PRIME TIME FOR MERLIN

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ABSTRACT

The R.N. development Merlin is flying with all mission avionic equipment. Problems overcome include aerodynamic ones, and airframe vibration has been greatly reduced by Active Control of Structural Response. Automatic test equipment plays a large part in achieving high availability. The required standard of aircraft performance and availability is to be achieved at minimum risk to MOD through a prime contractor arrangement.

Background

The last article to be published in the *Journal* on the EH 101 helicopter, or Merlin as the R.N. variant is now called, was, believe it or not, back in 1985[1]. Now, five years later, it should be no surprise that many of the plans, models and artists' impressions contained in that article have become reality, despite periodic prophesies of doom and gloom due to time and cost overruns. Certainly this complex project, now in the seventh year of full aircraft development, has had its fair share of technical difficulties and programme slippages, but eight out of the nine pre-production (PP) aircraft are flying and have logged a total of over 600 hours. PP5, designated the R.N. Mission Systems Development aircraft (FIGS. 1 and 4), first flew in October 1989. It contains the full suite of mission avionic equipment and, together with the Westland 'Hack' Sea King avionics test aircraft and a full scale avionic systems integration rig, has made good progress in the demanding task of

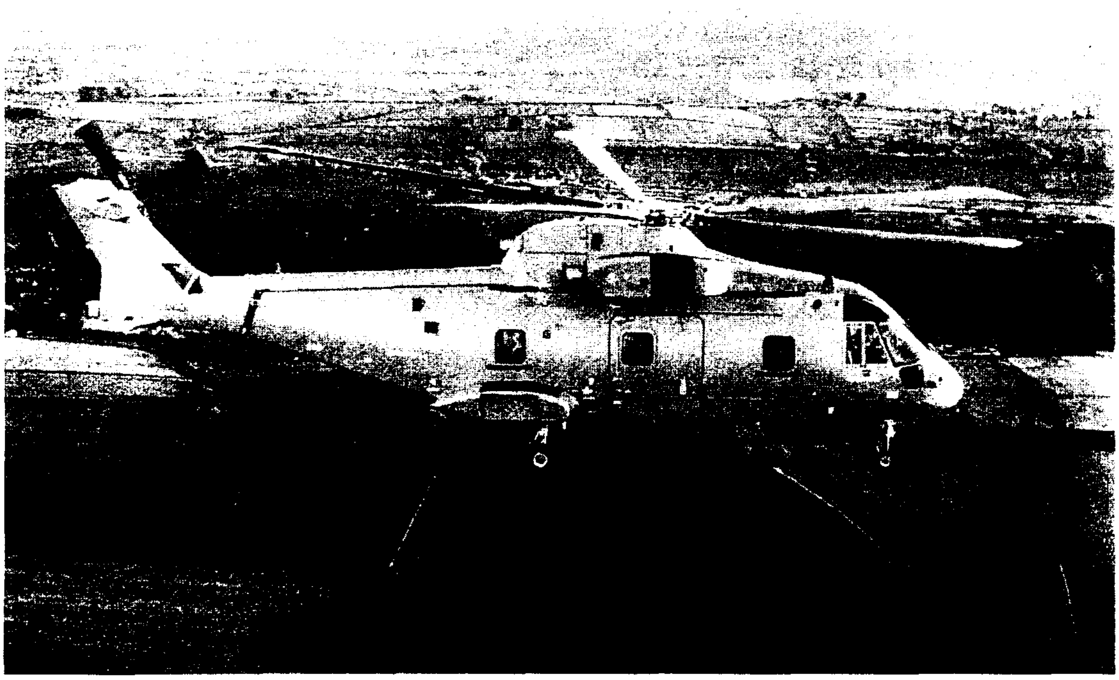

FIG. 1—THE MERLIN HELICOPTER. THE R.N. MISSION SYSTEMS DEVELOPMENT AIRCRAFT (PP5)

integrating the most sophisticated avionics system yet flying in any U.K. military aircraft, rotary or fixed wing. This article seeks to update the reader on the progress and problems of the Project and to indicate the way ahead to its introduction into R.N. service.

Modifications to the Requirement

In 1984, when full development started, it was not possible to define fully some of the equipments to meet the Staff Requirement. Since then, new technology and industrial competition have combined to allow specification of these uncertainties, and probably the most significant of these is the Low Frequency Active Dipping Sonar (LFADS). The definition of LFADS, together with other performance and weight growth factors has led in turn to the choice of the more powerful RTM 322 engine for production aircraft. These specification changes require, at a relatively late stage in the development programme, a more complex airframe and mission systems integration task, with implications for performance, crew workload and ergonomics, and of course cost.

The TRIAD concept of operations, using a group of frigates as forward operating bases for Merlin with an AOR (or CVS) always in company to provide the required level of support, will become primarily a wartime practice. In peacetime, it is now accepted that there will be greater emphasis on autonomous operations with frigates often operating as single units, so requiring more comprehensive support and maintenance facilities on board.

Automatic test equipment has now been specified as the predominant tool in the Merlin Avionic Test System (MATS) for 2nd Line fault diagnosis. The two main reasons for this choice, compared to the use of many special-to-type test sets, were the need to reduce the bulk of test equipment and documentation on board ship and the desirability of reducing skill levels of maintenance personnel in 2nd Line workshops.

Requirements have also been identified for advanced MAD submarine localization equipment, colour tactical displays to ease the workload of the Mission crew, ship/aircaft data link equipment and twin HF radios associated with data link.

The decision to fit Rolls Royce/Turbomeca RTM322 engines has only recently been confirmed at Government and Treasury level. After a competition, this engine was chosen in preference to the general Electric CT7-6, predominantly because of its greater power and growth potential for lower cost and risk.

At the end of 1989, a detailed review of the Project by the Secretary of State for Defence took place and the way ahead chosen was for a two-stage approach towards achieving the specified performance. A batch of Mk. 1 aircraft, to a defined, but lower, performance standard would be introduced to meet the planned In-Service Date. At some later time, a Mk. 2 aircraft, with uprated engine and transmission, would be delivered, which would fully meet the Requirement specification.

Development Problems

The avionics programme is generally going well. Obviously there are many problems still to be sorted out, but all are considered to be soluble within the current timescale of the development programme. Development of the air vehicle has been more troublesome and the programme is well behind schedule, but during the past 12 months much better progress has been made and the main problem areas, which have been Hover Performance, Pitch-up, Shuffle, Tail Rotor performance and Vibration, are now well understood and full solutions either achieved or close at hand. The first three of these problems are aerodynamic in nature. Poor hover performance is caused by excessive main rotor blade drag and has been cured by refinements to blade tip design; pitch-up is caused by main rotor downwash on the horizontal stabilizer; and Shuffle (a wagging of the aircraft in yaw) is caused by eddies from the main rotor head and various cowlings impinging on the tail unit. Poor tail rotor performance (and strength) has necessitated a change of hub design from 'semi-rigid' to 'teetering'.

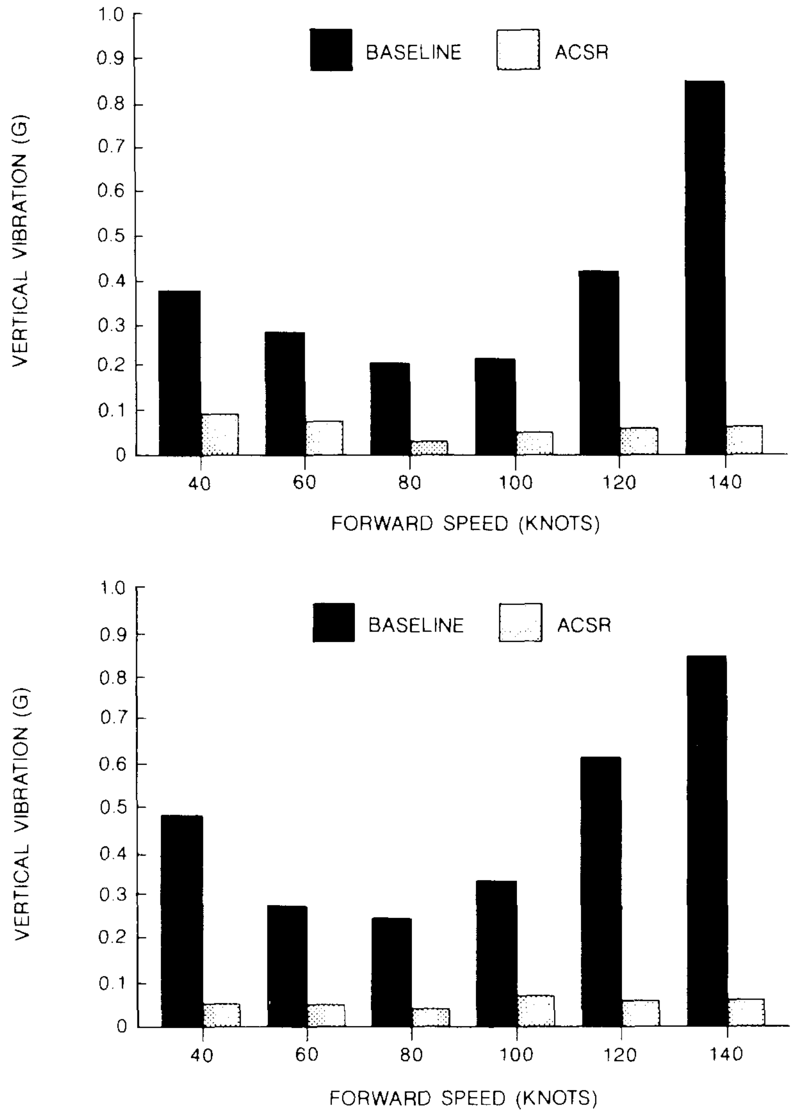

FIG. 2—ACTIVE CONTROL OF STRUCTURAL RESPONSE (ACSR) FLIGHT TESTS IN MERLIN PP3
(TOP) CO-PILOT POSITION
(BOTTOM) CABIN, STN. 8875 PORT
Based on a diagram provided by E. H. Industries Ltd

Airframe vibration has always been an inherent problem with helicopter flight, causing aircrew fatigue, airframe cracking and avionic systems unreliability. Merlin is no exception and vibration at the blade passing frequency (5R), in particular, has been unacceptably high, despite trials to increase airframe structure stiffness. Passive vibration absorbers, both on the main rotor head and in the cabin, have been tried, but they are only effective within a narrow frequency band and introduce a significant weight penalty.

Most recently, a computer-managed system for Active Control of Structural Response (ACSR), developed by Westland Helicopters Ltd., has been successfully demonstrated in pre-production aircraft, achieving 5R vibration level reductions of between 60% and 85% through most of the speed range (FIG. 2). A number of accelerometers, positioned at strategic points in the airframe, sense the structure's response to rotor-induced vibration and apply appropriate anti-phase forces via electro-hydraulic actuators built into the main transmission mounting struts (FIG. 3). ACSR, while requiring further refinement and development, appears to offer the greatest potential for reducing vibration levels sufficiently to meet, or better, Merlin's vibration specification and to ease its weight problem.

Weight growth tends to be a feature of any aircraft development programme and Merlin has stringent weight targets to prevent performance, endurance and payload capacity being compromised. Five phases of weight-saving measures have been implemented and a final, sixth phase is being considered. Increasingly, traditional aluminium alloys have been replaced by the new aluminium lithium and steel components by titanium. Care needs to be exercised to ensure that cost and maintainability considerations are not forgotten in the pursuit of 'slimming'.

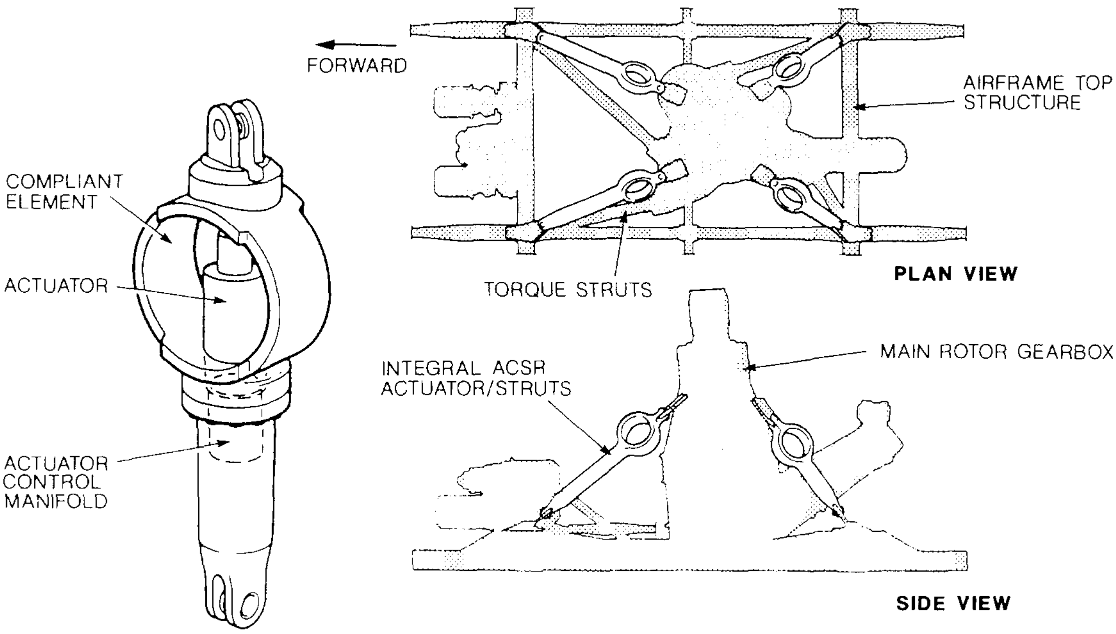

FIG. 3—ACSR ACTUATOR INSTALLATION AND CONFIGURATION

Courtesy of E. H. Industries Ltd

Maintenance and Support Policy

To obtain a high availability from an aircraft as complex as the Merlin while operating it from the cramped confines of a Type 22 or 23 frigate requires higher levels of equipment reliability and maintainability than have generally been achieved hitherto and the use of sophisticated fault diagnosis techniques and test equipment.

The specified overall aircraft reliability is 250 defects per 1000 flight hours, some three times better than currently achieved on Sea King. The corrective maintenance effort is not to exceed 1 man-hour per flight hour and the mean time to repair defects is not to exceed 2.7 hours. There are other, more detailed maintainability requirements; for example, any defective avionic LRU is to be identified, replaced and tested within 20 minutes.

The primary means of First Line (on aircraft) fault identification and investigation is the In-Built Check Out Ststem (IBCOS) which utilizes the Aircraft Management computer (AMC) to integrate the extensive Built In Test (BIT) facilities of each avionic equipment, and inputs from aircraft and engine Health and Usage Monitoring systems (HUM and EHUM respectively) to isolate defects to Line Replaceable Unit (LRU) level.

As their names imply, the HUM and EHUM monitor important parameters of transmission, hydraulics, electrical power, airframe and engines, highlighting faults through the IBCOS to the crew and recording component serviceability, condition and usage for post-flight downloading to a Ground-based Data system for analysis by Flight or Squadron maintenance personnel. This unit will interface with the Work Recording and Asset Management system that is being studied as part of a comprehensive Fleet Air Arm Information Technology programme[2] and should automate defect and maintenance recording activity and eradicate much tedious paper work.

As already mentioned, MATS, incorporating comprehensive automatic test equipment, is specified for use in Second Line workshops. It will confirm a LRU defect previously identified by BIT, localize the defect to circuit board(s) (CB) level and retest the LRU after fitting of a relacement CB.

Merlin is indeed a software-intensive weapon sytem. Fair comparisons are difficult to make, but as an example, the software content (in kBytes of ROM) of Merlin is 5000 compared to 700 for Sea Harrier FRS 2, 2700 for Nimrod Mk.2, and 3000 for Lynx Mk.8. Although the prime language is Pascal, developed under the Perspective support environment, there are several other high level languages used, due to the use of 'off-the-shelf' equipments and the more recent adoption of Ada for MOD developments, and even more assemblers for time-critical elements. To support this complex system, a Software and System Support Cell (SSSC) will be established, probably at the Main Support Base. It will provide a point of system expertise to enhance that available in service and will be an 'intelligent customer' for the software, able to produce comprehensive Statements of Requirement for software changes. The SSSC will not be the Design Authority for software nor is it the intention for it to produce changes to software, although the prototyping of changes might be undertaken.

Prime Contractorship (MPC)

There are several reasons why the Merlin has been subjected to close ministerial scrutiny over the last 12 months and why its future has been a trifle uncertain. Firstly, the project has been running considerably over time and over budget. Secondly, the Development Contract is not a fixed price one, so the MOD has been faced with an open-ended cost increase. Thirdly, although the current contract provides for the development and integration of the various systems and components that are required to meet the Staff Requirement (NSR 6646), there is no contracted performance standard for the aircraft. So, the risk of the aircraft entering R.N. service with a performance or an availability that does not meet the specification is held entirely by the MOD.

To rectify this state of affairs, in 1989, SEMA Scientific was contracted to produce a Mission System Integration (MSI) specification which would tautly define the requirement in terms of measurable overall weapon system performance, reliability and maintainability, against which a suitable contract could ensure compliance. It soon became clear that such a specification would be of minimal value unless it encompassed the whole aircraft and hence the MSI specification was expanded to become the Merlin Mission Performance and Acceptance Specification. It is this which will be used as the basis of a Merlin Prime Contract (MPC).

The use of a Prime Contractor is necessary to ensure that the maximum amount of risk can be transferred most effectively from the MOD to Industry. In addition, the Procurement Executive intends to employ the principles of competition and a fixed price contract to obtain best value for money. The objective is for a Prime Contact to be let by mid 1991, encompassing the remainder of Development and Production Investment for R.N.-specific equipments, a first Production batch of about 50 aircraft and much of the logistic, maintenance and training equipment required to support them. Development and Production Investment phases for the collaborative Basic and Naval, Utility and Civil variants of the aircraft will continue under existing agreements between Italy and U.K.

FIG. 4—PP5 OVER THE SEA

Summary

After just over six years of Full Development, the Merlin (EH101) project has come a long way; the R.N. development aircraft, PP5, is flying with a full suite of mission equipment, and integration of avionic equipment is well advanced. Perhaps not suprisingly, there have been problems associated with this exceedingly complex collaborative design and these have caused time and cost overruns to the development programme. However, many of the difficulties in this phase have now either been solved or cures are close to being achieved and the Production Investment phase is due to start by the end of 1990.

To achieve high availability from Merlin in the difficult environment of embarked operations from small ships, a tight specification for reliability and maintainability is required as well as sophisticated fault diagnosis and test facilities, both on and off aircraft. To try to ensure the required standards of aircraft performance and availability, to obtain better value for money, and to transfer risk away from the MOD, a fixed price Prime Contractorship is being sought. It will be a significant departure from existing arrangements and, whilst heralding a new era of PE policy, its introduction at this advanced stage of the Project will present some difficult transitional problems. However, the longer term benefits once the aircraft has entered R.N. service, in terms of performance, reliability and through-life cost, should vindicate the decision. There is every chance that the Navy will have, with Merlin, a world-beating ASW helicopter.

References

1. Bunday, D., and Whittingham, B. A.: The EH 101 advanced ASW helicopter; *Journal of Naval Engineering*, vol. 29 no. 1, June 1985, pp. 124–129.
2. Highton, R. A.: Information technology for a modern Fleet Air Arm; *Journal of Naval Engineering*, vol. 32, no. 3, Dec. 1990, pp. 669–675.