The Future of Passenger Airplanes

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INTRODUCTION

The airline industry relied on a new generation of planes with a 20% fuel efficiency improvement on average every 20 years. For the last six decades that efficiency gain has been made mostly by improvements in engine technology. By increasing the bypass ratio of the jet engines and the introduction of new materials planes have been able to make their efficiency gains. However, a limit has been reached in the bypass ratio possible and materials. Therefore, engineers must look to other ways to increase efficiency. This project evaluates the airplanes of the future and explains how the efficiency goals will be met.

RESEARCH METHODOLOGIES

This project is a meta analysis of preexisting sources as well as invaluable information provided by my mentor, Thomas Price. The sources consist of NASA documents, manufacturer data, and public sources. To organize the analysis, the airplanes will be evaluated on various categories. After preliminary research it was decided to separate the Transonic Truss-Braced Wing (TTBW) and Albatross One from the Blended Wing Body (BWB) due to the BWB being applicable to a different market. The TTBW and the Albatross One were selected for primary candidates as they are the products of Boeing and Airbus which maintain a duopoly in the commercial aircraft industry. Furthermore, the TTBW and Albatross One seek to replace the narrowbody (~180 passengers) market, this represents the largest share of commercial aircraft and 50% of CO_2 emissions for the airline industry.

DISCUSSION, ANALYSIS, AND EVALUATION

Boeing Transonic Truss-Braced Wing (TTBW)

1.) **Ultra-Thin Wing** creates challenges in fuel storage as fuel is stored in the wings on conventional aircraft.
2.) **High Wing** configuration is a better platform for future super-efficient unducted engines. The CFM-RISE engine has a diameter of 14 feet compared to less than 8 feet for the current 737. (Moving most air at lowest speed is most efficient)
3.) **High Aspect-Ratio Wing** greatly increases efficiency by decreasing drag.
4.) **Lifting-body Truss** is crucial in supporting wing, and therefore can not suffer failure.

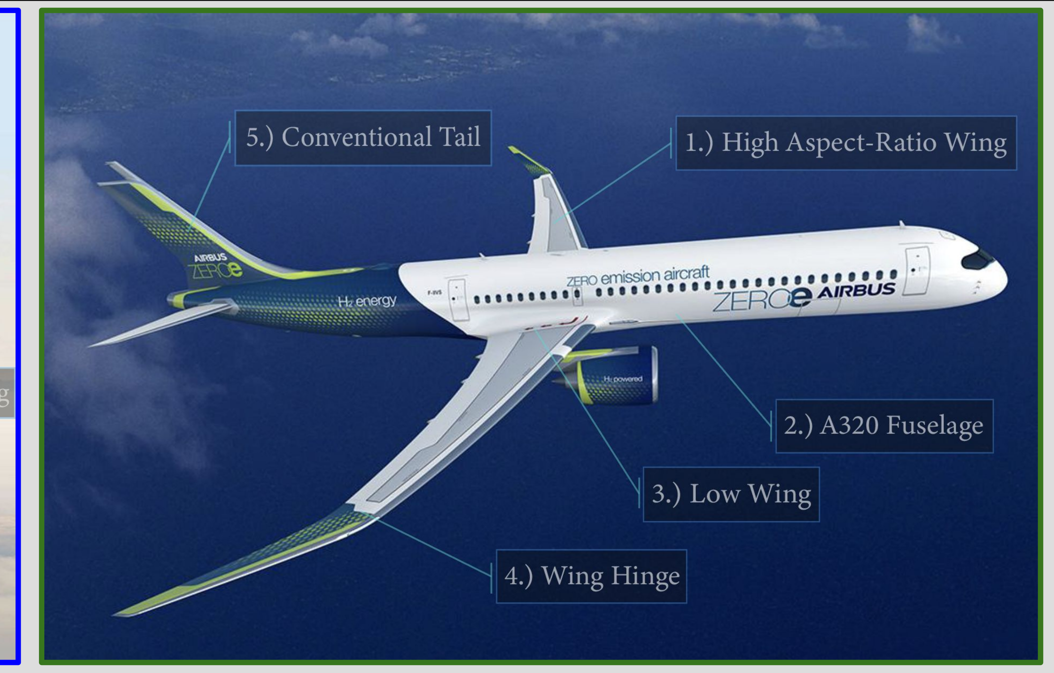
Airbus Albatross One

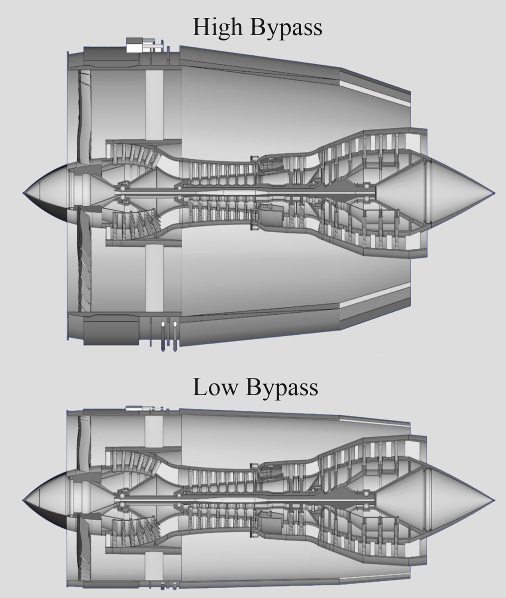
1.) **High Aspect-Ratio Wing** greatly increases efficiency by decreasing drag.
2.) The use of the **A320neo Fuselage** enables Airbus to not have to redesign the entire plane. (Clean sheet designs such as 787 costed $32 Billion)
3.) The conventional **Low Wing** design means the plane requires less redesign but is also less able to integrate future unducted engines than the TTBW.
4.) The **Wing Hinge** is crucial as it provides the extra wingspan that increases the aspect ratio. however, the hinge is a big risk for the design as it complicates the design and must function properly.

Delft Flying-V

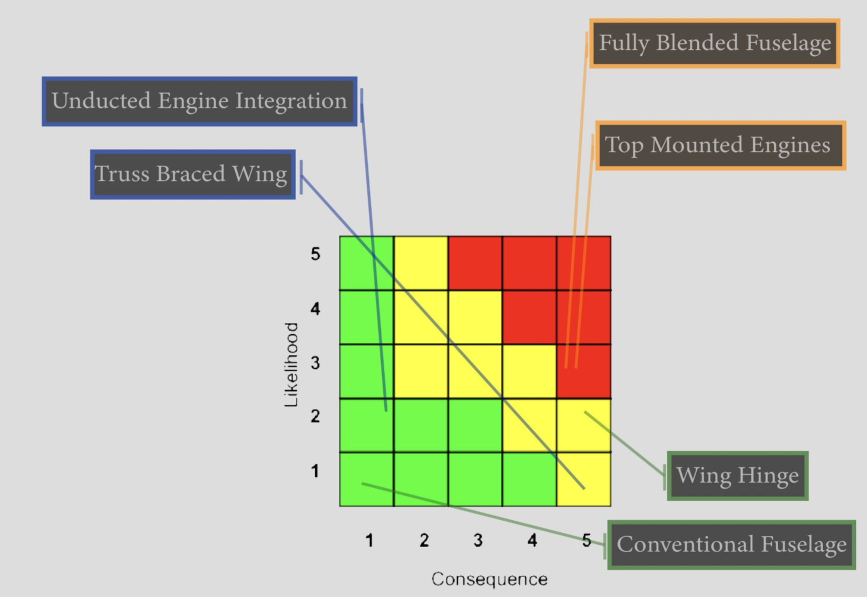
1.) **Top-Mounted Engines** allow for noise reduction both in the cabin and the exterior. However, they pose a risk as there is no fuselage or structure in between the two engines, so if one fails it could take out the other.
2.) **No Conventional Tail** represents a large drag reduction.
3.) The revolutionary oval **Spacious Cabin** serves as an attractive feature for customers.
4.) The **Fully-Blended Fuselage** is the Flying-V's major advantage as the entire body works as a wing giving the greatest efficiency gains.

DATA AND FINDINGS

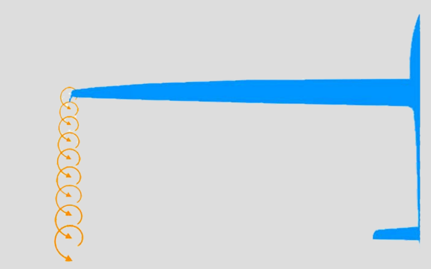




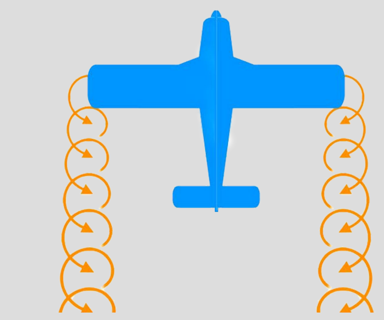
Unducted Engine



High Aspect-Ratio



Low Aspect-Ratio



Aspect Ratio =19.55 Cruise Speed = Mach 0.8 (593 mph) Wing Span = 170 ft (52 m) Passengers = 150-230	Aspect Ratio =18 Cruise Speed = Mach 0.8 (593 mph) Wing Span = 170 ft (52 m) Passengers = 150-250	Cruise Speed = Mach 0.85 (652 mph) Wing Span = 213 ft (65 m) Passengers = 315
Efficiency- up to 20% - ducted engine -up to 30% - unducted engine (compared to current equivalent planes)	Efficiency- up to 13% - ducted engine -up to 17% - unducted engine (compared to current equivalent planes)	Efficiency- up to 20% (compared to current A350)

CONCLUSIONS, IMPLICATIONS, AND NEXT STEPS

With respect to the TTBW and Albatross one; the NASA SUGAR project, which created the TTBW, reported that by 2030 there will be a need for almost 26,000 new aircraft. Of these, about 70% of this demand will be aircraft the size of the TTBW and Albatross One. This demonstrates a massive demand for production of both aircraft. Each manufacture will work to produce as many possible and at this stage we will assume that each will be produced at the same rate.

The TTBW is radically different to the current 737s, and therefore will require slightly more transition time than a carrier transitioning from A320 to Albatross One. However, the major advantage of the TTBW is its greater efficiency gains. These are essential and will separate it from the Albatross One as regulations against emissions increase. Boeing is relying on their greater efficiency gains to get orders.

Furthermore, as commercial travel grows, we have seen a great increase and expansion in budget airlines such as Ryanair. These airlines operate lean routes which are longer routes with smaller planes. This plays into the TTBW's advantages as it's efficiency gains are optimized during its cruise. Therefore, the plane is more efficient operating on the upper end of its range. This advantage as well as the massive growth in budget airlines leads to a convincing argument for the TTBW beating out the Albatross One for dominance in their market.

In regards to the Flying-V, the main concerns are its integration into the current infrastructure and passing regulations. The Flying-V is a radically new design for commercial aircraft and therefore will have to prove itself against strict regulations and have to rewrite some. One major concern is there being no structure between the two engines. This means that if one engine blows out it could knock out the other one which is intolerable. The untested nature of a blended wing commercial aircraft mean it would be at least 2040 before we see the Flying-V or other fully integrated wing aircraft enter service.

REFERENCES

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***Works Cited:**