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Huge steps in the history of civil aviation

Aviation is a young, fast growing and fascinating industry that has changed the world. The engineers of Boeing have thereby always played a vital role in designing and supplying state of the art air planes that fulfill the global desire of mobility for people, trade and industries. While our prime focus in the early days rested on reliability and durability issues, we later strove for range, comfort and cost efficiency. Lately the industry set additional and ambitious targets with regard to environmental friendliness. Technology – the driving force for all improvements - has enabled us to fly further, faster, higher, safer, cleaner, quieter and more economical.

Lufthansa is proud of its history to partner with Boeing for half a century. This year we are jointly celebrating the dawn of the jet age in Lufthansa, marked by the entry into service of the Boeing 707 in 1960 and we celebrate the launch of the Boeing 747 in 1970. Both events represented a huge step in the history of Lufthansa and the civil aviation. We are excited that very soon we will welcome yet another new generation of Boeing aircraft in our fleet, namely the 747-8. Progress made Boeing and Lufthansa strong. In the overall context Lufthansa Technik, our world wide leading MRO service provider, plays a key function in these developments. In summary the Lufthansa Group has always been in equal parts customer, challenger and partner of Boeing.

The Lufthansa Group with its partner airlines is looking forward to continuing the fruitful relationship with Boeing for many more decades to come.
Lufthansa and Boeing – 50 years of innovation and partnership

Boeing and Lufthansa proudly look back on 50 years of partnership and innovation and are eager to continue jointly shaping the future of aviation. Together, we have celebrated important historical milestones in aviation, including the delivery of the Boeing 707 which marked for Lufthansa the beginning of the jet age. The launch of the 737 program was largely based on Lufthansa's firm commitment, and Lufthansa was also the launch customer for the Boeing 747-200 Freighter.

Today, Lufthansa is not only an important partner but also a valued advisor in developing The Boeing Company’s new commercial airplanes. As launch customer for the new 747-8 Intercontinental, Lufthansa provided Boeing with valuable input that will make this airplane a leader in its class for fuel efficiency and passenger comfort.

As leaders in innovation and technology, Boeing and Lufthansa embrace the exciting opportunities and challenges ahead as we continue to work together to make air travel more efficient, comfortable and environmentally sustainable. We look forward to building on the successful relationship that many employees in our two companies have developed over the years, and we remain committed to many more decades of partnership and innovation.

W. James McNerney, Jr.
Chairman, President and CEO
The Boeing Company
LUFTHANSA AND BOEING – HISTORY WITH A FUTURE
In 1957, before the world had gotten used to the idea of jetting across the North Atlantic, Lufthansa chose the Boeing 707 from a field of three jet aircraft manufacturers as the most aerodynamic and technically advanced aircraft design. That decision made half a century ago was the beginning of a close partnership between Lufthansa and Boeing, a partnership that has left its mark on many aspects of aviation right down to today, including the development of new aircraft, increased comfort for passengers and reduced environmental pollution.

This successful partnership will be continued when Lufthansa becomes the launch customer for the passenger version of the new 747-8. Just as with the bestselling Boeing 737 in 1965, the 747-8 Intercontinental bears witness to a variety of Lufthansa’s ideas and wishes.

Boeing 707, 720, 727, 737, 747 – for decades, aircraft from Seattle have formed the backbone of Lufthansa’s fleet. The half century since the first scheduled flight of a 707 in Lufthansa’s colors has also seen the growth of a close, trust-based partnership between the two – a German airline and an American aircraft manufacturer with roots in Germany.

For a number of airframe designs, it was Lufthansa, known from day one for its outstanding technical knowledge that gave Boeing the necessary customer input that eventually turned a good design concept into an outstanding aircraft. And to this day, this unique symbiosis continues to pay off for both companies, increasing Boeing’s aircraft sales and
1 Roll-out of the first Lufthansa 707-430 registered D-ABOB in Renton, 18 November 1959.

2 The Boeing 727-030 was the first Lufthansa jet deployed on European routes.


4 Lufthansa was the first European customer for the tri-jet Boeing 727.

5 Lufthansa to a large extent influenced the development of the Boeing 747-400, first delivered in 1989.

6 In March 1970 Lufthansa accepted the first “Jumbo Jet”.

7 For Condor the US artist James Rizzi designed the legendary “Rizzi Bird”, a 757, as the then world’s largest piece of art.
ensuring products for Lufthansa that are precisely tailored to its needs.

The first four-engine jet

In fact, not even the 707 was an "off the rack" order: Lufthansa chose the lighter, quieter and more economical Rolls-Royce "Conway" engine in place of the standard Pratt & Whitney JT4A, and it continued this trend with the Boeing 720B. Boeing's engineers had developed the 720B as a smaller and lighter version of the 707 with only 125 seats. Lufthansa was the first European airline to buy it, ordering four aircraft with new Pratt & Whitney JT3D-3 fan-jet engines on January 30, 1960. The first 720B was delivered on March 8, 1961, and eventually Lufthansa had eight of these very fast planes in use for medium and long-distance flights. Boeing 720Bs in Lufthansa colors could be seen just as often at European and South American airports as on the airline's African and Asian routes. In 1962, a Lufthansa plane covered the 3,043 kilometers from Hong Kong to Tokyo in two hours, 39 minutes, for a ground speed of 1,148 km/h! The 720B's flight performance was outstanding: with engines that were identical to those in its larger and heavier sister the 707-330, the agile 720B was a great favorite with Lufthansa pilots.

Yet as popular as this aircraft was, it made only a guest appearance at Lufthansa; in 1964, medium-range transport requirements ushered in the era of the 727, which had only three engines and was even lighter and therefore more economical. Meanwhile, the volume of passengers and freight for long-haul routes had grown so much that it became necessary to move up to the larger 707-330. Thus Lufthansa closed the 720B chapter at the end of 1966 by retiring the last machine of this type, replacing it with brand new 707-330s.

First Boeing 727 customer in Europe

On November 30, 1960, Eastern Air Lines and United Air Lines ordered a total of 100 Boeing 727s, becoming Boeing's launch customer for one of the most successful aircraft programs in the history of aviation. And just as for the Boeing 720B, the first European order came from Deutsche Lufthansa, which commissioned its first twelve Boeing 727-100s on February 28, 1961.

Following the initial flight of the prototype on February 9, 1963, Lufthansa conducted a painstaking examination of the aircraft it called the "Europe Jet" in what was, at the time, the most lavish and expensive program of test flights ever carried out on a commercial aircraft. The cost was 30 million US dollars. By April 16, 1964 everything was ready. The first two European 727s with registrations D-ABIB and D-ABID took off for London and Madrid on their first flights with LH flight numbers. And these planes, made to Lufthansa's specifications as 727-30s, soon dominated the most important European routes and connections to the Middle East.

Family ties

Lufthansa was enthusiastic about the tri-jets' homogeneity with the Boeing 707s that were already being used for long-haul flights. For example, there were cost advantages: retraining times for 707 and 720B cockpit crews were shorter because of the similar flightdeck design, service procedures in the cabin were simplified because the two airframes have the same diameter fuselage, and the numerous related systems and components lowered maintenance costs. For Lufthansa, this family concept quickly paved the way to its becoming "the Boeing airline", and was continued with the 737 and 747. After the last turboprop – the Vickers Viscount 814 – was taken out of service on March 31, 1971, Lufthansa finally had a jet fleet made up entirely of Boeings.

In addition to the crews, who were particularly enthusiastic about the outstanding flight properties of the "two seven", passengers also valued the new jet experience on short and medium flights. Besides being able to fly "above the weather" and at greater speed than with the old propeller aircraft, they were particularly pleased with the Lufthansa 727s' specially designed cabin interiors and furnishings. The seats originated from a design created by a French architect, and the University of Ulm had
developed and designed the tableware for tourist class. Lufthansa had also considered the needs of its smallest passengers and their parents and installed diaper changing tables in the washrooms. Although the new Boeing 727s had a vastly greater capacity than the Convair 440 (48 seats) and Vickers Viscount (64 seats), from their very first day in service Lufthansa was able to record over 60 percent capacity utilization for its 96-seat Europe Jets.

In addition to the passenger version of the 727-30, Lufthansa also ordered the same aircraft type in a combi-version with a cargo door at the side of the main deck. These eleven “quick change” 727-30QC s could be converted from passenger airplanes to freighters – and back – in the space of 25 minutes. From 1967 on, the 727QC s flew passengers by day and were converted to carry freight during the night shift. The seats and galley were mounted on pallets and could be loaded and unloaded via the cargo door at the side of the main deck, and while the quick-change plane was doing duty as a freighter, the passenger facilities and equipment were stored in a specially constructed storage vehicle. Lufthansa used its “combi-Europe Jets” to carry freight both within Germany and to and from destinations elsewhere in Europe.

Comfort Jet 727

The 727 differs from the 707 and 720B in particular in the characteristic arrangement of the three Pratt & Whitney JT8D engines at the rear of the fuselage. Although the 727-30 is shorter than the four-engine version, the cabin diameter is the same as that of the long-haul aircraft, at 3.76 meters. Vibration isolators are installed at the rear to prevent vibration from the jet engines from affecting the passenger cabin.

Another advantage of this aircraft, which cost 17 million DM at the time of purchase, was its ingenious aerodynamics: The slats and three-part landing flaps enabled a maximum airspeed of 970 km/h coupled with a minimum landing speed of 200 km/h. In other words, the Europe Jet was no faster when coming in to land than the propeller planes it replaced. Even after landing at maximum speed, the 727 came to a halt after around 1,500 meters, and it needed only an additional 400 meters to become airborne at maximum take-off weight. This enabled Lufthansa to continue using the 727 at all the airports that had featured in the flight plans of Convair 440 or Vickers Viscount propeller aircraft.

With Boeing jets into the black

In 1961, Lufthansa was struggling with worldwide overcapacity in air transportation, as were most other airlines. The available supply was running far ahead of actual demand. The revaluation of the DM following the German economic miracle also put pressure on the airline’s revenues at the same time as its expenses were being incurred primarily in US dollars. There followed three more years of heavy losses before Lufthansa was able to reap the benefits of its farsighted fleet policy, but in 1964, its investment in the more profitable jet aircraft began to pay off, initially as an eight-figure profit, namely 36.9 million DM. That year, Lufthansa’s 42 aircraft with the crane logo on their tails transported over 2.5 million passengers. On average that year, a Lufthansa plane started and landed somewhere on its worldwide route network every 3.5 minutes. Yet another milestone was also reached in Stuttgart in June of 1964: borne on one of its giant Boeing jets, Deutsche Lufthansa was able to welcome its ten
The millionth passenger since it began flight operations on April 1, 1955.

737 – the Lufthansa Boeing

On February 19, 1965, the Lufthansa board authorized the purchase of 21 Boeing 737s – the youngest member of the family of jets from Seattle. It was primarily Prof. Gerhard Hölzle, at the time Lufthansa’s Technical Director, who convinced Boeing to build this tailor-made short-haul jet for Lufthansa. On December 28, 1967, Deutsche Lufthansa took delivery of the first “Bobby” of version 737-130. And today, the subsequently developed Boeing 737-300s and 737-500s with their quiet and economical General Electric/Snecma CFM56 engines are still an important part of Lufthansa’s European fleet.

The farsightness of the managers at Boeing and Lufthansa, who pressed for the construction and purchase of the 737 in the face of considerable in-house opposition, is manifest in the incomparable success of this aircraft series: just a few months ago, the 6,000th 737 left the production in Seattle, making this jet the single most purchased passenger aircraft of all time.

Encouraged by falling ticket prices that were made possible by more efficient aircraft, passenger numbers climbed steadily throughout the 1960s, so much so that Lufthansa began looking for a larger “Europe Jet”. In 1967 Boeing offered a stretched version of its successful 727 design. The fuselage of this aircraft, the 727-200, was 6.10 meters longer than that of the 727-30 and was equipped with more powerful engines from the Pratt & Whitney JT8D.
series. Lufthansa initially ordered four of these 727-230s and took delivery of the first one, registered D-ABCI, on January 27, 1971. It seated eight first class and 138 economy class passengers and was so successful on Lufthansa’s network of European routes that follow-up orders came quickly. The aircraft delivered to Germany were among the first 727-200s with cabins designed for the modern wide-body look. The new furnishings made a more spacious impression and subsequently became the standard for all brand new Boeing 727s.

On February 14, 1973, when Lufthansa took delivery of its 100th Boeing jet, it was a brand new “advanced” Boeing 727-230. It offered higher take-off and landing weights, more powerful engines, larger fuel tanks and a range that was 900 kilometers farther than the standard 727-200 model. In manufacturing this “advanced” model, Lufthansa was consciously investing in environmental protection, because the latest 727 design was considerably quieter than its predecessor and fulfilled all the international noise regulations that were in force at the time.

Altogether, 34 727-230s flew wearing the colors of Lufthansa and its charter subsidiary Condor Flugdienst, where they supplemented the seven smaller 727-30s that Condor was already flying. After delivery of the last 727-230 on January 19, 1979 the elegant tri-jets continued in service for almost 13 years on Lufthansa’s European network. The 727 era at Lufthansa did not end until October 4, 1992, by which time the Europe Jets had made over a million flights without a single instance of injury or death.

**Supercargo Jets**

In 1962, Lufthansa opened its fully automated airfreight center in Frankfurt/Main, which is still today one of the most modern cargo centers anywhere in the world. And just three years later, Lufthansa’s all-cargo flights also entered the jet age: on November 10, 1965, the airline took delivery of its first brand new Boeing 707-330C supercargo jet. Lufthansa ordered these freighters in a convertible version that could also be used as a combi-aircraft or just for passengers. When it was first put in service, the Boeing 707-330C was considered the most modern freight airliner in the world. To begin with, a supercargo jet made the round trip from Frankfurt to New York and back six times a week, each time transporting up to 30 tons of freight across the North Atlantic. The cargo bay was equipped with roll-on platforms and roller conveyors so that freight palettes could be loaded and unloaded very quickly. In Frankfurt the Boeing 707-330C’s turnaround time was a record-breaking two hours.

**Fleet synergy with Boeing**

At the time the first Boeing 727-30QC launched a new era for the European airfreight market in February 1967, there were already two Boeing 707-330C freighters flying long-haul routes for Lufthansa. Thanks to their identical fuselage diameter, it was no trouble at all to exchange palettes between the 707 and 727 freighters. Still, the Boeing 707-330Cs became the backbone of Lufthansa’s freight services; between 1965 and 1970, the airline took six aircraft into service, and these were subsequently handed over to Lufthansa’s freight subsidiary German Cargo Services (GCS). The chapter at GCS devoted to the 707 freighter lasted until 1984, when they were replaced by five Douglas DC-8-73s.
The Age of the Jumbo

The “little” 737 City Jet had barely taken to the air when Boeing brought out its gigantic counterpart, the 747 Jumbo Jet. The first buyer was the American airline Pan Am, which ordered 25 aircraft in 1966. Lufthansa then followed as the first customer outside the USA, with a modest order for three planes. Passengers who had only flown in smaller jets with one center aisle were extremely enthusiastic about the new dimensions of the 747: the first class lounge in the upper deck was reached by a spiral staircase, the high, wide main cabin with two aisles had just nine seats per row in tourist class, and the JT9D turbofan engines gave off a sonorous rumble in flight. This previously unknown flight experience moved even frequent flyers to spontaneous applause when this superb jet took to the air.

Since the entry into service of the first 747, 3.6 billion people have flown in a Jumbo Jet, equivalent to more than half the population of the entire world. Jumbo Jets have been airborne for about 876 million flying hours, the average journey time between departure and arrival airports lasting six hours. Equally impressive is the distance flown by Boeing 747’s, which totals 77.7 billion kilometers, equivalent to 1.9 million circumnavigations of the earth. Over a thousand Boeing 747’s are currently in service around the world. It took some 75,000 design drawings before the first aircraft, composed of around six million individual parts, could be built almost forty years ago.

There is no end of the 747 era at Lufthansa. Once again Lufthansa urged Boeing to take the comprehensive technological leap forward that became the 747-400 – and was rewarded with the best-selling version of the 747 series to date. Since May 23, 1989 and through today, the 747-400 has been the centerpiece of the long-haul fleet of Lufthansa and many other international carriers.

Subsidiaries flying high with Boeing

In 1990 Condor initiated a fleet roll-over replacing its highly reliable Boeing 727-230 tri-jets with more efficient and quieter Boeing 757-230 short- to medium-haul twins. At the occasion of the company’s 40th anniversary in 1996, the US artist James Rizzi designed the legendary “Rizzy Bird” as the then world's largest piece of art.

In the same year, Condor ordered as launch customer the Boeing 757-300 as the longest and last version of the successful 757 series. The first sample of this “stretched version” entered service with Condor in 1999. For long-haul routes Condor acquired the Boeing 767-330ER with the first aircraft entering the fleet in 1991.

Responding to strong demand from cargo operators around the world for an efficient, long-range and high-capacity freighter, in May 2005 Boeing launched the twin-engine 777 Freighter. Bringing unsurpassed efficiency to long-haul markets, the 777F flies farther than any other freighter and provides more capacity than any other twin-engine freighter. With a maximum take-off weight of 347,450 kilograms, the 777F has a revenue payload capability of 103 metric tons.

Through its joint venture cargo airline AeroLogic, Lufthansa once more recorded a first with Boeing aircraft in Germany. The first of a total of eight 777 freighters registered in Germany arrived at the cargo start-up's homebase in Leipzig in May 2009. With its growing fleet of currently four aircraft, AeroLogic is the largest operator of the 777F worldwide.
The mighty Pratt & Whitney JT3D-3B fan engines of the Boeing 707-330 offered a large fuel advantage over the preceding Rolls-Royce Conways.
The Boeing 707 characterizes our understanding of modern passenger jet design like no other, but what seems so obvious today was an absolute sensation when it was first developed. Wings swept back with the engines on gondolas underneath them, a plane that soared through the stratosphere well above the clouds and at almost the speed of sound – 50 years ago even aviation experts thought it sounded like science fiction!

And it wasn't just the jet engines that were revolutionary, it was also the aerodynamic formulas that were used to design the fast wings of the 707. The secret of swept-back wings had already been researched during the Second World War by German scientists who developed the design for fast flight, close to the sound barrier, and American aerodynamicists had successfully implemented it in the Boeing 707 after the end of the war. To try out this new technology, Boeing first built the 367-80 "Dash 80" with four Pratt & Whitney JT3 jet engines. It was considered a joint prototype of the military tanker KC-135 and the civil Boeing 707, which Pan American was the first to order on October 13, 1955. The jet age for long-haul flights had finally begun.

A launch without jets

In 1954, just as the Dash 80 was setting off for its first flight, today's Lufthansa was being founded in Germany. On August 6, 1954, the "Aktiengesellschaft für Luftverkehrsbedarf" or "Luftag" that had been incorporated on January 6, 1953, became Deutsche Lufthansa AG by purchasing the name from the "old" Deutsche Lufthansa stock corporation that was in liquidation. At that time, the fleet policy adopted by Lufthansa's management followed the principle of no experiments. So initially the airline put its faith in proven technology and purchased the tried and tested Convair 340 for short-haul flights and the four-engine Lockheed L-1049G "Super

2. The Boeing 707-430 D-ABOF was one of the first 707-jets for Lufthansa, which were delivered in 1960 and 1961 with the Rolls-Royce Conway engines.


4. Lufthansa ordered eight Boeing 720B fan jets for long European and thin intercontinental routes.

5. Graceful lines: the Boeing 707-430.
Constellation” propeller aircraft for intercontinental routes. On April 1, 1955, Lufthansa’s first two Convair liners rolled out onto the runway. The new Lufthansa made up for the drawback of not being among the first airlines to fly Boeing 707’s or Douglas DC-8s by offering a particularly high level of service, such as the Senator service offered on board the Lockheed Super Star in 1958 and 1959. At the time, this was the highest standard of passenger service on North Atlantic routes.

But even the very best service could not conceal the fact that the 707 jet clippers flown by Pan Am and other competing airlines were almost twice as fast as Lufthansa’s luxurious propeller aircraft. So in order to avoid being completely outstripped by the competition, on January 23, 1957, Lufthansa signed a contract to purchase four Boeing 707’s. At the time, the choice of engine was not yet decided. Lufthansa justified its decision not to purchase the competing Douglas DC-8 by citing Boeing’s greater experience of building heavy high-speed aircraft. In other words: even at the beginning of the jet age, Lufthansa remained true to its cautious fleet policy.

From paper airplane to flight operations

Even before signing up for its first Boeing 707, Lufthansa began making plans for its subsequent use in the North Atlantic. On November 5, 1956, it launched “Operation Paper Jet”. This was the name given to the airline’s desk simulation of daily flight operations on the assumed route between Frankfurt and New York. Each flight of a “paper jet” was calculated using current meteorological data from the weather services for the route and at the destination. The air-traffic control office, now the air navigation service provider (today’s DFS), also supplied information on traffic density on the planned routes.

Initially, the performance data for the paper jets was taken from the flight test records of the Boeing Dash 80 prototype, but from 1958 onward, planners used the genuine performance parameters of the 707-430 that had been ordered. From the large volume of available data, Lufthansa’s dispatchers calculated the most advantageous route and altitude for the shortest flying time between Frankfurt and New York. When actual flight operations began in March 1960, all this data served as the basis for the economical use of Lufthansa’s Boeing 707 fleet.

Even today, the wealth of experience gained in the 1950s from “Operation Paper Jet” is still the foundation of long-distance flight operations, including, for example, the practice of locating high-altitude jet streams to provide a tailwind, which shortens flying time and reduces fuel consumption. Even a detour of several hundred kilometers can pay off if a jet stream can carry the aircraft more quickly to its destination.

In addition to preparations for the administration of 707 flight operations, in January 1960 the company also began planning training for its future pilots. Flight captain Werner Utter, who was appointed to Lufthansa’s board on November 1, 1972, chose Tucson airfield in Arizona as a suitable location for training Lufthansa’s prospective 707 pilots. Even today, Lufthansa’s trainee pilots are prepared for their cockpit duties at the Lufthansa Airline Training Center in neighboring Phoenix, Arizona, where meteorological and climatic conditions are favorable.
In addition to training its pilots, Lufthansa also gave its ground personnel special training for dealing with the new jets. Trainees at the Hamburg-based training center practiced check-ins for Lufthansa 707 passengers at special “jet desks” that were later installed at Frankfurt airport when the service was launched. The goal was jet speeds even on the ground – and to achieve this the desks were equipped with pneumatic dispatch tubes and conveyor belts for tickets. The goal of speed also applied to getting the aircraft ready prior to take-off: for this reason, Lufthansa invited its station personnel to Hamburg so that they could learn, from a table model of the 707, exactly how to position the ground service equipment while the aircraft was on the ground.

The unexpectedly powerful air intake suction of the new jet engines represented a particular hazard for workers on the flightline who were accustomed to rotating propellers. So Lufthansa issued special warnings: “The ‘vacuum cleaner effect’ at the air intake of a jet engine represents a particular hazard. The suction effect is positively dangerous up to about ten meters from the aircraft; it can simply drag a person into it. Even from twelve meters away it can snatch and swallow headgear and other small objects. In other words: Be particularly cautious of air intake suction!”

Lufthansa’s jet age begins

At midday on March 2, 1960, Lufthansa’s first commercial jet plane came in to land in Hamburg, greeted by the city’s typically lousy winter weather and saluted by a chorus of factory sirens. In a non-stop flight lasting nine hours and 47 minutes, flight Captain Rudolf Mayr and Copilot Werner Utter had delivered the 707-430 with registration D-ABOB from the Boeing factory in Seattle to Hamburg Fuhlsbüttel.
The scene on the tarmac at Hamburg airport after the landing was described in an article in Lufthansa’s employee magazine “Lufthanseat” in 1960: “The crowds were overcome by their curiosity to take a look inside the miracle bird, and they just stormed into the plane in the wake of the cleaners. The station manager had to summon up all his powers of persuasion to get the motley crowd to leave – a task that became even more difficult when the hundred people who had boarded at the front cannoned into the hundred who had entered at the rear.”

The first commercial flight of a Lufthansa 707 was on March 17, 1960 from Hamburg Fuhlsbüttel via Frankfurt/Main to New York. The new long-haul jets rapidly superseded the slower Lockheed propeller aircraft on Lufthansa’s worldwide network. And something else changed when Lufthansa introduced the jets: Frankfurt/Main soon replaced Hamburg as the starting point for overseas routes, and took on the role it has held to this day – Lufthansa’s largest hub. Stationing the 707 fleet in Frankfurt brought with it the establishment of Lufthansa’s maintenance base at Rhine-Main airport. Here Lufthansa built what was, in 1960, the world’s largest aircraft maintenance hangar, known as the “butterfly hall” because of its characteristic shape. From then on, Lufthansa’s technical base in Hamburg focused on the repair and overhaul of the entire fleet.

The D-ABOB, which was subsequently given the name “Hamburg”, was the first of a series of 23 Boeing 707s that Lufthansa, Boeing’s customer number “30”, ordered in three versions. In 1960/61, Lufthansa took delivery of the first five 707-430s.
with Rolls-Royce Conway Mark 508 engines. The airline had chosen these lighter, more economical, quieter and cheaper Rolls-Royce engines rather than the alternative, Pratt & Whitney JT4A-3 engines – a wise choice that made it possible to operate the Frankfurt–Chicago route nonstop with a full payload, which would not have been possible with the Pratt & Whitney engines.

From 1963 onward, these were followed by twelve 707-330B and six 707-330C freighters, the next generation of the 707 series, equipped with even more powerful and even more economical JT3D-3B engines, this time from Pratt & Whitney. The speed with which engine technology was developing at that time is well illustrated by fuel consumption for the round trip Frankfurt–New York–Frankfurt, which was twelve percent lower than with the previous model with Rolls-Royce engines that had been delivered only three years earlier! This technological advance had an extremely positive effect on Lufthansa’s flight operations: the fleet could now be scheduled more flexibly, cost-intensive refueling stops could be eliminated, and revenues increased.

For the first time, with the 707-330B, it was now possible to offer really long-haul nonstop flights, for example from Frankfurt to the West Coast of the United States.

**Senator Service**

As on the Lockheed propliners “Super Constellation” and “Super Star”, Lufthansa offered its legendary Senator first class service on board its Boeing 707 “Jet Intercontinental” machines. A maximum of 24 first class passengers were cared for by a hostess, a chef de cabine and a cook/steward, for whom the Berlin fashion designer Oestergard had developed a special fashion collection. Its “elegant yet casual lines serve to remind passengers pleasantly that they are on board the fastest and most modern aircraft in the world of aviation,” as an internal Lufthansa document from 1960 described it. Starting with the 1960/61 winter timetable, the 707’s passengers were also welcomed on board by the first foreign Lufthansa stewardesses, in order to respond better to the individual wishes of
its cosmopolitan passengers. So began another Lufthansa tradition that continues to this day – using flight attendants of many different nationalities.

But VIP Senator service on board the Boeing 707 amounted to more than just an attractively dressed and helpful crew. There was also a bar lounge for socializing, with both freshly drawn draft beer from wooden casks and cocktails. Although the form of the Senator service may have changed somewhat in the intervening 50 years to reflect the spirit of the times and the travelling public's current enthusiasms, one detail has remained unchanged since the days of the Boeing 707: to this day, every first class passenger is welcomed on board with a dew-fresh, red Baccara rose.

In addition to the luxury of first class, Lufthansa also offered a lower priced economy class in the 707, initially with 120 seats. This offered a slight preview of the mass tourism that arrived starting in 1970, along with the later widebody jets. In 1961, the cost of the cheapest Lufthansa jet ticket from Frankfurt to New York and back in 1961 was almost 25 percent lower than two years earlier, when only propeller aircraft were used on the route.

The last 707 that was delivered to Lufthansa was a 707-330C freighter with the registration D-ABUY and named “Essen”. It arrived in Germany on October 16, 1970, more than ten years after the D-ABOB. The 707 continued to be flown at Lufthansa until New Year’s Eve 1984, when both the passenger and freight versions of the airline’s first jet model were ready for retirement.

But the fleet had produced some remarkable results for Lufthansa: For example, in its 75,000 flying hours, the freighter with registration D-ABUA covered a distance equivalent to that from the Earth to Mars. When it was introduced in 1960, the 707 was the most advanced long-haul aircraft of its day. Even so, technological progress had finally caught up with it, and ultimately it was primarily its excessive noise and fuel consumption that put an end to the 707’s career.

HARALD CLAASEN
“MR. 707” OF LUFTANSA

Harald Claasen understands the technical characteristics and details of the Boeing 707 better than almost anyone. After finishing his degree in engineering, Claasen went to work for Lufthansa as a test engineer, including acceptance testing for Boeing jets in Seattle, among them the first Boeing 747. Finally he was promoted to system engineer for aircraft structures at Lufthansa Technik in Hamburg. Today, Harald Claasen claims to be retired, but his expertise is still in great demand worldwide among operators of the Boeing 707. His experience of aging aircraft in general and corrosion in particular meets with great appreciation from customers and colleagues.

When asked about the technical challenges of the 707, Claasen, who became known among the Lufthansa engineers as “Mr. 707”, especially remembered the “Wing Life Extension Program”. This arose from the assessment of data collected from operating experience and laboratory analyses of structural parts that had been removed from aircraft. The result was extensive checks of and reinforcements to the wings, starting in 1968. These measures had the goal of guaranteeing the Boeing 707’s intended utilization period of 60,000 flying hours and 20,000 flights.

“Lufthansa’s 707 fleet was very reliable,” Claasen reports. The aircraft got over the “teething stage” in just three months, reaching an average daily utilization of 10.5 hours.
THE BOEING 737 – “MADE” BY LUFTHANSA

Arrival of the first Lufthansa Boeing 737-130 at the technical base in Hamburg-Fuhlsbüttel, after its delivery flight from Seattle on 4 February 1968.
Quite early in the company’s history, Lufthansa gained a reputation as an innovative airline that wasn’t satisfied just to purchase aircraft “off the rack”. From the very first days of the airline’s technical base in Hamburg and all the way to today’s Lufthansa Technik AG, the know-how of Lufthansa engineers and business specialists has been in great demand from aircraft manufacturers worldwide, who value the input of an experienced operator when fine-tuning their aircraft studies.

During development of the Boeing 737, which has become the best-selling commercial aircraft of all time, Boeing and Lufthansa entered into what is still an unparalleled symbiosis. Ultimately it was a success story – but one that Lufthansa first had to convince Boeing of by guaranteeing the launch customer order.

The Lufthansa Boeing 737

Always in search of the optimal fleet mix, the Technical Projects department of Lufthansa’s engineering began familiarizing itself back in November 1962 with the latest short-haul jets – the BAC 1-11, DC-9 and Fokker F28 – that were contenders for replacing the company’s European fleet. At that time, the fleet was still a mix of propeller aircraft with piston engines such as the Convair CV 440 “Metropolitan” and the Vickers 814D “Viscount” turboprop aircraft; delivery of the first Boeing 727 Europe Jets wasn’t scheduled to begin until 1964.

In a fleet planning study, Lufthansa analyzed a variety of different scenarios for the shape its European fleet could take in 1968. A detailed
1 A Boeing 737-230 sported in 1982 the short-lived blank test livery.

2 The Boeing Flightline clears the Lufthansa Boeing 737-130 D-ABEF for the following acceptance flights on 17 February 1968.

3 Final assembly of the first Lufthansa 737 in December 1966 still wearing the airline design of the 1960s. This was changed before the 737 was delivered to Lufthansa.

4 The Boeing 737-130 D-ABEF in flight prior to delivery.

5 The Boeing 737-130 D-ABEA entered Lufthansa service on 23 May 1968.
analysis was made of the potential costs and revenues for servicing different pairs of destination cities using the various available aircraft. The company focused on three principal variants: a fleet consisting entirely of 727s, each with 96 seats; a mix of the 727 and a so-called “jet X”, seating up to 70 passengers; and a mix of the 727 and “jet Y”, with a maximum capacity of 55 passengers. Lufthansa initially favored the third of these variants, which would have corresponded to an aircraft of the size of a Fokker F28, whereas the second variant would have pointed more towards the purchase of the larger BAC 1-11 or Douglas DC-9.

Discussion of initial studies

In July 1964, Lufthansa’s internal fleet planning was already well underway when head Boeing engineers Jack e. Steiner and Joe Sutter, the latter subsequently to become the “father of the 747”, came to Germany. One of the objectives of their visit was to discuss their initial studies of the planned 737 with Lufthansa Executive Board members Hans M. Bongers, Gerhard Höltje, Wolfgang A. Kittel and Hans Süßenguth.

Just two months earlier, on 8 May 1964, Boeing had launched a program study on a potential competitor aircraft for the top-selling Douglas DC-9, which already had a two-year head start. Boeing president Bill Allen was prepared to invest half a million US dollars and three months of his staff’s time to develop a new small Boeing jet and evaluate its chances on the market.

In line with prevailing trends, Boeing’s original concept called for a small narrow-bodied jet with two engines at the rear of the fuselage. The engines were to be positioned very high on the fuselage so that the stream from the jet engine would be directed over the tailplane. Alarmed by accidents involving several twin-engine aircraft with T-tails where the planes had locked in stall, Boeing was determined to avoid this type of vertical stabilizer. Even at this early stage, however, the Lufthansa management urged Boeing, in the interests of a homogeneous fleet, to deploy the same Pratt & Whitney JT8D engines used in the 727.

In particular Professor Gerhard Höltje, the Lufthansa Executive Board member responsible for engineering, was taken with the Boeing 737, even though Lufthansa’s fleet planning team tended to favor the larger Douglas DC-9. As a result, at the time Höltje could do no more than indicate to the Boeing engineers his support for the purchase of the 737 if it turned out to be the better aircraft in direct comparisons with the DC-9 and Fokker F28.

On that trip to Europe in the summer of 1964, Jack E. Steiner and Joe Sutter also called on aircraft manufacturer Hamburger Flugzeugbau GmbH in Hamburg-Finkenwerder, which was producing the HFB 320 Hansa commercial jet with forward-swept wings. The talks they held at the company on the pros and cons of the T-tail and engines installed at the rear of the fuselage (compared with under-wing installation) were an important factor in determining the ultimate design of the 737. Even the Hansa Jet’s forward-swept wings were considered for use in the 737 before being abandoned on the grounds that they would be of no great benefit to the larger Boeing jet.

Team Red versus Team Blue

After returning to the United States, Steiner and Sutter set up two teams tasked with pursuing alternative design concepts for the 737. While Jack E. Steiner and his Team Red favored engines at the rear of the fuselage, Joe Sutter’s Team Blue pursued his ingenious idea of positioning them under the wings. The outcome of this in-house competition, which included numerous tests in the company’s
wind tunnel, is well-known: there were simply too many convincing aerodynamic, operational and economic reasons for installing the engines under the wings. What's more, Joe Sutter's design was a good 1,200 lbs. lighter, created space for an additional row of seats and made for a wider cabin.

Another source of controversy at the time was the cabin diameter of the new 737. In their efforts to build an aircraft with a much lower capacity than the 727 and 20 fewer seats than the DC-9, the engineers originally opted for a narrower fuselage diameter with just five seats per row. But in the course of the project, more and more factors began to favor adoption of the 727's forward fuselage diameter. After countless wind tunnel tests, the basic design of the Boeing 737 was finally completed in late October 1964, paving the way for the homogeneous aircraft family 707/727/737.

Among other things, Boeing guaranteed that 17 percent of the aircraft structure, a full 64 percent of the purchased components, and 76 percent of the interiors of the 727 and 737 would be identical. Even the basic layout of the flight deck in both aircraft types would differ only marginally, with the exception of the third seat for the flight engineer in the cockpit of the 727.

On November 2, 1964, the project team presented the new short-haul jet to the Boeing Management Council. For Boeing meanwhile, a fundamental question had been raised: to what extent would the new 737, which had already grown to become an 84-seater, cannibalize sales of the company's own...
727? And this question was completely aside from the huge costs of developing the new aircraft just a few years after the market launch of the 707, 720 and 727: financially, Boeing could not afford for the 737 to flop. Just one week after negotiating its first hurdle (the company’s Management Council), the project team presented its baby to the Boeing Board of Directors along with a detailed market and feasibility study. The result could not have been better: the team was commissioned to test the market and submit concrete proposals to the airlines.

In December 1964 and January 1965, Boeing tried to win over the three potential first customers of the 737 – Lufthansa, United Air Lines and Eastern Air Lines – with a design that would be acceptable to all of them. Whereas United wanted a 737 with capacity for 90-100 passengers (which eventually led to development of the 737-200), Lufthansa was much more cautious about the capacity question. With the 96-seat 727 already in use, Lufthansa favored a much smaller jet. In order to influence the engineering concept of the 737 as much as it could, Lufthansa sent various teams to the Boeing factory near Seattle. In particular Professor Ernst Simon, for many years head of the central Technical Projects department at Lufthansa, worked intensively throughout mid-January to steer development in the desired direction. At the end of the day, Lufthansa’s interest in the 737 was key in determining the ultimate appearance and size of the new aircraft. With United and Eastern Air Lines unable to commit to the new aircraft, Lufthansa initially remained the only potential buyer.

Strong proponent of the 737: Gerhard Höltje

Given the danger of launching the 737 program with just a single customer, the Boeing managers repeatedly put off the decision for the final go-ahead, which had a detrimental effect on the company’s otherwise good relationship with Gerhard Höltje, the strongest proponent of the 737 at Lufthansa. He had vigorously opposed the BAC 1-11 and kept the DC-9 supporters at Lufthansa in check – only to see Boeing waver on the final go-ahead. Höltje was angry and disappointed, and issued an ultimatum to the management of Boeing to reach a final decision for or against the 737 before the meeting of the Lufthansa Supervisory Board on February 19, 1965. At Lufthansa everything was on track to purchase the 737 after the Supervisory Board’s influential Technical Committee, which included top-ranking aviation research experts, had favored the Boeing 737 over the Douglas DC-9 on February 16.

Höltjes must have had a nerve-racking morning on February 19: the first members of the Supervisory Board were already turning up and he still hadn’t received word from Seattle. Not to be deterred, Höltje picked up the telephone and called Ken Luplow, at that time Boeing’s Sales Executive for Europe, demanding a final assurance that Boeing would build the 737 if Lufthansa confirmed their order. In turn, Luplow called Bruce Connelly, Vice President of the Boeing Transport Division, waking him in the middle of the night. It was ten in the morning in Cologne, where the Lufthansa...
Supervisory Board meeting was taking place, and two in the morning in Seattle when Connelly finally gave the green light, and the trans-Atlantic cliffhanger came to a happy conclusion. On that eventful February 19, 1965, the Lufthansa Supervisory Board authorized the Executive Board to purchase 21 Boeing 737-130 and an additional five Boeing 727-030. The letter of agreement signed that same day was followed on March 15, 1965, by the official signing of the contract between Boeing and Lufthansa.

"Unmatched degree of technical reliability"

On February 22, Gerhard Höltje announced at a press conference in Hamburg that Lufthansa would be ordering 21 Boeing 737 aircraft as a launch customer, citing the following reasons: "Intensive comparative studies and analyses lasting over a year have confirmed that the similarity between the new jet and the other, larger Boeing aircraft already in use in Lufthansa’s fleet will generate substantial savings. Since many of the parts are identical for all types of Boeing aircraft, Lufthansa will benefit from lower spare parts inventories and workshop costs, less ground equipment and reduced expenditures on training for both cabin crews and ground staff." Höltje also said he expected the new aircraft, which had been "deliberately designed to be uncomplicated," would deliver "a hitherto unmatched degree of technical reliability." Each "130 series" 737, which had been tailored to Lufthansa’s specific requirements, was priced at 13 million Deutsche Mark.

In the political world, the purchase of the American aircraft triggered a minor upheaval in relations between the UK and Germany because the British government had been hoping to reduce its trade deficit with Germany through sale of the BAC 1-11 to Lufthansa. However, both the Executive Board and Supervisory Board were united in their resistance to massive pressure exerted by the German chancellor Ludwig Erhard to order the BAC 1-11, and rejected political interference in no uncertain terms.
The prototype of the new aircraft, which Lufthansa initially dubbed “Olympia Jet” and later “City Jet”, took off on its maiden flight on April 9, 1967 with test pilot Brien Wygle at the helm. An 8-month program of test flights followed that comprised some 14,000 flying hours before Lufthansa could finally take delivery of its first, very own 737-130 on December 27, 1967. After Lufthansa pilot training in Tucson, Arizona, the first Lufthansa City Jet went into service on February 10, 1968: it was the world premiere of the Boeing 737.

In the years that followed, Lufthansa ordered not just the 737-130, but its larger brother, the 737-230 and the more economical 737-230 adv. Although identical in its dimensions with the Boeing 737-230, the „230 advanced“ was a milestone of civil aviation concerning the automation of flight, integrating for the first time autopilot, auto thrust and the performance data system.

It incorporated not only the first flight envelope protection for a civil jetliner, but also the first full flight regime auto throttle and the first smart go-around system, just to name a few of many innovations. As an example the pilots of the first 747’s needed to check sixteen switches and annunciations to initiate a go-around – on the 737-230 adv. it was just one!

This roll-over program was followed by a further roll-over into the newest 737-330, -430 and -530 as well as the enhanced 737-330, -430 and -530 versions with quieter and more fuel-efficient CFM56 engines.

More than 8,000 sold thus far

All in all, the Lufthansa Group has purchased a grand total of more than 150 aircraft from the highly successful Boeing 737 model range, more than 8,000 of which have been sold thus far to airlines around the world, and which might not have made it off the ground at all if it hadn’t been for two courageous and far-sighted members of the Lufthansa team: Gerhard Höltje and Ernst Simon.
40 YEARS OF THE JUMBO JET

Thanks to the huge dimensions of the 747, passengers experienced for the first time the spaciousness of a wide-body cabin with twin aisles.
The Boeing 747 Jumbo Jet, which has been with us for over 40 years, conjures up more emotions than possibly any other aircraft, among pilots, flight attendants and passengers alike.

In the course of the development program there were many difficulties to be overcome before the first Jumbo saw the light of day. Boeing engineer Joe Sutter recalls the original requirements that Pan Am imposed on the aircraft manufacturer in Seattle: “The passenger numbers they were talking about sounded enormous.” In actual fact the airline managers wanted to transport over twice as many passengers in a single aircraft as was possible with a Boeing 707, which at that time was being used on long-haul flights. This signified a massive leap forward. Paving the way for the global village.

Forty years ago, on April 26, 1970, Lufthansa began scheduled services with its first 747-130. This occasion was also marked by a second premiere: for the first time, each passenger could choose from a variety of music channels on headphones or watch the movies offered as in-flight entertainment. The 747-130 could accommodate 361 passengers, which also brought about a new dimension in ticket prices: the Jumbo Jet’s efficiency as a means of mass transportation meant that air fares could be drastically reduced. Flying lost its exclusiveness, paving the way for today’s “global village”.

The first 747-130 was soon followed by the improved 747-230B in 1971, a passenger-only version with a longer range and higher payload. And what could better illustrate the profitability of the world’s first widebody jet than its use on Condor’s vacation routes? The Jumbos, named “Max” and “Fritz”, were the first 747s to be used by a charter airline, bringing sun-starved Condor passengers safely to their vacation destinations from 1971 to 1979.

747 Freighters: Lufthansa first customer

Lufthansa was the first airline in the world to order the 747-200 Freighter, a decision that would prove to be positively visionary. With its 90-ton payload, the 747-230F was able to transport three times the cargo of the Boeing 707-330C. In addition to the striking cargo door in the nose, the 747-230F with the registration D-ABYE that was delivered on
March 10, 1972, was the first freighter plane whose cargo bay incorporated an automatic loading system. The same principle is used to this day: electrically driven rollers embedded in the floor of Jumbo freighters transport palettes and containers to their position in the cargo bay by means of guide rails and switches. A Jumbo freighter can accommodate even standard 40-foot maritime freight containers.

On April 19, 1972, two days after being christened “Cargonaut”, this new Lufthansa freighter took over the Frankfurt–New York route from the 707. The record of what was carried during its first two weeks covers the entire bandwidth of airfreight that Lufthansa Cargo transports to this day all over the world: In April of that year, racehorses, dismantled helicopters, the gondola of a hot-air balloon, automobiles, replacement engines, and even Bengal tigers and rattlesnakes crossed the Atlantic.

This first 747-230F laid the foundation for the leading role that Lufthansa Cargo AG now plays on the world’s airfreight market. It was not until

Joe Sutter
THE FATHER OF THE 747

“Lufthansa has always been strongly shaped by technicians and engineers, and this is just as true for the large engineering departments as for top management. At other airlines, specialists in finance and marketing have traditionally dominated management, and this fact is an important element in the constructive and very successful partnership between Boeing and Lufthansa.”

This is something that Joe Sutter, the “father of the Boeing 747” and for many years the company’s lead developer for its most important civilian aircraft models from the 707 to the 737 and 747, ought to know. Even today he enjoys describing the many “very interesting” meetings with Gerhard Höltje and Reinhard Abraham, who amended Boeing’s designs with customer input in such a way that the aircraft design was more successful on the market. In some cases, customer feedback even formed the basis for an aircraft’s success!

In the case of the Boeing 707, this consisted of input from Gerhard Höltje, whom Sutter describes as having a “strong, impressive technician’s personality”. Höltje’s contribution to Boeing’s progress in building commercial aircraft should not be underestimated. “After the success of the 727, we were pretty slow to develop smaller jets, such as the 737,” Sutter remembers. In the latter case, it was Lufthansa’s Technical Director Gerhard Höltje and their engineer Ernst Simon who provided Boeing with decisive input on the size and configuration of this twin-engine short-haul jet at numerous meetings on both sides of the Atlantic.

Lufthansa also played an important role in the start and customer-oriented development of the Jumbo Jet, both as Boeing’s first customer for the 747 freighter and as a driving force in the aircraft’s further development into the 747-400. “Today we understand how important it was to follow Lufthansa’s urging to take a large and significant step toward modernization with the 747-400 – significantly larger than we initially planned.”

Joe Sutter retired in 1986, but has remained available to Boeing in a consulting capacity. Now 89, he’s still a technical visionary. “Once again, Lufthansa is the first customer and an important development partner for our new flagship, the 747-8. And that makes it very clear to me: this fruitful partnership has a great future.”
1. Lufthansa was the first customer outside the USA for the original 747-100 “Jumbo Jet” passenger version. The leading aircraft with the registration D-ABYA was handed over to Lufthansa on 9 March 1970 and entered scheduled service just one month later.

2. The original Lufthansa 747-230 Freighter could carry up to 90 metric tonnes of cargo between Frankfurt and New York, three times as much as the Boeing 707 Freighter it replaced on this high-density route.
The original 747 flight deck (1) was replaced in 1989 with a digital glass cockpit on the Boeing 747-400 (2). This allowed the 747 to fly, for the first time, with a two-man flight crew and without a flight engineer. Again it was Lufthansa that pushed Boeing for this significant change towards an advanced, digital 747-400 flight deck.

The design of the Boeing 747-400 has been largely influenced by Lufthansa.
December 2004 that Lufthansa finally retired its 747-230F fleet and replaced the Jumbos with the more fuel efficient tri-jet Boeing MD-11 freighters.

After a few years of service, in the mid of the seventies Lufthansa replaced the first 747 model with Pratt & Whitney engines with a new Jumbo fleet equipped with General Electric CF6-50E2 engines with a much higher reliability than the first generation engines. This laid the foundation of a long lasting partnership between Lufthansa and General Electric.

747-400: New Jumbo generation

In the course of the 1970s, the airlines became increasingly cost-conscious. Their cost concerns also affected the requirements regarding the technical fitting out of aircraft. If Lufthansa had already been involved in the planning of the 747-100, as one of the first airlines to order the Boeing 747-400 it played a significant role in the development of the new version.

Jürgen Weber, in the late eighties Lufthansa’s Chief Technical Operating Officer, later the airline’s CEO and its present Chairman of the Supervisory Board, played a material role in this work. He succeeded along with other airlines in convincing Boeing of the concept of a new generation of Jumbos.

Block change aircraft

Reinhardt Abraham, former Chief Executive Technical Services of the Lufthansa Group, and Jürgen Weber together with Dr. Rolf Stüssel, Director Engineering and Dr. Klaus Nittinger, Head of Aircraft Evaluation, pushed for a ‘block change aircraft’ instead of a year long sequence of a number of major single improvement and modification steps. One of the most significant changes, was the introduction of an advanced cockpit. The installation of digital systems made it possible to introduce the first two-person cockpit on the Jumbo Jet. All the essential data required for flight and system monitoring was presented on six large screens. The number of indicators, instruments and switches in the cockpit was reduced from 1,000 to less than 400. This one new block change approach included the new cockpit, new interior, new engines and a revised wing.

The modified Super Jumbo with the additional designation “Dash 400” rolled out of the assembly hall in Everett near Seattle on 26 January 1988. Technical expertise and over 20,000 hours of engineering effort had gone into this new variant. Along with the two-person cockpit, the most important changes included: an extended upper deck allowing seat capacity to be increased by 20 seats, improved aerodynamics thanks to a five-meter longer wingspan, and 1.8 meter high winglets fitted on the wingtips.

As a result, fuel consumption was significantly reduced. At the same time the aircraft was powered by more fuel-efficient engines that were also more powerful. Empty weight was reduced by four tons thanks to the use of new materials.
TECHNOLOGY UNLOCKS THE FUTURE

New engine technology paves the way into a greener future.
The progress in aviation over the last 50 years is nothing short of revolutionary. When it comes to economic and environmental efficiency, modern commercial aircraft are well positioned to compete with any other form of motorized transport. For aircraft manufacturer Boeing and for Lufthansa, continuous expansion of the technological envelope has always been key to rapid and successful improvements in efficiency and environmental footprint reduction. And these developments have left almost no part of the aircraft untouched.

From prop to jet

The introduction of jet aircraft in the 1950’s produced a gigantic leap in performance. While propeller aircraft were flying at speeds of around 480 km/h (300mph), the Boeing 707 managed over 800 km/h (500mph) – with twice the number of passengers. And since it flew mostly above the weather, the physical stress for passengers and crew was also drastically reduced; from this point on, flying became pleasant.

But at first there was, quite literally, a high price to pay for these improvements, so that flying remained a rather elitist pleasure. It took a long series of technological developments over the
following decades to make air transport more affordable. These technical advances form the basis of our current attitude to flying – we regard it as a commodity rather than a luxury.

From jet engines to the modern turbofan

The first engines that were used for the Boeing 707, Pratt & Whitney's JT3Cs, were "civilized" versions of a military jet engine. In this type, all the air drawn in is compressed and forced into the combustion chamber, where kerosene is injected. The ignited mixture drives the turbine and exits through the jet at high speed, with the stream of accelerated gas delivering the engine thrust.

In addition to their massively better performance, jet engines were also more reliable and therefore offered considerable flight safety benefits. The main disadvantage of this type of engine was the very high noise levels caused by the extremely high ex-haust speed, and their specific fuel consumption was also relatively high. However, with the right measures it was possible to overcome these disadvantages. The solution hinged on the realization that it is more efficient to accelerate a large volume of gas periodically than to accelerate a small volume of gas often.

The key element used by the engineers to put this insight to work is the bypass engine principle. It involves placing a second turbine behind the high-pressure turbine in the jet engine. This second turbine extracts energy from the gas stream and a shaft conveys this energy to the front of the engine, where it drives the large and clearly visible fan. Only part of the air accelerated by the fan is forced into the engine core; most of it bypasses the engine and generates thrust directly.

These fan jet engines offered considerably higher efficiency. One of the first engines to be constructed using this principle was already used in the Boeing 707: the JT3D that was also built by Pratt & Whitney. This technology laid the foundation for developments that eventually led to today's high-efficiency turbofans. Their modern design vastly reduces specific fuel consumption by more than 70 percent compared to that of the first engines of the jet age. No other means of mass transportation can point to comparable progress.

One welcome side-effect of fan jet engines: the less highly accelerated bypass flow reduces environmental noise pollution. In fact, it proved possible to reduce the noise footprint by 90 percent. And this development is still continuing: the Boeing 787 Dreamliner is equipped with particularly quiet engine nacelles with chevrons on their trailing edges – cutouts resembling saw teeth serve to help reduce the noise of the engine which combined with other innovations reduce the overall noise footprint by 60 percent.

1 “Saw teeth” resembling chevrons on the engine trailing edges considerably reduce the engine noise.

2 The Boeing 747-8 will be a quiet and efficient giant in the Lufthansa fleet.
Reinhardt Abraham Memorial Foundation
Fostering the Education of Young Scientists

In memory of Reinhardt Abraham, former Chief Executive Technical Services of the Lufthansa Group and initiator of many technical developments in Boeing aircraft, Boeing and Lufthansa in 1995 jointly established the Reinhardt Abraham Memorial Foundation in order to foster the further education and training of students and young German and American graduates in the field of aviation and air transportation.

The scheme of the Reinhardt Abraham Scholarships offers training and exchange programs to supplement the courses of dedicated students at Berlin University of Technology and the University of Washington in Seattle, USA. This means: Young scientists can deepen their knowledge of production and development in a trainee program at Boeing. Or they have the opportunity to spend six months on an exchange studying and researching at their partner university.

This program is available to students majoring in civil aviation at Berlin University of Technology. On top of this, the Reinhardt Abraham Scholarships also support the Deutsche Gesellschaft für Luft- und Raumfahrt (German Aerospace Centre) in fostering the education and training of young scientists by awarding the annual Reinhardt Abraham Foundation Prize.

About Reinhardt Abraham

Reinhardt Abraham played a key part in forming many aspects of Lufthansa. He began his career at Lufthansa in 1956. Abraham became CTO in 1972 and Deputy Board Chairman of Lufthansa in 1982. During the course of his successful career, Abraham gained a reputation as an outstanding civil-aviation expert well beyond the bounds of Lufthansa and Germany. Between retiring from the Board in 1989 and passing away in 1995, he took on numerous honorary posts. The purchase of the Junkers Ju 52/3m and, associated with this, the creation of the Lufthansa Berlin-Stiftung are due to his dedication and commitment.
Electronically controlled

In their search for increased reliability and efficiency, the engineers developed a whole series of new technologies, the most notable of which was electronic engine control – an innovation that has since become the standard. This “full authority digital engine control” (FADEC) has practically eliminated mechanical engine controllers. Since these controllers – unlike their mechanical predecessors – can process an almost unlimited number of input and output parameters, it is possible to optimize the control and regulation of the entire engine process, producing a significant reduction in both fuel consumption and noxious emissions.

The introduction of FADEC had the incidental side-effect that a very large number of engine parameters were now available as continuous digital readouts. The next logical development was therefore to introduce engine condition monitoring (ECM). This type of system transmits important engine parameters via a data link to a ground station, where the information is stored and analyzed. The resulting comprehensive view of the engine is a great deal more detailed than the view given to the pilot by the cockpit instruments; for example, it facilitates the precise identification and tracking of trends, enabling faults to be recognized very early on.

Lufthansa Technik carries out engine condition monitoring on behalf of a large number of customers. In some cases engineers have managed to alert well-briefed teams at an aircraft’s destination airport even before the cockpit crew had noticed any sign of the possible complications. ECM is thus an extremely effective system for improving operational reliability and safety.

Black metal: from aluminum to carbon

For decades, aluminum alloys have been the materials of choice in aircraft construction, but the development of fiber-reinforced polymers – particularly carbon fiber-reinforced plastics (CFRP) – has opened up a whole new dimension for the aircraft industry. These materials offer some extraordinarily attractive features: low specific gravity, high strength, and outstanding fatigue resistance, which is a particularly desirable quality in aircraft construction.
But a very long development phase was needed before the new materials could be used to build whole airplanes. Their use was initially restricted to aerodynamic fairings and other non-load-bearing parts of the aircraft. Practical experience also revealed a number of problems: for example, detecting damaged areas in these composite structures was extremely time consuming. Damage to an aluminum plate leaves a dent that can be easily identified and localized, but this isn’t true of fiber-reinforced polymers. They remain elastic right up to the point of total failure, which means that an undamaged surface doesn’t necessarily indicate an undamaged part. This meant that Lufthansa Technik, as an MRO provider, had to develop new ways of testing these structures, with techniques that range from literally “tapping” the structure to ultrasound scans and infrared measurement technology.

But the advantages of the new fiber-reinforced plastics gradually made them attractive for use in more and more parts of the aircraft. Once it was possible and safe to use CRP even for structural parts – for example, the Boeing 777’s horizontal tail and elevators are made of CFRP – Boeing finally decided to take the really big step: the Boeing 787 is the first commercial aircraft whose structure consists mainly of carbon fibers.

The 787 benefits from this with a lower empty weight and correspondingly better overall economic efficiency. Since age-related factors such as corrosion and fatigue are not likely to be a problem, we can expect the maintenance effort for the new jets to be markedly lower than for the previous generation. In fact, Boeing predicts a 30 percent lower cost. Lufthansa Technik has decades of experience and competence in the repair of composite materials and is therefore ready and able to maintain the new aircraft once certification is completed.

**Aerodynamics**

Engineers possess yet another weapon in the fight to improve the performance and economic efficiency of commercial aircraft, aerodynamics, and massive advances have been made in this field as well. One of the prerequisites was to improve numerical simulation: airfoil profiles are now designed on the computer using computational fluid dynamics (CFD). The performance explosion in computing has had the effect that more configurations can now be investigated and detailed solutions can be optimized more effectively than ever before. The Boeing 787 is a good example of this. The system of flaps on the trailing edge of the wing was previously constructed of at least three elements, but on the 787 the same system performance is possible with just two – simpler, more cost-effective and easier to maintain.
One example of an aerodynamic optimization that makes the 787 unmistakable is Boeing's raked wing tip design, which is curved upwards and towards the back, offering additional improvements in performance. The complex aerodynamic shape can be manufactured particularly economically from CFRP, bringing together innovations from two separate areas. The same applies to the extremely slender, aerodynamically optimized wings, which would be difficult to construct without fiber-reinforced plastics.

System efficiency is key

The benefits of even the most efficient flying machines are for naught if the infrastructure (i.e. the highway in the sky) in which it operates doesn't function optimally. For instance, if the situation at its destination airport forces an airplane to spend a long time in a holding pattern, fuel saving can be unrealized. Or when different countries' air traffic control systems are so poorly networked that the pilot has to meander towards the destination rather than taking the most efficient route, fuel is wasted instead of saved.

For this reason, considerations of economic and environmental efficiency in aviation always need to take a holistic approach. The rule that applies to an individual aircraft design also applies to air traffic as a whole: it can only be effective if the entire system is optimized and addresses all the factors associated with traveling by air. That's why we need to look not just at airports, but also at the traffic in the air, i.e. the air traffic control system.

In fact, the International Air Transport Association (IATA) estimates that air traffic management (ATM) enhancements could improve fuel efficiency and CO₂ emissions by up to 12 percent. Transforming the ATM system is critical to economic growth, will enhance safety and improve operational and environmental efficiency.

Boeing and Lufthansa are working with industry, regulators, airlines and airports to improve management of the air space and ensure efficient, safe and seamless operation worldwide.

Boeing's work includes the development of ATM solutions that reduce fuel use by minimizing delays and holding patterns over airports and capitalizing on precision navigation technologies in modern aircraft often left unexploited in the legacy system. One example: the Tailored Arrivals concept that increases airplane arrival efficiency by establishing a predictable continuous descent rather than the
current fuel intensive step-down descent. Tailored Arrivals enable aircraft to fully utilize air-to-ground data link technology to descend into an airport with minimal direct air traffic control intervention.

Sustainable second generation biofuels

In the early days of the jet age, speed and luxury were the drivers of intercontinental travel. Today, our engines are at the cutting edge of efficiency. Our aircraft are more aerodynamic. and lighter than ever before. We are making huge improvements in our air traffic control efficiency, how we fly our aircraft and in developing more environmentally-friendly operations at airports.

But we are still using the same fuel. That's about to change. The world is turning to governments and business to reduce the human impact on climate change. And the aviation industry is about to embark on a new journey. Sustainable biofuels are crucial to providing a cleaner source of fuel to power the world’s fleet of aircraft and help the billions of people who travel by air each year to lower the impact of their journey on our planet.
Boeing and Lufthansa develop Air Traffic Management solutions that help to avoid unnecessary holdings and fuel consumption, thus increasing the efficiency of modern aircraft, like the pictured 787-8, even further.

Both Lufthansa and Boeing invest in a more sustainable aviation industry and an environmentally progressive air traffic.

Biofuels are produced from renewable biological resources such as plant material (rather than traditional fossil fuels like coal, oil and natural gas). They absorb carbon dioxide from the atmosphere as the plant matter (biomass) is grown, which is then released back into the atmosphere when the fuel is burnt. First-generation biofuels have been used for a number of years for transport, home heating, power generation from stationary engines, and cooking. Second-generation biofuels are derived from new sources that do not compete for resources with food supplies and can be used in aviation.

Boeing is helping to pioneer the development of sustainable biofuels. The technology is proven, and together with leading global air carriers, Boeing is working with leaders in the fuel processing
and clean tech industries to certify and accelerate the market availability of new generations of low-carbon sustainable biofuels for aviation use. Boeing completed four test flights using different airframes equipped with the major engine brands (General Electric, Rolls-Royce, CFMI, Pratt & Whitney). Boeing has completed laboratory, ground and air testing and have validated the technical feasibility of using biofuels for aviation. The focus now is on certifying biofuels for aviation through fuel specification bodies.

Promoting alternative fuels

Also Lufthansa attaches great importance to the subject of alternative fuels. Aim is to add up to 10 percent of synthetically produced fuel to conventional kerosene by 2020.

Lufthansa places these requirements on alternative fuel:

- Suitable for air transport
- Available in sufficient quantities
- Acceptable price
- Not in competition with food production
- Proven environmental advantages

Being a partner in research and of industry, we will make our contribution to accelerating the development of sustainably produced alternative fuels for air transport to market maturity.

Fuels that have been produced from plant-based raw material emit carbon dioxide when burned, but only at levels that the plants absorbed from the atmosphere to support their growth – it remains a closed ecological circuit. Therefore, such biofuels have the potential of significantly lowering net carbon dioxide emissions in the future.

The historic developments made in commercial aircraft over the last 50 years underscore the fact that aircraft builders, MRO providers and – not least of all – engine manufacturers have created optimally maintained aircraft embodying the most advanced technology as the basis for environmentally progressive air traffic.
747-8 – LONG LIVE THE JUMBO!

The unique look of the Boeing 747 "Jumbo" distinguishes it from any other civil jetliner.
When the first 747-8 Freighter lifted off from Boeing’s Paine Field in Everett, Washington on 8 February 2010, the event marked a new chapter in the recorded history of the 747 program. The 747-8’s first flight came just one day before the 41st anniversary of the first flight of the 747 Jumbo Jet, which took off from the same airfield in 1969.

As the first airline worldwide, in December 2006 Lufthansa placed an order for 20 new 747-8 Intercontinental jets, at the same time securing further options for the “Dash 8”. Joe Sutter, the Boeing engineer regarded as the father of the original Jumbo Jet, attended the signing of the contract between Lufthansa and Boeing, and could hardly conceal his justifiable pride. For him the decision to build the new Boeing 747 with the suffix “Dash 8” offers something like eternal life to the aircraft once developed under his direction.

But the desired construction options need to be realistic and in harmony with the market. At the end of the day, Lufthansa needed an aircraft for its fleet to extend the upper limit of the Boeing 747-400’s existing capacity by about 50 seats. There was no such aircraft on the market and it was clear to Lufthansa’s engineers that a completely new development was not on the cards. That was when the idea of further developing the tried and tested Boeing 747 was born. The simplest solution would have been to stretch the fuselage – and there were and are plenty of examples for this approach – but the Lufthansa team wanted more.

So it was that the new Jumbo Jet was not only lengthened by 5.6 meters but also acquired completely new wings, with a four-meter wider wingspan and state-of-the-art engines. There have been considerable improvements in recent years, especially in the area of aircraft engines. As a result, fuel consumption has been significantly reduced, operating costs have been cut by 30 percent and CO₂ emissions by 16 percent, with a 30 percent lower noise footprint even than those of the 747-400. The 747-8 Intercontinental will carry about 420 passengers on long-distance flights to Asia or North America with greatly improved economic efficiency.

A Jumbo leap in technology

The 747-8 is a new aircraft – and yet it’s not. Although the iconic hump identifies it as a 747, it is the latest technology – and resulting efficiency – that distinguishes the 747-8 from the 747-400, the last of which left the Boeing plant in the summer of 2009. Boeing spent years considering how to replace the 747-400. The missing factor was the engines. Development then made a leap forward with the
launched the two-engine Dreamliner. These newly
developed 787 engines provided the right amount
of thrust for a four-engine 747 and, with some
modifications, promised to be a good replacement:
for example, the new 787 engines were larger than
any engine ever used on production 747s and the
wings needed to accommodate them.

Next-generation performance

The GEnx 2B engines from General Electric are
up to the minute in all possible respects and
features: composite third-generation fan blades,
a light-weight composite fan case, high-efficiency
aerodynamics, a low-emission combustor and
advanced engine diagnostics.

One engine feature that is clearly visible from
outside – and underlines Boeing’s initiative in the
use of quiet noise technologies – are the chevrons
on the trailing edges of the 747-8’s engine nacelles,
like those on the 787. The tips of these zigzag or
saw-tooth shapes are bent very slightly into the
engine’s air flow, creating vortices that enhance
the mixing rate of the air and thus reduce the total
engine noise by several decibels.

A new wing design for a new 747

Besides the environmental aspects, the 747-8 wing
also needed to be redesigned in order to maintain
the same take-off and landing performance as
the 747-400 while carrying more payload and
passengers. Looking along the edge of the 747-8
wing towards the tip, it’s easy to recognize the
complex curvature of the wing and see how it
accommodates the engines.

This new and advanced wing design had some
significant implications for production and
fabrication. The raw material used for wing skins
varies between 10 and 30 meters in length, and in
some places it’s more than 2.5 centimeters thick.
Traditional methods of contouring the skin include
shot peening, which consists of spraying it with
thousands of kilograms of tiny fragments of cut
steel wire, thus hardening the material and making
it more fatigue-resistant. But this method wouldn’t
work on the thicker parts of 747-8 wing skins, so
Boeing had to use something new – laser peening.
This technology had never been used before for
forming wing skins, but with it, the longest part of the
747-8 wing – the lower enclosure panel – receives a
quarter-million precisely placed laser spots.

Advanced technology and operational harmony

The flight deck is another element of the 747-8
that illustrates the symbiosis between legacy 747s
and the new technologies used in the 787. Boeing
wanted to ensure that the 747-8 not only offers
better performance, longer range (14,800 km/8,000
nautical miles) and all the other improvements,
but also fits smoothly in the current operational
environment of Lufthansa’s existing fleet of Jumbos.
JÜRGEN WEBER

THE NEXT CHAPTER IN A SUCCESS STORY

The saga goes on. Affectionately known as the “Jumbo Jet”, no other airplane than the Boeing 747 epitomizes so prominently the metamorphosis of air transport from a medium for the rich and the mighty to a means of mass transport for you and I. In 1970, Lufthansa was the first European airline to take a decisive step into a new era of aviation with a ‘giant’ airplane, one that set new standards in terms of passenger numbers, range and operating efficiency. To date, nearly four billion people have travelled in a Jumbo Jet. Aircraft of this type will soon have circled the earth two million times. “Lufthansa has played an important role in this phenomenon,” says Jürgen Weber, who was Lufthansa’s Chief Technical Operating Officer in the late eighties and later became the airline’s CEO and is its present Chairman of the Supervisory Board. He can look back on forty years’ involvement with this super aircraft at Lufthansa.

Above all, Weber is referring to Lufthansa’s crucial role in the 747 development during the 1980s into what has become the Boeing 747-400, the current head of the 747 family. This aircraft continues to be the indispensable backbone of many airlines’ long-haul fleets. “At the time, Boeing was fairly hesitant about taking a really big step forward into a new dimension, a step that we believed was absolutely necessary in terms of capacity and new technology,” Weber recalls. “I know for a fact that during our many visits in Seattle, we and our teams of engineers weren’t always the most welcome visitors,” he remembers. That’s because Weber and Chief Executive Technik, Reinhardt Abraham, insisted stubbornly on a big “block change”. They were demanding not less than a new wing, new engines, a significantly more flexible cabin and a entirely new, two-man glass cockpit.

“In spite of the fact that Boeing is traditionally highly customer-oriented, it took a lot of persuading. But today we know that the controversial and lively discussions we had on the dimensions of the technological quantum leap required of the 747 and also the 737 resulted in advantages for both, the manufacturer as well as the customer.” Because of the aircraft family concept, greater production standardization enables cost reductions and offers customers more flexibility in the configuration of their aircraft.

“This turned out to become one of the rock-solid foundations of the great success of these two planes. And I’m absolutely convinced that we’ll write the next successful chapter of the Jumbo success story with the newest member of the Boeing 747 family, the 747-8 Intercontinental, to join our fleet in the not too distant future.”

So it optimally merged the new technology with the successful 747-400 interface: a new flight management computer, vertical situation display and global positioning landing system with autoland capability are just a few of its outstanding features.

Lufthansa’s engineering skills feature prominently in the continued success story of the 747. As the first European airline to put the Jumbo Jet into service more than 40 years ago, the airline and its maintenance arm Lufthansa Technik have both accumulated many years of experience in the operation and technical support of the Jumbo. The company’s entire wealth of experience of the existing aircraft types has been brought into the program: Lufthansa Technik has maintained and overhauled the 747-400s and their engines for almost 20 years, and those two decades of experience are being transferred to the new 747.

Lufthansa Technik’s input into the development and specification of the 747-8 began long before Lufthansa will take delivery of the first 747-8 Intercontinental. To obtain the best possible solution
for future operators, experts from Lufthansa and Lufthansa Technik, along with representatives of the manufacturer and other future operators, organized work groups at Boeing focusing on various systems and aspects of the aircraft. For example, an industry steering committee was tasked with finding solutions that would permit longer intervals between maintenance events, thus further reducing the costs of future 747 operations. The goal is to help increase the aircraft's technical reliability even before it enters service.

A lot of attention has gone into plans for its future technical support, including a list of known issues and areas of the 747-400 that Lufthansa thought should be further developed for the 747-8. This included such issues as the position of valves to facilitate their maintenance, improvements to the cart lift and the integration of high-speed data buses.

The legend will live on

The partnership-inspired further development of the 747 to the “Dash 8” justifies our confidence that the legendary Jumbo Jet will survive for many more years. But emotions played only a supporting role in the decision to allow the Boeing 747 to live on into a third generation: the generally recognized opinion throughout the aerospace industry is that decisions on new aircraft always demand reliable farsightedness from both manufacturers and airlines. And the fruitful cooperation between Boeing and Lufthansa – then, now and in the future – is a shining example of this mutual understanding.
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