Encyclopedia of

Military Aircrafts

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Chapter- 1

Introduction to Military Aircraft

A **military aircraft** is any fixed-wing or rotary-wing aircraft that is operated by a legal or insurrectionary armed service of any type. Military aircraft can be either combat or non-combat:

German Fokker Triplanes of *Jasta* 26 in World War I

- Combat aircraft are aircraft designed to destroy enemy equipment using their own armament. Combat aircraft are normally developed and procured only by military forces.
- Non-combat aircraft are aircraft not designed for combat as their primary function, but may carry weapons for self-defense. These mainly operate in support roles, and may be developed by either military forces or civilian organizations.

Combat aircraft

Soviet Mi-24 attack helicopter

Combat aircraft (warplanes) divide broadly into fighters and bombers. Fighters include interceptors, such as the British Supermarine Spitfire, and heavy fighters, such as the German Messerschmitt Bf 110. Bombers include light bombers, such as the British Fairey Battle; medium bombers, such as the German Heinkel He-111; heavy bombers, such as the British Avro Lancaster; dive bombers, such as the German Junkers Ju 87; and torpedo bombers, such as the American Grumman TBF Avenger.

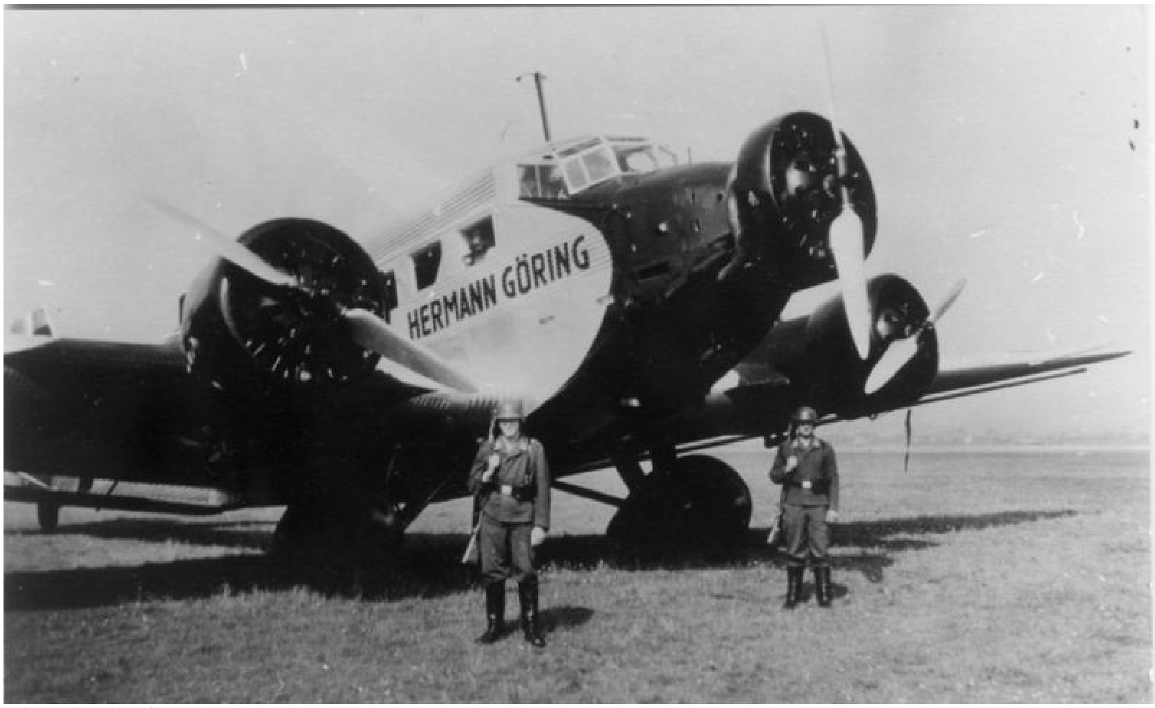
There are several variations between the fighter and the bomber, including fighter-bombers, such as the F-111 Aardvark, ground-attack aircraft, such as the Soviet Ilyushin Il-2 Shturmovik, and attack helicopters, such as the Eurocopter Tiger and the Russian Kamov Ka-50. Also included among combat aircraft are long-range maritime patrol aircraft, such as the Avro Shackleton and the S-3 Viking that are flown by the navies, air forces, and coast guards of the world, often equipped to attack with anti-ship missiles and anti-submarine weapons.

Heavy bomber B-52

Furthermore, several types of transport airplanes have been equipped as heavily-armed ground attack warplanes. These include the AC-47 *Puff the Magic Dragon* and AC-130 *Spectre* aircraft of the U.S. Air Force.

Non-combat aircraft

Non-combat aircraft are diverse, and include front-line aircraft for example surveillance aircraft and support types, for example, pilot trainers.



Transport Junkers Ju 52

Non-combat aircraft could be designed just for military use, for example tanker planes, or a civil aircraft design modified for this role, such as the USAF KC-10 Extender. For non-tanker use, there are military transport planes. Supporting roles are carried out by special-purpose search and rescue, reconnaissance, observation, aerial transports, trainer planes, and aerial tanker aircraft.

Many civil aircraft, both fixed wing and rotary, have been produced in separate models for military use, such as the civilian Douglas DC-3 airliner, which became the military C-47 Skytrain, naval R4D, and British "Dakota" transport planes, and decades later, the USAF's AC-47 aerial gunships. Even the small fabric-covered two-seater Piper J3 Cub had a military version:the L-4 liaison, observation and trainer aircraft. Gliders and balloons have also been used as military aircraft; for example, balloons were used for observation during the American Civil War and during World War I, and military gliders were used during World War II to deliver ground troops in airborne assaults.

Calling a military airplane a "cargo plane" is incorrect, because military *transport planes* also carry paratroopers and other soldiers and Marines.

Chapter- 2

Surveillance Aircraft

A Lockheed U-2, a Cold War era surveillance aircraft

A **surveillance aircraft** is a military aircraft used for monitoring enemy activity, usually carrying no armament. This article concentrates on military aircraft used in this role, though a major civilian aviation activity is reconnaissance and ground surveillance for mapping, traffic monitoring, science, and geological survey. In addition, civilian aircraft are used in many countries for border surveillance, fishery patrols or the prevention of smuggling and illegal migration.

A surveillance aircraft does not necessarily require high-performance capability or stealth characteristics. It may in fact be a modified civilian aircraft which has been disguised in order to look harmless. Technically, anything which can fly and make observations (dynamically or via recording equipment/sensors) of visual information or electronic emissions qualifies as a surveillance aircraft.

Such efforts long predate the invention of heavier-than-air flight, with experiments using balloons to provide targeting information for artillery beginning in France in 1794.

Continued attempts throughout the 19th Century proved militarily useless, but aerostat-based radar platforms are now in use.

History

Airborne reconnaissance goes back to the early era of ballooning. After the French Revolution, the new rulers became interested in using the balloon to observe enemy manoeuvres and appointed scientist Charles Coutelle to conduct studies using *l'Entreprenant* -- its name literally meaning "The Undertaking," which was the first reconnaissance aircraft. The balloon found its first use in the 1794 conflict with Austria, where in the Battle of Fleurus the French Aerostatic Corps gathered information and the demoralizing effect on the Austrian troops ensured victory for the French troops.

The first reconnaissance flights with winged aircraft in combat conditions took place during the Balkan wars, on 5 October 1912 by Greek and on 16 October 1912 by Bulgarian (Albatros) aircraft.

One of the first aircraft used for surveillance was the Rumpler Taube during World War I, when aviators like Fred Zinn evolved entirely new methods of reconnaissance and photography. The translucent wings of the plane made it very difficult for ground based observers to detect a Taube at an altitude above 400 m. The French also called this plane "the Invisible Aircraft", and it is sometimes also referred to as the "world's very first stealth plane". German Taube aircraft were able to detect the advancing Russian army during the Battle of Tannenberg (1914).

Before World War II the conventional wisdom was to use converted bomber types for airborne photo reconnaissance, since these were the only aircraft with the long range needed for the reconnaissance missions. These bombers retained their defensive armament, which was vital since they were unable to avoid interception.

The Japanese designed a twin-engine purpose-built reconnaissance aircraft in 1939, the highly effective Mitsubishi Ki-46, armed with only one light gun facing rearward. It entered service in 1941. Allied airmen designated it the "Dinah".

In 1939 Flying Officer Maurice Longbottom was among the first to suggest that airborne reconnaissance may be a task better suited to fast, small aircraft which would use their speed and high service ceiling to avoid detection and interception. Although this seems obvious now, with modern reconnaissance tasks performed by fast, high flying aircraft, at the time it was radical thinking.

As a result, fighters such as the British Spitfire and Mosquito and the American P-38 Lightning and P-51 Mustang were adapted for photo-reconnaissance during World War II. Such craft were stripped of weaponry, painted in sky camouflage colours to make them difficult to spot in the air, and often had engines modified for higher performance at very high altitudes (well over 40,000 feet). Early in the war the British developed a warming system to allow photographs to be taken at very high altitudes. The collection and interpretation of such photographs became a considerable enterprise. One site claims that the British, at their peak, flew over 100 reconnaissance flights a day, yielding 50,000 images per day to interpret. Similar efforts were taken by other countries.

Immediately after World War II, long range aerial reconnaissance was once again taken up by adapted bombers, albeit with jet engines, enabling them to fly faster and higher than before. Examples of such aircraft include the English Electric Canberra, and its American development, the Martin B-57.

A De Havilland Chipmunk T10 - as used for "Operation Schooner" and "Operation Nylon" missions by BRIXMIS during the Cold War

In the 1950s, the first purpose-built jet covert surveillance aircraft, the Lockheed U-2 was constructed secretly for the United States. Designed for flights over Soviet territory, the plane remained an obscurity until one piloted by Gary Powers was shot down over the Soviet Union in 1960, leading to the U-2 Crisis. Modified versions of the U-2 remain in service in 2007, though its capabilities and operations remain secret. In the 1960s the SR-71 Blackbird, the fastest manned jet-propelled aircraft ever built, was constructed. However, as both the United States and Soviet Union possessed surveillance satellites, overt interest in new types of photo-reconnaissance aircraft declined.

There are claims that the US constructed a new, secret, hypersonic surveillance aircraft - dubbed the Aurora - in the late 1980s to replace the Blackbird, but no confirmation of this has ever emerged.

RAF Nimrod MR2 taxis for takeoff

Another category of surveillance aircraft that has been in vogue since World War II is the maritime patrol aircraft. These are typically large, slow machines capable of flying continuously for many hours, with a wide range of sensors and electronic equipments on board. Such aircraft include the Avro Shackleton, the Hawker-Siddeley Nimrod, the Breguet Atlantique, the Tupolev Tu-95, and from Lockheed, the Neptune and later the Orion. The latter type became famous when a Chinese interceptor collided with the wing of a US Navy example patrolling. The crew of the larger US aircraft made an emergency landing. The Orion was impounded by the Chinese authorities then dismantled and returned to the USA. The crew were questioned but released prior to the aircraft's return.

Current use

Camera bay of a reconnaissance Mirage III R

Several unmanned remotely-controlled reconnaissance aircraft (UAVs) have been recently deployed or are under development in many countries, including Israel, the UK, the United States, China, Pakistan and India. Currently under development are, amongst others, the RQ-4 Global Hawk, a high-altitude jet-propelled craft that resembles the U-2, and the smaller, medium-altitude MQ-1 Predator. Schweizer Aircraft Corporation are developing remotely-piloted versions of a light helicopter.

Most air forces around the world lack dedicated surveillance planes, but have the capability of adding reconnaissance cameras to combat and transport aircraft.

Another type of surveillance aircraft is the electronic surveillance aircraft. Whilst other military aircraft, including photo-reconnaissance aircraft, have been used for that purpose, several countries adapt aircraft for electronic intelligence (ELINT) gathering. The Beech RC-12 Super King Air and Boeing RC-135 Rivet Joint are examples of this military activity, which helps to reduce opportunities for surprise attack or the risks of training exercises being misunderstood by potential enemies.

As well as the development of UAVs, another recent trend in surveillance aircraft design has been the realization that, with the addition of lightweight sensors and communications gear, every fighter plane and ground attack plane can simultaneously be used to perform surveillance. Hence, the in-development F-35 Joint Strike Fighter multirole fighter plane will have extensive surveillance and communications capabilities built in.

Chapter- 3

Ground-attack Aircraft

An A-10 Thunderbolt II, a ground-attack aircraft, fires its 30 x 173mm GAU-8 Avenger seven-barreled cannon

Ground-attack aircraft are military aircraft designed to attack targets on the ground and are often deployed as close air support for, and in proximity to, their own ground forces. The proximity to friendly forces require precision strikes from these aircraft that are not possible with typical bomber aircraft. The resultant proximity to enemy targets also require aircraft that are more robust than other types of military aircraft. Examples include the American A-10 Thunderbolt II and the Russian Sukhoi Su-25 Frogfoot.

They are typically deployed as close air support to ground forces, their role is tactical rather than strategic, operating at the front of the battle rather than against targets deeper in the enemy's rear. As such, they are often attached to and in the direct command and control structures of army units as opposed to air force units, though tactical air forces attached to army formations are still an organic part of the air force and ultimately under air-force command. A number of names have or are used for ground-attack aircraft: **attack aircraft**, **fighter-bomber**, **tactical fighter**, **tactical bomber**, **strafer**, **strike fighter**, **attack helicopter**, **gunship**, etc. A **light strike aircraft** is another category, based on adapted trainers or other light aircraft.

Definition

As with many classifications of combat aircraft, the definition of "ground attack" is somewhat vague. A key difference between it and otherwise similar designs like *attack aircraft* is the expectation that they will receive small arms fire and are generally armored to protect the pilot against this threat. In general a ground-attack aircraft will also be smaller and less "fighter like" than designs like strike fighters, attack aircraft or interceptors. They will usually have less speed, range and BVR ordnance than fighters. More often they carry more powerful guns and other weapons than fighters.

In US service ground-attack aircraft have been identified by the prefix A- as in "A-6". British designations have included FB for fighter-bomber and more recently "G" for Ground as in "Harrier GR1".

The NATO reporting names for Soviet/Russian ground attack aircraft classified them as "fighters" instead of "bombers" - possibly because they were often only variants of fighter aircraft, but always similar in size, range and weapons to fighters.

History

In the First World War Germany was the first country to produce dedicated ground attack aircraft such as the Junkers J.I, which pioneered the idea of a complete armored fuselage "bathtub" structure, that protected the engine and the aircraft's two crewmembers. The Allies experimented with attack planes such as the Sopwith Salamander and the Boeing GA-1 but the war ended before they could used in combat.

Between the World Wars, the United States Marine Corps Aviation pioneered ground attack and close air support tactics in the Banana Wars. Marine Aviators pioneered the technique of dive bombing during interventions in Haiti and Nicaragua.

At the start of World War II engine power was scarce and aircraft had to be tailored to individual roles. Ground attack aircraft during this era were generally created for the role, one that was considered largely unimportant and therefore saw little development. Perhaps the only early-war aircraft in this niche was the Henschel Hs 123, a biplane. The Germans worked on a suitable replacement and eventually delivered the Henschel Hs 129, which featured a steel-armored cockpit and windows made of bulletproof glass. Only small numbers were built, however, as the Germans widely used the more flexible Junkers Ju 87 *Stuka* dive-bomber in the ground attack role. A more famous example is the Soviet Ilyushin Il-2, a *shturmovik* (light bomber that was designed expressly for the ground attack role) with its own improved, armoured fuselage "bathtub" structure, powerful belt-fed heavy calibre anti-armor autocannon armament installations, and possibility of using air-to-ground rockets. More than 43,000 Ilyushin Il-2 were built through World War II. Joseph Stalin credited the Il-2 with winning the war.

P-47 Thunderbolt in flight firing rockets

As engine power improved, roughly doubling over the course of the war, even the average day fighter was more than capable enough to carry out the ground attack role, and some of the most successful designs were slight modifications of existing designs. One of the most successful of these was the RAF's Hawker Typhoons, although they deployed a variety of other aircraft due to changing availability. The Germans made a series of adapted versions of the Focke-Wulf Fw 190, the F and G series, serving roughly the same purpose. The same was true of the USAAF, who moved former front-line fighters into the ground attack role during the war, notably the P-38 Lightning and P-47 Thunderbolt, as newer aircraft took up the air superiority role.

While machine guns and cannon were sufficient against infantry and light vehicles, and one or two small bombs could be easily fitted to most fighters, for operations against tanks heavier weapons were needed such as the 40 mm Vickers S gun, equipped the Hawker Hurricane to good effect in North Africa Campaign. A barely adequate alternative were variety of high explosive rockets used by many British (the RP-3 60 lb rocket), US and Soviet aircraft. The Germans also deployed rockets, anti-tank cannons such as the *Bordkanone 3.7cm* or *Bordkanone 5.0cm*, as well as the first cluster bombs.

Post World War II

Su-22M4K in the markings of the 7th Tactical Sqn. of Polish Air Force

In the immediate post war era the piston engined ground attack aircraft remained useful - Royal Navy Hawker Sea Fury fighters and the US Vought F4U Corsair and Douglas A-1 Skyraider operated in the Korea with the latter plane effective into the Vietnam conflict. The long loiter times of the piston powered planes gave an advantage over fuel-thirsty jet planes.

In most of the post-World War II era air forces have been increasingly reluctant to develop combat aircraft specifically for ground attack. Although close air support and interdiction remain crucial to the modern battlefield, attack aircraft are less glamorous than fighters, and both pilots and military planners have a certain well-cultivated contempt for 'mud-movers.' More practically, the extra cost of a dedicated ground attack aircraft is harder to justify as opposed to having multi-role aircraft.

In the late 1960s the United States Air Force requested a dedicated air support plane that became the Fairchild Republic A-10 *Thunderbolt II*. It eventually became a primarily anti-armor weapon with limited capability in the interdiction and tactical bombing role, and even in the anti-tank role it was met with mixed feelings. However, the A-10's performance during Operation Desert Storm negated these criticisms. Current US doctrine increasingly emphasizes the use of United States Army helicopters for close air support and anti-tank missions. The Soviets' similar Sukhoi Su-25 (*Frogfoot*) found greater success in the flying artillery role, although it, too, shifted to anti-armor use in later versions and has largely been phased out in favour of 'fast mover' fighter-bomber versions of the MiG-29 and Su-27.

Examples of modern ground attack aircraft include the A-10 Thunderbolt II, Sukhoi Su-7, Sukhoi Su-17, Sukhoi Su-25 (*Frogfoot*), Nanchang Q-5. Ground attack has otherwise become the domain of converted trainers like the BAC Strikemaster, BAE Hawk, and Cessna A-37 and some trainers are already build with this task in mind, like the CASA 101.

Recent history

RAF Harrier GR7

U.S. experience in the Gulf War, Kosovo, Afghanistan, and Iraq War has resulted in renewed interest in fixed-wing ground-attack aircraft.

Under the Key West Agreement which governs the allocation of aircraft between the U.S. Army and the U.S. Air Force, fixed-wing ground-attack aircraft were generally allocated to the Air Force, while attack helicopters were generally allocated to the Army. The Army, wishing to have its own resources to support its troops in combat and faced with a lack of Air Force enthusiasm for the ground-attack role, developed the AH-64 Apache attack helicopter for ground-attack roles such as destroying enemy tanks and supporting troops in combat.

On January 17, 1991, Task Force Normandy began its attack on two Iraqi anti-aircraft missile sites. TF Normandy, under the command of LTC Richard A. "Dick" Cody, consisted of nine AH-64 Apaches, one UH 60 Black Hawk and four Air Force MH-53J Pave Low helicopters. The purpose of this mission was to create a safe corridor through the Iraqi air defense system. The attack was a huge success and cleared the way for the beginning of the Allied bombing campaign.

One concern involving the Apache arose when a unit of these helicopters was very slow to deploy during U.S. military involvement in Kosovo. According to the *Army Times*, the

Army is shifting its doctrine to favour ground-attack aircraft over attack helicopters for deep strike attack missions because ground-attack helicopters have proved to be highly vulnerable to small-arms fire. The U.S. Marine Corps have noted similar problems.

Officially, the U.S. Air Force planned to replace the only dedicated ground-attack aircraft currently in U.S. service, the A-10, with its new "Joint Strike Fighter", the F-35 Lightning II. But, facing political concerns that the new fighters were not designed for the ground-attack role that had proven particularly useful in Iraq and Afghanistan, a plan to decommission the A-10 has been replaced with a plan to upgrade the existing aircraft with improved electronics, extending the service life of the planes until as late as 2028. The U.S. Air Force has not commissioned any new designs for this role (in part, out of concern for the F-35 program).

The UK is replacing its current ground attack aircraft with the F-35 (replacing the Harriers), and the Eurofighter Typhoon (Jaguars and Tornado GRs).

The other major complication to plans of military forces to purchase new ground-attack aircraft is uncertainty over the degree to which manned fixed wing aircraft may be replaced by unmanned combat drones in this role, a possibility illustrated by the armed Predator drone, which has been used in this capacity.

Chapter- 4

Interceptor Aircraft

USN F-14 Tomcat

An **interceptor aircraft** (or simply **interceptor**) is a type of fighter aircraft designed specifically to intercept and destroy enemy aircraft, particularly bombers, usually relying on great speed. A number of such aircraft were built in the period starting just prior to World War II and ending in the late 1960s, when they became less important due to the shifting of the strategic bombing role to Intercontinental Ballistic Missiles (ICBMs).

Design

RAF English Electric Lightning

There are two types of interceptors, emphasizing different aspects of performance. **Point defense interceptors** were the first type, designed to take off and climb as quickly as possible to the attacking aircraft's altitude. This was a necessity in the era of relatively short range radar, which meant defenders had very short warning times before having to engage the enemy. **Area defense interceptors** are larger designs intended to protect a much larger area from attack. These were important only during the Cold War, when the US and USSR needed to provide a defense over their respective large land areas.

Both types of aircraft sacrifice performance in the air superiority fighter role (i.e., fighting enemy fighter aircraft) by tuning their performance for either fast climbs or high speeds, respectively. The result is that interceptors often look very impressive on paper, typically outrunning, outclimbing and outgunning less specialized fighter designs. Yet they tend to fare poorly in combat against those same "less capable" designs due to limited maneuverability.

In the 1970s, the utility of interceptors waned as the role became blurred into the roles of the heavy air superiority fighters dominant in military thinking at the time. In addition, it is arguable that the change of the great threat of the era — nuclear weapons that were carried on bombers being moved to various missile systems — left the interceptor-style aircraft without its primary target. Today interceptor missions are generally relegated to "mainline" fighters; for instance, the US Air Force bases its defense on its F-15 and F-16 fighters. The exceptions are the USSR, who maintained a number of dedicated interceptors in order to provide coverage over its huge and little inhabited coastline, and, perhaps oddly, the UK, who introduced a fleet of modified Panavia Tornados in the 1980s and continued to use them while awaiting the introduction of the Eurofighter Typhoon in 2005. The Eurofighter Typhoon has now replaced the role of an interceptor and the Tornado is now used for air superiority and attack.

Point defense

The MiG-25 'Foxbat' is a Russian interceptor that was the mainstay of the Soviet air defence.

Point defense interceptors, usually of European origin, are designed to defend specific targets. They are designed to take off and climb to altitude as quickly as possible, destroy any incoming threats, and then land. A particularly extreme example of a point defense interceptor is the rocket-powered Bachem Ba 349.

At the start of the Second World War, most single engine fighters were "short-legged", with limited internal fuel capacity. These were not designed specifically as interceptors, but the long-range bomber escort role had not been envisaged. This proved to be a critical problem for German single-engined fighters (essentially, only one design at that time, the Bf 109), during the Battle of Britain, which could escort bombers across the channel, but only had sufficient fuel for a few minutes of combat if they were also to return to their airfields in France. At this stage, the similar limitation of British single-engined fighters was less of a problem for the defending Royal Air Force (RAF).

When RAF Bomber Command began its own bombing campaign over Germany, most of its missions were flown at night, unescorted, or escorted by larger, longer-ranged and twin-engined night fighters. As the war progressed, however, Bomber Command flew increasing numbers of daylight missions. The Spitfire, designed several years before the war, was adapted to other roles – older machines were re-assigned to fighter-bomber squadrons, based nearer the front, while newer marks developed into more highly-focused interceptors. These later, Griffon-engined Spitfires were primarily retained in Britain to defend against V-1s and bombing raids by single, high-speed or high-altitude, German bombers. Newer designs, like the Hawker Tempest, and P-51 Mustangs bought under Lend-Lease, would fill the conventional and long-range fighter gap.

The Germans, quickly losing their ability to project their airpower over enemy territory, no longer had much requirement for a long-range escort fighter. They were obliged to keep using the Bf 109 throughout the war, although it and newer designs were developed as fighter bombers, the *Luftwaffe*'s most critical requirement was for interceptors as the Commonwealth and American air forces pounded German targets day and night. As the bombing effort grew, notably in early 1944, the Luftwaffe attempted to introduce a number of high-performance designs like the Messerschmitt Me 163 *Komet* and even odder designs like the Bachem Ba 349 *Natter* in the very-short-range interceptor role. In general these designs proved difficult to operate, and had little effect on the bombing effort.

A F-22 from Elmendorf AFB, Alaska intercepting a Russian Tupolev Tu-95 near Alaskan airspace

In the Cold War, bombers were expected to attack flying higher and faster (near supersonic). This led to fighter designs emphasizing acceleration and operational ceiling, such as the mixed power (jet/rocket) Saunders Roe SR.53, or Convair XF-92, or Soviet trials with catapult launched MiG-19s, although none of them found practical use. Improvements in jet engines made the rocket assistance redundant, and a new series of designs evolved that were purely jet powered, including the MiG-21, English Electric Lightning and F-104 Starfighter. This class of aircraft has since disappeared completely; ever increasing engine power has made even small aircraft suitable for practically any role, and aircraft that would have fallen into this class are generally multi-role and find most of their use in the attack role.

Examples of point defense interceptors

- Messerschmitt Me 163
- English Electric Lightning
- Saab Draken
- Saab Viggen (JA 37 variant)
- Mikoyan-Gurevich MiG-21
- F-104 Starfighter

Area defense

Lockheed YF-12

Area defense interceptors, usually of North American or Soviet origin, are designed to defend a large area of territory from attack. The design emphasis is on range, missile carrying capacity and radar quality rather than on acceleration and climb rate. They usually carry long-range or medium-range air-to-air missiles, and often had no bomb carrying capability.

In the Soviet Union during the Cold War, an entire military service, not just an arm of the pre-existing air force, was designated for their use. The planes of the *PVO-Strany* differed from those of the Red Air Force in that they were designed for airfield use only; they could not take off from grass, only concrete runways, they could not be towed for hundreds of kilometres from airfield to airfield by tractor across open fields; they could not be disassembled and shipped back to a maintenance center in a boxcar; and they were by no means small as necessary and rudely simple, but huge and refined with large, powerful radars. Similarly, they were not given the same training in combat maneuvers, but were directed to their targets by radio. Until the 1980s, they were fitted with medium-range or long-range missiles only, unsuitable for dogfight or destroying maneuvring targets. The basic interceptor was Sukhoi Su-9, then Sukhoi Su-15 and MiG-25. The newest and most advanced interceptor aircraft is MiG-31. Soviet Tupolev Tu-28 was the heaviest fighter aircraft ever to see service.

The USAF maintained a dedicated Air Defense Command (ADC) for some time, consisting primarily of dedicated interceptors. Many post-war designs were of limited performance, including designs like the F-86D and F-89 Scorpion. In the late 1940s ADC started a project to build a much more advanced interceptor under the 1954 interceptor effort, which eventually delivered the F-106 Delta Dart after a lengthy development process. Replacements were studied during the 1960s, but came to nothing as the USSR moved their strategic force to ICBMs. The F-106 ended up serving as the primary USAF interceptor into the 1980s, when the performance of general purpose aircraft like the F-15 Eagle rendered the need for a custom design moot.

Several other countries also introduced wide-area interceptor designs. Avro Canada produced the Avro CF-100, generally similar to the F-89, which went on to serve for a lengthy period of time in the Royal Canadian Air Force. Avro's replacement, the Avro Arrow, was controversially cancelled in the late 1950s. The Royal Air Force operated the Gloster Meteor and then Gloster Javelin in the night/all-weather role. Efforts to replace the Javelin with a supersonic design under Operational Requirement F.155 ever came to fruition, with the expectation that missiles would replace bombers. The Tornado ADV was eventually introduced into this role in the 1980s, and continue to serve in this role to this day.

A Shenyang J-8 interceptor in flight

Other examples of area defense interceptors

- F-101B/F Voodoo
- F-102 Delta Dagger
- F-14 Tomcat
- F-4 Phantom II
- Lockheed YF-12
- Shenyang J-8
- Sukhoi Su-15
- Yakovlev Yak-25
- Yakovlev Yak-28

Chapter- 5

Hawker Siddeley Nimrod

Nimrod

RAF Nimrod MR2 taxis for takeoff

Role	Maritime patrol aircraft
Manufacturer	Hawker Siddeley BAE Systems
First flight	May 1967
Introduced	October 1969
Retired	26 March 2010 (MR2)
Status	MR2 Inactive, R1 active until 2011, MRA4 cancelled
Primary user	Royal Air Force
Number built	49 (+2 prototypes)
Developed from	de Havilland Comet
Variants	Nimrod MRA4

The **Hawker Siddeley Nimrod** is a military aircraft developed and built in the United Kingdom. It is an extensive modification of the de Havilland Comet, the world's first jet airliner. It was originally designed by de Havilland's successor, Hawker Siddeley, now part of BAE Systems.

It was designed as a Royal Air Force maritime patrol aircraft, the **Nimrod MR1**/**MR2**, with the major role being anti-submarine warfare (ASW), although it also had secondary roles in maritime surveillance and anti-surface warfare. It served in this role from the early 1970s until March 2010. The current Nimrod series was due to be replaced by the now cancelled Nimrod MRA4.

The RAF also uses the **Nimrod R1** variant in an electronic intelligence gathering (ELINT) role.

Development

MR1

The development of the Nimrod patrol aircraft began in 1964 as a project to replace the Avro Shackleton. The Nimrod design was based on that of the Comet 4 civil airliner which had reached the end of its market life (the first two RAF aircraft were unfinished Comets). The Comet's turbojet engines were then replaced with Rolls-Royce Spey turbofans for better fuel efficiency, particularly at the low altitudes required for maritime patrol. Major fuselage changes were made, including an internal weapons bay, an extended nose for radar, a new tail with electronic warfare (ESM) sensors mounted in a bulky fairing, and a MAD (Magnetic anomaly detector) boom. After the first flight in May 1967, the RAF ordered 46 Nimrod MR1s. The first example (XV230) entered service in October 1969. Five squadrons were eventually equipped with the MR1.

R1

Hawker Siddeley (now BAE Systems) Nimrod R1

Three Nimrod aircraft were adapted for the Signals intelligence role, replacing the Comet C2s and Canberras of No. 51 Squadron in May 1974. The R1 is distinguished from the MR2 by the lack of a MAD boom. Only since the end of the Cold War has the role of the aircraft been officially acknowledged; they were once described as "radar calibration aircraft". The R1s have not suffered the same rate of fatigue and corrosion of the MR2s. New Bombardier Sentinel R1 (ASTOR) aircraft due for delivery from mid 2004 may take on some duties performed by the R1. One R1 has been lost in a flying accident since the type's introduction; this occurred in May 1995 during a flight test after major servicing, at RAF Kinloss. To replace this aircraft an MR2 was selected for extensive conversion, undertaken by BAE Systems at the Woodford factory, to R1 standard, and entered service in December 1996.

The Nimrod R1 is based at RAF Waddington in Lincolnshire, England and flown by 51 Sqn. The remaining Nimrod R1s will be retired in March 2011, and may be replaced by Boeing RC-135 Rivet Joint Aircraft around 2014.

MR2

Nimrod MR2 XV231 at NAS Norfolk (USA) in 1984

Starting in 1975, 32 aircraft were upgraded to MR2 standard, including modernisation of the electronic suite and (as the **MR2P**) provision for in-flight refuelling and additional ESM pods on the wingtips. The in-flight refuelling capability was introduced during the Falklands War, as well as hardpoints to allow the Nimrod to carry the AIM-9 Sidewinder missile for use against Argentine Air Force Boeing 707 which were configured for maritime patrol/surveillance duties shadowing the British naval task force. Eventually all MR2s gained refuelling probes and the "P" designation was dropped.

The Nimrod MR2 carried out three main roles - Anti-Submarine Warfare (ASW), Anti-Surface Unit Warfare (ASUW) and Search and Rescue (SAR). Its extended range enabled the crew to monitor maritime areas far to the north of Iceland and up to 4,000 km out into the Western Atlantic. With Air-to-Air Refuelling (AAR), range and endurance was greatly extended. The MR2 was a submarine killer carrying up to date sensors and data processing equipment linked to the weapon systems. In addition to weapons and sonobuoys, a searchlight was mounted in the starboard wing pod for Search and rescue (SAR) operations.

Nose of a Nimrod MR2 at RIAT 2009

The crew consisted of two pilots and one flight engineer, two navigators (one tactical navigator and a routine navigator), one Air Electronics Officer (AEO), the sonobuoy sensor team of two Weapon System Operators (WSOp ACO) and four Weapon System Operators (WSOp EW) to manage passive and active electronic warfare systems. Two of the WSOps were used as observers positioned at the port and starboard beam lookout windows when flying in dense air traffic. The MR2 had the longest bomb bay of any NATO aircraft.

The Nimrod MR2 was based at RAF Kinloss in Scotland and flown by 201, 120 and 42(R) Squadrons. First maintenance of the MR2 was carried out by the Nimrod Line Sqn. Software Support for the MR2 was carried out by the Nimrod Software Team also based at RAF Kinloss. The Nimrod MR2 aircraft was withdrawn on 31 March 2010, a year earlier than planned, for financial reasons. The last official flight of the MR2 Nimrod took place on 26 May 2010, with XV229 flying from RAF Kinloss to Kent International Airport, Manston in Kent, where it will be used by the nearby MOD Defence Fire Training and Development Centre as an evacuation training airframe.

AEW3

Nimrod AEW3

In the mid-1970s a modified Nimrod was proposed for the Airborne Early Warning (AEW) mission — again as a replacement for the Lancaster-derived, piston-engined Shackleton AEW.2 which was still in service in that role. Eleven existing Nimrod airframes were to be converted by British Aerospace at the former Avro plant at Woodford, Greater Manchester to house the GEC Marconi radars in a bulbous nose and tail. From the start of the first flight trials in 1982, the **Nimrod AEW3** project was plagued by cost over-runs and problems with the GEC 4080M computer used for the Mission System Avionics (MSA).

Eventually, the MoD realised that the cost of developing the radar system to achieve the required level of performance was prohibitive and the probability of success very uncertain, and in December 1986 the project was cancelled. The RAF eventually received seven Boeing E-3 Sentry aircraft instead, with proven radar performance, and electronic enhancements to the original USAF systems to address UK-specific requirements. Of the 11 RAF Nimrods (eight new airframes and three redeployed ex-203 Sqn following the closure of RAF Luqa) that were selected for conversion to AEW3 standard, none returned to the maritime reconnaissance role: all were eventually reduced for spares to support the maritime Nimrod fleet.

MRA4

BAE Systems Nimrod MRA4

The Nimrod MRA4 was intended to replace the capability provided by the MR2. It was essentially a new aircraft, with current-generation Rolls-Royce BR710 turbofan engines, a new larger wing, and fully refurbished fuselage. However the project was subject to delays, cost over-runs, and contract re-negotiations. It was cancelled in 2010 as a result of the Strategic Defence and Security Review at which point it was £789 million over-budget and 114 months (9.5 years) late.

Design

The Nimrod is the first jet-powered Maritime Patrol Aircraft (MPA). Earlier MPA designs used piston engines or turboprop engines to improve fuel economy and to allow for lengthy patrols at low altitudes, as with the Lockheed P-3 Orion. Jet engines are most economical at high altitudes and less economical at low altitudes; the aircraft can travel to the operational area at high altitude which is economical on fuel and fast compared to earlier piston aircraft. On reaching the patrol area the Nimrod descends to its working altitude.

On patrol at high weight all four engines are used, but as fuel is consumed and weight is reduced first one and then a second engine is shut down, allowing the remaining engines to be run at an efficient RPM rather than running all engines at less efficient RPM. A "rapid start" system is fitted should the closed-down engines need to be restarted quickly; instead of relying only on ram air for restarting an engine, compressor air from a live engine is used in a starter turbine which rapidly accelerates the engine being started. All engines are used for travel back to base at high altitude.

Operational history

At first the crews, who were transferred to the Nimrod from the piston-engine Avro Shackletons, were not enthusiastic with the craft, mainly because its sensor suite was only marginally superior to the Shackleton's. In fact most sensors were the same, although the aircraft had a new digital data fusion computer. The Nimrod gave sterling service during the "Cod Wars" between Iceland and the UK over fishing rights. During the Falklands war (Operation Corporate), several Nimrods combed the sea for enemy submarines. The Nimrods took part in Operation Granby (the Gulf War 1990/1991), the NATO operations against Serbia in 1999, Operation Telic (the Iraq war in 2003 and beyond) and the campaign in Afghanistan. They also took part in several search and rescue (SAR) operations in the North Sea.

Search and rescue

While the Nimrod MR1/MR2 was in service, one aircraft from each of the squadrons on rotation was available for search and rescue operations at one-hour standby. The standby aircraft carried two sets of Lindholme Gear in the weapons bay. Usually one other Nimrod airborne on a training mission would also carry a set of Lindholme Gear. As well as using the aircraft sensors to find aircraft or ships in trouble, it was used to find survivors in the water, with a capability to search areas of up to 20,000 square miles (52,000 km^2). The main role would normally be to act as on-scene rescue coordinator to control ships, fixed-wing aircraft, and helicopters in the search area.

Because of the search and rescue role, Nimrod aircraft often appeared in the media in connection with major rescue incidents. In August 1979 a number of Nimrods were involved in finding competitors in distress in the disaster-stricken 1979 Fastnet race, and directing helicopters to the scene. The *Alexander L. Kielland* was a Norwegian semi-submersible drilling rig that capsized whilst working in the Ekofisk oil field in March 1980 killing 123 people. Six different Nimrods searched for survivors and took it in turn to provide a rescue co-ordination role, involving the control of 80 surface ships and 20 British and Norwegian helicopters; control became particularly important as the visibility deteriorated. In an example of the search capabilities, in September 1977 when an attempted crossing of the North Atlantic in a Zodiac inflatable dinghy went wrong, a Nimrod found the collapsed dinghy and directed a ship to it.

Offshore Tapestry

Tapestry is a codeword for the activities by ships and aircraft that protect the United Kingdom's Sovereign Sea Areas, including the protection of fishing rights and oil and gas extraction. Following the establishment of a 200 nautical miles (370 km) Exclusive Economic Zone (EEZ) at the beginning of 1977 the Nimrod fleet was tasked with patrolling the 270,000 square miles (700,000 km^2) area. The aircraft would locate, identify, and photograph vessels operating in the EEZ. The whole area was normally covered every week, with each vessel being photographed. The aircraft would also check and communicate with all oil and gas platforms. In 1978 a Nimrod arrested an illegal fishing vessel from the air in the Western Approaches and made the vessel proceed to Milford Haven for further investigation. During the Icelandic Cod Wars of 1972 and 1975-1976 the Nimrod aircraft operated with Royal Navy surface vessels protecting British fishing fleets.

Operators

United Kingdom

- Royal Air Force

Squadron	Dates	**Aircraft**	**Station**
42 Squadron	1971–1984	Nimrod MR1	RAF St Mawgan
	1983–2010	Nimrod MR2	RAF St Mawgan, RAF Kinloss
51 Squadron	1971-current	Nimrod R1	RAF Wyton, RAF Waddington
120 Squadron	1970–1982	Nimrod MR1	RAF Kinloss
	1981–2010	Nimrod MR2	RAF Kinloss
201 Squadron	1970–1983	Nimrod MR1	RAF Kinloss
	1982–2010	Nimrod MR2	RAF Kinloss
203 Squadron	1971–1977	Nimrod MR1	RAF Luqa
206 Squadron	1970–1981	Nimrod MR1	RAF Kinloss
	1980–2005	Nimrod MR2	RAF Kinloss
236 OCU	1970–1992	Nimrod MR1 and MR2	RAF St Mawgan

Aircraft on display

MR2 variants

- XV226 - Bruntingthorpe Aerodrome
- XV231 - Manchester Airport viewing park
- XV232 - Coventry airport
- XV240 - Gate guardian at RAF Kinloss
- XV250 - Yorkshire Air Museum
- XV255 - City of Norwich Aviation Museum

AEW3

- Cockpit at Solway air Museum, Carlisle

Accidents and incidents

Five Nimrods have been lost in accidents:

- On 17 November 1980, a Nimrod MR2 XV256 crashed near RAF Kinloss after three engines failed following multiple birdstrikes. Both pilots were killed but the remaining crew survived.

- On 3 June 1984, a Nimrod MR2 XV257 stationed at RAF St Mawgan suffered extensive damage when a reconnaissance flare ignited in the bomb bay during flight. The aircraft successfully returned to base but was subsequently written-off due to fire damage. There were no casualties.

- On 16 May 1995, XW666, a Nimrod R1 from RAF Waddington, ditched in the Moray Firth 4.5 miles (7.2 km) from Lossiemouth after an engine caught fire during a post-servicing test flight from RAF Kinloss. The MoD inquiry identified a number of technical issues as the cause. There were no casualties.

- On 2 September 1995, a Nimrod MR2 XV239 crashed into Lake Ontario while participating in the Canadian International Air Show, killing the seven crew members.

- On 2 September 2006, a Nimrod MR2 XV230 crashed near Kandahar in Afghanistan, killing 12 airmen, one marine and one soldier — the largest single day loss of UK personnel since the Falklands War. This was the first Nimrod to enter operational service, originally as a MR1 but upgraded to MR2 standard in the 1980s. On 23 February 2007, the Ministry of Defence grounded all MR2 aircraft while fuel pumps were inspected. The MoD stressed that this was not necessarily related to the crash in Afghanistan.

- On 5 November 2007, XV235 was involved in a midair incident over Afghanistan when the crew noticed a fuel leak during air-to-air refuelling. After transmitting a mayday call, the crew landed the aircraft successfully. The incident came only a month before the issue of the report of a Board of Enquiry into the 2 September 2006 fatal accident to XV230 in (likely) similar circumstances. The RAF subsequently suspended air-to-air refuelling operations for this type.

Specifications

MR2

General characteristics

- **Crew:** 12
- **Capacity:** 24
- **Length:** 38.65 m (126 ft 9 in)

- **Wingspan:** 35.00 m (114 ft 10 in)
- **Height:** 9.14 m (31 ft)
- **Wing area:** 197.05 m² (2,121 sq ft)
- **Empty weight:** 39,009 kg (86,000 lb)
- **Max takeoff weight:** 87,090 kg (192,000 lb)
- **Powerplant:** 4× Rolls-Royce Spey turbofans, 54.09 kN (12,160 lbf) each

Performance

- **Maximum speed:** 923 km/h (575 mph)
- **Cruise speed:** 787 km/h (490 mph)
- **Range:** 8,340-9,265 km (5,180-5,755 mi)
- **Service ceiling:** 13,411 m (44,000 ft)

Armament

- **Guns:** None
- **Hardpoints:** 2× under-wing pylon stations and an internal bomb bay with a capacity of 20,000 lb (9,100 kg) and provisions to carry combinations of:
    - **Rockets:** None
    - **Missiles:**
        - Air-to-air missile: 2× AIM-9 Sidewinder (non-standard in RAF service, only mounted on the MR2 during the Falklands War)
        - Air-to-surface missile: Nord AS.12, Martel missile, AGM-65 Maverick, AGM-84 Harpoon
    - **Bombs:**
        - Depth charges, US-owned B57 nuclear depth bombs (2) (until 1992)
    - **Other:**
        - Air-dropped Mk.46 torpedoes, Sting Ray torpedoes
        - Naval mines
        - Sonobuoys

MRA4

General characteristics

- **Crew:** 10
- **Length:** 38.6 m (126 ft 9 in)
- **Wingspan:** 38.71 m (127 ft)
- **Height:** 9.45 m (31 ft)
- **Wing area:** 235.8 m2 (2,538 sq ft)
- **Empty weight:** 46,500 kg (102,515 lb)
- **Max takeoff weight:** 105,376 kg (232,315 lb)
- **Powerplant:** 4× Rolls-Royce BR710 turbofans, 68.97 kN (15,500 lbf) each

Performance

- **Maximum speed:** Mach 0.77, 496 kn (571 mph, 918 km/h)
- **Range:** 11,119 km (6,910 mi)
- **Service ceiling:** 12,800 m (42,000 ft)

Armament

- **Guns:** None
- **Hardpoints:** 4× under-wing pylon stations and an internal bomb bay with a capacity of 22,000 lb (10,000 kg) and provisions to carry combinations of:
    - **Rockets:** None
    - **Missiles:**
        - Air-to-air missile: 2× AIM-9 Sidewinder (non-standard in RAF service, only mounted on the MR2 during the Falklands War)
        - Air-to-surface missile: AGM-65 Maverick, AGM-84 Harpoon, Storm Shadow
    - **Bombs:**
        - Depth charges
    - **Other:**
        - Air-dropped Mk.46 torpedoes, Sting Ray torpedoes
        - Naval mines
        - Sonobuoys

Chapter- 6

Kamov Ka-25

Ka-25

Ka-25 of the Yugoslav Navy

Role	Anti-submarine/Multi-Purpose Shipboard Helicopter
Manufacturer	Kamov
First flight	26 April 1963 (hovering flight)
Introduction	1972
Primary users	Soviet Navy Russian Navy
Produced	1965–1977
Developed from	Kamov Ka-20

Ka-25 anti-submarine helicopter of SFR Yugoslav Air Force

The **Kamov Ka-25** (NATO reporting name 'Hormone') was a naval helicopter, developed for the Soviet Navy in the USSR from 1958.

Design and development

In the late 1950s there was an urgent demand for anti-submarine helicopters for deployment on new ships equipped with helicopter platforms entering service with the Soviet Navy. Kamov's compact design was chosen for production in 1958. To speed the development of the new anti-submarine helicopter Kamov designed and built a prototype to prove the cabin and dynamic components layout; designated Ka-20, this demonstrator was not equipped with mission equipment, corrosion protection or shipboard operational equipment. The Ka-20 was displayed at the 1961 Tushino Aviation Day display, and given the ASCC Reporting name 'Harp'.

Definitive prototypes of the Ka-25 incorporated mission equipment, corrosion protection for the structure. The rotor system introduced aluminium alloy blades pressurised with nitrogen for crack detection, lubricated hinges, hydraulic powered controls, alcohol de-icing and automatic blade folding. Power was supplied by two free-turbine engines sat atop the cabin, with electrically de-iced inlets, plain lateral exhausts with no Infra-Red countermeasures, driving the main gearbox directly and a cooling fan for the gearbox and hydraulic oil coolers aft of the main gearbox. Construction was of stressed skin duralumin throughout with flush-riveting, as well as some bonding and honeycomb sandwich panels. The 1.5m × 1,25m × 3.94m cabin had a sliding door to port flight deck forward of the cabin and fuel tanks underfloor filled using a pressure refueling nozzle on the port side. A short boom at the rear of the cabin had a central fin and twin toed in fins at the ends of the tailplane mainly for use during auto-ration. The undercarriage consisted of two noncastoring mainwheels with sprag brakes attached to the fuselage by parallel 'V' struts with a single angled shock absorber to dissipate landing loads, and two castoring nosewheels on straight shock absorbing legs attached directly to the fuselage either side of the cockpit which folded rearwards to reduce interference with the RADAR, all wheels were fitted with emergency rapid inflation flotation collars. Flying controls all act on the co-axial rotors with pitch, roll and collective similar to a conventional single rotor helicopter. Yaw was through differential collective which has a secondary effect of torque, an automatic mixer box ensured that total lift on the rotors remained constant during yaw maneuvers, to improve handling during deck landings. Optional extras included fold up seats for 12 passengers, rescue hoist, external auxiliary fuel tanks or containers for cameras, flares, smoke floats or beacons.

Variants

Ka-20
: (NATO reporting name 'Harp') The Ka-20 was a Soviet twin-engine demonstrator helicopter prototype for the Ka-25 built to demonstrate the feasibility of mounting the turboshaft engines above the cabin.

Ka-25BSh
: (NATO reporting name 'Hormone-A') Variants are used in the anti-submarine warfare role, equipped with radar, dipping sonar and a towed MAD and armed with torpedoes and nuclear or conventional depth-charges.

Ka-25BShZ
: Mine-sweeping version, eight built.

Ka-25C
: Little-known upgrade.

Ka-25F
: Proposed assault version in competition with the Mi-22 and the larger Mi-24. Full glazed nose, cargo compartment with four doors, an under-fuselage turret (GSh-23L), provision for six 9M17 or six UB-16 or bombs.

Ka-25K
: (NATO reporting name 'Hormone-B') Over The Horizon targeting version for relaying data to cruise missiles launched from surface warships and submarines. Anti-submarine equipment, Electronic Surveillance Measures and weapons bay removed and larger radar scanner/reflector in a bulged radome under the nose. Also recognisable by a small cylindrical data-link antenna under the rear fuselage.

Kamov Ka-25K in Aeroflot markings at the 1967 Paris Air Show

Ka-25K
: Civilian flying crane helicopter with a gondola under the lengthened nose for controlling unerslung loads up to 2,000kg (4,400lb). Fitted with electrically de-iced rotor blades and optional seats for 12 passengers. A single prototype(SSSR-21110) flown in 1966

Ka-25PS
: (NATO reporting name 'Hormone-C') Search and rescue and transport version with no weapons bay, radome as Ka-25BSh. Normal equipment included seats for 12, rescue winch, provision for stretchers and auxiliary tanks. Optional equipment included a homing receiver, Electronic Surveillance Measures, searchlight and loudspeaker. Ka-25PS helicopters were usually painted red and white.

Ka-25T
: (NATO reporting name 'Hormone-B'): Possibly mis identified or wrong designation for Ka-25K OTH targeting relay aircraft.

Ka-25TL
: Missile tracking version. Also known as the **Ka-25TI** and **Ka-25IV**.

Operators

Bulgaria

- Bulgarian Navy (withdrawn from service)

India

- Indian Navy

Russia

- Russian Naval Aviation (replaced with Kamov Ka-27)

Soviet Union

- Soviet Naval Aviation

Syria

- Syrian Air Force

Ukraine

- Ukrainian Naval Aviation

Vietnam

- Vietnam People's Air Force

Yugoslavia

- Yugoslav Air Force

Specifications (Ka-25BSh)

General characteristics

- **Crew:** 4
- **Length:** 9.75 m (31 ft 11¾ in)
- **Rotor diameter:** 15.74 m (51 ft 7¾ in)
- **Height:** 5.37 m (17 ft 7½ in)
- **Empty weight:** 4,765 kg (10,505 lb)
- **Loaded weight:** 7,500 kg (16,535 lb)
- **Powerplant:** 2× Glushenkov GTD-3F turboshafts

Performance

- **Maximum speed:** 209 km/h (118 knots, 130 mph)
- **Cruise speed:** 193 km/h (120)
- **Range:** 400 km (216 nm, 247 mi)
- **Service ceiling:** 3,350 m (10,990)

Chapter- 7

Supermarine Spitfire

Supermarine Spitfire

A Spitfire Mk IX flown by the late Ray Hanna at Flying Legends 2005. Built at Castle Bromwich as an LF Mk IX, MH434 shot down an Fw 190 in 1943 while serving on 222 Squadron.

Role	Fighter
Manufacturer	Supermarine
Designed by	R. J. Mitchell
First flight	5 March 1936
Introduction	4 August 1938
Retired	1961 Irish Air Corps
Primary user	Royal Air Force
Produced	1938–1948
Number built	20,351
Unit cost	£12,604 (1939) (£579,250 in current value)
Variants	Supermarine Seafire Supermarine Spiteful

The **Supermarine Spitfire** is a British single-seat fighter aircraft used by the Royal Air Force and many other Allied countries throughout the Second World War. The Spitfire continued to be used into the 1950s both as a front line fighter and in secondary roles. It was produced in greater numbers than any other British aircraft and was the only Allied fighter in production throughout the war.

The Spitfire was designed as a short-range high-performance interceptor aircraft by R. J. Mitchell, chief designer at Supermarine Aviation Works (since 1928 a subsidiary of Vickers-Armstrong). Mitchell continued to refine the design until his death from cancer in 1937, whereupon his colleague Joseph Smith became chief designer. The Spitfire's elliptical wing had a thin cross-section, allowing a higher top speed than several contemporary fighters, including the Hawker Hurricane. Speed was seen as essential to carry out the mission of home defence against enemy bombers.

During the Battle of Britain there was a public perception that the Spitfire was *the* RAF fighter of the battle whereas in fact the more numerous Hurricane actually shouldered a greater proportion of the burden against the *Luftwaffe*: the Spitfire units did, however, have a lower attrition rate and a higher victory to loss ratio than those flying Hurricanes.

After the Battle of Britain, the Spitfire became the backbone of RAF Fighter Command and saw action in the European, Mediterranean, Pacific and the South-East Asian theatres. Much loved by its pilots, the Spitfire served in several roles, including interceptor, photo-reconnaissance, fighter-bomber, carrier-based fighter, and trainer. It was built in many different variants, using several wing configurations. Although the original airframe was designed to be powered by a Rolls-Royce Merlin engine producing 1,030hp (768 kW), it was adaptable enough to use increasingly more powerful Merlin and the later Rolls-Royce Griffon engines; the latter was eventually able to produce 2,035 hp (1,520 kW).

Design and development

The unpainted Spitfire prototype *K5054* at Eastleigh airfield, just before the first flight. The angled rudder mass balance, fixed, unfaired main undercarriage and tailskid can be seen. This airframe was written off in a landing accident at the Royal Aircraft Establishment (R.A.E.) at Farnborough on 4 September 1939.

R. J. Mitchell's 1931 design to meet Air Ministry specification F7/30 for a new and modern fighter capable of 251 mph (404 km/h), the *Supermarine Type 224*, resulted in an open-cockpit monoplane with bulky gull-wings and a large fixed, spatted undercarriage powered by the 600 horsepower (450 kW) evaporative-cooled Rolls-Royce Goshawk engine. This made its first flight in February 1934. The Type 224 was a big disappointment to Mitchell and his design team, who immediately embarked on a series of "cleaned-up" designs, using their experience with the Schneider Trophy seaplanes as a starting point. Of the seven designs tendered to F/30, the Gloster Gladiator biplane was accepted for service.

Mitchell had already begun working on a new aircraft, designated *Type 300*, based on the Type 224 but with a retractable undercarriage and the wingspan reduced by 6 ft (1.8 m). The Type 300 was submitted to the Air Ministry in July 1934, but again was not accepted. The design then evolved through a number of changes, including incorporating a faired, enclosed cockpit, oxygen-breathing apparatus, smaller and thinner wings, and the newly-developed, more powerful Rolls-Royce PV-XII V-12 engine, later named the *Merlin*. In November 1934, Mitchell, with the backing of Supermarine's owner, Vickers-Armstrong, started detailed design work on this refined version of the Type 300 and, on 1 December 1934, the Air Ministry issued a contract *AM 361140/34* providing £10,000 for the construction of Mitchell's improved F7/30 design. On 3 January 1935, the Air Ministry formalised the contract and a new Specification F10/35 was written around the aircraft.

In April 1935 the armament was changed from two .303 in (7.7 mm) Vickers machine guns in each wing to four .303 in (7.7 mm) Brownings, following a recommendation by Squadron Leader Ralph Sorley of the Operational Requirements section at the Air Ministry.

On 5 March 1936 the prototype (*K5054*) took off on its first flight from Eastleigh Aerodrome (later Southampton Airport). At the controls was Captain Joseph "Mutt" Summers, chief test pilot for Vickers (Aviation) Ltd., who was reported in the press as saying *"Don't touch anything"* on landing.This eight minute flight came four months after the maiden flight of the contemporary Hurricane.

K5054 was fitted with a new propeller and Summers flew the aircraft on 10 March; during this flight the undercarriage was retracted for the first time. After the fourth flight a new engine was fitted, and Summers left the test-flying to his assistants, Jeffrey Quill and George Pickering. They soon discovered that the Spitfire was a very good aircraft, but not perfect. The rudder was over-sensitive and the top speed was just 330 mph (528 km/h), little faster than Sydney Camm's new Merlin-powered Hurricane. A new and better-shaped wooden propeller meant the Spitfire reached 348 mph (557 km/h) in level flight in mid-May, when Summers flew *K5054* to RAF Martlesham Heath and handed the aircraft over to Squadron Leader Anderson of the Aeroplane & Armament Experimental Establishment (A&AEE). Here, Flight Lieutenant Humphrey Edwardes-Jones took over the prototype for the RAF. He had been given orders to fly the aircraft and then to make his report to the Air Ministry as soon as he landed. Edwardes-Jones made a positive report; his only request was that the Spitfire be equipped with an undercarriage position indicator. A week later, on 3 June 1936, the Air Ministry placed an order for 310 Spitfires, before any formal report had been issued by the A&AEE; interim reports were later issued on a piecemeal basis.

The British public first saw the Spitfire at the RAF Hendon air-display on Saturday 27 June 1936. Although full-scale production was supposed to begin immediately, there were numerous problems which could not be overcome for some time and the first production Spitfire, *K9787*, did not roll off the Woolston, Southampton assembly line until mid-1938. The first and most immediate problem was that the main Supermarine factory at Woolston was already working at full capacity fulfilling orders for Walrus and Stranraer flying boats. Although outside contractors were supposed to be involved in manufacturing many important Spitfire components, especially the wings, Vickers-Armstrong (the parent company) were reluctant to see the Spitfire being manufactured by outside concerns and were slow to release the necessary blueprints and sub-components. As a result of the delays in getting the Spitfire into full production, the Air Ministry put forward a plan that production of the Spitfire be stopped after the initial order for 310, after which Supermarine would build Bristol Beaufighters. The managements of Supermarine and Vickers were able to persuade the Air Ministry that the problems could be overcome and further orders were placed for 200 Spitfires on 24 March 1938, the two orders covering the K, L and N prefix serial numbers.

Airframe

Spitfire Mk IIa of the BBMF. P7350 is the oldest airworthy Spitfire in the world and the only one to have fought in the Battle of Britain.

In the mid-1930s, aviation design teams worldwide started developing a new generation of all-metal, low-wing fighter aircraft. The French Dewoitine D.520 and Germany's Messerschmitt Bf 109, for example, were designed to take advantage of new techniques of monocoque construction and the availability of new high-powered, liquid-cooled, in-line aero engines. They also featured refinements such as retractable undercarriages, fully enclosed cockpits and low drag, all-metal wings (all introduced on civil airliners years before but slow to be adopted by the military, who favoured the simplicity and manoeuvrability of the biplane).

Mitchell's design aims were to create a well-balanced, high-performance bomber interceptor and fighter aircraft capable of fully exploiting the power of the Merlin engine while being relatively easy to fly. At the time, no enemy fighters were expected to appear over Great Britain; to carry out the mission of home defence, the design was intended to climb quickly to meet enemy bombers.

The Spitfire's airframe was complex: the streamlined, semi-monocoque duralumin fuselage featured a large number of compound curves built up from a skeleton of 19 frames, starting from the main engine bulkhead (frame number one) to the tail unit attachment frame. Aft of the engine bulkhead were five half-frames to accommodate the fuel tanks and cockpit. From the seventh frame, to which the pilot's seat and (later) armour plating was attached, to the nineteenth, which was mounted at a slight forward angle just forward of the vertical stabiliser, the frames were oval, each reducing slightly in size and each with numerous holes drilled through them to lighten them as much as possible without weakening them. The U-shaped Frame 20 was the last frame of the fuselage proper and the frame to which the tail unit was attached. Frames 21, 22 and 23 formed the fin; frame 22 incorporated the tailwheel opening and frame 23 was the rudder post. Before being attached to the main fuselage the tail unit frames were held in a jig and the eight horizontal tail formers were riveted to them.

A combination of 14 longitudinal stringers and two main longerons helped form a light but rigid structure to which sheets of alclad stressed skinning were attached. The fuselage plating was 24, 20 and 18 gauge in order of thickness towards the tail, while the vertical fin structure was completed using short longerons from frames 20 through 23, before being covered in 22 gauge plating. There was ample room for camera equipment and fuel tanks which were to be fitted during the Spitfire's operational service life.

The skins of the fuselage, wings and tailplane were secured by rivets and, in critical areas such as the wing forward of the main spar where an uninterrupted airflow was required, with flush rivets; the fuselage used standard dome-headed riveting. From February 1943 on, flush riveting was used on the fuselage, affecting all Spitfire variants. In some areas, such as the rear of the wing, the top was riveted and the bottom fixed by woodscrews into sections of spruce; later, pop-riveting would be used for these areas.

At first, the ailerons, elevators and rudder were fabric-covered. However, when combat experience showed that fabric-covered ailerons were impossible to use at high speeds, fabric was replaced with a light alloy, enhancing control throughout the speed range.

Elliptical wing design

The elliptical planform of a Spitfire Mk XIX, seen at a British air show in 2008

In 1934 Mitchell and the design staff decided to use an elliptical wing shape to solve two conflicting requirements; the wing needed to be thin, to avoid creating too much drag, while still able to house a retractable undercarriage, plus armament and ammunition. Beverley Shenstone, the aerodynamicist on Mitchell's team, explained why that form was chosen:

The elliptical wing was decided upon quite early on. Aerodynamically it was the best for our purpose because the induced drag, that caused in producing lift, was lowest when this shape was used: the ellipse was ... theoretically a perfection ... To reduce drag we wanted the lowest possible thickness-to-chord, consistent with the necessary strength. But near the root the wing had to be thick enough to accommodate the retracted undercarriages and the guns ... Mitchell was an intensely practical man...The ellipse was simply the shape that allowed us the thinnest possible wing with room inside to carry the necessary structure and the things we wanted to cram in. And it looked nice.

Mitchell has sometimes been accused of copying the wing shape of the Heinkel He 70, which first flew in 1932; but as Shenstone explained "Our wing was much thinner and had quite a different section to that of the Heinkel. In any case it would have been simply asking for trouble to have copied a wing shape from an aircraft designed for an entirely different purpose."

The wing section used was from the NACA 2200 series, which had been adapted to create a thickness-to-chord ratio of 13% at the root, reducing to 6% at the tip. A dihedral of six degrees was adopted to give increased lateral stability.

A feature of the wing which contributed greatly to its success was an innovative spar boom design, made up of five square tubes which fitted into each other. As the wing thinned out along its span the tubes were progressively cut away in a similar fashion to a leaf spring; two of these booms were linked together by an alloy web, creating a lightweight and very strong main spar. The undercarriage legs were attached to pivot points built into the inner, rear section of the main spar and retracted outwards and slightly backwards into wells in the non-load-carrying wing structure. The resultant narrow undercarriage track was considered to be an acceptable compromise as this reduced the bending loads on the main-spar during landing.

Ahead of the spar, the thick-skinned leading edge of the wing formed a strong and rigid D-shaped box, which took most of the wing loads. At the time the wing was designed, this D-shaped leading edge was intended to house steam condensers for the evaporative cooling system intended for the PV-XII. Constant problems with the evaporative system in the Goshawk led to the adoption of a cooling system which used 100% glycol. The radiators were housed in a new radiator-duct designed by Fredrick Meredith of the RAE at Farnborough; this used the cooling air to generate thrust, greatly reducing the net drag produced by the radiators. In turn the leading-edge structure lost its function as a condenser, but it was later to be adapted to house integral fuel tanks of various sizes.

Another feature of the wing was its washout. The trailing edge of the wing twisted slightly upward along its span, the angle of incidence decreasing from +2° at its root to -½° at its tip. This caused the wing roots to stall before the tips, reducing tip-stall that may have resulted in a spin. This washout was first featured in the wing of the Type 224 and became a consistent feature in subsequent designs leading to the Spitfire. The complexity of the wing design, especially the precision required to manufacture the vital spar and leading-edge structures, at first caused some major hold-ups in the production of the Spitfire. The problems increased when the work was put out to sub-contractors, most of whom had never dealt with metal-structured, high-speed aircraft. By June 1939 most of these problems had been resolved and Spitfire production was no longer held up by a lack of wings.

All of the main flight controls were originally metal structures with fabric covering. Designers and pilots felt that having ailerons which were too heavy to move at high speed would avoid possible aileron reversal, stopping pilots throwing the aircraft around and pulling the wings off. It was also felt that air combat would take place at relatively low speed and that high-speed manoeuvring would be physically impossible. During the Battle of Britain pilots found that the ailerons of the Spitfire were far too heavy at high speeds, severely restricting lateral manoeuvres such as rolls and high speed turns, which were still a feature of air-to-air combat. Flight tests showed the fabric covering of the ailerons "ballooned" at high speeds, adversely affecting the aerodynamics. Replacing the fabric covering with light alloy dramatically improved the ailerons at high speed.

Spitfire H.F Mk.VII. The shape of the ellipse was altered by the extended "pointed" wing tips used by the high altitude Mk VI and VIIs, and some early Mk VIIIs.

The Spitfire had detachable wing tips which were secured by two mounting points at the end of each main wing assembly: when the Spitfire took on a role as a high altitude fighter (Marks VI and VII and some early Mk VIIIs) the standard wing tips were replaced by extended, "pointed" tips which increased the wingspan to 40 ft 2 in (12.3 m). The other wing tip variation, used by several Spitfire variants, was the "clipped" wing; the standard wing tips were replaced by wooden fairings which reduced the span to 32 ft 6 in (9.9 m) The wing tips used spruce formers for most of the internal structure with a light alloy skin attached using brass screws.

The airflow through the main radiator was controlled by pneumatic exit flaps. In early marks of Spitfire (Mk I to Mk VI) the single flap was operated manually using a lever to the left of the pilot's seat. When the two-stage Merlin was introduced in the Spitfire Mk XI the radiators were split to make room for an intercooler radiator; the radiator under the starboard wing was halved in size and the intercooler radiator housed alongside. Under the port wing a new radiator fairing housed a square oil cooler alongside of the other half-radiator unit. The two radiator flaps were now operated automatically via a thermostat.

The light alloy split flaps at the trailing edge of the wing were also pneumatically operated via a finger lever on the instrument panel. Only two positions were available; fully up or fully down (85°). The flaps were normally lowered only during the final approach and for landing, and the pilot was to retract them before taxiing.

The ellipse also served as the design basis for the Spitfire’s fin and tailplane assembly, once again exploiting the shape’s favourable aerodynamic characteristics. Both the elevators and rudder were shaped so that their centre of mass was shifted forward, thus reducing control-surface flutter. The longer noses and greater propeller-wash resulting from larger engines in later models necessitated increasingly larger vertical and, later, horizontal tail surfaces to compensate for the altered aerodynamics, culminating in those of the Mk 22/24 series which were 25% larger in area than those of the Mk I.

Improved late wing designs

As the Spitfire gained more power and was able to manoeuvre at higher speeds, the possibility that pilots would encounter aileron reversal increased, and the Supermarine design team set about redesigning the wings to counter this. The original wing design had a *theoretical* aileron reversal speed of 580 mph (930 km/h), which was somewhat lower than that of some contemporary fighters. The Royal Aircraft Establishment noted that, at 400 mph (640 km/h) IAS, roughly 65% of aileron effectiveness was lost, due to wing twist.

The new wing of the Spitfire F Mk 21 and its successors was designed to help alleviate this problem; the wing's stiffness was increased by 47%, and a new design of aileron using piano hinges and geared trim tabs meant that the theoretical aileron reversal speed was increased to 825 mph (1,328 km/h). Alongside of the redesigned wing Supermarine also experimented with the original wing, raising the leading edge by one inch (2.54 cm), with the hope of improving pilot view and reducing drag. This wing was tested on a modified F Mk 21, also called the F Mk 23, (sometimes referred to as "Valiant" rather than "Spitfire"). The increase in performance was minimal and this experiment was abandoned.

Supermarine developed a new laminar flow wing based on new aerofoil profiles developed by NACA in the United States, with the objective of reducing drag and improving performance. Supermarine estimated that the new wing could give an increase in speed of 55 mph (89 km/h) over the Spitfire Mk 21. The new wing was initially fitted to a Spitfire Mk XIV; later a new fuselage was designed, with the new fighter becoming the Supermarine Spiteful.

Carburettor versus fuel injection

Early in its development, the Merlin engine's lack of direct fuel injection meant that both Spitfires and Hurricanes, unlike the Bf 109E, were unable to simply nose down into a steep dive. This meant a *Luftwaffe* fighter could simply "bunt" into a high-power dive to escape an attack, leaving the Spitfire behind, as its fuel was forced by negative "g" out of the carburettor. RAF fighter pilots soon learnt to "half-roll" their aircraft before diving to pursue their opponents. Carburettors were adopted because, as Sir Stanley Hooker explained, it was believed that the carburettor "increased the performance of the supercharger and thereby increased the power of the engine." In March 1941, a metal diaphragm with a hole in it was fitted In the fuel line, restricting fuel flow to the maximum the engine could consume. While it did not cure the problem of the initial fuel starvation in a dive, it did reduce the more serious problem of the carburettor being flooded with fuel by the fuel pumps under negative "g". It became known as "Miss Shilling's orifice" as it was invented by Beatrice "Tilly" Shilling. Further improvements were introduced throughout the Merlin series, with Bendix-manufactured pressure carburettors, which were designed to allow fuel to flow during all flight attitudes, introduced in 1942.

Armament

Due to a shortage of Brownings, which had been selected as the new standard rifle calibre machine gun for the RAF in 1934, early Spitfires were fitted with only four guns, with the other four fitted later. Early tests showed that while the guns worked perfectly on the ground and at low altitudes, they tended to freeze at high altitude, especially the outer wing guns. This was because the RAF's Brownings had been modified to fire from an open bolt; while this prevented overheating of the cordite used in British ammunition, it allowed cold air to flow through the barrel unhindered. Supermarine did not fix the problem until October 1938, adding hot air ducts from the rear of the wing mounted radiators to the guns, and bulkheads around the gunbays to trap the hot air in the wing. Red fabric patches were doped over the gun ports to protect the guns from cold, dirt and moisture until they were fired. Even if the eight Brownings worked perfectly, pilots soon discovered that they were not sufficient to destroy larger aircraft. Combat reports showed that an average of 4,500 rounds were needed to shoot down an enemy aircraft. In November 1938, tests against armoured and unarmoured targets had already indicated that the introduction of a weapon of at least 20 mm calibre was urgently needed. A variant on the Spitfire design with four 20mm Oerlikon cannon had been tendered to specification F37/35 but the order for prototypes had gone to the Westland Whirlwind in January 1939.

In June 1939, a single Spitfire was fitted with a single drum-fed Hispano in each wing, an installation that required large blisters on the wing to cover the 60-round drum. The cannons suffered frequent stoppages, mostly because the guns were mounted on their sides to fit as much of the magazine as possible within the wing. In January 1940, P/O George Proudman flew this prototype in combat, but the starboard gun stopped after firing a single round, while the port gun fired 30 rounds before seizing. If one cannon seized, the recoil of the other threw the aircraft off aim. Nevertheless, 30 more cannon-armed Spitfires were ordered for operational trials, and they were soon known as the Mk IB, to distinguish them from the Browning-armed Mk IA, and were delivered to No. 19 Squadron beginning in June 1940. The Hispanos were found to be so unreliable that the squadron requested an exchange of its aircraft with the older Browning-armed aircraft of an operational training unit. By August, Supermarine had perfected a more reliable installation with an improved feed mechanism and four .303s in the outer wing panels. The modified fighters were then delivered to 19 Squadron.

Production

In February 1936 the director of Vickers-Armstrongs, Sir Robert MacLean, guaranteed production of five aircraft a week, beginning 15 months after an order was placed. On 3 June 1936, the Air Ministry placed an order for 310 aircraft, for a price of £1,395,000. Full-scale production of the Spitfire began at Supermarine's facility in Woolston, Southampton, but it quickly became clear that the order could not be completed in the 15 months promised. Supermarine was a small company, already busy building the Walrus and Stranraer, and its parent company, Vickers, was busy building the Wellington. The initial solution was to subcontract the work out. The first production Spitfire rolled off the assembly line in mid-1938, and was flown on 15 May 1938, almost 24 months after the initial order.

The final cost of the first 310 aircraft, after delays and increased programme costs, came to £1,870,242 or £1,533 more per aircraft than originally estimated. Production aircraft cost about £9,500. The most expensive components were the hand-fabricated and finished fuselage at approximately £2,500, then the Rolls-Royce Merlin engine at £2,000, followed by the wings at £1,800 a pair, guns and undercarriage, both at £800 each, and the propeller at £350.

Castle Bromwich

Spitfire Mk IIA *P7666* of 41 Squadron, "Observer Corps" was built by Castle Bromwich in November 1940.

In 1935, the Air Ministry approached Morris Motor Company to ask how quickly their Cowley plant could be turned to aircraft production? This informal asking of major manufacturing facilities was turned into a formal plan to boost British aircraft production capacity in 1936, as the Shadow factory plan, under the leadership of Herbert Austin. Austin was briefed to build nine new factories, and further supplement the existing British car manufacturing industry, by either adding to its overall capacity or capability to reorganise to produce aircraft and their engines.

Under the plan, on 12 July 1938, the Air Ministry bought a site consisting of farm fields and a sewage works next to Castle Bromwich Aerodrome in the West Midlands. This shadow factory would supplement Supermarine's original factories in Southampton in building the Spitfire. The Castle Bromwich Aircraft Factory ordered the most modern machine tools then available, which were being installed two months after work started on the site. Although Morris Motors under Lord Nuffield (an expert in mass motor-vehicle construction) at first managed and equipped the factory, it was funded by government money. When the project was first mooted it was estimated that the factory would be built for £2,000,000, however, by the beginning of 1939 this cost had doubled to over £4,000,000. The Spitfire's stressed-skin construction required precision engineering skills and techniques outside the experience of the local labour force, which took some time to train. However, even as the first Spitfires were being built in June 1940 the factory was still incomplete, and there were numerous problems with the factory management, which ignored tooling and drawings provided by Supermarine in favour of tools and drawings of its own designs, and with the workforce which, while not completely stopping production, continually threatened strikes or "slow downs" until their demands for higher than average pay rates were met.

By May 1940, Castle Bromwich had not yet built its first Spitfire, in spite of promises that the factory would be producing 60 per week starting in April. On 17 May Lord Beaverbrook, Minister of Aircraft Production, telephoned Lord Nuffield and manoeuvered him into handing over control of the Castle Bromwich plant to Beaverbook's Ministry. Beaverbrook immediately sent in experienced management staff and experienced workers from Supermarine and gave over control of the factory to Vickers-Armstrong. Although it would take some time to resolve the problems, in June 1940, 10 Mk IIs were built; in July 23 rolled out, 37 in August, and 56 in September. By the time production ended at Castle Bromwich in June 1945, a total of 12,129 Spitfires (921 Mk IIs, 4,489 Mk Vs, 5,665 Mk IXs, and 1,054 Mk XVIs) had been built. Today it is owned by Jaguar Cars, and known as Castle Bromwich Assembly used for final assembly of all current Jaguar vehicles.

Production dispersal

This Spitfire PR Mk XI (PL965) was built at RAF Aldermaston in southern England

During the Battle of Britain, concerted efforts were made by the *Luftwaffe* to destroy the main manufacturing plants at Woolston and Itchen, near Southampton. The first raid, which missed the factories, came on 23 August 1940. Over the next month, other raids were mounted until, on 26 September 1940, both factories were completely wrecked, with 92 people being killed and a large number injured; most of the casualties were experienced aircraft production workers.

Fortunately for the future of the Spitfire, many of the production jigs and machine tools had already been relocated by 20 September, and steps were being taken to disperse production to small facilities throughout the Southampton area. To this end, the British government requisitioned the likes of *Vincent's Garage* in Station Square Reading, which later specialised in manufacturing Spitfire fuselages, and *Anna Valley Motors*, Salisbury, which was to become the sole producer of the wing leading-edge fuel tanks for photo-reconnaissance Spitfires, as well as producing other components. A purpose-built works, specialising in manufacturing fuselages and installing engines, was built at Star Road, Caversham in Reading. The drawing office in which all Spitfire designs were drafted was relocated to another purpose-built site at Hursley Park, near Southampton. This site also had an aircraft assembly hangar, with its associated aerodrome, where many of the prototype and experimental Spitfires were assembled and flown.

Four towns and their satellite airfields were chosen to be the focal points for these workshops:

- Southampton and Eastleigh Airport
- Salisbury with High Post and Chattis Hill aerodromes
- Trowbridge with Keevil aerodrome
- Reading with Henley and Aldermaston aerodromes.

Completed Spitfires were delivered to the airfields on large Commer "Queen Mary" low-loader articulated trucks, there to be fully assembled, tested, then passed on to the RAF.

Flight testing

All production Spitfires were flight tested before delivery. During the Second World War, Jeffrey Quill was Vickers Supermarine's chief test pilot, in charge of flight-testing all aircraft types built by Vickers Supermarine; he also oversaw a group of 10 to 12 pilots responsible for testing all developmental and production Spitfires built by the company in the Southampton area. Quill had also devised the standard testing procedures which, with variations for specific aircraft designs, operated from 1938. Alex Henshaw, chief test pilot at Castle Bromwich from 1940, was placed in charge of testing all Spitfires built at that factory, coordinating a team of 25 pilots; he also assessed all Spitfire developments. Between 1940 and 1946, Henshaw flew a total of 2,360 Spitfires and Seafires, more than 10% of total production.

Henshaw wrote about flight testing Spitfires:

After a thorough pre-flight check I would take off and, once at circuit height, I would trim the aircraft and try to get her to fly straight and level with hands off the stick ... Once the trim was satisfactory I would take the Spitfire up in a full-throttle climb at 2,850 rpm to the rated altitude of one or both supercharger blowers. Then I would make a careful check of the power output from the engine, calibrated for height and temperature ... If all appeared satisfactory I would then put her into a dive at full power and 3,000 rpm, and trim her to fly hands and feet off at 460 mph IAS (Indicated Air Speed). Personally, I never cleared a Spitfire unless I had carried out a few aerobatic tests to determine how good or bad she was. The production test was usually quite a brisk affair: the initial circuit lasted less than ten minutes and the main flight took between twenty and thirty minutes. Then the aircraft received a final once-over by our ground mechanics, any faults were rectified and the Spitfire was ready for collection. I loved the Spitfire in all of her many versions. But I have to admit that the later marks, although they were faster than the earlier ones, were also much heavier and so did not handle so well. You did not have such positive control over them. One test of manoeuvrability was to throw her into a flick-roll and see how many times she rolled. With the Mark II or the Mark V one got two-and-a-half flick-rolls but the Mark IX was heavier and you got only one-and-a-half. With the later and still heavier versions, one got even less. The essence of aircraft design is compromise, and an improvement at one end of the performance envelope is rarely achieved without a deterioration somewhere else.

When the last Spitfire rolled out in February 1948, a total of 20,351 examples of all variants had been built, including two-seat trainers, with some Spitfires remaining in service well into the 1950s. The Spitfire was the only British fighter aircraft to be in continuous production before, during and after the Second World War.

Operational history

K9795, the 9th production Mk I, with 19 Squadron in 1938

The operational history of the Spitfire with the RAF started with the first Mk Is *K9789*, which entered service with 19 Squadron at RAF Duxford on 4 August 1938. The Spitfire achieved legendary status during the Battle of Britain, a reputation aided by the famous "Spitfire Fund" organised and run by Lord Beaverbrook the Minister of Aircraft Production. Although the key aim of Fighter Command was to stop the *Luftwaffe's* bombers, in practice the tactic was to use Spitfires to counter German escort fighters, particularly the Bf 109s, while the Hurricane squadrons attacked the bombers.

Well-known Spitfire pilots included J E "Johnnie" Johnson (34 enemy aircraft shot down), who flew the Spitfire right through his operational career from late 1940 to 1945. Douglas Bader (20 e/a) and R S "Bob" Tuck (27 e/a) flew Spitfires and Hurricanes during the major air battles of 1940, and both were shot down and became POWs while flying Spitfires over France in 1941 and 1942. Some notable Commonwealth pilots were George Beurling (31 1/3 a/e) from Canada, A G "Sailor" Malan (27 e/a) from South Africa, New Zealanders Alan Deere (17 e/a) and C F Gray (27 e/a) and the Australian Hugo Armstrong (12 e/a).

The Spitfire continued to play increasingly diverse roles throughout the Second World War and beyond, often in air forces other than the RAF. The Spitfire, for example, became the first high-speed photo-reconnaissance aircraft to be operated by the RAF. Sometimes unarmed, they flew at high, medium and low altitudes, often ranging far into enemy territory to closely observe the Axis powers and provide an almost continual flow of valuable intelligence information throughout the war. In 1941 and 1942, PRU Spitfires provided the first photographs of the *Freya* and *Würzburg* radar systems and, in 1943, helped confirm that the Germans were building the V1 and V2 *Vergeltungswaffe* ("vengeance weapons") by photographing Peenemünde, on the Baltic Sea coast of Germany.

In the Mediterranean the Spitfire blunted the heavy attacks on Malta by the *Regia Aeronautica* and *Luftwaffe* and, from early 1943, helped pave the way for the Allied invasions of Sicily and Italy. On 7 March 1942, 15 Mk Vs carrying 90-gallon fuel tanks under their bellies took off from the HMS *Eagle* off the coast of Algeria on a 600-mile flight to Malta. Those Spitfires V were the first to see service outside Britain. Over the Northern Territory of Australia, RAAF Spitfires helped defend the port city of Darwin against air attack by the Japanese Naval Air Force. The Spitfire also served on the Eastern Front: approximately a thousand were supplied to the Soviet Air Force. Though some were used at the frontline in 1943, most of them saw service with the *Protivo-Vozdushnaya Oborona* (English: "Anti-air Defence Branch").

The Spitfire is listed in the appendix to the novel *KG 200* as "known to have been regularly flown by" the German secret operations unit KG 200, which tested, evaluated and sometimes clandestinely operated captured enemy aircraft during World War II.

Speed and altitude records

The Spitfire Mk XI flown by Sqn. Ldr. Martindale, seen here after its flight on 27 April 1944 during which it was damaged achieving a true airspeed of 606 mph (975 km/h).

Beginning in late 1943, high-speed diving trials were undertaken at Farnborough to investigate the handling characteristics of aircraft travelling at speeds near the sound barrier (i.e., the onset of compressibility effects). Because it had the highest limiting Mach number of any aircraft at that time, a Spitfire XI was chosen to take part in these trials. Due to the high altitudes necessary for these dives, a fully feathering Rotol propeller was fitted to prevent overspeeding. It was during these trials that *EN409*, flown by Squadron Leader J. R. Tobin, reached 606 mph (975 km/h, Mach 0.891) in a 45° dive. In April 1944, the same aircraft suffered engine failure in another dive while being flown by Squadron Leader A. F. Martindale, when the propeller and reduction gear broke off. Martindale successfully glided the Spitfire 20 mi (32 km) back to the airfield and landed safely.

A Spitfire was modified by the RAE for high speed testing of the stabilator (then known as the "flying tail") of the Miles M.52 supersonic research aircraft. RAE test pilot Eric Brown stated that he tested this successfully during October and November 1944, attaining Mach 0.86 in a dive.

On 5 February 1952, a Spitfire 19 of No. 81 Squadron RAF based in Hong Kong reached probably the highest altitude ever achieved by a Spitfire. The pilot, Flight Lieutenant Ted Powles, was on a routine flight to survey outside-air temperature and report on other meteorological conditions at various altitudes in preparation for a proposed new air service through the area. He climbed to 50,000 ft (15,240 m) indicated altitude, with a true altitude of 51,550 ft (15,712 m). The cabin pressure fell below a safe level and, in trying to reduce altitude, he entered an uncontrollable dive which shook the aircraft violently. He eventually regained control somewhere below 3,000 ft (900 m) and landed safely with no discernible damage to his aircraft. Evaluation of the recorded flight data suggested that, in the dive, he achieved a speed of 690 mph (1,110 km/h, Mach 0.96), which would have been the highest speed ever reached by a propeller-driven aircraft, but it has been speculated this figure resulted from inherent instrument errors.

The critical Mach number of the Spitfire's original elliptical wing was higher than the subsequently-used laminar-flow-section, straight-tapering-planform wing of the follow-on Supermarine Spiteful, Seafang and Attacker, illustrating that Reginald Mitchell's practical engineering approach to the problems of high-speed flight had paid off.

That any operational aircraft off the production line, cannons sprouting from its wings and warts and all, could readily be controlled at this speed when the early jet aircraft such as Meteors, Vampires, P-80s, etc, could not, was certainly extraordinary.—*Jeffrey Quill*

Variants

Pilots of 611 *West Lancashire* Squadron lend a hand pushing an early Spitfire Mark IXb, Biggin Hill, late 1942. (RAF Official)

As its designer, R. J. Mitchell will forever be known for his most famous creation. However, the development of the Spitfire did not cease with his premature death in 1937. Mitchell only lived long enough to see the prototype Spitfire fly. Subsequently a team led by his chief draughtsman, Joe Smith, developed more powerful and capable variants to keep the Spitfire current as a front-line aircraft. As one historian noted: "If Mitchell was born to design the Spitfire, Joe Smith was born to defend and develop it."

There were 24 marks of Spitfire and many sub-variants. These covered the Spitfire in development from the Merlin to Griffon engines, the high-speed photo-reconnaissance variants and the different wing configurations. More Spitfire Mk Vs were built than any other type, with 6,487 built, followed by the 5,656 Mk IXs. Different wings, featuring a variety of weapons, were fitted to most marks; the A wing used eight .303 in (7.7 mm) machine guns, the B wing had four .303 in (7.7 mm) machine guns and two 20 mm (.79 in) Hispano cannon, and the C or Universal Wing could mount either four 20 mm (.79 in) cannon or two 20 mm (.79 in) and four .303 in (7.7 mm) machine guns. As the war progressed, the C wing became more common. Another armament variation was the E wing which housed two 20 mm (.79 in) cannon and two .50 in (12.7 mm) Browning machine guns.

Supermarine developed a two-seat variant known as the T Mk VIII to be used for training, but none were ordered, and only one example was ever constructed (identified as N32/*G-AIDN* by Supermarine). In the absence of an official two-seater variant, a number of airframes were crudely converted in the field. These included a 4(SAAF) Squadron Mk VB in North Africa, where a second seat was fitted instead of the upper fuel tank in front of the cockpit, although it was not a dual-control aircraft and is thought to have been used as the squadron "run-about." The only unofficial two-seat conversions that were fitted with dual-controls were a small number of Russian lend/lease Mk IX aircraft. These were referred to as Mk IX UTI and differed from the Supermarine proposals by using an inline "greenhouse" style double canopy rather than the raised "bubble" type of the T Mk VIII.

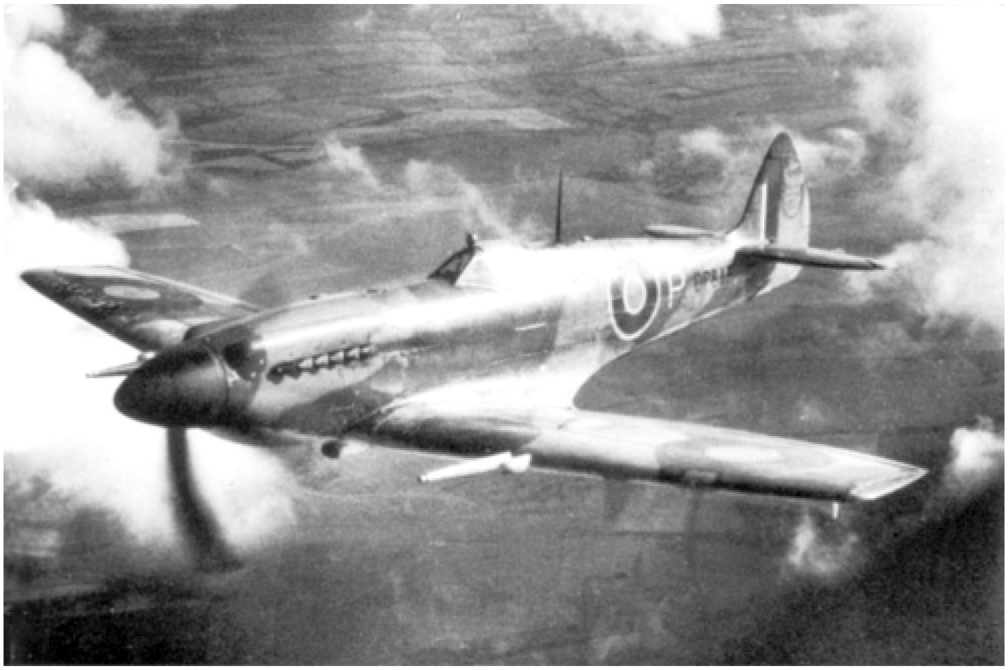
In the postwar era, the idea was revived by Supermarine and a number of two-seat Spitfires were built by converting old Mk IX airframes with a second "raised" cockpit featuring a bubble canopy. Ten of these TR9 variants were then sold to the Indian Air Force along with six to the Irish Air Corps, three to the Royal Dutch Air Force and one for the Royal Egyptian Air Force. Currently a handful of the trainers are known to exist, including both the T Mk VIII, a T Mk IX based in the U.S., and the "Grace Spitfire" *ML407*, a veteran flown operationally by 485(NZ) Squadron in 1944.

Seafire

The **Seafire**, a name derived from **Sea** Spit**fire**, was a naval version of the Spitfire specially adapted for operation from aircraft carriers. Although the Spitfire was not designed for the rough-and-tumble of carrier-deck operations, it was considered to be the best available fighter at the time, and went on to serve with distinction. The basic Spitfire design did impose some limitations on the use of the aircraft as a carrier-based fighter; poor visibility over the nose, for example, meant that pilots had to be trained to land with their heads out of the cockpit and looking alongside the port cowling of their Seafire; also, like the Spitfire, the Seafire had a relatively narrow undercarriage track, which meant that it was not ideally suited to deck operations. Early marks of Seafire had relatively few modifications to the standard Spitfire airframe; however cumulative front line experience meant that most of the later versions of the Seafire had strengthened airframes, folding wings, arrestor hooks and other modifications, culminating in the purpose-built Seafire F/FR Mk 47.

The Seafire II was able to outperform the A6M5 Zero at low altitudes when the two types were tested against each other during wartime mock combat exercises. Contemporary Allied carrier fighters such as the F6F Hellcat and F4U Corsair, however, were considerably more robust and practical for carrier operations. Performance was greatly increased when later versions of the Seafire were fitted with the Griffon engines. These were too late to see service in the Second World War.

Griffon-engined variants



The first Griffon-powered Spitfire, *DP845*, flown by Jeffrey Quill, 1942

The first Rolls Royce Griffon-engined Mk XII flew on August 1942, and first flew operationally with 41 Squadron in April 1943. This mark could nudge 400 mph (640 km/h) in level flight and climb to an altitude of 33,000 ft (10,000 m) in under nine minutes. Although the Spitfire continued to improve in speed and armament, range and fuel capacity were major issues: it remained "short-legged" throughout its life except in the dedicated photo-reconnaissance role, when its guns were replaced by extra fuel tanks.

Newer Griffon-engined Spitfires were being introduced as home-defence interceptors, where limited range was not an impediment. These faster Spitfires were used to defend against incursions by high-speed "tip-and-run" German fighter-bombers and V-1 flying bombs over Great Britain.

As American fighters took over the long-range escorting of USAAF daylight bombing raids, the Griffon-engined Spitfires progressively took up the tactical air superiority role as interceptors, while the Merlin-engined variants (mainly the Mk IX and the Packard-engined XVI) were adapted to the fighter-bomber role.

Spitfire LF Mk XIIs of 41 Squadron in mid-1943

Although the later Griffon-engined marks lost some of the favourable handling characteristics of their Merlin-powered predecessors, they could still out-manoeuvre their main German foes and other, later American and British-designed fighters.

The final version of the Spitfire, the Mk 24, first flew at South Marston on 13 April 1946. On the 20th February 1948, almost twelve years from the prototype's first flight, the last production Spitfire, *VN496*, left the production line. The Spitfire 24 was used by only one regular RAF unit, with 80 Squadron replacing their Hawker Tempests with F. Mk 24s in 1947. 80 Squadron continued its patrol and reconnaissance duties from Wunstorf in Germany as part of the occupation forces, until it relocated to Kai Tak Airport, Hong Kong in July 1949. During the Chinese Civil War, 80 Squadron's main duty was to defend Hong Kong from perceived Communist threats. They kept their Spitfires until 1 April 1954 when the last operational sortie of an RAF Spitfire was flown. Operation Firedog during the Malayan Emergency saw the Spitfire fly over 1,800 operational sorties against the Malaysian communists by Spitfires.

The last operational Spitfire sortie was by a PR Mk 19 Spitfire, *PS888* flying from RAF Seletar, in Singapore. Photographer George Yallop took a photo of PS888 in which the ground crew painted the words, "The Last" onto the port engine cowling of the PR 19 after the final flight.

The last non-operational flight of a Spitfire in RAF service, which took place on 9 June 1957, was by a PR 19, *PS583*, from RAF Woodvale of the Temperature and Humidity Flight. This was also the last known flight of a piston-engined fighter in the RAF. The last nation in the Middle East to operate Spitfires was Syria, which kept its F 22s until 1953.

In late 1962, Air Marshal Sir John Nicholls instigated a trial when he resurrected a Spitfire P.R 19 to fight against an English Electric Lightning F 3, a supersonic jet-engined interceptor, in mock combat at RAF Binbrook. At the time British Commonwealth forces were involved in possible action against Indonesia over Malaya and Nicholls decided to develop tactics to fight the Indonesian Air Force P-51 Mustang, a fighter that had a similar performance to the P.R 19. He concluded that the most effective and safest way for a modern jet-engined fighter to attack a piston-engined fighter was from below and behind, contrary to all established fighter-on-fighter doctrine at that time.

Operators

Spitfires Mk Vc (Trop) of 352 (Yugoslav) Squadron RAF (Balkan Air Force) before first mission on 18 August 1944, from Canne airfield, Italy.

- Argentina (two, ex civilian, test only)
- Australia
- Belgium
- Italy
- Netherlands
- New Zealand

- Burma
- Canada
- Czechoslovakia
- Denmark
- Egypt
- France
- Free France
- Nazi Germany
- Greece
- Hong Kong
- British Raj
    - Union of India
- Indonesia
- Ireland
- Israel
- Kingdom of Italy
- Norway
- Pakistan
- Poland
- Portugal
- Rhodesia
- South Africa
- Soviet Union
- Sweden
- Syria
- Thailand
- Turkey
- United Kingdom
- United States
- Yugoslavia

Survivors

There are approximately 44 Spitfires and a few Seafires in airworthy condition worldwide, although many air museums have examples on static display. For example, Chicago's Museum of Science and Industry has paired a static Spitfire with a static Ju 87 R-2/Trop. Stuka dive bomber.

Memorials

- The Israeli Air Force museum in Hatzerim displays a Spitfire flown by Ezer Weizmann during the 1948 Arab-Israeli War.the aircraft is still flown during aerial displays.
- *Sentinel* is a sculpture depicting three Spitfires in flight by Tim Tolkien at the roundabout junction (popularly known as Spitfire Island) of the A47 and A452 in Castle Bromwich, Birmingham England, commemorating the main Spitfire factory. The island sits at the adjoining southern corners of the former Castle Bromwich Aircraft Factory and Aerodrome (now Castle Vale housing estate). There is also both a Spitfire and a Hurricane in the nearby Thinktank science museum.
- A sculpture of the prototype Spitfire, *K5054*, stands on the roundabout at the entrance to Southampton International Airport, which, as Eastleigh Aerodrome, saw the first flight of the aircraft in March 1936.
- Jeffrey Quill, the former Supermarine test pilot, was pursuing a project to build an exact replica of K5054, the prototype Spitfire to be put on permanent public display as a memorial to R.J. Mitchell. A team of original Supermarine designers worked with Aerofab Restorations of Andover for 10 years to create the facsimile.

It was unveiled to the public in April 1993 by Quill at the RAF Museum, Hendon, and is currently on loan to the Tangmere Military Aviation Museum.

- A fibre glass replica in the colours of a Polish Squadron Leader based at the station during WWII is on display at RAF Northolt, the last Battle of Britain Sector Station still in RAF operational service.
- A Spitfire is on display on the Thornaby Road roundabout near the school named after Douglas Bader who flew a Spitfire in the Second World War. This memorial is in memory of the old RAF base in Thornaby which is now a residential estate.
- A fibreglass replica of a Spitfire has been mounted on a pylon in Memorial Park, Hamilton, New Zealand as a tribute to all New Zealand fighter pilots who flew Spitfires during the Second World War.
- At Bentley Priory, London, fibreglass replicas of a Spitfire Mk 1 and a Hurricane Mk 1 can be seen fixed in a position of attack. This was built as a memorial to everyone who worked at Bentley Priory during the war.
- 603 (City of Edinburgh) Squadron Royal Auxiliary Air Force Spitfire Memorial next to the Edinburgh Airport control tower.
- A fibreglass replica of a Spitfire Mk IX has been mounted on a pylon in Jackson Park, Windsor, Ontario alongside a Hurricane as a memorial to Royal Canadian Air Force pilots. This display replaces an Avro Lancaster bomber that had previously been on display and is currently undergoing restoration.
- One of the few remaining Supermarine Spitfires with a wartime record is on display (alongside a Hawker Hurricane) at the RAF Manston Spitfire and Hurricane Memorial Museum, near Kent International Airport.

Replicas

Several small manufacturers have produced replica Spitfires, either as complete aircraft, or as kits for self building. These range in scale from 3/4 full scale to full-size, although most use wooden construction, rather than the original all-metal monocoque design. Examples include the Jurca Spit from France, and those manufactured by Tally Ho Enterprises in Canada, SAC in California, USA, and even the microlight Silence Twister from Germany. Supermarine Aircraft from Brisbane, Australia, manufacture 80% scale Spitfire replicas. The Supermarine Spitfire Mk 26 is supplied in kit form and is the only all-aluminium reproduction Spitfire in production. The Isaacs Spitfire is a homebuilt 60% scale replica.

Specifications (Spitfire Mk Vb)

Replica Mk VB on display in 2009

General characteristics

- **Crew:** one pilot
- **Length:** 29 ft 11 in (9.12 m)
- **Wingspan:** 36 ft 10 in (11.23 m)
- **Height:** 11 ft 5 in (3.86 m)
- **Wing area:** 242.1 ft² (22.48 m²)
- **Airfoil:** NACA 2209.4(tip)
- **Empty weight:** 5,090 lb (2,309 kg)
- **Loaded weight:** 6,622 lb (3,000 kg)
- **Max takeoff weight:** 6,770 lb (3,071 kg)
- **Powerplant:** 1× Rolls-Royce Merlin 45 supercharged V12 engine, 1,470 hp (1,096 kW) at 9,250 ft (2,820 m)

Performance

- **Maximum speed:** 378 mph, (330 kn, 605 km/h)
- **Combat radius:** 410 nmi (470 mi, 760 km)
- **Ferry range:** 991 nmi (1,140 mi, 1,840 km)
- **Service ceiling:** 35,000 ft (11,300 m)
- **Rate of climb:** 2,665 ft/min (13.5 m/s)
- **Wing loading:** 27.35 lb/ft² (133.5 kg/m²)
- **Power/mass:** 0.22 hp/lb (0.36 kW/kg)

Armament

- **Guns:**

    - 2 × 20 mm (0.787-in) Hispano Mk II cannon, 60 rpg (drum magazine)
    - 4 × 0.303 in (7.7 mm) Browning machine guns, 350 rpg
- **Bombs:** 2 × 250 lb (113 kg) bombs

Chapter- 8

Messerschmitt Me 210

Me 210

A Luftwaffe Me 210 A-1 of the *Versuchsstaffel 210* test squadron, over France in 1942

Role	Heavy fighter, Ground-attack aircraft Fighter-bomber, Bomber destroyer, Dive bomber
Manufacturer	Messerschmitt, Dunai Repülőgépgyár Rt.
First flight	September 1939
Introduced	1943
Retired	1945
Primary users	*Luftwaffe* Hungary
Number built	90 finished and 320 partially completed in Germany, 272 in Hungary
Developed from	Bf 110
Variants	Me 410

The **Messerschmitt Me 210** was a German heavy fighter and ground-attack aircraft of World War II. The Me 210 was designed to replace the Bf 110 in heavy fighter role;

design started before the opening of World War II. The first examples of the Me 210 were ready in 1939, but they proved to have poor flight characteristics. A large-scale operational testing programme throughout 1941 and early 1942 did not cure the aircraft's problems. The design eventually entered limited service in 1943, but was almost immediately replaced by its successor, the Messerschmitt Me 410 *Hornisse* ("Hornet"). The Me 410 was a further development of the Me 210, renamed so as to avoid the 210's notoriety. The failure of the Me 210's development programme meant that the *Luftwaffe* was forced to continue fielding the outdated Bf 110, to mounting losses.

Design and development

Messerschmitt designers had started working on an upgrade of the Bf 110 in 1937, before the production version of the Bf 110 had even flown. In late 1938, the Bf 110 was just entering service, and the RLM started looking ahead for its eventual replacement. Messerschmitt sent in their modified Bf 110 design as the Me 210, and Arado responded with their all-new Ar 240.

The Me 210 was a straightforward cleanup of the 110, and used many of the same parts. The main differences were a modified nose area that was much shorter and located over the center of gravity, and an all-new wing designed for higher cruise speeds. On paper, the Me 210's performance was impressive. It could reach 620 km/h (390 mph) on two 1,350 PS (1,330 hp, 990 kW) Daimler-Benz DB 601F engines, making it about 80 km/h (50 mph) faster than the Bf 110, and nearly as fast as single-engine fighters of the era.

The Me 210's main landing gear followed some of the design philosophies that had resulted from the main change in the earlier Ju 88's main landing gear design, where each main gear had a single gear strut that twisted through 90º during retraction, to bring the main gear wheel resting atop the lower end of the main strut when retracted rearwards into the wing. Unlike the Ju 88, however, the Me 210's main gear wheels were "inside" the main gear struts when fully extended, while the Ju 88's were "outside" the struts.

Loading bombs onto an Me 210

The Bf 110 carried its ordnance externally, on the wings and fuselage, but this created drag; the Me 210 avoided this problem by housing the bombs in an enclosed bomb bay, in the nose of the aircraft. The Me 210 could carry up to two 500 kg (1,100 lb) bombs. The Me 210 had dive brakes fitted on the tops of the wings, and a Stuvi 5B bombsight in the nose, for shallow-angle dive bombing. In the fighter role, the bomb bay was fitted with four 20 mm cannons.

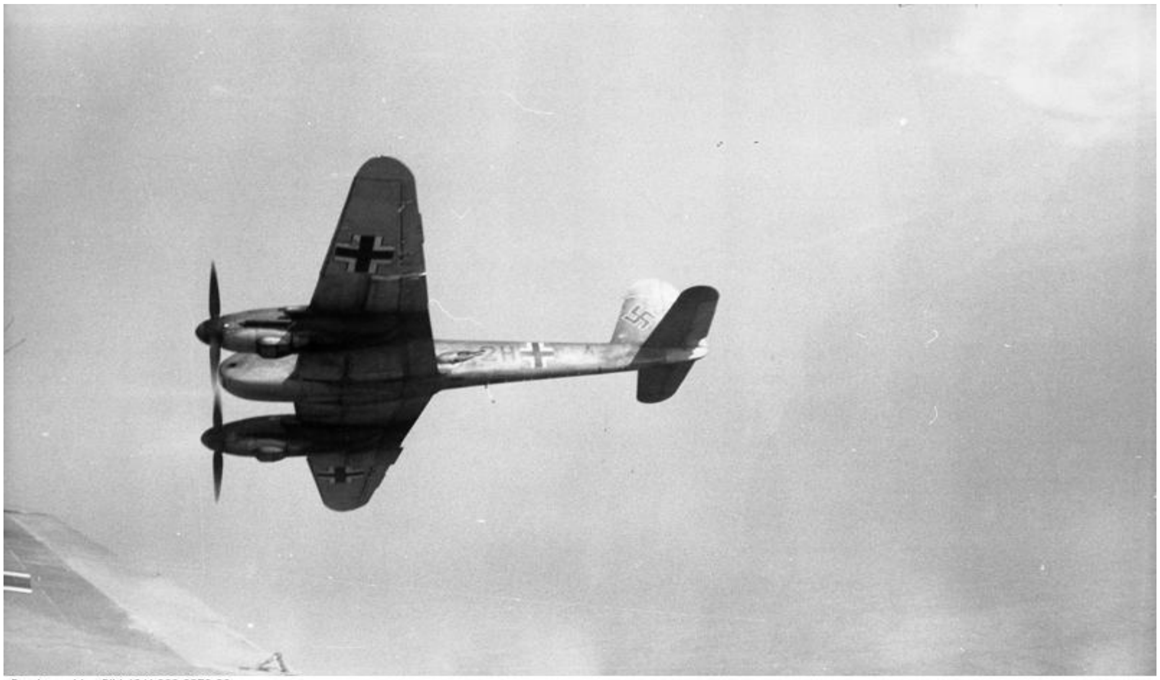
For defense, the Me 210's rear gunner was armed with two 13 mm (.51 in) MG 131 machine guns. Each of these were fitted into half-teardrop-shaped *Ferngerichtete Drehringseitenlafette* FDSL 131/1B turrets mounted on each side of the aircraft, and were remote-controlled from the gunner's position with a unique aiming setup, that had a rotating crossbar with a sideways-pivoting handgun-style grip and trigger at its center, "forked" at its forward pivoting end to fit around the crossbar. This unique aiming and control scheme rotated the crossbar axially, when the handgrip was elevated or depressed, to aim the guns vertically, and a sideways movement of the handgrip would pivot either one of the guns outwards from the fuselage for diagonal firing. The rear of the cockpit canopy's side glazing panels were bulged out to allow the gunner to see in almost any rearward-facing direction. The guns were electrically-fired, and an electrical contact breaker prevented the gunner from shooting off the Me 210's tailplane.

The FDSL 131 remote gun turret of a Me 210 being maintained

An order for 1,000 Me 210s was placed even before the prototype had flown. In time, this would prove to be a mistake. The first prototype flew with DB 601B engines in September 1939, and was considered unsafe by test pilots. Stability was bad in turns, and it tended to "snake" even while flying level. At first the designers concentrated on the twin-rudder arrangement that had been taken from the 110, and replaced it with a new and much larger single vertical stabilizer. However, this had almost no effect, and the plane continued to oscillate. The Me 210 also suffered from terrible stalls. With the nose up or in a turn, the stalls whipped into spins when the automatic leading edge slats opened. The second prototype, **Me 210 V2**, was lost this way in September 1940, when the pilot could not get out of the resulting spin and had to jump. The chief test pilot commented that the Me 210 had "all the least desirable attributes an aeroplane could possess." It took 16 prototypes and 94 pre-production examples to try and resolve the many problems. Nevertheless, the RLM was desperate to replace the Bf 110s currently in service, and ordered full production in the spring of 1941. The type exhibited grossly inadequate handling characteristics, and a result, several elements of airframe were redesigned, including lengthening the fuselage, designated as *lang* ("long"). The Me 210C was built with DB 605 engines, as well as incorporating the changes to the airframe. The Hungarian authorities were satisfied with the Me 210C in its current state, and purchased a production license for the type, designated Me 210Ca (a = *ausländisch*) as well as for its DB 605 engines. Several airframes were also purchased, to be completed in Hungarian factories for practice while the assembly lines were set up. Production started in the *Dunai Repülőgépgyár Rt.* (Danubian Aircraft Plant) as the **Me 210Ca** with the DB 605B engine, under an agreement where the *Luftwaffe* got two of every three produced.

The Me 210 was eventually developed into the Messerschmitt Me 410, with DB 603 engines.

Operational history



Bundesarchiv, Bild 101I-363-2270-09
Foto: Hönicke | 1942

Deliveries to front-line units started in April 1942 and the plane proved to be even less popular with pilots. Production was stopped at the end of the month, by which time only 90 had been delivered. Another 320 partially-completed models were placed in storage. In its place the Bf 110 was put back into production. Although the Bf 110 was now equipped with the newer DB 605B engines and greater firepower, it was still an outdated design.

The *Luftwaffe* started receiving their Hungarian-built planes in April 1943, but the Hungarians didn't get their own until 1944; however, when they did enter service they were more than happy with them. Production ended in March 1944, when the factory switched over to produce the BF 109G. By that time, a total of 267 Me 210C had been built, 108 of them had been given to the *Luftwaffe*. They operated mostly in Tunisia and Sardinia, but were quickly replaced by the Me 410.

Variants

Me 210 A-0
: Pre-production aircraft.

Me 210 A-1
: Single-seat twin-engined fighter-bomber, bomber destroyer.

Me 210 A-2
: Single-seat twin-engined dive bomber, bomber-destroyer aircraft.

Me 210C
: Improved airframe, DB 605 engines.

Me 210 Ca-1
: Hungarian licensed production version of the Me 210C.

Operators

Germany

- *Luftwaffe* operated 90 German-built Me 210A and 108 Hungarian-built Me 210 Ca-1.

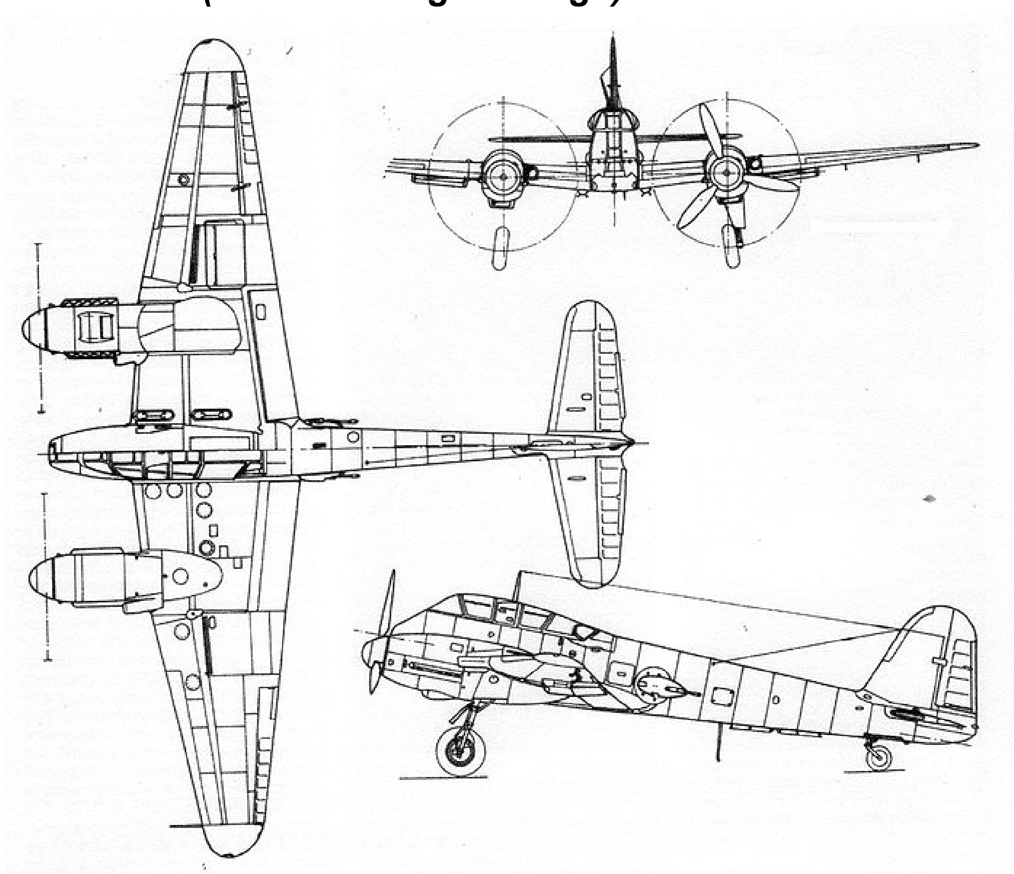
Hungary

- Royal Hungarian Air Force operated 179 Hungarian-built Me 210 Ca-1.

Japan

- Imperial Japanese Army Air Service received one aircraft bought in Germany for tests and delivered aboard of U-Boat.

Specifications (Me 210 - long fuselage)



General characteristics

- **Crew:** 2 (pilot and gunner)
- **Length:** 12.12 m (39 ft 9¼ in)
- **Wingspan:** 16.34 m (53 ft 7⅛ in)
- **Height:** 4.28 m (14 ft 0½ in)
- **Empty weight:** 7,070 kg (15,586 lb)
- **Max takeoff weight:** 9,706 kg (21,397 lb)
- **Powerplant:** 2× Daimler-Benz DB 601F liquid-cooled inverted V12 engine, 1,350 PS (1,332 hp, 993 kW) each

Performance

- **Maximum speed:** 564 km/h (304 knots, 350 mph) at 5,400 m (17,800 ft)
- **Range:** 1,820 km (983 nmi, 1,130 mi)
- **Service ceiling:** 8,900 m (29,200 ft)
- **Climb to 4,000 m (13,100 ft):** 7.5 min

Armament

- **Guns:**
  - 2 × 20 mm MG 151/20 cannons
  - 2 × 7.92 mm (0.312 in) MG 17 machine guns
  - 2 × 13 mm (0.512 in) MG 131 machine guns (rear armament), each one in FDSL 131/1B remotely operated turret
- **Bombs:** 2 × 500 kg (1,100 lb) or 250 kg (550 lb) or 8× 50 kg (110 lb) internal

Chapter- 9

Avro Lancaster

Avro Lancaster

Royal Air Force Avro Lancaster B I *PA474* of the Battle of Britain Memorial Flight.

Role	Heavy bomber
Manufacturer	Avro
Designed by	Roy Chadwick
First flight	8 January 1941
Introduced	1942
Retired	1963 (Canada)
Primary users	Royal Air Force Royal Canadian Air Force
Number built	7,377
Unit cost	£45-50,000 when introduced ≈£1.3-1.5 million in 2005 currency
Developed from	Avro Manchester
Variants	Avro Lancastrian

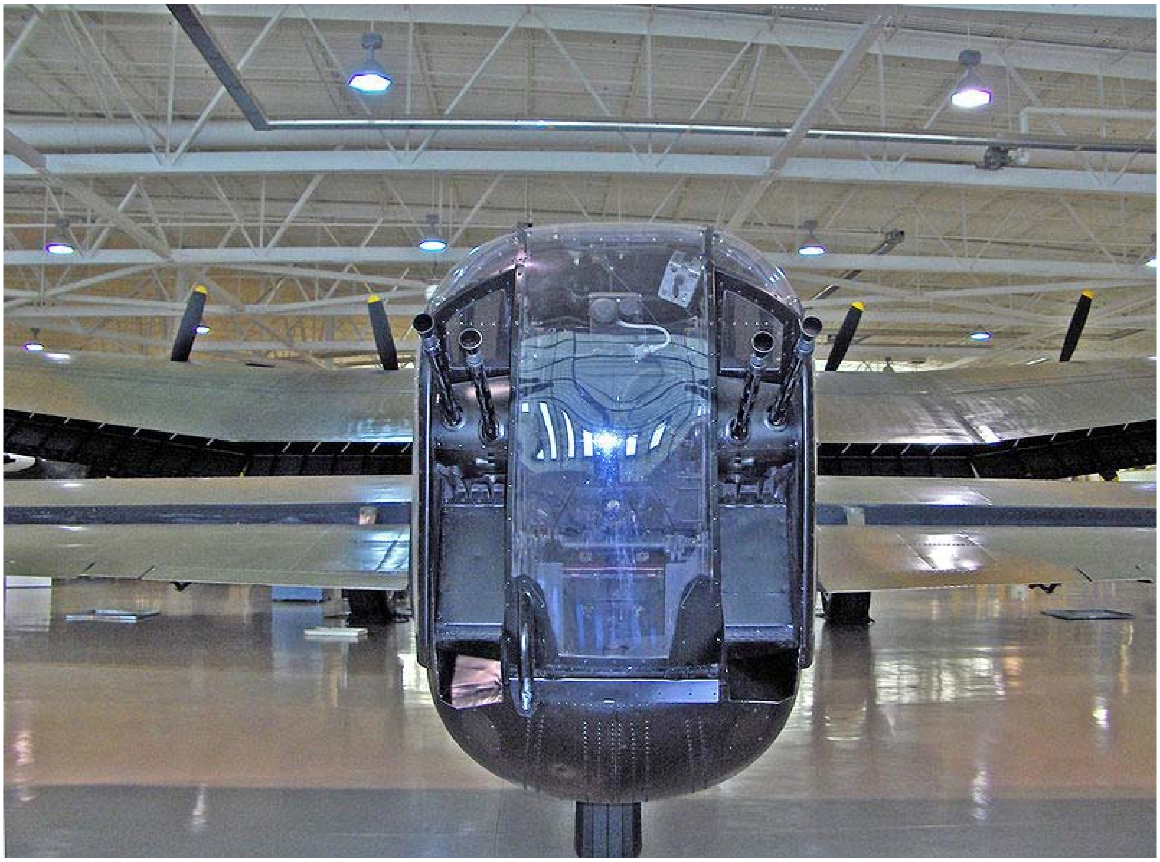
Developed into	Avro Lincoln Avro York

The **Avro Lancaster** is a British four-engined Second World War heavy bomber made initially by Avro for the Royal Air Force (RAF). It first saw active service in 1942, and together with the Handley Page Halifax it was one of the main heavy bombers of the RAF, the RCAF, and squadrons from other Commonwealth and European countries serving within RAF Bomber Command.

The "Lanc", as it was affectionately known, became the most famous and most successful of the Second World War night bombers, "delivering 608,612 tons of bombs in 156,000 sorties." Although the Lancaster was primarily a night bomber, it excelled in many other roles including daylight precision bombing, and gained worldwide renown as the "Dam Buster" used in the 1943 Operation Chastise raids on Germany's Ruhr Valley dams.

Design and development

Profile of the forward section of a Lancaster, showing the FN5 turret, bomb aimer's perspex blister and the Merlin engines



Tail-end Charlie's FN20 turret on a Canadian Lancaster

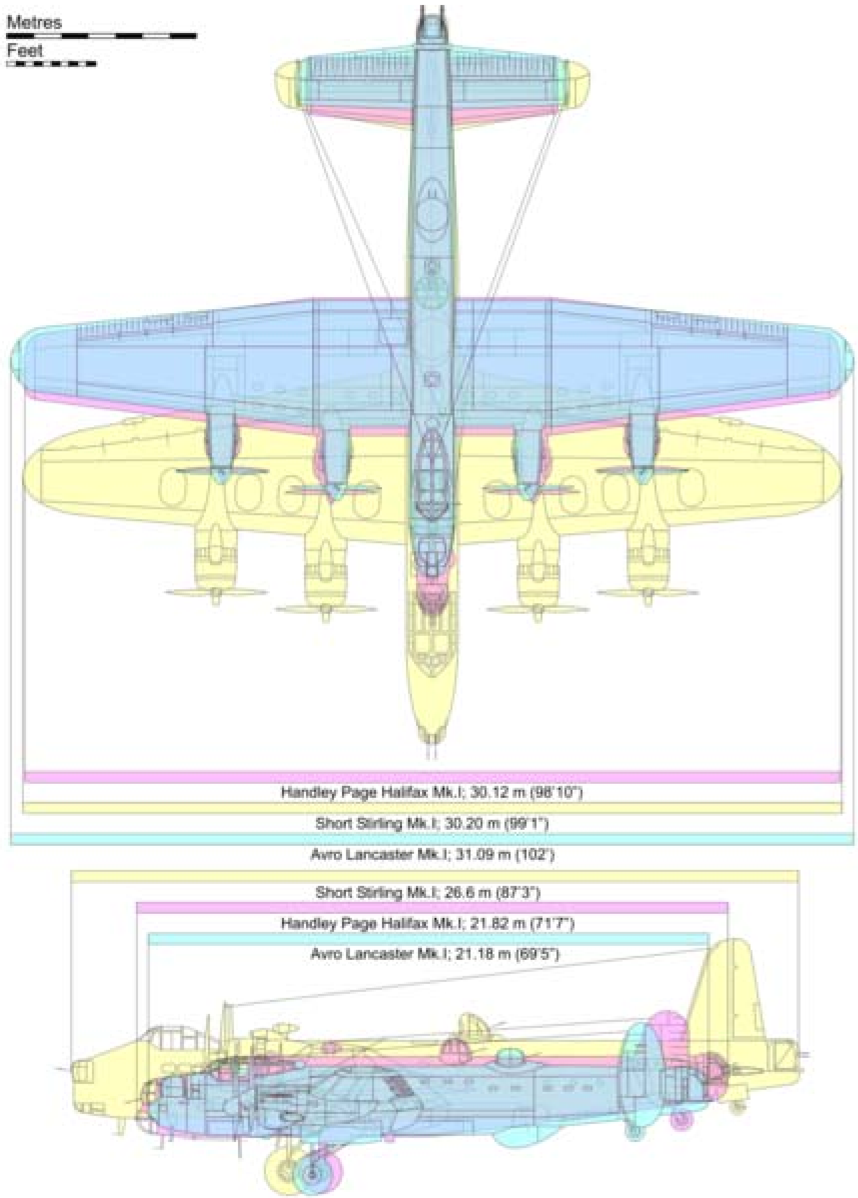


Diagram comparing the Lancaster with its contemporaries; the Short Stirling and the Handley Page Halifax

The origins of the Lancaster stem from a twin-engined bomber design submitted to meet Specification P.13/36, which was for a new generation of twin-engined medium bombers for "worldwide use", the engine specified as the Rolls-Royce Vulture. The resulting aircraft was the Manchester, which, although a capable aircraft, was troubled by the unreliability of the Vulture engine. Only 200 Manchesters were built and they were withdrawn from service in 1942.

Avro's chief designer, Roy Chadwick, was already working on an improved Manchester design using four of the more reliable but less powerful Rolls-Royce Merlin engines on a larger wing. The aircraft was initially designated Avro Type 683 Manchester III, and later re-named the Lancaster. The prototype aircraft *BT308* was assembled by Avro's experimental flight department at Manchester's Ringway Airport from where test pilot H.A. "Bill" Thorn took the controls for its first flight on Thursday, 9 January 1941. The aircraft proved to be a great improvement on its predecessor, being "one of the few warplanes in history to be 'right' from the start." Its initial three-finned tail layout, a result of the design being adapted from the Manchester I, was quickly changed on the second prototype *DG595* and subsequent production aircraft to the familiar twin-finned specification also used on the later Manchesters (below).

Some of the later orders for Manchesters were changed in favour of Lancasters; the designs were very similar and both featured the same distinctive greenhouse cockpit, turret nose, and twin tail. The Lancaster discarded the stubby central third tail fin of the early Manchesters and used the wider span tailplane and larger elliptical twin fins from the later Manchester IA.

The Lancaster is a mid-wing cantilever monoplane with an oval all-metal fuselage. The wing was constructed in five main sections, the fuselage in five sections. All wing and fuselage sections were built separately and fitted with all the required equipment before final assembly. The tail unit had twin oval fins and rudders. The Lancaster was initially powered by four wing-mounted Rolls-Royce Merlin piston engines with three-bladed airscrews. It had retractable main landing gear and fixed tail-wheel, with the hydraulically operated main landing gear raising rearwards into the inner engine nacelles.

The majority of Lancasters built during the war years were manufactured by Avro at their factory at Chadderton near Oldham, Lancashire, and test flown from Woodford Aerodrome in Cheshire. Other Lancasters were built by Metropolitan-Vickers (1080, also tested at Woodford), and Armstrong Whitworth. The aircraft was also produced at the Austin Motor Company works in Longbridge, Birmingham, later in the Second World War and postwar by Vickers-Armstrongs at Chester. Only 300 of the **Lancaster B II** fitted with Bristol Hercules engines were constructed; this was a stopgap modification caused by a shortage of Merlin engines as fighter production was of higher priority. Many BIIs were lost after running out of fuel. The **Lancaster B III** had Packard Merlin engines but was otherwise identical to contemporary B Is, with 3,030 B IIIs built, almost all at A.V. Roe's Newton Heath factory. The B I and B III were built concurrently, and minor modifications were made to both marks as new batches were ordered. Examples of these modifications were the relocation of the pitot head from the nose to the side of the cockpit, and the change from de Havilland "needle blade" propellers to Hamilton Standard or Nash Kelvinator made "paddle blade" propellers.

Of later variants, only the Canadian-built **Lancaster B X**, manufactured by Victory Aircraft in Malton, Ontario, was produced in significant numbers. A total of 430 of this type were built, earlier examples differing little from their British-built predecessors, except for using Packard-built Merlin engines and American-style instrumentation and electrics. Late-series models replaced the Frazer Nash mid-upper turret with a differently configured Martin turret, mounted slightly further forward for weight balance. A total of

7,377 Lancasters of all marks were built throughout the duration of the war, each at a 1943 cost of £45-50,000 (approximately equivalent to £1.3-1.5 million in 2005 currency).

Crew accommodation

Starting at the nose, the bomb aimer had two positions to man. His primary location was lying prone on the floor of the nose of the aircraft, with access to the controls for the bombsight head in front, with the bombsight computer on his left and bomb release selectors on the right. He would also use his view out of the large transparent perspex nose cupola to assist the navigator with map reading. To man the Frazer Nash FN5 nose turret, he simply had to stand up and he would be in position behind the triggers of his twin .303 in (7.7 mm) guns. The bomb aimer's position contained the nose parachute exit in the floor.

Battle of Britain Memorial Flight Lancaster PA474 at Kemble Battle of Britain Weekend 2009

Tail and dorsal gun turrets of the Battle of Britain Memorial Flight Lancaster (PA474)

Moving back, on the roof of the bomb bay the pilot and flight engineer sat side-by-side under the expansive canopy, with the pilot sitting on the left on a raised portion of the floor. The flight engineer sat on a collapsible seat (known as a "second dicky seat") to the pilot's right, with the fuel selectors and gauges on a panel behind him and to his right.

Behind these crew members, and behind a curtain fitted to allow him to use light to work, sat the navigator. His position faced to port with a large chart table in front of him. An instrument panel showing the airspeed, altitude, and other details required for navigation was mounted on the side of the fuselage above the chart table.

The radios for the wireless operator were mounted on the left-hand end of the chart table, facing towards the rear of the aircraft. Behind these radios, facing forwards, on a seat at the front of the main spar sat the wireless operator. To his left was a window, and above him was the astrodome, used for visual signalling and also by the navigator for celestial navigation.

Behind the wireless operator were the two spars for the wing, which created a major obstacle for crew members moving down the fuselage even on the ground. On reaching the end of the bomb bay the floor dropped down to the bottom of the fuselage, and the mid upper gunner's Frazer Nash FN50 or FN150 turret was reached. His position allowed a 360° view over the top of the aircraft, with two .303 in (7.7 mm) M1919 Browning machine guns to protect the aircraft from above and to the side. The mid-upper gunner had perhaps the most uncomfortable ride of all the crew, as he was seated on a rectangle of canvas that was slung beneath the turret once the gunner had occupied his position. He could be required to occupy this seat for up to eight hours at a time.

To the rear of the turret was the side crew door, on the starboard side of the fuselage. This was the main entrance to the aircraft, and also could be used as a parachute exit. At the extreme rear of the aircraft, over the spars for the tailplane, the rear gunner sat in his exposed position in the FN20, FN120 or Rose Rice turret, entered through a small hatch in the rear of the fuselage, and depending on the size of the rear gunner, the area was so cramped that the gunner would often hang his parachute on a hook inside the fuselage, near the turret doors. In the FN20 and FN120 turrets, he had four .303 in (7.7 mm) Brownings, and in the Rose Rice turret he had two .50 in (12.7 mm) Brownings. Neither the mid upper or rear gunner's positions were heated, and the gunners had to wear electrically heated suits to prevent hypothermia and frostbite. Many rear gunners insisted on having the centre section of perspex removed from the turret to give a completely unobstructed view.

Armament

Defensive

While eight .303 in (7.7 mm) machine guns were the most common Lancaster armament, twin .50 in (12.7 mm) turrets were later available in both the tail and dorsal positions. A Nash & Thomson FN-64 periscope-sighted twin .303 in machine gun ventral turret was fitted to early aircraft, but fitting was soon discontinued and the turret often removed as it was hard to sight, especially at night. (Similar problems afflicted the ventral turret in the North American B-25C and other bombers).

When the threat of attacks from below began to be appreciated in the winter of 1943/1944, modifications were made, including downward observation blisters mounted behind the bomb aimer's blister and official and unofficial mounts for .50 in (12.7 mm) machine guns or even 20 mm cannon, firing through ventral holes of various designs. The fitting of these guns was hampered as the same ventral position was used for mounting the H2S blister.

Bombs

An important feature of the Lancaster was its extensive bomb bay, at 33 ft (10.05 m) long. Initially, the heaviest bombs carried were 4,000 lb (1,820 kg) "Cookies". Bulged doors were added to 30% of B-MkIs to allow the aircraft to carry 8,000 lb (3,600 kg) and later 12,000 lb (5,450 kg) "Cookies". Towards the end of the war, attacking special and hardened targets, the B I Specials could carry the 21 ft (6.4 m) long 12,000 lb (5,450 kg) "Tallboy" or 25.5 ft (7.77 m) long 22,000 lb (9,980 kg) "Grand Slam" "earthquake" bombs: the Lancaster was able to deliver the heaviest bombs made. To carry the "Grand Slam" extensive modifications to the aircraft were required which led to them being named B I (Specials). The modifications included removal of the mid-upper turret, two guns from the rear turret, removal of all of the cockpit armour plating and installation of

Rolls-Royce Merlin Mk 24 Engines which had better take-off performance. The bomb-bay doors were removed and the rear end of the bomb bay cut away to clear the tail of the bomb. Later the nose turret was also removed to further improve performance.

Bombsights used on Lancasters included:

Mark IX Course-Setting Bombsight (CSBS).

This was an early preset vector bombsight that involved squinting through wires that had to be manually set based on aircraft speed, altitude and bombload. This sight lacked tactical flexibility as it had to be manually adjusted if any of the parameters changed and was soon changed in favour of the bombsights below.

Mark XIV bombsight

A vector bombsight where the bomb aimer input details of the bombload, target altitude and wind direction and the analogue computer then continuously calculated the trajectory of the bombs and projected an inverted sword shape onto a sighting glass on the sighting head. Assuming the sight was set correctly, when the target was in the cross hairs of the sword shape, the bomb aimer would be able to accurately release the bombs.

T1 bombsight

A Mark XIV bombsight modified for mass production and produced in the USA. Some of the pneumatic gyro drives on the Mk XIV sight were replaced with electronic gyros and other minor modifications were made.

Stabilizing Automatic Bomb Sight

Also known as "SABS", this was an advanced bombsight mainly used by 617 Squadron for precision raids. Like the American Norden bombsight it was a tachometric sight.

Radio, radar and countermeasures equipment

R1155 Receiver on top of T1154 Transmitter

The Lancaster had a very advanced communications system for its time. Most British-built Lancasters were fitted with the R1155 receiver and T1154 transmitter, whereas the Canadian built aircraft and those built for service in the Far East had American radios. These provided radio direction-finding, as well as voice and Morse capabilities.

H2S
: Ground-looking navigation radar system - eventually, it could be homed in on by the German night fighters' NAXOS receiver and had to be used with discretion.

Fishpond

An add-on to H2S that provided additional (aerial) coverage of the underside of the aircraft to display attacking fighters on an auxiliary screen in the radio operator's position.

Monica

A rearward-looking radar to warn of night fighter approaches. However, it could not distinguish between attacking enemy fighters and nearby friendly bombers and served as a homing beacon for suitably-equipped German night fighters. Once this was realised, it was removed altogether.

GEE

A receiver for a navigation system of synchronized pulses transmitted from the UK - aircraft calculated their position from the time delay between pulses. The range of GEE was 3-400 mi (483-644 km).

Boozer (radar detector)

A system of lights mounted on the aircraft's instrument panel that lit up when the aircraft was being tracked by Würzburg ground radar and Lichtenstein airborne radar. In practice it was found to be more disconcerting than useful, as the lights were often triggered by false alerts in the radar-signal-infested skies over Germany.

Oboe

A very accurate navigation system consisting of a receiver/transponder for two radar stations transmitting from widely separated locations in Southern England which together determined the range and the bearing on the range. The system could only handle one aircraft at a time, and was fitted to a Pathfinder aircraft, usually a fast and manoeuvrable Mosquito rather than a heavy Lancaster, which marked the target for the main force.

GEE-H

Similar to Oboe but with the transponder on the ground allowing more aircraft to use the system simultaneously. GEE-H aircraft were usually marked with two horizontal yellow stripes on the fins.

Village Inn

A radar-aimed gun turret fitted to some Lancasters in 1944.

Airborne Cigar (ABC) This was only fitted to the Lancasters of 101 Squadron. It was three aerials, two sticking out of the top of the fuselage and one under the bomb aimer's position. These aircraft carried a German speaking crew member on board and were used to jam radio to German night fighters and feed false information on allied bomber positions to them. Due to the nature of the equipment, the enemy was able to track the aircraft and due to this, 101 suffered the highest casualty rate of any squadron. Fitted from about mid-1943, they remained until the end of the war.

Operational history

Second World War

Avro Lancaster B I

Avro Lancaster over Hamburg

Avro Lancasters of No. 50 Squadron (No. 5 Group), based at Skellingthorpe, Lincolnshire, UK

The first RAF squadron to convert to the Lancaster was No. 44 Squadron RAF in early 1942.

Lancasters flew 156,000 sorties and dropped 608,612 long tons (618,378 tonnes) of bombs between 1942 and 1945. Just 35 Lancasters completed more than 100 successful operations each, and 3,249 were lost in action. The most successful survivor completed 139 operations, and was scrapped in 1947.

Lancs took part in the devastating round-the-clock raids on Hamburg during Air Marshall Harris' "Operation Gomorrah" in July 1943. A famous Lancaster bombing raid was the 1943 mission, codenamed Operation Chastise, to destroy the dams of the Ruhr Valley. The operation was carried out by 617 Squadron in modified Mk IIIs carrying special drum shaped bouncing bombs designed by Barnes Wallis. The story of the operation was later made into a film, *The Dam Busters.* Also famous was a series of Lancaster attacks using Tallboy bombs against the German battleship *Tirpitz*, which first disabled and later sank the ship.

Lancasters from Bomber Command were to have formed the main strength of Tiger Force, the Commonwealth bomber contingent scheduled to take part in Operation Downfall, the codename for the planned invasion of Japan in late 1945, from bases on Okinawa; the invasion was made unnecessary by the Japanese surrender.

RAF Lancasters dropped food into the Holland region of the occupied Netherlands, with the acquiescence of the occupying German forces, to feed people who were in danger of starvation. The mission was named 'Operation Manna' after the food Manna which is said to have miraculously appeared for the Israelites in the Book of Exodus. The aircraft involved were from 1, 3, and 8 Groups, and consisted of 145 Mosquitoes and 3,156 Lancasters, flying between them a total of 3,298 sorties. The first of the two RAF Lancasters chosen for the test flight was nicknamed "Bad Penny" from the old expression: "a bad penny always turns up." This bomber, with a crew of seven men (five Canadians including pilot Robert Upcott of Windsor, Ontario), took off in bad weather on the morning of 29 April 1945 without a ceasefire agreement from the German forces, and successfully dropped her cargo.

A development of the Lancaster was the Avro Lincoln bomber, initially known as the Lancaster IV and Lancaster V. These two marks became the Lincoln B1 and B2 respectively. A civilian airliner was based on the Lancaster, the Lancastrian. Other developments were the York, a square-bodied transport and, via the Lincoln, the Shackleton which continued in airborne early warning service up to 1992.

Postwar

In June 1947, the Argentine Air Force received 15 Lancasters. During its Argentinian service, Lancasters saw limited use in military coups, owing to the small number there.

A total of 59 Lancaster B.Is and B.VIIs were overhauled by Avro at Woodford and Langar and delivered to the *Aeronavale* (France) during 1952/53. These were flown until the mid-1960s by four squadrons in France and New Caledonia in the maritime reconnaissance and search-and-rescue roles.

Civil conversions continued postwar. In 1946, four Lancasters were converted by Avro at Bracebridge Heath, Lincolnshire as freighters for use by British South American Airways, but proved to be uneconomical, and were withdrawn after a year in service. In addition, four Lancaster IIIs were converted by Flight Refuelling Limited as two pairs of tanker and receiver aircraft for development of in-flight refuelling. In 1947, one aircraft was flown non-stop 3,459 mi (5,567 km) from London to Bermuda. Later the two tanker aircraft were joined by another converted Lancaster and were used in the Berlin Airlift, achieving 757 tanker sorties.

Variants


Lancaster B I *NG128* dropping its load over Duisburg on 14 October 1944. First 4lb Incendiaries then a 4000lb "cookie" and 30lb Incendiaries

Avro Lancaster B II

B I

The original Lancasters were produced with Rolls-Royce Merlin XX engines and SU carburettors. Minor details were changed throughout the production series - for example the pitot head design was changed from being on a long mast at the front of the nose to a short fairing mounted on the side of the fuselage under the cockpit. Later production Lancasters had Merlin 22 and 24 engines. No designation change was made to denote these alterations.

B I Special

32 Aircraft were adapted to take first the super-heavy "Tallboy" and then "Grand Slam" bombs. Upgraded engines with paddle-bladed propellers gave more power, and the removal of gun turrets reduced weight and gave smoother lines. For the Tallboy, the bomb-bay doors were bulged; for the Grand Slam, they were removed completely and the area faired over. For some Tallboy raids, the mid upper turret was removed. This modification was retained for the Grand Slam aircraft, and in addition the nose turret was later removed. Two airframes (*HK541* and *SW244*) were modified to carry a dorsal "saddle tank" with 1,200 gal (5,455 L) mounted aft of a modified canopy for increasing range. No. 1577 SD Flight tested the aircraft in India and Australia in 1945 for possible use in the Pacific, but the tank adversely affected handling characteristics when full and an early type of flight refuelling designed in the late 1930s for commercial flying boats was later used instead.

PR 1

B 1 modified for photographic reconnaissance, operated by RAF No. 82 and No. 541 Squadrons, wartime. All armament and turrets were removed with a reconfigured nose and a camera carried in the bomb bay. The type was also operated by 683 Squadron from circa 1950 for photographic reconnaissance based at Aden and subsequently Habbaniya in Iraq until disbanded 30 November 1953.

B I (FE)

In anticipation of the needs of the Tiger Force operations against the Japanese in the Far East (FE), a tropicalized variant was based on late production aircraft. The B I (FE) had modified radio, radar, navaids, and a 400 gal (1,818 L) tank installed in the bomb bay. The mid-upper turret was also removed.

B II

Bristol Hercules (Hercules VI or XVI engines) powered variant, of which 300 were produced by Armstrong Whitworth. One difference between the two engine versions was that the VI had manual mixture control, requiring an extra lever on the throttle pedestal. These aircraft were often (but not always) fitted with an FN.64 ventral turret and pronounced step in the bulged bomb bay.

B III

These aircraft were fitted with Packard-built Merlin engines and produced at the same time as the B I, the two marks being indistinguishable externally. The minor differences between the two variants were related to the engine installation, and included the addition of slow-running cut-off switches in the cockpit, a requirement due to the Bendix Stromberg pressure-injection carburettors fitted to the Packard Merlin engines.

B III (Special)

Known at the time of modification as the "Type 464 Provisioning" Lancaster, this variant built 23 Aircraft to carry the "Upkeep" bouncing bomb for the dam busting raids. The bomb-bay doors were removed and Vickers-built struts to carry the bomb were fitted in their place at Woodford Aerodrome near Stockport where the workers worked day and night. A hydraulic motor, driven by the pump previously used for the mid upper turret was fitted to spin the bomb. Lamps were fitted in the bomb bay and nose for the simple height measurement system which enabled the accurate control of low-flying altitude at night. The mid-upper turret was removed to save weight, and the gunner moved to the front turret to relieve the bomb aimer from having to man the front guns so that he could assist with map reading.

ASR III/ASR 3

B III modified for air-sea rescue, with three dipole ventral antennas fitted aft of the radome and carrying an airborne lifeboat in the re-configured bomb bay. The armament was often removed and the mid-upper turret faired-over, especially in postwar use. Observation windows were added to both sides of the rear fuselage, a port window just forward of the tailplane, and a starboard window into the rear access door. A number of ASR 3 conversions were fitted with Lincoln-style rudders.

GR 3/MR 3

B III modified for maritime reconnaissance.

B IV

The B IV featured an increased wingspan and lengthened fuselage and new Boulton Paul F turret (two X 0.5in) with re-configured framed "bay window" nose glazing. The prototypes (*PW925*, *PW929* and *PW932*) were powered by two-stage Merlin 85s inboard and later, Merlin 68s on the outboard mounts. Because of the major re-design, the aircraft was quickly renamed Lincoln B 1.

B V

Increased wingspan and lengthened fuselage, two-stage Merlin 85s. Renamed Lincoln B 2

B VI

Nine aircraft converted from B IIIs. Fitted with Merlin 85/87 which had two-stage superchargers, giving much improved high altitude performance. The Merlin 85/87 series engines were fitted with annular cowlings similar to the post war Avro Lincoln and four bladed paddle-type propellers were fitted. These aircraft were only used by Pathfinder units; by No. 7 Squadron RAF, No. 83 Squadron RAF, No. 405 Squadron RCAF and by No. 635 Squadron RAF. Often used as a "Master Bomber" the B VI's allocated to RAF Bomber Command (2 being retained by Rolls Royce for installation and flight testing) had their dorsal and nose turrets removed and faired-over. The more powerful engines proved troublesome in service and were disliked by ground maintenance staff for their rough running and propensity to 'surge and hunt', making synchronisation impossible. This 'hunting' is caused by variations in the fuel/air mixture and could over time eventually damage the engine. The B VI was withdrawn from service in November 1944 and the surviving aircraft were used by Rolls Royce, the Royal

Aircraft Establishment, and the Bomb Ballistics Unit (BBU) for various testing and experimental duties.

B VII

The B VII was the final production version of the Lancaster. The Martin 250CE mid-upper turret was re-positioned slightly further forward than on previous Marks, and the Nash & Thomson FN-82 tail turret with twin 0.50 in (12.7 mm) Browning machine guns replaced the FN.20 turret with four 0.303 in (7.7 mm) Browning machine guns.

B X

The B X was a Canadian-built B III with Canadian- and US-made instrumentation and electrics. On later batches the heavier Martin 250CE was substituted for the Nash & Thomson FN-50 mid-upper turret, mounted further forward to maintain centre of gravity balance. Canada was a long term operator of the Lancaster, utilising modified aircraft in postwar maritime patrol, search and rescue, and photo-reconnaissance roles until 1964. The last flight by the RCAF was flown by F/L Lynn Garrison in KB-976, on 4 July 1964 at the Calgary International Air Show.

Operators

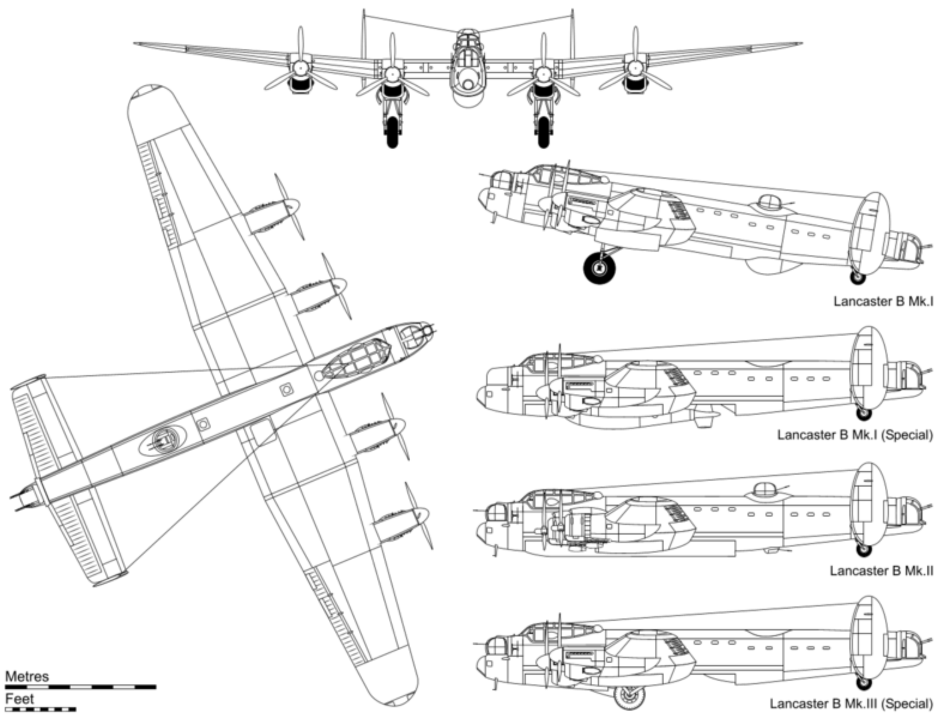
Battle of Britain Memorial Flight Lancaster at RIAT 2005

- Argentina
- Australia
- Canada
- Egypt
- France
- Poland
- Soviet Union
- Sweden
- United Kingdom

Surviving aircraft

There are 17 known largely complete Avro Lancasters remaining in the world with two airworthy. One of them is based in the UK, operated by The Battle of Britain Memorial Flight and the other is in Canada, operated by the Canadian Warplane Heritage Museum.

Specifications (Lancaster)



Orthographic projection of the Lancaster B Mk.I, with profiles detailing the B Mk.I (Special) with *Grand Slam* bomb, Hercules-powered B Mk.II with bulged bomb-bay doors and FN.64 ventral turret and the B Mk.III (Special) with the *Upkeep* store

General characteristics

- **Crew:** 7: pilot, flight engineer, navigator, bomb aimer, wireless operator, mid-upper and rear gunners

- **Length:** 69 ft 5 in (21.18 m)
- **Wingspan:** 102 ft (31.09 m)
- **Height:** 19 ft 7 in (5.97 m)
- **Wing area:** 1,300 ft² (120 m²)
- **Empty weight:** 36,828 lb (16,705 kg)
- **Loaded weight:** 63,000 lb (29,000 kg)
- **Powerplant:** 4× Rolls-Royce Merlin XX V12 engines, 1,280 hp (954 kW) each

Performance

- **Maximum speed:** 240 kn (280 mph, 450 km/h) at 15,000 ft (5,600 m)
- **Range:** 2,700 nmi (3,000 mi, 4,600 km) with minimal bomb load
- **Service ceiling:** 23,500 ft (8,160 m)
- **Wing loading:** 48 lb/ft² (240 kg/m²)
- **Power/mass:** 0.082 hp/lb (130 W/kg)

Armament

- **Guns:** 8× 0.303 in (7.7 mm) Browning machine guns in three turrets, with variations
- **Bombs:** Maximum normal bomb load of 14,000 lb (6,300kg) or 22,000 lb Grand Slam with modifications to bomb bay.

Noted Lancaster pilots and crew members

Victoria Cross awards

Many Lancaster crew members were highly decorated for actions while flying the aircraft. Amongst those who received the Victoria Cross were:

- Squadron Leader Ian Willoughby Bazalgette
- Wing Commander Guy Gibson
- Warrant Officer Norman Cyril Jackson
- Pilot Officer Andrew Mynarski
- Squadron Leader John Dering Nettleton
- Squadron Leader Robert Anthony Maurice Palmer
- Flight Lieutenant William Reid
- Flight Sergeant George Thompson
- Group Captain Leonard Cheshire - most unusually he did not receive the VC for any particular act, instead it was awarded for sustained courage on over 100 bombing missions. (N.B some flown in other aircraft including the Mosquito and Mustang).
- Captain (acting Major) Edwin Swales