

Know All About Airliners



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First Edition, 2012

ISBN 978-81-323-2789-9

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Published by:
Orange Apple
4735/22 Prakashdeep Bldg,
Ansari Road, Darya Ganj,
Delhi - 110002
Email: info@wtbooks.com

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Airliner



Airbus A320



The Boeing 747-400 wide-body airliner is arguably the world's most recognizable airliners.

An **airliner** is a large fixed-wing aircraft for transporting passengers and cargo. Such planes are owned by airlines. Although the definition of an airliner can vary from country to country, an airliner is typically defined as a plane intended for carrying multiple passengers in commercial service, and the Russian Sikorsky Ilya Muromets was the first official passenger aircraft by this definition. This airliner made its first flight in 1913, and thus began the industry of commercial airlines. The industry would slowly develop for the next several decades and would begin to expand at an incredible rate after World War II.

History



A United Airlines DC-6 at Stapleton Airport, Denver, in September 1966

When Wilbur and Orville Wright made the world's first flight in Kitty Hawk, North Carolina, they not only made history but also were laying the foundation for what would become a major transportation and industrial industry. This flight in Kitty Hawk, North Carolina in 1903 was just 11 years before what is often defined as the world's first airliner. These airliners would change the world socially, economically, and politically in a way that had never been done before.

If an airliner is defined as a plane intended for carrying multiple passengers in commercial service, the Russian Sikorsky Ilya Muromets was the first official passenger aircraft. The Ilya Muromets was a luxurious aircraft with an isolated passenger saloon, wicker chairs, bedroom, lounge and a bathroom. The aircraft also had heating and electrical lighting. The Ilya Muromets first flew on December 10, 1913. On February 25, 1914, it took off for its first demonstration flight with 16 passengers aboard. From June 21 – June 23, it made a round-trip from Saint Petersburg to Kiev in 14 hours and 38 minutes with one intermediate landing. If it had not been for World War I, the Ilya Muromets would have probably started passenger flights that same year.

The second airliner was the Farman F.60 Goliath from 1919, which could seat up to 14 passengers, approximately 60 were built.

The Ford Trimotor was an important early airliner. With two engines mounted on the wings and one in the nose and a slab-sided body, it carried eight passengers and was produced from 1925 to 1933. It was used by the predecessor to TWA as well as other airlines long after production ceased. In 1932 the 14-passenger Douglas DC-2 flew and in 1935 the more powerful, faster, 21–32 passenger Douglas DC-3. DC-3s were produced in quantity for WWII and sold as surplus afterward. The Douglas DC-3 was a particularly important airplane because it was the first airliner to be profitable without a government subsidy.

The first jet airliners came in the immediate post-war era. Turbojet engines were trialed on piston engine airframes such as the Avro Lancastrian and the Vickers VC.1 Viking, the latter becoming the first jet-engined passenger aircraft in April 1948. The first purpose-built jet airliners were the de Havilland Comet (UK) and the Avro Jetliner (Canada). The former entered production and service while the latter did not. The Comet was unfortunate in that metal fatigue caused crashes.

Jets did not immediately replace piston engines and many designs used the turboprop rather than the turbojet or the later turbofan engines.

Postwar Airliner History in the United States

The United States gained a huge advantage in design and production in the airline industry in the years leading up to the war, but many of the developments would be put off until after the war as the manufacturing efforts were placed on the war effort. The advancements that the United States would make in this industry were in large part due to the cooperation of the airlines discussing what they desired with the airliner manufacturers. Soon after the war though Douglas made a large advancement with the DC-4, although this could not cross the Atlantic at every point, it was able to make a nonstop flight from New York to the United Kingdom. Due to the war going on, the first batch of these planes went to the US Army and Air Forces, and was named the C-54 Skymaster. Some of these that were used in the war would later be converted for the airline industry, along with the passenger and cargo versions that were placed on the market once the war ended. Douglas would later develop a version of this plane that was pressurized and 5 feet longer; this redesigned plane would become the DC-6. These DC-6s would be grounded for 6 months to rectify a few safety issues that were causing in-flight fires.

Soon after the DC-4, Lockheed developed the Constellation; this was a major development because it was the first airliner to have pressurization. This pressurization was very important because it allowed the planes to fly higher, and therefore further and faster than ever before. This had a fuselage that was about 127 inches wider than that of the DC-4. Like the DC-4 this plane also had a late entry to the civilian airline industry because they were used in the war and later converted for the airline industry. The Constellation did experience some safety concerns soon after it entered service, requiring it to be grounded for 6 months while the problems were investigated and repaired.

In 1947, an airliner from third company made its maiden voyage. The Boeing 377 Stratocruiser entered the industry with a completely different design than the planes from Douglas and Lockheed. This plane was based on the C-97 military transport plane, and had a double deck, and pressurized fuselage. This plane was known for the luxury that it had to offer as well as its ability to hold 100 passengers. There were only 55 Stratocruisers produced, but this plane was still incredibly important as nearly 900 of the C-97s were produced for the military.

The American companies had done a great job of advancing the status of transcontinental travel, but there was also the aging fleet of DC-3s that had to be addressed. Convair decided that they were going to address this market, and would begin producing the Convair 240 which was a 40 person fully pressurized plane. There were 566 of these planes that would fly, including 2 that were equipped with jet-assisted take off units. Convair would later develop the Convair 340, which was slightly larger and could accommodate between 44 and 52 passengers, and there were 311 of this model plane were produced. Finally Convair would create a Convair 440, which had small modifications including much better soundproofing than the previous models. Convair would experience a little bit of competition from the Martin 2-0-2 and Martin 4-0-4, but in general Convair was able to control this market, as the 2-0-2 was had safety concerns and was unpressurized, and the 4-0-4 only sold around 100 units.

The United States was dominant in this industry for several reasons including a large domestic market for these planes. The market would also work in the United States favor as the American companies began to build pressurized airliners. During the postwar years engines became much larger and more powerful, and safety features such as deicing, navigation, and weather were added to the planes. Lastly, the planes produced in the United States were more comfortable and had superior flight decks than those produced in Europe.

Postwar Airliner History in Great Britain

Great Britain was in a very different position after the war than the United States. Unlike the United States, Great Britain had a small domestic market and almost all of the airplane construction that had take place domestically was for war. In December 1942 the British government had a committee put in place to set classifications for airplanes ranging from Non-Stop North Atlantic airplanes to Small Piston-engine airplanes for light traffic. These classifications were set up to encourage development of airliners of all types. In order to recover from the difficulties that this caused many of the postwar airliners were bombers that were converted to allow for commercial air travel, but this was not very economical as the planes could hold very few people. The first postwar program that was attempted in Great Britain was the Tudor airliner, however this was regarded as a failure due to safety concerns and few sales. The first successful British Airliner was a Vickers Armstrongs Viking. These were unpressurized and could hold between 21 and 27 people depending on the model. On April 6, 1948 one of these Viking airliners became the first jet-airliner to fly. The previous engines were now replaced with Rolls-Royce Nene Turbojets. In 1946 the Bristol 170 was the first transport aircraft to

receive a Certificate of Airworthiness from the British government. This plane remained in production for 12 years with 214 of the aircraft built. The British would also produce several smaller aircraft such as the Airspeed AS.57 Ambassador in 1947 and the Miles M.57 Aerovan in 1945. Most of the British planes produced in the postwar era were smaller planes that could hold less than 30 passengers, and did not sell as well as some of the planes produced in the United States, but these planes were enough to help the British airline industry from the lack of commercial production during the war.

Postwar Airliner History in France

In the postwar years France developed a few significant airliners, some of these being planes that could land on water, part of the reason that the French companies were so focused on these flying boats is that in 1936 the French Air Ministry requested transatlantic flying boats that could hold at least 40 passengers. Only one model from this request would ever be put into service. The first set of these was 3 Latecoere 631's that Air France purchased and put into service in July 1947. However, two of these planes crashed, and the third plane was soon removed because of these safety concerns. There would later be a SNCASE SE.161 Languedoc build, which was a much more successful plane, and over 100 of these were built, with 40 of them being placed into service through Air-France. The French also developed the Breguet 763 Deux Ponts, which first flew in February 1949. This was a double-decker transport airliner that would end up being used for both people and cargo. This four-engine airliner would end up being used to hold massive amounts of cargo or 97 passengers.

Postwar Airliner History in the USSR

Soon after the war most of the Soviet fleet of airliners consisted of DC-3s or the Lisunov Li-2. These planes were in desperate need of replacement, and in 1946 the Ilyushin Il-12 made its first flight. The Il-12 was very similar in design to American Convair 240, except was unpressurized. In 1953 the Ilyushin Il-14 would make its first flight, and this version was equipped with much more powerful engines. The main contribution that the Soviets made in regards to Airliners was the Antonov An-2. This plane is a bi-plane unlike most of the other airliners and sold more units than any other transport plane.

Types



The Airbus A330 is a wide-body airliner

Wide-body airliners

The largest airliners are *wide-body* jets. These aircraft are frequently called *twin-aisle aircraft* because they generally have two separate aisles running from the front to the back of the passenger cabin. Aircraft in this category are the Boeing 747, Boeing 767, Boeing 777, Airbus A300/A310, Airbus A330, Airbus A340, Airbus A380, Lockheed L-1011 TriStar, McDonnell Douglas DC-10, McDonnell Douglas MD-11, Ilyushin Il-86 and Ilyushin Il-96. These aircraft are usually used for long-haul flights between airline hubs and major cities with many passengers. Future wide-body models include the Boeing 787 and Airbus A350.

Narrow-body airliners



The Boeing 757 is a narrow-body airliner

A smaller, more common class of airliners is the *narrow-body* or *single aisle* aircraft. These smaller airliners are generally used for medium-distance flights with fewer passengers than their wide-body counterparts.

Examples include the Boeing 717, 737, 757, McDonnell Douglas DC-9 and MD-80/MD-90 series, Airbus A320 family, Tupolev Tu-204, Tu-214, Embraer E-Jets 190&195 and Tu-334. Older airliners like the Boeing 707, 727, Douglas DC-8, Fokker F70/F100, VC10, Tupolev, and Yakovlev jets also fit into this category.

Small airliners

Short haul airliners used by airlines and regional airlines



A JetBlue Airways Embraer 190 short haul airliner.



A PLUNA Bombardier CRJ900 short haul (regional) airliner taxiing.

Regional airliners - Small (Regional) short haul airliners typically seat fewer than 100 passengers and may be powered by turbofans or turboprops.



Direktflyg Jetstream 32 at Kristiansund Airport, Kvernberget

These airliners, though smaller than aircraft operated by most major carriers, legacy carriers, flag carriers, frequently serve customers who expect service, similar to that offered by the far larger airlines with their longer ranged larger jetliners. Therefore, these short haul airliners are usually equipped with lavatories, stand up cabins, pressurization, overhead storage bins, reclining seats, and have a flight attendant to look after the in-flight needs of the passengers upon point-to-point routes. Among some of earliest regional short haul airliners were the pre-airline deregulation Jetstream 31 aircraft.

Feederliner aircraft used by regional airlines



The Bombardier CRJ200



A Compass Airlines (North America) Embraer ERJ-170-200LR in the feederliner colors of Northwest Airlink

Regional airliners - (Regional) Feederliners typically seat fewer than 100 passengers and may be powered by turbofans or turboprops. These airliners, are the non mainline counterparts to the larger aircraft operated by the; major carriers, legacy carriers, and flag carriers and are used to feed traffic into the large airline hubs or focus cities. These particular routes may need the size of a smaller aircraft to meet the frequency needs and service levels, customers expect in the marketed product that is offered by larger airlines and their modern narrow and widebody aircraft. Therefore, most regional airliners are equipped with lavatories and have a flight attendant to look after the in-flight needs of the passengers, along with the features of a short haul regional airliner.

Typical aircraft in this category include the Bombardier CRJ and Embraer ERJ regional jets along with the "Q" (DASH-8) series, ATR 42/72 and Saab 340/2000 turboprop airliners. Airlines and their partners sometimes use these for flights between small hubs, or for bringing passengers to hub cities where they may board larger aircraft. Typically, these regional feederliners, are painted in the aircraft liveries and color schemes of the much larger airline partners so the regional airlines may offer and market a seamless transition between the larger airline to smaller airline.

Commuterliner aircraft used by regional airlines and air taxi charter operators



The Beechcraft 1900 short range commuter aircraft

The lightest (light aircraft, list of light transport aircraft) of short haul regional feeder airliner type aircraft that carry 19 or fewer passenger seats are called *commuter aircraft*, *commuterliners*, *feederliners*, and *air taxis*, depending on their size, engines, how they are marketed, region of the world, and seating configurations. The Beechcraft 1900, for example, has only 19 seats. Depending on local and national regulations, a commuter aircraft may not qualify as an airliner and may not be subject to the regulations applied to larger aircraft. Members of this class of aircraft normally lack such amenities as lavatories and galleys and typically do not carry a flight attendant as an aircrew member.

Other aircraft that may fall into this category are the Fairchild Metro, Jetstream 31, and Embraer EMB 110 Bandeirante. The Cessna Caravan and Pilatus PC-12, are single-engine turboprops, sometimes used as a small airliner, although many countries stipulate a minimum requirement of two engines for aircraft to be used as airliners.

Twin piston-engined aircraft made by Cessna, Piper, Britten-Norman, and Beechcraft are also in use as short haul, short range commuter type aircraft.

Engines

Until the beginning of the Jet Age, piston engines were common on propliners like the Douglas DC-3. Nearly all modern airliners are now powered by turbine engines, either turbofans or turboprops. Gas turbine engines operate efficiently at much higher altitudes, are more reliable than piston engines, and produce less vibration and noise. Prior to the Jet Age, it was common for the same or very similar engines to be used in civilian airliners as in military aircraft. In recent years, divergence has occurred so that it is now unusual for the same engine to be used on a military type as a civilian type. Usually military aircraft which share engine technology with airliners are transports or tanker types.

Airliner variants

Some variants of airliners have been developed for carrying freight or for luxury corporate use. Many airliners have also been modified for government use as VIP transports and for military functions such as airborne tankers (for example, the Vickers VC10, Lockheed L1011, Boeing 707), air ambulance (USAF/USN McDonnell Douglas DC-9), reconnaissance (Embraer ERJ 145, Saab 340, Boeing 737), as well as for troop-carrying roles.

Layout

Modern airliners are usually low-wing designs with engines mounted in underwing pods (usually two of them). For airliners, multi-engine design is mandated by some national regulations so that aircraft can continue to climb even in the worst case of power loss in one engine right after take-off. Another regulatory demand is that aircraft are able to fly a minimum specified amount of time after one engine fails in flight.

Mounting the engines underneath and to the fore of the wing moves weight from the fuselage to the wings, imposing less bending moment on them and allowing for a lighter wing structure. After this feature proved successful in military jets, Boeing introduced it to its 707 airliner design and it has been increasingly adopted since.

Mounting the engines in underwing pods also makes physical access for maintenance quicker and easier compared to tail-mounted engines.

Additionally, low wing design helps keep the engine nacelles and refueling valves closer to the ground to simplify access and the wing's surface acts as a barrier to prevent the engines' noise from reaching the fuselage in-flight.

Both Airbus and Boeing use this common layout for all of their current passenger aircraft and emerging manufacturers (e.g. Embraer and Sukhoi Superjet) follow the same scheme.

In a few special cases, where engine proximity to ground is detrimental (e.g. rural airfields with risk of foreign object damage or dirt), airliners will feature tail-mounted engines (e.g. MD-80 or Tu-334) or high-wing designs with underhung nacelles (e.g. BAe 146). These planes become rarer as almost all newly built airliners have underwing nacelles. Tail-engined designs are mostly used by business jet manufacturers.

Future airliners may feature innovative delta wing or lifting body outlines.

Manufacturers



Assembly of a Boeing 757 airliner nose section

These include:

- Asia
 - China
 - Comac (includes Shanghai Aircraft Manufacturing Factory)
 - Shenyang Aircraft Corporation
 - Xi'an Aircraft Industrial Corporation
- Europe

- Airbus S.A.S. (formerly a multinational conglomeration of the largest European aerospace companies of France, Germany, Spain and the UK)
 - Czech Republic
 - Let Kunovice
 - France/Italy
 - ATR
 - Netherlands
 - Fokker (now defunct)
 - Russian companies (formerly Soviet-controlled)
 - Ilyushin
 - Sukhoi
 - Tupolev
 - Yakovlev
 - Sweden
 - Saab (no longer manufactures civilian aircraft)
 - Ukraine (formerly Soviet-controlled)
 - Antonov
 - United Kingdom
 - BAE Systems (formerly British Aerospace, no longer manufactures civilian aircraft)
 - Britten-Norman
- North America
 - Canada
 - Bombardier (includes the former De Havilland Canada and Canadair)
 - United States
 - Boeing (includes the former McDonnell Douglas company which itself included the Douglas Aircraft Company)
 - Lockheed Corporation (now part of Lockheed Martin, and no longer involved in civil aviation)
- South America
 - Brazil
 - Embraer

The international market for middle-sized and large-sized airliners is now divided between Airbus and Boeing, although Russian/former Soviet manufacturers still sell significant numbers of airliners to their traditional markets. Smaller-sized aircraft manufacturers include, in addition to these two, ATR, Embraer and Bombardier.

Notable airliners



Notable airliners – a Boeing 747-400 "jumbo jet" of Qantas takes off



Notable airliners – an Airbus A380 "superjumbo" of Singapore Airlines takes off

- Boeing 247 – the first design to incorporate modern features such as all-metal construction and retractable landing gear
- Douglas DC-3 – still in service more than 70 years after its debut, it is generally regarded as one of the most significant transport aircraft ever made
- Douglas DC-6 – originally developed as a military transport, it was reworked for passenger service after World War II, a role it continues to perform today
- Boeing 377- Developed soon after World War 2, from the C-97 Stratofreighter, this was a luxurious double-decker airliner.
- Vickers Viscount – the first turboprop airliner to enter service
- Lockheed Constellation – a distinctive triple-tailed piston-engined airliner of the 1950s, it was one of the last large propeller-driven airliners
- De Havilland Comet – the world's first jetliner to reach mass production, its reputation was marred by a series of crashes due to structural failure
- Antonov An-2- Best selling transport airliner up to the point it was built.
- Sud Aviation Caravelle – one of the more successful European first-generation turbojet airliners
- Tupolev Tu-104 – the first turbojet airliner to provide sustained service, and the sole jetliner operating in the world between 1956 and 1958
- Boeing 707 – the first United States-built jetliner to enter production

- Douglas DC-8 – launched after the Boeing 707, it nevertheless established Douglas in the airliner market, and continues to serve as a cargo aircraft to this day
- Tupolev Tu-114 - long-range turbo-prop airliner and the world's largest and fastest passenger plane until 1968
- Tupolev Tu-154 - standard medium-range airliner for Russia (and others), carried half of all Soviet traffic since 1972 with 1015 built and the fastest airliner in service
- Ilyushin Il-62 - standard long-range airliner for Russia (and others) for three decades, first flight 1963 and still in service
- Boeing 727 – was the most produced commercial jet airliner in the world for over a decade, with 1,831 aircraft produced
- Douglas DC-9 – production of it and successive variants nearly reached 2,500
- Boeing 737 – currently the best selling civilian jet airliner
- Tupolev Tu-144 – the first supersonic transport aircraft constructed in Soviet Union
- Concorde – an Anglo-French supersonic transport, it remains the only supersonic aircraft to sustain a regular passenger service
- Boeing 747 "jumbo jet" – an iconic aircraft, it was the world's largest airliner between 1968 and 2005
- McDonnell Douglas DC-10 – a trijet competitor to the widebody 747
- Lockheed L-1011 TriStar – shared a similar configuration to the DC-10, but not its success, with only 250 produced
- Airbus A300 – the world's first twinjet widebody
- Airbus A320 – pioneered the use of fly-by-wire technology
- Airbus A340-600 - longest commercial airplane
- Boeing 777 – the first airliner designed entirely by computer, without physical mockups
- Airbus A380 "superjumbo" – the world's largest airliner from 2005 onwards
- Boeing 787 - the world's first jet airliner to make use of composite materials for most of its construction

Airliner recycling

As airliners are very expensive, most are leased out for times typically from 20 to 40 years. Very few go back into service after a long lease is up because evolving aerospace technology leaves older airliners unable to compete against newer machines that can be operated at a lower cost. Many end-of-service airliners end up in the Mojave Desert, at the Mojave Air and Space Port (also known as "The Boneyard"). From this, the term "Mojave" has come to refer to the temporary storage of aircraft, e.g. during decreased demand for air travel and between short-term leases. Another airliner retirement location is Marana, Arizona.

While almost every airliner will be reduced to scrap (the exceptions end up as museum pieces or flown by collector groups) they may pass through many owners before they are retired. A well-maintained airliner can operate safely for decades, depending on how

often it is flown, its operating environment, and whether damage and wear and tear is properly repaired.

What may end an airliner's working life is a lack of spare parts, as the original manufacturer and third manufacturers may no longer provide or support them. Corrosion and metal fatigue are other issues that become more expensive to deal with as time goes on. Eventually, these factors and advances in aircraft technology lead to older airliners becoming too expensive or inefficient to operate.

To protect the environment, the Airbus company has set up a centre in France to decommission and recycle older aircraft. More than 200 airliners will finish active life each year, and will be dismantled and recycled under the newly established PAMELA Project.

Cabin configurations and features



Interior of a Qatar Airways Airbus. Video systems (the vertical white panels) are visible above the very centre seats of the aircraft



Boarding an Airbus A380 at the Farnborough Airshow, 2006

An airliner will usually have several classes of seating: first class, business class, and/or economy class (which may be referred to as coach class or tourist class, and sometimes has a separate "premium" economy section with more legroom and amenities). The seats in more expensive classes are wider, more comfortable, and have more amenities such as "lie flat" seats for more comfortable sleeping on long flights. Generally, the more expensive the class, the better the beverage and meal service.

Domestic flights generally have a two-class configuration, usually first or business class and coach class, although many airlines instead offer all-economy seating. International flights generally have either a two-class configuration or a three-class configuration, depending on the airline, route and aircraft type. Many airliners offer movies or

audio/video on demand (this is standard in first and business class on many international flights and may be available on economy). Cabins of any class are provided with lavatory facilities.

Seats

The types of seats that are provided and how much legroom is given to each passenger are decisions made by the individual airlines, not the aircraft manufacturers. Seats are mounted in "tracks" on the floor of the cabin and can be moved back and forth by the maintenance staff or removed altogether. Naturally the airline tries to maximize the number of seats available in every aircraft to carry the largest possible (and therefore most profitable) number of passengers.

Passengers seated in an **exit row** (the row of seats adjacent to an emergency exit) usually have substantially more legroom than those seated in the remainder of the cabin, while the seats directly in front of the exit row may have less legroom and may not even recline (for evacuation safety reasons). However, passengers seated in an exit row may be required to assist cabin crew during an emergency evacuation of the aircraft opening the emergency exit and assisting fellow passengers to the exit. As a precaution, many airlines prohibit young people under the age of 15 from being seated in the exit row .

The seats are designed to withstand strong forces so as not to break or come loose from their floor tracks during turbulence or accidents. The backs of seats are often equipped with a fold-down tray for eating, writing, or as a place to set up a portable computer, or a music or video player. Seats without another row of seats in front of them have a tray that is either folded into the armrest or that clips into brackets on the underside of the armrests. However, seats in premium cabins generally have trays in the armrests or clip-on trays, regardless of whether there is another row of seats in front of them. Seatbacks now often feature small color LCD screens for videos, television and video games. Controls for this display as well as an outlet to plug in audio headsets are normally found in the armrest of each seat.

Overhead bins

The overhead bins are used for stowing carry-on baggage and other items. While the airliner manufacturer will normally supply a standard product, airlines may choose to have bins of differing size, shape, or color installed. Over time, these bins evolved out of what were originally overhead shelves used for little more than coat and briefcase storage. As concerns about falling debris during turbulence or in accidents increased, enclosed bins became the norm. Bins have increased in size in order to accommodate the larger carry-on baggage passengers may bring onto the aircraft. New bin designs may include a handrail, useful when moving through the cabin.

Passenger service units

Above the passenger seats are Passenger Service Units (PSU). These typically contain reading lights, air vents, and a flight attendant call light. On most narrowbody aircraft (and some Airbus A300s and A310s), the flight attendant call button and the buttons to control the reading lights are located directly on the PSU, while on most widebody aircraft, the flight attendant call button and the reading light control buttons are usually part of the in-flight entertainment system. The units frequently have small "Fasten Seat Belt" and "No Smoking" illuminated signage and may also contain a speaker for the cabin public address system.

The PSU will also normally contain the drop-down oxygen masks which are activated if there is a sudden drop in cabin pressure. These are supplied with oxygen by means of a chemical oxygen generator. By using a chemical reaction rather than a connection to an oxygen tank, these devices supply breathing oxygen for long enough for the airliner to descend to thicker, more breathable air. Oxygen generators do generate considerable heat in the process. Because of this, the oxygen generators are thermally shielded and are only allowed in commercial airliners when properly installed – they are not permitted to be loaded as freight on passenger-carrying flights. ValuJet Flight 592 crashed on May 11, 1996 as a result of improperly loaded chemical oxygen generators.

Cabin pressurization

Airliners developed since the 1940s have had pressurized cabins (or more accurately, pressurized hulls including baggage holds) to enable them to carry passengers safely at high altitudes where low oxygen levels and air pressure would otherwise cause sickness or death. High altitude flight enabled airliners to fly above most weather systems that cause turbulent or dangerous flying conditions, and also to fly faster and further as there is less drag due to the lower air density. Pressurisation is applied using compressed air, in most cases bled from the engines, and is managed by an environmental control system which draws in clean air, and vents stale air out through a valve.

Pressurization presents design and construction challenges to maintain the structural integrity and sealing of the cabin and hull and to prevent rapid decompression. Some of the consequences include small round windows, doors that open inwards and are larger than the door hole, and an emergency oxygen system.

To maintain a pressure in the cabin equivalent to an altitude close to sea level would, at a cruising altitude around 10,000 m (33,000 feet), create a pressure difference between inside the aircraft and outside the aircraft that would require greater hull strength and weight. Most people do not suffer ill effects up to an altitude of 1800–2500 m (6000–8000 feet), and maintaining cabin pressure at this equivalent altitude significantly reduces the pressure difference and therefore the required hull strength and weight. A side effect is that passengers experience some discomfort as the cabin pressure changes during ascent and descent to the majority of airports, which are at low altitudes.

Cabin climate control

The air bled from the engines is hot and requires cooling by air conditioning units. It is also extremely dry at cruising altitude, and this causes sore eyes, dry skin and mucosa on long flights. Although humidification technology could raise its relative humidity to comfortable middle levels, this is not done since humidity promotes corrosion to the inside of the hull and risks condensation which could short electrical systems, so for safety reasons it is deliberately kept to a low value, around 10%.

Baggage holds



An Airbus A320 baggage hold



Loading luggage onto a Boeing 747 at Boston Logan Airport, during a closure due to heavy snow



Boeing 747 front lower compartment. Note the rollers for ULDs on the floor and the partition labeled "Caution: Do Not Hit -- Potable Water Tank Inside".

Airliners must have space on board to store baggage that will not safely fit in the passenger cabin.

Designed to hold baggage as well as freight, these compartments are called "cargo bins", "holds", or occasionally "pits". Occasionally baggage holds may be referred to as **cargo decks** on the largest of aircraft. These compartments can be accessed through doors on the outside of the aircraft. Despite what is seen in many movies, access doors between passenger cabins and baggage holds are rare in modern airliners.

Depending on the aircraft, baggage holds are normally inside the hull and are therefore pressurized just like the passenger cabin although they may not be heated. While lighting is normally installed for use by the loading crew, typically the compartment is unlit when the door is closed.

Baggage holds on modern airliners are equipped with fire detection equipment and larger aircraft have automated or remotely activated fire-fighting devices installed.

Narrow-body airliners

Most "narrow-body" airliners with more than 100 seats have space below the cabin floor, while smaller aircraft often have a special compartment separate from the passenger area but on the same level.

Baggage is normally stacked within the bin by hand, sorted by destination category. Netting that fits across the width of the bin is secured to limit movement of the bags. Airliners often carry items of freight and mail. These may be loaded separately from the baggage or mixed in if they are bound for the same destination. For securing bulky items "hold down" rings are provided to tie items into place.

Wide-body airliners

"Wide-body" airliners frequently have a compartment like the ones described above, typically called a "bulk bin". It is normally used for late arriving luggage or bags which may have been checked at the gate.

However, most baggage and loose freight items are loaded into containers called Unit Load Devices (ULDs), often referred to as "cans". ULDs come in a variety of sizes and shapes, but the most common model is the LD3. This particular container has approximately the same height as the cargo compartment and fits across half of its width.

ULDs are loaded with baggage and are transported to the aircraft on dolly carts and loaded into the baggage hold by a loader designed for the task. By means of belts and rollers an operator can maneuver the ULD from the dolly cart, up to the aircraft baggage hold door, and into the aircraft. Inside the hold, the floor is also equipped with drive wheels and rollers that an operator inside can use to move the ULD properly into place. Locks in the floor are used to hold the ULD in place during flight.

For consolidated freight loads, like a pallet of boxes or an item too oddly shaped to fit into a container, flat metal pallets that resemble large baking sheets that are compatible with the loading equipment are used.

Chapter- 2

Regional Airliner



A Flybe Bombardier Q400

A **regional airliner** or a **feederliner** is a small airliner designed to fly up to 100 passengers on short-haul flights, usually feeding larger carriers' hubs from small markets. This class of airliners are typically flown by the regional airlines that are either contracted by or subsidiaries of the larger airlines. Feederliner, commuter, and local service are all alternate terms for the same class of flight operations.

History



The Douglas DC-3 first flew in 1935 and had a range of around 1,000 miles (1,625 kilometers.)

In the early days of aviation, most aircraft had a relatively short range so that all airlines were "regional" in nature. With the introduction of longer range aircraft, notably flying boats, these shorter range planes increasingly found their niche feeding the newer and longer range airliners by flying passengers to the mainline's airline hubs. Many of these smaller regional airlines were eventually bought by the larger flag carriers.

To keep these short routes economical, the airlines were generally unwilling to spend large amounts of money on new aircraft; they used what was available. Also, as new models slowly emerged, older aircraft were put into this service when they were replaced by progressively longer-range designs. In the immediate post-war era these were typically Douglas DC-3s, although even the De Havilland Dragon Rapide remained in service for some time. This "hand-me-down" process of supplying aircraft continued with designs like the Convair 440, Douglas DC-6 and Vickers Viscount also serving in this role while the first jets were introduced.

Turboprop designs

By the mid-1950s, demand for even more economical designs led to the production of the first custom feederliners. These were almost always turboprops, which had fuel economy on par with piston engine designs, but had far lower maintenance costs. Often the time between engine overhaul periods was five times that of the best piston engines. Early examples of these designs include the Avro 748, Fokker F27 and Handley Page Dart Herald.

These designs were so successful that it was many years before newer designs bettered them enough to make it worthwhile to develop. There were a few exceptions, generally tailored to more specific roles. For instance, the Handley Page Jetstream (first flight in 1968) was intended for fewer passengers at much higher speeds, displacing smaller designs like the Beechcraft Queen Air. The Fairchild/Swearingen Metro (developed from the original Queen Air through a number of stages) filled a similar niche.



The De Havilland Dash 8-100.

By the 1970s the first generation regional airliners were starting to wear out, but there had been little effort in producing new designs for this market. De Havilland Canada delivered its Dash 7 in 1978, but this was tailored more to the short-range and STOL

(Short Take-Off and Landing) role than as a regional airliner. Feedback from the airlines was fairly consistent, however, and De Havilland responded with the Dash 8 in 1984, which had economic benefits over the earlier generation machines, and was faster and quieter as well. Dash 8 sales were so strong that the company was unable to fund rebuilding the factory in order to meet demand, leading to a takeover by Bombardier.

In the early 1990's, the Dash 8's success sparked off development of a number of similar designs, including the ATR 42/72, Saab 340, Embraer Brasilia and Fokker F50. Consequently there were a relatively large number of aircraft offered by manufacturers in this sector of the market, pushing older 1950s designs from Fokker, Vickers and others into retirement. Due to the high level of competition, production of a number of these types ceased. Saab exited the civil aviation market and wrote its debts off, Daimler-Benz Aerospace "pulled the plug" on Dornier, and British Aerospace ended production of their BAe Jetstream 41 after 100 delivered. In 2006 only the ATR 42/72 models and the Dash 8 remain in production.

Regional jets



A Bombardier CRJ700 in Delta Connection livery.

Another reason for the downturn in the turboprop market was the introduction of the first regional jets. Although a number of small jets entered service in the 1950s and 60s, notably the Sud Aviation Caravelle, Fokker F28 and Yak-40, these could not compete in terms of cost of operation with the turboprop designs, and were suitable for routes with small numbers of passengers, as opposed to short routes where fuel economy was paramount. As engine technology improved, this difference continued to narrow, until the higher utilization factors due to higher cruising speeds erased any remaining advantage from lower operating costs.

The earliest example of a true short-range jet is the BAe 146, produced by BAE Systems. However, like the Dash 7 before it, the BAe 146 was tuned to a very specific market,

city-center to city-center service where low noise and excellent takeoff performance were paramount. Like the Dash 7, the market niche for this design proved to be fairly small, and its four engines meant it had higher maintenance costs than twin-engine designs. Unlike the Dash 7 example BAe did not respond by producing a twin-engine design that filled the same range requirements but offering lower operational costs.

This was addressed by Bombardier's twin-engine Canadair Regional Jet, which became a best-seller. The CRJ's range is enough to fill mid-range routes as well, routes previously served by larger aircraft such as the Boeing 737 and DC-9. These aircraft were originally intended to be used for direct airport-to-airport flights, bypassing hubs, and led to industry-wide discussions about the decline of the hub-and-spoke model. Although not as economical as the turboprop, by flying directly to and from smaller airports, they reduced the need for low-cost regional airliners. And although turboprops are quiet to outside observers, propwash makes them very noisy inside. Passengers greatly preferred jets, both for real and perception reasons.

As had happened with the turboprops of only a few years earlier, the success of the CRJ led to the introduction of a host of competitors. The only successful example is the Embraer ERJ 145, which has seen excellent sales and has competed strongly with the CRJ in most markets. Bombardier and Embraer have been locked in a series of counter-lawsuits over export taxes and subsidies ever since. The ERJ's success led to a totally new version, the Embraer E-Jets series, which Bombardier chose not to compete against until recently, with the announced Bombardier CSeries.

Other competitors have not been successful. Fairchild Dornier introduced the Fairchild Dornier 328JET to compete, but went bankrupt soon afterwards and the type did not enter large scale production. Their bankruptcy also ended development of the more competitive Fairchild-Dornier 728, which had attracted strong airline interest. The CRJ/ERJ also resulted in the end of the BAe 146 line.

The CRJ and ERJ success also played a minor part in the failure of Fokker, whose Fokker 100 found itself squeezed on both sides by new models of the Boeing 737 and Airbus A319 on the "large" side and the RJs on the "small side". Bombardier turned down the chance to purchase Fokker's assets, feeling that the 100-seat market was already saturated by designs like the A319.

The Sukhoi Superjet 100, a 60 to 95-seat jet developed by the Russian aerospace firm Sukhoi with assistance of Ilyushin and Boeing, is undergoing the certification process in 2010 so no commercial orders have been fulfilled yet. The Antonov An-148 entered service in 2009 but it remains to be seen if it will have any success in a market that has been fairly hesitant to adopt aircraft from the former Soviet Union.

Recent changes



CityJet is a European regional airline operating services on behalf of its owner Air France. This is a British Aerospace 146-200.

In 2005, the "regional jet" boom suddenly collapsed, as increasing fuel prices and airline bankruptcies led to a rethinking of route structures. The high per-seat operational costs of the classic 50-seat regional jet have been exacerbated by an environment of ever-lowering fares. Furthermore, RJs increasingly were assigned to operate flights of two hours or more. This led to angry passengers, as their comfort and ergonomics compare unfavorably to the larger "mainline" jets which they replaced on these flights.

Further, the replacement of the hub-and-spoke model simply never took place. The economics and routing advantages of this mode of operation were simply too great. As the hub-and-spoke model has always been supported by low-cost regional airliners, turboprop designs once again became a major market. Improving their attractiveness in relation to the jets was the introduction of active noise-reduction systems, which reduced cabin noise to levels comparable, or even lower, than the RJ's. Bombardier found their Dash 8 to be in high demand once again, and shifted production to their latest model, the Bombardier Q400.

In late 2005, Bombardier suspended its CRJ-200 production line. The new trend is for larger aircraft with better economics, exemplified by Bombardier's 70-seat CRJ-700 and the 70-110-seat E-Jets series. The E-Jets in particular blur the line between "mainline" and "regional," as their cabin comfort is comparable or superior to traditional narrowbody jets like the Boeing 737 and Airbus A320 while offering ranges of over 2,000 miles. By

comparison, the original DC-9 jet aircraft were designed to seat approximately 75 passengers.

Regional airliners are also being blamed for flight delays in the US. According to the Wall Street Journal, 30% of flights in June 2007 were late by an average of 62 minutes. The delays are being blamed on an increased number of smaller aircraft, which the airlines are using in order to fill out schedules and provide more flights per day. This has led to the grounding of 385 larger aircraft and the adding of 1,029 regionals over the period from 2000 to 2006. The downside to this approach is that airports are running out of gates, causing delays as aircraft queue up for this limited resource.

Features

Seating on regional airliners tends to be narrow and tight, and passengers typically are restricted from bringing on board carry-on items which would fit without difficulty in the overhead bins of larger aircraft. Often carry-on luggage is collected immediately prior to boarding and placed in the cargo hold, where it can be quickly retrieved by the ground staff while the passengers exit. While designed primarily for medium stage lengths, RJs may now be found supplementing major trunk routes alongside traditional larger jet aircraft. RJs allow airlines to open new "long, thin" routings with jet equipment which heretofore did not exist, such as Atlanta to Monterrey, Nuevo León. RJs have also meant a return of jet service to cities where full-size jet service had departed over a decade ago, such as Macon, Georgia, and Brownsville, Texas.

The notion that regional jet aircraft are less expensive (per seat mile) than traditional jets is a common misconception. On a seat-mile basis the RJ's cost is in fact higher. Regional jets are operated in the USA under a fee-per-departure payment structure. In this payment structure, a traditional airline contracts with a regional airline company on a per departure or per flight basis regardless of the number of passengers or the length of the flight. The traditional airline gets to keep all the revenue from the ticket sale and only pays the regional partner the agreed to amount. These contracts tend to be long term agreements, typically 10 year terms. The regional airline partner can then be relatively sure of the revenue side and only has to control cost in order to earn a modest return. However, these "regional airlines," now really "small jet providers" of contracted aircraft, have been squeezed by U.S. airline bankruptcies, fleet reductions and increasing operating costs. U.S. Legacy carriers have no longer been willing to shoulder burdensome losses from guaranteed-profit contracts with their small jet providers, and accordingly have played carrier against carrier in a low-bid game that has left hundreds of RJs idle and others potentially on their way to being laid up.

The idea that regional jets would provide point-to-point service and bypass the hub-and-spoke system may not be materializing as it was expected. As of January 2003, 90% of all regional jet flights in the United States had a hub or major airport at one end of that flight, and this number has been gradually increasing since 1995.

Chapter- 3

Jet Airliner



A widebody jet airliner, the Boeing 777



Cutaway of an Airbus A300 jet airliner showing cabin and cargo deck

A **jet airliner** is an airliner that is powered by jet engines. This term is sometimes contracted to **jetliner** or jet.

In contrast to today's relatively fuel-efficient, turbofan-powered air travel, first generation jet airliner travel was noisy and fuel inefficient. These inefficiencies were addressed by the invention of turboprop and turbofan engines.

Early history



Nene test-bed Lancastrian demonstrating in 1954 on the two jets with the two inner Merlins feathered

The first airliners with turbojet propulsion were experimental conversions of the Avro Lancastrian piston engined airliner, which were flown with several types of early jet engine, including the de Havilland Ghost and the Rolls-Royce Nene, however these retained the two inboard piston engines, the jets being housed in the outboard nacelles and these aircraft were therefore of 'mixed' propulsion. The first airliner with full jet power was the Nene-powered Vickers VC.1 Viking *G-AJPH*, which first flew on the 6 April 1948.

First generation

The first purpose-built jet airliner was the de Havilland Comet which first flew in 1949 and entered service in 1952. Also developed in 1949 was the Avro Jetliner, and although it never reached production, the term jetliner caught on as a generic term for all passenger jet aircraft.

These first jet airliners were followed some years later by the Sud Aviation Caravelle, Tupolev Tu-104 (2nd in service), Boeing 707, Douglas DC-8, and Convair 880. National prestige was attached to developing prototypes and bringing these first generation designs

into service. There was also a strong nationalism in purchasing policy, such that the Boeing and Douglas products became closely associated with Pan Am, while BOAC ordered British made Comets.

These two airlines with strong nautical traditions of command hierarchy rank and chain of command, retained from their days of operations with flying boats, undoubtedly were quick to capitalize upon, with the help of advertising agencies, the linkings of the "speed of jets" with the safety and secure "luxury of ocean liners" among public perception.

Aeroflot used Soviet Tupolevs, while Air France introduced French Caravelles. Commercial realities dictated exceptions, however, as few airlines could risk missing out on a superior product: American airlines ordered the pioneering Comet (but later cancelled when the Comet ran into fatigue problems), Canadian, British and European airlines could not ignore the better operating economics of the Boeing 707 and the DC-8, while some American airlines ordered the Caravelle.



DH.106 Comet 1 of BOAC at London Heathrow on 2 June 1953

Boeing became the most successful of the early manufacturers. The KC-135 Stratotanker and military versions of the 707 remain operational, mostly as tankers or freighters. The basic configuration of the Boeing, Convair and Douglas aircraft jet airliner designs, with widely spaced podded engines under slung on pylons beneath a swept wing, proved to be the most common arrangement and was most easily compatible with the large-diameter high-bypass turbofan engines that subsequently prevailed for reasons of quietness and fuel efficiency.

The de Havilland and Tupolev designs had engines incorporated within the wings next to the fuselage, a concept that endured only within military designs while the Caravelle pioneered engines mounted either side of the rear fuselage.

Second generation



Tupolev Tu-154M

In the 1960s, when jet airliners were powered by slim, low-bypass engines, many aircraft used the rear-engined, T-tail configuration, such as the BAC One-Eleven, Douglas DC-9 twinjets; Boeing 727, Hawker Siddeley Trident, Tupolev Tu-154 trijets; and the paired multi-engined Ilyushin Il-62, and Vickers VC10 whose engines were mounted upon the aft fuselage. This engine arrangement survives into the 21st century on numerous twin engined Douglas DC-9 derivatives plus newer short haul and range turbofan powered regional aircraft such as the "regional jet airliners" built by Bombardier, Embraer and, until recently, Fokker. However other "jetliner" developments, such as the concept of rocket assisted takeoffs RATO, and the briefly mentioned water-injection as used and tested upon first generation passenger jets, as well as trailing edge mounted powerplants, afterburners also known as reheat used upon supersonic jetliners (SSTs) such as Concorde and the Tupolev Tu-144, likewise have been relegated to the past.

For business jets, the rear-engined universal configuration pioneered by the turbojet powered early Learjet 23, North American Sabreliner, and Lockheed JetStar is common practice on smaller bizjet aircraft as the wing is too close to the ground to accommodate underslung engines. This is as opposed to early generation jet airliners, whose design engineers slung jet engines on the rear to increase wing lift performance and at the same time reduce cabin noise of the lower bypass "turbojet" engines.

Present day



An Airbus A340-600 on final approach. Notice the fourth undercarriage under the fuselage belly.

Airliner descriptions are commonly broken down into the distinctions of the generally long-haul civilian passenger jumbo and, widebody jet airliners, and short-haul civilian passenger "jet" airliners. Among some of these categories included among the short-haul civilian passenger "jets" are both longer and shorter ranged "narrow-body jet and regional jet types." Semantically, the terms "civilian" "turbine powered" "jet" "passenger" "air" "liner" aircraft are routinely dropped from these various terms to accurately describe "jet aircraft" which can lead to confusion among those practicing language purity. It is also referenced in the Paul Pena song, "Jet Airliner (song)", made famous by the Steve Miller Band.

Chapter- 4

Australian Airliners

de Havilland Australia DHA-3 Drover

DHA-3 Drover



DHA-3 Mk. 2 Drover

Role	short-haul airliner
Manufacturer	de Havilland Australia
First flight	1948
Introduced	1949
Status	Four registered in Australia Royal Flying Doctor Service of
Primary users	Australia Qantas
Produced	1949-1953
Number built	20
Unit cost	£14,000
Developed from	de Havilland Dove

The **de Havilland Australia DHA-3 Drover** is a small transport aircraft that was built by de Havilland Australia (DHA) in the 1940s and 1950s. The aircraft had some similarities with the two-engine British-built de Havilland Dove but used a trimotor configuration.

Design and development

Design work on the DHA-3 began in 1946 after DHA identified a need to replace the de Havilland Dragon biplane then in widespread use in Australia. Although the British parent company's Dove was being produced at the same time, DHA saw that the Dove was not entirely suitable for Australian conditions. Using the Dove as a starting point, DHA designed an aircraft with three four-cylinder Gipsy Major engines instead of the Dove's two Gipsy Queen six-cylinder engines and a fixed tailwheel undercarriage instead of the Dove's retractable tricycle undercarriage. Like the Dove the DHA-3 was sized to carry 8 to 9 passengers with a single pilot.

The result was an aircraft with the same wingspan as the Dove and a slightly shorter fuselage. The name 'Drover' was selected by Sir Geoffrey de Havilland after suggestions for a name were invited from DHA employees. Mr Thomas King from the Drawing Office came up with the winning name. The first **DHA-3 Mk. 1** Drover took to the air at Bankstown Airport on 23 January 1948 piloted by Brian (Black Jack) Walker, DHA's chief test pilot. The second aircraft did not fly until December 1949, while the first aircraft was delivered in October that year.

After entering service, by 1952 the type's shortcomings were becoming apparent. These included the aircraft's lack of power, especially in hot weather, and an unfortunate tendency for propellers to fail in-flight, resulting in the loss of two aircraft. The propeller problem was overcome by replacing the de Havilland variable-pitch propellers with Fairey Reed fixed-pitch propellers, modified aircraft being re-designated the **DHA-3 Mk. 1F**. All but the three aircraft that had crashed by that time were brought to this standard. The propeller change however did nothing to improve the type's performance. In a bid to improve lift all Mk. 1F aircraft were further modified with double slotted flaps in place of plain flaps, and were once again re-designated, this time as the **DHA-3 Mk. 2**.



A Mark 2 Drovver with Gipsy engines and fixed-pitch propellers



The Powerhouse Museum's DHA-3 Mk. 3a Drovver at Bankstown



Drover 3B, with Lycoming engines, at Bankstown in 1970

Sixteen aircraft had been delivered by the end of 1952, but the problems suffered by the type stalled further sales for several years. The last four of the twenty Drovers built were produced in 1953 but were not sold until 1955 and 1956. In another bid to rectify the type's poor performance DHA re-engined seven Mk. 2 aircraft with Lycoming O-360 horizontally-opposed engines driving Hartzell feathering constant-speed propellers. Changes were also made to the flap control system and the tail wheel assembly. The first modified aircraft, re-designated as a **DHA-3 Mk. 3**, was returned to its owner the Royal Flying Doctor Service of Australia (RFDS) on 4 June 1960. Three Mk. 3s were later further modified; two aircraft operated by the NSW Section of the RFDS were modified in 1962 as the **Mk. 3a** with the tailplane altered to have seven degrees of dihedral (14° according to one source) and the span increased by 2 ft (61 cm). The third was modified as a **Mk. 3b** with an increase in MTOW of 300 lb (137 kg) to 6,800 lb (3,087 kg).

Operational history

New aircraft deliveries

The type entered service with the Australian Department of Civil Aviation (DCA, now the Civil Aviation Safety Authority) in 1949, the DCA operating the first two aircraft. Qantas and the RFDS took delivery of their first aircraft in 1950, eventually receiving five and six new aircraft respectively. Qantas placed the Drover into service on its routes in what was then known as the Territory of Papua and New Guinea. Like many other

aircraft types before and since, the Drover was inadequate in the demanding operating conditions of the island and of the surviving four aircraft, three left Qantas service in 1954 and 1955. The last was retired by Qantas in 1960. The surviving DCA aircraft was also withdrawn and offered for sale in the latter 1950s and was sold at the end of 1959.

Trans Australia Airlines (TAA) briefly evaluated the prototype for a month in late 1950 and then received the first two of its eventual three new Drovers in 1952 (the third was delivered in 1956). TAA operated them on scheduled services in Queensland and as air ambulance aircraft, one of them as one of the six used by the RFDS. One aircraft crashed in January 1952 only five weeks after delivery and the other two were transferred to the RFDS in 1963 and 1964. The last main operators of new Drovers were the Australian Department of Health, which used two on outback aeromedical operations (one crashing in 1957); and Fiji Airways, which took delivery of two aircraft built for Qantas but refused by that company when the type's problems became apparent. The last aircraft built was delivered as a Mk. 2 to a private individual in July 1956.

Propeller problems

On 16 July 1951 the third Drover built (registration VH-EBQ in service with Qantas), crashed off the coast of New Guinea (in the Huon Gulf near the mouth of the Markham River) after the centre engine's propeller failed. The pilot and the six passengers on board were killed. As of November 2008 this was the last fatal accident suffered by Qantas. At the time of the crash the aircraft was only ten months old.

The prototype Drover VH-DHA operated by the Australian Department of Civil Aviation was ditched in the Bismarck Sea between Wewak and Manus Island on 16 April 1952. The port propeller failed, a propeller blade penetrated the fuselage and the pilot was rendered unconscious; the ditching was performed by a passenger. On this occasion the three occupants survived the ordeal to be rescued.

A third aircraft (VH-EBS, also owned by Qantas) suffered a propeller failure while still on the ground in September the same year.

Later operations

The RFDS had its Drovers modified to Mk. 3 standard in the early 1960s and operated the type until late in the decade when more modern aircraft such as the Beechcraft Queen Air were acquired. The seventh Mk. 3 was acquired second-hand from the Department of Health by the RFDS as a Mk. 2 and then modified. The RFDS Mk. 3s were configured to carry the pilot, two medical staff and two stretcher patients and were operated in the Northern Territory and outback New South Wales and Queensland.

The Drover became fairly well-travelled for an Australian design; apart from their initial use in Australia, New Guinea and Fiji already mentioned; second-hand Drovers were registered in the Western Pacific Islands (Solomon Islands) and operated by **New Hebrides Airways Ltd.** and **Air Melanesiae** in the New Hebrides, and others were

registered in New Zealand and the United Kingdom in addition to further examples making their way to Fiji.

By the end of the 1950s only nine Drovers were still in airline service worldwide. The last Drover to operate scheduled airline services was withdrawn from use by Mercury Airlines in New Zealand in the mid-1970s when it was replaced by a Cessna 207.

The final Drover built was modified in the late 1960s as an agricultural aircraft, flying for several years from Toowoomba, Queensland with a large hopper installed in the cabin. This Mk. 2 Drover is still airworthy in 2008 and is operated as VH-DHM from Illawarra Regional Airport by the **Historical Aircraft Restoration Society** on behalf of **Hawker de Havilland Aerospace**, now a part of Boeing.

Despite the small number produced the Drover survives in healthy numbers; in addition to VH-DHM already mentioned another three are on the Australian civil aircraft register as of November 2008 - a Mk. 3 and two Mk. 2s. Another Mk. 2, a composite of the 10th and 17th aircraft built, is on display at the RFDS Base at Mount Isa, Queensland while one of the Mk. 3a aircraft (owned by the Powerhouse Museum) can be seen at the **Australian Aviation Museum** at Bankstown Airport. The **Central Australian Aviation Museum** at Alice Springs has a Mk. 3 in its collection. Another Mk. 2 was in a museum at Lasham in England until its closure. It is now in 'storage' at Parkhouse Engineering in Booker nr. High Wycombe. and the **Queensland Air Museum** at Caloundra has two Mk. 3s.

Variants

- **Drover Mk. 1:** Manufactured with variable-pitch propellers.
- **Drover Mk. 1F:** Modified with fixed-pitch propellers.
- **Drover Mk. 2:** Modified with double-slotted flaps.
- **Drover Mk. 3:** Re-engined with three Lycoming O-360-A1A horizontally-opposed engines.
 - **Mk. 3a:** Fitted with modified tailplane of increased span and dihedral.
 - **Mk. 3b:** MTOW increased to 6,800 lb (3,087 kg).

Chapter- 5

Brazilian Airliners

Embraer E-Jet family

E-Jet family



An Air Canada E-175 departs Montréal-Pierre Elliott Trudeau International Airport

Role	Airliner
National origin	Brazil
Manufacturer	Embraer
First flight	February 19, 2002
Introduced	March 2004, LOT Polish Airlines
Primary users	Republic Airways Air Canada JetBlue Airways Compass Airlines
Number built	713 (January 2011)
Unit cost	US\$28.5–40.0 million (2010)
Variants	Embraer Lineage 1000

The **Embraer E-Jets** are a series of narrow-body, twin-engine, medium-range, jet airliners produced by Embraer, a Brazilian aerospace conglomerate that produces

commercial, military, and corporate aircraft. Announced at the Paris Air Show in 1999, and entering production in 2002, the aircraft series has been a success. As of September 30, 2010, there is a backlog of 245 firm orders for the E-Jets and 747 options. The manufacturer reported that 671 units had been delivered by September 30, 2010, and predicted that by the end of 2016, more than 1,100 units would be delivered.

Design and development



Interior of an Embraer E-170



Azul Brazilian Airlines E-195 at Campinas International Airport

The Embraer E-Jets line is composed of two main commercial families and a business jet variant. The smaller E-170 and E-175 make up the base model aircraft, with the E-190 and E-195 being stretched versions, with different engines and larger wing and landing gear structures. The 170 and 175 share 95% commonality, as do the 190 and 195. The two families share near 89% commonality, with identical fuselage cross-sections and avionics, featuring the Honeywell Primus Epic EFIS suite.

Although commonly referred to with simply an "E" prefix, the jets are technically still Embraer Regional Jets ("ERJ"s). Embraer dropped the ERJ prefix in its advertising early in production. The E-190/195 series of aircraft have similar capacities to the initial versions of the DC-9 and Boeing 737, which have always been considered mainline airliners. Embraer developed an innovative "double-bubble" design for its commercial passenger jet airplanes that provides stand-up headroom. Embraer E-Jets use four-abreast seating.

The launch customers for the aircraft were the French Régional Compagnie Aérienne Européenne with ten orders and five options for the E-170, and the Swiss Crossair with an order for 30 E-170s and 30 E-190s. The largest single order for any type of E-Jets has come from JetBlue with 100 orders for the E-190, and options for 100 more. JetBlue set the record for the longest flight of the E190 family on November 6, 2008, when aircraft N239JB made a non-stop flight from Anchorage, Alaska (ANC) to Buffalo, New York (BUF), a total of 2,694 nmi (4,989 km). This was an empty aircraft on a non-revenue

flight, the aircraft eventually returning to JFK after a two-month-long charter service with Vice Presidential candidate Sarah Palin.

Variants

E-170 and 175



Virgin Blue E-170



Embraer E-175, in company demonstrator colours, at Ottawa International Airport

The E-170/E-175 family is the smaller of the two E-Jet families. The E-170 and E-175 directly compete with the Bombardier CRJ-700 and Bombardier CRJ-900, respectively. They also loosely compete with the turboprop Bombardier Q400. It also seeks to replace the market segment occupied by earlier competing designs such as the BAe 146 and Fokker 70. The 170 and 175 are powered with GE CF34-8E engines of 14,200 pounds (62.28 kN) thrust each.

The Embraer 170 was the first version produced. The prototype was rolled out on 29 October 2001, with first flight 119 days later on February 19. The aircraft was displayed to the public in May 2002 at the Regional Airline Association convention. After a positive response from the airline community, Embraer launched the E-175. First flight of the stretched E-175 was on June 2003. Certification for the 170 took nearly 2 years after the public debut; delivery of the first E170 aircraft to the launch customer LOT Polish Airlines was in March 2004. The first E-175 was delivered to Air Canada and entered service in July 2005.

E-190 and 195



Rollout of the Embraer 190 at Embraer's São José dos Campos plant on 9 February 2004



Flybe E-195

The E-190/195 family is a larger stretch of the E-170/175 family fitted with a new, larger wing and a new engine, the GE CF34-10E, rated at 18,500 lb (82.30 kN). These aircraft compete with the Bombardier CRJ-1000. In addition, being in the 100-seat range, it competes with smaller mainline jets including the Boeing 717-200, and 737-500/-600 the Airbus A318, and the upcoming Bombardier CSeries.

The first flight of the E-190 was on March 12, 2004, with the first flight of the E-195 on December 7 of the same year. The launch customer of the E-190 was New York-based low cost carrier JetBlue with 100 orders and 100 options. British low cost carrier Flybe launched the E-195 with 14 orders and 12 options.

As the 190/195 family is of mainline aircraft size, many airlines will operate them as such, fitting them with a business class section and operating them themselves, instead of having them flown by a regional airline partner. For example, Air Canada operates 45 E-190 aircraft fitted with 9 business-class and 84 economy-class seats as part of their primary fleet.

Embraer Lineage 1000

On 2 May 2006, Embraer announced plans for the business jet variant of the E-190. This would have the same structure as the E-190, but with an extended range of up to 4,200 nm, and luxury seating for up to 19. The Argentine Air Force ordered one for its Presidential fleet. It was certified by the USA Federal Aviation Administration on 7 January 2009. The first two production aircraft were delivered in December 2008.

E-195X

Embraer considered producing an aircraft which was known as the E-195X, a stretched version of the E-195. It would have seated approximately 130 passengers. The E-195X was apparently a response to American Airlines' request for a replacement for their MD-80s. Embraer abandoned plans for the 195X in May 2010, following concerns that its range would be too short.

Operators

- **Embraer 170** (or EMB 170-100) - In October 2010 180 Embraer 170 aircraft (all variants) are in airline service, with 11 orders. Major operators include: Republic Airlines (48), Shuttle America (28), Saudi Arabian Airlines (15), EgyptAir Express (12), LOT Polish Airlines (10) and Australia's Virgin Blue (6). About 15 airlines operate the type in smaller numbers.
- **Embraer 175** (or EMB 170-200) - In October 2010, 130 Embraer 175 aircraft are in airline service, with 43 further orders. Major operators include Air Canada with 15 aircraft and LOT Polish Airlines with 12 aircraft. Major firm orders include 54 aircraft for Republic Airlines, which controls Frontier Airlines and Midwest Airlines, and 36 aircraft for Compass Airlines (a subsidiary of Delta Air Lines). Flybe, the British airline, ordered 35 Embraer 175 with options for an extra 60 and "purchase rights" for 40 more at the 2010 Farnborough airshow.
- **Embraer 190** (or EMB 190-100) — In October 2010, 301 Embraer 190 aircraft (all variants) are in airline service, with 156 orders. Operators include Air Canada with 45 aircraft (with options for 60 more), JetBlue Airways with 47 aircraft (104

firm orders), AeroMéxico Connect ordered 16 aircraft (with 15 options), Australia's Virgin Blue (14) and Nas Air (Saudi Arabia) (4). Other orders include 32 aircraft for US Airways and 20 for Austral Líneas Aéreas (Argentina).



Lufthansa Cityline E195LR

- **Embraer 195** (or EMB 190-200) — In October 2010 60 Embraer 195 aircraft (all variants) are in service and 35 firm orders. Major operators are Flybe (14), Lufthansa CityLine (15), Air Europa (5), Nas Air (2), Royal Jordanian (2). Azul Brazilian Airlines have 36 firm orders for the aircraft.

Embraer ERJ 145 family

ERJ 135/ERJ 140/ERJ 145



An ERJ 145 of Air France Régional

Role	Regional airliner
Manufacturer	Embraer
First flight	August 11, 1995
Introduction	December 1996
Status	In Service
Primary users	ExpressJet Airlines (As Continental Express) American Eagle Airlines
Produced	1989-present
Number built	1100+, 2009
Developed from	Embraer EMB 120 Brasilia
Variants	R-99 and P-99 Embraer Legacy 600

The **Embraer ERJ 145 family** is a series of regional jets produced by Embraer, a Brazilian aerospace company. Family members include the **ERJ 135** (37 passengers), **ERJ 140** (44 passengers), and **ERJ 145** (50 passengers), as well as the **Legacy** business jet and the **R-99** family of military aircraft. The ERJ 145 is the largest of the group. Each jet in the series is powered by two turbofan engines. The family's primary competition comes from the Bombardier CRJ regional jets.

Development

Early design

The ERJ 145 was launched at the Paris Airshow in 1989 as a stretched and turbofan-powered modification of the EMB 120 Brasilia. Key components of this design included:

- Straight wing (with winglets)
- Rear Fuselage-mounted engines
- Range of 2500 km
- 75% parts commonality with the EMB 120.

Interim design



Embraer ERJ 145 of Air France Régional



Embraer ERJ-145 of Aeroméxico Connect



Embraer ERJ 145 of BMI in planform view



Embraer ERJ 145XR wing with winglet detail

By 1990, Embraer engineers found that results from wind-tunnel testing were less than satisfactory, and began considering a significantly different design from the EMB 120. The proposed modified design included a slightly (22.3°) swept wing with winglets, as well as engines mounted in underwing nacelles. This second design showed markedly better aerodynamic performance, but the combination of swept wings and wing-mounted engines required an unusually high (and therefore heavy) undercarriage.

Production design

The design evolved until late 1991, at which time it was frozen. Though the aircraft went through many alterations before it was finalized, it did retain a few of the original influences of the EMB 120 such as the three abreast seating (2+1) configuration which was a similar configuration used for the Embraer/FMA CBA 123 Vector design which never reached production. The key features of the production design included:

- Rear fuselage-mounted engines
- Swept wings (no winglets)
- "T"-tail configuration
- Range of 2500 km

The company was seen to be at a disadvantage due to the delay in bringing the aircraft to service, partly because of the change in the aircraft's design. The first design was intended to retain as much commonality as possible with the EMB 120. However, the aircraft has sold well thus overcoming the initial setbacks. Embraer delivered 892 units of all variants through 2006, and predicts that another 102 units will be delivered in the 2007-2016 time period.

Derivatives

The ERJ 140 is based on the ERJ 145 with 96% parts commonality and the same crew type rating. The only significant changes are a shorter fuselage, a slightly derated engine and an increased range. At launch, Embraer estimated the cost of an ERJ 140 to be approximately US\$15.2 million. The estimated cost of development of the ERJ 140 was US\$45 million. The ERJ 135, with a service entry date of 1999, has 95% parts commonality with the ERJ 145, but is 11.7 feet (3.6 m) shorter.

The ERJ 145 seats 50 passengers, the ERJ 140 seats 44, and the ERJ 135 seats 37. The ERJ 140 was designed with fewer seats in order to meet the needs of some major United States airlines, which have an agreement with the pilot union as to the number of 50-seat aircraft that can be operated in their mixed fleets.

In 2003, Embraer entered a partnership with the Harbin Aircraft Manufacturing Corporation of Harbin, China. The resulting company, Harbin Embraer, began producing the ERJ 145 for the Chinese market by assembling complete knock down kits premanufactured by other worldwide Embraer operations.

Operations

The first flight of the ERJ 145 was on August 11, 1995, with the first delivery in December 1996 to ExpressJet Airlines (then the regional division of Continental Airlines). ExpressJet is the largest operator of the ERJ 145, with 270 of the nearly 1000 ERJ 145s in service. The second largest operator is American Eagle, with 206 ERJ 145 aircraft. Chautauqua Airlines also operates 95 ERJ 145s through its alliances with American Connection, Delta Connection, US Airways Express, Continental Express, United Express and Athens Airways .

By some accounts, the ERJ 145 has a cost of ownership of about \$2,500,000 per year.

In March 2007 ExpressJet entered into a short-term agreement to operate some regional routes for JetBlue Airways using its ERJ 145 aircraft.

The ERJ 140 was introduced in September 1999, first flew on June 27, 2000 and entered commercial service in July 2001. American Eagle Airlines, the regional jet subsidiary of American Airlines, operates the majority of the ERJ 140s built, including the first to be delivered, N800AE. Chautauqua Airlines also operate the ERJ 140.

As of early 2005, 74 ERJ 140s had been delivered.

This version is marketed as **ERJ 140**, but on the company's internal documents and on Federal Aviation Administration certification, the version is designated **EMB 135KL**.

Variants

Civilian models



City Airline Embraer ERJ 135



Embraer ERJ 145 of the Brazilian Federal Police

- **ERJ 135ER** - Extended range, although this is the Baseline 135 model. Simple shrink of the ERJ 145, seating thirteen fewer passengers, for a total of 37 passengers.
- **ERJ 135LR** - Long Range (increased fuel capacity and upgraded engines).
- **ERJ 140ER** - Simple shrink of the ERJ 145, seating six fewer passengers, for a total of 44 passengers.
- **ERJ 140LR** - Long Range (increased fuel capacity (5187 kg) and upgraded engines).
- **ERJ 145STD** - The baseline original
- **ERJ 145EU** - Model for European market. Same fuel capacity as 145STD (4174 kg) but an increased MTOW 19990 kg
- **ERJ 145ER** - Extended Range, although this is the Baseline 145 model.
- **ERJ 145EP** - Same fuel capacity as 145ER (4174 kg) but an increased MTOW 20990 kg.
- **ERJ 145LR** - Long Range (increased fuel capacity (5187 kg) and upgraded engines).
- **ERJ 145LU** - Same fuel capacity as 145LR (5187 kg) but an increased MTOW 21990 kg.
- **ERJ 145MK** - Same fuel capacity (4174 kg), landing weight (MLW) and MTOW as in the 145STD, but a changed MZFW (17700 kg).
- **ERJ 145XR** - Extra-long Range (numerous aerodynamic improvements, including winglets, strakes, etc. for lower cruise-configuration drag, a ventral fuel tank (aft location) in addition to the two main larger capacity wing tanks (same

- tanks as in the LR models), increased weight capacity, higher top speed and more powerful engines).
- **Legacy 600** - Business jet variant is a special variant based on the ERJ145.
 - Harbin Embraer ERJ145 - joint venture with Harbin Aircraft Manufacturing Corporation

MTOW - Maximum TakeOff Weight; MZFW - Maximum Zero Fuel Weight

The physical engines are the same (Rolls Royce Allison AE3007), however, the FADEC (Full Authority Digital Engine/Electronic Control) logic is what differs between the various models in regards to total thrust capability.

The extended range version, the ERJ-145ER, has Rolls Royce AE 3007A engines rated at 31.3 kN(7036 lb) thrust, with the option of more powerful AE 3007A1 engines. A, A1, A1P models are mechanically identical but differ in thrust due to variations in FADEC software. The A1E engine, however, has not only new software, but significantly upgraded mechanical components.

The long-range ERJ-145LR aircraft is equipped with Rolls Royce AE 3007A1 engines which provide 15% more power. The engines are flat rated at 33.1 kN (7440 lb) thrust to provide improved climb characteristics and improved cruise performance in high ambient temperatures.

The extra-long-range ERJ-145XR aircraft is equipped with Rolls-Royce AE 3007A1E engines. The high performance engines provide lower specific fuel consumption (SFC) and improved performance in hot and high conditions. The engines also yield a higher altitude for one-engine-inoperable conditions." ExpressJet is the sole operator of the ERJ 145XR.



Luxair Embraer ERJ 135LR

Despite the multiple variants, pilots need only one type rating to fly any variant of the ERJ aircraft. Companies like ExpressJet Airlines utilize this benefit with their mixed fleet of ERJ135ER/LR and ERJ145EP/LR/XR. Shared type ratings allows operators to utilize a single pilot pool for any ERJ aircraft.

Chapter- 6

British Airlines

BAe ATP

BAe ATP



Role	Airliner
Manufacturer	British Aerospace
First flight	1986
Introduced	1988
Produced	1988-1996
Number built	64
Developed from	Hawker Siddeley HS 748

The **BAe ATP** was an airliner produced by British Aerospace, designed as an evolution of the Hawker Siddeley HS 748. The fuel crisis and increasing worries about aircraft noise led business planners at British Aerospace to believe that there was a market for a short-range, low-noise, fuel-efficient turboprop aircraft. By the time it entered the market, the segment was already well represented by designs such as the de Havilland Canada Dash 8 and ATR 42, and production was ended after only 64 examples.

Design and development

The airframe of the HS 748 was redesigned with a lengthened 26.01 m body and a 30.62 m wing span. Minor modifications were made to the nose and tail shapes, as well as

smaller windows on a shorter pitch. The twin Rolls-Royce Dart engines were replaced with Pratt & Whitney Canada PW126 fuel efficient engines. A custom-designed, slow-turning, six-blade propeller was developed by Hamilton Standard.

The aircraft first flew in August 1986 and entered service with British Midland in 1988. The type has an advanced EFIS Flight Deck, and has a good short-field performance. In addition to these virtues, it is also very quiet upon take off.

In total 64 aircraft were assembled at BAe's Woodford and Prestwick facilities with the manufacture of the airframe and wings undertaken at Chadderton. Production ended at Prestwick in 1996. The plane can accommodate between 64 and 72 passengers depending on the seat configuration. The biggest operators of the aircraft are British Airways CitiExpress and West Air Sweden.

In 2001 the **ATP Freighter** project allowed six ATPs to be converted in to cargo aircraft for West Air Sweden. Using a modification of the HS 748 freight door, the ATPF can carry 30% more cargo than its predecessor with a 10% increase in running costs. The ATPF made its first flight from West Air Sweden's facility in Lidköping on 10 July 2002.

In August 2006 a total of 32 ATP aircraft remain in airline service with West Air Sweden (11), First Flight Couriers (1), Atlantic Airlines (3), Emerald Airways (5), Enimex (1), SATA Air Açores (5) and West Air Luxembourg (5) NextJet Sweden (3).

Variants

Several ATP variants were proposed and produced for civil and military use:

Jetstream 61

The British Aerospace Jetstream 61 was an improved derivative of the ATP. It featured an interior based on the Jetstream 41 with innovative cabin wall armrests and an increase in capacity from 64-70 seats. In addition the airframe incorporated more powerful PW127 engines and increased weights and range.

The first flight was completed by the original prototype ATP (serial number 2001) reregistered G-PLXI (LXI being the Roman numeral for 61) on the 10th May 1994. Four airframes were subsequently produced as Jetstream 61's (2064–2067) before British Aerospace's regional operations were merged with ATR on the 26th January 1995. With the already highly successful ATR72 now part of the same product range the Jetstream 61 was immediately cancelled with all four airframes being scrapped at Woodford.

The original ATP and Jetstream 61 prototype is currently in storage at Woodford awaiting for a final move to the Jetstream Club at Liverpool.

Maritime ATP

This was a variant for use in military naval operations, with a surveillance radar under the forward fuselage, nose-mounted FLIR and internal sonar buoys. A suite of special crew stations also featured, as did a choice of up to six weapon pylons under the wings and fuselage. The Maritime ATP was later known as the BAe P.132. None were built.

ATP-AEW

The AEW was a 1986 proposal for an Airborne Early Warning aircraft for Australia, with two EMI Skymaster radars in nose and tail radomes, similar in appearance to the Nimrod AEW.3. None were built.

Notable accidents and incidents involving BAe ATP aircraft

- On April 19, 1997 Merpati Nusantara Airlines Flight 106 lost control at 2000 feet on approach to Tanjung Pandan-Bulutumbang Airport in Indonesia. 15 people died and 43 survived the crash of Flight 106 the second worst air accident involving British Aerospace ATP aircraft.
- On December 11, 1999 SATA Air Açores Flight 530M crashed into mountain on the Sao Jorge Island, Açores, Portugal on a short haul flight. All 35 passengers and crew on board died in the crash. The accident was the worst air accident involving British Aerospace ATP.

BAe Jetstream 41

Jetstream 41



Eastern Airways BAe Jetstream 41

Role	Regional airliner/Feederliner
Manufacturer	British Aerospace
First flight	25 September 1991
Introduction	1992
Primary users	Eastern Airways South African Airlink Yeti Airlines
Produced	1992–1997
Number built	100
Developed from	Jetstream 31



Jetstream 41 of now-defunct Origin Pacific Airways at Wellington International Airport in June 2004.

The **Jetstream 41** is a turboprop-powered feederliner and regional airliner, designed by British Aerospace as a "stretched" version of the popular Handley Page Jetstream. Intended to compete directly with 30-seat aircraft like the Embraer Brasilia, Dornier 328 and Saab 340, the new design eventually accommodated 29 passengers in a two-by-one arrangement like the Jetstream 31. Eastern Airways is the biggest operator of Jetstream 41s in the world, with 23 in the fleet.

Design and development

The Jetstream 41's stretch added 16 feet (4.88 m) to the fuselage, consisting of an 8 foot 3 in (2.51 m) plug forward of the wing and a 7 feet 9 inches (2.36 m) plug to the rear; the fuselage design was all new and did not contain any parts of the old fuselage. The new design demanded a wing with increased span, which also included reworked ailerons and flaps. The wing was also mounted below the fuselage so that it did not carry through the cabin aisle, which also led to larger wing root fairings that increased baggage capacity.

The latest version of the Garrett TPE331 engines, the -14, now owned by Honeywell, delivered 1,500 shp (1,120 kW) and later 1,650 shp (1,232 kW) and were mounted in new nacelles with increased ground clearance. The flightdeck was improved with a modern EFIS setup, and a new windscreen arrangement. The J41 was the first turbo-prop certified to both JAR25 and FAR25 standards.

Operational service

The J41 flew for the first time on 25 September 1991 and was certified on 23 November 1992 in Europe, and 9 April 1993 in the United States, with the first delivery, to Manx Airlines on 25 November 1992. In January 1996, the J41 became part of the Aero International (Regional) (AI(R)), a marketing consortium consisting of ATR, Aérospatiale (of France), Alenia (of Italy), and British Aerospace. Sales initially were fairly strong, but in May 1997 BAe announced that it was terminating J41 production, with 100 aircraft delivered.

Preservation

Prototype Jetstream 41 G-JMAC is now preserved by the Jetstream Club on the former airside apron behind the Crowne Plaza Liverpool John Lennon Airport Hotel, which was the original terminal building of Liverpool Speke Airport.

Accidents and Incidents

- On January 7, 1994, Atlantic Coast Airlines Flight 6291 crashed short of the runway at Port Columbus International Airport killing five people out of nine passengers and crew.
- On September 24, 2009, Airlink Flight 8911 crashed in the suburb of Merebank in Durban, South Africa, shortly after takeoff from Durban International Airport. The crew of three and one person on the ground was injured. The captain, Allister Freeman, died as a result of complications from his injuries on 7 October 2009.

Chapter- 7

Canadian Airliners

Bombardier CRJ200

CRJ100 / CRJ200



A Cimber Air CRJ200 landing at London Heathrow Airport

Role	Regional jet/Business jet
Manufacturer	Bombardier Aerospace
First flight	10 May 1991
Introduction	1992 (Lufthansa)
Status	Active Service SkyWest Airlines, MexicanaLink
Primary users	Pinnacle Airlines Atlantic Southeast Airlines Comair
Number built	1,021 as of July 31, 2010
Unit cost	US\$24-39.7m as of 2006
Developed from	Bombardier Challenger 600
Variants	CRJ700/900/1000

The **Bombardier CRJ100** and **CRJ200** are a family of regional airliner manufactured by Bombardier, and based on the Canadair Challenger business jet.

Development



CRJ cockpit

The aircraft was based on the Canadair Challenger design, which was purchased by Canadair from Learjet in 1976.

The wide fuselage of the Challenger suggested early on to Canadair officials that it would be straightforward to stretch the aircraft to accommodate more seats, and there was a plan for a **Challenger 610E**, which would have had seating for 24 passengers. That lengthening did not occur, the effort being canceled in 1981, but the idea did not disappear.

In 1987, studies began for a much more ambitious stretched configuration, leading to the formal launch of the **Canadair Regional Jet** program in the spring of 1989. The "Canadair" name was retained despite the fact that Bombardier had bought out the company. The first of three development machines for the initial **CRJ100** performed its first flight on 10 May 1991, though one of the prototypes was lost in a spin mishap in

July 1993. The type obtained certification in late 1992, with initial delivery to customers late in that year.

CRJ100



A Lufthansa CRJ100 landing

The CRJ100 was stretched 5.92 meters (19 feet 5 inches), with fuselage plugs fore and aft of the wing, two more emergency exit doors, plus a reinforced and modified wing. Typical seating was 50 passengers, the maximum load being 52 passengers. The CRJ100 featured a Collins ProLine 4 avionics suite, Collins weather radar, GE CF34-3A1 turbofans with 41.0 kN (4,180 kgp / 9,220 lbf), new wings with extended span, more fuel capacity, and improved landing gear to handle the higher weights. It was followed by the **CRJ100 ER** subvariant with 20% more range, and the **CRJ100 LR** subvariant with 40% more range than the standard CRJ100. The **CRJ 100 SE** sub-variant was produced to more closely meet the needs of corporate and executive operators.

CRJ200



Air Nostrum CRJ200 ER

The CRJ200 is identical to the 100 model except for more efficient engines.

Pinnacle Airlines had operated some with 44 seats, designated as **CRJ440**, with closets in the forward areas of the passenger cabin though these were converted to 50 seat airplanes. These modifications were designed to allow operations under their major airline contract "scope clause" which restricts major airlines' connection carriers from operating equipment carrying 50 or more passengers to guard against usurpation of Air Line Pilots Association and Allied Pilots Association pilots' union contract. Similarly, Comair's fleet of 40-seat CRJ200s were sold at a discounted price to discourage Comair from purchasing the less expensive and smaller Embraer 135.

As of August 2006 a total of 938 CRJ100 and CRJ200 aircraft (all variants) are in airline service, with 8 further firm orders. Major operators include Comair (143), Pinnacle Airlines (121), SkyWest Airlines (136), Atlantic Southeast Airlines (110), Air Wisconsin (70), ALMA de Mexico (22), Air Canada Jazz (58), Mesa Airlines (60), Lufthansa CityLine (26), Air Nostrum (35, Plus 7 orders), PSA Airlines (35), Republic Airways Holdings (20) and Mesaba Airlines (19). Some 20 other airlines also operate smaller fleets of the type.

Variants



CRJ-100SE corporate aircraft at Kenosha, Wisconsin in 1997



CRJ-200

Several models of the CRJ have been produced, ranging in capacity from 40 to 50 passengers. The **Regional Jet** designations are marketing names and the official designation is **CL-600-2B19**.

CRJ100

The CRJ100 is the original 50-seat version. It is equipped with General Electric CF34-3A1 engines. Operators include Air Canada Jazz, Comair and more.

CRJ200

The CRJ200 is identical to the CRJ100 except for its engines, which were upgraded to the CF34-3B1 model, offering improved efficiency.

CRJ440

Certified up to 44-seat, this version was designed with fewer seats in order to meet the needs of some major United States airlines.

Challenger 800/850

A business jet variant of the CRJ200

Operators



Air Canada Jazz CRJ being fueled at La Guardia Airport

Incidents and accidents

- On 16 December 1997, Air Canada Flight 646, a Bombardier CRJ-100, crashed on a go-around at Greater Fredericton Airport in Fredericton, New Brunswick. No fatalities were reported.

- On 22 June 2003, Brit Air Flight 5672 from Nantes to Brest, France, crashed 2.3 miles short and 0.3 miles to the left of the runway when attempting a landing at Brest's airport. The aircraft's captain was the sole fatality.
- On 14 October 2004, Pinnacle Airlines Flight 3701, a Bombardier CRJ-200, crashed on a repositioning flight from Little Rock, Arkansas to Minneapolis. The two pilots pushed the airplane to its service ceiling of 41,000 feet at much higher climb rates than the engines and airframe could handle. This caused both engines to flame out and possibly experience core lock. The aircraft did not have any passengers onboard because the plane was being ferried (moved from one location to another). The aircraft crashed about fifteen minutes later, in sight of the diversion airport; both pilots were killed.
- On 21 November 2004, China Eastern Airlines Flight 5210, a Bombardier CRJ-200LR, crashed shortly after takeoff, killing all 53 on board as well as two on the ground.
- On 27 August 2006, Comair Flight 5191, marketed as a Delta Connection flight, a Bombardier CRJ-100ER, crashed during takeoff from the wrong runway at Blue Grass Airport in Lexington, Kentucky. There were 49 fatalities, with only the severely injured first officer surviving.
- On 20 May 2007, an Air Canada Jazz Bombardier CRJ-100 which originated in Moncton, New Brunswick, was substantially damaged when its landing gear collapsed after landing at Toronto-Pearson International Airport, ON (YYZ). There were no injuries to any crew or passengers. Flight AC8911 departed Moncton (YQM) on a domestic flight to Toronto. The aircraft landed on runway 06R with a 90 degree crosswind from the left, gusting from 13 to 23 knots. The aircraft first contacted the runway in a left-wing-down sideslip. The left main landing gear struck the runway first and the aircraft sustained a sharp lateral side load before bouncing. Once airborne again, the flight and ground spoilers deployed and the aircraft landed hard. Both main landing gear trunnion fittings failed and the landing gear collapsed. The aircraft remained upright, supported by the landing gear struts and wheels. The aircraft slid down the runway and exited via the Delta 3 taxiway, where the passengers deplaned. There was no fire. There were no injuries to the crew; some passengers reported minor injuries as a result of the hard landing.
- On 16 December 2007, Air Wisconsin flight 758A, a Bombardier CRJ-200LR, departed the runway during landing at T. F. Green Airport in Providence, Rhode Island. No injuries or fatalities were reported.
- On 13 February 2008, Belavia Flight 1834, a Bombardier CRJ-100LR, crashed and flipped-over during takeoff at Zvartnots International Airport in Yerevan, Armenia. Most passengers suffered some burns, and four were taken to the hospital. No fatalities were reported.
- On 12 November 2009, RwandAir Flight 205, a Bombardier CRJ-100, crashed into a VIP terminal shortly after an emergency landing at Kigali International Airport, Rwanda; out of the ten passengers and five crew members, one passenger died.
- On 19 January 2010, PSA Airlines Canadair CRJ-200 N246PS overran the runway at Yeager Airport, Charleston, West Virginia following an aborted take-

off. The aircraft was stopped by the EMAS at the end of the runway, sustaining substantial damage to its undercarriage.

Specifications

Variant	CRJ100 ER/LR	CRJ200 ER/LR
Crew	3 (2 pilots + flight attendant)	
Seating capacity	50	
Length	26.77 m (87 ft 10 in)	
Wing span	21.21 m (69 ft 7 in)	
Height	6.22 m (20 ft 5 in)	
Engines (2x)	GE CF34-3A1	GE CF34-3B1
Takeoff thrust (2x)	38.83 kN (8,729 lbf)	38.83 kN (8,729 lbf)
Thrust APR (2x)	41.01 kN (9,220 lbf)	41.01 kN (9,220 lbf)
Max Zero Fuel Weight (ZFW)	19,958 kg (44,000 lb)	
Max payload weight	6,124 kg (13,500 lb)	
Max Take Off Weight	24,091 kg (53,000 lb)	
Maximum range	ER: 3,000 km (1,864 mi, 1,620 nmi)	ER: 3,045 km (1,895 mi, 1,644 nmi)
	LR: 3,710 km (2,305 mi, 2,003 nmi)	LR: 3,713 km (2,307 mi, 2,004 nmi)
Basic cruising speed	Mach .78 [503 mph, 437 knots] (593.74 mph ground, 516 knots ground)	
Flight ceiling	12,496 m (41,000 ft)	
Number of Orders	1054	
Certification Date	unknown	July 1992

CRJ200:

Dimensions:

Wing area (net) 520.4 ft² 48.35 m²
 Fuselage maximum diameter 8 ft 10 in 2.69 m
 Turning Circle 75 ft 22.86 m

Bombardier CRJ700

CRJ700 / CRJ900 CRJ1000



A CRJ700 in Delta Connection livery

Role	Regional jet
National origin	Canada
Manufacturer	Bombardier Aerospace
First flight	1999
Introduction	2001
Status	In production, in operation
Primary users	SkyWest Airlines Mesa Airlines Atlantic Southeast Airlines Mesaba Airlines
Number built	543 as of July 2010
Unit cost	US\$24-39.7m (2006)
Developed from	Bombardier CRJ200

The **Bombardier CRJ700**, **CRJ900**, and **CRJ1000** are regional airliners based on the Bombardier CRJ200. Final assembly of the aircraft is at Montréal-Mirabel International Airport in Mirabel, Quebec, outside Montreal, Canada.

Development

Following the success of the CRJ100/200 series, Bombardier produced larger variants in order to compete with larger regional aircraft such as the Embraer E-Jets family, Fokker 70/100 series and the BAe 146/Avro RJ family.

CRJ700



Horizon Air CRJ700 in Denver

The *CRJ700* is a stretched 66-78 seat derivative of the CRJ200, with 70 seats being the most common. The CRJ700 features a new wing with leading edge slats and a stretched and slightly widened fuselage, with a lowered floor. The aircraft is equipped with the General Electric CF34-8C1 engine. Maximum speed is Mach 0.85 (556 miles per hour) at a maximum altitude of 41,000 feet (12,500 m). Depending upon payload, the CRJ700 can travel up to 2,250 miles (3,620 km) with current engines, and a new variant with CF34-8C5 engines will be able to travel up to 2,895 miles (4,660 km).



Lufthansa CRJ701 ER

The CRJ700 comes in three versions: Series 700, Series 701, and Series 702. The 700 is limited to 68 passengers, the 701 to 70 passengers, and the 702 to 78 passengers. The CRJ700 also has three fuel/weight options: standard, ER, and LR. The ER version has an increase in fuel capacity as well as maximum weight, which in turn increases the range. The LR increases those values further.

Its first flight was in 1999 and it entered service in 2001. The aircraft's FAA Type Certificate designation is the **CL-600-2C10**. The first airline to fly a CRJ700 was Brit Air in 2001.

The CRJ-700 directly competes with the Embraer 170, which typically seats 70 passengers. However, the CRJ-700 is 10% more cost-effective to operate than the E-170.

In 2008, the CRJ700 was replaced with the CRJ700 NextGen, featuring improved economics and a revised cabin common to the CRJ900 NextGen and CRJ1000 NextGen.

In January 2011 SkyWest Airlines ordered four CRJ700 NextGen.

CRJ705



Air Canada Jazz CRJ-705 at Regina International Airport

The *Series 705* is based on the CRJ900, with a business class and a reduced maximum seating capacity to allow operation with regional airlines. The Series 705 seat 75 passengers. Some regional airlines have contracts with their major airlines that limit the maximum passenger capacity of aircraft they operate. Air Canada Jazz was the launch customer for this aircraft in 2005 with 10 executive (business) class and 65 economy seats. The FAA Type Certificate designation of the CRJ705 is the **CL-600-2D15**. Air Canada Jazz operates 16 Series 705 aircraft.

CRJ900



Lufthansa CityLine Bombardier CRJ900LR takes off. (2010)

The *CRJ900* is a stretched 76-90 seat version of the CRJ700. The aircraft features the GE CF34-8C5 engines, 13,360 lbf (59,400 N) thrust with APR, and added leading edge slats. Max GTOW is 84,500 pounds. The airplane is loosely based on the CRJ200 series with a few major improvements. The environmental packs have a target temperature instead of a hot-cold knob. The cabin has a recirculation fan which aids in cooling and heating. The engines are controlled by FADEC digital engine control instead of control cables and a fuel control unit. The cabin floor has been lowered 2 inches which gains outward visibility from the windows in the cabin as the windows become closer to eye level height. The APU is a General Electric unit which supplies much more air to the AC packs and has higher limits for starting and altitude usage. The wingspan is longer, the tail is redesigned with more span and anhedral. In typical service the CRJ900 can cruise 8-10,000 ft higher with a slightly higher fuel burn and an average true airspeed of 450-500 knots, a significant improvement over its predecessor. The FAA Type Certificate designation of the CRJ900 is the **CL-600-2D24**.



Scandinavian Airlines was a new customer of the CRJ900 in 2008

The first CRJ900 (C-FRJX) was modified from the prototype CRJ700 by adding longer fuselage plugs fore and aft; it was later converted into the prototype CRJ1000 by installing yet longer fuselage plugs. The CRJ900 competes with the Embraer 175, and is more efficient per seat-mile, according to Bombardier.

In 2007, Bombardier launched the CRJ900 NextGen to replace the initial version. The new model has improved economics and a new cabin common to the CRJ700 NextGen and CRJ1000 NextGen. Mesaba Aviation, operating at the time as Northwest Airlink (now Delta Connection), was the launch customer, and remains the largest operator of the CRJ900 NextGen. The Mesaba fleet of CRJ900 NextGen aircraft are configured in a two class seating configuration, with 12 first class seats and 64 coach seats.

Comair, flying as Delta Connection, has ordered 14 CRJ900s, with at least 6 in service as of Nov 2007. These are in a two class configuration, with 12 first class seats and 64 coach seats. This is due to a limitation in Delta's contract with its pilots which limits its regional carriers to flying 76-seat aircraft.

In July 2008 PLUNA received its fifth plane (from an eventual total of 7). Estonian Air ordered 3 new CRJ900 NextGen 90-seat aircraft. Also SAS ordered 13 of these in March 2008. Iraqi Airways has ordered six Bombardier CRJ900 NextGen airliners and options on a further four of the type.

In June 2010 Lufthansa ordered eight CRJ900 NextGen.

CRJ1000



A CRJ1000 at Paine Field, Snohomish County, Washington

On 19 February 2007, Bombardier launched the *CRJ1000*, previously designated CRJ900X, as a stretched CRJ900, with up to 100 seats. Bombardier claims that it offers better performance and a higher profit per seat than the competing Embraer E-190. Brit Air and Air Nostrum are the launch customers for the CRJ1000. MyAir had ordered 15 CRJ900Xs that were converted to the CRJ1000, but the airline went bankrupt on 24 July 2009. Atlasjet also indicated interest in the new type.

The CRJ1000 successfully completed its first flight in 2008. Bombardier, however, stated that the introduction into service had been delayed until the first quarter of 2010. On 14 June 2009 Bombardier announced a new firm order for 15 CRJ1000 NextGen aircraft placed by Air Nostrum, for a total of 35 CRJ1000 NextGen aircraft. There are 49 firm orders and 4 options for the variant as of August 2009.

The variant completed its first production flight on 28 July 2009 in Montreal; the entry into service was planned then for the first quarter of 2010. A month after the first flight, however, a fault in the rudder controls forced the flight-test program to be grounded. The program was not resumed until February 2010, and deliveries were projected to begin by January 2011.

Bombardier Aerospace announced on 10 November 2010 that its 100-seat CRJ1000 was awarded Aircraft Type Certificates from Transport Canada and European Aviation Safety

Agency, clearing the way for deliveries to begin. On 14 December 2010, Bombardier began CRJ1000 deliveries to Brit Air and Air Nostrum. On 23 December 2010 it was announced that the Federal Aviation Administration had also awarded a type certificate, allowing the CRJ1000 to operate in US airspace.

Operators



A comparison between Bombardier CRJ700 (top) and CRJ900 (bottom)

As of July 2010, 316 CRJ700 aircraft (all variants) and 229 CRJ900 aircraft (all variants) were in airline service. Operators for these aircraft are SkyWest Airlines (104), Mesa Airlines (58), Atlantic Southeast Airlines (49), Mesaba Airlines (41), Lufthansa CityLine (32), Comair (28), American Eagle Airlines (25), GoJet Airlines (25), and other operators with fewer aircraft of the type.

Accidents and incidents

- On September 25, 2010, Delta Connection Flight 4951, a CRJ900, on a passenger flight from Atlanta, Georgia to White Plains, New York made a successful emergency landing at John F. Kennedy International Airport in New York City. The plane's right landing gear would not deploy and the right wing dragged along the runway during the landing. There were no injuries.

Chapter- 8

Boeing 747-8

Boeing 747-8



The Boeing 747-8F during the 747-8's maiden flight on February 8, 2010

Role	Wide-body jet airliner
National origin	United States
Manufacturer	Boeing Commercial Airplanes
First flight	February 8, 2010
Status	Testing/early production
Number built	3
Unit cost	747-8I: US\$293–308 million 747-8F: US\$301.5–304.5 million
Developed from	Boeing 747-400

The **Boeing 747-8** is a wide-body commercial jet airliner being developed by Boeing Commercial Airplanes. Officially announced in 2005, the 747-8 is the fourth-generation Boeing 747 version, with lengthened fuselage, redesigned wings and improved efficiency. The 747-8 is the largest 747 version and the largest commercial aircraft built in the United States, as well as the longest passenger aircraft in the world.

The 747-8 is offered in two main variants: the 747-8 Intercontinental (747-8I) for passengers and the 747-8 Freighter (747-8F) for cargo. The first 747-8F performed the model's maiden flight on February 8, 2010. Delivery of the first freighter aircraft has been postponed multiple times and is now expected in mid-2011; passenger model deliveries are to begin in late 2011 or early 2012. In December 2010, orders for the 747-8 totaled 107, including 74 of the freighter version, and 33 of the passenger version.

Development

Background



General Electric would fly its 747-100 testbed, used in the 1990s for the GE90, to test the new GEnx engine for the 747-8/787.

Boeing had considered larger-capacity versions of the 747 several times during the 1990s and 2000s. The 747-500X and -600X, proposed at the 1996 Farnborough Airshow, would have stretched the 747 and used a 777-derived wing, but did not attract enough interest to enter development. In 2000, Boeing offered the 747X and 747X Stretch derivatives as alternatives to the Airbus A3XX. This was a more modest proposal than the previous -500X and -600X. The 747X would increase the 747's wingspan to 229 ft (69.8 m) by adding a segment at the root. The 747X was to carry 430 passengers up to 8,700 nmi (16,100 km). The 747X Stretch would be extended to 263 ft (80.2 m) long, allowing it to carry 500 passengers up to 7,800 nmi (14,400 km). However, the 747X family was unable to attract enough interest to enter production. Some of the ideas developed for the 747X were used on the 747-400ER.



Elements from the 747X program were adopted for Extended Range (ER) variants of the 747-400, preceding the 747-8.

After the 747X program, Boeing continued to study improvements to the 747. The 747-400XQLR (Quiet Long Range) was meant to have an increased range of 7,980 nmi (14,780 km), with better fuel efficiency and reduced noise. Changes studied included raked wingtips similar to those used on the 767-400ER and a sawtooth engine nacelle for noise reduction. Although the 747-400XQLR did not move to production, many of its features were used for the 747 Advanced.

In early 2004, Boeing announced tentative plans for the 747 Advanced that were eventually adopted. Similar in nature to the 747X, the stretched 747 Advanced used technology from the 787 Dreamliner to modernize the design and its systems. On November 14, 2005, Boeing announced that it was launching the 747 Advanced as the "Boeing 747-8".

Design effort



Artist's rendering of the Boeing 747-8F. The 747-8 is stretched in two bands for a total extension of 18.3 ft (5.6 m) over the 747-400.

The 747-8 was designed to be the first lengthened 747 to go in to production. The 747-8 and 747SP are the only 747 variants with a fuselage of modified length. The 747-8 was intended to use the same engine and cockpit technology as that of the 787, including the General Electric GEnx turbofan and partial fly-by-wire. Boeing said that the new design would be quieter, more economical, and more environmentally friendly than previous versions of the 747. As a derivative of the already-common 747-400, the 747-8 has the economic benefit of similar training and interchangeable parts. Boeing firmed the 747-8 Freighter's configuration in October 2006.

The 747-8, as the current new development of Boeing's largest airliner, is notably in direct competition on long-haul routes with the Airbus A380, a full-length double-deck aircraft now in service. For airlines seeking very large passenger airliners, the two have been pitched as competitors on various occasions. Boeing claims that the 747-8 is more than 10 percent lighter per seat and will consume 11 percent less fuel per passenger than the A380, translating into a trip-cost reduction of 21 percent and a seat-mile cost reduction of over 6 percent.

Production of the first 747-8 Freighter began in Everett in early August 2008. On November 14, 2008, Boeing announced a delay to the 747-8 program, citing limited availability of engineering resources within Boeing, design changes, and the recent strike by factory workers. On July 21, 2009, Boeing released a photograph of the first cargo airplane, its fuselage and main wing assembled.



Artist's rendering of an early version of the passenger 747-8, then known as the 747 Advanced. This had a shorter stretch of 140 in (360 cm), rather than 220 in (560 cm).

In February 2009, only one airline customer (Lufthansa) had ordered the 747-8I passenger model, and Boeing announced it was reassessing the 747-8 project. Chief executive Jim McNerney stated that continuation of the project was not a foregone conclusion. The company was assessing various options.

In October 2009, Boeing announced that it had delayed the first flight on the 747-8 until first quarter 2010 and delayed 747-8I delivery. The company took a US\$1-billion charge against its earnings for this delay. In response, launch customer Cargolux told the Wall Street Journal it still intended to take delivery of the thirteen freighters it had ordered; Lufthansa confirmed its commitment to the passenger version. On November 12, 2009, Boeing announced that Cargolux's first airplane was fully assembled and entering the Everett plant's paint shop. It will undergo flight testing prior to delivery. Boeing

announced a further postponement on September 30, 2010, with the delivery of the first freighter to Cargolux expected in mid-2011.

On December 4, 2009, Korean Air became the second airline customer for the -8I passenger model, with an order for five airliners. On January 8, 2010, Guggenheim Aviation Partners (GAP) announced the reduction of its -8F order from four to two aircraft.

On April 21, 2010, Boeing chief executive officer Jim McNerney announced that the company would be accelerating the production of both the Boeing 747 and 777 to support increasing customer demand.

Flight testing



The Boeing 747-8F during flight testing at Everett, Washington

The 747-8's first engine runs were completed in December 2009. Boeing announced the new model had successfully completed high-speed taxi tests on February 7, 2010. On February 8, 2010, after a 2.5-hour weather delay, the 747-8 Freighter made its maiden flight, taking off from Paine Field, Washington at 12:39 PST. The aircraft landed at 4:18 pm PST. Boeing estimates that more than 1,600 flight hours will be needed in order to certify the 747-8. The second test flight in late February, a ferry flight to Moses Lake, Washington, tested new navigation equipment. Further flight testing will take place in Moses Lake, conducting initial airworthiness and flutter tests, before moving to Palmdale, California for the majority of flight tests, so as to not interfere with 787 flight tests based out of Boeing Field in Seattle.

By March 11, 2010, the 747-8F had flown thirteen flights for a total of 33 hours of flying time. On March 15, 2010, the second 747-8F first flew from Paine Field to Boeing Field, where it will be based for a short time before moving to Palmdale to continue flight testing with the first -8F. On March 17 the third -8F made its first flight, also between Paine Field to Boeing Field. Boeing plans to display the 747-8F at the 2010 Farnborough Airshow, along with the 787, although appearances by both aircraft are contingent on flight testing remaining on schedule.

During the flight tests, Boeing discovered a buffet problem with the aircraft, involving turbulence coming off the landing gear doors interfering with the inboard flaps. Boeing undertook an evaluation of the issue, which included devoting the third test aircraft to investigating the problem. The issue was resolved by a design change to the outboard main landing gear doors. In early April 2010, Boeing identified a possible defect in a part at the top of the fuselage called a longeron. According to Boeing, the parts, manufactured by subcontractor Vought Aircraft Industries, are, under certain loads, susceptible to cracking. Boeing said that the issue would not affect flight testing, but other sources stated that the problem could impact the operating envelope of the aircraft until it is fully repaired. Two other problems have been found, with oscillation in the inboard aileron, and a structural flutter, and have not yet been resolved. Combined, these problems have slowed flight testing and used up almost all the margin in Boeing's development schedule.



Boeing's Everett Facility at Paine Field, site of 747-8 assembly and early flight tests

On April 19, 2010, the second flight-test aircraft was moved from Moses Lake to Palmdale to conduct tests on the aircraft's engines in preparation for obtaining a type certification for the aircraft. The remaining aircraft in the test fleet are scheduled to be moved to Palmdale during May. It was reported on June 3, 2010 that an engine on the second 747-8F was struck by a tug during a ground move. The engine cowling was damaged, but there was no damage to the engine itself. After repairs the aircraft is to perform fuel efficiency testing. It was announced on June 14, 2010 that the 747-8 had completed the initial phase of flight-worthiness testing and that the FAA had given Boeing an expanded type inspection authorization for the aircraft.

By the end of June 2010, the three 747-8Fs that composed the flight-test program had flown a total of over 500 hours and had completed hot-weather testing in Arizona. In June 2010, Boeing determined that a fourth -8F aircraft was needed to help complete flight testing. It was decided to use the second production aircraft, RC503, to conduct the non-instrumented or minimally-instrumented tests, such as HIRF and Water Spray Certifications. The aircraft, painted in delivery customer Cargolux's new livery, first flew on July 23, 2010 from Paine Field in Everett to Moses Lake, before later returning to Everett.

On August 21, at Victorville California, the 747-8F proved its capability by taking off from the runway weighing 1,005,000 pounds (455,860 kg). Its design maximum take-off weight (MTOW) is 975,000 pounds (442,253 kg).

Compared to the 747-400, the main technical changes will be on the wing of the aircraft, which will undergo a complete design overhaul. The sweep and basic structure will be kept to contain costs, but the wing will be thicker and deeper, with the aerodynamics recalculated. The pressure distribution and bending moments will be different, with the new wing for the passenger version being planned to hold 64,225 US gal (243,120 L) of jet fuel, and the cargo aircraft 60,925 US gal (230,630 L). The new wing will have single-slotted outboard flaps and double-slotted inboard flaps.

Raked wingtips, similar to the ones used on the 777-200LR, 777-300ER, and 787 models, are used on the new 747 variant instead of winglets used on the 747-400. These wingtip structures help reduce the wingtip vortices at the lateral edges of the wings, decreasing wake turbulence and drag, and thereby increasing fuel efficiency. Another effort to reduce weight is the introduction of fly-by-wire technology for the majority of the lateral controls.



The General Electric GENx engine for the 747-8/787 on display at the 2009 Paris Air Show

The extra fuel capacity in the redesigned wing compared to the 747-400 obviates the need to radically change the horizontal tail unit to accommodate auxiliary tanks, further saving costs. The -8's vertical tail unit will be largely unchanged with a height of 63 feet 6 inches (19.35 m). Some carbon fiber-reinforced plastic will be part of the 747-8's airframe to reduce weight. However, structural changes will mostly be evolutionary, rather than revolutionary with respect to the 747-400.

The General Electric GENx, which is one of the two powerplant choices currently offered for the Boeing 787, will be the only engine available for the 747-8. However, the 747 variant will be adapted to provide bleed air for conventional aircraft systems and feature a smaller diameter to fit on the 747 wing. The flight tests of the GENx 2b engine fitted to a Boeing 747-100 aircraft at the left inner engine began in March 2009.

Variants

747-8 Freighter



Cargolux's first Boeing 747-8F in flight over Fresno, California

The 747 has proven to be a very popular freighter, carrying around half of the world's air freight as of 2007. In an effort to maintain this dominant position, Boeing designed a freight variant of the 747-8, named the *747-8 Freighter* or *747-8F*, which was launched on November 14, 2005. The 747-8F will be the initial model to see entry into service (EIS). As on the 747-400F, the upper deck is shorter than passenger models; the 18 feet 3½ inches (5.575 m) stretch is just before and just aft of the wing. With a 975,000 lb (442,000 kg) maximum take-off weight, it will have a total payload capability of 308,000 lb (140,000 kg) and a range of 4,390 nmi (8,130 km). Four extra pallet spaces will be created on the main deck, with either two extra containers and two extra pallets, or three extra pallets, on the lower deck. The 747-8F is expected to achieve a 16% lower ton-mile operating cost than the 747-400F and offer a slightly greater range.



The first 747-8 Freighter at the fuel dock of Boeing Everett Plant, November 23, 2009

The 747-8F will have more payload capacity but less range than the current 747-400ERF. When Boeing launched the -400ERF, all of the 35,000 lb (16,000 kg) increase in MTOW over the 747-400F 875,000–910,000 lb (397,000–410,000 kg) allowed airlines to take off with more fuel, burn it during flight, and land at the same weight as the regular 747-400F. This increased the range of the 747-400ERF compared to the 747-400F. Cargo carriers often move machinery or indivisible loads that require a plane with a higher payload and landing capability. As is common with cargo planes, range is given with maximum payload, not fuel. The 747-8's 65,000 lb (29,000 kg) MTOW increase has been directed exclusively to its Zero-Fuel weight or payload capacity. If taking off at maximum payload, the 747-8 takes off with its tanks not full. On trips where the payload is not at maximum, the plane can take on more fuel and extend its range.

Cargolux and Nippon Cargo Airlines were the first customers for the 747-8, placing orders for the freighter variant in November 2005. The firm configuration of the aircraft was finalized in October 2006. Major assembly of the aircraft began on August 8, 2008, and the aircraft first left Boeing's Everett factory on November 12, 2009.

747-8 Intercontinental



Artist's rendering of the finalized 747-8I configuration, with the same fuselage length as the 747-8F

The passenger version, named *747-8 Intercontinental* or *747-8I* was launched on November 14, 2005. The aircraft will be capable of carrying up to 467 passengers in a 3-class configuration over 8,000 nmi (15,000 km) at Mach 0.855. The 747-8I will carry 51 more passengers and two more freight pallets with 26% more cargo volume than the 747-400. Despite initial plans for a shorter stretch than the freighter model, the two variants will be the same length, increasing passenger capacity and allowing easier modification of the 747-8I to freighter use. The upper deck will be lengthened on the -8I. New engine technology and aerodynamic modifications will allow longer range. Boeing has stated that compared to the 747-400, the -8I will be 30% quieter, 16% more fuel-efficient, and have 13% lower seat-mile costs with nearly the same cost per trip.



Main deck seating on the 747-8 Intercontinental

For the 747-8, Boeing has proposed some changes to the interior layout of the aircraft. Most noticeable will be the curved stairway to the upper deck and a more spacious main passenger entrance. The 747-8's main cabin uses an interior similar to that of the 787. Overhead bins are curved, and the center row is designed to look as though it is attached to the curved ceiling, rather than integrated into the ceiling's curve like on the 777. The windows will also be of similar size to the type used on the 777, which are 8% larger than those on the current 747-400s. The 747-8 will feature a new solid-state light-emitting diode (LED) lighting system, which can create mood lighting. LED technology also offers improved reliability and lower maintenance costs.



Boeing 747-8 Intercontinental upper deck staircase and skylight

Further down the aircraft, it has been proposed to place cabin-accessible facilities in the "crown" area, the space above the passenger cabin, currently used for air-conditioning ducts and wiring. The wiring and ducts will be moved to the side to create extra space; as a consequence, this area will not have windows. The added space can be used for galleys and crew rest areas, freeing up main deck space for additional passenger seating.

During the initial 747-8 marketing phase, Boeing also proposed creating a revenue-generating "SkyLoft" passenger facility in the crown space. This facility would include "SkySuites", small individual compartments with sliding doors or curtains, featuring beds, seating, and entertainment or business equipment. A common lounge area could also be provided. Boeing also proposed smaller, more modest "SkyBunks". Access to the

crown area would be via a separate stairway at the rear of the aircraft. Passengers using the SkySuites, sold at a premium price, would sit in regular economy class seats for take-off and landing, and move to the crown area during flight. However, pricing feasibility studies found the SkyLoft concept difficult to justify. In 2007, Boeing dropped the SkyLoft concept in favor of upper-deck galley storage options, which were favored by the airlines. Outfitting the crown space for sleeping remains an option on VIP aircraft.

The first order for the 747-8 Intercontinental was placed by an undisclosed VIP customer in May 2006, widely believed to be a Middle Eastern head of state. Lufthansa became the first airline to order the 747-8 Intercontinental on December 6, 2006. In December 2009, Korean Air announced the order of five 747-8Is. Boeing announced on May 8, 2010, that the company had begun final assembly of the first 747-8I.

Boeing stated firm configuration for the -8I was reached in November 2007. Major assembly of the -8I began on May 8, 2010. The final body join occurred on October 15, 2010, slightly ahead of the projected schedule, and the first flight was predicted to occur within seven months. Two 747-8I aircraft are planned to take part in the 747-8I flight test program, the first destined for a VIP customer and the second for Lufthansa. Assembly of the first 747-8I is to be completed in February 2011 with deliveries to begin in late 2011 or early 2012.

Presidential aircraft replacement

The U.S. Air Force is seeking to upgrade Air Force One by replacing the Boeing VC-25 (two heavily modified 747-200Bs). Boeing is reported to be exploring a 747-8 proposal, along with a Boeing 787 variant. In 2010, South Korea government sources indicated that the country was considering purchasing the 747-8 to serve as the country's presidential aircraft.

Chapter- 9

Boeing 787

Boeing 787 Dreamliner



The first Boeing 787-8 *Dreamliner* on its maiden flight

Role	Wide-body jet airliner
National origin	United States, with international partners
Manufacturer	Boeing Commercial Airplanes
First flight	December 15, 2009
Status	In development, flight testing and early production
Number built	6
Unit cost	787-8: US\$185.2 million (2010) 787-9: US\$218.1 million (2010)

The **Boeing 787 Dreamliner** is a long-range, mid-size, wide-body, twin-engine jet airliner developed by Boeing Commercial Airplanes. It seats 210 to 330 passengers, depending on the variant. Boeing states that it is the company's most fuel-efficient airliner and the world's first major airliner to use composite materials for most of its construction. The 787 consumes 20% less fuel than the similarly-sized Boeing 767. Some of its distinguishing features include a four-panel windshield, noise-reducing chevrons on its engine nacelles, and a smoother contour regarding its nose.

The aircraft's initial designation *7E7* was changed to 787 in January 2005. The first 787 was unveiled in a roll-out ceremony on July 8, 2007, at Boeing's Everett assembly

factory, by which time it had become the fastest-selling wide-body airliner in history with 677 orders. By September 2010, 847 Boeing 787s had been ordered by 56 customers. As of 2010, launch customer All Nippon Airways has the largest number of 787s on order.

The 787 development and production has involved a large-scale collaboration with numerous suppliers around the globe. It is being assembled at the Boeing Everett Factory in Everett, Washington. Aircraft will also be assembled at a new factory in North Charleston, South Carolina. Both sites will deliver 787s to airline customers. Originally planned to enter service in May 2008, the project has suffered from repeated delays and is now more than three years behind schedule. The airliner's maiden flight took place on December 15, 2009, and it is currently undergoing flight testing with a goal of receiving certification in mid-2011 and entering service in Q3 2011.

Development

Background

During the late 1990s, Boeing began considering replacement aircraft programs as sales for the 767 and Boeing 747-400 slowed. The company proposed two new aircraft, the 747X, which would have lengthened the 747-400 and improved efficiency, and the Sonic Cruiser, which would have achieved 15% higher speeds (approximately Mach 0.98) while burning fuel at the same rate as the existing 767. Market interest for the 747X was tepid, but the Sonic Cruiser had brighter prospects. Several major airlines in the United States, including Continental Airlines, initially showed enthusiasm for the Sonic Cruiser concept, although they also expressed concerns about the operating cost.



Earlier proposed design configuration of the Boeing 7E7

The global airline market was upended by the September 11, 2001 attacks and increased petroleum prices, making airlines more interested in efficiency than speed. The worst-affected airlines, those in the United States, had been considered the most likely customers of the Sonic Cruiser, and thus Boeing officially canceled the Sonic Cruiser on December 20, 2002. Switching tracks, the company announced an alternative product

using Sonic Cruiser technology in a more conventional configuration, the 7E7, on January 29, 2003. The emphasis on a smaller midsize twinjet rather than a large 747-size aircraft represented a shift from hub-and-spoke theory towards the point-to-point theory, in response to analysis of focus groups.

“ The 7E7 looks fairly traditional on the outside, but it will be dramatically different on the inside. ”

—*Time*

The replacement for the Sonic Cruiser project was dubbed the "7E7" (with a development code name of "Y2"). Technology from the Sonic Cruiser and 7E7 was to be used as part of Boeing's project to replace its entire airliner product line, an endeavor called the Yellowstone Project (of which the 7E7 became the first stage). Early concept images of the 7E7 included rakish cockpit windows, a dropped nose and a distinctive "shark-fin" tail. The "E" was said to stand for various things, such as "efficiency" or "environmentally friendly"; however, in the end, Boeing claimed that it stood merely for "Eight". In July 2003, a public naming competition was held for the 7E7, for which out of 500,000 votes cast online the winning title was *Dreamliner*. Other names in the pool included *eLiner*, *Global Cruiser* and *Stratoclimber*.

Design effort

On April 26, 2004, Japanese airline All Nippon Airways became the launch customer for the 7E7 Dreamliner, by announcing a firm order for 50 aircraft with deliveries to begin in late 2008. All Nippon Airways's order was initially specified as 30 787-3, 290–330 seat, one-class domestic aircraft, and 20 787-8, long-haul, 210–250 seat, two-class aircraft for regional international routes such as Tokyo Narita–Beijing. The aircraft would allow All Nippon Airways to open new routes to cities not previously served, such as Denver, Moscow, and New Delhi. The 787-3 and 787-8 were to be the initial variants, with the 787-9 entering service in 2010.



All Nippon Airways launched the 787 Dreamliner program with an order for 50 aircraft in 2004. This aircraft made an emergency landing during a test flight in Texas, on November 9, 2010.

The 787 was designed to become the first production composite airliner, with the fuselage assembled in one-piece composite barrel sections instead of the multiple aluminum sheets and some 50,000 fasteners used on existing aircraft. Boeing selected two new engine types to power the 787, the General Electric GENx and Rolls-Royce Trent 1000. Boeing claimed the 787 would be near to 20% more fuel-efficient than the 767, with one-third of the efficiency gain from the engines, another third from aerodynamic improvements and the increased use of lighter-weight composite materials, and the final third from advanced systems.

During the design phase, the 787 underwent extensive wind tunnel testing at Boeing's Transonic Wind Tunnel, QinetiQ's five-meter wind tunnel at Farnborough, UK, and NASA Ames Research Center's wind tunnel, as well as at the French aerodynamics research agency, ONERA. The final styling of the aircraft was more conservative than earlier proposals, with the fin, nose, and cockpit windows changed to a more conventional form. By the end of 2004, customer-announced orders and commitments for the 787 reached 237 aircraft. Boeing initially priced the 787-8 variant at US\$120 million, a low figure that surprised the industry. In 2007, the list price was US\$146–151.5 million for the 787-3, US\$157–167 million for the 787-8 and US\$189–200 million for the 787-9.

Manufacturing and suppliers

After stiff competition, Boeing announced on December 16, 2003, that the 787 would be assembled in its factory in Everett, Washington. Instead of building the complete aircraft from the ground up in the traditional manner, final assembly would employ just 800 to 1,200 people to join completed subassemblies and to integrate systems. Boeing assigned its global subcontractors to do more assembly themselves and deliver completed subassemblies to Boeing for final assembly. This approach was intended to result in a leaner and simpler assembly line and lower inventory, with pre-installed systems reducing final assembly time by three-quarters to three days.



Assembly of Section 41 of a Boeing 787

Subcontracted assemblies included wing manufacture (Mitsubishi Heavy Industries, Japan, central wing box) horizontal stabilizers (Alenia Aeronautica, Italy; Korea Aerospace Industries, South Korea); fuselage sections (Global Aeronautica, Italy; Boeing, North Charleston, USA; Kawasaki Heavy Industries, Japan; Spirit AeroSystems, Wichita, USA; Korean Air, South Korea); passenger doors (Latécoère, France); cargo doors, access doors, and crew escape door (Saab, Sweden); floor beams (TAL Manufacturing Solutions Limited, India); wiring (Labinal, France); wing-tips, flap support fairings, wheel well bulkhead, and longerons (Korean Air, South Korea); landing gear (Messier-Dowty, France); and power distribution and management systems, air conditioning packs (Hamilton Sundstrand, Connecticut, USA). Boeing is considering

bringing construction of the 787-9 tail "in house"; the tail of the 787-8 is currently made by Alenia.

To speed delivery of the 787's major components, Boeing modified several used 747-400s into 747 Dreamlifters to transport 787 wings, fuselage sections, and other smaller parts. Japanese industrial participation was very important to the project, with a 35% work share, the first time Japanese firms had taken a lead role in mass production of Boeing airliner wings, and many of the subcontractors supported and funded by the Japanese government. On April 26, 2006, Japanese manufacturer Toray Industries and Boeing announced a production agreement involving US\$6 billion worth of carbon fiber, extending a 2004 contract and aimed at easing production concerns.

Production and delivery delays

Boeing had originally planned for a first flight by the end of August 2007 and premiered the first 787 at a rollout ceremony on July 8, 2007, which matches the aircraft's designation in the US-style month-day-year format (7/8/07). However, the aircraft's major systems had not been installed at that time, and many parts were attached with temporary non-aerospace fasteners requiring their later replacement with flight fasteners. Although intended to shorten the production process, 787 subcontractors initially had difficulty completing the extra work, because they could not procure the needed parts, perform the subassembly on schedule, or both, leaving remaining assembly work for Boeing to complete as "traveled work".



The 787 Dreamliner's first public appearance was webcast live on July 8, 2007.

On September 5, Boeing announced a three-month delay, blaming a shortage of fasteners as well as incomplete software. On October 10, 2007, a second three-month delay to the first flight and a six-month delay to first deliveries was announced due to problems with the foreign and domestic supply chain, including an ongoing fastener shortage, the lack of documentation from overseas suppliers, and continuing delays with the flight guidance software. Less than a week later, Mike Bair, the 787 program manager was replaced. On January 16, 2008, Boeing announced a third three-month delay to the first flight of the 787, citing insufficient progress on "traveled work". On March 28, 2008, in an effort to gain more control over the supply chain, Boeing announced that it planned to buy Vought Aircraft Industries' interest in Global Aeronautica; the company later agreed to also purchase Vought's North Charleston, S.C. factory.

On April 9, 2008, Boeing officially announced a fourth delay, shifting the maiden flight to the fourth quarter of 2008, and delaying initial deliveries by around 15 months to the third quarter of 2009. The 787-9 variant was postponed to 2012 and the 787-3 variant was to follow with no firm delivery date. On November 4, 2008, the company announced a fifth delay due to incorrect fastener installation and the Boeing machinists strike, stating that the first test flight would not occur in the fourth quarter of 2008. After assessing the 787 program schedule with its suppliers, Boeing confirmed on December 11, 2008 that the first flight would be delayed until the second quarter of 2009.

On June 15, 2009, during the Paris Air Show, Boeing said that the 787 would make its first flight within two weeks. However, on June 23, 2009, Boeing announced that the first flight is postponed "due to a need to reinforce an area within the side-of-body section of the aircraft". Boeing provided an updated 787 schedule on August 27, 2009, with the first flight planned to occur by the end of 2009 and deliveries to begin at the end of 2010. The company expects to write off US\$2.5 billion because it considers the first three Dreamliners built unsellable and suitable only for flight tests.

Boeing announced on July 15, 2010, that the first delivery to launch customer All Nippon Airways could slip into 2011, and on August 27, 2010 it confirmed that the first delivery would be delayed until early 2011. Boeing and Rolls-Royce state a lack of Trent 1000 engines as the cause, following shutdown of Rolls-Royce's test facility after a blowout in a Trent 1000 during ground testing on August 2. In August 2010, it was announced that Boeing was facing a US\$1 billion compensation claim from Air India due to the delays for the 27 Dreamliners it has on order.

In early November 2010, it was reported that some early 787 deliveries may be delayed, in one case some three months, to allow for rework to address issues found during flight testing. In January 2011, Boeing announced that the first 787 delivery was rescheduled to the third quarter of 2011 due to software and electrical updates following the in-flight fire in November 2010.

Pre-flight ground testing



The first Boeing 787 underwent taxi tests at Paine Field in November and December 2009.

As Boeing worked with its suppliers on early 787 production, the aircraft design had proceeded through a series of test goals. On August 7, 2007, on-time certification of the Rolls-Royce Trent 1000 engine by European and US regulators was received. On August 23, 2007, a crash test involving a vertical drop of a partial composite fuselage section from about 15 ft (4.6 m) onto a 1 in (25 mm)-thick steel plate occurred in Mesa, Arizona; the results matched what Boeing's engineers had predicted, allowing modeling of various crash scenarios using computational analysis instead of further physical tests. The alternative GE GENx-1B engine achieved certification on March 31, 2008. On June 20, 2008, the 787 team achieved "Power On" of the first aircraft, powering and testing the aircraft's electrical supply and distribution systems. A non-flight 787 test airframe was built for static testing, and on September 27, 2008, over a period of nearly two hours, the fuselage was successfully tested at 14.9 psi (102.7 kPa), which is 150 percent of the maximum pressure expected in commercial service (i.e., when flying at maximum cruising altitude). In December 2008, the Federal Aviation Administration (FAA) passed the maintenance program for the 787.

On May 3, 2009, the first test 787 was moved to the flight line following extensive factory-testing, including landing gear swings, systems integration verification, and a total run-through of the first flight. Boeing spent most of May 2009 conducting tests on the first 787 prototype in preparation for the first flight. On March 28, 2010, the 787 completed the ultimate wing load test, which requires that the wings of a fully assembled

aircraft be loaded to 150% of design limit load and held for 3 seconds. The wings were flexed approximately 25 ft (7.6 m) upward during the test. Unlike past aircraft however, the wings were not tested to failure. On April 7, Boeing announced that analysis of the data showed the test was a success. Boeing provided an updated 787 schedule on August 27, 2009, with the first flight planned to occur by the end of 2009 and deliveries to begin at the end of 2010. On December 12, 2009, the prototype 787 completed high speed taxi tests, the last major step before flight.



Takeoff of the first Boeing 787 built on its maiden flight

Flight test program

On December 15, 2009, Boeing conducted the Dreamliner's maiden flight with the first 787-8, originating from Snohomish County Airport in Everett, Washington at 10:27 am PST, and landing at Boeing Field in King County, Washington at 1:35 pm PST. Originally scheduled for four hours, the test flight was shortened to three hours because of bad weather. Boeing's schedule called for a 9-month flight test campaign (later revised to 8.5 months). The company's previous major aircraft, the 777, took 11 months with nine aircraft, partly to demonstrate 180-min ETOPS, one of its main features.

The 787 flight test program is composed of 6 aircraft, ZA001 through ZA006, four with Rolls-Royce Trent 1000 engines and two with GE GENx-1B64 engines. The second 787, ZA002 in All Nippon Airways livery, flew to Boeing Field on December 22, 2009 to join the flight test program; the third 787, ZA004 joined the test fleet with its first flight on February 24, 2010, followed by ZA003 on March 14, 2010. On March 24, 2010, testing for flutter and ground effects was completed, clearing the aircraft to fly its entire flight envelope.



The first 787 to visit Europe, ZA003 on display at the 2010 Farnborough Airshow

On April 23, 2010 Boeing delivered their latest 787 to a hangar at Eglin Air Force Base, Florida for extreme weather testing in temperatures ranging from 115 °F to -45 °F (46 °C to -42 °C), with all steps necessary to prepare for takeoff taken once the plane stabilizes at either temperature extreme. Dreamliner ZA005, the fifth 787 and the first with General Electric GEnx engines began ground engine tests in May 2010. ZA005 made its first flight on June 16, 2010 and joined the flight test program. In June 2010, gaps were discovered in the horizontal stabilizers of test aircraft, due to improperly installed shims; all aircraft produced then were to be inspected and repaired. The 787 made its first appearance at an international air show at the Farnborough Airshow, UK on July 18, 2010.

In September 2010, it was reported that a further two 787s might join the test fleet, making a total of eight flight test aircraft. On September 10, 2010, a partial engine surge or runaway occurred in a Trent engine on ZA001 at Roswell. On October 4, 2010, the sixth 787, ZA006 joined the test program with its first flight. As of November 8, 2010, the six 787 test aircraft have flown 2,290 hours in 735 flights combined.

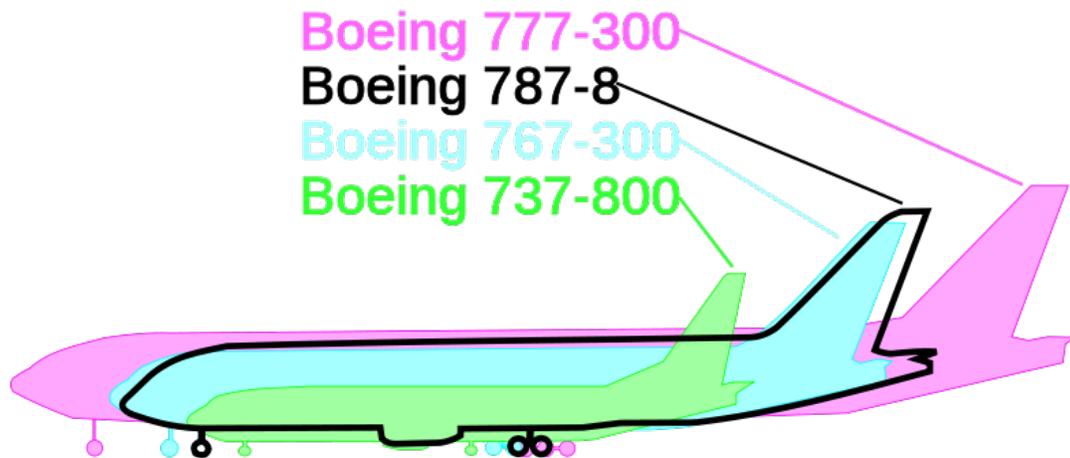
On November 9, 2010, Boeing 787, ZA002 made an emergency landing after smoke and flames were detected in the main cabin during a test flight over Texas. A Boeing spokeswoman said the airliner landed safely and the crew was evacuated after landing at the Laredo International Airport, Texas. The electrical fire caused some systems to fail before landing. Following this incident, Boeing suspended flight testing on November 10, 2010. Ground testing has been performed instead. On November 22, 2010, Boeing announced that the in-flight fire can be primarily attributed to foreign object debris (FOD) that was present in the electrical bay. After electrical system and software

changes, the 787 resumed company flight testing on December 23, 2010. Certifications by the European Aviation Safety Agency are expected by the end of 2011.

Design

The longest-range 787 variant can fly 8,000 to 8,500 nautical miles (14,800 to 15,700 km), enough to cover the Los Angeles to Bangkok or New York City to Taipei routes. It will have a cruising airspeed of Mach 0.85 (561 mph, 903 km/h at typical cruise altitudes). External features include raked wingtips and engine nacelles with noise-reducing serrated edges. The two different engine models compatible with the 787 use a standard electrical interface to allow an aircraft to be fitted with either Rolls-Royce or General Electric engines. This aims to save time and cost when changing engine types; while previous aircraft can have engines changed to those of a different manufacturer, the high cost and time required makes it rare. In 2006, Boeing addressed reports of an extended change period by stating that the 787 engine swap was intended to take 24 hours; engine interchangeability, it is reported, makes the 787 a more flexible asset to airlines, allowing them to change easily from one manufacturer's engine to the other if required.

Airframe



Size comparison of the Boeing 787-8 (**black outline**) with the Boeing 777-300 (**pink**), 767-300 (**cyan**), and 737-800 (**green**).

The 787 features lighter-weight construction. Its materials (by weight) are: 50% composite, 20% aluminum, 15% titanium, 10% steel, 5% other.; the craft will be 80% composite by volume. Each 787 contains approximately 35 short tons of carbon fiber reinforced plastic (CFRP), made with 23 tons of carbon fiber. Aluminum is used on wing and tail leading edges, titanium used mainly on engines and fasteners, with steel used in various places.

Carbon fiber composites have a higher strength-to-weight ratio than traditional aircraft materials, and help make the 787 a lighter aircraft. Composites are used on fuselage, wings, tail, doors, and interior. Boeing had built and tested the first commercial aircraft composite section while examining the Sonic Cruiser concept nearly five years before, the Bell Boeing V-22 Osprey military transport uses over 50% composites, and the C-17 has over 16,000 lb (7,300 kg) of structural composites.

In 2006, Boeing launched the 787 GoldCare program. This is an optional, comprehensive life-cycle management service whereby aircraft in the program are routinely monitored and repaired as needed. This is the first program of its kind from Boeing: Post-sale protection programs are not new, but have usually been offered by third party service centers. Boeing is also designing and testing composite hardware so inspections are mainly visual. This will reduce the need for ultrasonic and other non-visual inspection methods, saving time and money.



Boeing 787 flight deck

Flight systems

On the 787, Honeywell and Rockwell-Collins provide flight control, guidance, and other avionics systems, including standard dual head up guidance systems, while Thales supplies the integrated standby flight display and electrical power conversion system. A

version of Ethernet (Avionics Full-Duplex Switched Ethernet (AFDX) / ARINC 664) will be used to transmit data between the flight deck and aircraft systems. The flight deck features LCD multi-function displays, all of which will use an industry standard GUI widget toolkit (Cockpit Display System Interfaces to User Systems / ARINC 661). The Lockheed Martin Orion spacecraft will use a glass cockpit derived from Honeywell International's 787 flight deck. The 787 flight deck includes two head-up displays (HUDs) as a standard feature. Like other Boeing airliners, the 787 will use a yoke instead of a side-stick. The future integration of forward looking infrared into the HUD system for thermal sensing so the pilots can "see" through the clouds is under consideration.



Angled planform view of the second 787 Dreamliner during flight testing

The most notable contribution to efficiency is the new electrical architecture, which replaces bleed air and hydraulic power sources with electrically powered compressors and pumps, as well as completely eliminating pneumatics and hydraulics from some subsystems (e.g., engine starters or brakes). The 787's engines use all-electrical bleedless systems, eliminating the superheated air conduits normally used for aircraft power, de-icing, and other functions. Another new system is a wing ice protection system that uses electro-thermal heater mats on the wing slats instead of hot bleed air that has been traditionally used.

An active gust alleviation system, similar to the system used on the B-2 bomber, improves ride quality during turbulence. Boeing, as part of its "Quiet Technology Demonstrator 2" project, is experimenting with several engine noise-reducing

technologies for the 787. Among these are a redesigned air inlet containing sound-absorbing materials and redesigned exhaust duct covers whose rims are tipped in a toothed pattern to allow for quieter mixing of exhaust and outside air. Boeing expects these developments to make the 787 significantly quieter both inside and out.

Interior

The 787-8 is designed to seat 234 passengers in a three-class setup, 240 in two-class domestic configuration, and 296 passengers in a high-density economy arrangement. Seat rows can be arranged in four to six abreast in first or business (e.g. 1-2-1, 2-2-2), with eight or nine abreast in economy (e.g., 3-2-3, 2-4-2, 3-3-3). Typical seat room ranges from 46 to 61 in (120 to 150 cm) pitch in first, 36 to 39 in (91 to 99 cm) in business, and 32 to 34 in (81 to 86 cm) in economy.



Mockup of early Dreamliner cabin concept

Cabin interior width is approximately 18 feet (547 cm) at armrest, 1 inch (2.5 cm) over what was originally planned, and 15 in (38 cm) greater than that of the Airbus A330 and A340, while 5 in (13 cm) and 16 in (41 cm) less than the A350 and 777 respectively. For economy class in 3-2-3 or 2-4-2 arrangements, seat-bottom widths will be 18.5 in (47 cm), comparable to that found on the Boeing 777, and recommended by detailed passenger ergonomics studies; for 3-3-3 and the 2-5-2 maximum passenger density layout, seat widths would be 17.18 in (43.55 cm), with most airlines expected to select

the 3–3–3 maximum passenger density configuration. Boeing engineers designed the 787 interior to better accommodate persons with mobility, sensory, and cognitive disabilities. For example, a 56-inch (142 cm) by 57-inch (145 cm) convertible lavatory includes a movable center wall that allows two separate lavatories to become one large, wheelchair-accessible facility.



Interior mockup photo showing windows and LED mood lighting options for the 787 Dreamliner.

The 787's cabin windows are larger in area than all other civil air transports in-service or in development, with dimensions of 10.7 by 18.4 in (27 by 47 cm), and a higher eye level so passengers can maintain a view of the horizon. Electrochromism-based "auto-dimming" (smart glass) instead of window shades reduces cabin glare while maintaining transparency. These are to be supplied by PPG Industries. Standard for the first time on a jetliner, cabin lighting uses light-emitting diode (LED) in three colors instead of fluorescent tubes, allowing the aircraft to be entirely 'bulbless' and have 128 color combinations.

The internal pressure will be increased to the equivalent of 6,000 feet (1,800 m) altitude instead of the 8,000 feet (2,400 m) on conventional aircraft. According to Boeing, in a joint study with Oklahoma State University, this will significantly improve passenger comfort. A higher cabin pressure is possible in part because of better properties of composite materials. Higher humidity in the passenger cabin is possible because of the use of composites, which do not corrode. Cabin air is provided by electrically driven compressors using no engine-bleed air. An advanced cabin air-conditioning system provides better air quality: Ozone is removed from outside air; HEPA filters remove bacteria, viruses, and fungi; and a gaseous filtration system removes odors, irritants, and gaseous contaminants.

Technical concerns

Composites



Disassembled composite fuselage section of the Boeing 787

The risks of using a composite fuselage have been questioned by a former Boeing engineer, noting that carbon fiber, unlike metal, does not visibly show cracks and fatigue; the rival A350 was later announced to be using composite panels on a frame, a more traditional approach, which its contractors regarded as less risky. Further concerns include that, during crash-landings, survivable in metal planes, a composite fuselage could shatter and burn with toxic fumes. The porous properties of composite materials, allowing them to absorb unwanted moisture, have been questioned. As the aircraft reaches altitude, the moisture expands, and may cause delamination of the composite materials, and structural weakness over time. Boeing has dismissed criticisms of its fuselage materials, insisting that composites have been used on wings and other passenger aircraft parts for many years, and they have not been an issue. They have also stated that special defect detection procedures will be put in place to detect any potential hidden damage. Another concern arises from the risk of lightning strikes, with composite having as much as 1,000 times less electrical conductivity than aluminum, increasing the risk of damage. Boeing has stated that the 787's lightning protection will meet FAA requirements, and FAA management was planning to adjust some requirements, which will help the 787 show compliance. In summer 2010, a 787 experienced an in-flight lightning strike without damage.

Weight issues

While Boeing had been working to trim excess weight since assembly of the first airframe began, common for new aircraft in development, the company has stated that the first six 787s will be overweight, with the first aircraft expected to be 5,000 lb (2,270 kg) heavier than specified. The seventh and subsequent aircraft will be the first optimized 787s and are expected to meet all goals, with Boeing working on weight reductions. Boeing has redesigned some parts and made more use of titanium. According to International Lease Finance Corporation's (ILFC) Steven Udvar-Hazy, the 787-9's operating empty weight is around 14,000 lb (6,350 kg) overweight, which also could be a problem for the proposed 787-10. In early 2009, a number of 787 customers started to publicly mention their dissatisfaction with the weight and range issues.



The first Boeing 787 at Paine Field

In May 2009, a press report indicated a 10–15% range reduction, about 6,900 nmi (12,800 km) instead of the originally promised 7,700 to 8,200 nmi (14,800–15,700 km), for early aircraft that were about 8% overweight. Substantial redesign work is expected to correct this, which will complicate increases in production rates; Boeing stated the early 787-8s will have a range of almost 8,000 nmi (14,800 km). There have also been reports that this led Delta to delay deliveries of 787s it inherited from Northwest in order to take later planes that may be closer to the original estimates. Other airlines are suspected to have been given discounts to take the earlier models. Shanghai Airlines stated in March 2009 it wished to either delay or cancel its first order. Boeing expects to have the weight issues addressed by the 21st production model.

Computer networks

In January 2008, previous FAA concerns came to light regarding protection of the 787's computer networks from possible intentional or unintentional passenger access. The computer network in the passenger compartment, designed to give passengers in-flight internet access, is connected to the airplane's control, navigation, and communication systems. Boeing called the report "misleading", saying that various hardware and software solutions are employed to protect the airplane systems, including air gaps for the physical separation of the networks, and firewalls for their software separation. Measures are provided so data cannot be transferred from the passenger internet system to the maintenance or navigation systems. As part of certification, Boeing plans to demonstrate to the FAA that these provisions are acceptable.

Variants



The Boeing 787-8, the first model of the aircraft under production

Boeing has offered three variants of the 787 from the program launch in 2004. The 787-8 is scheduled to enter service in 2011; the 787-9 is to enter service in 2013.

787-8

The 787-8 is the base model of the 787 family, with a length of 186 feet (57 m) and a wingspan of 197 feet (60 m) and a range of 7,650 to 8,200 nautical miles (14,200 to 15,200 km) depending on seating configuration. The 787-8 seats 210 passengers in a three-class configuration. The variant will be the first of the 787 line to enter service in 2011. Boeing is targeting the 787-8 to replace the 767-200ER and 767-300ER, as well as expand into new non-stop markets where larger planes would not be economically viable. The bulk of 787 orders are for the 787-8.

787-9

The 787-9 will be the first variant of the 787 with a "stretched" or lengthened fuselage, seating 250–290 in three classes with a range of 8,000 to 8,500 nautical miles (14,800 to 15,750 km). This variant differs from the 787-8 in several ways, including structural strengthening, a lengthened fuselage, a higher fuel capacity, a higher maximum take-off weight (MTOW), but with the same wingspan as the 787-8. The targeted date for entry into service (EIS), originally planned for 2010, was scheduled for early 2013 in December 2008. Boeing is targeting the 787-9 to compete with both passenger variants of the Airbus A330 and to replace their own 767-400ER. Like the 787-8, it will also open up new non-stop routes, flying more cargo and fewer passengers more efficiently than the 777-200ER or A340-300/500. The firm configuration was finalised on July 1, 2010.



Artist's impression of the stretched 787-9, designed with greater range and payload capability

When first launched, the 787-9 had the same fuel capacity as the other two variants. The design differences meant higher weight and resulted in a slightly shorter range than the 787-8. After further consultation with airlines, design changes were incorporated to add a forward tank to increase its fuel capacity. It will now have a longer range and a higher MTOW than the other two variants. The -9 will be able to fly non-stop from New York to Manila or from Moscow to São Paulo or Bogota to Sydney and will have the lowest seat-mile cost of the three 787 variants.

Air New Zealand is the launch customer for the 787-9 and the second customer ever for the 787 behind ANA. Qantas, Etihad Airways, and Singapore Airlines have placed the largest orders for the 787-9.

Other variants

787-3

This variant was designed to be a 290-seat (two-class) short-range version of the 787 targeted at high-density flights, with a range of 2,500 to 3,050 nautical miles (4,650 to 5,650 km) when fully loaded. It was designed to replace the Airbus A300/A310 and Boeing 757-300/767-200 on regional routes from airports with restricted gate spacing. It would have used the same fuselage as the 787-8, though with some areas of the fuselage strengthened for higher cycles. The wing would have been derived from the 787-8, with blended winglets replacing raked wingtips. The change would have decreased the wingspan by roughly 25 feet (7.6 m), allowing the 787-3 to fit into more domestic gates, in particular, in Japan. This model would have been limited in its range by a reduced maximum take-off weight (MTOW) of 364,000 lb (163,290 kg). (Actual range is based on remaining available weight for fuel after the aircraft empty weight and payload are subtracted from the MTOW.)



An artist's impression of the 787-3, which would have featured a shorter wing with winglets.

A full load of passengers and cargo would limit the amount of fuel it could take on board, as with the 747-400D. This is viable only on shorter, high-density routes, such as Tokyo to Shanghai, Osaka to Seoul, or London to Berlin. Many airports charge landing fees based on aircraft weight; thus, an airliner rated at a lower MTOW, though otherwise identical to its sibling, would pay lower fees.

Boeing has projected that the future of aviation between very large (but close) cities of five million or more may stabilize around the capacity level of the 787-3. Boeing also believed legacy carriers could have used this variant to compete with low-cost airlines by

running twice the capacity of a single-aisle craft for less than twice its operating cost (fuel, landing fees, maintenance, number of flight crew, airspace fees, parking fees, gate fees, etc.).

Forty-three 787-3s were ordered by the two Japanese airlines, but production problems on the base 787-8 model led Boeing to postpone the introduction of the 787-3 in April 2008, following the 787-9 but without a firm delivery date. By December 2009, all 787-3 orders had been converted to the 787-8. At the time, it was likely the 787-3 variant would be shelved entirely following the lack of interest by potential customers caused by its being designed specifically for the Japanese market. On December 13, 2010, Boeing did cancel the 787-3, since it was no longer financially viable after its orders were canceled.

787-10

Boeing has stated that it is likely to develop another version, the longer 787-10, with seating capacity between 290 and 310. This proposed model is intended to compete with the planned Airbus A350-900. The 787-10 would supersede the 777-200ER in Boeing's current catalog and could also compete against the Airbus A330-300 and A340-300. Boeing was having discussions with potential customers about the 787-10 in 2006 and 2007. This variant has not yet been officially launched by Boeing, but Mike Bair, at that time head of the 787 program, stated that "It's not a matter of if, but when we are going to do it ... The 787-10 will be a stretched version of the 787-9 and sacrifice some range to add extra seat and cargo capacity." The 787-10 has remained under consideration by Boeing.

Further proposals

Although no date has been set, Boeing expects to build a freighter version, possibly in 10 to 15 years. Boeing is reported to be also considering a 787 variant as a candidate to replace the 747-based VC-25 as Air Force One.