LINKÖPING
UNIVERSITY

Blended Wing Body - Chances and Problems of a new Aircraft Concept

Andreas Wittenberg, Fabian Neumann, Michael Göbel, Philipp Podzus
TMAL02, Linköping University, 2017

Fig. 1 . Boeing, NASA, and AFRL Blended Wing Body Concept[1]

1 Introduction

Since the beginning of all public air transport the drake configuration dominated the aircraft market completely and was improved over the time on aerodynamical, flight systems, propulsion and many other aspects. Many other configurations were considered, tested or even produced in smaller series. The most famous example might be the flying wing concepts of the Horten company which were basis for the Northtrop B2 stealth bomber. Other concept were for example the box wing, strut-braced configurations or aircraft designs with three lifting surfaces. This paper will discuss the possible advantages and disadvantages of a long distance passenger aircraft with a "Blended-Wing-Body" configuration (BWB). A BWB is an aircraft with no clear dividing line between it's body and the wings, but were you can still recognize these parts which differentiates it from a flying wing. The main purposes for researches on this design are the potential drag reductions due to reduced wetted area and interference between body and wing as well as the better lift contribution resulting from an airfoil shaped lifting passenger cabin.

2 Aerodynamics

Due to the special design of the BWB where the fuselage is integrated into the wing, a nearly elliptical lift distribution can be obtained. This leads to a lower induced drag compared to a drake configuration. Additionally the BWB has a lower amount of transitions between the aircraft components so there is reduced interference drag. Because the BWB has the benefit to place seats in the wing and therefore has many seats abreast, the total length of the aircraft is shorter compared to a A380 which has the same amount of seats. So due to the short fuselage length and therefore a lower amount of wetted area, the BWB does also have reduced parasite drag. However the wing has a high thickness to chord ratio which leads to a bigger wave drag because of the lower drag divergence and critical Mach number. Because of the better lift distribution and the reduced drag the BWB has a better lift to drag ratio and a lower specific fuel consumption than other conventional aircraft configurations.[2]

3 Structure

In section deals with the structure of the BWB due to transverse force, bending moment and the pressure inside the cabin. Regarding to the transverse forces, Figure xx shows that the resulting transverse forces for the BWB are smaller in comparison with a conventional airplane. For this reason, the bending moment are also smaller. This means that BWB could have a reduced structure weight or a bigger span. The benefit of this is more space inside the airplane to include more seats.

A further topic regarding to the structure is the pressure inside the cabin. Generally, the fuselage should have a circular cross section so that only tension appears in the fuselage profile. For the BWB exists two different concepts. The first possibility is to integrate several circular cabins inside the wings. Another potential to get more seats is the integration directly into the wings. For this solutions, the wings have to laying up for higher critical bending moments and also for permanent occurrence of the pressure inside the cabin. To summarize this the wings need a high fatigue strength and high stiffness.[2]

4 Compatibility with further circumstances

A new vehicle concept normally leads to problems according to the compatibility with the existing infrastructure and acceptance by further actors like passengers or workers.

Passengers

An important aspect of safety feeling and travel comfort is the possibility for all passengers to look out of the aircraft window. This goal is hard to achieve with a BWB concept aircraft since the rows are much wider and the enclosing aircraft structure is not possible to be built with glass in this area (front edge of the wing).
Furthermore, you always have to take care about the inertial loads for passengers during the flight. Constructing an aircraft with a higher width of the seat rows will induce problems at the outer seats since their distance to the rotation axis x. With a higher distance the inertial forces will increase for a fix angle phi, given by the flight conditions. It doesn't seem realistic to limit these conditions like rolling angle because they are necessary for an economical cruise flight.
On the other hand, a BWB concept could cause a significant reduction of cabin noise. The reason is the position of the engines far behind the passenger areas within the BWB. You can compare it with the tail position at classical aircrafts. Additionally, this engine concept leads to lower noise problems during flight with low altitudes because the BWB will protect the ground against the strongest influence of the noise. [2]

Airport handling

This directly leads to the next aspect: the airport handling which is an important factor for development of every new aircraft. The most sensible engine position causes lots of problems for maintenance of the engines which are very easy to access in the normal position under the wing. Here we expect a significantly larger amount of time and techniques which will be necessary for this work.
Furthermore, you have to think about the airport infrastructure compatibility according to existing aircraft buildings. At the moment it's possible to deal with aircrafts until a length and width of 80 meters since this is the size of a standard aircraft box. Obviously, it would not be sensible to construct a larger aircraft which is not possible to handle at the existing destination airports. Therefore, BWB solutions with a foldable wing concept will be necessary. We can see that this is basically possible because such airplanes already exist (see aircraft carriers).
At least, an important point is the emergency evacuation time for the whole aircraft: There is a need for new concepts but studies already showed that it is possible to reach this necessary goal, so that BWB aircrafts can be permitted to passenger flights from this point of view.[2]

5 Conclusion

All in all, and after weighing up the pros and cons of the BWB it is clear, that this concept has the capability to improve the aerodynamic efficiency and the passenger capacity as well as to reduce the direct operating costs. On the other hand side, the investments which would have to be undertaken to be able to handle these new aircrafts at the airport would be rather high. But the most important reason for a possible failure of a new introduced BWB passenger airplane would be the public acceptance which is to be assumed very low due to the fact, that there are only few chances to have a look outside the window. Feeling like trapped in a can might lead to underused flight connections which would overweigh the reached improvements stated above. Because of this the BWB might be a nice aerodynamical, but not economical feasible concept.

Authenticity and Plagiarism

By submitting this report, the author(s) listed above declare that this document is exclusively product of their own genuine work, and that they have not plagiarized or taken advantage from any other student's work. If any irregularity is detected, the case will be forwarded to the University Disciplinary Board.

REFERENCES

[1] *https://www.nasa.gov/sites/default/files/styles/full_width_feature/public/images/253983main_ED06-0201-2_full.jpg*.
[2] Liebeck R H. *Design of the Blended Wing Body Subsonic Transport, 2004*. JOURNAL OF AIRCRAFT Vol. 41, No. 1, January–February 2004, 2004.