

DEVELOPMENT AND ENTRY INTO SERVICE OF AIRCRAFT BOEING 747-8

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Summary. Boeing Company is one of the largest passenger aircraft producers in the market. Its founder was William E. Boeing and it has been operating since 1910. Since then the company has undergone major changes from the first production aircraft powered by reciprocating engines to modern jets. In their range can be found narrow-body Boeing 737 NG / MAX and the Boeing 757, production of which has already been completed. A category of wide-body aircraft is represented by aircraft Boeing 747-8 Intercontinental, Boeing 787 Dreamliner, Boeing 777 and Boeing 767, production of which has been stopped by the company 0.

Keywords: Boeing, the aircraft structure, technical parameters, comparison, cockpit, flight deck

1. INTRODUCTION

After the failure in the military sector, the company decided to focus on the civilian market and started to construct modern aircraft by using technology that they had acquired from military projects. Their primary philosophy was to develop a completely new aircraft powered by engines with a large diameter bypass. At the end of 1960 there were 50,000 Boeing employees included in the group named Incredible. They were constructors, mechanics, secretaries and administrators who made aviation history by taking part in the construction of the largest commercial passenger aircraft in the world. It was Boeing 747 and should have been built in less than 16 months. The most important stimulus for constructing a "giant seven four seven" was the reduction of ticket prices and a response to the ever increasing number of passengers travelling by air 0.

The main aims of the structure B 747 compared to the B707 were focused by development team in the following points:

- to reduce direct operating costs per seat and flown mile by 30% despite the fact that the company demanded a more comfortable seating arrangement
- to redouble the capacity of passengers on one deck while maintaining favourable aerodynamic characteristics of the body
- to permit any change of the construction to a cargo plane
- to increase cruising speed
- to permit a flight at higher altitudes due to overcrowding flight corridors over the North Atlantic 0.

The final draft was completed in March 1968 and the following month, the company Pan-Am ordered 25 aircraft of Boeing 747. The sizes of aircraft were indeed monumental. Its size required the construction of a new production hall with volume of 200 million cubic feet, in town Everett, Wash. It was the largest building by volume in the world. The larger was only the Ford factory on the river Ropuge, but the system consists of several factories. The final design offered potential customers three configurations. Personal version designed exclusively for the carriage of passengers, further cargo version and the hybrid model to carry passengers and cargo. Cargo and convertible model could hold up to eight containers through the front hinged nose of the aircraft. The cargo compartment of an aircraft could hold up to 3,400 pieces of luggage and it could be unloaded within seven minutes thanks to the spacious loading doors. The total wing area was greater than the area of a basketball court. Despite its colossal size it weighed the global positioning system less than a modern laptop computer.

2. BOEING 747-8

After almost twenty-two years since taking off the first model of Boeing 747 piloted by Mark Feurstein and Thomas Imrich, it was followed by the first flight of a completely new "Jumbo". It was cargo version designated as 747-8F. This new member of the family received official designation Boeing 747-8R7F SCD. His first take-off was took place at factory Paine Field Airport in Everett watching by several thousands of employees, suppliers, customers and the general public. The flight began about twelve hours and thirty-nine minutes of local time, and after three hours and thirty nine minutes, the plane successfully landed at the same airport. His speed reached the maximum allowed limit of 426 km / h and flew up to 5181 m. During the flight, the crew verified the engine operation by the maximum speed in different flight levels and modes. This flight test program launched the test program, which was budgeted at 1 600 flight hours 0.

This program involved not only the first prototype designated RC501 with registration mark N747EX but also two more Boeing 747-8 RC521 marked with the same registration mark, which had been changed to N5017Q on 18.1.2010. The third plane was designated as RC522. In addition to the three planes there were also other planes on the production which were developed for various other companies. Among the first airlines there was, for example, the company Cargolux that has expressed interest for the new model of Boeing 747. It was a cargo versions of the Boeing 747-8RF7 SCD marked with serial number 35807/1424. Another company was Korean Air, which ordered version -8B5F SCD with serial number 37132. The development of the new 747-8 reflected the new, high-capacity, high economic plane made using the latest technology and using knowledge of aerodynamics, constructor ship and other air fields. Thanks to the new design and flight characteristics of the aircraft, it represented a new era for companies operating economy. Compared to the previous model of the Boeing 747-400, a new version -8 differed mainly in the design and shape of completely new wing and propulsion unit of the General Electric GEnx-2B, which had lower fuel consumption, reduced production of harmful fumes and lower noise level. There are two versions in the offer: passenger -8 I Intercontinental and cargo marked -8F. While the first mentioned version emphasizes the spaciousness and interior configuration and its concept is based on the Boeing 787 Dreamliner and the interior lounges designed to carry VIP passengers, cargo version is mainly focused on transmission capacity requirements and associated operating costs. During flight tests several mistakes appeared that Boeing's engineers had to remove. One of them was the door of the main chassis on the third test aircraft, those at moderate turbulence interfered with the inner flaps to the fuselage. After a detailed examination of the problem and investigating the causes, this error was eliminated by changing the design, construction and main landing gear doors. In early April of 2010, Boeing identified other disorders. This time, it was at the upper torso. According to the company, parts produced by subcontracting company Vought Aircraft Industries are under the influence of the load prone to fatigue which can lead to the cracking 0.

Although Boeing said that this problem does not affect the flight characteristics during test flights, but before its entry into service this error had to be removed to avoid damage to the aircraft skin and subsequent crash. Then the problem of aileron oscillation came that had not been resolved yet. All

these problems slowed flight test and consumed almost all financial resources from the reserve package within the development agenda of Boeing company. After moving test aircraft from Moses Lake Palmdale, engine testing began. During its testing, sucking a foreign object into the turbine was simulated. The test was carried out on the ground and after the hitting the engine housing was damaged but the engine itself was fine and after repairing, it was possible to test the fuel efficiency. After completion of basic tests, the FAA issued a type certificate about serviceability of the new 747. By the end of June 2010 a team of workers created the program tests, which ended by the testing in the hot climate of Arizona 0.

2.1. Construction

In terms of structural elements, the new seven-four-seven came and in compare to the previous version -400 it carried some news. These innovations include innovative hull built with modern construction materials. Its extension has been achieved through two segments inserted before and behind the wings. The length of these segments is 4.1 and 1.5 meters. Cargo version offers 16% more cargo space, it represents 692.7 cubic meters on the main deck and 82.3 m³ and 68.7 m³ in the hold. It means that the aircraft is capable of carrying on two standardized pallets (containers, or LD-1, LD-3) more and in the hold another three pallets. As for the passenger version, it can hold up to 467 passengers in three classes. It's 51 more passengers than in the previous version. In the first class, there can be placed 24 passengers, 87 in commercial class and 356 passengers in economy class. The appearance of the cabin is derived from the architecture of Dreamliner. It is a LED cabin lighting and spacious folding storage compartments, ergonomic seats etc. First Class is located in front of the main deck and it features separate position able seats. Business Class is located on the upper deck and it is designed according to the pattern of Private Jet, which means that its appearance and equipment is identical to equipment VIP aircraft. There is the supercritical wing profile, modernization of wings with winglets at the end of the wing that were added to reduce induced drag at the end of the winglets. To increase buoyancy, Krueger flaps were used, internal dual-slotted and external single-slotted. The news includes also the spoilers and flaps, which are controlled through a system of fly-by-wire steering, therefore steering by wire. The crew consists of two persons, who have at their disposal a modern glass cockpit with identical features of which can be found for example in the Boeing 777 or Boeing 787 Dreamliner. The cockpit is designed ergonomically and all the necessary instruments are within the crew reach. The other two screens placed alongside a pilot replace pilot's paper documentation, aka EFB- electronic flight bag. Due to identical equipment and arrangement of the cockpit, the time of retraining the crew when changing the type of aircraft is minimal. For example retraining period of the Boeing 747-400 takes three days, the Boeing 787 Dreamliner is nine days, and the Boeing 777 eleven days. The crew can relax in the room for the crew placed at the end of the upper deck during long flights, where there are ten beds. The drive is provided by foursome jet engines from General Electric GEnx-labeled 2bs maximum 295.8 kN thrust. The engines are classically controlled by a FADEC system of compressor is controlled digitally. It means that fuel consumption per seat for flights within 5550 km is 117.9 kg and up to a distance of 11 100 km it is 250.9 kg. Space on the flight deck offering to the crew comfort, visibility and ergonomics of individual devices. The technology in the new 747 is admittedly borrowed from Boeing's 787 Dreamliner, but deployment of equipment remained the original version -400. This allows shortening training time by changing versions. The aircraft is equipped with a new computer system for flight management, integrated navigation system and global positioning system, an automatic landing. Monitors set better known as glass cockpit is also available for the crew. Thanks to them, the weight of aircraft was reduced and the amount of information displayed was clarified to the crew. It is obvious that the new 747 with the same type rating allows operators to increase productivity and resilience plans, pilot deployment on various versions of the aircraft. It could be said that this new generation aircraft includes high - tech avionics and navigation systems. This includes FMC, Air Navigation System FANS (Future Air Navigation System), global positioning system and GNSS navigation system for precision zoom and landing.

3. BOEING 747-8 VERSION

The company offers two versions of the new 747. Personal version for intercontinental flights and cargo labelled F.

3.1. Boeing 747-8 Intercontinental

Main deck - Boeing has borrowed many of the features of the cab models B777 and B787. Mainly the storage space for hand baggage and windows, which are about 8% higher than previous versions - 400. As mentioned, cabin lighting is realized using powerful LED lighting. The intensity and colour of light is adjustable which allows creating a pleasant environment during long flights. Advantages of this lighting are lower maintenance costs, reliability and energy saving. 0.

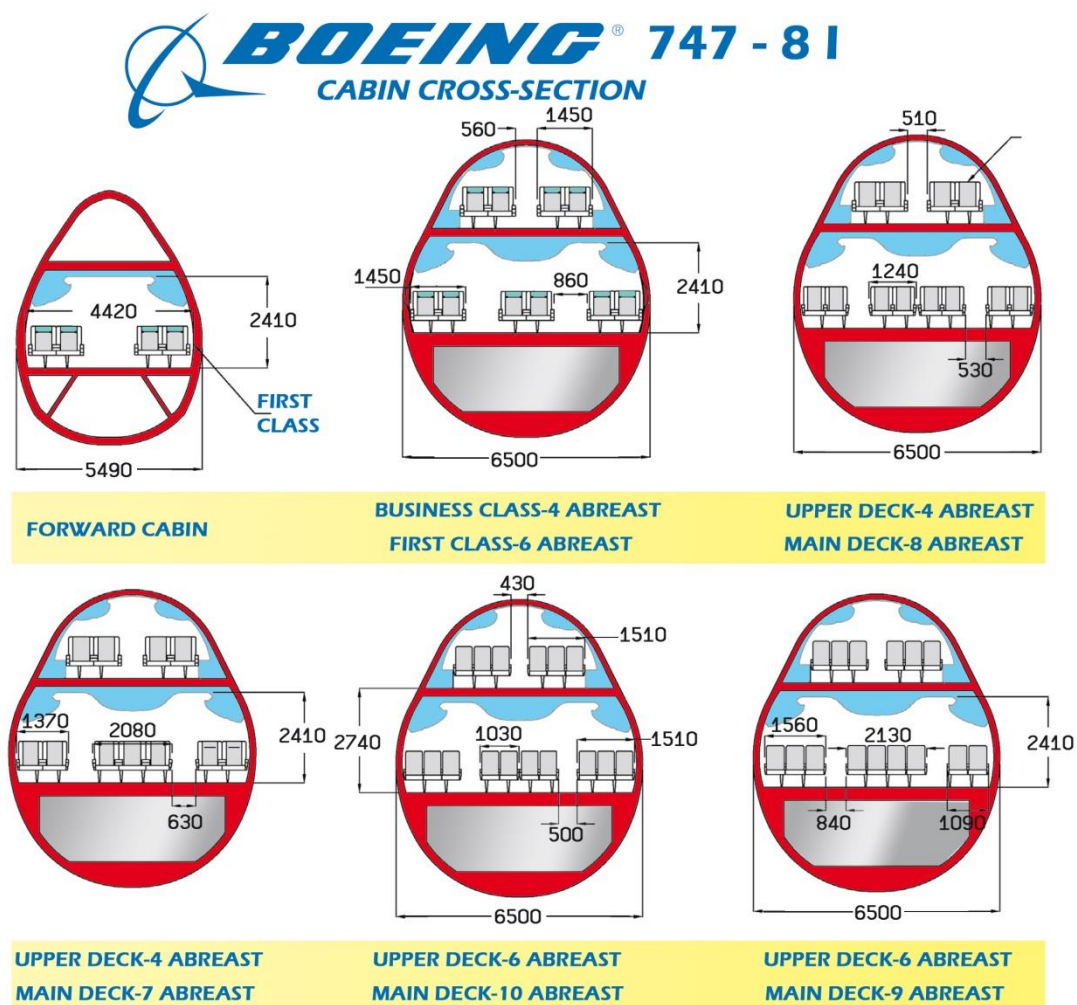


Figure 1 Cross-section of the cabin of Boeing 747-8I

Upper Deck - Another proposal was to introduce a room for rest at the end of the upper deck. It was the "living room" and although no windows but the comfortable chairs and entertainment technology. This room was created after moving the air conditioning wiring and wiring to the sides of the ceiling of the plane. In addition to rest rooms for passengers, there is also room for the gallery and space for the crew. Another idea was to make the newly established relaxation room called "Skyloft", a device "Sky Suite". It was a set of walls with sliding door or curtain. With this idea it is possible to change the "living room" to smaller "bedroom" or separate rooms for business meetings and

relaxation. These mobile cells were named "SkyBunks". Access to these areas would be provided through the staircase located at the rear of the upper deck. With this innovation, however; the problem occurred. It was a price and it was the reason why customers did not support it. It means that if passengers would like to use these facilities they would have to pay more, but they would have to wait in their place in the particular class during the take-off and landing. After the realization of a feasibility study and pricing of modern elements, SlySoft concepts and SkyBunks were rejected. The company, however; did not reject it entirely and they offered it only for VIP version. The internal control system of an aircraft environment was entrusted to companies Lieberherr-Aerospace Toulouse SAS 0.

3.2. Boeing 747-8 Freighter

Boeing 747-400F has proved to be very popular aircraft that was owned by more than half the cargo air carriers. In order to maintain this trend, Boeing suggested creating cargo version of the latest model -8 labelled F (Freighter) 0.

Table 1 Boeing 747-8 version 0

	B747-8 I	B747-8F
Length	76,3 m	
Width of hull	6,5 m	
wingspan	68,5 m	
MTOW	448 000 kg	
Operating empty weight	295 000 kg	330 000 kg
Cursing speed	Mach 0,855	Mach 0,845
Number of passengers	467-605	-
Fuel	239 000 l	228 000 l
Maximum range	14 800 km	8 130 km
Engines	GE GENx-2B67 (296 kN)	

4. COMPARISON WITH COMPETITORS

The biggest competitor of Boeing 747-8I is the largest airliner in the market, Airbus A380. The biggest difference between these aircraft is that Airbus A 380 is a full double-deck aircraft, which is also reflected in its seating capacity that is larger at about 35%. Boeing 747-8 Intercontinental is 3.58 m longer but wing span is 11.25 m smaller. This is reflected in total leaf surface which is 291 m² larger in Airbus. The height of Boeing measured from the ground to the top of the rudder is 19.40 meters. Airbus A380 is 4.69 meters higher than Boeing. Maximum take-off weight of Boeing 747-8I is 20% lower. It ensures lower landing fees for companies operating this aircraft. Landing weight of the aircraft Airbus A 380 by is more than half higher. Drive unit of Boeing 747-8I produces thrust 296 kN. Because of greater MTOW Airbus A380 requires greater thrust by about 5%. Fuel consumption of Airbus A 380 per passenger is about 2% lower. But Boeing 747-8I has 12% lower cost per flight compared to A380. Despite these factors, the Airbus A380 wide-body aircraft is the most economical aircraft in the market due to its capacity. The flying range of Airbus A380 is 855 km greater, which is caused by a higher volume of fuel tanks and larger wing area. Both aircraft are capable of flight at flight level FL380 to FL410. Cruising speed of the Airbus A 380 is 37 km / h higher than cruising speed of Boeing 747 **Chyba! Nenašiel sa žiaden zdroj odkazov..**

Both aircraft offer a spacious cabin for passengers, which can be divided into three classes and equip by modern entertainment technology. The clear cabin height of Boeing 747-8I is 7 cm higher but interior width of Airbus A 380 is 44 cm larger. The total floor area in the cab is significantly greater in the Airbus A380. To compare:

- Boeing 747-8I – 444,60 m².
- Airbus A 380 – 305 m² + 249 m².

Purchasing cost of Boeing 747-8I is lower compared to Airbus, but if we consider the proportion of seat capacity area of A380, the price of both aircraft is almost identical.

For a better understanding of the total price of the aircraft:

- Boeing 747-8I – 317,5 million dollars.
- Airbus A 380 – 357,3 million dollars.

Both planes are also available in the cargo version but Boeing 747-8I is more efficient for this purpose and therefore it is used by not only cargo airlines. Airbus A 380-800F has not attracted any airlines and therefore, this model does not fly **Chyba! Nenašiel sa žiaden zdroj odkazov..**

Table 2 Comparison with competitors **Chyba! Nenašiel sa žiaden zdroj odkazov.**

Boeing 747-8 I	Vs.	Airbus A 380-800
74,3 m	length	72,7 m
68,5 m	wingspan	79,8 m
19,60 m	height	24,1 m
4	number of engines	4
296 kN	engine thrust	311 kN
436 000 kg	MTOW	560 000 kg
13 450 km	maximum range	14 800 km
M 0,85	cruising speed	M 0,85
416 passengers	capacity	555 passengers
317,5	price (in million USD)	357,3

5. CONCLUSION

Boeing 747-8 Intercontinental is the successful continuation of one of the most popular aircraft in the market. Although its design has undergone many changes, the overall concept of shortened second floor is maintained. Nowadays, the aircraft is also very popular with airlines especially because of its efficiency, maximum range, diversity of use and ability to land almost at all the world's airports.

References

Books:

[1] PELLETIER, A.: BOEING The Compleat Story. Sparkford, Yeovil, Heynes Publishing, 2010, ISBN 978-1-84425-703-4

Web Sites:

[2] Boeing 747 [on line]. [s.a.]. [cit 2015-3-24]. Dostupné na internete: <<http://www.boeing.com/boeing/history/boeing/747.page>>.

[3] Boeing 747-8 history [on line]. [s.a.]. [cit 2015-1-16]. Dostupné na internete: <http://www.boeing-747.com/boeing_747_family/747-8.php>.

[4] Boeing 747-8 [on line]. [s.a.]. [cit 2015-1-16]. Dostupné na internete: <<http://www.boeing.com/commercial/747/#/design-highlights/characteristics/>>.

[5] Boeing 747-8I [on line]. [s.a.]. [cit 2015-1-16]. Dostupné na internete: <http://www.boeing-747.com/boeing_747_family/747-8i.php>.

[6] Boeing 747-8F [on line]. [s.a.]. [cit 2015-1-16]. Dostupné na internete: <http://www.boeing-747.com/boeing_747_family/747-8f.php>.

[7] Boeing 747-8 [on line]. [s.a.]. [cit 2015-1-18]. Dostupné na internete: <http://www.aviationexplorer.com/747_facts.htm>.

[8] B747 vs. A380 [on line]. [s.a.]. [cit 2015-3-19]. Dostupné na internete: <<http://www.traveller.com.au/boeing-7478-v-airbus-a380->