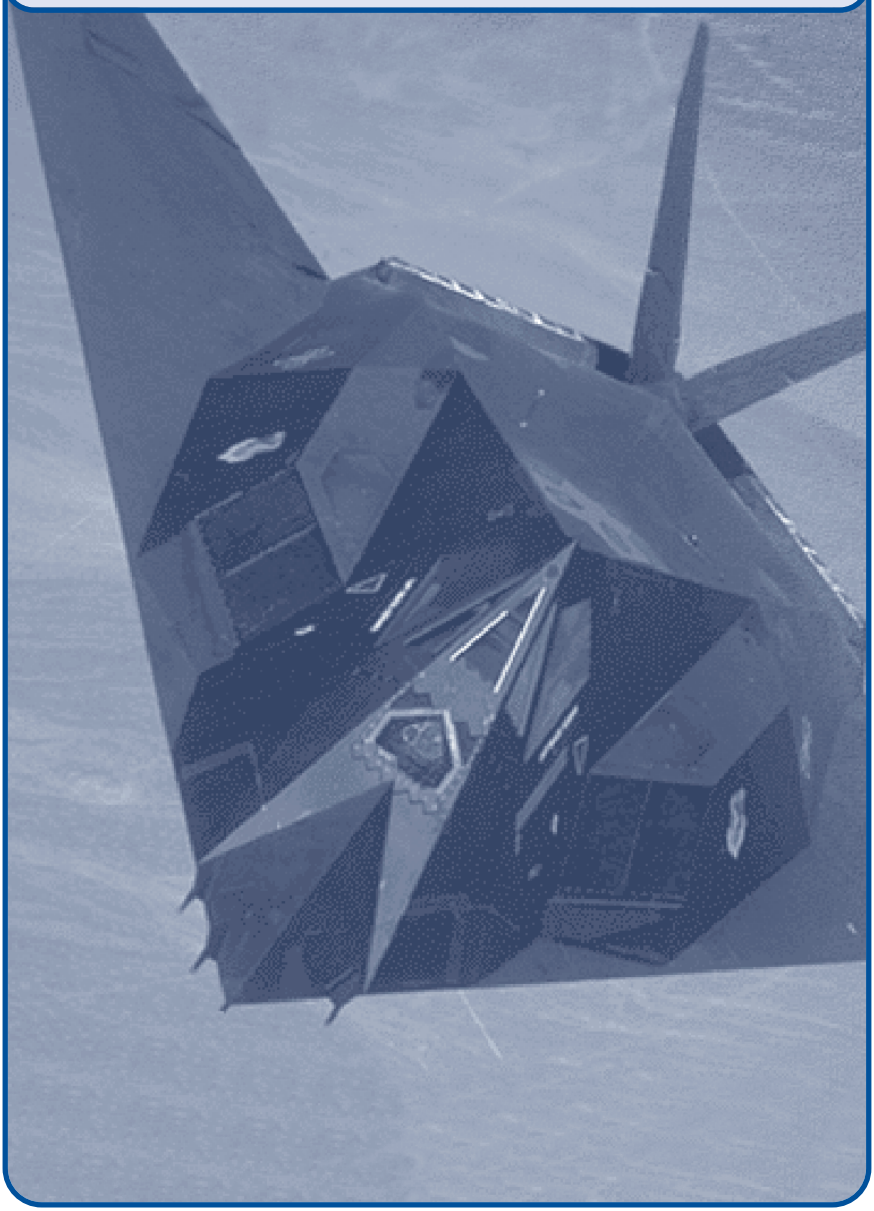
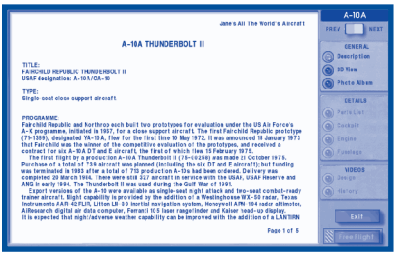
9 – SPECIFICATIONS



9. SPECIFICATIONS

INFORMATION IN THE GAME

You can get information on all of the objects in the game by choosing REFERENCE from the *Choose Activity* screen. This takes you to the *Reference* screen, where you can view 3-D models, photographs and videos; and read specifications and design history from Jane's Information Group.



- Choose which database you want to look at — FIGHTERS, BOMBERS, HELICOPTERS, SAMS, AAA, TANKS, SHIPS, OTHER VEHICLES, STRUCTURES or MISSILES — from the **OBJECTS** menu.
- Cycle through the objects in that database by clicking the PREV/NEXT switch in the upper right corner of the screen, or by pressing Ins and Del. The name of the current object appears in the box just above this switch.
- A series of lights on the right side of the screen indicate what types of reference material are available for each game object. The lights next to available options will be red; grayed-out lights mark unavailable options. Click on a light next to the following options to display:

OPTION	DISPLAYS
DESCRIPTION (D)	Jane's specifications for the object
3-D VIEW (3)	Moveable 3-D model of the object
PHOTO ALBUM (P)	Photos of the current object
PARTS LIST	Drawing of the object with unusual features called out
COCKPIT	Photo or drawing of the cockpit
ENGINE	Photo or schematic drawing of the engine
FUSELAGE	Drawing of fuselage
HISTORY	Video of object's history
DESIGN	Video of special design features
MANEUVERS	Video of special flight maneuvers
FREE FLIGHT	Test drive the selected aircraft

For **photographs** and **text** — use Pg Dn/Pg Up or left/right-click on the pages/photos to cycle through them.

For **3-D model** — toggle the background with SHOW BACKGROUND on the **MISC** menu. Left-click above, below, to the left and to the right of the model to rotate it. Left- and right-click *directly on* the model to zoom in and out.

For **videos** — press Spacebar to start and stop.

JANE'S SPECIFICATIONS

The descriptions and specifications in this section were taken from the **Military Aircraft — Fixed Wing** section of the *Jane's All The World's Aircraft*, except where noted. The descriptions and/or statistics have been abridged due to space constraints. All British spellings have been preserved.

Note: *Certain specifications presented here may still be classified and are subject to change throughout the development cycle.*

The following statistical information is provided for each plane, if available:

Length overall. Measured from nose to tail at longest point on fuselage (in meters).

Height overall. Measured from ground to highest point on tailplane or fuselage (in meters).

Wing span. Distance between wingtips (in meters).

Wing aspect ratio. Measure of wing slenderness as seen in plan view; square of the wingspan divided by the gross area (as a ratio).

Foreplane span. Measured from tip to tip (in meters).

Tail span, horizontal surfaces. Measured from tip to tip (in meters).

Tail span, vertical surfaces. Measured from base to highest point (in meters).

Propeller diameter. Diameter of main propellers (in meters).

Wheel track. Distance between mainwheels, measured from center of each wheel (in meters).

Wheelbase. Minimum distance from center of nosewheel or tailwheel to line joining mainwheels (in meters).

Gross wing area. Total projected area of clean wing (no flaps, slats, etc.) including all control surfaces and area of fuselage bounded by leading- and trailing-edges projected to centerline (in meters squared).

Weight empty. Weight of aircraft without crew, fuel, cargo and ordnance (in kilograms).

Operational weight empty. Aircraft weight that includes weight of all necessary avionic equipment (in kilograms).

Max weapons load. Maximum weight of ordnance that can be loaded after aircraft is loaded with full internal fuel and avionic equipment (in kilograms).

Internal weapons load. Maximum weight of ordnance that can be carried inside aircraft's weapons bay (in kilograms).

Max internal fuel capacity. Weight of fuel held by internal fuel tanks (in kilograms).

Max external fuel capacity. Weight of fuel that can be held by external tanks attached to hardpoints (in kilograms).

Normal/Max T-O weights. Limit to which an aircraft can be loaded and still take off (in kilograms).

Max landing weight. Limit at which aircraft can make a safe landing (in kilograms).

Max payload. In military aircraft, loosely used to mean total load (weight) carried of weapons, cargo or other mission equipment (in kilograms).

Max wing loading. Aircraft weight divided by wing area (in kilograms per meter squared).

Max power loading. Aircraft weight divided by total propulsive power or thrust at takeoff (in kilograms per kilo Newton).

Service ceiling. The height that is equivalent to the air density at which the maximum attainable rate of climb (100ft/min) occurs (in meters).

Range, hi-low-hi and hi-hi-hi. The distance an aircraft can fly under specified conditions. Hi-hi-hi and hi-low-hi refer to different types of runs: hi-low-hi means an aircraft approaches the target at a high altitude, sweeps low, and then returns to base at high altitude; on a hi-hi-hi the aircraft maintains a constant high altitude (in nautical miles).

Mission radius. Distance an aircraft can fly from base with enough fuel remaining to return (in nautical miles).

Max level speed. Maximum speed achieved by the aircraft's power plant alone (i.e., not accelerated by diving, etc.); varies by altitude (in knots).

Never exceed speed (V^{NE}). Aerodynamic or structural velocity limit (in knots).

Normal max operating speed. Normal speed beyond which the aircraft is not flown (in knots).

Econ operating speed. Speed which maximizes fuel efficiency (in knots).

Max rate of climb at S/L. Maximum rate of climb attainable at sea-level (in meters per minute).

Stall speed. Speed at which aircraft's wings no longer generate enough lift to keep the plane in the air (in knots).

T-O/landing run. Distance necessary for aircraft to take off or land safely (in meters).

T-O speed at normal combat weight. Initial speed necessary to lift aircraft off the ground (in knots).

Approach speed. Maximum speed at which the airplane can land without crashing (in knots).

G-limit. Structural limit of G-force the aircraft is able to withstand (in units of G).

A-7A/E Corsair II

Title

VOUGHT A-7 CORSAIR II

Type

Carrier-borne and land-based subsonic single-seat tactical fighter.

Programme

On 11 February 1964 the US Navy named the former LTV Aerospace Corporation winner of a design competition for a single-seat light attack aircraft. The requirement was for a subsonic aircraft able to carry a greater load of non-nuclear weapons than the A-4E Skyhawk. To keep costs to a minimum and speed delivery it was stipulated by the USN that the new aircraft should be based on an existing design; the LTV design study was based therefore, on the F-8 Crusader. An initial contract to develop and build three aircraft, under the designation A-7A was made on 27 September 1965.

Design Features

Cantilever high-wing monoplane. Wing section NACA 65A007. Anhedral 5°. Incidence -1°. Wing sweepback at quarter-chord 35°. Outer wing sections fold upward for carrier parking and, in the A-7H, to allow best utilization of revetments at combat airfields. One-piece all-moving tailplane, swept back 45° at quarter-chord and set at dihedral angle of 5° 25'.

Flying Controls

Plain sealed inset aluminum ailerons, outboard of wing fold, are actuated by fully triplicated hydraulic system. Leading-edge flaps. Large single-slotted trailing-edge flaps. Spoiler above each wing forward of flaps. Tailplane is operated by triplicated hydraulic systems, and the rudder powered by two systems.

Structure

All-metal multi-spar structure with integrally stiffened aluminum alloy upper and lower skins. The fuselage is an all-metal semi-monocoque structure. Large door-type ventral speed-brake under centre-fuselage. The tail unit consists of a large vertical fin and rudder, swept back 44.28° at quarter-chord.

Landing Gear

Hydraulically retractable tricycle type, with single wheel on each main unit and twin-wheel nose unit. Mainwheels retract forward into fuselage, nosewheels aft. Mainwheels and tyres size 28 x 9-12; nosewheels and tyres size 22 x 5.50. Nose gear launch bar for carrier catapulting. Sting-type arrester hook under rear fuselage for carrier landings, emergency landings or aborted takeoffs. Anti-skid brake system.

Power Plant

One Allison TF41-A-2 (Rolls-Royce Spey) non-afterburning turbofan engine, rated at 66.7 kN. The A-7E has a pneumatic starter requiring ground air supply; A-7H, TA-7H and A-7K engines have self-start capability through the medium of battery-powered electric motor that actuates a small gas turbine engine (jet fuel starter), which in turn, starts the main engine through the gearbox. The engine has self-contained ignition for start/airstart, automatic relight and selective ignition. Integral fuel in tanks in wings and additional fuselage tanks. Maximum internal fuel 5678 litres. Maximum external fuel 4542 litres.

Accommodation

Pilot on McDonnell Douglas Escapac rocket-powered ejection system. Complete with US Navy life support system on the A-7E/H. Escape system provides a fully inflated parachute three seconds after sequence initiation; positive seat/man separation and stabilization of the ejected seat and pilot. Boron carbide (HFC) cockpit armor.

Avionics and Equipment

The navigation/weapon delivery system is the heart of the A-7E/H light attack aircraft. It performs continuously the computations needed for greatly increased delivery accuracy, and for maneuvering freedom during navigation to a target and the attack, weapon release, pull up, and safe return phases of the mission. The system not only provides the pilot with a number of options during the navigation and weapon delivery, but also relieves him of much of his workload. The AN/ASN-91(V) navigation/weapon delivery computer is the primary element of the system, in constant “conversation” with basic electronic sensors, and computes and displays continuously present position, using computed position and stored data to calculate navigation and weapon delivery solutions, and

monitors the reliability of data inputs and outputs. An AN/ASN-90(V) inertial measurement set is the basic three-axis reference system for navigation and weapon delivery. AN/APN-190(V) Doppler measures ground speed and drift angle. AN/APQ-126(V) forward-looking radar provides pilot with 9 modes of operation; air-to-ground ranging; terrain-following; terrain-avoidance; ground mapping, shaped beam; ground mapping, pencil beam; beacon cross-scan terrain-avoidance; cross-scan ground mapping, pencil; TV; and Shrike integrated display system. AN/AVQ-7(V) HUD receives and displays computed attack, navigation and landing data from the tactical computer; aircraft performance data from flight sensors; and discrete signals from various aircraft systems.

Armament

A wide range of stores, to a total weight of more than 6805kg, can be carried on six underwing pylons and two fuselage weapon stations, the latter suitable for Sidewinder air-to-air missiles. Two outboard pylons on each wing can accommodate a load of 1587kg. Inboard pylon on each wing can carry 1134kg. Two fuselage weapon stations, one in each side, can each carry a load of 227kg. Weapons include air-to-air and air-to-ground (anti-tank and anti-radar missiles); electro-optical (TV) and laser-guided weapons; general purpose bombs; bomblet dispensers; rockets; gun pods; and auxiliary fuel tanks. In addition, an M61A-1 Vulcan 20mm cannon is mounted in the port side of the fuselage. This has a 1000 round ammunition storage and selected firing rates of 4000 or 6000 rds/min. Strike camera in lower rear fuselage for damage assessment.

Specifications

DIMENSIONS, EXTERNAL	
Wingspan	11.80m
Width, wings folded	7.24m
Wing chord	
at root	4.72m
at tip	1.18m
Wing aspect ratio	4
Length overall	14.06m
Height overall	4.90m

WEIGHTS AND LOADINGS	
Weight empty	8668 kg
Max T-O weight	19,050kg

PERFORMANCE	
Max level speed	
at S/L	600 knots
at 5000 ft	562 knots[1]
	(595 knots[2])
T-O run at max T-O weight	830m
Ferry range	
max internal fuel	1981nm
max internal and external fuel	2485nm

[1] with 12 Mk 82 bombs
[2] after dropping bombs

AC-130U Spectre

Title

LOCKHEED 382 HERCULES

Type

Tactical transport and multi-mission aircraft.

Programme

US Air Force specification issued 1951; first production contract for C-130A to Lockheed September 1952; two prototypes, 231 C-130As, 230 C-130Bs and 491 C-130Es manufactured. Lockheed delivered 2,000th Hercules (C-130H to Kentucky ANG) in April 1992.

Design Features

Can deliver loads and parachutists over lowered rear ramp and parachutists through side doors; removable external fuel tanks outboard of engines are standard fittings; cargo hold pressurized. Wing section NACA 64A318 at root and NACA 64A412 at tip; dihedral 2° 30'; incidence 3° at root, 0° at tip. Leading-edges of wing, tailplane and fin anti-iced by engine bleed air.

Flying Controls

All control surfaces boosted by dual hydraulic units; trim tabs on ailerons, both elevators and rudder; Lockheed-Fowler trailing-edge flaps; provision for two removable afterbody ventral strakes.

Power Plant

Four 3,362kW Allison T56-A-15 turboprops, each driving a Hamilton Standard type 54H60 four-blade constant-speed fully feathering reversible-pitch propeller. Fuel in six integral tanks in wings, with total capacity of 26,344 litres and two optional underwing pylon tanks, each with capacity of 5,146 litres. Total fuel capacity 36,636 litres. Single pressure refuelling point in starboard wheel well. Overwing gravity fuelling. Oil capacity 182 litres.

Accommodation

Crew of four on flight deck, comprising pilot, co-pilot, navigator and systems manager (fully performance qualified flight engineer on USAF aircraft). Provision for fifth man to supervise loading. Sleeping bunks for relief crew and galley. Flight deck and main cabin pressurized and air-conditioned. Standard complements for C-130H are as follows: 92 troops, 64 paratroopers, 74 litter patients plus two attendants. Corresponding data for C-130H-30 are 128 troops, 92 paratroopers, and 97 litter patients plus four attendants. Air transport and airdrop loads such as Sheridan light armored vehicle, 19,051kg when rigged for airdrop, are common to both C-130H and the C-130H-30; light and medium towed artillery weapons, or variety of wheeled and tracked vehicles and multiple 463L supply pallets (five in C-130H and seven in C-130H-30, plus one on rear ramp for each model) are transportable; C-130H-30 is only airlifter which can airdrop entire field artillery section (ammo platform, weapon, prime mover, and eight crew jumping over ramp) in one pass. Hydraulically operated main loading door and ramp at rear of cabin. Paratroop door on each side aft of landing gear fairing. Two emergency exit doors standard; two additional doors optional on C-130H-30.

Avionics

Standard fit specified by US government comprises dual AN/ARC-190 HF com, dual AN/ARC-186 VHC com, dual AN/ARC-164 UHF com, AN/AIC-13 PA system, AN/AIC-18 intercom, AN/APX-100 IFF/AIMS ATC transponder, dual AN/ARN-118 UHF nav, dual AN/ARN-147 VHF nav, self-contained navigation system (SCNS), dual DF-206A ADF, DF-301E UHF direction finder, emergency locator transmitter (ELT), AN/APN-218 Doppler nav, AN/APN-232 combined altitude radar alt, dual C-12 compass system, dual FD-109 flight director system, either capable of coupling with FD-109 autopilot, Sundstrand ground proximity warning system, Kollsman altitude alerter. Westinghouse low power colour radar (LPCR 130-1) replacing Sperry radar from March 1993, AN/APN-169C station keeping equipment, A-100A cockpit voice recorder, flight data recorder, AN/AAR-47 missile warning system, provisions for AN/ALE-47 flare and chaff dispensing system, provisions for AN/ALQ-157 infrared countermeasures system, provisions for KY-58 secure voice, provisions for microwave landing system (Canadian Marconi CMSLA system ordered for C-130 fleet retrofit, 1991), provisions for USTS Satcom system.

Armament

Consists of (front to rear) General Electric GAU-12/U 25mm six-barrel Gatling gun with 3000 rounds, Bofors 40mm gun, and a 105mm gun based on US Army howitzer; addition of Rockwell Hellfire ASMs under consideration 1992; guns can be slaved to Hughes AN/APQ-180 (modified AN/APG-70) digital fire con

trol radar, Texas Instruments AN/AAQ-117 FLIR or GEC-Marconi all-light-level television (ALLTV), for night and adverse weather attack on ground targets; sideways-facing HUD for visual aiming. Attack method is to circle target at altitude firing into apex of turn on ground, but guns can now be trained, relieving pilot of absolute precision flying; flight path is also less predictable; can fire on two targets simultaneously. Contains IR countermeasures; total of 300 chaff bundles and 90 MJU7 or 180 M206 flares in three AN/ALE-40 launchers under fuselage; ITT Avionics AN/ALQ-172 jammer in base of fin; Loral AN/ALR-56M RWR; AN/AAR-44 IR warner; QRC-84-2 IRCM and AN/APR-46 threat avoidance system; other equipment includes combined INS and GPS, triple MIL-STD-1553B digital databases and Spectra ceramic armor protection.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	40.41m
Wing chord	
at root	4.88m
mean	4.16m
Wing aspect ratio	10.1
Length overall[1]	29.79m
Height overall	11.66m
Tailplane span	16.05m
Propeller diameter	4.11m

WEIGHTS AND LOADINGS	
Operational weight empty	
C-130H	34,686kg
C-130H-30	36,397kg
Max fuel capacity	
internal	20,108kg
external	8,255kg
Max payload	
C-130H	19,356kg
C-130H-30	17,645kg
Wing loading[1]	434.5kg/m2
Power loading[2]	5.23kg/kN

PERFORMANCE	
(C-130H at max normal T-O weight, unless noted)	
Max cruising speed	325 knots
Econ cruising speed	300 knots
Stalling speed	100 knots
Max rate of climb at S/L	579m
Service ceiling[3]	10,060m
Service ceiling, OEI2	8075m
Range[4]	4250nm

[1] all except HC-130H and C-130H-30
[2] at max normal T-O weight
[3] at 58,970kg AUW
[4] with max fuel, incl external tanks, 7,081kg payload, reserves of 5% initial fuel plus 30 min at S/L

AV-8B Harrier II

Title

MCDONNELL DOUGLAS/BRITISH AEROSPACE HARRIER II

US Marine Corps designations: AV-8B and TAV-8B

Type

Single-seat V/STOL close support, battlefield interdiction, night attack and reconnaissance aircraft.

Programme

Early background given in several previous editions; present collaborative programme began with two YAV-8B (converted AV-8A) aerodynamic prototypes (first flights 9 November 1978 and 19 February 1979); followed by four FSD aircraft (first flight 5 November 1981); first 12 pilot production AV-8Bs ordered FY82 (first flight 29 August 1983), deliveries to USMC beginning 12 January 1984; development programme for night attack version announced November 1984; first flights of RAF GR. Mk 5 development aircraft 30 April (ZD318) and 31 July 1985 (ZD319); first USMC operational AV-8B squadron (VMA-331) achieved IOC August 1985; first flight of two-seat TAV-8B (No. 162747) 21 October 1986; first flight of night attack AV-8B prototype (162966) 26 June 1987; first GR. Mk 5 for RAF (ZD324) handed over 1 July 1987; TAV-8B deliveries (to VMAT-203) began August 1987; EAV-8B deliveries to Spain 1987-88; production contract for new-build GR. Mk 7s placed April 1988; first flight of Pegasus 11-61 power plant (ZD402) 10 June 1989; first production night attack AV-8B (163853) delivered to VMA-214 on 15 September 1989; first flight of RAF GR. Mk 7 (development aircraft, converted from GR. Mk 5) 29 November 1989; 27 GR. Mk 7s ordered April 1988 (later increased to 34); first flight of production Mk 7 (ZG471) May 1990; production contract for T. Mk 10 placed February 1990; first flight of Mk 10 (ZH653) 7 April 1994.

Design Features

Differences compared with Harrier GR. Mk 3/AV-8A include bigger wing and longer fuselage; use of graphite epoxy (carbonfibre) composite materials for wings and parts of fuselage and tail unit; adoption of supercritical wing section; addition of LIDS (lift improvement devices: strakes to replace gun/ammunition pods when armament not carried, plus retractable fence panel forward of pods) to augment lift for vertical take-off; larger wing trailing-edge flaps and drooped

ailerons; redesigned forward fuselage and cockpit; redesigned engine air intakes to provide more VTO/STO thrust and more efficient cruise; two additional wing stores stations; wing outriggers relocated at mid-span to provide better ground maneuvering capability; leading-edge root extensions (LERX) to enhance instantaneous turn rate and air combat capability; landing gear strengthened to cater for higher operational weights and greater external stores loads. Wing span and area increased by approx 20% and 14.5% respectively compared with GR. Mk 3/AV-8A; leading-edge sweep reduced by 10°; thickness/chord ratios 11.5% (root)/7.5% (tip); marked anhedral on wings and variable incidence tailplane. Increased size (100%) LERX from 79th UK production aircraft (ZG506); being retrofitted.

Structure

One-piece wing (incl main multi-spar torsion box, ribs and skins), ailerons, flaps, LERX, outrigger pods and fairings, forward part of fuselage, LIDS, tailplane and rudder, are manufactured mainly from graphite epoxy (carbonfibre) and other composites; centre and rear fuselage, wing leading-edges (reinforced against bird strikes on RAF aircraft), wingtips, tailplane leading-edges and tips, and fin, are of aluminum alloy; titanium used for front and rear underfuselage heatshields and small area forward of windscreen.

Landing Gear

Retractable bicycle type of Dowty design, permitting operation from rough unprepared surfaces of very low CBR (California Bearing Ratio). Hydraulic actuation, with nitrogen bottle for emergency extension. Single steerable nosewheel retracts forward, twin coupled mainwheels rearward, into fuselage. Small outrigger units, at approx mid-span between flaps and ailerons, retract rearward into streamline pods. Telescopic oleo-pneumatic main and outrigger gear; levered suspension nosewheel leg. Dunlop wheels, tyres, multi-disc carbon brakes and anti-skid system.

Power Plant

One 105.87 kN Rolls-Royce F402-RR-408 (Pegasus 11-61) vectored thrust turbofan in AV-8B (95.42 kN F402-RR-406A/Pegasus 11-21 in aircraft delivered before December 1990); one 95.63 kN Pegasus Mk 105 in Harrier GR. Mk 5/7; Mk 152-42 in Matador II. Redundant digital engine control system (DECS), with mechanical backup, standard from March 1987. Zero-scarf front nozzles. Air intakes have an elliptical lip shape, leading-edges reinforced against bird strikes, and a single row of auxiliary intake doors. Access to engine accessories through top of fuselage, immediately ahead of wing. Integral fuel tanks in wings, usable total 2,746 litres plus four fuselage tanks: front and rear, 609 litres each, port centre and starboard centre, 177 litres each. Internal fuel 4,319 litres usable; 4,410 litres total in single-seat versions; 4,150 litres total in two-seat versions.

Accommodation

Pilot only, on zero/zero ejection seat (UPC/Stencel for USMC, Martin-Baker for RAF), in pressurized, heated and air-conditioned cockpit. AV-8B cockpit raised approx 30.5cm by comparison with AV-8A/YAV-8B, with redesigned one-piece wraparound windscreen (thicker on RAF aircraft than on those for USMC) and rearward sliding bubble canopy, to improve all-round field of view. Windscreen de-icing. Windscreens and canopies for all aircraft manufactured by McDonnell Douglas.

Avionics

Include dual Collins RT-1250A/ARC U/VHF com (GEC-Marconi Avionics AD3500 ECM-resistant U/VHF-AM/FM in RAF GR. Mk 7 aircraft; military designation ARI 23447 but ARC-182/ARI 23387 in GR. Mk 5), R-1379B/ARA-63 all-weather landing receiver (AV-8B only), RT-1159A/ARN-118 Tacan (ARI 23368 for RAF), RT-1015A/APN-194(V) radar altimeter (ARI 23388 for RAF GR. Mk 5 but RT1042A/ARI 23388 in GR. Mk 7), Honeywell CV-3736/A com/nav/identification data converter, Bendix/King RT-1157/APX-100 IFF (Cossor IFF 4760 Mk 12/ARI 23389 transponder for RAF), Litton AN/ASN-130A inertial navigation system (replaced by GEC-Marconi FIN 1075 or 1075G with RAF), AiResearch CP-1471/A digital air data computer, Smiths Industries SU-128/A dual combining glass HUD and CP-1450/A display computer, IP-1318/A CRT Kaiser digital display indicator, and (RAF only) GEC-Marconi moving map display. Litton AN/ALR-67(V)2 fore/aft looking RWR (AV-8B only), UK MoD AN/ARR-51 FLIR receiver, Goodyear AN/ALE-39 flare/chaff dispenser (upper and lower rear fuselage; current two dispensers to be increased to six) (Tracor AN/ALE-40 in RAF aircraft).

Armament

Two underfuselage packs, mounting on port side a five-barrel 25mm cannon based on General Electric GAU-12/U, and 300-round container on starboard side, in AV-8B; or (RAF) two 25mm Royal Ordnance Factories cannon with 100 rds/gun (derived from 30mm Aden); delivery of Aden 25 still awaited, early 1994. Single 454kg stores mount on fuselage centerline, between gun packs. Three stores stations under each wing on AV-8B, stressed for loads of up to 907kg inboard, 454kg on intermediate stations, and 286kg outboard. Four inner wing stations are wet, permitting carriage of auxiliary fuel tanks; reduced maneuvering limits apply when tanks mounted on intermediate stations. RAF aircraft and new production Harrier II Plus have additional underwing station, for Sidewinder air-to-air missile, ahead of each outrigger wheel fairing. Typical weapons include two or four AIM-9L Sidewinder, Magic or AGM-65E Maverick missiles, or up to six Sidewinders; up to sixteen 540lb free-fall or retarded general purpose bombs, 12 BL 755 or similar cluster bombs, 1,000lb

free-fall or retarded bombs, 10 Paveway laser-guided bombs, eight fire bombs, 10 Matra 155 rocket pods (each with eighteen 68mm SNEB rockets), or (in addition to underfuselage gun packs) two underwing gun pods.

Specifications

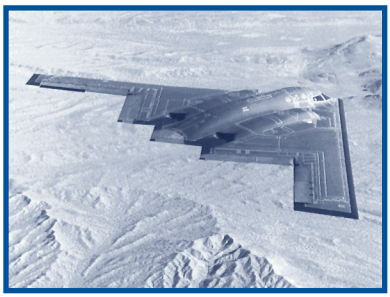
DIMENSIONS, EXTERNAL	
Wing span	9.25m
Wing aspect ratio	4.0
Length overall (AV-8B)	14.12m
Height overall	3.55m
Tailplane span	4.24m

WEIGHTS AND LOADINGS	
(single-seaters, except where indicated)	
Operational weight empty[1]	6,336kg
Max fuel capacity	
internal only[2]	3,519kg
internal and external[3]	7,180kg
Max payload[3]	
VTO	approx 3,062kg
STO	more than 7,710kg
Gross weight for 7G operation[4]	10,410kg
Max T-O weight	
435m STO	14,061kg
S/L VTO, ISA[5]	9,342kg
S/L VTO, 32°C	8,142kg
Design max landing weight	11,340kg
Max vertical landing weight	9,043kg

PERFORMANCE	
Max level speed	
at S/L	Mach 0.87
at altitude	Mach 0.98
STOL T-O run at max T-O weight	
ISA	435m
32°C	518m
G limits	+8/-3

[1]including pilot and unused fuel, AV-8B
[2]205kg (less in TAV-8B)
[3]incl fuel, stores, weapons, ammunition, and water injection for engine
[4]Basic flight design
[5]AV-8B/Pegasus 11-61

B-2A Spirit



Title

NORTHROP GRUMMAN B-2 SPIRIT

Type

Low-observable strategic penetration bomber.

Programme

Development of high level bomber started 1978; contract placed by USAF Aeronautical Systems Division October 1981; design modified for low altitude operation 1983; KC-135 testbed for B-2 avionics flying at Edwards AFB since January 1987; six B-2s assigned to trials; all but first will be refurbished for operational service; two static airframes also funded, of which structural test airframe exceeded ultimate (150%) load test before fracture at 161%, December 1992; 4,000 hour test programme planned, of which 26% concerned with low observables (LO); testing ends 1997.

Design Features

Blended flying wing, with straight leading-edges, swept at 33°; centre and tip sections have sharp, strongly under-cambered fixed leading-edges; two dielectric panels underwing outboard of flight deck cover dual radar antennae; 'double-W' trailing-edge incorporating elevons and drag rudders outboard of engines; two side by side weapons bays in lower centerbody each have small, drop-down spoiler panels ahead of doors, generating vortexes to ensure clean weapon release; engines fed by S-shaped air ducts; irregular-shaped air intakes feed engines, with three-pointed splitter plates ahead of inlets which remove boundary layer and provide secondary airflow for cooling and IR emissions control; upper lip of intake has single point; two auxiliary air inlet doors mounted on top of intake trunks remain open on ground and in slow-speed flight; two V-shaped overwing exhausts set well forward of trailing-edge; titanium on wing surface behind engine outlet; wingtips and leading-edges have dielectric covering of aerofoil section to mask radar-dissipating sawtooth construction.

Landing Gear

Tricycle type, adapted from Boeing 757/767. Inward retracting four-wheel main bogies have large trapezoidal door of thick cross-section. Rearward-retracting two-wheel nose unit has small door with sawtooth edges and large rear door, also used for crew access. Two landing lights on nosewheel leg. Landing gear limiting speed 224 knots.

Power Plant

Four 84.5 kN General Electric F118-GE-110 non-afterburning turbofans mounted in pairs within wing structure, each side of weapons bay. In-flight refuelling receptacle in centerbody spine. Initially fuelled by JP-4; conversion to JP-8 due by March 1996. Development of contrail management system due by December 1996, reportedly involving regulation of exhaust temperatures, rather than mixing chloro-fluoro-sulfonic acid with exhaust gases, as previously understood.

Accommodations

Two crew, with upward firing ejection seats: pilot to port, mission commander/instructor pilot to starboard. Provision for third member. Both forward positions have conventional control columns. Flight, engine, sensor and systems information presented on nine-tube EFIS display. Either crew member capable of flying complete mission, although data entry panels biased towards weapon systems officer on starboard seat. Four flight deck windows.

Avionics

Hughes AN/APQ-181 low-probability-of-intercept (LPI) J-band covert strike radar, having 21 modes including terrain following and terrain avoidance. Northrop Grumman GPS-Aided Targeting System (GATS) from Block 20, involving synthetic aperture mode on radar to establish GPS positional error of target for accurate high-level bombing; 4x zoom magnification available on radar picture. Loral Federal Systems AN/APR-50 RWR; Northrop Grumman ZSR-63 defensive aids equipment (role unspecified, but reportedly involves active cancellation of radar returns). Rockwell VLF/LF receiver. Rockwell Collins TCN-250 Tacan, VIR-130A ILS and ICS-150X intercom. Milstar satellite communications from Block 30.

Armament

Boeing rotary launcher assembly (RLA) in each of two side by side weapons bays in lower centerbody; detachable for loading at weapons dump with up to eight large stores each. Total capacity of 16 AGM-131 SRAM II or AGM-129 ACMs or 16 AGM-137 TSSAMs (Tri-Service Standoff Attack Missiles). Alternative weapons include 16 B61 tactical/strategic or 16 B83 strategic free-fall nuclear bombs; 80 Mk 82 1,000lb bombs; 16 Joint Direct Attack Munitions; 16 Mk 84 2,000lb bombs; 36 M117 750lb fire bombs; 36 CBU-87/89/97/98 cluster bombs; and 80 Mk 36 1,000lb or Mk 62 sea mines. Stores of 1,000lb and below held in four (two per weapons bay) bomb rack assemblies (BRA).

Specifications

DIMENSIONS, EXTERNAL	
Wing span	52.43m
Length overall	21.03m
Height overall	5.18m
Wheel track	12.20m

WEIGHTS AND LOADINGS	
Weight empty	45,360-49,900kg
Max weapon load	22,680kg
Max internal fuel capacity	81,650-90,720kg
Normal T-O weight	168,433kg
Max T-O weight	170,550kg
Max wing loading	367.2kg/m^2
Max power loading	504.53kg/kN

PERFORMANCE	
Approach speed	140 knots
Service ceiling	15,240m
Range[1]	
hi-hi-hi	6,300nm
hi-lo-hi (1,000nm at low level)	4,400nm
Range[2]	
hi-hi-hi	6,600nm
hi-lo-hi (1,000nm at low level)	4,500nm
Range[3]	over 10,000nm

[1]with eight SRAMs and eight B83 bombs, totalling 16,919kg, at max T-O weight

[2]with eight SRAMs and eight B61 bombs, totalling 10,886kg, at 162,386kg T-O weight

[3]with one aerial refuelling

Eurofighter 2000

Title

EUROFIGHTER 2000 (EFA)

Type

Single-seat, highly agile STOL-capable fighter, optimized for air defense/air superiority; secondary capability for ground attack.

Programme

Outline staff target for common combat aircraft issued December 1983 by air chiefs of staff of France, Germany, Italy, Spain and UK; initial feasibility study launched July 1984; France withdrew July 1985, shareholdings then being readjusted to 33% each to UK and Germany, 21% Italy and 13% Spain; project definition phase completed September 1986; definitive ESR-D (European Staff Requirement - Development) issued September 1987, giving military requirements in greater detail; definition refinement and risk reduction stage completed December 1987; main engine and weapons system development contracts signed 23 November 1988.

Programme halted 1992 by German demands for substantial cost reduction and studies of alternative proposals, which submitted in October 1992; Italy and Spain froze EFA work mid-October. Seven possible alternative configurations for New EFA (NEFA) offered to Germany, being permutations of single (three types) or twin engines; canards; and cranked wing. Only two of seven cheaper than EFA — both inferior to developments of MiG-29 and Su-27. Defense ministers' conference of 10 December 1992 re-launched aircraft as Eurofighter 2000, delaying service entry by three years, to 2000, and allowing Germany to incorporate off-shelf avionics (probably AN/APG-65 radar), lower standard of defensive aids and other deletions to effect 30% price cut. Production commitment due by Italy, Spain and UK in 1995 and by Germany in 1996; German service entry planned in 2002. Intended four production lines likely to be reduced.

Eurofighter 2000 remained grounded throughout 1993 for exhaustive cross-checking of digital flight control system (DFCS); first flight eventually achieved 29 March 1994. Further difficulties resulted from German under-funding and demands for further cost-cuts. Political re-apportionment of work-shares to be attempted in 1994, following reduction of German requirement. Revised European Staff Requirement Development signed by four air forces, 21 January 1994.

Variants

Single-seater. Standard version.

Two-seater. Combat-capable conversion trainer.

Design Features

Collaborative design by BAe, DASA, Alenia and CASA, incorporating some design and technology (incl low detectability) from BAe EAP programme; low-wing, low aspect ratio tail-less delta with 53° leading-edge sweepback; underfuselage box with side by side engine air intakes, each with fixed upper wedge/ramp and vari-cowl (variable position lower cowl lip) with Dowty actuators.

Intended service life, 6000 hours or 30 years. Maintainability features include 9 mmh/fh and double engine change by four engineers in 45 min.

Structure

Fuselage, wings (incl inboard flaperons), fin and rudder mainly of CFC (carbon-fibre composites) except for foreplanes, outboard flaperons and exhaust nozzles (titanium); nose radome and fin-tip (GFRP); leading-edge slats, wingtip pods, fin leading-edge, rudder trailing-edge and major fairings (aluminum-lithium alloy); and canopy surround (magnesium alloy). CFC constitutes 70% of surface area, with metal 15%, GFRP 12% and other materials 3%. Manufacture includes such advanced techniques as superplastic forming and diffusion bonding; CASA-led joint structures team. BAe responsible for front fuselage, foreplanes, starboard leading-edge slats and flaperons; DASA the centre-fuselage, fin and rudder; Alenia the port wing, incl all movable surfaces; Alenia/CASA the rear fuselage; and CASA/BAe the starboard wing; no duplication of tooling; final assembly line at each manufacturer's facility now in doubt; work-shares may be revised.

Power Plant

First two development aircraft each powered by two Turbo-Union RB199-122 (Mk 104E) afterburning turbofans (each more than 71.2 kN). DA3-DA7, and production aircraft, will have two Eurojet EJ200 advanced technology turbofans (each of approx 60 kN and 90 kN nominal thrust with afterburning), mounted side by side in rear fuselage with ventral intakes. Staged EJ200 improvements available (but not funded) to 103 kN and 117 kN. DASA digital engine control system. Lucas Aerospace fuel management system. Internal fuel capacity classified. Provision for in-flight refuelling and up to three external fuel tanks two 1000 litre and one 1500 litre carried simultaneously.

Systems

Normalair-Garrett environmental control system. Magnaghi hydraulic system. Lucas Aerospace electrical system, with GEC-Marconi/Bendix variable speed constant frequency generator (Sundstrand unit in DA1 and DA2) and GEC-Marconi transformer-rectifier units. Alenia-led utilities control system (UCS), controlled by microcomputer. Garrett APU for engine starting, systems running and NBC filtering. Microturbo UK air turbine starter motor.

Avionics

BAe has overall team leadership for avionics development and integration. Primary sensor will be GEC-Marconi ECR 90 multi-mode pulse Doppler radar; secondary is Eurofirst (THORN EMI consortium) PIRATE (Passive Infra-Red Airborne Tracking Equipment) port side of windscreen; advanced integrated defensive aids subsystem (DASS), contracted to Euro-DASS consortium, led by GEC-Marconi Defense Systems, includes RWR and active jamming pod at each wingtip plus laser warning receiver, missile approach warning and towed decoys (Germany withdrew from DASS, but still requires RWR and MAW; Spain also withdrew, but to re-join in 1994; UK and Spain are only nations to have LWR). Rohde & Schwarz Saturn VHF/UHF communications.

All avionics, flight control and utilities control systems will be integrated through database highways with appropriate redundancy levels, using fibre optics and microprocessors. Special attention given to reducing pilot workload. New cockpit techniques simplify flying aircraft safely and effectively to limits of flight envelope while monitoring and managing aircraft and its operational systems, and detecting/identifying/attacking desired targets while remaining safe from enemy defenses. This achieved through high level of system integration and automation, including HOTAS controls; GEC-Marconi wide-angle HUD able to display, in addition to other symbology, FLIR pictures from sensor pod-mounted externally to port side of cockpit; helmet-mounted sight (HMS), with direct voice input (DVI) for appropriate functions; and three Smiths Industries multi-function head-down (MFHD) colour CRT displays. Other cockpit instrumentation includes Computing Devices video and voice recorder, GEC-Marconi (Elmer) crash survival memory unit, and Teldix cockpit interface unit.

Armament

Interceptor will have internally mounted 27 mm Mauser gun on starboard side, plus mix of medium-range AIM-120 AMRAAM or Aspide and short-range air-to-air missiles carried externally; four AIM-120s carried in underfuselage troughs. Short-range missiles carried on ML Aviation underwing ejector release units. Eurofighter will, if necessary, be able to carry considerable load of air-to-surface weapons. Total of 13 external stores stations — five (incl one wet) under fuselage and four (incl one wet) under each wing.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	10.50m
Wing aspect ratio	2.205
Length overall	14.50m
Height overall	6.40m

AREAS	
Wings, gross	50.0m^2
Foreplanes	2.40m^2

WEIGHTS AND LOADINGS *(APPROX)*	
Weight empty	9750kg
Internal fuel load	4000kg
External stores load (weapons and/or fuel)	6500kg
Max T-O weight	21000kg

PERFORMANCE *(DESIGN)*	
Max level speed	Mach 2.0
T-O and landing distance[1]	500m
Combat radius	250-300nm
G limits[2]	+9/-3

[1]with full internal fuel, two AIM-120s and two dogfight missiles, ISA + 15°C

[2]with full internal fuel and two AIM-120s

F-4B/J Phantom

Title

McDONNELL DOUGLAS PHANTOM II

US Navy and USAF designations: F-4 and RF-4

Type

Twin-engined two-seat all-weather fighter aircraft.

Programme

The Phantom II was developed initially as a twin-engined two-seat long-range all-weather attack fighter for service with the US Navy. A letter of intent to order two prototypes was issued 18 October 1954, at which time the aircraft was designated AH-1. The designation was changed to F4H-1 26 May 1955, with change of mission to missile fighter, and the prototype XF4H-1 flew for the first time 27 May 1958. The first production Phantom II was delivered to US Navy Squadron VF-101 in December 1960. Trials in a ground attack role led to USAF orders, and the basic USN and USAF versions became the F-4B and F-4C respectively.

Variants

F-4B (formerly F4H-1). All-weather fighter for US Navy and Marine Corps, powered by two General Electric J79-GE-8 turbojet engines. Total of 649 built.

RF-4B (formerly F4H-1P). Multi-sensor reconnaissance version of the F-4B for US Marine Corps. No dual controls or armament. Reconnaissance system as for RF-4C. J79-GE-8 engines. High frequency single sideband radio. First flown 12 March 1965. Overall length increased to 19.2m. Total 46 built.

F-4J. Development of the F-4B for US Navy and Marine Corps, primarily as interceptor but with full ground attack capability. J79-GE-10 turbojets. Use of 16.5° drooping ailerons and slotted tailgives reduced approach speed in spite of increased landing weight. Westinghouse AN/AWG-10 pulse Doppler fire control system. Lear Siegler AJB-7 bombing system; 30kVA generators. First F-4J demonstrated publicly on 27 May 1966. Production of 518 completed in December 1972.

Design Features

Cantilever low-wing monoplane. Wing section NACA 0006.4-64 (mod) at root, NACA 0004-64 (mod) at wing fold line, NACA 0003-64 (mod) at tip. Average thickness/chord ratio 5.1%. Incidence 1°. Dihedral, inner panels 0°, outer panels 12°. Sweepback 45° on leading-edges. Outer panels have extended chord and dihedral of 12°.

Structure

Centre-section and centre wings form one-piece structure from wing fold to wing fold. Portion that passes through fuselage comprises a torsion-box between the front and main spars (at 15% and 40% chord) and is sealed to form two integral fuel tanks. Spars are machined from large forgings. Centre wings also have forged rear spar. Centerline rib, wing-fold ribs, two intermediate ribs forward of main spar and two aft of main spar are also made from forgings. Wing skins machined from aluminum panels 0.0635m thick, with integral stiffening. The fuselage is an all-metal semi-monocoque structure built in forward fuselage fabricated in port and starboard halves, so that most internal wiring and finishing can be done before assembly. Keel and rear sections make use of steel and titanium.

Landing Gear

Hydraulically retractable tricycle type, mainwheels retracting inward into wings, nose unit rearward. Single wheel on each main unit, with tyres size 30 x 11.5 Type VIII; twin-wheels on nose unit, which is steerable and self-centering and can be lengthened pneumatically to increase the aircraft's angle of attack for take-off. Brake-chute housed in fuselage tailcone. Mk II anti-skid system.

Power Plant

Two General Electric J79-GE-17A turbojet engines (each rated 79.6 kN with afterburning). Variable-area inlet ducts monitored by air data computer. Integral fuel tankage in wings, between front and main spars, and in seven fuselage tanks, with total capacity of 7022 litres. Provision for one 2270-litre external tank under fuselage and two 1400-litre underwing tanks. Equipment for probe-and-drogue and "buddy tank" flight refueling, with retractable probe in starboard side of fuselage. Oil capacity 39 litres.

Accommodation

Crew of two in tandem on Martin-Baker Mk H7 ejection seats, under individual rearward hinged canopies. Optional dual controls.

Armament

Four Falcon, Sparrow, Sidewinder, Shrike or Walleye missiles, or two Bullpup missiles, on four semi-submerged mountings under fuselage and four underwing mountings. Provision for carrying alternative loads of up to 7250kg of nuclear or conventional bombs and stores on seven attachments under wings and fuselage. Stores which can be carried include B-28, -43, -57, -61 nuclear bombs; M117, M118, M129, MC-1, Mk 36, Mk 81, Mk 82, Mk 83 and Mk 84 bombs; MLU-10 land mine; BLU-1, -27, -52 and -76 fire bombs; cluster bombs; practice bombs; flares; rocket packs; ECM pods; gun pods; spray tanks; tow targets" Pave Knife pod; and AAVSIV camera pod. One M61A-1 nose-mounted gun.

Specifications

DIMENSIONS, EXTERNAL	
Wingspan	11.77m
Wing mean aerodynamic chord	4.89m
Wing aspect ratio	2.82
Width, wings folded	8.41m
Length overall	19.20m
Height overall	5.02m

WEIGHTS AND LOADINGS	
Weight empty	13,757kg
Weight empty, basic mission	14,448kg
Combat T-O weight	18,818kg
Design T-O weight	26,308kg
Max T-O weight	28,030kg
Max landing weight	20,865kg
Max wing loading	569.2kg/m^2
Max power loading	176.1kg/kN

PERFORMANCE (AT 24,572KG)	
Max level speed[1]	over Mach 2
Average speed	504 knots
Stalling speed[2]	148.5 knots
Max rate of climb at S/L	2816m
Service ceiling	10925m
Combat radius	
Area intercept	683nm
Defensive counter-air	429nm
Interdiction	618nm
Ferry range	1718nm

[1] with external stores
[2] approach power with BLC

F-8J Crusader

Title

VOUGHT F-8 CRUSADER

Type

Supersonic single-seat carrier fighter.

Programme

Chance Vought (now Vought Aircraft Company was given a development contract for the F-8 in May 1953 after winning a design competition in which eight airframe manufacturers had participated. The prototype XF-8A Crusader flew for the first time 25 March 1955, exceeding the speed of sound in level flight. The first production F-8A flew 20 September 1955, and this version began reaching US Naval operational squadrons in March 1957.

On 21 August 1956 an F-8A set up the first US national speed record of over 864 knots. Operating under restrictions, it recorded a speed of 882 knots. On 16 July 1057 an RF-8A photo-reconnaissance version of the Crusader set up the first supersonic US transcontinental record by flying the 2125nm from Los Angeles to New York in 3 hours 22 minutes 50 seconds, at an average speed of 628 knots.

An outstanding feature of the F-8 is its two-position variable incidence wing. This provides a high angle of attack for take-off and landing, while permitting the fuselage to remain almost parallel to a flight deck or runway for good pilot visibility.

Design Features

Cantilever high-wing monoplane. Wings have thin laminar-flow section. Anhedral 5°. Sweepback 35°. Wing is adjustable to two incidence positions by a hydraulic self-locking actuator. Outer wing sections fold upward for carrier stowage. The tail unit consists of a large, swept vertical fin and rudder and one-piece horizontal “slab” tail.

Structure

The wing is an all-metal multi-spar structure with integrally stiffened aluminum alloy upper and lower skins. The fuselage is an all-metal structure in three main assemblies. Both magnesium alloy and titanium are used in the structure, the aft section and portion of the mid-section are titanium.

Landing Gear

Hydraulically retractable tricycle type. Mainwheels retract forward into fuselage, nosewheel aft. Sting-type arrestor hook under rear fuselage.

Power Plant

One Pratt & Whitney J57 turbojet engine with afterburner. Integral fuel tanks in wings inboard of wing fold. Other tankage in fuselage. Total internal fuel capacity approximately 5300 litres. Provision for in-flight refueling, with retractable probe housed in removable pack on port side of fuselage of F-8A and inside flush panel on RF-8A.

Accommodation

Pilot on Martin-Baker Mk F7 lightweight ejection seat in pressurized cockpit. Liquid oxygen equipment.

Armament

Four 20mm Colt cannon in fuselage nose, with 84 rounds per gun (average) for F-8C/K, F-8H and F-8E/J, and 144 rounds per gun for NTF-8A and F-8F/L. Two Sidewinder missiles (four in F-8C/K, F-8D/H and F-8E/J) mounted externally on sides of fuselage.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	10.87m
Length overall (F-8E/J)	16.61m
Height overall	4.80m
Width folded	6.86m
AREAS	
Wings, gross	34.84m^2

WEIGHTS AND LOADINGS	
Normal T-O weight (F-8C)	12500kg
Max T-O weight (F-8E/J)	15420kg

PERFORMANCE	
Max level speed	
F-8A, F-8C	over 868 knots
F-8D, F-8E	nearly Mach 2
Combat radius (F-8A)	521nm

F-14 Tomcat

Title

GRUMMAN TOMCAT

US Navy designation: F-14

Type

Two-seat carrier-based interceptor with attack capability.

Programme

Won US Navy VFX fighter competition 15 January 1969; first flight of 12 development aircraft 21 December 1970; original programme was for 497 Tomcats including 12 development aircraft; programme since extended into 1990s.

Initial F-14A deployed with USN squadrons VF-1 and VF-2 October 1972; total 557 including 12 development aircraft, delivered to US Navy by April 1987, when production ended; final 102 aircraft (beginning 161,597) delivered from FY 1983 powered by improved TF30-P-414A turbofans, having same rating as original 93 kN.

Design Features

Wing sweepback variable from 20° leading-edge to 68°; oversweep of 75° used for carrier stowage without wing fold; wing pivot point 2.72m from aircraft centerline; fixed glove has dihedral to minimize cross-sectional area and reduce wave drag; small canards on F-14A known as glove vanes extend forward progressively to 15° from inboard leading-edge to balance supersonic trim change and unload tail surfaces.

Flying Controls

Lateral control by long-span spoilers, ahead of flaps, and tailerons; automatic leading-edge slats assist maneuvering; strakes emerge from wing glove leading-edge at high airspeeds; automatic wing sweep has manual override; automatic scheduling of control with airspeed; autostabilization and angle of attack protection; autopilot and automatic carrier landing system (ALCS). Airbrake panel above and below tail, between fins. Twin fins and rudders.

Structure

Wing carry-through is one-piece electron beam-welded structure of TI-6A1-4V titanium alloy with 6.71m span. Fuselage has machined frames, titanium main longerons and light alloy stressed skin; centre-fuselage is fuel-carrying box; radome hinges upwards for access to radar; fuel dump pipe at extreme tail; fins and rudders of light alloy honeycomb sandwich; tailplanes have multiple spars, honeycomb trailing-edges and boron/epoxy composites skins.

Landing Gear

Retractable tricycle type. Twin-wheel nose unit and single-wheel main units retract forward, main units inward into bottom of engine air intake trunks. Arrester hook under rear fuselage, housed in small ventral fairing.

Power Plant (F-14B/D)

Two General Electric F110-GE-400 turbofans rated at 71.56 kN dry and 120.1 kN with afterburning. Garrett ATS200-50 air turbine starter. F110 engine has 43% more reheated thrust and 37% more military thrust (without afterburning) than TF30-P-414A in F-14A; results in 20% more specific excess energy, 30% lower specific fuel consumption in afterburner, 62% greater deck launch intercept radius and 34% more combat air patrol time; can be launched without afterburner; time to 10,670mreduced by 61% and acceleration time by 43%. Integral fuel fanks in outer wings, each with capacity of 1,117 litres; between engines in rear fuselage, with capacity of 2,453 litres; and forward of wing carry-through structure, capacity 2,616 litres; plus two feeder tanks with combined capacity of 1,726 litres. Total internal fuel capacity 9,029 litres. An external auxiliary fuel tank can be carried beneath each intake trunk, each containing 1,011 litres. Retractable flight refueling probe on starboard side of fuselage near front cockpit.

Accommodation

Pilot and naval flight officer seated in tandem on Martin-Baker NACES (or GRU7A in F-14A/B) rocket-assisted zero/zero ejection seats, under a one-piece bubble canopy, hinges at the rear and offering all-round view.

Avionics

In F-14A, Hughes AN/AWG-9 weapons control system, with ability to detect airborne targets at ranges of more than 65-170nm according to their size, and ability to track 24 enemy targets and attack six of them simultaneously at varied altitudes and distances. Fairchild AN/AWG-15F fire control set; CP-1066/A central air data computer; CP-1050/A computer signal data converter; AN/ASW-27B digital data link; AN/APX-76(V) IFF interrogator; AN/APX-72 IFF transponder; AN/ASA-79 multiple display indicator group; Kaiser Aerospace AN/AVG-12 vertical and head-up display system.

Armament

One General Electric M61A-1 Vulcan 20mm gun mounted in the port side of forward fuselage, with 675 rounds of ammunition. Four AIM-7 Sparrow air-to-air missiles mounted partially submerged in the underfuselage, or four AIM-54 Phoenix missiles carried on special pallets which attach to the bottom of the fuselage. Two wing pylons, one under each fixed-wing section, can carry four AIM-9 Sidewinder missiles or two additional Sparrow or Phoenix missiles with two Sidewinders. F-14D has bombing capability; Rockeye and CBU-59 cluster bombs validated for F-14 December 1992; GBU-16 LGB and Gator mine to follow; AGM-88 HARM ARM and SLAM ASMs planned.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	
unswept	**19.54m**
swept	**11.65m**
overswept	**10.15m**
Wing aspect ratio	**7.28**
Length overall	**19.10m**
Height overall	**4.88m**
Tailplane span	**9.97m**
Distance between fin tips	**3.25m**

WEIGHTS AND LOADINGS	
(F-14D with F110-GE-400)	
Weight empty	**18,951kg**
Max fuel capacity (usable)	
internal	**7,348kg**
external	**1,724kg**
Max external weapon load	**6,577kg**
T-O weight	
fighter/escort mission	**29,072kg**
fleet air defense mission	**33,157kg**
max	**33,724kg**
Max wing loading	**642.5kg/m2**
Max power loading	**140.4kg/kN**

PERFORMANCE (F110 ENGINES)	
Max level speed	**Mach 1.88**
Max normal operating speed	**Mach 0.72**
Carrier approach speed	**125 knots**
Service ceiling	**above 16,150m**
T-O run (field)	**762m**
Landing run (field)	**732m**
Range (with external fuel)	**approx 1,600nm**

F-16 Fighting Falcon

Title

LOCKHEED
(GENERAL DYNAMICS)
F-16 FIGHTING FALCON

Type

Single/two-seat multi-role fighter

Programme

Emerged from YF-16 of US Air Force Lightweight Fighter prototype programme 1972 (details under General Dynamics in 1977-78 and 1978-79 Jane's All the World's Aircraft); first flight of prototype YF-16 (72-01567) 2 February 1974; first flight of second prototype (72-01568) 9 May 1974; selected for full-scale development 13 January 1975; day fighter requirement extended to add air-to-ground capability with radar and all-weather navigation; production of six single-seat F-16As and two two-seat F-16Bs began July 1975; first flight of full-scale development aircraft 8 December 1976; first flight of F-16B 8 August 1977.

Variants

F/A-16. Proposed modification of 300 Block 30/32 aircraft for close air support (CAS)/battlefield air interdiction (BAI) in late 1990s; head-steered FLIR, Pave Penny laser ranger and 30 mm cannon pod. From 1995 200 F-16Cs are to receive CAS/BAI modifications, including DTS, Navstar GPS and improved data modem. Block 30/32 upgrade abandoned January 1992 in favor of CAS/BAI assignment of Block 40/42 aircraft, having LANTIRN capability; these require more simple modification with ground data link, laser spot-tracker, anti-jam radio, missile approach warner, provision for pilot's night vision goggles and upgrades to LANTIRN pods.

F-16A. First production version for air-to-air and air-to-ground missions; production for USAF completed March 1985, but still available for other customers; international sales continue; powered since late 1988 (Block 15OCU) by P&W F100-PW-220 turbofan; Westinghouse AN/APG-66 range and angle track radar.

Operational Capabilities Upgrade (OCU). USAF/NATO co-operative programme to equip F-16A/B for next-generation BVR air-to-air and air-to-surface

weapons; radar and software updated, fire control and stores management computers improved, data transfer unit fitted, combined radar-barometric altimeter fitted, and provision for AN/ALQ-131 jamming pods.

Mid-Life Update (MLU). Development authorized 3 May 1991 (signature of final partner); USAF withdrew 1992, but ordered 223 modular computer retrofit kits from MLU to equip Block 50/52 aircraft.

Cockpit similar to F-16C/D Block 50 with wide-angle HUD, night vision goggle compatibility, modular mission computer replacing existing three, digital terrain system, AN/APG-66(V2A) fire control radar, Navstar GPS, improved data modem and provision for microwave landing system (MLS). Inlet hardpoints and wiring for FLIR pods will be added to Block 10 aircraft.

F-16(ADF). Modification of 279 (actually 272 because of pre-conversion attrition) Block 15 F-16A/Bs as USAF air defense fighters to replace F-4s and F-106s with 11 Air National Guard squadrons; ordered October 1986. Modifications include upgrade of AN/APG-66 radar to improve small target detection and provide continuous-wave illumination, provision of AMRAAM data link, improved ECCM, Bendix/King AN/ARC-200 HF/SSB radio (F-16A only), Teledyne/E-Systems Mk XII advanced IFF, provision for Navstar GPS Group A, low altitude warning, voice message unit, night identification light (port forward fuselage of F-16A only), and ability to carry and guide two AIM-7 Sparrow missiles.

F-16B. Standard tandem two-seat version of F-16A; fully operational both cockpits; fuselage length unaltered; reduced fuel.

MSIP-F-16C/D. Single/two-seat USAF Multi-national Staged Improvement Program (MSIP) aircraft respectively, implemented February 1980. MSIP expands growth capability to allow for ground attack and beyond-visual-range missiles, and all-weather, night and day missions.

NF-16D. Variable stability in-flight simulator test aircraft (VISTA) modified from Block 30 F-16D (86-0048) ordered December 1988 to replace NT-33A testbed. RWR and chaff/flare equipment removed, providing space for Phase II and III growth including additional computer, reprogrammable display generator and customer hardware allowance.

F-16N. US Navy supersonic adversary aircraft (SAA) modified from F-16C/D Block 30; features include AN/APG-66 instead of AN/APG-68 radar, F110-GE-100 engine, deletion of M61 gun, AN/ALR-69 RWR, titanium in lower wing fittings instead of aluminum and cold working of lower wing skin holes to resist greater frequency of high g.

AFTI/F-16. Modified pre-series F-16A (75-0750) used for US Air Force Systems Command Advanced Fighter Technology Integration (AFTI). Trials

programmes include automatic target designation and attack (1988), night navigation and map displays (1988-89), digital data link and two-aircraft operations (1989), autonomous attack (1989-91) and night attack (1989-92).

F-16XL. Two F-16XL prototypes, in flyable storage since 1985, leased from General Dynamics by NASA; first flight of single-seat No. 1, 9 March 1989; NASA modified this aircraft at Dryden with wing glove having laser-perforated skin to smooth airflow over cranked arrow wing in supersonic flight, reducing drag and turbulence and saving fuel.

F-16B-2. Second prototype F-16B (75-0752) converted to private venture testbed of close air support and night navigation and attack systems; equipment includes F-16C/D HUD, helmet sight or GEC-Marconi Cat's Eyes NVGs, Falcon Eye head-steered FLIR or LANTIRN nav/attack pods, digital terrain system (Terprom), and automatic target handoff system.

F-16ES. Enhanced Strategic two-seat, long-range interdictor F-16 proposal; developed November 1993 in response to Israeli preference for F-15I Eagle.

F-16X. Projected development for 2010 service entry; 1.42m fuselage stretch; modified F-22 delta wing with increased leading-edge sweep, but similar taper, section, twist, camber, moving surfaces and structure; some 80% additional internal fuel, obviating drop tanks for most combat missions; conformal AIM-120 AMRAAM carriage; developed version of F100 or F110 engine; cost, two-thirds of F/A-18E Hornet.

Design Features

(Refers mainly to Block 40 F-16C/D) Cropped delta wings blended with fuselage, with highly swept vortex control strakes along fuselage forebody and joining wings to increase lift and improve directional stability at high angles of attack; wing section NACA 64A-204; leading-edge sweepback 40°; relaxed stability (rearward CG) to increase manueverability; deep wingroots increase rigidity, save 113 kg structure weight and increase fuel volume; fixed-geometry engine intake.

Structure

Wing, mainly of light alloy, has 11 spars, five ribs and single-piece upper and lower skins; attached to fuselage by machined aluminum fittings; leading-edge flaps are one-piece bonded aluminum honeycomb and driven by rotary actuators; fin is multi-spar, multi-rib with graphite epoxy skins; brake parachute or ECM housed in fairing aft of fin root; tailerons have graphite epoxy laminate skins, attached to corrugated aluminum pivot shaft and removable full-depth aluminum honeycomb leading-edge; ventral fins have aluminum honeycomb and skins; split speed-brakes in fuselage extensions inboard of tailerons open to 60°. Nose radome by Brunswick Corporation.

Power Plant

One 131.6 kN General Electric F110-GE-129, or one 129.4 kN Pratt & Whitney F100-PW-229 afterburning turbofan as alternative standard.

Systems

Regenerative 12 kW environmental control system, with digital electronic control, uses engine bleed air for pressurization and cooling of crew station avionics compartments. Two separate and independent hydraulic systems supply power for operation of the primary flight control surfaces and the utility functions. System pressure (each) 207 bars, rated at 161 litres. Bootstrap type reservoirs, rated at 5.79 bars.

Electrical system powered by engine driven Westinghouse 60kVA main generator and 10kVA standby generator (including ground annunciator panel for total electrical system fault reporting), with Sundstrand constant-speed drive and powered by a Sundstrand accessory drive gearbox. 17Ah battery.

Avionics

Westinghouse AN/APG-68(V) pulse Doppler range and angle track radar, with planar array in nose. Provides air-to-air modes for range-while-search, uplook search, velocity search, air combat, track-while-scan (10 targets), raid cluster resolution, single target track and (later) high PRF track to provide target illumination for AIM-7 missiles; and air-to-surface modes for ground mapping, Doppler beam sharpening, ground moving target, sea target, fixed target track, target freeze after pop-up, beacon, and air-to-ground ranging.

Forward avionics bay, immediately forward of cockpit, contains radar, air data equipment, inertial navigation system, flight control computer, and combined altitude radar altimeter (CARA). Rear avionics bay contains ILS, Tacan and IFF, with space for future equipment. A Dalmo Victor AN/ALR-69 radar warning system is replaced in USAF Block 50/52 by Loral AN/ALR-56M advanced RWR. Tractor AN/ALE-40(V)-4 chaff/flare dispensers (AN/ALE-47 in Block 50/52); provision for Westinghouse AN/ALQ-131 jamming pods and planned AN/ALQ-184.

Communications equipment includes Magnavox AN/ARC-164 UHF Have Quick transceiver (AN/URC-126 Have Quick IIA in Block 50/52); provisions for a Magnavox KY-58 secure voice system; Collins AN/ARC-186 VHF AM/FM transceiver (AN/ARC-205 Have Sync Group A in Block 50/52); government furnished AN/AIC-18/25 intercom; and SCI advanced interference blanker. Honeywell central air data computer.

Litton LN-39 standard inertial navigation system (ring laser Litton LN-93 or Honeywell H-523 in Block 50/52 and current FMS F-16A/B; Gould AN/APN-232 radar altimeter; Collins AN/ARN-108 ILS; Collins AN/ARN-118 Tacan; Teledyne Electronics AN/APX-101 IFF transponder with a government furnished IFF control; government furnished National Security Agency KIT-1A/TSEC cryptographic equipment; Lear Astronics stick force sensors; GEC-Marconi wide-angle holographic electronic head-up display with raster video capability (for LANTIRN) and integrated keyboard; Rockwell GPS/Navstar; General Dynamics enhanced stores management computer; Teledyne Systems general avionics computer; Honeywell multi-function displays; data entry/cockpit interface and dedicated fault display by Litton Canada and General Dynamics/Lockheed, Forth Worth; Fairchild data transfer set; and Astronautics cockpit/TV set.

Armament

General Electric M61A1 20 mm multi-barrel cannon in the port side wing/body fairing, equipped with a General Electric ammunition handling system and an enhanced envelope gunsight (part of the head-up display system) and 511 rounds of ammunition. Mounting for an air-to-air missile at each wingtip, one underfuselage centerline hardpoint, and six underwing hardpoints for additional stores.

Typical stores loads can include two wingtip-mounted AIM-9L/M/P Sidewinders, with up to four more on the outer underwing stations; Rafael Python 3 on Israeli F-16s from early 1991; centerline GPU-5/A 30 mm cannon; drop tanks on the inboard underwing and underfuselage stations; a Martin Marietta Pave Penny laser spot tracker pod along the starboard side of the nacelle; and bombs, air-to-surface missiles or flare pods on the four inner underwing stations.

Weapons launched successfully from F-16s, in addition to Sidewinders and AMRAAM, include radar-guided Sparrow and Sky Flash air-to-air missiles, French Magic 2 infra-red homing air-to-air missiles, AGM-65A/B/D/G Maverick air-to-surface missiles, HARM and Shrike anti-radiation missiles, Harpoon anti-ship missiles, and, in Royal Norwegian Air Force service, the Penguin Mk 3 anti-ship missile.

Specifications

DIMENSIONS, EXTERNAL: F-16C, D	
Wing span	
over missile launchers	9.45m
over missiles	10.00m
Wing aspect ratio	3.0
Length overall	15.03m
Height overall	5.09m
Tailplane span	5.58m
Wheel track	2.36m
Wheelbase	4.00m

AREAS (F-16C, D)	
Wings, gross	27.87m^2
Flaperons (total)	2.91m^2
Leading-edge flaps (total)	3.41m^2
Vertical tail surfaces (total)	5.09m^2
Rudder	1.08 m2
Horizontal tail surfaces (total)	5.92m

WEIGHTS AND LOADINGS	
Weight empty	
F-16C	8273kg (100-PW-220), 8627kg (F110-GE-100)
F-16D	494kg (F100-PW-220), 853kg (F110-GE-100)
Max internal fuel	
F-16C	104kg
F-16D	567kg
Max external fuel (both)	66kg
Max external load (both)	443kg
Typical combat weight F-16C (F110)	10780kg
Max T-O weight, air-to-air,	
no external tanks[1]	12331kg
with external load	17010kg[2], (19187kg)[3]
Wing loading	
at 12927kg AUW	464kg/m2
at 19187kg AUW	688 kg/m2
Thrust/weight ratio (clean)	1.1 to 1

PERFORMANCE	
Max level speed at 12200m	above Mach 2.0
Service ceiling	more than 15240m
Radius of action	
F-16C Block 40, two 907 kg bombs, two Sidewinders, 3940 litres external fuel, hi-lo-lo-hi	740nm (1371km)
F-16C Block 40, four 907 kg bombs, two Sidewinders, 1136 litres external fuel, hi-lo-lo-hi	340nm (630km)
F-16C Block 40, two Sparrows and two Sidewinders, 3940 litres external fuel	200nm (371km)
G limit (Max symmetrical design with full internal fuel)	+9

[1]F-16C (F110)

[2]F-16C Block 30/32

[3]F-16C Block 40/42

F/A-18 Hornet

Title

MCDONNELL DOUGLAS F/A-18 HORNET

US Navy/Marine Corps designations: F/A-18A, B, C, D

Type

Carrier-borne and land-based attack/fighter.

Programme

US Navy study of VFAX low cost, lightweight multi-mission fighter accepted Spring 1974; replaced by derivative of either General Dynamics YF-16 or Northrop YF-17 lightweight fighter prototypes; McDonnell Douglas proposed F-17 derivative with Northrop as associate; resultant Navy Air Combat Fighter called Hornet accepted in two versions, F-18 fighter and A-18 attack aircraft; single F/A-18 selected to fill both roles; McDonnell Douglas prime contractor and Northrop principal subcontractor for all versions agreed 1985; first Hornet flight (160775) 18 November 1978; 11 development aircraft flying by March 1980; delivery of F/A-18A/B (TF-18A designation dropped) to US Navy and Marines began May 1980 and completed 1987; millionth flying hour achieved 10 April 1990; two-millionth on 17 September 1993.

Design Features

Sharp-edged, cambered leading-edge extensions (LEX), slots at fuselage junction and outward-canted twin fins designed to produce high agility and performance at angles of attack over 50°; wings have 20° sweepback at quarter-chord; wings fold up 90° at inboard end of ailerons, even on land-based F/A-18s; landing gear designed for unflared landings on runways as well as on carriers.

Structure

Multi-spar wing mainly of light alloy, with graphite/epoxy inter-spar skin panels and trailing-edge flaps; tail surfaces mainly graphite/epoxy skins over aluminum honeycomb core; graphite/epoxy fuselage panels and doors; titanium engine firewall. Northrop Grumman produces rear and centre fuselages; assembly and test at McDonnell Douglas St Louis factory; CASA produces horizontal tail surfaces, flaps, leading-edge extensions, speedbrakes, rudders and rear side panels for all F/A-18s.

Power Plant

Two General Electric F404-GE-400 low bypass turbofans initially, each producing approx 71.2 kN with afterburning. F404-GE-402 EPE (Enhanced Performance Engine) standard from early 1992; rated at approx 78.3 kN. Self-sealing fuel tanks and fuel lines; foam in wing tanks and fuselage voids. Internal fuel capacity (JP5) approx 6061 litres. Provision for up to three 1250 litre external tanks.

Accommodation

Pilot only, on Martin-Baker SJU-5/6 ejection seat, in pressurized, heated and air-conditioned cockpit. Upward opening canopy, with separate windscreen, on all versions. Two pilots in F/A-18B and USN F/A-18D; pilot and Naval Flight Officer in USMC F/A-18D.

Avionics

Include an automatic carrier landing system (ACLS) for all-weather carrier operations; a Hughes Aircraft AN/APG-65 multi-mode digital air-to-air and air-to-ground tracking radar, with air-to-air modes which include velocity search (VS), range while search (RWS), track while scan (TWS), which can track 10 targets and display eight to the pilot, and raid assessment mode (RAM). Hughes AN/APG-73 radar in C/Ds for USN, USMC, Finland, Malaysia and Switzerland from May 1994. Smiths Industries multi-purpose colour map display; two Kaiser monochrome MFDs (colour on Night Attack Hornets). Collins AN/ARN-118 Tacan, AN/ARC-182 UHF/VHF com and DF-301E UHF/DF; Magnavox AN/ALR-50 and Litton AN/ALR-67 RWRs; GEC-Marconi Type 117 laser designator; Harris AN/ASW-25 radio data link; Eaton AN/ARA-63 receiver/decoder; GEC-Marconi FID 2035 horizontal situation display; Bendix/King HSI; J. E. T. ID-1791/A flight director indicator; General Electric quadruple-redundant fly-by-wire flight control system, with direct electrical backup to all surfaces and direct mechanical backup to tailerons; two Control Data AN/AYK-14 digital computers; Litton AN/ASN-130A inertial navigation system (plus GPS from FY 1993), but being replaced by Litton AN/ASN-139 ring laser system (including retrofits); two Kaiser multi-function CRTs, central GEC-Marconi-Bendix/King CRT and Kaiser AN/AVQ-28 HUD; Conrac communications system control; Normalair-Garrett digital data recorder for Bendix/King maintenance recording system; flight incident recording and monitoring system (FIRAMS).

Armament

Nine external weapon stations, comprising two wingtip stations for AIM-9 Sidewinder air-to-air missiles; two outboard wing stations for an assortment of air-to-air or air-to-ground weapons, including AIM-7 Sparrows, AIM-9 Sidewinders, AIM-120 AMRAAMs (launch trials by VX-4 in 1992; cleared for squadron use mid-1993), AGM-84 Harpoons and AGM-65F Maverick missiles; two inboard wing stations for external fuel tanks, air-to-ground weapons or Brunswick ADM-141 TALD tactical air-launched decoys; two nacelle fuselage stations for Sparrows or Martin Marietta AN/ASQ-173 laser spot tracker/strike camera (LST/SCAM) or AN/AAS-38 and AN/AAR-50 sensor pods (see Avionics); and a centerline fuselage station for external fuel or weapons. Air-to-ground weapons include GBU-10 and -12 laser-guided bombs, Mk 82 and Mk 84 general purpose bombs, and CBU-59 cluster bombs. An M61A1 20mm six-barrel gun, with 570 rounds, is mounted in the nose and has a McDonnell Douglas director gunsight, with a conventional sight as backup.

Specifications

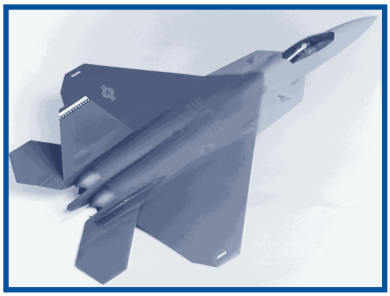
DIMENSIONS, EXTERNAL	
Wing span	11.43m
Wing span over missiles	12.31m
Wing chord	
at root	4.04m
at tip	1.68m
Wing aspect ratio	3.52
Width, wings folded	8.38m
Length overall	17.07m
Height overall	4.66m
Tailplane span	6.58m
Distance between fin tips	3.60m

WEIGHTS AND LOADINGS	
Weight empty	10,810kg
Max fuel capacity	
internal (JP5)	4,926kg
external (JP5)	3,053kg
Max external stores load	7031kg
T-O weight	
fighter mission	16,651kg
attack mission	23,541kg
max	approx 25401kg
Max wing loading[1]	600.83kg/m2
Max power loading[1]	156.80kg/kN

PERFORMANCE	
Max level speed	more than Mach 1.8
Max speed, intermediate power	more than Mach 1.0
Approach speed	134 knots
Service ceiling[1]	approx 15,240m

[1] attack mission loadout

F-22



Title

LOCKHEED MARTIN 645

US Air Force designation: F-22

Type

US Air Force next-generation tactical fighter, formerly known as Advanced Tactical Fighter (ATF) programme.

Programme

US Air Force ATF requirement for 750 (now 442) McDonnell Douglas F-15 Eagle replacements incorporating low observables technology and supercruise (supersonic cruise without afterburning); parallel assessment of two new power plants; request for information issued 1981; concept definition studies awarded September 1983 to Boeing, General Dynamics, Grumman, McDonnell Douglas, Northrop and Rockwell; requests for proposals issued September 1985; submissions received by 28 July 1986; USAF selection announced 31 October 1986 of demonstration/validation phase contractors: Lockheed YF-22 and Northrop YF-23; each produced two prototypes and ground-based avionics testbed; first flights of all four prototypes 1990. Competing engine demonstration/validation programmes launched September 1983; ground testing began 1986-87; flight-capable Pratt & Whitney YF119s and General Electric YF120s ordered early 1988; all four aircraft/engine combinations flown.

Lockheed teamed with General Dynamics (Fort Worth) and Boeing Military Airplanes to produce two YF-22 prototypes, civil registrations N22YF (with GE YF120) and N22YX (P&W YF119); USAF serial numbers 87-0700 and 87-0701 assigned, but only 87-0701 applied during second phase of testing, from late 1991. N22YF rolled out at Palmdale 29 August 1990; first flight/ferry to Edwards AFB 29 September 1990; first air refuelling (11th sortie) 26 October 1990; thrust vectoring in flight 15 November 1990; anti-spin parachute for high angle of attack tests on 34th to 43rd sorties; flight testing temporarily suspended 28 December 1990; 43 sorties/52 hours 48 minutes. N22YX first flight Palmdale-Edwards 30 October 1990; AIM-9M Sidewinder (28 November 1990) and AIM-120A AMRAAM (20 December 1990) launch demonstrations; achieved Mach 1.8 on 26 December 1990; temporarily grounded after 31 sorties/38 hours 48 minutes, 28 December 1990. Flight test demonstrations included 100°/s roll

rate at 120 knots and supercruise flight in excess of Mach 1.58 without Second (F119-powered) YF-22 taken by road to Palmdale mid-1991; fitted with strain gauges; began further 100 hour test programme 30 October 1991; gathered data on aerodynamic loads, flight control aerodynamic effects, vibration/acoustic fatigue and maximum coefficient of lift; flown by 6511th Test Squadron (F-22 Combined Test Force) of 6510th Test Wing at Edwards AFB; non-fatal crash landing at Edwards 25 April 1992, following pilot-induced oscillations; total 100 hours 24 minutes in 70 flights since October 1990; non-flyable, but repaired for use as antenna testbed at Rome Air Development Center, Griffiss AFB, New York.

Fabrication of first component for first EMD aircraft (c/n 4001) began 8 December 1993 at Boeing's facility in Kent, Washington; assembly of forward fuselage launched at Marietta on 2 November 1995 with start of work on nose landing gear well; assembly work also begun at Fort Worth Summer 1995 with mating of three assemblies that comprise the mid-fuselage of first EMD aircraft taking place in Spring 1996, followed by road transfer of entire section to Marietta in August 1996 for start of final assembly process; first flight planned May 1997; low-rate production decision in August 1998; first production delivery August 2000; high-rate production decision due March 2002.

Design Features

Low observables configuration and construction; stealth/agility trade-off decided by design team; target thrust/weight ratio 1.4 (achieved ratio 1.2 at T-O weight); greatly improved reliability and maintainability for high sortie-generation rates, including under 20 minute combat turnround time; enhanced survivability through 'first-look, first-shot, first-kill' capability; short T-O and landing distances; supersonic cruise and maneuvering (supercruise) in region of Mach 1.5 without afterburning; internal weapons storage and generous internal fuel; conformal sensors.

Highly integrated avionics for single pilot operation and rapid reaction. Radar, RWR and comms/indent managed by single system presenting relevant data only, and with emissions controlled (passive to fully active) in stages, according to tactical situation. Common integrated processor (CIP) handles all avionics functions, including self-protection and radio, and automatically reconfigures to compensate for faults and failures. F-22 has two CIPs, with space for third, linked by 400 Mbits/s fibre optic network (see Avionics).

Wing and horizontal tail leading-edge sweep 42° (both 48° on YF-22); trailing-edge 17° forward, increased to 42° outboard of ailerons (straight trailing-edge on YF-22); all-moving five-edged horizontal tail (four-edged elements on YF-22). Vertical tail surfaces (22% larger on YF-22) canted outwards at 28°; leading- and trailing-edge sweep 22.9°; biconvex aerofoil. F-22's wing and stabilator areas

same as YF-22, despite reprofiling. F-22 wing taper ratio 0.169; leading-edge anhedral 3.25°; root twist 0.5°; tip twist -3.1°; thickness/chord ratio 5.92 at root, 4.29 at tip; custom-designed aerofoil. Horizontal tails have no dihedral or twist.

Sidewinder AAMs stored internally in sides of intake ducts, with AMRAAMs, Sidewinders or GBU-32 JDAM 1000 precision-guided munitions in ventral weapons bay. Diamond-shaped cheek air intakes with highly contoured air ducts; intakes approximately 0.46m farther forward on YF-22; single-axis thrust vectoring included on PW119, but most specified performance achievable without.

Additional production F-22 changes from YF-22 include decreased wingroot thickness, modified camber and twist (increasing anhedral); all 48° plan angles changed to 42°; blunter nose; wheelbase reduced by approximately 0.46m; wheel track reduced by same; revised undercarriage legs and doors; constant chord ailerons; reprofiled cockpit canopy; dorsal airbrake deleted.

Landing Gear

Menasco retractable tricycle type, stressed for no-flare landings of up to 3.05m/s. Nosewheel tyre 23.5 x 7.5-10; mainwheel tyres 37 x 11.5-18.

Power Plant

Two 155 kN class Pratt & Whitney F119-PW-100 advanced technology reheated engines reportedly developed from F100 turbofan. Two-dimensional convergent/divergent exhaust nozzles with thrust vectoring for enhanced performance and manueverability.

Accommodation

Pilot only, on zero/zero modified ACES II ejection seat and wearing tactical life support system with improved G-suits, pressure breathing and arm restraint. Pilot's view over nose is -15°.

Systems

Include Normalair-Garrett OBOGS, AlliedSignal APU and Smiths 270 V DC electrical distribution system.

Avionics

Final integration, as well as integration of entire suite with non-avionics systems, undertaken at F-22 Avionics Integration Laboratory, Seattle, Washington; airborne integration supported by Boeing 757 flying testbed; high-fidelity Full Mission Simulation (FMS) for integrated system Pilot-Vehicle Interface (PVI) evaluations, avionics development and mission effectiveness assessment.

Comms: TRW communications/navigation/identification system, including Mk 12 IFF.

Radar: Westinghouse/Texas Instruments AN/APG-77 electronically scanned radar (air-to-air and navigation).

Flight: TRW communications/navigation/identification subsystem; Litton inertial reference system.

Instrumentation: Fused situational awareness information is displayed to pilot via four Sanders/Kaiser colour liquid crystal multifunction displays (MFD); MFD bezel buttons provide pilot format control.

Mission: Hughes common integrated processor (CIP); CIP also contains mission software that uses tailorable mission planning data for sensor emitter management and multisensor fusion; mission-specific information delivered to system through Fairchild data transfer equipment that also contains mass storage for default data and air vehicle operational flight programme; stores management system. General purpose processing capacity of CIP is rated at more than 700 million instructions per second (Mips) with growth to 2,000 Mips; signal processing capacity greater than 20 billion operations per second (Bops) with expansion capability to 50 Bops; CIP contains more than 300 Mbytes of memory with growth potential to 650 Mbytes. Intra-flight data link automatically shares tactical information between two or more F-22s. Airframe contains provisions for IRST and side-mounted phased-array radar.

Self-defense: Sanders/General Electric AN/ALR-94 electronic warfare (RF warning and countermeasures) subsystem.

Armament

Internal long-barrel M61A2 20 mm cannon with hinged muzzle cover and 480-round magazine capacity (production F-22). Three internal bays (see Design Features) for AIM-9 Sidewinder (one in each side bay) and/or four AIM-120A or six AIM-120C AMRAAM AAMs and/or GBU-32 JDAM 1000 PGMs on hydraulic weapon racks in main weapons bay. Four underwing stores stations at 317 mm and 442 mm from centerline of fuselage capable of carrying 2,268kg each.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	
YF-22	**13.11m**
F-22	**13.56m**
Length overall	
YF-22	**19.56m**
F-22	**18.92m**
Height overall	
YF-22	**5.41m**
F-22	**5.05m**

AREAS	
Wings, gross	
YF-22 and F-22	**78.0 m**

WEIGHTS AND LOADINGS *(ESTIMATED)*	
Weight empty	
YF-22	**over 13,608kg**
F-22, target	**14,365kg**
Max T-O weight	
F-22	**almost 27,216kg**

PERFORMANCE *(YF-22, DEMONSTRATED)*	
Max level speed	**supercruise Mach 1.58**
with afterburning	**Mach 1.7 at 9,150m**
Ceiling	**15,240m**
G limit+	**7.9**

PERFORMANCE *(F-22A, DESIGN TARGET, ESTIMATED)*	
Max level speed at S/L	**800 knots**
G limit **+9**	

F-104 Starfighter

Title

LOCKHEED STARFIGHTER

USAF designation: F-104

Type

Single-seat multi-purpose combat aircraft.

Programme

Development of the F-104 began in 1951. After production ceased in the USA, Canada, Italy and Japan continued to produce the aircraft under license. The F-104 is still in service within the following countries: Italy (135+), Taiwan (130+) and Turkey (170+).

Design Features

Cantilever mid-wing monoplane. Bi-convex supersonic wing section with a thickness/chord ratio of 3.36%. Anhedral 10°. No incidence. Sweepback 18° 6' at quarter-chord. Leading-edge nose radius of 0.41mm and razor-sharp trailing-edge. Narrow-chord ventral fin on centerline and two smaller lateral fins under fuselage to improve stability.

Structure

All-metal structure with two main spars, 12 spanwise intermediate channels between spars and top and bottom one-piece skin panels, tapering from thickness of 6.3mm at root to 3.2 mm at tip. Each half-wing measures 2.31 m from root to tip and is a separate structure cantilevered from five forged frames in fuselage. The fuselage is an all-metal monocoque structure. Hydraulically operated aluminum airbrake on each side of rear fuselage. The tail unit is a T-type cantilever unit with "all-flying" one-piece horizontal tail surface hinged at mid-chord point at top of the vertical fin and powered by a hydraulic servo. Tailplane has a similar profile to wing and is all-metal.

Landing Gear

Retractable tricycle type with Dowty patent liquid-spring shock absorbers on main units, oleo-pneumatic shock absorbers on nose unit. Hydraulic actuation. Mainwheels raised in and forward. Steerable nosewheel retracts forward into fuselage. Mainwheel legs are hinged on oblique axes so that the wheels lie flush within the fuselage when retracted. Mainwheels size 26 x 8.0, with Goodrich tyres size 26 x 8.0 Type VIII (18 ply rating), pressure 11.93 bars. Nosewheel tyre size 18 x 5.5 Type VII (14 ply rating). Bendix hydraulic disc brakes with Goodyear anti-skid units. Arrestor hook under rear of fuselage. Braking parachute in rear fuselage.

Power Plant

One General Electric J79-GE-19 turbojet engine, rated at 52.8 kN dry and 79.62 kN with afterburning. Electrical de-icing elements fitted to air intakes. Most of the aircraft's hydraulic equipment mounted inside large engine bay door under fuselage to facilitate servicing. Internal fuel in five bag-type fuselage tanks with total standard capacity of 3392 litres. Provision for external fuel in two 740-litre pylon tanks and two 645-litre wingtip tanks.

Accommodation

Pressurized and air-conditioned cockpit well forward of wings. Canopy hinged to starboard for access. Martin-Baker IQ-7A zero/zero ejection seat.

Armament

Nine external attachment points, at wingtips, under wings and under fuselage, for bombs, rocket pods, auxiliary fuel tanks and air-to-air missiles. Normal primary armament consists of two Raytheon AIM-7 Sparrow III air-to-air missiles under wings and/or two Sidewinders under fuselage and either a Sidewinder or 645-litre fuel tank on each wingtip. Alternatively, an M-61 20mm multi-barrel rotary cannon can be fitted in the port underside of the fuselage instead of the AIM-7 missile control package. Max external weapon load 3402kg.

Specifications

DIMENSIONS, EXTERNAL	
Wingspan without tip tanks	6.68m
Wing chord (mean)	2.91m
Wing aspect ratio	2.45
Length overall	16.69m
Length of fuselage	15.62m
Height overall	l4.11m
Tailplane span	3.63m

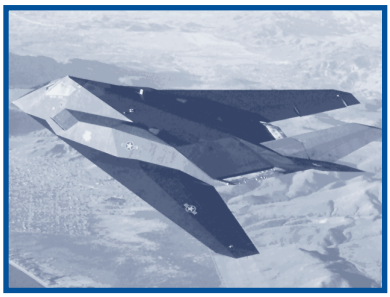
WEIGHTS AND LOADINGS	
Weight empty	6700kg
Max internal fuel load	2641kg
Max internal and external fuel load	5153kg
T-O weight (clean)	9840kg
Max T-O weight	14,060kg
Max zero-fuel weight (clean)	6806kg
Max zero-fuel weight (fighter-bomber)	7148kg
Max wing loading	540kg/m^2

PERFORMANCE1	
Never-exceed speed	Mach 2.2
Max level speed at 11,000m	Mach 2.2
Max level speed at S/L	Mach 1.2
Max cruising speed at 11,000m	530 knots
Econ cruising speed	Mach 0.85
Service ceiling	17,680m
Time to climb to 10,670m	1min 20s
Time to climb to 17,070m	2min 40s
Typical landing run at S/L	762m
Radius with max fuel	673nm
Ferry range2	1576nm

[1]At 9840kg AUW except where indicated

[2]Excluding flight refueling

F-117A Night Hawk



Title

LOCKHEED F-117A

Unofficial name: Night Hawk

Type

Precision attack aircraft with stealth elements, optimized for radar energy dispersion and low IR emission.

Programme

Production complete; details of development and early service appeared in the 1993-94 and earlier Jane's. Navalised F-117N proposal described separately.

Design Features

Multi-faceted airframe designed to reflect radar energy away from originating transmitter, particularly downward-looking AEW aircraft; vortexes from many sharp edges, including leading-edge of wing, designed to form co-ordinated lifting airflow pattern; wings have 67° 30' sweepback, much greater than needed for subsonic performance, with aerofoil formed by two flat planes underneath and three on upper surface; forward underwing surface blends with forward fuselage; all doors and access panels have serrated edges to suppress radar reflection; internal weapons bay 4.7m long and 1.75m wide divided longitudinally by two lengthwise doors hinged on centerline; boom refuelling receptacle on port side of top plate, aft of cockpit. Frontal radar cross-section estimated as 0.01 m^2.

Landing Gear

Tricycle type by Menasco, with single wheels all retracting forward. Loral brakes (steel originally, being replaced by carbon/carbon), wheels (F-15E size) and anti-skid system. Goodyear tyres. All doors have serrated edges to suppress radar reflections. Emergency arrester hook with explosively jettisoned cover; Pioneer Aerospace braking parachute (black).

Power Plant

Two 48.0 kN class General Electric F404-GE-F1D2 non-augmented turbofans. Rectangular overwing air intakes with 2.5 x 1.5 cm heated grid for anti-icing and low observability. Auxiliary air intake doors in horizontal surface immedi-

ately to the rear. Part of cold air ingested bypasses engine and is mixed with exhaust gases for cooling. Narrow-slot 'platypus' exhausts, designed by Astech/MCI, in rear fuselage, 1.65m long and 0.10m high, with extended lower lip, surrounded by heat tiles of type used on Space Shuttle and with 11 vertical, internal guide vanes. Sundstrand air turbine starter. In-flight refuelling receptacle in decking aft of cockpit, illuminated for night refuelling by lamp at apex of cockpit. Optional drop tank on internal weapons pylon.

Accommodation

Pilot only; McDonnell Douglas ACES II zero/zero ejection seat. Five Sierracin/Sylmar Corporation individually framed flat-plate windows, including single-piece windscreen. Transparencies gold-coated for radar dissipation. Canopy hinged to open upward and backward.

Systems

AiResearch environmental control, auxiliary power and emergency power systems.

Avionics

Forward-looking infrared (FLIR) sensor, with dual fields of view, in recessed emplacement, covered by fine mesh screen, below windscreen. Retractable downward-looking DLIR and laser designator beneath forward fuselage to starboard of nosewheel bay; FLIR and DLIR by Texas Instruments (to be replaced by improved equipment during third-phase retrofit in 1994). HUD based on Kaiser AN/AVQ-28; large head-down display for FLIR imagery flanked by two multi-function CRTs. Retractable radio antennae beneath fuselage, ahead of port main landing gear, and on spine. Honeywell radar altimeter, Honeywell SPN-GEANS INS (replaced by Honeywell H-423/E ring laser gyro from August 1991; Rockwell Collins GPS to be added); IBM AP-102 mission computer (replacing original three Delco M362F computers); GEC-Marconi flight control computer/navigation interface and autopilot computer (NIAC) system; SLI Avionic Systems Corporation expanded data transfer system and AHRS. Harris Corporation digital moving map added as retrofit with full-colour MFDs.

Armament

Full range of USAF tactical fighter ordnance', principally two 2000 lb bombs: BLU-109B low-level laser-guided or GBU-10/GBU-27 laser-guided glide weapons; alternatively, AGM-65 Maverick or AGM-88 HARM ASMs. Provision for AIM-9 Sidewinder (against AWACS aircraft). Internal carriage on two extendible beams in weapon bay. (Only missiles with seeker heads extended below aircraft prior to launch; bombs released from within weapons bay.)

Specifications

DIMENSIONS, EXTERNAL	
Wingspan	13.20m
Length overall	20.08m
Height overall	3.78m

WEIGHTS AND LOADINGS	
Weight empty (estimated)	13,381kg
Internal weapons load	2268kg
Max T-O weight	23,814kg

PERFORMANCE	
Max level speed	561 knots
Normal max operating speed	Mach 0.9
** T-O speed at normal combat weight*	165 knots
** Landing speed*	150 knots
Mission radius, unrefuelled, 2268kg weapon load	570 nm
G limit+	6

* (not confirmed by USAF)

JAS 39 Gripen

Title

JAS 39 GRIPEN (GRIFFIN)

Type

Single-seat all-weather, all-altitude interceptor, attack and reconnaissance aircraft.

Programme

Funded definition and development began June 1980; initial proposals submitted 3 June 1981; government approved programme 6 May 1982; initial FMV development contract 30 June 1982 for five prototypes and 30 production aircraft, with options for next 110; overall go-ahead confirmed Spring 1983; first test runs of RM12 engine January 1985; Gripen HUD first flown in Viggen testbed February 1987; study for two-seat JAS 39B authorized July 1989.

First of five single-seat prototypes (39-1) rolled out 26 April 1987; made first flight 9 December 1988 but lost in landing accident after fly-by-wire problem 2 February 1989; first production Gripen (39.101) made first flight 10 September 1992 and joined test programme in lieu of 39-1; flight test results in many cases (acceleration, speed, range, turn performance) better than specification due to lower zero drag; flight test programme to continue until 1995.

Variants

JAS 39A. Standard single-seater. Description applies to this version except where indicated.

JAS 39B. Two-seater (Gripen SK), under development; 0.65m fuselage plug and lengthened cockpit canopy. Primary roles conversion and tactical training. Avionics essentially as for JAS 39A except no HUD in rear cockpit; instead, HUD image from front seat can be presented on flight data display in rear cockpit. Redesigned environmental control system. No internal gun.

JAS 39C and D. Potential improved Swedish versions of A and B with enhanced data handling capability.

JAS 39X. Potential future export version, to upgraded standard of C/D.

Design Features

Intended to replace AJ/SH/SF/JA/AJS versions of Saab Viggen, in that order, and remaining J 35 Drakens; partners are Saab Military Aircraft, Ericsson Radar Electronics, Volvo Flygmotor and FFV Aerotech; to operate from 800m Swedish V90 road strips; simplified maintenance and quick turnround with conscript groundcrew.Delta wing with squared tips for missile rails has approx 45° leading-edge sweepback; independently movable foreplanes have leading-edge sweep of approx 43°.

Structure

First 3½ carbonfibre wing sets produced by BAe; all subsequent carbonfibre parts (30% of airframe) made by Saab, including wing boxes, foreplanes, fin and all major doors and hatches.

Systems

Hymatic environmental control system for cockpit air-conditioning, pressurization and avionics cooling. Hughes-Treitler heat exchanger. Two hydraulic systems, with Dowty equipment and Abex pumps. Sundstrand main electrical power generating system (40kVA constant speed, constant frequency at 400Hz) comprises an integrated drive generator, generator control unit and current transformer assembly. Lucas Aerospace auxiliary and emergency power system, comprising gearbox-mounted turbine, hydraulic pump and 10kVA AC generator, to provide auxiliary electric and hydraulic power in event of engine or main generator failure.

Avionics

CelsiusTech dual VHF/UHF com transceivers. Honeywell laser inertial navigation system and radar altimeter. Nordmicro air data computer. Ericsson EP-17 electronic display system incorporates Kaiser wide-angle HUD, using advanced diffraction optics to combine symbology and video images. PP1 or PP2 display processors (PP12 in production Lot 2), and three Ericsson head-down CRT displays; minimum of conventional analog instruments, for backup only. Left hand (flight data) head-down display normally replaces all conventional flight instruments.

Central display shows computer generated map of area surrounding aircraft with tactical information superimposed. Right hand CRT is a multi-sensor display showing information on targets acquired by radar, FLIR and weapon sensors. Ericsson SDS 80 central computing system (D80E 32-byte computer, Pascal/D80 high order language and programming support environment); three MIL-STD-1553 databases, one of which links flight data, navigation, flight control, engine control and main systems. BAe three-axis strapdown gyro-magnetic unit provides standby attitude and heading information.

Ericsson/GEC-Marconi Avionics PS-05/A multi-mode pulse Doppler target search and acquisition (lookdown/shootdown) radar (weight 156 kg). For fighter missions, this system provides fast target acquisition at long range; search and multi-target track-while-scan; quick scanning and lock-on at short ranges; and automatic fire control for missiles and cannon. In attack and reconnaissance roles its operating functions are search against sea and ground targets; mapping, with normal and high resolution; and navigation. FLIR pod, carried externally under starboard air intake trunk, forward of wing leading-edge, is for attack and reconnaissance missions at night, providing heat picture of target on right hand head-down CRT. Radar warning equipment and countermeasures.

Armament

Internally mounted 27 mm Mauser BK27 automatic cannon in fuselage and infra-red dogfight missiles at wingtips. (No internal gun in JAS 39B.) Five other external hardpoints (two under each wing and one on centerline) for short- and medium-range air-to-air missiles such as RB74 (AIM-9L Sidewinder) or AIM-120 AMRAAM; air-to-surface missiles such as RB75 (Maverick); anti-shipping missiles such as Saab RB 15F; DASA DWS 39 munitions dispenser; conventional or retarded bombs; air-to-surface rockets; or external fuel tanks. Series of mission pods to be developed.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	8.40m
Length overall	
JAS 39A	14.10m
JAS 39B	14.80m
Height overall	4.50m
Wheel track	2.40m
Wheelbase	
JAS 39A	5.20m
JAS 39B	5.90m

WEIGHTS AND LOADINGS	
Operating weight empty	6622kg
Internal fuel weight	2268kg
T-O weight, clean	approx 8500kg
Max T-O weight with external stores	approx 12500kg

PERFORMANCE	
Max level speed	supersonic at all altitudes
T-O and landing strip length	approx 800m
G limit	+9

MiG-17F "Fresco"

Title

MIKOYAN MiG-17

NATO reporting name: Fresco

Type

Single-seat fighter-bomber.

Programme

Less than a year after the MiG-15 had been sanctioned for production (1948), this design bureau initiated work on a follow-on fighter that would approach the speed of sound mainly through efinement of the basic airframe configuration. The first prototype received the designation I-330, and flew for the first time in January 1950. Claims that the I-330 managed to better Mach 1 during test flights are believed to be unsubstantiated, but the overall improvements in performance were important.

Following the loss of the first prototype, a second and further improved prototype took over, allowing testing to be completed in 1951, and production of the MiG-17 was given the go-ahead. Compared to the MiG-15, the MiG-17 had a lengthened fuselage with softer taper, larger area tail surfaces to benefit handling characteristics, and thinner section wings with rounded tips. Indeed, the wings were designed from scratch, with the inner leading-edges extended forward; this resulted in greater root chord and varying leading-edge sweepback (45° along inner portions, 42° on outer panels). A mark of identification was the MiG-17's three boundary layer fences on each wing.

Production began with a day fighter model (NATO "Fresco-A"), which retained the VK-1 engine. The later MiG-17PF introduced all-weather capability, housing Izumrud S-band radar in a "bullet" radome at the center of the nose air intake and in an extension on the upper lip of the intake. Subsequently, this S-band radar was superseded by an E/F-band version of "Scan Fix", which still gave neither a large antenna nor a wide angle of scan and is now thought obsolescent.

Design Features

Cantilever mid-wing monoplane. Sweepback 45° at roots, 42° on outer panels. Anhedral 3°. Three boundary layer fences on each wing.

Flying Controls

Split Fowler type flaps. Bulged rear airbrakes.

Structure

The fuselage is a semi-monocoque structure. The tail unit has sharply swept surfaces. Fin tip dielectric aerial.

Landing Gear

Retractable tricycle type. Mainwheel tyres diameter 60 cm.

Power Plant

One Klimov VK-1A turbojet engine, developing 33.83 kN with afterburning. Normal fuel load in internal tanks 1410 litres. A 400 litre external tank may be fitted at half-span on each wing.

Accommodation

Pilot only in pressurized cockpit with ejection seat. Rearward sliding canopy.

Armament

One 37mm Nudelmann-Suranov NS-37 cannon and two 23mm Nudelmann-Rikhter NR-23 cannon, or three 23mm cannon. Provision for four underwing packs of 8 x 55mm air-to-air rockets or a total of 500kg of bombs under the wings.

Specifications

AVIONICS
See Programme.

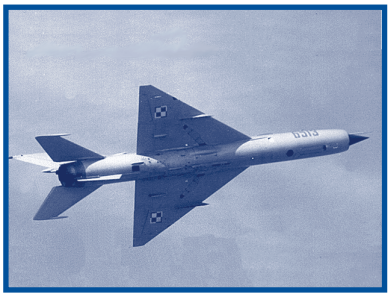
DIMENSIONS, EXTERNAL	
Wing span	9.63m
Length overall	11.36m
Height overall	3.80m
Wheel track	3.85m

WEIGHTS	
Weight empty	3930kg
Max T-O weight	6069kg

PERFORMANCE	
Max level speed at 3000m	617 knots
Max rate of climb at S/L	3900m
Service ceiling	16,600m
Max range[1]	755nm

[1]with external tanks and bombs

MiG-21F "Fishbed-C"



Title

MIKOYAN MiG-21

NATO reporting names: Fishbed and Mongol

Type

Single-seat multi-role fighter and two-seat operational trainer.

Programme

Development began to meet Autumn 1953 official requirements for short-range interceptor; tailed delta configuration selected for production late 1956 after flight testing of prototypes with swept and delta wings; Ye-6 pre-production prototype flew late 1957; MiG-21 production authorized 1958; deliveries began late that year; production completed except in China, where developed versions are manufactured by Chengdu Aircraft Corporation (CAC) and Guizhou Aviation Industry (GAIC).

Design Features

Diminutive tailed delta with clipped tips to mid-mounted wings; circular-section fuselage with prominent dorsal spine; nose intake with large three-position centerbody; swept tail, with large vertical surfaces and ventral fin; 2° wing anhedral from roots; TsAGI section, thickness/chord ratio 5% at root, 4.2% at tip; leading-edge sweep 57°; no wing leading-edge camber.

Flying Controls

Manual operation, with autostabilization in pitch and roll; hydraulically boosted inset ailerons; blown plain trailing-edge flaps, actuated hydraulically; forward hinged door type airbrake each side of underfuselage below wing leading-edge; third forward hinged airbrake under fuselage forward of ventral fin; airbrake actuated hydraulically; hydraulically boosted rudder and all-moving horizontal surface with two gearing ratios for varying combinations of altitude and airspeed; tailplane trim switch on control column; no tabs.

Structure

All-metal; wings have two primary spars and auxiliary spar; semi-monocoque fuselage, with spine housing control pushrods, avionics, single-point refueling cap and fuel tank; blister fairings on fuselage above and below each wing to accommodate retracted mainwheels.

Landing Gear

Hydraulically retractable tricycle type, with single wheel on each unit; all units housed in fuselage when retracted. Forward retracting non-steerable nosewheel unit, tyre size 500 x 180mm; inward retracting mainwheels which turn to stow vertically inside fuselage.

Power Plant

One Tumansky R-13-300 turbojet, rated at 41.55 kN dry and 64.73 kN with afterburning. Fuel tanks in fuselage, and two integral tanks in each wing, with total capacity of 2600 litres, of which approx 1800 litres are usable within CG limits at low speed. Provision for carrying one finned external fuel tank, capacity 490 litres or 800 litres, on underfuselage pylon and two 490 litre drop tanks on outboard underwing pylons. Two jettisonable solid propellant JATO rockets can be fitted under rear fuselage, aft of wheel doors.

Accommodation

Pilot only, on zero/zero ejection seat with spring loaded arm at top which ensures that seat cannot be operated unless hood is closed. Canopy is sideways hinged, to starboard, and is surmounted by a small rearview mirror. Flat bullet-proof windscreen. Cabin air-conditioned. Armor plating forward and aft of cockpit.

Systems

Duplicated hydraulic system, supplied by engine driven pump, with backup by battery powered electric pump, and emergency electric tailplane trim.

Avionics

Search and track radar (NATO "Jay Bird") in intake centerbody, with search range of 10.8nm. Other standard avionics include VOR, ARK automatic radio compass, IFF and Sirena 3 radar warning system with an indicator marked in 45° sectors in front of and behind the aircraft. Gyro gunsight maintains precision up to 2.75g. Automatic ranging can be fed into gunsight. Full blind-flying instrumentation, with attitude and heading indicators driven by remote central gyro platform.

Armament

One twin-barrel 23mm GSh-23 gun, with 200 rounds, in belly pack. Four underwing pylons for weapons or drop tanks. Typical loads for interceptor role include two AA-2/2D (K-13A) "Atoll" air-to-air missiles on inner pylons and two radar homing AA-2C "Atolls" or two UV-16-57 rocket packs (16 57mm rockets) on outer pylons; or two drop tanks and two AA-2/2D or AA-2C "Atoll". Typical loads for ground attack role are four UV-16-57 rocket packs, two 500kg and two 250kg bombs; or four 240mm S-24 air-to-surface rockets.

Specifications

DIMENSIONS, EXTERNAL (MIG-21MF)	
Wing span	7.15m
Length, incl. boom	15.76m
Fuselage length[1]	12.30m
Height overall	4.10m
AREAS	
Wings, gross	23.0 m^2

WEIGHTS AND LOADINGS (MIG-21MF)	
Weight empty	5843kg
T-O weight[2]	8200kg
Max T-O weight	9800kg
Max wing loading	426.0kg/m^2
Max power loading	151.4kg/kN

PERFORMANCE (MIG-21MF)	
Max level speed (above 11000m)	Mach 2.05
Max level speed (low-altitude)	Mach 1.06
Landing speed	146 knots
Design ceiling	18000m
Range, internal fuel only	593nm
Ferry range[3]	971nm

[1] intake lip to jet pipe nozzle
[2] with four K-13A missiles
[3] with three external tanks

Rafale C

Title

DASSAULT RAFALE (SQUALL)

Type

Two-seat Avion de Combat Tactique (French Air Force) or single-seat Avion de Combat Marine (French Navy) interceptor, multirole fighter and reconnaissance aircraft.

Programme

Ordered to replace French Air Force Jaguars and Navy Crusaders and Super Etendards; for early development history, see 1990-91 and earlier Jane's; first flight of Rafale A prototype (F-ZJRE) 4 July 1986; first flight with SNECMA M88 replacing one GE F404, 27 February 1990 (was 461st flight overall); 865th and final sortie, 24 January 1994. Rafale programme's 2,000th sortie, 5 September 1994. ACE International (Avion de Combat European) GIE set up in 1987 by Dassault Aviation, SNECMA, Thomson-CSF and Dassault Electronic, partly to attract international partners; none found. Production launch officially authorized, 23 December 1992 (and 31 December 1992 for M88-2 power plant). First Rafale B and Rafale M ordered 26 March 1993. Four preproduction aircraft, as under:

To accelerate programme, early Rafales for navy will be to SU0 interceptor standard, lacking ASMP, helmet-mounted sight, OSF and voice command controls; definitive SU1 attack version will be delivered subsequently to replace Super Etendards. Air force plans similarly limited capability for initial aircraft, but cost-saving measures applied in 1995 included postponement of first deliveries to 2005, when full standard aircraft will be available. Dassault offers export aircraft from 1999.

Variants

Rafale B. Originally planned dual control, two-seat version for French Air Force; weight 350kg more than Rafale C; 3 to 5% higher cost than Rafale C. Being developed into fully operational variant for either pilot/WSO or single pilot combat capability.

Rafale C. Single-seat combat version for French Air Force. Detailed description applies to Rafale C, except where indicated.

Rafale D. Original configuration from which production versions derived; now `Rafale Discreet' (stealthy) generic name for French Air Force versions.

Rafale M. Single-seat carrierborne fighter; navalisation weight penalty, 610kg; take-off weight from existing French carrier Foch limited to 16,500kg; has 80% structural and equipment commonality with Rafale C, 95% systems commonality. Navy's financial share of French programme cut in 1991 from 25 to 20%.

Design Features

Minimum weight and volume structure to hold minimum cost; thin, mid-mounted delta wing with moving canard; individual fixed, kidney-shaped intakes without shock cones.

Landing Gear

Hydraulically retractable tricycle type supplied by Messier Dowty, with single mainwheels and twin, hydraulically steerable, nosewheels. All wheels retract forward. Designed for impact at vertical speed of 3m/s, or 6.5m/s in naval version, without flare-out.

Power Plant

Two SNECMA M88-2 augmented turbofans, each rated at 48.7 kN dry and 72.9 kN with afterburning. M88-3 of 87 kN maximum rating in production aircraft. Internal tanks for more than 5,325 litres of fuel. Fuel system by Lucas Air Equipement and Zenith Aviation; equipment by Intertechnique. One 1,700 litre drop tank on centerline; 2,000 litre drop tank on each inboard underwing pylon; and/or 1,300 litre tank on each centre underwing pylon. Maximum external fuel 6,600 litres. Pressure refuelling in 7 minutes, or 4 minutes for internal tanks only. Fixed (detachable) in-flight refuelling probe on all versions.

Accommodation

Pilot only, on SEMMB (Martin-Baker) Mk 16 zero/zero ejection seat, reclined at angle of 29°. One-piece Sully Products Speciaux blister windscreen/canopy, hinged to open sideways to starboard. Canopy gold-coated to reduce radar reflection.

Avionics

Provision for more than 780kg of avionics equipment and racks.

Comms. EAS V/UHF and TRT Saturn UHF radios. TEAM intercom; Sextant Avionique voice activated radio controls and voice alarm warning system. Thomson-CSF/CNI SB 25A IFF. Chelton aerials. Radar: GIE Radar (Thomson-CSF/Dassault Electronic) RBE2 look-down/shoot-down radar, able to track up to eight targets simultaneously, with automatic threat assessment and allocation of priority.

Flight. SOCRAT VOR/ILS; SAGEM Sigma RL90 INS (interface with carrier's navigation on Rafale M); Thomson-CSF NC 12E Tacan; Sigma RL-90 ring-laser gyro INS; Thomson-CSF/CNI AHV 17 radio altimeter and SFIM/Dassault laser gyro INS; Thomson-CSF/CNI AHV 17 radio altimeter and SFIM/Dassault Electronic flight recorder. Sextant Avionique GPS.

Instrumentation: Digital display of fuel, engine, hydraulic, electrical, oxygen and other systems information on collimated eye-level display and two lateral multi-function touch-sensitive colour LCD displays by Sextant. Fourth cockpit screen is head-level tactical navigation/sensor display. Sextant Avionique CTH3022 wide-angle, holographic HUD incorporating Thomson TTD Optronique OTA 1320 CCD camera and recorder. Sextant/Intertechnique Topsight helmet-mounted sight.

Mission: Thomson-TRT/SAT OSF electro-optical sensors. MIDS (Multifunctional Information Distribution System) datalink (equivalent to JTIDS/Link 16). Various reconnaissance, ECM, FLIR and laser designation pods. Self-defense: Spectra radar warning and ECM suite by Thomson-CSF, Dassault Electronic and Matra. Thomson TTD Optronique DAL (Detecteur d'Alerte Laser) system.

Armament

One 30 mm Giat DEFA 791B cannon in side of port engine duct. Fourteen Alkan external stores attachments: two on fuselage centerline, two beneath engine intakes, two astride rear fuselage, six under wings and two at wingtips. Forward centerline position deleted on Rafale M. Normal external load 6,000kg; maximum permissible, 8,000kg. In strike role, one Aerospatiale ASMP standoff nuclear weapon. In interception role, up to eight Mica AAMs (with IR or active homing) and two underwing fuel tanks; or six Micas and 5,700 litres of external fuel. In air-to-ground role, typically sixteen 227kg bombs, two Micas and two 1,300 litre tanks; or two Apache standoff weapon dispensers, two Micas and 5,700 litres of external fuel; or FLIR pod, Atlis laser designator pod, two 1,000kg laser-guided bombs, two AS.30L laser ASMs, four Micas and single 1,700 litre tank. In anti-ship role, two Exocet or projected ANS sea-skimming missiles, four Micas and 4,300 litres of external fuel.

Specifications

DIMENSIONS, EXTERNAL	
Wing span, incl wingtip missiles	10.90m
Wing aspect ratio	2.6
Length overall	15.30m
Height overall (Rafale D)	5.34m

AREAS	
Wings, gross	46.00m

WEIGHTS AND LOADINGS (ESTIMATED)	
Basic weight empty, equipped	
Rafale D	9,060kg
Rafale M	9,670kg
External load	
normal	6,000kg
max	8,000kg

PERFORMANCE (ESTIMATED)	
Max level speed	
at altitude	Mach 2
at low level	750knots
Approach speed	115knots
T-O distance	
air defense	.400m
attack	600 m
G limits	+9.0/-3.6

Sea Harrier FA.2

Title

BAe SEA HARRIER

Royal Navy designations: FRS.Mk 1 and F/A.Mk 2

Type

V/STOL fighter, reconnaissance and strike aircraft.

Programme

Development of P1184 Sea Harrier announced by British government 15 May 1975; first flight (XZ450) 20 August 1978; first delivery to Royal Navy (XZ451) 18 June 1979; first ship trials (HMS Hermes) November 1979.

Ski jump launching ramp (proposed by Lt Cdr D. R. Taylor, RN) take-off trials ashore 1977, and at sea from 30 October 1980; HMS Invincible and Illustrious first fitted with 7° ramps, HMS Ark Royal 12°; latter allows 1,135kg increased load for same take-off run or 50-60% shorter run at same weight; HMS Invincible recommissioned with 13° ramp 18 May; HMS Illustrious received similar year re-work, May 1991 to April 1994.

Variants

FRS.Mk 1. Initial Royal Navy version; Pegasus 104 engine; first used operationally during Falkland Islands campaign 1982, from HMS Hermes and Invincible (29 flew 2,376 sorties, destroying 22 enemy aircraft in air-to-air combat without loss; four lost in accidents and two to ground fire). Total 37 remained, June 1993, including Mk 2 conversions. Following description applies to Sea Harrier FRS. Mk 1, except where indicated otherwise.

FRS.Mk 51. Similar to Mk 1, for Indian Navy.

F/A.Mk 2. Differs externally from Mk 1 by less pointed nose radome; longer rear fuselage, resulting from 35cm plug aft of wing trailing-edge; revisions of antennae and external stores. Internal changes include GEC-Marconi Blue Vixen pulse Doppler radar, offering all-weather lookdown/shootdown capability, with inherent track-while-scan, multiple target engagement, greatly increased missile launch range, enhanced surface target acquisition, and improved ECCM performance. Current weapons plus AIM-120 AMRAAM on Airscrew Howden (Frazer-Nash) rail launchers and McDonnell Douglas LAU-106A eject launchers. Wingtip extensions of 20cm and 30cm test-flown to enhance stability carrying AMRAAM, but proved unnecessary by 1990 trials.

Design Features

Single-engined V/STOL system with four rotatable exhaust nozzles that can be set through 98.5° from fully aft position; short take-off made with nozzles initially fully aft, then turned partially downward for lift-off and continued forward acceleration; nozzles can be vectored at high speed to tighten turn radius or decelerate suddenly; control at less than wing-borne airspeed automatically transferred to reaction control valves at wingtips, nose and tail, also enhancing combat maneuver.

Main differences from land-based Harriers include elimination of magnesium components, introduction of raised cockpit, revised operational avionics, and installation of multi-mode GEC-Marconi radar with air-to-air intercept and air-to-surface modes in redesigned nose that folds to port; Pegasus 104 turbofan of Mk 1 incorporates additional anti-corrosion features and generates more electrical power than land-based Pegasus 103.

Landing Gear

Retractable bicycle type of Dowty Aerospace manufacture, permitting operation from rough unprepared surfaces of CBR as low as 3 to 5%. Hydraulic actuation, with nitrogen bottle for emergency extension of landing gear. Single steerable nosewheel retracts forward, twin coupled mainwheels rearward, into fuselage. Small outrigger units retract rearward into fairings slightly inboard of wingtips. Nosewheel leg of levered suspension liquid spring type.

Power Plant

One Rolls-Royce Pegasus Mk 104 or (retrofit option) Mk 106 vectored thrust turbofan (95.6 kN), with four exhaust nozzles of the two-vane cascade type, rotatable through 98.5° from fully aft position. Engine bleed air from HP compressor used for jet reaction control system and to power duplicated air motor for nozzle actuation. Low drag intake cowls each have eight automatic suction relief doors aft of leading-edge to improve intake efficiency by providing extra engine air at low forward or zero speeds. A 227 litre tank supplies demineralized water for thrust restoration in high ambient temperatures for STO, VTO and vertical landings. Fuel in five integral tanks in fuselage and two in wings, with total capacity of approx 2,865 litres. This can be supplemented by two 455 litre jettisonable combat tanks, or two 864 litre tanks, or two 1,500 litre ferry tanks on the inboard wing pylons. Ground refueling point in port rear nozzle fairing. Provision for fixed in-flight refueling probe above the port intake cowl.

Accommodation

Pilot only, on Martin-Baker Mk 10H zero/zero rocket ejection seat which operates through the miniature detonating cord equipped canopy of the pressurized, heated and air-conditioned cockpit. Seat raised 28cm compared with Harrier. Manually operated rearward sliding canopy. Birdproof windscreen, with hydraulically actuated wiper. Windscreen washing system.

Pilot only, on Martin-Baker Mk 10H zero/zero rocket ejection seat which operates through the miniature detonating cord equipped canopy of the pressurized, heated and air-conditioned cockpit. Seat raised 28cm compared with Harrier. Manually operated rearward sliding canopy. Birdproof windscreen, with hydraulically actuated wiper. Windscreen washing system.

Avionics

Nose-mounted GEC-Marconi Blue Fox (Blue Vixen in F/A. Mk 2) multi-mode radar, with TV raster daylight viewing tube which conveys flight information, as well as radar data, to pilot. Smiths electronic HUD and 20,000 word digital weapon aiming computer, bus control unit and missile control system. Radar altimeter and Racal Doppler 72 radar. GEC-Marconi self-aligning attitude and heading reference platform and digital navigation computer, up-front control panel and multi-function display. Radio navaids include UHF homing, GEC-Marconi AD 2,770 Tacan with offset facility, Plessey PTR 446 D-band IFF transponder, Cossor IFF 3,500 interrogator, THORN EMI ARI 5983 I-band transponder and THORN EMI Microwave Airborne Digital Guidance Equipment (MADGE). Radio com by multi-channel Magnavox AN/ARC-164 UHF and GEC-Marconi AD 120 VHF with VHF standby via Dowty D 403M transceiver. GEC-Marconi Defense Systems Sky Guardian 200 RWR, Vinten video recording system for HUD and HDD. Intended 1994 retrofit of Mk XII IFF; GPS in 1997; JTIDS in 1997-99.

Armament

No built-in armament. Combat load carried on four underwing and three underfuselage pylons. Wing and centre-fuselage pylons fitted with ML ejector release units; other underfuselage pylons with McDonnell Douglas LAU-106/A missile eject launchers for AIM-120 AMRAAM. Inboard wing points and fuselage centerline point stressed for loads up to 907kg each, and outboard underwing pair for loads up to 295kg each; two strake fairings under the fuselage can each be replaced by a 30mm Aden gun pod and ammunition or, on F/A. Mk 2, by two missile pylons. Aircraft cleared for operations with maximum external load exceeding 2,270kg, and has flown with weapon load of 3,630kg. F/A. Mk 2 outboard pylons re-stressed to 454kg. Able to carry 30mm guns, bombs, rockets and flares of UK and US designs.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	
normal	7.70m
ferry	9.04m
Length overall	
FRS.Mk 1	14.50m
F/A.Mk 2	14.17m
Length overall, nose folded	
FRS.Mk 1	12.73m
F/A.Mk 2	13.16m
Height overall	3.71m
Tailplane span	4.24m

AREAS	
Wings, gross	18.68m2
Rudder, incl. tab	0.49m2
Tailplane	4.41m2

WEIGHTS AND LOADINGS (FRS. MK 1)	
Weight empty	6,374kg
Max fuel capacity	
internal	2,295kg
external	2,404kg
Max weapon load	
STO	3,630kg
VTO	2,270kg
Max T-O weight	11,880kg
Max wing loading	636.0kg/m2
Max power loading	124.27kg/kN

PERFORMANCE (FRS. MK 1)	
Max level speed	
at high altitude	Mach 1.25
at low altitude	above 640 knots EAS
Mission radius	250nm
G limits	+7.8/-4.2

Su-33 "Flanker-D"

Title

SUKHOI Su-33

NATO reporting name: Flanker-D

Type

Single-seat ship-based air defense fighter.

Programme

Development began 1976; based on production Su-27, but embodying folding wings, other features for shipboard operation, and movable foreplanes. Navalised Su-27 (T-10-25), with arrester hook, flew 1984; first Su-27K (K for *korabelnyy*: ship-based) prototype (T-10K-1) flew 17 August 1987; second (T-10K-2) made first conventional (non-V/STOL) landing by Soviet aircraft on ship, the Admiral of the Fleet Kuznetsov (then Tbilisi), 1 November 1989; production at Komsomolsk-on-Amur began 1990; first production Su-33 (T-10K-3) flew 1990; deliveries began 1991; initial operational capability 1992; 20 delivered and shore-based on Kola Peninsula mid-1994.

Design Features

Airframe similar to Su-35, but with folding wings, arrester hook and other features for carrier-borne operations; strengthened landing gear with twin nosewheels; long tailcone of land-based versions shortened to prevent tailscrapes during take-off and landing on ship; IRST with wider angle of view.

Structure

Generally as Su-27, but hydraulically folding outer wings (through 135°) and upward folding horizontal tail surfaces. Riveted and welded structure of aluminum and titanium alloys and steel.

Landing Gear

Hydraulically retractable tricycle type, made by Hydromash, with single wheel on each unit; mainwheels retract forward into wingroots; steerable nosewheel, with mudguard, also retracts forward; mainwheel tyres 1030 x 350mm, pressure 12.25-15.7 bars; twin nosewheel tyres 620 x 180mm, pressure 9.3 bars; hydraulic brakes with two-signal anti-skid system; brake-chute housed in fuse-lage tailcone. Arrester hook under tailcone.

Power Plant

Two Saturn/Lyulka AL-31F turbofans, each 122.6 kN with afterburning. Large auxiliary air intake louvres in bottom of each three-ramp engine duct near primary wedge intake; two rows of small vertical louvres in each sidewall of wedge, and others in top face; fine-grille screen hinges up from bottom of each duct to shield engine from foreign object ingestion during take-off and landing. Pressure or gravity fuelling. Retractable flight refueling probe beneath windscreen on port side; provision for centerline buddy refueling pack.

Accommodation

Pilot only, on K-36MD zero/zero ejection seat, under large rearward opening transparent blister canopy, with low sill.

Avionics

Track-while-scan coherent pulse Doppler lookdown/shootdown radar (antenna diameter approx 1.0 m) with reported search range of 130nmand tracking range of 100 nm; infra-red search/track (IRST) sensor in transparent housing forward of windscreen; Sirena-3 360° radar warning receivers, outboard of each bottom air intake lip and at tail. Integrated fire control system enables radar, IRST and laser rangefinder to be slaved to pilot's helmet-mounted target designator and displayed on wide-angle HUD; autopilot able to restore aircraft to right-side-up level flight from any attitude when "panic button" depressed. Nav systems specialized for use over sea.

Armament

One 30mm GSh-301 gun in starboard wingroot extension, with 150 rds. Up to 10 air-to-air missiles in air combat role, on tandem pylons under fuselage between engine ducts, beneath each duct, under each centre-wing and outer-wing, and at each wingtip. Typically, two short-burn semi-active radar homing R-27R (NATO AA-10A "Alamo-A") in tandem under fuselage; two short-burn infra-red homing R-27T (AA-10B "Alamo-B") missiles on centre-wing pylons; and long-burn semi-active radar homing R-27ER (AA-10C "Alamo-C") or infra-red R-27ET (AA-10D "Alamo-D") beneath each engine duct. The four outer pylons carry either R-73A (AA-11 "Archer") or R-60 (AA-8 "Aphid") close-range infra-red missiles. R-33 (AA-9 "Amos") missiles optional in place of AA-10s. Five-round packs of 130mm rockets, or larger rocket pods, under wings in ground attack role.

Ability to carry Kh-31 (AS-17 "Krypton") air-to-surface missiles underwing and 4,500kg Kh-41 (3M80 Moskit: mosquito) anti-ship missile on centerline.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	14.70m
Length overall, incl nose probe	21.185m
Width, wings folded	7.40m
Height overall	5.90m
Tailplane span	9.90m

WEIGHTS AND LOADINGS
Not available.

PERFORMANCE	
Never-exceed speed (V^{ne}) at 11,000m	Mach 2.165
Stall speed	130 knots
T-O run on carrier with 14° ramp	120m
Range with max internal fuel	1,620nm
G limit	+8

Su-35

Title

SUKHOI Su-35

Type

Single-seat all-weather counter-air fighter and ground attack aircraft.

Programme

Experimental version of Su-27 with foreplanes (T-10-24) flew May 1985; first of six prototypes (successively T-10S-70, Su-27M, Su-35) flew 28 June 1988; another was exhibited at 1992 Farnborough Air Show; in final stages of flight testing early 1993; 10 built by September 1993; scheduled entry into Russian Air Force service mid-1990s, for effective service until 2015-2020.

Design Features

Advanced development of Su-27; airframe, power plant, avionics and armament all upgraded; quadruplex digital fly-by-wire controls under development; claimed to be first series-built fighter with static instability and tandem 'tri-plane' layout, with foreplanes; double-slotted flaperons; taller twin tail fins with integral fuel tanks; reprofiled front fuselage for larger-diameter radar antenna; enlarged tailcone for rearward facing radar; twin-wheel nose landing gear; three-dimensional thrust vectoring nozzles under development for use on production aircraft.

Structure

Higher proportion of carbonfibre and aluminum-lithium alloy in fuselage; composites used for components such as leading-edge flaps, nosewheel door.

Power Plant

Two Saturn/Lyulka AL-31FM turbofans; each 137.3 kN with afterburning. Retractable flight refuelling probe on port side of nose.

Avionics

N011 multi-mode radar able to acquire airborne targets at ranges up to 216 nm, surface targets up to 108 nm; simultaneous tracking of more than 15 air targets and engagement of six; low-altitude terrain-following/avoidance; rearward facing radar may enable firing of rearward facing IR homing air-to-air missiles; new-type IRST moved to starboard; all combat flight phases computerized; enhanced ECM, including wingtip jammer pods. Shown at Farnborough with GEC Ferranti TIALD (thermal imaging airborne laser designator) night/adverse visibility pod fitted for possible future use.

Armament

One 30 mm GSh-30 gun in starboard wingroot extension. Mountings for up to 14 stores, including R-27 (AA-10 'Alamo-A/B/C/D'), R-40 (AA-6 'Acrid'), R-60 (AA-8 'Aphid'), R-73A (AA-11 'Archer') and R-77 (AA-12) AMRAAM class air-to-air missiles, Kh-25ML (AS-10 'Karen'), Kh-25MP (AS-12 'Kegler'), Kh-29 (AS-14 'Kedge') and Kh-31 (AS-17 'Krypton') air-to-surface missiles, KAB-500 bombs and rocket packs. Max weapon load 8000 kg.

Specifications

DIMENSIONS, EXTERNAL	
Wing span, over ECM pods	**15.00m**
Length overall	**22.00m**
Height overall	**6.00m**

PERFORMANCE	
Max level speed	
at height	**Mach 2.35**
at S/L	**Mach 1.18**
Service ceiling	**18000m**
Balanced runway length	**1200m**
Range	
with max internal fuel	**more than 2160nm**
with flight refuelling	**more than 3510nm**

X-29

Title

Grumman X-29

Type

Forward Swept Wing Advanced Technology Demonstrator.

Description

At first glance, the X-29 may appear to be flying backwards. It's sharply angled-forward swept wings are mounted far back on the fuselage while the canards - horizontal stabilizers for controlling pitch - are mounted in front of the wings rather than at the tail. The X-29 uses a close-coupled design that places the canards close to and in the same plane as the wing. The complex geometries of the main wings and canards combine to give the aircraft exceptional maneuverability, supersonic performance, a very light structure and low drag. Using one F404 engine, the X-29 will demonstrate technologies that are expected to allow future aircraft to fly faster and farther for a given engine thrust.

Programme

The X-29 represents a unified commitment to future aircraft development by the Defense Advanced Research Projects Agency (DARPA), the US Air Force, the National Aeronautics and Space Administration (NASA), and aerospace manufacturers. Intensive investigations and technology validation studies to develop a viable forward-swept wing supersonic aircraft have been under way since 1976. The $87 million X-29 program began officially in December 1981 when DARPA awarded a contract to Grumman Aerospace Corporation to produce two test aircraft.

Design Features

The X-29 uses a three-control-surface configuration for pitch control. The canards, flaperons, and strake flaps are driven in concert to minimize trim drag. This maximizes the aircraft's responsiveness at the onset of maneuvers by increasing pitch acceleration. The three surfaces, which jointly minimize the aircraft's drag, are driven continuously: the canard for primary pitch control; the flaperons for roll control, high lift, and camber changing; and the strake flaps to augment the canards at low speeds, which rotates the aircraft on takeoff or pitches the aircraft down from a deep stall.

Technologies

The forward swept wing of the X-29 could alter the thinking of future aircraft designers. It performs more efficiently over a wider range of speeds than aircraft with traditionally swept wings, which mean less drag, more lift, better maneuverability, and more efficient cruise speed. In flight, air moving over the forward swept wing tends to flow inward toward the root of the wing rather than outward toward the wing tip as it does on an aft swept wing. This reversed airflow allows the wing tips, with their ailerons, to remain unstalled at high angles of attack. Stall (loss of lift) that does occur tends to develop at the root of the forward swept wing where it is easier to control. Because of this, the X-29 is more responsive to low speed and high angle-of-attack maneuvering commands than an aircraft with aft swept wings.

Future Benefits

The combined efforts of government and commercial enterprise built the X-29. Beyond evaluating its own flying qualities, the demonstrator may serve as a host aircraft to prove the value of advanced technology features for incorporation in future aircraft designs. A two-dimensional engine nozzle that will be able to deflect thrust up or down and reverse the thrust for braking the aircraft is under development. This mechanism could enhance short-field performance and handling qualities. Advanced cockpit designs that include a complete geometric rearrangement of the cockpit and an advanced autopilot require intensive testing and crew orientation. A pilot's seat reclined at a sharp angle to prevent blood from draining from the head during high-gravity turns, and a head-up display on a screen mounted at eye level or perhaps even on the pilot's visor are among the designs under consideration. Research in these technologies will lead aircraft designers into the 21st century.

Power Plant

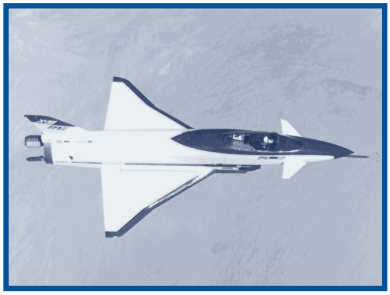
The X-29 powerplant is a 16,000 -pound-thrust-class General Electric F404-GE-400 turbofan engine, the same type as that currently used to power the twin engine F-18 aircraft.

Specifications

DIMENSIONS, EXTERNAL	
Wingspan	27 feet
Overall Length	48 feet
Height	14 feet

WEIGHTS AND LOADINGS	
Empty Weight	13,600 pounds
Maximum Fuel	4,000 pounds
Takeoff Gross Weight	17,600 pounds

X-31 EFM



Title

ROCKWELL/DASA X-31 EFM

Type

Single-seat combat manueverability research aircraft.

Programme

Evolved from work begun at MBB (now Deutsche Aerospace Military Aircraft Division) in 1977; joined by Rockwell 1983; feasibility study began November 1984, followed by US/German MoU May 1986 and start of one-year Phase 2 (vehicle preliminary design) September 1986; two prototypes funded August 1988 and assembled by Rockwell under 22 month Phase 3; first prototype (BuAer No. 164584) rolled out 1 March 1990, making first flight 11 October 1990; first flight of second prototype (164585) 19 January 1991; first aircraft made first flight with thrust vectoring paddles installed 14 February 1991; post-stall testing started November 1991 and 52° angle of attack reached by end 1991, after total 108 flights; International Test Organization formed when testing moved to Dryden in January 1992.

Phase 4 high angle of attack (AoA) tests started June 1992; final target 70° AoA with 45° bank reached 18 September; first ever 360° rolls at 70° AoA performed 6 November; post-stall programme completed March 1993 and followed by tactical utility trials with military pilots at Naval Air Test Center Patuxent River; first one X-31 with post-stall controls against the other X-31 with post-stall controls disabled; then dissimilar combat against various operational aircraft. On 17 March 1994, X-31 climbed to 11,582m and showed stability and manueverability at Mach 1.2 with normal fin and rudder neutralized by other controls and using only engine thrust vectoring for directional control. First 180° turn at 70° AoA achieved 29 April 1993. In 1993 dogfights against an evenly matched F/A-18, the X-31 showed high lethality in attack and good survival in defensive situations. Some flights were flown with the pilot wearing a GEC-Marconi Avionics Viper visual and audio display helmet and fighting a 'virtual' enemy generated by another pilot in a dome simulator on the ground.

Funding ended in April 1994, but other funds are keeping the programme alive until a new 25-month series of tests can be started in October.

Design Features

Low-mounted cranked delta wings with Rockwell transonic aerofoil section (thickness/chord ratio 5.5%), incorporating camber and twist; no dihedral or anhedral; incidence 0°; sweepback at quarter-chord 48° 6' inboard, 36° 36' outboard; sweptback foreplanes, fin and rudder; no horizontal tail surfaces. Design integrates several technologies to expand maneuvering flight envelope, including vectored thrust, integrated control systems and pilot assistance; enhanced manueverability could yield significant exchange ratio advantages in future close-in fighter combat, and X-31 is intended to break so-called stall barrier by allowing close-in aerial combat beyond normal stall angles of attack; design also expected to enable extremely rapid target acquisition and fuselage pointing for future low-speed, transonic and supersonic engagements; earlier programmes such as Rockwell HiMAT RPV and MBB's TKF-90 contributed much useful data to X-31 design and development. Rockwell primarily responsible for configuration, aerodynamics and construction, DASA for control systems and thrust-vectoring design, plus some major components and subassemblies (incl wings).

Landing Gear

Menasco landing gear adapted from F-16; hydraulically retractable tricycle type, main units retracting forward into fuselage, nose unit rearward. Main units have Goodrich (Cessna Citation III) wheels and brakes and Vought A-7D tyres (pressure 15.51 bars). Syndex tail braking parachute.

Power Plant

One 71.17 kN (with afterburning) General Electric F404-GE-400 turbofan. Single fuel tank in fuselage, with gravity feed filler just aft of canopy. Single ventral air intake, with movable lower lip.

Accommodation

Pilot only, on Martin-Baker SJU-5/6 ejection seat in pressurized, heated and air-conditioned cockpit. Windscreen and rear-hinged, upward opening canopy from McDonnell Douglas F/A-18 Hornet. General Electric's Aerospace Business Group assisted in cockpit development.

Specifications

DIMENSIONS, EXTERNAL	
Wingspan	**7.26m**
Wing aspect ratio	**2.51**
Foreplane span	**2.64m**
Length overall	
incl nose probe	**14.85m**
excl probe	**13.21m**
fuselage, excl probe	**12.39m**
Height overall	**4.44m**
Wheel track	**2.29m**
Wheelbase	**3.51m**

WEIGHTS AND LOADINGS	
Weight empty, equipped	**5175kg**
Fuel weight	**1876kg**
Normal flying weight	**6622kg**
Max T-O weight	**7228kg**

PERFORMANCE *(ESTIMATED, AT MAX T-O WEIGHT)*	
Never-exceed (VNE) and max level speed	
S/L to 8535m	**1485knots**
8535-12,200m	**Mach 1.3**
Max rate of climb at S/L	**13,106m/min**
Max operating altitude	**12,200m**
T-O run	**457m**
T-O to 15m	**823m**
Landing from 15m	**1128m**
Landing run	**823m**
Design G limits	**+9/-4**

X-32 ASTOVL

Title

ADVANCED STOVL
STRIKE FIGHTER (ASTOVL)

Type

SSF - short take-off/vertical landing (STOVL) strike-fighter.

Programme

Lockheed among five contenders in ARPA (US Advanced Research Projects Agency) contest for SSF, late 1992; foreseen as possible F/A-18 Hornet replacement; service entry 2015. Selected March 1993 for further studies, in competition with McDonnell Douglas/British Aerospace consortium; Boeing elected to continue private funding of own CALF design, which was later officially adopted as third competitor; Lockheed immediately received first part of $32.9 million, three-year contract to develop design of aircraft employing mechanical drive for lifting fan. Allison (for fan), Pratt & Whitney, Hercules and Rolls-Royce collaborating on development of F119 engine and incorporation of lifting technology. Phase 2, begun April 1994, is full-scale wind tunnel tests at NASA Ames, 1995, for concept validation; identification of required technologies; and demonstration of operational aircraft design margin and affordability. UK government funding 35% of $60 million Phase 2 costs.

In third phase, from 2000, ARPA to select one contractor to produce two flying aircraft, although merger with JAST programme is likely beforehand.

Design Features

Trapezoidal wing with canards and twin fins. Lifting fan for vertical component of flight is mechanically driven by a clutch and gearbox linked to the engine low-pressure spool. Fan forms forward lifting component; engine exhaust ducted downwards to provide rear component.

Power Plant

One 155 kN class Pratt & Whitney F119 advanced afterburning turbofan.

Specifications

WEIGHTS AND LOADINGS *(OTHER STATS ARE UNDETERMINED AT PRESENT)*	
Weight empty	not exceeding 10,886kg

Yak-141 "Freestyle"

Title

YAKOLEV YAK-141

NATO reporting name: Freestyle

Type

Single-seat carrier-based V/STOL multi-purpose combat aircraft

Program

Authentic details first released by Yakolev OKB at 1991 Paris Air Show; project started 1975; first flight of prototype March 1989; first vertical take-off 29 December 1989. Intended originally to replace Yak-38 for air defense of "Kiev" class carriers/cruisers, with secondary attack capabilities. Flight tests planned to continue until 1995, but programme stopped due to termination of Defense Ministry funding. Yakolev OKB continuing development in refined land-based and naval combat aircraft forms.

Design Features

Multi-engine lift/thrust configuration as Yak-38, but twin fins widely separated on flat-sided tailbooms, extending well beyond nozzle of propulsion engine; inner surface of each tailboom protected by curved titanium heatshield; rectangular wedge engine air intake each side of fuselage; recirculation of jet efflux restricted by large door that hinges down forward of vectored main nozzle, and smaller doors between this and liftjets; shallow "fence" forward of each fin root, as on MiG-29 but longer, probably housing chaff/flare dispensers; bulged wingtips for "puffer-jet" stability control system.

Flying Controls

Triplex full-authority digital fly-by-wire control of aerodynamic surfaces and "puffer-jets," with inputs from inertial and area nav systems via nav computer and from air computer system, with provision for satellite navigation; all-moving horizontal tail surfaces; leading-flaps on wing.

Structure

Extensive use of aluminum/lithium; 26% by weight CFRP, including flaps, slats, leading- and trailing-edges, and tail surfaces; swept-back wings fold upward at mid-span for stowage; wing leading-edge extension (also CFRP) on side of each intake duct forward of wing root.

Landing Gear

Retractable tricycle type with single wheel on each unit; nosewheel retracts rearward; main wheels, on trailing-link legs, retract forward into engine ducts. Brake chute housing on centerline above jet nozzle.

Power Plant

Primary power plant is Soyuz RD-79V-300 turbofan, 88.25 kN dry, 152.0 kN with afterburning; door beneath nozzle allows it to be vectored 65° downward for short take-off , 95° downward and forward for vertical landing. RD-79 lift thrust is approx 80% of cruise rating. Two RKBM Rybinsk RRD-41 liftjets, each 40.2 kN, inclined at 10° from vertical immediately aft of cockpit in installation similar to Yak-38 liftjets, able to vector rearward to 24° from vertical for STOL, and 2° forward of vertical for braking; "puffer-jet" stability controls at wingtips and nose; computerized engine control system. Conformal centerline 2,000 litre external fuel tank.

Accommodation

Pilot only, on Zvezda K-36 zero/zero ejection seat under blister canopy; flat bullet-proof windscreen; automatic ejection system for pilot in emergency during vertical and transition flight modes.

Avionics

Manual or automatic flight-control from take-off to landing, day and night, in all weathers; multi-mode fire control radar similar to that of MiG-29 with slightly smaller antenna, providing information to HUD and multi-function displays via computer that also receives input from IFF and stores management systems, with optional laser/TV target designator and helmet-mounted display.

Armament

One 30mm gun, 120 rds; four underwing hardpoints for R-27 (NATO AA-10 "Alamo"), R-73 (AA-11 "Archer") or R-77 air-to-air missiles, anti-ship missiles Kh-31 A/P (AS-17 "Krypton") or Kh-25 (AS-12 "Kegler"), air-to-surface missiles, 500kg bombs, rockets or 23mm gun pods.

Specifications

DIMENSIONS, EXTERNAL	
Wing span	10.10m
Wing aspect ratio	3.22
Width, wings folded	5.90m
Length overall	18.30m
Height overall	5.00m

AREAS	
Wings, gross	31.70m^2

WEIGHTS AND LOADINGS	
Weight empty	11,650kg
Max fuel capacity	
internal	4,400kg
external	1,750kg
Max external weapons load, STOL	2,600kg
Max T-O weight	
VTOL	15,800kg
STOL	19,500kg

PERFORMANCE	
Max level speed	
at height	Mach 1.7
at S/L	Mach 1.02
Service ceiling	15,000m
STOL T-O run	30-100m
STOL landing run	240m
Mission radius[1]	372nm
Range[2]	
at S/L	545nm
at 10,000-12,000m	1,133nm
G-limit, 50% fuel	+7

[1] STOL, with 2,000kg weapons
[2] STOL, with 1,000kg weapons