SEA HARRIER

A MID-LIFE UPDATE

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Admiral Sir Henry Leach said after the Falklands conflict 'without the Sea Harrier there could have been no Task Force'. There could have been no better accolade for the part played by the Harrier which, in spite of the lack of organic Airborne Early Warning aircraft, proved the value to the Fleet of operating VSTOL aircraft within a maritime environment.

Early in the 1950s a patent had been submitted by a Monsieur Wibault for a ground attack Gyropter. This was passed to Bristol Siddeley Engines Ltd. and there resulted a joint patent with Wibault, issued in 1956, which identified several features now to be seen in the Pegasus engine. The early Pegasus was embodied in an airframe produced by Hawkers and the two have evolved into the Harrier Jet as known today. The decision to provide the Fleet with an organic VSTOL aircraft was stated in 1974 in the Naval Staff Requirement, NSR 6451, and written large throughout the requirement were the words Minimum Time, Risk, and Cost. Also written large was the fact that the new aircraft was to be based on the R.A.F. Harrier GR3 ground attack aircraft and the only changes to be allowed from the GR3 were those essential because of the revised weapon system, or essential to make the aircraft compatible with its shipborne environment. Additionally certain cost-effective changes were allowed to increase the pilot's ability to fight the aircraft.

The Sea Harrier's weapon system centres round the Blue Fox radar which was developed from the Lynx helicopter's radar. Blue Fox was optimized to look for aircraft flying at medium height. Teeth are provided by AIM 9 Sidewinder heat-seeking missiles and a pair of Aden 30 mm cannon based on a World War II design.

Although the Sea Harrier acquitted itself well in the South Atlantic, its limitations, already known to the Naval Staff, were confirmed. These were:

- poor radar range
- lack of look-down capability
- poor missile load
- poor missile range
- limited endurance.

Illustrious sailed for the South Atlantic having embarked Harriers with an increased missile load and increased endurance (FIG. 1). The normal combat fuel tanks had been replaced by hastily manufactured and untested tanks of larger capacity. These were temporary expedients and the NSR 6455 mid-life

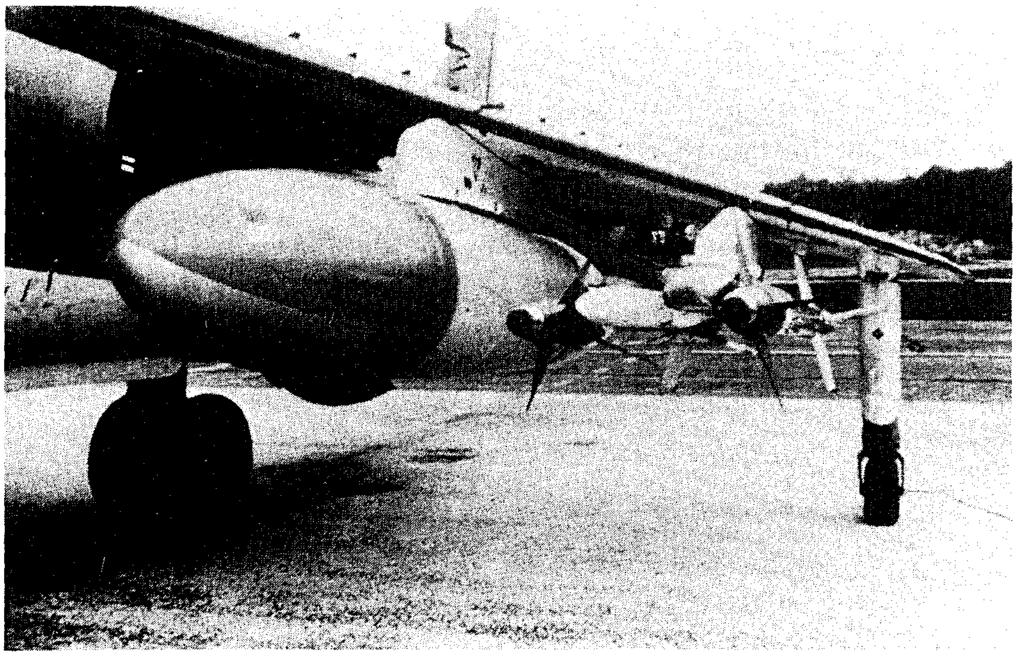

FIG. 1—SEA HARRIER WITH LARGER FUEL TANK AND INCREASED MISSILE LOAD

update was conceived, intended to transform the Sea Harrier from a fighter having severely limited all-weather capability into an interceptor variant with a true all-weather capability. NSR 6455 introduces a new missile and a new radar.

The new missile is the Hughes Aircraft Corporation's AMRAAM—Advanced Medium Range Air-to-Air Missile—destined to be the NATO standard aircraft missile from 1986. AMRAAM will provide all-weather all-aspect engagement capability and must be complemented by a radar which allows the full engagement envelope of the missile to be utilized.

Ferranti have been awarded the contract to develop the Blue Vixen radar. This will be capable of long-range detection in both look-up and look-down situations and will provide the necessary target track and velocity information and data link facilities. Blue Vixen will have the ability to track a considerable number of targets whilst scanning and will enable several targets to be engaged at any one time. The system will be compatible with current weapons such as Sea Eagle and future weapons like ASRAAM and ALARM (Air Launched (Anti Radiation Missile)).

Sea Harrier to NSR 6455 standard will provide the Fleet with a viable outer defence against the foreseen threat. This threat includes attacks in strength by supersonic bombers carrying air-to-air and anti-radar missiles. These aircraft must be engaged before releasing their weapons, which will inevitably be when they are well outside the range of Force area defence weapons. A continuing threat is presented by enemy reconnaissance aircraft which must be neutralized before acquiring or relaying their target information. Similarly, the elimination of enemy ECM aircraft will lift the cover of any attacking forces and restore the effectiveness of Force defensive weapons.

Sea Harrier to NSR 6455 standard will be able to meet these threats and will also provide the Task Force Commander with increased options. Thus the Mk. 2 Sea Harrier will be vastly improved from the present Mk. 1 aircraft. The introduction of the Blue Vixen radar will more than double the radar search capability of Sea Harrier and the AMRAAM engagement zone is in a totally different league to that of Sidewinder, being of the same order as Sea Dart.

In the NST precursor the Naval Staff asked for a whole range of new equipment as well as nice-to-have items to be considered in the mid-life update. Feasibility studies have shown that not all these can be accommodated because of the increased weight they would cause.

The main features of the mid-life update are outlined below.

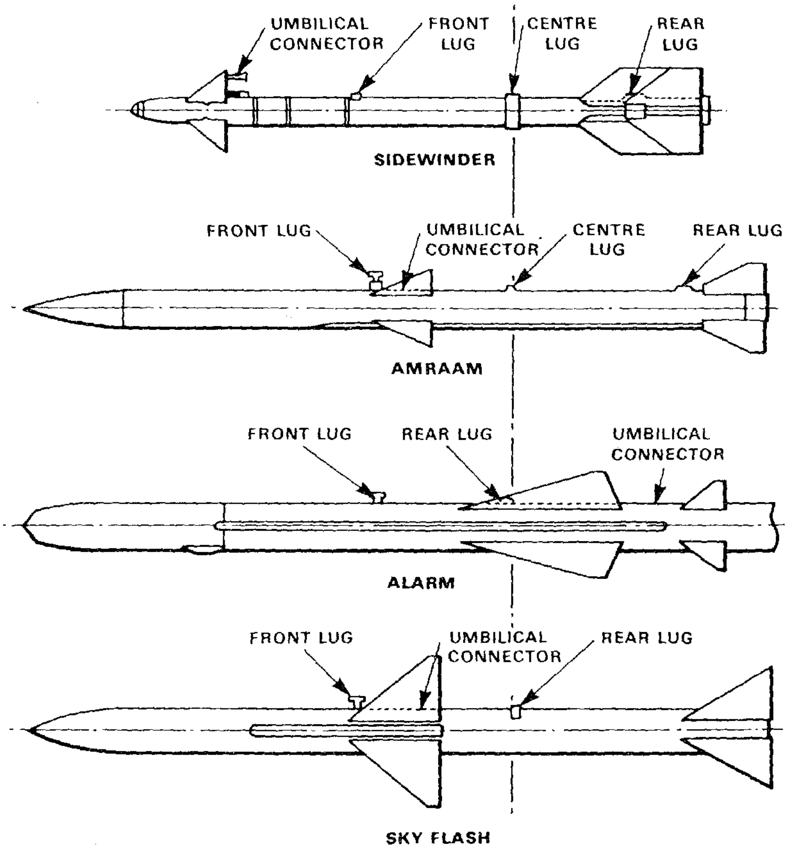

FIG. 2—AMRAAM AND OTHER MISSILES

AMRAAM

AMRAAM (FIG. 2) is currently under development in the U.S. for use on their F14, F15, F16, and F18 aircraft. It is available to NATO; the Germans intend fitting AMRAAM to their Phantoms and in the U.K. it is being fitted to the Tornado air defence variant as well as Sea Harrier.

AMRAAM is reasonably light-weight—it is heavier than Sidewinder but significantly lighter than Skyflash. Its effective range is roughly the same as Skyflash or Sea Dart, or about ten times that of Sidewinder. AMRAAM's main advantage over weapons such as Skyflash and Sea Dart is that it uses active rather than semi-active homing, thus allowing simultaneous multiple-target engagements.

AMRAAM's primary guidance mode (FIG. 3) is termed Command Inertial, which is a slight misnomer as it is not 'command' guidance in the true sense. Immediately before launch the missile is given target position and motion.

The missile is launched with its seeker silent. Using its own inertial system the missile flies out on a trajectory which will put it in the best position to acquire and intercept the target. While in flight the missile periodically receives data link messages from the launch aircraft, transmitted via the aircraft's radar, with updated information on target position and manoeuvre. If necessary the missile adjusts its flight path to optimize its approach to the target. The missile decides when to switch its radar seeker on—this will be as late as possible to deny the target time to manoeuvre or deploy countermeasures. When transmitting update messages to the missile the launch aircraft radar is not constrained to point towards the missile, or the target, indeed the radar can continue scanning. Several missiles may be launched in a ripple, each one directed at a different target.

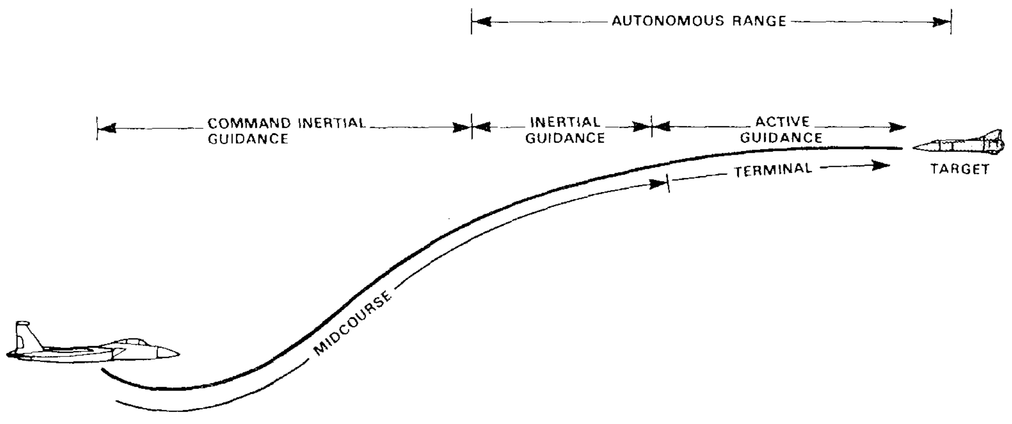

FIG. 3—AMRAAM GUIDANCE

Blue Vixen Radar

To make full use of AMRAAM's potential on Sea Harrier a radar is required which can:

(*a*) detect small targets at long range, often at low level and thus seen against a sea clutter background;

(*b*) track multiple targets;

(*c*) transmit AMRAAM mid-course update messages.

The Blue Vixen radar is a multi-mode, pulse-doppler, I-band radar. It has a larger antenna than Blue Fox and is somewhat heavier. For Sea Harrier, weight is always a problem, but weight in the nose would be catastrophic. It is worthwhile disgressing for a moment to explain this fundamental problem.

The standard method of operating Sea Harrier is short take-off, using a ski-jump and vertical landing. The ski-jump, invented by Lieutenant-Commander D. Taylor, an Air Engineer Officer, allows the aircraft to get airborne at high weights, with full fuel and full weapon load. When the aircraft returns it is light enough to hover and land vertically, thus requiring minimum clear deck space. In the hover, attitude is maintained by bleeding off high pressure air from the engine and blowing it, as required, from four puffer ducts at each wing tip and at the nose and tail. (FIG. 4). There is a limit on the control moment available, so the aircraft centre of gravity must be within reasonable limits or it becomes impossible to hold attitude in the hover. At the moment the Sea Harrier is nose heavy and all aircraft carry some ballast in the tail.

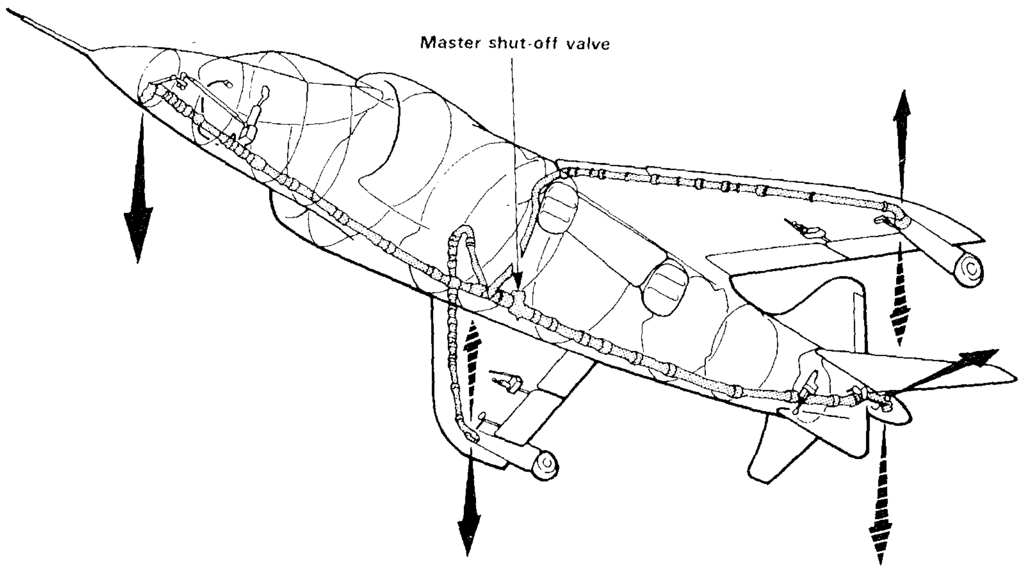

FIG. 4—SYSTEM FOR ATTITUDE CONTROL IN THE HOVER

Returning to Blue Vixen radar, which is heavier than Blue Fox; if all this were added in the nose it would be necessary to add a similar weight to the tail to maintain balance. To avoid this, Ferranti have divided the radar into two main packages. The RF units (transmitter, receiver, and antenna) will be mounted in the nose but the processors will be fitted in the rear equipment bay which is aft of the centre of gravity. This is novel for AI radars which, for all previous fighter applications, have had all units packaged as closely together as possible in the aircraft nose. The data link between front and rear equipments is a critical feature of the Blue Vixen installation. The link will use fibre optics. This use of advanced technology will undoubtedly introduce some interesting problems during development but a fibre optic link is essential to meet the demanding requirements of wide bandwidth and immunity to electro-magnetic interference.

Endurance

One other major performance improvement sought at mid-life update is endurance. In its present air-to-air configuration—with a full load of Sidewinders and existing combat fuel tanks—Sea Harrier can remain on combat air patrol (CAP) well ahead of the force for under a hour. A substantial improvement can be achieved with the larger tanks which were rapidly brought into service just after the Falklands Campaign but unfortunately these tanks are not of the optimum size or shape and they give problems in terms of stability and ability to jettison. A number of improved ways of increasing fuel capacity are being considered, including under-fuselage tanks and wing-mounted slipper tanks.

JTIDS

One other system which it is hoped to introduce into Sea Harrier during the mid-life update is JTIDS (Joint Tactical Information Distribution System). This is a data link system which is to be fitted to all R.N. ships and aircraft over the next decade to provide secure, ECM-resistant, high capacity voice and data communications.

Consequent Changes

As a consequence of embodying the major features outlined, a number of other changes become essential or desirable and cost-effective.

Aerodynamics

Initial wind tunnel studies indicated that the carriage of the desired load of AMRAAM could significantly reduce aerodynamic stability, making the aircraft difficult and in some circumstances impossible to fly. Further wind tunnel studies have been carried out to identify ways of eliminating this problem. Early results suggest that small winglets may have to be fitted to the wing tips to maintain acceptable stability margins or alternative store-carrying configurations may be necessary.

Propulsion

The mid-life update will increase the aircraft basic weight making vertical landing, particularly at high ambient temperatures, a problem with the present engine. An uprated engine—produced by modification of the present engine—is being considered, capable of greater thrust particularly at high ambient temperatures.

Structure and Cooling

The aircraft equipment cooling system has to be uprated to cope with the increased heat dissipation of the new equipments, particularly the radar. It is possible that a fuselage extension will be necessary to provide the space needed to install a cooling system of the required capacity.

Avionics

At present data transfer between avionic equipments such as the radar, the weapon-aiming computer, and the navigation computer is via analogue links or dedicated uni-directional digital data streams. The modern approach to inter-unit data exchange is to use a digital data bus. This significantly reduces the number of interconnecting cables required, all data being passed using two wires on a time-sharing basis. System integrity is also enhanced as all data is available to all equipments connected to the bus. AMRAAM is designed to interface via a U.S. MIL-STD-1553B[1] data bus, so as part of the mid-life update we intend to introduce such a data bus to interconnect all the main avionic equipments.

Support

From the brief review of the weapon systems it is apparent that we will have moved from a single processor system to one which has seven processors each with its own integrated software problems. It is policy to support all operational software at 2nd line and to this end a software management facility for Sea Harrier has been established at Yeovilton. Mid-life update means that operational software will reside not only in the head-up display weapon aiming computer but also in the Blue Vixen radar, JTIDS, RWR, and MIL-STD-1553B bus controller. The Software Management Facility will be expanded in capacity and capability to embrace these new systems and additionally a synthetic development unit will be incorporated which will be capable of testing software changes dynamically. This enhanced software facility will be operational ahead of the Mk. 2 Sea Harrier so that we can make a positive contribution to the complete weapon system design during development.

AMRAAM support has not yet been clearly defined; in principle AMRAAM is a 'no test' weapon capable of living in its container for a considerable time before being loaded on to aircraft. At 1st line it will require minimal maintenance or logistic support. Responsibility for 3rd line support lies with the R.A.F. who are acting as supply managers for the weapon; 4th line support currently requires the missile to be returned to Hughes in the U.S.A. but is it hoped that sister firm arrangements will be established in Europe.

As far as Blue Vixen radar is concerned it is hoped that built-in test equipment (BITE) will detect up to 93 per cent. of all faults at 1st line and diagnose them to the Line Replaceable Unit and possibly even module level. 2nd line facilities on board should enable fault isolation to a single module with 90 per cent confidence and to 3 modules with certainty. 3rd line testing equipment will utilize in-Service equipment where possible.

Conclusions

The Sea Harrier mid-life update will provide the Fleet with an aircraft which has a real all-weather interceptor capability. It cannot be emphasized too strongly that Sea Harrier, AMRAAM, and Blue Vixen combine to make a very effective team which will be a major advance from the Sea Harrier we know today. The Mk. 2 Sea Harrier will come into service before the end of this decade in sufficient numbers to maintain three squadrons in the front line if necessary.

Reference

1. Military Standard MIL-STD-1553B: 'Aircraft internal time division command/responsible multiplex data bus' (Sept. 1978, amended Feb. 1980).