

Development of the boeing 747



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Boeing 747 Jumbo Jet: The aircraft that changed the world

Introduction

In the early days of commercial airline transport, air travel saw a large increase in travellers and airport congestion rising in the 1960s. This era of commercial airline travel was led by the enormous popularity of the Boeing 707 and the Douglas DC-8, both of which had revolutionized the standard for long-distance travel[1]. With the increase of commercial airline passengers and the relatively small aircrafts available at the time, airport congestion was becoming a major problem in the industry. Juan Trippe, of Pan Am (Pan American World Airways), one of the Boeing's most important airline customers thought this problem could be addressed by a newer and larger aircraft[2].

During the summer of 1965 on a quiet fishing trip in Alaska, Bill Allen of Boeing and Juan Trippe of Pan Am, the two biggest names in the aviation industry at the time, Trippe told Allen of his vision for a super plane. Trippe wanted an aircraft that was two and a half times larger than any other passenger aircraft that had ever existed before. Both Trippe and Allen were reaching retirement, and both wanted to leave their mark in the aviation industry. It was at this point when the birth story of the Boeing 747 began and would change the aviation industry forever.

Development

In April 1966, Trippe had signed for an order for 25 of the newly proposed super jets and for them to be called the 747. This was one of the largest aircraft orders ever to be made in history. The cost for this order at the time came

to a total of approximately US\$525 million dollars which translates to a value of a staggering US\$4.2 billion dollars today [3]. Allen had also agreed that Tripple could have his order in just a mere 28 months. This had set an almost impossible challenge for Boeing's engineers to complete.

Joe Sutter, a young aeronautical engineer whom graduated from the University of Washington in 1943 was transferred from Boeing's 737 development team to lead and manage the team for the development and design of the new 747 as the Chief Engineer. This was Sutter's first big break as an engineer. With a small team of only 20 members, Sutter and his team were required to go through preliminary studies for this aircraft which provided them with their first challenge for the development of the 747 as at the time all they knew was that the aircraft had to be bigger, have good range and go as fast as possible. Back then, Sutter was only a junior engineer in the company and often faced a hostile reception from the more senior engineers of the company. Despite the size of the project Sutter and his team were facing and how they were working around the clock, they were still not Boeing's number one priority. At the time, the development of the 747 was overshadowed by the development of a supersonic transport aircraft in which Boeing believed would be the future of the aviation industry [4]. This meant that Boeing's best talent and resources was directed into the development of this aircraft.

A supersonic transport aircraft that was designed to travel at three times the speed of sound and to compete with its European supersonic rival, Concorde, which was also in its development stage. When the supersonic transport aircraft was to be completed and come into service, Boeing's 747 would then

be relegated to shipping freight. This influenced the design of the 747 so that it be adapted easily to carry freight and heavy cargo and to remain in production even if the sales of the passenger version were to decline.

Because of this, the 747 was almost expected to be an afterthought and Boeing didn't expect for more than 50 of the 747s to be made and until the supersonic aircraft was completed, the 747 was playing second fiddle the whole time. This led to Sutter and his team being shoved into old premises and starved of resources making their challenge even more difficult than before.

Initially, the shape of the 747 could have potentially ended up very different from the familiar shape we all know today. Tripp demanded an ocean liner of a design, with two narrow decks, one on top of the other. The first idea was to take the original 707 and two of the single aisle fuselages and putting them on top of each other. This idea did not appeal to Sutter because of the poor capability of carrying cargo and he worried that in emergency situations, it was not feasible for passengers to evacuate off the top deck which would have been 25 feet (7.62 metres) off the ground. Sutter also thought the original idea looked like a "Turkey" [5]. Sutter and his team decided that the best move would be to have a wide single deck aircraft by having the two decks side by side which would then be the world's first widebody freighter aircraft. The opening of the nose was the best way to load cargo into the aircraft which caused a problem for Sutter, where to put the cockpit? In a moment of pure genius, they decided the best move would be to place it on top, this birthed the distinctive "bulge" on the 747 [6].

This caused concern for Boeing as they were worried that Trippe, who was paying for these aircrafts would be unhappy that he would not be receiving the double decker aircraft he was originally hoped for. They decided to tell Trippe of the bad news but however, Sutter's management refused to let Sutter tell Trippe as they were concerned Sutter would go too hard on him and make Trippe furious. Instead, they sent their interior designer. They eventually convinced Trippe of the idea by showing him a mock up of what his plane would look like. This enabled Sutter to continue the development of the first widebody aircraft in history.

The next challenge for Sutter and his team was to turn a wooden mock up of the aircraft into a real flying machine. Using wind tunnels, they evaluated the aircraft and its performance in aerodynamic situations. Only the first flight could tell if the aircraft could really fly. This part was still critical because if they had gotten the design wrong during the wind tunnel testing, the consequences could have been disastrous. Sutter's team drew up seventy-five thousand drawings, all of which detailed how every part fitted in the prototype of the aircraft. Soon, Sutter and his team were running out of space. This led to the construction of Boeing's Everett factory. This factory is the largest building in the world in terms of volume and was initially built specifically to produce the Boeing 747 [7].

The first prototype of the 747 was made up of 4.5 million parts, over 100 miles (160 kilometres) of wiring and nearly 75 tonnes (75000 kilograms) of aluminium. The expenses for this prototype were costly and Boeing was faced with another challenge when new orders for the aircraft were made by 25 other airlines meaning that production models needed to be started. The 747

was costing over US\$6million a day, despite this amount, there was no “real” money being received by Boeing as the airline companies only agreed to pay upon delivery of the finished aircraft. This caused a cash crisis for Boeing[8]. To deal with this crisis, Sutter was summoned to a high-level meeting and was faced with the decision of losing his job or being forced to cut over a thousand engineers, which at this point was over a quarter of his workforce. Sutter took a leap of faith and refused to back down or let any of his workforce go. Sutter eventually won the standoff. Boeing had no option but to continue with the project. At this point, Sutter and his team had to speed up the production of the prototype as the scheduled press-launch day was fast approaching. This was a problem as the prototype had more parts on the floor than in the actual aircraft. Sutter and his team managed to put together the first 747 prototype 2 days before the scheduled show day and on September 30, 1968, the 747-prototype rolled out of the Everett assembly building in front of the world’s press and representatives of 26 airlines that had ordered the aircraft[9]. For Bill Allen, this was a relief for him as there was something to show for the press, Pan Am and the representatives of the other airline companies.

This was the aircraft sensation of the decade. However, behind all the excitement, the aircraft still could not fly, and the engines mounted to the aircraft were purely decorative and not functional. From this point, Sutter and his team only had 54 days before the prototype was scheduled for its first flight and they had a major crisis on their hands with the engines as commercial jet engine at the time had the enough power to lift even half the weight of the 747. Jet engine manufacturers, Pratt & Whitney had developed

a new, untested engine that could provide enough power to lift the 747. This engine was the Pratt & Whitney JT9D, a high-bypass turbo fan engine which was an entirely new concept which promised good fuel efficiency, low noise and phenomenal thrust [10]. Fundamentally, this engine was a jet engine which drove a massive fan on the front. The secret to the design was the massive 8-foot (2.4 metre) fan on the front. This allowed for more air to pass through the central turbine and bypassed more than five times as much air around the outside. This bypassing air added an extra 70% more thrust and softened the roar of the turbine at the exhaust, allowing for a quieter engine. Pratt & Whitney promised to make the Boeing 747 quieter than aircrafts half its size and two and a half times more powerful. However, when tests of the engine came around, it had seemed that Pratt & Whitney were promising too much. During testing of the engine, Pratt & Whitney faced the problem of the engine suddenly combusting into flames. For a while, no one could figure out the problem with the engine. During the time, a total of 6 multi-million-dollar engines were written off.

Despite all this, Boeing could not wait any longer and had to prove to the world that the 747 could fly. On February 9, 1969 and two months behind schedule, the first flight of the prototype 747 was conducted [11]. Test pilots Jack Waddell and Brien Wygle conducted the first test flight of the prototype. Despite a minor problem with one of the wing flaps, Waddell and Wygle confirmed that the 747 handled very well. Now that they had proven that the 747 prototypes could fly, they now had to prove to the aviation authorities that the aircraft was also safe enough to carry passengers.

With just 11 months left, Sutter and his team had to begin putting the aircraft through a series of harsh tests regardless of the weather conditions. This included slamming on the brakes at high speeds on the runway, which caused the wheels to burst into flames. The standby crew had to wait an anxious five minutes before they could extinguish the flames. Test pilot, Waddell deliberately flew the aircraft into death defying storms as well as scraping the tail along the runway to simulate a too steep of a take-off. Above all, the aviation authorities wanted to check that the 747 could be evacuated in less than 90 seconds as the 747 would be carrying more passengers than ever before as a single fatal accident could kill more than four hundred passengers. Soon after, the 747 was passing the tests with flying colours due to Sutter's ingenuity to install unparalleled safety features. These features included three back up systems that would enable the aircraft to remain airborne even if only one was working. To Sutter, the safety of the aircraft and of the passengers was the most important features to him during the designing phase of the 747. The very thought of the aircraft crashing due to inadequate safety design is what would keep Sutter up during the night. This set the bar for the safety standard of aircrafts in the industry and the same standard can be seen followed closely by aircrafts made today.

However, Sutter and his team face what is considered every aircraft designer's worst nightmare- "flutter". At certain speeds, wind tunnel tests showed that flutter caused violent vibrations that can shake an entire aircraft apart. Test pilots Waddell and Wygle had to deliberately put the aircraft into the danger zone (when flutter would occur) for short periods of time to learn more about the condition of flutter. After a month a repeated testing and

gathering of information of flutter, they had worked out a solution to the problem. They found that by using small heavyweights at the tip of the wing were able to dampen the vibrations caused by flutter.

During this time, airline companies were investing millions into new facilities to prepare for the arrival of the 747. However, this would have been all for nothing if the engine faults and problems were still unsolved. And with only months left before the 747 were due to go into service, production models of the 747 were piling up outside of the Everett factory. These models usually had concrete blocks hanging off their wings in where the engines should have been mounted [12]. This was to prevent the aircraft from tipping up on their tails as they waited for their completed engines. With all these models grounded, Boeing was closer to bankruptcy than ever before. The team knew the engine problems were serious, but they also felt that Pratt & Whitney were not taking it seriously enough. To solve this problem, test pilots Waddell & Wygell decided to take the president of Pratt & Whitney on a test flight and show them the problem. Waddell blew the first engine and then the second to prove it just wasn't a rogue engine. As he was about to do the third, the president of Pratt & Whitney finally understood how serious the problem was. Because of this, Pratt & Whitney worked harder to find the cause of the problem. The cause of the problem was due to the large front fan distorting the inner engine casing under certain conditions so that it no longer made a snug fit around the spinning turbine blades which caused the air and fuel mixture to break up and explode. This was solved by simply stiffening the casing [13]. At long last, engineers raced to fit the new engines and the 747 could finally go into service.

Conclusion

The Boeing 747 was built in just a mere 28 months and against all the odds and difficulties. The engineers apart of the team responsible will take pride that their creation will be looked at with wonder, well into the future!

[1]“ Boeing 707 Multimedia Image Gallery” retrieved August 28, 2018, from <https://web.archive.org/web/20120111124513/http://www.boeing.com/companyoffices/gallery/images/commercial/707-03.html>

[2]“ Innovators: Juan Trippe” retrieved August 28, 2018, from http://www.pbs.org/wgbh/theymadeamerica/whomade/trippe_hi.html

[3]“ 1965 Dollars in 2018” retrieved August 28, 2018, from <http://www.in2013dollars.com/1965-dollars-in-2018?amount=525000000>

[4]“ Air travel: A supersonic future?” retrieved August 28, 2018, from http://news.bbc.co.uk/2/hi/uk_news/852087.stm

[5]“ Boeing 747 Double Decker Early Proposal” retrieved August 28, 2018, from <https://web.archive.org/web/20150512211307/http://airwaysnews.com/html/museums/boeing-archives-bellevue-washington-usa/boeing-747-double-decker-early-proposed-design-model-mid-to-late-1960s/19091>

[6]“ Boeing 747 Early Proposed Designs” retrieved August 29, 2018, from <https://web.archive.org/web/20150616121707/http://airwaysnews.com/html/museums/boeing-archives-bellevue-washington-usa/boeing-747-anteater-early-proposed-designs-model-mid-to-late-1960s/19088>

<https://assignbuster.com/development-of-the-boeing-747/>

[7]“ Boeing Major Construction Facilities” retrieved, August 29, 2018, from <https://web.archive.org/web/20071115211523/http://www.boeing.com/commercial/facilities/index.html>

[8]“ The Boeing 747” retrieved August 29, 2018, from https://web.archive.org/web/20121007143215/http://www.centennialofflight.gov/essay/Aerospace/Boeing_747/Aero21.htm

[9]“ All but off the ground” retrieved August 29, 2018, from <http://content.time.com/time/magazine/article/0,9171,838835,00.html>

[10]“ Aero Engines 1968” retrieved August 30, 2018, from <https://www.flightglobal.com/FlightPDFArchive/1968/1968%20-%200022.PDF>

[11]“ Queen of the Skies” retrieved August 30, 2018, from, https://web.archive.org/web/20041207091236/http://www.boeing.com/news/releases/2004/q1/nr_040209g.html

[12]“ The Trouble with Jumbo” retrieved August 30, 2018, from, <http://content.time.com/time/magazine/article/0,9171,844949,00.html>

[13]“ JT9D Engine” retrieved August 31, 2018, from, <http://www.pw.utc.com/products-and-services/products/commercial-engines/JT9D-Engine/>