% chord & Max camber 1.7% at 36.6% chord) from below surveyed airfoils.

The following Reflex airfoils were surveyed which had widely used.

MH 60, t/c = 10.08%

MH 61, t/c = 10.28%

MH 62, t/c = 9.30%

MH 64, t/c = 8.61%

MH 44, t/c = 9.66%

MH 45, t/c = 9.85%

MH 46, t/c = 11.39%

MH 49, t/c = 10.50%

In these paper, it had been selected MH 60 t/c=10.08% due to its characteristics where this is compatible for stable flying wing design which can be observed from the following airfoil analysis results at range of Re=1,50,000 to 2,50,000.

Characteristics

Table 1: Characteristics of MH 60 t/c=10.08% Airfoil

Thickness	10.12%
Low moment coefficient	$C_{m\frac{c}{4}} = +0.0140$
Re	=1,50,000

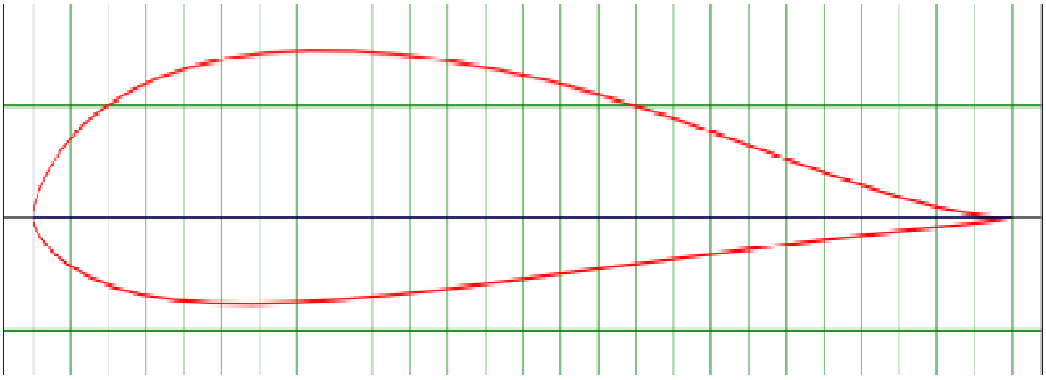

Figure 2: MH 60 T/C=10.08% Airfoil

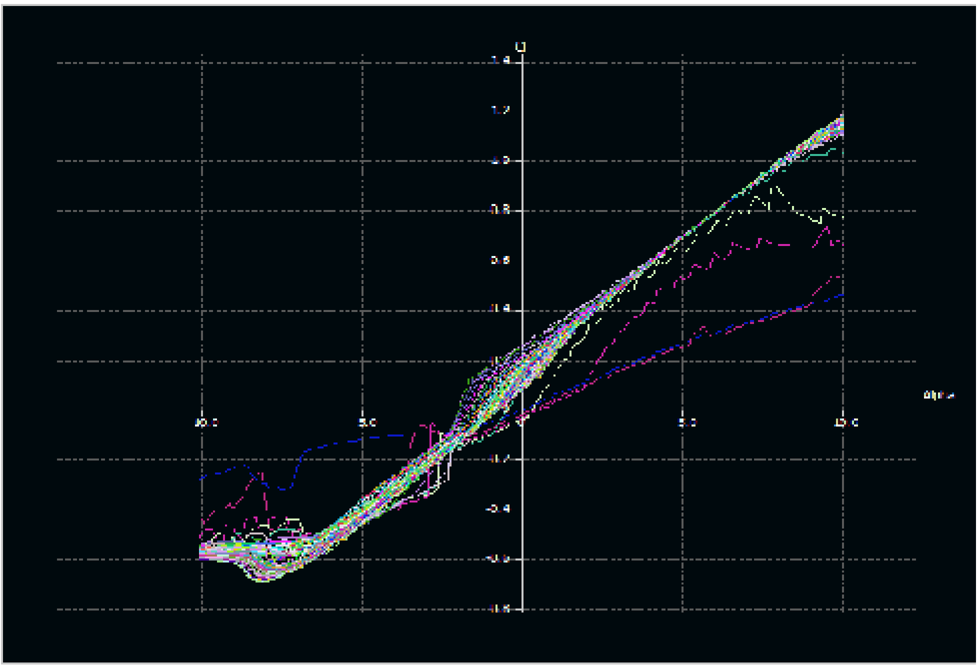

Figure 3: Cl VS Alpha Plot

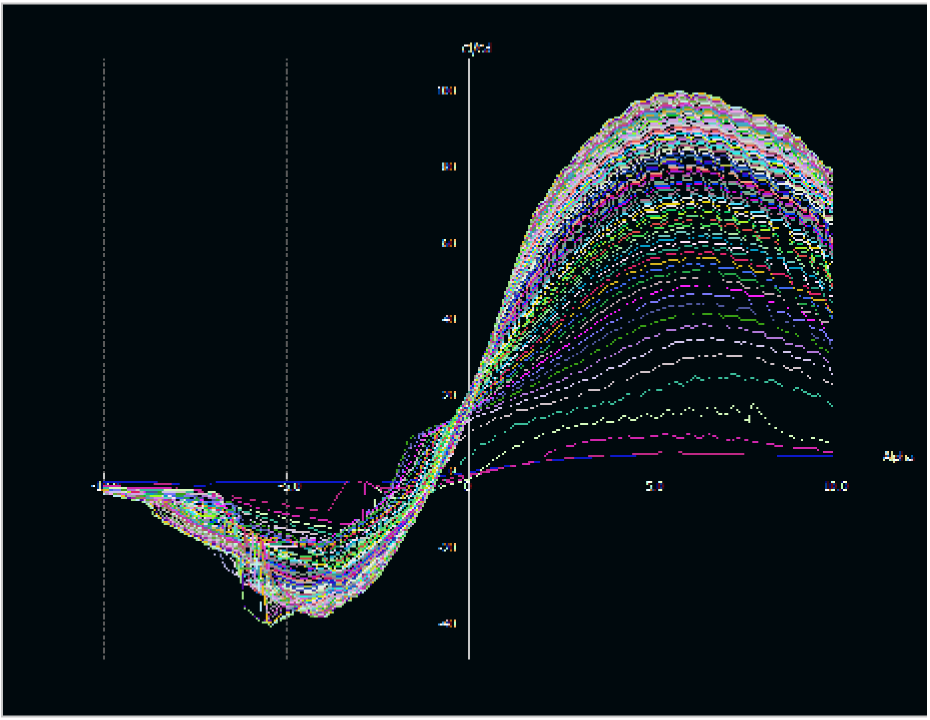

Figure 4: Cl/Cd VS Alpha Plot

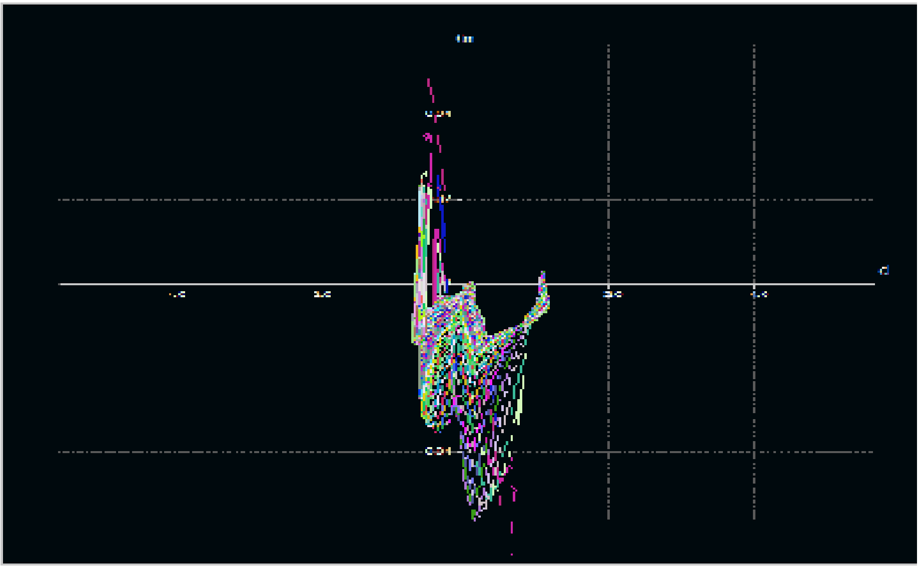

Figure 5: Cm VS Cl Plot

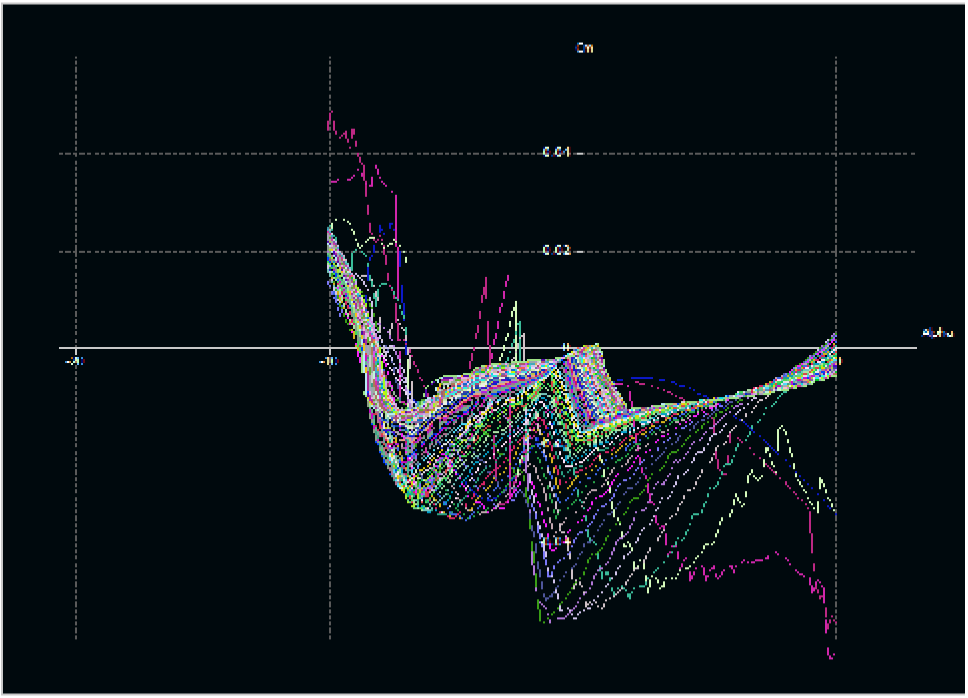

Figure 6: Cm VS Alpha Plot

Flying Wing Design and Analysis

XFLR5 is software that enables 2D and 3D aerodynamic analysis of bodies and bearing areas, separately or jointly. The software makes analysis for small Reynolds numbers. The latest version has implemented five applications: a direct 2D analysis and design, a 3D analysis and design (airfoil & wing), two ways to design and compare 2D, design a 2D QDES and MDES. According to XFLR5 manual (Guidelines for XFLR5, 2011), the steps should be taken into account when developing polar diagrams appropriate to the input data.

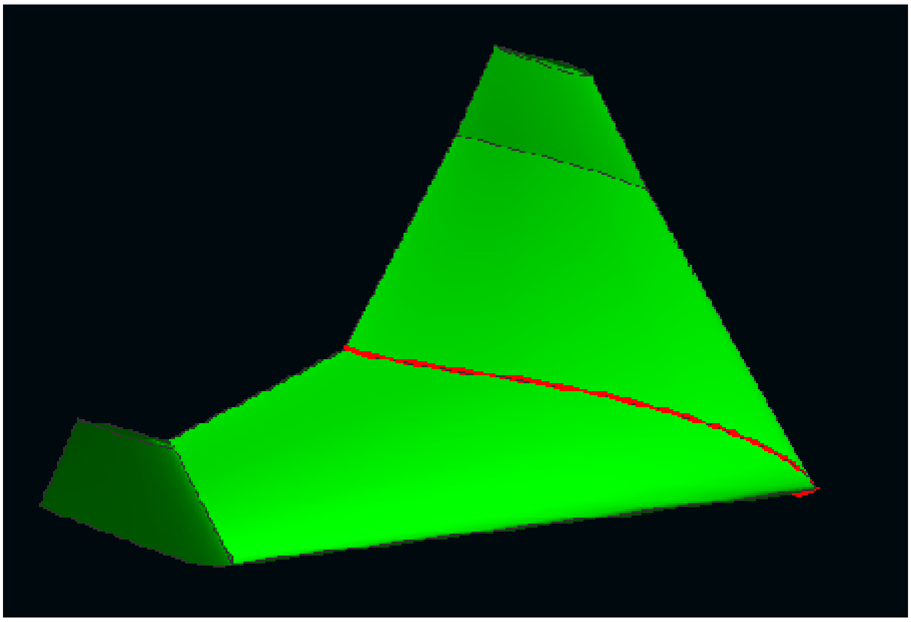

Figure 7: Orthogonal View

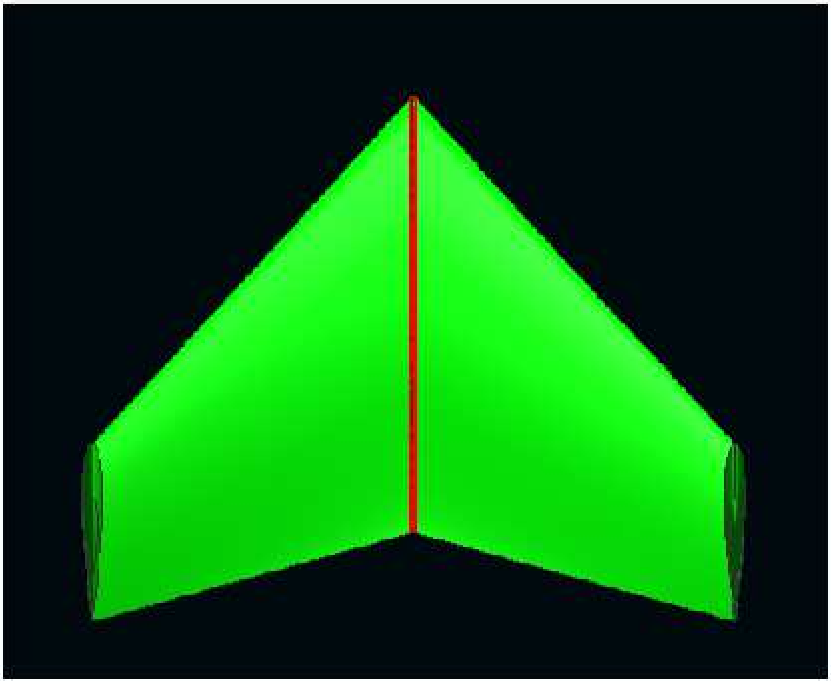

Figure 8: Top View

CONCLUSIONS

The design of an aircraft is not an easy process, it is complicated process. It does not mean whether it is manned or unmanned, regular or micro or Nano; they have their own complexity. Flying wing has been heard from decades, which is recently has rise in fabrication. It was shown that there are many trade-offs when designing the wing plan form. When one aspect of the design is increased or optimized then at least one, most likely multiple, aspects or parameters will be decreased. Many important factors were left out such as materials, structures, and the propulsion unit enough the aerodynamic modeling was briefly described, however a detailed analysis of the aerodynamics and thrust forces and moments need to be conducted in order to create the needed complex flight control system. This paper helps to know the stability of flying wing with following analysis wing platform. As more aircraft of this design are developed, the aerodynamic performance will become greater and a detailed design layout will become just as generalized as a conventional tube and wing aircraft.

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