Encyclopedia of Civil and Business Aircrafts

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Chapter 1

Agricultural Aircraft and Cargo Aircraft

Agricultural aircraft

The Antonov An-2 was the first purpose-built agricultural aircraft to be mass-produced.

Polish M-18 Dromader waterbomber used in Western Australia

A Grumman Ag Cat applies a low-insecticide bait on a soybean field

An **agricultural aircraft** is an aircraft that has been built or converted for agricultural use - usually aerial application of pesticides (crop dusting) or fertilizer (aerial topdressing); in these roles they are referred to as "crop dusters" or "top dressers". Agricultural aircraft are also used for hydroseeding.

The most common agricultural aircraft are fixed-wing, such as the Air Tractor, Cessna Ag-wagon, Gippsland GA200, Grumman Ag Cat, M-18 Dromader, PAC Fletcher, Piper PA-36 Pawnee Brave and Rockwell Thrush Commander but helicopters are also used.

Early use of aircraft in agriculture

Crop dusting with insecticides began in the 1920s in the United States. The first widely used agricultural aircraft were converted war-surplus biplanes, such as the De Havilland Tiger Moth and Stearman. After more effective insecticides and fungicides were developed in the 1940s, and aerial topdressing was developed by government research in New Zealand, purpose-built agricultural fixed-wing aircraft became common.

Agricultural aircraft designs

In the US and Europe they are typically small, simple, and rugged. Many have spraying systems built into their wings, and pumps are usually driven by wind turbines. In places where farms are larger, such as New Zealand, Australia, the former Warsaw pact nations and parts of the developing world, larger and more powerful aircraft have been used, including turboprop powered aircraft such as the PAC Cresco, twin engined types, such as the Lockheed Lodestar and varying from the versatile and utilitarian Antonov An-2 biplane to the bizarre turbofan powered biplane, the WSK-Mielec M-15 Belphegor- all however tend to be of simple rugged STOL design. In places where dedicated use as an agricultural aircraft is uneconomic, utility types such as the De Havilland Canada DHC-2 Beaver have been used.

In the case of helicopters, tanks are placed on or outside the body of the aircraft, while a spray rig, extending outward to the sides, is attached well below the main rotor blades. Hydroseeding is often done by helicopters using tanks and drop systems much like those used for aerial firefighting.

Techniques

To reduce drift of the sprayed materials, agricultural pilots attempt to fly as low as possible, usually just above the crops being treated (4.5 meters/15 feet). Fields are often surrounded by obstacles such as trees, telephone lines, and farm buildings, so pilots have to switch quickly from the task of dropping chemicals accurately and smoothly to the task of dodging obstacles. It is not unusual for pilots to fly *under* telephone and power lines at the end of their runs. Nonetheless, accidents are inevitable when airplanes routinely fly so near the ground. Purpose-built agricultural airplanes are designed to protect the pilot and cargo if they strike the ground.

Conflicting views on aerial spraying

Australian Commonwealth CA-28 Ceres crop spraying aircraft of the 1950s

Aerial spraying has been controversial since the 1960s, due to environmental concerns about pesticide drift (raised for example by Rachel Carson's book *Silent Spring*). It is now often subject to restrictions, for example spraying pesticide is generally banned in Sweden, although exceptions can be made such as for an area plagued by mosquitoes during summer. Even the spread of fertilizer has raised concerns, for example in New Zealand fertilizer entering streams has been found to disproportionately promoted growth of species more able to exploit the increased nutrients, so leading to restrictions on topdressing near waterways. Even putting out forest fires has been criticized in the U.S.A. as preventing natural consumption of flammable material, and increasing long term risk.

Cargo aircraft

Antonov An-225: the largest cargo aircraft

Lockheed C-5 Galaxy

A large military transport aircraft: the Boeing C-17A Globemaster III

A Bristol Freighter from the 1960s, with front opening clamshell doors and flight deck bulge

The Boeing 747 Large Cargo Freighter 'Dreamlifter'

A **cargo aircraft** (also known as **freight aircraft** or **freighter**) is a fixed-wing aircraft designed or converted for the carriage of goods, rather than passengers. They are usually devoid of passenger amenities, and generally feature one or more large doors for the loading and unloading of cargo. Freighters may be operated by civil passenger or cargo airlines, by private individuals or by the armed forces of individual countries. However most air freight is carried in special ULD containers in the cargo holds of passenger aircraft.

Aircraft designed for cargo flight use have a number of features that distinguish them from conventional passenger aircraft: a "fat" looking fuselage, a high-wing to allow the cargo area to sit near the ground, a large number of wheels to allow it to land at unprepared locations, and a high-mounted tail to allow cargo to be driven directly into and off the aircraft.

History

Aircraft were put to use carrying cargo in the form of air mail as early as 1911. Although the earliest aircraft were not designed primarily as cargo carriers, by the mid 1920s aircraft manufacturers were designing and building dedicated cargo aircraft.

The earliest "true" cargo aircraft is arguably the World War II German design, the Arado Ar 232. The Ar 232 was intended to supplant the earlier Junkers Ju 52 freighter conversions, but only small numbers were built. Most other forces used freighter versions of airliners in the cargo role as well, most notably the C-47 Skytrain version of the Douglas DC-3, which served with practically every allied nation. Post war Europe also served to play a major role in the development of the modern air cargo and air freight industry during what became known as the "Cold War." It is during the Berlin Airlift at the height of this "Cold War," when a massive mobilization of aircraft was undertaken by the "free world," to supply West Berlin residents with food and supplies, in a virtual around the clock air bridge; after the Soviet Union closed and blockaded Berlin's borders, and land links to the west.

In the years following the war era a number of new custom-built cargo aircraft were introduced, often including some "experimental" features. For instance, the US's C-82 Packet featured a removable cargo area, while the C-123 Provider introduced the now-common upswept tail with a drop-down loading and unloading ramp. But it was the introduction of the turboprop that allowed the class to mature, and even one of its earliest examples, the C-130 Hercules, is still the yardstick against which newer military transport aircraft designs are measured.

Today

Most conversions are carried out on older aircraft no longer suitable for passenger use, often due to changing safety or noise requirements, or when the aircraft type is considered to have become uncompetitive in passenger airline service, but there is also a market for new-build freighter designs. Freighter aircraft normally have strengthened cabin floors and the inclusion of a broad top-hinged door on the port fuselage in addition to an absence of passenger cabin windows which are "plugged."

The Boeing 747 can be ordered in a freighter version with a large nose door which could be raised above the cockpit for loading. The bulged top deck housing the cockpit was originally designed to allow an unobstructed main deck, and to keep cargo from crushing the pilots in the case of an accident. The interior size of the fuselage is matched to the size of a standard shipping container, stacked two high and two wide.

Other types of specialized civilian cargo aircraft configurations, include the swing-tail Canadair CL-44 and Boeing 747 Large Cargo Freighter, and the clamshell tail CASA CN-235.

Examples

Early Air mail and airlift logistics aircraft

The Type 158 York

Important "airlift and logistics;" "cargo-liners," "mail-liners," and "mail aircraft."

- Avro Lancastrian (Transatlantic mail)
- Avro York (Berlin Airlift)
- Boeing C-7000
- Curtiss JN-4
- Douglas M-2

Civilian cargo/freight aircraft

Air India Airbus A310-304

Cargolux Boeing 747-400F

Aeroflot Il-76TD

- Aero Spacelines Super Guppy
- Airbus A300
- Airbus A310
- Airbus A320 (Conversions)
- Airbus A330
- Airbus A380F
- Airbus Beluga
- Antonov An-124
- Antonov An-225 (the largest and heaviest aircraft in the world)
- Boeing 727
- Boeing 737 (Conversions)
- Boeing 757
- Boeing 767
- Boeing 747 Freighter
- Boeing 747 Large Cargo Freighter (Dreamlifter)
- Boeing 777 Freighter
- Douglas DC-3
- Douglas DC-9
- Ilyushin Il-76
- Ilyushin Il-96
- McDonnell Douglas DC-10
- McDonnell Douglas MD-11
- Tupolev Tu-204

Light aircraft

- Cessna Caravan - freight door and belly pod equipped
- Shorts 330 - drop ramp and twin tailed vertical stabilizer
- LET 410

Military cargo aircraft

A turboprop twin-engined transport aircraft: the Antonov An-32

Experimental cargo aircraft

- Hughes H-4 Hercules ("Spruce Goose")
- Lockheed R6V Constitution
- LTV XC-142

Comparisons

Aircraft	Cargo Volume	Cargo Mass	Cruise Speed	Maximum Range	Aircraft Category
Airbus A400M	-	37,000 kg (82,000 lb)	780 km/h (420 kn; 480 mph)	6,390 km (3,450 nm)	Military
Airbus 330-200F	475 m3	-	871 km/h (537 mph)	7,400 km (4,000 nm, 4,600 mi)	Commercial
Airbus Beluga	1210 m3	47,000 kg	-	4,632 km (2500 nm)	Commercial
Antonov 124	-	150,000 kg	800 km/h	5,400 km (2,900	Military &

		(330,000 lb)	(430 kn, 490 mph)	nm, 3,360 mi)	Commercial
Antonov 225	1,300 m3 (46,000 cu ft))	250,000 kg (550,000 lb)	800 km/h (430 kn, 500 mph)	15,400 km (9,570 mi)	Commercial
Boeing 747-8F	854.5 m3 (30,177 cu ft)	134,200 kg (295,800 lb)	908 km/h (490 kn, 564 mph)	-	Commercial
Lockheed C-5 (Galaxy)	-	122,470 kg (270,000 lb)	919 km/h	4,440 km (2,400 nmi; 2,760 mi)	Military
Lockheed C-130H (Hercules)	-	33,000 kg (72,000 lb)	540 km/h (292 kn, 336 mph)	3,800 km (2,050 nm, 2,360 mi)	Military

Chapter 2

Airliner

Boeing 747-400, one of the most recognizable airliners in history

The Airbus A320 narrow-body is a popular short-medium distance aircraft.

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 slabsided 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 trialled 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 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 Stratocrusiers 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 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 767 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 a 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 3

Business Jet

Gulfstream IV business jet

Bombardier Global 5000 business jet takes off

Business jet, **private jet** or, colloquially, **bizjet** is a term describing a jet aircraft, usually of smaller size, designed for transporting groups of up to 19 business people or wealthy individuals. Business jets may be adapted for other roles, such as the evacuation of casualties or express parcel deliveries, and a few may be used by public bodies, governments or the armed forces. The more formal terms of *corporate jet*, *executive jet*, *VIP transport* or *business jet* tend to be used by the firms that build, sell, buy and charter these aircraft.

Background

Almost all production business jets, such as General Dynamics' Gulfstream and the Gates Lear Jet (now built by Bombardier), have had two or three engines, though the Jetstar, an early business jet, had four. Advances in engine reliability and power have rendered four-engine designs obsolete, and only Dassault Aviation still builds three-engine models (in the Falcon line). The emerging market for so-called "very light jets" and "personal jets", has seen the introduction (at least on paper) of several single-engine designs as well.

Almost all business jets have rear-mounted engines, because the wing (mounted low for performance reasons) is too near the ground for engines to be slung underneath it.

Airliners are sometimes converted into luxury business jets. Such converted aircraft are often used by celebrities with a large entourage or press corps, or by sports teams, but

airliners often face operational restrictions based on runway length or local noise restrictions.

Private Boeing 737-800 lands at London Luton Airport, England

Cessna 525 CitationJet

A focus of development is at the low end of the market with small models, many far cheaper than existing business jets. Many of these fall into the very light jet (VLJ) category and are used by the air taxi industry. Cessna has developed the Mustang, a six-place twinjet (2 crew + 4 passengers) available for $2.55 million USD. A number of smaller manufacturers have planned even cheaper jets; the first was the Eclipse 500 from the now defunct Eclipse Aviation which was available at around 1.5 million USD. It remains to be seen whether the new jet manufacturers will complete their designs, or find the market required to sell their jets at the low prices planned.

There are approximately 11,000 business jets in the worldwide fleet with the vast majority of them based in the United States or owned by US companies. The European market is the next largest, with growing activity in the Middle East, Asia, and Central America.

Since 1996 the term "fractional jet" has been used in connection with business aircraft owned by a consortium of companies. Costly overheads such as flight crew, hangarage and maintenance can be shared through such arrangements.

Because of their low-volume productions and long lead times, new aircraft orders can take two to three years for delivery. This peculiarity fuels a large pre-owned marketplace, with aircraft for immediate availability.

Classes

The business jet industry groups the jets into five loosely-defined classes:

Heavy jets

The most expensive type of private jet is the heavy jet type, which is designed for the ultimate in large capacity luxury air travel. These aircraft, sometimes referred to as *Bizliners* (contraction of *Business Airliners*), are based on or converted from airliner types. Aircraft of this class include:

- Airbus
  - Airbus A318 Elite
  - Airbus A319CJ
  - Airbus A380 Flying Palace
- Boeing
  - Boeing Business Jet
- Embraer
  - Lineage 1000

Large Cabin jets

- Bombardier Aerospace
  - Bombardier Global 5000
  - Bombardier Global 7000
  - Bombardier Global 8000
  - Bombardier Global Express
  - Bombardier Challenger 850

- Dassault
  - Dassault Falcon 7X

- Gulfstream Aerospace
  - Gulfstream G500
  - Gulfstream G550
  - Gulfstream G650

Super mid-size jets

The elite class of the business and private jet aircraft are the super mid-size jets that feature wide body cabin space, high altitude, speed, and ultra long range capabilities. These ultra luxurious private jets combine the long range transatlantic capability with the speed and comfort of a wide body, high altitude aircraft. Aircraft of this class include:

- Bombardier Aerospace
  - Bombardier Challenger 300
  - Challenger 605

- Cessna
  - Citation X

- Dassault
  - Dassault Falcon 900DX
  - Dassault Falcon 900EX
  - Dassault Falcon 2000DX
  - Dassault Falcon 2000EX

- Embraer
  - Legacy 600

- Gulfstream
  - Gulfstream G350
  - Gulfstream G450

- Hawker Beechcraft
  - Hawker 4000

Mid-size jets

These aircraft are suitable for longer range travel such as transcontinental flights and for travel with larger passenger capacity requirements. Aircraft of this class include:

- Bombardier Aerospace
  - Learjet 60 XR
  - Learjet 85
- Cessna
  - Citation Columbus
  - Citation XLS
  - Citation Sovereign
- Dassault
  - Dassault Falcon 50EX
- Embraer
  - Embraer Legacy 450
  - Embraer Legacy 500
- Gulfstream
  - Gulfstream 150
  - Gulfstream 250
- Hawker Beechcraft
  - Hawker 750
  - Hawker 850 XP
  - Hawker 900XP

Light jets

The light jets have been a staple of the business jet industry since the advent of the Learjet 23 in the early 1960s. The light jets provide access to small airports and the speed to be an effective air travel tool. Aircraft of this class include:

- Bombardier Aerospace
  - Learjet 40
  - Learjet 40 XR
  - Learjet 45
  - Learjet 45 XR
- Cessna
  - Citation CJ1
  - Citation CJ2
  - Citation CJ3

    - Citation CJ4
    - Citation Bravo
    - Citation Encore

- Embraer
    - Phenom 300

- Grob
    - Grob SPn

- Hawker Beechcraft
    - Beechcraft Premier I
    - Hawker 400

- Sino Swearingen
    - SJ30-2

Very light jets

Very light jets, also known as Microjets or VLJs, are designed to provide air travel, for example, to the more than 5,000 small community airports in the United States. VLJs have a maximum take off weight of not more than 10,000 lb. Aircraft of this class include:

- Adam Aircraft Industries
    - Adam A700

- Cessna
    - Citation Mustang

- Cirrus Design
    - Cirrus Vision SF50

- Comp Air
    - Comp Air Jet

- Diamond Aircraft Industries
    - D-Jet

- Eclipse Aviation
    - Eclipse 500
    - Eclipse 400

- Embraer
    - Phenom 100

- Epic Aircraft
  - Epic Elite
  - Epic Victory

- Honda
  - HondaJet

- Piper
  - PiperJet

- Spectrum Aeronautical
  - Spectrum S-33 Independence

Operators

There are three basic types of operators who own, manage and operate private jets.

Flight Departments

Flight departments are traditionally corporate owned operators who manage the aircraft of a specific company. i.e. Ford Motor Company, Chrysler, Altria are all example of companies that own, maintain and operate their own fleet of private aircraft for the exclusive use of their executives. Flight Departments handle all aspects of aircraft operation and maintenance. These aircraft are managed under the FAA rules (FAR's) Part 91.

Charter Companies

Charter operators are traditionally operators who own or simply manage private jets for multiple clients. Like traditional flight departments, charter companies handle all aspects of aircraft operation and maintenance. However, they are not aligned with just one corporation. They manage aircraft for a private owner or corporation and also handle the sales of available flight time on the aircraft they own or manage. These aircraft are usually operated under Part 135 of the FAA regulations.

Fractional Ownership

This is commonly known in the industry as "time share". An individual or corporation pays an up front equity share for the cost of an aircraft, Say 1/4 of the aircraft price, known in the industry as a "quarter share". The individual or corporation is now an equity owner in that aircraft and can sell their equity position if necessary. This entitles the new owner to 100 hours of flight time on that aircraft, or any comparable aircraft in the fleet. Additional fees include monthly management fees and incidentals like catering and ground transportation. These aircraft may operate under part 91 or part 135 of the FAA regulations, depending on the passengers using the aircraft.

Chapter 4

Homebuilt Aircraft

A Rutan Long-EZ homebuilt in 1984 in England

Also known as *amateur-built aircraft* or *kit planes*, **homebuilt aircraft** are constructed by persons for whom this is not a professional activity. These aircraft may be constructed from "scratch," from plans, or from assembly kits.

Overview

In the United States, Australia and New Zealand, homebuilt aircraft may be licensed Experimental under FAA or similar local regulations. Provided that the owner has done at least 51% of the construction work themselves they can also apply for a repairman's

certificate for that airframe. The repairman's certificate allows the holder to perform and sign off on most of the maintenance, repairs, and inspections themselves.

Alberto Santos-Dumont was the first to offer for free construction plans, publishing drawings of its Demoiselle in the June 1910 edition of Popular Mechanics. The first aircraft to be offered for sale as plans, rather than a completed airframe, was the Baby Ace in the late 1920s.

Canada's first homebuilt aircraft, Stitts SA-3A Playboy CF-RAD, first flown in 1955, seen in the Canada Aviation and Space Museum.

Homebuilt aircraft gained in popularity in the US in 1924 with the start of the National Air Races, held in Dayton, Ohio. These races required aircraft with useful loads of 150 lb (68 kg) and engines of 80 cubic inches or less and as a consequence of the class limitations most were amateur-built. The years after Lindberg's transatlantic flight brought a peak of interest between 1929-33. During this period many aircraft designers, builders and pilots were self taught and the high accident rate brought public condemnation and increasing regulation to amateur-building. The resulting federal standards on design, engineering, stress analysis, use of aircraft-quality hardware and testing of aircraft brought an end to amateur building except in some specialized areas, such as racing. In 1946 Goodyear restarted the National Air Races, including a class for aircraft powered by 200 cubic inch and smaller engines. The midget racer class spread

nationally in the US and this led to calls for acceptable standards to allow recreational use of amateur-built aircraft. By the mid-1950s both the US and Canada once again allowed amateur-built aircraft to specified standards and limitations.

Homebuilt aircraft are generally small, one to four-seat sportsplanes which employ simple methods of construction. Fabric-covered wood or metal frames and plywood are common in the aircraft structure, but increasingly, fiberglass and other composites as well as full aluminum construction techniques are being used. Engines are most often the same as, or similar to, the engines used in certified aircraft (such as Lycoming, Continental, Rotax, and Jabiru). A minority of homebuilts use converted automobile engines, with Volkswagen air-cooled flat-4s, Subaru-based liquid-cooled engines, Mazda Wankel and Chevrolet Corvair six-cylinder engines being common. The use of automotive engines helps to reduce costs, but many builders prefer dedicated aircraft engines, which are perceived to have better performance and reliability. Other engines that have been used include chainsaw and motorcycle engines.

A combination of cost and litigation, especially in the mid-1980s era, which has discouraged general aviation manufacturers from introducing new designs, has led to homebuilts outselling factory types by five to one. In 2003, the number of homebuilts produced in the USA exceeded the number produced by any single certified manufacturer.

History

The history of amateur-built aircraft can be traced to the beginning of aviation. Even if the Wright brothers, Clément Ader, and their successors had commercial objectives in mind, the first aircraft were constructed by passionate enthusiasts whose goal was to fly.

Early years

Aviation took a leap forward with the industrialization that accompanied World War I. In the post-war period, manufacturers needed to find new markets and introduced models designed for tourism. However, these machines were affordable only by the very rich.

Many U.S. aircraft designed and registered in the 1920s onward were considered "experimental" by the (then) CAA, the same registration under which modern homebuilts are issued Special Airworthiness Certificates. Many of these were prototypes, but designs such as Bernard Pietenpol's first 1923 design were some of the first homebuilt aircraft. In 1928, Henri Mignet published plans for his HM-8, as did Pietenpol for his Air Camper. Pietenpol later constructed a factory, and in 1933 began creating and selling partially-constructed aircraft kits.

In 1936, an association of amateur aviation enthusiasts was created in France. Many types of amateur aircraft began to make an appearance, and in 1938 legislation was amended to provide for a *Certificat de navigabilité restreint d'aéronef* (*CNRA*, "restricted operating certificate for aircraft"). 1946 saw the birth of the Ultralight Aircraft

Association which in 1952 became the Popular Flying Association in the United Kingdom, followed in 1953 by the Experimental Aircraft Association in the United States and the Sport Aircraft Association in Australia.

Technology and innovation

The Questair Venture set new standards for speed in kit-built aircraft design

Until the late 1950s, builders had mainly kept to wood-and-cloth and steel tube-and-cloth design. Without the regulatory restrictions faced by production aircraft manufacturers, homebuilders introduced innovative designs and construction techniques. Burt Rutan introduced the canard design to the homebuilding world and pioneered the use of composite construction. Metal construction in kitplanes was taken to a new level by Richard VanGrunsven in his RV series. As the sophistication of the kits improved, components such as autopilots and more advanced navigation instruments became common.

Litigation during the 1970s and 1980s caused stagnation in the small aircraft market, forcing the surviving companies to retain older, proven designs. In recent years, the less restrictive regulations for homebuilts allowed a number of manufacturers to develop new and innovative designs; many can outperform certified production aircraft in their class.

An example of high-end homebuilt design is Lancair, which has developed a number of high-performance kits. The most powerful is the Lancair Propjet, a four-place kit with cabin pressurization and a turboprop engine, cruising at 24,000 feet (7,300 m) and 370 knots (425 mph, 685 km/h). Although aircraft such as this are considered "home-built" for legal reasons, they are typically built in the factory with the assistance of the buyer. This allows the company which sells the kit to avoid the long and expensive process of certification, because they remain owner-built according to the regulations. One of the terms applied to this concept is commonly referred to as "The 51% Rule", which requires that builders perform the majority of the fabrication and assembly to be issued a Certificate of Airworthiness as an Amateur Built aircraft.

A small number of jet kitplanes have been built since the 1970s, including the tiny Bede Aircraft BD-5J.

Building materials

Homebuilt aircraft can be constructed out of any material that is light and strong enough for flight. Several common construction methods are detailed below.

Wood and fabric

A typical wood and fabric construction amateur-built, the Bowers Fly Baby

A Pietenpol Air Camper under construction, showing the wooden frame structure that will be covered with aircraft fabric.

This is the oldest construction, seen in the first aircraft and hence the best known. For that reason, amateur-built aircraft associations will have more specialists for this type of craft than other kinds.

The most commonly-used woods are Sitka spruce and Douglas fir, which offer excellent strength-to-weight ratios. Wooden structural members are joined with adhesive, usually epoxy. Unlike the wood construction techniques used in other applications, virtually all wooden joints in aircraft are simple butt joints, with plywood gussets. Joints are designed to be stronger than the members. After the structure has been completed, the aircraft is covered in aircraft fabric (usually aircraft-grade polyester). The advantage of this type of construction is that it does not require complex tools and equipment, but commonplace items such as saw, planer, file, sandpaper, and clamps.

Examples of amateur-built wood and fabric designs include:

- The classic Pietenpol Air Camper, a homebuilt that has been built since the 1920s.
- The Bowers Fly Baby, a low-wing monoplane which has been popular since the 1960s.
- Fisher Flying Products (built with geodetic cross-bracing).
- The Ison miniMAX
- the Jodel models, including the *bébé* D-9, D-112, and the more recent D-18, D-19, and D-20

- the Piel CP-30 *Émeraude*
- the VP-1 and VP-2, designed by Bud Evans in the late 1960s and commonly called Volksplanes

Wood/composite mixture

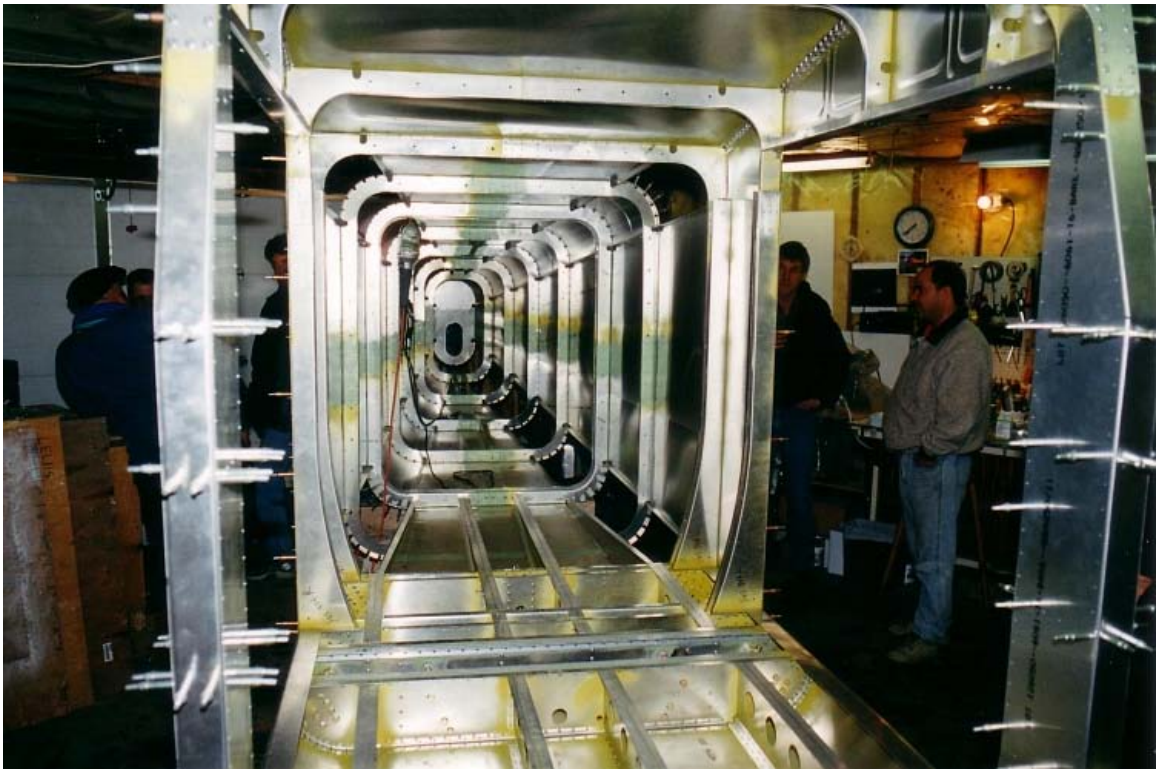
A recent trend is toward wood-composite aircraft. The basic load carrying material is still wood, but it is combined with foam (for instance to increase buckling resistance of load carrying plywood skins) and other synthetic materials like glass- and carbon fibre (to locally increase the modulus of load carrying structures like spar caps, etc.).

Examples of wood-composite designs include:

- Ibis experimental aircraft project, designed by Roger Junqua
- KR series of homebuilts designed by Ken Rand
- PIK-26 designed by Kai Mellen

Metal

Van's Aircraft like this RV-4 are the most common metal homebuilt type



Inside of the tail cone of a Murphy Moose under construction, showing the all-metal semi-monocoque design

Planes built from metal use similar techniques to more conventional factory-built aircraft. They can be more challenging to build, requiring metal-cutting, metal-shaping, and riveting if building from plans. "Quick-build" kits are available which have the cutting, shaping and hole-drilling mostly done, requiring only finishing and assembly. Such kits are also available for the other types of aircraft construction, especially composite.

There are three main types of metal construction: sheet aluminum, tube aluminum, and welded steel tube. The tube structures are covered in aircraft fabric, much like wooden aircraft.

Examples of metal-based amateur aircraft include:

- The Murphy Aircraft SR3500 Moose, Rebel and Super Rebel, Maverick, Elite, JDM-8, and Yukon. Murphy Aircraft is a Canadian manufacturer that offers kits for self construction.
- The Vans RV-4, RV-8, RV-10 and other models produced by Van's Aircraft, are the most popular metal homebuilt aircraft.
- Chris Heintz's Zenith CH601 Zodiac and Zenith STOL CH701
- Sonex Aircraft's Sonex, Waiex, and Xenos kit planes

Composite

A fiberglass/foam Quickie Q2

A composite construction Cirrus VK-30

Composite material structures are made of cloth with a high tensile strength (usually fiberglass or carbon fiber, or occasionally Kevlar) combined with a structural plastic (usually epoxy, although vinylester is used in some aircraft). The fabric is saturated with the structural plastic in a liquid form; when the plastic cures and hardens, the part will hold its shape while possessing the strength characteristics of the fabric.

The two primary types of composite planes are molded composite, where major structures like wing skins and fuselage halves are prepared and cured in molds, and moldless, where shapes are carved out of foam and then covered with fiberglass or carbon fiber.

The advantages of this type of construction include smooth surfaces (without the drag of rivets), the ability to do compound curves, and the ability to place fiberglass or carbon fiber in optimal positions, orientations, and quantities. Drawbacks include the need to work with chemical products as well as low strength in directions perpendicular to fiber. Composites provide superb strength to weight. Material stiffness dependent upon direction (as opposed to equal in all directions, as with metals) allows for advanced "elastic tailoring" of composite parts.

Examples of amateur craft made of composite materials include:

- Canard designs such as the VariEze and Long EZ designed by Burt Rutan.
- The Jabiru range.
- All Lancair designs
- The pusher propeller Cirrus VK-30.
- The Europa Aircraft range.

Safety

The safety record of homebuilts is not as good as certified general aviation aircraft. In the United States, in 2003, amateur-built aircraft experienced a rate of 21.6 accidents per 100,000 flight hours; the overall general aviation accident rate for that year was 6.75 per 100,000 flight hours.

The accident rate for homebuilt aircraft in the USA has long been a concern to the Federal Aviation Administration. At Sun 'n Fun 2010 FAA Administrator Randy Babbitt said that homebuilts "account for 10 percent of the GA fleet, but 27 percent of accidents. It's not the builders [getting into accidents], but the second owners. We need better transition training."

Chapter 5

3I Sky Arrow

A Sky Arrow 650 TCN (*VH-IOI*)

Role	Recreational aircraft
Manufacturer	3I, also for homebuilding
First flight	13 July 1992

The **Sky Arrow** is a tandem seat, pusher configuration, high wing and carbon fibre light aircraft manufactured by 3I (Iniziative Industriali Italiane). With only 16½ inches of hip room, the aircraft is considered open due to a large amount of unobstructed view from the large canopy, rear engine, and seating positions ahead of the wing.

Variants

The rear of the Sky Arrow 650 TCN (VH-IOI), sporting its rear propeller

The seating of the Sky Arrow 650 TCN (VH-IOI)

General aviation - out of production

- Sky Arrow 650 TC
- Sky Arrow 650 TCN
- Sky Arrow 650 TCNS

General aviation - in production

- Sky Arrow 650TCS:

(100 hp engine), VFR and Sky Arrow 650 TCNS for VFR Night - Maximum Take-Off Weight (MTOW) of 650 kg (1,433 lb)

- Sky Arrow 710RG:

  100 hp engine, C for VFR and CN for VFR Night with an increased MTOW of 710 kg (1,565 lb) and retractable landing gear

- Sky Arrow 710 PLUS:

  100 hp engine, C and CN with an increased MTOW of 710 kg (1,565 lb) and the fixed landing gear

- Sky Arrow 650 ERA:

  fitted with RAWAS instrumentation by the Atmospheric Turbulence Diffusion Division of the National Oceanic Atmospheric Administration and Iniziative Industriali Italiane, for use in territory control environmental monitoring and for scientific research purposes.

Light aircraft

- Sky Arrow 450TS (100 hp)
- Sky Arrow 480TS (100 hp)
- Sky Arrow 500TF (80 hp)

Light sport - in production

- Sky Arrow Sport (100 hp)

  Meets ATSM requirements for the FAA Light-Sport category of aircraft.

Self assembly kit

- Sky Arrow 1450L (100 hp/115 hp)

  Hombuilt package consists of 10 subkits. Meets the FAA 51 percent builder rule.

Specifications (650)

General characteristics

- **Crew:** 2
- **Length:** 7.60 m (24 ft 11 in)
- **Wingspan:** 9.68 m (31 ft 9 in)
- **Height:** 2.56 m (8 ft 5 in)
- **Wing area:** 13.5 m^2 (145 sq ft)
- **Gross weight:** 650 kg (1,433 lb)

- **Useful load:** 250kg (556 lbs)
- **Powerplant:** 1 × Rotax 912 F2 , 73.5 kW (98.6 hp)

Performance

- **Maximum speed:** 194 km/h (121 mph; 105 kn)
- **Cruising speed:** 187 km/h (116 mph; 101 kn)
- **Service ceiling:** 4,100 m (13,451 ft)
- **Rate of climb:** 4.3 m/s (850 ft/min)

Chapter 6

Glider (Sailplane)

Single-seat high performance fiberglass Glaser-Dirks DG-808 over the Lac de Serre Ponçon in the French Alps

A **glider** or **sailplane** is a type of glider aircraft used in the sport of gliding. Some gliders, known as motor gliders are used for gliding and soaring as well, but have engines which can, in some cases, be used for take-off or for extending a flight. Foot-launched aircraft (such as hang gliders and paragliders) are described in separate articles, though their differences from sailplanes are covered below. Gliders have also been used for purposes other than recreation, for example for military purposes and for research.

Sports gliders benefit from creating the least drag for any given amount of lift, and this is best achieved with long, thin wings and a fully faired narrow cockpit. Aircraft with these features are able to climb efficiently in rising air and can glide long distances at high speed with a minimum loss of height in between.

Use of engines

Although most gliders do not have engines, there are a few that do. The manufacturers of high-performance gliders will list an optional engine with a retractable propeller that can be used to sustain flight, if required; these are known as 'self-sustaining' gliders. Some have enough thrust to launch themselves before the engine is retracted and are known as 'self-launching' gliders. There are also 'touring motor gliders' which can self launch and switch off the engine in flight without retracting their propellers.

History

HAWA Vampyr 1921

Sir George Cayley's gliders achieved brief wing-borne hops from around 1849. Otto Lilienthal built (barely) controllable gliders in the 1890s using weight shift with which he could ridge soar. Wright Brothers achieved full control in the early 1900s using movable surfaces, to which they successfully added an engine.

After World War I gliders were built for sporting purposes in Germany and in the United States (Schweizer brothers). Germany's strong links (continuing today) to gliding were to a large degree due to Post-WWI regulations forbidding the construction and flight of motorised planes in Germany, so the country's aircraft enthusiasts often turned to gliders and were actively encouraged by the German government.

The sporting use of gliders rapidly evolved in the 1930s and is now the main application. As their performance improved, gliders began to be used for cross-country flying and

now regularly fly hundreds or even thousands of kilometers in a day if the weather is suitable.

Glider design

Early gliders had no cockpit and the pilot sat on a small seat located just ahead of the wing. These were known as "primary gliders" and they were usually launched from the tops of hills, though they are also capable of short hops across the ground while being towed behind a vehicle. To enable gliders to soar more effectively than primary gliders, the designs minimized drag. Gliders now have very smooth, narrow fuselages and very long, narrow wings with a high aspect ratio and winglets.

Cockpit of a typical modern glider (Glaser-Dirks DG-101G ELAN)

A glider releasing its water ballast

The early gliders were made mainly of wood with metal fastenings, stays and control cables. Later fuselages made of fabric-covered steel tube were married to wood and fabric wings for lightness and strength. New materials such as carbon-fiber, fiber glass and Kevlar have since been used with computer-aided design to increase performance. The first glider to use glass-fiber extensively was the Akaflieg Stuttgart FS-24 Phönix which first flew in 1957. This material is still used because of its high strength to weight ratio and its ability to give a smooth exterior finish to reduce drag. Drag has also been minimized by more aerodynamic shapes and retractable undercarriages. Flaps are fitted to the trailing edges of the wings on some gliders to minimise the drag from the tailplane at all speeds.

With each generation of materials and with the improvements in aerodynamics, the performance of gliders has increased. One measure of performance is the glide ratio. A ratio of 30:1 means that in smooth air a glider can travel forward 30 meters while losing only 1 meter of altitude. Comparing some typical gliders that might be found in the fleet of a gliding club - the Grunau Baby from the 1930s had a glide ratio of just 17:1, the glass-fiber Libelle of the 1960s increased that to 39:1, and modern flapped 18 meter gliders such as the ASG29 have a glide ratio of over 50:1. The largest open-class glider, the eta, has a span of 30.9 meters and has a glide ratio over 70:1. Compare this to the infamous Gimli Glider, a Boeing 767 which ran out of fuel mid-flight and was found to have a glide ratio of only 12:1, or to the Space Shuttle with a glide ratio of 4.5:1.

Due to the critical role that aerodynamic efficiency plays in the performance of a glider, gliders often have aerodynamic features seldom found in other aircraft. The wings of a modern racing glider have a specially designed low-drag laminar flow airfoil. After the wings' surfaces have been shaped by a mold to great accuracy, they are then highly polished. Vertical winglets at the ends of the wings are computer-designed to decrease drag and improve handling performance. Special aerodynamic seals are used at the ailerons, rudder and elevator to prevent the flow of air through control surface gaps. Turbulator devices in the form of a zig-zag tape or multiple blow holes positioned in a span-wise line along the wing are used to trip laminar flow air into turbulent flow at a desired location on the wing. This flow control prevents the formation of laminar flow bubbles and ensures the absolute minimum drag. Bug-wipers may be installed to wipe the wings while in flight and remove insects that are disturbing the smooth flow of air over the wing.

Modern competition gliders carry jettisonable water ballast (in the wings and sometimes in the vertical stabilizer). The extra weight provided by the water ballast is advantageous if the lift is likely to be strong, and may also be used to adjust the glider's center of mass. Moving the center of mass toward the rear by carrying water in the vertical stabilizer reduces the required down-force from the horizontal stabilizer and the resultant drag from that down-force. Although heavier gliders have a slight disadvantage when climbing in rising air, they achieve a higher speed at any given glide angle. This is an advantage in strong conditions when the gliders spend only little time climbing in thermals. The pilot can jettison the water ballast before it becomes a disadvantage in weaker thermal conditions. Another use of water ballast is to dampen air turbulence such as might be encountered during ridge soaring. To avoid undue stress on the airframe, gliders must jettison any water ballast before landing.

Most gliders are built in Europe and are designed to EASA Certification Specification CS-22 (previously Joint Aviation Requirements-22). These define minimum standards for safety in a wide range of characteristics such as controllability and strength. For example, gliders must have design features to minimize the possibility of incorrect assembly (gliders are often stowed in disassembled configuration, with at least the wings being detached). Automatic connection of the controls during rigging is the common method of achieving this.

Launch and flight

Double aerotow

The two most common methods of launching sailplanes are by aerotow and by winch. When aerotowed, the glider is towed behind a powered aircraft using a rope about 60 meters (about 200 ft) long. The glider pilot releases the rope after reaching the desired altitude. However, the rope can be released by the towplane also. Winch launching uses a powerful stationary engine located on the ground at the far end of the launch area. The glider is attached to one end of 800–1200 metres (about 2,500-4,000 ft) of cable and the winch rapidly winds it in. The glider can gain about 1200-2000 feet of height with a winch launch (about 400 - 600 metres), depending on the head wind. Less often, automobiles are used to pull gliders into the air, by pulling them directly or through the use of a reverse pulley in a similar manner to the winch launch. Elastic ropes (known as bungees) are occasionally used at some sites to launch gliders from slopes, if there is sufficient wind blowing up the hill. Bungee launching was the predominant method of launching early gliders. Some modern sailplanes can self-launch with the use of retractable engines and/or propellers, which can also be used to sustain flight once airborne.

Once launched sailplanes try to gain height using thermals, ridge lift or lee waves and can remain airborne for hours. This is known as 'soaring'. By finding lift sufficiently often experienced pilots fly cross-country, often on pre-declared tasks of hundreds of

kilometers, usually back to the original launch site. Cross-country flying and aerobatics are the two forms of competitive gliding. For information about the forces in gliding flight.

Glide slope control

Pilots need some form of control over the glide slope to land the glider. In powered aircraft, this is done by reducing engine thrust. In gliders, other methods are used to either reduce the lift generated by the wing, increase the drag of the entire glider, or both. Glide slope is the distance traveled for each unit of height lost. In a steady wings-level glide with no wind, glide slope is the same as the lift/drag ratio (L/D) of the glider, called "L-over-D". Reducing lift from the wings and/or increasing drag will reduce the L/D allowing the glider to descend at a steeper angle with no increase in airspeed. Simply pointing the nose downwards only converts altitude into a higher airspeed with a minimal initial reduction in total energy. Gliders, because of their long low wings, create a high ground effect which can significantly increase the glide angle and make it difficult bring the glider to Earth in a short distance.

- Side Slipping - A slip is performed by crossing the controls (rudder to right with ailerons to left, for example) so that the glider is no longer flying aligned with the air flow. This will present one side of the fuselage to the air-flow significantly increased drag. Early gliders primarily used slipping for glide slope control.

- Spoilers - Spoilers are movable control surfaces in the top of the wing, usually located mid-chord or near the spar which are raised into the air-flow to eliminate (spoil) the lift from the wing area behind the spoiler, disrupting the spanwise distribution of lift and increasing lift-induced drag. Spoilers significantly increase drag and serve as air brakes.

- Air brakes - Air brakes, also known as dive brakes, are devices whose primary purpose is to increase drag. On gliders, the spoilers act as air brakes. They are positioned on top of the wing and, on some types, below the wing also. When slightly opened the upper brakes will spoil the lift, but when fully opened will present a large surface and so can provide significant drag. Some older gliders have *terminal velocity dive brakes*, which provide enough drag to keep its speed below maximum permitted speed, even if the glider were pointing straight down. This capability is considered a safer way to descend without instruments through cloud (or to descend vertically in confined terrain), than the only alternative, an intentional spin.

- Flaps - Flaps are movable surfaces on the trailing edge of the wing. The primary purpose of flaps is to change the camber of the wing and so change the lift-to-drag ratio of the wing. This reduces the stall speed and so allows reduced landing speeds. It was possible to lower the flaps on some older gliders by up to 90 degrees to increase drag significantly as well as increasing lift coefficient when landing. Another feature that flapped gliders possess are *negative flaps* that are

also able to deflect the trailing edge upward. This feature is included on some competition sailplanes in order to reduce the pitching moment on the wing and allowing better glide ratios at higher speeds (a particularly desirable characteristic for racing sailplanes).

- Parachute - Some high performance gliders from the 1960s and 1970s were designed to carry a small drogue parachute because their air brakes are not particularly effective. This is stored in the tail-cone of the glider during flight. When deployed, a parachute causes a large increase in drag, but has a significant disadvantage over the other methods of controlling the glide slope. This is because a parachute does not allow the pilot to finely adjust the glide slope. Consequently a pilot may have to jettison the parachute entirely, if the glider is not going to reach the desired landing area.

Landing

A typical training glider, Schleicher ASK 21 just before landing

Early glider designs used skids for landing, but modern types generally land on wheels. Some of the earliest gliders used a dolly with wheels for taking off and the dolly was jettisoned as the glider left the ground, leaving just the skid for landing. A glider may be designed so the center of gravity (CG) is behind the main wheel so the glider sits nose high on the ground. Other designs may have the CG forward of the main wheel so the nose rests on a nose-wheel or skid when stopped. Skids are now mainly used only on training gliders such as the Schweizer SGS 2-33. Skids are around 100mm (3 inches)

wide by 900mm (3 feet) long and run from the nose to the main wheel. Skids help with braking after landing by allowing the pilot to put forward pressure on the control stick, thus creating friction between the skid and the ground. The wing tips also have small skids or wheels to protect the wing tips from ground contact.

In most high performance gliders the undercarriage can be raised to reduce drag in flight and lowered for landing. Wheel brakes are provided to allow stopping once on the ground. These may be engaged by fully extending the spoilers/air-brakes or by using a separate control. Although there is only a single main wheel, the glider's wing can be kept level by using the flight controls until it is almost stationary.

Pilots usually land back at the airfield from which they took off, but a landing is possible in any flat field about 250 metres long. Ideally, should circumstances permit, a glider would fly a standard pattern, or circuit, in preparation for landing, typically starting at a height of 300 metres (1,000 feet). Glide slope control devices are then used to adjust the height to assure landing at the desired point. The ideal landing pattern positions the glider on final approach so that a deployment of 30-60% of the spoilers/dive brakes/flaps brings it to the desired touchdown point. In this way the pilot has the option of opening or closing the spoilers/air-brakes to extend or steepen the descent to reach the touchdown point. This gives the pilot wide safety margins should unexpected events occur.

Instrumentation and other technical aids

Schempp-Hirth Janus-C in flight, showing instrument panel configured in the basic-T, with airspeed, turn and bank and altitude displays across the top row; below a GPS-driven computer, with wind and glide information, drives two electronic variometer displays to the right. The yaw string and compass are above the glare shield

In addition to an altimeter, compass, and an airspeed indicator, gliders are often equipped with a variometer, turn and bank indicator and an airband radio (transceiver), each of which may be required in some countries. An Emergency Position-Indicating Radio Beacon (ELT) may also be fitted into the glider to reduce search and rescue time in case of an accident.

Much more than in other types of aviation, glider pilots depend on the variometer, which is a very sensitive vertical speed indicator, to measure the climb or sink rate of the plane. This enables the pilot to detect minute changes caused when the glider enters rising or sinking air masses. Both mechanical and electronic 'varios' are usually fitted to a glider. The electronic variometers produce a modulated sound of varying amplitude and frequency depending on the strength of the lift or sink, so that the pilot can concentrate on centering a thermal, watching for other traffic, on navigation, and weather conditions. Rising air is announced to the pilot as a rising tone, with increasing pitch as the lift increases. Conversely, descending air is announced with a lowering tone, which advises the pilot to escape the sink area as soon as possible. (Refer to the *variometer* article for more information).

Gliders' variometers are sometimes fitted with mechanical devices such as a "MacCready Ring" to indicate the optimal speed to fly for given conditions. These devices are based on the mathematical theory attributed to Paul MacCready though it was first described by Wolfgang Späte in 1938. MacCready theory solves the problem of how fast a pilot should cruise between thermals, given both the average lift the pilot expects in the next thermal climb, as well as the amount of lift or sink he encounters in cruise mode. Electronic variometers make the same calculations automatically, after allowing for factors such as the glider's theoretical performance, water ballast, headwinds/tailwinds and insects on the leading edges of the wings.

Soaring flight computers, often used in combination with PDAs running specialized soaring software, have been designed for use in gliders. Using GPS technology in conjunction with a barometric device these tools can:

- Provide the glider's position in 3 dimensions by a moving map display
- Alert the pilot to nearby airspace restrictions
- Indicate position along track and remaining distance and course direction
- Show airports within theoretical gliding distance
- Determine wind direction and speed at current altitude
- Show historical lift information
- Create a GPS log of the flight to provide proof for contests and gliding badges
- Provide "final" glide information (i.e. showing if the glider can reach the finish without additional lift).
- Indicate the best speed to fly under current conditions

After the flight the GPS data may be replayed on computer software for analysis and to follow the trace of one or more gliders against a backdrop of a map, an aerial photograph or the airspace.

Because collision with other gliders is a risk, the anti-collision device FLARM is becoming increasingly common in Europe and Australia. In the longer term, gliders may eventually be required in some European countries to fit transponders once devices with low power requirements become available.

Swift S-1 of the UK Swift Aerobatic Display Team at Kemble 2009

Markings

To distinguish gliders in flight, very large numbers/letters are sometimes displayed on the fin and wings. Registrations on narrow fuselages are difficult to read. These numbers were first added for use by ground-based observers in competitions, and are therefore known as "competition numbers" or "contest IDs". They are unrelated to the glider's registration number, and are assigned by national gliding associations. They are useful in radio communications between gliders, so glider pilots often use their competition number as their call-signs.

Fibreglass gliders are white in color after manufacture. Since fibreglass resin softens at high temperatures, white is used almost universally to reduce temperature rise due to solar heating. Color is not used except for a few small bright patches on the wing tips; these patches (typically bright red) improve gliders' visibility to other aircraft while in flight (and are a requirement for mountain flying in France). Non-fibreglass gliders (those made of aluminum and wood) are not subject to the temperature-weakening problem of fibreglass, and can be painted any color at the owner's choosing; they are often quite brightly painted.

Comparison of gliders with hang gliders and paragliders

There is sometimes confusion about gliders, hang gliders and paragliders. In particular paragliders and hang gliders are both foot-launched. The main differences between the types are:

	Paragliders	**Hang gliders**	**Gliders/Sailplanes**
Undercarriage:	Pilot's legs used for take-off and landing	Pilot's legs used for take-off and landing	Aircraft takes off and lands using a wheeled undercarriage or skids
Wing structure:	entirely flexible, with shape maintained purely by the pressure of air flowing into the wing in flight and the tension of the lines. prone to collapse in turbulence.	generally flexible but supported on a rigid frame which determines its shape and thus does not collapse in turbulence, but note that rigid wing hang gliders also exist	rigid surface to wings that totally encases structure
Pilot position:	sitting ‘supine’ in a seated harness.	usually lying ‘prone’ in a cocoon-like harness suspended from the wing. Seated, and 'supine' are also possible.	sitting in a seat with a harness surrounded by a crash-resistant structure.
Speed range (stall speed – max speed):	slower – hence easier to launch and fly in light winds, can get into trouble when winds pick up, poor wind penetration and no pitch control, cannot dive for speed, although some pitch variation can be achieved with speed bar.	faster – much faster, up to 145 km/h (90+ mph), hence easier to launch and fly in stronger conditions with better wind penetration, and can outrun bad weather, full pitch control	even faster - maximum speed up to about 280 km/h (170 mph); stall speed typically 65 km/h (40mph). Able to fly in windier turbulent conditions and can outrun bad weather. Exceptional penetration into the wind. Semi- or fully aerobatic.
Maximum glide ratio:	about 12, relatively poor glide performance makes long-distances more difficult. The current world record is just	about 17 for flexible wings, though up to 20 for rigid wings. Glide performance enables longer-	Open class sailplanes typically around 60:1 but in more common 15-18 meter span aircraft, glide ratios are between 38:1 and 52:1. , high glide performance

	above 500km (310 miles)	distance flying, 700km (430+ mile) record	enabling long distances, 3000km (1800+ mile record)
Turn radius:	tighter turn radius, allowing circling in the rapidly rising center of thermals	somewhat larger turn radius, not allowing such a high rate of climb in thermals	even greater turn radius but still able to circle tightly in thermals
Landing-out:	smaller space needed to land, offering more landing options from cross-country flights. Also easier to carry back to the nearest road	longer approach & landing area required, but can reach more landing areas due superior glide range	can land in less than 200 metres and can often reach another airfield. Specialised trailer needed to retrieve by road
Learning:			teaching is done in a two seat glider with dual controls
Convenience:	pack smaller (easier to transport and store); lighter (easier to carry); quicker to rig & de-rig; transported in the trunk of a car	more awkward to transport & store; longer to rig and de-rig; transported on the roof of a car	trailers are typically 10 m (30 ft) long. Rigging & de-rigging takes about 20 minutes
Cost:			Cost of new gliders very high but long lasting (several decades), so active second hand market typically from €2000 to €145,000 . Often shared ownership

Competition classes of glider

DG Flugzeugbau DG-1000 of the Two Seater Class

Eight competition classes of glider have been defined by the FAI. They are:

- Standard Class (No flaps, 15 m wing-span, water ballast allowed)
- 15 metre Class (Flaps allowed, 15 m wing-span, water ballast allowed)
- 18 metre Class (Flaps allowed, 18 m wing-span, water ballast allowed)
- Open Class (No restrictions except a limit of 850 kg for the maximum all-up weight)
- Two Seater Class (maximum wing-span of 20 m), also known by the German name "Doppelsitzer"
- Club Class (This class allows a wide range of older small gliders with different performance and so the scores have to be adjusted by handicapping. Water ballast is not allowed).
- World Class (The FAI Gliding Commission which is part of the FAI and an associated body called Organisation Scientifique et Technique du Vol à Voile (OSTIV) announced a competition in 1989 for a low-cost glider, which had moderate performance, was easy to assemble and to handle, and was safe for low hours pilots to fly. The winning design was announced in 1993 as the Warsaw Polytechnic PW-5. This allows competitions to be run with only one type of glider.
- Ultralight Class, for gliders with a maximum mass less than 220 kg.

Major manufacturers of gliders

The full list of gliders and manufacturers, past and present, shows that a large proportion have been and are still made in Germany, the birthplace of the sport. The principal German manufacturers are:

- DG Flugzeugbau GmbH
- Schempp-Hirth GmbH
- Alexander Schleicher GmbH & Co

though there are other specialist manufacturers in Germany, Poland and in other eastern European countries.

Chapter 7

Aerobatics

The UK Utterly Butterly display team perform an aerobatic maneuver with their Boeing Stearmans

Red Arrows BAE Hawks in Apollo formation. (2010).

Patrouille de France producing colored smoke during an air show

Aerobatics is the practice of flying maneuvers involving aircraft attitudes that are not used in normal flight. Aerobatics are performed in airplanes and gliders for training, recreation, entertainment and sport. Some helicopters, such as the MBB Bo 105, are capable of limited aerobatic maneuvers.

Most aerobatic maneuvers involve rotation of the aircraft about its longitudinal (roll) axis or lateral (pitch) axis. Other maneuvers, such as a spin, displace the aircraft about its vertical (yaw) axis. Maneuvers are often combined to form a complete aerobatic sequence for entertainment or competition.

Aerobatic flying requires a broader set of piloting skills and exposes the aircraft to greater structural stress than for normal flight. In some countries, the pilot must wear a parachute when performing aerobatics.

While many pilots fly aerobatics for recreation, some choose to fly in aerobatic competitions, a judged sport.

Overview

In the early days of flying, some pilots used their aircraft as part of a flying circus to entertain. Maneuvers were flown for artistic reasons or to draw gasps from onlookers. In due course some of these maneuvers were found to allow aircraft to gain tactical advantage during aerial combat or dogfights between fighter aircraft.

Aerobatic aircraft fall into two categories — specialist aerobatic, and aerobatic capable. Specialist designs such as the Pitts Special, the Extra 200 and 300, and the Sukhoi Su-29 aim for ultimate aerobatic performance. This comes at the expense of general purpose use such as touring, or ease of non aerobatic handling such as landing. At a more basic level, *aerobatic capable* aircraft, such as the Cessna 152 Aerobat model, can be dual purpose— equipped to carrying passengers and luggage, as well as being capable of basic aerobatic figures.

Flight formation aerobatics are flown by teams of up to sixteen aircraft, although most teams fly between four and ten aircraft. Some are state funded to reflect pride in the armed forces whilst others are commercially sponsored. Coloured smoke trails may be emitted to emphasise the patterns flown and/or the colours of a national flag. Usually each team will use aircraft similar to one another finished in a special and dramatic colour scheme, thus emphasising their entertainment function.

Teams often fly V-formations (otherwise known as echelon formation)— they will not fly directly behind another aircraft because of danger from wake vortices or engine exhaust. Aircraft will always fly slightly below the aircraft in front, if they have to follow in line (the "trail formation").

The UK Swift Aerobatic Display Team at Kemble Battle of Britain Weekend 2009. A Swift glider is performing continuous full rolls while towed by a Piper Pawnee

Aerobatic maneuvers flown in a jet powered aircraft are limited in scope as they cannot take advantage of the gyroscopic forces that a propeller driven aircraft can exploit. Jet powered aircraft also tend to fly much faster which increases the size of the figures and the length of time which the pilot has to withstand increased g-forces. Jet aerobatic teams often fly in formations which further restricts the maneuvers that can be safely flown.

To enhance the effect of aerobatic maneuveres smoke is sometimes generated; the smoke allows viewers to see the path travelled by the aircraft. Due to safety concerns, the smoke is not a result of combustion but is produced by the vaporization of fog oil into a fine aerosol, achieved either by injecting the oil into the hot engine exhaust or by the use of a dedicated device that can be fitted in any position on the aircraft. The first military aerobatic team to use smoke at will during displays was Fleet Air Arm 702 Squadron "The Black Cats" at the Farnborough Air show in September 1957.

Training

Aerobatics are taught to military fighter pilots as a means of developing flying skills and for tactical use in combat. Aerobatics and formation flying is not limited solely to fixed wing aircraft, helicopters are also used—the British Army, Royal Navy, Spanish Air Force and the Indian Air Force, among others, have helicopter display teams. All aerobatic maneuvers demand training and practice to avoid accidents. Such accidents are

rare but can result in fatalities; safety regulations are such that there has not been an airshow spectator fatality in the USA since the 1950s. Low-level aerobatics are extremely demanding and airshow pilots must demonstrate their ability before being allowed to gradually reduce the height at which they may fly their show.

There are aerobatic training schools in the U.S. and other countries.

Patty Wagstaff show at JeffCo Airport

"Blue Impulse" (JASDF)

Competition

Competitions start at Primary, or Graduate level and proceed in complexity through Sportsman, Intermediate and Advanced, with Unlimited being the top competition level. Experienced aerobatic pilots have been measured to pull +/-5g for short periods while unlimited pilots can perform more extreme maneuvers and experience higher g levels - possibly up to +8/-6g. The limits for positive g are higher than for negative g and this is due to the ability to limit blood pooling for positive g maneuvers, but it is generally accepted that +9 g for more than a few seconds will lead to loss of consciousness (also known as GLOC).

Performance

The Australian Roulettes

Aerobatics are most likely to be seen at a public airshows. Famous teams include:

- Asas de Portugal (Portuguese Air Force)
- August 1st (People's Liberation Army Air Force)
- Black Cats (Royal Navy Fleet Air Arm - United Kingdom)
- Black Eagle (Republic of Korea Air Force)
- Black Knights (Republic of Singapore Air Force)
- Blue Angels (United States Navy)
- Blue Diamonds (Philippine Air Force)
- Blue Eagles (Army Air Corps—United Kingdom)
- Blue Impulse (Japan Air Self-Defense Force)
- Breitling Jet Team (private (Breitling))
- Cartouche doré (French Air Force)
- Cruz del Sur ("Southern Cross"—Argentine Air Force)
- Diables Rouges (Belgian Air Force)
- Elang Biru (Indonesian Air Force)
- Esquadrilha da Fumaça (Smoke Squadron - Brazilian Air Force)
- Frecce Tricolori (Italian Air Force)
- Halcones (Falcons-Chilean Air Force)
- Hungarian Sky Hussars (Imitated Dogfight with MIG-21 bis - Hungarian Air Force)

- Green Hawk (Bureau of Royal Rainmaking and Agricultural Aviation, Thailand)
- Midnight Hawks (Finnish Air Force)
- Orlik Aerobatic Team, White-Red Sparks (known also as Team Iskry), Scorpion (aerobatic team) (Polish Air Forces)
- Patrouille de France (French Air Force)
- Patrouille Suisse (Swiss Air Force)
- Patrulla Aguila, Patrulla Aspa (Eagle Patrol; Blade Patrol—Spanish Air Force)
- Red Arrows (Royal Air Force—United Kingdom)
- Red Checkers (Royal New Zealand Air Force)
- Red Pelicans, Rothmans, Silver Falcons (South African Air Force)
- Rotores de Portugal (Portuguese Air Force—Helicopters)
- Roulettes (Royal Australian Air Force)
- Royal Jordanian Falcons (Royal Jordanian Air Force)
- Russian Knights, Strizhi (Swifts), Rus (Russian Air Force)
- Sagar Pawan (Indian Navy)
- Sanmueang (Royal Thai Air Force)
- Sarang (Indian Air Force)
- Saudi Hawks, (Royal Saudi Air Force)
- Sherdils (Pakistan Air Force)
- Silver Falcons (South African Air Force)
- Silver Swallows Irish Air Corps
- Snowbirds (Canadian Forces)
- Surya Kiran (Indian Air Force)
- Team Jupiter (Indonesian Air Force)
- Team 60 (Swedish Air Force)
- Team RV Formation Demontration Team
- The Flying Bulls (civilian, Austria)
- Thunder Tiger (Republic of China Air Force)
- Thunderbirds (United States Air Force)
- Turkish Stars (Türk Yıldızları) (Turkish Air Force)
- Ukrainian Falcons (Ukrainian Air Force)
- Wings of Storm (Croatian Air Force)

Former teams

Stunt flyer flying low in a Curtiss Pusher plane, California, circa 1927

Martin B-57B-MA Serial 52-1560 of the 71st Light Bomber Squadron - 1957. This aircraft was also one of the "Black Knights" aerial acrobatic team. After its withdrawal from France in 1958, this aircraft was eventually assigned to the 8th Tactical Bomb Squadron at Phan Rang Air Base South Vietnam and flew combat bombing missions into the late 1960s.

- Akrobatika (a particular Squadron from Ubatuba, São Paulo, Brazil)

- Yellowjacks (UK, RAF)
- Black Arrows (No. 111 Squadron RAF, 1950s)
- Blue Herons (UK, Royal Navy, FRADU)
- Simon's Sircus (UK, Royal Navy, Fleet Air Arm)
- Fred's Five (UK, Royal Navy, 892 Naval Air Squadron)
- The Sharks (UK, Royal Navy, 705 Naval Air Squadron)
- Blue Diamonds (No. 92 Squadron RAF)
- The Tigers (No. 74 Squadron RAF)
- The Firebirds (No. 56 Squadron RAF)
- The Red Pelicans (UK, RAF)
- The Red Knight (Royal Canadian Air Force)
- Golden Hawks (Royal Canadian Air Force)
- Golden Centennaires (Royal Canadian Air Force)
- Acrojets (USAF Fighter School at Williams Air Force Base, Arizona 1949-1950)
- Acrojets (USAFE at Fürstenfeldbruck AB, Germany in the mid-1950s)
- Skyblazers (USAFE at Fürstenfeldbruck AB, Germany from late 1940s to 1962)
- The Black Knights (38th Tactical Bombardment Wing, USAFE, 1950s)
- Flying Jokers (Squadron 332, Royal Norwegian Air Force)
- Golden Sabres (Philippine Air Force)
- *Silver Birds* (Austrian Armed Forces)
- Karo Ass (Diamonds Ace) (1975-1984 - Austrian Armed Forces)
- *Cavallino Rampante* (Prancing Horse) (1950-52 and 1956-57 - Italian Air Force)
- *Getti Tonanti* (Thundering Jets) (1953-55 and 1959-60 - Italian Air Force)
- *Tigri Bianche* (White Tigers) (1955-56 - Italian Air Force)
- *Diavoli Rossi* (Red Devils) (1957-59 - Italian Air Force)
- *Lancieri Neri* (Black Lancers) (1960- Italian Air Force)
- *Taj-Talaee* (Golden Crown) (1955-1979 -Imperial Iranian Air Force)

Chapter 8

Brazilian Business Aircrafts

Embraer Legacy 450

Legacy 450

MLJ concept drawing as of October, 2007.

Role	Business jet
Manufacturer	Embraer
Status	In development
Number built	None
Unit cost	15.25 million
Variants	Embraer Legacy 500

The **Embraer Legacy 450** is a business jet being developed by Brazilian aircraft manufacturer Embraer.

Design and development

Launched as a concept called the **MLJ** (Mid-Light Jet) at the NBAA Convention in 2007, the Legacy 450 (and its big brother the Legacy 500) were officially launched at EBACE in May 2008. It is designed to carry 7 to 8 passengers over 2,300 nautical miles (4,300

km). The aircraft has full fly-by-wire flight controls, a Collins ProLine Fusion flight deck, Honeywell HF7500 series engines, and a full stand up flat floor cabin. First flight is scheduled for 2012, and entry into service is in late 2013.

Specifications

General characteristics

- **Crew:** 2 pilots
- **Capacity:** 7 to 10 passengers
- **Length:** 19.15 m (62 ft 10 in)
- **Wingspan:** 20.25 m (66 ft 5 in)
- **Height:** 6.74 m (22 ft 1 in)
- **Powerplant:** 2 × Honeywell HTF7500E

Performance

- **Maximum speed:** Mach 0.83
- **Range:** 4,260 km (2,647 mi; 2,300 nmi)
- **Service ceiling:** 14,000 m (45,932 ft)

Avionics

Rockwell Collins Pro Line Fusion

Embraer Legacy 500

Legacy 500

MSJ concept drawing as of October, 2007

Role	Mid-size jet
Manufacturer	Embraer
Status	In development
Number built	None
Unit cost	$18,400,000
Variants	Embraer Legacy 450

The **Embraer Legacy 500** is a business jet being developed by Brazilian aircraft manufacturer Embraer.

Design and development

Initially called the **MSJ** (Mid-Size Jet) Concept at NBAA 2007, the Legacy 500 was officially launched at EBACE in 2008, along with its smaller sibling, the Legacy 450. It can be configured to carry between 8 and 10 passengers. It can carry 8 passengers over 2,800 nautical miles (5,190 km), or four passengers over 3,000 nautical miles (5,600 km). First flight is scheduled for 2011 and entry into service in late 2012.

Specifications

General characteristics

- **Crew:** 2 pilots
- **Capacity:** up to 15 passengers

- **Length:** m (67 ft 4in)
- **Wingspan:** m (66 ft 5in)
- **Height:** m (22 ft 1in)
- **Wing area:** m² (ft²)
- **Empty:** kg (lb)
- **Loaded:** kg (lb)
- **Maximum takeoff:** kg (lb)
- **Powerplant:** Honeywell HTF7500E
- **Avionics:** Rockwell Collins Pro Line Fusion

Performance

- **Maximum speed:** Mach 0.82 (870.84 km/h)
- **Range:** 5,186 kilometers (3,000 nautical miles)
- **Service ceiling:** 45,000 ft (13,700 m)
- **Rate of climb:**
- **Wing loading:**
- **Thrust-to-weight:**

Embraer Legacy 600

Embraer Legacy 600

An Embraer Legacy 600 at the Berlin Air Show.

Role	Business jet
Manufacturer	Embraer
First flight	2001
Introduced	2000
Status	In production
Produced	183 as of Dec. 31, 2010
Unit cost	US$27.450 million

Developed from Embraer ERJ 135 family

The **Embraer Legacy 600** is a business jet derivative of the Embraer ERJ 135 family of commercial jet aircraft.

Design and development

The Legacy 600 is based on the ERJ 135 model, with avionics from ERJ 140 model, includes added range with extra fuel tanks in the tail and forward of the wing, added winglets and an extensive drag reduction. It is certified to 41,000-foot (12,000 m) altitude versus 37,000 feet (11,000 m) for the airline configuration. Launched in 2000 at the Farnborough Airshow, the Legacy carries 16 passengers for 3,050 nautical miles (5,650 km) or 8 passengers for 3,450 nautical miles (6,390 km). The Legacy family includes the **Legacy Shuttle**, which is an ERJ 135 with a 19-seat passenger cabin configuration as standard (it does not have the same range as the Legacy Executive / Legacy 600).

The Legacy 600 competes on the upper end of the small to mid sized range of business jets. It has nearly the opposite design progression as the rival Canadair Challenger. The Legacy 600 was derived from the established ERJ family of regional jets, while the Canadair Regional Jet was developed by Bombardier from the Challenger business jet. Both lines of aircraft are competitors. Embraer has since launched an extensive lineup of business aircraft, from the entry-level Phenom 100 to the Lineage 1000, a very-long-range business jet version of the company's 100-seat E-190.

Embraer Legacy 600 at Birmingham International Airport, England

In seven years of service, Embraer have delivered over 150 Legacy 600 aircraft in more than 20 countries. It has seating for 16 passengers in three partitioned sections, or seating for 19–37 in airline-style seats on the Legacy Shuttle. In the cockpit, the Legacy also includes a Honeywell Primus 1000 avionics suite, with a full glass cockpit.

Legacy 650

The Legacy 650 is a longer-range version of the Legacy 600 giving it a range capability of 7,223km (3,900nm), nonstop with four passengers, or 3,840 nm. (7,112 km.) with eight passengers, or about 500 nm (926 km.) farther than the Legacy 600. It was announced at the 2009 NBAA show.

Incidents

- On 29 September 2006, an ExcelAire Embraer Legacy EMB-135BJ, civil registration N600XL, collided with Gol Transportes Aéreos Flight 1907, a Boeing 737-800, while flying over the northern state of Mato Grosso, Brazil en route to Manaus from São José dos Campos. The Boeing crashed and the Embraer landed safely with minor damage.

Aircraft deliveries

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Number of deliveries	9	13	13	20	27	36	36	18	11

Specifications

General characteristics

- **Crew:** Three - pilot, co-pilot, flight attendant (optional)
- **Capacity:** 13 passengers + 1 in cockpit jumpseat
- **Length:** 26.33 m (86 ft 5 in)
- **Wingspan:** 21.17 m (68 ft 11 in)
- **Height:** 6.76 m (22 ft 2 in)
- **Empty weight:** 16,000 kg (30,000 lb)
- **Max takeoff weight:** 22,500 kg (49,604 lb)
- **Powerplant:** 2× Rolls-Royce AE 3007/A1P turbofans, 39,2 kN (8,810 lbs) each

Performance

- **Maximum speed:** 834 km/h (450 kt, 518 mph)
- **Range:** 6,060 km (3,250 nm, 3,740 mi)
- **Service ceiling:** 12,496 m (41,000 ft)
- **Thrust/weight:** 0.36:1Max fuel capacity: 18,800 lb (Legacy Executive) / 11,321 lb (Legacy Shuttle) - both figures approx.

Embraer Lineage 1000

Lineage 1000	
Role	Business jet
Manufacturer	Embraer
First flight	October 26, 2007
Status	in production
Unit cost	US$49.25M
Developed from	Embraer E-Jets

The **Embraer Lineage 1000** is a variant of the Embraer 190 regional jet airliner, launched as a private jet on May 2, 2006. Manufactured by the Brazilian aerospace firm Embraer, the Lineage is advertised as an "ultra-large" business jet with comfortable seating for 19.

Design

The Lineage 1000 is largely based on the successful Embraer passenger jet, the Embraer 190. The greatest change in the Lineage 1000 is the added fuel tanks in the lower deck cargo hold space, nearly doubling the jet's range, which also boasts a lavish interior, divided into up to 5 sections including an optional bedroom, washroom with running water, and a walk-in cargo area at the rear. Another selling point is the larger fuselage cross-section than other comparable business jets, such as the Gulfstream V and the Bombardier Global Express. The Lineage 1000 is only topped in available space by the 737 and A319 conversions, the BBJ and ACJ.

Production history

The Lineage 1000 received its certification from Brazil's ANAC and from EASA in December 2008. It was certified by the USA Federal Aviation Administration on 7 January 2009.The first Lineage 1000 was delivered to HE Aamer Abdul Jalil Al Fahim on May 7, 2009.

The aircraft has gained significant popularity in the Middle East as several operators have taken delivery or have ordered the Lineage 1000. Al Jaber Aviation has taken delivery of their first Lineage in January 2010 with four more ordered. Flemming House has taken delivery of their corporate Lineage 1000 aircraft in June 2010.. In September 2010, Royal Jet has added a Lineage 1000 to their fleet to be managed on behalf of Al Habtoor Group. Falcon Aviation Services has ordered one Lineage 1000 to be delivered in 2010.

Outside of the Middle East, Grupo Omnilife de Mexico has taken delivery of their Lineage 1000 aircraft in August 2010. Hangar8, one of Europe’s leading operators of privately owned passenger jets, took delivery of the first Embraer Lineage 1000 aircraft available for charter outside of the Middle East.

The aircraft is priced at $49.25 million based on 2009 figures.

Specifications

General characteristics

- **Crew:** Three (pilot, co-pilot, optional flight attendant)
- **Capacity:** 19 passengers
- **Length:** 36.24 m (118 ft 11 in)
- **Wingspan:** 28.72 m (94 ft 3 in)
- **Height:** 10.28 m (34 ft 7 in)
- **Max takeoff weight:** 55,000 kg (121,252 lb)
- **Powerplant:** 2× GE CF34-10E turbofans, 82.3 kN (18,500 lb_f) each

Performance

- **Maximum speed:** Mach 0.82 (481 knots, 890 km/h)
- **Range:** 8,344 km (4,500 nm, 5,179 mi)
- **Service ceiling:** 12,496 m (41,000 ft)
- **Thrust/weight:** 0.41:1
- **Balanced field length (SL, ISA, MGTOW):** 6,660 ft (2,030 m)

Embraer Phenom 300

Phenom 300

Embraer Phenom 300 Mockup in 2006

Role	Light business jet
National origin	Brazil
Manufacturer	Embraer
First flight	2008
Introduction	2009

Status	Certified
Unit cost	US$8.14million (2010)
Variants	Embraer Phenom 100

The Phenom 300 interior mockup at the Oakland NBAA, 8 November 2007

The **Embraer Phenom 300** is a light jet aircraft developed by the Brazilian aircraft manufacturer Embraer. It can carry 8 or 9 occupants with a flying range of 1,971 nautical miles. Its price is estimated at US$ 8.14 million in 2010 economic conditions, with a production date of 2009. The plane has a flexible configuration for up to nine occupants, with a private rear lavatory, refreshment center and baggage area. At 45,000 feet, the Phenom 300 is pressurized to a cabin altitude of 6,000 feet. The jet features single-point refueling and an externally serviced lavatory. It received FAA Type Certification on 14 December 2009 as the Embraer EMB-505.

On 29 December 2009 Embraer delivered the first Phenom 300 to Executive Flight Services at the company's headquarters at São José dos Campos, Brazil. Prior to delivery the company trained four customer pilots in the aircraft type at its CAE Training Services Facility at Dallas, TX.

Operators

United Kingdom

- Flairjet (European launch customer)

United States

- - The first operator in the United States to certify the Phenom 300 under FAR Part 135

Specifications

General characteristics

- **Crew:** 1 pilot
- **Capacity:** 6 passengers standard (8 maximum)
- **Length:** 15.9 m (52 ft 1 in)
- **Wingspan:** 16.2 m (53 ft 2 in)
- **Height:** 5 m (16 ft 4 in)
- **Max takeoff weight:** 7951 kg (17526 lb)
- **Powerplant:** 2× Pratt & Whitney Canada PW535E turbofans, 14.2 kN (3,200 lbf) each

Performance

- **Maximum speed:** 834 km/h (453 ktas)
- **Range:** 3,650 km (IFR reserves, 6 occupants) (1,971 NM)
- **Service ceiling:** 13,716 m (45,000 ft)

Avionics

Embraer "Prodigy" Flight Deck 300 (based on Garmin G1000)

Chapter 9

British Business Aircrafts

British Aerospace BAe 125

BAe 125/Dominie
Hawker 1000

A Dominie navigation trainer of the Royal Air Force

Role	Mid-size business jet
Manufacturer	de Havilland (design) Hawker Siddeley (to 1977) British Aerospace (1977-1993) Raytheon (1993- 2007) Hawker Beechcraft (Since 2007)
First flight	13 August 1962
Primary users	Royal Air Force South African Air Force United States Air Force
Number built	1,000+
Variants	Hawker 800

The **British Aerospace BAe 125** is a twin-engined mid-size corporate jet, with newer variants now marketed as the Hawker 800. It was known as the **Hawker Siddeley HS.125** until 1977. It is also used by the British Royal Air Force as a navigation trainer (as the **Hawker Siddeley Dominie T1**), and was used by the United States Air Force as a calibration aircraft (as the **C-29**).

Development

In 1961, de Havilland began working on a revolutionary small business jet, the **DH.125 Jet Dragon**, intended to replace the piston engined de Havilland Dove business aircraft and light transport. The DH.125 design was for a low-winged monoplane with a pressurised fuselage accommodating two pilots and six passengers. It was powered by two Bristol Siddeley Viper turbojets mounted on the rear fuselage. The slightly swept wing employed large slotted flaps and airbrakes to allow operation from small airfields. The first of two prototypes flew on 13 August 1962, with the second following on 12 December that year. The first production aircraft, longer and with a greater wingspan than the two prototypes, flew on 12 February 1963, with the first delivery to a customer on 10 September 1964.

The aircraft went through many designation changes during its service life. Hawker Siddeley had bought de Havilland the year before project start, but the old legacy brand and the "DH" designation was used throughout development. After the jet achieved full production, the name was finally changed to "HS.125". When Hawker Siddeley Aircraft merged with the British Aircraft Corporation to form British Aerospace in 1977, the name changed to **BAe 125**. Then, when British Aerospace sold its Business Jets Division to Raytheon in 1993, the jet acquired the name **Raytheon Hawker**. The fuselage, wings and tail-fin are to this day fully assembled and partially equipped (primary and secondary flight controls) in Airbus UK's Broughton plant, on the outskirts of Chester, sub-assemblies are produced in Airbus UK's Buckley (Bwcle in Welsh) site. All these assembled components are then shipped to Wichita, Kansas in the United States, to where final assembly was transferred in 1996.

Over 1,000 aircraft have been built.

Variants

BAe 125 CC3 of No. 32 Squadron, RAF

Raytheon Hawker 800

- **DH.125 Series 1** - first version, powered by 3,000 lbf (13 kN) Viper 20 or 520 engines. Nine built, including two prototypes (43 ft 6 in (13.26 m) long, 44 ft (13.41 m) span) and seven production aircraft (47 ft 5 in (14.56 m) long, 47 ft (14.33 m) long.
- **DH.125 Series 1A/1B** - upgraded Bristol Siddeley Viper 521 or 522 engines with 3,100 lbf (14 kN) of thrust each, and five cabin windows instead of six. Series 1A for US FAA certification (62 built), Series 1B for sale elsewhere (13 built).
- **HS.125 Series 2** - navigation trainer for Royal Air Force, known in service as the **Dominie T.Mk.1** - (Rolls Royce Viper 301)
- **HS.125 Series 3** - upgraded engines
- **HS.125 Series 400** - upgraded engines
    - **HS.125 CC1** - Series 400 liaison aircraft for Royal Air Force
- **HS.125 Series 600** - 3 ft 1 in (0.94 m) fuselage stretch to increase capacity to 14 passengers
    - **HS.125 CC2** - Series 600 liaison aircraft for Royal Air Force
- **HS.125 Series 700** - Honeywell TFE731-3RH turbofan engines with 3,720 lbf (16.5 kN) of thrust each, first flight 19 June 1976
    - **BAe 125 CC3** - Series 700 liaison aircraft for Royal Air Force
- **HS.125 Protector** - Series 700-based maritime patrol aircraft with a search radar and cameras
- **BAe 125 Series 800** - increased wingspan, streamlined nose, tail fin extension, increased fuel capacity, first corporate jet to feature an EFIS cockpit, upgraded engines, first flight 26 May 1983
- **Hawker 800** - BAe 125-800 after 1993
- **Hawker 800XP** - TFE731-5BR1H turbofan engines with 4,660 lbf (20.7 kN) of thrust each
- **Hawker 800SP and 800XP2** - New designation for 800A/B and 800XP aircraft when upgraded with aftermarket winglets
- **Hawker 850XP** - 800XP with factory installed winglets and interior updates
- **Hawker 900XP** - 850XP with Honeywell TFE731-50R turbofan engines for increased hot/high performance and longer range
- **Hawker 750** - 800XP with a light-weight interior and heated baggage compartment in place of the ventral fuel tank
- **C-29A** - Series 800 for US military designed to replace the Lockheed C-140A, used by the Air Force to accomplish the combat flight inspection and navigation mission (C-FIN) at US airbases around the world, participated in Operation Desert Shield and Operation Desert Storm during the First Persian Gulf War.
- **U-125** - Series 800-based flight inspection aircraft for Japan (similar to C-29A)
- **U-125A** - Series 800-based search and rescue aircraft for Japan
- **BAe 125 Series 1000** - intercontinental version of the Series 800, 2 ft 9 in (0.84 m) fuselage stretch to increase capacity to 15, increased fuel capacity, Pratt & Whitney Canada PW-305 turbofans with 5,200 lbf (23 kN) thrust each, first flight 16 June 1990, 52 built
- **Hawker 1000** - BAe 125-1000 after 1993
- **Handley Page HP.130** - A 1965 proposal with boundary layer control wings (not built). It was to be powered by two Bristol Siddeley Viper 520s of 3,000 lbf (13

kN) thrust with a projected Maximum speed of Mach 0.8. This conversion was for laminar-flow research purposes.

Operators

Civil operators

Private operators, air taxi, shared ownership and corporate charter operators worldwide.

Australia

- Qantas - Two HS.125 Series 3s were used for crew training. The aircraft were in service from 1965 to 1972.

Canada

- Air Georgian - 1 HS.125 in service operated on behalf of Air Canada

Nigeria

- Associated Aviation - 2 HS. 125 Series 700 are in use.

China

- Deerjet, Hainan Airlines - 4 Hawker 800XP, 2 Hawker 850XP and 1 Hawker 900XP are in service in Deerjet based at Beijing. Deerjet is a branch of Hainan Airlines(HNA)
- Shanghai Airlines - 1 Hawker 800XP is in service in Shanghai Airlines based at Shanghai.

Pakistan

- Royal Airlines - 1 Hawker Siddeley HS 125 (Passenger) V.I.P

Military operators

Argentina

- Argentine Naval Aviation operated one VIP.

Biafra

- Biafran Air Force operated one aircraft.

Brazil

- Brazilian Air Force

Botswana

- Botswana Defence Force Air Wing

Ireland

- Irish Air Corps

Japan

- Japan Air Self-Defense Force

Malawi

- Military of Malawi

Malaysia

- Royal Malaysian Air Force

Nicaragua

- National Guard (Nicaragua)

Nigeria

- Nigerian Air Force

Saudi Arabia

- Royal Saudi Air Force

South Africa

- South African Air Force
  - No. 21 Squadron SAAF

United Kingdom

- Royal Air Force
  - No. 32 Squadron RAF
  - No. 55(R) Squadron RAF (Dominie T1)

United States

- United States Air Force

Accidents and incidents

- On 22 November 1966, de Havilland DH.125 N235KC of Florida Commuter Airlines crashed into the sea 7.3 kilometres (3.9 nmi) off Grand Bahama International Airport, Freeport, Bahamas during an illegal flight from Miami, Florida.
- On 26 May 1971, three Mercurius HS-125 aircraft belonging to the South African Air Force flew into Devil's Peak, Cape Town, while practising for a flypast for the 10th anniversary of the republic.
- On 20 November 1975, a British Aerospace BAe 125 overran the runway at Dunsfold Aerodrome after a bird strike on take off. The aircraft hit a car and stopped in a field, killing six people in the car and one crew member out of nine passengers and crew.
- On March 16, 1991 a Hawker Siddeley charter aircraft carrying band members for Reba McEntire crashed into the side of Otay Mountain. The accident occurred shortly after take off from a municipal airport outside of San Diego, California. All eight band members aboard plus two pilots were killed in the crash believed to have been caused by poor visibility.
- On 3 January 2006, Russian aircraft (AVCOM - Moscow) crashed in Kharkiv, Ukraine into the Komsomolsk lake, 3 people died (crew).
- On 31 July 2008, East Coast Jets Flight 81 crashed on approach to an airport in Owatonna, Minnesota killing all 8 passengers and crew.
- On 26 October 2009, S-Air Flight 9607, operated by BAe 125 RA-02807 crashed on approach to Minsk International Airport. All three crew and both passengers were killed.

Specifications (HS 125 Series 600)

General characteristics

- **Crew:** 2
- **Capacity:** 8 passengers (normal layout), 14 passengers in high density layout
- **Length:** 50 ft 6 in (15.39 m)
- **Wingspan:** 47 ft 0 in (14.33 m)
- **Height:** 17 ft 3 in (5.26 m)
- **Wing area:** 353.0 ft² (32.8 m²)
- **Empty weight:** 12,530 lb (5,683 kg)
- **Max takeoff weight:** 25,000 lb (11,340 kg)
- **Powerplant:** 2× Rolls-Royce Viper 601-22 turbojets, 3,750 lbf (16.7 kN) each

Performance

- **Maximum speed:** 522 mph (454 knot, 840 km/h) at 28,000 ft (8,500 m) (Max cruise)
- **Cruise speed:** 464 mph (403 knot, 747 km/h) at 39,000 ft (11,900 m) (Econ cruise)

- **Stall speed:** 96 mph (83 knots, 155 km/h) (flaps down)
- **Range:** 1,796 mi (1,560 nmi, 2,891 km) max fuel and payload
- **Service ceiling:** 41,000 ft (12,500 m)
- **Rate of climb:** 4,900 ft/min (24.9 m/s)

CMC Leopard

Leopard

CMC Leopard, *G-BRNM*, on display at the Midland Air Museum.

Role	Business jet
Manufacturer	Chichester-Miles Consultants
Designed by	Ian Chichester-Miles

First flight	12 December 1988
Status	Project cancelled, both aircraft withdrawn from use
Number built	2

The **CMC Leopard** was a British light personal business jet aircraft under development in the United Kingdom in the 1980s. Two prototypes were built and flown but the type was not put into production.

Design and development

The Leopard was a low-wing cantilever monoplane of composite construction with all-swept flying surfaces and jet fighter-like styling other than the podded engines on either side of the aft fuselage. The entire canopy hinged forward to allow access to the four seats. A mockup was completed in 1982, leading to a prototype (registration *G-BKRL*) built by the Designability company. The prototype first flew late in 1988. Development suffered a major setback when the engine manufacturer (Noel Penny Turbines) ceased business, leading to the grounding of the prototype. A second, refined prototype (registration *G-BRNM*) was then constructed to use Williams International turbofans. This aircraft also incorporated a pressurised cabin, revised undercarriage, and a generally strengthened airframe. This second prototype was unveiled at the 1996 Farnborough International Airshow and first flew on 9 April 1997.

As of 2002, development was confined to these two aircraft, by then retrospectively redesignated **Leopard FOUR** to distinguish them from a proposed six-seat variant, the **Leopard SIX**.

Aircraft on display

Until 2008 the two prototype Leopards (001 & 002) were on display at The Bournemouth Museum. But with the museum closing in early 2008, 002 moved to the Midland Air Museum at Coventry. 001 was on display at the Bournemouth Aviation Museum.

Specifications (second prototype)

General characteristics

- **Crew:** One pilot
- **Capacity:** 3 passengers
- **Length:** 24 ft 9 in (7.54 m)
- **Wingspan:** 23 ft 6 in (7.16 m)
- **Height:** 6 ft 9 in (2.06 m)
- **Wing area:** 63 ft² (5.85 m²)
- **Powerplant:** 2 × Williams FJX-1, 700 lbf (3.1 kN) each

Performance

- **Maximum speed:** 540 mph (869 km/h)
- **Range:** 1,726 miles (2,778 km)
- **Service ceiling:** 55,000 ft (16,765 m)
- **Rate of climb:** 6,340 ft/min (32.7 m/s)

Chapter 10

Canadian Business Aircrafts

Bombardier Global Express

Global Express / Global 5000

A Global Express of Tyrolean Jet Service landing at Frankfurt Airport

Role	Business jet
National origin	Canada
Manufacturer	Bombardier Aerospace
First flight	October 13, 1996
Introduced	1993
Status	In Service
Number built	400 (as of November 11, 2010)
Unit cost	Global Express XRS:US $45 million (2008$) Global 5000:US $40 million (2008$)
Variants	Raytheon Sentinel

The **Bombardier Global Express** is an ultra long range corporate and VIP high speed jet aircraft produced by Bombardier Aerospace. The **Bombardier Global 5000** is a slightly shorter version. The Global Express has also been modified for military missions, such as the Raytheon Sentinel.

Design and development

Bombardier Aerospace began studies in 1991 and the aircraft was officially launched in 1993. The first flight occurred on October 13, 1996. The Global Express shares the Canadair Regional Jet's fuselage cross section and is similar in length, but despite the size similarities the two aircraft are very different due to the nature of their roles. The Global Express features an advanced all new supercritical wing with a 35° sweep and winglets, plus a new T-tail. The aircraft is powered by two BMW RollsRoyce BR-710 turbofans with FADEC. The advanced flightdeck features a six screen Honeywell Primus 2000 XP EFIS suite and is offered with optional heads-up displays.

Bombardier Global Express takes off

The Global Express was announced on October 28, 1991 at the NBAA convention. Full-scale cabin mockup was exhibited at the NBAA convention in September 1992. Conceptual design started early 1993 and the programme was officially launched on December 20, 1993. The aircraft high-speed configuration was frozen in June 1994 and the low-speed configuration was established in August 1994.

The Global Express can fly intercontinental ranges without refueling (e.g. New York–Tokyo) or between most two points in the world with only one stop. In this class the Global Express competes with the Airbus Corporate Jet, Boeing Business Jet, Dassault Falcon 7X and Gulfstream G550.

Bombardier subsidiaries have three specific roles in the project: Canadair is the design leader and manufactures the nose; Short Brothers, Belfast is responsible for the design and manufacture of the engine nacelles, horizontal stabiliser and forward fuselage; and de Havilland Canada builds the rear fuselage and vertical tail and carries out final assembly. The major external supplier is Japan's Mitsubishi Heavy Industries which builds the wing and centre fuselage sections.

Global Express XRS

The **Global Express XRS** is an improved version of the original aircraft, (announced on October 6, 2003 during the NBAA Convention at Orlando (Florida)) offering higher cruise speed, increased range, improved cabin layout and lighting. It is reported that the letters have no significance, but were chosen by focus groups simply to improve the brand image. The range increase is achieved by addition of a 1,486 lb (674 kg) fuel tank at the wing root. The Global Express XRS entered service in early 2006. The unit price is estimated to be $45.5 million (US). Bombardier claims it takes 15 minutes less to fuel the XRS than the original model thanks to improved computer systems and mechanical refinements.

Global 5000

A Global 5000 takes off

Global 5000

The **Global 5000** (model designation BD-700-1A11) is a derivative based on Global Express, with 0.813 m (32 in) reduction in forward fuselage length, and 1,200 nm reduction in maximum range. Seating capacity is up to 19 passengers. The aircraft was announced at a special event on October 25, 2001 in Montreal. The official launch came (with a slight delay) on 5 February 2002, after a positive market assessment with letters of intent for 15 aircraft.

The aircraft is manufactured by Bombardier Aerospace in Toronto, Canada, and flown "green" to Montreal, St. Louis or Savannah for final completion.

The Global 5000 is built on the same production line as the Global Express XRS, and the two types' serial numbers are intermingled.

The first Global 5000 aircraft (s/n 9127) took off from Bombardier's Downsview, Ontario facility under clear skies, at 12:24 p.m. EST and returned at 4:08 p.m. EST on March 7, 2003. During the course of its three-hour, 44-minute flight northwest of Toronto, it reached a maximum altitude of 45,000 feet (13,716 m), and a maximum indicated airspeed of 340 knots (391 mph; 630 km/h). The flight was dedicated to testing basic system functionality and assessing the aircraft's handling and flying qualities. Captain Craig Tylski, principal engineering test pilot, Bombardier Flight Test Center, flew the aircraft with co-pilot Gary Bruce, senior engineering test pilot. Also on board was flight test engineer Scott Runyan. Loaded with 23,000 pounds (10,433 kg) of fuel, the aircraft's takeoff weight was 77,600 pounds (35,199 kg). The aircraft completed its preliminary

testing at Bombardier's Downsview facility, before it moved to Bombardier's Wichita facility to begin the flight test program. The Global 5000 made its first appearance at the Paris Air Show in June 2003.

The Global 5000 can fly close to 5,000 nautical miles (9,300 km) nonstop at Mach 0.80. The average trip lengths for most operators is 2.5 hours where the aircraft will cruise between Mach 0.85 and Mach 0.89, making it one of the fastest long range jets available today.

Typical configuration features 18 passenger seats including fully berthable seats and an aft lounge/bedroom. The aircraft has a full galley and two lavatories. The crew rest area was removed, but is being considered on newer versions.

Originally, the maximum takeoff weight was 89,700 lb (40,700 kg). With typical equipment and passenger accoutrements, the empty weight was 52,000–55,000 pounds (22,600–25,000 kg). In April 2008, Bombardier announced that the certified gross weight had been increased to 92,500 lb (41954 kg), which permitted an increased fuel load—projected maximum range increased to 5,200 nm (9637 km).

The maximum certified altitude is 51,000 ft (16,000 m) The typical approach speed is 108 knots (200 km/h) requiring approximately 2,600 feet (790 m) of runway for landing. Template:Prose-section Global 5000 changes compared to the Global Express are:

- Fuselage shortened by 0.813 m (32 in).
- Removal of the fuel tank in the tail and limiting fuel in the wings.
- Reduction in MTOW by 5,500 pounds (2,500 kg).
- Reduction in maximum range by 1,200 nm.
- Rearrangement of some avionics to gain usable cabin length.
- generous allowance for interior completions (3200 kg).

Variants

- **Global Express** - (model designation BD-700-1A10) is the basic model.
- **Global Express XRS** -
- **Global Express 5000** -
- **Raytheon Sentinel** -

Operators

Military operators

 Botswana

- Botswana Air Force - operates a single BD-700-1A10 for VIP transport.

 Germany

- Luftwaffe - 4 ordered

Malaysia

- Royal Malaysian Air Force - 1

United Kingdom

- Royal Air Force - 5

Mexico

- Mexican Air Force - 1 ordered

Civilian operators

- Orion Air Group, LLC.
- Ion Țiriac Air
- Albninati Aeronautics
- TAG Aviation
- Tyrolean Jet Services
- Global jet luxembourg
- ACM Air Charter
- VistaJet Holding SA

Specifications

Global Express XRS

General characteristics

- **Crew:** Two (minimum) - four (typical)
- **Capacity:** 8-19 passengers
- **Length:** 99 ft 5 in (30.3 m)
- **Wingspan:** 94 ft 0 in (28.65 m)
- **Height:** 24 ft 10 in (7.57 m)
- **Wing area:** 1,022 ft² (94.9 m²)
- **Empty weight:** 49,750 lb (22,600 kg)
- **Useful load:** 1,775 lb (w/full fuel) (805 kg)
- **Max takeoff weight:** 99,500 lb (44,500 kg)
- **Powerplant:** 2× Rolls-Royce Deutschland BR710A2-20 turbofans, 14,750 lbf (65.5 kN) each
- **Cabin length:** 48 ft 4 in (14.73 m)
- **Cabin max width (centerline):** 8 ft 2 in (2.49 m)
- **Cabin max width (floorline):** 6 ft 11 in (2.11 m)
- **Cabin height:** 6 ft 3 in (1.91 m)

- **Cabin floor area:** 335 ft² (31.1 m²)

Performance

- **Maximum speed:** Mach .89 (513 kt, 590 mph, 950 km/h)
- **Cruise speed:** Mach .85 (488 kt, 564 mph, 907 km/h)
- **Range:** 6,325 nm (7,080 mi, 11,390 km)
- **Service ceiling:** 51,000 ft (15,500 m)
- **Wing loading:** 95.9 lb/ft² (468 kg/m²)
- **Thrust/weight:** 0.301
- **Balanced field length (SL, ISA, MGTOW):** 6,120 ft (1,870 m)
- **Landing distance (SL, ISA, MLW):** 2,670 ft (814 m)

Global 5000

General characteristics

- **Crew:** Two - Three
- **Capacity:** 8 in a typical configuration, up to 19 in high density arrangement
- **Length:** 96.8 ft (29.5 m)
- **Wingspan:** 94 ft 0 in (28.65 m)
- **Height:** 25.5 ft (7.7 m)
- **Wing area:** 1,882 ft² (53.29 m²)
- **Useful load:** 1,775 lb (w/full fuel) (805 kg)
- **Max takeoff weight:** 92,750 lb (42,071 kg)
- **Powerplant:** 2× Rolls-Royce Deutschland BR710A2-20 turbofans, 14,750 lbf (65.6 kN) each
- **Cabin length:** 42.47 f (12.94 m)
- **Cabin width (centerline):** 8.17 ft (2.49 m)
- **Cabin width (floorline):** 6.92 ft (2.11 m)
- **Cabin height:** 6.25 ft (1.91 m)
- **Cabin floor area:** 317 ft² (29.4 m²)
- **Cabin Total Volume 1,884 ft³ (53.9 m³)**

Performance

- **Maximum speed:** Mach .89 (513 kt, 590 mph, 950 km/h)
- **Cruise speed:** Mach .85 (488 kt, 562 mph, 904 km/h)
- **Range:** 5,200 nm (9,360 km)
- **Service ceiling:** 51,000 ft (15,000 m)
- **Basic Operating Weight:** 50,840 lb (23,061 kg)
- **Maximum Ramp Weight:** 92,750 lb (42,071 kg)
- **Maximum Takeoff Weight:** 92,500 lb (41,957 kg)
- **Maximum Zero Fuel Weight:** 56,000 lb (25,401 kg)
- **Maximum Fuel Weight** 39,250 lb (17,804 kg)
- **Balanced field length (SL, ISA, MTOW):** 5,540 ft (1,689 m)

- **Landing distance (SL, ISA, MLW):** 2,670 ft (814 m)

Avionics

- Rockwell Collins Pro Line Fusion avionics suite

Bombardier Challenger 600

Challenger 600/601/604/605

Bombardier CL-604, built 2001

Role	Business jet
Manufacturer	Bombardier Aerospace
First flight	8 November 1978
Status	In production

The **Bombardier Challenger 600 series** is a family of business jets designed by Bill Lear and produced first by Canadair until that company was bought by Bombardier Aerospace in 1986.

Development

The aircraft was an independent design by Bill Lear in 1976, who had resigned as Chairman of Lear Jet seven years previously. Originally dubbed the **LearStar 600**, Lear sold exclusive rights to produce and develop the design to Canadair, who renamed it the **CL-600 Challenger**.

While similar in general configuration to Lear's previous designs, notable changes were made that distinguished the new aircraft from the Learjets, including the use of a widened fuselage that allowed a 'walk-about cabin', a feature not shared by any other business aircraft of the time. The Challenger was also one of the first bizjets designed with a supercritical wing.

On 8 November 1978, the prototype aircraft took off at Montreal, Canada. The second and third prototypes flew in 1979. An 3 April 1980 test flight in the Mojave Desert resulted in disaster, the aircraft crashing due to a deep stall, killing one of the test pilots (the other test pilot and the flight test engineer parachuted to safety).

Despite the crash, both Transport Canada and the Federal Aviation Administration in the United States certified the aircraft in 1980, albeit with restrictions to pilots including a limited maximum take-off weight. A program to reduce the aircraft's weight was then implemented to improve the aircraft's range.

Challengers can be identified visually by their distinctive fowler flap design, where the fairings can be seen below the wings, a sight much more common on commercial airliners.

Variants

Bombardier Challenger 601 shortly after take off. The main undercarriage wheels are left exposed during flight

Bombardier Challenger 605 at the Paris Air Show 2007

CL-600

- **CL-600** - original production version, powered by Avco Lycoming ALF 502L turbofans of 7,500 lbf (33.6 kN) thrust each. Built until 1983 (83 built)
  - **CL-600S** - 76 CL-600s retrofitted with the winglets introduced on the CL-601-1A. 12 aircraft purchased by Canadian Forces Air Command, named **CC-144**, **CE-144**, and **CX-144**.

CL-601

- **CL-601-1A** - refined version including winglets to reduce drag and more powerful General Electric CF-34 engines. (66 built, including 4 Canadian Forces CL-144/ CC-144B)
  - **CL-601-1A/ER** - 601-1A retrofitted with an additional fuel tank in the tail
- **CL-601-3A** - engine with a higher flat rating and a glass cockpit. This was the first version marketed by Bombardier.
  - **CL-601-3A/ER** - 601-3A with an additional, optional fuel tank in the tail
- **CL-601-3R** - the tail tank was made standard, and airline style 'unsided' engines (no left or right) were used, matching what was used on the CRJ.

CL-604

CL-604 of the Royal Danish Air Force at RIAT 2010

- **CL-604** - major upgrade of the 601 design, incorporating more powerful engines, larger fuel supply, including saddle tanks in the rear of the aircraft, new undercarriage for a higher takeoff and landing weight, structural improvements to wings and tail, and a new Collins ProLine 4 avionics system. The **C-143A** is a single Challenger 604 aircraft, which was acquired by the United States Coast Guard in December 2005 as its new Medium Range Command and Control Aircraft (MRC2A).

    - **CL-604 Multi-Mission Aircraft** - militarized version in Danish service. The aircraft are employed on maritime patrol and Search and Rescue missions. They are capable of landing on the short, rough, gravel airstrips common in the Arctic.

CL-605

- **CL-605** - introduced in early 2006 as an avionics and structural upgrade of the 604 design. Structural improvements include larger cabin windows. Cockpit instrumentation updated with the Collins Proline 21 avionics and "electronic flight bag" capability. It can be visually identified by a new, rounded tailcone.

CL-610

- **CL-610 Challenger E** was to have been a stretched version with seating for 24 passengers. Development was halted by Canadair in 1981 without any having been built. A few years later, a new project would develop the Canadair Regional Jet based on a stretched Challenger design.

Operators

Military operators

The Challenger 601 is used to transport the Canadian Royal Family, Governor General, and Prime Minister using the designation CC-144 Challenger.

U.S. Coast Guard VC-143 Challenger provides VIP transport for high-ranking members of the Department of Homeland Security and U.S. Coast Guard using the designation *Coast Guard 02*.

Argentina

- Argentine Air Force

Australia

- Royal Australian Air Force
  - No. 34 Squadron RAAF

Canada

- Canadian Forces - designated as the Bombardier CC-144 Challenger
  - No. 412 Squadron
  - No. 434 Squadron (former)

China

- People's Liberation Army Air Force

Croatia

- Croatian Government (EMS and VIP Transport)

Czech Republic

- Czech Air Force

Denmark

- Royal Danish Air Force

Germany

- Luftwaffe

United States

- United States Air Force
- United States Coast Guard - designated as the Bombardier VC-143 Medium Range Command and Control Aircraft.

Civilian operators

- VistaJet Holding SA
- Nomad Aviation SA

Specifications (CL-601-3A)

General characteristics

- **Crew:** Two (pilot & co-pilot)
- **Capacity:** Up to 19 passengers, depending on configuration
- **Length:** 20.85 m (68 ft 5 in)
- **Wingspan:** 19.61 m (64 ft 4 in)
- **Height:** 6.30 m (20 ft 8 in)
- **Wing area:** 48.3 m² (520 ft²)
- **Empty weight:** 9,292 kg (20,485 lb)
- **Loaded weight:** 19,618 kg (43,250 lb)
- **Useful load:** 1,814 kg (4,000 lb)
- **Max takeoff weight:** 19,550 kg (43,100 lb)
- **Powerplant:** 2× General Electric CF34-3A turbofans, 40.7 kN (9,140 lbf) each

Performance

- **Maximum speed:** 882 km/h (476 knots, 548 mph)

- **Cruise speed:** 851 km/h, (459 knots, 529 mph)
- **Range:** 6,236 km (3,366 nm, 3,875 mi)
- **Service ceiling:** 12,500 m (41,000 ft)
- **Rate of climb:** 1,355 m/min (4,450 ft/min)

Bombardier Challenger 300

Challenger 300

A Bombardier Challenger 300 lifts off from London Luton Airport

Role	Business jet
Manufacturer	Bombardier Aerospace
First flight	14 August 2001
Status	In production
Unit cost	U$20 million

Bombardier Challenger 300

TAG Aviation Challenger 300

The **Bombardier Challenger 300** is a super-mid-sized jet capable of traversing transcontinental distances. It is not developmentally related to the similarly named Challenger 600-series or the 600-series derived 800-series.

Design and development

The project was launched at the Paris Air Show on July 13, 1999, at which time it was called the **Bombardier Continental**. The jet was renamed in September 2002, and entered commercial service in January 2004.

Specifications (Challenger 300)

General characteristics

- **Crew:** Two (pilot & co-pilot)
- **Capacity:** Up to 16 passengers (normally 8)
- **Length:** 20.93 m (68 ft 8 in)
- **Wingspan:** 19.46 m (63 ft 10 in)
- **Height:** 6.20 m (20 ft 4 in)
- **Wing area:** 48.5 m² (522 ft²)
- **Empty weight:** 10,591 kg (23,349 lb)
- **Useful load:** 7031 kg (15,501 lb)
- **Max takeoff weight:** 17,622 kg (38,850 lb)
- **Powerplant:** 2× Honeywell HTF7000 turbofan engines, 30.4 kN (6,825 lbf) each

Performance

- **Maximum speed:** 0.84 Mach (481 knots,553 mph,891 km/h)
- **Range:** 5,741 km (3,100 NM, 3,568 mi) at 0.78 Mach
- **Service ceiling:** 13,716 m (45,000 ft)
- **Rate of climb:** 25.4 m/s (5,000 ft/min) at 17,622 kg (38,850 lb) max gross weight
- **Wing loading:** 359.5 kg/m² (73.52 lb/ft²)

Bombardier Challenger 850

Challenger 800 / 850

Challenger 850 C-GWWW at Manchester May 2008

Role	Business jet
Manufacturer	Bombardier Aerospace
Status	In production
Developed from	Bombardier CRJ200

The **Bombardier Challenger 800** is the largest super-mid size business aircraft offered by Bombardier Aerospace. It is based on Bombardier's 50-seat CRJ200LR. The **Challenger 850** is the updated, current version.

Design and development

The **Challenger 850** is derived from the Bombardier CRJ200 airliner. It is capable of accommodating 15-19 passengers. The Challenger 850 jet has a transcontinental range and a high-speed cruise of Mach 0.80.

The average price for the Challenger 850 is $31.862 million.

Specifications

General characteristics

- **Crew:** 2 + 1
- **Capacity:** 15 to 19 passengers
- **Length:** 87.83 ft (26.77 m)
- **Wingspan:** 69.58 ft (21.21 m)
- **Height:** 20.42 ft (6.22 m)
- **Wing area:** 520.4 ft^2 (48.35 m^2)
- **Empty weight:** 34,790 lb (15,780 kg)
- **Useful load:** 18,210 lb (8,261 kg)

- **Max takeoff weight:** 53,250 lb (24,041 kg)
- **Powerplant:** 2× General Electric CF34-3B1 turbofan engines, 8,729 lbf (38.84 kN) each

Performance

- **Cruise speed:** 442 kts (819 km/h)
- **Range:** 2,811 nm (5,206 km)
- **Service ceiling:** 41,000 ft (12,497 m)
- **Balanced field length (SL, ISA, MTOW):** 6,305 ft (1,922 m)
- **Landing distance (SL, ISA, MLW):** 2,910 ft (887 m)
- Noise Level (EPNdB): Flyover: 78.8, Approach: 92.1, Lateral: 82.4

Chapter 11

French Business Aircrafts

Aérospatiale Corvette

SN 601 Corvette

Aérospatiale Corvette

Role	Business jet
Manufacturer	Aérospatiale
First flight	16 July 1970
Produced	1974 - 1977
Number built	40

The **Aérospatiale SN 601 Corvette** is a French business jet of the early 1970s, Aérospatiale's only venture into that market. Sales were disappointing, and only 40 prototype and production Corvettes were built.

Design and development

Design work began in the second half of the 1960s as a joint venture between Sud Aviation and Nord Aviation. In January 1968 Sud and Nord decided to proceed with the programme after SNECMA announced it was developing a suitable engine, the M49 Larzac. The SN 600 was first shown to the public as a scale model, on display described as the **SN 600 Diplomate** at the 1968 Hannover ILA Air Show. It was a conventional design for its class, a low-wing monoplane with turbofan engines mounted in rear fuselage nacelles. The prototype SN 600 first flew on 16 July 1970 with two Pratt & Whitney Canada JT15Ds installed; the Larzac was never fitted to the aircraft as it was still in development over a year after the SN 600 crashed on 23 March 1971.

The first of two prototype **SN 601**s (by this time called **Corvette 100**), with a fuselage 3 ft 5½ in (1.05 m) longer than the SN 600's 41 ft 11½ in (12.79 m), flew for the first time on 20 December 1972. In late 1976 Aérospatiale decided to cease production after the company had only received orders for 27 aircraft in the two-and-a-half years following the type's certification (it had hoped to sell six per month). Aérospatiale studied a version with a further fuselage stretch to accommodate 18 seats, to be called the **Corvette 200**, but SN 601 production ended before any had been built.

Operational history

SN601 Corvette of Sterling Airways at Brussels Airport in 1985

A number of Corvettes sold were used by French regional airlines Air Alsace, Air Alpes, Air Champagne and TAT. Sterling Airways of Denmark also operated the type. One

Corvette was used as a VIP transport by the Congolese Air Force. As of January 2009 a small number of Corvettes are still active in Europe and Africa, including one (F-GPLA cn 28) in France fitted out for aerial photography. This Corvette was used in the TGV high speed test as a chase vehicle/aircraft.

Airbus industries used a fleet of five Corvettes for internal transportation from 1981 to 2009.

Variants

SN 600
: The first Corvette prototype, powered by two 2,200 lbf (9.8 kN) thrust Pratt & Whitney Canada JT15D-1 turbofan engines.

SN 601
: Production version with longer fuselage than SN 600 and 2,500 lb (11.1 kN) thrust JT15D-4 engines. 39 built, including two prototypes.

Operators

 Algeria

- Air Algerie

 Belgium

- Sotramat

 Benin

- Government of Benin

 Central African Republic

- Government of the Central African Republic

 Congo

- Congolese Air Force

 Denmark

- Sterling Airways

 France

- Aero Vision
- Air Alsace

- Air Alpes
- Air Languedoc
- Centre d'Essais en Vol
- Protection Civile
- Cogesat
- SFACT
- Sterlings Airways
- TAT European Airlines
- Uni-Air

 Gabon

- Air Inter Gabon

 Netherlands

- Jetstar Holland

 Senegal

- Air Africar

 Sweden

- Scan Fly

 United States

- Aero Service Corporation
- Air National

Accidents

Including the prototype SN 600, a total of seven Corvettes are recorded as having been written-off in crashes. The worst loss of life in a Corvette crash was on 3 September 1979, when an SN 601 of Sterling Airways crashed in the Mediterranean Sea off Nice following a double engine failure. All ten occupants were killed.

On March 19, 1998 a Corvette crashed in Portland, Oregon after the pilots decided to take off with only the portside engine running, while the starboard one was inoperational due to a damaged engine starter. Nobody was injured, while the aircraft suffered damage after only a short flight.

Specifications (SN 601)

General characteristics

- **Crew:** 1 or 2 pilots
- **Capacity:** 6 to 14 passengers, depending on configuration
- **Length:** 13.83 m (45 ft 4½ in)
- **Wingspan:** 12.87 m (42 ft 2½ in)
- **Height:** 4.23 m (13 ft 10½ in)
- **Wing area:** 22.00 m² (236.8 sq ft)
- **Aspect ratio:** 7.45
- **Empty weight:** 3,510 kg (7,738 lb)
- **Max takeoff weight:** 6,600 kg (14,550 lb)
- **Powerplant:** 2× Pratt & Whitney Canada JT15D-4 turbofan, 11.12 kN (2,500 lbf) each

Performance

- **Maximum speed:** 760 km/h (410 knots, 472 mph) at 9,000 m (30,000 ft) (max cruise)
- **Cruise speed:** 566 km/h (306 knots, 352 mph) at 11,900 m (39,000 ft) (econ cruise)
- **Stall speed:** 168 km/h (91 knots, 105 mph) flaps and wheels down
- **Range:** 2,555 km (1,380 nmi, 1,588 mi) (econ cruise power, with tip tanks, 45 min reserves)
- **Service ceiling:** 12,500 m (41,000 ft)
- **Rate of climb:** 13.7 m/s (2,700 ft/min)

Dassault Falcon 900

Falcon 900

A Dassault Falcon 900B of Gazpromavia at Pulkovo Airport in Saint Petersburg

Role	Business jet
National origin	France
Manufacturer	Dassault Aviation
First flight	21 September 1984
Primary users	French Air Force Japan Coast Guard Nigerian Air Force Royal Malaysian Air Force
Number built	260
Developed from	Dassault Falcon 50
Variants	Dassault Falcon 2000 Dassault Falcon 7X

The **Dassault Falcon 900** is a French-built corporate jet aircraft made by Dassault Aviation. It, and its larger sibling the Falcon 7X, are the only trijets in production. Both aircraft are notable in featuring an S-duct central engine.

Development

The Falcon 900 is a development of the Falcon 50, itself a development of the earlier Falcon 20. The Falcon 900 design incorporates composite materials.

Improved models include the **Falcon 900B**, featuring improved engines and increased range, and the **Falcon 900EX** featuring further improvements in engines and range and an all-glass flight deck. The **Falcon 900C** is a lower-cost companion to the Falcon

900EX and replaces the Falcon 900B. Later versions are the **Falcon 900EX** EASy and the **Falcon 900DX**. At EBACE 2008, Dassault announced another development of the 900 series; the Falcon 900LX incorporating High Mach Blended Winglets designed by Aviation Partners Inc. The same winglets are being developed for the entire Falcon 900 series as a retrofit kit with certification planned for 2011.

Pre-owned value: $18,000,000-$40,000,000

Operational service

Dassault Falcon 900EX

Dassault Falcon 900 at Centennial Airport

A Falcon 900 on Sal Island, Cape Verde

Dassault Falcon 900B lands at Birmingham International Airport, England

Italian Air Force Falcon 900EX in 2008

The Falcon 900 is used by the *Escadron de transport, d'entraînement et de calibrage* which is in charge of transportation for officials of the French state.

Variants

Falcon 900
: Original production. Powered by three 20 kN (4,500 lbf) Garrett TFE731-5AR-1C turbofan engines.

Falcon 900 MSA
: Maritime patrol version for Japan Coast Guard. Equipped with search radar and hatch for dropping rescue stores.

Falcon 900B
: Revised production version from 1991. Powered by 21.13 kN (4,750 lbf) TFE731-5BR-1C engines.

Falcon 900EX
: Long range version, with 22.24 kN (5,000 lbf) TFE731-60 engines and more fuel to give range of 8,340 km (5,180 miles). Improved avionics. Entered service 1996.

Falcon 900C
: Replacement for 900B with improved avionics. Introduced 2000.

Falcon 900DX
: Current medium range production type. TFE731-60 engines.

Falcon 900LX
: Variant of EX fitted with Blended Winglets designed by Aviation Partners Inc.. Improved range of 8,890 km (5,525 miles).

Operators

Civil operators

A wide range of private owners, businesses and small airlines operate Falcon 900s.

Military operators

 Algeria

- Algerian Air Force

 Australia

- Royal Australian Air Force - five in service from 1989-2003.
  - No. 34 Squadron RAAF

 Belgium

- Belgian Air Component

 Bolivia

- Bolivian Air Force

 France

- French Air Force

 Gabon

- Gabon Air Force

 Italy

- Italian Air Force

 Japan

- Japan Coast Guard

 Malaysia

- Royal Malaysian Air Force

 Namibia

- Namibian Air Force

 Nigeria

- Nigerian Air Force

 South Africa

- South African Air Force

 Spain

- Spanish Air Force

 Syria

- Syrian Air Force

 United Arab Emirates

- United Arab Emirates Air Force

Venezuela

- Venezuelan Air Force

Specifications (Falcon 900B)

General characteristics

- **Crew:** Two
- **Capacity:** 19 passengers
- **Length:** 20.21 m (66 ft 4 in)
- **Wingspan:** 19.33 m (63 ft 5 in)
- **Height:** 7.55 m (24 ft 9.5 in)
- **Wing area:** 49 m² (527 ft²)
- **Empty weight:** 10,255 kg (22,608 lb)
- **Max takeoff weight:** 20,640kg (45,503 lb)
- **Powerplant:** 3× Honeywell TFE731-5BR-1C turbofan, 21.13 kN (4,750 lbf) each

Performance

- **Maximum speed:** Mach 0.84-0.87
- **Cruise speed:** 950 km/h (513 knots, 590 mph) at 36,000ft (10,970 m) (Mach 0.85)
- **Stall speed:** 158 km/h (85 knots, 98 mph) (wheels and flaps down)
- **Range:** 7,400 km (3,995 nm, 4,598 mi) (7 passengers)
- **Service ceiling:** 15,500 m (51,000 ft)
- **Wing loading:** 435kg/m² (91lb/ft²)

Dassault Falcon 7X

Falcon 7X

Rossiya Falcon 7X in May 2010.

Role	Business jet
Manufacturer	Dassault Aviation
First flight	5 May 2005
Status	In production
Unit cost	US$50m

The **Dassault Falcon 7X** is a large-cabin, long range business jet manufactured by Dassault Aviation, the flagship offering of their business jet line. It was first presented to the public at the 2005 Paris Air Show.

Development

The aircraft has over 200 orders to date. It has received its Type certification from both FAA and EASA on 27 April 2007. The first 7X, MSN05, entered service on June 15 2007; the hundredth was delivered in November 2010.

In 2001, the Falcon 7X, at approximately $35 million, was nearly $10 million cheaper than its nearest competitors in the long range, large cabin market segment, the Gulfstream G550 and Bombardier Global Express. Its 2007 cost is $41 million. As of 2008, the approximate unit cost of the 7X is $50 million.

Design

Dassault Falcon 7X at Paris—Le Bourget

It is the first fully fly-by-wire business jet. It is also equipped with the same avionics suite, the Honeywell Primus EPIC "Enhanced Avionics System" (EASy), that was used on the Falcon 900EX and later on the Falcon 2000EX.

The Falcon 7X is notable for its extensive use of computer-aided design, the manufacturer claiming it to be the "first aircraft to be designed entirely on a virtual platform", using Dassault Systemes' CATIA and PLM products.

It is also unusual in having an S-duct central engine, and is one of only two trijets currently in production, the other being the Dassault Falcon 900 (the Russian Tupolev Tu-154 is on a limited production run since 1998 as the **Tu-154M**). It was also the first production Falcon jet to offer winglets.

Specifications (Falcon 7X)

General characteristics

- **Crew:** Three (pilot/co-pilot & 1 cabin crew)
- **Capacity:** Up to 14 passengers (not including crew)
- **Length:** 23.19 m (76 ft 1 in)
- **Wingspan:** 26.21 m (86 ft)

- **Height:** 7.863 m (25 ft 8 in)
- **Wing area:** 70.7 m² (761 ft²)
- **Empty weight:** 15,456 kg (34,072 lb)
- **Useful load:** 15,843 kg (34,928 lb)
- **Max takeoff weight:** 31,750 kg (70,000 lb)
- **Powerplant:** 3× Pratt & Whitney Canada PW307A turbofans, 28.46 kN (6,400 lbf) each

Performance

- **Maximum speed:** 953 km/h (515 knots, 593 mph)
- **Cruise speed:** 900 km/h (486 knots, 559 mph)
- **Range:** 11,019 km (5,950 nm) 8 passengers
- **Service ceiling:** 15,545 m (51,000 ft)
- **Wing loading:** 435 kg/m² (91 lb/ft²)

Avionics

- Falcon EASy

Chapter 12

German Business Aircrafts

HFB-320 Hansa Jet

Hansa Jet

Hamburger Flugzeugbau HFB-320 Hansa Jet of the Luftwaffe at Basle Airport

Role	Business jet
Manufacturer	Hamburger Flugzeugbau
First flight	21 April 1964
Retired	24 June 1994
Number built	≈45

The **HFB-320 Hansa Jet** is an all-metal, twin-engine, 10-seat business jet built by German aircraft manufacturer Hamburger Flugzeugbau between 1964 and 1973.

The most notable feature of the aircraft is its forward-swept wing, which is mid-mounted in the fuselage. This arrangement allows the wing spar to pass through the fuselage behind the passenger cabin without decreasing cabin volume. As of 2011, it remains the only civilian jet ever to use a forward-swept wing.

Development

The prototype first flew on April 21, 1964 and was followed by a second prototype on October 19 of the same year. On May 12, 1965, the first prototype was lost in an accident caused by a design issue with the T-tail. Hamburger Flugzeugbau's chief test pilot perished in the crash. As a result of the accident, modifications were made to improve the aircraft's stall performance, including a stick pusher on production models. Assembly of the first ten production aircraft began in May 1965, with the first flying on February 2, 1966 and two others shortly thereafter. Certification was achieved in 1967, and General Air of Hamburg took first customer delivery in March 1968.

The Luftwaffe had ordered 13 HFB-320s in 1963. As part of the evaluation of the type, two production aircraft were delivered to the Est61 wing at Oberpfaffenhoffen in 1966. Production deliveries for use as VIP transports commenced in 1969.

Increased competition from newer executive jet models and a comparatively poor safety record led to dwindling orders, with production ceasing in 1973. The Aviation Safety Network lists a total of nine accidents (six fatal) for the type, an astounding 20 percent hull-loss rate, but only the crash of the prototype was directly attributable to the aircraft's design. Pilot error was blamed in a majority of the accidents.

Military operators

 West Germany

- Luftwaffe

Specifications (HFB 320)

General characteristics

- **Crew:** Two
- **Capacity:** 7, 11 or 15 passenger configurations
- **Length:** 16.61 m (54 ft 6 in)
- **Wingspan:** 14.48 m (47 ft 6 in)
- **Height:** 4.92 m (16 ft 2 in)
- **Wing area:** 30.14 m² (324.4 ft²)
- **Empty weight:** 5,511 kg (12,125 lb)
- **Max takeoff weight:** 9,218 kg (20,280 lb)
- **Powerplant:** 2× General Electric CJ610-5 turbojet engines, 13.15 kN (2,950 lbf) each

Performance

- **Cruise speed:** 825 km/h (445 knots, 513 mph)
- **Range:** 2,413 km (1,303 nm, 1,500 mi)

- **Service ceiling:** 11,433 m (37,500 ft)
- **Rate of climb:** 21.6 m/s (4,250 ft/min)

Grob GF 200

GF 200

Role	Business aircraft
National origin	Germany
Manufacturer	Grob Aircraft
First flight	26 November 1991
Number built	1

The **Grob GF 200** was a business aircraft of unorthodox design developed in Germany during the 1990s. It was a low-wing cantilever monoplane with retractable tricycle undercarriage and a highly streamlined fuselage. The engine was mounted within the fuselage, to the rear of the passenger cabin, and drove the pusher propeller via a driveshaft. The GF 200 has a T-tail, but also a large ventral fin beneath the fuselage. Like other Grob designs, construction throughout was of composite materials, in the case of this particular aircraft, including the driveshaft.

Development commenced in 1983 but was postponed due to concerns about achieving certification for the composite design. However, with financial support from the German government, development commenced in earnest by the end of the decade. The project officially launched at the Hannover Show in May 1988, at which a mockup of the design was displayed and a hope expressed to have the aircraft flying within two years. As it

transpired, the prototype was rolled out in March 1991, in the hope of a first flight by May, and which finally took place on 26 November. The aircraft made its first public appearance at the Berlin Air Show in 1992. Initial flight tests revealed problems with engine cooling and excessive noise. The former concern was addressed by a redesign of the engine air intakes.

The prototype was intended as a test aircraft and technology demonstrator, and lacked many of the refinements that would have been incorporated into a production aircraft, including cabin presurisation, de-icing equipment, and even a complete cabin interior. When Grob was unable to find financial backing to take the design further, the company embarked on the construction of a more "true-to-life" prototype in 1997, the **GF 250**, in the belief that this would prove more attractive to potential business partners.

Further planned developments included the turboshaft-powered **GF 300**, and the **GF 350** with twin turboshaft engines driving a common propeller.

Specifications (GF 200)

General characteristics

- **Crew:** One pilot
- **Capacity:** 4 passengers
- **Length:** 8.70 m (28 ft 6 in)
- **Wingspan:** 11.00 m (36 ft 1 in)
- **Height:** 3.42 m (11 ft 3 in)
- **Wing area:** 12.5 m² (135 ft²)
- **Gross weight:** 1,600 kg (3,527 lb)
- **Powerplant:** 1 × Teledyne Continental TSIOL-550, 230 kW (310 hp)

Performance

- **Cruising speed:** 370 km/h (230 mph)
- **Range:** 1,850 km (1,160 miles)
- **Rate of climb:** 6.2 m/s (1,220 ft/min)

Chapter 13

Israeli Business Aircrafts

IAI Westwind

Jet Commander/Westwind

IAI 1124 Westwind

Role	Business jet
Manufacturer	Israel Aircraft Industries
First flight	2 January 1963
Introduced	1965
Status	Active service
Primary user	Pel-Air
Produced	1965-1987
Number built	442
Developed from	Aero Commander 500
Variants	IAI Astra Gulfstream G100

The **Israel Aircraft Industries (IAI) Westwind** is a business jet that became a cornerstone of the Israeli aircraft manufacturing industry and remained in production for twenty years. Usually set up for seven passengers, it can carry as many as ten, or be quickly reconfigured as a fast air freight aircraft.

Development

The Westwind was originally designed in the United States by Aero Commander as a development of its twin-propeller namesake aircraft, first flying on 2 January 1963 as the **Aero Commander 1121 Jet Commander**. It was of broadly conventional business jet arrangement, with two engines mounted in nacelles carried on the rear fuselage. However the wings were mounted halfway up the fuselage instead of the typical low-wing arrangement of aircraft in this class. After successful testing, the aircraft was put into series production with deliveries to customers beginning in early 1965.

Shortly thereafter, Aero Commander was acquired by North American Rockwell. The Jet Commander created a problem, since Rockwell already had an executive jet of its own design, the Sabreliner, and could not keep both in production because of anti-trust laws. It was therefore decided to sell off the rights to the Jet Commander, which were purchased by IAI in 1968.

Jet Commander production amounted to 150 aircraft in the United States and Israel before IAI undertook a series of modifications to create the **1123 Westwind**. These included stretching the fuselage and increased maximum takeoff, maximum landing, and maximum zero-fuel weights, with the wing modified to incorporate double-slotted flaps and drooped leading edges and tip tanks. The trimmable horizontal stabiliser was also modified to have increased span and more travel. Not long after the aircraft went into production, the original turbojet engines were replaced by more fuel-efficient Garrett TFE731 turbofans There were also numerous airframe modifications, such as drooped leading edges on the wings, a dorsal fin, revised engine pylons and nacelles, and further increases in maximum takeoff, maximum landing, and maximum zero-fuel weights. With improvements to a number of onboard systems incorporated as well, these changes resulted in the **1124 Westwind** delivered from 1976.

In 1976, in the wake of the terrorist takeover of the Savoy hotel in Tel Aviv, the Israeli Air Force decided to use the Westwind as the basis for a maritime patrol aircraft, which became known as the **IAI Sea Scan**.

In 1980 deliveries of the Model 1124A commenced; modifications included a new wing centre-section and the addition of winglets to the tips. The revamped aircraft was called the **Westwind II**, replacing the original design in production. IAI built its last Westwind in 1987, after a total of 442 Jet Commanders and Westwinds had been built, switching production to the Astra.

Variants

Aero Commander

1121 Jet Commander
: Original production version, powered by two General Electric CJ610-1 engines developing 2,850 lbf (12,700 N) each; or modified with two CJ610-5 engines developing 2,950 lbf (13,100 N) each. 120 built including two prototypes.

1121A
: Slightly modified version with CJ610-1 engines. Eleven built.

1121B Commodore
: Version manufactured with CJ610-5 engines. Nineteen built.

1122
: Improved version developed but not put into production; two aircraft built and subsequently converted to 1123 Westwinds.

IAI

Westwind II

1123 Westwind
: Improved version of the 1121. The cabin was stretched by 0.51m (1 ft 8in) and the aircraft was fitted with more powerful CJ610-9 engines developing 3,100 lbf (14,000 N) each and a Microturbo Saphir III auxiliary power unit (APU). 36 built

1124 Westwind
: Greatly improved version powered by two Garrett TFE731-3-1G turbofan engines developing 3,700 lbf (16,000 N) each, APU deleted.

1124 Westwind I
: Name given to 1124 after introduction of Westwind II.

1124N Sea Scan
: Maritime surveillance aircraft.
1124A Westwind II
: Refined version of the 1124 built from 1980 onwards.

Operators

New Zealand
Canada
Chile
Germany
Guatemala
Honduras

- Honduran Air Force

Israel

- Israeli Air Force

Uganda

Specifications (1124A Westwind II)

General characteristics

- **Crew:** Two (pilot & co-pilot)
- **Capacity:** Up to 10 passengers
- **Length:** 15.93 m (52 ft 3 in)
- **Wingspan:** 13.65 m (44 ft 9½ in)
- **Height:** 4.81 m (15 ft 9½ in)
- **Wing area:** 28.64 m² (308.3 ft²)
- **Empty weight:** 6,010 kg (13,250 lb)
- **Max takeoff weight:** 10,660 kg (23,500 lb)
- **Powerplant:** 2× Garrett TFE731-3-1G turbofan engines, 16.46 kN (3,700 lbf) each

Performance

- **Maximum speed:** 868 km/h (469 knots, 539 mph) at 8,840 m (29,000 ft)
- **Cruise speed:** 723 km/h (390 knots, 449 mph) econ cruise, at 11,890–12,500 m (39,000–41,000 ft)
- **Stall speed:** 184 km/h (99 knots, 114 mph) CAS, flaps down, engines idling
- **Range:** 4,430 km (2,392 nmi, 2,770 mi) with maximum payload
- **Service ceiling:** 13,720 m (45,000 ft) (max certificated ceiling)
- **Rate of climb:** 25.4 m/s (5,000 ft/min)

Chapter 14

Italian Business Aircrafts

Piaggio PD.808

PD.808

Piaggio PD.808

Role	Business & military jet
Manufacturer	Piaggio Aero
First flight	29 August 1964
Introduced	November 1966
Primary user	Italian Air Force

The **Piaggio PD.808** was designed by the Douglas Aircraft Company of Long Beach, California, as a business jet. No orders were received, and the complete project was bought by Piaggio Aero, which flew the first prototype in August 1965. Piaggio also failed to secure any worthwhile commercial interest, but a few examples were taken by the Italian Air Force.

Only 24 examples of this type, with low-set wings and aft-mounted turbojet engines, were produced, and 22 of these went to the Italian Air Force. The first aircraft were configured for the utility role, but the last six aircraft were completed as electronic

platforms with cabin accommodation for specialist electronic intelligence equipment and its three operators.

Variants

- **PD-808VIP**: VIP transport
- **PD-808 ECM**: Electronic warfare aircraft
- **PD-808TA**: navigation trainer
- **PD-808RM**: radio calibration
- **PD-808GE**: EW aircraft
- **PD-808TF**: Proposed turbofan-powered version. Not built.

Military operators

- Italy: Italian Air Force

Specifications (P.166)

PD.808 in a special commemorative colour scheme at the aircraft show *Giornata Azzurra* 2006

General characteristics

- **Crew:** two pilots plus mission crew
- **Length:** 12.8 m (42 ft 2 in)
- **Wingspan:** 13.2 m (43 ft 3 in)
- **Height:** 4.8 m (15 ft 9 in)
- **Empty weight:** 4,830 kg (10,650 lb)
- **Max takeoff weight:** 8,165 kg (18,000 lb)
- **Powerplant:** 2× Rolls Royce Viper Mk526 turbojets

Performance

- **Maximum speed:** 852 km/h (529 mph)
- **Range:** 2,128 km (1,148 nmi)

Piaggio P.180 Avanti

P180 Avanti

Aeronautica Militare Piaggio P180 Avanti

Role	Executive transport
Manufacturer	Piaggio Aero
First flight	26 September 1986
Primary users	Italian Armed Force Avantair
Number built	203 delivered to September 2010

Unit cost US$ 7 million

The **Piaggio P180 Avanti** is an Italian twin-engine turboprop aircraft produced by Piaggio Aero. It seats up to nine passengers in a pressurized cabin, and may be flown by one or two pilots.

The innovative design places the main wing behind and above the canard-like horizontal stabiliser, features a laminar flow fuselage and has engines in pusher configuration.

Development

Cockpit and instrument panel aboard a P180 Avanti

The P180 design was tested in wind tunnels in Italy and the U.S. in 1980 and 1981. A collaboration with Learjet to develop the aircraft began in 1983 but ended on 13 January 1986, with Piaggio continuing development on its own. The first prototype flew on 23 September 1986. U.S. and Italian certification was obtained on 7 March 1990. Learjet's influence can be seen in the two "delta fins" mounted on the bottom of the tail, as found on most Learjets; these devices provide aerodynamic recovery force in the event of an aerodynamic stall. The first 12 fuselages were manufactured in Wichita, with H & H Parts and Plessey Midwest, then flown to Italy for final assembly. Avanti Aviation Wichita ran out of money in 1994; the project languished until a group of investors led by Piero Ferrari became involved in 1998. The 100th aircraft was delivered in October 2005

and the 150th in May 2008. Piaggio has reported that as of October 2010, the Avanti and Avanti II fleets have now logged over 500,000 flight hours.

An improved **Avanti II** obtained European and U.S. certification in November 2005. Six months later, 70 planes were already ordered, including 36 by Avantair. The Avanti II features uprated Pratt & Whitney Canada PT6 turboprop engines and flies about 18 km/h (11 mph) faster, with better fuel economy; an all-new "glass panel" avionics suite reduces cockpit clutter. In addition to heading, attitude and navigation information, flat panel color LCD displays add collision avoidance (TCAS), ground proximity (TAWS) and real-time graphic weather depiction.

Design

The Avanti's turboprop engines are placed on a mid-fuselage, high aspect ratio wing, located behind the cabin. The design utilizes both a T-tail and a pair of small, fixed anhedral forward wings that lack control surfaces. The arrangement of the wing surfaces allows all three to provide lift, as opposed to a conventional configuration, where the horizontal stabilizer creates a downward force to counteract the nose-down moment generated by the center of gravity being forward of the center of lift. This is patented as "Three-Lifting-Surface Configuration" (3LSC). The Avanti II's forward wing has flaps that move in concert with main wing flaps. The forward wing pitch angle is set so it stalls before the main wing, producing an automatic nose-down effect; its five degree negative dihedral keeps the stream wash interference clear of the engine inlets, the main wing and the horizontal stabilizer

Distinctive design features include a non-constant cross section cabin, the revolutionary shape of which approximates a NACA airfoil section. Piaggio claims the fuselage contributes up to 20% of the Avanti's total lift, with horizontal stabilizer, front and rear wing providing the remaining 80%. Because of the unusual fuselage shape, the mid cabin is considerably wider than the cockpit, and the entire cabin is ahead of the main wing spar. The front and rear airfoils are custom sections designed by Dr. Jerry Gregorek of The Ohio State University's AARL to achieve a drag-reducing 50% laminar flow at cruise.

The company claims the overall design of the P180 Avanti II enables the wing to be 34% smaller than on conventional aircraft and a specific range of 0.84 nmi/lb of fuel. This is significantly better than the 0.31-0.48 nmi/pound of similar small jets.

The P180 makes a distinctive square wave noise when passing overhead, similar to the Beech Starship, due to the wing wake and engine exhaust effects on the pusher propellers.

Variants

Aeronautica Militare P180 Avanti

P.180 Avanti
: First production version.

P180 M
: **P180 Avanti** military version. Combi configuration for VIP and light utility transport. FLIR, SAR radar and surveillance systems predisposition.

P.180 RM
: Radio calibration. Chaff and flares predisposition.

P.180 AMB
: Ambulance Service.

P.180 APH
: Aerial cartography.

P.180 Avanti II
: Variant with improved avionics.

Operators

Avanti belonging to Vigili del Fuoco, Rome-Ciampino

Avanti parked on tarmac

Avanti at Colorado Springs Municipal Airport

Civil

Bangladesh

- Youngone - 1

Canada

- Avmax International Aircraft - 3
- Bell Aliant - 1
- Cascades Inc. - 2
- Skyservice Business Aviation - 2
- Royal Canadian Mounted Police - 1
- Starlink Aviation - 1

France

- Brittany Ferries - 1
- Pan Européenne Air Service - 1
- Transport'Air - 4

Indonesia

- Susi Air - 2

India

- TajAir - 1

Italy

- Blue Panorama Airlines - 2
- Eurofly Service - 1
- Protezione Civile
- State Forestry Corps - 1
- State Police - 1
- Vigili del Fuoco - 2
- Windjet - 2

Jordan

- Saraya Skies - 3 (3 others in option)

Mexico

- Republicair

Poland

- Lotnicze Pogotowie Ratunkowe (Polish Medical Air Rescue) - 2

Netherlands

- JetNetherlands - 1
- Solid Air - 1

United States

- Avantair - 56 aircraft ordered
- Mountain Aviation - 1

Military

Italy

- Italian Air Force
- Italian Army
- Italian Navy

United Arab Emirates

- United Arab Emirates Air Force ordered two aircraft at the 2009 Paris Air Show.

Specifications (P180 Avanti)

General characteristics

- **Crew:** one or two pilots
- **Capacity:** up to nine passengers
- **Cabin dimensions:** 1.75 m (5 ft 9 in) high, 1.85 m (6 ft 1 in) wide, 4.45 m (14 ft 7 in) long
- **Payload:** 907 kg (2,000 lb)
- **Length:** 14.41 m (47 ft 3½ in)
- **Wingspan:** 14.03 m (46 ft 0½ in)
- **Height:** 3.97 m (13 ft 0¾ in)
- **Wing area:** 16 m² (172.2 ft²)
- **Empty weight:** 3,400 kg (7,500 lb)
- **Useful load:** 1,860 kg (4,100 lb)
- **Max takeoff weight:** 5,239 kg (11,550 lb)
- **Powerplant:** 2× Pratt & Whitney Canada PT6A-66 turboprops, 634 kW (850 shp) each

Performance

- **Maximum speed:** 732 km/h (395 kn, 455 mph)
- **Cruise speed:** 593 km/h (320 kn, 368 mph) (econ cruise)
- **Range:** 2,592 km (1,400 nmi, 1,612 mi) at 11,900 m (39,000 ft) with reserves
- **Service ceiling:** 12,500 m (41,000 ft)
- **Rate of climb:** 14.98 m/s (2,950 ft/min)
- **Wing loading:** 327 kg/m² (67.1 lb/ft²)
- **Power/mass:** 0.24 kW/kg (6.79 lb/hp)

Chapter 15

Japanese Business Aircrafts

Honda HA-420 HondaJet

HA-420 HondaJet

Role	Business jet
National origin	Japan
Manufacturer	Honda Aircraft Company
Designed by	Michimasa Fujino
First flight	3 December 2003
Introduced	2011
Status	Under development
Number built	2 prototypes
Unit cost	US$4.5 million

The **Honda HA-420 HondaJet** is the first aircraft available to the general aviation market to be developed by the Honda Motor Company.

Development

Honda began research into small sized business jets in the late 1980s, using engines from other manufacturers. The Honda MH02, an organic matrix composite prototype, was

fabricated and assembled at Mississippi State University's Raspet Flight Research Laboratory in the late 1980s and early 1990s.

The HondaJet made its maiden flight in December 2003 and was debuted to the public at the EAA AirVenture air show in Oshkosh, Wisconsin, in July 2005. On July 25, 2006, Honda returned to Oshkosh to announce it would commercialize the HondaJet, establishing the Honda Aircraft Company to seek both type and production certification of the HondaJet with production to take place in the United States. The company began taking customer orders for HondaJet in the fall of 2006 at a price of approximately $3.65 million US. The plan is to build 70 jets per year.

In August 2006 Honda and Piper Aircraft announced a partnership to market the HondaJet.

In May 2010, it is reported assembly of major components of the first conforming HondaJet, including the composite fuselage, metal wings, empennage, landing gear and over-the-wing-mounted engine pylons has completed, and work to complete integration of major systems, including electrical, hydraulic and environmental control, has started. The first conforming engine will be delivered in the third quarter of 2010 and be installed on the aircraft. Honda Aircraft is reported to begin static testing of a conforming airframe in May 2010.

Because of delays in some components, maiden flight of the first design- and production-conforming plane was scheduled for November 2010, but actually took place on the 20-21st of December 2010 while FAA certification is expected to follow 20 months later. Delivery of the first plane is planned for the third quarter of 2012.

Design

Honda decided to go with an unusual over-the-wing podded engine configuration, a feature developed on the innovative Vereinigte Flugtechnische Werke VFW-614 decades earlier, which allows for more space within the fuselage and reduction of drag at higher speeds. The fuselage itself is made from lightweight composite materials, while the wings are made from structurally reinforced single sheets of aluminum. The use of a single sheet allows for a smoother surface than more conventional methods. Honda claims that the combination of lightweight materials, aerodynamics and the efficient engines gives the HondaJet a 30-35% higher fuel efficiency than similar aircraft.

Honda began developing its own small turbofan engine, the HF118, in 1999. This led to the evolution of the HF120, which was developed with GE Aviation under the GE Honda partnership, and was test-flown on a Cessna Citation and on a modified Boeing 727-100. The engine features a single fan, a two-stage compressor and a two-stage turbine. Further design testing on wing shape and design were done on a T-33 Shooting Star, modified by AVTEL Services, Inc, and flight tested at the Mojave Airport.

The aircraft is equipped with a touchscreen 3-display Garmin G3000 glass cockpit system (i.e. most of the cockpit readouts are presented on flat-panel displays).

Production

The aircraft will be made at Piedmont Triad International Airport, Greensboro, North Carolina, USA. The plant for making the aircraft was started in 2007 and will be completed by the end of 2011.

Honda expects to sell 70 planes per year.

Specifications (HA-420 HondaJet)

General characteristics

- **Crew:** 1-2 crew members
- **Capacity:** 5 passengers (6 Passengers for AirTaxi)
- **Length:** 41.70 ft (12.71 m)
- **Wingspan:** 39.87 ft (12.15 m)
- **Height:** 13.21 ft (4.03 m)
- **Max takeoff weight:** 9,200 lb (4,173 kg)
- **Powerplant:** 2× GE Honda HF120 turbofan engines, 1,880lbf each (Bypass Ratio= 2.9) (8.04kN) each

Performance

- **Maximum speed:** 420 KTAS (778 km/h, 483 mph)
- **Cruise speed:** 420 KTAS (FL300)
- **Range:** 1400 nm (1611 mi, 2,593 km) (VFR Range)
- **Service ceiling:** 43,000 ft (13,107 m)
- **Rate of climb:** 3990 ft/min (20.27 m/s)

Avionics

Garmin G3000 glass cockpit