= Hawker Siddeley Harrier =

The Hawker Siddeley Harrier , developed in the 1960s , was the first of the Harrier Jump Jet series of aircraft . It was 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 . Similar V / STOL operational aircraft include the contemporary Soviet Yakovlev Yak @-@ 38 . The F @-@ 35B V / STOL variant of the Lockheed Martin F @-@ 35 Lightning II is under development .

= = Development = =

= = = Origins = = =

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 . 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 .

= = = Tripartite evaluation = = =

In 1961 the United Kingdom , United States and West Germany jointly agreed to purchase nine aircraft developed from the P.1127 , for the evaluation of the performance and potential of V / STOL aircraft . These aircraft were built by Hawker Siddeley and were designated Kestrel FGA.1 by the UK . The Kestrel was strictly an evaluation aircraft and to save money the Pegasus 5 engine was not fully developed as intended , only having 15 @,@ 000 pounds (67 kN) of thrust instead of the projected 18 @,@ 200 pounds (81 kN) . The Tripartite Evaluation Squadron numbered ten pilots ; four each from the UK and US and two from West Germany . The Kestrel 's first flight took place on 7 March 1964 .

A total of 960 sorties had been made during the trials , including 1 @,@ 366 takeoffs and landings , by the end of evaluations in November 1965 . One aircraft was destroyed in an accident and six others were transferred to the United States , assigned the US designation XV @-@ 6A Kestrel , and underwent further testing . The two remaining British @-@ based Kestrels were assigned to further trials and experimentation at RAE Bedford with one being modified to use the uprated Pegasus 6 engine .

= = = P.1154 = = =

At the time of the development of the P.1127 Hawker and Bristol had also undertaken considerable development work on a supersonic version , the Hawker Siddeley P.1154 , to meet a North Atlantic Treaty Organisation (NATO) requirement issued for such an aircraft . The design used a single Bristol Siddeley BS100 engine with four swivelling nozzles , in a fashion similar to the P.1127 , and required the use of plenum chamber burning (PCB) to achieve supersonic speeds . The P.1154 won the competition to meet the requirement against strong competition from other aircraft manufacturers such as Dassault Aviation 's Mirage IIIV . The French government did not accept the decision and withdrew ; the NATO requirement was cancelled shortly after in 1965 .

The Royal Air Force and the Royal Navy planned to develop and introduce the supersonic P.1154 independently of the cancelled NATO requirement . This ambition was complicated by the conflicting requirements between the two services ? while the RAF wanted a low @-@ level supersonic strike aircraft , the Navy sought a twin @-@ engine air defence fighter . Following the election of the Labour Government of 1964 the P.1154 was cancelled , as the Royal Navy had already begun procurement of the McDonnell Douglas Phantom II and the RAF placed a greater importance on the BAC TSR @-@ 2 's ongoing development . Work continued on elements of the project , such as a supersonic PCB @-@ equipped Pegasus engine , with the intention of developing a future Harrier variant for the decades following cancellation .

= = = Production = = =

Following the collapse of the P.1154 's development the RAF began considering a simple upgrade of the existing subsonic Kestrel and issued Requirement ASR 384 for a V / STOL ground attack jet . Hawker Siddeley received an order for six pre @-@ production aircraft in 1965 , designated P.1127 (RAF) , of which the first made its maiden flight on 31 August 1966 . An order for 60 production aircraft , designated as Harrier GR.1 , was received in early 1967 . The aircraft was named for the Harrier , a small bird of prey .

The Harrier GR.1 made its first flight on 28 December 1967 . It officially entered service with the RAF on 18 April 1969 when the Harrier Conversion Unit at RAF Wittering received its first aircraft . The aircraft were built in two factories ? one in Kingston upon Thames , southwest London , and the other at Dunsfold Aerodrome , Surrey ? and underwent initial testing at Dunsfold . The ski @-@ jump technique for launching Harriers from Royal Navy aircraft carriers was extensively trialled at RNAS Yeovilton from 1977 . Following these tests ski @-@ jumps were added to the flight decks of all RN carriers from 1979 onwards , in preparation for the new variant for the navy , the Sea Harrier .

In the late 1960s the British and American governments held talks on producing Harriers in the United States . Hawker Siddeley and McDonnell Douglas formed a partnership in 1969 in preparation for American production , but Congressman Mendel Rivers and the House Appropriations Committee held that it would be cheaper to produce the AV @-@ 8A on the pre @-@ existing production lines in the United Kingdom ? hence all AV @-@ 8A Harriers were purchased from Hawker Siddeley . Improved Harrier versions with better sensors and more powerful engines were developed in later years . The USMC received 102 AV @-@ 8A and 8 TAV @-@ 8A Harriers between 1971 and 1976 .

= = Design = =

= = = Overview = = =

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 . 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 " . 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 , 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 .

= = = 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 . 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 .

= = = Differences between versions = = =

The two largest users of the Harrier were the Royal Air Force and the United States Marine Corps (USMC) . The exported model of the aircraft operated by the USMC was designated the AV @-@ 8A Harrier , which was broadly similar to the RAF 's Harrier GR.1. Changes included the removal of all magnesium components , which corroded quickly at sea , and the integration of American radios and Identification Friend or Foe (IFF) systems ; furthermore the outer pylons , unlike the RAF aircraft , were designed from delivery to be equipped with self @-@ defence AIM @-@ 9 Sidewinder heat @-@ seeking air @-@ to @-@ air missiles . Most of the AV @-@ 8As had been delivered with the more powerful Pegasus engine used in the GR.3 instead of the one used in the earlier GR.1. Two @-@ seat Harriers were operated for training purposes ; the body was stretched and a taller tail fin added . The RAF trained in the T.2 and T.4 versions , while T.4N and T.8 were training versions the Navy 's Sea Harrier , with appropriate fittings . The US and Spain flew the TAV @-@ 8A and TAV @-@ 8S , respectively .

All RAF GR.1s and the initial AV @-@ 8As were fitted with the Ferranti FE541 inertial navigation / attack suite , but these were replaced in the USMC Harriers by a simpler Interface / Weapon Aiming Computer to aid quick turnaround between missions . The Martin @-@ Baker ejection seats were also replaced by the Stencel SEU @-@ 3A in the American aircraft . The RAF had their GR.1 aircraft upgraded to the GR.3 standard , which featured improved sensors , a nose @-@ mounted laser tracker , the integration of electronic countermeasure (ECM) systems and a further upgraded Pegasus Mk 103 . The USMC upgraded their AV @-@ 8As to the AV @-@ 8C configuration ; this programme involved the installation of ECM equipment and adding a new inertial navigation system to the aircraft 's avionics . Substantial changes were the Lift Improvement Devices , to increase VTOL performance ; at the same time several airframe components were restored or replaced to extend the life of the aircraft . Spain 's Harriers , designated AV @-@ 8S or VA.1 Matador for the single @-@ seater and TAV @-@ 8S or VAE.1 for the two @-@ seater , were almost identical to USMC Harriers differing only in the radios fitted .

The Royal Navy 's Fleet Air Arm (FAA) operated a substantially modified variant of the Harrier , the British Aerospace Sea Harrier . The Sea Harrier was not intended for ground @-@ attack duties and , unlike the standard Harrier , was equipped with radar and Sidewinder missiles for air combat duties and fleet air defence . The Sea Harrier was also fitted with navigational aids for carrier landings , modifications to reduce corrosion and a raised bubble @-@ canopy for greater visibility . The aircraft were later equipped to use AIM @-@ 120 AMRAAM beyond @-@ visual @-@ range anti @-@ aircraft missiles and the more advanced Blue Vixen radar for longer range air @-@ to @-@ air combat , as well as Sea Eagle missiles for conducting anti @-@ ship missions .

The McDonnell Douglas AV @-@ 8B Harrier II is the latest Harrier variant , a second @-@ generation series to replace the first generation of Harrier jets already in service ; all the above variants of the Harrier have mainly been retired with the Harrier II taking their place in the RAF , USMC and FAA . In the 1970s the United Kingdom considered two options for replacing their existing Harriers : joining McDonnell Douglas (MDD) in developing the BAE Harrier II , or the independent development of a " Big Wing " Harrier . This proposal would have increased the wing area from 200 to 250 square feet (19 to 23 m2) , allowing for significant increases in weapons load and internal fuel reserves . The option of cooperation with MDD was chosen in 1982 over the more risky isolated approach .

= = Operational history = =

= = = Royal Air Force = = =

The first RAF squadron to be equipped with the Harrier GR.1 , No. 1 Squadron , started to convert to the aircraft at RAF Wittering in April 1969 . An early demonstration of the Harrier 's capabilities was the participation of two aircraft in the Daily Mail Transatlantic Air Race in May 1969 , flying between St Pancras railway station , London and downtown Manhattan with the use of aerial refuelling . The Harrier completed the journey in 6 hours 11 minutes . Two Harrier squadrons were established in 1970 at the RAF 's air base in Wildenrath to be part of its air force in Germany ; another squadron was formed there two years later . In 1977 , these three squadrons were moved forward to the air base at Gütersloh , closer to the prospective front line in the event of an outbreak of a European war . One of the squadrons was disbanded and its aircraft distributed between the other two .

In RAF service , the Harrier was used in close air support (CAS) , reconnaissance , and other ground @-@ attack roles . The flexibility of the Harrier led to a long @-@ term heavy deployment in West Germany as a conventional deterrent and potential strike weapon against Soviet aggression ; from camouflaged rough bases the Harrier was expected to launch attacks on advancing armour columns from East Germany . Harriers were also deployed to bases in Norway and Belize , a former British colony . No. 1 Squadron was specifically earmarked for Norwegian operations in the event of war , operating as part of Allied Forces Northern Europe . The Harrier 's capabilities were necessary in the Belize deployment , as it was the only RAF combat aircraft capable of safely operating from the airport 's short runway ; British forces had been stationed in Belize for several years due to tensions over a Guatemalan claim to Belizean territory ; the forces were withdrawn in 1993 , two years after Guatemala recognized the independence of Belize .

In the Falklands War in 1982 , 10 Harrier GR.3s of No. 1 Squadron operated from the aircraft carrier HMS Hermes . As the RAF Harrier GR.3 had not been designed for naval service , the 10 aircraft had to be rapidly modified prior to the departure of the task force . Special sealants against corrosion were applied and a new deck @-@ based inertial guidance aid was devised to allow the RAF Harrier to land on a carrier as easily as the Sea Harrier . Transponders to guide aircraft back to the carriers during night @-@ time operations were also installed , along with flares and chaff dispensers .

As there was little space on the carriers , two requisitioned merchant container ships , Atlantic Conveyor and Atlantic Causeway , were modified with temporary flight decks and used to carry Harriers and helicopters to the South Atlantic . The Harrier GR.3s focused on providing close air support to the ground forces on the Falklands and attacking Argentine positions ; suppressing enemy artillery was often a high priority . Sea Harriers were also used in the war , primarily conducting fleet air defence and combat air patrols against the threat of attacking Argentine fighters . However , both Sea Harriers and Harrier GR.3s were used in ground @-@ attack missions against the main airfield and runway at Stanley .

If most of the Sea Harriers had been lost , the GR.3s would have replaced them in air patrol duties , even though the Harrier GR.3 was not designed for air defence operations ; as such the GR.3s quickly had their outboard weapons pylons modified to take air @-@ to @-@ air Sidewinder missiles . From 10 to 24 May 1982 , prior to British forces landing in the Falklands , a detachment of three GR.3s provided air defence for Ascension Island until three F @-@ 4 Phantom IIs arrived to take on this responsibility . During the Falklands War , the greatest threats to the Harriers were deemed to be surface @-@ to @-@ air missiles (SAMs) and small arms fire from the ground . In total , four Harrier GR.3s and six Sea Harriers were lost to ground fire , accidents , or mechanical failure . More than 2 @,@ 000 Harrier sorties were conducted during the conflict ? equivalent to six sorties per day per aircraft .

Following the Falklands war , British Aerospace explored the Skyhook , a new technique to operate Harriers from smaller ships . Skyhook would have allowed the launching and landing of Harriers from smaller ships by holding the aircraft in midair by a crane ; secondary cranes were to hold weapons for rapid re @-@ arming . This would potentially have saved fuel and allowed for operations in rougher seas . The system was marketed to foreign customers , and it was speculated

that Skyhook could be applied to large submarines such as the Russian Typhoon class , but the system attracted no interest .

The first generation of Harriers did not see further combat with the RAF after the Falklands War , although they continued to serve for years afterwards . As a deterrent against further Argentine invasion attempts , No. 1453 Flight RAF was deployed to the Falkland Islands from August 1983 to June 1985 . However the second generation Harrier IIs saw action in Bosnia , Iraq , and Afghanistan . The first generation Hawker Siddeley airframes were replaced by the improved Harrier II , which had been developed jointly between McDonnell Douglas and British Aerospace .

= = = United States Marine Corps = = =

The United States Marine Corps began showing a significant interest in the aircraft around the time the first RAF Harrier squadron was established in 1969 , and this motivated Hawker Siddeley to further develop the aircraft to encourage a purchase . Although there were concerns in Congress about multiple coinciding projects in the close air support role , the Marine Corps were enthusiastic about the Harrier and managed to overcome efforts to obstruct its procurement .

The AV @-@ 8A entered service with the Marine Corps in 1971 , replacing other aircraft in the Marines ' attack squadrons . The service became interested in performing ship @-@ borne operations with the Harrier . Admiral Elmo Zumwalt promoted the concept of a Sea Control Ship , a 15 @,@ 000 @-@ ton light carrier equipped with Harriers and helicopters , to supplement the larger aircraft carriers of the US Navy . An amphibious assault ship , USS Guam , was converted into the Interim Sea Control Ship and operated as such between 1971 and 1973 with the purpose of studying the limits and possible obstacles for operating such a vessel . Since then the Sea Control Ship concept has been subject to periodic re @-@ examinations and studies , often in the light of budget cuts and questions over the use of supercarriers .

Other exercises were performed to demonstrate the AV @-@ 8A 's suitability for operating from various amphibious assault ships and aircraft carriers , including a deployment of 14 Harriers aboard USS Franklin D. Roosevelt for six months in 1976 . The tests showed , amongst other things , that the Harrier was capable of performing in weather where conventional carrier aircraft could not . In support of naval operations , the USMC devised and studied several methods to further integrate the Harrier . One result was Arapaho , a stand @-@ by system to rapidly convert civilian cargo ships into seagoing platforms for operating and maintaining a handful of Harriers , to be used to augment the number of available ships to deploy upon .

When the reactivation of the Iowa @-@ class battleships was under consideration , a radical design for a battleship @-@ carrier hybrid emerged that would have replaced the ship 's rear turret with a flight deck , complete with a hangar and two ski jumps , for operating several Harriers . However , the USMC considered the need for naval gunfire support to be a greater priority than additional platforms for carrier operations , while the cost and delay associated with such elaborate conversions was significant , and the concept was dropped .

The Marines Corps ' concept for deploying the Harriers in a land @-@ based expeditionary role focused on aggressive speed . Harrier forward bases and light maintenance facilities were to be set up in under 24 hours on any prospective battle area . The forward bases , containing one to four aircraft , were to be located 20 miles (32 km) from the forward edge of battle (FEBA) , while a more established permanent airbase would be located around 50 miles (80 km) from the FEBA . The close proximity of forward bases allowed for a far greater sortie rate and reduced fuel consumption .

The AV @-@ 8A 's abilities in air @-@ to @-@ air combat were tested by the Marine Corps by conducting mock dogfights with McDonnell Douglas F @-@ 4 Phantom IIs ; these exercises trained pilots to use the vectoring @-@ in @-@ forward @-@ flight (VIFF) capability to outmanoeuvre their opponents and showed that the Harriers could act as effective air @-@ to @-@ air fighters at close range . The success of Harrier operations countered scepticism of V / STOL aircraft , which had been judged to be expensive failures in the past . Marine Corps officers became convinced of the military advantages of the Harrier and pursued extensive development of the aircraft .

Starting in 1979 the USMC began upgrading their AV @-@ 8As to the AV @-@ 8C configuration ? the work focused mainly on extending useful service lives and improving VTOL performance . The AV @-@ 8C and the remaining AV @-@ 8A Harriers were retired by 1987 . These were replaced by the Harrier II , designated as the AV @-@ 8B , which was introduced into service in 1985 . The performance of the Harrier in USMC service led to calls for the United States Air Force to procure Harrier IIs in addition to the USMC 's own plans , but these never resulted in Air Force orders . Since the late 1990s , the AV @-@ 8B has been slated to be replaced by the F @-@ 35B variant of the Lockheed Martin F @-@ 35 Lightning II , a more modern V / STOL jet aircraft .

Like the next generation AV @-@ 8Bs , nevertheless , the AV @-@ 8A / C Harriers suffered many accidents , with around 40 aircraft lost and some 30 pilots killed during ' 70 and ' 80s .

= = = Other operators = = =

Due to the Harrier 's unique characteristics it attracted a large amount of interest from other nations , often as attempts to make their own V / STOL jets were unsuccessful , such as in the cases of the American XV @-@ 4 Hummingbird and the German VFW VAK 191B . Operations by the USMC aboard USS Nassau in 1981 and by British Harriers and Sea Harriers in the Falklands War proved that the aircraft were highly effective in combat . These operations also demonstrated that " Harrier Carriers " provided a powerful presence at sea without the expense of big deck carriers .

Following the display of Harrier operations from small carriers , the navies of Spain and later Thailand bought the Harrier for use as their main carrier @-@ based fixed @-@ wing aircraft . Spain 's purchase of Harriers was complicated by long @-@ standing political friction between the British and Spanish governments of the era ; even though the Harriers were manufactured in the UK they were sold to Spain with the US acting as an intermediary . During tests in November 1972 , the British pilot John Farley showed that the wooden deck of Daedalus was able to withstand the temperature of the gases generated by the Harrier . Since 1976 , the Spanish Navy operated the AV @-@ 8S Matador from their aircraft carrier Dédalo (formerly the USS Cabot) ; the aircraft provided both air defence and strike capabilities for the Spanish fleet . Spain later purchased five Harriers directly from the British government to replace losses .

Hawker Siddeley aggressively marketed the Harrier for export . At one point the company was holding talks with Australia , Brazil , Switzerland , India and Japan . Of these only India became a customer , purchasing the Sea Harrier . At one point China came very close to becoming an operator of the first generation Harrier . Following an overture by the UK in the early 1970s , when relations with the West were warming , China became interested in the aircraft as it sought to modernise its armed forces ; British Prime Minister James Callaghan noted significant hostility from the USSR over the sales bid . The deal was later cancelled by the UK as part of a diplomatic backlash after China invaded Vietnam in 1979 .

The Spanish Navy , Thai Navy , Royal Air Force , and United States Marine Corps have all retired their first @-@ generation Harriers . Spain sold seven single @-@ seat and two twin @-@ seat Harriers to Thailand in 1998 . The Royal Thai Navy 's AV @-@ 8S Matadors were delivered as part of the air wing deployed on the new light aircraft carrier HTMS Chakri Naruebet . The Thai Navy had from the start significant logistical problems keeping the Harriers operational due to a shortage of funds for spare parts and equipment , leaving only a few Harriers serviceable at a time . In 1999 , two years after being delivered , only one airframe was in airworthy condition . Around 2003 , Thailand considered acquiring former Royal Navy Sea Harriers , which were more suitable for maritime operations and better equipped for air defence , to replace their AV @-@ 8S Harriers ; this investigation did not progress to a purchase . The last first @-@ generation Harriers were retired by Thailand in 2006 .

= = 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 . 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 .

= = Operators = =

Thailand
Royal Thai Navy
India
Indian Navy
Spain
Spanish Navy
United Kingdom
Royal Air Force
Royal Navy
United States
United States Marine Corps

= = Aircraft on display = =

= = = Canada = = =

AV @-@ 8A
158966 - Canada Aviation and Space Museum , Ottawa , Ontario .

= = = Germany = = =

GR.1
XV278 - Luftwaffenmuseum der Bundeswehr , Gatow .
GR.3
XZ998 - Flugausstellung Leo Junior at Hermeskeil .

= = = Poland = = =

GR.3
XW919 - Polish Aviation Museum , Kraków , Poland .

= = = New Zealand = = =

GR.3
XZ129 - Ashburton Aviation Museum , Ashburton , New Zealand .

= = = United Kingdom = = =

GR.1
XV277 - National Museum of Flight , East Fortune .
GR.3
XV744 - Tangmere Military Aviation Museum , Chichester , West Sussex .
XV748 - Yorkshire Air Museum , Elvington .
XV751 - Gatwick Aviation Museum , Surrey .
XV752 - South Yorkshire Aircraft Museum , Doncaster , South Yorkshire .
XV753 - Classic Air Force , St Mawgan , Newquay , Cornwall .
XV779 - RAF Wittering (Gate Guardian) .
XZ133 - Imperial War Museum , Duxford .
XZ968 - Muckleburgh Collection , Norfolk .
XZ997 - RAF Museum , Hendon .
ZD667 - Bentwaters Cold War Museum , Suffolk .
Mk.52 G @-@ VTOL
ZA250 - Brooklands Museum , Surrey .
T.2
XW269 - Airworld Aviation Museum Caernarfon Wales
T.4
XW934 - Farnborough Air Sciences Trust , Farnborough , Hampshire .
AV @-@ 8A
159233 - Imperial War Museum North

= = = United States = = =

AV @-@ 8A
158695 - Air Park , Yuma MCAS , Yuma , Arizona .
159239 - San Diego Air and Space Museum , San Diego , California .
158963 - Craven County Regional Airport , Grantham , North Carolina .
158976 - City of Havelock , Havelock , North Carolina .
TAV @-@ 8A
159381 - Oakland Aviation Museum , Oakland , California .
159382 - Pima Air & Space Museum , Tucson , Arizona .
AV @-@ 8C
158387 - Flying Leatherneck Aviation Museum , Marine Corps Air Station Miramar , San Diego , California .
158710 - Quonset Air Museum , North Kingstown , Rhode Island .
158959 - Pacific Coast Air Museum , Santa Rosa , California .
158975 - National Naval Aviation Museum , NAS Pensacola , Pensacola , Florida .
158977 - Museum of Flight , Seattle , Washington .
159232 - Intrepid Sea , Air & Space Museum , New York City , New York .
159238 - Hangar 25 Museum , Webb AFB (formerly) , Big Spring , Texas .
159241 - Pima Air & Space Museum , Tucson , Arizona .
159247 - Naval Inventory Control Point (NAVICP) Philadelphia , Philadelphia , Pennsylvania .
159249 - United States Naval Museum of Armament and Technology , NCC China Lake (North) , Ridgecrest , California .

= = Specifications (Harrier GR.3) = =

Data from Jane 's All The World 's Aircraft 1988 ? 89
General characteristics
Crew : One
Length : 46 ft 10 in (14 @.@ 27 m)
Wingspan : 25 ft 3 in (7 @.@ 70 m)
Height : 11 ft 11 in (3 @.@ 63 m)
Wing area : 201 @.@ 1 ft ² (18 @.@ 68 m ²)
Empty weight : 13 @,@ 535 lb (6 @,@ 140 kg)
Max. takeoff weight : 25 @,@ 200 lb (11 @,@ 430 kg)
Powerplant : 1 × Rolls @-@ Royce Pegasus 103 turbofan with four swivelling nozzles , 21 @,@ 500 lbf (95 @.@ 6 kN) Four vertical flight puffer jets use engine bleed air , mounted in the nose , wingtips , and tail .
Performance
Maximum speed : 730 mph (635 knots , 1 @,@ 176 km / h) at sea level
Combat radius : 230 mi (200 nmi , 370 km) lo @-@ lo @-@ lo with 4 @,@ 400 lb (2 @,@ 000 kg) payload
Ferry range : 2 @,@ 129 mi (1 @,@ 850 nmi , 3 @,@ 425 km)
Endurance : 1 hr 30 min (combat air patrol ? 115 mi (185 km) from base)
Service ceiling : 51 @,@ 200 ft (15 @,@ 600 m)
Time to climb to 40 @,@ 000 ft (12 @,@ 200 m) : 2 min 23 s
Armament
Guns : 2 × 30 mm (1 @.@ 18 in) ADEN cannon pods under the fuselage
Hardpoints : 4 × under @-@ wing & 1 × under @-@ fuselage pylon stations with a capacity of 5 @,@ 000 lb (2 @,@ 268 kg) and provisions to carry combinations of :
Rockets : 4 × Matra rocket pods with 18 × SNEB 68 mm rockets each
Missiles : 2 × AIM @-@ 9 Sidewinders Air @-@ to @-@ air missiles
Bombs : A variety of unguided iron bombs , BL755 cluster bombs or laser @-@ guided bombs
Others :
1 × Reconnaissance pod
2 × drop tanks for extended range / loitering time

= = Popular culture = =