Conceptual Design and Analysis of Flying Wing Drone

Sai Vinay Sandapeta, Sai Kiran Parre, Venkata Naga Charan Nath Mitta

Abstract— Integrating innovative solutions in the designing of the UAVs is one of the best research trends in the field having direct influence on the performance of unmanned airborne systems. The aerodynamic concepts applied to the UAV disregard the human component – the overload factor limit, but are still dependent on performance as well as on the breaking boundaries of the UAV structures. The design and analyze the flying wing using XFLR5 V6 which is an open-source software. The Analyzing the airfoil graphs with the existing airfoil graph results are described. The Aerodynamic & static stability analysis using XFLR5 and obtaining Cl vs. Alpha & Cm vs. Alpha graph plotting from results are discussed in the present work..

Index Terms— Flying wing, drone, XFLR5,UAVs,UAV design and analysis, Aerodynamic performance, Airfoil design and analysis.

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1 INTRODUCTION

More examples of aircraft that incorporate the flying wing design include the X-47B, a demonstration unmanned combat air vehicle (UCAV) currently in development by Northrop Grumman. Designed for carrier-based operations, the X-47B is a result of collaboration between the Defense Advanced Research Projects Agency (DARPA) and the US Navy's Unmanned Combat Air System Demonstration (UCAS-D) program. The X-47B first flew in 2011, and as of 2015, its two active demonstrators successfully performed a series of air-strip and carrier-based landings. Eventually, Northrop Grumman hopes to develop the prototype X-47B into a battlefield-ready aircraft known the Unmanned Carrier-Launched Airborne Surveillance and Strike (UCLASS) system, which is expected to enter service in the 2020s. Interest in flying wings was renewed in the 1980s due to their potentially low radar reflection cross-sections. Stealth technology relies on shapes that reflect radar waves only in certain directions, thus making the aircraft hard to detect unless the radar receiver is at a specific position relative to the aircraft—a position that changes continuously as the aircraft moves. This approach eventually led to the Northrop Grumman B-2 Spirit stealth bomber. This paper describes the conceptual design of a delta-like tailless unmanned aircraft for intelligence, surveillance and reconnaissance missions, with possible strike capabilities and this research explodes the conceptual aerodynamic design of a variant of a delta blended wing body tailless mid range UAV with surveillance, intelligence, and ISR and possible strike.

2 OPTIMIZATION METHODOLOGY

Flying wings are unconventional and challenging to analyze because they lack a tail to control the plane in the longitudinal and the lateral directions. In general most of the stability derivatives that govern the dynamic behaviour of an airplane are simplified so they would only include the terms that represent the greatest contribution to its final value. The airplane accomplished numerous acrobatic manoeuvres such loops, barrel rolls, inverted flight and quasi-hammerheads. It has been shown that by decoupling the longitudinal and lateral stability derivatives into their wing and vertical tail components, one can achieve longitudinal and lateral stability for unconventional airplanes, such flying wings, without the aid of augmented systems. It is also shown that by selecting the correct winglet parameters, leading edge sweep, taper ratio and winglet area, a model can be constructed so the desired lateral stability characteristics for an airplane can achieved.Where XFLR5 is an analysis tool for airfoils, wings and planes operating at low Reynolds Number. It includes : XFoil's Direct and Inverse analysis capabilities ,Wing design analysis based on the Lifting line theory and the Vortex Lattice Method. So it is used to analysis the airfoil and flying wing.

3 AIRFOIL SELECTION AND ANALYSIS

While Smaller tailless airplanes, like ultra-light and foot launched gliders should be designed with a larger safety margin regarding stall speed and stall behavior. Due to their low flight speed, the are responding lively to guests during the takeoff and landing phase, which may cause large angle of attack variations. Additionally, they operate in a Reynolds number range between 200'000 and 1 million, where the boundary layer has a strong impact on airfoil performance and behavior. MH60 airfoil is chosen for this flying drone due to its characteristics and aerodynamic performance and also NACA 0012 as fin for the flying wing.

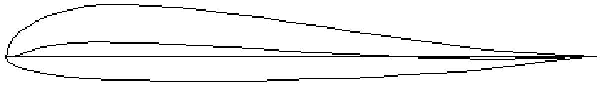


Fig. 1. MH60 Airfoil.This is the airfoil chosen for the flying wing drone.

The analysis results of the MH60 airfoil predict that MH60 airfoil has good performance where the graphs are plotted between cofficient of lift and cofficient of lift ; cofficient of lift and Alpha ; cofficient of the momet and Alpha ; which shown in the Fig. 2. as follows:

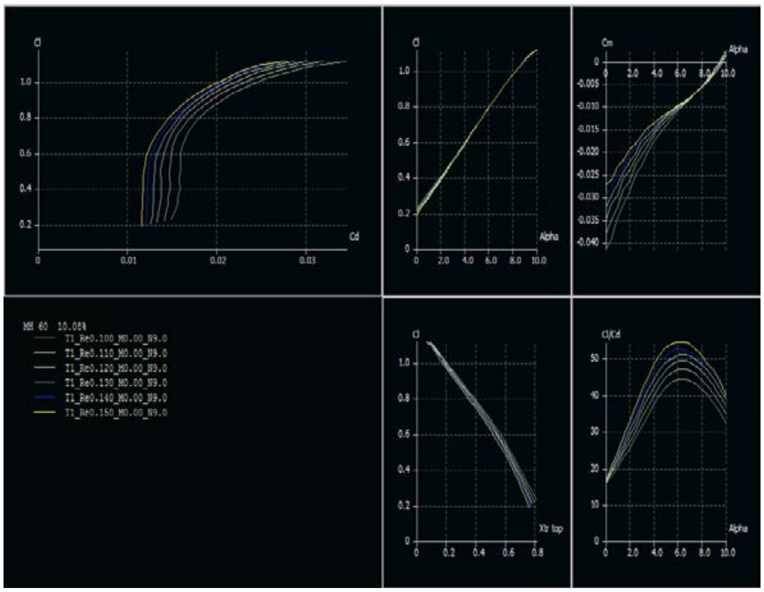


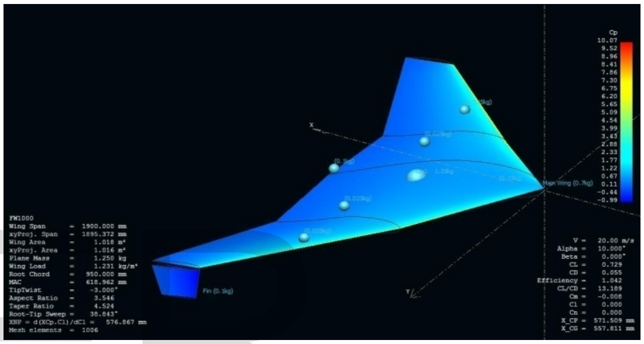
Fig. 2. Analysis of MH60 Airfoil

4 WING PLANFORM

This approach was taken from environment in the development of its replica of the largest flying creature, Quetzelcoatlus Northropi.Quetzalcoatlus northropi is one of the largest known flying animals of all time. It is a member of the family Azhdarchidae, a family of advanced toothless pterosaurs with unusually long, stiffened necks. Its name comes from the Mesoamerican feathered serpent god, Quetzalcoatlus.Once airborne, even the largest of these flyers, such as Quetzalcoatlus northropi whose wingspan reached 35 feet (10 m), could stay aloft by flapping their impressive wings. Actively controlled fore and aft motion of the wing combined with a zero moment section produced successfully gliding and powered flights of this model. It provides good controllability in which, increased pitch damping , and the potential for good lateral handling qualities.

Fig. 3. Quetzelcoatlus Northropi Bird

So based on this concept, the flying wing is designed in the XFLR5 environment using MH60 airfoil for wing and NACA0012 airfoil for fin as shown in Fig. 4



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FW1000
Wing Span      =  1900.000 mm
xyProj. Span   =  1895.372 mm
Wing Area      =     1.018 m²
xyProj. Area   =     1.016 m²
Plane Mass     =     1.250 kg
Wing Load      =     1.231 kg/m²
Root Chord     =   950.000 mm
MAC            =   618.962 mm
TipTwist       =    -3.000°
Aspect Ratio   =     3.546
Taper Ratio    =     4.524
Root-Tip Sweep =    38.843°
XNP = d(XCp.Cl)/dCl =   576.867 mm
Mesh elements  =  1006
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         V =   20.00 m/s
     Alpha =   10.000°
      Beta =    0.000°
        CL =    0.729
        CD =    0.055
Efficiency =    1.042
     CL/CD =   13.189
        Cm =   -0.008
        Cl =    0.000
        Cn =    0.000
      X_CP =  571.509 mm
      X_CG =  557.811 mm
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Fig. 4. Flying wing Design and Analysis

5 RESULTS AND DISCUSSIONS

The flying drone designed is analyzed , the following results plotted between the aerodynamic parameters are discussed below:

[1] The graph plotted between the coefficient of lift and angle of attach (Alpha) as follows:

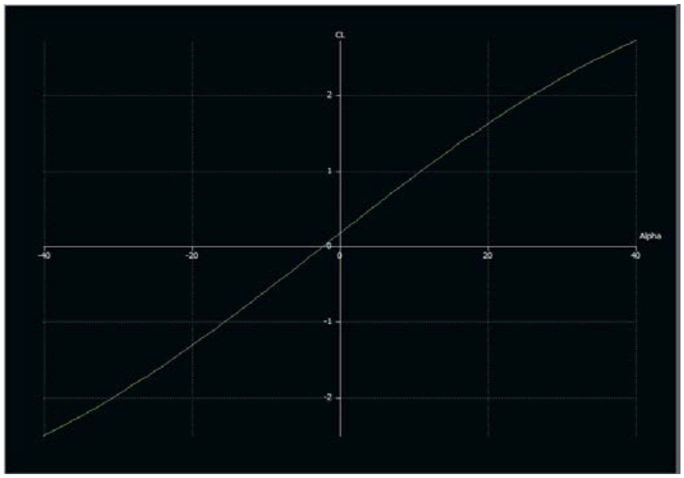

Fig. 5. Cl vs. Alpha

The following results describes about the flying wing that it is aerodynamically efficient with positive slope having coeffi-

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cient of lift about 0.3 at zero degree of angle of attack (alpha).

[2] The graph plotted between the coefficient of moment and angle of attach (Alpha) as follows:

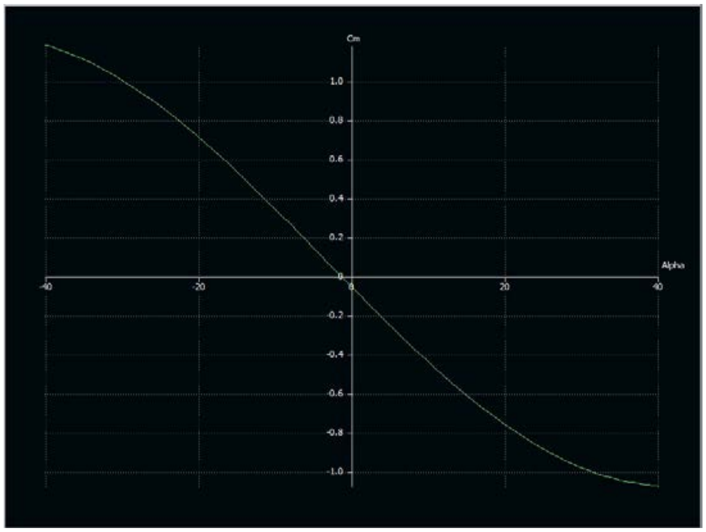

Fig. 6. Cm vs. Alpha

The following results describes about the flying wing that it is statically stable with negative slope.

[3] The graph plotted between the coefficient of Drag and coefficient of Lift as follows:

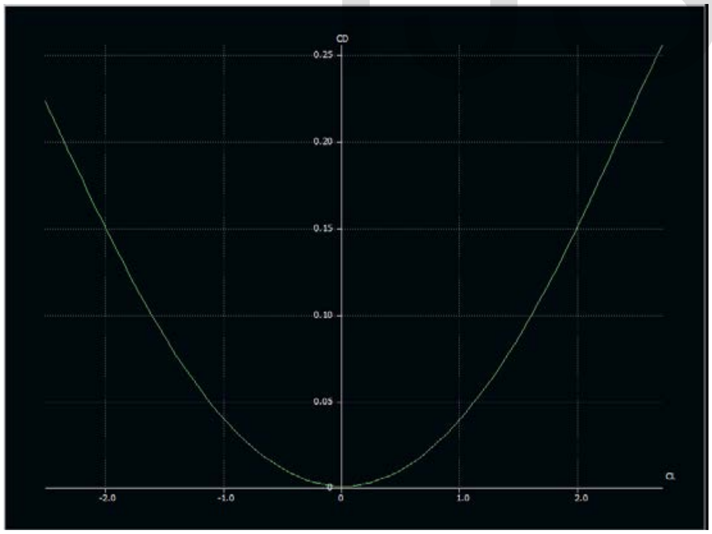

Fig. 7. Cd vs. Cl

The following results describes about the flying wing that it is to have efficient propulsion system to overcome the drag and to produce affordable lift.

6 CONCLUSION

A clean flying wing is theoretically the most aerodynamically efficient (lowest drag) design configuration for a fixed wing aircraft. It also offers high structural efficiency for a given wing depth, leading to light weight and high fuel efficiency. XFLR5 is used as design and performance analysis tool where we developed a new configuration from observation of bird and got best performance results. The goal was achieved to design and analysis of a flying wing drone.

References

[1] Alexander S. Goodman, "Conceptual Aerodynamic Design of Delta-type Tailless Unmanned Aircraft," IJUSEng , Vol. **2**, No. S2, 1-15, 2014, doi: 10.14323/ijuseng.2014.4.

[2] Sepideh Afshar, Aghil Yousefi-Koma, Hossein Shahi, Donya Mohammadshahi, Hesam Maleki, " Design and Fabrication of a Delta Wing Micro Aerial Vehicle," International Journal of Mechanics, Issue 4, Volume **1**, 2007.

[3] Anderson JD, "Fundamentals of aerodynamics". (5th ed.). McGraw-Hill, NewYork, 2010.

[4] Flying Wing aerodynamic analysis (*"Transilvania" University, Brasov, **"Henri Coandă" Air Force Academy , Technical Sciences and Applied Mathematics).

[5] ***.(2011). Guidelines for XFLR5 v6.39.

[6] Aero design. (2001). Airfoil database for tailless and flying wings. URL: http://www.aerodesign.de

[7] Airfoil Design for Tailless Airplanes. URL: www.mh-aerotools.de

[8] Airfoil Tools. (2014). URL: http://airfoiltools.com

[9] Airfoil Design for Flying Wing UAV (Unmanned Aerial Vehicle) [Proceedings of the 4th WSEAS International Conference on APPLIED and THEORETICAL MECHANICS(MECHANICS '**08**)].

[10] Raymer, Daniel P., "Aircraft Design: A Conceptual Approach", American Institute of Aeronautics and Astronautics, Inc., Washington, DC, 1992.

[11] Etkin, Bernard, and Lloyd Duff Reid, "Dynamics of Flight – Stability and Control", John Wiley & Sons, Inc., 1996.

[12] Roskam, Jan, "Airplane Flights and Automatic Flight Controls", Volume I and Volume II, DARcorporation, Kansas City, 1995.

[13] Nickel, Karl, and Michael Wohlfahrt, "Tailless Aircraft – In Theory and Practice", American Institute of Aeronautics and Astronautics, Inc., Washington, DC, 1994.

[14] Anderson, John D, "Introduction to Flight", McGraw-Hill, Inc., New York, 1989.