HAWKER SIDDELEY HARRIER

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- The Hawker Siddeley Harrier is the first of the Harrier Jump Jet series of aircraft. It was developed in the 1960s as the first operational close-support and reconnaissance fighter aircraft with vertical/short takeoff and landing (V/STOL) capabilities and the only truly successful V/STOL design of the many that arose in that era. The Harrier was developed directly from the Hawker Siddeley Kestrel prototype aircraft, following the cancellation of a more advanced supersonic aircraft, the Hawker Siddeley P.1154. The British Royal Air Force (RAF) ordered the Harrier GR.1 and GR.3 variants in the late 1960s. It was exported to the United States as the AV-8A, for use by the US Marine Corps (USMC), in the 1970s.
- During the Harrier's service the RAF positioned the bulk of the aircraft in West Germany to defend against a potential invasion of Western Europe by the Warsaw Pact forces; the unique abilities of the Harrier allowed the RAF to disperse their forces away from vulnerable airbases. The USMC used their Harriers primarily for close air support, operating from amphibious assault ships, and, if needed, forward operating bases. Harrier squadrons saw several deployments overseas. The Harrier's ability to operate with minimal ground facilities and very short runways allowed it to be used at locations unavailable to other fixed-wing aircraft. The Harrier received criticism for having a high accident rate and for a time-consuming maintenance process.
- In the 1970s the British Aerospace Sea Harrier was developed from the Harrier for use by the Royal Navy (RN) on Invincible-class aircraft carriers. The Sea Harrier and the Harrier fought in the 1982 Falklands War, in which the aircraft proved to be crucial and versatile. The RN Sea Harriers provided fixed-wing air defence while the RAF Harriers focused on ground-attack missions in support of the advancing British land force. The Harrier was also extensively redesigned as the AV-8B Harrier II and British Aerospace Harrier II by the team of McDonnell Douglas and British Aerospace. The innovative Harrier family and its Rolls-Royce Pegasus engines with thrust vectoring nozzles have generated long-term interest in V/STOL aircraft.

DEVELOPMENT:

- The Harrier's design was derived from the Hawker P.1127. Prior to developing the P.1127 Hawker Aircraft had been working on a replacement for the Hawker Hunter, the Hawker P.1121. The P.1121 was cancelled after the release of the British Government's 1957 Defence White Paper, which advocated a policy shift away from manned aircraft and towards missiles. This policy resulted in the termination of the majority of aircraft development projects then underway for the British military. Hawker sought to quickly move on to a new project and became interested in Vertical Take Off/Landing (VTOL) aircraft, which did not need runways. According to Air Chief Marshal Sir Patrick Hine this interest may have been stimulated by the presence of Air Staff Requirement 345, which sought a V/STOL ground attack fighter for the Royal Air Force.
- Design work on the P.1127 was formally started in 1957 by Sir Sydney Camm, Ralph Hooper of Hawker Aircraft, and Stanley Hooker (later Sir Stanley Hooker) of the Bristol Engine Company. The close cooperation between Hawker, the airframe company, and Bristol, the engine company, was viewed by project engineer Gordon Lewis as one of the key factors that allowed the development of the Harrier to continue in spite of technical obstacles and political setbacks.[9] Rather than using rotors or a direct jet thrust, the P.1127 had an innovative vectored thrust turbofan engine, the Pegasus. The Pegasus I was rated at 9,000 pounds (40 kN) of thrust and first ran in September 1959. A contract for two development prototypes was signed in June 1960 and the first flight followed in October 1960. Of the six prototypes built, three crashed, including one during an air display at the 1963 Paris Air Show.

DESIGN:

- The Harrier was typically used as a ground attack aircraft, though its manoeuvrability also allows it to effectively engage other aircraft at short ranges. The Harrier is powered by a single Pegasus turbofan engine mounted in the fuselage. The engine is fitted with two air intakes and four vectoring nozzles for directing the thrust generated: two for the bypass flow and two for the jet exhaust. Several small reaction nozzles are also fitted, in the nose, tail and wingtips, for the purpose of balancing during vertical flight. It has two landing gear units on the fuselage and two outrigger landing gear units, one near each wing tip. The Harrier is equipped with four wing and three fuselage pylons for carrying a variety of weapons and external fuel tanks.
- The Kestrel and the Harrier were similar in appearance, though approximately 90 per cent of the Kestrel's airframe was redesigned for the Harrier. The Harrier was powered by the more powerful Pegasus 6 engine; new air intakes with auxiliary blow-in doors were added to produce the required airflow at low speed. Its wing was modified to increase area and the landing gear was strengthened. Several hardpoints were installed, two under each wing and one underneath the fuselage; two 30 mm (1.2 in) ADEN cannon gun pods could also be fitted to the underside of the fuselage. The Harrier was outfitted with updated avionics to replace the basic systems used in the Kestrel; a navigational-attack system incorporating an inertial navigation system, originally for the P.1154, was installed and information was presented to the pilot by a head-up display and a moving map display.
- The Harrier's VTOL abilities allowed it to be deployed from very small prepared clearings or helipads as well as normal airfields. It was believed that, in a high-intensity conflict, air bases would be vulnerable and likely to be quickly knocked out. The capability to scatter Harrier squadrons to dozens of small "alert pads" on the front lines was highly prized by military strategists and the USMC procured the aircraft because of this ability. Hawker Siddeley noted that STOL operation provided additional benefits over VTOL operation, saving fuel and allowing the aircraft to carry more ordnance.
- "I still don't believe the Harrier. Think of the millions that have been spent on VTO in America and Russia, and quite a bit in Europe, and yet the only vertical take-off aircraft which you can call a success is the Harrier. When I saw the Harrier hovering and flying backwards under control, I reckoned I'd seen everything. And it's not difficult to fly." -Thomas Sopwith
- The Harrier, while serving for many decades in various forms, has been criticised on multiple issues; in particular a high accident rate, though Nordeen notes that several conventional single-engine strike aircraft like the Douglas A-4 Skyhawk and LTV A-7 Corsair II had worse accident rates.[54] The Los Angeles Times reported in 2003 that the Harrier "...has amassed the highest major accident rate of any military plane now in service. Forty-five Marines have died in 148 noncombat accidents".[55] Colonel Lee Buland of the USMC declared the maintenance of a Harrier to be a "challenge"; the need to remove the wings before performing most work upon the engine, including engine replacements, meant the Harrier required considerable man-hours in maintenance, more than most aircraft. Buland noted however that the maintenance difficulties were unavoidable in order to create a V/STOL aircraft.

ENGINE:

- The Pegasus turbofan jet engine, developed in tandem with the P.1127 then the Harrier, was designed specifically for V/STOL manoeuvring. Bristol Siddeley developed it from their earlier conventional Orpheus turbofan engine as the core with Olympus compressor blades for the fan. The engine's thrust is directed through the four rotatable nozzles. The engine is equipped for water injection to increase thrust and takeoff performance in hot and high altitude conditions; in normal V/STOL operations the system would be used in landing vertically with a heavy weapons load. The water injection function had originally been added following the input of US Air Force Colonel Bill Chapman, who worked for the Mutual Weapons Development Team. Water injection was necessary in order to generate maximum thrust, if only for a limited time, and was typically used during landing, especially in high ambient temperatures.
- The aircraft was initially powered by the Pegasus 6 engine which was replaced by the more powerful Pegasus 11 during the Harrier GR.1 to GR.3 upgrade process. The primary focus throughout the engine's development was on achieving high performance with as little weight as possible,[60] tempered by the amount of funding that was available. Following the Harrier's entry to service the focus switched to improving reliability and extending engine life; a formal joint US–UK Pegasus Support Program operated for many years and spent a £3-million annual budget to develop engine improvements. Several variants have been released; the latest is the Pegasus 11–61 (Mk 107), which provides 23,800 lbf (106 kN) thrust, more than any previous engine.

PEGASUS ENGINE:

CONTROLS AND HANDLING:

- The Harrier has been described by pilots as "unforgiving". The aircraft is capable of both forward flight (where it behaves in the manner of a typical fixed-wing aircraft above its stall speed), as well as VTOL and STOL manoeuvres (where the traditional lift and control surfaces are useless) requiring skills and technical knowledge usually associated with helicopters. Most services demand great aptitude and extensive training for Harrier pilots, as well as experience in piloting both types of aircraft. Trainee pilots are often drawn from highly experienced and skilled helicopter pilots.
- In addition to normal flight controls, the Harrier has a lever for controlling the direction of the four vectoring nozzles. It is viewed by senior RAF officers as a significant design success, that to enable and control the aircraft's vertical flight required only a single lever added in the cockpit.[63] For horizontal flight, the nozzles are directed rearwards by shifting the lever to the forward position; for short or vertical takeoffs and landings, the lever is pulled back to point the nozzles downwards.
- The Harrier has two control elements not found in conventional fixed-wing aircraft: the thrust vector and the reaction control system. The thrust vector refers to the slant of the four engine nozzles and can be set between 0° (horizontal, pointing directly backwards) and 98° (pointing down and slightly forwards). The 90° vector is normally deployed for VTOL manoeuvring. The reaction control is achieved by manipulating the control stick and is similar in action to the cyclic control of a helicopter. While irrelevant during forward flight mode, these controls are essential during VTOL and STOL manoeuvres.
- The wind direction is a critical factor in VTOL manoeuvres. The procedure for vertical takeoff involves facing the aircraft into the wind. The thrust vector is set to 90° and the throttle is brought up to maximum, at which point the aircraft leaves the ground. The throttle is trimmed until a hover state is achieved at the desired altitude. The short-takeoff procedure involves proceeding with normal takeoff and then applying a thrust vector (less than 90°) at a runway speed below normal takeoff speed; usually the point of application is around 65 knots (120 km/h). For lower takeoff speeds the thrust vector is greater. The reaction control system involves a thrusters at key points in the aircraft's fuselage and nose, also the wingtips. Thrust from the engine can be temporarily syphoned to control and correct the aircraft's pitch and roll during vertical flight.
- Rotating the vectored thrust nozzles into a forward-facing position during normal flight is called vectoring in forward flight, or "VIFFing". This is a dog-fighting tactic, allowing for more sudden braking and higher turn rates. Braking could cause a chasing aircraft to overshoot and present itself as a target for the Harrier it was chasing, a combat technique formally developed by the USMC for the Harrier in the early 1970s.

THRUST VECTORING NOOZLE

VARIANTS:

Harrier GR.1, GR.1A, GR.3

- Single-seat versions for the RAF. The RAF ordered 118 of the GR.1/GR.3 series, with the last production aircraft delivery in December 1986. 122 built.

AV-8A, AV-8C Harrier

- Single-seat versions for the US Marine Corps. The USMC ordered 102 AV-8As (company designation: Harrier Mk. 50). The AV-8C was an upgrade to the AV-8A. 110 built.

AV-8S Matador

- Export version of the AV-8A Harrier for the Spanish Navy, who designated them as VA-1 Matador; later sold to the Royal Thai Navy. 10 built.

Harrier T.2, T.2A, T.4, T.4A

- Two-seat training versions for the RAF, with a stretched body and taller tail fin. 25 built.

Harrier T.4N, T.8, T.60

- Two-seat training versions for the Royal Navy and Indian Navy with avionics based on the Sea Harrier.

TAV-8A Harrier

- Two-seat training version for the USMC, powered by a Pegasus Mk 103.

TAV-8S Matador

- Two-seat training version for the Spanish Navy and later sold to the Royal Thai Navy.

SPECIFICATIONS:

General:

- **Crew:** 1
- **Length:** 46 ft 10 in (14.27 m)
- **Wingspan:** 25 ft 5 in (7.75 m)

  29 ft 8 in (9 m) with ferry tips fitted
- **Height:** 11 ft 11 in (3.63 m)
- **Wing area:** 201.1 sq ft (18.68 m2)

  216 sq ft (20 m2) with ferry tips fitted
- **Aspect ratio:** 3.175

  4.08 with ferry tips fitted
- **Airfoil: root:** Hawker 10% ; tip: Hawker 3.3%[190]
- **Empty weigh:** 13,535 lb (6,139 kg)
- **Max takeoff weight:** 55,556 lb (25,200 kg)
- **Fuel capacity:** 5,060 lb (2,295 kg) internal

  2x 100 imp gal (120 US gal; 450 l) (790 lb (358 kg)) drop-tanks for combat

  2x 330 imp gal (400 US gal; 1,500 l) (2,608 lb (1,183 kg)) drop-tanks for ferry
- **Powerplant:** 1 × Rolls-Royce Pegasus 103 Vectored-thrust high-bypass turbofan engine, 21,500 lbf (96 kN) thrust with water injection

Performance:

- **Maximum speed:** 635 kn (731 mph, 1,176 km/h) at sea level
- **Maximum diving speed:** Mach 1.3
- **Combat range:** 360 nmi (410 mi, 670 km) ho-lo-hi with 4,400 lb (1,996 kg) payload

  200 nmi (230 mi; 370 km) lo-lo with 4,400 lb (1,996 kg) payload
- **Ferry range:** 1,850 nmi (2,130 mi, 3,430 km) with 330 imp gal (400 US gal; 1,500 l) drop-tanks

  3,000 nmi (3,500 mi; 5,600 km) with one AAR
- **Endurance:** 1 hour 30 minutes combat air patrol 100 nmi (120 mi; 190 km) from base.

  7 hours plus with one AAR

  Service ceiling: 51,200 ft (15,600 m)
- **g limits:** +7.8 -4.2
- **Time to altitude:** 40,000 ft (12,192 m) in 2 minutes 23 seconds from a vertical take-off
- **Take-off run CTOL:** 1,000 ft (300 m) at max TO weight

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Avionics:

- Ferranti LRMTS
- Marconi ARI 18223 RWR
- Plessy U/VHF comms
- Ultra standby UHF
- GEC Avionics AD2770 TACAN
- Cossor IFF
- Ferranti FE541 INAS
- Sperry C2G compass
- Smiths HUD

COMPLETED THIS:
1ST YEAR STUDENT OF THE SPECIALTY 25.05.03
IF MGTU GA
ALEKSANDER AVETYAN

THANKS
FOR WATCHING!