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Boxed Wing's Drone Preliminary Design

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ABSTRACT

The 21st century has become actually well know for new advances in technologies in many fields like aeronautics and mechanics. As a response to a lot of versatile challenging needs expressed by the actual community in the development of unmanned aerial vehicles (UAV), advance in technology become a must. In fact, UAV design has evolved from year to year to reach an extent and actually an opportunity for the future is here, the boxed wing design or Prandtl- plane design, which will be able to reduce fuel consumption and drastically increase the payload. This concept is actually studied for transport aircraft within the frame of a European project called Parsifal or Prandtl-plane Architecture for the Sustainable Improvement of Future Airplanes, involving 3 million Euros of funds. Are these benefits only interesting for transport aircraft or could it be applied for UAV as well? What methodology could we follow to assess the pros and cons of the boxed wing design? This paper presents actually the methodology approach and the needed numerical tool for designing a boxed wing structure and assessing it's potential.

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1. INTRODUCTION

UAVs or unmanned aerial vehicles are now a day of great interest thanks to their ability to get involved in many fields of application like agriculture, fire fighting and military missions [1] …..

That's why their structures and designs have to be well-thought and studied, simulated and tested before costly manufacture and heavy investment.

Actually, a new concept showed off in the UAV field like blended wing body (BWB), joined wing and Boxed wing Drone.

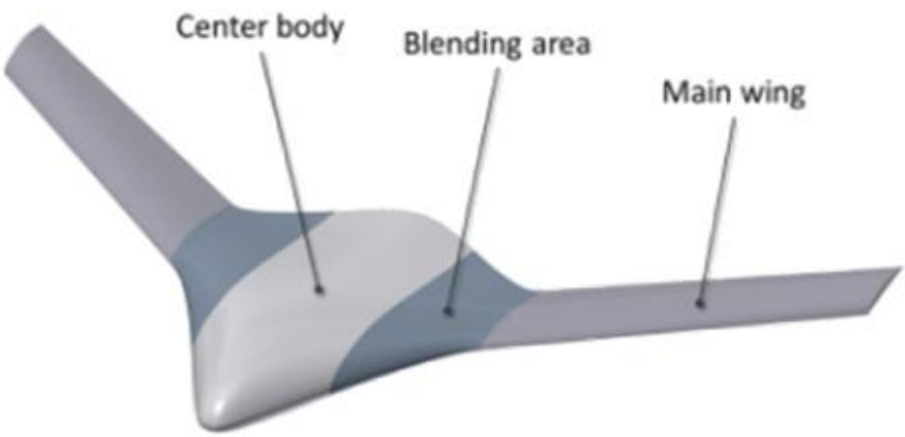

Figure 1: Blended wing concept [2]

Figure 2: Joined wing concept [3]

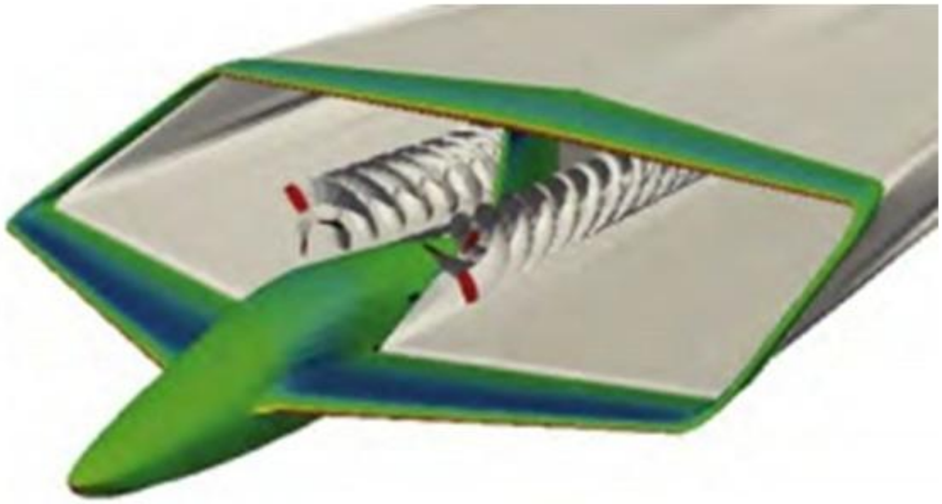

Figure 3: Boxed wing concept [4]

One concept of a big interest is the boxed wing design which allows getting better aerodynamic performances by reducing induced drag, enhancing lifting capability and improving the span efficiency factor [5]. This concept is achieved by the use of two wings and two joints. Altogether, these aerodynamic enhancements assure saving in fuel consumption. In a study [6], the box wing configuration has proven to consume 9 % less fuel as a result of a 14 % increase in the lift to drag ratio.

Due to these advantages, further investigations were required to confirm box wing efficiency, to do so, a first step was to make a preliminary design using a box wing structure configuration which is the main purpose of this paper, then aerodynamic and structural analysis has to be conducted to assess the potential of the concept.

2. METHODOLOGY

In order to design a box wing key parameters has to be first identified as airfoils, span, twist, stagger and joint's parameters (height, twist). After that a numerical model has to be realized with a CAD software like CATIA or Solidworks then it has to be implemented into a dedicated analysis software like NASTRAN, ABAQUS, ANSYS, depending on the further desired study: modal, stress or CFD analysis. In our case, the design and study have been conducted with Ansys using Design modeler as a CAD interface and fluent for CFD analysis. Thus, reducing interpretation issues due to model importation from external CAD software, Moreover using the CAD interface of the analysis software reduces the meshing issues and avoids compatibility matters.

3. RESULTS

The boxed wing design that has been achieved gives the user the ability to modify certain parameters quickly from Ansys interface giving the user the full authority to act upon the design by changing theses parameters wingspan, chord length, wings twist, wing joint height, and twist.

Hereby a schematic of the developed conceptual design of boxed wing followed by examples of parameterized
Wing models resulting from the use of the design approach in Ansys design modeler.

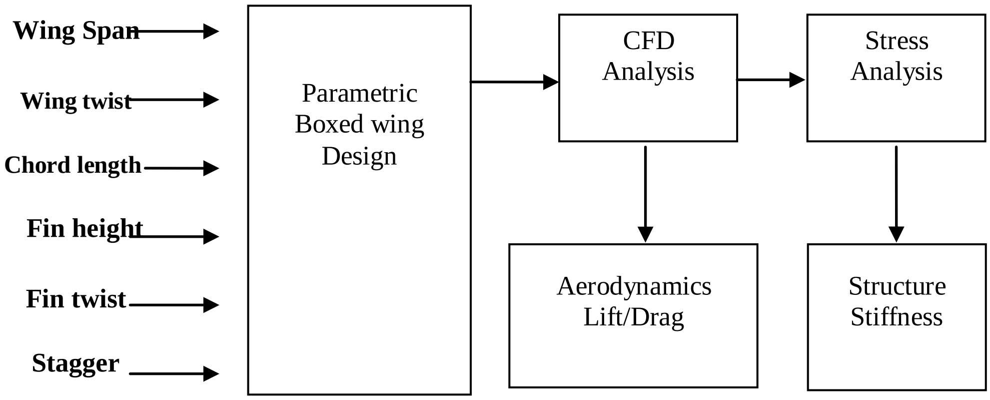

Figure 4: Actual and future capabilities of the developed conceptual design

Table 1: Parameterized Models of boxed wing resulting from the Design Approach in Ansys.

	Case 1	**Case 2**	**Case 3**
Wing span	4 m	4m	4m
Wing twist	- 2 °	- 2 °	- 2 °
Wing joints height	0,8 m	0,8 m	0,8 m
Wing joints twist	- 0.34 °	- 0.34 °	- 0.34 °
Wing sweep	25 °	0 ° -25°	0°
Stagger	0,5 m	2,5 m	0 m
Chord length	1 m	1 m	1 m

From case one to three we fixed some parameters like wingspan, chord length in order to maintain the same aspect ratio, joints height has been fixed to 20% of wingspan in order to obtain maximum reduction in induced drag according to Kroo study [5], we also varied some parameters like wing sweep and stagger to show the possibility of the conceptual model, as a result, we obtained the current CAD models.

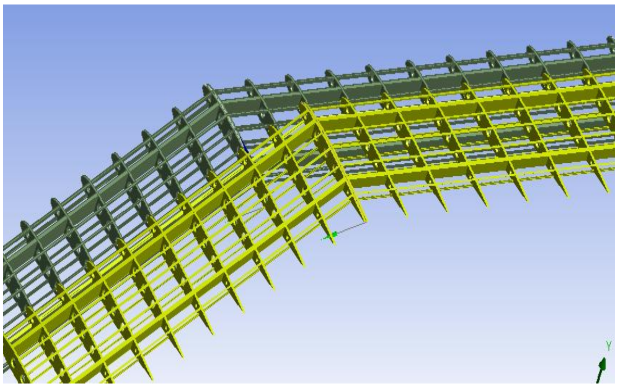

Figure 5: Boxed wing design with two swept wings

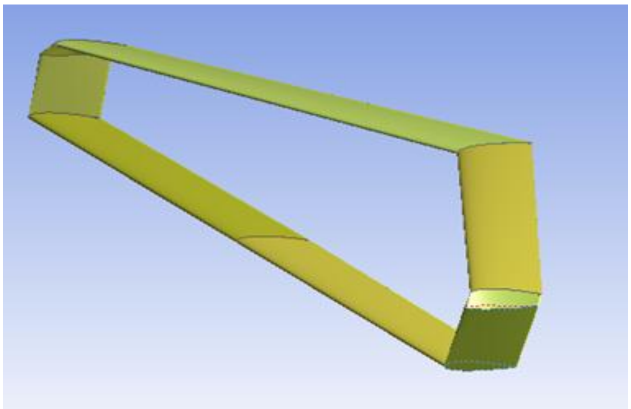

Figure 6: Boxed wing design with one swept wing

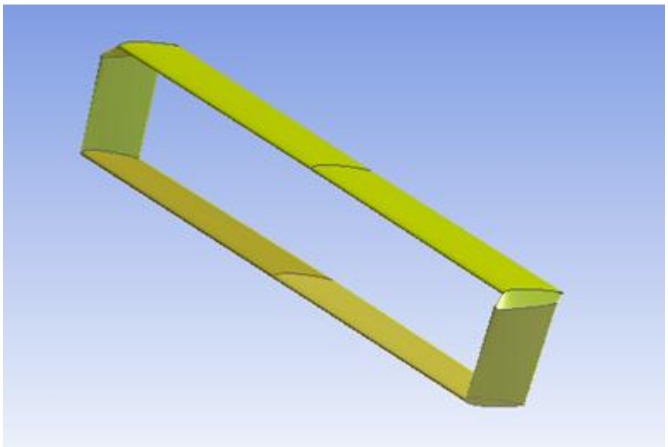

Figure 7: Boxed wing design with two straight wings

CONCLUSION

In this paper, a short review of UAV's fixed-wing structure was presented including examples of blended, joined and boxed wings concepts. Also, the advantages of the boxed wing design were underlined passing by drag reduction and lift to drag ratio enhancement. Furthermore, a conceptual design methodology for creating a box wing was presented with key parameters. Finally, future applications of the developed model were shown including aerodynamic and stress analysis.

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