Fighter Planes

1960-2002

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Monday September 16 2002

Contents

Chapter 1

1960-1970

1.1 Great Britain

1.1.1 BAC Lightning F.6

Figure 1.1: BAC Lightning F.6

The layout of the Lightning was unusual: two engines above each other, a sharp-edged nose intake, and 60 degrees wing sweep. The Mach 2+ Lightning was the first supersonic British fighter. It was a good dogfighter, with a speed, acceleration and climb that were difficult to match. Armament and fuel capacity were limited, however, and the Lightning found few export orders. Retired in 1988.

Function	fighter
Year	1960
Crew	1
Engines	2 * 72.6 kN R.R Avon 302-C
Wing Span	10.62 m
Length	16.84 m
Height	5.97 m
Wing Area	42.59 m^2
Empty Weight	12719 kg
Max.Weight	18900 kg
Speed	2271 km/h
Ceiling	18300 m
Range	2500 km
Armament	3630 kg

The English Electric Lightning was the first operational British aircraft capable of achieving twice the speed of sound. It was an unusual design with two turbojets mounted one above the other in the fuselage and the cockpit placed on top of the nose intake. Although it was designed primarily as a Mach 2 interceptor to meet incoming Soviet bombers at heights up to 60,000ft, it was later developed for ground attack. The Royal Air Force used this variation in Germany and ground-attack versions were sold to Kuwait and Saudi Arabia.

Manufacturer	English Electric/British Aerospace Corp.
Designation	Lightning
Type	Fighter
Service Dates	1960 to present
Length	55'-3"
Wingspan	34'-10"
Height	19'-7"
Empty Weight	25,000 lbs
Gross Weight	42,000 lbs
Maximum Speed	1,500 mph at 40,000 feet
Maximum Range	800 miles
Maximum Altitude	70,000 ft
Number of Crew	1 (2 in trainer)
Engine Type	Jet
Engine Manufacturer	Rolls-Royce
Engine Designation	Avon x 2
Engine Thrust	16,360 lbs

1.1.2 Vulcan B Mk.2

Figure 1.2: Avro Vulcan

Large, delta-wing jet bomber. Its service life was reduced when its role was changed from high-altitude to low-altitude bombing, but it can be considered the most successful of the V-bombers. According to the fans, it was also the most beautiful one. Its saw operational use in the Falklands war, when Vulcan bombers attacked the local airfield at Port Stanly after a long flight during which they were refuelled several times by Victor tankers. There was also a reconnaissance version.

Type	Vulcan B Mk.2
Function	bomber
Year	1960
Crew	5
Engines	4 * 9980 kg Bristol Siddeley Olympus 301
Wing Span	33.83 m
Length	32.15 m
Max.Weight	113400 kg
Speed	1030 km/h
Ceiling	19800 m
Range	7650 km
Armament	21454 kg

Built by A.V.Roe of Manchester, England, between 1956 - 1964, and only in service with the RAF, Vulcan bombers came in two main variants, the B1 and B2, with the B2(K) tanker conversions only being added during the Falklands War. The Vulcan was known by many as the "Tin Triangle" due to its massive and imposing delta wing shape, the B2 having a wing span of 111 feet (33.83m) compared to it's total length of only 105.6 feet (32.16m). Even on the ground it is imposing, standing well over 6 feet (1.8m) high up on the undercarriage, making it possible to walk upright underneath the whole airframe.

They were manned by a crew of 5, Captain, co-pilot, nav plotter, nav radar, and air electronics officer (AEO), and were powered by 4 Olympus engines each with a thrust of 20,000lb giving a maximum speed of approx. 645 mph (mach 0.95). The maximum armament was up to 21,000 lbs (9,526 kg) of conventional or nuclear bombs. The conventional bombs were carried in the bomb bay, or a single Blue Steel nuclear missile would be carried externally under a modified bomb bay, or 2 Skybolt missiles could be mounted on wing mounted pylons. Their service ceiling was 55,000 feet (16,765 m) allowing a maximum range of 2,300 miles (3,700 km) although this was greatly extended with the later fitting of in-flight refueling probes. One unusual feature for such a large aircraft were the joystick style control columns used instead of the more traditional ”spectacle” type found in most other bombers, together with the lack of switches and controls on the cockpit ceiling these gave the Vulcan a much more fighter style feel.

Vulcan's were part of Britain's three pronged nuclear deterrent V-force of the 50's and 60's, the other aircraft being the Vickers Valiant and Handley Page Victor. During the early 60's Vulcan's had the added capability of being able to start all four of their engines at once, and could be airborne within 4 minutes in the event of a nuclear attack.The planes main function then were as a high level nuclear bomber, although in it's later life, due to the strength of its airframe, the Vulcan was the only one of the three that could also be used for low level bombing and maritime reconnaissance.

Several of the airframes in their later lives were used as the test bed for the engines of the Tornado, Concorde and the ill fated BAC TSR2. The Vulcan was finally phased out during 1984 and replaced by the all weather Panavia Tornado fighter-bomber.

At present there are no Vulcan's left flying, most are now in museums or on airfields, the full list is below. The last Vulcan to fly was XH558, as the RAF's display aircraft at airshows, a sight and, especially sound, unmatched by any other single aircraft, with it's ability to be thrown about like a fighter. XH558 was also the first B2 variant to be delivered to the RAF, her maiden flight being on 21 May 1960 and delivery was on 1 July 1960, going to No.230 OCU based at RAF Waddington in Lincolnshire. She last flew as the RAF's display aircraft on 20 Sept 1992 in an airshow at RAF Cranfield, starting her display behind the Red Arrows display team in a V shape formation. Her farewell flight was on 23 March 1993 and she was sold on by the RAF to C.Walton and now resides at Bruntingthorpe airfield in Leicestershire, England. Only 3 airframes are still in working condition - XH558 , XL426 , and XM655. All are regularly ground run with their engines taken up to 100% thrust and are taxied around the airfield.

1.1.3 Buccaneer

Figure 1.3: Buccaneer

Low-altitude attack aircraft of extremely strong construction, originally designed for the RN but later, after all carriers were retired, used by the RAF. The Buccaneer is a mid-wing aircraft; its appearance is determined by an area-ruled fuselage, circular engine bays flanking the fuselage, a bulged rotating bomb bay door, and a T-tail. It is intended to keep them in service into the mid-90's. The longevity of the type due to its high subsonic speed at low altitude, as well as the cancellation of the TSR.2. The Buccaneer was also used, until 1991, by South Africa.

Type	Buccaneer S.2B
Function	attack
Year	1965
Engines	2 * 5105 kg R.R. RB.168 Spey Mk.101
Wing Span	13.41 m
Length	19.33 m
Height	4.97 m
Wing Area	47.82 m^2
Empty Weight	13608 kg
Max.Weight	28123 kg
Speed	Mach 0.92
Ceiling	12190 m
Range	6440 km
Armament	7260 kg

1.1.4 Hawker Harrier GR3

Figure 1.4: Hawker Harrier GR3

For a long time this was the only operational western VTOL aircraft. It is a small ground-attack aircraft. VTOL operation is achieved by the four swivelling nozzles of the R.R. Pegasus engine. The basic concepts dates back to 1960, but production still continues. The type was adopted by the USMC as the AV-8. Later versions have enlarged wings, wing root extensions, and longer noses for additional electronics.

Type	Harrier GR.3
Function	attack
Crew	1
Engines	1 * 8752 kg R.R. Pegasus Mk.103
Wing Span	7.70 m
Length	13.87 m
Height	3.45 m
Wing Area	18.68 m^2
Empty Weight	5579 kg
Max.Weight	11340 kg
Speed	1186 km/h
Ceiling	15240 m
Range	5560km
Armament	2268 kg

Harrier - The World's most flexible combat aircraft

The operational characteristics of Harrier are unique - it can operate out of restricted spaces and can deliver with pin-point accuracy a wide range of stores by day or night. Harrier roles include close air support, reconnaissance, fleet air defence and maritime attack and the aircraft has brought a completely new flexibility to offensive air operations on land and at sea.

Harrier II

Harrier II is an extensively modified and updated version of the Harrier GR3/AV-8A Vertical/Short Take-Off and Landing (V/STOL) close air support aircraft, allowing even greater tactical deployment. The ground attack and close air support aircraft has been jointly developed with Boeing and is in service with the Royal Air Force (GR7 and T10), US Marine Corps (AV-8B and TAV-8B) and Spanish Navy (EAV-8B). Like its predecessor, the Harrier II can operate from conventional bases, dispersed sites and a wide range of surface vessels but is able to carry double the payload - or operate over twice the range - of earlier versions. Both the RAF and USMC operate night attack variants of the Harrier II.

Harrier II Plus

Harrier II Plus is the latest variant of the Harrier, developed as a radar equipped multi-role fighter/ground attack aircraft capable of all weather, day and night operations. The aircraft features the Hughes APG-65 radar and a highly integrated state-of-the-art cockpit permits the accurate delivery of a wide range of modern weapons including AMRAAM (Advanced Medium Range Air-to-Air Missile), precision guided munitions and anti-ship missiles.

Sea Harrier FA2

Sea Harrier FA2 is a modified and updated version of the Royal Navy's Sea Harrier FRS1 fighter, reconnaissance and strike aircraft, equipped with the Blue Vixen multi-mode, pulse doppler radar and AMRAAM. This combination of long range detection and simultaneous engagement of multiple targets at Beyond Visual Range is a potent enhancement to maritime all-weather defences.

Description

Single-engine, "jump-jet" fighter-bomber designed to fly from combat areas and aircraft carriers and to support ground forces. It was made by Hawker Siddeley Aviation and first flew on Aug. 31, 1966, after a long period of development. (Hawker Siddeley became part of British Aerospace in 1977, and the latter firm, in partnership with McDonnell Douglas in the United States, continued to manufacture the Harrier.) The several versions of the Harrier could take off straight up or with a short roll (Vertical and Short Take-off and Landing, or V/STOL), and thus the Harrier did not need conventional runways. Powered by a vectored-thrust turbofan engine, the plane diverted its engine thrust downward for vertical takeoff using rotatable engine exhaust ports. It could carry a combination of armaments, including air-to-air missiles, air-to-surface antiship missiles, rockets, and bombs. Ground-attack versions of the Harrier could carry two 30-millimetre cannons as well as rockets and bombs. The Sea Harrier saw combat in the British campaign during the Falkland Islands War of 1982. A larger and heavier version built for the U.S. Marines was used for both air defense and support of ground forces.

1.2 USA

1.2.1 A-5 Vigilante

Figure 1.5: A-5 Vigilante

The A-5 was a very advanced supersonic attack aircraft, optimized for low-level attacks at high speed. It was long and angular, with rectangular air intakes, small, thin swept wings incorporating large full-span flaps, and all-moving tail surfaces. But the A-5, one of the biggest aircraft ever operated from a carrier, was not successful in its intended role as nuclear bomber, It has been claimed that the bomb ejection mechanism was unsatisfactory. The bomb bay was between the engines, and the plan was to expell the bomb rearwards, together with two empty fuel tanks. 63 bombers were built, but all but ten were converted to RA-5C reconnaissance aircraft. There were also 55 new RA-5Cs built. These were very effective and served until 1980.

Type	RA-5C
Function	reconnaissance
Year	1964
Crew	2
Engines	2 * 79.4 kN G.E. J79-GE-10
Wing Span	16.15 m
Length	23.32 m
Height	5.91 m
Wing Area	70.05 m^2
Empty Weight	17009 kg
Max.Weight	29937 kg
Speed	Mach 2.1
Ceiling	14750 m
Range	4820 km
Armament	1 nuclear weapon, and conventional weapons on two hard points.

History

Designed to meet a US Navy requirement for a high-performance all-weather attack aircraft, the North American NA-247, known at first as the NAG-PAW (North American General Purpose Attack Weapon), won an order for two YA3J-1 prototyes on 29 June 1956. The name Vigilante was allocated soon after this, and teh A3J designation was changed subsequently to A-5. The design's cantilever monoplane swept wing incorporated no ailerons, roll control being by the use of spoilers in conjunction with differential use of an all moving tailplane on each side of the fuselage and, when it entered service, the Vigilante was the first US production aircraft to introduce variable geometry intakes for its two General Electric J79 engines. The first of the prototypes, then powered by two YJ79-GE-2 engines each developing 6804-kg (15,000lbs) afterburning thrust, was fown for the first time on 31 August 1958, and carrier trials were completed abourd the USS Saratoga in July 1960. Initial productino version A-5A, US Navy Squadron VAH-7 becoming the first operational unit in June 1961. The primary weapon of the A-5A was a free-fall nuclear bomb ejected rearwards from a bomb bay between the tailpipes of he two turbojet engines. A-5A prduction totalled 57 aircraft. This version was followed by an interim long-range bomber version designated A-5B, incorporating greater fuel capacity and aerodynamic improvements, but, because of changes in the US Navy policy only six were built and then converted to serve as a long-ranged unarmed reconaissance verson designated RA-5C, equipped with side-looking airborne radar, cameras and electronic counter-measures equipment. The first RA-5C flew on 30 June 1962, being followed by 55 new production aircraft and the conversion to reconnaissance configuration of the 53 A-5As. The first squadron equipped with the RA-5C was RVAH-5 which, in June 1964, was operating fromt he USS Ranger, and other Vigilante squadrons included RVAH-1, RVAH-7, RVAH-9, and RVAH-11.

Specifications

RA-5C Vigilante:
Type: carrier-based long-range reconnaissance aircraft
Powerplant: 2 8101-kg(17,860lb) afterburning thrust General Electric J79-GE-10 turboets

Performance:
max speed-Mach 2.1
operational ceiling-14,750 m (48,400 ft)
range-4828 km (3,000 miles)

Weights:
empty-17009 kg (37498 lbs)
max take-off weight-29937 kg (66,000 lbs)

Dimensions:
span-16.15m (53ft)
length-23.32m (76.5ft)
height-5.91m (19 feet 4.75 inches)
wing area-70.05m^2 (754 sq ft)

1.2.2 XB-70 Valkyrie

Figure 1.6: XB-70 Valkyrie

The B-70 was a high-flying Mach 3 bomber, intended to replace the B-52. It was a canarded delta wing aircraft, designed to 'ride' on the shock wave contained between the lower fuselage and its movable, downturned wingtips. Because of kinetic heating at high speed, the B-70 was built from titanium and steel honeycomb parts. The advent of surface-to-aircraft missiles made the high-flying bomber obsolete. Two were built, as two-seat research aircraft.

Type	XB-70
Year	1964
Crew	4 (pilot, copilot, bombardier, and defensive systems operator)
Engines	6 * 13075 kg G.E. YJ93-GE-3
Wing Span	32.00 m
Length	59.75 m
Height	9.22 m
Wing Area	585.43 m2
Empty Weight	92990 kg
Max.Weight	249470 kg
Speed	3200 km/h
Ceiling	22860 m
Range	9650 km
Unit (prototype) cost	$700 millions

Armament:
No defensive weapons except ECM. Internal bay for up to 14 nuclear or thermonuclear bombs, or an assortment of conventional bombs. Externally carried stand-off missiles were also considered. With research and development studies beginning in 1955, the XB-70 was a large, long-range strategic bomber was planned to be the replacement for the B-52. As in the B-58 program, the Air Force wanted new technology advances. To this end, the Air Force gave the prime contractor total weapon system responsibility. Competition between Boeing and North American for the

contract occurred during the design phase. In 1958, the North American design was chosen and a development contract awarded. The Air Force requirement was for a Mach 3, high-altitude, long-range bomber capable of carrying nuclear and conventional weapons. Although there was a technology breakthrough in 1957 that made Mach 3 possible, the XB-70 never went into production. The continuing emergence of new SAMs was the key factor in the demise of the XB-70, just as it affected the B-47 and B-58.

The XB-70 had a length of 196 feet, a height at the tail of 31 feet, and an estimated maximum gross weight of 521,000 pounds. It had a crew of four: pilot, copilot, bombardier, and defensive systems operator. The delta wing had a span of 105 feet with six turbojet engines side by side in a large pod underneath the fuselage. The wing was swept at about 65 1/2o, and the wing tips were folded down hydraulically 25o to 65o to improve stability at the aircraft's supersonic speeds of up to Mach 3. At this speed the Valkyrie was designed to ride its own shock wave. A large canard foreplane near the front of the fuselage with a span of 28 feet, 10 inches was used for stability. In addition to its sharply swept delta wings, the XB-70s had two large vertical tails. The aircraft was fabricated using titanium and brazed stainless steel "honeycomb" materials to withstand the heating during the sustained high Mach number portions of the flights. The propulsion system consisted of six General Electric turbojet engines (J93-GE 3) with two large rectangular inlet ducts providing two-dimensional airflow.

The entire mission (including return) was to be flown at Mach 3, but even then the aircraft was vulnerable to SAMs of the 1960's vintage. A high altitude, Mach 3 penetrator cannot maneuver well; its straight and level trajectory would have been an easy course to plot and intercept. Further, the technology that made Mach 3 possible yielded an airframe with a large RCS that added to the effectiveness of SAMs against the XB-70. The airframe was not adaptable to low level penetration to avoid SAMs because the delta wings were very thin and did not lend themselves to the structural modifications necessary for sustained, low level flight.

The XB-70 design had payload flexibility but not mission flexibility. In 1959, the XB-70 concept was changed to a recon/strike RS-70, making it a reconnaissance aircraft with a bomber strike capability. However, its reconnaissance capability would not have been as good as the super high altitude aircraft designed to fill the reconnaissance role. The XB-70 was an aircraft which fulfilled the criteria it was designed to meet, but whose mission had been eliminated by defensive threat technology. The high drag of the Mach 3 airframe required a fuel load comparable to the B-52 but limited the range to about 5,000 nm. It was capable of carrying both conventional and nuclear weapons internally, but due to its design and Mach 3 mission profile, it could not carry external ordnance.

In 1961, President Kennedy announced that the XB-70 program was to be reduced to research only, citing high cost (over $700 million per prototype) and vulnerability. The Kennedy administration felt ICBMs were more cost effective because they were less vulnerable and were cheaper operationally. Although two XB-70 prototypes were built, with the first flight in 1964, the program terminated in 1969. The XB-70 had speed, range, and adequate payload, but it was expensive, not suited to low level penetration, and thus did not compete with ICBMs for strategic funds.

During the early 1960s, the NASA Flight Research Center was involved in support of the national Supersonic Transport Program (SST). Two prototype Mach 3+ high altitude bombers, built by North American Aviation for the Air Force, became available for SST research with the cancellation of their intended military program. Aircraft No. 2 (serial # 62-0207) with its improved wing design, was capable of sustained Mach 3 flight at altitudes around 70,000 ft. This highly instrumented vehicle was destroyed in a mid-air collision with NASA F-104N (N813NA) on 8 June 1966. An attempt to substitute the slower No. 1 aircraft (serial # 62-0001) into the research program met with limited success. Ship #1 was flown by the NASA Flight Research Center (now NASA Dryden), Edwards AFB, Calif. from March 1967 through early 1969. The XB-70A program produced a significant quantity of information about supersonic flight up to Mach 3 speeds. In many areas, such as noise (including sonic boom runs), clear air turbulence, flight controls, aerodynamics and propulsion system performance and operation problems, it related to SSTs.

1.2.3 SR-71 Blackbird

Figure 1.7: SR-71B - in flight over snow-capped mountains

The SR-71 is a famous Mach 3+ spy plane. This is the fastest aircraft ever known to be in service with an air force. The large, delta-winged SR-71 gets is performance from the unusual J-58 engines, that act at as ramjets at high altitude and speed. It was related to the the YF-12 fighter and its precessor, the A-12 CIA-operated spy aircraft. Recently, the a number of SR-71s was put back in service from a premature retirement.

The SR-71 Blackbird strategic reconnaissance aircraft was developed by the Advanced Developments Projects Division at Lockheed Martin's Skunk Works. It is the world's fastest and highest flying aircraft to reach full-scale development and production. SR-71 aircraft are assigned to the 9th Reconnaissance Wing at Beale Air Force Base and operate from Edwards Air Force Base, California.

The SR-71 entered service in 1968 and was retired in 1990, but in 1994 the US Congress directed that the SR-71 should be re-instated to operational readiness and deployed to meet the need for a broad area coverage reconnaissance platform. The aircraft were brought out of retirement and two aircraft were mission ready by the third quarter of 1995.

NASA has two SR-71 aircraft, one SR-71A and one SR-71B trainer aircraft for aeronautical research. The aircraft are based at the Dryden Flight Research Centre at Edwards, California. The characteristics of the aircraft and its flight are used in the development of new supersonic and hypersonic aircraft and propulsion systems.

SR-71 has a crew of two, pilot and reconnaissance officer. The aircraft is unarmed but is equipped with an electronic countermeasures (ECM) system.

Design

The airframe structure is mainly of titanium and titanium alloys capable of withstanding the heat generated by sustained supersonic flight. The aircraft's control surfaces are: the all-moving nearly vertical tail surfaces above each engine nacelle; the ailerons forming the trailing edge on the outer wings, which provide control in roll; and the elevators on the trailing edges between the engine exhausts, which govern the pitch of the aircraft.

Sensors

The aircraft, which can survey 100,000 square miles per hour, is equipped with a suite of intelligence sensors, including the Lockheed Martin ASARS-1 Advanced Synthetic Aperture Radar, which provides all weather day and night intelligence data. ASARS-1 is installed in the nose of the aircraft.

The Common Data Link (CDL), operating at 274 Mbs, can be used to download the data gathered by the ASARS to a ground station. The CDL operates over a 300 nautical mile line of sight. If the aircraft is out of range of a ground station, ASARS data can be stored on the DCR recorder installed in the aircraft. The stored data can be processed when the aircraft has landed or can be transmitted via the downlink when the aircraft is next in range of a ground station.

According to the particular mission requirement, a panoramic Optical Bar Camera can be installed in the nose of the aircraft instead of the ASARS radar. The Litton Itek Optical Bar Camera is a wide angle system using high resolution wet film.

The point and shoot framing camera installed on the port and starboard side of the aircraft is the Boeing Technical Objective Camera (TEOC) which uses wet film. A 25 megapixel electro-optic sensor backplane, integrated into the TEOC, has been demonstrated in flight trials. The SR-71 can carry two wet film TEOCs, two electro-optical TEOCs or one of each.

The NASA SR-71 aircraft being used as high speed high altitude testbeds are fitted with sensors for aeronautical research. The SR-71 has been used as a camera platform for NASA's Jet Propulsion Laboratory. An upward looking ultraviolet camera is installed in the nosebay. A downward looking camera is used to study rocket engine exhaust signatures, volcano plumes and the spectrum of the earth's atmosphere.

Engines

The Blackbird SR-71 has two Pratt and Whitney J-58 axial flow turbo-jet engines with afterburners, each generating a thrust of 32,500 pounds. The aircraft can achieve a speed over Mach 3.2, more than 2200 miles per hour, and altitudes more than 85,000 feet.

The aircraft carries 12,200 gallons (84,000 pounds) of fuel. The unrefuelled range is more than 2000 miles. An in-flight refuelling receptacle is located on the centreline top of the fuselage.

Type	SR-71A
Task	reconaissance
Year	1966
Crew	2
Wing Span	16.94 m
Length	32.74 m
Height	5.64 m
Engines	2 * 14740 kg P&W J-58
Max.Weight	77111 kg
Max. Speed	3715 km/h
Ceiling	26000 m
Max. Range	4800 km
Armament	none

1.2.4 A-4 SkyHawk

Figure 1.8: A-4 SkyHawk

This small and simple tailed delta jet, originally designed as carrier-based (nuclear) bomber, later enjoyed a long career as an extremely versatile attack aircraft. Later developments had a large dorsal spine to make room for electronics. The A-4 was kept in production for 22 years, and is still serving with some air forces. The OA-4 is a two-seat FAC version for the USMC, and the trainer version is known as TA-4. 2960 built.

Type	A-4F	A-4M
Function	attack	attack
Year	1966	1966
Crew	1	1
Engines	1 * 41.4 kN P&W J52-P-8A	1 * 5080 kg P&W J52-P-408A
Wing Span	8.38 m	8.38 m
Length	12.22 m	12.29m
Height	4.57 m	4.57 m
Empty Weight	4536 kg	4747 kg
Max.Weight	11113 kg	11113 kg
Speed	1100 km/h	1078 km/h
Ceiling	14940 m	12880 m
Armament	2*g20mm, 3720kg	2*g20 mm 4153 kg

1.2.5 U2-R

Figure 1.9: U2-R

The U-2, a high-flying reconaissance aircraft, was camouflaged by this inoccent 'utility' designation. Ironically, it has become the most famous U-designated aircraft... The extremely high-flying U-2 spyplane became infamous in 1960 by being shot down over the Soviet Union. After that, the U-2 was claimed to be restricted to meteorological and environment control flights, but it continued to spy above countries other than the USSR, such as China and Cuba. Some were shot down. The WU-2 was used for sampling of the stratosphere, and examining the fall-out from nuclear tests. Later versions had a J75 engine. The U-2R is a much-modified version with two large pods on the wing, built in the second and third production runs — the aircraft of the third series were named TR-1 for some time. The latest U-2R models were still present during the 1991 Gulf War. Reengining with the lighter and more powerful G.E. F118-GE-F29 engine is under way.

Type	U-2B	U-2R
Task	reconaissance	reconaissance
Year	1956	1967
Crew	1	1
Engines	1 * 7710kg P&W J57-P-13B	1 * 7710kg P&W J75-P-13B
Max. Speed	850km/h	M0.8
Ceiling	27400m	24380m
Max. Range	6640km	10060km

Mission

The U-2 provides continuous day or night, high-altitude, all-weather, stand-off surveillance of an area in direct support of U.S. and allied ground and air forces. It provides critical intelligence to decision makers through all phases of conflict, including peacetime indications and warnings, crises, low-intensity conflict and large-scale hostilities.

Features

The U-2 is a single-seat, single-engine, high-altitude, reconnaissance aircraft. Long, wide, straight wings give the U-2 glider-like characteristics. It can carry a variety of sensors and cameras, is an extremely reliable reconnaissance aircraft, and enjoys a high mission completion rate.

Because of its high altitude mission, the pilot must wear a full pressure suit. The U-2 is capable of collecting multi-sensor photo, electro-optic, infrared and radar imagery, as well as performing other types of reconnaissance functions. However, the aircraft can be a difficult aircraft to fly due to its unusual landing characteristics.

The aircraft is being upgraded with a lighter engine (General Electric F-118-101) that burns less fuel, cuts weight and increases power. The entire fleet should be reengined by 1998. Other upgrades are to the sensors and adding the Global Positioning System that will superimpose geo-coordinates directly on collected images.

Background

Current models are derived from the original version that made its first flight in August 1955. On Oct. 14, 1962, it was the U-2 that photographed the Soviet military installing offensive missiles in Cuba.

The U-2R, first flown in 1967, is significantly larger and more capable than the original aircraft. A tactical reconnaissance version, the TR-1A, first flew in August 1981 and was delivered to the Air Force the next month. Designed for stand-off tactical reconnaissance in Europe, the TR-1 was structurally identical to the U-2R. Operational TR-1A's were used by the 17th Reconnaissance Wing, Royal Air Force Station Alconbury, England, starting in February 1983. The last U-2 and TR-1 aircraft were delivered to the Air Force in October 1989. In 1992 all TR-1s and U-2s were redesignated U-2R. Current U-2R models are being reengined and will be designated as a U-2S/ST. The Air Force accepted the first U-2S in October, 1994.

When requested, the U-2 also has provided photographs to the Federal Emergency Management Agency in support of disaster relief.

U-2s are based at Beale Air Force Base, Calif. and support national and tactical requirements from four operational detachments located throughout the world. U-2R/U-2S crew members are trained at Beale using three U-2ST aircraft. The last R model trainer will be converted to an S model trainer in 1999.

General Characteristics

Primary Function	high-altitude reconnaissance
Contractor	Lockheed Aircraft Corp.
Power Plant	One Pratt & Whitney J75-P-13B engine
Thrust	17,000 pounds (7,650 kilograms)
Length	63 feet (19.2 meters)
Height	16 feet (4.8 meters)
Wingspan	103 feet (30.9 meters)
Speed	475+ miles per hour (Mach 0.58)
Maximum Takeoff Weight	40,000 pounds (18,000 kilograms).
Range	Beyond 7,000 miles (6,090 nautical miles)
Ceiling	Above 70,000 feet (21,212 meters)
Crew	One (two in trainer models)
Date Deployed	U-2, August 1955; U-2R, 1967; U-2S, October 1994
Cost	Classified
Inventory	Active force, 36 (4 trainers); Reserve, 0; ANG, 0

1.2.6 F-4E Phantom II

Figure 1.10: First of the McDonnell Phantom II Series

The big F-4 fighter-bomber was gradually evolved from theF3H, with which it had no more than a configurational similarity. Despite its size and bulky look, the F-4 had excellent performance and good manoeuvrability; it was adopted by both the USN and the USAF. Early F-4's had no fixed gun, but this was corrected after combat experience in Vietnam showed the need for one. Over 5000 were built, making the F-4 one of the most numerous modern combat aircraft. Many are still in service. Now and then, plans are announced to upgrade the F-4 with new engines and electronics. The RF-4 is a recce version of the F-4 fighter with a camera nose. Currently retired F-4s are being converted into QF-4 target drones.

Type	F-4E
Function	fighter
Year	1967
Crew	2
Engines	2 * 8120kg GE J79-GE-17A
Wing Span	11.71 m
Length	19.20 m
Height	5.03 m
Wing Area	49.24 m^2
Empty Weight	13397 kg
Max.Weight	17964 kg
Max. Speed	2410 km/h
Ceiling	21600 m
Max. Range	4180 km
Armament	1*g20mm 1370 kg 5888 kg 4*AIM-7

1.2.7 A-7D Corsair II

Figure 1.11: A-7D Corsair II

The A-7 was a very capable attack aircraft, bought by both USN and USAF. The design used F-8 Crusader experience in a smaller, subsonic airframe. It was phased out of service recently, but efforts to sell upgraded versions continue. 1551 were built.

Type	A-7B
Year	1968
Crew	1
Wing Span	11.81 m
Length	14.05 m
Height	4.87 m
Engines	1 * 54.8 kN P&W TF30-P-8
Empty Weight	8165 kg
Max.Weight	19050 kg
Speed	Mach 0.8
Range	4540 km
Armament	2*g 20 mm, 2*msl AIM-9, 9072 kg
Unit cost	15 million USD

1.3 France

1.3.1 Mirage IIIE

Figure 1.12: Dassault Mirage III

The delta-winged Mirage III jet fighter has been the largest succes of the post-war French aviation industry. More than 20 countries bought the Mirage III, and it is still in service, now undergoing extensive modernisation programmes in South-Africa, Chili and Switzerland. One of the most elegant aircraft ever flown, the Mirage III has a large delta wing and circular intakes with shock cones. A rectangular recess under the aft fuselage can contain either a fuel tank or a rocket engine.

Type	Mirage IIIE
Function	fighter-bomber
Year	1964
Crew	1
Engines	1 * 6200 kg SNECMA Atar 9C0-1 * 1500 kg SEPR 844
Wing Span	8.22 m
Length	15.03 m
Height	4.05m
Wing Area	35.00 m^2
Empty Weight	7050 kg
Max.Weight	13700 kg
Speed	2350 km/h
Ceiling	17000 m
Armament	2*g30 mm 4400 kg
Unit cost	7 million USD

Dassault Mirage 3 NG

This was an upgrade of the Mirage III, proposed by Dassault. The changes included canards, extended wing root leading edges, a fly-by-wire control system, and the Atar 9K-50 engine. Prototype only.

Type	Mirage 3NG
Function	fighter
Year	1982
Crew	1
Engines	1 * 7200 kg SNECMA Atar 9K-50
Wing Span	8.22 m
Length	15.65 m
Height	4.50 m
Wing Area	35.00 m2
Max.Weight	14700 kg
Speed	2125 km/h

1.3.2 Mirage F-1C

Figure 1.13: Mirage F-1C

The Mirage F.1 replaced the familiar delta wing of the Mirage with a swept wing, set at shoulder height and fitted with flaps and slats. This was combined with a low-set slab tailplane. The F.1 did not achieve the enormous sales of the Mirage III, but was nevertheless sold to France, Ecuador, Greece, Iraq, Libya, Marocco, Quatar, Jordania, South-Africa, and Spain. A more advanced version, the F.1E with a M53 engine, lost the NATO fighter competition to the F-16. The Mirage 2000 has replaced the F1 one the production lines, but the Mirage F1 will continue in service for some time.

Type	Mirage F.1C
Function	fighter
Year	1970
Crew	1
Engines	1 * 7200 kg SNECMA Atar 9K-50
Wing Span	9.32 m
Length	15.30 m
Height	4.50 m
Wing Area	25.00 m^2
Empty Weight	7400 kg
Max.Weight	16200 kg
Speed	2740 km/h
Ceiling	20000 m
Range	1390 km
Armament	2 * gun 30mm 6300 kg payload
Unit cost	11 million USD

1.4 Sweden

1.4.1 J35 Draken

Figure 1.14: J35 Draken

Swedish jet fighter. The Draken was optimized for short runways and high climbing speed. It has a double delta wing: the inboard section is higly swept and has the oval jet intakes in the leading edges; the outbords sections have less sweep. The Saab 35 has high performance, but is said to be difficult to fly. A number are still in service. The J 35 was exported to Denmark, Finland and Austria. 606 built.

Type	J 35F
Country	Sweden
Function	fighter
Year	1965
Crew	1
Engines	1 * 76kN SFA RM.6C
Wing Span	9.42m
Length	15.34m
Height	3.89m
Wing Area	49.22m^2
Empty Weight	7865kg
Max.Weight	16000kg
Speed	M2
Ceiling	19800m
Range	3250km
Armament	1*g30mm

1.5 Soviet Union

1.5.1 SU17/SU22 Fitter

Figure 1.15: SU17 Fitter

The Su-17 was a large step in the development of the Su-7 to a more useful attack aircraft. The most important change was the introduction of swivelling outer wing panels, improving take-off and landing performance, and thus allowing a larger weapons load. The Su-20 and Su-22 were export versions.

The Su-17 was a significant step in the development of the Su-7 to a more useful attack aircraft. The most important change was the introduction of swivelling outer wing panels. Although only the outer half of the wing span moved, and weight increased, the modification considerably improved take-off and landing performance, and allowed a larger weapons load to be carried. The Su-17M introduced the smaller, lighter and more powerful AL-21F engine. The Su-17M3 and M4 versions had an enlarged dorsal spine aft of the cockpit, originally designed for the second seat of the trainer version, but now filled with fuel. The Su-20 and Su-22 were export versions. Over

3000 were built.

SU22

Export version of the Su-17M2. The Su-22 had the Tumansky R-29B-300 engine instead of the Lyulka AL-21F. The larger diameter of the engine required changes to the aft fuselage. It resulted in a degraded performance, but in 1976 production for export began. Later models had the avionics fit of the Su-17M3 or M4.

Specification

Type	Su-17	Su-17 Fitter-C	Su-17M4
Function	attack	attack	attack
Year	1969	1971	1980
Crew	1	1	1
Length	16.42 m	17.75 m	17.34 m
Height	4.96 m	4.75 m	5.13 m
Empty Weight	10090 kg	19000 kg	10800 kg
Max.Weight	16950 kg	19000 kg	19400 kg
Speed	2150 km/h	2304 km/h	1830 km/h
Ceiling	16300 m	18000 m	15200 m
Range	1450 km	2500 km	2650 km
Armament	2*g30 mm (80rpg), 3000 kg	4000kg	4000kg

Chapter 2

1970-1980

2.1 Soviet Union

2.1.1 MiG-25RB Foxbat-B

Figure 2.1: MiG-25RB Foxbat-B

This was the USSR's answer to the design in the US of fast, high- flying aircraft as the B-70, F-108 and SR-71. The MiG-25 lacked technological refinement, but its performance caused much concern in the west. It was designed to function both as long- range interceptor and reconnaissance aircraft (which in the Middle-East proved invulnerable to the Israeli F-4 Phantom IIs) The center fuselage is a big, welded steel fuel tank, so avionics, radar or cameras are in the nose. Speed is limited to Mach 2.83 mainly by controllability problems. Main versions are the Mig-25P fighter, the upgraded MiG-25PD fighter, the MiG-25R reconnaissance aircraft, the MiG-25RB 'Foxbat-B' dual-role reconnaissance aircraft and tactical bomber, and the MiG-25BM 'Foxbat-F'defence suppression aircraft. There are two-seat trainer versions of both the fighter and the reconnaissance version. Production of the fighter ended in 1983. The MiG-25 saw combat in several wars in the Middle East. Over 1200 have been built, of which about 75% were interceptors.

Type	MiG-25	MiG-25PD Foxbat-E
Function	fighter	fighter
Year	1978	1978
Crew	1	1
Engines	2 * 12250kg Tumansky R-31	2 * 11200kg Tumansky R-15D-300
Wing Span	13.95 m	14.02m
Length	23.82 m	21.67m
Height	6.10 m	6.50m
Empty Weight	20000 kg	20000kg
Max.Weight	36200 kg	36720kg
Speed	3000+ km/h	3000km/h at 13000m
Ceiling	24400 m	20700m
Range	1730km	1730km
Armament	4 missiles	4 missiles

Type	MiG-25RB Foxbat-B
Function	reconaissance / attack
Year	1970
Crew	1
Engines	2 * 10210 kg Tumansky R-15B-300
Wing Span	13.42m
Length	21.55m
Height	6.5m
Empty Weight	20755kg
Max.Weight	41200 kg
Speed	3000 km/h at 13000
Ceiling	23000 m
Range	2900 km
Armament	bombs 4000 kg

2.1.2 Mig-27M Flogger

Figure 2.2: Mig-27M Flogger

This is a version of the MiG-23 optimized for the ground attack role, with a new nose, simpler engine intakes and nozzle, and other changes. These limit supersonic performance, but reduce cost, weight and fuel consumption.

Type	MiG-27M Flogger-J
Function	attack
Year	1973
Crew	1
Engines	1 * 11500kg Tumanski R-29-300
Wing Span	14.25 m / 8.17 m
Length	16.00 m
Height	4.50 m
Wing Area	27.25 m^2
Empty Weight	10790 kg
Speed	1700 km/h
Ceiling	17000m
Max.Weight	20100 kg
Armament	1*g 23 mm 4000 kg payload

2.1.3 SU24-MK Fencer

Figure 2.3: SU24-MK Fencer

A variable geometry strike/attack aircraft, obviously inspired by the U.S. F-111, but more optimized for the low-level tactical strike role, and with a generally lower performance. There also are reconnaissance versions.

Type	Su-24MK
Function	attack
Year	1974
Crew	2
Engines	2 * 110 kN Lyulka AL-21F3A
Wing Span	17.63m–10.36 m
Length	24.53 m
Height	6.19 m
Wing Area	55.16 m2
Empty Weight	22320 kg
Max.Weight	39700 kg
Speed	Mach 1.35 at low, Mach 2.18 at high altitude
Ceiling	17500 m
Range	2850 km
Armament	1*g30 mm

The wings are high-mounted, variable, swept-back, and tapered. There are twin turbofan engines. The air intakes are tapered away from the body, rectangular-shaped, and mounted on the body forward of the wings' leading edges. There are twin exhausts. The fuselage is long, slender, with pointed, solid nose, and rectangular-shaped body from the air intakes to the exhausts. There are two belly fins and four pylons. There is a bubble canopy. The dorsal spine extends from the cockpit to the tail. The tail fin is swept-back and tapered with square tip. The flats are high-mounted on the fuselage, swept-back, and tapered with angular tips.

Variants

Later production marks may have different engines, POS R-29Bs @11500Kg.

- Fencer A is initial production variant w/ squared off aft fuselage.
- Su-24B has rounded fuselage.
- Su-24C has changes in EW equipment.
- Su-24D can be inflight refueled and has longer nose.
- Su-24E is recon variant for navy; can also carry antiship weapons.
- Fencer F possible version; perhaps EW variant.

Specification: Su-24M Fencer

The Su-24 is an all-weather supersonic low-level bomber able to deliver conventional and nuclear warloads with great precision. Quite large in size, it features a wide, slab-sided fuselage that houses two turbojets and a side-by-side cockpit with seating for two. The high variable-geometry wings feature large full-span slats to enhance handling. In the large nose radome are two radar scanners: one for navigation, attack, and terrain following, and another for airborne ranging.

The main bomber variant today is the Su-24M, which was introduced in 1983. It features extended wing roots to accommodate two extra external weapons pylons, a shorter nose radome which houses an improved TFR system and a forward-looking attack radar. Near the nose-wheel door is a Kaira-24 laser/designator to be used with laser guided weapons, while up to two AAMs can be used for self defence. A combat capable reconnaissance variant also exists.

The Fencer has an extremely high fuel capacity, enabling it to penetrate deep into enemy territory. Comparible to the similar Tornado strike aircraft, the Su-24 is approximately 50% more powerful. It has been exported to Iran, Iraq, Libya, and Syria.

General Characteristics

Prime contractor: Sukhoi Design Bureau
Nation of origin: Soviet Union
Function: Attack
Crew: 2
Year: 1974
In-service year: 1983
Engine: Two Lyulka AL-21F-3A afterburning turbojets, 24,690 lb thrust each
Fully swept: 10.36 m / 34 ft
Fully spread: 17.64 m / 57 ft 11 in
Length: 24.59 m / 80 ft 8 in
Height: 6.19 m / 20 ft 4 in
Weight: 41,885 lb empty / 87,520 lb max. take off
Ceiling: 57,400 ft
Speed, high altitude: 2,317 km/h / 1,440 mph
Speed, sea level: 1,320 km/h / 820 mph
Armament: One GSh-6-23 23mm six-barrel cannon, plus 17,637 lb including AAMs, laser-guided bombs, TV-guided bombs, gun pods, nuclear weapons, rockets, and four drop tanks carried on nine external points

2.1.4 SU-25 Frogfoot

Figure 2.4: SU-25 Frogfoot

Heavily armoured attack and anti-tank aircraft. The Su-25 is a well-armoured aircraft, capable of carrying a large load under its shoulder-placed wing. Compared to its US counterpart, the A-10, it is faster and more agile. The Su-25 saw combat in Afghanistan, and experience there led to major improvements. A navalized version was built for the large carriers. Late models have more powerful R-195 engines.

This Ground-Attack plane , the A-10 soviet in a way, constitute for the soviet strength a real bomb truck... The development of the Su-25 started at the end of years 60 by the Sukhoï office when needs in Ground-Attack planes had himself felt cruelly. The first produced units fell to pick indeed for the red army that able to directly put them in service to sides of the Mi-24 " hind " in missions of destruction of armored and of bombing at the time of the war of Afghanistan. In 1984 losses to the fight of the Su-25 began to become préocuping ? ... A new project of Frogfoot was launched therefore in the goal to fill his main hiatuses: limited survivability, lack of all-weather capacity, insufficient action radius and avionics limits. This new model was developed from the two-seater version for reasons of space. This Su-25T again called Su-34 took air for the first time the 17/08/1984. As to the habit at Sukhoï, it exists a big number of versions of the Frogfoot. The Su-25 " Frogfoot-A " is the first of the one-seater versions able to carry away 6 400 kg of bombs. His version of export is designated Su-25K. The Su-25UB " Frogfoot-Bs " are the version in tandem of practice. His version of export is the Su-25UBK. The Su-25UT " Frogfoot-B " are the same version that the Su-25 UBS but destitute of arming and rebaptisé Su-28. The Su-25UTG (G as Gak : landing (crosse) is an identical version to the UT but provided this time of a langing (crosse) for use on aircraft carrier. The Su-25T is a version identical one-seater in his structure at Su-25UT intended to the attack anti-tank that specified higher how has been modernized entirely and improven. His version of export is the Su-25TK. The Su-25BM is a version of target tow and the Su-34 is the new designation of the Su-25T. Engineers pulled in particular for this greatly gone version of teachings of the Afghan war his survivability in intense anti-aircraft environment. The Frogfoot has been produced to more of 330 copies and his users are Russia, Hungary, Bulgaria, Iraq, ex-Czechoslovakia and Afghanistan.

Main versions

Su-25 **Frogfoot-A**: One-seater initial version.
Su-25K: Version of export of the Su-25A.
Su-25UB **Frogfoot-B** : Two-seater training version.
Su-25UBK: Version of export of the Su-25UB.
Su-25UTG: Version endowed of a landing (crosse).
Su-25TP: Version in maritime attack development.
Su-25T/Su-34: Modernized version and improven.
Su-25TK: Version of export of the Su-25T.

General Characteristics

The Su-25 was designed as a low level attack aircraft used in support of ground forces, much like the A-10 Thunderbolt II. Titanium, 24 mm thick, is used to protect the cockpit and other vital components from ground fire, while the internal fuel tanks are lined with a special foam to help protect against explosion. A two-seat variant was later designed as the Su-25UB, and an un-armed version was built - the Su-25UT, which later became the Su-28. Poor combat performance of the Su-25 in Afghanistan led to a much improved 'Frogfoot', named the Su-39. Designed from the Su-25UB, the Su-39 included wing-tip ECM pods, chaff/flare dispensers, IR jammer, and a new navigation and attack system which provided fully automatic weapon selection and release.

Prime contractor: Sukhoi Design Bureau
Nation of origin: Russia
Function: Attack
Crew: 1
In-service year: 1978
Engine: Two Tumansky R-195 non-afterburning turbofans, 9,921 lb thrust each
Wing span: 14.36 m / 47 ft 2 in
Length: 15.53 m / 50 ft 2 in
Height: 4.8 m / 15 ft 9 in
Weight: 20,950 lb empty / 38,800 lb max. take off
Ceiling: 22,965 ft
Attack speed: 690 km/h / 428 mph
Max speed sea level: 975 km/h / 606 mph

Range: 1,250 km / 777 miles
Armament: One AO-17A 30mm twin-barrel cannon with 250 rounds, plus 9,700 lb including Kh-23/25/29 ASMs, laser-guided bombs, cluster bombs, S-5 57mm rockets, S-8 80mm rockets, S-24 240mm rockets, S-25 330mm rockets, Gsh-23 23mm twin-barrel gun pods with 260 rounds each, R-3S/60 AAMs, or four fuel tanks on ten external points

Type	Su-25 **Frogfoot-A**
Function	attack
Year	1978
Crew	1
Engines	2 * 4100kg Tumansky R-95Sh
Wing Span	14.36 m
Length	15.53 m
Height	4.80 m
Wing Area	30.10 m2
Max.Weight	17600 kg
Speed	970 km/h
Ceiling	7000 m
Range	1250 km
Armament	1*g30 mm (250rpg), 4400 kg

2.2 Israel

2.2.1 F-21 Kfir C7

Figure 2.5: F-21 Kfir C7

These were Israeli aircraft that were in service in the US as "agressors" for dissimilar air combat training. The Kfir is a development of the French Mirage 5 with an J79 engine, built in Israel after France refused to deliver the original aircraft. Twelve were used by the US Navy and thirteen by the USMC.

The original Kfir prototype which first flew on October 19, 1970 was a combination of the Dassault Mirage III airframe with the GE-J79 afterburning turbojet of the F-4 Phantom II. Produced in small numbers in 1972, 25 aircraft were eventually leased to the US Navy and Marine Corps as

F-21As. Approximately 125 Kfirs remain in service today with Israel, as well as Columbia and Equador.

Type	Kfir C-1
Function	fighter
Year	1975
Crew	1
Engines	1 * 8120kg P&W J79-PW-17
Wing Span	8.22 m
Length	15.65 m
Height	4.55 m
Wing Area	34.80 m2
Max. Speed	2445 km/h
Ceiling	18000 m
Max. Range	1300+ km
Armament	2*g30mm

General Characteristics

Prime contractor: Israel Aircraft Industries Ltd.
Nation of origin: Israel
Function: Multi-role fighter
Crew: 1
Year: 1970
In-service year: 1972 as C1
Engine: One General Electric J79-J1E afterburning turbojet, 18,750 lb thrust
Wing span: 8.22 m / 27 ft
Length: 15.65 m / 51 ft 5 in
Height: 4.55 m / 14 ft 11 in
Weight: 16,060 lb empty / 36,376 lb max. take off
Ceiling: 58,000 ft
Speed: 2,440 km/h / 1,516 mph at high altitude
Armament: Two DEFA 553 30mm cannons with 140 rounds each, plus up to 13,415 lb including AAMs, cluster bombs, free-fall bombs, laser guided bombs, Durandal anti-runway bombs, AGM-65 Maverick ASMs, napalm tanks, ECM pods, or drop tanks.

2.3 UK/France

2.3.1 Jaguar GR.1

Figure 2.6: Jaguar GR.1

French/British low-altitude ground attack aircraft. The French and British air forces each bought around 200; the Jaguar also did well on the export market. The Jaguar is a relative small aircraft with a tiny shoulder-wing, giving a smooth 'ride' at low altitude. It is not very sophisticated, but versatile and effective, and upgrade programs are now extending its capabilities. The British versions are the S attack aircraft (Jaguar GR) and the B two-seat trainer (Jaguar T). The Jaguar A is the French attack version, and the E the French two-seat trainer. The Jaguar M shipboard attack aircraft was cancelled. The Jaguar International is the export version; it is being license-built in India.

Type	Jaguar GR.1	Jaguar International
Function	attack	attack
Year	1973	1978
Crew	1	1
Engines	2 * 35.7kN R.R.-TA.[1] Mk.104	2 * 3647kg R.R.-TA. Mk.804
Wing Span	8.69 m	8.69 m
Length	16.83 m	16.83 m
Height	4.89 m	4.89 m
Wing Area	14.18 m^2	24.18 m^2
Empty Weight	7000 kg	7000 kg
Max.Weight	15700 kg	15700 kg
Speed	M1.6	1699 km/h
Ceiling	14020 m	14020 m
Range	4210 km	4210 km
Armament	2*g 30mm 4765 kg	2*g30mm 4763kg
Unit cost	8 million USD	unknown

2.4 USA

2.4.1 A-6E Intruder

Figure 2.7: Grumman A-6 Intruder

All-weather attack aircraft, entered service in 1963. The A-6 is an ugly mid-wing aircraft, with side-by-side seating in a blunt nose. The subsonic A-6 is a true all-wheater attack aircraft; it has good range and carries a heavier load than any previous USN attack aircraft. It is still in service, but near the end of its career. Over 660 were built. 51 were converted to KA-6D trainers. The A-attack aircraft was the basis for two electronic warfare versions, the two-seat EA-6A and the four-seat EA-6B Prowler. The EA-6B carries up to five AN/ALQ-99 pods, each with two jamming transmitters.

Type	A-6E
Function	attack
Year	1972
Crew	2
Engines	2 * 41.4kN P&W J52-P-8A
Wing Span	16.15 m
Length	16.69 m
Height	4.93 m
Wing Area	49.13 m2
Empty Weight	12093 kg
Max.Weight	27397 kg
Speed	1043 km/h
Ceiling	14480 m
Range	4690 km
Armament	8165 kg
Unit cost	25 million USD

Type	EA-6B
Task	electronic warfare
Year	1971
Crew	4
Engines	2 * 49.8kN P&W J52-P-408
Wing Span	16.15 m
Length	18.11 m
Height	4.93 m
Empty Weight	14588 kg
Max.Weight	29485 kg
Max. Speed	1048 km/h
Ceiling	12550 m
Max. Range	3861 km
Armament	possibly HARM-missiles.

Aircraft Description

Powerplant :
Two Pratt & Whitney J52-P8B/C, nonafterburning, axial-flow turbojet engines; each rated approximately 9,300 lb. thrust. The C version is a reliability and maintainability improvement to the combustion chamber, fuel nozzles and seals in the oil tank. The engine, used in other internationally operated aircraft is supported by several corporations.

Accommodations :
Crew of two: pilot and bombardier/navigator.

Performance :
Maximum speed 568 knots at sea level, max range greater than 2,800 miles.

Armament :
Provision for carrying up to 18,000 lbs. of ordnance on 5 external weapon stations.

Aircraft Mission and Capabilities

The A-6E is the U.S. Navy's heavy payload attack aircraft that provides all-weather, day or night, long-range strike capability. It has recently been modified with a composite wing to extend the plane's operational fatigue life another 20 years and is equipped with an all-weather multiple-mode radar, DRS (Detecting and Range Set), and a self-contained carrier airborne inertial navigation system. The APQ-156 integrated radar provides the capabilities of search, target tracking, airborne moving target identification, and beacon interrogation. The high resolution, real beam ground mapping radar, complemented by the Tactical Altitude Director (TAD) system, also provides terrain clearance and avoidance for low-level navigation. The DRS contains a FLIR, laser range-finder designator, and forward air control (FAC) receiver located beneath the nose in a sensor turret for precision attacks against tactical targets at night and in adverse weather. The A-6E can deliver the Navy's entire arsenal of available air-to-ground weapons from general purpose bombs to ground attack missiles, and the AIM-9L/M air-to-air missile. The SWIP (Systems Weapons Improvement Program) is the latest upgrade that enables the Intruder, through a MIL-STD-1553 avionics multiplex databus to employ multiple advanced precision guided missiles against land- and sea-based targets and emitters. Most A-6Es have been further modified to night multi-place attacks. The integrated attack navigation weapon system coupled with a two man, side-by-side crew, significantly enhances crew coordination, situational awareness, and safety of flight by reducing data saturation associated with the real world tactical environment.

Program Summary

The A-6E was removed from U.S. Naval Air Forces in February 1997. One hundred (100) aircraft are stored in War Reserve and the additional excess aircraft are stored for potential Foreign Military Sales (FMS) all of the SWIP composite wing configuration. The A-6F, the next generation Intruder, started development in 1984 incorporating General Electric F404 engines, an inverse synthetic aperture radar with air-to-air mode, and improved structural changes. This program was cancelled in 1989 with 5 prototypes built.

The A-6 has played an essential part in the changes that have reshaped the world: Vietnam War - 1963-1971, Lebanon/Libya/Grenada - 1971-1986, and Operation Desert Storm in 1991. A total of 693 production A-6s were built, including 488 A-6As, 95 A-6Es, 71 A-6E TRAM, 34 A-6E SWIP and 5 A-6Fs. Over its 33 year history, the A-6 has been in active service in 17 U.S. Navy and 7 U.S. Marine Corps squadrons.

Presently the attack version and/or the Tanking Version (KA-6E) are being offered by the U.S. Navy for FMS.

2.4.2 F-14A Tomcat

Figure 2.8: F-14A Tomcat

Large and powerful two-seat shipboard fighter with variable geometry wings. The weapons system and the Phoenix missile armament are unrivalled for long-distance interceptions, making the F-14 one of the most effective heavy fighters. The original F-14A model was powered by TF30 engines, but the TF30 was too unreliable and not powerful enough. After a lot of experimentation, the F110 engine was adopted, and installed in new-built F-14Ds or upgraded F-14Bs (Formerly known as F-14A+.) The F-14D also introduced digital instead of analog avionics. The F-14 is expensive and very maintenance intensive, and the only export customer was Iran.

Type	F-14A
Function	fighter
Year	1972
Crew	2
Engines	2 * 9500 kg P&W TF30-P-412A
Wing Span	19.54 m/11.65 m
Length	19.10 m
Height	4.88 m
Wing Area	52.49 m^2
Empty Weight	18036 kg
Max.Weight	33724 kg
Max. Speed	2500 km/h
Ceiling	18300 m
Max. Range	3220 km
Armament	1*g20mm msl
Unit cost	35 million USD

Mission

The F-14 Tomcat is a supersonic, twin-engine, variable sweep wing, two-place fighter designed to attack and destroy enemy aircraft at night and in all weather conditions.

Features

The F-14 can track up to 24 targets simultaneously with its advanced weapons control system and attack six with Phoenix AIM-54A missiles while continuing to scan the airspace. Armament also includes a mix of other air intercept missiles, rockets and bombs.

Background

The Grumman F-14, the world's premier air defense fighter, was designed to replace the F-4 Phantom II fighter (phased out in 1986). F-14s provided air cover for the joint strike on Libyan terrorist targets in 1986. The F-14A was introduced in the mid-1970s. The upgraded F-14A+ version, with new General Electric F-110 engines, now widespread throughout the fleet, is more than a match for enemy fighters in close-in, air combat.

General Characteristics

Function: Carrier-based multi-role strike fighter
Contractor: Grumman Aerospace Corporation
Unit Cost: $38 million
Propulsion:
F-14: two Pratt & Whitney TF-30P-414A turbofan engines with afterburners;
F-14B and F-14D: two General Electric F-110-GE-400 augmented turbofan engines with afterburners
Thrust:
F-14A: 20,900 pounds (9,405 kg) static thrust per engine;
F-14B and F-14D: 27,000 pounds (12,150 kg) per engine
Length: 61 feet 9 inches (18.6 meters)
Height: 16 feet (4.8 meters)
Wingspan: 64 feet (19 meters) unswept, 38 feet (11.4 meters) swept
Maximum Takeoff Weight: 72,900 pounds (32,805 kg)
Ceiling: Above 50,000 feet
Speed: Mach 2+

Crew: Two: pilot and radar intercept officer
Armament: Up to 13,000 pounds of AIM-54 Phoenix missile, AIM-7 Sparrow missile, AIM-9 Sidewinder missile, air-to-ground ordnance, and one MK-61A1 Vulcan 20mm cannon
Date Deployed: First flight: December 1970

2.4.3 F-15 Eagle

Figure 2.9: F-15 Eagle

Big twin-engined air-superiority fighter. The F-15 was the US answer to the MiG-25. While not as fast, it is a better all-round fighter. The armament was optimized to down any opponent, although the basic missile types (AIM-9 and AIM-7) are the same as carried by the F-4. F-15's made nearly all air-to-air 'kills' in the (second) Gulf War. From the F-15 fighter the F-15E two-seat Strike aircraft was developed, which retained retained its air-to-air combat capability, but added the equipment for all-weather attack missions. The F-15I is an export version for Israel.

Type	F-15C
Function	fighter
Year	1973
Crew	1
Engines	2 * 106 kN P&W F100-PW-100
Wing Span	13.05 m
Length	19.43 m
Height	5.63 m
Wing Area	56.48 m^2
Max. Speed	M 2.5
Ceiling	19200 m
Empty Weight	12973 kg
Max.Weight	30844 kg
Max. Range	5.25 hrs
Armament	1*g20mm 7300 kg
Unit cost	35 million USD

Features

The Eagle's air superiority is achieved through a mixture of unprecedented maneuverability and acceleration, range, weapons and avionics. It can penetrate enemy defense and outperform and outfight any current or projected enemy aircraft. The F-15 has electronic systems and weaponry to detect, acquire, track and attack enemy aircraft while operating in friendly or enemy-controlled airspace. Its weapons and flight control systems are designed so one person can safely and effectively perform air-to-air combat.

The F-15's superior maneuverability and acceleration are achieved through high engine thrust-to-weight ratio and low wing loading. Low wing-loading (the ratio of aircraft weight to its wing area) is a vital factor in maneuverability and, combined with the high thrust-to-weight ratio, enables the aircraft to turn tightly without losing airspeed.

A multimission avionics system sets the F-15 apart from other fighter aircraft. It includes a head-up display, advanced radar, inertial navigation system, flight instruments, UHF communications, tactical navigation system and instrument landing system. It also has an internally mounted, tactical electronic-warfare system, "identification friend or foe" system, electronic countermeasures set and a central digital computer.

Through an on-going multistage improvement program the F-15 is receiving extensive upgrade involving the installation or modification of new and existing avionics equipment to enhance the tactical capabilities of the F-15.

The head-up display projects on the windscreen all essential flight information gathered by the integrated avionics system. This display, visible in any light condition, provides the pilot information necessary to track and destroy an enemy aircraft without having to look down at cockpit instruments.

The F-15's versatile pulse-Doppler radar system can look up at high-flying targets and down at low-flying targets without being confused by ground clutter. It can detect and track aircraft and small high-speed targets at distances beyond visual range down to close range, and at altitudes down to tree-top level. The radar feeds target information into the central computer for effective weapons delivery. For close-in dog fights, the radar automatically acquires enemy aircraft, and this information is projected on the head-up display.

An inertial navigation system enables the Eagle to navigate anywhere in the world. It gives aircraft position at all times as well as pitch, roll, heading, acceleration and speed information.

The F-15's electronic warfare system provides both threat warning and automatic countermeasures against selected threats. The "identification friend or foe" system informs the pilot if an aircraft seen visually or on radar is friendly. It also informs U.S. or allied ground stations and other suitably equipped aircraft that the F-15 is a friendly aircraft.

A variety of air-to-air weaponry can be carried by the F-15. An automated weapon system enables the pilot to perform aerial combat safely and effectively, using the head-up display and the avionics and weapons controls located on the engine throttles or control stick. When the pilot changes from one weapon system to another, visual guidance for the required weapon automatically appears on the head-up display.

The Eagle can be armed with combinations of four different air-to-air weapons: AIM-7F/M Sparrow missiles or AIM-120 Advanced Medium Range Air-to-Air Missiles on its lower fuselage corners, AIM-9L/M Sidewinder or AIM-120 missiles on two pylons under the wings, and an internal 20mm Gatling gun (with 940 rounds of ammunition) in the right wing root.

Low-drag, conformal fuel tanks were especially developed for the F-15C and D models. Conformal fuel tanks can be attached to the sides of the engine air intake trunks under each wing and are designed to the same load factors and airspeed limits as the basic aircraft. Each conformal fuel tank contains about 114 cubic feet of usable space. These tanks reduce the need for in-flight refueling on global missions and increase time in the combat area. All external stations for munitions remain available with the tanks in use. AIM-7F/M Sparrow and AIM-120 missiles, moreover, can be attached to the corners of the conformal fuel tanks.

Background

The first F-15A flight was made in July 1972, and the first flight of the two-seat F-15B (formerly TF-15A) trainer was made in July 1973. The first Eagle (F-15B) was delivered in November 1974 to the 58th Tactical Training Wing, Luke Air Force Base, Ariz., where pilot training was accomplished in both F-15A and B aircraft. In January 1976, the first Eagle destined for a combat squadron was delivered to the 1st Tactical Fighter Wing at Langley Air Force Base, Va.

Other units equipped with F-15s include the 36th Fighter Wing, Bitburg Air Base, Germany; 325th Fighter Wing at Tyndall Air Force Base, Fla.; 33d Fighter Wing, Eglin Air Force Base, Fla.; 32d Fighter Squadron, Soesterberg AB, Netherlands; and the 3d Fighter Wing, Elmendorf Air Force Base, Alaska. In January 1982, the 48th Fighter-Interceptor Squadron at Langley Air Force Base became the first Air Force air defense squadron to transition to the F-15.

The single-seat F-15C and two-seat F-15D models entered the Air Force inventory beginning in 1979. Kadena Air Base, Japan, received the first F-15C in September 1979. These new models have Production Eagle Package (PEP 2000) improvements, including 2,000 pounds (900 kilograms) of additional internal fuel, provision for carrying exterior conformal fuel tanks and increased maximum takeoff weight of up to 68,000 pounds (30,600 kilograms).

F-15C's, D's and E's were deployed to the Persian Gulf in 1991 in support of Operation Desert Storm where they proved their superior combat capability with a confirmed 26:0 kill ratio.

General Characteristics

Primary Function: Tactical fighter.
Contractor: McDonnell Douglas Corp.

Power Plant: Two Pratt & Whitney F100-PW-100 turbofan engines with afterburners.
Thrust: (C/D models) 25,000 pounds each engine (11,250 kilograms).
Length: 63 feet, 9 inches (19.43 meters).
Height: 18 feet, 8 inches (5.69 meters).
Wingspan: 42 feet, 10 inches (13.06 meters)
Speed: 1,875 mph (Mach 2.5-plus at sea level).
Ceiling: 65,000 feet (19,697 meters).
Maximum Takeoff Weight: (C/D models) 68,000 pounds (30,600 kilograms).
Range: 3,450 miles (3,000 nautical miles) ferry range with conformal fuel tanks and three external fuel tanks.
Armament: One M-61A1 20mm multibarrel gun mounted internally with 940 rounds of ammunition; four AIM-9L/M Sidewinder and four AIM-7F/M Sparrow missiles, or a combination of AIM-9L/M, AIM-7-F/M and AIM-120 missiles.
Crew: F-15A/C: one. F-15B/D: two.
Unit cost: $15 million.
Date Deployed: July 1972
Inventory: Active force, 403; ANG, 126; Reserve, 0.

2.4.4 F-5E Tiger II

Figure 2.10: F-5E Tiger II

The F-5 was developed as a cheap 'export fighter' for military assistance programs. It was a small jet fighter with short-span wings, twin-engined and optimized for easy maintenance. The F-5 was never used on a large scale by the USAF, but because of characteristics similar to the MiG-21, the F-5 was used as 'agressor' aircraft. The USAF did also use the closely related T-38 supersonic trainer. While the F-5A (799 built) was a very basic aircraft with minimal equipment, the F-5E Tiger II (1166 built) was much more capable. Finally, the much-modified, single-engined F-5G was renamed F-20. At least 28 countries used the F-5.

Type	F-5A	F-5E Tiger II
Function	fighter	fighter
Year	1963	1973
Crew	1	1
Engines	2 * 1800 kg G.E. J85-GE-13	2 * 22.24 kN G.E. J85-GE-21A
Wing Area	15.79 m^2	17.28 m^2
Wing Span	7.70 m	8.13 m
Length	14.38 m	14.68 m
Height	4.01 m	4.08 m
Empty Weight	3667 kg	4410 kg
Max. Speed	1490 km/h	Mach 1.64
Range	2600 km	2860 km
Ceiling	15200 m	15790 m
Armament	2*g20mm	2*g20mm
Unit cost	5 million USD	unknown

F-5A Freedom Fighter

The F-5 is a supersonic fighter combining low cost, ease of maintenance, and great versatility. More than 2,000 F-5 aircraft have been procured by the USAF for use by allied nations. The F-5, which resembles the USAF Northrop T-38 trainer, is suitable for various types of ground-support and aerial intercept missions, including those which would have to be conducted from sod fields in combat areas.

The F-5 first flew on July 30, 1959 and deliveries to the Tactical Air Command for instructing foreign pilots began in April 1964. Pilots from Iran and South Korea were the first to be trained in the F-5, followed by pilots from Norway, Greece, Taiwan, Spain, and other Free World nations which have adopted the F-5. A two place combat trainer version, the F-5B, first flew in February 1964. In 1966-67, a USAF squadron of F-5s flew combat missions in Southeast Asia for operational evaluation purposes.

F-5E Tiger II

The F-5E "Tiger II" was a greatly improved version of the earlier F-5A "Freedom Fighter". Redesigned as a highly maneuverable, lightweight and inexpensive air superiority fighter, the -E featured an air-to-air fire control radar system and a lead computing gunsight. More powerful J85 engines required the fuselage to be both widened and lengthened. The forward wing root was redesigned to give the "Tiger II" wing its characteristic triple delta shape.

The first flight of the F-5E was on 11 August 1972. The first USAF unit to receive the aircraft was the 425th TFS at Williams AFB, Arizona responsible for training foreign pilots in the F-5 aircraft. The most well known use of the "Tiger II" was as an aggressor aircraft at the USAF Fighter Weapons School, Nellis AFB Nevada. The aggressor pilots of the 64th Fighter Weapons Squadron were trained in Soviet tactics and used the -Es to simulate MiG-21s for training USAF pilots in aerial combat skills. Eventually, aggressor squadrons were formed at RAF Alconbury, U.K. and Clark AB, PI for training USAF pilots stationed overseas along with pilots of friendly foreign nations.

General characteristics F-5E

Primary function: Lightweight fighter
Power plant: Two General Electric J85-GE-21B turbojets
Thrust: 2x 5,013 lb or 2x 22.3 kN
Max. speed: 1,082 mph or 1,741 km

Initial climb rate: 574 ft/s or 175 m/s
Ceiling: 51,800 ft or 15,790 m
Range: 2,314 miles or 3,724 km
Combat radius: 190 miles or 306 km
Weight empty: 9,725 lb or 4,410 kg
Weight max. takeoff: 24,725 lb or 11,214 kg
Wingspan: 26.7 ft or 8.13 m
Length: 47.4 ft or 14.45 m
Height: 13.35 ft or 4.07 m
Wingarea: 186 sq. ft or 17.28 sq. m
Armament: Two 20mm cannons M39; under wings up to 3,175 kg weapons (guided missiles, bombs, rockets, cannons and ECM, on each wingtip one guided missile).

2.4.5 A-10 Thunderbolt

Figure 2.11: A-10 Thunderbolt

Battlefield tank-killer, heavily armoured and built around a powerful 30mm gun and its enormous munition drum. The large unswept wing, the two turbofan engines in pods on top of the fuselage, and twin tailfins are all designed to keep the A-10 flying after suffering serious damage. The cockpit is armoured to resist 23mm rounds. It seems that its career is going to be rather short, because the USAF now prefers faster and less specialized aircraft for the combat support role. The USAF bought 727.

Type	A-10A
Function	attack
Year	1976
Crew	1
Engines	2 * 40.3kN G.E. TF34-GE-100
Wing Span	17.53 m
Length	16.26 m
Height	4.47 m
Wing Area	47.01 m^2
Empty Weight	11321 kg
Speed	805 km/h
Range	4200 km
Max.Weight	22680 kg
Armament	1*g30 mm, 7260 kg
Unit cost	20 million USD

Features

The A-10 and OA-10 have excellent maneuverability at low air speeds and altitude, and are highly accurate weapons-delivery platforms. They can loiter near battle areas for extended periods of time and operate under 1,000-foot ceilings (303.3 meters) with 1.5-mile (2.4 kilometers) visibility. Their wide combat radius and short takeoff and landing capability permit operations in and out of locations near front lines.

Thunderbolt IIs have single-seat cockpits forward of their wings, and a large bubble canopy which provides pilots all-around vision. The pilots are encircled by titanium armor that also protects parts of the flight-control system. The redundant primary structural sections allow the aircraft to enjoy better survivability during close air support than did previous aircraft. The aircraft can survive direct hits from armor-piercing and high-explosive projectiles up to 23mm. Their self-sealing fuel cells are protected by internal and external foam. Their redundant hydraulic flight-control systems are backed up by manual systems. This permits pilots to fly and land when hydraulic power is lost.

The Thunderbolt II can be serviced and operated from bases with limited facilities near battle areas. Many of the aircraft's parts are interchangeable left and right, including the engines, main landing gear and vertical stabilizers.

Avionics equipment includes communications, inertial navigation systems, fire control and weapons delivery systems, and target penetration aids. Their weapons delivery systems include head-up displays that indicate airspeed, altitude and dive angle on the windscreen, and Pave Penny laser-tracking pods under the fuselage. The aircraft also have armament control panels, and infrared and electronic countermeasures to handle surface-to-air-missile threats.

The Thunderbolt II's 30mm GAU-8/A Gatling gun can fire 3,900 rounds a minute and can defeat an array of ground targets, to include tanks. Some of their other equipment includes an inertial navigation system, electronic countermeasures, target penetration aids, self-protection systems, and AGM-65 Maverick and AIM-9 Sidewinder missiles.

Background

The first production A-10A was delivered to Davis-Monthan Air Force Base, AZ., in October 1975. It was designed specially for the close air support mission and had the ability to combine large military loads, long loiter, and wide combat radius, which proved to be vital assets to America and its allies during Operation Desert Storm. In the Gulf War A-10s, with a mission capable rate of 95.7 percent, flew 8,100 sorties and launched 90 percent of the AGM-65 Maverick missiles used there.

General Characteristics

Primary Function: Close air support.
Contractor: Fairchild Republic Co.
Power Plant: Two General Electric TF34-GE-100 turbofans.
Thrust: 9,065 pounds (4079.25 kilograms) each engine.
Length: 53 feet, 4 inches (16.16 meters).
Height: 14 feet, 8 inches (4.42 meters).
Wingspan: 57 feet, 6 inches (17.42 meters).
Speed: 420 mph (Mach 0.56).
Ceiling: 1,000 feet (303 meters).
Maximum Takeoff Weight: 51,000 pounds (22,950 kilograms).
Range: 288 miles (250 nautical miles) carrying 9,500 pounds (4,275 kilograms) of weapons and with a 1.7-hour loiter time.
Armament: One 30 mm GAU-8/A seven-barrel Gatling gun; up to 16,000 pounds (7,200 kilograms) of mixed ordnance on eight under-wing and three under-fuselage pylon stations, including 500 pounds (225 kilograms) of retarded bombs, 2,000 pounds (900 kilograms) of general-purpose bombs, incendiary and Rockeye II cluster bombs, combined effects munitions, Maverick missiles and laser-guided/electro-optically guided bombs; infrared countermeasure flares; electronic countermeasure chaff; jammer pods; 2.75-inch (6.99 centimeters) rockets; and illumination flares.
Crew: One.
Introduction Date: March 1976.
Unit Cost: $8.8 million.
Inventory: Active force, 72 A-10s and 60 OA-10s; ANG, 84 A-10s, 24 OA-10s; Reserve, 87 A-10s.

2.4.6 F-16 Falcon

Figure 2.12: F-16 Falcon

The F-16 was the most successful fighter of its generation. In early 1997 about 3600 had been delivered (it's in use with over 17 air forces), and production was expected to exceed 4000. The F-16 began life as a research project for a very light fighter, optimized for dogfighting. The project looked promising enough to develop a real fighter from it, but common sense dictated that manoeuvrability is not the only requirement for a fighter, and the production F-16 is heavier and bigger than the original concept. Still, it is one of the best dogfighting aircraft. Typical for the F-16 are the wings of cropped delta configuration, blended with the fuselage, and with long forward wing extensions.

Type	F-16A
Function	fighter
Year	1976
Crew	1
Engines	1 * 105.7kN P&W F100-PW-220
Wing Span	10.00 m
Length	15.03 m
Height	5.09 m
Wing Area	27.90 m2
Empty Weight	7387 kg
Max.Weight	17010 kg
Max. Speed	Mach 2.05
Ceiling	16750 m
Max. Range	3900 km
Armament	1*g 20 mm 9276 kg payload
Unit cost	20 million USD

The Lockheed (formerly General Dynamics) F-16 Fighting Falcon is the most numerous fighter in the West. Many F-16A/Bs have seen over a decade of service, being modernised in operational upgrade programs. The Fighting Falcon was conceived as lightweight *no frills* fighter for air-to-air combat but despite this, and despite its small dimensions and light weight, has envolved into a versatile and effective multi-role workhorse. First flown on 20 January 1974, the service-test YF-16 defeated Northtropś YF-17 in a fly-off competition. The first of eight FSD F-16A airframes flew in 1975, the first FSD F-16B in 1977. The two-seat version retains wing and fuselage dimensions of the single seater while sacrificing 1,500 lb (680 kg) of fuel.

Nicknames the *Viper*, the F-16 cuts a unique silhoutte, with its shock-inlet air intake located under the forward fuselage below its pilot. The Falconś unusual shape features wing/body blending and large leading-edge root extensions to enhance lift at high angles of attack. While its high Alpha cabability is limited by comparison with that of the F/A-18 and the latest Russian *superfighters* its very high trust to weight ratio, fast roll rate and high wing lift make it a very agile fighter. Among its once novel characteristics, the F-16 is statically unstable, relying on a central computer and electronic *Fly By Wire* controls to remain controllable.

The F-16A pilot sits on a zero-zero ACES II canted to recline 30°. This improves average g tolerance and necessitates provision of a limited movement pressure-sensing sidestick controller in place of a conventional joystick. The cockpit has HUD and multifunction displays, and a one-piece canopy of blown polycarbonate with no windscreen and thus no framing forward of the pilotś shoulderline. This gives an incomparable all-round view, the F-16ś most radically new feature and a great boon for dogfighting. The two-seat F-16B has full combat capability, but with reduced fuel capacity.

The F-16A/B is armed with a General Electric M61A1 Vulcan, 20-mm cannon with 511 rounds, located on the port side at the blend between wing and fuselage. On a typical mission, an F-16A/B can carry as much as 16,700 lb (7575 kg) of ordnance, including Mk 20 Rockeye and CBU-87 cluster bombs, Mk 83 and Mk 84 500-lb (227-kg) and 1,000 lb (454 kg) bombs, AGM-65 Maverick missiles, and GBU-10 and GBU-15 guided weapons. Except for ADF variants, all F-16A/Bs now have air-to-ground work as their primary duty, with air combat important but secondary. Still, pilots praise the manoeuvrability, high g tolerance, heat-seeking missiles and gun, all which enable them to *yank and bank* with an enemy fighter. Pilots are not pleased about what one fliers calls **the conscious decision not to give it a radar missile** to fight beyond visual range, claiming that **we dont́ have a long enough spear to do battle with *Floggers* and *Fulcrums*.**

NATOś search for an F-104 replacement led in June 1975 to the *sale of the century* in which Belgium, Denmark, the Netherlands and Norway selected the F-16A/B. SABCA in Belgium was responsible for the manufacture of 221 aircraft mainly for Belgium and the Denmark, whilst Fokker in Holland built 300 aircraft primarily for the Royal Netherlands Air Force and Norway. Some Dutch aircraft are equipped with a centerline tactical reconnaissance pod, and are designated F-16A(R). Subsequent OCUs have brought improvements to F-16A/Bs on both continents, while additional countries have taken the A model *Viper* into their inventories. Many of these nations were initially offered the significantly inferior J79-powered F-16/79, but were able to buy the full-standard F100-engine F-16 when President Reagan relaxed some of the arms sales controls imposed by his predecessor.

Service Entry

Delivery of operational USAF F-16A/Bs began in January 1979 to the 338th Tactical Fighter Wing at Hill AFB, UT. Despite teething troubles with engine malfunctions and structural cracks, the F-16 developed into a superb fighter-bomber. The F100-PW-100 engine encountered problems, including ground-start difficulties, compressor stalls, fuelpump breakdowns and afterburner malfunctions, most of which were corrected early in the aircraft's career. The F-15, which shared a common powerplant, suffered simular problems, an ironic development when this commonality was a powerful factor in the selection of the F-16 over the rival Northtrop YF-17.

Versions of the F-16A were tested with APG-65 radar and J79 and YJ101 engines. In December 1975, the first YF-16 was rebuilt with twin canards added, to become the USAF Flight Dynamics Laboratory's CCV (Control-Configured Vehicle). General Dynamics converted the fifth FSD F-16A into the AFTI (Advanced Fighter Technology Integration) aircraft, or AFTI/F-16A. The AFTI/F-16A has a triplex digital flight-control system, larger vertical canard surfaces at the air intake, and a thick dorsal spine; this aircraft was used in recent close air support studies before being laid up by funding constraints. The SCAMP (Supersonic Cruise and Manoeuvring Prototype), or F-16XL, was yet another special version with a 'cranked delta' wing. Two F-16XLs, a single- and a two-seater, have gone on to participate in various research efforts.

The F-16A/B was built in distinct production blocks numbered 1, 5, 10, and 15. Forty-three F-16A/B Block 1s (21 F-16As and 22 F-16Bs) can be distinguished from later Fighting Falcons by their black radomes. F-16A/B Block 5s numbered 126 (99 F-16As and 27 F-16Bs). F-16A/B Block 10 consists of 170 aeroplanes including 145 F-16As and 25 F-16Bs, in addition to all surviving earlier machines which have been upgraded.

F-16A/B Block 15 introduced the first important changes to the F-16. Noteworthy in Block 15 is the extended horizontal stabilator, or 'big tail', now standard on these and all subsequent Fighting Falcons. Pilots prefer the small tail for dogfighting but the big tail gives greater rudder authority when carrying a heavy ordnance load. Because of the wing cracks and afterburner problems, the USAF is expected to retire all of its pre-Block 15 'small tail' ships by the mid-1990s, making Block 15s the oldest F-16s in service. Block 15 compromises 457 American aircraft (410 F-16As, 47 F-16Bs), 270 of which were chosen for conversion to F-16A/B ADF with interceptor duties.

European Upgrades

The OCU (Operational Capabilities Upgrade) program, adopted by Belgium, Denmark, the Netherlands and Norway, improves the avionics and fire control systems, adds ring-laser INS and provides for the upgrading of the F100-PW-200 engine to F100-PW-220E. From 1988 exports were to Block 15 OCU standard, while surviving F-16A/Bs of the AFRES and ANG were upgraded with F100-PW-220Es. Further improvements planned for the F-16A/B include the MLU (Mid-life update) which brings the cockpit to Block 50 standard with wide-angle HUD and NVG compability. New avionics include a modular mission computer, APG-66(V2A) radar and Navstar GPS. Options include wiring for intake-mounted FLIR and helmet-mounted sight. The four European nations are customers for MLU aircraft, and the aircraft offered to Taiwan are also to this standard. USAF aircraft will adopt some of the MLU features.

F-16C and F-16D

The Lockheed (General Dynamics) F-16C Fighting Falcon first flew on 19 June 1984. F-16C and two-seat F-16D models are distinguished by an enlarged base or 'island' leading up to the vertical fin with a small blade antenna protruding up from it. This space was intended for the internal ASPJ (airborne self-protection jammer) which the USAF abondoned in favor of continuing use of external ECM pods.

Compared with earlier versions, the F-16C/Ds gives the pilot a GEC wide-angle HUD and a function keyboard control at the base of the HUD (located in a console to his left in earlier ships) and an improved data-display with key items of information located at 'design eye' level for HOTAS flying. F-16C/Ds employ Hughes APG-68 multi-mode radar with increased range, sharper resolution and expanded operating modes, and have a weapons interface for the AGM-65D Maverick and AMRAAM missiles.

F-16C single-seat and combat-capable F-16D two-seat fighters introduced progressive changes, some installed at the factory and other parts of MSIP II (avionics, cockpit and airframe changes) and MSIP III (further systems installation) programs, aimed at enhancing the Fighting Falcons's ability to fly and fight at night.

F-16C/D aircraft retain the unique, low-slung configuration of earlier Fighting Falcons variants, with fuselage-wing 'blending', fly-by-wire controls, ACES II ejection seat, and a blown polycarbonate canopy which, in these later versions, has a gold tint because of its lining of radar reflecting materials. F-16C/D models retain the General Electric M61A1 20-mm cannon with 515 rounds and a capability for the delivery of up to 16,700 lb (7575 kg) of ordnance, including most bombs and missiles in the inventory.

Block 25 aircraft entered production in July 1984 and numbered 319, 289 F-16Cs and 30 F-16Ds. With Block 30/32 came configured (formerly 'common') engine bay with options for the GE F110-GE-100 (Block 40) or PW&W F100-PW-220 (Block 42).

F-16C Blocks 30 and 40 are powered by the General Electric F110-GE-100 offering 28, 984 lb (128.9 kN), while F-16C Blocks 32 and 42 Falcons introduced 23,840-lb (106.05-kN) thrust Pratt & Whitney F100-PW-200s. This powerplant change brought a need to alter the contours of the F-16's air intake to accommodate the larger amount of air ingested. Because the change was not made initially, early F-16C/D Block 30s are 'small inlet' aeroplanes, the 1-ft (0.30-m) larger air intake having become standard for GE power on 'big inlet' ships after deliveries began. USAF F-16C/D delivery totals slightly favor the GE engine.

F-16C/D Block 32 aeroplanes are identical to those in Block 30 but for the F100-PW-220 engine, introduction of which marks a maturing of the original F-16 powerplant. While the improved

P&W engine is not as powerful as the GE-powerplant, it is lighter and crew chiefs consider it 'smarter' and more dependable then earlier P&W models. In addition, Block 30/32 aircraft have the capability for carriage of AGM-45 Shrike and AGM-88A HARM anti-radiation missiles, and AIM-120 AMRAAM. Avionics hardware changes are also introduced with Block 30/32, which total 501 aircraft, comprising 446 F-16Cs and 55 F-16Ds. In addition to tactical squadrons, the F-16C/D Block 32 is flown by the USAF's Adversary Tactics Division on aggressor duties, and by the 'Thunderbirds' aerial demonstration team.

F-16C/D Block 40/42 Night Falcon aircraft began to come off the Fort Worth production line in December 1988. This version introduces LANTIRN navigation and targeting pods, Navstar GPS navigation receiver, AGM-88B HARM II, APG-68V radar, digital flight controls, automatic terrain following and, as a consequence, increased take-off weight. Greater structural strength increases the Night Falcon's 9-g capability from 26,900 lb (12201 kg) to 28,500 lb (12928 kg).

The heavier all-up weight has resulted in larger landing gear to accommodate LANTIRN, bulged landing gear doors and the movement of landing lights to the nose gear door. Block 40/42 Night Falcons have been delivered to the USAF, Israel, Egypt, Tyrkey, and Bahrain. An AMRAMM-equipped Block 42 F-16D became the first USAF 'Viper' to score an air-to-air victory by downing an Iraqi Mig-25 on 27 December 1992. In 1994 F-16s shot down three Serbian aircraft over Bosnia.

A total of 249 F-16 Fighting Falcons was deployed to Operation Desert Storm and flew almost 13,500 sorties, the highest sortie total for any aircraft in the war, while maintaining a 95.2 per cent mission capable rate, 5 per cent better than the F-16's peacetime rate. F-16s attacked ground elements in the Kuwaiti Theatre of Operations, flew anti 'Scud' missions, destroying military production, chemical production facilities, and airfields.

In December 1991, General Dynamics began delivering F-16C/D Block 50 and 52 aircraft. First flight date for Block 50 was 22 October 1991. The first Block 50s went to the 338th Fighter Wing at Hill Air Force Base, UT, in 1992, followed by delivery to USAFE's 52nd FW. Block 50/52 'Vipers' introduced the Westinghouse AN/APG-68(V5) radar with improved memory and more modes, new NVG-compatible GEC HUD, and improved avionics computer. Numerous other additions to Block 50/52 include a Tracor AN/ALE-47 chaff/flare dispenser, ALR-56M radar warning receiver, Have Quick IIA radio, Have Sync anti-jam VHF and full HARM integration.

These latest F-16s are powered by the IPE (Improved Performance Engine) versions of GE and P&W engines, the 29,588-lb (131.6-kN) F110-GE-229 and 29,100-lb (129.4-kN) F100-PW-220, respectively. Problems arose with developmental test ships for the Block 52 program in July 1991, and these had to be refitted with older F100 variants until Pratt & Whitney IPE's fourth fan blade could be redesigned.

Around 100 USAF F-16C/D Block 50/52 aircraft are being raised to Block 50/52D standard, with provision for the ASQ-213 pod carried under the starboard side of the intake. This pod is known at the HARM Targeting System, and provides the F-16 with a limited Wild Weasel defence suppression capability to argument the dwindling F-4G force. Further USAF programs now include the RF-16 tactical reconnaissance aircraft carrying the ATARS IR/EO sensor pod, fitment of head-steered FLIR sensor and helmet-mounted sights and modifications of Block 30/32/40/42 aircraft for the CAS/BAI mission.

In 1991, USAF began studying an MRF (Multi-Role Fighter) which would replace the F-16 in the 21st century. The future of MRF is doubtful, especially since USAF F-16C/Ds (in contrast to ageing F-16A 'small tail' Block 10s) have a relatively low airframe hours and will not need early replacement. The proposed Block 60/62 F-16 would utilise some technology developed for the F-22 to answer the MRF requirement.

The F-16C/D has been widely exported. Licensed production is undertaken by TAI in Turkey and Samsung Aerospace in South Korea.

Many F-16Ds delivered to Israel have been subsequently fitted with a very bulged spine, housing unidentified indigenous avionics reportedly associated with the Wild Weasel/SAM suppression role. No. 101 Squadron now seems to be entirely equipped with these aircraft.

2.5 Sweden

2.5.1 JA-37 Viggen

Figure 2.13: JA-37 Viggen

STOL-jet fighter of canarded delta configuration. The Viggen was designed to fulfill several roles with one basic airframe, but in multiple versions: fighter-bomber, attack aircraft, tactical recce, sea surveillance, operational trainer, and pure fighter. The canards and a thrust reverser — the combination of this with an afterburner is unique — make the Viggen capable of operating from small, dispersed airstrips. The JA 37 is the fighter version.

Saab 37 Viggen

Viggen is a multi-role fighter, through upgrades still modern and with some almost unique features, in service with the Swedish air force in several versions, since 1971 and until after 2006. The name Viggen means The Thunderbolt, especially those resulting from the Norse god Thor's warhammer Mjölner.

In 1952 studies were started to design a replacement for Saab Draken. "Project 1357" in 1954, was the first to have a canard layout (lots of other layouts were studied as well). I n 1961, PW JT8D-22 was the chosen engine to be locally built, with a locally designed afterburner and lots of material changes in the rest. In 1962 the design was frozen, and the prototype first flew in Feb 8:th 1967. During the 1960's, it was foreseen that the Swedish air force would purchase 800+ Viggens, but the final figure ended up at 329. In order to make the airframe smaller, it was early decided to replace the navigator with a good navigational computer. It's designed to withstand 12 G, but the limit in operation is 7 G.

Emergency power is supplied by a ram air turbine just before the left wing leading edge, which extends automatically on hydraulic power failure, and just before touch down. (Earlier, it was also always deployed whenever the landing gear was down.) The canard doesn't contribute much lift in itself during normal flight, it acts more as a gigantic vortex generator for the main wing. During low speed flight, its rear edge flap can be lowered to increase lift and permit a high nose angle.

The requirement was that the aircraft would be able to operate from 500 m runways. A short take-off run is possible due to the powerful engine (then, it was the most powerful installed in a fighter). Landing distance is reduced by several means: The HUD is used as a precision landing aid, making it possible to aim just 30 m in from the threshold; The landing gear thinks a landing sink rate of 5 m/s is normal, so landings are done without any flare; The thrust reverser is interconnected with the nose gear link, so it can be selected in the air and will operate when the nose is lowered. (It is not intended to be used in the air.).

The aircraft must be servicable very quickly by concripts with relatively short training. Refueling and re-arming by 7 men, of which 6 are concripts, must take less than 10 min for the JA 37 Viggen. The time limits for reconnaissance and attack configured aircraft are 15 and 20 minutes. It is said that attack squadrons expect to fly 11 missions per aircraft and 24-hour period.

AJ 37 Viggen

108 delivered starting in 1971, expected to remain in service until about 1998. Serial numbers 37001-37108.
This is the strike variant. When it was designed, guns were definitely passé, so there was no provision made for an internal cannon. Dumb bombs weren't popular either, so during the preliminary design stages, the only armament considered were missiles. It wasn't until the prototypes were actually in progress of beeing built, that someone thought of incorporating wiring for iron bombs, presumably as it was realised the HUD/Weapons Aiming Computer system would enable them to be dropped with good precision.

Main armament for the anti-shipping role, a very important role, is the Saab 304 rocket-powered anti-ship missile. For ground attack, 135 mm Bofors M70 rockets in pods of six each, were together with the command controlled, smoke-less liquid fuel Saab 305 missile, the main weapons, with the 120 kg bombs and 30 mm podded guns used when appropriate. The Saab 305/Rb 05 missile is now an all round weapon, as it is rather effective against slow, large aircraft and helicopters too. A TV version was contemplated as the Rb 05B, but it was cheaper to buy Mavericks instead. It has always had a secondary fighter role, with Sidewinders and 30 mm cannon in pods. In service, it replaced the A 32A Lansen.

Sk 37 Viggen

17 delivered starting in 1973, will remain in service for a long time yet. Serial numbers 37801-37817.
To make room for the second cockpit, fuel and avionics was removed, so it has a shorter range and lacks a radar. The fin is taller. The rear cockpit has two periscopes to give forward vision. The trainer version wasn't planned from the outset, as it was considered enough for pilots to learn to fly delta winged aircraft on Draken trainers.

SF 37 Viggen

28 delivered between 1977 and 1980, will remain in service until about 2005. Serial numbers 37950-37977.
All fixed cameras are carried in the nose, that lacks a radar. There are three SKa 24C-120 for horizon-to-horizon coverage, an SKa 24-57 for wide angle pictures and two SKa 31-600 for high altitude or stand off photography. There is also an IR-linescan designated VKA 702. For night photography, a pod is carried on the left fuselage station, with three SKa 34-75 cameras loaded

with IR sensitive film in the front. The rear of the pod houses electronic IR flashes, as does a complementary pod on the starboard fuselage station. In service it has replaced the S 35E Draken.

JA 37 Jaktviggen

149 delivered between 1979 and 1990, will remain in service until 2010-15. Serial numbers 37301-37449.
By the time this version was in final design, it was clear that guns were definitely useful, so it was given the most powerful cannon a fighter has had, a 30 mm Oerlikon KCA with 150 rounds. Rate of fire is 22.5 0.36 kg rounds/s at 1050 m/s, which gives them six times more kinetic energy than the 30 mm Adens on the attack version. A unique feature is the coupling of the radar gunsighting mode to the autopilot. When the pilot places a target in a capture window, the autopilot takes over pitch and yaw, and presents bank information on the HUD for the pilot to follow. Even if it's not followed, the pitch and yaw channels have enough authority to precision aim the cannon, reducing pilot workload letting him or her concentrate on tactics and situational awareness. The fighter version has an intertial navigation system instead of the earlier versions' doppler navigation system. It is 13 cm longer, partly because the RM8B engine, which is smokeless, more powerful and better suited to high altitude than the RM8A which powers the other Viggen versions, is 8 cm longer than the RM8A. There is a three stage fan, three stage LP compressor and a seven stage HP compressor, as compared to 2/4/7 on RM8A.

The fin is the same tall one as on Sk 37 to compensate for the longer fuselage. The external tank is the same size as on the other versions, but because there's a bulge where the gun is installed, there is no room for the abbrevited top fin of the tank, instead of three fins, this tank has four fins, in a flattened 'X'. The system has gone through numerous upgrades since service entry. The radar is able to track more targets now, than at service entry, for example. The lastest software upgrade, EDIT 33, enables the JA 37 to use AMRAAM missiles. In spite of having a strengthened wing, an engine 100 kg heavier (2200 kg) and a fixed cannon, it only has an empty weight 400 kg more than earlier versions. In service it has replaced and supplemented the J 35 Draken.

Technical data

	AJ/SH	SF	SK	JA
Take off run	400 m	400 m	400 m	400 m
Landing run	450 m	450 m	450 m	450 m
Landing speed	220 km/h	220 km/h	220 km/h	220 km/h
Length	16.30 m	16.50 m	16.30 m	16.43 m
Span	10.6 m	10.6 m	10.6 m	10.6 m
Height	5.6 m	5.6 m	5.6 m	5.9 m
w folded fin	4.0 m	4.0 m	4.0 m	4.0 m
Engine thrust	6690 kp	6690 kp	6690 kp	7415 kp
w afterburner	11790 kp	11790 kp	11790 kp	13125 kp
Range	2000 km	2000 km		2000 km
Empty weight	9500 kg	9500 kg		9500 kg
Max payload	3600 kg	2500 kg		1700 kg
Max take off weight	18000 kg	17000 kg		18600 kg
Max speed low altitude	Mach 1.1	Mach 1.1		Mach 1.2
Max speed high altitude	Mach 2+	Mach 2+		Mach 2+
Guaranteed speed high altitude	Mach 1.7	Mach 1.7		Mach 1.8
Guaranteed speed Max altitude	18000 km	18000 m		18000 m

Time from brake release to 10 km or Mach 1 at low altitude: 100 s

Type	JA 37
Country	Sweden
Function	fighter
Year	1977
Crew	1
Engines	1 * 12750kg Volvo RM 8B
Wing Span	10.60m
Length	16.40m
Height	5.90m
Wing Area	52.20m2
Max.Weight	about 17000kg
Speed	2124km/h
Ceiling	18300m
Armament	1*g30mm 6000 kg

2.6 France

2.6.1 Super Etendard

Figure 2.14: Super Etendard

This is a development of the Etendard IVM, reengined and with many changes in structure and equipment. The Super Etendard is a shipboard attack aircraft. The French Aeronavale bought 71; fourteen were sold to Argentina and five were loaned to Iraq. The Argentinian and Iraqi aircraft saw combat and proved effective in combination with the Exocet missile. In French service, the Super Etendard can carry nuclear weapons.

Type	Super Etendard
Function	attack
Year	1978
Crew	1
Engines	1 * 49.03kN SNECMA Atar 8K-50
Wing Span	9.60 m
Length	14.31 m
Height	3.86 m
Wing Area	28.40 m2
Empty Weight	6460 kg
Max.Weight	11500 kg
Speed	1380 km/h
Ceiling	13700 m
Armament	2*g30 mm 2100kg
Unit cost	12 million USD

2.7 France/Germany

2.7.1 Alpha Jet

Figure 2.15: Alpha Jet

French/German jet trainer and strike aircraft. That is, the French version is a trainer, and the German one is primarly a strike aircraft, replacing the Fiat G.91. The Alpha Jet is a twin-engined aircraft with a high-set, moderately swept wing.

The Alpha Jet shows that an aircraft need not be a technological marvel to be an effective warplane. Simple, cheap and easy to maintain, the Alpha Jet is perfectly suited to lower intensity warfare.

State-of-the-art ground attack and strike aircraft do not come cheap, and for many air forces the capabilities of the Tornado or the Strike Eagle would be wasted. However, there are much less expensive aircraft, often designed for different purposes, which are capable of undertaking ground attack missions in lower threat environments. The Dassault-Breguet/Dornier Alpha Jet is a Franco-German advanced trainer which was designed to have a secondary attack role. Indeed, German Alpha Jets are flown almost exclusively as single-seat close-support, weapons trainer or battlefield reconnaissance aircraft. Weapons load and avionics do not match those of more advanced jets, but the Alpha Jet is maneuverable, easy to fly and simple to maintain. The Alpha Jet has been sold to a number of countries in Africa and the Middle East.

Type	Alpha Jet A
Function	trainer / strike
Year	1977
Engines	2 * 1350 kg SNECMA/Turbomeca Lazrac O4-C5
Wing Span	9.11 m
Length	13.23 m
Height	4.33 m
Wing Area	17.50 m2
Empty Weight	3515 kg
Max.Weight	8000 kg
Speed	Mach 0.86
Ceiling	15000 m
Range	2780 km
Speed	Mach 0.86
Armament	1*g27 mm 2500 kg
Unit cost	7 million USD

Chapter 3

1980-1990

3.1 USA

3.1.1 F/A-18 Hornet

Figure 3.1: F/A-18 Hornet

Twin-engined shipboard fighter, developed from the smaller F-17. Because of its dual role as attack aircraft, it is officially known as the F/A-18. The F-18 is a medium-sized fighter, heavier than the F-16 but lighter than the F-14 and F-15. The RF-18 is a recce version, without the internal gun and with cameras in the nose. The USN planned to replace a lot of combat aircraft by the multifunctional F/A-18. The F-18 has also been sold abroad, to Canada, Australia, Spain, and others. Current planning is for a substantially modified F-18E 'Super Hornet', which was rolled out at the end of 1995 and made its first carrier landing in early 1997. This F-18E and the two-seat F-18F can be recognized easily by their rectangular engine intakes, which reduced radar reflection and provide a greater mass flow for their more powerful engines. The F-18E is also longer and has a bigger wing, with two additional hardpoints, and has sturdier landing gear to cope with the increased weight. Range has been increased by 40%. The F-18E is expected to enter service in 2000.

Type	F-18A	F-18E
Function	fighter/attack	fighter/attack
Crew	1	1
Year	1980	2000
Engines	2 * 7250kg GE F404-GE-400	2 * 97.9 kN G.E. F414-GE-400
Max.Weight	22317 kg	29937 kg
Max. Speed	2125 km/h	Mach 1.8+
Ceiling	15250 m	15240m
Armament	1*g20mm 7700 kg	unknown
Unit cost	32 million USD	unknown

F/A-18A/B, C/D Hornet

Description: All-weather fighter and attack aircraft. The single-seat F/A-18 Hornet is the nation's first strike-fighter. It was designed for traditional strike applications such as interdiction and close air support without compromising its fighter capabilities. With its excellent fighter and self-defense capabilities, the F/A-18 at the same time increases strike mission survivability and supplements the F-14 Tomcat in fleet air defense. F/A-18 Hornets are currently operating in 37 tactical squadrons from air stations world-wide, and from 10 aircraft carriers. It is proudly flown by the U.S. Navy's Blue Angels Flight Demonstration Squadron.

Features: The F/A-18 Hornet, an all-weather aircraft, is used as an attack aircraft as well as a fighter. In its fighter mode, the F/A-18 is used primarily as a fighter escort and for fleet air defense; in its attack mode, it is used for force projection, interdiction and close and deep air support.

Background: The F/A-18 demonstrated its capabilities and versatility during Operation Desert Storm, shooting down enemy fighters and subsequently bombing enemy targets with the same aircraft on the same mission, and breaking all records for Tactical aircraft in availability, reliability, and maintainability. The aircraft's survivability was proven by Hornets taking direct hits from surface-to-air missiles, recovering successfully, being repaired quickly, and flying again the next day. The F/A-18 is a twin engine, mid-wing, multi-mission tactical aircraft. The F/A-18A and C are single seat aircraft. The F/A-18B and D are dual-seaters. The B model is used primarily for training, while the D model is the current Navy aircraft for attack, tactical air control, forward air control and reconnaissance squadrons. The newest models, the E and F were rolled out at McDonnell Douglas on Sept. 17, 1995, and are currently undergoing further testing at the Patuxent Naval Air Station in Maryland. The E is a single seat while the F is a two-seater.

All F/A-18s can be configured quickly to perform either fighter or attack roles or both, through selected use of external equipment to accomplish specific missions. This "force multiplier" capability gives the operational commander more flexibility in em ploying tactical aircraft in a rapidly changing battle scenario. The fighter missions are primarily fighter escort and fleet air defense; while the attack missions are force projection, interdiction, and close and deep air support.

The F/A-18C and D models are the result of a block upgrade in 1987 incorporating provisions for employing updated missiles and jamming devices against enemy ordnance. C and D models delivered since 1989 also include an improved night attack capability.

General Characteristics, C and D models

Primary Function: Multi-role attack and fighter aircraft
Contractor: Prime: McDonnell Douglas; Major Subcontractor: Northrop
Unit Cost: $ 24 million
Propulsion: Two F404-GE-402 enhanced performance turbofan engines

Thrust: 17,700 pounds (8,027 kg) static thrust per engine
Length: 56 feet (16.8 meters)
Height: 15 feet 4 inches (4.6 meters)
Maximum Take Off Gross Weight: 51,900 pounds (23,537 kg)
Wingspan: 40 feet 5 inches (13.5 meters)
Range Fighter: 1,379 nautical miles (1585.9 miles/2,537 km);
Range Attack: 1,333 nautical miles (1532.9 miles/2,453 km)
Ceiling: 50,000+ feet
Speed: Mach 1.7+
Crew:
A,C and E models: One
B,D and F models: Two
Armament: One 20mm M-61A1 Vulcan cannon; External payload: AIM 9 Sidewinder, AIM 7 Sparrow, AIM-120 AMRAAM, Harpoon, Harm, Shrike, SLAM, SLAM-ER, Walleye, Maverick missiles; Joint Stand-Off Weapon (JSOW); Joint Direct Attack Munition (JDAM); various general purpose bombs, mines and rockets.
First flight: November 1978
Operational: October 1983 (A/B models); September 1987 (C/D models)

General Characteristics, E and F models

Primary Function: Multi-role attack and fighter aircraft
Contractor: McDonnell Douglas
Unit Cost: $ 35 million
Propulsion: Two F414-GE-400 turbofan engines
Thrust: 22,000 pounds (9,977 kg) static thrust per engine
Length: 60.3 feet (18.5 meters)
Height: 16 feet (4.87 meters)
Maximum Take Off Gross Weight: 66,000 pounds (29,932 kg)
Wingspan: 44.9 feet (13.68 meters)
Ceiling: 50,000+ feet
Speed: Mach 1.8+
Crew:
A,C and E models: One
B,D and F models: Two
Armament: One 20mm M-61A1 Vulcan cannon; External payload: AIM 9 Sidewinder, AIM 7 Sparrow, AIM-120 AMRAAM, Harpoon, Harm, Shrike, SLAM, SLAM-ER, Walleye, Maverick missiles; Joint Stand-Off Weapon (JSOW); Joint Direct Attack Munition (JDAM); various general purpose bombs, mines and rockets.
First Flight: December 1995

3.1.2 EF-111A Raven

Figure 3.2: EF-111A Raven

The swing-wing F-111 was designed as a multi-role aircraft, but ended as an attack/strike aircraft. It was the result of an unwise and unhappy attempt to fulfill different USAF and Navy requirements with a single aircraft. The F-111B shipboard fighter, developed in cooperation with Grumman, was a complete failure. The F-111 strike fighter itself had a difficult start, but accumulated a good service and combat record in later years. Production was 563 aircraft. One F-111A was modified to the RF-111A/D configuration with cameras and SLAR.

The FB-111 is a strategic bomber development of the F-111. The FB-111 is longer and can carry more fuel, but doesn't have real intercontinental range; this is compensated by its missile armament.

The EF-111A is a modified F-111A. The F-111A was well-suited for modification to the role of an airborne electronic warfare platform because of its structural strength, maneuverability and performance – including the ability to penetrate enemy airspace and escape at supersonic speed. Exterior modifications include a narrow canoe-shaped radome, about 16 feet (4.85 meters) long, mounted under the fuselage, which house antennas for the high-powered jamming transmitters. Also, a fin-tip pod is mounted on the reinforced vertical stabilizer to house receiving antennas and ancillary equipment, including a processor to detect hostile radar emissions. The total equipment weight is about 3.5 tons (3,150 kilograms).

Interior modifications include a rearranged cockpit – the right-seat crew member is an electronic warfare officer responsible for navigation, terrain-following flight and electronic warfare operations. The electronic warfare officer plans jamming tactics in advance, and then programs, operates and monitors the jamming system. Previous radar-jamming aircraft required several operators and more equipment to perform radar-jamming sessions. The primary electronic countermeasures unit is the AN/ALQ-99E jamming subsystem. It is an improved version of the U.S. Navy's first ALQ-99 jamming subsystem. Improvements to the Navy version include: capability to more rapidly detect and identify enemy transmissions; greater automation (and less reliance on human involvement and manual operations); expanded computer functions providing sophisticated and flexible jamming options; and more independent jamming signals over a wider range of frequencies. The AN/ALQ-99E detects radar signals, processes them and compares them to known threat radar characteristics stored in an on-board computer. Jamming subsystem receivers scan across frequency bands under computer or manual control. When threats are identified, appropriate countermeasures are initiated. Information about new threats, not in the memory of the computer, can be fed into the system either through entries on the electronic warfare officer's cockpit keyboard or by programming the computer via a cassette that plugs directly into the plane. Changing the programming takes about five minutes if plug-in modules are used. The electronic warfare officer can test the information and, if necessary, make corrections using the keyboard and cockpit display unit.

A self-protection subsystem is designed to protect the EF-111A against radar-directed, anti-aircraft artillery, and missile or aircraft threats. The EF-111A provides protection by using a jamming orbit where it stands off from threat radars to cover friendly aircraft entering and leaving the threat areas, or by using the aircraft's high-performance capabilities to directly support attacking forces. In the direct support mission, the Raven may fly as in escort position or enter a threat area to the best jammer position. Ravens engaged in direct support often use the extensive night terrain-following capability built into the basic F-111 design.

The aircraft are being updated with modern digital navigation and flight-control systems, which equip the airplane with ring-laser gyro and global-positioning navigation systems, as well as improved controls and displays. The radar and terrain-following flight system are also being updated. Grumman modified about 40 F-111As to EF-111 configuration.

Type	F-111D	F-111F
Function	attack	attack
Year	1971	
Empty Weight		21398kg
Max.Weight		45359kg
Engines	2 * 8890kg P&W TF30-P-9	2 * 11385kg P&W TF30-P-100
Max. Speed	2660km/h	2655km/h
Max. Range	6100km	4710km
Armament		1*g 20mm

Type	FB-111A	EF-111A
Function	bomber	electronic warfare aircraft
Year	1969	1981
Engines	2 * 90.58kN P&W TF30-P-7	2 * 8391kg P&W TF30-P-3
Speed	2335 km/h	2216 km/h
Wing Span		19.20m/9.74m
Length		23.16m
Height		6.10m
Wing Area		48.77 m^2
Empty Weight		25072 kg
Max.Weight		40370 kg
Range		3300 km.
Armament	17000kg	
Unit cost	50 million USD	

Mission

The F-111 is a multipurpose tactical fighter bomber capable of supersonic speeds. It can operate from tree-top level to altitudes above 60,000 feet (18,200 meters).

Features

The F-111 has variable-sweep wings that allow the pilot to fly from slow approach speeds to supersonic velocity at sea level and more than twice the speed of sound at higher altitudes. Wings angle from 16 degrees (full forward) to 72.5 degrees (full aft). Full-forward wings give the most surface area and maximum lift for short takeoff and landing. The F-111 needs no drag chute or reserve thrust to slow down after landing.

The two crew members sit side-by-side in an air-conditioned, pressurized cockpit module that serves as an emergency escape vehicle and as a survival shelter on land or water. In emergencies, both crew members remain in the cockpit and an explosive cutting cord separates the cockpit module from the aircraft. The module descends by parachute. The ejected module includes a small portion of the wing fairing to stabilize it during aircraft separation. Airbags cushion impact and help keep the module afloat in water. The module can be released at any speed or altitude, even under water. For underwater escape, the airbags raise the module to the surface after it has been severed from the plane.

The aircraft's wings and much of the fuselage behind the crew module contain fuel tanks. Using internal fuel only, the plane has a range of more than 2,500 nautical miles (4,000 kilometers). External fuel tanks can be carried on the pylons under the wings and jettisoned if necessary.

The F-111 can carry conventional as well as nuclear weapons. It can carry up to two bombs or additional fuel in the internal weapons bay. External ordnance includes combinations of bombs, missiles and fuel tanks. The loads nearest the fuselage on each side pivot as the wings sweep back, keeping ordnance parallel to the fuselage. Outer pylons do not move but can be jettisoned for high-speed flight.

The avionics systems include communications, navigation, terrain following, target acquisition and attack, and suppression of enemy air defense systems. A radar bombing system is used for precise delivery of weapons on targets during night or bad weather.

The F-111's automatic terrain-following radar system flies the craft at a constant altitude following the Earth's contours. It allows the aircraft to fly in valleys and over mountains, day or night, regardless of weather conditions. Should any of the system's circuits fail, the aircraft automatically initiates a climb.

Background

The F-111A first flew in December 1964. The first operational aircraft was delivered in October 1967 to Nellis Air Force Base, Nev. A models were used for tactical bombing in Southeast Asia.

Developed for the U.S. Navy, the F-111B was canceled before its production . F-111C's are flown by the Royal Australian Air Force.

The F-111D has improved avionics with better navigation, air-to-air weapon delivery systems, and newer turbofan engines. The F-111D's are flown by the 27th Fighter Wing, Cannon Air Force Base, N.M.

The E model has modified air intakes to improve the engine's performance at speeds above Mach 2.2. Most F-111Es serve with the 20th Fighter Wing, Royal Air Force Station Upper Heyford, England, to support NATO. F-111E's were deployed to Incirlik Air Base, Turkey, and were used in Operation Desert Storm.

The F-111F has Improved turbofan engines give F-111F models 35 percent more thrust than previous F-111A and E engines. The avionics systems of the F model combine features of the F-111D and E. The last F model was delivered to the Air Force in November 1976. The F models have been modified to carry the Pave Tack system in their weapons bays. This system provides an improved capability to acquire, track and designate ground targets at night for delivery of laser, infrared and electro-optically guided weapons.

The F-111F was proven in combat over Libya in 1986 and again over Iraq in 1991. Although

F-111F's flew primarily at night during Operation Desert Storm, aircrews flew a particularly notable daytime mission using the Guided Bomb Unit (GBU-15) to seal the oil pipeline manifold sabotaged by Iraq, allowing the oil to flow into the Persian Gulf.

The F-111G is assigned to the 27th Fighter Wing at Cannon Air Force Base and is used in a training role only. The G model is a converted FB-111A. The conversion made minor avionics updates and strengthened the aircraft to allow its use in a more dynamic role as a fighter aircraft.

General Characteristics

Primary Function: Multipurpose tactical fighter bomber.
Contractor: General Dynamics Corporation.
Unit cost: $18 million.
Power Plant: F-111A/E, two Pratt & Whitney TF30-P103 turbofans.
Thrust: F-111A/E, 18,500 pounds (8,325 kilograms) each with afterburners; F-111D, 19,600 pounds (8,820 kilograms) with afterburners; F-111F, 25,000 pounds (11,250 kilograms) with afterburners.
Length: 73 feet, 6 inches (22.0 meters).
Height: 17 feet, 1 1/2 inches (5.13 meters).
Wingspan: 63 feet (19 meters) full forward; 31 feet, 11 1/2 inches (11.9 meters) full aft.
Speed: F-111F – Mach 1.2 at sea level; Mach 2.5 at 60,000 feet.
Ceiling: 60,000-plus feet (18,200 meters).
Range: 3,565 miles (3,100 nautical miles) with external fuel tanks.
Weight: F-111F, empty 47,481 pounds (21,367 kilograms).
Maximum Takeoff Weight: F-111F, 100,000 pounds (45,000 kilograms).
Armament: Up to four nuclear bombs on four pivoting wing pylons, and two in internal weapons bay. Wing pylons carry total external load of 25,000 pounds (11,250 kilograms) of bombs, rockets, missiles, or fuel tanks.
Crew: Two, pilot and weapon systems officer.
Date Deployed: October 1967.
Inventory: Active force, 225; ANG, 0; Reserve, 0.

3.1.3 F-20 TigerShark

Figure 3.3: F-20 TigerShark

The previous name of this fighter was F-5G, indicating that it was a single-engined development of the F-5. The F-20 had 80% more engine power, modern avionics, and an enlarged wing. It was a capable aircraft but found no customer, because the USAF preferred to stick with the F-16. It was also offered to the USN in the ”aggressor” role, but was again rejected in favour of the F-16. Without home market there was little hope for export orders. Three built.

Type	F-20
Function	fighter
Year	1982
Crew	1
Engines	1 * 7711 kg G.E. F404-GE-100
Wing Span	8.13 m
Length	14.17 m
Height	4.22 m
Wing Area	17.28 m^2
Empty Weight	5089 kg
Max.Weight	12475 kg
Max. Speed	2124 km/h
Ceiling	
Max. Range	2965 km
Armament	2*g 20 mm 3175 kg

3.1.4 F-117 NightHawk

Figure 3.4: F-117 NightHawk

The F-117 is a 'Stealth' attack aircraft. The logic behind its out-of-series designation remains mysterious or is non-existent. The F-117 uses flat, angled fuselage and wing panels to direct radar reflections in a few sharply defined directions. Despite the aerodynamic disadvantages of such design, and because of the computer controls, it is easy to fly. The F-117 can execute precision attacks on point targets with impunity, but has a limited weapons load. On 27 March 1999 a NightHawk was shot down over Yugoslavia.

Type	F-117A
Function	attack
Year	1982
Crew	1
Engines	2 * 48kN G.E. F404-GE-F102
Wing Span	13.20 m
Length	20.08 m
Height	3.80 m
Wing Area	105.9 m^2
Empty Weight	13609 kg
Max.Weight	23814 kg
Max. Speed	700 mph
Armament	5000 lb
Unit cost	120 million USD

Mission

The F-117A Nighthawk is the world's first operational aircraft designed to exploit low-observable stealth technology.

Features

The unique design of the single-seat F-117A provides exceptional combat capabilities. About the size of an F-15 Eagle, the twin-engine aircraft is powered by two General Electric F404 turbofan engines and has quadruple redundant fly-by-wire flight controls. Air refuelable, it supports worldwide commitments and adds to the deterrent strength of the U.S. military forces.

The F-117A can employ a variety of weapons and is equipped with sophisticated navigation and attack systems integrated into a state-of-the-art digital avionics suite that increases mission effectiveness and reduces pilot workload. Detailed planning for missions into highly defended target areas is accomplished by an automated mission planning system developed, specifically, to take advantage of the unique capabilities of the F-117A.

Background

The first F-117A was delivered in 1982, and the last delivery was in the summer of 1990. The F-117A production decision was made in 1978 with a contract awarded to Lockheed Advanced Development Projects, the "Skunk Works," in Burbank, Calif. The first flight was in 1981, only 31 months after the full-scale development decision. Air Combat Command's only F-117A unit, the 4450th Tactical Group, (now the 49th Fighter Wing, Holloman Air Force Base, N.M.), achieved operational capability in October 1983.

Streamlined management by Aeronautical Systems Center, Wright-Patterson AFB, Ohio, combined breakthrough stealth technology with concurrent development and production to rapidly field the aircraft. The F-117A program has demonstrated that a stealth aircraft can be designed for reliability and maintainability. The aircraft maintenance statistics are comparable to other tactical fighters of similar complexity. Logistically supported by Sacramento Air Logistics Center, McClellan AFB, Calif., the F-117A is kept at the forefront of technology through a planned weapon system improvement program located at USAF Plant 42 at Palmdale, Calif.

General Characteristics

Primary Function: Fighter/attack
Contractor: Lockheed Aeronautical Systems Co.

Unit Cost: $45 million
Power Plant: Two General Electric F404 engines
Length: 65 feet, 11 inches (20.3 meters)
Height: 12 feet, 5 inches (3.8 meters)
Weight: 52,500 pounds (23,625 kilograms)
Wingspan: 43 feet, 4 inches (13.3 meters)
Speed: High subsonic
Range: Unlimited with air refueling
Armament: Internal weapons carriage
Crew: One
Date Deployed: 1982
Inventory: Active force, 53; (the Air Force site lists 54, they probably don't watch the news)

3.1.5 B-1B Lancer

Figure 3.5: B-1B Lancer

The variable geometry B-1 bomber was designed as the successor for the elderly B-52. The B-1A was cancelled, partly because the high- flying bomber was obsolete, and partly for political reasons. The B-1B Lancer version, more optimized for low-altitude attacks and stealth, is now built in small numbers.

Type	B-1B
Function	bomber
Year	1986
Crew	4
Engines	4 * 13600 kg G.E. F101-GE-11
Wing Span	41.67 m/23.84 m
Length	44.81 m
Height	10.36 m
Wing Area	181.16 m2
Max.Weight	216364 kg
Speed	1375 km/h
Ceiling	14600 m
Range	12000 km
Armament	29030 kgs
Unit cost	200 million USD

Mission

The B-1B is a multi-role, long-range bomber, capable of flying intercontinental missions without refueling, then penetrating present and predicted sophisticated enemy defenses. It can perform a variety of missions, including that of a conventional weapons carrier for theater operations.

Features

The B-1B's electronic jamming equipment, infrared countermeasures, radar location and warning systems complement its low-radar cross-section and form an integrated defense system for the aircraft.

The swing-wing design and turbofan engines not only provide greater range and high speed at low levels but they also enhance the bomber's survivability. Wing sweep at the full-forward position allows a short takeoff roll and a fast base-escape profile for airfields under attack. Once airborne, the wings are positioned for maximum cruise distance or high-speed penetration.

The B-1B uses radar and inertial navigation equipment enabling aircrews to globally navigate, update mission profiles and target coordinates in-flight, and precision bomb without the need for ground based navigation aids. Included in the B-1B offensive avionics are modular electronics that allow maintenance personnel to precisely identify technical difficulties and replace avionics components in a fast, efficient manner on the ground.

The aircraft's AN/ALQ 161A defensive avionics is a comprehensive electronic counter-measures package that detects and counters enemy radar threats. It also has the capability to detect and counter missiles attacking from the rear. It defends the aircraft by applying the appropriate counter-measures, such as electronic jamming or dispensing expendable chaff and flares. Similar to the offensive avionics, the defensive suite has a re-programmable design that allows in-flight changes to be made to counter new or changing threats.

The B-1B represents a major upgrade in U.S. long-range capabilities over the aging B-52 – the previous mainstay of the bomber fleet. Significant advantages include:

- Low radar cross-section to make detection considerably more difficult.
- Ability to fly lower and faster while carrying a larger payload.
- Advanced electronic countermeasures to enhance survivability.

Numerous sustainment and upgrade modifications are ongoing or under study for the B-1B aircraft. A large portion of these modifications which are designed to increase the combat capability are known as the conventional mission upgrade program. This three phase program will increase the lethality, survivability and supportabilty of the B-1B fleet. Phase I of the program, scheduled for completion by the end of FY 96, will add the capability to release cluster bomb unit weapons. Phases II and III will further upgrade the B-1B capability, to include the ability to deliver joint direct attack munitions ans standoff weapons.

Background

The first B-1B was delivered to the Air Force at Dyess Air Force Base, Texas, in June 1985, with initial operational capability on Oct. 1, 1986. The final B-1B was delivered May 2, 1988.

The B-1B holds several world records for speed, payload and distance. The National Aeronautic Association recognized the B-1B for completing one of the 10 most memorable record flights for 1994.

General Characteristics

Primary Function: Long-range, multi-role, heavy bomber
Builder: Rockwell International, North American Aircraft
Operations Air Frame and Integration: Offensive avionics, Boeing Military Airplane; defensive avionics, AIL Division
Unit Cost: $200-plus million per aircraft
Power Plant: Four General Electric F-101-GE-102 turbofan engine with afterburner
Thrust: 30,000-plus pounds with afterburner, per engine
Length: 146 feet (44.5 meters)
Height: 34 feet (10.4 meters)
Wingspan: 137 feet (41.8 meters) extended forward, 79 feet (24.1 meters) swept aft
Speed: 900-plus mph (Mach 1.2 at sea level)
Ceiling: Over 30,000 feet (9,000 meters)
Weight: Empty, approximately 190,000 pounds (86,183 kilograms)
Maximum Takeoff Weight: 477,000 pounds (214,650 kilograms)
Range: Intercontinental, unrefueled
Armament: Up to 84 Mark 82 conventional 500-pound bombs and 30 CBU-87/89/97. Also can be reconfigured to carry a wide range of nuclear weapons
Crew: Four (aircraft commander, pilot, offensive systems officer and defensive systems officer)
Date Deployed: June 1985
Inventory: Active force, 50 (PAA) 84 (actual); ANG, 10 PAA (11 actual); Reserve , 0

3.2 Europe

3.2.1 Panavia Tornado

Figure 3.6: Panavia Tornado

Multi-role aircraft developed and built in cooperation with Germany and Italy. It is a compact twin-engined variable-geometry aircraft. The Tornado was also the first production military aircraft with flight-by-wire controls. There are strike-attack (IDS), air defence (ADV) and electronic warfare (ECR) versions. The ADV has an elongated nose. The original contractors bought 933 aircraft, but production is still underway for Saudi-Arabia. The IDS version is considered a very effective attack aircraft, but the ADV has been critized because it is a long-range interceptor with little capacity for dogfights. British IDS Tornadoes will be upgraded to GR.4 configuration. The loss of six Tornadoes during the 1992 Gulf War resulted in a storm of criticisim, most of it unjustified.

Type	Tornado F Mk.3	Tornado GR.1
Function	fighter	attack
Year	1986	1982
Crew	2	2
Engines	2 * 8530kg [1]	2 * 71.4 kN [2]
Wing Span	13.91m /8.60m	13.90m / 8.60m
Length	18.08 m	16.70m
Height	5.95 m	5.70m
Wing Area	30 m^2	30 m^6
Empty Weight	14501 kg	
Max.Weight	27987 kg	27210 kg
Speed	2333 km/h	1480 km/h
Ceiling	21335 m	15240 m
Range	3600 km	3890 km
Armament	1*g27 mm msl	2*g27mm 8980kg

History of Development.

The Tornado IDS is the baseline model that resulted from a 1968 feasibility study undertaken by the Belgian, British, Canadian, Dutch, Italian and West German governments for an advanced warplane to be designed, developed and built as collaborative venture with the object of providing the air forces of the partner nations with a STOL warplane able to undertake the close air support, battlefield interdiction, long-range interdiction, counter-air attack, air-superiority, interception and air defence, reconnaissance and naval strike roles.

Belgium and Canada withdrew at an early date, being followed by the Netherlands at a later date, and this left Italy, the UK and West Germany to persevere with project definition from May 1969 and development from July 1970. The resulting MRCA- 75 (Multi-Role Combat Aircraft for 1975) was designed as a high-performance type with a fly-by-wire control system and advanced avionics for extremely accurate navigation and safe flight at supersonic speeds and very low levels in all weathers, this being deemed the only way to ensure pinpoint day/night first-pass attacks with a heavy (and highly diverse) warload against a variety of well defended targets. Design and development of the MRCA-75 was entrusted to Panavia, which was created in 1969 as a joint venture by Aeritalia (now Alenia), BAC (now BAe) and MBB (now DASA), while the parallel engine consortium was created as Turbo-Union by Fiat, MTU and Rolls-Royce. The two main subcontractors were IWKA-Mauser for the cannon and Elliott for the electronics, and government control was provided by the NAMMA organization established in 1970 to supervise each country's contribution, which was fixed at 42.5% each by the UK and West Germany, and 15% by Italy.

With the new warplane's roles finalized, the task of the design team was to create an airframe/powerplant/electronic combination able to fulfill the resulting requirement. This demanded five core capabilities: the ability to take-off and land in very short distances for continued operational capability even if the main runways were damaged, the ability to fly at high speed at very low level over long ranges without significant degradation of crew performance, the ability to undertake low-level penetrations of hostile air space by day and/or night under all weather conditions, the ability to hit any target with complete accuracy in a first-pass attack, and the ability to attain high supersonic speed at all altitudes. The aerodynamic core of the airframe demanded by these capabilities was a variable-geometry wing: in its minimum-sweep configuration of 25 degrees this would generate high lift at takeoff and landing (thereby reducing lift-off and touch-down speeds and consequently reducing runway requirements), and in its maximum-sweep configuration of 68 degrees it would produce low wave drag for high supersonic speed as well as low gust response for a smooth low-level ride. The wing was also planned with extensive high-lift devices for further enhancement of its take-off and landing performance: these devices included double-slotted flaperons across virtually the full span of the variable-sweep trailing edges, automatically controlled slats across virtually the full span of the variable-sweep leading edges, and Krueger flaps under the leading edges of the fixed inboard wing sections. The primary flight-control surfaces were all powered, and the primary surfaces were the rudder and all-flying tailerons. The latter operated collectively for longitudinal control and differentially for lateral control, being augmented in the latter task by spoilers on the wing upper surfaces: these were designed to become operational only at sweep angles of 45 degrees and less, and to operate collectively as lift dumpers after touch-down.

Flight control was exercised via a fly-by-wire system operating in conjunction with a command stability augmentation system. The airframe was, of course, schemed in association with the powerplant and electronics. The powerplant was to comprise a pair of reheated turbofans of very low specific fuel consumption for long range and high afterburning thrust for maximum acceleration at take-off, and fitted with thrust-reversers for maximum reduction of the landing run. The avionics were based on an extremely advanced nav/attack system with fully automatic terrain-following capability to ensure all-weather penetration capability. Structural design was completed in August 1972, and the first of nine prototypes flew in April 1974, the type being named Tornado later in the same year. The Tornado IDS baseline warplane was ordered into production during July 1976, the first pre-production Tornado IDS flew in February 1977 and the type entered service in July 1980.

3.3 Soviet Union

3.3.1 SU-27 Flanker

Figure 3.7: SU-27 Flanker

The Su-27 is a big long-range air superiority fighter, comparable to the U.S. F-15 but superior in many respects. It is a twin-engined aircraft with a blended wing and fuselage, and twin tail fins. At airshows the Su-27 demonstrated an exceptional controllability at high angles of attack. A shipboard version of the Su-27, also known as the Su-33, with canards and folding wings, has been tested on Russia's first big carriers, and there also is a two-seat attack version, the Su-27IB or Su-34, with side-by-side seating in a reshaped nose.

Type	Su-27
Function	fighter
Year	1986
Crew	1
Engines	2 * 12500 kg Lyulka AL-31F
Wing Span	14.70 m
Length	21.93 m
Height	5.93 m
Empty Weight	22500 kg
Max.Weight	30000 kg
Speed	Mach 2.35
Ceiling	18000 m
Range	4000 km
Armament	1*g 30mm msl

Quick Technical Overview

The huge Su27's airframe is constructed from advanced lightweight aluminum lithium alloys, making it light for its size. The wing is designed using an ogival shape and wingroot extension. The wing has a 42 degrees leading edge sweep with full span leading edge slats and trailing edge flaperons. The flaperons combine the functions of conventional flaps and ailerons and move in unison as flaps to provide lift and drag. They move out of unison to function as ailerons.

The engines of the Su-27 are two AL31F turbofan engines designed by A.M. Lyul'la, the MMZ Saturn General Designer. These engines are deemed highly economical and is rated at 12500 kg static thrust in afterburner and at 7600 kg in military power. The AL31F engine has been proven to be reliable, robust, and maintainable. When tested in severely disturbed airflow, and in extreme conditions, the engine performed effectively. That is why maneuvers like the tail-slide and the Cobra are possible.

When the aircraft is in flight, the pilot has many options at his fingertips. He won't enter into any fatal spins or pull too many G's because of the highly sophisticated quadruplex fly-by-wire remote control system (designated EDSU by Russians) with built-in angle of attack and G limiters. The pilot has a sophisticated weapons control system using a RLPK27 coherent pulse-Doppler jam proof radar with track while scan and look-down shoot-down capabilities. The radar detection range is 240 km, and it can simultaneously track up to 10 targets at 185 km away. The pilot can simultaneously fire missiles at two targets. In case of radar failure, the pilot is backed up by a 36sh electro-optical system designed by Geophysica NPO. The electro-optical system contains a laser range finder (which has a range of 8km) and Infrared Search and Track system (which as a range of 50km). The electro-optical system can be attached to the pilot's helmet mounted target designator to allow the pilot to target by moving his head.

History

In 1969 Russia decided that they need a new fighter which is capable of outperforming all current U.S. aircraft including the F-15 Eagle and the F-16 Falcon. Sukhoi OKB won the contract, and with that they began their task of constructing what was to become the world's best fighter jet. The name designated to the development project was T10. The aircraft produced had to be capable of lookdown/shootdown capability, and be capable of destroying targets at long ranges. May 20, 1977 the first prototype designated T10-1 took off. After an evaluation it was discovered that the T10-1 did not fulfill its requirements for maximum range, and maneuverability, and thus proved inferior to its western counterparts. The prototype had aerodynamics problems, engine problems and fuel consumption problems. The second prototype the T10-2 crashed because of a fly-by-wire software failure which resulted in the death of the test pilot. After such disappointing results the from the T10 program Sukhoi seemed to stop T10 development, because there were no more T10 prototypes tested. They didn't, by 1981 a new design was introduced loosely based on the old T10. The new aircraft was designated T10S which was to become what today is known as the Su27 Flanker. The T10S prototype flew on April 20, 1981. The T10S showed it self to be a masterpiece of engineering having no equal anywhere in the world in range, maneuverability, and combat effectiveness.

Performance Specifications

Data	Performance
Weight	16,000 kg
Range	More than 4,000 km
Service ceiling	18,000 m
Dynamic ceiling	24,000 m
Thrust Augmented	25,000 kg
Thrust:Weight	1.5625 : 1
Min takeoff weight	22,500 kg
Max takeoff weight	30,000 kg
Payload	6,000 kg
Max fuel	9,400 kg
Climb rate	300 m/sec
Max G-load	-3.0 and +9.0
Critical AOA	33°
Top speed	1,470 km/h
Top speed(Sea level)	1,470 km/h
Top speed(Height)	2,500 km/h
Maximum Rate of Turn(Substained)	22.5°/sec
Maximum Rate of Turn(Instant)	28.5°/sec
Wing Span	14.7 m
Length (excluding nose probe)	21.94 m
Height	5.93 m
Wing surface	62 m^2

Specification: Su-27 'Flanker-B'

Designed in the late 1960s as a high performance fighter with a fly-by-wire control system, and with the ability to carry up to 10 AAMs, the highly maneuverable Su-27 was one of the most opposing fighters ever built at the time. The first 'Flanker-A' prototypes flew on May 20, 1977 and entered service as the 'Flanker-B' in 1984. The 'Flanker' has seen a number of aerodynamic changes since, and exists in a variety of forms today. The Su-27IB, or Su-34 designation, is a long range attack variant with side-by-side seating for two. The Su-27UB 'Flanker-C', or Su-30 designation, is a tandem two-seat long range interceptor and trainer. A navalized version called the Su-27K 'Flanker-D', designated Su-33, was designed in 1992 for deployment on Russian aircra ft carriers. It has folded wings, retractable flight refueling probe, arrester hook, strengthened landing gear, and moving canard foreplanes. Next generation 'Flanker' derivatives include the Su-35 and the thrust-vector controlled Su-37, both vastly more enhanced then the Su-27, with canard foreplanes and the ability to carry up to 11 and 14 external stores, respectively.

Prime contractor: Sukhoi Design Bureau
Nation of origin: Soviet Union
Function: Multi-role fighter
Crew: 1
Year: 1977
In-service year: 1984
Engine: Two Lyulka AL-31F a fterburning turbofans, 27,557 lb thrust each
Wing span: 14.7 m / 48 ft 3 in
Length: 21.94 m / 72 ft
Height: 5.93 m / 19 ft 5 in
Weight: 45,801 lb empty / 66,138 lb max. take off
Ceiling: 59,055 ft

Speed: 2,500 km/h / 1,553 mph
Range: 4,000 km / 2,485 miles
Armament: One GSh-30-1 30 mm cannon with 150 rounds, plus 13,228 lb including AAMs, AGMs, bombs, rockets, drop tanks, and ECM pods carried on ten external points

3.3.2 MiG-31 Foxhound

Figure 3.8: MiG-31 Foxhound

The MiG-31 long-range interceptor was developed from the MiG-25. The two-seat MiG-31 fighter has more capable equipment, including the powerful 'Zaslon' phased array radar with a range of 200 km. It is claimed that an unit of MiG-31 can link their radars together, to establish a search pattern – covering a width of 800-900 km with four aircraft, spaced at 200 km.

Type	MiG-31
Function	fighter
Year	1983
Crew	2
Engines	2 * 15500kg Perm D-30F6
Wing Span	13.40 m
Length	22.6 m
Height	6.1 m
Wing Area	61.6 m2
Empty Weight	21825 kg
Max.Weight	46200 kg
Speed	3000 km/h
Ceiling	20600 m
Range	3000km
Armament	1*g30 mm

Mikoyan MiG-31M "Foxhound-B"

Under development since 1984, the MiG-31M, a substantially improved MiG-31, will most likely not see service. Only six prototypes have been built, and none have been ordered, although it was originally scheduled to enter service in the mid-1990s. The MiG-31M can carry six under-fuselage missiles in three columns. It can carry the R-37, a development of the R-33 (AA-9 'Amos'), and the R-77 (AA-12 'Adder'). A fully-retractable IRST and a new 1.4m-diameter Phazotron phased-array radar, which can simultaneously engage six targets, are used. The redesigned rear cockpit has three color CRT MFDs. The MiG-31M also has a one-piece canopy and windscreen, a bulged, wider dorsal spine for more fuel, no gun, and uprated engines. Aerodynamic refinements include redesigned LERXes for better high AoA handling, larger curved fin root fillets, and smaller wing fences. It also has a larger brake parachute housing, a retractable IFR probe on the starbord side (as opposed to on the port side like on the standatd MiG-31), rounder wingtips with front and rear dielectric panels, and the nosewheel landing gear is redesigned. Its maximum takeoff weight is raised to 52,000 kg (114,537 lb). One has been observed with large finned wingtip ESM pods. The MiG-31D is a version with the "Foxhound-A's" 1.1m-diameter radar. Converted MiG-31Ds are called MiG-31BS.

3.3.3 MiG-29 Fulcrum

Figure 3.9: MiG-29 Fulcrum

A medium-sized air superiority fighter. 'Fulcrum' is an impressive aircraft, with good performance, armament and maneuvrability, and the ability to use rough airfields. Range is weak point, and later versions were modified to carry more fuel. A navalized version has also been flown. The Russian air force prefers the larger Su-27 and its derivatives, but the development of the advanced MiG-29M version has been funded recently. Over 2000 have been built.

Type	MiG-29 'Fulcrum-A'
Function	fighter
Year	1985
Crew	1
Engines	2 * 81.4kN Klimov (Isotov) RD-33
Wing Span	11.36 m
Length	17.32 m
Height	4.73 m
Empty Weight	11000 kg
Max.Weight	18500 kg
Speed	Mach 2.3
Ceiling	18000 m
Range	2100 km
Armament	1*g30 mm
Unit cost	11 million USD

Development

The Mig29 is one of the first Russian aircraft that was considered by many to be an equal to those in the west. It incorperated a number of innovative technologies, some of which had never been on any western fighter. It also reflected a change in the Russian tactics in the air. For example, previously there had been a very heavy reliance on command and guidance from the ground, therefore there was little need for a cockpit with an excellent view, and since it was easier to make them smaller for aerodyanamic reasons this was the trend with the Mig21, Mig23 and Mig25. But the Mig 29 was designed with a large bubble canopy similar to those on most western fighters suggesting a change in tactics.

Louvered doors close the engine intakes while on the ground protecting the compressor from Foreign Object Damage (FOD). The air is sucked in through a number of slits on the upper side of the wing root. On the Mig29M (a further development) these doors have been replace with a mesh grill similar to the one on the Su27. It reduces complexity and created extra space for fuel and avionics by removing the intaces on top of the wing root.

Mig29 Fulcrum

The Mig 29 Fulcrum is of a comparable size to the F/A 18 Hornet. It first became operational in early 1985 and since then has been exported to a number of countries. About 345 of these counter air fighters are in service with the Russian tactical air forces and 110 with the naval forces. The Mig 29 has a high level of manouverability and the coherent pulse dopplar radar (which can track up to 10 targets simultanieously at 69km) combined with a laser range finder and infra-red search and track (IRST) lijnked to the Helmet Mounted Sight (HMS) make it an excellent close in fighter.

The two engines on the Mig29 are the Kilmov/Sarkisov RD-33 each providing 18 000 pounds of thrust. Even if one engine is dammaged and providing no thrust the Mig 29 is able to accelerate and start on the one engine. Also the engines have proven their ability to take rough handeling with manouvers such as tail slides which were performed by Anatolij Kvocur at Farnbourough in 1988.

The Mig29M has addressed many of the fighters shortcommings. Unfortunately due to the economic position in Russia Mig-Mapo has not had any orders for this excellent aircraft. The internal fuel storage has been incresed dramatically; is controlled by quadruplex fly-by-wire; glass cockpit; new terrain following Zhuk radar; improved engines with reduced smoke trails, better efficency and more power; new IRST, added TV; longer canopy, a wider, longer and less curved dorsal spine; bulged wing tips with fore and aft Radar Warning Recievers (RWR), eight under wing hardpoints (as opposed to six on earlier versions); aluminium-lithium center section; and finally larger, sharper, repositioned wing roots which create stronger vortices and modifications to extend back the center of gravity limit for relaxed stability whcih increases the max angle of attack giving more manouverability and better efficency. As you can see the Mig29M is a much imporved aircraft.

Power Plant of the Mig29

Thrust, (sea level, static, dry): 5 098 kg
Thrust, (sea level, static, after burning): 8 300 kg
Internal fuel, kg: unknown
In flight refueling provision: Was not included on early versions but has since be retrofitted on most Mig29 in service. Retractable probe standard on Mig29M

Dimensions of the Mig29

Wing Span: 11.36 m
Length (excluding nose probe): 17.32 m
Height: 4.73 m
Wing surface: unknown

Weights of the Mig29

Empty: 8 175 kg
Normal take-off: 15 000 kg
Maximum take-off: 18 000 kg

Performance of the Mig29

Max speed at height: > Mach 2.3
Max speed at sea level: Mach 1.225
Ceiling: 55 000 ft
Take off run: 820 ft
Landing run: 1 970 ft
Comabt radius: 710 km
Maximum range: 2 100 km

Armament of the Mig29

One 30 mm cannon: 150 rounds
Up to 6 Air to Air missiles including:

- R-60 (AA-8 "Aphid")
- R-60T/MK (AA-8 "Aphid")
- R-27R-1 (AA-10A "Alamo A")
- R-77A/E (AA-11"Archer")

8 820 lb of air to surface weapons: Most of the guided and free fall types in inventory

3.4 France

3.4.1 Mirage 2000C

Figure 3.10: Mirage 2000C

The Mirage 2000 reverted to the familiar delta wing shape of the Mirage III, in a new, sophisticated form with slats and small canards. As light air-superiority fighter, it achieved some succes, despite the competition of the F-16 and F-18. The Mirage 2000C is the fighter version; the Mirage 2000N is a two-seat nuclear-armed strike aircraft, and the 2000D a conventional attack aircraft.

Type	Mirage 2000C
Function	fighter
Year	1983
Crew	1
Engines	1 * 95.0kN SNECMA M53-P2
Wing Span	9.13 m
Length	14.36 m
Height	5.20 m
Wing Area	41 m2
Empty Weight	7500 kg
Max.Weight	17000 kg
Speed	Mack 2.35
Ceiling	17060 m
Range	3335 km
Armament	2*g 30 mm 6300 kg payload
Unit cost	23 million USD

3.4.2 Mirage 4000

Figure 3.11: Mirage 4000

The twin-engined Mirage 4000 was developed by Dassault, presumably to be used in a high/low mix with the Mirage 2000. It was virtually a scaled-up Mirage 2000. The French air force showed no interest in this canarded delta. No production.

Type	Mirage 4000
Function	fighter
Year	1979
Crew	1
Engines	2 * 8500kg SNECMA M53-2
Wing Span	12.0 m
Length	18.70 m
Height	5.80 m
Wing Area	73.00 m2
Empty Weight	13000 kg
Max.Weight	
Speed	2445 km/h
Ceiling	20000 m
Range	+2000 km
Armament	2*g30mm 8000 kg payload

Development

In September 1975, M Marcel Dassault announced that Dassault-Breguet would develop a one-third scaled-up twin-tubrofan powered version of the Mirage 2000 at their own expense. Originally called the Super Mirage Delta and then the Super Mirage 4000, it was to be used mainly for interception and low-altitude penetration. The prototype, No. 01/F-ZWRM, was unveiled in December 1977.

On its first flight, on 9 March 1979 at Istres, it reached Mach 1.2, piloted by Jean-Marie Saget. It reached Mach 1.6 on its second flight and, on its sixth flight (on 11 April), it reached Mach 2.04 and flew at angles of attack of up to 25° during a spin analysis. It performed that June at the

Paris airshow. At the end of 1980, the aircraft had about 100 flying hours. M53-5 engines were added by 1981, replaceing the -P2s. In 1982 it flew in interceptor and attack configurations at Farnborough.

Configuration

The Mirage 4000 made use of computer-derived aerodynamics, with a fly-by-wire active control system and a rearward CG. It was designed to be easy to maintain on forward airfields. It also had variable-incidence sweptback foreplanes and a blister-type cockpit canopy with a 360° FOV. Boron and carbon fiber composites were used extensively in the fin, rudder, elevons, fuselage access panels, foreplanes, and other parts. The wings had large-radius root fairings. The entire trailing edge of each wing was taken up by two-section elevons. Variable camber was provided by automatic full-span leading-edge flaps. The rear fuselage was shorter, which made Karman fairings unneccessary. The rudder, elevons, and flaps were actuated by the fly-by-wire control system. The vertical fin was made of carbon composite and contained fuel tanks, which helpd to give the 4000 about three times as much internal fuel as the Mirage 2000 (other fuel tanks were in the wings and fuselage). The fuselage was of conventional semi-monocoque structure. Door-type airbrakes were located in each intake trunk above the wings' leading edges. The tricycle landing gear was designed by Messier-Hispano-Bugatti and had twin nosewheels and a single wheel on each main unit. Each intake had a moveable half-cone centerbody. The two M53s provided a thrust-to-weight ratio of above 1:1 - if it had entered service, it would have been equivalent to the F-15 or the Su-27.

When possible, systems and avionics were adapted from the Mirage 2000. The hydraulic system was made by Messier-Hispano-Bugatti, and was pressurized to 280 bars (4,000 lb/sq in). It was powered by four advanced pumps and used lightweight titanium pipelines. The Mirage 4000 also used two Auxilec electric generators. In a compartment behind the pilot was a Turboméca Palouste gas turbine APU (to start the engines). The prototype used the same RDM multi-mode Doppler radar as the Mirage 2000, but a radar as big as 80 cm (31.5 in) in diameter could fit in the very large nose radome. Other avionics included a digital autopilot, multi-mode displays, a SAGEM Uliss 52 INS, a Crouzet Type 80 air data computer, a Thomson-CSF VE-130 HUD, and a digital automated weapon delivery system.

Sales

By the time that the mock-up was displayed, Saudi Arabia had been funding development, and by 1980, Defense Minister Prince Sultan Ubn Abdul Aziz said that they were considering acquiring them. France's defense committee ruled that 50 Mirage 4000s should be acquired to replace the Mirage IV. However, no orders materialized, mainly because of its high cost (and because the Mirage 2000 was a better value). In 1986, Dassualt re-activated the Mirage 4000 (and renamed it 'Mirage 4000,' from 'Super Mirage 4000') and re-painted it with desert camouflage on the upper surfaces. It was used as a chase plane and a testbed for the Rafale program (researching the behaviour of a canard-delta configuration in turbulence). It appeared at Paris in 1987. In 1995 it was transferred to Paris again as a permanent exhibit outside the Musée de l'Air et de l'Espace.

Specification

Type: Multirole combat aircraft
Powerplant: Two 22,046 lb thrust SNECMA M53 afterburning turbofans
Accommodation: Pilot only, on a Martin-Baker F10R zero-zero ejection seat, under a starboard-opening transparent canopy (a two-seat version was under study)
Armament: Two 30-mm DEFA cannon in lower air intakes plus twelve hardpoints (six under-fuselage, six underwing, and one centerline) allowing carriage of up to 8,000kg (17,620 lb) of stores including bombs, AAMs and ASMs such as Magics and Exocets, rocket pods, or a buddy refueling pod. 2550 L (550 Imp gal) drop tanks could be located under each wing and on the centerline. The

4000 carried two fuel tanks, two Sycamor jamming pods, two Magic AAMs, a laser designator, two AS30Ls, two 1000kg LGBs, and a podded Antilope radar during the 1928 Farnborough airshow
Max speed: Mach 2.3 (2333 km/h / 1260 kts / 1450 mph) at altitude
Service ceiling: 20,000m (65,600 ft)
Radius w/ fuel tanks and recce pod: 1850km (100 nm/1150 mi)
Initial Climb Rate: 18,300 m/min (60,024 ft/min)
Empty, refueled: 6500 kg (14,320 lb)
Max payload: 3500 kg (7710 lb)
Landing: 10,400kg (22,910 lb)
MTOW: 12,500kg (27,590 lb)
Wingspan: 12m (39 ft 4.5 in)
Length: 18.7m (61 ft 4.25 in)
Height: 5.8m (19 ft)
Wheelbase: 6.9 m (22 ft 7.5 in)
Wheel track: 4.36 m (14 ft 3.5 in)
Wing area: $73m^2$ (786sq ft)

3.5 Russia

3.5.1 Tu-160 Blackjack

Photo taken by: Russian Air Force

Figure 3.12: Tu-160 Blackjack

Variable geometry bomber, similar in appearance to the American Rockwell B-1 but much bigger. A small number is operational, but production has been halted and it is reported that few are in operational condition.

Type	Tu-160 'Blackjack-A'
Function	bomber
Year	1987
Crew	4
Engines	4 * 25015 kg Samara Trud Nk-231
Wing Span	55.70m / 35.60m
Length	54.10 m
Height	13.10 m
Wing Area	232 m2
Empty Weight	110000 kg
Max.Weight	275000 kg
Speed	Mach 1.88
Ceiling	13715 m
Range	12000 km
Armament	16330 kg

Tu-160 BLACKJACK (TUPOLEV)

The Tu-160 is a multi-mission strategic bomber designed for operations ranging from subsonic speeds and low altitudes to speeds over Mach 1 at high altitudes. The two weapons bays can accommodate different mission-specific loads, including strategic cruise missiles, short-range guided missiles, nuclear and conventional bombs, and mines. Its basic armament of short-range guided missiles and strategic cruise missiles enables it to deliver nuclear strikes to targets with preassigned coordinates.In the future, after the aircraft is equipped with high-precision conventional weapons it may also be used against mobile or tactical targets.

The Tu-160 was the outcome of a multi-mission bomber competition, which included a Tupolev proposal for an aircraft design using elements of the Tu-144, the Myasishchev M- 18, and the Sukhoi a design based on the T-4 aircraft. The project of Myasishchev was considered to be the most successful, although the Tupolev organization was regarded as having the greatest potential for completing this complex project. Consequently, Tupolev was assigned to develop an aircraft using elements of the Myasishchev M-18 bomber design. The project was supervised by V.N. Binznyuk. Trial operations in the Air Forces began in 1987 with serial production being conducted at the Kazan Aviation Association.

The Tu-160 is characterized by low-mounted, swept-back, and tapered, variable geometry wings with large fixed-center section. The variable geometry wings (from 20 degrees up to 65 degrees) allows flight at supersonic and and subsonic speeds. Four NK-32 TRDDF [turbojet bypass engines with afterburners] of 25,000 kilograms-force power the T-160. The four turbofans, developed by OKB Kuznetsov in 1977, are mounted in pairs under the fixed-center section with square intakes and exhausts extending behind the wings' trailing edges. The fuselage's slim structure is marked by a long, pointed, slightly upturned nose section and a stepped canopy. Tail flats are swept-back, tapered, and mid-mounted on the fin. The tail fin is back-tapered with a square tip and a fairing in the leading edge. The tail cone is located past the tail section. During the design of the aircraft, special attention was paid to reducing its signature. Measures were applied to reduce the signature of the engines to infra-red and radar detectors. Tests of these survivability measures were first tested on a TU-95 aircraft in 1980.

As the most powerful combat aircraft of the Soviet Air Forces, the T-160 flies at 2,000 km/hr and can exceed the 2,000 mark with a mission-specific load. The T-160 can climb 60-70 meters per second and reach heights of up 15,000 meters. The bomber can be refueled during flight by IL-78 and ZMS-2 tanker aircraft. The air refueling system consists of a probe and drogue airborne refueling system.

The TU-160 can carry up to 12 Kh-55 long range missiles and Kh-15 short range missiles. The weapons bays can accommodate different loads: carries various bombs: From fee falling nuclear and regular up to 1500 kg bombs. The bomber is not equipped with artillery armament.

The Tu-160 is equipped with a combined navigation-and-weapon aiming system, RID; [radar] for detecting targets on the ground and sea at long distances, an optical-electronic bombsight, an automatic terrain-following system, and active and passive radio-electronic warfare systems, as well as a probe-and-drogue airborne refueling system. It is equipped with K-36DM ejection seats. The cockpit instruments are the traditional electromechanical type. The aircraft is controlled with the aid of a central control column. The engine control throttles are located between the pilots' seats. There is a rest area, a toilet, and a cupboard for warming up food.

Studies have also been conducted on using the aircraft as a launch platform for the "Burlak" space launch vehicle, which is designed to carry payloads with a mass of 300 to 500 kg in polar orbits at an altitude of 500 to 700 km. Under this concept the launch vehicle, which has a solid-fuel engine and a delta wing, would be suspended under the airplane's fuselage.

In 1981 OKB Tupolev built two prototypes of the bomber and one mock-up that was used for static tests. The first flight test of the "70" aircraft took place on 19 December 1981. During flight tests, one of the two original planes was lost. Shortly after tests began, series production started. In 1984, the factory in Kazan started producing the bomber which received the designation TU-160. Initial plans provided for the construction of 100 airplanes but when their production was stopped in 1992, only 36 bombers had been built.

In May 1987, deployment of the first bombers began. Until the end of 1991, 19 TU-160 bombers served in the 184th regiment in Ukraine and became Ukrainian property after the dissolution of the USSR. In 1992 the 121th air regiment based at the aerodrome B.G. Engels was equippd with TU-160 bombers. Subsequently the bombers were tested to carry long range missiles.

It was reported on 02 July 1999 that the Gorbunov Kazan Air Industrial Association received an order from the Ministry of Defense of Russia to complete the production of one Tu-160 strategic bomber. According to the Association's general director Nail Hairullin the contract for the aircraft production was worth 45 million rubles.

In July 1999 the Minister of Defense of Ukraine Alexander Kuzmuk confirmed that Kiev officially proposed that Moscow accept as payment for the gas debts "about 10 strategic bombers Tu-160 and Tu-95". He refused to tell the exact cost of missile carriers, however, in his judgement, it would be "considerably more" than 25 million dollars for each machine. On 12 October 1999 the Russian air force announced an agreement that would allow Ukraine to pay some of its multimillion-dollar energy debts by handing over 11 strategic bombers. Ukraine had tried to unload the bombers since the Soviet Union collapsed in 1991, but talks had foundered because of differences over the price tag and other conditions. The deal includes eight Tupolev 160 Blackjack bombers and three Tupolev 95 Bears.

The 11 strategic bombers and 600 air-launched missiles exchanged by Ukraine to Russia in payment for the gas debt were transfered in mid-February 2000. Two Tu-160 bombers flew from Priluki in the Ukrainian Chernigov region for the Russian air base in Engels. The missiles were sent to Russia by railroad. Three Tu-95MS bombers and six Tu-160 airplanes had already arrived at Engels since October 1999 in fulfilment of the intergovernmental agreements. Before being moved to Russia, 19 Tu-160 airplanes were stationed at the Priluki airfield and 21 Tu-95MS were located in Uzin.

Specifications

Soviet Designation	TU-160
US-Designation	Blackjack
Design Bureau	OKB-156 Tupolev
Manufacturer	Plant Nr. 22 Kazan
Power Plant	4 HK-32 turbojet engines
Thrust	25.000 kg each
Length	54.1
Height	13.1
Wingspan	35.6m (minimum), 55.7m (maximum)
Wing surface	232 sqm
Speed	2200 km/h (maximum), 1030 km/h (ground)
Ceiling	16.000m
Weight (empty)	110.000kg
Fuel weight	148.000 kg
Maximum take-off weight	275.000 kg
Normal load	9.000 kg
Maximum load	40.000
Range	14.000 km (with a load of 9.000kg)
Range	10.500 km (with a load of 40.000 kg)
Armament	12 H-55 or 24 H-15 missiles
Armament	free falling bombs
Crew	4
Development began	1975
First Flight	12/19/1981
Series production started	1984
Date deployed	1987

Tupolev Tu-160

Country of origin: Russia
Type: Strategic bomber
Powerplants: Four 137.3kN (30,865lb) dry and 245.2kN (55,115lb) with afterburning Samara/Trud NK-231 turbofans.
Performance: Max speed at 40,000ft Mach 2.05 or 2220km/h (1200kt), cruising speed at 45,000ft 960km/h (518kt). Max initial rate of climb 13,780ft/min. Service ceiling 49,200ft. Radius of action at Mach 1.32000km (1080nm). Max unrefuelled range 12,300km (6640nm).
Weights: Empty 110,000kg (242,505lb), max takeoff 275,000kg (606,260lb).
Dimensions: Wing span wings extended 55.70m (182ft 9in), wing span wings swept 35.60m (116ft 9in), length 54.10m (177ft 6in), height 13.10m (43ft 0in). Wing area wings extended 360.0m (3875sq ft).
Accommodation: Grew of four, with two pilots side by side and with navigator/bombardier and electronic systems operator behind them.
Armament: Max weapon load 40,000kg (88,185lb), comprising freefall bombs or ASMs in two internal bomb bays. One rotary launcher can be carried in each bay to carry six Kh-55MS (AS-1 5 'Kent') ALCMs or 12 Kh-15P (AS-16 'Kickback') SRAMs. No defensive armament.
Operators: Russia, Ukraine.
History: The massive Tu-160 ('Blackjack' to NATO) is the heaviest and most powerful bomber ever built and was developed as a direct counter to the Rockwell B- 1A.

Tupolev began design work under the leadership of V I Bliznuk of its all new 'Aircraft 70', a direct response to the B-1, in 1973. Although the B-1A was cancelled in 1977, design and development work on the new bomber continued, resulting in a first flight on December 19 1981, about a month after it was first spotted by a US spy satellite. Production of 100 Tu-160s was authorized in 1985 although only about 30 were built before the line closed in 1992.

The Tu-160 is similar in overall configuration to the B-1, but is much larger overall and has a number of different features. The four NK-231 afterburning turbofans are the most powerful engines fitted to a combat aircraft and are mounted in pairs under the inner fixed wings. The variable geometry air inlets are designed for speed (Mach 1 at low level, over Mach 2 at altitude). The Tu-160 has a retractable in-flight refuelling probe although it is rarely used due to the aircraft's massive 130 tonne internal fuel capacity.

The variable geometry wings have full span leading edge slats and double slotted trailing edge flaps, while the airframe is free of any protuberances (except for a small video camera window for the pilots). The nav/attack radar is believed to have a terrain following function, while the Tu-160 has a comprehensive ECM jamming system. The four crew sit on their own ejection seats and the pilots have fighter style sticks. The Tu-160 has a fly-by-wire flight control system.

About a dozen Tu-160s are in Russia (some are not airworthy) and 19 in the Ukraine, with an initial 10 of these due to be transferred to Russian control.

The Tu-160SK is a commercial variant being offered as a launch vehicle for the Burlak-Diana satellite launching rocket."

3.6 Italy / Brazil

3.6.1 AMX

Figure 3.13: AMX

This is a light attack aircraft, jointly developed in Italy and Brazil. The AMX has a small shoulder-mounted swept wing, optimized for flight at low altitude, and fly-by-wire controls. It is a small and agile aircraft. Italian aircraft have a single 20mm M61 cannon, and Brazilian aircraft two 30mm DEFA cannon. A two-seat electronic warfare version is under development.

Type	AMX
Country	Italy / Brazil
Function	attack
Year	1988
Crew	1
Engines	1 * 5000kg R.R. RB168 Spey 807
Wing Span	8.87 m
Length	13.57 m
Height	4.57 m
Wing Area	21.00 m2
Empty Weight	6000 kg
Max.Weight	11500 kg
Speed	M0.86
Ceiling	13000 m
Range	3150 km
Armament	1*g20mm (or 2*g 30mm) 3800 kg payload, 5 hardpoints
Unit cost	10 million USD

Surface attack aircraft for battlefield interdiction, close air support and reconnaissance missions. The AMX is capable of operating at high subsonic speed and low altitude, by day or night, and if necessary, from bases with poorly equipped or damaged runways. Low IR signature, reduced radar equivalent cross section and low vulnerability of structure and systems guarantee a high probability of mission sucess. Integrated ECM, air-to-air missiles and nose-mounted guns provide self-defense capabilities.

The AMX is a joint program undertaken by Alenia, Aermacchi and Embraer. It is used by the Brazilian Air Force (59 aircraft) and the Italian Air Force(107), and it will enter service with the Venezuelan Air Force (8) soon, in the advanced training role with the AMX-T variant. It has seen combat in the Kosovo Campaign in the hands of italian pilots, who call it "Ghibli". Over 250 sorties were flow, with none aircraft returning to base before the mission's completion with mechanical problems and none aircraft was lost.

Lenght: 43.40 ft
Wing span: 32.71 ft
Height: 14.92 ft
Wing area: 226.0 ft2
Aspect ratio: 3.75
Wing sweep (at 25% MAC): 27.5°
Engine: Rolls Royce Spey MK 807 turbofan
Take-off thrust: 11023 lb
Operating empty weight: 14638 lb
Max take-off weight: 28660 lb
Max external load: 8380 lb

AMX International A-1

The AMX is a subsonic attack aircraft, powered by a single non-afterburning turbofan produced by the Italian-Brazilian consortium AMX International, with Aeritalia (todays Alenia Aerospazio)-Aermacchi-EMBRAER as the main participating companies.

The development of AMX has its roots in studies developed in 1973 by Aeritalia, the Italian state aeronautical company (formed in 1969 starting from FIAT Aviazone). Those studies sought an attack airplane capable to replace the FIAT G.91 (in the R and Y versions) then in service with the Aeronautica Militare Italiana (AMI), as well as to complement the expensive and complex

PANAVIA Tornado then in development. The studies initially proposed the G.291, a modification of the G.91 with a larger wing, allowing to carry a larger warload; however, given the limitations to the project in function of the small size of the G-91, other alternatives were investigated.

About the same time, Aermacchi was interested in the development of a light fighter aircraft. Obviously, the state-owned Aeritalia would be the principal contractor in the eventual production of such an aircraft; even so, Aermacchi had a good presence in the international market, having exported more than 760 MB.326 training jets to thirteen countries, three of which - South Africa, Australia and Brazil - built under license versions of the MB.326.

By the end of the Seventies, the Força Aérea Brasileira (FAB) developed the A-X project, a series of studies that sought the construction - if possible through the Brazilian aeronautical industry - of a light attack aircraft, with emphasis on range, rather than supersonic capacity.

Given the strong liaisons aeronaveing Aermacchi to EMBRAER, the first proposed the MB.340 project, an aircraft with a shoulder-mounted wing (swept-back at 20°) and a "T" tail configuration, to be jointly developed with EMBRAER. The MB.340 was designed to carry a warload between 1,360 and 2,270Kg on a mission with "LO-LO" profile, range of 465Km, penetration speed of 860Km/h, and running speed of 0.8M (Mach), in clean configuration after the attack.

The running speed led to the choice of a high by-pass turbine Rolls-Royce MB.45H, which offered several advantages, among which we can mention the need of a smaller take off distance, better climb rate, longer range and a reduced infrared signature. It was expected to achieve a speed of 0.82M at sea level, and 0.675M when armed with five 454Kg type Mk. 83 bombs; in this configuration, range would be around 490Km on a "LO-LO" mission and of 815Km for a "LO-HI-LO" mission.

The MB.340 project was not carried on, since it had conflicting parameters with the AMI: an aircraft that would operate together with the Tornado, and that would be responsible for short distance attacks at high speed, carrying a large bombload. Besides, the need to operate in bombed, cratered runways, demanded a better short take-off and landing performance. As Brazil could not finance alone the development of the project, it was abandoned.

By April of 1978, Aeritalia and Aermacchi reached an agreement, following an AMI suggestion, to initiate the project of a light attack aircraft, in order to substitute the G.91R-3, G-91Y, Lockheed F-104G and F-104S then in AMI service. The project was designated AMX, whose first two letters of the acronym represented the two companies (Aeritalia and aerMacchi); X indicated its experimental character. In 1979 both companies were contracted for the project definition phase and, in 1981, EMBRAER joined in, to develop a variant that satisfied FAB requirements.

The Italian and Brazilian governments signed an agreement in March of 1981 to jointly set the aircraft requirements, and in July of 1981 the three companies signed a development agreement. It was originally foreseen the acquisition of 187 aircraft for AMI and 79 for FAB, resulting in the division of the development costs and production: Italy would participate with 70,3% (divided in the proportion of 7:3 among the Italian companies, leaving 46,7% to Aeritalia and 23,6% to Aermacchi) and Brazil with 29,7%, attributed to EMBRAER.

According to the work share, the aircraft was divided in sections, whose responsibility for the project and production was thus distributed:

- Aeritalia: central fuselage, rudder and fin, radome, fibercarbon components for the wings and tail;

- EMBRAER: wings and elevators, air intakes, pylons, landing gear, fuel tanks, reconnaissance pallet and installation of the Brazilian variant specific cannons;
- Aermacchi: front and rear fuselage.

Back to its development history: the programme foresaw the construction of six prototypes, two of the which mounted and tested in Brazil. The first prototype, A.01, received the Italian military registration MM X594 and took off for the first time on 15 May 1984, under the command of Aeritalia chief test pilot, Manlio Quarantelli. Just fifteen days later, during the fifth flight of the A.01, the turbine suffered a surgeduring the approach for landing. In spite of having ejected, Quarantelli came to die later due to the wounds suffered, given the high vertical speed of the falling aircraft. The failure happened due to the reduction of admission of air to the turbine, caused by the angle-of-attack (18°, the limit set to the aircraft during that phase of the development), combined with 52% flight idling RPM of the turbine during the approach. Rolls-Royce proceeded to a modification, changing to 60% flight idling RPM to be used on the approach, which corrected the malfunction; AMX has already been successfully flown at an 45° angle-of-attack.

Following the accident, Egidio Nappi substituted Manlio Quarantelli in Aeritalia; the other test pilots involved in the test programme were Napoleone Bragagnolo (Aeritalia), Franco Bonazzi (Aermacchi) and Luiz Cabral (EMBRAER). The test programme was restarted with the flight of the second prototype, A.02 MM X595, on 19 November 1984; the third prototype, A.03 MM X596 accomplished its first flight on 28 January 1985 and it was used for the avionics and armament development. To replace A.01, an additional prototype was built, A.11 MM X597, which flew on 24 May 1985.

The AMX received the A-1 designation in the FAB. The fourth and first Brazilian prototype, YA-1, registration FAB 4200, took to the skies at 15h47min on 16 October 1985. The fifth prototype, A.05 MM X599 flew on 26 July 1986 and the sixth and last prototype, Brazilian-built YA-1 FAB 4201, made its first flight on 16 December 1986.

In 1986, it was decided to produce a two-seat training variant (pilot and instructor sitting in staggered tandem seats) with the production of three specific prototypes, one of them manufactured in Brazil; those prototypes flew in 1989 and 1990. The training version is a fully-capable attack aircraft, the only difference being the smaller internal fuel capacity, caused by the installation of a second seat in the cockpit.

The production of AMX is distributed among the three participant companies; each one has its own assembly line, with the different components being transported from a company to the others, for the final assembly.

AMX is a aircraft with shoulder-mounted wings, swept-back at 27.5°, with the engine air intakes placed in the top half of the fuselage, behind the cockipt. The pilot sits down in high position, offering a good view around the airplane. The tail is of traditional design, with the single fin and mobile elevators being similar to those of the Tornado. An in-flight refuelling probe, equipped with a spotlight at the base of the probe, may be installed by the right side of the cockpit.

AMX is powered by a Rolls-Royce Spey RB.168 Mk.807 turbofan, of 11,030lb st, without afterburner. The Spey was originally designed in 1960 to equip the British carrier-based aircraft Hawker Siddeley Buccaneer (later on used by the Royal Air Force, having participated with distinction in the 1991 Gulf War). Other versions of Spey equipped the maritime patrol aircraft Hawker Siddeley Nimrod and the British FG.1 and FGR.2 versions of the McDonnell-Douglas Phantom II. More than 5,500 units were sold internationally; the version that equips AMX is tested and set up in Italy by FIAT/Piaggio and in Brazil by CELMA.

One of the main characteristics of the AMX is the existent redundancy in its electric, hydraulic and avionics systems. As all those systems are duplicated, with physical separation of certain elements as the cabling and actuators, it is expected that the aircraft is capable to complete the mission in case any of those systems suffer a failure. For example, in case the hydraulic system develops a fault, electric accumulators allow the operation of the landing gear, brakes and the front wheel, allowing for a smooth transition to the manual control of the elevators and ailerons.

AMX is also equipped with electronic counter measure devices, including flares and chaff dispensers, to disorient the action of infrared or active/semi-active guided missiles. For its self-defence, AMX is equipped with two air-air infrared guided missiles on wingtip rails as well as, in the Brazilian version, two DEFA 30mm cannons installed in the lower front fuselage (the Italian version carries a General Electric M61A1 Vulcan 20mm cannon, in the left lower front fuselage). Those cannons are also used in the ground-attack rôle, primary function of the aircraft.

In ground-attack missions, AMX may be equipped with conventional bombs (a typical load consists of six low-drag Mk. 82 type bombs), unguided rockets, laser-guided intelligent bombs, air-ground and anti-radar missiles and laser target designators. In the anti-surface ship rôle, AMX may also carry missiles such as the German MBB Kormoran 1 (previously used by the German Marineflieger Tornado squadrons) and the Aérospatiale AM39 Exocet, responsible for the sinking the HMS Sheffield destroyer and the Atlantic Conveyor container carrying merchant ship during the Falklands/Malvinas War, carried out by the crews of the Comando de Aviación Naval Argentina.

The Brazilian version of AMX will be equipped with a look-down/shoot-down multimode radar which will substantially enhance is combat capability. The AMX can easily operate from places with little infrastructure, due to its built-in auxiliary power unit (APU) which allows the start-up of its turbine and other systems. Its reinforced landing gear as well as the Speys power all combine to ease the take-off and landing on unprepared runways (the distance for take-off weighing 10,500Kg is of approximately 760m).

Another characteristic that contributes to its ease of operation is the use of line replacement units (LRUs) on the flight line, whose eventual failures are detected through the built-in test equipment (BITE). The maintenance of the aircraft is still largely facilitated by the multiplicity of inspection panels, two thirds of the which are set not higher than 1.70m.

The AMX entered Italian service in 1989, with the delivery in April of that year of the first six production-series aircraft to the AMI test unit, "Riparto Sperimentale de Volo" based at Pratica di Mare. The first production-series aircraft, MM 7089, flew on 11 May 1989 and it was soon followed by the other five examples for extensive tests by the AMI.

The following Italian units operate the AMX: 13° Gruppo/32° Stormo, 14° Gruppo/2° Stormo, 28° Gruppo/3° Stormo, 101° Gruppo/32° Stormo, 103° Gruppo/51° Stormo and 132° Gruppo/3° Stormo. Italian AMXs were based in Turkey during the 1991 Gulf War but they didn't enter in action; during the Bosnian War they were used for the control of the air space in the area. Due to reduction of defence-expenditure costs in Brazil, the original order was cut from 79 to 56 aircraft. The FAB will operate 41 A-1s and A-1Bs (training version) and 15 RA-1s, the tactical reconnaissance dedicated version.

In the FAB, the A-1/A-1B equip two squadrons: the 1°/16° Aviation Group ("Adelfi" Squadron), which was specifically created to operate the aircraft, starting from 23 October 1990; and the 3°/10° Aviation Group ("Centauro" Squadron), which received its first two A-1s in 15 January 1999, which will replace the AT-26 Xavante now in use. A third Brazilian unit will be reequiped with the AMX: the 1°/10° Aviation Group ("Poker" Squadron) will replace its RT-26 Xavantes by the RA-1 in the tactical reconnaissance rôle. The A-1 has been demonstrating its capacity in several exercises, for its long range - even without in-flight refuelling; for its great accuracy in the ground-attack missions; and for its agility in aerial combat.

Completing ten years of service in 1999, the AMX continues in development. AMI requested the production of an electronic combat version, designated AMX-E and based on the biplace version, to accompany the Tornado and AMX in attack missions. Viability studies were already concluded by Alenia, Aermacchi, and Elettronica and in December of 1997 a contract was signed for completing its configuration, which will include a avionics revision, installation of GPS and of coloured LCD displays with mobile maps for the electronic systems operator in the rear-seat. The AMX-E will lose its M-61A1 cannon to accommodate the necessary electronic equipments; it will be equipped with HARM and MARM anti-radar missiles.

The AMX was never an export success, being sold only to the two participant countries of the programme, contrary to what was expected. Alenia is now offering to South Africa the Super AMX, equipped with new avionics and a new turbine - Eurojet EJ200, the same that will equip Eurofighter.

Technical Specifications (AMX International A-1)

Engine: One high by-pass turbofan Rolls-Royce RB.168 Spey Mk.807, without afterburner
Fuel Capacity: 3.555l in internal tanks (fuselage and wing); two 1,000l drop tanks in the inner wing stations and two 500l drop tanks in the outer wing stations
Wingspan: 8,87m
Length: 13,57m
Heigth: 4,57m
Wing area: 21,0 m^2
Weigth: 6.000Kg (unloaded), 11.500Kg (maximum)
Speed: 1.160Km/h (maximum, at 305m)
Climb rate: 3.840m/min
Service ceiling: 13.000m
Range: 890 Km with 907Kg warload on a "HI-LO-HI" mission profile; 555Km with 907Kg warload on a "LO-LO-LO" mission profile; 520Km with 2,720Kg warload on a "HI-LO-HI" mission profile; 370Km with 2,720Kg warload on a "LO-LO-LO" mission profile; 3,150Km with two external 1,000 l drop tanks
Armament: Two DEFA 554 30mm cannons; 907Kg on ventral station; 907Kg on wings inner stations; 454Kg on wings outer stations; two AAMs on wing-tip rails

Chapter 4

1990-2000

4.1 USA

4.1.1 YF-23A Black Widow II

Figure 4.1: YF-23A Black Widow II

The YF-23 was a stealth air-superiority fighter, which lost the competition with the YF-22. The YF-23 was the most unconventional of the two designs; it had a diamond-shape wing platform and a V-tail. Missiles were to be carried in two fuselage bays. The second prototype had the General Electric YF120 engine.

The body of the YF-23A is a blend of stealthy shapes and aerodynamic efficiency, hopefully providing a low radar cross section without compromising performance. The YF-23A was longer and more slender than the Lockheed YF-22A. The main load-bearing fuselage structure, measured from the stablizer to the front of the cockpit, is about 7 feet longer than the YF-22A. From the side, the profile of the YF-23A is reminiscent of that of the Lockheed SR-71. The general impression from other angles is that of a long, high forebody mounted between two widely-separated engine nacelles. The lengthwise variation in cross-sectional area is very smooth, minimizing transonic and supersonic drag. The forward section has a modified double-trapezoid cross section, one above the other in mirror image, with the aft region blending into a circular cross section and disappearing into the rear fuselage. The upper component of the engine box is dominated by two parallel engine nacelles that blend smoothly into the wing, each nacelle being of a modified trapezoidal cross section. The forebody has the cockpit, the nose landing gear, the electronics, and the missile bay. The YF-23 engine nacelles were larger than they would have been on the production F-23, since they had been designed to accommodate the thrust reversers originally planned for the ATF but later deleted.

Trapezoid-shaped air inlets are located underneath each wing, with the leading edge forming the forward lip of a simple fixed-geometry two-shock system. The placement of the intakes underneath the wings has the advantage in removing them from the sides of the fuselage so that a large boundary-layer scoop is not needed. Instead, the thin boundary layer which forms on the wing ahead of the inlet is removed through a porous panel and is vented above the wing. An auxiliary blow-in inlet door is located on each of the upper nacelles just ahead of the engine to provide additional air to the engines for takeoff or for low speeds. The inlet ducts leading to the engines curve in two dimensions, upward and inward, to shield the faces of the compressors from radar emitters coming from the forward direction.

The leading edge of the YF-23A's wing is swept back at 40 degrees, and the trailing edge is swept forward at the same angle. When viewed from above, the wing has the planform of a clipped triangle. On the YF-23A, every line in the planform is parallel to one or the other of the wing leading edges, which has become one of the guiding principles in stealthy design. The wing is structurally deep, and there is ample room for fuel inside the wing box.

The wing has leading-edge slats which extend over about two-thirds of the span. The trailing edge has a set of flaps inboard and a set of drooping ailerons outboard. In contrast to the Lockheed YF-22A, no speedbrake is fitted to the YF-23A.

The all-flying twin V-tails are set far apart on the rear fuselage. They are canted 50 degrees outwards in an attempt to avoid acute corners or right angles in elevation or front view. These all-flying tail sections are hinged at a single pivot. Their leading and trailing edges are parallel to the main wings but in a different plane. The all-flying canted tails double as shields for the engine exhaust in all angles except those immediately above or hehind the aircraft.

In the YF-23A, Northrop elected not to use thrust-vectoring for aerodynamic control. This was done in order to save weight and to help achieve better all-aspect stealth, especially from the rear. All controls are by aerodynamic surfaces. The V-tails work in pitch, roll, and yaw. The wing trailing edge controls provide roll control and lift augmentation, but they also function as speedbrakes and rudders. For straight line deceleration, the control system commands the outer ailerons to deflect up and the inboard flaps to deflect down, thus producing a decelerating force but creating no other moments. Yaw control can be provided by doing this on one side only.

There is a midair refuelling receptacle located on the upper fuselage behind the pilot's cockpit. Like the YF-22A, the YF-23A has a fly-by-wire system that controls the settings of the aerodynamic surfaces in response to inputs from the pilot.

The edge treatment is sustained on the fuselage afterbody, where a jagged-edged boat-tail deck fills in the gap between the two V-tails and blends the engine exhausts into the low-RCS planform. Unlike the YF-22A, the YF-23A does not use thrust vectoring. The exhaust nozzles are located well forward on the upper fuselage, between the tails, and are of the single expansion ramp type. There is one variable external flap on top of each nozzle, and the lower half of each nozzle is faired into a curved, fixed ramp. The engines exhaust into tunnels or trenches cut into the rear fuselage decking. These trenches are lined with head-resistant material, cooling the engine exhaust rapidly and making for a weaker IR source.

In the pursuit of stealth, all of the weapons carried by the F-23 were to have been housed completely internally. The forward section of the fuselage underbelly was flat, with a capacious weapons bay immediately aft of the nose gear bay. The bay could carry four AIM-120 AMRAAM air-to-air missiles. The missiles were to be launched by having the doors open and the missiles extend out into the airstream on trapezes. The missiles would then drop free and the motor would fire. The doors would then immediately shut, minimizing the amount of time that they were open and thus possibly causing more intense radar returns. It was planned that production F-23 would have had a stretched forebody, accommodating an extra missile bay for a pair of AIM-9 Sidewinders or ASRAAM air-to-air missiles in front of the AMRAAM bay. In addition, production F-23s would have carried a 20-mm M61 Vulcan cannon fitted inside the upper starboard fuselage just above the main weapons bay.

The first YF-23A, powered by Pratt & Whitney engines, was shipped to Edwards AFB in California in 1989. It was rolled out at Edwards AFB in a public ceremony on June 22, 1990. The first YF-23A flew at the Air Force Flight Test Center on August 27, 1990, with test pilot Paul Metz at the controls. It stayed in the air for 20 minutes. The only problem during this first flight was a left main gear which failed to latch correctly. A further four flights had taken place by mid-September, including flights at supersonic speeds and inflight-refuelling tests with a KC-135 which were carried out on September 14.

The second YF-23A (87-0801), powered by General Electric YF120 engines, followed on October 26. Both YF-23s remain in storage at Edwards AFB.

Technical Description

Length: 67' 5" (20.6 meters)
Wing span: 43' 7" (13.3 meters)
Height: 13' 11" (4.3 meters)
Max Take Off Weight: 64,000 lb (29,029 kg)
Speed: Mach 2
Range: 864-921 miles (750-800 nautical miles) unrefuelled
Armament: Four AIM-9 Sidewinder missiles are carried in internal bays in the sides of the engine intake ducts. Four AIM-120 AMRAAM missiles are carried in internal bays underneath the air intakes.
Crew: 1
Unit cost: Unknown
Constructor: Northrop/McDonnel Douglas

Type	YF-23A Black Widow II
Function	fighter
Year	1990
Crew	1
Engines	2 * P&W YF119-PW-100
Wing Span	13.29 m
Length	20.54 m
Height	4.24 m
Wing Area	88.25 m2
Empty Weight	14970 kg
Max. Speed	1915 km/h
Armament	1*g20 mm

4.1.2 B-2 Spirit

Figure 4.2: B-2 Spirit

Revealed on November 22, 1988, the B-2A is a stealth strategic bomber which resulted from a program started in 1978. The first of six prototypes made its maiden flight on July 17, 1989 with testing scheduled to be completed in 1997. The B-2 is shaped in the form of a 'flying wing', with smoothly contoured surfaces and rounded edges to help deflect radar. Engine exhausts are positioned above and back of the wing front-edge to help reduce infrared signatures. The USAF plan to acquire a total of 20 B-2A aircraft.

The B-2 will probably only be built in small numbers (currently 21 have been ordered), because the cost of replacing all the old B-52's is considered to be far too high. The B-2 is a stealth bomber, a flying wing design with a smooth, rounded upper surfaces, but angular wingtips and a0 double-W trailing edge. The four engines are deeply buried in the midwing section.

Development of the ATB (Advanced Technology Bomber) began in 1978; the programme was revealed to the public in 1981, when Northrop's design was chosen over a Lockheed/Rockwell proposal. Although no details of the design were revealed, it was widely assumed that the aircraft would be a "flying wing" design, based on Northrop's experience with the XB-35 and YB-49, and this was confirmed when the first prototype was rolled out on 22 November 1988. It made its first flight on 17 July 1989, and the first production B-2 was delivered to the USAF in 1993. Production plans have been drastically cut from 135 aircraft to only 20, of which the last is expected to be delivered in 1997. The aircraft was officially named "Spirit" in February 1994; Northrop became Northrop Grumman in May 1994.

Vital statistics (B-2A): length 21.03 m, span 52.42 m, empty weight 72575 kg, max weight 168434 kg, max speed 1103 km/h, range 13898 km, payload 22370 kg; power plant: four 84.51 kN General Electric F118-100 turbofans.

Prime contractor: Northrop Grumman Corporation
Nation of origin: USA
Function: Strategic stealth bomber
Crew: 2/3
Year: 1989

In-service year: Complete delivery by 2000
Engine: Four General Electric F118-GE-110 non-afterburning turbofans, 19,000 lb thrust each
Wing span: 52.43 m
Length: 21.03 m
Height: 5.18 m
Weight: 168434 kg
Ceiling: 50,000 ft
Speed: 1103 km/h
Range: 18,520 km with one air refuel
Armament: Up to 80,000 lb including 16 B61/B83 nuclear bombs, 80 Mk82 1,000 lb bombs or 16 Mk84 2,000 lb bombs, 36 M117 750 lb fire bombs, 36 cluster bombs, or 80 Mk36 1,000 lb sea mines
Unit cost: 800-1300 million USD

Mission

The B-2 Spirit is a multi-role bomber capable of delivering both conventional and nuclear munitions. A dramatic leap forward in technology, the bomber represents a major milestone in the U.S. bomber modernization program. The B-2 brings massive firepower to bear, in a short time, anywhere on the globe through previously impenetrable defenses.

Features

Along with the B-52 and the B-1B, the B-2 provides the penetrating flexibility and effectiveness inherent in manned bombers. Its low-observable, or "stealth," characteristics give it the unique ability to penetrate an enemy's most sophisticated defenses and threaten its most-valued, and heavily defended, targets. Its capability to penetrate air defenses and threaten effective retaliation provide a strong, effective deterrent and combat force well into the 21st century.

The revolutionary blending of low-observable technologies with high aerodynamic efficiency and large payload gives the B-2 important advantages over existing bombers. Its low-observability provides it greater freedom of action at high altitudes, thus increasing its range and a better field of view for the aircraft's sensors. Its unrefueled range is approximately 6,000 nautical miles (9,600 kilometers). The B-2's low observability is derived from a combination of reduced infrared, acoustic, electromagnetic, visual and radar signatures. These signatures make it difficult for the sophisticated defensive systems to detect, track and engage the B-2. Many aspects of the low-observability process remain classified; however, the B-2's composite materials, special coatings and flying-wing design all contribute to its "stealthiness."

The B-2 has a crew of two pilots, an aircraft commander in the left seat and mission commander in the right, compared to the B-1B's crew of four and the B-52's crew of five.

Background

The first B-2 was publicly displayed on Nov. 22, 1988, when it was rolled out of its hangar at Air Force Plant 42, Palmdale, Calif. Its first flight was July 17, 1989. The B-2 Combined Test Force, Air Force Flight Test Center, Edwards AFB, Calif., is responsible for flight testing the Engineering, Manufacturing, and Development aircraft as they are produced. Five of the six developmental aircraft delivered to Edwards are still involved in continuing flight testing. The first test aircraft is currently kept in flyable storage.

Whiteman AFB, Mo., is the B-2's only operational base. The first aircraft, Spirit of Missouri, was delivered Dec. 17, 1993. Primary maintenance responsibility for the B-2 is divided between Oklahoma City Air Logistics Center at Tinker AFB, Okla. for avionics software (contractor);

Ogden Air Logistics Center, Hill AFB, Utah for landing gear and trainers (contractor); and the Northrop-Grumman facility at Air Force Plant 42 at Palmdale for periodic depot maintenance.

The prime contractor, responsible for overall system design and integration, is Northrop Grumman's B-2 Division. Boeing Military Airplanes Co., Vought Aircraft Co., Hughes Radar Systems Group and General Electric Aircraft Engine Group are key members of the aircraft contractor team. Another major contractor, responsible for aircrew training devices (weapon system trainer and mission trainer) is Hughes Training Inc. (HTI) - Link Division, formerly known as C.A.E. - Link Flight Simulation Corp. Northrop-Grumman and its major subcontractor HTI, excluding Link Division, is responsible for developing and integrating all aircrew and maintenance training programs.

General Characteristics

Primary function: Multi-role heavy bomber.
Prime Contractor: Northrop B-2 Division.
Contractor Team: Boeing Military Airplanes Co., Vought Aircraft Co., and General Electric Aircraft Engine Group and Hughes Training Inc. – Link Division
Unit cost: Approximately $1.3 billion
Power Plant/Manufacturer: Four General Electric F-118-GE-100 engines
Thrust: 17,300 pounds each engine
Length: 69 feet (20.9 meters)
Height: 17 feet (5.1 meters)
Wingspan: 172 feet (52.12 meters)
Speed: High subsonic
Ceiling: 50,000 feet (15,152 meters)
Takeoff Weight (Typical): 336,500 pounds (152,635 kilograms)
Range: Intercontinental, unrefueled
Armament: Nuclear or conventional weapons
Payload: 40,000 pounds (18,144 kilograms)
Crew: Two pilots, with provisions for a third crew station
Date Deployed: December 1993
Air Force Inventory: Active force: 20 planned (operational aircraft); ANG: 0; Reserve: 0

4.2 Soviet Union

4.2.1 Yak141 Freestyle

Figure 4.3: Yak141 Freestyle

The Yak-141 is the world's first supersonic VTOL fighter. It operates with lift engines in the forward fuselage and a vectoring nozzle on the main engine, placed well forward, between twin tail booms. The Yak-141 seems to be more a technology demonstrator than an actual fighter aircraft, and the need to use afterburner for take-off is a distinct problem. Development is continuing, after being halted temporarily.

Yakovlev Yak-41/141 Freestyle Design of the Yak-41 began in 1975; the first prototype flew on 9 March 1987, followed by a second in April 1989. Tests were conducted on the aircraft carrier "Admiral Gorshkov". In April 1991, one of the prototypes set several records for VTOL aircraft; it was displayed at the Paris Air Show shortly afterwards. One prototype was lost in a crash (attributed to pilot error) on the carrier in November 1991, after which development was suspended (due to lack of funds rather than any problems with the aircraft); the surviving aircraft was mothballed.

Yakovlev have recently announced their intention to restart development of the Yak-41, apparently as a result of renewed interest from the Russian Ministry of Defence (a similar revival of the twin-turboprop Yak-44 AEW aircraft is also being considered).

A more advanced version, has also been designed, with the emphasis now on Air Force rather than Navy service. This version has an extensively modified airframe, with a strong emphasis on stealth (there is a distinct resemblance to the F-22), a much more powerful engine, and more fuel and payload.

The "Freestyle" has been referred to as both Yak-41 and Yak-141; it appears that one designation refers to the standard fighter (Yak-41) and one to the single prototype modified for record attempts (Yak-141).

Type	Yak-141
Function	fighter
Year	1989
Crew	1
Engines	1 * 15500kg Soyuz R-79V-300, 2 * 4100kg Rybinsk RD-41
Wing Span	10.10 m
Length	18.30 m
Max.Weight	19500 kg
Speed	1800 km/h
Ceiling	+15000 m
Range	2100 km
Armament	1*g30mm, 2600 kg payload
	missiles R-27
	R-73 (air to air)
	Kh-58 (anti-ship)
	Kh-25MP
	Kh-31P (antiradar)

4.3 Russia

4.3.1 SU-35 Super Flanker

Figure 4.4: SU-35 Super Flanker

Improved 'glass cockpit' version of the Su-27, with canard foreplanes, more powerful radar, more powerful engines, and possibly thrust-vectoring nozzles, and an electronics upgrade.

Type	Su-35
Year	1994
Crew	1
Function	fighter
Engines	2 * 137.3kN AL-31MF
Wing Span	15.16 m
Length	21.96 m
Height	6.84 m
Wing Area	62 m^2
Empty Weight	18400 kg
Max.Weight	34000 kg
Speed	2440 km/h
Ceiling	18000 m
Range	3500 km
Armament	1*g30mm 8200 kg payload

The Su-35 has a completely new FCS from that on the Su-27. As well as canards, it has a new, square-topped tailfin (with internal fuel tanks). It also has a new N-011 radar with a range of up to 400 km (or 200 km against ground targets) which can simultaneously track more than 15 targets, engaging six. The new EO complex gives compatibility with advanced "smart" weapons. An advanced datalink allows coordinated group operation and the tailcone houses the antenna for a rear-facing radar which will allow "over-the-shoulder" missile shots. The Su-35 will be compatible with the new 400-km Novator KS-172 AAM-L missile. Flight testing in now reportedly complete and production has been funded. The Su-35 looks a lot like the Su-33. Consideration is being given to retrofit Su-35s with thrust vector control as seen in the Su-37.

Su-35 Specifications

Crew: 1
In-service year: 1996
Powerplant: Two Lyulka AL-31FM afterburning turbofans, 30,855 lb thrust each
Armament: One GSh-30-1 30mm cannon with 150 rounds, plus up to 17,636 lb including R-27B/T/TM AAM, R-73R IR/LASER-guided AAM, R-73RM thrust-vector AAM, R-77 AAM, KS-172 AAM-L, Kh-25ML/MP anti-bunker AGM, Kh-29 anti-armor AGM, Kh-29V anti-radar AGM, Kh-31 anti-armor or Kh-31Sh anti-bunker AGM on eleven external points
Weights (Empty): 40648
Weights (MTOW): 74956
Dimensions (Wingspan): 49 ft 9 in (15.2 m)
Dimensions (Length): 72 ft 9 in (22.2 m)
Dimensions (Height): 22 ft 5 in (6.9 m)
Performance (Ceiling): 59050 ft
Performance (Speed): 1550 mph (2500 km/h)
Performance (Range): 2610 mi (4200 km)

4.4 Taiwan

4.4.1 Ching-Kuo Indigenous Defense Fighter

Figure 4.5: Ching-Kuo Indigenous Defense Fighter

The Ching-Kuo is a light fighter aircraft, developed in Taiwan because of the increasing difficulties the country has in buying modern military equipment. It was developed in collaboration with General Dynamics, and has some similarities to the F-16, although it is twin-engined and has the jet intakes under the wing root (in F-18 style). The Ching-Kuo entered production, despite the new availability of the F-16A and Mirage 2000, but orders have been reduced to 130 (from 420 originally). It entered service in 1994.

Type	Ching-Kuo
Country	Taiwan
Function	fighter
Year	1994
Crew	1
Engines	2 * 42.2 kN ITEC TFE 1042-70
Wing Span	9.46 m
Length	14.21 m
Height	4.42 m
Wing Area	24.2 m^2
Empty Weight	6486 kg
Max.Weight	12247 kg
Speed	+1275km/h at 10975m
Ceiling	16760m
Armament	1*g 20 mm 3900 kg

Ching-Kuo Indigenous Defense Fighter

After the severance of diplomatic relations between Washington and Taipei in January 1979, the future supply of military equipment for Taiwan's armed forces was in question. Thanks to the enactment of the the Taiwan Relations Act (TRA) in early 1979, Taiwan was able to purchase advanced weapons and military equipment from the US.

Taiwan built nearly 300 Northrop F-5s under license from 1974 to 1986. From the early 1980's, Taiwan expressed an interest in purchasing US fighter aircraft to replace its obsolescent Northrop

F-5 and Lockheed F-104 fighters. The United States, which was interested in improving relations with China, denied Taiwan's request to purchase the more capable F-16, and blocked a subsequnetly proposed $1 billion sale of 100 F-20 Tigersharks in July 1982. The 1982 decision by the Reagan administration to bar export of new fighters to Taiwan left technical assistance unrestricted. Taiwan decided to go it alone to build the Indigenous Defense Fighter (IDF).

Taiwan produced the Ching-kuo Indigenous Defense Fighter with extensive assistance by American corporations, led by General Dynamics. The project consisted of four sub-projects. They were the Ying-yang project (in cooperation with General Dynamics Corporation) which made the air-frame; the Yun-han project (in cooperation with Hughes Corporation), which designed the engine; the Tian-lei project (in cooperation with Westinghouse Company), which took care of the avionics system; and the Tian-chien project, which developed the weapons system.

The twin-engine IDF is similar to the F-16 except that it is slightly smaller and has a slightly shorter range. The IDF is a hybrid as far as its external appearance is concerned. The nose of the fighter jet is a replica of the F-20A Tigershark, while ts body, wings, and vertical tail surface are apparently lifted from the F-16, and the shape of its cockpit hood and vertical tail wing and its girth near the engine inlets have a notable French flavor.

The IDF is superior to the F-5E in airborne performance. The IDF accelerates better than the F-104 and its turning radius is smaller than that of the F-5. The aircraft, equipped with four Sidewinder missiles, but without spare fuel tanks, has a combat endurance of three minutes on afterburner and a combat radius of between 70 and 90 nautical miles. With a combat radius of 600 nautical miles while carrying out armed reconnaissance and patrol missions, the IDF is capable of conducting preemptive raids and strikes at airports along the Chinese coast. It is mainly used in combat for air control and is capable of using "Hsiung Feng"-II missiles to attack targets at sea. Most of the IDFs are expected to be armed with the indigenously-produced, BVR Tien Chien-II (Sky Sword-II) ARAAM.

It is equipped with a GD-53 radar, which evolved from the APG-67 and is essentially similar to it in performance. The APG-67 radar uses pulse Doppler technology at X-band and has 15 operational modes in all, eight air-to-air and seven air-to-ground. It can also operate at three different pulse repetition frequencies [PRF]–high, medium, and low–depending on whether the plane is looking up, looking down, or involved in a dogfight in the air, respectively. In a look-down mode, the plane has an effective scanning range of 39 kilometers; looking up, 57 kilometers. The eight air-to-air modes are as follows: searching and range finding while looking down, searching and range finding while looking up, speed searching, tracking (10 targets) and scanning simultaneously, dogfight, tracking a single target, surveying the situation, and continuous-wave indicator interfacing. The seven air-to-ground modes are as follows: real wave velocity topography, Doppler wave velocity sharpening, air-to-ground range finding, moving surface target indicating, freezing, and searching for target at sea surface. In April 1997 Litton's Applied Technology division was awarded a production contract and options totaling $116.2 million by the Aerospace Industrial Development Corporation of Taiwan, ROC, for Improved Radar Warning Receivers (IRWR) to be installed aboard the Indigenous Defense Fighter.

Despite its compact and light external design, the IDF is fitted with two large engines short on propulsive force. The fatal weakness of the IDF is inadequate engine propulsion, and its excess body weight has made the plane accident-prone. Initial versions of the IDF have a top speed of Mach 1.2, using an engine jointly produced by Taiwan and Allied Signal Garret Engine Division. The TFE1042-70 engine was designed for lightweight fighter/attack applications to provide improved aircraft performance and reduced life-cycle costs. The first production TFE1042-70 engine was delivered to Taiwan in 1992, and since then ITEC has delivered more than 300 production engines for the IDF. The International Turbine Engine Corporation (ITEC) operates through a joint venture between AlliedSignal Engines and the Aero Industrial Development Corp. of the

Republic of China. The plan to replace its existing engine with a more powerful one was scrapped because of the commissioning of the F-16 and Mirage 2000. A higher thrust version of the engine would be incorporated into a more capable successor designated the Advanced Defensive Fighter.

Manufacture of the initially planned 250 IDFs was initially estimated at $4.2 billion with a unit cost between $25 and $30 million. At least $1 billion was invested in propulsion and avionics. The IDF is manufactured and assembled in Taichung, which is the manufacturing center of Taiwan's aerospace industry. The Aerospace Industrial Development Corporation is Taiwan's leading manufacturer of military aircraft, including the IDF. With a work force of 6000 employees, AIDC was established in 1969 under the Ministry of Defense as the Aero Industry Development Center (AIDC). The AT-3 advanced trainer, a twin-turbofan aircraft, was designed, developed and produced by the AIDC. In cooperation with Bell Helicopter Inc., it has produced the UH-1H helicopter. Joining forces with the Northrop Corporation, it jointly produced the F-5E/F fighter plane. The T-53 engine was built in cooperation with Textron Lycoming Inc., while both the TFE731 and TFE1042 engines were jointly manufactured with the Allied Signal Aerospace Company. The organization was renamed Aerospace Industrial Development Corporation effective 01 July 1996, when it was moved under the aegis of the Ministry of Economic Affairs. The change of the overseeing agency is seen as a step in the direction of privatization by the year 2000. The Taiwan Aerospace Corporation (TAC) is a private company in which the government holds a 29 percent stake. TAC provides several parts for the IDF, including frames and bulk-heads.

The IDF has faced numerous developmental and operational problems since its inception in the 1980s. Nevertheless, its technical sophistication, with its fly-by-wire controls and blended wing-body design, is believed to be superior to any aircraft produced and deployed by China to date. By 1997 some 60 had been built, and production of all 130 IDFs is scheduled to be completed by early 2000.

The ROC Air Force cut its order of 250 IDFs to 130 after September 1991, in the wake of jet-fighter deals with the United States and France. Taiwan remaining requirements were partially filled when the Bush Administration agreed to sell 150 F-16's, a decision made with an understanding that Taiwan already possessed the capability of producing advanced fighters. For the remaining shortfall Taiwan ordered 60 Mirage 2000 fighters from France. Taiwan purchased 120 single-seat F-16A models and 30 two- seat F-16B models. On-island deliveries, which began in April 1997, were scheduled for completiong by the end of 1999. These aircraft are armed with upgraded AIM-7M/SPARROW SAR and AIM-9P4 and AIM-9S SIDEWINDER IR AAMs. Deliveries of 60 French-built Mirage 2000-5s also began in April 1997 and were completed by October 1998. With its four MICA active radar (AR) and two MAGIC II infrared (IR) AAMs, the Mirage 2000-5 is Taiwan's most formidable air defense fighter.

The first squadron of IDFs joined the ROC Air Force in December 1994, with each carrying a price tag of US$24 million. As of early December 1994, 32 IDF fighter planes were stationed at Ching-chuan-kang Air Force Base. After the delivery of the 130th IDF by the end of 1999 the IDF assembly line will be shut down.

4.5 France

4.5.1 Rafale C

Figure 4.6: Rafale C

French next-generation fighter. France decided to developed its own fighter, rejecting the European EFA as too heavy for carrier use and too costly for export. Rafale is also a canarded delta, but has less angular lines than EFA. Extensive use was made of composite materials. Rafale A was the prototype, Rafale B is the two-seat version, Rafale C the single-seater, and Rafale M carrier fighter version. Four prototypes were flying in early 1997. Orders for 272 production aircraft for the French armed forces are expected.

France chose to produce the Rafale, which will begin operation in 1999, instead of the Eurofighter. The Rafale is lighter and smaller than the Eurofighter. It will be produced in three versions: Rafale M, Rafale C, and Rafale D. The M is the carrier version, with a spring-loaded nose wheel to help it into the air when launching. The C is a one-seater and the D it a somewhat stealthy version for the air force.

Type: Rafale C
Country: France
Export: N/A
Function: Multi-role fighter
Year: 1997
Crew: 1
Engines: 2 * 77 kN SNECMA M88-2
Wing Span: 10.90 m
Length: 15.30 m
Height: 5.34 m
Wing Area: 46.0 m^2
Wing Aspect Ratio: 2.6
Canard Area: Unknown
Tail Plane Area: N/A
Empty Weight: 9060 kg
Max.Weight: 19500 kg
Internal Fuel: 4000 kg

Speed: Mach 2.0
Ceiling: 18290 m
Ferry Range: 3125 km
Combat Radius: 925 km
G-limits: 9/-3.2
Maximum instantenous turn rate: 30 degrees/second
Maximum sustained turn rate: Unknown
Rollrate: 270 degrees/sec
TWR(50% fuel, 2 EM A2A missile, 2 IR A2A missile): 1.3:1
TWR(100% fuel, 2 EM A2A missile, 2 IR A2A missile): 1.10:1
Armament: One internal 30 mm Giat DEFA 791B cannon. Normal external load up to 6000 kg (13,230lb) on 6 underwing, 2 wingtip, 2 centerline, and 4 underfuselage stations. Options include an ASMP nuclear standoff missile, up to 8 Matra Mica AAMs, AM 39 Exocets, LGBs, AS 30L LGASMs, or Apache dispensers with antiarmour or anti runway munitions.
Unit cost: 50 million USD

4.6 Sweden

4.6.1 JAS-39 Gripen

Figure 4.7: JAS-39 Gripen

Despite it's small size, the JAS 39 will be a true multi-role aircraft, carrying all electronics required for every mission. Thus a single aircraft will be able to replace the Viggen in all its versions. The JAS 39 is one of the lightest of the new generation of fighters for the late '90s. Its configuration is that of a canarded delta, powered by a more powerful derivative of the G.E. F404 engine.

The JAS 39 (Jakt Attack Spaning - Fighter/Attack/Reconnaissance) is a new all-purpose fighter designed to replace all models of the Royal Swedish Air Force's Viggens and the remaining Drakens currently in service. Small, agile, and lightweight, the first delta-winged, canard configured Gripen (Griffon) prototype made its maiden flight on December 8, 1988. The JAS 39 is truely a multi-role aircraft in every sense of the word. Configuring the aircraft for fighter, attack, or recce mission types is done simply by modifying the onboard computer software and related systems. Data is passed on to the pilot via three head-down MFDs and wide-angle HUD. For enemy targetting, the MFD to the right of the pilot presents targetting data acquired by the radar, FLIR, and weapons sensors. The total requirement for the Swedish Air Force stands at 300 aircraft to equip 16 squadrons.

Prime contractor: Saab Military Aircraft
Nation of origin: Sweden
Function: Multi-role fighter, attack, and recon
Crew: 1
Year: 1988
In-service year: 1997
Engine: One General Electric/Volvo Flygmotor RM12 afterburning turbofan, 18,100 lb thrust
Dimensions:
Wing span: 8.4 m / 27 ft 7 in
Length: 14.1 m / 46 ft 3 in
Height: 4.5 m / 14 ft 9 in
Weight: 14,600 lb empty / 27,560 lb max. take off
Ceiling: 50,000 ft
Speed: 2,126 km/h / 1,321 mph
Armament: One Mauser BK27 27mm cannon, plus up to 14,330 lb including Rb74/AIM-120 AAMs, Rb15F/Rb75 ASMs, free-fall bombs, rockets, DWS 39 submunition dispensor weapons, recce/sensor pods, and fuel tanks on eight external points

Type	JAS 39 Gripen
Country	Sweden
Export	South Africa/Hungary
Function	fighter / attack / reconaissance
Year	1998
Crew	1
Engines	1 * 80 kN G.E.-Volvo RM 12 (F404-GE-400)
Wing Span	8.00 m
Wing area	30 m^3
Length	14.00 m
Height	4.70 m
Canard Area	Unknown
Wing Aspect Ratio	2.13
Tail Plane Area	N/A
Empty Weight	6622 kg
Max.Weight	12474 kg
Internal Fuel Weight	2,268 kg
Maximum Speed	Mach 1.8
Maximum Speed at low altitudes	Mach 1.15
Ferry Range	3000 km (with external tanks)
Combat Radius	800 km
G-limits	9/-3.0
Maximum instantenous turn rate	30 degrees/second
Maximum sustained turn rate	20 degrees/second
Rollrate	> 250 deg/sec TWR[1]: 0.98:1, TWR[2]: 0.88:1
Armament	1*g 27 mm

JAS 39 Gripen

The JAS 39 Gripen is the result of a joint development by Saab Military Aircraft, Ericsson Microwave Systems, Volvo Aero Corporation and Celsius Aerotech. It is a fourth generation, multi-role combat aircraft. The Gripen fighter combines new knowledge-based, software-controlled avionics systems; modern materials; advanced aerodynamic design; a well-proven engine and fully-integrated system to produce a highly-capable, true multi-role combat aircraft. The Gripen is the first Swedish aircraft that can be used for interception, ground-attack and reconnaissance (hence the Swedish abbreviation JAS – Fighter (J), Attack (A) and Reconnaissance (S) in Swedish) and is now successively replacing the Draken and the Viggen.

In 1978 the Swedish Government decided that the Swedish Air Force needed a new multirole aircraft for the turn of the century. At the same time as the Swedish aerospace industry was defining a new project, the Air Force made an evaluation of existing foreign aircraft such as the American F-16 and F-18. After an evaluation process, Parliament decided in June 1982 to go ahead with the Swedish project and the Defence Materiel Administration signed a contract for development of the JAS 39 Gripen, and the final flight tests were completed in December of 1996.

A total of 204 aircraft in three batches have been ordered for the Swedish Air Force. The first batch of 30 aircraft has been completed. Deliveries from the second batch are ongoing, and comprises 96 one-seater and 14 two-seater aircraft. About 60 Gripens are in service with the Swedish Air Force. In June 1997, a third batch of 64 Gripens was approved by the Swedish Government and ordered by the Defence Materiel Administration (FMV). This will take the total for the Swedish Air Force to 204 aircraft, including 28 two-seaters. Production of batch thre is scheduled for 2002-2007.

Gripen offers high agility, advanced target acquisition systems - including a powerful multi-role radar, modern weapons, low environmental signatures and a comprehensive electronic warfare (EW) suite. The JAS39 Gripen system is designed to counter all current and future threats. The aircraft has been developed for the Swedish Air Force by the Industry Group JAS (SAAB, Ericsson, Volvo Aero and FFV Aerotech) in close co-operation with the Swedish Defence Material Administration (FMV). In partnership with Sweden's Saab, British Aerospace is engaged in a number of marketing campaigns for the highly capable Gripen fourth generation combat aircraft. Engineering activity associated with improving the operability of the aircraft in the export market is now underway.

In 1995 Saab and British Aerospace (BAe) signed an agreement for the joint marketing of the Gripen. Hereby, Saab gained access to the global sales organization of British Aerospace, as well as to its governmental support in international marketing. British Aerospace will adapt the export version of the Gripen to NATO standards, and also produce certain subsystems for the aircraft. The agreement, which followed on more than a decade of cooperation between the two companies, became the basis for a consolidation between Saab and British Aerospace. It also paves the way for SaabCs deepened integration with the European aerospace industry. Saab intends to be an active player along with British Aerospace, Aerospatiale (France), DASA (Germany) and CASA (Spain) in the creation of an integrated European defense and aerospace industry - Eurospace.

In November 1998, South Africa announced that it will probably buy 28 Gripens. The value of the order is 12 billion SEK (1.5 billion USD) and the contract was expected to be signed in May or June of 1999. During the coming 10-15 years, Saab hopes to export at least 400 aircraft, on a total market for fighter aircraft estimated at 2,000 aircraft. The Gripen is currently being offered to Chile, the Philippines, the Czech Republic, Hungary, Austria and Brazil. Another candidate, Poland, recently announced that it will chose the Boeing F 18 Hornet.

An important factor when offering the Gripen for export, is the aircraft missile system. Currently, the Gripens used by the Swedish Air Force are armed with AIM-120 AMRAAM, AIM-9 Sidewinder, the Saab Dynamics RBS 15 for ship targets, and the Maverick ground attack missile. Saab Dynamics cooperates with the major European missile manufacturers in the development of new air-to-air missiles for the Eurofighter, the Rafale and the Gripen. The two main projects currently underway are the Meteor and the IRIS-T. The Meteor is a radar-guided, medium range (10-120 km.) air-to-air missile, which will compete with future versions of the Raytheon AIM-120

AMRAAM. The Meteor program features Matra BAe Dynamics, Saab Dynamics, Alenia Difesa, Marconi and German LFK. The IRIS-T is an IR-guided, short-range air-to-air missile, primarily funded by Germany for the Eurofighter. The project group includes Bodenseewerk Geratechnik and Saab Dynamics.

Specifications

Wing span: 8,0 m
Length overall: 12,0 m
Weight: Approx. 6.500 kg
Max take off weight: Approx. 12500 kg
Armament: Gun, Missiles, Bombs, Rockets and Stand off dispenser

- internally-mounted 27mm gun
- Advanced Medium Range Air-to-Air Missiles (AMRAAM)
- Sidewinder or new generation Short Range Air-to-Air Missiles (SRAAM).
- Sea-Skimming anti-ship missiles.
- Advanced dispenser weapon systems (DWS).
- Air-to-Ground weapons (Maverick, Rocket pods).
- Active/passive Electronic Warfare (EW) systems.
- Internal and external reconnaissance systems.
- Three external fuel tanks.

Powerplant: Volvo Aero RM 12 (General Electric F404J)
Thrust: 80,0 kN (18.000 lbs)
Max Speed: Supersonic at all altitude
Maximum Speed: Mach 1 15 at low altitude, Mach 1.9 at high altitude.
Climb: Less than 2 minutes from brake release to 10km (33,000ft), approx. 3 minutes to 14km (46,000ft)
Level Acceleration: Approx. 30 seconds from Mach 0.5 to Mach 1.1 at low altitude.
Turn Performance: Sustained - approx. 20 4eglsec. Instantaneous - approx. 30 deg/sec.
Max. Load Factor: 9g maximum sustained Nz

Chapter 5

2000-2002

5.1 USA

5.1.1 F/A-22A Raptor

Figure 5.1: F/A-22A Raptor

The F/A-22 is destined to replace the F-15 and become the next-generation fighter of the USAF. Together with the competing F-23 it is one of the first fighter designs optimized for stealth. In addition, it was designed to "supercruise", i.e. fly at supersonic speeds without afterburner. The F/A-22 has a relatively conventional appearance, with twin tails and flat fuselage sides. The engines have two-dimensional thrust vectoring nozzles. To conserve a low radar cross-section, the armament is carried in internal weapons bays.

The Lockheed F/A-22 Raptor, to be in service the United States Air Force, is undoubtedly the most advanced of all the fighter aircraft in development today. This aircraft is a true air dominance fighter and uses highly advanced technology to insure air superiority. The F-22 will provide first look/first shot/first kill ability in all environments. The F-22's sophisticated sensor suite, cockpit design, and avionics that improve the pilot's situational awareness all make up the supercomputing power of the F-22. The F-22's engines allow the aircraft to "supercruise" to a high threat environment, thus greatly increasing the F-22's speed and range over other fighters. The F-22 will make use of its high thrust to weight ratio and thrust vectoring engines to outmaneuver all current and projected fighters. The F-22 uses the most advanced stealth technologies involving a very stealthy airframe, internal carriage of weapons, RAM, reduced IR signature, and much more to extremely diminish the enemy's ability to see the aircraft on radar or lock onto the aircraft with IR guided missiles. The F-22 also possesses a secondary air to surface role. In addition to the two 2000 lb. GPS guided Joint Direct Attack Munitions carried internally, the F-22 can be modified with under wing pylons to carry air to ground munitions once air superiority has been established. The F-22 will enter service in 2005.

First look/first kill in all environments

A combination of improved sensor capability , improved situational awareness, and improved weapons provides first-kill opportunity against the threat. The F-22 possesses a sophisticated sensor suite that allow the pilot to track, identify, and shoot the threat before it detects the F-22. Significant effort is being placed on cockpit design and avionics fusion to improve the pilot's situational awareness. Advanced avionic technologies allow the F-22 sensors to gather, integrate, and display essential information in the most useful format to the pilot.

Reduced observables

Advances in low-observable technologies provide significantly improve survivability and lethality against air-to-air and surface-to-air threats. The F-22's combination of reduced observability and supercruise accentuate the advantage of surprise in a tactical environment.

Supersonic persistence

The F-22 engines produce more thrust than any current fighter engine, especially in the military (non-afterburner) power. This characteristic allows the F-22 to efficiently cruise at supersonic airspeeds without using afterburner (supercruise). This capability greatly expands the F-22's operating envelope in both speed and range over current fighters which must use afterburner to operate at supersonic speeds.

Increased maneuverability

The F-22 has been extensively designed, tested, and refined aerodynamically during the Demonstration/Validation (DEM/VAL) process and coupled with high-maneuver capability. The sophisticated F-22 aerodesign and high thrust-to-weight provides the capability to outmaneuver all current and projected threat aircraft.

Improved combat radius on internal fuel

To ensure the F-22 provides air superiority for deep-interdiction aircraft, it operates at medium and high altitude at ranges superior to current generation air-superiority aircraft.

Improved reliability and maintainability

To ensure operational flexibility, the F-22 has better reliability and maintainability than any military fighter in history. Increased F-22 reliability and maintainability pays off in less manpower required to fix the aircraft and consequently less aircraft required to support a deployed squadron. Additionally, reduced maintenance support provides the benefit of reduced life cycle cost and the ability to operate more efficiently from prepared of dispersed operating locations. The F-22 exceeds current fighter sortie surge rates with a reduced support structure.

Increased lethality and survivability

The above characteristics provide a synergistic effect that ensures F-22 lethality against an advanced air threat. The combination of reduced observability and supercruise drastically shrinks surface-to-air engagement envelopes and minimizes threat capabilities to engage and shoot the F-22.

Air-to-surface capability

The F-22 has a secondary role to attack surface targets. The aircraft will be capable of carrying 2 x 1,000 pound Joint Direct Attack Munitions (JDAMs) internally and will use on-board avionics for navigation and weapons delivery support.

Specifications

Destined to become the next generation fighter of the USAF. The F-22 is a stealthy air-superiority fighter. Another requirement is the ability to cruise at supersonic speeds without afterburner. The F-22 has a rather conventional appearance, with twin tails and flat fuselage sides; the armament is carried in internal weapons bays. The engines have two-dimensional nozzles. Plans for a naval version, intended to replace the F-14, with extensive changes to make the aircraft suitable for carrier use, have been shelved. Service entry is expected in 2005, and the first F-22A production aircraft flew on 7 September 1997.

The ATF (Advanced Technology Fighter) programme began in September 1983, when design contracts were awarded to seven companies; in October 1986, development contracts were awarded to two consortia, one consisting of Lockheed (prime contractor), Boeing, and General Dynamics, the other of Northrop (prime contractor) and McDonnell Douglas. The first Northrop/MD YF-23A (unofficially "Black Widow II") flew on 27 August 1990, followed by the first Lockheed/Boeing/GD YF-22A (unofficially "Lightning II") on 29 September 1990. In April 1991, the YF-22A was selected for development and eventual service.

Recent budget cuts have slowed down the schedule slightly; the first flight of the production Lockheed/Boeing F-22A (General Dynamics sold its fighter division to Lockheed in December 1992), originally scheduled for June 1996, will now be in September 1997. Service entry is expected to begin in 2005; the USAF is currently fighting an attempt by the General Accounting Office to delay this to 2010. Total production, originally planned to be 648 aircraft, has now been reduced to 339.

Reports differed as to whether the aircraft had an official name yet; for a while the Pentagon was considering "Superstar", and some magazine reports have claimed that the name "Rapier" has been assigned. However, Chris Ridlon of USAF ROTC/Academy reports that all the USAF people he knows (including F-22 acquisition officers) are using Lockheed's name of "Lightning II", so that may be officially approved after all. We now know it's Raptor...

Vital statistics (YF-22A): length 18.90 m, span 13.56 m, empty weight 15422 kg, max weight 28123 kg, max speed 2655 km/h (Mach 2.5), ferry range 3704 km; power plant: two 155.68 kN Pratt & Whitney F119-100 augmented turbofans; armament: 20mm cannon, internal bays for two AIM-9 and four AIM-120A or six AIM-120C air-to-air missiles, or two AIM-9, two AIM-120, and two air-to-surface missiles, external hardpoints for four more AIM-120s or other ordnance; radar: Westinghouse/Texas Instruments APG-77.

Type	YF-22
Function	fighter
Year	1990
Engines	2 * 156kN P&W F119-PW-100
Wing Span	13.10m
Length	19.55 m
Height	5.39 m
Wing Area	77.10 m^2
Empty Weight	14061 kg
Max.Weight	26308 kg
Speed	2335 km/h
Range	3704 km
Armament	(prototypes unarmed)
Unit cost	90 million USD

Type: F/A-22 A/C Raptor
Dimensions:
Wing span: 13.56 m
Length overall: 18.92 m
Height overall: 5.05 m
Wing area: 78 m^2
Propulsion:
Powerplant: 2 Pratt & Whitney F119-PW-100 augmented turbofans
Bypas ration: 0.2:1
Intermediate power: 116 kN
Augmented power: 173 kN
Weights:
Operational empty: 14,375 kg
Internal fuel: 11,400 kg
Clean take-off: 27,200 kg
Max take-off: 36,300 kg
Performance:
Maximum speed: Mach 1.9
Supercruise speed: Mach 1.6
Combat Radius: 1400 km

5.1.2 X-35A JSF (F-35)

Figure 5.2: X-35A JSF (F-35)

The Joint Strike Fighter (JSF) is going to be the mass produced 5th generation aircraft of the 21st century. Until 26 October 2001 there was an ongoing competition between Lockheed Martin (designer of aircraft on the left, the X-35) and Boeing (designer of aircraft on the right, the X-32). The winner of this competition will produce the F-16's replacement. Unlike the F-22, the JSF will be a relatively low cost aircraft. The U.S. Air Force, U.S. Navy and Royal Navy, and the US Marine Corps will use the JSF.

Overall the airframes will be alike with a few exceptions; the U.S. Air Force version will be a conventional takeoff multi-role fighter. The U.S. Navy's version of the JSF will be similar to the Air Force version except with a stronger internal structure, landing gear, and arresting hook to allow carrier landings. The U.S. Marine Corps and Britain's Royal Navy version (X-35B) will have a short takeoff and vertical landing (STOVL) capability thus allowing this version of the JSF to land almost anywhere. The JSF will use many of the advanced technologies employed in the F-22 yet still remain a low cost 5th generation fighter. It is scheduled to enter service in around 2012.

And the winner is...

October 26, 2001: 4:58 p.m. ET

NEW YORK (CNNmoney) - The U.S. Department of Defense Friday awarded Lockheed-Martin Corp. a contract that could be worth upwards of $200 billion to build its new radar-evading Joint Strike Fighter. Lockheed, the nation's No. 1 defense contractor, beat out rival Boeing Corp. for the long-coveted deal which is the largest in U.S. military history.

"The Lockheed Martin team is the winner on a best value basis," said Jim Roche, Secretary of the Air Force who announced the contract award along with Undersecretary of Defense Pete Aldridge.

Officials made the announcement at a press conference at the Pentagon near Washington, D.C.

Friday. Aldridge said conditions of the contract do not require Lockheed-Martin (LMT: Research, Estimates) to share any of the work with Boeing (BA: Research, Estimates) , but added that the government would not stop them from doing so. "While the Boeing team was not selected, they did an excellent job in the process," Aldridge said. "If Lockheed-Martin wishes to use the unique talents of Boeing they may do so."

The Joint Strike Fighter is intended to replace the nation's aging fleet of fighter aircraft including the A-10 and the FA-18. The plane is expected to be the government's primary fighter aircraft beginning in 2008 through 2040, Aldridge said.

Joint Strike Fighter (JSF)

The Joint Strike Fighter (JSF) is a multi-role fighter optimized for the air-to-ground role, designed to affordably meet the needs of the Air Force, Navy, Marine Corps and allies, with improved survivability, precision engagement capability, the mobility necessary for future joint operations and the reduced life cycle costs associated with tomorrow's fiscal environment. JSF will benefit from many of the same technologies developed for F-22 and will capitalize on commonality and modularity to maximize affordability.

The 1993 Bottom-Up Review (BUR) determined that a separate tactical aviation modernization program by each Service was not affordable and canceled the Multi-Role Fighter (MRF) and Advanced Strike Aircraft (A/F-X) program. Acknowledging the need for the capability these canceled programs were to provide, the BUR initiated the Joint Advanced Strike Technology (JAST) effort to create the building blocks for affordable development of the next-generation strike weapons system. After a review of the program in August 1995, DoD dropped the "T" in the JAST program and the JSF program has emerged from the JAST effort. Fiscal Year 1995 legislation merged the Defense Advanced Research Projects Agency (DARPA) Advanced Short Take-off and Vertical Landing (ASTOVL) program with the JSF Program. This action drew the United Kingdom (UK) Royal Navy into the program, extending a collaboration begun under the DARPA ASTOVL program.

The JSF program will demonstrate two competing weapon system concepts for a tri-service family of aircraft to affordably meet these service needs:

USAF-Multi-role aircraft (primarily air-to-ground) to replace F-16 and A-10 and to complement F-22. The Air Force JSF variant poses the smallest relative engineering challenge. The aircraft has no hover criteria to satisfy, and the characteristics and handling qualities associated with carrier operations do not come into play. As the biggest customer for the JSF, the service will not accept a multirole F-16 fighter replacement that doesn't significantly improve on the original.

USN-Multi-role, stealthy strike fighter to complement F/A-18E/F. Carrier operations account for most of the differences between the Navy version and the other JSF variants. The aircraft has larger wing and tail control surfaces to better manage low-speed approaches. The internal structure of the Navy variant is strengthened up to handle the loads associated with catapult launches and arrested landings. The aircraft has a carrier-suitable tailhook. Its landing gear has a longer stroke and higher load capacity. The aircraft has almost twice the range of an F-18C on internal fuel. The design is also optimized for survivability.

USMC-Multi-role Short Take-Off & Vertical Landing (STOVL) strike fighter to replace AV-8B and F/A-18A/C/D. The Marine variant distinguishes itself from the other variants with its short takeoff/vertical landing capability.

UK-STOVL (supersonic) aircraft to replace the Sea Harrier. Britain's Royal Navy JSF will be very similar to the U.S. Marine variant.

The JSF concept is building these three highly common variants on the same production line using flexible manufacturing technology. Cost benefits result from using a flexible manufacturing approach and common subsystems to gain economies of scale. Cost commonality is projected in the range of 70-90 percent; parts commonality will be lower, but emphasis is on commonality in the higher-priced parts.

The Lockheed Martin X-35 concept for the Marine and Royal Navy variant of the aircraft uses a shaft- driven lift-fan system to achieve Short-Takeoff/Vertical Landing (STOVL) capability. The aircraft will be configured with a Rolls-Royce/Allison shaft-driven lift-fan, roll ducts and a three-bearing swivel main engine nozzle, all coupled to a modified Pratt & Whitney F119 engine that powers all three variants. The Boeing X-32 JSF short takeoff and vertical landing (STOVL) variant for the U.S. Marine Corps and U.K. Royal Navy employs a direct lift system for short takeoffs and vertical landings with uncompromised up-and-away performance.

Key design goals of the JSF system include:

- *Survivability:* radio frequency/infrared signature reduction and on-board countermeasures to survive in the future battlefield–leveraging off F-22 air superiority mission support
- *Lethality:* integration of on- and off-board sensors to enhance delivery of current and future precision weapons
- *Supportability:* reduced logistics footprint and increased sortie generation rate to provide more combat power earlier in theater
- *Affordability:* focus on reducing cost of developing, procuring and owning JSF to provide adequate force structure

JSF's integrated avionics and stealth are intended to allow it to penetrate surface-to-air missile defenses to destroy targets, when enabled by the F-22's air dominance. The JSF is designed to complement a force structure that includes other stealthy and non-stealthy fighters, bombers, and reconnaissance / surveillance assets.

JSF requirements definition efforts are based on the principles of Cost as an Independent Variable: Early interaction between the warfighter and developer ensures cost / performance trades are made early, when they can most influence weapon system cost. The Joint Requirements Oversight Council has endorsed this approach.

The JSF's approved acquisition strategy provides for the introduction of an alternate engine during Lot 5 of the production phase, the first high rate production lot. OSD is considering several alternative implementation plans which would accelerate this baseline effort.

Program Status

The focus of the program is producing effectiveness at an affordable price-the Air Force's unit flyaway cost objective is $28 million (FY94$). This unit recurring flyaway cost is down from a projected, business as usual,cost of $36 million. The Concept Demonstration Phase (CDP) was initiated in November 1996 with the selection of Boeing and Lockheed Martin. Both contractors are: (1) designing and building their concept demonstration aircraft, (2) performing unique ground demonstrations, (3) developing their weapon systems concepts. First operational aircraft delivery is planned for FY08.

The JSF is a joint program with shared acquisition executive responsibilities. The Air Force and Navy each provide approximately equal shares of annual funding, while the United Kingdom is a collaborative partner, contributing $200 million to the CDP. CDP, also known as the Program Definition and Risk Reduction (PDRR) phase, consists of three parallel efforts leading to Milestone II and an Engineering and Manufacturing Development (EMD) start in FY01:

Concept Demonstration Program. The two CDP contracts were competitively awarded to Boeing and Lockheed Martin for ground and flight demonstrations at a cost of $2.2 billion for the 51-month effort, including an additional contract to Pratt & Whitney for the engine. Each CDP contractor will build concept demonstrator aircraft (designated X-32/35). Each contractor will demonstrate commonality and modularity, short take-off and vertical landing, hover and transition, and low-speed carrier approach handling qualities of their aircraft.

Technology Maturation. These efforts evolve key technologies to lower risk for EMD entry. Parallel technology maturation demonstrations are also an integral part of the CDP / PDRR objective of meeting warfighting needs at an affordable cost. Focus is on seven critical areas: avionics, flight systems, manufacturing and producibility, propulsion, structures and materials, supportability, and weapons. Demonstration plans are coordinated with the prime weapon system contractors and results are made available to all program industry participants.

Requirements Definition. This effort leads to Joint Operational Requirements Document completion in FY00; cost/performance trades are key to the process.

Specifications

Type	X35-A	X35B	X35C
Function	fighter		
Contractor	two competing teams: Lockheed-Martin & Boeing		
Service	U.S. Air Force	U.S. Marine Corps U.K. Royal Navy	U.S. Navy
Variants	CTOL[1]	STOVL[2]	Carrier-based (CV)
Unit Cost FY94$	$28M	$35M	$38M
Propulsion	Baseline: Pratt & Whitney F119-PW-100 derivative from F-22 Raptor Alternate Engine: General Electric F120 core		
Empty Weight	~22,500 lbs		~24,000 lbs
Internal Fuel	15,000 lbs		16,000 lbs
Payload	13,000 lbs		17,000 lbs
Maximum Takeoff Weight	~50,000 lbs		
Length	45 feet		
Wingspan	36 feet		30 feet
Speed	supersonic		
Combat Radius	over 600 nautical miles		
Crew	one		
First flight (Date Deployed)	1999 (2008)		
Inventory Objectives	U.S. Air Force (2,036 aircraft) U.K. Royal Navy (60 aircraft)	U.S. Marine Corps (642 aircraft)	U.S navy (300 aircraft)
Length	15.41 m		15.50 m
Wingspan	10.00 m	13.12 m	9.10 m folded
Height	4.07 m		
Wing Area	41.8 m^2		50.2 m^2
Weigths(empty)	about 9,980 kg		
Weigth(max Takeoff)	about 22,680 kg		
Max Payload	about 6,805 kg		
Thrust(PW)	about 155kN		
Max Speed(altitude)	Maxh 1.5		

First Flight: (X-35A) 24 October 2000
Service Entry: winning design to become operational about 2008
Powerplant: one Pratt & Whitney F119-611 turbofan and one Rolls-Royce/Allison shaft-driven lift-fan
Armament:

- *Gun:* one 20-mm cannon
- *Mountings:* 2 internal weapons bays and external hardpoints (only for non-stealthy missions)
- *Air-to-Air Missile:* AIM-120 AMRAAM
- *Air-to-Surface Missile:* unknown
- *Bomb:* up to two 1,000 lb (455 kg) bombs (internally) or two 2,000 lb (900 kg) bombs, presumably JDAM

Known Variants:

- *X-35A:* Multi-role conventional takeoff (CTOL) fighter for US Air Force; 1 built
- *X-35B:* Multi-role short takeoff and vertical landing (STOVL) fighter for US Marines and UK Royal Navy equipped with lift fan; X-35A to be converted to X-35B for STOVL tests

- *X-35C:* Navalized (CV) fighter similar to X-35A but with larger wings for increased fuel capacity as well as larger horizontal tails and control surfaces; 1 built

description

The Joint Strike Fighter project may be the largest and most important military aircraft program of the early 21st century, and both the military and contractors have placed large stakes on its outcome. While Boeing's competing X-32 is of unusual configuration, the Lockheed approach tends to resemble its larger cousin, the F-22. The advanced engine derived from that used on the F-22 is fed by two side intakes mounted beneath swept wings of similar planform to the F-22. As with the Boeing entrant, three variants are being studied: the conventional takeoff and landing (CTOL) X-35A for the US Air Force, the short takeoff and vertical landing (STOVL) X-35B for the US Marines and UK Royal Navy, and the carrier-based (CV) X-35C for the US Navy. Also like the X-32, Lockheed has constructed two prototypes for evaluation. The initial X-35A will be used for early flights before being modified and fitted with a second engine. This additional engine, a shaft-driven lift-fan system plus roll control jets along the wings, is coupled to the primary engine to provide the lift for vertical flight. Once complete, this modified airframe will be redesignated X-35B for completion of the STOVL portion of the evaluation process. During the three-month conversion process, the bulk of test flights will be assumed by the X-35C demonstrator for the Navy. This model features an enlarged wing of greater span and area for larger fuel capacity as well as enlarged horizontal tails and flaperons for greater control effectiveness during low-speed carrier approaches. While Boeing has adopted a direct lift STOVL design based on that used in the Harrier, Lockheed has opted for a different approach in meeting the vertical flight requirements. Inspired by the Russian Yak-141, the X-35B incorporates a separate lift fan that is powered by the F119 engine but provides an independent source of thrust in hover. While the Boeing design is more conventional, Lockheed argues that their strategy is better in the long term since it offers more room for growth as the aircraft evolves. The winner of the JSF contest will be announced on 26 October 2001.

5.1.3 F/A-18E Super Hornet

Figure 5.3: F/A-18E Super Hornet

Twin-engined shipboard fighter, developed from the F-18. Because of its dual role as attack aircraft, it is officially known as the F/A-18E. The substantially modified F-18E 'Super Hornet', was rolled out at the end of 1995 and made its first carrier landing in early 1997. This F-18E and the two-seat F-18F can be recognized easily by their rectangular engine intakes, which reduced radar reflection and provide a greater mass flow for their more powerful engines. The F-18E is also longer and has a bigger wing, with two additional hardpoints, and has sturdier landing gear to cope with the increased weight. Range has been increased by 40%. The F-18E is expected to enter service in 2002.

Introduction

The F/A18-E/F Super Hornet is the US Navy's new long-range, multi-mission, all-weather strike fighter. The aircraft made its debut at Patuxent River (Md.) Naval Air Station in September 1995. A total of ten test aircraft are being used for the test program. Seven are flying test aircraft and three are ground test aircraft. All seven flying aircraft are currently at Patuxent River.

The F/A18-E/F has achieved many milestones since its debut. The most significant was initial sea trials aboard USS John C. Stennis (CVN 74), the Navy's newest aircraft carrier. These first Super Hornet carrier qualifications occurred in January 1997 off the coast of Florida, and consisted of a series of tests including catapult launches, arrested landings and various other system evaluations conducted by flight deck crews.

Background

The F/A18-E/F is an evolutionary upgrade of the combat-proven F/A18-C/D, built by an industry team led by McDonnell Douglas, Northrop Grumman, General Electric and Hughes. The upgrade provides a state of the art multi-mission capability and decades of growth potential at one third to one half the cost of a new aircraft design.

The Super Hornet is fully capable to conduct both air-to-air and air-to-ground combat missions. This includes air superiority, day/night strike with precision-guided weapons, fighter-escort, close air support, suppression of enemy air defenses, reconnaissance, forward air control and refueling. The Super Hornet has greater range/endurance, can carry a heavier payload, has enhanced survivability, and a built-in potential to incorporate future systems and technologies.

F/A18-E/F as it compares with the F/A18-C/D

The F/A18-E/F:

- can fly up to 40% farther on a typical interdiction mission.
- can remain on station 80% longer during a typical combat air patrol scenario.
- has three times the "bring back" capability (will be able to "bring back" approximately three times the amount of payload (unused ordnance) to the ship.)

Other F/A18-E/F facts

- has increased internal fuel capacity by 3600 pounds (33%).
- has increased engine power.
- can extend of the mission radius by up to 40%.
- has additional weapon stations now totaling 11.
- has increased surface area by 100 square feet (25%).
- carries modified display mechanisms to include crew station features, up-front controls and color CRT instrumentation

Summary

The U. S. Navy believes the F/A18 Super Hornet is the right airplane at the right time. The single seat F/A18-E and the two seat F/A18-F will continue to uphold the Hornet's proud tradition as the U. S. Navy's benchmark for high reliability, low maintenance, outstanding survivability and cost-effective fleet operations. The Super Hornet test program holds much promise for the future as it leads naval aviation into the 21st century!

General Characteristics, E and F models

Primary Function: Multi-role attack and fighter aircraft
Contractor: McDonnell Douglas
Unit Cost: $ 35 million
Propulsion: Two F414-GE-400 turbofan engines
Thrust: 22,000 pounds (9,977 kg) static thrust per engine
Length: 60.3 feet (18.5 meters)
Height: 16 feet (4.87 meters)
Maximum Take Off Gross Weight: 66,000 pounds (29,932 kg)
Wingspan: 44.9 feet (13.68 meters)
Ceiling: 50,000+ feet
Speed: Mach 1.8+
Crew:
A,C and E models: One
B,D and F models: Two
Armament: One 20mm M-61A1 Vulcan cannon;
External payload: AIM 9 Sidewinder, AIM 7 Sparrow, AIM-120 AMRAAM, Harpoon, Harm, Shrike, SLAM, SLAM-ER, Walleye, Maverick missiles; Joint Stand-Off Weapon (JSOW); Joint Direct Attack Munition (JDAM); various general purpose bombs, mines and rockets.
First Flight: December 1995

5.1.4 Aurora

Figure 5.4: Aurora

Background

Does the United States Air Force or one of America's intelligence agencies have a secret hypersonic aircraft capable of a Mach 6 performance? Continually growing evidence suggests that the answer to this question is yes. Perhaps the most well-known event which provides evidence of such a craft's existence is the sighting of a triangular plane over the North Sea in August 1989 by oil-exploration engineer Chris Gibson. As well as the famous "skyquakes" heard over Los Angeles since the early 1990s, found to be heading for the secret Groom Lake installation in the Nevada desert, numerous other facts provide an understanding of how the aircraft's technology works. Rumored to exist but routinely denied by U.S. officials, the name of this aircraft is Aurora.

The outside world uses the name Aurora because a censor's slip let it appear below the SR-71 Blackbird and U-2 in the 1985 Pentagon budget request. Even if this was the actual name of the project, it would have by now been changed after being compromised in such a manner.

The plane's real name has been kept a secret along with its existence. This is not unfamiliar though, the F-117a stealth fighter was kept a secret for over ten years after its first pre-production test flight. The project is what is technically known as a Special Access Program (SAP). More often, such projects are referred to as "black programs".

So what was the first sign of the existence of such an aircraft? On 6 March 1990, one of the United States Air Force's Lockheed SR-71 Blackbird spyplanes shattered the official air speed record from Los Angeles to Washington's Dulles Airport. There, a brief ceremony marked the end of the SR-71's operational career. Officially, the SR-71 was being retired to save the $200-300$ million a year it cost to operate the fleet. Some reporters were told the plane had been made redundant by sophisticated spy satellites.

But there was one problem, the USAF made no opposition towards the plane's retirement, and congressional attempts to revive the program were discouraged. Never in the history of the USAF had a program been closed without opposition. Aurora is the missing factor to the silent closure of the SR-71 program.

Testing such a new radical aircraft brings immense costs and inconvenience, not just in the design and development of a prototype aircraft, but also in providing a secret testing place for aircraft that are obviously different from those the public are aware of.

Groom Dry Lake, in the Nevada desert, is home to one of America's elite secret proving grounds. Here is Aurora's most likely test location. Comparing today's Groom Lake with images of the base in the 1970s, it is apparent that many of the larger buildings and hangars were added during the following decade. Also, the Groom Lake test facility has a lake-bed runway that is six miles long, twice as long as the longest normal runways in the United States. The reason for such a long runway is simple: the length of a runway is determined either by the distance an aircraft requires to accelerate to flying speed, or the distance that the aircraft needs to decelerate after landing. That distance is proportional to the speed at which lift-off takes place. Usually, very long runways are designed for aircraft with very high minimum flying speeds, and, as is the case at Edwards AFB, these are aircraft that are optimized for very high maximum speeds. Almost 19,000 feet of the runway at Groom Lake is paved for normal operations.

Lockheed's Skunk Works, now the Lockheed Advanced Development Company, is the most likely prime contractor for the Aurora aircraft. Throughout the 1980s, financial analysts concluded that Lockheed had been engaged in several large classified projects. However, they weren't able to identify enough of them to account for the company's income.

Technically, the Skunk Works has a unique record of managing large, high-risk programs under an incredible unparalleled secrecy. Even with high-risk projects the company has undertaken, Lockheed has a record of providing what it promises to deliver.

Hypersonic Speed

By 1945, only a small amount of jets had the capability of reaching speeds of 500mph. In 1960, aircraft that could exceed 1,500mph were going into squadron service. Aircraft capable of 2,000mph were under development and supposed to enter service by 1965. This was a four-fold increase in speed in two decades.

From this, the next logical step was to achieve hypersonic speed. The definition of hypersonic isn't as clearly defined as supersonic, but aerodynamicists consider that the hypersonic realm starts when the air in front of the vehicle's leading edges "stagnates": a band of air is trapped, unable to flow around the vehicle, and reaches extremely high pressures and temperatures. The edge of the hypersonic regime lies at a speed of roughly one mile per second - 3,600mph or Mach 5.4.

What is regarded by many as the most successful experimental aircraft program in USAF history, the X-15 rocketplane was created in response to a requirement issued by NASA (then NACA) for an air-launched manned research vehicle with a maximum speed of more than Mach 6 and a maximum altitude of more than fifty miles.

The X-15 program, which involved three test aircraft, went on to exceed all goals set and provided valuable data which has been used on many high speed/altitude aircraft of today, including NASA spacecraft, and most likely, the Aurora aircraft.

In the early 1960s, Lockheed and the USAF Flight Dynamics Laboratory began a hypersonic research program which would provide data on travel at hypersonic speed as well as more efficient shapes for hypersonic vehicles. From this program came the FDL-5 research vehicle, which beared an amazing resemblance to the North Sea Aurora sighting of Chris Gibson. Building on both the FDL-5 Project and Aurora, the aircraft which may have been seen over the North Sea could have been Northrop's A-17 stealth attack plane.

Possible forms of hypersonic propulsion that Aurora could be using include:

- Pulse Detonation Wave Engines
- Pulsejet Engines
- Advanced Ramjets

Hypersonic Requirements

There are three reasons why the North Sea sketch drawn by Chris Gibson is the most persuasive rendition of the Aurora vehicle. Firstly, the observer's qualifications, with which he couldn't identify the aircraft; which would have been instantaneous if the aircraft was known to the "white world". Second is the fact that the North Sea aircraft corresponds almost perfectly in shape and size to hypersonic aircraft studies carried out by McDonnell Douglas and the USAF during the 1970s and 1980s. The third factor is that the North Sea aircraft looks unlike anything else. No aircraft other than a high-supersonic vehicle, or a test aircraft for such a vehicle, has ever been built or studied with a similiar planform.

At hypersonic speeds, traditional aerodynamic design gives way to aero-thermodynamic design. In order for a hypersonic vehicle to remain structurally intact at such high speeds and stresses, the vehicle must produce minimum drag and be free of design features that give rise to concentrations of heat. The aircraft design must be able to spread the heat over the surface of the structure.

Thermal management is critical to high-speed aircraft, especially hypersonic vehicles. Skin friction releases heat energy into the aircraft and must be pumped out again if the vehicle is to have any endurance. The only way to do this is to heat the fuel before it enters the engine, and dump the heat through the exhaust. On a hypersonic vehicle, thermal management is very critical, the cooling capacity of the fuel must be used carefully and efficiently or else the range and endurance of the aircraft will be limited by heating rather than the actual fuel tank capacity.

So how will an aircraft reach such speeds? Conventional turbojet engines won't be able to handle the incoming airstreams at such speeds, they can barely handle transonic speeds. In the case of hypersonic propulsion, an aero-thermodynamic duct, or ramjet, is the only engine proven to work efficiently at such speeds. Even ramjets have drawbacks though, such as drag created in the process of slowing down and compressing a Mach 6 airstream.

To make a ramjet engine efficient is to spread the air over the entire length of the body. In a hypersonic ramjet aircraft, the entire underside of the forward body acts as a ramp that compresses the air, and the entire underside of the tail is an exhaust nozzle. So much air underneath the aircraft serves another purpose, it keeps the plane up.

The ramjets need a large inlet area to provide the high thrust needed for Mach 6 cruise. As a result, the engines occupy a large area beneath vehicle and the need to accomodate a large quantity of fuel means that an all-body shape is most feasible.

Structurally, the all-body shape is highly efficient. As well as being extremely aerodynamic, the average cross-sectional area being very large provides a great deal of space for load, equipment and fuel. This being inside a structure that is light and compact having a relatively small surface area to generate frictional drag.

The spyplane's airframe may incorporate stealth technology, but it doesn't really require it should its mission simply involve high altitude reconnaissance. Hypersonic aircraft are much harder to shoot down than a ballistic missile. Although a hypersonic plane isn't very maneuverable, its velocity is such that even a small turn puts it miles away from a SAM's projected interception point.

Choosing The Right Fuel

Choosing the right type of fuel is crucial to the success of Aurora. Because various sections of the craft will reach cruising-speed temperatures ranging from 1,000 degrees fahrenheit to more than 1,400 degrees fahrenheit, its fuel must both provide energy for the engines and act as a structural coolant extracting destructive heat from the plane's surface.

At hypersonic speeds, even exotic kerosene such as the special high-flashpoint JP-7 fuel used by the SR-71 Blackbird can't absorb enough heat. The plausible solution is cryogenic fuel.

The best possibilities are methane and hydrogen. Liquid hydrogen provides more than three times as much energy and absorbs six times more heat per pound than any other fuel. The downfall is its low density, which means larger fuel tanks, a larger airframe and more drag. While liquid hydrogen is the fuel of choice for spacelaunch vehicles that accelerate quickly out of the atmosphere, studies have shown that liquid methane is better for an aircraft cruising at Mach 5 to Mach 7. Methane is widely available, provides more energy than jet fuels, and can absorb five times as much heat as kerosene. Compared with liquid hydrogen, it is three times denser and easier to handle.

Specifications

Speed: Speeds are reported to be in the range of Mach 5-8.
Length: 110 feet (33.5 meters)
Wingspan: 60 feet (18.2 meters)
Ceiling: 150,000 feet (28.4 miles)
Design: The Aurora aircraft has an airframe like a flattened American football, about 110 ft long and 60 ft wide, smoothly contoured, and covered in ceramic tiles similar to those used on the Space Shuttle which seem to be coated with "a crystalline patina indicative of sustained exposure to high temperature. . . a burnt carbon odor exudes from the surface."
Engine:
Several have heard a distinctive low frequency rumble followed by a very loud roar, which could be the exotic engine used by a Mach 6 (4,400 miles per hour) aircraft. Experts say a methane-burning combined cycle ramjet engine (uniting rocket and ramjet designs) could have been developed to power Aurora. Observers in California have also reported seeing a large aircraft with a delta-wing shape and foreplanes. Some think this could be an airborne launch platform for satellite-delivery rockets or even the Aurora, before its more advanced engines were developed.

Power comes from conventional jet engines in the lower fuselage, fed by inlet ducts which open in the tiled surface. Once at supersonic speed, the engines are shut down, and Pulse Detonation Wave Engines take over, ejecting liquid methane or liquid hydrogen onto the fuselage, where the fuel mist is ignited, possibly by surface heating.

A vast amount of runours, conjecture, eye-witness sightings and other evidence point to an aircraft, funded as a Black Project, built by the Lockheed Skunk Works, operating out of the Groom Lake / Area 51 location. Always at night, never photographed, officially denied... This is the Aurora Project. No matter what speculation takes place, it seems the secrets that lie beyond the mountains of the Nevada desert will remain until the US military decides otherwise.

Power Plant:
At subsonic speeds power comes from conventional jet engines in the lower fuselage, fed by inlet ducts which open in the tiled surface. Once at supersonic speed, there are three possibilities for the propulsion that carries the plane up to its mach 5+ speed:

- PWDE Pulse Detonation Wave Engines - Essentially, liquid methane or liquid hydrogen is ejected onto the fuselage, where the fuel mist is ignited, possibly by surface heating. The PDE Pulse Detonation Engine (PDE) operates by creating a liquid hydrogen detonation inside a specially designed chamber when the aircraft is traveling beyond the speed of sound. When traveling at such speeds, a thrust wall (the aircraft is traveling so fast that a molecules in the air are rapidly pushed aside near the nose of the aircraft which in essence becomes a wall)is created in the front of the aircraft. When the detonation takes place, the the aircraft's thrust wall is pushed forward. This all is repeated to propel the aircraft. From the ground, the jet stream looks like "rings on a rope". Another reader thinks this method is very suspicious. He goes on "a serious problem with the SR-71 and other high-speed aircraft is excessive skin heating. The last thing you want is to add combustion at or near the surface."

- Ramjet - A reader points out that there is "a second possible power plant design, the Combined Cycle Ramjet Engine. Essentially, it is a rocket until it goes supersonic. At that point the rocket nozzles are withdrawn and the engines run as ramjets up to Mach 4-6. With a few minor modifications to the shape of the combustion housing, you could soup the power plant up to a scramjet, which could see speeds up to and beyond Mach 8. The fuel for this power plant could be liquid methane or methylcyclohexane, plus liquid oxygen as an oxidizer in the primary 'rocket' stage. Further data on this power plant is available through Popular Science Magazine, March 1993 issue. " However another reader feels that a ramjet is not a possible propulsion source because "the National Aerospace Plane (NASP) was cancelled in large part due to the inability to solve the materials problems with the proposed supersonic ramjets. I don't think there has been enough progress, even in the black world to solve these problems. Further, RAMJET doesn't leave doughnuts on a rope."

- Regular Pulsejet - Pulsejets uses the forward speed of the engine and the inlet shape to compress the incoming air, then shutters at the inlet close while fuel is ignited in the combustion chamber and the pressure of the expanding gases force the jet forward. The shutters open and the process repeats itself at a high frequency. This results in the buzzing drone for which the pulsejet missile is named: the buzzbomb. A reader points out that "pulsejets can be cooled to solve the materials problems of supersonic ramjets. They could also generate doughnuts on a rope although this is speculation as I am unaware of any previous actual tests at high altitude."

Armament: Although it has been rumored that the Aurora is equipped with the capability of carrying air-to-ground armaments, it is unlikely that the aircraft is designed for, or able to, support armaments. It is likely the plane is equipped for reconnaissance only.

There has been some debate about this though, as there was a Phoenix Air to Air missile that was designed to be carried in the F-12 (Basically a later interceptor version of the SR-71). This missile can only be carried by the F-12, the F-111 and the F-14 Tomcat. This missile might also be usable on the Aurora.

Mission: Reconnaissance missions.

Contractor: It is rumored that the Aurora was designed and built by Lockheed Aeronautical Systems Co., the same company who built the SR-71.

The SR-71 has served as one of the only aircraft capable of performing a mobile reconnaissance mission. Although satellites are useful in this role, the SR-71 had the advantage of going wherever and whenever an "eye-in-the-sky" is needed. In spite of this funding for the SR-71 program was canceled in 1989 and SR-71 flights ceased.

Given the importance of the role of the SR-71, and the fact that it is the only plane capable of performing that role, it has been suggested that government must have some secret aircraft that was capable of replacing the SR-71. According to Richard H. Graham, Col., USAF in his book SR-71 Revealed, "in 1990, Senator Byrd and other influential members of congress were told a successor to the SR-71 was being developed and that was why it was being retired. The "Aurora" could be this plane.

This argument is weakened by the fact that in 1995, congress approved $100 million to bring the SR-71's back into service. One argument is that the Aurora was abandoned, either due to expense or technical difficulties, and that the SR-71 had to be brought back to resume its mobile surveillance role.

Legacy: The Aurora might be a follow-up project, or research project from the XB-70 Valkyrie.

5.2 Europe

5.2.1 EuroFighter Typhoon

Figure 5.5: EuroFighter Typhoon

The first flight of the prototype Eurofighter 2000 took place on March 27, 1994, when Messerschmitt-Bülkow-Blohm (MBB) chief test pilot Peter Weger took the prototype on a test flight around Bavaria. The basic configuration is reminiscent of the British Aerospace (BAe) EAP agile combat aircraft demonstrator, which flew back in August, 1986. In fact, the EAP was used to test many Eurofighter systems before final configuration of the latter plane was decided. (The relationship is similar to the F-17 and F/A-18, where the basic planform is the same but many design changes were made.)

The EF2000 is built by a consortium made up of BAe (UK), MBB and Dornier (Germany), Aeritalia (Italy), and CASA (Spain). It was initially designed for air-superiority and air defense roles, but a changing world situation has also resulted in an emphasis on excellent air-to-surface capabilities as well.

The STOL (Short Take-Off and Landing) aircraft has a fundamentally unstable aerodynamic design; while this requires computer assistance for stable flight, gives the EF2000 superior agility. Two Eurojet EJ200 advanced technology turbofans each provide 20,250 pounds of afterburning thrust; with a maximum take-off weight of 37,480 pounds fully loaded, this means the EF2000 has power to spare. Although it's not actually a stealth aircraft, careful shaping and use of composites and low-detectability technologies (the airframe surface is only 15 % metal) means the EF2000 is extremely light and has a much smaller radar profile than 1980s-era fighters.

The fly-by-wire control system ensures the pilot can't stall or overstress the plane, and there's even a button that will automatically return the plane to a wing-level, nose-up attitude if the pilot becomes disoriented after a high-G maneuver. All important switches are mounted on the throttle or stick, giving the EF2000 true HOTAS (Hands On Throttle And Stick) control. Three panel-mounted MFDs are supplemented by a HUD and a helmet-mounted sight for aiming AS-

RAAM missiles.

Initial deliveries to the RAF are set, for the year 2003. Analysts generally agree that the only fighter with a demonstrable superiority to the EF2000 is the American F-22, which costs twice as much and doesn't have the EF2000's air-to-surface capability.

The EF-2000 is the product of a consortium of British Aerospace, Deutsche Aerospace (Germany), Alenia (Italy), and CASA (Spain), with the United Kingdom and Germany providing technological leadership. Under full-scale development since 1988, the EF-2000 is a 46,000 lb, single-seat, twin-engine short takeoff and landing (STOL) multirole fighter, optimized for air superiority with both beyond-visual-range (BVR) missile capability and close-in combat agility, but also featuring air-to-ground capabilities. Computer simulations (focusing on BVR air-to-air combat) conducted by European contractors and government agencies suggest that the EF-2000 is superior to all U.S., Russian, and European fighters examined, with the exception of the F-22. While it is impossible to assess the validity of these findings, they do indicate that the developers of the Eurofighter are aiming for highly impressive capabilities.

Technical Briefing

The EF2000 is a product of a four nation consortium made up of the UK, Germany, Italy, and Spain. The Eurofighter program began in 1983 with a desire to produce an aircraft that could be used for worldwide defense well into the 21st century. Formal development began with the EAP (Experimental Aircraft Programme) in 1988. In March of 1994, the first flight of the EF2000 prototype occurred. The EF2000 is now slated for delivery to the RAF in the year 2003.

The EF2000 is a canard equipped delta aircraft optimized for the air-superiority role but able to be used for ground attack. Extensive use of high technology materials has been made including carbon composites, glass reinforced plastics, titanium, and aluminum lithium, in 80% of the airframe. Like the Gripen and Rafale the EF2000 uses canards and a broad delta wing to get the best combination of agility, lift, and speed.

The cockpit environment is one of the most advanced in the world using digital fly-by wire and multi-function displays. Twin EJ2000 reheated turbofans provide for a powerful yet efficient propulsion system.

Advanced armament makes the EF2000 a deadly adversary for any enemy.

Specification and Dimensions

Type	Eurofighter
Country	Britain/Germany/Italy/Spain
Export	Greece/Austria
Function	Multi-role fighter
Year	2002
Crew	1
Engines	2 * 102 kN EJ-200 reheated turbofans
Wing span	10.5m (34 ft 5.5 in)
Length	14.5 m (47 ft 7 in)
Height	6.4 m (21 ft)
Wing area	50.0 m^2 (538 sq. ft)
Wing aspect ratio	2.205
Canard Area	2.4 m^2
Tail Plane Area	N/A
Maximum speed	Mach 2.0 (2060 kmh, 1280 mph)
Maximun speed at low altitude	1390 km/h
Minimum speed	203 km/h
Service ceiling	18,290m (60,000 ft)
Time to 10600m/Mach 1.5	2,5 min
Runway length	500m (1,640 ft)
Max range with max internal fuel	600 n miles, (1112 km, 690 miles)
Combat Radius	900 km
Ferry Range	3700 km
Basic mass empty	9,750 kg (21,495 lb.)
Empty Weight	10,995 kg
Max take-off mass	21,000 kg (46,218 lb.)
Max external stores	6,500 kg (14,300 lb.)
Internal Fuel Weight	5000 kg
G-limits	9/-3.5
Maximum instantenous turn rate	Unknown
Maximum sustained turn rate	Unknown

TWR(50% fuel, 2 EM A2A missile, 2 IR A2A missile): 1.42:1
TWR(100% fuel, 2 EM A2A missile, 2 IR A2A missile): 1.20:1

The Eurofighter carries NATO's best weapons. It has a high load Capacity with flexible missile configurations. It has thirteen carriage points, three of which are capable of holding external fuel tanks. The maximum fuel or weapons payload is 6,500 kg (14,330 lb.).

5.2.2 Air-to-Air

- S-225 long range (radar guided)
- AIM 120 medium range(radar guided)
- ASRAAM short range infra-red
- AIM 9M short range infra-red
- 27mm Mauser cannon

A mixture of at least ten ASRAAMs (advanced short range air-to-air missiles) and AMRAAM (advanced medium range air-to-air missiles) can be carried with four of the AMRAAMs housed in low drag, low observability fuselage stations.

Air-to-ground

- AGM 65 Maverick
- ALARM anti-radar missile
- Sea Eagle anti-ship missile
- Paveway laser guided bombs
- CR-V7 unguided rockets
- BL755 cluster bombs.v
- Durandal, other free fall bombs.

A wide variety of air-to-surface weapons can be carried on seven stations, including avionics stores such as laser designators.

5.3 Russia

5.3.1 SU-47 (S-37 Berkut)

Figure 5.6: SU-47 (S-37 Berkut)

The Sukhoi's candidate for the Russian air force requirement for a Mnogo-funktsional'ny Frontovoy Istrebitel' (MFI - multifunctional frontal fighter) is less known than its rival Mikoyan article 1.42. Vladimir Ilyushin, Sukhoi's veteran test pilot, revealed in mid 1997 that the aircraft was "close to completion", adding that it will be a "worldwide sensation" when it is unveiled. The scarce information on Simonov's new fighter indicate that it had already underwent high-speed taxi tests by the end of the summer and made its maiden flight at Zhukovsky at September 25th, 1997, in hands of Sukhoi's test pilot Igor Votintsev.

What's in the Name?

The S-32 (do not mix with Su-32!) is an internal Sukhoi OKB designation which is rationalized in terms of commonly used yet controversial indexing originated with Sukhoi Su-7 and Su-9 prototypes. These were designated S-1 and T-1 respectively, with "S" being a first letter of swept wing in Russian "Strelovidnoe krylo" and "T" from the Russian for delta wing "Treugol'noe krylo". Clearly, the "S" in S-32 implies that new Sukhoi has a swept wing but the index conflicts with another S-32 taken by Sukhoi Su-17 prototypes few decades ago. There is a great deal of hints that S-32 is a phony designation and presently a different designation is used in conjunction with new Sukhoi fighter – S-37 (do not mix with Su-37!). The S-37 index was formerly allocated to a single-engined lightweight multirole combat aircraft broadly similar to French Rafale which was cancelled in 1994. In any event, both S-32 and S-37 are internal bureau designation, and could become Su- anything. Reported name of S-37 is Berkut (Ber-koot) which means golden eagle in Russian.

From Tailless Canard to Tandem Triplane

The fifth-generation Sukhoi fighter features forward-swept wings (FSW), canards and twin outward-canted vertical stabilisers and incorporates low-observable and thrust-vectoring technologies. Comparing blown up photograph of the scale model and early speculative sketches and artist renderings, which appeared in western aviation press, it is clear that S-37's forward-swept wing is closely coupled to canards. Nonetheless, the aircraft retains the horizontal stabilisers, evolving from pure canard to a tandem triplane layout. The first S-37 photographs show that the stabilizer are highly swept (ca 70 deg) and their leading edges appear to extend aft from the wing roots of FSW. This is very different from X-29A strakes which were extensions of the wing roots themselfs ending with a trailing edge flaps.

The tandem triplane configuration was test flown in 1985 on T-10-24 which served as one of the naval Flanker prototypes. The addition of the canards, referred PGO in Russian (Perednee Gorizontal'noe Operenie - Forward Horizontal Stabilizers), solved the control problems encountered at high angle-of-attack (AOA) flight regimes when the tailerons lost their efficiency in the wake of the wing. The PGO's seemed to be a favourite choice for forth-and-a-half generation of Sukhoi's Su-34, -32FN, -35 and Su-37 and fifth-generation S-37 and S-54.

Although the genesis of the S-37 remains unclear, some sources suggested that original layout was much closer to X-29A tailless scheme and that aerodynamic of early S-37 directly benefited from Central Aerohydrodynamics Institute (TsAGI) wind-tunnel tests with X-29A scale models. It is possible that S-32 may be a technology demonstrator, built to examine FSW aerodynamics and composite wing structures or may have started its life as one, but realities of 90's urged Simonov to take this project one step further in attempt to present the S-32 as a genuine contender for a fifth-generation fighter seeked by the Russian air force. This might explain the fact that the S-32 seems to be much too heavy for a research testbed, being a considerably larger aircraft than Northrop F-5 sized X-29A.

In fact, the S-37 is in the class of Su-27 as seen from comparison of its scale model to the advanced Su-27 Flanker model presented at the same meeting. Moscow Aerospace (MAKS 97) provided additional data on S-37 and confirmed that dimensions, performance and tandem triplane layout of the S-37 are similar to that of Su-37. First public photographs of the S-37 suggested that the front part of the fuselage including the "hooded cobra" LERX could have come from the original S-37 canard-delta. If true, this could possibly clear up the origins of the S-37 index.

Forward Swept Wing

The early Soviet designs to feature moderately forward swept wing were Belyaev's DB-LK and Babochka aircraft and Mikoyan Gurevitch PBSh-2 (MiG-6) biplane. Captured at the end of WWII, German FSW Junkers Ju-287 was test flown by German and Russian crews. A six engined EF-131 was build and underwent extensive structural and flight testing until 1947, when theme was closed. At about the same time Pavel Tsybin build several testbeds LL (Letauchaya Laboratoriya) -1, -2 and -3 with stright, swept back and forward swept wings respectively (40 degrees). The LL-1 and LL-3 rocket powered gliders performed number of powered flights and provided TsAGI with much needed FSW data. In one of the flights LL-3 reached Mach 0.97 in dive.

Sukhoi Fifth-generation Fighter Philosophy

The FSW is a better performer at high angles of attack in post-stall manoeuvring much needed in close-in dogfight. The fact that Simonov had chosen FSW for his fifth-generation fighter once again confirms Sukhoi's commitment to the superagility as a crucial requirement for the next generation air-superiority fighter. This approach, so much different from western concepts of stealth, supercruise and BVR engagements, was taken to the limits in Su-37. The FSW S-32 fitted with TVC expected to outperform its stalemate in close-in dogfight involving post-stall flight regimes. Having the edge in manoeuvring, the S-32 is clearly catching up in stealth with US and European new-generation fighters. However even with its internal weapon bay and RAM coating, the new Sukhoi is a very different concept than F-22. The heavy accent on RAM rather than radar absorbing structures (RAS) is obvious. The reason for such attitude is not clear, although a combination of the technology limitations and operational doctrine is most likely candidate. The major components of radar stealth – RAM coatings and surface quality – are subject to the production and maintenance tolerance as it was shown by USAF F-117 and B-2 operational experience. Untightened screws, scratches or unfastened access panels were known to greatly deteriorate the RCS of the aircraft, reducing the engineering efforts put into aircraft design. It remains to be seen how Sukhoi will overcome the looser production standards of the Russian aircraft plans.

The Afghanistan experience where Sukhoi's encountered a thread of the shoulder launched infrared homing surface-to-air missiles such as Redeye, Stinger and SA-7, forced Sukhoi team to work on the reduction of the infrared signature of the Su-25. The results materialized in the Su-25T development – Su-25TM (Su-39 in Sukhoi's nomenclature). The installation of the intake cones hiding the turbine blades and efficient mixing of the exhaust with cold air reduced the IR signature of the Frogfoot from front and rear aspects. This fourfold reduction at expense of 2% lower SFC is indeed an impressive achievement. Further experiments with low visibility involved the advanced Flanker development prototypes, aircraft of 700 (Su-35,-37) and 600 (Su-30) series. These fighters wear eye catchy new camouflage schemes designed to reduce the visual signature of the aircraft on the ground and in the sky. One of the most interesting examples of Sukhoi experiments was a scheme applied to 701, designed to deceive space based optical systems. Some effort was directed in reduction of the radar cross sections of advanced Flankers as well. The Su-34,-32FN have optimized radar random shape, lack variable geometry intakes and were reported to have partial RAM coating. Recently Sukhoi stated that basic export models of Su-30MK can be treated with RAM to fulfill customer requirement for a lower RCS aircraft. Clearly benefitting from previous research, the S-37 prototype relies heavily on the Sukhoi's state of the art low observable technology. The forward swept wing, a conformal underfuselage weapon station(s), use of RAM and the inward-canted tailfins, suggest a further reduction of the aircraft radar signature down from similarly sized Flanker's 3-5 sq m. The extend of the reduction of the IR signature of the S-37 exhausts will depend on the choice of the trust vectoring nozzle. The F-22 type flat 2D nozzle can give a better results while 2D nozzle might contradict to Simonov's superagility ideas favouring 3D exhaust. The Saturn-Lulka was reported to work on reduction of the IR signature of the axi-symmetric trust vector controlled (TVC) Al-37FU power plant on non-afterburning regimes.

Powerplant

The scarce availability of trust vectoring Saturn-Lulka Al-41F engineered for the Mikoyan's article 1.42 forced Sukhoi to seek a replacement for the originally planned powerplant. According to MAPO MIG sources, the limited number of Al-41F are involved in Mikoyan's Article 1.42 tests and not available to Sukhoi's competitor. Reluctance of MAPO MIG made a trust-vectoring control (TVC) Al-37FU (sometime referred as Al-31FU where FU stands for Forsazh, Upravlaemoye soplo - afterburning, articulated nozzle) powerplant used in Sukhoi's Su-37 a natural choice for fifth-generation fighter, but would have been premature for the first S-32 airframe. Additionally, the availability of the Al-37FU could be a problem since all prototypes are involved in flight tests on the Su-37 and in the bench endurance tests. At the time of the Su-37 first flight only three Al-37FU were built.

The ultimate S-32 powerplant – Al-37FU – operates in automatic and manual modes. In manual mode the nozzle deflection angle is set by the pilot, and in automatic mode the axi-symmetric nozzles are controlled by the MNPK Avionika full-authority, digital fly-by-wire flight control system (FCS). The movable in pitch axis nozzle deflects ±15 degree at 30 deg/s by a pair of hydraulic jacks. The production Al-37FU will use jet fuel instead of hydraulic liquid to drive the nozzles. Surprisingly, as a temporal solution, instead of similar and widely available Su-27 Flanker's Al-31F powerplants, the S-32 prototype received a pair of Perm Aviadvigatel D-30F6 engines used on MiG-31 Foxhound interceptors. Designed by the 1980, this full authority digital engine control (FADEC) engine comprises six interchangeable modules and a core module. Although powerplant accumulated several thousand flight hours and experienced no operational drawbacks, it has estimated 300 hrs life between overhauls (Russian engine maintenance is very different from western philosophy and term "overhauls" has a different meaning). There were no reports on TVC versions of D-30F6.

The photographs of S-37 Berkut, show two details: the starboard tail sting is slightly longer than the port one and the two auxiliary intakes on the top of the fuselage. There are three reasonable explanations to the sting asymmetry: a) it houses a breaking or a spin recovery shute b) it is due to the asymmetric engine installation typical for prototypes. The port engine will be used to test a 3D TVC nozzle which will require adequate space for the yaw vectoring c) Sukhoi used two 2D nozzles oriented perpendicular to each other to control pitch and yaw separately. Combined action give a pseudo 3D effect. This last explanation is least likely since Lulka reported to have 3D TVC nozzle "in the pocket" at the time of Farnborough 96. Auxiliary intakes could be used during take offs for increased air flow to the engines. These could have been repositioned from the underside of the aircraft due to the reduces radar cross section considerations or/and lack of the space taken by internal missile bay(s).

Avionics

In early September, defence-ministry acquisition chief Col Gen Anatoly Sitnov noted: "What is the use of developing the Sukhoi fifth-generation fighter, if the aircraft's cockpit dates back to a second- or third-generation design?" While Sitnov statement clearly implying the state of the art of the S-32, one can hardly expect that a first test airframe will incorporate all innovations planned for the series production. Similarly, the sole Su-37 demonstrator flies with a counterweight instead of the advanced radar hence the aircraft is intended to explore among other things the trust vectoring modes of the new powerplant. However, the Su-37 fighter will have the top notch avionics suit which is tested on other 700 series airframes – Sukhoi Su-35s. It is expected that the sophistication of S-32 cockpit and avionics suit should at least match that of forth-and-a-half generation Su-35 and Su-37 aircraft. The cockpit of the S-32 does most certainly feature the color liquid crystal MFDs and wide angle HUD. The test proven in Su-37 demonstrator inclined pilot seat, a fixed pressure sensitive throttle and side-stick controller will also find its way to the cockpit of new fighter expected to impose even greater G-loads on pilot than superagile Su-37.

The type of the radar intended for S-32 is not known. The size of the random seems to be somewhat smaller than that of Su-27 family, possibly implying the smaller diameter antenna. Since the S-32 lacks the Flanker's sting, the placement of the rearward facing radar will be challenging at best.

Armament

The armament of the S-32 will most likely never get close to the air-to-air arsenal of Mikoyan's article 1.42, enjoying super long range K-37. However the ram jet version of AA-12 Adder, R-77PD (RVV-AE-PD), seems to be the most appropriate long stick for the new fighter. The missile's collapsible lattice stabilizers give R-77 family the compactness well suited for the internal weapon bay(s) of the stealth S-32. However, the aerodynamically superior lattice stabilizers have reportedly a much greater RCS than conventional surfaces, thus potentially revealing the position of the aircraft at the moment of the missile launch. The exact number of weapon bays is not known, although the total number of the hardpoints will be fourteen. The use of the internal/external weapon loads will depend on the mission.

S-37/S-32 Specifications

Wingspan	16.7 m
Length overall	22.6 m
Height overall 6.40 m	
Weight empty, equipped	24,000 kg (52,910 lb)
Max T-O weight	34,000 kg (74,960 lb)
Max level speed at height	2,500km/h (1,350 knots)
Max level speed at S/L	1,400km/h (756 knots)
Service ceiling	18,000 m (59,050 ft)
Range with max fuel at height	1,782 nm (3,300 km/2,050 miles)
Number of hardpoints	14 & 2 wingtip, 6-8 underwing, 6-4 conformal underfuselage
Air-to-air	R-77, R-77PD, R-73, K-74
Air-to-surface	X-29T, X-29L, X-59M, X-31P, X-31A, KAB-500, KAB-1500

5.3.2 SU-37 Terminator

Figure 5.7: SU-37 Terminator

A derivative of the Su-27 'Flanker', the Su-37 is a super-maneuverable thrust vectoring fighter. Designed from an Su-35 prototype, the Su-37 test aircraft (designated T10M-11) made its maiden flight in April 1996 from the Zhukovsky flight testing center near Moscow. The Su-37 powerplant features more standard thrust than all earlier 'Flanker' variants, including the Su-35. In addition, the hydraulically actuated nozzles of its Lyulka/Saturn AL-37FU (Forsazh Upravlaemoye meaning 'afterburning steerable') engines are steerable -15 to +15 degrees along the vertical plane. Thrust control is fully integrated into the flight control system, requiring no input from the pilot. An emergency system can automatically return the nozzles to level flight in the event of an onboard failure. The Su-37 has the newer, more powerful, NIIP NO-11M pulse-Doppler phased-array nose radar. A rearward-facing missile system and NIIP NO-12 rear-radar will give the pilot the ability to fire at enemy aircraft behind the Su-37, in addition to the front. While the Su-37 is the first Russian aircraft to feature thrust vector control comparable to that of the American F-22, it may not be the last. A new axisymmetrical (three-dimensional) nozzle is currently being developed by Lyulka for the future Sukhoi S-55 aircraft, a single-engined version of the Su-35. Nozzles are also being readied to make current Su-35s TVC capable.

Prime contractor: Sukhoi Design Bureau
Nation of origin: Russia
Function: Multi-role fighter
Crew: 1
Year: 1996
In-service year: unknown
Engine: Two Lyulka AL-37FU vectored-thrust afterburning turbofans, 30,855 lb thrust each
Dimensions Wing span: 14.70 m
Length: 22.10 m
Height: 6.32 m
Weight: 40,565 lb empty / 74,956 lb max. take off
Ceiling: 59,055 ft
Speed: 2,440 km/h
Range: 3,500 km
Armament: One GSh-30-1 30mm cannon, plus up to 18,075 lb including R-73/R-77 AAMs, ASMs, bombs, rockets, drop tanks, and ECM pods carried on fourteen external points

Multi-role combat version of the Su-27, developed from the Su-35. The Su-37 uses full digital FBW controls in combination with two- dimensional thrust vectoring nozzles. Like the Su-35, it has canards. The Su-37 is not yet in production.

Type	Su-37
Function	fighter
Year	1996
Crew	1
Engines	2 * 137kN Saturn AL-37FU
Wing Span	14.70 m
Length	22.10 m
Height	6.32 m
Wing Area	
Empty Weight	18500 kg
Max.Weight	34000 kg
Speed	2400 km/h
Ceiling	17800 m
Range	
Armament	1*g30mm 8000 kg

5.3.3 MiG/MAPO 1.42 MFI

Figure 5.8: MiG/MAPO 1.42 MFI

The MiG 1-42 MFI (Mnogofunktsionalny Frontovoi Istrebitel - Multifunctional Frontline Fighter), sometimes referred to in the West as "ATFski," is a low-observable (LO) multirole fighter. The primary mission of the 1.42 is air-superiority, which makes 1.42 a direct Russian equivalent of the USAF F-22, but, being a multi-functional fighter, it performs almost just as well in a strike mission. Two prototype have been built, called the MiG 1-44. The program has been suspended many times due to lack of funds but it has survived. It carries missiles in internal bays and on external pylons (like the F-22) and, as MiG MAPO claims, it is stealthier than the F-22. The chief designer of the 1.42 claims it will have greater agility and range than the F-22 (It has 3D TVC and it is big). If it's built, it could enter service around 2006-2008. It is a twin-engined aircraft with a cranked delta wing, canards, twin tail fins, jet intakes under the nose, and 3D vectoring nozzles. It's supposed to be incredibly agile and it will be able to supercruise. It features the new Phazotron N-014 phased array fire control radar as well as a rearward-facing N-012 radar. To reduce RCS it sports a heavy coating of RAM, S-shaped compressor channels, internal weapon storage, LO airframe geometry, and maybe an active radar cancellation system (RCS) or a plasma cloud stealth (PCS) system. The MiG 1.42 will cost about $70 million, compared to the EF2000's $60 million, the USAF JSF's $24 million, and the F-22's $150 million. Though it will probably never enter service in Russia due to its high price tag and Russia's financial crisis, China and India could supply some of the money to develop it and might be primary customers. It is featured in Jetfighter: Full Burn (as the MiG-42) but looks a little different.

Type	MiG/MAPO 1.42
Function	Multirole Fighter
Crew	1
Engines	2 * Two three-dimensional thrust-vectoring Saturn/Lyulka AL-41F turbofans[3]
Wing Span	16.40 m
Length	20.00 m
Height	5.60 m
Max.Weight	34500 kg
Empty Weight	16500 kg
Speed	2450 km/h
Ceiling	18945 m
Range	4000 km
Armament	1*cannon 30 mm 6000kg 12 internal hardpoints

5.4 China

5.4.1 Chengdu J-10

Figure 5.9: Chengdu J-10

J-10 (Project 10/Project 8810?) is a multi-role single-engine fighter being developed by Chengdu Aircraft Corporation (CAC) and 611 Institute. It has been selected by PLAAF as the next generation fighter to replace the obsolete J-7 fighter and Q-5 attack aircraft. The aircraft appears to have an Su-27 style nose and retangular air intake, an AL-31F type engine, twin nosewheels, and a distinct low-visibility camouflage color scheme. The aircraft also has a large vertical tail plus twin F-16 style ventral stablizers believed to provide greater stability at high AoA. Its fuselage looks considerably longer compared to Israeli Lavi. However its bubble canopy appears less elevated than that of F-16, suggesting the pilot has yet to possess a true 360° view. Unlike J-7E with double-delta wings, it appears to have a pair of inverted gull wings (i.e. the inner portion extends slightly downward, while the outer portion extends flat). Two red dummy PL-8 AAMs are regularly seen carried under the wing as well.

The J-10 project was started in the mid-80s based on the experience (tailless delta wing and canard foreplanes) with J-9 which was cancelled earlier in favor of the less risky J-7C/MIG-21MF project. An early model of J-10 revealed a Mirage 2000 style intake with a center shock cone for better high speed performance and a Lavi style tail section, suggesting a possible connection with the cancelled Israeli fighter (however this was firmly denied by both parties). The change indicates that J-10 has gone through at least one major redesign in its 10-year development period from the initial conventional layout (as an air-superiority fighter) to the latest semi-stealthy design (as a multi-role fighter). This change may reflect a shift of its potential adversaries from former Soviet MiG-29/ Su-27 to current American F-15/F-16 after end of the Cold War.

The new design will certainly be fitted with advanced avionics including a "glass cockpit" (1 wide-angle HUD + 2 monochrome MFD + 1 color MFD), HMS, HOTAS, GPS/INS, air data computer, RWR, digital quadruplex FBW, digital fuel management system, 1553B databus, and a new PD fire-control radar (search distance 52 148km, track 8 targets simutaneously), which can be either Israeli Elta EL/M 2035, Russian Phazotron Zhuk derivative (Zhemchoug?), or the indigenous JL-10A from LETRI (with technical assistance from Phazotron?). A variety of newly developed air-to-air (e.g. PL-8 short-range IR-guided AAM and PL-11/PL-12/SD-10 medium-range radar-guided AAM) and air-to-surface weapons (e.g. C-701 TV-guided ASM & LGBs) are also expected to be carried under 11 hardpoints. Although it was believed to be powered initially by a 27,560lb/12,500kg thrust AL-31FN turbofan, a modified AL-31F which itself powers Su-27/J-11, Russia reportedly had denied China the license to produce the engine locally. As the result, an indigenous engine (WS-10A?) may be fitted later when the serial production starts.

Some US military analysts believe that J-10 could pose a serious challenge to F/A-18E in terms of maneuverability. Some specifications of J-10 are (speculated): empty weight 9,750kg, max TO weight 18,500kg, internal fuel 4,500kg, external load 4,500kg, g load -3 +9, max speed Mach 2.0 (high altitude)/Mach 1.2 (sea level), TO distance ¡500m, combat radius 463̃566km.

The development of J-10 has proven to be tortuous. The prototype was rumored to have first flown in 1996, but the project suffered a serious setback in late 1997 when the 02 prototype lost control and crashed, as the result of certain system failure, presumably with either the FBW system or the engine. After careful redesign and extensive ground test, the successful flight of the new prototype (J-10A?) took place on March 23, 1998, which put the project back on the track. Initially 6 prototypes (serial numbers 1001-1006) were built undergoing various static and flight tests at CAC in Chengdu and at the CFTE in Yanliang. Subsequently 3 more prototypes were built (1007-1009) as the project is moving to the pre-production phase while PLAAF remains fully committed. A carrier based version (J-10B?) was rumored but never confirmed. The earliest service date was expected to be 2005. The latest news suggested that the test flight of J-10 is near completion and the full scale production will start in 2003 while 300 are planned. The first J-10 in production standard first flew on June 28, 2002.

General Informations

Name:
PLA Designation: J-10
Westernised Name: F-10

Manufacter: Chengdu Aircraft Industry Co. (CAC)
Type: Single-engine, single-seater multirole fighter capable for interception, air superiority, and ground attack missions.

Programme

The Chengdu (CAC) J-10 fighter, China's fourth generation multi-role fighter aircraft, will be the most advanced fighter in the PLAAF's inventory once introduced to service. The J-10 programme (Project No.10) has been under way for over a decade. Six prototypes have been built by 2001 and these aircraft are reported being undertaking extensive test flights at CAC's test site.

The J-10 programme can trace its origins back to the J-9, a Mach 2.5 canard-delta fighter, which is a blend mixture of MiG-23 and Saab JA-37 Viggen. The J-9 project was transferred from Shenyang to Chengdu in 1969 and was later cancelled due to insufficient funds.

Work on the J-10 began in the 1980s as a counter to the Soviet Union's fourth-generation fighters, the MiG-29 and Su-27. The original mission was air superiority, but the break-up of the Soviet Union and changing requirements shifted development towards a multirole fighter to replace the Shenyang J-6 (MiG-19) and Chengdu J-7 (MiG-21), which are backbone of China's air force.

Originally based on the cancelled Israel Avation Industry (IAI) 'Lavi' lightweight fighter, the J-10's development has experienced some major re-design work due to the changes of requirements. Some estimates project that the as many as 300 aircraft will be produced for the Chinese air force, although reports suggest as few as 30 aircraft will have been built by 2005 - a drop in the ocean of J-6s and J-7s in the PLAAF's inventory waiting to be replaced.

Design features

The J-10 has a rectangle belly air intake, with low-mounted delta wings, a pair of front canard wings, a large vertical fin, and two underfuselage fins. The design is aerodynamically unstable, to provide a high level of agility, low drag and enhanced lift. The pilot controls the aircraft through a computerised digital fly-by-wire system, which provides artificial stabilisation and gust elevation to give good control characteristics throughout the flight envelope.

Cockpit: The J-10's cockpit is fitted with three flat-panel liquid crystal multifunction displays (MFDs), including one colour MFD, wide field-of-view head-up display (HUD), and possibly helmet-mounted sight (HMS). It is not know whether the HMS is the basic Ukrainian Arsenel HMS copied by China's Luoyang Avionics, or a new helmet display featured briefly at the 2000 Zhuhai air show.

The pilot manipulates the J-10 by the 'Iron Bird' flight-control system, a quadruple (four channels) digital fly-by-wire (FBW) based on the active control technology tested by the Shenyang J-8IIACT demonstrator aircraft. The pilot will also be aided by advanced autopilot and air data computer.

Radar: Several options are available for the J-10 fighter. These include the Russian Phazotron Zhuk-10PD, a version of the system in later Su-27s, with 160 km search range and ability to track up to six targets. Israel has offered its Elta EL/M-2035 radar for competition. In addition, China has also developed its own design JL-10A, which might be assisted by Russian technology.

For low-level navigation and precision strike, a forward-looking infrared and laser designation pod is likely to be carried F-16-style on an inlet stores station. A Chinese designed pod similar to the Israeli Rafael Litening was revealed at the 1998 Zhuhai air show.

Engine: The single-seat, single-engine J-10 is similar in size to the Lockheed Martin F-16C/D. The initial batch J-10s are going to be powered by 27,500 lb-thrust (120 kN) Russian Lyulka Saturn AL-31F turbofan, the same power plant also being used by Chinese air force Sukhoi Su-27s and Su-30s. Some report indicated that 100 AL-31F engines with features specially designed for the

J-10 have already been delivered to China in early 2001.

China is also developing its own WS-10 turbofan power plant, and it could be fitted on the later versions of the J-10. According to the U.S. intelligence, the J-10 might be slightly more manoeuvrable than the F-18E/F, which is slated to become the U.S. Navy's next principal combat aircraft.

Armarments: The J-10 has 11 stores stations - six under the wing and five under the fuselage. The inner wing and centre fuselage stations are plumped to carry external fuel tanks. Fixed weapon is a 23-mm inner cannon hidden inside fuselage.

In addition to the PL-8 short-range infrared-guided air-to-air missile, which was derived from Israeli Rafael Python-3 technology, the J-10 could also carry Russian Vympel R-73 (AA-11) short-range and R-77 (AA-12) medium-range missiles carried by Chinese Flankers. It may also be fitted with indigenously developed PL-11 or PL-12 medium-range AAM for BVR combat.

For ground attack missions, the J-10 will carry laser-guided bombs, YJ-8K anti-ship missile, as well as various unguided bombs and rockets. Some missiles surrently under development such as the YJ-9 ramjet-powered anti-radiation missile may also be carried by the J-10.

Upgrade: An all-aspect vectored-thrust version of the AL-31F was revealed for the first time at Zhuhai Air Show 1998, leading to speculation that this advanced engine may wind up on the J-10, potentially conferring phenomenal manoeuvrability. It also projects that a naval variant of the J-10, perhaps with twin-engines, may equip a possible Chinese aircraft carrier. China might also be considering upgrading the J-10 with more advanced phased-array radar to improve its combat capabilities.

Type	Chendgu J-10
Country	China
Function	Fighter
Year	2003
Crew	1
Engines	1 * Lyulka Saturn AL-31F turbofan[4]
Wing Span	8.78 m
Wing area	33.1 m^2
Canard area	5.45 m^2
Length	14.57 m
Height	4.78 m
Ceiling	18000 m
Empty Weight	9750 kg
Max.Weight	18500 kg
Speed	Mach 2.0
Range	3200 km (combat radius)
Armament	1 * g 23 mm, 4500 kg payload on 11 hardpoints

5.5 India

5.5.1 Light Combat Aircraft

Figure 5.10: Light Combat Aircraft

The LCA (Light Combat Aircraft) is India's second indigenous jet fighter design, after the HF-24 Marut of the 1950s. It's the world's smallest, light weight, multi-role combat aircraft designed to meet the requirements of the Indian Air Force as its frontline multi-mission single seater tactical aircraft during the period 2000 - 2020. Development began in 1983; the basic design was finalised in 1990; the first prototype rolled out on 17 November 1995. On 04 January 2001 at 10.18 a.m. the first LCA Prototype TD-1 (Technology Demonstrator-1), finally took off on its first flight from Yelahanka AFS.

The configuration is a delta wing, with no tailplanes or foreplanes, and a single vertical fin. The LCA is constructed of aluminium-lithium alloys, carbon-fibre composites, and titanium. The design incorporates "control-configured vehicle" concepts to enhance manoeuvrability, and quadruplex fly-by-wire controls. Both prototypes are powered by General Electric F404-GE-F2J3 engines, but an indigenous engine, the GTX-35VS Kaveri, is being developed for the production LCA. No official name or other designation has been assigned to the LCA yet.

The Light Combat Aircraft (LCA) is a small, lightweight, supersonic, multi-role, single-seat fighter designed primarily to replace the MiG-21 series of aircraft of Indian Air Force as its front-line multi-mission single-seat tactical aircraft. The LCA integrates modern design concepts like static instability, digital fly-by-wire flight control system, integrated avionics, glass cockpit, primary composite structure, multi-mode radar, microprocessor based utility and brake management systems.

Short takeoff and landing, high maneuverability with excellent maintainability and a wide range of weapon fit are some of LCA's features. Two aircraft technology demonstrators are powered by single GE F404/F2J3 augmented turbofan engines. For maintenance the aircraft has more than five hundred Line Replaceable Units (LRSs), each tested for performance and capability to meet the severe operational conditions to be encountered. Major subsystems like fly-by-wire digital flight control system, integrated avionics, hydraulic and electrical systems, environmental control system, fuel system etc., are being tested to ensure performance and safety. Following satisfactory subsystem test results the flight test program of the LCA will begin in 2001.

The LCA has been designed and developed by a consortium of five aircraft research, design, production and product support organizations pooled by the Bangalore-based Aeronautical Development Agency (ADA), under Department of Defense Research and Development Organization (DRDO). Hindustan Aeronautics Limited (HAL) is the Principal Partner in the design and fabrication of the LCA and its integration leading to flight testing. Several academic institutions from over the country have participated in the development of design and manufacturing software for LCA. National teams formed by pooling the talents and expertise in the country are entrusted with the responsibility of the development of major tasks such as development of carbon composite wing, design, design of control law and flight testing. Several private and public sector organizations have also supported design and manufacture of various LCA subsystems.

Various international aircraft and system manufacturers are also participating in the program with supply of specific equipment, design consultancy and support. For example, GE Aircraft Engines provides the propulsion and Lockheed Martin the flight control system.

The Indian Light Combat Aircraft (LCA) is the world's smallest, light weight, multi-role combat aircraft designed to meet the requirements of Indian Air Force as its frontline multi-mission single-seat tactical aircraft to replace the MiG-21 series of aircraft. The delta wing configuration , with no tailplanes or foreplanes, features a single vertical fin. The LCA is constructed of aluminium-lithium alloys, carbon-fibre composites, and titanium. LCA integrates modern design concepts and the state-of-art technologies such as relaxed static stability, flyby-wire Flight Control System, Advanced Digital Cockpit, Multi-Mode Radar, Integrated Digital Avionics System, Advanced Composite Material Structures and a Flat Rated Engine.

The LCA design has been configured to match the demands of modern combat scenario such as speed, acceleration, maneuverability and agility. Short takeoff and landing, excellent flight performance, safety, reliability and maintainability, are salient features of LCA design. The LCA integrates modern design concepts like static instability, digital fly-by-wire flight control system, integrated avionics, glass cockpit, primary composite structure, multi-mode radar, microprocessor based utility and brake management systems.

The avionics system enhances the role of Light Combat Aircraft as an effective weapon platform. The glass cockpit and hands on throttle and stick (HOTAS) controls reduce pilot workload. Accurate navigation and weapon aiming information on the head up display helps the pilot achieve his mission effectively. The multifunction displays provide information on engine, hydraulics, electrical, flight control and environmental control system on a need-to-know basis along with basic flight and tactical information. Dual redundant display processors (DP) generate computer-generated imagery on these displays. The pilot interacts with the complex avionics systems through a simple multifunction keyboard, and function and sensor selection panels. A state-of-the-art multimode radar (MMR), laser designator pod (LDP), forward looking infra-red (FLIR) and other opto-electronic sensors provide accurate target information to enhance kill probabilities. A ring laser gyro (RLG)-based inertial navigation system (INS), provides accurate navigation guidance to the pilot. An advanced electronic warfare (EW) suite enhances the aircraft survivability during deep penetration and combat. Secure and jam-resistant communication systems, such as IFF, VHF/UHF and air-to-air/air-to-ground data link are provided as a part of the avionics suite. All these systems are integrated on three 1553B buses by a centralised 32-bit mission computer (MC) with high throughput which performs weapon computations and flight management, and reconfiguration/redundancy management. Reversionary mission functions are provided by a control and coding unit (CCU). Most of these subsystems have been developed indigenously.

The digital FBW system of the LCA is built around a quadruplex redundant architecture to give it a fail op-fail op-fail safe capability. It employs a powerful digital flight control computer (DFCC) comprising four computing channels, each powered by an independent power supply and all housed in a single line replaceable unit (LRU). The system is designed to meet a probability of loss of control of better than 1x10-7 per flight hour. The DFCC channels are built around 32-bit microprocessors and use a safe subset of Ada language for the implementation of software.

The DFCC receives signals from quad rate, acceleration sensors, pilot control stick, rudder pedal, triplex air data system, dual air flow angle sensors, etc. The DFCC channels excite and control the elevon, rudder and leading edge slat hydraulic actuators. The computer interfaces with pilot display elements like multifunction displays through MIL-STD-1553B avionics bus and RS 422 serial link. The digital FBW system of the LCA is built around a quadruplex redundant architecture to give it a fail op-fail op-fail safe capability. It employs a powerful digital flight control computer (DFCC) comprising four computing channels, each powered by an independent power supply and all housed in a single line replaceable unit (LRU). The system is designed to meet a probability of loss of control of better than 1x107 per flight hour. The DFCC channels are built around 32-bit microprocessors and use a safe subset of Ada language for the implementation of software. The DFCC receives signals from quad rate, acceleration sensors, pilot control stick, rudder pedal, triplex air data system, dual air flow angle sensors, etc. The DFCC channels excite and control the elevon, rudder and leading edge slat hydraulic actuators. The computer interfaces with pilot display elements like multifunction displays through MIL-STD-1553B avionics bus and RS 422 serial link.

Multi-mode radar (MMR), the primary mission sensor of the LCA in its air defence role, will be a key determinant of the operational effectiveness of the fighter. This is an X-band, pulse Doppler radar with air-to-air, air-to-ground and air-to-sea modes. Its track-while-scan capability caters to radar functions under multiple target environment. The antenna is a light weight (¡5 kg), low profile slotted waveguide array with a multilayer feed network for broad band operation. The salient technical features are: two plane monopulse signals, low side lobe levels and integrated IFF, and GUARD and BITE channels. The heart of MMR is the signal processor, which is built around VLSI-ASICs and i960 processors to meet the functional needs of MMR in different modes of its operation. Its role is to process the radar receiver output, detect and locate targets, create ground map, and provide contour map when selected. Post-detection processor resolves range and Doppler ambiguities and forms plots for subsequent data processor. The special feature of signal processor is its real-time configurability to adapt to requirements depending on selected mode of operation.

Seven weapon stations provided on LCA offer flexibility in the choice of weapons LCA can carry in various mission roles. Provision of drop tanks and inflight refueling probe ensure extended range and flight endurance of demanding missions. Provisions for the growth of hardware and software in the avionics and flight control system, available in LCA, ensure to maintain its effectiveness and advantages as a frontline fighter throughout its service life. For maintenance the aircraft has more than five hundred Line Replaceable Units (LRSs), each tested for performance and capability to meet the severe operational conditions to be encountered.

Hindustan Aeronautics Limited (HAL) is the Principal Partner in the design and fabrication of LCA and its integration leading to flight testing. The LCA has been designed and developed by a consortium of five aircraft research, design, production and product support organizations pooled by the Bangalore-based Aeronautical Development Agency (ADA), under Department of Defense Research and Development Organization (DRDO). Various international aircraft and system manufacturers are also participating in the program with supply of specific equipment, design consultancy and support. For example, GE Aircraft Engines provides the propulsion.

The first prototype of LCA rolled out on 17 November 1995. Two aircraft technology demonstrators are powered by single GE F404/F2J3 augmented turbofan engines. Regular flights with the state-of-the-art "Kaveri" engine, being developed by the Gas Turbine Research Establishment (GTRE) in Bangalore, are planned by 2002, although by mid-1999 the Kaveri engine had yet to achieve the required thrust-to-weight ratio.

The LCA is India's second attempt at an indigenous jet fighter design, following the somewhat unsatisfactory HF-24 Marut Ground Attack Fighter built in limited numbers by Hindustan Aeronautics Limited in the 1950s. Conceived in 1983, the LCA will serve as the Indian air force's frontline tactical plane through the year 2020. The LCA will go into service in the 2003-2005 timeframe.

Following India's nuclear weapons tests in early 1998, the United States placed an embargo on the sale of General Electric 404 jet engines which are to power the LCA. The US also denied the fly-by-wire system for the aircraft sold by the US firm Lockheed-Martin. As of June 1998 the first flight of the LCA had been delayed due to systems integration tests. The first flight awaits completion of the Digital Flight Control Systems, being developed by the Aeronautical Development Establishment (ADE).

Type	LCA
Country	India
Function	fighter
Crew	1
Engines	1 (83.4 kN GTRE GTX-35VS augmented turbofan)
Wing Span	8.20 m
Length	13.20 m
Empty Weight	5500 kg
Ceiling	16400 m
Range	850 km
Armament	GSh-23 twin-barrel 23mm cannon (220 rounds) 7 hardpoints, max external load over 4000 kg
Unit cost	21 million USD

Bibliography

[1] Fighter Planes Links.
http://www.fighter-planes.com/jetlink.htm.

[2] Fighter Planes.
http://www.fighter-planes.com.

[3] Aircraft Museum.
http://www.aerospaceweb.org