

Handbook of
Tailless and Push-Pull
Aircrafts



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Chapter 1

Tailless Aircraft



The DH108 *Swallow*

A **tailless aircraft** (often **tail-less**) traditionally has all its horizontal control surfaces on its main wing surface. It has no horizontal stabilizer - either **tailplane** or **canard** foreplane (nor does it have a second wing in **tandem** arrangement). A 'tailless' type usually still has a vertical stabilising fin (vertical stabilizer) and control surface (rudder). However, NASA has recently adopted the 'tailless' description for the novel X-36 research aircraft which has a canard foreplane but no vertical fin.

The most successful tailless configuration has been the **tailless delta**, especially for combat aircraft.

Flying wings

Flying wings are tailless designs which also lack a distinct fuselage, having the pilot, engines, etc. located directly in or on the wing.

Aerodynamics

Longitudinal stability

A tailless aeroplane has no separate horizontal stabiliser, either behind (Tailplane) or in front of (canard foreplane) the main lifting surface. Because of this the aerodynamic center of an ordinary wing would lie ahead of the aircraft's center of gravity, creating

instability in pitch. Some other method must be used to move the aerodynamic center backward and make the aircraft stable. There are two main ways for the designer to achieve this:

- Sweep the wing leading edge back, either as a swept wing or delta wing, and reduce the angle of incidence of the outer wing section so that it acts rather like a conventional tailplane stabiliser. If this is done progressively along the span of the outer section, it is called **tip washout**. The outer section of the wing now acts as a conventional tailplane, and in level flight the aircraft should be trimmed so that the tips do not contribute any lift: they may even need to provide a small downthrust. This reduces the overall efficiency of the wing, but for many designs - especially for high speeds - this is outweighed by the reductions in drag, weight and cost over a conventional stabiliser. This method was developed by the English aeronaut J. W. Dunne in the early 20th century, but did not gain widespread use until the jet age. Since Dunne, this approach has been augmented by the use of low or null pitching moment airfoils, seen for example in the Horten series of sailplanes and fighters.
- Use a wing aerofoil section with reflex or reverse camber. With reflex camber the flatter side of the wing is on top, and the strongly curved side is on the bottom, so the front section presents a high angle of attack while the back section is more or less horizontal and contributes no lift, so acting like a tailplane or the washed-out tips of a swept wing. Reflex camber can be simulated by fitting large elevators to a conventional airfoil and trimming them noticeably upwards; the center of gravity must also be moved forward of the usual position. Due to the Bernoulli effect, reflex camber tends to create a small downthrust, so the angle of attack of the wing is increased to compensate. This in turn creates additional drag. This method allows a wider choice of wing planform than sweepback and washout, and designs have included circular (Arup) and straight wings. But the drag inherent in a high angle of attack is generally regarded as making the concept inefficient, and only a few types, such as the Fauvel and Marske Aircraft series of sailplanes, use it.

An alternative approach is to locate the main weight of the aircraft a significant distance below the wing center, so that gravity will tend to maintain the aircraft in a horizontal attitude and so counteract any aerodynamic instability. In practice this is not sufficient to provide stability on its own, and typically is augmented by sweepback and washout as described. A classic example is the Rogallo wing hang glider.

There is a trade-off between stability and maneuverability. A high level of maneuverability requires a low level of stability. Some modern hi-tech combat aircraft are aerodynamically unstable in pitch and rely on fly-by-wire computer control to provide stability. The Northrop B-2 *Spirit* flying wing is an example.

Pitch control

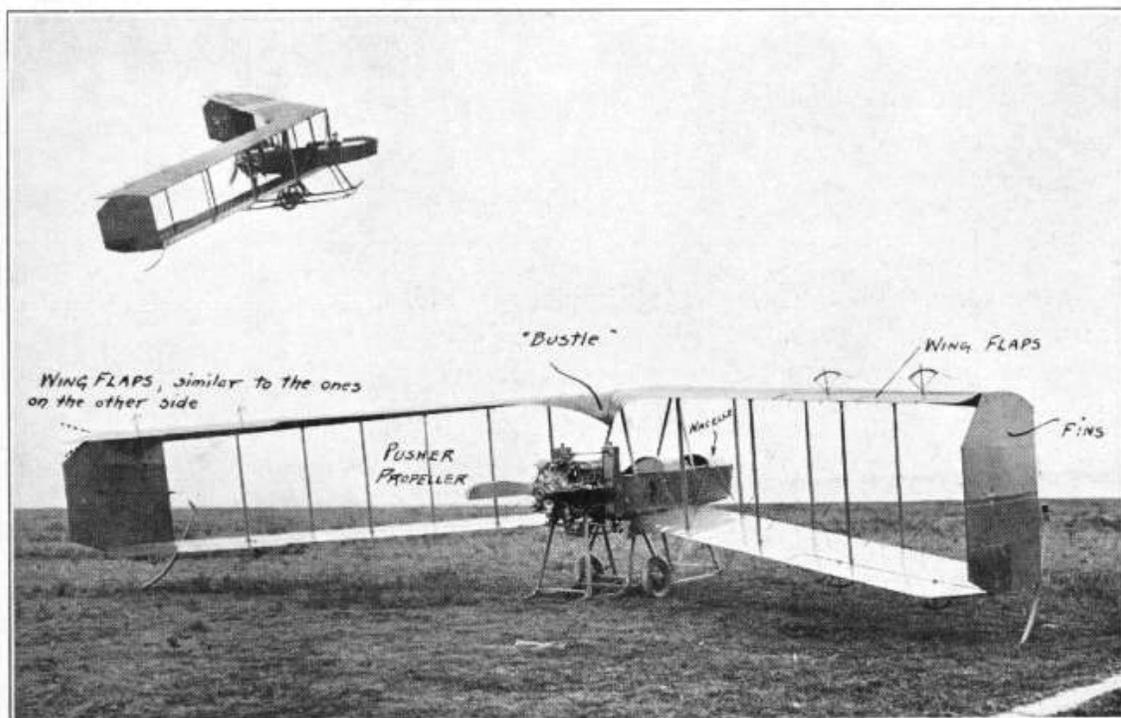
Many early designs failed to provide effective pitch control to compensate for the missing stabiliser. As a result, these aircraft could pitch up or down sharply and uncontrollably if they were not carefully handled. These gave tailless designs a reputation for instability. The original Dunne biplanes and the later success of the tailless delta configuration show that the problem was due as much to inadequate design, as to any problem inherent in the tailless configuration.

The solution usually adopted is to provide large elevator and/or elevon (combined elevator and aileron) surfaces on the wing trailing edge. These must generate large control forces, as their distance from the aerodynamic center is small. Consequently, when maneuvering, a tailless type may suffer higher drag than the conventional equivalent, even though it has less drag in level flight. High maneuverability demands high control moments (force times "lever arm" distance), and the short lever arm inherent in tailless types means they are not as manoeuvrable as their conventional equivalents.

Notable examples

The examples given here are in historical order.

J. W. Dunne



THE U. S. ARMY DUNNE TYPE BIPLANE

A Dunne type biplane in the US Army of 1917

During and shortly after the First World War, the English engineer J. W. Dunne developed a series of tailless aircraft characterised by having swept wings. In his book *An Experiment with Time* he claims that one of these was the first aeroplane ever to achieve natural stability in flight. Certainly, Dunne designed the first practical tailless aeroplanes. Few records of these aircraft remain.

Most of Dunne's designs were biplanes, typically featuring a fuselage nacelle between the planes, with rear-mounted 'pusher' propeller, and twin rudders between each pair of wing tips.

The D.6 monoplane of 1910 was a pusher type high-wing monoplane which featured turned-down wingtips with pronounced wash-out.

Many of Dunne's ideas on stability remain valid, and he is known to have influenced later designers such as John K. Northrop (father of the B-2 spirit stealth bomber).

Dunne gave some help initially to Geoffrey T. R. Hill who produced the Pterodactyl series of aircraft from 1920s onwards which were specifically designed to reduce the likelihood of stalling and spinning.

Lippisch deltas

The German designer Alexander Lippisch produced the first tailless delta design, the Delta I, in 1931. He went on to build a series of ever-more sophisticated designs, and after the Second World War went to America to continue his work.

Messerschmitt Me 163 Komet

During the Second World War, Lippisch worked for the German designer Willy Messerschmitt on the first tailless aircraft to go into production, the Me 163 *Komet*. It was a rocket-powered interceptor, and was the fastest aircraft to reach operational service during the war. Its rocket propulsion system was highly unsafe, especially the early versions. Landing was hazardous not only because the Komet had no wheels, but because sparks from the metal landing skid often flew up and ignited fuel vapours escaping from the propulsion system. More pilots were killed in takeoff and landing incidents than in combat.

De Havilland DH 108 Swallow

In the 1940s, the English designer Geoffrey de Havilland made a few examples of a tailless jet-powered research aircraft called the DH108 *Swallow*, based on the forward fuselage of the de Havilland Vampire jet fighter. One of these was the first aircraft ever to break the sound barrier - it did so during a shallow dive, and the sonic boom was heard by several witnesses.

Dassault *Mirage*

The French Mirage series of supersonic jet fighters were an example of the tailless delta configuration, and became one of the most widely produced of all Western jet aircraft. By contrast the Soviet Union's equivalent widely produced delta-winged fighter, the Mikoyan-Gurevich MiG-21, does have a tail stabiliser.

Convair F2Y *Sea Dart*

In the 1950s, the Convair F2Y Sea Dart prototype became the only seaplane ever to exceed the speed of sound. Convair built several other successful tailless delta types.

Supersonic airliners

The Anglo-French Concorde SST and its Soviet counterpart the Tupolev Tu-144 were tailless supersonic jet airliners, with gracefully curved *ogival delta* wings. The grace and beauty of these aircraft in flight were often remarked upon.

Lockheed SR-71 *Blackbird*

The American Lockheed SR-71 Blackbird reconnaissance aircraft was the fastest known operational aircraft, achieving speeds above Mach 3.

Northrop B-2 *Spirit*

The most recent tailless type to see operational service is the Northrop B-2 Spirit flying wing. It is unstable in flight and has artificial stability provided by a fly-by-wire system.

Other tailless aircraft

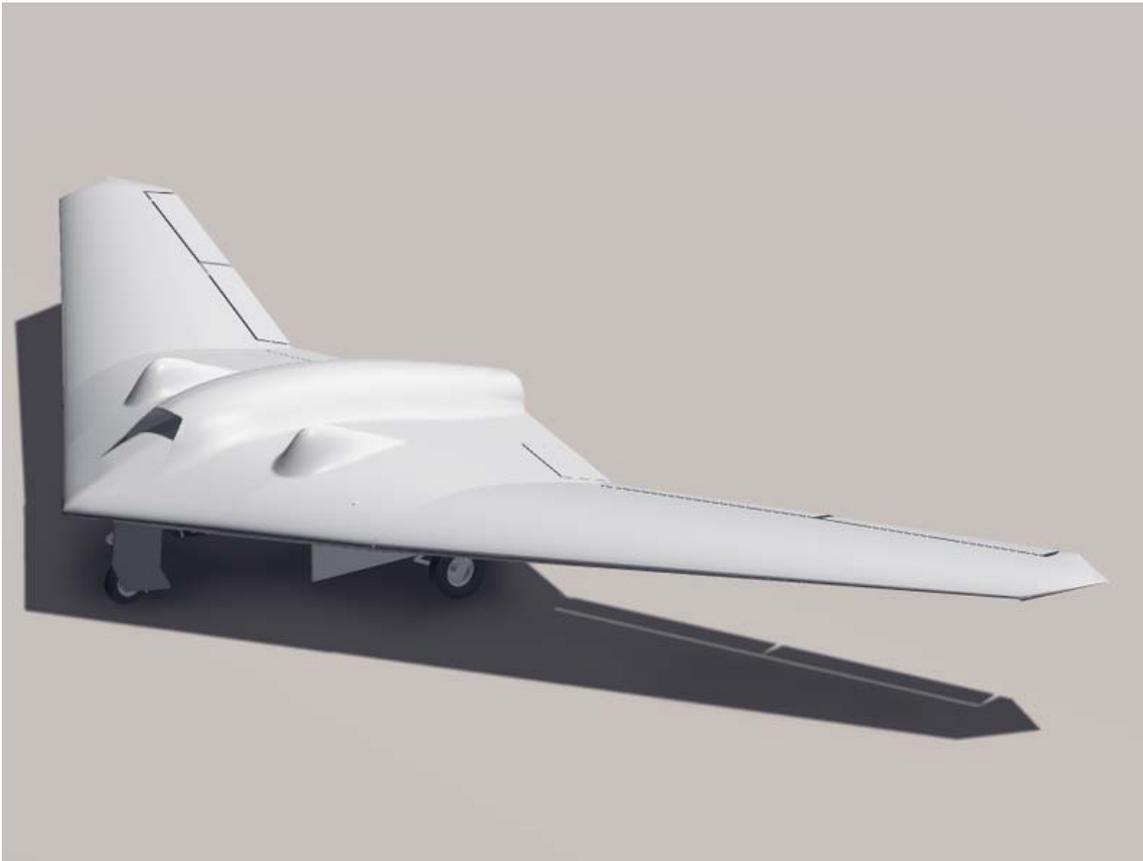
- Avro 707 - research for Avro Vulcan, 1/3 scale of Vulcan
- Avro CF-105 Arrow - delta wing fighter
- Avro Vulcan - delta wing subsonic bomber
- Boulton Paul P.111 - delta wing research
- Convair B-58 Hustler - delta wing supersonic bomber
- Convair F-102
- Convair F-106
- Fauvel AV.36 and others by Charles Fauvel
- Douglas F-4D Skyray
- Vought F-7 Cutlass
- General Dynamics F-16XL
- Granger Archaeopteryx
- HAL Tejas
- Pterodactyl Pledge — ultralight aircraft produced in large numbers
- Westland-Hill Pterodactyl
- X-44 MANTA

Experimental

- Armstrong Whitworth A.W.52 - flying wing
- Short SB.1 (glider) and Short SB.4 Sherpa - tested aero-isoclinic wing
- Handley Page Manx -
- Handley Page HP.115 - low speed handling of delta wing
- Fairey Delta 2 - high speed delta design

Chapter 2

Flying Wing



Graphic rendering

A **flying wing** is a tailless fixed-wing aircraft which has no definite fuselage, with most of the crew, payload and equipment being housed inside the main wing structure.

A flying wing may have various small protuberances such as pods, nacelles, blisters, booms, vertical stabilizers (tail fins), or undercarriage. Some aircraft have no fuselage but do have a separate horizontal stabilizer surface mounted on one or more booms; these are also commonly referred to as flying wings, although this is not strictly correct. An example of such a design is the Northrop X216H.

Theoretically the flying wing is the most efficient aircraft configuration from the point of view of aerodynamics and structural weight. It is argued that the absence of any aircraft components other than the wing should naturally provide these benefits. However in practice an aircraft's wing must provide for flight stability and control; this imposes additional constraints on the aircraft design problem. Therefore, the expected gains in weight and drag reduction may be partially or wholly negated due to design compromises needed to provide stability and control.

History



Northrop YB-49 flying wing



The US-produced B-2 Spirit, a strategic bomber capable of intercontinental missions.

Tailless aircraft have been experimented with since the earliest attempts to fly. But it was not until the deep-chord monoplane wing became practicable after World War I that the opportunity to discard any form of fuselage arose and the true flying wing could be realised.

Hugo Junkers patented a wing-only air transport concept in 1910. He saw it as a natural solution to the problem of building an airliner large enough to carry a reasonable passenger load and enough fuel to cross the Atlantic in regular service. He believed that the flying wing's potentially large internal volume and low drag made it an obvious design for this role. In 1919 he started work on his "Giant" JG1 design, intended to seat passengers within thick wings, but two years later the Allied Aeronautical Commission of Control ordered the incomplete JG1 destroyed for exceeding post-war size limits on German aircraft. Junkers conceived futuristic flying wings for up to 1,000 passengers; the

nearest this came to realisation was in the 1931 Junkers G-38 34-seater *Grossflugzeug* airliner which featured a large thick-chord wing providing space for fuel, engines and two passenger cabins. However, it still required a short fuselage, ending in a double tail, and containing the crew and additional passengers.

The flying wing configuration was studied extensively in the 1930s and 1940s, notably by Jack Northrop and Cheston L. Eshelman in the United States, and Alexander Lippisch and the Horten brothers in Germany.

Soviet designers such as Boris Ivanovich Cheranovsky started research independently and in secret under Stalin after the 1920s. With significant breakthrough in materials and construction methods, aircraft such as the BICh-3, BICh-14, BICh-7A and so on became possible. Men like Chizhevskij and Antonov also came into the spotlight of the communist party by designing aircraft such as the tail-less BOK-5 (Chizhevskij) and OKA-33 (the first ever built by Antonov) which were designated as "motorized gliders" due to their similarity to popular gliders of the time. The BICh-11 by Cheranovsky in 1932 was competing with the Horten brothers H1 (and Adolf Galland) at the Ninth Glider Competitions in 1933, but did not demonstrate in the 1936 summer Olympics in Berlin. The BICh-26 was one of the first attempts at a supersonic jet flying-wing aircraft, ahead of its time in 1948 the airplane was not accepted by the military and the design died with Cheranovsky.

Early examples of true flying wings include:

- The Soviet Boris Ivanovich Cheranovsky built and tested tailless flying wings, from 1924 gliders, eventually also powered BICh-3.
- The French Charles Fauvel designed the AV3 glider, successfully flown in 1933, featuring a self-stabilizing airfoil on a straight wing.
- The German Horten H1 glider flown with partial success in 1933, and the subsequent H2 flown successfully in both glider and powered variants.
- The American Freeland Flying Wing glider flown in 1937.
- The American Northrop N-1M of 1940
- The British Armstrong Whitworth A.W.52G of 1944, a glider test bed for the later Armstrong Whitworth A.W.52 jet-powered version.
- The German Horten Ho 229 of 1945 - the world's first twin jet engine pure flying wing

Several late-war German military designs were based on the flying wing concept (or variations of it) as a proposed solution to extend the range of the otherwise very short-range jet engined aircraft. Most famous of these would be the Horten Ho 229 fighter. This aircraft, first flown in 1944, combined a flying wing, or *Nurflügel*, design with twin jet engines. The surviving prototype remains in storage at the Smithsonian Institution in an unrestored state.

After the war, a number of experimental designs were based on the flying wing concept, but the known difficulties remained intractable. Some general interest continued until the

early 1950s, when the concept was proposed as a design solution for long range bombers. Such trends culminated in the Northrop YB-35 and YB-49, which did not enter production. Those designs did not necessarily offer a great advantage in range and presented a number of technical problems, leading to the adoption of "conventional" solutions like the Convair B-36 and the B-52 Stratofortress.

Interest in flying wings was renewed in the 1980s due to their potentially low radar reflection cross-sections. Stealth technology relies on shapes which only reflect radar waves in certain directions, thus making the aircraft hard to detect unless the radar receiver is at a specific position relative to the aircraft - a position that changes continuously as the aircraft moves. This approach eventually led to the Northrop B-2 Spirit stealth bomber. In this case the aerodynamic advantages of the flying wing are not the primary needs. However, modern computer-controlled fly-by-wire systems allowed for many of the aerodynamic drawbacks of the flying wing to be minimised, making for an efficient and stable long-range bomber.

Due to the practical need for a deep wing, the flying wing concept is most practical for designs in the slow-to-medium speed range, and there has been continual interest in using it as a tactical airlifter design. Boeing continues to work on paper projects for a Blended Wing Body Lockheed C-130 Hercules-sized transport with better range and about 1/3 more load, while maintaining the same size characteristics. A number of companies, including Boeing, McDonnell Douglas and de Havilland, did considerable design work on flying-wing airliners, but to date none have entered production.

Design issues



A Northrop N-1M on display at the National Air and Space Museum's Steven F. Udvar-Hazy Center

A clean flying wing is theoretically the most aerodynamically efficient (lowest drag) design configuration for a fixed wing aircraft. It also offers high structural efficiency for a given wing depth, leading to light weight and high fuel efficiency.

Because it lacks conventional stabilizing surfaces or the associated control surfaces, in its purest form the flying wing suffers from the inherent disadvantages of being unstable and difficult to control. These compromises are difficult to reconcile, and efforts to do so can reduce or even negate the expected advantages of the flying wing design, such as reductions in weight and drag. Moreover, solutions may produce a final design that is still too unsafe for certain uses, such as commercial aviation.

Further difficulties arise from the problem of fitting the pilot, engines, flight equipment and payload all within the depth of the wing section. A wing that is made deep enough to contain all these elements will have an increased frontal area, when compared to a conventional wing and fuselage, which in turn results in higher drag and thus slower speed than a conventional design. Typically the solution adopted in this case is to keep the wing reasonably thin, and the aircraft is then fitted with an assortment of blisters, pods, nacelles, fins and so forth to accommodate all the needs of a practical aircraft.

Directional stability

For any aircraft to fly without constant correction it must have directional stability in yaw.

Flying wings lack the long fuselage which provides a convenient attachment point for an efficient vertical stabilizer or fin. The fin must attach directly on to the rear part of the wing, giving a small moment arm from the aerodynamic center, which in turn means that to be effective the fin area must be large. This large fin has weight and drag penalties, and can negate the advantages of the flying wing. The problem can be minimized by increasing the leading edge sweepback, as for example in a low-aspect-ratio delta wing, but most flying wings have gentler sweepback and consequently have, at best, marginal stability. In the so called ruptured duck configuration, the wing tip sections are angled sharply downwards (anhedral), increasing the area at the rear of the aircraft when viewed from the side.

Yaw control

In most flying wing designs, the stabilizing fins are so far forward that any control rudders mounted on them have little effect, thus alternative means for yaw control must be provided. The only practical solution is differential drag: the drag near one wing tip is artificially increased, causing the aircraft to yaw in the direction of that wing. Typical methods include:

- Split ailerons. The top surface moves up while the lower surface moves down, to create an air brake effect.

- Spoilers. A spoiler surface in the upper wing skin is raised, to disrupt the airflow and increase drag. This effect is generally accompanied by a loss of lift, which must be compensated for either by the pilot or by complex design features.
- Spoilerons. An upper surface spoiler which also acts to reduce lift (equivalent to deflecting an aileron upwards), so causing the aircraft to bank in the direction of the turn - the angle of roll causes the wing lift to act in the direction of turn, reducing the amount of drag required to turn the aircraft's longitudinal axis.

A consequence of the differential drag method is that if the aircraft manoeuvres frequently then it will frequently create drag. So flying wings are at their best when cruising in still air: in turbulent air or when changing course, the aircraft may be less efficient than a conventional design.

Borderline cases

Some aircraft have no fuselage but do have a horizontal stabilizer mounted on one or more booms. Strictly, these are not flying wings although they are usually referred to as such. An example is the Northrop X-216H, which has a tail stabilizer mounted on two tail booms but is regarded as Northrop's first flying wing type.

Many hang gliders and microlight aircraft are tailless. Although often referred to as flying wings, these types carry the pilot (and engine where fitted) below the wing structure rather than inside it, and so are not true flying wings.

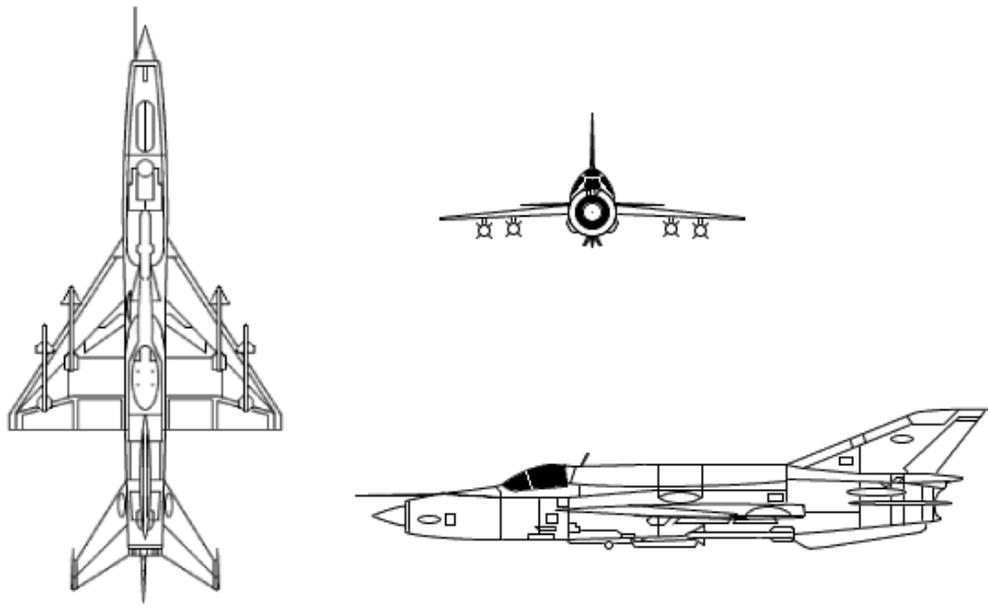
An aircraft of sharply-swept delta planform and deep center section represents a borderline case between flying wing, blended wing body and/or lifting body configurations.

Chapter 3

Delta Wing



Eurofighter Typhoon of the German Luftwaffe has a tailless delta wing configuration



MiG-21 had a tailed delta wing configuration (it had a conventional tail)



The delta wing Avro Vulcan bomber

The **delta wing** is a wing planform in the form of a triangle. It is named for its similarity in shape to the Greek uppercase letter delta (Δ).

History

Delta-shaped stabilizers

Between 1529 and 1556 Conrad Haas wrote a book in which he described rocket technology, involving the combination of fireworks and weapons technologies. This manuscript was re-discovered in 1961, in the Sibiu public records (Sibiu public records Varia II 374). His work dealt with the theory of motion of multi-stage rockets, different fuel mixtures using liquid fuel, and also introduced delta-shaped stabilizers.

As the manuscript was discovered only in 1961 until recently the conception of such stabilizers and their name had been suggested in the 17th century by the Polish-Lithuanian military engineer Kazimierz Siemienowicz.

Delta wing

The first practical uses of delta wing came in the form of so called "tailless delta", i.e. without the horizontal tailplane. In fact the designs were at the same time also the first flying wings. It could be argued if 1924 Cheranovsky designs, having one-of-a-kind parabolic planform, fit the category of delta wings. Nevertheless, a triangular wing was pioneered especially by Alexander Lippisch in Germany. He was first to fly tailless delta aircraft in 1931, followed by four improved designs. None of these was easy in handling at slow speeds, and none saw widespread service. During the war Lippisch studied a number of ramjet powered (sometimes coal-fueled) delta-wing interceptor aircraft, one progressing as far as a glider prototype.

After the war, Lippisch was taken to the United States of America, where he worked at the Convair company in California. Some high-ranking Convair engineers became quite interested in his interceptor designs, and they started work on a larger test version known as the Convair XF-92. The prototype—although never put into production—was extensively flight-tested, and its design generated a lot of interest of various airplane manufacturers in several countries. Soon many aircraft designs, particularly interceptors, would be designed around the delta wing. The tail-less delta became a favored design for high-speed use, and was used almost to the exclusion of other designs by Convair and by Dassault Aviation in France. Convair's F-102 was the first fighter with a tailless delta wing in service with any air force anywhere in the world.

Meanwhile, the British also developed aircraft based on the data from Lippisch, notably the Avro Vulcan strategic bomber and the Gloster Javelin fighter. The Javelin incorporated a tailplane in order to rectify some of the perceived weaknesses of the pure delta, to improve low-speed handling and high-speed manoeuvrability and to allow a greater center of gravity range.

The tailed delta configuration was again adopted by the TsAGI (Central Aero and Hydrodynamic Institute, Moscow), to take advantage of both high angle-of-attack flying capability and high speeds. It was used in the MiG-21 (Fishbed) and Sukhoi Su-9/Su-11/15 fighters, built by the tens of thousands in several different communist countries.

More recently, Saab AB used a close-coupled canard foreplane in front of the main wing of the Viggen fighter. The close coupling actively modifies the airflow over the wing, most notably during flight at high angles of attack. In contrast to the classic tail-mounted elevators, the canards add to the total lift, enabling the execution of extreme maneuvers, improving low-speed handling and lowering the landing speed. The design was copied in other aircraft, such as the Eurofighter Typhoon.

Aerodynamic advantages

The primary advantage of the delta wing is that with a large enough angle of rearward sweep the wing's leading edge will not contact the shock wave boundary formed at the nose of the fuselage as the speed of the aircraft approaches and exceeds transonic to supersonic velocity. The rearward sweep angle vastly lowers the airspeed normal to the leading edge of the wing, thereby allowing the aircraft to fly at high subsonic, transonic, or supersonic speed, while the over wing speed of the lifting air is kept to less than the speed of sound. The delta plan form gives the largest total wing area (generating useful lift) for the wing shape, with very low wing per-unit loading, permitting high maneuverability in the airframe. As the delta's platform carries across the entire aircraft, it can be built much more strongly than a swept wing, where the spar meets the fuselage far in front of the center of gravity. Generally a delta will be stronger than a similar swept wing, as well as having much more internal volume for fuel and other storage.

Another advantage is that as the angle of attack increases the leading edge of the wing generates a vortex which energizes the flow, giving the delta a very high stall angle. A normal wing built for high speed use is typically dangerous at low speeds, but in this regime the delta changes over to a mode of lift based on the vortex it generates. The disadvantages, especially marked in the older tailless delta designs, are a loss of total available lift caused by turning up the wing trailing edge or the control surfaces (as required to achieve a sufficient stability) and the high induced drag of this low-aspect ratio type of wing. This causes delta-winged aircraft to 'bleed off' energy very rapidly in turns, a disadvantage in aerial maneuver combat and dogfighting.

Additional advantages of the delta wing are simplicity of manufacture, strength, and substantial interior volume for fuel or other equipment. Because the delta wing is simple, it can be made very robust (even if it is quite thin), and it is easy and relatively inexpensive to build - a substantial factor in the success of the MiG-21 and Mirage aircraft.

A canard-delta suffers from a smaller shift in the center of lift with increasing mach number than a wing and tail configuration, but requires a stronger wing in order to provide control inputs that a canard is less effective than a tail at providing.

When used with a T-tail as in the Gloster Javelin the large delta wing could give rise to a "deep stall"; at high angles of attack the wing blanked airflow over the tail and left the aircraft uncontrollable.

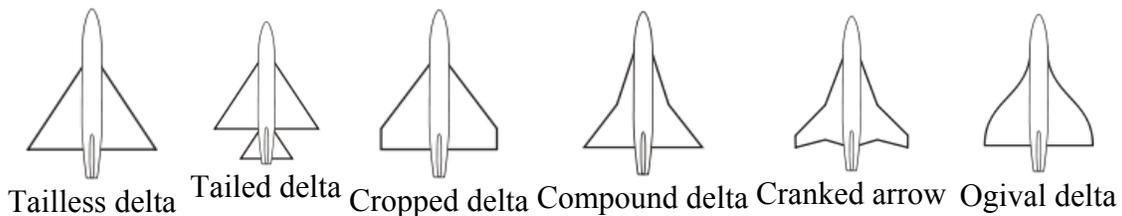
Delta-wing variations

Pure delta-wings fell out of favour somewhat due to their undesirable characteristics, notably flow separation at high angles of attack (swept wings have similar problems), and high drag at low altitudes. This limited them primarily to high-speed, high-altitude interceptor roles.

Many modern fighter aircraft, such as the JAS 39 Gripen, the Eurofighter Typhoon and the Dassault Rafale use a combination of canards and a delta wing.

Tailed delta - adds a conventional tailplane (with horizontal tail surfaces), to improve handling. Popular on Soviet types such as the Mikoyan-Gurevich MiG-21. **Cropped delta** - tip is cut off. This helps avoid tip drag at high angles of attack. Used for example in F-16.

In another variant known variously as **compound delta**, **double delta** or **cranked arrow**, the inner part of the wing has a very high sweepback, while the outer part has less sweepback, to create the high-lift vortex in a more controlled fashion, reduce the drag and thereby allow for landing the delta at acceptably slow speed. This design can be seen on the Saab Draken fighter, the prototype F-16XL "Cranked Arrow" and in the High Speed Civil Transport study. The **ogee delta** (or **ogival delta**) used on the Anglo-French Concorde Mach 2 airliner is similar, but with a smooth 'ogee' curve joining the two parts rather than an angle.



As the performance of jet engines grew, fighters with other planforms could perform as well as deltas, and do so while maneuvering much harder and at a wider range of altitudes. Today a remnant of the compound delta can be found on most fighter aircraft, in the form of leading edge extensions. These are effectively very small delta wings placed so they remain parallel to the airflow in cruising flight, but start to generate a vortex at high angles of attack. The vortex is then captured on the top of the wing to

provide additional lift, thereby combining the delta's high-alpha performance with a conventional highly efficient wing planform.

Chapter 4

Avro 707

Avro 707



Avro 707B VX790 at Farnborough in 1951.

Role	Experimental aircraft
Manufacturer	Avro
First flight	4 September 1949
Retired	1967
Status	3 aircraft survive in museums
Primary users	Avro Royal Aircraft Establishment Australian Aeronautical Research Council
Number built	5

The **Avro 707** (also known as **Type 707**) was a British experimental aircraft built to test the tailless thick delta wing configuration chosen for the Avro 698 jet bomber, later named the Vulcan. In particular, the low-speed characteristics of such aircraft were not well known at the time. Aerodynamically, it was a 1/3-scale version of the Vulcan.

Design and development

The 707 was a "proof-of-concept" delta design that was principally the work of Stewart D. Davies, Avro Design Office leader. The diminutive experimental aircraft initially

incorporated a wing with about 50° sweep, without a horizontal tail on a fin with trailing edge sweep. The trailing edge of the wing carried two pairs of control surfaces: inboard elevators and outboard ailerons. Retractable airbrakes were provided above and below the wings. The prototypes were ordered by the Air Ministry to Specification E.15/48. The aircraft were produced quickly using a few components from other aircraft including the first prototype utilizing a Gloster Meteor canopy. The 707 programme provided valuable insights into the Vulcan's flight characteristics, most of the information coming from the second and third prototypes which flew before the Vulcan. All 707s were powered by a single Rolls Royce Derwent centrifugal turbojet. The air intake on the first prototype and later 707B was located on the upper rear fuselage. Five 707s were built altogether.

Operational history

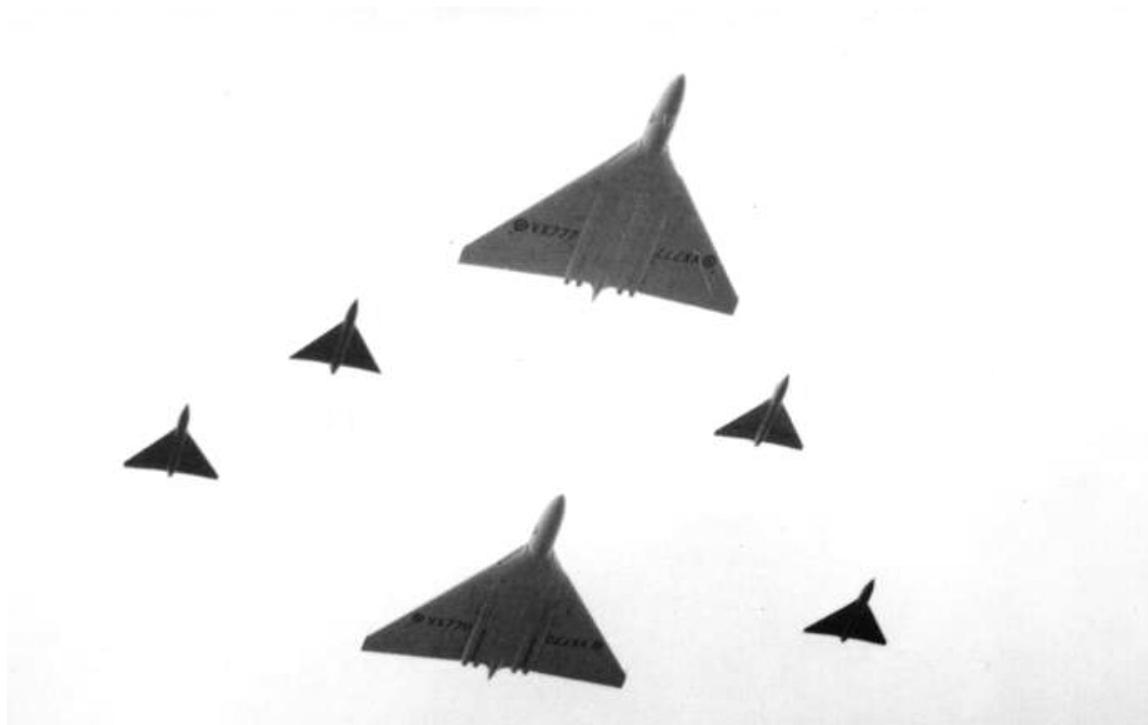


The second Avro 707A *WZ736* displayed next to an Avro Shackleton at the Museum of Science & Industry in Manchester in 1985

The first, the Avro **707**, *VX784* first flew from Boscombe Down on 4 September 1949 with S.E. "Red" Esler, at the controls. The prototype crashed less than a month later, on 30 September, near Blackbushe. The next prototype, *VX790*, renamed the **707B**, had a longer nose, different cockpit canopy, a wing of different (51°) sweep and a longer nose wheel leg to provide the high angle of incidence required by deltas for landing and take off. The 707B was given the same dorsal engine intake as the 707, although this was later modified to a N.A.C.A design. It first flew on 6 September 1950. Both these aircraft were built to test low speed characteristics.

The third aircraft, designated **707A**, *WD280* was built for higher speed testing. Experience with the dorsal intake of the earlier 707 and 707B had shown that as speed increased, the cockpit induced turbulence which interrupted the intake airflow, so the intakes were moved to the wing roots. When the Vulcan appeared, it looked very much like an enlarged 707A. Later, this 707A was used to test the compound leading edge sweep subsequently used on all Vulcans. Although the first Vulcan prototype was already flying, a second 707A *WZ736* was built to speed the development programme, making its maiden flight on 20 February 1953.

The final variant was the two-seat **707C**; originally four examples were ordered by the RAF for use in orientation training revolving around flying aircraft with delta wing configurations. The 707C had "side-by-side" seating with dual-controls but the production order was cancelled with only the sole prototype, *WZ744* built. The 707C had its maiden flight on 1 July 1953 and was ultimately employed in other research that did not involve Vulcan development.



Two Avro 707As, 707B and 707C with Vulcan prototypes at SBAC Farnborough Show, September 1953

Even after the Vulcan development phase was over, the four surviving 707s, resplendent in individual bright blue, red, orange and silver (natural metal) colour schemes, continued in use as research aircraft. After the compound sweep investigation and a period with the Royal Aircraft Establishment (R.A.E) carrying out handling trials with powered controls, the first 707A went to the Aeronautical Research Laboratories in Australia for low-speed delta wing airflow measurements. The second 707A was also at the R.A.E from June 1953 for aerodynamic and later, automatic control investigations.

The Avro 707B joined the R.A.E. in September 1952 and was one of the aircraft used by the Empire Test Pilots School from January to September 1956, when it was damaged on landing, and broken up at R.A.E. Bedford. The two-seat 707C joined the R.A.E. January 1956; perhaps its most substantial research contribution was to the development of fly-by-wire control systems, one of the first of their kind, and fitted with a side stick controller. This aircraft was flying with the R.A.E. until September 1966.

The Avro 707s made public appearances at the Farnborough Airshows in both September 1952 and 1953; in 1952, the first prototype Vulcan flew with the 707s A and B and in 1953, the four surviving 707s flew alongside the first two Vulcan prototypes.

Survivors

No 707s are now airworthy. Both examples of the Avro 707A variant survive. One, *WZ736* is preserved at the Museum of Science and Industry in Manchester, the other, *WD280* at the RAAF Museum in Point Cook, Victoria. *WZ744*, the single 707C is displayed at the RAF Museum, Cosford near Wolverhampton.

Operators

 Australia

- Royal Australian Air Force
- Australian Aeronautical Research Council

 United Kingdom

- Aeroplane and Armament Experimental Establishment
- Royal Aircraft Establishment

Specifications (707C)

General characteristics

- **Crew:** 2 instructor/pupil
- **Length:** 42 ft 4 in (12.90 m)
- **Wingspan:** 34 ft 2 in (10.41 m)
- **Height:** 11 ft 7 in (3.53 m)
- **Wing area:** 420 ft² (39 m²)
- **Empty weight:** lb (kg)
- **Loaded weight:** 10,000 lb (4,535 kg)
- **Powerplant:** 1× Rolls-Royce Derwent 8 turbojet, 3,600 lbf (16 kN)

Performance

- **Maximum speed:** 406 kn (467 mph, 747 km/h)
- **Wing loading:** 22.6 lb/ft² (110 kg/m²)
- **Thrust/weight:** 0.38

Chapter 5

Convair XB-53 and de Havilland DH 108

Convair XB-53

XB-53



1946 design then designated XA-44

Role	Attack aircraft
Manufacturer	Convair
First flight	n/a
Status	Cancelled in 1949
Primary user	United States Air Force
Number built	0

The **Convair XB-53** was a proposed jet powered medium bomber aircraft, designed by Convair for the United States Army Air Force. With a radical tailless, forward-swept wing design, the aircraft appeared futuristic, however the project was cancelled before either of the two prototypes were completed.

Design and development

The project was originally designated **XA-44** in 1945 under the old "attack" category. An unusual forward-swept wing-design powered by three J35-GE turbojets, the project was developed in parallel with Convair's XB-46. It would have a wing with a 30° forward-

sweep and 8° dihedral that borrowed from German wartime research. The swept-forward configuration would give the aircraft a greater climb rate and maneuverability. It looked promising enough at one point that the Army Air Force considered cancelling the XB-46 in favor of the XA-44 since there was not enough funding for both.

Classified as a medium bomber, the XB-53 would have carried up to 12,000 pounds of bombs as well as 40 High Velocity Aerial Rockets (HVAR) mounted on underwing pylons.

Convair argued for completion of the XB-46 prototype as a flying testbed sans armament and other equipment and substitution of two XA-44s for the other two B-46 airframes on contract. The Air Force ratified this in June 1946 but the project did not progress, nor were additional B-46s built. The XA-44 was redesignated XB-53 in 1948 when the "attack" category was dropped but the project was cancelled before the two prototypes were completed. The XA-44 program was reinstated in February 1949 but only for a short while.

Specifications (XB-53)

General characteristics

- **Crew:** 4
- **Length:** 79 ft 6 in (24.2 m)
- **Wingspan:** 80 ft 7 in (24.6 m)
- **Height:** 23 ft 8 in (7.22 m)
- **Wing area:** 1,370 ft² ()
- **Empty weight:** 31,760 lb ()
- **Loaded weight:** 60,000 lb ()
- **Max takeoff weight:** 60,000 lb (27,000 kg)
- **Powerplant:** 3× General Electric J35 turbojets, 4,000 lbf (18 kN) each

Performance (estimated)

- **Maximum speed:** 580 mph (500 knots, 930 km/h)
- **Range:** 2,000 mi (1,700 nm, 3,200 km)
- **Service ceiling:** 44,000 ft (13,400 m)
- **Rate of climb:** Unknown ()
- **Wing loading:** Unknown ()
- **Thrust/weight:** Unknown

Armament

- **Bombs:** 12,000 lb (5,400 kg)

de Havilland DH 108

DH 108 "Swallow"



The first DH 108 built – TG283. The torpedolike objects on the wing tips are containers for anti-spin parachutes.

Role	experimental
Manufacturer	de Havilland
Designed by	John Frost
First flight	15 May 1946
Introduced	Experimental programme only
Status	Cancelled
Primary user	Royal Aircraft Establishment
Produced	1946–1947
Number built	Three

The **de Havilland DH 108 "Swallow"** was a British experimental aircraft designed by John Carver Meadows Frost in October 1945. The DH 108 featured a tailless, swept wing with a single vertical stabilizer, closely resembling the layout of the wartime German Messerschmitt Me 163 *Komet* rocket-powered point-defense interceptor. Initially designed to evaluate swept wing handling characteristics at low and high subsonic speeds for the proposed early tailless design of the Comet airliner, three examples of the DH 108 were built to the Air Ministry specifications E.1/45 and E.11/45. With the adoption of a conventional tail for the Comet, the aircraft were used instead to investigate swept wing handling up to supersonic speeds. All three prototypes were lost in fatal crashes.

Design and development

Employing the main fuselage section and engine of the de Havilland Vampire mated to a longer fuselage with a single tail fin and swept wings, the de Havilland DH 108 was proposed in 1944 as a test "mule" for the DH 106 Comet which had initially considered a tailless, swept-wing concept. Despite the Comet design taking on more conventional features, the value of testing the unique configuration to provide basic data for the

DH.110 spurred de Havilland to continue development of the DH 108. Selecting two airframes from the English Electric Vampire F 1 production line, the new aircraft had unmistakable similarities to its fighter origins, especially in the original forward fuselage which retained the nose, cockpit and other components of the Vampire. The Ministry of Supply named the DH 108 the "Swallow", a name that was never officially adopted by the company.

The new metal wing incorporating a 43° sweepback was approximately 15% greater in area than the standard Vampire wing. Control was based on the conventional rudder in combination with elevons that were part elevator and ailerons, fitted outboard of the split trailing edge flaps. Although the Vampire fuselage was retained, as development continued, a revised nose and streamlined, reinforced canopy were incorporated.

Testing

The first DH 108 prototype, *TG283*, utilising the Vampire fuselage and a 43° swept wing, flew on 15 May 1946. Designed to investigate low-speed handling, it was capable of only 280 mph (451 km/h). De Havilland Chief Test Pilot Geoffrey de Havilland Jr., son of de Havilland company owner-designer Geoffrey de Havilland, gave a display flight in the DH 108 during the 1946 Society of British Aircraft Constructors (SBAC) airshow at Radlett. In later low-speed testing designed to clear the rear fuselage at high angles of attack, the first prototype was fitted with longer Sea Vampire landing gear.

The second, high-speed prototype, *TG306*, with a 45° swept wing incorporating automatic leading-edge Handley Page slats and powered by a de Havilland Goblin 3 turbojet, flew soon after in June 1946. Modifications to the design included a more streamlined, longer nose and a smaller canopy (framed by a strengthened metal fairing) facilitated by lowering the pilot's seat. While being used to evaluate handling characteristics at high-speed, on 27 September 1946 *TG306* suffered a catastrophic structural failure that occurred in a dive from 10,000 ft (3,050 m) at Mach 0.9 and crashed in the Thames Estuary. The pilot, Geoffrey de Havilland Jr., was killed in the accident. Early wind tunnel testing had pointed to potentially dangerous flight behaviours, but pitch oscillation at high-speed had been unexpected. The subsequent accident investigation centred on a structural failure that occurred as air built up at Mach 0.9, pitching the aircraft into a shock stall that placed tremendous loads on the fuselage and wings. The main spar cracked at the roots with the wings immediately folding backwards.



VW120 in flight, about 1949

After the loss of the second prototype, *VW120* became the third and final prototype based on the newer Vampire F.5 fighter built at Hatfield. It differed from the first test aircraft in that it featured an even more streamlined pointed nose and smaller reinforced canopy (lowering the pilot's seat allowed for a more aerodynamic canopy shape to be employed). Power-assisted elevators had been specified as a means to control the pitch oscillations at the root of the earlier disaster. A more powerful Goblin 4 of 3,738 lbf (16.67 kN) thrust had the potential to push the DH 108 into the supersonic range. *VW120* first flew on 24 July 1947 flown by John Cunningham, the wartime nightfighter ace.

Considered an important testbed for high-speed flight, *VW120* was readied for an attempt at the World Speed Record then held by a Gloster Meteor at 616 mph (991 km/h). The second prototype, *TG306*, was a "back up" for the attempt before it fatally crashed. On 12 April 1948, *VW120* established a new World Air Speed Record of 604.98 mph (974.02 km/h) on a 62 mile (100 km) circuit. Then, on 9 September 1948, John Derry is thought to have probably exceeded the speed of sound in a shallow dive from 40,000 ft (12,195 m) to 30,000 ft (9,145 m).

In 1949, *VW120* put on an aerial display at Farnborough and scored third place in the Society of British Aircraft Constructors Challenge Trophy Air Race before being turned over to the Ministry of Supply and test flown at RAE Farnborough. It was destroyed on 15 February 1950 in a fatal crash near Brickhill, Buckinghamshire, killing its test pilot, Squadron Leader Stuart Muller-Rowland. Accident investigation pointed to a faulty oxygen system that incapacitated the pilot.

Finally, on 1 May 1950 during low-speed sideslip and stall tests the first prototype, *TG283*, was lost in a crash at Hartley Wintney killing the pilot Sqdn Ldr George E.C. Genders AFC DFM, when, after abandoning the aircraft at low altitude in an inverted

spin, his parachute failed to open in time. In all, 480 flights had been made by the three Swallows.

Legacy

The DH108 established a number of "firsts" for British aircraft: it was the first British swept-winged jet aircraft and the first British tailless jet aircraft; it was the first British aircraft to exceed Mach 1, one of the first jet-powered aircraft in the world to achieve this landmark speed. The XP-86 (the prototype for the F-86 Sabre) had also broken the sound barrier in a test flight on 26 April 1948. Two of the aircraft which earlier had exceeded the speed of sound, the Bell X-1 and the Douglas Skyrocket, were both rocket-powered.

Operators

 United Kingdom

- Royal Aircraft Establishment

Specifications (DH 108 VW120: third prototype)

General characteristics

- **Crew:** one, pilot
- **Length:** 26 ft 10 in (8.17 m)
- **Wingspan:** 39 ft 0 in (11.89 m)
- **Height:** 14 ft 0 in (4.27 m)
- **Wing area:** 327.86 ft² (30.47 m²)
- **Loaded weight:** 8,940 lb (4,064 kg)
- **Powerplant:** 1× de Havilland Goblin-4 turbojet, 3,738 lbf (16.67 kN)

Performance

- **Maximum speed:** 580 kn (677 mph, 1,090 km/h)
- **Range:** 634 nmi (730 mi, 1,175 km)
- **Service ceiling:** 35,425 ft (10,800 m)
- **Wing loading:** 27 lb/ft² (133 kg/m²)
- **Thrust/weight:** 0.42

Chapter 6

Dunne D.8

D.8



Dunne D.8 at Farnborough, 11 March 1914

Role	Experimental aircraft
National origin	United Kingdom
Manufacturer	Blair-Atholl Syndicate Ltd, London
Designed by	J. W. Dunne
First flight	June 1912
Status	original aircrafts lost or destroyed; 1 replica exists in Canada
Primary users	Royal Flying Corps US Signal Corps United States Navy Canadian Aviation Corps
Produced	5
Number built	5
Developed from	Dunne D.5

The **Dunne D.8** of 1912 was one of a series of tailless swept wing biplanes, designed by J. W. Dunne to have inherent stability. One of the few built was the only Dunne aircraft to fly, albeit very briefly, with the Royal Flying Corps (RFC). Others were used by the US Signal Corps and United States Navy and the short-lived Canadian Aviation Corps. It was the latter's first and only warplane.

Design and development

J. W. Dunne's first swept biplane wing aircraft, designed to have automatic stability, dated from his employment at the Balloon (later) Aircraft Factory at Farnborough during 1906–09. To preserve military secrecy testing was done at Blair Atholl in Scotland. After leaving Farnborough, Dunne set up a private company, the Blair-Atholl Syndicate Ltd. Its first aircraft was the Dunne D.5. When this crashed in 1911 it was rebuilt as the D.8. The two models shared very similar wings and the same engine, but the D.8 had a single pusher propeller instead of the chain-driven pair of the D.5. Their fuselages and undercarriages were also different.

The D.8 was a tailless four bay unstaggered biplane with its wings swept at 32°. Its constant chord wings were built up around two spruce spars, the forward one forming the leading edge. To help achieve stability the incidence and interplane gap decreased outboard, the former becoming negative. This washout on tips well behind the centre of gravity provided longitudinal stability in the same way as a conventional tailplane, set at lower incidence than the wings. Camber increased outwards. Simple, near parallel, pairs of interplane struts joined the spars. The outer interplane struts were enclosed with fabric, forming fixed side curtains that provided directional (yaw) stability. Wing tip elevons were used for control, operated by a pair of levers, one either side of the pilot. The D.8 initially used just a pair of these, mounted on the upper wing, a rectangular cutout in the side curtains allowing for their movement as on the D.5. Large parts of the aircraft were built by Short Brothers.

The D.8's water cooled 4-cylinder, 60 hp (45 kW) Green engine directly drove a four-bladed pusher propeller, saving weight compared with the D.5's chain drive. Though it is not certain when the propeller was changed, most photographs show the Green engine driving a two bladed airscrew. As a consequence of the propeller position the fuselage was shortened at the rear; it was also extended in the nose. This first D.8 seems to have been a single seater like its D.5 predecessor, the pilot sitting at mid chord.

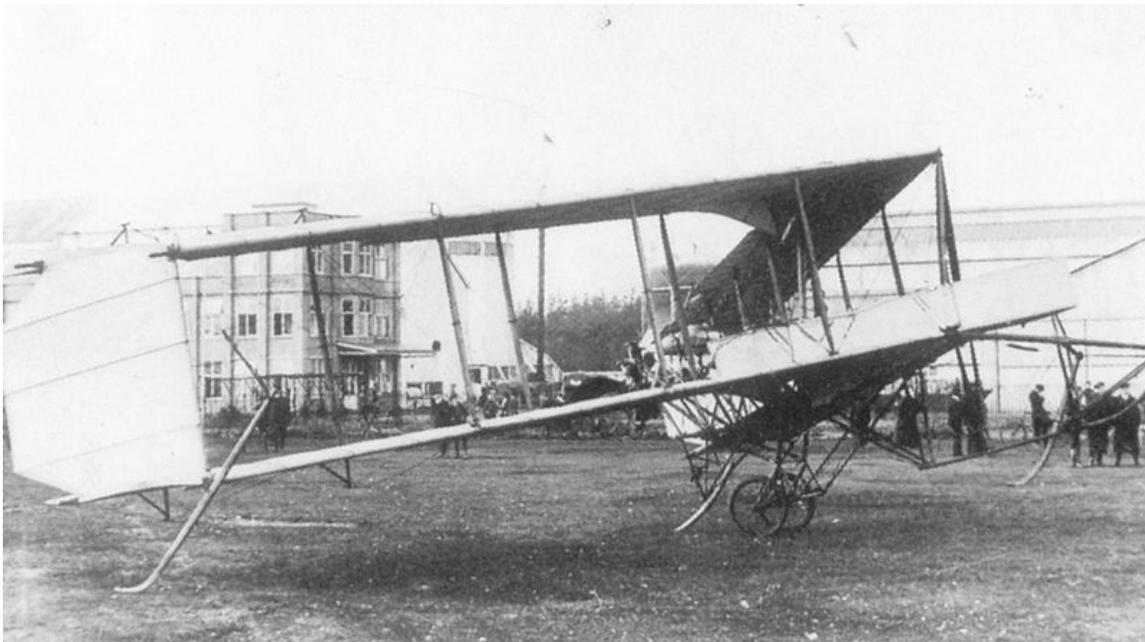
Contemporary sources remarked on the complexity of the D.8's undercarriage, which combined a narrow track pair of sprung wheels pair with wingtip skids. Part of its complication came from opposing springing in the absence of dampers, and part from an elaborate anti-noseover skid.

In this form the D.8 first flew in June 1912 at Eastchurch. It attended the Larkhill Military trial in August 1912, though it did not take part in the competition. It flew regularly at Eastchurch through 1911 and 1912 and was still active there in November

1912. Despite the two handed arrangement of the D.8's controls, the one-handed Capt. A.D. Carden gained his Royal Aero Club Aviator's Certificate on it in June 1912.

It is not known if this machine was later modified aerodynamically, but by August 1913 the Green engine had been replaced by an 80 hp (60 kW) 7-cylinder Gnome rotary engine. This much shorter engine also powered the second aircraft, which was a two seater with the pilot placed just ahead of the wing leading edge and the passenger (who had dual control) at the trailing edge. There were now control surfaces on both upper and lower wings, the side curtains having a pair of tapered notches to allow them to move. Each of the upper wings carried a pair of elevons, nearly doubling the control surface area, though it is not certain if these moved as one or differentially. It first flew, with Felix at the controls, on 18 October 1913.

In August 1913 Commandant Felix piloted a D.8 across the English Channel from Eastchurch to Villacoublay. Nieuport had obtained a licence to build the D.8 and Felix gave demonstration flights in France on their behalf. A Nieuport-built Dunne appeared at the Paris Aero Salon in December 1913. Like the second D.8 it was a Gnome powered two seater, but with significant differences both aerodynamically and structurally. It combined the double upper wing elevons into a single surface and had very rounded rear wingtips. The fuselage was slightly modified and built around steel tubes rather than wood. The interplane struts were streamlined steel tubes. It also had a strikingly simplified undercarriage.



Dunne D.8 at Farnborough, 11 March 1914

Dunne had obtained a War Office order for two D.8s, though one was cancelled because of late delivery. One, possibly the machine flown in October 1913 and certainly similar to it, was delivered to Farnborough on 3 March 1914. It made several flights on 11 March

piloted by N.S.Percival, who had flown the first D.8 many times at Eastchurch and was now a RFC officer. Though it carried the RFC number 366, there is no record of it flying again though it may have survived until at least the summer of 1914. The general judgement was that in the search for balance between stability and controllability, the Dunne design overemphasised the former.

Variants

- **D.10** A shorter span (45 ft, 13.7 m) two seat Gnome powered version, later converted to D.8.
- **Burgess-Dunne** The Burgess Company and Curtiss, based in Marblehead, Mass, USA gained the US manufacturing rights and built a series of aircraft based on the D.8. They became known as Burgess-Dunne machines and were mostly single-float planes. The first flew in March 1914, piloted by Clifford Webster. Apart from wingtip floats the wings were identical to those of the D8, but the fuselage was revised with a distinct nacelle containing a more enclosed cockpit. The aircraft was a single seater, with the heavier 100 hp (75 kW) Curtiss OXX2 water cooled engine moved forwards, shortening the fuselage and with its radiator placed between engine and pilot. The single float was 17 ft 8 in long (5.38 m), shallow and flat bottomed viewed from in front, with a single step. The prototype behaved well in the air and on the water. The second machine was very similar to the first, but room was made for a second seat by replacing the single fuselage mounted radiator with a pair fixed to the rear float struts.

The second machine was bought by the Canadian government for the Canadian Aviation Corps and was their first military aircraft. It was shipped to Europe for service in World War I, but was seriously damaged in transit and not used. The third machine, another two seater but powered by a Salmson M-9 radial providing 135 hp (100 kW), was delivered to the US Signal Corps in either 1914 or 1915. Two were also delivered to the US Navy as type AH-7, fitted with a 90 hp (60 kW) Curtiss engine and AH-10 with the 100 hp Curtiss. The latter set a US altitude record of 10,000 ft (3,050 m) on 23 April 1915. One Burgess-Dunne was configured as a landplane for a time.



The first Burgess-Dunne floatplane at Marblehead in 1914

The Dunne-Burgess types were

- BDI - as the prototype.
- BD - as the second aircraft, first aimed at the military market then as a sports plane.
- BDH - a two seater with a 140 hp (104 kW) Sturtevant V-8 engine and a slightly increased span (46 ft, 14.0 m).
- BDF - a three seat, flying boat variant with the Curtiss engine but a span increased to 53 ft (16.2 m).

There is a full scale, non-flying replica of a Burgess-Dunne in the RCAF Memorial Museum, CFB Trenton, Ontario, largely built by Barry D. MacKeracher.

Specifications (second aircraft)

General characteristics

- **Crew:** 1
- **Length:** 25 ft 9 in (7.85 m)
- **Wingspan:** 46 ft 0 in (14.02 m)
- **Wing area:** 545 sq ft (50.6 m²)
- **Empty weight:** 1,400 lb (635 kg)

- **Gross weight:** 1,900 lb (862 kg)
- **Powerplant:** 1 × Gnôme 7-cylinder rotary, 80 hp (60 kW)

Performance

- **Maximum speed:** 56 mph (90 km/h; 49 kn)
- **Rate of climb:** 500 ft/min (2.5 m/s)

Chapter 7

Fauvel AV.36, Kayaba Ku-2 and Kayaba Ku-3

Fauvel AV.36

AV.36



Fauvel AV 36 at the French Air & Space Museum.

Role	Flying wing glider
Manufacturer	Homebuilt
Designed by	Charles Fauvel
First flight	December 31 1951
Number built	over 100

The **Fauvel AV.36** was a single-seat tailless glider designed in France in the 1950s by Charles Fauvel. Although the "AV" in *AV.36* stands for *Aile Volante* (Flying Wing), it was not a true flying wing: it featured two large fins mounted on stubby tailbooms extending back from the wing's trailing edge, and accommodated the pilot within a stubby fuselage. The aircraft was designed to be quickly disassembled for road transport, with the nose detaching, and the fins able to fold back against the trailing edge of the wing. A refined version with a slightly longer wingspan, the **AV.361** was introduced in 1960.

The AV.36 lent itself to easy motorisation, with some builders installing an engine at the rear of the cockpit pod to drive a pusher propeller turning between the tail fins, and the Bölkow factory manufactured some aircraft in this configuration as the **AV.36 C11**.

Plans for the AV.36 have not been available in France since Fauvel's death in 1979, but as of 2007 they are still available from a Canadian supplier.

Specifications (AV.36)

General characteristics

- **Crew:** one pilot
- **Length:** 3.17 m (10 ft 5 in)
- **Wingspan:** 11.95 m (39 ft 2 in)
- **Wing area:** 14.2 m² (153 ft²)
- **Empty weight:** 120 kg (265 lb)
- **Gross weight:** 225 kg (496 lb)

Performance

- **Maximum speed:** 180 km/h (112 mph)
- **Maximum glide ratio:** 26:1
- **Rate of sink:** 0.9 m/s (180 ft/min)

Kayaba Ku-2

Ku-2

Role	Research glider
National origin	Japan
Manufacturer	Kayaba
Designed by	Hidemasa Kimura
First flight	October 1940
Number built	1

The **Kayaba Ku-2** was a glider built in Japan in 1940 to investigate the possibilities of tailless aircraft. It was developed as part of an Imperial Japanese Army contract that had been offered to designer Hidemasa Kimura following the successful flights of his HK-1 tailless glider over the previous years.

Developed with the help of the Kayaba company's chief designer Shigeki Naito, the Ku-2 had a swept wing with two vertical fins at the end of the wings. The Ku-2 flew 262 test flights between October 1940 and May 1941 before being damaged beyond repair in a crash.

Specifications

General characteristics

- **Crew:** One pilot
- **Length:** 3.04 m (10 ft 0 in)
- **Wingspan:** 9.80 m (32 ft 2 in)
- **Wing area:** 14.5 m² (156 ft²)

Performance

- **Maximum speed:** 75 km/h (47 mph)

Kayaba Ku-3

Ku-3

Role	Research glider
National origin	Japan
Manufacturer	Kayaba
Designed by	Hidemasa Kimura and Joji Washimi
First flight	February 1941
Number built	1

The **Kayaba Ku-3** was a glider built in Japan in 1941 to investigate the possibilities of tailless aircraft. Building on the success of the Ku-2 design of the previous year, the Ku-3 was a substantially larger aircraft with several novel features. The small vertical fins of the Ku-2 were abandoned, leaving the Ku-3 with no vertical control surfaces. The wing was a cranked delta design, with three pairs of control surfaces on the trailing edge. The outer, less-swept wing sections had a greater dihedral than the inner sections.

The prototype crashed after 67 flights, when the test pilot was unable to recover from a spin.

Chapter 8

Lippisch P.13 and Nike PUL 9

Lippisch P.13

P.13

Role	Bomber
National origin	 Nazi Germany
Manufacturer	Messerschmitt
Designed by	Josef Hubert
Number built	0

The **Lippisch P.13** was a 1942 design for a high-speed bomber aircraft by Josef Hubert. Of highly unconventional configuration, it was a tail-less, swept-wing design with an engine and propeller mounted at both the front and rear of the aircraft. A large ventral fin gave it an almost cruciform cross-section.

At the time of the P.13's design, Hubert was working in Dr Alexander Lippisch's department at Messerschmitt; when Lippisch left the firm in April 1943, the department was dissolved and its designs (including the P.13) were abandoned.

The similarly-named Lippisch P.13a and P.13b were completely unrelated projects, undertaken after Lippisch's relocation to Vienna.

Specifications (P.13, as designed)

General characteristics

- **Crew:** one, pilot
- **Length:** 9.40 m (30 ft 10 in)
- **Wingspan:** 12.80 m (42 ft 0 in)
- **Height:** 5.10 m (16 ft 9 in)

Performance

Armament

- 1 × bomb

Nike PUL 9

PUL 9

Role	Experimental tailless aircraft
National origin	Argentina
Manufacturer	Nike Aeronautica srl
Designed by	Reimar Horten & Siegfried Panek
First flight	22 July 1990
Number built	1

The **Mike PUL 9** is an Argentine experimental tailless aircraft powered by a Rotax 447 engine.

Design and development

The PUL 9 had its origins in Argentina, the home of the German flying wing pioneer Reimar Horten since 1948. In late 1989 a collaboration between Horten and Siegfried Panek produced a design for a single seat, single pusher engine tailless aircraft. The name was an acronym of Panek UltraLight, with 9 the span in metres. Construction began near Frankfurt, Germany in January 1990 but was transferred to the Italian company Nike Aeronautica in the Spring. The PUL 9 first flew on 22 June 1990.

It had 30° of sweep on the leading edges of its thick (thickness/chord ratio 20%), symmetric aerofoil, wings, built using carbon fibre and Kevlar with glassfibre for the spars. The wingtips were rounded, with washout. Elevons controlled both pitch and roll; there was no vertical stabilizing surface, rudder or separate tailplane.

Like some of Horten's tailless gliders, the I.Ae. 34 Clen Antú for example, the PUL 9 had a well defined, though short, fuselage or pod. This was a deep steel tube structure starting about mid-chord and extending well behind the trailing edge, with a single seat open cockpit at the front and a 42 hp (31 kW) Rotax 447 two cylinder two-stroke engine in pusher mode behind. The main wheels of the PUL 9's fixed tricycle undercarriage were

also mounted on the steel frame, with the nosewheel attached near the leading edge. The undercarriage used rubber cord shock absorbers and drum brakes.

The PUL 9 is reported to have flown several times and handled well. By the end of 1991 attention had turned to a two seat version, the PUL 10.

Specifications

General characteristics

- **Crew:** 1
- **Length:** 3.90 m (12 ft 10 in)
- **Wingspan:** 9.00 m (29 ft 6 in)
- **Height:** 1.60 m (5 ft 3 in)
- **Wing area:** 11.60 m² (124.9 sq ft) approximate
- **Empty weight:** 150 kg (331 lb)
- **Max takeoff weight:** 300 kg (661 lb)
- **Powerplant:** 1 × Rotax 447UL 2-cylinder inline two-stroke, 31.3 kW (42.0 hp)
- **Propellers:** 3-bladed Arplast 148GAM adjustable pitch pusher, 1.48 m (4 ft 10 in) diameter

Performance

- **Maximum speed:** 225 km/h (140 mph; 121 kn) at sea level
- **Cruising speed:** 140 km/h (87 mph; 76 kn) economical, at sea level
- **Stall speed:** 55 km/h (34 mph; 30 kn)
- **Rate of climb:** 5.08 m/s (1,000 ft/min)

Chapter 9

Payen Pa 49 and Saab 35 Draken

Payen Pa 49

Pa 49 Katy



The sole Pa 49 Katy on display at the 1957 Paris Air Show wearing French military markings

Role	Experimental tailless delta
National origin	France
Manufacturer	Payen-Aviation, Juvisy, Seine et Oise
Designed by	Roland Payen
First flight	22 January 1954
Retired	1958
Number built	1

The **Payen Pa 49 Katy** was a small experimental French turbojet powered delta wing aircraft, first flown in 1954, was the first French aircraft of this kind and the smallest jet aircraft of its day.

Design and Development

Roland Payen was a pioneer of tailless and delta winged aircraft, building two designs, a light aircraft and a fighter, before the second world war. The Pa 49 Katy was his first post-war design.

The all wood Katy was a true tailless aircraft, in the sense that it had no separate horizontal stabiliser. The wing leading edge was swept at about 55° but, unlike the classic delta with its straight trailing edge, the Katy's was swept at about 30° with each trailing edge carrying full span control surfaces, elevators inboard and ailerons outboard.

At its root, the wing merged gently into the fuselage with small air intakes for the 1.47 kN (330 lbf) Turboméca Palas engine built into the leading edge. The cockpit was placed just aft of the intakes and the long straight-edged fin, swept at about 75° and initially as wide as the cockpit, began immediately behind it, narrowing to a slightly swept trailing edge carrying a full depth rudder. Images recorded before the first flight show the Katy with a low bicycle undercarriage with wing tip skids but, by the time of the flight itself, this was replaced by a fixed, un-faired tricycle undercarriage.

Operational History



The Pa 49 Katy has been in the Musée de l'Air at Le Bourget since 1958

The first flight of what was now the Pa 49A took place on 22 January 1954 at Melun-Villaroche flown by Tony Ochsenein, a comparatively inexperienced pilot, who had previously logged only 30 minutes on jets. Ten hours of manufacturer's testing was followed, in April 1954, by assessment at the Centre d'Essais en Vol (CEV), Brétigny-sur-Orge. The aerobatic ability of the Pa 49 was established. At the CEV it was fitted with a split rudder airbrake; the two surfaces of the rudder separated from just below the tip, driven via faired external links near the bottom, into a V at the hinge for braking,

rotating together for yaw control. This airbrake was designed by Fléchair SA, a company founded by Payen. At the time of its appearance at the 12th Salon International d'Aeronautique at Paris, in 1957, the undercarriage legs were faired and the main wheels enclosed in spats and the aircraft renamed the Pa 49B. For a time the nosewheel was also spatted. There were plans for a version with a retractable undercarriage, but this did not come about.

When the flight testing programme ended in 1958 Payen gave the aircraft to the Musée de l'Air at Paris - Le Bourget Airport. He continued to design delta winged aircraft and the Payen Pa 71 and Pa 149 projects of the 1970s were direct developments of the Katy.

Specifications



The Pa 49 at le Bourget

General characteristics

- **Crew:** 1
- **Length:** 5.10 m (16 ft 9 in)
- **Wingspan:** 5.16 m (16 ft 11 in)
- **Height:** 2.50 m (8 ft 2 in)
- **Empty weight:** 457 kg (1,008 lb)
- **Gross weight:** 650 kg (1,433 lb)
- **Powerplant:** 1 × Turboméca Palas centrifugal turbojet, 1.5 kN (330 lbf) thrust

Performance

- **Maximum speed:** 500 km/h (310 mph; 270 kn)
- **Cruising speed:** 350 km/h (220 mph; 190 kn)
- **Range:** 450 km (280 mi; 243 nmi)
- **Service ceiling:** 8,500 m (27,887 ft)
- **Rate of climb:** 5.8 m/s (1,140 ft/min) initial

Saab 35 Draken

Saab 35 Draken



An Austrian Air Force Draken in a special paint scheme.

Role	Fighter
National origin	Sweden
Manufacturer	Saab
First flight	25 October 1955
Introduced	8 March 1960
Retired	1993 Denmark 1999 Swedish Air Force 2000 Finland 2005 Austria
Status	Retired from military service
Primary users	Swedish Air Force Austrian Air Force Finnish Air Force Royal Danish Air Force
Produced	1955–1974
Number built	644

Developed from Saab 210

The **Saab 35 Draken** is a Swedish fighter aircraft manufactured by Saab between 1955 and 1974. The Draken was built to replace the Saab J 29 Tunnan and, later, the fighter variant (J 32B) of the Saab 32 Lansen. The indigenous J 35 was an effective supersonic Cold War fighter that was also successfully exported to Austria, Denmark and Finland.

Design and development

As the jet era started, Sweden foresaw the need for a jet fighter that could intercept bombers at high altitude and also successfully engage fighters. Although other interceptors such as the US Air Force's F-104 Starfighter were being conceived during the same period, Saab's "Draken" would have to undertake a combat role unique to Sweden. Other demanding requirements were the capability to operate from reinforced public roads used as part of wartime airbases, and for refuelling/rearming to be carried out in no more than ten minutes, by conscripts with minimal training. In September 1949, the Swedish Defence Material Administration issued a request for a fighter/interceptor aircraft, and work began at Saab the same year.



A line-up of J 35As

Draken's design incorporated a distinctive "double-delta" configuration, with one delta wing within another larger delta. The inner wing has an 80° angle for high speed performance, while the outer 60° wing gives good performance at low speeds. Propulsion

was provided by a single Svenska Flygmotor RM 6B/C turbojet (Rolls-Royce Avon 200/300). A ram turbine, under the nose, provided emergency power and the engine had a built-in emergency starter unit. The Draken could deploy a drag chute to reduce its landing distance.

The double-delta shape was so revolutionary that it warranted the only sub-scale test aircraft built in Sweden: the Saab 210, unofficially nicknamed "Lilldraken" (the little kite). The Saab 210 tested the concept of the double delta, first flying on 21 January 1952. The 210's successful testing results led to an order for three full-size Draken prototypes. The first prototype, not fitted with an afterburner, made its maiden flight on 25 October 1955. The second prototype, equipped with an afterburner, unintentionally broke the sound barrier on its first flight while climbing.

Operational history

Although not designed to be a dogfighter, the J 35 Draken proved to have good instantaneous turn capability and was a very capable fighter. It entered service in 1960 with the Swedish Air Force; 644 Saab Drakens were built for Sweden as well as other European nations. Sweden's Draken fleet came in six different variants while two Draken models were offered for export. The early models were intended purely for air defence. The last model built was the J 35F, the final variant to remain in Swedish service. These aircraft were retired in the 1990s and replaced by the Saab Gripen.



Ex-RDAF RF-35XD N217FR operated by the National Test Pilot School takes off from the Mojave Spaceport.

The J 35 Draken design underwent several upgrades. The last was the J 35J version, in the late 1980s, although by then, the Draken had been almost totally replaced by the Saab 37 Viggen in Swedish service. The J 35J was a service-life extension program since the delivery of the new Saab JAS 39 Gripen was still in the development stage and suffering from delivery delays. The extension program was to keep the Draken flying into the 2000s, but due to cutbacks and high maintenance costs the Draken was eventually phased out. The Swedish Drakens were officially retired in December 1998, although the type remains in limited numbers in both military and civilian versions. Export customers included Denmark and Finland. In 1985, the Austrian Air Force purchased 24 J 35D s reconditioned by Saab, designated J 35Ö.

All Drakens are interceptors with limited air-to-ground capability, with the sole exception of the Danish Drakens, which are strike aircraft capable of carrying AGM-12 Bullpup missiles, advanced "jammers", and increased internal and external fuel stores. The Danish Drakens are so far the heaviest of the series to have been in service. Danish F-35 aircraft were retired in 1993.

Finland updated its 35XS fleet with new avionics, cockpit displays, navigational/attack systems and electronic countermeasures during the 1990s but finally retired the Draken in 2000.

Austria was the last country to operate the Draken in military service. They bought refurbished J 35D which was the last Austrian Air Force fighter with two internal cannons due to the restriction in the Austrian State Treaty of 1955 of not being allowed to carry air-to-air missiles. This restriction was dropped in 1993 due to airspace violations from the nearby Yugoslavian internal conflict on its southern border, AIM-9 Sidewinder missiles were purchased. These Drakens were retired in 2005, when they were replaced by former Swiss Tiger IIs, while waiting for new Eurofighters.

In the United States, the National Test Pilot School (NTPS) owns six Drakens that were formerly in Danish service; of these, two TF-35XD s and one RF-35XD are operational, based at the Mojave Spaceport.

Variants

Proof of concept

Saab 210 Draken

(also known as **Lilldraken**) - A scaled-down, "proof of concept" experimental aircraft to evaluate the double-delta wing configuration, not specifically a Draken variant but included here for sequence purposes.

Full-size Drakens

J 35A

Fighter version, total production: 90. The J 35As were delivered between 1959-1961. The tail section was lengthened after the 66th aircraft to house a new afterburner for additional thrust. This forced the installation of a retractable tail-

wheel. The two versions were nicknamed *Adam kort* (Adam short) and *Adam lång* (Adam long).

J 35B

Fighter version, built and delivered between 1962–1963, total production: 73. This variant had improved radar and gun sights, and was also fully integrated into the Swedish STRIL 60 system; a combat guidance and air surveillance system.

SK 35C

25 J 35As with short tail sections rebuilt into a twin-seated trainer version. The minor modification meant that the aircraft could easily be converted back to a J 35A standard if necessary. The trainer version lacked armament.

J 35D

Fighter version, delivered between 1963–1964, total production: 120. The aircraft had a new and more powerful Rolls-Royce Avon 300 (RM 6C), which could deliver 77.3 kN thrust when using its afterburner. This was also the fastest Draken version, capable of accelerating until out of fuel. It was also the last Draken to carry two cannons.

S 35E

Reconnaissance version, total production: 60. The radar and the armament had been removed and several cameras (of ortho and oblique types) fitted. The aircraft was unarmed but was fitted with a countermeasure system to increase its survivability. A total of 28 aircraft were re-built J 35Ds.

J 35F

Fighter version, delivered between 1965 and 1972, total production: 230. This variant had improved electronics and avionics, e.g. integrated radar, aim and missile systems. The aircraft's main armament were IR and SARH versions of the Hughes Falcon missile originally intended for the J 35D, but one of the cannon was removed to make space for more avionics. The **J 35F2** was a J 35F, produced with a Hughes Aircraft Company N71 infra red sensor, a so-called IR seeker. This was a change in the production line from the no. 35501 airframe.

J 35J

In 1985 the Swedish government decided to modify 54 J 35F2s to J 35J standard. In 1987, 12 more modifications were ordered. Between 1987 and 1991, the aircraft were given a longer lifespan, more modern electronics, a modernized cannon, an additional two sidewinder pylons under the air intakes and increased fuel capacity. The final operative J 35J flew for the last time in 1999.

Saab 35H

Proposed export version for the Swiss Air Force; none sold or delivered.

Saab 35XD

Danish export versions: **F-35** single-seat Strike Aircraft, **TF-35** two-seat trainer and **RF-35** reconnaissance aircraft. The type was heavily modified to make it into a strike aircraft compared the Swedish versions.

Saab 35XS

Fighter version for the Finnish Air Force; built by Saab and assembled under licence by Valmet in Finland.

Saab 35BS

Used J 35Bs sold to Finland.

Saab 35FS

Used J 35F1s sold to Finland.

Saab 35CS

Used SK 35Cs sold to Finland.

Saab 35Ö

In the mid-1980s, Saab purchased back 24 J 35D aircraft from the Swedish Air Force and converted them into the J 35Ö version (also called **J 35OE** in English literature). These were later exported to Austria.

Proposed modifications

Before it was decided to develop the JAS 39 Gripen in the late 1970s, an intensive study was undertaken on an AJ 35 modification for the remaining S 35E and J 35F variants. The main goal was to give the aircraft strike capability while waiting for a replacement for the AJ 37 Viggen.

35 MOD Level 4

The most ambitious modification in the program. The proposed modifications were; new outer wing, additional weapon stations, RBS 15 capability, the addition of canard wings by the air intakes for increased maneuverability and maximum take-off weight increased to 15 000 kg.

35 MOD Level 1b

Essentially the aircraft that became the J 35J.

The total number of Drakens produced and delivered: 644.

Operators



former Saab 35 Draken Operators in red

The Saab 35 Draken was withdrawn from military use in 2005. Several aircraft fly in the civil circuit, mainly in the USA.

 Austria

- Austrian Air Force, 24 aircraft:
 - Fliegerregiment 2
 - Staffel 1
 - Staffel 2

 Denmark

- Royal Danish Air Force, 51 aircraft:
 - No. 725 Squadron
 - No. 729 Squadron

 Finland

- Finnish Air Force, 50 aircraft:
 - Fighter Squadron 11
 - Fighter Squadron 21

 Sweden

- Swedish Air Force
 - F 1 Hässlö
 - F 3 Malmslätt
 - F 4 Frösön
 - F 10 Ängelholm
 - F 11 Nyköping
 - F 12 Kalmar
 - F 13 Norrköping
 - F 16 Uppsala
 - F 17 Kallinge
 - F 18 Tullinge
 - F 21 Luleå

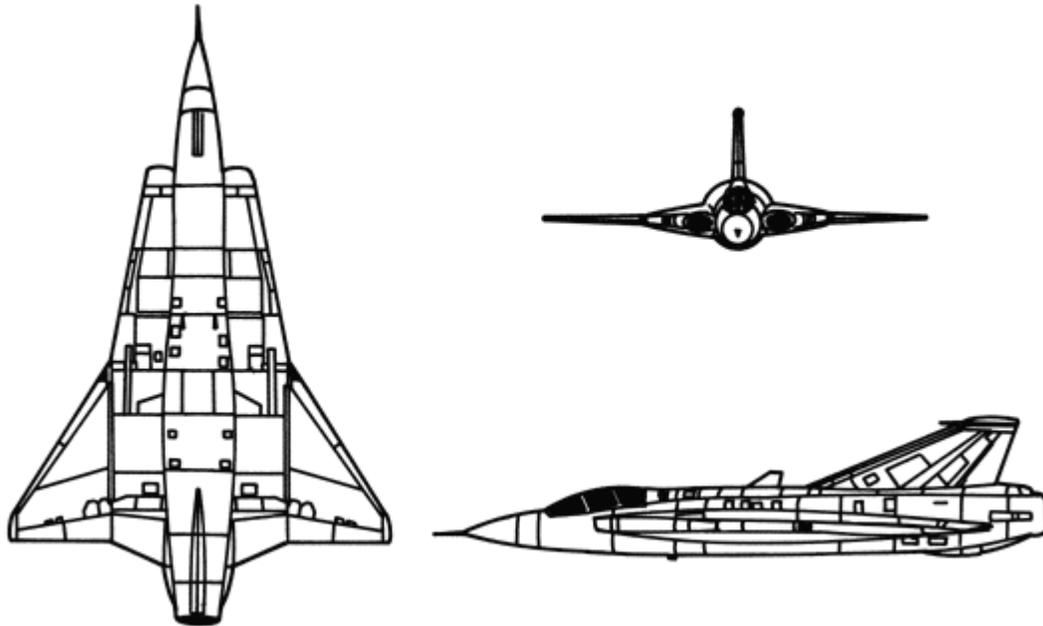
 United States

- National Test Pilot School (6)

Survivors

- J 35J, 35556 in the Swedish Air Force Museum at F 14 Halmstad, Sweden Only airworthy Saab J 35 in Sweden
- J 35J, 35630 at the at the Ängelholms Flyg Museum on the former Scandia Air Force Wing F 10 Ängelholm

Specifications (*J 35F Draken*)



General characteristics

- **Crew:** One
- **Length:** 15.34 m (50 ft 4 in)
- **Wingspan:** 9.42 m (30 ft 10 in)
- **Height:** 3.89 m (12 ft 9 in)
- **Wing area:** 49.22 m² (529.82 ft²)
- **Empty weight:** 7,865 kg (17,340 lb)
- **Loaded weight:** 11,400 kg (25,132 lb)
- **Max takeoff weight:** 16,000 kg (35,273 lb)
- **Powerplant:** 1× Volvo Flygmotor RM 6C afterburning turbojet
 - **Dry thrust:** 56.5 kN (12,787 lbf)
 - **Thrust with afterburner:** 78.4 kN (17,637 lbf)

Performance

- **Maximum speed:** Mach 2+, 2,120 km/h (1,317 mph) at 11,000 m (36,100 ft)
- **Range:** 3,250 km (2,020 mi) with external drop tanks
- **Service ceiling:** 20,000 m (65,600 ft)
- **Rate of climb:** 175 m/s (34,450 ft/min)
- **Wing loading:** 231.6 kg/m² (47.4 lb/ft²)
- **Thrust/weight:** 0.70
- **Takeoff roll:** 650 m (2,133 ft)

Armament

- **Guns:** 1x 30 mm M-55 ADEN cannon with 100 rounds (2x 30 mm M-55 ADEN cannon with 90 rounds each in earlier models)
- **Hardpoints:** for fuel tanks or ordnance with a capacity of 2,900 kg (6,393 lb) and provisions to carry combinations of:
 - **Rockets:** 2x 75 mm air-to-air rocket pods ventrally or 12x 135mm rockets on six underwing pylons
 - **Missiles:** Rb 24, Rb 27 and Rb 28 air-to-air missiles
 - **Bombs:** 55, 220, 500, and 1,000 pound bombs

Chapter 10

Vought F7U Cutlass

F7U Cutlass



An F7U-3 Cutlass on the ramp at Naval Air Station Jacksonville.

Role	Naval multirole fighter
Manufacturer	Chance Vought
First flight	29 September 1948
Introduced	July 1951
Retired	2 March 1959
Primary user	United States Navy
Produced	1948-1955
Number built	320

The **Vought F7U Cutlass** was a United States Navy carrier-based jet fighter and fighter-bomber of the early Cold War era. It was a highly unusual, semi-tailless design, allegedly based on aerodynamic data and plans captured from the German Arado company at the end of World War II, though Vought designers denied any link to the German research at the time. The F7U was the last aircraft designed by Rex Beisel, who was responsible for the first fighter ever designed specifically for the US Navy, the Curtiss TS-1 of 1922.

Regarded as a radical departure from traditional aircraft design, the Cutlass suffered from numerous technical and handling problems throughout its short service career. The type was responsible for the deaths of four test pilots and 21 other U.S. Navy pilots. Over one quarter of all Cutlasses built were destroyed in accidents. The poor safety record was largely the result of the advanced design built to apply new aerodynamic theories and insufficiently powerful, unreliable engines.

Design and development



The first F7U-1 launching from the *USS Midway* in 1951

The Cutlass was Vought's entry to a U.S. Navy competition for a new carrier capable day fighter opened on 1 June 1945. The requirements were for an aircraft that was able to fly at 600 mph (966 km/h) at 40,000 ft (12,192 m). The design featured broad chord, low aspect ratio, swept wings, with twin wing-mounted tail fins either side of a short fuselage. The cockpit was situated well forward to provide good visibility for the pilot during aircraft carrier approaches. The design was given the company type number of V-346 and then the designation F7U when it was announced the winner of the competition.

Pitch and roll control was provided by elevons, though Vought called these surfaces "ailevators" at the time. Slats were fitted to the entire span of the leading edge. All controls were hydraulically-powered. The very long nose landing gear strut required for high angle of attack takeoffs was rather weak, and a collapse could seriously jeopardize

the pilot's safety. The F7U was also largely let down by its underpowered Westinghouse turbojets, an engine which some pilots wryly observed put out less heat than the same company's toasters. Naval aviators referred to the F7U as the "gutless cutlass" or, in kinder moments, as the "praying mantis".

Operational history



Vought F7U-3 Cutlass



Ramp strike of a VF-124 F7U-3 on the USS *Hancock* on 14 July 1955 resulting in the death of the pilot but only relatively minor injuries to deck crew.

Three prototypes were ordered in 1946, with the first example flying on 29 September 1948, piloted by Vought's Chief Test Pilot, J. Robert Baker. The maiden flight took place from Naval Air Station Patuxent River and was not without its problems. During testing one of the prototypes reached a maximum speed of 625 mph (1,058 km/h)

Production orders were placed for the **F7U-1** in a specification very close to the prototypes, and further developed **F7U-2** and **F7U-3** versions with more powerful engines. Because of development problems with the powerplant, however, the F7U-2 would never be built, while the F7U-3 would incorporate many refinements suggested by tests of the -1. The first 16 F7U-3s had non-afterburning Allison J35-29 engines. The -3 with its Westinghouse J46-WE-8B turbojets would eventually become the definitive production version, with 288 aircraft equipping 13 U.S. Navy squadrons. Further development stopped once the F8U Crusader flew.

The F7U bore the fleet nickname of the *Gutless Cutlass* in reference to its lack of engine thrust; consequently its carrier landing and takeoff performance was notoriously poor. The J35 was actually known to flameout in the rain, a very serious fault.

The first fleet squadron to receive F7Us was VF-81 in April 1954; the last with Cutlasses was VA-66 in November 1957. Few squadrons made deployments with the type, and most "beached" them during part of the cruise owing to operating difficulties. Those units known to have taken the type to sea were:

VF-124, USS *Hancock* (CVA-19), August 1955 - March 1956; VF-81, USS *Ticonderoga* (CVA-14), November 1955 - August 1956; VF-86, USS *Forrestal* (CVA-59), January - March 1956; VF-83, USS *Intrepid* (CVA-11), March - September 1956; VF-212, USS *Bon Homme Richard* (CVA-31), August 1956 - February 1957.

VC-3 and VX-4 also operated Cutlasses at sea for evaluation purposes.

Blue Angels

The Navy Flight Demonstration Squadron, the Blue Angels, flew two F7U-1 Cutlasses as a side act during their 1953 show season in an effort to promote the new aircraft, but did not use them as part of their regular formation act. Both the pilots and ground crews found the aircraft generally unsatisfactory and it was apparent that the type was still experiencing teething troubles.

During the Blue Angels' first airshow appearance in 1953, pilot LT Edward "Whitey" Feightner, the former program manager for the F7U, experienced a total loss of hydraulics on a full afterburner takeoff and steep climb. While trying to gain enough altitude for ejection he was able to stay with the aircraft until the back up system came on. He clipped trees on the end of the runway, causing the left engine to flame out. With hydraulic fluid streaming back in a bright flame, he made a hard turn and got the plane back on the runway, much to the excitement of the crowd. Later, while traveling to the airshow at Naval Air Station Glenview in Chicago, Blue Angel pilot LT Harding MacKnight experienced an engine flameout in his Cutlass, forcing him to make an emergency landing at Glenview. Traveling with him, "Whitey" Feightner was redirected to make his landing at Chicago's former Orchard Airpark, which had been expanded and renamed O'Hare Airport. The runway had just been completed and was covered with peach baskets to prevent aircraft from landing until it was opened. LT Feightner was told to ignore the baskets and land on the new runway. As a result, LT Feightner's F7U became the first aircraft to land on the new runway for Chicago's O'Hare Airport.

Following these incidents the two F7U were deemed unsuitable for demonstration flying and were flown to Naval Air Station Memphis, Tennessee, where they were abandoned to become aircraft maintenance instructional airframes for the Naval Technical Training Center.

Variants

XF7U-1

Three prototypes ordered on 25 June 1946. First flight, 29 September 1948, all three aircraft were destroyed in crashes.

F7U-1

The initial production version, 14 built. Powered by two J34-WE-32 engines.
F7U-2

Proposed version, planned to be powered by two Westinghouse J34-WE-42 engines with afterburner, but the order for 88 aircraft was cancelled.

XF7U-3

Designation given to one aircraft built as the prototype for the F7U-3. First flight: 20 December 1951.

F7U-3

The definitive production version, 192 built.



F7U-3P reconnaissance aircraft

F7U-3P

Photo-reconnaissance version, 12 built. With a 25 in longer nose and equipped with photo flash cartridges none of these aircraft saw operational service, being used only for research and evaluation purposes.

F7U-3M

This version was armed with the AIM-7 Sparrow air-to-air missile, 98 built. A total of 48 F7U-3 existing airframes were upgraded to F7U-3M standard. An order for 202 aircraft was cancelled.

A2U-1

Designation given to a cancelled order of 250 aircraft to be used in the ground attack role.

Operators



A VF-83 F7U-3M launches from the *USS Intrepid* in 1954

United States

- United States Navy
 - Attack Squadron 12 (VA-12)
 - VA-34
 - VA-35
 - VA-66
 - VA-83
 - VA-86
 - VA-116
 - Fleet Composite Squadron 3 (VC-3)
 - Fighter Squadron 124 (VF-124)
 - VA-126**VA-155**VF-83
 - VF-81
 - VF-84
 - VF-122
 - VF-151
 - VF-212
 - Test and Evaluation Squadron 4 (VX-4)

Survivors

Seven F7U Cutlass aircraft are known to have survived.

F7U-3 BuNo 128451

Formerly at the Fred E. Weisbrod Aviation Museum/International B-24 Museum in Pueblo, Colorado. It was unrestored and incomplete, in poor condition. It is now at the USS Midway (CV-41) Museum in San Diego, California, to be combined with BuNo 129565 to make one complete aircraft.

F7U-3 BuNo 129554

Purchased by Len Berryman from Geiger Field, Washington in May 1958 and displayed outside the Berryman War Memorial Park in Bridgeport, Washington from 1958 until 1992. In June 1992 it was sold to Tom Cathcart of Ephrata, Washington for restoration to eventual flying condition. This aircraft is currently undergoing restoration at the Museum of Flight in Everett, Washington.

F7U-3 BuNo 129565

Was undergoing restoration for display at the USS Hornet (CV-12) Museum at the former NAS Alameda in Alameda, California. Has now been transferred to USS Midway (CV-41) Museum in San Diego, California for final restoration and display.

F7U-3 BuNo 129622

Ex VA-12 aircraft that sustained crash-landing damage at NAS Glenview, Illinois; was moved to the Oakdale Elementary School for playground use, and was subsequently dissected and sold for its engines. Forward fuselage was part of Earl Reinart's collection in Mundelein, Illinois, while the rest of the aircraft went to J-46 dragster builder Fred Sibley. Its components are currently reunited in the collection of noted F7U historian Al Casby of Phoenix, Arizona.



F7U-3M at the National Museum of Naval Aviation at NAS Pensacola, Florida

F7U-3 BuNo 129642

On display at the Wings of Freedom Aviation Museum at the Naval Air Station Joint Reserve Base Willow Grove, Pennsylvania. The aircraft belonged to Attack Squadron 12 (VA-12) and was flown to NAS Willow Grove in May 1957 to take part in an air show. Upon arrival the aircraft was stricken from active duty. It was given to the Navy Reserve as a ground training aircraft, and eventually placed as a gate guard in front of the base on US Route 611. The airframe has only 326.3 hours total time.

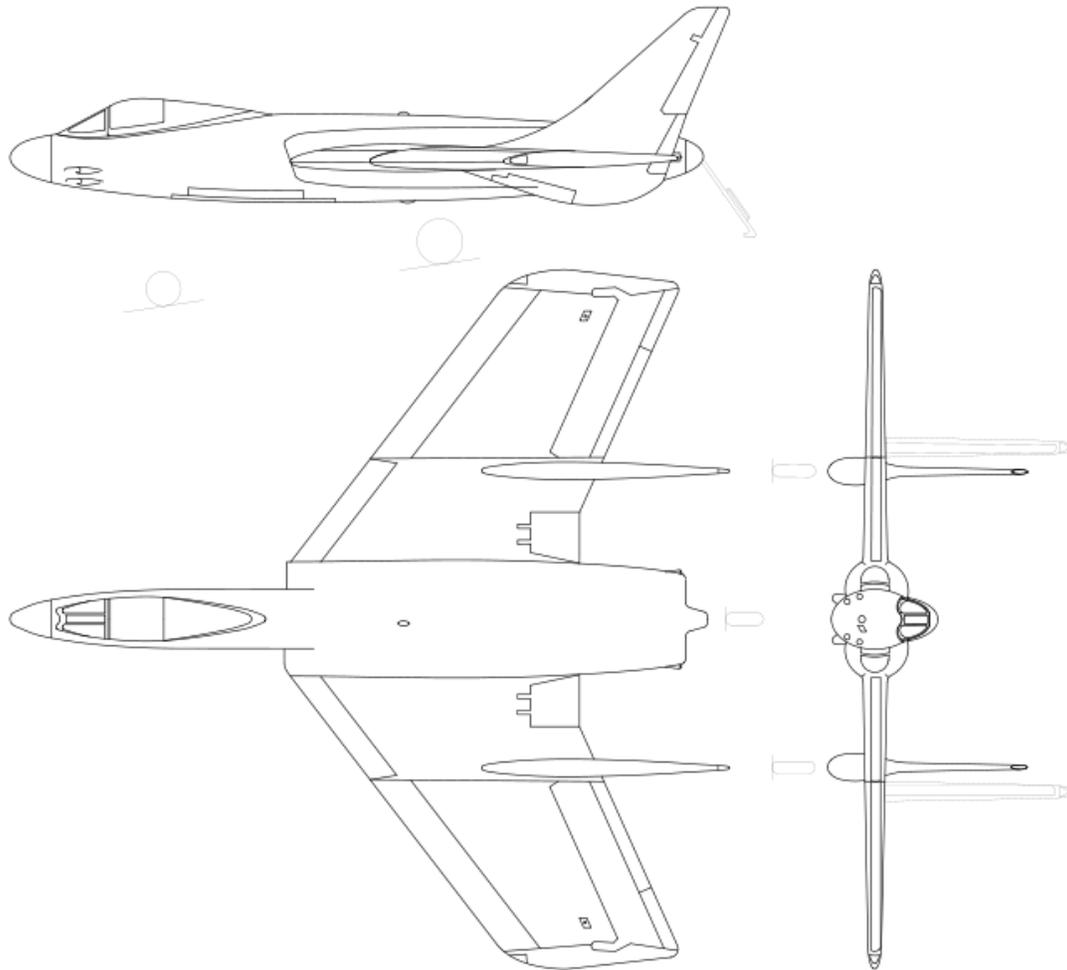
F7U-3 BuNo 129655

Although marked as an F7U-3M, this aircraft on display at the National Museum of Naval Aviation at NAS Pensacola, Florida is in reality an F7U-3 which was factory upgraded to F7U-3M standards. Formerly displayed at Griffith Park, California.

F7U-3 BuNo 129685

Located for many years at the aircraft collection of Walter Soplata in Newbury, Ohio. Like most aircraft on this famous farm, the aircraft appears complete, though it is exposed to the elements and unrestored.

Specifications (F7U-3M)



General characteristics

- **Crew:** 1
- **Length:** 44 ft 3 in (13.49 m)
- **Wingspan:** 38 ft 8 in (11.79 m)
- **Height:** 14 ft 0 in (4.27 m)
- **Wing area:** 496 ft² (46.1 m²)
- **Empty weight:** 18,210 lb (8,260 kg)
- **Max takeoff weight:** 31,642 lb (14,353 kg)
- **Powerplant:** 2× Westinghouse J46-WE-8A turbojets, 4,600 lbf (20.46 kN) each

Performance

- **Maximum speed:**
 - **Clean:** 680 mph (590 kn, 1,095 km/h)
 - **With missiles:** 648 mph (562 kn, 1,040 km/h)
- **Range:** 660 mi (570 nmi, 1,060 km)
- **Service ceiling:** 40,000 ft (12,000 m)
- **Rate of climb:** 13,000 ft/min (67 m/s)
- **Wing loading:** 64 lb/ft² (312 kg/m²)
- **Thrust/weight:** 0.29

Armament

- **Guns:** 4× 20 mm (0.787 in) M3 cannons above inlet ducts, 180 rounds/gun
- **Hardpoints:** 4 with a capacity of 5,500 lb (2,500 kg) and provisions to carry combinations of:
 - **Missiles:** AIM-7 Sparrow air-to-air missiles

Chapter 11

Adam A500

A500



Adam A500 during flight test at the Mojave Spaceport

Role	civil utility aircraft
Manufacturer	Adam Aircraft Industries
First flight	July 11, 2002
Status	Production completed
Number built	7
Developed into	Adam A700



M-309 on display at Wings Over the Rockies Museum(May 2007)



Adam A500 during flight test at the Mojave Spaceport



Adam A500



M-309 CarbonAero technology demonstrator at Mojave

The **Adam A500** is a six-seat civil utility aircraft that was produced by Adam Aircraft Industries. The aircraft is of pod-and-boom, push-pull configuration with its two Continental TSIO-550-E piston engines mounted to provide centerline thrust.

Adam Aircraft ceased operations on 11 February 2008, and filed for Chapter 7 bankruptcy on 19 February 2008, having delivered seven A500s.

In April 2008 Adam Aircraft was purchased from bankruptcy by AAI Acquisition Inc. At the time of purchase this new company indicated that they would pursue certification of the A700 jet as a priority and that the A500 would not be produced due to the continuing poor market for piston-engined aircraft. AAI went out of business in April 2009 without producing any aircraft.

In July 2009 there was an indication that a new buyer, Triton America and Thomas Hsueh were interested in purchasing the A500 design and returning the aircraft to production.

M-309

The A500 was developed from the **M-309 CarbonAero** technology demonstrator designed by Burt Rutan and built by Scaled Composites at the Mojave Airport. The "309" designation refers to this being Rutan's 309th aircraft design. The 309 first flew in March 2000, but the aircraft has since been gutted and was used as a static display outside the

Adam Aircraft Industries headquarters. In 2006 the 309 was loaned to the Wings Over the Rockies Air and Space Museum and is now on display outside.

Description

Compared to conventional twin-engine installations, the centerline thrust arrangement reduces drag and maximizes the controllability of the aircraft should one engine malfunction or fail. This engine configuration was used by the similar Cessna Skymaster. The A500 airframe is largely built of carbon epoxy skins composite materials with Nomex honeycomb core. Other features include cabin pressurization.

The prototype A500 first flew on July 11, 2002 and was FAA certified in May 2005.

A500 payload issues

In evaluation flights conducted in 2007 the A500 was noted as being over the projected empty weight by 1,260 lb (570 kg) or 30%.

The initial design empty weight publicized in 2003 was 4,200 lb (1,910 kg), while the actual empty weight of the serial number 7 A500 was 5,460 lb (2,480 kg). Initial gross weight was to be 6,300 lb (2,860 kg), which was increased to 7,000 lb (3,180 kg). This resulted in a change of useful load from a forecast 2,100 to 1,540 lb (950 to 700 kg).

With the 230 US gal (870 l) fuel tanks full, the available payload for crew, passengers and baggage is 160 lb (73 kg), down from a projected 720 lb (327 kg). This means that the A500 cannot carry full fuel and one standard weight adult male or female pilot.

Adam Aircraft had intended to address the lack of useful load by demonstrating that the current 30 US gal (110 l) of unusable fuel is actually 10 US gal (40 l). This would have increased the useful load by 120 lb (50 kg) and allowed a full fuel crew weight of 280 lb (127 kg).

Support and aircraft type club formation

The five A500s in private service have run into problems obtaining parts and at least one was reported as grounded due to parts issues in August 2008.

The aircraft owners organized an aircraft type club, the *A500 Owners Association*, with the goal of convincing the new owners of the design at that time, AAI Acquisitions to provide parts support for the existing aircraft.

AAI's head of customer support, Jan D'Angelo, responded in August 2008, saying:

“ There's no economic model that justifies setting up a support team to support just five planes in the field. There's no critical mass to make it economically ”

viable.

A600 Turboprop Derivative

Discussion of an A600 Turboprop derivative aircraft led to the development of preliminary performance specifications, cost models, and even a small show model. Variations were conceived that retained a single turboprop engine on the nose as well as variations with a single turboprop engine on the tail. The show model was made for the variation with a single Pratt & Whitney Canada PT6A pusher engine mounted on the aft fuselage.

The A600 concept made little economic sense, due to the price of a single PT6A 500 hp engine being equal to the price of two Williams International FJ33 engines at the time.

Specifications (A500)

General characteristics

- **Crew:** one
- **Capacity:** five passengers
- **Length:** 37 ft 6 in (11.43 m)
- **Wingspan:** 44 ft 0 in (13.41 m)
- **Height:** 9 ft 7 in (2.92 m)
- **Airfoil:** NASA LS(1)-0417
- **Empty weight:** 5,350 lb (2,427 kg)
- **Gross weight:** 7,000 lb (3,175 kg)
- **Fuel capacity:** 230 gal (872 litres)
- **Powerplant:** 2 × Teledyne Continental TSIO-550E , 350 hp (260 kW) each

Performance

- **Maximum speed:** 225 kn (259 mph; 417 km/h)
- **Cruise speed:** 220 kn (250 mph; 410 km/h)
- **Stall speed:** 75 kn (86 mph; 139 km/h) in landing configuration with gear and flaps down
- **Range:** 892 nmi (1,026 mi; 1,652 km) at 75% power
- **Ferry range:** 1,286 nmi (1,480 mi; 2,382 km) at 45% power
- **Service ceiling:** 25,000 ft (7,600 m) maximum certified ceiling, 14900 feet on one engine

Chapter 12

Canaero Toucan and Caproni Ca.4

Canaero Toucan

Toucan



Role	Ultralight aircraft
National origin	Canada
Manufacturer	Canaero Dynamics Aircraft
Designed by	Peter Corley
First flight	September 1983
Introduction	January 1986
Primary user	private owners

The **Canaero Toucan** is a Canadian high-wing, two seats in tandem, twin engine push-pull configuration, twin-boom ultralight kit aircraft that was produced from 1983 to the late 1980s by Canaero Dynamics Aircraft of Rexdale, Ontario.

The Toucan greatly resembles an ultralight Cessna Skymaster.

Development

The Toucan design work started in January 1983 and was completed in April of the same year, with the first flight of the prototype in September 1983. Construction of the first pre-production aircraft was started in July 1985 with the first production aircraft flying in January 1986.

Four prototypes/pre-production aircraft were completed, which were followed by a run of twelve Toucans, all completed by June 1986. A second batch of 25 aircraft were planned to have been completed by November 1986 as well.

The Toucan design features a strut-braced high wing built from aluminum covered with aircraft fabric. The wing's leading edge is of "D" cell construction and has fiberglass wing tips. Flight controls are conventional three-axis with full-span flaperons and twin rudders. The fuselage is constructed from welded 4130 steel tube. When originally delivered an airframe parachute was standard.

The landing gear is of tricycle gear configuration with the main gear legs of sprung steel and brakes are standard equipment. Wheel pants, skis and pontoons were optional.

The original engines were 28 hp (21 kW) Rotax 277s with 35 hp (26 kW) Rotax 377 engines as optional, although some aircraft have been modified with larger engines.

Operational history

In Canada Toucans are registered as basic ultralights which prohibits passenger-carrying. Both seats can only be occupied by a student and instructor or two licensed pilots.

In November 2009 there were still five Toucans registered in Canada.

Specifications (Toucan T-IV)

General characteristics

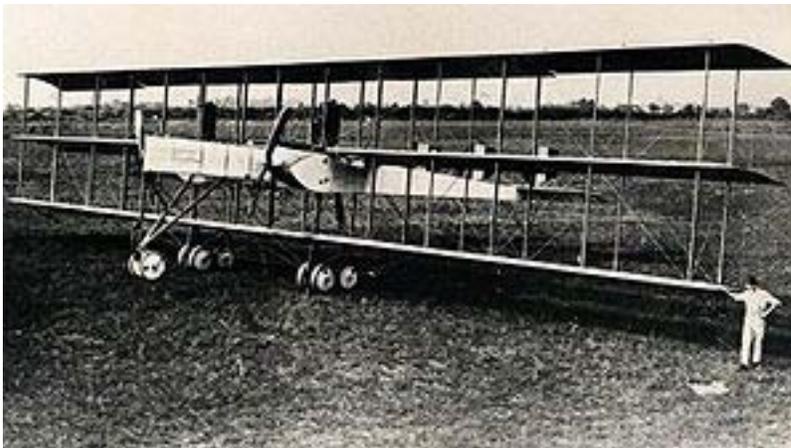
- **Crew:** one
- **Capacity:** one passenger
- **Length:** 18 ft 11.75 in (5.7848 m)
- **Wingspan:** 38 ft 6 in (11.73 m)
- **Height:** 9 ft 4 in (2.84 m)
- **Wing area:** 182 sq ft (16.9 m²)
- **Empty weight:** 393 lb (178 kg)
- **Gross weight:** 900 lb (408 kg)
- **Powerplant:** 2 × Rotax 277 single cylinder two-stroke aircraft engine, 28 hp (21 kW) each

Performance

- **Maximum speed:** 75 mph (121 km/h; 65 kn)
- **Cruise speed:** 65 mph (56 kn; 105 km/h)
- **Stall speed:** 24 mph (21 kn; 39 km/h)
- **Range:** 170 mi (148 nmi; 274 km)
- **Service ceiling:** 10,000 ft (3,048 m)
- **G limits:** +6/-3
- **Rate of climb:** 1,150 ft/min (5.8 m/s) solo, 165 lb pilot
- **Wing loading:** 4.95 lb/sq ft (24.2 kg/m²)

Caproni Ca.4

Ca.4



Caproni Ca.40 heavy bomber prototype

Role	Heavy bomber; later variants included airliners
Manufacturer	Caproni
First flight	1917
Introduced	1918
Primary users	Italian Army United Kingdom (Royal Naval Air Service) United States
Number built	44 to 53

The **Caproni Ca.4** was an Italian heavy bomber of the World War I era.

Development

After designing the successful Ca.3, Gianni Caproni of the Caproni works designed a much bigger aircraft. It shared the unusual layout of the Caproni Ca.3, being a twin-boom aircraft with one pusher engine at the rear of a central nacelle and two tractor engines in front of twin booms, making a push-pull configuration. The twin booms carried a single elevator and three fins. The main landing gear was fixed and consisted of two sets of four wheels each. The most distinguishing feature of the new plane was, that it was built in a rare triplane layout, instead of the more common biplane.

The huge new bomber was accepted the Italian Army under a military designation **Ca.4**, but it was produced in several variants, differing in factory designations.

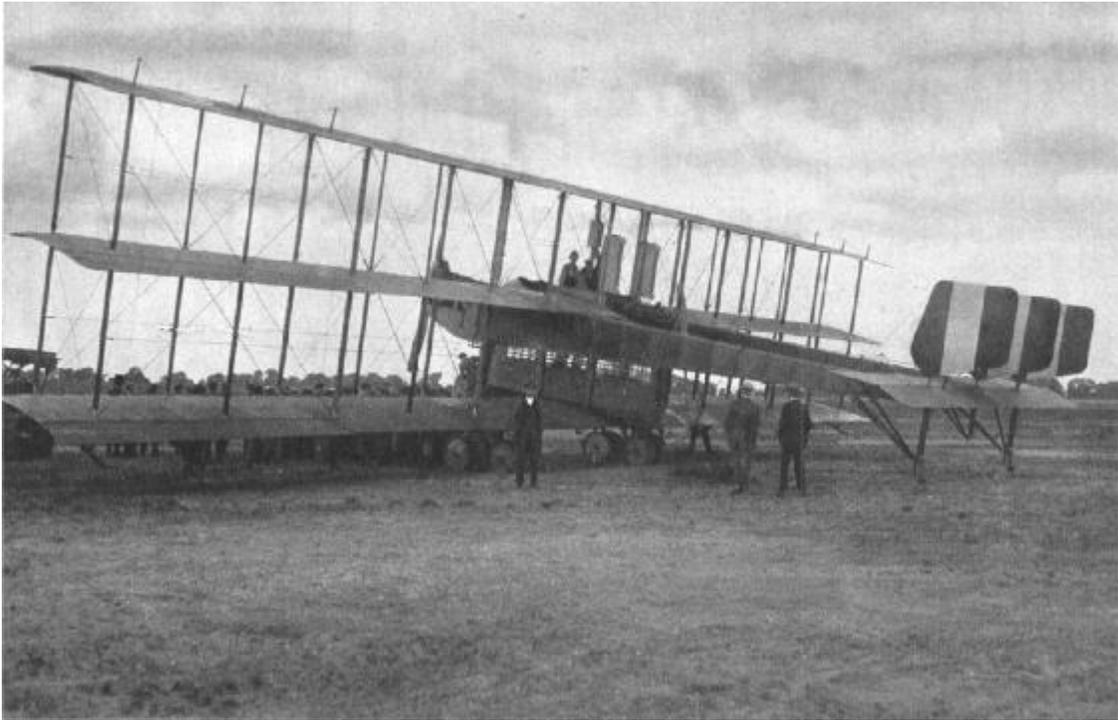
Description

The Ca.4 was a three-engine, twin-boom triplane of a wooden construction with a fabric-covered frame. The open center nacelle was attached to the undersurface of the center wing. It contained the pusher engine, pilot, and forward gunner. At least one variation of the center nacelle seated the crew in a two-seat tandem format with the forward position a gunner/pilot and the rear position the pilot. Others used a forward gunner with side by side pilot positions to the rear of the gunner. Two rear gunners were positioned one in each boom behind the center wing. An engineer or second pilot could also be accommodated there.

Armament consisted of four (but up to eight) Revelli 6.5 mm or 7.7 mm machine guns in front ring mounting and two boom ring mountings. Bombs were suspended in a bomb bay, which was a long and narrow container fixed to a lower wing. Photographs show at least four different arrangements with regard to the bombing nacelle.

- 1. No nacelle - presumably not a combat configuration.
- 2. A tall, narrow nacelle that housed approximately 12 internal bombs vertically and another 18–20 strapped to the outside.
- 3. A shorter nacelle that may be the lower half of the tall nacelle but with no external bombs.
- 4. No nacelle but with a single long bomb/torpedo slung under the bottom wing.

Variants



The Ca.48 airliner



The Ca.52 (Caproni Ca.42) - second production series of Ca.4-Ca.40 family - Aircraft of N°227 Squadron Royal Naval Air Service

Note: during the war, all these aircraft were designated Ca.4 by the Italian Army. At the time, Caproni referred to the various designs by the total power of their engines. After the war, Caproni devised a new designation scheme for their own design—these are used below.

- **Ca.40** - single prototype.
- **Ca.41** - production variant, essentially similar to the prototype and powered by 3 Fiat A.12 inline engines of 210 kW (280 hp). A few Ca.41s were powered by 186 kW (250 hp) Isotta-Fraschini engines instead. These were referred to internally by Caproni as the **Caproni 750 hp**. Forty-one built.
- **Ca.42** - powered by Liberty 298 kW (400 hp) inline engines and known internally as the Caproni 1,200 hp. Twelve built.
- **Ca.43** - single example of a floatplane variant.
- **Ca.48** - Airliners converted from Ca.42s after World War I; the Ca.48 first flew in 1919. The double-deck passenger cabin mounted between the booms seated a total of 23 passengers who entered via the nose nacelle; 16 of them sat in the lower cabin on long benches alongside its walls with large windows providing them with good views, and the other seven passengers sat on an upper deck, as did the pilots. The Ca.48 was powered by three 298-kilowatt (400-horsepower) Liberty L-12 engines. Although it is unlikely that the Ca.48 ever entered airline service, a Ca.48 did visit the First Aviation Exhibition Amsterdam of August–September 1919, where it was very popular with visitors, among whom was Prince Hendrick (1876–1934), Prince Consort of the Netherlands (1901–1934).
- **Ca.51** - single example of a considerably enlarged design with biplane tail and tail barrette. Three × 522 kW (700 hp) Fiat A.14 engines.
- **Ca.52** - Ca.42s built for the RNAS. Six built.
- **Ca.58** - Ca.48s re-engined with Fiat A.14 or Isotta-Fraschini V.6.
- **Ca.59** - as for the Ca.58, but this designation used for customers outside Italy.

Production figures differ in publications. The most likely number is 38 of all Ca.4 variants (other quoted figures are: 38 of Ca.40 and Ca.41 and 6 Ca.42 or 32 Ca.42 and 21 of other variants). Numerous publications incorrectly refer to all variants as the Ca.42.

Service history

Ca.4s were tested by the Italian Air Force in 1917 and began operations in 1918. They were used for attacking targets in Austro-Hungary. In April 1918, 6 Ca.42s were used by the British RNAS (No. 227 Sqn). At least three CA.42s were sent to the USA for evaluation. After the war, the Ca. 4 was replaced in Italy by the Ca.36.

Despite its unstable and fragile appearance, the Ca.4 was well-designed. Its size, without regards to its height, was not any larger than that of other foreign heavy bombers. With Liberty engines, it had a fast speed, similar to other heavy bombers, while its bomb load had one of the largest capacities of that era, surpassed only by that of the Imperial German: Zeppelin-Staaken R.VI. If it had been flown with other engines, its performance would have suffered.

Operators

-  Italy : *Corpo Aeronautico Militare*
-  UK
-  USA

Specifications

Ca.42

General characteristics

- **Crew:** 4 (pilot, co-pilot, front gunner, and rear gunner/mechanic)
- **Length:** 13.10 m (42 ft 11 in)
- **Wingspan:** 29.90 m (98 ft 1 in)
- **Height:** 6.30 m (20 ft 8 in)
- **Wing area:** 200 m² (2,150 ft²)
- **Empty weight:** 6,709 kg (14,791 lb)
- **Max takeoff weight:** 7,500 kg (16,535 lb)
- **Powerplant:** 3× Isotta Fraschini, 201 kW (270 hp) each

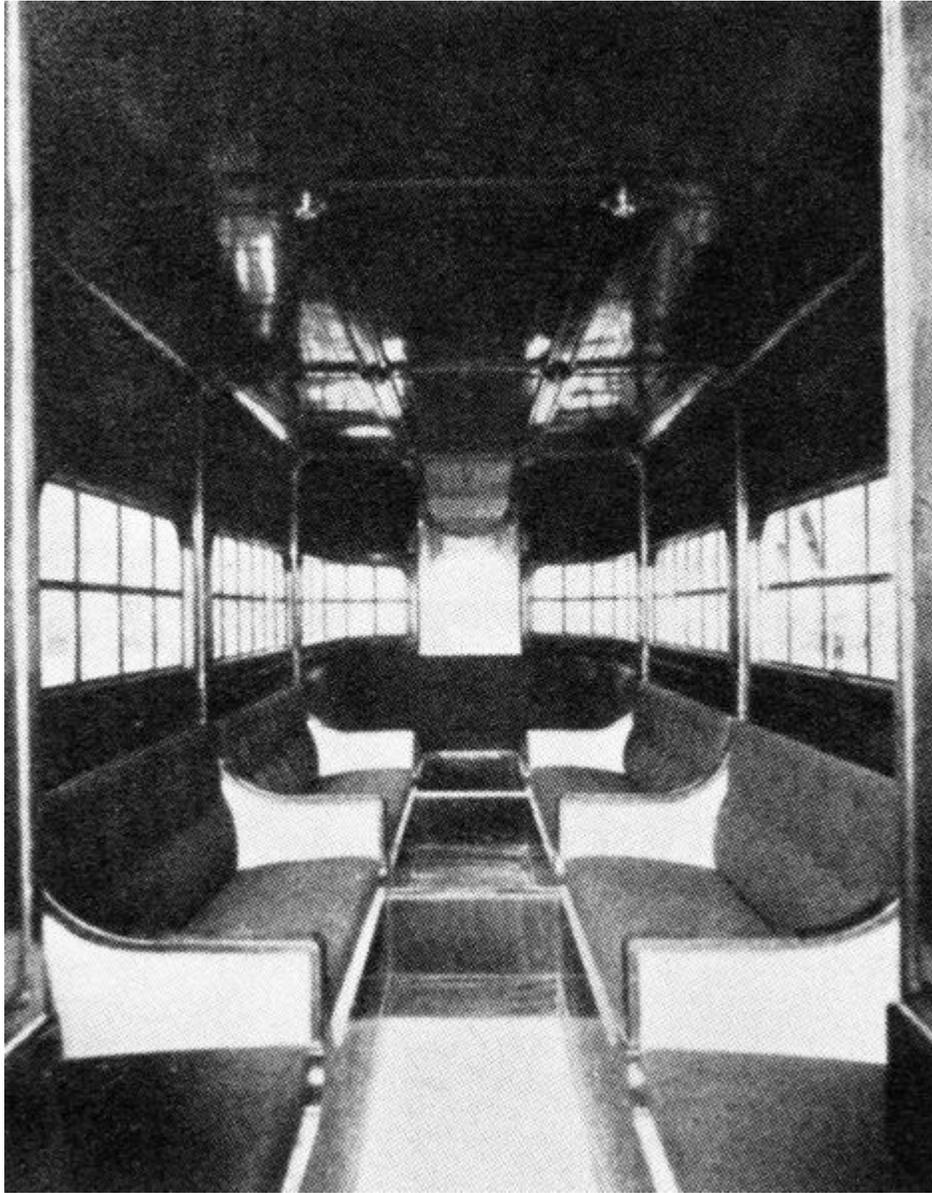
Performance

- **Maximum speed:** 140 km/h (76 kn, 87 mph)
- **Range:** 700 km (378 nmi, 438 mi)
- **Service ceiling:** 3,000 m (9,800 ft)
- **Rate of climb:** 125 m/min (410 ft/min)

Armament

- 4 × 6.5 mm FIAT-Revelli machine guns, two in forward mounting and one in each of two rearward positions.
- 1,450 kg (3,200 lb) of bombs

Ca.48



Interior of lower main passenger cabin of Ca.48 airliner, which accommodated 17 of the 23 passengers

General characteristics

- **Crew:** 2 (pilot, co-pilot)
- **Capacity:** 23 passengers
- **Length:** 13.20 m (43 ft 3.7 in)
- **Wingspan:** 29.90 m (98 ft 1 in)
- **Height:** 6.30 m (20 ft 8 in)
- **Wing area:** 200 m² (2,150 ft²)

- **Empty weight:** 4,000kg (8,818 lb)
- **Max takeoff weight:** 7,200 kg (15,873 lb)
- **Powerplant:** 3× Liberty L-12, 298 kW (400 hp) each

Performance

- **Maximum speed:** 140 km/h (76 kn, 87 mph)

Chapter 13

Cessna O-2 Skymaster

O-2 Skymaster



An O-2 Skymaster

Role	Observation aircraft
Manufacturer	Cessna
First flight	January 1967
Primary users	United States Air Force Vietnam Air Force Royal Thai Navy
Number built	532
Developed from	Cessna Skymaster

The **O-2 Skymaster** (also known as the "Oscar Deuce" or "The Duck") is a military version of the Cessna 337 Super Skymaster utilized as an observation and forward air control (FAC) aircraft. The United States Air Force commissioned Cessna to build a military variant to replace the O-1 Bird Dog in 1966.

Design and development

As with the civilian version, the Skymaster was a low cost twin-engine piston powered aircraft, with one engine in the nose of the aircraft and a second engine in the rear of the fuselage. The push-pull configuration meant a simpler single-engine operating procedure due to centerline thrust compared to the common low-wing mounting of most twin

engine light planes, and also allowed for a high wing, providing clear observation below and behind the aircraft. During the Vietnam War, the Skymaster was intended to be replaced in the forward air control (FAC) mission by the OV-10 Bronco, but the O-2A maintained a night mission role after the OV-10's introduction due to the OV-10's high level of cockpit illumination, rendering night reconnaissance impractical. The O-2 was phased out completely after additional OV-10 night upgrades.

The first O-2 flew in January 1967 and the plane went into production shortly thereafter, with the USAF taking delivery in March 1967. A total of 532 O-2s were built in two variants for the USAF by 1970. The O-2A served as a FAC aircraft with the 20th Tactical Air Support Squadron, while the O-2B was equipped with loudspeakers and a leaflet dispenser for use in the psychological operations (PSYOPS) role. Several USAF O-2 aircraft were later transferred to and operated by the former VNAF South Vietnamese Air Force.

Following the Vietnam War, the O-2 continued to operate with both U.S. Air Force and Air National Guard units well into the late 1980s. Six former USAF O-2A airframes were also transferred to the U.S. Navy in 1983 for use as "range controllers" with Attack Squadron 122 (VA-122), the Pacific Fleet Replacement Squadron for the A-7 Corsair II at Naval Air Station Lemoore, California. These same aircraft were later transferred to Strike Fighter Squadron 125 (VFA-125), the F/A-18 Hornet FRS at NAS Lemoore, in 1986 for use in the same range control role.

The six Navy O-2A's remained in this role until September 1990, when they were replaced by T-34C Turbo Mentor aircraft transferred from the Naval Air Training Command. Four of the Navy O-2A aircraft were retired and two of these became civil registered in October 1991. These two aircraft were flown in U.S. airshows performing a "Viet Nam Warbird COIN/FAC" routine during the 1990s. The routine debuted at the "Wings Over Houston" (Texas) airshow in October 1991.

Of the six USN aircraft mentioned above, two were transferred to the U.S. Army in late 1990. O-2As had originally entered the U.S. Army's inventory in 1967 from USAF stocks and were augmented by the 1990 aircraft transfer from the U.S. Navy. Several disassembled USAF O-2s remain in storage at Davis-Monthan AFB, Arizona. Two O-2As were used at Laguna Army Airfield, Arizona as part of testing programs carried out by the Yuma Proving Ground. These were retired in October 2010 and sent to a museum.

Operational history



USAF O-2 *Skymaster* in flight

A total of 178 USAF O-2 Skymasters were lost in the Vietnam War, to all causes.

Civilian use

CAL FIRE

In the mid 1970s, the California Department of Forestry and Fire Protection, or CAL FIRE, found that the contractor-owned air attack aircraft, mostly single-engine Cessna 182s and Cessna 210s, did not provide the airspeed and safety needed for the department's new air tanker program. In 1974, Senior Air Operations Officer, Cotton Mason, inspected 40 USAF O-2s at Davis-Monthan Air Force Base. The best 20 were selected and shipped to Fresno, California. These aircraft had been FAC aircraft in Vietnam and were shipped back to the United States in containers, and were disassembled and on pallets when they arrived at Fresno. A crew of California Conservation Corps (CCC) members under the supervision of a CDF Battalion Chief who was an FAA Certificated Mechanic with Inspection Authorization (IA), reassembled the aircraft. They were placed in service in 1976, and successfully served CALFIRE for more than 20 years, until replaced by a fleet of OV-10 Broncos.

Variants



An O-2B Skymaster dropping leaflets over Vietnam

O-2A

Version designed for use in forward air control missions, features ordnance hard points underneath the wings to hold rockets, gun pods or flares. 513 were delivered.

O-2B

Version designed for psychological warfare, and was equipped with loudspeakers and a leaflet dispenser, but otherwise carried no weapons. Thirty-one former civil 337s were converted to O-2Bs.

Operators



Cessna 337 Skymaster on the ground in New Jersey, 2008

 Botswana

- Botswana Air Force - Nine O-2A delivered 1993.

 Chile

- Chilean Navy - 10 O-2A, six operated, two to Navy Aero Club, two used for spares.

 Colombia

- Colombian Air Force

 Costa Rica

- Civil Guard Air Section - Three O-2A.

 Dominican Republic

- Dominican Air Force - Five O-2A (retired)

 El Salvador

- Salvadoran Air Force - 18 O-2A and two O-2B, delivered starting 1981. Eight O-2A and one O-2B remain in service.

 Haiti

- Haitian Air Force - Eight (in service 1975-98) Reportedly six of these are Model 337s, and only two O-2As.

 Côte d'Ivoire

- National Armed Forces of Côte d'Ivoire - One O-2A delivered 1993.

 Namibia

- Namibian Air Force - Six O-2A.

 Solomon Islands

- Solomon Islands Government - Two O-2A.

 South Korea

- Republic of Korea Air Force - at least 14 O-2A.

 South Vietnam

- Vietnam Air Force - at least 35.

 Thailand

- Royal Thai Navy - between 11 and 40 aircraft.

 Trinidad and Tobago

- Trinidad and Tobago Defence Force

 United States

- United States Air Force - between 11 and 40 aircraft
- United States Navy
- United States Army
- California Department of Forestry & Fire Protection

 Zimbabwe

- Zimbabwe Air Force - Two O-2A delivered 1994-1995.

Specifications (O-2)

General characteristics

- **Crew:** 2 - pilot and observer
- **Length:** 29.75 ft (9.07 m)
- **Wingspan:** 38.17 ft (11.63 m)
- **Height:** 9.17 ft (2.79 m)
- **Wing area:** 202.5 ft² (18.8 m²)
- **Empty weight:** 2,848 lb (1,292 kg)
- **Loaded weight:** 5,400 lb (2,448 kg)
- **Powerplant:** 2× Continental IO-360C six-cylinder flat engines, 210 hp (157 kW) each

Performance

- **Maximum speed:** 200 mph (322 km/h)
- **Range:** 1,325 mi (2,132 km) combat
- **Service ceiling:** 18,000 ft (5,490 m)
- **Rate of climb:** 1,180 ft/min (6 m/s)

Aircraft on display

- O-2A, AF Ser. No. 67-21331, National Museum of the United States Air Force, Wright-Patterson AFB, Ohio
- O-2A, AF Ser. No. 67-21368, Air Commando Park, Hurlburt Field, Florida
- O-2A, AF Ser. No. 68-10962, Main Gate, Shaw AFB, South Carolina
- O-2A, AF Ser. No. 68-6864, Air Force Armament Museum, Eglin AFB, Florida
- O-2A, AF Ser. No. 67-21376, 105th Airlift Wing area, Stewart Air National Guard Base, New York
- O-2A, AF Ser. No. 68-11164, USAF History and Traditions Museum, Lackland AFB, Texas
- O-2A, AF Ser. No. 68-6865, Kelly Field Heritage Museum, Lackland AFB/Kelly Field Annex (formerly Kelly AFB), Texas
- O-2A, AF Ser. No. 67-21326, Dyess Linear Air Park, Dyess AFB, Texas
- O-2A, AF Ser. No. 67-21395, Air Mobility Command Museum, Dover AFB, Delaware
- O-2A, AF Ser. No. 68-10848, Travis Air Force Museum, Travis AFB, California
- O-2A, AF Ser. No. 67-21380, Museum of Aviation, Robins AFB, Georgia
- O-2A, AF Ser. No. 68-6871, Grissom Air Museum, Grissom Air Reserve Base (formerly Grissom AFB), Indiana
- O-2A, AF Ser. No. 68-11160, 182nd Airlift Wing complex, Peoria Air National Guard Base, General Wayne A. Downing Peoria International Airport, Illinois
- O-2A, AF Ser. No. 68-6901, Pima Air and Space Museum (adjacent to Davis-Monthan AFB), Tucson, Arizona
- O-2A, AF Ser. No. 67-21413, Castle Air Museum (former Castle AFB), Atwater, California
- O-2A, AF Ser. No. 67-21411, Chanute Display Center, Rantoul National Aviation Center (former Chanute AFB), Illinois
- O-2A, AF Ser. No. 67-21330, Valiant Air Command Warbird Museum, Space Coast Regional Airport, Titusville, Florida
- O-2B, AF Ser. No. 67-21465, March Field Air Museum, March Air Reserve Base (formerly March AFB), California

Chapter 14

Aeronix Airelle and Bristol Braemar

Aeronix Airelle

Airelle

Role	Kit-built ultralight
National origin	France
Manufacturer	Aeronix sarl, La Chapelle-Vendômoise
First flight	February 2002
Status	Out of production
Number built	5

The **Aeronix Airelle** is a tandem wing ultralight with twin engines in push-pull configuration, that was designed and built in France at the start of the millennium. Intended to be homebuilt from kits, a few prototypes were constructed but development ended when the company went into receivership in 2006.

Design and development

Design of the Airelle began in 1999 and a one third scale model flew the following October. The full scale Airelle was formally introduced with a mock-up at the Paris air show held at le Bourget in June 2003, though its first flight was made in February 2002.

Its layout was very unusual, both in that it had a tandem pair of wings and that its twin engines were in push-pull configuration. The rear wing had the greater span and chord, and was swept (at 30°) and tapered, with outward-leaning fins and rudders at its tips. rather as in traditional lifting canard aircraft. However, the unswept, straight tapered foreplane had a much greater fore/rear wing span ratio (about 80%) than most of this type, for example 66% for the World War II Miles Libellula. The whole trailing edge of each rear wing, which had a dihedral of 2°, was occupied by a combination of outboard mass balanced ailerons and inboard plain flaps. The foreplane had full span elevators and slightly turned down tips. The wings, like the rest of the Airelle's structure, were largely

carbon fibre. The fins had inward turned tips. The Airelle's rudders had several modes of operation: used together they controlled yaw, as normal; they could be split on one side only, as spoilers; or both faces could separate to act as airbrakes.

The Airelle's fuselage was short, with the centrally hinged, forward opening, transparent cabin doors between the wings and engines. Both two and four seat variants were planned. A glass cockpit and a control system without rudder bars was fitted. The fuselage was deeper aft, carrying the rear wing higher than the foreplane. The prototype Airelles were powered by 30 kW (40 hp) Zazottera flat four engines, though Hirth F2ES engines of the same power were planned for production aircraft and a projected VLA version was intended to take engines of up 75 kW (100 hp). The Airelle had a tricycle undercarriage with sprung, composite main legs mounted on the fuselage.

Operational history

After the Paris Air Show of 2003, Aeronix concentrated on promoting and delivering kits of the ultralight version, with deliveries starting that year. By June, 7 had been sold. By 2005 at least 5 had been built and the third prototype, with the French experimental registration *F-WATC* flew at that year's Paris show. By that time the, first two Airelles were in store at the Aeronix factory, the second prototype having been damaged in an engine fire during testing. The fifth Airelle was prepared for a Pole to Pole publicity flight, equipped with non-standard instrumentation. Gary Purdom, the company test pilot, was to fly the aircraft; but before it could be done Aeronix went into receivership in February 2006.

Specifications (Ultralight prototype)

General characteristics

- **Capacity:** 2
- **Length:** 5.88 m (19 ft 3 in)
- **Wingspan:** 9.46 m (31 ft 0 in)
- **Height:** 3.015 m (9 ft 10.7 in)
- **Wing area:** 15.00 m² (161.5 sq ft)
- **Empty weight:** 295 kg (650 lb)
- **Max takeoff weight:** 472.5 kg (1,042 lb)
- **Fuel capacity:** 60 L (13.2 Imp gal, 15.9 US gal)
- **Powerplant:** 2 × Zanzoterra flat twin, 30 kW (40 hp) each
- **Propellers:** 3-bladed ground adjustable pitch, from Duc, Arplast or Ecoprop, 1.60 m (5 ft 3 in) diameter

Performance

- **Maximum speed:** 230 km/h (140 mph; 120 kn)
- **Cruising speed:** 200 km/h (120 mph; 110 kn)
- **Stall speed:** 58 km/h (36 mph; 31 kn)

- **Never exceed speed:** 290 km/h (180 mph; 160 kn)
- **Range:** 700 km (435 mi; 378 nmi)
- **Rate of climb:** 10 m/s (2,000 ft/min)

Bristol Braemar

Bristol Types 24 and 25 Braemar

Role	Heavy bomber
Manufacturer	Bristol Aeroplane Company
Designed by	Frank Barnwell
First flight	1918-08-13
Number built	2
Developed into	Bristol Pullman

The **Bristol Braemar** was a British heavy bomber aircraft developed at the end of the First World War for the Royal Air Force. Only two prototypes were constructed.

Development

The prototype Braemar was developed in response to the establishment of the Independent Air Force in October 1917, as a bomber capable of the long-range bombing of Berlin if necessary. A large triplane, it had internal stowage for up to six 250 lb (110 kg) bombs.

The initial design featured a unique engine installation with a central engine room housing all four engines. The engines were to be geared in pairs and power taken from the engines to the four propellers by power shafts. This design was abandoned early in development, and both the completed Braemars had a conventional engine installation, with the engines in inline tandem pairs, driving pusher and tractor propellers. However, the engine-room design was resurrected later in the Braemar's development life, for the proposed steam-powered Tramp.

The first prototype Braemar flew on 13 August 1917, with four Siddeley Puma engines of 230 hp (170 kW) each. The prototype showed generally good performance with a top speed of 106 mph (171 km/h), but there were complaints from the test pilots about the view from the cockpit and the controls, and so the next aircraft produced was an improved version designated Braemar Mk.II. The Mk.II had considerably more power, in its four Liberty L-12 engines of 400 hp (300 kW), which gave it an improved speed of 125 mph (201 km/h).

The Braemar never entered service with the RAF, and the two prototypes were the only Braemars built. The Braemar design was subsequently developed as the Pullman passenger aircraft.

Specifications (Braemar Mk.II)

General characteristics

- **Crew:** 6 - two pilots, wireless operator, engineer and two gunners
- **Length:** 51 ft 6 in (15.73 m)
- **Wingspan:** 81 ft 8 in (24.89 m)
- **Height:** 20 ft (6.10 m)
- **Wing area:** 1,905 ft² (177 m²)
- **Empty weight:** 10,650 lb (4,840 kg)
- **Loaded weight:** 18,000 lb (8,170 kg)
- **Powerplant:** 4× Liberty L-12 inline engine, 400 hp (300 kW) each

Performance

- **Maximum speed:** 109 kn (125 mph, 200 km/h) at sea level
- **Range:** more than 1,000 mi ()
- **Service ceiling:** 17,000 ft (5,100 m)
- **Wing loading:** 9.45 lb/ft² (46.2 kg/m²)
- **Power/mass:** 0.08 hp/lb (150 W/kg)

Armament

- **Guns:** 2 × 0.303 in (7.7 mm) machine guns
- **Bombs:** 1,500 lb (680 kg)

Chapter 15

Bristol Pullman and AD Seaplane Type 1000

Bristol Pullman

Bristol Types 26 and 33 Pullman

Role	Passenger aircraft
Manufacturer	Bristol Aeroplane Company
Designed by	Frank Barnwell
First flight	May 1920
Status	Prototype
Primary user	Royal Air Force
Number built	1
Developed from	Bristol Braemar
Developed into	Bristol Tramp

The **Bristol Pullman** was a British prototype passenger aircraft developed from the Braemar triplane heavy bomber.

Design and development

The first **Pullman** was actually built as the third **Braemar**, and first flew early in May 1920. It was shown at the International Aero Show at Olympia in July of that year, where its great size and interior fittings were much admired. The Pullman was one of the earliest British aircraft to have a fully-enclosed crew cabin, and this feature was disliked by service pilots, who often carried fireman's axes with them to enable them to escape in an emergency.

Operational history

Ultimately the Pullman was not accepted for squadron use by the Royal Air Force, nor was it selected for use by any civil operator. The prototype was the sole example of the type constructed or configured.

Operators

 United Kingdom

- Royal Air Force

Specifications

General characteristics

- **Crew:** 2
- **Capacity:** 14
- **Length:** 52 ft (15.88 m)
- **Wingspan:** 81 ft 8 in (24.89 m)
- **Height:** 20 ft (6.10 m)
- **Wing area:** 1,905 ft² (177 m²)
- **Empty weight:** 11,000 lb (5,000 kg)
- **Loaded weight:** 17,750 lb (8,070 kg)
- **Powerplant:** 4× Liberty L-12 inline engine, 400 hp (300 kW) each

Performance

- **Maximum speed:** 135 mph (216 km/h)
- **Range:** more than 1,000 mi ()
- **Service ceiling:** 15,000 ft (4,500 m)

AD Seaplane Type 1000

AD Seaplane Type 1000

Role	Torpedo bomber bomber
Manufacturer	J. Samuel White
Designed by	Harris Booth
First flight	1916
Primary user	Royal Naval Air Service
Number built	1

The **AD Seaplane Type 1000** also known as the **Admiralty Type 1000** and the **AD.1** (from Air Department) was a British seaplane of the First World War designed to attack German warships. When it first flew, it was the largest British aircraft yet to take to the air.

Development

The design of the AD.1 was by Harris Booth of the Admiralty's Air Department just prior to World War I. It was the world's first aircraft designed from scratch as a torpedo bomber, one of the three planned versions of the plane. The other two were a bomber and a plane armed with a recoilless Davis 12-pounder gun (approximately 76 mm calibre).

The aircraft was a float-equipped biplane of pod-and-boom design, with engines mounted at the front of both booms, as well as at the rear of the crew pod. Development began in 1915; it was completed and flown for the first time during the summer of 1916. It was found that the Davis gun would project a blast rearwards so the weapon was changed for a conventional 12-pounder "Naval Landing Gun" though in practice a gun was never installed in the AD.1.

Initially the plane was to use Sunbeam Nubian engines, but this was delayed and Hispano-Suiza selected instead, though eventually the Sunbeam Nubian IIs of 150 hp were delivered in 1917.

Service

Seven aircraft were ordered from J. Samuel White, but when the first one delivered was tested, it was found that its weight was higher than expected, its performance was unexpectedly poor and its undercarriage was not robust enough.

Based on these findings, the contract for the remaining six aircraft was cancelled.

The sole example is known to have survived until 1916, probably at the Royal Naval Air Service's Seaplane Experimental Station, Felixstowe base.

Specifications (AD Seaplane Type 1000)

General characteristics

- **Crew:** 5
- **Length:** 64 ft 3 in (19.6 m)
- **Wingspan:** 115 ft (35.1 m)
- **Height:** ()
- **Empty weight:** 22,352 lb (10,160 kg)
- **Max takeoff weight:** 27,900 lb (12,700 kg)
- **Powerplant:** 3× Hispano-Suiza rotary engines, 100 hp (75 kW) each

Performance

- **Maximum speed:** 73 knots (84 mph, 135 km/h)
- **Range:** 481 nm (553 mi, 885 km)
- **Service ceiling:** 4,900 ft (1,500 m)

Armament

- One 12 pdr gun or two 14 in, 810 lb (360 mm, 367 kg) torpedoes

Chapter 16

Cessna Skymaster

336 Skymaster 337 Super Skymaster



A Cessna 337 Super Skymaster.

Role	Personal use and air taxi aircraft
Manufacturer	Cessna Reims Aviation
First flight	1961
Status	Active service
Primary user	Private individuals and organizations
Produced	1963-1982
Number built	2,993
Variants	O-2 Skymaster Conroy Stolifter Spectrum SA-550



Part of the contract fleet of **Cessna 337 Skymasters** on firefighting detection duty with the Ontario Ministry of Natural Resources at Dryden, Ontario, 1996.

The **Cessna Skymaster** is a United States twin-engine civil utility aircraft built in a push-pull configuration. Its engines are mounted in the nose and rear of its pod-style fuselage. Twin booms extend aft of the wings to the vertical stabilizers, with the rear engine between them. The horizontal stabilizer is aft of the pusher propeller, mounted between and connecting the two booms. The combined tractor and pusher engines produce 'centerline' thrust and a unique sound.

Development

The first Skymaster, model **336**, had fixed landing gear and first flew on February 28, 1961. It went into production in May 1963, and 195 were produced through mid 1964.

In February 1965 Cessna introduced the model **337 Super Skymaster**. The model was larger, and had more powerful engines, retractable landing gear, and a dorsal air scoop for the rear engine ("Super" was subsequently dropped from the name). In 1966 the turbocharged **T337** was introduced, and in 1973 the pressurized **P337G** entered production.

Cessna built 2993 Skymasters of all variants, including 513 military O-2 versions. Production in America ended in 1982 but continued with Reims in France with the **FTB337** STOL and the military **FTMA Milirole**. Production totalled 94 units.

Design

The Skymaster handles differently from a conventional twin-engine aircraft, primarily in that it will not yaw into the dead engine if one engine fails. Without the issue of differential thrust inherent to conventional (engine-on-wing) twins, engine failure on takeoff will not produce yaw from the runway direction. With no one-engine-out minimum controllable speed (V_{mc}), in-flight control at any flying speed with an engine inoperative is not as critical as it is with engines on the wing with the associated leverage. Nevertheless, the Skymaster requires a multi-engine-rating, although many countries issue a special "centerline thrust rating" for Skymaster and other like-configured aircraft.

Ground handling requires certain attention and procedures. The rear engine tends to overheat and can quit while taxiing on very hot days. There have been accidents when pilots, unaware of the shutdown, have attempted take-off on the nose engine alone, even though the single-engine take-off roll exceeded the particular runway length. FAA Airworthiness Directive 77-08-05 prohibits single engine take-offs and requires the installation of a placard with words that say "DO NOT INITIATE SINGLE ENGINE TAKEOFF".

The Skymaster produces a unique sound: a combination sound of its rear propeller slicing through turbulent air from the front prop and over the airframe, while its nose propeller addresses undisturbed air.

Operational history

From 1976 until the middle 1990s, the California Department of Forestry and Fire Protection used O-2 variants of the 337 Skymaster as tactical aircraft during firefighting operations. These were replaced with North American OV-10 Broncos, starting in 1993.

Brothers to the Rescue

From 1991 until 2001 the Cuban exile group *Hermanos al Rescate* (Brothers to the Rescue) used Skymasters, among other aircraft, to fly search and rescue missions over the Florida Straits looking for rafters attempting to cross the Straits to defect from Cuba and, when they found them, dropped life-saving supplies to them. Rescues were coordinated with the US Coast Guard, who worked closely with the group. They chose Skymasters because their high wing offered better visibility of the waters below, they were reliable and easy to fly for long-duration missions (averaging 7 hours), and they added a margin of safety with twin engine centerline thrust. In 1996, two of the Brothers to the Rescue Skymasters were shot down by the Cuban Air Force (FAC) over international waters. Both aircraft were downed by a MiG-29, while a second jet fighter, a MiG-23 orbited nearby.

Variants

Cessna

- **327 Baby Skymaster** - reduced scale four-seat version of the 337, with cantilever wings replacing the 336/337 strut-braced configuration. It first flew in December 1967. One prototype was built before the project was cancelled in 1968 due to lack of commercial interest in the design. The prototype was delivered to NASA to serve as a full-scale model for wind tunnel testing. It was used in a joint Langley Research Center and Cessna project on noise reduction and the use of ducted versus free propellers.
- **336 Skymaster** - production version powered by two 195 hp (145 kW) Continental IO-360-A engines, 195 built.
- **337 Super Skymaster** - 336; retractable undercarriage, redesigned nose cowling and new rear engine intake, and greater wing angle of incidence, powered by two 210 hp (160 kW) Continental IO-360-C engines, 239 built.
- **337A Super Skymaster** - 337; minor detail changes, 255 built.
- **337B Super Skymaster** - 337A; increased take-off gross weight, optional belly cargo pack, 230 built.
- **T337B (1967) Turbo Super Skymaster** - 337B; two Continental turbocharged fuel injected 210 hp (160 kW) engines which boosted service ceiling to 33,000 feet (10,000 m), cruise speed to 233 mph (375 km/h), and range to 1,640 miles (2,640 km)
- **337C Super Skymaster** - 337B; new instrument panel and increased take-off gross-weight, 223 built.
- **337D Super Skymaster** - 337C; minor detail changes, 215 built.
- **337E Super Skymaster** - 337D; cambered wingtips and minor changes, 100 built.
- **337F Super Skymaster** - 337E; increased take-off gross weight, 114 built.
- **337G Super Skymaster** - 337F; split airstair entry door, smaller rear side windows, improved flaps, larger front propeller, powered by Continental IO-360-G engines, 352 built.
- **P337G Super Skymaster** - 337G; pressurized cabin and turbocharged engines, 292 built.
- **337H Skymaster** - 337G; minor changes and optional turbocharged engines, 136 built.
- **P337H Pressurized Skymaster** - T337G; minor changes, 64 built.
- **337M** - US military version designated O-2 Skymaster in service, 513 built.



Cessna Skymaster O-2

- **O-2A** - US military designation of the 337M Forward air control, observation aircraft for the US Air Force. 501 delivered to the USAF and 12 to the Imperial Iranian Air Force
- **O-2B**: Psychological warfare version for the US Air Force (31 former civil aircraft were converted to O-2B).
- **O-2TT**: Twin turboprop-powered version of the O-2.
- **Summit Sentry O2-337** : Military version.
- **Lynx**: Armed military version for the Rhodesian Air Force.
- **T337H-SP**

Reims Cessna

- **F337E Super Skymaster**, 24 built.
- **F337F Super Skymaster**, 31 built.
- **F337G Super Skymaster**, 29 built.
- **FT337G Super Skymaster**, 22 built.
- **F337H Super Skymaster**, 1 built.
- **FP337H Pressurized Skymaster**, 1 built.
- **FTB337G Milirole**; military F337G with Sierra Industries Robertson STOL modifications and underwing hardpoints, 61 built.
- **Lynx** : Rhodesian designation for 21 FTB337Gs delivered to the Rhodesian Air Force.

Conversions/modifications

- **Conroy Stolifter** - an extensive single-turboprop engine STOL cargo plane conversion of the Skymaster. Front engine was replaced with a Garrett AiResearch TPE-331 turboprop; rear engine was deleted, and its space filled with an extended cargo pod.
- **AVE Mizar** - flying car, created by Advanced Vehicle Engineers, was an attachment of Skymaster wings, tail, and rear engine to a Ford Pinto outfitted with aircraft controls and instruments.
- **Summit Sentry** - Summit Aviation re-manufactured existing used 337 airframes into the militarized **O2-337** which includes four wing-mounted NATO standard pylons capable of carrying 350 lb (159 kg) each for 7.62 mm and 12.7 mm gun pods, rocket launchers, bombs, markers and flares. The aircraft was marketed for the target identification and marking, reconnaissance, helicopter escort and aerial photography roles. Examples were sold to the Haitian Air Force Honduras, Nicaragua, Senegal and the Thai Navy. The variant was still in production in 1987.
- **Spectrum SA-550** - built by Spectrum Aircraft Corporation of Van Nuys, California, it was an extensive single-turboprop engine conversion of a Reims FTB337G constructed in the mid 1980s. They removed the nose engine, lengthened the nose, and replaced the rear engine with a turboprop.

Military operators

-  Bangladesh
Bangladesh Army
-  Burkina Faso
-  Chad
-  Chile
Chilean Air Force
-  Colombia
-  Costa Rica
-  Ecuador
-  El Salvador
-  Equatorial Guinea
-  Guinea-Bissau
-  Haiti
Haitian Air Force
-  Iran
Imperial Iranian Air Force
-  Jamaica
-  Mexico
-  Nicaragua
8 x 0-2A
1 x 0-2B
-  Niger
Military of Niger

 Paraguay
Paraguayan Air Force: 1 x 337RG

 Peru

 Portugal

Portuguese Air Force (32 x FTB-337G) - Purchased in 1973 to replace the force's aging Dornier Do 27 fleet, which had been used intensively in the Portuguese Colonial War. The first 337 deliveries did not arrive until December 1974 - after the end of the war. The last Skymaster in service with the Portuguese Air Force was retired on July 25, 2007.

 Rhodesia

Rhodesian Air Force

 South Africa

South African Air Force

 South Korea

Republic of Korea Air Force

 Sri Lanka

Sri Lanka Air Force

 Swaziland

Military of Swaziland

 Thailand

Royal Thai Navy

 Togo

Togo Air Force

 Trinidad and Tobago

 United States

United States Air Force

 Zimbabwe

Air Force of Zimbabwe

Specifications (337D)

General characteristics

- **Crew:** 1
- **Capacity:** 5 passengers
- **Length:** 29 ft 9 in (9.07 m)
- **Wingspan:** 38 ft 0 in (11.58 m)
- **Height:** 9 ft 4 in (2.84 m)
- **Wing area:** 201 ft² (18.7 m²)
- **Empty weight:** 2,655 lb (1,204 kg)
- **Max takeoff weight:** 4,400 lb (2,000 kg)
- **Powerplant:** 2× Continental IO-360-C piston engine, 210 hp (157 kW) each

Performance

- **Maximum speed:** 200 mph (174 kn, 320 km/h)
- **Range:** 764 mi (664 nmi, 1,220 km)
- **Service ceiling:** 19,500 ft (5,944 m)
- **Rate of climb:** 1,200 ft/min (6.1 m/s)

Chapter 17

Dornier Do 18

Do 18



Role	Flying boat
Manufacturer	Dornier
First flight	15 March 1935
Primary users	Luftwaffe Lufthansa
Number built	170

The **Dornier Do 18** was a development of the Do 16 flying boat. It was developed for the *Luftwaffe*, but *Lufthansa* got 5 aircraft and used these for tests between the Azores and the North American continent in 1936 and on their mail route over the South Atlantic from 1937 to 1939.

27–29 March 1938 a "Do 18 W" established a seaplane record flying non-stop a straight distance of 8,391 km (5,214 mi) from Start Point, Devon to Caravelas in Brazil.

Design and development

In 1934, the Dornier *Flugzeugwerke* started development of a new twin engined flying boat to replace the Dornier Do J "*Wal*" (Whale) in both military and civil roles. The resultant design, *Do 18* retained the layout of the *Wal*, with a metal hull fitted with

distinctive stabilising sponsors, and powered by two engines above the wing in a push-pull layout, but was aerodynamically and hydrodynamically more efficient. It was planned to be powered by two of the new Junkers Jumo 205 diesel engines. Although heavy, these promised to give much lower fuel consumption than conventional petrol engines of similar power.

The first prototype, the **Do 18a**, registration *D-AHIS* (and named *Monsun* by Lufthansa) flew on 15 March 1935, powered by two of the earlier 410 kW (550 hp) Junkers Jumo 5c diesels as the planned Jumo 205s were not yet available. It was lost on 2 November 1935 over the Baltic during high-speed tests. Three further prototypes followed, two (the Do 18d and Do 18b) being prototype military aircraft, and the Do 18c (later redesignated Do 18 V3), a civil prototype.

The Do 18c was delivered to Lufthansa as a Do 18E civil transport (*D-ABYM Aeolus*), quickly followed by a further two aircraft, (*D-AANE Zyklon* and *D-ARUN Zephir*) with a final Do 18E (*D-ARoz Pampero*) being built in 1938.

A further civil Do 18 was the **Do 18F**, a modified aircraft with longer wingspan and higher weights built for extended-range flights. The sole Do 18F, *D-ANHR*, first flew on 11 June 1937. It was later modified with 656 kW (880 hp) BMW 132N radial engines to test a possible upgrage for the Luftwaffe's aircraft, flying in this form on on 21 November 1939 as the **Do 18L**. It suffered cooling problems, however, and further development of the radial powered Do 18 was abandoned.

Operational history

Civil service

In 1936, Lufthansa started a series of endurance trials, culminating on 10–11 September when *Zephir*, flown by *Flugkapitän* Blankenburg with Lufthansa Director Freiherr von Gablenz as passenger, was launched by catapult from the seaplane tender *Schwabenland* at Horta, Azores, flying the 4,460 km (2,270 mi) to New York in 22 hours 12 minutes. Also on 11 September, *Aeolus* flew from Horta to Hamilton, Bermuda in 18 hours 15 minutes, continuing to New York the next day. For the main leg of the North Atlantic the aircraft needed the help of the catapult on *Schwabenland*. On 22 September *Aeolus* returned to Horta in 17:50 h (3850 km). *Zephir* was catapulted on 28 September at Hamilton. The second Flights to New York followed on 5-6 and 6–7 October and the returnflights this time 17 and 18 October from Sydney, Nova Scotia. The flying boats did not wait for their tender and went on to Lisbon and Travemünde.

In April 1937 *D-ARUN Zephir* and *D-ABYM Aeolus* started their service on the South Atlantic mail route from Bathurst, now Banjul, Gambia to Natal, Brazil (3040 km). Catapult ships were based in Bathurst and Fernando de Noronha to allow the aircraft to cross the Atlantic carrying a full load of mail.

In June they were joined by V6 D-AR0Z *Pampero*. *Aeolus* was lost on 30 July 1937, when it had to make an ocean landing due to engine problems and was heavily damaged when *Ostmark* tried to retrieve the plane. *Pampero* (20 August) and *Zephir* (29 January 1938) also had to make ocean landings. *Pampero* was lost at sea nearly without trace on 1 October 1938 with a crew of five.

Lufthansa's fifth aircraft was the only **Do 18F** V7 D-ANNE *Zyklon*, that first took to the skies on 11 June 1937. This was the only Do 18 with a wider span which enable it to stay in the air with one engine out. This was a special demand of *Lufthansa Zyklon* was used over the South Atlantic between September 1937 and March 1939. The Do 18s crossed the South Atlantic 73 times.

Zyklon is not the aircraft, that established the England to Brazil distance record from 27–29 March 1938 as often stated.

The record-aircraft D-ANHR was taken from the military production line and was specially prepared. It was flown as a builder's machine with a Lufthansa crew augmented by the works pilot *Gundermann*. On the way back to the South American station the seaplane tender *Westfalen* took the plane in the English Channel where it was catapulted to Brazil. On the record flight the conditions were not optimal and the plane did not reached Rio de Janeiro as planned.

Military use

In *Luftwaffe* service, it was obsolete by the outbreak of World War II, but - as the only military flying boat - 62 (58 serviceable) in 6 squadrons were in use mainly on North Sea reconnaissance missions. In 1940 some squadrons changed their base to Norway. The vulnerable and underpowered flying boat was soon relegated to training and the air/sea rescue role. In the middle of 1941 only one Squadron was still operational on Do 18. The Blohm & Voss BV 138 had superseded the Dornier.

A Do 18 was the first German aircraft to be shot down by British aircraft during the war, when one of a formation of three was caught over the North Sea by nine Fleet Air Arm Blackburn Skua fighter-bombers of 803 Naval Air Squadron flying from HMS *Ark Royal* on 26 September 1939. The flying boat was able to make an emergency landing but was sunk by the destroyer HMS *Somali*.

Variants

Civil variants

Do 18E

Initial civil version, powered by 410 kW (550 hp) Jumo 205C-1 engines. Four built.

Do 18F

Long range civil version V7 D-ANNE *Zyklon*, with extended-span (26.30 m (86 ft 3 in)) wings and increased take-off weight. One built.

Do 18L

The record-aircraft D-ANHR modified with BMW 132M radials. One converted.

Military variants

- The **Do 18D** 79 built, was the first military version, powered by two 450 kW (600 hp) Jumo 205C engines, armed with one 7.92 mm (0.312 in) MG 15 machine gun in the bow and dorsal positions.
- The **Do 18G** 62 built, was an improved version, powered by two 656 kW (880 hp) Jumo 205D engines, armed with a 13 mm (0.51 in) MG 131 machine gun in the bow, and a 20 mm MG 151 cannon in a power-operated dorsal turret. This version had an altered bow contour and broader sponsons
- The **Do 18H** 22 built (+ conversions ?) was an unarmed dual-control training version.
- The **Do 18N** was a designation for unarmed air-sea search and rescue conversions.

Including the civilian flying boats 170 Dornier Do 18 were built by Dornier in Manzell (48 until March 1939) and Weser-Flugzeugbau in Einswarden and Nordenham (122 until August 1940).

Operators

-  Germany
 - *Lufthansa*
 - *Luftwaffe*

Specifications (Do 18D-1)

General characteristics

- **Crew:** 4
- **Length:** 19.23 m (63 ft 1 in)
- **Wingspan:** 23.70 m (77 ft 9 in)
- **Height:** 5.32 m (17 ft 5¾ in)
- **Wing area:** 98.0 m² (1,055 ft²)
- **Empty weight:** 6,680 kg (14,727 lb)
- **Max takeoff weight:** 8,500 kg (18,739 lb) (Normal take-off) (Catapult weight: 10,000 kg (22,046 lb))
- **Powerplant:** 2× Junkers 205C-4 six-cylinder, vertically opposed diesel engine, 451 kW (C-engine) (605 hp) (take-off power) each

Performance

- **Maximum speed:** 250 km/h (135 knots, 155 mph) at sea level
- **Cruise speed:** 190 km/h (103 knots, 118 mph) (max endurance cruise)
- **Range:** 3,500 km (1,890 nmi, 2,175 mi)
- **Service ceiling:** 4,350 m (14,270 ft)
- **Climb to 1,000 m (3,300 ft):** 7.5 min

Armament

- **Guns:** 1 × 7.92 mm MG 15 machine gun in each of bow and dorsal positions
- **Bombs:** 2 × 50 kg (110 lb) bombs under starboard wing

Chapter 18

Dornier Do 335

Do 335 *Pfeil*



Role	Fighter-bomber
Manufacturer	Dornier Flugzeugwerke
First flight	October 1943
Introduced	1944
Primary user	<i>Luftwaffe</i>
Number built	37

The **Dornier Do 335 *Pfeil*** ("Arrow") was a World War II heavy fighter built by the Dornier company. The two-seater trainer version was also called *Ameisenbär* ("anteater"). The *Pfeil's* performance was much better than other twin-engine designs due to its unique "push-pull" layout and the much lower drag of the in-line alignment of the two motors. The *Luftwaffe* was desperate to get the design into operational use, but delays in engine deliveries meant only a handful were delivered before the war ended.

Development

The origins of the Do 335 trace back to World War I when Claudius Dornier designed a number of flying boats featuring remotely-driven propellers and later, due to problems with the drive shafts, tandem engines. Tandem engines were used on most of the multi-engine Dornier flying boats that followed, including the highly successful Do J and the gigantic Do X. The remote propeller drive, intended to eliminate parasitic drag from the engine entirely, was tried in the innovative but unsuccessful Do 14, and elongated drive

shafts as later used in the Do 335 saw use in the rear engines of the four-engined, twinned tandem-layout Do 26 flying boat.

There are many advantages to this design over the more traditional system of placing one engine on each wing, the most important being power from two engines with the frontal area (and thus drag) of a single-engine design, allowing for higher performance. It also keeps the weight of the twin powerplants near, or on, the aircraft centerline, increasing the roll rate compared to a traditional twin. In addition, a single engine failure does not lead to asymmetric thrust, and in normal flight there is no net torque so the plane is easy to handle. The choice of a full "four-surface" set of cruciform tail surfaces in the Do 335's design, allowed the ventral vertical fin-rudder assembly to project downwards from the extreme rear of the fuselage, in order to protect the rear propeller from an accidental ground strike on takeoff.

In 1939, Dornier was busy working on the **P.59** high-speed bomber project, which featured the tandem engine layout. In 1940, he commissioned a test aircraft to validate his concept for turning the rear pusher propeller with an engine located far away from it and using a long driveshaft. This aircraft, the Göppingen Gö 9 showed no unforeseen difficulties with this arrangement, but work on the P.59 was stopped in early 1940 when Hermann Göring ordered the cancellation of all projects which would not be completed within a year or so.

In May 1942, Dornier submitted an updated version with a 1,000 kg (2,200 lb) bombload as the **P.231**, in response to a requirement for a single seat high-speed bomber/intruder. P.231 was selected as the winner after beating rival designs from Arado, Junkers, and Blohm & Voss development contract was awarded as the Do 335. In autumn 1942, Dornier was told that the Do 335 was no longer required, and instead a multi-role fighter based on the same general layout would be accepted. This delayed the prototype delivery as it was modified for the new role.

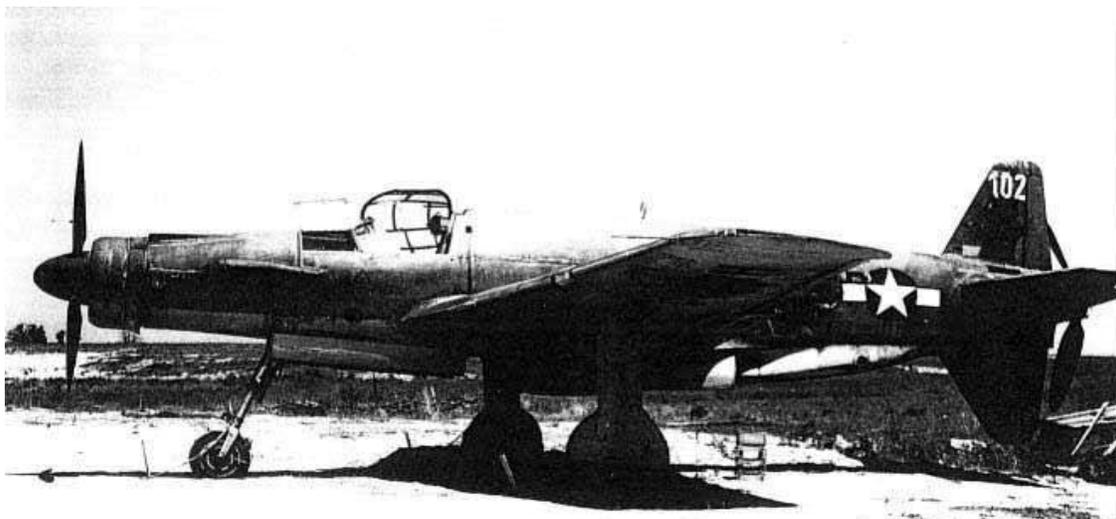
Fitted with DB 603A engines delivering 1,750 PS (1,287 kW, 1,726 hp) at takeoff, the Do 335 V1 first prototype, bearing the *Stammkennzeichen* (factory radio code) of **CP+UA**, flew on 26 October 1943 under the control of *Flugkapitän* Hans Dieterle, a regular Heinkel test pilot and later primary Dornier test pilot. The pilots were surprised at the speed, acceleration, turning circle, and general handling of the type; it was a twin that flew like a single. However, several problems during the initial flight of the Do 335 would continue to plague the aircraft through most of its short history. Issues were found with the weak landing gear and with the gear doors, resulting in them being removed for the remainder of V1 flights. V1 made 27 flights, flown by three different pilots. During these test flights V2 (W.Nr 230002), *Stammkennzeichen* CP+UB was completed and made its first flight on 31 December 1943, again under the control of Dieterle. New to the V2 were upgraded DB603 A-2 engines, and several refinements learned from the test flights of V1 as well as further windtunnel testing. On 20 January 1944, V3 (W.Nr. 230004), *Stammkennzeichen* CP+UC was completed and flown for its first time by Werner Altrogge. V3 was powered by the new DB603 G-0 engines which could produce 1,900 PS (1,400 kW) at take-off and featured a slightly redesigned canopy which

included rear-view mirrors in blisters, one in each of two matching side panels of the main canopy. Following the flights of the V3, in mid January 1944, RLM ordered five more prototypes (V21–V25), to be built as night fighters. By this time more than 60 hours of flight time had been put on the Do 335 and reports showed it to be a good handling, but more importantly, very fast aircraft, described by Miltch himself as "...holding its own in speed and altitude with the P-38 and does not suffer from engine reliability issues". Thus the Do 335 was scheduled to begin mass construction, with the initial order of 120 preproduction aircraft to be manufactured by DWF (Dornier-Werke Friedrichshafen) to be completed no later than March 1946. This number included a number of bombers, destroyers (heavy fighters), and several yet to be developed variants. At the same time, DWM (Dornier-Werke München) was scheduled to build over 2000 Do 335s in various models, due for delivery in March 1946 as well.

On 23 May 1944, Hitler, as part of the *Jägernotprogramm* directive, ordered maximum priority to be given to Do 335 production. The main production line was intended to be at Manzel, but a bombing raid in March destroyed the tooling and forced Dornier to set up a new line at Oberpfaffenhofen. The decision was made, along with the rapid shut-down of many other military aircraft development programs, to cancel the Heinkel He 219 night fighter, and use its production facilities for the Do 335 as well. However, Ernst Heinkel managed to delay, and eventually ignore, its implementation.

At least 16 prototype Do 335s were known to have flown (V1–V12, W.Nr 230001-230012 and *Müster*-series prototypes M13–M17, W.Nr 230013-230017) on a number of DB603 engines including the DB603A, A-2, G-0, E and E-1. The first preproduction Do 335 (A-0s) starting with W.Nr 240101, *Stammkennzeichen* VG+PG, were delivered in July 1944. Approximately 22 preproduction aircraft were thought to have been completed and flown before the end of the war, including approximately 11 A-0s converted to A-11s for training purposes.

Flight tests



Do 335 tested in the USA

The first 10 **Do 335 A-0s** were delivered for testing in May. By late 1944, the **Do 335 A-1** was on the production line. This was similar to the A-0 but with the updated DB 603 E-1 engines and two underwing hardpoints for additional bombs, drop tanks or guns. It was capable of a maximum speed of 763 km/h (474 mph) at 6,500 m (21,300 ft) with MW 50 boost, or 686 km/h (426 mph) without boost, and able to climb to 8,000 m (26,250 ft) in under 15 minutes. Even with one engine out, it could reach about 563 km/h (350 mph).

Delivery commenced in January 1945. When the United States Army overran the Oberpfaffenhofen factory in late April 1945, only 11 Do 335 A-1 single-seat fighter-bombers and two Do 335 A-12 trainers had been completed.

French ace Pierre Clostermann claimed the first Allied combat encounter with a *Pfeil* in April 1945. In his book *The Big Show* (pages 273-274) he describes leading a flight of four Hawker Tempests from No. 3 Squadron RAF over northern Germany, he intercepted a lone Do 335 flying at maximum speed at treetop level. Detecting the British aircraft, the German pilot reversed course to evade. Despite the Tempest's considerable low altitude speed, the RAF fighters were not able to catch up or even get into firing position.

Variants

- **Do 335 A-0** : 10 pre-production aircraft.
- **Do 335 A-1** : Single-seat fighter-bomber aircraft.
- **Do 335 A-2** : Proposed single-seat fighter-bomber aircraft with new weapon aiming systems, later proposed longer wing and updated DB603L engines.
- **Do 335 A-3** : Proposed single-seat reconnaissance aircraft built from A-1 aircraft, later proposed with longer wing.
- **Do 335 A-4** : Proposed single-seat reconnaissance aircraft with smaller cameras than the A-3
- **Do 335 A-5** : Proposed single-seat night fighter aircraft, later night and bad weather fighter with enlarged wing and DB603L engines.
- **Do 335 A-6** : Proposed two seat night fighter aircraft.
- **Do 335 A-7** : Proposed A-6 with longer wing.
- **Do 335 A-8** : Proposed A-4 fitted with longer wing.
- **Do 335 A-9** : Proposed A-4 fitted with longer wing, DB603L engine and pressurized cockpit.
- **Do 335 B-1** : Abandoned in development.
- **Do 335 B-2** : Single-seat destroyer aircraft. Fitted with 2 additional Mk 103 in the wings and two 315 auxiliary fuel tanks.
- **Do 335 B-3** : Proposed updated B-1 but with longer wing.
- **Do 335 B-4** : Proposed update of the B-1 with longer wing, DB603L engine.
- **Do 335 B-12**: Proposed dual seat trainer version for the B-series aircraft.
- **Do 435** : A Do 335 with the redesigned, longer wing. Allied intelligence reports from early May 1945 make a report of a spotted Do 435 at the Dornier factory airfield at Lowenthal.
- **Do 535** : Actually the He 535, once the Dornier P254 design was handed over to Heinkel in October 1944.

- **Do 635** : Proposed long-range reconnaissance version. Also called Junkers Ju 635 or Do 335Z. Mock up only.
- **Do P 256**: Proposed turbojet nightfighter version, with two podded He S011 engines, based on Do 335 airframe. Not built.

Survivors



The only surviving Do 335 (VG+PH) at the Steven F. Udvar-Hazy Center near Washington, DC

Only one Do 335 survives today. The aircraft was the second preproduction Do 335 A-0, designated **A-02**, with construction number (*Werknummer*) 240102, and factory radio code registration, or *Stammkennzeichen*, of VG+PH. The aircraft was assembled at Dornier's plant in Oberpfaffenhofen (southern Germany) on 16 April 1945. It was captured by Allied forces at the plant on 22 April 1945. The aircraft was test flown from a grass runway at Oberwiesenfeld, near Munich, to Cherbourg, France while escorted by two P-51s. The Do 335 was easily able to out distance the escorting Mustangs and arrived at Cherbourg 45 minutes before the P-51s. VG+PH was one of two Do 335s to be shipped to the United States aboard the Royal Navy escort carrier HMS *Reaper*, along with other captured German aircraft, to be used for testing and evaluation under a USAAF program called "Operation Sea Horse". One Do 335 (registration FE-1012) went to the USAAF and was tested in early 1946 at Freeman Field, Indiana. Its fate is not recorded.

VG+PH went to the Navy for evaluation and was sent to the Test and Evaluation Center, Patuxent River Naval Air Station, Maryland. Following testing from 1945 to 1948, the aircraft languished in outside storage at Naval Air Station Norfolk. In 1961, it was donated to the Smithsonian's National Air Museum, though it remained in deteriorating condition at Norfolk for several more years before being moved the National Air & Space Museum's storage facility in Suitland, Maryland. In October 1974, VG+PH was returned to the Dornier plant in Oberpfaffenhofen, Germany (then building the Alpha Jet) for a complete restoration. In 1975, the aircraft was restored by Dornier employees, many of whom had worked on the airplane originally. They were amazed to find that the

explosive charges built into the aircraft to blow off the tail fin and rear propeller in the event of an emergency were still on the aircraft and active 30 years later.

Following restoration the completed Do 335 was displayed at the Hanover, Germany Airshow from 1 May to 9 May 1976. After the air show, the aircraft was lent to the Deutsches Museum in Munich where it was on display, without a swastika on the dorsal vertical tail in accordance with German law, until 1986, when it was shipped back to Silver Hill, Maryland. VG+PH can be seen today in the Steven F. Udvar-Hazy Center of the National Air & Space Museum alongside other unique late-war German aircraft such as the only known example of the Arado Ar 234B-2 *Blitz* jet recon-bomber, and the only surviving Heinkel He 219A *Uhu* (Eagle-Owl) night fighter's fully restored fuselage and tail surfaces is on display as an assembled unit, as the wings and engines/nacelles of the surviving He 219A there are still undergoing restoration as of Oct 2009.

Specifications (Do 335 A-0)

General characteristics

- **Crew:** 1, pilot
- **Length:** 45 ft 5 in (13.85 m)
- **Wingspan:** 45 ft 1 in (13.8 m)
- **Height:** 15 ft (4.55 m)
- **Wing area:** 592 ft² (55 m²)
- **Empty weight:** 11,484 lb (5,210 kg)
- **Max takeoff weight:** 19,500 lb (8,590 kg)
- **Powerplant:** 2× Daimler-Benz DB 603A 12-cylinder inverted engines, 1,287 kW, 1,726 hp (1,750 PS) each

Performance

- **Maximum speed:** 474 mph (765 km/h)
- **Combat radius:** 721 mi (1,160 km (half load))
- **Service ceiling:** 37,400 ft (11,400 m)

Armament

- 1 × 30 mm (1.18 in) MK 103 cannon (as forward engine-mounted *Motorkanone*)
- 2 × 20 mm MG 151 cannons
- Up to 1,000 kg (2,200 lb) bombload

Chapter 19

Dornier Seastar and Handley Page V/1500

Dornier Seastar

Seastar



Role	Utility amphibian
National origin	Germany/United States
Manufacturer	Dornier Seaplane Company
Designed by	Claudius Dornier
First flight	1985

The **Dornier Seastar** is a turboprop-powered amphibious aircraft built largely of composite materials. Developed by Claudius Dornier of Germany, it first flew in 1985. The design is owned by Claudius Dornier's son, Conrado, who founded Dornier Seawings AG (now Dornier Seaplane Company) to continue work on the project.

Design and development

The Seastar is a parasol wing flying boat, with its two engines mounted in a single nacelle over the wings in a push-pull configuration. In general layout, it strongly resembles Dornier's Do 18 of the 1930s.

The first prototype, a proof-of-concept aircraft using the metal wings from a Dornier Do 28 and with large struts bracing the wing to the sponsons, made its maiden flight from Hamburg on 17 August 1984. The second prototype, representing the definitive design was larger, and featured a new, unbraced composite wing. It first flew from Oberpfaffenhofen on 24 April 1987.

In October 2009, Dornier Seaplane announced that it would launch production of the Seastar.

In May 2010, Dornier announced that it would build the Seastar in St-Jean-sur-Richelieu, about half an hour away from Montreal, Canada.

Variants

Seastar CD-2

Specifications (Seastar CD-2)



The Dornier Seastar on the Wolfgangsee in Austria

General characteristics

- **Crew:** One or two
- **Capacity:** 12 passengers
- **Length:** 12.46 m (40 ft 10½ in)
- **Wingspan:** 15.50 m (50 ft 10¼ in)
- **Height:** 4.60 m (15 ft 1 in)
- **Wing area:** 28.48 m² (306.6 ft²)
- **Empty weight:** 2,400 kg (5,291 lb)
- **Gross weight:** 4,200 kg (9,259 lb)
- **Powerplant:** 2 × Pratt & Whitney Canada PT6A-112, 373 kW (500 hp) each each

Performance

- **Cruising speed:** 341 km/h (212 mph)
- **Stall speed:** 115 km/h (72 mph)
- **Range:** 1,850 km (1,150 miles)
- **Endurance:** 9 hours 12 min
- **Service ceiling:** 8,535 m (28,000 ft)
- **Rate of climb:** 8.0 m/s (1,575 ft/min)
- **Takeoff Distance to 15 m (50 ft):** 410 m (1,345 ft)
- **Landing Distance from 15 m (50 ft) (on land):** 480 m (1,575 ft)

Handley Page V/1500

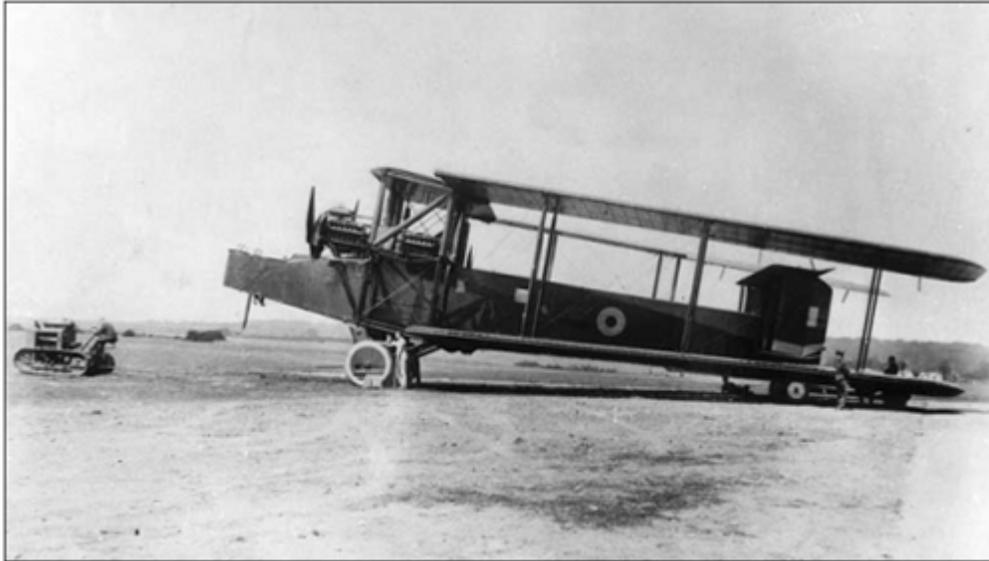
Handley Page V/1500



Role

Heavy Bomber

Manufacturer	Handley Page
Designed by	George Rudolph Volkert
First flight	22 May 1918
Introduction	1918
Primary user	Royal Air Force
Number built	63



Handley Page V/1500 illustrating its folding wing capability

The **Handley Page V/1500** was a British night-flying heavy bomber built by Handley Page towards the end of the First World War. It was a large four-engined biplane, which resembled a larger version of Handley Page's earlier O/100 and O/400 bombers, intended to bomb Berlin from East Anglian airfields. The end of the war stopped the V/1500 being used against Germany, but a single aircraft was used to carry out the first flight from England to India, and later carried out a bombing raid on Kabul during the Third Anglo-Afghan War. It was colloquially known within the fledgling Royal Air Force as the "Super Handley".

Development and design

The V/1500 was produced to meet a British Air Board 1917 requirement for a large night bomber capable of reaching deeper into Germany than the Handley Page O/100 which had recently entered service, carrying a 3,000 lb (1,400 kg) bombload. This implied the ability to bomb Berlin from bases in East Anglia.

While the V/1500 had a similar fuselage to that of the O/100, it had longer-span, four-bay biplane wings and was powered by four 375 hp (280 kW) Rolls-Royce Eagle VIII engines mounted in two nacelles, so two engines were pulling in the conventional manner and two pushing, rather than the two Eagles of the smaller bomber. Construction was of

wood and fabric materials. A relatively novel design feature was the gunner's position at the extreme rear of the fuselage, between the four fins.

Owing to pressure of work at Handley Page's Cricklewood factory, and to ensure security, the first prototype was constructed by Harland and Wolff at Belfast, Northern Ireland, being assembled at Cricklewood and first flying on 22 May 1918. Orders were placed with a number of companies (including Harland and Wolff, Beardmore, Handley Page, Grahame-White and Alliance Aircraft for a total of 210 V/1500s, although only 40 aircraft were completed, with a further 22 produced as spares.

Service

Three aircraft were delivered to No. 166 Squadron at RAF Bircham Newton (Norfolk) during October 1918. The squadron commander did not get clear orders for his mission until November 8, due to debate at high level. A mission was scheduled for that night (bomb Berlin, fly on to Prague as the Austro-Hungarian forces had surrendered by then, refuel, re-arm, bomb Düsseldorf on the way back). No mission was flown - a technical expert insisted that all the engines on one aircraft be changed. The same happened the following day (but with a different aircraft). The three aircraft were about to taxi out after the second set of engine changes when an excited ground crew member ran out to stop them — the Armistice had just been declared.

One of the original batch of aircraft (J1936, *Old Carthusian*) went on to record two significant 'firsts'. On 13 December 1918, the bomber, flown by Major A.C.S. Maclaren and Captain Robert Halley, accompanied by Brigadier General N.D.K. McEwan, made the first ever 'through-flight' from England to India. Taking off from Britain the aircraft flew via Rome, Malta, Cairo, and Baghdad, finally reaching Karachi on 15 January 1919.

The same aircraft played a pivotal role in ending the Third Anglo-Afghan War. On 24 May 1919, flying from Risalpur piloted by Captain Halley and with Lt E. Villiers as observer, the V/1500 reached Kabul in three hours. Of its payload of four 112 lb (51 kg) bombs on improvised bomb racks removed from B.E.2cs and 16 20 lb (10 kg) bombs carried in the fuselage and dropped by hand, four bombs hit the royal palace. Although the bombing did little physical damage, it had a great psychological impact on the citizens - the ladies of the royal harem rushed onto the streets in terror, causing great scandal. A few days later King Amanullah sued for peace, bringing an end to the war after less than one month of hostilities. This could be said to be the first decisive use of strategic bombing..

The Handley Page V/1500 aircraft *Atlantic* was shipped to Newfoundland in early 1919 to attempt the first non-stop Transatlantic flight. Unfortunately the prize was won by Alcock and Brown in a Vickers Vimy in June 1919. The crew departed for New York but was forced to land in Parrsboro, Nova Scotia on 5 July 1919 where it was repaired over the course of the summer. The *Atlantic* continued to New York on 9 October 1919 carrying with it the first Airmail from Canada to the United States of America.

Final production of the V/1500 totalled 60 aircraft. They were eventually replaced in service by the Vickers Vimy. J1936 ended its life being consumed by termites.

Operators

 United Kingdom

- Royal Air Force
 - No. 166 Squadron RAF
 - No. 167 Squadron RAF
 - No. 274 Squadron RAF

Specifications (V/1500)

General characteristics

- **Crew:** Eight or nine
- **Length:** 64 ft 0 in (19.51 m)
- **Wingspan:** 126 ft 0 in (38.41 m)
- **Height:** 23 ft 0 in (7.01 m)
- **Wing area:** 2,800 ft² (260 m²)
- **Empty weight:** 17,600 lb (8,000 kg)
- **Max takeoff weight:** 30,000 lb (14,000 kg)
- **Powerplant:** 4× Rolls-Royce Eagle VIII V-12 water cooled, 375 hp (280 kW) each

Performance

- **Maximum speed:** 99 mph (159 km/h) at sea level
- **Range:** 1,300 mi (2,090 km)
- **Service ceiling:** 11,000 ft (3,350 m)
- **Endurance:** 17 hours
- **Climb to 10,000 ft (3,000 m):** 41 min 25 sec

Armament

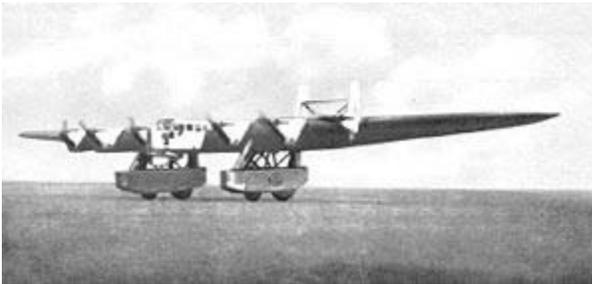
- **Guns:** 3 × .303 in (7.7 mm) Lewis guns each in nose, dorsal and tail positions
- **Bombs:** Up to 7,500 lb (3,400 kg) of bombs (30 × 250 lb/113 kg carried internally)

Chapter 20

Kalinin K-7 and Latécoère 550

Kalinin K-7

K-7



Role	Heavy bomber
National origin	Soviet Union
First flight	1933
Number built	One



A detailed scale model of a K-7

Kalinin K-7 (Ukrainian: *Калінін К-7*) was a heavy experimental aircraft designed and tested in the Soviet Union in the early 1930s. K-7 was of unusual configuration with twin booms and large underwing pods housing fixed landing gear and machine gun turrets. In the passenger version, seats were arranged inside the 2.3 meter (7 ft 7 in) thick wings. The airframe was welded from *KhMA* chrome-molybdenum steel. The original design called for six engines in the wing leading edge but when the projected loaded weight was exceeded, two more engines were added to the trailing edges of each wing, one right and one left of the central passenger pod. However V. Nemecek states in his book, *The History of Soviet Aircraft from 1918*, that there was only one further pusher engine added; this agrees with the specification supplied far below.

Designed by World War I Aviator Kostyantyn Kalinin with a wingspan close to that of a B-52 and a much greater wing area, the K-7 was one of the biggest aircraft built before the jet age. It was only one engine short of the B-52 as well, having the curious arrangement of six pulling on the wing leading edge and one pushing at the rear.

The K-7 was built in two years at Kharkiv starting in 1931.

The K-7's very brief first flight showed up instability and serious vibration caused by the airframe resonating with the engine frequency. The solution to this 'flutter' was thought to

be to shorten and strengthen the tail booms, little being known then about the natural frequencies of structures and their response to vibration.

K-7 first flew on 11 August 1933. The aircraft completed seven test flights before a crash due to structural failure of one of the tail booms on November 21, 1933. The accident killed 14 people aboard and one on the ground. Although two more prototypes were ordered in 1933, the project was cancelled in 1935 before they could be completed.

In 1938 Kalinin was executed as an enemy of the state.

Specifications (K-7)

General characteristics

- **Crew:** minimum 11
- **Capacity:** 120 passengers in civilian configuration
- **Length:** 28 m (91 ft 10 in)
- **Wingspan:** 53 m (173 ft 11 in)
- **Height:** ()
- **Wing area:** 454 m² (4,886.8 ft²)
- **Empty weight:** 24,400 kg (53,793 lb)
- **Loaded weight:** 38,000 kg (83,776 lb)
- **Powerplant:** 7× Mikulin AM-34F V-12 piston engines, 560 kW (750 hp) each

Performance

- **Maximum speed:** 225 km/h (121 knots, 140 mph)
- **Service ceiling:** 4,000 m (13,123 ft)
- **Wing loading:** 84 kg/m² (17 lb/ft²)
- **Power/mass:** 103 W/kg (0.06 hp/lb)

Latécoère 550

Latécoère 550

Role	Torpedo bomber
National origin	France
Manufacturer	La société industrielle d'aviation Latécoère
First flight	29 April 1933
Number built	1

The **Latécoère 550** was a four engined French seaplane, designed in the early 1930s as a bomber/torpedo bomber. Though initial handling problems were partly resolved, the aircraft was deemed too slow and did not go into production.

Design and development

In late 1932 Latécoère received an order from the Commission d'examen des Prototypes et Appareils Nouveaux de l'Aéronautique (CEPANA) for a large four engined floatplane for bomber and torpedo bomber rôles. The resulting aircraft, the Latécoère 550 flew the following year. It was a high wing monoplane with its four Gnôme et Rhône 9 Kdr radial engines mounted on the wings in tandem, tractor-pusher pairs. The tractor motors, neatly cowled, projected well clear of the leading edge; the pusher pair were placed in deep cut-outs in the trailing edge. The cowlings of the latter pair were removed after the first few flights to improve cooling. The wing centre section, between the engines, had an all-metal internal structure and the forward part of the skin was also metal, replaced by fabric further aft. The outer wing sections were slightly tapered on the leading edge only, with elliptical tips; they were entirely fabric covered over a largely wooden structure, though the principal ribs were metal lattices. 6° of dihedral were added after the first tests. Double ailerons of mixed wood and metal construction filled almost all the trailing edges beyond the engine cut-outs.

The fuselage was flat sided and bottomed and only slightly curved on the upper surface. The forward part, from the nose to about midway to the tail was an all steel structure built on four longerons. Further aft, the longerons continued but were now internally braced with spruce struts and fabric covered. The forward part was deeper, ending at the rear with an open position for a ventral gunner. At the nose, where the upper fuselage sides curved inwards to an upper gun turret and a navigator's glazed position below, the lower part ended slightly further aft in an enclosure for the bomb aimer. Pilot and co-pilot sat side by side in a glazed cockpit ahead of the leading edge. Behind them, under the same glazing, sat the engineer and the radio operator. Further aft, at the wing trailing edge, was a dorsal gunner's turret. All crew positions were joined by a corridor.

The Latécoère 550 had its tailplane mounted on top of the fuselage, strut braced from below and bearing twin inboard fins and rudders separately braced to the top of the fuselage. During flight trials, these vertical surfaces evolved in stages from a rather blunt shape, with extensions below the tailplane to a surface with a smoothly curved trailing edge entirely above the tailplane. The rudders were fitted with trim tabs. Because of the inboard rudders, the elevators had three sections.

The 550 was normally equipped with long, single stepped floats. These were mounted below the engines with four vertical spars per side and braced to the fuselage with a further pair running upwards and inwards. Each float also held the inner ends of a pair of lift struts which joined the outer section of the wing at about mid-span. Between engine, float and fuselage the bracing was complicated by further diagonal struts. The floats were replaced for a time with a pair of single wheels, contained in a streamlined structure strong enough to allow attachment of the same struts that connected to the floats. In this

landplane configuration a small steerable tailwheel was added. The split undercarriage allowed the 550 to launch torpedoes and bombs from a longitudinally divided bay beneath the fuselage, with a maximum weapons weight of 1,500 kg (3,100 lbs) and torpedoes carried on the port side.

The first flight was made from Latécoère's marine base at Biscarosse on 29 April 1933 with the 550 in seaplane form. After some modifications to engine cowlings, wings and tail it went to CEPANA at Saint-Raphaël, Var for trials in October 1933 and in November was converted, in less than four hours, into a landplane. It was not well received and described as unfit for purpose: instabilities, high control loads and pitching on contact with the water were amongst the criticisms. After modifications, including the final vertical stabiliser changes, the 550 went back to CEPANA in April 1934 in seaplane form. It seems to have handled better, but by now its maximum speed was seen as low; when the sole 550 was lost in October 1934, its port float struts collapsing on alighting, there was no enthusiasm for further development.

Specifications (seaplane)

General characteristics

- **Crew:** 5
- **Length:** 19.79 m (64 ft 11 in)
- **Wingspan:** 33.97 m (111 ft 5 in)
- **Height:** 5.79 m (19 ft 0 in)
- **Wing area:** 129 m² (1,390 sq ft)
- **Empty weight:** 7,264 kg (16,014 lb) up to 7,305 kg depending on equipment
- **Gross weight:** 10,569 kg (23,301 lb)
- **Powerplant:** 4 × Gnôme et Rhône 9 Kdr 9-cylinder radial, 370 kW (500 hp) each at 2,250 rpm

Performance

- **Maximum speed:** 252 km/h (157 mph; 136 kn) at 100 m
- **Combat range:** 1,000 km (621 mi; 540 nmi)
- **Service ceiling:** 6,500 m (21,325 ft) calculated
- **Rate of climb:** 4.10 m/s (807 ft/min) to 4000 m (13,125 ft)

Armament

- 1× 7.7 mm (0.303 in) Lewis machine gun in each of the turrets and in the open ventral position.
- Bombs and torpedoes up to 1,500 kg (3,100 lb) in total in fuselage bay, bombs in starboard side racks and torpedo port side.

Chapter 21

Moynet Jupiter and Rutan Defiant

Moynet Jupiter

Jupiter



The Moynet 360-6 second prototype Jupiter at Toussus-le-Noble airfield near Paris in June 1971. (Rear propeller is hidden by starboard fin.)

Role	Executive transport
National origin	France
Manufacturer	Engins Matra/Sud-Aviation
Designed by	André Moynet
First flight	17 December 1963
Number built	2

The **Moynet 360 Jupiter** was a small executive transport built in France in the 1960s. It had an unusual twin push-pull configuration, single fuselage configuration. Two prototypes were produced, the second with more power and seating, but no sales resulted.

Design and development

Some civil propeller driven aircraft that have used one or more pairs of engines in push-pull configuration have been flying boats, with engines mounted above the wing and

clear of spray. Others have had a pair of engines, one at either end of a pod fuselage with a tail unit mounted on a pair of booms, for example the Cessna Skymaster, the Adam A500 or the Rutan Voyager. The Moynet 360 Jupiter was an example of a push-pull aircraft of a less common configuration, where a single conventional fuselage has an engine at either end; the Dornier Do 335 fighter used the same arrangement. For light civil aircraft, the aim was to combine the performance of a conventional twin-engined aircraft with the ease of handling of a single-engined one.

The Jupiter was an executive transport with between four and seven seats, depending on engine power. It was designed by André Moynet, a member of the National Assembly of France and a former government minister, while also a test-pilot, and built by S.S. Engines Matra (so it is sometimes referred to as the **Matra Moynet Jupiter**), the first prototype flying on 17 December 1963 with the designer and Lucien Tieles at the controls. Its wing had a straight trailing edge, but the centre section had strong taper on the leading edge which continued more weakly outboard. It was of two spar, stressed skin construction, carrying mass balanced ailerons and slotted flaps. The main undercarriage legs, placed at the end of the centre section each carried a single wheel and retracted inwards electrically. A retractable nosewheel completed the landing gear.

One horizontally opposed Lycoming engine was conventionally placed in the nose. Behind it was a standard cabin, though the front seats were further ahead of the leading edge than usual because of the rearward shift of the centre of gravity caused by the rear engine. There were three large windows on each side. For the same reason the rear fuselage was quite short, and it lacked the normal taper, giving it a boxy look, so that the second, pusher Lycoming could be mounted in the extreme tail. This was cooled by air from rectangular intakes on the upper sides of the rear fuselage. The straight edged, tapered tailplane was mounted on the fuselage top above the engine, with small endplate fins carrying balanced rudders. These fins extended above and below the tailplane, with arrow shaped leading edges and straight, swept trailing edges. There was also a long, shallow strake over the rear fuselage. Seen from below, the long span of the tailplane was striking, about 44% of that of the wings; the elevators filled most of the outer part of its trailing edge, avoiding the propeller airstream.

Only two Jupiters were built. The first, designated 360-4 and initially registered as *F-WLKE* had two 200 hp (150 kW) Lycoming IO-360-A1A engines driving two bladed propellers and was configured as a 4-5 seater.

The second prototype was of a more powerful and slightly larger variant designated the model 360-6; it first flew on 25 May 1965. This model had a choice of engines, either 290 hp (216 kW) Lycoming IO-540 six cylinder engines driving constant speed, three bladed propellers, or 310 hp (231 kW) Lycoming TIO-541 engines. The span was increased by 0.37 m (15 in) and length by 0.64 m (25 in). The increased length allowed seats for 6-7, with two rows of two single seats and a bench seat at the rear that could accommodate 2 or 3. The cabin was sound-proofed and air conditioned and could be pressurised. Access was via a forward starboard side door. There was baggage space behind the cabin with its own external door. The sole 360-6 was registered as *F-WLKY*.

The intention was for Sud-Aviation to produce the 360-6 Jupiter as the **Sud-Aviation M 360-6 Jupiter**. An order was obtained from the French government for some 360-6 pre-production aircraft, but this seems to have been cancelled. Despite sales campaigns in Europe and the U.S.A. no further orders resulted.

The first prototype is now in the reserve collection of the Musée de l'Air et de l'Espace, Le Bourget Airport, Paris museum and the second in the Musée Regional de l'Air, Angers - Loire Airport, France. At le Bourget, the 360-4 bears the normal French registration *F-BLKE* rather than the French prototype style *F-WLKE*.

Variants

M 360-4 Jupiter

First prototype, 4–5 seats, two 149 kW (200 hp) Lycoming IO-360 engines.

M 360-6

Second prototype, with stretched fuselage with seven seats and two 216 kW (290 hp) Lycoming IO-540 engines.

M 360-6P

Proposed pressurised seven-seat version, with Lycoming O-480 engines. Unbuilt.

Sud-Aviation Présidence

Further enlarged, pressurised version planned by Sud-Aviation.

Specifications (360-6, Lycoming IO-540)

General characteristics

- **Capacity:** 6 or 7 including crew
- **Length:** 8.77 m (28 ft 9 in)
- **Wingspan:** 11.49 m (37 ft 8 in)
- **Height:** 2.46 m (8 ft 1 in)
- **Wing area:** 16.81 m² (180.9 sq ft)
- **Empty weight:** 1,338 kg (2,950 lb)
- **Gross weight:** 2,390 kg (5,269 lb)
- **Fuel capacity:** 566 L
- **Powerplant:** 2 × Lycoming IO-540 6-cylinder horizontally opposed air cooled, 216 kW (290 hp) each
- **Propellers:** 3-bladed Hartzell constant speed

Performance

- **Maximum speed:** 363 km/h (226 mph; 196 kn) at sea level. All performance figures estimates at maximum take-off weight.
- **Cruising speed:** 338 km/h (210 mph; 183 kn) at 1,830 m (6,000 ft) on 75% power
- **Range:** 2,060 km (1,280 mi; 1,112 nmi) at 4,500 m(15,000 ft) and 45% power.
- **Rate of climb:** 7.3 m/s (1,440 ft/min) at sea level

Rutan Defiant

The **Rutan Model 40 Defiant** is a four-seat, twin-engine aircraft with the engines in a push-pull configuration. It was designed by well-known aerospace engineer Burt Rutan for the Rutan Aircraft Factory.



Rutan Defiant N57KS



Rutan Defiant

Development

The prototype Defiant, N78RA, first flew on 30 June 1978. It was intended as a proof-of-concept of a very safe light twin design, requiring little trim change and no pilot action in case of engine failure, and with good single engine performance. A comparison of the Defiant single engine climb rate with a Grumman Cougar showed about 390 vs 280 ft/min at low altitude with both aircraft cleaned up. The prototype is now owned by the Hiller Aviation Museum.

In 1979 the Rutan Aircraft Factory announced they would proceed with certification of a Defiant-based light twin. Adequate financing was not secured for this project, and the design was modified for homebuilt construction as the **Model 74**, with the second aircraft (built by Fred Keller) appearing at Oshkosh 1983. Plans were offered in mid-1984. Nine examples were known to be flying as of mid-1987. Nineteen are registered with the FAA as of 2005.

Specifications (Defiant)

General characteristics

- **Crew:** one, pilot
- **Capacity:** 3 passengers
- **Length:** 22.8 ft (6.95 m)
- **Wingspan:** 30 ft 9 in (9.4 m)
- **Height:** 9.33 ft ()
- **Wing area:** 139.4 ft² (12.95 m²)
- **Empty weight:** 1,701 lb (771.5 kg)
- **Loaded weight:** 2,997 lb (1,360 kg)
- **Max takeoff weight:** 2,997 lb (1,360 kg)
- **Powerplant:** 2× Lycoming O-320, 160 hp (119 kW) each

Performance

- **Maximum speed:** 188 kts (216 mph / 342 km/h)
- **Range:** 1,130 miles (1,808 km)
- **Service ceiling:** 18,000 ft (5,485 m)
- **Rate of climb:** 1,600 ft/min (488 m/min)

Chapter 22

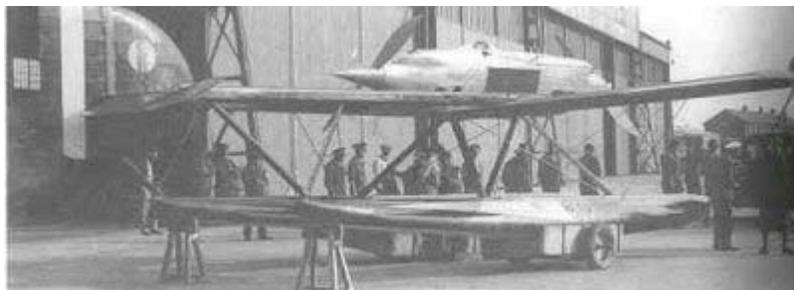
Savoia-Marchetti S.65 and Schweizer RU-38 Twin Condor

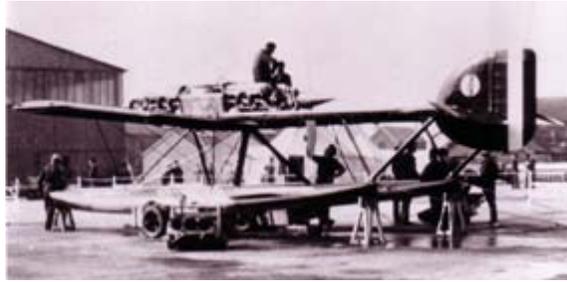
Savoia-Marchetti S.65

Savoia-Marchetti S.65



Role	Racing seaplane
National origin	Italy
Manufacturer	Savoia-Marchetti
First flight	1929
Number built	1





The **Savoia-Marchetti S.65** was an Italian racing seaplane built for the 1929 Schneider Trophy race.

Design and development

The S.65 was a single-seat twin-engine floatplane of low-wing monoplane configuration with two floats. Its tailplane was supported by two booms and the floats, which extended well toward the rear of the aircraft. Its two 745-kilowatt (1,000-horsepower) Isotta-Fraschini engines were mounted in tandem, each driving a two-bladed propeller, one in the nose in a tractor configuration and the other at the rear of the fuselage in a pusher configuration.

Operational history

The S.65 was excluded from the 1929 race due to mechanical problems, and Italy was instead represented in the race by one Macchi M.52R and two Macchi M.67 seaplanes.

Tomasso Dal Molin of the Italian Schneider Trophy racing team was killed flying the S.65 during training at Lake Garda in northern Italy in 1930.

Operators

-  Italy

Schweizer RU-38 Twin Condor

RU-38 Twin Condor

Role	Covert reconnaissance aircraft
National origin	USA
Manufacturer	Schweizer Aircraft Corporation
Designed by	Leslie Schweizer
First flight	31 May 1995
Introduction	May 1997
Status	In production
Primary users	United States Coast Guard United States Department of Justice
Produced	RU-38A 1995-1997 RU-38B 2004-2005
Number built	RU-38A - 2 RU-38B - 3
Developed from	RG-8A

The **Schweizer RU-38 Twin Condor** is a two or three-seat, fixed gear, low wing, twin boom covert reconnaissance aircraft.

RU-38 is the US military designation for the aircraft, indicating *Utility, Reconnaissance*. The Schweizer company model number is **Schweizer SA 2-38A Condor** and, in its three-seat configuration, **Schweizer SA 3-38A Condor**

Based on the Schweizer SGM 2-37 motor glider, a total of five RU-38s were produced between 1995 and 2005. The aircraft remains in production.

Background

The development of the Schweizer SGM 2-37 motor glider for training use at the United States Air Force Academy led to two reconnaissance versions of that design, carrying the company model numbers SA 2-37A and SA 2-37B. In Central Intelligence Agency, US Army and US Coast Guard service these were designated RG-8A and B. The RG-8s were employed in border security and surveillance missions.

In the mid-1990s the Coast Guard decided that the aircraft would be more useful if their capabilities were improved to include night operations by the addition of more mission sensor equipment. Discussions with Schweizer Aircraft resulted in a plan to upgrade two RG-8As and build one new aircraft to provide a total of three.

Development

The RU-38 was intended to fulfill both the low altitude, quiet, over water/hostile terrain reconnaissance role and also the high altitude standoff surveillance role.

The design missions for the RU-23A were:

- Border integrity
- Counter-terrorism surveillance
- Drug enforcement
- Electronic intelligence
- Fishery patrols
- Illegal alien surveillance
- Intelligence collection
- Maritime patrol
- Pollution patrol & environmental monitoring
- Search and Rescue

In converting to the new RU-38A configuration, the conventional RG-8A airframe was greatly modified by:

- Removing the single 235 hp (175 kW) Lycoming O-540-B powerplant
- Installing two Teledyne Continental Motors GIO-550A engines with a 3:2 gear reduction to 2267 operating rpm. The engines are mounted one in the nose and the other in the rear of the fuselage.
- Enlarging the crew compartment
- Improving the engine mufflers
- Increasing the wingspan from 56.5 ft (18.14 m) to 84.13 ft (25.65 m)
- Changing the single tail fin to a twin-boom configuration with two fins
- Greatly enlarged sensor bays
- Improved noise signature reduction
- Tricycle landing gear replacing the conventional landing gear

RU-38A

The resulting aircraft bears little resemblance to the original TG-8. Installation of the twin-boom pods permits the carriage of more sensors. The left-hand pod houses an AN/APN-215(V) color multi-function X-band sea search radar with mapping capabilities. The right-hand pod houses the AN/AAQ-15 forward looking infrared (FLIR) and Low-Light TV enhanced vision systems.

For navigation the RU-38A originally carried both OMEGA and GPS receivers, although the Omega has since been removed with that system's withdrawal from service in 1997. The aircraft also has HF, VHF and UHF radios for voice and encrypted voice communications, plus direction finding. The crew may also use night vision goggles.

The aircraft has no flaps and instead retains the top and bottom surface divebrakes of its sailplane ancestors. Maximum take-off weight of the RU-38A is 5300 lb (2404 kg)

The RU-38A is designed to transit to its operational area with both engines operating. Once in the surveillance area the rear engine would normally be shut down and the aircraft operated in "quiet surveillance mode". The second engine would be available for use in an emergency and for transit back to base.

The first Coast Guard RG-8A was returned to Schweizer for conversion to RU-38A status on 24 January 1994. The initial plan called for the conversion of two RG-8As and then build one new RU-38A.

The first flight of the converted aircraft took place on 31 May 1995. The second USCG RG-8A aircraft that was earmarked for RU-38A upgrade crashed near Puerto Rico in 1996. As a result the program was reduced to provide only two RU-38As to the USCG. The loss of the RG-8A delayed the program for many months and it was not completed until May 1997.

The first RU-38 was tested by the Air Force 445th Flight Test Squadron at Edwards AFB on behalf of the Coast Guard, starting in July 1998. The RU-38A was subject to approximately 100 test flights during the four month test program.

By September 1999 the two converted RU-38As had been delivered to the Coast Guard in Miami, Florida for operational employment. The RU-38As were flown in drug interdiction missions over the Gulf of Mexico and the Caribbean Sea, but the aircraft were reportedly grounded during 2000, due to problems with the aircraft meeting mission requirements or serviceability.

RU-38B

The company further improved the aircraft by replacing the two piston engines with two Rolls Royce Allison 250-B17F turboprop engines which allowed raising the gross weight to 7200 lbs (3265 kg). The new aircraft carries the military designation of RU-38B.

The RU-38B has 140 cubic feet (4.1 cu m) of payload space with a payload weight of 800 lbs (363 kg) available. The payload bays all have large access doors and are located both in the tailbooms and also behind the pilot and co-pilot seats in the fuselage. The latter space can also accommodate a third crew member, if required. Using pallet-mounted sensor packages the aircraft can be quickly changed from one mission to another.

The RU-38B is able to achieve quiet operation while loitering by using a propeller speed as low as 1000 rpm. This is possible because the sailplane-derived wing is efficient and flight at low airspeed can be sustained with low power.

Two RU-38Bs were delivered to the US Department of Justice, one in 2004 and one in 2005.

The RU-38B model is still being actively marketed by Schweizer in 2010.

Certification

Neither the RU-38A or B was certified by the Federal Aviation Administration. Instead all aircraft operate as experimental aircraft in the *Research and Development* category.

Operators

 United States

- Schweizer Aircraft - Two RU-38A and one RU-38B
- United States Department of Justice - two RU-38B

Specifications (RU-38B)

General characteristics

- **Crew:** two in side-by-side seating or three, with two pilots in side-by-side seating and one sensor operator in the rear
- **Length:** 35.1 ft (10.7 m)
- **Wingspan:** 84.13 ft (25.65 m)
- **Height:** ()
- **Wing area:** 334.2 ft² (31.06 m²)
- **Airfoil:** Wortmann Fx 61-163
- **Empty weight:** 4265 lb (1934 kg)
- **Loaded weight:** 7200 lb (3265 kg)
- **Useful load:** 2935 lb (1331 kg)
- **Max takeoff weight:** 7200 lb (3265 kg)
- **Powerplant:** 2× Rolls Royce Allison 250-B17F Constant Speed, Full Feather, unknown horsepower () each

Performance

- **Never exceed speed:** 168 knots (312 km/h)
- **Maximum speed:** 168 knots (312 km/h)
- **Cruise speed:** 83 knots (mission speed) (155 km/h)
- **Stall speed:** 62 knots with divebrakes closed (116 km/h)
- **Service ceiling:** 30,000 ft (9230 m)
- **Rate of climb:** ft/min (m/s)
- **Wing loading:** 21.5 lb/ft² (105.1 kg/m²)