Identification and Investigation of Aspect Ratio Definition and Mean Aerodynamic Chord for Blended Wing Body Aircraft: Balancing Geometric and Aerodynamic Considerations

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The blended wing body (BWB) aircraft concept has gained significant attention in recent years due to its potential for increased fuel efficiency, reduced noise levels and increased payload/fuel capacity. However, the lack of standardized methods for BWB aircraft has led to confusion and inconsistency in BWB aircraft design and performance analyses.

One of the challenges in the preliminary design of BWB aircraft is handling the wing aspect ratio and the mean aerodynamic chord (MAC), which are connected to significant aerodynamic performance parameters of the aircraft. Furthermore, in many cases the aspect ratio is part of preliminary aircraft design methods such as mass estimations or handbook methods for aerodynamic calculations. Among the crucial design parameters, the aspect ratio of the wing also plays a pivotal role in characterizing aerodynamic efficiency, meanwhile the MAC is necessary for stability analysis which are crucial for the BWB aircraft configuration. However, determining the aspect ratio and MAC based solely on the geometric principle used for conventional aircraft ($span^2$/reference area) may not fully capture the actual aerodynamic performance and stability characteristics resulting from them.

Therefore, this study redefines the aspect ratio and MAC of BWB aircraft by integrating both, geometric and aerodynamic considerations, to obtain a consistency between the known preliminary aircraft design methods in which the aspect ratio is widely used, and the actual aerodynamic performance. This is achieved through a combination of analytical methods, aerodynamic simulations and optimization techniques where the intricate relationship between geometric aspect ratio and aerodynamic aspect ratio is investigated. The findings are synthesized to a geometrically dependent method to determine the aspect ratio and MAC of a BWB aircraft. Furthermore, sensitivity analyses are employed to assess the influence of various design parameters to determine the optimal aspect ratio of BWB aircraft.

The outcomes of this research provide valuable insights into achieving an optimal balance between geometric constraints and aerodynamic performance objectives in BWB aircraft design. In addition, the resulting methods are further facilitated for the use in preliminary aircraft design tools such as UNICADO[1].

The proposed methods leads to more accurate predictions of aerodynamic performance and provides a consistent basis for comparison between different BWB aircraft designs and conventional aircraft. Moreover, the methods can serve as a useful baseline for future BWB aircraft design and optimization studies. Finally, this work provides a valuable contribution to the development of BWB aircraft design and sizing methodologies, and highlights the potential benefits of this configuration for advancing the frontiers of environmentally sustainable aviation.

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