A COMPREHENSIVE ANALYSIS OF TWO INNOVATIVE AIRCRAFT DESIGN CONFIGURATIONS

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ABSTRACT: The purpose of this study is to understand the need to pivot for newer Aircraft of different design configurations. A comparative study has been made in terms of design, performance, controllability, layout structure, production, economical constraints, noise, and safety concerns by keeping environmental impacts and an increase in demand for air travel in mind. The two configurations that have been compared in this study are the Blended wing body and The Flying V.
This study also includes a public opinion about the requirements of an aircraft. A research analysis was made by considering factors like design, price, safety, comfort, and speed. A detailed statistical analysis was made using graphical representation and a conjecture was made based on it.
A feasible design configuration for future Aviation is found through this comparative study.

Keywords: Blended wing body(BWB), The Flying V, Aircraft, Design, Performance, Fuel consumption, Aviation.

INTRODUCTION:

Every day, global ties improve, making trading between countries simpler and faster, resulting in increased demand for air travel. According to the International Civil Aviation Organization (ICAO), air travel revenue and demand are expanding at a blistering pace of 4.5 percent per year [1], resulting in a contribution of 1.5 trillion dollars to global GDP by 2036 [1]. This demand will result in higher consumption of fuel and increased amount of greenhouse emissions through various means like jet propulsions, manufacturing, and wastage management, It is estimated that by the year 2050, the aviation industry would contribute 10-15% of global warming [1], and current emissions of co2 will grow to 21.2 billion tons by 2050 [2]. This huge expansion will not help the global climate change targets of keeping global warming to 1.5 degrees Celsius above pre-industrial levels [3]. Remarkable efforts are being made in order to reduce fuel consumption and fuel emissions as part of the 'Net Zero Carbon Emission Challenge' by the International Air Transport Association(IATA) [2] via using of composites in the structure to reduce aircraft's weight, synthetic fuels having better thermal efficiencies over conventional fuels, advancements in jet propulsions, evolutionary changes in structure and design Despite the fact that these efforts resulted in significant reductions in fuel consumption, a modification in the conventional aircraft's complete design configuration is necessary to attain the projected objective of fuel economy. This prompted extensive study and development of aircraft design options that might assist the aviation industry in meeting its green objectives.
Among various researched configurations a distinguishing study about the two most probable configurations is selected because of their aerodynamic efficiency and compactness.

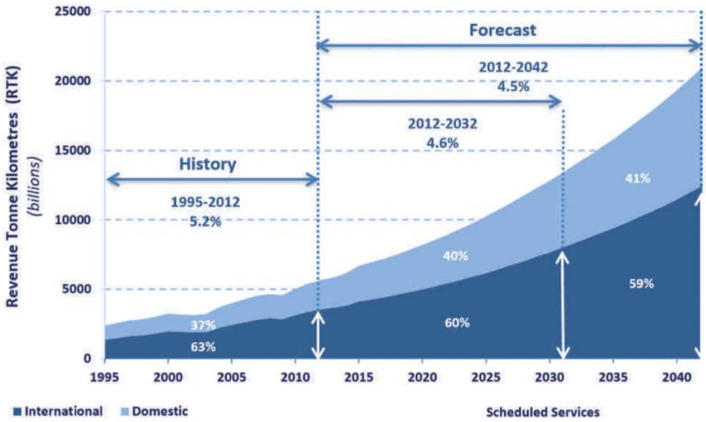


FIG1: **REVENUE PROJECTIONS FOR COMMERCIAL AIRLINES TILL 2050**

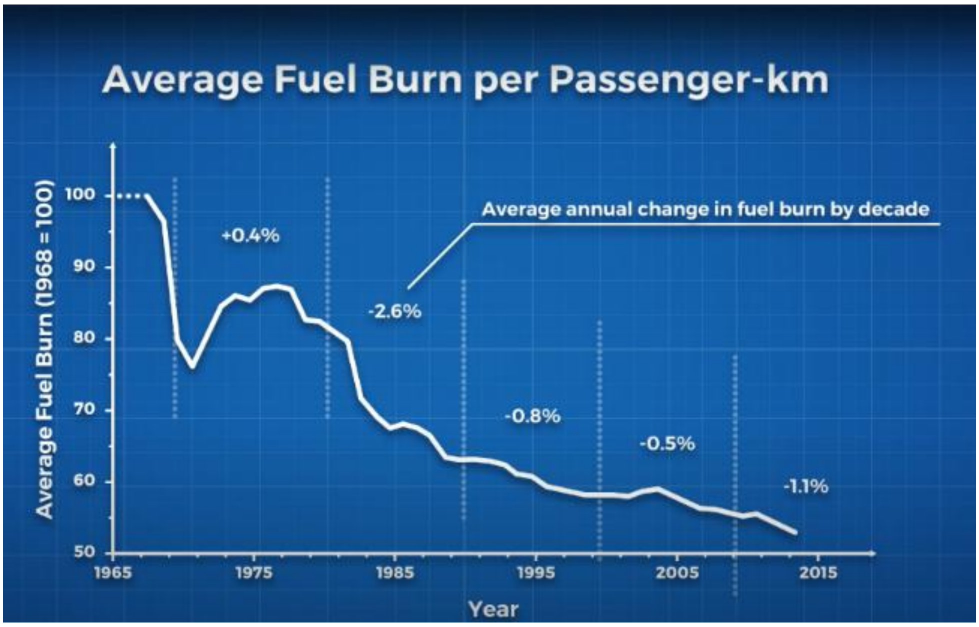


FIG2: AVERAGE FUEL BURN PER PASSENGER-KM

1. Blended wing body

First proposed by Liebeck in 1988 in the Langley workshop attended by various aerodynamic engineers and aerodynamicists to answer what could be the next revolution in the long haul aviation [4]. A blended wing body is a smoothly blended structure of aircraft wings with a central fuselage into a single entity of lifting surface. Along with its increased aerodynamic performance, it facilitates increased passenger space(high enough to carry 800 members) and comfort as well as for cargo [4]. The biggest advantage of BWB over any conventional aircraft is the absence of tail and vertical stabilizer which together are the reason for almost 20% drag created. Reduced drag can lead to lesser fuel consumption which in turn can result in longer and cheaper travels. The study conducted by Liebeck promised 25.1% less fuel burn, 15% weight saving, 12% lower empty weight, 27% less total thrust required, 20% higher lift to drag ratio and 12% less operational cost relative to current commercial aircraft of similar size(A380-700). [4]

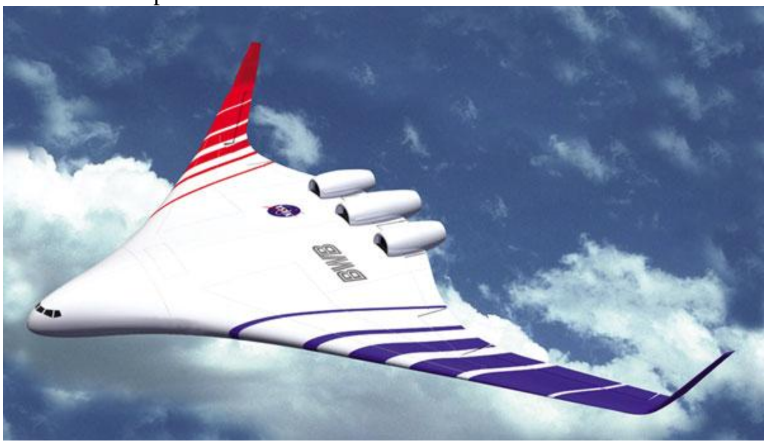


FIG 3: BLENDED WING BODY AEROPLANE CONCEPT PICTURE

2. The Flying V

To counter the required aviation goals J.Benad introduced ‘The Flying V’ in his post-grad thesis in 2015 [5]. It comprises two fuselages aligned at an angle which allowed the cylindrically pressurised cabins to create lift maintaining a smooth lift distribution throughout the body. His ingenious airfoil design allowed the aircraft wing to be wide enough to generate enough lift without any requirement of highly complex HLDs (High lift devices) making its manufacturing quicker and easier [6]. The benefits of placement of jet engines at the rear can increase their fuel efficiency. It is observed an increase of 10% in (L/D) ratio, a reduction of 2% in empty weight, about 20% less fuel consumption when compared with a reference aircraft having same capacity(315) and a Mach number Ma = 0.85 i.e, Airbus 380- 900 [5]

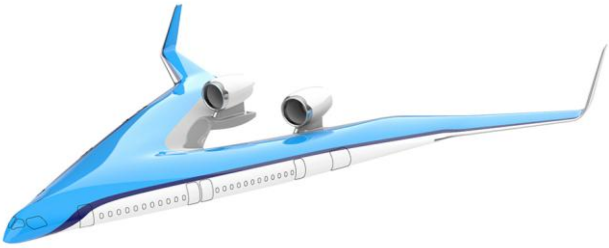


FIG 4: ARTIST VIEW OF THE FLYING V AEROPLANE

In-depth comparisons are done between these two configurations in five distinct criteria, three of which are chosen from the manufacturer's perspective and two from the passengers' perspective.
According to the manufacturers, the parameters that can provide them with an advantage over their competitors while still complying with environmental aims and safety protocols are the most important.
These can be broadly classified into
1. Design
2. Controllability
3. Performance
4. Safety protocols
5. Luxury
A Research survey is undertaken to get consumer feedback on their desires

HYPOTHESIS:

Since the BWB configuration concept was introduced almost 40 years ago extensive quantitative and qualitative research has been made into this, aerodynamicists from all over the world have been modifying its design to make it more and more efficient and sustainable as compared to that of conventional aircraft. Whereas, The flying V design is a new concept introduced in 2015 with limited research, based solely on simulations and theoretical calculations. So the hypothesis of this study is that Blended wing Body aircraft is better than The flying V aircraft.

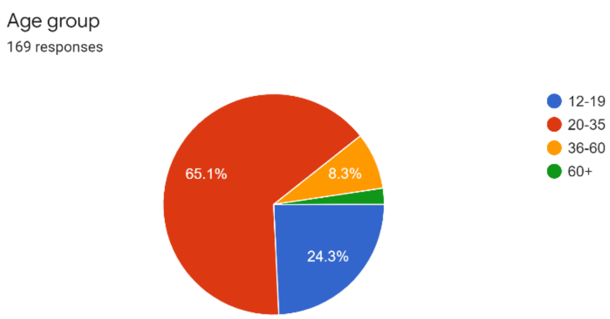
RESEARCH OBJECTIVE:

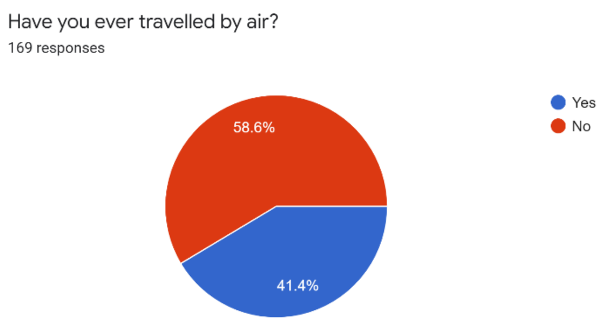
To do a thorough comparison of the BWB and the Flying V aircrafts.
To gain a better understanding of the consumer's viewpoint on air travel
To determine the sustainable design configuration between The BWB and The Flying V

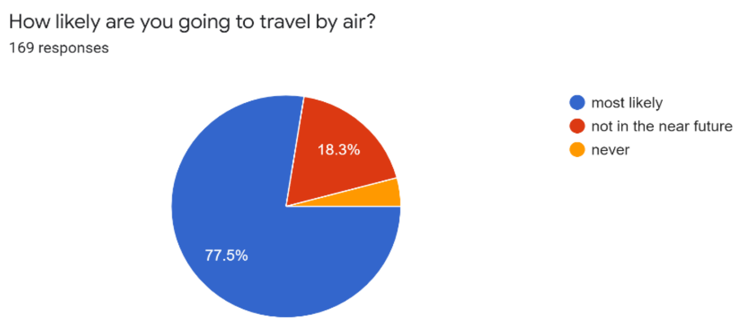
METHODOLOGY:

The present study is based on both primary and secondary research. The qualitative and quantitative methodology has been adopted for the purpose of the study.
Primary research: We have conducted a research survey with some set of questions on the public’s requirements for their present as well as future air travel.
Secondary research: We have used secondary sources that are available study materials, such as books, journals, research papers, websites, and many more. We want to capture an in-depth understanding of two new aircraft configurations and their sustainability.
Point system: Each aircraft was graded on five factors namely Design, controllability, performance, safety, and comfort, a point was awarded to the aircraft with a better advantage over the other for each factor. The aircraft with higher points out of five is considered the next possible sustainable commercial aircraft.

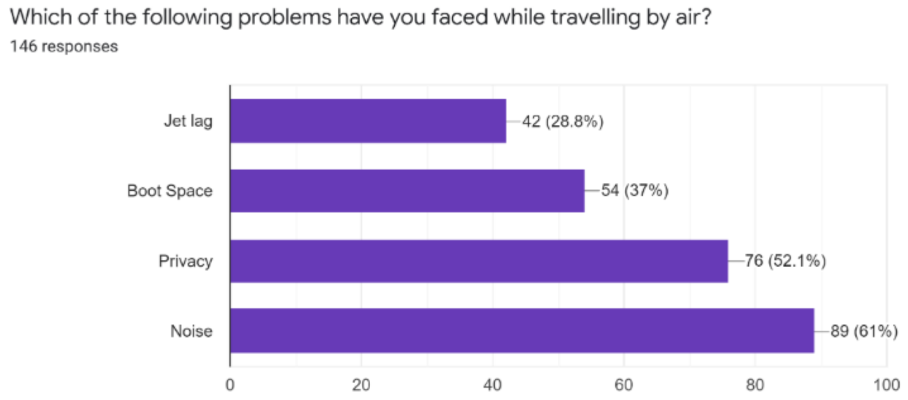
RESEARCH ANALYSIS:



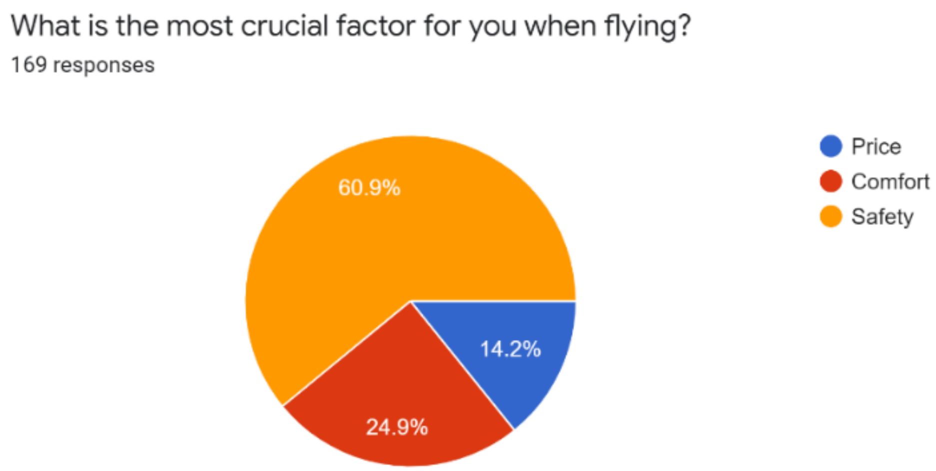


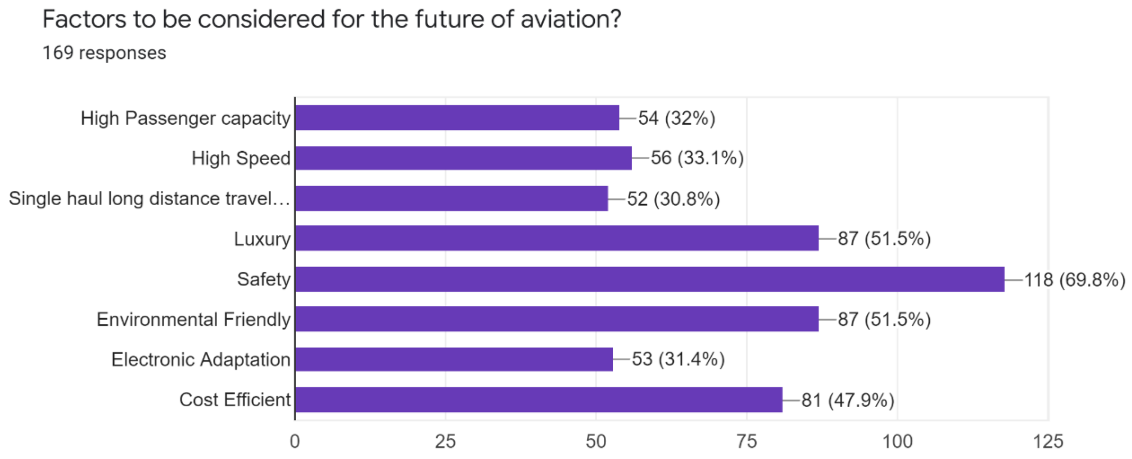


A survey is conducted with 169 participants from various professions majorly in the age group 20-35(about 65%), out of which about 58.6% of participants never travelled, but that situation is about to change as Approximately 77.5% of them are extremely likely to travel by plane soon. This suggests that demand for air travel is increasing, resulting in more planes and crowded airports.

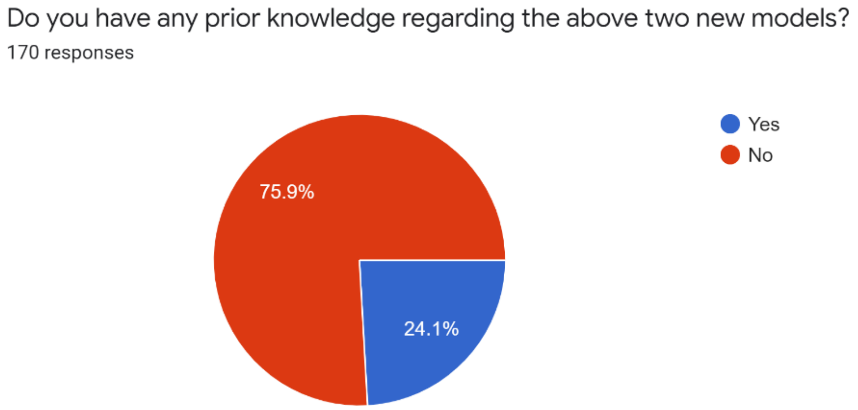


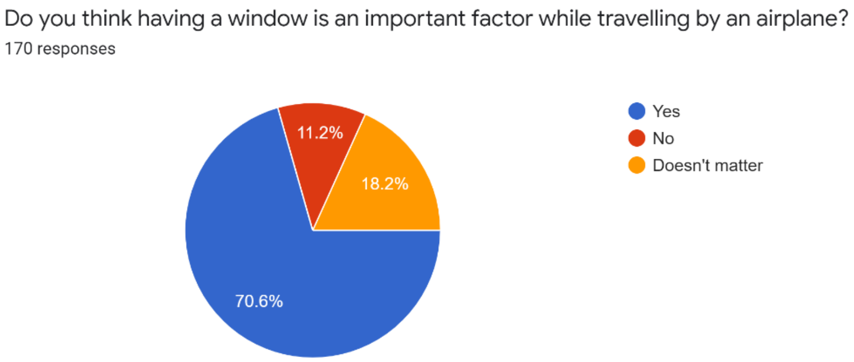
As the statistics show (approximately 61% of passengers had noise-related issues), noise is one of the most serious issues that current air travellers face, and with more planes in the air, the situation is only going to get worse, possibly leading to a situation where living near airports is simply unbearable. Another major issue (about 37%) is a shortage of boot space. As many commercial airlines strive for cost-effective travel, spacious boot space is frequently insufficient, and high amounts of payments are necessary to carry extra luggage. About 42 out of 169 mentioned jetlag but it can be overlooked because jet lag is a natural phenomenon that cannot be remedied. Privacy is becoming a more significant demand (52.1% chose privacy). It is critical to recognize that while privacy can be had by traveling first class, it is out of reach for the majority of people.





According to the results of the poll, 103 out of 169 participants choose safety over affordability and comfort, making safety the most crucial factor for any traveller while flying. With the recent Boeing 737 Max tragedies, the world's dread of flying has grown. This prompted individuals to seek safer alternatives at a monetary expense. Cost efficiency was chosen by 81 participants (47.9%), and an environmentally friendly route was chosen by 87 participants (51.5%) after deciding that safety is their top priority. The public's desire for luxury and solitude is a startling finding. People began to be hesitant to fly with other passengers after the Covid 19 scares, as they had grown accustomed to the luxury and comfort of their own homes, prompting airliners to go the extra mile in their hunt for more comfort and luxury at affordable prices. Future commercial air travel will be defined by luxurious travel at very low prices.





It was discovered that approximately 70.6% of those polled preferred windows while flying because they allow them to see what is going on outside and it does not create a sense of claustrophobia. It will be extremely important in emergency scenarios and in inclement weather to determine the state of the exterior.75.9% of people polled had no knowledge of BWB and The Flying V aircraft configurations, indicating a lack of knowledge and awareness among the general public about next-generation aviation.
Thus, by analysing and evaluating all of the responses, it was discovered that just a few individuals considered high speed (33.1%), high passenger capacity (32%), and EV adaption (31.4%) to be the future of aviation, demonstrating that the future is all about safer and more comfortable travel.

This prompted us to select **Safety** and **Luxury** as the other two categories in this research along with **Design**, **Controllability**, and **Performance** to arrive at the conclusion of this comparison study and choose the optimal design configuration.

1. DESIGN

Both aeroplane structures were designed with the sole purpose of increasing aerodynamic efficiency via innovation, but the methods employed to achieve this efficiency differ. The Blended wing Body configuration is created by searching for the best aerodynamic design with the least amount of drag that can create lift throughout the entire body. All of the problems that this configuration has, such as control, stability, engine placement, and complexity, are solved through years of research. The flying V configuration attempted to address all of these issues with a novel and simple construction that nevertheless had a more aerodynamically efficient wing arrangement than traditional aircraft.

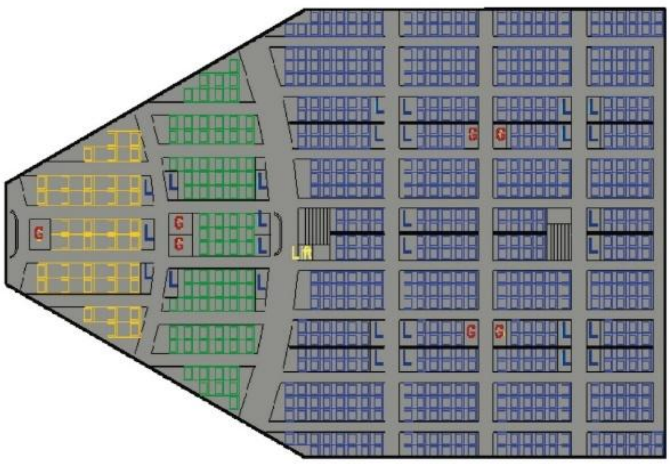
Design of the Blended Wing Body:

As the name suggests the fuselage (Tube) of a convention commercial aircraft is completely fused with its wings increasing the cabin space in the wing structure while uniformly distributing the lift throughout its body [7]. The wings are swept backward and thicker in size, winglets at the end of the wings are designed to reduce the amount of vortex drag and also to manoeuvre the aircraft due to the absence of a vertical stabilizer [8]. One of the brilliant characteristics of this configuration is the placement of Jet Engines on the top of the aircraft at the center of the rear end, allowing for the possibility of bigger and high thermal efficiency Jet propulsors that are not possible to place in the conventional tube and wing configuration, underneath the wings because of the limited clearance space with ground and the fear of structural distortion due to high bending moments. This placement also helps combat noise generated due to turbulence and jet exhaust.[i]

FIG 5: LAYOUT STRUCTURE FOR 750 PASSENGERS

The seating for passengers is arranged in the form of 6-8 aisles in the upper deck of the aircraft with business class represented as green and economy class represented as blue and an exit way accessible to each aisle, The cockpit at the front of the aircraft is similar to that of a conventional but with complicated controls [9]. The position of Lavatories and crew space can easily be seen from the figure. The lower deck of the aircraft is occupied by cargo and fuel tanks. The doorway for cargo loading and unloading is provided at the rear end of the aircraft. Most of the fuel is stored in the lower deck of the aircraft and about 20% of it is in the wings. The fuel is supplied from both the wings simultaneously to the engine to uniformly balance the weight composition of the aircraft. The major conflict with this aircraft configuration is the absence of windows. This conflict is combated with the use of a Large LCD screen to present the outside view. [4]

The unconventional BWB fuselage is designed considering aerodynamic effects while keeping bending, torsional, and longitudinal loads in mind. The pressurised cabinet is ovulated to increase space for passengers and cargo. This oval shape of the cabin can be constructed in two different ways either a centralised square structure or an internal cylindrical structure to make sure that pressure is uniformly varied in the cabin so that the structural stress is lessened. passenger cabin consisting of several cylindrical pressure



vessels tied together in a fashion similar to a conventional double-bubble fuselage. [6]

Because the BWB central body is a noncircular pressure vessel, all of its outside surfaces bowed, as opposed to a circular or cylindrical pressure vessel's pure tension. (Interior features like cabin walls are used as membranes to keep the wing skins in place.) As a result, the pressure vessel encircling the passenger compartment was far thicker than a typical airliner's narrow pressure vessel. Furthermore, the pressure vessel's upper and lower surfaces served as wing skins, absorbing wing-bending stresses. Surprisingly, this increased their strength and, as a result, their weight. [7]

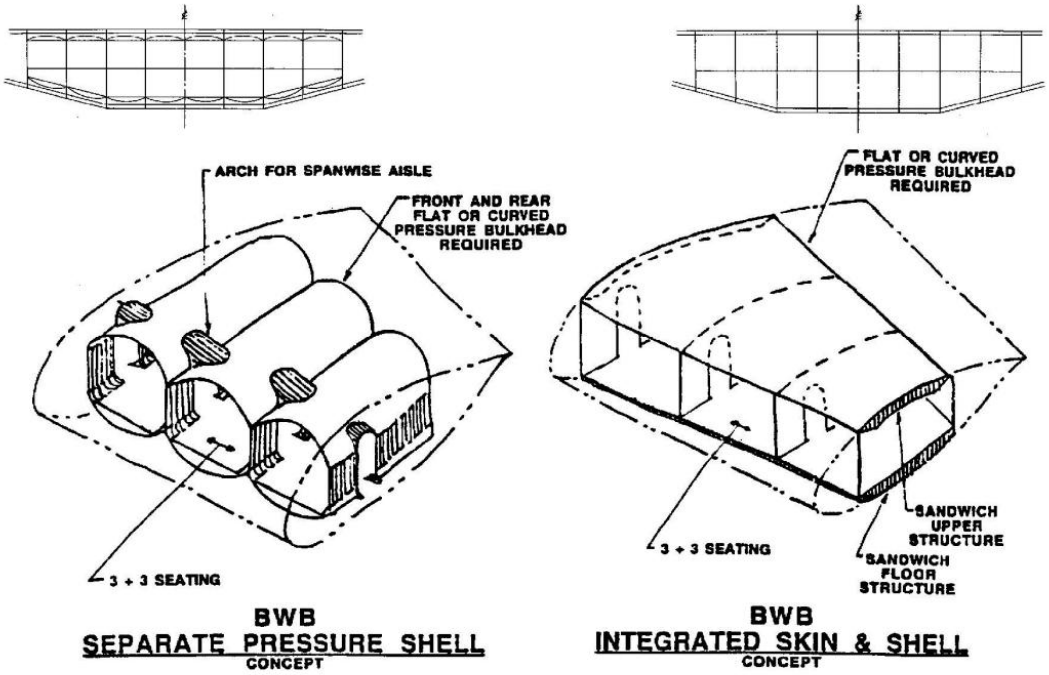


FIG 6: INTERIOR DESIGN LAYOUT OF BLENDED WING BODY

Design of the flying V:

This configuration adopts the inclination of two conventional fuselages, this enables uniform weight distribution, smooth lift variation and reduced size hence making it versatile. This also makes it possible to use the aircraft for longer hauls, higher passenger count and short duration luxurious travels. [6]

Its main advantage is having a shorter length due to its V shape which helps it commute even between smaller airports with shorter runways which was not the case in BWB aircraft. [5]

Position of fuselage and jet engines:

The fuselage is in the shape of an airfoil enabling lift and aerodynamic stability while the V shape helps transformation of weight equally. [5]

The winglets are attached at the toe end of the fuselage which reduces the vortex and induced drag. These winglets are designed in such a way that their sleek and strong structure can easily control the roll actions of the aircraft while maintaining drag to the least possible extent. [6]

The proposed position for Jet engines is in the mid-way of the fuselage so that streamlined air can enter the turbines and exhaust noise can be dampened with its rear structure, thus increasing its thermal efficiency to an unprecedented level and reduction in noise pollution [10]. Making it the most efficient design configuration. This design layout allows for a bigger engine configuration, which reduces specific fuel consumption. [5]

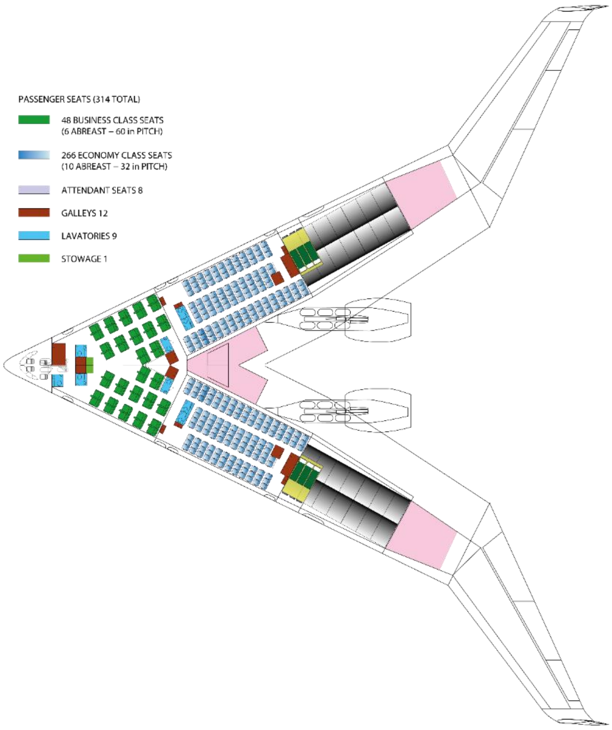


FIG 7: SEATING ARRANGEMENT OF THE FLYING V [6]

Seating Arrangement:

The seating arrangement in flying is shown in the above figure with a business class at the front followed by an economy class in the back. Seating for passengers is allotted to avoid the creation of additional bending moments. Exit ways are provided similarly to that of conventional aircraft. These seats are aligned at an angle of 25° to vertical to create more boot space and compensate for the aligned V model. [5]

Since the seats are aligned at an angle of 25 degrees and are not along with the V shape of the aircraft, the onboard experience is similar to that of a conventional aircraft.

Cock pit resides at the front with controls that are different to that from conventional.

The simplicity of the structure will act as an advantage as it is easier to adapt to the present aircraft manufacturing hub. The fuel is placed on the toe end of the airfoil. [5]

Similar to that of BWB fuel in flying V is also supplied from different compartments in a coordinated sequence to ensure no additional moments are added.

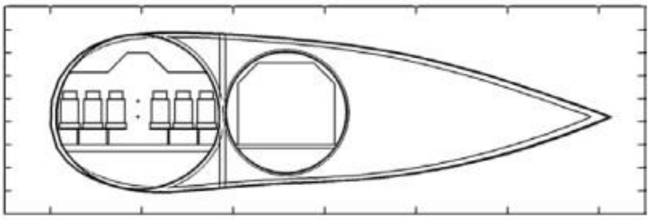


FIG 7:DESIGN LAYOUT OF THE FLYING V

In a conventional aircraft in which the pressure is uniformly distributed along the length of the aircraft the bending stresses acting are constant. But in the case of the BWB, according to its design specifications, if it is built in such a way, the pressure distribution is not constant and hence the bending stresses acting vary. To counter these bending stresses material with high tensile strength should be used, but this increases weight and a decrease in overall performance. To overcome this issue, the design of the Flying V is modified in such a way that each of the segments namely passenger seating, cargo and fuel has been fit into a cylindrical or tubular area similar to the conventional aircraft along the aerofoil cross-section. This design allows the pressure to be uniformly distributed and overcome the problem of varying bending stresses [4].

So when compared with the BWB aircraft, its complex design configuration along with the unconventional cabin structure makes it difficult to avoid stresses which are induced at a certain point and also makes it difficult to avoid the residual stresses. Hence this results in the usage of high strength materials requiring high elasticity which are often hard to extract making them expensive and time-consuming. **This puts Flying V one step ahead.**

2.CONTROLLABILITY

The centre of lift of any aircraft doesn't coincide with its centre of gravity as the aircraft constantly experience turbulence It is imperative to have a stabilizer that rotates the aircraft about a centre eccentric to the centre of gravity so that even minute disturbances can be easily dampened enabling smooth travel, thus the inclusion of horizontal and vertical stabilizers and the rear end of the aeroplane is essential for smoother and safer travel. This inclusion comes with the cost of up to 20% increased drag and 5 % reduced lift [4], keeping fuel efficiency in mind and with the availability of better technology making wire controlling easier and effective. The different aircraft directional movements are classified into the following:

1. Lateral direction
2. longitudinal direction (or lift)
3. pitch
4. roll
5. yaw

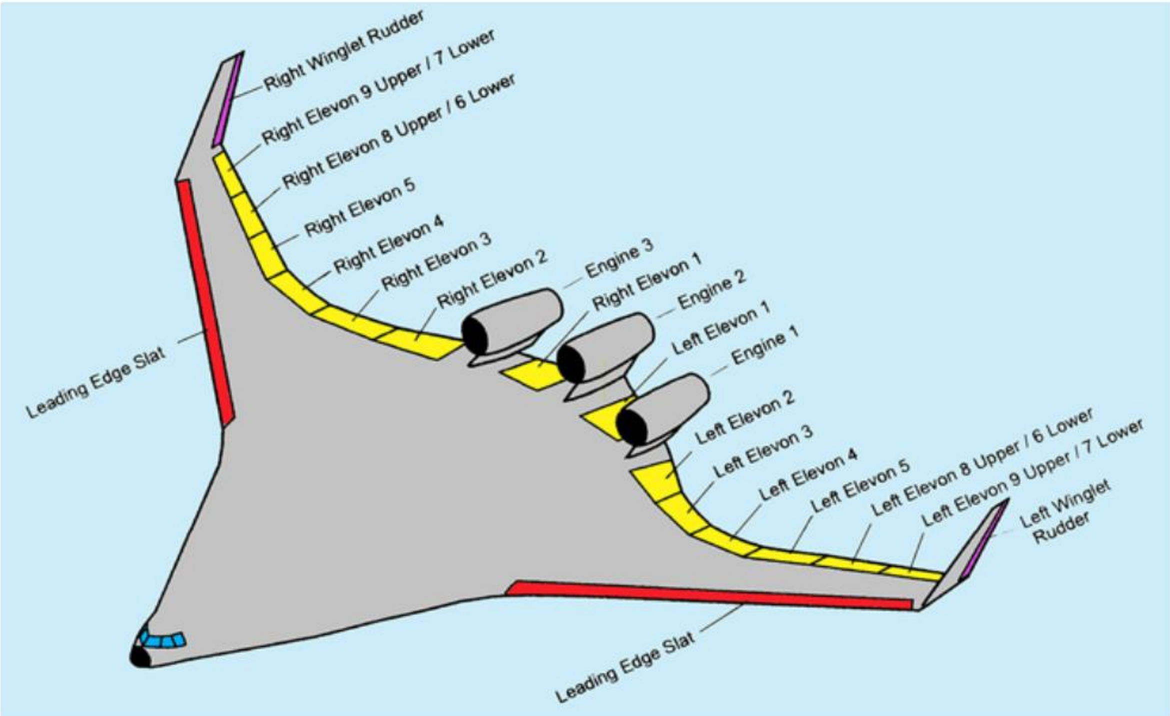
The various developments obtained to control these 5 movements of BWB aircraft and The Flying V are given below

The BWB:

Lateral direction movement is provided by thrust generated by jet engines which are present centrally at the aft end of the aircraft, when thrust generated by these engines is equal to the drag induced the aircraft moves at a constant velocity, the aircraft accelerates when thrust generated is greater than that of drag induced and decelerates drag induced is greater. [7] This drag can be obtained by rudders attached to the winglets. Leading-edge slats located at the front of the blended wing can control the roll actions of the aircraft. [4]

The BWB's pitch controls had a shorter lever arm to the vehicle's centre of gravity than on a conventional aircraft configuration with a long fuselage extending the rear of the wing and sprouting a tail group [8]. This basic BWB tunnel configuration had 18 elevons distributed along the trailing edge (two of the outboard elevons were split that is, they formed both an upper surface panel and a lower surface panel, with twin actuators, so they could serve both as elevons for pitch-and-roll control and as drag rudders), rudders located on each winglet, and leading-edge slats. The configuration had three pylon-mounted engine nacelles located on the upper rear centre body. [4]

FIG 8:



The 18-elevon BWB-450-1L configuration used as the basis for NASA and other wind tunnel model studies. (NASA)

The Flying V:

Similar to that of BWB aircraft Lateral movement in The flying V is also controlled by mid-way placed Jet engines. The lift is provided by the entire design configuration shaped as an airfoil.

Pitch and roll control is provided by the segmented elevons at the trailing edge of the outboard wing. Yaw control is provided by the rudders, which are integrated into the winglets The large sweep angle and low aspect ratio of the aircraft imply that a relatively large inclination angle is required to attain enough lift during low-speed conditions the aircraft comes in for a landing with its nose raised fairly high the undercarriage consists of relatively long landing gear legs. [11] Because of its simplicity and airfoil design number of elevons required to control the aircraft are similar to that of conventional aircraft and very less when compared with BWB. [5]

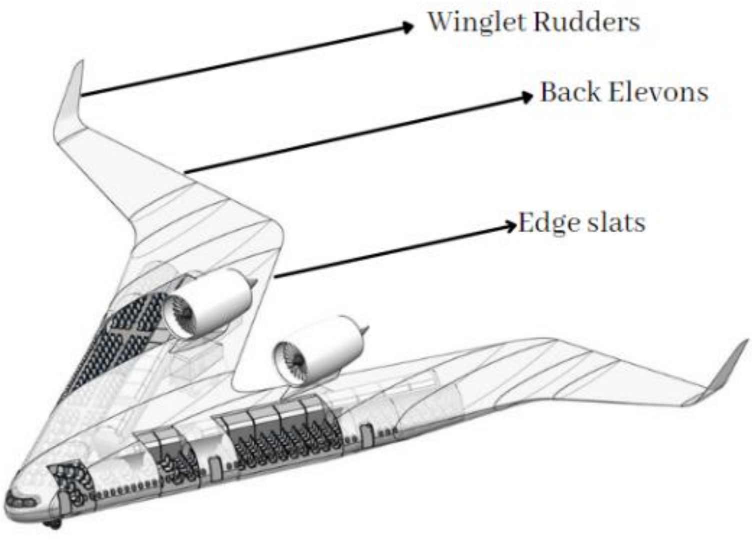


FIG 9: ARRANGEMENT OF ELEVONS AND OTHER CONTROLLING FLAPS IN THE FLYING V

The Increased number of elevons on an aircraft makes controlling difficult and complex, without the involvement of advanced technology making those subtle changes to stabilize the aircraft movement, it is highly laborious and difficult even for skilled pilots to maintain its orientation throughout take-off, high elevation flight, landing each movement requires different orientations of an aircraft for an extended period which makes the job harder to balance the aircraft. This autonomous manoeuvrability comes with its setbacks like assessing corrupt data due to the failure of sensors, the ability to recognise and return the vehicle to a stable position when one of the wing flaps is destroyed, and data processing under adverse weather conditions. All these factors combined impact recapitulation of Blended wing body structure over a period of time**, thus taking the certainty of The Flying V configuration one more step ahead**

3. PERFORMANCE:

Advances in technology in both the design and production sectors pushed the aviation industry to improve its competence and productivity, making air travel more affordable and safe. As a result, several businesses were able to enter the aviation industry. This made Airlines seek greater performance and qualities in every aspect of the plane as the number of flying alternatives grows in tandem with the growth in competition. Thus, performance is by far the most crucial component for an aircraft, as it aids airlines in surviving in this competitive environment.

The main aim of this chapter is to compare the performances of these two configurations and find out better-performing aircraft using this comparative data as well as Breguet's efficiency formula. This comparison is performed between two BWBs of comparable size, flying in V configurations, with similar passenger numbers and powered by the same jet engines. As a result, we can draw a fair comparison. [4] [6]

TABLE 1: Common Specifications of the BWB and the Flying V.

Specifications	**BWB**	**The Flying V**	**Units**
Design Range	13680	15750	Kilometre
Passengers	368	378	-
Cruise Mach	0.85	0.85	-
Engines	2	2	VHBR Engines
Wing Span	80	65	metre

The majority of the research and development on both configurations is done with these five variables in mind.

1. Aspect ratio – The ratio of the square of wingspan with the wetted area (surface area of the aircraft body which is contributing to lift), the general rule is that higher the aspect ratio lesser the induced drag which further reduces fuel consumption. Higher the aspect ratio greater the wingspan resulting in reduced vortex drag, but wings with higher wing spans require greater strength to counter bending and torsional stresses this leads to increased weight thus ideal ratio should be maintained.

Formula: **AR - b^2/wetted area**

2. Lift/drag ratio - it is the ratio of lift generated by an aircraft wing per unit drag induced, Aircrafts with greater L/D ratios are more efficient since less drag is created on the winglet, the aircraft can be lifted with less amount of energy, thus resulting in fuel efficiency.

It is determined by the formula

$$\left(\frac{L}{D}\right)_{\max} = \sqrt{\frac{\pi AR}{4kC_{D_0}}} = b\sqrt{\frac{\pi}{kS_{D_0}}} \quad (1)$$

where AR and b are the aircraft wing aspect ratio and wingspan, Cd0 is the zero-lift drag, Sd0 is the zero-lift drag wetted area and k is the induced drag factor, with all the parameters being similar except for Sd0, the lower wetted area gives higher L/D ratio.

It can also be determined as the ratio of lift coefficient with drag coefficient.

3. Operating empty weight (OEW)

structural weight of aircraft measured when manufactured without the inclusions of payload weight, passengers and crew members' weight, and fuel weight. Aircraft with less Operating empty weight (OEW) is more feasible as the number of raw materials required to manufacture will be decreased, this will also decrease manufacturing time and fuel consumption.

4. Total Maximum Operating Weight (TMOW)

The maximum amount of weight that can be added to the aircraft in terms of crew members, payload and fuel is called total maximum operating weight. Higher the total maximum operating weight (TMOW) more fuel is consumed during take-off and stall periods. Thus it is ideal to have lower TMOW for economical travel.

5. Efficiency

It determines how effectively an aircraft can travel while conserving fuel consumption to the maximum extent possible.

According to the Breguet formula, the efficiency can be given by

$$\frac{ds}{dm} = \frac{a \cdot Ma \cdot L/D}{sfc \cdot m \cdot g} \quad [12]$$

Where ds/dm is the distance travelled by aircraft per unit of fuel,

5.1. a is the speed of sound = 343 m/s

5.2. Ma is Mach number = 0.85

5.3. L/D is lift by drag ratio

For flying V = 20.6

For BWB = 33.3

5.4. m is the mass of aircraft

for flying V TMOW = 266000 kg

for BWB TMOW = 153677.24 kg

5.5. SFC is the specific fuel consumption of engines
Assuming similar jet engines SFC of airbus 350-1000 is taken for both configurations
μ = (efficiency of BWB/efficiency of Flying V) (3)
By substituting the values of the provided table in equations 2 and 3
$\mu = 2.79$
The efficiency of BWB is twice that of flying V

TABLE 1: Performance Characteristics of BWB and Flying V

Characteristics	BWB aircraft	The Flying V	Units
L/D ratio	33.3	20.6	-
Aspect ratio	15	9.55	-
TMOW	153677.14	266000	kg
OEW	88585.58	129000	kg
Efficiency	2.79x	x	-

From the given data and overshadowing radar graph we can understand that the L/D ratio of BWB aircraft is 61.1% higher than that of The Flying V which corresponds to the 57.3% increase of both aspect ratios, For a similar number of passengers and almost identical range distances it is observed that BWB aircraft can operate with 31.3% less Operating empty weight while the Total maximum operating weight of BWB is reduced by staggering 42.2%.The efficiency through Breguet's formula indicates that the efficiency of BWB configuration is more than 2.5times that of efficiency of The flying V.
All these factors combined and many other factors resulted in 5.7% less fuel consumption in BWB configuration than that of 'The flying V'. The radar graph plotting these 5 factors confirms BWB's upper hand. These five factors together and the confirming fuel consumption indicates that BWB aircraft has a better performance making it one step closer to the flying V.

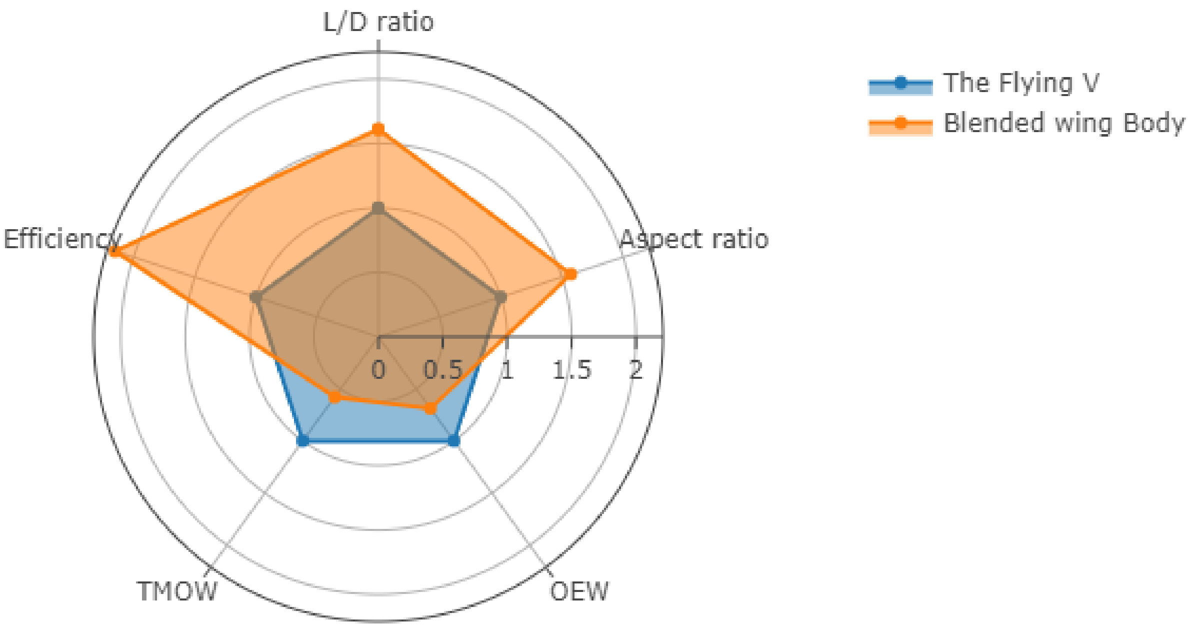


FIG 10: PERFORMANCE CHARACTERISTICS

4. SAFETY

Safety simulation:
The first thing that comes to mind while talking about flying in air is safety. How safe is it to fly by a particular aeroplane? The most important factor to approve any aeroplane are the safety measures taken while manufacturing the plane or any aircraft. The safety factor is the factor that describes the structural capacity of a system beyond the expected loads or the actual loads.
For a General passenger aircraft, structural design is based on a safety factor of 1.5, which has the probability of failure between .001 and .01. Safe life: time period in which a component will not fail when used within the given optimum conditions. Designing a model is not practical to check its safety in real life so rather than going through the probabilistic approaches code-based designs are used to ensure more accuracy while considering the safety measures. The two planes the blended wing body and the flying v are to be checked for safety.
According to the certifications, regulations state that in case of any emergency the passengers should be able to evacuate the aircraft within a time span of 90 seconds when half of all doors are closed. which one do you think is safer? The BWB? or the Flying V? let's check it out by taking the safety simulations of both the BWB and the flying V.
The flying V:
Evacuation simulation of the flying v:
The flying V has two passenger cabins arranged in the shape of V. The passengers face towards the front side of the aircraft and the cargo is more to the outside.

The two main projects seen are the evacuation simulations and the CFD simulations with the lattice Boltzmann method [13].

Evacuation simulations:

A model of The Flying V and the current conventional design is made using the cellular automata software and is compared with the current conventional design with regards to an emergency evacuation. In the current conventional design, the floor field model developed in 2001 is still in usage where a discrete or continuous field is set to diffusion and decay [13].

This model is used to simulate pedestrian traffic. The model follows the idea similar to chemotaxis but with a pedestrian following a virtual rather than a chemical trace.

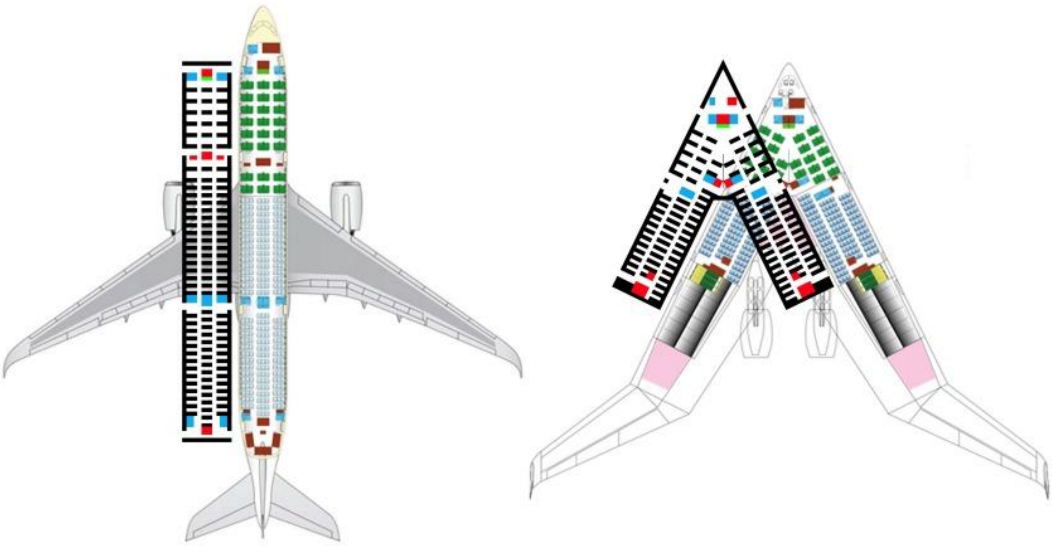


FIG 11: Cabin Comparison of Air 350-900 and The Flying V

The above picture represents the cabin geometry of both the Airbus A350-900 the reference aircraft and the flying V to compare the safety simulations.

The passenger decides where to go by a probability calculated by layering different fields. Here there are three fields taken into consideration they are: gradient, distance and the direction field. gradient field is where the passenger is in an urge to find an exit door in the shortest way possible. The distance field is where the passengers attain random motions.

The overall influence of the distance field is used to calculate the random motion of passengers during the evacuation process. this parameter can be calibrated to find out the evacuation time of the aeroplane configurations. A correction field is applied so that the passengers do not get stuck at the end. it is considered that in this preliminary model all the passengers move with the same velocity is v= 1.3m/s which is considered to be the average velocity of a pedestrian. the transition probability used in the simulation is given by

FIG12

with $i, j \in \{1, 2, 3\}$, where $p_{d_{ij}}$ represents the distance field, $p_{g_{ij}}$ the gradient field, $p_{c_{ij}}$ the correction field, and w_{ij} the wall grid, where a movement is prohibited. The variables i and j represent the adjacent cells that are considered for the calculation of the probability.

From the above simulation, a target evacuation time of 60 seconds could be derived where all the exit doors on the right side are kept closed. multiple simulations were run for calibration [13].

the result achieved from the simulation is as follows

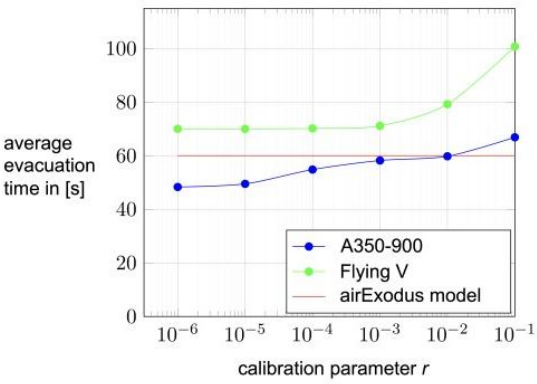


FIG 13: EVACUATION TIME OVER CALIBRATION PARAMETER R

Similarly, various other closed-door configurations were examined and the results were as follows:

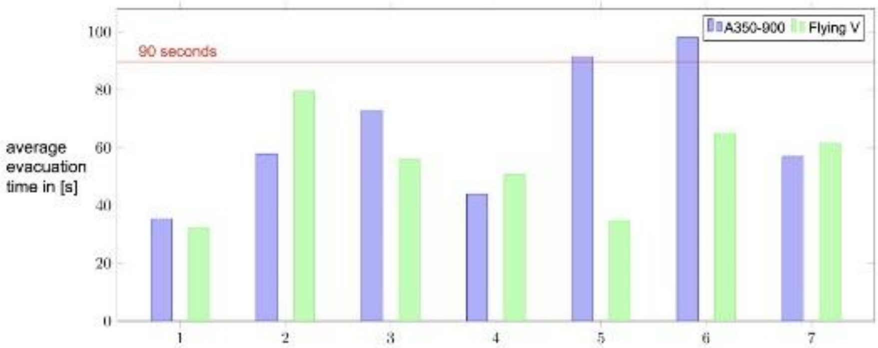


FIG 14: CLOSED-DOOR SIMULATIONS CONFIGURATIONS.

After multiple simulations, the results state that the V-shaped cabin has some advantages over the current conventional design aircraft and the only disadvantage occurs when the doors [13]

are closed on one side, In other all configurations, the Flying V has better evacuation when compared to the A350-900 airbus.

The BWB:

The Blended Wing Body aircraft is one of the most heard aircraft which has a high probability to gear up in the very coming future same like the Flying V. The Blended wing Body models were already made and were tested for evacuation time as we all know safety is the first priority. unlike in the Flying V here, we use a different model known as the air EXODUS. Here it is considered that the agents wouldn't make the same decisions if the simulation is repeated. Considering the designed aisle it was observed that only 2 to 3 exits wouldn't be enough to reach the certification regulations i.e., the plane must be evacuated within a time limit of 90 seconds in an emergency. So the number of exit ways is increased as per the number of aisles provided. Considering the air EXODUS model it had a total of 20 exits that is 10 exits on each side (left and right). simulating the model for times by keeping the right exits closed. [14]

It is found that evacuation time still exceeds the required period of 90 seconds in some configurations and had an average time of 85.9s. Even though the minimum and the average evacuation times are less than 90 seconds as the maximum time observed is 3 seconds over the maximum permitted time it has to be recalled. From the simulations done it was observed that not all exit ways are used with the same importance. the figure given below shows the cabin layout of the FW1-1-1 model of the Blended wing body. [14]

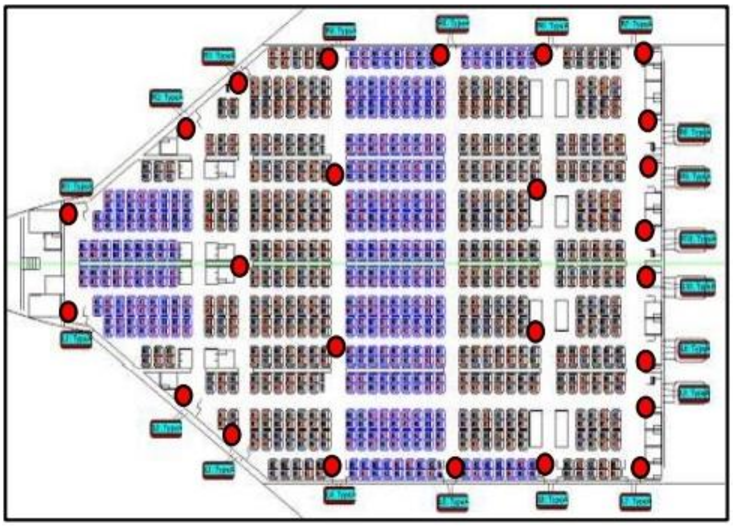


FIG 15: CABIN LAYOUT FOR FW1-1-1 SHOWING THE LOCATION OF CABIN CREW(CIRCLES) AND EXITS (BLUE RECTANGLES)

From the predicted results it was noted that the exits in the south-east corner are not used as much as the others. This is due to the low space availability and the low space congested movement between the passengers is observed. These two exits at the bottom right corner could allow atmost of 56 passengers but due to the less space in the corner, the random movement of the passenger is increased and so is the evacuation time. Due to the large free area near exits 1,2,3,4, it is observed that these exits are the most utilised exits [14].

To utilise the exits 7 and 8 the passengers have to bypass other exits which result in an increase in entropy within the plane. As a result, it is difficult to reduce the congestion in the cross aisles and heavy usage of forward exits can be seen. when the ratio of time spent in congestion to the time spent in evacuation it is observed that a passenger spends an average of 40% of his time in congestion. As we can't just rely on the simulated values it was necessary to undertake experimental evacuation trials.

Keeping the high manufacturing cost and to be practical it was decided to experiment on a cabin of the BWB several times in different configurations for accuracy. A series of 4 trials were conducted over two days with two groups of passengers so that the passenger congestion can also be taken into consideration. It had a count of 375 passengers on the 1st day and 358 passengers on the second day. data was collected using 12cameras which were fixed near different exits to check for the random movements and the congestion. It was found that the result from the air EXODUS software was reflected even in the experimental trials.

The below graph represents the comparative study between the simulated results and the experimental evacuation results for the same configurations [14].

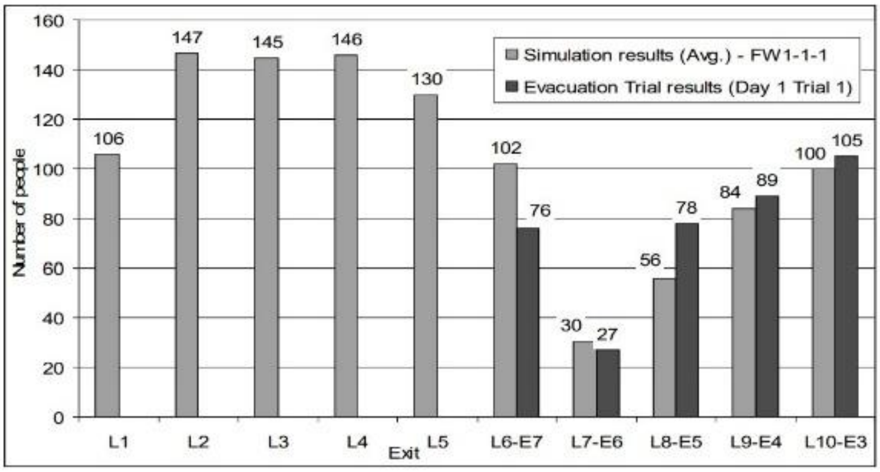


FIGURE 16: SIMULATION RESULTS VS EXPERIMENTAL EVACUATION TRAIL RESULTS

Improved performance compared to the above results can be expected by better utilisation of the rear and the corner exits. This can happen only when the random movement of the passengers decreases and when congestion is also decreased by a suitable factor.

Now By comparing the safety simulation, especially the evacuation simulation we can conclude that **The flying V** is better than the BWB.

5. LUXURY AND PRIVACY:

Luxury! One of the most considered factors while taking the Flight.

Every person from the current generation is waving towards luxury. The term luxury is observed to be gearing up in all the modes of transport including air travel.

Individuals' perceptions of luxury have shifted, with an increasing number of people seeking out lavish choices. From simple bath areas to Jacuzzis, from Benz Motor Car to Limousines, Ferraris, Lamborghinis, from basic ships to large cruises, from warner brothers' simple aeroplane to the emirates first-class flights the evolution has reached.

The Blended Wing Body:

The Blended Wing Body now enters the league to gear up the luxury to the next level where one can have jacuzzis included in the flights, clubs included in the flight, and at the same time having the capacity to carry passengers up to a number 350. The blended wing body has the capacity to conquer the league of luxury. [15]

The Blended Wing Body is in the position to travel for longer distances without taking a stop. As of now, the Blended Wing Body consumes 23% a lesser amount of fuel compared to the current conventional design of an aircraft. The Blended Wing Body also can be used to cover long distances ie., it is capable of single haul long-distance travelling.

The Blended Wing Body is capable to have 3 compartments where the 1st cabin can have the First-class cabinets, 2nd compartment have the business class travellers and the 3rd with the economy travellers. By this time of division, the privacy of each class is taken care of. no passenger from one compartment can face any disturbances from the other. All this is possible only due to the large available space in the Blended Wing Body. This type of flight due to its design can also be modified where the entire aircraft can be made in a luxurious manner where the 1st compartment can include a private club it second can include a party hall and theatre with a rest area [15].

The only challenge that is faced with this configuration of aircraft is the absence of windows in it but this can be overcome by the placement of large screens where they live mirroring can be done. As single haul, long-distance travels are possible with this type of aircraft the requirement to change flights to reach the destination can be called out.

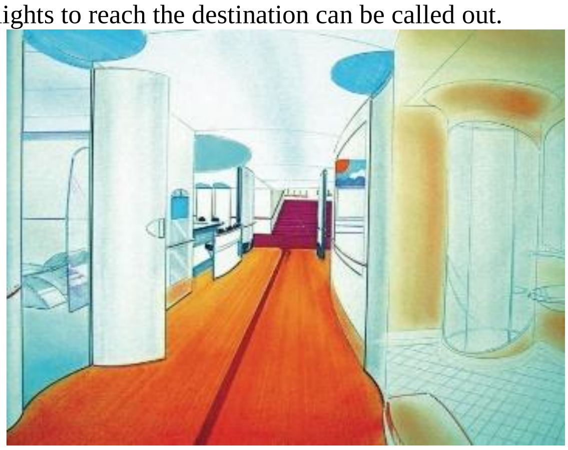


FIG 17: THE LOWER-DECK FACILITIES COULD INCLUDE A BAR AND A HEALTH SPA AREA [15]

FIG 18: ARTISTIC VIEW OF LUXURIOUS CABINS [15]

The Flying V:

The Flying V has only two passenger cabins arranged in the shape of V. The passengers face towards the front while the cargo is placed at the back. The Flying V has small cargo space when compared to the other configurations of aircraft. Due to the compact shape and design, the Flying V, unfortunately, couldn't have more cargo when compared to the other conventional aircraft. [16]
This can be overcome by decreasing the number of passengers and so increasing the free space. The compact design of this aircraft also restricts the plane from making any internal modifications to be lavish enough. The Flying V's compact design can be help full for travelling shorter distances. This design of flying V also enables the possibility for the aircraft to land at the smaller airports in an emergency which is in fact not possible for the current conventional plane configurations. The seating arrangement in the flying V is a little bit congested but can be adjusted for smaller distances. Taking the research completed on the Flying V to date we can conclude that the Flying V is a little bit less luxurious when compared to other Airplanes. The Flying V has windows placed the same as the current conventional designs which help a person suffering from claustrophobia. Taking privacy as a concern the Flying V has less privacy compared to the other configurations as the design is compact and the plane can't be divided into compartments.

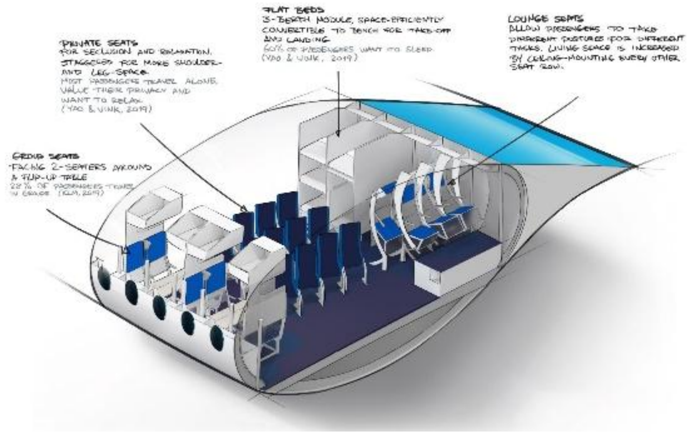


FIG 19: CABIN INTERIOR OF THE FLYING V [16]

From the above two pieces of research, we can come to a conclusion that the Blended Wing Body is more lavish compared to the Flying V in many aspects. Some of the aspects taken into consideration.
These comparisons are:
Total Free space available, possibility to make internal modifications that do not affect the plane's performance characteristics, presence of Windows and privacy.
The Blended Wing Body takes the upper arm by a lead of 3 points whereas the Flying V has only 1 positive point which is the presence of Windows.
So from the above comparative study, we can come to a conclusion that the blended wing body can be more luxurious when compared to the Flying V.

CONCLUSION:

After assigning a point to either The BWB or The Flying V in each criteria depending on their edge in attributes, the result was as follows:
The Blended wing Body: **2/5**
The Flying V: **3/5**
Our hypothesis that The BWB configuration is superior to The Flying V was proven incorrect, as the BWB configuration has a few fundamental conflicts that are difficult to resolve, despite years of research and analysis. Whereas The Flying V configuration overcame all of these conflicts through its unique yet simple design.

As a result, we decided that The Flying V has a modest advantage over The BWB in terms of design, controllability, and safety, all of which work together to bring this design configuration to reality faster than others. This battle for future domination is so tight that even a minor change in topologies can give one significant advantage over the other. Other issues like manufacturing and maintenance costs, noise, and electrical flexibility will also have an influence and can be considered. It is critical to note that the performance of both setups may be significantly improved by optimization and technological developments, which might easily overturn our result.

WAY FORWARD:

This research may be expanded upon in different areas, such as wing and aerofoil design for improved performance. Practical tests with tiny models based on this work may be undertaken in either wind tunnels or the atmosphere, and the findings can be compared to theoretical results. Lift parameters and stress concentrations optimization may be contemplated using simulation tools such as Ansys and Autodesk Fusion 360. It is possible to perform research on next-generation Jet engines that are compatible with these design configurations. Additional studies may also be undertaken to make operating these aircrafts easier. It is possible to do research into transforming these configurations into hybrid or fully electronic versions.

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REFERENCES:

1. D. R. P. Anastasia Kharina, *FUEL EFFICIENCY TRENDS FOR NEW COMMERCIAL JET AIRCRAFT: 1960 - 2014,* 2015.
2. “The Net Zero Carbon Emission Challenge,” in *IATA*, Boston, 2021.
3. “Paris Agreement,” no. United States, p. 27, 2015.
4. B. I. Larrimer, Beyond Tube and Wing, columbus, 2020.
5. J. Benad, “The Flying V,” *A NEW AIRCRAFT CONFIGURATION FOR COMMERCIAL PASSENGER TRANSPORT,* p. 8, 2015.
6. T. Nieuwenhuizen, “CONCEPTUAL DESIGN OPTIMIZATION OF FLYING V AIRCRAFT,” p. 63, 2021.
7. Merino-Martinez, “ Design and analysis of the control and stability of a Blended Wing Body aircraft.,” 2015.
8. G. L. R. F. D. Mark Voskuijl, *CONTROLLABILITY OF BLENDED WING BODY* , no. 26TH INTERNATIONAL CONGRESS OF THE AERONAUTICAL SCIENCES, p. 10, 2008.
9. T. Ikeda, “Aerodynamic Analysis of a Blended-Wing-Body Aircraft,” p. 160, 2006.
10. B. R. P. a. R. Vos, “The Effect of Engine Location on the Aerodynamic Efficiency of a Flying-V Aircraft,” no. American Institute of Aeronautics and Astronautics, Inc., 2020.
11. F. Faggiano, *Aerodynamic Design Optimization of a Flying V Aircraft,* p. 99, 2016.
12. E. Torenbeek, “Synthesis of Subsonic Airplane Design,” 1982.
13. J. G. a. J. Benad, “Flying V and Reference Aircraft Evacuation,” no. Technische Universität Berlin, p. 6, 2021.
14. L. F. Z. W. P. J. L. a. J. E. E. R. Galea, “Evacuation analysis of 1000+ seat Blended Wing aircraft configurations: Computer Simulations and Full-Scale Evacuation Experiment,” no. University of Greenwich, 2010.
15. W.Granzeier, “Blended Wing Body cabin design insights,” no. Hamburg University of Applied Sciences., 2020.
16. P. V. Jun Wu, “Een comfortabele lichtgewicht interieurervaring,” 2021.