

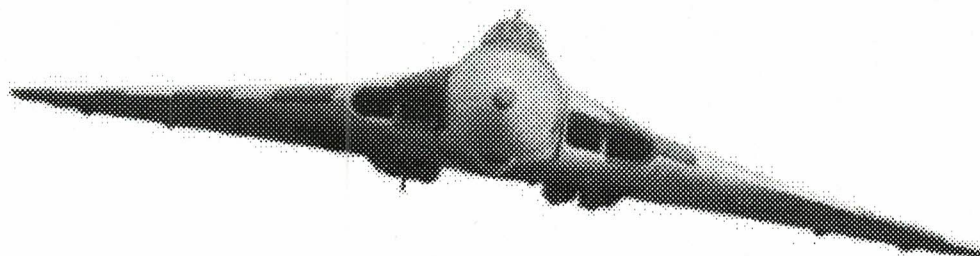
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## AVRO VULCAN

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This page last updated on 1st August 1999

*"At its operational height the Vulcan can outfly and outmanoeuvre any fighter in squadron service today."*

- Air Ministry Press Release (1958).



**Vulcan B.2 XM655; Dick Clements**

The first time I saw a Vulcan displaying, I merely stared open-mouthed for the twenty or so minutes the display lasted, completely awestruck. The sheer size, grace and power of this machine is something that mere photos can never show. If you can imagine an aircraft the size of an airliner being thrown around the sky as if it were a Spitfire, you have some idea of what a Vulcan display was like.

The second time I saw a Vulcan displaying, I was in much the same awestruck state. If you can imagine the scene, a house in Portsmouth, where we don't usually get much in the way of air displays, and suddenly a roaring sound swells into a great throbbing crescendo... every rooftop and tree seems to explode as startled birds take flight... and several hundred people like myself, who can recognise the sound of a Vulcan after a single 'Tin Triangle' experience, rush out into their gardens for a glimpse of this great aircraft. I had the presence of mind to bring a camera outside, but unfortunately never actually took any pictures, I was too busy just watching the display!

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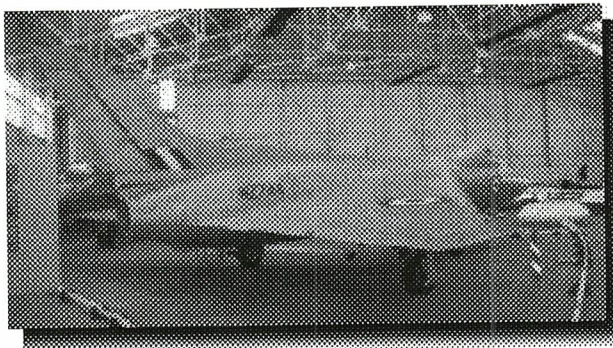
## AVRO VULCAN

### HISTORY

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This page last updated on 12th May 1999

The Vulcan was designed in response to a specification issued in 1947; a four engined nuclear bomber was required as the growing menace of the Soviet Union made itself felt. Avro's chief designer, Roy Chadwick immediately began an unusual design based on a delta wing concept and a matter of months later, the design had been submitted and had won the contest (along with Handley Page's HP.80 design - later to become the Victor). The design was changed before the familiar Vulcan layout was settled on; fins on the wingtips became a single conventional fin, and the nose was extended along with the addition of a distinct fuselage section as opposed to the near-flying-wing idea originally envisaged. Tragically, Chadwick was killed in an air accident later in the year, but S. Davies, his assistant, survived the crash and continued development on the Avro Type 698 design.



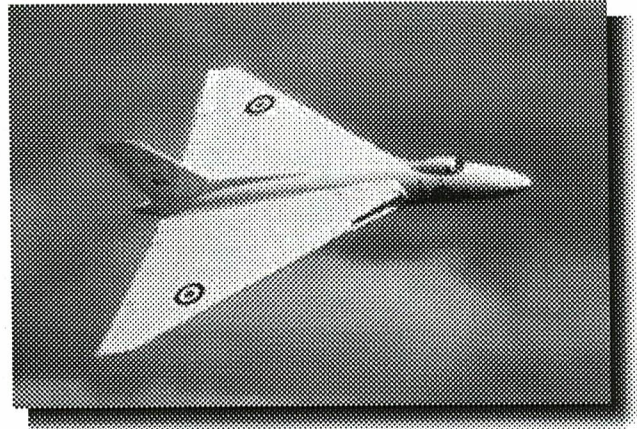
Avro 707C WZ744 at Cosford Aerospace Museum;  
author

To help gain data for the radical new design, several 'mini-Vulcans' were built; these were the Avro Type 707s. At one point the RAF wanted a twin-seat 707 for use as a Vulcan trainer, but eventually this was not required and only one such 707, the 707C, was built. Finally, in 1952, the first type 698, VX770, was piloted by Wing Commander Roly Falk. While recognisably a Vulcan, the wings were a pure delta form; no kinked leading edges, and there were several other differences in shape. Aircraft development in the 1950s was very different to modern-day development - whereas nowadays it seems most time and effort is put into complex computer simulations and making sure the flight control software is working before risking a first flight, in the days of the Vulcan's development, rather more primitive methods were used.

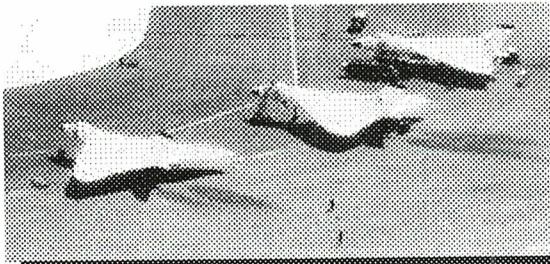
For instance, before the advent of appropriate recording systems, cockpit instruments were filmed with cine cameras and the films were then read by a team of film-readers and transcribed to tabular form. These tables were then plotted on graph paper by any handy apprentices! During a series of tests of emergency braking systems which involved large rubber brake pads carried between the main bogie wheels and extended to contact the runway direct, the company photographer, Paul Culerne, was actually strapped to the front undercarriage leg to photograph the operation of the pads (no videos in those days!). This was while the aircraft was moving at landing speed - not when stationary!



Soon the first prototype was ready for its first flight. Roly Falk took VX770 up and, watched only by Avro employees and a small band of press, he showed just why he had fought for a fighter- style joystick instead of the traditional yoke. The first flight did not go entirely to plan - two objects were seen to detach from the aircraft and float to the ground. These turned out to be the triangular undercarriage doors attached to the rear of the main gear legs, and the aircraft flew without them for a short time. In 1953 the type 698 was officially named the Vulcan, and surely there can not have been a more fitting appellation given to any aircraft? Several spectacular Farnborough appearances followed, including a full roll at the 1955 show (try that in a B-52!). Falk had actually rolled the Vulcan on returning to Avro's Woodford base after a previous Farnborough appearance - that time he did it so low and so noisily that he smashed all the skylight windows in the assembly building!



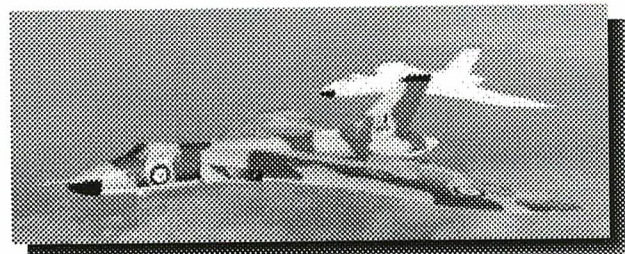
**Type 698 VX770 at 1952 Farnborough SBAC show; Flight**



**Vulcan B.1s of 617 squadron at RNZAF Ohakea, New Zealand in June 1960; Bob Mitchell**

Delivery of production B.1s began in 1956; it had been found that the outer sections of the delta wing could suffer from buffeting, so a kinked leading edge was now in place. While the B.1 provided useful service and provided part of the UK's nuclear deterrent force, the changes in the defences of the then-enemy, the Soviet Union, meant that the B.1 force was becoming less and less of a viable option for attacking deep into Soviet territory.

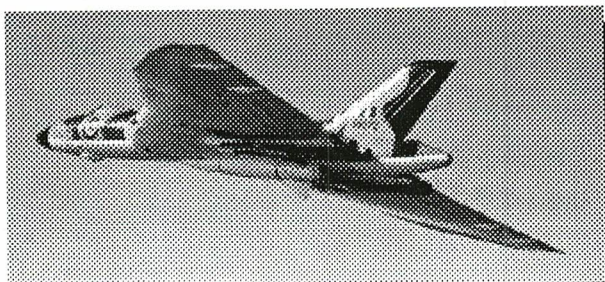
More powerful engines, an electronic warfare (ECM) suite in a new larger tailcone and in-flight refuelling capability along with further improved, larger, wings were reasons enough for a new variant - the B.2 (though some B.1s had some B.2 improvements made to them, then being called B.1As). With longer range, the ability to carry a heavier payload and much improved self-defence measures in a vastly more powerful ECM suite, the B.2 made sure that missions into the Soviet Union wouldn't be the suicide mission they would have been with the B.1s.



**A pair of Vulcan B.2s showing off the camouflage scheme (XM645 in foreground) and the overall white anti-flash scheme; MoD**

The nuclear capability of the B.2 was also improved compared to the B.1. Two nuclear weapons (Yellow Sun and Red Beard) could be carried though one was more normal. But even with the B.2's improvements, the delivery of free fall nuclear weapons into the increasingly deadly defences of the Soviet Union was becoming far too dangerous a proposition.





**Vulcan B.2 XM572 carrying Blue Steel; MoD**

Instead a stand-off nuclear missile was developed; Blue Steel. This could be fired from 100 miles away from the target. In common with the Victor, Blue Steels were carried in a partially-recessed manner on the Vulcan. The bomb bay area was modified accordingly and the lower tailfin of the missile would be folded over on the ground to give enough ground clearance. On launching the fin would fold down and the Vulcan crew would turn for home. An improvement over the Blue Steel would have been the American's Skybolt missile, which were intended for use by B-52s and Vulcans. Vulcans would have been able to carry two, one under each wing, and many B.2s were built with suitable attachment points under their wings. However, the programme was a troubled one and despite it looking like becoming a success towards the end, the Americans cancelled it late on in development.

In common with most British aircraft, a number of unusual proposals were made during the Vulcan's life, none of which came to anything. These include an airliner version (the Avro Atlantic), a fighter-support Vulcan which would have carried three Gnats semi-recessed in the fuselage and wings and even a vertical take-off Vulcan (complete with no less than ten lift engines in the bomb bay). Even the least ambitious proposal, the 'Phase 6' Vulcan, which would have had larger wings and tail and an extended fuselage housing a second crew (for very long missions) along with provision for extra bombs in pods on the wings, came to naught, not least because the Americans cancelled the troubled Skybolt nuclear missile that was to have been carried by the Phase 6 Vulcan (and indeed many B.2s - the Skybolt attachment points were put to good use in the Falklands, enabling the carriage of ECM pods and Shrike missiles).

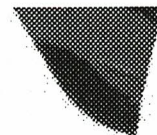
The loss of Skybolt meant that the RAF was fielding a nuclear deterrent force that was increasingly outmoded and soon the arrival of Polaris ICBMs meant that the Royal Navy's submarine force took over the V-Force's nuclear deterrent role.

The final Vulcan variant was the K.2 - a tanker version. Requested by the MoD during the Falklands war, a mere 51 days passed between request and delivery of the first K.2. The K.2 was basically a B.2 with an ugly box tacked underneath the tailcone (containing the drogue unit; hoses and drum unit in the ECM bay within the tailcone) and the bomb bay filled with three huge fuel tanks. The huge white areas underneath the wings (used to help pilots lining up on the tanker) added their own final





uglification.



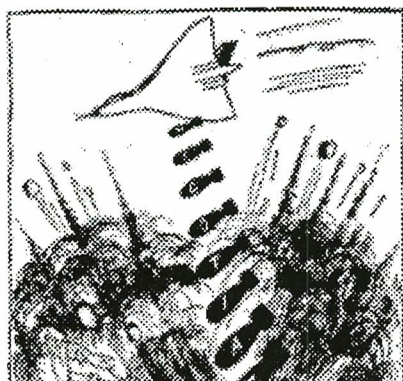
**XH558 showing off her bomb bay - note the additional fuel tank at the rear of the bay; Paul Osborne**

The Vulcan would have flown for its entire service life without ever dropping a bomb in anger had it not been for the Falklands war in 1982. The famous Black Buck missions, considering the age of the aircraft & their equipment and the incredible distances covered, were incredible feats. The task was to put a Vulcan over the Falklands and do some damage to the Argentine installations there. Had the Falklands not been 3,886 miles away from the nearest useable airfield, this would not have been such a difficult task to actually carry out!



**XH558 climbing steeply; Garry Lakin**

**Black Buck 1, 30th April/1st May 1982:** The nearest useable airfield was on Ascension Island, a small island near the coast of Africa. The trip to the Falklands would take eight hours flying time and require multiple in-flight refuelling sessions. In all eleven Victor tankers would be needed. A carefully planned sequence had the Victors refuelling both the Vulcan (XM607) and the other tankers, with increasingly smaller numbers of tankers continuing with the Vulcan while empty tankers returned to Ascension. Due to unexpected differences in the performance of the Vulcan and Victor, many of the Victors returned with barely enough fuel to land - at one point several Victors had to land one after the other, without even enough spare fuel to allow the previous Victors to clear the end of the runway. The last Victor had to give up so much fuel to the Vulcan that it did not have enough fuel left to reach the island, so another Victor had to be scrambled to refuel the incoming Victor so it could reach the airfield! Had one not been available that last Victor would have crashed into the sea 400 miles short of Ascension.



With refuelling finished, the Vulcan continued alone towards the Falklands. About 300 miles out, they descended to 300 feet above the sea. At about 40 miles out they began to detect signals from the Argentine radars and climbed to 10,000 feet to begin their bombing run. 10 miles out the AEO detected a gun-laying radar attempting to lock-on to the Vulcan. The American ALQ-101 jamming pod was activated and no lock-on was made. The bomb doors were opened. Two miles out and the bombs began to drop. The aim of the mission was to place at least one bomb on the runway at Port Stanley. A textbook attack was carried out, laying 21 1,000lb bombs in a diagonal line across the width of the runway. One bomb hit the runway dead centre.





'Negotiate' cartoon; Daily Telegraph, May 4th 1982

Another blew a large crater in the edge of the runway and the rest missed the runway and made a mess of the surrounding area. Not only did some fuel and ammo stores suffer, so did the golf course! Racking the huge bomber into a tight turn, the Vulcan crew quickly made their exit. Much more lightly loaded on the return trip, fewer refuelling sessions were necessary and a single Victor kept them company on the home trip once they had reached the rendezvous point near Brazil.

While any damage caused was more to Argentine morale than Argentine installations, the message sent to Buenos Aires - *you are not out of range* - was obviously one that was heeded, because many Argentine fighters were kept back from the Falklands to defend against a possible attack on Argentina. Several more Black Buck missions were flown against the Argentine radars on the islands. Black Buck 2 was a repeat of Black Buck 1 but had less success, with the bombs missing the runway. Black Bucks 3 and 4 were cancelled because of problems with refuelling. The navigator of Vulcan XM597, Dave Castle provides the following accounts of the next two missions:

**Black Buck 5, 30th May/1st June 1982:** Just before midnight on 30th May 1982, Vulcan XM597 launched from Wideawake Airfield on Ascension Island equipped with 2 AGM-45 Shrike anti-radar missiles. Its mission was SEAD; to locate and suppress the Argentinian Westinghouse AN/TPS 43F radar which had been hitherto providing attack support for Argentinian Super Etendards and Sky Hawks against the British Task Force positioned off the Falklands. The Shrike missiles had been covertly supplied to the RAF by the Americans and were to be used in preference to the BAe AR Martel missile used by RAF maritime strike Buccaneers (though XM597 had successfully fired Martels during trials in the UK days before). At 200 nm from the Falklands and after refueling 5 times en-route from a fleet of Victor tankers, XM597 descended to 300 ft above the sea and ingressed to Port Stanley airfield at 300 kts. At just over 20 nm she climbed to 16,000 ft and attempted to locate the TPS 43 radar with both active and passive sensors (H2S radar and RWR). A game of 'cat and mouse' ensued between the Vulcan crew and the Grupo 2 VYCA crew of the radar. After 40 mins XM597 successfully located the TPS 43 mobile radar and ripple fired its 2 Shrike missiles, one of which impacted 10 metres from the target inflicting minor blast damage to the radar's waveguide assembly. The TPS 43 radar was then wisely shut down by the Argentinian crew who feared further attack (but which then allowed an RAF Harrier raid to attack Port Stanley relatively unopposed). XM597 subsequently returned unharmed to Ascension Island after a total flight time of precisely 16 hours, the longest mission in the history of air warfare (a record that remained until a B-52 broke it during the Gulf war in 1991).

**Black Buck 6, 2nd/3rd June 1982:** The same aircraft and crew were launched from Wideawake on the night of 3rd June, this time armed with 4 Shrike missiles: 2 with radar heads optimized against the TPS 43 radar (the primary target), and 2 with heads programmed for opportunity attacks against mobile Sky Guard/Super Oerlikon AAA installations protecting the environs of Port Stanley. Once again, some 40 minutes were spent by the crew trying to establish the position of the primary target which never 'rose to the bait' by switching on its radar. Determined not to return to Ascension without a strike, the Vulcan captain elected to descend from a sanctuary height at 16,000 ft into the engagement envelope of the Super Oerlikon AAA. This enticed the Sky Guard crew to illuminate the Vulcan. However, XM597 broke radar lock and manoeuvred to fire 2 Shrike missiles, one of which successfully destroyed the radar killing 4 Argentinian Ejercito radar operators. After a another short period spent trying to entice the TPS 43 to 'switch on', XM597 departed the Falklands for Ascension Island. On the final rendezvous with a Victor tanker, however, XM597's refueling probe snapped off and the crew were forced to divert. There were no pre-arranged or recognised diversions and the crew's brief was to ditch the aircraft should the final refueling RV fail. Reluctant to ditch XM597 in the South Atlantic the crew elected to climb to 43,000 ft for best range/endurance



performance and headed west towards South America and Brazil. Before entering Brazilian airspace the un-used Shrikes had to be jettisoned to prevent any potential embarrassment to the British and Brazilian authorities. Unfortunately, one missile 'hung-up' which was to create many problems later. After de-pressurizing at 43,000 ft and jettisoning secret documents and film through the crew entrance door, XM597 cruise descended to around 20,000 ft whilst evading a pair of Brazilian F-5 fighter aircraft which had been scrambled to intercept it. With insufficient fuel for a procedural instrument approach into Rio's Galeao International Airport, XM597 was flown to the overhead where it commenced a spiral descent and visual approach. The aircraft was landed with only a few hundred pounds remaining in the tanks.

After being held under 'open arrest' (but well treated) on the military side of Galeao Airport for 7 days, and to prevent further embarrassment to Brazil and Britain, XM597 and its crew were finally released and allowed to return to Ascension Island. The captain of XM597, Sqn Ldr Neil McDougall was subsequently awarded the Distinguished Flying Cross (DFC) on behalf of his crew's endeavour. The other crew members of XM597 were Flt Lt Dave Castle (Nav Radar), Flt Lt Barry Smith (Nav Plotter), Flt Lt Rod Trevaskus (AEO), Flt Lt Brian Gardner (AAR pilot), and Fg Off Chris Lackman (Co-pilot). A final Black Buck raid, number 7, delivered airburst bombs to Port Stanley, and with that, the Vulcan bowed out of the war.

Two years after the Falklands War, in March 1984, the last Vulcan squadron was disbanded, leaving only the Vulcan Display Team to fly on. XL426 thrilled airshow visitors, until 1986 when it was offered for tender. Bought by Roy Jacobsen, now XL426 is looked after at Southend airport by the Vulcan Restoration Trust. The sale of XL426 did not mean the end of the Vulcan Display Team though - it was replaced by XH558, which was to roar through the skies for many years, becoming probably the most famous Vulcan there is.



One of the last displays - XH558 and the Red Arrows; Paul Osborne



While the Vulcan Display Team continued to operate the Vulcan very publicly, the RAF itself no longer operated them at all, and many were scrapped or burned. A few were thankfully preserved and sold to museums or private individuals. Unfortunately defence cuts began to bite into all of the UK's armed forces, and maintaining a single aircraft for display purposes could no longer be justified by the MoD's bean-counters. In early 1993, despite intensive public lobbying to keep her flying, XH558 was finally also offered for tender, and sold to David Walton who now keeps it at Bruntingthorpe airfield in





**The sad end - Vulcans being scrapped at Scampton; via Colin**

Leicestershire. XH558, like XL426, is looked after with a view to getting her flying again. That was the end of the Vulcan in RAF service, and none have flown since then.

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